DEMERSAL FISH ASSEMBLAGES FROM THE SCOTIAN SHELF AND BAY OF FUNDY, BASED ON TRAWL SURVEY DATA (1970-1993)

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TABLE OF CONTENTS

ABSTRACT

Mahon, R. 1997. Demersal fish assemblages from the Scotian Shelf and Bay of Fundy, based on trawl survey data (1970-1993). Can. Manu. Rep. Fish. Aquat. Sci. No. 2426.

Demersal research trawl survey data for the Scotian Shelf and Bay of Fundy, were analysed by cluster analysis in order to: define and map the demersal fish assemblages; examine the patterns of diversity of demersal fishes; and explore a simple habitat suitability model for yellowtail flounder.

The analysis producing six site groups was selected as the most reasonable and interpretable. Similarly, a clustering level producing six species groups was selected for display. Site group 1 occurs mainly on the eastern Scotian Shelf, but also in the mouth of the Bay of Fundy (main species, American plaice, thorny skate, smooth skate, Vahl's eelpout). Site group 2 occurs mainly on the western shelf in deep water between banks and along the Fundian Channel (main species, spiny dogfish, pollock, cusk, blackbelly rosefish, argentine). Site group 3 occurs mainly on banks and in the head of the Bay of Fundy (main species, haddock, halibut, wolfish, sand lance) Site group 4 occurs primarily in the central Scotian Shelf (main species, red hake, silver hake, angler). Site group 5 is in deep water along the slope of the Laurentian Channel, the outer Scotian Shelf slope and the mouth of the Fundian Channel (main species, common grenadier, longfin hake, redfish). Site group 6 is largely in shallow water in the Bay of Fundy and around Sable Island (main species, longhorn sculpin, sea raven, winter flounder).

Depth and temperature were used to predict the occurrence and abundance of yellowtail flounder. Years 1970-1989 were used to develop the model which was used to predict for years 1990-1993. There was significant correlation between predicted and observed values.

RÉSUMÉ

Mahon, R. 1997. Demersal fish assemblages from the Scotian Shelf and Bay of Fundy, based on trawl survey data (1970-1993). Can. Manu. Rep. Fish. Aquat. Sci. No. 2426.

L'auteur a étudié les données du relevé au chalut des poissons démersaux effectué sur le plateau néo-écossais et dans la baie de Fundy au moyen de l'analyse de groupage. Il s'sgissait d'établir et de cartographier les assemblages de poissons démersaux, d'examiner les profils de diversité des poissons démersaux, et d'explorer un modèle simple d'habitat adapté à la limande à queue jaune.

L'analyse par laquelle on a obtenu six types de sites abritant six groupes de poissons a été choisie comme la plus pratique et la plus facile à interpréter. De la même façon, un niveau de groupage permettant d'obtenir les six groupes d'espèces a été choisi pour la présentation. Le site du groupe 1 occupe principalement la partie est du plateau néo-écossais, mais aussi l'entrée de la baie de Fundy (principales espèces : plie canadienne, raie épineuse, raie à queue de velours, lycode à carreaux). Le site du groupe 2 se trouve notamment dans les eaux profondes entre les bancs de la partie ouest du plateau et le long du chenal de Fundy (principales espèces : aiguillat commun, goberge, brosme, chèvre impériale, argentine). Le site du groupe 3 couvre principalement les bancs et le fond de la baie de Fundy (principales espèces : aiglefin, flétan, loup et lançon). Le site du groupe 4 occupe principalement la partie centrale du plateau néo-écossais (principales espèces : merluche rouge, merlu argenté, baudroie). Le site du groupe 5 se trouve en eau profonde le long du talus du chenal laurentien, sur le talus extérieur de plateau néo-écossais et à l'entrée du chenal de Fundy (principales espèces : grenadier, merluche à longues nageoires, sébaste). le site du groupe 6 se trouve en grande partie dans les eaux peu profondes de la baie de Fundy et autour de l'île de Sable (principales espèces : chaboisseau à dix-huit épines, hémitriptère atlantique, plie rouge).

L'auteur a eu recours à la profondeur et à température de l'eau pour prévoir la présence et l'abondance de la limande à queue jaune. Les données pour la période de 1970 à 1989 ont servi à l'élaboration du modèle de prévision pour la péroide de 1990 à 1993. Il a relevé une corrélation importante entre les valeurs prévues et les valeurs observées.

INTRODUCTION

The East Coast of North America Strategic Assessment Project (ECNASAP) will incorporate existing data, information, and knowledge on living marine resources and the environment into an information system framework for mapping and analysis in support of environmental decision-making (ACRICS/SEA 1995). The objective of the offshore case study is "To support multi-species management on the continental shelf within an ecosystem context by identifying demersal fish and invertebrate assemblages, and analyzing their relationships with habitat, inshore ecosystems, key exploited species, and other major species groups." Demersal finfishes are an important component of the offshore ecosystem. The ECNASAP system will include information on individual demersal fish species and assemblages.

Assemblages are groups of species which tend to occur together, either because they have similar habitat preferences, or because they interact with each other. The description of assemblages can indicate where various combinations of species may be caught by fishing, and where fishing may affect non-target species. It is the starting point in the process of examining the possible interactions among species. The patterns do not of themselves tell us which species are interacting, but they do indicate where interactions might be taking place. Assemblages may also provide insight into ecosystem process, as a context for marine resource conservation and management.

There have been several previous studies of demersal fish assemblages on the continental shelf off the east coast of North America (e.g. Colvocoresses and Musick 1984, Mahon and Sandeman 1985, Gabriel 1992, Gomes *et al.* 1992, Gomes 1993), including the Scotian Shelf and Bay of Fundy (Mahon and Smith 1988). The latter study included data from 1970 to 1982 only and adopted a methodological approach which could not meet the needs of the present study. Thus a new analysis which included the entire time series and addressed the needs of ECNASAP was deemed necessary.

This report describes the analysis of demersal research trawl survey data for the Scotian Shelf and Bay of Fundy (Fig. 1) which was carried out in order to: (1) define and map the demersal fish assemblages on the Scotian Shelf and Bay of Fundy; (2) examine the patterns of diversity in the demersal assemblage; and (3) develop a simple habitat suitability model for yellowtail flounder. Since the aim of these analyses was to provide inputs to the ECNASAP Pilot Information System, much of it via desktop mapping software (SPANSMAP), the mapping and spatial analysis provided in this report is minimal.

METHODS

Research Trawl Surveys on the Scotian Shelf

Standard groundfish surveys have been carried out by the Department of Fisheries and Oceans, Marine Fish Division, on the Scotian Shelf and in the Bay of Fundy each summer since 1970. These provide a continuous time-series from which trends in distribution and abundance of demersal species can be examined. Spring and Fall surveys have also been carried out for various periods.

The summer groundfish surveys use a stratified random design with depth as the major stratifying variable. Strata are divided into shallow (<50 fm), intermediate (50-100 fm), and deep (>100 fm) categories. Except in the Bay of Fundy, the area inshore of 50 fathoms is generally not surveyed due to untrawlable bottom. Sampling stations are chosen randomly with a minimum of two stations per strata per survey. Additional stations within a stratum are allocated roughly in proportion to its area. Sampling is conducted around the clock. The net is towed for 30 minutes, from touchdown to liftoff, at approximately 3.5 knots. Catch rates are adjusted to a standard tow distance of 1.75 nautical miles.

Hydrographic information is collected at the end of each tow with, as a minimum, surface and bottom temperature and salinity taken. At selected stations a vertical profile of hydrographic samples is taken using reversing bottles. Since 1990 conductivity, temperature, depth (CTD) recorders have been used to collect hydrographic information at all stations from the surface to 5 m off the bottom.

Survey procedures have remained more or less constant, though vessels and gear have changed. The A.T. Cameron began the survey series in 1970 using a 36 Yankee trawl. The A.T. Cameron was retired in 1981. The 1982 survey was conducted by the Lady Hammond (a 58 m stern trawler) using a Western IIA trawl. Beginning in 1983, and continuing until the present, the Alfred Needler (a 50 m stern trawler) has conducted the survey using a Western IIA trawl. The 1989 and 1990 surveys were changed slightly to include a number of stations on the northeast peak of Georges Bank. Bottom trawls are selective. For example, pelagic species like Atlantic herring, American shad, and Atlantic mackerel will be under-represented. The results of the survey are not considered representative for age group 0 cod and haddock in stock assessments. It can, therefore, be expected that other smaller species are also under-represented, though the use of a three-quarter inch (19 mm) liner in the codend retains many juveniles and smaller species.

The changes in vessels and gear and their effect on the catchability of some species made it necessary to apply conversion rates to those species from the A.T. Cameron and Lady Hammond surveys, to make their catches equivalent with the Alfred Needler's surveys. Catches of Atlantic cod, witch flounder, and yellowtail flounder, were multiplied by 0.8, while haddock catches were multiplied by 1.2 to bring them in line with the Alfred Needler time series. White hake, silver hake, redfish, and winter flounder exhibited no significant differences in catchability over the series. American plaice had different catchability based on lengths greater or less than 28 cm. We made no attempt to separate American plaice by length and, therefore, no corrections were made in this analysis.

The criteria for identifying many species have been constantly changing, resulting in the separation of some species pairs: for example red/white hake, winter/little skate, offshore/silver hake, and alligatorfish/Atlantic poacher. The species group redfish is composed of three separate species. Eelpouts other than Vahl's eelpout are recorded only as eelpouts.

Data collected on the RV groundfish surveys is maintained at the Canada Department of Fisheries and Oceans, St. Andrews Biological Station, St. Andrews, N.B. The nomenclature used is based on Atlantic Fishes of Canada by Scott and Scott (1988). For more information see (Simon and Comeau 1994).

Data Preparation

The description of assemblages of demersal fishes on the Scotian Shelf and Bay of Fundy provided in this study uses data from the 1970-1993 research trawl surveys. Only the summer surveys, conducted during the months of July and August, were used. There was a total of 3,794 trawl sets for the entire 23-year period.

The data were first compiled into a database as described in Appendix 1. This database included data from the Southern Gulf of St. Lawrence. However, the latter data were not included in the analysis.

The overall composition of the catch in the demersal trawl is shown in Appendix 2. The trawl captures some benthic invertebrates, of which the crabs are probably best sampled, but the catches of these species was considered to be too small, and the selectivity too poorly known to include them in the analysis. The trawl also captures some pelagic species, e.g. capelin, herring, mackerel and short-fin squid, which may be taken above the bottom, or when the trawl is on its way up or down through the water column. The analysis was restricted to species which are known to live on or in association with the bottom.

In several instances, specimens in the catch cannot be identified to species, and there are several aggregate groups in the list provided in Appendix 2. The only aggregate groups used in the analysis were redfishes, which comprise three *Sebastes* species, and eelpouts (*Lycodes* spp.) which consists of all eelpouts excluding Vahl's eelpout. In this study, 31 species which contributed more than 0.1% to biomass or numbers were used in the analysis (Appendix 2).

Assemblage Analysis

There are several approaches to analysing and describing assemblages of animals (or plants). The two main types of approach are clustering of samples into groups (see Clifford and Stephenson 1975), or ordination (see Gauch 1982). There is a variety of software available for these types of analyses. The most frequently used among these are the Cornell Ecology Programs which provide software for a number of ordination procedures and some classification procedures (Gauch 1982) and CLUSTAN which is specifically for cluster analysis (Wishart 1987). Standard statistical packages such as the Statistical Package for the Social Sciences (SPSS) and the Statistical Analysis System (SAS) have limited cluster analysis capability. The most recently developed methodology for ordination is canonical correspondence analysis which can be carried out using the CANOCO software (Ter Braak 1986). Although this has not been used for analysis of marine fishes, it has been used for assemblages of other marine organisms (e.g. Kautsky van der Maarel 1990, Künitzer *et al.* 1992).

One of the major limitations for ordination and some aspects of clustering is the need to perform matrix operations which require considerable amounts of computer memory. The approach used in this study was to analyse the entire data set. Therefore, with over 3,000 trawl sets, approaches which require matrix operations, or the extraction of a dissimilarity matrix, were beyond the limitations of available computer hardware. In this study, a straightforward approach was adopted, involving clustering of a random sample of sites, and subsequent classification of the remaining sets. In view of the intended use of the outputs in an information system for non-

technical users, an advantage of cluster analysis over ordination was that it is intuitively more understandable and thus simpler to communicate.

The number of individuals caught was used for the analysis. The values were square root transformed to reduce the effect of very large data points which can dominate distance indices. Cluster analysis was carried out on a random subsample of 400 trawl sets using procedure CLUSTER (Wishart 1987). The remaining trawl sets were classified into the groups defined by the cluster analysis. The classification procedures used the same similarity index and placed each trawl set into the group to which it was most similar using procedure CLASSIFY (Wishart 1978).

The similarity between two sites or two species was estimated using squared Euclidean distance as a similarity index. The analysis was carried out separately for sites (trawl sets) and species. Ward's method was used to determine the sequence of clustering in the analysis. The number of site groups for which cluster membership was calculated was 7-3. On the basis of previous experience, fewer than 3 groups would be expected to result in too great a loss of information, and more than 7 groups would be expected to result in excessive geographical fragmentation of the site groups. This was checked subsequently.

