dragging our assets

TOWARD AN ECOSYSTEM APPROACH TO BOTTOM TRAWLING IN CANADA

David Suzuki Foundation

SOLUTIONS ARE IN OUR NATURE

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Dragging Our Assets:
Toward an Ecosystem Approach to Bottom Trawling in Canada

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WRITTEN BY: Scott Wallace, PhD

David Suzuki Foundation sustainable fisheries analyst Scott Wallace has a PhD in Resource Management from the University of British Columbia. His research interests include fisheries impacts on marine ecosystems, the use of marine protected areas as a tool for fisheries management, ecosystem-based fisheries management, and the conservation of marine species at risk.

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David Suzuki Foundation
2211 West 4th Avenue, Suite 219
Vancouver, B.C., Canada V6K 4S2
www.davidsuzuki.org
Tel 604.732.4228
Fax 604.732.0752

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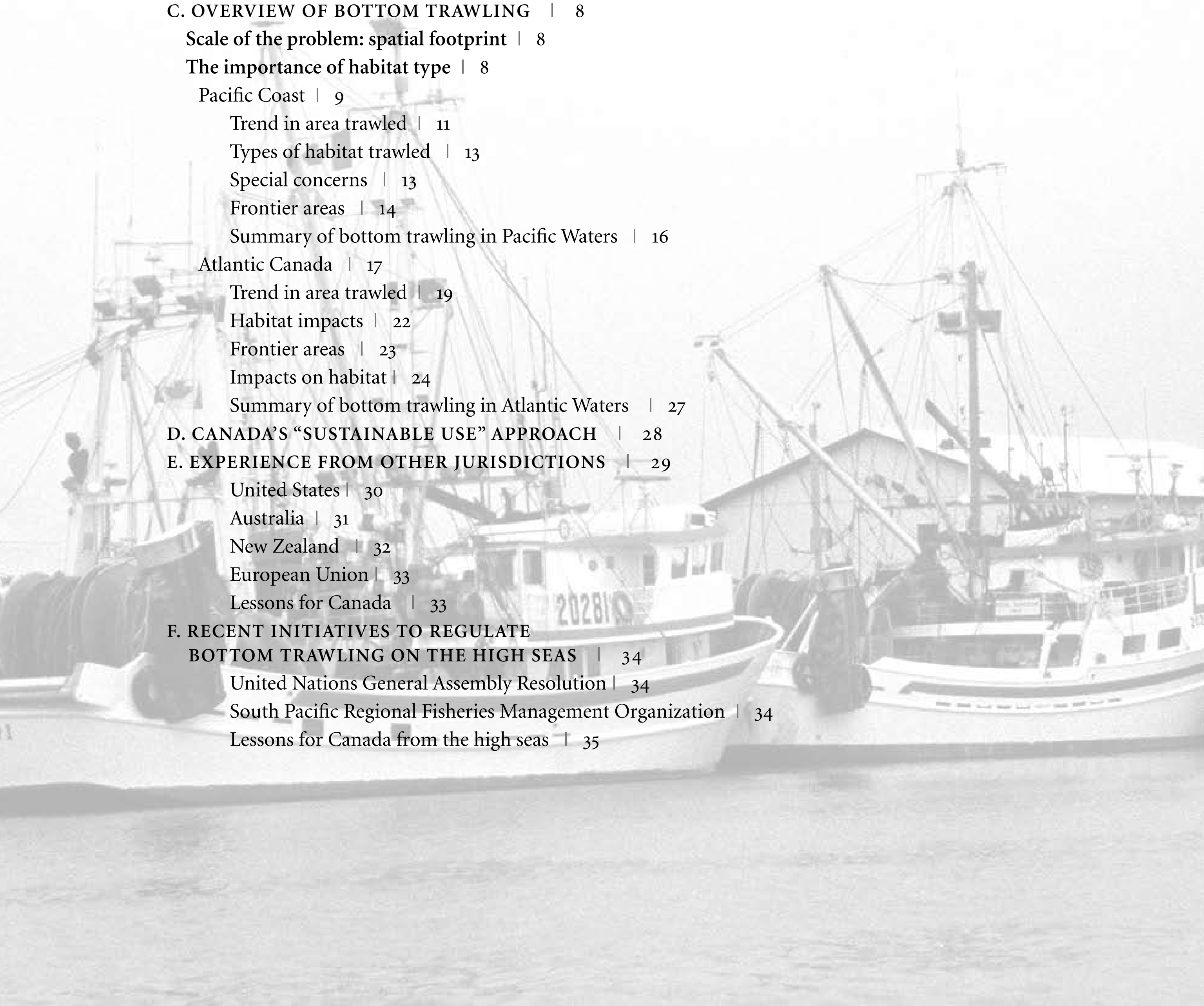

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Executive Summary

The scientific consensus is clear: bottom trawls are the most damaging type of fishing gear to benthic populations, communities, and habitats.

Canada's approach to addressing habitat impacts from bottom trawling is narrow in scope, does not measure up to international best practice, and does not fulfill the letter and spirit of international agreements made by Canada.

Canada, unlike other progressive fishing nations, refuses to formally recognize that bottom trawling can be an ecologically destructive practice.

Canada's fisheries-management plans do not include habitat protection from fishing gears and do not consider the impacts of trawling on new or frontier areas.

Pacific Summary

Researchers found that 97 per cent of the area along the west coast of Vancouver Island in the depth range of 150 to 1,200 metres has been contacted by bottom-trawl gear over the past decade based on presence and absence of trawling in one-square-kilometre grid cells.

Given that the most sensitive habitats are destroyed by the first few fishing events, it is unlikely that any large tracts of coral and sponge habitat still exist along the west coast of Vancouver Island.

In Canada's Pacific waters, bottom trawling is highly concentrated, with the top 90 per cent of the effort being distributed over only 28 per cent of the area fished and the top 50 per cent of effort being distributed over only six per cent of the area fished. Clearly, the footprint of the trawl fishery can be reduced while maintaining access to the resource.

In recent years, the intensity (effort) and annual area trawled by British Columbia's bottom-trawl fisheries (groundfish and shrimp) have been reduced.

Atlantic Summary

Following the initial groundfish moratoria in 1992, trawling effort has expanded to deeper waters and areas further north, as fisheries focused on new target species (northern shrimp and Greenland halibut).

Fishing in previously unfished areas continues to have irreversible impacts on large areas of seafloor habitat – as is indicated by sponge and coral bycatch.

Trawl effort has decreased in Atlantic Canada predominantly as a result of groundfish stock collapses.

Recommendations

Canada must:

- Reduce the level of fishing and spatial extent of fishing gears recognized to have the most severe impacts on marine biodiversity with the objective of significantly reducing and limiting the impact to natural habitats.
- Identify the extent of trawling by habitat type for Canada's oceans.
- Identify the boundaries of frontier areas (untrawled areas) in all three oceans, based on historical and current use.
- Immediately prohibit expansion of bottom trawling into frontier areas consistent with interim measures found in the *UN Sustainable Fisheries Resolution.*
- Significantly reduce the use of bottom trawling in deepwater habitats.
- Impose an interim moratorium on bottom trawling in *oxygen minimum zones* (areas where the oxygen saturation is the lowest) until sufficient scientific research into chemical and biological processes in these habitats have been undertaken.
- Prohibit the use of bottom trawls in "sensitive areas" (i.e., corals and sponges).
- Zone and restrict trawling to areas of highest historical fishing effort.
- Zone and restrict trawling to areas of high natural disturbance.
- Implement a system of no-trawl zones for all habitat types similar to the management found in New Zealand, where all types of benthic habitats will receive some level of protection from fishing-gear impacts.
- Preferentially allocate resource access to gear types that significantly reduce and limit the potential impact on benthic habitats.

Introduction

In 1376, England's House of Commons became the first government in history to be petitioned on concerns surrounding the ecological impacts of bottom trawling *(see page 2)*.[1] At that time it was recognized that trawling "destroys the living slime and the plants growing on the bottom under the water".[2] France went so far as making trawling a capital offence in 1584. Four hundred and twenty-three years later, governments of all coastal nations continue to be petitioned to regulate these impacts. With each passing year, the scale of the impact is broadened as technology furthers the boundaries accessible to bottom trawling, from distant seamounts to deep tracts of continental slopes. While the geographical scale of bottom trawling has continued to increase, so has the scientific understanding of the detrimental impacts of bottom trawling on seabed habitats. Bottom trawling is responsible for loss of seafloor structure and complexity through the removal of structure-forming organisms and smoothing of the substrate. This habitat in turn is critical for several species, including some targeted by fisheries. As a result of this fundamental change in the seafloor, the ecological community in heavily trawled areas shifts to favour species adapted to high disturbance. The question is not whether bottom trawling has an impact on seabed habitats and species, but rather how can countries best reduce and limit these impacts.

Some countries, such as the United States, have formally recognized the link between impacts from bottom trawling to fish habitat and the long-term viability of fisheries resources. In response, the U.S. has closed extensive marine areas to this method of fishing, including a recent decision in June 2007 to close over half of the Bering Sea to bottom trawling.[3,4] Canada has not taken any significant action to demonstrate recognition of the connection between the destruction of fish habitat from fishing practices and the sustainability of fisheries.

For nearly two decades, conservation groups have been pressuring the Canadian government to address concerns about the negative environmental effects of trawling. In response, Fisheries and Oceans Canada has begun a process aimed at developing a policy to address commercial fishing-gear impacts on benthic habitats. To guide the formation of this policy, Canada has committed to using an "ecosystem approach" consistent with the principles of Canada's *Oceans Act* *(see page 3)*.[5] Although the *Oceans Act* has been law for 10 years, "ecosystem approaches" have only recently been considered in the management of Canada's marine fisheries.

This report has been produced to advance the dialogue about the effects of trawling and to provide recommendations that would facilitate the adoption of an ecosystem approach in Canada's fisheries and limit the negative effects of bottom trawling in Canada. The report provides workable recommendations in the context of the available science, international fisheries management precedents, and the socioeconomic realities of the Canadian fishery. The recommendations do not call for a ban on bottom trawling in Canadian waters. However, if an ecosystem approach is to be realized, significant changes in bottom-trawl practices will need to ensue.

WHAT IS BOTTOM TRAWLING?

Bottom trawling is a non-selective fishing method that involves towing nets along the seafloor. It is also referred to as "dragging" or "mobile bottom gear". In Canada this practice is broadly broken down into two forms: beam and otter trawls.

Beam trawling gets its name from the long metal beam used to hold open the mouth of the net. Beam-trawl vessels are typically small and in Canada are most often used for harvesting shrimp species.

Otter trawling derives its name from the "otter-boards", also called doors, that are used to keep the mouth of the net open. As the doors are towed along the bottom, the pressure from the water forces them outward, thereby pulling the net open. In Canada, otter trawling is the preferred method for capturing groundfish species and northern shrimp in Atlantic Canada.

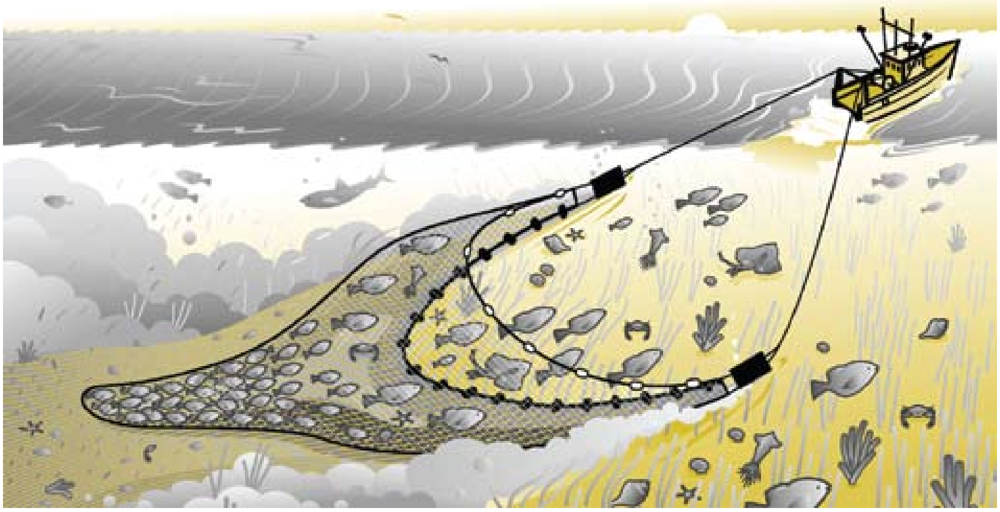

Image Credit: Joe Shoulak (www.joeshoulak.com)

WHAT IS AN ECOSYSTEM APPROACH?

Although no universally accepted definition of an *ecosystem approach* or *ecosystem based management* exists, general principles relevant to the management of bottom-trawling impacts include[6,7]:

- Conserve the biodiversity of the system to maintain the natural resilience of the ecosystem.
- Conserve and restore the physical and chemical properties of the ecosystem, including seafloor features and water quality.
- Maintain the productivity of the ecosystem through maintaining trophic structure, primary productivity, and natural population age structures.
- Acknowledge that linkages between ecosystem components, such as food-web structures, predator-prey relationships, habitat associations, and other biotic and abiotic interactions, should be incorporated into management decisions.
- Use conservative management when threats to the ecosystem are uncertain (Precautionary Approach).
- Recognize that ecosystem processes occur over wide spatial scales and that management plans must be spatially defined.

Ecological Impacts from Bottom Trawling

A growing body of scientific literature articulates the ecological damage associated with bottom trawling.[8,9,10,11] Scientists agree that bottom trawling is the most damaging gear type to benthic populations, communities, and habitats.[12] As trawl doors and nets are towed along the bottom, a variety of impacts to seafloor habitat will occur along with changes in water-column characteristics due to the suspension of nutrients and sediment from the seafloor. Furthermore, the food web itself is altered through the landing of targeted species, discarding of unwanted species, mortality and injury of species escaping trawl nets, and the alteration of the relative abundance of various species groups (community structure). The severity and longevity of the impact varies depending on factors such as depth, substrate, fishing intensity (i.e., the frequency of trawling), natural disturbance regime, and the life histories of the species being impacted. For the purpose of this report, impacts are broadly divided into direct effects, indirect effects, and unknown effects. The information presented below is intended to provide only a brief summary of the scientifically accepted ecological impacts associated with bottom trawling.

Direct Effects

HABITAT LOSS

The alteration and, in some cases, destruction of seafloor habitat, is a well-recognized consequence of bottom trawling. Many studies and reviews have concluded that trawling results in a loss of seafloor structure and complexity through the removal of structure-forming organisms (e.g., corals, hydroids, and sponges) and smoothing of the substrate (e.g., removal of boulders, flattening of sand waves) (Figure 1).[13] The exact role of seafloor structure and complexity is poorly understood but is thought to be vitally important to overall food-web functioning. The extent of the impact on structure-forming organisms is a function of the recovery time of the species involved and the interval between trawling. The greatest impacts to sensitive communities comprising long-lived, slow-growing species are caused by the first few trawling events. Recovery of habitats to a "pre-trawled" state may take days to centuries, depending on the structure of the ecological community being damaged.

