Final Report

for

A PHYSICAL AND BIOLOGICAL MONITORING STUDY OF THE HILTON HEAD BEACH NOURISHMENT PROJECT

by

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EXECUTIVE SUMMARY

Background and Objectives:

In 1990, the Town of Hilton Head Island completed a major beach nourishment project to improve 6.6 miles of the island's front beach. This required dredging approximately 2.5 million cubic yards of sand from two offshore shoals located at Joiner Bank and Gaskin Bank. Due to the size of this project and the lack of sufficient data to evaluate the biological impacts of beach nourishment operations in South Carolina, a physical and biological monitoring study was conducted by the Marine Resources Research Institute of the South Carolina Wildlife and Marine Resources Department. Specific objectives of this study were to:

1. document changes in the bottom-dwelling invertebrate communities and sediment characteristics of areas affected by the nourishment operation,
2. quantify the density of early life stages of economically important finfish and crustacean species at risk of being affected by the nourishment operation,
3. identify the finfish species of recreational importance present at the offshore borrow sites, and
4. measure bottom turbidity levels in areas affected by the nourishment operation.

Sampling Methods:

The dredging operation was conducted from March through August 1990. Field sampling was initiated in February 1990, just before the nourishment operation began, and continued through August 1991 to evaluate recovery. Benthic sampling was conducted quarterly to obtain data on changes in the bottom-dwelling invertebrate communities (benthos) and sediment characteristics. Stations included two beach sites within the nourishment area at Folly Field Beach (Phase I site) and North Forest Beach (Phase II site), and at a beach reference site on Fripp Island. Several offshore sites were also sampled within each borrow area, and at a reference site off Hilton Head Island in similar water depths. Plankton was sampled monthly during the dredging operation (March through

August 1990) at stations in the offshore borrow areas and offshore reference site, and in the surf zone near recently nourished areas and a surf zone reference site. Beach seine samples were collected from the dredge effluent to identify whether larger biota were being entrained by the dredge. Sampling for finfish at the two borrow sites was conducted during July, August and October, 1990 using gill nets and through hook and line sampling. Turbidity samples were collected at all stations sampled for benthos and plankton during each sampling period. The extent of the plume was determined by turbidity samples collected at varying distances from the pipeline outfall during one sampling period.

Major Findings:

Beach Profiles and Sediment Characteristics:

The addition of sand altered the intertidal beach profile at both of the nourished beach sites. Fill material at Folly Field Beach (Phase I site) remained relatively stable following nourishment, and the intertidal zone profiles were similar to pre-nourishment conditions. Profile surveys conducted at North Forest Beach (Phase II site) showed greater erosional characteristics than those at the Phase I study site, and reflected adjustment of the fill material onto the lower beach and subtidal zone. Sediment samples collected from both nourished beach sites indicated little change in the sediment composition and sand grain size compared to pre-nourishment conditions. Fine-grained sands with less than 10% silt/clay content were observed at most of the intertidal and subtidal stations sampled both before and after nourishment.

Sediments at the Gaskin Bank borrow site after dredging were similar to pre-dredging conditions and consisted of predominantly fine-grained sands with less than 5% silt/clay material. At Joiner Bank, however, sediment composition was markedly altered compared to pre-nourishment conditions. Before dredging, sediments in this area consisted of predominantly fine-grained sand with less than 4% silt/clay material. After dredging, unconsolidated muddy sediments accumulated in the borrow pit. This condition persisted at the stations sampled in the Joiner Bank borrow site throughout the rest of the study period.

Benthic Communities:

Benthic samples collected at the beach sites provided some evidence of decreased faunal abundance and species diversity immediately after nourishment at all tidal levels assessed. The declines observed were generally of short duration and small in comparison to natural seasonal fluctuations. No drastic changes were observed in species composition or the relative abundance of major taxa at any of the nourished sites. The rapid recovery of benthic communities inhabiting the nourished beach was probably due to the similarity of fill material to existing sediments and the fact that the nourishment material was placed high on the beach, well above the intertidal and subtidal levels sampled for the benthos.

Benthic macrofaunal communities at the two borrow sites showed more obvious impacts resulting from the dredging operations than were noted for the beach communities. Both the density of macrofauna and the number of species were significantly reduced shortly after the dredging operation was completed at each site. These effects were relatively short-term and within 3-6 months the density of macrofauna and number of species observed at the stations sampled had increased to levels comparable to pre-nourishment conditions and/or those observed at the reference site. Significant changes were also observed in species composition of the benthos which recolonized these borrow sites following dredging. The greatest changes were observed at Joiner Bank, and the effects persisted throughout the study period. Before dredging, amphipods were the dominant fauna at this borrow site. After dredging, mollusks became numerically dominant and species composition changed frequently. These changes were probably due to the altered sediment characteristics in this area. Changes in faunal composition at Gaskin Bank were less marked and persisted for less than one year.

Plankton:

Plankton tows made at the offshore and surf zone sites resulted in the collection of several species designated as priority species due to their recreational or commercial importance. These included blue crab megalopae, pink, white and brown shrimp postlarvae, and larval forms of kingfishes, Atlantic croaker, red drum, spotted seatrout and seabass. The effects of season and station location appeared to be the primary factors influencing faunal similarity among the sites sampled. Differences in faunal similarity among sites did not appear to be related to effects from the dredging/nourishment operation. Estimates of the maximum numbers of fish, crab and shrimp that could have been entrained by the dredge were small when compared to the number of larvae typically spawned by adults of each species considered.

Seine samples of the dredge effluent captured 14 species. Burrowing shrimp, sea pansies, sand dollars, sea catfish, and mole crabs were the dominant species observed in the catches. None of these species were collected in large numbers and no species of commercial or recreational importance were observed in any of the samples.

Finfish sampling resulted in the collection of 41 species, including 9 species that are considered to be recreationally important. Discernable differences were noted in the species composition and diversity of fishes at the two borrow sites, with more fish and more species collected at Joiner Bank. Based on diet studies, most of the fish species observed at these shoals should not have been affected by the removal of bottom sediments since only the catfishes and whitings had diets comprised of non-motile or slow moving bottom prey items that would have been removed by the dredging operation. The other fish species had diets composed mostly of fish or highly motile invertebrates.

Water Quality Conditions:

Turbidity levels at most of the stations sampled were fairly stable over time. Among the offshore sites, turbidities were greatest at Joiner Bank before, during and after dredging. Some of the elevated turbidities observed at this site may have been due to the accumulation of mud in the Joiner Bank borrow pit, but heavy silt loads in the water exported from Port Royal Sound may have also contributed to the higher turbidities observed there. Gaskin Bank and the offshore control site had relatively low and stable turbidity levels. Turbidities within the sediment plume formed at the pipeline outfall were significantly higher than those observed at reference sites, but the plume did not appear to extend more than a few hundred meters from the outfall in any direction. Turbidities in the surf zone off newly nourished beaches were not very different from turbidities observed in reference areas.

Long term biological impacts resulting from the dredging operation appeared to be limited to the Joiner Bank borrow site. We recommend that this area should be re-sampled in the future to determine the duration of impacts at this site. Additionally, any future dredging that may be required at Joiner Bank should be conducted in a manner that would avoid long-term alterations in bottom sediment characteristics and benthic macrofaunal communities.

INTRODUCTION

In 1990, the Town of Hilton Head Island began a major beach nourishment project under Permit No. 97-3T-170-P from the South Carolina Coastal Council. This project, which was completed in August 1990, involved placing approximately 2.5 million cubic yards of sand along 6.6 miles of the island's front beach. Sand was obtained from two large offshore borrow sites located at Joiner and Gaskin Banks, which together encompassed approximately 0.76 square miles of shallow sand-bottom habitat (Figure 1). The volume of material used in the Hilton Head project was much greater than all previous nourishment projects completed in South Carolina to date (Kana, 1990), and it was one of the largest nourishment operations ever performed in the southeast to date (Olsen, pers. comm.).

Although the effects of beach nourishment have been studied in other states (for reviews, see Naqvi and Pullen, 1982; Ford, 1983; Nelson, 1985), few studies have assessed the biological effects of beach nourishment in South Carolina (Lankford and Baca, 1987; Lankford et. al. 1988; Baca and Lankford, 1988), and none have evaluated biological effects at offshore borrow sites. Furthermore, the studies conducted in other states have documented effects which have been quite variable with respect to the duration and extent of impacts on benthic communities, particularly within areas used as borrow sites (Naqvi and Pullen, 1982; Nelson, 1985). These invertebrate communities represent an important source of food for many species of fish and crustaceans in the nearshore environment, as well as for birds that forage in the intertidal zone of beaches (Nelson, 1985).

Due to the lack of sufficient data on the effects of beach nourishment in South Carolina, the Marine Resources Research Institute of the South Carolina Wildlife and Marine Resources Department initiated a physical and biological monitoring program in conjunction with the Hilton Head nourishment project. The primary objectives of this study were to:

1. document changes in the macrobenthic communities and sediment characteristics of areas affected by the nourishment operation,

2. quantify the density of early life stages of economically important finfish and crustacean species that were at risk of being affected by the nourishment operation, and
3. identify finfish species of recreational importance present at the offshore shoals where the borrow sites were located.

The study as initially proposed did not include monitoring water clarity impacts associated with nourishment operations since the mud content of the sand in the offshore borrow sites was anticipated to be less than 10%. However, a limited sampling effort was completed to measure turbidities at the borrow sites and in the surf zone near the pipeline outfall and compare these levels with turbidities measured in un-disturbed areas.

Results obtained from the above study objectives are described in this report.

METHODS

Benthic Sampling:

Benthic infaunal communities inhabiting the beach and surf zone were sampled along six transects. Two transects were located near the north-eastern end of Hilton Head Island in the Folly Field beach area which was nourished during April 1990. These transects were designated as the Phase I study area (Figure 1). Two other transects were located near the center of Hilton Head Island in the North Forest beach area which was nourished in June, 1990. These were designated as the Phase II study area. The remaining two transects were located in the central portion of Fripp Island, which served as a reference beach (control area). Fripp Island was selected as the control area because it was the nearest island to Hilton Head that had a beach with similar wave energy, and which would not be affected by this or other nourishment operations during the study period. A control area was not located on Hilton Head Island because the beach southwest of the nourished area might have been affected by the nourishment operation and beach sites to the northeast of the project area were very different with respect to wave energy.

Within the two beach areas selected for study on Hilton Head Island, two transects were established oriented perpendicular to the waterline. One transect was located by randomly selecting a benchmark from among several benchmarks established along the beach for Olsen and Associates, Inc. by Sea Island Engineering, Inc. The second transect in each area was then located approximately 300 m (1000 ft) to the northeast of the first transect. At Fripp Island, the benchmark nearest to the center of the island was selected for one transect, and a second transect was established approximately 360 m (1200 ft) to the northeast. Benchmarks corresponding to the transects sampled in this study were labelled as follows:

Area	Transect	Benchmark
Phase I	H11	HH17B
Phase I	H12	HH18
Phase II	H21	HH4
Phase II	H22	HH4B
Fripp Is.	F31	SCGS7187
Fripp Is.	F32	SCGS7187

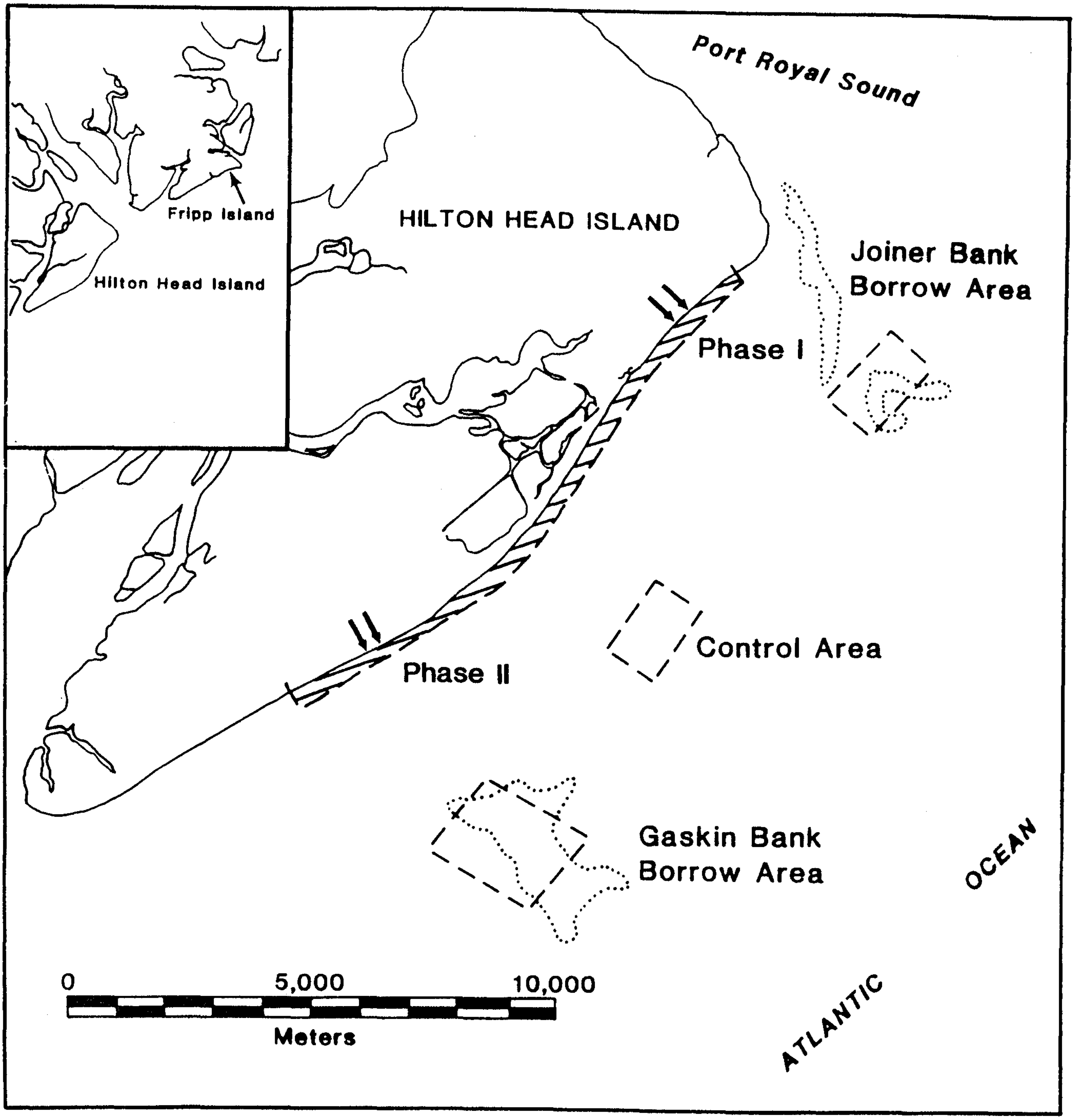


Figure 1. Map of the Hilton Head Island study area showing the location of borrow sites, offshore control area, and beach sites. Arrows at the beach sites indicate the approximate transect locations. Fripp Island, which was used as the control site for beach stations, is shown in the insert.

The transects were surveyed from the dune line or rock revetment to MLW on each sampling date by measuring elevations at 5-m intervals. Four stations were sampled along each transect at mean sea level (MSL), mean low water (MLW), a shallow subtidal level at 15 m (50 ft) from MLW in the surf zone, and a deeper subtidal level 60 m (200 ft) from MLW. The intertidal stations were measured from the benchmarks using a transit to ensure that vertical elevations among the transects were equivalent ($\pm$ 10 cm) during all sampling periods. The subtidal stations were measured from MLW using a measuring tape. Since vertical elevation has a major influence on infaunal composition in the intertidal zone, beach stations were repositioned along the transect line during each sampling period to ensure that equivalent intertidal levels were sampled throughout the study. Similarly, stations in the subtidal zone were relocated to keep distance from MLW constant.

Benthic infaunal communities were sampled at three stations within each of the borrow sites located at Joiner and Gaskin Banks, and in a nearby control area (Figure 1). Stations within the borrow and control sites were randomly selected from a grid of LORAN-C coordinates during the first sampling period. After the borrow sites had been dredged, some of the stations were relocated to ensure that they were well within the dredged area. Site locations were then fixed for the remainder of the study. The control area was located between the two borrow sites, and was similar to those sites with respect to depth, size and distance from the shore.

Benthic fauna were sampled at all intertidal and subtidal stations by collecting 10 replicate cores that were 7.6 cm in diameter and 15 cm deep. At intertidal stations, a rectangular grid subdivided into 20 subquadrats was placed on the beach at the appropriate level and a core was taken from the center of 10 randomly selected subquadrats. Two additional quadrates were randomly selected for sediment cores, which were 3.5 cm in diameter and 15 cm deep. The sediment cores were combined to form a composite sample for each station.

