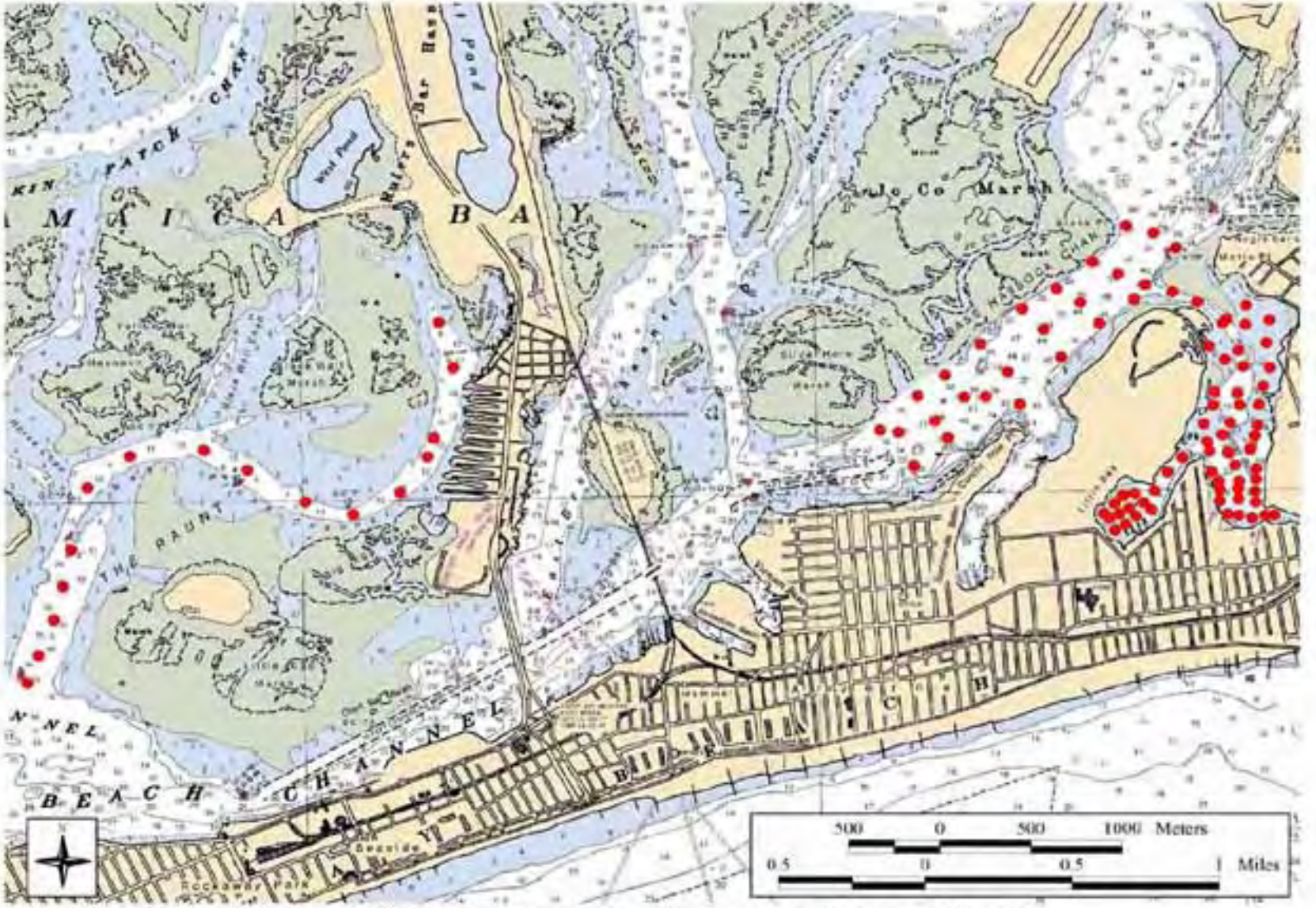



**Figure 3.4.1** Sediment profile imagery (SPI) sample locations in Norton Basin study and reference areas, May 2002.

sediments appear to be oxidized. The term “apparent” is used in describing this parameter because no actual measurement is made of the redox potential. An assumption is made that, given the complexities of iron and sulfate reduction-oxidation chemistry, reddish-brown sediment color tones, (or in black and white images whiter or lighter areas of the image) are indications that the sediments are oxidized, or at least are not intensely reducing (Rhoads and Germano 1986, Diaz and Schaffner 1988). The depth of the apparent color RPD is defined as the area of all the pixels in the image discerned as being oxidized divided by the width of the digitized image. The area of the image with oxidized sediment is obtained by digitally manipulating the image to enhance characteristics associated with oxidized sediment (greenish-brown color tones). The enhanced area is then determined from a density slice of the image.

#### 3.4.3.4 Sediment Grain Size

Grain size is an important parameter for determining the nature of the physical forces acting on a habitat and is a major factor in determining benthic community structure (Rhoads 1974). The sediment type descriptors used for image analysis follow the Wentworth classification as described in Folk (1980), and represent the major modal class for each image. Grain size is determined by comparison of collected images with a set of standard images for which mean grain size has been determined in the laboratory.

#### 3.4.3.5 Surface Features

These parameters include a wide variety of features, each of which provides information on the type of habitat and its quality for supporting benthic species. The presence of certain surface features is indicative of the overall nature of a habitat. For example, bedforms are always associated with physically dominated habitats, whereas the presence of worm tubes or feeding pits is indicative of a more biologically accommodating habitat (Rhoads and Germano 1986, Diaz and Schaffner 1988). Surface features are visually evaluated from each image and compiled by type and frequency of occurrence.

