Atlantic cod spawning biomass in Placentia Bay Extension

Potentially Harmful Activity (X)			Potentially Harmful Stressor (X)		
Fishing	Bottom trawl		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	**X**
	Ship strikes			Disease organisms (human waste)	
	Ecotourism			Disease organisms (aquaculture)	
	Marine construction			Other (specify)	
	Seismic surveys		Other		
	Navy sonar				
	Other (specify)				

Background Information

This CP refers to the biomass of sexually mature cod, rather than the act of spawning. The female cod reaches sexual maturity at about 6 years of age (the age range is 5-8 years), with males maturing at a slightly younger age and smaller size (Lear, W. H., 1993). Atlantic cod spawning biomass in Placentia Bay is only one component of the total 3Ps stock. The 3Ps stock off southern Newfoundland extends from Cape St. Mary's to just west of Burgeo Bank, and over St. Pierre Bank and most of Green Bank. Cod from the 3Ps stock generally grow faster than those from areas further north, and female cod mature at younger ages in recent years (Fisheries and Oceans Canada, 2009). Cod are known to spawn in the same area each year, but numbers and timing vary. Large mature fish in good condition are necessary for large egg potential because fecundity increases exponentially with fish size (Rose, G. A. et al., 2008). Lawson and Rose (2000) tagged cod in Placentia Bay spawning grounds and found that the majority (87%) were recaptured inside the bay. Ten to 30%, mainly large fish, migrated long distances outside the bay during the spring and summer, but returned to the bay to spawn (Lawson, G. L. & Rose, G. A, 2000). Cod is predominately fished using gillnets in Placentia Bay, as 94% of harvesters interviewed use gillnets (FFAW, 2007).

Studies within Placentia Bay have detected three areas where dense aggregations of cod in spawning condition may be found: Bar Haven in the inner bay, Perch Rock and Oderin Bank in the outer bay (Lawson & Rose, 1999; Lawson & Rose, 2000; Carew, 2001). Rose *et al.* (2008) found that spawning biomass in the Bar Haven area varied from 2,000 to 25,000t (from 1996 to 2003). Total stock spawning biomass estimated from sequential population models ranged from about 60,000t in 1996 to about 85,000t in 1998 and 1999 (See Figure 2, below) (Rose, G. A. et al., 2008).

The fishery in 3Ps reopened in May 1997 with a TAC of 10,000 t. This was subsequently increased to 20,000 t for 1998 and to 30,000 t for 1999. In 2000 the management year was changed to begin on 1 April. An interim quota of 6,000 t was set for the first three months of 2000. For April 2000 to 31 March 2001 the TAC was set at 20,000 t. For the next five management years ending 31 March 2006 the TAC was set at 15,000 t, but this was reduced to 13,000 t for the 2006/07, 2007/08 and 2008/09 management years (Fisheries and Oceans Canada, 2009).

In 2001, Bradbury *et al.* stated that Placentia Bay has the largest spawning stock of Atlantic cod in the Northwest Atlantic (Bradbury, I. R., Snelgrove, P. V. R., & Fraser, S., 2001), but total biomass from DFO RV surveys indicates a decline by more than 20% per year since 2004. The 2008 biomass estimate is less than 50% of the average for 1997-2008, indicating that the spawning stock biomass (SSB) is in decline and is near the lowest levels observed. The most recent stock assessment states that if the Precautionary Approach is to be applied, then catches should be reduced compared to recent levels, and greater priority should be given to increasing SSB (Fisheries and Oceans Canada, 2009).

Scoping

Gillnets (bottom):
Bottom gillnets are constructed of monofilament netting and are secured to the seafloor with weights. Bottom gillnets are in direct contact with the seafloor and have a high incidence of bycatch. Fish are caught as they attempt to swim through the webbing, entangling their gills. Within the EBSA, license holders are limited to 20-500 nets that are 91m in length and are usually joined together. This amounts to a maximum of 45.5km of net per license holder. Gillnets are the most commonly used gear in Placentia Bay Extension, and were responsible for 62% of landings by weight in this EBSA over the period 1998-2007 (Appendix A, Table 17). In the last five years (2003-2007), landings from gillnet averaged 4,216t in the EBSA (Fisheries and Oceans Canada, 2008).

In 2007/08, total reported landings of cod were 12,875t in 3Ps (mostly 5-9 year olds), of which 77% was from the fixed gear sector (mainly gillnets). (Fisheries and Oceans Canada, 2009). The standardized total annual catch rate index for gillnets in 3Ps was high from 1995-97, but progressively lower in 1998 and 1999, and remained quite low from 2000 to 2008 (Fisheries and Oceans Canada, 2009). The main directed fisheries using gillnet target lumpfish, cod, Greenland halibut, skate/monkish and winter flounder. Most of these fisheries are open from May 1 to February 28 (Appendix A, Table 9), which overlaps with the presence of cod spawning biomass in Placentia Bay. **Screened in.**

Recreational cod fishery:
The CP of cod spawning biomass refers to the amount of Atlantic cod in the population at reproductive maturity which may occur in Placentia Bay throughout the year. 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. 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. Landings of cod in Placentia Bay in the recreational cod fishery were significant in 2007, with a total of 6,489 fish harvesters participating and 45,000 fish caught (BriLev Consulting Inc., 2008). Placentia Bay only encompasses a small part of NAFO Division 3Ps, therefore landings for 3Ps are much greater than those noted for Placentia Bay (3Psc). Sexually mature adult fish which makeup spawning biomass are caught in this fishery and studies have shown that spawners may return to the same area year after year. During the 2007 recreational cod fishery, fisheries observers estimated that 542t of cod fish were taken. 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.**

Ghost nets:
Ghost nets are fishing gear that have been lost or discarded at sea. Factors such as weather, currents, tides, sea state, depth, fishing intensity, presence of sea ice, the make up of the

seafloor, the condition of the gear, equipment and vessel all contribute to the risk of lost gear (Hareide et al., 2005; The British Ecological Society, 2000). Lost nets may float freely in the water column, snag on a bottom feature with the free ends floating in the water column, or form a ball on the sea floor, with folds of netting moving with the motion of the water. These ghost nets attract a range of marine species as they provide convenient but deadly structural habitat and a constant food supply for predators, scavengers and decomposers. 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. 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.