As a check for consistency of results produced by different methods, the random sample of sets was also analysed using CLUSTAN procedure RELOCATE to define site groups. In this procedure, the Bray-Curtis non-metric distance index was used.

Demersal Fish Diversity

Ecologists recognize two components of diversity, both of which are shown for demersal fish species on the Scotian Shelf. The first is the species richness which is the total number of demersal species in each trawl tow. Species richness of all demersal species and the 31 major species was compared and the average difference in the number of species per tow was only 0.5. This shows that the minor species occur very infrequently. Only the 31 major species were used in estimating species richness.

The second component of species diversity that is shown is the evenness or equitability which is a reflection of how evenly the numbers of individuals caught are distributed among the species (or inversely, the extent to which a few species are dominant). To examine this, Simpson's Index of evenness (E) was used.

$$E = 1 - p_i^2,$$

where p is the probability of occurrence of the *i*th species (see Krebs 1978).

Habitat Suitability

Two environmental variables were used to predict the occurrence and abundance of yellowtail flounder. Years 1970-1989 were used to develop the model which was used to predict for years 1990-1993. The predictions are then compared with the observed data in those years.

The environmental variables used were temperature and depth and these were divided into intervals (one degree and 10 meters respectively). The median abundance was estimated for each combination of the two variables. Thus the model consists of a set of median abundances for yellowtail flounder for each combination of depth and temperature interval.

From the observed depth and temperature each trawl set in the period 1990-1993 was assigned the corresponding median abundance as the predicted value for the abundance of yellowtail flounder. These predicted values were compared to the observed abundance of yellowtail. The observed as predicted occurrence of yellowtail were also compared by mapping them.

RESULTS

Species Assemblages

The results of the analyses producing 5, 6 and 7 site groups were compared by mapping them. The analysis which produced 6 site groups was selected as providing the most reasonable, and interpretable maps. Therefore, the results presented here are based on the analysis which provided six site groups and these results were provided as input to the ECNASAP Pilot System.

The hierarchical relationship between the site groups is shown by the dendrogram in Fig. 2. This dendrogram was determined by cluster analysis using the average species composition in each site group after the classification procedure was carried out. Therefore, it might change depending on the number of site groups requested from the classification procedure. For example, going from six to five site groups would not simply be a case of combining the two most similar groups, namely groups two and four, in Fig. 2. In providing a five group procedure, the iterative classification process would probably reassign sites to or from the other three site groups.

The distribution of trawl sets in each site group on the Scotian Shelf and in the Bay of Fundy is shown in Fig. 3. More detailed maps with coastline and bathymetry are available from the ECNASAP Pilot System.

The hierarchical relationship between the species is shown in Fig. 4. In the latter case, the species groups shown were defined by arbitrarily selecting an index level which would result in six species groups. In contrast to the site groups, the reader can use the dendrogram to define groups at any level of clustering which may be considered useful.

The distribution of species among the site groups is shown in Fig. 5. The values shown are the percentage of the total numbers of each species which occurs within each site group. The values shown cannot be compared between species within site groups. They have not been adjusted for differences in the number of sets per site group.

The differences among the six site groups in terms of depth, bottom temperature and bottom salinity (Table 1) are displayed in boxplots (Fig. 6). Following is a descriptive summary of the six site groups which attempts to characterise them by species composition and environment.

SITE GROUP 1 (26% of sets) occurs mainly on the eastern Scotian Shelf, but there is also a cluster of group 1 sites in the mouth of the Bay of Fundy. The main species in this group are American plaice, thorny skate, smooth skate, and Vahl's eelpout (species group 5). However, other species groups, mainly groups 6, 2 and 1 are present at these sites.

SITE GROUP 2 (13% of sets) occurs mainly on the western shelf in the deep water between banks and along the Fundian Channel in warm water with relatively high salinity. The main species are spiny dogfish, pollock, cusk, blackbelly rosefish and argentine (species group 4). This site group has the cleanest species composition.

SITE GROUP 3 (32% of sets) is the most widespread. It occurs mainly in shallow areas on banks and in the head of the Bay of Fundy. It is characterised by haddock, halibut, wolfish and sand lance (species group 2) but also has appreciable quantities of species group 1 (see site group 6 for composition). This site group is the least distinctive in terms of species composition.

SITE GROUP 4 (14% of sets) occurs primarily in the warm saline waters of the central Scotian Shelf and is characterised by red hake, silver hake and angler (species group 3).

SITE GROUP 5 (7% of sets) is restricted to the deep water of the slope of the Laurentian Channel, the outer Scotian Shelf slope and the mouth of the Fundian Channel. It is characterised by the presence of common grenadier, longfin hake and redfish (of species group 6). the other members of species group 6, white hake, the eelpouts and witch flounder are also common in Site group 1.

SITE GROUP 6 (8% of sets) is also restricted in distribution, largely to the shallow water in the Bay of Fundy and around Sable Island. Several species (primarily those of species group 1) are found at these sites. Longhorn sculpin, sea raven and winter flounder are characteristic species.

It is also important to note that details of site and species group composition shift to some degree depending on the method of analysis used. The species associations with the site groups produced by CLUSTER on the random sample, RELOCATE on the random sample, and CLUSTER/CLASSIFY on the entire data set are shown in Table 2. Note that in Table 2, species group 6, at the bottom of the table is consistently present in site group 5 in all analyses. However, species group 2, haddock, halibut, etc., although identifiable in site group 3 in all analyses, is not as consistent. This is due mainly to sand lance. Clearly sites with sand lance were placed in group 3 by CLUSTER, but were placed in Group 1, by RELOCATE.

Diversity

The frequency distribution of the number of major species per tow is shown in Fig. 7b. The number of demersal species caught on the Scotian Shelf ranges up to about 20, but the average is about 8. The frequency distribution of Simpson's index of evenness is shown in Fig. 7b. The index of evenness is useful only in comparative terms, and is most interesting when mapped over the study area, as was done with the ECNASAP system.

Table 1. Environmental statistics for each site group defined by cluster analysis of trawl sets on the Scotian Shelf and Bay of Fundy.

Site Groups	Mean	Median	Percentile		Min	Max
			25th	75th		
			Depth			
1	67	60	40	84	17	197
2	98	94	76	116	19	196
3	54	49	39	62	13	193
4	78	75	47	104	17	196
5	152	152	131	177	62	211
6	40	40	29	49	17	75
			Temperature			
1	4.1	3.5	2.1	6.1	-0.6	11.8
2	8.0	8.1	7.1	9.1	1.3	13.0
3	5.0	4.7	2.7	7.1	-0.5	13.6
4	7.1	7.4	5.7	8.9	-0.3	14.4
5	6.1	5.8	5.2	7.1	1.2	11.3
6	7.1	7.2	5.9	8.3	2.3	13.6
			Salinity			
1	33.0	32.8	32.4	33.5	30.8	35.4
2	34.4	34.6	34.0	34.9	30.5	35.6
3	33.1	32.9	32.4	33.7	30.4	35.3
4	33.9	34.2	33.1	34.7	31.3	35.4
5	34.6	34.7	34.5	34.8	32.0	35.4
6	32.3	32.3	32.0	32.6	30.6	34.5

Visual examination of boxplots of species richness and evenness by site group suggest that site groups differ more in terms of the former than in terms of the latter (Fig. 8). Site group 6, which occurs in the shallow waters around Sable Island and in the Bay of Fundy, and which was characterised by longhorn sculpin, sea raven and winter flounder, was highest in richness and evenness. Site group 3, also occurring in shallow water and characterised by haddock, halibut, wolffish and sandlance was lowest in richness, but similar in evenness to the remaining groups.

There were no discernible trends in either species richness or evenness over the 23 year time period covered by the survey data set (Fig. 9).

Habitat Suitability

The observed and estimated catch per tow are plotted against each other in Fig. 10. There is a significant correlation between these two variables, suggesting that depth and temperature can be used to predict yellowtail flounder abundance. The relatively high number of data points along the y-axis indicates that the model tended to predict fish at locations where none were observed. This tendency is continued in the higher values of the scattergram, where there is a

relatively high proportion of points above the line with slope = 1. The failure of the model to predict the highest values of yellowtail catch per tow is to be expected because median catch per tow within each environmental range was used in the model.

The predicted distribution of yellowtail flounder on the Scotian Shelf in 1990-1993 is compared with the observed distribution in Fig. 11. Again, the model predicts fish at locations where none were observed. This tendency could be due to the influence of an unmeasured environmental variable, such as substrate which was previously found to affect yellowtail distribution (Mahon and Smith 1989).

DISCUSSION

Regarding the assemblage analysis, it is important to note that the level of clustering selected, i.e. the number of site and species groups which is chosen for interpretation, can be extremely subjective. This may often depend on the purpose of the analysis. In this case, the purpose was to illustrate the joint distribution patterns of demersal finfish species on the Scotian Shelf as a context for fishery management. Therefore, it would have been inappropriate to select a level of clustering which produced so many site groups that when mapped they were distributed at so fine a scale as to be irrelevant to fisheries management. If the aim had been to explore ecological interactions between pairs or triplets of species, it may have been appropriate to use a level of clustering which produced more site groups.

As other studies have noted, the site groups and species groups of demersal fishes on the Scotian Shelf do not correspond cleanly (Fig. 5). Thus a species or group of species may be common in more than one site group.

The preliminary habitat suitability model for yellowtail suggest that there is value in pursuing this idea. Subsequent efforts should consider the feasibility of building on the work currently in progress at the Marine Fish Division (e.g. Smith *et al.* 1991, Smith and Page 1994), such as the use of cumulative density functions as the basis for habitat suitability modeling (e.g. Perry and Smith 1994).

Table 2. Comparison of species association (percent of total catch) with groups defined by analysis using CLUSTAN procedures CLUSTER and RELOCATE as described in the text. The horizontal lines show the species groups based on the CLUSTER/CLASSIFY procedures.

	Site groups defined by:																	
	CLUSTER (random sample only)						RELOCATE (random sample only)						CLUSTER/CLASSIFY (all samples)					
Species	5	1	2	4	3	6	5	1	2	4	3	6	5	1	2	4	3	6
longhorn sculpin	0.0	17.3	1.1	6.6	26.3	48.8	0.0	5.6	0.4	25.0	1.0	67.9	0.1	16.2	0.6	5.1	13.2	64.7
sea raven	0.3	8.3	0.3	4.7	28.9	57.5	0.3	6.0	3.7	12.6	4.7	72.8	0.3	8.9	0.8	4.3	14.7	71.0
winter fl.	0.0	2.1	0.2	2.2	9.8	85.7	0.0	0.1	0.3	14.3	0.1	85.3	0.0	3.0	0.4	5.1	12.8	78.8
mailed sculpin	0.0	8.2	0.5	8.2	33.8	49.2	0.0	38.2	0.0	0.5	6.9	54.3	1.1	17.8	1.6	4.0	49.1	26.4
cod	0.9	8.8	2.8	10.0	59.8	17.6	3.3	23.7	1.8	3.8	13.1	54.3	0.2	25.4	1.0	3.1	28.3	41.9
litte skate	2.3	4.6	0.0	4.6	46.9	41.7	0.6	0.0	2.3	11.4	5.7	80.0	3.9	6.9	4.9	6.8	29.7	48.0
winter skate	8.0	18.8	6.6	11.9	12.4	42.2	8.0	6.4	0.0	21.2	1.1	63.3	5.5	23.3	2.4	10.0	18.0	40.7
yellowtail fl.	0.0	20.7	0.7	19.2	34.3	25.2	0.0	19.8	0.0	10.3	0.4	69.5	0.0	33.6	0.2	11.6	21.4	33.1
ocean pout	2.9	47.5	7.9	4.3	6.1	31.4	7.1	10.0	11.1	24.6	1.8	45.4	2.2	36.7	7.9	12.0	3.3	37.9
haddock	0.7	5.4	6.5	40.9	35.8	10.8	1.6	0.7	1.8	6.2	16.6	73.0	0.4	9.0	8.5	18.6	42.4	21.1
halibut	14.9	7.7	3.0	22.6	48.2	3.6	20.8	6.0	2.4	4.8	30.4	35.7	9.3	8.6	6.5	20.8	44.1	10.7
Atlantic wolffish	0.6	5.6	3.2	7.4	69.9	13.3	4.7	27.4	2.7	1.2	35.4	28.6	2.0	30.6	6.9	5.6	43.5	11.3
sand lance	0.1	2.2	0.0	0.0	97.7	0.0	0.1	75.8	0.0	0.0	0.0	24.1	0.1	22.8	0.0	0.3	75.3	1.5
red hake	0.2	22.2	9.1	63.7	3.7	1.0	13.8	0.2	1.6	72.3	2.1	10.0	7.7	11.5	23.9	46.0	5.8	5.1
silver hake	1.2	7.0	19.4	60.9	1.9	9.6	1.3	0.2	1.1	94.1	0.3	3.1	2.1	6.1	26.3	42.2	6.8	16.4
angler	16.5	15.8	2.5	62.7	1.9	0.6	22.8	10.1	1.9	29.1	6.3	29.7	14.6	6.1	6.6	69.1	0.6	3.1
spiny dogfish	0.2	8.4	66.9	2.2	5.9	16.4	4.3	2.8	36.5	13.8	1.6	41.0	0.3	4.9	69.1	5.4	6.7	13.7
pollock	0.2	2.1	61.0	10.3	23.9	2.6	18.9	0.9	8.1	11.8	53.7	6.6	2.5	3.4	54.6	14.7	16.8	8.1
cusk	12.0	1.0	67.7	7.3	4.2	7.8	20.8	0.0	44.3	13.0	10.4	11.5	5.6	2.1	86.1	3.4	1.6	1.2
rosefish	3.6	0.0	93.1	1.8	1.5	0.0	16.1	0.0	55.1	28.5	0.4	0.0	13.1	1.6	79.6	1.6	4.2	
argentine	10.7	1.9	17.9	59.4	10.1	0.0	13.2	0.0	16.7	24.6	15.1	30.4	7.3	2.8	67.3	16.8	5.9	0.0
American plaice	2.1	49.3	1.3	11.2	27.8	8.2	3.3	70.1	1.1	5.0	2.6	17.8	2.2	66.4	2.3	9.0	15.7	4.4
thorny skate	3.8	57.5	3.7	5.9	22.9	6.2	6.9	45.5	4.3	5.8	3.3	34.2	4.2	72.2	3.7	4.7	7.6	7.5
smooth skate	23.3	57.2	4.1	6.2	7.2	2.1	37.3	26.7	4.1	8.2	6.5	17.1	13.8	63.3	6.1	8.0	3.3	5.4
Vahl's eelpout	0.4	93.3	0.0	0.0	6.3	0.0	0.7	95.9	2.2	0.0	1.1	0.0	2.0	95.7		0.2	1.9	0.1
grenadier	95.4	0.0	2.3	0.8	1.5	0.0	87.7	0.0	4.6	6.9	0.8	0.0	95.6	0.5	2.0	0.6	1.3	
longfin hake	79.6	1.5	13.9	4.2	0.7	0.0	81.5	0.1	3.3	15.2	0.0	0.0	86.6	2.3	5.8	4.3	1.0	
redfish	81.9	4.9	6.5	3.2	3.2	0.3	94.5	1.0	1.3	2.0	0.8	0.5	65.1	9.4	12.3	10.1	3.0	0.2
white hake	32.0	15.9	20.9	12.5	4.7	14.1	44.8	1.0	4.6	40.9	3.0	5.8	44.8	15.0	16.8	14.3	2.7	6.4
eelpouts	81.8	13.6	0.0	4.5	0.0	0.0	86.4	4.5	0.0	9.1	0.0	0.0	43.9	43.5	0.7	1.2	9.3	1.5
witch fl.	35.1	43.3	3.6	10.8	6.4	0.8	44.2	19.0	4.9	21.6	1.4	8.9	36.5	37.0	4.5	16.3	2.9	2.7