#### 3.4.3.6 Subsurface Features

These parameters include a wide variety of features and are used to characterize the physical and biological processes influencing the bottom. For example, the presence of methane gas voids has been found to be an indication of anaerobic metabolism associated with high rates of bacterial activity (Rhoads and Germano 1986). Muddy habitats with large amounts of methane gas are generally associated with areas of oxygen stress or high organic loading. Habitats with burrows, infaunal feeding voids, and/or actual infauna visible are generally considered "healthy" (Rhoads and Germano 1986, Diaz and Schaffner 1988, Valente et al. 1992). Surface features are visually evaluated from each slide and compiled by type and frequency of occurrence.

## 4.0 RESULTS

### 4.1 Benthic Macroinvertebrates

#### 4.1.1 June, 2002 Community Composition

A total of 80,934 individuals, representing 127 taxa, were identified from the 90 grab samples collected at 30 stations within the Norton Basin/Little Bay study areas and reference areas in June of 2002. Arthropods were the most abundant taxa, representing 49.4% of the total assemblage. Annelids (marine worms) represented 48.3% of the total organisms. A list of all taxa is provided in **Appendix I-A**.

Polychaetes dominated the annelid community. The ubiquitous estuarine spionid polychaete *Streblospio benedicti* was well represented among samples, as was *Polydora cornuta*, *Mediomastis* spp., *Sabellaria vulgaris*, and *Capitella capitata*. Tubificid oligochaetes represented nearly two percent of the annelid community.

The arthropod community was dominated by amphipods, primarily *Ampelisca vadorum*, which accounted for nearly one-third of the total benthic macroinvertebrate community in June. Other amphipods present included *Monocorophium turberculatum*, *Microdeutopus gryllotalpa*, and *Unciola serrata*. Mud crabs (*Xanthidae*) and the ostracod *Parasterope pollex* were collected but represented only a minor component of the arthropod community.

Molluscs were a minor component of the benthic community (< 2%). The mollusc community included various bivalves and gastropods, most notably the mud snail *Ilyanassa obsoleta*. Proboscis worms, flatworms, peanut worms, tunicates, bryozoans, and brachiopods were present in some samples but accounted for < 0.5% of the total benthic community. The total number of macroinvertebrate taxa ranged from 0 (LB3, LB4, LB5, LB7, and LB8) to 56 (NB13) (**Figure 4.1.1.1; Figure 4.1.1.2; Appendix I-B**). The total number of individuals per station (composite of 3 grabs) ranged from 0 (LB3, LB4, LB5, LB7, and LB8) to 10,937 (NB14) (**Table 4.1.1.1**).

