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# ST. GEORGES BAY ECOSYSTEM PROJECT (GBEP): RESEARCH REPORT III: A REVIEW OF BENTHIC FAUNA/COMMUNITY STUDIES IN ATLANTIC CANADA AND NORTHEASTERN AMERICAN SHALLOW WATERS

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# St. Georges Bay EcosystemProject (GBEP): Research Report III: A Review of Benthic Fauna/Community Studies in Atlantic Canada and Northeastern American Shallow Waters

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Appendix 3: Species list from sampling in Northumberland Strait in 1975.

**Abstract:**

Mitchell, S. 2000. St. Georges Bay Ecosystem Project (GBEP): Research Report III: A Review of Benthic Fauna/Community Studies in Atlantic Canada and Northeastern American Shallow Waters. Document prepared by the Interdisciplinary Studies in Aquatic Resources, St. Francis Xavier University, Antigonish Nova Scotia for Fisheries and Oceans Canada, Can. Manuscr. Rep. Fish Aquat. Sci. 2513, iv + 71p + Appendix.

This report presents the results of preliminary research focused on the St. Georges Bay Ecosystem, located along Nova Scotia's Northumberland Strait, in the Southern Gulf of St. Lawrence. Report III contains a review of benthic fauna and community structure within the Bay done through a comprehensive literature review. It summarises existing information on the benthic fauna and communities of nearby and relevant locations. The information is principally drawn from the primary literature and is delimited by depths of 0 to 150 m, and north-south geography of the northern Gulf of St. Lawrence, south to North Carolina. This large area of coastline was grouped and reported on as five separate zones – Northumberland Strait, Gulf of St. Lawrence, Nova Scotia (Atlantic Coast), New Brunswick (Bay of Fundy), and American coastal studies.

**Résumé:**

Mitchell, S. 2000. St. Georges Bay Ecosystem Project (GBEP): Research Report III: A Review of Benthic Fauna/Community Studies in Atlantic Canada and Northeastern American Shallow Waters. Document prepared by the Interdisciplinary Studies in Aquatic Resources, St. Francis Xavier University, Antigonish Nova Scotia for Fisheries and Oceans Canada, Can. Manuscr. Rep. Fish Aquat. Sci. 2513, iv + 71p + Appendix.

Le rapport présente les résultats de la recherche préliminaire sur l'écosystème de la baie St. Georges situé le long du détroit de Northumberland qui jouxte la Nouvelle-Écosse dans le sud du golfe du Saint-Laurent. Le rapport III examine la faune benthique et la structure des communautés à l'intérieur de la baie grâce à un dépouillement exhaustif de la documentation. Il résume l'information existante sur la faune benthique et les communautés habitant les régions contiguës et d'autres qui peuvent être pertinentes aux fins de l'étude. L'information est tirée principalement de la documentation primaire et est délimitée par les profondeurs de 0 à 150 m, et la géographie nord-sud, délimitée au nord par le golfe du Saint-Laurent et au sud par la Caroline du Nord. Cette vaste étendue de côtes a été regroupée et a fait l'objet d'études en tant que cinq zones distinctes – le détroit de Northumberland, le golfe du Saint-Laurent, la Nouvelle-Écosse (côte Atlantique), le Nouveau-Brunswick (baie de Fundy), et les études de la côte américaine

# Acknowledgements

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# 1. Introduction

The St. Georges Bay Ecosystem Project is a collaborative study between Government, harvesters, First Nations and the Interdisciplinary Studies in Aquatic Resources (ISAR) program at St. Francis Xavier University of the St. Georges Bay ecosystem. There are a number of social and ecological goals for this project (see Cameron et al., 2000), two of which are the:

- Assemblage of the major bodies of information, data, and published material regarding the geology, oceanography, marine biology, ecology, fisheries, human occupation and use of the watersheds and marine waters.
- Employing these materials, construction of a dynamic, though preliminary, ecological model of the St. Georges Bay system.

In addressing the first goal, a lack of information on benthic fauna and community structure within the St. Georges Bay area was identified. Therefore, a comprehensive literature review was initiated to assess and summarize existing information on the benthic fauna and communities of nearby and relevant locations. Published information has been collected and is reported below for five principle areas:

1. Northumberland Strait
2. Gulf of St. Lawrence
3. Nova Scotia (Atlantic Coast)
4. New Brunswick (Bay of Fundy)
5. U.S. Coastal Studies

The information presented has been principally drawn from the primary literature (i.e., published journals) with the more local information coming from secondary sources (government and University reports). It is recognized, as pointed out by Dunbar et al. (1980), "***There is a real possibility that a great deal of faunistic information exists in unpublished form, especially in government marine laboratories***". However, determination and gathering of this diffuse information was beyond the scope of this review. This review is drawn almost exclusively from English publications only, though it must be recognized that there is a large extant body of marine information published in French. In order to limit this review to relevant studies, a study or station within a study was only included if the water depth was less than 150 m (maximum depth to be expected within the study area), and subtidal (intertidal communities not included). This review incorporates American studies as far south as North Carolina. This is justified in that some of the physical parameters of St. Georges Bay area are, in many ways, more similar to the American coastal waters than to the northern Gulf of St. Lawrence (see Cameron and Mitchell, 2000). In order to incorporate as much relevant information as possible, studies in which the benthos was included as a secondary component (e.g., as part of a commercial lobster or scallop investigation) are also included in this review.

Four caveats must be borne in mind by the reader:

1) There are differences in sampling methods between studies and this will result in different species, and different proportions of species, being captured. Therefore, making detailed direct comparison between studies will probably not reflect the actual benthic composition between the two or more studies. Sanders (1968) recommends that to have data comparable, the type of gear, methodology used in processing the sample, and the screen size employed in washing the sample should be approximately similar. These are not so between the variety of studies presented here.

2) Sampling does not capture all of the bottom fauna. Samples will be biased to certain species/taxa and may give an incorrect picture of the details of the benthic community/assemblage. Stickney and Stringer (1957) provide three cases where this may be true: 1) when organisms are of such size and shape that some will be retained by large mesh screens while others will not, 2) When a species is collected in only scattered samples or is represented by only one individual in but occasional samples, and 3) when organisms burrow too deeply into the substrate to be taken by the sampler.

3) Reporting detail: Depending upon the purpose of the research, and the argument the author of a paper is presenting, the level of detail within published works ranges from species presence, biomass, and density to simple reporting of the phyla present as a percentage of total species present. These variations in information presented within papers further limits the ability to compare across studies.

4) Benthic fauna/communities exist in seasonally fluctuating environments. Results (particularly biomass) will depend upon the time of year of sampling. The majority of the sampling is done in the summer months, but there are fluctuations even within the relatively short time of early summer to late summer. As well, as Dexter (1944) points out, population changes occur from time to time [from unknown or undetermined stochastic events] which would alter the relative significance of many species in their community relationships.

While these caveats must be borne in mind, comparison of a large number of studies at a broader scale may dampen the fluctuations and so provide some reliable information on broad scale trends.

The following discussion is presented in order of geographic location with the most proximal areas presented first (Northumberland Strait, Gulf of St. Lawrence) and moving to more distant locations (American coastal studies) The level of detail reported herein decreases with increasing distance to reduce the probability of drawing erroneous conclusions from levels of detail not applicable over large areas. Within each broad location, the reported studies are presented in chronological order to the degree practical. For each study summarized the year of sampling, water depths and substrate type are presented where they were reported. One of the challenges of the benthic invertebrate literature is the use of scientific names without inclusion of classification to phyla/class. Unless the reader is intimately familiar with all benthic species, this may get confusing. In an attempt to clarify this, Appendix 1 contains an alphabetical list of invertebrate species mentioned in the text with their higher level classification, and Appendix 2 contains the same for algae and marine plants. As well, to the degree practical while maintaining readability, the classification has been given in the text to assist the reader.

### *Comments on Communities and Trophic Guilds*

The following comments are intended to provide the reader with the background for the discussions through the text of this document.

The ecological literature contains a great deal of discussion regarding communities; whether they exist in reality or are sampling artifacts, what they represent, how to define them, etc. I will not discuss this but Mills (1969) and Jones (1950), though 30 and 40 year old papers, provide very good discussion of these issues in the marine environment. For the purposes of this review, I accept that communities are natural structures and intend the term in the form of Mills (1969): "*Community means a group of organisms occurring in a particular environment, presumably interacting with each other and with the environment, and separable by means of ecological survey from other groups*".

Benthic surveys have shown that areas having similar environmental conditions will support a benthic fauna of like composition (Peer, 1963). The environmental factors affecting community structure include substrate, salinity, water temperature, water energy, light, oxygen content and sedimentation (Jones, 1950; Logan et. al., 1983). The three most important factors are temperature, salinity and the nature of the substrate; where two of these factors are relatively homogenous, the third play a more significant role (Jones, 1950). So, over large areas of similar salinity and bottom temperature (e.g., Northumberland Strait) the substrate may be considered to be the more important variable affecting benthic fauna presence and community structure. In the deeper waters communities must shift from autotrophy to heterotrophy. Benthic marine organisms are predominantly either suspension or deposit feeders (Rhoads and Young, 1970), apparently due largely to the forms of the food supply in this environment. The inputs of energy reach the benthos below the euphotic zone in only two ways, either as current transported particles (food for suspension feeders) or as sedimented particles (food for deposit feeders); other trophic groups (e.g., carnivores, omniverous scavengers) are basically dependent upon these groups for energy (Wildish, 1983).

## 2. Study Area

The following description is adapted from Cameron et al. (2000).

The St. Georges Bay Ecosystem Project study area extends from Lismore, Nova Scotia (Lat. 45° 42.5'N Long., 62° 16.4'W) northeast to Pleasant Bay, Cape Breton (Lat. 46° 49.8'N, Long. 48.00°W) and offshore to a line between these two points. This area consists of approximately 2,625 $km^2$ of marine waters. The bay itself is roughly square in shape with estimated dimensions of 30 km by 30 km, a mean depth of 30 m and maximum depth of 40 m (Petrie and Drinkwater, 1978). The surface area is estimated at between 940 $km^2$ (Prouse and Hargrave, 1977) and 1160.5 $km^2$ (Harding et al., 1979; Kenchington, 1980). Freshwater input to the bay through land drainage is estimated at an annual average of 37 $m^3/s$ with a maximum of 114 $m^3/s$ (Petrie and Drinkwater, 1978). Spring tidal range for the bay is typically 1.4 m and the tides have a marked diurnal irregularity (Drinkwater, 1979).

St. Georges Bay and the coastline along the western edge of Cape Breton are part of the Magdalen Shelf and are bounded to the west by the Cape Breton Trough (Loring and Nota, 1973). Water depths within St. Georges Bay are shallow (less than 40 m) while farther up the coast, near Cheticamp and Pleasant Bay, depths are greater; extending down to 50-60 m (Figure 1). The Cape Breton Trough deepens from 18 m at the western end of the study area to 140 m at the eastern (Loring and Nota, 1973).

The surface water is cold immediately after the ice leaves the area (April-May), with typical water temperatures of 3-5°C (Cameron et al., 2000). With solar heating the surface waters warm though the year to commonly reach 18-19°C and occasionally 20°C The temperatures of deeper water (i.e., >20 m) range from lows of less than 0°C in the spring to >10°C by September/October. Swain (1993) provides bottom temperatures from between 1971 and 1992 for the offshore depths of the study area. From Lismore to approximately Inverness bottom temperatures have averaged 1-10°C with a range of 0-18°C, while from Inverness to Pleasant Bay bottom temperatures have averaged 0.5-5°C and ranged from –0.5 to 8°C. Swain (1993) also reports that for the Gulf of St. Lawrence as a whole, bottom temperatures between 40-59 m tended to be fairly warm in the 1970's and relatively cold since the mid-1980's.

Seafloor sediment composition has been reported in the St. Georges Bay area by Kranck (1971) and Loring and Nota (1973). The following description, and Figure 2, is generalized from these publications. Bottom sediments of the coast from Lismore to St. Georges Bay are mixtures of sands and gravels including pelites (material <5μm), pebbles, cobbles, blocks and boulders. The thickness of sediment varies from less than 1 m to 10-15 m thick. In general, this deposit (termed *Buctouche sand and gravel* in Kranck, 1971) is found in areas of strong currents, with an average maximum tidal current greater than 0.5 knots [26 cm/s]. This Buctouche sand and gravel is comprised of medium grained well sorted sand to coarse gravel with all gradations between the two. There are two facies, the first consisting of sand containing <5% gravel and the second containing >5%. In both facies the mud size component is less than 5% and the median particle size is 0.3 mm.

Within St. Georges Bay proper, the eastern, southern and western nearshore areas are basically of the same composition as that described for Lismore to St. Georges Bay (i.e., Buctouche sand and gravel). In the central area of the bay there are intrusions of finer sediments from Northumberland Strait. These sediments are largely (>30%) pelite with median particle diameters on the order of 0.01-0.02 mm. These *Pugwash muds* (terminology from Kranck, 1971) conform to areas of low tidal current speeds (<0.5 knots [<26 cm/s]). These sediments are composed of three facies: 1) a silty mud containing 95% silt and clay (median particle diameter 0.01 mm), 2) sandy mud containing 50-90% silt and clay (median particle diameter 0.02 mm), and 3) muddy sand containing 5-50% silt and clay (median particle diameter 0.12 mm). In addition, Kranck (1971) recognizes large areas within the bay of mixed bottom, areas that are not dominated by any particular sediment classification. The primary sources of these new fine grained sediments to St. Georges Bay are the river and shoreline erosion of the adjacent landmasses.

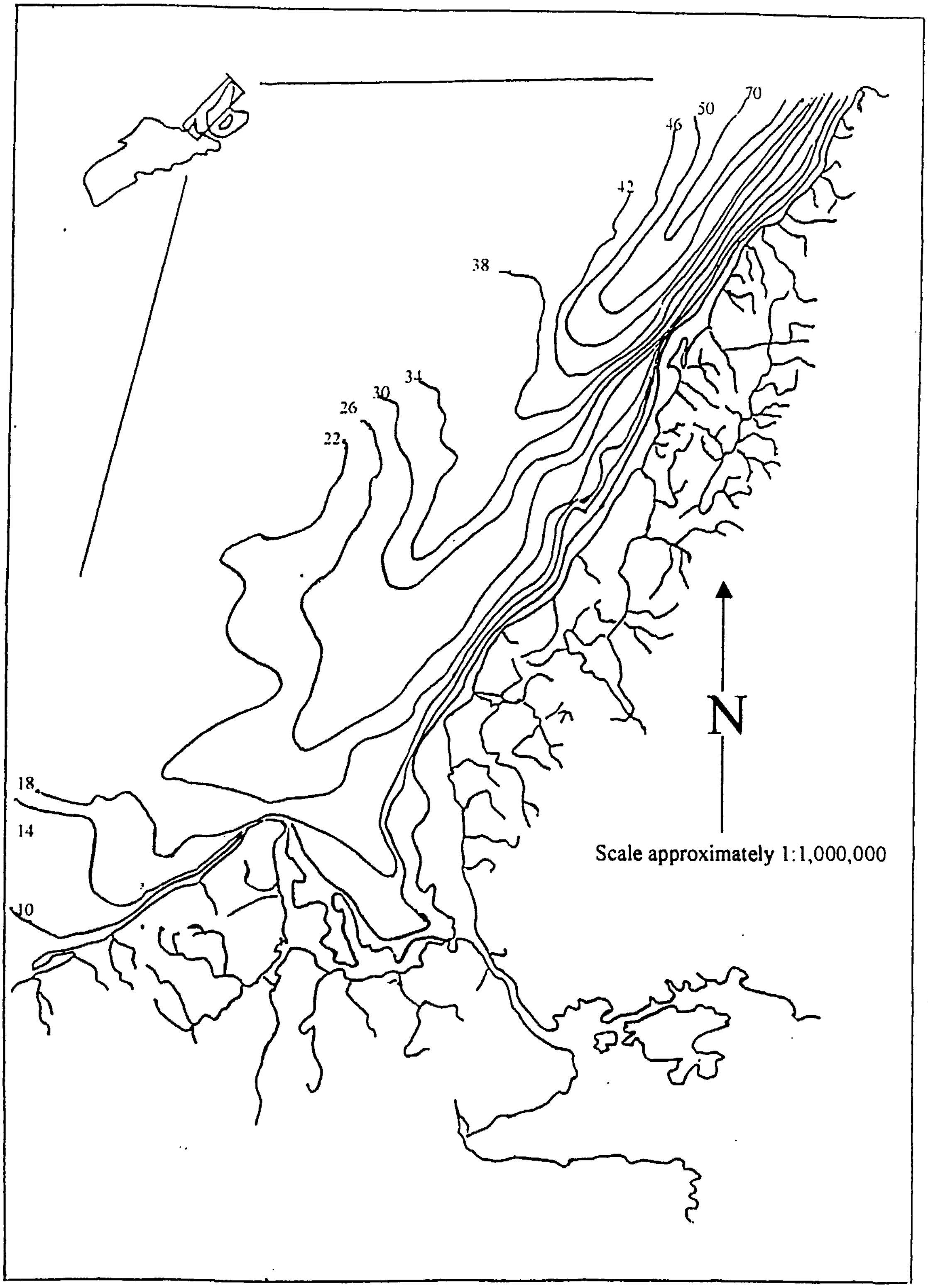



Figure 1: Bathymetry (fathoms) of the St. Georges Bay study area; from Loring and Nota (1973). Note: isobaths in four fathom increments except at northern end where depth increases rapidly.

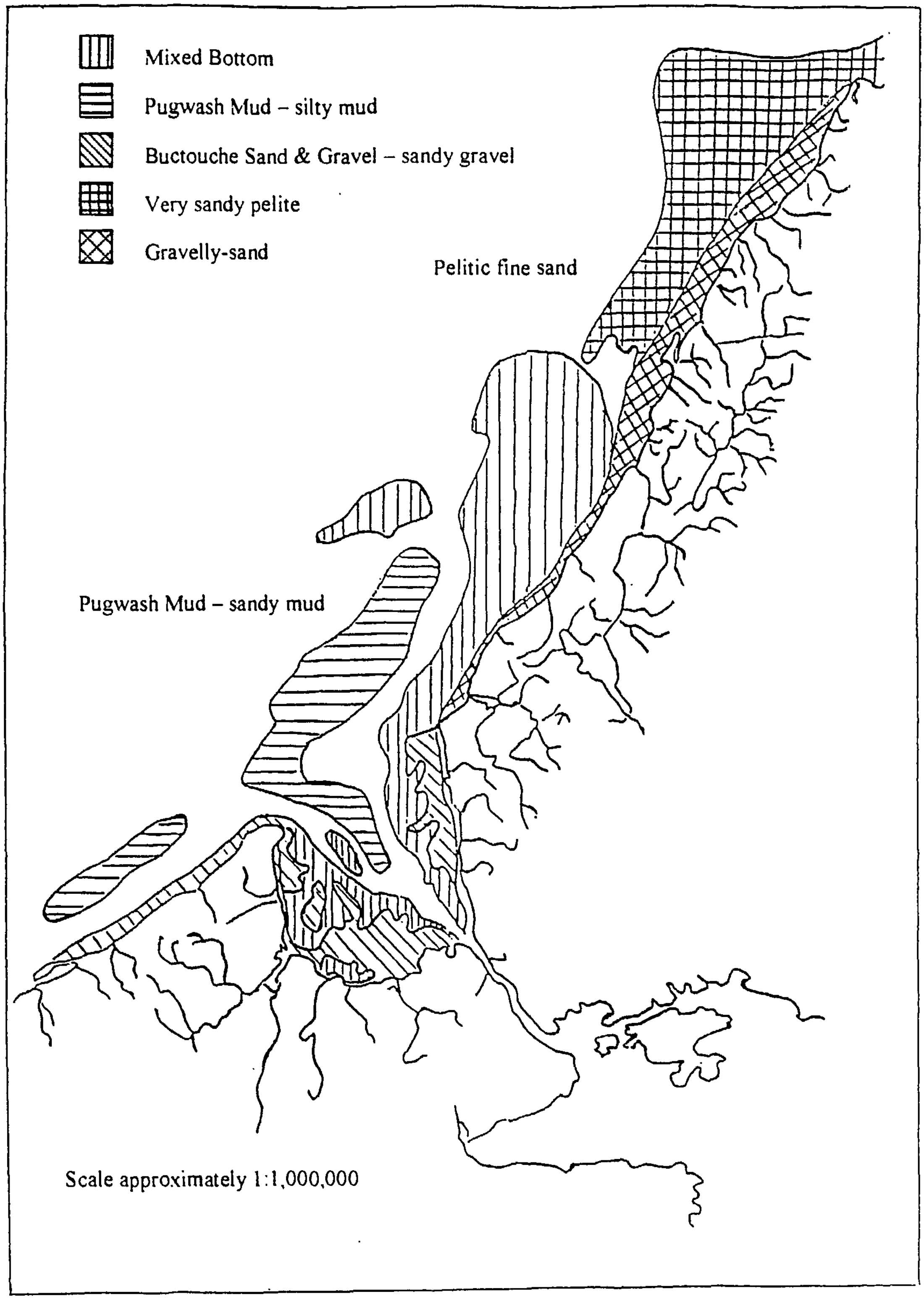



Figure 2: Generalized sediment distribution within St. Georges Bay study area. Compiled from Kranck (1971), and Loring and Nota (1973).

Sediment composition along the Cape Breton shores, from St. Georges Bay to Pleasant Bay, is composed of very sandy fines [pelites] along the northern edge of St. Georges Bay and Port Hood and fine sands in the offshore areas from Port Hood to Pleasant Bay. The nearshore areas within this same stretch are gravelly poorly-sorted sands (from Loring and Nota, 1973). Kranck (1971) maps the lower half of this section as mixed bottom consisting of small patches of thin discontinuous layers of mud deposited over older coarser sediment. The composition of this area varies greatly from clean well sorted gravel to poorly sorted, silty sandy gravel or fine mud.

The sources of these sediments are attributed to erosion of the local landmasses (Kranck, 1971; Prouse and Hargrave, 1977) and resuspension of deposited shallow water sediments by advective or turbulent near bottom flow (Hargrave, 1977; Prouse and Hargrave, 1977). Ice rafting of material and deposition is not thought to be an important sediment transport process within this area (Kranck, 1971; Loring and Nota, 1973), nor is the sediment ejected by the large but distant St. Lawrence River (Sundby, 1974 cited in Schafer and Mudie, 1980).

# 3. Benthic Fauna/Communities

Published studies are reviewed/summarized and laid out below for five principle areas:

1. Northumberland Strait
2. Gulf of St. Lawrence (Southern and Northern)
3. Nova Scotia (Atlantic Coast)
4. New Brunswick (Bay of Fundy)
5. US Coastal Studies

Figure 3, and the legend that accompanies it, indicate the locations of the reviewed studies.

## *3.1 Northumberland Strait*

Northumberland Strait is that area between Prince Edward Island and the mainland of the provinces of New Brunswick and Nova Scotia, and has water depths of 10-20 m at the western end and >30 m at the eastern end (Kranck, 1972). The environmental conditions within the Strait are markedly different from those prevailing on the exposed Atlantic and lower Fundy shores (MacFarlane, 1966); conditions within St. Georges Bay however, are largely similar to conditions in the Strait (Moseley and MacFarlane 1969). Despite the intensive use of the area for fisheries by three provinces, and megaproject development (Confederation Bridge), little work has been done on the benthos in the Northumberland Strait area.