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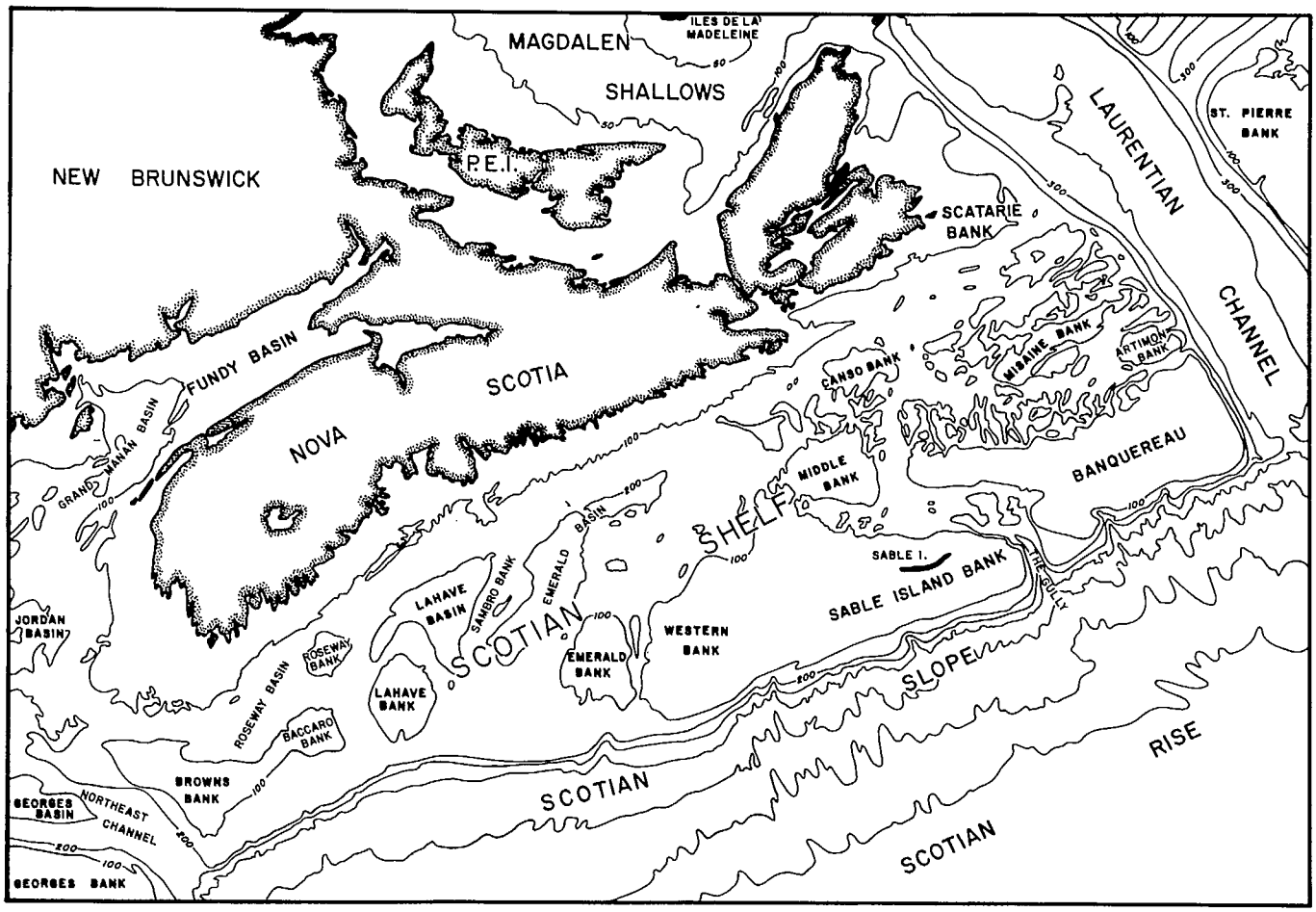

Figure 1. The Scotian Shelf and the Bay of Fundy.

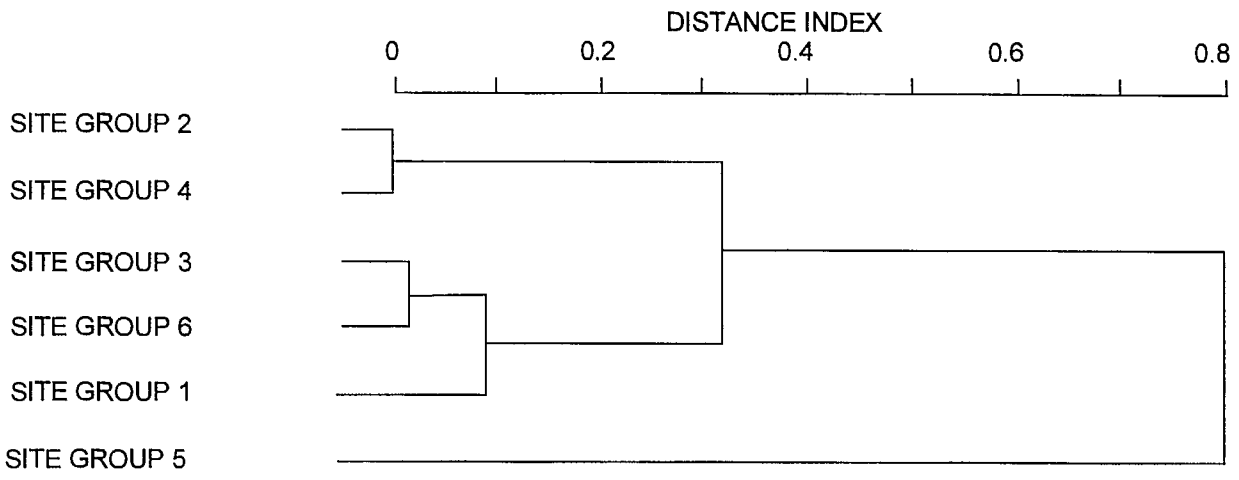

Figure 2. Dendrogram from cluster analysis of trawl sets on the Scotian Shelf and Bay of Fundy

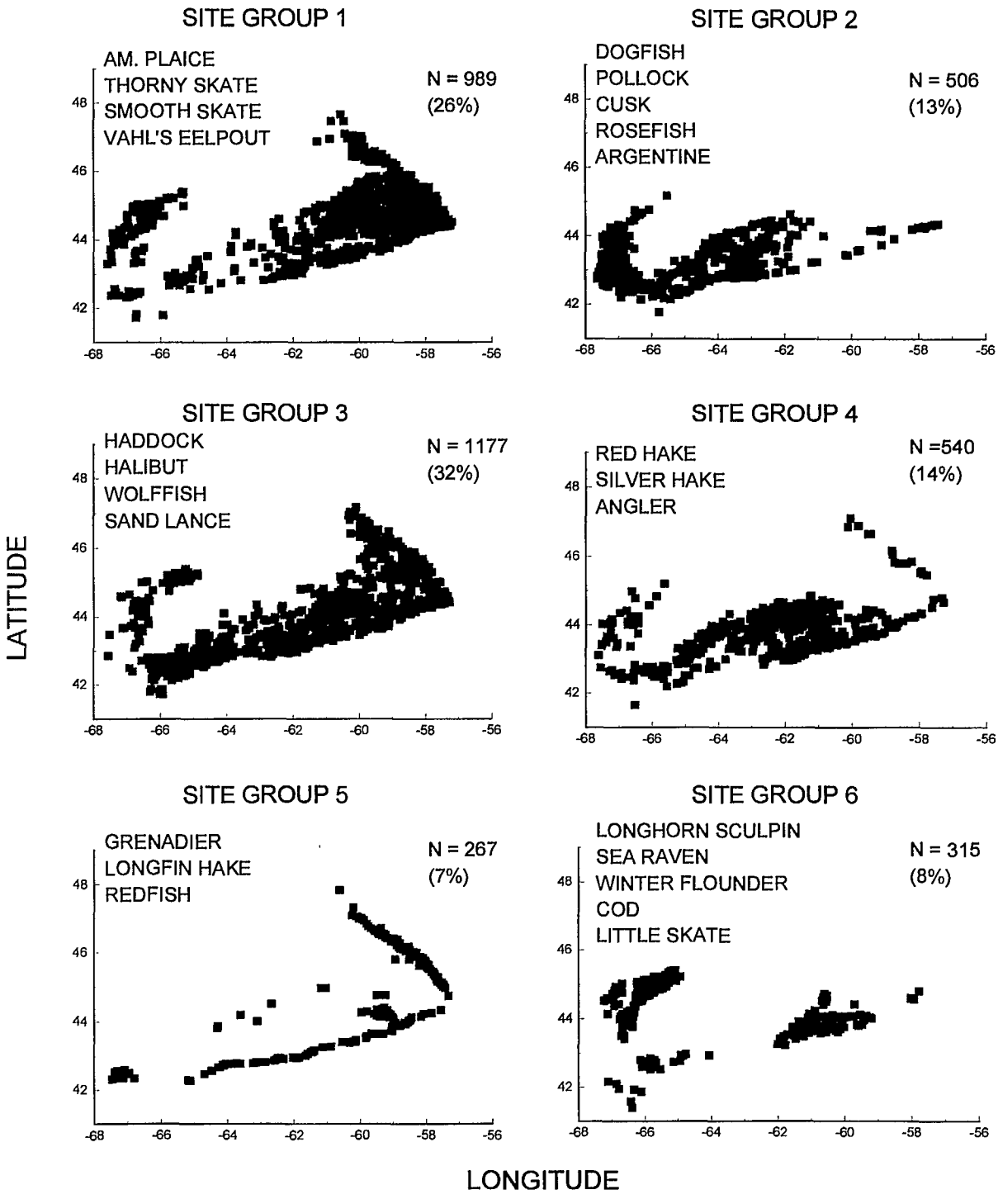

Figure 3 . The distribution of site groups on the Scotian Shelf and Bay of Fundy, and the most common species associated with each site group (the number and percentage contribution of sets in each site group is also shown)