CHANGE IN SPECIES COMPOSITION AND DIVERSITY

Repeated trawling in a given area causes a shift from communities dominated by species with large body size to increased abundance of species with a smaller body size. The resultant community in a heavily trawled area is one dominated by species that are well adapted to regular physical disturbance and often quite different from those in an undisturbed area. For example, along the coast of Oregon, a recent study observed 23% more fish over untrawled compared to trawled seafloors, and recorded 27 fish species on untrawled bottoms, but only 19 species on trawled seafloors.[14] Typically, seafloors rich in habitat diversity and complexity can support a greater diversity of species. Trawling typically removes this complexity, resulting in a general decline in species diversity in the trawled area (Figure 1).

Figure 1. Sponges, corals, and Greenland halibut captured in 2006 by bottom trawling in a "frontier area" in Canada's North Atlantic waters. Photo credit: DFO

REDUCTION IN OVERALL PRODUCTIVITY

Productivity is the measure of an ecosystem's ability to produce biomass or living matter over a given time period. Long-term trends in the productivity of benthic environments damaged by trawling are difficult to discern due to a masking effect by larger-scale natural events. Nonetheless, several studies have found declines in overall productivity in heavily trawled areas.[15]

NATURAL DISTURBANCE

Not all seafloor habitats are exposed to the same natural disturbance regimes. Natural disturbance is a function of depth, substrate type (e.g., sand, gravel, boulder), and exposure to waves. Communities found in stable substrates with low natural disturbance (e.g., deep ocean) are particularly vulnerable to the impacts of trawling. It is important to note that some benthic communities actually stabilize the substrate from natural disturbance. Removal of these communities through trawling can change the ability of the community to withstand natural disturbance similar to the way terrestrial vegetation can prevent erosion on land.

Indirect Effects

SEDIMENT PROCESSES

The towing of the net and trawl doors along the ocean floor results in the suspension of sediment, organic matter, and nutrients in the water column (Figure 2). The environmental effects resulting from the suspension of this matter are difficult to ascertain. One thing is certain: the magnitude of this type of cycling does not occur naturally except in the most extreme wave-impacted environments. Rates of nutrient cycling can have profound impacts on ecosystem function depending on the natural background level of nutrient and sediment fluxes. In evaluating the disturbance by trawl gears, sediment processes must be considered and precautionary management should be applied.

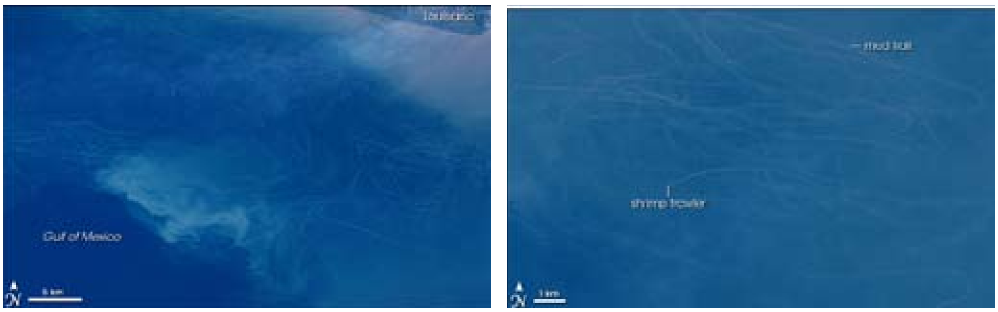

Figure 2. Satellite image of mud trails left by shrimp trawlers in the Gulf of Mexico.[16]

FOOD WEB AND COMMUNITY STRUCTURE IMPACTS

It is well documented (see Direct Effects) that trawling changes the structure of the benthic community in trawled areas. This change in structure may have cascading ecosystem consequences depending on the scale of the trawl impact relative to the ecosystem processes. For example, benthic habitats are used as shelter or food for several juvenile fish, some of which move far away from the benthic habitat as they mature. If bottom trawling impacts the habitat and survivorship of that particular species, there is potential for far-reaching ecosystem impacts.

Unknown Effects

The intuitive and easily observed impacts associated with dragging heavy equipment along the ocean floor, such as the destruction of sensitive habitat features and reduction in habitat complexity, are relatively easy to document. However, the far-reaching ecosystem consequences of nutrient and sediment suspension and alteration of food-web structure are much more difficult to fully understand. Because of these unknowns, Canada's fishing policy should address the uncertainty surrounding bottom trawling by implementing the *Precautionary Approach* as stated in the *Rio Declaration on Environment and Development.*[17] Under this approach, trawling in frontier areas, sensitive habitats, and deepwater ecosystems would necessarily be restricted. In other areas, including presently and historically trawled areas, precautionary management would require a reduction and limiting of the current area or "footprint" trawled.

Scale of the problem: Spatial extent or footprint

When trying to understand the ecological damage caused by bottom trawling, the first question that needs to be answered is "How much area is being trawled?" Although this appears to be a basic question, the answer is not known for most of Canada's trawling grounds. Any analysis attempting to quantify the total trawl area is complicated by the assumptions used to measure the area affected by trawling. One definition of "area trawled" or the "footprint" is the cumulative area on the seafloor that has been directly contacted by the net and doors of the trawl gear. Another definition includes the distance in which suspended sediment is transported. Although these definitions may capture the direct ecological effects of bottom trawls, the data required for this level of detail are often not available. In some trawling grounds, including those in Atlantic and Pacific Canada, there are several thousand trawl tows per year. Most published accounts of trawl footprints use surrogate measures based on assumptions surrounding the start and end point of a trawl tow and assign some spatial assumption around these points.

The importance of habitat type

The "area trawled" may not, in itself, be a suitable indicator of ecological impact without some context regarding the contribution of the trawled area to other ecosystem processes. The most relevant proxy of ecosystem processes is habitat type.[18] Claims such as the one made by the B.C. groundfish trawl industry that "vessels fish on less than 6% of the ocean floor off the coast of British Columbia" has no ecological meaning unless the composition of the six per cent is understood.[19] The statement is roughly true, but if the analysis is refined to habitat types and depth strata, then the six per cent value is grossly misleading (Figure 3, Table 1) and clearly does not give a complete picture of the ecological relevance of trawling.

Seventy-five per cent of Canada's Pacific Exclusive Economic Zone is considered as abyssal waters greater than 1,000 metres, which is mostly beyond the current maximum trawling depth in B.C. of 1,200 metres. The actual area trawled in non-abyssal waters is about 36 per cent, or six times greater than the area claimed by industry. Ecosystem-based policy and regulation require a better understanding of trawl distribution in relation to habitat type on both the Atlantic and the Pacific coasts as a necessary first step.

Pacific Coast

In November 2006, DFO produced a paper examining the spatial extent of bottom trawling by commercial groundfish fisheries in Canada's Pacific waters.[23] This analysis concluded that between 1996 and 2005, a cumulative total of 38,320 square kilometres of the ocean floor had been contacted by bottom trawling based on one-by-one kilometre grid squares.[24] Further analysis by the David Suzuki Foundation found that the spatial extent of bottom trawling was very intensive in some depths and some areas. For example, along the west coast of Vancouver Island in the depth range of 150 to 1,200 metres, 97 per cent of the area had been contacted by bottom trawl gear over the last decade based on presence and absence of trawling in one-square-kilometre grid cells (Table 1, Figure 3). In the depth range of 150 to 500 metres, 100 per cent of the area had been contacted by trawl gear over this same time period. Bottom trawling has been conducted for approximately 60 years throughout much

PACIFIC COAST BOTTOM TRAWL PROFILE

FISHERIES USING BOTTOM TRAWLING IN PACIFIC CANADA: groundfish and shrimp.
PERCENT OF TOTAL SEAFOOD LANDINGS BY BOTTOM TRAWL:20 ~17 per cent

Groundfish

NUMBER OF GROUNDFISH BOTTOM-TRAWL LICENCES: 142
NUMBER OF ACTIVE GROUNDFISH BOTTOM-TRAWL LICENCES: ~74
PRIMARY SPECIES CAUGHT (DESCENDING ORDER): Arrowtooth flounder, Pacific ocean perch, Dover sole, yellowtail rockfish, yellowmouth rockfish, lingcod, rock sole, spiny dogfish, silvergray rockfish, big skate, Pacific cod and English sole.
TOTAL FOOTPRINT (SEE DESCRIPTION IN TEXT): ~38,000 km^2
HOURS OF BOTTOM TRAWLING PER YEAR: 30,000 - 40,000
HABITAT TYPE TRAWLED21: Sand and gravels (~40 per cent of trawled area), mud (30 per cent), bedrock (~25 per cent), other (~five per cent).
AVERAGE CATCH: 38,500 tonnes (~23 per cent of catch is discarded).

Shrimp Trawl

NUMBER OF SHRIMP TRAWL LICENCES: 248 eligible licenses
NUMBER OF ACTIVE SHRIMP TRAWL LICENCES[22]: ~80
PRIMARY SPECIES CAUGHT (DESCENDING ORDER): smooth pink, northern pink, and sidestripe shrimp
TOTAL FOOTPRINT: Unknown
SHRIMP TRAWLING GROUNDS AVAILABLE: ~11400 km^2
HOURS OF TRAWLING PER YEAR: Decline from ~84,000 hrs/yr to ~23,000 hrs/yr (2005)
HABITAT TYPE: soft bottoms, mud and sand

of B.C.'s continental shelf; however, precise geo-referenced data (i.e., GPS coordinates of trawl tows) has only been systematically collected for a decade. Trawling effort (i.e., number of hours of trawling) was historically much higher than it is today and therefore it is fair to assume that these areas have been trawled several times during the past 60 years. Given that the most sensitive habitats are destroyed from the first few fishing events, it is unlikely that any large tracts of sensitive habitat still exist along the west coast of Vancouver Island in the depth range of 150 to 1,200 metres.

TABLE 1

Table showing the area bottom trawled in British Columbia by depth strata and Pacific Fisheries Management Areas from 1996 to 2005. Trawled area based on trawl tows transecting one-square-kilometre grid squares.[25] The data in these tables were derived from an overlay of a GIS shapefile of management areas (provided by DFO) and a bathymetry combined with published outputs of cumulative trawled area by management area.[26]

TOTAL AREA (KM2) IN DEPTH STRATA AND PFMA					
Depth	3CD	5AB	5CD	5E	All areas
0-150	13283	14771	27833	2523	58411
150-500	3746	14574	14434	3817	36570
500-1200	4996	2539	40	3583	11158
All Depths	22025	31884	42307	9924	106140

CUMULATIVE NEW AREA (KM2) TRAWLED (1996-2005) BY DEPTH STRATA AND PFMA					
Depth	3CD	5AB	5CD	5E	All areas
0-150	4305	3918	5550	10	13783
150-500	3762	7408	4249	1869	17288
500-1200	4677	871		1704	7249
All Depths	12744	12194	9799	3583	38320

PERCENTAGE OF AREA TRAWLED BY DEPTH STRATA AND PFMA (1996-2005)					
Depth	3CD	5AB	5CD	5E	All areas
0-150	32	27	20	0	24
150-500	100	51	29	49	47
500-1200	34	0		65	
All Depths	58	38	23	36	36

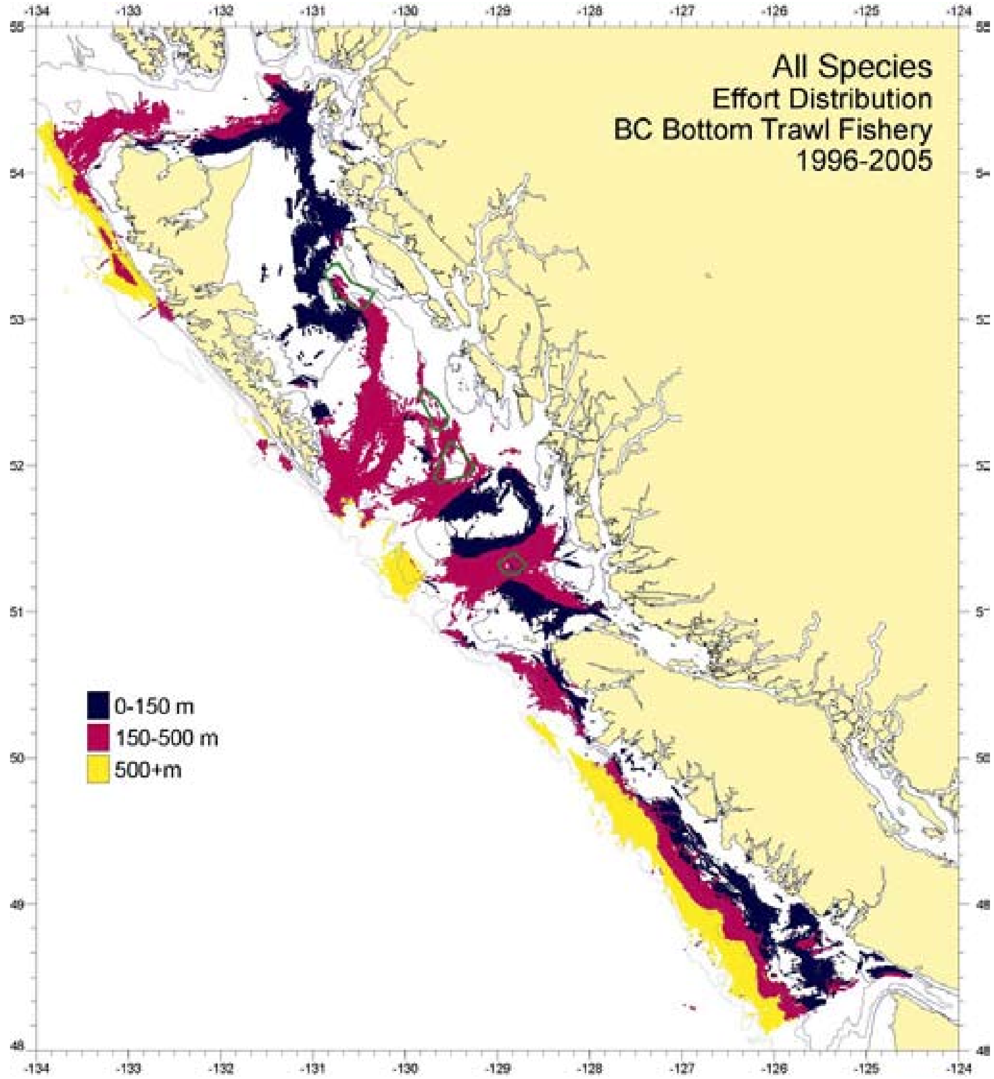

Figure 3. Area trawled by B.C.'s groundfish bottom-trawl fishery based on presence/absence of trawl tows transecting one-km^2 grid cells. Figure source: Sinclair (2007).

