Large Gorgonian corals (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	X		Industrial effluent	
	Clam dredges	X		Fishplant effluent	
	Midwater trawl			Sewage	
	Gillnets (bottom)	X		Historic military waste	
	Gillnets (pelagic)			Long range transport of nutrients	
	Longline	X		Acid rain	
	Seine (pelagic)			Persistent Organic Pollutants	
	Recreational cod fishery			Eutrophication	
	Crab pots	X		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	X
	Seaweed harvest			Current shifts	X
Seabed alteration	Anchor drops/drags	X		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	X		*Membranipora*	
	Cables	X		Golden Star Tunicate	
Coastal alteration	Freshwater diversion			Violet Tunicate	
	Subtidal construction			Vase Tunicate	
	Intertidal/coastal construction			*Codium fragile*	
				Clubbed Tunicate	
	Other (specify)			*Didemnum*	X
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

Large Gorgonian corals increase the complexity of benthic environments through their arboreal growth and robust skeletons; in turn, these structures can create habitat for other benthic organisms during some stages of their life history. By increasing the spatial and hydrodynamic complexity of habitats, deep-sea corals may provide important, but not obligate, habitat for a wide variety of species including fishes. A variety of sessile invertebrates may grow commensally on deep-sea corals. Hard substances may be limited in some areas, and large corals can make an important contribution towards creating and structuring deep-sea habitat, including habitat for other deep-sea corals (Wareham & Edinger, 2007). Deep-sea coral communities are high in biological diversity. Fishers report that areas with deep-sea corals are good fishing grounds. They may play important ecological roles in the lifecycles of many species associated with them, providing feeding sites, physical substrates for attachment and shelter from predators for invertebrates and fish, including both commercial and non-commercial species (Edinger et al., 2007a). Several commercially important species have also been found in association with Gorgonian corals. One such species is the Greenland halibut (Gass, 2003).

Twenty-eight species of corals occur in Atlantic Canada. In total, there were 13 alcyonaceans, two antipatharians, four solitary scleractinians and 11 pennatulaceans, with most species found deeper than 200m (Wareham & Edinger, 2007). Structure-forming Gorgonians are found in high concentrations in some areas of the Newfoundland offshore area (Templeman & Davis, 2006). The large, long-lived Gorgonians known to be present in Newfoundland and Labrador waters include *Primnoa resedaeformis* (Gunnerus, 1763), *Paragorgia arborea* (Linnaeus, 1758), *Keratoisis ornata* (Verrill, 1878), *Acanthogorgia armata* (Verrill, 1878), *Paramuricea grandis* (Verrill, 1884) and/or *Paramuricea placomus* (Linnaeus, 1758), and antipatharians: *Bathypathes arctica* (Lütken, 1871; two growth forms, which may represent separate species). Most large and small Gorgonians occurred in multiple species assemblages, and occurred within 168-1433m depth range (Edinger et al., 2007b). Wareham and Edinger (2007) found that the site with the highest coral species richness (10 coral species per set) in Newfoundland and Labrador waters occurred on the southwestern Grand Banks and was dominated by large Gorgonians, but had several species of pennatulaceans (Wareham & Edinger, 2007).

Gorgonian corals, called *horny corals*, build a calcium-protein skeleton (Gass, 2003). They have rigid to semi-flexible skeletons composed of calcium carbonate and/or protein, and can reach heights greater than 1m (Edinger et al., 2007a). Gorgonian corals generally grow in a plant-like fashion with slender branching stems protruding from a short main trunk fastened to the basal plate. Gorgonian colonies can branch either in one plane in a feathery manner or in all directions, resulting in a bushy shape. Both branching forms are seen in the Gorgonian species in Atlantic Canada. Areas with a relatively high abundance of these large Gorgonian corals are often referred to as a coral "forest" or "field," but these corals do not develop reefs (Gass, 2003). Hard substrates are believed to be important, especially to larger Gorgonian corals such as *Primnoa resedaeformis* and *Paragorgia arborea*; two species that are typically found attached to cobbles, boulders or bedrock (Wareham & Edinger, 2007). Large Gorgonian corals are long-lived (decades to hundreds of years) and have slow growth rates;

once corals have been damaged or destroyed, their recovery could take over 100 years (Gass, 2003).

Any activity or stressor that affects the height and structural complexity of coral habitat provided by large Gorgonian corals could potentially have a significant negative affect on other components in the ecosystem.

Coral distribution is strongly controlled by surficial geology. The Southwest Slope and Edge is identified by Edinger *et al.* (2007) as being an area of 'peak concentrations of coral density' (Edinger et al., 2007a). In addition, the southwest Grand Banks is identified as a region of 'relatively high coral species richness' and an area of aggregation for Gorgonian corals. The largest concentrations of Gorgonian coral are found between the 500 to 600m depths, but they can be found in depths ranging from 168 to 1433m (Wareham, 2007).

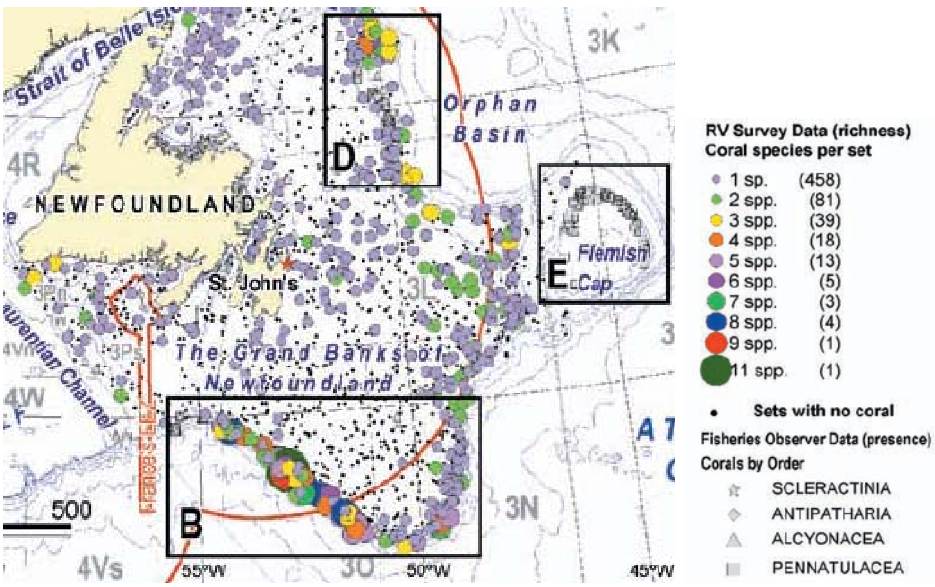


Figure 1. Coral species richness per set in scientific survey data, showing most species areas (Wareham & Edinger, 2007).

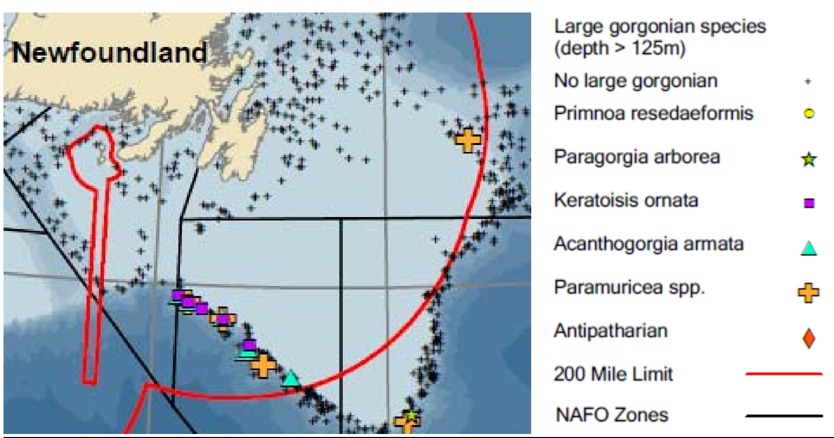


Figure 2. Large Gorgonian distribution, 2003-2005 (Edinger et al., 2007a).

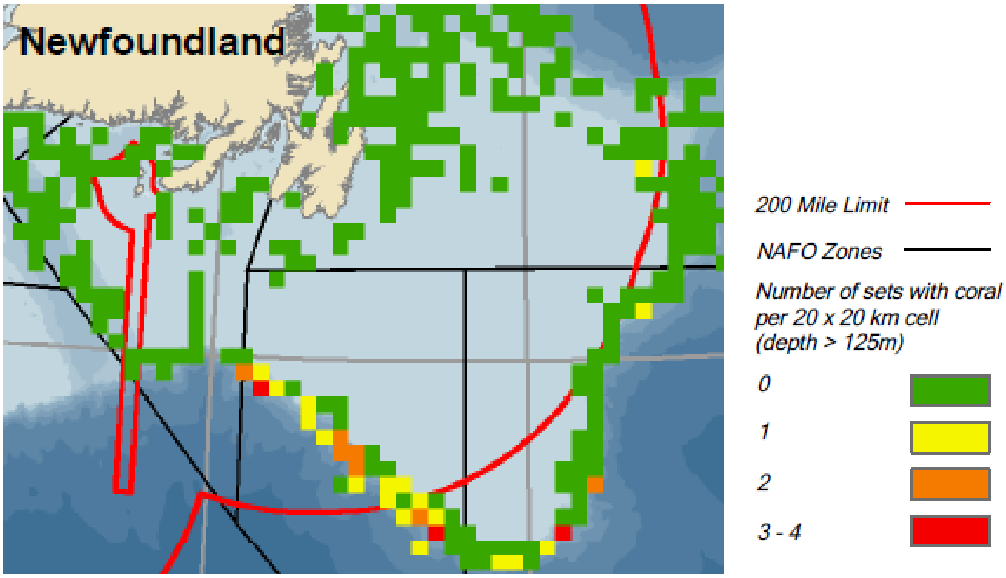


Figure 3. Large and small Gorgonian density, 2003-2005 (Edinger et al., 2007a).

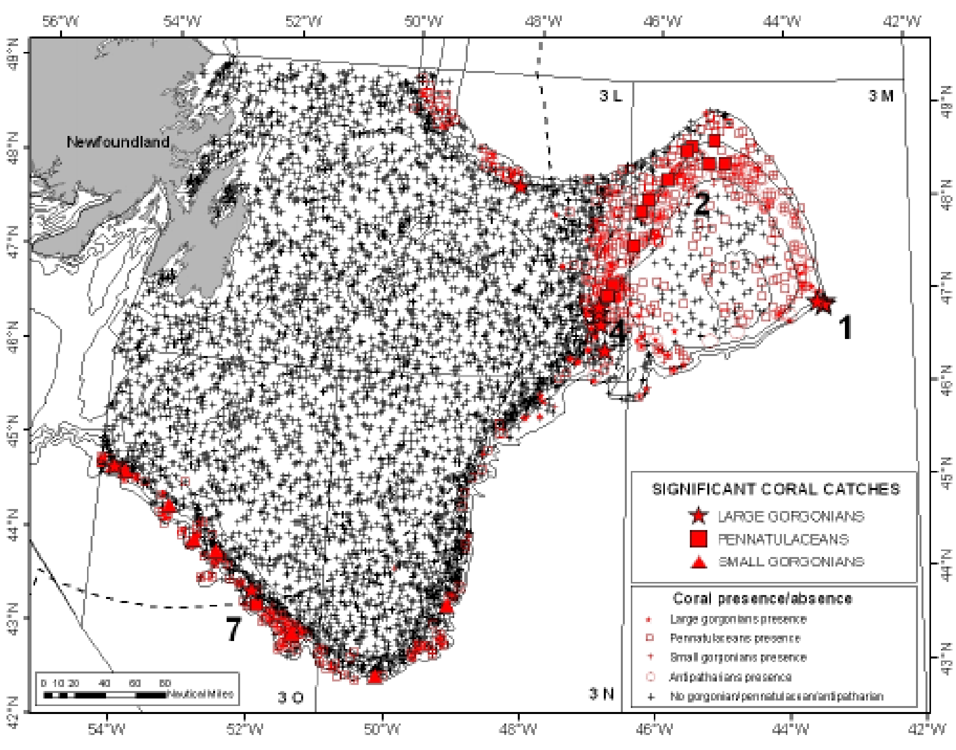


Fig. 2. Significant concentrations of coral taxa as determined from research vessel survey data. The numbers refer to the cVME area. As indicated in the figure itself, large (red) symbols indicate signficant concentrations while small ones denote presence of corals below significant catch levels.

Figure 4. Significant coral catches. Note: Large Gorgonian corals are indicated by a star symbol (NAFO, 2009).

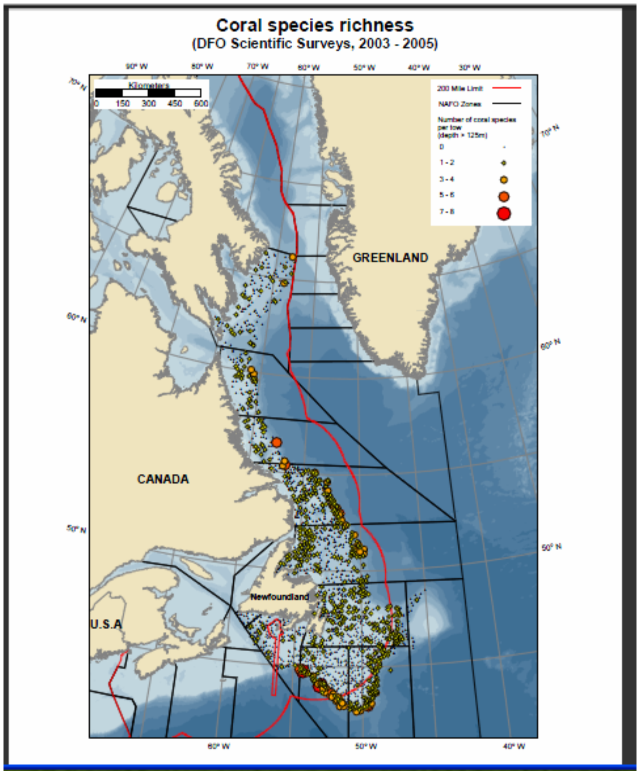


Figure 5. Coral species richness 2003-2005 (Edinger et al., 2007a).

