Atlantic cod (depleted or rare species) within the PBGB LOMA

Potentially Harmful Activity (X)			Potentially Harmful Stressor (X)		
Fishing	Bottom trawl	**X**	Marine pollution	Oil pollution	
	Scallop dredges			Industrial effluent	
	Clam dredges			Fishplant effluent	
	Midwater trawl			Sewage	
	Gillnets (bottom)	**X**		Historic military waste	
	Gillnets (pelagic)			Long range transport of nutrients	
	Longline			Acid rain	
	Seine (pelagic)			Persistent Organic Pollutants	
	Recreational cod fishery	**X**		Eutrophication	
	Crab pots			Ghost nets	**X**
	Lobster pots			Litter	
	Whelk pots			Other contaminants (specify)	
	Other (specify)		Climate Change	Ice distribution	
Other harvest	Otter trapping			Temperature change	**X**
	Seal hunt			Sea-level rise	
	Seabird hunt			Ocean acidification	
	Seaweed harvest			Current shifts	**X**
Seabed alteration	Anchor drops/drags			Increased storm events	
	Ore spill			Increased UV light	
	Fish offal dumping			Oxygen depletion	
	Finfish aquaculture			Changes in freshwater runoff	
	Dredge spoil dumping			Other (specify)	
	Dredging		Harmful species	Green crab	
	Mining/Oil & gas drilling			*Membranipora*	
	Cables			Golden Star Tunicate	
Coastal alteration	Freshwater diversion			Violet Tunicate	
	Subtidal construction			Vase Tunicate	
	Intertidal/coastal construction			*Codium fragile*	
				Clubbed Tunicate	
	Other (specify)			*Didemnum*	
Disturbance	Vessel traffic			Harmful Algal Blooms	
	Ship strikes			Disease organisms (human waste)	
	Ecotourism			Disease organisms (aquaculture)	
	Marine construction			Other (specify)	
	Seismic surveys		Other		
	Navy sonar				
	Other (specify)				

Background Information

During the early 1960s, total cod biomass (age 3+) was estimated to have been about 3 million tonnes. It collapsed in the late 1980s and early 1990s to about 1-2% of that level, leading to a moratorium on all directed fishing of Atlantic cod in 1992 (Templeman & Davis, 2006). Historically, most cod over-wintered in deep water (300-500m) on the outer slopes of the shelf and migrated during spring-autumn to feeding areas near the coast or on the plateau of Grand Banks. On the Grand Banks, there appears to be a northerly distribution during the fall with a southward progression in early spring. The main areas of concentration are the northeast slope of the Grand Banks (fall), the central portion of Grand Banks, and the upper Southwest Slope of the Grand Banks (Templeman & Davis, 2006).

The dominant prey for medium-sized cod are planktivorous fish, notably capelin and sand lance on the Grand Banks. Predators change with cod size and there is considerable interest in the role of seals, particularly harp seals (Templeman & Davis, 2006).

Juvenile cod have been linked to a variety of structured habitats (macrophytes, cobble, sponges, etc.) during their first year of life, likely as a means of reducing predation and physical exposure while possibly increasing feeding opportunities. In coastal areas, juvenile cod have been shown to select structured habitats during settlement, but it is uncertain whether such processes are important to spatial patterns of cod in the offshore. Larger juvenile cod (age 1-2 yrs) gradually move into deeper water and often associate with kelp beds near eelgrass nursery areas. One-year old Atlantic cod are often observed in these habitats at 15-25m of water over the entire winter. Three-year old fish also have been shown to associate with a variety of substrates, but they are typically much more widely distributed amongst a greater range of depths (Templeman & Davis, 2006).

Two populations of Atlantic cod occur within the LOMA, the Laurentian North population (3Ps, and 3Pn4RS) and the Newfoundland and Labrador population (2J3KL, and 3NO). Both populations were assessed by COSEWIC in 2003 and the Laurentian North population was designated as *threatened*, and the Newfoundland and Labrador population was designated as *endangered*. Over-fishing led to the devastating collapse of groundfish stocks in the early 1990s (Pepper & Pepper, 1995). A commercial groundfish moratorium was put in place for the waters off the northeast coast of Newfoundland and southern Labrador (2J3KL) in 1992, and extended to include the Eastern Scotian Shelf and southern Gulf of St. Lawrence in 1993. By 1994, the northern Gulf, the southern Grand Banks (3NO), and waters off the south coast of Newfoundland (3Ps) were also closed. By 1997, only the 3Ps cod stock had recovered to a level which could support a small commercial fishery. A partial recovery of the 4R3Pn and 2J3KL stocks resulted in a re-opening of limited commercial/index fisheries in these areas in 1997 and 1998 (Action Team for Cod Recovery, 2005).

During the late 1990s, some cod fisheries reopened at a greatly reduced Total Allowable Catch (TAC). 3Ps stock increased most rapidly during the moratorium and was reopened in 1997. Stocks have declined since the moratorium was lifted but remain near average levels. The TAC for 2001-2002 was set at 15,000 tons. The Northern Gulf also reopened in 1997 but stocks remain low. TAC for 2001-2002 was set at 7,000 tons. The NE coast (2J3KL)

reopened in 1998. Although the overall stock was still at an extremely low level, significant aggregations were evident, largely inshore, with highest densities in Bonavista Bay, Trinity Bay (Smith's Sound), St. Mary's Bay, and Tobin's Point (~100m offshore on 3K/3L boundary). The TAC for 2001-2002 was set at 5,600 tons. The Southern Gulf reopened in 2000 although stocks remain low. The Scotian Shelf and the Southern Grand Banks remain closed. The TAC for the Canadian North Atlantic in 2001 was 33,600 tons, less than four percent of the total cod harvested in the marine waters of Newfoundland and Labrador in 1968 (Fisheries and Oceans Canada, 2000). Northern cod stocks currently remain low and a complete closure of all areas is under discussion for 2003.

Division 2J3KL cod

- Moratorium declared in 1992.
- A small fishery directed at these inshore populations was introduced in 1998. Catch rates declined and the directed commercial fishery was closed in 2003. A food/recreational fishery, which had been open for several years, was also closed. Catches during 2003-2005 were limited mainly to bycatch during a winter flounder (black back) fishery (Fisheries and Oceans Canada, 2008b).
- A directed stewardship fishery and recreational fisheries were re-opened in the inshore in 2006 and continued into 2009.
- Reported total landings from the 2007 stewardship fishery were 2364t. This included 2192t taken as directed catch and 172t as bycatch. In addition, 182t were landed in the sentinel surveys. The offshore portion of the stock area remained closed to directed fishing.
- Based on autumn and spring surveys, the average biomass of cod in the offshore over the last 3 years is 4-5% of the average during the 1980s. However, survey biomass has been increasing since 2003 (Fisheries and Oceans Canada, 2008b).
- The only aggregation known to exist at the present time in this stock over-winters in a deep-water inlet in northern Division 3L, Smith Sound. Acoustic studies have estimated this aggregation to be around 20,000t. Fish from this aggregation migrate seasonally out of the sound in the spring, mainly northward in Division 3L and into southern Division 3K, supporting most of the commercial fishery, which took place in the autumn between 1998 and 2003. The fishery was closed in 2003 (Rosenberg et al., 2005).
- There is no single measure of the biomass of the stock as a whole. The information from the RV survey in the offshore and the three inshore areas are not directly comparable. However, information from offshore and inshore areas suggests that the biomass of the overall stock is increasing (Fisheries and Oceans Canada, 2008b).

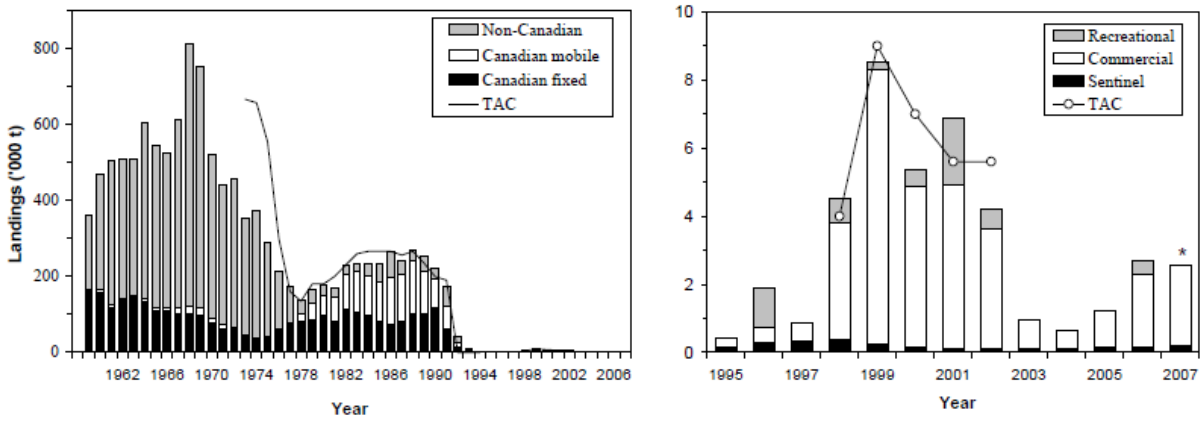

Figure 3: TACs and landings (thousands of tons) in 1959-2007. The right panel is expanded to show trends from 1995 onwards. Non-Canadian catch since 1995 is estimated at less than 80 t per year. The asterisk indicates the 2007 value excludes the recreational catch which has not been determined.

Figure 1. Landings of cod from 1959 – 2007 (Fisheries and Oceans Canada, 2008b)

Bycatch Issues - 2J3KL cod

- *European Union*: In 2001, the EU reportedly took 54t of cod in Divisions 2J3KL as bycatch.
- *Canada*: In 2003, the Canadian shrimp fishery in 3LMNO reported taking 2t of Atlantic cod aged 1-3 years. The 3LMNO shrimp stock is distributed along the edge of the Grand Banks, mainly in Division 3L. Commercial-sized cod were taken as bycatch in the turbot gillnet test fishery, and the level of bycatch increased from about 2% in 2004-2006 to 18% in 2007, suggesting that the abundance of cod in the offshore increased (Fisheries and Oceans Canada, 2008b).
- *Russia*: The Russian Greenland halibut fishery reported taking 5t of Atlantic cod out of a total catch of 2,262t in 2003 from Division 3L, constituting 0.22% of the total catch (Rosenberg et al., 2005).

Division 3NO cod

- Fish are distributed over the shallower parts of the bank in summer, particularly in the Southeast Shoal area (Div. 3N), and on the slopes of the bank in winter when cooling occurs.
- Despite the instigation of a directed-fishing moratorium in February 1994, bycatch is impeding stock recovery. Spawner biomass decreased to its lowest level in 2004, and since then has varied with little trend.
- Low spawner biomass, low recruitment and high fishing mortality point to poor prospects for this stock in the medium term. This stock is currently well below B_{lim}. Recovery will require a number of relatively strong year-classes that survive to maturity, rebuilding the spawner biomass.
- Most NAFO fishing effort (~66%), outside the EEZ, can be attributed to vessels fishing for groundfish in Divisions 3LMNO (Power et al., 2005).

Table 2. Cod landings (t) by month and gear from NAFO Divisions 3NO by Canada in 2005 and 2006.

2005	Canada (N)				Canada (M)			
	3N	3O			3N	3O		
Month	Ottertrawl	Ottertrawl	Gillnet	Longline	Longline	Ottertrawl	Longline	
Jan	0.33	24.03	0.04	3.22	0.00	0.00	0.00	
Feb	0.00	0.00	0.03	9.13	0.00	0.00	0.00	
Mar	0.16	0.00	0.00	10.68	0.00	0.00	0.50	
Apr	2.18	22.04	0.41	13.18	0.00	0.00	0.00	
May	3.30	15.32	2.41	4.43	0.00	2.60	0.60	
Jun	3.85	3.91	2.71	0.00	14.50	0.00	3.40	
Jul	0.00	0.00	0.01	0.17	3.00	0.00	1.50	
Aug	0.00	24.02	0.00	0.00	0.00	0.00	0.00	
Sep	37.43	85.35	0.26	0.00	0.00	0.00	0.00	
Oct	89.47	52.22	0.00	0.00	1.00	0.00	0.00	
Nov	22.43	9.65	0.03	0.00	0.00	0.00	0.00	
Dec	16.81	1.41	0.00	0.00	0.00	0.00	0.00	
	175.96	237.96	5.90	40.81	18.50	2.60	6.00	487.72

2006	Canada (N)				Canada (M)			
	3N	3O			3N	3O		
Month	Ottertrawl	Ottertrawl	Gillnet	Longline	Longline	Ottertrawl	Longline	
Jan	0.09	23.66	1.71	1.61	0.00	0.00	0.50	
Feb	0.00	7.29	0.03	3.76	0.00	0.00	0.00	
Mar	0.00	0.00	0.00	4.42	0.00	0.00	1.90	
Apr	0.00	18.61	0.00	5.16	0.00	0.00	0.00	
May	0.00	1.16	1.55	0.00	1.30	0.00	0.00	
Jun	0.00	0.51	2.18	0.00	2.30	0.00	12.90	
Jul	0.00	0.00	0.00	0.27	7.60	0.00	6.20	
Aug	0.00	0.00	0.09	0.00	3.00	0.00	0.00	
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Oct	0.22	0.00	0.35	0.00	0.00	0.00	0.60	
Nov	0.00	0.09	0.00	0.00	0.00	0.00	0.30	
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.31	51.33	5.91	15.22	14.20	0.00	22.40	109.36

Table 1. Cod landings for 3NO 2005-2006. N= Newfoundland Region, M= Maritimes Region. (Morgan et al., 2007).

Bycatch Problems - 3NO cod

- 3NO cod bycatch has increased more than tenfold during the moratorium period from 172t in 1995 to 2,194t in 2002. In 2002, Canada took 444t, Spain 40t, Portugal 405t, Russia 338t and other countries 967t for a total of 2,194t (all reported as bycatch). This is almost half the current biomass estimate (Rosenberg et al., 2005).
- An accurate assessment is difficult because some fisheries only report percentage bycatch or present a range of bycatch estimates.
- *Canada*: According to Canadian white hake fishery observer data from 1997 to 2003, cod under moratorium dominated in longline catches. Estimated amounts averaged 109t annually from 1994 to 2003. The Canadian 3LNO yellowtail flounder fishery had an increase in cod bycatch from 2.1% of the observed catch in 2002 to 3.5% in 2003, taking an estimated 445t of cod in the area.
- *European Union*: Spain reports taking 24t of cod in all its fisheries operating in Division 3LMNO in 2003 (9t in 3N, 15t in 3O) and an additional 175t of unspecified groundfish in 3LMNO. In total, Portuguese fisheries (unidentified fisheries, but most likely skate and redfish) took about 653t of cod as bycatch in 3NO in 2003, and as much as 328t of cod were caught as bycatch in certain months. In the Portuguese roughead grenadier fishery in 3LMNO, cod was also the top bycatch species taken in area 3O in 2003. The fishery operated in 3O in April and reported 23.5% cod bycatch.

- *Russia*: Reported bycatch in the Russian directed skate (unspecified species) fishery in Division 3NO amounted to 3,226t of skate taken, and 97t of cod were taken as bycatch (Rosenberg et al., 2005).