A survey of the benthic fauna of Northumberland Strait from the northwestern to eastern end of Prince Edward Island was conducted in 1975 with 96 stations being occupied taking samples from depths ranging from 5-49 m (the majority were 10-20 m deep) (Caddy et al., 1977). Bottom sediments were composed of gravel/coarser material, sand, and silt/clay. The Strait was divided into four areas (A-D) of which Area D, with a substrate of principally mud and mud-clay, is immediately adjacent to St. Georges Bay Results are summarized here for both the entire Strait as well as Area D. Seventy four species of algae (43 species of Rhodophyta, 27 species Phaeophyta, 2 species each of

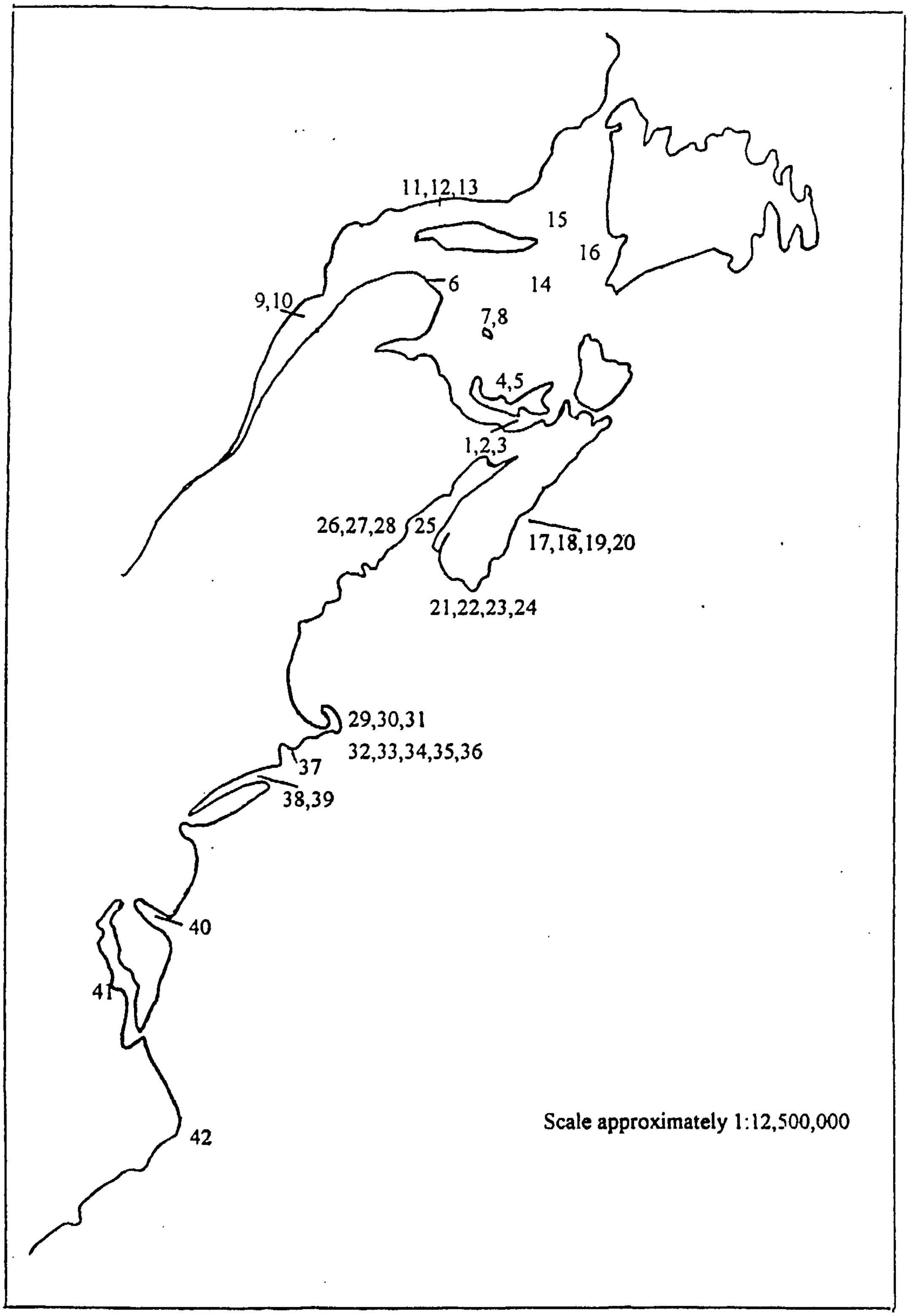



Figure 3: Locations of studies reviewed. See Legend on following page for locations and sources of studies.

| Study | Source | Location |
|---|---|---|
| 1 | Caddy et al.,1977 | Northumberland Strait |
| 2 | Anonymous, 1997,1998 | Northumberland Strait |
| 3 | Scarrat & Lowe, 1972 | Kouchibouguac Bay, Northumberland Strait |
| 4 | Hughes & Thomas, 1971a | Bedeque Bay, Prince Edward Island |
| 5 | Hughes & Thomas, 1971b | Bideford River estuary, Prince Edward Island |
| 6 | Brunel, 1971 | Bay of Gaspe, Gulf of St. Lawrence |
| 7 | Bourget & Messier, 1983 | Magdalen Islands |
| 8 | Hudon & Lamarche, 1989 | Magdalen Islands |
| 9 | Robert, 1979 | St. Lawrence Estuary |
| 10 | Himmelman & Lavergne, 1985 | St. Lawrence Estuary |
| 11 | Himmelman, 1991 | Mingan Islands |
| 12 | Jalbert et al., 1989 | Mingan Islands |
| 13 | Himmelman & Dutil, 1991 | Mingan Islands |
| 14 | Peer, 1963 | Magdalen Shallows/Laurentian Channel |
| 15 | Long & Lewis, 1987 | Anticosti & Esquiman Channels |
| 16 | Wieczorek & Hooper, 1995 | Bonne Bay, Newfoundland |
| 17 | Brawn et al., 1968 | St. Margarets Bay, Nova Scotia |
| 18 | Miller et al., 1971 | St. Margarets Bay, Nova Scotia |
| 19 | Peer, 1970 | St. Margarets Bay, Nova Scotia |
| 20 | Volkaert, 1987 | St. Margarets Bay, Nova Scotia |
| 21 | Elner & Campbell, 1987 | Southern Nova Scotia |
| 22 | Hatcher et al., 1996 | Southern Nova Scotia |
| 23 | Barbeau et al., 1996 | Southern Nova Scotia |
| 24 | Drummond-Davis et al., 1982 | Southern Nova Scotia |
| 25 | Caddy, 1970 | Bay of Fundy |
| 26 | Wildish et al., 1972 | L'Etang Inlet, Bay of Fundy |
| 27 | Wildish, 1983 | Passamoquoddy area, Bay of Fundy |
| 28 | Logan et al., 1983 | Passamoquoddy area, Bay of Fundy |
| 29 | Dexter, 1944 | Ipswich Bay, Massachusetts |
| 30 | Dexter, 1947 | Cape Ann, Massachusetts |
| 31 | Young & Rhoads, 1971 | Cape Cod Bay, Massachusetts |
| 32 | Sanders, 1958 | Buzzards Bay, Massachusetts |
| 33 | Sanders, 1960 | Buzzards Bay, Massachusetts |
| 34 | Weiser, 1960 | Buzzards Bay, Massachusetts |
| 35 | Wigley & McIntyre, 1964 | Martha's Vineyard, Massachusetts |
| 36 | Lee, 1944 | Menemsha Bight, Massachusetts |
| 37 | Stickney & Stringer, 1957 | Greenwhich Bay, Rhode Island |
| 38 | MacKenzie, 1977 | Long Island Sound, Conneticut |
| 39 | O'Connor, 1972 | Moriches Bay, Long Island, New York |
| 40 | Maurer et al., 1978 | Delaware Bay, Delaware |
| 41 | Virnstein, 1977 | Chesapeake Bay, Maryland |
| 42 | Day et al., 1971 | Cape Lookout North Carolina |

Legend for Figure 3 providing literature sources and locations for marine benthic studies displayed in Figure 3.

Chlorophyta and Cyanophyta) were found with the most commonly occurring (>50% of samples) being *Phyllophora* spp., *Polysiphonia* spp., and *Laminaria longicruris*. Species found in 25-50% of samples included *Ectocarpus siliculosus, Desmarestia aculeata, Fucus* spp., *Cystoclonium purpureum, Rhodomela confervoïdes*, and *Rhodymenia palmata.*

Benthic macrofauna results from van Veen grab samples are presented in Table 1 including both the Strait as a whole and Area D. A complete species list of the 343 invertebrate species collected from this sampling program is presented in Appendix 3. Polychaetes indicate the greatest species abundance followed by amphipods, bivalves and arthropods, gastropods, and finally echinoderms. Sampling by beam trawl and scallop dredge indicated that echinoderms (*Asterias vulgaris* [64% of stations], *Henricia sanguinolenta* [53%], *Echinarachinus parma* [47%]) were the most widespread benthic fauna. Of 25 bivalve species sampled by trawl the mussels *Modiolus modiolus* (35.5% of stations) and *Mytilus edulis* (31.3%) were most common. Of 37 gastropod species the most commonly encountered were *Nassarius trivittatus* (21% of stations), *Lunatia heros* (17%) and *Neptunea decemcostata* (14%). The most common arthropods, excluding the prevalent amphipods, were *Crangon septemspinosa* (36% of stations), *Pagurus acadianus* (30%), and *Pandalus montagui* (21%). Other commonly encountered fauna included hydroids (51% of stations), bryozoans (47%) and Porifera (47%).

In terms of biomass, the echinoderms contributed the majority in the western half of Northumberland Strait (41.1-86.38% of total biomass). The polychaetes, bivalves and gastropods made up 13-28% of the biomass in this area and arthropods <2%. In Area D however, adjacent to St. Georges Bay, bivalves contributed greatest to the biomass (42.48%) followed by polychaetes (25.18%) echinoderms (15.13%), gastropods (2.32%), and arthropods (0.62%). Other species not falling into these taxa account for 14.26 %. Biomass of fauna (g wet weight/$m^2$) for the whole Strait ranged from 0.01-750.6 for polychaetes, 0.01-112.6 for bivalves, 0.01-137.1 for gastropods, 0.01-555.2 for echinoderms, and 0.01-19.3 for arthropods. Within Area D total biomass (all taxa combined) ranged from 2.25-141.6 g wet weight/$m^2$, with biomass of individual taxa

Table 1: Number of species. families, and most common species captured in Northumberland Strait in 1975 in van Veen grab samples. Area D is that portion of the Northumberland Strait study area immediately adjacent to St. Georges Bay. Data from Caddy et al. (1977)

| | Northumberland Strait | | | Area D | | |
|---|---|---|---|---|---|---|
| | # of species | # of families | Most common species | # of species | # of families | Most common species |
| **Bivalves** | 26 | 13 | *Astarte undata*<br>*Clinocardium ciliatum*<br>*Tellina agilis*<br>*Thyasira gouldii* | 19 | 11 | *Clinocardium ciliatum*<br>*Modiolus modiolus*<br>*Nucula tenuis*<br>*Thyasira gouldii*<br>*Yoldia sapotilla* |
| **Gastropods** | 16 | 12 | *Nassarius trivittatus*<br>*Retusa canaliculata* | 5 | 4 | *Admete couthouyi*<br>*Oenopta (Lora) elegans*<br>*Oenopta turricula* |
| **Polychaetes** | 91 | 29 | *Ninoe nigripes*<br>*Pholoe minuta*<br>*Prionospio steenstrupi* | 58 | 25 | *Pholoe minuta*<br>*Prionospio steenstrupi*<br>*Spio* sp. |
| **Arthropods** | 26 | 13 | *Aeginina longicornis*<br>*Diastylis quadraspinosa*<br>*Diastylis sculpta*<br>*Eudorella trunculata* | 16 | 8 | *Diastylis quadraspinosa*<br>*Eudorella emarginata*<br>*Eudorella trunculata*<br>*Leucon nasica* |
| **Amphipods** | 73 | 19 | *Ampelisca macrocephala*<br>*Ampelisca vadorum*<br>*Corophium bonelli*<br>*Phoxocephalus holbolli*<br>*Unciola irrorata* | 41 | 17 | *Ampelisca macrocephala*<br>*Byblis gaimardi*<br>*Corophium bonelli*<br>*Harpinia propinqua*<br>*Phoxocephalus holbolli* |
| **Echinoderms** | 6 | | *Echinarachinus parma*<br>*Ophiura robusta* | 5 | 5 | *Asterias vulgaris*<br>*Ophiura robusta*<br>*Strongylocentrotus drobachiensis* |

ranging as: polychaetes (0.3-750.6 g wet weight/$m^2$), bivalves (0.44-112.6), gastropods (0.21-123.2), echinoderms (0.01-418.1) and arthropods (1.52-608.1).

In 1967, Scarrat and Lowe (1972) conducted a study on the biology of the rock crab (*Cancer irroratus*) in Kouchibouguac Bay. Sampling between 4 and 18 m depth these authors found a standing stock ranging from 0.7 to 3.8 g/$m^2$, with the greater values being found on boulders in both the spring and fall.

In 1980, Dunbar et al. (1980) compiled existing information to "describe and map the known distribution of the marine communities and faunal and floral elements in the Gulf of St. Lawrence". Benthic invertebrates and algae reported by these authors in the vicinity of the St. Georges Bay study area are listed in Table 2. Due to the paucity of information on the St. Georges Bay area, the mobility of invertebrates, and the prevailing currents from west through the Strait into St. Georges Bay, distribution information from Dunbar et al. (1980) was extracted from as distant as the eastern point of P.E.I. and westward to Pictou Harbour. Dunbar et al. (1980) emphasize that the blank areas on their charts from which this information is drawn are not reflective of absence of a given species but often these areas have not been sampled to determine presence. Thus, the list derived from their work is not to be construed as thorough or complete. Further sampling is required to establish presence and distributions of most components of the benthic flora and fauna.

Construction through the mid-1990s of the Confederation Bridge linking New Brunswick with Prince Edward Island resulted in the examination of benthic fauna and flora as part of an Environmental Impact Assessment. The two principle sampling methods were direct observation, by SCUBA and Remotely Operated Vehicles (ROV), and colonisation studies of organisms on the newly placed piers. The water depths ranged from 5 to 25 m and substrate was primarily cobble, shell, sand, and silt but with some bedrock and boulders. The following discussion is drawn from Anonymous (199?, 1998). Underwater video indicated only a few macrobenthic invertebrates. These were

*Homarus americanus*, *Cancer irroratus*, *Placopecten magellanicus, Pagurus* sp., *Metridium* sp., *Mytilus edulis, Asterias* sp. *Modiolus modiolus*, hydrozoans and poriferans. Calculated densities based on this video for the prominent species were 0-0.04 individuals/m$^2$ for *H. americanus*, 0-0.32/m$^2$ for *C. irroratus*, 0-0.056/m$^2$ for *P. magellanicus*, and 0-0.012/m$^2$ for *Pagurus* sp. In a dredge disposal site in Amherst Cove, *Homarus americanus* densities were almost consistently zero animals/m$^2$ between 1994 and 1997 though occasionally did rise to 0.6/m$^2$. *Cancer irroratus* in this same time period ranged from 0 to 2.23 animals/m$^2$, though 1/m$^2$ may be more representative of maximum density.

The colonisation study of piers in Northumberland Strait (Table 3) indicate quite evenly distributed species numbers between the three phyla of algae and 11 phyla/classes of invertebrates. The bivalves, gastropods, polychaetes and crustaceans together only account for 54% of the 68 species recorded. The bryozoans, hydroids and poriferans also contribute significantly to the total species present (together accounting for 25% of species present). Unfortunately biomass was not recorded in this survey, instead presence was quantified by percent cover. On the piers the dominant faunal and floral groups in 1996-97 were (approximated from Figures 4.23-4.26 in Anonymous 1998):

**0-5 m depth** - Barnacles (20-60% cover), *Enteromorpha* (25-45% cover), algal mat (5-80% cover), bryozoans/hydrozoans (5-25% cover) and mussels (generally < 15% cover).

**5-10 m depth** - Barnacles (25-40% cover), algal mat (20-30% cover), bryozoans/hydrozoans (<5-45% cover), and sea anenomes (5 - 20% cover).

**10-15 m depth** - Barnacles (20-40% cover), algal mat (15-85% cover), bryozoans/hydrozoans (20-45% cover), sea anenomes (5 - 25% cover) and sea stars (0 – 25% cover).

**15-20 m depth** - Barnacles (10-45% cover), bryozoans/hydrozoans (10-55% cover) and sea anenomes (10 - 30% cover).

**20-25 m depth** - Barnacles (25-40% cover), bryozoans/hydrozoans (10-50% cover) and sea anenomes (5 - 35% cover).

**>25 m depth** – Barnacles (15 – 35% cover), bryozoans/hydrozoans (20-55% cover), algal mat (5-20% cover), and sea anenomes (5-30% cover)

Table 2: Species list for St. Georges Bay area and eastern Northumberland Strait from Dunbar et al. (1980).

| Algae | | Macroinvertebrates | |
|---|---|---|---|
| **Phaeophycea** | *Laminaria digitata* | **Bivalvia** | *Arctica islandica* |
| | *Laminaria saccorhina* | | *Astarte subaequilatera* |
| | *Pilayella littoralis* | | *Astarte undata* |
| | | | *Clinocardium ciliatum* |
| **Rhodophycea** | *Ceramium fastigatum* | | *Crassostrea virginica* |
| | *Ceramium rubrum* | | *Crenella glandula* |
| | *Euthora cristata* | | *Macoma tenta* |
| | *Polysiphonia harveyi* | | *Mercenaria mercenaria* |
| | *Polysiphonia urceolata* | | *Mulina lateralis* |
| | *Rhodymenia palmata* | | *Mya arenia* |
| | *Trailliella intricata* | | *Mya truncata* |
| | | | *Nucula proxima* |
| **Chlorophycea** | *Enteromorpha linza* | | *Nucula tenuis* |
| | *Ulva lactuca* | | *Pandora glacialis* |
| | | | *Periploma leanum* |
| | | | *Petricola pholadiformis* |
| | | | *Pitar morrhuana* |
| | | | *Placopecten magellanicus* |
| | | | *Teredo navalis* |
| | | | *Yoldia limatula* |
| | | | *Volsella modiolus* |
| | | | *Yoldia sapotilla* |
| | | | *Yoldia thraciaeformis* |
| | | **Gastropoda** | *Acmaea testudinalis* |
| | | | *Admete couthouyi* |
| | | | *Buccinum undatum* |
| | | | *Crepidula fornicata* |
| | | | *Crepidula plana* |
| | | | *Nassarius trivittatus* |
| | | | *Polineces heros* |
| | | | *Polineces immaculata* |
| | | | *Urosalpinix cinerea* |
| | | **Polyplacophora** | *Ischnochiton ruber* |
| | | | *Ischnochiton alba* |
| | | **Crustacea** | *Cancer irroratus* |
| | | | *Crangon septemspinosa* |
| | | | *Homarus americanus* |
| | | | *Pagurus acadianus* |

Table 3. Species list of algae and invertebrates reported from two years (1996, 1997) sampling in Northumberland Strait in 5-20 m of water as part of Confederation Bridge Project. Table compiled from Anonymous, 1997 (Tables 5.7-5.10) and 1998 (Tables 4.2-4.12)

| Algae | | Invertebrates | |
|---|---|---|---|
| **Phaeophyta** | *Asperococcus echinatus* | **Bryozoa** | *Averillia* sp. |
| | *Chorda filum* | | *Bryozoa membranacea* |
| | *Chordaria flagelliformis* | | *Bugula turrita* |
| | *Eudesme virescens* | | *Flustra foliacea* |
| | *Fucus serratus* | | *Membranipora* sp. |
| | *Saccorhiza dermatodea* | | *Schizoporella unicornis* |
| **Chlorophyta** | *Chaetomorpha melangonium* | **Hydroid** | *Bougainvillia* sp |
| | *Chaetomorpha* sp. | | *Campanularia calceolifera* |
| | *Cladomorpha* sp. | | *Campanularia sp.* |
| | *Cladophora albida* | | *Hydractinia* sp. |
| | *Cladophora seriacea* | | *Sertularia argentea* |
| | *Cladophora* sp. | | *Sertularia* sp |
| | *Enteromorpha* (2 species) | | *Tubularia crocea* |
| | | | *Tubularia* sp. |
| **Rhodophyta** | *Antithamnion* sp. | **Nematode** | Nematoda |
| | *Ceramium* (2 species) | | |
| | *Ceramium rubrum* | **Porifera** | *Halichondria bowerbanki* |
| | *Chondrus crispus* | | *Scypha ciliata* |
| | *Corallina offinalis* | | *Scypha* sp. |
| | *Cystoclonium ceranoides* | | |
| | *Gelidium* sp. | **Anthozoa** | *Metridium senile* |
| | *Phyllophora pseudoceranoides* | | *Metridium* sp. |
| | *Polysiphonia nigrescens* | | *Tealia felina* |
| | *Polysiphonia* sp. | | *Tealia crassicornis* |
| | *Spermothamnion repens* | | |
| | *Spermothamnion* sp | **Bivalvia** | *Anomia simplex* |
| | | | *Gammarus* sp. |
| | | | *Hiatella arctica* |
| | | | *Modiolus modiolus* |
| | | | *Modiolus* sp. |
| | | | *Mytilus edulis* |
| | | | *Mytilus* sp. |
| | | | *Spisula solidissima* |
| | | **Gastropoda** | *Aeolidia papillosa* |
| | | | *Coryphella* sp |
| | | | *Crepidula convexa* |
| | | | *Crepidula fornicata* |
| | | | *Crepidula plana* |
| | | | *Dendronotus frondosus* |
| | | | *Eubranchus* sp. |
| | | | *Facelina bostoniensis* |
| | | | *Lacuna vincta* |
| | | | *Littorina* sp. |
| | | | *Mitrella lunata* |
| | | | *Nassarius trivittatus* |

Table 3: (con't)

| Algae | Invertebrates | |
|---|---|---|
| | **Gastropoda** | *Notoacmaea testudinalis* |
| | | *Onchidoris* |
| | **Polychaeta** | *Eulalia viridis* |
| | | *Eusyllis blomstrandi* |
| | | *Gattyana cirrosa* |
| | | *Harmothoe* sp. |
| | | *Neries* sp. |
| | | *Polydora ciliata* |
| | | *Phyllodoce* sp. |
| | **Crustacea** | *Aeginella longicornis* |
| | | *Balanus balanoides* |
| | | *Balanus* sp. |
| | | *Cancer irroratus* |
| | | *Caprella linearis* |
| | | *Caprella sp.* |
| | | *Corophium volutator* |
| | | *Homarus americanus* |
| | | *Jassa falcata* |
| | | *Pagurus acadianus* |
| | | *Pagurus pubescens* |
| | **Pycnogoda** | *Phoxocilidium femoratum* |
| | **Echinodermata** | *Asterias forbesi* |
| | | *Asterias vulgaris* |
| | | *Henricia* sp. |
| | **Tunicata** | Thaiacea (salp) |
| | | *Doliolum* sp. |

*Summary of Northumberland Strait*

Based on the reported sampling from Northumberland Strait between 1967 and 1998 it appears that polychaetes are present in the greatest species abundance (up to 91 species) followed by amphipods (up to 73 sp.), bivalves (up to 26 sp.), gastropods (up to 16 sp.), and non-amphipod crustaceans and echinoderms each up to 6 species present. Algal species are present in the range of 3-27 species (Phaeophyta), 7-43 species (Rhodophyta), and 2-8 species (Chlorophyta).

