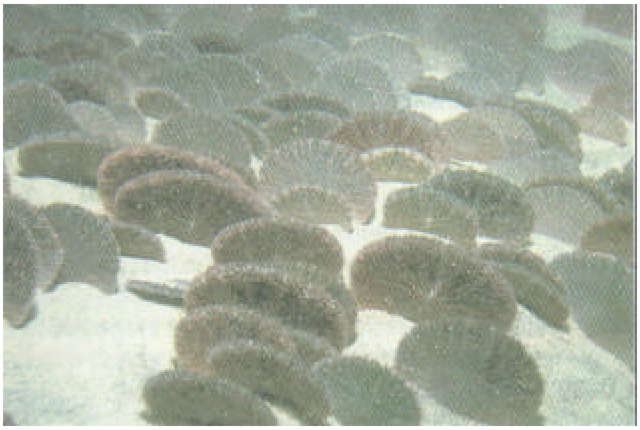


FIRE ISLAND INLET *to* MONTAUK POINT

Reformulation Study

Compilation and Comparative Analysis of Physical and Biological Characteristics of Available Sand Sources

October 2004

Prepared by U.S. Army Corps of Engineers

US Army Corps of Engineers
New York District

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Fire Island to Montauk Point Storm Damage Reduction Reformulation Study Compilation, Analysis, and Comparative Analysis of Physical and Biological Characteristics of Available Sand Sources

I. PROJECT OVERVIEW

The Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point, New York, Storm Damage Reduction Reformulation Study (FIMP) seeks to evaluate long-term solutions for storm damage reduction along the southern shore of Suffolk County, Long Island. The FIMP study is a multi-year and multi-task effort, involving project planning and engineering, economic analyses and environmental studies. Numerous study tasks are involved in the planning of storm damage reduction projects for the approximately 83-mile study area length. The study area also includes 26 miles of the Fire Island National Seashore (FINS), which is under the jurisdiction of the National Park Service (NPS).

The project area is located entirely in Suffolk County, Long Island, New York, along the Atlantic and bay shores of the towns of Babylon, Islip, Brookhaven, Southampton, and East Hampton (Figure I-1). The study area includes three estuarial bays, which are in order from west to east: Great South Bay, Moriches Bay, and Shinnecock Bay. These bays are connected to the Atlantic Ocean through Fire Island, Moriches, and Shinnecock Inlets, all of which are federally maintained navigation channels. The project area includes the ocean and bay shorelines, the aforementioned inlets, barrier island beaches, the mainland, as well as suitable offshore sand borrow areas for beach construction and replenishment. The study encompasses approximately 70 percent of the total Atlantic Ocean frontage of Long Island, as well as hundreds of miles of bay shoreline.

The potential exists for breaching and/or flooding of the barrier islands that may significantly impact mainland communities bordering Great South Bay, Moriches Bay, and Shinnecock Bay. Coastal communities of the study area are subject to economic losses during severe storms. Principal damages to these coastal areas are the result of flooding and erosion associated with extreme tides and wave action. These storms, as well as alternatives that provide for storm damage reduction, also have the potential to affect back bay environments and the species associated with them.

As part of this federally authorized effort, the US Army Corps of Engineers, NY District, is conducting a number of environmental studies to understand ecosystem function in the study area. One aspect of the studies is the collection and analysis of baseline data concerning potentially affected environments. The Corps is evaluating the potential placement of sand on barrier island and mainland beaches to restore sediment transport and to reduce storm damage associated with breaching and overwash. Potential offshore sand sources, or "borrow areas", have been identified (Figure I-1) From 1999 to 2002, seven environmental studies were conducted to develop an understanding of the physical and biological characteristics of these sites. This information will be used in later phases of the analysis to evaluate the impacts of sand removal to the biological and physical resources in the borrow areas.

A total of 1400 samples were collected including finfish, megainvertebrates, and macroinvertebrates. In addition, water quality was recorded for each sample and sediment grain size was collected during the three benthic studies (Table I-1).

These data have been assembled into an MS Access database for ease of use, analysis, and distribution. The data will be used to characterize the physical and biological resources of each borrow area, and comparative analyses will be performed between and among borrow sites. The database will be made available to researchers interested in the biological and physical resources present in the potential borrow areas.

For more information about this database, please contact the Howard Ruben, at the US Army Corps of Engineers, New York District, Environmental Analysis Branch (e-mail: Howard.Ruben@nan02.usace.army.mil

1.0 Trawls

Finfish, squid, and other megainvertebrates were collected using a 30-foot otter trawl with 1/2" mesh cod end, which was towed at a speed of 2-3 kt for 0.25 nautical miles. Transects were located at the 30, 40, 50, and 60-foot contours within and adjacent to the borrow areas (Figure I-2). Sampling was performed once per month for the duration of each study. Finfish and squid were weighed, counted, measured, and identified to species. Finfish and squid length and total weight by species was recorded for up to 30 individuals per station. In cases where more than 30 individuals were collected, the total number was recorded. Therefore, the weight indicated is always the weight of 30 or fewer organisms. When the finfish weight was less than 10 g, the limit of the scale, the database entry is indicated by -9999. Megainvertebrates collected during trawls were enumerated only.

See Table I-2 for a list of all units of measure used in the database.

2.0 Benthic Grabs

Benthic grabs were collected using a 0.025-meter square modified Young grab. Macroinvertebrates were identified to the lowest practical identification level, which in most cases was to the species level. Exceptions include those organisms that were too difficult to differentiate (such as nemerteans), organisms that were damaged, or those that were too scarce for positive identification. The wet weight of organisms was determined for the major taxonomic groups identified. Organisms not falling under the four major taxonomic groups of Annelida, Echinodermata, Arthropoda, and Mollusca, are included under the heading of "Other." In cases where the weight was below the limit of the scale (0.01g) the value in the database is indicated by -9999.

Grain size is indicated by percent type, using size classes of silt, sand, and gravel. The sediment was analyzed using a hydrometer based on ASTM methods D 422 and D 2487. Grain sizes and corresponding U.S. Standard Sieve Sizes are listed in Table I-3.

3.0 Water Quality

Water quality measurements, including salinity, temperature, and dissolved oxygen were made with a Yellow Springs Instruments (YSI) model R85-10. pH was recorded using the YSI or an Oakton Waterproof pH tester. A Secchi disk was used to determine the depth of light penetration. Water quality, with the exception of Secchi depth, was measured at the beginning and end of each trawl. In cases where there was instrument malfunction or measurements were not made per the sampling protocol (e.g. at benthic stations only bottom water quality was recorded), water quality measurements are indicated by 9999 in the database.

4.0 Station Information

Geographic location was recorded from a Garmin 45 XL and/or Garmin 185 interfaced with a Garmin GBR-21 differential receiver. Although every effort was made to ensure accurate positioning, inherent errors in GPS measurements were unavoidable. In the case of the Clam Survey, a commercial clam vessel was retained and station position was recorded with their shipboard navigation (LORAN C).

When applicable, stations are also identified by the borrow area in which they occur. Since borrow areas are subject to change, this is meant only as a guideline. Table I-4 lists borrow area and the corresponding notation used in benthic sampling. See the map included with the database for station locations of grabs, trawl start and end (Figure I-2), and surf clam survey (Figure I-3).

Note that although Shinnecock (SH) benthic stations were sampled as part of Work Order 13, they are included with the rest of Benthos I/II in Work Orders 10 and 17.

For more information on sampling protocols contact Howard Ruben, Project Biologist, at the USACE, New York District, Environmental Analysis Branch, (e-mail: Howard.Ruben@nan02.usace.army.mil)

II. DATABASE DEVELOPMENT

The database was constructed using Microsoft Access 2000, which was chosen because it is a commonly used database program. MS Access comes as part of the Microsoft Office Professional Edition bundle or can be purchased separately. It is used by state and federal agencies for distribution of data. The appearance is similar to that of MS Excel, which most data users are familiar with. MS Access is also compatible with MS Excel and tables can be exported or copied and pasted from the Access database directly into an Excel spreadsheet. Access will perform simple descriptive statistics such as sum, average, minimum, and maximum. Data can also be filtered and sorted within each of the tables before exporting the data for analysis. Exported data can also be evaluated in statistical processing software such as SPSS, SAS, and SYSTAT.

In the Access database, data tables are organized by the type of data collected (e.g. invertebrates, finfish, water quality) and the measurement made (total catch, length, salinity, etc.). Also included are species lists providing common and scientific names of finfish and macroinvertebrates.

III. DATA ANALYSIS AND RESULTS

1.0 Data Analysis Methods

Benthic invertebrate, finfish, and sediment data collected as part of the 1999, 2000, and 2001 FIMP reformulation studies were evaluated to assess:

1. Spatial and temporal differences in benthic community attributes among potential borrow areas;
2. Spatial and temporal differences in finfish communities among potential borrow areas;
3. Spatial and temporal differences in the occurrence of species of interest including, summer flounder, winter flounder, winter skate, squid, and surf clam; and
4. Spatial differences in sediment grain size distribution.

These four analyses were chosen by the Corps as the result of discussions of how best to present the utility of the database and Access, while concurrently presenting practical analyses that provide useful answers for various groups interested in the FIMP project. Data analysis methods used in the evaluations are summarized in the sections below.

1.1 Benthic Community Analysis

Benthic invertebrate communities in potential borrow areas were evaluated based on three community attributes: taxa richness (number of taxa per sample), density (number of individuals per m^2), and biomass (biomass per m^2). The number of benthic invertebrate samples available for the analysis is summarized by area and season in Table III-1. Each evaluation included an analysis of variance (ANOVA) and hierarchical cluster analysis.

A two-way ANOVA model (potential borrow area x season) was used to identify statistically significant differences in each community attribute between eleven potential borrow areas and two seasons (fall and spring). The adequacy of the ANOVA model was evaluated based on probability plots of model residuals for each community attribute; density and biomass were transformed (log(x+1)) to satisfy the normality assumption of the ANOVA model. To control for Type I errors (rejecting a "true" null hypothesis) resulting from multiple analyses, a Bonferonni correction was applied to the standard alpha (α) of 0.05 to determine an adjusted threshold for statistically significant differences. A difference was deemed to be statistically significant if the p-value was less than the Bonferroni-adjusted threshold of p=0.0167 (p=0.05 / 3 tests or p=0.0167). When an interaction effect (i.e., potential borrow area x season) was statistically significant (i.e., $p<0.0167$), a Tukey-Kramer HSD test (Tukey test) was used to determine statistically significant differences between all combinations of potential borrow areas and seasons. If the interaction effect was not significant, but a main effect (i.e., potential borrow area or season) was statistically significant, a Tukey test was performed to identify significant differences in means within the main effect. All statistical analyses were conducted using SYSTAT 10.2.

Hierarchical cluster analysis was used to determine the similarity of benthic communities among combinations of potential borrow areas and seasons based on measures of taxa richness, density, and biomass. The objective of cluster analysis is to identify combinations of potential borrow areas and seasons that have high affinities with each other, thus forming discrete groups or clusters (Pielou 1984). Similarity of potential borrow area and season combinations is illustrated by a dendrogram, which plots the most similar potential borrow area and season combinations closest to each other. The most similar combinations are linked on the left side of the dendrogram, and the least similar combinations are linked on the right side of the dendrogram.

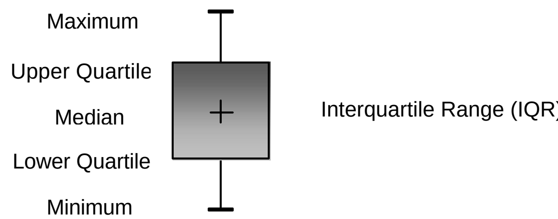
The cluster analysis was performed in SYSTAT 10.2 using the geometric means of each community attribute for each potential borrow area and season as input variables into the model. The geometric mean is often reported as a measure of location for positively skewed datasets because it limits the influence of extreme values compared to an arithmetic mean, which may be greatly influenced by extreme values (Helsel and Hirsch 2002). Values of density and biomass were positively skewed; therefore, the geometric mean was considered an appropriate measure of location for these datasets. The geometric mean was also used as a measure of location for the taxa richness dataset to maintain consistency among all attributes. Attributes were standardized based on a sample standard score (*z*-score) to create a common scale between input variables. A Euclidean distance algorithm was used to measure the distance (or differences) between samples and average linkage (unweighted-pair group method) was selected as the algorithm to determine how clusters were joined.

1.2 Finfish Communities

Finfish data collected during the FIMP reformulation studies were semi-quantitatively evaluated to assess spatial and temporal differences in finfish communities between potential borrow areas and seasons. Table III-2 provides a summary of finfish trawls completed as a part of the 1999, 2000, and 2001 reformulation studies by area, season, and depth contour.

The scope of the reformulation studies was sufficient to support a semi-quantitative evaluation of finfish communities. Variable spatial distributions and cyclical population trends inherent in fish communities often precludes more rigorous quantitative assessments, particularly in the absence of long-term, systematic collection of fisheries data. For this reason, fish communities in the reformulation study areas were assessed based on semi-quantitative evaluations to establish a general baseline of more common fish species likely present and their relative distributions.

Finfish communities were evaluated based on catch per unit effort (CPUE) as it relates to seasons and depth contours. Differences in finfish communities between potential borrow areas and seasons were evaluated using graphical comparisons of box and whisker plots that represent the maximum, minimum, upper and lower quartile, and median values of each dataset:



The median represents the 50th percentile of sample data; upper and lower quartiles represent the 75th and 25th percentiles of the data, respectively. The interquartile range (IQR) is the range of values between the upper and lower quartiles. For plotting purposes, the maximum value is the greatest value that falls between the upper quartile value and the upper inner fence, which is defined as the upper quartile value plus 1.5 times the IQR. The minimum value is defined as the lowest value that falls within the lower quartile value and the lower inner fence, defined as the lower quartile value minus 1.5 times the IQR. Values that fall outside of the inner fences are considered outliers. Values that fall between the inner fences and outer fences, defined as 3.0 times the IQR plus/minus the quartiles, are considered outside values and are represented as open circles by SYSTAT 10.2. Values that fall outside the outer fences are considered far outside values and are represented by asterisks.