Division 3Ps cod

- The distribution of 3Ps cod does not conform well to management boundaries and the stock is considered a complex mixture of sub-components (Fisheries and Oceans Canada, 2009).
- Fish are caught offshore by mobile and fixed gear, and inshore by fixed gear only.
- A moratorium on fishing initiated in August 1993 ended in 1997 with a quota set at 10,000t. The TAC was increased to 20,000t for 1998 and to 30,000t for 1999. The TAC for the 2006/07, 2007/08 and 2008/09 management years have been 13,000t. Since 1994, France (St. Pierre and Miquelon) receives 15.6% of the total TAC.
- Commercial catches by Canada and France combined for the ongoing 2008/09 management year totaled 9,300t (to 31 Dec 2008), including 25t from Sentinel surveys. Estimated landings from the recreational fishery in the summer of 2008 were 101t.
- Inshore fish harvesters (<65' vessel sector) feel that the stability in their catch rates indicates there has been good recruitment and an overall stability in stock status.
- Total biomass from DFO RV surveys indicates a decline since 2004. The 2008 biomass estimate is less than 50% of the average for 1997-2008. The survey spawning stock biomass (SSB) is in decline and is near the lowest levels observed.

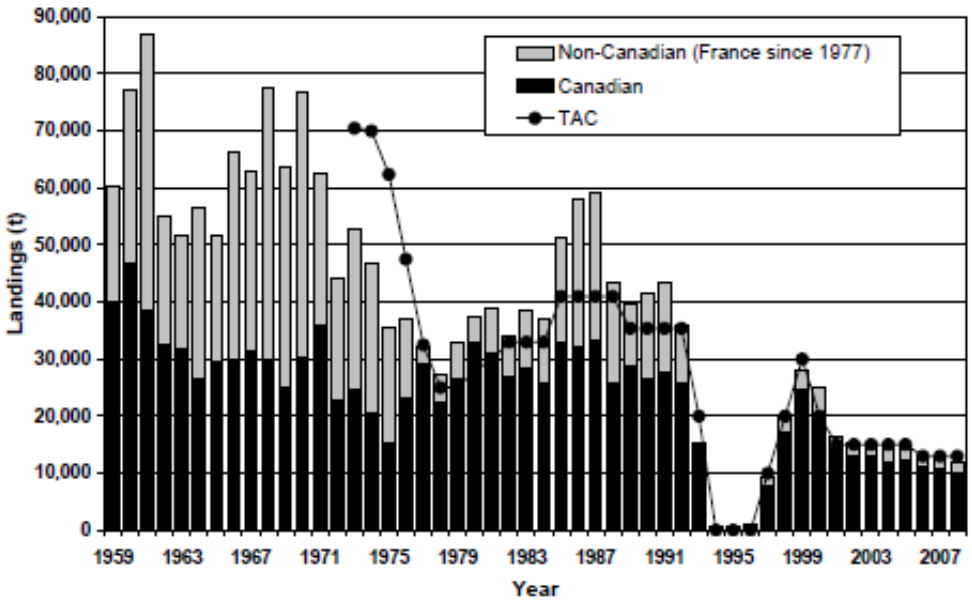

Fig. 2. Reported calendar year landings (t) of cod in 3Ps, 1959-2008. Note that TAC's are by management year (1 April-31 March) since 2000.

Figure 2. Cod landings in Division 3Ps, 1959 - 2008 (Fisheries and Oceans Canada, 2009).

Division 3Pn4RS cod

- Every year, Northern Gulf of St. Lawrence cod (NAFO Divisions 3Pn and 4RS) undertake extensive migrations. In winter, they gather off southwestern and southern

- The 2007 total allowable catches (TAC) were established at 7,000 tons. Preliminary landings available in January 2008 totaled 6,406 tons.
- The results from the two sequential population analyses indicate that spawner abundance and biomass levels remained low and have not increased since 1997.
- A 7,000t fishery in 2008 would not cause any increase in spawning stock biomass based on the formulation accepted last year. According to the other model which estimates natural mortality, there would be no spawning stock biomass increase if catches exceed 5,000 tons in 2008. Without the fishery, the spawning stock biomass would increase by 22 or 20% respectively. Exploitation rates reached 21 to 28% in 2007 based on the model used; this will not enable the stock to recover.
- In summary, catch rates are still very high and the positive trend in catch rates both in terms of level and the extensive geographic area observed continue to indicate to harvesters that the abundance of this stock is much higher than what the current assessment indicates. In order to reach a spawning stock biomass of 100,000t in 10 years at current productivity conditions, a reduction in fishing mortality of 50% would be necessary (Fisheries and Oceans Canada, 2008a).

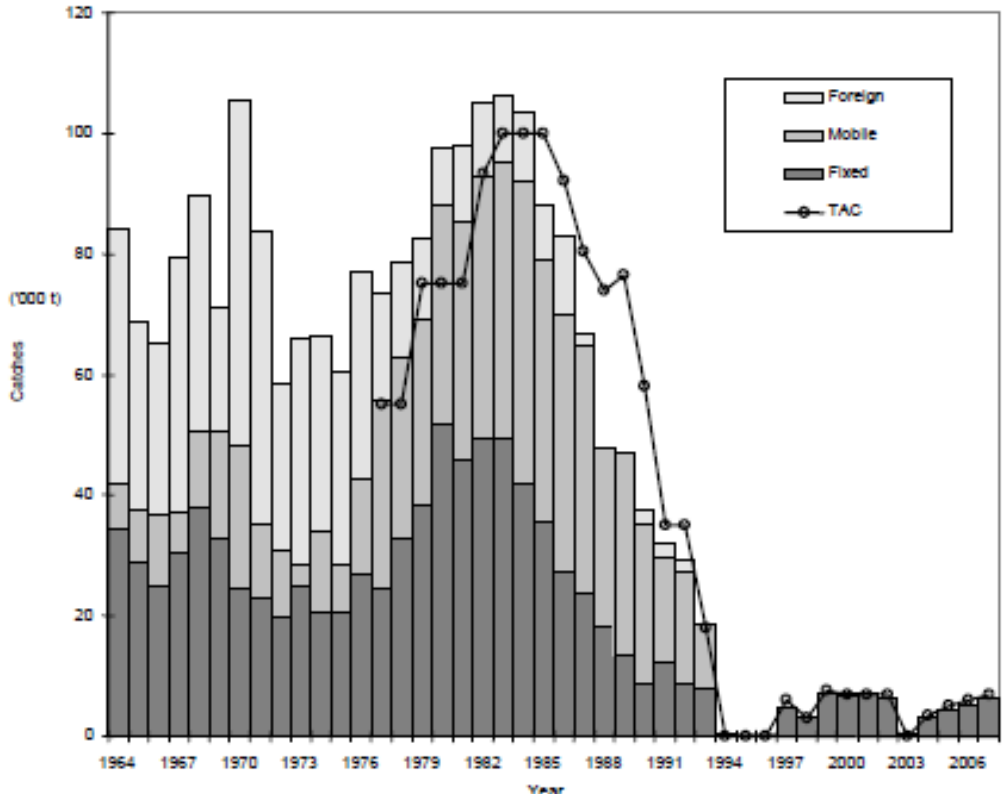

Figure 3. Landings of cod in Division 3Pn4RS, 1964 - 2006 (Fisheries and Oceans Canada, 2008a).

Major threats identified by COSEWIC for all stocks are:

1. Fishing (including legal, illegal and unreported catches), notably on northern cod.
2. Fishing-induced and natural changes to the ecosystem, resulting in altered levels of inter-specific competition and predation, notably predation by seals and fish on northern cod.
3. Alteration of bottom habitat by fishing gear represents a potential but unevaluated threat (COSEWIC, 2003).

Recreational cod fishery 2007:

NAFO sub-division	Cod caught in 2007	
	Number	Weight (mt)
2J	11,555	23.3
3K	280,794	567.2
3L	726,813	1,468.2
3Pn	18,124	36.6
3Ps	107,589	217.3
4R	61,794	124.8
Total	1,206,669	2,437.5

Table 2: Estimated number and weight of cod caught, by NAFO sub-division of activity (BriLev Consulting Inc., 2008).

Bottom trawl:

Trawls are long, wedge-shaped nets of synthetic webbing that narrow into a funnel-shaped bag. The bottom trawl is dragged along the seafloor and kept open during a tow with large, oval, metal plates (doors). Footropes are often rigged with heavy steel rollers or chains to keep the net on the seafloor. Multi-year studies of the impacts of groundfish trawling carried out in the Atlantic by DFO show short-term disruption of benthic communities, including reductions in the biomass and diversity of benthic organisms. Some previously fished seafloor habitats showed recovery within one to three years but frequently trawled habitats remain in an altered state (Fisheries and Oceans Canada, 2006). Fisheries targeting Atlantic cod (3Ps), Greenland halibut, skate, white hake, redfish and yellowtail flounder may occur in the PBGB LOMA using bottom trawl.

Cod are widely distributed throughout the LOMA in both spring and fall. The main areas of concentration are the northeast slope of the Grand Banks in fall and the central portion of the banks, including the upper Southwest Slope, in spring and fall (Kulka et al., 2003). The Southeast Shoal EBSA has been identified as a key nursery area for Atlantic cod, and Smith Sound EBSA in Trinity Bay was noted to have the largest remaining known spawning area for northern cod (Bradbury et al., 2001).

Although directed fisheries for Atlantic cod within the LOMA have been minimal for the past 15 years, fishing mortality is still considered to be the major threat to the survival and recovery of the stock (COSEWIC, 2003). Kulka and Pitcher (2001) found that Canadian Atlantic trawl grounds are patchy and complex, with the tops of the banks untrawled except for the Grand Banks and the Magdelen Shallows. Locations of high intensity trawling were

quite similar from one year to the next. The only place on the Grand Banks where fishing was sustained over the entire period (1980-2000) was along Southwest Slope (Kulka & Pitcher, 2001). Legal landings (directed fisheries and bycatch) by bottom trawl are significant. DFO fisheries data from 1998-2007 (Appendix A, Table 13) shows that bottom trawl was responsible for 22% of landings by weight for the entire PBGB LOMA (169,159 tonnes) - second only to pot gear. From 2001-2005, bottom trawl averaged 23,707t of landed weight (all species combined) in the PBGB LOMA, but a significant decrease is evident from 2006-2007, as the average landings were 6,717t. Illegal and unreported catches are also significant, since 3NO cod bycatch has increased more than tenfold during the moratorium period from 172t in 1995 to 2,194t in 2002 (Rosenberg et al., 2005). **Screened in.**

Gillnets (bottom):
Gillnets are vertical walls of mesh, with mesh openings sized such that target species in the desired size range are caught as they attempt to swim through the webbing, entangling their gills. Bottom gillnets are secured in direct contact with the seafloor by weights and have a high incidence of bycatch. Within the LOMA, offshore license holders are limited to 100-500 nets that are 91m in length and are usually joined together (Appendix A, Table 5). This amounts to a maximum of 45.5km of net per license holder.

Cod are widely distributed throughout the LOMA in both spring and fall. The main areas of concentration are the northeast slope of the Grand Banks in fall, and the central portion of the bank including the upper Southwest Slope in spring and fall (Kulka et al., 2003). The Southeast Shoal EBSA has been identified as a key nursery area for Atlantic cod, and Smith Sound EBSA in Trinity Bay was noted to have the largest remaining known spawning area for northern cod (Bradbury et al., 2001).

Gillnets are used extensively in the PBGB LOMA, especially inshore, and were responsible for 9% of landings by weight (67,894t) over the period 1998-2007 (Appendix A, Table 13). Average annual gillnet landings (directed and bycatch) for the LOMA in 2000-2003 amounted to 2050t for offshore fleets (Fisheries and Oceans Canada, 2007). Inshore landings in 3Ps are also significant; in the last five years (2003-2007), landings from gillnet in Placentia Bay averaged 479t. Edinger *et al.* (2007) state that peak areas of gillnet use in the Newfoundland Region were found along the Bonavista Corridor and along the Southwest Grand Banks (Edinger et al., 2007). The main directed fisheries using gillnet in the LOMA target monkfish, Greenland halibut, skate, white hake, Atlantic cod, lumpfish, winter flounder and redfish. The average depths fished with gillnets in the entire Newfoundland Region are 218m for white hake, 439m for skate, 331m for monkfish and 995m for Greenland halibut (Wareham & Edinger, 2007). Gillnets are commonly used on the shelf and at most depths along the shelf edge. **Screened in**.

Longline:
Bottom longlines consist of a single mainline to which shorter lines, armed with baited hooks, are attached (maximum of 6,000). Anchors attached to the longline secure the gear to the ocean floor. Longlines are often deployed deeper than trawls (>500m), precisely targeting rough-bottom ("un-trawlable") areas. There is also bycatch associated with this

gear type, resulting in removal of Atlantic cod, but there is a lack of discard data for the Atlantic Canada bottom longline fisheries.

Cod are widely distributed throughout the LOMA in both spring and fall. The main areas of concentration are the northeast slope of the Grand Banks in fall, and the central portion of the bank including the upper Southwest Slope in spring and fall (Kulka et al., 2003). The Southeast Shoal EBSA has been identified as a key nursery area for Atlantic cod, and Smith Sound EBSA in Trinity Bay was noted to have the largest remaining known spawning area for northern cod (Bradbury et al., 2001). Longlines are not used in the Southeast Shoal or Smith Sound EBSAs to any significant degree. Because of the depths currently fished, the Greenland halibut fishery takes significant bycatch.

Cod undergo an inshore/offshore migration and thus their presence in the Greenland halibut fishery is higher during the fall/winter period when they are further offshore. Kulka (2001) found that cod in the NAFO regulatory area were observed to have a majority of their biomass (75%) in less than 150m depth, although there is also a peak at 300-350m depth (Kulka, 2001). On average, about 60% of the southern Grand Bank cod bycatch has been taken in the NAFO Regulatory Area (NRA) over the last few years. Inside Canada's 200 nautical mile zone, bycatch of southern Grand Banks cod is reported to be generally less than 5%, but has sometimes been higher, for example 30% overall in the directed skate directed fishery in 1999 (Morgan & Rideout, 2005).

Longline fisheries are concentrated on the Southwest Shelf Edge and Slope and south coast including the St. Pierre and Burgeo Banks. The main directed fisheries using longline in the LOMA target Greenland halibut, Atlantic halibut, skate, white hake, Atlantic cod and large pelagics (Appendix A, Table 5-11). Based on logbook data from 2000 to 2003, average annual landings (directed and bycatch) of cod was 580 tonnes (Fisheries and Oceans Canada, 2007). Over the period 1998-2007, longlines were responsible for 2% of landings by weight (15,320t) in the PBGB LOMA, for all species combined. **Screened in.**

Recreational cod fishery:
The recreational cod fishery is conducted in the fall, although dates are variable. In 2007, the fishery was open for five weeks (35 days): July 25 to August 19 and September 29 to October 7, and in total, 73,425 anglers participated and caught an estimated 1.2 million cod. Recreational fishers are limited to five groundfish per day (including cod). The maximum boat limit when three or more persons are fishing is 15 groundfish. This includes tour boats. This limit applies at any one time – a boat may make repeated trips during one day as long as individuals on board do not exceed their personal daily bag limits. Only handline and angling gear is permitted. Handlines include baited hooks, feathered hooks and artificial lures. A maximum of three hooks per line may be used. The use of jiggers is prohibited.