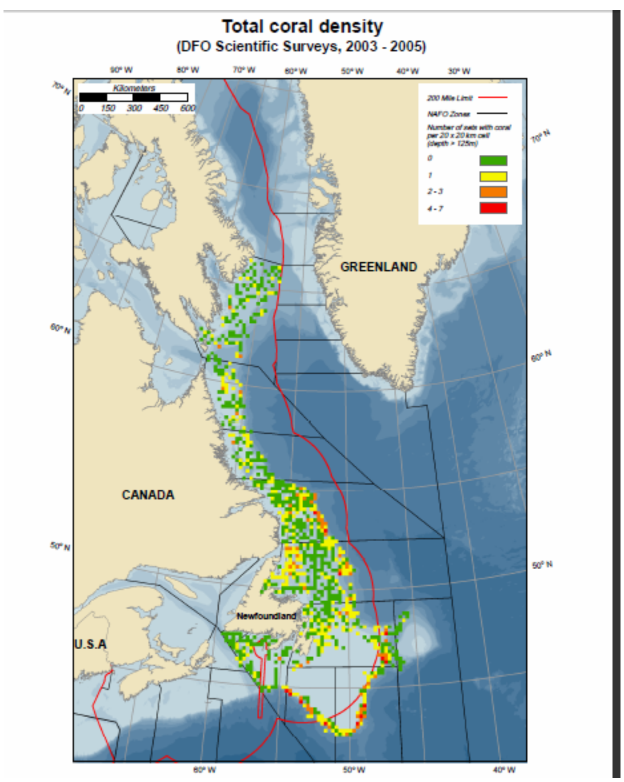


Figure 6. Total coral density 2003-2005 (Edinger et al., 2007a)

NOTE: Sept 29, 2007. The Northwest Atlantic Fisheries Organization closed a large area of the Grand Banks to all fishing activity involving bottom contact gear for the next five years in a bid to protect fragile coral formations in international waters. The ban on bottom contact gears is for depths between 800m and 2,000m, along a stretch of the seabed that extends from the Hudson Strait off Labrador to the Grand Banks off southern Newfoundland. These measures will be reviewed in 2012 by the Fisheries Commission, based on the advice from the Scientific Council and a decision shall be taken on future management measures. This closure encompasses a portion of the EBSA, but because it is only a temporary closure which may be reversed, it will not influence the score given for this activity-CP combination.

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).

The surface area of the ocean floor that a bottom trawl covers is significantly larger than that covered by a longline or gillnet, and as a mobile gear, it has a greater effect when it comes into contact with the ocean floor and corals. In the past, deep-sea corals may naturally have been protected from most trawling simply because they generally are found on rough bottom types not conducive to trawling, and because the corals themselves get caught in and foul the nets (Gass, 2003).

Mobile fishing gear negatively affects large gorgonian corals in several ways. Direct impact by fishing gear results damage or removal of corals, resulting in a reduction in overall physical complexity on the sea floor. Indirect effects of trawling include the physical alteration and removal of nonbiotic structures, such as boulders, causing loss of suitable substrate for coral colonization or recolonization by coral larvae. Deep-sea corals also are sensitive to increased sedimentation and, therefore, if the pass of a trawl does not physically remove them, the increased sediment load in the water column may hinder their physiology (Gass, 2003).

The relatively low average coral biomass per tow observed in some studies of the Newfoundland Region may result from habitat limitations on coral density, low coral catchability, or past damage to coral populations from several decades of intensive bottom trawling (Edinger et al., 2007a; Kulka & Pitcher, 2001). Of these, historical trawling damage may be the most likely explanation (Edinger et al., 2007b). Although coral distributions are unlikely to have changed due to trawling damage, coral abundance, and in particular the abundance of large corals, is likely to have been diminished. If large, long-lived corals have the greatest importance in structuring habitat and have been greatly reduced in frequency due to fisheries impacts, patterns of association between fishes and corals are likely to have been obscured (Edinger et al., 2007b).

Corals with carbonate skeletons are more sensitive than non-skeletal corals, because they cannot re-attach if they are dislodged. Sensitivity to disturbance is generally correlated with longevity. Large Gorgonian and antipatharian corals are the longest lived, with the least flexible skeletons, and are probably the set of species most sensitive to damage from fishing gear. The redfish fishery in the southwest Grand Banks recorded a high percentage of bycatch of large Gorgonian corals (Edinger et al., 2007a).

Fisheries targeting Atlantic cod (3Ps), Greenland halibut, skate, white hake, redfish and yellowtail flounder may occur in the PBGB LOMA using bottom trawl. DFO fisheries data from 1998-2007 (Fisheries and Oceans Canada, 2008) 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. Edinger et al. (2007) found that 16.1% of trawl sets (for all directed species) resulting in coral bycatch in their study of the Grand Banks (Edinger et al., 2007a). Wareham & Edinger found that otter trawl had the highest frequency of coral bycatch (n = 636) of all gear types (Wareham & Edinger, 2007) . **Screened in.**

Scallop dredge:
While dredges do have the potential to cause harm to corals, scallops are harvested mainly on St. Pierre Bank, where there are no large Gorgonian corals. Fisheries and Oceans Canada fisheries data from 1998-2007 show that dredges were responsible for 9% of landings by weight (72,570t) in the PBGB LOMA (Fisheries and Oceans Canada, 2008). **Screened out.**

Clam dredge:
While dredges do have the potential to cause harm to corals, Stimpson's surf clam is harvested mainly in depths of 50-100m, northwest of Carson Canyon on the Banks. Large Gorgonian corals are not found in that area. Fisheries and Oceans Canada fisheries data from 1998-2007 show that clams made up 7% of landings by weight (56,454 t) in the PBGB LOMA (Fisheries and Oceans Canada, 2008). **Screened out.**

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 200-500 nets that are 91m in length and are usually joined together (Appendix D, Table 5). This amounts to a maximum of 45.5km of net per license holder.

Corals with carbonate skeletons are more sensitive than non-skeletal corals, because they cannot re-attach if they are dislodged. Sensitivity to disturbance is generally correlated with longevity. Large Gorgonian and antipatharian corals are the longest lived, with the least flexible skeletons, and are probably the set of species most sensitive to damage from fishing gear. The redfish and monkfish fisheries caught high densities of coral along the southwest Grand Banks (Edinger et al., 2007a).

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 D, 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). 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., 2007a). 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 Northwest Atlantic 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. Gillnets are often used in areas of the LOMA where trawls cannot be used, commonly the areas where corals are found. Edinger *et al*. (2007) found that gillnets caught high densities of corals along the southwest Grand Banks, with 32.6% of gillnet sets (for all directed species) resulting in coral bycatch in their study of the Grand Banks (Edinger et al., 2007a). **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.

Corals with carbonate skeletons are more sensitive than non-skeletal corals, because they cannot re-attach if they are dislodged. Sensitivity to disturbance is generally correlated with longevity. Large Gorgonian and antipatharian corals are the longest lived, with the least flexible skeletons, and are probably the set of species most sensitive to damage from fishing gear.

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 (Fisheries and Oceans Canada, 2008). 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. The average depths fished with longline in the Newfoundland and Labrador region are 867m for Atlantic halibut and 1,070m for Greenland halibut (Wareham & Edinger, 2007). Longlines are commonly used on the shelf and at most depths along the shelf edge, where trawls cannot be used. This is commonly the areas where corals are found. Edinger *et al*. (2007) found that longlines caught high densities of corals along the southwest Grand Banks, with 24.3% of longline sets (for all directed species) resulting in coral bycatch in their study of the Grand Banks (Edinger et al., 2007a). **Screened in.**

Crab pots:
Landings of crab have been significant in the PBGB LOMA. From 1998-2007, crab landings ranged from 24,056t to 33,577t. Over the period 1998-2007, crab landings (by weight) in the LOMA amounted to 276,907t , which is 36% of total landings (Fisheries and Oceans Canada, 2008). Although crab pots can impact corals when set or hauled from the seafloor, they are harvested on the shallow shelf (limited coral distribution on the shelf) to a minimal degree. Edinger *et al.* (2007) did not find any crab pot sets with coral bycatch (Edinger et al., 2007a). **Screened out.**

Anchor drops/drags:
Although shipping does occur through the LOMA, vessels are not likely to drop anchor that far offshore where large Gorgonian corals are found. If an anchor was used, it would most likely occur on the shelf in more shallow water. **Screened out.**

Oil and gas drilling:
Oil and gas exploration and production drilling can negatively affect deep-sea corals by the placement of rigs and pipelines in coral areas and by the discharge of drilling mud and cuttings. Platform placement and pipeline building can damage corals by directly crushing them, by increasing sedimentation levels in the water column via the re-suspension of naturally occurring bottom sediments, and by altering essential currents and nutrient flows, resulting in less suitable habitat for corals. Drilling muds that do not contain drill cuttings have a fairly high density. Therefore, the reactions of corals to the muds could be caused by the increase in sedimentation due to the increase in particles in the water rather than by the potentially toxic chemicals present in the muds (Gass, 2003).

Exposure to disturbances, either physical or chemical, often results in the retraction of coral polyps. If these defence reactions persist for long periods of time because of continued exposure to a pollutant or physical disturbance, they can have various results: decreased nutrient assimilation and production, altered biochemical composition, depressed respiration and nitrogen excretion, partial or complete inhibition of growth and deposition of calcium carbonate skeleton, bacterial infection, and eventually death can result from chronic exposure to a pollutant. If enough drill cuttings are discharged to form piles, then any sessile, filter-feeding benthic organism, such as coral, will be smothered and killed (Gass, 2003).

The Canada-Newfoundland Offshore Petroleum Board has completed Strategic Environmental Assessments (SEA) for the Northeast Newfoundland Shelf, Western Newfoundland, Sydney Basin, Orphan Basin and the Labrador Shelf offshore areas. The preparation of a SEA for the Southern Newfoundland has begun. A SEA for the Laurentian Sub-basin was conducted in collaboration with the Canada-Nova Scotia Offshore Petroleum Board.

Since 1966, there have been over 200 wells drilled in offshore Newfoundland & Labrador, with approximately 129 of these drilled within areas 3L, 3N and 3O. The Figure below illustrates the approximate location of wells within these areas. There are three offshore oil production facilities all located within 3L: Hibernia, White Rose and Terra Nova oil fields.

The Atlantic Canada offshore (Grand Banks and Scotian Shelf) accounts for approximately 7% of Canada's total production (ORCA Inc., 2005).

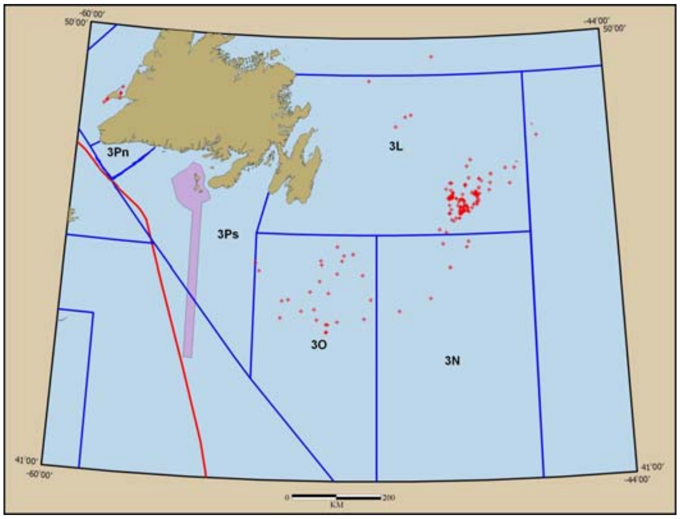


Figure 7. Location of wells drilled in offshore Newfoundland & Labrador including the Grand Banks (1966-2004) ((ORCA Inc., 2005) Figure 31).

The main area of large Gorgonian coral distribution is the Southwest Shelf Edge and Slope. The exploration licence for this area has expired. Gorgonian corals have also been identified within the Jeanne d'Arc Basin which is currently the main area of interest for oil and gas within the LOMA. **Screened in**.

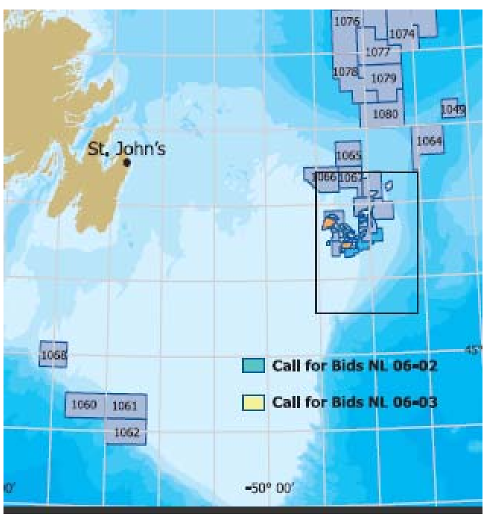


Figure 8. South Whale Basin, expired licence (CNLOPB, 2006).

Cables:
Plans for a fibre optic link from Newfoundland to Nova Scotia are underway, but the track of the cable will only cross the Laurentian Channel EBSA, an area with little evidence of large Gorgonian corals. No other cable projects exist at the current time. **Screened out.**

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. The Northwest Straits Commission estimated that there are nearly 3,900 gillnets remaining in Puget Sound from domestic salmon fisheries from the 1970s and 1980s. 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 (National Academy of Sciences, 2008).

Studies have shown that mobile gear has a greater impact than fixed gear and that the impacts on benthic habitats were a function of the degree of bottom contact and sediment penetration of the gear. Bottom trawling is the largest potential threat to deep coral habitat because the area of seafloor contacted per haul is relatively large, the forces on the seafloor from the trawl gear are substantial and the spatial distribution of bottom trawling is extensive. Fixed gear, such as bottom-set gillnets, bottom-set longlines, pots and traps all contact the benthos to some degree. Gillnets, traps, trawls and line fisheries are considered the most harmful in relation to derelict fishing gear (National Academy of Sciences, 2008). Bottom trawl is responsible for 22% of the landings in the LOMA, gillnets for 9% and longline for 2% over the period 1998-2007 (Fisheries and Oceans Canada, 2008).

