GRAND BANKS OTTER TRAWLING IMPACT EXPERIMENT: I. SITE SELECTION PROCESS, WITH A DESCRIPTION OF MACROFAUNAL COMMUNITIES

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ABSTRACT

Prena, J., T.W. Rowell, P. Schwinghamer, K. Gilkinson, and D.C. Gordon, Jr. 1996. Grand Banks otter trawling impact experiment: I. Site selection process, with a description of macrofaunal communities. Can. Tech. Rep. Fish. Aquat. Sci. 2094: viii + 38 p.

As part of a long-term study on the potential impacts of mobile fishing gear on benthic habitat and communities, it was necessary to identify suitable experimental sites on the continental shelf off Atlantic Canada. Selection criteria included: little or no recent bottom disturbance from fishing activity, likelihood of excluding bottom-disturbing fisheries during the experiment, the uniformity of environmental properties, the efficiency of sampling equipment and ease of processing, and the characteristics of the benthic communities. A preliminary evaluation initially suggested the 4TVW haddock nursery area on Western Bank, which has been closed to mobile groundfish gear since 1987, and a specific site on the nose of the Grand Banks. After a trial research mission in 1991, sampling on Western Bank in 1992 was focused at two specific sites in the closed area about 30 km apart. Field observations at all sites consisted of sidescan sonar surveys and biological sampling using a video-equipped epibenthic sled and a newly developed video grab. The macrobenthos of each site was evaluated in terms of species occurrence, abundance, commonality, richness, and homogeneity. The two Western Bank areas, although species-rich, were found to be sparsely and heterogeneously populated and would require a high level of sampling effort to detect changes to species assemblages which might result from trawling activities. The Grand Banks site community was also species-rich but was much more homogeneously populated as well as having a greater number of epibenthic species, abundant species and individuals, and a greater biomass. Hence, this site would require less sampling effort to detect a given level of change. Assessing all available information against the selection criteria, it was concluded that of the three candidate sites the most suitable location for a single otter trawl impact experiment is the one on the Grand Banks. New faunistic information for each of the three sites is also presented.

RÉSUMÉ

Prena, J., T.W. Rowell, P. Schwinghamer, K. Gilkinson, and D.C. Gordon, Jr. 1996. Grand Banks otter trawling impact experiment: I. Site selection process, with a description of macrofaunal communities. Can. Tech. Rep. Fish. Aquat. Sci. 2094: viii + 38 p.

Dans le cadre d'une étude de longue haleine au sujet des effets possibles des engins de pêche mobiles sur l'habitat et les communautés benthiques, on a dû trouver des sites expérimentaux adéquats sur la plate-forme continentale, au large du Canada atlantique. Le choix de ces sites était fondé sur les critères suivants: absence de perturbation récente, ou perturbation négligeable, due à la pêche; possibilité d'éliminer les pêches ayant des effets perturbants sur le fond durant l'expérience, uniformité des propriétés environnementales, efficacité du matériel d'échantillonnage et facilité de traitement, et caractéristiques des communautés benthiques. Une évaluation préliminaire avait initialement permis de retenir la frayère d'aiglefin du banc Western, dans 4TVW, fermée à la pêche du poisson de fond aux engins mobiles depuis 1987, et un endroit précis du Nez des Grands Bancs de Terre-Neuve. Après une mission d'essai en 1991, l'échantillonnage réalisé en 1992 sur le banc Western s'est concentré sur deux sites particuliers de la zone délimitée, distants d'environ 30 km l'un de l'autre. Les observations réalisées sur place dans tous les sites consistaient en des relevés au sonar à balayage vertical et en des échantillonnages biologiques au moyen d'un traîneau épibenthique et d'une nouvelle vidéobenne. Dans chacun des sites, on a évalué la présence, l'abondance, le caractère commun, la richesse et l'homogénéité des espèces du macrobenthos. On a constaté que la population des deux sites du banc Western, quoique riche en espèces, était éparse et hétérogène et qu'il faudrait procéder à de nombreux échantillonnages pour déceler des changements dans les communautés d'espèces pouvant résulter du chalutage. Quant au site des Grands Bancs de Terre-Neuve, sa population était aussi riche en espèces, mais elle était beaucoup plus homogène, et comptait un plus grand nombre d'espèces épibenthiques et d'individus, ainsi qu'une plus grande biomasse. En évaluant tous les renseignements obtenus par rapport aux critères de sélection, on en a conclu que parmi les trois sites possibles, celui qui se prêtait le mieux à une seule expérience sur les effets du chalut à panneaux était celui du Grand Banc de Terre-Neuve. On présente également ici de nouveaux renseignements sur la faune de chacun des trois sites.

INTRODUCTION

The fishing industry around the world uses various types of mobile fishing gear to harvest commercial species associated with the sea floor. The gear types include otter trawls, beam trawls, scallop rakes, and clam dredges. Concern has been expressed about the potential effects of this gear on benthic habitat, benthic communities, and the fish stocks themselves. As a result, numerous investigations have been conducted in recent years to provide scientific information that can help to resolve this important issue (for example Graham 1955, Caddy 1973, Gibbs et al. 1980, Meyer et al. 1981, de Groot 1984, van der Veer et al. 1985, Smith and Howell 1987, Churchill 1989, Messieh et al. 1991, Van Dolgh et al. 1991, Bergman and Hup 1992, Eleftheriou and Robertson 1992, Jones 1992, Rumohr and Krost 1992, Brylinsky et al. 1994, de Groot and Lindeboom 1995).

The results of previous studies clearly indicate that impacts of mobile fishing gear are quite variable and depend on several factors including the type of gear being used, the nature of the benthic habitat, and the kind of benthic communities being impacted. The relative impacts of different gear types depend on factors such as their design and operating principle, weight, towing speed, and intensity of use. Benthic impacts depend on factors such as the type of bottom (i.e. bedrock, boulder, sand, mud, etc.) and the kind of organisms present (i.e. migratory versus attached, surface dwelling versus burrowing, etc.).

To date, all experimental studies have been restricted to evaluating only the immediate impacts of mobile gear. However, it is recognized that intensive and repeated trawling in the same area can possibly lead to long-term changes in both benthic habitat and communities. An example is the well-documented change in the composition of the North Sea benthos (Riesen and Reise 1982, Reise et al. 1989, Bergman et al. 1991). Bergman and Hup (1992) and Jones (1992) have argued that experimental studies conducted at sites that have been intensively trawled for decades may underestimate potential impacts as benthic communities may already have been altered by constant selection of species more tolerant of physical disturbance.

Three types of mobile fishing gear which contact the seafloor are commonly used in the marine waters of eastern Canada. In decreasing order of commercial usage, they are: otter trawls (for demersal fish), scallop rakes, and clam dredges (Messieh et al. 1991). Analysis of sidescan sonar records, collected for geological applications, indicates that physical disturbance from mobile fishing gear, especially from otter trawls (Harrison et al. 1991, Jenner et al. 1991), is visible on the seafloor at numerous locations off the coast of the Atlantic provinces. However, little is known about the actual areal coverage and persistence of trawl marks as well as the short- or long-term ecological effects of this disturbance.

In 1990, the Department of Fisheries and Oceans (DFO) initiated a long-term study to evaluate the potential impacts of mobile fishing gear in Atlantic Canada. The primary motive for the study was to determine whether the alteration of benthic habitat or community structure by mobile fishing gear could have been a factor contributing to the unprecedented collapse of demersal fisheries experienced in the region, including northern cod. Accordingly, funding was provided by the Northern Cod Science Program, the Atlantic Fisheries Adjustment Program, the Green Plan Sustainable Fisheries Program, as well as DFO A-Base.

An initial experiment was conducted using an otter trawl on intertidal sediments of the Minas Basin in the Bay of Fundy. As the average tidal range at this location is on the order of 11 m, trawling could be done at high water while subsequent sampling could be done while the intertidal area was exposed. This greatly simplified the logistics of field work, making it relatively easy to design and conduct a controlled experiment. The impacts of otter trawling on this physically stressed habitat dominated by infaunal organisms were found to be minor (Brylinsky et al. 1994).

From the outset of the program, it was intended to conduct a series of mobile gear experiments on offshore fishing banks off both Newfoundland and Nova Scotia. Early on it was decided that the initial experiments should consider the potential impacts of otter trawls as they are the most widely used mobile gear type in Atlantic Canada. It was proposed that two study sites should be selected for comparative experiments: one on the more boreal Grand Banks, that could potentially be more physically stressed, and one on the more temperate Scotian Shelf.

This report presents and discusses the results of two research missions carried out to evaluate equipment and collect background information at the candidate sites. The first mission, in 1991 (Mission 91-016 on the C.S.S. *Dawson*), was of a preliminary nature and limited quantitative data were collected. Its prime benefit was to test sampling equipment, gain experience in its application, and decide what further equipment development work was necessary. Grabs were collected with a 0.5 m^2 Van Veen bottom grab equipped with lights and video. While it appeared to work satisfactorily under some conditions, it was decided that a more dependable and versatile grab should be designed and constructed for use in the project. This was subsequently done over the winter of 1991/92. The second mission, in 1992 (Mission 92-034 on the C.S.S. *Parizeau*), successfully tested the new video grab, collected further background information on bottom disturbance using sidescan sonar, and collected data on benthic habitat and community structure at candidate study sites. Results are presented in this report and used to compare the candidate sites relative to their suitability for conducting an otter trawl impact experiment.