1.3 Species of Interest

The evaluation of species of interest involved comparisons of CPUE for summer flounder, winter flounder, winter skate and squid across all seasons and four depth contours. The number of trawls completed as a part of the 1999, 2000, and 2001 reformulation studies for these finfish and squid are summarized in Table III-2.

Surf clam sampling was conducted in August and September of 2001. The number of surf clam samples collected is summarized by season in Table III-3. Surf clam abundance was evaluated based on comparisons of U.S. bushels harvested between potential borrow areas. It is important to note that at the time of the surf clam survey, areas 2a and 2d (represented as 2ad) were considered to be a combined potential borrow area; similarly areas 5a and 5b (represented as 5ab) were considered to be a combined potential borrow area.

CPUE for each species of interest was compared graphically using box and whisker plots as described in Section 1.2.

1.4 Sediment Grain Size Distribution

Sediment grain size data was collected from six potential borrow areas during the fall (November) of 1999 and 2000 and the summer (June and July) of 1999 and 2001. A summary of sediment grain size samples by area, depth, and season is presented in Table III-4. Sediment grain size distributions were evaluated across potential borrow areas and depth contours; grain size distributions were also compared between potential borrow areas and seasons. Box and whisker plots (Section 1.2) were used to illustrate the range of gravel (75 mm to 4.75 mm), sands (4.75 mm to 75 µm), and fines (< 75 µm) found within each combination of potential borrow area and depth or season.

2.0 Results and Discussion

The following sections present the results of the preliminary analysis of benthic invertebrate, finfish, squid, surf clam, and grain size data collected during 1999, 2000, and 2001 of the FIMP reformulation studies. The discussion of the results that is provided in these sections is intended to provide an initial description of the reformulation data and. The analysis is intended to make general spatial and temporal comparisons between potential borrow areas and seasons, but not to assess potential ecological impacts.

2.1 Benthic Invertebrate Communities

2.1.1. ANOVA

Spatial and temporal differences in benthic invertebrate communities were evaluated based on two-way ANOVA (potential borrow areas x seasons) of taxa richness, density, and biomass data. The results of the two-way ANOVA of taxa richness data indicate statistically significant differences in the main effects of potential borrow area and season, but do not indicate a significant interaction between potential borrow area and season (Table III-5). Plots of least squares means produced in the ANOVA indicate that taxa richness was significantly higher during spring sampling events (Figure III-1). Subsequent pairwise comparisons (Tukey tests) of taxa richness means between potential borrow areas indicate significantly lower taxa richness in areas: 1) 5a & 5b when compared to areas 2a, 2b, 2c, 3a, and 7; 2) SH relative to areas 2b, 2c, 3a, and 7; and 3) 4a & 4b when compared to area 2c (Table III-6; Figure III-1).

Results of the two-way ANOVA of benthic invertebrate density data indicate significant differences in the main effects and the interaction effect of potential borrow area and season (Table III-5). Least squares means plots of each effect are presented in Figure III-2. The results of Tukey test pairwise comparisons of the interactions indicate the significant differences between the combinations of potential borrow area and season (Table III-7). Invertebrate densities measured during the fall at 4a & 4b, 5a & 5b, 6a, and SH were significantly lower than densities measured in either season at 2a, 2b, 2c, and 3a, with the exception of spring samples from 2a and fall samples from 2b that were not statistically different from fall samples at 4a & 4b or 6a (Table III-7). Invertebrate densities measured at 3a during the spring were significantly higher than densities measured in either season at 4a & 4b, 5a & 5b, 7, and SH, and fall samples at 6a, 7a, and 8a (Table III-7; Figure III-2). Significant differences between other combinations of potential borrow areas and seasons are identified in Table III-7.

Results of the two-way ANOVA of benthic invertebrate biomass data indicate significant differences in biomass between potential borrow areas; however, differences in biomass were not significant between seasons or interactions of potential borrow areas and seasons (Table III-5). Least squares means plots of each effect are presented in Figure III-3. Tukey tests comparing the means of biomass between potential borrow areas indicate that biomass was significantly lower in 5a & 5b relative to biomass in 2a, 2b, 2c, 7, and SH (Table III-8; Figure III-3). Areas 2b and

2c had significantly greater invertebrate biomass relative to 3a, 4a & 4b, 5a & 5b, and SH (Table III-8; Figure III-3).

2.1.2 Hierarchical Cluster Analysis

Hierarchical cluster analysis was used to determine the similarity of benthic invertebrate communities among combinations of potential borrow areas and seasons. The results of the cluster analysis based on the geometric mean values of taxa richness, density, and biomass produced six clusters of potential borrow area/season combinations (Figure III-4). Clusters 1 and 2 consist of fall sampling events, with the exception of spring collections at areas 7, SH, and 5a & 5b, which are all members of cluster 2. Four of five members of cluster 3 are spring samples, three of which are spring complements to fall samples contained in clusters 1 and 2. Fall sampling events at areas 2a, 2b, and 2c were members of cluster 4; spring samples collected at areas 2b, 2c, and 6a were members of cluster 5. Spring and fall sampling events at 3a are the only members of cluster 6.

The results of the cluster analysis generally indicate that taxonomically richer and more densely populated benthic communities are associated with potential borrow area/season combinations contained in clusters 5 and 6 relative to clusters 1 and 2. The cluster analysis results were interpreted based on box and whisker plots of the values used to form the clusters (Figure III-5). The results indicate greater values of taxa richness and density with increasing cluster number; a similar trend in biomass data is observed in clusters 1 through 4, but not clusters 5 and 6. The cluster analysis indicates that regardless of the season, a richer and denser invertebrate community is likely to be found in area 3a (cluster 6). Decreased invertebrate richness and density are associated with areas contained in clusters 1 and 2, which consist primarily of fall sampling events. Combinations of potential borrow areas and seasons found in cluster 3 represent communities of intermediate richness and density.

The results of the cluster analysis are consistent with the findings of the ANOVA, which generally found significantly greater richness and density in areas 2a, 2b, 2c, and 3a (generally clusters 4, 5, and 6) and lower richness and density in 4a & 4b, 5a & 5b, and SH (generally clusters 1, 2, and 3). Although differences in benthic community attributes have been identified by the ANOVA and cluster analysis, the ecological significance of these differences is uncertain and will require additional evaluation.

2.2 Finfish Communities

An evaluation of CPUE for all finfish species indicates that sampling events during fall months generally yielded more fish than sampling events in other seasons (Figure III-6). CPUE was generally consistent across depth contours in each borrow area, with the exception of area 2a, where CPUE at the 30 foot contour was generally lower than other contours in all seasons. Variability in CPUE was evident at all depth contours, but appeared greatest in the 30-foot contour. Trawls at this depth resulted in zero catch in at least one sample during all four seasons within potential borrow areas 2a and SH.

2.3 Species of Interest

Summer flounder were generally caught in the greatest numbers during the summer months in area SH (Figure III-7). Summer flounder were caught at lower rates in the spring and fall, and were caught infrequently during the winter. CPUE of summer flounder was generally lower at stations in the 30-foot contour relative to other contours; CPUE of summer flounder was generally consistent among the 40 to 60 foot contours.

Winter flounder were generally caught during the winter and spring months and found infrequently during the summer and fall (Figure III-8). The highest catches of winter flounder were during the spring in area SH. CPUE of winter flounder was generally lower at stations in the 30-foot contour relative to other contours; CPUE of winter flounder was generally consistent among the 40 to 60 foot contours.

Winter skate were collected at the greatest rate during spring sampling events (Figure III-9). Catches of winter skate during other seasons were low relative to spring sampling events, but were generally consistent across borrow areas. During the spring, winter skate were collected at a higher CPUE at stations associated with the 40-foot contour and deeper.

Squid were collected at the greatest rates during fall sampling events, followed by summer events (Figure III-10). In the spring, squid catches were generally limited to deeper water; squid were collected infrequently during winter. CPUE of squid was generally lower at stations in the 30-foot contour relative to other contours; CPUE of squid tended to increase with increasing depth contours across all locations (Figure III-10).

Surf clam were harvested in the greatest numbers at area 2ad relative to other potential borrow areas that were sampled (Figure III-11). Harvest at 2ad ranged from 0 to 67 U.S. bushels. The number of bushels harvested among the other potential borrow areas was generally consistent, with the exception of an extreme harvest of 70 bushels in SH.

2.4 Sediment Grain Size Distribution

Sand (4.75 mm to 75 µm) is the predominant substrate across all borrow areas and depths (Figure III-12). In general, sand comprises greater than 90 percent of sediment grain size, with the exception of outlying samples that generally had a lower percent composition of sand and higher percent composition gravel and fines. In Figure III-12, the 50-foot contour of 4a & 4b appears to have a lower percent composition of sand and greater percent composition gravel. However, there is little data to base any conclusions regarding sediment grain size in the 50-foot contour of area 4a & 4b, as only two samples were collected from this depth contour (Table III-4). With the exception of outlying samples, sediment grain size distribution was generally consistent across depth contours. Sediment grain size distributions generally remained consistent between seasons at each borrow area (Figure III-13).

3.0 Summary and Conclusions of Data Analysis

3.1 Summary

Benthic invertebrate communities within the FIMP reformulation study area were evaluated based on ANOVA and hierarchical cluster analysis. The evaluation identified combinations of potential borrow areas and seasons with benthic communities that were generally taxonomically richer and more densely populated than benthic communities associated with other combinations of potential borrow area and season. In general, greater richness and density were found in potential borrow areas 2a, 2b, 2c, and 3a, and lower richness and density were in areas 4a & 4b, 5a & 5b, and SH. Lower richness and population density were also generally associated with benthic communities observed during fall sampling events.

The semi-quantitative evaluation of finfish communities indicated that overall CPUE was generally greater during the fall months in water depth contours greater than 30 feet. When considering finfish of interest, CPUE was generally lower at stations associated with the 30-foot depth contour. CPUE for finfish of interest varied by species: summer flounder were caught at a greater rate during summer months; winter flounder were caught at a greater rate during winter and spring; and winter skate were caught at a greater rate during spring. Relative to the other borrow areas, CPUE for all species tended to be greater at area SH.

Squid were collected at the greatest rates during fall sampling events, followed by summer events. Squid collection was generally lower at stations in the 30-foot depth contour relative to other contours, particularly during spring sampling. Surf clam was harvested in greater numbers at area 2ad relative to the other potential borrow areas that were sampled. The number of bushels of surf clam harvested among the other potential borrow areas was generally consistent, with the exception of an extreme harvest of 70 bushels in SH.

Sand is the predominant substrate across all borrow areas and depths. Sediment grain size was generally consistent across borrow areas and depths, with the exception of outlying samples, which generally had a lower percent composition of sand and a higher percent composition gravel and fines. Sediment grain size distribution was generally consistent between seasons within each borrow area.

3.2 Conclusions

This evaluation of benthic and finfish communities, species of interest, and sediment grain size distribution represents a preliminary characterization of potential borrow areas in the FIMP reformulation study area. The results of the preliminary characterization identified spatial and temporal differences in the biological characteristics of the potential borrow areas. Further evaluations of these differences will be necessary to characterize their ecological significance and to assess potential ecological impacts. The results of this evaluation may provide a useful tool in further describing the biological and physical characteristics of these areas and assessing potential ecological impacts associated with reformulation activities.

IV. TABLES AND FIGURES

Table I-1. Studies Included in Database

Studies included in the USACE Database Compilation and sampling conducted during each effort

Study Title	Work Order #	# Samples	Dates Sampled	Data Type
Reformulation Benthos I Macrobenthic Invertebrate Analysis Napeague to East of Fire Island Inlet	10	275	July - August 1999	invertebrate abundance, biomass water quality grain size
West of Shinnecock Inlet: Offshore Borrow Area Multi-Species Sampling	13	192	April 1999 - April 2000 (no sample Jan. 2000)	finfish abundance, biomass, age, length invertebrate abundance water quality
Reformulation Benthos II Napeague to East of Fire Island Inlet Benthic Invertebrate Survey	17	275	November - December 1999	invertebrate abundance, biomass water quality grain size
Reformulation Benthos III WOSI to East of Fire Island Inlet Benthic Invertebrate Survey	22	130260	November 2000 & June 2001	invertebrate abundance, biomass water quality grain size
WOSI and Cherry Grove: Multispecies Sampling	23	192	May 2000 - April 2001	finfish abundance, biomass, age, length invertebrate abundance water quality
Surf Clam Survey	24	240	August - Sept 2001	surf clam abundance (bushels), width
Cherry Grove Offshore Borrow Area Finfish Sampling Year 3	25	96	May 2001 - April 2002	finfish abundance, biomass, age, length invertebrate abundance water quality

Table I-2: Database Parameters and Units of Measurement	
Parameter	**Units**
Salinity	ppt
Temperature	° Celsius
Secchi	Feet
Station Depth	Feet
Length	Millimeters
Weight	Grams
Position	Decimal Degrees
Sample Volume	Milliliters
Dissolved Oxygen	milligrams/Liter
Fish Age	Year class
Clam Width	Millimeters

Table I-3: Grain Sizes
Grain size according to ASTM method D 422.