Gillnets are the most commonly used gear to target demersal fish in Placentia Bay (Appendix A, Table 17). The main directed fisheries using bottom gillnet in the areas occupied by the CP target cod, winter flounder and lumpfish. Over the past decade, numerous programs have been initiated to retrieve ghost nets in Placentia Bay, usually focusing on the spawning area near Bar Haven and the head of the bay where much of the fishing activity is focused. Sixty ghost nets retrieved in Placentia Bay in the 1990s were found to contain 30,000 lbs of rotting cod, as well as other species (CBC News, 2000a; CBC News, 2000b). Clearly this retrieval rate indicates a significant problem with ghost nets in the area occupied by spawning cod. **Screened in.**

Current shifts:
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. Cold water is more dense than warm water and so tends to sink, but saline water is more dense than freshwater and also tends to sink. 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, S., 2008). 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.

An inshore branch of the Labrador Current is the key oceanic current influencing the counter-clockwise currents in Placentia Bay. Predicted changes to oceanic currents, including a decrease in Gulf Stream flow and potential increases in the flow of the Labrador Current, are not expected to cause significant changes in current flow in Placentia Bay in the next 10 years. **Screened out.**

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, G. A., 2005), and therefore may decrease in density within the EBSA. Many believe that temperature shifts were at least partially responsible for the poor recovery of over-fished cod stocks in the 1990s (Rose, G. A., 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, K. F., 2005). These responses of cod to future climate changes are highly uncertain however, as they will also depend on 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.**

Harmful algal blooms (HABs):
The term "harmful" has been used to describe blooms of algae that can cause a range of deleterious physiological and environmental effects. Some harmful algae produce potent natural toxins that are bio-concentrated by some filter feeding shellfish and finfish and passed along the foodchain, causing illness or death if consumed by humans or other organisms. The last 20 years have seen a drastic increase in harmful algal blooms worldwide, including Placentia Bay. Ballast water is considered a major vector of HABs, and climate change is expected to further promote the frequency of HABs. Therefore, high ship traffic and Placentia Bay's southern location may increase its susceptibility to HABs. Harmful algal blooms of concern in the LOMA include toxic PSP, ASP, DSP, Spirolides, Yessotoxin, and Pectenotoxin. PSP (paralytic Shellfish poisoning) is among the most toxic HABs, with small quantities leading to rapid paralysis and death. HABs can accumulate in the foodchain leading to mortality of marine organisms at all trophic levels including zooplankton, fish, seabirds and marine mammals (Agriculture and Consumer Affairs, 2004; Sindermann, C. J., 2003).

Weise *et al*. (2001) found that rainfall, local river runoff and wind regime greatly affected the pattern of bloom development, with the development of blooms favoured by high run-off from local tributary rivers, combined with prolonged periods of low winds. More intense algal outbreaks were associated with extreme climate events, such as heavy rainfall (Weise, A. M. et al., 2001). If conditions such as these become more common in the future, we can expect to see an increase in the onset and proliferation of toxic algal blooms in eastern Canada, which may impact populations of mature cod**. Screened out.**

<u>Key Activities/Stressors:</u>
- Gillnets (groundfish)
- Recreational cod fishery
- Ghost nets

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Atlantic cod spawning biomass in Placentia Bay Extension

Gillnets (groundfish)

Magnitude of Interaction

Areal extent:

- Cod in spawning condition are widely distributed in all areas of the bay with the exception of the deep central portion of the outer bay (see Fig. 1 below):

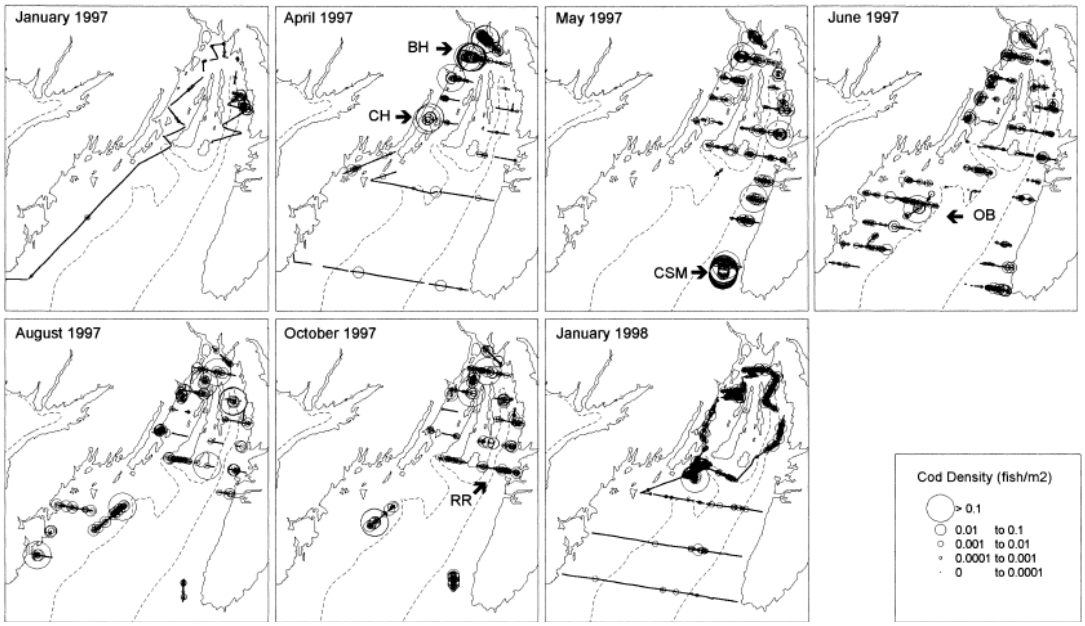


Figure 1. Cod density in Placentia Bay based on Acoustic Surveys (1997-1998) (Lawson, G. L. & Rose, G. A, 2000).

- Three key spawning grounds for cod have been identified at Bar Haven, Oderin Bank and Cape St. Mary's (Fig. 2 below) (Carew, A. M. E., 2001; Lawson, G. L. & Rose, G. A, 2000).

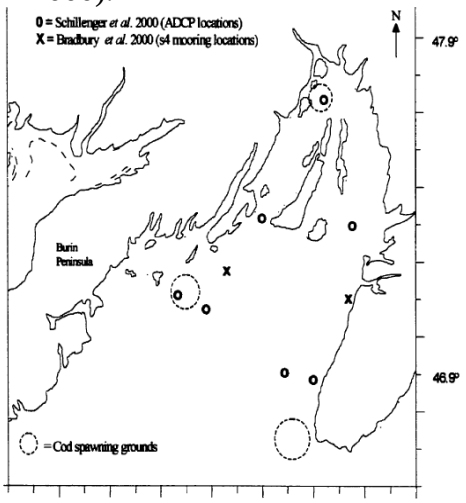


Figure 2. Locations of cod spawning grounds in Placentia Bay (Carew, A. M. E., 2001).