Biomass ranges up to 1,400 g/m$^2$ with bivalves, gastropods, polychaetes and echinoderms making up the majority of the contribution. The biomass is generally greatest for the larger organisms (echinoderms and bivalves), with lower contributions by the polychaetes, gastropods and arthropods. However, this large contribution by molluscs and echinoderms includes inedible tests/skeletons etc., and so it is questionable how relevant these biomass estimates are from a trophic level perspective, as much of the greatest biomass contribution may not be passed on to consumers. Common invertebrate species reported in Northumberland Strait (from Tables 1-3) include 31 bivalves, 23 gastropods, 11 polychaete species, 25 arthropods and 6 echinoderms. The most commonly encountered species in this limited sampling of Northumberland Strait were:

Bivalves: *Modiolus modiolus, Mytilus edulis, Placopecten magellanicus*
Gastropods: *Nassarius trivittatus, Lunatia heros, Neptunea decemcostata*
Arthropods: *Crangon septemspinosa, Pagurus acadianus, Pandalus montagui, Homarus americanus, Cancer irroratus*
Echinoderms: *Asterias vulgaris, Henricia sanguinolenta, Echinarachinus parma*

## *3.2 Gulf of St. Lawrence*

The fauna and subtidal communities of the Gulf of St. Lawrence are poorly known (Robert, 1979; Long and Lewis, 1987), except perhaps in qualitative or semi-quantitative terms (Bourget and Messier, 1983). The Gulf is a very large embayment composed of many different localized environments with differing factors (e.g., depth, temperature, salinity, substrate, etc.) affecting benthic community organization and structure. There appears to be different community structures and controls between the southern and northern Gulf; in the southern Gulf decapod crustaceans and fishes are thought to be influential in controlling community structure, while their absence in the northern Gulf results in whelks and seastars filling these predatory roles (Himmelman, 1991). The fauna and flora of the estuary itself are subarctic and boreal, more closely resembling the north shore of the Gulf and the Labrador coast than the southern Gulf and Maritimes (Himmelman and Lavergne, 1985). These differences must be kept in mind in the descriptions of the various studies below.

3.2.1 Southern Gulf

Sampling was conducted in the Bay of Gaspe between 1956 and 1960 involving 91 stations at depths of 9-100 m on substrates of sand, muddy sand, and mud (Brunel, 1971). Nineteen polychaete species were reported (two most common: *Harmothoe extenuata* and *Gattyana cirrosa*), as well as 11 bivalve species (most common: *Serripes groenlandica, Clinocardium ciliatum, Spisula polynyma*), 17 decapod crustaceans (most common: *Sabinea septemcarinata, Argis dentata, Eualus macilentus*), and 12 echinoderms (*Ophiuri sarsi* and *Asterias vulgaris* most common). The author recognized eight communities within this area; these are presented with their species in Table 4.

In a classification and ordination exercise, Hughes and Thomas (1971a) delineated six groups within a Bedeque Bay, Prince Edward Island estuary from samples collected in 1967 from depths of 0.3 to 5.4 m (substrate description not provided). However, for the purposes of this paper only their first division, into euryhaline and lower estuarine species, is relevant. Their further divisions are of fine scale and statistical divisions; their biological or field assessment would be problematic in trying to define other areas with respect to these communities due to great variability in environmental and biological conditions. Their species groupings are presented in Table 5. These authors reported 62 species of which 20 are polychaetes, 14 bivalves, 9 gastropods, 6 crustaceans, 1 echinoderm and 8 algae species accounting for 93.5% of the total species number. Dominant species (i.e., > 50 individuals/$m^2$ or >50 g dry weight/$m^2$ for plants) at this location were *Mytilus edulis, Tellina agilis, Nassarius obsoletus, Nassarius trivittatus, Littorina littorea, Crepidula plana, Lunatia heros, Polycirrus eximius, Neopanpoe texana, Balanus improvisus*, Nemertea, *Ulva lactuca, Chondrus crispus, Gracilaria verrucosa*, and *Zostera marina*.

In an analysis of a second Prince Edward Island estuary (Bideford River; sampling date not provided), Hughes and Thomas (1971b) collected benthic samples along four transects ranging in depths from intertidal to 4.7 m and substrates ranging from silt-clay to coarse sand (median particle size range 0.0085-0.79 mm). The most commonly captured invertebrates are provided in Table 6.

Table 4: Communities recognized in the Bay of Gaspe, 1956-1960. Data from Brunel (1971)

| Euryboreal Soft Mud | Euryboreal Sand | Euryboreal Mixed Ground |
|---|---|---|
| *Casco bigelowi* | *Asteria vulgaris* | *Ophiopholis aculeata* |
| *Chiridotea tuftsi* | *Bostrichobranchus pilularis* | *Ophiura robusta* |
| *Diastylis polita* | *Chiridotea tuftsi* | *Strongylocentrotus drobachiensis* |
| *Nephthys incisa* | *Crangon septemspinosa* | |
| *Pholoe minuta* | *Diastylis polita* | |
| *Phyllodoce mucosa* | *Echinarachinus parma* | |
| | *Edotea triloba* | |
| | *Hippomedon serratus* | |
| | *Photis macrocoxa* | |
| | *Phoxocephalus holbolli* | |
| | *Phyllodoce mucosa* | |
| | *Spisula polynyma* | |
| | *Tmetonyx nobilis* | |
| **Subarctic Muddy Sand** | | **Subarctic Sandy Mud** |
| *Cerastoderma pinnulatum* | | *Aporrhais occidentalis* |
| *Clinocardium ciliatum* | | *Gattyana cirrosa* |
| *Leptocheirus pinguis* | | *Harmothoe exteniuata* |
| *Macoma calcarea* | | *Harmothoe imbricata* |
| *Ophiura sarsi* | | *Harmothoe nodosa* |
| *Serripes groenlandica* | | *Macoma calcarea* |
| *Sternaspis scutata* | | *Maldane sarsi* |
| *Thyasira gouldii* | | *Mya truncata* |
| | | *Nuculana pernula* |
| | | *Ophiura sarsi* |
| | | *Priapulus caudatus* |
| | | *Sabina septemcarintat* |
| | | *Serripes groenlandica* |
| | | *Steguphiura nodosa* |
| | | *Yoldia norvegica* |
| **Arctic Cohesive Mud** | **Arctic Sandy & Pebbly Mud** | **Arctic Mixed Ground** |
| *Arrhis phyllonyx* | *Boltenia ovifera* | *Chlamys islandica* |
| *Chionoecetes opilio* | *Ophiura sarsi* | *Ophiocantha bidentata* |
| *Ctenodiscus crispatus* | | *Ophiopholis aculatea* |
| *Eualus macilentus* | | *Ophiura robusta* |
| *Neohela monstrosa* | | *Ophiura sarsi* |
| *Spiochaeopterus* sp. | | *Strongylocentrotus pallidus* |

Table 5: Large scale division of estuarine species from Bedeque Bay, Prince Edward Island, 1967. Table modified from Hughes and Thomas (1971a).

| Euryhaline | | Lower Estuarine | |
|---|---|---|---|
| **Bivalvia** | *Crassostrea virginica* | **Bivalvia** | *Ensis directus* |
| | *Mulinia lateralis* | | *Mya arenia* |
| | *Mytilus edulis* | | *Pitar morrhuana* |
| | *Petricola pholadiformis* | | *Tellina agilis* |
| | *Venus mercenaria* | | |
| | | **Gastropoda** | *Lunatia heros* |
| **Gastropoda** | *Crepidula fornicata* | | *Nassarius trivittatus* |
| | *Crepidula plana* | | |
| | *Littorina littorea* | **Polychaeta** | *Glycera dibranchiata* |
| | *Nassarius obsoletus* | | *Maldanopsis elongata* |
| | | | *Nephthys incisa* |
| **Polychaeta** | *Glycera americanus* | | *Pectinaria gouldii* |
| | *Harmothoe imbricata* | | *Pectinaria granulata* |
| | *Nereis virens* | | *Pherusa affinis* |
| | *Notomastus latericeus* | | |
| | *Scoloplos fragilis* | **Crustacea** | *Pandora gouldiana* |
| | | **Amphipoda** | *Leptocheiros pinguis* |
| **Crustacea** | *Balanus improvisus* | | |
| | *Cancer borealis* | **Echinodermata** | *Asterias vulgaris* |
| | *Crangon septemspinosa* | | |
| | *Neopanope texana* | | |
| **Plantae** | *Chondrus crispus* | | |
| | *Enteromorpha prolifera* | | |
| | *Gracilaria verrucos* | | |
| | *Phyllophora* sp. | | |
| | *Polysiphonia grescens* | | |
| | *Ulva lactuca* | | |
| | *Zostera marina* | | |

Table 6: Ranges of densities and biomass of common invertebrates (> $20/m^2$ for transect 1-3; >$100/m^2$ for transect 4) from Bideford River estuary, Prince Edward Island. Data from Hughes and Thomas (1971b).

| | Species | Density ($/m^2$) | Biomass (g dry weight/$m^2$) |
|---|---|---|---|
| **Bivalvia** | *Cumingia tellinoides* | 2-300 | 0.01-2.33 |
| | *Gemma gemma* | 5-29,120 | 0.01-16.32 |
| | *Macoma balthica* | 1-286 | 0.01-6.47 |
| | *Modiolus demissus* | 1-42 | 0.37-18.02 |
| | *Mya arenia* | 1-565 | 0.01-189.97 |
| | *Mytilus edulis* | 1-273 | 0.47-157.28 |
| | *Tellina agilis* | 1-438 | 0.01-1.03 |
| **Gastropoda** | *Crepidula fornicata* | 1-688 | 0.01-25.4 |
| | *Crepidula plana* | 1-334 | 0.01-7.09 |
| | *Littorina saxitalis* | 1-1,500 | 0.02-6.0 |
| | *Nassarius obsoletus* | 1-1,557 | 0.02-37.76 |
| | *Odostomia* sp. | 15-441 | 0.01-4.97 |
| | *Retusa canaliculata* | 10-300 | 0.01-0.68 |
| **Polychaeta** | *Clymenella torquata* | 2-780 | 0.01-3.59 |
| | *Harmothoe imbricata* | 2-260 | 0.01-1.04 |
| | *Nereis succina* | 2-134 | 0.04-0.49 |
| | *Nereis virens* | 1-790 | 0.01-11.33 |
| | *Notomastus latericeus* | 12-875 | 0.01-0.52 |
| | *Pectinaria gouldii* | 2-264 | 0.02-0.59 |
| | *Scalopolos fragilis* | 1-170 | 0.01-0.59 |
| **Amphipoda** | *Corophium insidiosum* | 30-570 | 0.01-0.22 |
| | *Gammarus locusta* | 1-120 | 0.01-0.19 |
| **Isopoda** | *Leptochelia rapex* | 100-375 | 0.01-0.06 |
| **Unclassified** | *Mysella planulata* | 40-375 | 0.02-0.18 |

A Magdalen Island lagoon (maximum depth 8 m) was sampled in 1975 for macrobenthos density and biomass (Bourget and Messier, 1983). The substrate was predominantly sands with minor amounts of silt, clay and gravel (median particle diameter 0.25 mm). Fifty four benthic species were reported with a mean subtidal density of 3,398.1 individuals/$m^2$ and mean biomass of 6.4 g/$m^2$. The most common (i.e., present in highest density) organisms were the bivalve *Gemma gemma* (1,398.7 /$m^2$), the gastropods *Littorina saxatillis* (1,345.6 /$m^2$), *Cingula aculeus* and *Hydrobia minuta* (526.7 and 524.8 /$m^2$ respectively), and the crustacean *Corophium insidiosum* (771.2 /$m^2$). All other species were present at less than 500 individuals/$m^2$. Table 7 presents ranges of values for individual densities and biomass for this area.

Table 7: Ranges of individual species densities and biomass grouped by Phyla/class for Magdalen Islands sampled in 1975. Data from Bourget and Messier (1983).

| | Individual density (/m$^2$) | Biomass (g dry wt./m$^2$)* |
|---|---|---|
| **Sipuncula** | 1.6-1.8 | |
| **Mollusca** | | |
| Gastropoda | 1.0-1345.6 | 0.578-1.249 (13.1-14.4) |
| Bivalvia | 1.0-1398.7 | 0.407-2.344 (6.4-32.8) |
| **Polychaeta** | 1.1-92.5 | 2.2-3.943 (33.6-62.1) |
| **Crustacea** | 1.0-771.2 | 0,1-2,151 (2.3-24.9) |

* range in brackets is percent biomass

The Magdalen Island lagoons were sampled again in 1985 (Hudon and Lamarche, 1989), this time by SCUBA. Lobster (*Homarus americanus*) densities were found to range from 0.018-0.975 lobster/m$^2$ and rock crab (*Cancer irroratus*) from 0.008 to 3.358 crab/m$^2$. Four major substrate types were identified and the associated flora and fauna are listed below:

**Small stones imbedded in soft sediments** – Algae – *Ptilota serrata, Chordaria tomentosa, Corallina officinalis*. Invertebrates – *Mytilus edulis, Modiolus modiolus*, polychaetes (particularly *Lepidonotus squamatus*), littorinid gastropods, hydroids, barnacles, brittle stars.

**Bedrock (sandstone)** – similar to above

**Piles of large rocks** – Algae –*Laminaria* spp., *Ulva* spp., *Chondrus crispus, Chordaria tomentosa, Rhodomenia palmata*. Invertebrates – Caprellid amphipods, *Strongylocentrotus drobachiensis*, gastropods (*Lacuna vincta, Nassarius* sp.), *Mytilus edulis, Modiolus modiolus*, hydroids, ascidians, Porifera, nereid polychaetes.

**Sand** – *Zostera marina, Ulothryx*. Invertebrates – *Echinarachinus parma*, polychaetes, burrowing bivalves (*Venus mercenaria, Ensis directus, Mya arenia, Crangon septemspinosa*).

3.2.2 Northern Gulf

In 1962 benthic sampling was undertaken in the northern Gulf of St. Lawrence along the northeast edge of the Magdalen Shallows and the Laurentian Channel (Peer, 1963). Two of the stations (Stations 26 & 78) were within the depth range of the St. Georges Bay study area; at depths of 73 and 86 m respectively. Station 26 had a substrate of unsorted gravel and Station 78 substrate was fine sand. Thirty one taxa were identified from Station 26, with *Yoldia myalis* (15.5%), *Strongylocentotus droebachiensis* (13.9%), polychaetes (12.1%), and *Gephryea* (11.7%) each contributing the greatest presence. *Pagurus* spp. (9.0%), Ophiuridea (7.3%), and Coelenterata (7.1%) contributed between 5 and 10% each, and the remaining 22 taxa each contributed <5% to the standing crop. Estimated biomass at this station was 6.16 g dry organic matter/m$^2$. Seventeen taxa at this site made up 95% of the biomass. Station 78, on fine sand, was dominated by the sand dollar *Echinarachinus parma* (78.8% of standing crop) with much lesser contributions by Ophiuroidea (9.3%) and 28 other taxa. Estimated biomass at Station 78 was 21.59 g organic matter/m$^2$. At this station 95% of the biomass was represented by five taxa (*E. parma*, Ophiuroidea, *Priscillina armata*, *Pectinaria* spp., and *Macoma balthica*).

Long and Lewis (1987) report results of a 1981 sampling program in Anticosti and Esquiman Channels in the northern Gulf. Sample depths ranged from 37 to 285 m; only results from less than 150 m depth are included in Table 8. The substrate at the stations sampled was largely sand (0.062-1.0 mm) and gravel (1.0-64 mm), with some (generally <35%) pelite (<0.062 mm). They report 73 taxa collected when all of their sites (including the deep stations) are included of which 25 are molluscs, 22 are polychaetes, 9 amphipods, 4 echinoderms and the remainder as Cumacea (3 taxa), Cnidaria (3 taxa) and Other Phyla (6 taxa). They found that, in general, benthic diversity was maximum between 75 and 94 m and appeared to be highest on shelf/slope breaks and decreased to moderate levels on slopes. This is in agreement with Robert (1979) who found in a cluster analysis of environmental and biological variables in the St. Lawrence Estuary that there is a complete distinction between their sampled stations above and below 75 m depth. Robert (1979) also reports the shallower stations having the greatest diversity. However, though diversity decreased on slopes, abundance was high (Long and Lewis, 1987). Within depths representative of the St. Georges Bay study area the range of substrate component values in the study of Long and Lewis (1987) was from 5-98% pelites, 8-71% sand, and 4-32% gravel. Macrobenthos abundance ranged from 640 to 5,250 individuals/$m^2$ and diversity (Shannon Weaver H') from 0.746-1.234.

Table 8: Depth, abundance and diversity/eveness indices of samples from the Anticosti and Esquiman Channels, 1981. Table modified from Long and Lewis (1987).

| Depth (m) | Abundance (/$m^2$) | Diversity Index (H')* | Evenness Index (J) |
|---|---|---|---|
| 37 | 1,030 | 1.089 | 0.236 |
| 40 | 2,875 | 1.092 | 0.193 |
| 55 | 640 | 1.212 | 0.292 |
| 55 | 3,750 | 1.299 | 0.219 |
| 65 | 1,685 | 1.205 | 0.278 |
| 66 | 2,160 | 1.132 | 0.211 |
| 70 | 1,365 | 1.029 | 0.299 |
| 70 | 750 | 1.234 | 0.286 |
| 75 | 730 | 0.746 | 0.174 |
| 75 | 2,310 | 1.114 | 0.208 |
| 78 | 3,056 | 1.132 | 0.211 |
| 92 | 2,540 | 0.071 | 0.239 |
| 95 | 1,596 | 1.205 | 0.252 |
| 95 | 1,896 | 1.078 | 0.247 |
| 95 | 5,250 | 1.226 | 0.196 |
| 96 | 2,932 | 1.176 | 0.243 |
| 125 | 3,775 | 0.993 | 0.171 |
| 130 | 4,120 | 1.129 | 0.188 |
| 135 | 672 | 0.984 | 0.269 |

* H' = Shannon Weaver diversity index

Himmelman (1991) provides qualitative description of the communities to depths of 20 m on four different substrate types from the Mingan Islands, northern Gulf of St. Lawrence. Macrobenthic species and principle algal species reported are presented below for three of his descriptions – 1) Moderately exposed, medium sloped bottoms, 2) Rocky faces; and 3) Gently sloping sediment bottoms in areas of strong tidal currents. These areas are thought to physically represent some of the areas within the St. Georges Bay study area though the previous caveat about differences in biotic communities between the southern and northern Gulf must be borne in mind.

**Moderately exposed, medium sloped bottoms**

- 4-6 m depth to bottom of rocky zone – *Ophiopholis aculeata, Halocynthia pyriformis, Metridium senile, Tealia felina, Psolus fabricii* and *Cucumaria frondosa.* Algal species *Alaria* sp., *Saccorhiza dermatodea, Laminaria digitata, L. longicruris, Agarum cribrosum*
- sediment bottoms below rocky slopes – *Echinarachinus parma, Clinocardium ciliatum, Serripes groenlandica,* and *Spisula polynyma.*

**Rocky faces**

- *Ophiopholis aculeata, Halocynthia pyriformis, Metridium senile, Tealia felina, Myriopora subgrucila, Pallina sitiens.*

**Gently sloping sediment bottoms in areas of strong tidal currents**

- *Gersemia* sp., *Cucumaria frondosa, Echinarachinus parma, Psolus fabricii, Boltenia ovifera, Halocynthia pyriformis, Metridium senile, Lurcenaria quadricornis, Chlamys islandica, Tealia felina, Gorgonocephalus arcticus, Ophiura sarsi, Buccinum undatum, Aporrhais occidentalis.* Algal species *Agarum* sp., *Ptilota* sp.

Himmelman (1991) also reports densities for predatory invertebrates in the Mingan Island area. The whelk *Buccinum undatum* had the highest density (0.417 /m$^2$), four seastar species (*Leptasterias polaris, Asterias vulgaris, Crossater paposus*, and *Solaster endeca*) ranged from 0.002 to 0.15 /m$^2$ and the crabs *Hyas araneus* (0.055 /m$^2$) and *Cancer irroratus* (0.053 /m$^2$) were also present at low densities. The gastropod *Neptunea despecta tornata* was only present at a density of 0.006 /m$^2$. During 1982-1983, in this area the mean density of *Buccinum undatum* was found to range from 1.25 to 2.86 individuals/m$^2$ between 0 and 20 m water depth with biomass estimates including 1.2 g/m$^2$ (juveniles), 6.2 g/m$^2$ (immatures) and 23.0 g/m$^2$ (mature animals) (Jalbert et al., 1989). Densities of other species reported by Jalbert et al. (1989) are provided in Table 9. The percentage occurrence of various species by substrate are provided in Table 10. In this area the urchin *Strongylocentratus drobachiensis* is the most abundant organism on all substrates, with four each of bivalve and gastropod species, two other echinoderms, and a single polychaete species forming the remainder of the most commonly occuring species. Based on 1984 SCUBA sampling at the Mingan Islands, Himmelman and Dutil (1991) report the seastars *Asterias vulgaris* and *Leptastarias polaris* at densities <0.25/m$^2$ at depths below 2 m (though up to 1.71/m$^2$ in depths of 0-2 m). *Crossater papposus* is consistently below 0.03 individuals/m$^2$. These results must be qualified, however, as

Himmelman and Dutil (1991) point out that the reduced number of fish in the northern Gulf acting as predators relative to the Maritimes, and the resultant importance of seastars and whelks, suggest major differences in community structure between the two areas.

Table 9: Estimated densities of selected invertebrates from Mingan Islands, Quebec, 1982-83. Data from Jalbert et al. (1989).

| Species | Depth (m) | Density ($/m^2$) |
|---|---|---|
| **Gastropoda** | | |
| *Aporrhais occidentalis* | 14-20 | 0.22-0.27 |
| *Neptunea despecta* | <10 | 0.01-0.06 |
| **Crustacea** | | |
| *Hyas araneus* | 0-8 | 0.06-0.08 |
| | 8-20 | <0.045 |
| *Pagurus* sp. | 0-2 | 1.13 |
| | 18-20 | 4.94 |
| **Echinodermata** | | |
| *Asterias vulgaris* | 4-8 | 0.19 |
| | 12-20 | 0.01-0.03 |
| *Crossater paposus* | 0-20 | 0.01 |
| *Leptastaria polaris* | 4-8 | 0.74 |
| | 16-20 | 0.06 |
| *Solaster endeca* | 0-20 | 0.002 |

Sampling in the St. Lawrence estuary from 1970-72 is reported for mollusc species by Robert (1979). Sampling at stations between 15 and >365 m depth over sediments of silt-sand, silt-clay, and sand-silt (median particle diameter <0.063 – 0.25 mm) resulted in 52 mollusc species (Bivalvia = 32 species, Gastropoda = 16, Scaphapoda = 2, Polyplacophora = 1, Aplacophora = 1 species). Combined, the bivalves and gastropods represented 92% of the total mollusc species present. As stated previously, Robert (1979) found the highest diversity in shallow water and also suggests that sediment type is a more precise determinant than water temperature with respect to organism presence/absence. Robert (1979) also found that when diversity is high, the dominant molluscan species is not exceedingly abundant (<200 individuals) and is always a suspension feeder. He clustered mollusc 'assemblages' by species present and environmental variables (temperature, substrate) and two of the resultant clusters may be relevant to the St. Georges Bay study area (Table 11) despite the differences between the northern Gulf and the Maritimes. The number of species and individuals per sample, and diversity indices, are generally lower for the deeper group than the shallow water group.