SELECTION OF CANDIDATE SITES

Experiments to investigate the potential impacts of mobile fishing on offshore benthic habitat and communities, and subsequent recovery, should be conducted at sites with particular properties. Ideally, they should:

- never have been trawled or dredged (or at least not for several years) so that benthic habitat and communities are in as close to a "natural" state as possible;

- be protected from unplanned mobile gear disturbance for the duration of the project (on the order of 5 yr);

- have a sediment type and benthic community which is representative of large areas of the continental shelf that support commercial demersal fisheries;

- have relatively uniform environmental conditions (e.g. water depth, currents, sediment type, etc.) within their bounds to reduce biological variability;

- have a sediment type that can be easily sampled and processed in a quantitative manner; and

- have a biological community that is abundant (both in terms of numbers and biomass), diverse in number of species representative of major phyla and life history strategies, and relatively homogeneous.

Discussions were held with marine scientists and managers in both the Newfoundland and Scotia-Fundy Regions to identify specific areas off the east coast of Atlantic Canada that potentially met these criteria. Two areas were subsequently selected for further evaluation during the two site-selection missions: the general area of Western Bank off Nova Scotia, and a specific area on the Grand Banks of Newfoundland.

WESTERN BANK

Western Bank is located on the outer part of the Scotian Shelf to the west of Sable Island Bank (Fig. 1). This general area was selected because most of it lies within the 4TVW haddock nursery area which has been closed year round to mobile groundfish gear since 1987 for conservation purposes. Traditionally, this region had been the site of a winter-spring trawl fishery for pre-spawning and spawning haddock (*Melanogrammus aeglefinus*) and cod (*Gadus morhua*), particularly in deeper water along the slopes of Western and Emerald Banks and the saddle between them. Immediately prior to the 1987 closure, trawlers were conducting a summer shallow-water fishery on juvenile haddock, which caused concern within the industry and led to the closure. The first mission tested equipment and conducted sidescan sonar surveys both outside and inside the closed area, while sampling on the second mission focused on just two sites within the closed area which were selected on the basis of depth and surficial sediments (Fig. 1). Site A was centred at 43°28'N; 61°41'W in an average water depth of 74 m, while Site B was centred at 43°35'N; 61°58'W in an average water depth of 91 m. These two sites were about 30 km apart. Unfortunately, it was not until the field program was under way that it was realized that the region remained open to scallop (*Placopecten magellanicus*) dredging and that bottom disturbance was still taking place within the closed area.

Surficial sediments on Western Bank are primarily Sable Island Sand and Gravel. This sediment unit consists of fine- to coarse-grained, well-sorted sand which grades laterally into coarse gravel with rounded boulders (Lawrence et al. 1989). Thickness does not generally

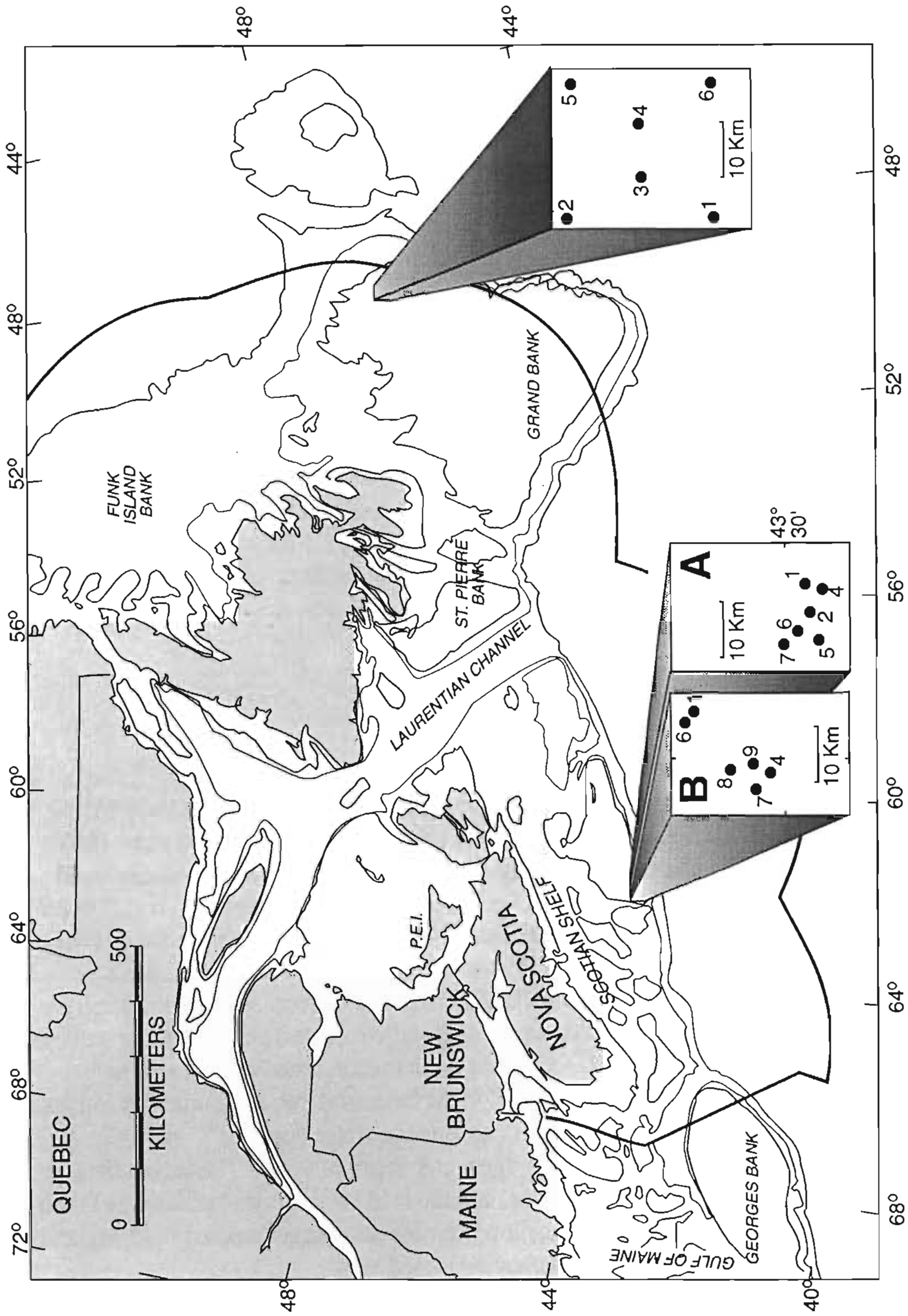

Figure 1. Map of the continental shelf off eastern Canada showing the location of the three candidate study sites and the position of the six stations within each site at which biological samples were collected by epibenthic sled and video grab.

exceed 15 m. The sand surface is smooth, hard, and flat with some bedforms while the gravel surface is rough. There is no published background information on the benthos of Western Bank, but benthic studies have been conducted at other areas on the Scotian Shelf.

GRAND BANKS

A specific area, centred at 47°10'N; 48°17'W and having an average water depth of 137 m, was selected near the nose of the Grand Banks almost due east of St. John's (Fig. 1). This area, about 60 km northeast of the Hibernia oil-production site now under development, was selected because analysis of the commercial trawling effort data collected as part of the DFO Observer Program between 1980 and 1992 indicated that it had not been subjected to heavy trawling since the early 1980s (Kulka 1991). Prior to that period, the area had supported a mixed fishery in the 100- to 150-m depth stratum, dominated by American plaice (*Hippoglossoides platessoides*). To facilitate the study, in 1992 DFO closed an area 10 naut. mi. x 10 naut. mi. at this site to all mobile fishing gear for an indefinite period.

Surficial sediments at this site are composed of Adolphus Sand. This sediment unit is a moderately to well-sorted fine- to medium-grained sand which grades into sandy gravel (Lawrence et al. 1989). It generally exists as a thin veneer only a few meters thick. No previous benthic studies have been conducted at this site, but the benthos of the Grand Banks region has been studied and described by Nesis (1965) and Hutcheson et al. (1981). In addition, Schneider et al. (1987) explored spatial relationships in the occurrence of megabenthic species on the outer Grand Banks in the vicinity of Hibernia.

METHODS

SIDESCAN SONAR

Previous studies (e.g. Jenner et al. 1991, Harrison et al. 1991) clearly demonstrated that sidescan sonar can be used to determine if the seafloor has recently been disturbed by mobile fishing gear. Therefore, on both missions, Klein sidescan sonar instrumentation was installed and operated by staff from the Geological Survey of Canada Atlantic (formerly the Atlantic Geoscience Centre) to determine if any fishing gear disturbance could be detected on the seafloor at the candidate sites. Relatively extensive surveys were conducted on Western Bank because of the large area initially being considered, while those on the Grand Banks were restricted to the immediate vicinity of the pre-selected site. All records were archived in the Geological Survey of Canada Atlantic.

