Cruise Report for the CCGS *Alfred Needler* Maritimes Region Research Vessel Summer Multispecies Survey, June 28 to August 14, 2017: Benthic Invertebrates

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CRUISE REPORT FOR THE CCGS *ALFRED NEEDLER* MARITIMES REGION RESEARCH VESSEL SUMMER MULTISPECIES SURVEY, JUNE 28 to AUGUST 14, 2017: BENTHIC INVERTEBRATES

by

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ABSTRACT

Murillo, F.J., Kenchington, E., Clark, D., Emberley, J., Regnier-McKellar, C., Guijarro, J., Beazley, L., Wong, M.C. 2018. Cruise Report for the CCGS *Alfred Needler* Maritimes Region Research Vessel Summer Multispecies Survey, June 28 to August 14, 2017: Benthic Invertebrates. Can. Tech. Rep. Fish. Aquat. Sci. 3262: v + 41 p.

Distribution and composition of benthic invertebrates collected on the 2017 DFO Summer Research Vessel Multispecies Survey (NED2017020) on the Scotian Shelf and Slope and Bay of Fundy (NAFO Divisions 4VWX5Z) between 49 and 1348 m depth are described. Pending a more detailed taxonomic study, the total number of benthic invertebrate taxa identified from the 244 valid stations was 177, representing 12 different phyla. Benthic biomass ranged from 0.02 to 477.24 kg per station, and was dominated by the Arthropoda and Echinodermata. The data collected were also used to evaluate previously published species distribution models and Significant Benthic Areas (SBAs). In general there was good congruence between the survey catch data, and both the predictive surfaces and SBAs for corals, sponges, and other benthic taxa forming ecologically or biologically significant areas.

RÉSUMÉ

Murillo, F.J., Kenchington, E., Clark, D., Emberley, J., Regnier-McKellar, C., Guijarro, J., Beazley, L., Wong, M.C. 2018. Rapport d'expédition du NGCC *Alfred Needler* pour le relevé d'été plurispécifique effectué par le navire de recherche dans la Région des Maritimes du 28 juin au 14 août 2017 : Les invertébrés benthiques. Rapp. tech. can. sci. halieut. aquat. 3262: v + 41 p.

Description des données concernant la répartition et la composition des invertébrés benthiques recueillis lors du relevé d'été plurispécifique effectué par le navire de recherche dans la Région des Maritimes du MPO en 2017 (NED2017020), sur le plateau néo-écossais et le talus de la baie de Fundy (divisions 4VWX5Z de l'OPANO), à une profondeur allant de 49 à 1 348 m. D'ici à l'obtention d'une étude taxonomique plus détaillée, le nombre total de taxons d'invertébrés benthiques identifiés à partir des 244 stations valides est établi à 177, dont 12 phylums différents. La biomasse benthique variait de 0,02 à 477,24 kg par station, et elle était dominée par les arthropodes et les échinodermes. Les données recueillies ont également été utilisées pour évaluer les modèles de répartition des espèces et les zones benthiques importantes publiés à une date antérieure. En général, la concordance était bonne entre les données sur les prises du relevé, les surfaces prédictives et les zones benthiques importantes pour les coraux, les éponges et les autres taxons d'invertébrés benthiques des zones d'importance écologique et biologique.

INTRODUCTION

Organisms that live on and under the seafloor (benthos) play important roles in marine ecosystems. They represent a key link between benthic and pelagic ecosystems (i.e., Perea-Blázquez et al. 2012; Kutti et al. 2013) and are an important food source for fish and marine mammals (i.e., Oliver et al. 1983; Kenchington et al. 2005). Through their physical structure, some benthic organisms enhance habitat complexity increasing biodiversity and ecosystem function (i.e., Danovaro et al. 2008; Buhl-Mortensen et al. 2010), provide nursery areas (i.e., Aldrich and Lu; Etnoyer and Warrenchuk 2007) and modify biochemical regimes (i.e., Kaufmann and Smith 1997; Soltwedel and Vopel 2001). Furthermore, benthic invertebrates are good indicators of the effects of fishing, oil spills, and climate change (i.e., Kaiser et al. 2000; Gómez Gesteira and Dauvin 2000; Kortsch et al. 2012). Despite their importance to healthy marine ecosystems, the benthic invertebrate communities of the Scotian Shelf Bioregion have never been comprehensively identified and mapped over large spatial scales. Most of the detailed information on benthic invertebrate communities off Nova Scotia is based on spatially limited *in situ* camera observations (e.g., Kenchington et al. 2014; Buhl-Mortensen et al. 2017; Lacharité and Metaxas 2018) and benthic habitat mapping studies (i.e., Kostylev et al. 2001; Todd and Kostylev 2011).

The Department of Fisheries and Oceans (DFO), Maritimes Region, is leading a process to create a marine protected area (MPA) network for the Scotian Shelf Bioregion. One of the overarching objectives of this MPA network is to protect representative examples of the different ecosystem and habitat types that occur in the bioregion (DFO 2018). For offshore benthos, classification of seabed features based on geomorphology, and community characterization using a benthic habitat template based on Scope for Growth and Natural Disturbance (Kostylev and Hannah 2007) have been used as proxies for benthic habitats (DFO 2012), as there is no comprehensive map of benthic communities in this region. Neither are valid substitutes for benthic habitat maps based on benthic species distributions, as have been produced on Flemish Cap area (Murillo et al. 2016) in support of Northwest Atlantic Fisheries Organization (NAFO) management decisions. Such maps are needed in the Scotian Shelf Bioregion in order to address the protection of representative habitats.

In the Scotian Shelf Bioregion, DFO has identified ecologically or biologically significant areas (EBSAs) formed by marine benthic species, a subgroup of the broader list of representative benthic habitats. Information on EBSAs was compiled from the literature (Kenchington 2014), and predictive distribution models of some of these EBSA-forming taxa (i.e. soft corals, stalked tunicates) have been mapped (Beazley et al. 2017), complementing previous works on the identification of significant benthic areas for corals and sponges (Beazley et al. 2016; Kenchington et al. 2016a,b).

DFO's Science Guidance on the Development of Networks of Marine Protected Areas (DFO 2010) states that, "…*representative MPAs should capture examples of different biogeographic subdivisions that reasonably reflect the full range of ecosystems which are present at the scale of network development, including the biotic and habitat diversity of those ecosystems*". To fully address this guidance, a complete evaluation of benthic species is required. Although identification of coral and sponge-dominated ecosystems has been accomplished, there remains a need to validate these results in some areas, and to undertake a systematic survey of the benthos on the Scotian Shelf. This information will be integral to evaluate the MPA network design against representative targets (i.e., DFO 2018).

DFO has conducted annual summer research vessel surveys using a bottom otter trawl gear in the Maritimes Region since 1970 (Emberley and Clark 2012). These surveys provide information on trends in abundance for most groundfish and other fish and invertebrate species on the Scotian Shelf and in the Bay of Fundy, and since 1999 cover depths down to 750 m. Furthermore, additional survey tows were completed in deeper water off the slope (750 – 1,800 m) in some years to investigate species composition and biomass in deeper waters (Clark and Emberley 2011; Emberley and Clark 2012). The systematic recording of benthic invertebrates began in 2006 and identifications at sea have been improving each year. For example, 100 and 120 invertebrate taxa were recorded in 2010 and 2011, respectively (Clark and Emberley 2011; Emberley and Clark 2012). However, there are several important faunal groups, such as sponges, soft corals, and sea anemones that require expert and laboratory identification. Thus far these fauna are only identified to broad taxonomic groups at sea. This relatively coarse identification diminishes the taxonomic resolution of benthic biodiversity and community composition. Therefore, improvements to the identification of benthic species on these research vessel ecosystem surveys are required in order to accurately map and validate the benthic EBSAs previously described and the broader benthic communities for assessment of ecosystem representivity relevant for conservation planning on the Scotian Shelf.

The aim of this report is to provide a summary of the benthic invertebrates collected on the 2017 Maritimes Research Vessel Summer Survey and their at-sea identifications. This information represents a baseline to identify consistent groupings or communities, which will be mapped to assist Ocean Managers in the identification of representative benthic habitats and the application of marine spatial planning (e.g., adjustment of MPA boundaries) towards comprehensive habitat protection objectives. This is an important aspect of maintaining healthy and productive ecosystems that are a key component of ecosystem-based management and sustainable fisheries. Additionally, new information on corals, sponges, and other EBSA-forming taxa from these surveys will be used to validate the predictive models and significant benthic areas (SBAs) previously generated for these taxa in the Scotian Shelf Bioregion (Beazley et al. 2016, 2017; Kenchington et al. 2016a,b).

MATERIAL AND METHODS

Data presented in this report came from the 2017 Maritimes Research Vessel (RV) Summer Ecosystem Survey (NED2017020), carried out by DFO on the Scotian Shelf, Scotian Slope, and Bay of Fundy (NAFO Divisions 4VWX and Canadian portions of 5YZ) between 49 and 1348 m depth (Figure 1). The RV Summer Survey was conducted on the CCGS *Alfred Needler* between June 28 and August 14. Fishing stations were allocated using a stratified random sampling design (Halliday and Kohler 1971) and conducted with standardized 30-minute bottom tows at vessel speed of approximately 3.5 knots using a Western II-A bottom trawl gear.

All invertebrate fauna retained by the trawl net, which has a 19 mm mesh lining in the codend (Tremblay et al. 2007), were sorted on board to the lowest possible taxonomic level. Wet weight for each taxon was measured and numbers of individuals recorded (except for colonial organisms that in most cases were only weighed). Attached rocks were removed before weighing. The trawl net was examined after each set when time allowed to collect entangled fauna and to minimize contamination of preceding sets. A photographic catalogue of all species caught was created and voucher specimens for subsequent definitive identification in the laboratory were fixed in 70% ethanol or in 4% buffered formaldehyde depending on the taxon. Additionally, some specimens were preserved in 95% ethanol for subsequent DNA barcoding (Glover et al. 2016).

Detailed measurements were made on the glass sponge *Vazella pourtalesi* (Russian Hat sponge), where length, maximum width and osculum diameter were recorded to the nearest millimetre (rounded down) for all intact specimens using a regular measuring board for length and width and calipers for osculum diameter (Appendix 1). Furthermore, small 1-cm^2 samples of each sponge were preserved in 95% ethanol for subsequent DNA barcoding or frozen at -20°C and brought back to the Bedford Institute of Oceanography when time constraints did not allow the sponge sampling at sea. These samples will be part of a future genetic connectivity study of the *V. pourtalesi* populations on the Scotian Shelf as part of the EU-funded Horizon 2020 project SponGES (http://www.deepseasponges.org/).

Profiles of temperature, salinity, oxygen, fluorescence, and irradiance (PAR extinction) were planned at all stations with SBE-25 CTD on a rosette. Niskin bottles attached to the CTD-Rosette were used to collect water samples from the bottom, intermediate depths, and from near the surface. Additionally, one vertical zooplankton net tow from bottom to surface (200 microns with flow meter if possible) for the Atlantic Zonal Monitoring Program (AZMP) was conducted at a subset of pre-determined stations.

Data summaries of benthic biomass and tentative species richness by faunal group were made for each station. Representation of the phyla at each station was expressed as a percentage of the total biomass at that station. Only benthic invertebrates, mainly epibenthic species, were included in the analysis of biomass and tentative species richness although all invertebrates collected during the survey are listed in Appendix 2. Separation between benthic and bentho-pelagic habitat for crustaceans was based on Wenner (1978), Cartes (1998), Aguzzi and Company (2010), and MacIsaac (2011). Nesis (2001) and FAO (2005, 2010, 2015) were used for cephalopods.

New information on EBSA-forming species, including coral and sponges, were overlaid with previous predictive models and SBAs for corals and sponges mapped on the Scotian Shelf Bioregion (Beazley et al. 2016, 2017; Kenchington et al. 2016a,b).

All metadata collected during the surveys, including position of the fishing stations, were included in the Maritimes fisheries science databases.

RESULTS

A total of 261 fishing stations were completed during the survey, with 244 valid sets (Figure 1). Seventeen tows were designated as unrepresentative (null set) either due to net damage or because tow duration was less than 20 minutes. At 200 stations, profiles of temperature, salinity, oxygen, fluorescence, and irradiance were obtained and zooplankton samples were collected at 34 stations. Bottom temperature recorded from the CTD ranged between 0.98 and 13.72°C.

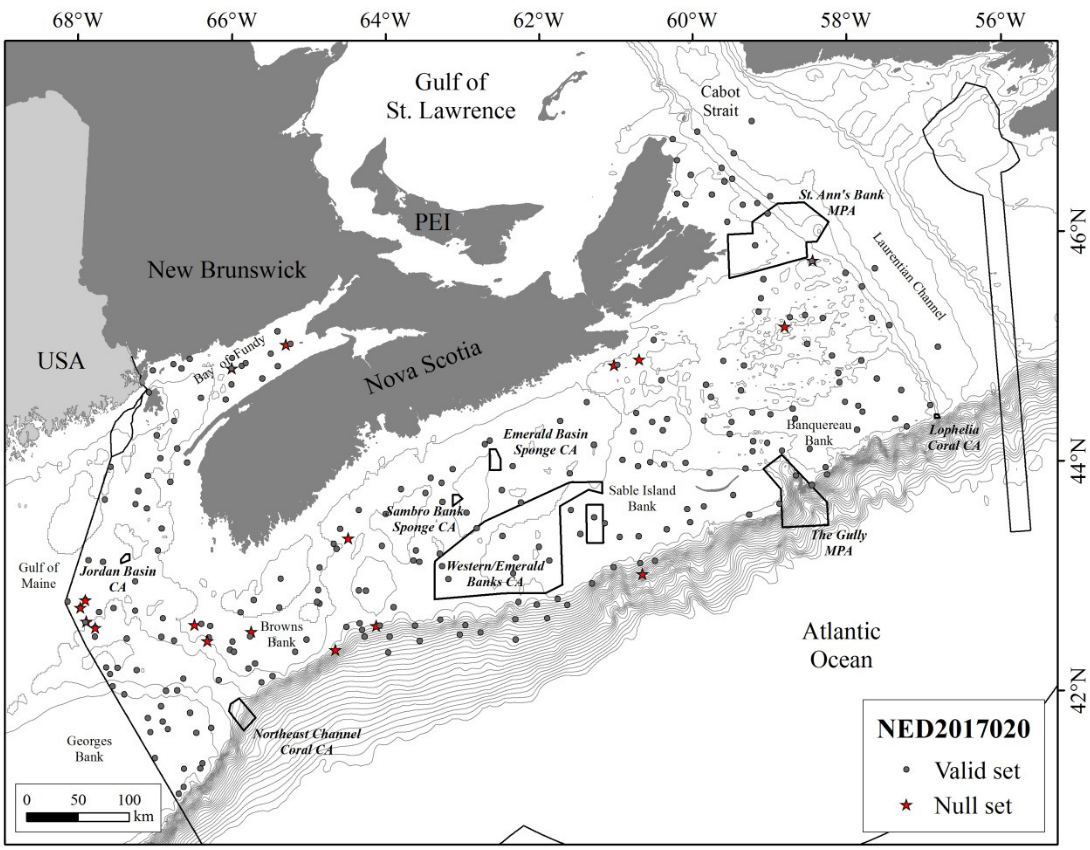

Figure 1. 2017 Summer Research Vessel Survey (NED2017020) station distribution. Areas closed to protect benthic species and habitats are indicated in black outline. MPA, Marine Protected Area; CA, Conservation Area.