Within the LOMA, gillnets are are restricted to a maximum of 91 metres in length, with 100 to 400 nets allowed per license, depending on the fisheries (Fisheries and Oceans Canada, 2008). This amounts to a maximum of 36.4km 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.

Edinger *et al.* (2007) found that coral bycatch frequencies were largely a function of fishing effort and the natural controls on coral distribution; there were not specific to any gear type (Edinger et al., 2007a). Therefore, all bottom gear types caused coral bycatch in areas of peak coral abundance.

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

Temperature change:
Coldwater-corals may be impacted in several important ways by ocean warming. Cold-water corals rely on zooplankton as their primary food source, but warmer water may reduce the availability of phytoplankton and zooplankton as prey items. Increased ocean temperatures may also lead to a change in the depths where carbonate is available in usable form, forcing coral populations to migrate or perish. Due to their slow growth and longevity, however, and with potentially serious consequences to population and species viability, cold-water corals are not predicted to be capable of rapid adaptation to changing conditions.

Drinkwater (UNEP & UNFCCC, 2002) predicts a temperature increase of 2-4^{o}C in Southern Newfoundland waters by 2100, based on IPCC 2001 models. This rise will likely not be linear, but is expected to accelerate over time, but even given the worst case scenario an increase in 0.4^{o}C is all we can expect over the next ten years. This change is not expected to significantly affect deep water habitats (>500m) where cold water corals predominate. This predicted rise in temperature may be balanced by a potential drop in temperature resulting from a reduced flow of the warm Gulf Stream Current and increased flow from the Labrador Currents as a result of increased ice melt. Temperatures in the deep water habitats occupied by the CP tend to be relatively stable and corals do not appear to be extremely sensitive to temperature change and are not expected to be significantly affected. **Screened out.**

Ocean acidification:
The global oceans represent earth's greatest natural carbon sink, holding more than 88% of all CO_2 on the planet and cycling a significant portion of human CO_2 emissions every year. The potential impacts of climate change on cold-water corals are not well understood, but over the next few centuries, ocean uptake of CO_2 and its acidifying reaction with seawater is expected to substantially decrease oceanic pH. Acidification results in a reduction in the availability of carbonate ions essential to calcifying organisms such as hard corals, and in extreme cases, may even corrode these organisms' skeletons (Campbell & Simms, 2009).

Hard corals (including large Gorgonians and antipatharian corals) create skeletons of calcium carbonate, usually in one of two forms, aragonite or calcite. Calcite is less soluble than aragonite and therefore less vulnerable to ocean acidification than skeletal structures formed of pure aragonite. Both calcite and aragonite structures also become more soluble with decreasing temperature and increasing pressure (depth). Across most of the ocean, under current conditions, calcite production cannot occur at depths less than 1.5 to 5km, while aragonite production is restricted to depths above 0.5 to 2.5km (The Royal Society, 2005). The depth to which aragonite or calcite is stable is known as the saturation horizon. Within the LOMA, hard corals have been found to occur at depths of 200-2200m (Wareham, 2007). If the aragonite saturation horizon rises 250m over the next ten years, hard corals living in the deepest areas may be impacted, and if the trend continues to progress, many coral species may be significantly impacted within decades.

The horny corals (Gorgonians) use calcite in combination with a horn-like structural protein called gorgonin. Since Large Gorgonian corals utilize the less sensitive form of calcium carbonate (calcite) in combination with a protein which is thought to be unaffected by increased acidity, ocean acidification is not considered to be a key stressor to the CP. **Screened out.**

Current shifts:
The flow of major ocean currents is driven by the sinking of super-cooled (heavy) water in specific areas of the ocean - as cold water sinks, warm water flows in to replace it, driving the large scale circulation of the ocean. Global warming is weakening this process. This weakening could cause changes in the currents over the next few years or decades. The exact effect and timing of such changes is hard to predict because currents and weather systems take years to respond and because there are other (unstudied) areas around the north Atlantic where water sinks, helping to maintain circulation. A decline in sub-polar circulation in the North Atlantic has been detected in recent years (Hakkinen & Rhines, 2004), potentially indicating a weakening of the Labrador Current. At the same time, rising temperatures leading to increased polar ice melt may at least temporarily increase the volume and decrease the salinity of the Labrador Current. The progress and consequences of these changes are difficult to forecast and research and monitoring are required to produce more informed predictions.

The Southwest Shelf Edge and Slope, a major coral hotspot within the LOMA, has bathymetric features which are considered good habitat for corals, because they are associated with strong currents that winnow away fine sediment, exposing harder substrates, and provide a reliable source of fine particulate organic matter for suspension feeding corals (Wareham & Edinger, 2007). Corals are thought to depend on zooplankton and organic matter, which is transported by currents or deposited by productivity at the sea surface above, and are expected to be affected by changes in both surface and deep water circulation. has Although current shifts have the potential to permanently impact this CP in the long term, they are unlikely to reach a level where the CP is seriously harmed within the next ten years, and so are not considered to be a key stressor to the CP. **Screened out.**

Didemnum:
This invasive tunicate is spreading rapidly in the George's Bank area, forming dense colonies which smother benthic organisms, but so far has not been detected in the LOMA. A major vector is scallop fishery which is not prosecuted in the area of the CP. **Screened out.**

<u>Key Activities/Stressors:</u>
- Bottom trawl
- Gillnets (bottom)
- Longline
- Oil and gas drilling
- Ghost nets

Reference List

1. Campbell, J. S. & Simms, J. M. Status Report on Coral and Sponge Conservation in Canada. *Oceans, Habitat and Species at Risk Report Series*, (in press).

2. CNLOPB (2006). *Canada-Newfoundland and Labrador Offshore Petroleum Board Annual Report 2005-2006*.

3. Edinger, E., Baker, K., Devillers, R., & Wareham, V. (2007a). *Coldwater Corals off Newfoundland and Labrador: Distribution and Fisheries Impacts* Halifax, Canada: World Wildlife Fund.

4. Edinger, E. N., Wareham, V. E., & Haedrich, R. L. (2007b). Patterns of groundfish diversity and abundance in relation to deep-sea coral distributions in Newfoundland and Labrador waters. *Bulletin of Marine Science, 81,* 101-122.

5. Fisheries and Oceans Canada (2006). *Impacts of trawl gears and scallop dredges on benthic habitats, populations and communities* (Rep. No. Science Advisory Report 2006/025). Canadian Science Advisory Secretariat, National Capital Region.

6. Fisheries and Oceans Canada. (2007). The Grand Banks of Newfoundland: Atlas of Human Activities. The Grand Banks of Newfoundland: Atlas of Human Activities . Fisheries and Oceans Canada.
   Ref Type: Map

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

8. Gass, S. E. (2003). *Conservation of Deep-Sea Corals in Atlantic Canada* Toronto: World Wildlife Fund.

9. Hakkinen, S. & Rhines, P. (2004). Decline of Subpolar North Atlantic Circulation During the 1990s. *Science, 304,* 555-559.

10. Kulka, D. W. & Pitcher, D. A. (2001). *Spatial and Temporal Patterns in Trawling Activity in the Canadian Atlantic and Pacific* (Rep. No. ICES CM 2001/R:02).

11. NAFO (2009). *Report of Scientific Council Meeting, 22-30 October 2008* (Rep. No. NAFO SCS Doc. 08/26).

12. National Academy of Sciences (2008). *Tackling Marine Debris in the 21st Century*.

13. ORCA Inc. (2005). *Grand Banks Environmental Overview Report: Part D - Human Use* Prepared for: Dr. Robert S. Gregory, Environmental Sciences Division, Fisheries and Oceans Canada, St. John's, NL.

14. Templeman, N. D. & Davis, M. B. (2006). *Placentia Bay-Grand Banks Ecosystem Overview and Assessment Report (DRAFT)* Newfoundland & Labrador: Fisheries and Oceans Canada.

15. The Royal Society (2005). *Ocean acidification due to increasing atmospheric carbon dioxide* (Rep. No. ISBN 0 85403 6172). Cardiff, UK: The Clyvedon Press Ltd.

16. UNEP & UNFCCC (2002). *Climate Change Information Kit* UNEP and UNFCCC.

17. Wareham, V. (2007). Research Technologist, Fisheries and Oceans Canada.
Ref Type: Personal Communication

18. Wareham, V. E. & Edinger, E. N. (2007). Distribution of deep-sea corals in the Newfoundland and Labrador region, Northwest Atlantic Ocean. *Bulletin of Marine Science, 81,* 289-313.

Large gorgonian corals (depleted or rare species) within the PBGB LOMA.

Bottom trawl

<u>Magnitude of Interaction</u>

Areal Extent:

- Within the LOMA, the SW Slope and Edge is considered a hot-spot for large gorgonian corals (Figure 1-3 below), with the largest concentrations found between the 500 to 600m depths. The tail of the Grand Banks, Laurentian Channel and Northeast Shelf also has gorgonian corals. (Wareham, 2007).

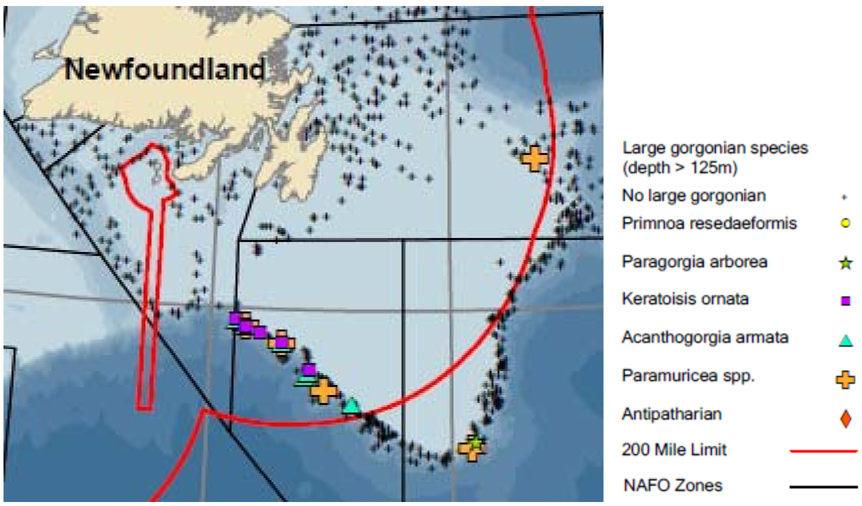


Figure 1. Distribution of large gorgonian corals in scientific surveys 2003-2005 (Edinger et al., 2007).

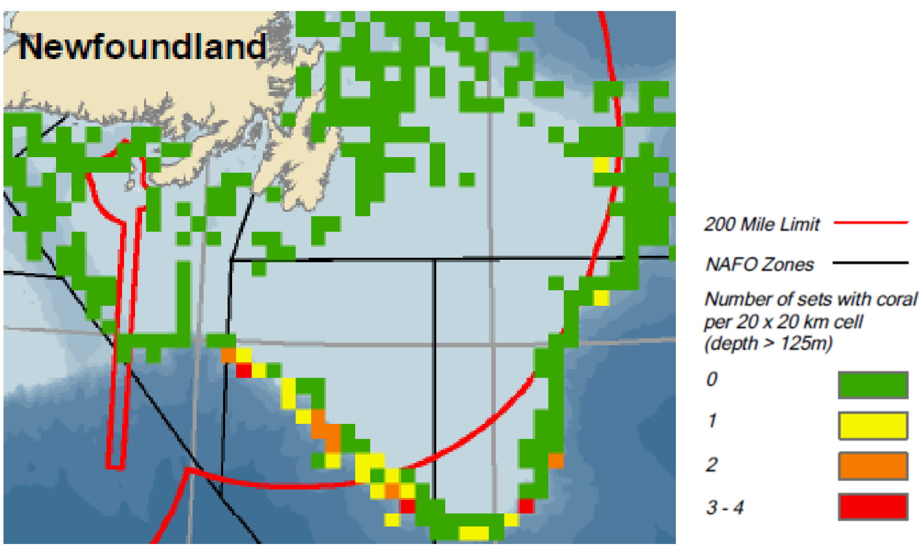


Figure 2. Large and small gorgonian density, 2003 – 2005 (Edinger et al., 2007).

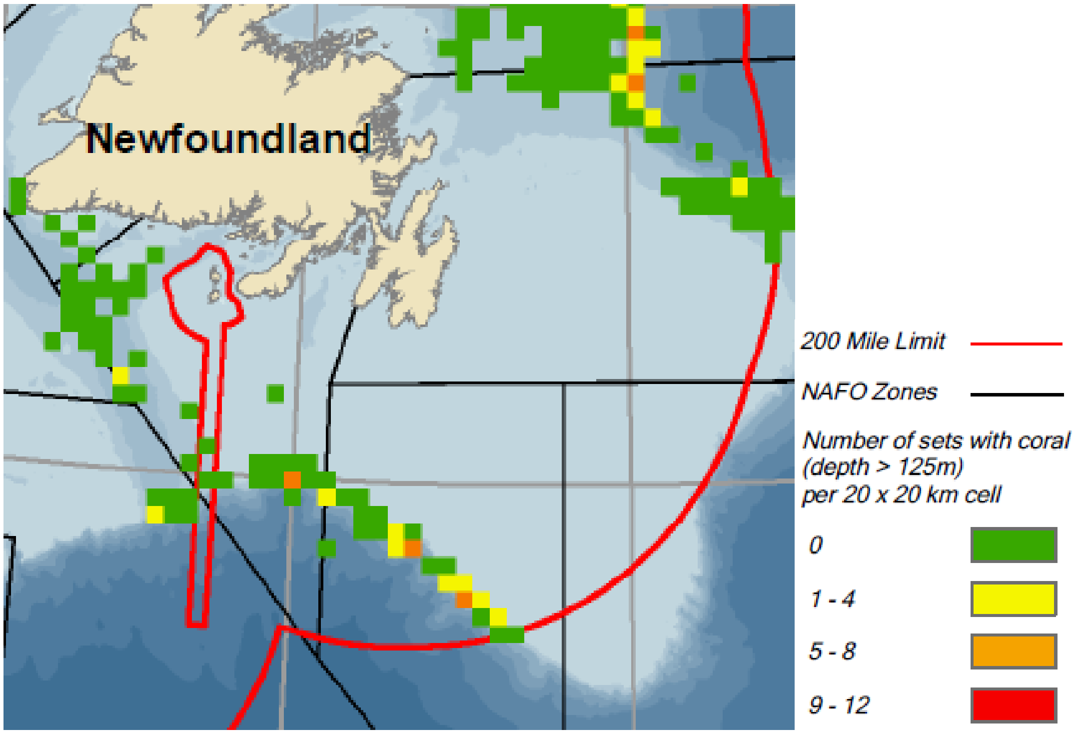


Figure 3. Large gorgonian bycatch (all fisheries, all trawl gears, 2004 & 2005) (Edinger et al., 2007).