Cod caught in Trinity, Notre Dame, Bonavista and Conception Bays accounted for two-thirds of the total cod harvest. Sexually mature adult fish and juveniles are caught in this fishery, and studies have shown that spawners may return to the same area year after year. The daily personal limit for cod in the 2007 recreational fishery was 5 fish, the total number of days the fishery was open was 35. In total, therefore, anglers could have taken 175 fish each. Given

there were over 73,400 anglers who fished, the theoretical total harvest would have been about 12,845,000 cod. The harvest estimated from the survey represents less than 10% of the total theoretical harvest, demonstrating a responsible harvest for the 2007 recreational cod fishery. Fisheries observers estimated that 542t of cod fish were taken in 2007. However, during a phone survey after the fishery that year, the consultant concluded that 2,400t of cod were taken, and that more boats and people were on the water than DFO had thought. DFO is looking at introducing a licensing program which could be in place by 2010, if approved (CBC News, 2008). **Screened in.**

Residence Area	Anglers < 16	Anglers 16+	Total	%
Avalon Peninsula	3,447	27,193	30,641	41.7
Burin-South Coast	432	4,949	5,380	7.3
West NL- N. Peninsula	739	5,956	6,695	9.1
Central-NE Coast	1,942	14,616	16,558	22.6
Bonavista-Trinity	1,151	10,599	11,750	16.0
Labrador	271	2,130	2,401	3.3
Total	7,982	65,443	73,425	

Table 3: Number of anglers in Recreational Cod Fishery in 2007 (BriLev Consulting Inc., 2008).

NAFO sub-division	Cod caught in 2007	
	Number	Weight (mt)
2J	11,555	23.3
3K	280,794	567.2
3L	726,813	1,468.2
3Pn	18,124	36.6
3Ps	107,589	217.3
4R	61,794	124.8
Total	1,206,669	2,437.5

Table 4:. Estimated number and weight of cod caught in Recreational Cod Fishery, by NAFO sub-division of activity (BriLev Consulting Inc., 2008).

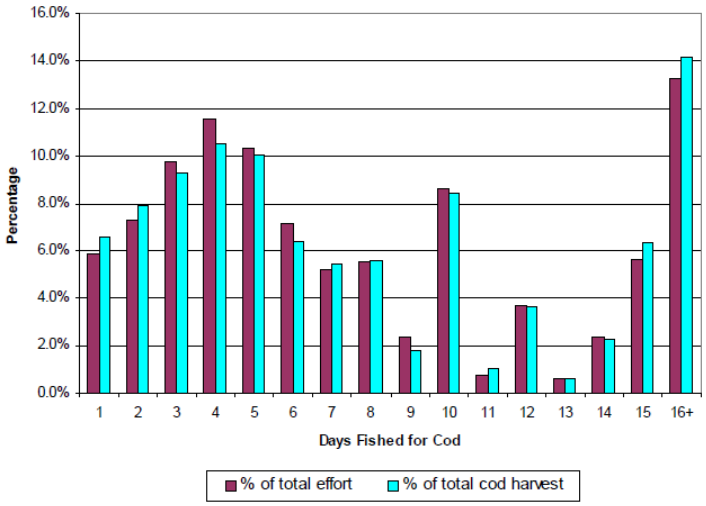

Figure 4. Distribution of total effort and total cod harvest for adult anglers in 2007, by days fished for cod (BriLev Consulting Inc., 2008).

Ghost nets (derelict fishing gear):

Ghost nets are fishing gear that have been lost or discarded at sea. Since the 1960s, fishing nets have been constructed from highly durable plastic materials such as nylon, polypropylene and polyethylene, which do not biodegrade. Unlike their natural predecessors, the new materials can last for years or decades in the marine environment, are largely impervious to biodegradation and are resistant to chemicals and abrasion (National Academy of Sciences, 2008). Sun exposure can lead to photodegradation of some synthetic materials, but on the sea bottom, protected from UV radiation, there is no evidence that these nets weaken or degrade over time. As a result, lost gear can continue to fish for decades (National Academy of Sciences, 2008).

Gillnets, traps, trawls and line fisheries are considered the most harmful in relation to derelict fishing gear (National Academy of Sciences, 2008). Bottom trawl are responsible for 22% of the landings in the LOMA, gillnets for 9% and longline for 2% over the period 1998-2007 (Appendix A, Table 13). Lost gillnets are thought to be the most problematic for cod migration since trawl nets are less likely to remain open in the water column, longlines are more likely to entangle marine mammals or leatherbacks, and crab pots are not widely utilized in the LOMA.

Within the LOMA, gillnets are are restricted to a maximum of 91 metres in length, with 100 to 500 nets allowed per license, depending on the fisheries (Appendix A, Table 5). This amounts to a maximum of 45.5km of net per license holder. Set bottom gillnets, by virtue of their fixed, anchored framing, may remain fully deployed and fishing long after they are lost or abandoned. As nets become fouled, they become more visible, lose their vertical profile and their fishing capacity declines. However, limited investigations have shown that gillnets lost in deepwater (>400m) can fish for years after they are lost because there is very little bio-fouling or water movement in depths below 400m (National Academy of Sciences, 2008). Even when nets collapse, forming balls on the sea floor, they have been observed to self bait such that predators and scavengers attracted to entangled animals are themselves entangled, thereby perpetuating the cycle of destruction.

In north Atlantic fisheries, the amount of lost and discarded nets associated with each fishery is unknown, but anecdotal evidence suggests that in some fisheries, 30km of net are lost or discarded during a typical 45-day trip, which translates into 1,254km of lost or discarded netting per year (Hareide et al., 2005). In Canada, fish harvesters are required to report lost nets to DFO. Although the loss of nets appears to be common, the Department receives very few reports and therefore useful data is not readily available. Although most research has been focused on inshore waters, a number of factors indicate that the problem is significantly worse in the offshore where water is deeper, fish harvesters use larger amounts of gear and weather conditions are more severe, all factors which lead to increased rates of gear loss (Hareide et al., 2005).

Due to a high intensity of fishing activity, particularly gillnet fishing, in the LOMA, combined with the deep water, rough bottom and dynamic nature of the environment, loss of gear is likely significant. **Screened in.**

Temperature change:
Drinkwater (UNEP & UNFCCC, 2002) predicts a temperature increase of 2-4^{o}C in Southern Newfoundland waters by 2100 based on IPCC 2001 models. Temperature rise will likely not be linear, but is expected to accelerate over time. Even given the worst case scenario, an increase in 0.4^{o}C is likely the most we can expect over the next ten years. Cod are predicted to shift north (Rose, 2005), and therefore may decrease in density within the PBGB LOMA. Many believe that temperature shifts were at least partially responsible for the poor recovery of over-fished cod stocks in the 1990s (Rose, 2007). Drinkwater (2005) states that the range of cod may extend northward with increasing temperature, and it is likely that spring migrations will occur earlier and fall returns will be later (Drinkwater, 2005). These responses of cod to future climate changes are highly uncertain, however, as they will also depend on the changes to climate and oceanographic variables besides temperature, such as plankton production, the prey and predator fields and industrial fishing. Temperature changes are not likely to be significant over the next 10 years. **Screened out.**

Current shifts:
Homing and migrating cod are associated with strong unidirectional and persistent currents, at both large and small scales, and dispersive life histories are generally associated with banks isolated by oceanographic gyres (Robichaud & Rose, 2004). Significant changes in currents resulting from climate change could therefore affect cod migration and feeding within the PBGB LOMA.

Climate change models project a slow-down in the thermohaline circulation, the large-scale ocean circulation driven by fluxes of heat and salinity at the ocean surface. The strength of this circulation depends on a subtle balance between the rate of cooling and the input of less dense freshwater from melting ice sheets, precipitation and river runoff in sub-polar regions and the rate of heating and evaporation in the tropics. Currently, thermal forcing dominates and circulation is driven by the sinking of cold water in polar regions, but without the temperature effects, circulation would reverse, with sinking in the tropics and rising in the sub-polar regions (Drijfhout, 2008).

In the north Atlantic, the Gulf Stream is a warm, shallow (0-1,500m), northeast flow, giving off heat and sinking as it moves north, returning as a deep (1,500m-3,000m), cold, southwest flow. Labrador Current waters are relatively fresh; they do not sink deeper than 150-200m, despite their cold temperatures. Much of the LOMA is shallower than this, so Labrador Current waters dominate from surface to bottom. The coverage of the Grand Banks by the Labrador Current varies from year to year, which influences productivity and extent of the Banks which have favourable conditions for cod (Rose, 2007).

Global models generally show that Atlantic thermohaline circulation weakens by 15% to 50% with a doubling of atmospheric CO_2 (as predicted in moderate climate change scenarios by 2100), but the weakening will not occur in a simple linear manner. The actual amount of CO_2 is less important than the rate of increase – little happens at first as the circulation rapidly removes the freshwater, but there is a well-defined threshold beyond which the thermohaline circulation cannot cope with additional freshwater and breaks down (Rahmstorf, 1997). As a result, the thermohaline circulation can be subject to sudden transitions (linked to melting sub-polar ice sheets) which could lead to abrupt climate change, but this is not anticipated during the century (Drijfhout, 2008). **Screened out.**

Mixing of Labrador Current and Gulf Stream (Marrs, 2007).

Key Activities/Stressors:

- Bottom trawl
- Gillnets (bottom)
- Longline
- Recreational cod fishery
- Ghost nets

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Atlantic cod (depleted or rare species) within the PBGB LOMA

Two populations of Atlantic cod occur within the LOMA, the Laurentian North population (3Ps and 3Pn4RS) and the Newfoundland and Labrador population (2J3KL, and 3NO). Both populations were assessed by COSEWIC in 2003 and the Laurentian North population was designated as threatened, and the Newfoundland and Labrador population was designated as endangered.

Bottom trawl

<u>Magnitude of Interaction</u>

Areal extent:

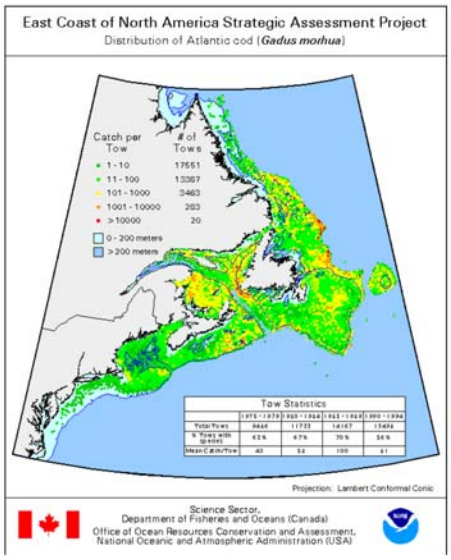


Figure 1. Map depicting distribution of Atlantic cod (Brown et al., 2005).

- Cod (see Figure 1 above) are widely distributed throughout the LOMA in both spring and fall. The main areas of concentration are the northeast slope of the Grand Banks in fall, and the central portion of the banks including the upper SW Slope in spring and fall (see Figure 2 below).

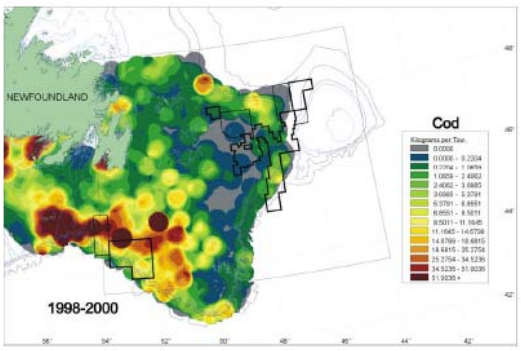


Figure 6d. Atlantic cod distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

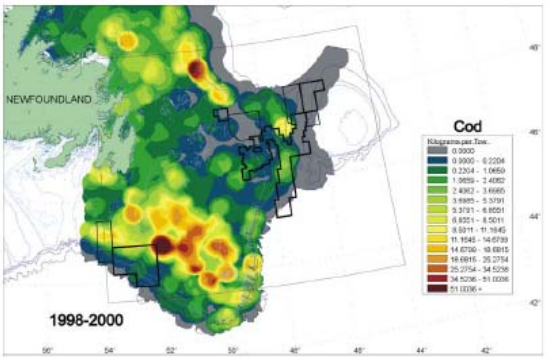


Figure 7d. Atlantic cod distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

Spring survey **Fall survey**

Figure 2. Cod distribution during spring and fall 1998-2000 on the Grand Banks (Kulka et al., 2003).

- Southeast Shoal and Tail of the Banks EBSA has been identified as a key nursery area for Atlantic cod.
- Bay stocks are also significant - since the collapse of the cod stocks in the early 1990s, much of the remaining biomass has been concentrated in coastal regions. Although cod were historically known to over-winter and spawn in these coastal areas, the recent concentration of cod in coastal bays, in contrast to the dearth of fish in adjacent shelf regions, may be without precedent (Lawson & Rose, 2000). Coastal bays provide significant spawning, nursery and over-wintering habitat for Atlantic cod within the LOMA.
- Trawling occurs throughout much of offshore areas of the LOMA and is currently one of the most commonly used gear types in the LOMA. A map depicting persistent areas of high intensity trawling in the Atlantic over the period 1980 2000 is shown in Figure 3 (left). The second figure (right) shows locations where >100% of the area was trawled in the Atlantic in any year (that is, where all of the area was trawled at least once during the year) (Kulka & Pitcher, 2001).

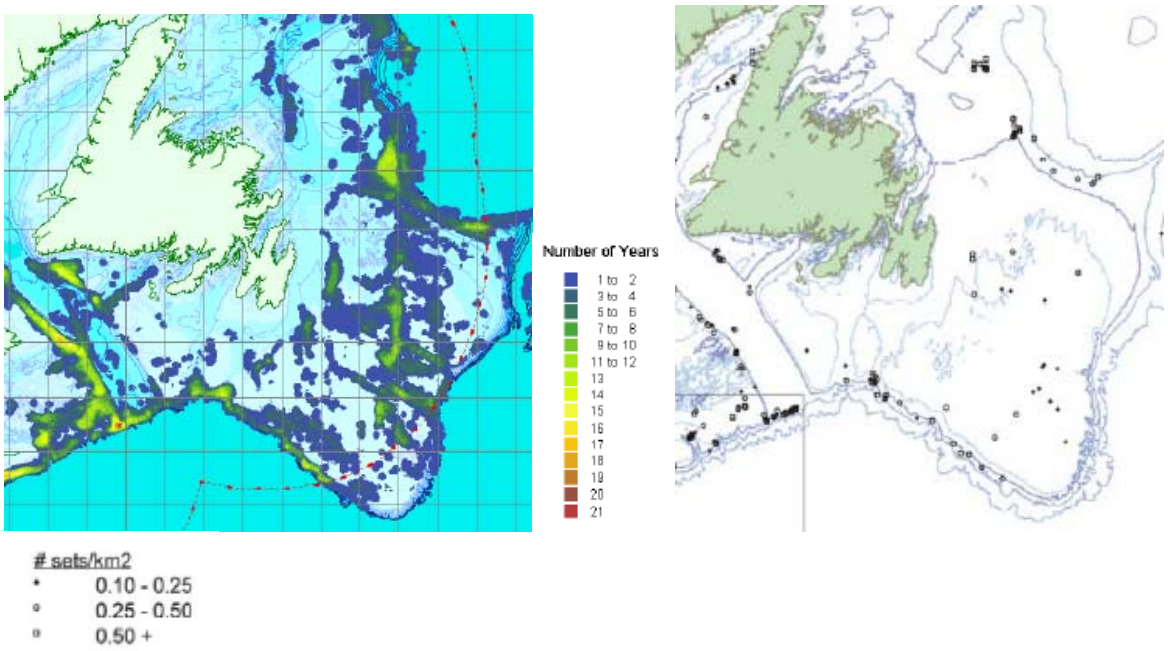


Figure 3. Areas of high intensity trawling (Kulka & Pitcher, 2001).