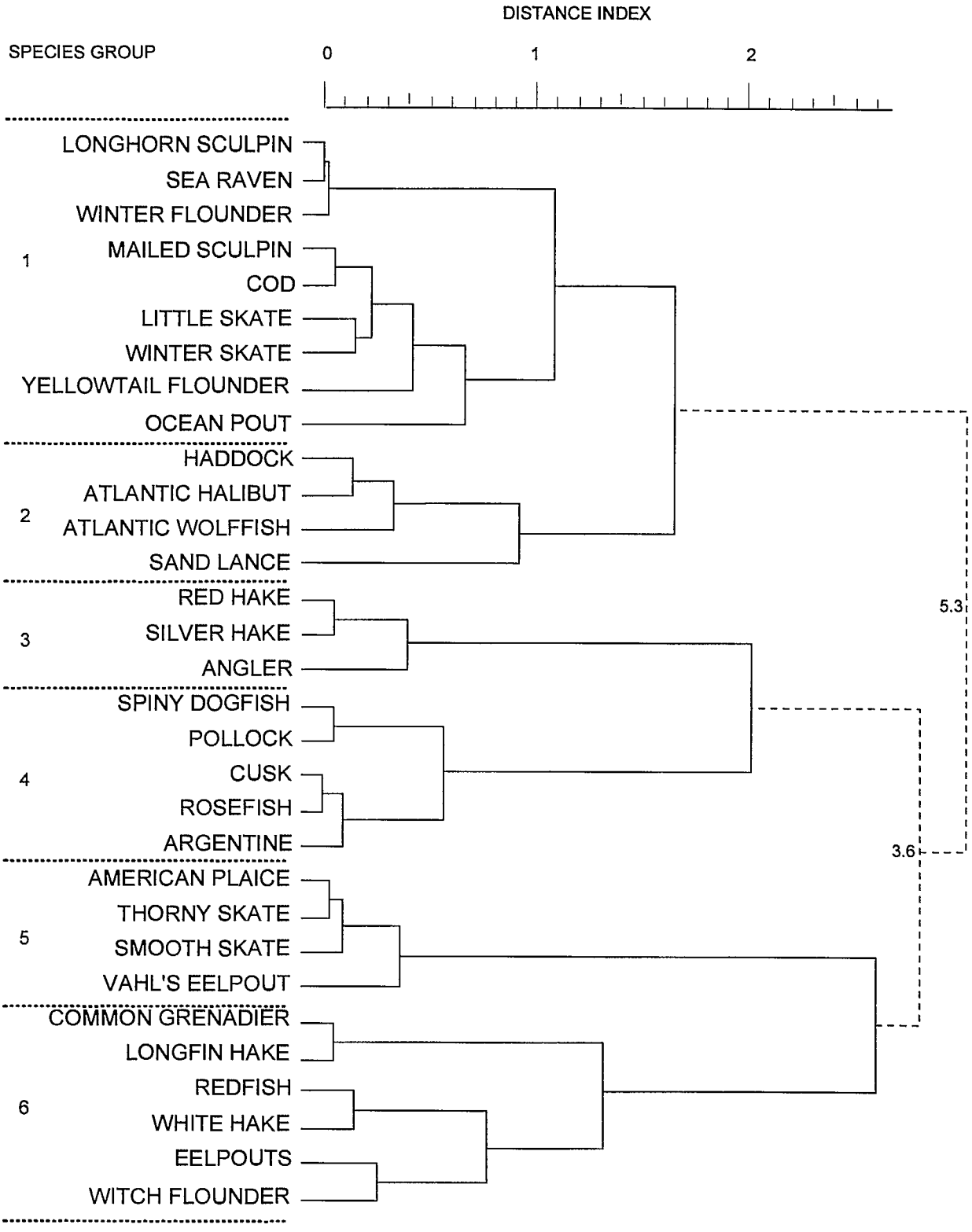

Figure 4. Dendrogram from cluster analysis of demersal species on the Scotian Shelf and Bay of Fundy

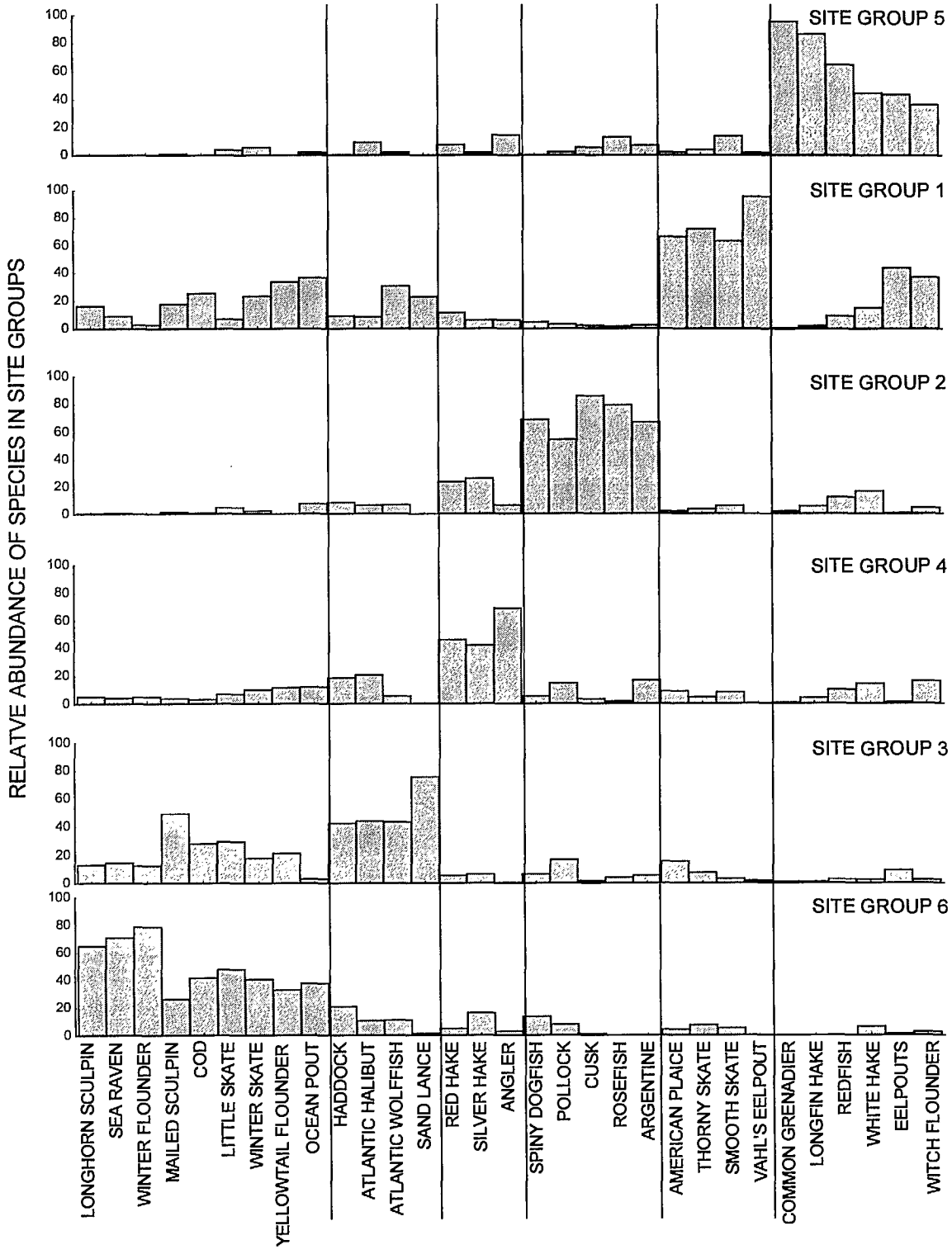

Figure 5. The relative contribution of each species in each site group. The vertical lines divide the species into the groupings determined by cluster analysis

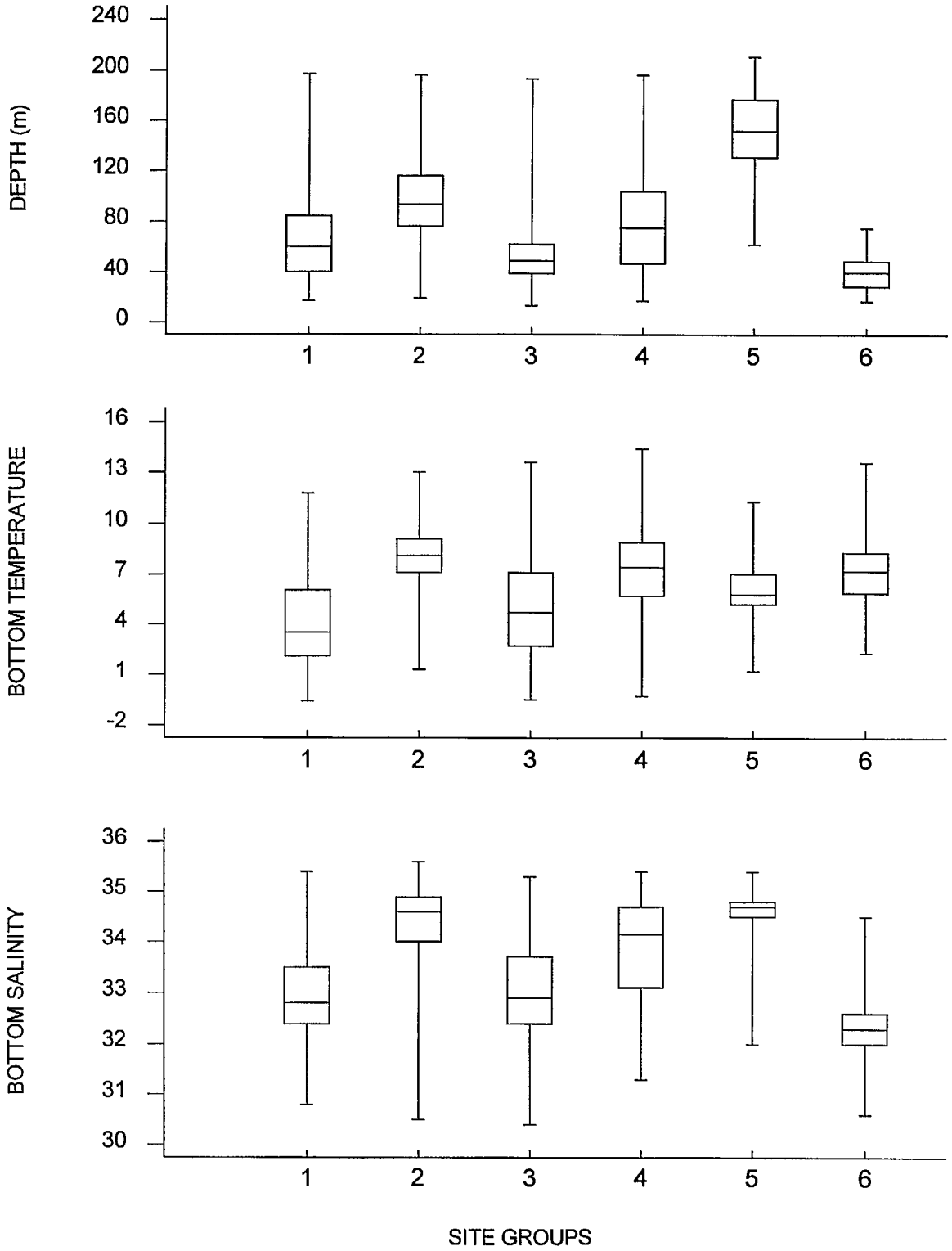

Figure 6. Environmental differences between site groups on the Scotian Shelf and Bay of Fundy

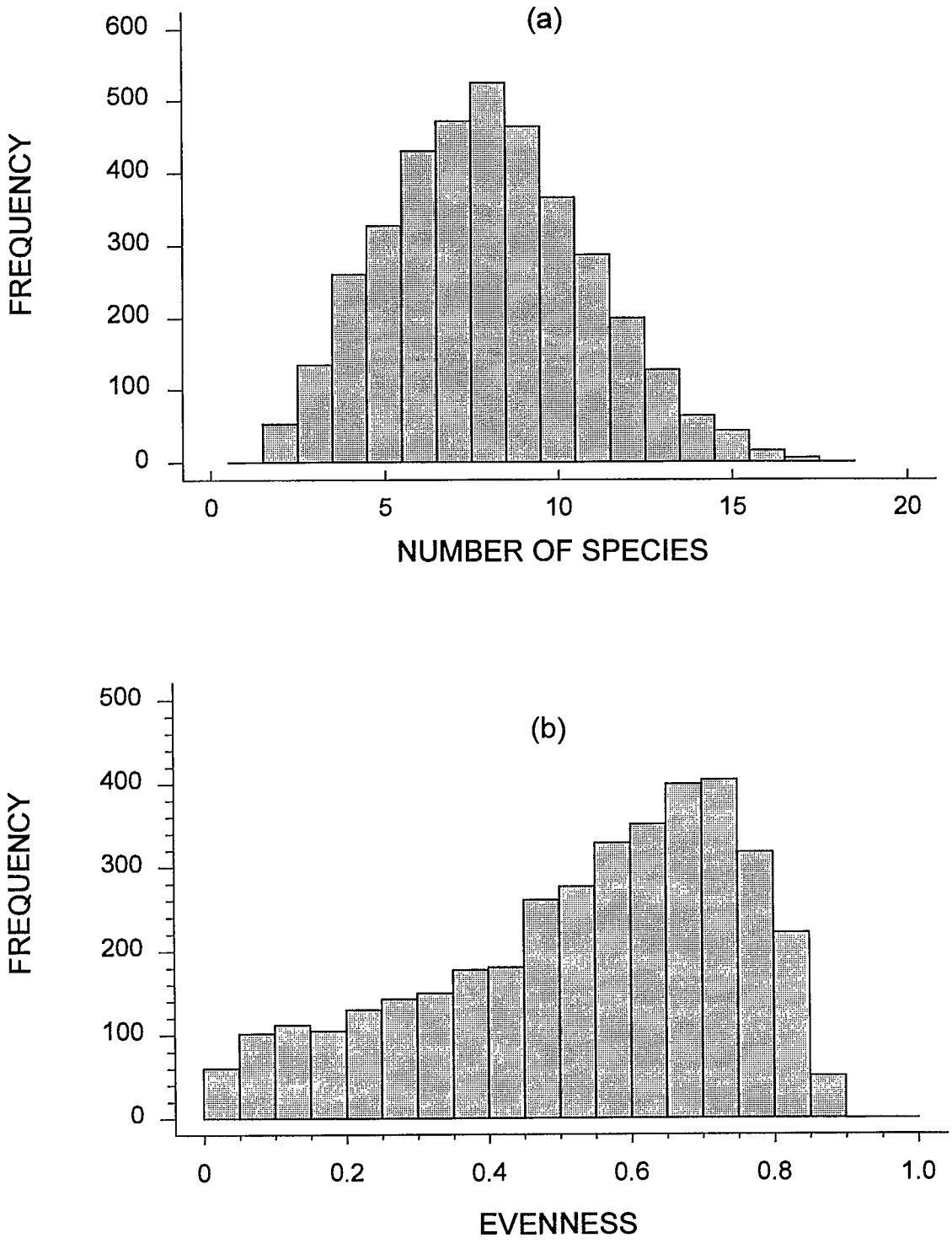

Figure 7. Frequency distribution of (a) species richness of demersal fishes, and (b) Simpson's index of evenness