In the deep areas of Norton Basin (over 40 ft. deep), arthropods represented 70.8% of the total assemblage, annelids represented 27.6%, mollusks represented 1.6%, and flatworms and brachiopods represented < 1% (**Figure 4.1.1.3**). The dominant species was *A. vadorum*, representing 45.1% of the total assemblage. In the intermediate depth areas of Norton Basin (20-ft. to 35-ft. deep), annelids represented 54.6% of the total assemblage, arthropods represented 44.4%, mollusks represented 1.0%, and proboscis worms and bryozoans represented < 1% (**Figure 4.1.1.3**). The dominant species again was *A. vadorum*, representing 32.5% of the total assemblage.

At the Norton Basin Entrance Channel, annelids represented 76.2% of the total assemblage, arthropods represented 20.3%, and molluscs represented 3.3%. Proboscis worms and tunicates represented < 1%of the total assemblage (**Figure 4.1.1.4**). The dominant species again was *S. benedicti*, representing 18.7% of the total assemblage.

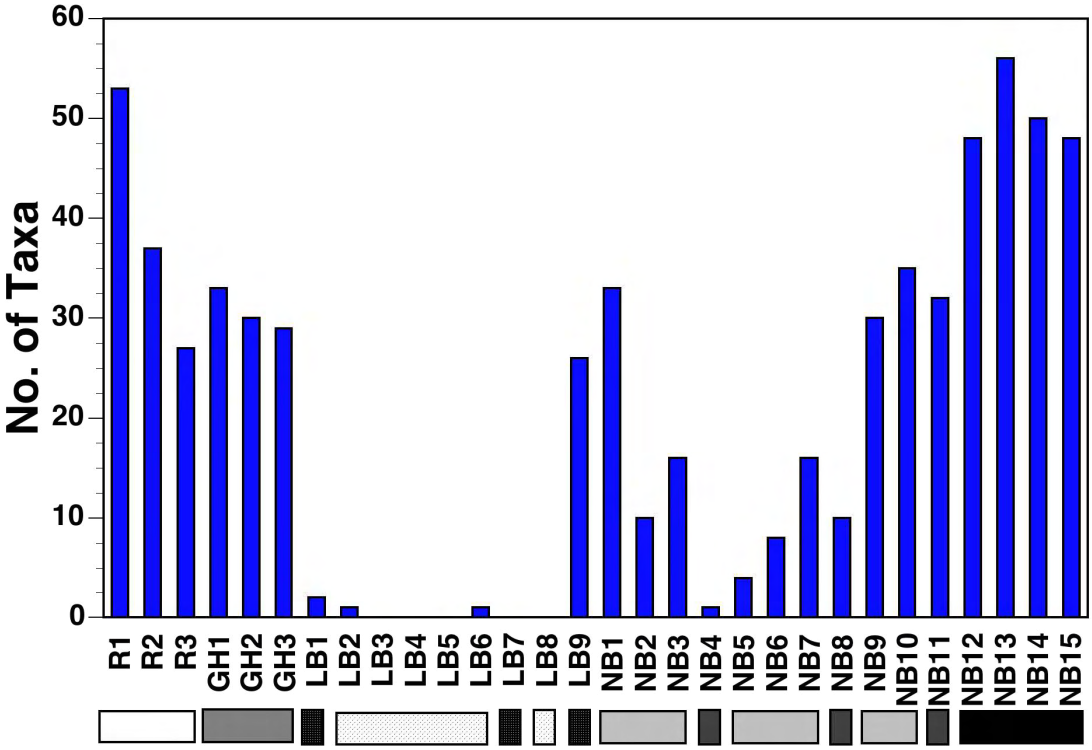
A total of two individuals were collected from the deep areas of Little Bay (over 40-ft. deep). One individual was an amphipod (*Gammarus mucronatus*), while the other was an annelid (*Enchytraeidae* spp.). In the intermediate depths of Little Bay (approx. 30-ft. deep), annelids represented 92.4% of the total assemblage, arthropods represented 4.1%, molluscs represented 3.3%, and bryozoans represented < 1% (**Figure 4.1.1.3**). The dominant species was *S. benedicti*, representing 57.9% of the total assemblage.