- Figure 4 below shows the distribution of trawling activity from 1998 to 2007 by Newfoundland Region fisheries, and the distribution of NAFO (foreign) vessels fishing outside the EEZ in 2006 is shown in Figure 5.

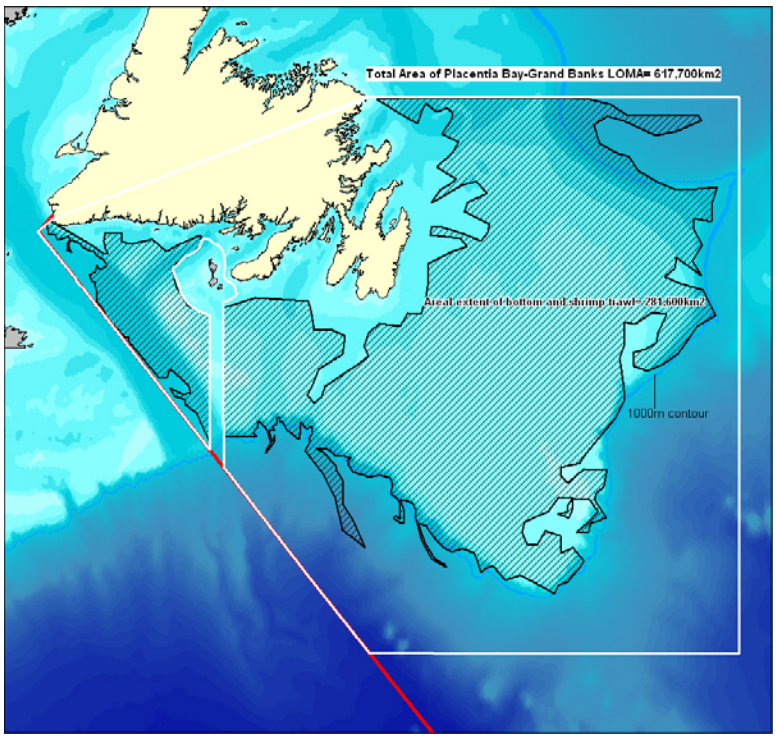


Figure 4. Areal extent of Newfoundland Region landings by bottom trawling in the LOMA 1998-2007 (Fisheries and Oceans Canada, 2008).

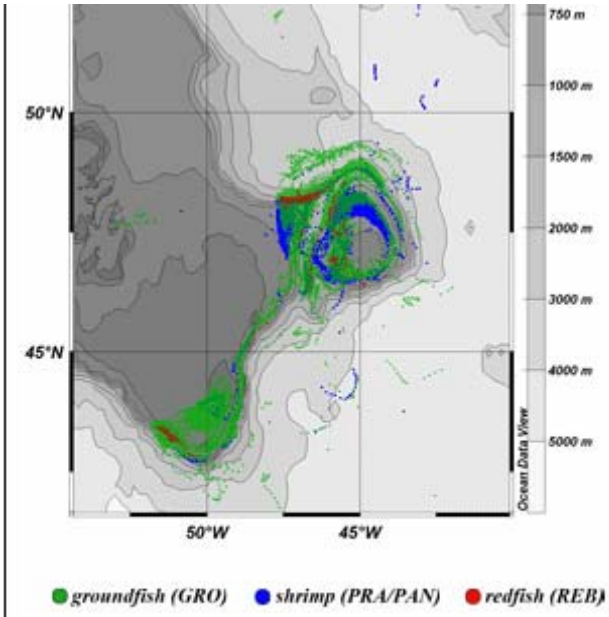


Figure 2B – ODV plot of VMS mid-positions for vessels fishing for groundfish, shrimp and redfish (*Sebastes mentella*) in 2006.

Figure 5. NAFO fishing vessels using bottom trawl, outside EEZ (Campanis, 2007).

- Benthic bottom trawling is generally restricted to the offshore. The areal extent of trawling for Newfoundland Region fisheries is shown to be approximately 281,600km^2/617,700km^2, which is 46%. However, NAFO fisheries also occur within the LOMA, and up-to-date information for these fisheries is limited. We have chosen a score in the high end of the medium range as a way to incorporate those fisheries with limited spatial information.
- Based on this information we have estimated an overlap of 65%.

Score 6.5

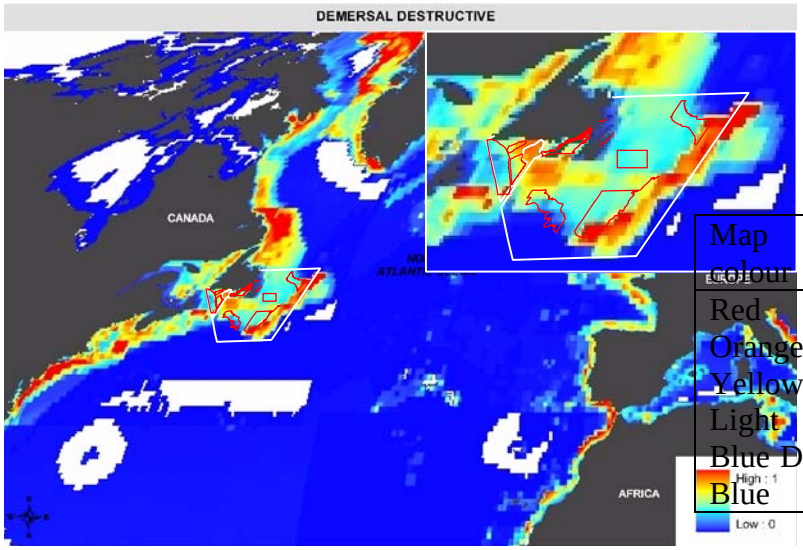
Contact:
- In relation to bottom trawl, Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for "contact" are high (75-100%) for bony fish species.
- There is a moratorium on 3LNO Atlantic cod but fish from these stocks can be legally caught and retained as bycatch in other directed fisheries on the Grand Banks, and bycatch levels are significant.
- The Laurentian north 3Ps and 3Pn both have directed bottom trawl fisheries for cod at greatly reduced TAC compared to historical levels. Directed fisheries score 100%.
- Since cod are targeted in a portion of the area of overlap within the LOMA, and bycatch seems to be significant in the remaining portion of the LOMA, we have selected a score slightly below the score for a directed fishery.

Score 9.5

Duration:
- Bottom trawl is used within the LOMA throughout the year to harvest a range of species including skate, white hake, Greenland halibut and shrimp. NAFO vessels also trawl outside the EEZ.
- Some limited closures are in place to protect significant cod spawning areas.
- Atlantic cod remain in the LOMA throughout the year, over-wintering in deeper water on the slope, and moving on to the banks in spring.
- The average annual duration of the activity (bottom trawling) occurs 100% of the time the LOMA is occupied by the CP (Atlantic cod). We have reduced this score slightly to reflect the closures implemented to protect and conserve some key cod spawning areas within the LOMA.

Score 9.5

Intensity:
- Halpern *et al.* (2008) have developed maps showing the global intensity of several anthropogenic stressors including demersal destructive fishing, which includes bottom trawl fisheries (see Figure 6 below). This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum (100%) intensity in a global context, in accordance with the scale provided below.
- Figure 6 shows a high intensity (80-100%) along the eastern slope of the northern and southern Grand Banks, but lower levels on the Southwest Edge and Slope. Halpern's



Map colour	Intensity
Red	80-100%
Orange	60-80%
Yellow	40-60%
Light Blue	20-40%
Dark Blue	0-20%

Figure 6. Global Intensity of Bottom trawl (adapted from (Halpern et al., 2008)

- Kulka and Pitcher (2001) studied the spatial extent of highly trawled areas in the Grand Banks (see Figure 3 above). Some locations within the LOMA are shown as being persistent areas of high intensity trawling (Kulka, 2006).
- Bottom trawl is responsible for 32% of landings (shrimp and groundfish combined) from 1998 – 2007 in the LOMA, for Newfoundland Region fisheries, with average annual landings from Newfoundland Region fisheries (Fisheries and Oceans Canada, 2008) of 16,915t, followed by gillnet at 6,789t and longline landings of 1,532t.
- Based on both global and local data, we have estimated an intensity of 90%.

Score 9

<u>Magnitude of Interaction</u>: (6.5 x 9.5 x 9.5 x 9)/1000 = 5.3

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- In relation to bottom trawl, Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for "harm" are variable (1-100%) for bony fish species, depending on the fishery, and without greater detail on the rationale behind the scores, they do not provide particularly useful guidance.
- Two populations of Atlantic cod occur within the LOMA, the Laurentian North population (south coast) and the Newfoundland and Labrador population (NE coast and Grand Banks). Both populations were assessed by COSEWIC in 2003 and the Laurentian North population was designated threatened, and the Newfoundland and Labrador population was designated endangered. The Status Report (COSEWIC, 2003) lists "fishing (including legal, illegal and unreported catches) and fishing-induced changes to the ecosystem as key threats to cod recovery".

- Over-fishing is widely believed to be the major cause of the devastating collapse of Canadian North Atlantic cod stocks in the early 1990s (Pepper & Pepper, 1995). Since this time, numerous management actions have been put in place to conserve cod stocks including fishing moratoria, closed areas to protect spawning areas, closure of the recreational cod fishery, bycatch limits and greatly reduced total allowable catch (TAC). Cod landings within the LOMA are now (2001-2007) less than one percent of the total cod harvested in the marine waters of Newfoundland and Labrador in 1968 (Fisheries and Oceans Canada, 2000).
- Despite these conservation measures, stocks remain at low levels and fishing mortality (directed and bycatch) is not considered sustainable. Bottom trawl (shrimp and groundfish) accounts for 32% (Appendix D, Table 13) of the total landings of all species in the LOMA over the last 10 years and bycatch of cod is significant. Details of landings and bycatch for each cod stock within the LOMA are included in the Scoping document.

Score 9

Sensitivity of CP to chronic impacts:

- Despite fishing moratoria and other conservation measures, cod have not recovered to historical levels.
- Generation time is reportedly 11 years for Atlantic cod (Lough, 2004). Sexual maturity is reached in females around 5-8 years, with males being slightly younger (Lear, 1993). Cod are very prolific, particularly large cod. Female cod about 80cm long produce about two million eggs, while a cod of about 130cm produced over 11 million eggs, yet recovery of depleted stocks has been slow.
- Projections by Power *et al*. (2005) indicate that even under the scenario of no removals, spawner biomass of the NL population Atlantic cod within the LOMA is expected to decline by 11% to 4,900t by 2010, and if the stock continues to be fished at current bycatch rates, spawner biomass will decrease by 76% to about 1,300t (Power et al., 2005). The 2008 stock status report recommends that the moratorium on directed fishing in the offshore should be continued and bycatch should be minimized.
- Recent stock status reports for the Laurentian North population (south coast) indicate that annual total mortality rates (age 5-11) inferred from the DFO RV combined survey have increased from an average of 23% in 1997-2004 to an average of 55% in 2005-07. Spawning stock biomass (SSB) has also been decreasing in recent years and in 2008 was just above the limit reference point. The report recommends that catches be reduced compared to recent levels, and greater priority should be given to increasing SSB (Fisheries and Oceans Canada, 2009).
- Alteration of bottom habitat by fishing gear may also be a contributing factor in the slow recovery of cod stocks in offshore areas (COSEWIC, 2003). Bottom trawls are considered to be among the most destructive gear utilized within the LOMA (Fuller et al., 2008).
- Since overall harvest rates associated with the bottom trawl fishery including bycatch, as well as illegal and unreported catches, are generally considered unsustainable within the LOMA, we have selected a score of 9.

- Atlantic cod are listed in the CP document as a 'depleted and rare species'(Fisheries and Oceans Canada, 2007b) and will therefore rank higher on this scale than other CPs because they are already in need of recovery (**add one point**).

Score 10

Sensitivity of ecosystem to harmful impacts to the CP:

- Historically, cod have had a huge influence on the ecosystem of the LOMA, mainly because of their large biomass, broad distribution (compared to other species) and their role as both predator and prey at all trophic levels as they grow and move from one trophic level to another. Even though they are currently at less then one percent of their former biomass, they still represent a significant component of the total goundfish population.
- Since the sharp decline in cod biomass in the 1990s, biomass of invertebrates such as shrimp and crab have expanded to record highs in what has been termed a 'trophic cascade'. These changes have been blamed on over-fishing resulting in perturbations to the predator-prey systems, and although environmental change may have had a contribution, it is clear that the role of Atlantic cod in the ecosystem is highly significant to its structure and function.
- Since cod is a highly important and influential species in the ecosystem of the LOMA, we have given a score of 8.
- Atlantic cod are listed as an 'ecologically significant species'(Fisheries and Oceans Canada, 2007b) (**add one point**).

Score 9

<u>Sensitivity:</u> (9 + 10 + 9)/3 = 9.3

<u>Risk of Harm:</u> MoI x S = 5.3 x 9.3 = 49.3

Certainty Checklist

Answer yes or no to all of the following questions. Record the number of NO's to the 9 questions, and record certainty according to the scale provided below:

1 No's = High certainty
2 - 3 No's = Medium certainty
≥ 4 No's = Low certainty

Y/N

N Is the score supported by a large body of information?
Y Is the score supported by general expert agreement?
N Is the interaction well understood, without major information gaps/sources of error?
Y Is the current level of understanding based on empirical data rather than models, anecdotal information or probable scenarios?
Y Is the score supported by data which is specific to the region, (EBSA, LOMA, NW Atlantic)?
Y Is the score supported by recent data or research (the last 10 years or less)?
Y Is the score supported by long-term data sets (ten years or more) from multiple surveys (5 years or more)?
Y Do you have a reasonable level of comfort in the scoring/conclusions?
N Do you have a high level of confidence in the scoring/conclusions?

Certainty Score: Medium

For interactions with Low certainty, underline the main factor(s) contributing to the uncertainty:

Lack of comprehensive data
Lack of expert agreement
Predictions based of future scenarios which are difficult to predict
Other (provide explanation)

Suggest possible research to address uncertainty.

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Ref Type: Pamphlet

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Atlantic cod (depleted or rare species) within the PBGB LOMA

Gillnets (bottom)

Magnitude of Interaction

Areal extent:

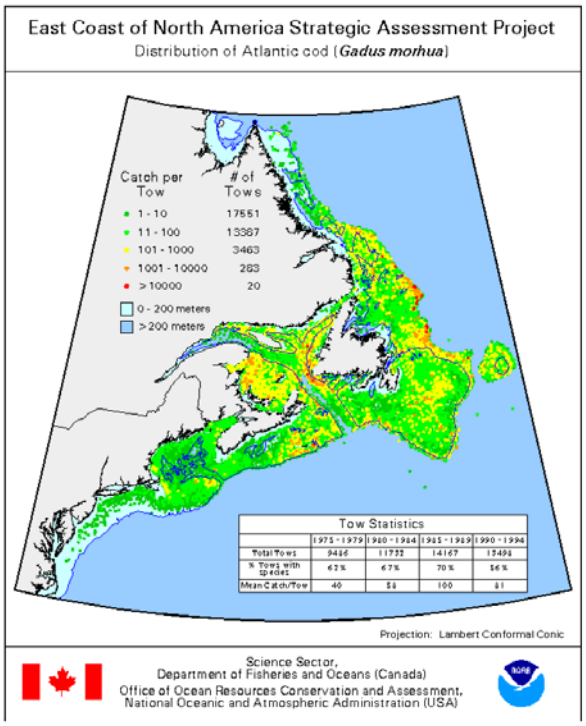


Figure 1. Distribution of Atlantic cod (Brown et al., 2005).