SAMPLE COLLECTION AND PROCESSING

Epibenthic organisms were collected with a modified AQUAREVE III epibenthic sled (Thouzeau et al. 1991) fitted with wings to ensure an upright landing on the seafloor. The width of sampling was 1 m, the blade cut to a depth on the order of 5 cm, and the length of tow was in the range of 50-150 m. Operation of the sled was monitored using a video camera. Under these conditions, relatively large samples were collected which were difficult to immediately process in their entirety. Therefore, after the sled contents were dumped into a wooden dump tray, a representative subsample was transferred to a sorting table and sorted immediately aboard ship to the species level. Numbers were counted and volume estimated by displacement volume. Less-abundant species were frozen and returned to the laboratory for later processing and taxonomic confirmation. Due to generally greater concentrations of epibenthic organisms at the Grand Banks site, the sled tows there were shorter, which reduced the likelihood of capturing less-abundant species.

It was quite evident from the video information that the sled was not collecting quantitative samples during these missions. For example, the mouth quickly plugged with a rolling mass of sediment and organisms, part of which passed over the top and around the sides instead of entering the collection box. In addition, it was difficult to accurately determine the endpoint of the tow because the sled could continue to sample during the start of its retrieval. During the second mission it was possible to collect six sled samples at each of the three candidate sites; and, while not quantitative, these could be used to provide a general description of the species composition of the epibenthic communities. Substantial improvements to make the sled more quantitative were subsequently made prior to the 1993 field season and are described in detail by Rowell et al. (1994a).

Six quantitative video grab samples were collected at each of the three candidate sites in 1992. The details of the new video grab, which is designed to sample the upper 10 to 25 cm of sediment with minimum disturbance within a 0.5 m^2 rectangular sample area, are provided by Rowell et al. (1994a). In brief, it incorporates three significant improvements. The video grab assembly lands on the seafloor with the bucket still open 20 cm above the bottom, thus allowing the area to be sampled to remain essentially undisturbed. Secondly, the high-resolution colour video camera mounted above the bucket gives the operator a real-time view of the area of the seafloor just before landing and while the grab is closing. Thirdly, the video grab is closed (or opened if necessary) hydraulically on command by the operator. Thus, it can be used to sample specific microhabitats on the seafloor; and unsatisfactory samples (failure of the grab to close completely, which is determined using the video information) can be discarded without having to bring the grab on board. The video information can be recorded for later review and analysis.

Upon retrieval, the video grab was placed on a deck-mounted stand and opened hydraulically. Contents were dumped into a wooden tray, transferred by shovel to a sorting table, and washed with seawater through a 1-mm screen. All material retained on the screen was transferred to a plastic container and preserved in 4% buffered formaldehyde for later sorting and analysis ashore. Organisms were identified to species level wherever possible and counted.

Biomass was determined as wet weight after removal of excess surficial water using a paper towel. Mantle cavity liquid in molluscs is therefore included.

STATISTICS

The total number of benthic species present at each of the candidate sites was estimated by means of a species-area relationship using the data from the six grabs. A recipocal transformation was used to normalize the data. The reciprocal average number of species present in all possible subsample combinations was correlated with the reciprocal sample size. As demonstrated using the data from the Grand Banks site (Fig. 2), linearity in the relationship was further improved by applying a correction factor (c) which shifted the data points along the y-axis using the coefficient of determination (r^2) as a goodness-of-fit criterion. The total number of species present (S) can be estimated by means of the reciprocal y-intercept (Fig. 2) or computed as:

$$S = \frac{(i-1)\,(S_1-c)\,(S_i-c)}{i\,(S_1-c) - (S_i-c)} + c$$

where S_1 = mean number of species in one sample unit, S_i = number of species in all sample units, i = total sample size or number of sample units, and c = correction factor. The use of this method to estimate the total number of species present assumes an approximately random species distribution. This criterion was less well met for the two Western Bank sites; therefore, estimates for these sites are likely to be less accurate.

The influence of spatial distance between the six replicate grabs on sample similarity was examined using the Soerensen Index (Soerensen 1948, Kronberg 1987) for nominal data (i.e. the presence or absence of species) and the Kulczynski Index (Kulczynski 1927, Kronberg 1987) for numerical data (i.e. abundance of individual species). In both cases, this was done by correlating the similarity of all possible sample pairs with the distance between them for each of the three sites. Sampling accuracy was estimated by means of a similarity-area relationship (Weinberg 1978, Kronberg 1987) using the Soerensen and Kulczynski Indices.

Video information on seafloor habitat and benthos was also collected at all three candidate sites on the second mission using BRUTIV but is not considered in this report.

RESULTS

SIDESCAN SONAR

The sidescan sonar surveys on Western Bank in 1991 demonstrated a widespread distribution of physical disturbance from scallop rakes, both within and outside the closed area. This gear leaves a very distinctive mark on the seafloor (Jenner et al. 1991). In fact, several

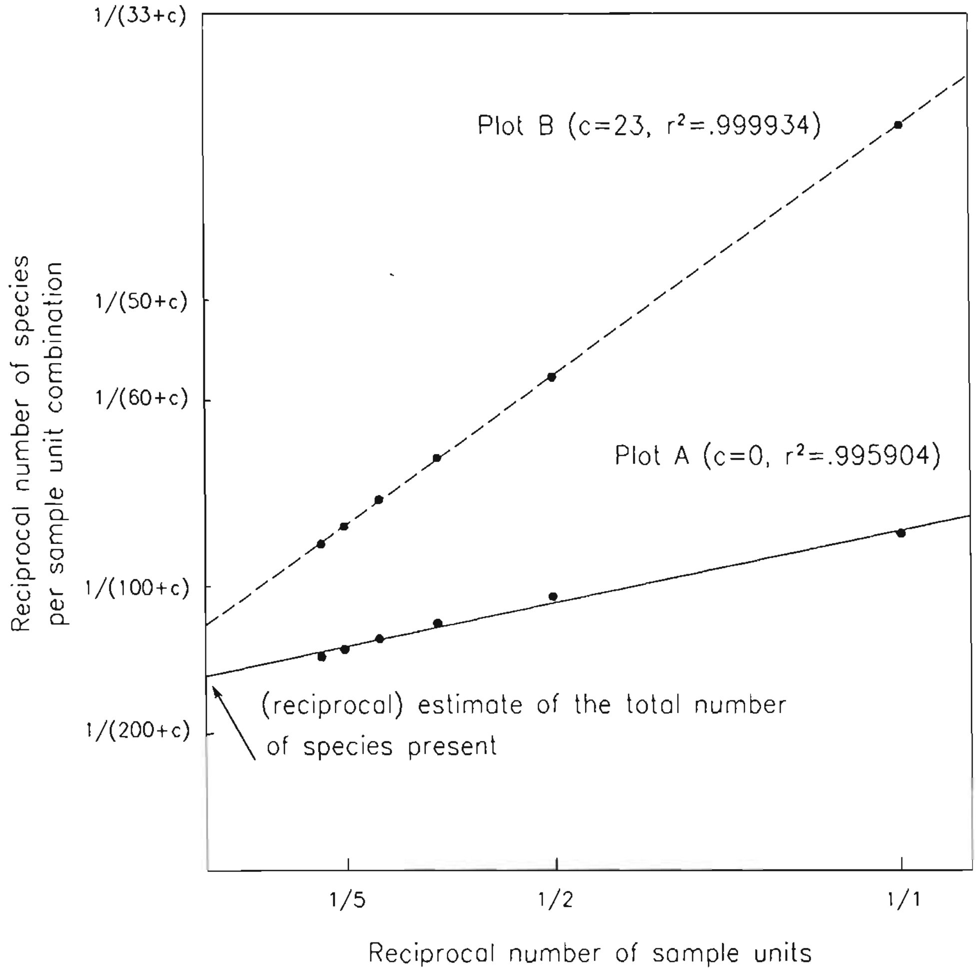

Figure 2. Species-area relationship using a reciprocal transformation for the six video grab samples collected at the Grand Banks site. Plot A illustrates the relationship without any correction. Plot B illustrates the improved coefficient of determination (r^2) when a correction factor of 23 is applied.

scallop boats were actively fishing while sampling was being conducted. On the second mission in September 1992, ten sidescan lines on Western Bank were deliberately run across eight otter trawl tracks made by recent DFO groundfish surveys and hence of known age. What appeared to be trawl marks were visible for all three of the 1992 tracks and possibly visible for one of the two 1991 tracks. However, both Sites A and B were found to be free of any detectable bottom disturbance in September 1992.

Sidescan sonar surveys at the Grand Banks site confirmed that there was no visible physical disturbance from mobile fishing gear within the proposed study area. However, several large iceberg furrows of indeterminate age were detected.

SEDIMENT PROPERTIES AND EFFECTS ON SAMPLING

The surficial sediments at both Western Bank sites are Sable Island Sand and Gravel (Lawrence et al. 1989). Site A was dominated by a medium sand with less than 50% gravel. In contrast, sediment at Site B generally had more than 50% gravel and considerably more cobble. Overall, the distribution of particle sizes was much broader and more heterogeneous at Site B which was deeper (average water depth of 91 m) than Site A (average water depth 74 m). Some mud was encountered at Station B7 (Fig. 1).