- Figure 4 below shows Canadian trawling activity in the LOMA, while foreign fishing outside the 200 mile limit is shown in Figure 5.

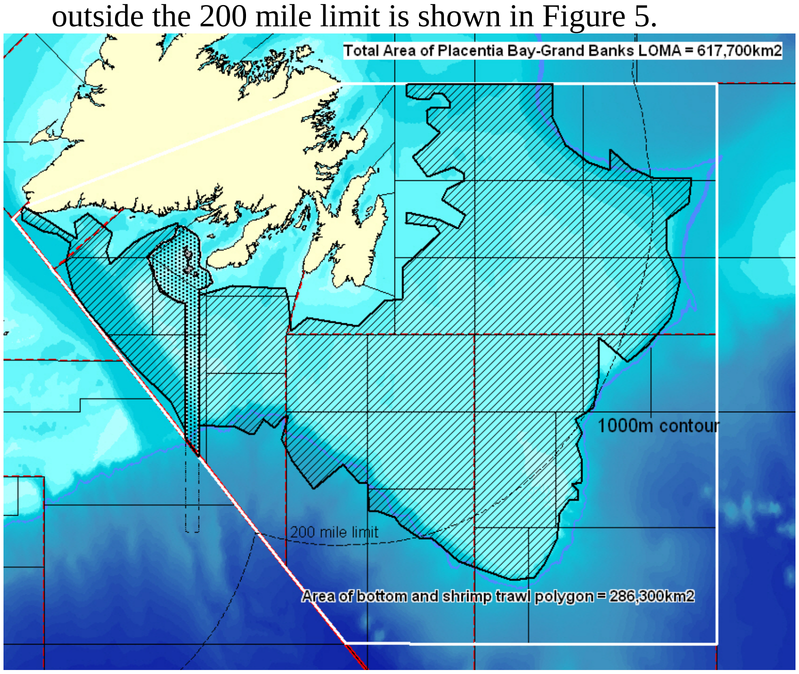


Figure 4. Areal extent of trawling, Newfoundland Region fisheries 1998 – 2007 (Fisheries and Oceans Canada, 2008).

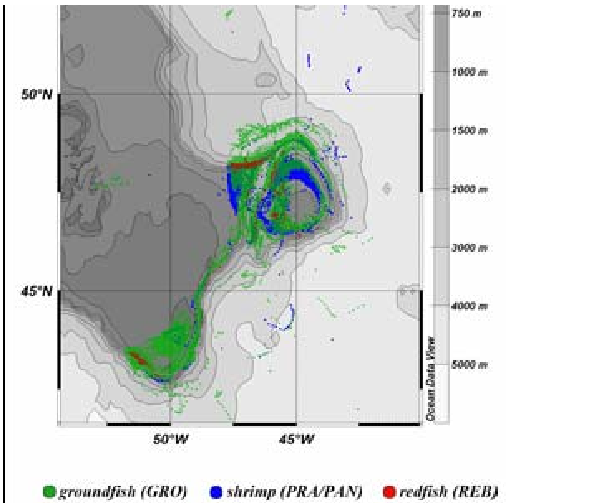


Figure 2B – ODV plot of VMS mid-positions for vessels fishing for groundfish, shrimp and redfish (*Sebastes mentella*) in 2006.

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

- Coral locations and trawling distribution are shown in Figure 6, and demonstrate a high area of overlap.

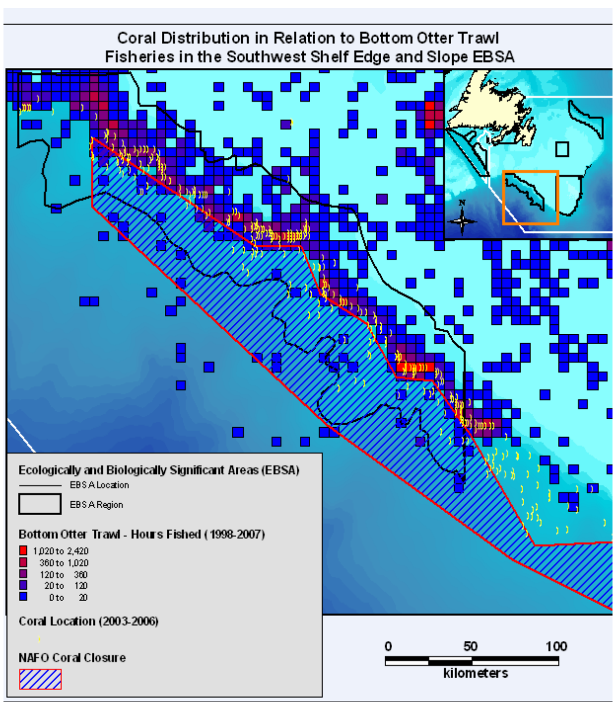


Figure 6. Coral locations (yellow) and trawling distribution (Fisheries and Oceans Canada, 2008).

- We have estimated the area of overlap at 85%.

Score 8.5

Contact:

- Fishing gear spread sheet "contact" scores for both hard and soft corals are high (75-100%). Taller, more rigid hard coral species such as gorgonian corals provide the most structural habitat and would have the highest likelihood of contact with trawls, and so are scored at the high end of the range (100%)(Fisheries and Oceans Canada, 2007).

Score 10

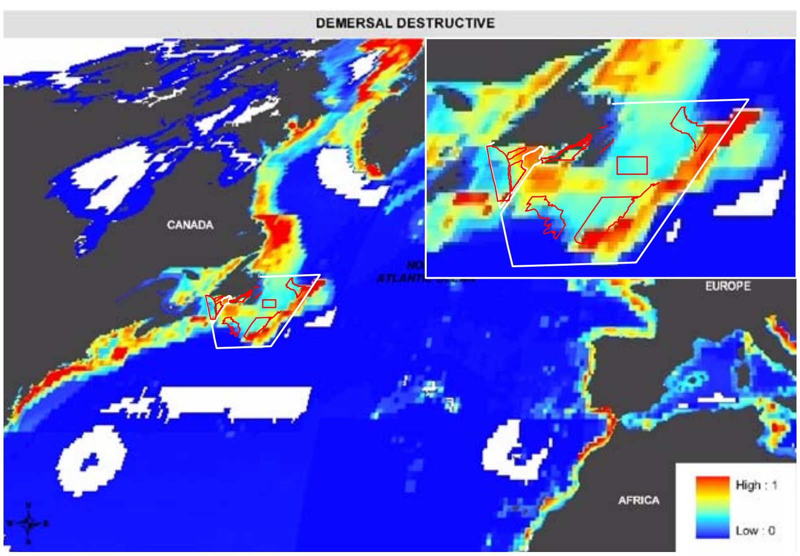
Duration:

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

Score 10

Intensity:

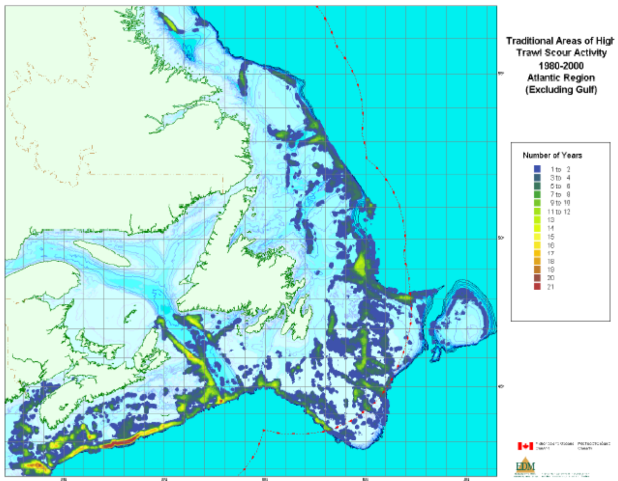
- Halpern *et al.* (2008) have developed maps showing the global intensity of several anthropogenic stressors including demersal destructive fishing, which includes bottom trawl fisheries (Figure 7 below). This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum (FAM, 2007) intensity in a global context in accordance with the scale provided below.
- Figure 7 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 fishing maps are based on (1999-2003) data, and best represent NAFO fisheries.



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

Figure 7. 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 8). Some locations within the LOMA are shown as being persistent areas of high intensity trawling (Kulka, 2006).



Maps depicting persistent areas of high intensity trawling in the Atlantic over the period 1980-2000, Gulf of St. Lawrence excluded

Figure 8. Areas of high intensity trawling in the Atlantic over the period 1980-2000 (Kulka & Pitcher, 2001).

- Bottom trawl is responsible for 22% of landings from 1998 – 2007 in the LOMA, for Newfoundland Region fisheries (Fisheries and Oceans Canada, 2008).
- Based on both global and local data, we have estimated an intensity of 90%.

Score 9

<u>Magnitude of Interaction</u>: (8.5 x 10 x 10 x 9)/1000 = 7.7

<u>Sensitivity</u>

Sensitivity of CP to Acute Impacts:

- Mobile bottom fishing gears result in direct mortality of corals as a result of breaking, crushing and burying. Large gorgonian corals that have carbonate skeletons are more sensitive than non-skeletal corals, because skeletal corals cannot re-attach if they are dislodged. Trawling also increases sedimentation which can be hazardous to corals, congesting polyps and inhibiting feeding processes (Edinger et al., 2007).
- Fishing Gear Quantitative Scores (Fisheries and Oceans Canada, 2007) "harm" category scores are high (75-100%) for hard corals.
- Wareham and Edinger (2007) analyzed coral bycatch data from the 'Fisheries Observer Program' and found that the otter trawl had the highest frequency of coral bycatch of all gear types (Wareham & Edinger, 2007).
- Sensitivity to disturbance is generally correlated with longevity. Large gorgonian corals are among the longest-lived, with the least flexible skeletons, and are probably the set of species most sensitive to damage from fishing gear. These species were aggregated at the edge of the southwest Grand Banks (Edinger et al., 2007).
- Trawling is likely to damage far more corals than just those that are recovered by the trawl. Most corals will be broken off but pass between the footgear and the base of the net, remaining broken on the seafloor. Indirect effects of trawling also include the

- The CP focuses on the large gorgonian coral which contribute to important structural habitat in the LOMA and are also among the most sensitive species to trawling damage.

Score 9

Sensitivity of CP to Chronic Impacts:

- Deep-sea corals are slow-growing and long-lived (Edinger et al., 2007). Due to low growth rates, anthropogenic impacts to corals include immediate physical damage with subsequent slow recovery rates, as well as the potential for secondary effects due to alterations in associated benthic and fish communities (Templeman & Davis, 2006). Growth rates of deep-sea corals are similar to growth rates of most massive, shallow water coral species which is estimated between 4.1mm to 25mm per year. Growth rates and life spans are particularly important when determining recovery rates for damaged coral colonies (Gass, 2003). Some of the coldwater corals are hundreds of years old and take decades to recover after being damaged (The Canadian Press, 2007). The deep-sea corals could sustain long-term damage through even limited contact with mobile bottom fishing gears (i.e., the first pass effect) (Gilkinson et al., 2006).
- Evidence of deleterious effects on deep-sea corals by mobile fishing gear (e.g. trawls) has been published in detail (Wareham & Edinger, 2007). Although the deep-sea coral clusters recognized by fishers have persisted despite a long history of intensive deep-water trawl fishing in the region (Kulka & Pitcher, 2001), there is little information on changes in abundances of deep-sea corals through time (Gass & Willison, 2005). Impacts on the CP are long lasting because of their slow growth rate, and chronic impact is considered high (8).
- Large gorgonian corals are listed as a depleted species. Add one point.

Score 9

Sensitivity of ecosystem to harmful impacts to the CP:

- The southwest Grand Banks exhibits peak areas of coral abundance and diversity, fish species richness and fishing effort (Edinger et al., 2007). Cold water corals and sponges provide some of the only biogenic structures in deep areas of the sea. Large gorgonian corals are tall, structurally complex species which contribute most to important structural habitat in the LOMA, and can provide protection from predation for other species among their branches.
- Given the apparent importance of cold-water corals as habitat for species of redfish, several of which, such as *Sebastes mentella* and *Sebastes marinus*, form straddling stocks in both the Northeast and Northwest Atlantic, as well as other commercially important species, bottom contact fisheries may well be impacting important habitat for straddling fish stocks in the region.
- Deep-sea coral communities are high in biological diversity. Fishers report that areas with deep-sea corals are good fishing grounds. They may play important ecological roles in the lifecycles of many species associated with them, providing feeding sites, physical substrates for attachment and shelter from predators for invertebrates and fish, including

- Any activity or stressor that affects the height and structural complexity of coral habitat provided by large Gorgonian corals could potentially have a significant negative affect on other components in the ecosystem.
- The CP is an important component of the deep sea ecosystem, providing structural habitat and increasing biodiversity and nutrient cycling (7.5)
- Corals are listed as providing 'structural habitat' in the CP document (**add one point**).

Score 8.5

<u>Sensitivity:</u> (9 + 9 + 8.5)/3 = 8.8

<u>Risk of Harm:</u> MoI x S = 7.7 x 8.8 = 67.8

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
$\geq$ 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?
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)?
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: 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. Campanis, G. (2007). *Information on Fishing Effort in the NRA for 2006* (Rep. No. NAFO SCR Doc. 07/48, Serial No. N5400). Northwest Atlantic Fisheries Organization.