Shallow subtidal stations were sampled by wading into the surf and collecting the 10 benthic cores and two sediment cores along a line parallel to the shoreline at the appropriate distance from MLW. Offshore borrow sites and the control area stations were sampled by divers, who collected the cores at 0.5-m intervals along two transect lines attached to an anchor. The divers attempted to avoid sampling areas that were disturbed by their movements. Turbidity samples and water temperature measurements were taken approximately 0.5 m above the bottom at all subtidal sampling stations during each visit.

The use of 10 replicate cores was based on power analyses (Cohen, 1988) performed on preliminary samples, which indicated that 10 cores were sufficient to detect at least a 50% change in the mean density of organisms and number of species (80% probability and 95% confidence level). Reilly and Bellis (1978), Nelson (1985) and the Environmental Protection Agency (unpublished data) have also found that 10 cores provide an adequate number of replicates to monitor changes in infaunal communities inhabiting beach and subtidal sandy bottoms.

Benthic core samples were washed through a 0.5 mm mesh sieve and the material retained on the sieve was preserved in a 10% formalin-seawater solution stationed with rose bengal. In the laboratory, all invertebrates were sorted from the sediments, identified to species level or lowest practical taxonomic level, and enumerated.

Sediment cores were analyzed in the laboratory using procedures described by Folk (1980) and Pequegnat et al. (1981) to identify the percent composition of sand, CaCO3, silt and clay, and to determine the relative grain-size composition of the sand fraction. Sand fractions were dry-sieved using a Ro-tap mechanical shaker and fourteen ½ phi interval screens for grain size determinations. Mean grain size, sorting and skewness were then derived from individual and cumulative weight percentages for each size class. Measurements of total organic matter were obtained by burning a portion of each sample at 550°C for two hours as described by Plumb (1981).

Sampling was conducted before, immediately after (within 30 days) nourishment or dredging, and then at quarterly intervals for one year after the first post-nourishment sampling period.

Mean faunal density and the number of species/core were compared among sites and sampling dates using two-way analysis of variance tests applied to log-transformed data. Tukey's pair-wise comparison tests were used to compare group means. Community structure analyses were performed on pooled replicate samples from each station and sampling date using Shannon's diversity index (H'), species richness (SR) and evenness (J') described by Margalef (1958) and Pielou (1975). Changes in overall community composition were evaluated using numerical classification techniques similar to those described by Boesch (1977). Both normal and inverse cluster analyses were performed on data pooled by station and season to determine similarity among sites with respect to their species composition (normal) and among species with respect to their distribution among sites (inverse). The Bray-Curtis similarity coefficient was used in the cluster analyses on log-transformed abundance data, with a flexible sorting strategy and a cluster intensity coefficient of $\beta = -0.25$ (Clifford and Stephenson, 1975). Relationships between site groups and species groups were determined using two-way coincidence tables resulting from the nodal analyses (Boesch, 1977), with constancy indicating the relative extent that a species group occurred among stations within a site group, and fidelity indicating the relative extent that a species group occurred only at stations within a site group.

Plankton Sampling:

Sampling for larval and postlarval fishes and crustaceans was conducted monthly at five stations. These were located at Joiner Bank, Gaskin Bank, the offshore control area, and the surf zone (approx. 100 m beyond MLW) at the Phase I and Phase II beach sites. The Joiner Bank and Phase I surf zone sites were sampled from March through July, 1990, and the others were sampled from April through August, 1990. This sampling schedule ensured that each site was sampled before, during and after dredging or nourishment occurred at that area. The offshore control area was sampled from March through August, 1990 and served as a reference area which remained undisturbed throughout the study. In the surf zone, the Phase II station served as an undisturbed reference area for comparison with samples taken in Phase I when it was being nourished. When Phase II was nourished, the Phase I station was used as the reference site. These stations were approximately 7 km (4.5 miles) apart and data obtained from the turbidity studies (see later sections) indicated that the turbidity plume associated with the pipeline outfall was limited to the immediate vicinity of the outfall.

All samples were collected with a 1.0 x 0.5 m bottom sled fitted with a 1.0-mm mesh plankton net and flow meter. Five 10-minute tows were made at each station on all sampling dates. Flow meter readings were taken at the beginning and end of each tow to calculate the volume of water filtered. Samples were preserved in a 10% formalin-seawater solution and brought to the laboratory, where they were sorted to obtain all penaeid postlarvae, blue crab megalopae, and larvae of the finfish families Sciaenidae, Bothidae, Scombridae, and Serranidae. All organisms from these families were identified to species level. Bottom turbidity samples and water temperature measurements were taken approximately 0.5 m above the bottom at all stations during each visit using a Kemmerer bottle.

Comparisons of the mean numbers of fish, shrimp and crabs collected each month were made between disturbed and un-disturbed areas using one-way analysis of variance. A-posteriori comparisons of group means were made using the Duncan's multiple range test. Numbers were standardized to number/1000 cu. meters of water filtered and log-transformed. Cluster and nodal analyses were performed on log-transformed data pooled by station and season to determine similarity among site groups (normal) and species groups (inverse). Cluster and nodal analyses were performed using a the similarity coefficient and clustering algorithm described for the benthic sampling effort.

Since individual species have specific spawning seasons, temporal comparisons of the collected specimens were not made. Instead, comparisons between impacted and reference sites were conducted for each month separately for the nearshore and offshore areas.

Beach Seine Sampling:

In an effort to more directly determine whether larger organisms were being entrained by the dredge, the dredge effluent was sampled by seine net. During July, 1990, with the dredge actively pumping onto Phase II of the beach, a 7.6 m (25 ft) seine net with 3 mm mesh was held across the effluent stream formed on the beach by the outfall pipe. Five replicate collections of five minutes each were made. After each sampling effort, captured animals were sorted on the beach and identified.

Finfish Sampling:

In order to determine whether recreationally valuable fish species were utilizing the offshore shoals where the borrow sites were located, gill nets and hook and line sampling was conducted at both Joiner and Gaskin Bank during the months of May, August, and October, 1990. Three sets each of two different sized gill nets (3" stretch x 220 yds; 10" stretch x 200 yards) were set in each borrow area during the three sampling periods. Each net was set for approximately one hour, with sampling limited to incoming tide periods. A three day sampling effort was completed for each sampling period. All fishes caught in the nets were identified, enumerated, measured and weighed. Stomach contents of the species of recreational interest were also analyzed. Species composition and the relative use of these areas by larger fishes were recorded as catch per net hour. Hook and line sampling was completed during early incoming tides.

Turbidity Sampling:

In addition to the turbidity samples collected during the benthic and planktonic sampling, an effort was made to obtain turbidity samples along a gradient of distance away from the pipeline outfall during August, 1990. For this study component, turbidity samples were collected at 13 locations along the beach during a period when the dredge was pumping. These locations represented the outfall site, and sites along the beach that were 100, 200, 300, 500, and 1000 m to the north and south of the outfall. At each of these sites, divers collected a turbidity sample approximately 0.5 m off the bottom at distances of 15 and 60 m from MLW. These and all other turbidity samples collected in the field were preserved using a 5% mercuric chloride solution and stored on ice until they were processed in the laboratory using a Hach Model 2100A turbidimeter.

RESULTS AND DISCUSSION

Physical Setting:

Phase I Beach Site:

Phase I transects were located at the northeast end of Hilton Head Island on Folly Field Beach. Previous monitoring studies have indicated that this area has been depositional (Kana et al., 1986). Prior to nourishment, the mean high water level (MHW) was approximately 30 m (70 ft) from the dune line on both transects. The nourishment operation moved the MHW level to a distance of approximately 65 m (~215 ft) from the dune line. During the 16 month survey period, we observed considerable temporal variability in beach profiles at the Phase I study site as a result of nourishment (Figure 2). Adjustments of the fill material following nourishment were confined primarily to the intertidal zone as the beach equilibrated (Olsen Associates, Inc., 1991) after the addition of 1 - 2 m of sand at the original MSL and MLW stations. Immediately following beach nourishment, the width of the upper intertidal zones decreased at both transects due to an increased slope in the landward portion of the beach face (Table 1). Beach profiles one year later were very similar to the profiles observed shortly after nourishment. Initially, areal width of the lower intertidal zone (MSL to MLW) was expanded somewhat at H12 and overall, H11 displayed an increase in upper intertidal area due to contouring (Figure 2). However, other sections in Phase I remained unchanged during the study.

In general, sediment composition for the intertidal strata from Phase I and Fripp Island contained more than 90% sand that was predominantly fine grained, both before and after nourishment (Appendices I.1, I.2.a,b.). The only exception was at MSL of the Phase I site, where medium-grained sands were observed prior to nourishment. In the subtidal zone, sediments from 200 ft beyond MLW had a higher sand content after nourishment, and the sand was both coarser and more poorly sorted compared to pre-nourishment conditions. These conditions persisted throughout the remainder of the study. The percentage of calcium carbonate, primarily in the form of crushed shell was reduced at all levels where comparisons to pre-nourishment data were available. However, subsequent sampling

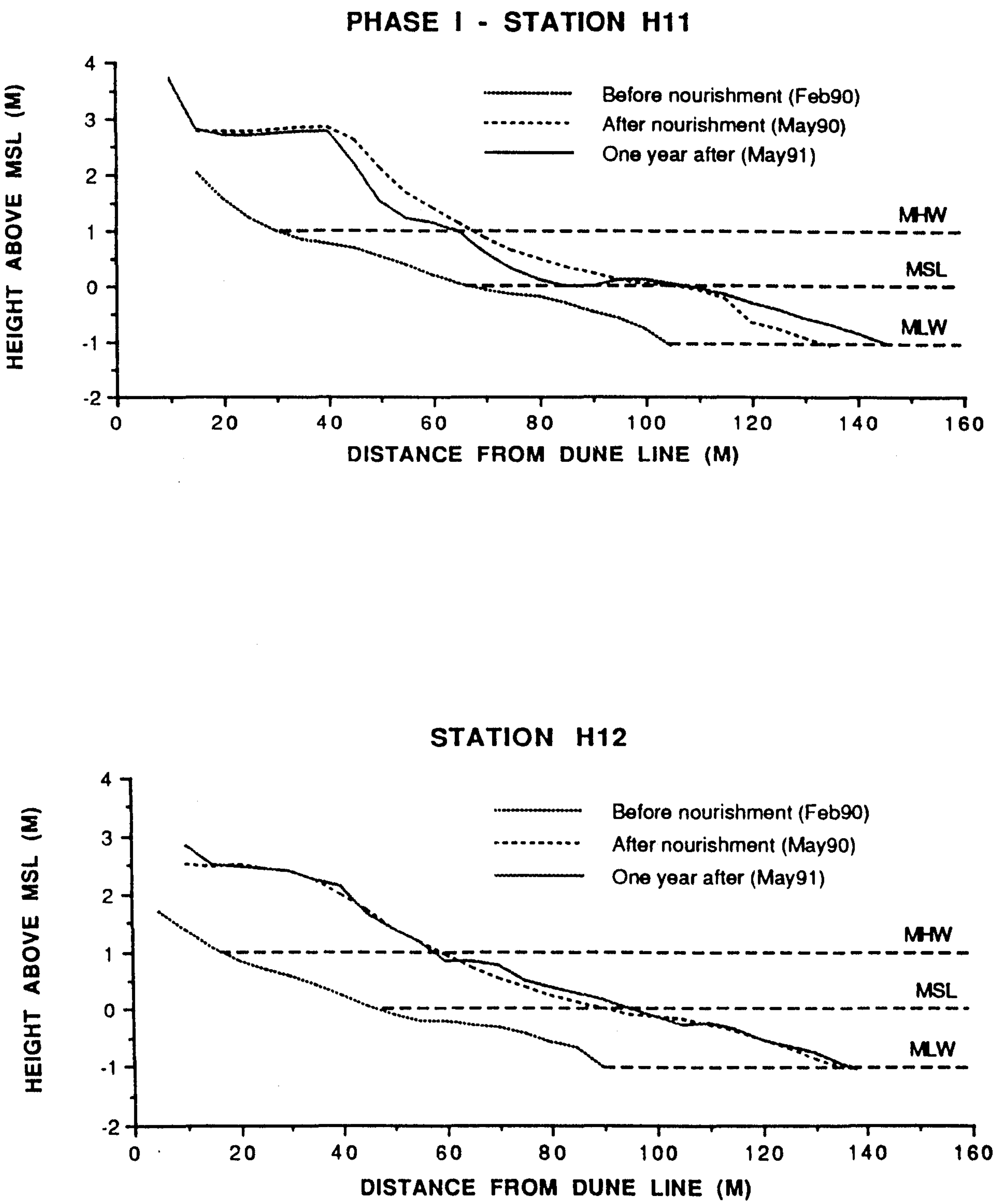


Figure 2. Selected beach profiles from the Phase I transects.

Table 1. Linear distances (meters) along the profile transects representing the upper (MHW to MSL) and lower (MSL to MLW) intertidal zones. Values in parentheses represent sampling dates before nourishment (B), immediately after nourishment (A) and 3, 6, 7, and 12 months after nourishment.

Phase I

	Upper		Lower	
	H11	H12	H11	H12
Before (B)	40	45	40	45
Spr 90 (A)	35	40	40	50
Sum 90 (3A)	35	35	50	50
Fall 90 (6A)	45	40	40	50
Win 90 (9A)	55	40	40	35
Spr 91 (12A)	50	45	40	45

Phase II

	Upper		Lower	
	H21	H22	H21	H22
Before (B)	30	30	85	85
Sum 90 (A)	50	45	40	35
Fall 90 (3A)	50	35	65	60
Win 91 (6A)	25+10*	40	50+25*	50
Spr 91 (9A)	40	30	70	70
Sum 91 (12A)	30	35	75	65

* Low tide terrace

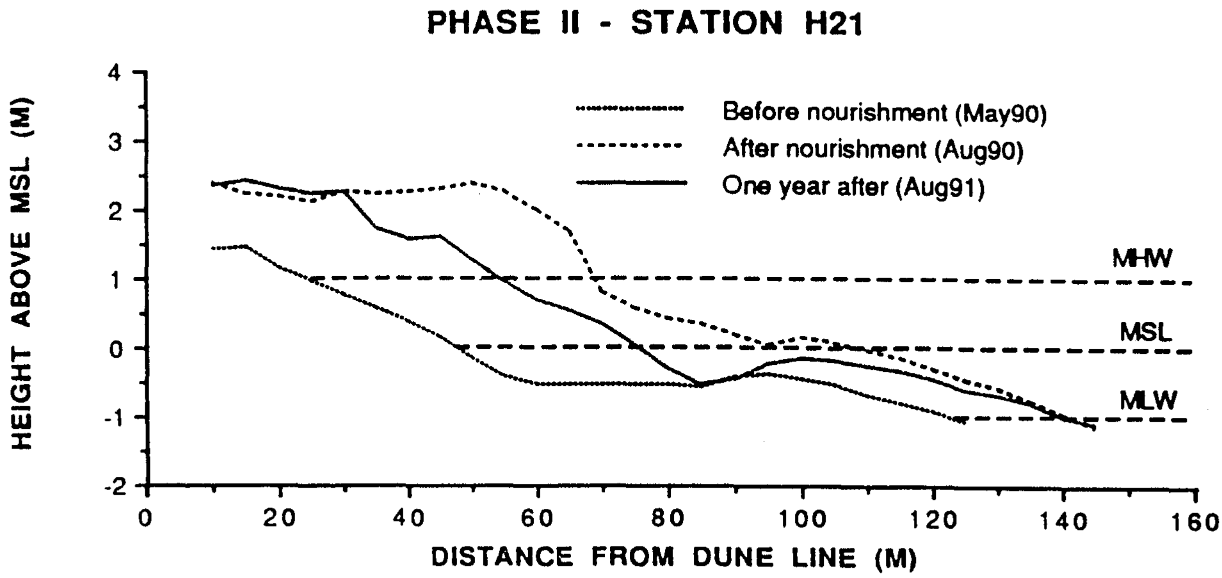
periods indicated that carbonate composition was variable at both Phase I and Fripp Island. Organic matter was a minor component of sediments from Phase I and the control transects and showed no obvious trends with respect to nourishment or season. Temporal variability of sand composition at the Fripp Island control area was minimal.

