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Associations of Demersal Fish with Sponge Grounds in the Northwest Atlantic Fisheries Organization Regulatory Area and Adjacent Canadian Waters

Associations de poissons démersaux avec les fonds marins dominés par les éponges dans la zone réglementée par le Organisation des pêches de l'Atlantique Nord-Ouest et dans les eaux canadiennes adjacentes

E. Kenchington[1], D. Power[2], M. Koen-Alonso[2]

Fisheries and Oceans Canada

[1]Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

[2]Northwest Atlantic Fisheries Centre
P.O. Box 5667
St. John's, Newfoundland
Canada A1C 5X1

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ABSTRACT

The association of demersal fish taxa with *Geodia*-dominated sponge grounds was examined using data collected from 104 research vessel survey trawl sets of 500 to 1500 m depth along a portion of the continental slopes of the Grand Banks (NAFO [Northwest Atlantic Fisheries Organization] Divisions 3KLNO) and Flemish Cap (NAFO Division 3M). The total number of taxa and their total biomass were negatively correlated with both depth and sponge biomass in the catch, and sponge biomass increased with depth. Species composition was evaluated by analysis of similarity (ANOSIM), similarity of percent contribution (SIMPER) and multidimensional scaling (MDS) using log-transformed abundance and biomass of individual taxa. These analyses identified a small number of fish taxa as being more abundant and contributing to a significantly distinct faunal assemblage on the high density sponge grounds than elsewhere. Most other taxa showed the reverse, that is, lower abundance on the high density sponge grounds, or else a neutral response. The three taxa which contribute most to the community dissimilarity in biomass between the low and high sponge catch trawl sets are Black Dogfish (*Centroscyllium fabricii*), Blue Hake (*Antimora rostrata*) and the Longnose Eel (*Synaphobranchus kaupii*). The three taxa which contribute most to the community dissimilarity in abundance between the low and high sponge catch trawls are Lanternfish (*Myctophidae*), Common Grenadier (*Nezumia bairdii*) and Roundnose Grenadier (*Coryphaenoides rupestris*). All of these fish had higher biomass/abundance in the catches with low sponge by-catch. Six fish taxa had larger biomass in catches with high sponge: Shortnose Snipe Eel (*Serrivomer beanii*), Deepsea Cat Shark (*Apristurus profundorum*), Eelpout (*Lycodes spp*.), Spinytail Skate (*Bathyraja spinicauda*), White Skate (*Dipturus linteus*) and Deepwater Chimaeras (*Hydrolagus affinis*). The first three were also more abundant in those catches and are considered to be most strongly associated with the sponge grounds. Five fish taxa were never caught in the same sets with high sponge catches: Deepwater Redfish (*Sebastes mentella*), American Plaice (*Hippoglossoides platessoides*), Witch Flounder (*Glyptocephalus cynoglossus*), Vahl's Eelpout (*Lycodes vahlii*) and Thorny Skate (*Amblyraja radiata*) and this may be explained by depth or substrate preferences. Determining the active or passive nature of the association of these taxa with the sponge grounds requires further research.

RÉSUMÉ

L'association de taxons de poissons démersaux avec les fonds marins dominés par les éponges du genre Geodia a été examinée à l'aide de données recueillies dans 104 traits de chalut par relevé de navire de recherche de 500 à 1 500 m de profondeur le long d'une partie des pentes continentales des Grands Bancs de Terre-Neuve (OPANO [Organisation des pêches de l'Atlantique Nord-Ouest] Divisions 3KLNO) et du Bonnet flamand (OPANO Division 3M). Le nombre total de taxons et leur biomasse totale présentaient une corrélation négative tant avec la profondeur qu'avec la biomasse des éponges dans les prises, et la biomasse des éponges a augmenté avec la profondeur. La composition de l'espèce a été évaluée par une analyse de comparabilité, la comparabilité des pourcentages de participation ou contribution et une analyse multidimensionnelle en utilisant la biomasse et l'aire d'occupation de chaque taxon. Ces analyses ont permis de déterminer qu'un petit nombre de taxons de poissons était plus abondant et contribuait à un ensemble faunistique considérablement distinct plus dans les fonds marins à haute densité dominés par les éponges qu'ailleurs. La plupart des autres taxons ont montré l'inverse, c'est-à-dire, une abondance plus faible dans les fonds marins à haute densité dominés par les éponges ou une réponse neutre. Les trois taxons contribuant le plus à la dissemblance communautaire dans la biomasse entre les données de captures (faible et élevé) d'éponges par trait de chalut sont l'aiguillat noir (*Centroscyllium fabricii*), le hoki (*Antimora rostrata*) et l'anguille égorgée bécue (*Synaphobranchus kaupii*). Les trois taxons contribuant le plus à la dissemblance communautaire dans l'abondance entre les données de captures (faible et élevé) d'éponges par trait de chalut sont le poisson-lanterne (*Myctophidae*), le Grenadier du Grand Banc (*Nezumia bairdii*) et le Grenadier de roche (*Coryphaenoides rupestris*). La biomasse/l'abondance de tous ces poissons était plus élevée dans les prises avec de faibles prises accessoires d'éponges. Six taxons de poissons avaient une biomasse plus importante dans les prises avec un nombre élevé d'éponges : le serrivomer trapu (*Serrivomer beanii*), la roussette de profondeur (*Apristurus profundorum*), la lotte (*Lycodes spp*.), la raie à queue épineuse (*Bathyraja spinicauda*), la raie blanche (*Dipturus linteus*) et la chimère de profondeurs (*Hydrolagus affinis*). Les trois premiers étaient également plus abondants dans ces prises et sont jugés les plus fortement liés aux fonds marins dominés par les éponges. Cinq taxons de poissons n'ont jamais été pris dans les mêmes traits avec des prises élevées d'éponges : le sébaste atlantique (*Sebastes mentella*), la plie canadienne (*Hippoglossoides platessoides*), la plie grise (*Glyptocephalus cynoglossus*), la lycode à carreaux (*Lycodes vahlii*) et la raie épineuse (*Amblyraja radiata*), ce qui peut s'expliquer par la profondeur ou les préférences en matière de substrat. Il faut mener d'autres recherches pour déterminer la nature active ou passive de l'association de ces taxons avec les fonds marins dominés par les éponges.

INTRODUCTION

Sponge grounds are recognized as important structural habitats for a variety of species (cf. Boutillier et al. 2010). The importance of individual sponges as microhabitat for invertebrate species has been widely demonstrated and includes a wide range of ecological interaction including both facultative and obligate commensalisms (see recent reviews by Wulff 2006 and Bell 2008, and articles specific to the North Atlantic by Bett and Rice 1992, Klitgaard 1995, Klitgaard and Tendal 2004, ICES 2009). For those taxa, sponge architecture is an important determinant of the type and strength of such interactions.

The general co-occurrence of temperate sponge grounds with demersal fish assemblages has been less well documented (Hixon et al. 1991, ICES 2009, Hogg et al. 2010). Fish often use the structural habitat that sponge grounds provide for shelter, reproduction and to forage for food (Bell 2008). The three dimensional spatial complexity of sponge grounds also provides important nursery grounds for juvenile fish in their early stages of growth (Freese and Wing 2003). Rockfish (or 'redfish') of the genus *Sebastes* are particularly prevalent in sponge grounds in some areas, living both inside and between the sponges (Richards 1986, Freese and Wing 2003, Burton Marliave et al. 2009). Burton Marliave et al. (2009) describe habitat partitioning by *Sebastes maliger* where adults are associated with the reef structures (bioherms) and juveniles are associated with single sponges or lower density "sponge gardens". *S. maliger* feeds on benthic crustaceans and the authors hypothesize that increased species richness in the food resource on the sponge gardens drives this distribution pattern.

There may also be an avoidance of certain sponges by some species. Bell (2008) cites a number of examples where the chemical compounds of the sponges act as deterrents to other organisms. Burton Marliave et al. (2009) show regional patterns in British Columbian waters (northeast Pacific) in the association of adult *Sebastes maliger* with the sponge reef structures, with the fish absent from some sponge reefs entirely but present in nearby areas.

There is also some evidence that removal of sponge grounds by trawling changes the composition of the fish fauna (cf. Klitgaard and Tendal 2004). Thus, it seems that sponge grounds may be an important refuge and habitat for fish although little ecological work has been carried out to understand the exact nature of this habitat use in the deep sea, and most studies to date are limited to tropical waters (e.g., McCormick 1994, Cleary and de Voogd 2007).

Here we describe the relationship between the fish fauna associated with the sponge grounds on the continental slopes of the Grand Banks (NAFO [Northwest Atlantic Fisheries Organization] Divisions 3KLNO) and Flemish Cap (NAFO Division 3M) (cf. Kenchington et al. 2010), with a particular focus on the NAFO Regulatory Area (NRA, seaward of the 200 mile limit). The sponges in this area are dominated by *Geodia* species (Fuller et al. 2008), which are massive ball sponges found throughout the north Atlantic (ICES 2009). We document the demersal fish assemblages caught in research vessel trawl catches and assess whether those assemblages differ in areas of low, medium and high sponge biomass.

METHODS

Data used for these analyses come from the Fisheries and Oceans Canada (DFO) Newfoundland Region fall multispecies surveys. These surveys use a Campelen trawl towed for approximately 1 km. The catch is sorted at sea and the number and weight (kg) of each taxon recorded using a standard set of species codes. Only records from 2001 to 2007 were used in order to avoid confounding the results by temporal trends due to environmental factors (cf. Colbourne 2004) and to ensure consistency of reporting. These records were further reduced to include: 1) only those deeper than 500 m, to minimize confounding of the results by including both shelf and slope taxa, 2) only those from below 50 N latitude, in order to reduce confounding of the results by introducing biogeographic differences in community composition, and 3) only records where the sponge catch was certified at sea through species keys or identified via representative samples post-survey. For the last, zero sponge catch records were not included as it could not be certain that sponges were not caught as they may just not have been recorded. These criteria produced 104 trawl records for analysis with an average depth of 1096 m (range 578-1446 m).