TREND IN AREA TRAWLED

Generally speaking, since 1996 there has been a downward trend in the total annual area trawled in Canada's Pacific waters (Figure 4). This trend is a function of increasing consolidation in the groundfish trawl fleet resulting from a new management plan imposed on the fishery in 1996. Since that time, the number of bottom-trawl vessels fishing has dropped from approximately 100 to 120 in the late '90s to 74 in 2006.[27] The reduction in the number of vessels fishing has resulted in a decline in the total number of hours fished (Figure 5). The exact amount of area trawled by shrimp trawlers in Canada's Pacific waters is unknown and needs to be determined. The maximum area available to shrimp-trawl vessels is about 11,400 square kilometres.[28] The total hours of fishing in the shrimp-trawl fishery have declined by about 72 per cent since its peak in 1996 due to combined effects of declining market conditions, fuel prices, and increased management fees (Figure 6). The decline in fishing effort has likely resulted in a reduction in area trawled.

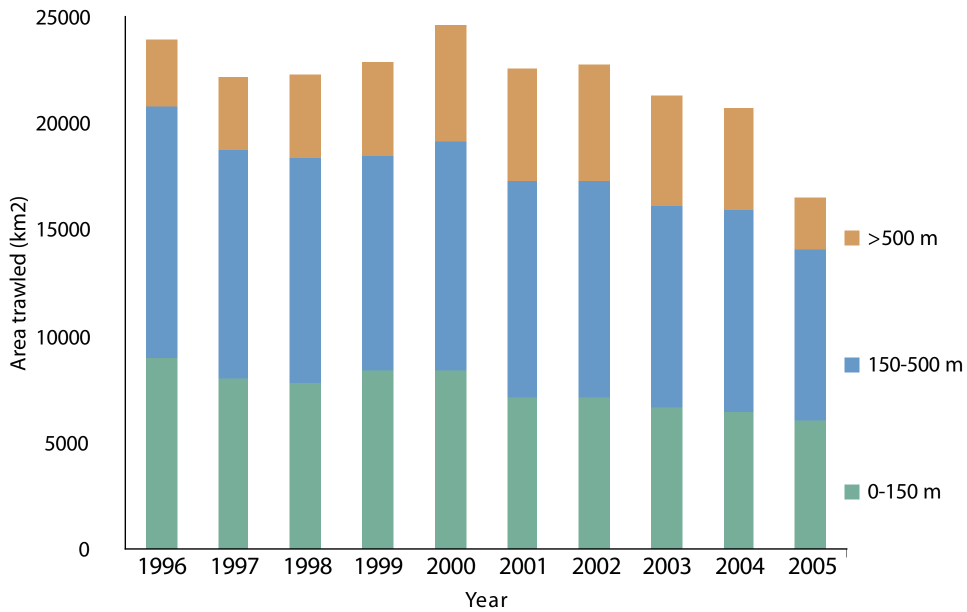

Figure 4. Annual area trawled (km^2) by commercial groundfish bottom trawlers in Canada's Pacific waters. Figure assembled from data published in Sinclair (2007).

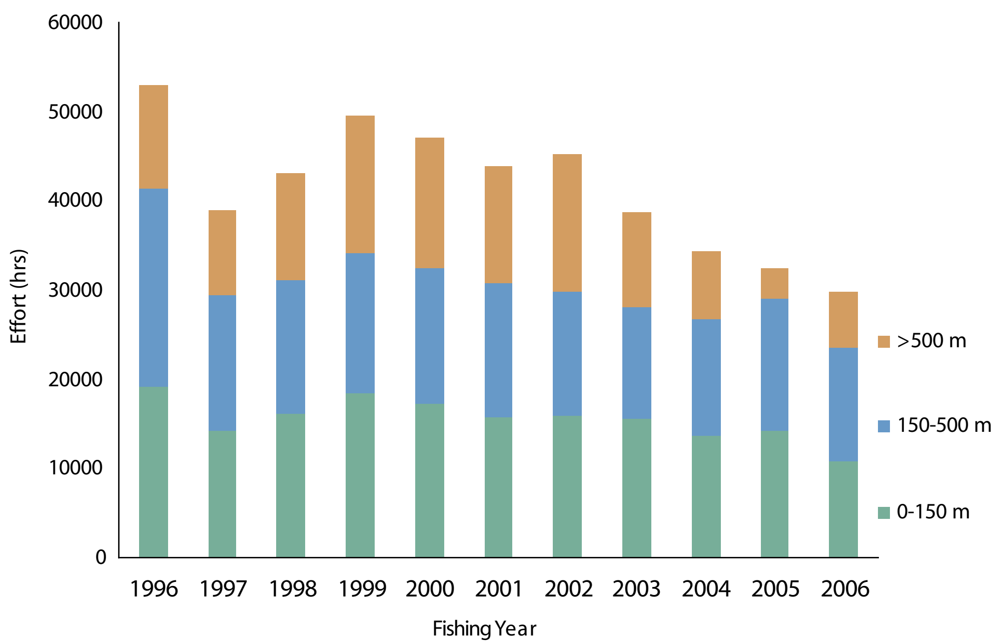

Figure 5. Bottom trawling effort (hours) in Canada's Pacific groundfish fisheries. Data source: Fisheries and Oceans Canada PacHarvTrawl database[29]

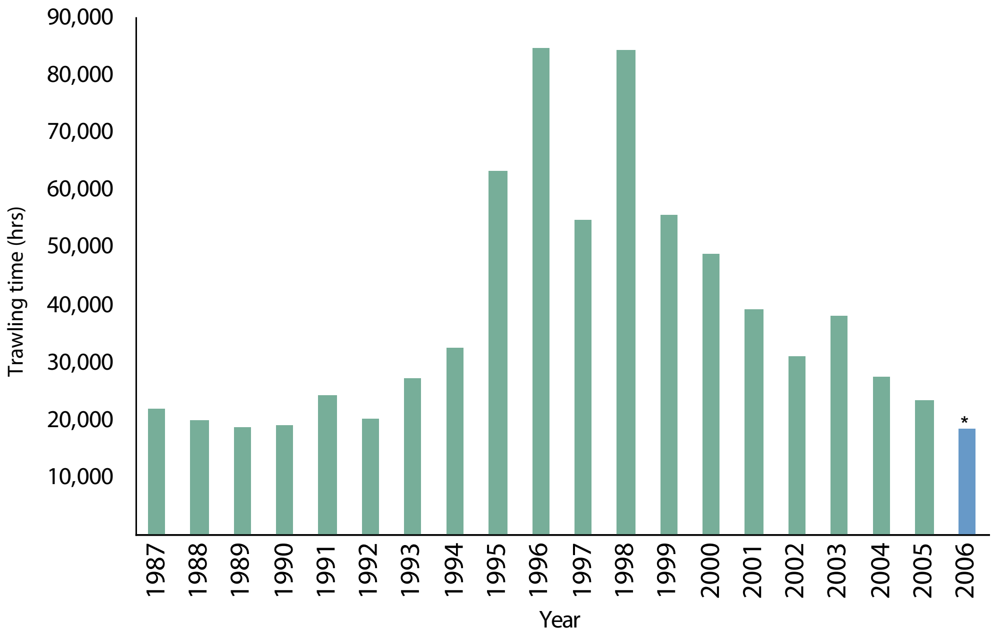

Figure 6. Total trawling effort (hours) in Canada's Pacific shrimp trawl fishery. Note: 2006 data is preliminary. Data source: Fisher logbook data, FOC.

TYPES OF HABITAT TRAWLED

Several habitat-related concerns associated with groundfish bottom trawling in B.C. have been raised. To date, only one published analysis has attempted to overlay trawling effort with habitat type (geological data). It was found that trawling effort in B.C. primarily occurs over sand and gravel substrates (about 40 per cent) followed by mud (about 30 per cent) and bedrock (about 25 per cent).[30] The authors did not calculate the area trawled relative to the total amount of each habitat type. The shrimp-trawl fishery is confined to sandy-mud bottoms at depths of 40 to 200 metres.

Canada could learn from New Zealand's approach to managing trawl impacts. In New Zealand, fisheries managers are applying a *Habitat Standard* to ensure that a defined amount of each seabed habitat will remain free of damage from trawling and other human activities.[31] This approach will ensure that the effects of fishing do not stop seabed habitats from functioning and contributing effectively to fish production and the marine ecosystem. The use of *Habitat Standards* recognizes that all habitats, not only sensitive ones, are vulnerable to both the known and unknown consequences of fishing-gear impacts.

SPECIAL CONCERNS

A special concern on Canada's Pacific Coast is the impact that bottom trawling has on sensitive habitats, in particular the hexactinellid glass sponge reefs in Hecate Strait. These globally unique sponge reefs are thought to be about 9,000 years old and cover an area of about 1,000 square kilometres. Analyses using observer data have shown that the sponge reefs and other areas of high sponge concentrations have been damaged by the groundfish bottom-trawl fleet and continue to be impacted but to a much lesser degree. Damage has also been verified by underwater submersible observations (Figure 7). In 2007, DFO increased protection for these areas by extending the boundaries of trawl-fishing closures. It is anticipated that these measures should now fully protect the known extent of the sponge reefs from direct trawling impact. The degree to which resuspended sediments from trawling activity close to the boundary impact the sponge reefs is not known.[32] This is an area requiring research and potential future modifications to trawl management.

Several other smaller reefs, primarily in the Strait of Georgia, have been identified in Canada's Pacific waters. DFO is in the process of developing a conservation strategy for coldwater corals and sponges in order to have a systematic approach to managing them. However, to date, there has been virtually no progress on this strategy.

Figure 7. Images of untrawled and trawled sections of the hexactinellid sponge reefs in Hecate Strait, British Columbia. Photo credits: Dr. Manfred Krautter, Universitaet Hannover, Germany.

FRONTIER AREAS

On Canada's Pacific Coast, most suitable trawling grounds have already been trawled (under present economic and technological conditions). Trawling is now largely confined to depths less than 1,200 metres. All seafloor deeper than 1,200 metres is considered frontier area.

Prior to 1996, very little directed trawl effort was in waters deeper than 500 metres. Over a period of only a decade, the trawl fishery expanded into 7,000 square kilometres of new sand and mud bottom habitats between depths of 500 and 1,200 metres in pursuit of the longspine thornyhead. Most of the accessible habitat in this depth range was fished during the rapid expansion of the fishery. Currently, there is no depth restriction on the trawl fishery and no restriction on further expansion. The depleted status of the longspine thornyhead combined with surging fuel prices and increased value of the Canadian dollar has reduced the incentive for expansion in the short term. The ecological impact of Pacific

Canada's deep-sea (>500 metres) trawl fishery is poorly understood; however, based on experience elsewhere the habitat and water quality impacts are likely significant due to the low natural disturbance of deep-sea habitats.[33]

Annually, there are still incremental incursions into new areas by the groundfish trawl fishery. Since 2003, an additional 703 square kilometres (0.5 per cent of total area trawled) of seafloor area has been trawled that had not been accessed from 1996 to 2002 (Figure 8).[34] It is unknown whether these "new" areas had been accessed in the 50 years of trawling on the Pacific Coast prior to 1996. In the short term, improved technologies allowing incursions around the edges of previously untrawlable areas may lead to additional expansion. Under present management and market conditions there is little incentive for expanding into large unexplored areas; however, these conditions can change over relatively short periods. Similarly, the shrimp-trawl fishery is largely confined to traditional areas with no immediate incentive for further expansion.

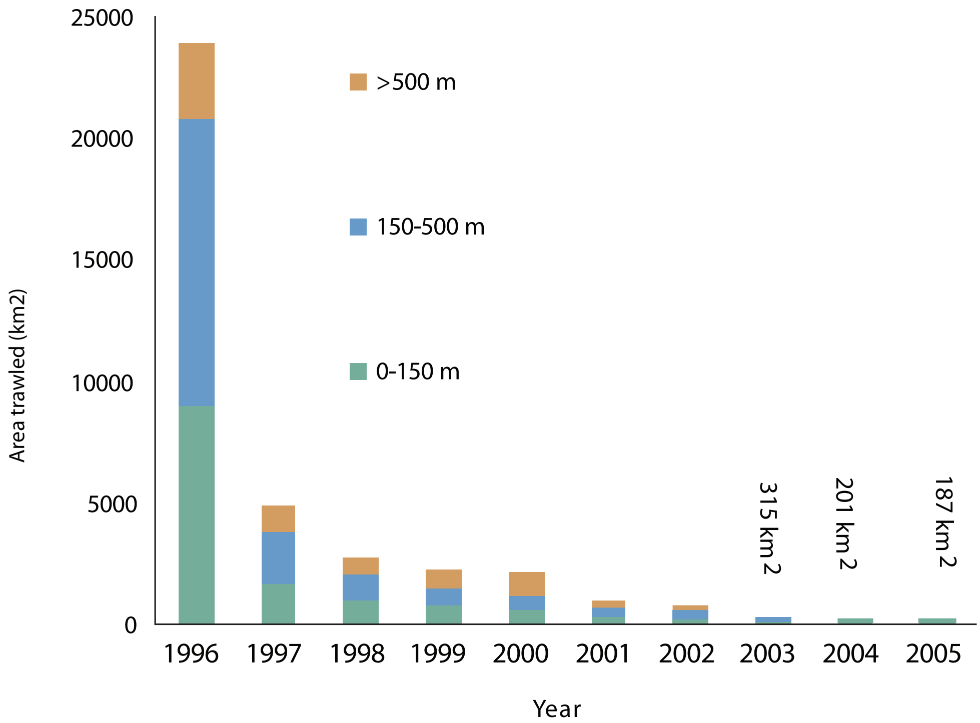

Figure 8. Annual incremental new area trawled (km^2) by groundfish trawlers on Canada's Pacific Coast beginning in 1996 based on presence/absence of trawl tows through one-km^2 grid cells. Data source: Sinclair (2007).

Deep Sea Longspine Thornyhead Fishery

BEGINNING IN 1996, British Columbia's groundfish bottom-trawl fishery started making regular trips into waters deeper than 500 metres to pursue a little-known fish species called the longspine thornyhead. Commercial catches peaked only three years later in 1999, and since that time catch rates have declined dramatically coast-wide suggesting a rapid reduction in the abundance of this species. The reduction has been so severe that the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recently listed this species as *Special Concern*.[35]

The preferred depth of the longspine thornyhead is between 600 and 1,200 metres, with the highest commercial catch rates in British Columbia occurring at about 855 metres depth.[36] Off the West Coast of Canada, oxygen saturation in the waters between 600 and 1,000 metres is extremely low and is technically classified as the *oxygen minimum zone*.[37] While the depletion of the longspine thornyhead has been documented, the ecosystem consequences of both habitat damage and releasing sediment comprising organic matter into an already oxygen-poor environment are unknown. Empirical evidence from elsewhere shows that oxygen levels in the water column can be reduced after bottom trawling.[38] The depletion of oxygen may be caused by an increased rate of bacterial respiration or alternatively through chemical consumption through reactions with hydrogen sulfide and methane. Research examining the impact of bottom trawling on oxygen levels in the *oxygen minimum zone* has not been undertaken.