Phase II Beach Site:

Phase II transects were located on North Forest Beach. This reach has been described as erosional (-0.5 ft/yr to -5.6 ft/yr) and contains an armored shoreline that has limited the extent of the sand deficit (Kana et al., 1986, Eiser et al., 1988). In fact, this section of the restoration project received the greatest cumulative volume of fill material (Olsen Associates, Inc., 1991). Nourishment at Phase II resulted in greater changes in beach profiles than at Phase I (Table 1). Prior to nourishment, there was very little beach above the MHW level. Shortly after nourishment there was approximately 50 to 70 m (165 - 230 ft) of beach above this point. This persisted throughout the one-year post-nourishment study period at transect H22, although there was considerable erosion in the upper beach area. On transect H21, erosion had moved the MHW mark approximately 20 m closer to the revetment one year after the project. The areal extent of the upper intertidal zones remained fairly constant, while lower intertidal widths were reduced by over 50% following construction (Figure 3).

The upper intertidal areas of the Phase II transects gradually decreased in width following nourishment (Table 1). The areal extent of the upper intertidal zone was approximately the same one year after nourishment as it had been previously (Figure 3). This pattern appeared to reflect the redistribution of fill material from the upper beach face onto the lower intertidal and nearshore environments. Conversely, lower intertidal portions of our transects increased during the same period. At H21 this appears to be a reflection of deep contouring similar to pre-nourishment conditions while at H22 this zone had extended seaward.

The sedimentological aspects of the Phase II transects remained similar to both reference site and pre-nourishment conditions. Sand deposited at all levels differed little in percentage of total sample weight or mean grain size (Appendix I.3.a-d.). The sands



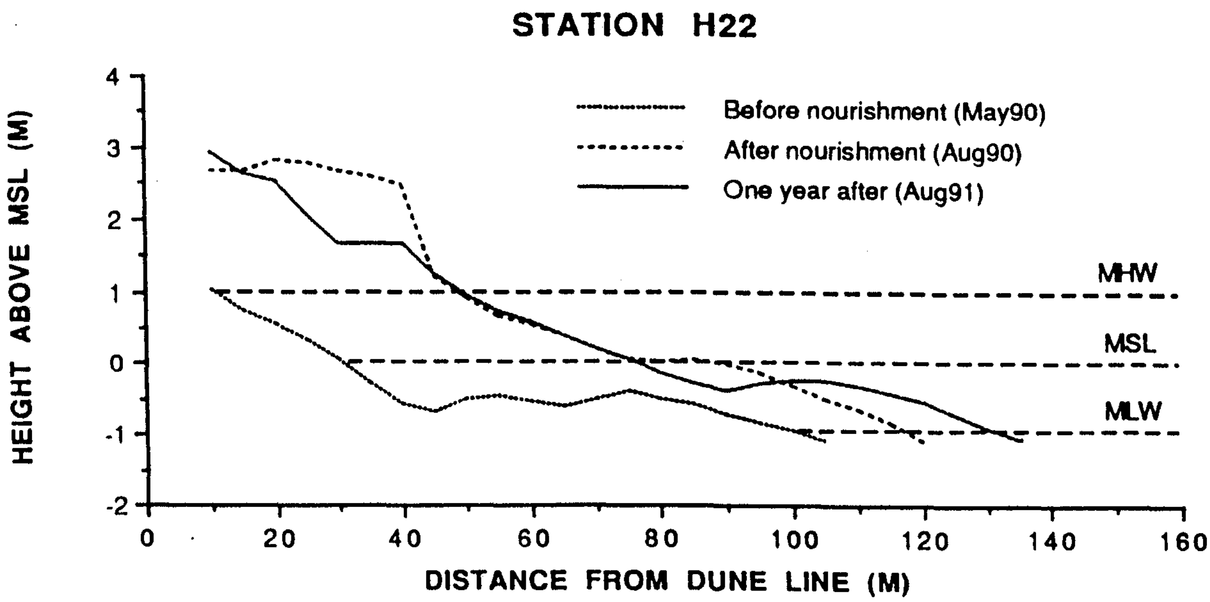


Figure 3. Selected beach profiles from the Phase II transects.

became more well sorted at all strata following nourishment and displayed less temporal variability in sorting characteristics than at the control transects. Calcium carbonate and organic content of Phase II sediments displayed considerable variability; however, the overall trend for these parameters after nourishment remained consistent with pre-existing conditions.

Joiner Bank Borrow Site:

Immediately prior to dredging in April 1990, Joiner Bank and control area sediments were both very similar, consisting of approximately 95%, well-sorted sand (Appendix I.1.). Joiner Bank sand was slightly more coarse by an average 0.7 phi. Silt, clay, calcium carbonate and organic matter were roughly equivalent among sites, accounting for less than 5% by weight (Figure 4).

Sampling conducted immediately after dredging was completed at Joiner Bank revealed substantial changes in sediment composition within this area. The percentage of sand in the samples declined by 31% and silt and clay content increased. Average grain size of the sand component was slightly finer after the dredge operation, and similar to the texture observed at the control area (Appendix I.4.). Long-term trends within Joiner Bank sediments continued to reflect a muddy substrate without a measurable return to conditions that existed prior to dredging. A notable exception occurred in summer 1990 when a higher sand content was observed. This change in the relative percentage of sand may be an artifact of the lack of data from JB03 during this season (Appendix I.1.). Sediment samples from Joiner Bank contained more organic matter after dredging primarily in the form of silt (Appendix I.4.). The substantial increase in organic matter upon completion of dredging corresponded to increases in silt composition. In contrast to the Joiner Bank area, sediment composition at the control site remained relatively consistent throughout the study.

The Joiner Bank borrow area was dredged to a depth of 11 feet below the pre-existing elevation. Divers involved in the sampling effort observed a murky layer of suspended sediment near the bottom. Beneath this was a layer of loosely consolidated mud that varied from less than one foot to an unknown depth beyond the divers' reach. These conditions remained on all subsequent sampling periods, indicating that the borrow site at Joiner Bank served as a basin for deposition of ebb tidal sediment from Port Royal Sound.

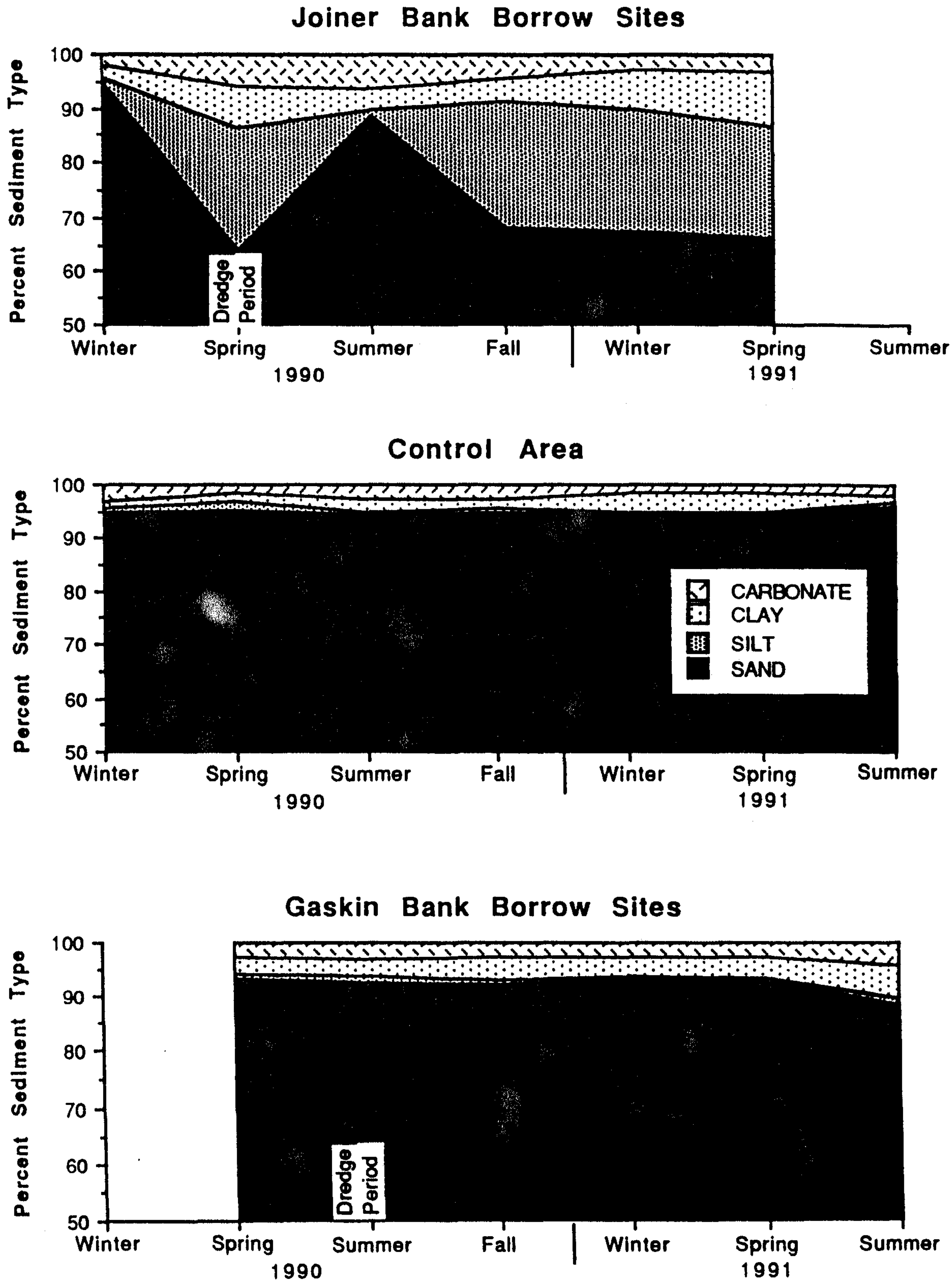


Figure 4. Sediment composition at the borrow sites and control area.

Gaskin Bank Borrow Site:

Sedimentological changes following dredging at Gaskin Bank were minimal. Sites located within this borrow area were dominated by fine-grained, well-sorted sand, similar to that of the control area (Figure 4 and Appendix I.4.). Silt, clay, calcium carbonate and organic matter content remained fairly constant, throughout the study, with no indication of dredging effects. Organic matter was primarily of a silt size class (Appendix I.4.).

The Gaskin Bank borrow area was dredged to a depth of 10 feet below the previous elevation. The sand source for subsequent refilling of the depression was probably from the surrounding bottom area which was probably very similar in composition and texture to the pre-existing substrate. Divers at Gaskin Bank encountered neither the dense suspended sediment nor accumulated mud that characterized Joiner Bank.

Benthic Communities:

Phase I Beach Site:

Benthic core samples taken at the Phase I study site on Hilton Head Island showed some evidence of short-term adverse effects on both the density of organisms (Figure 5) and the average number of species per core (Figure 6) as a result of beach nourishment. Declines in these two parameters were observed at all tidal elevations in the spring of 1990, immediately following nourishment, while increases were generally observed at the Fripp Island control site during the same time period. Thereafter, numbers of organisms and species at the nourished site generally followed seasonal trends similar to those observed at the control site, with both parameters frequently attaining levels significantly exceeding those in the control area, particularly at the two subtidal sites (50 ft and 200 ft beyond MLW). Appendix II.1 provides a complete listing of all benthic macrofaunal species collected, and their total abundances in cores from each site during each season.

The seemingly anomalous peak in abundance at the 50 ft Phase I study site in the fall of 1990 (Figure 5) was due to an irruptive increase in the abundance of a small, opportunistic bivalve, *Mulinia lateralis* (Table 2). Similar peaks in total abundance, also attributable to *M. lateralis*, were observed at the 200 ft sites in both the nourished and

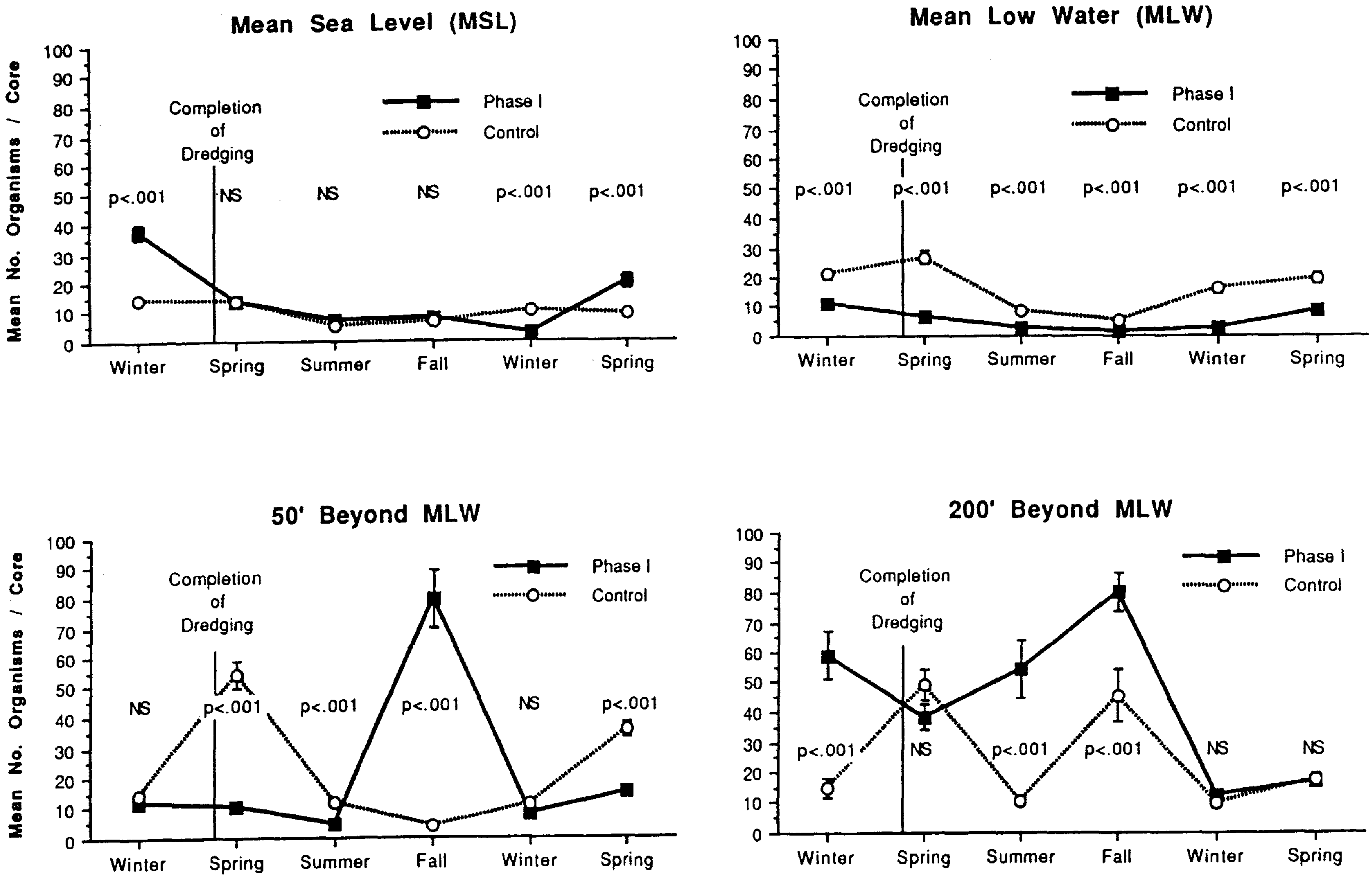


Figure 5. Mean density of benthic organisms at Phase I and control beach sites, with probabilities (p) associated with Tukey's pairwise comparisons of means for each sampling date. (NS=not significant at p=0.05; vertical bars represent ± 1 standard error of the mean).