The 104 selected trawls contained non-zero records for 200 taxa. The weights and abundance of each of the taxa were standardized to a 1 km trawl. This involved only a minor adjustment to the data as the average trawl length was 0.8 ± 0.07 km (range 0.6-1.0).

The 200 taxa were reduced by: 1) combining some species to higher-level groupings, and 2) eliminating all rarities after combining the data to include only taxa greater than 0.1% of total biomass/abundance. The first of these steps was done to avoid introducing errors due to taxonomic imprecision among trips and also sets within trips. The second was to eliminate taxa that may not be reliably caught in the trawl, or whose rarity may escape detection in the routine sorting and sub-sampling processes. To determine the low end cut off, decisions were made on the size of the taxon relative to the biomass record before removing it from the list.

The analytical variables calculated per standard trawl set were: Total Number of Taxa (of the 34 species for which biomass was analyzed), Total Biomass, Total Abundance, Taxon Biomass, Taxon Abundance, Total Sponge Biomass and Average Trawl Depth.

For each trawl set, the Total Sponge Biomass was used to classify the set according to one of three arbitrary Sponge Catch Weight Classes (Table 1): High (greater than or equal to 250 kg/km), Medium (10.01-249.99 kg/km) and Low (less than or equal to 10 kg/km). The variance of the Average Trawl Depth (Table 1) was tested for equality among Sponge Catch Weight Classes using Levene's test and was found to be unequal (P=0.040). This variable was analyzed in its untransformed state and Welch's ANOVA was used to test for an effect of Sponge Catch Weight Class on Average Trawl Depth. Tukey's Honestly Significant Difference test was used for *post hoc* comparisons of the mean values to identify differences between factor levels. These and similar analyses below were performed with JMP v.6.0.3 software (SAS Institute Inc.). The locations of the trawl sets used in this analysis, identified by their Sponge Catch Weight Class, are illustrated in Figure 1.

Number of Taxa

The variance of the Total Number of Taxa (Table 1) was tested for equality among Sponge Catch Weight Classes using Levene's test and was found to be unequal. This variable was analyzed in its untransformed state and Welch's ANOVA was used to test for an effect of Sponge Catch Weight Class on Total Number of Taxa. Tukey's Honestly Significant Difference test was used for *post hoc* comparisons of the mean values to identify differences between factor levels. The Total Number of Taxa was regressed against Average Trawl Depth and log10 transformed Total Sponge Biomass.

Biomass

The variances of the log10 transformed Total Biomass (Table 1) were tested for equality among Sponge Catch Weight Classes using Levene's test and were found to be equal. ANOVA was used to assess whether mean Total Biomass was equal among Sponge Catch Weight Classes. Tukey's Honestly Significant Difference test was used for *post hoc* comparisons of the mean values to identify differences between factor levels. The transformed Total Biomass was regressed against Average Trawl Depth and log10 transformed Total Sponge Biomass.

Community composition was examined through an ANOSIM of a Bray-Curtis similarity matrix of station pairs based on log10 transformed biomass of 34 fish taxa (Table 2). A similarity of percentages analysis (SIMPER) was performed to quantify the level of similarity within and between groups and to identify the taxa contributing most to the dissimilarities. An MDS ordination of the Bray Curtis similarity matrix was used to visualize the relationships among the trawl set catches. These analyses and similar analyses described below were performed with Primer v. 6.1.5 software (2006 Primer-E Ltd.).

Abundance

The variances of the log10 transformed Total Abundance (Table 1) were tested for equality among Sponge Catch Weight Classes using Levene's test and were found to be equal. ANOVA was used to assess whether mean Total Abundance was equal among Sponge Catch Weight Classes. The transformed Total Abundance was regressed against Average Trawl Depth and log10 transformed Total Sponge Biomass.

Community composition was examined through an ANOSIM of a Bray-Curtis similarity matrix of station pairs based on log10 transformed abundance of 34 fish taxa (Table 3). A similarity of percentages analysis (SIMPER) was performed to quantify the level of similarity within and between groups and to identify the taxa contributing most to the dissimilarities. An MDS ordination of the Bray Curtis similarity matrix was used to visualize the relationships among the trawl set catches.

RESULTS

There was a significant difference in Average Trawl Depth among Sponge Catch Weight Classes (P<0.0001) and *post hoc* analyses showed that this difference was due to a shallower Average Trawl Depth in the Low Sponge Catch Weight Class than in the Medium and High classes, which were not significantly different from each other. The average depths (± standard deviation (range)) for each class were: Low: 981± 247 m (578-1420 m), Medium: 1165± 205 m (589-1385 m), and High: 1250± 1677 m (827-1446 m).

Thirty-four fish taxa had biomass greater than 0.1% of the total biomass for the trawl set. The Total Biomass standardized to a 1 km trawl and summed across the 104 trawl sets for the 34 selected taxa (Table 1) was 13,514.92 kg. Greenland Shark accounted for 26.56% of the total biomass in the data, with Roughhead Grenadier accounting for 18.51%. Eleven taxa accounted for 90% of the total biomass in these sets (Table 2).

A *different* set of 34 fish taxa had abundance greater than 0.1% of the total abundance for the trawl set [note it was just coincidental that both biomass and abundance should produce 34 fish taxa for analyses after data reduction]. The Total Abundance standardized to a 1 km trawl and summed across the 104 trawl sets for the 34 selected taxa was 40,453.63 fish. Eleven taxa accounted for 90% of the total abundance, with myctophids (Lanternfish) being the largest taxon and accounting for 25.25% of total abundance (Table 3). Blue Hake (*Antimora rostrata*) was the second most abundant taxon and this species also ranked high in total biomass (Table 2).

The Total Number of Taxa and the Total Biomass were significantly different among the Sponge Catch Weight Classes (P<0.001). *Post hoc* analyses showed that Total Biomass was not significantly different between the Medium and High Sponge Catch Weight Classes but that the Low Sponge Catch Weight Class had significantly higher Total Biomass. The Total Number of Taxa was significantly lower in the High Sponge Catch Weight Class and did not differ between Medium and Low classes. Total Abundance did not differ significantly among Sponge Catch Weight Classes (P=0.079).

Linear regressions between the log10 transformed Total Biomass and Total Sponge Biomass by Depth were statistically significant (P<0.0001) (Figure 2). Sponge Biomass increased significantly with Depth (R^2=0.197), while Total Biomass of the fish taxa significantly decreased (R^2=0.182). The Total Number of Taxa and Total Abundance were not significantly correlated with Depth (P=0.249, P=0.797 respectively). Total Biomass and the Total Number of Taxa were both significantly negatively correlated with Total Sponge Biomass (P<0.0001, R^2=0.133 and R^2=0.209 respectively) (Figure 3).

Community Analyses: Biomass

Analysis of Similarity (ANOSIM) of the 104 trawl sets found a significant difference in community composition of the biomass between Sponge Catch Weight Classes (Global R=0.129, P=0.001). There was no significant difference between Low and Medium Classes (R=0.056, P=0.087), however, there was a significant difference between the Low and High Classes (R=0.232, P=0.001), and between Medium and High Sponge Catch Weight Classes (R=0.122, P=0.001) even after adjusting the P-value for multiple tests.

Similarity of Percentages Analyses (SIMPER) indicated an overall similarity of taxon biomass within groups of 54%, however there was greater similarity within the Low (54.8%) and Medium (57.6%) classes than within the High Class (49.7%). The taxa which accounted for 90% of the similarity in biomass within each class are listed in Table 4.

Average dissimilarity in taxon biomass between the Low and Medium classes was 45.9%, 51.9% between the Low and High classes, and 49.3% between the Medium and High classes. The taxa contributing to the dissimilarity between the Low and High classes are provided in Table 5. Of the 22 taxa accounting for 90% of the dissimilarity in biomass between these two classes, Black Dogfish (*Centroscyllium fabricii*), Blue Hake and Longnose Eels (*Synaphobranchus kaupii*) accounted for a quarter of the dissimilarity (Table 5). All had higher biomass in the Low Sponge Catch Weight Class, although they were also found in the High Sponge Catch Weight Class. Only six taxa showed increased biomass in the High Class, namely the Deepsea Cat Shark (*Apristurus profundorum*), Spinytail Skate (*Bathyraja spinicauda*), White Skate (*Dipturus linteus*), Shortnose Snipe Eel (*Serrivomer beanii*), Eelpout (*Lycodes* spp.), and Deepwater Chimaeras (*Hydrolagus affinis*) (Table 5). Another four taxa were never found in association with High sponge catches, namely Deepwater Redfish

(*Sebastes mentella*), American Plaice (*Hippoglossoides platessoides*), Witch Flounder (*Glyptocephalus cynoglossus*), and Thorny Skate (*Amblyraja radiata*) (Table 5). Most other taxa showed increased biomass in the Low Class to varying degrees. These relationships are visualized in the MDS plot in Figure 4 with stations with an average similarity of 54% circled. Owing to the high stress of the 2D presentation (0.20), the 3D presentation is also shown (stress=0.15). It can be seen that although some sets with high sponge catch cluster together, most of the stations share a similarity of taxa that is not explained by the Sponge Catch Weight Class (Figure 4). The relative proportions of biomass for selected pairs of taxa are indicated in the MDS ordination in Figure 5. Each graph highlights a taxon which has increased biomass in the High or Low Sponge Catch Weight Class and shows the discreteness of the groups.