There were no major problems in collecting and processing sled or video grab samples at Site A. Only one deployment of the video grab failed to collect a suitable sample (i.e. incomplete closure of the video grab). However, sampling and processing at Site B proved much more difficult because of the more heterogeneous nature of the sediment. When soft sediments were encountered by the sled, the odometer did not rotate properly; thus, the towing distance was underestimated. Additionally, the abundance of cobbles interfered with the closure of the video grab. It was impossible to collect satisfactory video grab samples at three of the intended six stations, so alternate locations in the immediate vicinity had to be selected. Altogether, 18 deployments of the video grab were necessary to collect six suitable samples at Site B. The occurrence of clay in samples increased the sieving time considerably.

The Grand Banks site lies in the province of the Adolphus Sand (Lawrence et al. 1989). The sediment collected in the video grab at the proposed study site was a medium-fine sand which was generally homogeneous and contained only a small fraction of silt and gravel. This sediment proved easy to sample and process with both the sled and video grab. The average volume of sediment collected by the 0.5 m^2 video grab at the Grand Banks site was about 80 L, which means that the penetration depth averaged 16 cm. This volume of sediment could be sieved in approximately 12 to 20 min.

BIOLOGICAL CHARACTERISTICS

Epibenthic Sled Samples

The epibenthic sled collected organisms living on or just below the sediment surface from a relatively large area on the seafloor (50 to 150 m^2 depending on the length of the tow). As previously noted, the sled samples collected during the two site-selection missions covered in this report were not quantitative because both the design and operating procedures for the sled were still under development. However, the data from the six sled tows at each candidate site collected during the second mission do provide a general description of the epibenthic communities at the phylum level (Table 1).

A total of 60 species were collected at the Grand Banks site compared to 40 and 48 at Western Bank Sites A and B respectively. At all three sites, the phyla Mollusca and Echinodermata comprised approximately two- thirds of the collected species. In terms of numerical abundance, Annelida were important at all sites, but especially at the Grand Banks site. Volumetrically, Echinodermata dominated at the Western Bank A and Grand Banks sites while Mollusca dominated at the Western Bank B site. Generally speaking, the fourth most important phylum at all three sites was the Arthropoda. Brachiopoda, Chordata, Cnidaria, Nemertini, Porifera, and Sipuncula were occasionally encountered at some but not all sites.

The most abundant species of molluscs at the Western Bank A site were *Colus* spp., *Pandora inornata*, and *Margarites* sp. The most abundant at the Western Bank B site were *Astarte undata*, *A. crenata*, *Cyclocardia borealis*, *Antalis entale*, and *Nuculana permula*, while those at the Grand Banks site were *Astarte borealis*, *Cyclocardia* spp., and *Margarites sordidus*. The most abundant echinoderms were the sand dollar *Echinarachnius parma* and the brittle star *Ophiura sarsi*. The brittle stars *Ophiacantha bidentata* and *Ophiopholis aculeata*, the basket star *Gorgonocephalus arcticus*, the sea urchin *Strongylocentrotus pallidus*, the snow crab *Chionoecetes opilio*, and the coelenterate *Gersemia* sp. were common at the Grand Banks site. The relatively large proportion of annelids in the epibenthic community at all three sites is due to the abundance of the tube-dwelling polychaete *Nothria conchylega*. The crustaceans *Hyas coarctatus*, *Pagurus acadianus*, and *P. pubescens* were commonly collected but only in low numbers.

Video Grab Samples

In contrast to the sled, the video grab sampled a known but much smaller area of the seafloor (0.5 m^2). It also penetrated much deeper into the sediment (on the order of 16 cm at the Grand Banks site and presumably to a similar depth at the two Western Bank sites). Although there was some drainage of water and fine sediment when the video grab was brought on board, the samples are considered quantitative and provide detailed information on the biological characteristics of the macrobenthic communities including species occurrence, abundance, commonality, richness, and homogeneity.

Table 1. Number of species and the total catch composition (numbers of individuals and their volume, expressed as a percent of the total) by phylum at the three candidate sites as determined from six replicate non-quantitative epibenthic sled samples at each site. WB A is the Western Bank A site; WB B, the Western Bank B site; and GB, the Grand Banks site (Fig. 1).

	Number of species present in six tows			Percentage of total catch composition					
				Abundance			Volume		
Phylum	WB A	WB B	GB	WB A	WB B	GB	WB A	WB B	GB
Annelida	5	6	4	15.3	34.3	54.6	0.9	12.4	12.0
Arthropoda	4	4	6	4.6	2.3	2.0	1.1	5.4	6.7
Brachiopoda	0	1	0	0.0	9.1	0.0	0.0	5.1	0.0
Chordata	0	2	3	0.0	11.7	0.1	0.0	17.7	0.9
Cnidaria	1	1	3	1.5	0.0	6.8	0.2	0.5	2.5
Echinodermata	8	12	10	62.6	6.8	34.0	92.8	11.6	76.4
Mollusca	22	21	30	16.0	35.9	2.4	4.9	32.3	2.3
Nemertini	0	0	1	0.0	0.0	0.0	0.0	0.0	0.0
Porifera	0	1	2	0.0	0.4	0.0	0.0	15.1	0.1
Sipuncula	0	0	1	0.0	0.0	0.0	0.0	0.0	0.0
Total:	40	48	60						

<u>Species Occurrence and Abundance</u>: The abundant species in video grab samples (defined as having an average abundance greater than or equal to 10 individuals m^{-2}) at each site are listed in Table 2. There were 10 abundant species at the Western Bank A site, 17 at the Western Bank B site, and 21 at the Grand Banks site.

Both sites on Western Bank were dominated by tube-dwelling amphipods and polychaetes. Only four of the abundant species at each of the sites were found in all six samples and several were found in just three or less, indicating considerable patchiness in distribution. The abundant species were mostly infaunal forms, with the exception of the polychaete *Nothria conchylega* and an unidentified ascidian which occurred in high numbers in one grab at Site B. Only five abundant species were common to both Western Bank sites: the amphipods *Erichthonius rubricornis* and *Unciola irrorata*, the ocean quahog *Arctica islandica*, the polychaete *Nothria conchylega*, and Nemertini. Thus, despite the proximity of these sites (about 30 km apart), their species compositions were distinctly different.

The macrobenthic community assemblage at the Grand Banks site was much more diverse and dominated by molluscs, polychaetes, amphipods, and echinoderms (Table 2). The species collected represented a wide variety of living strategies including surface-dwellers, free-burrowing forms and tube-builders, as well as organisms with shell or exoskeleton. Particularly abundant species were the bivalve *Macoma calcarea*, the polychaetes *Prionospio steenstrupi*, *Nothria conchylega*, and *Chaetozone setosa*, and the amphipod *Priscillina armata*. Epibenthic echinoderms such as the sand dollar *Echinarachnius parma* and the brittle star *Ophiura sarsi* were also abundant in all the samples. Deep-burrowing species were *M. calcarea*, *Praxillella praetermissa*, and *Axiothella catenata*. The abundant species at the Grand Banks site were much more regular in their occurence than observed at the two Western Bank sites; 19 of the 21 abundant species were found in all six replicate samples (Table 2).

Only two species had a mean abundance greater than 50 individuals m^{-2} at the Western Bank A site and just three at the Western Bank B site (Table 2). In contrast, there were nine species with a mean abundance greater than 50 individuals m^{-2} at the Grand Banks site. The density of all species was clearly higher at the Grand Banks site which had an average of 2172 individuals m^{-2} compared to 475 and 690 individuals m^{-2} observed at the two Western Bank sites (Table 2).

The mean biomass of macrobenthic organisms at the Western Bank A and B sites is estimated to be 250 and 280 g m^{-2}, respectively. One of the six replicate grabs at the Western Bank B site had a biomass of 1200 g m^{-2} because of the abundance of large specimens of *Arctica islandica*; if these are omitted the mean biomass drops to 80 g m^{-2}. The mean biomass at the Grand Banks site is estimated to be 658 g m^{-2}, much higher than observed at the two Western Bank sites.

Also notable at the Grand Banks site is the occurrence of some mobile species with Arctic and subArctic distributions such as the polynoid polychaete *Bylgides annenkovae*; the amphipods *Guernea nordenskioldi*, *Erichthonius tolli*, *Paramphithoe* cf. *hystrix*, *Photis*

Table 2. Mean abundance (number m^{-2}) of the abundant species (10 or more individuals m^{-2}) and their frequency of occurrence (in parentheses) within the six replicate video grabs (0.5 m^2 each) at each of the three candidate study sites. A indicates Amphipoda; B, Bivalvia; C, Cumacea; E, Echinodermata; G, Gastropoda; P, Polychaeta; Sc, Scaphopoda; and Si, Sipunculida. Also provided is the mean total abundance (number m^{-2}), plus minimum and maximum, of all species at the three sites.

