Area of highest overall benthic biomass on the Grand Banks in the Southeast Shoal and Tail of the Banks

Potentially Harmful Activity X			**Potentially Harmful Stressor (X)**		
Fishing	Bottom trawl	**X**	Marine pollution	Oil pollution	**X**
	Scallop dredges	**X**		Industrial effluent	
	Clam dredges	**X**		Fishplant effluent	
	Midwater trawl			Sewage	
	Gillnets (bottom)			Historic military waste	
	Gillnets (pelagic)			Long range transport of nutrients	
	Longline			Acid rain	
	Seine (pelagic)			Persistent Organic Pollutants	
	Recreational cod fishery			Eutrophication	
	Crab pots	**X**		Ghost nets	
	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			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			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

Significance of the CP:

- The benthic community of the Southeast Shoal may be considered exceptional due to high benthic biomass, high productivity, individual animal abundance, diversity and endemic species. It has been noted as the most highly productive on the Grand Banks, and exceptionally high benthic biomass estimates indicate the community is possibly significant on an international scale (Coughlan, 2002).
- Nesis (1965) observed that the overall biomass in the Southeast Shoal exceeds 5 kg/ m^2, extremely rare so far from the coast. The average for the Grand Banks is 544mg/ m^2. (Coughlan, 2002)
- The area is dominated by shallow sandy habitat which is naturally dynamic (subject to regular wave action/storms) and so is less sensitive to disturbance than more structured habitats (Templeman & Davis, 2006).
- Early Russian surveys provide data on species collected in dredge samples which include both boreal and Arctic species assemblages due to the cold and warm water currents circulating on either side of the banks (Fuller & Myers, 2004).
- Hutcheson et al. (1981) identified a combination of factors that may promote the prolific benthic community in the Southeast Shoal area. High primary productivity, shallow, slow moving water and periodic mixing allow organic matter to reach the bottom where it accumulates in depressions formed by dense concentrations of clams and barnacles. These animals may also concentrate organic material in the form of feces retained in the depressions. Collectively, these conditions influence the benthic community (Coughlan, 2002).
- The shallow water depth with likely turbulent currents, high water column primary production, and large bivalve community suggests a relatively direct link between water column production and benthic productivity for this portion of the Grand Banks (Hutcheson & Stewart, 1994).
- Hutcheson and Stewart (1994) suggested the unusual presence of these species resulted from the recent geological history of the Southeast Shoal. When the shoal was above sea level during glaciation, a shallow littoral zone would have provided typical conditions for clams and mussels.
- The Southeast Shoal has the warmest summertime bottom water temperatures on the entire Grand Bank, with average temperatures reaching 4^oC. The area is a transition area occupied by both cold and warm-water species, which contributes to its high biodiversity.
- High benthic biomass in the area suggests a relatively direct linkage between planktonic production systems and the benthic communities on the Grand Banks (Coughlan, 2002).
- The Southeast Shoal is considered an area of high phytoplankton productivity and diversity due to the influence of the various water masses on the area. They are the basis of the oceanic food chain and the benthic community of the area depends on them as the source of their organic material. Since there is such a high level of primary productivity supplied by phytoplankton, the area is able to support a high benthic biomass.
- Benthic abundance depends on an adequate supply of organic material reaching the bottom. Phytoplankton serves as the main source of such material (Coughlan, 2002).

Components of the CP:

- Major taxonomic groupings include Echinoderms (sea urchins, sand dollars, sea stars and sea cucumbers), Molluscs (mussels, clams, and scallops), Polychaetes (segmented worms) and Crustaceans (barnacles, shrimps and crabs) (Coughlan, 2002).
- Nesis (1965) determined the SE Shoal area displayed a distinct biocenosis consisting primarily of Arctic wedge clam (*Mesodesma arctatum*), sea cucumber and blue mussel (*Mytilus edulis*). The Grand Bank benthic biomass also consists of sand dollar and sand lance.
- The Southeast Shoal also supports two unique populations of bivalves, wedge clams and blue mussels. An exceptionally high biomass of wedge clams is found in the area- a characteristic extremely rare so far from shore. The population of blue mussels is one of few sub-littoral populations of blue mussels and the farthest one from shore. Sea cucumbers also occur with these species of bivalves. This grouping has no counterpart anywhere else in the world. These species are thought to be relict populations from when the Shoal was an offshore island (Templeman & Davis, 2006).

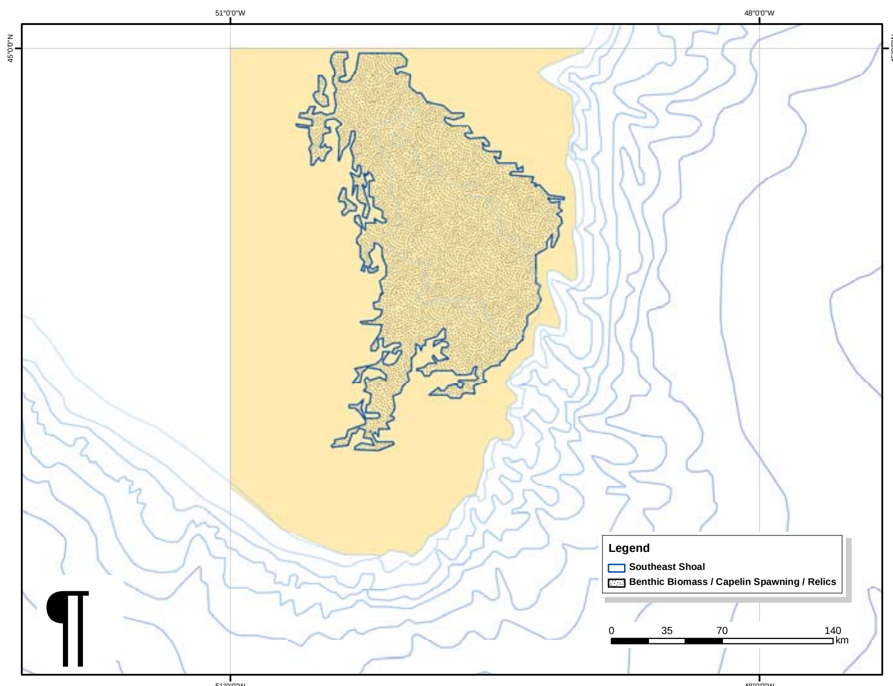

Figure 1. Area delineating benthic biomass on the Southeast Shoal (Source: DFO 2008)