U.S. Standard Sieve Size	Grain Size	Classification
4”		Gravel
3”	75.00 mm	
1 ½”	37.50 mm	
¾”	19.00 mm	
$^3/_8$”	9.50 mm	
#4	4.75 mm	
#10	2.00 mm	Sand
#20	850 µm	
#40	425 µm	
#60	250 µm	
#100	150 µm	
#200	75 µm	
	<75 µm	Silt or Clay

Table I-4: Borrow Areas, Location, and Benthic Station Identification		
Borrow Area	**Location**	**Benthic Station ID**
2a	Water Island	WI
2b	Fire Island Pines	FIP
2c	Cherry Grove	CG
3a	Bayberry Dunes	BD
4a & 4b	Westhampton West	WHW
5a & 5b	West Hampton	WH
6a	Agawam Lake	AL
7	Hook Pond	HP
7a	Georgica Pond	GP
8a	Beach Hampton	BH
SH	Shinnecock	SH
IB	Inter- Borrow Areas	IB

TABLE III-1

NUMBER[1] OF BENTHIC INVERTEBRATE SAMPLES BY AREA AND SEASON

Potential Borrow Area	Number of Samples		
	Fall	Spring	Total by Area:
2a	38	38	76
2b	27	26	53
2c	53	53	106
3a	23	24	47
4a & 4b	35	34	69
5a & 5b	51	46	97
6a	10	10	20
7	41	42	83
7a	10	10	20
8a	20	20	40
SH	65	60	125
Total by Season:	373	363	736

Notes:

1, Numbers represent total samples collected at each area and season during years 1999, 2000, and 2001.

TABLE III-2
NUMBER[1] OF FINFISH TRAWLS BY AREA, SEASON, AND DEPTH CONTOUR

Potential Borrow Area	Number of Samples																
Season:	Fall				Winter				Spring				Summer				Total by Area:
Depth Contour:	30 ft	40 ft	50 ft	60 ft	30 ft	40 ft	50 ft	60 ft	30 ft	40 ft	50 ft	60 ft	30 ft	40 ft	50 ft	60 ft	
2a	12	6	6	---	12	6	6	---	11	6	6	---	12	6	6	---	95
2b	---	6	6	---	---	6	6	---	---	6	6	---	---	6	6	---	48
2c	---	---	---	12	---	---	---	12	---	---	---	12	---	---	---	12	48
SH	24	12	24	12	20	9	19	9	26	14	26	14	27	13	27	13	289
Total by Season:	120				105				127				128				480

Notes:
1, Numbers represent total trawls conducted at each area, season, and depth contour during years 1999, 2000, and 2001.
---, No data collected.

TABLE III-3
NUMBER[1] OF SURF CLAM SAMPLES BY AREA

Potential Borrow Area	Number of Samples
2AD	56
2B	28
2C	28
3A	28
4A	16
5AB	28
8A	28
SH	28
Total:	240

Notes:
1, Numbers represent samples collected in August and September 2001.

TABLE III-4

NUMBER[1] OF SEDIMENT GRAIN SIZE SAMPLES BY AREA, DEPTH, AND SEASON

Potential Borrow Area	Station Depth Contour				Total by Area:
	30 ft	40 ft	50 ft	60 ft	
2a	2	4	4	---	10
2b	---	2	8	10	20
2c	---	---	---	39	39
4a & 4b	---	10	2	18	30
5a & 5b	22	14	2	2	40
SH	16	28	26	60	130
Total by Depth:	40	58	42	129	269

Potential Borrow Area	Number of Samples		
	Season		Total by Area:
	Fall	Spring	
2a	5	5	10
2b	10	10	20
2c	20	19	39
4a & 4b	15	15	30
5a & 5b	20	20	40
SH	65	65	130
Total by Season:	135	134	269

Notes:

1, Numbers represent total samples collected at each area, season, and depth contour during years 1999, 2000, and 2001.

TABLE III-5
RESULTS OF TWO-WAY ANOVA (POTENTIAL BORROW AREA X SEASON) OF BENTHIC INVERTEBRATE TAXA RICHNESS, DENSITY AND BIOMASS DATA

Taxa Richness:

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
AREA	1799.194	10	179.919	10.291	< 0.001
SEASON	894.433	1	894.433	51.157	< 0.001
AREA*SEASON	359.192	10	35.919	2.054	0.026
Error	12483.551	714	17.484		

Density:

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
AREA	26.963	10	2.696	14.733	< 0.001
SEASON	3.928	1	3.928	21.462	< 0.001
AREA*SEASON	7.024	10	0.702	3.838	< 0.001
Error	130.668	714	0.183		

Biomass:

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
AREA	31.707	10	3.171	7.928	< 0.001
SEASON	1.495	1	1.495	3.739	0.054
AREA*SEASON	6.16	10	0.616	1.54	0.121
Error	285.575	714	0.4		

TABLE III-6
MATRIX OF PAIRWISE COMPARISONS (TUKEY TEST) OF BENTHIC INVERTEBRATE TAXA RICHNESS BETWEEN POTENTIAL BORROW AREAS

Matrix of Pairwise Comparisons (Tukey HSD):

	2a	2b	2c	3a	4a & 4b	5a & 5b	6a	7	7a	8a	SH
2a	--										
2b	--	--									
2c	--	--	--								
3a	--	--	--	--							
4a & 4b	--	--	X	--	--						
5a & 5b	X	X	X	X	--	--					
6a	--	--	--	--	--	--	--				
7	--	--	--	--	--	X	--	--			
7a	--	--	--	--	--	--	--	--	--		
8a	--	--	--	--	--	--	--	--	--	--	
SH	--	X	X	X	--	--	--	X	--	--	--

Key: X = Significant Difference ($p < 0.05$); -- = No Significant Difference; F = Fall Sampling Event; S = Summer Sampling Event

TABLE III-7
MATRIX OF PAIRWISE COMPARISONS (TUKEY TEST) OF BENTHIC INVERTEBRATE DENSITY

Matrix of Pairwise Comparisons (Tukey HSD):

	2a_F	2a_S	2b_F	2b_S	2c_F	2c_S	3a_F	3a_S	4a & 4b_F	4a & 4b_S	5a & 5b_F	5a & 5b_S	6a_F	6a_S	7_F	7_S	7a_F	7a_S	8a_F	8a_S	SH_F	SH_S
2a_F	--																					
2a_S	--	--																				
2b_F	--	--	--																			
2b_S	--	--	--	--																		
2c_F	--	--	--	--	--																	
2c_S	--	--	--	--	--	--																
3a_F	--	--	--	--	--	--	--															
3a_S	--	--	--	--	--	--	--	--														
4a & 4b_F	X	--	--	X	X	X	X	X	--													
4a & 4b_S	--	--	--	--	--	--	--	X	--	--												
5a & 5b_F	X	X	X	X	X	X	X	X	--	X	--											
5a & 5b_S	--	--	--	--	--	--	--	X	--	--	X	--										
6a_F	X	--	--	X	X	X	X	X	--	--	--	--	--									
6a_S	--	--	--	--	--	--	--	--	--	--	--	--	--	--								
7_F	--	--	--	--	--	--	--	X	--	--	X	--	--	--	--							
7_S	X	--	--	--	--	X	X	X	--	--	--	--	--	--	--	--						
7a_F	--	--	--	--	--	X	X	X	--	--	--	--	--	--	--	--	--					
7a_S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--				
8a_F	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--	--	--			
8a_S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
SH_F	X	X	X	X	X	X	X	X	--	X	--	X	--	--	X	X	--	--	--	X	--	
SH_S	--	--	--	--	--	X	--	X	--	--	X	--	--	--	--	--	--	--	--	--	X	--

Key: X = Significant Difference ($p < 0.05$); -- = No Significant Difference; F = Fall Sampling Event; S = Summer Sampling Event

TABLE III-8
MATRIX OF PAIRWISE COMPARISONS (TUKEY TEST) OF BENTHIC INVERTEBRATE BIOMASS BETWEEN POTENTIAL BORROW AREAS

Matrix of Pairwise Comparisons (Tukey HSD):

	2a	2b	2c	3a	4a & 4b	5a & 5b	6a	7	7a	8a	SH
2a	--										
2b	--	--									
2c	--	--	--								
3a	--	X	X	--							
4a & 4b	--	X	X	--	--						
5a & 5b	X	X	X	--	--	--					
6a	--	--	--	--	--	--	--				
7	--	--	--	--	--	X	--	--			
7a	--	--	--	--	--	--	--	--	--		
8a	--	--	--	--	--	--	--	--	--	--	
SH	--	X	X	--	--	X	--	--	--	--	--

Key: X = Significant Difference ($p < 0.05$); -- = No Significant Difference; F = Fall Sampling Event; S = Summer Sampling Event