Western Bank A		Western Bank B		Grand Banks	
Unciola irrorata (A)	105 (6)	*Nothria conchylega* (P)	111 (6)	*Macoma calcarea* (B)	606 (6)
Clymenura borealis (P)	52 (2)	*Chone infundibuliformis* (P)	81 (4)	*Prionospio steenstrupi* (P)	241 (6)
Erichthonius rubricornus (A)	44 (2)	*Erichthonius rubricornis* (A)	51 (5)	*Nothria conchylega* (P)	214 (6)
Corophium insidiosum (A)	27 (3)	*Bathyarca pectunculoides* (B)	34 (6)	*Priscillina armata* (A)	185 (6)
Nothria conchylega (P)	20 (3)	*Ascidiidae* 1	33 (1)	*Chaetozone setosa* (P)	129 (6)
Trochidae (G)	18 (5)	*Phascolion strombi* (Si)	24 (5)	*Echinarachnius parma* (E)	124 (6)
Aglaophamus circinata (P)	13 (6)	*Eunice pennata* (P)	23 (4)	*Pectinaria hyperborea* (P)	83 (6)
Arctica islandica (B)	11 (5)	*Ampelisca agassizi* (A)	22 (5)	*Lysippe labiata* (P)	71 (6)
Travisia forbesi (P)	11 (6)	*Unciola irrorata* (A)	22 (3)	*Ophiura sarsi* (E)	63 (6)
Nemertini	11 (6)	*Notomastus latericeus* (P)	19 (5)	*Phoxocephalus holboelli* (A)	28 (6)
		Antalis entale (Sc)	14 (6)	*Scoloplos armiger* (P)	25 (6)
		Arctica islandica (B)	14 (5)	*Praxillella praetermissa* (P)	24 (6)
		Cyclocardia borealis (B)	13 (5)	*Ampharete finmarchica* (P)	18 (6)
		Ophiura sarsi (E)	12 (6)	*Spio filicornis* (P)	16 (6)
		Astarte crenata (B)	12 (5)	*Harpinia plumosa* (A)	15 (6)
		Nemertini	12 (5)	*Cylichna alba* (G)	14 (6)
		Scalibregma inflatum (P)	12 (4)	*Eudorellopsis deformis* (C)	14 (5)
				Eteone longa (P)	13 (6)
				Harmothoe imbricata (P)	12 (6)
				Axiothella catenata (P)	11 (5)
				Cyrtodaria siliqua (B)	10 (6)
Mean total individuals	475		690		2172
Minimum	178		132		1120
Maximum	1004		1462		3472

tenuicornis, *Pleustes medius*[1], *Protomedia fasciata*, *P. grandimana*, *Sympleustes* aff. *pulchellus*; the isopods *Eurycope pygmaea*[1], *Munna fabricii*[1], *Pleurogonium rubicundum1*[1], *P. spinosissimum*[1]; and the cumaceans *Cumella carinata*[1] and *Lamprops fuscata*[1].

The complete species lists for the six video grab samples collected at each candidate site are presented in the Appendix.

Species Commonality: The frequency of occurrence of abundant species in the six grabs collected at each site is given in parentheses in Table 2. A Number 1 indicates that the species was found in just one of the six video grab samples, while a Number 6 indicates that the species was found in all. Only four abundant species were found in all six video grabs at each of the Western Bank sites. The Western Bank A site had two abundant species that were found in just two grabs, while the Western Bank B site had one abundant species that was found in just one video grab. In contrast, the Grand Banks site had 19 abundant species which were found in all six video grabs, or 90% of the total. The other two abundant species were found in five of the six video grabs collected.

The commonality of all species within each of the three candidate sites is illustrated graphically in Figure 3. For example, 24% of the total number of species encountered at the Grand Banks site were found in just one video grab sample compared to 37% and 42% for Western Bank A and B sites. On the other hand, 24% of the total species at the Grand Banks site were common to all six video grab samples compared to just 6% and 8% for the Western Bank A and B sites. Approximately 37% of the species at the two Western Bank sites occurred in three or more of the video grabs compared to approximately 57% at the Grand Banks site.

In summary, the commonality of all species in the six video grabs collected was much higher at the Grand Banks site while the proportion of infrequently encountered species is greater at both Western Bank sites.

Species Richness: The mean number of species collected as a function of the number of grabs is listed in Table 3 for the three candidate sites. As expected, the number of species increases as the area of the seafloor sampled (i.e. number of grabs) increases. The total number of species collected by the six grabs was similar at each site: 91, 115, and 110 at the Western Bank A, Western Bank B, and Grand Banks sites, respectively. The estimated number of total species, calculated using the species-area relationship with a reciprocal transformation (Fig. 2), are 149, 173, and 139 for the Western Bank A, Western Bank B, and Grand Banks sites, respectively. Therefore, it appears that the Western Bank B site has a greater number of species compared to the other two sites.

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[1]Were collected during subsequent missions to the site in 1993.

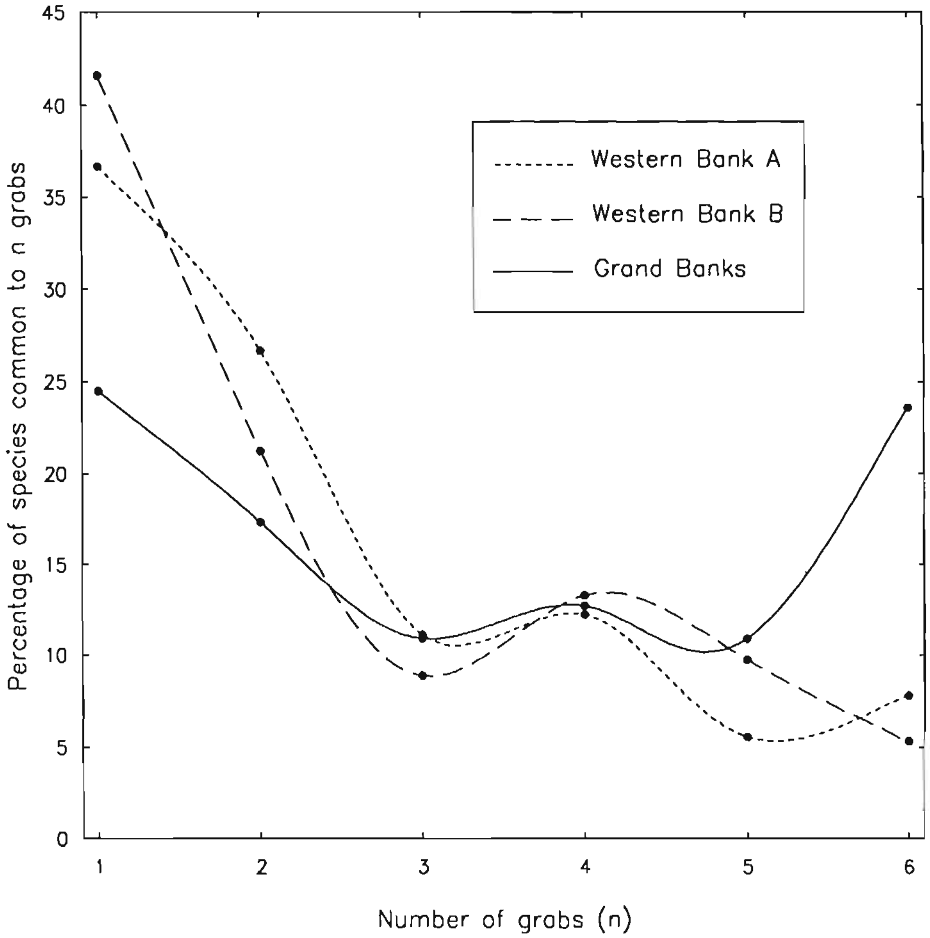

Figure 3. Regularity in the occurrence of all species within the six replicate video grabs for each of the three candidate sites expressed as the percentage of all species which occur in a specific number (n) of video grab samples. For example, at the Grand Banks site, 24% of the total species present were found in all six video grab samples compared to just 6 and 8% at the two Western Bank sites.

Table 3. Mean number of species encountered in one to six video grabs (or sample units) at each of the three candidate sites, the percentage of the estimated total, the respective total number of species estimated from the linearized species-area relationship (i.e. Fig. 2), and the coefficient of determination (r^2) for the species-area relationship.

Number of video grabs (or sample units) (0.5 m^2)	Mean number of species per sample unit combination		
	Western Bank A	Western Bank B	Grand Banks
1	34 (22%)	43 (25%)	61 (44%)
2	53 (35%)	69 (40%)	81 (58%)
3	66 (44%)	85 (49%)	92 (66%)
4	77 (52%)	97 (56%)	100 (72%)
5	85 (57%)	107 (61%)	106 (76%)
6	91 (61%)	115 (66%)	110 (79%)
Total estimated	149 (100%)	173 (100%)	139 (100%)
r^2	0.999997	0.999727	0.999934

These results indicate that six video grab samples were able to collect 61 to 66% of the species at the two Western Bank sites and 79% of the species at the Grand Banks site (Table 3). On average, single video grab deployments collected approximately 22 to 25% of the species present at the two Western Bank sites compared to 44% at the Grand Banks site. It is estimated from the data in Table 3 that in order to collect approximately 80% of the species present, it would be necessary to collect 15, 12, and 6 replicate grab samples (0.5 m^2 each) at the Western Bank A, Western Bank B, and Grand Banks sites, respectively.