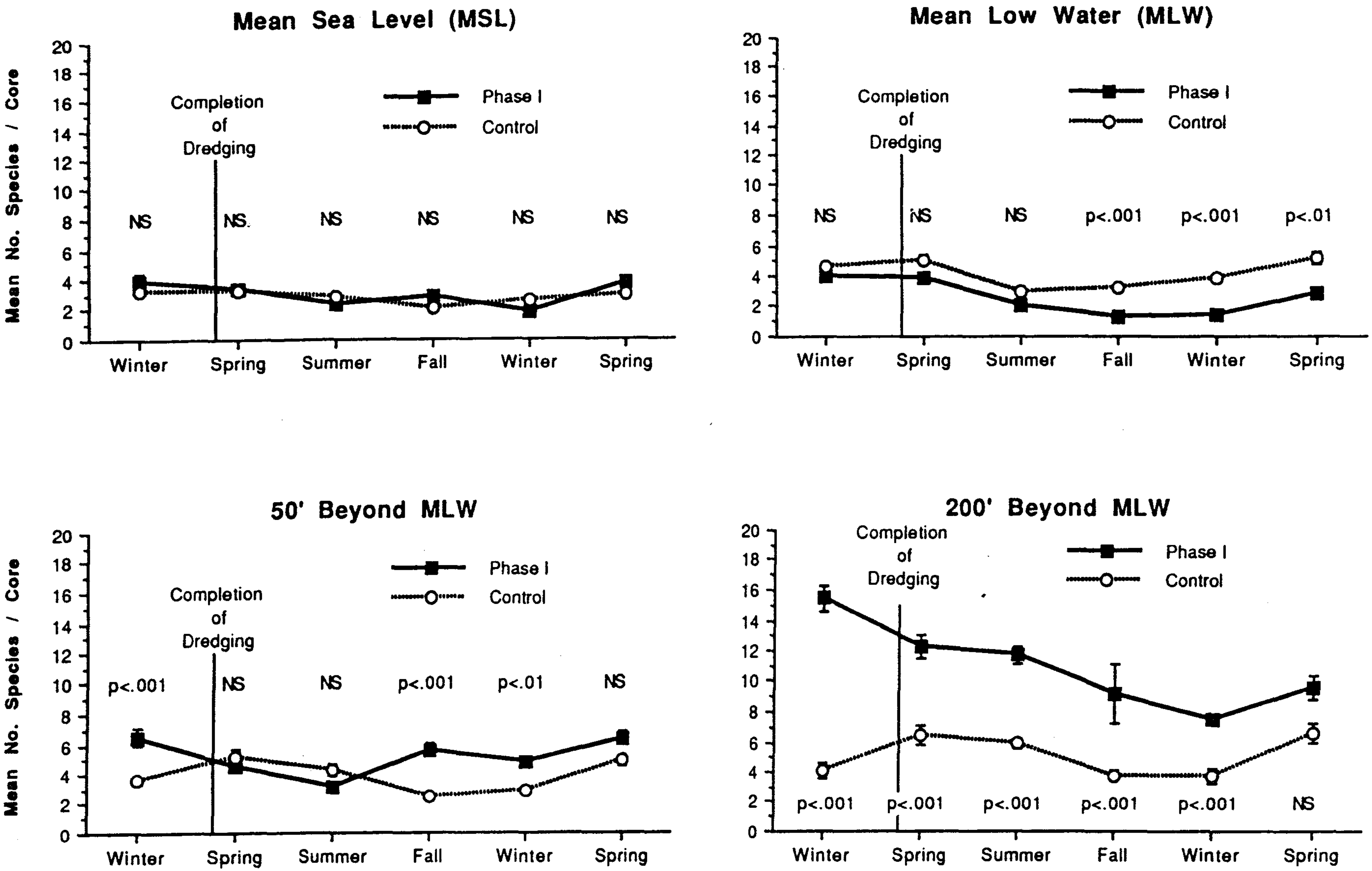


Figure 6. Mean number of species per core at Phase I and control beach sites, with probabilities (p) associated with Tukey's pairwise comparisons of means for each sampling date. (NS=not significant at $p=0.05$; vertical bars represent ± 1 standard error of the mean).

Table 2. Listing of the five most abundant macrofaunal species collected in core samples at each tide level in the Hilton Head Phase I area, and the percentage of total faunal abundance represented by these species during each season. A = amphipod, C = cumacean, M = mollusk, P = polychaete.

SPECIES	PERCENTAGE OF TOTAL ABUNDANCE					
	1990				1991	
	Winter	Spring	Summer	Fall	Winter	Spring
Phase I - Mean Sea Level						
Neohaustorius schmitzi (A)	24.1	68.9	63.8	2.1	67.9	73.6
Donax variabilis (M)	62.5	14.2	27.5	63.4	8.9	2.5
Nematoda	8.6	---	---	---	---	---
Parahaustorius longimerus (A)	---	8.2	0.7	2.8	5.4	6.7
Haustorius canadensis (A)	1.6	1.5	---	---	3.6	6.5
Phase I - Mean Low Water						
Scolelepis squamata (P)	27.2	8.9	---	---	59.2	44.1
Paraonis fulgens (P)	5.0	4.1	24.5	31.0	14.3	43.5
Neohaustorius schmitzi (A)	33.0	1.6	---	---	---	---
Donax variabilis (M)	17.2	---	18.4	3.4	---	1.8
Cyclaspis varians (C)	---	30.1	---	---	---	0.6
Phase I - 50' Beyond MLW						
Mulinia lateralis (M)	4.6	---	---	90.0	---	0.7
Protohaustorius deichmannae (A)	17.6	43.1	34.8	3.2	17.4	26.3
Paraonis fulgens (P)	18.1	1.0	20.2	2.1	7.4	13.0
Scolelepis texana (P)	---	---	2.2	0.2	---	20.5
Acanthohaustorius millsi (A)	---	6.9	---	0.4	18.0	3.6
Phase I - 200' Beyond MLW						
Mulinia lateralis (M)	19.7	0.8	3.5	87.0	5.2	2.6
Mediomastus californiensis (P)	9.1	14.1	59.4	3.0	29.1	16.7
Tellina texana (M)	7.6	5.7	9.1	1.1	3.6	5.3
Ampharete americana (P)	14.0	7.7	0.1	---	---	0.3
Oxyurostylis smithi (C)	2.7	22.1	0.9	0.3	0.4	2.4

control areas (Table 3). The absence of this bivalve from the 50 ft control site is consistent with its known preference for muddier habitats and its general absence from clean, shifting sands (Stanley, 1970; Thayer, 1975). Sediments at the 50 ft sites in both areas were generally characterized by a lower silt/clay content and slightly coarser sands than those at the deeper 200 ft site (see Physical Setting section).

Another dominant species, the capitellid worm *Mediomastus californiensis*, was consistently more abundant at the 200 ft Phase I site than at the corresponding control site, (Tables 2 and 3). Like *M. lateralis*, this polychaete is more common in muddy sands than in clean sands (Ewing, 1984). This observation is consistent with our sediment analyses which showed a higher percentage of silts and clays at the 200 ft Phase I site.

The higher abundance of benthic organisms at the mean low water and 50 ft control sites in spring was due largely to greater densities of two dominant sand-dwelling species, the haustoriid amphipod *Protohaustorius deichmannae* and the bivalve *Donax variabilis* (Table 3). Both before and after nourishment was completed, these two species generally comprised a greater proportion of total macrofaunal abundance at the control site than at the nourished site, possibly as a result of more suitable sediments there. Nevertheless, each species followed similar seasonal trends at the two sites, except in the winter of 1991 when *D. variabilis* declined at mean sea level in the nourished area. These data suggest that, with few exceptions, temporal and spatial differences in the relative abundance of many dominant species were due more to natural variation in season, sediment type, and possibly wave exposure than to the effects of nourishment.

Community structure parameters also showed some evidence of short-term adverse effects from nourishment at Phase I, particularly at the subtidal sites (50 ft and 200 ft beyond MLW) where species richness declined initially. This pattern was not observed at the Fripp Island control site (Table 4). Species richness values had returned to pre-nourishment levels at the 200 ft site by the spring of 1991, but remained somewhat lower at the 50 ft site throughout the study. Consistent with the observations of other researchers (see Nelson, 1985 for a review), species diversity was higher in the nearshore sublittoral zone than in the intertidal zone at both nourished and control sites before and after nourishment.

Table 3. Listing of the five most abundant macrofaunal species collected in core samples at each tide level in the Fripp Island control area, and the percentage of total faunal abundance represented by these species during each season. A = amphipod, C = cumacean, M = mollusk, P = polychaete.

SPECIES	PERCENTAGE OF TOTAL ABUNDANCE						
	1990				1991		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer
Control - Mean Sea Level							
Donax variabilis (M)	66.0	---	43.5	75.7	78.5	19.2	30.5
Neohaustorius schmitzi (A)	4.5	62.8	29.6	11.4	10.0	64.2	54.2
Parahaustorius longimerus (A)	22.6	18.2	5.6	2.9	6.0	7.5	1.7
Scolelepis squamata (P)	3.1	6.6	11.1	0.7	---	0.5	6.8
Protohaustorius deichmannae (A)	0.4	7.4	---	2.1	---	1.6	---
Control - Mean Low Water							
Protohaustorius deichmannae (A)	25.4	74.3	35.2	34.6	35.8	69.3	60.9
Donax variabilis (M)	50.2	0.9	49.1	29.7	---	0.3	6.0
Scolelepis squamata (P)	4.3	1.5	0.6	1.0	49.7	5.2	3.8
Parahaustorius longimerus (A)	14.2	0.8	---	---	0.6	8.2	---
Mancocuma sp. (M)	---	7.7	---	---	5.0	3.9	---
Control - 50' Beyond MLW							
Protohaustorius deichmannae (A)	65.8	62.0	52.2	31.5	62.7	85.0	68.2
Donax variabilis (M)	0.7	28.4	23.2	35.6	---	0.3	2.6
Scolelepis squamata (P)	4.2	0.2	---	4.1	22.3	3.0	---
Parahaustorius longimerus (A)	20.6	---	---	4.1	2.3	1.3	---
Acanthohaustorius millsi (A)	1.0	2.3		5.5	3.2	2.5	4.2
Control - 200' Beyond MLW							
Protohaustorius deichmannae (A)	70.5	84.0	26.9	4.8	60.7	52.0	39.2
Mulinia lateralis (M)	1.7	0.5	4.5	89.7	1.5	---	---
Nemertinea	2.7	1.5	---	0.8	12.2	2.6	5.4
Leitoscoloplos fragilis (P)	---	---	12.9	---	---	9.1	3.8
Synchelidium americanum (A)	---	2.0	8.5	0.3	0.5	2.0	0.8

Table 4. Pooled species diversity (H'), evenness (J') and richness (S-1/ln N) estimates for the stations sampled on the beaches of Hilton Head Island (Phase I and II) and Fripp Island (control)

		Fripp Island			Hilton Head Island - Phase I			Hilton Head Island - Phase II		
Tide Level*	Season	H'	J'	S-1/ln N	H'	J'	S-1/ln N	H'	J'	S-1/ln N
MSL	Feb, '90	1.5	0.4	1.9	1.6	0.4	2.3	---	---	---
"	May, '90	1.7	0.5	1.6	1.7	0.4	2.5	1.7	0.4	2.3
"	Aug, '90	2.2	0.6	2.1	1.4	0.5	1.6	2.4	0.8	2.0
"	Nov, '90	1.4	0.4	1.8	2.0	0.5	2.4	1.5	0.5	1.6
"	Feb, '91	1.2	0.4	1.7	1.8	0.6	2.2	1.8	0.5	1.9
"	May, '91	1.7	0.5	1.7	1.7	0.4	2.8	1.9	0.6	1.7
"	Aug, '91	1.8	0.6	1.7	---	---	---	1.5	0.6	1.0
MLW	Feb, '90	2.0	0.4	1.9	2.5	0.7	2.2	---	---	---
"	May, '90	1.7	0.5	1.6	3.5	0.8	4.8	3.1	0.6	4.9
"	Aug, '90	2.0	0.6	2.1	3.3	0.8	3.9	2.9	0.7	3.0
"	Nov, '90	2.9	0.4	1.8	3.0	0.8	3.3	3.4	0.9	3.8
"	Feb, '91	1.9	0.4	1.7	2.2	0.6	2.8	1.7	0.4	2.7
"	May, '91	2.0	0.5	1.7	1.8	0.5	1.9	2.7	0.6	4.2
"	Aug, '91	2.2	0.6	1.7	---	---	---	2.7	0.7	3.1
50'	Feb, '90	1.7	0.4	2.3	3.9	0.8	5.8	---	---	---
"	May, '90	1.6	0.4	2.9	3.0	0.7	4.5	3.9	0.8	5.1
"	Aug, '90	2.4	0.5	4.1	2.9	0.7	3.3	3.5	0.8	4.3
"	Nov, '90	2.7	0.7	3.3	0.8	0.2	3.3	3.4	0.7	4.7
"	Feb, '91	1.8	0.5	2.8	3.4	0.7	4.5	2.7	0.6	3.5
"	May, '91	1.2	0.3	3.4	3.5	0.7	4.6	3.0	0.7	4.0
"	Aug, '91	2.1	0.5	3.4	---	---	---	3.0	0.8	2.9
200'	Feb, '90	2.1	0.4	4.7	4.1	0.7	9.3	---	---	---
"	May, '90	1.4	0.3	5.5	4.2	0.7	7.5	4.6	0.8	9.9
"	Aug, '90	3.8	0.8	5.5	2.8	0.5	7.2	4.5	0.8	9.2
"	Nov, '90	0.8	0.2	2.8	1.1	0.2	5.8	2.3	0.4	6.7
"	Feb, '91	2.4	0.5	4.2	4.2	0.8	6.3	3.5	0.6	7.3
"	May, '91	3.1	0.6	6.3	4.4	0.8	9.3	3.7	0.7	7.4
"	Aug, '91	3.4	0.7	5.3	---	---	---	4.1	0.8	6.9

*MSL = mean sea level; MLW = mean low water; 50' and 200' = distance beyond MLW
**Pre-nourishment sampling datess

Comparisons of the relative abundance of major taxa before and after nourishment show little evidence of major shifts in community structure as a result of this activity (Figures 7 and 8). In the intertidal zone, amphipods increased in relative abundance, at both nourished and control sites, while mollusks decreased immediately following nourishment of Phase I in the spring of 1990 (Figure 7). The decrease in abundance of mollusks at both sites was due primarily to a seasonal decline in the abundance of coquina clams (*D. variabilis*). Abundances of *D. variabilis* remained relatively low at the nourished site through the summer of 1990, but returned to pre-nourishment levels by fall of the same year. Reilly and Bellis (1978, 1983) reported a similar decline in numbers of *Donax* spp. following beach restoration in North Carolina and suggested that adults were killed in the offshore wintering area by sediment burial, due to their limited mobility.

In the subtidal zone, communities at the nourished and control sites were strikingly different, even in the winter of 1990 before nourishment took place (Figure 8). As mentioned earlier, this was probably due to differences between the two sites in sediment type and wave exposure. Thus, during all seasons except the fall of 1990, polychaetes were dominant at the muddier Phase I sites; whereas, amphipods were more abundant at the sandier Fripp Island control sites. In the fall of 1990, mollusks (primarily *M. lateralis*) were overwhelmingly dominant at both nourished and control sites.

The absence of remarkable shifts in community composition in the Phase I study area as a result of nourishment activities is further illustrated by cluster and nodal diagrams (Figures 9a and b). Broadly stated, the cluster dendrograms show that similarity in species composition among benthic core samples was determined largely by similarity among sampling sites with respect to tide level, sediment type and possibly wave exposure. Core samples from areas subjected to nourishment did not form a discrete group but, instead, clustered with other samples from the same tide level and sediment regime (Table 5). This suggests that, compared to the effects of natural variation in physical parameters, nourishment effects were relatively insignificant as a determinant of community structure in the intertidal and shallow subtidal zones. Species groups A and B (Table 6) dominated the fauna at the 200 ft Phase I site, exhibiting very high constancy and moderate to very high fidelity among samples in site group 1; whereas, species in groups C and D were more ubiquitous, but most commonly found in samples from sandier subtidal and intertidal sites.