DISTRIBUTION, BIOMASS, AND SPECIES RICHNESS

Benthic invertebrate biomass dominated most of the catches relative to demersal fishes in the Bay of Fundy and eastern Scotian Shelf, especially north of St. Ann's Bank MPA, Banquereau Bank, and Sable Island Bank (Figure 2). Biomass ranged between 0.02 and 477.24 kg per station, with a mean (± SD) 20.54 ± 48.52 kg across all stations. Highest values of biomass were found at the entrance of the Bay of Fundy and northwest of Banquereau Bank (Figure 3) owing to the large biomass of lobster (*Homarus americanus*) and sea cucumber (*Cucumaria frondosa*), respectively. Arthropoda and Echinodermata were the main phyla in terms of biomass, with 60% and 25% of the total biomass, respectively. Bryozoa, Porifera, and the remaining phyla encountered constituted the remaining 15% (Figure 4A). Abundance was greatest for the brittle-star *Ophiura sarsii*, with over 12,000 individuals collected. Other abundant taxa were the sea star *Ctenodiscus crispatus* and lobster.

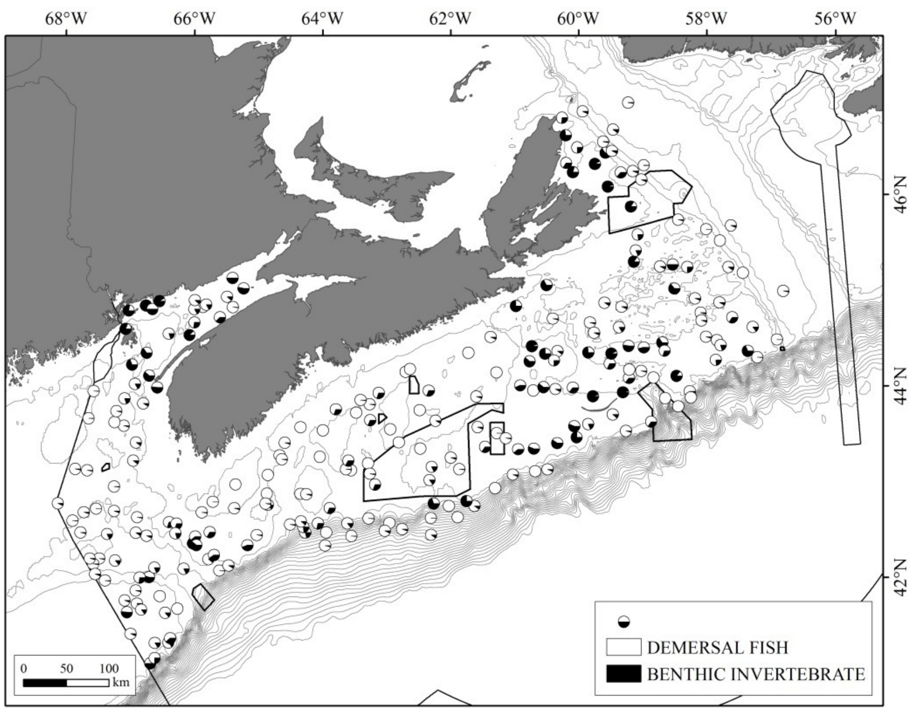

Figure 2. Relative biomass composition of demersal fish and benthic invertebrate catches recorded during the 2017 Summer Research Vessel Surveys (NED2017020).

Pending a more detailed invertebrate taxonomic review, the total number of invertebrate taxa identified from the 244 fishing stations was 219, representing 12 different phyla. Of these 219 taxa, 177 were considered benthic, and the rest were pelagic or bentho-pelagic (Appendix 2). Estimated species richness by phylum showed a different pattern in dominance, when compared to biomass, where the number of species found was quite balanced between the main phyla ranging between 50 and 60 species of cnidarians, echinoderms, arthropods, molluscs, and sponges (Figure 4B, Table 1). However, these proportions may change once the full taxonomic review is completed.

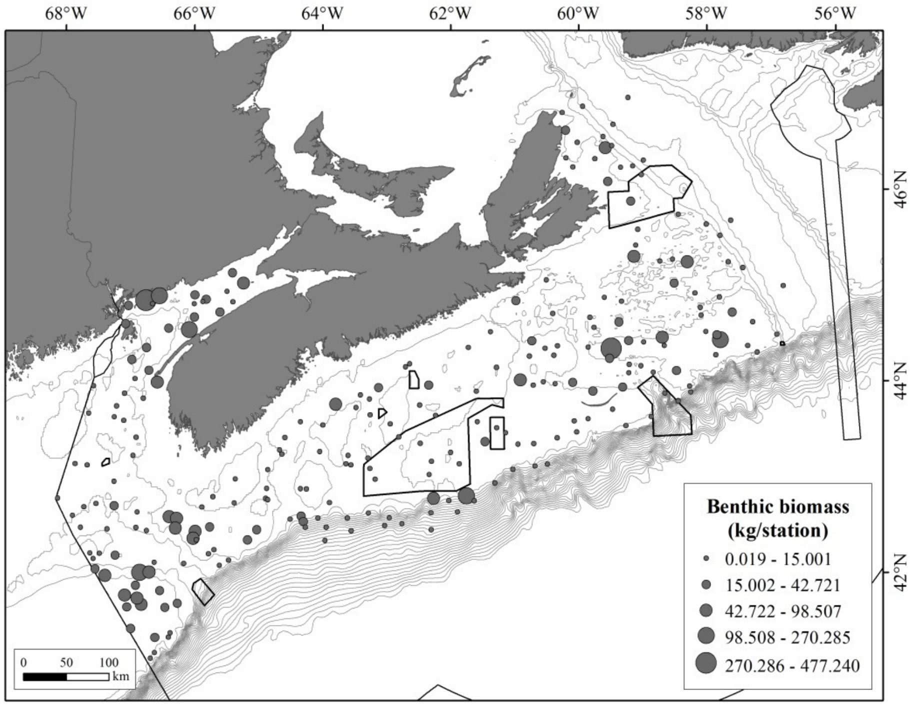

Figure 3. Benthic biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

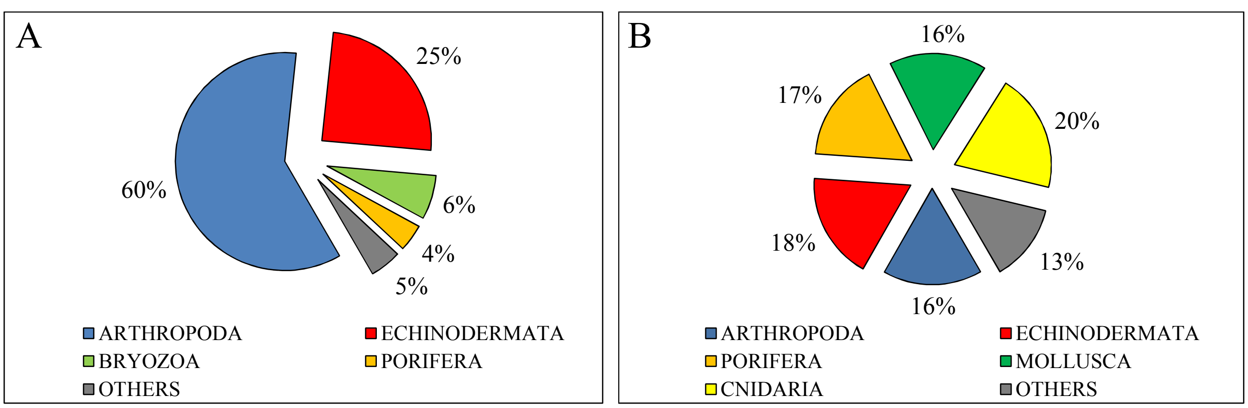

Figure 4. Phylum dominance based on biomass (kg/station) (A) and estimated species richness (B) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

Table 1. Total biomass (kg), percentage (%) of occurrence, and estimated species richness (SR) by phylum collected during the 2017 Summer Research Vessel Survey (NED2017020).

	Biomass (kg)	**% occurrence**	**Estimated SR**
Arthropoda	3011	98%	~50
Echinodermata	1242	95%	~54
Bryozoa	329	30%	>10
Porifera	201	70%	~50
Others	237	-	>40
Mollusca	110	66%	~50
Chordata (Ascidiacea)	81	37%	~8
Cnidaria	44	86%	~60
Annelida	3	39%	~15
Brachiopoda	<1	9%	1
Sipuncula	<1	2%	2
Platyhelminthes	<1	<1%	1
Nemertea	<1	<1%	2

Owing to the large catches of lobster and crabs, Arthropoda was the dominant phylum in most stations on the western Scotian Shelf, whereas Echinodermata dominated the stations of the eastern Scotian Shelf due to the large catches of sea cucumbers (*Cucumaria frondosa*), sand dollar (*Echinarachnius parma*), and other echinoderms (Figure 5). Some sets in the Bay of Fundy were dominated by the bryozoan *Flustra foliacea* (lemon weed), whereas the glass sponge *V. pourtalesi* explained the dominance of Porifera in Emerald Basin (Figure 5). Other phyla, such us Mollusca, Cnidaria, or Chordata were only dominant in a few sets (Figures 5 and 6).

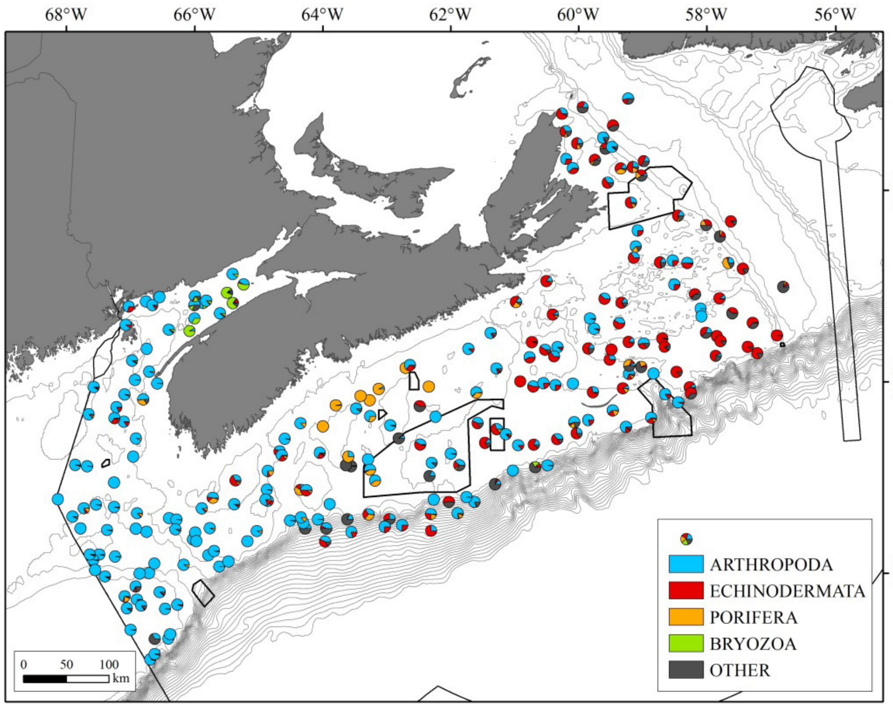

Figure 5. Relative composition of phyla expressed as a percentage of the total benthic biomass recorded during the 2017 Summer Research Vessel Survey (NED2017020).

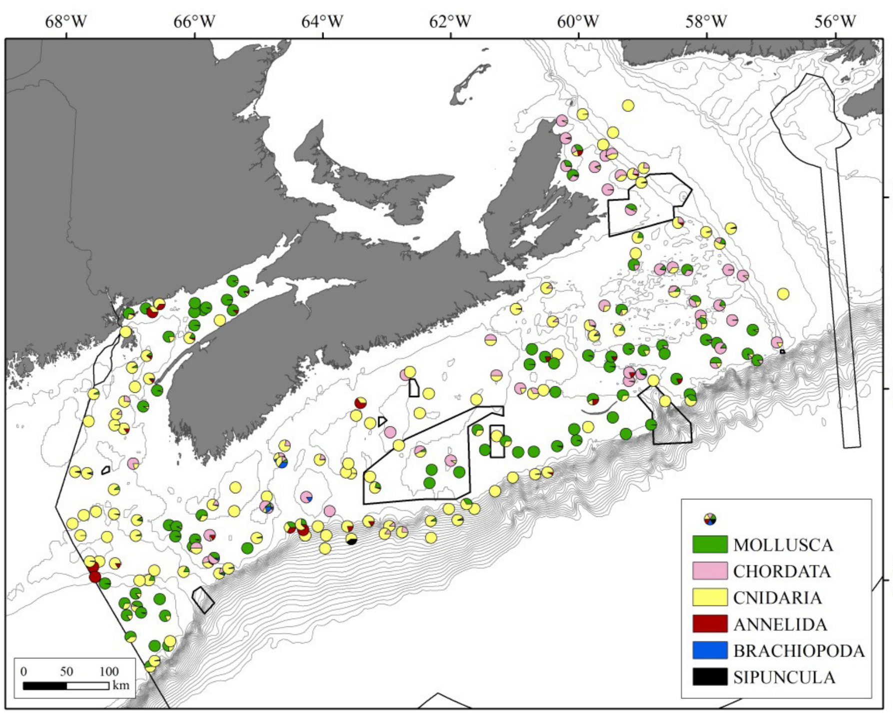

Figure 6. Relative composition of the remaining phyla expressed as a percentage of the biomass of the "OTHER" phyla from Figure 5.