- The distribution of wedge clam (Hutcheson & Stewart, 1994) on the Grand Banks appears to be localized on the Southeast Shoal and possibly only on the eastern parts of it. The striking feature of the occurrence of *M. deauratum* was the extremely high densities (Hutcheson & Stewart, 1994).

TABLE 3. Dominant benthic invertebrate species at Station 48 during four samplings in 1980.

May	July	September	November
Crustacea	Crustacea	Crustacea	Crustacea
Balanus crenatus	*Acanthohaustorius spinosus*	*Amphiporeia lawrenciana*	*Acanthohaustorius spinosus*
Amphipoda: Pleustidae	*Anonyx nugax*	*Monoculodes edwardsi*	*Anonyx nugax*
	Phoxocephalus holbolli	*Phoxocephalus holbolli*	Amphipoda: Pleustidae
	Amphipoda: Pleustidae	*Priscillina armata*	*Pontogeneia inermis*
	Priscillina aramata	*Unciola irrorata*	*Unciola irrorata*
Mollusca	Mollusca	Mollusca	
Colus sp.	*Mesodesma deauratum*	*Mesodesma deauratum*	
Mesodesma deauratum			
Modiolus modiolus			
Hiatella arctica			
Polychaeta	Polychaeta	Polychaeta	Polychaeta
Exogone hebes	*Harmothoe imbricata*	*Micronephtys minuta*	*Exogone hebes*
Harmothoe imbricata	*Harmothoe spinulosa*	*Ophelia limacina*	*Glycera capitata*
Nephtys discors	*Pholoe minuta*	*Scolelepis squamata*	*Scolelepis squamata*
Phyllodoce maculata	*Scoloplos acutus*		
		Echinodermata	Echinodermata
		Stereoderma unisemita	*Stereoderma unisemita*

Table 1: Benthic invertebrate species identified in the Southeast Shoal area (Hutcheson & Stewart, 1994).

<u>Scoping</u>

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).

Over the period 1998-2007, bottom trawl use by Newfoundland Region fisheries was responsible for 60% of landings (by weight) in the Canadian portion of the EBSA. The Southeast Shoal EBSA has the second highest landings of all 11 EBSAs in the LOMA during that period, and the majority of these are taken with bottom trawl (Appendix A, Table 15). NAFO vessels use bottom trawl in the EBSA, outside the EEZ (200 nautical mile limit) (Kulka, 2001). Bottom trawl is used by Canadian fisheries and NAFO fisheries throughout the year to harvest skate, Greenland halibut, yellowtail flounder, and white hake (NAFO only), in this area (Appendix A, Table 6: yellowtail fishery closed from June 15- July 31). Biomass reduction immediately after trawling can be significant for benthic species, including snow crabs, sand dollars, brittle stars, sea urchins and soft corals. However, some reports show only minor effects of otter trawling on molluscs (Gordon Jr. et al., 2002). **Screened in.**

Scallop dredge:

Hydraulic dredges belong to a unique class of mobile bottom fishing gear since they are designed to penetrate deeply into the sediment in order to harvest infaunal bivalves. From international reviews of fishing impacts, scallop dredging had the highest impact on seafloor ecology of any mobile fishing method (Rice, 2006). Specific impacts of scallop dredging documented in Canada include damage both to scallops not caught in the dredge and to other nontarget shellfish; impacts to seafloor habitat; and, in one study, a change in community structure from long-lived sessile species to short-lived mobile species (Ecology Action Centre et al., 2007). A very small amount of Iceland scallops have been harvested in this EBSA. Landings were taken from the northeast corner of the EBSA, in an area outside the noted area of ‘benthic biomass’ concentration (Fisheries and Oceans Canada, 2007b). DFO data from 1998-2007 show scallop dredge is responsible for only 1% of landings in the EBSA over that period (Appendix A, Table 15). Data indicates that in some years, no scallops were harvested. This gear type could impact benthic biomass and is known to have high ecological impact (Ecology Action Centre et al., 2007), but due to its limited use, is not considered a key stressor in this EBSA. **Screened out.**

Clam dredges:
Hydraulic clam dredges produce the most dramatic effects on seabed habitat of any gear type, and remove benthic biomass (Gordon Jr. et al., 2006). The commercial clam dredge tows two hydraulic dredges from the stern. Each dredge measures 4m (wide opening) by 3.6m (length) by 1m (height) and weighs approximately 12 tonnes. The bottom of the dredge is lined with steel bars. In front of the dredge opening is a blade set at a cutting depth of 20cm. A manifold directs jets of water under pressure into the sediment in front of the blade in order to loosen the sediment. A study conducted on the Scotian Shelf showed the benthic community remained altered two years after dredging ceased (Gilkinson et al., 2009).