- Gillnet fisheries make up 62% of total landings within the EBSA from 1998 - 2007. Geo-referenced fishing locations are available for vessels over 35ft (Fig. 3 below) with major fisheries in Placentia Bay targeting cod, plaice and skate.

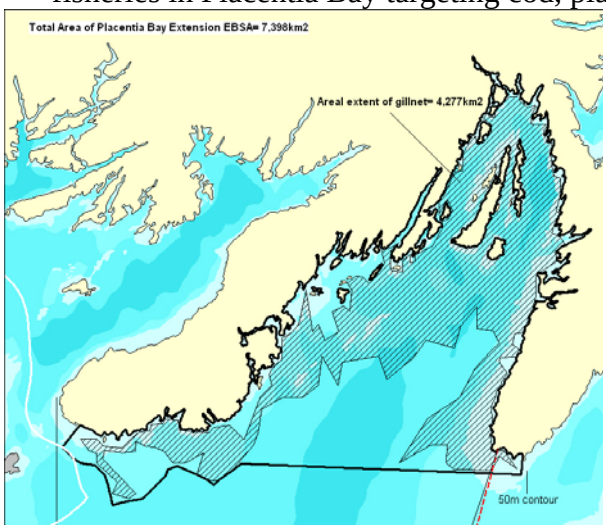


Figure 3. Areal extent of gillnet fisheries (vessels > 35ft) Newfoundland Region fisheries, 1998-2007 (Fisheries and Oceans Canada, 2008).

- Gillnet vessels over 35ft account for only 10% of the total landings in the EBSA from 1998-2007.
- There is also a significant inshore gillnet fishery (vessels <35ft), largely targeting cod, lumpfish and winter flounder, accounting for 52% of the total landings for the EBSA from 1998-2007. The distribution of these fisheries is shown on Fig. 4 below:

Figure 4. Distribution of lumpfish, winter flounder, and Atlantic cod gillnet fisheries in Placentia Bay from 1984-2000 (Community Resource Services Ltd & Jacques Whitford Environment Ltd, 2001).

- Since we have defined the area occupied by the CP as the entire bay with the exception of the deep central portion of the outer bay, we have estimated an area of overlap of 95%.

Score 9.5

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.
- Since there is a directed fishery for cod in Placentia Bay, we have given a score of 100%.

Score 10

Duration:

- Cod spawning biomass refers to the amount of Atlantic cod in the population at reproductive maturity, which may occur in Placentia Bay throughout the year. Timing of spawning is variable and extremely protracted, with spawning fish present from March until August in Placentia Bay.
- Fisheries which utilize gillnet (Atlantic cod, Greenland halibut, skate/monkfish, winter flounder, and lumpfish) take place between mid May and the end of February. The fisheries are therefore open 9.5 months during the 12 months occupied by the CP.

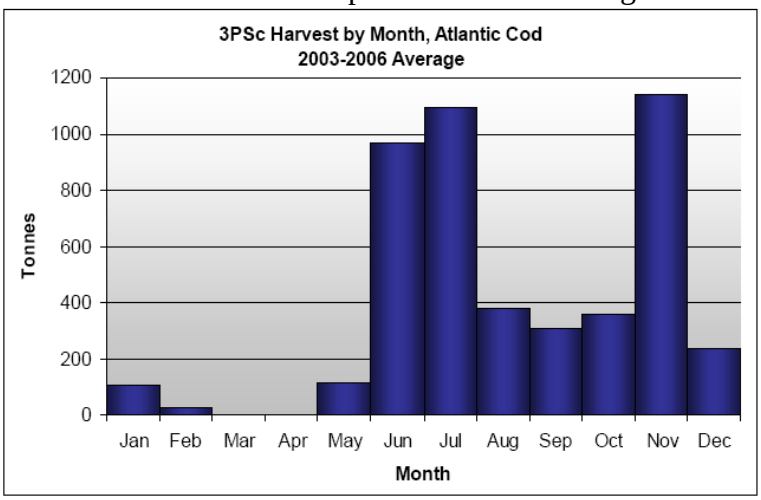


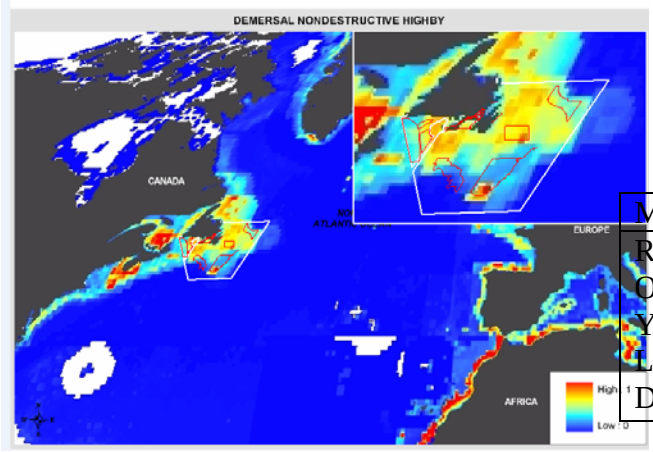
Figure 5. Harvest of Atlantic cod in 3Psc by month (Newfoundland and Labrador Refining Corporation (NLRC), 2007).

- 9.5/12% = 79%.

Score 7.9

Intensity:

- Halpern *et al.* (2008) have developed maps showing the global intensity of several anthropogenic stressors including a range of fisheries. These maps 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 map of demersal non-destructive fisheries with high bycatch, which include gillnets, is shown in Fig. 6 below.



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 demersal non-destructive fisheries with high bycatch, which include gillnets, adapted from (Halpern, B. S. et al., 2008).

- Figure 6 shows a medium (yellow) intensity relative to global levels for a score range of 40% to 60% for the EBSA. Gillnet fisheries account for 62% of the total landings in the EBSA from 1998-2007 (Fisheries and Oceans Canada, 2008), and gillnets have historically been the dominant gear used in Placentia Bay, therefore we have selected the highest score in the global range.