FIGURE I-1

MAP OF POTENTIAL BORROW AREAS

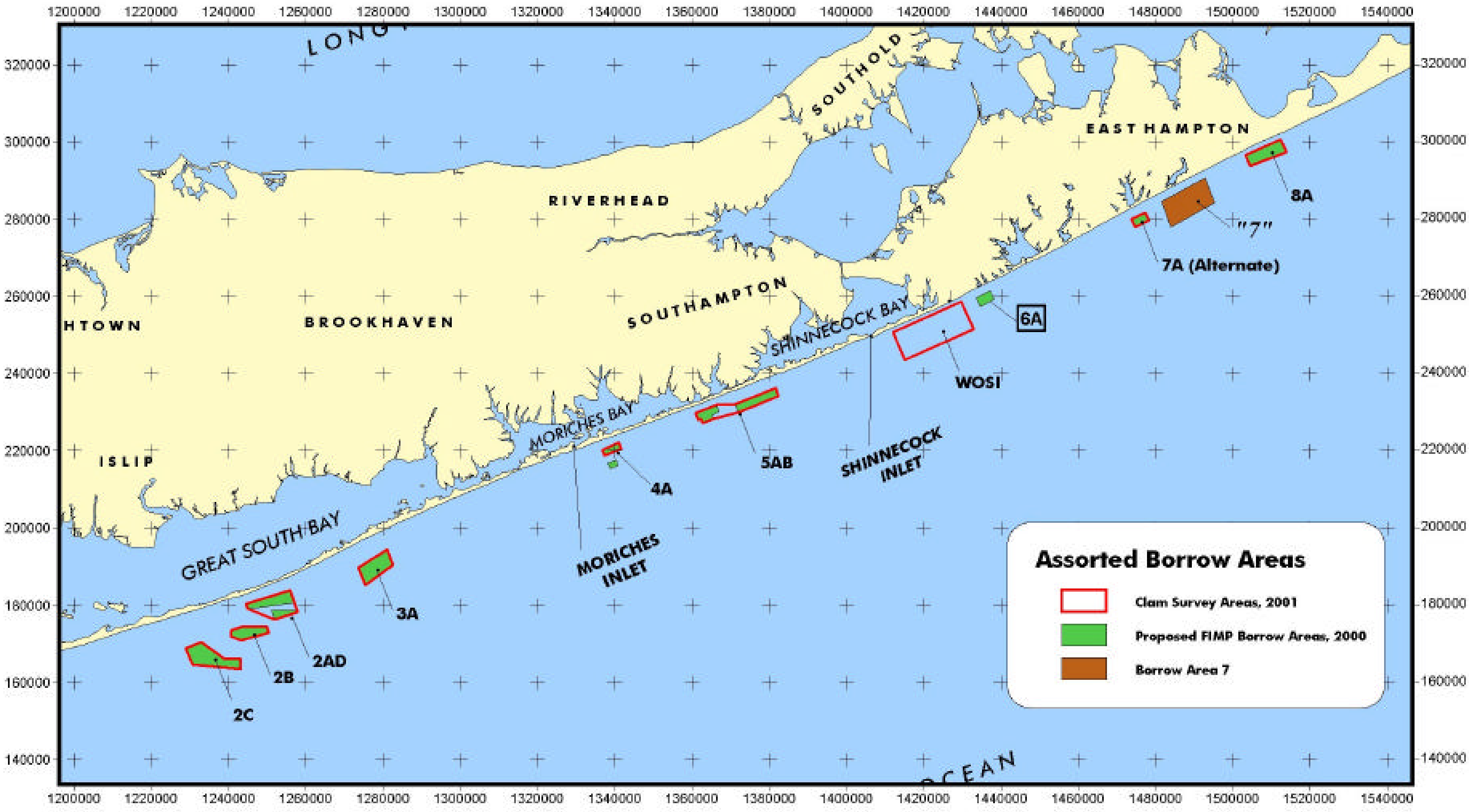


FIGURE I-2

BENTHIC GRAB AND TRAWL SAMPLE LOCATIONS

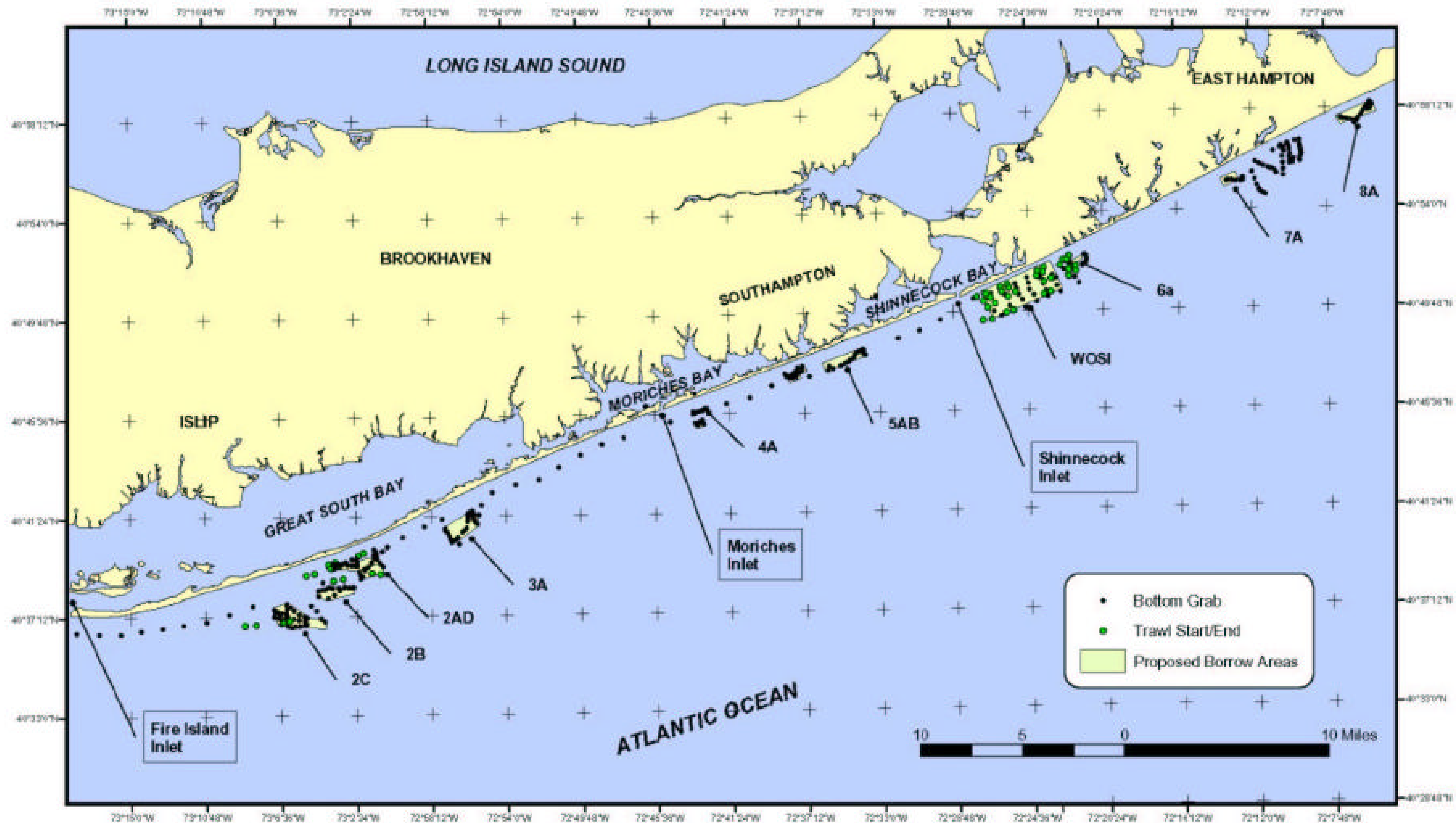


FIGURE I-3

SURF CLAM SURVEY SAMPLE LOCATIONS

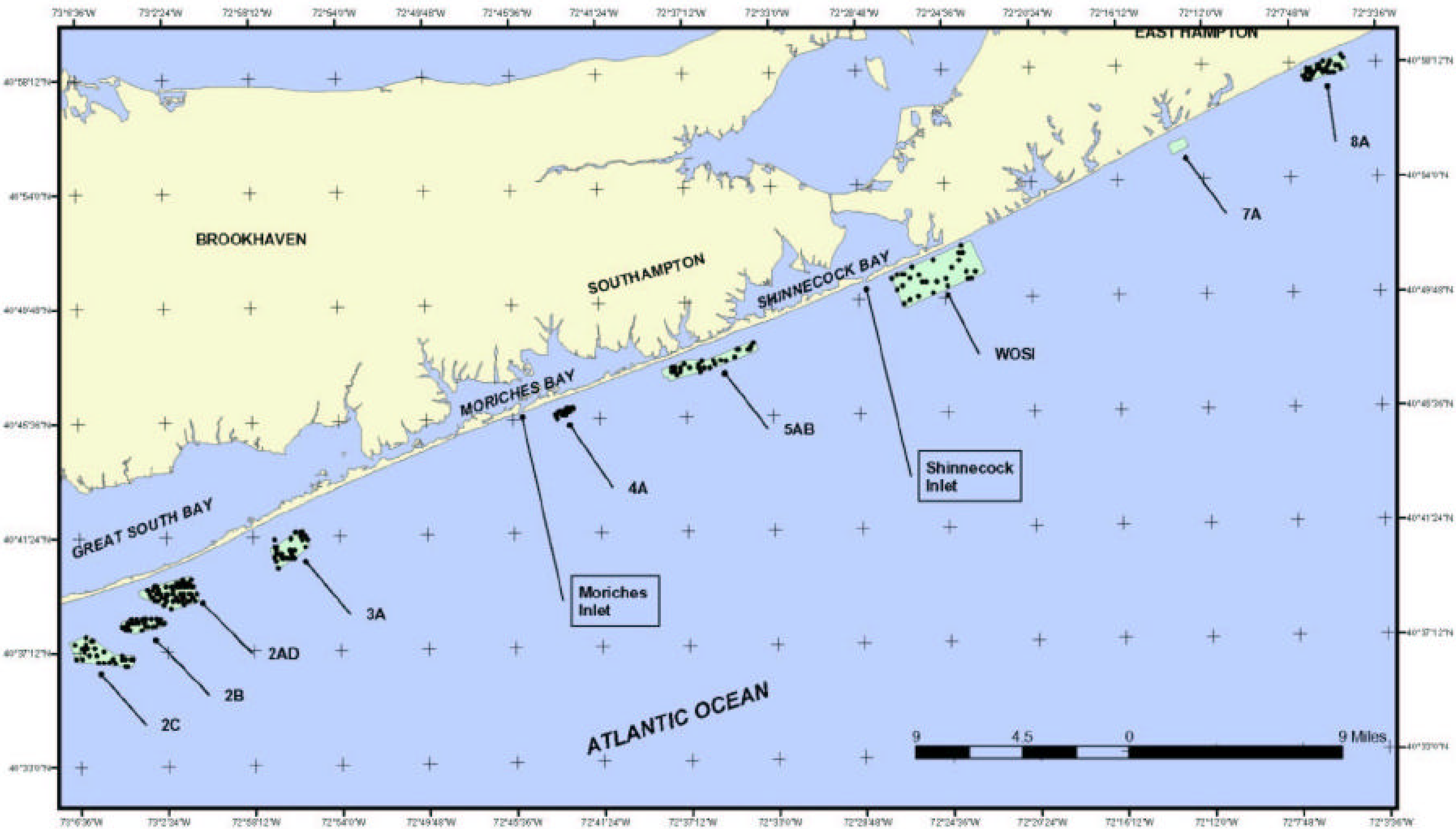


FIGURE III-1
BENTHIC INVERTEBRATE TAXA RICHNESS ANOVA: PLOTS OF LEAST SQUARES MEANS OF AREA, SEASON, AND AREA X SEASON INTERACTION EFFECTS

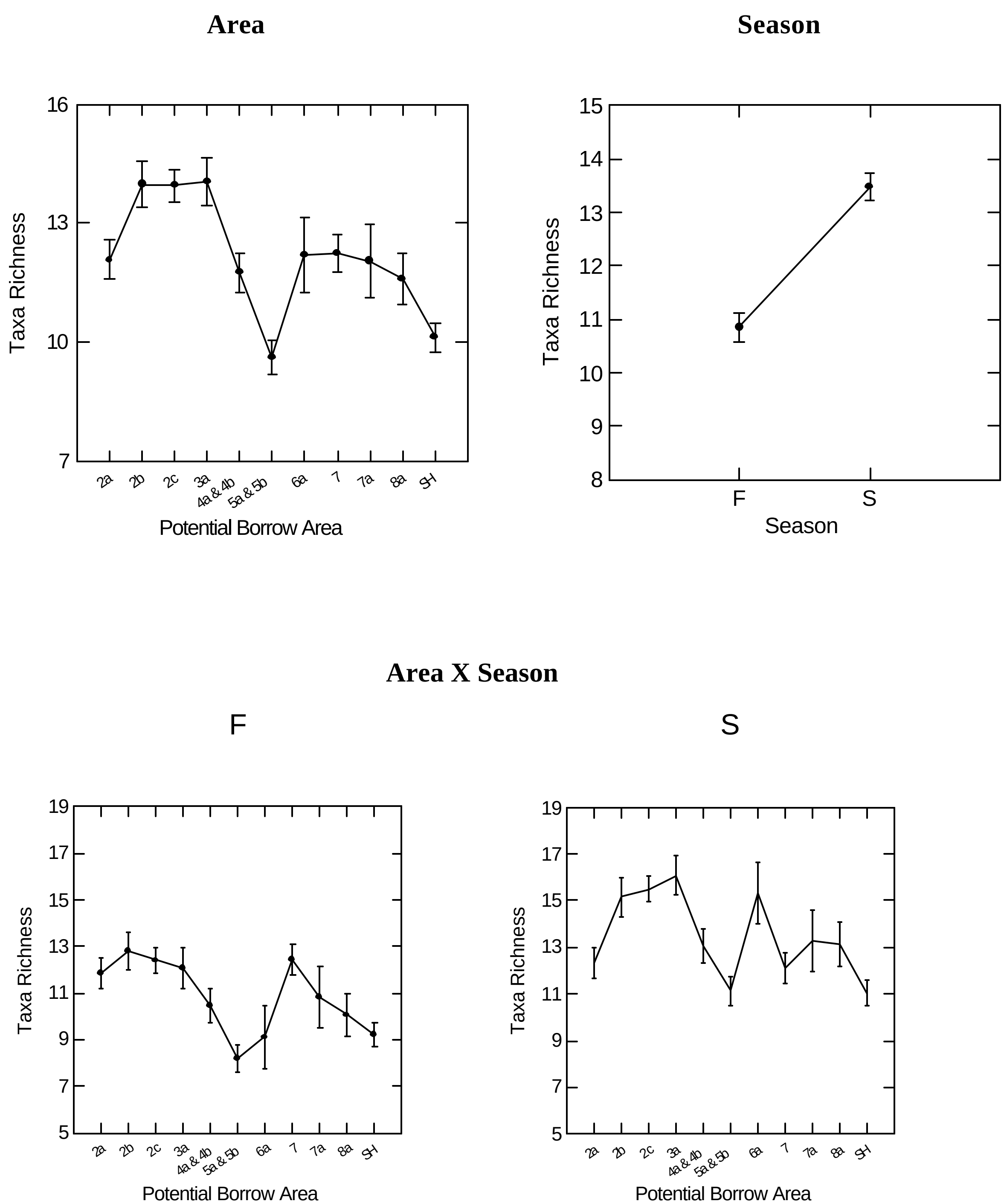


FIGURE III-2
BENTHIC INVERTEBRATE DENSITY ANOVA: PLOTS OF LEAST SQUARES MEANS OF AREA, SEASON, AND AREA X SEASON INTERACTION EFFECTS

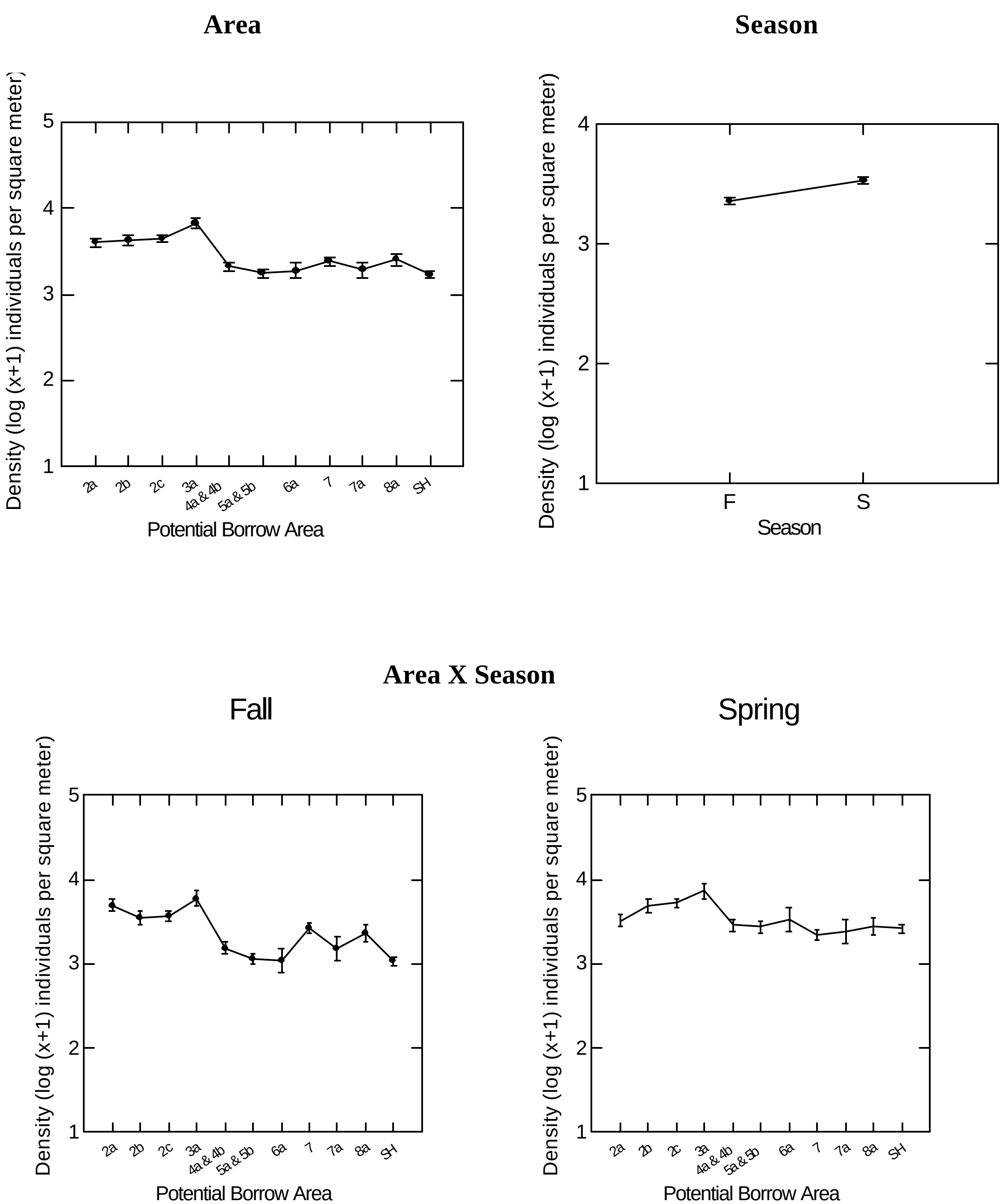


FIGURE III-3
BENTHIC INVERTEBRATE BIOMASS ANOVA: PLOTS OF LEAST SQUARES MEANS OF AREA, SEASON, AND AREA X SEASON INTERACTION EFFECTS

