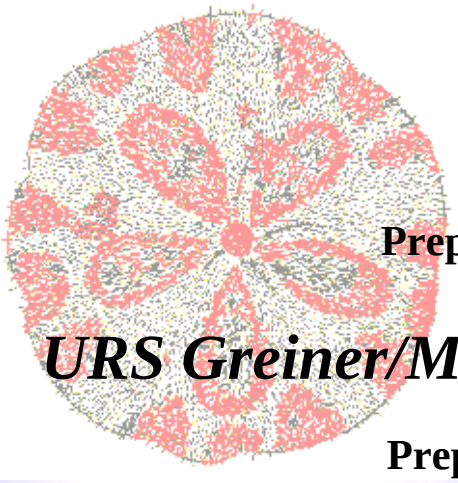
U. S. Army Corps of Engineers
New York District

Benthic Invertebrate Survey:

Napeague to East of Fire Island Inlet



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May 2001

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1.0 INTRODUCTION

This report is one of a series of natural resource, physical science, and engineering studies being conducted for the U.S. Army Corps of Engineers (ACOE) Reformulation Study. Overall objectives of the program include:

- Characterization of the benthic macrofauna in and around ten potential sand borrow areas;
- Comparison of the areas based on species composition, numerical abundance, and biomass;
- Preliminary selection of areas requiring further study; and
- Compilation of a baseline data set for future impact assessments.

The overall study area covers 83 linear miles from Fire Island Inlet to Montauk Point. EEA, Inc.,under contract to URS Greiner/Moffatt & Nichol, JV, collected and analyzed 240 macrobenthic samples at ten (10) proposed borrow locations. The borrow areas extended from just east of the Fire Island Inlet to the Napeague area.

This report presents the methodology, findings, and a comparison to previously conducted studies off Fire Island, Shinnecock, Coney Island, and the New Jersey barrier islands, as well as programs sponsored by the ACOE or their scientific contractors. Data reported herein covers 240 stations sampled during July and August, 1999. Subsequent sampling was repeated in November, 1999. This latter data set has been incorporated into this report, which has been revised from the October 2000 report. Two additional benthic surveys of 130 stations each have been completed in July and November 2000.

Benthic macroinvertebrate investigations are typically used in quantitative aquatic investigations. The most common approaches for assessment of benthic communities are analysis of species composition, numerical abundance and biomass. This report incorporates all three approaches into community description, however, the biomass data is not sufficiently robust to assess statistically at this time. As the data base grows with ongoing and future work, this analysis will be revisited.

Infaunal assemblages of the offshore borrow areas contain forage for commercially and ecologically important finfish species. Mining of the borrow areas for sand to be used as beach fill could have potentially deleterious effects on the species composition, abundance, and standing crop of these assemblages. This study, therefore, will be used to predict potential impacts and be presented in a yet to be prepared Environmental Impact Statement (EIS) for the overall Reformulation Project.

2.0 STUDY AREA

The project area for the present field study includes ten offshore borrow areas which extend from just east of the Fire Island Inlet to the Napeague area. These borrow areas were selected based on earlier geophysical studies. All borrow areas have different sizes and shapes. Borrow areas were usually from one to three miles offshore and ranged in depth from approximately 8 to 21 meters. Because the borrow area boundaries were adjusted during the course of the program, some stations are presently outside the newer boundaries. Since the boundaries are somewhat approximate, this does not influence the reliability of the data.

The overall Reformulation project area is located entirely within Suffolk County, along the Atlantic and bay shore towns of Babylon, Islip, Brookhaven, Southampton and East Hampton. The study area includes three large estuaries. Great South Bay is connected to the Atlantic Ocean through the Fire Island Inlet, which is a federal navigation channel. Similarly, Moriches and Shinnecock Bays are connected to the Atlantic Ocean through the Moriches and Shinnecock Inlets, respectively, and are federal navigation channels. Great South Bay, Moriches Bay and Shinnecock Bay are connected by narrow channels behind the barrier islands. The westernmost portion of the study area is Fire Island Inlet, located approximately 52 miles (by water) east of the Battery, New York.

3.0 METHODOLOGY

3.1 Sample Collection

A total of 240 stations were distributed throughout the 10 potential borrow areas per sampling effort. The borrow areas were not all the same size, so larger borrow areas were sampled more frequently than smaller borrow areas, to obtain a representative sample. The minimum amount of samples that any borrow area received was 10. The coordinates of the borrow areas were obtained from the USACOE and loaded into the differential GPS navigation system of the survey vessel (RV Kingfisher).

Samples were collected during July and August and November and December of 1999. When the survey vessel arrived at the borrow area, the actual stations were randomly selected, sampled, and recorded on the navigation system.

The grab used for the collections was a 0.025 meter square modified Young grab sampler as shown on the cover page of this report. Samples were collected at each of the proposed borrow locations on the following dates:

Table 1: Number of Samples at each Borrow Area

Borrow Area	Date	Number of Samples
		(Each sampling period)
2A	8/2/99 and 12/9/99	33
2B	8/3/99 and 12/8/99	17
2C	8/3/99 and 12/8/99	33
3A	7/28/99 and 12/3/99	24
4(A&B)	7/27/99 and 11/30/99	20
5(A&B)	7/21/99 and 11/23/99	31
6A	7/13/99 and 11/22/99	10
7	7/14/99 and 11/19/99	42
7A	7/13/99 and 11/18/99	10
8A	7/16/99 and 11/18/99	20

Individual samples (entire contents of the Young grab) were washed on a 0.5 millimeter mesh sieve to remove fine particles. Contents were then transferred to a jar, labeled, and preserved with a buffered 10 percent formalin solution. Only full grab samples were utilized. Rose bengal stain was added to the formalin to aid in later sorting of the organisms.

3.2 Sample Analysis

In the laboratory, all grab samples were rinsed gently through a 0.5-mm mesh sieve to remove preservatives and sediment, stained with Rose Bengal, and stored in 70% isopropanol solution until processing. Subsequently, the organisms were carefully removed with forceps and placed in labeled plastic vials containing 70% isopropanol. After sorting, macroinvertebrates were identified to the lowest practical identification level (LPIL) which in most cases was to the species level unless the organism was a juvenile, damaged, or otherwise unidentifiable. The oligochaetes, chironomids, nemerteans, anthozoans, and hydrozoans were left as high taxonomic groupings because of the difficulty associated with their identification or the small size and scarcity of specimens. The number of individuals for each taxon, excluding fragments, was recorded.

3.3 Biomass Analysis

Each sample was weighed for wet weight biomass (standing stock biomass in g/square meter) for the major taxonomic groups identified. In the laboratory, the organisms were removed from the vials and placed on a filter paper pad, gently blotted with a paper towel to remove moisture, placed in a tared weighing pan, and weighed to the nearest 0.1 mg.

3.4 Qualitative Data Analysis

All data generated as a result of laboratory analysis of macroinvertebrate samples were recorded in EXCEL spreadsheet format. Data were reduced to a summary report for each borrow area. The data were then evaluated for taxa diversity, composition, and abundance. Borrow areas were compared to each other to analyze similarities and differences between the observed data. Water quality, sample depth and spatial differences were analyzed to find any correlations between these variables and the similarities or differences in the data among the stations.

Data were standardized to abundance by calculating the number of organisms per square meter. This was calculated by dividing the total number of each species by the number of samples taken from each borrow area. This number was then multiplied by 40 to calculate the abundance per square meter (since the grab sample was .025 square meters). This analysis provides useful information in comparing borrow areas to each other in terms of actual abundance.

3.5 Statistical Data Analysis

Data analysis included comparing the total number of species, organisms, and species occurrences for the borrow areas. As the data set was complex, a simple statistical test could not be found to compare the borrow areas. Therefore, four representative statistical measures were used to compare the borrow areas. These measures are: abundance per borrow area, mean number of individuals in each taxonomic group, Jaccard's Indices, and biological diversity indices (H') for each borrow area. Details of these statistical metrics are listed below.

1. Abundance Per Borrow Area- the number of total organisms per square meter for each borrow area was calculated.

2. Mean Number Of Individuals In Each Taxonomic Group- using the taxonomic groups of the biological analysis, the borrow areas with the highest number of individuals in each group were identified.

3. Shannon and Weaver Biological Diversity Index (H')

$$H' = -\sum_{i=1}^{s} (p_i \ln p_i)$$

H' = average uncertainty per species in an infinite community of S species.
$p_1, p_2, p_3 \ldots p_s$ = proportional abundances for each species.

The Shannon-Weaver Index is used as a measure of community diversity. If an individual of the community is selected at random, the Shannon-Weaver Index gives a measure of the uncertainty that the selected individual with be of a particular

species. The Index increases as the number of species in the sample increases. It also increases as the species populations become more alike. Both of these conditions decrease the certainty that the selected individual is a particular species. Alternatively, if there are few species in the community and most of the individuals in the community were of the same species, then there would be a more certain outcome in predicting the species of a randomly selected individual.

4. Jaccard's Index- to investigate the similarities between borrow areas, the Jaccard's Index for each pair of borrow areas was computed. This index is the proportion of the number of species observed in either of two borrow areas that occurred in both borrow areas. It pertains only to the presence or absence of a species, not its abundance. The mean and the standard deviation was computed for all the Jaccard's Indices, and these were grouped into four groups, two groups below the mean and two above the mean. The mean Jaccard's Index for each borrow area was then computed as an indication of its overall similarity to the other borrow areas.

4.0 SPRING 1999 RESULTS

4.1 Community Structure, Numerical Abundance and Biomass Data

A total of 31,972 organisms (or approximately 133 per grab) were collected and identified. The archiannelid worm (*Polygordius triestinus*) was the most abundant (30 percent) of all the organisms throughout the entire study area. Dominant taxa found in the borrow areas were: Rhynchocoela, Nematoda, Archiannelid, Annelida, Mollusca, Arthropoda, Echinodermata, and Chordata. Arthropods, Annelids, and Archiannelid numerically dominated the samples. *P. triestinus* and *Echinarachnius parma* were consistently found as two of the most abundant organisms at each borrow area. A relatively even distribution was evident for the dominant organisms (with the exception of the highly abundant *P. triestinus*). This includes: sand dollar (*E. parma*), 9 percent; amphipods (*Protohaustorius wigleyi*), 8 percent; (*Pseudunciola obliqua*), 6 percent; and the polychaete worm (*Spiophanes bombyx*); 5 percent. While the commercially important surf clam (*Spisula solidissima*) was present at all proposed borrow locations, it was not present in every grab sample and only accounted for 1 percent of all organisms identified. Along a west to east transect, there appears to be an increase in the abundance of organisms starting at Borrow Area 2A, peaking at Borrow Area 3A, and decreasing in Borrow Area 8A. Interestingly, borrow area 3A had the highest abundance of organisms and the lowest biomass. This borrow area was comprised primarily of archiannelids, annelids, and arthropods which all have a relatively low biomass.

Infaunal biomass at the borrow areas ranged from 21 to 209 grams. Echinodermata dominate the biomass at all borrow areas with the exception of 8A, which has a greater biomass of molluscs.

Borrow areas 3A and 5 had the lowest biomass (~25 grams), while borrow areas 2B and 8A had the highest biomass (~200 grams). Unlike the abundance data, there does not appear to be a west-east trend in biomass data. Values for all borrow areas are scattered. There also does not appear to be a difference when comparing shallow versus deep sampling areas.

5.0 FALL 1999 RESULTS

5.1 Community Structure, Numerical Abundance and Biomass Data

A total of 38,395 organisms (or approximately 160 per grab) were collected and identified. The *Gammarus annulatus* was the most abundant (38 percent) of all the organisms throughout the entire study area, followed closely by *Polygordius triestinus*. Arthropods, Annelids, and Archiannelid numerically dominated the samples again in the fall 1999 samples. P. triestinus and G. annulatus were consistently found as two of the most abundant organisms at each borrow area. A relatively even distribution was evident for the dominant organisms (with the exception of the highly abundant *G. annulatus* and *P. triestinus*). This includes: *Asabellides oculata*, 4 percent; amphipod (*Protohaustorius wigleyi*), 2 percent; sand dollar (*Echinarachnius parma*), 2 percent; and the polychaete worm (*Tharyx acutas*); 1 percent. While the commercially important surf clam (*Spisula solidissima*) was present at all proposed borrow locations, it was not present in every grab sample and again only accounted for approximately 1 percent of all organisms identified. Borrow area 2 consisted of the highest numbers of the surf clam, with 127 in Borrow Area 2B, 98 in Borrow Area 2A, and 52 in Borrow Area 2C (these numbers are total abundances, not standardized per sample per meter). Borrow area 2A had the highest abundance of organisms, with 15,924. This was predominately attributable to the very large abundance of *Gammarus annulatus*, with 13,035 individual organisms.