- Cod (see Figure 1 above) are widely distributed throughout the LOMA in both spring and fall. The main areas of concentration are the northeast slope of the Grand Banks in fall, and the central portion of the banks including the upper SW Slope in spring and fall (see Figure 2 below).

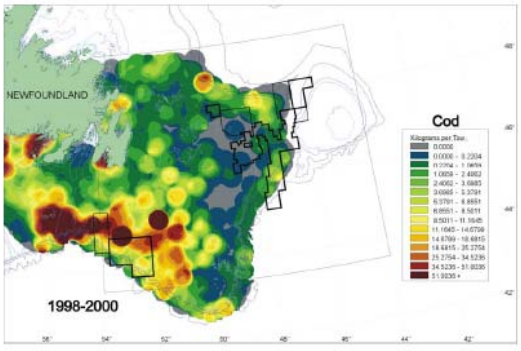


Figure 6d. Atlantic cod distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

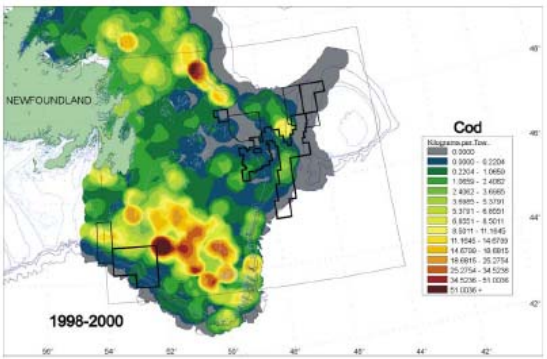


Figure 7d. Atlantic cod distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

Spring survey **Fall survey**

Figure 2. Cod distribution during spring and fall 1998-2000 on the Grand Banks (Kulka et al., 2003).

- The Southeast Shoal EBSA has been identified as a key nursery area for Atlantic cod.
- Bay stocks are also significant - since the collapse of the cod stocks in the early 1990s, much of the remaining biomass has been concentrated in coastal regions. Although cod were historically known to over-winter and spawn in these coastal areas, the recent concentration of cod in coastal bays, in contrast to the dearth of fish in adjacent shelf regions, may be without precedent (Lawson & Rose, 2000). Coastal bays provide significant spawning, nursery and over-wintering habitat for Atlantic cod within the LOMA.
- Bottom gillnet fisheries occur throughout the inshore and much of offshore areas of the LOMA, particularly along the southwest slope and edge, St. Pierre Bank and northeast slope area. Figure 3 (below) shows the distribution of bottom gillnet fishing activity from 1998 to 2007 by Newfoundland Region fisheries.

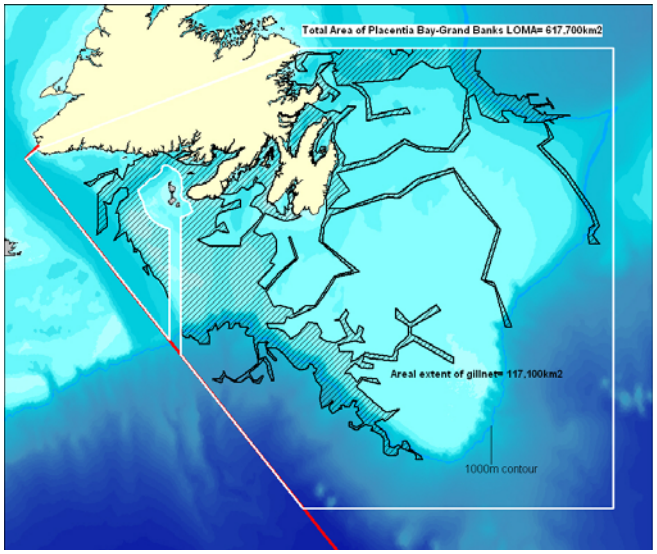


Figure 3. Areal extent of gillnet use, Newfoundland Region fisheries, 1998 - 2007 (Fisheries and Oceans Canada, 2008)

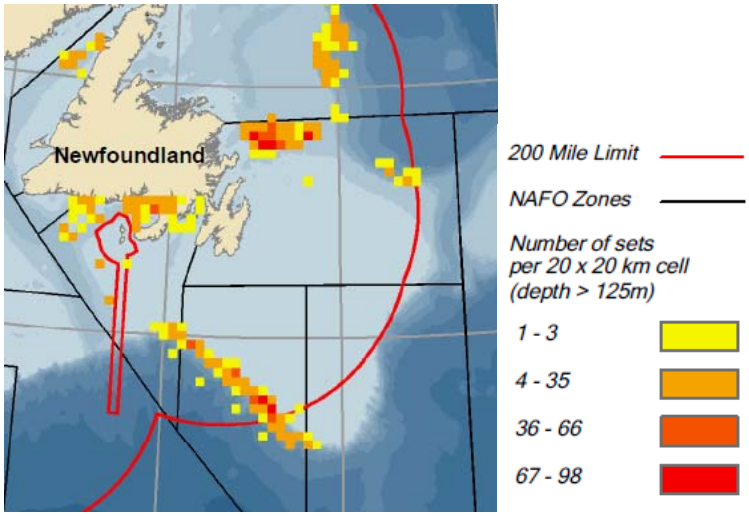


Figure 4. Total gillnet fishing effort density, 2004-2005 (Wareham & Edinger, 2007).

- Based on Figure 3, the areal extent of gillnet fishing within the entire LOMA is 117,100/617,700 = 19%. Since the main areas of cod concentration are coastal areas and the slope of the banks where gillnet fish is concentrated, we have estimated an overlap of 30%.

Score 3

Contact:

- In relation to bottom gillnet, Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for "contact" are high (75-100%) for bony fish species.
- There is a moratorium on 2J3KL, 3NO Atlantic cod but fish from these stocks can be legally caught and retained as bycatch in other directed gillnet fisheries on the Grand Banks. Power *et al*. (2005) report that gillnets in Division 3O took 17t of cod in 2003 and again in 2004 (Power et al., 2005). This amount is significant, but minimal compared to the estimated total cod bycatch within Divisions 2J3KL and 3NO which amounts to approximately 6,000t (Rosenberg et al., 2005), largely associated with bottom trawling.
- Since cod are targeted in a portion of the LOMA but at a greatly reduced TAC, and bycatch is significant in the remaining portion of the LOMA, but minimal compared to other fisheries, we have selected a score in the high range.

Score 8

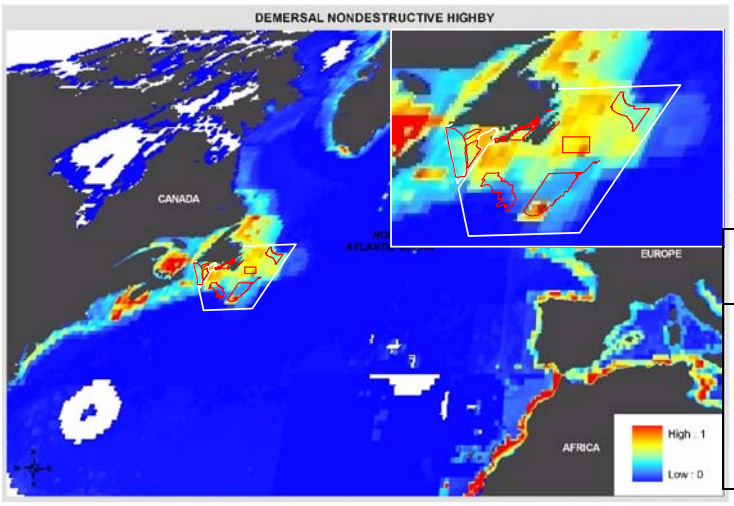
Duration:

- Bottom gillnet fishing is open within the LOMA for one or more fisheries all year round (100% of the time), but the vast majority are closed during March and April (see Appendix D, Table 5- 11).

Score 9

Intensity:

- Global maps (Halpern et al., 2008) for demersal non-destructive fisheries with high bycatch, which include gillnets, shows medium (light blue) to high (orange) intensity relative to global levels, for a score range of 20% to 80% (see Figure 5 below). This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum (100%) intensity in a global context, in accordance with the scale provided below. Halpern's fishing maps are based on (1999-2003) data, and better represent NAFO fisheries, which are notoriously variable year to year, rather than Canadian fisheries, and are not as spatially precise on a local scale as long term local data is.



Map colour	Intensity
Red	80-100%
Orange	60-80%
Yellow	40-60%
Light Blue	20-40%
Dark Blue	0-20%

Figure 5. Global intensity of demersal non-destructive fisheries (adapted from (Halpern et al., 2008)).

- Gillnet fisheries within the LOMA represented an average of 9% of the landings from 1998-2007, however, in the Southwest Shelf Edge and Slope EBSA, gillnets accounted for 30% of landings from 1998 - 2007 (Fisheries and Oceans Canada, 2008).
- We have selected an intermediate score of 50%., as suggested by the predominant yellow within the LOMA in Figure 5.

Score 5

<u>Magnitude of Interaction</u>: (3 x 8 x 9 x 5)/1000 = 1.1

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- In relation to bottom gillnet, Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for "harm" are high (75-100%) for bony fish species in 3NO.
- Bottom gillnets were also given a "high impact" rating in relation to groundfish (Fuller et al., 2008).
- Over-fishing is widely believed to be the major cause of the devastating collapse of Canadian North Atlantic cod stocks in the early 1990s (Rose, 2007). Since this time, numerous management actions have been put in place to conserve cod stocks including fishing moratoria, closed areas to protect spawning areas, closure of the recreational cod fishery, bycatch limits and greatly reduced total allowable catch (TAC). Cod landings within the LOMA are now (2001-2007) less than one percent of the total cod harvested in the marine waters of Newfoundland and Labrador in 1968 (Fisheries and Oceans Canada, 2000a).
- Despite these conservation measures, stocks remain at low levels and fishing mortality (directed and by catch) is not considered sustainable.
- The 3Ps stock increased most rapidly during the moratorium and was reopened in 1997. Stocks have declined since the moratorium was lifted.

- Average annual gillnet landings (directed and bycatch) for the LOMA in 2000-2003 amounted to 2050t for offshore fleets (Fisheries and Oceans Canada, 2007b). Inshore landings in 3Ps (vessels <35ft) are also significant – during the period 2003-2007, landings from gillnet in Placentia Bay averaged 4,216t.
- Cod bycatch in 2J3KL, 3NO was estimated at almost 6,000t in 2003 (Rosenberg et al., 2005), but the majority of this is attributable to other gear types.
- Since there is a directed bottom gillnet fishery in the southern portion of the LOMA (score in high range) and high bycatch in the remaining portion of the LOMA, but gillnet fisheries account for only a moderate amount of the total landings, we have selected a score at the low end of the high range.

Score 7.5

Sensitivity of the CP to chronic impacts:

- Two populations of Atlantic cod occur within the LOMA, the Laurentian North population (south coast) and the Newfoundland and Labrador population (NE coast and Grand Banks). Both populations were assessed by COSEWIC in 2003, with the Laurentian North population designated *threatened*, and the Newfoundland and Labrador population designated *endangered*. The Status Report lists fishing (including legal, illegal and unreported catches) and fishing-induced changes to the ecosystem as key threats to cod recovery (COSEWIC, 2003).
- Generation time is reportedly 11 years for Atlantic cod (Lough, 2004). Sexual maturity reached in females around 5-8 years, with males being slightly younger (Lear, 1993). Cod are very prolific, particularly large cod. Female cod about 80cm long produce about two million eggs, while a cod of about 130cm produces over 11 million eggs.
- Alteration of bottom habitat by fishing gear may also be a contributing factor in the decline of cod stocks in the LOMA. Gillnets can cause harm to fragile bottom habitat such as corals, but is generally considered non-destructive.
- Projections by Power *et al*. (2005) indicate that even under the scenario of no removals, spawner biomass of the NL population Atlantic cod within the LOMA is expected to decline by 11% to 4,900t by 2010, and if the stock continues to be fished at current by catch rates, spawner biomass will decrease by 76% to about 1,300t (Power et al., 2005).
- The 2008 stock status report recommends that the moratorium on directed fishing in the offshore should be continued, and bycatch should be minimized.
- Recent stock status reports for the Laurentian North population (south coast) indicate that annual total mortality rates (age 5 -11) inferred from the DFO RV combined survey have increased from an average of 23% in 1997-2004 to an average of 55% in 2005-07. Spawning stock biomass (SSB) has also been decreasing in recent years and in 2008 was just above the limit reference point. The report recommends that catches be reduced compared to recent levels, and greater priority should be given to increasing SSB (Fisheries and Oceans Canada, 2009).
- If steps are not taken soon to substantially reduce bycatch, there appears to be little prospect for rebuilding of Grand Bank cod to within safe biological limits (Shelton & Morgan, 2005).
- Legal landings of cod (including bycatch) for the LOMA are moderate using gillnet compared to other fisheries. However, stocks are generally at a low level, recovery has

- Atlantic cod is listed as a 'depleted and rare species' (**add one point**).

Score 8

Sensitivity of ecosystem to harmful impacts to the CP:

- Historically, cod had a huge influence on the ecosystem of the LOMA, mainly because of their large biomass and broad distribution compared to other species and their role as both predator and prey at all trophic levels as they grow and move from one trophic level to another. Even though they are currently at less then one percent of their former biomass, they still represent a significant component of the total groundfish population.
- With the sharp decline in cod biomass in the 1990s, stocks of invertebrates such as shrimp and crab expanded to record highs in what has been termed a trophic cascade (Fisheries and Oceans Canada, 2000b). These changes have been blamed on over fishing resulting in perturbations to the predator-prey systems, although environmental change may have had a contribution, it is clear that the role of Atlantic cod in the ecosystem is highly significant to its structure and function. Score 8.
- Atlantic cod are listed in the CP document as an 'ecologically significant species' (**add one point**).

Score 9

<u>Sensitivity:</u> (7.5 + 8 + 9)/3 = 8.2

<u>Risk of Harm:</u> MoI x S = 1.1 x 8.2 = 9

Certainty Checklist

Answer yes or no to all of the following questions. Record the number of NO's to the 9 questions, and record certainty according to the scale provided below:

1 No's = High certainty
2 - 3 No's = Medium certainty
≥ 4 No's = Low certainty

Y/N

Y Is the score supported by a large body of information?

Y Is the score supported by general expert agreement?
N Is the interaction well understood, without major information gaps/sources of error?
Y Is the current level of understanding based on empirical data rather than models and probable scenarios?
Y Is the score supported by data which is specific to the region, (EBSA, LOMA, NW Atlantic?
Y Is the score supported by recent data or research (the last 10 years or less)?
N Is the score supported by long-term data (ten years or more) from multiple surveys (5 years or more)?
Y Do you have a reasonable level of comfort in the scoring/conclusions?
N Do you have a high level of confidence in the scoring/conclusions?