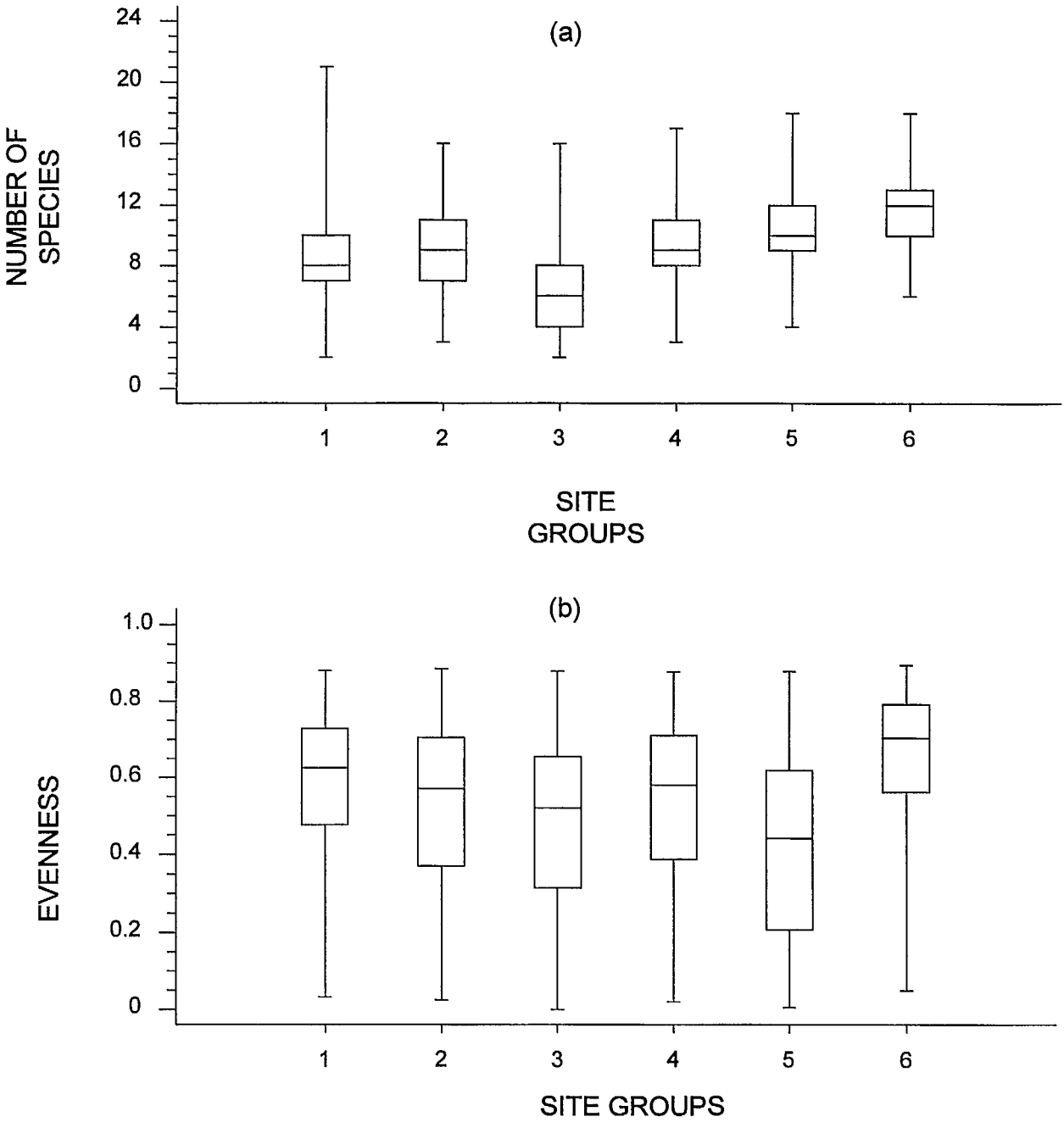

Figure 8. Comparison of site groups regarding (a) species richness and (b) evenness

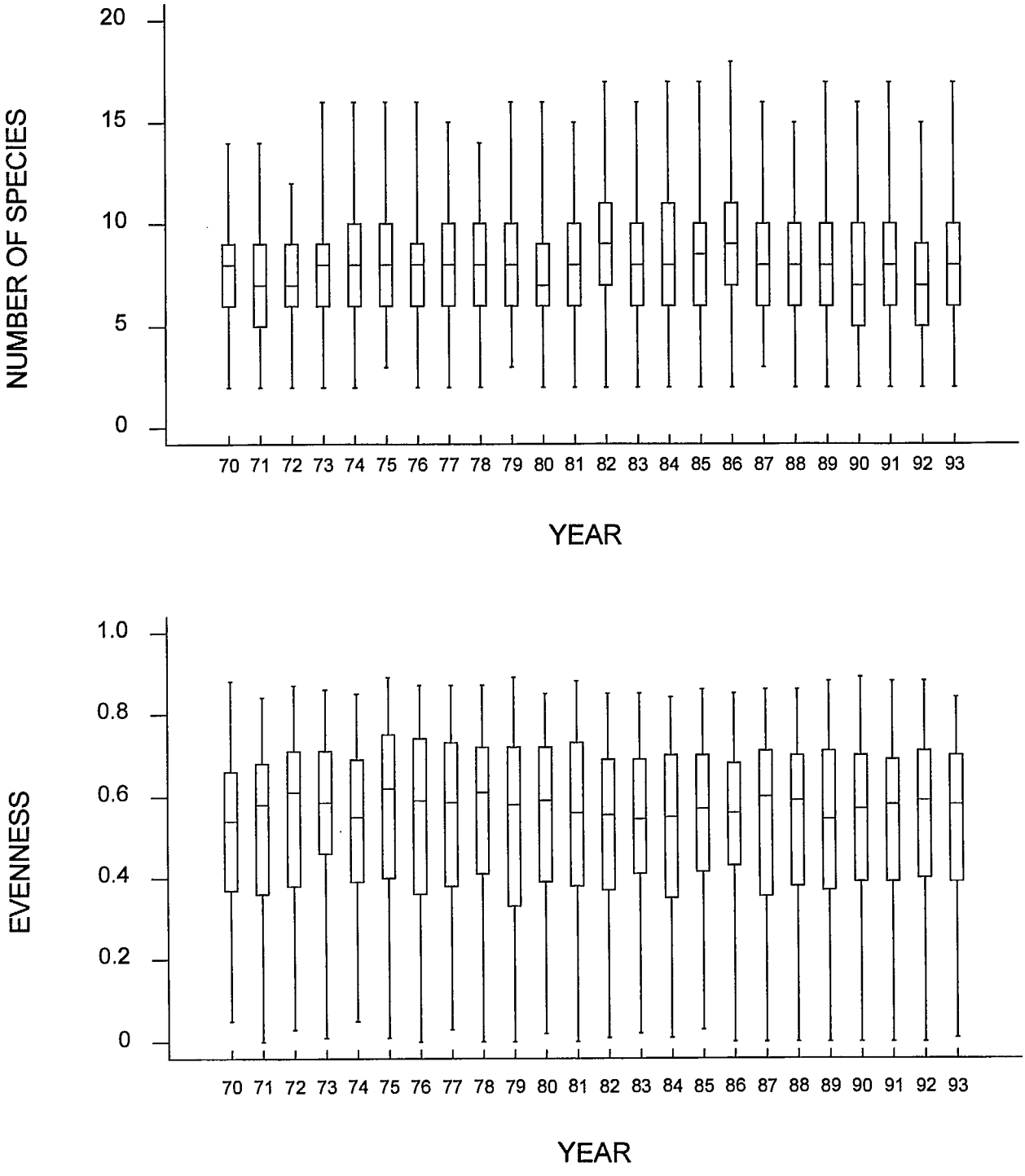

Figure 9. Trends in species richness and evenness (Simpson's index) for demersal finfish on the Scotian Shelf and Bay of Fundy

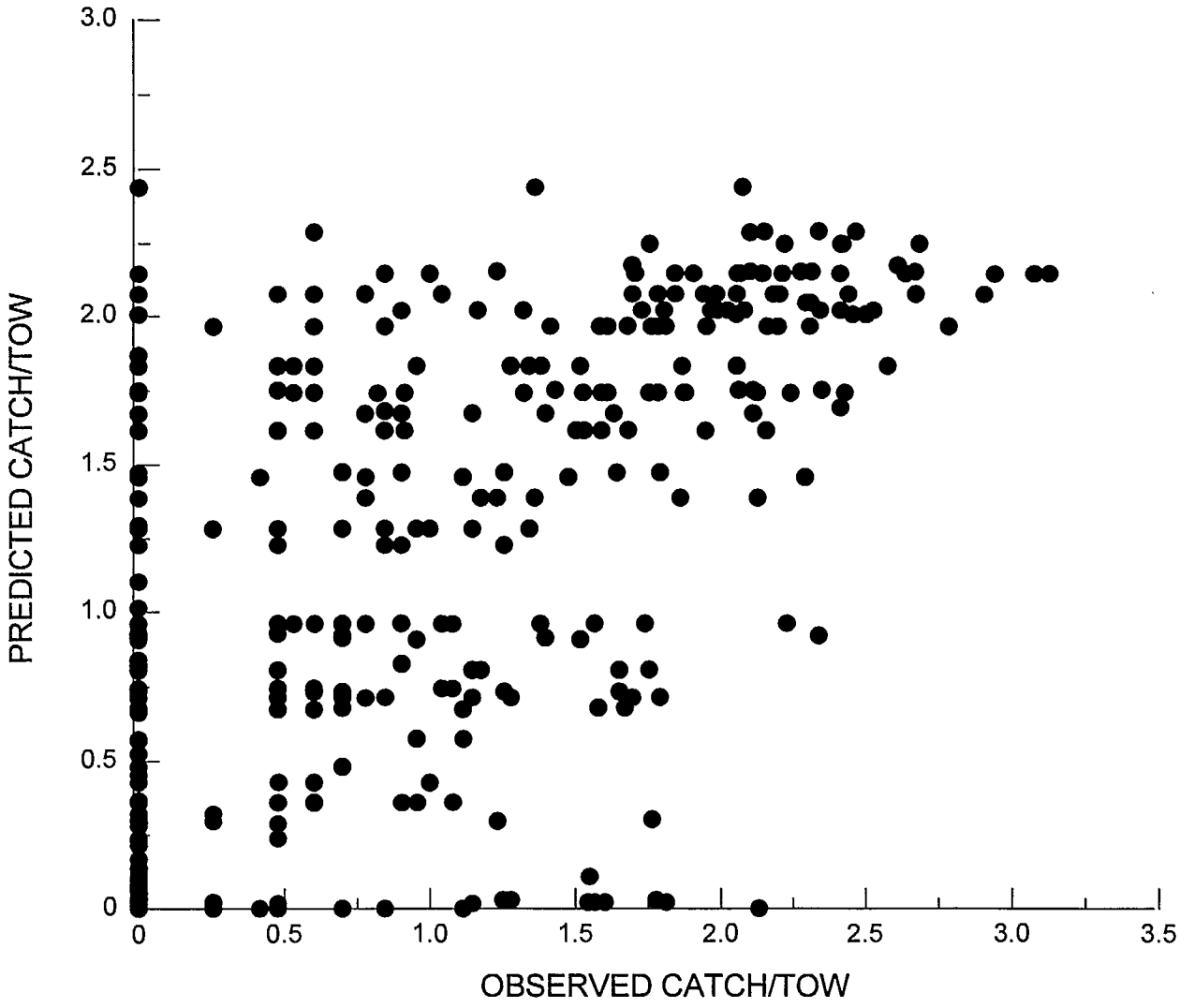

Figure 10. Observed versus predicted catch/tow of yellowtail flounder on the Scotian Shelf and Bay of Fundy for 1990-1993. Estimates are based on median catch/tow in depth and temperature intervals at which they were caught during the period 1970-1989.