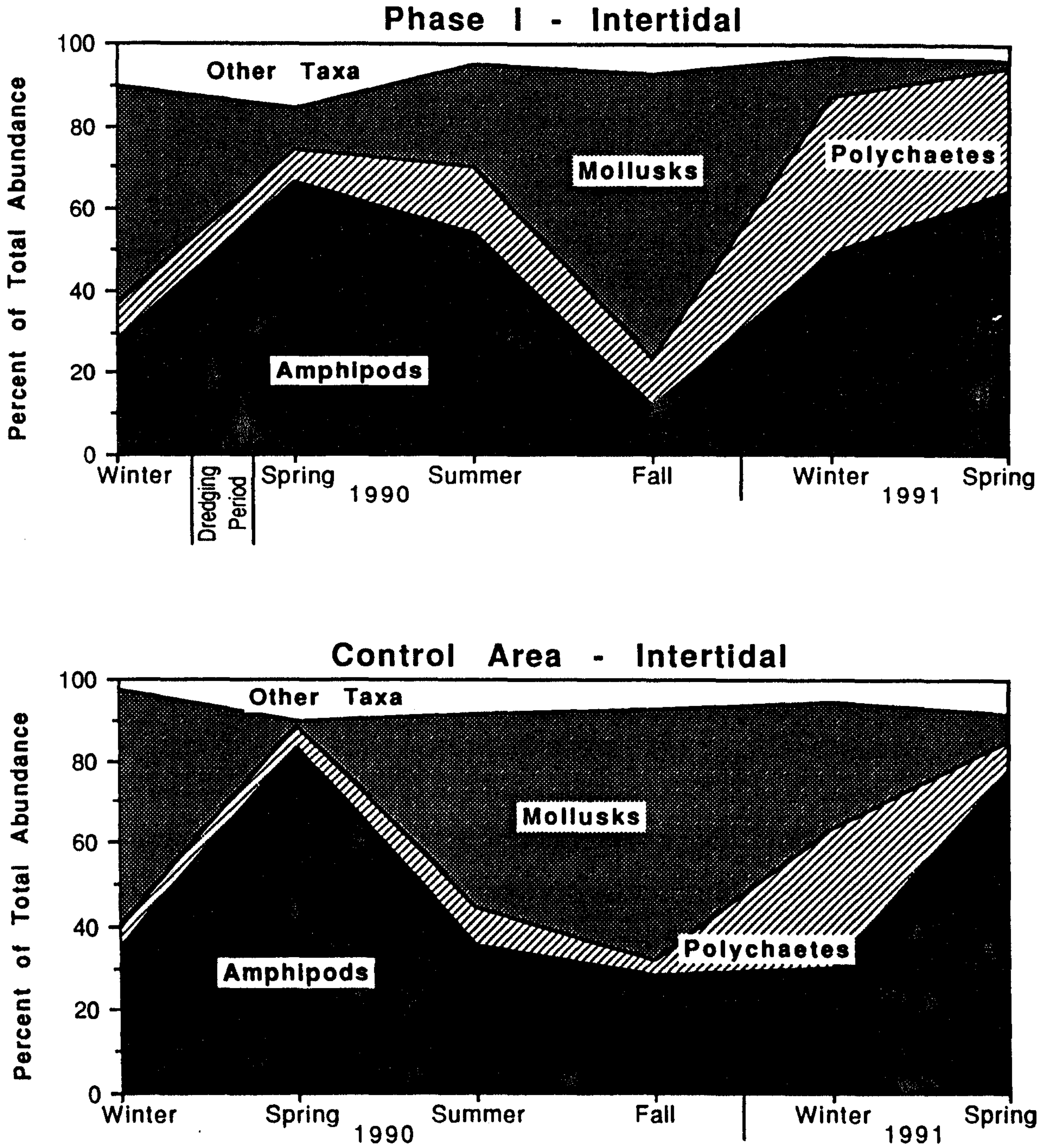


Figure 7. Percentage of total faunal abundance contributed by each major taxon to intertidal core samples from Phase I and control sites.

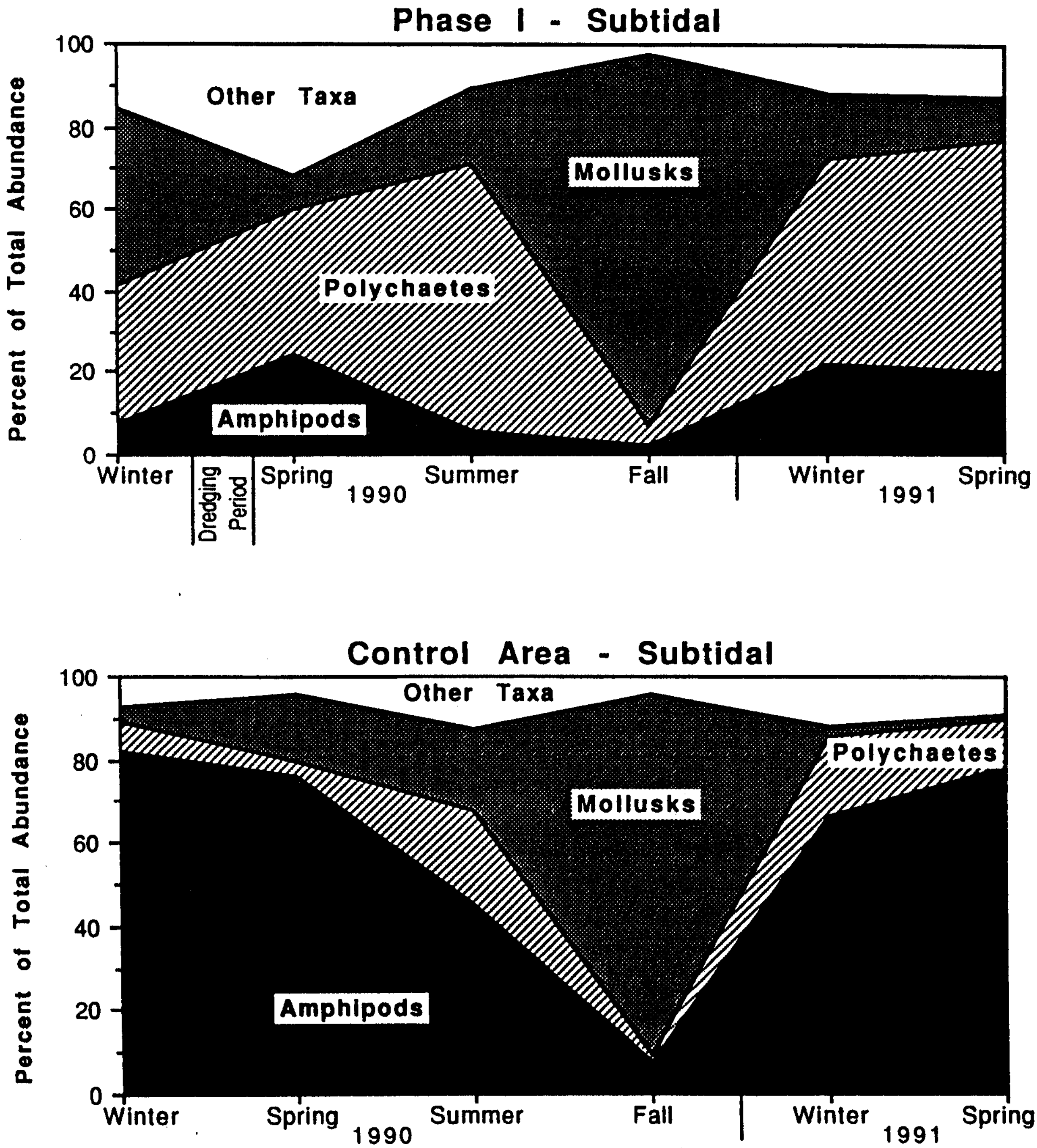


Figure 8. Percentage of total faunal abundance contributed by each major taxon to subtidal core samples from Phase I and control sites.

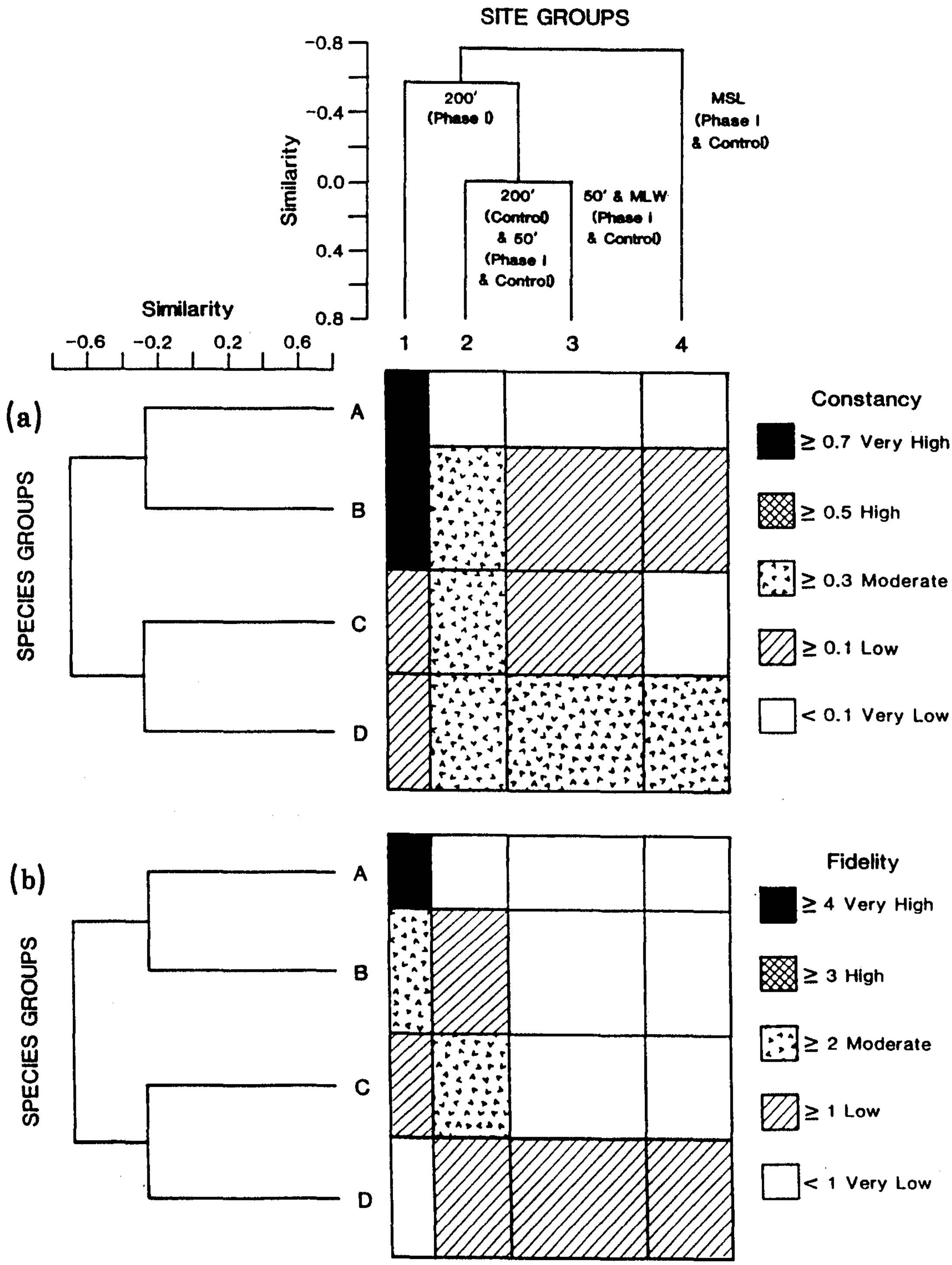


Figure 9. Normal (site group) and inverse (species group) cluster dendrograms with nodal constancy (a) and fidelity (b) diagrams for Phase I and control sites. (Normal analysis based on species occurring in >3% of all core samples; inverse analysis based on species occurring in >10% of all core samples).

Table 5. Site groups formed by a normal cluster analysis of pooled beach samples from Phase I Hilton Head (H) and Fripp Island control (F) areas. (A=mean sea level; B=mean low water; C=50' beyond mean low water; D=200' mean low water).

Site Group 1	Time Relative to Nourishment (mo.)
*HD, Feb '90	-2
HD, May '90	+1
HD, Feb '91	+10
HD, May '91	+13
HD, Aug '90	+4
HD, Nov '90	+7

Site Group 2	Time Relative to Nourishment (mo.)
FD, Feb '90	-2
FD, May '90	+1
FB, May '91	+13
FC, May '91	+13
FD, May '91	+13
HC, May '91	+13
HC, Nov '90	+7
FD, Nov '90	+7
FD, Feb '91	+10
*HC, Feb '90	-2
FD, Aug '90	+4

Site Group 3	Time Relative to Nourishment (mo.)
HB, Aug '90	+4
HC, Aug '90	+4
HB, Nov '90	+7
HB, May '90	+1
HC, May '90	+1
FB, May '90	+1
FC, May '90	+1
FB, Aug '90	+4
FC, Aug '90	+4
FB, Nov '90	+7
FC, Nov '90	+7
FB, Feb '90	-2
FC, Feb '90	-2
FA, May '90	+1
FB, Feb '91	+10
FC, Feb '91	+10
HC, Feb '91	+10
HB, Feb '91	+10
HB, May '91	+13

Site Group 4	Time Relative to Nourishment (mo.)
FA, May '91	+13
HA, May '90	+1
HA, May '91	+13
FA, Feb '90	-2
FA, Feb '91	+10
FA, Aug '90	+4
HA, Aug '90	+4
HA, Feb '91	+10
FA, Nov '90	+7
HA, Nov '90	+7
*HA, Feb '90	-2
*HB, Feb '90	-2

* =Hilton Head samples taken prior to nourishment

Table 6. Species groups formed by an inverse cluster analysis of pooled beach samples from Phase I Hilton Head (H) and Fripp Island control (F) areas. (A = amphipod; B = bivalve; C = cumacean; D = decapod; G = gastropod; In = insect; Is = isopod; M = mysid; N = nemertinean; P = polychaete).

Group A	Group B	Group C	Group D
Tharyx sp. (P)	*Ampharete americana* (P)	*Magelona papillicornis* (P)	*Mancocuma sp.* (C)
Glycera americana (P)	*Abra aequalis* (B)	*Nephtys picta* (P)	*Ancinus depressus* (Is)
Callianassa biformis (D)	*Eteone heteropoda* (P)	*Cyclaspis bacescui* (C)	*Neohaustorius schmitzi* (A)
Aricidea suecica (P)	*Microprotopus raneyi* (A)	*Cyclaspis* sp. A (C)	*Donax variabilis* (B)
Arabellidae (P)	Nematoda	*Aglaophamus verrilli* (P)	*Parahaustorius longimerus* (A)
Pagurus hendersoni (D)	*Mulinia lateralis* (B)	*Pinnixa* sp. (D)	*Scolelepis squamata* (P)
Batea catharinensis (A)	*Dispio uncinata* (P)	*Bowmaniella* sp. (M)	*Paraonis fulgens* (P)
Edotea montosa (Is)	*Synchelidium americanum* (A)	*Ogyrides hayi* (D)	Nemertinea
Carinomella lactea (N)	*Oxyurostylis smithi* (C)	*Onuphis eremita* (P)	*Acanthohaustorius millsi* (A)
Monoculodes edwardsi (A)	*Spiophanes bombyx* (P)	Turbellaria	*Protohaustorius deichmannae* (A)
Parvilucina multilineata (B)	*Solen viridis* (B)	*Chiridotea stenops* (Is)	*Lepidopa websteri* (D)
	Leitoscoloplos fragilis (P)	*Nephtys* sp. (P)	Nephtydae (P)
	Scolelepis texana (P)	*Nereis* sp. (P)	*Haustorius canadensis* (A)
	Rhepoxynius epistomus (A)	*Cyclaspis varians* (C)	*Isotoma dispar* (In)
	Oligochaeta	*Nephtys bucera* (P)	*Pinnixa cristata* (D)
	Acteocina candei (G)		*Sphaeroma quadridentatum* (Is)
	Tellina texana (B)		*Chiridotea coeca* (Is)
	Mediomastus californiensis (P)		

Phase II Beach Site:

The density of benthic organisms and mean number of species per core declined at the Phase II study site in the summer of 1990, immediately after nourishment took place; however, similar declines also occurred at the Fripp Island control site, suggesting a seasonal basis for the observed pattern (Figures 10 and 11). Mean sea-level (MSL) sites in both nourished and control areas were dominated by the coquina clam *Donax variabilis*, and the haustoriid amphipod *Neohaustorius schmitzi* (Tables 3 and 7). Spring peaks in abundance at low intertidal (MLW) and subtidal control sites were primarily due to higher densities of another haustoriid amphipod, *Protohaustorius deichmannae*. Fall peaks in abundance at the 200 ft sites in both nourished and control areas were due to increased densities of the bivalve *Mulinia lateralis*. Higher densities, overall, at the 200 ft Phase II site were due largely to higher densities of the capitellid polychaete *Mediomastus californiensis*. These patterns of abundance are remarkably similar to those observed at Phase I, suggesting that seasonal differences in timing of nourishment had little effect on the intertidal and shallow subtidal beach fauna.

Species richness and diversity at the Phase II study site also showed a pattern similar to that at Phase I, with values of both parameters decreasing at the two subtidal sites after nourishment was completed (Table 4). Unlike Phase I, however, species richness also declined in the two intertidal zones and, by the end of the study, had not returned to pre-nourishment levels at any of the four tidal elevations sampled. Nevertheless, species richness values were generally similar to, or higher than, those measured at the Fripp Island control site during the same season.