Score 6

<u>Magnitude of Interaction:</u> (9.5 x 10 x 7.9 x 6)/ 1000 = 4.5

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- There is a direct commercial harvest of the CP, so we have selected a score in the high range.
- Over the period 1998 - 2007, 62% of landings were taken with gillnet. During that same period, 61% of landings comprised of Atlantic cod (Fisheries and Oceans Canada, 2008).
- Numerous management strategies are in place to protect spawning cod in Placentia Bay, including a fishing closure of the largest spawning area near Bar Harbour during the spawning season to protect the spawning biomass, and the closure of most relevant fisheries during peak spawning (March-mid-May). The 2009-2010 3Ps cod Integrated Fisheries Management Plan indicates that there have been a number of compliance issues noted in the winter along with concern about fishing areas known for spawning.
- Based on this information we have selected a score at the low end of the high range.

Score 8

Sensitivity of the CP to chronic impacts:

- The Laurentian North population of Atlantic cod (includes Placentia Bay) was assessed by COSEWIC in 2003 and was designated *threatened***.** 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.

- Generation time is reportedly 11 years for Atlantic cod (Lough, R. G., 2004). Sexual maturity reached in females around 5-8 years, with males being slightly younger (Lear, W. H., 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. Cod are batch spawners, releasing eggs in batches over a period of weeks or months depending on their size (Scott, W. B. & Scott, M. G., 1988).
- Atlantic cod populations are currently at a very low level compared to historical levels, and although TAC are correspondingly low, catch rates are significant given the low level of the stock.

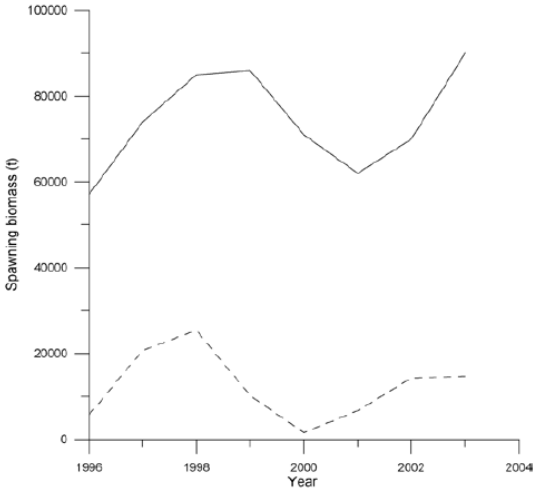


Figure 2. Spawning biomass from acoustic surveys at Bar Haven (dashed) and in the 3Ps stock.

Figure 7. Spawning biomass from acoustic surveys at Bar Haven (dashed line) and in the 3Ps stock (Rose, G. A. et al., 2008).

- The status of inshore components of the 3Ps stock are uncertain, but exploitation rates for most inshore components in 2008 were approximately 10%, which seems sustainable. Indicators from the inshore are stable, and inshore fish harvesters (<65' vessel sector) feel that the stability in their catch rates indicate there has been good recruitment and an overall stability in stock status(Fisheries and Oceans Canada, 2009).
- Inshore components of the stock appear to be more stable than offshore components as both sentinel fishery indices and commercial catch rates are stable (Fisheries and Oceans Canada, 2009).
- Chronic impacts are therefore considered to be moderate (6).
- Atlantic cod are listed 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 7

Sensitivity of ecosystem to harmful impacts to the CP:

- Coastal bays provide significant spawning, nursery and over-wintering habitat for Atlantic cod within the LOMA. Since the collapse of the cod stocks in the early 1990s,

- Spawning cod represent a key life stage upon which the population depends. Bay stocks are relatively stable compared to offshore stocks and are seen by many as a key component in the recovery of cod stocks within the LOMA as a whole.
- Cod have historically had a huge influence on the ecosystem, largely because of their abundance and broad distribution compared to other species and their significant 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 a low level, 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' (Rose, G. A., 2007). 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 an influential species in the ecosystem of the LOMA, and the Placentia Bay spawners support a significant portion of the population, we have given a score of 6.
- Atlantic cod are listed as an 'ecologically significant species'(Fisheries and Oceans Canada, 2007b) (**add one point**).

Score 7

Sensitivity: (8 + 7 + 7)/3 = 7.3

Risk of Harm: MoI x S = 4.5 x 7.3 = 32.9

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, 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)?
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?

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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5. Fisheries and Oceans Canada (2007b). *Placentia Bay-Grand Banks Large Ocean Management Area Conservation Objectives* (Rep. No. 2007/042). Canadian Science Advisory Secretariat Science Advisory Report.

6. Fisheries and Oceans Canada. 1998-2007 3LMNOP4R Effort and Catch. Policy and Economics Branch. [Newfoundland and Labrador Region Catch and Effort]. 2008. Fisheries and Oceans Canada.
   Ref Type: Data File

7. Fisheries and Oceans Canada (2009). *Stock Assessment of Subdivision 3Ps cod stock* (Rep. No. Science Advisory Report 2009/008). Canadian Science Advisory Secretariat, Newfoundland and Labrador Region.

8. Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C., Bruno, J. F., Casey, K. S., Ebert, C., Fox, H. E., Fujita, R., Heinemann, D., Lenihan, H. S., Madin, E. M. P., Perry, M. T., Selig, E. R., Spalding, M., Steneck, R., & Watson, R. (2008). A Global Map of Human Impact on Marine Ecosystems. *Science, 319,* 948-952.

9. Lawson, G. L. & Rose, G. A. (2000). Seasonal distribution and movements of coastal cod (*Gadus morhua* L.) in Placentia Bay, Newfoundland. *Fisheries Research, 49,* 61-75.

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

11. Lough, R. G. (2004). *Atlantic Cod, Gadus morhua, Life History and Habitat Characteristics* (Rep. No. NMFS-NE-190). NOAA Technical Memorandum, NOAA, U.S. Department of Commerce.

12. Newfoundland and Labrador Refining Corporation (NLRC) (2007). *Environmental Impact Statement, Newfoundland and Labrador Refinery Project* (Rep. No. Environmental Impact Statement Volume 4, Socio-Economic Assessment Volume 2). NLRC.