The geographical scale of this fishery relative to the available habitat area in the depth zone is significant. The longspine thornyhead is sparsely distributed over sandy bottoms. To make the trawl tows cost-effective at this low density, the tows are on average seven hours long and cover over 30 kilometres.[39] As of May 2007, more than 15,000 trawl tows have been directed at the longspine thornyhead over 10 years, covering a distance of nearly 500,000 kilometres. Between 1996 and 2005, 86 per cent of the catch was taken from the continental slope off the west coast of Vancouver Island. In the process 94 per cent of the seafloor in the depth range of 500 to 1,200 metres has been trawled in this area.[40]

Clearly, this fishery is not managed with broader ecosystem consequences in mind.

SUMMARY OF BOTTOM TRAWLING IN PACIFIC WATERS

Generally, the intensity (effort) and annual area trawled by British Columbia's bottom-trawl fisheries (groundfish and shrimp) have been reduced over the past few years. The total volume of fish caught by groundfish bottom-trawl fishery has remained stable at about 39,000 tonnes for the past 10 years. Approximately 23 per cent of the catch is discarded. Under present management and market conditions there does not appear to be any immediate concern regarding the expansion of the area trawled; however, these conditions can change quickly and therefore immediate safeguards must be put in place. The expansion of the deepwater bottom-trawl fishery (> 500 metres) for longspine thornyhead during the late 1990s and early part of this decade is a clear example of how quickly a fishery can expand. Over the course of 10 years, this fishery impacted huge tracts of previously untrawled grounds (about 7,000 square kilometres) and depleted the abundance of the target species to the point of being listed as a *Species at Risk*. The ongoing ecological impacts with this fishery on the deep-sea continental slope ecosystem continue to be a concern, especially given the low natural disturbance regime (it is an area not adapted to large, frequent disturbances), extremely low oxygen concentrations, and massive change in community structure due the depletion of the predominant fish species.

Atlantic Canada

The Atlantic continental shelf (zero to 2,000 metres) is much larger than the Pacific shelf and covers about 1.3 million square kilometres. The width of the shelf extends a minimum of 175 kilometres from nearest land (off Labrador) to a maximum of 650 kilometres to the outer Flemish Cap (see figure 11). This shelf provides a very large and diverse fishing ground, including substantial area accessed by bottom trawling. Bottom trawling on the shelf is primarily for groundfish and shrimp.

Patterns of bottom trawling have changed over time as the fishery transitioned from one primarily fishing for Atlantic cod and other groundfish to one targeting shrimp and lesser amounts of groundfish, particularly in the years following the groundfish collapse (post-1992) (Figure 9). Trawling effort has decreased on the cod banks in those years; however, effort has also expanded to frontier areas as shrimp populations are sought.

ATLANTIC COAST BOTTOM TRAWL PROFILE

TYPES OF BOTTOM TRAWLING IN ATLANTIC CANADA: groundfish and shrimp
PERCENT OF TOTAL SEAFOOD LANDINGS BY BOTTOM TRAWL:[41] about 23 per cent

Groundfish
NUMBER OF GROUNDFISH BOTTOM-TRAWL LICENCES: Maritimes Region, about 467[42]
NUMBER OF ACTIVE GROUNDFISH BOTTOM-TRAWL LICENCES: Maritimes region, 166
PRIMARY SPECIES CAUGHT: Atlantic cod, redfish, witch flounder, American plaice, skate.
TOTAL FOOTPRINT (SEE DESCRIPTION BELOW): 1980s, about 390,000 square kilometers; present day, about 200,000 square kilometers. [43]
HABITAT TYPE TRAWLED: Not available

Shrimp Trawl
NUMBER OF SHRIMP-TRAWL LICENCES: Scotia Fundy, 23; Gulf, 29; Newfoundland and Labrador, 17
NUMBER OF ACTIVE SHRIMP-TRAWL LICENCES: Not available
PRIMARY SPECIES CAUGHT: northern shrimp
TOTAL FOOTPRINT: Unknown
HABITAT TYPE: soft bottoms, mud and sand

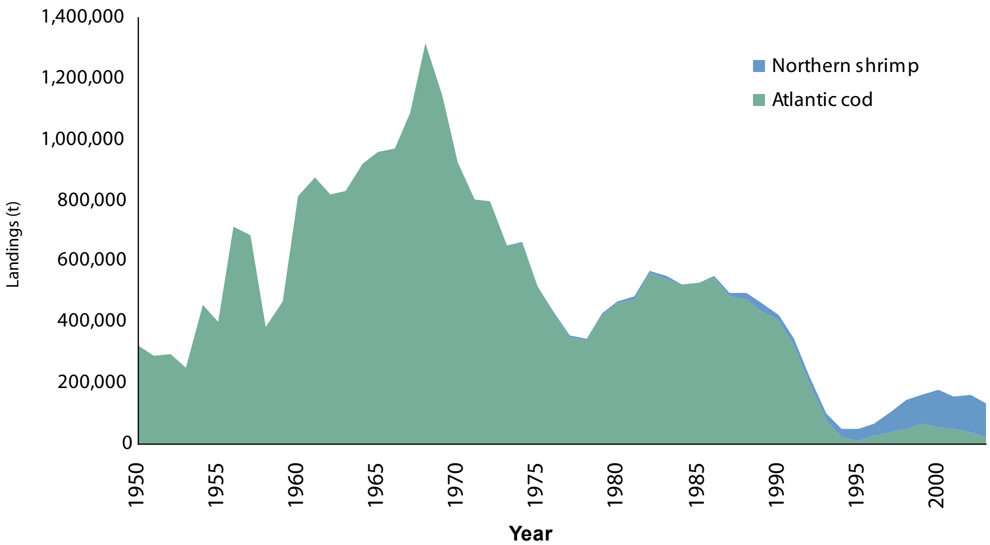

Figure 9. Landings (tonnes) of Atlantic cod and northern shrimp in Canada's Atlantic waters.

The Atlantic Region has four Fisheries and Oceans Canada science and management regions, and each region compiles and analyzes data separately. Recent analyses similar to the Pacific Coast, where area trawled information is available, is not currently available for the entire Atlantic Coast. The Scotia Fundy Region has assembled figures of landings broken down according to gear type[44] (Figure 10). Fisheries and Oceans Canada is currently undertaking a comprehensive assessment of the spatial distribution and impact of all bottom-contact fishing gears in Atlantic Canada. The results of this assessment should be available in late 2007.[45]

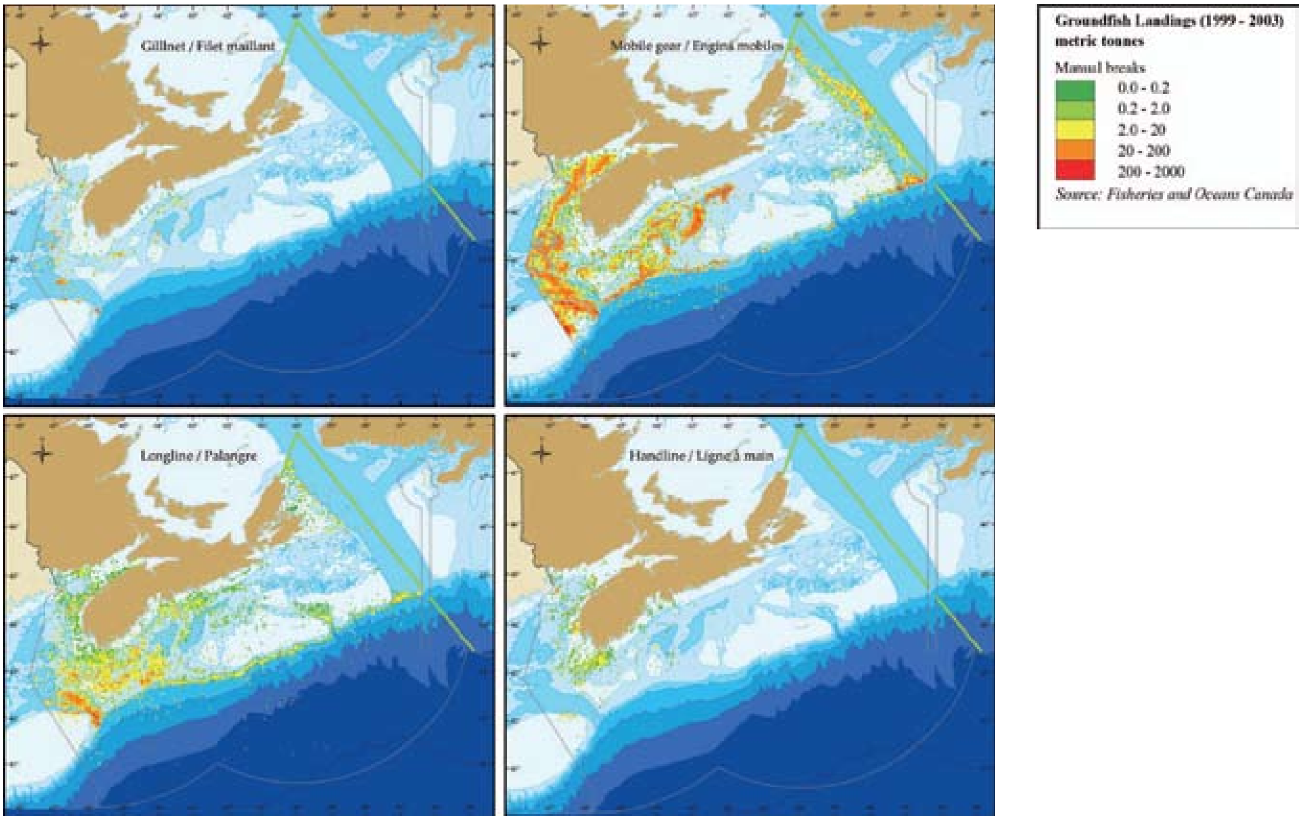

Figure 10. Landings of groundfish between 1999 and 2003 in the Scotia Fundy Region by gear type.
Note: mobile gear is bottom trawling.

TREND IN AREA TRAWLED

Only one study has been previously published on the distribution of all trawling effort in Atlantic Canada (Figure 11). The spatial extent of the trawl fleet is not well known prior to 1980. Throughout the early to mid-1980s, trawl intensity on the shelf was at its greatest in the recorded period (1980 to 2000). From 1980 to 1986, the area trawled decreased from about 390,000 square kilometres (38 per cent of total shelf area) to 290,000 square kilometers, or 27 per cent of total area. The area trawled decreased to a recorded low of 90,000 square kilometres (eight per cent of total area) in 1997 before increasing to 205,000 square kilometres (20 per cent) in 1999/2000 due to an expanding shrimp fishery.[46]

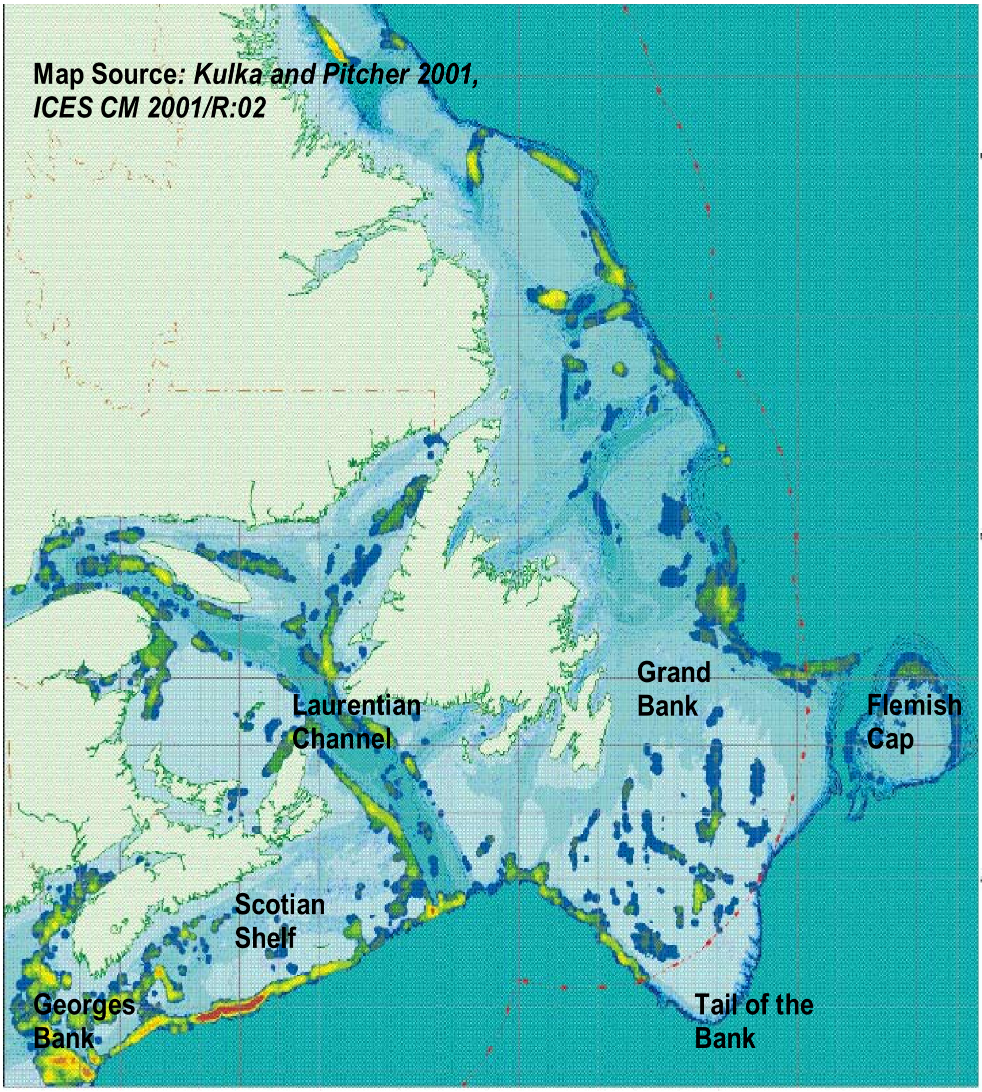

Figure 11. Map depicting persistent areas of high-intensity bottom trawling in the Atlantic over the time period 1990 to 2000. Legend: During time period, light blue-untrawled; dark blue-trawled once; green/yellow-trawled three to nine times; orange/red-area trawled 10 to 11 times.

In all 21 years of available data, the most used trawling grounds were centred on Georges Bank and the Scotian Shelf, extending in a continuous band along the outer Scotian Shelf to the southwest slope of the Grand Bank and extending to include the western slope of the Laurentian Channel (Figure 11). On the Flemish Cap, a shrimp fishery commenced in 1994 that greatly increased the extent of effort on the northern part of the Cap starting in 1994 and persisting through 2000.

Across all years (1980 to 2000), most trawl effort in Atlantic Canada occurred at depths less than 350 metres. However, the proportion of trawling at greater depths, exceeding 600 metres, shifted dramatically between 1992 and 1994 corresponding to the collapse of a number of stocks, ultimately resulting in a closure of the fishery. Recent trawling effort is offshore with effort increasing in northern areas (Figure 12).