Changes in the relative abundance of major taxa following nourishment of Phase II were similar to those described for Phase I. In the intertidal zone mollusks decreased slightly in relative abundance at the Phase II study site immediately following nourishment, while they increased greatly at the control site during the same time period (Figure 12). Mollusks then increased at both nourished and control sites in the fall, due largely to changes in the abundance of *D. variabilis* and *M. lateralis*. In the subtidal zone (Figure 13), polychaetes (dominated by *M. californiensis*) were the most abundant taxa at the Phase II

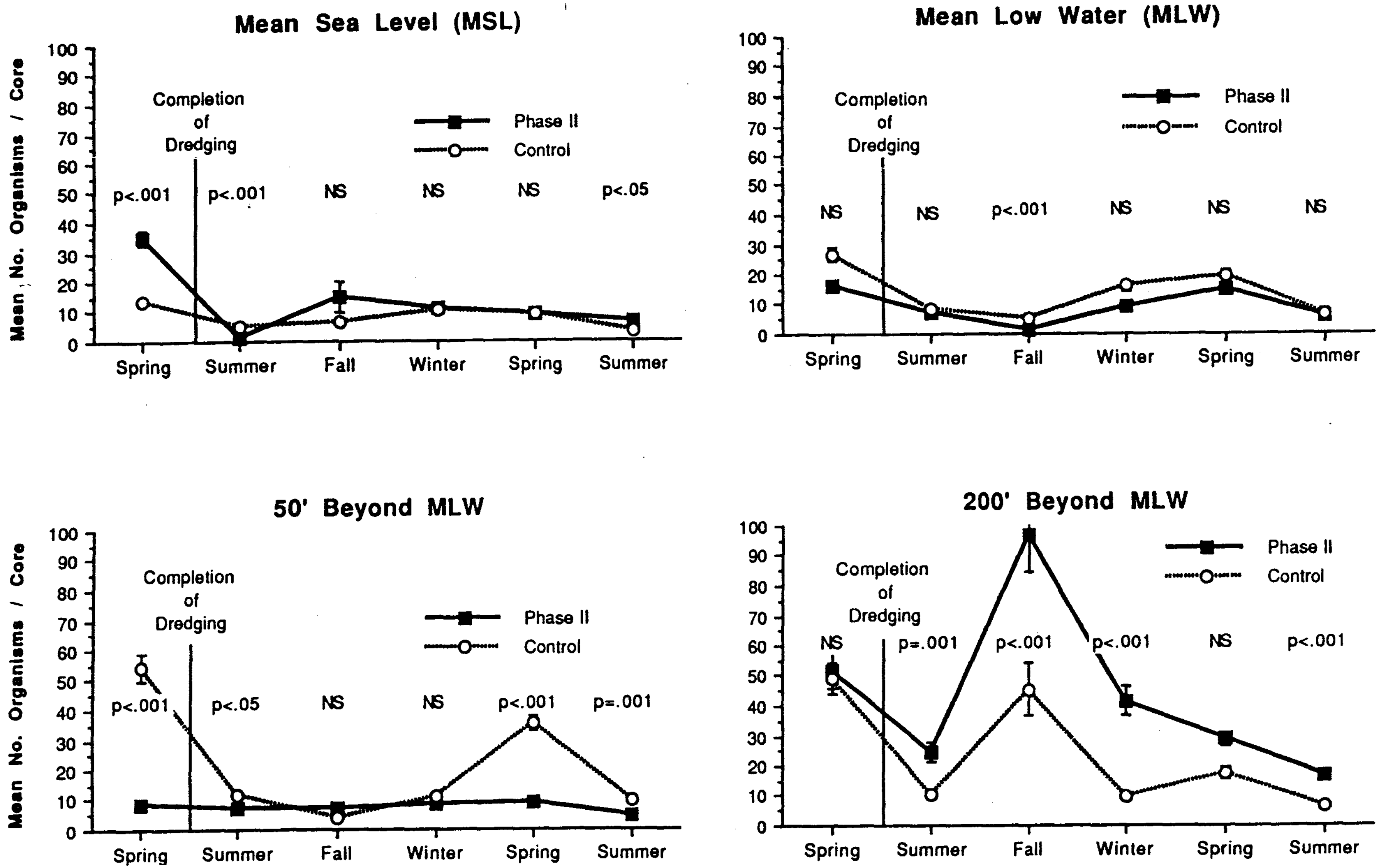


Figure 10. Mean density of benthic organisms at Phase II and control beach sites, with probabilities (p) associated with Tukey's pairwise comparisons of means for each sampling date. (NS=not significant at p=0.05; vertical bars represent ± 1 standard error of the mean).

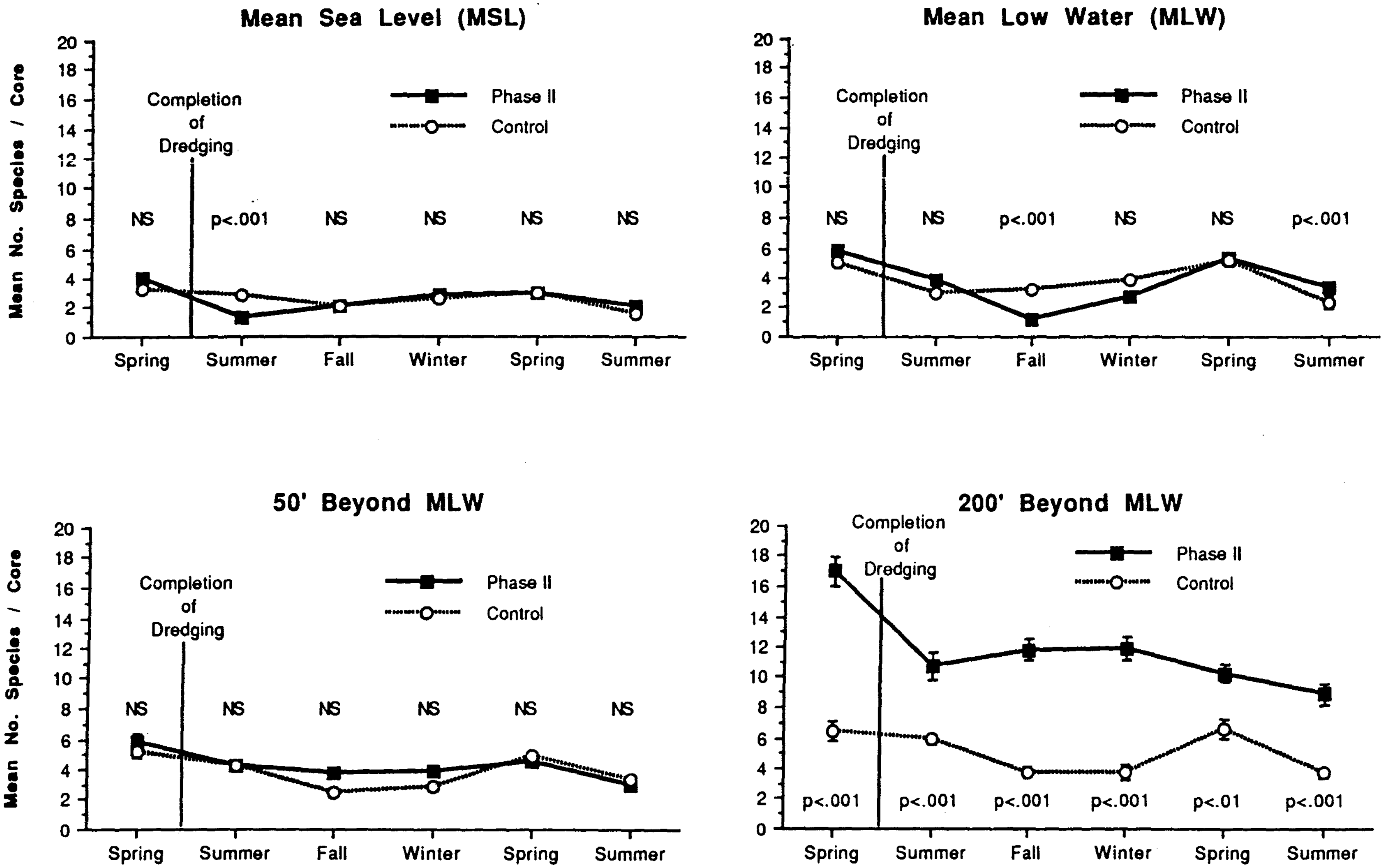
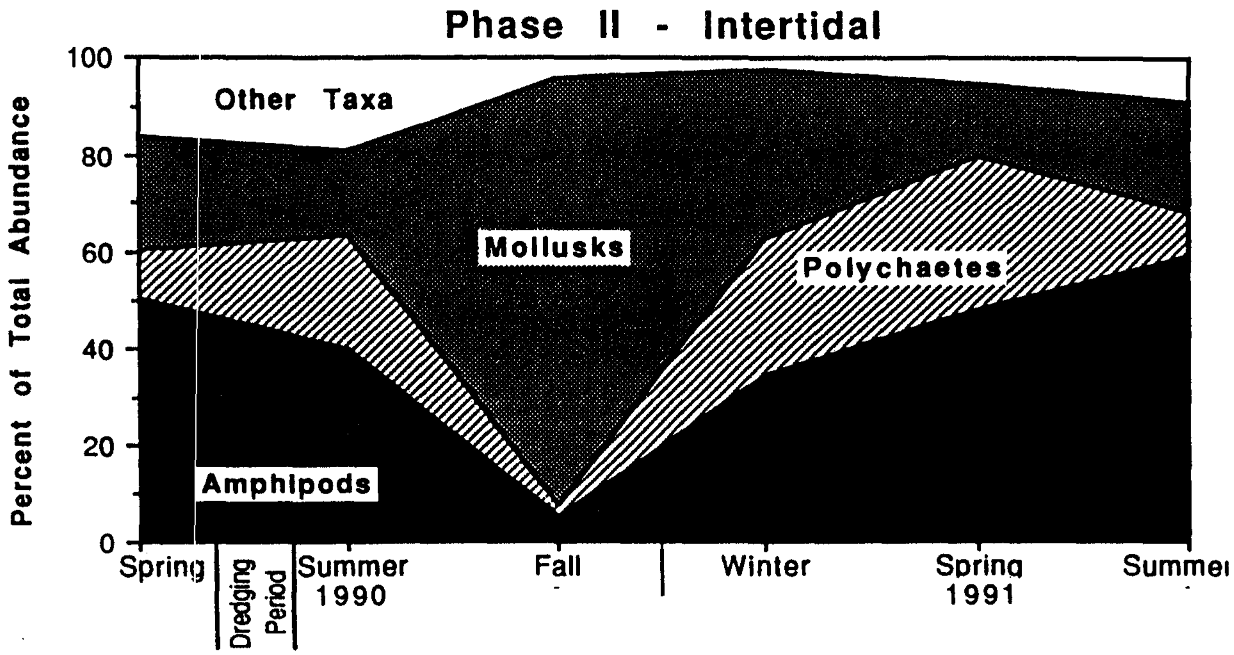


Figure 11. Mean number of species per core at Phase II and control beach sites, with probabilities (p) associated with Tukey's pairwise comparisons of means for each sampling date. (NS=not significant at $p=0.05$; vertical bars represent $\pm$ 1 standard error of the mean).

Table 7. Listing of the five most abundant macrofaunal species collected in core samples at each tide level in the Hilton Head Phase II area, and the percentage of total faunal abundance represented by these species during each season. A = amphipod, C = cumacean, M = mollusk, P = polychaete.

SPECIES	PERCENT OF TOTAL ABUNDANCE 1990			1991		
	Spring	Summer	Fall	Winter	Spring	Summer
Phase II - Mean Sea Level						
Donax variabilis (M)	34.3	29.0	46.2	61.5	33.5	38.1
Neohaustorius schmitzi (A)	54.0	---	1.3	18.3	48.6	53.2
Mulinia lateralis (M)	---	---	46.2	---	---	---
Parahaustorius longimerus (A)	0.1	29.0	2.0	9.4	8.9	0.8
Haustorius canadensis (A)	4.3	---	---	2.4	3.9	---
Phase II - Mean Low Water						
Parahaustorius longimerus (A)	30.0	33.6	4.2	29.5	23.4	47.1
Scolelepis squamata (P)	17.4	4.9	---	60.1	39.9	14.3
Mancocuma sp. (M)	25.6	---	4.2	0.6	1.7	0.8
Protohaustorius deichmannae (A)	2.5	6.3	---	0.6	14.1	13.4
Paraonis fulgens (P)	4.1	18.2	8.3	---	5.2	---
Phase II - 50' Beyond MLW						
Protohaustorius deichmannae (A)	6.5	31.8	21.6	20.2	45.1	11.1
Parahaustorius longimerus (A)	18.2	4.6	0.7	21.5	18.2	34.4
Scolelepis squamata (P)	4.1	---	---	37.4	4.4	5.6
Paraonis fulgens (P)	20.0	3.8	2.2	0.6	4.9	14.4
Solen viridis (M)	---	---	28.1	1.2	1.1	---
Phase II - 200' Beyond MLW						
Mulinia lateralis (M)	0.5	1.0	62.7	21.0	10.4	---
Mediomastus californiensis (P)	18.9	17.6	6.8	33.3	36.5	23.2
Solen viridis (M)	0.2	0.2	14.4	2.4	1.6	---
Tellina texana (M)	3.9	10.7	2.8	12.7	4.0	1.8
Oligochaeta	6.2	6.8	0.8	0.2	10.4	6.0



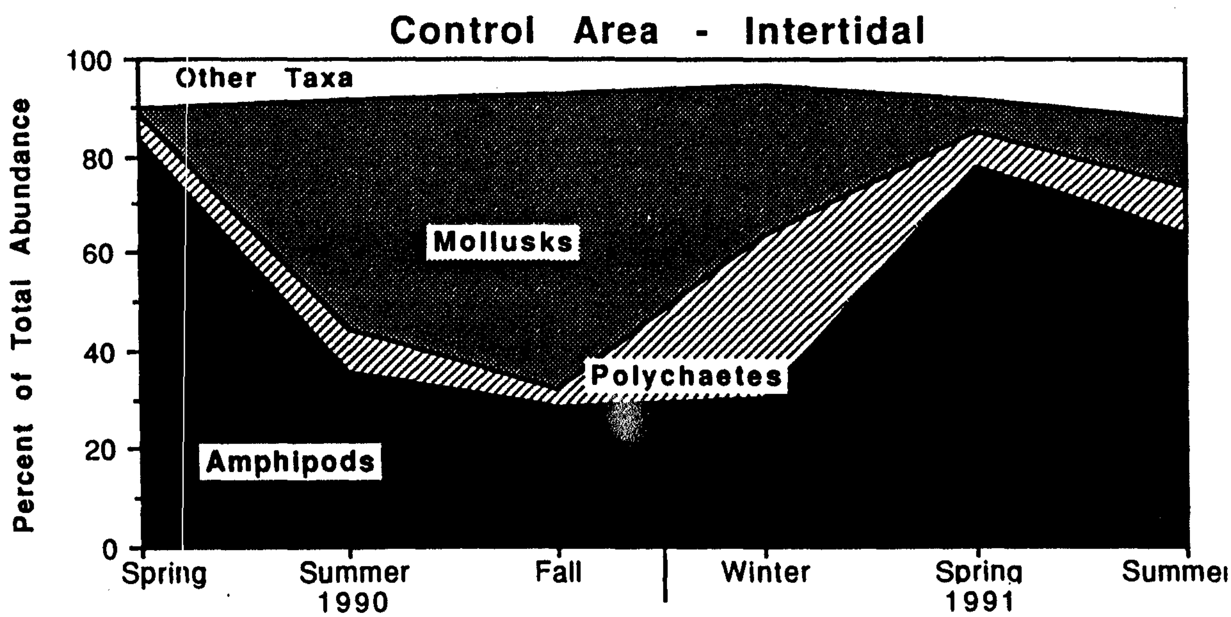


Figure 12. Percentage of total faunal abundance contributed by each major taxon to intertidal core samples from Phase II and control sites.