Echinodermata dominate the biomass at most borrow areas again in the fall of 1999 samples. However, arthropods dominated borrow areas 6A and 2A, while mollusca dominated the samples collected at borrow areas 2B and 5. There were no trends evident in the biomass from the spring 1999 to the fall of 1999, as the borrow areas that had the highest biomass in the spring actually contained some of the lowest relative biomass. Borrow areas 2A and 2C consisted of the highest biomass, while Borrow areas 6A and 2B consisted of the lowest biomass. Again with the Fall 1999 samples, unlike the abundance data, there does not appear to be a west-east trend in biomass data. Values for all borrow areas are scattered. A station by station breakdown is as follows:

Borrow Area 2A

Spring 1999

Abundance:

Table 2: Borrow Area 2A Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 8/2/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2A			
Number of Samples: 33			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	1753	0.46	2125
Echinarachnius parma	296	0.08	359
Spiophanes bombyx	275	0.07	333
Pseudunciola obliqua	195	0.05	236
Protohaustorius wigleyi	150	0.04	182
Tellina agilis	127	0.03	154
Nematoda	98	0.03	119
Asabellides oculata	71	0.02	86
Spisula solidissima	70	0.02	85
Tanaidacea	70	0.02	85
Nemertean worm	47	0.01	57
Syllidae	46	0.01	56
Nephtys bucera	43	0.01	52
Gammarus annulatus	41	0.01	50
Acanthohaustorius millsi	36	0.01	44
Amphipoda	32	0.01	39
Polychaeta	28	0.01	34
Paraphoxus epistomus	28	0.01	34
Ovalipes ocellatus	27	0.01	33
Asterias forbesi	27	0.01	33
Aricidea catherinae	26	0.01	32
Oligochaeta	25	0.01	30

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 8/2/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2A			
Number of Samples: 33			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Tharyx acutus	23	0.01	28
Goniada maculata	20	0.01	24
TOTALS	**3780**	**100%**	**N/A**

Biomass:

Table 3: Borrow Area 2A Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 2A	
Rhynchocoela	
Archiannelids	
Annelida	4.67
Mollusca	4.642
Arthropoda	2.509
Echinodermata	47.854
Chordata	

Water Quality:

Table 4: Borrow Area 2A Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 8/2/99						
Water Quality Results						
Borrow Area 2A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
1	17.4	7.6	31.8	8.6	3.4	41.57
2	17.7	7.35	31.9	8.4	3.8	41.87
3	19.8	7.61	31.6	8.3	3.9	43.42
4	17.7	7.64	31.7	8.3	4.2	41.67
5	17.8	7.54	31.7	8.3	4	41.55
6	18	7.6	31.3	8.2	4.8	41.88
7	18.1	7.57	31.6	8.2	4.8	41.96
15	19.4	7.53	31.7	8.4	4.3	43.38
16	17.9	7.65	31.7	8.2	4.6	41.88
17	17.7	7.4	31.5	8.2	4	41.88
18	18.8	7.64	31.6	8.3	3.8	42.7
19	18.2	7.55	31.7	8.2	3.1	42.12
20	18.3	7.45	31.6	8.3	4.4	42.24
21	18.4	7.45	31.6	8.2	4.7	42.32
32	19.3	7.44	31.3	8.2	2.9	42.94
33	19.2	7.63	31.7	8.2	2.9	43.06
Mean	**18.36**	**7.54**	**31.63**	**8.28**	**3.98**	**42.28**

Biodiversity Index: 2.43 (Rank: 9)

A total of 33 benthic samples were collected from Borrow Area 2A on August 2, 1999. The mean water temperature recorded for this sampling period was 18.4 ^{o}C . The mean salinity recorded for this sampling period was 31.6 ppt (parts per thousand). The average collection depth in this borrow area was approximately 14 meters. There was a total of 3,780 species identified for this borrow area during this sampling period. Table 2 shows the dominant organisms present during this sampling period. The archiannelid *P. triestinus* was the most abundant, comprising 46 percent of the organisms identified. Additional dominant species included the sand dollar (*E. parma*) at 8 percent, and the polychaete worm (*S. bombyx*) at 7 percent. Additional prevalent species included the amphipods (*P. obliqua* and *P. wigleyi*), the clam (*Tellina agilis*), and species from the class Nematoda.

Standardizing borrow area 2A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 2,125 individuals of the archiannelid *P. triestinus* per square meter, 359 individuals of the sand dollar (*E. parma*) per square meter, 333 individuals of the polychaete worm *S. bombyx*, and 236 individuals of the amphipod *P. obliqua* per square meter.

The total biomass at this borrow area was dominated by the Sand dollar (47.84 grams), followed by annelid worms (4.67 grams) and bivalve mollusks (4.64 grams).

Fall 1999

Abundance:

Table 5: Borrow Area 2A Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2A			
Number of Samples: 33			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Gammarus annulatus	13035	0.82	15800
Polygordius triestinus	1237	0.08	1499
Asabellides oculata	340	0.02	412
Tellina agilis	145	0.01	176
Nephtys bucera	132	0.01	160
Spisula solidissima	98	0.01	119

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2A			
Number of Samples: 33			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Protohaustorius wigleyi	87	0.01	105
TOTALS	**15924**	**100%**	**N/A**

Biomass:

Table 6: Borrow Area 2A Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 2A	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.37	0.45
Annelida	5.42	6.57
Mollusca	6.28	7.61
Arthropoda	295.40	358.06
Echinodermata	20.99	25.44
Chordata	0.00	0.00
Other	0.00	0.00

Water Quality:

Table 7: Borrow Area 2A Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 2a						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
1	9.7	8.08	33			35.84
2						
3	9.7	8.08	33			35.78
4					4.5	
5	9.6	8.12	32.9			35.68
6	9.5	8.21	32.9			35.6
7	9.4	8	32.9			35.51
8	9.6	8.18	32.9			35.66
9						
10	9.7	8.36	32.9			35.75
11						
12	9.6	8.23	32.9			35.67
15	9.8	8.38	33			35.91
16	9.7	8.32	32.9			35.83
17	9.6	8.23	32.9			35.67
18	9.5	8.01	32.8			35.5
19	9.4	8.03	32.8			35.37
20	9.2	8.07	32.8			35.23
22	9.3	8.26	32.7			35.14
28	9.4	8.23	32.8			35.39
29					4.5	
Mean	**9.54**	**8.17**	**32.88**		**4.50**	**35.60**

Biodiversity Index: 0.94 (Rank: 10)

A total of 33 benthic samples were collected from Borrow Area 2A on December 9, 1999. The mean water temperature recorded for this sampling period was 9.5 ^{o}C . The mean salinity recorded for this sampling period was 32.8 ppt (parts per thousand). The average collection depth in

this borrow area was approximately 14 meters. There was a total of 15,924 species identified for this borrow area during this sampling period. Table 5 shows the dominant organisms present during this sampling period. The amphipod *Gammarus annulatus* was the most abundant, comprising 82 percent of the organisms identified. Additional dominant species included the archiannelid *Polygordius triestinus* at 8 percent, and the polychaete worm (*Asabellides oculata*) at 2 percent.

Standardizing borrow area 2A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 15,800 individuals of the amphipod *G. annulatus* per square meter, 1,499 individuals of the archiannelid (*P. Triestinus*) per square meter, and 412 individuals of the polychaete worm *A. oculata*.

The total biomass at this borrow area was dominated by the arthropods (295.4 grams) followed by Sand dollar (20.99 grams), followed by bivalve mollusks (6.28 grams) and anelid worms (5.42 grams).

Borrow Area 2B

Spring 1999

Abundance:

Table 8: Borrow Area 2B Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 8/2/99 and 8/3/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2B			
Number of Samples: 17			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Echinarachnius parma	701	0.27	1649
Polygordius triestinus	676	0.26	1591
Pseudunciola obliqua	294	0.11	692
Protohaustorius wigleyi	87	0.03	205
Tanaidacea	68	0.03	160

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 8/2/99 and 8/3/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2B			
Nematoda	66	0.03	155
Leptognatha caeca	50	0.02	118
Aricidea sp.	48	0.02	113
Polychaeta	43	0.02	101
Psammonyx nobilis	42	0.02	99
Acanthohaustorius millsi	41	0.02	96
Nemertean worm	36	0.01	85
Aricidea catherinae	35	0.01	82
Amphipoda	31	0.01	73
Oligochaeta	30	0.01	71
Syllidae	29	0.01	68
Glycera sp.	24	0.01	56
Tharyx acutus	22	0.01	52
Tellina agilis	21	0.01	49
Paraphoxus epistomus	21	0.01	49
Nudibranchia	19	0.01	45
Nephtys bucera	17	0.01	40
Spisula solidissima	16	0.01	38
Tharyx sp.	15	0.01	35
Corophidae	15	0.01	35
Aricidea jeffreysii	14	0.01	33
TOTALS	**2601**	**100%**	**N/A**

Biomass:

Table 9: Borrow Area 2B Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 2B	
Rhynchocoela	
Archiannelids	8.023
Annelida	2.4
Mollusca	5.011
Arthropoda	2.04
Echinodermata	191.22
Chordata	

Water Quality:

Table 10: Borrow Area 2B Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 8/2/99 and 8/3/99						
Water Quality Results						
Borrow Area 2B						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
1	18.2	7.65	31.6	8.2	4.2	42.04
2	18.1	7.93	31.7	8.1	4	42.01
3	18	7.29	31.7	8	3.6	41.98
4	18.1	7.37	31.7	8	4.2	42.11
10	19.3	7.89	31	8.2	3.8	42.75
11	18.7	7.46	31.7	8.2	4	42.68
12	18.6	7.72	31.7	8.2	4.3	42.58
13	22.6	7.52	31.8	8.3	3.6	na
14	17.7	7.17	31.8	8.2	4.4	41.87
Mean	**18.81**	**7.56**	**31.63**	**8.16**	**4.01**	**42.25**

Biodiversity Index: 2.63 (Rank: 5)

A total of 17 benthic samples were collected from Borrow Area 2B on August 2 and 3, 1999. The mean water temperature recorded for this sampling period was 18.8 ^{o} C. The mean salinity recorded for this sampling period was 31.6 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 2,601 individuals identified for this borrow area during this sampling period. Table 8 shows that 53 percent of the individuals identified were the sand dollar (*E. parma*), 27 percent, and the archiannelid (*P. triestinus*), 26 percent. Additional prevalent species included the amphipods (*P. obliqua* and *P. wigleyi*), 11 and 3 percent, respectively. Individuals from the classes Tanaidacea and Nematoda each comprised 3 percent.

Standardizing borrow area 2B for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 1,649 individuals of the sand dollar (*E. parma*) per square meter, 1,591 individuals of the archiannelid *P. triestinus* per square meter, 205 individuals of the amphipod *P. wigleyi* per square meter, and 692 individuals of the amphipod *P. obliqua* per square meter.

The biomass at this borrow area was dominated by sand dollars (191 grams), followed by archiannelid worms (8 grams) and bivalve mollusk species (5 grams).

Fall 1999

Abundance:

Table 11: Borrow Area 2B Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2B			
Number of Samples: 17			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	1575	0.64	3706
Echinarachnius parma	128	0.05	301
Spisula solidissima	127	0.05	299
Leptognatha caeca	113	0.05	266
Protohaustorius wigleyi	38	0.02	89
Aricidea jeffreysii	32	0.01	75
Goniadella gracillis	31	0.01	73
Tellina agilis	29	0.01	68
Nucula atacellana	27	0.01	64
Astarte castanea	25	0.01	59
Orchomanella pinguis	25	0.01	59
Tanaidacea	25	0.01	59
Asabellides oculata	23	0.01	54
Acanthohaustorius millsi	18	0.01	42
Nephtys bucera	17	0.01	40

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2B			
Number of Samples: 17			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Unidentified Nemertean sp.	16	0.01	38
Littorina obtusata	16	0.01	38
Gammarus annulatus	16	0.01	38
Syllidae	15	0.01	35
Bivalvia sp. (Unidentified)	15	0.01	35
Tharyx acutus	13	0.01	31
Pseudunciola obliqua	13	0.01	31
TOTALS	**2479**	**100%**	**N/A**

Biomass:

Table 12: Borrow Area 2B Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 2B		
Station No.	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.03	0.04

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 2B		
Station No.	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Annelida	1.59	1.93
Mollusca	9.39	11.38
Arthropoda	1.78	2.16
Echinodermata	5.86	7.10
Chordata	0.00	0.00
Other	0.03	0.04

Water Quality:

Table 13: Borrow Area 2B Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 2B						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
1	10	8.4	33			36.13
2	10	8.47	33		3.6	36.12
3	10.1	8.43	33			36.22
4	10	8.42	33			36.11
5	10.1	8.46	33			36.08
6					3.3	
10	9.9	8.32	33		2	36.02
11	9.9	8.46	33			35.98
12	9.8	8.44	33			35.86
13	9.8	8.46	33			35.89

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 2B						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
14					4.25	
Mean	**9.96**	**8.43**	**33.00**		**3.29**	**36.05**

Biodiversity Index: 2.01 (Rank: 7)

A total of 17 benthic samples were collected from Borrow Area 2B on December 8, 1999. The mean water temperature recorded for this sampling period was 9.9 ^{o} C. The mean salinity recorded for this sampling period was 33.0 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 2,479 individuals identified for this borrow area during this sampling period. Table 11 shows that 64 percent of the individuals identified were the archiannelid (*P. triestinus*), the sand dollar (*E. parma*), the surf clam (*Spisula solidissima*), and the blind tanaid, *Leptognatha caeca* each comprised 5%.

Standardizing borrow area 2B for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 3,706 individuals of the archiannelid *P. triestinus* per square meter, 301 individuals of the sand dollar (*E. parma*) per square meter, 299 individuals of the surf clam (*S. solidissima*) per square meter, and 266 individuals of the tanaid *L. caeca* per square meter.