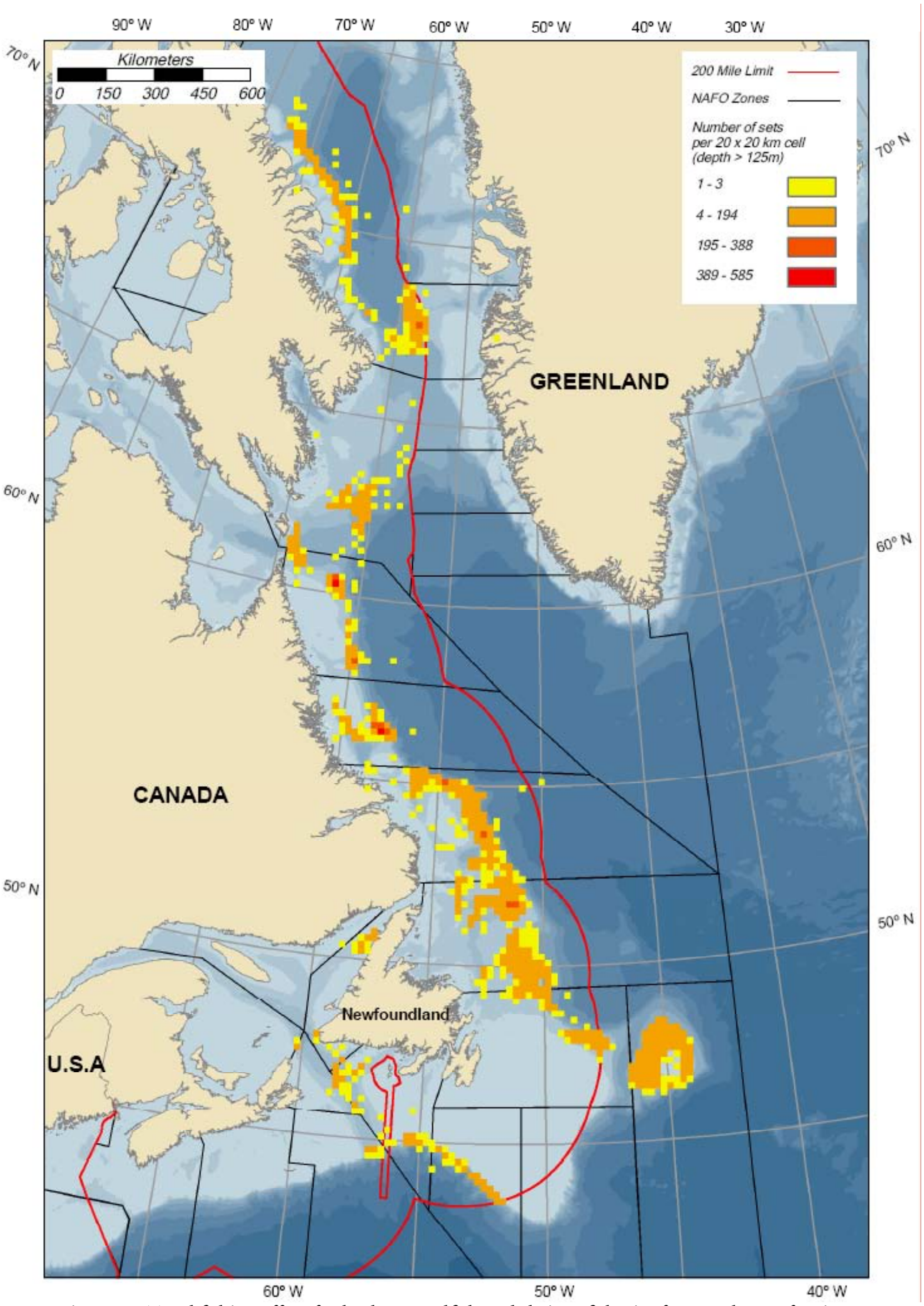

Figure 12. Trawl fishing effort for both groundfish and shrimp fisheries for vessels >65 feet in Newfoundland and Labrador in 2004 and 2005.[47]

HABITAT IMPACTS

Fishermen have raised commercial fish-habitat concerns in Atlantic Canada, specifically related to the impacts of trawling, since the beginning of the large-scale trawler fishery following the First World War.[48] Specifically, anecdotal reports of the impacts of trawling on cold-water corals on the Scotian Shelf collected in the late 1990s were among the first documentation of reported coral locations and fishery-related destruction in the Northwest Atlantic[49]. *In situ* data of corals in the Northeast Channel, between Georges and Browns Bank, found evidence of damage from fishing gear.[50] A closed area of 424 square kilometres was established in 2002 to protect corals remaining in the area. Additional photographic data from coral beds in the Stone Fence area, at the entrance to the Laurentian Channel, showed 95 per cent of *Lophelia pertusa* reefs destroyed (Figure 13).

Figure 13. *Lophelia pertusa* reefs on the Stone Fence, Scotian Shelf.
A *(left)* Intact *Lophelia* with Sebastes sp. B *(right) Lophelia* rubble, as a result of trawl damage.

More recent documentation of corals off Newfoundland and Labrador illustrates the impact of trawling and other fishing methods on these structural species, and shows the locations of coral hot spots. All coral data for the Newfoundland work has been collected through observer programs on commercial trawl vessels and DFO trawl surveys, and therefore the full extent of coral distribution is unknown.[51]

DFO has undertaken research on the impacts of bottom trawling through a series of experimental trawls on the Grand Banks and on the Western Bank of the Scotian Shelf. Experiments conducted on sandy bottoms on the Grand Banks showed recovery following trawling after one year.[52] Analysis of benthic samples taken following experimental trawling on gravel habitat on the Scotian Shelf found that inter-annual differences in invertebrate populations were greater than that attributed to trawl impacts, as compared to control sites. The experimental site has been historically trawled, but had been closed for a decade at the time of the study.[53] Research has also been conducted on the Georges Bank, with sample sites of heavy and light trawl effort on both the Canadian and U.S. sides. Results indicated that areas with light trawl effort had a higher abundance of benthic organisms with a community structured by fragile species not present on the heavily fished site.[54] Overall, much of the experimental work done within Canada's Atlantic EEZ has yielded either inconclusive results or shown little effect of the experimental trawl impact, partially due to the lack of adequate control sites (areas that have never been trawled) as well as experimental design that has been constrained by sampling opportunities.

FRONTIER AREAS

Following the cod collapse and subsequent moratoria, which began in 1992, fishing on Canada's Atlantic Coast expanded to new areas and new depths. Observer data shows that trawling rarely occurred below 600 metres until the early 1990s, when vessels began to fish off the edges of the banks, along the continental slope, in efforts to find new species and to abide by the moratorium on most groundfish species (Figure 14). While the area trawled was significantly decreased as a result of the fisheries closures, the impact on deepwater species and particular cold-water structural species, such as corals and sponges, was intensified. The majority of the fishery expansion occurred in Newfoundland, as groundfish fisheries in this region were most affected and vessels searched for alternatives.

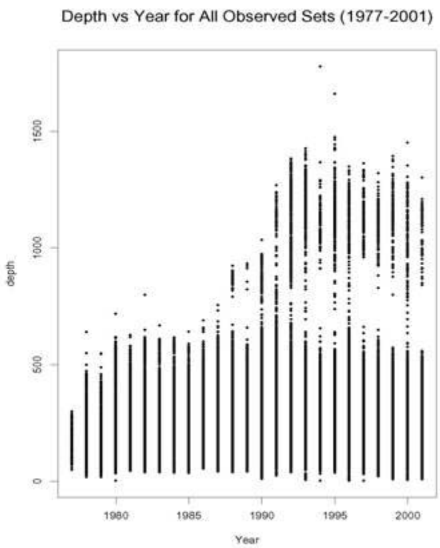

Figure 14. Observer data for the Scotia Fundy region otter-trawl fleet (10 to 50 per cent coverage depending on target species and area fished) shows the shift from bank fisheries to slope fisheries in Atlantic Canada, following the cod collapse.

This expansion of the fishery was predominantly an increase in effort for new species – particularly Greenland halibut and Northern shrimp in the North Atlantic Fisheries Organization (NAFO) Areas OA and OB, which are located in the Davis Strait, between Labrador and Baffin Island (Figures 15 & 16).

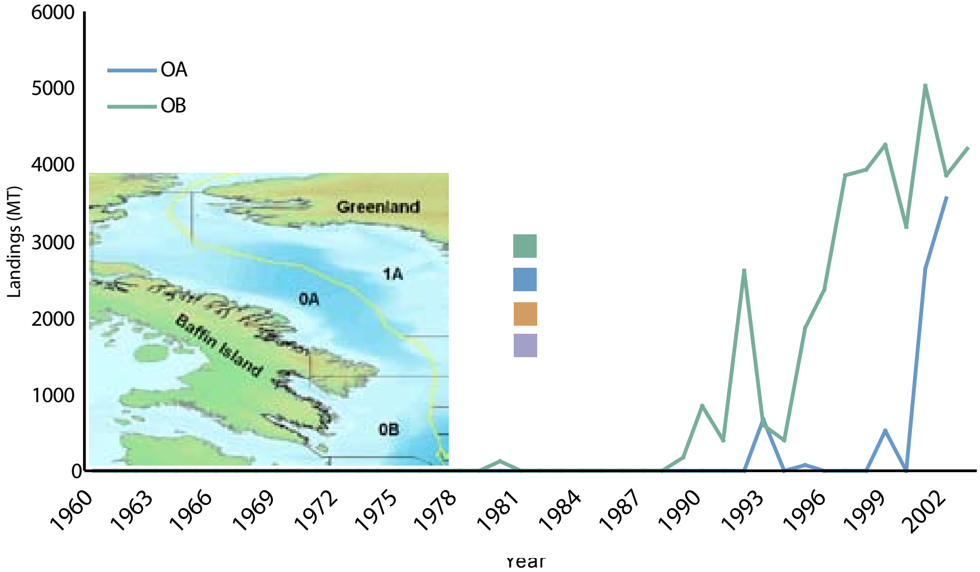

Figure 15. Canadian landings of Greenland halibut in NAFO Areas OA and OB. (Data from NAFO Fishstat).

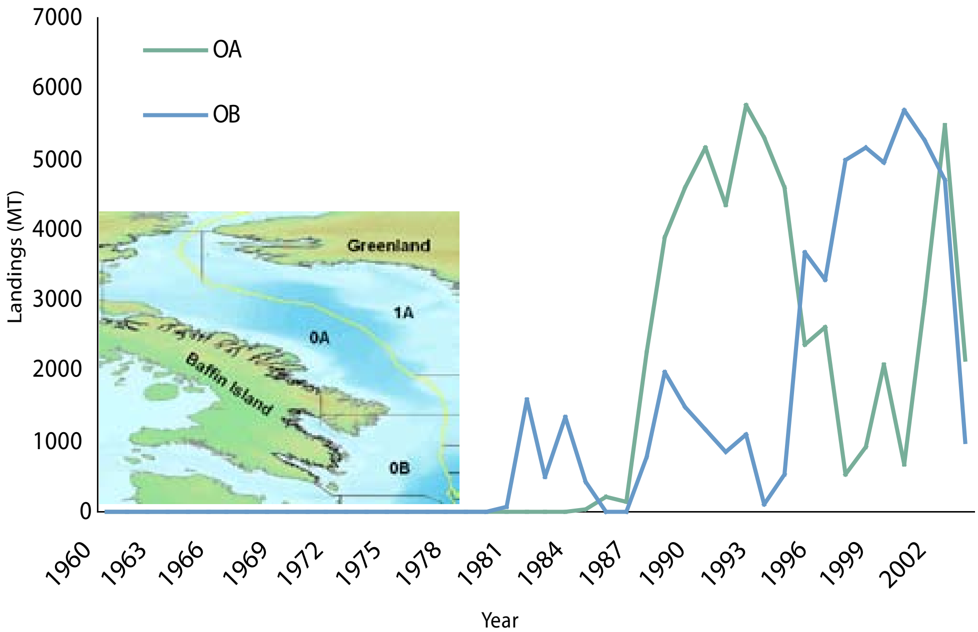

Figure 16. Canadian Northern shrimp landings in NAFO areas OA and OB (Arctic) from 1960 to 2003. (Data: NAFO Fishstat).

IMPACTS ON HABITAT

Increased fishing effort in frontier areas has resulted in increased catches of emergent epifaunal species, particularly cold-water corals and sponges (Figure 1). These species, which live attached to the bottom, are an essential component of the benthic food web. Observer data from the Scotia Fundy Region shows sponge bycatch increasing by two orders of magnitude in the period between 1997 and 2001 as compared to that recorded in the early years of the observer program and before the cod collapse (see Figure 17).

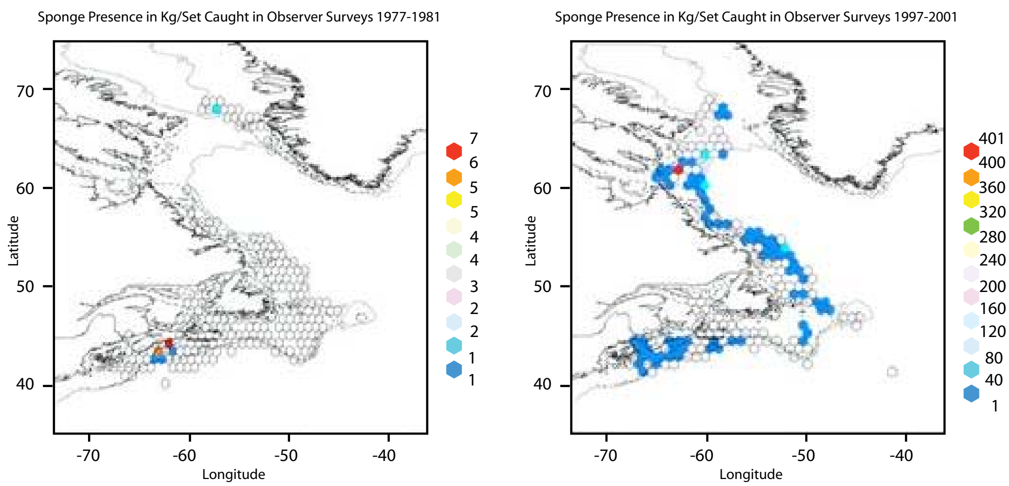

Figure 17. Observer data from the Scotia Fundy Region, indicating trawl effort and sponge bycatch.[55]

Bycatch of cold-water coral has also been recorded, both in trawl surveys and in the Newfoundland Region Observer data. Figure 18 shows recent catches of *Paragorgia arborea* and *Primnoa resedeaformis* in a research survey in NAFO area OB using shrimp-trawl gear.

Photo no longer available
March 2008

Figure 18. Cold-water coral (*Paragoria arborea* and *Primnoa* spp) caught in shrimp-trawl survey in September 2006 in the Davis Strait area. Photo: DFO Newfoundland Region.