At the Grass Hassock Channel reference area, arthropods represented 87.4% of the total assemblage, while annelids represented 11.8%. Molluscs, proboscis worms, and peanut worms represented < 1% of the total assemblage (**Figure 4.1.1.4**). The dominant species was *A. vadorum*, representing 67.1% of the total assemblage.

At the Raunt reference area, arthropods represented 53.5% of the total assemblage, annelids represented 41.4%, molluscs represented 3.3%, and proboscis worms represented 1.8% of the total assemblage (**Figure 4.1.1.4**). The dominant species was *A. vadorum*, representing 29.2% of the total assemblage.

### 4.1.2 October, 2002 Community Composition

A total of 40,095 individuals, representing 109 taxa, were identified from the 90 grab samples collected at 30 stations within the Norton Basin/Little Bay study areas and reference areas in October of 2002. Annelids (marine worms) were the most abundant taxa, representing 69.7% of the




The Raunt.....R1 - R3
Grass Hassock Channel.....GH1 - GH3
Intermediate depth stations (approx. 30 ft.) in Little Bay..... LB1, LB7, LB9
Deep stations (over 40 ft.) in Little Bay.....LB2 - LB6, LB8
Intermediate depth stations (20 ft. to 35 ft.) in Norton Basin..... NB1 - NB3, NB5 - NB7, NB9, NB10
Deep stations (over 40 ft.) in Norton Basin.....NB4, NB8, NB11
Norton Basin entrance channel.....NB12 - NB15

**Figure 4.1.1.1** Total number of benthic macroinvertebrate taxa, June 2002.

**Figure 4.1.1.2** Total number of benthic macroinvertebrate taxa, June 2002.

**Table 4.1.1.1** Community Parameters, Norton Basin study and reference area benthic stations, June 2002.

| Station | Date (m/d/y) | Total No. Taxa | Total No. Individuals | Mean Density (No. $m^{-2}$) | Density (Std Err) | H' Shannon (log e) | J' Pielou Evenness |
|---|---|---|---|---|---|---|---|
| R1 | 6/1/02 | 53 | 5023 | 41858.3 | 11206.6 | 2.20 | 0.56 |
| R2 | 6/1/02 | 37 | 2659 | 22158.3 | 12038.3 | 1.72 | 0.48 |
| R3 | 6/1/02 | 27 | 2499 | 20825.0 | 17206.7 | 1.62 | 0.49 |
| GH1 | 6/1/02 | 33 | 8842 | 73683.3 | 36224.9 | 1.01 | 0.29 |
| GH2 | 6/1/02 | 30 | 8386 | 69883.3 | 12596.6 | 1.25 | 0.37 |
| GH3 | 6/1/02 | 29 | 2901 | 24175.0 | 8941.2 | 1.86 | 0.55 |
| LB1 | 6/1/02 | 2 | 7 | 58.3 | 22.0 | 0.68 | 0.99 |
| LB2 | 6/1/02 | 1 | 1 | 8.3 | 8.3 | 0.00 | 0.00 |
| LB3 | 6/1/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB4 | 6/1/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB5 | 6/1/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB6 | 6/1/02 | 1 | 1 | 8.3 | 8.3 | 0.00 | 0.00 |
| LB7 | 6/1/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB8 | 6/1/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB9 | 6/1/02 | 26 | 573 | 4775.0 | 3632.3 | 1.65 | 0.51 |
| NB1 | 6/1/02 | 33 | 3945 | 32875.0 | 17147.3 | 2.01 | 0.58 |
| NB2 | 6/1/02 | 10 | 923 | 7691.7 | 2273.5 | 0.34 | 0.15 |
| NB3 | 6/1/02 | 16 | 1782 | 14850.0 | 4824.0 | 1.04 | 0.37 |
| NB4 | 6/1/02 | 1 | 1 | 8.3 | 8.3 | 0.00 | 0.00 |
| NB5 | 6/1/02 | 4 | 531 | 4425.0 | 398.7 | 0.45 | 0.32 |
| NB6 | 6/1/02 | 8 | 1148 | 9566.7 | 1558.5 | 1.27 | 0.61 |
| NB7 | 6/1/02 | 16 | 1751 | 14591.7 | 5306.2 | 1.34 | 0.48 |
| NB8 | 6/1/02 | 10 | 380 | 3166.7 | 1665.2 | 1.31 | 0.57 |
| NB9 | 6/1/02 | 30 | 2928 | 24400.0 | 10726.8 | 1.78 | 0.52 |
| NB10 | 6/1/02 | 35 | 9264 | 77200.0 | 47495.9 | 1.57 | 0.44 |
| NB11 | 6/1/02 | 32 | 2400 | 20000.0 | 11441.0 | 1.70 | 0.49 |
| NB12 | 6/1/02 | 48 | 7496 | 62466.7 | 23463.3 | 1.97 | 0.51 |
| NB13 | 6/1/02 | 56 | 3433 | 28608.3 | 9512.9 | 2.72 | 0.68 |
| NB14 | 6/1/02 | 50 | 10937 | 91141.7 | 31473.5 | 2.62 | 0.67 |
| NB15 | 6/1/02 | 48 | 3123 | 26025.0 | 12122.1 | 2.56 | 0.66 |