2. Edinger, E., Baker, K., Devillers, R., & Wareham, V. (2007). *Coldwater Corals off Newfoundland and Labrador: Distribution and Fisheries Impacts* Halifax, Canada: World Wildlife Fund.

3. FAM (2007). *Conservation Harvesting Plan (CHP), Atlantic-wide for Mobile Gear Vessels 65-100', February 8, 2007 (unpublished)* Fisheries and Oceans Canada, Newfoundland & Labrador Region.

4. Fisheries and Oceans Canada (2007). Draft proceedings of the Workshop on Qualitative Risk Assessment of Fishing Gears. In Government of Canada.

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

6. Gass, S. E. (2003). *Conservation of Deep-Sea Corals in Atlantic Canada* Toronto: World Wildlife Fund.

7. Gass, S. E. & Willison, J. H. M. (2005). An assessment of the distribution of deep-sea corals in Atlantic Canada by using both scientific and local forms of knowledge. In *Cold-Water Corals and Ecosystems* (pp. 223-245). Springer Berlin Heidelberg.

8. Gilkinson, K., Dawe, E., Forward, B., Hickey, B., Kulka, D., & Walsh, S. (2006). *A Review of Newfoundland and Labrador Region Research on the Effects of Mobile Fishing Gear on Benthic Habitat and Communities* (Rep. No. Research Document 2006/055). Canadian Science Advisory Secretariat, Fisheries and Oceans Canada.

9. Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C. et al. (2008). A Global Map of Human Impact on Marine Ecosystems. *Science, 319,* 948-952.

10. Kulka, D. W. (2006). *Abundance and Distribution of Demersal Sharks on the Grand Banks with Particular Reference to the NAFO Regulatory Area* (Rep. No. 06/20).

11. Kulka, D. W. & Pitcher, D. A. (2001). *Spatial and Temporal Patterns in Trawling Activity in the Canadian Atlantic and Pacific* (Rep. No. ICES CM 2001/R:02).

12. Templeman, N. D. & Davis, M. B. (2006). *Placentia Bay-Grand Banks Ecosystem Overview and Assessment Report (DRAFT)* Newfoundland & Labrador: Fisheries and Oceans Canada.

13. The Canadian Press (2007). NAFO bans bottom trawling on Grand Banks for five years to protect coral. http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html [On-line]. Available: http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html

14. Wareham, V. (2007). Research Technologist, Fisheries and Oceans Canada. Ref Type: Personal Communication

15. Wareham, V. E. & Edinger, E. N. (2007). Distribution of deep-sea corals in the Newfoundland and Labrador region, Northwest Atlantic Ocean. *Bulletin of Marine Science, 81*, 289-313.

Large Gorgonian corals (depleted or rare species) within the PBGB LOMA.

Gillnets (bottom)

<u>Magnitude of Interaction</u>

Areal extent:

- Corals and sponges within the LOMA are largely concentrated in deeper waters along the slope and edge of the shelf.
- The Lily Canyon and Carson Canyon area is a hot-spot for large sponges.
- Concentrations of both corals and sponges are found along the SW Slope and Edge, Laurentian Channel, Burgeo Bank and northeast edge of the Grand Banks including the Bonavista Corridor and Northeast Shelf EBSA (see figures 1-3 below).

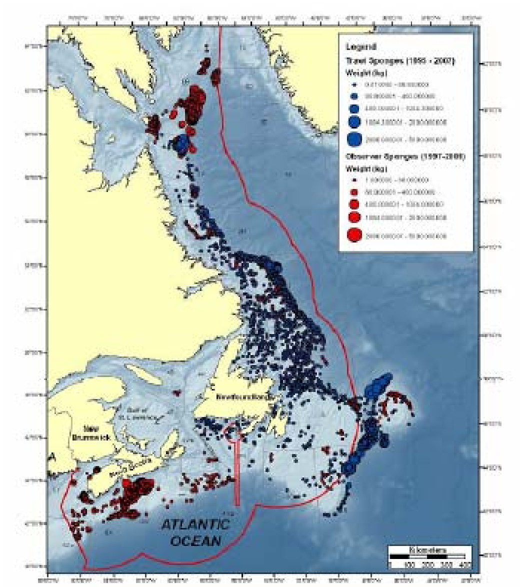


Figure 1. Sponge Distribution in the NAFO Area, Canadian Trawl Survey data 1995 – 2007 and Maritime Fisheries Observer data (Northwest Atlantic Fisheries Organization, 2010)

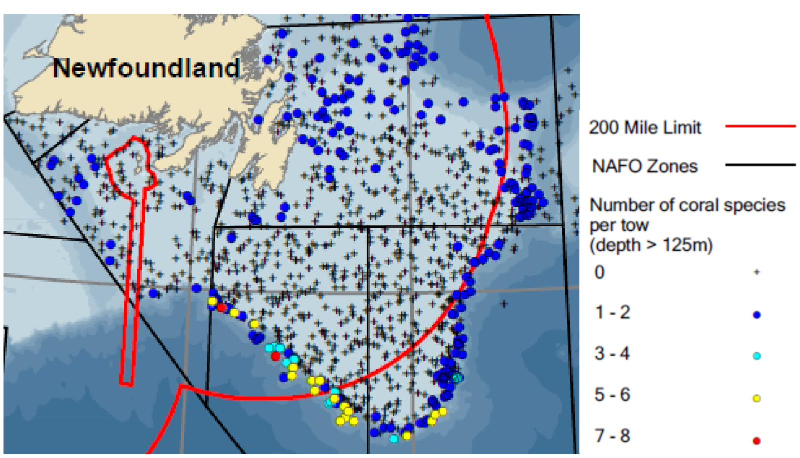


Figure 2. Coral species richness 2003 – 2005 (Edinger et al., 2007).

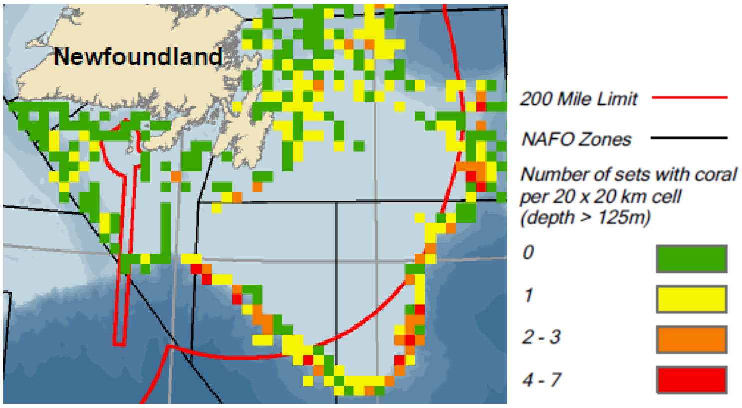


Figure 3. Total coral density, 2003 – 2005 (Edinger et al., 2007).

- Bottom gillnet fisheries occur throughout the inshore and much of offshore areas of the LOMA, particularly along St. Pierre Bank, southwest slope and edge, and northeast slope of the Grand Banks. The map below shows the approximate distribution of bottom gillnet fishing activity from 1998 to 2007 by Newfoundland Region fisheries.

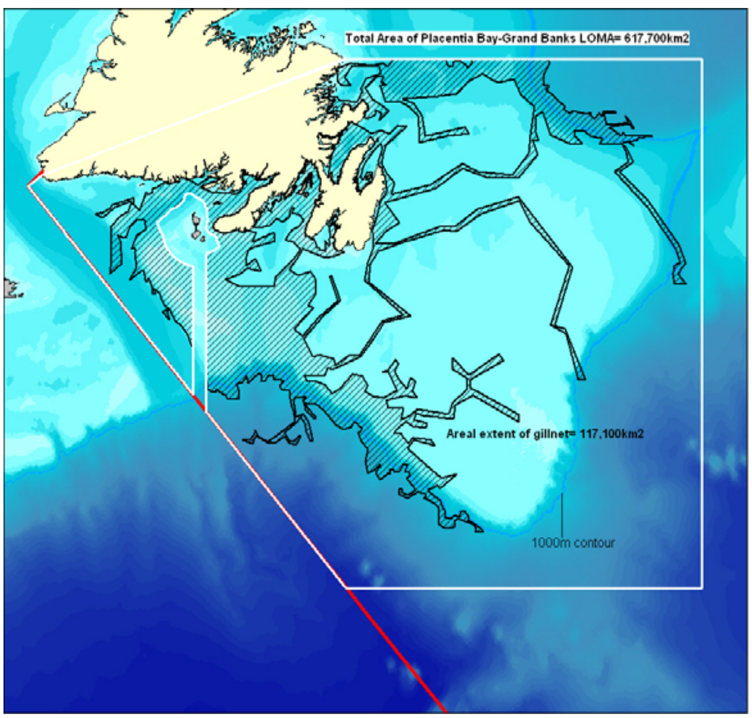


Figure 4. Areal extent of gillnet use in the PBGB LOMA, 1998 - 2007 (Fisheries and Oceans Canada, 2008)

- The gillnet fishery is concentrated in the area of the St. Pierre Bank and the Southwest Shelf Edge and Slope.
- The Southwest Shelf Edge and Slope is considered a hot-spot for corals and particularly large Gorgonian species.

- Although most research has been focused on inshore waters, a number of factors indicate that the loss of nets 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).
- Area of overlap is estimated at 75%, and includes the areas of highest large Gorgonian concentrations.

Score 7.5

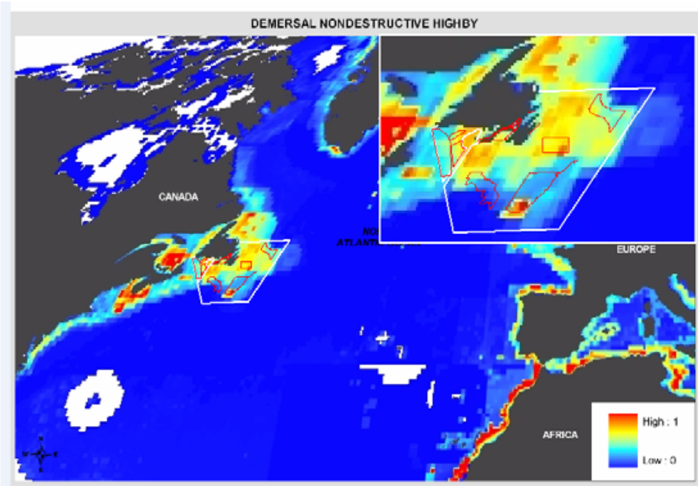
Contact:
- Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007) for "contact" are low (<25%) for hard corals, and medium (25-75%) for soft corals.
- Large Gorgonian corals are large and long-lived, with the least flexible skeletons, and hence probably the set of species most sensitive to damage from fishing gear.
- Since these species are tall and often highly branched, contact with gillnets is considered to be more likely than with lower, flatter species.
- Based on expert advice (Wareham, 2007) we have deviated slightly from the Quantitative Fishing Gear Scores for hard corals, and scored this factor in the medium range.

Score 5.5

Duration:
- Bottom gillnet fishing is open within the LOMA for one or more fisheries all year round (100% of the time).

Score 10

Intensity:
- Halpern *et al.* (2008) have developed maps showing the global intensity of several anthropogenic stressors including 'demersal non-destructive fishing with high bycatch', which includes bottom gillnet fisheries (see Figure 5 below). This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum intensity in a global context in accordance with the scale provided below
- Figure 5 shows a medium (yellow) intensity relative to global levels for a score range of 40% to 60% for the LOMA, but a lower score of 1-20% for the SW Slope and Edge (coral hot spot). Halpern's fishing maps are based on data from 1999-2003, and better represent NAFO fisheries, which are notoriously variable year to year, than Canadian fisheries, and are not as spatially precise on a local scale, as Fisheries and Oceans fisheries data.



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)).

- Canadian gillnet fisheries within the PBGB LOMA represented an average of 9% of the landings from 1998-2007, but were focused on the SW Slope and Edge (coral hot spot), where they made up 30% of the total landings (Fisheries and Oceans Canada, 2008).
- We have therefore selected a score in the moderate range.

Score 5

<u>Magnitude of Interaction</u>: (7.5 x 5.5 x 10 x 5)/1000 = 2.1

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- Fishing Gear Quantitative Scores (Fisheries and Oceans Canada, 2007) for "harm" between groundfish and gillnets are moderate for both soft and hard corals.
- Wareham and Edinger (2007) analyzed coral bycatch data from the 'Fisheries Observer Program' and found that bottom gillnets had significant bycatch of corals and sponges, particularly in area with high coral abundance (Wareham & Edinger, 2007).
- Lost nets eventually end up on the bottom, snagging on bottom features such as corals, or sinking as they are weighed down by captured fish, and may form heavy balls.
- Lost gillnets are likely to damage and dislodge corals which become entangled, with the tall, structurally complex gorgonian species most vulnerable. In storms heavy balls of netting may roll along the bottom damaging fragile habitats in a localized area, but are not likely to crush or bury large coral populations, so we have selected a score in the medium range.
- Sensitivity to disturbance is generally correlated with longevity. Large Gorgonian and antipatharian corals are the longest-lived, with the least flexible skeletons, and are probably the set of species most sensitive to damage from fishing gear. These species were aggregated at the edge of the southwest Grand Banks (Edinger et al., 2007).
- The CP focuses on the large Gorgonian corals which contribute to important structural habitat in the LOMA and are also among the most sensitive species to trawling damage.

Score 5

Sensitivity of the CP to chronic impacts:

- Deep-sea corals are slow growing and long-lived (Edinger et al., 2007). Growth rates of deep-sea corals are similar to growth rates of most massive, shallow water coral species which are estimated between 4.1mm to 25mm per year. Growth rates and life spans are particularly important when determining recovery rates for damaged coral colonies (Gass, 2003). Some of the coldwater-corals are hundreds of years old and take decades to recover after being damaged (The Canadian Press, 2007).
- Damage is considered moderate and long lasting for a score of 5.
- Gorgonian corals are on the list of depleted species (**add one point**).