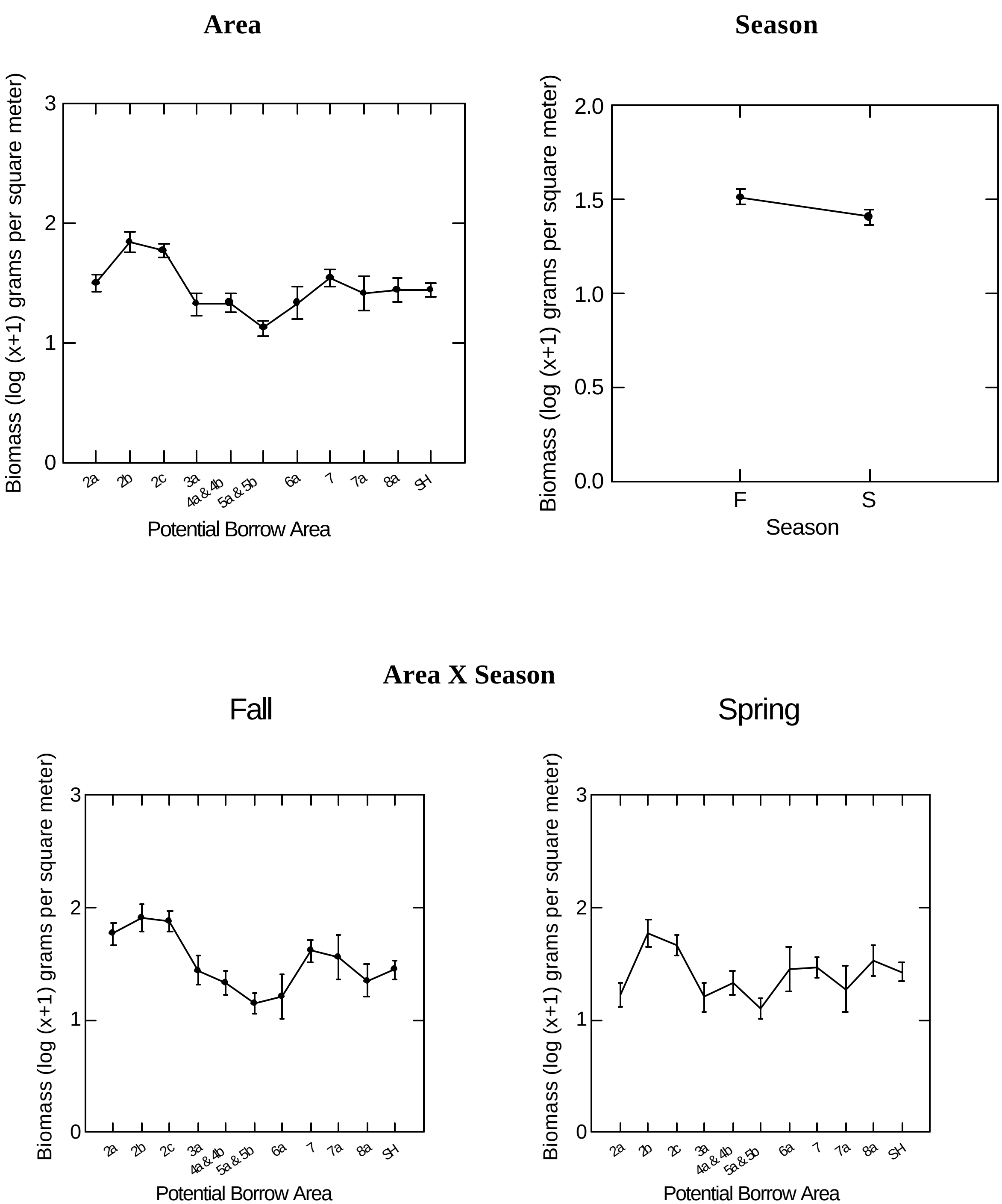


FIGURE III-4
HIERARCHICAL CLUSTER ANALYSIS (AVERAGE LINKAGE/EUCLIDEAN DISTANCE) BASED ON THE GEOMETRIC MEANS OF TAXA RICHNESS, DENSITY, AND BIOMASS FOR EACH COMBINATION OF POTENTIAL BORROW AREA AND SEASON

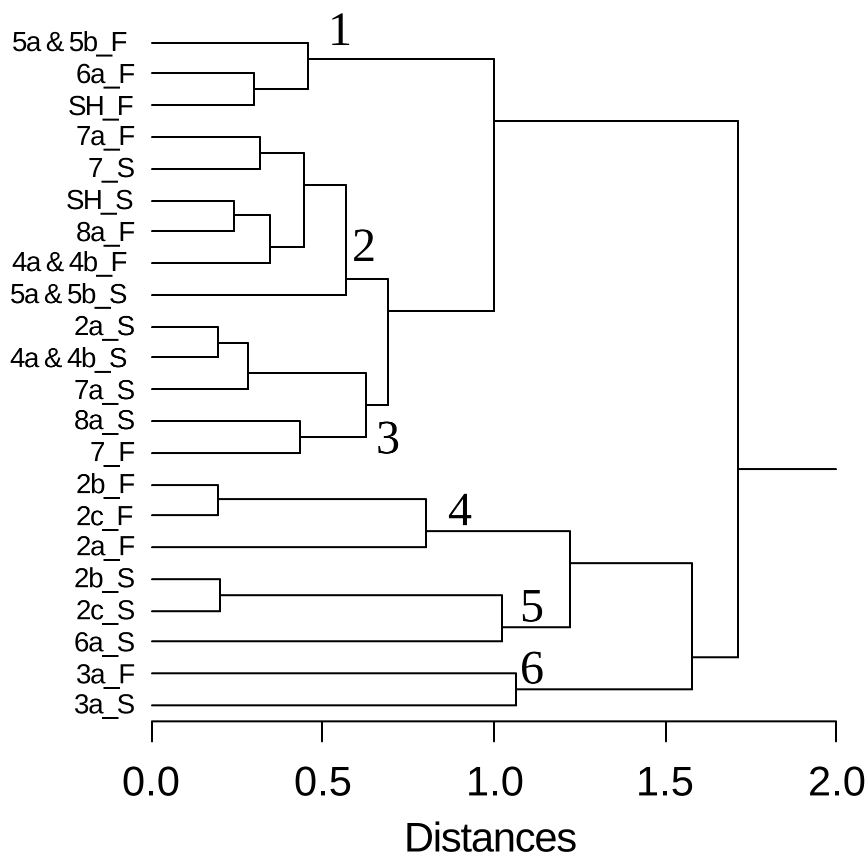


FIGURE III-5
BOX AND WHISKER PLOTS OF DENSITY, TAXA RICHNESS, AND BIOMASS FOR MEMBERS OF CLUSTERS IDENTIFIED BY HIERARCHICAL CLUSTER ANALYSIS