A recent report on cold-water coral bycatch illustrates areas of high-density catches for all gear types (Figure 19). Both cold-water corals and sponges are sessile and slow-growing. The highest catches are often recorded in the initial expansion of a fishery, with catches declining over time as fishing effort increases and as these animals are removed from the substrate to which they are normally attached and have not had time to regrow.

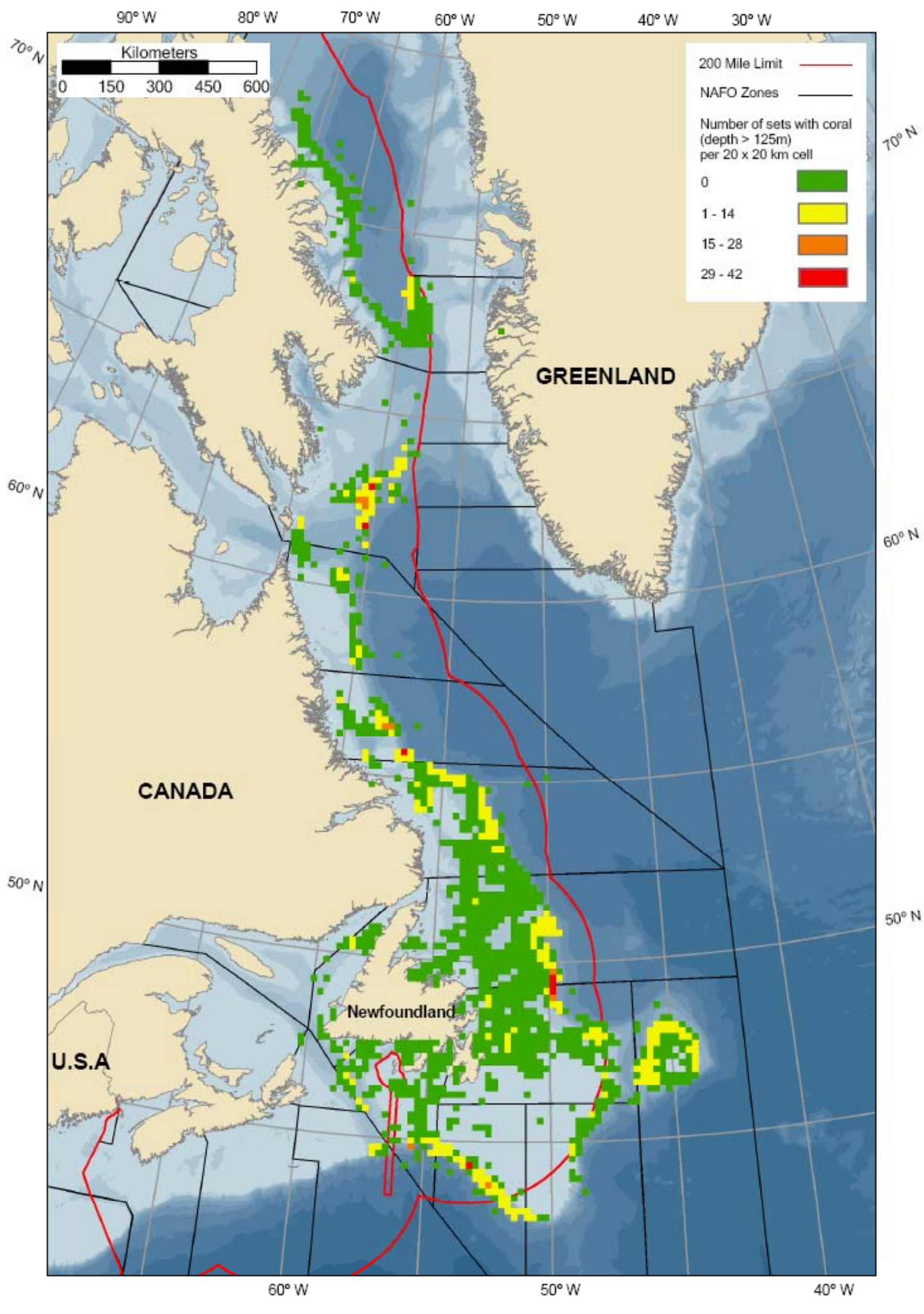

Figure 19. Coral bycatch in all gear types (predominantly trawl) and fisheries in Newfoundland and Labrador in 2004 and 2005.[56]

SUMMARY OF BOTTOM TRAWLING IN ATLANTIC WATERS

Overall, trawl effort has decreased in Atlantic Canada, from a peak in the 1970s and 1980s, predominantly as a result of groundfish stock collapses. Bottom trawls still remain the dominant gear type for fishing groundfish and shrimp. Prior to the implementation of the 200-mile limit in 1979, overfishing by foreign fleets was the focus of fisheries conservation in Atlantic Canada. Upon limiting the vast area inside the 200-mile limit to Canadian vessels, groundfish stocks were still heavily fished and within 15 years, the once abundant Northern cod stock had collapsed. Fishing by foreign fleets continues in the NAFO Regulatory Area, outside the 200-mile limit, but effort there has also reduced due to an enforceable ban on 10 stocks as of 2007.[57] Following the initial groundfish moratoria in 1992, trawling effort has expanded to deeper waters and areas further north, as fisheries focused on new target species such as shrimp and Greenland halibut. These fisheries have impacted large areas of previously unfished ground – as indicated by the cold-water sponge and coral bycatch, both of which are only caught in significant amounts once as pristine colonies are removed from the sea floor. The trawl fishery, and particularly that which has expanded into new areas, has had irreversible impacts on the benthic ecosystem. Current fisheries management does not include habitat protection in fisheries-management plans, nor does there appear to be consideration of the impacts of trawling on new or frontier areas.

Canada's "Sustainable Use" Approach

"Canada's position has been that all activities should be managed to ensure that all impacts are sustainable, including those on benthic populations, communities, and habitats."

– SAS, SAR 2006/025

It is clear that bottom trawling in Canadian waters continues to have widespread ecological impacts. Thus far, Canada's limited attention to this issue has focused on developing a "sustainable use" approach to managing the impacts. Although "sustainable use" is generally a laudable goal when applied to resource extraction, it is not a suitable goal when considering management options for controlling habitat damage stemming from bottom trawling. An "ecosystem approach", which the Canadian government has agreed to, is fundamentally different than a "sustainable use" approach, in that the management goal is to maintain the ecosystem as close as possible to its natural state. This section describes Canada's current approach to managing the impacts of bottom trawling.

In 2006 the Canadian government released a *Science Advisory Report* (SAR) that summarized the known science around bottom-trawl impacts as well as providing the context for policy development.

It is apparent from the *Science Advisory Report* that Canada's direction is one of "sustainable use" where the habitat impacts from a particular fishing activity (e.g., bottom trawling) are to be managed at a predefined sustainable level.[58] The following points capture the high-level direction Canada is taking.[59]

1. All fishing causes impacts to marine ecosystems through the removal of fish (trophic impacts) and impact on the seafloor (habitat impacts).
2. By allowing any type of fishing, the Canadian Government is endorsing some level of disruption to naturally functioning ecosystems (both habitat and food webs).

3. The resultant ecosystem impacts, whether trophic or habitat, can be managed sustainably provided that the extent of the fishing practice is carried out at a scale that does not adversely impact larger-scale ecosystem processes.

The overarching approach of "sustainable use" guiding Canada's policy on bottom trawling and other benthic fishing-gear impacts is fundamentally different from approaches found in several other jurisdictions (e.g., U.S., N.Z., Australia, E.U.) and is inconsistent with the overarching conservation principle stated in the UN *Convention on Biological Diversity*.[60] The *Convention* states that the "fundamental requirement for the conservation of ecosystems and natural habitats is the *in-situ* conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings". The proposed Canadian approach of "sustainable use" (i.e., intentional habitat perturbation) is non-precautionary, is not ecosystem-based, and undermines the spirit and intent of the *Convention on Biological Diversity*.

It is well recognized through hundreds of scientific publications and reviews that bottom trawling can fundamentally change the benthic ecosystem structure (see Section B above). A precautionary guiding principle for Canada should be one that reduces and limits the impacts of bottom trawling on "natural habitats" and restores degraded habitats.

Furthermore, the fundamental assumption with a "sustainable use" approach is that scientific understanding of marine ecosystems and fish population dynamics is robust enough to determine a sustainable level of purposeful habitat perturbation.

TOBACCO CONTROL COMPARED TO MANAGING BOTTOM TRAWL IMPACTS

The Canadian government, through the *Federal Tobacco Control Strategy*, has recognized the weight of scientific evidence surrounding the health risks posed by smoking. This has led to specific objectives to reduce the impacts of smoking on the health of Canadians.[61] Health Canada is not promoting "sustainable" smoking by trying to determine a level of smoking (e.g., 8.76 cigarettes a day) where the risks of smoking become equal to other life risks posed by accidents and disease, nor are they encouraging youth to take up smoking at a moderate level (cf. mobile benthic fishing gears in frontier areas). Instead, there is general recognition that government policy should reduce the health impacts from smoking through four mutually reinforcing components: protection, prevention, cessation, and harm reduction.

Experience from Other Jurisdictions

Canada's approach for addressing the impacts from bottom trawling, as described in the previous section, is narrow in scope, does not measure up to international best practice, and does not fulfill the letter and spirit of international agreements made by Canada. Under the current approach, for example, ongoing incursions into previously untrawled areas would not be prohibited and historically trawled areas would not be restored. Canada can learn from examples found in nations with progressive fisheries policies such as the United States, Australia, New Zealand, and the European Union.

United States

The United States has recognized in its fishery law that the loss of habitat poses one of the largest threats to fisheries.[62] To address this concern, the U.S. government has made the identification and description of Essential Fish Habitat (EFH) a fundamental component of Fisheries Management Plans through the *Magnuson-Stevens Fishery Conservation and Management Act*. The management of the fishery is guided by the general principle of *minimizing to the extent practicable the impacts caused by fishing on the identified habitat.*[63] Since EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity", and since the *Act* applies to all fish, it is not surprising that EFH comprises essentially all benthic areas. It can therefore be concluded that the U.S. approach is to reduce and limit the impacts on the bottom however practicable. This is clearly illustrated by the Pacific Fishery Management Council's recent actions, which have resulted in large closures to mobile benthic fishing gears.

To achieve the goal of "minimizing" harm to benthic habitats, the U.S. has adopted three broad categories of management measures recognized as being effective for mitigating adverse impacts to EFH: gear modifications, closed areas, and overall reductions of fishing effort.

ESSENTIAL FISH HABITAT (PACIFIC FISHERY MANAGEMENT COUNCIL)

DEFINITION OF EFH IN THE PACIFIC COUNCIL'S MANAGEMENT AREA: Depths less than or equal to 3,500 metres (1,914 fathoms) to mean higher high water level (MHHW) or the upriver extent of saltwater intrusion.

Gear Prohibitions

- Fish with dredge gear anywhere within EFH within the EEZ.
- Fish with beam trawl gear anywhere within EFH within the EEZ.
- Fish with bottom-trawl gear anywhere within EFH within the EEZ seaward of a line approximating the 700 fathoms (1280 metres) depth contour.
- Fish with bottom-trawl gear with a footrope diameter greater than 19 inches (48 centimetres) (including rollers, bobbins, or other material encircling or tied along the length of the footrope) anywhere within EFH within the EEZ.
- Fish with bottom-trawl gear with a footrope diameter greater than eight inches (20 centimetres) anywhere within the EEZ shoreward of a line approximating the 100-fathom (183-metre) depth contour.

Area Closures

In addition to gear prohibitions, dozens of large areas have been closed to bottom-trawl gear and several other areas closed to all bottom-contact gear.[64]

Australia

To demonstrate an "ecologically sustainable fishery", Australia's fisheries must operate under a management regime that meets two general principles defined in the *Guidelines for the Ecologically Sustainable Management of Fisheries*.[65] The first pertains to general principles of sustainable fisheries (i.e., stock assessments, prevention of overfishing, etc.). The second principle and associated sub-objectives are based on broader ecological concepts with the explicit overarching principle of "minimizing" the impact of the fishery on the structure, productivity, function, and biological diversity of the ecosystem.

Australia's governing principles clearly recognize that reducing and limiting ecological impacts from fishing, including impact on benthic communities, must be the operational goal.

In addition to complying with international or regional regimes, the *Guidelines* have recognized that it is sometimes necessary to implement fishery-management controls "that are more stringent than those required through the international or regional regime".

AUSTRALIA'S GUIDELINES FOR THE ECOLOGICALLY SUSTAINABLE MANAGEMENT OF FISHERIES

PRINCIPLE 2: Fishing operations should be managed to minimize their impact on the structure, productivity, function and biological diversity of the ecosystem.

Objective 3: The fishery is conducted in a manner that minimizes the impact of fishing operations on the ecosystem generally.

New Zealand

"It is widely accepted that some fishing methods, such as bottom trawling and dredging, impact on the seabed and may cause damage to marine habitats and ecosystems."[66]

— MINISTRY OF FISHERIES, NEW ZEALAND

Over the past seven years, New Zealand has made several progressive steps toward controlling the impacts of fishing gear on benthic habitats. New Zealand's *Strategy for Managing the Environmental Effects of Fishing* is centred on the primary principle to "Avoid, remedy, or mitigate any adverse effects of fishing on the aquatic environment." The application of this principle has been a "least cost" approach; that is, "where areas are to be set aside for preservation, frontier areas that are not impacted should be chosen first. This ensures that areas not already degraded are set aside first whilst allowing the business of fishing to continue."[67] A fundamental difference from the current Canadian approach is that the government of New Zealand has recognized that some gear types are worse than others and that frontier areas should be protected in order to maximize the protection.

Early outcomes from this approach include a trawling (including mid-water trawls) and dredging prohibition of 19 seamounts. This was further complemented by a recently announced system of "Benthic Protection Areas" comprising an additional 17 BPAs that, combined with the previous closures, account for approximately 32 per cent (1.25 million square kilometres) of New Zealand's waters.[68] Although much of the BPAs occupy infrequently trawled areas, the closure did impact some of the trawling effort, but more importantly, the closures are recognition that some gear types cause significant damage to benthic habitats and that frontier areas require immediate protection. Furthermore, the Ministry has made it clear that the announced BPAs are only the start.

Further closures will ensue with the development of New Zealand's *Benthic Impacts Strategy* that will become available for public consultation sometime this year. The BIS will bring together all current protection of the seabed into a single strategy to ensure management is adequate and comprehensive. The *Strategy* sets out the process for developing standards that, when met, will meet the obligations set out in New Zealand's *Fisheries Act* to "avoid, remedy or mitigate any past, present or future adverse effects of fishing on the benthic environment".[69] The Strategy will establish the government's process for setting limits around the effects of fishing on seabed habitats. The limits will be called *Habitat Standards*.

A *Habitat Standard* will define how much of each seabed habitat must remain free of damage, including from fishing. This will ensure that the effects of fishing do not prevent seabed habitats from functioning and contributing effectively to fish production and the marine ecosystem. The use of *Habitat Standards* recognizes that all habitats, not only sensitive ones, are vulnerable to both the known and unknown consequences of gear impacts.