FAUNAL GROUPS

Phylum Porifera

Sponges were collected in 172 stations (70%) and sponge biomass ranged between 0.001 and 73.14 kg per station (Figure 7). Maximum values were found in Emerald Basin due to the presence of the glass sponge *V. pourtalesi.* The majority of sponges were identified at the phylum level, although *V. pourtalesi* and those belonging to the family Polymastiidae were recorded separately (Appendix 2). Other sponges identified at sea were *Mycale lingua* and *Tentorium semisuberites*. Most sponge identification requires microscopic work and samples will be identified in the laboratory. As part of this full taxonomic review, Dr. Claire Goodwin (Huntsman Marine Science Centre, NB) will assist with sponge identification.

A total of 57 1-cm^2 samples of *V. pourtalesi* preserved in 95% ethanol were brought to the Bedford Institute of Oceanography for subsequent DNA barcoding and two large plastic bags containing 10 and 25 frozen specimens for additional sampling. One large individual of 374 mm length was also kept frozen for a growth and aging study as part of the EU-funded Horizon 2020 project SponGES (http://www.deepseasponges.org/).

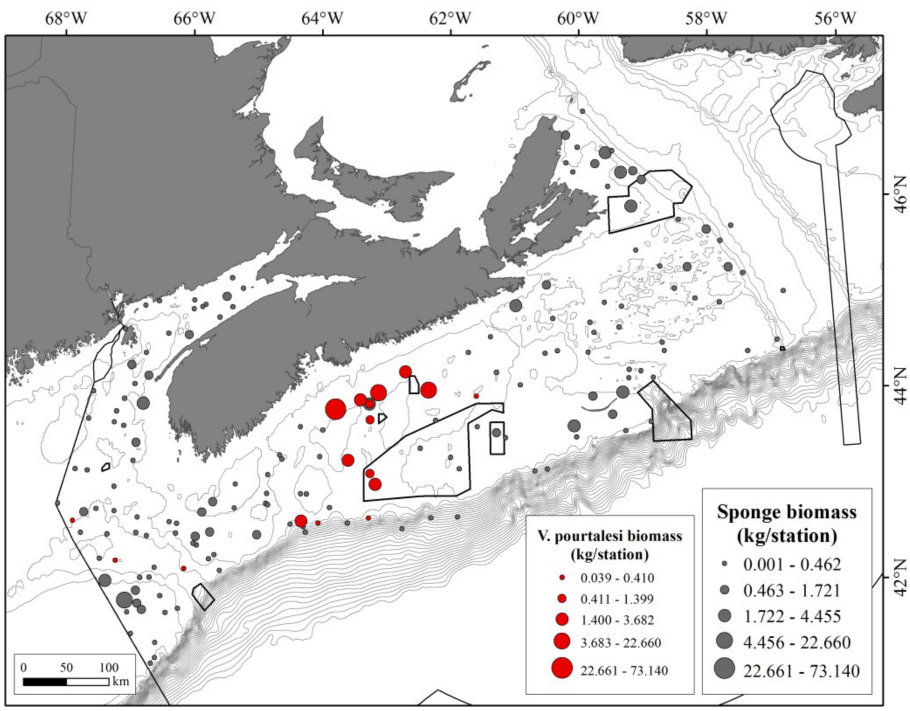

Figure 7. Sponge biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020). *Vazella pourtalesi* biomass is also indicated.

Phylum Cnidaria

Cnidarians were collected in 209 stations (86%) and biomass ranged between 0.0002 and 4.862 kg per station (Figure 8). Due to the presence of large catches of sea anemones, a group that accounted for 64% of the total cnidarian biomass, maximum values were found in 4Vn, north of the St. Ann's Bank MPA and in deeper waters near the mouth of the Laurentian Channel and southeast of Browns Bank.

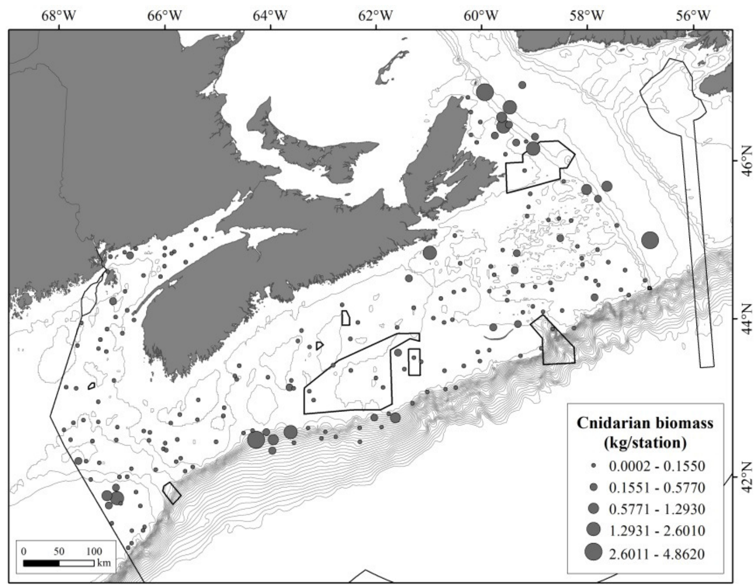

Figure 8. Cnidarian biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

Phylum Mollusca

Molluscs were collected in 160 stations (66%) and their biomass ranged between 0.0002 and 17.429 kg per station (Figure 9). Maximum values were found on Georges Bank due to the presence of large catches of the sea scallop *Placopecten magellanicus*, a species that accounted for 63% of the total molluscan biomass.

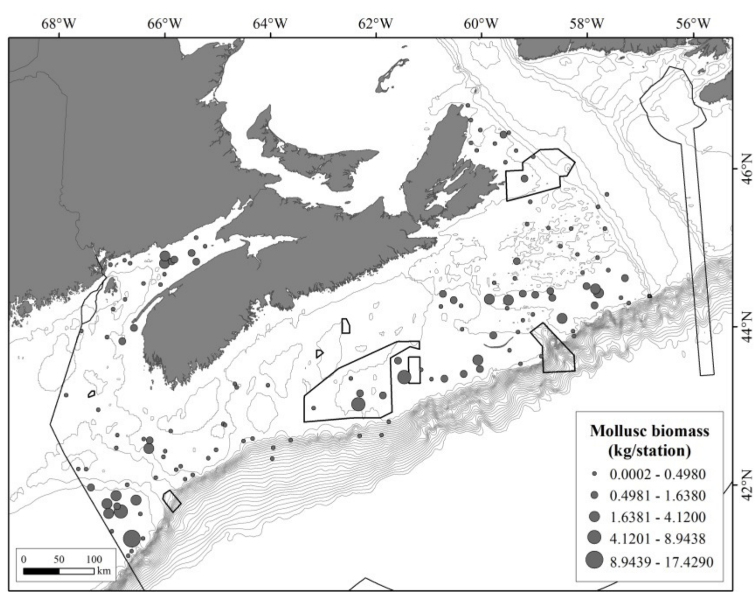

Figure 9. Molluscan biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

Phylum Arthropoda

Arthropods were collected in 240 stations (98%) and their biomass ranged between 0.0002 and 476.68 kg per station (Figure 10). Maximum values were found on Georges Bank, on the north side of the Bay of Fundy and on Browns Bank due to the presence of large catches of lobsters (*Homarus americanus*), which in total accounted for 87% of the total arthropod biomass.

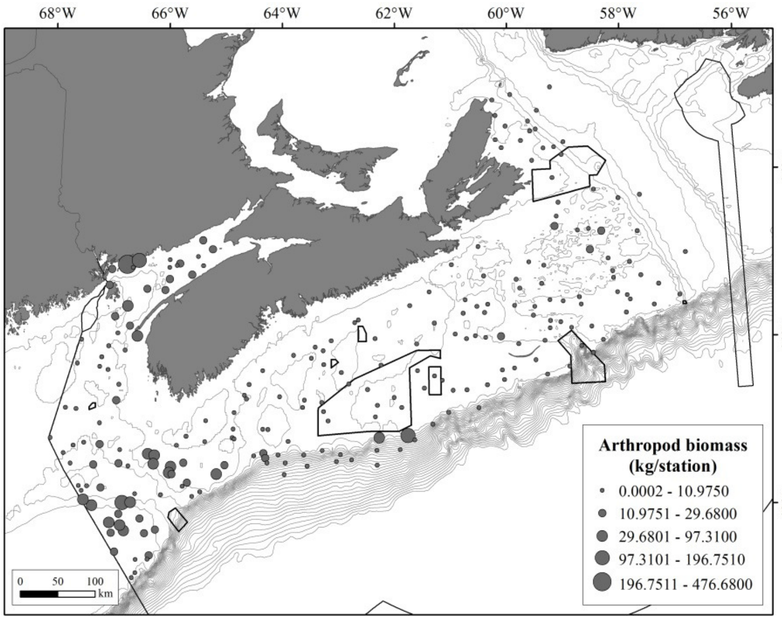

Figure 10. Arthropod biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

Phylum Echinodermata

Echinoderms were collected in 233 stations (95%), and their biomass ranged between 0.001 and 434.99 kg per station (Figure 11). Maximum values were found on Banquereau Bank due to the presence of large catches of sea cucumbers (*Cucumaria frondosa*), which accounted for 71% of the total echinoderm biomass.

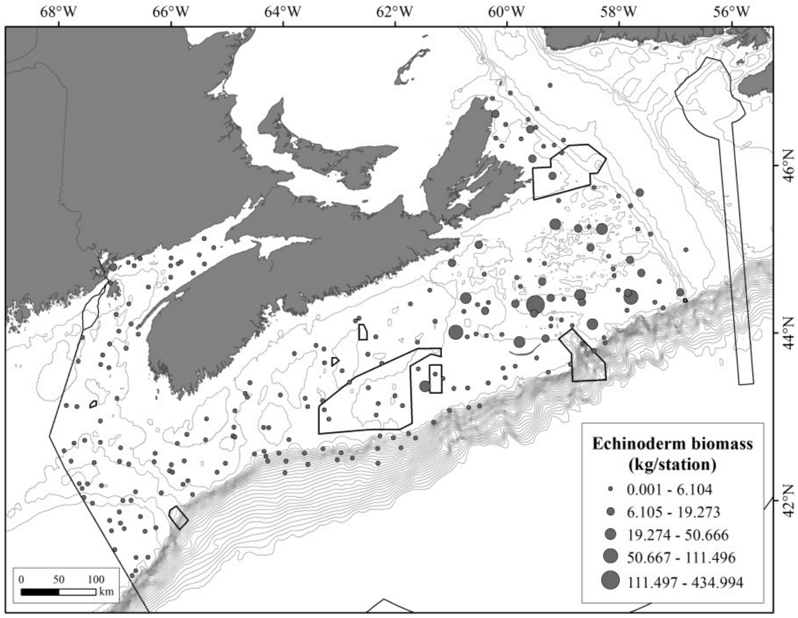

Figure 11. Echinoderm biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

Phylum Bryozoa

Bryozoans were collected in 73 stations (30%), and their biomass ranged between 0.0001 and 247.60 kg per station (Figure 12). Maximum values were found in the Bay of Fundy due to large catches of the bryozoan *Flustra foliacea* (lemon weed), which accounted for more than 99% of the total bryozoan biomass.

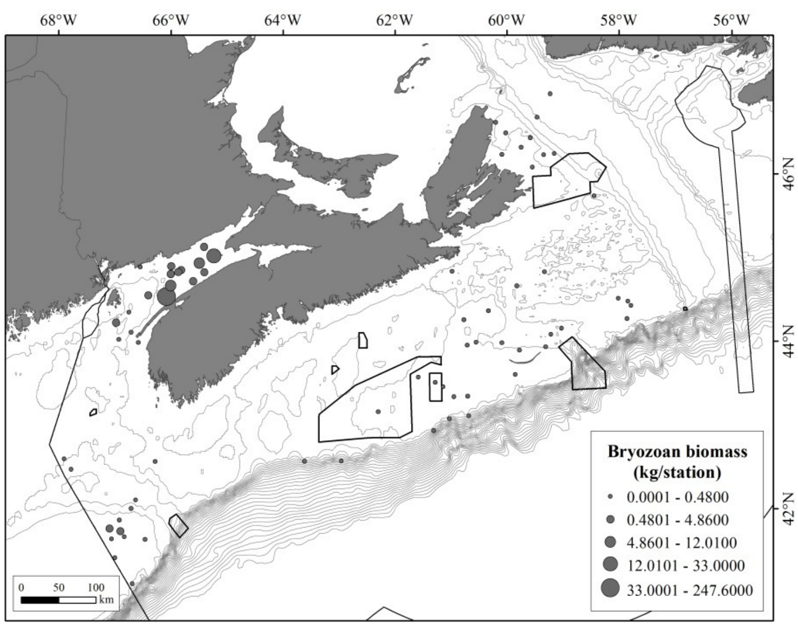

Figure 12. Bryozoan biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

Phylum Chordata. Class Ascidiacea

Ascidians were collected in 90 stations (37%), and their biomass ranged between 0.001 and 25.654 kg per station (Figure 13). Maximum values were found in the eastern Scotian Shelf due to large catches of the stalked tunicate *Boltenia ovifera*.