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

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Atlantic cod spawning biomass in Placentia Bay Extension

Recreational cod fishery

Magnitude of Interaction

Areal extent:

- Cod in spawning condition are widely distributed in all areas of the bay with the exception of the deep central portion of the outer bay (see Fig. 1 below):

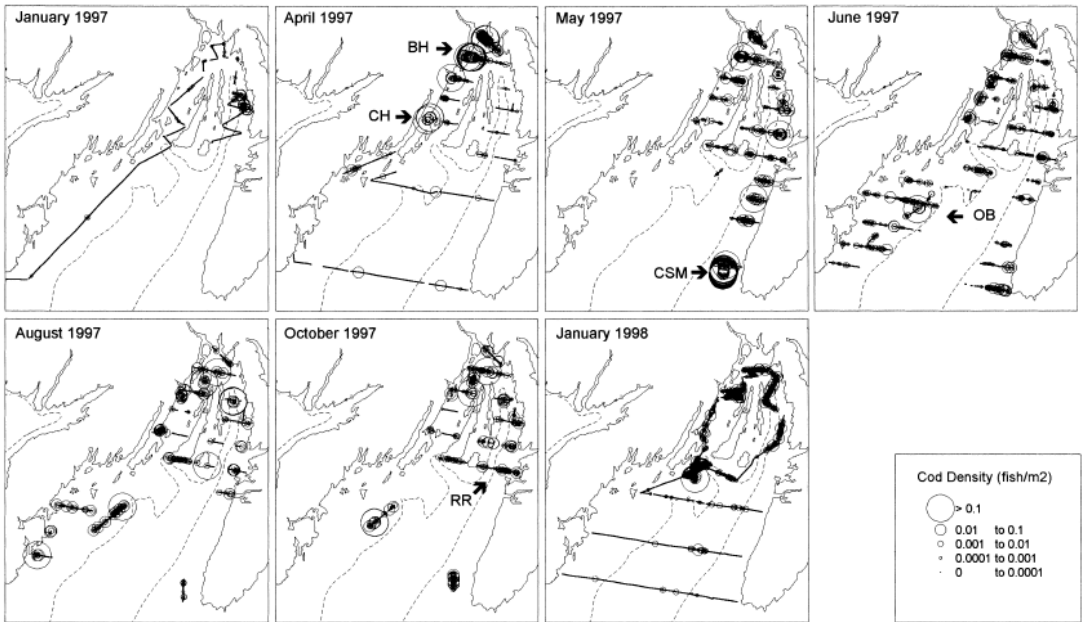


Figure 1. Cod density in Placentia Bay based on Acoustic Surveys (1997-1998) (Lawson, G. L. & Rose, G. A, 2000).

- Three key spawning grounds for cod have been identified at Bar Haven, Oderin Bank and Cape St. Mary's (Fig. 2 below) (Carew, A. M. E., 2001; Lawson, G. L. & Rose, G. A, 2000).

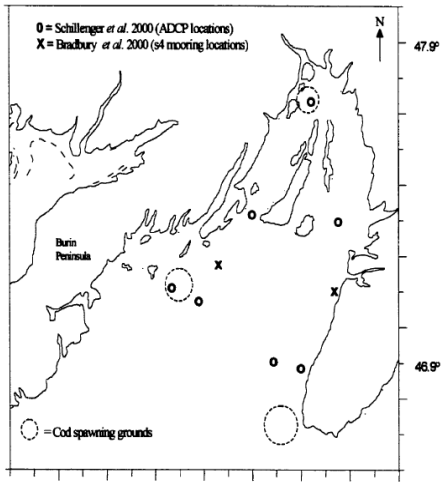


Figure 2. Locations of Cod Spawning grounds in Placentia Bay (Carew, A. M. E., 2001).

- Seasonal distribution and movements of cod in Placentia Bay in 1997, monitored using acoustic and tag and recapture surveys, found that cod tagged primarily on spawning grounds in Placentia Bay were recaptured mostly within the bay (87%), where fishing effort was high. Ten to 30%, mainly large fish, migrated long distances outside the bay during the spring and summer, but returned to the bay to spawn (Lawson, G. L. & Rose, G. A, 2000).
- The recreational fishery takes place inshore wherever cod can be found, but generally, close to shore. Fish are frequently located with electronic fish-finding devices by fishers, so the area of overlap with the CP is considered to be 100%.

Score 10

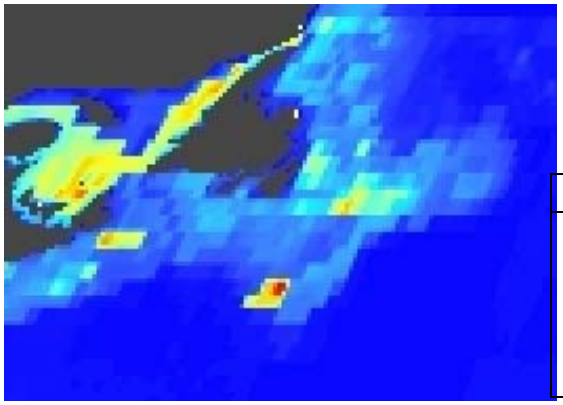
Contact:
- Only handline and angling gear is permitted. Handlines include baited hooks, feathered hooks and artificial lures. A maximum of three hooks per line may be used. The use of jiggers is prohibited.
- Since there is a directed recreational fishery for cod in Placentia Bay, we have given a score of 100%.

Score 10

Duration:
- The cod spawning biomass refers to the amount of Atlantic cod in the population at reproductive maturity, which may occur in Placentia Bay throughout the year. Timing of spawning is variable and extremely protracted, with spawning fish present from March until August in Placentia Bay.
- The recreational cod fishery is conducted in the fall, although dates are variable, the 2007 fishery was open for five weeks (35 days): July 25 to August 19 and September 29 to October 7.
- 35days/365 = 9.5%.

Score 1

Intensity:
- Halpern *et al.* (2008) have developed maps showing the global intensity of several anthropogenic stressors including a range of fisheries. These maps 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.
- Global maps for demersal non-destructive fisheries with low bycatch, which includes handlines, shows a medium-low (light blue) intensity for the EBSA and other coastal areas of the LOMA, relative to global levels for a score range of 20% to 40%.



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

Figure 3. Demersal, non-destructive, low bycatch (adapted from (Halpern, B. S. et al., 2008)

- Landings of cod in Placentia Bay in the recreational cod fishery were significant in 2007, with a total of 45,000 fish caught, but accounted for less than 6% of the total landings in the LOMA.
- Since landing were relatively low compared to other areas in the LOMA, but not the lowest (3 areas were lower), we have selected a score in the low end of the global range (20-40%).

Score 2.5

<u>Magnitude of Interaction</u>: (10 x 10 x 1 x 2.5)/ 1000 = 0.3

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- There is a directed harvest of the CP, resulting in a score of 9.
- Division 3Ps had the third highest landings in the LOMA, with 217.3 tonnes in 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

Figure 4. Estimated number and weight of cod caught, by NAFO sub-division of activity (BriLev Consulting Inc., 2008).

