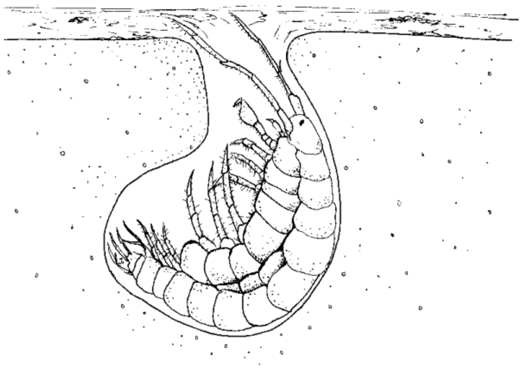
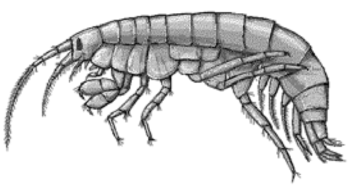
U. S. Army Corps of Engineers
New York District

Benthic Invertebrate Survey:

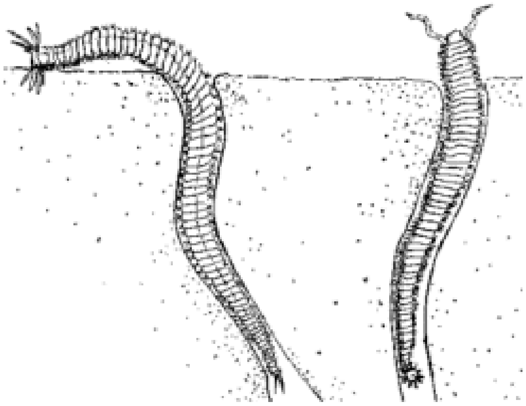
East of Shinnecock Inlet to
East of Fire Island Inlet



Amphipod



Gammarus Oceanicus



Polychaetes

U.S. Army Corps of Engineers
Planning Division

-DRAFT-

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Sources for Cover Illustrations:

Amphipod: State of Maryland Department of Natural Resources Chesapeake Bay Homepage: http://www.dnr.state.md.us/bay/cblife/benthos/common_burrower_amphipod.html

Gammarus Oceanicus: Institute of Oceanology, Polish Academy of Sciences. http://www.iopan.gda.pl/projects/puckbay/html/embs_6/612_gammarus.html

Polychaetes: State of Maryland Department of Natural Resources Chesapeake Bay Homepage: http://www.dnr.state.md.us/bay/cblife/benthos/polychaetes.html

EXECUTIVE SUMMARY

The Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point (FIMP), New York, Storm Damage Reduction Reformulation Study seeks to evaluate long-term solutions for storm damage reduction along the south shore of Suffolk County, Long Island, NY. As part of this major Reformulation Study, a multitude of studies is being conducted in order to understand ecosystem function in the study area.

Included in this effort, several benthic macroinvertebrate assessments were conducted in 1996, 1997, 1998, 1999, 2000 and 2001. For the present study, one hundred thirty macroinvertebrate samples were collected from six proposed borrow areas and inter-borrow areas from east of the Fire Island Inlet to just east of the Shinnecock Inlet area in June and November of 2000 and June of 2001.

Data analysis included measures of abundance and composition, the Shannon-Weaver Biological Diversity Index (H') and Jaccard's Index. Results of the analyses indicated that most of the potential borrow areas exhibited a high degree of uniformity in the benthic assemblages encountered for species composition and numerical abundances. However, a few potential borrow areas showed differences from the other borrow areas when comparing taxonomic group assemblages and species abundances.

Deeper borrow areas and borrow areas to the west generally had higher numbers of organisms than borrow areas to the east. Taxonomic representation among borrow areas was similar however, Borrow Area 7 had one of the highest diversity indices while Borrow Area 2A had one of the lowest. The samples collected in the Fall of 2000 consisted of fewer organisms than the samples collected in the Spring 2001 sampling effort. Diversity indices were comparatively lower in the Fall than in the Spring.

In general, the results of this assessment are comparable to those of previous studies in habitats off Long Island and New Jersey. The benthic communities of Long Island's south shore represented in the present study were more similar to those of New Jersey than those of the Rockaways. This is probably due to the proximity of the Rockaways to New York Harbor and similar habitat conditions.

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LIST OF ACRONYMS

EIS	**Environmental Impact Statement**
GPS	**Global Positioning System**
H’	**Shannon Weaver Biological Diversity Index**
IB	**Inter-Borrow**
LPIL	**Lowest Practical Identification Level**
USACE	**United States Army Corps of Engineers**
USACE-NYD	**United States Army Corps of Engineers, New York District**
WOSI	**West of Shinnecock Inlet**

1.0 INTRODUCTION

This report is one of a series of natural resource, physical science, and engineering studies being conducted by the U.S. Army Corps of Engineers, New York District (USACE-NYD) as part of the FIMP Reformulation Study. The overall objectives of the study are:

- Characterization of the benthic macrofauna in and around six potential sand borrow areas and 30 inter-borrow areas;
- Comparison of the areas based on macroinvertebrate 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, Long Island, New York. Six potential borrow areas that are being considered as a source for sand to replenish study area beaches extend from just east of the Fire Island Inlet to just east of the Shinnecock Inlet area. One hundred macrobenthic samples were collected and analyzed from the potential borrow areas, and an additional 30 samples (total of 130 samples) from locations spread out between the borrow areas during November 2000 and June 2001.

This report presents the methodology and findings of this study, as well as a comparison with the findings of previously conducted USACE studies off Fire Island, Shinnecock, Coney Island, and the New Jersey barrier islands. Two previous benthic surveys were conducted in ten borrow areas off of Long Island during July and November 1999. A total of 240 samples were collected during July 1999 and 270 samples were collected in November 1999.

Qualitative and quantitative benthic macroinvertebrate analyses are commonly used to characterize aquatic habitats. The most common metrics for assessment of benthic communities are analyses of species composition, numerical abundance and biomass. This report incorporates all three metrics along with community diversity and similarity into the description of the benthic community. Since benthic community composition is largely dictated by non-biological physicochemical environmental features, such as sediment grain size, grain size analysis was conducted to facilitate benthic data interpretation and to assess substrate suitability for beach nourishment. In situ water quality data were also collected to characterize the aquatic habitat and facilitate benthic data interpretation for the potential borrow areas.

Benthic macroinvertebrates of the offshore borrow areas represent forage for commercially and ecologically important finfish species. Mining of the borrow areas for sand to be used as beach fill could have deleterious effects on the species composition, abundance, and standing crop of these communities. This study, therefore, will be used to predict potential impacts as part of the Environmental Impact Statement (EIS) that will be prepared for the overall

Reformulation Project.

2.0 STUDY AREA

The FIMP study area is located entirely within Suffolk County, along the Atlantic and bay shore towns of Babylon, Islip, Brookhaven, Southampton and East Hampton (Figure 1). The study area extends 83 miles from Fire Island Inlet to Montauk Point. This study area includes three major bay systems. Great South Bay is connected to the Atlantic Ocean through the Fire Island Inlet, which is a federal navigation channel. Moriches and Shinnecock Bays are connected to the Atlantic Ocean through the Moriches and Shinnecock Inlets, respectively, and are also 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.

The project area for the present field study (described in this report) is a subsection of the overall FIMP study area, and extends from east of Fire Island Inlet to east of Shinnecock Inlet. The present field study area includes six potential offshore borrow areas, and 30 reference locations spaced evenly between the borrow areas identified as inter-borrow area stations (Figures 1-6). The borrow areas were selected based on earlier geophysical studies. All borrow areas have different sizes and shapes. Borrow areas were usually located from one to three miles offshore and in surface water depths ranging 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.

3.0 METHODOLOGY

3.1 Station Locations

A total of 100 stations were distributed throughout the 6 potential borrow areas and 30 stations were distributed in between the borrow areas per sampling effort. The number of stations sampled per borrow area was generally proportional to the size of the borrow area, with five stations being the minimum. Larger borrow areas were sampled more frequently than smaller borrow areas to insure adequate coverage. The present survey included sampling of all the stations in the Shinnecock Borrow Area (Figure 6), and a subset of the stations previously sampled (July and November 1999) in Borrow Area 2 (Figure 2), Borrow Area 4 (Figure 4), and Borrow Area 5 (Figure 5). An additional 30 stations were evenly distributed between 6 of the original 8 borrow areas (Figures 1-5). The coordinates of the borrow areas were obtained from the USACE-NYD and loaded into the differential GPS navigation system of the survey vessel (*RV Kingfisher*). 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 (per sampling period)
2A	Nov. 20, 2000 and June 4, 2001	5
2B	Nov. 20, 2000 and June 4, 2001	10
2C	Nov. 20, 2000 and June 4, 2001	20
4 (A&B)	Nov. 14 & 16, 2000 and June 6, 2001	15
5 (A&B)	Nov. 13, 2000 and June 6, 2001	20
WOSI	Nov. 9 & 16, 2000 and June 5, 2001	30
IB	Nov. 13, 16 & 20, 2000 and June 1 & 4, 2001	30

3.2 Sample Collection

Samples were collected during November 2000 and June 2001. Sampling stations were located using the survey vessel's Garmin 185 Global Positioning System (GPS) unit navigation system. Once on station, latitude and longitude coordinates were recorded. The coordinates of each sampling station are presented in Appendix I. In situ water quality was measured using a hand-held Yellow Springs Instrument (YSI) R85-10 instrument and Oakton pH meter. The following water quality parameters were measured at the bottom of the water column: temperature, salinity, conductivity, dissolved oxygen, pH. Bottom water samples were collected with a Niskin bottle. Surface light transmission was measured using a Secchi Disk. All pertinent station data were recorded on field sheets.

Samples for benthic community and grain size analysis were collected using a 0.025 m^2 modified Young grab sampler. The sampler was lowered onto the substrate and the grab activated to close upon hitting the sediment. The sampler was retrieved by winch. Once on board, the sampler was checked to determine if the grab was full. If the sample was rejected, i.e. the grab was not full, the sampler was re-deployed. If the sampler was effective in retrieving a suitable sediment sample, the contents were carefully emptied into a bucket and poured into a 0.5 mm mesh sieve, rinsing with surface water to remove fine particles. Contents remaining in the sieve were then transferred to a jar, labeled, and preserved with a buffered 10% formalin solution. Rose bengal stain was added to the formalin to aid in later sorting of the organisms. Samples were transported to the laboratory under proper chain of custody for subsequent analysis.

3.3 Laboratory Sample Analysis

In the laboratory, all grab samples were rinsed gently with tap water through a 0.5 mm mesh sieve to remove preservatives and sediment, stained with Rose Bengal, and stored in 70%

isopropanol solution until processing. Sediment samples were processed under a stereoscope separating sediment from biota. Organisms were carefully removed from the remainder of the sample 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 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.

Once taxonomic identification was complete and data recorded on laboratory bench sheets, all organisms were separated into one of five groups (e.g.; Echinodermata, Mollusca, Polychaeta, Arthropoda and Other) for biomass analyses. 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 tarred weighing pan and weighed to the nearest 0.01 g. Separate weights were recorded for each of the five major groups of organisms. All laboratory benchsheet data were transferred to EXCEL format spreadsheets by borrow area for subsequent analyses.

The sample that had been retained for sediment grain size distribution was analyzed using ASTM Method D422.

3.4 Data Analysis

Numerical data were transposed to abundance (density) data by calculating the number of organisms per square meter. Abundance was calculated by dividing the total number of individuals in each taxon 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 0.025 m^2). This analysis provides useful information in comparing borrow areas to each other in terms of actual abundance.

For each station in each potential borrow area taxa diversity, composition, and abundance were calculated. Borrow areas were compared to analyze similarities and differences between the observed data. Water quality, sample depth and spatial differences were also analyzed to identify potential relationships between these variables and the similarities or differences in the benthic data among the stations.

The total number of taxa, organisms, and species occurrences were calculated for each of the borrow areas as a basis for comparison of the potential borrow areas. In addition, the metrics of Abundance Per Borrow Area, Shannon-Weaver biological diversity index (H’), and Jaccard’s Index were calculated for each borrow area as described below.

1. Abundance Per Borrow Area- the total number of organisms per square meter for each borrow area. Abundance was calculated as the total number of organisms divided by $0.025m^2$ (the area of the Young grab). In keeping with other USACE reports, abundance was used to refer to the number of animals per meter square. However, abundance is also referred to as density in other benthic investigations. The abundance of organisms was frequently displayed as a percent composition. Percent composition was based on total abundance and calculated by dividing the number of organisms for each taxonomic group by the total number of organisms for all taxa.

2. Shannon -Weaver Biological Diversity Index (H')

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

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

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

3. Jaccard's Index was used to compare the taxonomic similarities between borrow areas. Jaccard's Index was computed for each pair of borrow areas. This index is the proportion of the number of taxa 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 were 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.

Each of the metrics used in the analysis evaluates the data in a different way. The abundance per borrow area analysis is a simple measurement of the overall density of organisms in a certain area that serve as prey for other biota, such as fish. The Shannon-Weaver Biological Diversity Index measures community diversity for a particular species population. The likelihood that an individual selected at random will be of a particular species or taxon can be predicted by the Shannon-Weaver Index. This information is useful in identifying the areas that contain the highest and lowest community diversity and distinguishes communities that are more stable than others. The Jaccard's Index measures similarities between borrow areas giving an indication of how uniform, in taxonomic terms, the entire study area is overall and, in particular, which sampling areas have comparable biological resources.

Data tables are provided for each borrow/inter-borrow area. The tables provide summary information on species abundance (density), biomass, water quality and diversity. The format of the tables will be the same for each borrow and inter-borrow area analyzed in the report. The abundance tables show the total number of organisms collected at each borrow/inter-borrow area (all stations within the borrow/inter-borrow area combined), the percent composition (calculated as a fraction of the total) each taxonomic group represents for the borrow/inter-borrow area, and the abundance of each taxonomic group (all stations within borrow/inter-borrow area combined) calculated as the total number of organisms per grab (m^2). The biomass tables show the weight of the five major taxa analyzed for the study. The biomass is represented in the table as the total weight of each taxonomic group (all stations within the borrow/inter-borrow area combined) and the total weight per grab (m^2). The water quality table shows the individual station values for temperature, dissolved oxygen, salinity, pH, visibility (light transmission) and conductivity. In addition, mean values for water quality parameters were calculated for each borrow/inter-borrow area by combining all station values and dividing by the total number of stations.

4.0 FALL 2000 RESULTS

In this section, overall results for the study area will be discussed followed by results for each borrow area within the study area for each sampling season.

Community Structure, Numerical Abundance and Biomass Data

A total of 8,177 organisms representing 77 invertebrate taxa were recovered from the entire study area in Fall, 2000. The archiannelid worm family Polygordiidae was the most abundant (16 %) of all the organisms throughout the entire study area (Appendix III). The only species of Polygordiidae identified from the samples was *Polygordius triestinus*, therefore individuals identified as Polygordiidae were *probably P. triestinus.* Dominant taxa found in the borrow areas were: archiannelid, Annelida, Mollusca, Arthropoda and Echinodermata.

Arthropods, annelids, and archiannelids numerically dominated the samples. The family Polygordiidae (*P. triestinus*) and the amphipod *Protohaustorius wigleyi* were consistently the most abundant organisms at each borrow area. A relatively even distribution was evident for the dominant organisms. The species distribution includes amphipods, *P. wigleyi* and *Gammarus oceanicus* (15 % and 14.5 % respectively); the tanaid *Leptochelia savignyi* (6.4 %); sand dollar *Echinarachnius parma* (5.7 %); and the polychaete worm *Magelona rosea* (5.7 %). The percent composition of each taxonomic group, based on numerical abundance, is presented in Figure 7. Arthrophods, archiannelids and annelids were dominant in both the Spring and Fall collections. Nematodes were also dominant during the Spring, but not in the Fall. The abundance of organisms was fairly uniform across the borrow areas with average numerical abundances ranging from 50 to 75 organisms per grab per borrow area. While the commercially important surf clam, *Spisula solidissima,* was present at six of the 30 inter-borrow area stations and at several stations in four of the six proposed borrow locations, it only accounted for a small percent of all organisms identified.

Benthic biomass at the borrow areas ranged from 47 to 174 g/m^2. Echinodermata dominated the biomass at all borrow areas with the exception of Borrow Area 5, which had a greater biomass of Arthropoda, and the inter-borrow areas, which had a greater biomass of Mollusca. A graphic presentation of total biomass is shown in Figure 8. Borrow areas 4 and 5 had the lowest biomass (63 g/m^2 each). Borrow area 2B and 2C had the highest biomass (174 g/m^2 and 162 g/m^2, respectively). Borrow area biomass values were variable, with no apparent relationship to either space or water depth.

Data tables for each borrow area are provided below summarizing species abundance (density), biomass, water quality and diversity. Refer to the methodology section for information on the calculation of values in the following tables. Three tables are shown for each borrow/inter-borrow area. The abundance table lists the taxa collected from the borrow/inter-borrow area, the total number of each taxon, percent composition each taxon represents of the total, and the abundance of each taxon for that area (all stations within the borrow area combined). The biomass table shows values of biomass as total weight and total weight per grab for the five major taxa represented in the study. The water quality table shows values for each water quality parameter measured at each station within each borrow/inter-borrow area, as well as mean values for the entire area.

Table 2: Borrow Area 2A Species Abundance, Fall 2000

Date Sampled: 11/20/00			
Number of Samples: 5			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Gammarus oceanicus	56	0.28	448
Protohaustorius wigleyi	45	0.22	360
Magelona rosea	23	0.11	184
Polygordiidae	19	0.10	152
Gemma gemma	16	0.08	128
Echinarachnius parma	16	0.08	128
Echinodermata	16	0.08	128
Nephtys bucera	11	0.05	88
TOTALS	**202**		**N/A**

Table 3: Borrow Area 2A Biomass, Fall 2000

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	2.03	16.24
Mollusca	2.07	16.56
Arthropoda	1.33	10.64
Echinodermata	4.37	34.96
Other	0.11	0.88
TOTAL BIOMASS	**9.91**	**79.28**

<u>Table 4: Borrow Area 2A Water Quality, Fall 2000</u>

Date Sampled: 11/20/00						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
5	9.7	8.61	31.0	8.6	3.0	33.98
20	9.9	8.10	30.8	8.6	3.0	33.90
25	9.8	8.54	31.0	8.6	4.0	33.96
Mean	**9.8**	**8.42**	**30.9**	**-**	**3.33**	**33.95**

The Shannon-Weaver Diversity Index for Borrow Area 2A is 2.56. Based on the diversity index, Borrow Area 2A ranks fourth in comparison with the other borrow/inter-borrow areas sampled.

Water quality data summarized above is shown in Figure 9. Due to instrument malfunction, no water quality data was obtained from stations 10 and 15. The average collection depth in this borrow area was approximately 13 meters. A total of 250 individuals representing 28 taxa were identified for Borrow Area 2A during the Fall. Table 2 shows the dominant organisms present during this sampling period. The arthropods, *G. oceanicus* and *P. wigleyi*, were the most abundant comprising 28 % and 22 % of the organisms identified, respectively. Additional dominant species included the polychaete worm *M. rosea* (11%), and the archiannelid Family Polygordiidae (10%). Additional common species included the clam, *Gemma gemma*, and the sand dollar, *E. parma*.

Arthropods, specifically *G. oceanicus* (444 indiv/m^2) and *P. wigleyi* (360 indiv/m^2) were present in the highest densities. The polychaete worm, *M. rosea* (184 indiv/m^2), and the archiannelid Family Polygordiidae (152 indiv/m^2) were also abundant. Percent composition of the dominant taxa is plotted in Figure 10.

Echinodermata (4.37 g) had the highest biomass at this borrow area, followed by Mollusca (2.07 g). A graphical presentation of the percent composition by biomass of the dominant taxa for Borrow Area 2A is shown in Figure 11.

Sediment at the borrow area consisted of mostly sand and a small amount of clay. Sediment grain size distribution for this borrow area is shown in Figure 12.

Table 5: Borrow Area 2B Species Abundance, Fall 2000

Date Sampled: 11/20/00			
Number of Samples: 10			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Polygordiidae	251	0.42	1,004
Leptochelia savignyi	111	0.19	441
Echinarachnius parma	60	0.10	240
Syllidae	40	0.07	160
Astarte castanea	35	0.06	140
Protohaustorius wigleyi	30	0.05	120
Glycera sp.	20	0.03	80
Tharyx acutus	20	0.03	80
Nematoda	17	0.03	68
Oligochaeta	13	0.02	52
TOTALS	**597**		**N/A**

Table 6: Borrow Area 2B Biomass, Fall 2000

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	0.58	2.32
Mollusca	4.62	18.48
Arthropoda	0.84	3.36
Echinodermata	37.10	148.40
Other	0.48	1.92
TOTAL BIOMASS	**43.62**	**174.48**

Table 7: Borrow Area 2B Water Quality, Fall 2000

Date Sampled: 11/20/00						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(ms)
3	10.0	8.97	31.2	8.6	2.5	34.28
5	10.3	8.80	31.1	8.6	3.0	34.47
6	10.2	8.65	31.1	8.5	2.78	34.39
12	9.8	9.23	30.7	8.6	2.0	33.61
14	10.4	8.57	31.1	8.6	3.0	34.55
15	n/a	n/a	n/a	8.6	2.5	n/a
Mean	**10.14**	**8.84**	**31.04**	**-**	**2.63**	**34.26**

The Shannon-Weaver Diversity Index for Borrow Area 2B is 2.29. Based on the diversity index, Borrow Area 2B ranks sixth in comparison with the borrow/inter-borrow areas sampled.

Water quality data summarized above is hown in Figure 13. The average collection depth in this borrow area was approximately 16 meters. A total of 675 individuals representing 32 taxa were identified for Borrow Area 2B during the Fall. Table 5 shows the dominant organisms present during this sampling period. The archiannelid Family Polygordiidae was the most abundant taxonomic group representing 42% of the total organisms, followed by the tanaid *L. savignyi* (19%) and the sand dollar, *E. parma* (10%). Additional common organisms were syllid worms at 7% and the chestnut astarte clam, *Astarte castanea,* at 6 %.

Polygordiidae was present in the the highest density (1,004 indiv/m^2). The tanaid, *L. savignyi* (441 indiv/m^2), the sand dollar *E. parma* (240 indiv/m^2) and the polychaete worm Family Syllidae (160 indiv/m^2) were also abundant. Percent composition of the dominant taxa is plotted in Figure 10.

Echinodermata (37.10 g) had the highest biomass at this borrow area, followed by Mollusca (4.62 g) and Arthropoda (0.84 g). Percent composition by biomass of the dominant taxonomic groups is shown in Figure 11.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay and gravel. Sediment grain size distribution for this borrow area is presented graphically in Figure 12.

Table 8: Borrow Area 2C Species Abundance, Fall 2000

Date Sampled: 11/20/00			
Number of Samples: 20			
Taxa	Total Number (all samples combined)	Percent Composition	Abundance (Number per m^2)
Polygordiidae	689	0.52	1,378
Leptochelia savignyi	240	0.18	480
Echinarachnius parma	164	0.12	328
Paraphoxus epistomus	43	0.03	86
Protohaustorius wigleyi	40	0.03	80
Syllidae	38	0.03	76
Glycera sp.	34	0.03	68
Nephtys bucera	29	0.02	58
Tharyx acutus	23	0.02	46
Astarte castanea	23	0.02	46
TOTALS	**1,323**		**N/A**

Table 9: Borrow Area 2C Biomass, Fall 2000

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	2.87	6.04
Mollusca	7.06	14.86
Arthropoda	1.18	2.48
Echinodermata	66.16	139.28
Other	0.12	0.25
TOTAL BIOMASS	**77.39**	**162.91**

Table 10: Borrow Area 2C Water Quality, Fall 2000

Date Sampled: 11/20/00						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
1	10.6	8.64	31.3	8.5	3.0	34.93
2	10.7	8.86	31.1	8.6	2.5	34.76
4	10.5	8.60	31.1	8.6	2.5	34.65
5	10.5	8.67	31.1	8.6	2.5	34.62
7	10.5	8.70	31.0	8.6	2.0	34.52
16	10.5	8.42	31.1	8.6	2.5	34.62
17	10.3	8.66	31.3	8.6	2.5	34.65
19	10.4	8.51	31.2	8.6	3.5	34.64
20	10.5	8.08	31.0	8.6	3.5	34.62
22	10.5	8.28	30.3	8.6	4.5	33.89
Mean	**10.5**	**8.54**	**31.05**	**-**	**2.9**	**34.59**

The Shannon-Weaver Diversity Index for Borrow Area2C is 2.06. Based on the diversity index, Borrow Area 2C ranks seventh in comparison with the other borrow/inter-borrow areas.

Water quality data summarized above is shown in Figure 14. The average collection depth in this borrow area was approximately 19 m. A total of 1,498 individuals representing 38 taxa were identified for Borrow Area 2C during the Fall. Table 8 shows that the dominant organisms collected in this borrow area were the archiannelid Family Polygordiidae (52%), the tanaid *L. savignyi* at 18% and the sand dollar *E. parma* at 12 % .

Polygordiidae worms were present in the highest desnsities (1,378 indiv/m^2). The arthropod *L. savignyi* (480 indiv/m^2) and the sand dollar *E. parma* (328 indiv/m^2) were also abundant. Percent composition of the dominant taxa is plotted in Figure 10.

Echinodermata (66.16 g) had the highest biomass at this borrow area, followed by Mollusca (7.06 g). A graphic presentation of the percent compositin by biomass of the dominant taxonomic groups is shown in Figure 11.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay and gravel. Sediment grain size distribution for this borrow area is shown in Figure 12.

Table 11: Borrow Area 4 Species Abundance, Fall 2000

Date Sampled: 11/14/00 & 11/16/00			
Number of Samples: 15			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Gammarus oceanicus	235	0.34	627
Tellina agilis	80	0.12	213
Tharyx acutus.	71	0.10	189
Protohaustorius wigleyi	70	0.10	187
Spiophanes bombyx	57	0.08	152
Echinarachnius parma	45	0.07	120
Echinodermata	34	0.05	91
Magelona rosea	32	0.04	85
Diastylis sculpta	20	0.03	53
Nephtys bucera	18	0.03	48
Polygordiidae	16	0.02	43
Leptochelia savignyi	15	0.02	40
TOTALS	**693**		**N/A**

Table 12: Borrow Area 4 Biomass, Fall 2000

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Sq. Meter
Polychaeta	0.59	1.57
Mollusca	4.52	12.05
Arthropoda	1.18	3.15
Echinodermata	16.96	45.23
Other	0.60	1.60
TOTAL BIOMASS	**23.85**	**63.6**

Table 13: Borrow Area 4 Water Quality, Fall 2000

Date Sampled: 11/14/00 & 11/16/00						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
1	12.5	7.82	31.3	8.6	3.5	36.57
2	12.4	7.69	31.2	8.6	3.0	36.48
3	12.5	7.66	31.2	8.6	2.5	36.47
4	12.4	7.59	31.2	8.6	2.0	36.45
5	12.4	7.46	31.2	8.6	2.0	36.37
14	11.5	7.80	31.1	8.6	3.5	35.55
18	11.7	8.00	31.1	8.6	4.5	35.70
Mean	**12.2**	**7.72**	**31.19**	**-**	**3.00**	**36.23**

The Shannon-Weaver Diversity Index for Borrow Area 4 is 2.62. Based on the diversity index, Borrow Area 4 ranks second in comparison with the other borrow/inter-borrow areas sampled.

Water quality data summarized above is shown graphically in Figure 15. The average collection depth in this borrow area was approximately 16 m. A total of 803 individual organisms representing 36 taxa were identified for Borrow Area 4 during the Fall. Table 11 shows the dominant taxa for this borrow area. The amphipod, *G. oceanicus* was the most abundant comprising 34% of the total organisms identified. Additional dominant species included the bivalve *T. agilis* (12%), the polychaete *T. acutus* (10%) and the amphipod *P. wigleyi* (10 %).

The arthropod *G. oceanicus* was present in the highest density (627 indiv/m^2). The following species were also abundant: *T. agilis* (213 indiv/m^2), *T. acutus* (189 indiv/m^2), *P. wigleyi* (187 indiv/m^2). Percent composition of the dominant taxa is plotted in Figure 10.

Arthropoda (7.88 g) had the highest biomass at this borrow area, followed by Mollusca (7.57 g), and Echinodermata (6.52 g). Figure 11 shows the percent composition by biomass of the dominant taxa.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay and gravel. Sediment grain size distribution for this borrow area is shown graphically in Figure 12.