Species Homogeneity: To assess the similarity of the species assemblage among the six replicate video grabs collected within each of the three candidate sites, the nominal Soerensen Index and the numerical Kulczynski Index were computed and averaged (Table 4). Both the range of spatial separation and water depth were similar at the three sites. Both indices indicate a clearly greater similarity among the six replicate video grabs collected at the Grand Banks site compared to those collected at the two Western Bank sites.

The potential influence of spatial distance between sampling locations and water depth on sample similarity was examined by means of linear correlation (Table 4). Each correlation comprises 15 data pairs which gives some preliminary insight into possible relationships. The similarity indices of the grab samples collected at the two Western Bank sites show a consistent negative relationship with both depth and distance, which suggests that these variables may contribute to sample heterogeneity. However, the only correlations that are statistically significant are those between similarity index and depth at the Western Bank A site (Table 4). Potential correlations are less apparent at the Grand Banks site, indicating greater faunal homogeneity.

The available data allow the computation of similarity-area relationships (Kronberg 1987) for up to three sample units. The Kulczynski Index is constantly larger for the samples collected at the Grand Banks site compared to those collected at the two Western Bank sites (Fig. 4). By extrapolating the relationship in Figure 4, it is estimated that five grabs are the minimum number of replicates required for the Grand Banks site to obtain similarity values greater than 0.75 which are considered necessary for the kind of experiment being designed.

DISCUSSION

Diverse benthic communities were found at all three of the candidate study sites. The number of species, both the observed and the total estimated from species-area relationships, were similar, although it appears that Site A on Western Bank has more species than the other two sites.

There is good agreement in the faunal composition of the epifaunal and surface-dwelling species observed at the Grand Banks site with those reported by Nesis (1965) and Hutcheson et al. (1981) for other areas of the Grand Banks. However, it appears that these earlier

Table 4. Mean Soerensen and Kulczynski Similarity Indices of the six replicate video grab samples collected at each of the three candidate sites and their relationship (correlation factor and probability) with the differences in water depth and the spatial distance between the video grabs. Only probabilities equal to or less than 0.05 are considered to represent significant correlations.

	Western Bank A	Western Bank B	Grand Banks
Mean Soerensen Index (I_S)	0.28	0.25	0.59
Mean Kulczynski Index (I_K)	0.35	0.23	0.59
Spatial distance between video grab samples (km)	1.4-12.6	3.4-23.4	7.1-25.3
Water depth (m)	68-80	88-100	121-148
$r(I_S$, distance)	-0.277 ($p<0.31$)	-0.515 ($p<0.05$)	-0.234 ($p<0.40$)
$r(I_K$, distance)	-0.293 ($p<0.29$)	-0.331 ($p<0.23$)	-0.084 ($p<0.77$)
$r(I_{K(\ln)}$, distance)	-0.398 ($p<0.14$)	-0.495 ($p<0.06$)	0.027 ($p<0.92$)
$r(I_S$, depth)	-0.675 ($p<0.006$)	-0.469 ($p<0.08$)	0.270 ($p<0.33$)
$r(I_K$, depth)	-0.775 ($p<0.001$)	-0.411 ($p<0.13$)	-0.170 ($p<0.55$)
$r(I_{K(\ln)}$, depth)	-0.706 ($p<0.003$)	-0.453 ($p<0.09$)	0.164 ($p<0.56$)

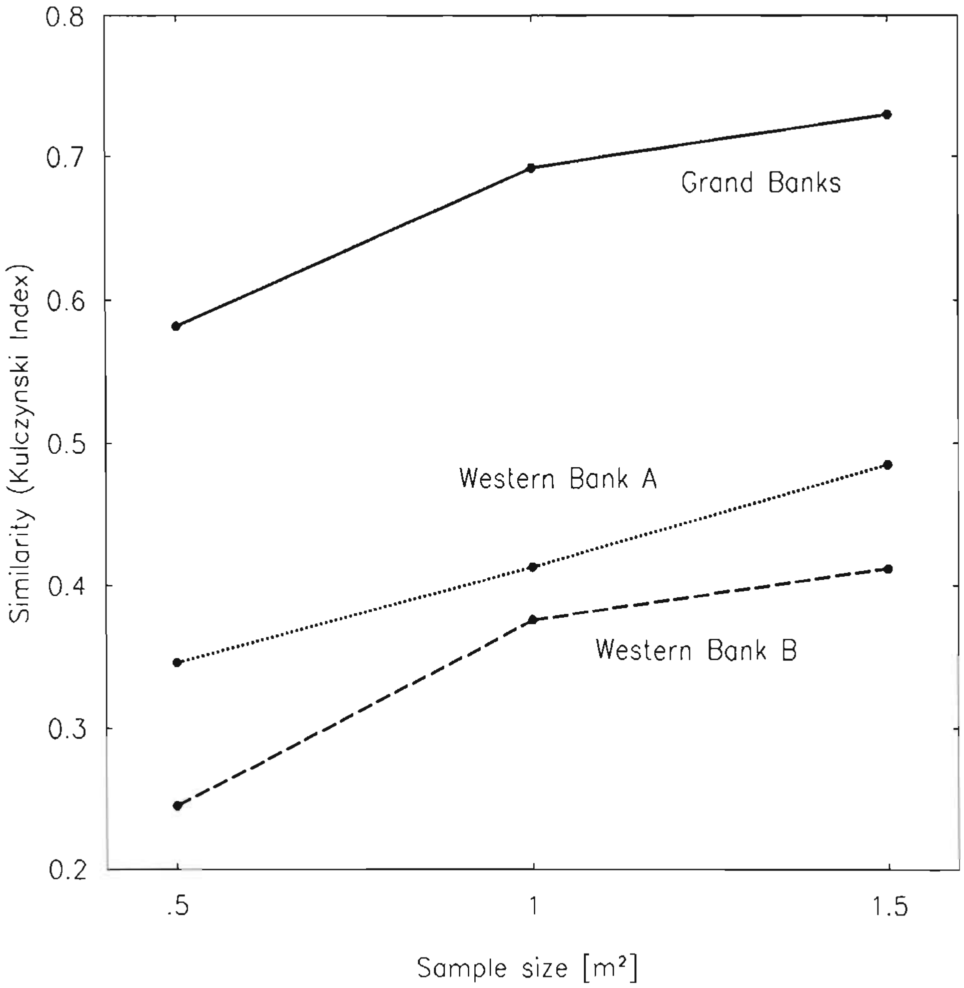

Figure 4. Relationship between the Kulczynski Index of species similarity and sample size for the three candidate study sites.

investigations underestimated the populations of some larger, deeper-dwelling species such as *Macoma calcarea*, *Praxillella praetermissa*, *Axiothella catenata*, and *Mya truncata* as well as some larger specimens of less abundant shallow-dwelling molluscs such as *Clinocardium ciliatum* and *Serripes groenlandicus*. In the case of deeper-dwelling species, these differences presumably are caused by the greater penetration of the new video grab. Some of the species found at the Grand Banks site show a boreal distribution while others are confined to Arctic and subArctic waters and have been reported from other Newfoundland and Labrador areas (e.g. Dunbar 1954, Bousfield 1973, Fenwick and Steele 1983, Stewart et al. 1985, Pettibone 1993). The observation of several Arctic and subArctic species supports the previously reported influence of the cold Labrador Current and Arctic deep water on the faunal zonation on the Grand Banks below a depth of 100 m (Nesis 1965, Hutcheson et al. 1981, Pocklington and Tremblay 1987). The Grand Banks of Newfoundland may represent a transition zone between the Arctic and boreal zone. Hutcheson et al. (1981) could not demonstrate any major seasonal changes in the benthos. Some temporal changes of rare immigrants may occur, but these should not jeopardise the suitability of the Grand Banks site for a trawl impact experiment.

No published information is available on the benthic communities of Western Bank. However, the species collected during this survey show an Atlantic-boreal distribution and have also been previously collected on Georges Bank (Maurer and Leathem 1980, Dickinson and Wigley 1981, Thouzeau et al. 1991) and other areas of the Scotian Shelf (Hughes et al. 1972).

The differences in the benthic communities at the three candidate sites as sampled by the video grab were quite striking. Even though the total number of species was similar, the Grand Banks site had a greater number of epibenthic species (Table 1) as well as a greater number of abundant species (Table 2). The average number of individuals (2172 m^{-2}) was on the order of four times that observed on Western Bank (Table 2). The total biomass at the Grand Banks site (658 g m^{-2}) was more than double that at the two Western Bank sites (250 and 280 g m^{-2}). This figure exceeds earlier estimates of benthic biomass on the Grand Banks which were in the range of 168 to 576 g m^{-2} (Nesis 1965, Hutcheson et al. 1981). The difference may be due, to some degree, to natural spatial variability in organism abundance, but it most likely also reflects the ability of the new video grab to collect animals that live deeper in the sediment.