Table 10: Occurrence (percentage presence in sampled quadrats) of various invertebrate and algal species on various substrates near the Mingan Islands, 1982-83. Table from Jalbert et al. (1989).

| Species | Bedrock | Boulders | Cobbles | Gravel | Sand-Mud |
|---|---|---|---|---|---|
| **Bivalvia** | | | | | |
| *Chlamys islandica* | 0 | 1.8 | 10.9 | 1.0 | 0.9 |
| *Hiatella arctica* | 47.3 | 22.9 | 8.3 | 6.9 | 1.7 |
| *Mya truncata* | 11.3 | 17.3 | 39.8 | 32.7 | 47.2 |
| *Mytilus edulis* | 19.4 | 21.8 | 10.2 | 6.9 | 2.7 |
| Other large clams | 0.4 | 2.1 | 8.3 | 7.9 | 24.3 |
| **Gastropoda** | | | | | |
| *Acmeae testudinalis* | 40.3 | 73.6 | 53.0 | 45.5 | 17.7 |
| *Littorina* sp. | 14.5 | 11.6 | 12.4 | 5.0 | 2.7 |
| *Margarites* sp. | 17.3 | 34.5 | 18.8 | 4.0 | 6.1 |
| *Tonicella* sp. | 38.9 | 46.1 | 38.7 | 31.7 | 9.4 |
| **Polychaeta** | | | | | |
| *Pectinarea granulata* | 6.7 | 9.9 | 28.2 | 10.9 | 13.2 |
| **Echinodermata** | | | | | |
| *Echinarachinus parma* | 0 | 2.8 | 11.7 | 21.8 | 29.9 |
| *Ophiopholis aculeata* | 75.3 | 57.0 | 43.2 | 9.9 | 9.7 |
| *Strongylocentrotus drobachiensis* | 95.8 | 92.6 | 94.7 | 87.1 | 87.2 |
| **Algae** | | | | | |
| *Agarum cribrosum* | 20.8 | 14.8 | 9.4 | 5.9 | 1.7 |
| *Alaria esulenta* | 7.4 | 6.0 | 3.0 | 2.0 | 0.4 |
| *Ptilota serrata* | 34.3 | 7.0 | 16.9 | 5.0 | 9.8 |

Table 11: Range of diversity and eveness indices (Group A, n=13, Group F, n=10) of molluscan fauna in two depth ranges from the St. Lawrence Estuary, 1970-1972. Table adapted from Robert (1979).

| | Group A (<75 m depth) | Group F (86-165 m depth) |
|---|---|---|
| Number of species per sample (S) | 15-34 | 8-18 |
| Number of individuals per sample (N) | 121-1140 | 64-631 |
| Brillions diversity index (H) | 0.18-0.98 | 0.1-0.59 |
| Shannon Weaver diversity index (H') | 0.17-0.99 | 0.1-0.66 |
| $H_{max}$ | 1.17-1.53 | 0.9-1.26 |
| Evenness (J) | 0.14-0.74 | 0.11-0.57 |

$H_{max} = \log(S)$

Himmelman and Lavergne (1985) identify four subtidal zones in the St. Lawrence Estuary based on 111 SCUBA diving transects. Their results are on rocky, shallow (<12 m) shorelines and their zonation is presented in Table 12. The Fringe Algal Zone extends from the low intertidal to a depth up to 4 m below Lowest Water at Spring tides (LWST). The Zone of Grazing-Resistant Algae is immediately below this, and at greater depth is the Barren Zone; an area lacking in species and unproductive. Finally, the Zone of Filter Feeders is found in the St. Lawrence Estuary at depths where the urchin density is much reduced, generally 4-10 m depth. The depths of these zones, if present in the St. Georges Bay study area, are unlikely to coincide with the depths reported here as the local conditions are different between the St. Lawrence estuary and the west coast of Nova Scotia.

In Bonne Bay, Newfoundland, sampling in 1990 of substrate at depths of 44 to 212 m indicated that annelids were the most abundant group in terms of both abundance and biomass (Wieczorek and Hooper, 1995). The substrate at these sampling locations was composed of fine sand, very fine sand, and silt/clay. Two of these stations (South Arm and Wigwam Point) were less than 150 m deep and so the following is a discussion of these stations only as they are most relevant to the depths found in St. Georges Bay (Table 13). The annelids made up the greatest contribution to the faunal density, comprising 43-66% of the total invertebrates (the sedentary polychaetes formed 28.7-50% of total density), with crustaceans contributing 21.7-30% and the molluscs from 9.8-21%. The remaining groups each contributed less than 2% to the faunal density. Biogenic material (living and dead plant material, mollusc shells, polychaete mucous tubes and casings, fish bones and scales, and dead animal remains) made up by far the largest mass of organic matter within the substrate (56.7-84.5% of total). In general, the annelids contributed the greatest 'living' mass (12-20% of total) with the cnidarians providing a large contribution at Wigwam Point (17%). Contributions by the other groups to wet mass was variable between stations.

Table 12: Characteristic species of the subtidal zonation of the St. Lawrence Estuary shallow water (<12 m) zones. Table modified from Himmelman and Lavergne (1985)

| | Algae | Invertebrates |
|---|---|---|
| **Fringe Algal Zone** | *Alaria esculanta* | *Acmeae testudinalis* |
| | *Chordaria flagelliformis* | *Caprella* spp. |
| | *Desmarestia aculeata* | Gammarid amphipods |
| | *Halosaccion ramentaceum* | *Lacuna vincta* |
| | *Laminaria* spp. | *Margarites costalis* |
| | *Palmaria palmata* | *Margarites groenlandica* |
| | *Petalonia fascia* | *Mytilus edulis* |
| | *Polysiphonia urceolata* | *Tonicella* spp. |
| | *Porphyra* spp. | |
| | *Rhodomela confervoides* | |
| | *Saccorhiza dermatodea* | |
| | *Spongomorpha arcta* | |
| | *Ulvaria obscura* | |
| **Zone of Grazing-Resistant Algae** | *Agarum cribrosum* | *Acmeae testudinalis* |
| | *Callophylis cristata* | *Strongylocentrotus droebchiensis* |
| | *Clathromorphum* spp. | *Tonicella* spp. |
| | *Desmarestia viridis* | |
| | *Lithothamnion* spp. | |
| | *Phycodrys rubens* | |
| | *Ptilota serrata* | |
| **Barren Zone** | *Clathromorphum* spp. | *Acmeae testudinalis* |
| | *Desmarestia viridis* | *Hiatella arctica* |
| | *Lithothamnion* spp. | *Strongylocentrotus droebchiensis* |
| | | *Tonicella* spp. |
| **Zone of Filter Feeders** | *Clathromorphum* spp. | *Ascidia* spp. |
| | *Lithothamnion* spp. | *Boltenia ovifera* |
| | *Peyssonnelia rosenvingii* | *Chondractinia tuberculata* |
| | | *Cucumaria frondosa* |
| | | *Didendium candidum* |
| | | Ectoprocts |
| | | *Halocynthia pyriformis* |
| | | Hydroids |
| | | *Metridium senile* |
| | | *Ophiopholis aculeata* |
| | | *Psolus fabricii* |
| | | Porifera |
| | | *Strongylocentrotus droebachiensis* |
| | | *Tealia feline* |

Table 13: Density and wet mass from sampling at two stations in Bonne Bay, Newfoundland, 1990. Note. Data has been converted to /m$^2$, it is originally reported as /13,000 g substrate (sampled with a 0.1 m$^2$ Petersen grab). Table adapted from Wieczorek and Hooper (1995).

| | South Arm | | Wigwam Point | |
|---|---|---|---|---|
| Depth (m) | 44-150 | | 68-126 | |
| Dominant particle diameter (mm) | <0.062-0.25 | | <0.062-0.125 | |
| | Density (/m$^2$) | Wet mass (g/m$^2$) | Density (/m$^2$) | Wet mass (g/m$^2$) |
| **Mollusca** | **81** | **45** | **129** | **51** |
| Bivalvia | 9 | 11 | 67 | 35 |
| *Cerastoderma* spp. | 0 | 0 | 3 | 12 |
| Small, thin shelled bivalvia | 6 | 1 | 52 | 5 |
| Gastropoda | 53 | 32 | 41 | 13 |
| Small gastropoda | 53 | 32 | 40 | 12 |
| Scaphopoda | 19 | 2 | 22 | 3 |
| **Annelida** | **542** | **732** | **267** | **343** |
| Sedentary, burrowing and tubiculous Polychaeta | 411 | 551 | 176 | 238 |
| Errant surface dwelling Polychaeta | 53 | 109 | 24 | 42 |
| Errant burrowing Polychaeta | 2.8 | 5.5 | 26 | 45 |
| **Crustacea** | **178** | **49** | **187** | **45** |
| Amphipoda | 156 | 46 | 163 | 43 |
| Small crustacea | 22 | 3 | 24 | 2 |
| **Echinodermata** | **3** | **82** | **2** | **4** |
| Ophiuroidea | 0 | 0 | 1 | 1 |
| Asteroidea | 1 | 80 | 0 | 0 |
| Holothuroidea | 2 | 2 | 1 | 3 |
| Cnidaria | 8 | 6 | 12 | 293 |
| Colonial Hydrozoa | 6 | 3 | 10 | 1 |
| Anthozoa | 0 | 0 | 2 | 292 |
| Porifera | 1 | 1 | 4 | 1 |
| Other invertebrates | 9 | 31 | 4 | 8 |
| **Total invertebrates** (/m$^2$) | 820 | | 613 | |
| **Total mass** (g/m$^2$) | | 6,105 | | 1,725 |

*Summary of Gulf of St. Lawrence*

This review of the benthos of the Gulf of St. Lawrence clearly indicates the difference between the southern and northern Gulf. The results are summarized below.

Based on the limited sampling reported for the southern Gulf (five studies) the bivalves, gastropods and polychaetes appear to be the dominant organisms with up to 14 bivalve species, 9 gastropod species and 20 polychaete species being reported within single studies. In terms of biomass, bivalves appear to contribute to a greater degree than gastropods, Polychaetes are variable, ranging from the greatest contributor of biomass (Bourget and Messier, 1983) to the least of the three groups (Hughes and Thomas 1971b).

Seven reported studies from the northern Gulf of St. Lawrence and the estuary produce different results from the southern Gulf. Crustaceans are a more significant component of the presence, being in greater abundance than molluscs and echinoderms in one study. Individual species appear to dominate the benthos to a greater degree in the northern Gulf (e.g., *Buccinum undatum, Strongylocentrotus drobachiensis, Yoldia myalis, Asteria* sp.). Polychaetes, however, continue to contribute significantly to the benthic community in the northern Gulf of St. Lawrence.

Perhaps the greatest contrast between the southern and northern Gulf is in the 'Dominant' species collected (i.e., most commonly encountered or abundant per capture event). See Table 14 for species comparison. As may be readily seen, the benthic composition of the two areas are significantly different. The number of common species per phyla/class for the most common groups range from 8-10 for bivalves, 7-11 for gastropods, 1-11 for polychaetes, and 2 – 10 for echinoderms. Decapod crustaceans are conspicuously absent from this list.

Table 14: Listing of 'dominant' species reported from the southern and northern Gulf of St. Lawrence. Absence of species from the table does not imply that it is absent, only that it is present at lower density/abundance than more dominant species. (e.g., *Buccinum* is present in southern Gulf, but not commonly reported as abundant or dominant species). Table compiled from studies reviewed herein.

| | Southern Gulf | Northern Gulf |
|---|---|---|
| **Bivalvia** | *Clinocardium ciliatum* | *Chlamys islandica* |
| | *Cumingia tellunoides* | *Clinocardium ciliatum* |
| | *Gemma gemma* | *Hiatella arctica* |
| | *Macoma balthica* | *Mya truncata* |
| | *Modiolus demissus* | *Mytilus edulis* |
| | *Mya arenia* | *Serripes groenlandica* |
| | *Mytilus edulis* | *Spisula polynyma* |
| | *Serripes groenlandica* | *Yoldia myalis* |
| | *Spisula polynyma* | |
| | *Tellina agilis* | |
| **Gastropoda** | *Cingula aculeus* | *Acmae testudinalis* |
| | *Crepidula fornicata* | *Aporrhais occidentalis* |
| | *Crepidula plana* | *Buccinum undatum* |
| | *Hydrobia minuta* | *Lacuna vincta* |
| | *Littorina littorea* | *Littorina* sp. |
| | *Littorina saxitalis* | *Margarites* sp. |
| | *Lunatia heros* | *Neptunea despecta* |
| | *Nassarius obsoletus* | |
| | *Nassarius trivittatus* | |
| | *Odostomia* sp. | |
| | *Retusa canaliculata* | |
| **Polychaeta** | *Clymenella torquata* | *Pectinarea granulata* |
| | *Gattyana cirrosa* | |
| | *Harmothoe extenuata* | |
| | *Harmothoe imbricata* | |
| | *Lepidonotus squamatus* | |
| | *Nereis succina* | |
| | *Nereis virens* | |
| | *Notomastus laticerus* | |
| | *Pectinaria gouldii* | |
| | *Polycirrus eximius* | |
| | *Scalopolos fragilis* | |
| **Echinodermata** | *Asterias vulgaris* | *Asteria vulgaris* |
| | *Ophiuri sarsi* | *Crossaster papposus* |
| | | *Cucumaria frondosa* |
| | | *Echinarachinus parma* |
| | | *Gorgonocephala arctica* |
| | | *Leptastarias polaris* |
| | | *Ophiopholis aculatea* |
| | | *Psolus fabricii* |
| | | *Solaster endeca* |
| | | *Strongylocentrotus drobachiensis* |
| **Total Species** | 34 | 26 |
| **Number of species in common** | 6 | |

## *3.3 Nova Scotia (Atlantic Coast)*

Benthic assessments have been reported for the Atlantic coast of Nova Scotia for only four locations, and for the most part (i.e., West Dover, Shelburne Harbour, and Lunenburg Bay) the benthic descriptions were a secondary component of a project; thus they are not comprehensive. As the Gulf of St. Lawrence has been shown to have very different communities due to differing environmental conditions, so too, the more exposed Atlantic coastline may be expected to possess different benthic communities from the sheltered Northumberland Strait.

Seventeen stations in St. Margaret's Bay were sampled at depths between 28 and 62 m in 1966 and 1967 (Brawn et al., 1968). Caloric content was determined rather than faunal density or biomass and the standing crop within this bay during the summer was found to average 76 kcal/$m^2$ and range between stations from 8-174 kcal/$m^2$. Annelids contributed 42% of the total caloric content followed by echinoderms (35%), arthropods (12%) and molluscs (11%). The arthropods contributed the greatest mass-specific content (>1.05 kcal/g live weight) while the annelids contributed 0.463-1.06 kcal/g, molluscs 0.374-0.791 kcal/g, and echinoderms 0.114-0.633 kcal/g. As well, the substrate quality appears to affect the total calories per square metre, peaking where there were almost equal amounts of fine sand (44% of material between 0.037-0.25 mm) and silt with clay (52% of material <0.037 mm). On either side of this peak the caloric content per square metre declines (See Figure 2 in Brawn et al., 1968). The authors suggest that as a rough approximation the biomass in grams wet weight per square metre may be multiplied by 644 cal/g (their mean value) to convert biomass to caloric content. Miller et al. (1971) published an energy flow diagram for St. Margaret's Bay and provide the following biomass estimates (kcal/$m^2$) – lobsters (1.7), brittle stars (2.0), seastars (4.0), periwinkles (12.0), mussels (13.6), and sea urchins (87.1).

In 1967-68 St. Margaret's Bay was sampled for the polychaete *Pectinaria hyperborea* (Peer, 1970). Samples were collected from 60-80 m water depth within bottom deposits consisting of fine aerobic mud. This was an area of known high *P. hyperborea* density (1.4-478 individuals/$m^2$; mean=100.4 /$m^2$, n=24 stations). Production estimates ranged from 0.07 to 15.6 g/m$^2$, with all of the stations producing >5 g/m$^2$ laying within the deep, muddy areas of the bay.

The spatial organization and abundance of polychaetes was also investigated in St. Margarets Bay between 1977 and 1981 (Volkaert, 1987). Sampling at depths of 46 m in substrates of clay-silt (fine sand 12-21%, silt 46-67%, clay 19-37%) 58 and 62 polychaete species were identified at two separate stations with the combined sites representing 67 species. Polychaetes formed 95% of the benthic fauna sampled. Total benthic biomass was estimated at 227.47 g wet weight/m$^2$. Polychaete mean densities ranged from <1 individuals/m$^2$ (24 species) to >1,000 individuals/m$^2$ (*Aricidea* sp. [juveniles] and *Cossura longocirrata* [juveniles]). Filter feeders formed 10.4% of the fauna and surface deposit feeders 23.9%. The remaining trophic groups were burrowers (25.4%), herbivores (7.5%), carnivores (31.3%) and unknown (1.5%).

Elner and Campbell (1987) provide brief descriptions of two sites in southern Nova Scotia sampled in 1979-81 – a macroalgal bed (Lobster Bay) and an urchin barren (Shelburne Harbour). Depths at each station ranged from 3 to 10 m and the substrates at each consisted of cobbles and boulders densely embedded in a shell-sand matrix. At the macroalgal (ungrazed by urchins) site macroalgae (predominantly *Chondrus crispus* and *Laminaria* spp.) were present at near 90% cover and the invertebrates present were gastropods (predominantly *Buccinum undatum*), the bivalves *Mytilus edulis* and *Modiolus modiolus*, polychaetes, amphipods, the crabs *Pagurus* spp., *Hyas* spp., *Cancer* spp. and *Carcinus maenas*, and the seastar *Asterias* spp. In contrast, at the urchin barren site, fleshy macroalgal cover (mainly *Desmarestia*) was reduced to <3% cover and most of the algal biomass was the crustose coralline, and urchin resistant, *Corallina officinalis*. Sea urchins (*Strongylocentrotus drobachiensis*) dominated, with densities between 29 and 90 individuals/m$^2$. Other invertebrates present included *Littorina littorea, Acmaea testudinalis*, *Tonicella* sp., *Mytilus edulis, Modiolus modiolus*, the brittlestar *Ophiura* spp, *Homarus americanus*, *Cancer irroratus* and *borealis*, and *Asterias* spp.

Densities of 0.4 scallops (*Placopecten magellanicus*)/m$^2$, 3.71 seastars/m$^2$ for *Asteria vulgaris* and *forbesi*, 0.03 rock crabs (*Cancer irroratus*)/m$^2$ and <0.05 moon snails (*Lunatia heros*)/m$^2$ were reported for Lunenburg Bay based on sampling in 1990 (Hatcher et al., 1996). Water depth in this area is approximately 8 m (below low tide) and the substrate is large cobble with kelp, grading through shale gravel and shell fragments, to mud and silt at the channel margins. Within this same bay in 1991-1992 mean scallop densities were estimated at 0.525/m$^2$, *Asterias* spp. densities at 0.8-1.2/m$^2$, and rock crabs at 0.02/m$^2$ (Barbeau et al., 1996). Sampling in 1991-92 was done in <10 m water depth on substrates of shell fragments, medium to fine granite slate, and cobble on silty sediment, grading to sands and silt size sediments as it shoals near the shoreline.

Drummond-Davies et al. (1982), in a mark-recapture population estimate in West Dover during 1977 estimated a biomass of 26.3-61.0 g/m$^2$ for *Cancer irroratus* in a kelp bed of depth 1-9 m. They refined their estimate to 52.1-61.8 g/m$^2$ which they equated with approximately 0.5 crabs/m$^2$.

*Summary of Nova Scotia (Atlantic Coast)*

Very little work has been done along the Nova Scotia shores with respect to benthic fauna or communities. Polychaetes have been reported on and in some areas (with appropriate substrate) may form up to 95% of the benthic biomass. Annelids in general were found in St. Margaret's Bay to contribute the greatest to the caloric content of the benthic community, followed by echinoderms, arthropods and molluscs. However, on a mass-specific basis the arthropods contribute the greatest caloric content, followed by the annelids, molluscs and echinoderms. Typical species within these groups reported in the literature for this area are:

Bivalves: *Mytilus edulis, Modiolus modiolus, Placopecten magellanicus*
Gastropods: *Buccinum undatum. Littorina littorea, Acmeae testudinalis, Lunatia heros*
Polychaetes: *Pectinaria hyperborea, Aricidea* sp., *Cossura longocirrata*
Arthropods: *Pagurus* spp., *Cancer irroratus, Cancer borealis, Carcinus maenas, Homarus americanus, Hyas* spp.
Echinoderms: *Asterias* spp., *Ophiura* spp.

### *3.4 New Brunswick (Bay of Fundy)*

The Bay of Fundy, separating New Brunswick from Nova Scotia, has been the subject of few studies since Whiteaves (1901) summarized early work in the 19th Century by Verrill, Stimpson, Ganong and others (Caddy, 1970). This current literature review found no relevant studies on the benthic fauna or communities within the bay prior to 1966, and in the intervening 30 years since then only six relevant studies have been published.

During 1966-1967, 196 dredge hauls were retrieved from depths of 55-128 m in the Bay of Fundy. Caddy (1970) describes the results of these surveys. The substrate is composed of rock, gravel, sand and mud but was not sampled in detail and quantified. One hundred and thirty invertebrate species were found forming five faunal assemblages, with three of these assemblages appearing to be correlated with substrate type (Table 15). Due to the dredge hauls extending over large areas (up to 1.5 km long), it is likely that the collection incorporated more than one community and so faunal assemblages were described rather than communities. The 130 invertebrate species came from nine taxa (Table 16) with molluscs contributing the greatest species number (36; [18 bivalves, 14 gastropods]), followed by poriferans (21), echinoderms (18), polychaetes (17), bryozoans (16) and crustacean (12). The remaining groups contributed approximately 7% of the total species number.

Wildish et al. (1972) determined two animal assemblages in L'Etang Inlet, Bay of Fundy in 1970-1971, prior to the discharge of effluent from a hardwood pulp mill into this environment. Their study site was a shallow water inlet (0-20 m deep) with a substrate of mud, shell, gravel, and sand. The assemblages are:

1. Euryhaline assemblage on inshore mud – *Nephthys ciliata, Neries virens, Mya arenia, Macoma balthica*
2. Stenohaline assemblage on inshore mixed mud/sand/shell gravel – *Lumbinereis fragilis, Ninoe nigripes, Nephthys incisa, Astarte* sp.

Table 15: Constituent species of the benthic assemblages and related substrate type from Bay of Fundy sampling 1966-1967. Data from Caddy (1970).