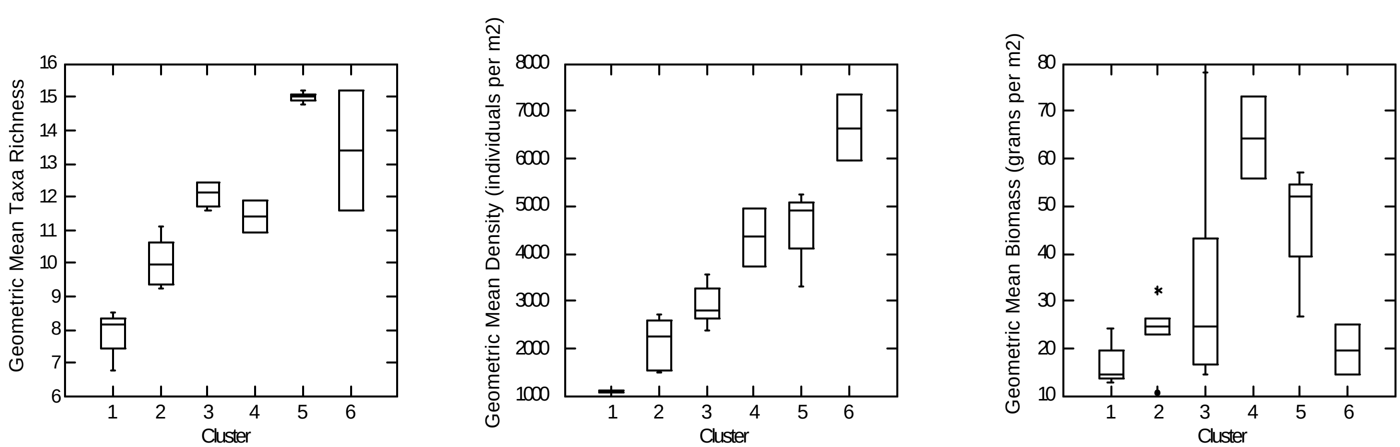


FIGURE III-6
CATCH PER UNIT EFFORT (CPUE) OF ALL FINFISH BY SEASON, POTENTIAL BORROW AREA, AND DEPTH

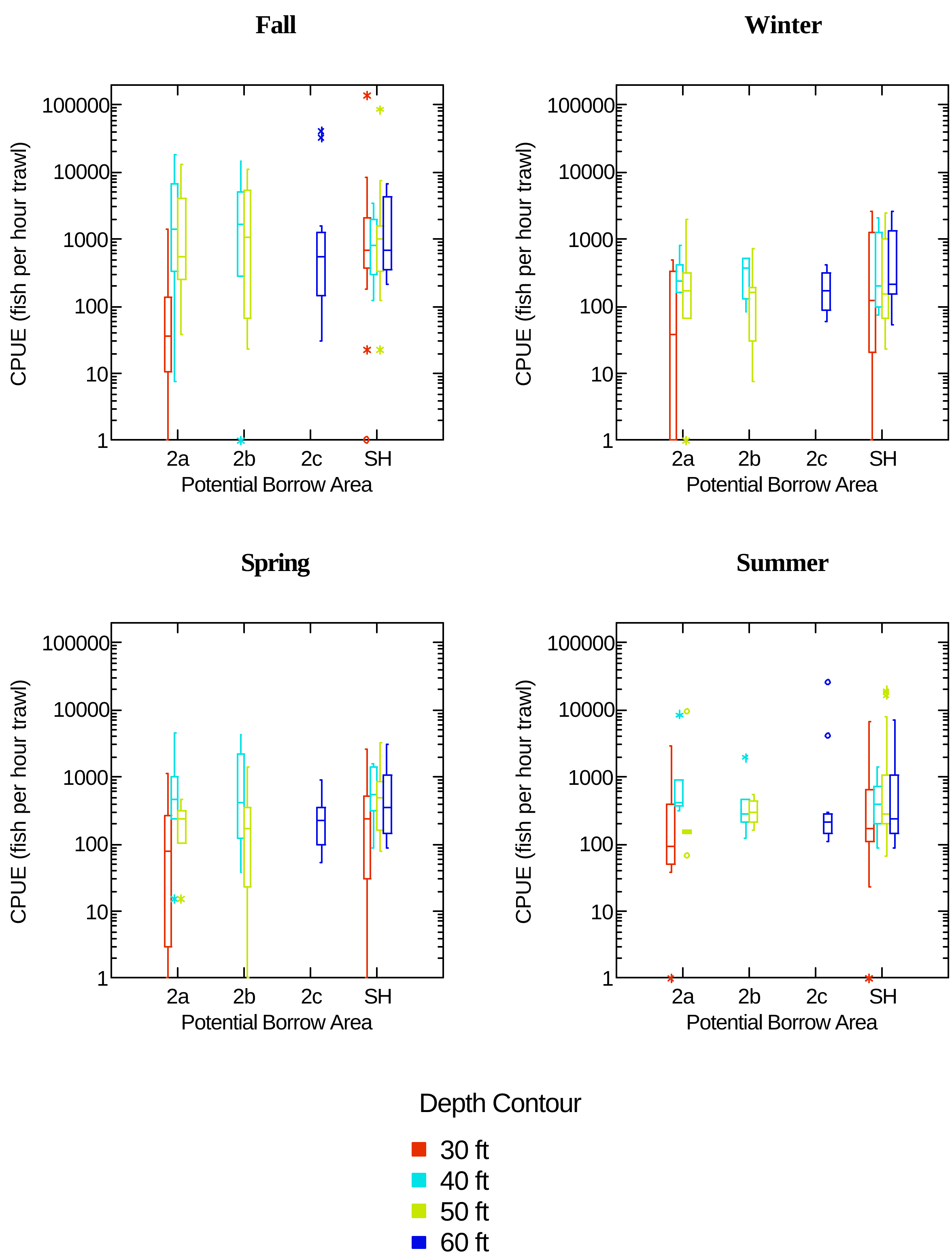


FIGURE III-7
CATCH PER UNIT EFFORT (CPUE) OF SUMMER FLOUNDER BY SEASON, POTENTIAL BORROW AREA, AND DEPTH

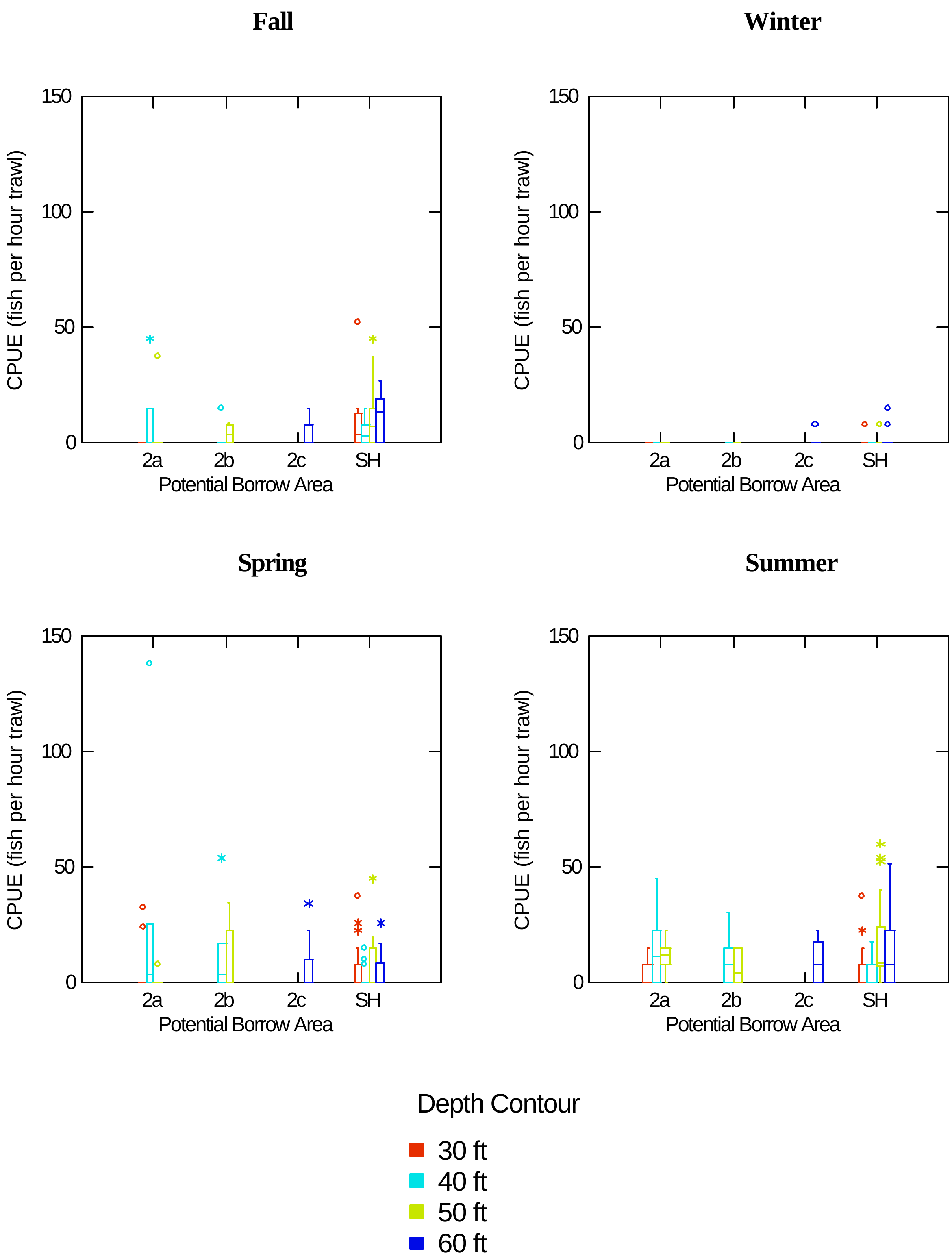


FIGURE III-8
CATCH PER UNIT EFFORT (CPUE) OF WINTER FLOUNDER BY SEASON, POTENTIAL BORROW AREA, AND DEPTH

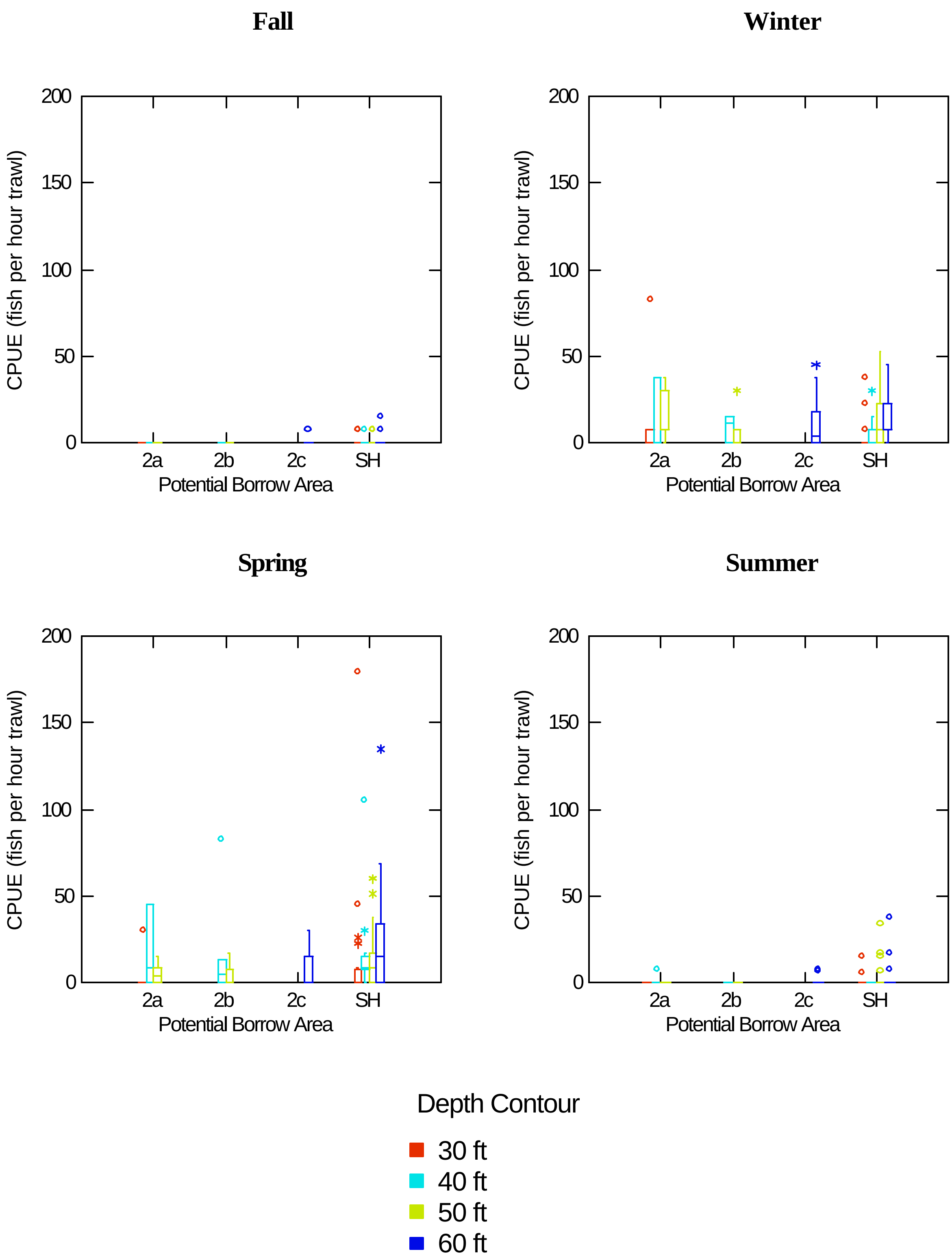


FIGURE III-9
CATCH PER UNIT EFFORT (CPUE) OF WINTER SKATE BY SEASON, POTENTIAL BORROW AREA, AND DEPTH

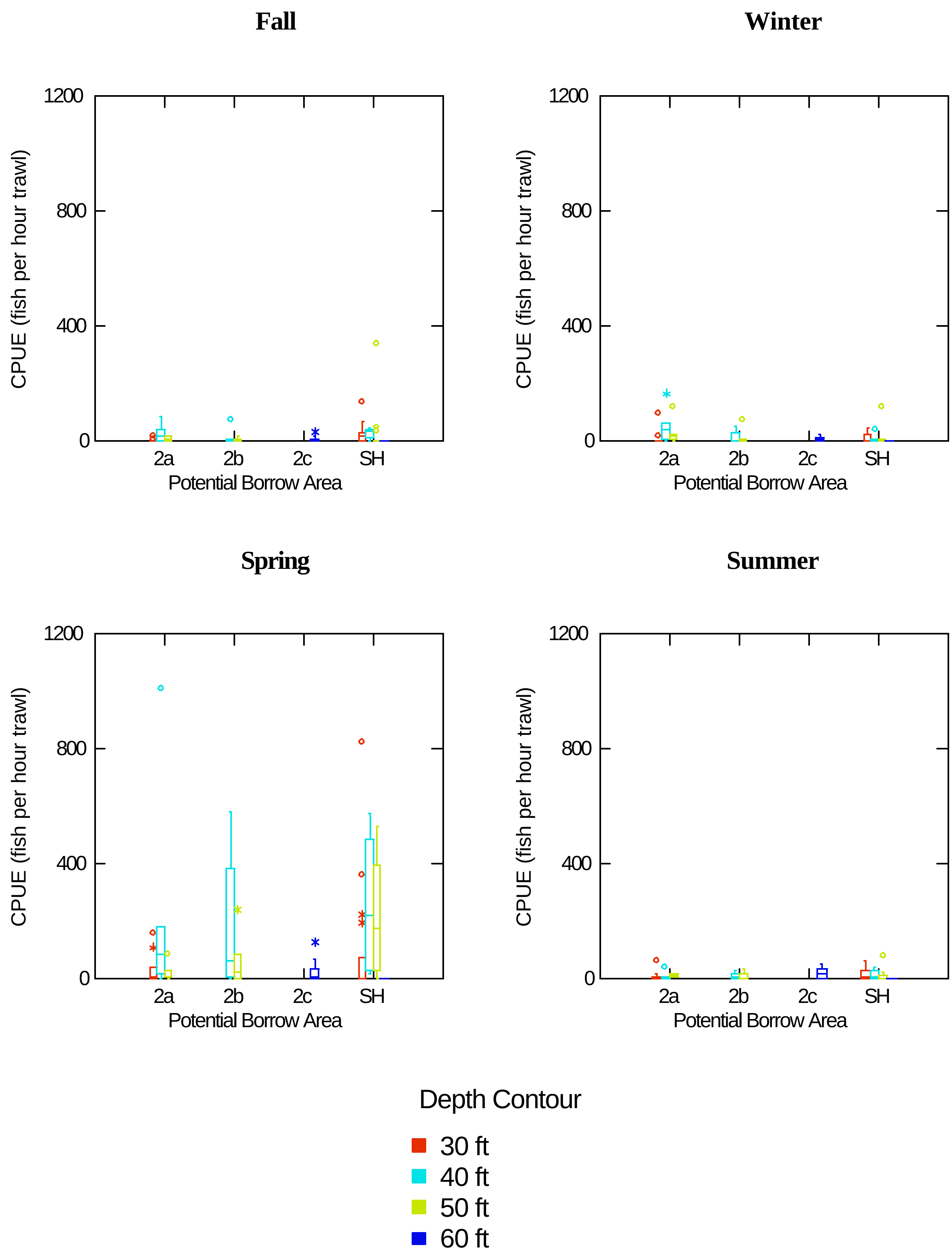


FIGURE III-10
CATCH PER UNIT EFFORT (CPUE) OF SQUID BY SEASON, POTENTIAL BORROW AREA, AND DEPTH