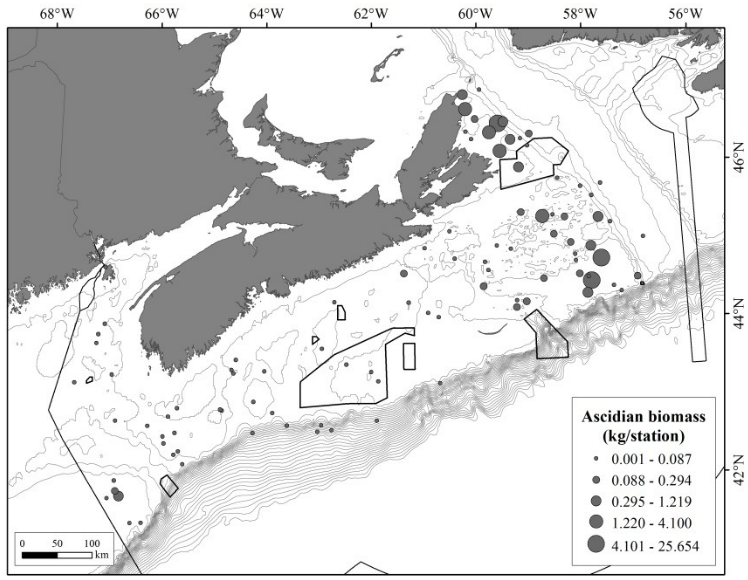

Figure 13. Ascidian biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

Other phyla

The remaining phyla were collected in 110 stations (45%), and their biomass ranged between 0.0002 to 0.5996 kg per station (Figure 14). Other phyla included polychaetes, brachiopods, sipunculids, platyhelminths, and nemerteans.

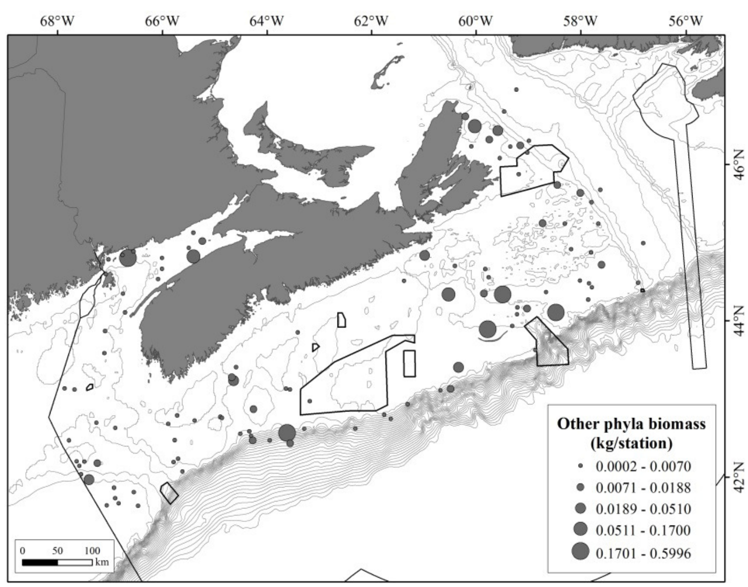

Figure 14. Other phyla biomass (kg/station) recorded during the 2017 Summer Research Vessel Survey (NED2017020).

VALIDATION OF SIGNIFICANT BENTHIC AREAS (SBAs) AND SPECIES DISTRIBUTION MODELS (SDMs)

Sponges

Ten significant catches of sponges based on the 3 kg threshold defined in Kenchington et al. (2016b) were recorded, with 4 inside the sponge SBAs, 3 in close proximity, while the remaining 3 were from new areas (Figure 15). Of the 172 stations that recorded sponges, 48% were located in areas deemed as suitable sponge habitat based on the species distribution model, and 52% in areas deemed unsuitable for sponges (red and blue areas in Figure 15, respectively). Of those catches considered absence of sponges, 78% were located in areas of unsuitable habitat (Figure 15).

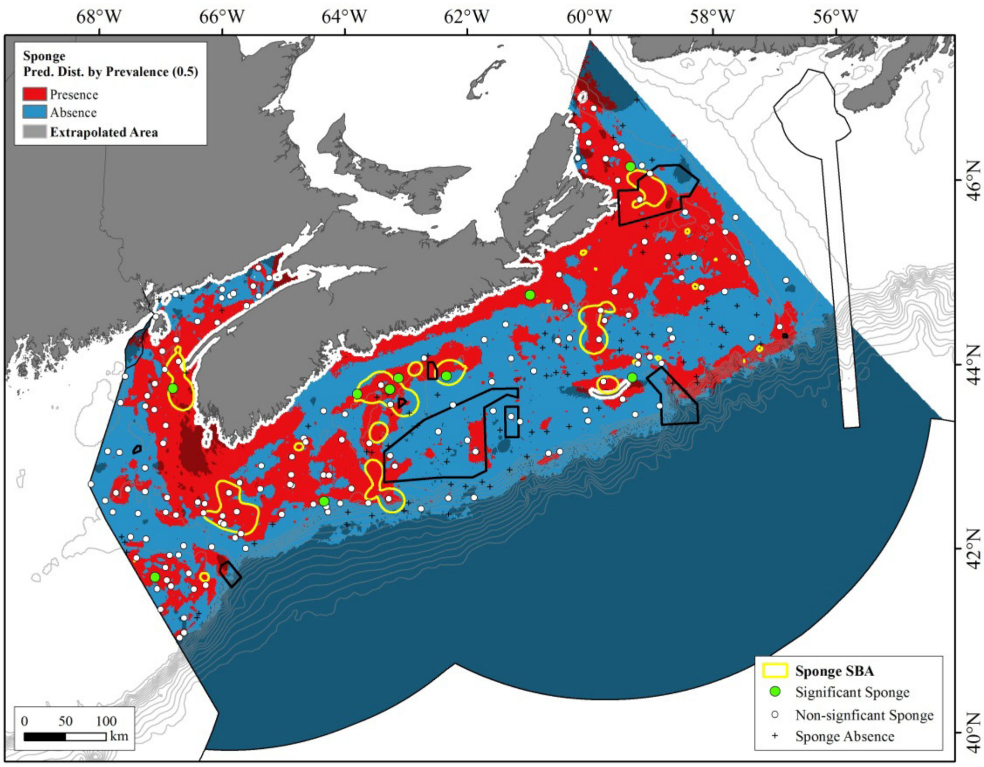

Figure 15. Location of the sponge catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold (Beazley et al. 2016) and the sponge Significant Benthic Areas (SBAs, Kenchington et al. 2016a). Sponge significant catches, non-significant catches, and absences as defined by Kenchington et al. (2016b) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Vazella pourtalesi

The glass sponge *V. pourtalesi* was collected in 17 stations (7%), and the biomass ranged between 0.039 and 73.14 kg per station. A total of 259 sponges ranging between 21 and 374 mm length were collected. Up to 141 sponges were collected in one single station. One additional record was collected from a null set. In order to validate the *V. pourtalesi* model (Beazley et al. 2016), all the *V. pourtalesi* records (valid and null) have been considered. Of the 18 stations with *V. pourtalesi* presence, 83% of them were located in areas of suitable habitat of *V. pourtalesi*, with 17% occurring in areas predicted as unsuitable habitat. Of those catches considered absence of *V. pourtalesi*, 91% were located in areas of unsuitable habitat (Figure 16).

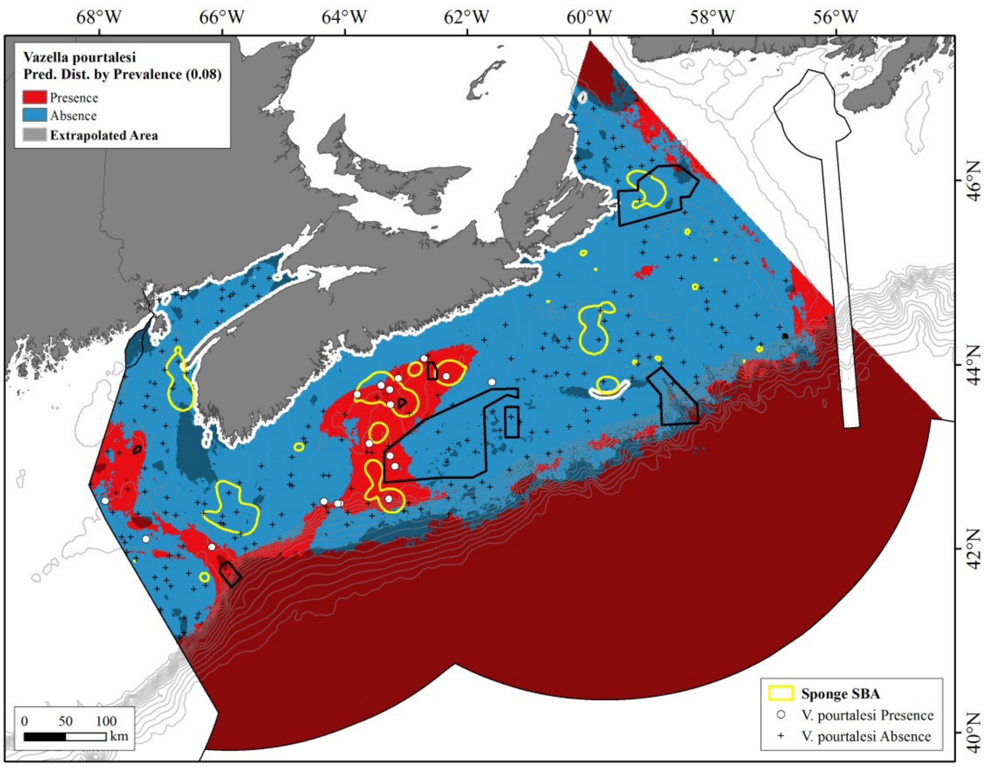

Figure 16. Location of the *V. pourtalesi* catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat (Beazley et al. 2016) and Sponge Significant Benthic Areas (SBAs, Kenchington et al. 2016a). Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Sea pens

Sea pens were collected in 45 stations (18%). The most common species recorded was *Pennatula aculeata*, which accounted for 85% of the sea pen biomass and was recorded in 91% of stations with sea pen presence. Other sea pen species identified were *Anthoptilum grandiflorum, Funiculina quadrangularis, Kophobolemnon stelliferum* and *Pennatula grandis* (Appendix 2). Two additional specimens in bad physical condition were recorded as Pennatulacea and require further examination.

Twenty significant catches of sea pens based on the 0.01 kg threshold defined in Kenchington et al. (2016b) were recorded with 13 located inside Sea pen SBAs, 5 in the kernel density estimation (KDE)-based SBAs and 8 in the model-based SBAs (Figure 17). Of the total catches containing sea pens (45), 64% were located in areas predicted as suitable sea pen habitat, and 36% located in areas predicted as unsuitable habitat. Most of the significant catches (90%) were located in areas predicted as suitable sea pen habitat. Of those catches considered absence of sea pens, 86% were located in areas predicted as unsuitable sea pen habitat (Figure 17).

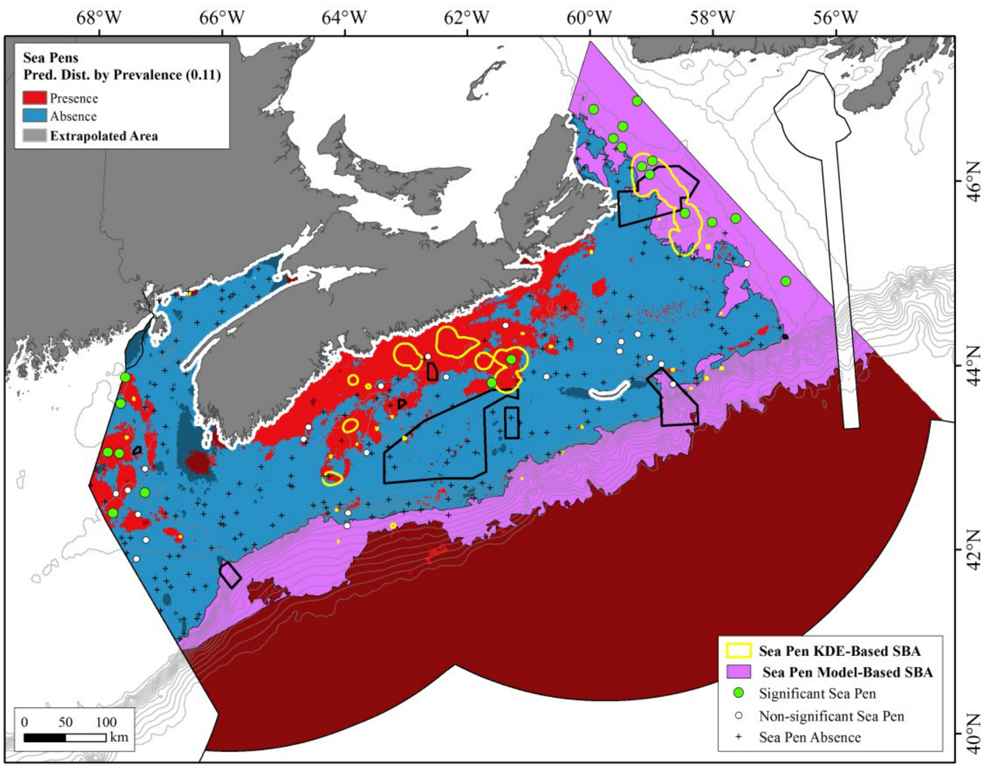

Figure 17. Location of the sea pen catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold (Beazley et al. 2016) and the sea pen Significant Benthic Areas (SBAs, Kenchington et al. 2016a). Sea pen significant catches, non-significant catches, and absences as defined by Kenchington et al. (2016b) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Large gorgonians

Large gorgonians were collected in 7 stations (3%) with three taxa identified: *Keratoisis grayi, Paragorgia arborea* and *Paramuricea* sp. (Appendix 2). *K. grayi* was found south of the Western/Emerald Banks Conservation Area; a small piece of *P. arborea* was found on Georges Bank at 90 m depth in the proximities of Carson Canyon; and several colonies of *Paramuricea* were found in Jordan Basin (Figure 18). Two species of *Paramuricea* have been previously recorded on the Scotian Shelf, *P. grandis* and *P. placomus* (Breeze et al. 1997). However, the genus *Paramuricea* in the northwest Atlantic may include cryptic species previously assigned to *P. placomus* (Radice et al. 2016). Therefore, pending a taxonomic review of this genus these records were identified only to genus level. The small weight (0.015 kg) associated to the catch of *P. arborea* and its shallow location may indicate contamination from a previous set carried out between Georges and Carson canyons, area known to host high densities of *P. arborea* (http://www.dfo-mpo.gc.ca/oceans/publications/backgrounder-fiche/index-eng.html). Therefore, this record should be taken with caution.