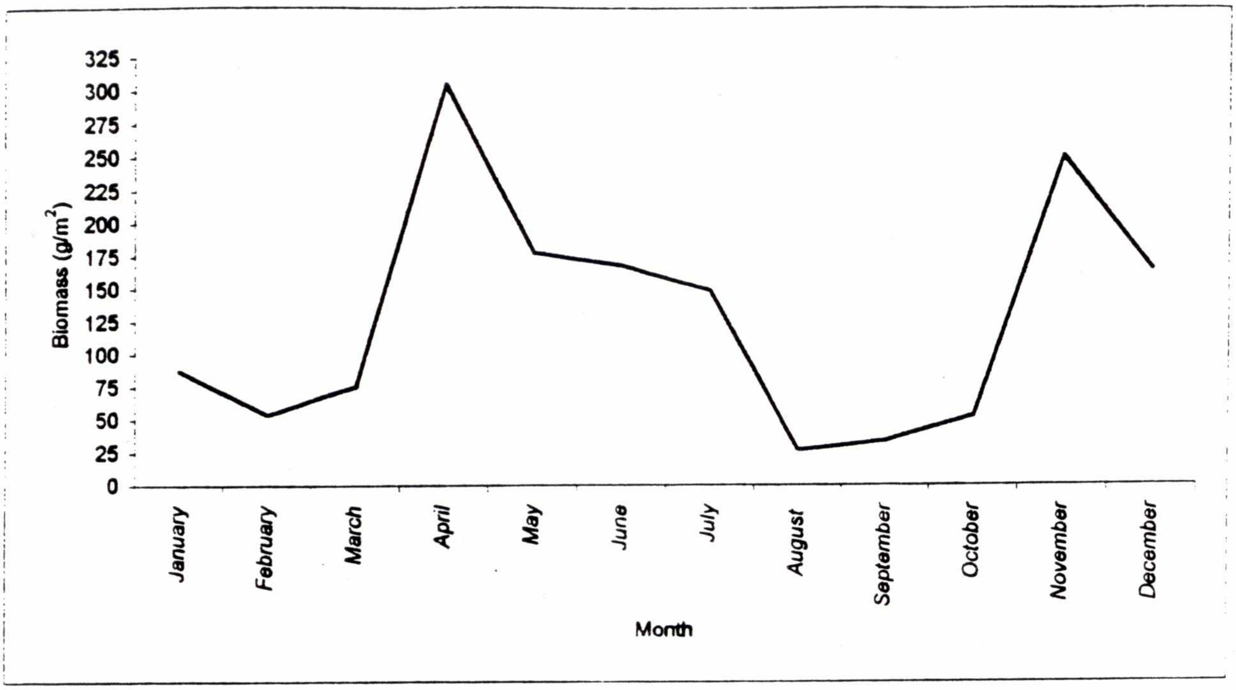
| Assemblage | Constituent | Species | Substrate |
|---|---|---|---|
| **Coastal Sand Assemblage** | *Eucratea loricata* | *Asterias vulgaris* | Sand |
| | *Polymastia* spp | *Colus stimpsoni* | |
| | *Spisula* spp | *Polydora* sp | |
| **Upper Bay Assemblage** | *Boltenia ovifera* | *Balanus balanus* | Not correlated |
| | *Chlamys islandicus* | *Buccinum undatum* | |
| | *Henricia* spp. | *Hiatella arctica* | |
| | Hydroids | *Hyas coarctatus* | |
| | *Modiolus modiolus* | *Pagurus* spp | |
| | *Pteraster militaris* | *Weberella bursa* | |
| **Scallop Ground Assemblage** | *Crossaster papposus* | *Anomia* spp | Gravel (suspected) |
| | *Neptunea decemcostata* | *Balanus balanus* | |
| | *Placopecten magellanicus* | *Clione vastificia* | |
| | *Solaster endeca* | *Thelepus cincinnatus* | |
| **Deep Water Mud Assemblage** | *Gorgonocephalus arcticus* | | Mud |
| | *Terebratulina septentrionalis* | | |
| **Deep water Offshore Assemblage** | *Balanus hameri* | *Placopecten magellanicus* | Not correlated |
| | *Hippasteria phryginia* | *Thelepus cincinnatus* | |
| | *Terabratulina septentrionalis* | Yellow papillate sponge | |
| | *Urticina* sp. | | |

Table 16: Distribution of 130 invertebrate species by Phyla/Class from Bay of Fundy sampling 1966-1967. Data from Caddy (1970).

| Taxon | Number of species |
|---|---|
| **Mollusca** | |
| Bivalvia | 18 |
| Gastropoda | 14 |
| Scaphapoda, Polyplacophora, Cephalapoda | 4 |
| **Polychaeta** | 17 |
| **Crustacea** | 12 |
| **Echinodermata** | 18 |
| **Brachipoda** | 1 |
| **Bryozoa** | 16 |
| **Coelenterata** | 7 |
| **Porifera** | 21 |
| **Tunicata** | 2 |

Calculated mean densities of individuals and species, and biomass, for this sampling period based on 116 grab samples reported by Wildish et al. (1972) are presented in Figure 4. The overall mean densities for individual animals was 182.2 /$m^2$, for species density was 36.36 species/$m^2$, and the mean biomass was 139.24 g/$m^2$. The mean individual density appears to peak in spring and during the sampling period samples ranged between 10 and 772 individuals/$m^2$. Mean species density remained quite constant, with samples ranging from 3 to 112 species/$m^2$. Biomass per month ranged from 2.54 g/$m^2$ (August) to 1,532 g/$m^2$ (April), with the mean biomass fluctuating through the year between approximately 25 and 300 g/$m^2$. Biomass appears to peak in this area in spring and late Autumn, and decline to low levels through winter and summer. Stations were revisited in L'Etang Inlet in 1972 and 1975 (Wildish et al., 1977) but these data are not included here as the pulp mill had been operating since 1971 discharging effluent into the inlet and so the benthic assemblages no longer represented 'natural' conditions.

In a review of the marine and coastal systems of the Passamoquoddy region, Wildish (1983) provides data on four estuaries (L'Etang, St. Croix, Digdeguash, Musquash) and the Saint John Harbour. In depths ranging from 1 to 28 m, on substrate ranging from fine sand to fine silt the mean number of species at these locations combined was 17.16 species/$m^2$ and ranged from 2 to 68 species/$m^2$. The mean number of individuals/$m^2$ was 199 with a range from 3 to 1,390 /$m^2$. One value of 1,208,470 /$m^2$ (St. Croix estuary, 1974) was excluded from this analysis as being so influential as to make the mean unrepresentative and is almost three orders of magnitude larger than the next highest value. Mean densities for the individual areas are provided in Table 17.



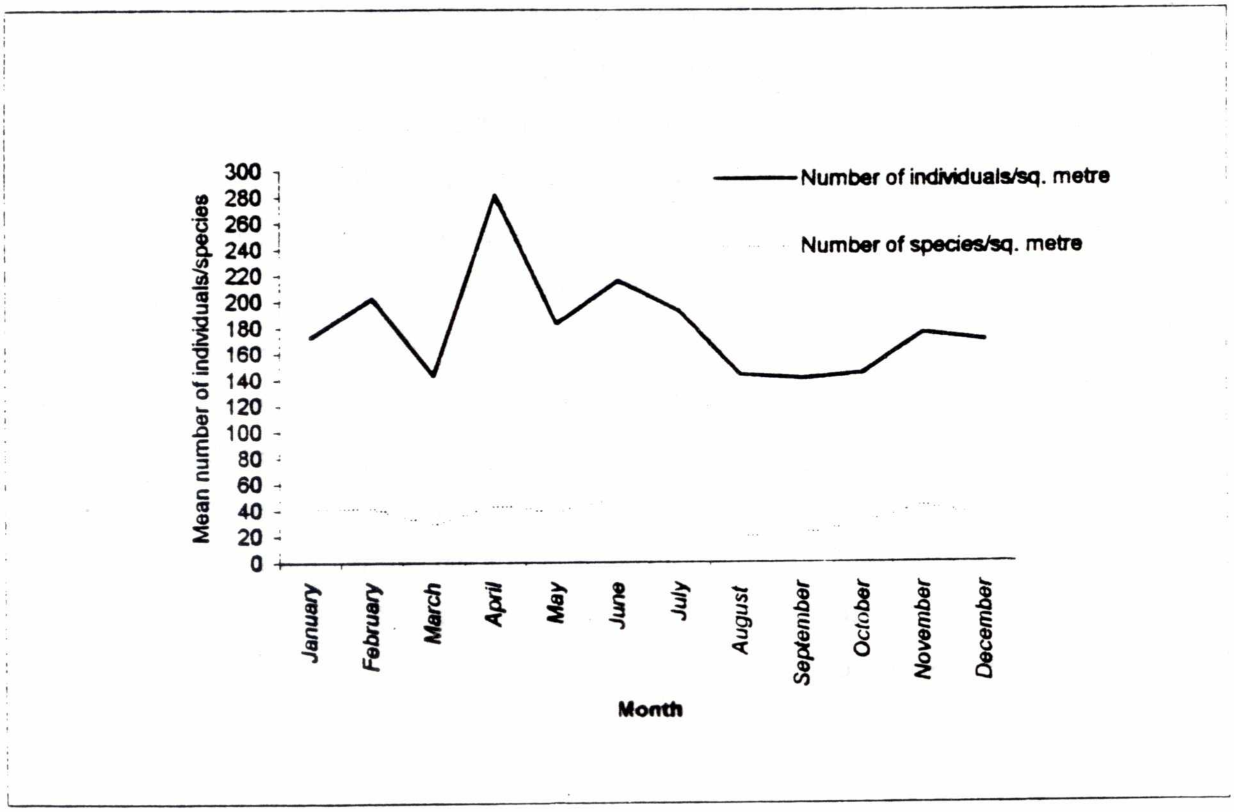




Figure 4: Mean biomass (upper), and density of individuals and species (lower) over time in L'Etang Inlet, New Brunswick, 1970-71. Data from Wildish et al. (1972).

Table 17: Means and standard deviations of species and individuals densities (/$m^2$) in four water bodies in New Brunswick. Digdeguash estuary was excluded due to single sample only and extreme value from St. Croix referred to in text is also excluded. Data from Wildish (1983).

| **Body** | **Species/m²** | | **Individuals/m²** | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| L'Etang Estuary | 46.25 | 24.54 | 663.5 | 568.9 |
| St. Croix Estuary | 23.125 | 19.73 | 308.57 | 327.9 |
| Musquash Estuary | 9.625 | 4.72 | 84.25 | 78.65 |
| Saint John Harbour | 10.37 | 6.61 | 76.81 | 88.6 |

Within Passamoquoddy Bay, Logan et al. (1983) recognized four distinctive communities on hard surfaces (e.g. boulders, rock ledges, etc.) – 1) Crustose coralline algae, 2) *Terebratulina septentrionalis* (Brachipoda), 3) man-made structures, and 4) shell substrates. The crustose coralline community is characterized by the widespread occurrence of several species of encrusting coralline algae and is generally a moderately shallow community (i.e., 20-40 m) dominated by suspension feeders and herbivorous browsers. The *Terebratulina septentrionalis* community is the most important hard substrate community in Passamoquoddy Bay in terms of total biomass and is dominated by chitons, hydroids, anenomes and bryozoans in addition to *T. septentrionalis*. It is generally under boulders in depths of 0-20 m, progressively emerging with increasing depth to become completely emergent below 50 m. This community is also dominated by suspension feeders and browsers. The other two communities are very localized to two surfaces: man-made structures such as weir poles, wharf pilings and floats, and to abandoned valves of bivalve shells. The number of species present within these communities is greatest for the crustose coralline and least for the shell substrates (Table 18). Differences in species number between these communities are greatest for the Mollusca, Arthropoda and Echinodermata.

Table 18: Number of species per taxon from four benthic communities in Passamoquddy Bay, New Brunswick based on 15 years of sampling. Table modified from Logan et al. (1983). An equal number of species does not imply the same species are present in the different communities. For list of species present, and relative abundance, see Logan et al. (1983).

| **Taxon** | **Community** | | | |
|---|---|---|---|---|
| | Crustose Coralline | *Terebatrulina* | Man-made-structures | Shell substrates |
| Mollusca | 25 | 15 | 9 | 4 |
| Annelida | 6 | 6 | 6 | -- |
| Arthropoda | 10 | 6 | 8 | 2 |
| Echinodermata | 12 | 6 | 5 | 1 |
| Brachiopoda | -- | 1 | 1 | 1 |
| Bryozoa | 1 | 2 | 2 | 2 |
| Coelenterata | 8 | 6 | 6 | 7 |
| Nematoda | -- | 1 | -- | -- |
| Porifera | 7 | 5 | 9 | 1 |
| Protochordata | 5 | 4 | 5 | 1 |
| Algae | 9 | -- | 6 | 2 |
| Total | 83 | 52 | 57 | 21 |

*Summary of New Brunswick (Bay of Fundy)*

The reported studies from the Bay of Fundy describe communities from two substrate types – soft sediment and hard surface. Within the soft sediments there is great variability depending upon sampling site and time of year. Species density ranges from approximately 3-112 species/m$^2$, individual density from 10 to 772 individual/m$^2$ and biomass from approximately 2.5 – 1,500 g/m$^2$. On hard substrates molluscs have the greatest species diversity, forming up to 30% of all species in the two most widespread hard surface communities. Echinoderms represent approximately 11-14% on the surfaces, arthropods ~12%, coelenterates 9-11% and annelids <10%.

In towing over large areas, and so presumably several substrate types, the percentage composition of the catch by group becomes quite even. There were 18 bivalve species, 14 gastropods, 17 polychaetes, 12 crustaceans and 18 echinoderms collected by Caddy (1970). However, these do not represent distinct communities but rather combined assemblages over 1.5 km length tows.

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| Taxon | Commun | | |
|---|---|---|---|
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| Mollusca | 25 | 15 | |
| Annelida | 6 | 6 | |
| Arthropoda | 10 | 6 | |
| Echinodermata | 12 | 6 | |
| Brachiopoda | -- | 1 | |
| Bryozoa | 1 | 2 | |
| Coelenterata | 8 | 6 | |
| Nematoda | -- | 1 | |
| Porifera | 7 | 5 | |
| Protochordata | 5 | 4 | |
| Algae | 9 | -- | |
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Ipswich Bay, Massachusetts, was sampled during summer months between 1933 and 1940 using 58 dredge hauls at depths beween 3.5 and 24.5 m (Dexter, 1944). The substrate was of two types in the sampled areas – hard sand and rocky bottom. Including fishes, 110 species were identified as part of the bottom community in this bay. The most commonly captured invertebrate and algal species (>20% occurrence in dredge hauls) were:

**Bryozoa** - *Bugulla flabellata, Membranipora* spp.
**Hydroza** - *Sertularia pumila, Obelia* spp.
**Annelida** - *Spirobis spirobis, Lepidonotus squamatus*
**Gastropoda** - *Lacuna vincta, Polinices heros*
**Crustacea** - *Gammarus* sp., *Caprella acutifrons, Aeginella longicornis, Idothea baltica, Pagurus longicarpus, Cancer irroratus, Crangon septemspinosa*
**Echinodermata** - *Strongylocentrtus drobachiensis, Echinarachinus parma, Asterias vulgaris, Henricia sanguinolenta*
**Tunicata** – *Molgula manhattensis*
**Algae** – *Laminaria saccarhina, Agarum cribrosum, Euthora cristata, Ulva lactuca, Chondrus crispus, Callithamnion* sp. *Gigartina stellata, Chaetomorpha* sp., *Enteromorpha* sp.

In Ipswich Bay, maximum densities per haul (mean densities not provided) of invertebrates ranged from one organism captured/100m$^2$ (0.01/m$^2$) for uncommon organisms up to 0.52/m$^2$ (*Gammarus* sp.), 0.93/m$^2$ (*Asterias vulgaris*), 1.0/m$^2$ (*Sertularia pumila*), 1.1/m$^2$ (*Spirobis spirobis*), and 5.31/m$^2$ (*Echinarachinus parma*) (Dexter, 1944).

In the late 1930s-early 1940s (sampling date not given) Menemsha Bight, Massachusettes, was examined for benthic fauna (Lee, 1944). Samples were taken from depths ranging from 2 to 25 m and substrates of two qualitatively described types – 1) fine to coarse sands, and 2) a soft fine clay. Typical species ($\geq$5 individuals/20 L sample) collected from the sand areas were *Tellina tenera, Glycera dibranchiata, Emerita talpoida, Clymenella torquata, Gammarus locusta, Ampelisca macrocephala*, and invertebrates ranged from one organism captured/60m$^2$ (0.016/m$^2$) for uncommon organisms up to 0.56/m$^2$ (*Crepidula fornicata*), 0.62/m$^2$ (*Carcinus maenas*), 0.65/m$^2$ (*Pagurus longicarpus*), 0.66/m$^2$ (*Crangon septemspinosa*), 0.68/m$^2$ (*Asterias vulgaris*), 0.85/m$^2$ (*Cancer irroratus*), and 1.33/m$^2$ (*Nassarius trivittatus*).

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*Corophium cylindricum* (0-700/m$^2$), *Spiochaetopterus oculatus* (2-362/m$^2$), *Nereis succinea* (0-296/m$^2$), *Nassa obsoleta* (7-282/m$^2$), *Pectinaria gouldii* (0-266/m$^2$), *Podarke obscura* (0-260/m$^2$), *Heteromastus filiformis* (0-63/m$^2$), and *Venus mercenaria* (average abundance 1-22 individuals/m$^2$).

In the 1950's, another embayment, Buzzards Bay, Massachussets received a great deal of research. In 1955, 19 stations were sampled between 7 and 20 m depth over two substrate types, a sand bottom (median particle size 0.18-0.68 mm) and a silt-clay bottom (median particle size 0.01-0.04 mm) (Sanders, 1958). The results from these two substrates are presented in Table 19. Differences in the composition of the two communities are quite clear with the sand bottom dominated by the amphipods *Ampelisca spinipes, Ampelisca macrocephala*, and *Byblis errata*, together accounting for 36% (by number) of the community. The silt-clay community is not dominated by a single group; the five species of polychaetes listed comprise 29.6% of the community and bivalves (3 species) contribute an equal amount (29.1%) by number. Filter feeders are more common on the sand bottom while deposit feeders predominate on the silt-clay bottom.

Continued sampling in Buzzards Bay in 1956-57 resulted in the identification of 95 species in these years (Sanders, 1960). Samples were taken in 19 m of water with the majority (20 of 24 stations) of the substrate composed of 78-90% silt clay. Of the 95 species collected, 33 were polychaetes, 26 molluscs (12 bivalves, 14 gastropods), and 24 crustaceans. The remainder were oligochaetes, turbellarians, nemertines, sipunculids, enteropneustans, tunicates, anthozoans, and pycnogonids. The most commonly occurring species by number were the polychaetes *Nephthys incisa, Ninoe nigripes, Lumbrinereis tenuis*, the molluscs *Nucula proxima, Callocardia morrhuana, Cylichna orzya, Turbonilla* sp., and the crustaceans *Hutchinsoniella macracantha*, and *Ampelisca spinipes*. The polychaetes *Nucula proxima and Nephthys incisa* together comprise >76% of the benthic fauna, and 95% of the assemblage is formed from only 11 species (*Nucula proxima, Nephthys incisa, Ninoe nigripes, Cylichna orzya, Callocardia morrhuana Hutchinsoniella macracantha, Lumbrinereis tenuis, Turbonilla sp., Spio filicornis, Retusa canaliculata*, and *Dorvillea caeca*). In terms of biomass, the most significant species were *Nephthys incisa* (28.95% by weight), *Bostrichobranchus pilularis* (23.49%), *Callocardia morrhuana* (14.97%), *Nucula proxima* (13.98%), and *Micrura leidyi* (4.83%). An additional eight species (*Arabella iricolor, Lumbrinereis fragilis, Ninoe nigripes, Nassarius trivittatus, Cerianthus americana, Flabelligera affinis, Cerastoderma pinnulatum, Yoldia limatula*) each contributed less than 2%, but combined, these 13 species accounted for 95% of the measured biomass. Sanders (1960) estimates that a minimum of 87.5% of these organisms are deposit feeders with suspension feeders only representing about 4.3% of the community.

Table 19: Sampling conditions and benthic results (ranges and percentages) of Buzzards Bay sampling, 1955. Data from Sanders (1958)

| | **Sand Bottom** | **Silt-Clay Bottom** |
|---|---|---|
| Depth range (m) | 7-20 | 12-19 |
| Silt-clay (%) | 0.99-13.29 | 43.64-93.36 |
| Total animal density (/m$^2$) | 1,629-12,576 | 1,064-7,982 |
| Density filter feeders (/m$^2$) | 295-5,185 | 0-447 |
| % Filter feeders | 0.11-45.73 | 0.8-19 |
| Density deposit feeders (/m$^2$) | 227-3,084 | 742-7,089 |
| % Deposit feeders | 10.38-46.99 | 45.53-97.3 |
| **Dominant species*** (% presence in brackets) | | |
| **Bivalvia** | *Cerastoderma pinnulatum* (10.17)<br>*Tellina tenera* (3.29) | *Cerastoderma pinnulatum* (2.69)<br>*Nucula proxima* (23.83)<br>*Pitar morrhuana* (2.55) |
| **Gastropoda** | | *Cylichna orzya* (4.56)<br>*Retusa canaliculata* (6.0)<br>*Turbonilla* sp. (9.21) |
| **Polychaeta** | *Glycera americana* (5.47)<br>*Lumbinereis tenuis* (2.69)<br>*Nepthys bucera* (4.47)<br>*Nephthys incisa* (1.99)<br>*Ninoe nigripes* (2.97) | *Lumbrinereis tenuis* (1.52)<br>*Nephthys incisa* (17.13)<br>*Nerinidea* sp. (6.85)<br>*Ninoe nigripes* (3.01)<br>*Tharyx acutus* (1.08) |
| **Crustacea** | *Ampelisca macrocephala* (6.31)<br>*Ampelisca spinipes* (18.59)<br>*Byblis serrata* (11.31)<br>*Unicola irroratus* (1.65) | *Ampelisca spinipes* (2.92)<br>*Unicola irroratus* (1.85) |

* Dominant species = only species present >1% of total population

Rhoads and Young (1970) suggest three trophic group distributions within Buzzards Bay:

1. **Homogenous suspension feeder trophic group** – Resulting when deposit feeders are largely excluded from the suspension feeder biotope by an inadequate food source in the sediment.
2. **Homogenous deposit feeder trophic groups** – Resulting when suspension feeders are largely excluded from the deposit feeder biotope by frequent resuspension of biogenically reworked sediments containing fine particles. Sediment instability and turbidity probably limiting for most suspension feeders.
3. **Mixed trophic groups** – Occurrence of a diverse suspension-feeder population on a mud bottom reworked by deposit feeders indicating physical stability of the bottom.

Meiofauna (nematodes, kinorhynchs, ostracods, copepods, turbellarians, halacarids, gastrotrichians, and cephalocarideans) were also sampled in Buzzards Bay by Weiser (1960) in 1957 at three of the stations used by Sanders (1958). Total density of organisms ranged from $1.69*10^5$ to $1.86*10^6$ individuals/$m^2$ with dry weights calculated as between 1 and 6 g/$m^2$. Nematodes (103 species) formed 89-99% of the total meiofauna with seven nematode species (*Odontophora pugilator, Odontophora pupusi, Anticoma litoris, Dorylaimopsis metatypicus, Terschellingia longicaudata, Neochromadora pistillata*, and *Odontophora loffleri*) each contributing >8% abundance. By number of individuals, the meiofauna was found to exceed the macrofauna by factors between 30 and 100 times, with a factor of 100 being the more common. Wigley and McIntyre (1964) report meiobenthos:macrobenthos ratios of 30:1 to 100:1 for a variety of studies in the eastern and western North Atlantic as well. The nematodes in Buzzards Bay could be grouped according to substrate and there was discerned an *Odontophora-Leptonemella* community in sandy habitats (corresponding to the *Ampelisca* macrofauna community) and a *Terschellingia longicaudata-Trachydemus mainensis* (kinorhynch) community in the silty habitat (corresponding to the *Nucula proxima-Nephthys incisa* macrofauna community).

A cruise in 1962 south of Marthas Vineyard, Massachusetts, sampled six stations at depths from 40-146 m (among deeper as well, not included here) over a substrate predominantly of sands and small gravels (median particle size 0.04-1.47 mm) (Wigley and McIntyre, 1964). Crustaceans (amphipods) dominated with densities ranging from 5 to 4,235/$m^2$ and wet weights of 0.02 to 33.07 g/$m^2$. Polychaetes were second ranging from 270 to 1,735/$m^2$ and 6.37 to 47.55 g wet weight/$m^2$. Polychaetes account for between 12 % (40 m) and 51.5% (69 m) of the total density, and when combined with the crustaceans account for >88% of all invertebrates in depths < 70 m. As percentage of total numbers molluscs ranged from 63 to 83% at less than 60 m and 2.8 to 37% between 60 and 100 m. At the greater depths (>70 m) the molluscs (27-30% of density) and echinoderms (15-38% of density) predominate. The greatest total density of fauna (>5,000 individuals/$m^2$) occurred in the shallow water (<60 m) and was <2,000 /$m^2$ in all deeper stations. Between 40 and 100 m nematodes were found to generally comprise 78-94% of the meiofauna (One value of 39% was recorded at 51 m on a gravel substrate), with estimated total meiofauna densities of $1.27*10^5$-$9.88*10^5$ individuals/$m^2$. The ratio of meibenthos density to macrobenthos between 40 and 100 m averaged 170:1 and ranged from 35:1 to 770:1 with four of the six station showing ratios between 170:1 and 185:1.

Sampling of an offshore transect from 2.5 to 200 m depth off of Cape Lookout, North Carolina, was conducted in 1965 (Day et al., 1971). Only those stations between 2.5 and 80 m depth are discussed here. The substrate ranged from fine to coarse sand (median particle diameters 0.15-0.609 mm). Thirty invertebrate species were collected at 2.5 m depth, 35 species at 5 m, 66 species at 10 m, 75 species at 20 m, 79 species at 39 m, and 77 species at 80 m. The species list of collected organisms in this area is considerably different from all other studies reported herein (i.e., is of a different biome than the more northern studies). Polychaetes showed the greatest diversity ranging from 13 species (2.5 m depth) to 50 species (20 m) per station. The number of species of other groups captured per station ranged from 4 (20 m) to 11 (39 m) for amphipods, 2 (5 m) to 13 (20 and 80 m) for bivalves, 2 to 4 for decapods at all depths, and 1-2 at all depths for gastropods and echinoderms. The most abundant organisms in depths of less than 80 m were amphipods and polychaetes. Of note with this survey is the very large sample size: the authors report 15,777 individuals of 619 species being identified.