Table 14: Borrow Area 5 Species Abundance, Fall 2000

Date Sampled: 11/13/00			
Number of Samples: 20			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Gammarus oceanicus	394	0.32	788
Protohaustorius wigleyi	321	0.26	642
Tellina agilis	127	0.10	254
Spiophanes bombyx	97	0.08	194
Magelona rosea	88	0.07	176
Echinodermata	66	0.05	132
Psammonyx noblis	51	0.04	102
Nephtys bucera	23	0.02	46
Polygordiidae	21	0.02	42
Echinarachnius parma	19	0.02	38
Naticidae	19	0.02	38
TOTAL	**1,226**		**N/A**

Table 15: Borrow Area 5 Biomass:

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Mollusca	7.57	15.14
Arthropoda	7.88	15.76
Echinodermata	6.52	13.04
Polychaeta	1.11	2.22
Other	0.53	1.06
TOTAL BIOMASS	**23.61**	**47.22**

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Table 16: Borrow Area 5 Water Quality, Fall 2000:

Date Sampled: 11/13/00						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
1	12.5	7.82	31.3	8.6	3.5	36.57
2	12.4	7.69	31.2	8.6	3.0	36.48
3	12.5	7.66	31.2	8.6	2.5	36.47
4	12.4	7.59	31.2	8.6	2.0	36.45
5	12.4	7.46	31.2	8.6	2.0	36.37
14	11.5	7.80	31.1	8.6	3.5	35.55
18	11.7	8.00	31.1	8.6	4.5	35.70
Mean	**12.2**	**7.72**	**31.2**	**-**	**3.00**	**36.22**

The Shannon-Weaver Diversity Index for Borrow Area 5 is 2.39. Based on the diversity index, Borrow Area 5 ranks fifth in comparison with other borrow/inter-borrow areas.

Water quality data summarized above is shown graphically in Figure 16. The average collection depth in this borrow area was approximately 12 meters. A total of 1,374 individuals representing 47 taxa were identified for Borrow Area 5 during the Fall. Table 14 shows the dominant organisms in this borrow area. The amphipods, *G. oceanicus* and *P. wigleyi* were the most abundant comprising 32% and 26% of the organisms identified, respectively. The bivalve *T. agilis* was also common comprising 10 % of the total organisms.

Arthropods, specifically the amphipods *G. oceanicus* (788 indiv/m^2) and *P. wigleyi* (642 indiv/m^2) were present in the highest densities. The bivalve *T. agilis* (254 indiv/m^2) was also abundant. Percent composition of the dominant taxa is plotted in Figure 10.

Echinodermata (16.96 g) had the highest biomass at this borrow area, followed by Mollusca (4.52 g). Percent composition by biomass of the dominant taxa for Borrow Area 5 is shown in Figure 11.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay. Sediment grain size distribution for this borrow area is shown graphically in Figure 12.

Table 17: West of Shinnecock Inlet Borrow Area Species Abundance, Fall 2000

Dates Sampled: 11/9/00 & 11/13/00			
Number of Samples: 30			
Taxa	Total Number (all species combined)	Percent Composition	Abundance (Number per m^2)
Protohaustorius wigleyi	315	0.26	420
Gammarus oceanicus	249	0.20	332
Polygordiidae	124	0.10	165
Echinarachnius parma	100	0.08	133
Leptochelia savignyi	81	0.07	108
Tellina agilis	57	0.05	76
Magelona rosea	54	0.04	72
Nematoda	48	0.04	64
Psammonyx nobilis	47	0.04	63
Tharyx acutus	37	0.03	49
Spiophanes bombyx	33	0.03	44
Scolelepis squamata	24	0.02	32
Leptocuma minor	21	0.02	28
Diastylis sculpta	20	0.02	27
TOTALS	**1,210**		**N/A**

Table 18: West of Shinnecock Inlet Borrow Area Biomass, Fall 2000

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	1.56	2.08
Mollusca	6.90	9.20
Arthropoda	3.19	4.25
Echinodermata	44.17	58.89
Other	0.62	0.08
TOTAL BIOMASS	**56.44**	**74.5**

<u>Table 19: West of Shinnecock Inlet Borrow Area Water Quality, Fall 2000</u>

Dates Sampled: 11/9/00 and 11/13/00						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
5	12.7	7.84	31.1	8.7	5.0	36.60
6	12.6	7.91	31.2	8.7	3.5	36.54
7	12.4	8.15	31.3	8.7	5.5	36.54
8	12.5	7.84	31.1	8.6	5.5	36.47
10	12.3	8.00	31.2	8.7	3.5	36.33
16	13.2	9.74	31.3	8.6	3.0	37.25
17	13.0	8.18	31.3	8.6	3.5	37.07
18	13.0	8.26	31.3	8.6	4.5	37.03
19	12.8	8.53	31.3	8.6	5.5	36.91
20	12.8	8.53	31.3	8.6	5.5	36.91
26	13.2	8.23	31.4	8.6	4.5	37.31
27	13.2	8.22	31.3	8.6	5.0	37.24
28	13.1	8.11	31.4	8.6	5.0	37.19
29	12.8	8.13	31.3	8.6	4.5	36.85
30	12.6	8.18	31.3	8.6	4.5	36.73
Mean	**12.8**	**8.26**	**31.27**	**-**	**4.6**	**36.86**

The Shannon-Weaver Diversity Index is 2.59 for the WOSI Borrow Area. Based on the diversity index, the WOSI Borrow Area ranks third in comparison with the other borrow/inter-borrow areas sampled.

Water quality data summarized above is plotted in Figure 17. The average collection depth in this borrow area was approximately 16 m. A total of 927 individuals representing 38 taxa were identified for the WOSI Borrow Area during the Fall. Table 17 shows the dominant taxa in this borrow area. The amphipod, *P. wigleyi* was most abundant comprising 26% of the total organisms. Additional dominant organisms were the amphipod *G. oceanicus*, and worms in the Family Polygordiidae comprising 20% and 10% of the total number of organisms, respectively.

Arthropods, specifically *P. wigleyi* (420 indiv/m^2) and *G. oceanicus* (332 indiv/m^2), were present in the highest densities. The Polygordiidae worms (165 indiv/m^2) were also abundant. Percent composition by abundance of the dominant taxa is shown in Figure 10.

Echinodermata (44.17 g) had the highest biomass at this borrow area, followed by Mollusca (6.90 g) and Arthropoda (3.19 g). Percent composition by biomass of the dominant taxa is shown in Figure 11.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay and gravel. Sediment grain size distribution for this borrow area is shown graphically in Figure 12.

Table 20: Inter-Borrow Area Species Abundance, Fall 2000

Dates Sampled: 11/13/00, 11/16/00 and 11/20/00			
Number of Samples: 30			
Taxa	Total Number (all samples combined)	Percent Composition	Abundance (Number per m^2)
Protohaustorius wigleyi	419	0.21	559
Magelona rosea	254	0.12	339
Gammarus oceanicus	239	0.12	319
Polygordiidae	202	0.10	269
Tharyx acutus	186	0.09	248
Gemma gemma	150	0.07	200
Tellina agilis	127	0.06	169
Spiophanes bombyx	120	0.06	160
Nephtys bucera	82	0.04	109
Leptochelia savignyi	66	0.03	88
Echinarachnius parma	63	0.03	84
Psammonyx nobilis	56	0.03	75
Polydora sp.	33	0.02	44
Nematoda	29	0.01	39
Corophiidae	24	0.01	32
TOTALS	**2,050**		**N/A**

Table 21: Inter-Borrow Area Biomass, Fall 2000

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	3.22	4.29
Mollusca	53.94	71.92
Arthropoda	4.51	6.01
Echinodermata	30.94	41.25
Other	0.33	0.44
TOTAL BIOMASS	**92.94**	**123.91**

Table 22: Inter-Borrow Area Water Quality, Fall 2000

Dates Sampled: 11/13/00, 11/16/00 & 11/20/00						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
1	12.4	8.25	31.3	8.6	6.5	36.55
2	12.6	7.75	31.1	N/A	N/A	36.54
3	12.5	7.84	31.2	8.6	5.0	36.47
5	12.5	7.68	31.2	8.6	3.0	36.52
7	12.4	7.79	31.3	8.6	4.0	36.47
9	11.2	8.35	31.0	8.6	3.5	35.22
11	11.9	7.87	31.3	8.6	4.0	36.10
13	12.1	7.84	31.4	8.6	4.0	36.38
16	11.8	7.93	31.4	8.6	3.5	36.12
18	11.6	7.92	31.4	8.6	3.0	35.82
20	11.5	7.89	31.4	8.6	3.5	35.83
23	10.4	8.22	31.0	8.6	4.5	34.51
24	10.4	8.42	31.0	8.6	4.5	34.54
26	10.3	8.47	31.0	8.6	4.0	34.39
30	10.3	8.33	31.2	8.6	3.0	34.55
Mean	**11.6**	**8.04**	**31.2**	**-**	**3.7**	**35.73**

The Shannon-Weaver Diversity Index for the Inter-Borrow Area is 2.79. Based on the diversity index, the Inter-Borrow Area ranks first in comparison with the borrow areas sampled.

Water quality data summarized above is shown graphically in Figure 18. The average collection depth in this borrow area was approximately 13 m. A total of 2,250 individuals representing 51 taxa were identified for the Inter-Borrow Area during the Fall. Table 20 shows the dominant organisms present during this sampling period. The amphipod, *P*. wigleyi was most abundant comprising 21% of the total organism abundance. Additional dominant organisms were the polychaete *M. rosea* (12%), the amphipod *G. oceanicus* (12%), the worm Family Polygordiidae (10 %), and the polychaete *T. acutus* (9%).

The amphipod *P. wigleyi* (559 indiv/m^2) was present in the highest density. The polychaete *M. rosea* (339 indiv/m^2), the amphipod *G. oceanicus* (319 indiv/m^2) and Polygordiidae worms (269 indiv/m^2) were also abundant. Since the Inter-Borrow Area stations were spread out across the overall study area, they were divided into 3 regions for a more thorough analysis. Region One consisted of the locations between the Shinnecock Inlet Borrow Area and Borrow Area 4. Region Two consisted of the locations between Borrow Area 4 and Borrow Area 2. Region Three consisted of the locations from Borrow Area Two to Fire Island Inlet. Percent composition by abundance of the dominant taxa in each region is shown in Figure 19.

Mollusca (53.94 g) had the highest biomass at this borrow area, followed by Echinodermata (30.94 g). Percent composition by biomass of the dominant taxa for the Inter-Borrow area is shown in Figure 20.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay. Sediment grain size distribution for this borrow area is shown graphically in Figure 21.

5.0 SPRING 2001 RESULTS

<u>Community Structure, Numerical Abundance and Biomass Data</u>

A total of 11,092 organisms were recovered from the entire study area in Spring, 2001 representing 102 invertebrate taxa. Nematode worms were the most abundant (24 %) of all the organisms throughout the entire study area (Appendix III), followed by the archiannelid Family Polygordiidae (*P. triestinus)* (18.5 %). Numerically dominant taxa found in the study area were Arthropoda, Nematoda, and Annelida. The amphipods, *G. oceanicus* (10.5 %) and *P. wigleyi* (10 %) were consistently two of the most abundant organisms at each borrow area in Spring 2001. The clam, *T. agilis* (5 %), polychaete worm *Spiophanes bombyx* (3 %), and sand dollar *E. parma* (3 %) were also relatively abundant at all borrow areas. While the commercially important surf clam, *S. solidissima*, was present at several of the 30 inter-borrow area stations and at several stations (3 of the 6 proposed borrow locations) it only accounted for a small percent of all organisms identified. The percent composition of each taxonomic group based on numerical abundance is presented in Figure 7.

Benthic biomass data collected in Fall 2000 and Spring 2001 were generally consistent between the seasons. The borrow areas that had the highest biomass in the Fall also had relatively high biomasses in the Spring. Borrow Area 5 had the lowest biomass during both the Spring and Fall (15.1 g/m^2 and 47.22 g/m^2, respectively). Borrow Areas 2B and 2C had the highest biomasses in both the Spring and Fall with values approximating 200 g/m^2. Echinoderms had the highest biomass at all borrow areas sampled in the Spring of 2001. Total biomass for Spring 2001 is shown in Figure 8. Unlike the abundance data, biomass data is less uniform and does not appear to exhibit any spatial patterns or trends.

Data tables summarizing species abundance (density), biomass, water quality and diversity are provided below for each borrow/inter-borrow area. Refer to the methodology section for information on the calculation of values in the following tables. Three tables are shown for each borrow/inter-borrow area. The abundance table lists the taxa collected from the borrow/inter-borrow area, the total number of each taxon, percent composition each taxon represents of the total, and the abundance of each taxon for that area (all stations within the borrow area combined). The biomass table shows values of biomass as total weight and total weight per grab for the five major taxa represented in the study. The water quality table shows values for each water quality parameter measured at each station within borrow/inter-borrow area, as well as mean values for the entire area

Table 23: Borrow Area 2A Species Abundance, Spring 2001

Date Sampled: 6/04/01			
Number of Samples: 5			
Taxa	Total Number (all samples combined)	Percent Composition	Abundance (Number per m^2)
Gammarus oceanicus	329	0.54	2632
Amphiporeia gigantea	120	0.20	960
Protohaustorius wigleyi	93	0.15	744
Nematoda	25	0.04	200
Tellina agilis	16	0.03	128
Polygordius triestinus	12	0.02	96
Spiophanes bombyx	5	0.01	40
Asabellides oculata	4	0.01	32
TOTALS	**604**		**N/A**

Table 24: Borrow Area 2A Biomass, Spring 2001

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	0.06	0.48
Mollusca	0.06	0.48
Arthropoda	0.53	4.24
Echinodermata	4.20	33.60
Other	0.00	0.00
TOTAL BIOMASS	**4.85**	**38.8**

Table 25: Borrow Area 2A Water Quality, Spring 2001

Date Sampled: 6/4/01						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
5	12.1	8.66	30.8	8.0	2.4	35.79
15	11.8	8.63	30.9	8.0	2.1	35.62
25	11.9	8.79	30.8	7.9	1.5	35.61
Mean	**11.9**	**8.69**	**30.8**	**-**	**2.0**	**35.67**

The Shannon-Weaver Diversity Index for Borrow Area 2A is 1.57. Based on the diversity index, Borrow Area 2A ranks seventh in comparison with the other borrow/inter-borrow areas sampled.

Water quality data summarized above is shown in Figure 22. The average collection depth in this borrow area was approximately 13 meters. A total of 635 individuals representing 23 taxa were identified for Borrow Area 2A during the Spring. Table 23 shows the dominant organisms present during this sampling period. The amphipod, *G. oceanicus* was the most abundant, comprising 54 % of the organisms identified. Additional dominant species included the amphipods, *Amphiporeia gigantea,* at 20 %, and *P. wigleyi* at 15 %.

Amphidods, specifically *G. oceanicus* (2,632 indiv/m^2), *A. gigantean* (960 indiv/m^2) and *P. wigleyi* (744 indiv/m^2) were most abundant. Percent composition of the dominant taxa is shown in Figure 23.

Echinodermata (4.20 g) had the highest biomass at Borrow Area 2A, followed by Arthropoda (0.53 g). Percent composition by biomass of the dominant taxa for this borrow area is shown in Figure 24.

Sediments at this borrow area consisted mostly of sand with a small amount of clay. Sediment grain size distribution for this borrow area is shown graphically in Figure 25.

Table 26: Borrow Area 2B Species Abundance, Spring 2001

Date Sampled: 6/04/01			
Number of Samples: 10			
Taxa	Total Number (all samples combined)	Percent Composition	Abundance (Number per m^2)
Nematoda	502	0.43	2,008
Polygordius triestinus	254	0.22	1,016
Syllidae	82	0.07	328
Gammarus oceanicus	67	0.06	268
Dorvilleidae	51	0.05	204
Astarte castanea	44	0.04	176
Goniada maculata	41	0.04	164
Aricidea jeffreysii	36	0.03	144
Echinarachnius parma	33	0.03	132
Gemma gemma	29	0.03	116
Leptognatha caeca	23	0.02	92
TOTALS	**1,162**		**N/A**

Table 27: Borrow Area 2B Biomass, Spring 2001

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	0.55	2.44
Mollusca	13.41	59.60
Arthropoda	0.04	0.18
Echinodermata	32.39	143.96
Other	0	0

TOTAL BIOMASS	**46.39**	**206.18**

Table 28: Borrow Area 2B Water Quality, Spring 2001

Date Sampled: 6/04/01						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
2	12.1	8.61	30.5	8.0	5.0	35.51
3	12.1	9.12	30.7	8.0	5.0	35.61
11	12.1	8.61	30.5	8.0	5.0	35.47
12	12.0	8.77	29.5	7.9	5.0	34.33
14	12.2	8.63	30.6	7.9	6.5	35.62
Mean	**12.1**	**8.75**	**30.36**	**-**	**5.3**	**35.31**

The Shannon-Weaver Diversity Index for Borrow Area 2B is 2.20. Based on the diversity index, Borrow Area 2B ranks fourth in comparison with other borrow/inter-borrow areas sampled.

Water quality data summarized above is shown in Figure 26. The average collection depth in this borrow area was approximately 15 m. A total of 1,283 individuals representing 39 taxa were identified for Borrow Area 2B during the Spring. Table 26 shows the dominant organisms present during this sampling period. Nematoda were most abundant, comprising 43 % of the individuals identified, followed by the archiannelid worm *P. triestinus (*22 %) and the polychaete worm Family Syllidae (7%).

Nematoda was present in the highest density, 2,008 indiv/m^2. The archiannelid, *P. triestinus* (1,016 indiv/m^2), polychaete Family Syllidae (328 indiv/m^2) and amphipod *G. oceanicus* (268 indiv/m^2) were also abundant. Percent composition by abundance of the dominant taxa is shown in Figure 23.

Echinodermata (32.39 g) had the highest biomass at this borrow area, followed by Mollusca (13.41 g). Percent composition by biomass of the dominant taxa is shown in Figure 24.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay and gravel. Sediment grain size distribution is shown in Figure 25.

Table 29: Borrow Area 2C Species Abundance, Spring 2001

Date Sampled: 6/04/01			
Number of Samples: 20			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Polygordius triestinus	910	0.43	1,820
Nematoda	642	0.30	1,284
Leptognatha caeca	156	0.07	312
Syllidae	88	0.04	176
Echinarachnius parma	71	0.03	142
Goniada maculata	64	0.03	128
Tellina agilis	55	0.03	110
Aricidea jeffreysii	52	0.03	104
Paraonis sp.	38	0.02	76
Gemma gemma	29	0.01	58
Astarte castanea	27	0.01	54
TOTALS	**2,132**		**N/A**

Table 30: Borrow Area 2C Biomass, Spring 2001

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	0.99	3.96
Mollusca	2.75	11.00
Arthropoda	0.13	0.52
Echinodermata	52.32	209.28
Other	0.01	0.04
TOTAL BIOMASS	**56.2**	**224.8**

Table 31: Borrow Area 2C Water Quality, Spring 2001

Date Sampled: 6/04/01						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
7	12.8	8.32	30.1	7.9	4.0	35.71
8	12.7	8.46	30.1	7.9	4.0	35.58
10	12.5	8.21	29.8	7.9	5.5	35.20
11	12.0	8.77	30.5	7.9	4.25	35.33
13	12.6	8.26	30.1	7.9	4.25	35.57
23	12.0	8.90	30.7	7.9	5.5	35.60
25	12.1	8.91	30.5	7.9	4.5	35.47
26	11.9	8.82	30.7	7.9	4.5	35.54
28	11.8	8.94	30.9	7.9	4.25	35.62
29	13.1	8.62	30.2	7.9	4.0	35.98
Mean	**12.35**	**8.62**	**30.3**	**-**	**4.5**	**35.56**

The Shannon-Weaver Diversity Index for Borrow Area 2C is 2.08. Based on the diversity index, Borrow Area 2C ranks fifth in comparison with the other borrow/inter-borrow areas sampled.

Water quality data summarized above is shown graphically in Figure 27. The average collection depth in this borrow area was approximately 19 meters. A total of 2,382 individuals representing 48 taxa were identified for Borrow Area 4 during the Spring. Table 29 shows the dominant organisms present during this sampling period. The archiannelid worm *P. triestinus* was the most abundant organism comprising 43 % of the total organisms. Additional dominant taxa were nematode worms (30 %) and the tanaid *Leptognatha caeca* (7 %).

The archiannelid *P. triestinus* (1,820 indiv/m^2) and Nematoda (1,284 indiv/m^2) were present in the highest densities. The tanaid *L. caeca* (312 indiv/m^2) was also abundant. Percent composition by abundance of the dominant taxa is shown in Figure 23.

Echinodermata (52.32 grams) had the highest biomass at this borrow area, followed by Mollusca (2.75 grams). Percent composition by biomass of the dominant taxa is shown in Figure 24.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay and gravel. Sediment grain size distribution for this borrow area is shown in Figure 25.

Table 32: Borrow Area 4 Species Abundance, Spring 2001

Date Sampled: 6/6/01			
Number of Samples: 15			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Nematoda	143	0.16	286
Spiophanes bombyx	141	0.15	282
Tellina agilis	134	0.15	268
Polygordius triestinus	96	0.11	192
Amphiporeia sp.	94	0.10	188
Diastylis sculpta	74	0.08	148
Protohaustorius wigleyi	67	0.07	134
Gammauus oceanicus	54	0.06	108
Echinarachnius parma	33	0.04	66
Tharyx acutus	22	0.02	44
Clymenella torquata	19	0.02	38
Nephtys bucera	18	0.02	36
Aricidea jeffreysii	18	0.02	36
TOTALS	**913**		**N/A**

Table 33: Borrow Area 4 Biomass, Spring 2001

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	0.28	0.80
Mollusca	1.53	4.37
Arthropoda	0.54	1.54
Echinodermata	17.62	50.34
Other	0	0
TOTAL BIOMASS	**19.97**	**57.05**

Table 34: Borrow Area 4 Water Quality, Spring 2001

Date Sampled: 6/6/01						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
6	13.4	9.74	30.7	8.0	4.25	36.74
7	12.1	8.97	30.8	8.0	4.25	35.84
8	13.9	9.00	30.7	8.0	4.0	37.12
9	13.4	9.06	30.8	8.0	4.0	36.91
10	12.9	9.33	30.7	8.0	4.5	36.35
14	11.7	8.85	30.9	8.0	3.0	35.45
18	13.9	9.18	30.7	8.0	4.0	37.20
Mean	**13.04**	**9.16**	**30.76**	**-**	**4.0**	**36.52**

The Shannon-Weaver Diversity Index for Borrow Area 4 is 2.86. Based on the diversity index, Borrow Area 4 ranks first in comparison with other borrow/inter-borrow areas sampled.

Water quality data summarized above is shown in Figure 28. The average collection depth in this borrow area was approximately 15 meters. A total of 1,070 individuals representing 52 taxa were identified for Borrow Area 4 during the Spring. Table 32 shows the dominant organisms present during this sampling period. Nematode worms were most abundant comprising 16 % of the total organisms collected. Additional dominant species included the polychaete worm *S. bombyx*, and the clam *T. agilis*, each contributing 15 % to the total catch The archiannelid worm *P. triestinus* was also common comprising 11 % of the total sample.

Nematode worms (286 indiv/m^2), the polychaete worm *S. bombyx* (282 indiv/m^2), and the clam *T. agilis* (268 indiv/m^2) were present in the highest densities. The archiannelid *P. triestinus* (192 indiv/m^2) was also abundant. Percent composition by abundance of the dominant taxa is shown in Figure 23.

Echinodermata (17.62 grams) had the highest biomass, followed by Mollusca (1.53 grams), and Arthropoda (0.54 grams). Percent composition by biomass of the dominant taxa is shown in Figure 24.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay and gravel. Sediment grain size distribution is shown in Figure 25.

Table 35: Borrow Area 5 Species Abundance, Spring 2001

Date Sampled: 6/06/01			
Number of Samples: 20			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Protohaustorius wigleyi	414	0.35	818
Gammarus oceanicus	264	0.22	528
Nematoda	175	0.15	350
Asabellides oculata	102	0.09	204
Tellina agilis	94	0.08	188
Spiophanes bombyx	90	0.08	180
Polygordius triestinus	32	0.03	64
TOTAL	**1,171**		**N/A**

Table 36: Borrow Area 5 Biomass, Spring 2001

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	0.04	0.09
Mollusca	1.28	3.01
Arthropoda	0.53	1.25
Echinodermata	4.57	10.75
Other	<0.01	<0.01
TOTAL BIOMASS	**6.42**	**15.1**

Table 37: Borrow Area 5 Water Quality, Spring 2001

Date Sampled: 6/06/01						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
3	12.5	7.73	31.2	8.6	5.0	36.52
5	12.4	8.00	31.3	8.6	6.0	36.54
7	12.5	7.34	31.3	8.6	5.0	36.57
9	12.5	8.11	31.2	8.6	5.5	36.56
11	12.5	7.97	31.3	8.6	5.0	36.61
22	12.3	7.76	31.4	8.6	3.5	36.49
23	12.4	7.52	31.3	8.6	3.5	36.50
24	12.5	7.45	31.2	8.6	4.0	36.52
25	12.1	7.55	31.2	8.6	3.0	36.49
26	12.4	7.51	31.2	8.6	3.5	36.47
Mean	**12.4**	**7.69**	**31.3**	**-**	**4.40**	**36.53**

The Shannon-Weaver Diversity Index for Borrow Area 5 is 2.04. Based on this diversity index, Borrow Area 5 ranks sixth in comparison with other borrow/inter-borrow areas sampled.

Water quality data is plotted in Figure 29. A total of 1,328 individuals representing 30 taxa were identified for Borrow Area 5 during the Spring. Table 35 shows the dominant organisms present during this sampling period. The amphipod, *P. wigleyi* was most abundant comprising 35 % of the total organisms collected. Additional taxa were the amphipod *G. oceanicus* (22 %) and Nematoda (15 %).

The amphipods, *P.wigleyi* (818 indiv/m^2) and *G. oceanicus* (528 indiv/m^2) were present in the highest densities. Nematoda (350 indiv/m^2) were also abundant. Percent composition by abundance of the dominant taxa is shown in Figure 23.

Echinodermata (4.57 g) had the highest biomass, followed by Mollusca (1.28 g) and Arthropoda (0.53 g). Percent composition by biomass of the dominant taxa is shown in Figure 24.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay. Sediment grain size distribution is shown in Figure 25.

Table 38: West of Shinnecock Inlet Borrow Area Species Abundance, Spring 2001

Date Sampled: 6/5/01			
Number of Samples: 30			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Nematoda	995	0.42	1,327
Polygordius triestinus	584	0.25	779
Protohaustorius wigleyi	169	0.07	225
Gammarus oceanicus	149	0.06	199
Echinarachnius parma	95	0.04	127
Tellina agilis	78	0.03	104
Leptognatha caeca	65	0.03	87
Paraphoxus epistomus	42	0.02	56
Scolelepis squamata	34	0.01	45
Spiophanes bombyx	29	0.01	39
Acanthohaustorius millsi	28	0.01	37
Clymenella torquata	28	0.01	37
Syllidae	27	0.01	36
Nephtys bucera	23	0.01	31
Tellina sp.	22	0.01	329
Nemeterean	21	0.01	28
TOTALS	**2,389**		**N/A**

Table 39: West of Shinnecock Inlet Borrow Area Biomass, Spring 2001

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Sq. Meter
Polychaeta	0.1	0.14
Mollusca	5.87	8.39
Arthropoda	1.87	2.67
Echinodermata	78.64	112.34
Other	<0.01	<0.01
TOTAL BIOMASS	**86.48**	**123.54**

Table 40: West of Shinnecock Inlet Borrow Area Water Quality, Spring 2001

Date Sampled: 6/5/01						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
1	13.2	9.16	30.6	7.9	4.25	36.42
2	12.4	8.84	30.7	7.9	4.0	35.95
3	12.8	9.01	30.7	7.9	5.5	36.29
4	13.1	9.04	30.6	7.9	5.3	36.40
5	12.2	8.76	30.7	7.9	6.0	35.71
11	13.4	9.09	30.7	7.9	5.0	36.82
12	12.6	8.85	30.7	7.9	4.75	36.05
13	13.5	8.90	30.6	7.9	5.0	36.76
14	12.6	8.96	30.6	7.9	5.5	35.95
15	13.7	8.97	30.6	7.9	6.0	36.93
22	13.8	9.16	30.7	7.9	2.75	37.13
23	13.6	8.97	30.7	7.9	4.25	36.91
24	12.6	9.00	30.7	7.9	5.5	36.13
25	12.3	8.99	30.6	7.9	7.6	35.72
26	12.3	8.98	30.7	7.9	6.0	35.87
Mean	**12.94**	**8.98**	**30.66**	**-**	**5.2**	**36.34**

The Shannon-Weaver Diversity Index for the WOSI Borrow Area is 2.21. Based on the diversity index, the WOSI Borrow Area ranks third in comparison with the other borrow/inter-borrow areas sampled.