Three significant catches of large gorgonians based on the 0.01 kg threshold defined in Kenchington et al. (2016b) were recorded, all of them outside the large gorgonian SBAs (Figure 18). No large gorgonian catch was located in areas predicted as suitable large gorgonian habitat. Of those catches considered absence of large gorgonians, 89% were located in areas predicted as unsuitable habitat (Figure 18).

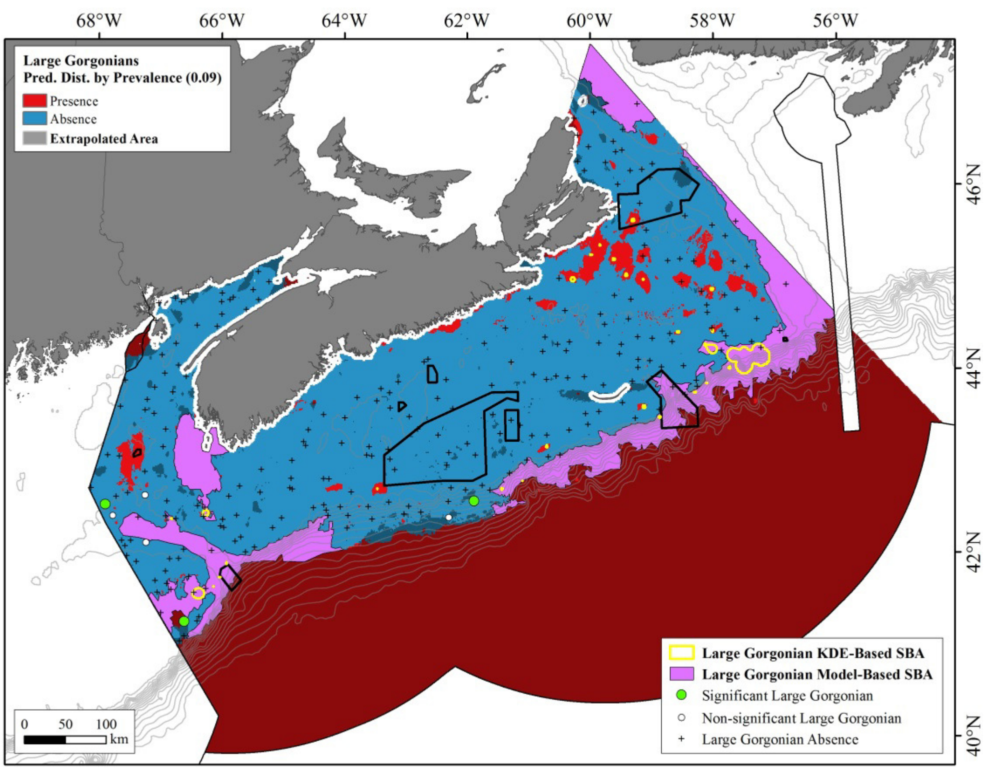

Figure 18. Location of the large gorgonian catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold (Beazley et al. 2016) and the large gorgonian Significant Benthic Areas (SBAs, Kenchington et al. 2016a). Large gorgonian significant catches, non-significant catches and absences as defined by Kenchington et al. (2016b) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Small gorgonians
Small gorgonians were collected only in 1 station inside the small gorgonian Significant Benthic Area (SBA) identified from a model-based approach (Figure 19). No significant benthic areas based on the KDE analysis exist for this taxon (see Kenchington et al. 2016b). Two species were identified from this station: *Acanella arbuscula* and *Radicipes gracilis* (Appendix 2). Of the 243 stations considered absence of small gorgonians, 87% were found in areas of predicted as unsuitable habitat for this taxon (Figure 19).

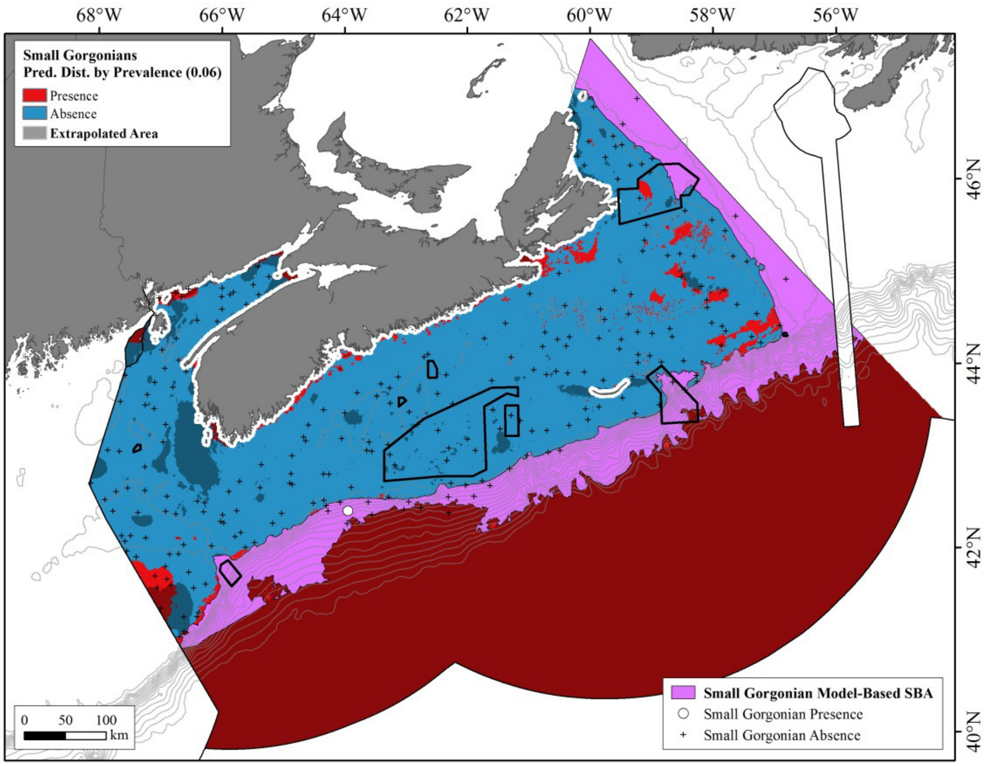

Figure 19. Location of the small gorgonian catch recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold (Beazley et al. 2016) and the small gorgonian Significant Benthic Area (SBA, Kenchington et al. 2016a). Small gorgonian presences and absences are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

***Horse mussel* (*Modiolus modiolus*)**
The horse mussel *M. modiolu*s was collected in 10 stations (4%). Three significant catches of horse mussel based on the 0.25 kg threshold defined in Beazley et al. (2017) were recorded, all of them outside of the horse mussel KDE significant area polygons (Figure 20). These 3 significant catches were less than 20 km apart, likely forming a reef with *Mytilus* and barnacles. Of the 10 stations that recorded horse mussels, 60% were located in areas predicted as suitable

horse mussel habitat, while 40% were located in areas predicted as unsuitable habitat. Of those catches considered absence of horse mussels, 92% were located in areas of unsuitable habitat (Figure 20).

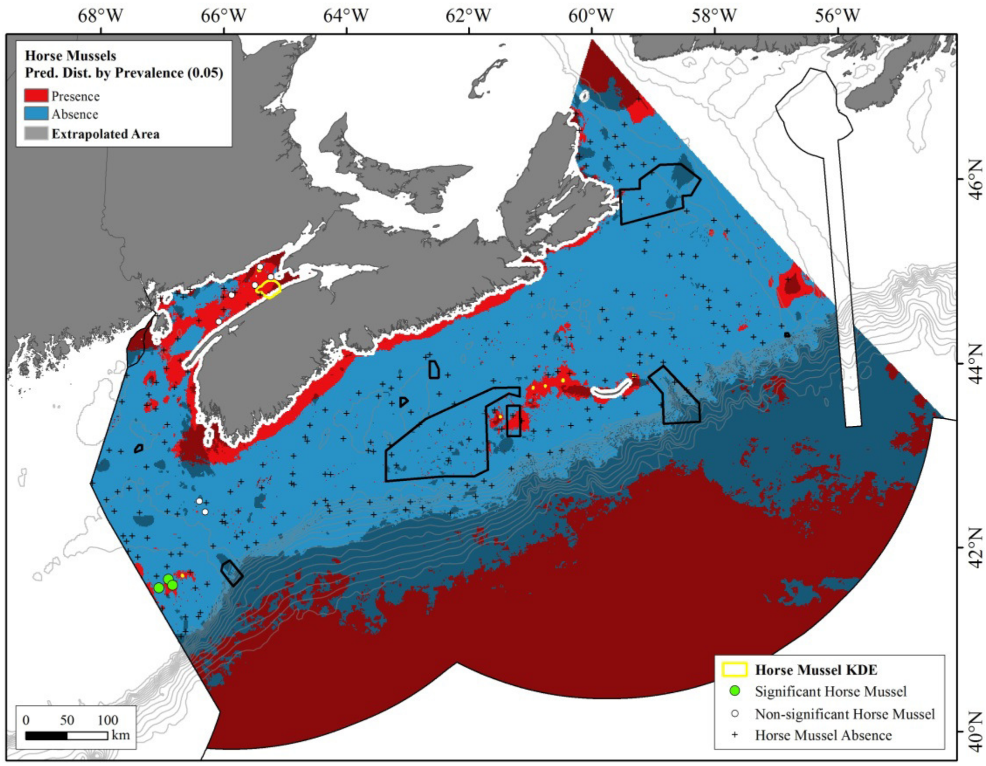

Figure 20. Location of the horse mussel (*Modiolus modiolus*) catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold and the horse mussel kernel density estimation (KDE) significant area polygons (Beazley et al. 2017). Horse mussel significant catches, non-significant catches, and absences as defined by Beazley et al. (2017) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

***Stalked tunicate fields* (*Boltenia ovifera*)**

The stalked tunicate *B. ovifera* was collected in 34 stations (14%). Seven significant catches of stalked tunicates based on the 1 kg threshold defined in Beazley et al. (2017) were recorded. Of these, 5 were inside the stalked tunicate KDE significant area polygons (Figure 21), including a large catch of 17.6 kg corresponding to 276 individuals (Figure 22). Of the 34 stations that recorded stalked tunicates, 79% were located in areas predicted as suitable stalked tunicate habitat, whereas 21% were located in areas of unsuitable habitat. Of those catches considered absence of stalked tunicates, 80% were located in areas of unsuitable habitat (Figure 21).

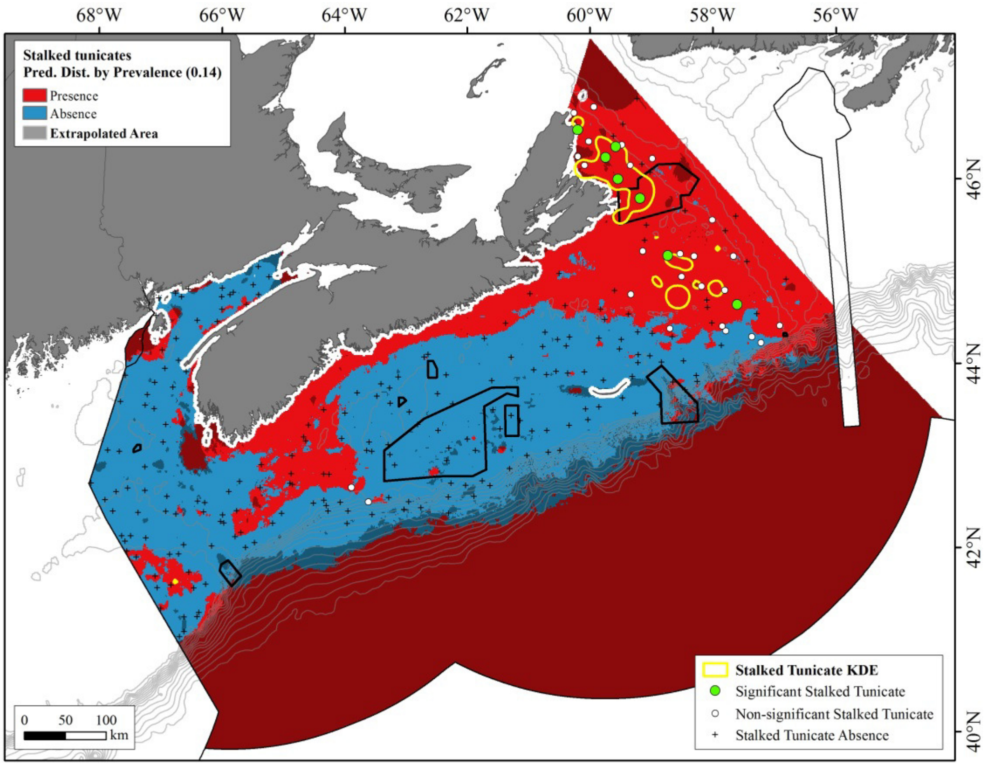

Figure 21. Location of the stalked tunicate (*Boltenia ovifera*) catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold (Beazley et al. 2017) and the stalked tunicate kernel density estimation (KDE) significant area polygons (Beazley et al. 2017). Stalked tunicate significant catches, non-significant catches, and absences as defined by Beazley et al. (2017) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Figure 22. Large catch (17.6 kg, 276 individuals) of stalked tunicates (*Boltenia ovifera*) collected north of St. Ann's Bank MPA on the 2017 Summer Research Vessel Survey (NED2017020).

***Sand dollar beds* (*Echinarachnius parma*)**

The sand dollar *E. parma* was collected in 51 stations (21%). Only one significant catch of sand dollars according to the 2 kg threshold defined in Beazley et al. (2017) was recorded outside the sand dollar KDE significant area polygons (Figure 23). Of the 51 stations that recorded sand dollars, 86% of them were located in areas predicted as suitable sand dollar habitat, while 14% were found in areas predicted as unsuitable habitat. Of those catches considered absence of sand dollars, 80% were located in areas of unsuitable habitat (Figure 23).