Community Analyses: Abundance

Analysis of Similarity (ANOSIM) of the 104 trawl sets found a significant difference in community composition in abundance of taxa between Sponge Catch Weight Classes (Global R=0.245, P=0.001), and between all weight class pairs. However there was a low R (0.083) produced between the Low and Medium classes and the associated probability was 0.034, a value which would not be considered significant if corrected for the total number of tests performed.

Similarity of Percentages Analyses (SIMPER) indicated an overall similarity of taxon abundance within groups of 59%, however there was greater similarity within the Low (62.6%) and Medium (63%) classes than within the High Class (51%). The taxa which account for 90% of the similarity in abundance within each class are listed in Table 6.

Average dissimilarity in taxon abundance between the Low and Medium classes was 39%, 52% between the Low and High classes, and 48% between the Medium and High classes. The taxa contributing to the dissimilarity between the Low and High classes are provided in Table 7. Of the 25 taxa accounting for 90% of the dissimilarity in abundance between these two Classes, Lanternfish, Common and Roundnose Grenadiers accounted for a quarter of the dissimilarity (Table 7). These all have higher abundance in the Low Sponge Catch Weight Class than in the High class. The only taxa which had increased abundance in the High Sponge Catch Weight Class were the Deepsea Cat Shark, Eelpout and the Shortnose Snipe Eel. All other taxa (N=22) had decreased abundance in the High Sponge Catch Weight Class and four taxa were not found in that class: Deepwater Redfish, American Plaice, Witch Flounder and Vahl's Eelpout (*Lycodes vahlii*) (Table 7).

The relationships between the trawl sets labeled by Sponge Catch Weight Class are visualized in the MDS plot in Figure 6 with stations with an average similarity of 59% circled. It can be seen that although some sets with high sponge catch cluster together, most of the stations share a similarity of taxa that is not explained by the Sponge Catch Weight Class (Figure 6).

DISCUSSION

There is a significantly higher sponge biomass with increasing depth and a correspondingly lower fish biomass (of the 34 selected taxa). At the same time, both the number of taxa and the total fish biomass decreased with increasing sponge weight in the catch. These relationships could represent true ecological properties or they could be artefacts of the handling procedures (both of the net *in situ* and of the catch on deck) when large sponge catches are hauled in.

Community analyses showed that although distinct faunal assemblages are associated with the Low and High sponge catches, Medium sponge catches have similar communities to areas with Low sponge. This result was produced using both abundance and biomass of the fish taxa, and suggests that there are only two community types with respect to sponge biomass, with sponge biomass greater than 250 kg/km distinguishing them. This is not consistent with the average depth of the Sponge Catch Weight Classes, which showed that trawl sets in the Low class were on average shallower than those in the Medium and High classes, which did not differ from one another. The three taxa which contributed most to the dissimilarity in biomass and in abundance between the Low and High sponge catch trawl sets were found in both classes of catch but differed in their relative contributions to each. In all cases, the taxa had lower biomass/abundance in the High Sponge Weight Class. The three taxa which contributed most to the dissimilarity in biomass were Black Dogfish, Blue Hake and Longnose Eel, and the three taxa which contributed most to the dissimilarity in abundance were Lanternfish, Common Grenadier and Roundnose Grenadier.

The only taxa which had higher abundance and/or biomass in trawl sets with High sponge catches were Deepsea Cat Sharks, Spinytail Skates, White Skates, Shortnose Snipe Eels, Eelpouts and Deepwater Chimaeras (Table 8). None of the fish taxa examined were found exclusively in catches with High sponge weight. The Deepsea Cat Shark is one of the larger species in the trawl catch (Table 2) with lengths up to 50 cm reported. Shortnose Snipe Eels have small biomass but can reach lengths of 150 cm. All are deep-living fish (Rose 2005) and active predators and it is unlikely that these fish would be overlooked in the sorting of catch. A summary of the habitat preference and diet of these fish taxa is summarized in Table 8. This table was produced using information recorded on FishBase (www.fishbase.org) and from Coad and Reist (2004) and Troyanovsky (1992) and helps to provide some interpretation of these results.

Although the depth ranges were similar among Sponge Catch Weight Classes, mean Average Trawl Depth was significantly shallower in the Low Sponge Catch Weight Class where the mean depth was 980 m. Five species were never reported in the High Sponge Catch Weight Class: Deepwater Redfish, American Plaice, Witch Flounder, Vahl's Eelpout and Thorny Skate. All of these fish had median depth ranges in our study of less than 980 m (Table 8). Therefore their negative association with sponge grounds may be better explained by depth distribution. Of these, Deepwater Redfish have been associated with sponge grounds elsewhere (see Introduction) and the negative association here is best explained by differences in preferred depth as only 5 fish were captured below 1000 m regardless of sponge catch weight. Further, three species never reported in the High Sponge Catch Weight Class (American Plaice, Thorny Skate and Witch Flounder) are associated with mud or sandy bottoms and may actively avoid the sponge grounds. Lastly, two of the species in Table 8 are known to spend time in the water column, feeding in the shallower surface waters at night (Deepwater Redfish, Shortnose Snipe Eel). There is a possibility that the trawl sets in the High Sponge Catch Weight Class were biased by time of day to produce those results, but this was not the case. The trawl sets were almost evenly split between day and night times.

Of the 11 taxa listed in Table 8, only Shortnose Snipe Eel, Eelpout and Spinytail Skate were evenly collected across the depth range of this study and all three were positively associated with the sponge grounds. Eelpout (*Lycodes* spp.) are known to eat sponge remains (Table 8, Coade and Reist 2004) and so may use the sponge grounds to feed. However, dietary information for most taxa of interest was generally not specific enough to explain the observed distributions (Table 8).

Collectively these data suggest that the *Geodia*-dominated sponge grounds of the NAFO Regulatory Area (NRA) host unique fish faunal assemblages, although the active or passive nature of this association is not known. A more detailed analysis of these data using less coarse taxonomic categories may have revealed greater differences in community composition. However, trawl survey by-catch can only give a generalized picture of the species associations for those species that are caught by the gear. The smaller invertebrate and fish species and life history stages that have been reported elsewhere as associated with sponge grounds require other sampling tools to elucidate. The results reported here will be compared with *in situ* photographic and video data collected in 2009 to further describe the species associated with sponge grounds in the NRA.

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TABLES

***Table 1**. The location and characteristics of the data records used for analyses.*

Trawl Code	Latitude (dd)	Longitude (dd)	Average Depth (m)	Total Number of Taxa (N=34)	Total Biomass of 34 Taxa (Standardized)	Total Abundance of 34 Taxa (Standardized)	Sponge Biomass (Standardized)	Sponge Catch Weight Class
3935892001	45.8550	-46.4517	1202	17	50.95	428.00	35.505	Medium
3941252002	44.8533	-48.8900	1377	16	123.16	415.00	1600.000	High
3960932005	42.9450	-49.5867	1190	12	154.64	787.00	1.440	Low
3968342006	48.2467	-48.6250	874	14	183.40	200.00	0.224	Low
3975132007	44.9433	-48.7083	1377	11	54.29	848.00	240.000	Medium
3975162007	45.4483	-48.1617	1361	17	49.98	676.44	12.375	Medium
3975172007	45.5517	-48.2617	871	13	86.92	347.56	15.600	Medium
3975182007	45.5483	-48.2133	999	13	110.71	1244.80	9.640	Low
3975192007	45.5833	-48.0650	1245	12	68.14	500.00	202.500	Medium
3975222007	47.8817	-46.4217	1178	16	79.76	594.67	15.995	Medium
30487342003	46.9033	-47.2167	630	15	77.99	728.00	4.100	Low
30558342004	43.4883	-49.1767	601	13	171.86	661.00	8.880	Low
30558712004	45.8067	-47.8733	629	16	164.71	110.00	2.200	Low
30628182005	45.9983	-47.6817	589	13	54.56	192.00	31.400	Medium
30630372005	46.5183	-47.0400	676	13	137.74	244.00	3.320	Low
30705342006	43.1083	-49.5100	587	13	207.97	587.00	6.255	Low
30707212006	48.0983	-48.2933	610	15	3652.14	16.00	0.990	Low
30707332006	48.8000	-49.8500	614	14	229.82	210.00	0.720	Low
30771612007	43.3250	-49.2733	578	12	70.57	250.29	0.256	Low
30772332007	45.5617	-48.3217	603	14	190.76	126.22	1.296	Low
30772492007	46.5550	-47.0850	634	15	171.84	197.00	12.950	Medium
39357362001	44.5333	-48.9183	1384	14	172.69	41.00	16.400	Medium
39357382001	44.9000	-48.7983	1410	10	39.04	96.00	3200.000	High
39357402001	45.0550	-48.6500	1245	16	74.73	40.00	450.000	High
39357412001	45.3550	-48.3067	1352	18	112.63	167.27	400.000	High
39357432001	45.5883	-47.8400	1358	16	100.05	275.00	800.000	High
39357462001	45.9767	-47.5200	1168	7	6.31	268.44	350.000	High
39357472001	45.9333	-47.5917	1015	15	123.27	70.00	400.000	High
39357482001	46.2850	-46.9033	965	13	162.74	84.00	490.000	High