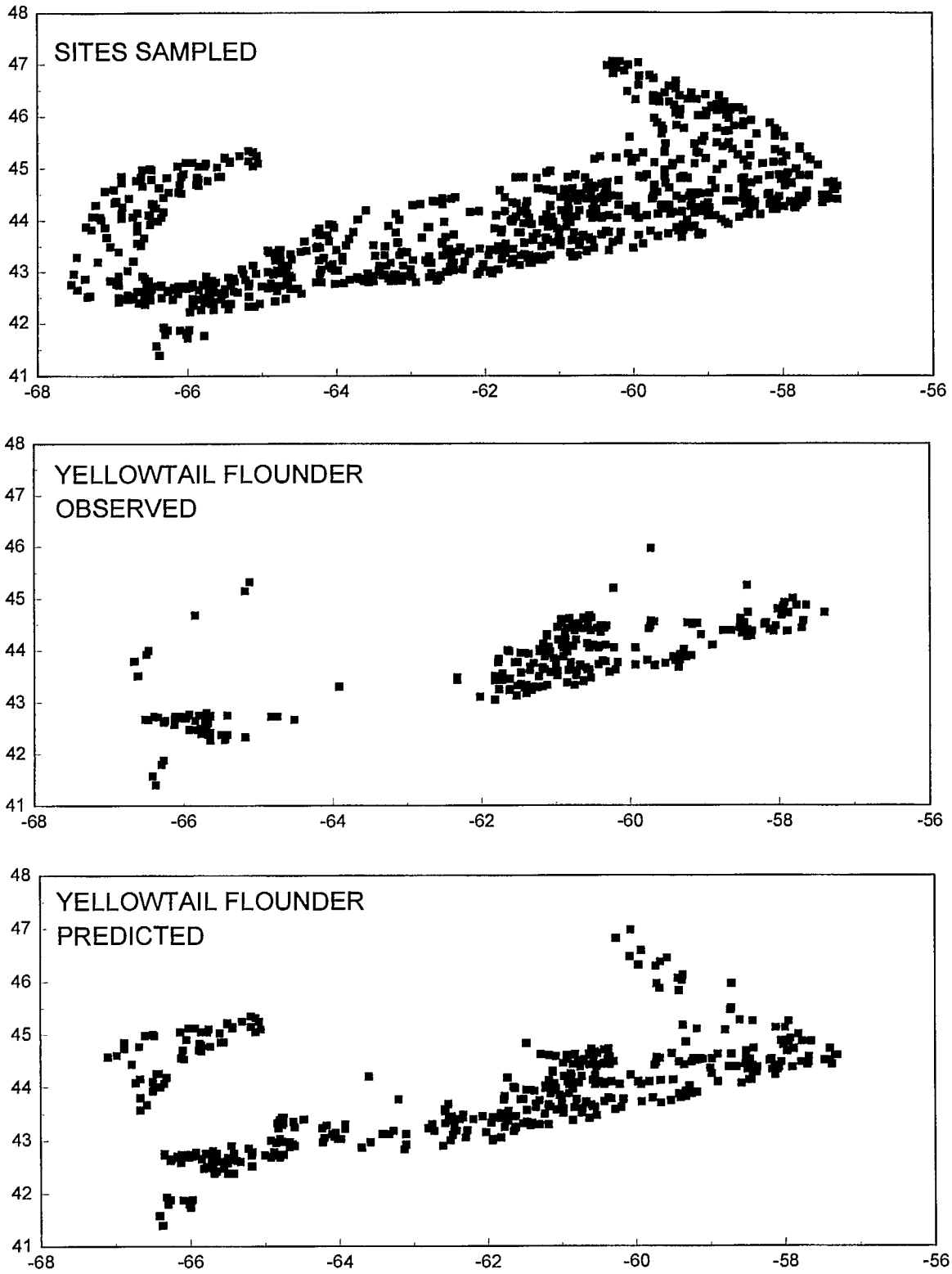

Figure 11. Observed and predicted distribution of yellowtail flounder on the Scotian Shelf and Bay of Fundy for 1990-1993. Estimates are based on median catch/tow in depth and temperature intervals at which they were caught during the period 1970-1989.

Appendix 1. Groundfish trawl survey data for Atlantic Canada: Database description

INTRODUCTION

A wide variety of surveys have been carried out for the exploited species off Atlantic Canada from the establishment of the Fisheries Research Board of Canada up to the present. They have been conducted for both research and monitoring purposes. Groundfish trawl surveys have been used to monitor fish stock abundance in the northwest Atlantic from the early 1950s. However, the most extensive and consistent body of survey information is the standard groundfish surveys which were established for the shelf waters off Atlantic Canada between 1969 and 1972 (Doubleday and Rivard, 1980).

Some examples of other research and monitoring surveys, usually conducted for a finite period to address a specific problem, are:

trawl surveys for squid, shrimps;
dredge surveys for scallops;
silver hake surveys;
surveys for juvenile groundfish, both mid-water and demersal phases;
acoustic surveys for pelagic fishes, herring, capelin etc.;
trap surveys for lobsters and crabs;
trawl surveys for deepwater fishes.

These data are recorded and stored in a wide variety of formats and media. A full inventory of survey data for the waters off Atlantic Canada is beyond the scope of this report.

This report documents a database developed to bring together the standard (stratified random) groundfish trawl survey data from all survey areas in Atlantic Canada. This is being done to facilitate the analysis of distributions of trawl caught fishes and invertebrates for the entire east coast of Canada. During this first phase data from the Scotia-Fundy and Gulf Regions were acquired and included.

STANDARD GROUNDFISH SURVEYS

The standard groundfish surveys were established to provide a consistent index of abundance for demersal finfishes on the shelf areas off Atlantic Canada. The index is the mean catch per standard tow. They are conducted according to a random stratified design in order to provide statistically valid estimates of mean catch per tow and its associated variance. The stratification schemes for these surveys and the protocols for allocation of sampling effort among strata are described by Doubleday (1981) for all areas under consideration. Stratification is by depth and area. Stratum maps and lists of stratum areas are provided by Doubleday (1989), Strong and Gavaris (1994 MS) and Hurlburt and Clay (1990). For each survey, sets are allocated among strata in approximate proportion to stratum size. Three sets is the minimum per stratum to allow the estimation of the variance in catch per tow. Each stratum is divided into sampling units, and the allocated number of units is selected at random prior to the survey.

The protocols and methods for collection of the data which are contained in the database files are described in several reports. A general description for the entire North Atlantic Fisheries Organisation (NAFO) are is provided by Doubleday (1989).

The original data files from which these database files have been compiled contain fields which have not been included in the current database. Detailed biological data -- length frequencies, sex, maturity, otoliths for aging -- are also collected on the surveys, these data are not included in the database. Strong and Gavaris (1993 MS) and Hurlburt and Clay (1990) provide detailed descriptions of the original files for the Scotia-Fundy and Gulf Regions respectively.

The responsibility for the surveys in Canadian waters has varied over the years, thus although there has been a standard approach to the surveys, there have been some differences among regions in the procedures for coding, editing and storage of the data. The data are managed at several localities. Data for the Scotian Shelf and Bay of Fundy are managed by the Marine Fish Division, St. Andrews Biological Station, New Brunswick. Data for the southern Gulf of St. Lawrence are managed by the Marine and Anadromous Fish Division, Gulf Fisheries Center, Moncton, New Brunswick. Data for the Northern Gulf of St. Lawrence are managed by the Department of Fisheries and Oceans, Mont-Joli, Quebec. Data for the Grand Banks of Newfoundland, St. Pierre Bank, Flemish Cap and Labrador Shelf are managed by the Northwest Fisheries Center, St. John, Newfoundland.

The surveys in the various areas have been conducted using a variety of vessels and gears. Where there have been changes in survey equipment within areas, comparative fishing experiments have been used to develop conversion factors (e.g. Fanning 1985, Mahon and Smith 1989, CAFSAC 1992 p. 20). There have been no comparative fishing experiments aimed at providing conversion factors between areas. Any such conversions must be based on considerations of relative swept area of, or volume strained by, the trawls used (e.g. Wolotira et al 1993).

DATABASE STRUCTURE

The database consists of two types of survey data tables, the Trawl Set Table, the Catch Table, and a lookup table for species codes.

The Trawl Set Database Tables

These database tables (set tables) provide the information which is specific to each trawl set as described in Table A1.1.

Table A1.1. The structure of the trawl set database table

FIELD	TYPE	SIZE	VALUES	DESCRIPTION
VESSEL	C	1		An identifier for the vessel used for the cruise.
			P	E.E. Prince
			H	Lady Hammond
			N	Needler
			V	Navicula
			*	Charter vessel
			T	Templeman
CRUNO	N	3	001-999	Indicates the number of the cruise. Cruises are numbered sequentially throughout the life of the vessel.
SETNO	N	3	001-999	A unique number identifying each set in a cruise. GULF 1970-1983: The set numbers were allocated sequentially throughout the entire cruise. 1984-1987: The set numbers were fixed to the stations surveyed. 1988 - : The set numbers are allocated sequentially throughout the entire cruise. SCOTIA-FUNDY The set numbers are allocated sequentially throughout the entire cruise.
STRATUM	C	3		Indicates the stratum in which the station surveyed lies.
			401-403	GULF
			425-432	
			397-411	SCOTIA FUNDY
			434	
			436-466	
			470-478 480-485	
			490-495 516-522	
			551-557 5Z1-5Z8	
			999	Not recorded
DD	N	2	01-31	Indicates the day when the set began.
MM	N	2	01-12	Indicates the month when the set began.
YY	N	2	70-93	Indicates the year when the set began.

FIELD	TYPE	SIZE	VALUES	DESCRIPTION
TIME	C	4		Reading on the 24 hour clock (local time) when the set tow is started.
				GULF
				1970-1984:
			00-23	Indicates the hour of beginning followed by:
			05	Indicates 0 - 9 minutes
			15	Indicates 10-19 minutes
			25	Indicates 20-29 minutes
			35	Indicates 30-39 minutes
			45	Indicates 40-49 minutes
			55	Indicates 50-59 minutes
				1985- :
			00-23	Indicates the hour of beginning followed by:
			00-59	Indicates the minutes
				SCOTIA-FUNDY
			00-23	Indicates the hour of beginning followed by:
			00-59	Indicates the minutes
GEAR	N	3		The fishing gear used in a set.
			01	Indicates #3/4 35 otter trawl
			09	Indicates western IIA
LATDEG	N	2	45-49	Starting latitude degrees of latitude north.
LATMIN	N	2	01-60	Starting latitude minutes of latitude north (rounded off from seconds)
LONDEG	N	2	58-67	Starting longitude degrees of longitude west.
LONMIN	N	2	01-60	Starting longitude minutes of longitude west (rounded off from seconds)
DEPTH	N	4		The average depth at which the gear was towed during a set.
			001-998	Indicates the average of maximum and minimum depths in meters.
			999	Indicates no observation (Scotia-Fundy Region all years, Gulf Region 1970-1985)
			000	Indicates no observation (Gulf Region 1986 -)
DIST	N	4.1		The distance traveled to the nearest tenth of a mile by the vessel during a set.
			0.1-98.9	Indicates nautical miles to nearest tenth.
			99.9	Indicates no observation (Gulf Region 1970-1985, Scotia-Fundy all years)
			00.0	Indicates no observation (Gulf Region 1986 -)

FIELD	TYPE	SIZE	VALUES	DESCRIPTION
STEMP	N	4.1		A measure of the surface water temperature at the station surveyed, to the nearest tenth of a Celsius degree.
			-99.9 - 998.9	Indicates temperature to nearest tenth of a degree centigrade.
			999	Indicates no observation.
BTEMP	N	4.1		The measure of the water temperature on bottom at the station surveyed, to the nearest tenth of a Celsius degree.
			-99.9 - 998.9	Indicates temperature to nearest tenth of a degree centigrade.
			999	Indicates no observation.
SSAL	N	4.1		The measure of the salinity of a sample of the water from the surface taken at a station surveyed, to the nearest tenth of a part per thousand.
			00.0-98.9	Indicates parts per thousand in tenths of parts.
			99.9	Indicates no observation.
BSAL	N	4.1		The measure of the salinity of a sample of the water from the bottom taken at a station surveyed, to the nearest tenth of a part per thousand.
			00.0-98.9	Indicates parts per thousand in tenths of parts.
			99.9	Indicates no observation.
BTYPE	N	3		The type of ocean bottom at the station surveyed.
				GULF
			1	Indicates muddy bottom.
			2	Indicates sand or sand and mud.
			3	Indicates gravel.
			4	Indicates sand and gravel.
			5	Indicates mud and rocks.
			6	Indicates rocks.
			7	Indicates sand and rocks.
			9	Indicates no observation.
				SCOTIA-FUNDY
			9	not included in data set

The Trawl Catch Database Tables

These database tables (catch tables) provide the information on the species caught in each set as described in Table A1.2. In the catch table there may be several records which correspond to one record in the set table. The catch tables can be linked to the trawl set data base tables by the combination of the VESSEL, CRUNO and SETNO fields which is unique to each set (the tables are not currently linked since the links may be software dependent).

Table A1.2. The structure of the trawl catch database table.