In 1969 Cape Cod Bay, Massachusetts, was sampled for benthic organisms (Young and Rhoads, 1971). Water depths sampled ranged from 12 to 42 m and the substrate was composed of sand, silt, and clayey-silt (mean particle diameter < 0.75 mm). One hundred and thirteen species were reported consisting of polychaetes (46 sp.), molluscs (25 sp. [18 bivalves, 6 gastropods]), and amphipods (18 sp.). The remaining groups were isopods (3 sp.) Cumacea (5 sp.), mysids (3 sp.) echinoderms (5 sp.), cnidarians (3 sp.) and one species each of Ascidiacea, Archiannelidae, Oligochaeta, Nemertea, and Phoronida. Polychaetes, molluscs and amphipods comprise 94-98% of the macrofauna by number. Total densities of all species combined averaged 15,410 animals/$m^2$ with a maximum of 30,150/$m^2$ and the density of species (number species/0.1$m^2$) ranging from 34 to 56. The most abundant macrofauna are all polychaetes (*Euchone incolor, Capitella capitata, Spio limicola, Ninoe nigripes*, and *Asabellides oculata*). Polychaetes also predominate in terms of biomass (24.5-91.8% of total ash-free dry weight) if hard parts (i.e., large bivalve shells, urchin tests) are excluded. Calculation of diversity indices within Cape Cod Bay (Brillouns index) resulted in values of H between 2.65 and 3.53 (mean H = 3.08). Deposit feeders are reported as being four to seven times as abundant than suspension feeding species in this bay.

O'Connor (1972) reported on 144 samples taken in Moriches Bay, Long Island, New York, in 1969-70. This is a shallow bay (mean depth 1.2 m) with three types of substrate – sand, clay-silt, and transitional between these two. He found bivalve molluscs the most abundant group on the sand substrate (4,136 individuals/$m^2$), with polychaetes next in abundance (557 /$m^2$), followed by gastropods (462 /$m^2$) and amphipods (189 /$m^2$). All other groups were present at less than 25 /$m^2$. In the clay-silt substrate amphipods were most abundant (662 /$m^2$) followed by polychaetes (317 /$m^2$), gastropods (269 /$m^2$), bivalves (76 /$m^2$) and tunicates (50 /$m^2$). A square metre of the transition sediments supported 1,253 amphipods, 541 gastropods, 501 polychaetes, 486 bivalves, and 54 decapods. Total densities of all organisms combined ranged from 1,433 to 5,401 /$m^2$. Bivalves were found to dominate the biomass in the sand (36.1 g wet weight/$m^2$) and transitional substrates (49.9 g/$m^2$). In the clay-silt substrate polychaetes (17.7 g/$m^2$) and tunicates (15.8 g/$m^2$) predominated. With the exception of the polychaetes (5.5 g in sand, 10.6 g in transition sediments) in sand all other taxa were present at <2.1 g/m$^2$, in silt-clay at <7.5 g/m$^2$, and in the transition sediments at <5.3 g/m$^2$. Total biomass in sediments was calculated as 58.9 g/m$^2$ for sand, 71.9 g/m$^2$ for the transitional sediments, and 46.1 g/m$^2$ for the clay-silt substrate. The dominant species by weight in Moriches Bay were *Mercenaria mercenaria, Mytilus edulis, Clymenella torquata, Bostrichobranchus pilularis, Molgula provisionalis, Neries succina*, and *Nassarius obsoletus*. Suspension feeders were found to dominate in sandy (71.5% of biomass) and transitional (61.2 % of biomass) sediments. In clay-silt sediments deposit feeders form the majority (55.5%) of the biomass.

Two hundred and seven stations were sampled in Delaware Bay, Delaware, in 1972 and 1973 (Maurer et al., 1978). A total of 169 different species were collected in the two years from depths primarily (95% of stations) less than 15.5 m. This large number of stations sampled a very large variety of substrates, from 0-20% silt clay, to 70-100% silt clay. Annelids are reported as dominating (40.8% of total species), followed by arthropods (28.9% of species), molluscs (17.8%), ectoprocts (7.1%) and nemertean, cnidarians and echinoderms together accounting for 5.3% of species. Total density of organisms was low in this bay (722 individuals/m$^2$), and most samples were dominated by only one or two species. The most commonly occuring species and their respective densities were:

- *Tellina agilis* (Bivalve, 57-62% occurrence, average density 45/m$^2$, maximum density 410-800/m$^2$).
- *Ensis directus* (Bivalve, 34% occurrence, average density 62.5/m$^2$, maximum density 490-780/m$^2$).
- *Glycera dibranchiata* (Polychaete, 24-29% occurrence, average density 5/m$^2$, maximum density 60-80/m$^2$).
- *Heteromastus filiformis* (Polychaete, 24-28% occurrence, average density 17/m$^2$, maximum density 490/m$^2$).
- *Gemma gemma* (Bivalve, 25% occurrence, average density 319/m$^2$, maximum density 2,290-4,160/m$^2$).
- *Mulinia lateralis* (Bivalve, 16-21% occurrence, average density 26/m$^2$, maximum density 2,760/m$^2$).
- *Nucula proxima* (Bivalve, 12-21% occurrence, average density 13/m$^2$, maximum density 250-630/m$^2$).

- *Nephthys picta* (Polychaete, 16-18% occurrence, average density 2.5/m$^2$, maximum density 60/m$^2$).
- *Protohaustorius wigleyi* (Amphipod, 14% occurrence, average density 8.4/m$^2$, maximum density 160-310/m$^2$).

Using cluster analysis techniques, Maurer et al. (1978) determined nine separate faunal assemblages in the bay in 1972 and four in 1973. Deposit feeders were estimated to comprise 45% of the community, while suspension feeders form 24.8% and the remainder were carnivores (18.3%), omnivores (10.7%), and ectoparasite or commensals (1.2%). It was concluded that Delaware Bay comprises a mosaic of faunal assemblages, some of which fit the classic community concept but others are thought to represent species distributed along an environmental continuum rather than as discrete groups.

In Chesapeake Bay, Maryland, in 1973-74, as part of an enclosure predation study, the natural benthic fauna was examined (Virnstein, 1977). The area sampled was shallow water (1.4 m) of sand bottom. Of the 13 top ranked species 11 were annelids (10 of these polychaetes). In ranked order the dominant species reported were *Peloscolex gabriella*, *Spiochaetopterus oculatus*, *Heteromastus filiformis*, *Streblospio bendeicti*, *Phoronis psammophila*, *Glycinde solitaria*, *Polydora ligni*, *Paraprionspio pinnata*, *Scolelepsis squamata*, *Scoloplos robustus*, *Eteone heteropoda*, *Nereis succinea*, and *Acteon punctostriatus*. Average densities ranged from 89 *Acteon punctostriatus*/m$^2$ to 3,971 *Peloscolex gabriellae*/m$^2$. The polychaete density ranged from 105 *Eteone heteropoda*/m$^2$ to 1,424 *Heteromastus filiformis*/m$^2$. Of note is the complete lack of bivalves and crustaceans from the dominant species list. *Phoronis psammophila* is the only suspension feeder, the remainder of the dominant species are all deposit feeders.

As part of an experiment on clam predation, MacKenzie (1977) reports some predator densities in Long Island Sound, Connecticut. The crab *Cancer irroratus* density was estimated at 3.6-57.0/m$^2$ (juveniles) and 0.7-1.1/m$^2$ (adults). The mud crab *Neopanope sayi* was estimated at 7.5-53.8/m$^2$ and the gastropods *Urosalpinix cinerea* and *Eupleura caudata* from 3.3-19.5/m$^2$. Juveniles of the seastar *Asterias forbesi* ranged in density from 1.1-72.1 individuals/m$^2$ and adults from 0.1-2.3/m$^2$. Finally, the quahog *Mercenaria mercenaria* was present at $<1$ clam/m$^2$.

*Summary of U.S. Coastal Studies*

As may be expected from sampling over an area as large as the eastern American seaboard, and consequently over a large variety of temperature, salinity and substrate characteristics, the resulting invertebrate communities are quite variable. Table 20 summarizes the number of dominant or common species by group from the studies reported here.

Table 20: Summary of number of reported dominant or common species by group for various U.S. studies. For sources of studies see text.

| | Bivalves | Gastropods | Polychaetes | Crustaceans[a] | Amphipods | Echinoderms |
|---|---|---|---|---|---|---|
| Cape Ann | 1 | 5 | - | 3 | 1 | - |
| Ipswich Bay | - | 1 | 2 | - | 3 | 4 |
| Menemsha Bight | 2 | 1 | 2 | 1 | 2 | 1 |
| Greenwhich Bay | 4 | 1 | 5 | 3 | 3 | - |
| Buzzards Bay | 4-12 | 5-14 | 11-33 | 3 | 11-21 | 1 |
| Cape Lookout[b] | 2-13 | - | 13-50 | 2-4 | 4-11 | 2-4 |
| Cape Cod Bay | 18 | 6 | 46 | - | 18 | 5 |
| Moriches Bay | 2 | 1 | 2 | - | - | - |
| Delaware Bay | 5 | - | 3 | - | 1 | - |
| Chesapeake Bay | - | 1 | 10 | - | - | - |

[a] = Crustaceans includes only non-amphipod crustaceans
[b] = Cape Lookout includes total species captured in each group rather than only common/dominant

Total densities of fauna on and in appropriate substrate commonly range up to >5,000 individuals/m$^2$, with some notable densities including 1,735 polychaetes/m$^2$, 4,136 bivalves/m$^2$, and 4,235 amphipods/m$^2$. Deposit feeders are generally reported as being between 2 and 20 times as abundant as suspension feeders, though this is entirely dependent upon the substrate being sampled. The ratio of meiofauna to macrofauna is on the order of 100:1 to 170:1.

# 4. Discussion

A significant feature became apparent on examining the benthic studies of the Atlantic from the last 60 years; there has been a loss of emphasis on this component of the marine ecosystem in recent years. If study effort is allocated as "study-year" (i.e., one study-year = a study occurring in a given year, so a 3 year study is 3 study years), then 62% of the research reported here occurred between 1950 and 1980, with another 20% having taken place between 1930 and 1940. The years 1980 to the present comprise only approximately 16% of the research effort directed at benthic communities since 1930. Further, of the eight studies which make up the effort for the last 18 years, four were directed at other questions (e.g., commercial lobster, scallop issues) and benthos was only included as a secondary component and so in very little detail. In contrast, from 1960-1980 there were 12 published Canadian studies including benthos data, all of which were concerned with benthic ecology, to differing levels of detail, rather than treating the benthic community secondarily to commercial species.

The 42 studies (see Figure 3) reported here range over a large area and diversity of environments, yet they contain a good deal of consistency in results. This consistency may be useful in generalizing to St. Georges Bay, though it must be recognized that this is in no way a substitute for the field sampling of benthic fauna/communities in St. Georges Bay (see Recommendations).

Within environmental conditions (water depth and substrate type) relatively similar to St. Georges Bay the greatest number of individual species per phyla/class (i.e., diversity within phyla/class) appears to belong to the polychaetes. Due to the differences in sampling methods and target species, direct comparison of polychaete diversity between studies is not feasible. However, in those studies which reported polychaete numbers, these invertebrates accounted for between 10 and 70% of the total species present. Within Northumberland Strait, polychaetes represented 26.5-38% of all species present (Table 21). The classes which contributed the next greatest species numbers were the bivalve and the gastropod molluscs. These two groups occurred in generally similar numbers (i.e., between 0.6-3.8 bivalves/gastropod) and together represent approximately

12-37% of the total species present on the substrate. Sanders (1968) reports that the combination of polychaetes and bivalves comprise about 80% of the animals by number within many environments – deep sea, tropical shallow water, tropical estuary, and boreal shallow water. Within the studies reported here, the combination of polychaetes and bivalves ranges generally between 22 and 56% of the total species number, with only one study (Day et al., 1971) reporting species numbers for these two groups at 80% of total species present.

Species presence of non-amphipod crustaceans are variable in their representation, depending upon the location being sampled, but based on the studies reviewed here these crustaceans are present as 3-16% of the total species. Amphipods are not consistently reported, though at some locations (e.g., Northumberland Strait) they obviously form a large contribution to the total species diversity. The echinoderms are consistently represented with low species number, generally <10% of total, and <15% of total species in all reviewed studies. The remainder of the species consist of nematodes, tunicates, hydroids, bryozoans, cnidarians, cumaceans, poriferans, polyplacophorans, and several associated phyla present only in minor quantities. There are indications that the diversity of the benthic fauna is greatest in intermediate depths (e.g., < 75 m depth).

Individual organism densities of >1,000/m$^2$ are not uncommon for some species of bivalves, gastropods, polychaetes and amphipods on the appropriate substrate. In contrast, predator species (e.g., decapod crustaceans and seastars) are almost always reported at < 4/m$^2$. The meiofauna (primarily nematodes) within the substrate, largely ignored in marine benthic studies, are present at densities approaching three orders-of-magnitude greater than the most common macrofaunal species. The density of total fauna (all species combined) commonly exceeds 1,000 organisms/m$^2$, but such assessments are very dependent upon the level of detail of the investigator. There are suggestions that the greatest densities of total individuals (all species combined) occurs in relatively shallow water (<60 m) and decreases in deeper water.

Table 21: Summary of number of species per taxa for various areas reported in Atlantic Canada/U.S.A. Absence of species in a row does not indicate that group is not present, only that it was not sampled for/recorded/analyzed.

| | Northumberland Strait | | | | Southern Gulf | | | Northern Gulf | | Fundy |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dunbar et al. (1980) | Caddy et al (1977)[a] | Caddy et al (1977)[b] | Anonymous (1997, 1998) | Hughes & Thomas (1971a) | Hughes & Thomas (1971b) | Brunel (1971) | Peer (1963) | Robert (1979) | Caddy, (1970) |
| Depth (m) | | 5-49 | 7-49 | 5-20 | 0.3-5.4 | 0-4.7 | 9-100 | 73 & 86 | 15-150 | 55-128 |
| Substrate | | Gravel/coarse material; sand; silt-clay | Mud; mud-clay | Cobble; shell; sand; silt; bedrock; boulders | | Silt-clay to coarse sand | Sand; muddy sand; mud | Unsorted gravel to fine sand | Silt-sand; silt-clay; sand-silt | Rock; gravel; sand; mud |
| **Bivalves** | 23 | 26 | 19 | 8 | 14 | 7 | 11 | | 36 | 18 |
| **Gastropods** | 9 | 16 | 5 | 14 | 9 | 6 | | | 16 | 14 |
| **Crustaceans** | 4 | | | 11 | 6 | | 17 | | | 12 |
| **Polychaetes** | | 91 | 58 | 7 | 20 | 7 | 19 | 22 | | 17 |
| **Amphipods** | | 73 | 41 | | | 2 | | 9 | | |
| **Echinoderms** | | 6 | 5 | 3 | 1 | | 12 | 4 | | 18 |
| **Algae** | 12 | 74 | | 25 | 8 | | | | | |
| **Total reported species** | N/A | 343 | 153 | 68 | 62 | Not Reported | Not reported | 31 | 52 | 130 |

[a] = Entire Northumberland Strait

[b] = Area D only

| | Buzzards Bay | | Cape Cod Bay | Greenwhich Bay | Cape Lookout |
|---|---|---|---|---|---|
| | Sanders (1958) | Sanders (1960) | Young & Rhoads (1971) | Stickney & Stringer (1957) | Day et al. (1971) |
| Depth (m) | 7-20 | 19 | 12-42 | 3-9 | 2.5-80 |
| Substrate | Sand; silt-clay | Silt-clay | Sand; silt; clayey-silt | Silt-mud; mud | Fine to coarse sand |
| **Bivalves** | 4-7 | 12 | 18 | 19 | 2-13 |
| **Gastropods** | 5 | 14 | 6 | 13 | 1-2 |
| **Crustaceans** | 3 | 3 | | 12 | 2-4 |
| **Polychaetes** | 11-17 | 33 | 46 | 37 | 13-50 |
| **Amphipods** | 4-16 | 21 | 18 | 4 | 4-11 |
| **Echinoderms** | | 1 | 5 | 2 | 1-2 |
| **Total reported species** | Not reported | 95 | 113 | 114 | 30-79 (per station) |

The biomass of benthic organisms fluctuates over the annual season but appears to range from <5 g to as high as 1,400 g wet weight/m$^2$ based on the limited information provided by the reported studies. Unfortunately, biomass is not reported as often as species numbers and densities. In addition, variations in the analysis and reporting of biomass (e.g., wet weight, dry weight, ash free dry weight, with or without shells/tests) make comparison of the limited biomass information impossible. As generalizations, polychaetes, bivalves, gastropods and echinoderms appear to often form the bulk of the invertebrate biomass in northern Atlantic waters, with polychaetes contributing to a greater degree if shells and tests of the other classes/phyla are excluded. Larger but less commonly occurring taxa, such as decapod crustaceans, form only a minor component of the benthic biomass. Often the bulk of the biomass (>95%) is represented by only a few species (i.e., ≤17).

Deposit and suspension feeders were generally reported to dominate the benthic communities, though other trophic guilds (browsers, carnivores, omnivores, ectoparasites) are also present. Deposit feeders appear to be between 2 and 20 times as abundant as suspension feeders, though this is entirely dependent upon the substrate being sampled. Deposit feeders predominate on silt-clay bottoms while the suspension feeders are more common on sand substrate.

The substrate plays a dominant role in structuring the benthic community and determining what taxa are present. Suspension feeders are most abundant on sandy sediments free from large amounts of silt and clay (Levinton, 1972); a median grain size of 0.18 mm diameter has been theoretically postulated as the optimal size for this trophic guild (Sanders, 1958). The higher velocity currents over sand bottoms, relative to mud bottoms, is thought to assist in suspending and transporting food to suspension feeders (Sanders, 1958). In contrast, deposit feeders are more abundant on finer silt/mud sediments; it has been hypothesized that part of the reason is that the larger surface area of the smaller particles provides more surface for growth of a primary deposit feeder food, bacteria (Levinton, 1972). As well, the slower water currents allow the settling out of food particles (Sanders, 1958) and so an enrichment of the sediment from above.

Probert (1984) indicates that this is not simply passive selection of substrate by the guild, but that once established, the organisms can themselves substantially alter the properties of the sediment. Sanders (1968) suggests that the tubes of amphipod and polychaetes increase sediment stability and spatial complexity of the sand, increasing the diversity due to the greater variety of microhabitats. It has been argued by Gray (1981) that mixed communities of deposit and suspension feeders tend to be the rule rather than distinct communities of each. Thus, while the substrate grain size is correlated with benthic distribution; the mechanisms controlling this distribution and the interactions between various guilds remain unclear.

## *4.1 Implications for St. Georges Bay*

The St. Georges Bay study area substrate is composed of distinct areas of gravelly poorly-sorted sands, coarse gravel to well sorted sand, fine sands, very sandy fines, silty mud, sandy mud, and muddy sand, as well as a continuum of combinations of these substrate types. Therefore, it should be expected that there will be a large number and variety of benthic communities within the study area. Figure 5 attempts to capture this by generalizing diversity, trophic guilds, individual phyla/classes and dominant phyla for the various substrates found within St. Georges Bay. This figure indicates changes in these parameters based on differing substrates. For example, bivalves (species numbers, density, biomass) may be expected to increase with decreasing particle size (i.e., sands, silts) down to a point at which the substrate is too fine (i.e., anoxic, difficult burrowing, etc.) when the bivalves may be expected to decrease; only specialized species will be able to inhabit these sediments. It is necessary that it be recognized that this figure is a generalization of studies from elsewhere and that the sediments constitute a continuum of substrates.

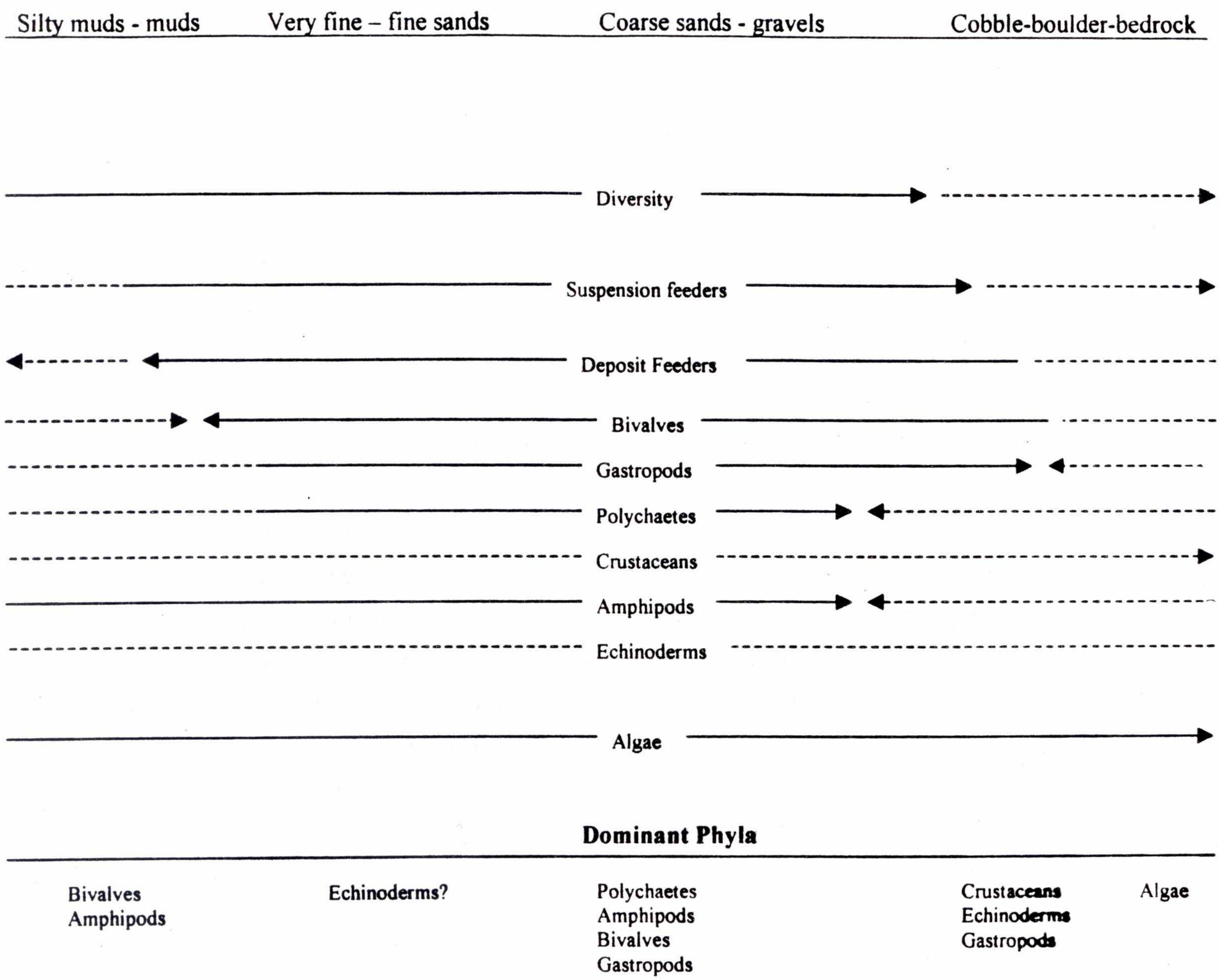


Figure 5: Generalized relationships of diversity, trophic guild, and phyla to sediment type based on review of studies within this document. Broken lines indicate hypothesized (unknown) trajectories.