Fisheries and Oceans fisheries data indicates that clams made up 29% of landings in this EBSA over the period 1998-2007 (Appendix A, Table 23). Bycatch of propeller clams and quahogs are associated with the Stimpson’s surf clam fishery, and a total bycatch of almost 6000t of these species was reported in logbooks for the 2000-2003 period (Fisheries and Oceans Canada, 2007b). Stimpson’s surf clam is harvested in the area northeast corner of the EBSA, outside the area of the CP, and therefore unlikely to be a key stressor to benthic biomass, which is delineated by the 55m bathymetry line. **Screened out.**

Crab pots:
Landings of snow crab are taken in the northeast portion of the EBSA (near Lily Canyon) and in the southwest corner, which is outside the 200 mile limit, while benthic biomass is concentrated within the Shoal (area of 55m bathymetry line). Fisheries and Oceans fisheries data shows that 7% of landings in the EBSA were taken by pot over the 1998-2007 period, with tonnage increasing every year since 2002 (Fisheries and Oceans Canada, 2008). Crab pots could have an impact on benthic biomass as the gear sits on the seafloor and may come in contact with certain species, but Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) rank crab pot ‘contact’ with benthic infauna and epifauna as low. Since contact is low, and the crab harvesting occurs outside the area of the CP, this is not expected to be a key stressor. **Screened out.**

Mining/ Oil and gas drilling:
Carbonate deposits in the form of shell beds and concentrations of sand, gravel, silica sand, and phosphorite are potential targets for offshore mining operations. Coughlan (2002)

mentions the possibility of calcium carbonate mining in Southeast Shoal (Coughlan, 2002), but there are no current plans to mine in that area (Government of Newfoundland and Labrador, 2009).

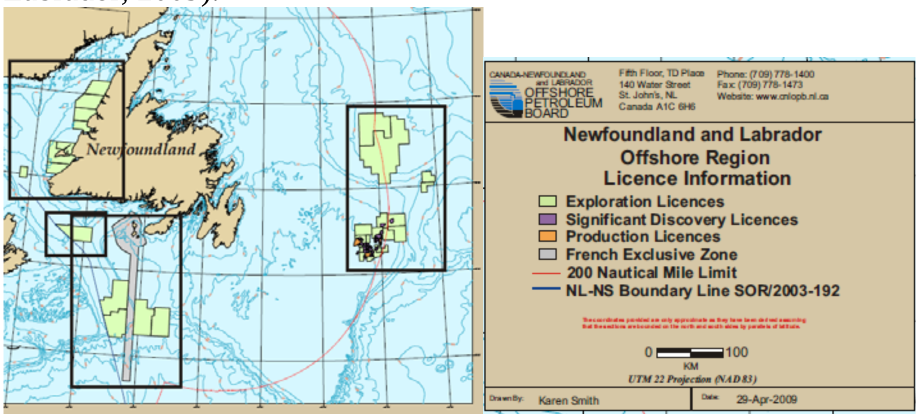

Figure 2. Licence information (Government of Newfoundland and Labrador, 2009).

This stressor should be re-assessed if plans are established to begin mining in the Southeast Shoal. There are no oil exploration licences in this EBSA, and no parcels have been delineated for bids as of 2009 (CNLOPB, 2008). Therefore oil and gas drilling is not expected to occur in the next 10 years. This stressor is not expected to occur in area of CP to any significant level. **Screened out.**

Oil pollution:

Currently, there is no oil exploration in this area, therefore potential sources of oil pollution are ship traffic and possible spills. The Southeast Shoal has between 1,500 - 4,799 total vessel transits in an average year (Pelot & Wootton, 2004). This is considered ‘low’ within the LOMA (see image below). However, between 550 - 889 of these vessel transits are tankers, which ranks among the highest density of tanker traffic in the LOMA. In addition, some foreign vessels in NAFO area may not have adequate regulations with respect to bilge water disposal. Because of their feeding mechanism, the organisms encompassing ‘benthic biomass’ can accumulate chemical and/or bacteriological pollutants and naturally occurring toxins from the surrounding waters even at a considerable distance from pollution sources. The toxic effects can result in death of the organism (lethal effect) or can impair its behaviour or biochemistry and therefore its ability to reproduce, move, feed, etc. (sublethal effect) (Britwell & McAllister, 2002). They may also be smothered by oil or harmed by eating oil-sediment particles. Many molluscs and worms have a natural ability to purify themselves of contaminants if the concentration is low or if the source has been removed. This EBSA has ‘low’ traffic density overall, and no oil exploration licences (i.e. low risk of spills or blowouts), therefore oil pollution is not expected to be a key stressor to benthic biomass. **Screened out.**

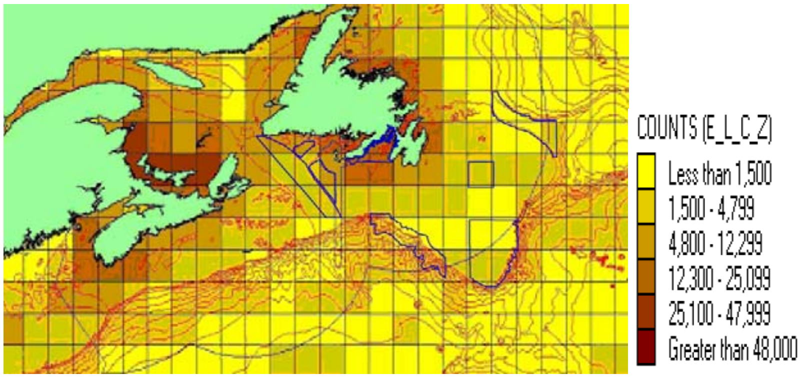

Figure 3. Annual vessel transits for all vessel types combined (merchant, fishing, cruise ships) (Pelot & Wootton, 2004).