Score 6

Sensitivity of ecosystem to harmful impacts to the CP:

- The southwest Grand Banks exhibits peak areas of coral abundance and diversity, fish species richness and fishing effort (Edinger et al., 2007). Cold water corals and sponges provide some of the only biogenic structures in deep areas of the sea. Large gorgonian corals are tall, structurally complex species which contribute most to important structural habitat in the LOMA, and can provide protection from predation for other species among their branches.
- Given the apparent importance of cold-water corals as habitat for species of redfish, several of which, such as *Sebastes mentella* and *Sebastes marinus*, form straddling stocks in both the Northeast and Northwest Atlantic, as well as other commercially important species, bottom contact fisheries may well be impacting important habitat for straddling fish stocks in the region.
- Deep-sea coral communities are high in biological diversity. Fishers report that areas with deep-sea corals are good fishing grounds. They may play important ecological roles in the lifecycles of many species associated with them, providing feeding sites, physical substrates for attachment and shelter from predators for invertebrates and fish, including both commercial and non-commercial species (Edinger et al., 2007). Several commercially important species have also been found in association with Gorgonian corals. One such species is the Greenland halibut (Gass, 2003).
- Any activity or stressor that affects the height and structural complexity of coral habitat provided by large Gorgonian corals could potentially have a significant negative affect on other components in the ecosystem.
- The CP is an important component of the deep sea ecosystem, providing structural habitat and increasing biodiversity and nutrient cycling (7.5)
- Corals are listed as providing ‘structural habitat’ in the CP document (**add one point**).

Score 8.5

<u>Sensitivity:</u> (5 + 6 + 8.5)/3 = 6.5

<u>Risk of Harm:</u> MoI x S = 2.1 x 6.5 = 13.7

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
$\geq$ 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

1. Edinger, E., Baker, K., Devillers, R., & Wareham, V. (2007). *Coldwater Corals off Newfoundland and Labrador: Distribution and Fisheries Impacts* Halifax, Canada: World Wildlife Fund.

2. Erzini, K., Monteiro, C., Ribeiro, J., Santos, M., Gaspar, M., Monteiro, P. et al. (1997). An experimental study of gillnet and trammel net 'ghost fishing' off the Algarve (southern Portugal). *Marine Ecology Progress Series, 158,* 257-265.

3. Fisheries and Oceans Canada (2007). Draft proceedings of the Workshop on Qualitative Risk Assessment of Fishing Gears. In Government of Canada.

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

5. Gass, S. E. (2003). *Conservation of Deep-Sea Corals in Atlantic Canada* Toronto: World Wildlife Fund.

6. Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C. et al. (2008). A Global Map of Human Impact on Marine Ecosystems. *Science, 319,* 948-952.

7. Hareide, N.-R., Garnes, G., Rihan, D., Mulligan, M., Tyndall, P., Clark, M. et al. (2005). *A preliminary Investigation on Shelf Edge and Deepwater Fixed Net Fisheries to the West and North of Great Britain, Ireland, around Rockall and Hatton Bank*.

8. Northwest Atlantic Fisheries Organization (2010). *Report of the NAFO Scientific Council Working Group on Ecosystem Approach to Fisheries Management (WGEAFM)* (Rep. No. Serial No. N5511).

9. The Canadian Press (2007). NAFO bans bottom trawling on Grand Banks for five years to protect coral. http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html [On-line]. Available: http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html

10. Wareham, V. (2007). Research Technologist, Fisheries and Oceans Canada.
    Ref Type: Personal Communication

11. Wareham, V. E. & Edinger, E. N. (2007). Distribution of deep-sea corals in the Newfoundland and Labrador region, Northwest Atlantic Ocean. *Bulletin of Marine Science, 81,* 289-313.

Large Gorgonian corals (depleted or rare species) within the PBGB LOMA.

Longline

Magnitude of Interaction

Areal extent:

- Within the LOMA, the SW Slope and Edge is considered a hot-spot for large Gorgonian corals (see Figures 1-3 below), with the largest concentrations found between the 500 to 600m depths. The tail of the Grand Banks, Laurentian Channel and Northeast Shelf also have Gorgonian corals (Wareham, 2007).

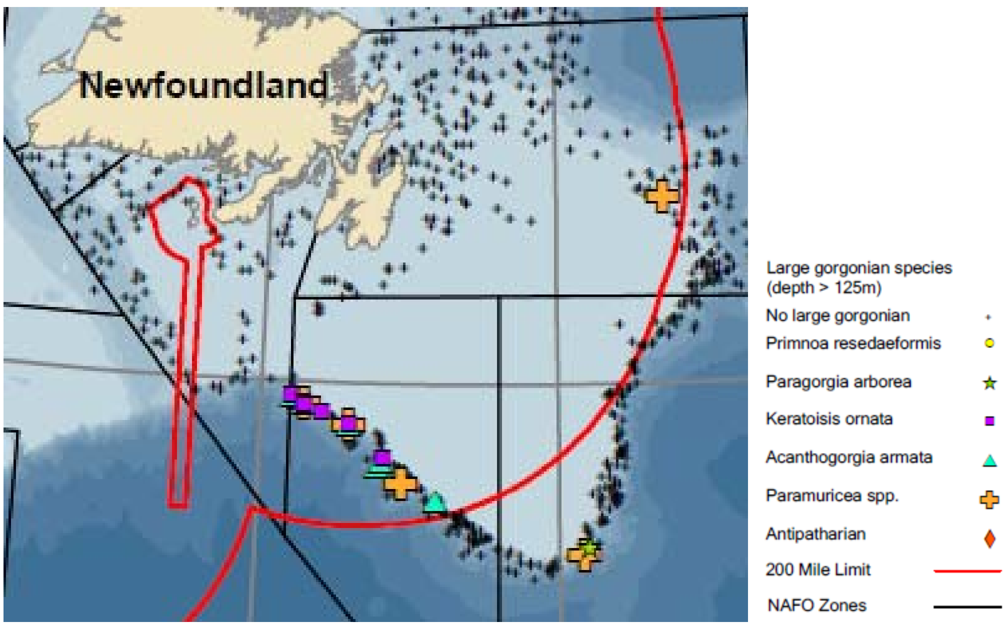


Figure 1. Distribution of large Gorgonian corals in scientific surveys 2003-2005 (Edinger et al., 2007).

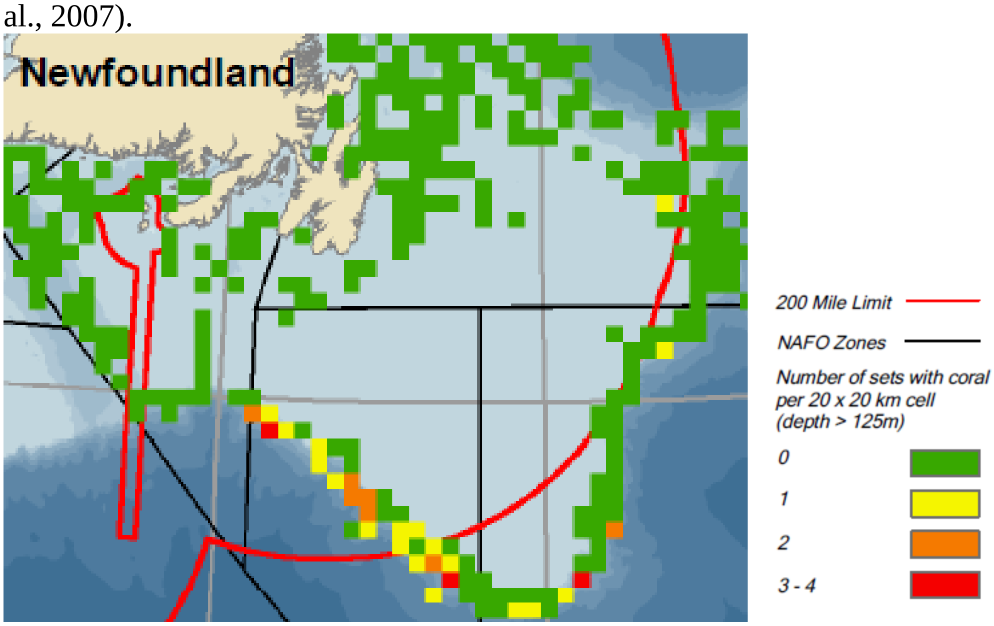


Figure 2. Large and small Gorgonian density, 2003 – 2005 (Edinger et al., 2007).

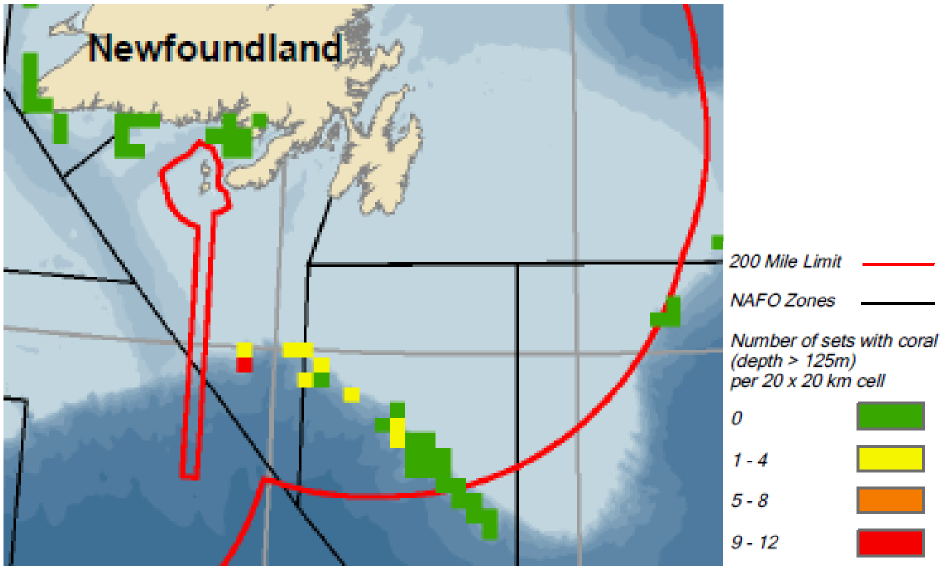


Figure 3. Large Gorgonian bycatch, all longline gear, 2004 & 2005 (Edinger et al., 2007).

- Longline fisheries are concentrated on the Southwest Shelf Edge and Slope and south coast including the St. Pierre and Burgeo Banks, as well as outside the 200 nautical mile limit. Longlines are deployed in a range of depths, precisely targeting rough-bottom areas.

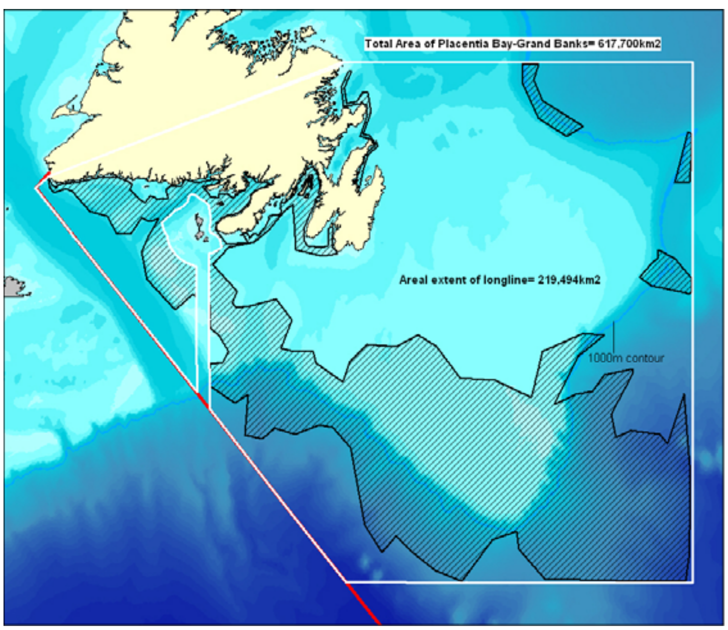


Figure 4. Total longline fishing effort (Fisheries and Oceans Canada, 2008) (Fisheries and Oceans Canada, 2008).

- Large Gorgonian corals are concentrated on the Southwest Shelf Edge and Slope.
- We have estimated the area of overlap at 75%.

Score 7.5

Contact:

- Longline fisheries are generally considered non-destructive.
- Longline fishing often targets the canyons and crevasses which are difficult to trawl and act as a refuge for corals. Corals which have not been impacted by destructive demersal fishing tend to be taller and more structurally complex, increasing the likelihood of contact and entanglement with longlines. As a result, bycatch of corals in longline fisheries is high, with 35% of longline fishing sets containing corals based on the fisheries observer program in 2004-2005 (Edinger et al., 2007).
- Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007) for "contact" for longline fisheries are low (<25%) for both hard and soft corals.
- Given the high percentage of bycatch reported in longline fisheries, we have selected the highest score within the low category (25%).

Score 2.5

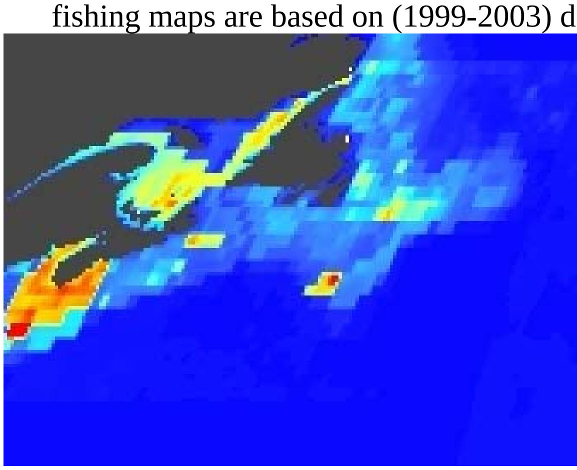
Duration:

- 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 best represent NAFO fisheries.



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>: (7.5 x 2.5 x 10 x 2)/1000 = 0.38

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- Longlines can hook or become entangled in corals, particularly structurally complex species, causing corals to become dislodged or broken.
- Longline fishing often targets the canyons and crevasses which are difficult to trawl, and act as a refuge for corals. Corals which have not been impacted by destructive demersal fishing tend to be more structurally complex, increasing the likelihood of entanglement with longlines.
- Bycatch of corals in longline fisheries is high, with 35% of longline fishing sets containing corals based on the fisheries observer program in 2004-2005 (Edinger et al., 2007).
- High bycatch data clearly indicates that corals are acutely sensitive to longline, but the data may also reflect lack of more destructive fishing activity in areas targeted by longlines (Edinger et al., 2007).
- Fishing Gear Quantitative Scores (Fisheries and Oceans Canada, 2007) "harm" category scores for longline fisheries are low for both soft and hard corals.
- This CP considers large Gorgonian corals which are particularly vulnerable to destruction by longline fisheries so we have selected a high score in the low range.