Following the philosophy of Jones (1950) that "*It is probably true that no two assemblages of animals from different places are ever exactly alike, but it is possible to draw up lists of species that will almost certainly be found on a particular type of bottom within the region, provided that temperature and salinity are within some limits.*" A preliminary species list (Table 22) has been constructed below based on Northumberland Strait sampling. Due to the commonality of these species among studies, and their abundance, it is suggested that they will also probably form significant components of the benthic community on the appropriate substrate. The low number of polychaetes in Table 22 is more likely a lack of sampling for them than a lack of presence, based on the majority of studies reporting an abundance of species and densities of Polychaeta.

It is expected that St. Georges Bay will show a large scale fluctuation in biomass through the year; this is a result of the relatively large changes in water temperature with the seasons. Due to growth and metabolism of ectotherms being dependent upon the ambient temperature of the surroundings, it is suggested that biomass will peak during and slightly after temperature maxima and be at a low during the period of temperature minima.

Table 22: Common (abundant or widespread) species from Northumberland Strait studies (Tables 1-3) and hence likely to occur in St. Georges Bay.

| Algae | Bivalves | Gastropods | Crustaceans |
|---|---|---|---|
| *Antithamnion* sp. | *Anomia simplex* | *Acmaea testudinalis* | *Aeginella longicornis* |
| *Asperococcus echinatus* | *Arctica islandica* | *Admete couthouyi* | *Balanus balanoides* |
| *Ceramium* | *Astarte subaequilatera* | *Aeolidia papillosa* | *Balanus* sp. |
| *Ceramium fastigatum* | *Astarte undata* | *Buccinum undatum* | *Cancer irroratus* |
| *Ceramium rubrum* | *Clinocardium ciliatum* | *Coryphella* sp | *Caprella linearis* |
| *Chaetomorpha melangonium* | *Crassostrea virginica* | *Crepidula convexa* | *Caprella sp.* |
| *Chaetomorpha* sp. | *Crenella glandula* | *Crepidula fornicata* | *Corophium volutator* |
| *Chondrus crispus* | *Gammarus* sp. | *Crepidula plana* | *Crangon septemspinosa* |
| *Chorda filum* | *Hiatella arctica* | *Dendronotus frondosus* | *Homarus americanus* |
| *Chordaria flagelliformis* | *Macoma tenta* | *Eubranchus* sp. | *Jassa falcata* |
| *Cladomorpha* sp. | *Mercenaria mercenaria* | *Facelina bostoniensis* | *Pagurus acadianus* |
| *Cladophora albida* | *Modiolus modiolus* | *Lacuna vincta* | *Pagurus pubescens* |
| *Cladophora seriacea* | *Modiolus* sp. | *Littorina* sp. | *Diastylis quadraspinosa* |
| *Cladophora* sp. | *Mulina lateralis* | *Mitrella lunata* | *Eudorella trunacta* |
| *Corallina offinalis* | *Mya arenia* | *Nassarius trivittatus* | *Leucon nasica* |
| *Cystoclonium ceranoides* | *Mya truncata* | *Notoacmaea testudinalis* | *Eudorella emarginata* |
| *Enteromorpha* | *Mytilus edulis* | *Onchidoris* | |
| *Enteromorpha linza* | *Mytilus* sp. | *Polineces heros* | |
| *Eudesme virescens* | *Nucula proxima* | *Polineces immaculata* | |
| *Euthora cristata* | *Nucula tenuis* | *Urosalpinix cinerea* | |
| *Fucus serratus* | *Pandora glacialis* | *Oenopta (Lora) elegans* | |
| *Gelidium* sp. | *Periploma leanum* | *Oenopta (Lora) turricula* | |
| *Laminaria digitata* | *Petricola pholadiformis* | | |
| *Laminaria saccorhina* | *Pitar morrhuana* | | |
| *Phyllophora pseudoceranoides* | *Placopecten magellanicus* | | |
| *Pilayella littoralis* | *Spisula solidissima* | | |
| *Polysiphonia harveyi* | *Teredo navalis* | | |
| *Polysiphonia nigrescens* | *Thyasira gouldii* | | |
| *Polysiphonia* sp. | *Volsella modiolus* | | |
| *Polysiphonia urceolata* | *Yoldia limatula* | | |
| *Rhodymenia palmata* | *Yoldia sapotilla* | | |
| *Saccorhiza dermatodea* | *Yoldia thraciaeformis* | | |
| *Spermothamnion repens* | | | |
| *Spermothamnion* sp | | | |
| *Trailliella intricata* | | | |
| *Ulva lactuca* | | | |

| Polychaetes | Echinoderms |
|---|---|
| *Eulalia viridis* | *Asterias forbesi* |
| *Eusyllis blomstrandi* | *Asterias vulgaris* |
| *Gattyana cirrosa* | *Henricia* sp. |
| *Harmothoe* sp. | *Ophiura robusta* |
| *Neries* sp. | *Strongylocentrotus drobachiensis* |
| *Polydora ciliata* | |
| *Phyllodoce* sp. | |

# 5. Conclusions

Benthic fauna and communities display great variability in their component species and abundance over both spatial and temporal scales. Generalizations regarding presence of species on different substrates can be made (e.g., deposit feeding bivalves on mud-silt substrates), but specific statements cannot be derived for individual communities due to the great complexity of these systems. The most significant phyla, in terms of diversity, density and biomass appear to be bivalve and gastropod molluscs, polychaetes, amphipods, and nematodes. In some areas echinoderms and decapod crustaceans contribute significantly to the density and biomass of benthic invertebrates. Meiofauna appears to form a large, but as yet unstudied, component of benthic communities.

Although this report has reviewed the communities in the surrounding areas as indicators of what might be present within St. Georges Bay, it is not possible to extrapolate communities from nearby areas to the bay of interest. The findings of this review indicate that such an approach would be incorrect and misleading. Benthic communities are functions of their substrate and water quality environments, but they can and do vary significantly over short spatial and temporal scales. The mixed substrates of St. Georges Bay, combined with its unusual temperature regime, suggest the presence of mixtures of communities, and growth and biomass, unusual for similar depth waters from elsewhere. The heterogenous nature of St. Georges Bay sediments will probably support an equally heterogenous collection of communities, differing in diversity, species and individual density, biomass, and trophic guilds.

Published research on benthic fauna and communities has been almost non-existent in the last twenty years. There appears to have been a decrease in appreciation of the importance of this component of the marine ecosystem. The benthic system is tightly coupled to the pelagic system via suspended and deposited food and in turn provides a food source and living space for many animals that live in the water column and upper layers. Greater emphasis on the benthic system, including detailed sampling of macro- and meiofauna, is required before any model of St. Georges Bay may be constructed.

# 6. Recommendations

The following research approaches are recommended for St. Georges Bay in order to better understand benthic dynamics and interactions with the community within the water column. This information is required in order to build a model of the St. Georges Bay ecosystem.

I. Collect unpublished information from government/consultants offices to expand the local database. As well, review the French language publications. This will add to what has been presented here.

II. Sample St. Georges Bay for benthic fauna and community structure. This should include number of species present (diversity), density (species and individual), biomass, trophic structure, and meiofauna. Suggested methodology is SCUBA transects in shallow water and a combination of grab samples and short tows in deeper water. A well designed sampling procedure and schedule is the required first step. Such sampling is necessary and critical if information is to be gathered on the benthos of St. Georges Bay.

III. Three aspects of sampling in St. Georges Bay are strongly recommended for focus: 1) Determination/analysis of feeding guilds (suspension vs. deposit vs. others) on the various sediments; 2) The magnitude of the meiofauna abundance within differing substrate types and it's role in the community; and 3) Interactions between the surface benthic fauna and the community in the water column above the substrate.

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**Appendix 1**: Alphabetical listing of species names of invertebrates referred to in the text.
Classification according to Whiteaves (1901), Gosner (1978), and Barnes (1987)

| Species Name | Phylum |
|---|---|
| *Acmaea testudinalis* | Mollusca; Gastropoda |
| *Actean punclostriatus* | Mollusca; Gastropoda |
| *Admete couthouyi* | Mollusca; Gastropoda |
| *Aeginella longicornis* | Arthropoda; Crustacea (amphipod) |
| *Aeolida papillosa* | Mollusca; Gastropoda (Nudibranchs) |
| *Ampelisca macrocephala* | Arthropoda; Crustacea (amphipod) |
| *Ampelisca spinipes* | Arthropoda; Crustacea (amphipod) |
| *Anomia simplex* | Mollusca: Bivalvia |
| *Anomia* spp. | Mollusca: Bivalvia |
| *Anticoma litoris* | Nematoda |
| *Apporrhais occidentalis* | Mollusca; Gastropoda |
| *Arabella iricolor* | Annelida; Polychaeta (Errant) |
| *Arctica islandica* | Mollusca: Bivalvia |
| *Argis dentata* | Arthropoda; Crustacea (shrimp) |
| *Aricidea* sp. | Annelida; Polychaeta (Sedentary) |
| *Arrhis phyllonyx* | Arthropoda; Crustacea (amphipod) |
| *Asabellides oculata* | Annelida; Polychaeta (Sedentary) |
| *Ascidia* sp. | Chordata; Tunicata (sea squirts) |
| *Astarte* sp. | Mollusca: Bivalvia |
| *Astarte subaequilatera* | Mollusca: Bivalvia |
| *Astarte undata* | Mollusca: Bivalvia |
| *Asterias forbesi* | Echinodermata; Stelleroidea (seastars) |
| *Asterias* sp. | Echinodermata; Stelleroidea (seastars) |
| *Asterias vulgaris* | Echinodermata; Stelleroidea (seastars) |
| *Averillia* sp. | Bryozoa |
| | |
| *Balanus balanoides* | Arthropoda; Crustacea (barnacle) |
| *Balanus balanus* | Arthropoda; Crustacea (barnacle) |
| *Balanus hemero* | Arthropoda; Crustacea (barnacle) |
| *Balanus improvisus* | Arthropoda; Crustacea (barnacle) |
| *Balanus* sp. | Arthropoda; Crustacea (barnacle) |
| *Boltenia ovifera* | Chordata; Tunicata (sea squirts) |
| *Bostrichobranchus pilulons* | Chordata; Tunicata (sea squirts) |
| *Bougainvillia* sp. | Cnidaria; Hydrozoa |
| *Bryozoa membranaceum* | Bryozoa |
| *Buccinum undatum* | Mollusca; Gastropoda |
| *Bugula turrita* | Bryozoa |
| *Bugulla flabellata* | Bryozoa |
| *Byblis errata* | Arthropoda; Crustacea (amphipod) |
| | |
| *Callocardia morrhuana* | Unclassified |
| *Campanularia calceolifera* | Cnidaria; Hydrozoa |
| *Campanularia* sp. | Cnidaria; Hydrozoa |

**Appendix 1 (con't)**

| Species Name | Phylum |
|---|---|
| *Cancer borealis* | Arthropoda; Crustacea (crabs) |
| *Cancer irroratus* | Arthropoda; Crustacea (crabs) |
| *Cancer* spp. | Arthropoda; Crustacea (crabs) |
| *Capitella capitata* | Annelida; Polychaeta (Sedentary) |
| *Caprella acutifrons* | Arthropoda; Crustacea (amphipod) |
| *Caprella linearis* | Arthropoda; Crustacea (amphipod) |
| *Caprella* sp. | Arthropoda; Crustacea (amphipod) |
| *Carcinus maenas* | Arthropoda; Crustacea (crabs) |
| *Casco bigelowi* | Arthropoda; Crustacea (amphipod) |
| *Cerastoderma pinnulatum* | Mollusca: Bivalvia |
| *Cerastoderma* spp. | Mollusca: Bivalvia |
| *Cerianthes americana* | Cnidaria; Anthozoa |
| *Chalina oculata* | Porifera |
| *Chionoectes opilio* | Arthropoda; Crustacea (crab) |
| *Chiridotea tuftsi* | Arthropoda; Crustacea (isopods) |
| *Chlamys islandica* | Mollusca: Bivalvia |
| *Chondractinia tuberculata* | Unclassified |
| *Cingula aculeus* | Mollusca; Gastropoda |
| *Clinocardium ciliatum* | Mollusca: Bivalvia |
| *Clione vastificia* | Mollusca; Gastropoda |
| *Clymenella torquata* | Annelida; Polychaeta (Sedentary) |
| *Colus stimpsoni* | Mollusca; Gastropoda |
| *Corophium cylindricum* | Arthropoda; Crustacea (amphipod) |
| *Corophium insidosium* | Arthropoda; Crustacea (amphipod) |
| *Corophium volutator* | Arthropoda; Crustacea (amphipod) |
| *Coryphella* sp. | Mollusca; Gastropoda (Nudibranchs) |
| *Cossura longocirrata* | Annelida; Polychaeta (Sedentary) |
| *Crangon septemspinosus* | Arthropoda; Crustacea (shrimp) |
| *Crassostrea virginica* | Mollusca: Bivalvia |
| *Crenella glandula* | Mollusca: Bivalvia |
| *Crepidula convexa* | Mollusca; Gastropoda |
| *Crepidula fornicata* | Mollusca; Gastropoda |
| *Crepidula plana* | Mollusca; Gastropoda |
| *Crossaster papposus* | Echinodermata; Stelleroidea (seastars) |
| *Ctenodiscus crispatus* | Echinodermata; Stelleroidea (seastars) |
| *Cucumaria frondosa* | Echinodermata; Holothuria (sea cucumber) |
| *Cumingia tellinoides* | Mollusca: Bivalvia |
| *Cylichna orzya* | Mollusca; Gastropoda |
| *Cyprina islandica* | Unclassified |
| *Dendronotus frondosus* | Mollusca; Gastropoda (Nudibranchs) |
| *Diastylis polita* | Arthropoda; Crustacea (Cumacea) |
| *Didemnum candidum* | Chordata; Tunicata (sea squirts) |
| *Dioptera cupreae* | Annelida; Polychaeta (Errant) |
| *Doliolum* sp. | Chordata; Thaliacea (Salps) |
| *Dorvillea caeca* | Annelida; Polychaeta (Errant) |

**Appendix 1 (con't)**

| Species Name | Phylum |
|---|---|
| *Dorylaimopsis metatypicus* | Nematoda |
| | |
| *Echinarachinus parma* | Echinodermata; Ehinoidea (urchins & sand dollars) |
| *Edotea triloba* | Arthropoda; Crustacea (isopods) |
| *Emerita talpoidea* | Arthropoda; Crustacea (crabs) |
| *Ensis directus* | Mollusca: Bivalvia |
| *Eteone heteropoda* | Annelida; Polychaeta (Errant) |
| *Eualus macilentus* | Arthropoda; Crustacea (shrimp) |
| *Eubranchus* sp. | Mollusca; Gastropoda (Nudibranchs) |
| *Euchone incolor* | Annelida; Polychaeta (Sedentary) |
| *Eucrata loricata* | Bryozoa |
| *Eulalia viridis* | Annelida; Polychaeta (Errant) |
| *Eupleura caudata* | Mollusca; Gastropoda |
| *Eusyllis biomstarndi* | Annelida; Polychaeta (Errant) |
| | |
| *Facelina bostoniensis* | Mollusca; Gastropoda (Nudibranchs) |
| *Flabelligera affinis* | Annelida; Polychaeta (Sedentary) |
| *Flustra foliacea* | Bryozoa |
| | |
| *Gammarus locusta* | Arthropoda; Crustacea (amphipod) |
| *Gammarus* sp. | Arthropoda; Crustacea (amphipod) |
| *Gattyana cirrosa* | Annelida; Polychaeta (Errant) |
| *Gemma gemma* | Mollusca: Bivalvia |
| *Gephryea* sp. | Unclassified |
| *Gersemia* sp. | Cnidaria; Anthozoa |
| *Glycera americana* | Annelida; Polychaeta (Errant) |
| *Glycera dibranchiata* | Annelida; Polychaeta (Errant) |
| *Glycinde solitaria* | Annelida; Polychaeta (Errant) |
| *Gorgonocephalus arcticus* | Echinodermata; Stelleroidea (seastars) |
| | |
| *Halichondria bowerbanki* | Porifera |
| *Halocynthia pyriformis* | Chordata; Tunicata (sea squirts) |
| *Haploscolops fragilis* | Annelida; Polychaeta (Sedentary) |
| *Harmothoe exteniata* | Annelida; Polychaeta (Errant) |
| *Harmothoe imbricata* | Annelida; Polychaeta (Errant) |
| *Harmothoe nodosa* | Annelida; Polychaeta (Errant) |
| *Harmothoe* sp. | Annelida; Polychaeta (Errant) |
| *Henricia sanguinolenta* | Echinodermata; Stelleroidea (seastars) |
| *Henricia* spp. | Echinodermata; Stelleroidea (seastars) |
| *Heteromastus filiformis* | Annelida; Polychaeta (Sedentary) |
| *Hiatella arctica* | Mollusca: Bivalvia |
| *Hippasteria phryginia* | Echinodermata; Stelleroidea (seastars) |
| *Hippomedon cirratus* | Arthropoda; Crustacea (amphipod) |
| *Homarus americanus* | Arthropoda; Crustacea (lobster) |
| *Hutchinsoniella macracanth*ε | Arthropoda; Crustacea (amphipod) |
| *Hyas areneus* | Arthropoda; Crustacea (crabs) |

**Appendix 1 (con't)**

| Species Name | Phylum |
|---|---|
| *Hyas coarctatus* | Arthropoda; Crustacea (crabs) |
| *Hyas* spp. | Arthropoda; Crustacea (crabs) |
| *Hydractinia* sp. | Cnidaria; Hydrozoa |
| *Hydrallmania furcuta* | Cnidaria; Hydrozoa |
| *Hydrobia minuta* | Mollusca; Gastropoda |
| | |
| *Idothea baltica* | Arthropoda; Crustacea (isopods) |
| *Ischnochiton alba* | Mollusca; Polyplacophora (chitons) |
| *Ischnochiton ruber* | Mollusca; Polyplacophora (chitons) |
| | |
| *Jassa falcata* | Arthropoda; Crustacea (amphipod) |
| | |
| *Lacuna vincta* | Mollusca; Gastropoda |
| *Lepidonotus squamatus* | Annelida; Polychaeta (Errant) |
| *Leptastarias polaris* | Echinodermata; Stelleroidea (seastars) |
| *Leptocheiros pinguis* | Arthropoda; Crustacea (amphipod) |
| *Leptochelia rapex* | Arthropoda; Crustacea (isopods) |
| *Leptonemella* sp. | Nematoda |
| *Libinia emarginata* | Arthropoda; Crustacea (crabs) |
| *Littorina littorea* | Mollusca; Gastropoda |
| *Littorina saxitalis* | Mollusca; Gastropoda |
| *Littorina* sp. | Mollusca; Gastropoda |
| *Lumbrinereis fragilis* | Annelida; Polychaeta (Errant) |
| *Lumbrinereis tenuis* | Annelida; Polychaeta (Errant) |
| *Lunatia heros* | Mollusca; Gastropoda |
| *Lurcenaria quadricornis* | Cnidaria; Hydrozoa |
| | |
| *Macoma balthica* | Mollusca: Bivalvia |
| *Macoma calcarea* | Mollusca: Bivalvia |
| *Macoma tenta* | Mollusca: Bivalvia |
| *Maldane sarsi* | Annelida; Polychaeta (Sedentary) |
| *Maldanopsis elongata* | Annelida; Polychaeta (Sedentary) [=*Asychis*] |
| *Margarites costalis* | Mollusca; Gastropoda |
| *Margarites groenlandica* | Mollusca; Gastropoda |
| *Membranipora* sp. | Bryozoa |
| *Mercenaria mercenaria* | Mollusca: Bivalvia |
| *Metridium senile* | Cnidaria; Anthozoa |
| *Metridium* sp. | Cnidaria; Anthozoa |
| *Micrura leidyi* | Platyhelminthes;Rhyncocoela (Nemertean worms) |
| *Mitrella lunata* | Mollusca; Gastropoda |
| *Modiolus demissus* | Mollusca: Bivalvia |
| *Modiolus modiolus* | Mollusca: Bivalvia |
| *Molgula manhattensis* | Chordata; Tunicata (sea squirts) |
| *Molgula provisionalis* | Chordata; Tunicata (sea squirts) |
| *Mulinia lateralis* | Mollusca: Bivalvia |
| *Mya arenia* | Mollusca: Bivalvia |

**Appendix 1 (con't)**

| Species Name | Phylum |
|---|---|
| *Mya truncata* | Mollusca: Bivalvia |
| *Myriopora subgrucila* | Ectoproct |
| *Mysella planulata* | Unclassified |
| *Mytilus edulis* | Mollusca: Bivalvia |
| | |
| *Nassarius obsoletus* | Mollusca; Gastropoda |
| *Nassarius trivatatta* | Mollusca; Gastropoda |
| *Neochromodora pistillata* | Nematoda |
| *Neohela monstrosa* | Arthropoda; Crustacea (amphipod) |
| *Neopanope sayi* | Arthropoda; Crustacea (crabs) |
| *Neopanope texana* | Arthropoda; Crustacea (crabs) |
| *Nephthys bucera* | Annelida; Polychaeta (Errant) |
| *Nephthys ciliata* | Annelida; Polychaeta (Errant) |
| *Nephthys incisa* | Annelida; Polychaeta (Errant) |
| *Nephthys picta* | Annelida; Polychaeta (Errant) |
| *Neptunea decemcostata* | Mollusca; Gastropoda |
| *Neptunea despecta tornata* | Mollusca; Gastropoda |
| *Nereis* sp. | Annelida; Polychaeta (Errant) |
| *Nereis succina* | Annelida; Polychaeta (Errant) |
| *Nereis vivens* | Annelida; Polychaeta (Errant) |
| *Nerinidea* sp. | Annelida; Polychaeta |
| *Ninoe nigripes* | Annelida; Polychaeta (Errant) |
| *Notoacmeae testudinalis* | Mollusca; Gastropoda |
| *Notomastus latericeus* | Annelida; Polychaeta (Sedentary) |
| *Nucula proxima* | Mollusca: Bivalvia |
| *Nucula tenuis* | Mollusca: Bivalvia |
| *Nuculans pernula* | Mollusca: Bivalvia |
| | |
| *Obelia* spp. | Cnidaria; Hydrozoa |
| *Odontophor loffleri* | Nematoda |
| *Odontophora pugilator* | Nematoda |
| *Odontophora pupusi* | Nematoda |
| *Odostomia* sp. | Mollusca; Gastropoda |
| *Onchidoris* sp. | Mollusca; Gastropoda (Nudibranchs) |
| *Ophiacantha bidentata* | Echinodermata; Stelleroidea (seastars) |
| *Ophiopholis aculeata* | Echinodermata; Stelleroidea (seastars) |
| *Ophiura robustus* | Echinodermata; Stelleroidea (seastars) |
| *Ophiura sarsi* | Echinodermata; Stelleroidea (seastars) |
| *Ophiura* sp. | Echinodermata; Stelleroidea (seastars) |
| | |
| *Pagurus acadianus* | Arthropoda; Crustacea (hermit crabs) |
| *Pagurus longicarpus* | Arthropoda; Crustacea (hermit crabs) |
| *Pagurus pubescens* | Arthropoda; Crustacea (hermit crabs) |
| *Pagurus* sp. | Arthropoda; Crustacea (hermit crabs) |
| *Pallina sitiens* | Porifera |
| *Pandalus montagui* | Arthropoda; Crustacea (shrimp) |