Temperature change:
Drinkwater (UNEP & UNFCCC, 2002) predicts a temperature increase of 2-4^{o}C in Southern Newfoundland waters by 2100, based on IPCC 2001 models. 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 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.

Key species which contribute to the high benthic biomass of the area include scallops, surf clams, blue mussels, sea urchins, sand dollars, sea stars and sea cucumbers, and barnacles, (Coughlan, 2002). All have high temperature tolerances, and frequently inhabit littoral environments where temperature fluctuations can be extreme. Mussels can tolerate significant temperature variations- in Newfoundland from -1.5° to 23°C. (Stewart, 1994), although sea scallop distribution is thought to be temperature limited (Naidu et al., 2001). The highest concentration of many permanent beds appears to correspond to areas of suitable temperatures, food availability, substrate, and where physical oceanographic features such as fronts and gyres may keep larval stages in the vicinity of the spawning population (NOAA, 2005). Temperature changes are not likely to be significant over the next 10 years unless annual fluctuations in temperature are much greater than the average predicted change. **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 benthic invertebrates 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 and in extreme cases, may even corrode these organisms' skeletons (Campbell & Simms, 2009).

The skeletons of molluscs, echinoderms and crustaceans- key components of the CP- are formed through calcification. Calcifiers use oceanic carbonate and calcium to form their shells. The more acidic the ocean becomes, the less available these salts and metals are, putting an important part of the marine food web at risk (Chameides, 2009).

While there is uncertainty about many aspects of climate change, the geochemical processes driving these changes are highly predictable. There are measurable impacts on growth rates and survival rates of echinoderms and gastropods at 560ppm atmospheric CO_2, which is the projected levels for 2050. Impacts include slower growth rates and lower final weights. This would imply losses of commercially important species such as lobsters, mussels and scallops (IUCN, 2008). There is a high rate of mortality of scallops at pH 7 (Turley, 2006). The intensity of this stressor is likely to be low over the next ten years, but given the low level of certainty associated with these predictions and the lack of local information, research and monitoring are required to create more informed predictions and more adequately assess the potential impacts. **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.

Benthic communities are comprised of invertebrate species that live on or in the sediment, and many rely on filter feeding from currents. Their diet primarily consists of phytoplankton and microzooplankton (such as ciliated protozoa), but particles of detritus can also be ingested, especially during periods of low phytoplankton concentrations (Hart & Chute, 2004). Current shifts could affect their ability to feed, but changes are unlikely to reach a level where the CP is seriously harmed within the next ten years, but has the potential to permanently damage this CP in the future. **Screened out.**

Didemnum:
This invasive tunicate is spreading rapidly in the George's Bank Area, forming dense colonies which smoother benthic organisms, but so far has not been detected in the LOMA. The major vector is scallop fishery which is not prosecuted in the area of the CP (less than 1% of landings over 1998-2007). **Screened out.**

Key Activities/Stressors:

- Bottom trawl

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Benthic biomass on the Southeast Shoal and Tail of the Banks

Bottom trawl

<u>Magnitude of Interaction</u>

Areal extent:

- "Benthic biomass" is found all over the EBSA, but is especially high in the Southeast Shoal (Coughlan, 2002). The second figure below, from Coughlan (2002), shows the distribution of wedge clam, blue mussel and sea cucumber over the Southeast Shoal and Tail of the Bank.
- Since these characteristics are attributable to the sandy habitat of the Southeast Shoal, we define the area by bathymetry of the shoal (55m)

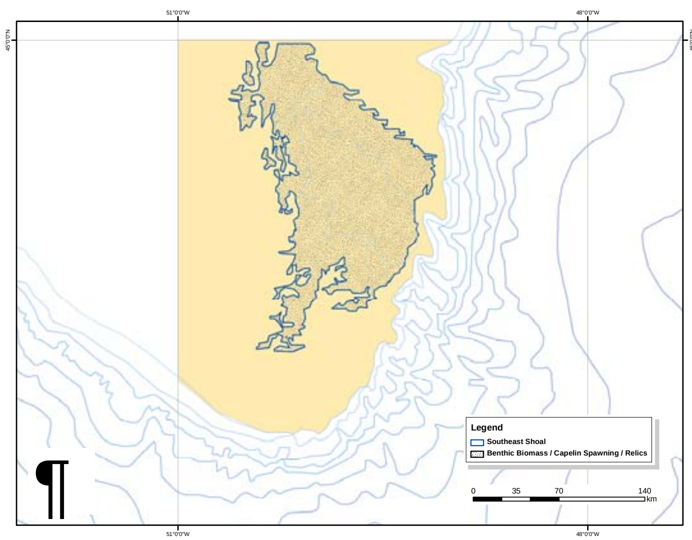


Figure 1. Area delineating benthic biomass on the Southeast Shoal (Source: DFO 2008)

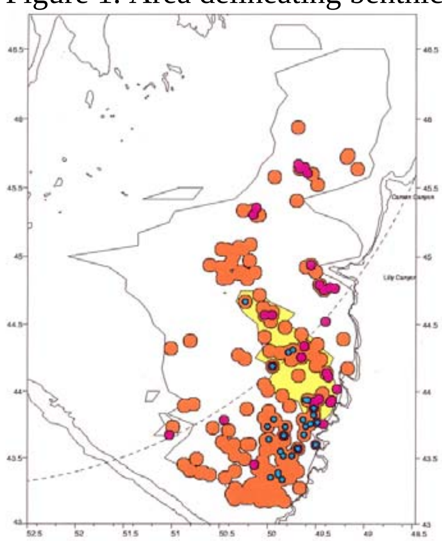


Figure 2. Distribution of wedge clam (pink), Blue Mussel (blue), and Sea Cucumber (orange), from 1996-98 (Coughlan, 2002).