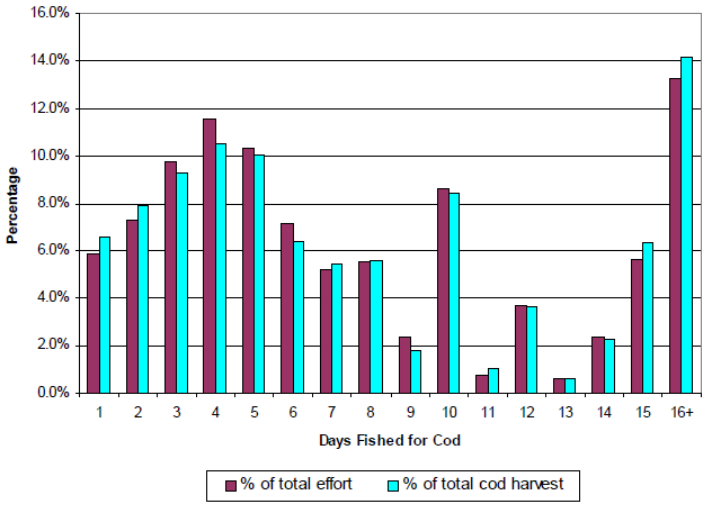


Figure 5. Distribution of total effort and total cod harvest for adult anglers in 2007, by days fished for cod (BriLev Consulting Inc., 2008).

Score 9

Sensitivity of the CP to chronic impacts:

- The Laurentian North population of Atlantic cod (includes Placentia Bay) was assessed by COSEWIC in 2003 and was designated *threatened***.** 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.
- Generation time is reportedly 11 years for Atlantic cod (Lough, R. G., 2004). Sexual maturity reached in females around 5-8 years, with males being slightly younger (Lear, W. H., 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. Cod are batch spawners, releasing eggs in batches over a period of weeks or months depending on their size (Scott, W. B. & Scott, M. G., 1988).
- Cod from this stock generally grow faster than those from areas further northward. Female cod from this stock are maturing at younger ages in recent years. For example, at least 30% of the females are mature by age 5 (~48 cm) in recent cohorts, compared to only about 10% at age 5 (~58 cm) among cohorts present in the 1970s-early 1980s (Fisheries and Oceans Canada, 2009).
- Cod landings taken specifically in Placentia Bay from the recreational fishery were estimated at 45,165 fish in 2007. If the average weight of a commercially caught cod is 4.5 kg (Scott, W. B. & Scott, M. G., 1988) this amounts to 203,243kg or ~203 tonnes, likely an over-estimate as the average size of a cod has probably decreased since 1988. This is significantly less than the 4,002t landed in commercial cod fisheries (largely gillnet) in the EBSA in 2007 (Fisheries and Oceans Canada, 2008) and is not likely to have significant long term impacts on the stock (score 3).
- Inshore components of the stock appear to be more stable than offshore components as both sentinel fishery indices and commercial catch rates are stable (Fisheries and Oceans Canada, 2009).

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

Score 4

Sensitivity of the ecosystem to harmful impacts to the CP:

- Coastal bays provide significant spawning, nursery and over-wintering habitat for Atlantic cod within the LOMA. 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, G. L. & Rose, G. A, 2000).
- Spawning cod represent a key life stage upon which the population depends. Bay stocks are relatively stable compared to offshore stocks, and are seen by many as a key component in the recovery of cod stocks within the LOMA as a whole.
- Cod have historically had a huge influence on the ecosystem, largely because of their abundance and broad distribution compared to other species and their significant 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 a low level, 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' (Rose, G. A., 2007). 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 an influential species in the ecosystem of the LOMA, and the Placentia Bay spawners support a significant portion of the population, we have given a score of 6.
- Atlantic cod are listed in the CP document as an 'ecologically significant species' (**add one point**).

Score 7

<u>Sensitivity:</u> (9 + 4 + 7)/ 3 = 6.7

<u>Risk of Harm:</u> MoI x S = 0.3 x 6.7 = 2

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?

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

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

2. Carew, A. M. E. (2001). *Oil Pollution and the Newfoundland and Labrador Fishery: Current and Potential Threats for the Conservation of Commercial Fisheries Resources in Placentia Bay.* Master of Marine Studies, Fisheries Resource Management The Marine Institute of Memorial University of Newfoundland.

3. COSEWIC (2003). *COSEWIC Assessment and Update Status Report on the Atlantic Cod Gadus morhua in Canada* Ottawa: Committee on the Status of Endangered Wildlife in Canada.

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

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

Atlantic cod spawning biomass in Placentia Bay Extension

Ghost nets (derelict fishing gear)

Magnitude of Interaction

Areal extent:

- Cod in spawning condition are widely distributed in all areas of the bay with the exception of the deep central portion of the outer bay (see Fig. 1 below):

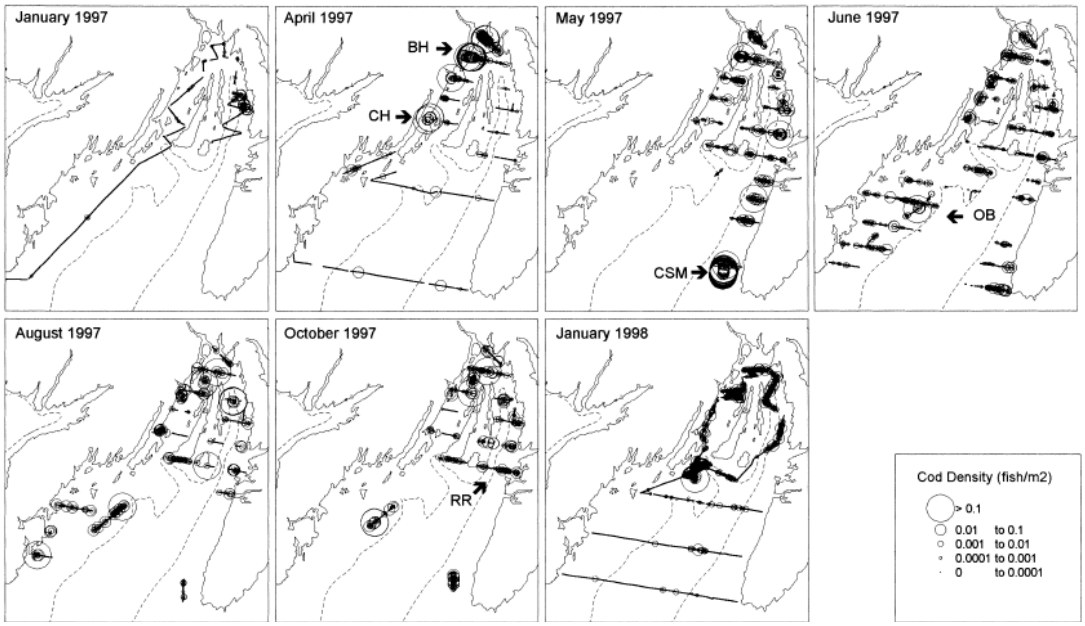


Figure 1. Cod density in Placentia Bay based on Acoustic Surveys (1997-1998) (Lawson, G. L. & Rose, G. A, 2000).