The biomass at this borrow area was dominated by bivalve mollusk species (9.39 grams), followed by sand dollars (5.86 grams).

Borrow Area 2C

Spring 1999

Abundance:

Table 14: Borrow Area 2C Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 8/3/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2C			
Number of Samples: 33			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	2030	0.36	2461
Pseudunciola obliqua	900	0.16	1091
Echinarachnius parma	836	0.15	1013
Tanaidacea	183	0.03	222
Aricidea sp	173	0.03	210
Leptognatha caeca	134	0.02	162
Glycera sp.	116	0.02	141
Polychaeta	105	0.02	127
Nemertean worm	101	0.02	122
Nematoda	95	0.02	115
Aricidea wassi	71	0.01	86
Syllidae	68	0.01	82
Tharyx acutus	63	0.01	76
Protohaustorius wigleyi	55	0.01	67
Oligochaeta	53	0.01	64
Aricidea catherinae	43	0.01	52
Paraphoxus epistomus	41	0.01	50

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 8/3/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2C			
Tharyx sp.	37	0.01	45
Nephtys bucera	33	0.01	40
Astarte castanea	29	0.01	35
Corophidae	29	0.01	35
TOTALS	**5580**	**100%**	**N/A**

Biomass:

Table 15: Borrow Area 2C Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 2C	
Rhynchocoela	
Archiannelids	0.1818
Annelida	3.697
Mollusca	14.158
Arthropoda	3.745
Echinodermata	76.727
Chordata	0.6303

Water Quality:

Table 16: Borrow Area 2C Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 8/3/99						
Water Quality Results						
Borrow Area 2C						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
1	19.5	7.53	31.7	8.2	1.6	43.4
2	18.9	7.89	31.8	8.2	4.1	42.93
3	18.9	7.5	31.9	8.2	na	43.05
4	23.3	7.54	31.7	8.2	na	46.8
5	19.7	6.3	31.9	8.2	na	43.76
6	18.7	7.04	31.8	8.2	na	42.65
7	19.6	6.94	31.7	8.2	na	43.49
8	19.3	7.02	31.8	8.2	na	43.33
16	24	6.38	31.8	8.2	na	47.65
17	20.9	6.95	31.7	8.2	na	44.7
18	21.2	7.06	31.8	8.2	na	45.06
19	22.1	6.84	31.8	8.2	na	45.98
20	22.2	7.1	31.7	8.4	na	45.91
21	19.7	7.14	31.8	8.3	na	43.8
22	19.2	7.07	31.8	8.2	na	43.25
23	23.7	7.14	31.8	8.2	na	47.5
Mean	**20.68**	**7.09**	**31.78**	**8.22**	**2.85**	**44.58**

Biodiversity Index: 2.53 (Rank: 8)

A total of 33 benthic samples were collected from Borrow Area 2C on August 3, 1999. The mean water temperature recorded for this sampling period was 20.7 ^{o} C. The mean salinity recorded for this sampling period was 31.8 ppt. The average collection depth in this borrow area was approximately 19 meters. There was a total of 5,580 individual organisms identified for this borrow area during this sampling period. Table 8 shows that 67 percent of the organisms identified were the archiannelids (*P. triestinus*, 36 percent), amphipods (*P. obliqua*, 16 percent), and sand dollar (*E. parma*, 15 percent).

Standardizing borrow area 2C for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 2,461 individuals of the archiannelid *P. triestinus* per square meter, 1091 individuals of the amphipod *P. obliqua,* and 1,013 individuals of the sand dollar *E. parma* per square meter.

The biomass at this borrow area was dominated by sand dollars (76 grams), followed by bivalve mollusks (14 grams).

Fall 1999

Abundance:

Table 17: Borrow Area 2C Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2C			
Number of Samples: 33			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	3743	0.73	4537
Echinarachnius parma	217	0.04	263
Tharyx acutus	122	0.02	148
Leptognatha caeca	113	0.02	137
Tanaidacea	87	0.02	105
Tellina agilis	84	0.02	102
Aricidea sp.	56	0.01	68
Spisula solidissima	52	0.01	63

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 2C			
Number of Samples: 33			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Goniadella gracillis	44	0.01	53
Oligochaeta	43	0.01	52
Protohaustorius wigleyi	43	0.01	52
Pseudunciola obliqua	40	0.01	48
Unidentified Nematoda sp.	37	0.01	45
Aricidea jeffreysii	36	0.01	44
Syllidae	34	0.01	41
Sigalion arenicola	33	0.01	40
Unidentified Nemertean sp.	32	0.01	39
Polychaeta	31	0.01	38
Nephtys bucera	27	0.01	33
TOTALS	**5105**	**100%**	**N/A**

Biomass:

Table 18: Borrow Area 2C Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 2C	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.14	0.17
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 2C	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Cnidaria	0.00	0.00
Archiannelids	0.02	0.02
Annelida	5.75	6.97
Mollusca	9.10	11.03
Arthropoda	1.39	1.68
Echinodermata	229.69	278.41
Chordata	0.00	0.00
Other	0.72	0.87

Water Quality:

Table 19: Borrow Area 2C Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 2C						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
11	9.8	8.34	32.8		4	35.77
12	9.9	8.3	33			36.01
13	10	8.3	32.9			36.09
14	10	8.34	32.5			35.69
15	10.1	8.34	33.1			36.25
17	10.1	8.3	33			36.2
18	10.2	8.35	32.7			35.9

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 2C						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
19						
20	10.2	8.34	33.1			36.38
21	10.1	8.31	33			36.25
24	9.9	8.31	33	9.3		35.99
25	9.8	8.18	33	9.3		35.95
26	9.8	8.26	33	9.1		35.93
27	9.8	8.17	32.9	9.1		35.86
28	9.7	8.23	32.9	8.9		35.83
31	9.7	8.31	32.9	8.9		35.65
33	9.7	8.39	33	8.9		35.89
Mean	**9.93**	**8.30**	**32.93**	**9.07**	**4.00**	**35.98**

Biodiversity Index: 1.49 (Rank: 8)

A total of 33 benthic samples were collected from Borrow Area 2C on December 8, 1999. The mean water temperature recorded for this sampling period was 9.93 ^{o} C. The mean salinity recorded for this sampling period was 32.93 ppt. The average collection depth in this borrow area was approximately 19 meters. There was a total of 3,743 individual organisms identified for this borrow area during this sampling period. Table 17 shows that 73 percent of the organisms identified were the archiannelids (*P. triestinus*, 36 percent), sand dollar (*E. parma*, 4 percent), polychaete worm (*Tharyx acutus*, 2%), tanaids (*L.caeca* at 2% and *Tanaidacea* at 2%) and the clam (*Tellina agillis* at 2%).

Standardizing borrow area 2C for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 4,537 individuals of the archiannelid *P. triestinus* per square meter, 263 individuals of the sand dollar *E. parma* per square meter, 148 individuals of the polychaete worm (*T. acutus*) per square meter, and 137 individuals of the blind tanaid (*L. caeca*) per square meter.

The biomass at this borrow area was dominated by sand dollars (229.69 grams), followed by bivalve mollusks (9.10 grams) and annelid worms (5.75 grams).

Borrow Area 3A

Spring 1999

Abundance:

Table 20: Borrow Area 3A Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/28/99			
Species Abundance per Sample per Square Meter			
Borrow Area 3A			
Number of Samples: 24			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	2191	0.36	3652
Gammarus annulatus	689	0.11	1148
Oligochaeta	367	0.06	612
Nematoda	359	0.06	598
Clymanella torquata	303	0.05	505
Nemertean worm	221	0.04	368
Aricidea catherinae	192	0.03	320
Pseudunciola obliqua	185	0.03	308
Leptognatha caeca	180	0.03	300
Echinarachnius parma	144	0.02	240
Aricidea wassi	100	0.02	167
Orbiniidae	98	0.02	163
Polychaeta	77	0.01	128
Amphipoda	77	0.01	128
Asabellides oculata	75	0.01	125
Syllidae	71	0.01	118

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/28/99			
Species Abundance per Sample per Square Meter			
Borrow Area 3A			
Exogone sp.	68	0.01	113
Spiophanes bombyx	57	0.01	95
Paraphoxus epistomus	57	0.01	95
Aricidea jeffreysii	55	0.01	92
Paraonidae	54	0.01	90
Tharyx acutus	48	0.01	80
Phyllodocidae	41	0.01	68
Tellina agilis	38	0.01	63
Aricidea sp.	35	0.01	58
Protohaustorius wigleyi	32	0.01	53
Unciola irrorata	32	0.01	53
TOTALS	**6166**	**100%**	**N/A**

Biomass:

Table 21: Borrow Area 3A Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 3A	
Rhynchocoela	0.0833
Archiannelids	
Annelida	5.5167
Mollusca	0.8333
Arthropoda	5
Echinodermata	9.1833
Chordata	

Water Quality:

Table 22: Borrow Area 3A Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/28/99						
Water Quality Results						
Borrow Area 3A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
1	21.2	8.76	31.8	8.6	3.1	44.87
2	18.1	7.69	31.8	8.5	3	42.2
3	18.6	7.9	31.8	8.4	2.9	42.74

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/28/99						
Water Quality Results						
Borrow Area 3A						
4	19.3	7.83	31.8	8.3	3	43.37
5	18.4	7.99	31.7	8.3	2.5	42.34
6	18.3	7.95	31.8	8.2	3.2	42.41
7	18.7	7.69	31.8	8.2	2.8	42.84
8	18.4	7.5	31.8	8.2	2.8	42.46
9	18.3	7.85	31.9	8.2	3.2	42.42
10	21.7	8.19	31.8	8.1	3.3	45.54
11	18.3	7.97	31.8	8.2	3	42.38
12	18.1	8.09	31.8	8.1	2.8	42.3
Mean	**18.95**	**7.95**	**31.80**	**8.28**	**2.97**	**42.99**

Biodiversity Index: 2.72 (Rank: 3)

A total of 24 benthic samples were collected from Borrow Area 3A on July 28, 1999. The mean water temperature recorded for this sampling period was 18.9 ^{o} C. The mean salinity recorded for this sampling period was 31.8 ppt. The average collection depth in this borrow area was approximately 18 meters. There was a total of 6,166 individual organisms identified for this borrow area during this sampling period. Table 20 shows that 47 percent of the organisms identified were archiannelids (*P. triestinus*, 36 percent) and amphipods (*Gammarus annulatus*, 11 percent). Additional prevalent species included individuals from the classes Oligochatea and Nematoda, each comprising 6 percent; the worm *Clymenella torquata*, 5 percent; *Nemertean* worms, 4 percent; and *Aricidea catherinae*, 3 percent. The amphipod *P. obliqua* and the arthropod (*Leptognatha caeca*) each comprised 3 percent.

Standardizing borrow area 3A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 3,652 individuals of the archiannelid *P. triestinus* per square meter, 1,148 individuals of the amphipod *G. annulatus,* 612 individuals of the class *Oligochaeta* per square meter, 598 individuals of the class Nematoda and 505 individuals of the annelid *C. torquata* per square meter.

The biomass at this borrow area was dominated by Echinodermata (9 grams), followed by Annelida (5.5 grams).

Fall 1999

Abundance:

Table 23: Borrow Area 3A Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 3A			
Number of Samples: 24			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	5753	0.81	9588
Asabellides oculata	369	0.05	615
Tharyx acutus	226	0.03	377
Bivalvia sp. (Unidentified)	90	0.01	150
Aricidea sp.	53	0.01	88
Tharyx sp.	46	0.01	77
Echinarachnius parma	46	0.01	77
Tanaidacea	42	0.01	70
Nephtys bucera	38	0.01	63
Unidentified Nemertean sp.	37	0.01	62
TOTALS	**7149**	**100%**	**N/A**

Biomass:

Table 24: Borrow Area 3A Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 3A	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	2.48	4.13
Annelida	7.92	13.20
Mollusca	5.67	9.45
Arthropoda	2.48	4.13
Echinodermata	12.52	20.87
Chordata	0.00	0.00
Other	0.15	0.25

Water Quality:

Table 25: Borrow Area 3A Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 3a						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
1	10.4	7.3	33.2	8.2	4	36.64
3	10.3	7.9	33.1	7.8		36.5
5	10.3	7.83	33.1	8.4		36.46
7	10.1	8.02	33.1	8.6		36.34
8	10.1	7.92	33.1	8.7		36.3
11	10.3	8.01	33.1	8.6		36.47
12	10.4	7.9	33.1	8.6		36.58
14	10.2	8.08	33.1	8.9		36.36
15	10	8.16	33.1	8.6		36.2
16	10	8.06	33	8.6		36.05
17	10.1	8.12	32.6	8.5		36.3
19	10.2	8.25	33.1	8.7	2.5	36.42
22					2.3	
Mean	**10.20**	**7.96**	**33.06**	**8.52**	**2.93**	**36.39**

Biodiversity Index: 1.08 (Rank: 9)

A total of 24 benthic samples were collected from Borrow Area 3A on December 3, 1999. The mean water temperature recorded for this sampling period was 10.20 ^{o} C. The mean salinity recorded for this sampling period was 33.06 ppt. The average collection depth in this borrow area was approximately 18 meters. There was a total of 5,753 individual organisms identified for this borrow area during this sampling period. Table 23 shows that 81 percent of the organisms identified were archiannelids (*P. triestinus*, 36 percent. Additional prevalent species included the worms *A. oculata*, 5 percent and *T. acutus*, 3 percent.