- The EBSA consists of area inside the 200 mile limit (EEZ), and an area outside the 200 mile limit, and bottom trawling occurs in both. Newfoundland Region fisheries information from 1998 - 2007 is mapped, but the distribution of NAFO fisheries which occur outside the 200 mile limit are not readily available. Available spatial data is limited to the year 2006 (Campanis, 2007). The image below is a composite created from the several sources (Campanis, 2007; Fisheries and Oceans Canada, 2007b; Kulka & Pitcher, 2001).

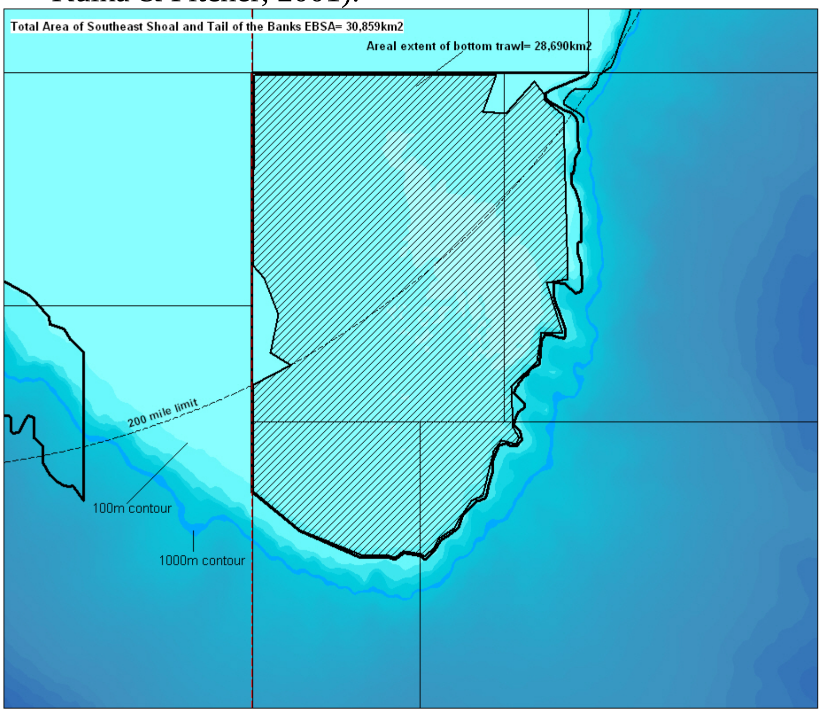


Figure 3. Distribution of bottom trawl use 1998 – 2007 (area outside of EEZ based on 2006 data only) (Campanis, 2007; Fisheries and Oceans Canada, 2008).

- The overlap between unique benthic biomass and bottom trawling (inside and outside the 200 mile limit) is estimated to be 100%.

Score 10

Contact:

- Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for "contact" between bottom trawl and 'benthic infauna', 'benthic epifauna (Johnston et al., 2002) and 'benthic epifauna (mobile)' are all scored high (75-100%).
- The bottom trawl is dragged along the seafloor and kept open during a tow with large, oval, metal plates (doors). The 2 doors, which are in continuous contact with the seabed, have the greatest physical impact and affect 2 linear zones about 1 to 2 m wide. The rockhopper gear and net, which are in contact with the seabed most of the time during a set, affect an area about 20 m wide midway between the doors. The remaining path of the trawl is influenced by the ground warps which, while not in

direct contact with the seabed, can create turbulence that resuspends sediment (Prena et al., 1999).

- Since benthic biomass occurs on/in the seafloor, and bottom trawling occurs along the seafloor, contact will be scored in the high range. It will not be scored at 100%, since some species are in the sandy seafloor, and would have less chance of contact with the gear.

Score 9

Duration:

- The components that comprise this CP are mainly sessile organisms, or have very low motility. The CP is present in the EBSA throughout the year.
- The use of otter trawl depends on the species targeted in 3N (inside EEZ):
    - Greenland halibut- May 1- March 31= 11 months
    - Skate- April 1- March 31= 12 months
    - Yellowtail- Aug 1- May 31= 10 months
- For NAFO fisheries outside the EEZ: the table below shows that fishing occurs in all quarters of the year in division 3N, but from July to September the tail of the Grand Banks is targeted considerably more than between January and June (Campanis, 2007)

Quarter	1F	2J	3K	3L	3M	3N	3O
1	-	-	8	15936	4687	1159	1547
2	-	-	-	10174	5776	874	1611
3	162	24	22	6989	8872	4402	2268
4	-	-	-	9128	2578	6223	3635

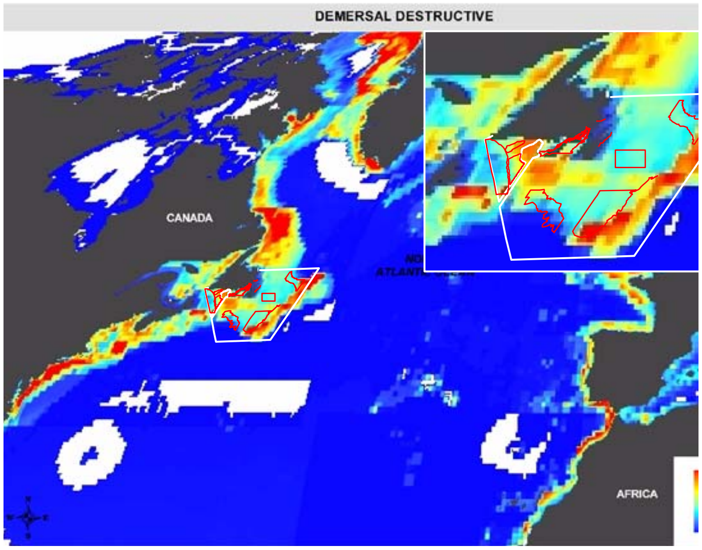
Table 1: Quarterly comparison of fishing hours for groundfish in 2006, shown by NAFO Division(Campanis, 2007)

- Fishing (by both Canada and NAFO members) occurs in all months of the year. Benthic biomass is present in all months of the year. Therefore, temporal overlap is 100%, although it is noted that bottom trawl might not be used every single day of the year.