The species composition at the Grand Banks site was much more homogeneous than that observed on Western Bank. Ninety percent of the dominant species and 24% of the total number of species were found in all six replicate grabs (Table 2 and Fig. 3). The six replicate grabs collected 79% of the estimated total number of species compared to 61 to 66% on Western Bank (Table 3). Both similarity indices were substantially higher at the Grand Banks site (Table 4). Therefore, a given number of grab samples will provide a much more representative sample of benthic communities at the Grand Banks site. This is a very important consideration because of the need to reduce the sampling error in order to increase the chances of detecting differences due to trawling impacts.

A power analysis of species number and biomass was considered to compare the number of video grab samples that would have to be collected at each site to detect a given level of difference caused by trawling. However, this was not pursued because the spatial separation of the six video grabs at each site (Fig. 1) was considerably greater than would be the case in a trawling impact experiment.

EVALUATION OF SITES AGAINST SELECTION CRITERIA

The results of the two site-selection missions can be used to evaluate the relative advantages and disadvantages of each of the three candidate experimental sites against the pre–selected criteria described above.

- The sidescan sonar surveys indicated that all three sites were free from recent disturbance by mobile fishing gear. However, the Western Bank sites could have been trawled as recently as 1987 and were perhaps influenced even more recently by scallop rakes because of the continued existence of this fishery in the closed area. Analysis of commercial fishing effort indicates that the Grand Banks site has not been subjected to heavy trawling since the early 1980s (Kulka 1991). Therefore, the benthic habitat and community at this site have had on the order of 10 yr to recover from any possible impacts caused by previous trawling and should represent natural conditions.

- The Grand Banks site has been closed by DFO since 1992 to all mobile gear for an indefinite period. The general moratorium on groundfisheries on the Grand Banks provides an additional degree of protection from disturbance. While the Western Bank sites are closed to mobile groundfish gear, they are open to scallop fishing which is being actively pursued. Thus, the Grand Banks site offers the greatest protection from unplanned mobile fishing gear disturbance. However, it can infrequently be affected by iceberg scouring.

- Both the Western Bank and Grand Banks sites have surficial sediments that are regionally representative. For example, the Sable Island Sand and Gravel blankets most of the fishing banks off Nova Scotia, while the Adolphus Sand blankets most of the perimeter of the Grand Banks (Lawrence et al. 1989).

- The available data indicate that the Grand Banks site has more uniform environmental conditions. The bottom was relatively flat and few sedimentary features could be discerned by sidescan sonar.

- Because of its more heterogeneous nature, the sediment at Western Bank (especially Site B) was more difficult to sample with the epibenthic sled and video grab and took substantially longer to process. All gear worked well in the well-sorted sand found at the Grand Banks site, and samples could be quickly seived so that processing was usually completed before the ship arrived at the next station.

- While the greatest number of species seems to occur at Site B on Western Bank, the Grand Banks site had a greater number of epibenthic species, a greater number of abundant species (at least 10 individuals m^{-2}), greater abundance of individuals, and greater biomass. In addition, the species composition was much more homogeneous. Therefore, a much lower level of sampling effort is required at the Grand Banks site to attain the desired level of accuracy.

CONCLUSIONS

After the results of the two site-selection missions had been assessed and more thought given to the detailed design of an otter trawl experiment, it quickly became obvious that the original proposal of conducting two parallel experiments - one on Western Bank and one on the Grand Banks - was not practical for logistical reasons. Therefore, a single site had to be selected for the initial experiment. The data summarized in this report clearly indicate that, of the three sites considered, the most suitable for an initial offshore otter trawl impact experiment was the Grand Banks site (Fig. 1). Subsquently, a 3-yr experiment was designed and initiated at this location in 1993. Full details of the experiment are provided in Rowell et al. 1994b, and the results will be presented in future publications.

The two Western Bank sites will still be considered when selecting the location(s) for possible future mobile gear impact experiments on the Scotian Shelf. However, they first would have to be protected from potential disturbance by scallop rakes.

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APPENDIX. SPECIES LISTS AND ABUNDANCE (NUMBERS M^{-2}) FOR THE SIX VIDEO GRAB SAMPLES COLLECTED AT EACH CANDIDATE STUDY SITE.

WESTERN BANK, SITE A (C.S.S. *PARIZEAU* MISSION 92-034 - SEPTEMBER 1992)

	Station: A1	A2	A4	A5	A6	A7
	Depth (m): 68	73	69	68	80	79
Cerianthus sp.	2					6
Halcampa duodecimcirrata	8	8	2		6	10
Nemertini	4	6	12	8	22	14
Sipunculoidea					18	22
Bryozoa					+	+
Calliostoma occidentale					2	
Trochidae A	2	26		32	10	22
Margarites sp.			16			
Acirsa eschrichti						2
Polinices immaculatus					2	
Naticidae						4
Neptunea sp.						2
Colus pygmaeus					2	6
Oenopota sp. R						2
Oenopota sp. S						2
Oenopota sp. T						2
Philinoidea		2	2			
Cylichna alba		4	2		12	16
Scaphander punctostriatus		2	4			
Antalis entale					2	2
Liocyma fluctuosa					2	
Pectinidae						2
Arctica islandica		8	4	6	10	42
Cerastoderma pinnulatum					6	16
Cyclocardia borealis						4
Cyrtodaria siliqua			4		6	2
Scoloplos armiger	2			2	2	4
Orbinia sp.		2				
Aricidea wassi	10	4	4	12		
Aricidea catherinae			2			
Spio filicornis				6		
Laonice cirrata		2	4	4	2	
Spiophanes bombyx		16		12		
Scolelepis squamata					2	
Spiochaetopterus typicus	4	6		4	12	8

Station:	A1	A2	A4	A5	A6	A7
Depth (m):	68	73	69	68	80	79
Tharyx sp.		6	6	2	4	
Capitella capitata						4
Notomastus latericeus	6	2	22	12	12	
Praxillura ornata		2			2	2
Clymenura borealis	98	68	28	58	44	16
Nicomache lumbricalis						4
Travisia forbesi	12	6	6	12	18	14
Ophelia limacina	2		8	2	4	
Euzonus flabelliferus	4	10		4		
Scalibregma inflatum				2		2
Eulalia bilineata					2	
Phyllodoce groenlandica					4	4
Phyllodoce mucosa					2	2
Eteone longa					4	
Enipo gracilis						2
Harmothoe imbricata					2	
Bylgides annenkovae	4					2
Syllidae			2			4
Nereis zonata					4	2
Glycera capitata			2		8	
Goniada maculata	2			2	10	8
Nephtys caeca	2	6	2	6	8	10
Aglaophamus circinata	6	4	12	12	32	16
Nothria conchylega				16	74	28
Owenia fusiformis					2	50
Galathowenia oculata					12	4
Pectinaria hyperborea						2
Ampharete finmarchica	2	2		4		2
Polycirrus medusa		2		6		2
Laphania boecki			2			
Potamilla reniformis					2	
Chone sp.					2	2
Leucon nasicoides						2
Eudorellopis deformis	2				28	20
Petalosarsia declivis						2
Cirolana polita		10				
Synidotea nodulosa						2

Station:	A1	A2	A4	A5	A6	A7
Depth (m):	68	73	69	68	80	79
Argissa hamatipes						2
Phoxocephalus holboelli	2	2				2
Ampelisca macrocephala	4		2		12	4
Anonyx sarsi			2			4
Hippomedon serratus			2	4		
Psammonyx terranovae		4	12	2		
Unciola irrorata	4	6	6	2	386	228
Leptocheirus pinguis					2	52
Photis tenuicornis					10	2
Protomedeia fasciata				2		
Corophium insidiosum	2			2	136	20
Ischyrocerus sp.						2
Erichthonius rubricornis					4	260
Dulichia monacantha					2	4
Pagurus acadianus				2		2
Pagurus pubescens	6					2
Echinarachnius parma		2	10	8	16	2
Asteriidae					2	2
Ophiura sarsi		4		4	26	14

WESTERN BANK, SITE B (C.S.S. *PARIZEAU* MISSION 92-034, SEPTEMBER 1992)

Station:	B9	B7	B8	B4	B6	B1
Depth (m):	91	100	94	92	94	88
Anthozoa A	2					
Cerianthus sp.	2					
Halcampa duodecimcirrata		6	2			
Nemertini	14	12	6	26	12	
Ischnochiton albus		2				
Crystallophrisson nitidulum		6			4	
Puncturella noachina	2	4				
Trochidae					14	4
Acirsa eschrichti		2				
Epitonium greenlandicum		2				
Aporrhais occidentalis					2	
Velutina velutina		4				
Natica clausa				2		
Colus pygmaeus					2	2
Buccinum sp. E	2			2		
Oenopota sp. R						2
Oenopota sp. Q						2
Cylichna alba		2		2		
Philine quadrata						4
Antalis entale	10	4	24	26	16	2
Bathyarca pectunculoides	12	56	14	82	18	22
Enucula tenuis		6			2	
Nucula tenuisulcata					8	6
Yoldia sapotilla		2				
Musculus discors			2			
Pectinidae			2			
Anomia squamula	4		6	8		
Crenella glandula		2				
Astarte sp.	4	16	2		42	6
Astarte elliptica	4	6	4	6	30	2
Arctica islandica		4	2	4	30	46
Thyasira sp.					18	
Cyclocardia borealis	8		6	4	56	2
Cerastoderma pinnulatum	2	4		8	16	
Macoma calcarea	2					