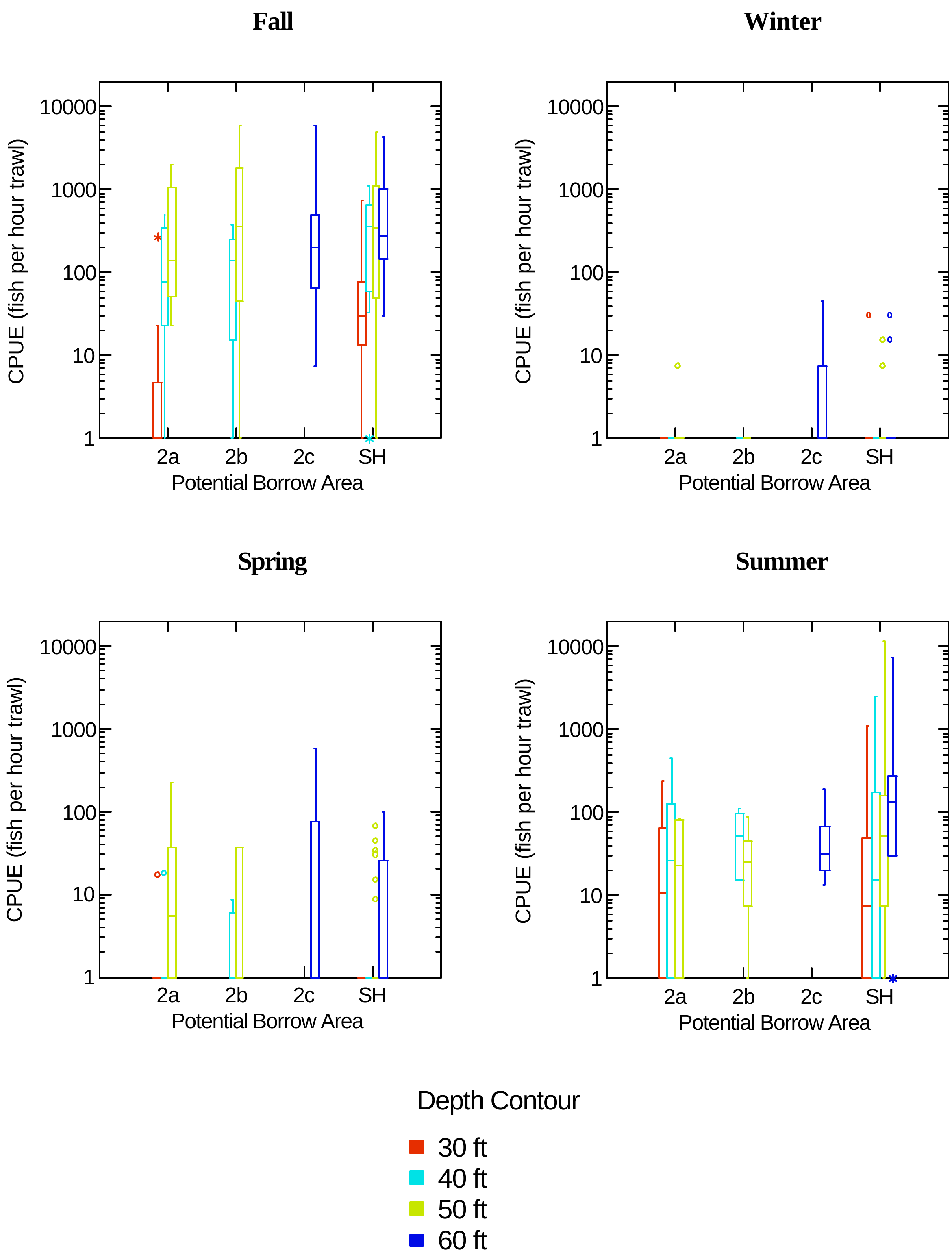


FIGURE III-11
SURF CLAM (US BUSHELS) COLLECTED IN POTENTIAL BORROW AREAS DURING AUGUST AND SEPTEMBER SAMPLING

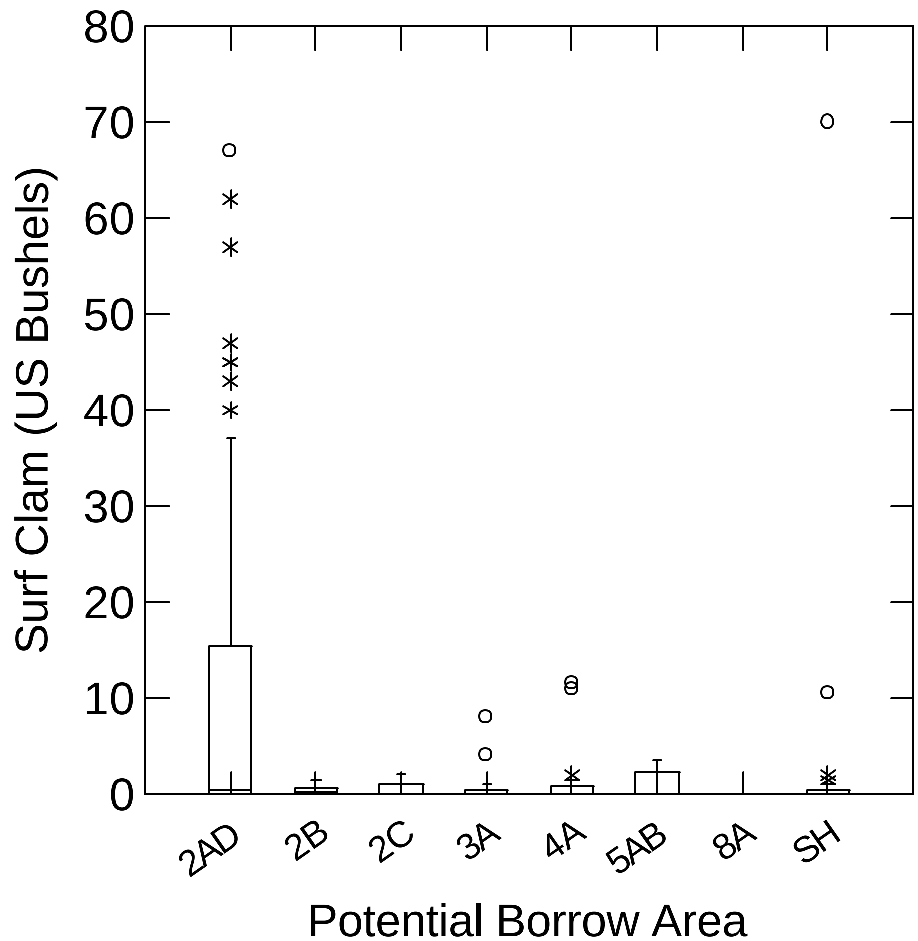


FIGURE III-12
GRAIN SIZE DISTRIBUTION OF SEDIMENT IN POTENTIAL BORROW AREAS BY DEPTH CONTOUR

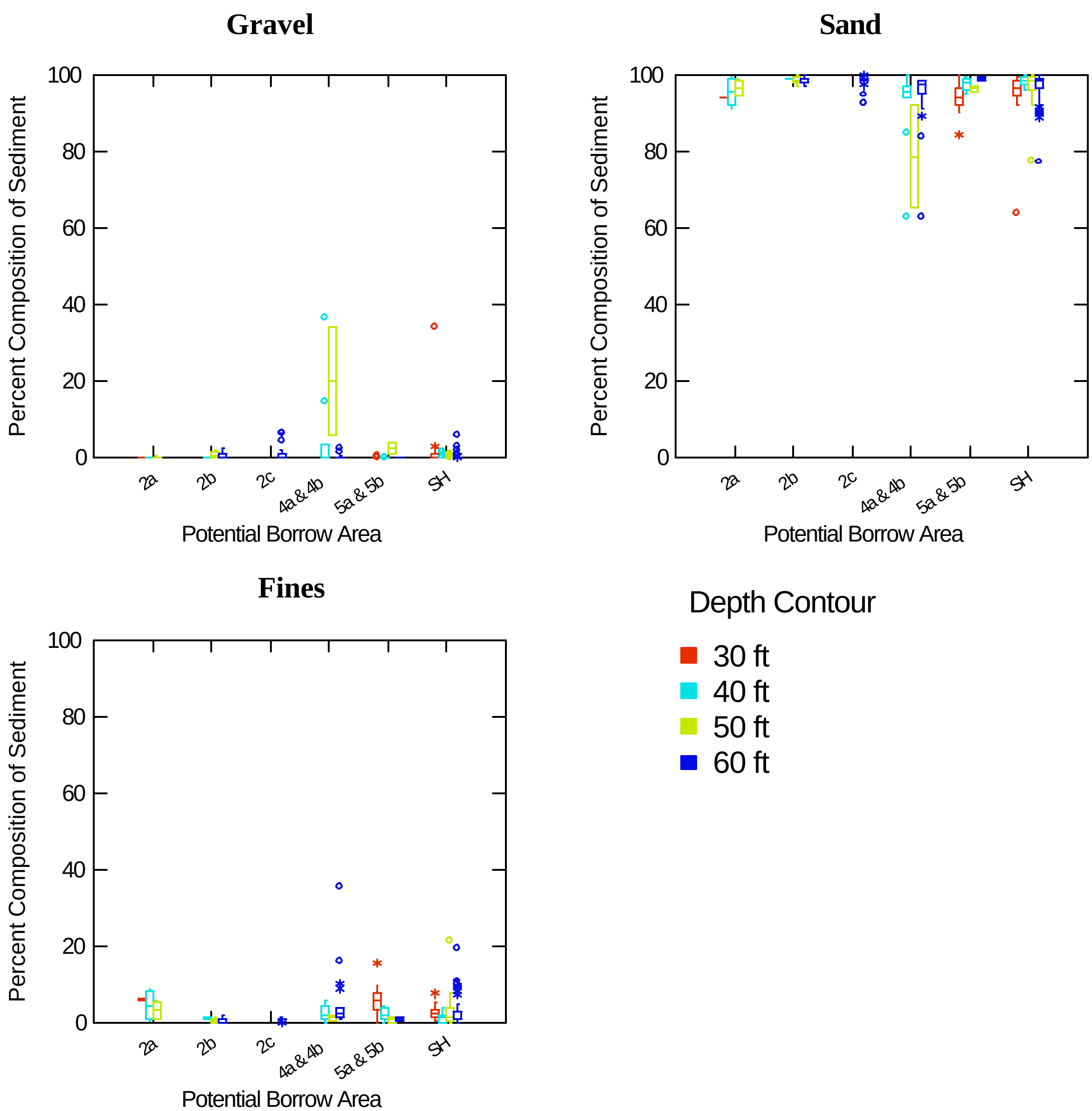
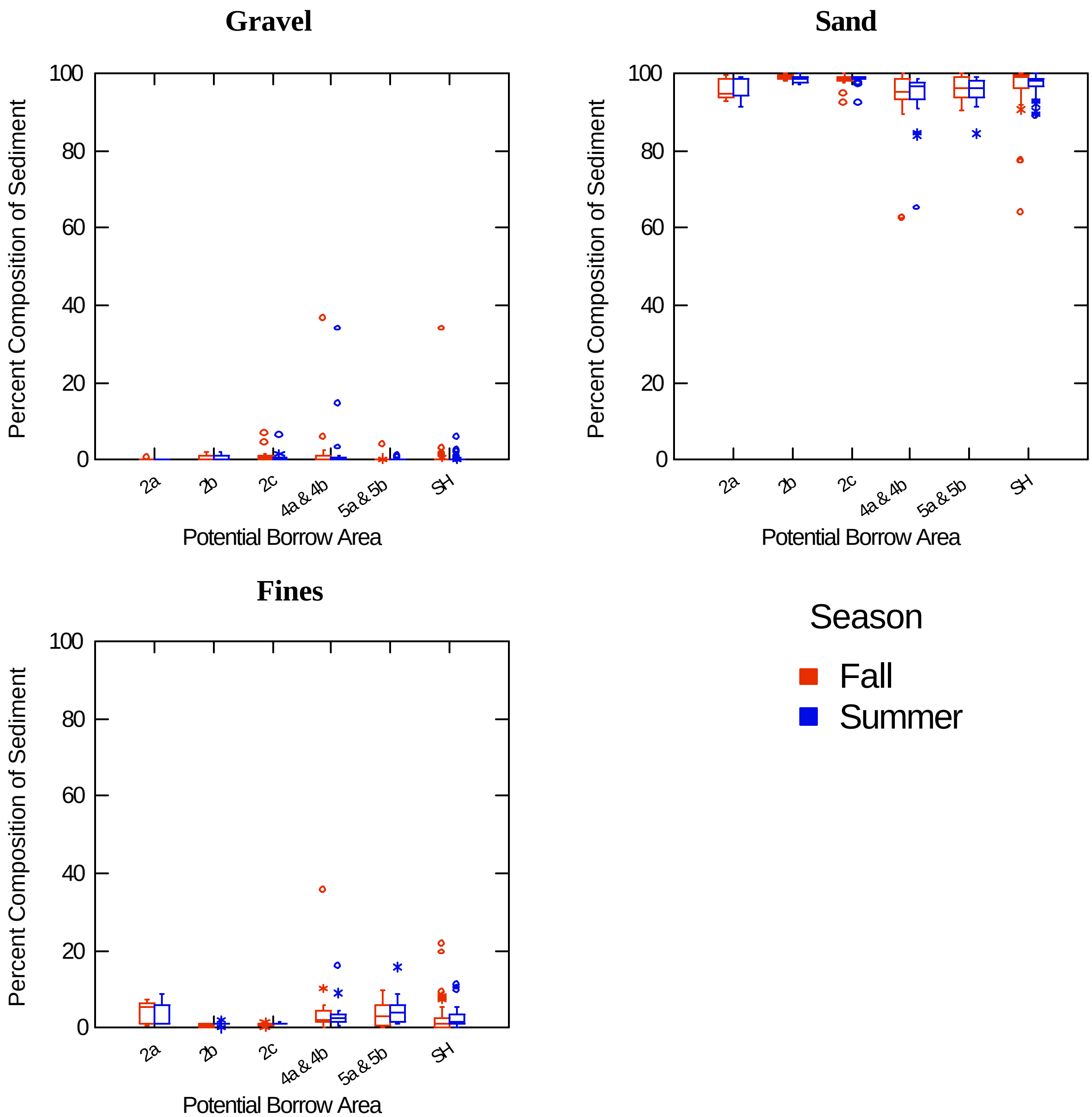


FIGURE III-13
GRAIN SIZE DISTRIBUTION OF SEDIMENT IN POTENTIAL BORROW AREAS BY SEASON



V. References

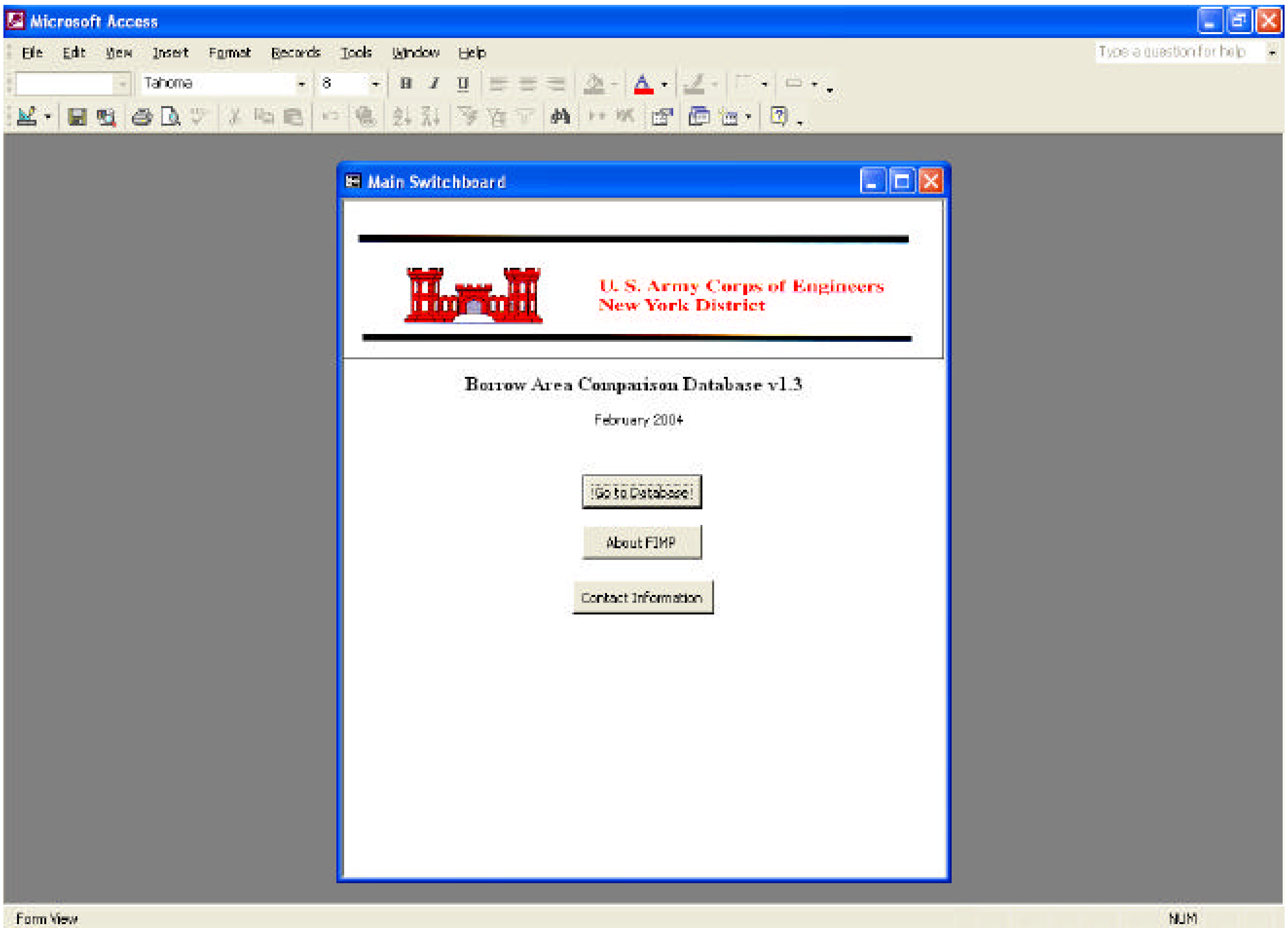
Helsel, D.R., and R.M. Hirsch. 1991. Statistical Methods in Water Resources. U.S. Geological Survey, Techniques of Water-Resources Investigations Book 4, Chapter A3.