Score 10

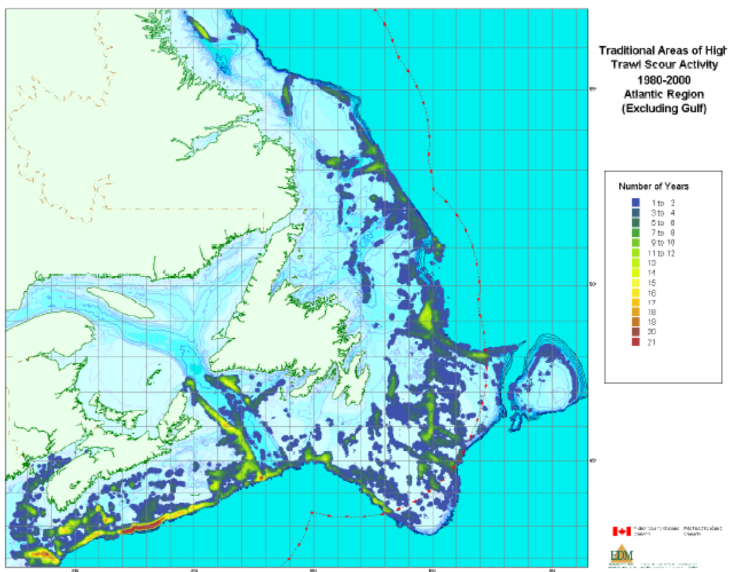
Intensity:

- Halpern *et al.* (2008) have developed maps showing the global intensity of several anthropogenic stressors including demersal destructive fishing, which includes bottom trawl fisheries (see Fig. 4 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 et al., 2008) shows a high (red) intensity relative to global levels for a score range of 80% to 100%.
- Kulka and Pitcher (2001) studied the spatial extent of highly trawled areas in the Grand Banks (see Fig. 5 below). Some locations within the EBSA are shown as being persistent areas of high intensity trawling (Kulka, 2006).



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

Figure 4. Global intensity of bottom trawl, adapted from (Halpern et al., 2008)



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

Figure 5. Map depicting persistent areas of high intensity trawling in the Atlantic over the period 1980-2000 (Kulka & Pitcher, 2001).

- *NAFO Fisheries*: from the NAFO website, the average catch in 3N (the EBSA is in NAFO Division 3N) for groundfish (caught with otter trawl), from all countries is around 20,000 tonnes for 2000-2004 (see graph below). Just less than ½ of that came from Canadian vessels. Note that this total includes more than just the area delineated by the EBSA. In 2004 there were 132 vessels registered for the NAFO regulatory area, and in 2006 there were 92 vessels (NAFO, 2009).

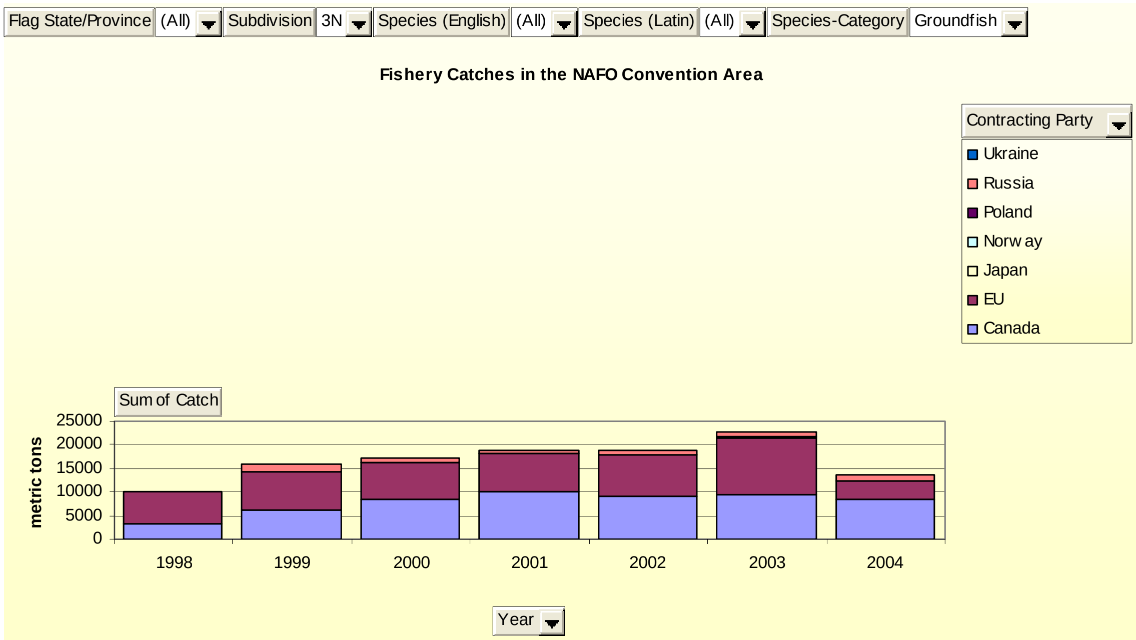


Figure 6. NAFO landings of groundfish in Division 3N (STATLANT 21A data)

- *Newfoundland Region Fisheries*: bottom trawl harvesting totalled 169,159 tonnes in the entire LOMA from 1998-2007. Of that total, 50,747 tonnes were taken with bottom trawl specifically in this EBSA over the period, which is 60% of total landings (Appendix A, Table 15) in the EBSA. In the last five years, landings from bottom trawl ranged from a low of 179 tonnes in 2006, to a high of 8,222 tonnes in 2003 (Fisheries and Oceans Canada, 2008).
- We will score intensity at the middle of the range suggested by the global map from Halpern (2008), at 80%.