Water quality data summarized above is plotted in Figure 30. The average collection depth in this borrow area was approximately 14 meters. A total of 2,603 individuals representing 57 taxa were identified for the WOSI Borrow Area during the Spring. Table 38 shows the dominant organisms present during this sampling period. Nematode worms were the most abundant comprising 42 % of the total organisms collected. Additional dominant species included the archiannelid worm *P. triestinus* (25 %) as well as the amphipods *P. wigleyi* (7 %) and *G. oceanicus* (6 %).

Nematode worms (1,327 indiv/m^2) and the archiannelid *P. triestinus* (779 indiv/m^2) were present in the highest densities. The amphipods, *P. wigleyi* (225 indiv/m^2) and *G. oceanicus* (199 indiv/m^2) were also abundant. Percent composition by abundance of dominant taxa is shown in Figure 23.

Echinodermata (78.64 g) had the highest biomass, followed by Mollusca (5.87 g), and Arthropoda (1.87 g). Percent composition by biomass of the dominant taxa is shown in Figure 24.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay. Sediment grain size distribution is shown in Figure 25.

Table 41: Inter-Borrow Area Species Abundance, Spring 2001

Dates Sampled: 6/01/00 & 6/04/00			
Number of Samples: 30			
Taxa	Total Number (all stations combined)	Percent Composition	Abundance (Number per m^2)
Protohaustorius wigleyi	370	0.25	493
Gammarus oceanicus	285	0.19	380
Polygordius triestinus	165	0.11	220
Nematoda	147	0.10	196
Tellina agilis	138	0.09	184
Spiophanes bombyx	91	0.06	121
Gemma gemma	56	0.04	75
Echinarachnius parma	52	0.04	69
Mytilus edulis	38	0.03	51
Goniada maculata	37	0.03	49
Tricophoxus epistomus	35	0.02	47
Aricidea quadrilobata	33	0.02	44
Aricidea jeffreysii	29	0.02	39
TOTALS	**1,500**		**N/A**

Table 42: Inter-Borrow Area Biomass, Spring 2001

Biomass of Organisms		
Taxa	Total Weight (grams)	Total No. per Square Meter
Polychaeta	2.85	3.80
Mollusca	7.91	10.55
Arthropoda	0.63	0.84
Echinodermata	22.36	29.81
Other	<0.01	<0.01
TOTAL BIOMASS	**33.75**	**45.0**

Table 43: Inter-Borrow Area Water Quality, Spring 2001

Dates Sampled: 6/1/01& 6/4/01						
Station	Bottom Temperature	Bottom Dissolved Oxygen	Bottom Salinity	Bottom pH	Visibility	Bottom Conductivity
	(EC)	(mg/l)	(ppt)		(meters)	(mS)
2	12.1	9.48	30.7	8.0	3.25	35.66
4	12.3	8.64	30.8	8.0	3.25	35.88
6	11.5	8.79	31.0	7.9	3.75	35.28
8	13.4	8.77	30.3	7.9	3.0	36.35
10	12.5	9.00	30.8	8.0	2.0	36.10
12	11.8	8.49	31.1	7.9	2.25	35.78
14	11.5	8.52	31.0	7.9	2.5	35.43
16	11.5	8.54	30.8	7.9	2.0	35.19
18	12.2	8.59	30.9	7.9	1.5	35.92
20	11.8	8.13	30.9	8.0	2.5	35.56
22	11.9	8.48	30.7	7.9	5.5	35.53
23	12.0	8.30	30.6	8.0	6.0	35.57
24	13.4	8.48	29.7	7.9	4.0	35.77
27	12.0	9.25	30.7	8.0	3.25	35.44
29	11.8	9.54	30.7	8.0	3.25	35.44
Mean	**12.1**	**8.73**	**30.7**	**-**	**3.2**	**35.66**

The Shannon-Weaver Diversity Index for the Inter-Borrow Area is 2.77. Based on the diversity index, the Inter-Borrow Area ranks second in comparison with the borrow areas sampled.

Water quality data summarized above is plotted in Figure 31. The average collection depth in this borrow area was approximately 13 meters. A total of 1,791 individuals representing 54 taxa were identified for the Inter-Borrow Area during the Spring. Table 41 shows the dominant organisms present during this sampling period. The amphipods, *P. wigleyi* and *G. oceanicus* were the most abundant comprising 25 % and 19 % of the organisms identified, respectively. Additional dominant species included the archiannelid worm *P. triestinus (11 %),* Nematoda (10 %), and the clam *T. agilis* (9 %).

The amphipods, *P. wigleyi* (493 indiv/m^2) and *G. oceanicus* (380 indiv/m^2) were present in the highest densities. The archiannelid *P. triestinus* (220 indiv/m^2) and nematode worms (196 indiv/m^2) were also abundant. Percent composition by abundance of the dominant taxa is shown in Figure 32.

Echinodermata (22.36 g) had the highest biomass, followed by Mollusca (7.91 g). Percent composition by biomass of the dominant taxa for the Inter-Borrow area is shown in Figure 33.

Sediment at the borrow area consisted of mostly sand, with a small amount of clay. Sediment grain size distribution is shown in Figure 34.

6.0 STATISTICAL SUMMARY

This section summarizes the results of the statistical analyses performed. Abundance, diversity and similarity between borrow areas is presented below.

1) Abundance per Borrow Area

Tables 44A and 44B summarize abundances for each of the borrow areas for the two sampling periods.

Table 44A: Abundance (number per square meter) by Borrow Area, Fall 2000

Phylum	Borrow Area						
	2A	2B	2C	4	5	WOSI	IB
Rhynchocoela	0	0	0	0	0	0	0
Nematoda	0	68	36	5	6	64	39
Platyhelminthes	0	8	2	3	6	0	1
Cnidaria	8	0	0	3	2	0	1
Archiannelida	224	1,004	1,378	48	42	165	269
Annelida	416	460	398	648	544	292	1,033
Mollusca	208	216	142	267	350	109	427
Arthropoda	880	664	700	955	1,626	1,001	1,129
Echinodermata	256	280	340	213	170	137	84
Nematomorpha	0	0	0	0	2	0	16
Totals	**1,992**	**2,700**	**2,996**	**2,142**	**2,748**	**1,768**	**2,999**

Table 44B: Abundance (number per square meter) by Borrow Area, Spring 2001

Phylum	Borrow Area						
	2A	2B	2C	4	5	WOSI	IB
Rhynchocoela	0	4	8	5	6	28	0
Nematoda	200	2,008	1,284	381	350	1,327	196
Platyhelminthes	0	8	0	29	0	5	1
Cnidaria	0	0	0	5	0	0	0
Chaetognatha	0	0	0	0	0	0	0
Archiannelida	96	1,016	1,820	256	64	779	220
Annelida	160	988	704	752	564	303	516
Mollusca	192	432	256	413	224	157	355
Arthropoda	4,408	544	550	923	1438	745	1,031
Echinodermata	24	132	142	88	10	127	69
Nematomorpha	0	0	0	0	0	0	0
Totals	**5,080**	**5,132**	**4,764**	**2,852**	**2,656**	**3471**	**2,388**

Borrow Areas 2B, 2A and 2C had the highest overall densities in the Spring, respectively. The Inter-Borrow Area had the lowest overall density during the Spring. Except for Borrow Area 5 and the Inter-Borrow Area stations, all other borrow areas had higher densities in Spring 2001 than Fall 2000. Borrow Area 5 had approximately the same number of organisms in both Fall and Spring, while the Inter-Borrow Area had more organisms in the fall.

The phylum with the highest overall density was Arthropoda, constituting 36.6% of the total composition. Nematoda (21.8%), Archiannelida (16.1%), Annelida (15.1%) and Mollusca (7.7%) also contributed significantly to percent composition.

2) Shannon-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 the principle of information theory (see methods section). A higher H' value indicates a greater diversity. A value of H' was calculated for each borrow area and borrow areas were ranked accordingly (see Tables below).

Table 45A: Biological Diversity Index (H') Values, Fall 2000

Borrow Area	H' Value
IB	2.79
4	2.62
WOSI	2.59
2A	2.56
5	2.39
2B	2.29
2C	2.06

Table 45B: Biological Diversity Index (H) Values, Spring 2001

Borrow Area	H' Value
4	2.86
IB	2.77
WOSI	2.21
2B	2.20
2C	2.08
5	2.04
2A	1.57

Comparison between Fall 2000 and Spring 2001 Shannon-Weaver Indices:

Diversity was slightly higher in the Fall, with a mean H' of 2.47 compared to a mean H' of 2.25 in the Spring. The range in the Spring H' values, however, was slightly higher, ranging from 1.57 to 2.86, compared to a range of 2.06 to 2.79 in the Fall. A statistical comparison of Fall 2000 and Spring 2001 data indicated that there was no significant difference in the mean Shannon-Weaver Index values. Both H' mean values were normally distributed (p= 0.27 for 2-tailed, p= 0.13 for 1-tailed tests).

With little exception, diversity was fairly uniform over the two sampling efforts. The two most diverse areas for both seasons were Borrow Area 4 and the Inter-borrow Area. Borrow Areas 2A and 2C were the least diverse.

3) Jaccard's Index

Jaccard's Indices were computed for the ten borrow areas and arranged in the matrix shown in Table 46A. The indices are deliberately repeated in the table, with repeats 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 46A Jaccard's Index Summary for All Borrow Areas, Fall 2000

JACCARD'S INDEX - November 2000

	IB	WOSI	2A	2B	2C	4	5
IB		0.571	0.393	0.390	0.492	0.443	0.556
WOSI	0.571		0.404	0.489	0.583	0.551	0.536
2A	0.393	0.404		0.395	0.435	0.404	0.382
2B	0.390	0.489	0.395		0.707	0.489	0.538
2C	0.492	0.583	0.435	0.707		0.490	0.564
4	0.443	0.551	0.404	0.489	0.490		0.593
5	0.556	0.536	0.382	0.538	0.564	0.593	

The computed indices for Fall 2000 range from 0.382 to 0.707, with a mean of 0.495 and a standard deviation of 0.087. Borrow areas with the least proportion of species in common are 2A and 5, as indicated by the lowest index of 0.382. Borrow areas 2B and 2C are the most similar in terms of species composition, as indicated by the highest index of 0.707. Twelve pairs of borrow areas had less than 50% of species in common, while 9 pairs had more than 50% of their species in common.

Distinctive Borrow Areas:

Table 46B: Jaccard's Index Summary for All Borrow Areas, Spring 2001

JACCARD'S INDEX - June 2001

	IB	WOSI	2A	2B	2C	4	5
IB		0.507	0.327	0.397	0.397	0.485	0.357
WOSI	0.507		0.328	0.460	0.547	0.500	0.333
2A	0.327	0.328		0.386	0.417	0.298	0.361
2B	0.397	0.460	0.386		0.482	0.413	0.362
2C	0.397	0.547	0.417	0.482		0.477	0.365
4	0.485	0.500	0.298	0.413	0.477		0.328
5	0.357	0.333	0.361	0.362	0.365	0.328	

The computed Jaccard Indices for Spring 2001 range from 0.298 to 0.547, with a mean of 0.406 and a standard deviation of 0.0718. The lowest index of 0.298, comparing Borrow Areas 2A and 4, indicates that the samples collected from these areas had the least similar species composition of all borrow area pairs. The highest index of 0.547 is shared by one pair of borrow areas, SH and 2C. Borrow areas WOSI and 2C are most alike, having a higher proportion of species in common than the other borrow areas. During the Spring 2001, 18 pairs of borrow areas had less than 50% of their species in common, while only three pairs had more than 50% of their species in common.

Comparison between Fall 2000 and Spring 2001 Jaccard's Indices:

A comparison of the Fall 2000 and Spring 2001 Jaccard's Indices is summarized in Table 47 below.

Table 47: Comparison between Fall 2000 and Spring 2001 Jaccard's Indices:

	Fall 2000	Spring 2001
Mean Jaccard's Index (standard deviation)	0.496(0.087)	0.406(0.072)
Least similar Borrow Areas	2A and 5	2A and 4
Number of pairs with 0.250 < JI < 0.350	0	5
Number of pairs with 0.351 < JI < 0.450	8	9
Number of pairs with 0.451 < JI < 0.550	6	7
Number of pairs with 0.551 < JI < 0.650	6	0
Number of pairs with 0.651 < JI < 0.750	1	0
Most similar Borrow Areas	2B and 2C	WOSI and 2C

In general, borrow areas had more species in common in the Fall than the Spring. Notable among the borrow areas are 2A and 2C. Borrow Area 2A had the weakest similarity to other borrow areas in both seasons. Borrow Area 2C had the strongest similarity to other borrow areas.

7.0 DISCUSSION

7.1 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. In addition to the present study, sampling was completed by the USACE in separate studies during 1983, 1996, 1997/1998 and 1999. 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). The present 2000/2001 study (the subject of this investigation) includes analyses on four of the eight borrow areas east of the Fire Island Inlet, as well as sampling sites between the borrow areas (referred to as Inter-Borrow Area stations). The shape and position of the borrow areas have been redesigned over time and is different from earlier studies. This restructuring of the borrow areas was done so that the borrow areas contain habitat with sediment suitable for beach replenishment. In most of the borrow areas, a subset of the original stations was sampled as part of this study.

Non-site specific sampling occurred off the Rockaways, Long Island by the USACE (1999) and in adjacent areas off New Jersey by the USACE 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 (USACE 1996) to 198 taxa from USACE (1983). The key variable appears to be a seasonal Spring/Fall variation in species composition throughout all the collection periods. Although, the dominant species remain similar, the magnitude of the dominance varies by season and station.

Summary of Studies Conducted by USACE (1983)

The study conducted by USACE (1983) indicated that the samples were dominated by the following species during the Spring, Summer, and Fall sampling periods: *S. bombyx, T. agilis, P. wigleyi*, Nematoda, *Asabellides oculata, S. solidissima, Magelona rioja*, and *G. annulatus.* Only *S. bombyx* and *T. agilis* were dominant species during Spring, Summer and Fall sampling periods. The additional taxa, *P. wigleyi,* Nematoda, and *A. oculata*, were dominant during two out of the three sampling periods. *S. solidissima, M. rioja,* and *G. annulatus* were dominant during one of the three sampling periods.

Summary of Studies Conducted by USACE (1996)

The USACE 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, and *P. wigleyi*. The Fire Island Borrow Area was primarily dominated by Annelida, Nemertea, and Nematoda. The Shinnecock station was dominated by the following species: *P. wigleyi, Psammonyx nobilis, T. agilis, G. annulatus*, and *A. millsi* (accounting for 60.7

% of the organisms found at the Shinnecock Borrow Area).

Most species were present at both stations in varying abundances, with the exception of two species. The annelid, *T. acutus* was absent from the Fire Island station and the arthropod, *P. nobilis* was absent from the Shinnecock station. *T. 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 within their range.

Summary of Studies Conducted by USACE 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 USACE 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, A. oculata* and individuals belonging to the families Cirratulidae and Maldanidae. The annelid species *A. oculata* and the archiannelid *Polygordius* sp., as well as the arthropod *G. annulatus,* were the most abundant during November 1997. The dominant species composition changed during the Spring and Fall of 1998. The samples collected in June of 1998 were dominated by the annelid species *Brania wellfleetensis* along with members of the genus *Polygordius* sp., oligochaetes, and rhynchocoels. The October 1998 indicated the dominance of two mollusc species, *S. solidissima* and *T. agilis.* This distribution differed from the October 1997 effort in which neither species was dominant.

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 with the dominants including, *S. solidissima*, *E. parma*, *Polygordius* sp., and *Tanaissus psammophilus*. Samples collected in June 1998 varied from the previous year. In June 1998, oligochaetes, rhynchocoels and the species *Scolelepis squamata* were dominant. This varied again in the Fall when the annelid *Polygordius* sp. was observed to be dominant. However, *P. wigleyi* and *Protohaustorius* sp. were also abundant in the Fall.

Summary of Studies Conducted by USACE 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 indicated that although the area is typically comprised of sand (ranging from an average of 93 % in 1992 to 89 % in 1998), the benthic community structure is different from those observed in samples collected by the USACE in 1999 further east on Long Island.

The dominant benthic species identified were organisms typically classified as recovery species, species that typically dominate after a disturbance occurs. These species are deposit feeders and would also occur in areas where there is a greater incidence of sediment fines and organics. Such recovery species would include, *Mediomastus ambiseta*, *Ampelisca abdita*, *Streblospio benedicti* and oligochaetes. Under normal conditions, sandy sediments support a high diversity and great abundance of benthic species. However, the abundance of these species in addition to the limited species diversity (associated with reduced species abundance, i.e., 2 to 4 species dominance) suggests that the sediments, although sandy, were adversely influenced by poor water quality conditions in New York Harbor. Despite the low periodic diversity, two clam species were abundant, the surf clam (*S. solidissima*) and the dwarf tellin *(T. agilis)*.

<u>Summary of Studies Conducted by USACE at New Jersey (1994-1999)</u>

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

<u>Discussion of Studies Conducted by USACE (1999)</u>

In general, a review of the study results from the 1999 borrow areas show similar numerical abundance by species to other studies conducted in the area. One notable difference in 1999 project findings compared to other studies was the presence of taxa such as *P. triestinus*, nematodes, and nemertean worms. This was most likely due to the fact that these are smaller organisms that were not collected in either the 1983 or 1996 studies. During 1999 the program utilized a 0.5 mm sieve, whereas most of the earlier programs used a 1.0 mm sieve, thereby accounting for the differences in species occurrence and abundance. Although these species are abundant, they weigh little, not contributing greatly to biomass.

The sand dollar (*E. parma*) was one of the most abundant species observed in the 1999 study. *Echinarachnius parma* also had the greatest weight per sample, contributing significantly to biomass. This was due the weight of the heavy calcareous shells of the organisms. Molluscs had the second largest biomass (kg/m^2) per sample. Molluscs were represented by 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 molluscs 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. obliquua*, *G. annulatus*, and *A. millsi*. In Fall 1999, the benthic community of Borrow

Area 2A included 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 were somewhat less abundant than other annelids, their comparative size can be much larger, thus increasing their biomass significantly. This can be observed in species like *C. torquata*, it has been reported to grow to a length of 150 mm (6 inches).

Comparison with Water Quality:

The following environmental variables were measured at the bottom for every other sample at each borrow area: temperature, dissolved oxygen, salinity, visibility (transparency), pH. 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. Due to the fact that there were no noticeable differences in water quality among the borrow areas, no comparison between species composition and water quality could be determined.

7.2 Comparison of Previous Investigations to USACE 2000/2001 Study

Assessments of the Study Area Comparisons

The results of USACE's Fall 2000/Spring 2001 study are comparable to other studies conducted in the waters off of eastern Long Island and 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 other USACE studies. The benthic species that were noted during the Coney Island study include pioneer species which are indicative of a disturbed system. However, subtle differences in physical habitat features may have also contributed to this observed difference.

The sand dollar (*E. parma*) was present at all of the borrow areas, although not as abundant in 2000/2001 as it was in USACE's 1999 study. The sand dollar accounted for the majority of the biomass in both seasons of the present study. Molluscs were consistently high in biomass at all borrow areas and were also fairly high in abundance during both sampling events. The clam *T. agilis* and *G. gemma* accounted for the majority of the molluscs. Arthropods dominated the borrow areas in abundance due to the presence of high numbers of the amphipods *G. oceanicus* and *P. wigleyi*. The biomass of arthropods ranked third in both the Fall and Spring, after Echinodermata and Mollusca.

Annelids were extremely abundant. The high number of polychaete worms, *M. rosea* in the Fall and *S. bombyx* in the Spring accounted for the high abundance of annelids. Although abundant, the annelids did not contribute significantly to biomass. Nematoda was the second highest taxon in abundance during the Spring, but only accounted for a small portion of the Fall collection. The biomass of this organism was not significant. Archiannelida were numerically abundant during both collection periods. The high abundance of archiannelids was due to the presence of the worm Family Polygordiidae and *P. triestinus.* Annelids did not contribute significantly to overall biomass in the samples.

Occurrence of Surf Clam (*S. solidissima*) - Fall 2000

Tables 48a and 48b summarize the distribution of the surf clam (*S. solidissima*) in this study. The surf clam was present in relatively low densities at Borrow Areas 4, 5 WOSI and Inter-Borrow locations. The greatest concentrations of surf clams were observed at the Inter-Borrow locations and Borrow Area 5. It is difficult to draw conclusions on spatial abundances based on these results. A detailed USACE study of the presence of adult surf clams in the potential borrow areas found the greatest abundances in the nearshore sampling stations of Borrow Area 2AD and a dense localized population near Shinnecock Inlet in the WOSI borrow area. (USACE, 2002) In the current study, no adult surf clams were observed in any of the samples, only younger stages. This could be due to the type of collection gear used in project. The dredge gear that is typically used by commercial fishermen to catch adult surf clams was not employed for this project.

Table 48A: Occurrence of *Spisula solidissima*, Fall 2000

Occurrence of *Spisula solidissima*	
Borrow Area	Abundance (Number per M^2)
2A	0
2B	0
2C	0
4	160
5	400
WOSI	360
IB	800

In the Fall of 2000, the borrow areas that contained the highest number of *S. solidissima* were the Inter-Borrow Area stations (800 per m^2), followed by Borrow Area 5 (400 per m^2).

<u>Table 48B: Occurrence of *Spisula solidissima*, Spring 2001</u>

Occurrence of *Spisula solidissima*	
Borrow Area	Abundance (Number per M^2)
2A	0
2B	320
2C	0
4	0
5	120
WOSI	40
IB	40

In the Spring of 2001, the borrow areas that contained the highest number of *S. solidissima* were Borrow Area 2B (320 per m^2), followed by Borrow Area 5 (120 per m^2).

The sampling effort conducted in Fall 2000 yielded higher average numbers of *S. solidissima* than the Spring 2001 effort; 246 per m^2 in the Fall, compared to 74 per m^2 in the Spring.

<u>Grain Size Comparisons</u>

Grain size distribution was fairly consistent for all borrow areas with the exception of Borrow Area 4 which had a higher percentage of clay and gravel. Grain size for the Inter-Borrow Area was grouped into four regions from east to west. Region 1 included the sample stations from west of the WOSI Borrow Area to Borrow Area 4. The combined results of the Fall and Spring grain size analyses for the borrow areas are shown in Figure 35. Grain size for the study area is primarily sand (96%), with much smaller fractions of clay (2%) and gravel (1%). Grain size for the Inter-Borrow Area stations were similar between regions and had minor, but consistently higher amounts of clay than the designated borrow areas (Figures 12, 21, 25 and 34).

8.0 CONCLUSIONS

The results of the Fall 2000 and Spring 2001 benthic sampling and analyses program are consistent with earlier programs given the inherent spatial and temporal variability of benthic communities. The south shore benthic communities are more similar to those of New Jersey than those found off the Rockaways. This is to be expected, given the close proximity of the

Rockaways to the impaired water quality of New York Harbor and the differences in other physical and chemical aspects of the systems. Physical and chemical habitat features, along with poor water quality can influence the nature of benthic communities. Considering the results of the above program, the following conclusions were drawn and supported by statistical analyses:

- Numerical abundance of benthic macroinvertebrates was generally consistent among borrow areas and between seasons (Fall and Spring). The borrow areas to the east generally had lower densities than the borrow areas to the west for both sampling efforts.

- Diversity indices were generally similar among borrow areas and between seasons. Borrow Area 7 had one of the highest diversity indices for both sampling efforts, while Borrow Area 2A had one of the lowest. The diversity indices were comparatively lower for the Fall sampling effort than the Spring.

- Overall biomass values were similar to biomass values attributable to sand dollars.

- Water quality was similar among the borrow areas; no relationship between species composition or distribution and water quality was evident.

- Borrow areas in deeper water tended to have higher abundances of organisms.

- Results of this program were comparable to programs conducted offshore of New Jersey, but noticeably different than those conducted offshore of Coney Island.

- Results of this program were comparable to other programs conducted by the USACE in 1983 and 1996 in the Long Island waters of Fire Island and Shinnecock, but were noticeably different than those conducted in 1997/1998 in the same region.

- The total number or organisms collected in the Fall of 2000 was slightly less than the total number collected during the Spring of 2001 (8,177 indiv/m^2 compared to 11,092 indiv/m^2).

- The commercially important surf clam, *S. solidissima,* was noted in varying densities in the study area. However, conclusions cannot be determined as the most efficient collecting gear for this organism was not used.