VARIABLE	TYPE	SIZE	VALUES	DESCRIPTION
VESSEL	C	1		As in Table A1.1 above.
CRUNO	N	3		
SETNO	N	3		
SPEC	C	4	As per lookup table	The species of the catch of a SET that the information contained on this record pertains to.
TOTNO	N	5		The count of estimated total number of specimens of a species which were caught in a set.
			00001-99998	Indicates counted or estimated number caught.
			00000 or 99999	Indicates numbers not counted.
TOTWT	N	4.1		The total weight in kilograms of the species caught during the set.
				GULF
			0.1-9998.9	Indicates weight in kg to the nearest 1/10th.
				SCOTIA-FUNDY
			2.0-9998.0	Indicates weight in kg (1/10ths not measured).
			0	Indicates a weight less than 0.5 kg.
			1	Indicates a weight of 0.5 to 1.5 kg.
			0000 or 9999.9	Indicates no observation.

The Species Code Lookup Table

In the catch tables only numeric species codes are given. The common and scientific names corresponding to the codes are contained in the species code lookup table as described in Table A1.3. A listing of this Table is provided in Appendix 2. The codes for other coded fields in the set and catch tables are given in Tables A1.1 and A1.2. Lookup tables for these are not provided since the numbers of codes are relatively few.

Table A1.3. The structure of the species code lookup table.

VARIABLE	TYPE	SIZE	VALUES	DESCRIPTION
SPEC	C	4	1-	The unique numeric code for the species or taxonomic group.
COMMON NAME	C	35		The common name or names by which the species or group is known. NS (not specified) indicates a grouping above species level.
SCIENTIFIC NAME	C	35		The scientific name (*Genus species*, family, order, etc.) name by which the species or group is known.

DATABASE CONTENTS

Database File Names

The database currently includes data from the Scotia-Fundy Region and the Gulf Region. The set tables have the same field structure and can be combined into a single set table to facilitate queries. Similarly, the catch tables can be combined.

Notes on Database Fields

Vessel (VESSEL), cruise number (CRUNO) and set number (SETNO) - These three fields uniquely identify each set, and provide the link between the set and catch data tables.

Stratum (STRATUM) - The values in the STRATUM field in the set tables are the values shown on stratum maps provided by Doubleday (1989), Strong and Gavaris (1994 MS) and Hurlburt and Clay (1990), preceded by the number four (e.g. stratum 40 on the map is stratum 440 in the data table), to indicate that the stratum is in NAFO area 4. For NAFO area 5, Georges Bank, the strata are numbered 5Z1-5Z8 as shown by Strong and Gavaris (1994 MS).

Gear (GEAR) - A variety of bottom trawls have been used for groundfish research and surveys. However, only two have been used in the standard groundfish surveys. These are the Western IIA Trawl and the Yankee #36 Otter Trawl. The specifications for these and other trawls are given by Carrothers (1988).

Trawl design may significantly affect the amount of fish caught by a trawl. Trawls may differ in several ways: swept area will affect the number of fishes encountered during a tow; the height of the head rope will affect the extent to which the trawl encounters fishes which may occur off the bottom; the footrope configuration and roller gear may affect the extent to which benthic fishes, such as flatfishes, enter the trawl.

Distance towed (DIST) - Survey methodology requires a standard tow during which the net should be on the bottom for 30 minutes towed at a speed of 3.5 knots. Thus a standard tow is 1.75 nautical miles. Owing to variability in vessel speed, current, or the need to retrieve the gear before 30 mins, the actual towed distance may vary from the standard distance

The towed distance is provided here so that the numbers and weight of fish caught can be adjusted to the standard tow distance for comparative analysis.

Salinity (SSAL, BSAL) - Salinity measurements were not taken in the Gulf of St. Lawrence after 1983.

Bottom type (BTYPE) - Bottom type is not recorded for cruises conducted in the Scotia-Fundy Region.

Total number (TOTNO) - The total number of individuals caught is sometimes estimated from the number of baskets of fish caught, and the mean number of individuals per subsampled basket.

Total weight (TOTWT) - In the data from the Scotia-Fundy Region when the total weight of fish in a species is clearly less than 0.5 kg the fish are not weighed and a value of 0 is recorded.

Scientific name (SCIENTIFIC) - The scientific names used are those provided by Scott and Scott (1988).

FILE NAME	CONTENTS	# OF RECORDS
SFRSET.DBF	Set table for Scotia Fundy Region	7,570
GRSET.DBF	Set table for Gulf Region	2,534
SFRCAT.DBF	Catch table for Scotia Fundy Region	75,380
GRCAT.DBF	Catch table for Gulf Region	27,534
SPPLST.DBF	Species code lookup table	551

Cruises

The survey cruises included from the Scotia-Fundy and Gulf Regions are listed in Table A1.4.

Table A1.4. Summary of cruises included in the trawl survey database.

VESSEL	CRUISE NUMBER	YEAR	MONTH	NUMBER OF SETS
Scotian Shelf and Bay of Fundy				
Cameron	175-176	70	JUL	63-70
Cameron	188-189	71	JUN-JUL	49-69
Cameron	200-201	72	JUN-JUL	65-82
Cameron	212-213	73	JUL-AUG	56-78
Cameron	225-226	74	JUL-AUG	75-78
Cameron	236-237	75	JUL-AUG	72-71
Cameron	250-251	76	JUL-AUG	64-71
Cameron	265-266	77	JUL	91-53
Cameron	279-280	78	JUL	77-64
Lady Hammond	9-10	78	NOV	46-35
Lady Hammond	13-14	79	MAR-APR	44-71

VESSEL	CRUISE NUMBER	YEAR	MONTH	NUMBER OF SETS
Cameron	292-293	79	JUL	75-72
Lady Hammond	26-27	79	OCT-NOV	62-63
Lady Hammond	33-34	80	MAR-APR	48-65
Cameron	306-307	80	JUL	59-85
Lady Hammond	42-43	80	SEP-OCT	70-71
Lady Hammond	48-49	81	MAR-APR	73-46
Cameron	321-322	81	JUL	70-73
Lady Hammond	60	81	JUL	7
Lady Hammond	64-65	81	SEP-OCT	62-65
Lady Hammond	71-72	82	MAR-APR	62-69
Lady Hammond	80-81	82	JUL	72-78
Lady Hammond	84-85	82	SEP-OCT	73-73
Needler	5-6	82	NOV	96-13
Lady Hammond	94-95	83	MAR-APR	68-72
Needler	12-13	83	JUL	72-74
Needler	17-18	83	OCT	89-88
Needler	20	83	NOV	99
Needler	24-25	84	MAR-APR	80-91
Needler	31-32	84	JUL-AUG	65-78
Needler	36-37	84	OCT	70-75
Needler	41	85	MAR-APR	47
Needler	48-49	85	JUL	75-77
Needler	53	85	OCT	83
Needler	59-60	86	MAR-APR	77-77
Needler	65-66	86	JUL	93-78
Needler	69-70	86	OCT	75-98
Needler	77-78	87	MAR-APR	71-92
Needler	85-86	87	JUN-JUL	96-75
Needler	87	87	AUG	17
Needler	92	87	OCT	87
Needler	97-98	88	MAR-APR	132-68
Needler	105-106	88	JUL	87-90
Needler	116-117	89	FEB-MAR	116-79
Needler	123-124	89	AUG	107-77
Needler	133-134	90	FEB-MAR	123-77
Needler	139-140	90	JUL	151-72
Needler	148-149	91	MAR-APR	132-94
Lady Hammond	231	91	JUL	104
Needler	154	91	JUL	85
Needler	165-166	92	MAR-APR	91-74
Needler	173-174	92	JUN-JUL	90-103
Needler	182	93	MAR-APR	78
Templeman	134	93	MAR-APR	65
Needler	189-190	93	JUL-AUG	86-104
Southern Gulf of St. Lawrence				
Prince	79	70	SEP	39

VESSEL	CRUISE NUMBER	YEAR	MONTH	NUMBER OF SETS
Prince	91	71	SEP	67
Prince	106	72	SEP	73
Prince	122	73	AUG-SEP	74
Prince	143	74	SEP	70
Prince	157	75	SEP	68
Prince	172	76	SEP	66
Prince	188	77	SEP	71
Prince	204	78	SEP-OCT	63
Prince	229	79	SEP-OCT	80
Prince	244	80	SEP	74
Prince	260	81	SEP	72
Prince	278	82	SEP	73
Prince	296	83	SEP	69
Prince	312	84	AUG-SEP	108
Prince	327	85	SEP	84
Lady Hammond	159	86	SEP	73
Lady Hammond	179	87	AUG-SEP	162
Lady Hammond	192	88	SEP	167
Lady Hammond	204	89	SEP	169
Lady Hammond	219	90	SEP	147
Lady Hammond	232	91	SEP	192
Needler	178	92	SEP	176
Needler	192	93	SEP	197

DATA COMPILATION, QUALITY AND CAVEATS

The data from the standard groundfish surveys have been subjected to rigorous editing. During entry, the data are electronically checked for compliance with limits associated with each field. The data have also been analysed on numerous occasions, and users report values which appear to be anomalous. The data managers check and correct these reported values. Most of the analysis has been carried out in relation to stock assessment for species which are of commercial importance. Therefore, the data will be most thoroughly edited for those species.

It should be noted that the trawl surveys are designed primarily to provide abundance indices for the commercially important species. Therefore, the catch per tow of small or less common species may not be a reliable indicator of abundance. Similarly, although the surveys record pelagic fishes, such as herring and mackerel, and invertebrates, the trawl may not sample these efficiently, and catch per tow may not reflect abundance.

For commercial species which are targeted by the trawl, the variance associated with the estimated mean catch per tow is usually high, due to the relatively low sample size per stratum (usually in the order of 3-5 sets). Nonetheless, the indices of abundance are considered to be a reliable indicator of abundance for those species.

The data included in the set and catch tables were acquired on diskette as ASCII files from the Department of Fisheries and Oceans, Scotia-Fundy and Gulf Regions. The data tables were compiled by sorting and selecting the files electronically. No editing has been performed on the data provided, except to fill blanks with missing value codes. All data table fields have been queried to ensure that their contents are consistent with the values indicated in Tables A1.1 and A1.2. The species code fields in the catch and species code tables have been queried and compared for consistency. Two codes which appear once each in the catch tables are not valid codes (according to the data managers at Fisheries and Oceans) and are indicated as such in the lookup table.

Appendix 2. Species which occurred in the summer groundfish research survey dataset from 1970-1993. Species which were included in the analysis are in bold type.

CODE	COMMON NAME	SCIENTIFIC NAME	Total No.	% No.	Total Wt. (kg.)	% Wt.
Demersal finfish						
40	**American Plaice**	*Hippoglossoides platessoides*	93486	14.6	27519	4.1
10	**Atlantic cod**	*Gadus morhua*	91950	14.3	91619	13.7
42	**Yellowtail flounder**	*Limanda ferruginea*	71148	11.1	16427	2.5
220	**Spiny dogfish**	*Squalus acanthias*	57038	8.9	80567	12.0
23	**Redfishes (NS)**	*Sebastes spp.*	46169	7.2	113862	17.0
610	**Northern sandlance**	*Ammodytes dubius*	35619	5.5	1231	0.2
12	**White hake**	*Urophycis tenuis*	31542	4.9	28964	4.3
300	**Longhorn sculpin**	*Myoxocephalus octodecemspinosus*	28482	4.4	5777	0.9
16	**Pollock**	*Pollachius virens*	26574	4.1	57980	8.7
201	**Thorny skate**	*Raja radiata*	21418	3.3	20223	3.0
11	**Haddock**	*Melanogrammus aeglefinus*	20519	3.2	145060	21.7
160	**Atlantic argentine**	*Argentina silus*	19300	3.0	4305	0.6
14	**Silver hake**	*Merluccius bilinearis*	18674	2.9	26890	4.0
112	**Longfin hake**	*Urophycis chesteri*	15924	2.5	1267	0.2
43	**Winter flounder**	*Pseudopleuronectes americanus*	11229	1.7	4961	0.7
41	**Witch flounder**	*Glyptocephalus cynoglossus*	10960	1.7	4611	0.7
13	**Red hake**	*Urophycis chuss*	5509	0.9	1430	0.2
304	**Mailed sculpin**	*Triglops murrayi*	4217	0.7	25	0.0
204	**Winter skate**	*Raja ocellata*	3320	0.5	7454	1.1
320	**Sea raven**	*Hemitripterus americanus*	2851	0.4	3289	0.5
50	**Atlantic wolffish**	*Anarhichas lupus*	2850	0.4	5484	0.8
202	**Smooth skate**	*Raja senta*	2679	0.4	1234	0.2
640	**Ocean pout**	*Macozoarces americans*	2300	0.4	1304	0.2
647	**Vahl's, Checker eelpout**	*Lycodes vahlii*	2059	0.3	306	0.0
400	**American angler, monkfish**	*Lophius americanus*	1785	0.3	6284	0.9
15	**Cusk**	*Brosme brosme*	1536	0.2	4331	0.6
410	**Common grenadier**	*Nezumia bairdi*	1439	0.2	120	0.0
123	**Blackbelly rosefish**	*Helicolenus dactylopterus*	1416	0.2	86	0.0
203	**Little skate**	*Raja erinacea*	1401	0.2	966	0.1
30	**Atlantic halibut**	*Hippoglossus hippoglossus*	1257	0.2	3588	0.5
642	**Eelpouts (NS)***	*Lycodes sp.*	896	0.1	178	0.0
306	Sculpin, Snoflake Hookear	*Artediellus uncinatus*	638	0.1	-	0.0
150	Myctophids(NS),	Myctophidae f.	443	0.1	5	0.0