Score 8

<u>Magnitude of Interaction:</u> (10 x 9 x 10 x 8)/1000 = 7.2

<u>Sensitivity</u>

Sensitivity of the CP to acute impacts:

- In relation to bottom trawl, Quantitative Fishing Gear Scores (Fisheries and Oceans Canada, 2007a) for “harm” are high (75-100%) for ‘benthic infauna’, ‘benthic epifauna (sessile)’ and ‘benthic epifauna (mobile)’.
- Bottom trawl was assigned an ecological rating of “high impact” (the highest of 5 categories) in relation to invertebrates and the seafloor (Fuller et al., 2008).
- Some components of the CP (scallops, Stimpson’s surf clam) are harvested with dredges, but ‘benthic biomass’ can by captured as bycatch with bottom trawl gear. Prena *et al.* (1999) indicate that the otter trawl is very inefficient in catching epibenthic species, presumably due to its larger mesh size and its practice of traveling just above the sediment surface rather than cutting through it as the dredge does. However, the remains of dead organisms were commonly seen fouling the wings and

belly of the net. In addition, large numbers of damaged organisms left behind on the seabed were detected soon after trawling (Prena et al., 1999).

- This gear type causes substantial physical damage to the ocean bottom on both hard and soft substrates. Benthic organisms can be expected to vary their sensitivity to trawling disturbance due to factors such as size and life habits (Gordon Jr. et al., 2002).
- The area is dominated by shallow, sandy habitat which is naturally dynamic (subject to regular wave action/storms) and so is less sensitive to disturbance than more structured habitats (Templeman & Davis, 2006).
- Mobile bottom-contact fishing gears impact benthic populations, communities, and habitats. The effects are not uniform, however, but depend on at least:
    - The specific features of the seafloor habitats, including the natural disturbance regime;
    - The species present;
    - The type of gear used, the methods and timing of deployment of the gear, and the frequency with which a site is impacted by specific gears; and
    - The history of human activities, especially past fishing, in the area of concern (Fisheries and Oceans Canada, 2006).
- Otter trawls can potentially affect benthic habitat and organisms in a wide variety of ways. Immediate impacts can include:
    - Re-suspension and displacement of sediment, organic matter, shells and small organisms.
    - Burial of habitat structures and organisms by re-deposited sediment.
    - Digging of furrows, creation of berms, realignment of rocks and shells, and generally smoothing of surficial sediment features.
    - Destruction of habitat structures (mounds, tubes, burrows, etc.).
    - Capture and removal of organisms, as well as lethal damage to individuals remaining on the seafloor.
    - Temporary exposure of sediment-dwelling organisms (Jennings et al., 2002), making them more available to predators.
    - Attraction of scavengers because of the increased availability of prey (Gordon Jr. et al., 2002).
- An experimental study of the effects of otter trawling was conducted in a deep (120 to 146 m) sandy bottom ecosystem of the Grand Banks of Newfoundland from 1993 to 1995. Each year, three 13 km long corridors were trawled 12 times within 31 to 34 h with an Engel 145 otter trawl equipped with rockhopper foot gear. The width of the disturbance zones created was on the order of 120 to 250 m. The total biomass of invertebrate bycatch in the trawl decreased significantly over the 12 sets, even though only a very small proportion of the biomass present was removed and each set did not pass over exactly the same area of seabed. Biomass was on average 24 % lower in trawled corridors than in reference corridors (Prena et al., 1999).
- The reduced biomass of epibenthic organisms in trawled corridors is thought to be due to several interacting factors including direct removal by the trawl, mortality, damage, predation and migration. Snow crabs, basket starts, and sea urchins dominated the trawl invertebrate bycatch. Iceland scallops and a few other bivalve

molluscs were occasionally captured by the trawl. In all 3 years, the biomass in trawled corridors was lower than in reference corridors (Prena et al., 1999).

- Sand dollars, brittle stars and sea urchins demonstrated significant levels of damage from trawling. This experiment indicates that otter trawling on a sandy bottom ecosystem can produce detectable changes on both benthic habitat and communities, in particular a significant reduction in the biomass of large epibenthic fauna (Prena et al., 1999).
- Highest mortalities are generally found for organisms that are large, fragile, live on or near the seabed surface, sessile, long-lived and have slow growth and recruitment rates. Conversely, the lowest mortalities are generally found for organisms that are small, robust, live deep in the seabed, mobile, short-lived and have high growth and recruitment rates (Gordon Jr. et al., 2002). In general, thin-shelled bivalves are more easily damaged by otter trawl doors than thick-shelled bivalves (Prena et al., 1999).
- Otter trawl may not be the most damaging gear to some of these benthic species, as one review (Fisheries and Oceans Canada, 2008) states that scallop dredge and hydraulic clam dredge are more harmful to infauna than otter trawl, as they penetrate deeper into the seabed.
- We do not have fisheries data to show the likelihood of bycatch/damage from trawling for the variety of species which make up the CP. However, evidence has shown that there can be a wide range of effects, and a decrease in biomass of epibenthic organisms in trawled corridors. Different species will have different vulnerability to this gear type, therefore the score assigned is in the low range of that suggested by Quantitative Fishing Gear Scores (75-100%).