Table 1. *Continued.*

Trawl Code	Latitude (dd)	Longitude (dd)	Average Depth (m)	Total Number of Taxa (N=34)	Total Biomass of 34 Taxa (Standardized)	Total Abundance of 34Taxa (Standardized)	Sponge Biomass (Standardized)	Sponge Catch Weight Class
39358132001	46.3317	-46.6150	956	15	26.20	156.00	3.560	Low
39358162001	45.3370	-48.1930	1215	3	33.14	333.00	1600.000	High
39358172001	46.3330	-47.0510	1196	4	55.25	569.60	1200.000	High
39358372001	47.5930	-46.5440	1341	3	15.95	140.57	1600.000	High
39358402001	44.3200	-48.5510	1360	5	70.04	278.00	3300.000	High
39412142002	44.5400	-48.4790	1310	18	79.22	243.43	23.625	Medium
39412152002	45.0330	-48.3900	1170	8	50.20	402.29	800.000	High
39412162002	45.2130	-48.1840	1037	9	49.30	497.00	400.000	High
39412182002	45.3530	-47.5040	1029	9	99.46	330.00	1600.000	High
39412222002	45.5860	-47.3120	960	14	130.07	604.00	78.400	Medium
39412232002	45.5600	-47.3550	1314	13	76.18	515.00	1.775	Low
39412262002	46.1710	-46.5420	1358	9	40.54	393.00	700.000	High
39412272002	46.1990	-46.3690	1208	16	54.32	232.00	23.400	Medium
39412282002	46.4040	-46.5530	1403	14	22.29	144.00	5.810	Low
39412292002	46.4840	-46.5870	1197	16	72.94	195.43	6.055	Low
39412352002	48.4570	-45.3570	1211	15	102.96	93.71	111.840	Medium
39412372002	48.2070	-46.3330	1145	17	69.86	326.00	20.040	Medium
39513432004	45.4210	-47.3840	985	16	173.34	295.00	0.200	Low
39513662004	45.5520	-47.3450	1168	15	114.14	463.00	9.800	Low
39513782004	45.5680	-47.3460	1162	14	120.53	238.00	57.200	Medium
39513852004	46.1190	-47.1060	1280	13	74.88	934.00	400.000	High
39513862004	46.1950	-47.0130	1353	15	88.66	343.00	640.000	High
39513882004	46.1110	-46.5500	1446	13	84.39	296.00	2800.000	High
39513892004	45.5300	-46.1180	1385	10	30.70	425.00	215.600	Medium
39513902004	46.0170	-46.1420	1013	12	164.93	330.00	39.720	Medium
39513922004	46.1200	-46.1060	816	16	131.28	465.00	6.640	Low
39513932004	46.1420	-46.0760	801	16	186.46	410.00	3.440	Low
39513942004	46.4880	-46.5450	1221	12	37.59	528.00	10.600	Medium
39609112005	47.0450	-46.5770	1373	19	47.36	196.44	45.880	Medium
39609132005	48.4070	-49.3240	1355	12	45.44	719.00	253.440	Medium
39682562006	48.2230	-45.5370	1303	15	92.02	619.00	0.672	Low

Table 1. *Continued.*

Trawl Code	Latitude (dd)	Longitude (dd)	Average Depth (m)	Total Number of Taxa (N=34)	Total Biomass of 34 Taxa (Standardized)	Total Abundance of 34 Taxa (Standardized)	Sponge Biomass (Standardized)	Sponge Catch Weight Class
39682632006	47.2000	-46.4070	1353	15	129.37	611.00	0.320	Low
39682652006	45.5460	-46.1210	1205	13	64.36	419.56	0.200	Low
39682672006	48.6433	-49.5700	828	14	112.03	307.43	0.400	Low
39683112006	48.4900	-46.1483	1355	12	49.90	347.56	648.000	High
39683152006	48.5367	-45.6767	1159	18	119.45	404.00	0.840	Low
39683192006	48.1150	-46.3050	1167	14	68.42	500.00	0.600	Low
39683292006	47.4033	-46.7533	1161	19	82.41	613.00	2.640	Low
39683322006	47.0633	-46.9550	1162	15	94.89	302.86	47.520	Medium
39683332006	46.9517	-46.9367	1186	18	58.32	151.00	52.920	Medium
39683342006	46.9083	-47.1350	940	12	112.20	632.00	0.396	Low
39683352006	46.9200	-46.6933	818	17	78.36	501.00	5.800	Low
39683362006	46.8100	-46.6250	908	18	151.34	563.00	0.840	Low
39683372006	46.6633	-46.7067	978	16	70.61	130.00	2.080	Low
39683392006	46.4617	-46.3533	953	16	65.21	213.09	0.231	Low
39683412006	46.0250	-46.2383	1131	12	26.52	1220.00	4.000	Low
39683422006	46.3533	-47.1150	875	14	153.16	536.00	9.600	Low
39683432006	46.4800	-47.0733	888	16	231.21	190.22	5.840	Low
39750292007	42.9450	-49.5883	1176	13	180.49	211.00	3.400	Low
39751112007	45.7633	-47.7533	1153	15	97.87	597.00	80.000	Medium
39751132007	46.2117	-47.0833	1058	16	198.48	302.00	5.000	Low
39751142007	46.2217	-46.9900	1369	16	118.43	69.00	803.440	High
39751152007	46.3150	-46.9067	827	7	27.13	470.00	400.000	High
39751162007	46.0983	-47.4183	846	10	69.08	418.00	172.000	Medium
39751172007	46.2483	-46.6467	941	15	95.25	182.00	0.400	Low
39751182007	45.8500	-46.2883	1370	12	31.73	81.78	40.000	Medium
39751192007	45.9300	-46.1817	1262	12	28.68	369.00	101.970	Medium
39751202007	46.2083	-46.1850	1369	14	95.92	195.00	2.600	Low
39751212007	46.2317	-46.1250	1217	14	54.18	387.00	1.040	Low
39751222007	46.4000	-46.2767	930	14	120.49	271.11	1.680	Low
39751242007	46.6217	-46.9167	1243	16	89.42	247.11	109.521	Medium
39751252007	46.8233	-46.8550	1213	15	65.87	762.67	10.890	Medium

Table 1. *Continued.*

Trawl Code	Latitude (dd)	Longitude (dd)	Average Depth (m)	Total Number of Taxa (N=34)	Total Biomass of 34 Taxa (Standardized)	Total Abundance of 34 Taxa (Standardized)	Sponge Biomass (Standardized)	Sponge Catch Weight Class
39751272007	46.9933	-47.0000	1157	12	104.52	571.00	23.625	Medium
39751282007	47.0517	-46.6150	768	16	86.25	540.57	1.600	Low
39751292007	47.0767	-46.6600	928	15	106.16	387.00	4.130	Low
39751302007	47.1633	-46.8033	1162	14	78.05	625.00	15.760	Medium
39751312007	47.3817	-46.9467	1067	13	81.56	526.40	1.184	Low
39751332007	47.3283	-46.4850	824	16	73.93	430.86	3.740	Low
39752112007	48.9500	-45.2200	1378	13	29.44	152.00	350.000	High
39752122007	48.8200	-45.5300	1404	12	83.96	168.00	900.000	High
39752212007	48.3617	-48.7300	1249	14	117.50	545.00	0.720	Low
39752232007	48.5333	-49.4533	812	15	69.03	584.00	1.715	Low
39752242007	48.6633	-49.2367	1404	12	111.72	435.00	1.584	Low
39752252007	48.6733	-49.5400	964	14	82.73	462.40	0.290	Low
39752272007	48.8900	-49.5467	1420	16	96.69	702.86	0.735	Low

Table 2. *List of the 34 fish taxa analyzed for fish biomass association with sponge grounds, their common names, total taxon biomass in kilograms (Total B) and percent of total biomass (%) in 104 trawl sets.*

Fish Taxon	Common Name	Total B (kg)	%	Fish Taxon	Common Name	Total B (kg)	%
Somniosus microcephalus	Greenland Shark	3555.56	26.56	*Hydrolagus affinis*	Deepwater Chimaera	87.46	0.65
Macrourus berglax	Roughhead Grenadier	2477.42	18.51	*Amblyraja jenseni*	Jensen's Skate	81.82	0.61
Antimora rostrata	Blue Hake	1738.51	12.99	*Dipturus linteus*	White Skate	62.07	0.46
Centroscyllium fabricii	Black Dogfish	1091.65	8.16	Myctophidae	Lanternfishes	51.96	0.39
Reinhardtius hippoglossoides	Turbot	846.83	6.33	Notacanthidae	Spiny Eels	38.78	0.29
Sebastes mentella	Deepwater Redfish	574.43	4.29	*Lycodes* spp.	Eelpout	37.96	0.28
Hippoglossoides platessoides	American Plaice	546.04	4.08	*Lycodes vahlii*	Vahl's Eelpout	37.37	0.28
Synaphobranchus kaupii	Longnose Eel	543.07	4.06	*Serrivomer beanii*	Shortnose Snipe Eel	31.25	0.23
Coryphaenoides rupestris	Roundnose Grenadier	374.73	2.80	*Harriotta raleighana*	Longnose Chimaera	25.57	0.19
Apristurus profundorum	Deepsea Cat Shark	185.44	1.39	*Phycis chesteri*	Longfin Hake	19.33	0.14
Bathyraja spinicauda	Spinytail Skate	171.28	1.28	*Bathylagus euryops*	Goitre Blacksmelts	19.22	0.14
Nezumia bairdii	Common Grenadier	156.29	1.17	*Anarhichas minor*	Spotted Wolfish	16.41	0.12
Anarhichas denticulatus	Broadhead Wolfish	134.40	1.00	*Bathytroctes* spp.	Black Herring	16.39	0.12
Notacanthus chemnitzii	Largescaled Tapirfish	112.52	0.84	*Amblyraja hyperborea*	Arctic Skate	16.30	0.12
Amblyraja radiata	Thorny Skate	109.71	0.82	*Chauliodus sloani*	Viperfish	16.19	0.12
Glyptocephalus cynoglossus	Witch Flounder	96.09	0.72	*Rajella bathyphilia*	Abyssal Skate	12.63	0.09
Gaidropsarus spp.	Threebeard Rockling	89.31	0.67	*Stomias boa ferox*	Boa Dragonfish	11.31	0.08

Table 3. *List of the 34 fish taxa analyzed for fish abundance association with sponge grounds, their common names, total taxon abundance (Total A) and percent of total abundance (%) in 104 trawl sets.*