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Figure 1- Benthic Sampling Locations

Westernmost Limit of Sampling

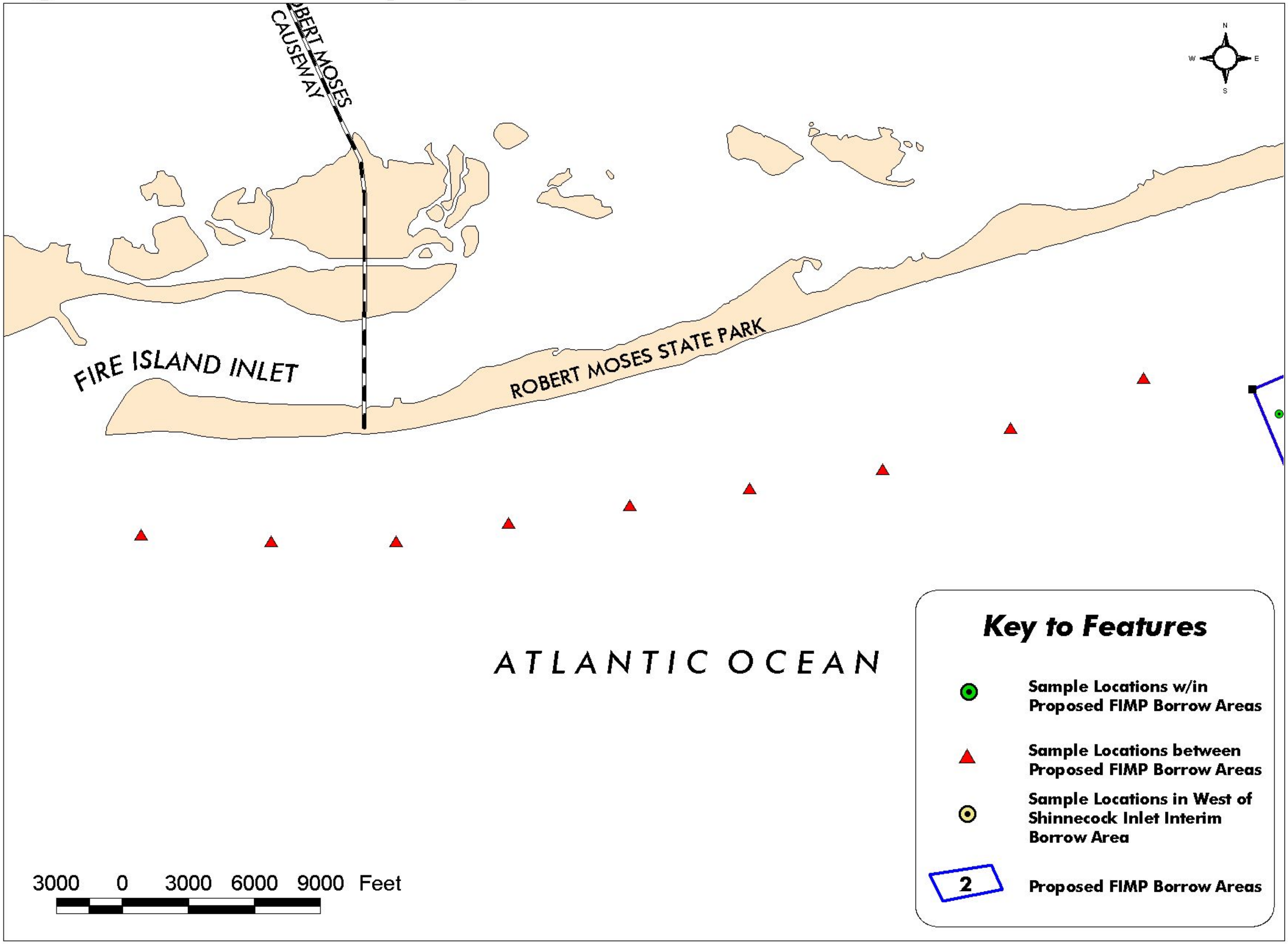


Figure 2- Benthic Sampling Locations

Borrow Areas 2A, 2B, 2C, 3A

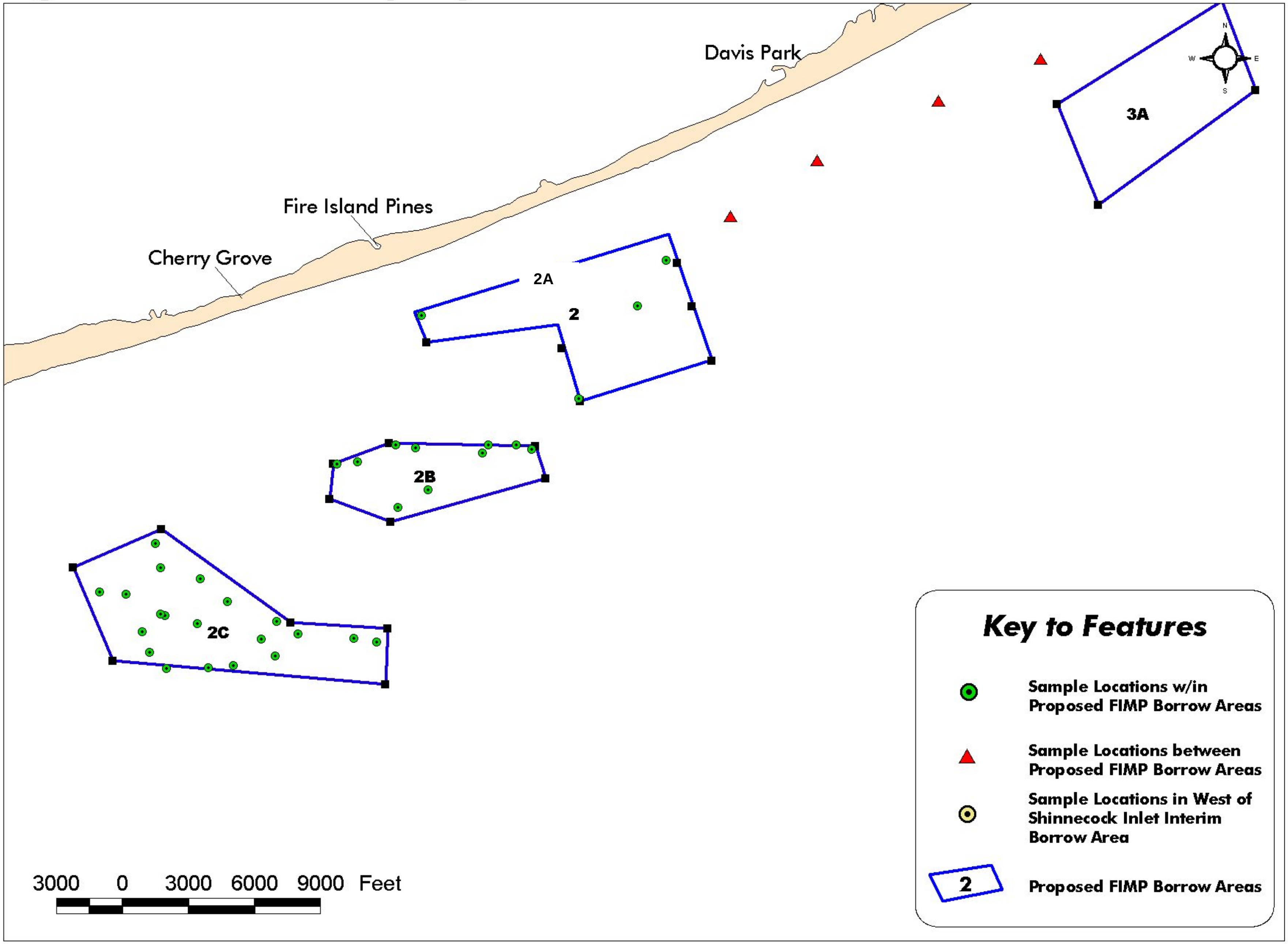


Figure 3- Benthic Sampling Locations

Borrow Areas 3A

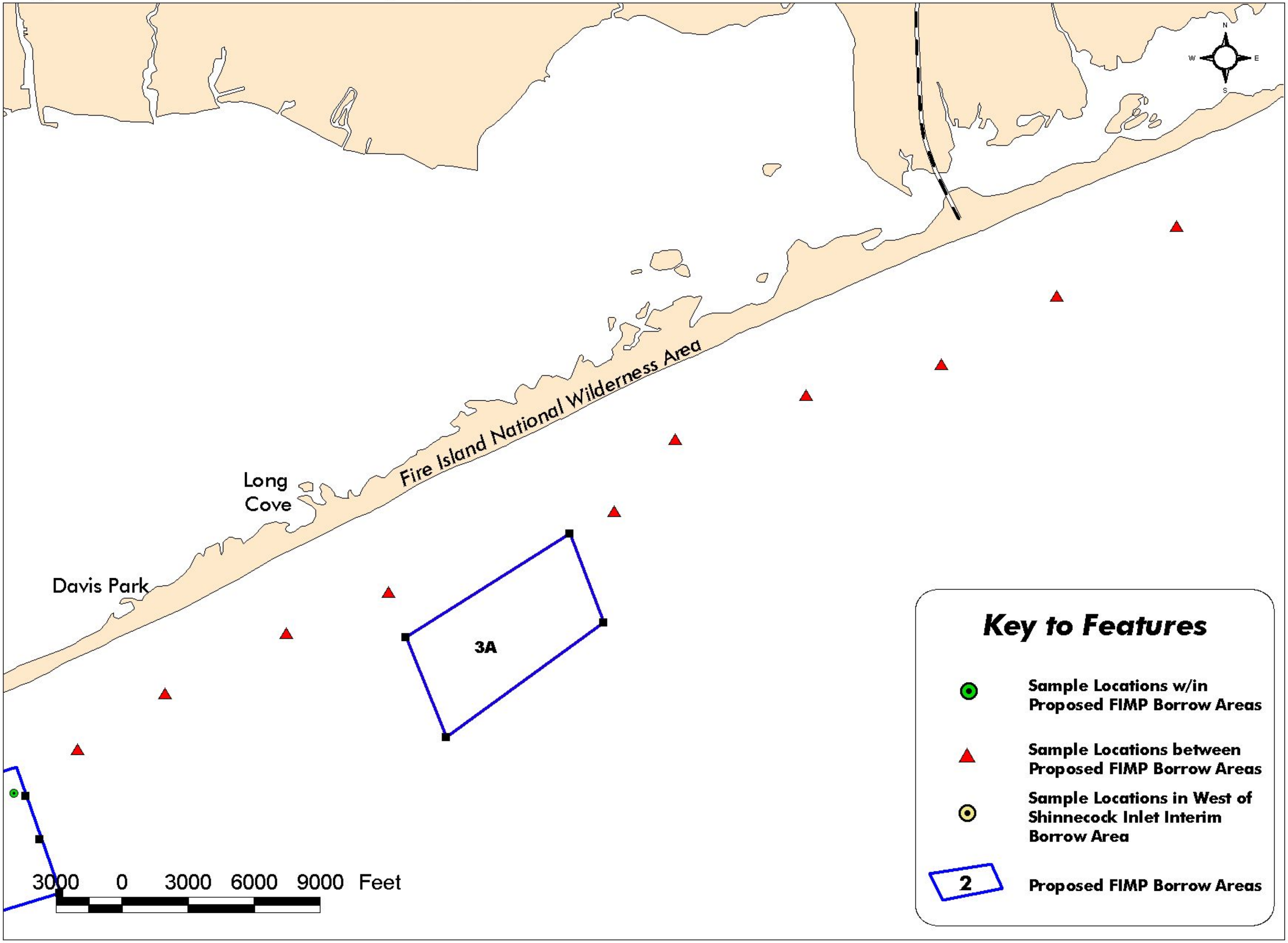
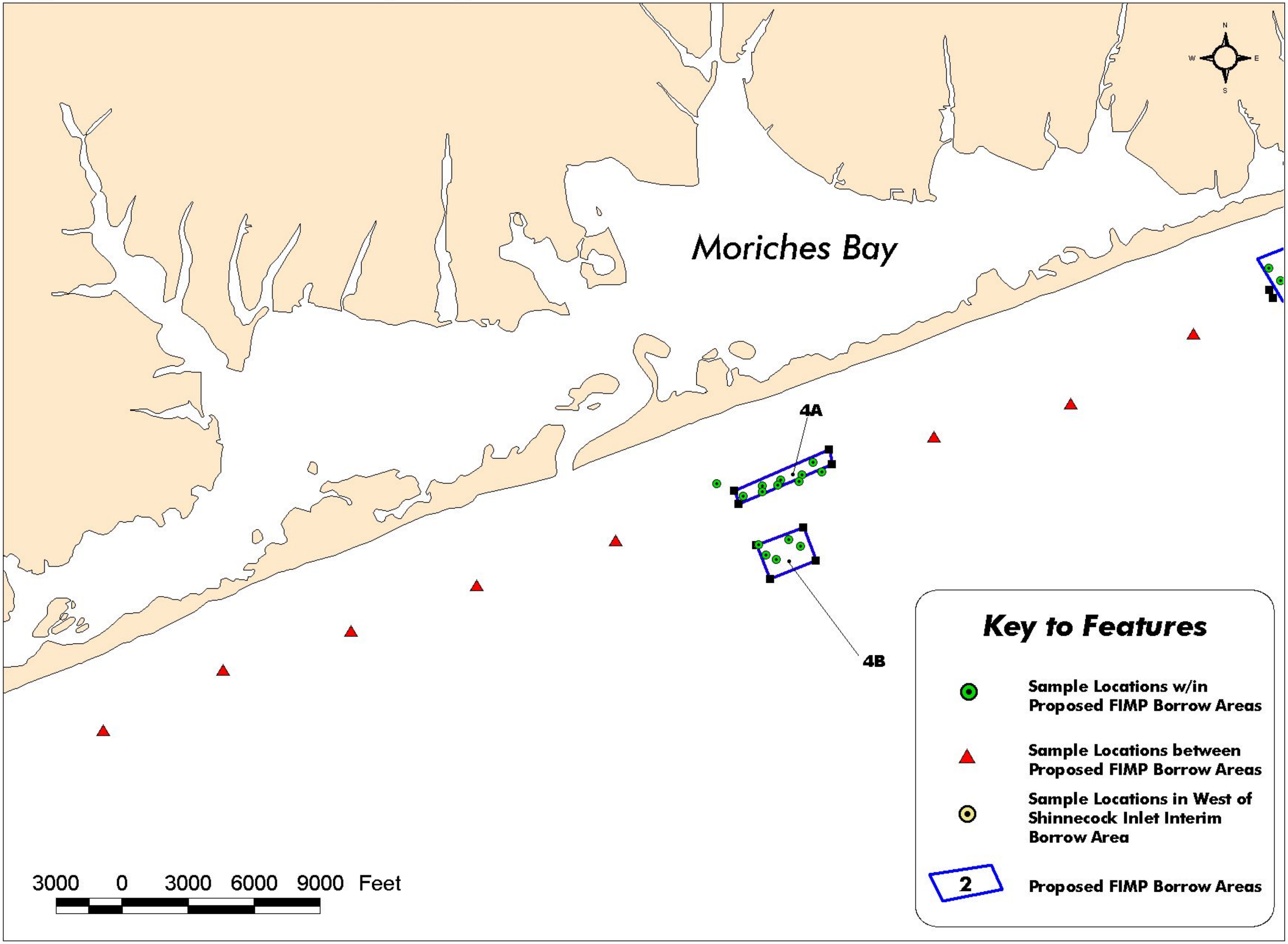


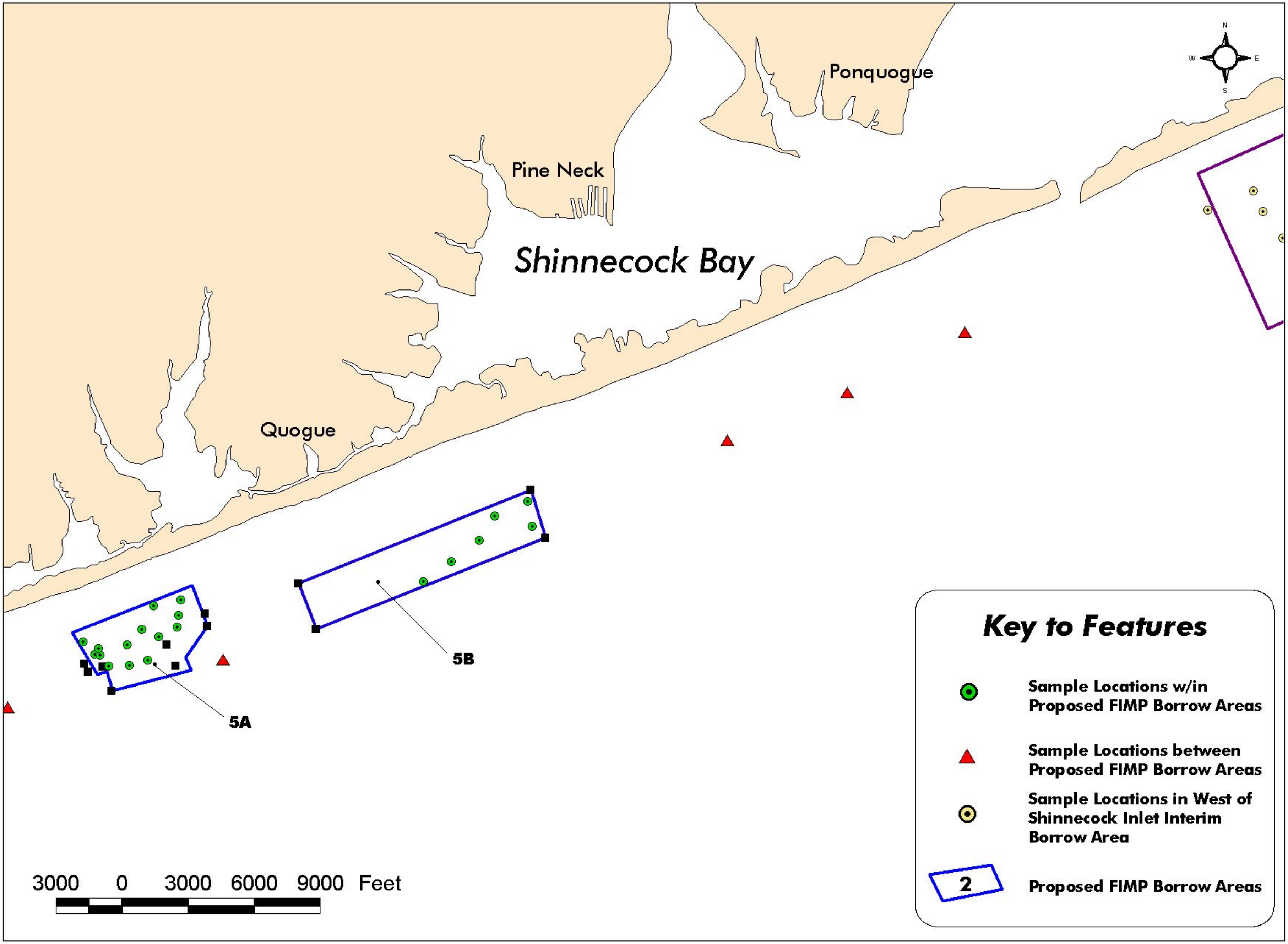
Figure 4- Benthic Sampling Locations

Borrow Areas 4A, 4B



Borrow Areas 5A, 5B

Figure 5- Benthic Sampling Locations



Borrow Areas 6A, WOSI

Figure 6- Benthic Sampling Locations

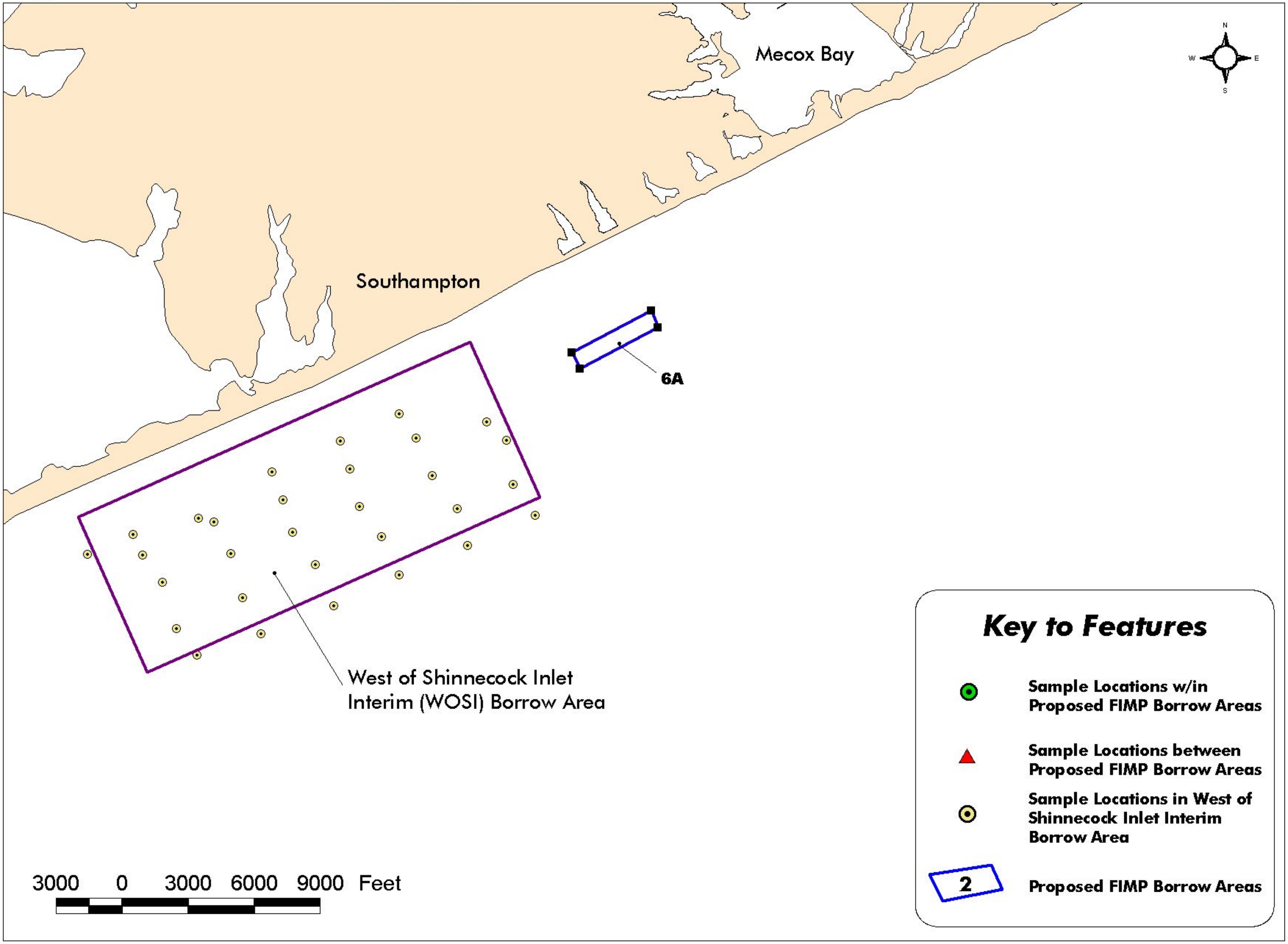
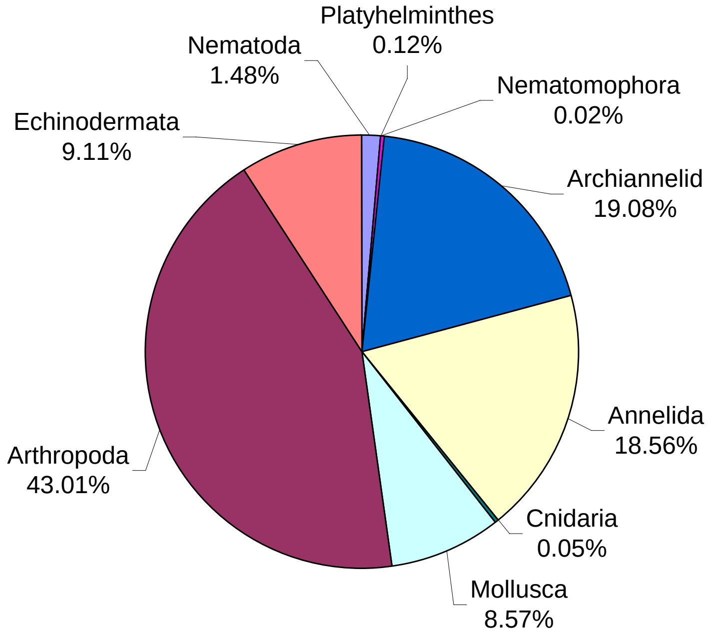
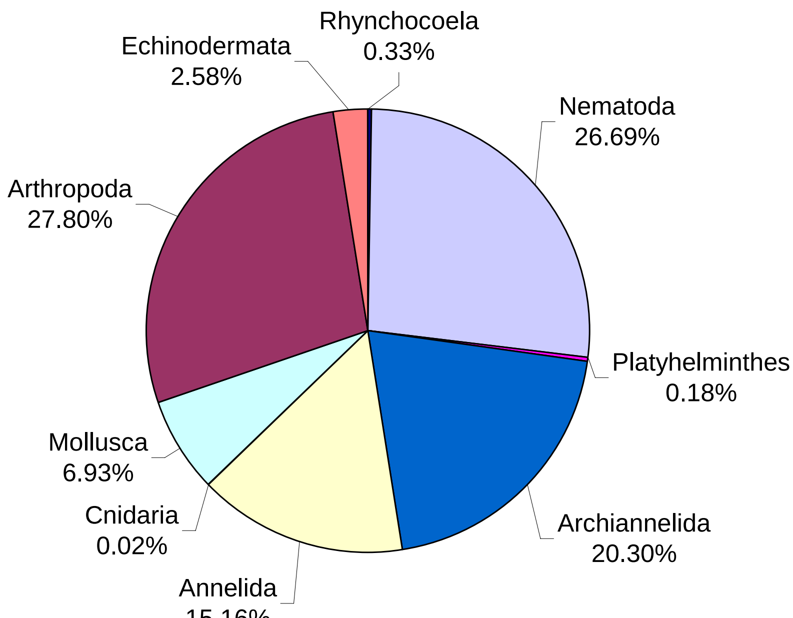


FIGURE 7
Percent Composition by Abundance at the Proposed Borrow Areas in Fall 2000 and Spring 2001

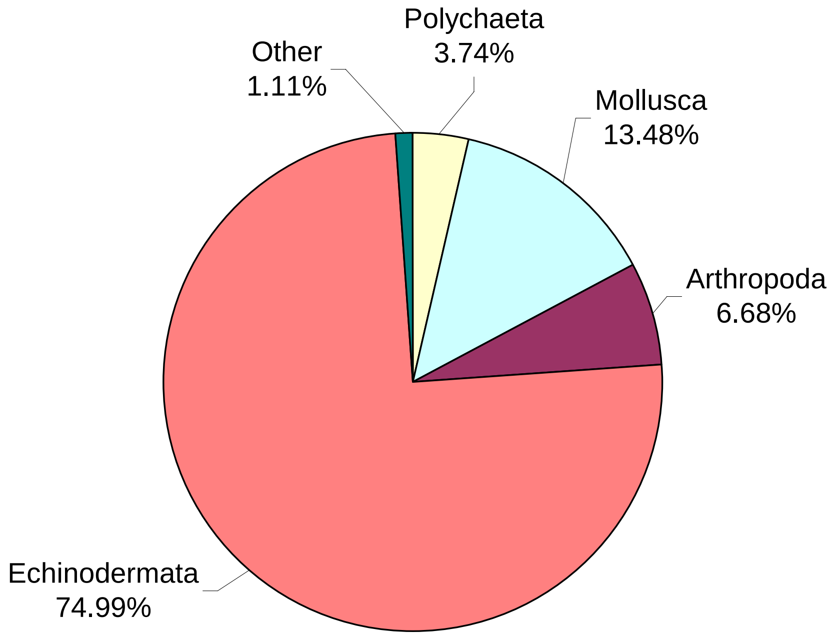


Fall 2000

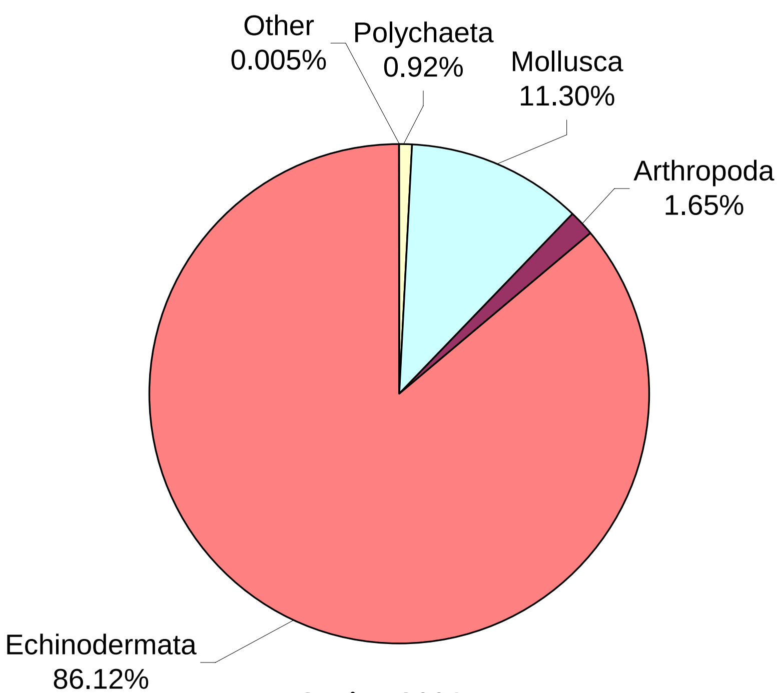


Spring 2001

FIGURE 8
Percent Composition by Biomass of Benthic Organisms Collected from Proposed Borrow Areas in Fall 2000 and Spring 2001