total assemblage. Arthropods represented 27.9% of the total organisms. A list of all taxa is provided in **Appendix I-C**. Polychaetes dominated the worm community. The ubiquitous estuarine spionid polychaete *S. benedicti* was well represented among samples, as was *Mediomastis* spp., *S. vulgaris*, and *C. capitata*. Tubificid oligochaetes represented 4.4% of the annelid community.

The arthropod community was dominated by amphipods, primarily *A. vadorum*, which accounted for nearly a quarter of the total benthic macroinvertebrate community during October. Other amphipods present included *Lysianopsis alba*, *Melita nitida*, and *M. tuberculatum*. Mud crabs (*Xanthidae*) were collected but represented only a minor component of the arthropod community.

Molluscs were a minor component of the benthic community (< 4%). The mollusc community included various bivalves and gastropods, most notably the mud snail *I. Obsoleta*. Proboscis worms, flatworms, hydrozoans, tunicates, horseshoe worms, and sponges were present in some samples, but only accounted for < 0.5% of the total benthic community. The total number of macroinvertebrate taxa ranged from 0 (LB6, LB7, LB8, NB3) to 52 (NB14) (**Table 4.1.2.1; Figure 4.1.2.1; Figure 4.1.2.2; Appendix I-D**).

In the deep areas of Norton Basin (over 40 ft deep), annelids represented 91.1% of the total assemblage, mollusks represented 7.9%, and arthropods represented 1.0% (**Figure 4.1.2.3**). The dominant species was *S. benedicti*, representing 47.8% of the total assemblage. In the intermediate depth areas of Norton Basin (20 ft. to 35 ft. deep), annelids represented 93.7% of the total assemblage, molluscs represented 5.0%, arthropods represented 1.3%, and flatworms represented < 1.0% (**Figure 4.1.2.3**). The dominant species again was *S. benedicti*, representing 62.8% of the total assemblage.

At the Norton Basin entrance channel, annelids represented 90.2% of the total assemblage, arthropods represented 6.0%, and molluscs represented 3.7%. Hydrozoans, flatworms, sponges, and tunicates represented < 1% (**Figure 4.1.2.4**). The dominant species was *S. benedicti*, representing 37.8% of the total assemblage.

A total of six individuals were collected from the deep areas of Little Bay (over 40 ft. deep). Three were molluscs (gastropods), two were annelids (polychaetes), and one was an arthropod (*Ampelisca* spp.) (**Figure 4.1.2.3**). In the intermediate depth areas of Little Bay (approximately 30 ft. deep), annelids represented 87.0% of the total assemblage, molluscs represented 8.7%, and arthropods represented 4.3% (**Figure 4.1.2.3**). The dominant species was *C. capitata*, representing 78.3% of the total assemblage.