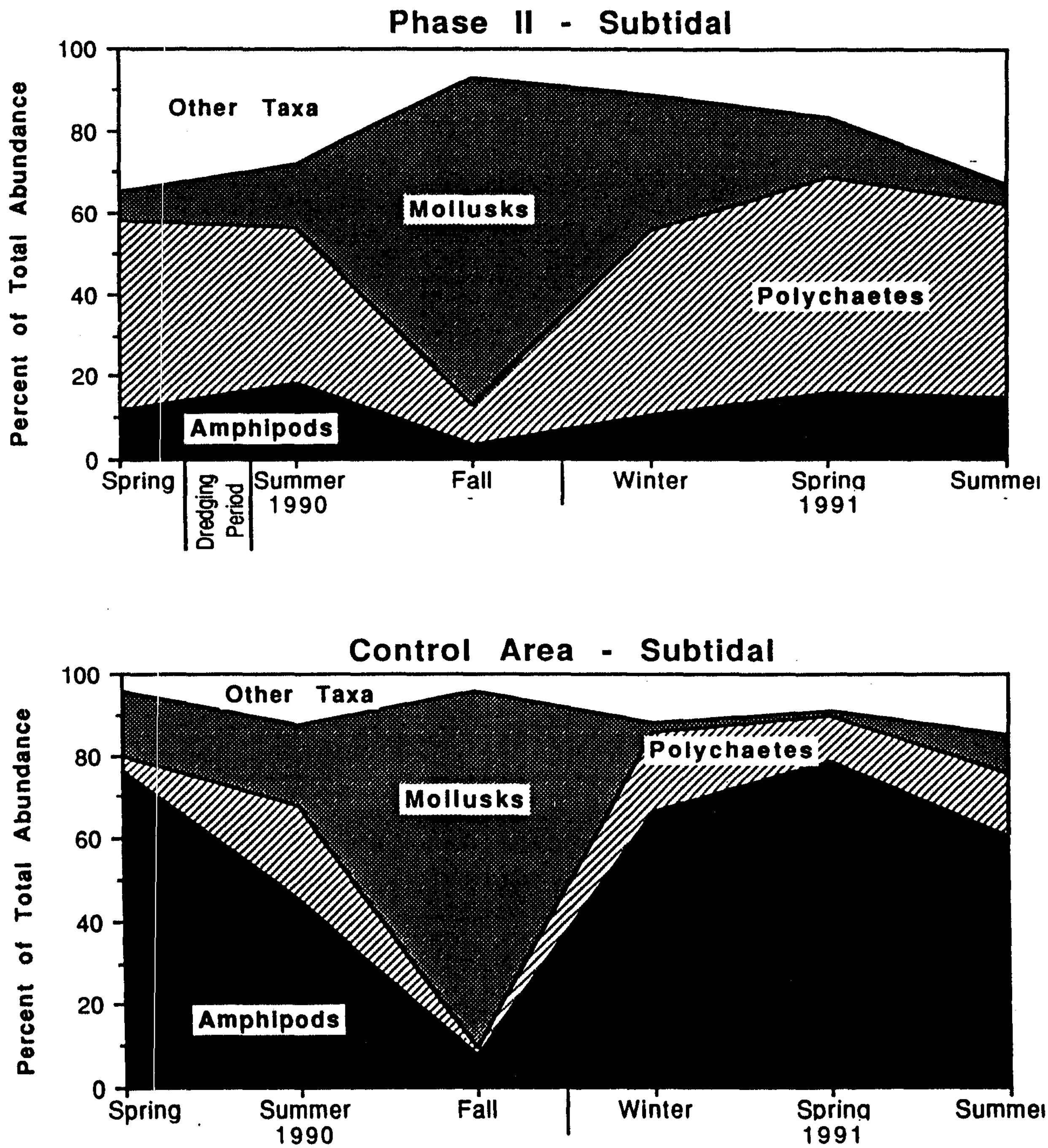


Figure 13. Percentage of total faunal abundance contributed by each major taxon to subtidal core samples from Phase II and control sites.

site, while amphipods were dominant at the Fripp Island control site during all seasons except the fall of 1990, when mollusks (dominated by *M. lateralis*) became most abundant at both nourished and control sites. In summary, while seasonal differences were apparent at both sites, nourishment appeared to have had little effect on the relative abundance of major taxa at Phase II.

Cluster and nodal analyses showed no evidence of dramatic shifts in community composition at the Phase II study site (Figures 14a and b; Tables 8 and 9). Pooled core samples clustered together by tidal elevation and sampling area (control vs. Phase II) rather than by time relative to nourishment. Differences in faunal composition between Hilton Head and Fripp Island sites probably reflected differences in sediment type, wave exposure, or other factors that were unrelated to nourishment activities. Species groups A and B were most frequently collected at the deeper subtidal sites, particularly at the muddier Phase II sites, while species groups C and D were most frequently collected at sandier intertidal and shallow subtidal sites.

In conclusion, while there was some evidence of decreased macrofaunal abundance and species diversity at all tide levels in both Phase I and Phase II study areas immediately following nourishment, these declines were generally of short duration and small in comparison to natural seasonal fluctuations in these parameters. Other researchers have suggested that seasonal variability in species distributions and abundances may minimize or mask the effects of nourishment in the intertidal and nearshore zones (Gorzelany and Nelson, 1987).

The more consistent decline in species richness at subtidal sites than at intertidal sites suggests that nearshore communities may be less adaptable to physical disturbance than intertidal communities, which must be able to withstand a much higher degree of environmental variability. The lack of consistently negative effects on the intertidal fauna may also be due to the fact that sediments from the borrow site were similar in grain size composition to the ambient beach sediments. The importance of using compatible sediments in nourishment projects to minimize adverse effects on the beach fauna, as well

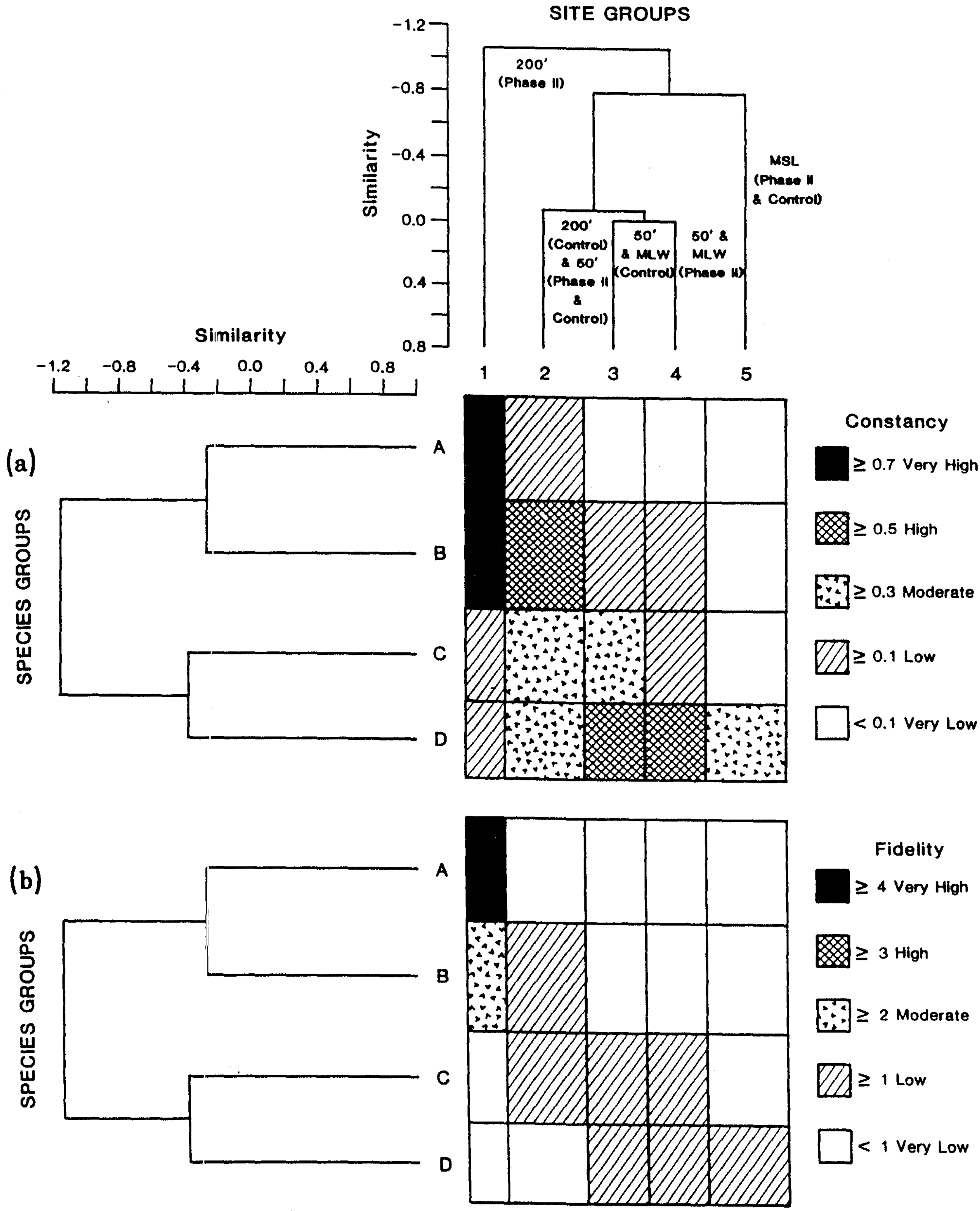


Figure 14. Normal (site group) and inverse (species group) cluster dendrograms with nodal constancy (a) and fidelity (b) diagrams for Phase II and control sites. (Normal analysis based on species occurring in >3% of all core samples; inverse analysis based on species occurring in >10% of all core samples).

Table 8. Site groups formed by a normal cluster analysis of pooled beach samples from Phase II Hilton Head (H) and Fripp Island control (F) areas. (A = mean sea level; B = mean low water; C = 50' beyond mean low water; D = 200' beyond mean low water).

Site Group 1	Time Relative to Nourishment (mo.)
*HD, May '90	-2
HD, Aug '90	+1
HD, Feb '91	-7
HD, May '91	+10
HD, Nov '90	+4
HD, Aug '91	+13

Site Group 2	Time Relative to Nourishment (mo.)
FB, May '91	+10
FC, May '91	+10
HB, May '91	+10
HC, May '91	+10
FD, May '90	-2
FD, May '91	+10
FD, Feb '91	+7
HC, Aug '90	+1
FD, Aug '90	+1
HC, Nov '90	+4
FD, Nov '90	+4
FD, Aug '91	+13

Site Group 3	Time Relative to Nourishment (mo.)
FB, May '90	-2
FC, May '90	-2
FB, Nov '90	+4
FC, Nov '90	+4
FB, Aug '91	+13
FC, Aug '91	+13
FB, Aug '90	+1
FC, Aug '90	+1
HB, Nov '90	+4

Site Group 4	Time Relative to Nourishment (mo.)
FB, Feb, '91	+7
FC, Feb, '91	+7
HC, Feb, '91	+7
HB, Feb, '91	+7
*HB, May '90	-2
*HC, May '90	-2
HB, Aug '90	+1
HC, Aug '91	+13
HB, Aug '91	+13

Site Group 5	Time Relative to Nourishment (mo.)
FA, May '91	+10
HA, May '91	+10
FA, Feb '91	+7
HA, Feb '91	+7
FA, Nov '90	+4
HA, Nov '90	+4
FA, Aug '90	+1
FA, Aug '91	+13
HA, Aug '91	+13
FA, May '90	-2
*HA, May '90	-2
HA, Aug '90	+1

* = Hilton Head samples taken prior to nourishment.

Table 9. Species groups formed by an inverse cluster analysis of pooled beach samples from Phase II Hilton Head (H) and Fripp Island control (F) areas. (A = amphipod; B = bivalve; C = cumacean; D = decapod; G = gastropod; Is = isopod; M = mysid; N = nemertinean; P = polychaete).

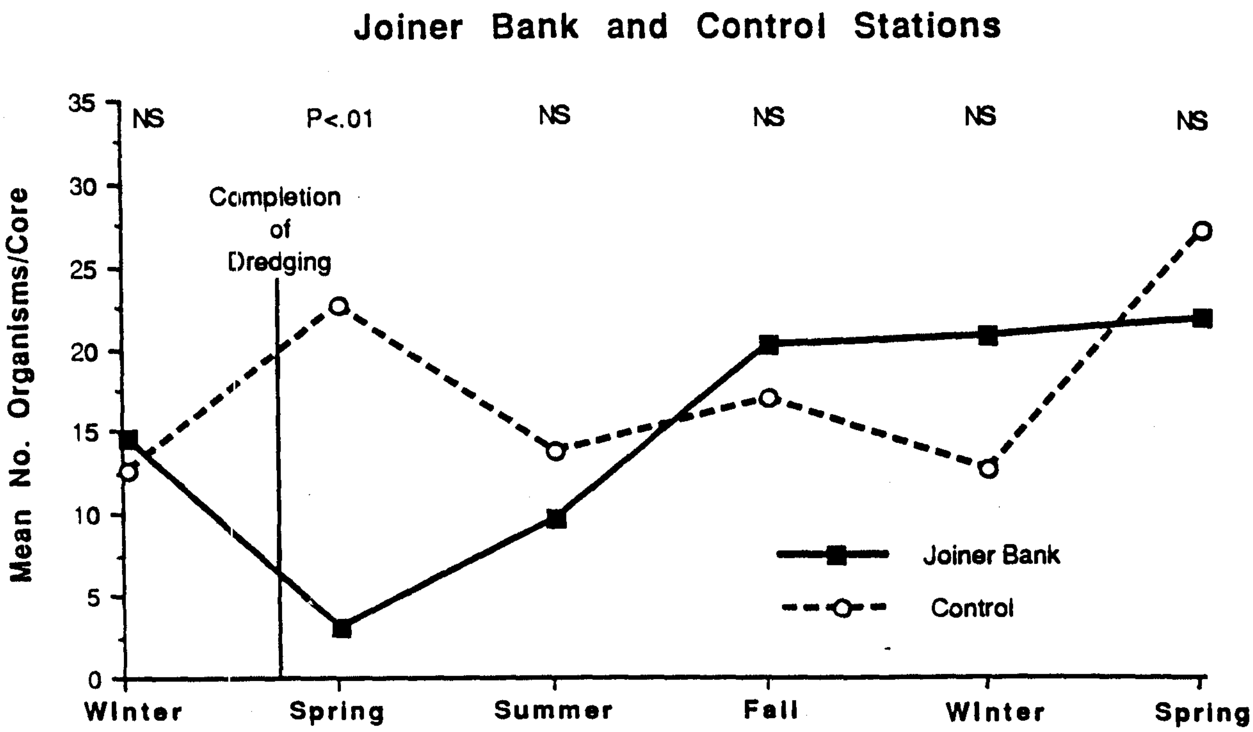
Group A	Group B	Group C	Group D
Aricidea suecica (P)	*Synchelidium americanum* (A)	*Cyclaspis varians* (C)	*Neohaustorius schmitzi* (A)
Carinomella lactea (N)	*Nephtys picta* (P)	*Nephtys bucera* (P)	*Donax variabilis* (B)
Callianassa biformis (D)	*Tellina texana* (B)	*Nereis* sp. (P)	*Paraonis fulgens* (P)
Pinnixa chaetopterana (D)	*Spiohanes bombyx* (P)	*Cyclaspis bacescui* (C)	*Acanthohaustorius millsi* (A)
Ampharete americana (P)	Nemertinea	*Pinnixa cristata* (D)	*Mancocuma* sp. (C)
Abra aequalis (B)	*Scolelepis texana* (P)	*Ogyrides hayi* (D)	*Parahaustorius longimerus* (A)
Parvilucina multilineata (B)	Turbellaria	*Lepidopa websteri* (D)	*Scolelepis squamata* (P)
Acteocina candei (G)	*Solen viridis* (B)	*Magelona papillicornis* (P)	*Protohaustorius deichmannae* (A)
Drilonereis longa (P)	*Leitoscoloplos fragilis* (P)	*Cyclaspis* sp. (C)	*Chiridotea coeca* (Is)
Arabellidae (P)	*Onuphis eremita* (P)	Pinnotheridae (D)	*Haustorius canadensis* (A)
Glycinde solitaria (P)	*Mulinia lateralis* (B)	*Aglaophamus verrilli* (P)	*Sphaeroma quadridentatum* (Is)
Oligochaeta	*Oxyurostylis smithi* (C)	Nematoda	*Ancinus depressus* (Is)
Rhepoxynius epistomus (A)	*Edotea montosa* (Is)	*Bowmaniella* sp. (M)	
Mediomastus californiensis (P)	*Pinnixa* sp. (D)	*Dispio uncinata* (P)	
Caulleriella sp. (P)	*Microprotopus raneyi* (A)		
Listriella barnardi (A)	*Chiridotea stenops* (Is)		
	Eteone heteropoda (P)		

as maximize the success of the nourishment project, has been well documented (Baca and Lankford, 1988; Gorzelany and Nelson, 1987; Hayden and Dolan, 1974; Lankford et al., 1988; Nelson 1985). Furthermore, sediments from the borrow site were deposited on the beach well above mean sea level (our highest sampling site in the intertidal zone). Thus, any burial of animals in the lower intertidal and shallow subtidal zones, as a result of sediment redistribution, was probably gradual enough to have permitted the more motile benthic organisms to move away from the nourishment area or burrow up through the overburden material, as suggested by Nelson (1985). This contention is supported by laboratory evidence that some benthic animals are able to migrate vertically through more than 30 cm of sediment (Maurer et al. 1978). The absence of any drastic changes in species composition or the relative abundance of major taxa at either of the nourished sites on Hilton Head Island is consistent with the findings of other researchers (Baca and Lankford, 1988; Gorzelany and Nelson, 1987; Hayden and Dolan, 1974; Lankford et al., 1988; Nelson 1985; Parr et al., 1978).