Fish Taxon	Common Name	Total A	%	Fish Taxon	Common Name	Total A	%
Myctophidae	Lanternfishes	10214.69	25.25	*Glyptocephalus cynoglossus*	Witch Flounder	209.09	0.52
Antimora rostrata	Blue Hake	7006.51	17.32	*Notacanthus chemnitzii*	Largescale Tapirfish	160.21	0.40
Macrourus berglax	Roughhead Grenadier	4875.68	12.05	*Lycodes vahlii*	Vahl's Eelpout	156.67	0.39
Synaphobranchus kaupii	Longnose Eel	4038.52	9.98	Polymixiidae	Beardfishes	114.87	0.28
Coryphaenoides rupestris	Roundnose Grenadier	3435.24	8.49	*Lycodes* spp.	Eelpout	111.25	0.28
Nezumia bairdii	Common Grenadier	1645.77	4.07	*Phycis chesteri*	Longfin Hake	110.62	0.27
Sebastes mentella	Deepwater Redfish	1570.75	3.88	*Apristurus profundorum*	Deepsea Cat Shark	99.65	0.25
Centroscyllium fabricii	Black Dogfish	961.89	2.38	*Nemichthys scolopaceus*	Atlantic Snipe Eel	97.60	0.24
Reinhardtius hippoglossoides	Turbot	961.67	2.38	*Malacosteus niger*	Loosejaw	89.99	0.22
Hippoglossoides platessoides	American Plaice	897.63	2.22	*Chiasmodon niger*	Black Swallower	83.95	0.21
Stomias boa ferox	Boa Dragonfish	867.42	2.14	*Bathytroctes* spp.	Black Herring	61.06	0.15
Bathylagus euryops	Goitre Blacksmelts	673.56	1.67	*Polyacanthonotus rissoanus*	Shortspine Tapirfish	58.04	0.14
Chauliodus sloani	Viperfish	485.04	1.20	Alepocephalidae	Smoothheads	52.30	0.13
Notacanthidae	Spiny Eels	333.03	0.82	*Amblyraja radiata*	Thorny Skate	49.92	0.12
Paralepididae	Barracudinas	322.96	0.80	*Cottunculus microps*	Polar Deepsea Sculpin	48.14	0.12
Serrivomer beanii	Shortnose Snipe Eel	289.72	0.72	Stomiinae	Scaled Dragonfishes	44.28	0.11
Gaidropsarus spp.	Threebeard Rockling	283.74	0.70	*Anarhichas denticulatus*	Broadhead Wolfish	42.17	0.10

Table 4. *Taxa contributing to > 90% of the similarity in biomass of research vessel catch composition (2001-2007) within each of Low, Medium and High Sponge Catch Weight Classes.*

Species	Common Name	Average Lg10(B)	Av. Sim	Sim/StDev	Contrib%	Cum.%
Low Sponge Catch Weight Class Average similarity: 54.85						
Macrourus berglax	Roughhead Grenadier	3	12.52	3.39	22.83	22.83
Antimora rostrata	Blue Hake	2.58	10.79	2.68	19.68	42.5
Reinhardtius hippoglossoides	Turbot	2.1	8.06	2.08	14.69	57.2
Synaphobranchus kaupii	Longnose Eel	1.5	4.76	1.26	8.68	65.88
Centroscyllium fabricii	Black Dogfish	1.53	3.56	0.69	6.5	72.38
Coryphaenoides rupestris	Roundnose Grenadier	1.24	3.48	1.01	6.35	78.73
Nezumia bairdii	Common Grenadier	0.95	2.91	1.23	5.31	84.04
Myctophidae	Lanternfishes	0.47	1.46	1.36	2.66	86.7
Notacanthus chemnitzii	Largescaled Tapirfish	0.59	1.28	0.71	2.34	89.04
Gaidropsarus spp.	Threebeard Rockling	0.55	1.15	0.65	2.1	91.14
Medium Sponge Catch Weight Class Average similarity: 57.59						
Antimora rostrata	Blue Hake	2.79	14.1	2.66	24.48	24.48
Macrourus berglax	Roughhead Grenadier	2.71	13.34	3.58	23.16	47.63
Synaphobranchus kaupii	Longnose Eel	1.63	6.5	1.83	11.29	58.93
Reinhardtius hippoglossoides	Turbot	1.5	5.51	1.33	9.56	68.49
Centroscyllium fabricii	Black Dogfish	1.42	3.94	0.91	6.84	75.33
Coryphaenoides rupestris	Roundnose Grenadier	1.07	3.82	1.52	6.64	81.97
Apristurus profundorum	Deepsea Cat Shark	0.75	1.69	0.54	2.93	84.9
Nezumia bairdii	Common Grenadier	0.55	1.59	0.93	2.76	87.67
Gaidropsarus spp.	Threebeard Rockling	0.55	1.52	0.81	2.64	90.31
High Sponge Catch Weight Class Average similarity: 49.73						
Macrourus berglax	Roughhead Grenadier	2.79	17.77	2.28	35.74	35.74
Reinhardtius hippoglossoides	Turbot	1.76	9.04	1.48	18.18	53.91
Antimora rostrata	Blue Hake	2.13	8.66	1.23	17.41	71.32
Centroscyllium fabricii	Black Dogfish	1.22	2.9	0.55	5.83	77.15
Synaphobranchus kaupii	Longnose Eel	0.96	2.88	0.83	5.79	82.93
Coryphaenoides rupestris	Roundnose Grenadier	0.74	2.87	0.87	5.77	88.7
Apristurus profundorum	Deepsea Cat Shark	0.93	1.81	0.48	3.64	92.34

Table 5. *Taxa contributing to > 90% of the dissimilarity in biomass of research vessel catch composition (2001-2007) between the Low and High Sponge Catch Weight Classes.*

			Average Log10 (Biomass)			
Taxon	**Common Name**	**Direction of Change From Low to High Sponge Catch Weight Class**	**Low Sponge Class**	**High Sponge Class**	**Percent Contribution to Dissimilarity**	**Cumulative Percent Contribution to Dissimilarity**
Centroscyllium fabricii	Black Dogfish	▼	1.53	1.22	9.23	9.23
Antimora rostrata	Blue Hake	▼	2.58	2.13	7.83	17.05
Synaphobranchus kaupii	Longnose Eel	▼	1.50	0.96	6.67	23.73
Reinhardtius hippoglossoides	Turbot	▼	2.10	1.76	6.04	29.77
Macrourus berglax	Roughhead Grenadier	▼	3.00	2.79	5.87	35.64
Coryphaenoides rupestris	Roundnose Grenadier	▼	1.24	0.74	5.74	41.38
Apristurus profundorum	Deepsea Cat Shark	▲	0.29	0.93	5.08	46.46
Nezumia bairdii	Common Grenadier	▼	0.95	0.37	4.54	51.00
Sebastes mentella	Deepwater Redfish	▼▼	0.76	0.00	4.17	55.17
Hippoglossoides platessoides	American Plaice	▼▼	0.79	0.00	4.12	59.29
Anarhichas denticulatus	Broadhead Wolfish	▼	0.64	0.15	3.94	63.23
Bathyraja spinicauda	Spinytail Skate	▲	0.34	0.42	3.73	66.96
Notacanthidae	Spiny Eels	▼	0.59	0.31	3.65	70.61
Gaidropsarus spp.	Threebeard Rockling	▼	0.55	0.16	3.20	73.80
Myctophidae	Lanternfishes	▼	0.47	0.11	2.53	76.34
Glyptocephalus cynoglossus	Witch Flounder	▼▼	0.44	0.00	2.34	78.68
Dipturus linteus	White Skate	▲	0.03	0.41	2.25	80.93
Amblyraja radiata	Thorny Skate	▼▼	0.40	0.00	2.16	83.10
Serrivomer beanii	Shortnose Snipe eel	▲	0.18	0.32	1.96	85.05
Lycodes spp.	Eelpout	▲	0.09	0.33	1.94	86.99
Hydrolagus affinis	Deepwater Chimaera	▲	0.01	0.33	1.61	88.60
Amblyraja jenseni	Jensen's Skate	▼	0.19	0.10	1.61	90.21

Table 6. *Taxa Contributing to > 90% of the similarity in abundance of research vessel catch composition (2001-2007) within each of Low, Medium and High Sponge Catch Weight Classes.*

Species	Common Name	Average Lg10(A)	Av. Sim	Sim/StDev	Contrib%	Cum.%
Low Sponge Catch Weight Class Average similarity: 62.58						
Myctophidae	Lanternfishes	4.46	9.45	3.24	15.10	15.10
Antimora rostrata	Blue Hake	4.13	9.27	5.26	14.81	29.91
Macrourus berglax	Roughhead Grenadier	3.66	7.75	3.49	12.38	42.29
Synaphobranchus kaupii	Longnose Eel	3.21	6.01	2.03	9.60	51.89
Coryphaenoides rupestris	Roundnose Grenadier	2.90	4.73	1.33	7.55	59.45
Nezumia bairdii	Common Grenadier	2.58	4.47	1.53	7.14	66.59
Reinhardtius hippoglossoides	Turbot	2.20	4.09	2.41	6.54	73.13
Stomias boa ferox	Boa Dragonfish	2.02	3.36	1.25	5.37	78.50
Chauliodus sloani	Viperfish	1.28	1.67	0.85	2.66	81.16
Gaidropsarus spp.	Threebeard Rockling	1.11	1.61	1.06	2.57	83.73
Paralepididae	Barracudinas	1.24	1.58	0.87	2.52	86.25
Bathylagus euryops	Goitre Blacksmelts	1.44	1.55	0.61	2.48	88.73
Centroscyllium fabricii	Black Dogfish	1.41	1.55	0.66	2.48	91.21
Medium Sponge Catch Weight Class Average similarity: 63.13						
Antimora rostrata	Blue Hake	4.09	10.51	5.47	16.64	16.64
Macrourus berglax	Roughhead Grenadier	3.50	8.86	5.35	14.04	30.69
Synaphobranchus kaupii	Longnose Eel	3.29	7.47	2.61	11.84	42.52
Myctophidae	Lanternfishes	3.44	6.74	1.60	10.68	53.21
Coryphaenoides rupestris	Roundnose Grenadier	2.72	5.49	2.09	8.69	61.90
Chauliodus sloani	Viperfish	1.77	3.46	1.48	5.49	67.39
Nezumia bairdii	Common Grenadier	1.72	2.76	1.10	4.37	71.75
Reinhardtius hippoglossoides	Turbot	1.52	2.73	1.37	4.33	76.08
Stomias boa ferox	Boa Dragonfish	1.68	2.51	0.91	3.97	80.05
Gaidropsarus spp.	Threebeard Rockling	1.22	1.87	1.01	2.97	83.02
Centroscyllium fabricii	Black Dogfish	1.31	1.74	0.82	2.75	85.76
Lycodes spp.	Eelpout	0.79	1.14	0.77	1.80	87.56
Serrivomer beanii	Shortnose Snipe Eel	0.89	1.10	0.63	1.74	89.31
Polymixiidae	Beardfishes	0.81	1.02	0.68	1.61	90.92