Score 8

Sensitivity of the CP to chronic impacts:

- Mobile fishing gear is a widespread cause of physical disturbance to the global continental shelf benthos. Of the variety of mobile gear types used, the otter trawl is considered to be one of the more environmentally benign, however, it is still capable of inflicting considerable disturbance on benthic ecosystems (Prena et al., 1999).
- The greatest impacts occur when an area is fished for the first time. As the seabed habitat and communities adapt to fishing disturbance, the effects of future fishing become less. Many of the studies of gear impacts have been conducted in previously fished areas and so effects may be underestimated (Fisheries and Oceans Canada, 2006; Gordon Jr. et al., 2002).
- Longer-term impacts, especially if otter trawling is repeated frequently over the same bottom, can potentially include:
    - Altering the sediment habitat structure which could affect its suitability for particular species and the rates of biogeochemical fluxes between the sediment and water column.
    - Changing the composition of benthic communities (e.g. presence/absence, relative abundance, biomass and size of individual species).
    - Changing ecosystem processes such as the rates of primary and secondary production and organic matter dynamics.

    - Altering fisheries recruitment through changes in physical habitat and food supply which affect the survival of juvenile fish (Gordon Jr. et al., 2002).
- Gordon *et al*. (2002) found evidence that the biological community recovered from the annual trawling disturbance in less than a year, and no significant effects could be seen on benthic community structure after three years of otter trawling. The habitat and biological community at an experimental site are naturally dynamic and exhibited marked changes irrespective of trawling activity, and this natural variability appeared to over-shadow the effects of trawling (Gordon Jr. et al., 2002).
- However, continuous fishing pressure could keep benthic habitat and communities in a permanently altered state. Benthic habitats and communities substantially altered by otter trawling will not necessarily return to their original state once the disturbance is removed (Gordon Jr. et al., 2002).
- This CP comprises many species, some of which are slow growing and long-lived (ie. Stimpson's surf clam) while others are fast growing and very fecund (ie. sea scallop). Recovery time would vary for each species.
- Invertebrates such as blue mussel and wedge clam have not shown to be heavily impacted by bottom trawling (Kenchington et al., 2001). In 'Proceedings of the national peer review on impacts of trawl gear and scallop dredges on benthic habitats and communities'(Fisheries and Ocean Canada, 2006), researchers noted that the Grand Banks otter trawling experiment (Gordon Jr. et al., 2002) resulted in "few immediate impacts on infauna and no detectable impacts on molluscs, with recovery from disturbance in 1year. However, these areas were not regularly trawled, whereas the Southeast Shoal is constantly trawled in some areas, therefore recovery may be longer".

Score 6

Sensitivity of ecosystem to harmful impacts to the CP:
- Offshore scallops feed mainly on phytoplankton and re-suspended organic material.
- Larvae for some species are planktonic, and therefore potentially preyed upon by filter feeders and planktonic carnivores.
- Predators include Atlantic cod, wolfish, eel pouts, sculpins, American plaice, winter flounder, and yellowtail flounder. Invertebrate predators include crabs, lobsters, and sea star species (Fisheries and Oceans Canada, 1996; Hart & Chute, 2004; Stewart, 1994).
- Hutcheson *et al.* (1981) identified a combination of factors that may promote the prolific benthic community in the Southeast Shoal area. High primary productivity, shallow, slow moving water and periodic mixing allow organic matter to reach the bottom where it accumulates in depressions formed by dense concentrations of clams and barnacles. These animals may also concentrate organic material in the form of feces retained in the depressions. Collectively, these conditions influence the benthic community (Coughlan, 2002).
- The benthic community of the Southeast Shoal area may be considered exceptional due to high benthic biomass, high productivity, individual animal abundance, diversity and endemic species. Nesis (1965) compared Newfoundland-Labrador region benthos to those of other highly productive seas such as the Barents Sea,

Bering Sea and the Sea of Okhotsk and concluded: “The shallow of the Grand Bank of Newfoundland, where the biomass reaches 5 kg/m^2, is one of the richest areas of all the seas (Menon & MacDonald C.E., 1978).” (Coughlan, 2002).

- The benthic community of the Southeast Shoal area has been noted as the most highly productive on the Grand Banks, and exceptionally high benthic biomass estimates indicate the community is possibly significant on an international scale. Some benthic species sampled in the Southeast Shoal area are endemic to the northwest Atlantic (Coughlan, 2002). (Score 6)
- Such productivity may contribute to why this area is a noted nursery ground for American plaice, yellowtail flounder, and Atlantic cod (Walsh et al., 2001).
- “Benthos” is listed as an ESS (**add 1 point**).

Score 7

<u>Sensitivity:</u> (8 + 6 + 7)/3 = 7

<u>Risk of Harm:</u> MoI x S= 7.2 x 7 = 50.4

Certainty Checklist

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

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

Y/N

N Is the score supported by a large body of information?
Y Is the score supported by general expert agreement?
Y Is the interaction well understood, without major information gaps/sources of error?
Y Is the current level of understanding based on empirical data rather than models, anecdotal information or probable scenarios?
Y Is the score supported by data which is specific to the region, (EBSA, LOMA, NW Atlantic?
Y Is the score supported by recent data or research (the last 10 years or less)?
Y Is the score supported by long-term data sets (ten year period 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: High

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

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

Suggest possible research to address uncertainty.

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Summary Table: Benthic biomass on the Southeast Shoal and Tail of Grand Banks.

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	10	9	10	8	**7.2**	8	6	7	**7**	**50.4**	**High**
									Cumulative CP Score	**50.4**	