Standardizing borrow area 3A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 9,588 individuals of the archiannelid *P. triestinus*

per square meter, 615 individuals of the worm *A. oculata,* and 377 individuals of the worm, *T. acutus*.

The biomass at this borrow area was dominated by the sand dollar (12.52 grams), followed by annelid worms (7.92 grams) and bivalve mollusks (5.67 grams).

Borrow Area 4

Spring 1999

Abundance:

Table 26: Borrow Area 4 Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/27/99			
Species Abundance per Sample per Square Meter			
Borrow Area 4			
Number of Samples: 20			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Splophanes bombyx	785	0.26	1570
Polygordius triestinus	600	0.20	1200
Pseudunciola obliqua	325	0.11	650
Tellina agilis	187	0.06	374
Tharyx sp.	181	0.06	362
Protohaustorius wigleyi	158	0.05	316
Echinarachnius parma	114	0.04	228
Spisula Solidissima	71	0.02	142
Capitellidae	55	0.02	110
Leptognatha caeca	51	0.02	102
Nematoda	49	0.02	98
Phyllodocidae	48	0.02	96
Tanaidacea	40	0.01	80

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/27/99			
Species Abundance per Sample per Square Meter			
Borrow Area 4			
Nemertean worm	38	0.01	76
Bivalvia	35	0.01	70
Aricidae catherinae	34	0.01	68
Nephtys bucera	34	0.01	68
Acanthohaustorius millsi	29	0.01	58
Tharyx acutus	20	0.01	40
Aricidea sp.	18	0.01	36
Polychaeta	17	0.01	34
Ovalipes ocellatus	16	0.01	32
TOTALS	**3068**	**100%**	**N/A**

Biomass:

Table 27: Borrow Area 4 Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 4	
Rhynchocoela	0.08
Archiannelids	
Annelida	8.94
Mollusca	8.88
Arthropoda	2.48
Echinodermata	62.64
Chordata	0.12

Water Quality:

Table 28: Borrow Area 4 Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/27/99						
Water Quality Results						
Borrow Area 4						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
1	18.1	7.58	31.8	8.6	3.7	42.2
2	19.6	8.06	31.8	8.6	3	43.6
3	20.3	8.16	31.8	8.6	3.9	43.97
4	18.5	7.53	31.7	8.4	4.1	42.46
5	19.2	7.42	31.8	8.2	4.3	42.91
11	17.9	7.55	31.8	8.4	3.9	42.11
12	19.8	8.42	31.7	8.3	3.1	43.78
13	18.1	7.93	31.7	8.2	3.1	42.09
14	17.6	7.87	31.8	8.2	3.5	41.65
15	16.8	7.79	32	8.2	4.2	41.2
Mean	**18.59**	**7.83**	**31.79**	**8.37**	**3.68**	**42.60**

Biodiversity Index: 2.71 (Rank: 4)

A total of 20 benthic samples were collected from Borrow Area 4 on July 27, 1999. The mean water temperature recorded for this sampling period was 18.6 ^{o} C. The mean salinity recorded for this sampling period was 31.8 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 3,068 individual organisms identified for this borrow area during this sampling period. Table 26 indicates that 57 percent of the organisms collected were the worms (*S. bombyx*, 26 percent) and (*P. triestinus*, 20 percent), and the amphipod (*P. obliqua*). Additional prevalent species included the clam (*T. agilis*, 6 percent), unidentified

Tharyx individuals, 6 percent, the amphipod (*P. wigleyi*, 5 percent), and the sand dollar (*E. parma*, 4 percent).

Standardizing borrow area 4 for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 1,570 individuals of the worm *S. bombyx* per square meter, 1,200 individuals of the archiannelid *P. triestinus,* 650 individuals of the amphipod *P. obliqua* per square meter.

The biomass at this borrow area was dominated by the Echinodermata (62 grams), followed by Annelida (8.9 grams), and Mollusca (8.9 grams).

Fall 1999

Abundance:

Table 29: Borrow Area 4 Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 4			
Number of Samples: 20			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Gammarus annulatus	162	0.14	324
Asabellides oculata	157	0.14	314
Polygordius triestinus	133	0.12	266
Protohaustorius wigleyi	98	0.09	196
Echinarachnius parma	79	0.07	158
Tharyx acutus	64	0.06	128
Tharyx sp.	43	0.04	86
Tellina agilis	36	0.03	72
Nephtys bucera	32	0.03	64
Polychaeta	23	0.02	46
Tanaidacea	23	0.02	46
Spiophanes bombyx	21	0.02	42
Spisula solidissima	20	0.02	40
Pseudunciola obliqua	16	0.01	32
Leptognatha caeca	16	0.01	32

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 4			
Number of Samples: 20			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Magelona sp.	15	0.01	30
Aricidea sp.	14	0.01	28
Haustoriidae	12	0.01	24
Aricidea wassi	10	0.01	20
Tellina sp.	10	0.01	20
Edotea montusa	10	0.01	20
Bivalvia sp. (Unidentified)	8	0.01	16
Cirratulidae	7	0.01	14
Nucula atacellana	7	0.01	14
Chiridotea coeca	7	0.01	14
Nephtys picta	6	0.01	12
TOTALS	**1131**	**100%**	**N/A**

Biomass:

Table 30: Borrow Area 4 Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 4	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 4	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.00	0.00
Annelida	2.12	4.24
Mollusca	3.65	7.30
Arthropoda	3.07	6.14
Echinodermata	22.44	44.88
Chordata	0.00	0.00
Other	0.00	0.00

Water Quality:

Table 31: Borrow Area 4 Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 4						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
4	11.5	7.35	32.7	8.9		37.36
7	11.6	7.5	33	8.9	2.1	37.69
8	11.5	7.6	33	8.9		37.58
9	11.5	7.35	33	8.9		37.52
10	11.3	7.56	33	8.9		37.2
13	11.6	7.38	33	8.9	2	37.72

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 4						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
17	11.6	7.5	33	8.9		37.63
18	11.7	7.48	33	8.9		37.46
19	11.7	7.35	33	8.9		37.78
20	11.6	7.72	33.1	8.9		37.71
Mean	**11.56**	**7.48**	**32.98**	**8.90**	**2.05**	**37.57**

Biodiversity Index: 3.11 (Rank: 1)

A total of 20 benthic samples were collected from Borrow Area 4 on November 30, 1999. The mean water temperature recorded for this sampling period was 11.56 ^{o} C. The mean salinity recorded for this sampling period was 32.98 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 1,131 individual organisms identified for this borrow area during this sampling period. Table 29 indicates that 14 percent of the organisms collected were the amphipod *G. annulatus*, 14 percent of the organisms collected were the worm *A. oculata*, and 12 percent were the archiannelid *P. triestinus*. Additional prevalent species included the amphipod (*P. wigleyi*, 9 percent), the sand dollar (*E. parma*, 7 percent) the clam (*T. agilis*, 6 percent), and unidentified *Tharyx* individuals, 4 percent.

Standardizing borrow area 4 for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 324 individuals of the amphipod *G. annulatus* per square meter, 314 individuals of the worm *A. oculata*, 266 individuals of the archiannelid *P. triestinus,* and 196 individuals of the amphipod *P. wigleyi* per square meter.

The biomass at this borrow area was dominated by the sand dollar (22.44 grams), followed by bivalve mollusks (3.65 grams), arthropods (3.07 grams) and annelid worms (2.12 grams).

Borrow Area 5

Spring 1999

Abundance:

Table 32: Borrow Area 5 Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/21/99			
Species Abundance per Sample per Square Meter			
Borrow Area 5			
Number of Samples: 31			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Protohaustorius wigleyi	1524	0.38	2032
Polygordius triestinus	493	0.12	657
Acanthohaustorius millsi	221	0.06	295
Echinarachnius parma	176	0.04	235
Spisula solidissima	173	0.04	231
Nematoda	157	0.04	209
Spiophanes bombyx	140	0.03	187
Tellina agilis	120	0.03	160
Gammarus sp.	98	0.02	131
Psammonyx nobilis	89	0.02	119
Gammarus annulatus	86	0.02	115
Nemertean worm	77	0.02	103
Syllidae	48	0.01	64
Arabella iricolor	45	0.01	60
Amphipoda	39	0.01	52
Haustoriidae	38	0.01	51

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/21/99			
Species Abundance per Sample per Square Meter			
Borrow Area 5			
Number of Samples: 31			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Magelona papillicornis	35	0.01	47
Asabellides oculata	33	0.01	44
Oligochaeta	33	0.01	44
Ovalipes ocellatus	30	0.01	40
Leptognatha caeca	28	0.01	37
Polychaeta	25	0.01	33
Nephtys bucera.	24	0.01	32
Glycera sp.	21	0.01	28
Goniadella gracillis	21	0.01	28
TOTALS	**4003**	**100%**	**N/A**

Biomass:

Table 33: Borrow Area 5 Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 5	
Rhynchocoela	0.08
Archiannelids	
Annelida	2.4133

Mollusca	15.573
Arthropoda	7.1067
Echinodermata	6.16
Chordata	0.6267

Water Quality:

Table 34: Borrow Area 5 Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/21/99						
Water Quality Results						
Borrow Area 5						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
1	19.5	7.85	31.8	8.6	4.5	43.62
2	17.3	8.29	31.9	8.3	4.3	41.59
3	17.8	8.17	32	8.4	4.2	42.07
4	19.6	7.77	31.9	8.4	5.3	43.77
5	19.6	7.78	32	8.3	5.2	43.75
6	20.7	8.02	31.8	8.2	4.5	44.73
7	20.7	7.67	31.8	8.3	4	44.84
8	20.6	8.05	31.8	8.3	4.1	44.57
18	21.4	7.84	31.9		5.2	45.26
19	20.9	7.56	31.9	8.1	6	44.87
20	19.5	7.26	31.9	8.3	6.0+	43.62
21	19.3	7.45	32	8.3	4.3	43.55
22	21	7.78	31.9	8.2	4	45.09
23	18.7	7.35	32	8.2	4.3	43

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/21/99						
Water Quality Results						
Borrow Area 5						
24	20.9	8.17	32	8.2	4.4	45
Mean	**19.83**	**7.80**	**31.91**	**8.29**	**4.59**	**43.96**

Biodiversity Index: 2.60 (Rank: 6)

A total of 31 benthic samples were collected from Borrow Area 5 on July 21, 1999. The mean water temperature recorded for this sampling period was 19.8 ^{o} C. The mean salinity recorded for this sampling period was 31.9 ppt. The average collection depth in this borrow area was approximately 12 meters. There was a total of 4,003 individuals identified for this borrow area during this sampling period. Table 17 indicated that 50 percent of the organisms collected consisted of the amphipod (*P. wigleyi*, 38 percent), and the archiannelid (*P. triestinus*, 12 percent). Additional dominant species included the amphipod (*Acanthohaustorius millsi*, 6 percent), the sand dollar (*E. parma*, 4 percent), the clams, (*S. solidissima* and *T. agilis*, 4 percent and 3 percent, respectively), and the worms (Nematoda and *S. bombyx*, 4 percent and 3 percent, respectively).

Standardizing borrow area 5 for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 2,032 individuals of the arthropod *P. wigleyi* per square meter and 657 individuals of the archiannelid *P. triestinus* per square meter.

The biomass at this borrow area was dominated by the Mollusca (15 grams), followed by Arthropoda (7 grams).

Fall 1999

Abundance:

Table 35: Borrow Area 5 Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 5			
Number of Samples: 31			

Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Protohaustorius wigleyi	267	0.24	345
Gammarus annulatus	196	0.18	253
Polygordius triestinus	116	0.11	150
Asabellides oculata	90	0.08	116
Acanthohaustorius millsi	88	0.08	114
Tellina agilis	40	0.04	52
Psammonyx nobilis	38	0.03	49
Magelona papillicornis	36	0.03	46
Magelona riogai	26	0.02	34
Spisula solidissima	23	0.02	30
Echinarachnius parma	21	0.02	27
Glycera sp.	13	0.01	17
Nephtys bucera	13	0.01	17
Magelona sp.	12	0.01	15
Leptognatha caeca	11	0.01	14
Spiophanes bombyx	9	0.01	12
Nephtys picta	6	0.01	8
Scoleoepis squamata	6	0.01	8
Pyramidellidae	6	0.01	8
Phoxocephalus holbolli	6	0.01	8
TOTALS	**1102**	**100%**	**N/A**

Biomass:

Table 36: Borrow Area 5 Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 5	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.00	0.00
Annelida	1.01	1.35
Mollusca	9.29	12.39
Arthropoda	5.50	7.33
Echinodermata	2.94	3.92
Chordata	0.00	0.00
Other	0.00	0.00

Water Quality:

Table 37: Borrow Area 5 Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 5						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
1	12.4	7.9	32.9	8.9		38.15
3	12.4	7.52	33.1	8.8	2.5	38.38
5	12.4	7.75	33.1	8.9		38.33
6	12.4	7.9	33.1	8.9		38.31
7	12.4	8	33.2	8.8		38.3
8	12.4	7.99	33.1	8.9		38.18
9	12.4	8	32.9	8.8		38.25
10	12.4	7.92	33.1	8.8	2	38.25
18	12.5	8.15	32.9	8.8	1.5	38.31
19	12.4	7.74	33	8.8		38.31
20	12.3	7.77	33.1	8.8		38.32
21	12.5	7.91	33	8.9		38.42
22	12.3	7.75	32.8	8.8		37.78
23	12.3	7.78	33	8.8		38.14
24	12.3	7.66	32.8	8.8		38.27
Mean	**12.39**	**7.85**	**33.01**	**8.83**	**2.00**	**38.25**

Biodiversity Index: 2.70 (Rank: 4)

A total of 31 benthic samples were collected from Borrow Area 5 on November 23, 1999. The mean water temperature recorded for this sampling period was 12.39 ^{o} C. The mean salinity recorded for this sampling period was 33.01 ppt. The average collection depth in this borrow area was approximately 12 meters. There was a total of 1,102 individuals identified for this borrow area during this sampling period. Table 17 indicated that 42 percent of the organisms collected consisted of the amphipods (*P. wigleyi*, 24 percent and *G. annulatus*, 18 percent), and. Additional dominant species included the archiannelid (*P. triestinus*, 11 percent), the amphipod (*Acanthohaustorius millsi*, 8 percent), the worm A. oculata (8%) and the clam, T. agillis (4%).