Fall 2000



Spring 2001

FIGURE 9
Water Quality for Borrow Area 2A
Fall 2000

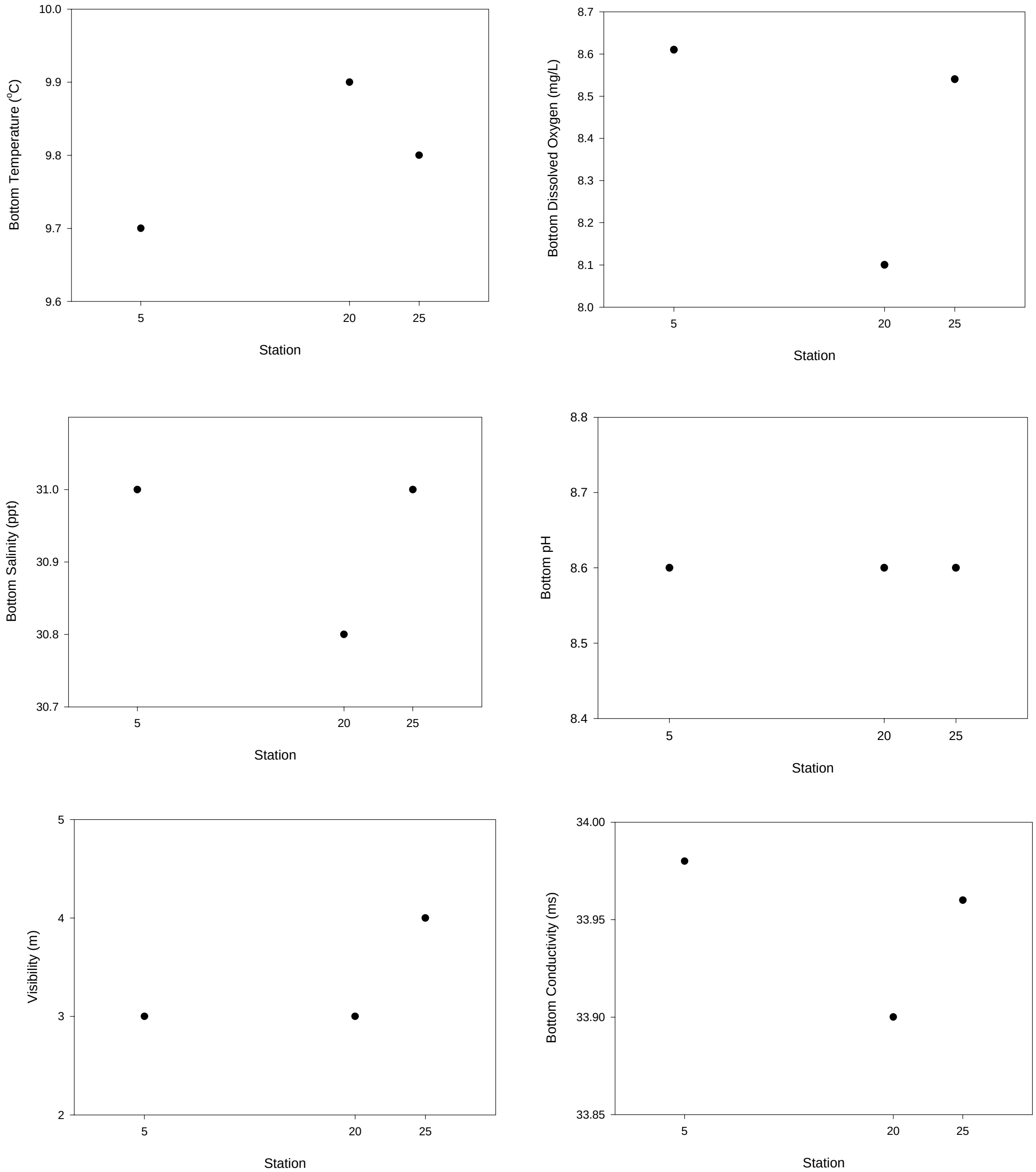
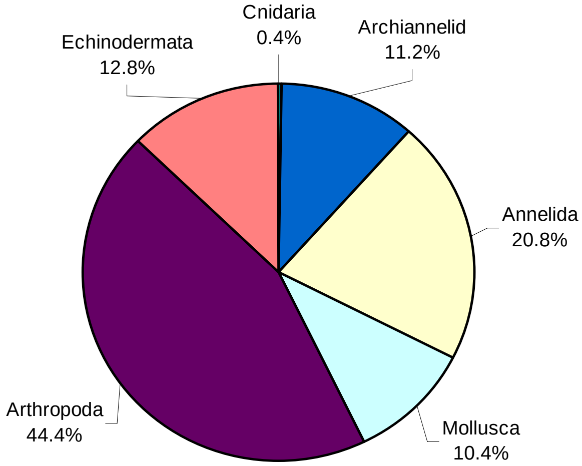
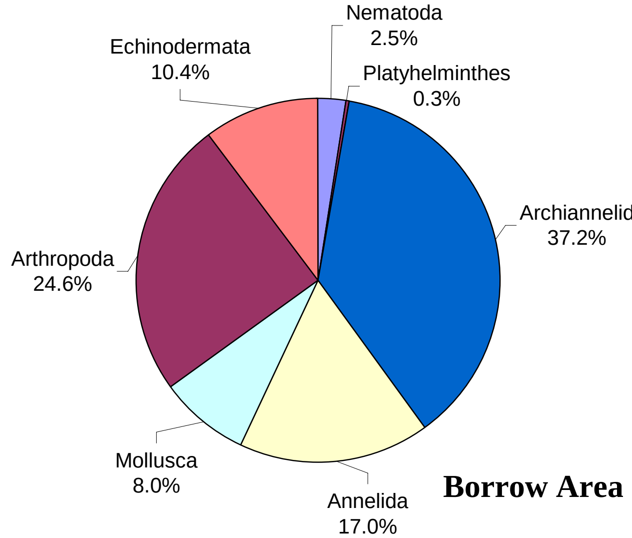


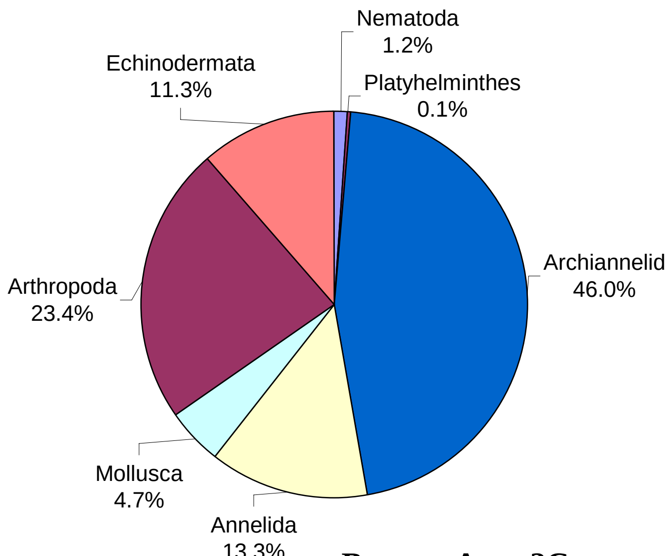
FIGURE 10
Percent Composition by Abundance of Benthic Organisms
Collected from Proposed Borrow Areas in Fall 2000



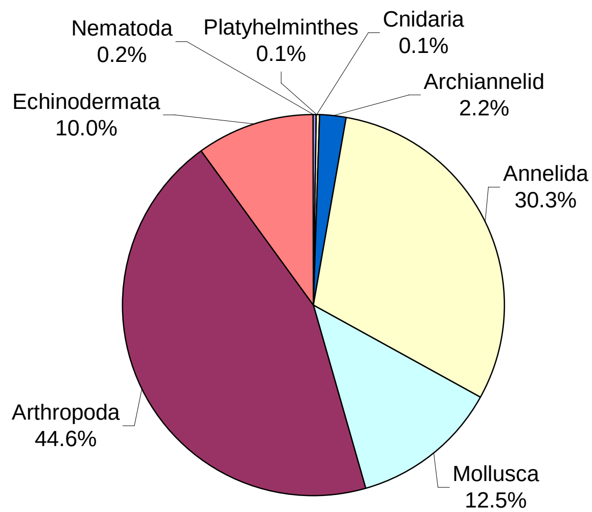
Borrow Area 2A



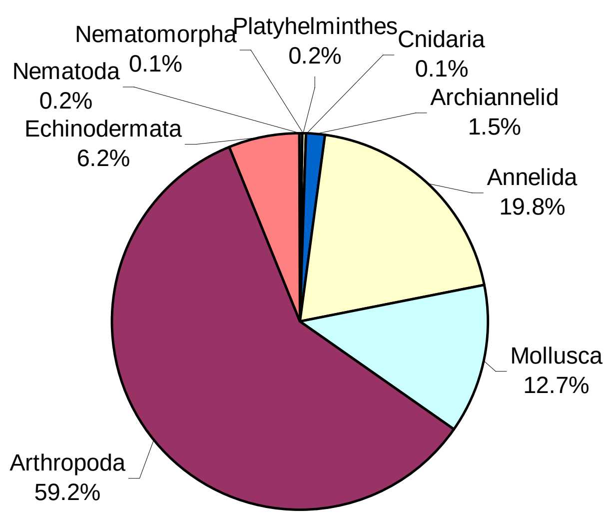
Borrow Area 2B



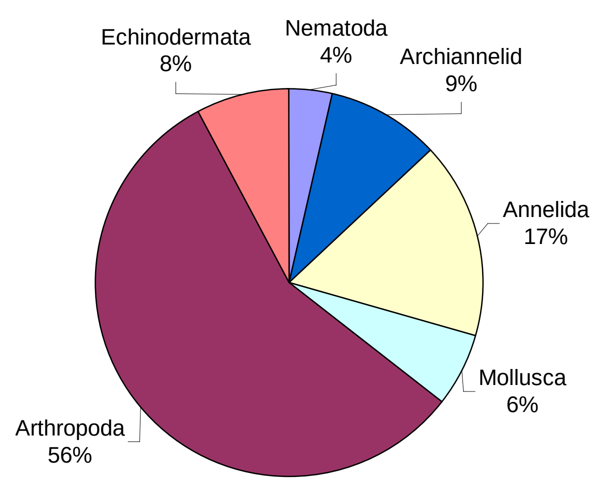
Borrow Area 2C



Borrow Area 4



Borrow Area 5



WOSI Borrow Area

FIGURE 11
Percent Composition by Biomass of Benthic Organisms
Collected from Proposed Borrow Areas in Fall 2000