Table 6. *Continued.*

Species	Common Name	Average Lg10(A)	Av. Sim	Sim/StDev	Contrib%	Cum.%
High Sponge Catch Weight Class Average similarity: 51.13						
Macrourus berglax	Roughhead Grenadier	3.48	14.55	2.12	28.46	28.46
Antimora rostrata	Blue Hake	3.06	8.34	1.35	16.30	44.76
Coryphaenoides rupestris	Roundnose Grenadier	2.01	5.56	1.08	10.88	55.64
Synaphobranchus kaupii	Longnose Eel	2.23	5.07	1.02	9.92	65.56
Reinhardtius hippoglossoides	Turbot	1.61	4.96	1.49	9.70	75.26
Centroscyllium fabricii	Black Dogfish	1.24	2.01	0.59	3.93	79.19
Nezumia bairdii	Common Grenadier	1.11	1.89	0.66	3.69	82.88
Serrivomer beanii	Shortnose Snipe Eel	1.04	1.60	0.69	3.14	86.02
Bathylagus euryops	Goitre Blacksmelts	0.74	0.98	0.59	1.92	87.94
Myctophidae	Lanternfishes	0.93	0.86	0.43	1.67	89.61
Apristurus profundorum	Deepsea Cat Shark	0.69	0.85	0.47	1.66	91.27

Table 7. *Taxa contributing to > 90% of the dissimilarity in abundance of research vessel catch composition (2001-2007) between the Low and High Sponge Catch Weight Classes.*

Taxon	**Common Name**	**Direction of Change From Low to High Sponge Catch Weight Class**	**Average Log10 (Abundance)**		**Percent Contribution to Dissimilarity**	**Cumulative Percent Contribution to Dissimilarity**
			Low Sponge Class	**High Sponge Class**		
Myctophidae	Lanternfishes	▼	4.46	0.93	11.61	11.61
Nezumia bairdii	Common Grenadier	▼	2.58	1.11	5.95	17.55
Coryphaenoides rupestris	Roundnose Grenadier	▼	2.90	2.01	5.81	23.36
Synaphobranchus kaupii	Longnose Eel	▼	3.21	2.23	5.80	29.16
Stomias boa ferox	Boa Dragonfish	▼	2.02	0.55	5.28	34.44
Antimora rostrata	Blue Hake	▼	4.13	3.06	5.22	39.66
Centroscyllium fabricii	Black Dogfish	▼	1.41	1.24	4.68	44.34
Bathylagus euryops	Goitre Blacksmelts	▼	1.44	0.74	4.35	48.69
Sebastes mentella	Deepwater Redfish	▼▼	1.17	0.00	3.66	52.35
Paralepididae	Barracudinas	▼	1.24	0.28	3.55	55.90
Reinhardtius hippoglossoides	Turbot	▼	2.20	1.61	3.48	59.38
Chauliodus sloani	Viperfish	▼	1.28	0.60	3.45	62.84
Serrivomer beanii	Shortnose Snipe Eel	▲	0.79	1.04	3.20	66.04
Macrourus berglax	Roughhead Grenadier	▼	3.66	3.48	3.08	69.12
Gaidropsarus spp.	Threebeard Rockling	▼	1.11	0.45	2.99	72.11
Hippoglossoides platessoides	American Plaice	▼▼	0.89	0.00	2.70	74.81
Notacanthus chemnitzii	Largescale Tapirfish	▼	0.78	0.28	2.32	77.13
Apristurus profundorum	Deepsea Cat Shark	▲	0.19	0.69	2.04	79.17
Lycodes spp.	Eelpout	▲	0.25	0.54	1.85	81.02
Glyptocephalus cynoglossus	Witch Flounder	▼▼	0.59	0.00	1.82	82.84
Malacosteus niger	Loosejaw	▼	0.44	0.37	1.75	84.59
Chiasmodon niger	Black Swallower	▼	0.41	0.31	1.57	86.16
Nemichthys scolopaceus	Atlantic Snipe Eel	▼	0.46	0.15	1.57	87.73
Phycis chesteri	Longfin Hake	▼	0.51	0.03	1.55	89.27
Lycodes vahlii	Vahl's Eelpout	▼▼	0.47	0.00	1.41	90.69

Table 8. *A summary of known habitat and diet characteristics of those fish taxa showing a positive association with sponge grounds in Biomass (B) and/or Abundance (A) and those never captured with High Sponge Catches in the study (Tables 5 and 7).*

Common Name (Taxon)	**Metric Response**	**Zone**	**Ecology**	**Diet**	**Depth Information**
Fish Taxa Showing a Positive Association with Sponge Grounds in Biomass (B) and/or Abundance (A)					
Shortnose Snipe Eel (*Serrivomer beanii*)	Increase B; Increase A	Epibenthic-mesopelagic	Exhibits vertical migrations to feed during the night	Shrimps, other crustaceans, small fish	To 5998 m Canadian Atlantic: 850-925 m mostly in depths of 550–1000 m; This study (N=57 sets): Range 768-1446 m Median 1211 m
Deepsea Cat Shark (*Apristurus profundorum*)	Increase B; Increase A	Bathydemersal; Inhabits the continental slope			1100 - 1750 m; This study (N=37 sets): Range 871-1446 m Median 1303 m
Eelpout (*Lycodes* spp.)	Increase B; Increase A	Demersal	Muddy bottoms. It seems to get the bulk of its food by burrowing in the sediment	Small bivalves, polychaetes, small crustaceans. *Lycodes terraenovae* eats sponge	19 - 1750 m; This study (N=40 sets): Range 589-1410 m Median 1164 m
Spinytail Skate (*Bathyraja spinicauda*)	Increase B	Benthic; bathydemersal		Invertebrates, fish	140 - 1463m usually 65-255 m; This study (N=17 sets): Range 601-1384 m Median 1202 m
White Skate (*Dipturus linteus*)	Increase B	Benthic; bathydemersal		Worms, crustaceans, fishes	150 - 1170m usually 250 m; This study (N=14 sets): Range 1153-1446 m Median 1357 m
Deepwater Chimaera (*Hydrolagus affinis*)	Increase B	Epibenthic; bathydemersal	Found on continental slopes	Fish, invertebrates	Deep waters to 2400 m; 300 - 2400 m; This study (N=9 sets): Range 1058-1370 m Median 1243 m

Table 8. *Continued.*

Common Name (Taxon)	**Metric Response**	**Zone**	**Ecology**	**Diet**	**Depth Information**
Fish Taxa Never Captured with High Sponge Catches in the Study					
Deepwater Redfish (*Sebastes mentella*)	Decrease B; Decrease A	Epibenthic-pelagic; bathypelagic		Crustaceans, fish	300 -1441 m; 500–700 m in NAFODiv.2J,3K; This study (N=27 sets): Range 578-1243 m Median 812 m
American Plaice (*Hippoglossoides platessoides*)	Decrease B; Decrease A	Benthic; demersal	Soft bottoms	Worms, molluscs, echinoderms, crustaceans, fish	10 - 3000 m usually 9-250 m; This study (N=18 sets): Range 589-1161 m Median 739 m
Witch Flounder (*Glyptocephalus cynoglossus*)	Decrease B; Decrease A	Benthic; demersal	Soft mud bottoms in fairly deep water	Worms, crustaceans, molluscs, brittle stars, fish	8 - 1570 m usually 45 - 366 m; This study (N=14 sets): Range 578-1384 m Median 622 m
Vahl's Eelpout (*Lycodes vahlii*)	Decrease A	Benthic; bathydemersal		Worms, crustaceans, molluscs	65 - 1200 m; This study (N=12 sets): Range 578-985 m Median 630 m
Thorny Skate (*Amblyraja radiata*)	Decrease B	Benthic; demersal	Sandy and muddy bottoms	Worms, crustaceans, fish	20 -1000 m; This study (N=12 sets): Range 578-1190 m Median 655 m