Score 3

Sensitivity of the CP to chronic impacts:

- Deep-sea corals are slow-growing and long-lived (Edinger et al., 2007). Due to low growth rates, anthropogenic impacts to corals include immediate physical damage with subsequent slow recovery rates, as well as the potential for secondary effects due to alterations in associated benthic and fish communities (Templeman & Davis, 2006). Growth rates of deep-sea corals are similar to growth rates of most massive, shallow water coral species which is estimated between 4.1mm to 25mm per year. Growth rates and life spans are particularly important when determining recovery rates for damaged coral colonies (Gass, 2003). Some of the coldwater corals are hundreds of years old and take decades to recover after being damaged (The Canadian Press, 2007). The deep-sea corals can sustain long-term damage through even limited contact with mobile bottom fishing gears (i.e., the first pass effect) (Gilkinson et al., 2006).
- Large Gorgonian corals are long-lived (decades to hundreds of years) and have slow growth rates, making them particularly vulnerable. Once these corals have been damaged or destroyed, their recovery could take over 100 years (Gass, 2003).
- We have selected a score reflecting a moderate, long term impact to reflect high bycatch and slow recovery rates of the CP.

Score 5

Sensitivity of ecosystem to harmful impacts to the CP:

- The southwest Grand Banks exhibits peak areas of coral abundance and diversity, fish species richness and fishing effort (Edinger et al., 2007). Cold water corals and sponges provide some of the only biogenic structures in deep areas of the sea. Large gorgonian corals are tall, structurally complex species which contribute most to important structural habitat in the LOMA, and can provide protection from predation for other species among their branches.
- Given the apparent importance of cold-water corals as habitat for species of redfish, several of which, such as *Sebastes mentella* and *Sebastes marinus*, form straddling stocks in both the Northeast and Northwest Atlantic, as well as other commercially important species, bottom contact fisheries may well be impacting important habitat for straddling fish stocks in the region.
- Deep-sea coral communities are high in biological diversity. Fishers report that areas with deep-sea corals are good fishing grounds. They may play important ecological roles in the lifecycles of many species associated with them, providing feeding sites, physical substrates for attachment and shelter from predators for invertebrates and fish, including both commercial and non-commercial species (Edinger et al., 2007). Several commercially important species have also been found in association with Gorgonian corals. One such species is the Greenland halibut (Gass, 2003).
- Any activity or stressor that affects the height and structural complexity of coral habitat provided by large Gorgonian corals could potentially have a significant negative affect on other components in the ecosystem.
- The CP is an important component of the deep sea ecosystem, providing structural habitat and increasing biodiversity and nutrient cycling (7.5)
- Corals are listed as providing ‘structural habitat’ in the CP document (**add one point**).

Score 8.5

<u>Sensitivity:</u> (3 + 5 + 8.5)/3 = 5.5

<u>Risk of Harm:</u> MoI x S = 0.38 x 5.5 = 2.1

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

$\geq$ 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

1. Edinger, E., Baker, K., Devillers, R., & Wareham, V. (2007). *Coldwater Corals off Newfoundland and Labrador: Distribution and Fisheries Impacts* Halifax, Canada: World Wildlife Fund.

2. Fisheries and Oceans Canada (2007). Draft proceedings of the Workshop on Qualitative Risk Assessment of Fishing Gears. In Government of Canada.

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

4. Gass, S. E. (2003). *Conservation of Deep-Sea Corals in Atlantic Canada* Toronto: World Wildlife Fund.

5. Gilkinson, K., Dawe, E., Forward, B., Hickey, B., Kulka, D., & Walsh, S. (2006). *A Review of Newfoundland and Labrador Region Research on the Effects of Mobile Fishing Gear on Benthic Habitat and Communities* (Rep. No. Research Document 2006/055). Canadian Science Advisory Secretariat, Fisheries and Oceans Canada.

6. Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C. et al. (2008). A Global Map of Human Impact on Marine Ecosystems. *Science, 319,* 948-952.

7. Templeman, N. D. & Davis, M. B. (2006). *Placentia Bay-Grand Banks Ecosystem Overview and Assessment Report (DRAFT)* Newfoundland & Labrador: Fisheries and Oceans Canada.

8. The Canadian Press (2007). NAFO bans bottom trawling on Grand Banks for five years to protect coral. http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html [On-line]. Available: http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html

9. Wareham, V. (2007). Research Technologist, Fisheries and Oceans Canada.
   Ref Type: Personal Communication

Large Gorgonian corals (depleted or rare species) within the PBGB LOMA.

Oil and gas drilling

<u>Magnitude of Interaction</u>
Areal extent:

- Within the LOMA, the main area of large Gorgonian coral distribution is the Southwest Shelf Edge and Slope. Gorgonian corals have also been identified within the Jeanne d'Arc Basin, as shown in Figure 1 below:

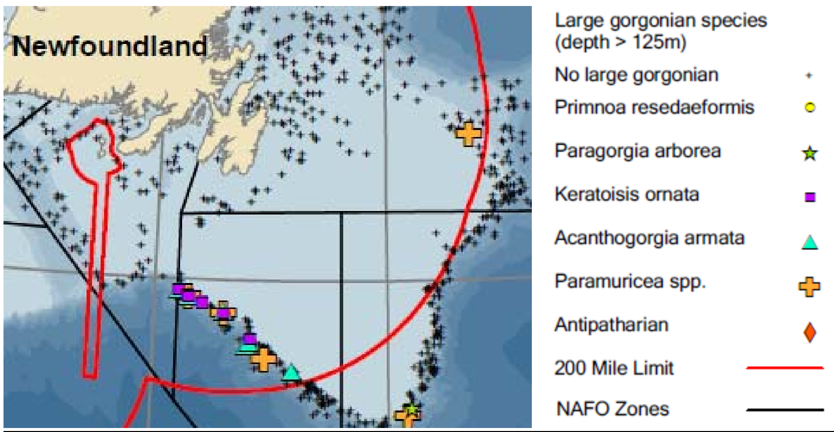


Figure 1. Distribution of large Gorgonian corals in scientific surveys 2003-2005 (Edinger et al., 2007).

- The Jeanne d'Arc Basin is currently the main area of interest for oil and gas within the LOMA, with three production facilities currently located in the area (ORCA Inc., 2005).
- Since 1966, there have been over 200 wells drilled in offshore Newfoundland & Labrador, with approximately 129 of these drilled within areas 3L, 3N and 3O as shown in Fig 2 below:

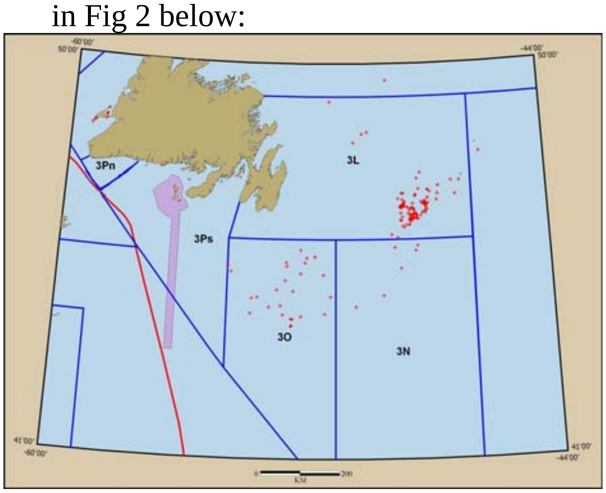


Figure 2. Location of wells drilled in offshore Newfoundland & Labrador including the Grand Banks (1966-2004) (ORCA Inc., 2005).

- Mesozoic sedimentary basins are found all along the continental margin from of the Laurentian Basin, the South Whale basin, and through the deeper waters of the Flemish Pass and Orphan Basins. All the basins along the margin can be considered to have hydrocarbon potential, and contain high quality reservoir and source rocks (Enachescu & Fagan, 2005) (see Figure 3 below), and may be subject to future oil and gas drilling, as exploration and development in these reserves continues.

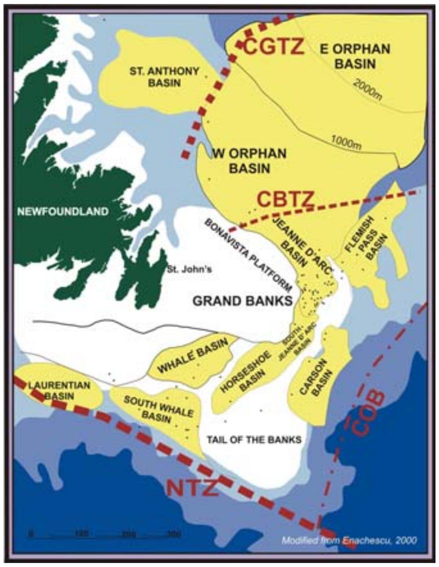


Figure 3. Distribution of Mesozoic sedimentary basins around the Grand Banks. (CGTZ = Charlie Gibbs Transfer fault Zone, CBTZ = Cumberland Belt Transfer fault Zone, NTZ = Newfoundland Transfer fault Zone, COB = Continent-Ocean Boundary). Source: (Enachescu & Fagan, 2005).

- Based on this information we have estimated an area of overlap of 65%.

Score 6.5

Contact:

- Oil and gas drilling involves removal of bottom sediments and any associated benthic organisms, including corals. Impacts on habitat can be substantial as production wells are drilled in clusters inside of large excavated “glory holes” to protect them from ice scour.
- Since this activity will directly remove corals and underlying sediments, contact is considered to be 100%.

Score 10

Duration:

- Exploratory licenses are issued every year for specific areas, and may be anywhere within the basins of interest with the appropriate geology for oil and gas potential. Exploration licences may expire after 9 years (Jacques Whitford, 2003)

- Drilling is considered a chronic stressor that may not occur every year (0-25%).
- Because the activity is likely to increase over the next ten years, we have selected a high score within this range.

Score 2.5

Intensity:

- Oil and gas drilling associated with exploration and development in the LOMA is moderate (40-60%) on a global scale (Halpern et al., 2008) and is expected to increase over the next ten years.

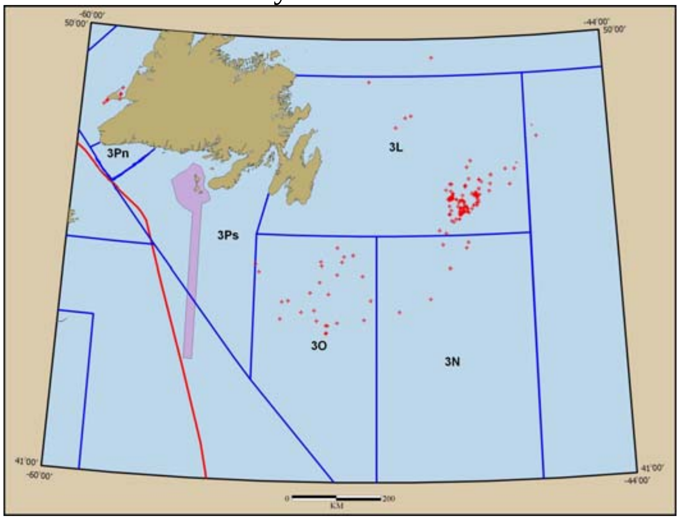


Figure 4. Location of wells drilled in offshore Newfoundland & Labrador including the Grand Banks (1966-2004) ((ORCA Inc., 2005) Figure 31).

- The Southwest Shelf Edge and Slope area is the hot-spot for Gorgonian corals in the LOMA, and although there are currently no oil and gas development projects or significant discoveries in the area, exploratory drilling has been conducted in the South Whale Basin, and significant exploratory drilling in the area occupied by the CP is likely over the next ten years, with potential for a significant discovery. This would rate a medium score within the global scale (50%).
- Gorgonian corals have also been identified within the Jeannie d'Arc Basin which is currently the main area of interest for oil and gas within the LOMA, with three production projects and several significant discoveries. This would rate a high score within the global scale (60%). We have selected an average score of 55%.

Score 5.5

<u>Magnitude of Interaction</u>: (6.5 x 10 x 2.5 x 5.5)/1000 = 0.89

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- Oil and gas drilling involves removal of bottom sediments and any associated benthic organisms, including corals. Impacts on habitat can be substantial as production wells are drilled in clusters inside of large excavated “glory holes” to protect them from ice scour, and the excavated material must be deposited on the seafloor outside on the glory hole, and is frequently dispersed over a wide area.
- Associated activity including placement of rigs and pipelines and the discharge of drilling mud and cuttings in coral areas can damage corals over a wider area by directly crushing them, or smothering them through the deposition of drill cuttings and muds.
- Since this activity has the potential to directly crush, smoother or remove corals, we have selected a score of 100%.

Score 10

Sensitivity of the CP to chronic impacts:

- Deep-sea corals are slow-growing and long-lived (Edinger et al., 2007). Due to low growth rates, anthropogenic impacts to corals include immediate physical damage with subsequent slow recovery rates, as well as the potential for secondary effects due to alterations in associated benthic and fish communities (Templeman & Davis, 2006). Growth rates of deep-sea corals are similar to growth rates of most massive, shallow water coral species which is estimated between 4.1mm to 25mm per year. Growth rates and life spans are particularly important when determining recovery rates for damaged coral colonies (Gass, 2003). Some of the coldwater-corals are hundreds of years old and take decades to recover after being damaged (The Canadian Press, 2007).
- Any corals that are directly removed by drilling, excavation activity or associated pipeline construction, or buried under dredge spoils, drill cuttings or muds will be permanently destroyed.
- Associated activities may affect corals over a broader area by increasing sedimentation levels in the water column, as well as potentially toxic drill cuttings and muds (Gass, 2003).
- Exposure to disturbances, either physical or chemical, often results in the retraction of coral polyps. If these defense reactions persist for long periods of time because of continued exposure to a pollutant or physical disturbance, they can have various results-decreased nutrient assimilation and production, altered biochemical composition, depressed respiration and nitrogen excretion, partial or complete inhibition of growth and deposition of calcium carbonate skeleton, bacterial infection, and eventually death can result from chronic exposure to a pollutant (Gass, 2003).
- Since this activity can result in permanent destruction of corals in the immediate footprint, we have selected a score of 100%.