Certainty Score: Medium

For interactions with Low certainty, underline the main factor(s) contributing to the uncertainty

Lack of comprehensive data
Lack of expert agreement
Predictions based of future scenarios which are difficult to predict
Other (provide explanation)

Suggest possible research to address uncertainty:

Reference List

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   Ref Type: Data File

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Atlantic cod (depleted or rare species) within the PBGB LOMA

Longline

Magnitude of Interaction

Areal extent:

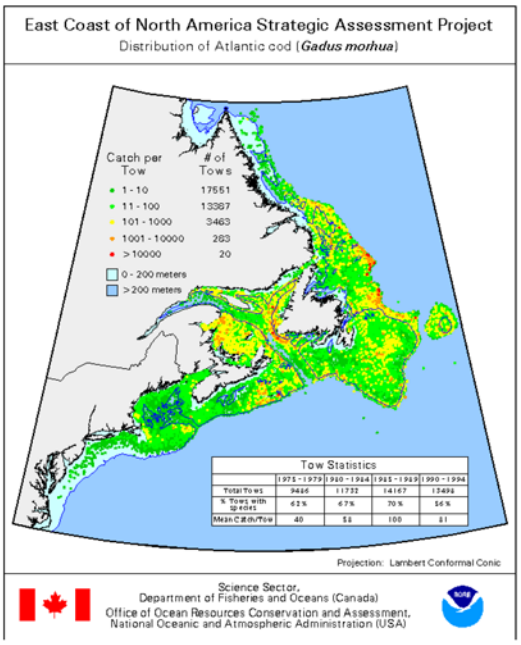


Figure 1. Distribution of Atlantic cod (Brown et al., 2005).

- Cod are widely distributed throughout the LOMA in both spring and fall. The main areas of concentration are the northeast slope of the Grand Banks in fall, and the central portion of the bank including the upper southwest slope in spring and fall (Kulka et al., 2003).

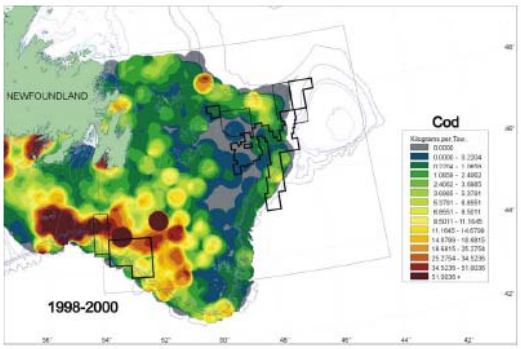


Figure 6d. Atlantic cod distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

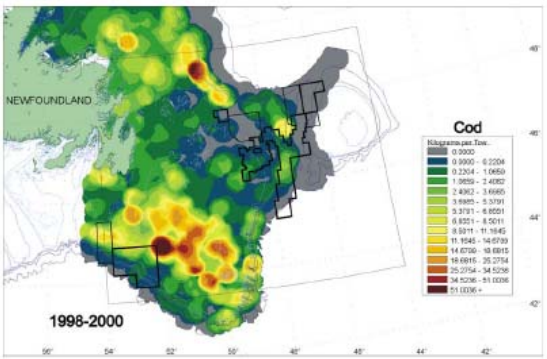


Figure 7d. Atlantic cod distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

Spring survey **Fall survey**

Figure 2. Cod distribution during spring and fall 1998-2000 on the Grand Banks (Kulka et al., 2003).

- The Southeast Shoal and Tail of the Banks EBSA has been identified as a key nursery area for Atlantic cod, and Smith Sound EBSA in Trinity Bay was noted to have the largest remaining known spawning area for northern cod (Bradbury et al., 2001).
- Longline fisheries are concentrated on the Southwest Shelf Edge and Slope and south coast, including the St. Pierre and Burgeo Banks. Longlines are deployed in a range of depths, precisely targeting rough-bottom areas.

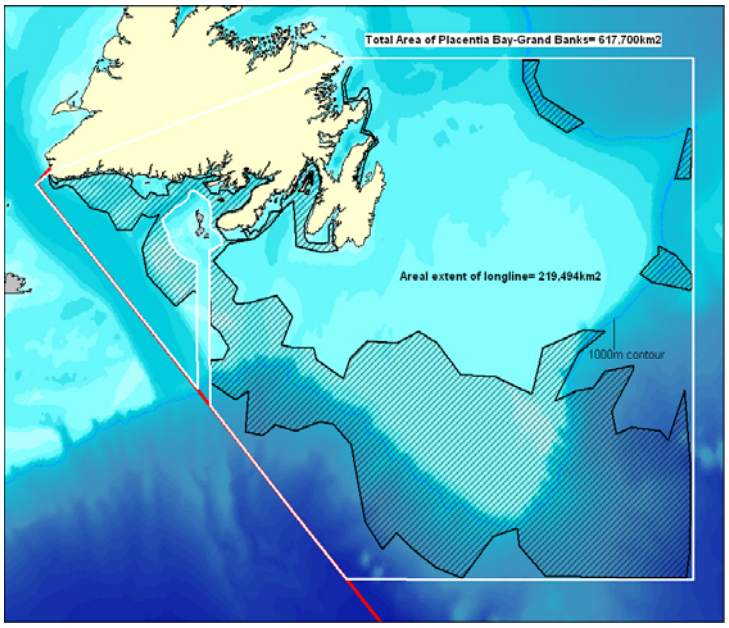


Figure 3. Areal extent of longline use, Newfoundland Region fisheries, 1998-2007 (Fisheries and Oceans Canada, 2008).

Figure 4. Total longline fishing effort density, 2004-2005 (Edinger et al., 2007).

- Estimated area of overlap based on Figure 3 is 219,494/617,700 =35%.

Score 3.5

Contact:
- Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for "contact" in longline fisheries are high (75-100%) for bony fish.
- Cod was noted as the groundfish species of highest landings by longline (Fisheries and Oceans Canada, 2007b) between 2000-2003, with cod landings (bycatch and directed) within the LOMA totalling 580t.
- Longlines tend to capture large fish, but over the period 1998-2007, longlines were responsible for only 2% of landings by weight (15,320t) in the PBGB LOMA, for all species combined

Score 7.5

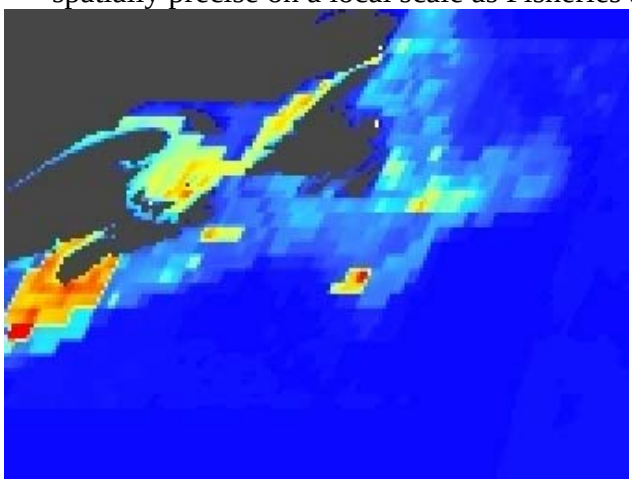
Duration:

- Longline fisheries occur annually and the season is open within the LOMA for one or more fisheries all year round (100% of the time).

Score 10

Intensity:

- Global maps (Halpern et al., 2008) for demersal non-destructive fisheries with low bycatch, which include longlines, show medium low (light blue) intensity relative to global levels for a score range of 20% to 40% (see figure below). This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum (100%) intensity in a global context in accordance with the scale provided below. Halpern's fishing maps are based on (1999-2003) data, and better represent NAFO fisheries, which are notoriously variable year to year, rather than Canadian fisheries, and are not as spatially precise on a local scale as Fisheries and Oceans data is.



Map colour	Intensity
Red	80-100%
Orange	60-80%
Yellow	40-60%
Light Blue	20-40%
Dark Blue	0-20%

Figure 5. Global Intensity of demersal non-destructive, low-bycatch fisheries, adapted from (Halpern et al., 2008)).

- Longline fisheries within the LOMA are concentrated on the Southwest Shelf Edge and Slope and represent only 2% of the landings in the LOMA.
- We have selected a score at the low end of the global scale 20%.

Score 2

<u>Magnitude of Interaction</u>: (3.5 x 7.5 x 10 x 2)/1000 = 0.5

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- In relation to longline, Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for "harm" are variable, ranging from medium to high (25-100%) for bony fish species in 3NO.

- Longlines were also given a "high impact" rating in relation to groundfish (Fuller et al., 2008).
- Two populations of Atlantic cod occur within the LOMA, the Laurentian North population (south coast) and the Newfoundland and Labrador population (NE coast and Grand Banks). Both populations were assessed by COSEWIC in 2003, with the Laurentian North population designated *threatened*, and the Newfoundland and Labrador population designated *endangered***.** The Status Report lists fishing (including legal, illegal and unreported catches) and fishing-induced changes to the ecosystem as key threats to cod recovery.
- Over-fishing is widely believed to be the major cause of the devastating collapse of Canadian North Atlantic cod stocks in the early 1990s (Rose, 2007). Since this time, numerous management actions have been put in place to conserve cod stocks including fishing moratoria, closed areas to protect spawning areas, closure of the recreational cod fishery, bycatch limits and greatly reduced total allowable catch (TAC). Cod landings within the LOMA are now (2001-2007) less than one percent of the total cod harvested in the marine waters of Newfoundland and Labrador in 1968 (Fisheries and Oceans Canada, 2000a).
- Despite these conservation measures, stocks remain at low levels and fishing mortality (directed and bycatch) is not considered sustainable. Cod was noted as the groundfish species of highest landings by longline from 2000-2003, when average annual cod landings (bycatch and directed) within the LOMA totalled 580t. Within this period, average annual landings of cod by gillnet fisheries amounted to 2,050t (Fisheries and Oceans Canada, 2007b). Over the period 1998-2007, longlines were responsible for only 2% of landings by weight (15,320t) in the PBGB LOMA, for all species combined
- The score assigned is in the low range.

Score 2

Sensitivity of the CP to chronic impacts:

- Cod are very prolific, particularly large cod. Female cod about 80cm long produce approximately two million eggs, while a cod of about 130cm produces over 11 million eggs. Generation time is reportedly 11 years for Atlantic cod (Lough, 2004). Sexual maturity in females occurs around 5-8 years, with males being slightly younger (Lear, 1993). Consequently, recovery for excessive fishing mortality is very slow.
- Projections by Power *et al*. (2005) indicate that even under the scenario of no removals, spawner biomass of the NL population Atlantic cod within the LOMA is expected to decline by 11% to 4,900t by 2010, and if the stock continues to be fished at current by catch rates, spawner biomass will decrease by 76% to about 1,300t (Power et al., 2005). The 2008 stock status report recommends that the moratorium on directed fishing in the offshore should be continued, and bycatch should be minimized.
- Recent stock status reports for the Laurentian North population (south coast) indicate that annual total mortality rates (age 5-11) inferred from the DFO RV combined survey have increased from an average of 23% in 1997-2004 to an average of 55% in 2005-07. Spawning stock biomass (SSB) has also been decreasing in recent years and in 2008 was just above the limit reference point. The report recommends that catches be reduced

- Since there is a directed longline fishery for cod on the south coast, and landings (directed and bycatch) are significant, but low compared to other gear types, this is considered minor. However, given the poor condition of the stock even this low level of bycatch is likely not sustainable. (Score of 3)
- Atlantic cod are listed in the CP document as a 'depleted and rare species', and will therefore rank higher on this scale than other CPs because they are already in need of recovery (**add one point**).

Score 4

Sensitivity of ecosystem to harmful impacts to the CP:

- Historically, cod had a huge influence on the ecosystem of the LOMA, largely because of their large biomass and broad distribution compared to other species and their role as both predator and prey at all trophic levels as they grow and move from one trophic level to another. Even though they are currently at less then one percent of their former biomass, they still represent a significant component of the total groundfish population.
- With the sharp decline of cod biomass in the 1990s, stocks of invertebrates such as shrimp and crab expanded to record highs in what has been termed a trophic cascade (Fisheries and Oceans Canada, 2000b). These changes have been blamed on over fishing, resulting in perturbations to the predator-prey systems, and although environmental change may have had a contribution, it is clear that the role of Atlantic cod in the ecosystem is highly significant to its structure and function. Score 8.
- Atlantic cod are listed in the CP document as an 'ecologically significant species' (**add one point**).

Score 9

<u>Sensitivity:</u> (2 + 4 + 9)/3 = 5.0

<u>Risk of Harm:</u> MoI x S = 0.5 x 5 = 2.5

Certainty Checklist

Answer yes or no to all of the following questions. Record the number of NO's to the 9 questions, and record certainty according to the scale provided below:

1 No's = High certainty
2 - 3 No's = Medium certainty
≥ 4 No's = Low certainty

Y/N

N Is the score supported by a large body of information?
Y Is the score supported by general expert agreement?
Y Is the interaction well understood, without major information gaps/sources of error?
N Is the current level of understanding based on empirical data rather than models, anecdotal information or probable scenarios?
Y Is the score supported by data which is specific to the region, (EBSA, LOMA, NW Atlantic)?
Y Is the score supported by recent data or research (the last 10 years or less)?
Y Is the score supported by long-term data sets (ten years or more) from multiple surveys (5 years or more)?
Y Do you have a reasonable level of comfort in the scoring/conclusions?
N Do you have a high level of confidence in the scoring/conclusions?

Certainty Score: Medium

For interactions with Low certainty, underline the main factor(s) contributing to the uncertainty:

Lack of comprehensive data
Lack of expert agreement
Predictions based of future scenarios which are difficult to predict
Other (provide explanation)

Suggest possible research to address uncertainty.

Reference List

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12. Kulka, D. W., Antle, N. C., & Simms, J. M. (2003). *Spatial Analysis of 18 Demersal Species in Relation to Petroleum License Areas on the Grand Banks (1980-2000)* (Rep. No. Canadian Technical Report of Fisheries and Aquatic Sciences 2473). Fisheries and Oceans Canada.

13. Lear, W. H. (1993). Underwater World: Atlantic Cod. Ottawa, Ontario, Communications Directorate, Fisheries and Oceans Canada.
Ref Type: Pamphlet

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16. Rose, G. A. (2007). *Cod: The Ecological History of the North Atlantic Fisheries*. Breakwater Books.

Atlantic cod (depleted or rare species) within the PBGB LOMA

Recreational cod fishery

<u>Magnitude of Interaction</u>

Areal extent:

- The recreational fishery is prosecuted in all coastal areas of the province, with the highest landings in Trinity Bay.