- Three key spawning grounds for cod have been identified at Bar Haven, Oderin Bank and Cape St. Mary's (Fig. 2 below) (Carew, A. M. E., 2001; Lawson, G. L. & Rose, G. A, 2000).

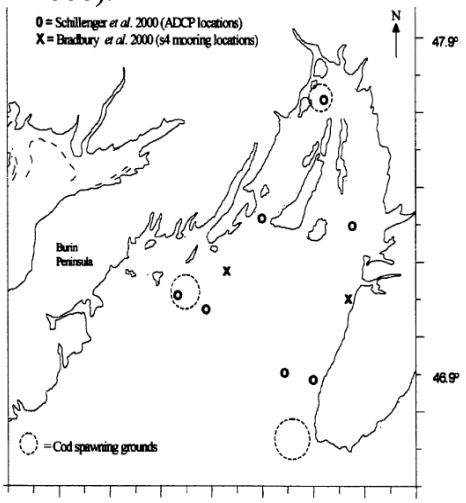


Figure 2. Locations of cod spawning grounds in Placentia Bay (Carew, A. M. E., 2001).

- Lost gillnets are thought to be most problematic in relation to goundfish. Over the past decade numerous programs have been initiated to retrieve ghost nets in Placentia Bay, usually focusing on the spawning area near Bar Haven and the head of the bay where much of the fishing activity is focused. Five nets were retrieved after 55 tows in 2001. Other programs have reported the retrieval of 60 nets with 30,000 lbs of cod and 43 nets with 25,000 lbs of cod (CBC News, 2000). Clearly, this retrieval rate indicates a significant problem with ghost nets in the area occupied by spawning cod.
- We have no comprehensive data on the number or distribution of ghost nets in Placentia Bay but given the dynamic environment, and the current and historical use of gillnets, we have assumed a broad distribution of lost nets throughout the commonly fished areas.
- Gillnet fisheries make up 62% of the total landings within the EBSA. Geo-referenced fishing locations are available for vessels over 35ft (Fig. 3 below) with major fisheries in Placentia Bay targeting cod, plaice and skate.

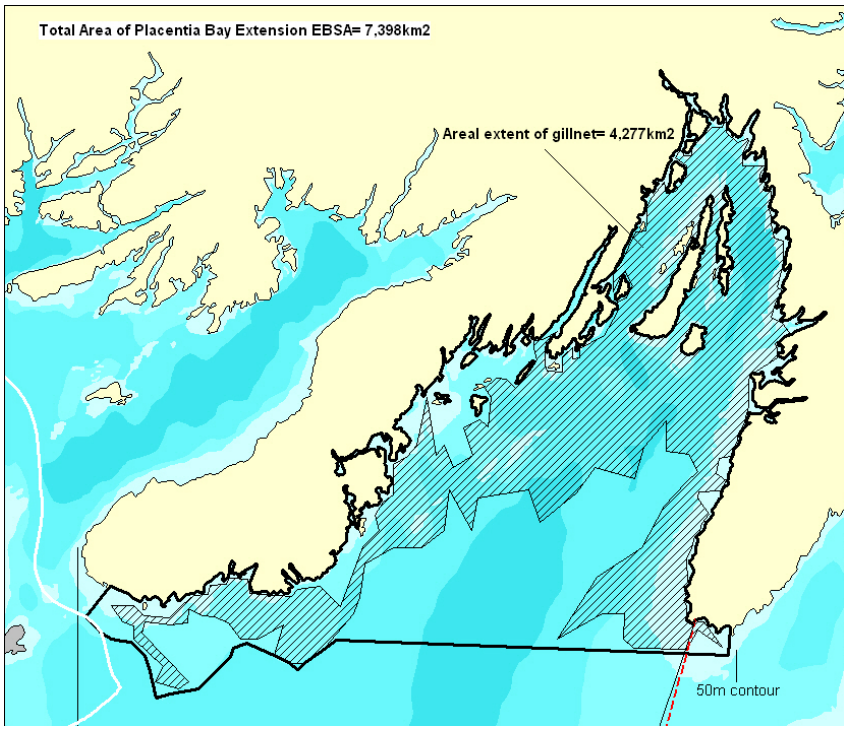


Figure 3. Areal extent of gillnet fisheries (vessels > 35ft), Newfoundland Region fisheries, 1998-2007 (Fisheries and Oceans Canada, 2008).

- Gillnet vessels over 35ft account for only 10% of the total landings in the EBSA from 1998-2007.
- There is also a significant inshore gillnet fishery, largely targeting cod, lumpfish and winter flounder, accounting for 52% of the total landings for the EBSA from 1998-2007. The distribution of these fisheries is shown on Fig. 4 below:

Figure 4. Distribution of lumpfish, winter flounder, and Atlantic cod gillnet fisheries in Placentia Bay from 1984-2000 (Community Resource Services Ltd & Jacques Whitford Environment Ltd, 2001).

- Based on this information we have estimated an area of overlap of 95%

Score 9.5

Contact:

- Lost nets may float freely in the water column, snag on a bottom feature with the free ends floating in the water column, or form a ball on the sea floor, with folds of netting moving with the motion of the water. These ghost nets appear to attract a range of marine species as they provide convenient but deadly structural habitat and a constant food supply for predators, scavengers and decomposers.
- Cod may be found throughout the water column, depending on the temperature, and contact with ghost nets is likely. Sixty ghost nets retrieved in Placentia Bay in the 1990s were found to contain 30,000 lbs of rotting cod, as well as other species (CBC News, 2000), therefore the score is in the low end of the high range.