Score 10

Sensitivity of ecosystem to harmful impacts to the CP:

- The southwest Grand Banks exhibits peak areas of coral abundance and diversity, fish species richness and fishing effort (Edinger et al., 2007). Cold water corals and sponges provide some of the only biogenic structures in deep areas of the sea. Large gorgonian corals are tall, structurally complex species which contribute most to important structural habitat in the LOMA, and can provide protection from predation for other species among their branches.
- Given the apparent importance of cold-water corals as habitat for species of redfish, several of which, such as *Sebastes mentella* and *Sebastes marinus*, form straddling stocks in both the Northeast and Northwest Atlantic, as well as other commercially important species, bottom contact fisheries may well be impacting important habitat for straddling fish stocks in the region.
- Deep-sea coral communities are high in biological diversity. Fishers report that areas with deep-sea corals are good fishing grounds. They may play important ecological roles in the lifecycles of many species associated with them, providing feeding sites, physical substrates for attachment and shelter from predators for invertebrates and fish, including both commercial and non-commercial species (Edinger et al., 2007). Several commercially important species have also been found in association with Gorgonian corals. One such species is the Greenland halibut (Gass, 2003).
- Any activity or stressor that affects the height and structural complexity of coral habitat provided by large Gorgonian corals could potentially have a significant negative affect on other components in the ecosystem.
- The CP is an important component of the deep sea ecosystem, providing structural habitat and increasing biodiversity and nutrient cycling (7.5)
- Corals are listed as providing 'structural habitat' in the CP document (**add one point**).

Score 8.5

<u>Sensitivity:</u> (10 + 10 + 8.5)/3 = 9.5

<u>Risk of Harm:</u> MoI x S = 0.89 x 9.5 = 8.5

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
$\geq$ 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)?
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. Edinger, E., Baker, K., Devillers, R., & Wareham, V. (2007). *Coldwater Corals off Newfoundland and Labrador: Distribution and Fisheries Impacts* Halifax, Canada: World Wildlife Fund.

2. Enachescu, M. & Fagan, P. (2005). *Newfoundland and Labrador Call for Bids* (Rep. No. NL05-01). Department of Natural Resources, Government of Newfoundland and Labrador.

3. Gass, S. E. (2003). *Conservation of Deep-Sea Corals in Atlantic Canada* Toronto: World Wildlife Fund.

4. Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C. et al. (2008). A Global Map of Human Impact on Marine Ecosystems. *Science, 319*, 948-952.

5. Jacques Whitford (2003). *Strategic Environmental Assessment Laurentian Subbasin*.

6. ORCA Inc. (2005). *Grand Banks Environmental Overview Report: Part D - Human Use* Prepared for: Dr. Robert S. Gregory, Environmental Sciences Division, Fisheries and Oceans Canada, St. John's, NL.

7. Templeman, N. D. & Davis, M. B. (2006). *Placentia Bay-Grand Banks Ecosystem Overview and Assessment Report (DRAFT)* Newfoundland & Labrador: Fisheries and Oceans Canada.

8. The Canadian Press (2007). NAFO bans bottom trawling on Grand Banks for five years to protect coral. http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html [On-line]. Available: http://www.nafo.int/about/media/oth-news/2007/ban_btrawling.html

Large gorgonian corals (depleted or rare species) within the PBGB LOMA.

Ghost nets (derelict fishing gear)

<u>Magnitude of Interaction</u>

Areal extent:

- We have no comprehensive data on the distribution of ghost nets in the LOMA, but offshore gillnet fisheries largely target areas with rugged bottom topography along the slope and edge. Given the dynamic nature of the environment and high intensity of fishing activity, the loss of gear is likely significant.
- This is supported by localized research, fisher surveys, and anecdotal reports of gear entanglement in trawling gear in lost nets. Lost gear must be reported to DFO, but we were unable to locate any database cataloguing these reports, and have no information on the rate of fisher compliance with this regulation.
- Although all gear types contribute to ghost fishing, gillnets are generally thought to be the most problematic gear type. In the offshore, depending on the fishery, 200 to 500 gillnets, each up to 91m in length, are allowed by each license holder. If retrieval is delayed by bad weather, storm forces may have shifted the location of the nets, often into deeper water, making retrieval difficult. Gear loss may also result when gear is damaged due to entanglement of marine mammals, bottom features, vessels or other fishing gear.
- Loss of fishing gear is unpredictable and intermittent, occurring chronically, but is not restricted to any specific area. Therefore, areal extent must be estimated (high, medium, low) based on the areal extent of fishing activity and relevant environmental factors.
- Area of overlap between corals and gillnet fishing within the LOMA is estimated as moderate and includes the areas of highest gorgonian coral concentrations. We have therefore estimated areal extent as moderate (50-75%) based on the moderate level of gillnet fishing, combined with the rugged topography and dynamic conditions (wind, waves, etc.) common in areas targeted by gillnets.

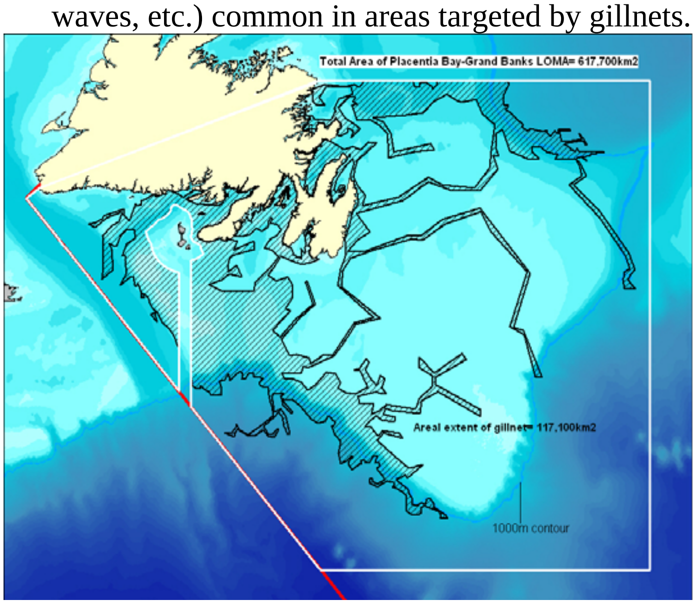


Figure 1. Areal extent of gillnet use in the LOMA, 1998 - 2007 (Fisheries and Oceans Canada, 2008a)

- Gillnet fisheries account for only 9% of the landings in the LOMA, but these fisheries focus largely on the areas occupied by the CP, so we have selected a low-intermediate score in the moderate range.

Score 6

Contact:

- Ghost nets may drift in the water column for extended periods of time, particularly in very deep water or where bottom topography is smooth and flat. Eventually nets sink, weighed down by entangled fish and other marine organisms, and snag on rugged bottom features such as corals.
- Once on the bottom, gillnets tend to form huge balls which can move on the bottom, but generally become snagged, with contact limited to fixed area. Since corals are sessile, likelihood of further contact with additional corals is limited.
- Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007) contact between gillnet and hard corals as low (1- to 25%)
- Therefore although contact with coral, particularly large structural coral is likely significant, it is considered low (<25%).
- Since this CP focuses on structurally complex corals which have a higher likelihood of contact then your average coral, we have selected the highest score within the low range.

Score 2.5

Duration:

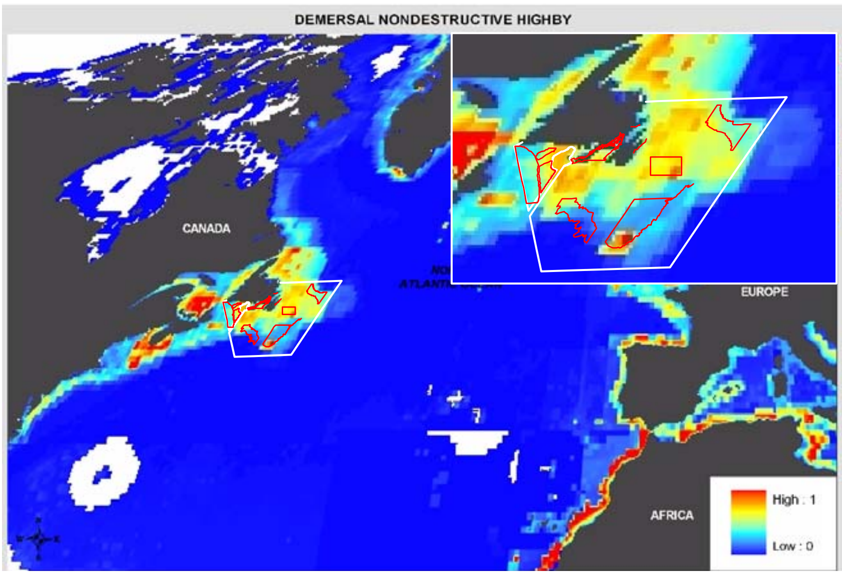
- Loss of fishing gear is unpredictable and intermittent, occurring chronically throughout the year, but is not restricted to any specific time. Therefore duration must be estimated (high, medium, low) based on the pollution potential of the area and the persistence of the stressor.
- Since the 1960s, 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.
- Based on the high persistence of lost fishing gear in the environment and high potential for lost gear in the area, duration is estimated as high.

Score 8

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 Newfoundland Region fisheries data is.



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 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.
- Gillnet fisheries within the LOMA represent an average of 9% of the landings from 1998-2007 (Fisheries and Oceans Canada, 2008).
- Since gillnet fisheries in the LOMA are concentrated in the area where the CP is concentrated, we have selected the highest score in the global range.

Score 6

<u>Magnitude of Interaction</u>: (6 x 2.5 x 8 x 6)/1000 = 0.72

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- Ghost nets may cause damage (crushing, breakage, dislodging) to corals, but the damage tends to be localize in extent and considered minor.
- Since this CP relates to structural species which are more sensitive than an average coral, we have selected a high score in the low range.

Score 3

Sensitivity of CP to chronic impacts:

- Corals grow very slowly, and therefore recovery times are slow.
- Once ghost nets are securely snagged on the bottom, corals may grow up through them, with the netting actually adding to the structural complexity of the habitat. Unfortunately, rather than providing a refuge for mobile fish species, they may continue to entangle and kill mobile species. If the net is hooked by fishing gear, any attached or intertwined corals may be damaged or dislodged.
- Overall, chronic impacts are likely minor but long-term, due to the strength and persistence of the plastic polymers used in modern fishing gear for a score of 2.
- Gorgonian corals are listed as depleted species (**add one point**).

Score 3

Sensitivity of ecosystem to harmful impacts to the CP:

- The southwest Grand Banks exhibits peak areas of coral abundance and diversity, fish species richness and fishing effort (Edinger et al., 2007). Cold water corals and sponges provide some of the only biogenic structures in deep areas of the sea. Large gorgonian corals are tall, structurally complex species which contribute most to important structural habitat in the LOMA, and can provide protection from predation for other species among their branches.
- Given the apparent importance of cold-water corals as habitat for species of redfish, several of which, such as *Sebastes mentella* and *Sebastes marinus*, form straddling stocks in both the Northeast and Northwest Atlantic, as well as other commercially important species, bottom contact fisheries may well be impacting important habitat for straddling fish stocks in the region.
- Deep-sea coral communities are high in biological diversity. Fishers report that areas with deep-sea corals are good fishing grounds. They may play important ecological roles in the lifecycles of many species associated with them, providing feeding sites, physical substrates for attachment and shelter from predators for invertebrates and fish, including both commercial and non-commercial species (Edinger et al., 2007). Several commercially important species have also been found in association with Gorgonian corals. One such species is the Greenland halibut (Gass, 2003).
- Any activity or stressor that affects the height and structural complexity of coral habitat provided by large Gorgonian corals could potentially have a significant negative affect on other components in the ecosystem.

- The CP is an important component of the deep sea ecosystem, providing structural habitat and increasing biodiversity and nutrient cycling (7.5)
- Corals are listed as providing ‘structural habitat’ in the CP document (**add one point**).

Score 8.5

<u>Sensitivity:</u> (3 + 3 + 8.5)/3 = 4.8

<u>Risk of Harm:</u> MoI x S = 0.72 x 4.8 = 3.5

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
$\geq$ 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 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)?
Y 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?
Y 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

1. Edinger, E., Baker, K., Devillers, R., & Wareham, V. (2007). *Coldwater Corals off Newfoundland and Labrador: Distribution and Fisheries Impacts* Halifax, Canada: World Wildlife Fund.

2. Fisheries and Oceans Canada (2007). Draft proceedings of the Workshop on Qualitative Risk Assessment of Fishing Gears. In Government of Canada.

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

4. Gass, S. E. (2003). *Conservation of Deep-Sea Corals in Atlantic Canada* Toronto: World Wildlife Fund.

5. Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C. et al. (2008). A Global Map of Human Impact on Marine Ecosystems. *Science, 319,* 948-952.

6. National Academy of Sciences (2008). *Tackling Marine Debris in the 21st Century*.

Summary Table CO # 42: Large Gorgonian corals (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	8.5	10	10	9	**7.7**	9	9	8.5	**8.8**	**67.8**	**Med.**
Gillnets (bottom)	7.5	5.5	10	5	**2.1**	5	6	8.5	**6.5**	**13.7**	**Med.**
Longline	7.5	2.5	10	2	**0.38**	3	5	8.5	**5.5**	**2.1**	**Med.**
Oil & gas drilling	6.5	10	2.5	5.5	**0.89**	10	10	8.5	**9.5**	**8.5**	**Low**
Ghost nets	6	2.5	8	6	**0.72**	3	3	8.5	**4.8**	**3.5**	**Med.**
									Cumulative CP Score	**95.6**	