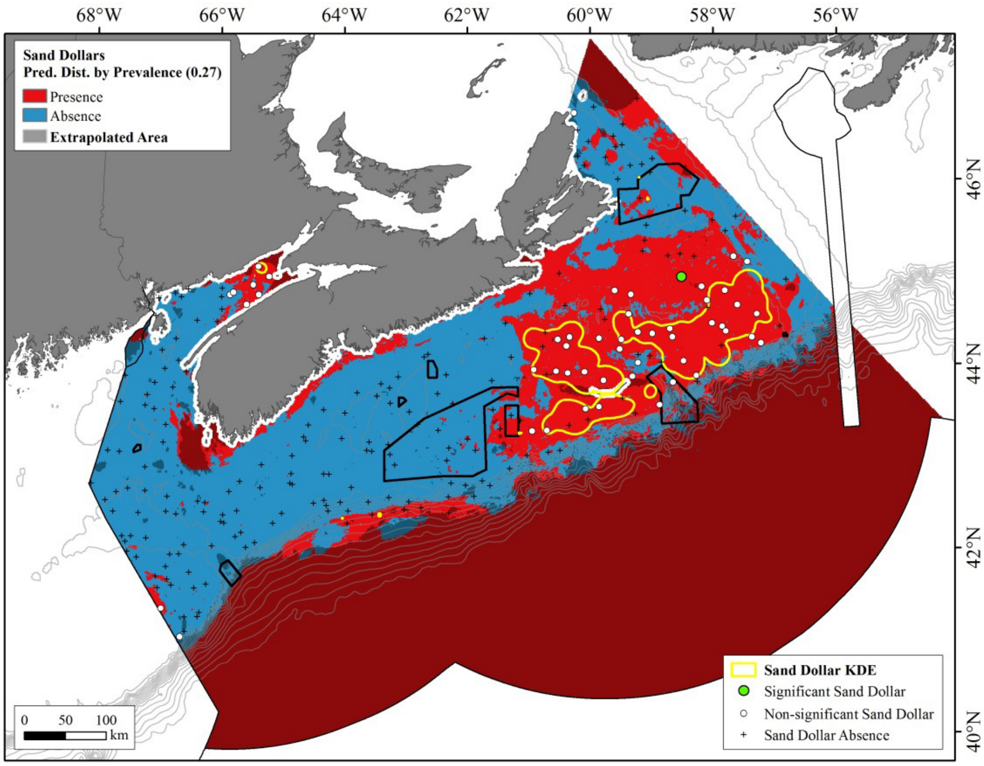

Figure 23. Location of sand dollar (*Echinarachnius parma*) catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold and the sand dollar kernel density estimation (KDE) significant area polygons (Beazley et al. 2017). Sand dollar significant catches, non-significant catches, and absences as defined by Beazley et al. (2017) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Soft coral gardens

Soft corals were collected in 37 stations (15%). Six species were identified, 5 belonging to the family Nephtheidae (*Duva florida*, *Drifa glomerata*, *Drifa* sp.B, *Gersemia rubiformis*, and *G. fruticosa*) and 1 to the family Alcyoniidae (*Heteropolypus sol*). Five of these taxa were identified to species level for the first time on the Summer Research Vessel Survey and a code therefore needs to be assigned to ensure future recording. However, identification of some species of soft coral requires microscopic examination making identification to species level difficult at sea, although they could at least be identified to family level improving the current identification.

Six significant concentrations of soft corals based on the 0.05 kg threshold defined in Beazley et al. (2017) were recorded, 2 of them inside the soft coral KDE significant area polygons and 4 in the proximity (Figure 24). Of the 37 stations that recorded soft corals, 70% were located in areas predicted as suitable soft coral habitat, whereas 30% were predicted to occur in areas of unsuitable habitat. Of those catches considered absence of soft corals, 85% were located in areas of unsuitable habitat (Figure 24).

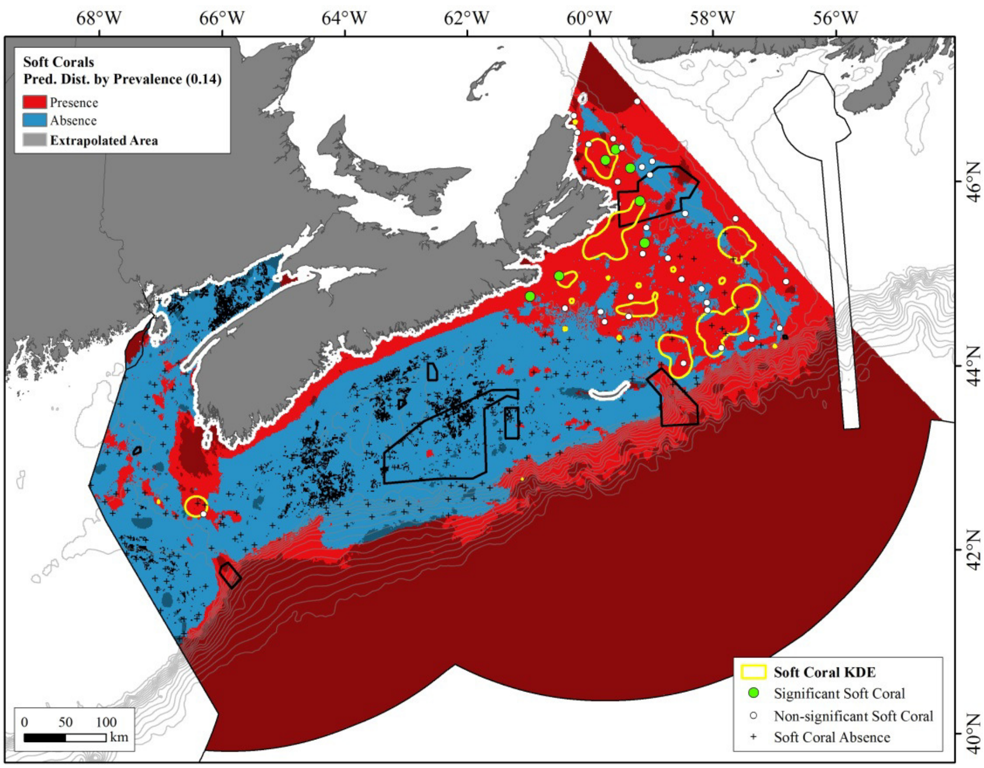

Figure 24. Location of soft coral catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold and the soft coral kernel density estimation (KDE) significant area polygons (Beazley et al. 2017). Soft coral significant catches, non-significant catches, and absences as defined by Beazley et al. (2017) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Cup corals (Flabellum spp.)

The cup coral *Flabellum* spp. was collected in 12 stations (5%) along the slope. Ten of the catches were identified as *F. alabastrum* (Appendix 2). The two records identified to genus level were broken pieces that require further examination.

Three significant catches of cup corals according to the 0.06 kg threshold defined in Beazley et al. (2017) were recorded, all of them outside the *Flabellum* KDE significant area polygons but in close proximity (Figure 25). All stations with a presence of cup corals were located in areas predicted as suitable cup coral habitat, whereas 92% of the absence catches were found in areas of unsuitable habitat (Figure 25).

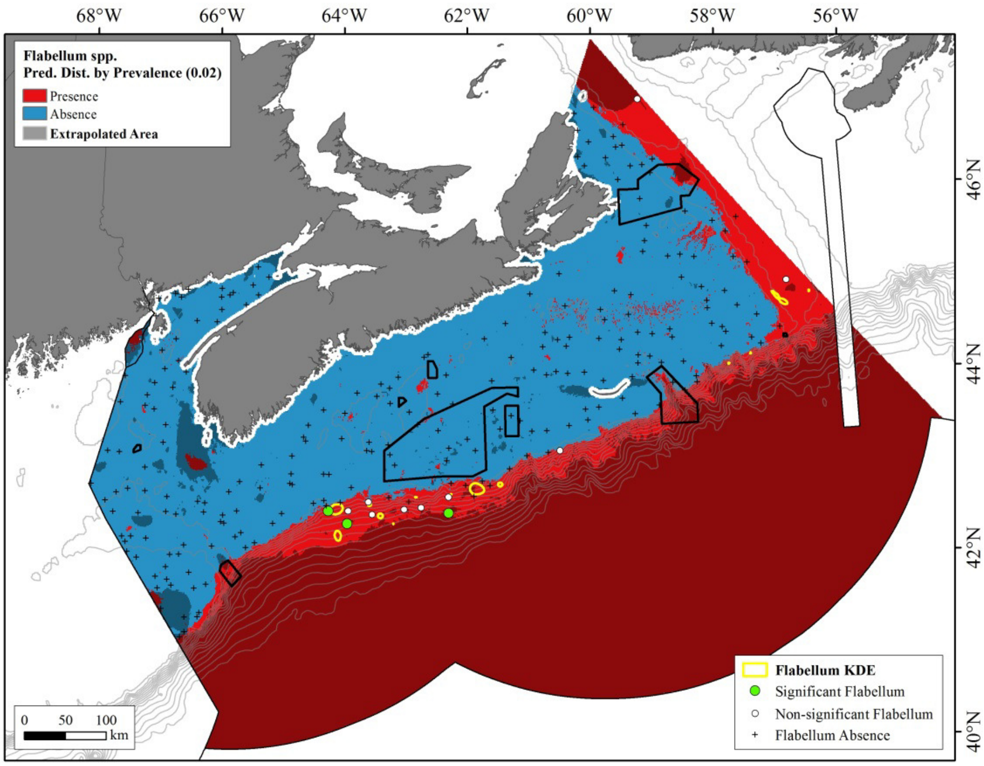

Figure 25. Location of cup coral (*Flabellum* spp.) catches recorded during the 2017 Summer Research Vessel Survey (NED2017020) overlaid on the predicted distribution (Pred. Dist.) of suitable (presence) and unsuitable (absence) habitat based on the prevalence threshold and the *Flabellum* kernel density estimation (KDE) significant area polygons (Beazley et al. 2017). *Flabellum* significant catches, non-significant catches, and absences as defined by Beazley et al. (2017) are indicated. Areas closed to protect benthic species and habitats are indicated in black outline. Also shown are the areas of model extrapolation (grey polygon may appear dark red or dark blue).

Tube-dwelling anemone fields

Tube-dwelling anemone fields were identified as EBSAs by Kenchington (2014). However, this organism has the ability to retract into their tubes buried in the sediment where they live and therefore their catchability from trawl gears is very low. Therefore, no further analysis has been conducted to map the tube-dwelling anemone fields on the Scotian Shelf. During the 2017 Summer Research Vessel Survey (NED2017020) two tube-dwelling anemones were collected; one of them was identified as *Pachycerianthus borealis* and the other requires further examination (Figure 26, Appendix 2). The specimen of *P. borealis* was found entangled in the net of the gear. In addition, empty tube-dwelling anemone tubes were recorded (Figure 26) and could be indicative of tube-dwelling anemone presences in the absence of better information.

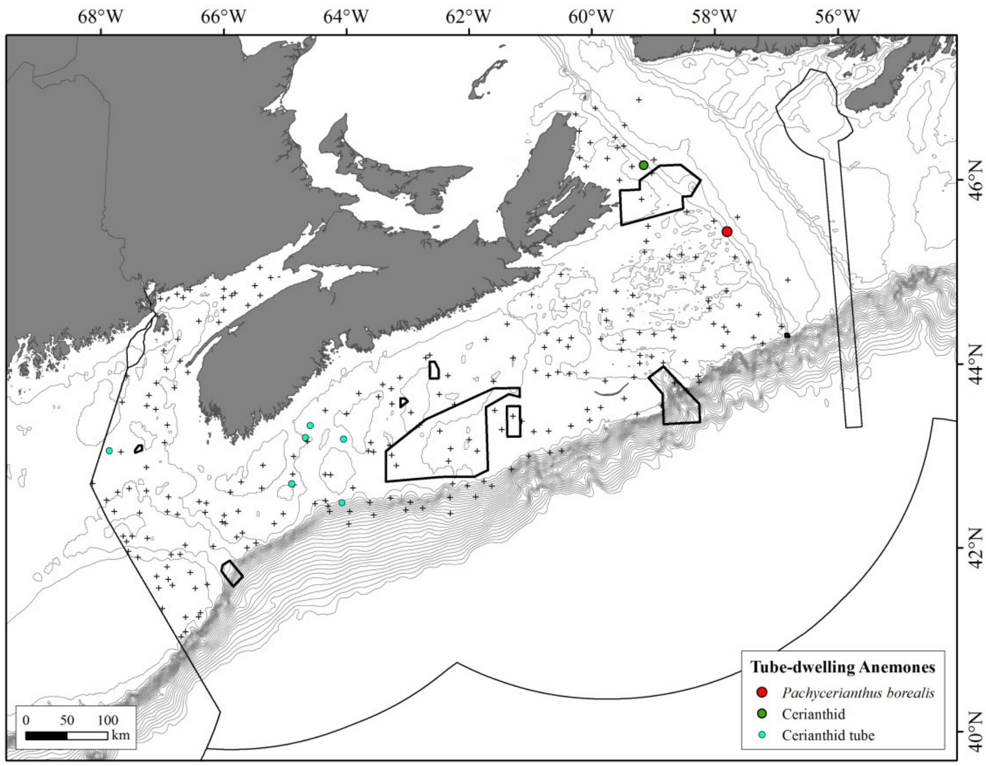

Figure 26. Location of tube-dwelling anemone catches including empty tubes recorded during the 2017 Summer Research Vessel Survey (NED2017020). Areas closed to protect benthic species and habitats are indicated in black outline.

Erect bryozoan turf

Erect bryozoan turf are also considered EBSAs (Kenchington 2014). However, their distribution has not yet been mapped due to sparse data on their location. The distribution of erect bryozoan *Flustra foliacea* catches, commonly known as lemon weed, from the 2017 Summer Research Vessel Survey (NED2017020) is shown in Figure 27. The largest biomass was recorded in the Bay of Fundy where a 247.6 kg catch was collected (Figure 28). Bryozoan identification normally requires microscopic examination and a full list of species collected will be provided upon full taxonomic review.