Pielou, E.C. 1984. The Interpretation of Ecological Data: A Primer on Classification and Ordination. New York: John Wiley and Sons, 263 p.

VI. DATABASE USER'S GUIDE

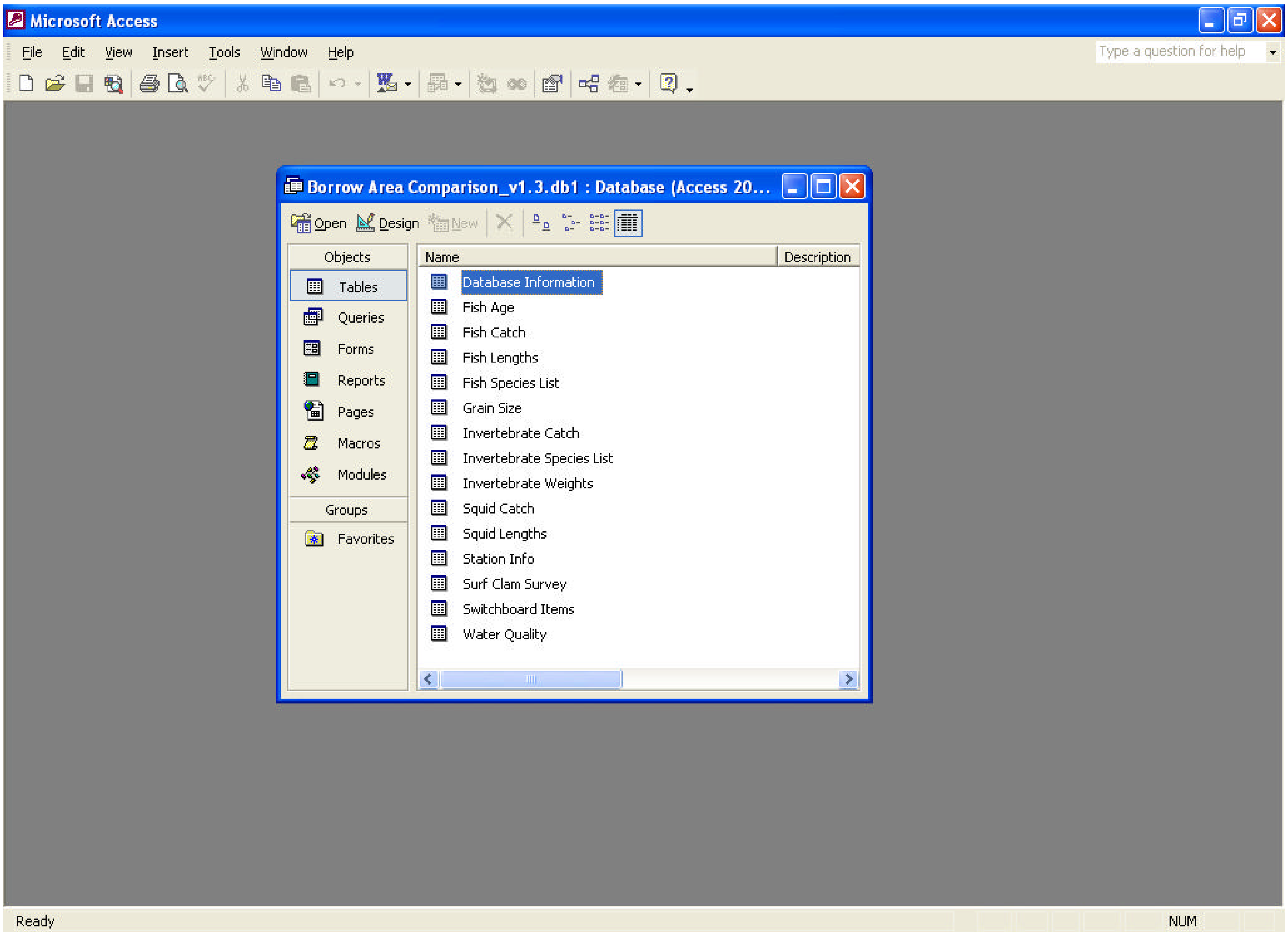
1.0 General Overview

Upon opening the database the user is presented with a switchboard or "welcome window" offering several options including *Go to Database, About FIMP, and Contact Information.*



Welcome window

Choosing *Go to Database* brings the user to the *Database Window* which shows all tables included in the database:



Database Window

Opening the *Fish Catch* table:

Microsoft Access - [Fish Catch : Table]

Project #	Month	Day	Year	Lat	Lon	Station	Area	Species	Total Numb	Weight	Comments
13	2	22	2000	40.839983	-72.4454	T-40-A	outside SH	Anchoa hepsetus	6	15	
13	2	22	2000	40.865833	-72.37328	T-40-D	outside SH	Anchoa hepsetus	4	15	
13	2	22	2000	40.830633	-72.42328	T-60-B	SH	Brevoortia tyrannus	2	15	
13	2	22	2000	40.865917	-72.37683	T-30-D	outside SH	Anchoa hepsetus	9	20	
13	2	22	2000	40.832917	-72.4476	T-50-A	outside SH	Anchoa hepsetus	10	25	
13	2	22	2000	40.830633	-72.42328	T-60-B	SH	Anchoa hepsetus	19	55	
13	2	22	2000	40.860667	-72.39492	T-50-C	SH	Anchoa hepsetus	8	100	
13	2	22	2000	40.867833	-72.36495	T-60-D	outside SH	Brevoortia tyrannus	1	100	
13	2	22	2000	40.8436	-72.39842	T-60-C	SH	Anchoa hepsetus	20	115	
13	2	22	2000	40.846467	-72.42758	T-40-B	SH	Anchoa hepsetus	23	160	
13	2	22	2000	40.846467	-72.42758	T-40-B	SH	Pseudopleuronectes ar	1	325	
13	2	22	2000	40.8436	-72.39842	T-60-C	SH	Pseudopleuronectes ar	1	400	
13	2	22	2000	40.839983	-72.4454	T-40-A	outside SH	Pseudopleuronectes ar	1	500	
13	2	22	2000	40.84665	-72.43573	T-30-B	SH	Raja erinacea	1	530	
13	2	22	2000	40.8572	-72.3956	T-40-C	SH	Pseudopleuronectes ar	1	550	
13	2	22	2000	40.839983	-72.4454	T-40-A	outside SH	Raja ocellata	1	600	
13	2	22	2000	40.868333	-72.40092	T-30-C	SH	Raja ocellata	1	620	
13	2	22	2000	40.832917	-72.4476	T-50-A	outside SH	Raja ocellata	1	650	
13	2	22	2000	40.840567	-72.42863	T-50-B	SH	Raja erinacea	1	650	
13	2	22	2000	40.824717	-72.44385	T-60-A	outside SH	Pseudopleuronectes ar	3	675	
13	2	22	2000	40.8572	-72.3956	T-40-C	SH	Raja ocellata	3	700	
13	2	22	2000	40.846467	-72.42758	T-40-B	SH	Raja erinacea	2	1000	
13	2	22	2000	40.85915	-72.37167	T-50-D	outside SH	Pseudopleuronectes ar	2	1000	
13	2	22	2000	40.824717	-72.44385	T-60-A	outside SH	Raja erinacea	2	1100	
13	2	22	2000	40.840567	-72.42863	T-50-B	SH	Raja ocellata	3	1200	
13	2	22	2000	40.860667	-72.39492	T-50-C	SH	Pseudopleuronectes ar	6	1450	
13	2	22	2000	40.865833	-72.37328	T-40-D	outside SH	Pseudopleuronectes ar	5	1500	
13	2	22	2000	40.830633	-72.42328	T-60-B	SH	Pseudopleuronectes ar	4	1500	
13	2	22	2000	40.8436	-72.39842	T-60-C	SH	Raja ocellata	2	1500	
13	2	22	2000	40.867833	-72.36495	T-60-D	outside SH	Pseudopleuronectes ar	6	1650	

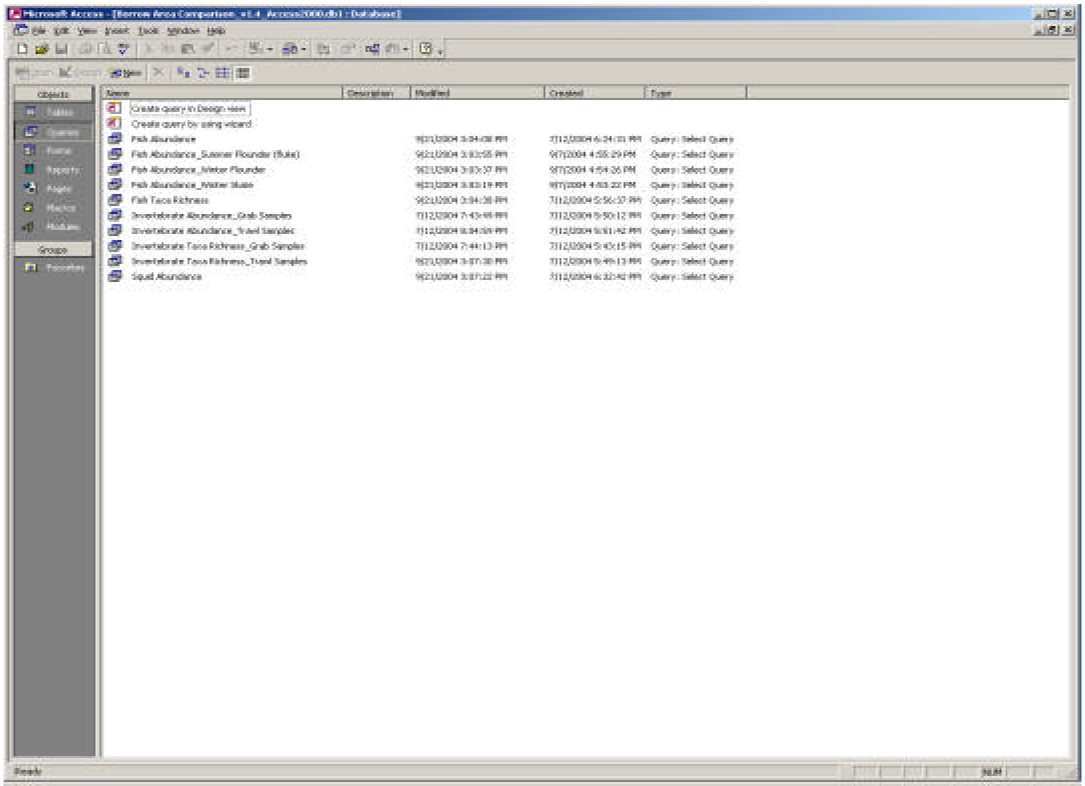
Record: 1 of 3207

Datasheet View NUM

Fish Catch Table

Each table contains the latitude, longitude, and date of the sample in M/D/YYYY format. In this way, each table could be exported and analyzed without requiring a query to be performed to extract sample information from the *Station Info* table. A comments column is included with each table for field notes.

A limited number of queries have been built in to the database to provide summary information for selected data tables. The queries provide summaries of abundance and taxa richness[1] for fish, invertebrate, and squid data tables. To access these queries, select *Queries* from the list of objects in the *Database Window*:



To run the query, double-click on the selected query and the results will automatically be displayed.

---

[1] Richness calculations assume that all identified organisms represent distinct taxa. This assumption may introduce limited error into the calculations (inflated estimates) if these organisms actually belong to lower taxonomic levels identified within the same sample.

2.0 Other Documentation

There are several other documents included with the Database:

Map of Potential Borrow Areas: indicating approximate location of borrow areas.
Benthic Grab and Trawl Sample Locations: showing the location of trawl transects and benthic grabs.
Surf Clam Survey Sample Locations: showing the locations of stations sampled during the surf clam survey.
Summary of Database Tables and Parameters: listing all tables included in the database and the parameters and projects in each.