Score 7.5

Duration:

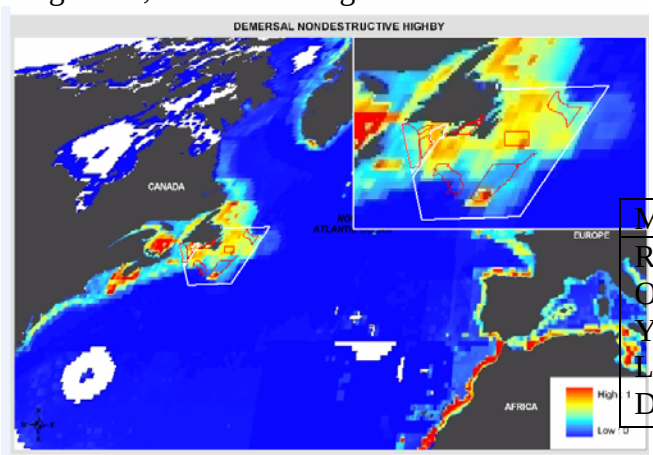
- Cod spawning biomass refers to the amount of Atlantic cod in the population at reproductive maturity, which may occur in Placentia Bay throughout the year. Timing of spawning is variable and extremely protracted, with spawning fish present from March until August in Placentia Bay.
- Since the 1960s, fishing nets have been constructed from highly durable plastic materials such as nylon, polypropylene and polyethylene, which do not biodegrade. When exposed to the sun for a period of years, photo-degradation will weaken these materials releasing fragments of plastic, 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 nets can continue to fish for weeks, or even years.

Score 10

Intensity:

- Since we have no comprehensive data on the density of ghost nets or the frequency of gear loss within the LOMA, we have based our intensity scores on data related to **sources**

- Halpern *et al.* (2008) have developed maps showing the global intensity of several anthropogenic stressors including a range of fisheries. These maps 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 map of demersal non-destructive fisheries with high bycatch, which include gillnets, is shown in Fig. 5 below.



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 with high bycatch, which include gillnets, adapted from (Halpern, B. S. et al., 2008).

- Gillnet fisheries account for 62% of the total landings in the EBSA, and historically, gillnets were the dominant gear used in Placentia Bay.
- Since the intensity of ghost nets is clearly lower than that of active nets, we have selected the lowest score within the range indicated for the EBSA.

Score 4

<u>Magnitude of Interaction :</u> (9.5 x 7.5 x 10 x 4)/ 1000 = 2.9

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- Derelict pots and hand lines 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 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.
- Some 10,000 vessels, mainly small boat, inshore operations, fished monofilament gillnets in Atlantic Canada prior to the northern cod moratorium. While it is difficult to quantify the amount of lost gear, studies suggest that some 8,000 active gillnets were lost on

average each year for a number of years up to 1992. In a survey of 100 Atlantic Canada gillnet fish harvesters (vessels under 65 feet), losses averaged 1-3 nets per fisher per year (Memorial University of Newfoundland & Fisheries and Oceans Canada, 1995).

- Although use of gillnets has declined since the moratorium, gillnets are still the most commonly used gear in Placentia Bay Extension, and are responsible for 62% of landings by weight in Placentia Bay over the period 1998-2007 (Appendix A, Table 17).
- Various ghost net retrieval programs have been conducted over the years, with retrieved nets commonly containing hundreds of pounds of dead fish, and other marine life (Welsh, C., 2001). In 2001, one such project in Placentia Bay recovered 60 nets that contained lumpfish, seal, redfish, flounder, lobster and 30,000 lbs of rotting cod (CBC News, 2000).
- Based on available data, impacts are considered significant, but relative to fishing mortality are likely low, for a score of 3. We have selected a high score in the low range.

Score 3

Sensitivity of the CP to chronic impacts:

- Since the 1960s, fishing nets, lines and pots have been constructed from highly durable plastic materials such as nylon, polypropylene and polyethylene, which do not biodegrade. As a result, lost nets can continue to fish for years.
- Although the use of gillnets in inshore areas such as Placentia Bay has declined, a recent survey of over 1,000 fish harvesters currently operating within Placentia Bay found that 67% of fish harvesters reported experiencing loss of gear (FFAW, 2007).
- Atlantic cod (Laurentian North) are listed as *threatened* by COSEWIC. The Status Report lists fishing (including legal, illegal and unreported catches) and fishing-induced changes to the ecosystem as key threats to cod recovery.
- Generation time is reportedly 11 years for Atlantic cod (Lough, R. G., 2004). Sexual maturity reached in females around 5-8 years, with males being slightly younger (Lear, W. H., 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. Cod are batch spawners, releasing eggs in batches over a period of weeks or months depending on their size (Scott, W. B. & Scott, M. G., 1988).
- 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. The long-term impacts are therefore considered to be moderate (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:

- Coastal bays provide significant spawning, nursery and over-wintering habitat for Atlantic cod within the LOMA. Since the collapse of the cod stocks in the early 1990s, much of the remaining biomass has been concentrated in coastal regions. Although cod

- Spawning cod represent a key life stage upon which the population depends. Bay stocks are relatively stable compared to offshore stocks, and are seen by many as a key component in the recovery of cod stocks within the LOMA as a whole.
- Cod have historically had a huge influence on the ecosystem, largely because of their abundance and broad distribution compared to other species and their significant 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 a low level, 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' (Rose, G. A., 2007). 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 an influential species in the ecosystem of the LOMA, and the Placentia Bay spawners support a significant portion of the population, we have given a score of 6.
- Atlantic cod are listed as an 'ecologically significant species'(Fisheries and Oceans Canada, 2007) (**add one point**).

Score 7

<u>Sensitivity:</u> (3 + 6 + 7)/ 3 = 5.3

<u>Risk of Harm:</u> MoI x S = 2.9 x 5.3 = 15.4

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?
N 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?
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?

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. Carew, A. M. E. (2001). *Oil Pollution and the Newfoundland and Labrador Fishery: Current and Potential Threats for the Conservation of Commercial Fisheries Resources in Placentia Bay.* Master of Marine Studies, Fisheries Resource Management The Marine Institute of Memorial University of Newfoundland.

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Summary Table: Atlantic cod spawning biomass in Placentia Bay Extension

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
Gillnets (bottom)	9.5	10	7.9	6	**4.5**	8	7	7	**7.3**	**32.9**	**Med**
Recreational cod fishery	10	10	1	2.5	**0.3**	9	4	7	**6.7**	**2.0**	**Med**
Ghost nets	9.5	7.5	10	4	**2.9**	3	6	7	**5.3**	**15.4**	**Low**
Cumulative CP Score										**50.3**	