Standardizing borrow area 5 for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 345 individuals of the arthropod *P. wigleyi* per square meter, 253 individuals of the amphipod *G. annulatus* per square meter, and 150 individuals of the archiannelid *P. triestinus* per square meter.

The biomass at this borrow area was dominated by the Mollusca (9.29 grams), followed by Arthropoda (5.50 grams).

Borrow Area 6A

Spring 1999

Abundance:

Table 38: Borrow Area 6A Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/13/99			
Species Abundance per Sample per Square Meter			
Borrow Area 6A			
Number of Samples: 10			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	294	0.32	1176
Echinarachnius parma	145	0.16	580
Protohaustorius wigleyi	86	0.09	344
Tellina agilis	52	0.06	208
Nemertean worm	51	0.06	204
Acanthohaustorius millsi	49	0.05	196
Spiophanes bombyx	46	0.05	184
Gammarus annulatus	30	0.03	120
Goniada maculata	19	0.02	76
Nephtys bucera	16	0.02	64

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/13/99			
Species Abundance per Sample per Square Meter			
Borrow Area 6A			
Paraphoxus epistomus	14	0.02	56
Psammonyx nobilis	10	0.01	40
Nematoda	9	0.01	36
Tharyx acutus	9	0.01	36
Cirolana borealis	9	0.01	36
Leptognatha caeca	9	0.01	36
Haploscoloplosus sp.	8	0.01	32
Ovalipes ocellatus	8	0.01	32
Polychaeta	7	0.01	28
Syllidae	6	0.01	24
Cancer irrorata	5	0.01	20
TOTALS	**927**	**100%**	**N/A**

Biomass:

Table 39: Borrow Area 6A Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 6A	
Rhynchocoela	
Archiannelids	
Annelida	1.88
Mollusca	1.32
Arthropoda	5.84
Echinodermata	70.52

Chordata	0.56

Water Quality:

Table 40: Borrow Area 6A Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/13/99						
Water Quality Results						
Borrow Area 6A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
6	19.6	7.75	32			43.78
7	19.6	7.95	31.9			43.76
8	19.8	8	31.8			41.93
9	19.7	7.78	31.9			43.86
10	19.7	7.62	31.9			43.81
Mean	**19.68**	**7.82**	**31.90**			**43.43**

Biodiversity Index: 2.53 (Rank: 7)

A total of 10 benthic samples were collected from Borrow Area 6A on July 13, 1999. The mean water temperature recorded for this sampling period was 19.68 ^{o} C. The mean salinity recorded for this sampling period was 31.90 ppt. The average collection depth in this borrow area was approximately 14 meters. There was a total of 927 individuals identified for this borrow area during this sampling period. Table 38 indicates that 57 percent of the organisms collected consisted of the archiannelid (*P. triestinus*, 32 percent), the sand dollar (*E. parma*, 16 percent), and the amphipod (*P. wigleyi*, 9 percent). Additional dominant individuals were: the clam (*T. agilis*, 6 percent), the worms (*Nemertean* and *S. bombyx*, 6 and 5 percent), respectively, and the amphipods (*A. millsi* and *G. annulatus*, 5 and 3 percent, respectively).

Standardizing borrow area 6A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 1,176 individuals of the archiannelid *P. triestinus* per square meter and 580 sand dollars per square meter.

The biomass at this borrow area was dominated by the Echinodermata (70 grams), followed by Arthropoda (6 grams).

Fall 1999

Abundance:

Table 41: Borrow Area 6A Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 6A			
Number of Samples: 10			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	59	0.20	236
Protohaustorius wigleyi	40	0.14	160
Echinarachnius parma	35	0.12	140
Gammarus annulatus	33	0.11	132
Leptognatha caeca	20	0.07	80
Tellina agilis	19	0.06	76
Acanthohaustorius millsi	16	0.05	64
Bivalvia sp. (Unidentified)	12	0.04	48
Gammarus sp.	8	0.03	32
Nephtys bucera	5	0.02	20
Paraonidae	5	0.02	20
Syllidae	5	0.02	20
Amphipoda	5	0.02	20
Unidentified Nematoda sp.	3	0.01	12
Spisula solidissima	3	0.01	12
Aricidea jeffreysii	2	0.01	8
Asabellides oculata	2	0.01	8
Goniadella gracillis	2	0.01	8
Sigalionidae	2	0.01	8
Tharyx acutus	2	0.01	8
Gammarus oceanicus	2	0.01	8
Hippomedan serratus	2	0.01	8
Paraphoxus epistomus	2	0.01	8

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 6A			
Number of Samples: 10			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
TOTALS	**301**	**100%**	**N/A**

Biomass:

Table 42: Borrow Area 6A Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 6A	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.00	0.00
Annelida	0.13	0.52
Mollusca	0.26	1.04
Arthropoda	3.15	12.60
Echinodermata	1.78	7.12
Chordata	0.75	3.00
Other	0.00	0.00

Water Quality:

Table 43: Borrow Area 6A Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 6A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
1	12.4	7.6	33.3	8.9	3.2	38.55
2	12.4	7.29	33.1	8.8		38.34
3	12.6	7.89	33.3	8.9		38.76
4	12.5	7.43	33.3	8.9	3	38.65
5	12.7	7.32	33.4			38.97
Mean	**12.52**	**7.51**	**33.28**	**8.88**	**3.10**	**38.65**

Biodiversity Index: 2.79 (Rank: 3)

A total of 10 benthic samples were collected from Borrow Area 6A on November 22, 1999. The mean water temperature recorded for this sampling period was 12.52 ^{o}C. The mean salinity recorded for this sampling period was 33.28 ppt. The average collection depth in this borrow area was approximately 14 meters. There was a total of 301 individuals identified for this borrow area during this sampling period. Table 41 indicates that 57 percent of the organisms collected consisted of the archiannelid (*P. triestinus*, 20 percent), the amphipod (*P. wigleyi*, 14 percent), the sand dollar (*E. parma*, 12 percent), and the amphipod *(G. annulatus* 11 percent). Additional dominant individuals were: the clam (*T. agilis*, 6 percent) and the amphipod (*Leptognatha caeca*).

Standardizing borrow area 6A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 236 individuals of the archiannelid *P. triestinus* per square meter, 160 individuals of the amphipod (*P. wigleyi*) per square meter, 140 sand dollars per square meter, and 132 individuals of the amphipod (*G. annulatus*).

The biomass at this borrow area was dominated by the arthropods (3.15 grams), followed by the sand dollar (1.78 grams).

Borrow Area 7

Abundance:

Table 44: Borrow Area 7 Individuals Abundance

ACOE Benthic Sampling - Spring 1999			
Dates Sampled: 7/14/99 and 7/16/99			
Species Abundance per Sample per Square Meter			
Borrow Area 7			
Number of Samples: 42			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	603	0.18	574
Ampelisca verrilli	464	0.14	442
Protohaustorius wigleyi	365	0.11	348
Nematoda	285	0.09	271
Echinarachnius parma	238	0.07	227
Nemertean worm	124	0.04	118
Acanthohaustorius millsi	104	0.03	99
Ampelisca vadorum	101	0.03	96
Tellina agilis	99	0.03	94
Spiophanes bombyx	85	0.03	81
Leptognatha caeca	79	0.02	75
Syllidae	70	0.02	67
Nephtys bucera	65	0.02	62
Gammarus palustris	65	0.02	62
Paraphoxus epistomus	60	0.02	57
Pseudunciola obliqua	60	0.02	57
Oligochaeta	51	0.02	49
Gammarus annulatus	30	0.01	29
Spisula solidissima	25	0.01	24

ACOE Benthic Sampling - Spring 1999			
Dates Sampled: 7/14/99 and 7/16/99			
Species Abundance per Sample per Square Meter			
Borrow Area 7			
Polychaeta	24	0.01	23
Chiridotea	23	0.01	22
Paraonidae	22	0.01	21
Ovalipes ocellatus	22	0.01	21
Glycera sp.	20	0.01	19
Goniada maculata	17	0.01	16
TOTALS	**3344**	**100%**	**N/A**

Biomass:

Table 45: Borrow Area 7 Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 7	
Rhynchocoela	0.0571
Archiannelids	0.0286
Annelida	3.4857
Mollusca	1.0381
Arthropoda	4.7524
Echinodermata	96.533
Chordata	

Water Quality:

Table 46: Borrow Area 7 Water Quality

ACOE Benthic Sampling - Spring 1999						
Dates Sampled: 7/14/99 and 7/16/99						
Water Quality Results						
Borrow Area 7						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
8	20.1	7.5	31.4	6.6	6.0+	43.55
9	19.3	7.55	31.6	6.6	6.0+	43.14
10	19.8	7.79	31.5	6.6	6.0+	43.58
11	19.6	8.02	31.5	6.6	6.0+	43.25
12	19.5	8.1	31.6	6.6	6.0+	43.25
13	19.5	8.15	31.6	6.7	6.0+	43.1
14	19.4	7.7	31.5	6.8	6.0+	43.09
22	20.1	7.37	31.6	6.6	6.0+	43.8
23	19.8	8	31.5	6.7	4.5	43.44
24	19.5	8.25	31.6	6.7	6.0+	43.2
25	19.4	8.15	31.7	6.7	6.0+	43.03
26	19.7	8.03	31.6	6.7	6.0+	43.57
27	19.4	8.04	31.5	6.6	6.0+	43.08
28	19.8	7.91	31.5	6.8	6.0+	43.35
36	17.1	8.28	31.1	6.6	6.0+	41.12
37	17.6	8.47	31.7	6.7	6.0+	41.5
38	17.2	8.11	31.7	6.7	6.0+	41.19
39	17.7	8.45	31.5	6.6	6.0+	41.61
40	17	8.4	31.8	6.7	6.0+	41.1
Mean	**19.03**	**8.01**	**31.55**	**6.66**	**4.50**	**42.79**

Biodiversity Index: 3.05 (Rank: 1)

A total of 42 benthic samples were collected from Borrow Area 7 on July 14 and 16, 1999. The mean water temperature recorded for this sampling period was 19.0 ^{o} C. The mean salinity recorded for this sampling period was 31.55 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 3,344 individuals identified for this borrow area during this sampling period. Table 44 indicates that 52 percent of the organisms identified were composed of the archiannelid *P. triestinus*, 18 percent, and the amphipods (*Ampelisca verrilli* and *P. wigleyi*, 14 and 11 percent), respectively. Additional dominant species included the worms (Nematoda, Nemertean, and *S. bombyx*, 9,4, and 3 percent, respectively), the sand dollar (*E. parma*, 7 percent), the amphipods (*A. millsi* and *Ampelisca vadorum*, each at 3 percent), and the clam (*T. agilis*, at 3 percent).

Standardizing borrow area 7 for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 574 individuals of the archiannelid *P. triestinus* per square meter and 442 individuals of the arthropod *A. verrilli* per square meter.

The biomass at this borrow area was dominated by the Echinodermata (97 grams), followed by Arthropoda (5 grams).