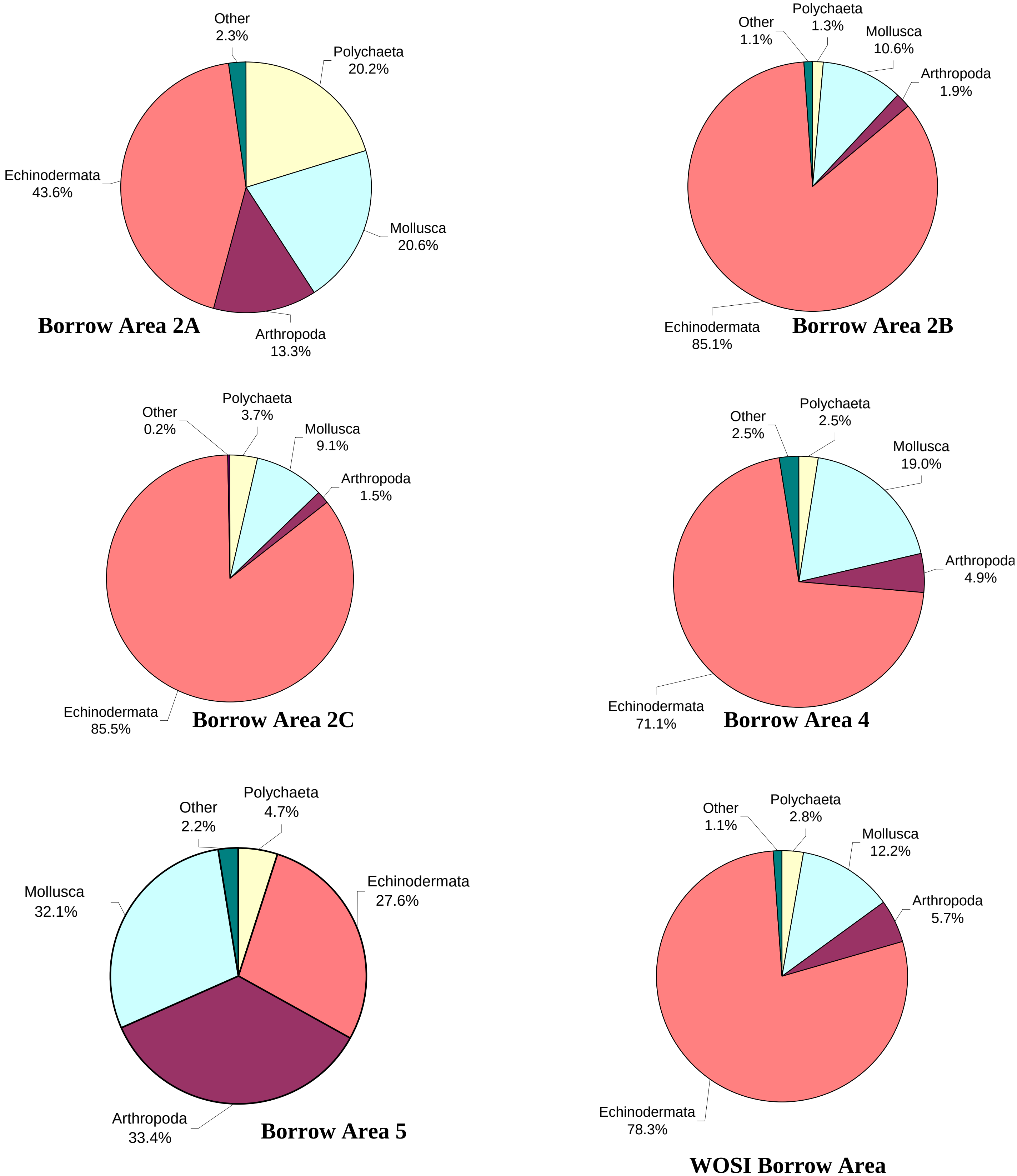


FIGURE 12
Grain Size Analysis for Proposed Borrow Areas in Fall 2000

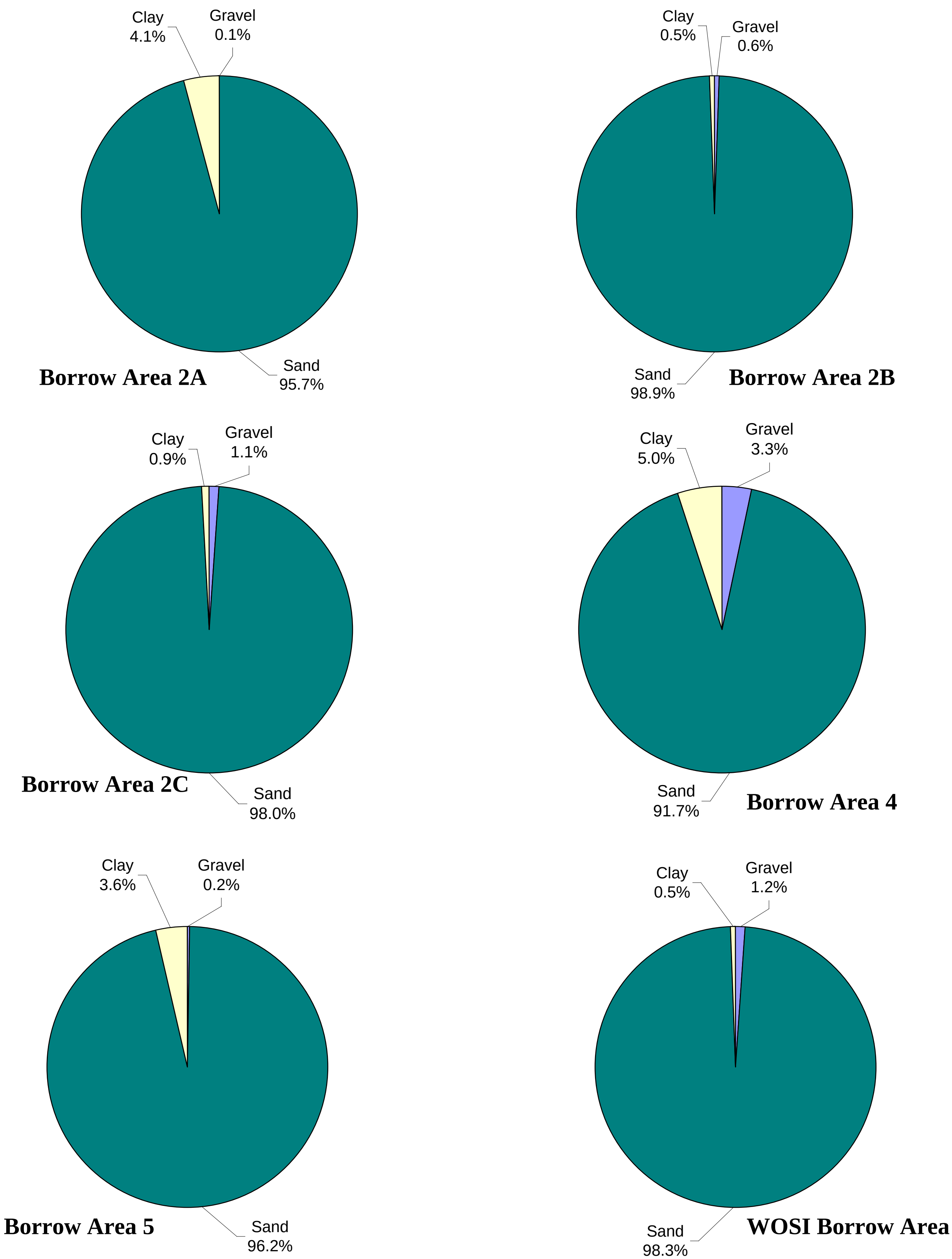


FIGURE 13
Water Quality for Borrow Area 2B
Fall 2000

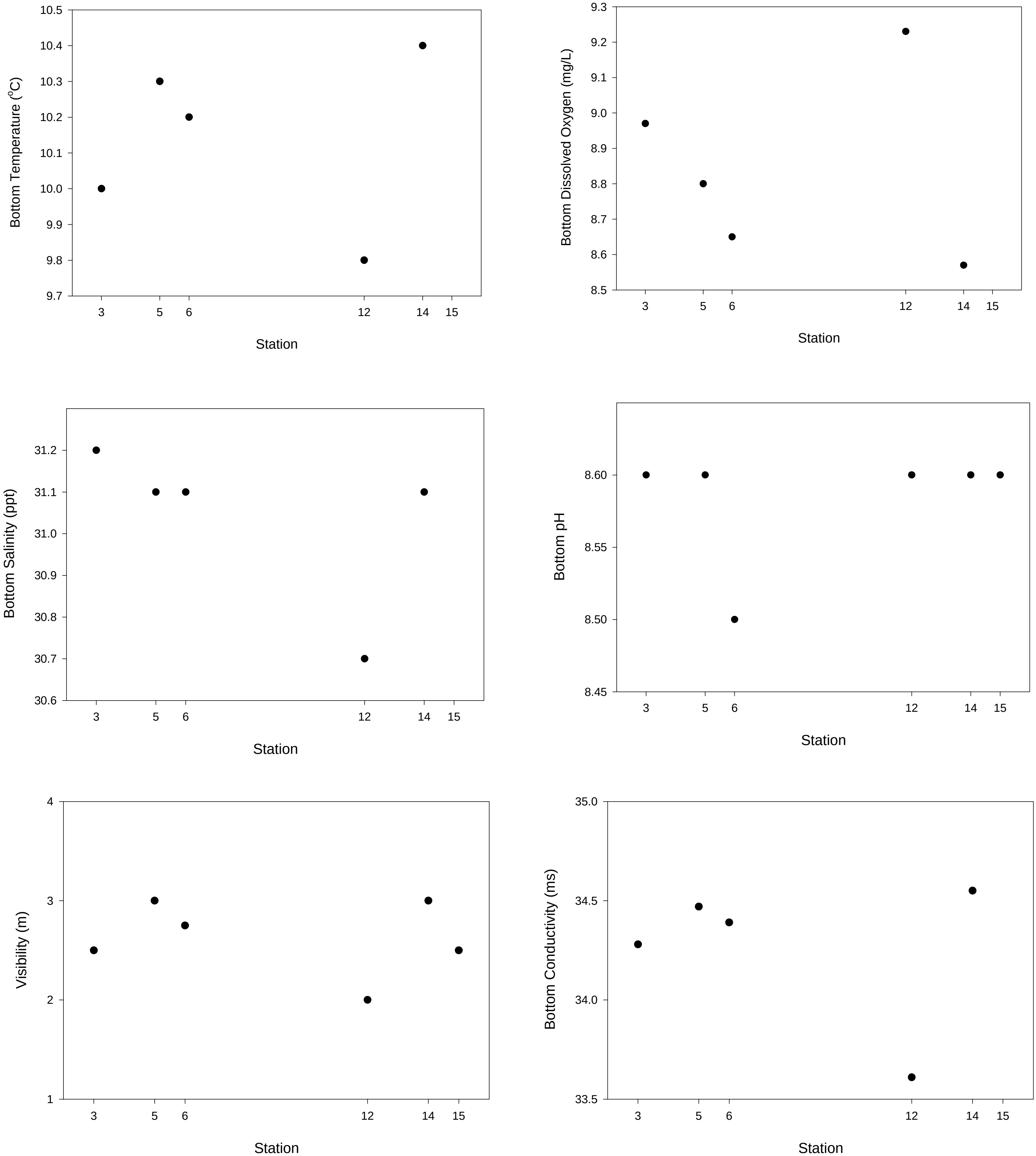


FIGURE 14
Water Quality for Borrow Area 2C
Fall 2000

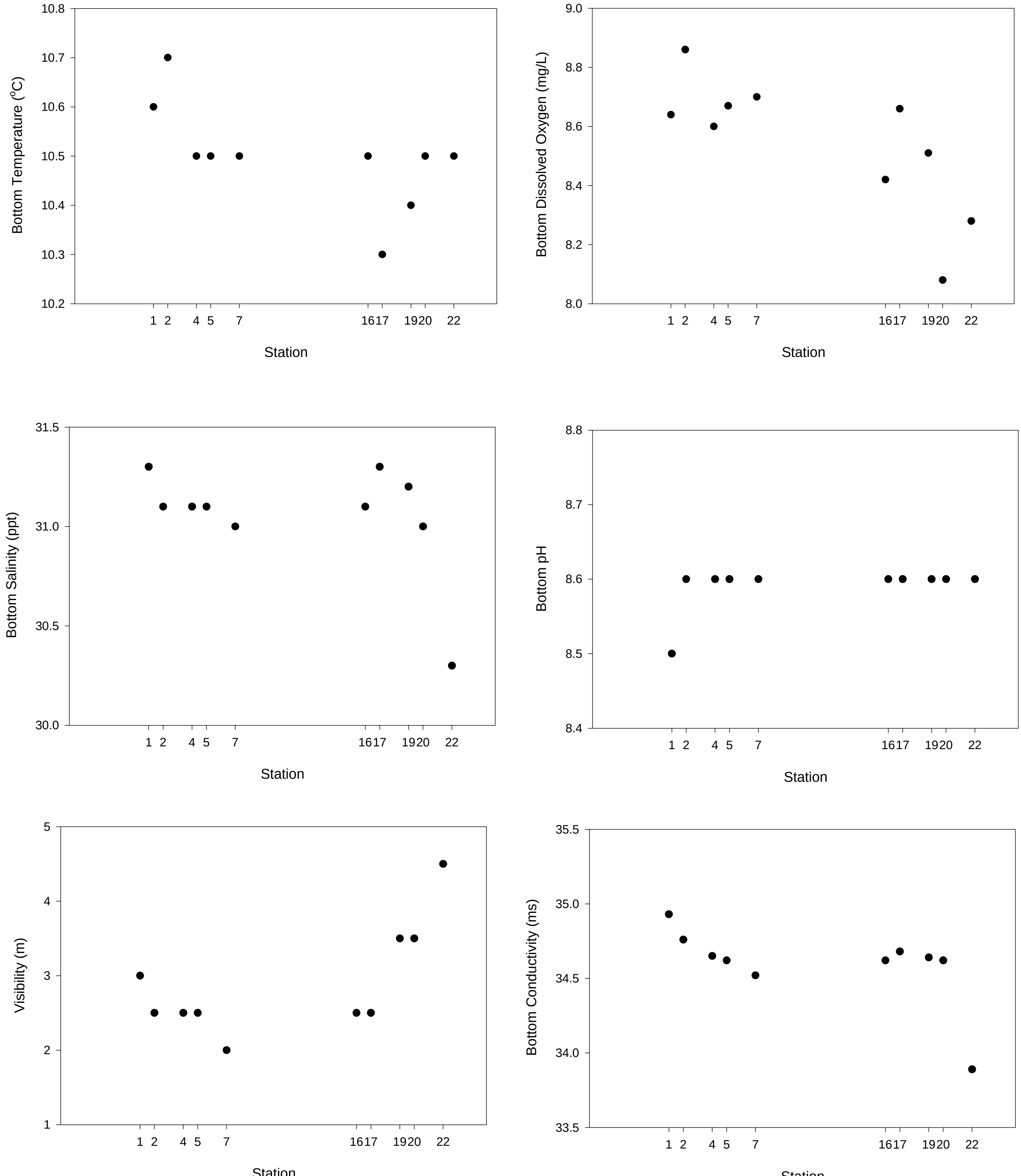


FIGURE 15
Water Quality for Borrow Area 4
Fall 2000

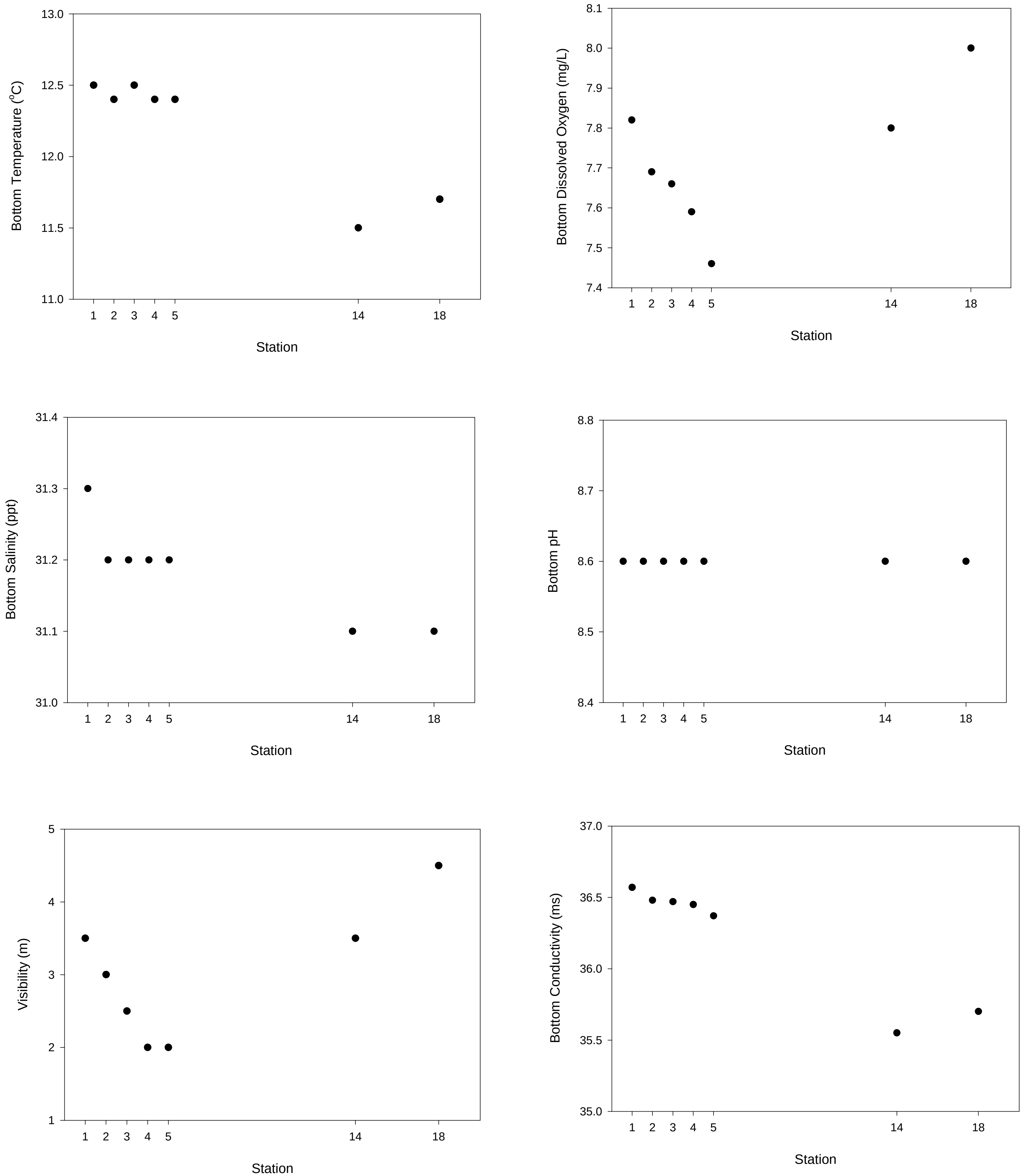


FIGURE 16
Water Quality for Borrow Area 5
Fall 2000

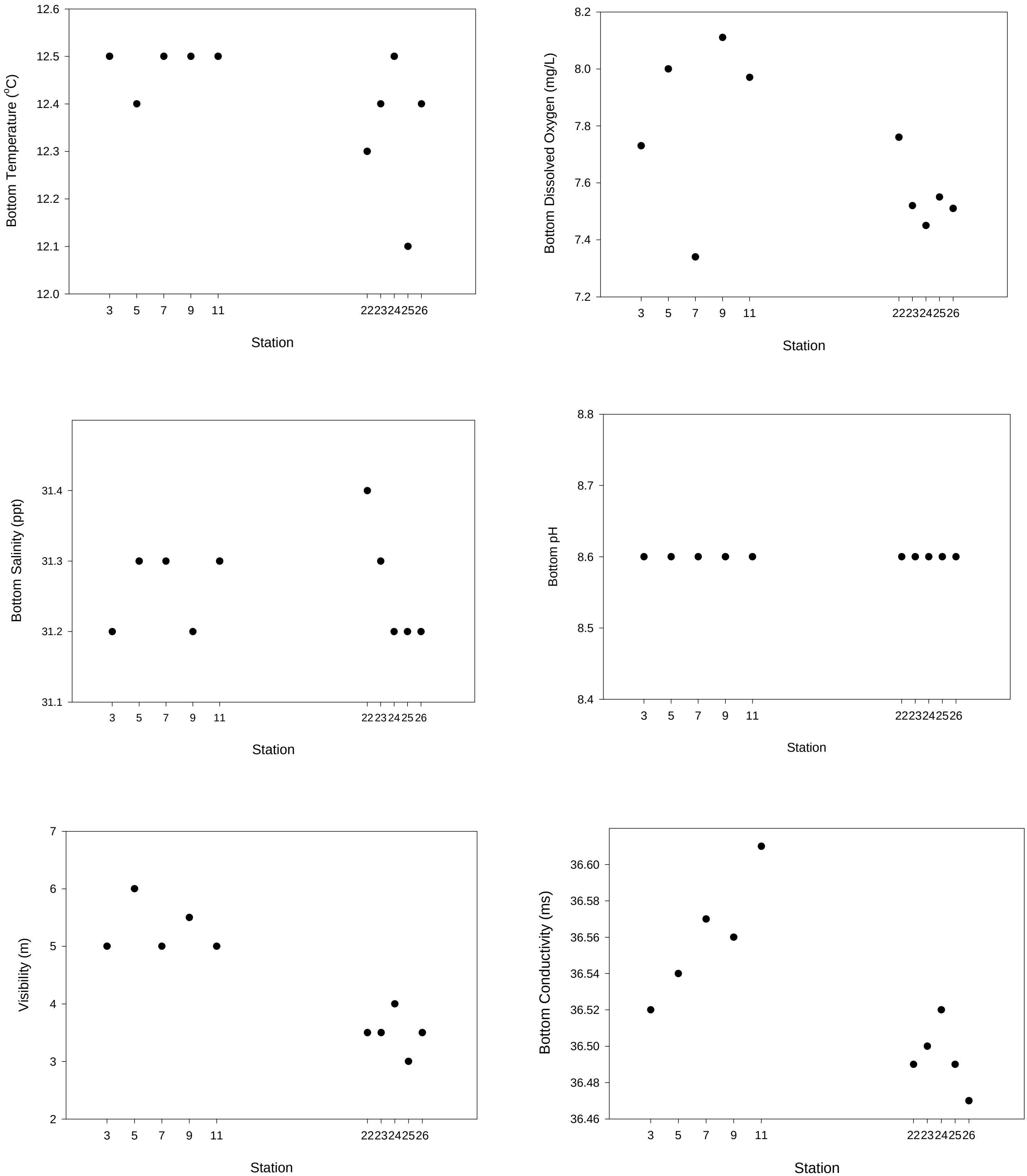


Figure 17
Water Quality for West of Shinnecock Inlet Borrow Area
Fall 2000

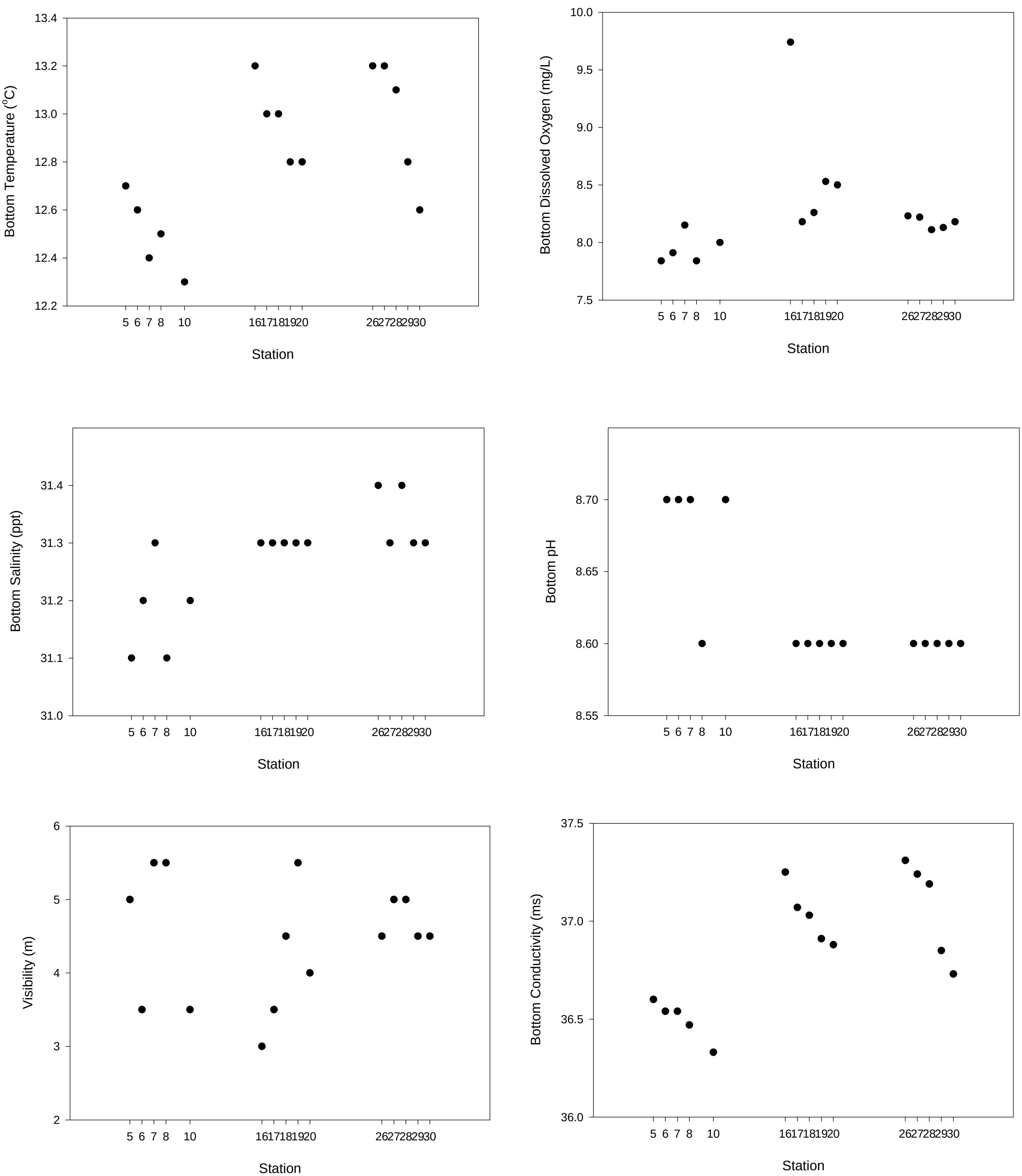
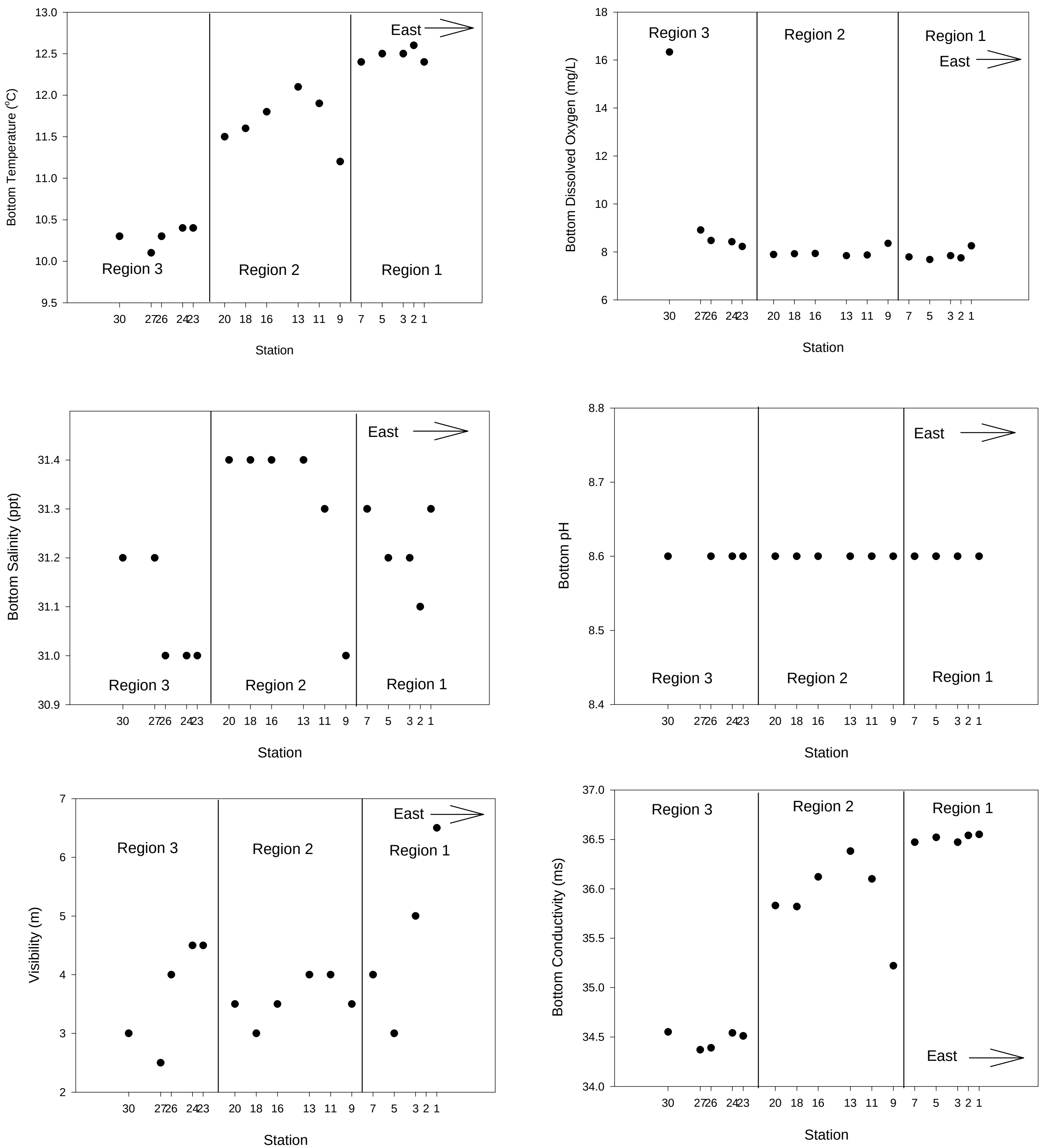
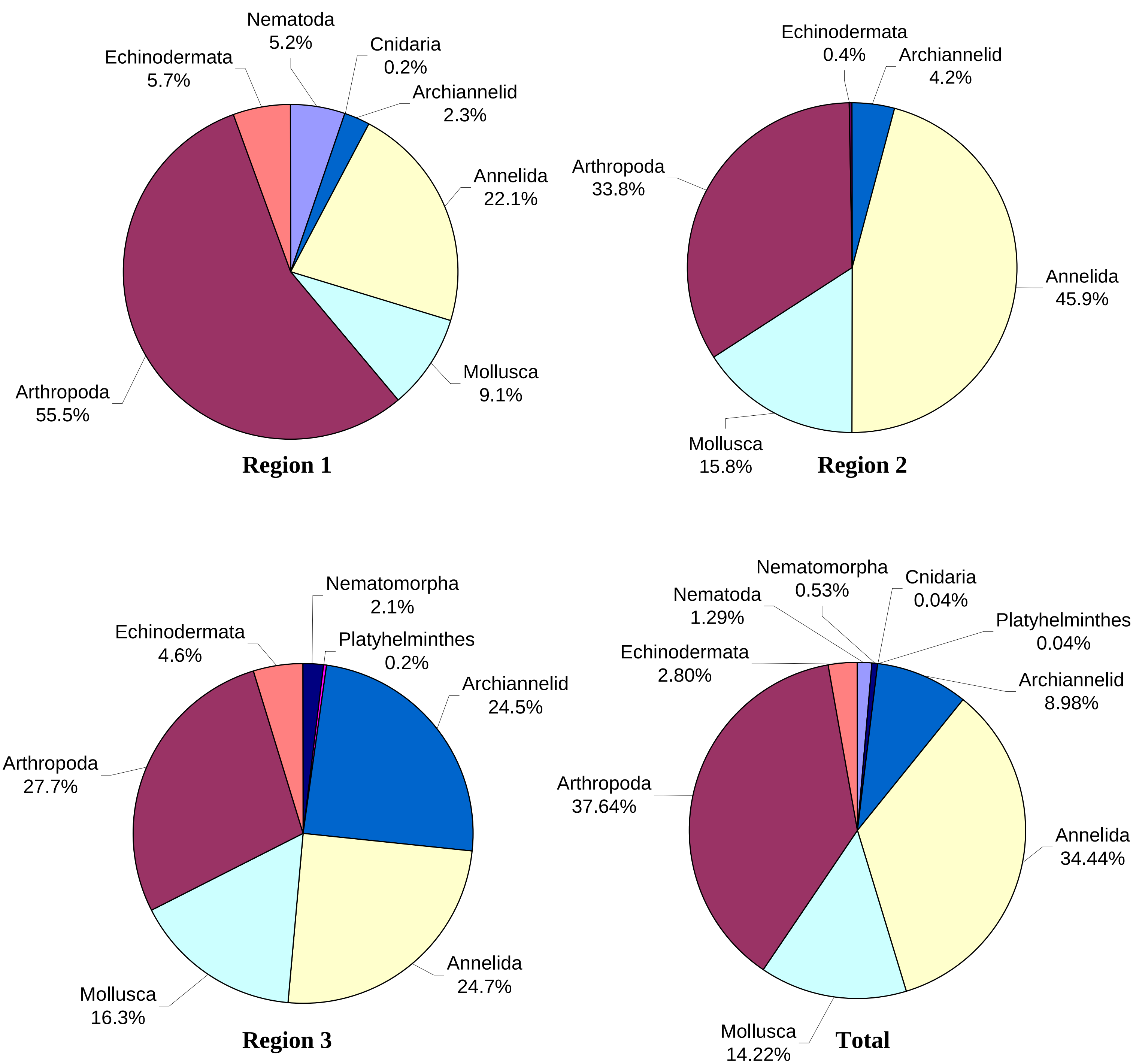


FIGURE 18
Water Quality for Inter-Borrow Areas
Fall 2000



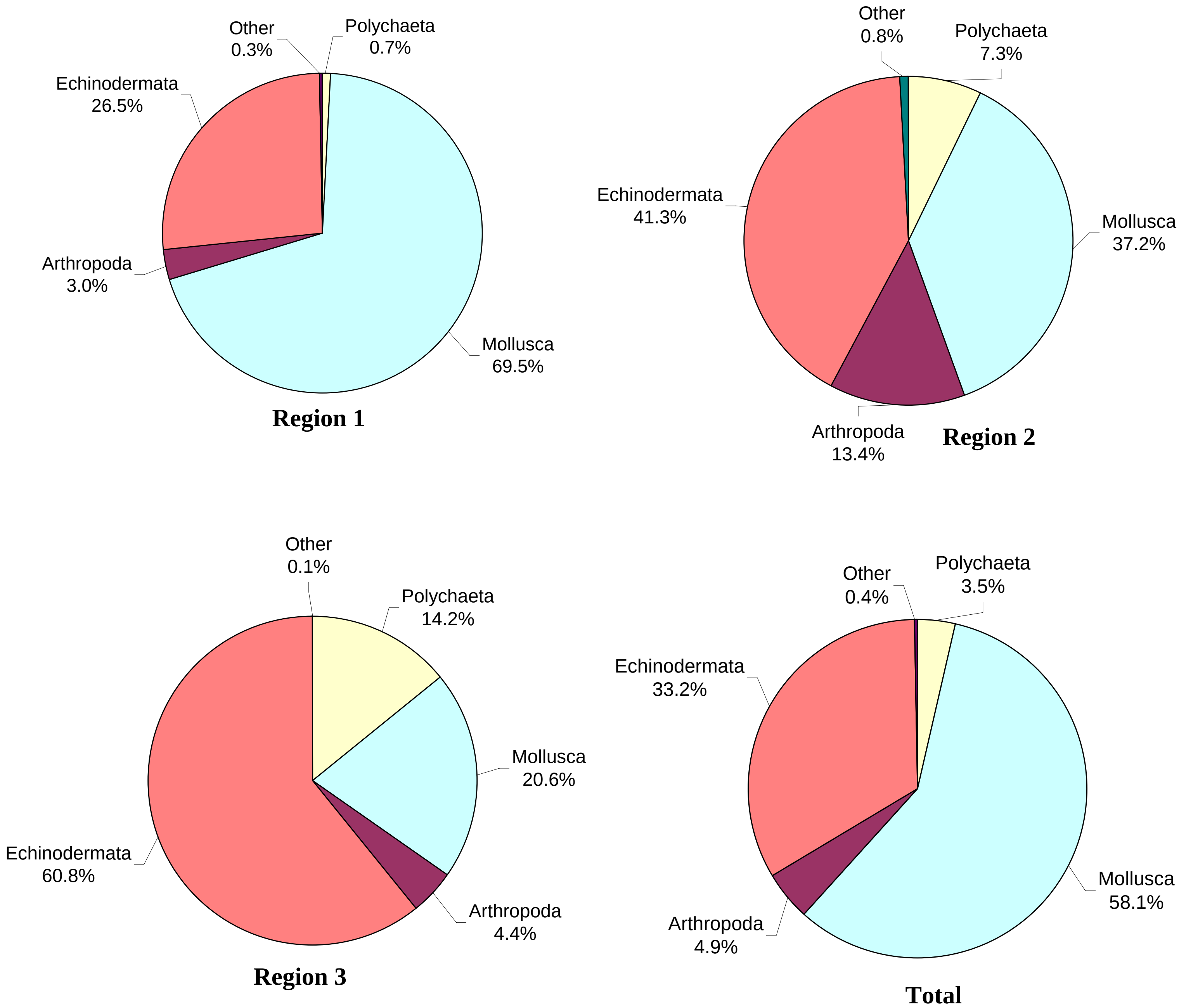
Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 19
Percent Composition by Abundance of Benthic Organisms Collected from Inter-Borrow Area Locations in Fall 2000



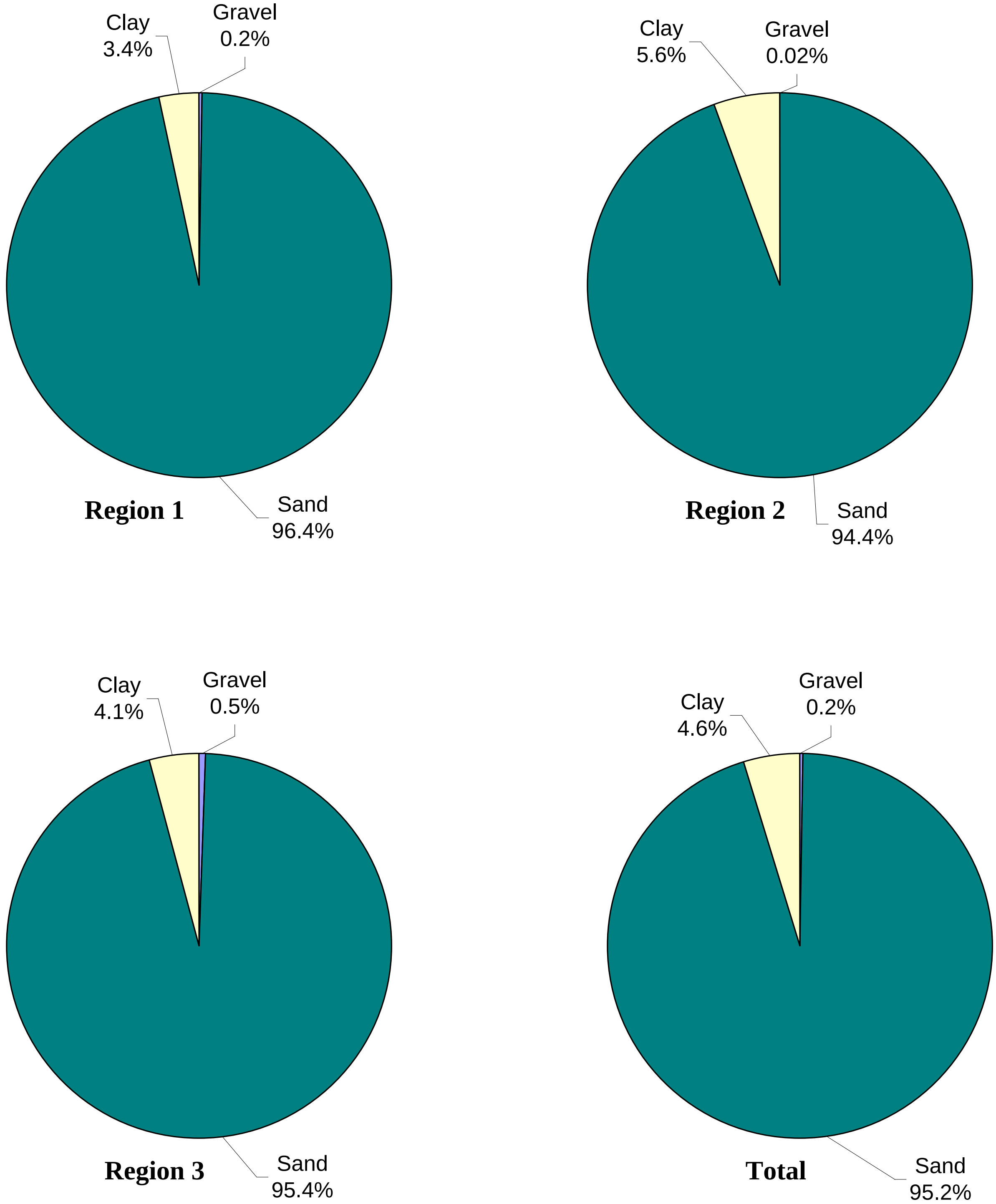
Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 20
Percent Composition by Biomass of Benthic Organisms
Collected from Inter-Borrow Area Locations in Fall 2000



Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 21
Grain Size Analysis for
Inter-Borrow Areas in Fall 2000



Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 22
Water Quality for Borrow Area 2A
Spring 2001

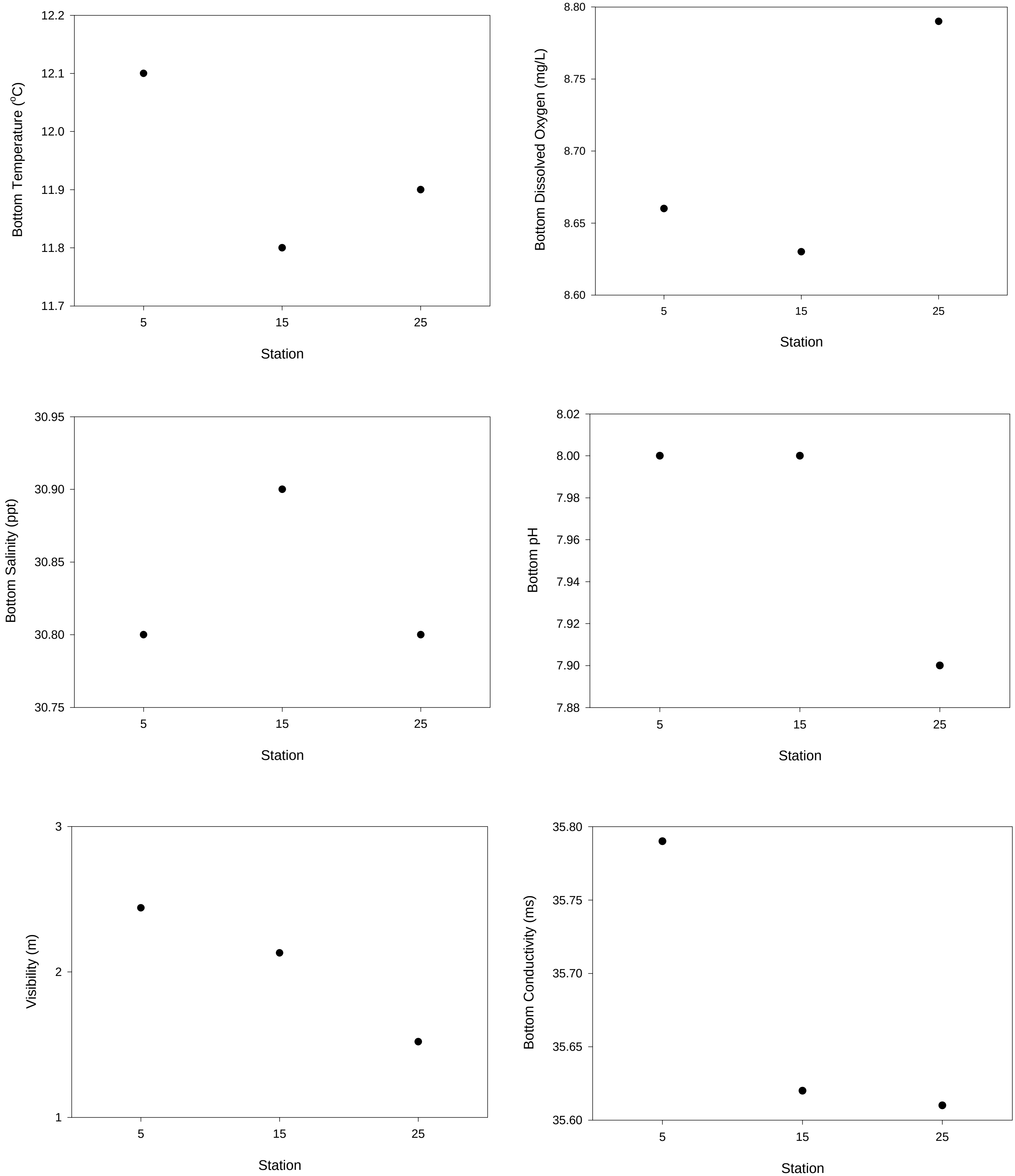
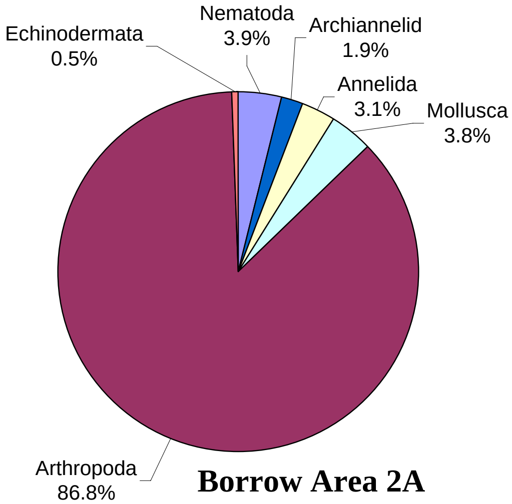
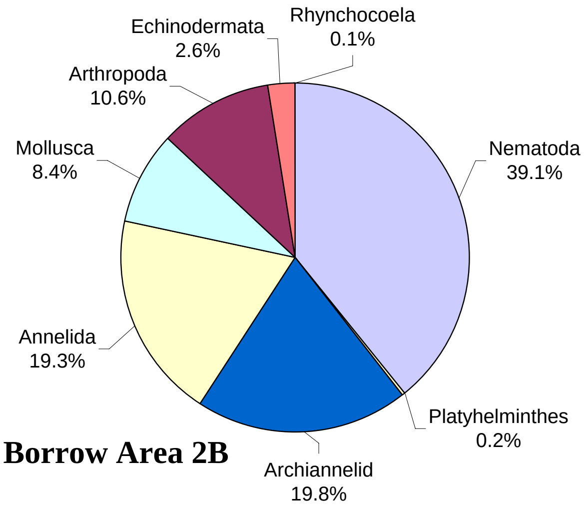


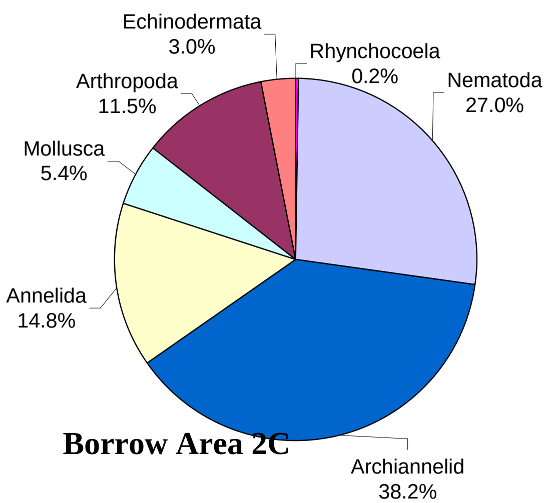
FIGURE 23
Percent Composition by Abundance of Benthic Organisms
Collected from Proposed Borrow Areas in Spring 2001