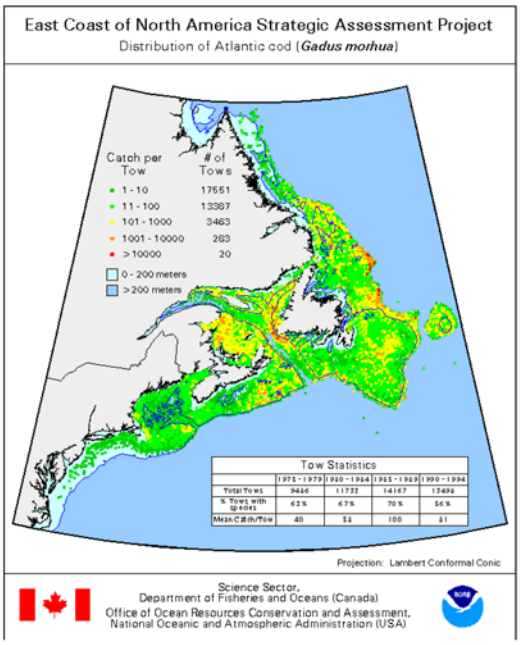


Figure 1. Distribution of Atlantic cod (Brown et al., 2005).

- Cod are widely distributed throughout the LOMA in both spring and fall. The main areas of concentration are the northeast slope of the Grand Bank in fall, the central portion of the bank including the upper Southwest Slope in spring and fall and inshore areas.
- Abundance is highest inshore in July-September as mostly migrant younger cod mix with inshore stocks. Some inshore cod, mainly large fish, migrate offshore in summer.
- Thee overall stock is at an extremely low level, but significant aggregations are evident, largely inshore, with highest densities in Bonavista Bay, Trinity Bay (Smith's Sound), St. Mary's Bay, and Tobin's Point (~100m offshore on 3K/3L boundary).
- The recreational fishery is prosecuted in all inshore areas of the LOMA, with highest landings in Trinity Bay.
- Based on this information we have estimated an overlap of 30%.

Score 3

Contact:

- The recreational fishery targets cod for a score of 100%.

Score 10

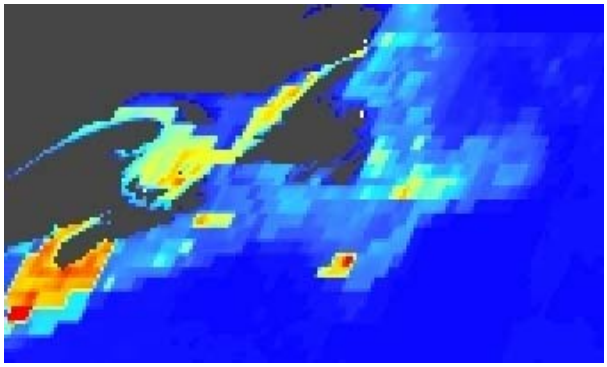
Duration:

- Cod are widely distributed in the LOMA throughout the year, with significant concentrations in inshore areas.
- The recreational cod fishery is conducted in the fall, although dates are variable. The 2007 fishery was open for five weeks long (35 days): July 25 to August 19 and September 29 to October 7.
- 35days/365 = 9.5%.

Score 1

Intensity:

- Global maps (Halpern et al., 2008) for demersal non-destructive fisheries with low by-catch, which include handlines, and hook and line fisheries, shows medium low (light blue) intensity relative to global levels for a score range of 20% to 40% (see Fig. 2 below). This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum (100%) intensity in a global context in accordance with the scale provided below. Halpern's fishing maps are based on (1999-2003) data, and better represent NAFO fisheries, which are notoriously variable year to year, rather than Canadian fisheries, and are not as spatially precise on a local scale as long term local data.



Map colour	Intensity
Red	80-100%
Orange	60-80%
Yellow	40-60%
Light Blue	20-40%
Dark Blue	0-20%

Figure 2. Global Intensity of demersal non-destructive, low bycatch fisheries (adapted from (Halpern et al., 2008)).

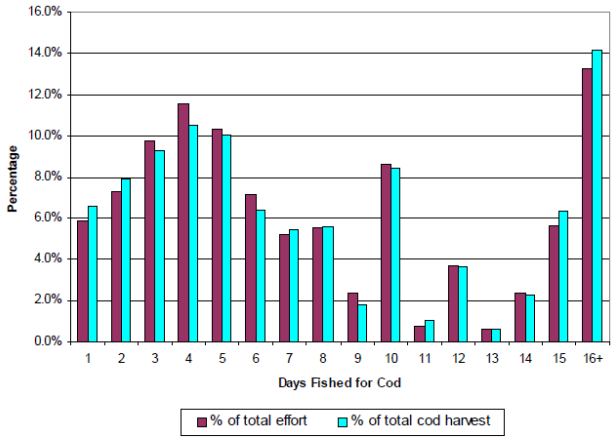


Figure 3. Distribution of total effort and total cod harvest for adult anglers in 2007, by days fished for cod (BriLev Consulting Inc., 2008).

- Landings of cod in LOMA by the recreational cod fishery were significant in 2007, with total landings of 852, 526 fish (see Table 1 below) (BriLev Consulting Inc., 2008).
- Since the average weight of a commercially caught cod is 4.5 kg (Scott & Scott, 1988) this amounts to 3,375t. Since these landings are significant compared to other sources of fishing mortality, we have selected the highest score in the global range (20-40%).

Score 4

<u>Magnitude of Interaction</u>: (3 x 10 x 1 x 4)/1000 = 0.12

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- Recreational cod fishery landings, 2007:

NAFO sub-division	Cod caught in 2007	
	Number	Weight (mt)
2J	11,555	23.3
3K	280,794	567.2
3L	726,813	1,468.2
3Pn	18,124	36.6
3Ps	107,589	217.3
4R	61,794	124.8
Total	1,206,669	2,437.5

Table 1: Estimated number and weight of cod caught, by NAFO sub-division of activity (BriLev Consulting Inc., 2008).

- The recreational cod fishery is a directed harvest, for a score of 9.

Score 9

Sensitivity of the CP to chronic impacts:

- Two populations of Atlantic cod occur within the LOMA, the Laurentian North population (south coast) and the Newfoundland and Labrador population (NE coast and Grand Banks). Both populations were assessed by COSEWIC in 2003, with the Laurentian North population designated *threatened*, and the Newfoundland and Labrador population designated *endangered*. The Status Report lists fishing (including legal, illegal and unreported catches) and fishing-induced changes to the ecosystem as key threats to cod recovery (COSEWIC, 2003).
- Over fishing is widely believed to be the major cause of the devastating collapse of Canadian North Atlantic cod stocks in the early 1990s (Rose, 2007). Since this time, numerous management actions have been put in place to conserve cod stocks including fishing moratoria, closed areas to protect spawning areas, closure of the recreational cod fishery, bycatch limits and greatly reduced total allowable catch (TAC). Cod landings within the LOMA are now (2001-2007) less than one percent of the total cod harvested in the marine waters of Newfoundland and Labrador in 1968 (Fisheries and Oceans Canada, 2000a).
- Projections by Power *et al*. (2005) indicate that even under the scenario of no removals, spawner biomass of the NL population Atlantic cod within the LOMA is expected to

- Recent stock status reports for the Laurentian North population (south coast) indicate that annual total mortality rates (age 5-11) inferred from the DFO RV combined survey have increased from an average of 23% in 1997-2004 to an average of 55% in 2005-07. Spawning stock biomass (SSB) has also been decreasing in recent years and in 2008 was just above the limit reference point. The report recommends that catches be reduced compared to recent levels, and greater priority should be given to increasing SSB (Fisheries and Oceans Canada, 2009).
- Despite significant conservation measures, stocks remain at low levels and fishing mortality is not considered sustainable.
- The recreational cod fishery is a significant source of fishing mortality, affecting mainly inshore stocks, although there appears to be some inshore migration of offshore stocks during the period of the recreational fishery (July-October).
- Since there is a directed recreational fishery throughout inshore waters of the LOMA, with moderate landings, it is scored in the medium range. (Score 5)
- Atlantic cod are listed as a 'depleted and rare species'(Fisheries and Oceans Canada, 2007), and will therefore rank higher on this scale than other CPs because they are already in need of recovery (**add one point**).

Score 6

Sensitivity of ecosystem to harmful impacts to the CP:

- Historically, cod had a huge influence on the ecosystem of the LOMA, mainly because of their large biomass and broad distribution compared to other species and their role as both predator and prey at all trophic levels as they grow and move from one trophic level to another. Even though cod are currently at less then one percent of their former biomass, they still represent a significant component of the total groundfish population.
- Since the sharp decline in cod biomass in the 1990s, stocks of invertebrates such as shrimp and crab have expanded to record highs in what has been termed a 'trophic cascade' (Fisheries and Oceans Canada, 2000b). These changes have been blamed on over-fishing, resulting in perturbations to the predator-prey systems, and although environmental change may have had a contribution, it is clear that the role of Atlantic cod in the ecosystem is highly significant to its structure and function. (Score 8)
- Atlantic cod are listed as an 'ecologically significant species'(Fisheries and Oceans Canada, 2007) (**add one point**).

Score 9

<u>Sensitivity:</u> (9 + 6 + 9)/3 = 8

<u>Risk of Harm:</u> MoI x S = 0.12 x 8 = 0.96

Certainty Checklist

Answer yes or no to all of the following questions. Record the number of NO's to the 9 questions, and record certainty according to the scale provided below:

1 No's = High certainty
2 - 3 No's = Medium certainty
≥ 4 No's = Low certainty

Y/N

N Is the score supported by a large body of information?
Y Is the score supported by general expert agreement?
Y Is the interaction well understood, without major information gaps/sources of error?
N Is the current level of understanding based on empirical data rather than models, anecdotal information or probable scenarios?
Y Is the score supported by data which is specific to the region, (EBSA, LOMA, NW Atlantic)?
N Is the score supported by recent data or research (the last 10 years or less)?
N Is the score supported by long-term data sets (ten years or more) from multiple surveys (5 years or more)?
Y Do you have a reasonable level of comfort in the scoring/conclusions?
N Do you have a high level of confidence in the scoring/conclusions?

Certainty Score: Low

For interactions with Low certainty, underline the main factor(s) contributing to the uncertainty:

Lack of comprehensive data
Lack of expert agreement
Predictions based of future scenarios which are difficult to predict
Other (provide explanation)

Suggest possible research to address uncertainty.

Reference List

1. BriLev Consulting Inc. (2008). *2007 Survey of the Recreational Cod fishery of Newfoundland and Labrador*.

2. Brown, S. K. R., Zwanenburg, K., & Branton, R. (2005). *East Coast of North America Strategic Assessment Project, Groundfish Atlas* Bedford Institute of Oceanography, Dartmouth, Nova Scotia: OBIS Canada.

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9. Power, D., Healey, B. P., Murphy, E. F., Brattey, J., & Dwyer, K. (2005). *An Assessment of the Cod Stock in NAFO Divisions 3NO* (Rep. No. NAFO SCR Doc. No. 05/67). Northwest Atlantic Fisheries Organization.

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11. Scott, W. B. & Scott, M. G. (1988). Atlantic Fishes of Canada. *Canadian Bulletin of Fisheries and Aquatic Sciences, 219.*

Atlantic cod (depleted or rare species) within the PBGB LOMA

Ghost nets (derelict fishing gear)

Magnitude of Interaction

Areal extent:

- We have no spatial data on the number or distribution of ghost nets in the LOMA, but given the high current and historical level of fishing activity, combined with the deep water, rough bottom and dynamic nature of the environment, significant loss of gear is likely.
- Gillnets, pots, trawls and line fisheries are considered the most harmful in relation to derelict fishing gear (National Academy of Sciences, 2008), with gillnets likely the more harmful to groundfish such as cod.
- Figures 1-4 below show the areal extent of fishing by gear type by Newfoundland Region fisheries from 1998 to 2007, based on DFO data (Fisheries and Oceans Canada, 2008).

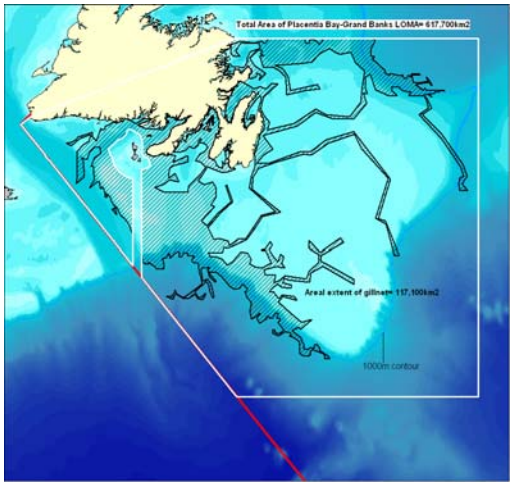


Figure 1. Areal extent of gillnet use, Newfoundland Region fisheries, 1998 - 2007 (Fisheries and Oceans Canada, 2008)

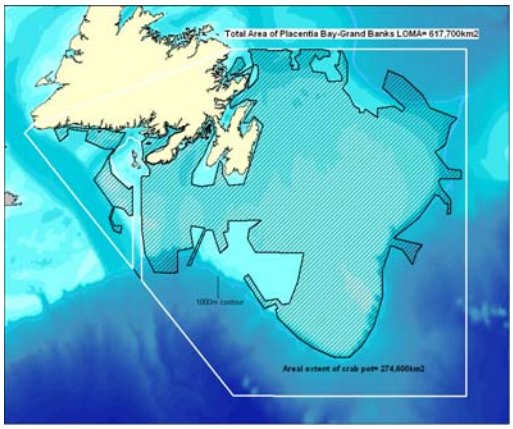


Figure 2. Areal extent of crab pot use, Newfoundland Region fisheries, 1998 - 2007 (Fisheries and Oceans Canada, 2008)

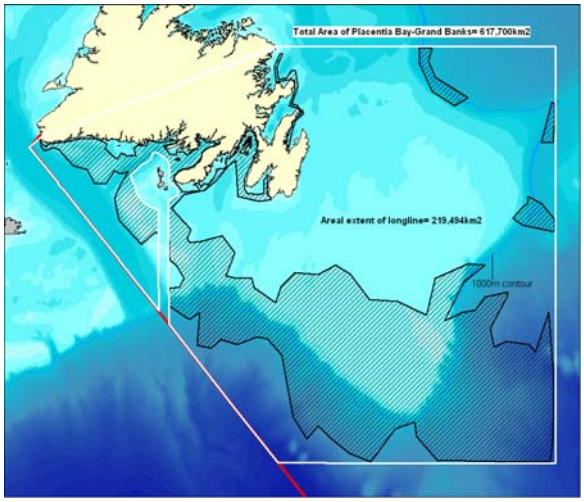


Figure 3. Areal extent of longline use, Newfoundland Region fisheries, 1998 - 2007 (Fisheries and Oceans Canada, 2008)

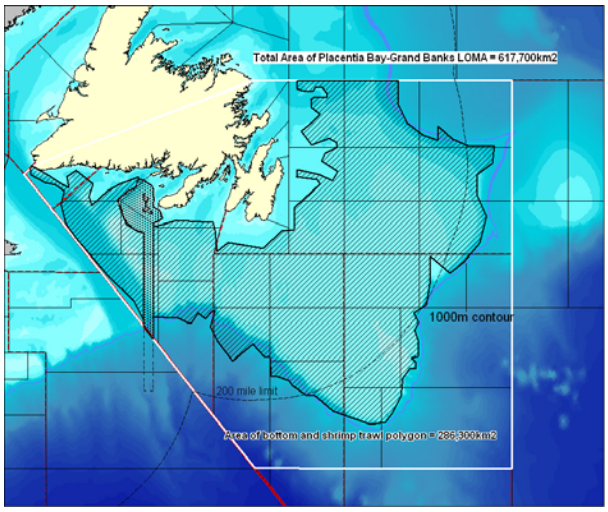


Figure 4. Areal extent of bottom trawl use, Newfoundland Region fisheries, 1998 - 2007 (Fisheries and Oceans Canada, 2008).