Station:	B9	B7	B8	B4	B6	B1
Depth (m):	91	100	94	92	94	88
Scoloplos armiger					2	
Orbinia sp.	4					
Aricidea aff. albatrossae		4	2			
Spio filicornis	12		2			
Laonice cirrata	6					
Prionospio cirrifera	8	2		18	4	2
Polydora concharum	2	2				
Polydora quadrilobata	2					
Polydora socialis	2					
Spiophanes kroeyeri					2	
Scolelepis squamata	2			4	6	
Spiochaetopterus typicus	6		2	14	6	
Tharyx sp.	18	2		16	6	
Notomastus latericeus	26	44	4	16	22	
Mediomastus ambiseta	2	6		8	4	
Praxillura ornata	4	2		6	16	
Clymenura borealis	2				2	
Rhodine loveni	8				10	
Nicomache lumbricalis			2	16		
Praxillella praetermissa		2	2	4		
Ophelina acuminata					4	
Euzonus flabelliferus	2					
Scalibregma inflatum	18		6	18	32	
Phyllodoce groenlandica	2					
Phyllodoce mucosa	2					
Syllidae	2	6	4	2		
Nereis zonata		4		8	12	
Glycera capitata	14	2	2	10	4	
Goniada maculata	14	12	4	4	4	
Nephtys sp.		2				
Aglaophamus circinata	26	4	4	6	8	2
Nothria conchylega	194	2	4	336	130	2
Eunice pennata	22	92	20	2		
Lumbrineris acuta	2					
Lumbrineris fragilis		6		4		
Lumbrineris latreilli		6		2	8	
Ninoe nigripes	10	4	2		10	
Arabella iricolor		10				

Station:	B9	B7	B8	B4	B6	B1
Depth (m):	91	100	94	92	94	88
Drilonereis magna	2		2			
Owenia fusiformis	10				4	2
Galathowenia oculata	6		4	4		
Melinna elizabethae				2		
Ampharete finmarchica	4		2	14	10	
Streblosoma spiralis		6				
Neoamphitrite affinis	6		8			
Polycirrus medusa	22	12	2	10		
Pista cristata	6	6	10	30		
Leaena ebranchiata	10					
Lysippe labiata	2		4	4		
Potamilla reniformis	10	4	6		4	
Chone sp.	26	14		442	2	
Eudorella pusilla	4	6		16	2	
Diastylis quadrispinosa		8	2	8	2	
Cyathura polita	2					
Janira alta	2	8				
Tiron acanthurus	4			4		
Ampelisca agassizi	16	8	28	16	64	
Ampelisca vadorum					2	
Ampelisca aequicornis	4	4				
Ampelisca macrocephala	2					
Byblis gaimardi					2	
Atylus carinatus	2					
Hippomedon serratus		2			2	
Unciola irrorata		6	6		118	
Leptocheirus pinguis	4	2				
Corophium insidiosum	2					
Erichthonius rubricornis	72		2	188	44	2
Axius serratus		2				
Dichelopandalus leptocerus	2					
Sipunculoidea	42	34	4	30	34	
Nymphon grossipes		2				
Bryozoa	+					
Terebratulina septentrionalis	18	2	2			
Ascidiidae		200				

Station:	B9	B7	B8	B4	B6	B1
Depth (m):	91	100	94	92	94	88
Thyone scabra				2		
Strongylocentrotus droebachiensis	2					
Brissopsis sp.	2					
Ophiura sarsi	4	4	2	28	12	20
Ophiopholis aculeata	10	4				

GRAND BANKS SITE (C.S.S. *PARIZEAU* MISSION 92-034, SEPTEMBER 1992)

Station:	GB1	GB2	GB3	GB4	GB5	GB6
Depth (m):	121	142	135	139	148	137
Gersemia sp.	16	18		10	14	32
Nemertini	6	2	2	4	18	2
Eudorellopsis deformis	22	20		8	28	4
Eudorellopsis integra		2				
Diastylis rathkei					2	2
Leptognatha sp.	14				6	
Melita dentata			4		2	4
Stenula peltata					2	
Syrrhoe crenulata				2		
Acanthonotozoma inflatum						2
Sympleustes aff. pulchellus				4		
Harpinia plumosa	10	10	2	26	26	18
Harpinia sp.		2				
Phoxocephalus holboelli	22	38	6	24	48	28
Ampelisca macrocephala	8	4	2	2	6	
Byblis gaimardi	12	8	24	8		
Guernea nordenskioldi	2	4		6	10	
Anonyx sp.			2	4		
Hippomedon propinquus				2	6	2
Priscillina armata	220	492	154	98	138	30
Bathymedon obtusifrons				2	2	
Oediceros borealis	6	12		10	18	
Photis tenuicornis		2				
Protomedia fasciata			2	4	4	4
Protomedia grandimana	6	6	2	4	4	8
Erichthonius tolli	2		2		6	
Decapoda indet.	2					
Chionoecetes opilio	4				6	2
Nymphon grossipes	2					
Scoloplos armiger	60	2	42	6	4	38
Aricidea wassi				2	16	
Aricidea sp.			16	14	6	8
Apistobranchus typicus			4	4	2	
Spio filicornis	12	2	48	10	24	2
Laonice cirrata					2	

Station:	GB1	GB2	GB3	GB4	GB5	GB6
Depth (m):	121	142	135	139	148	137
Prionospio steenstrupi	76	62	110	294	842	62
Polydora socialis	2			2	2	4
Chaetozone setosa	112	86	120	174	112	170
Chaetozone sp.	2	2		2	2	
Capitella capitata	2		2	2	2	
Notomastus latericeus		2				2
Mediomastus ambiseta		2	2	2	14	2
Axiothella catenata		38	4	4	20	2
Praxillella praetermissa	24	24	6	40	20	30
Ophelia limacina	12	6				2
Ophelina breviata			2	2	12	4
Phyllodoce groenlandica		2			6	2
Mysta barbata			2	2		
Eteone longa	10	2	34	8	10	14
Gattyana cirrosa	4	12	4	4	4	4
Harmothoe imbricata	6	36	6	4	8	14
Arcteobia anticostiensis	10	6	8	6	4	
Bylgides annenkovae	2		2		2	4
Pholoe sp.	16	2		8	4	4
Nereimyra punctata	4		2	2	12	2
Syllidae				6	2	
Goniada maculata	2	14		10	10	4
Nephtys caeca	10	8	6	10	10	10
Nothria conchylega	156	456	26	192	130	324
Owenia fusiformis		2				2
Myriochele heeri		2				
Pectinaria hyperborea	32	168	20	62	178	36
Ampharete finmarchica	18	28	12	14	28	8
Ampharete acutifrons			6	12	6	
Polycirrus medusa				18	32	4
Laphania boecki	12	4	6	14	10	8
Leaena ebranchiata	2		2		2	
Lysippe labiata	34	146	24	92	72	56
Euchone papillosa					2	2
Jasmineira sp.		2				
Oligochaeta	4	4	2		12	

Station:	GB1	GB2	GB3	GB4	GB5	GB6
Depth (m):	121	142	135	139	148	137
Crystallophrisson nitidulum		2				
Margarites sordidus		4			2	
Solariella obscura			2			
Solariella varicosa			2			
Amauropsis islandica		2			2	
Natica clausa				4		2
Polinices pallidus						6
Propebela nobilis				2	2	
Oenopota sp. E		2	2		4	2
Oenopota sp. I			2			
Oenopota sp. U					2	
Cylichna alba	10	24	4	24	6	18
Philine sp.				6		8
Diaphana minuta						2
Nudibranchia					2	
Liocyma fluctuosa		4	2			
Enucula tenuis					2	
Nuculana minuta		6			10	
Yoldia myalis	6	10	2		10	2
Crenella decussata		2	2			
Astarte borealis	18	8	8	6	8	
Astarte sp. A			2			
Thyasira sp. A	12	10	6	2	2	2
Cyclocardia novangliae	24		2	4		10
Cyclocardia sp. A.						2
Clinocardium ciliatum		4		2		2
Macoma calcarea	304	580	260	778	1156	558
Cyrtodaria siliqua	14	8	20	6	4	6
Lyonsia arenosa		2				
Chiridota laevis						2
Strongylocentrotus pallidus	2	4	6	4	4	2
Echinarachnius parma	120	106	68	152	132	168
Ctenodiscus crispatus					2	
Asteriidae					4	
Ophiura sarsi	14	78	30	104	118	34
Ophiacantha bidentata		2			2	

	Station:	GB1	GB2	GB3	GB4	GB5	GB6
	Depth (m):	121	142	135	139	148	137
Myriapora sp.		+	+	+	+	+	+
Pelonaia corrugata			6	2			10