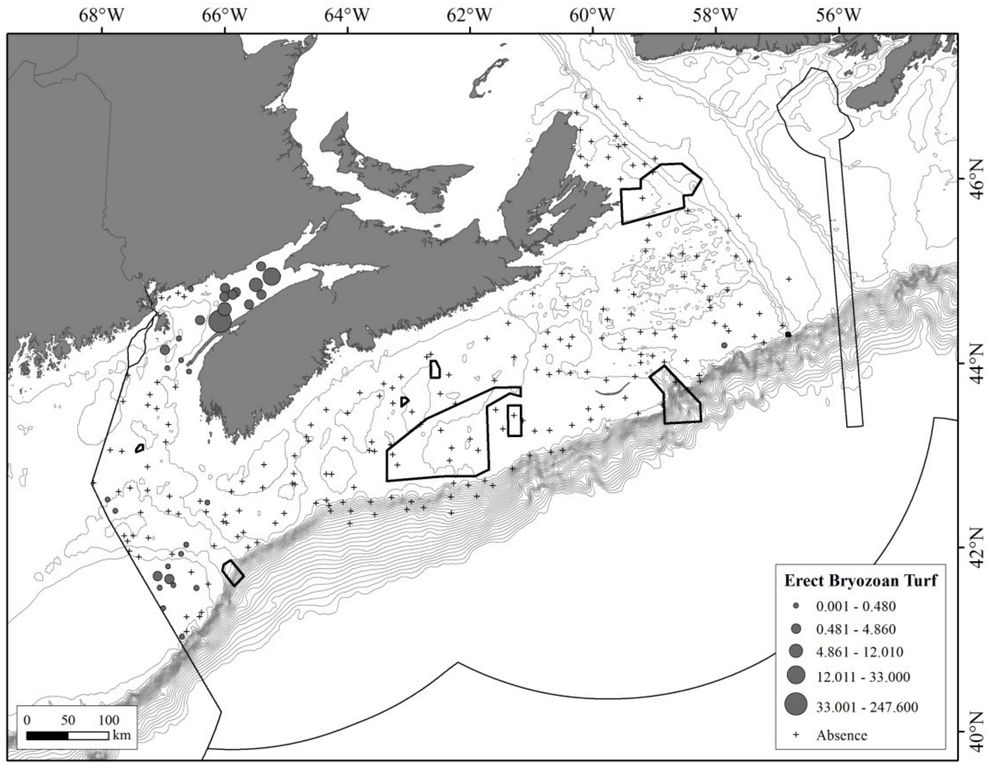

Figure 27. Location of erect bryozoan turf or lemon weed (*Flustra foliacea*) catches recorded during the 2017 Summer Research Vessel Survey (NED2017020). Areas closed to protect benthic species and habitats are indicated in black outline.

Figure 28. Large catch (247.6 kg) of erect bryozoan turf or lemon weed (*Flustra foliacea*) collected in the Bay of Fundy during the 2017 Summer Research Vessel Survey (NED2017020).

DISCUSSION

The information on invertebrate distribution and composition presented in this study will form a baseline from which to identify consistent groupings or communities in the Scotian Shelf Bioregion. The number of invertebrate taxa recorded on the 2017 Summer Research Vessel Survey (NED2017020) almost doubles that listed in previous studies, which also included deep water stations (Clark and Emberley 2011; Emberley and Clark 2012). Moreover, several faunal groups, such as sponges, sea anemones, and hydroids require further identification and expert consultation. Only a few representatives of these groups are included in the present report, suggesting that additional species will likely be identified in the future. Additionally, the current invertebrate identification is preliminary and up to 53 (43 benthic) of the taxa listed did not have the corresponding at-sea identification codes (Appendix 2).

Once the invertebrate identification is finalized faunal analysis will be performed following the approach used by Murillo et al. (2016) to describe benthic community types in the region. Habitat suitability models will be created to interpolate/extrapolate results to areas not directly sampled in the survey. These models apply the recently developed joint species distribution models (Warton et al. 2015; Ovaskainen et al. 2017), which account for both the correlation between taxa and response to predictor variables. The resulting maps will be provided to Ocean Managers to assist in the identification of representative benthic habitats and adjustment of MPA and other boundaries to ensure that all benthic habitat types are to some degree protected. In addition, the invertebrate identification will be used to improve the benthic invertebrate collection and documentation on the DFO research vessel surveys.

Overall, the SBAs for corals and sponges (Kenchington et al. 2016a), KDE significant concentrations for other EBSA-forming taxa (Beazley et al. 2017), and predictive models previously presented (see Beazley et al. 2016, 2017), showed good congruence with the new data collected during the 2017 Summer Research Vessel Survey (Table 2). Most of the significant concentrations outside of existing SBAs or KDEs are in close proximity to them, although a few new areas (i.e., horse mussels) were not identified in any previous analyses. The poor congruence between the sponge catches from this survey and the sponge predictive model can likely be attributed to the poor performance of the sponge model due to the coarse taxonomic resolution of this group as discussed in Beazley et al. (2016). Models encapsulate the range of habitat conditions that a sponge or species would likely occur in. Variation in this probabilistic analysis caused by variability in what the suitable conditions are among species will likely lead to model performance issues, as observed here. Once sponges are identified, species with similar environmental requirements can be modelled together following a similar approach as done for the eastern Arctic sponges (Murillo et al. 2018), which would improve model performance. The large gorgonian coral catches from this survey also did not show good congruence with the predictive model results. Some of these catches were outside areas known for large concentrations of gorgonian corals (i.e. the canyons and channels on the slope). There were doubts at the time on the reliability of the data for several of the shallowest *Paragorgia arborea* records on the eastern Shelf and participation in this survey seems to support their absence (although there could be some that were in very small patches). Moreover, large gorgonians from Atlantic Canada live attached to hard substrates mainly from glacial or glaciomarine origin (Edinger et al. 2011). These hard substrates sometimes consist of isolated cobbles or boulders found in muddy sand bottoms which are difficult to capture on large scale maps and subsequently to include in the models. Therefore, more efforts should be done to improve large gorgonian models and precautionary measures, such as decreasing the cut-off threshold when moving from a probability surface to a presence-absence surface (Beazley et al. 2016) would increase the predicted large gorgonian presence surface.

Table 2. Number of new significant concentrations of corals, sponges and other EBSA-forming species from the 2017 Summer Research Vessel Surveys (NED2017020) inside and outside the Significant Benthic Areas (SBAs) for coral and sponges, and kernel density estimation (KDE) significant area polygons for the rest of EBSA-forming species (Kenchington et al., 2016a, b; Beazley et al. 2017). Percentage (%) of correctly predicted presences and absences based on the models presented in Beazley et al. (2016, 2017) is also indicated. N/A, not applicable.

	New significant concentration		**% correct presence prediction**	**% correct absence prediction**
	Inside SBA/KDE polygon	**Outside SBA/KDE polygon**		
Sponges	4	6	48%	78%
Vazella pourtalesi	N/A	N/A	83%	91%
Sea pens	13	7	64%	86%
Large gorgonians	0	3	0%	89%
Small gorgonians	N/A	N/A	100%	87%
Horse mussel (*Modolus modiolus*)	0	3	60%	92%
Stalked tunicate fields (*Boltenia ovifera*)	5	2	79%	80%
Sand dollar beds (*Echinarachnius parma*)	0	1	86%	80%
Soft coral gardens	2	4	70%	85%
Cup corals (*Flabellum* spp.)	0	3	100%	92%

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APPENDIX 1. VAZELLA POURTALESI (CODE: 8601) SAMPLING PROTOCOL

When catches of the sponge *V. pourtalesi* are obtained, all specimens should be counted and weighed removing any rock from the base of the sponge if it is still attached. Height, maximum width, and osculum diameter (large hole in top of sponge) should be measured. Always wear thick gloves to avoid sponge spicules from breaking the skin. In most cases the *Vazella* specimens will come on board flattened or squished (Figure A1) and broken. In order to get the best estimate of the maximum width and osculum diameter, these two measurements should be taken with the specimen cylindrical to the extent possible. If the specimen is broken and the total height cannot be measured, this should be recorded.

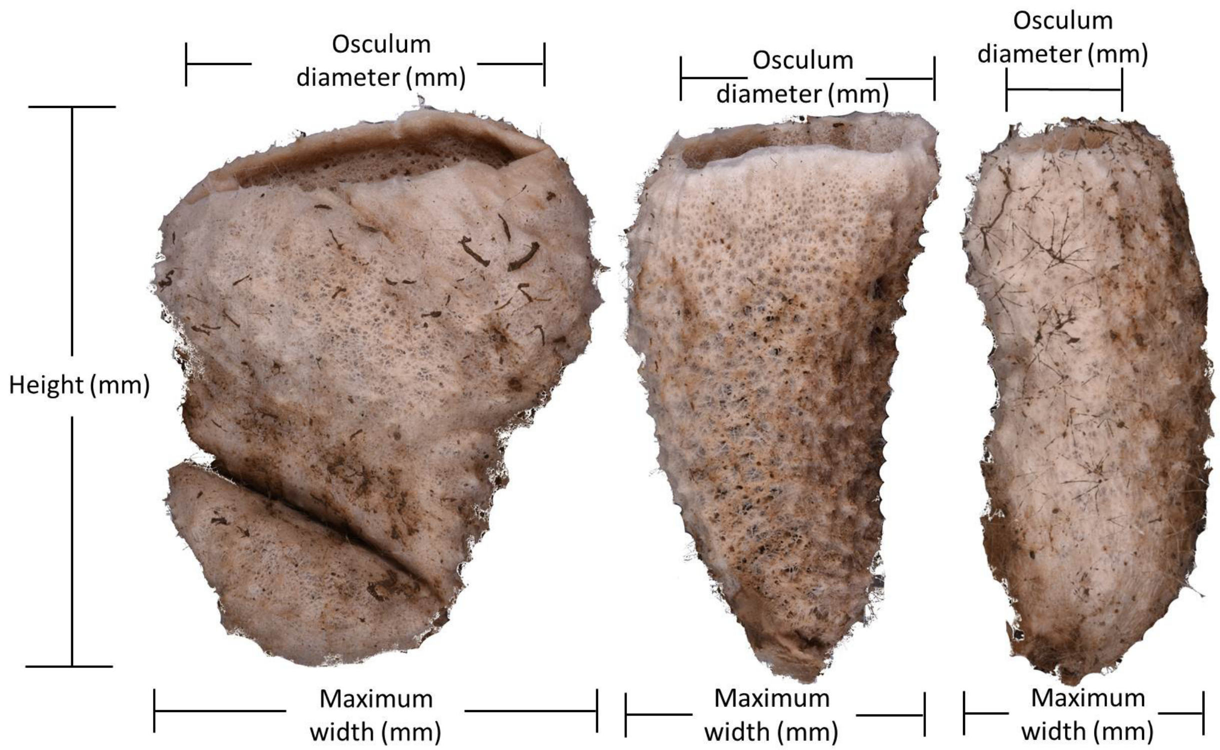

Figure A1. Examples of *V. pourtalesi* specimens and measurements to be recorded.

APPENDIX 2. LIST OF PRELIMINARY SPECIES IDENTIFICATIONS

Table A1. List of at-sea and preliminary invertebrate identifications collected during the 2017 Summer Research Vessel Survey (NED2017020) and Code assigned. Number of fishing stations (N) with presence of the taxa, biomass (kg), and abundance (except for colonial organisms) are indicated. Pelagic and bentho-pelagic habitat invertebrates are marked with an asterisk (*). Open Nomenclature used for taxa not identified to species level follows the recommendation provided by Sigovini et al. (2016).

	Code	N	Biomass (kg)	Abundance
PHYLUM PORIFERA				
Porifera	8600	144	62.360	-
CLASS HEXACTINELLIDA				
Order Lyssacinosida				
Family Rossellidae				
Vazella pourtalesi	8601	17	128.334	259
CLASS CALCAREA				
Calcarea	-	2	0.001	3
CLASS DEMOSPONGIAE				
Order Poecilosclerida				
Family Mycalidae				
Mycale lingua	8616	3	0.365	-
Order Polymastiida				
Family Polymastiidae				
Polymastiidae	-	64	9.376	412
Tentorium semisuberites	8612	2	0.001	2
Order Tetractinellida				
Family Theneidae				
Thenea	-	4	0.149	4
PHYLUM CNIDARIA				
CLASS ANTHOZOA				
Order Alcyonacea				
Alcyonacea	-	1	0.0003	4
Family Alcyoniidae				
Heteropolypus sol	-	1	0.006	5
Family Chrysogorgiidae				
Radicipes gracilis	8330	1	0.0001	1
Family Isididae				
Acanella arbuscula	8329	1	0.001	1
Keratoisis grayi	8325	2	0.022	2
Family Nephtheidae				
Duva florida	-	10	1.346	31
Gersemia rubiformis	8324	20	0.633	266
Gersemia fruticosa	-	17	0.267	60
Drifa glomerata	-	12	0.257	77
Drifa sp.B	-	1	0.003	1
Family Paragorgiidae				
Paragorgia arborea	8323	1	0.015	1
Family Plexauridae				

Paramuricea	8333	4	0.131	-
Order Pennatulacea				
Pennatulacea	8318	2	0.004	2
Family Anthoptilidae				
Anthoptilum grandiflorum	8361	1	0.248	19
Family Funiculinidae				
Funiculina quadrangularis	8359	1	0.07	51
Family Kophobelemnidae				
Kophobelemnon stelliferum	-	1	0.193	188
Family Pennatulidae				
Pennatula	-	1	0.002	1
Pennatula aculeata	-	41	4.214	702
Pennatula grandis	8360	3	0.089	3
Order Actiniaria				
Actiniaria	8208	68	4.472	486
Family Actiniidae				
Bolocera tuediae	-	32	4.785	124
Family Actinostolidae				
Actinostola	-	10	5.603	31
Family Hormathiidae				
Actinauge	-	4	3.582	355
Hormathiidae	-	21	2.585	167
Phelliactis	-	7	6.609	20
Order Ceriantharia				
Ceriantharia	8370	1	0.007	1
Family Cerianthidae				
Pachycerianthus borealis	8320	1	0.187	1
Order Scleractinia				
Family Flabellidae				
Flabellum	8335	2	0.014	17
Flabellum alabastrum	8362	10	0.791	127
Order Zoantharia				
Family Epizoanthidae				
Epizoanthus	8382	53	1.186	1132
Epizoanthus paguriphilus	-	3	0.208	68
CLASS HYDROZOA				
Hydrozoa	8400	142	5.729	-
CLASS SCYPHOZOA				
*Scyphozoa	8500	150	43.292	-
Order Coronatae				
Family Atollidae				
**Atolla*	-	7	0.998	18
Family Periphyllidae				
**Periphylla periphylla*	-	5	3.673	6
Order Semaeostomeae				
Family Cyaneidae				
**Cyanea capillata*	8511	1	1.187	1
Family Ulmaridae				
**Aurelia aurita*	8010	1	0.064	1
CLASS STAUROZOA				
Staurozoa	-	4	0.108	14