- Cod (Figure 5 below) are widely distributed throughout the LOMA in both spring and fall (Brown et al., 2005). The main areas of concentration are the northeast slope of the Grand Banks in fall, and the central portion of the bank including the upper Southwest Slope in spring and fall, and inshore areas.

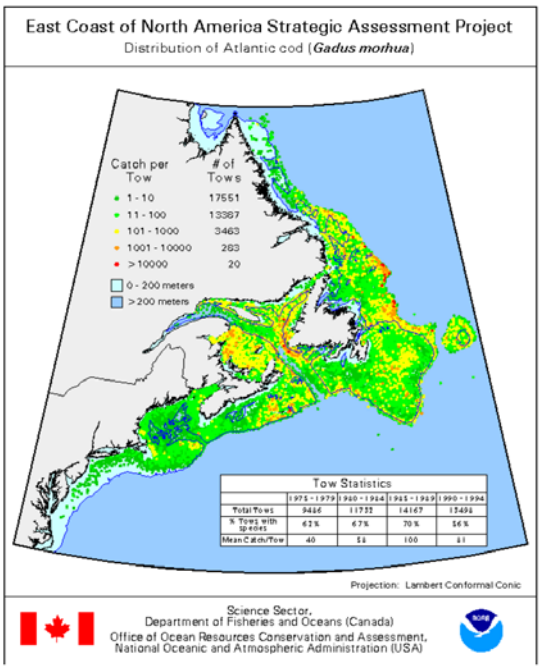


Figure 5. Distribution of Atlantic cod (Brown et al., 2005).

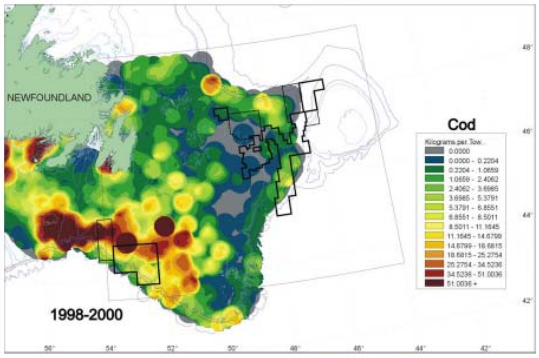


Figure 6d. Atlantic cod distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

Figure 6. Atlantic cod distribution in spring research surveys 1998-2000 (Kulka et al., 2003).

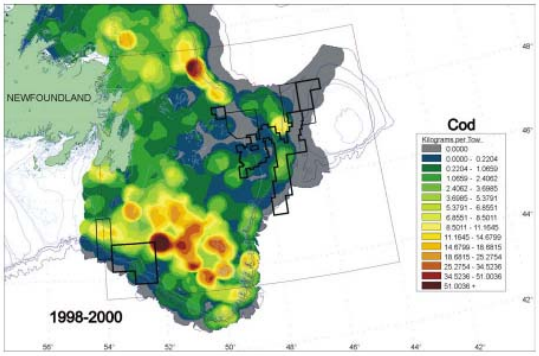


Figure 7d. Atlantic cod distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

Figure 7. Atlantic cod distribution in fall research surveys 1998-2000 (Kulka et al., 2003).

- We have estimated a 35% overlap (117,100/617,700) for areal extent in relation to gillnets (Figure 1) which is likely the most problematic gear type, and then increased the score by 0.5 to account for the other common fishing gear types which are widely used in the LOMA, but are less problematic to cod in relation to loss of fishing gear.

Score 4

Contact:

- Gillnets, pots, trawls and line fisheries are considered the most harmful in relation to derelict fishing gear (National Academy of Sciences, 2008), with gillnets likely contributing the most to ghost nets.
- Set gillnets, by virtue of their fixed, anchored framing, may remain fully deployed and fishing long after they are lost or abandoned. As nets become fouled, they become more visible, lose their vertical profile and their fishing capacity declines, but limited investigations have shown that gillnets lost in deepwater (>400m) can fish for years after they are lost because there is very little bio-fouling or water movement in depths below 400m (National Academy of Sciences, 2008).
- Even when nets collapse, forming balls on the sea floor, they have been observed to self-bait such that predators and scavengers attracted to entangled animals are themselves entangled, thereby perpetuating the cycle of destruction.
- Cod may be found throughout the water column, but most cod over-wintered in deep water (300-500m) on the outer slopes of the shelf and migrated during spring-autumn to feeding areas near the coast or on the plateau of Grand Banks, and contact with ghost nets is likely high.
- This is supported by gillnet retrieval programs within the LOMA which found cod to be the most common species captured in ghost nets.

Score 7.5

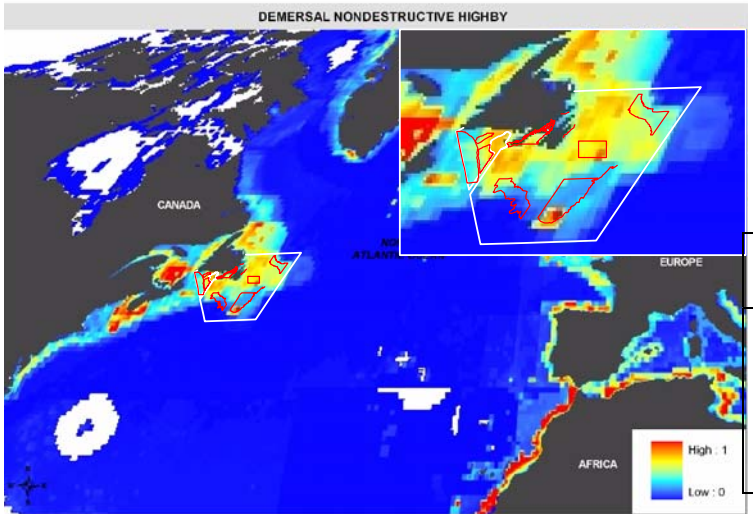
Duration:

- Since the 1960s, fishing nets have been constructed from highly durable plastic materials such as nylon, polypropylene and polyethylene, which do not biodegrade. Unlike their natural predecessors, the new materials can last for years or decades in the marine environment. They are largely impervious to biodegradation, they are resistant to chemicals and abrasion (National Academy of Sciences, 2008). Sun exposure can lead to photodegradation of some synthetic materials, but on the sea bottom, protected from UV radiation, there is no evidence that these nets weaken or degrade over time and as a result, lost gear can continue to fish for decades.
- The Northwest Straits Commission estimates that there are nearly 3,900 gillnets remaining in Puget Sound from domestic salmon fisheries from the 1970s and 1980s (National Academy of Sciences, 2008). One derelict net off Lopez Island in Puget Sound that had been in place for 15 years is estimated to have caught over 16,500 invertebrates, 2,340 fish and 1,260 seabirds.
- Ghost nets may actively fish for weeks or years, but they are present in the environment forever until they degrade.

Score 10

Intensity:

- Gillnets, traps, trawls and line fisheries are considered the most harmful in relation to derelict fishing gear (National Academy of Sciences, 2008). Trawls, pots and gillnets are among the most common gear types utilized in the LOMA. In relation to the CP, gillnets are considered the most problematic.
- Global maps (Halpern et al., 2008) for demersal non-destructive fisheries with high bycatch, which include gillnets, shows medium low (light blue) intensity relative to global levels for a score range of 20% to 40% (see figure below). This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum (100%) intensity in a global context, in accordance with the scale provided below.
- Halpern's fishing maps are based on (1999-2003) data, and better represent NAFO fisheries, which are notoriously variable year to year, rather than Canadian fisheries, and are not as spatially precise on a local scale as long term local data is.



Map colour	Intensity
Red	80-100%
Orange	60-80%
Yellow	40-60%
Light Blue	20-40%
Dark Blue	0-20%

Figure 8. Global Intensity of demersal non-destructive fisheries (adapted from (Halpern et al., 2008)

- Ghost net retrieval programs and surveys indicate a significant problem with lost gear in inshore areas of the LOMA.
- Offshore gillnet fisheries are concentrated on the slope and edge of the banks. Research has shown a clear connection between water depth and loss rates, and limited investigations have shown that gillnets lost in deep water (>400m) can fish for years after they are lost because there is very little bio-fouling or water movement in depths below 400m (National Academy of Sciences, 2008).
- Other factors such harsh weather and large numbers of nets deployed by a single enterprise (compared to inshore) likely increase the risk of lost nets in the LOMA.
- Based on these factors, we have selected the highest score within the range indicated for the LOMA.

Score 6

Magnitude of Interaction: (4 x 7.5 x 10 x 6)/1000 = 1.8

Sensitivity

Sensitivity of the CP to acute impacts:

- Derelict trawl webbing and longlines may contribute to mortality of cod within the EBSA, but lost gillnets are thought to be most problematic.
- Set gillnets, by virtue of their fixed, anchored framing (held in position by buoys on top and lead rope on bottom), may remain fully deployed and fishing long after they are lost or abandoned. As nets become fouled, they become more visible and lose their vertical profile, and their fishing capacity declines, but limited investigations have shown that lost gillnets set in deepwater (>400m) can fish for years after they are lost because there is very little bio-fouling or water movement in depths below 400m (National Academy of Sciences, 2008). Even when nets collapse, forming balls on the sea floor, they have been observed to self bait such that predators and scavengers attracted to entangled animals are themselves entangled, thereby perpetuating the cycle of destruction.
- Although most research has been focused on inshore waters, a number of factors indicate that the problem is significantly worse in the offshore where water is deeper, fish harvesters use larger amounts of gear and weather conditions are more severe- all factors which lead to increased rates of gear loss (Hareide et al., 2005). For example, research has shown a clear connection between water depth and loss rates in the Norwegian gillnet fishery, with an estimated loss of 15 nets (750m) per day in the Greenland halibut fishery at depths of 550 to 700m (Hareide et al., 2005).
- Five major gillnet fisheries are currently prosecuted within the LOMA (cod, Greenland halibut, monkfish, skate and white hake). While it is difficult to quantify the amount of lost gear, studies suggest that some 8,000 active gillnets were lost in Atlantic Canada on average each year for a number of years up to 1992 (Erzini et al., 1997).
- Based on available information, ghost nets may be widespread within the LOMA, but relative to fishing, mortality rates are low. We have therefore selected a score at the high end of the low range, for a score of 3.

Score 3

Sensitivity of the CP to chronic impacts:

- Ghost nets can continue to fish for weeks, months or years. The Northwest Straits Commission estimates that there are nearly 3,900 gillnets remaining in Puget Sound from domestic salmon fisheries from the 1970s and 1980s (National Academy of Sciences, 2008).
- Atlantic cod (NL) are listed as endangered by COSEWIC, and are currently at less then one percent of their former biomass (Hutchings, 2004).
- Recent stock status reports for the Laurentian North population (south coast) indicate that annual total mortality rates (age 5-11) inferred from the DFO RV combined survey have increased from an average of 23% in 1997-2004 to an average of 55% in 2005-07. Spawning stock biomass (SSB) has also been decreasing in recent years and in 2008 was just above the limit reference point. The report recommends that catches be reduced compared to recent levels, and greater priority should be given to increasing SSB (Fisheries and Oceans Canada, 2009).

- ‘A Strategy for the Recovery and Management of Cod Stocks in Newfoundland and Labrador’ lists fishing (including legal, illegal and unreported catches) and fishing-induced changes to the ecosystem as key threats to cod recovery (Action Team for Cod Recovery, 2005).
- The impacts of ecosystem changes and mortality rates associated with ghost nets are unknown, but are likely low relative to fishing mortality. The chronic, cumulative nature of the threat is a greater concern. Fishing activity can be reduced as required to conserve stocks, but once ghost nets are lost, retrieval is very difficult and expensive, and mortalities can continue for decades.
- Considering the very low level of the stock, and the persistent nature of the stressor, chronic sensitivity is considered moderate, >25years for a score of 6.
- Atlantic cod are listed as a ‘depleted and rare species’(Fisheries and Oceans Canada, 2007), and will therefore rank higher on this scale than other CPs because they are already in need of recovery (**add one point**).

Score 7

Sensitivity of ecosystem to harmful impacts to the CP:

- Historically, cod had a huge influence on the ecosystem of the LOMA, mainly because of their large biomass and broad distribution compared to other species and their role as both predator and prey at all trophic levels as they grow and move from one trophic level to another. Even though they are currently at less then one percent of their former biomass, they still represent a significant component of the total groundfish population.
- Since the sharp decline in cod biomass in the 1990s, stocks of invertebrates such as shrimp and crab expanded to record highs in what has been termed a ‘trophic cascade’ (Fisheries and Oceans Canada, 2000). These changes have been blamed on over-fishing resulting in perturbations to the predator-prey systems, although environmental change may have had a contribution. The role of Atlantic cod in the ecosystem is highly significant to its structure and function. Score 8
- Atlantic cod are listed as an ‘ecologically significant species’(Fisheries and Oceans Canada, 2007) (**add one point**).

Score 9

<u>Sensitivity:</u> (3 + 7 + 9) = 6.3

<u>Risk of Harm:</u> MoI x S = 1.8 x 6.3 = 11.3

Certainty Checklist

Answer yes or no to all of the following questions. Record the number of NO's to the 9 questions, and record certainty according to the scale provided below:

1 No's = High certainty
2 - 3 No's = Medium certainty
≥ 4 No's = Low certainty

Y/N

N Is the score supported by a large body of information?

N Is the score supported by general expert agreement?
N Is the interaction well understood, without major information gaps/sources of error?
N Is the current level of understanding based on empirical data rather than models and probable scenarios?
Y Is the score supported by data which is specific to the region, (EBSA, LOMA, NW Atlantic?
Y Is the score supported by recent data or research (the last 10 years or less)?
N Is the score supported by long-term data (ten years or more) from multiple surveys (5 years or more)?
Y Do you have a reasonable level of comfort in the scoring/conclusions?
N Do you have a high level of confidence in the scoring/conclusions?

Certainty Score: Low

For interactions with Low certainty, underline the main factor(s) contributing to the uncertainty

Lack of comprehensive data
Lack of expert agreement
Predictions based of future scenarios which are difficult to predict
Other (provide explanation)

Suggest possible research to address uncertainty:

- Encourage reporting of lost gear through fishing gear marking systems and return incentives, and develop a comprehensive database for the region.
- Provide incentives for retrieved ghost nets, and add data on retrieval to database.
- Collect observer data on ghost net encounters

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Summary Table: Atlantic cod (depleted or rare species) within the PBGB LOMA.

Key Activity/Stressor	a	c	d	i	**MoI** (a x c x d x i) / 1000	as	cs	es	**S** (as+cs+es) / 3	**Risk of Harm**	Certainty
Bottom trawl	6.5	9.5	9.5	9	**5.3**	9	10	9	**9.3**	**49.3**	**Med**
Gillnets (bottom)	3	8	9	5	**1.1**	7.5	8	9	**8.2**	**9.0**	**Med**
Longline	3.5	7.5	10	2	**0.5**	2	4	9	**5.0**	**2.5**	**Med**
Recreational cod fishery	3	10	1	4	**0.12**	9	6	9	**8**	**1.0**	**Low**
Ghost nets	4	7.5	10	6	**1.8**	3	7	9	**6.3**	**11.3**	**Low**
Cumulative CP Score										**73.1**	