FIGURES

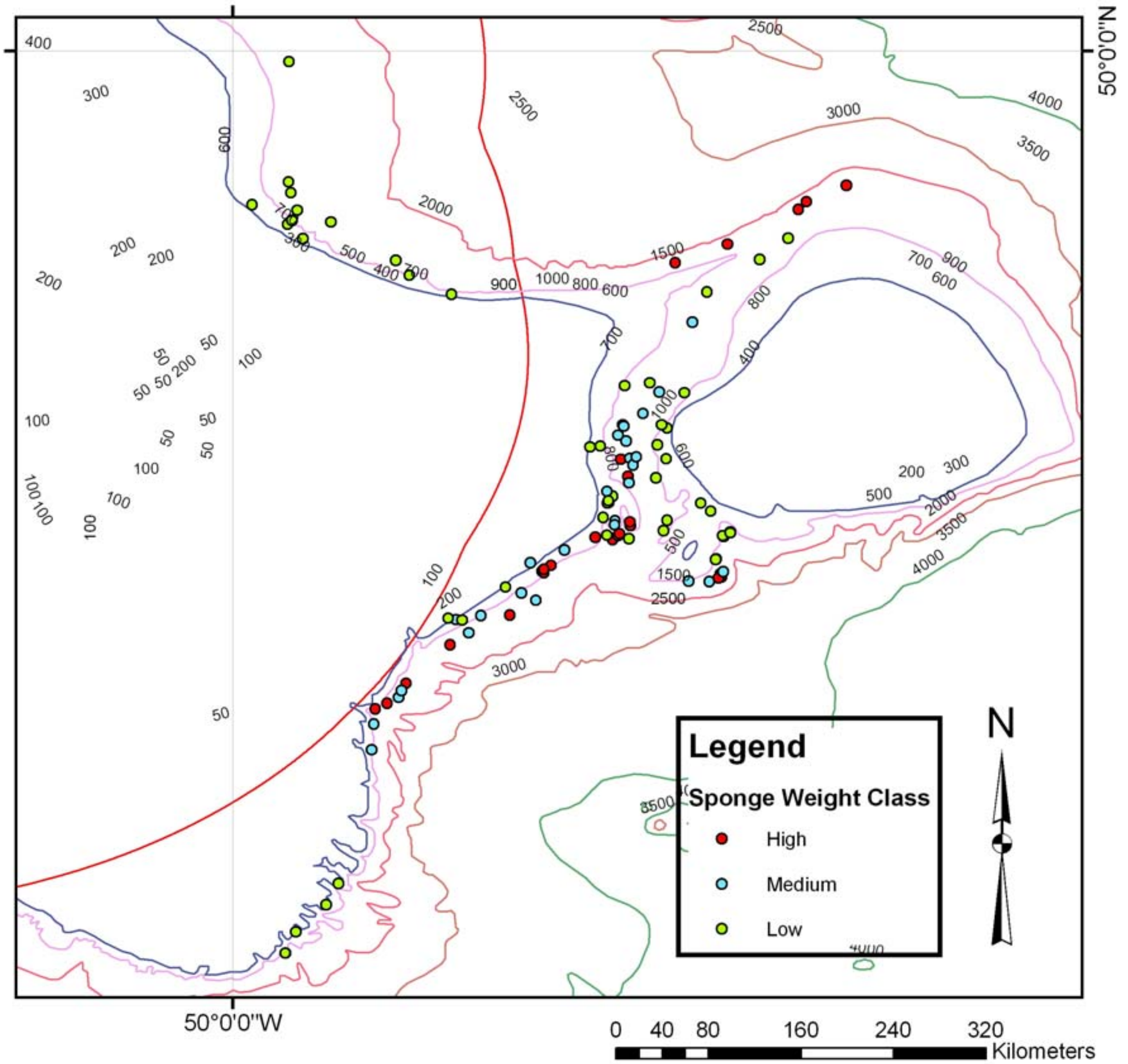


Figure 1. *Location of the research vessel trawls used in our analyses with the corresponding Sponge Catch Weight Class identified.*

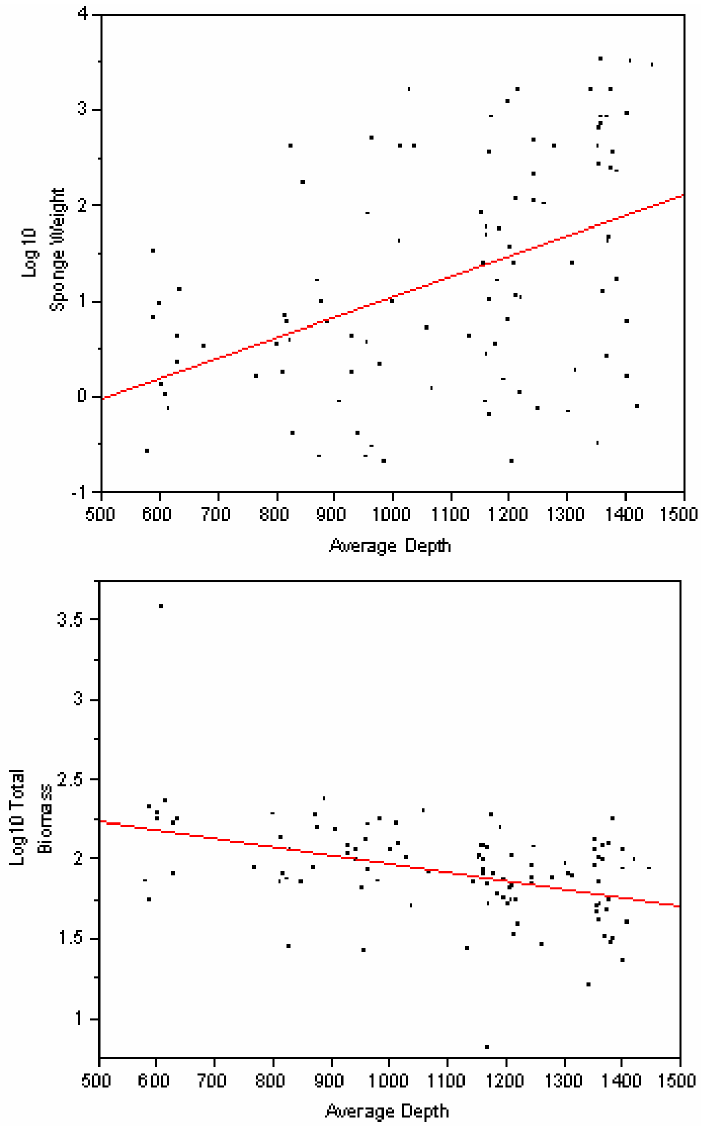
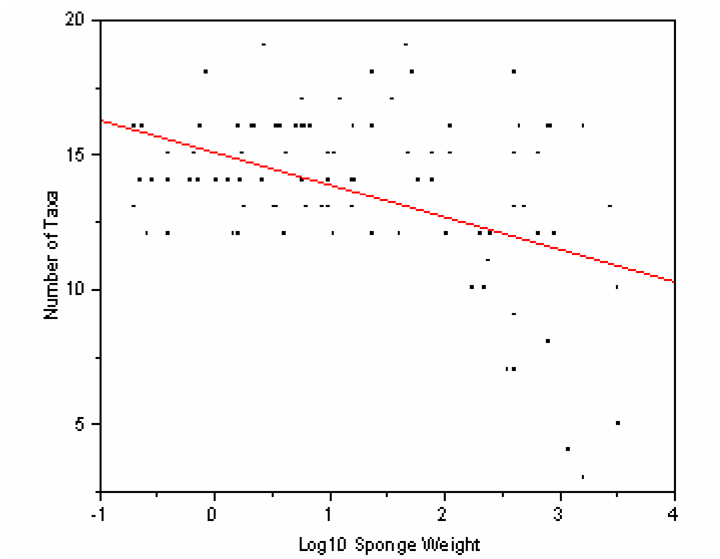


Figure 2. *Bivariate plots of log10 transformed Total Biomass and Total Sponge Bomass per trawl set by average depth (m). Linear regression lines are statistically significant.*



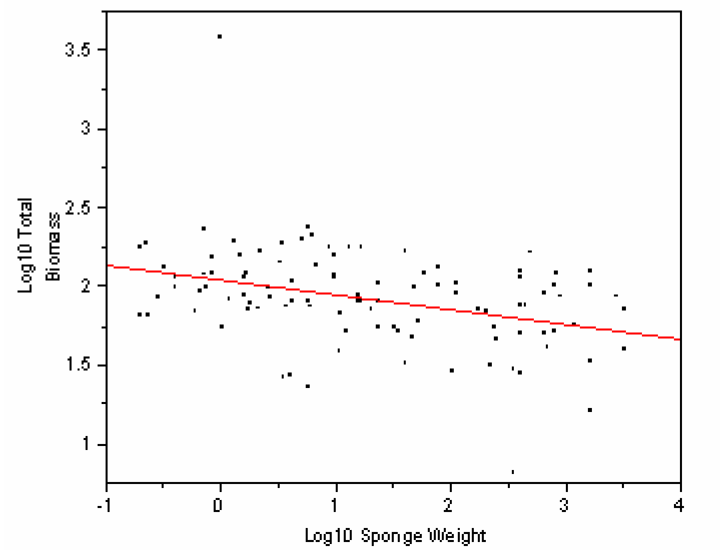


Figure 3. *Bivariate plots of the Total Number of Taxa and the log10 transformed Total Biomass (kg) by log10 transformed Total Sponge Biomass (kg). Linear regression lines are statistically significant.*