In the Canadian context, such standards would need to be developed in a context of ecosystem-based management of large ocean-management areas (LOMAs) to ensure that the cumulative effects of various ecosystem impacts were considered when determining fishery-based habitat standards.

European Union

The European Union's approach to managing the impacts of fishing gear on the benthic environment is found in its *Biodiversity Action Plan for Fisheries*.[70] The E.U. has recognized that benthic fishing gear decreases habitat diversity and has also recognized the important widespread ecological consequences associated with nutrient/sediment resuspension caused by mobile benthic fishing gears.[71] Recognizing the potential impacts from sediment resuspension and other seemingly benign impacts is an important distinction from the Canadian approach. The ecological impact from the resuspension of sediments applies equally to historic and frontier areas and is best addressed through a lessening of the effort.

Section 4.3.1 of the *Action Plan* recognizes the need for an overall reduction of fishing pressure as a means to "contribute to the protection of other elements of marine ecosystems". The *Action Plan* states that "a reduction in fishing pressure by fishing gears towed across the seabed will lead to less impact on bottom-living organisms and their habitats by reducing the frequency of passage of such fishing gears."

While the E.U. plan understands the need for special protection of extremely fragile or sensitive habitats, the overall principle is one of reducing fishing pressure, not just a focus on sensitive habitats. The *Action Plan* states that the widespread effects of fishing lead to less "biodiverse" ecosystems and that it is "generally believed that a decrease in fishing pressure on commercially important fish stocks would contribute in the mid-term to increase the overall biodiversity of the marine ecosystems."[72]

Lessons for Canada: Regulation of bottom trawling in other countries

- Managing to reduce and limit impacts from fishing practices as found in the U.S., U.K., N.Z., and A.U. is fundamentally different than Canada's "sustainable use" approach.
- Several countries recognize that a general reduction in fishing effort and spatial extent of the fishery will lessen the negative effects to biodiversity.
- Based on scientific weight of evidence, several countries have accepted that some gear types are inherently more destructive to seabed habitats than others.
- Several countries have recognized that frontier areas should receive immediate protection from mobile benthic fishing gears.
- The U.S. uses gear modifications, closed areas, and overall reductions of fishing effort to reduce and limit harm to benthic habitats.
- New Zealand aims to "Avoid, remedy, or mitigate any adverse effects of fishing on the aquatic environment."
- *Habitat Standards* (N.Z.) provide a more scientifically defensible and systematic approach to zoning benthic impacts associated with fishing.
- Other countries have recognized that seemingly benign impacts, such as the resuspension of nutrients and sediments, pose a widespread negative effect on the ecosystem.

Recent Initiatives to Regulate Bottom Trawling on the High Seas

United Nations General Assembly Resolution

On December 8, 2006, the UN General Assembly agreed on a Resolution on Sustainable Fisheries calling for international action to address the issue of high-seas bottom fishing and its impacts on vulnerable marine ecosystems.[73] After a long process of negotiation, the Resolution has resulted in a plan for action to protect sensitive marine ecosystems from bottom fishing in areas beyond national jurisdiction.

Specifically, the Resolution calls on states and Regional Fisheries Management Organizations (RFMOs) to assess the impacts of all types of bottom fishing on the high seas and, within one to two years, prohibit any high-seas bottom fisheries that cannot be managed to prevent "significant adverse impacts" to vulnerable marine ecosystems. States are also asked to close areas of the high seas to all bottom fishing where vulnerable marine ecosystems are known or likely to occur, unless or until they are able to regulate such fisheries effectively to prevent significant adverse impacts on vulnerable marine ecosystems. A key element of the Resolution calls for states to implement interim measures, including temporary closures by December 2007 in order to ensure that all bottom fishing is conducted in a precautionary manner.

South Pacific Regional Fisheries Management Organization

In May 2007, fishing nations utilizing the South Pacific, an area covering approximately 25 per cent of the world's high seas, agreed to strong measures consistent with the UN GA Resolution.[74] Beginning September 30, 2007, an immediate freeze on any further expansion of bottom fishing on the high seas of the South Pacific will be imposed until 2010. Beyond 2010, a country/vessel can only fish in a new area after the country concerned has done an impact assessment reviewed by an established scientific committee. In existing fishing grounds, vessels will not be allowed to bottom trawl in areas that are identified or likely to have vulnerable marine ecosystems without prior assessment. In particular, most seamounts, the preferred fishing grounds, will effectively be off limits. Other controls will also be employed, such as vessel-locator monitoring and comprehensive observer programs. If observers record vessels bringing up deep-water corals in nets, there will be an automatic five-nautical-mile radius (270 square kilometres) closure around the vulnerable area.

Lessons for Canada: Regulation of bottom trawling on the high seas

- Canada should adopt immediate interim measures for existing and frontier trawling grounds including:
  - An immediate freeze to further expansion of trawling grounds until impact-assessment protocols are established, especially in new grounds in the Atlantic and Arctic Oceans.
  - Immediate bottom-trawl closures around known and newly discovered sensitive areas.

Other Considerations for Canada's Policy on Bottom Trawling

Reduction of effort and area trawled in historically fished areas

Much of the spatial extent of "fished areas" in Canadian waters has been fished for several decades. Bottom-trawl policy must consider reducing the spatial extent of bottom trawling in historical areas for restoration and general lessening of habitat impacts. This entails restricting the trawling grounds to only the core areas. In Canada's Pacific waters, bottom-trawling effort is highly concentrated, with the top 90 per cent of the effort being distributed over only 28 per cent of the area fished and the top 50 per cent of effort being distributed over only six per cent of the area fished.[75] It is clear that the footprint of the trawl fishery can be reduced while maintaining access to the resource.

Ongoing ecological impacts from fishing gear in heavily fished areas include sediment resuspension and general diminishment of habitat complexity. The New Zealand approach using *Habitat Standards* would ensure that a certain proportion of all benthic habitats would be protected regardless of current and historical use.

Benthic habitat = fish habitat

Canadian policy on bottom trawling must not only focus on "sensitive" habitats but should also consider the much broader need for the management of fish habitat. An ecosystem approach to managing bottom trawling necessarily requires the identification and protection of fish habitat. The recently tabled Bill C-45, despite many shortcomings, acknowledges this need as a component of fisheries management (section 25 [1]).

Deep-sea habitats

Deep-sea benthic habitats are inherently vulnerable to disturbance and are widely considered to be unsuitable for sustainable commercial fisheries.[76] Canadian bottom-trawl policy must explicitly recognize the need for special management for deep-sea habitats. Several scientifically recognized oceanographic boundaries could be used for policy development (i.e., bathypelagic zone, *oxygen minimum zones*). In particular, *oxygen minimum zones* (areas where the oxygen saturation is the lowest) are perhaps a logical starting place for managing fishing-gear impacts to the deep-sea benthos. The resuspension of nutrients and sediments in already low oxygen environments further accelerates oxygen depletion through biological and chemical processes such as bacterial metabolism and mixing with methane and hydrogen sulfide.[77] It should be noted that increased oxygen demand results in a release of carbon dioxide that must also be considered in the context of climate change.

The widespread ecological consequences of bottom trawling in the deep ocean are poorly understood. Canadian policy needs to recognize that deep-sea habitats are particularly vulnerable to any form of disturbance. Several fishing jurisdictions around the world have progressed with their fisheries policy to address deep-sea impacts. For example, the *General Fisheries Commission for the Mediterranean* (GFCM) has implemented a ban on trawls and dredges below 1,000 metres.[78] Similarly, Brazil is in the process of banning bottom trawling in waters deeper than 1,000 metres, and off the west coast of the United States much of the deep-sea habitat (>1,280 metres) is closed to bottom trawling.

Frontier areas

The concept of "sustainable use" as it applies to habitat disruption in frontier areas is inconsistent with international policy and efforts to preserve the world's biodiversity. Sustainable use for frontier areas means that some predefined level of authorized "sustainable" habitat perturbation will be permitted. Under a guiding principle of "reducing and limiting" impacts to biodiversity, as observed in other countries (see section on experience from other jurisdictions), bottom trawling would only be permitted in frontier areas under tightly managed situations backed by comprehensive scientific information. It should also be noted that the *Science Advisory Report* concluded that mobile benthic fishing gears would readily impact sensitive features in frontier areas.[79] The report further mentions that spatial information sources from historical and recent fisheries should be reviewed to delineate the boundaries of potential frontier areas appropriate for all three oceans.

It is unlikely that the data requirements sufficient for understanding sustainable use in frontier areas will ever be adequately met due to the inordinate costs of undertaking this type of research at the spatial resolution required. In data-poor international waters, the *UN Sustainable Fisheries Resolution* calls for nations to implement interim measures and to take a precautionary approach to ensure the protection of vulnerable marine ecosystems from the adverse effects of fishing. This translates into an appropriate placing of the burden proof on fishing interests, whereby fisheries could expand into frontier areas only if a strong case could be made that there would be no adverse effects. The Canadian policy, at a minimum, should adopt interim measures consistent with the UN resolution and impose temporary bottom-trawl closures in all frontier areas.

A failure to include interim measures in a benthic-impacts policy will likely result in a reliance of output controls, such as data derived from fisheries-observer programs, to define and identify sensitive areas. Using fisheries-derived data to identify sensitive areas is wrought with problems, most notably that sensitive areas may be destroyed before restrictive management measures are in place. Output controls involving immediate, large, and enforceable closures around identified sensitive habitats, such as those recently agreed to in the South Pacific (see Section F), could be one effective tool in protecting vulnerable ecosystems (e.g., corals, sponges).

Bottom trawling and contribution to greenhouse gases

Bottom trawling releases large quantities of carbon into the water column and atmosphere by removing and oxidizing accumulated organic material and increasing respiration through decomposition of organic matter.[80] It is unknown whether this release of carbon, especially from deep-sea habitats, is contributing carbon dioxide to the atmosphere from what otherwise would be a long-term carbon sink.

Regardless of the biogeochemical processes resulting from bottom trawling, the engines pulling the trawl nets are highly energy intensive. The *Canadian Code of Conduct for Responsible Fishing Operations* calls for the cooperation of regulatory agencies to investigate ways and methods to optimize fuel consumption by fishing fleets.[81] Bottom trawling is considered one of the most fuel-intensive fishing methods.[82] Fuel consumption by trawlers may appear unrelated to habitat impacts, but the price of fuel is often the basis for trawling practices. Low fuel costs allow for the exploration of new grounds or targeting species and areas otherwise less profitable. Recent research has found that much of the unregulated high-seas bottom-trawling fleet receives government fuel subsidies, allowing these fleets to operate at an economic loss.[83]

Fuel subsidies should be eliminated and a concerted effort by both the fishing industry and the Canadian government should be made to reduce the trawl footprint to only the most important grounds. These measures would have the co-benefits of reducing direct ecosystem damage and greenhouse-gas emissions.

Conclusion and Policy Recommendations

Canada's fisheries-management policies and the specific policy that addresses the environmental effects of bottom trawling must be strengthened in order to honour Canada's international commitments to protect biological diversity and to support international efforts aimed at conserving marine ecosystems and fish stocks. Canada should at least match fisheries-policy direction found in other leading fishing jurisdictions and ideally be a leader in sustainable fishing policies both within our exclusive economic zone and on the high seas.

An ecosystem approach to managing impacts from bottom trawling

For Canada's approach to bottom trawling to be more in line with an ecosystem approach, the David Suzuki Foundation recommends the following progression, based on analysis of both the scientific literature and global policy approaches.

1. Protection of marine biodiversity is the central priority for maintaining fisheries productivity (i.e., wild fisheries are a direct product of marine biodiversity).
2. Based on the best available science, it is recognized that bottom trawling causes a general erosion in marine biodiversity through a variety of well-documented impacts to benthic habitat and ecosystem structure.
3. Due to a lack of capacity to undertake more comprehensive science, the true extent of the impact of this gear on targeted fish populations and marine biodiversity in general will never be fully understood, and therefore a precautionary approach is warranted.
4. At a policy level, adopting a precautionary approach translates into a fisheries-management regime that encourages a reduction in effort and spatial extent of fishing gears recognized to have the most severe impacts on marine biodiversity with

the objective of significantly reducing and limiting the impact to natural habitats. This principle applies to frontier and historically fished areas alike.

Canadian fisheries policy should aim to significantly reduce and limit impacts to seafloor habitats from bottom trawling rather than manage the "sustainable" and ongoing perturbation of seafloor habitats. Significantly reducing and limiting damage to seafloor habitat:

- Is consistent with the United Nations *Convention on Biological Diversity*.
- Is in accordance with the accepted understanding of the ecosystem approach.
- Is a primary objective of several other fishing jurisdictions.
- Recognizes a link between habitat and sustainable fisheries.
- Is precautionary.
- Resonates with the Canadian public's expectations for responsible fisheries management.
- Will help protect and recover both important habitat and fish stocks.

Reducing and limiting the impacts to the seafloor from bottom trawling requires:

- Immediately prohibiting expansion of bottom trawling into frontier areas unless the impacts can be shown not to have significant adverse and lasting environmental effects.
- Significantly reducing the use of bottom trawling in deepwater habitats.
- Imposing an interim moratorium on bottom trawling in *oxygen minimum zones* until sufficient scientific research into chemical and biological process in these habitats has been undertaken.
- Prohibiting the use of bottom trawls in "sensitive areas" (i.e., corals and sponges).
- Zoning and restricting trawling to areas of highest historical CPUE.
- Zoning and restricting trawling to areas of high natural disturbance.
- Implementing a system of no-trawl zones for all habitat types.

Canada's bottom-trawl policy should apply to the entire seafloor, and not just "sensitive" or "vulnerable" habitats. Broadening the scope to all seafloor habitats:

- Recognizes that all habitats play a functional role within the ecosystem.
- Is an essential element in realizing an ecosystem-based approach to fisheries management.
- Recognizes other gear-related impacts such as resuspension of nutrients and sediments.
- Recognizes that full understanding of the impacts is unknown and is therefore precautionary.

Canada should explore alternative management approaches currently used by other countries to assist in policy development. Specifically, Canada should:

- Implement *Habitat Standards* similar to New Zealand, where all types of benthic habitats will receive some level of protection from fishing-gear impacts.
- Adopt the U.S. *Essential Fish Habitat* approach of "minimizing to the extent practicable the impacts caused by fishing" on identified habitat.

- Delineate the extent of trawling by habitat type for Canada's oceans.

In frontier areas, it is recommended that Canada:

- Delineate the boundaries of frontier areas in all three oceans, based on historical and current use.
- Fully accept current scientific understanding of bottom-trawling impacts on habitat in frontier areas and reflect this understanding in fisheries law and policy, and fisheries-management plans.
- Significantly reduce and limit impacts rather than prescribe "sustainable use".
- Adopt interim measures consistent with the UN Sustainable Fisheries Resolution that would see no expansion into frontier areas unless the impacts can be shown not to have significant adverse effects.
- Preferentially allocate resource access to gear types that significantly reduce and limit the potential impact on benthic habitats.
- Utilize fisheries-independent data (prior to any fishery) for the identification of sensitive areas.