Fall 1999

Abundance:

Table 47: Borrow Area 7 Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 7			
Number of Samples: 42			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Gammarus annulatus	528	0.15	503
Asabellides oculata	439	0.13	418
Ampelisca vadorum	337	0.10	321
Polygordius triestinus	277	0.08	264
Protohaustorius wigleyi	269	0.08	256
Gammarus sp.	252	0.07	240

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 7			
Number of Samples: 42			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Echinarachnius parma	193	0.06	184
Acanthohaustorius millsi	170	0.05	162
Tanaidacea	155	0.04	148
Gammarus palustris	97	0.03	92
Tellina agilis	91	0.03	87
Leptognatha caeca	71	0.02	68
Paraphoxus epistomus	68	0.02	65
Nephtys bucera	62	0.02	59
Polychaeta	44	0.01	42
Bivalvia sp. (Unidentified)	35	0.01	33
Aricidea sp.	31	0.01	30
Glycera sp.	28	0.01	27
Pseudunciola obliqua	21	0.01	20
TOTALS	**3447**	**100%**	**N/A**

Biomass:

Table 48: Borrow Area 7 Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 7	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.19	0.18

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 7	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.00	0.00
Annelida	9.97	9.50
Mollusca	3.60	3.43
Arthropoda	15.99	15.23
Echinodermata	54.79	52.18
Chordata	0.00	0.00
Other	0.00	0.00

Water Quality:

Table 49: Borrow Area 7 Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 7						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
5	12.4	7.59	33.2	8.9		38.61
8	11.5	7.31	33.1	8.8		37.46
10	12	7.11	33.2	8.8		38.04
11	12.2	7.25	33.2	8.8		38.29
12	12.2	7.36	33.2	8.8		38.37
13	12	7.46	33.3	8.8		38.49

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 7						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
15	12.5	7.39	32.9	8.8		38.57
16	12.4	7.35	33.2	8.8		38.5
17	12.1	7.39	33.2	8.8		38.2
18	12	7.43	32.9	8.8		38
22	11.2	7.51	32.6	8.8		37.26
25	12.1	7.46	33.2	8.8		38.22
27	12.1	7.36	33.1	8.8		38.26
28	12.3	7.45	33.2	8.8		38.39
30	12.1	7.4	32.9	8.7		37.83
37	12	7.27	33.1	8.8		38.03
38	12	7.33	33.2	8.7		38.04
39	12.3	7.37	33.2	8.8	3	38.33
40	12.3	7.45	33.1	8.8		38.18
41	12.2	7.4	33.2	8.8		38.35
42	12.3	7.42	33.2	8.8		38.32
Mean	**12.10**	**7.38**	**33.11**	**8.80**	**3.00**	**38.18**

Biodiversity Index: 3.02 (Rank: 2)

A total of 42 benthic samples were collected from Borrow Area 7 on November 19, 1999. The mean water temperature recorded for this sampling period was 12.10 ^{o} C. The mean salinity recorded for this sampling period was 33.11 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 3,447 individuals identified for this borrow area during this sampling period. Table 47 indicates that 38 percent of the organisms identified were composed of the amphipods *(G. annulatus*, 15 percent and *Ampelisca vadorum*, 10 percent) and the annelid *A. oculata*, 13 percent. Additional dominant species included the archiannelid (*P.triestinus*, 8 percent) and the amphipods (*P. wigleyi*, 8 percent and *Gammrus sp.* 7 percent).

Standardizing borrow area 7 for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 503 individuals of the amphipod *G. annulatus* per square meter, 418 individuals of the amphipod *A. oculata* per square meter, 321 individuals of the amphipod *A. vadorum* per square meter, and 264 individuals of the archiannelid *P. triestinus* per square meter.

The biomass at this borrow area was dominated by the sand dollar (54.79 grams), followed by the arthropods (15.99 grams) and annelid worms (9.97 grams).

Borrow Area 7A

Abundance:

Table 50: Borrow Area 7A Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/13/99			
Species Abundance per Sample per Square Meter			
Borrow Area 7A			
Number of Samples: 10			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	449	0.54	1796
Nemertean worm	69	0.08	276
Protohaustorius wigleyi	53	0.06	212
Nematoda	35	0.04	140
Acanthohaustorius millsi	30	0.04	120
Syllidae	25	0.03	100
Echinarachnius parma	23	0.03	92
Tellina agilis	22	0.03	88
Nephtys bucera	13	0.02	52
Ovalipes ocellatus	12	0.01	48
Tharyx acutus	11	0.01	44
Leptognatha caeca	10	0.01	40
Exogene dispar	9	0.01	36
Oligochaeta	8	0.01	32
Gammarus annulatus	8	0.01	32
Paraphoxus epistomus	6	0.01	24

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/13/99			
Species Abundance per Sample per Square Meter			
Borrow Area 7A			
Psammonyx nobilis	6	0.01	24
Pseudunciola obliqua	6	0.01	24
Spiophanes bombyx	5	0.01	20
TOTALS	**835**	**100%**	**N/A**

Biomass:

Table 51: Borrow Area 7A Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 7A	
Rhynchocoela	0.08
Archiannelids	
Annelida	1.2
Mollusca	1.48
Arthropoda	5.996
Echinodermata	53.6
Chordata	

Water Quality:

Table 52: Borrow Area 7A Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/13/99						
Water Quality Results						
Borrow Area 7A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
5	20.3	7.45	31.7	6.8	6.0+	44.32
6	20.3	7.43	31.9		6.0+	44.39
7	20.2	6.99	31.9			44.27
8	20.1	7.29	31.9		6.0+	44.29
9	20.2	7.39	31.9		6.0+	44.31
10	20.2	8.31	31.9		6.0+	44.24
Mean	**20.22**	**7.48**	**31.87**	**6.80**	**6.00**	**44.30**

Biodiversity Index: 2.03 (Rank: 10)

A total of 10 benthic samples were collected from Borrow Area 7A on July 13, 1999. The mean water temperature recorded for this sampling period was 20.2 ^{o} C. The mean salinity recorded for this sampling period was 31.9 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 835 individuals identified for this borrow area during this sampling period. Table 50 indicates that 54 percent of the organisms identified were the archiannelid (*P. triestinus*). The remaining species in the samples were dominated by the worm (Nemertean, Nematoda, and *Syllidae*), 8, 4, and 3 percent, respectively, the amphipods (*P. wigleyi* and *A. millsi*), 6 and 4 percent, respectively, the sand dollar (*E. parma*), 3 percent, and the clam (*T. agilis*), 3 percent.

Standardizing borrow area 7A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 1796 individuals of the archiannelid *P. triestinus* per square meter and 276 of the *Nemertean* worm species per square meter.

The biomass at this borrow area was dominated by the Echinodermata (54 grams), followed by Arthropoda (6 grams).

Fall 1999

Abundance:

Table 53: Borrow Area 7A Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 7A			
Number of Samples: 10			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	143	0.34	572
Gammarus annulatus	79	0.19	316
Protohaustorius wigleyi	34	0.08	136
Tanaidacea	24	0.06	96
Echinarachnius parma	22	0.05	88
Asabellides oculata	18	0.04	72
Glycera sp.	11	0.03	44
Bivalvia sp. (Unidentified)	11	0.03	44
Tellina agilis	10	0.02	40
Acanthohaustorius millsi	9	0.02	36
Leptognatha caeca	9	0.02	36
Aricidea sp.	7	0.02	28
Nephtys bucera	7	0.02	28
Polychaeta	7	0.02	28
Hippomedan serratus	7	0.02	28
Psammonyx nobilis	7	0.02	28
Disodactylus mellitae	7	0.02	28
Spisula solidissima	6	0.01	24
Sigalion arenicola	3	0.01	12
TOTALS	**424**	**100%**	**N/A**

Biomass:

Table 54: Borrow Area 7A Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 7A	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.00	0.00
Annelida	0.40	1.60
Mollusca	4.69	18.76
Arthropoda	2.81	11.24
Echinodermata	20.83	83.32
Chordata	0.00	0.00

Water Quality:

Table 55: Borrow Area 7A Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 7A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
6	11.8	7.55	33	8.9		37.77
7	11.6	7.37	33.1	8.9		37.72
8	11.4	7.53	32.7	8.9	2	37.2
10	11.4	7.45	33.1	8.9		37.51
Mean	**11.55**	**7.48**	**32.98**	**8.90**	**2.00**	**37.55**

Biodiversity Index: 2.62 (Rank: 5)

A total of 10 benthic samples were collected from Borrow Area 7A on November 18, 1999. The mean water temperature recorded for this sampling period was 11.55 ^{o} C. The mean salinity recorded for this sampling period was 32.98 ppt. The average collection depth in this borrow area was approximately 16 meters. There was a total of 424 individuals identified for this borrow area during this sampling period. Table 53 indicates that 53 percent of the organisms identified were the archiannelid (*P. triestinus*, 34 percent) and the amphipod (*G. annulatus*, 19 percent). The remaining species in the samples were dominated by the amphipod (*P. wigleyi*, 8 percent), *Tanaidacea*, 6 percent, and the sand dollar (*E. parma*), 5 percent.

Standardizing borrow area 7A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 572 individuals of the archiannelid *P. triestinus* per square meter, 316 individuals of the amphipod *G. annulatus* per square meter, and 136 individuals of the amphipod *P. wigleyi* per square meter.

The biomass at this borrow area was dominated by the sand dollar (20.83 grams), followed by bivalve mollusks (4.69 grams).

Borrow Area 8A

Spring 1999

Abundance:

Table 56: Borrow Area 8A Species Abundance

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/16/99			
Species Abundance per Sample per Square Meter			
Borrow Area 8A			
Number of Samples: 20			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Polygordius triestinus	422	0.25	844
Echinarachnius parma	226	0.14	452
Nematoda	198	0.12	396
Protohaustorius wigleyi	95	0.06	190
Spiophanes bombyx	85	0.05	170
Acanthohaustorius millsi	76	0.05	152
Syllidae	75	0.04	150
Tellina agilis	69	0.04	138
Nemertean worm	66	0.04	132
Polychaeta	47	0.03	94
Oligochaeta	46	0.03	92
Nephtys bucera	36	0.02	72
Tanaidacea	18	0.01	36
Aricidea sp	15	0.01	30
Leptognatha caeca	15	0.01	30
Glycera sp.	13	0.01	26
Orbiniidae	13	0.01	26
Spisula solidissima	11	0.01	22
Cirolana concharum	11	0.01	22
Glycera americana	9	0.01	18

ACOE Benthic Sampling - Spring 1999			
Date Sampled: 7/16/99			
Species Abundance per Sample per Square Meter			
Borrow Area 8A			
Ampelisca verrilli	9	0.01	18
TOTALS	**1669**	**100%**	**N/A**

Biomass:

Table 57: Borrow Area 8A Biomass

ACOE Benthic Sampling - Spring 1999	
Biomass of Organisms	
Unit: Grams	
Borrow Area 8A	
Rhynchocoela	
Archiannelids	
Annelida	7.6
Mollusca	123.26
Arthropoda	3.3
Echinodermata	38
Chordata	

Water Quality:

Table 58: Borrow Area 8A Water Quality

ACOE Benthic Sampling - Spring 1999						
Date Sampled: 7/16/99						
Water Quality Results						
Borrow Area 8A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	ms
5	18.7	8.18	31.7	6.9	5.9	42.59
6	17.8	8.44	31.8	6.9	4.7	41.53
7	17.1	8.08	31.8	6.9	4.9	41.28
8	17.1	8.03	31.8	6.8	4.5	41.28
9	17.3	7.78	31.8	6.8	5	41.3
13	17.3	8.06	31.7	6.8	6	41.29
14	16.9	8.19	31.9	6.8	6.0+	41.18
15	17.1	7.65	31.9	6.8	6	41.16
16	17.5	8.12	31.8	6.8	6.0+	41.29
17	17	7.97	31.9	6.8	6.0+	41.29
Mean	**17.38**	**8.05**	**31.81**	**6.83**	**5.29**	**41.42**

Biodiversity Index: 2.78 (Rank: 2)

A total of 20 benthic samples were collected from Borrow Area 8A on July 16, 1999. The mean water temperature recorded for this sampling period was 17.4 ^{o}C. The mean salinity recorded for this sampling period was 31.8 ppt. The average collection depth in this borrow area was approximately 14 meters. There was a total of 1,669 individuals identified for this borrow area during this sampling period. Table 56 indicates that 51 percent of the organisms identified included the archiannelid (*P. triestinus*), 25 percent, the sand dollar (*E. parma)*, 14 percent and 12 percent were identified as Nematoda. The remainder of the dominant species were the amphipods (*P. wigleyi* and *A. millsi*), 6 and 5 percent, respectively, the worms (*S. bombyx* (5 percent), *Syllidae*

(4 percent), and Nemertean (4 percent)), the clam (*T. agilis*), 4 percent, and individuals from the classes Polychaeta and Oligochatea, each comprising 3 percent.

Standardizing borrow area 8A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 844 individuals of the archiannelid *P. triestinus* per square meter, 452 sand dollars per square meter, and 396 individuals from the class Nematoda per square meter.

The biomass at this borrow area was dominated by bivalve mollusks (123 grams), followed by sand dollars (38 grams).