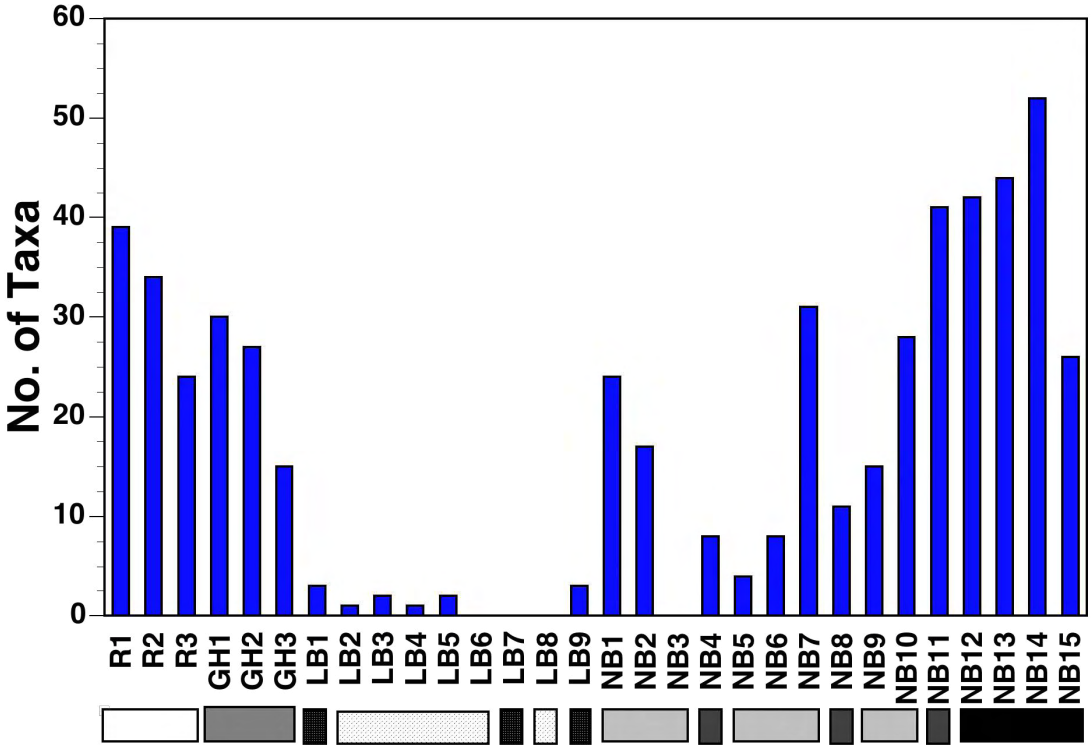
At the Grass Hassock Channel reference area, arthropods represented 62.3 % of the total assemblage, annelids represented 36.1 % and molluscs represented 1.5%. Proboscis worms and flatworms represented < 1 % of the total assemblage (**Figure 4.1.2.4**). The dominant species was *A. vadorum*, representing 37.8 % of the total assemblage.

At the Raunt reference area, annelids represented 90.5 % of the total, arthropods represented 5.7%, and molluscs represented 3.7 %. Proboscis worms and horseshoe worms represented < 1% of the total assemblage (**Figure 4.1.2.4**). The dominant species was *S. benedicti*, representing 67.3% of the total assemblage.

### 4.1.3 Abundance and Distribution

#### 4.1.3.1 Total Macroinvertebrates

In June 2002, mean density of macroinvertebrates ranged from 0.0 ind. $m^{-2}$ (LB3 - LB5, LB7 LB8) to 91,141.7 ind. $m^{-2}$ (NB14). In October of 2002, mean density of macroinvertebrates ranged from 0.0 ind. $m^{-2}$ (LB6 - LB8, NB3) to 46,241.7 ind. $m^{-2}$ (GH2). Total macroinvertebrate density at the




The Raunt.....R1 - R3
Grass Hassock Channel.....GH1 - GH3
Intermediate depth stations (approx. 30 ft.) in Little Bay..... LB1, LB7, LB9
Deep stations (over 40 ft.) in Little Bay.....LB2 - LB6, LB8
Intermediate depth stations (20 ft. to 35 ft.) in Norton Basin..... NB1 - NB3, NB5 - NB7, NB9, NB10
Deep stations (over 40 ft.) in Norton Basin.....NB4, NB8, NB11
Norton Basin entrance channel.....NB12 - NB15