For deep-water habitats, it is recommended that Canada:

- Specifically recognize that deep-sea habitats, with or without corals and sponges, are vulnerable to any form of disturbance and therefore aim to significantly reduce and limit negative effects of fishing in these areas.
- Prohibit bottom trawling in *oxygen minimum zones* until the ecological impacts are better understood.

NOTES

1 Graham, M. 1955. Effect of trawling on animals of the seabed. Deep-sea research 3, supplement: 1-6.

2 Russel, D. 1997. Hitting bottom. The Amicus Journal, Winter: 21-25. http://www.dickrussell.org/articles/hitting.htm

3 U.S. Essential Fish Habitat. http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/index.htm

4 Associated Press, "Bering Sea Bottom Trawling Banned". June 11, 2007.

5 Canada's *Oceans Act* (1996, c. 31)

6 Jamieson et al. 2001. Proceedings of the national workshop on objectives and indicators for ecosystem based management. Canadian Science Advisory Secretariat 2001/09.

7 Arkema et al. 2006. Marine ecosystem-based management: From characterization to implementation. Frontiers in Ecology and the Environment 4: 525-532.

8 National Research Council. 2002. Effects of trawling and dredging on seafloor habitat. National Academies Press, Washington DC.

9 Thrush, S. F. and P. K. Dayton. 2002. Disturbance to marine benthic habitats by trawling and dredging: Implications for marine biodiversity. Annual Review of Ecology and Systematics, Vol. 33: 449-473.

10 Fisheries and Oceans Canada. 2006. Impacts of trawl gears and scallop dredges on benthic habitats, populations, and communities. Canadian Science Advisory Secretariat, Science Advisory Report 2006/025.

11 Watling, L. 2005. The global destruction of bottom habitats by mobile fishing gears. In Marine Conservation Biology, EA Norse & LB Crowder (eds). Washington DC: Island Press: 198-210.

12 Canadian Science Advisory Secretariat, Science Advisory Report 2006/025

13 National Research Council. 2002. Effects of trawling and dredging on seafloor habitat. National Academies Press, Washington DC.

14 Hixon, M.A. and B.N. Tissot. 2007. Comparison of trawled vs untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon. Journal of Experimental Marine Biology and Ecology 344:23-34

15 Jennings, S., J.K. Pinnegar, N.V.C. Polunin, and K.J. Warr. 2001. Impacts of trawling disturbance on the trophic structure of benthic invertebrate communities. Marine Ecology Progress Series 213:127-142.

16 http://earthobservatory.nasa.gov/Newsroom/NewImages/images_topic.php3?img_id=17668&topic=life. Accessed June 14, 2007.

17 Rio Declaration on Environment and Development, Principle 15, In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

18 Habitat classification varies depending on several factors, including substrate type (i.e., mud, sand, gravel, bedrock), depth, and current.

19 http://www.groundfishsociety.com/fishinfo.html Accessed May 28, 2007

20 Based on 1996-2003 data available at, http://www.seaaroundus.org/eez/summaryInfo.aspx?EEZ=124. Accessed August 9, 2007.

21 Sinclair, A.F., K.W. Conway and W.R. Crawford. 2005. Associations between bathymetric, geologic and oceanographic features and the distribution of the British Columbian bottom trawl fishery. ICES CM 2005/L:25. Percentages estimated from figure 5. Note that geological classification is at a larger scale than the trawl tows, therefore it is possible that sand and gravel can exist within a bedrock unit and vice versa.

22 Personal communication with Dan Clark, Resource Management Biologist, Department of Fisheries and Oceans, telephone conversation with author, June 5, 2007.

23 Sinclair, A. 2007. Trends in groundfish bottom trawl fishing activity in BC. Canadian Science Advisory Secretariat Research Document 2007/006. Available at: http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2007/2007_006_e.htm

24 Based on start and end points of a trawl tow. If a trawl tow transected any portion of a 1X1km2 grid cell then that cell was considered 'trawled'.

25 Sinclair, A. 2007.

26 Table from Wallace, S. 2006. Unsolicited Review of Groundfish PSARC subcommittee paper:Trends in Groundfish Bottom Trawl Fishing Activity in BC. Pacific Biological Station, November 21, 2006.

27 Data provided by Barry Ackerman, Groundfish Trawl Manager, Department of Fisheries and Oceans. Data provided by email May 28, 2007.

28 The area of shrimp trawl grounds is based on trawlable shrimp habitat throughout BC. Area estimate provided to author from Jim Boutilier, Pacific Biological Station, Nanaimo, British Columbia. Telephone conversation with author on June 5, 2007.

29 Data retrieved from database June 6, 2007.

30 Sinclair, A.F., K.W. Conway and W.R. Crawford. 2005. Associations between bathymetric, geologic and oceanographic features and the distribution of the British Columbian bottom trawl fishery. ICES CM 2005/L:25

31 New Zealand's Benthic Impacts Strategy http://www.fish.govt.nz/en-nz/Environmental/Seabed+Protection+and+Research/default.htm. Accessed May 29, 2007.

32 Jamieson, G.S., K. Conway and J.V. Barrie. 2007. Re-evaluation of sponge reef complex occurrences and their protection in Pacific Canada. Canadian Science Advisory Secretariat Research Document 2007/010 Available online: http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2007/2007_010_e.htm

33 Gage, J.D., J.M. Roberts, J.P. Hartley & J.D. Humphery. 2005. Potential impacts of deep-sea trawling on the benthic ecosystem along the Northern European continental margin: a review. In Benthic Habitats and the Effects of Fishing: American Fisheries Society Symposium 41, PW Barnes and JP Thomas (eds). Bethesda: American Fisheries Society: 503-518.

34 Sinclair, A. 2007.

35 Longspine thornyhead listed as *Special Concern*. www.cosewic.gc.ca/eng/sct0/index_e.cfm?#results

36 Schnute, J. T., N. Olsen, and R. Haigh. 1999a. Slope rockfish assessment for the west coast of Canada in 1998. Can. Stock Assess. Sec. Res. Doc 99/16.

37 Mullins, H.T., Thompson, J.B., McDougall, K., and Vercoutere, T.L. 1985. Oxygen-minimum zone edge effects: evidence from the central California coastal upwelling system. Geology (Boulder), 13: 491–494.

38 Riemann, B. and E. Hoffmann. 1991. Ecological consequences of dredging and bottom trawling in the Limfjord, Denmark. Marine Ecological Progress Series 69:171-178

39 From 1996-May 2007 there were 15340 trawl tows directed at the longspine thornyhead (>500 m). The average length of the tow was 7.1 hrs, towing speed is on average 4.5 km/hr. Total distance trawled in this time period is 490, 000 km. Data provided by Rowan Haigh, Groundfish Scientist, Pacific Biological Station. Email correspondence with author on May 30, 2007.

40 Calculation based on the percentage of 1 km^2 grid cells contacted by bottom trawl gear. Sinclair, A. 2007.

41 Based on 1996-2003 data available at, http://www.seaaroundus.org/eez/summaryInfo.aspx?EEZ=124. Accessed August 9, 2007.

42 http://www.mar.dfo-mpo.gc.ca/communications/maritimes/factsheets04e/GroundfishE.html. Note: this does not include all Atlantic licenses, only the maritime region.

43 Area trawled based on circular areas ranging from 25km^2 to 68 km^2. See Kulka and Pitcher 2001.

44 As part of the first integrated management plan to be introduced under the *Oceans Act*, the ESSIM process has begun to compile use data for the area. The Atlas of the Scotian Shelf can be accessed at http://www.mar.dfo-mpo.gc.ca/oceans/e/essim/atlas/essim-atlas-e.html

45 Personal communication with Dave Kulka, Newfoundland Region, Fisheries and Oceans Canada. Conversation with author, May 30, 2007.

46 Kulka, D.W. and D.A. Pitcher. 2001. Spatial and temporal patterns in trawling activities in the Canadian Atlantic. ICES CM 2001/R:2.

47 Map from Edinger, E. et al. 2007. Coldwater Corals off Newfoundland and Labrador: Distribution and Impacts. Prepared for WWF Atlantic Region.

48 Fuller, S.D. and P.E. Cameron. 1998. Marine Benthic Seascapes: Fishermen's Perspectives. Ecology Action Centre. Marine Issues Committee Publication No.2. 69p.

49 Breeze, H. 1997. Distribution and Status of Deep Sea Corals off Nova Scotia. Ecology Action Centre Marine Issues Committee Publication No 1. 60p.

50 Mortensen et al. 2005. Effects of Fisheries on Deepwater Gorgonian Corals in the Northeast Channel, Nova Scotia. American Fisheries Society Symposium. Vol. 41, pp. 369-382.
51 Edinger, E. et al. 2007.
52 Gordon et al. 2005. Summary of the Grand Banks Otter Trawling Experiment (1993-1995): Effects on Benthic Habitat and Macrobenthic Communities. American Fisheries Society Symposium .Vol. 41, pp. 411-424.
53 Henry, L-A. et al. 2006. Impacts of otter trawling on colonial epifaunal assemblages on a cobble bottom ecosystem on Western Bank (Northwest Atlantic). Marine Ecology Progress Series. Vol. 306, pp. 63-78.
54 Collie et al. 2005. Effects of Fishing on Gravel Habitats: Assessment and Recovery of Benthic Megafauna on Georges Bank American Fisheries Society Symposium. Vol. 41, pp. 325-343. 2005.
55 Figures from Fuller, S.F. Trawling in the Northwest Atlantic: Implications for Marine Sponge Populations. PhD. Dissertation, Dalhousie University. In prep.
56 Map from Edinger et al. 2007.
57 NAFO 2007 Quota Table http://www.nafo.int/about/frames/about.html
58 Fisheries and Oceans Canada. 2006. Impacts of trawl gears and scallop dredges on benthic habitats, populations, and communities. Canadian Science Advisory Secretariat, Science Advisory Report 2006/025.
59 Bullets are paraphrased from discussion with Jake Rice, Fisheries and Oceans Canada, March 23, 2007, Ottawa.
60 Convention on Biological Diversity, Preamble, http://www.biodiv.org/convention/articles.shtml?a=cbd-00
61 Federal Tobacco Control Strategy, http://www.hc-sc.gc.ca/hl-vs/alt_formats/hecs-sesc/pdf/pubs/tobac-tabac/ffa-ca/ffa-ca_e.pdf
62 Magnuson-Stevens Fishery Conservation and Management Act, 'Findings' section (104-297), "One of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats. Habitat considerations should receive increased attention for the conservation and management of fishery resources of the United States." http://www.nmfs.noaa.gov/sfa/magact/
63 "describe and identify essential fish habitat for the fishery based on the guidelines established by the Secretary under section 305(b)(1)(A), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat".
64 Magnuson-Stevens Act Provisions; Fisheries off West Coast States; Pacific Coast Groundfish Fishery, Federal Register / Vol. 71, No. 91 / Thursday, May 11, 2006 / Rules and Regulations, available at: http://www.nwr.noaa.gov/Publications/FR-Notices/2006/upload/71FR27408.pdf
65 Australia's Guidelines for the Ecologically Sustainable Management of Fisheries http://www.environment.gov.au/coasts/fisheries/pubs/guidelines.pdf
66 Quotation taken from, http://www.fish.govt.nz/en-nz/Environmental/Seabed+Protection+and+Research/default.htm
67 Personal communication with Dr. Jeremy G. Helson, Policy Analyst, Deepwater and National Issues, Ministry of Fisheries, New Zealand. Email correspondence with Scott Wallace, April 11, 2007.
68 http://www.nzherald.co.nz/search/story.cfm?storyid=000A1B2E-14F0-1613-90A683027AF10128
69 New Zealand Fisheries Act, Section 8, 2b. http://www.legislation.govt.nz/browse_vw.asp?content-set=pal_statutes
70 European Union *Biodiversity Action Plan for Fisheries* http://europa.eu/eur-lex/en/com/pdf/2001/act0162en02/4.pdf
71 European Union *Biodiversity Action Plan for Fisheries,* paragraph 25.
72 Ibid., paragraph 51.
73 UN GA Resolution 61/105, Paragraphs 80 to 91.
74 Wording of the South Pacific RFMO agreement. http://www.southpacificrfmo.org/assets/Third%20International%20Meeting/SPRFMO%20Interim%20Measures_Final.doc
75 Sinclair et al. (2005)
76 Roberts, CM. 2002. Deep impact: the rising toll of fishing in the deep sea. Trends in Ecology & Evolu-

tion 17(5): 242-245.

77 Riemann, B and E. Hoffmann. 1991. Ecological consequences of dredging and bottom trawling in the Limfjord, Denmark. Marine Ecological Progress Series 69:171-178

78 *General Fisheries Commission for the Mediterranean*, deep-sea trawl resolution, ftp://ftp.fao.org/docrep/fao/008/a0031e/a0031e00.pdf

79 SAR report, page 7

80 Watling, L. 2005. The global destruction of bottom habitats by mobile fishing gears. In Marine Conservation Biology, EA Norse & LB Crowder (eds). Washington DC: Island Press: 198-210.

81 http://www.dfo-mpo.gc.ca/communic/fish_man/code/cccrfo-cccppr_e.htm

82 Tyedmers, P. 2001. Energy consumed by North Atlantic fisheries. In: Fisheries' Impacts on North Atlantic Ecosystems: Catch, Effort and National/Regional Datasets. Zeller, D., Watson, R. and Pauly, D. (eds.). Fisheries Centre, University of British Columbia, Vancouver, pp. 12–34. http://www.seaaroundus.org/report/method/tyedmers10.pdf

83 Sumaila, U.R., A. Khan, L. Teh, R. Watson, P. Tyedmers and D. Pauly. 2006. Subsidies to high seas bottom trawl fleets. In Sumaila, U.R and D. Pauly (eds.). 2006. Catching more bait: A bottom-up re-estimation of global fisheries subsidies. Fisheries Centre Research Report, Vol. 14(6) (Second Version).

Bottom trawling involves dragging large nets along the ocean floor, disrupting everything in their path, including corals and other marine habitats. Due to the non-selective nature of the gear, it also captures significant levels of fish that are subsequently discarded as bycatch, some of which are species at risk. Bottom trawling is also very fuel intensive, consuming the greatest amount of fossil fuel per unit of fish landed of any fishing method.

Canada's approach to addressing habitat impacts from bottom trawling is narrow in scope, does not measure up to international best practices, and does not fulfill the letter or the spirit and intent of international agreements signed by Canada.

This report, by sustainable fisheries analyst Scott Wallace, offers recommendations to reduce the ecological impact of bottom trawling while still maintaining access to fisheries resources.

The David Suzuki Foundation is committed to achieving sustainability within a generation. Ecosystem-based fisheries are vital to this commitment.

David Suzuki Foundation

2211 West 4th Avenue, Suite 219
Vancouver, BC, Canada V6K 4S2
www.davidsuzuki.org
Tel 604.732.4228
Fax 604.732.0752

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