Fall 1999

Abundance:

Table 59: Borrow Area 8A Species Abundance

ACOE Benthic Sampling - Fall 1999			
Date Sampled: 11/99			
Species Abundance per Sample per Square Meter			
Borrow Area 8A			
Number of Samples: 20			
Species	Totals	Fraction of Total	Abundance per Sample per Square Meter
Gammarus annulatus	562	0.42	1124
Polygordius triestinus	314	0.24	628
Echinarachnius parma	101	0.08	202
Protohaustorius wigleyi	55	0.04	110
Acanthohaustorius millsi	48	0.04	96
Tanaidacea	48	0.04	96
Leptognatha caeca	24	0.02	48
Nephtys bucera	20	0.02	40
Polychaeta	19	0.01	38
Syllidae	17	0.01	34
Glycera sp.	13	0.01	26
Tellina agilis	13	0.01	26
Bivalvia sp. (Unidentified)	11	0.01	22
Aricidea sp.	9	0.01	18
Unidentified Nemertean sp.	7	0.01	14
TOTALS	**1333**	**100%**	**N/A**

Biomass:

Table 60: Borrow Area 8A Biomass

ACOE Benthic Sampling - Fall 1999		
Biomass of Organisms		
Unit: Grams		
Borrow Area 8A	Totals	Totals per Sq. Meter per grab
Taxa	(grams)	
Anthozoa	0.00	0.00
Rhynchocoela	0.00	0.00
Nematoda	0.00	0.00
Platyhelminthes	0.00	0.00
Cnidaria	0.00	0.00
Archiannelids	0.00	0.00
Annelida	0.62	1.24
Mollusca	0.25	0.50
Arthropoda	7.31	14.62
Echinodermata	8.99	17.98
Chordata	0.00	0.00
Other	0.00	0.00

Water Quality:

Table 61: Borrow Area 8A Water Quality

ACOE Benthic Sampling - Fall 99						
Date Sampled: 11/18/99						
Water Quality Results						
Borrow Area 8A						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(C)	mg/l	ppt		meters	mS
11	11.7	7.62	33	8.9		37.65
12	11.6	7.6	33.1	8.9		37.65
13		7.45	33.1	8.9		37.75
14	11.8	7.37	33.1	8.9		37.81
15	11.9	7.63	33	8.9		37.78
16	11.7	7.56	33.1	8.9		37.76
17	11.6	7.56	33.1	8.9		37.54
18	11.6	7.55	32.9	8.8	1.4	37.61
19	11.5	7.47	33.1	8.9		37.54
20	11.4	7.49	33.1	8.9		37.44
Mean	**11.64**	**7.53**	**33.06**	**8.89**	**1.40**	**37.65**

Biodiversity Index: 2.10 (Rank: 6)

A total of 20 benthic samples were collected from Borrow Area 8A on November 18, 1999. The mean water temperature recorded for this sampling period was 11.64 ^{o} C. The mean salinity recorded for this sampling period was 33.06 ppt. The average collection depth in this borrow area was approximately 14 meters. There was a total of 1,333 individuals identified for this borrow area during this sampling period. Table 59 indicates that 66 percent of the organisms identified included the amphipod (*G. annulatus*, 42 percent) and the archiannelid (*P. triestinus*), 24 percent, 14 percent and 12 percent were identified as Nematoda. The remainder of the dominant species were the sand dollar (*E. parma,* 8 percent), and the amphipods (*P. wigleyi* and *A. millsi*), each comprising 4 percent.

Standardizing borrow area 8A for abundance (i.e., number of organisms per square meter) show this borrow area to contain approximately 1124 individuals of the amphipod G. annulatus per square meter, 628 individuals of the archiannelid *P. triestinus* per square meter, 202 sand dollars per square meter, and 110 individuals of the amphipod *P. wigleyi*.

The biomass at this borrow area was dominated by the sand dollar (8.99 grams), followed by the arthropods (14.62 grams).

5.2 Statistical Analyses

The results from the statistical metrics discussed in the Methodology section of this report are as follows:

1) Abundance per Borrow Area

The abundance of each phylum for all borrow areas per meter squared was calculated and appears below in Table 62 A and B.

Table 62A: Abundance per Square Meter per Borrow Area
Spring 1999

Infaunal Abundance by Phylum by Borrow Area per Square Meter - Spring 1999										
	2A	**2B**	**2C**	**3A**	**4**	**5**	**6A**	**7**	**7A**	**8A**
Anthozoa	0	0	1	0	2	0	0	0	0	0
Rhynchocoela	57	85	122	368	76	99	204	118	276	132
Nematoda	119	155	115	598	98	203	36	271	140	396
Platyhelminthes	0	2	0	0	0	0	0	0	0	0
Cnidaria	0	0	0	0	2	0	0	0	0	0
Chaetognatha	0	0	1	0	0	0	0	0	0	0
Archiannelid	2125	1591	2461	3652	1200	636	1176	574	1796	844
Annelida	823	765	1135	3013	2524	667	548	471	364	762
Mollusca	275	205	132	128	594	401	240	133	120	182
Arthropoda	0	0	0	0	0	0	0	0	0	0
Arthropoda	789	1666	1779	2273	1402	2925	924	1390	552	570
Echinodermata	394	1652	1015	242	230	227	580	227	92	452
Chordata	0	0	1	2	8	6	0	0	0	0
Grand Totals	**4582**	**6120**	**6762**	**10277**	**6136**	**5165**	**3708**	**3185**	**3340**	**3338**

Table 62B: Abundance per Square Meter per Borrow Area
Fall 1999

Infaunal Abundance by Phylum by Borrow Area per Square Meter - Fall 1999										
	2A	2B	2C	3A	4	5	6A	7	7A	8A
Anthozoa	2	0	0	1	0	0	0	1	0	0
Rhynchocoela	7	7	26	22	3	4	0	8	0	4
Nematoda	8	4	31	19	0	2	1	4	0	1
Platyhelminthes	0	0	0	1	0	0	0	3	0	0
Cnidaria	0	0	0	0	0	0	0	0	0	0
Chaetognatha	0	0	0	0	0	0	0	0	0	0
Archiannelid	1021	669	3088	3452	67	90	15	291	36	157
Annelida	771	96	464	569	218	195	8	815	17	57
Mollusca	273	98	141	89	46	61	10	155	8	16
Arthropoda	11001	125	283	110	193	487	33	2138	39	383
Echinodermata	54	54	179	28	40	16	9	203	6	51
Chordata	0	0	0	0	0	0	0	1	0	0
Grand Totals	**13137**	**1054**	**4212**	**4289**	**566**	**854**	**75**	**3619**	**106**	**667**

Besides borrow area 7 and 2A, every borrow area had more organisms per square meter in the spring than the fall. This was expected, since conditions in the spring are more conducive than during the fall (temperature and sunlight). This fall sampling effort also occurred in late November into early December, so temperatures were low, as can be observed in the water quality data. Borrow area 2A had more organisms in the fall than the spring due to the extremely high abundance of *G. annulatus* at several of the samples. If not for the high numbers of this organism, the abundance of organisms would have been higher for the spring than the fall, similar to the other borrow areas. Borrow area 7 (the only other borrow area that had higher numbers in the fall than the spring samples) had very similar abundances (3185 in the spring and 3447 in the fall).

2) Mean Number of Individual in Each Taxonomic Group

Some borrow areas appear to have different taxonomic groupings while others did not. This conclusion was partially based on a measure of biological diversity. To obtain a measure of the biological diversity of a borrow area, the mean number of individuals observed in each taxonomic group is compared. After this analysis, the taxonomic group means at a particular borrow area are

compared to other borrow areas. A weakness of this approach is that the measure is dominated by the most numerous species in each taxonomic group.

The statistical measure of biodiversity indicated that borrow areas 3A and 4 appear to be different from the others. Borrow areas 3A and 4 each had four taxonomic groups that were statistically different. Borrow area 2B had two statistically different taxonomic groups, while borrow area 5 had only one. Therefore, borrow areas 2B and 5 are probably not different from the other borrow areas. Borrow areas 2A, 2C, 6A, 7, 7A and 8A appear remarkably similar based on this analysis.

Table 63: Borrow Area Statistics for Most Common Species

ACOE Benthic Sampling - Spring 1999					
Borrow Area Statistics for the Most Common Species					
Rank	Species	Mean	Standard Deviation	Borrow Area	Probability
1	Polygordius triestinus	40.18	23.73	3A	0.05
2	Echinarachnius parma	13.87	12.74	2B	0.05
3	Protohaustorius wigleyi	9.87	14.6	5	0.01
4	Spiophanes bombyx	6.68	11.71	4	0.01
5	Nematoda	5.34	4.22	3A	0.05
6	Pseudunciola obliqua	4.45	6.67	2C	0.01
7	Gammarus annulatus	3.94	8.75	3A	0.01
8	Nemertean	3.85	2.48	3A	0.05
9	Tellina agilis	3.39	2.51	4	0.01
10	Pseudunciola	3.2	3.59	4	0.05
11	Acanthohaustorius millsi	2.69	2.23	5	0.05
12	Oligochaeta	2.52	4.53	3A	0.01
13	Leptognatha caeca	2.3	2.15	3A	0.01
14	Syllidae	1.89	0.97	8A	0.05
15	Tanaidacea	1.64	1.83	2C	0.05

3) Shannon and Weaver Biological Diversity Index (H)

The Shannon-Weaver Index (H) for biological diversity was calculated for each borrow area. This index is widely used and based on information theory. A higher value of H indicates a greater diversity. After calculating H, the borrow areas were ranked accordingly (see table below).

Table 64A: Biological Diversity Index (H) Values

Spring 1999:

Borrow Area	H Value
7	3.05
8A	2.78
3A	2.72
4	2.71
2B	2.63
5	2.60
6A	2.53
2C	2.53
2A	2.43
7A	2.03

Table 64B: Biological Diversity Index (H) Values

Fall 1999:

Borrow Area	H Value
4	3.11
7	3.02
6A	2.79
5	2.70
7A	2.62
8A	2.10
2B	2.01
2C	1.49
3A	1.08
2A	0.94

Comparison between Spring and Fall 1999 Shannon-Weaver Indices:

The resulting Shannon-Weaver Index for the Fall, 1999 data ranged from 0.94 to 3.11. The Spring data has a much narrower range of 2.43 to 3.05. Distribution of the S-W Indices are as follows:

SHANNON-WEAVER	Spring, 1999	Fall, 1999
mean	2.60	2.18
<1	0	1
1.0-1.5	0	2
1.5-2.0	0	0
2.0-2.5	2	2
2.5-3.0	7	3
>3	1	2

Despite this apparently different distribution, parametric statistics found no significant difference in mean Shannon-Weaver values, when using the standard of 95% confidence. However, a 2 sample t test that the mean SW Index for the Spring sampling is greater than that for the fall (1-tailed test) shows a 93.6% confidence (p=0.064). A 2-tailed test that the mean S-W Index is different has a confidence of 87% (p=0.129). Parametric statistics was used only on the Shannon-Weaver Index which was tested and found to be normally distributed, not on the general data. Also, no significant difference in means was found using Mann-Whitney, a nonparametric test.

For the borrow areas, only two ranked in the top five in both Spring and Fall, being the most diverse. These are Borrow Areas 7 and 4. Borrow Area 2A ranked 9th in the Spring and 10th in the Fall, being the least diverse. Notably, this area had the largest number of individuals in the Fall sampling.

4) Jaccard's Index

For the ten borrow areas, 45 Jaccard's Indices were computed and arranged in a matrix as Table 35. The indices are deliberately repeated in the table, reflected across the diagonal, for easier comparison of the borrow areas. A Jaccard's Index of zero would mean the borrow areas are completely dissimilar, having no species in common. An index of one would mean the borrow areas are exactly alike, having all the same species.

Table 65A: Jaccard's Index Summary for All Borrow Areas
Spring 1999

The computed indices range from 0.312 to 0.535, with a mean of 0.439 and a standard deviation of 0.0620. The lowest index of 0.312, comparing borrow areas 2A and 7B, is more than two standard deviations below the mean. Borrow areas 2A and 7B, therefore, are the least similar of all the pairs. There are 10 pairs with an index from one to two standard deviations below the mean, 9 with an index within one standard deviation below the mean, 19 with an index within one standard deviation above the mean, and six with an index more than one standard deviation above the mean. The highest index of 0.535 is shared by two pairs of borrow areas: 2A and 4, and 2C and 3A. These two pairs are most alike, having a higher proportion of species in common than the other borrow areas.

Distinctive Borrow Areas:

The mean Jaccard's Index for each borrow area indicates the overall similarity of that borrow area to the others. Three borrow area stand out: borrow area 3A with the highest average index, 0.484, borrow area 7B with the lowest average index, 0.358, and borrow area 6A, with the second lowest average index, 0.393. The other borrow areas have approximately the same average index, ranging from 0.443 to 0.458. This suggests that borrow area 3A has the highest proportion of species in common with other borrow areas, borrow are 7B has the lowest proportion of species in common with other borrow areas, and borrow area 6A the second lowest proportion. The other borrow areas have about the same proportion of species in common. Note that borrow area 3A has four of the six indices in the highest category, and borrow area 7B has eight of the 11 indices in the lowest category.

Table 65B: Jaccard's Index Summary for All Borrow Areas
Fall 1999

	JACCARD'S SUMMARY TABLE - Fall, 1999 Benthos Data									
	2A	2B	2C	3A	4	5	6A	7	7B	8A
2A	X	0.348	0.518	0.470	0.422	0.462	0.313	0.533	0.314	0.400
2B	0.348	X	0.376	0.366	0.348	0.391	0.269	0.404	0.288	0.381
2C	0.518	0.376	X	0.495	0.444	0.443	0.341	0.483	0.371	0.436
3A	0.470	0.366	0.495	X	0.392	0.418	0.345	0.541	0.407	0.411
4	0.422	0.348	0.444	0.392	X	0.563	0.304	0.467	0.305	0.395
5	0.462	0.391	0.443	0.418	0.563	X	0.370	0.495	0.368	0.463
6A	0.313	0.269	0.341	0.345	0.304	0.370	X	0.347	0.367	0.397
7	0.533	0.404	0.483	0.541	0.467	0.495	0.347	X	0.432	0.520
7B	0.314	0.288	0.371	0.407	0.305	0.368	0.367	0.432	X	0.500
8A	0.400	0.381	0.436	0.411	0.395	0.463	0.397	0.520	0.500	X

mean	0.420	0.352	0.434	0.427	0.404	0.441	0.339	0.469	0.372	0.434	
sd	0.0828	0.0459	0.0606	0.0630	0.0824	0.0632	0.0387	0.0646	0.0673	0.0500	
rank	6	8	3.5	5	7	2	10	1	8	3.5	

Comparison between Spring and Fall 1999 Jaccard's Indices:

The overall mean value of the Jaccard's Index for the fall 1999 data was 0.409 compared to the Spring 1999 data with 0.439. The Jaccard's Indices were grouped by their distance from the mean value for each data set, and the results are summarized below:

	Spring 1999	Fall 1999
Mean Jaccard's Index	0.439	0.409
Number of pairs from 2 to 1 s below the mean	11	17
Number of pairs from 1 to 0 s below the mean	9	8
Number of pairs from 0 to 1 s below the mean	19	11
Number of pairs above 1 s above the mean	6	9

The Fall 1999 samples appear to have more pairs with weaker associations, with 25 of the 45 Jaccard's Indices below the mean, compared to the Spring 1999 samples which had 20 of 45 Jaccard's Indices below the mean.