**Appendix 1 (con't)**

| Species Name | Phylum |
|---|---|
| *Pandora glacialis* | Mollusca: Bivalvia |
| *Pandora gouldani* | Mollusca: Bivalvia |
| *Paraprionspio pinnata* | Annelida; Polychaeta (Sedentary) |
| *Pectinarea hyperborea* | Annelida; Polychaeta (Sedentary) |
| *Pectinaria gouldii* | Annelida; Polychaeta (Sedentary) |
| *Pectinaria granulata* | Annelida; Polychaeta (Sedentary) |
| *Pectinaria* sp. | Annelida; Polychaeta (Sedentary) |
| *Periploma leanum* | Mollusca: Bivalvia |
| *Petricola pholadiformis* | Mollusca: Bivalvia |
| *Pherusa affinis* | Annelida; Polychaeta (Sedentary) |
| *Pholoe minuta* | Annelida; Polychaeta (Errant) |
| *Phoronis psammophila* | Phoronida (Phoronid worms) |
| *Photis macrocoxa* | Arthropoda; Crustacea (amphipod) |
| *Phoxocephalus holbolli* | Arthropoda; Crustacea (amphipod) |
| *Phoxochilidium femoratum* | Arthropoda; Pycnogonida (sea spiders) |
| *Phyllodoce mucosa* | Annelida; Polychaeta (Errant) |
| *Phyllodoce* sp. | Annelida; Polychaeta (Errant) |
| *Pitar morrhuana* | Mollusca: Bivalvia |
| *Placopecten magellanicus* | Mollusca: Bivalvia |
| *Podarke obscura* | Annelida; Polychaeta (Errant) |
| *Polineces heros* | Mollusca; Gastropoda |
| *Polineces immaculatus* | Mollusca; Gastropoda |
| *Polycirrus eximius* | Annelida; Polychaeta (Sedentary) |
| *Polydora ciliata* | Annelida; Polychaeta (Sedentary) |
| *Polydora ligni* | Annelida; Polychaeta (Sedentary) |
| *Polydora* spp. | Annelida; Polychaeta (Sedentary) |
| *Polymastia sp.* | Porifera |
| *Priapulus caudatus* | Aschelmenthea |
| *Priscillina ornata* | Unclassified |
| *Protohaustorius wigleyi* | Arthropoda; Crustacea (amphipod) |
| *Psolus fabricci* | Echinodermata; Holothuria (sea cucumber) |
| *Pteraster militaris* | Echinodermata; Stelleroidea (seastars) |
| | |
| *Retusa canaliculata* | Mollusca; Gastropoda |
| | |
| *Sabinea septemcarinata* | Arthropoda; Crustacea (shrimp) |
| *Schizoporella unicornis* | Bryozoa |
| *Scololepsis robustus* | Annelida; Polychaeta (Sedentary) |
| *Scololepsis squamata* | Annelida; Polychaeta (Sedentary) |
| *Scoloplos fragilis* | Annelida; Polychaeta (Sedentary) |
| *Scypha ciliata* | Porifera |
| *Scypha* sp. | Porifera |
| *Serripes groenlandica* | Mollusca: Bivalvia |
| *Sertularia argentea* | Cnidaria; Hydrozoa |
| *Sertularia pumila* | Cnidaria; Hydrozoa |
| *Sertularia* sp. | Cnidaria; Hydrozoa |

**Appendix 1 (con't)**

| Species Name | Phylum |
|---|---|
| *Solaster endeca* | Echinodermata; Stelleroidea (seastars) |
| *Spio filicornis* | Annelida; Polychaeta (Sedentary) |
| *Spio limicola* | Annelida; Polychaeta (Sedentary) |
| *Spio setosa* | Annelida; Polychaeta (Sedentary) |
| *Spiochaeopterus sp.* | Annelida; Polychaeta (Sedentary) |
| *Spiochaetopterus oculatus* | Annelida; Polychaeta (Sedentary) |
| *Spirobis spirobis* | Annelida; Polychaeta (Sedentary) |
| *Spisula polynyma* | Mollusca: Bivalvia |
| *Spisula solidissima* | Mollusca: Bivalvia |
| *Stegophiura nodosa* | Echinodermata |
| *Sternaspis scutata* | Annelida; Polychaeta |
| *Streblospio bendicti* | Annelida; Polychaeta (Sedentary) |
| *Strongylocentrotus drobachi* | Echinodermata; Ehinoidea (urchins & sand dollars) |
| *Strongylocentrtus pallidus* | Echinodermata; Ehinoidea (urchins & sand dollars) |
| | |
| *Tealia crassicornis* | Cnidaria; Anthozoa |
| *Tealis felina* | Cnidaria; Anthozoa |
| *Tellina agilis* | Mollusca: Bivalvia |
| *Tellina tenera* | Mollusca: Bivalvia |
| *Terebratulina septentrionalis* | Brachiopoda (lamp shells) |
| *Teredo navalis* | Mollusca: Bivalvia |
| *Terschellingia longicaudata* | Nematoda |
| *Tharyx acutus* | Annelida; Polychaeta (Sedentary) |
| *Thelepus cincinnatus* | Annelida; Polychaeta (Sedentary) |
| *Thyasira gouldii* | Mollusca: Bivalvia |
| *Tmentonyx nobilis* | Arthropoda; Crustacea (amphipod) |
| *Tonicella* sp. | Mollusca; Polyplacophora (chitons) |
| *Trachydemus mainensis* | Kinorhyncha |
| *Trochostoma sp.* | Echinodermata; Holothuria (sea cucumber) |
| *Trophonia affinis* | Unclassified |
| *Tubelaria* sp. | Cnidaria; Hydrozoa |
| *Tubularia crocea* | Cnidaria; Hydrozoa |
| *Turbonilla* sp. | Mollusca; Gastropoda |
| | |
| *Unicola irroratus* | Arthropoda; Crustacea (amphipod) |
| *Urosalpinix cinerea* | Mollusca; Gastropoda |
| *Urticina* sp. | Cnidaria; Anthozoa |
| | |
| *Venericardia borealis* | Mollusca: Bivalvia [=*Cyclocardia borealis*] |
| *Venus mercenaria* | Mollusca: Bivalvia [=*Mercenaria*] |
| *Volsella modiolus* | Mollusca: Bivalvia |
| | |
| *Weberella bursa* | Porifera |
| | |
| *Yoldia limatula* | Mollusca: Bivalvia |
| *Yoldia myalis* | Mollusca: Bivalvia |

**Appendix 1 (con't)**

| Species Name | Phylum |
|---|---|
| *Yoldia norvegica* | Mollusca: Bivalvia |
| *Yoldia sapotilla* | Mollusca: Bivalvia |
| *Yoldia thracaeformis* | Mollusca: Bivalvia |

**Appendix 2**: Alphabetical listing of species names of algae and plants referred to in the text. Classification from Gosner (1978), and Bold & Wynne (1985)

| **Species Name** | **Phylum** |
|---|---|
| *Agarum cribrosum* | Phaeophyta |
| *Agarum* sp. | Phaeophyta |
| *Alaria esculenta* | Phaeophyta |
| *Alaria* sp. | Phaeophyta |
| *Antithamnion* sp. | Rhodophyta |
| *Asperococcus echinatus* | Phaeophyta |
| | |
| *Callithamnion* sp. | Rhodophyta |
| *Callophylis cristata* | Rhodophyta |
| *Ceramium fastigatum* | Rhodophyta |
| *Ceramium rubrum* | Rhodophyta |
| *Ceramium* sp. | Rhodophyta |
| *Chaetomorpha melangonium* | Chlorophyta |
| *Chaetomorpha* sp. | Chlorophyta |
| *Chladomorpha* sp. | Unclassified |
| *Chlathromorphum* spp. | Rhodophyta |
| *Chondrus crispus* | Rhodophyta |
| *Chorda filum* | Phaeophyta |
| *Chordaria flagelliformis* | Phaeophyta |
| *Chordaria tomentosa* | Phaeophyta |
| *Cladoohora seriacea* | Chlorophyta |
| *Cladophora albida* | Chlorophyta |
| *Cladophora* sp. | Chlorophyta |
| *Corallina offinalis* | Rhodophyta |
| *Cystoclonium ceranoides* | Rhodophyta |
| *Cystoclonium purpureum* | Rhodophyta |
| | |
| *Desmarestia aculeata* | Phaeophyta |
| *Desmarestia viridis* | Phaeophyta |
| | |
| *Ectocarpus siliculosis* | Phaeophyta |
| *Enteromorpha linza* | Chlorophyta |
| *Enteromorpha prolifera* | Chlorophyta |
| *Enteromorpha* sp. | Chlorophyta |
| *Eudesme virescens* | Phaeophyta |
| *Euthora cristata* | Rhodophyta |
| | |
| *Fucus serratus* | Phaeophyta |
| *Fucus* spp. | Phaeophyta |
| | |
| *Gelidium* sp. | Rhodophyta |
| *Gigartina stellata* | Rhodophyta |
| *Gracilaria verrucosa* | Rhodophyta |

**Appendix 2: (con't)**

| Species Name | Phylum |
|---|---|
| *Halosaccion ramentaceum* | Rhodophyta |
| *Laminaria digitata* | Phaeophyta |
| *Laminaria longicrurus* | Phaeophyta |
| *Laminaria saccharina* | Phaeophyta |
| *Lithothamnion* spp. | Rhodophyta |
| *Palmaria palmata* | Rhodophyta |
| *Petalonia fascia* | Phaeophyta |
| *Peyssonnelia rosenvingi* | Rhodophyta |
| *Phycodrys rubens* | Rhodophyta |
| *Phyllophora* sp. | Rhodophyta |
| *Phyllorphora pseudoceranoides* | Rhodophyta |
| *Polysiphonia grescens* | Rhodophyta |
| *Polysiphonia harveyi* | Rhodophyta |
| *Polysiphonia nigrescens* | Rhodophyta |
| *Polysiphonia* spp. | Rhodophyta |
| *Polysiphonia urceolata* | Rhodophyta |
| *Porphyra* spp. | Rhodophyta |
| *Ptilota serrata* | Rhodophyta |
| *Ptilota* sp. | Rhodophyta |
| *Pylaiella littoralis* | Phaeophyta |
| *Rhodomela confervoides* | Rhodophyta |
| *Rhodymenia palmata* | Rhodophyta |
| *Sacchoriza dermatodea* | Phaeophyta |
| *Spermothamnion repens* | Rhodophyta |
| *Spermothamnion* sp. | Rhodophyta |
| *Spongomorpha arcta* | Chlorophyta |
| *Trailliella intricata* | Rhodophyta |
| *Ulothryx* | Chlorophyta |
| *Ulva lactuca* | Chlorophyta |
| *Ulvaria obscura* | Chlorophyta |
| *Zostera marina* | Seed Plant |

**Appendix 3**: Species list from sampling in Northumberland Strait in 1975.
List from Caddy et. al. (1977). Classification according to Whiteaves (1901), Gosner (1978), and Barnes (1987).

| Taxon | Species Name |
|---|---|
| **Amphipoda** | *Acanthonotozoma serratum* |
| | *Acanthostephia malmgreni* |
| | *Aceroides liatipes* |
| | *Ampelisca eschrichti* |
| | *Ampelisca macrocephala* |
| | *Ampelisca vadorum* |
| | *Ampithoe longimana* |
| | *Anonyx liljeborgl* |
| | *Anonyx sarsi* |
| | *Arrhis phyllonyx* |
| | *Byblis gaimardi* |
| | *Calliopius laevisculus* |
| | *Casco bigelowi* |
| | *Centromedon pumilus* |
| | *Corophium bonelli* |
| | *Corophium crassicorne* |
| | *Corophium volutator* |
| | *Dexamine thea* |
| | *Dyopedos arctica* |
| | *Dyopedos monocantha* |
| | *Erichthonius rubricornis* |
| | *Gammaropsis melanops* |
| | *Haploops tubicola* |
| | *Harpinia propinqua* |
| | *Hippomedon serratus* |
| | *Ischyrocerus anguipes* |
| | *Leptocheirus pinguis* |
| | *Maera loveni* |
| | *Melita dentata* |
| | *Melita nitida* |
| | *Melita obtusata* |
| | *Melita quadrispinosa* |
| | *Metopella angusta* |
| | *Metopella carinata* |
| | *Monoculodes edwardsi* |
| | *Monoculodes intermedius* |
| | *Monoculodes latimanus* |
| | *Monoculodes schneideri* |
| | *Monoculodes tesselatus* |
| | *Monoculodes tuberculatus* |
| | *Monoculopsis longicornis* |
| | *Neohela monstrosa* |
| | *Onesimus edwradsi* |
| | *Onesimus normani* |

**Appendix 3 (con't)**

| Taxon | Species Name |
|---|---|
| **Amphipoda** | *Orchomenalla minuta* |
| | *Paradulichia typica* |
| | *Paraediceros propinquis* |
| | *Parametopella sp.* |
| | *Paroediceros lynceus* |
| | *Photis macrocoxa* |
| | *Phoxocephalus holbolli* |
| | *Pleustes panoplus* |
| | *Pleusymtes glaber* |
| | *Podoceropsis imaequistylis* |
| | *Podoceropsis nitida* |
| | *Pontogeneia imermis* |
| | *Pontoporeia femorata* |
| | *Proboloides nordmanni* |
| | *Protomedia fasciata* |
| | *Protomedia stephonsoni* |
| | *Psammonyx nobilis* |
| | *Stenula peltata* |
| | *Synchelidium tenuimamum* |
| | *Unicola irrorata* |
| | *Westwoodilla caecula* |
| | *Westwoodilla sp.* |
| **Annelida** | *Aphrodita hastata* |
| | *Potamilla reinformis* |
| | *Spirobis borealis* |
| **Arthropoda** | *Achelia scabra* |
| | *Aeginina longicornis* |
| | *Argis dentata* |
| | *Balanus balanoides* |
| | *Balanus balanus* |
| | *Brachidiastylis resima* |
| | *Campylaspis rubricunda* |
| | *Cancer irroratus* |
| | *Caprella linearis* |
| | *Caprella penantis* |
| | *Corophium acheruscium* |
| | *Crangon septemspinosus* |
| | *Diastylis quadrispinosa* |
| | *Diastylis rathkei* |
| | *Diastylis sculpta* |
| | *Dyopedos spinossima* |
| | *Eualus pusiolus* |
| | *Eudorella emarginata* |
| | *Eudorella trunculata* |

**Appendix 3 (con't)**

| Taxon | Species Name |
|---|---|
| **Arthropoda** | *Eudorellopsis deformis* |
| | *Euphasia sp.* |
| | *Homarus americanus* |
| | *Hyas araneus* |
| | *Hyas coarctatus* |
| | *Ischyrocerus anguipes* |
| | *Ischyrocerus commensalis* |
| | *Lamprops quadriplicata* |
| | *Lebbeus groenlandicus* |
| | *Leptostylis longimana* |
| | *Leptostylis villosa* |
| | *Leucon nasica* |
| | *Leucon nasicoides* |
| | *Maera danae* |
| | *Metopella bruzeli* |
| | *Monoculodes longirostris* |
| | *Monoculodes norvegicus* |
| | *Mysis mixta* |
| | *Nymphon grossipes* |
| | *Nymphon hirtipes* |
| | *Nymphon longitarse* |
| | *Orchomenella pinguis* |
| | *Pagurus acadianus* |
| | *Pagurus longicarpus* |
| | *Pagurus pubescens* |
| | *Pandalus montagui* |
| | *Photis reinhardi* |
| | *Potoceropsis inaequistylis* |
| | *Pycnogonum littorale* |
| | *Rhacotropis lobata* |
| | *Sabinea septemcarinata* |
| | *Stenethoe brevicornis* |
| | *Syrrhoe crenulata* |
| **Bivalvia** | *Anomia simplex* |
| | *Arctica islandica* |
| | *Astarte subaequilatera* |
| | *Astarte undata* |
| | *Clinocardium ciliatum* |
| | *Crassostrea virginica* |
| | *Crenella faba* |
| | *Crenella glandula* |
| | *Ensis directus* |
| | *Gemma gemma* |
| | *Hiatella arctica* |
| | *Lyonsia hyalina* |

**Appendix 3 (con't)**

| Taxon | Species Name |
|---|---|
| **Bivalvia** | *Macoma balthica* |
| | *Macoma tenta* |
| | *Modiolus modiolus* |
| | *Musculus niger* |
| | *Mya arenia* |
| | *Mya truncata* |
| | *Mytilus edulis* |
| | *Nucula proxima* |
| | *Nucula tenuis* |
| | *Pandora gouldiana* |
| | *Pitar morrhuana* |
| | *Placopecten magellanicus* |
| | *Spisula solidissimus* |
| | *Tellina agilis* |
| | *Thracia septentrionalis* |
| | *Thyasira gouldii* |
| | *Thyasira insinis* |
| | *Yoldia limatula* |
| | *Yoldia sapotilla* |
| | *Yoldia thraciaeformis* |
| **Brachipoda** | *Hemithiris psittacea* |
| **Bryozoa** | *Bugula turrita* |
| | *Dendrobeania murrayana* |
| | *Eucratea loricata* |
| | *Membranipora pilosa* |
| **Cephalapoda** | *Loligo sp.* |
| **Chordata** | *Halocynthia pyriformis* |
| | *Molgula sp.* |
| | *Pelonaia corrugata* |
| **Cnidaria** | *Actinauge sp.* |
| | *Bunodactis stella* |
| | *Cyanea capillata* |
| | *Cyanea sp.* |
| | *Edwardsia sp.* |
| | *Metridium dianthus* |
| | *Metridium senile* |
| | *Tealia feliña* |
| **Echinodermata** | *Asterias forbesi* |
| | *Asterias vulgaris* |
| | *Ctenodiscus crispatus* |

**Appendix 3 (con't)**

| Taxon | Species Name |
|---|---|
| **Echinodermata** | *Cucumaria frondosa* |
| | *Echinarachinus parma* |
| | *Gorgonocephalus sp.* |
| | *Henricia sanguinolenta* |
| | *Leptastaris tenera* |
| | *Leptasteria polaris* |
| | *Malpodia oolitica* |
| | *Ophiopholis aculatea* |
| | *Ophiopholis aculeata* |
| | *Ophiura robusta* |
| | *Ophiura robustus* |
| | *Ophiura sarsi* |
| | *Psolus fabricii* |
| | *Psolus phantapus* |
| | *Solaster endeca* |
| | *Solaster papposus* |
| | *Strongylocentrotus drobachiensis* |
| **Ectoprocta** | *Stomphia coccinea* |
| **Gastropoda** | *Aclis tenuis* |
| | *Acmaea testudinalis* |
| | *Admete couthouyi* |
| | *Aeolidia papillosa* |
| | *Aporrhais occidentalis* |
| | *Buccinum tenui* |
| | *Buccinum totteni* |
| | *Buccinum undatum* |
| | *Colus obesus* |
| | *Colus pygmaeus* |
| | *Colus syimpsoni* |
| | *Coryphella sp.* |
| | *Crepidula fornicata* |
| | *Crepidula plana* |
| | *Littorina saxatilis* |
| | *Lunatia heros* |
| | *Lunatia immaculata* |
| | *Lunatia triseriata* |
| | *Margarites groenlandica* |
| | *Mitrella dissimilis* |
| | *Mitrella lunata* |
| | *Nassarius obsoletus* |
| | *Nassarius trivittatus* |
| | *Neptunea decemcostata* |
| | *Oenopota (Lora) elegans* |
| | *Oenopota (Lora) concinnula* |

**Appendix 3 (con't)**

| Taxon | Species Name |
|---|---|
| **Gastropoda** | *Oenopota (Lora) harpularia* |
| | *Oenopota (Lora) incisula* |
| | *Oenopota (Lora) turricula* |
| | *Puncturella noachina* |
| | *Retusa canaliculata* |
| | *Retusa obtusa* |
| | *Trichotropis borealis* |
| | *Trichotropsis bicarinata* |
| | *Turbonilla elengatula* |
| | |
| **Hydroid** | *Abietinaria abietina* |
| | *Campanularia angulata* |
| | *Campanularia groenlandica* |
| | *Diphasia fallax* |
| | *Duva multiflora* |
| | *Halecium flexile* |
| **Hydroid** | *Hydrallmania falcata* |
| | *Lafoea dumosa* |
| | *Lafoea gracillima* |
| | *Selaginopsis mirabilis* |
| | *Sertuarella fusiformis* |
| | *Thuiria cupressina* |
| | |
| **Polychaeta** | *Africidea sp.* |
| | *Aglaophamus sp.* |
| | *Ampharete acutifrons* |
| | *Ampharete arctica* |
| | *Amphitrite sp.* |
| | *Anobothrus gracilis* |
| | *Antinoella sarsi* |
| | *Apistobranchus tullbergi* |
| | *Arcteobia anticostiensis* |
| | *Asabellides oculata* |
| | *Autolytus sp.* |
| | *Brada villosa* |
| | *Capitella capitata* |
| | *Chaetozone setosa* |
| | *Chone sp.* |
| | *Cirratulus sp.* |
| | *Cistena sp.* |
| | *Clymenella torquata* |
| | *Clymenella zonalis* |
| | *Clymenura sp.* |
| | *Diplocirrus hirsutus* |
| | *Drilonereis sp.* |
| | *Enipo canadensis* |

**Appendix 3 (con't)**

| Taxon | Species Name |
|---|---|
| **Polychaeta** | *Eteone sp.* |
| | *Euchone sp.* |
| | *Eulalia sp.* |
| | *Eunoe sp.* |
| | *Eusyllis sp.* |
| | *Exogone sp.* |
| | *Gattyana cirrosa* |
| | *Glycera sp.* |
| | *Goniada maculata* |
| | *Goniadella gracilis* |
| | *Harmothoe extenuata* |
| | *Harmothoe imbricata* |
| | *Harmothoe oerstedi* |
| | *Harmothoe sp.* |
| | *Hartmani moorei* |
| | *Heteromastus filiformis* |
| | *Laena sp.* |
| | *Laonice sp.* |
| | *Lepidonotus squamatus* |
| | *Lumbrinereis acuta* |
| | *Lumbrinereis fragilis* |
| | *Maldane sarsi* |
| | *Myriochele heeri* |
| | *Nephthys sp.* |
| | *Nereimura punctata* |
| | *Nereis sp.* |
| | *Ninow nigripes* |
| | *Notomastus sp.* |
| | *Ophelina acuminata* |
| | *Owenia fusiformis* |
| | *Paraonis sp.* |
| | *Pherusa plumusa* |
| | *Phloe minuta* |
| | *Phyllodoce sp.* |
| | *Polycirrus sp.* |
| | *Polydora sp.* |
| | *Polyphysia crassa* |
| | *Potamilla neglecta* |
| | *Potamilla reniformis* |
| | *Praxillela gracilis* |
| | *Praxillela praetermissa* |
| | *Praxillura ornata* |
| | *Prionspio steenstrupi* |
| | *Rhodine gracilis* |
| | *Sabella sp.* |
| | *Sabellides octocirrata* |

**Appendix 3 (con't)**

| Taxon | Species Name |
|---|---|
| **Polychaeta** | *Scalibregma inflatum* |
| | *Scolelepsis sp.* |
| | *Scoloplos sp.* |
| | *Sphaerodoropsis minuta* |
| | *Spio sp.* |
| | *Spiophanes bombyx* |
| | *Spirobis spirillum* |
| | *Stenelais limicola* |
| | *Sternaspis scutata* |
| | *Streptosyllis sp.* |
| | *Syllis sp.* |
| | *Terebbelides sp.* |
| | *Tharyx acutus* |
| | *Tharyx sp.* |
| | *Trochocaeta multisetosa* |
| **Polyplacophora** | *Ischnochiton alba* |
| | *Ischnochiton ruber* |
| **Porifera** | *Clathria delicata* |
| | *Clione celata* |
| | *Esperia lingus* |
| | *Grantia ciliata* |
| | *Haliclona oculata* |
| | *Isodycta deichmannae* |
| | *Mycale ovulum* |
| | *Myxillae incrustans* |
| | *Polymastis mammilaris* |
| | *Polymastis robusta* |
| | *Trichostemma hemisphericum* |
| **Sipunculid** | *Phascolosoma eremita* |
| **Unclassified** | *Cytiodaria siliqua* |
| | *Philine lima* |
| | *Ptychatractus ligatus* |
| | *Solariella varicosa* |
| | *Tachyrhynchus erosus* |
| | *Thais lapillus* |
| | *Velutina sp.* |