**Figure 4.1.2.1** Total number of benthic macroinvertebrate taxa, October 2002.

**Figure 4.1.2.2** Total number of benthic macroinvertebrate taxa, October 2002.

**Table 4.1.2.1** Community Parameters, Norton Basin study and reference area benthic stations, October 2002.

| Station | Date (m/d/y) | Total No. Taxa | Total No. Individuals | Mean Density (No. $m^{-2}$) | Density (Std Err) | H' Shannon (log e) | J' Pielou Evenness |
|---|---|---|---|---|---|---|---|
| R1 | 10/10/02 | 39 | 2601 | 21675.0 | 1925.9 | 1.20 | 0.33 |
| R2 | 10/10/02 | 34 | 3877 | 32308.3 | 12080.2 | 1.27 | 0.36 |
| R3 | 10/10/02 | 24 | 2223 | 18525.0 | 2224.9 | 1.20 | 0.38 |
| GH1 | 10/10/02 | 30 | 4692 | 39100.0 | 6445.4 | 1.46 | 0.43 |
| GH2 | 10/10/02 | 27 | 5549 | 46241.7 | 6432.3 | 1.26 | 0.38 |
| GH3 | 10/10/02 | 15 | 3460 | 28833.3 | 1257.4 | 0.67 | 0.25 |
| LB1 | 10/10/02 | 3 | 3 | 25.0 | 0.0 | 1.10 | 1.00 |
| LB2 | 10/10/02 | 1 | 1 | 8.3 | 8.3 | 0.00 | 0.00 |
| LB3 | 10/10/02 | 2 | 2 | 16.7 | 16.7 | 0.69 | 1.00 |
| LB4 | 10/10/02 | 1 | 1 | 8.3 | 8.3 | 0.00 | 0.00 |
| LB5 | 10/10/02 | 2 | 2 | 16.7 | 8.3 | 0.69 | 1.00 |
| LB6 | 10/10/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB7 | 10/10/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB8 | 10/10/02 | 0 | 0 | 0.0 | 0.0 | 0.00 | 0.00 |
| LB9 | 10/10/02 | 3 | 20 | 166.7 | 96.1 | 0.39 | 0.36 |
| NB1 | 10/10/02 | 24 | 1091 | 9091.7 | 2904.4 | 1.46 | 0.46 |
| NB2 | 10/10/02 | 17 | 402 | 3350.0 | 3250.0 | 1.35 | 0.48 |
| NB3 | 10/10/02 | 0 | 0 | 0 | 0.0 | 0.00 | 0.00 |
| NB4 | 10/10/02 | 8 | 21 | 175.0 | 104.1 | 1.76 | 0.84 |
| NB5 | 10/10/02 | 4 | 20 | 166.7 | 58.3 | 1.24 | 0.89 |
| NB6 | 10/10/02 | 8 | 16 | 133.3 | 84.6 | 1.84 | 0.88 |
| NB7 | 10/10/02 | 31 | 2843 | 23691.7 | 11286.4 | 1.14 | 0.33 |
| NB8 | 10/10/02 | 11 | 159 | 1325.0 | 215.5 | 1.53 | 0.64 |
| NB9 | 10/10/02 | 15 | 188 | 1566.7 | 423.9 | 1.69 | 0.62 |
| NB10 | 10/10/02 | 28 | 633 | 5275.0 | 1081.2 | 1.73 | 0.52 |
| NB11 | 10/10/02 | 41 | 1556 | 12966.7 | 1419.4 | 1.97 | 0.53 |
| NB12 | 10/10/02 | 42 | 1673 | 13941.7 | 1879.2 | 1.93 | 0.52 |
| NB13 | 10/10/02 | 44 | 2037 | 16975.0 | 1650.3 | 1.77 | 0.47 |
| NB14 | 10/10/02 | 52 | 4795 | 39958.3 | 16035.9 | 2.76 | 0.70 |
| NB15 | 10/10/02 | 26 | 2230 | 18583.3 | 8526.9 | 1.26 | 0.39 |