PHYLUM CTENOPHORA				
*Ctenophora	8100	50	0.481	257
PHYLUM PLATYHELMINTHES				
Platyhelminthes	5300	1	0.01	1
PHYLUM NEMERTEA				
Nemertea	8343	2	0.001	2
PHYLUM SIPUNCULA				
Sipuncula	3300	4	0.020	11
PHYLUM ANNELIDA				
CLASS POLYCHAETA				
Polychaeta	3100	46	0.218	150
Order Eunicida				
Eunicida	-	6	0.023	8
Family Onuphidae				
Hyalinoecia cf. *tubicola*	3099	3	0.592	354
Order Phyllodocida				
Family Aphroditidae				
Aphrodita hastata	3200	14	1.579	20
Laetmonice filicornis	-	21	0.009	11
Family Nephtyidae				
Nephtyidae	3115	3	0.006	7
Family Nereididae				
Nereis	3130	1	0.0003	1
Family Polynoidae				
Polynoidae	3500	21	0.084	92
Order Sabellida				
Family Sabellidae				
Sabellidae	3138	2	0.013	2
Order Terebellida				
Family Terebellidae				
Terebellidae	3160	1	0.001	1
PHYLUM MOLLUSCA				
CLASS SOLENOGASTRES				
Solenogastres	-	2	0.0005	3
CLASS POLYPLACOPHORA				
Polyplacophora	4700	2	0.0015	2
CLASS GASTROPODA				
Order Cephalaspidea				
Family Philinoidea				
Scaphander punctostriatus	4431	4	0.017	7
Order Littorinimorpha				
Family Naticidae				
Euspira heros	4221	11	1.745	18
Naticidae	4220	2	0.004	2
Family Velutinidae				
Velutinidae	-	2	0.002	3
Order Neogastropoda				
Family Buccinidae				

Buccinidae	4209	18	6.365	188
Buccinum undatum	4211	24	8.206	215
Colus	4228	11	0.532	19
Neptunea decemcostata	4227	19	2.008	26
Order Nudibranchia				
Nudibranchia	4400	32	0.1122	53
Family Cadlinidae				
Aldisa zetlandica	-	9	0.0156	18
Family Dendronotidae				
Dendronotus	4410	5	0.0157	9
Order Trochida				
Family Trochidae				
Trochidae	4255	3	0.0042	6
CLASS BIVALVIA				
Bivalvia	4300	13	0.1829	110
Family Mactridae				
Mactromeris polynyma	4355	1	0.156	2
Order Adapedonta				
Family Hiatellidae				
Cyrtodaria siliqua	4312	4	0.598	9
Hiatella arctica	4319	9	0.0796	92
Order Cardiida				
Family Cardiidae				
Cardiidae	4340	6	0.0685	60
Serripes groenlandicus	4343	1	0.191	2
Order Carditida				
Family Astartidae				
Astarte	4316	7	0.0516	10
Order Mytilida				
Family Mytilidae				
Modiolus modiolus	4332	10	9.7717	76
Mytilus	4330	10	2.7436	116
Order Pectinida				
Family Pectinidae				
Chlamys islandica	4322	15	4.137	85
Placopecten magellanicus	4321	57	69.443	1993
Order Venerida				
Family Arcticidae				
Arctica islandica	4304	4	0.412	7
CLASS CEPHALOPODA				
*Cephalopoda	4500	7	0.3338	17
Order Myopsida				
Family Loliginidae				
**Doryteuthis pealeii*	4512	4	0.27	23
Order Octopoda				
Octopoda	4521	20	1.533	48
Family Bathypolypodidae				
Bathypolypus	-	18	0.9904	2
Family Cirroteuthidae				
**Cirroteuthis*	-	2	0.098	1
Order Oegopsida				

Family Cranchiidae				
**Teuthowenia megalops*	4657	2	0.019	4
*Taoniinae	4590	1	0.018	2
Family Gonatidae				
**Gonatus*	4569	1	0.066	1
Family Histioteuthidae				
**Histioteuthis reversa*	4580	3	0.046	3
Family Ommastrephidae				
**Illex illecebrosus*	4511	197	3890.47	29126
Order Sepiida				
Family Sepiolidae				
Sepiolidae	4536	30	0.3365	68
PHYLUM ARTHROPODA				
CLASS HEXANAUPLIA				
Cirripedia	2990	28	9.3056	360
Order Sessilia				
Family Balanidae				
Balanidae	2995	3	0.0065	14
CLASS MALACOSTRACA				
Order Amphipoda				
Amphipoda	2800	10	0.0271	22
*Hyperiidea	2906	6	0.0029	8
Family Cystisomatidae				
**Cystisoma*	-	2	0.0045	2
Family Eusiridae				
Rhachotropis aculeata	2848	2	0.028	54
Family Phronimidae				
**Phronima*	2946	5	0.0023	6
Family Uristidae				
Anonyx	2833	1	0.001	1
Order Decapoda				
Decapoda	2100	1	0.001	1
Brachyura	2510	2	0.008	3
*Caridea	3240	21	0.4957	496
Family Acanthephyridae				
**Acanthephyra pelagica*	8353	12	1.5042	451
**Acanthephyra purpurea*	2362	9	0.161	79
Family Aristeidae				
**Aristaeopsis edwardsiana*	1281	1	0.114	1
*Aristeidae	-	1	0.036	3
Family Benthesicymidae				
**Benthesicymus bartletti*	-	6	0.299	37
**Gennadas*	2471	10	0.0253	55
Family Cancridae				
Cancer	2524	1	0.002	3
Cancer borealis	2511	100	52.4231	356
Cancer irroratus	2513	57	57.1803	523
Family Crangonidae				
Argis dentata	2411	28	4.297	1233
Crangon septemspinosa	2417	13	0.3012	523

Metacrangon jacqueti	-	5	0.0813	53
Pontophilus norvegicus	2415	30	0.1755	119
Sabinea	2420	2	0.0141	7
Sabinea hystrix	-	3	0.054	11
Sabinea septemcarinata	2421	3	0.064	68
Sclerocrangon boreas	2414	6	0.284	77
Family Geryonidae				
Chaceon quinquedens	2532	8	24.276	92
Family Glyphocrangonidae				
Glyphocrangon longirostris	-	6	0.2185	45
Family Lithodidae				
Lithodes maja	2523	21	10.338	39
Neolithodes grimaldii	2528	1	1.34	1
Family Munididae				
Munida iris	2555	3	0.023	5
Munida valida	2556	2	0.0035	2
Family Munidopsidae				
Munidopsis curvirostra	2566	10	0.0287	43
Family Nephropidae				
Homarus americanus	2550	114	2606.062	3609
Family Nematocarcinidae				
**Nematocarcinus*	-	8	0.556	137
Family Oplophoridae				
**Oplophorus spinosus*	2369	3	0.0032	4
Family Oregoniidae				
Chionoecetes opilio	2526	53	205.738	1540
Hyas	2520	16	0.0398	41
Hyas araneus	2527	10	2.89	29
Hyas coarctatus	2521	39	18.9609	473
Family Paguridae				
Paguridae	2559	38	2.2751	102
Pagurus acadianus	2562	17	2.696	64
Pagurus arcuatus	2568	15	2.028	59
Family Pandalidae				
**Atlantopandalus propinqvus*	2213	16	1.6453	400
**Dichelopandalus leptocerus*	2214	3[(1)]	-	-
**Pandalus borealis*	2211	21	375.677	62082
**Pandalus montagui*	2212	155[(1)]	96.8186[(1)]	41480[(1)]
Family Parapaguridae				
Parapagurus pilosimanus	-	3	0.208	68
Family Pasiphaeidae				
**Parapasiphae sulcatifrons*	2222	6	0.0489	25
**Pasiphaea multidentata*	2221	22	8.9426	4865
**Pasiphaea tarda*	2220	7	0.54	27
Family Polybiidae				
Bathynectes	-	2	0.171	2
Family Polychelidae				
Pentacheles laevis	-	3	0.137	5
Stereomastis nana	-	5	0.141	46
Stereomastis sculpta	1056	8	1.16	41
Family Sergestidae				

**Eusergestes arcticus*	2223	24	3.1314	5104
**Robustosergia robusta*	1283	5	0.021	16
**Sergestes*	2461	1	0.002	4
**Sergia*	8354	5	0.0043	5
Family Thoridae				
Eualus fabricii	2332	7	0.313	464
Eualus gaimardii	2333	1	0.027	54
Eualus macilentus	2331	4	0.739	868
Lebbeus groenlandicus	2319	2	0.409	412
Lebbeus polaris	2312	14	0.2937	331
Spirontocaris	2310	1	0.001	1
Spirontocaris liljeborgii	2313	9	0.031	31
Spirontocaris phippsii	2315	4	0.008	15
Spirontocaris spinus	2316	4	0.155	167
Order Euphausiacea				
*Euphausiacea	2600	29	2.4631	8618
Family Euphausiidae				
**Meganyctiphanes norvegica*	2611	13	0.3749	1390
Order Isopoda				
Isopoda	2980	11	0.0189	12
Order Lophogastrida				
Family Gnathophausiidae				
**Gnathophausia zoea*	-	3	0.0246	11
*Gnathophausiidae	-	4	0.0025	6
Order Mysida				
*Mysida	2700	4	0.0086	28
CLASS Pycnogonida				
Pycnogonida	5100	3	0.0172	47
Order Pantopoda				
Family Colossendeidae				
Colossendeis	-	5	0.041	9
Family Nymphonidae				
Nymphon	2893	14	0.0099	22
Family Pycnogonidae				
Pycnogonum litorale	5102	2	0.0011	2
PHYLUM ECHINODERMATA				
CLASS CRINOIDEA				
Order Comatulida				
Family Bourgueticrinidae				
Rhizocrinus	-	1	0.0002	5
CLASS OPHIUROIDEA				
Ophiuroidea	6200	35	3.7957	9631
Order Euryalida				
Family Gorgonocephalidae				
Gorgonocephalus	6310	22	29.707	258
Order Ophiurida				
Family Ophiactidae				
Ophiopholis aculeata	6211	86	5.1049	2304
Family Ophiuridae				
Ophiura sarsii	6213	36	8.2847	12137

CLASS ASTEROIDEA				
Asteroidea	6100	44	5.0999	956
Order Forcipulatida				
Family Asteriidae				
Asterias forbesi	6109	2	0.044	3
Asterias rubens	6111	103	39.7252	1838
Leptasterias	6114	21	0.2291	120
Leptasterias polaris	6113	25	23.556	315
Stephanasterias albula	-	9	0.03	35
Order Notomyotida				
Family Benthopectinidae				
Pontaster	6133	9	0.1883	59
Order Paxillosida				
Family Astropectinidae				
Leptychaster arcticus	8348	3	0.0038	5
Psilaster andromeda	8347	11	1.892	84
Family Ctenodiscidae				
Ctenodiscus crispatus	6115	32	24.32	4587
Family Pseudarchasteridae				
Pseudarchaster	6116	10	0.4	16
Order Spinulosida				
Family Echinasteridae				
Henricia	6118	124	1.9804	836
Order Valvatida				
Family Goniasteridae				
Ceramaster granularis	6101	20	0.818	38
Hippasteria phrygiana	6117	45	17.205	162
Mediaster bairdi	-	4	0.13	9
Family Poraniidae				
Porania pulvillus	6102	22	3.804	73
Poraniomorpha hispida	6129	10	0.609	16
Family Solasteridae				
Crossaster papposus	6123	53	21.003	365
Solaster endeca	6121	26	5.823	54
Order Velatida				
Family Pterasteridae				
Pteraster	-	9	0.1096	55
Pteraster militaris	6125	22	0.704	78
CLASS ECHINOIDEA				
Order Camarodonta				
Family Strongylocentrotidae				
Strongylocentrotus droebachiensis	6411	58	140.4973	3554
Order Clypeasteroida				
Family Echinarachniidae				
Echinarachnius parma	6511	51	13.879	855
Order Echinothurioida				
Echinothurioida	-	6	8.74	66
Family Phormosomatidae				
Phormosoma placenta	-	1	0.045	2
Order Spatangoida				
Family Schizasteridae				

Brisaster fragilis	6413	8	2.201	147
Class HOLOTHUROIDEA				
Holothuroidea	6600	3	0.091	15
Order Dendrochirotida				
Family Cucumariidae				
Cucumaria frondosa	6611	58	881.944	1882
Family Psolidae				
Psolus	6710	10	0.2702	16
Order Molpadida				
Family Molpadiidae				
Molpadia	6718	1	0.026	1
PHYLUM BRYOZOA				
Bryozoa	1900	31	0.4271	589
CLASS GYMNOLAEMATA				
Order Cheilostomatida				
Family Eucrateidae				
Eucratea loricata	-	10	0.205	44
Family Flustridae				
Flustra foliacea	1901	32	328.6765	336
PHYLUM BRACHIOPODA				
Brachiopoda	1930	23	0.1223	134
PHYLUM CHORDATA				
CLASS ASCIDIACEA				
Ascidiacea	-	31	40.0204	1093
Order Aplousobranchia				
Family Didemnidae				
Didemnidae	-	1	0.003	1
Order Phlebobranchia				
Family Ascidiidae				
Ascidia	1821	58	4.350	784
Order Stolidobranchia				
Family Pyurida				
Boltenia ovifera	-	34	36.38	582
CLASS THALIACEA				
Order Salpida				
Family Salpidae				
*Salpidae	1840	6	0.021	19

(1) Five specimens from three stations identified at sea as *Pandalus montagui* were reviewed in the laboratory and they correspond to *Dichelopandalus leptocerus.* Therefore the total biomass, abundance and number of fishing stations with presence of *P. montagui* likely include records of *D. leptocerus.* Revision of the photos collected at sea suggests that some of the southern/western records of *P. montagui* are suspicious and a detailed sampling is needed for future surveys.