6.0 DISCUSSION

6.1 Previous Investigations

The benthic environment found south of Long Island, New York between Fire Island Inlet and Shinnecock has been extensively sampled from 1996 to 1999. Sampling was completed by RMC Environmental Services (1996), Vittor Associates (1997 and 1998), Cerrato (1983) and EEA (identified in this report). Two of the most heavily-sampled areas include the Shinnecock borrow area and the Fire Island borrow area (referenced in this report as borrow areas 2A, 2B, and 2C). EEA's present 1999 study (the subject of this investigation) includes the analysis of all the borrow areas east of the Fire Island Inlet. These borrow areas have been redesigned from earlier studies to incorporate only habitat with sediment which is adequate for beach replenishment.

Non-site specific sampling occurred off the Rockaways, Long Island, by Vittor Associates, Inc. (1999) and in adjacent areas off New Jersey by the ACOE in 1995 through 1999. In all cases, the sampling was conducted in association with previously identified borrow areas that were currently in use. In all cases, the number of species found was highly variable, ranging from 54 taxa

(RMC Environmental Services) to 198 taxa from Cerrato (1983). The key variable appears to be a spring/fall variation in species throughout all the collection periods. In most cases, the dominant species remains similar. The dominant species are generally variable only by season and station.

Summary of Studies Conducted by Cerrato (1983)

The study conducted by Cerrato (1983) indicated that the samples were dominated by the following species during the spring, summer, and fall sampling period: *S. bombyx, T. agilis, P. wigleyi,* Nematoda spp., *Asabellides oculata, S. solidissima, Magelona* riojai, and *G. annulatus.* Only *S. bombyx* and *T. agilis* were dominant species during the spring, summer and fall sampling periods. The additional species, *P. wigleyi,* Nematoda, and *A. oculata* were dominant during two out of the three sampling periods. *S. solidissima, M. riojai,* and *G. annulatus* were dominant during one of the three sampling periods.

Summary of Studies Conducted by RMC Environmental Services (1996)

RMC Environmental Services sampled the Fire Island/Shinnecock area during July of 1996. The dominant species of the 54 collected were: *Tharyx acutus, T. agilis, Magelona papillicornis,* Nemertean spp., Nematoda spp., and *P. wigleyi*. The Fire Island borrow area was primarily dominated by Annelida, Nemertean, and Nematoda. The Shinnecock Station was dominated by the following species: *P. wigleyi, Psammonyx nobilis, T. agilis, G. annulatus*, and *A. millsi* (these accounted for 60.7 percent of the organisms found at the Shinnecock borrow area).

Most species were present in both stations in varying abundances with the exception of the annelid, *T. acutus*, at the Fire Island station and the arthropod, *P. nobilis,* at the Shinnecock station. The only potential explanation for the absence of each species is that *Tharyx acutus* is found from Maine to the New York Bight while *P. nobilis* is slightly more northern (reported to occur only as far south as Long Island Sound). In both cases, they are classified as common species.

Summary of Studies Conducted by B.A. Vittor Associates at Fire Island and Shinnecock (1997-1998)

Sampling at the two borrow areas offshore of Fire Island and Shinnecock were continued during 1997 and 1998 by B.A. Vittor & Associates in June/November 1997 and June/October 1998. Exact sampling station locations were not available at the time of this report.

In June 1997, the dominant species at the Fire Island borrow area were *T. acutus* and *A. oculata* and individuals belonging to the families Irratulidae and Maldanidae. The annelid species *A. oculata* and *Polygordius* sp., as well as the arthropod *G. annulatus,* were the most abundant during November of 1997. This changed completely during the spring and fall of 1998. The samples collected in June of 1998 were dominated by the annelid species *Barnia wellfleetensis* along with

members of the genus *Polygordius* sp., the class (Oligochaeta and the phylum Rhynchocoela). The October 1998 sampling again varied from the 1997 samples, as the Mollusca species (*S. solidissima* and *T. agilis*) were identified as abundant (which was not observed in the October 1997 study).

The Shinnecock samples were also variable between sampling periods. During June of 1997, the borrow area was dominated by *P. nobilis* and *Protohaustorious* sp., species from the family ampharetidae, as well as the annelid species *S. bombyx*. The dominant species composition changed in November 1997, where the most dominants included *S. solidissima*, *E. parma*, *Polygordius* sp., and *Tanaissus psammophilus*. Again, the samples collected in June 1998 varied from the previous year. The members of the class Oligochatea and the phylum Rhynchocoela and the species *Scoleoepis squamata* were dominant. This varied again in the fall when the annelida species (*Polygordius* sp.) again was observed to be dominant. However, *P. wigleyi* and *Protohaustorius* sp. were additionally observed to be abundant.

Summary of Studies Conducted by B. A. Vittor Associates at Coney Island, New York (1992-1998)

Additional benthic studies have been conducted west of the study area from Coney Island, New York south to various central New Jersey locations. The borrow area off Coney Island was sampled in 1992 during the pre-dredging period through 1998 in order to determine impacts on benthic communities. The results of this study indicate that although the area is typically comprised of sand, (ranging from an average of 93 percent in 1992 to 89 percent in 1998) the benthic community structure is different from those observed in samples collected by EEA (1999) further east on Long Island. The dominant benthic species were identified as organisms that are characterized as recovery species that typically dominate the abundance after a disturbance occurs. These would include *Mediomastus ambiseta, Ampelisca abdita, Streblospio benedicti* and organisms from the class Oligochaeta. The abundance of these species types in addition to limited species diversity in association with the reduced species abundance (i.e., 2 to 4 species dominance) would clearly indicate that the sediments, although sandy, were influenced by water quality conditions from the New York Harbor. Interestingly, given the low periodic diversity, two clam species, the surf clam (*S. solidissima*) and the Dwarf *(Tellina agilis)* were also abundant.

Summary of Studies Conducted by ACOE at New Jersey (1994-1999)

The benthic community structure sampled during the 1994 - 1999 study conducted by the ACOE off the New Jersey shoreline between Asbury Park and Manasquan is also comparable to that encountered along the south shore of Long Island. The most abundant species identified include: *Polygordius* sp., the arthropods (*P. obliqua* and *Tanaissus psammolphilus*), and the annelids (*S. bombyx* and *Magelona papilicornis*). The biomass of species was also similar to EEA's study. The sand dollar (*E. parma*) comprised the majority of the biomass followed by clams, worms, and other bivalves.

6.2 Comparison of Previous Investigations to EEA's 1999 Study

Assessments of the Study Area Comparisons

The results are comparable in the study conducted by EEA in the Spring and Fall of 1999 to most of the studies that were conducted in the waters off of eastern Long Island and off of New Jersey for species composition, abundance, and diversity. However, the study conducted in the waters off of Coney Island, New York reveal benthic species composition, abundance and diversity which is different than EEA's study. The benthic species that were noted during the Coney Island study include pioneer species; these spp. indicate a disturbed system.

Discussion of Studies Conducted by EEA (1999)

In general, a review of the study results from the 1999 borrow areas show similar numerical abundance by species to other studies conducted in this area. One notable difference in project findings of EEA's study compared to other studies conducted in this area was the presence of species such as *P. triestinus*, Nematoda, and nemertean worms. This was most likely due to the fact that these are microbenthic species which were not counted in studies conducted by Cerrato (1983) or RMC Environmental (1996). The present (EEA) program utilized a 0.5 mm sieve, where most of the earlier programs used a 1.0 mm sieve; this largely accounts for the differences in species occurrence and abundance. Though these species are abundant, they have limited biomass. This makes the comparison of past and present studies more difficult.

The sand dollar (*E. parma*) was one of the most abundant species observed in EEA's study. This organism also had the greatest weight in biomass (per sample, due to the weight of the heavy calcarious shells of the organisms.

Mollusks had the second largest biomass per sample. This group contained a relatively low number of individual species, including clams (*T. agilis* and *S. solidissima*) and the New England dog whelk (*Nassarius trivittatus*). The primary reason that these organisms weighed more relative to the other groups of benthic organisms is the presence of heavy shells.

Arthropods had the third largest biomass per sample. The biomass was largely comprised of the species *P. wigleyi*, *P. obliqua*, *G. annulatus*, and *A. millsi*. In the Fall 1999 samples, Borrow Area 2A consisted of a relatively large number of *G. annulatus,* which contributed to the increased biomass..

Although the annelids were numerically abundant, their biomass was relatively low. The major contributors to the biomass of the annelid group were organisms such as *A. catherinae*, *C. torquata*, *Nephtys bucera*, *T. acutus* and *A. oculata*. While these are somewhat less abundant than other annelid, the comparative size can be much larger, thus increasing their biomass significantly.

This can be observed in species like *C. torquata* which have been reported to grow to a length of 150 mm (6 inches).

Comparison with Depth:

A comparative analysis was conducted between the most abundant species identified in this study, and correlating depth data. Borrow areas were separated as shallow and deep by taking the midpoint of the average depths. Those with a depth less than or equal to 16 meters were considered shallow. Borrow areas with a depth greater than 16 meters were classified as deep. Lower abundances appear to occur at shallower borrow areas, including borrow areas 6A, 7, 7A, and 8A with approximately 3,000 organisms per square meter. Of these borrow areas, 6A, 7 and 8A have an average depth of approximately 15 meters. The highest abundance was found at borrow area 3A (~10,000 organisms per square meter) with a mean depth of 18 meters. At both shallow and deep borrow areas, arthropods, archiannelids, and annelids dominated the community composition. More annelids were noted in the deeper borrow areas.

Comparison with Water Quality:

At every other sample for each borrow area, temperature, dissolved oxygen, salinity, visibility (transparency), and pH of the bottom water were measured. There were no noticeable differences between any of the borrow areas for all the parameters measured. Data points are consistent with those expected for the region. Since there were no noticeable differences in water quality among the borrow areas, no comparison between species composition and water quality could be determined.

Occurrence of Surf Clam (*S. solidissima*) - Spring 1999

The surf clam (*S. solidissima*), although present at all borrow locations, was found in fairly low densities. The greatest concentrations were observed at borrow areas 2A and 4. This indicates that the surf clam was relatively more abundant in the western-most borrow area. No adult surf clams were observed in any of the samples. This, however, may be due to the particular gear used for this project. The gear that is typically used by commercial fishermen to catch adult surf clams was not employed for this project, as it was not part of the scope of the project. Further studies determining the presence of adult surf clams in these waters will be conducted in future projects.

Table 67A: Occurrence of *Spisula solidissima*
Spring 1999

Occurrence of *Spisula solidissima*	
Borrow Area	Abundance per Square Meter
2A	85
2B	38
2C	32
3A	37
4	142
5	3
6A	16
7	24
7A	16
8A	22

In the fall of 1999, the borrow areas that contained the highest number of S. solidissima included 2A and 2B. Borrow area 2A contained high numbers of the surf clam during both sampling efforts.

Table 67B: Occurrence of *Spisula solidissima*
Fall 1999

Occurrence of *Spisula solidissima*	
Borrow Area	Abundance per Square Meter
2A	119
2B	299
2C	63
3A	35
4	40
5	30
6A	12
7	14
7A	24
8A	4

The sampling effort conducted in the fall of 1999 consisted of higher numbers (640) of surf clams compared to the sampling effort conducted in the spring of 1999 (415).

7.0 CONCLUSIONS

The results of both the July/August and November/December 1999 benthic sampling and analyses program are reasonably consistent with earlier programs given the inherent variability of biological organisms over time and distance. The south shore benthic communities are more comparable to those of New Jersey than to those found off the Rockaways. This is to be expected, given the close proximity of the Rockaways to the degraded water quality of the New York Harbor, which limits the growth of healthy benthic communities. Considering the results of the above program, the following conclusions were drawn and supported by statistical analysis:

- Numerical abundance of infauna was generally consistent between borrow areas and between seasons (fall and spring). The borrow areas to the east generally had lower numerical abundances than the borrow areas to the west (for both sampling efforts).

- Biodiversity indices were similar between borrow areas and between seasons. Borrow area 7 had one of the highest biodiversity indices for both sampling efforts, and borrow area 2A had one of the lowest. The biodiversity indices were comparatively lower for the fall sampling effort than the spring.
- Biomass values were generally similar with most of the biomass attributable to sand dollars.
- Water quality was similar among the borrow areas; no comparison between species composition and water quality could be determined.
- Deeper borrow areas generally had higher abundances of organisms.
- The results of this program were comparable to those programs conducted offshore of New Jersey, but were noticeably different than those conducted offshore of Coney Island.
- The results of this program were comparable to those programs conducted by RMC Environmental and Cerrato, but were noticeably different than those conducted by Vittor & Associates.
- The samples collected in the fall of 1999