CODE	COMMON NAME	SCIENTIFIC NAME	Total No.	% No.	Total Wt. (kg.)	% Wt.
340	Alligatorfish	*Aspidophoroides monopterygius*	435	0.1	-	0.0
114	Rockling, Fourbeard	*Enchelyopus cimbrius*	432	0.1	10	0.0
19	Hake, Off-shore	*Merluccius albidus*	425	0.1	480	0.1
701	Butterfish	*Peprilus triacanthus*	424	0.1	39	0.0
31	Turbot, Greenland Halibut	*Reinharditus hippoglossoides*	424	0.1	265	0.0
241	Hagfish	*Myxine glutinosa*	316	0.0	63	0.0
641	Eelpout, Arctic	*Lycodes reticulatus*	290	0.0	77	0.0
221	Dogfish, Black	*Centroscyllium fabricii*	286	0.0	7	0.0
623	Shanny, Daubed	*Lumpenus maculatus*	240	0.0	2	0.0
622	Blenny, Snake	*Lumpinus lumpretaeformes*	221	0.0	11	0.0
143	Flounder, Windowpane, Brill	*Scophthalmus aquosus*	207	0.0	61	0.0
350	Sea Poacher, Atlantic	*Agonus decagonus*	148	0.0	2	0.0
44	Flounder, Gulfstream	*Citharichthys arctifrons*	136	0.0	-	0.0
200	Skate, Barndoor	*Raja laevis*	134	0.0	565	0.1
630	Wrymouth	*Cryptacanthodes maculatus*	131	0.0	32	0.0
502	Lumpsucker, Atl. Spiny	*Eumicrotremus spinosus*	125	0.0	-	0.0
414	Grenadier, Rock, Roundnose	*Coryphaenoides rupestris*	99	0.0	5	0.0
501	Lumpfish	*Cyclopterus, lumpus*	91	0.0	258	0.0
619	Eelpout, Newfoundland	*Lycodes terraenova*	88	0.0	6	0.0
122	Cunner	*Tautogolabrus adspersus*	78	0.0	34	0.0
412	Grenadier, Roughnose	*Trachyrhynchus murrayi*	75	0.0	1	0.0
625	Shanny, Radiated	*Ulvaria subbifurcata*	53	0.0	1	0.0
156	Greeneye, Short-nosed	*Chlorophthalmus agassizi*	49	0.0	-	0.0
712	Barracudina, White	*Notolepis rissoi kroyeri*	48	0.0	3	0.0
351	Sea Poachers (NS)	Agonidae f.	46	0.0	-	0.0
17	Tomcod, Atlantic	*Microgadus tomcod*	45	0.0	2	0.0
18	Hake (NS)	Hake unid.	40	0.0	-	0.0
626	4-Line Snake Blenny	*Eumesogrammus praecisus*	30	0.0	-	0.0
727	White Barracudina	*Notolepis rissoi*	29	0.0	-	0.0
611	Sand Lance (NS)	*Ammodytes sp.*	26	0.0	9	0.0
163	Lanternfish, Horned	*Ceratoscopelus maderensis*	21	0.0	-	0.0
603	Eelpout, Wolf	*Lycenchelys verrilli*	18	0.0	-	0.0
742	Batfish, Atlantic	*Dibranchus atlanticus*	16	0.0	-	0.0
694	Batfishes	*Ogcocephalidae f.*	15	0.0	1	0.0
704	Dory, American John	*Zenopsis conchifera*	14	0.0	1	0.0
505	Snailfish, Gelatinous	*Liparis fabricii*	13	0.0	-	0.0
115	Rockling, Threebeard	*Gaidropsarus ensis*	13	0.0	1	0.0
720	Saury, Atlantic	*Scomberesox saurus*	13	0.0	-	0.0
307	Sculpin, Polar	*Cottunculus micropes*	11	0.0	-	0.0
288	Argentines (N.S.)	Argentinidae f.	10	0.0	-	0.0
52	Wolffish, Northern	*Anarhichas denticulatus*	10	0.0	81	0.0

CODE	COMMON NAME	SCIENTIFIC NAME	Total No.	% No.	Total Wt. (kg.)	% Wt.
644	Blennies, Shannies, Gunnels	Blennioidei s.o.	10	0.0	-	0.0
142	Flounder Fourspot	*Paralichthys oblongus*	9	0.0	4	0.0
621	Gunnel, Rock	*Pholis gunnelius*	9	0.0	-	0.0
631	Eelblenny, Slender	*Lumpinus fabricii*	8	0.0	-	0.0
51	Wolffish, Spotted	*Anarhichas minor*	8	0.0	53	0.0
149	Greeneye, Longnose	*Parasudis truculenta*	7	0.0	-	0.0
159	Dragonfish, Boa	*Stomias boa ferox*	6	0.0	1	0.0
301	Sculpin, Shorthorn	*Myoxocephalus scorpius*	6	0.0	-	0.0
500	Seasnails (NS)	*Liparis sp.*	6	0.0	-	0.0
520	Sea Tadpole	*Careproctus reinhardi*	6	0.0	-	0.0
741	Hatchetfishes (NS)	Sternoptychidae f.	6	0.0	-	0.0
151	Stomiatoid unid.	Stomiatidae	6	0.0	-	0.0
158	Pearlsides, Muller's	*Maurolicus muelleri*	6	0.0	-	0.0
155	Anglemouth, Longtooth	*Gonostoma elongatum*	5	0.0	-	0.0
341	Alligatorfish, Arctic	*Aspidophoroides olriki*	5	0.0	-	0.0
240	Sea Lamprey	*Petromzon marinus*	4	0.0	1	0.0
409	Grenadier, Straptail	*Malacocephalus occidentalis*	4	0.0	-	0.0
370	Myctophum sp.	*Myctophum sp.*	4	0.0	-	0.0
645	Shanny unid.	Lumpenidae f.	4	0.0	-	0.0
2560	Paguroidea s.f.	Paguroidea s.f.	4	0.0	-	0.0
416	Grenadiers (NS)	Macrouridae f.	4	0.0	-	0.0
308	Sculpin, Pallid	*Cottunculus thompsoni*	3	0.0		0.0
90	Fish (Unidentified)	Pisces p.	3	0.0	-	0.0
503	Snailfish, Atlantic	*Liparis atlanticus*	3	0.0	-	0.0
507	Longfin Seasnail	*Careproctus longipinnis*	3	0.0	-	0.0
180	Lanternfish, Spotted	*Myctophum punctatum*	3	0.0	-	0.0
118	Cod, Greenland	*Gadus ogac*	3	0.0	1	0.0
119	Rocklings (NS)	*Gaidropsarus sp.*	3	0.0	-	0.0
771	Beardfish	*Polymixia lowei*	2	0.0	-	0.0
744	Beardfish, Stout	*Polymixia nobliis*	2	0.0	-	0.0
604	Eel, Snipe	*Nemichthys scolopaceus*	2	0.0	-	0.0
616	Fishdoctor	*Gymnelis viridis*	2	0.0	-	0.0
595	Dory, Red	*Cuttus roseus*	2	0.0	-	0.0
620	Eelpout, Laval's	*Lycodes lavalaei*	2	0.0	1	0.0
617	Wolf Eel, Common	*Lycenchelys paxillus*	2	0.0	-	0.0
713	Barracudina unid.	*Paralepididae f.*	2	0.0	-	0.0
711	Barracudina, Duckbill	*Paralepis atlantica*	2	0.0	1	0.0
219	Skates and Rays (NS)	Batoidei o.	2	0.0	2	0.0
643	Eelpout, Vachon's	*Lycodes esmarki*	2	0.0	2	0.0
243	Sturgeon, Atlantic	*Acipenser oxrhynchus*	1	0.0	25	0.0
312	Sculpins (NS)	Cottidae f.	1	0.0	-	0.0
530	Chaunax sp.	*Chaunax sp.*	1	0.0	-	0.0
330	Searobin, Northern,	*Priondius carolinus*	1	0.0	1	0.0

CODE	COMMON NAME	SCIENTIFIC NAME	Total No.	% No.	Total Wt. (kg.)	% Wt.
605	Blennies, Shannies, Gunnels	*Blennioidei s.o.*	1	0.0	-	0.0
677	None	*Epigonus denticulatus*	1	0.0	-	0.0
331	Armored Sea Robin	*Peristedion miniatum*	1	0.0	-	0.0
224	Sagre, Rough	*Etmopterus princeps*	1	0.0	2	0.0
608	Eel, Conger	*Conger oceanicus*	1	0.0	-	0.0
316	Sculpin, Arctic	*Myoxocephalus scorpiodes*	1	0.0	-	0.0
205	Skate, Spinytail	*Raja spinicauda*	1	0.0	3	0.0
141	Flounder, Summer	*Paralichthys dentalus*	1	0.0	-	0.0
169	Viperfish, Sloan's	*Chauliodus sloani*	1	0.0	-	0.0
743	Barrelfish	*Hyperoglyphe perciformes*	1	0.0	-	0.0
117	Whiting, Blue	*Micromesistius poutassou*	1	0.0	-	0.0
512	Snailfish, Dusky	*Liparis gibbus*	1	0.0	-	0.0
385	Flounder, Deepwater	*Monolene sessilicauda*	1	0.0	-	0.0
413	Grenadier, Saddled	*Coelorhynchus coelorhynchus*	1	0.0	-	0.0
714	Frostfish	*Benthodesmus elongatus*	1	0.0	-	0.0
717	Dragonshish, Torpedo	*Grammatostomias dentatus*	1	0.0	11	0.0
746	Puffer, Northern	*Sphoeroides maculatus*	1	0.0	-	0.0
504	Seasnail, Striped	*Liparis liparis*	1	0.0	-	0.0
774	Ogrefish	*Anoplogaster cornuta*	1	0.0	-	0.0
498	Yellowfin Bass	*Anthias nicholsi*	1	0.0	-	0.0
Subtotal			642147		669472	
Pelagic finfish						
64	Capelin	*Mallotus villosus*	36647	50.3	956	8.4
60	Herring, Atlantic	*Clupea harengus harengus*	26674	36.6	6766	59.4
70	Mackerel, Atlantic	*Scomber scombrus*	4975	6.8	2522	22.1
62	Alewife, Gaspereau	*Alosa pseudoharengus*	4166	5.7	843	7.4
61	Shad, American	*Alosa sapidissima*	354	0.5	298	2.6
63	Smelt, Rainbow	*Osmerus mordax*	82	0.1	-	0.0
165	Herring, Blueback	*Alosa aestivalis*	1	0.0	-	0.0
65	Salmon, Atlantic	*Salmo salar*	1	0.0	3	0.0
337	Smelts/Capelins (NS)	Osmeridae f.	1	0.0	-	0.0
Subtotal			72901		11388	
4511	Squid, Short Finned	*Illex illecebrosus*	154399	96.2	15887	8.1
2210	Shrimps (NS)	*Pandalus s.p.*	3646	2.3	120458	61.1
2600	Krill Shrimp	Euphausiacea o.	600	0.4	10026	5.1
2550	Lobster, American	*Homarus americanus*	464	0.3	653	0.3
2526	Crab, Queen, Snow	*Chionoecetes opilio*	423	0.3	88	0.0
2522	Spider/(Queen, Snow) unid.	*Chionoecetes sp.*	305	0.2	40035	20.3
2520	Toad Crab unid.	*Hyas sp.*	168	0.1	23	0.0
2511	Crab, Jonah	*Cancer borealis*	159	0.1	24	0.0
4320	Scallops (NS)	Pectinidae f.	135	0.1	10011	5.1
2523	Crab, Northern Snow	*Lithodes maja*	64	0.0	39	0.0

CODE	COMMON NAME	SCIENTIFIC NAME	Total No.	% No.	Total Wt. (kg.)	% Wt.
2513	Crab, Atlantic Rock	*Cancer irroratus*	58	0.0	7	0.0
6100	Starfishes (NS)	Asteroidea s.c.	37	0.0	1	0.0
2528	Spiny Spider Crab	*Neolithodes grimaldi*	20	0.0	9	0.0
2510	Crabs (NS)	Brachyura s.o.	16	0.0	3	0.0
2525	Crabs, Spiny (NS)	Lithodes/Neolithodes f.	15	0.0	3	0.0
4521	Octopus (NS)	Octopoda o.	7	0.0	-	0.0
2527	Toad Crab	*Hyas araneus*	5	0.0	-	0.0
2519	Crabs, Spider (NS)	Majidae f.	4	0.0	-	0.0
2524	Cancer sp.	*Cancer sp.*	2	0.0	-	0.0
2532	Crab, Deepsea Red	*Geryon quinquedens*	2	0.0	-	0.0
4512	Squid, Long Finned	*Loligo pealei*	1	0.0	-	0.0
3600	Snails, Sea (NS)	Heteropoda s.o.	1	0.0	-	0.0
Subtotal			160531		197267	

* Combined with 641, 619, 620, 643 for assemblage analysis