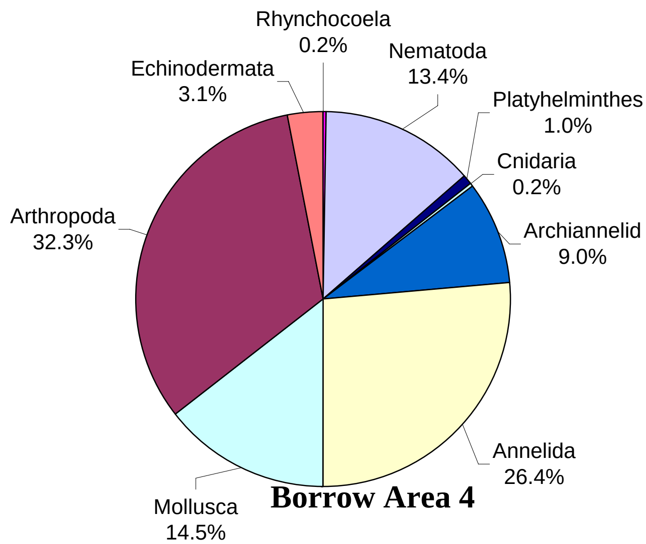
Borrow Area 2A



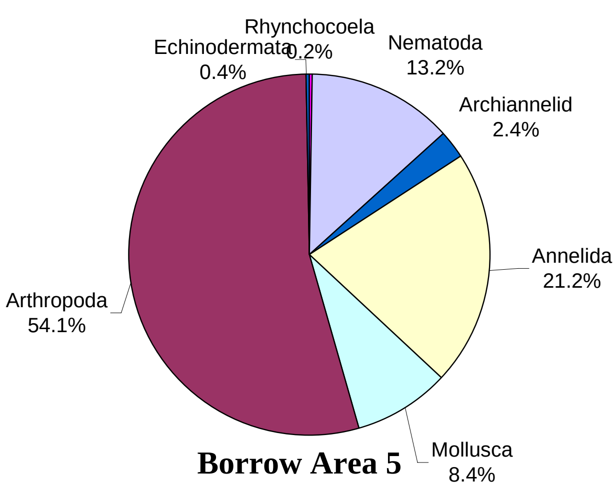
Borrow Area 2B



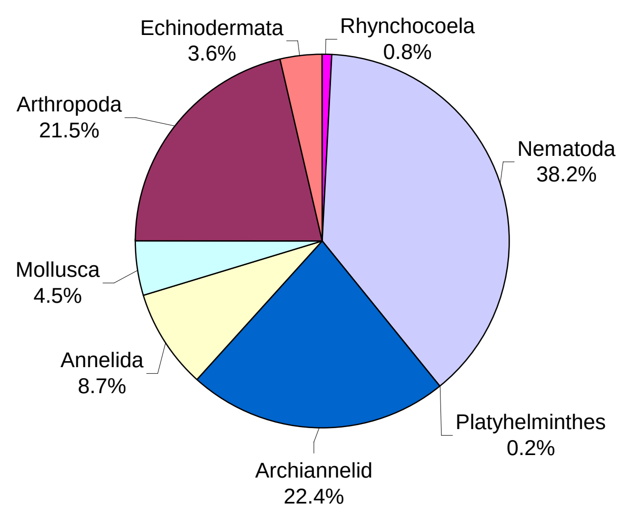
Borrow Area 2C



Borrow Area 4

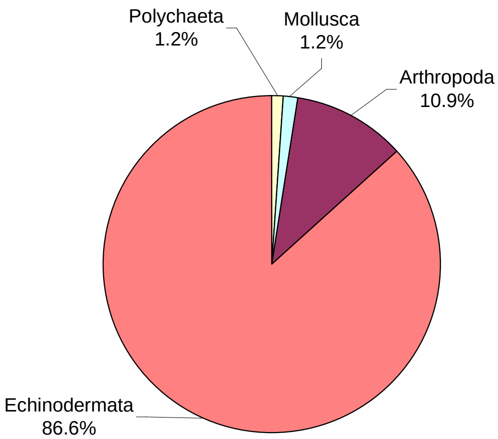


Borrow Area 5

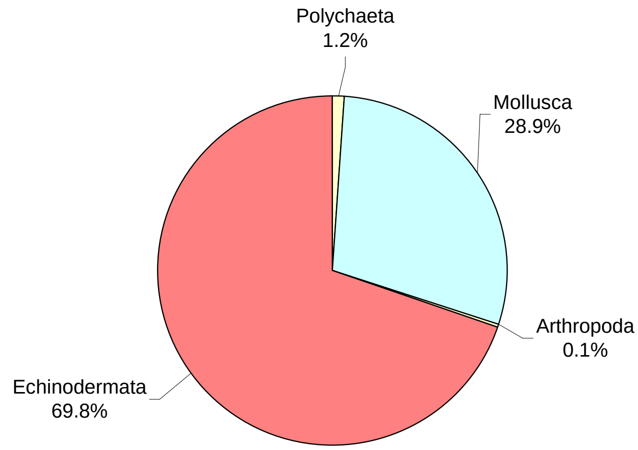


West of Shinnecock Inlet Borrow Area

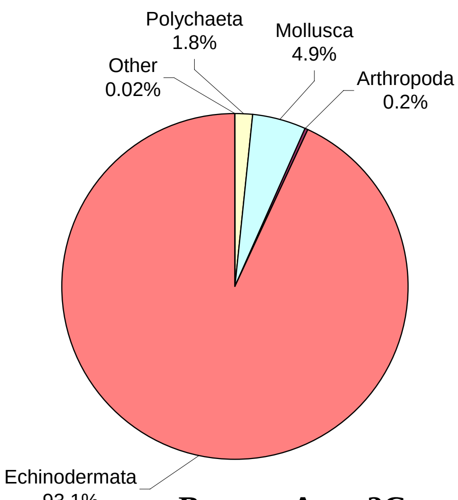
FIGURE 24
Percent Composition by Biomass of Benthic Organisms Collected from Proposed Borrow Areas in Spring 2001



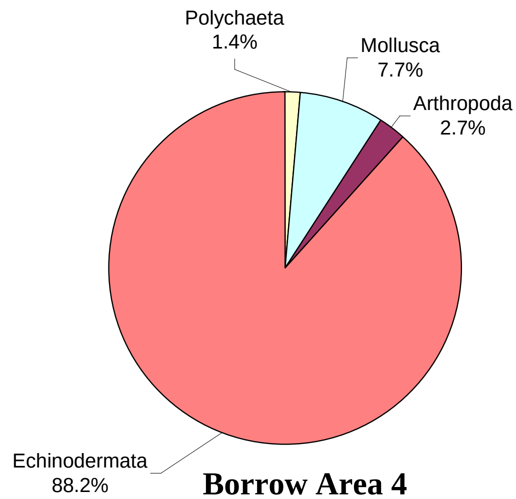
Borrow Area 2A



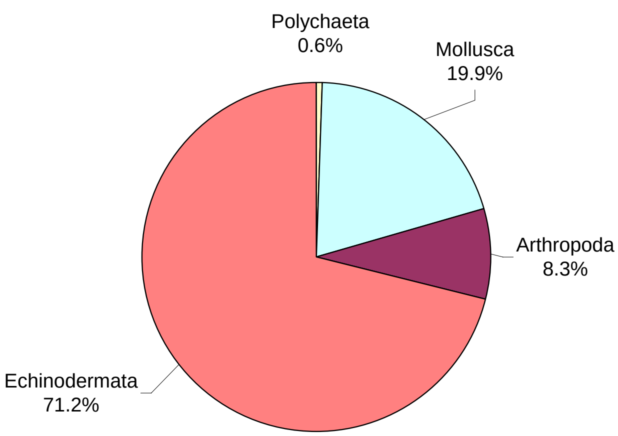
Borrow Area 2B



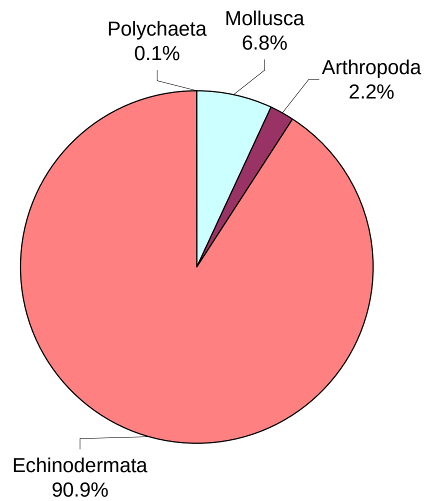
Borrow Area 2C



Borrow Area 4

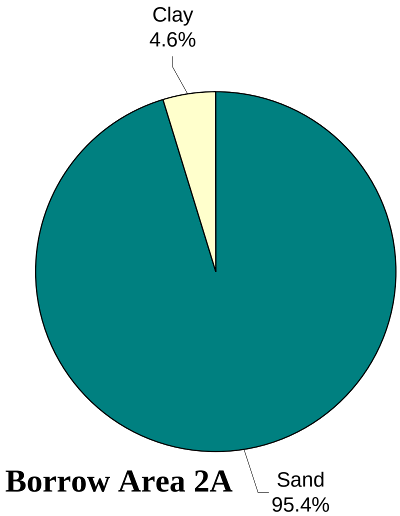


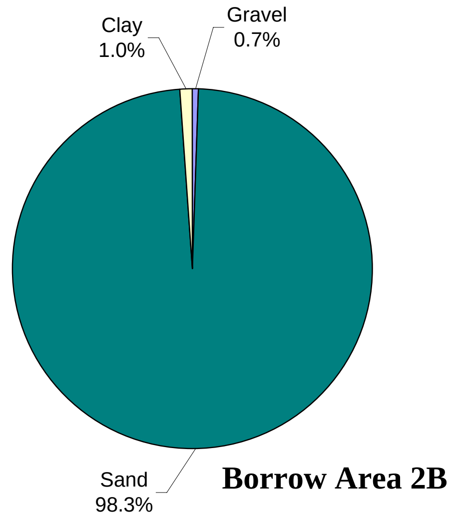
Borrow Area 5

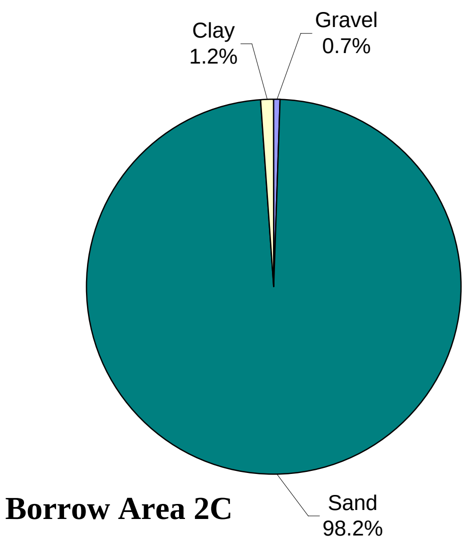


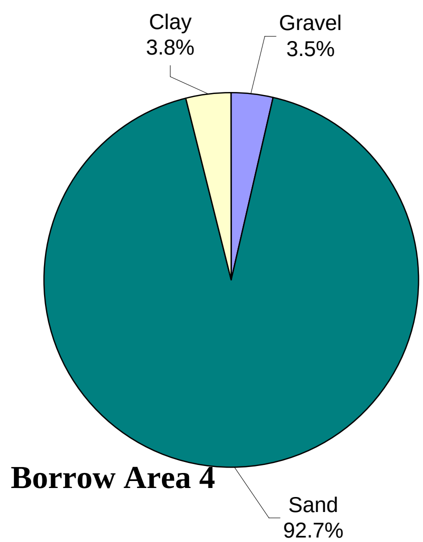
West of Shinnecock Inlet Borrow Area

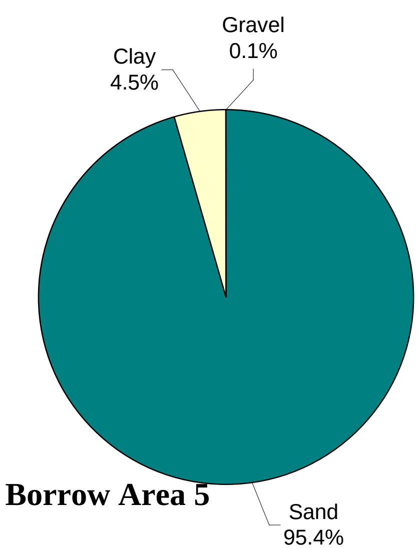
FIGURE 25
Grain Size Analysis for Proposed Borrow Areas in Spring 2001











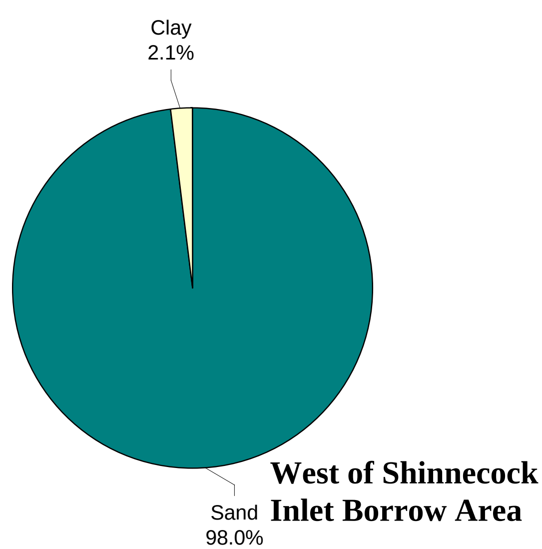
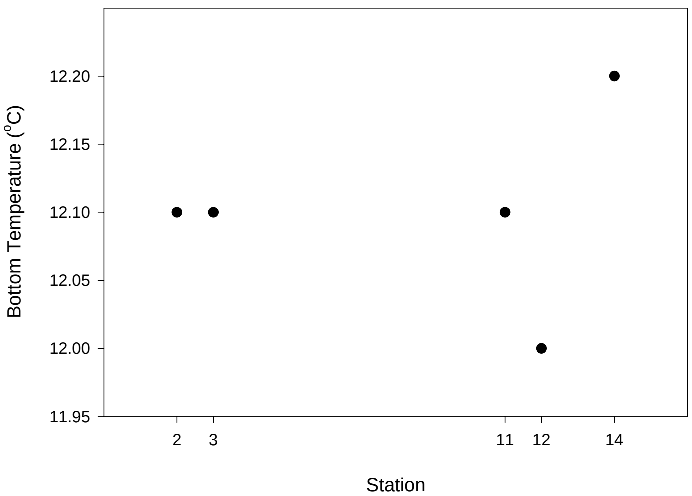
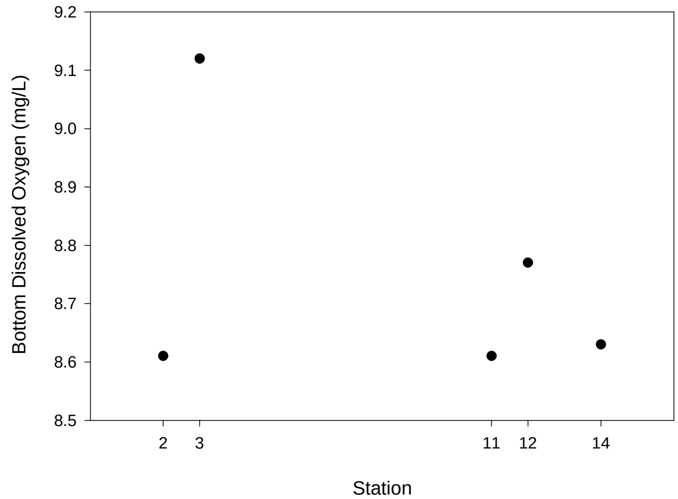
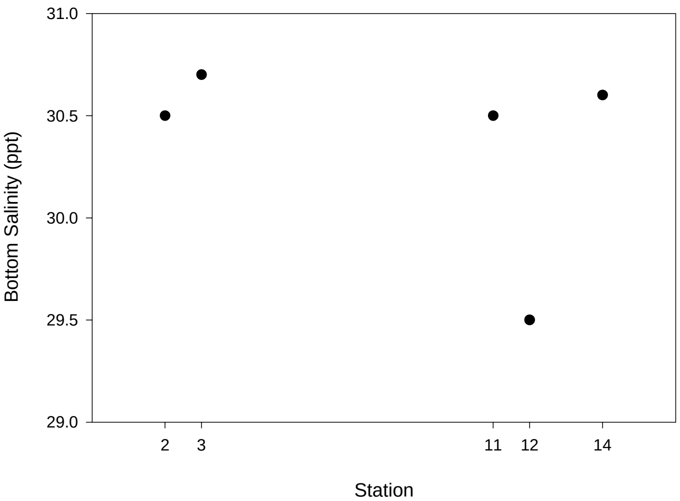
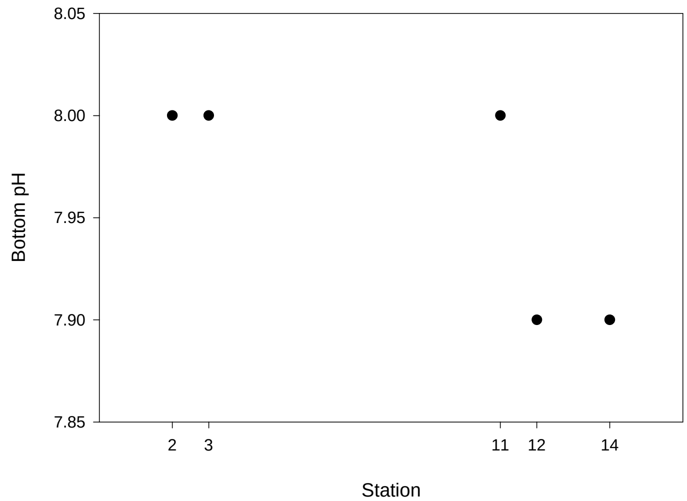


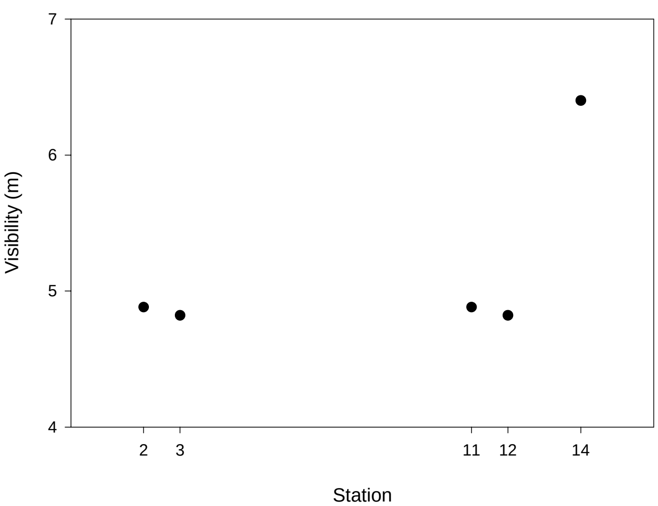
FIGURE 26
Water Quality for Borrow Area 2B
Spring 2001











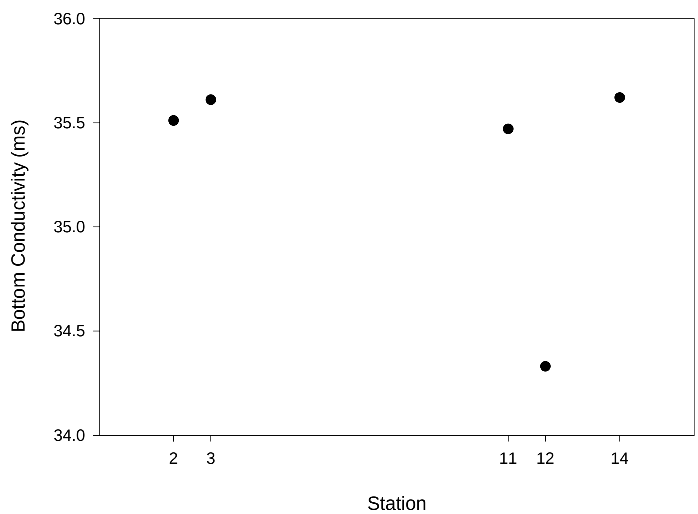
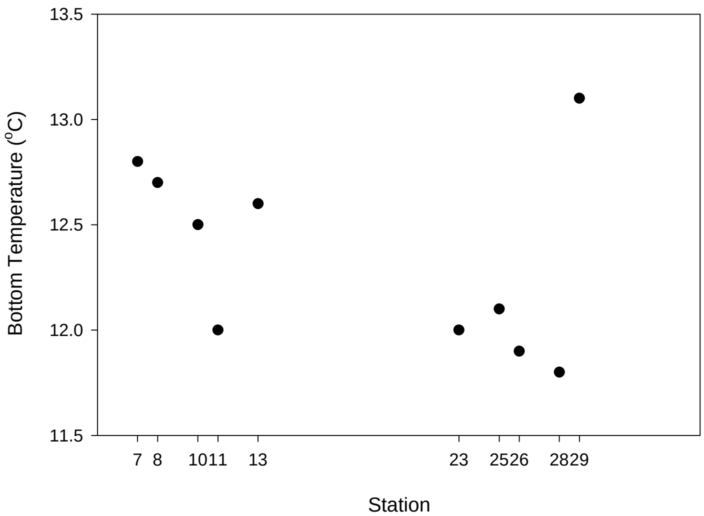
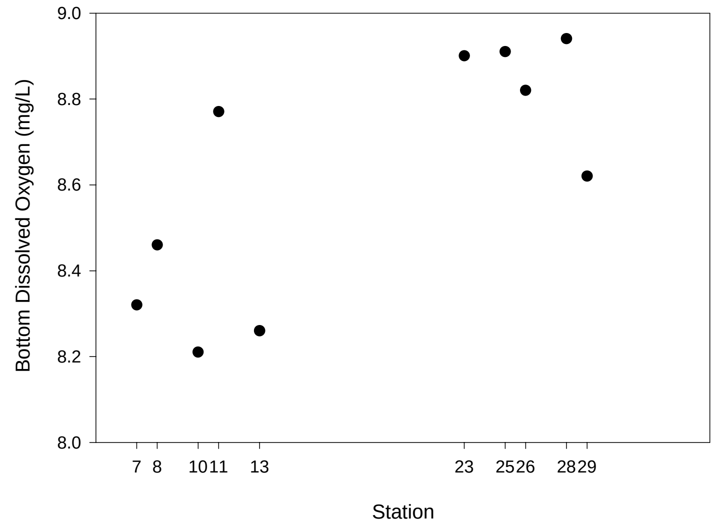
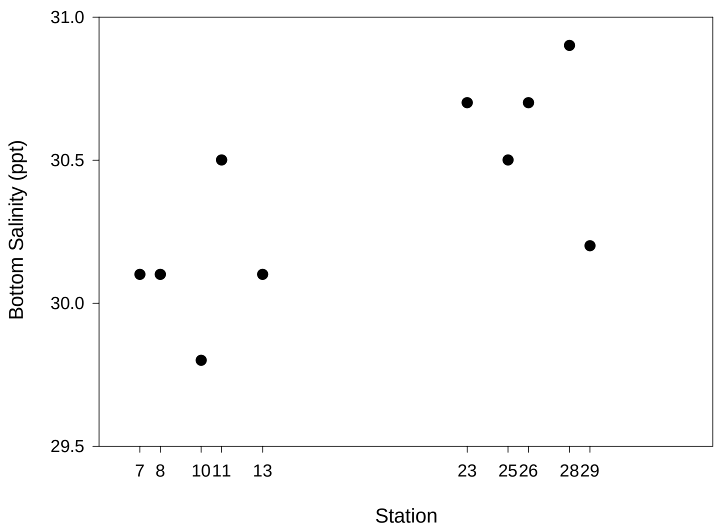
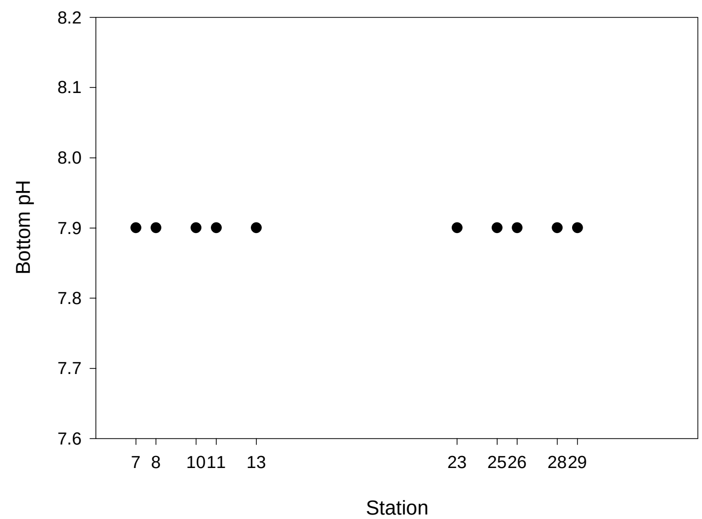


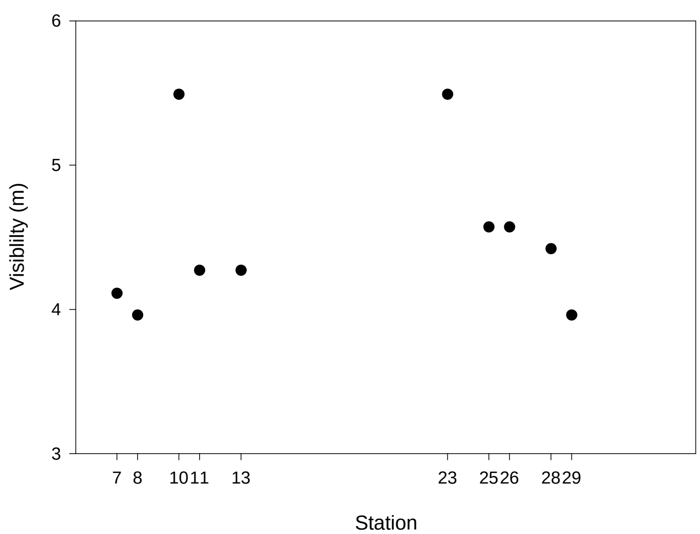
FIGURE 27
Water Quality for Borrow Area 2C
Spring 2001