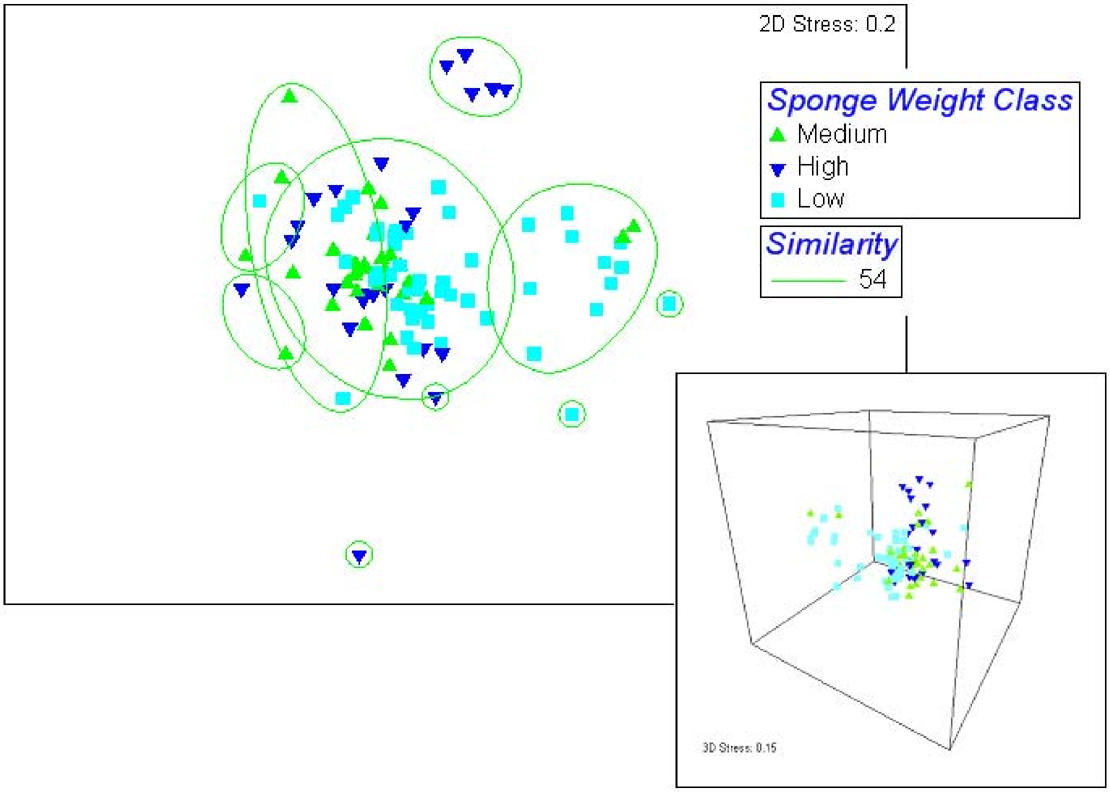


Figure 4. *MDS configuration of the trawl catches (2001-2007) in 2D and 3D based on Bray-Curtis similarity matrix calculated from log10-transformed biomass data for each of 34 taxa. Trawl catches are labelled according to Sponge Catch Weight Class. In the 2D representation, stations with 54% similarity to each other are indicated. This is the average similarity level within each of the three classes (see text).*

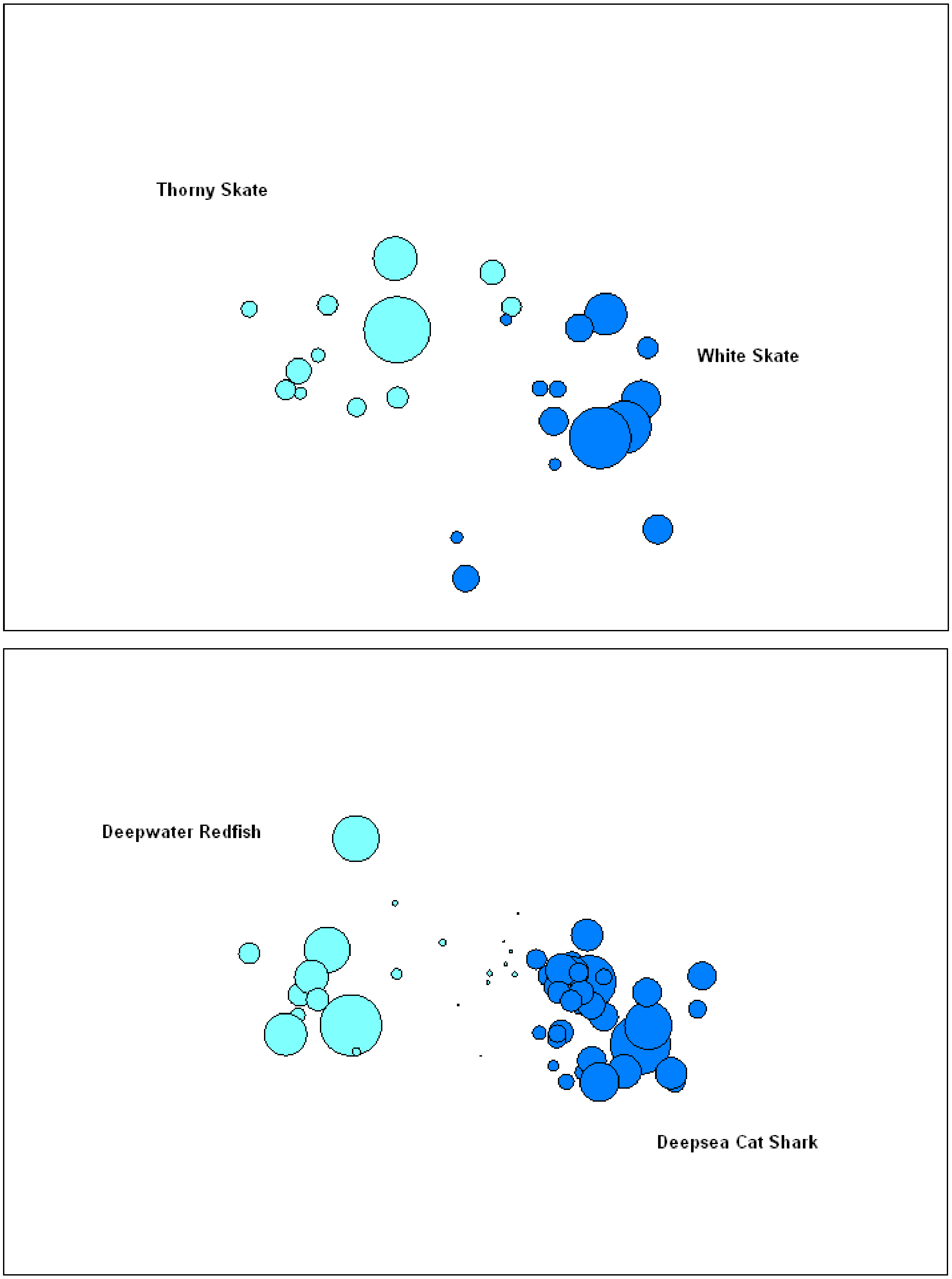


Figure 5. *MDS configuration of the trawl catches (2001-2007) based on Bray-Curtis similarity matrix calculated from log10-transformed biomass data for each of 34 taxa. The proportional biomass of pairs of taxa which favour the sponge grounds (High Sponge Catch Weight Class – dark blue) or areas with Low Sponge (light blue) are illustrated. Note that proportions are relative to each taxon and the values have not been added to allow comparisons as the purpose was largely to illustrate the non-overlap of the selected taxa.*

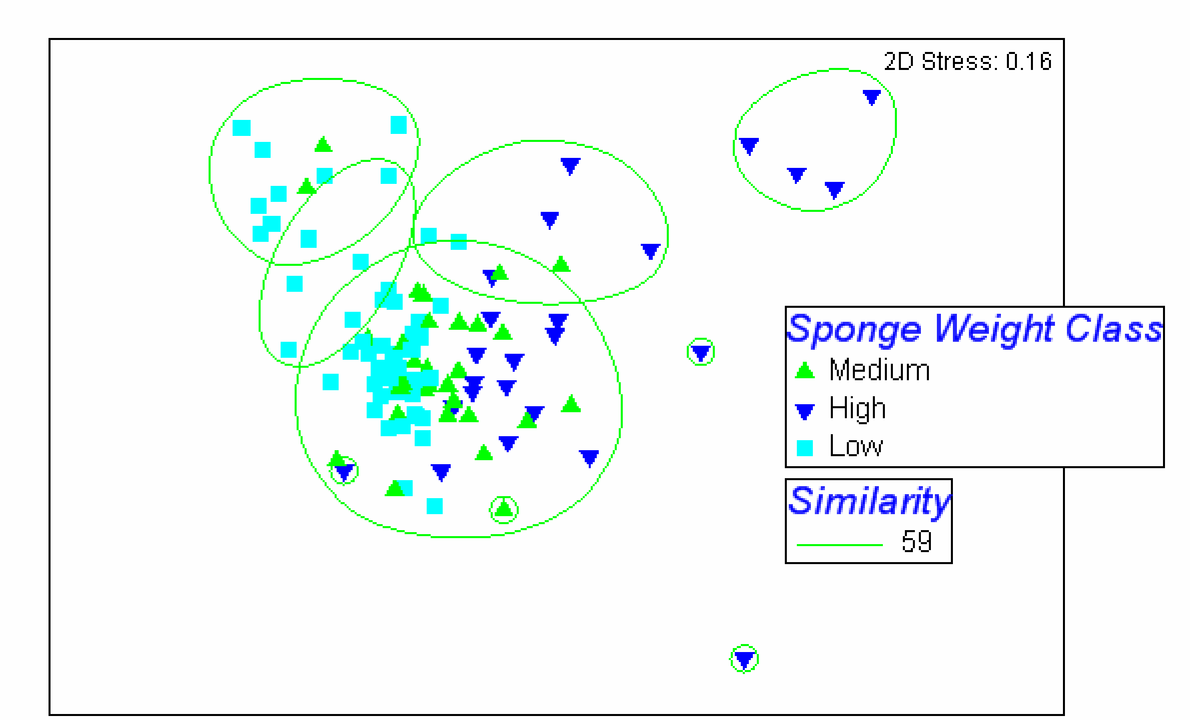


Figure 6. *MDS configuration of the trawl catches (2001-2007) in 2D based on Bray-Curtis similarity matrix calculated from log10-transformed abundance data for each of 34 taxa. Trawl catches are labelled according to Sponge Catch Weight Class. Stations with 59% similarity to each other are indicated. This is the average similarity level within each of the three classes (see text).*