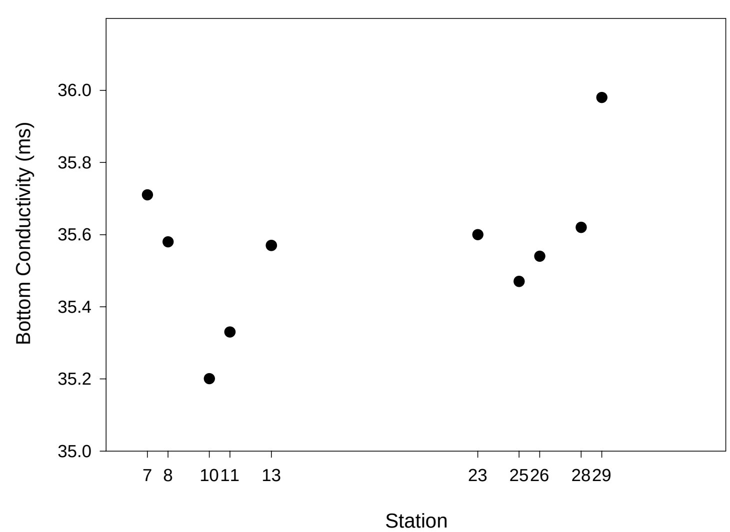


FIGURE 28
Water Quality for Borrow Area 4
Spring 2001

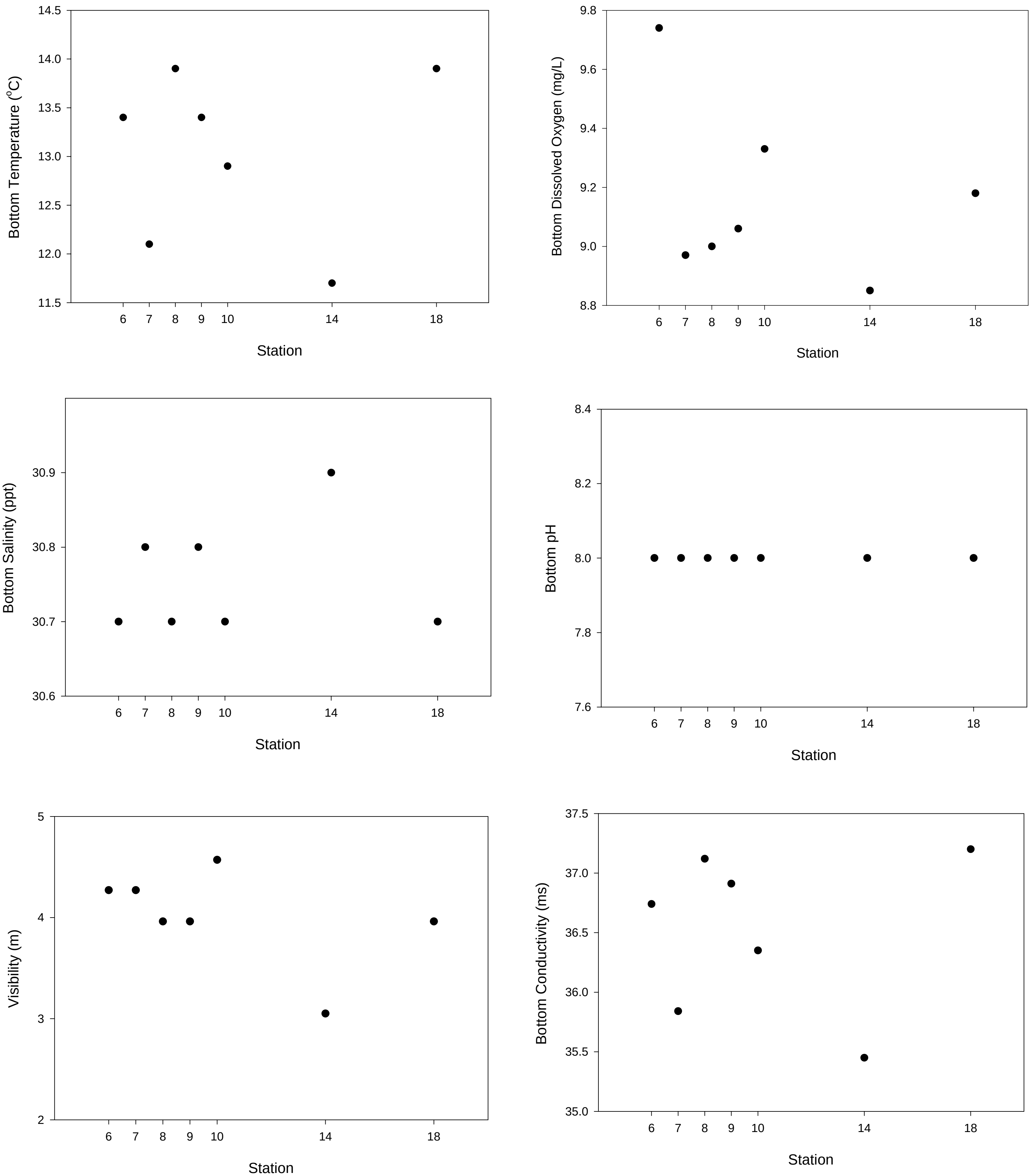


FIGURE 29
Water Quality for Borrow Area 5
Spring 2001

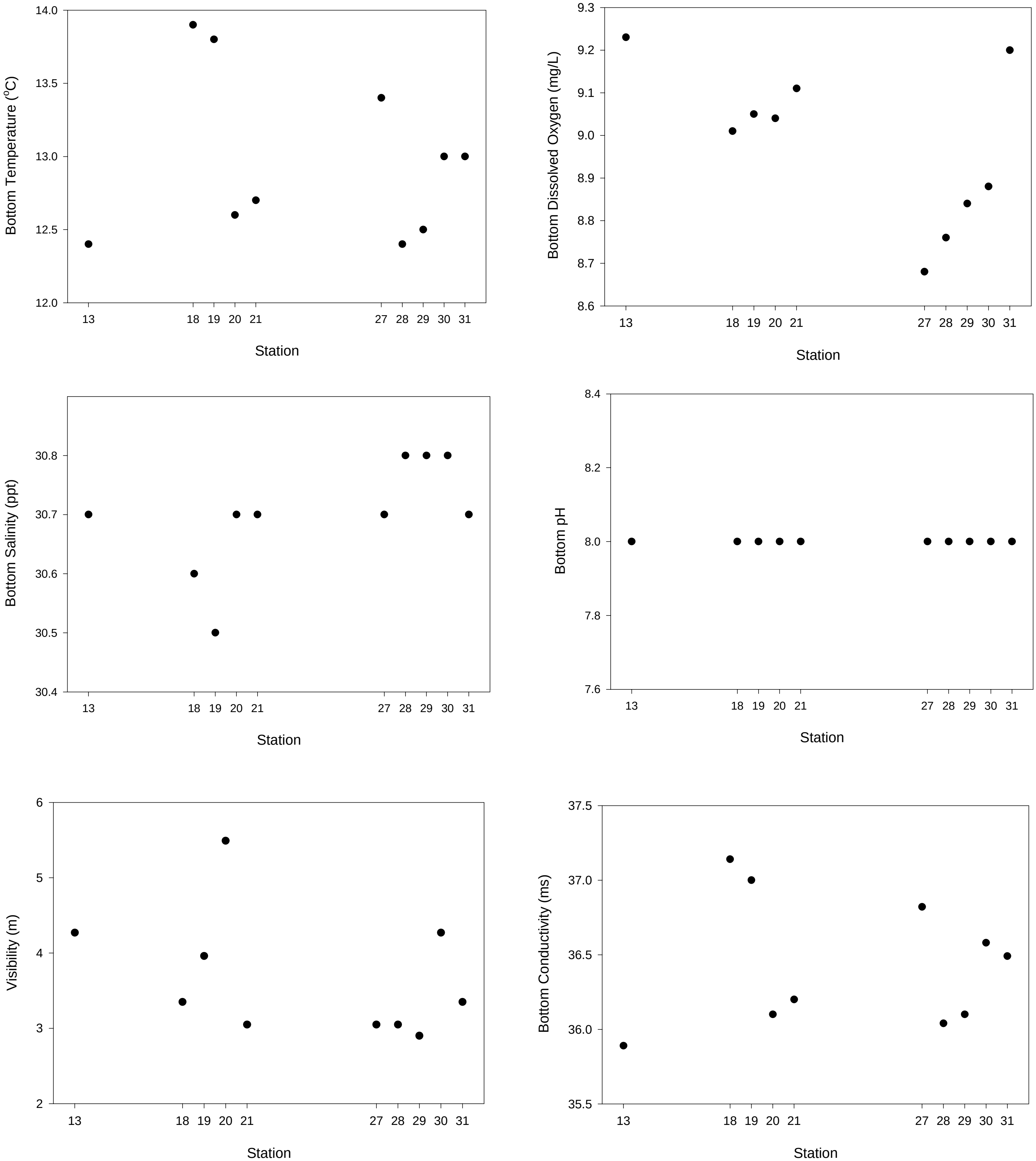


FIGURE 30
Water Quality for West of Shinnecock Inlet Borrow Area
Spring 2001

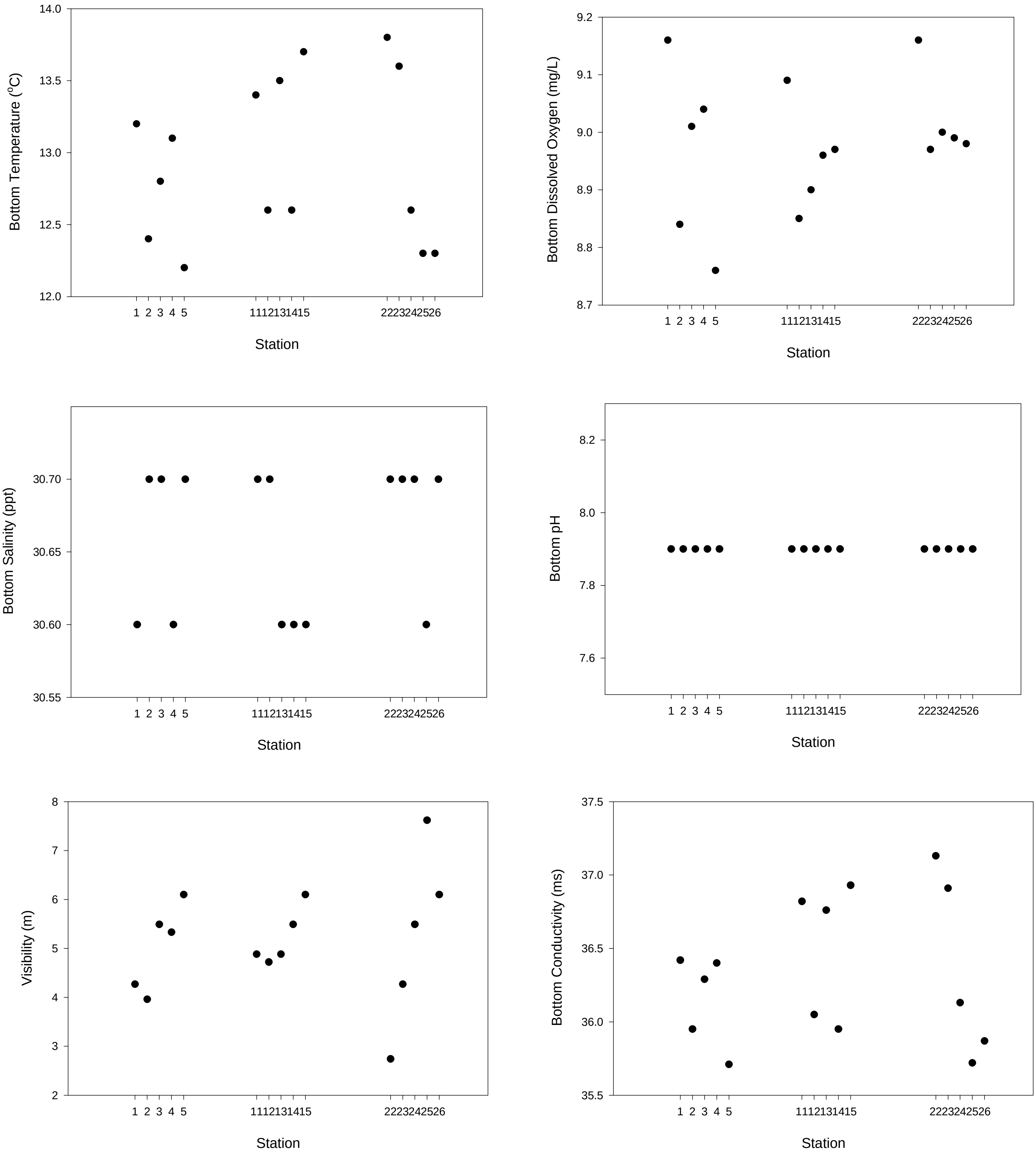
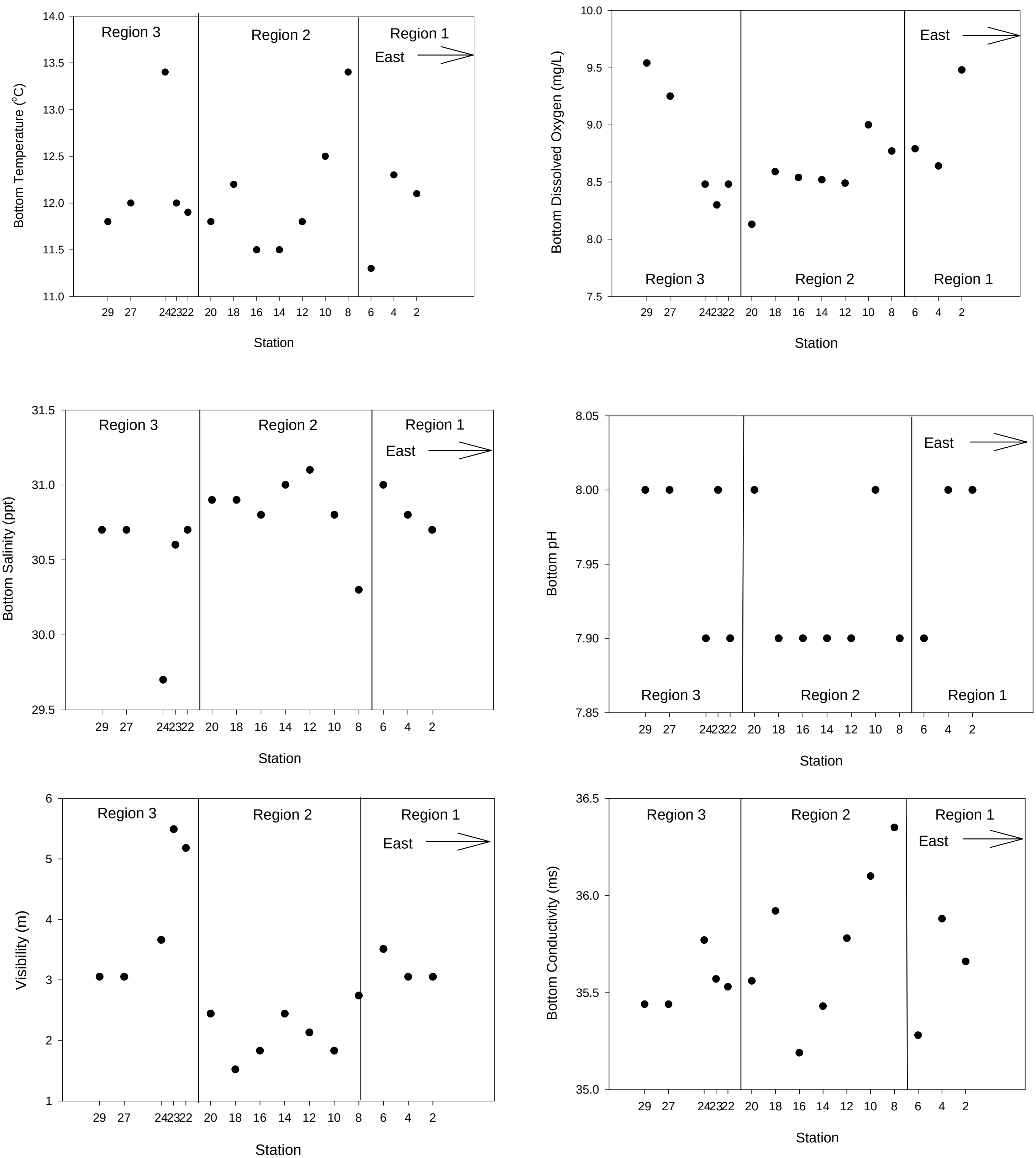
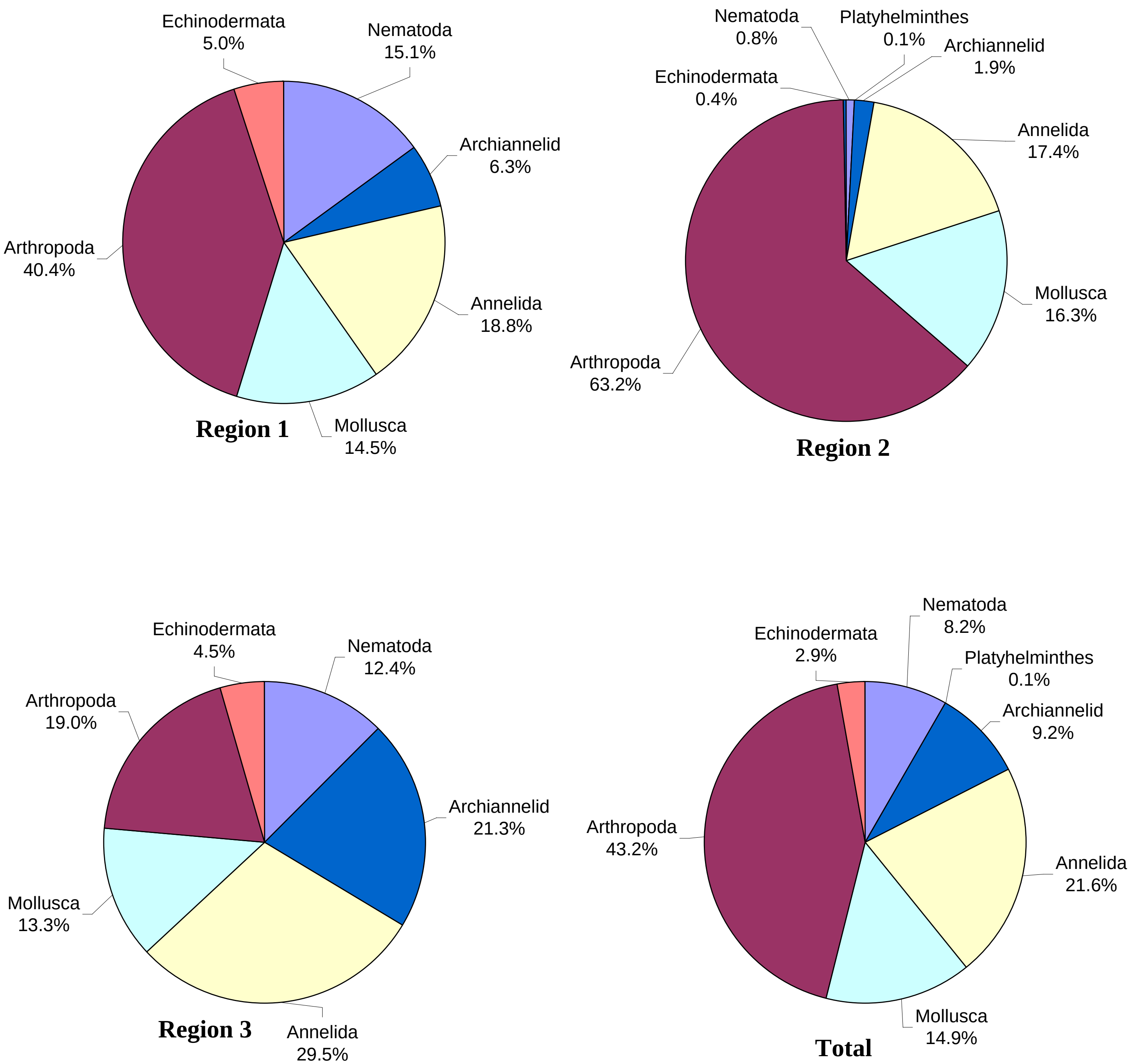


FIGURE 31
Water Quality for Inter-Borrow Areas
Spring 2001



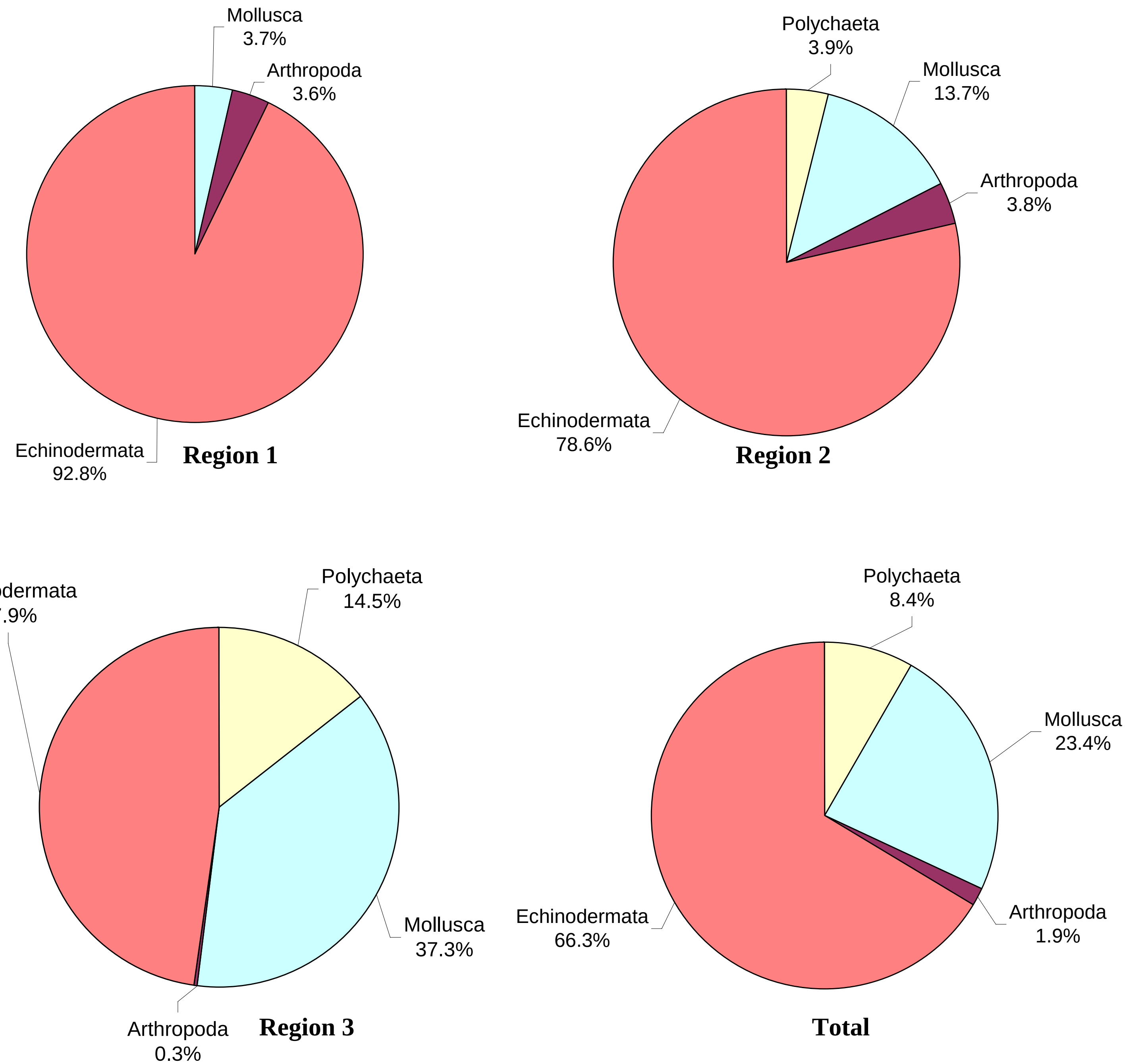
Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 32
Percent Composition by Abundance of Benthic Organisms Collected from Inter-Borrow Area Locations in Spring 2001



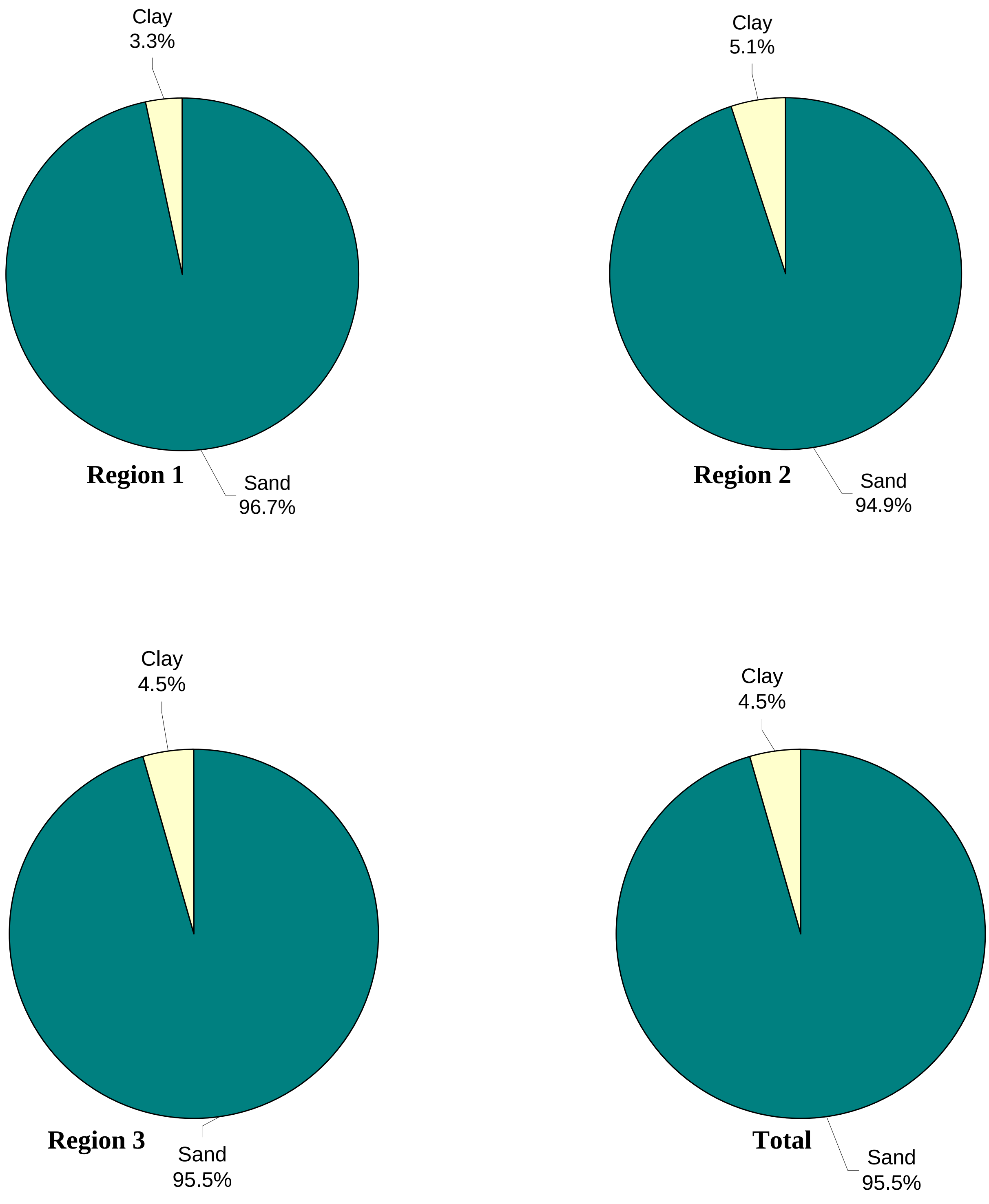
Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 33
Percent Composition by Biomass of Benthic Organisms Collected from Inter-Borrow Area Locations in Spring 2001



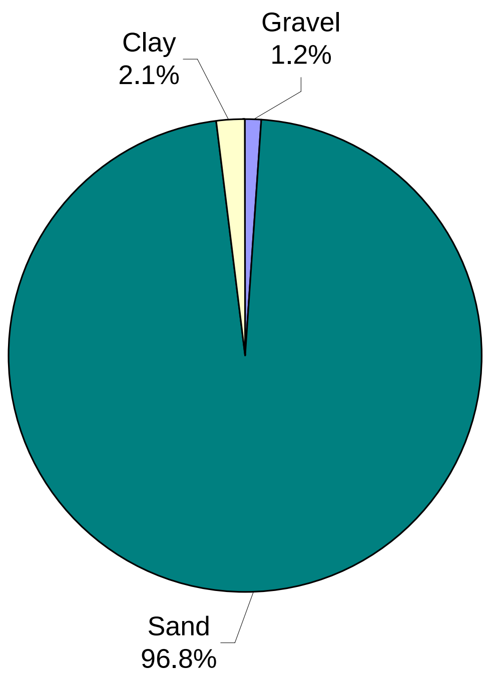
Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 34
Grain Size Analysis for
Inter-Borrow Areas in Spring 2001

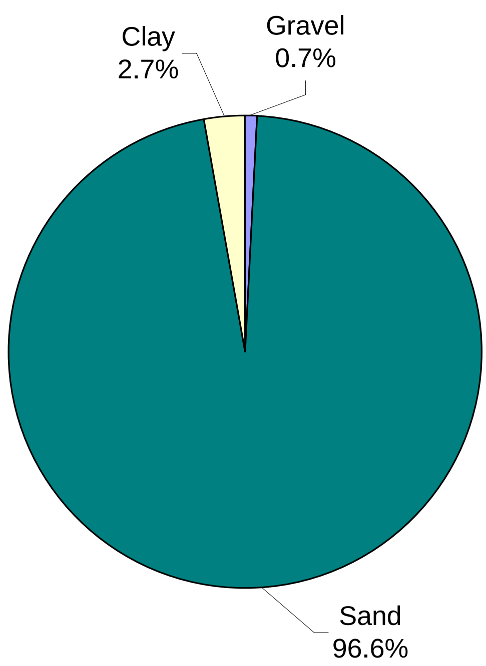


Region 1 = Locations between the Shinnecock Inlet Borrow Area and Borrow Area 4
Region 2 = Locations between Borrow Area 4 and Borrow Area 2
Region 3 = Locations from Borrow Area 2 westward

FIGURE 35
Grain Size Analysis of Combined
Borrow Areas in Fall 2000 and Spring 2001



Fall 2000



Spring 2001