Joiner Bank Borrow Site:

Benthic communities in the Joiner Bank borrow site were significantly altered by the dredging operations with respect to faunal abundance, diversity and species composition. Comparisons with the control site indicated that the effects persisted throughout the one-year study period following dredging. Appendix II.1 provides a complete listing of all benthic macrofauna collected at the stations sampled in both areas.

Comparisons of the mean faunal abundance and the mean number of species/core at Joiner Bank versus the control area indicated significant area effects with respect to both variables, and significant seasonal effects with respect to faunal abundance ($P < .05$, ANOVA). Just prior to dredging, Joiner Bank and the control area were similar with respect to the density of organisms and the number of species collected ($P > .05$, Tukey's test; Figure 15). Both areas supported benthic assemblages dominated by haustoriid amphipods, primarily *Protohaustorius deichmannae* (Table 10, Figure 16). This species, and most of the other dominant taxa observed at the two sites, are commonly found in nearshore sand bottom habitats of South Carolina (Knott et al., 1983; Van Dolah et al., 1983, 1984, 1991; Winn et. al., 1989).



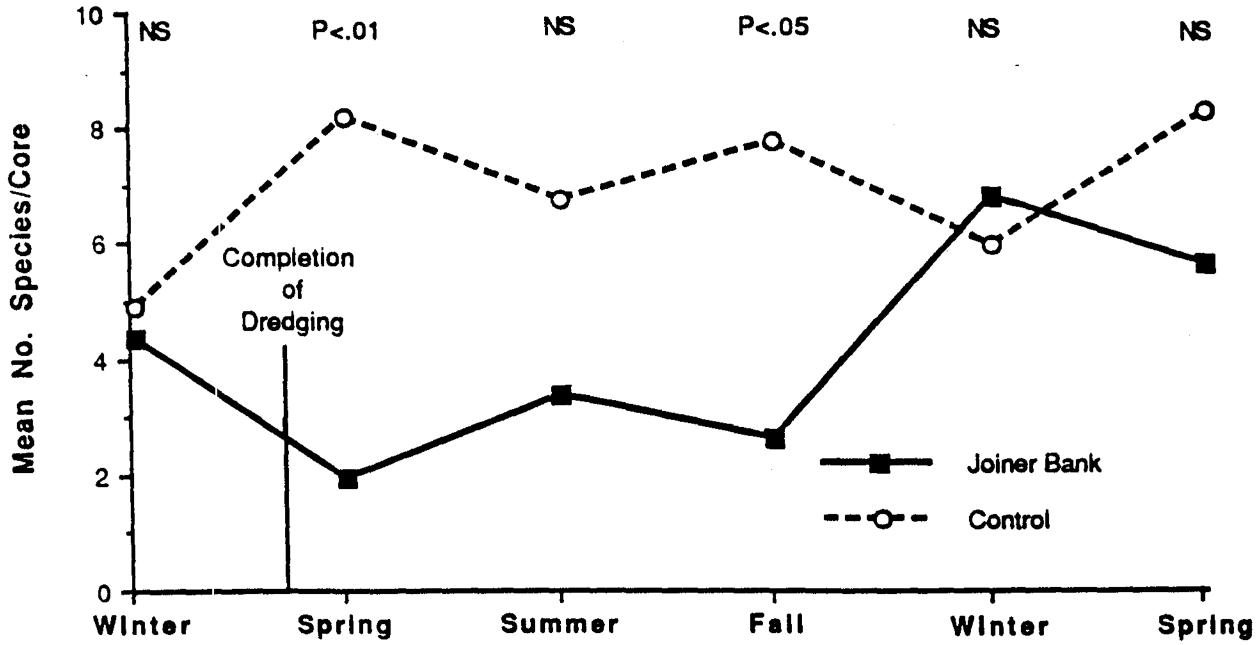


Figure 15. Mean number of organisms and species collected in core samples from the Joiner Bank borrow site and the control area. Probabilities listed at the top of each graph indicate the results from Tukey pairwise comparisons of means observed in each area on the different sampling dates. NS indicates no significant difference (P > .05).

Table 10. Listing of the ten most abundant species collected from Joiner Bank and the offshore control area and the percent of total faunal abundance represented by these species during each season. A = amphipod, C = cumacean, O = decapod, M = mollusks, P = polychaete.

SPECIES	PERCENT OF TOTAL FAUNA					
	1990				1991	
	Winter	Spring	Summer	Fall	Winter	Spring
Joiner Bank						
Protohaustorius deichmannae (A)	72.7	1.1	17.8	---	4.9	2.8
Mulinia lateralis (M)	---	1.1	35.5	1.5	4.9	50.0
Mediomastus californiensis (P)	---	1.1	1.4	2.5	13.7	10.9
Tellina texana (M)	---	5.4	26.3	1.3	24.4	4.1
Leucon sp. (C)	---	57.0	---	---	0.3	
Solen viridis (M)	0.2	---	0.4	0.5	---	6.3
Synchelidium americanum (A)	0.5	---	1.0	0.8	3.0	0.2
Acteocina candei (M)	---	---	---	87.8	24.6	2.1
Shpiophanes bombyx (P)	0.5	---	---	---	3.0	4.4
Leitoscoloplos fragilis (P)	1.6	10.8	0.3	0.5	4.1	3.3
Control Area						
Protohaustorius deichmannae (A)	59.4	52.1	36.2	18.8	37.7	33.7
Eudevenopus honduranus (A)	7.6	7.9	5.1	12.0	8.2	1.8
Spiophanes bombyx (P)	3.8	6.5	2.7	1.4	6.9	8.3
Paraonis fulgens (P)	3.0	2.8	15.2	29.2	14.5	12.3
Rhepoxynius epistomus (A)	2.5	0.9	5.6	3.3	3.7	8.0
Ogyrides hayi (D)	1.9	---	7.3	1.4	1.9	0.1
Bathyporeia parkeri (A)	1.9	6.6	0.7	0.2	0.5	0.3
Tellina texana (M)	---	1.0	1.9	2.8	3.2	3.1
Solen viridis (M)	---	0.4	1.0	0.8	0.5	18.3
Nemertinea	---	1.9	3.9	1.8	5.5	2.2

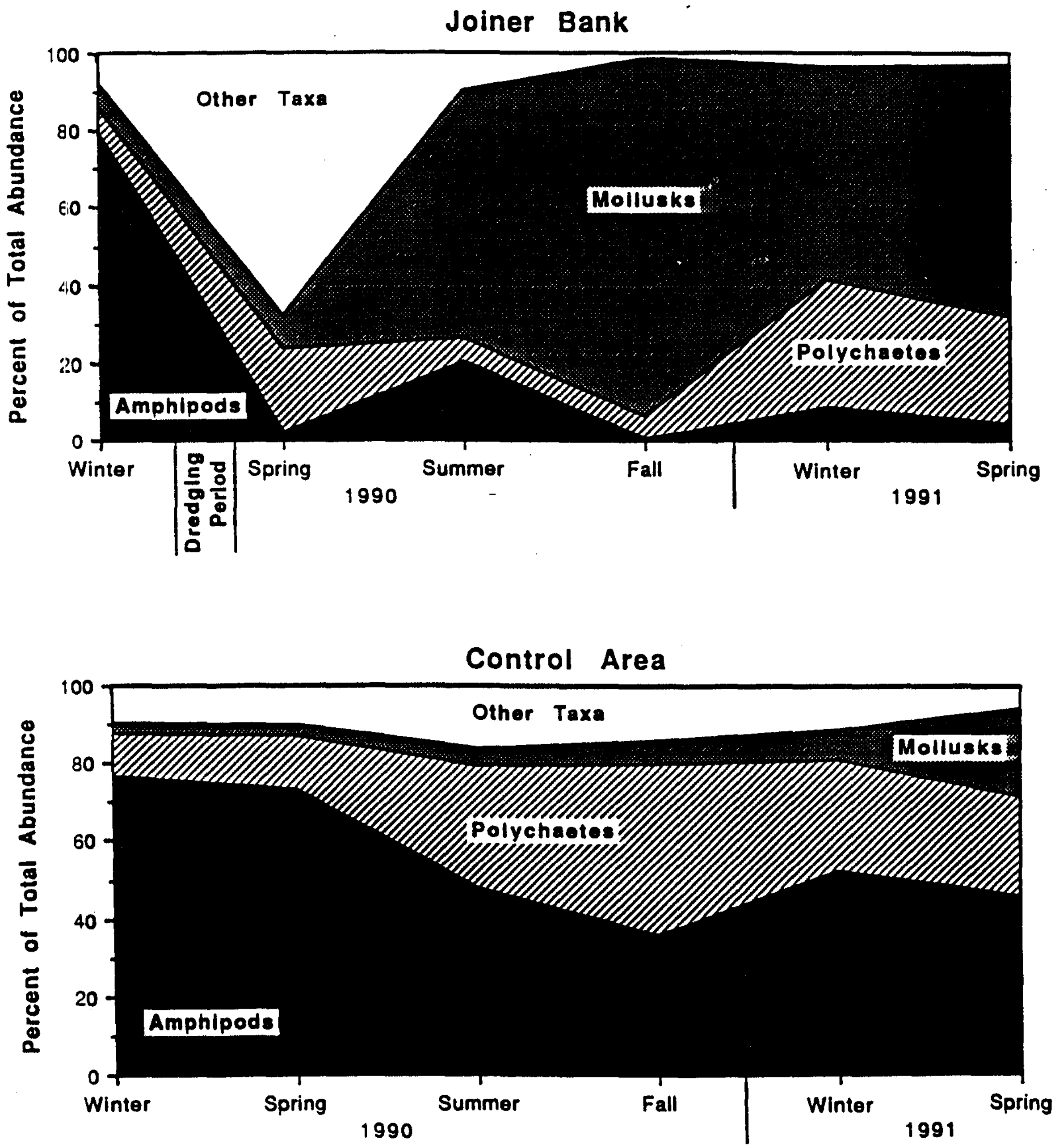


Figure 16. Percentages of total faunal abundance represented by the major taxonomic groups collected from at Joiner Bank and the control area.

Shortly after Joiner Bank was dredged, the abundance and number of species collected from that area were significantly reduced compared to the pre-dredging samples taken at that site ($P<.05$), and compared to samples collected at the same time in the control area ($P<.01$, Figure 15). A cumacean, *Leucon* sp., was the predominant organism found at Joiner Bank stations shortly after dredging, but the overall density of all fauna averaged less than three organisms/core (Figure 15, Table 10). In contrast, faunal abundance and the number of species had increased at the control site by the first post-dredging sampling period, with the haustoriid amphipod, *P. deichmannae*, remaining as the dominant species.

Three months later (August, 1990), faunal recruitment to the Joiner Bank stations had resulted in a higher density of organisms, as well as a slight increase in the mean number of species. Pairwise comparisons of group means indicated no significant differences between the control area and Joiner Bank in either faunal abundance or species number ($P>.05$), although the number of species at Joiner Bank was only half that observed at the control site (Figure 15). Faunal densities continued to increase at Joiner Bank on subsequent sampling dates, with no significant differences observed between areas during any sampling period ($P>.05$). The mean number of species/core remained lower at Joiner Bank compared to the control area through November 1990, and then increased to values comparable to those observed at the control area by the winter of 1991 (Figure 15). Species numbers at Joiner Bank and the control area remained similar during the spring of 1991, when sampling was terminated.

Estimates of community diversity (H'), evenness (J'), and species richness (SR) showed seasonal variability, as well as differences between the Joiner Bank and control area stations (Table 11). Diversity estimates (H') at Joiner Bank stations were generally lower than those observed in the control area on most sampling dates, which may reflect effects related to dredging. However, estimates of H' were also lower at this borrow site compared to the control area even before the dredging operation occurred. On most occasions, the lower H' values were generally due to lower species richness.

Although the Joiner Bank borrow site appeared to have recovered within four months after dredging in terms of faunal abundance, and within 10 months after dredging in terms

Table 11. Pooled species diversity (H'), evenness (J') and richness (S-1/ln N) estimates for the offshore borrow sites and control area.

	Offshore Control Area				Joiner Bank Borrow Site				Gaskin Bank Borrow Site			
Season	Station	H'	J'	S-1/ln N	Station	H'	J'	S-1/ln N	Station	H'	J'	S-1/ln N
Feb, '90	BC01	3.1	0.7	5.3	JB01	1.7	0.4	3.9	GB01	---	---	---
May, '90	"	3.2	0.6	6.1	"	3.2	0.9	3.5	"	4.1	0.7	8.0
Aug, '90	"	3.2	0.7	4.7	"	2.6	0.6	4.3	"	3.8	0.8	4.7
Nov, '90	"	4.0	0.7	6.4	"	2.7	0.9	2.2	"	3.5	0.7	6.3
Feb, '91	"	3.5	0.7	5.4	"	3.3	0.7	4.5	"	1.5	0.3	5.5
May, '91	"	3.3	0.7	5.6	"	3.9	0.8	5.4	"	2.5	0.5	4.7
Aug, '91	"	2.7	0.6	4.0	"	---	---	---	"	2.2	0.5	4.1
Feb, '90	BC02	1.8	0.5	3.0	JB02	1.8	0.4	4.0	GB02	---	---	---
May, '90	"	2.5	0.6	3.6	"	1.3	0.5	1.4	"	3.8	0.7	6.6
Aug, '90	"	2.8	0.7	2.7	"	2.0	0.6	2.0	"	4.2	0.8	5.9
Nov, '90	"	2.7	0.7	2.0	"	0.7	0.2	2.2	"	4.1	0.9	5.6
Feb, '91	"	1.7	0.5	2.0	"	2.8	0.7	3.4	"	3.0	0.6	5.4
May, '91	"	2.8	0.6	4.7	"	0.7	0.2	1.6	"	3.1	0.6	5.7
Aug, '91	"	3.0	0.7	4.1	"	---	---	---	"	3.6	0.7	7.3
Feb, '90	BC03	2.4	0.6	3.6	JB03	1.8	0.5	2.4	GB03	---	---	---
May, '90	"	2.8	0.6	5.3	"	2.1	0.6	2.5	"	3.9	0.8	5.6
Aug, '90	"	3.6	0.7	5.5	"	1.3	0.4	1.6	"	3.9	0.8	6.7
Nov, '90	"	3.6	0.7	6.1	"	1.0	0.3	1.9	"	4.5	0.8	8.1
Feb, '91	"	3.5	0.8	4.6	"	2.4	0.6	3.4	"	1.9	0.4	4.4
May, '91	"	3.1	0.7	4.1	"	1.8	0.4	2.8	"	2.6	0.5	6.5
Aug, '91	"	3.8	0.8	5.2	"	---	---	---	"	2.2	0.5	5.0

of species numbers, the species composition at this borrow site was substantially altered after the dredging operation and the effects persisted throughout the study period. Following completion of the dredging, mollusks became the dominant taxa at Joiner Bank. The two most abundant species collected during the summer of 1990, approximately four months after dredging, were the bivalves *Mulinia lateralis* and *Tellina texana* (Table 10). Both of these species are typically found in muddy sediments (Ruppert and Fox, 1988), which were characteristic of the Joiner Bank site after dredging had occurred. These species, and the small snail, *Acteocina candei*, were the most abundant species found at the borrow site stations during subsequent sampling periods, with the order of abundance changing among the three species in different seasons. Amphipods were always less abundant in post-dredging cores collected from Joiner Bank than in those from the control area (Figure 16). In contrast, the amphipod *Protohaustorius deichmannae*, was generally the most abundant in the control area throughout the study. Other species also abundant in this area, but rare at Joiner Bank, included the amphipods *Eudevenopus honduranus*, *Rhepoxynius epistomus*, and *Bathyporeia parkeri*, and the polychaetes *Spiophanes bombyx* and *Paraonis fulgens* (Table 10).

Cluster and nodal analyses provide additional evidence that faunal composition was altered substantially after dredging at Joiner Bank (Figure 17). Prior to dredging, faunal composition at the Joiner Bank site and the control site were similar. After dredging, faunal composition at the Joiner Bank stations was very different from the control area on four of the five post-dredge sampling dates. Faunal composition was also dissimilar to pre-dredge samples taken at Joiner Bank. Changes in faunal composition were also observed at the control site, most probably due to seasonal effects, but the differences observed among seasons were not as great as those observed before versus after dredging at the borrow site.

Five general species groups were identified in the inverse cluster analyses (Table 12). Groups A,E, and F showed the highest constancy among control area stations. Groups C,E, and F showed high constancy among Joiner Bank sites (Figure 17). Group E comprised many of the species that were numerically dominant in one or more seasons at each site (Tables 10, Appendix 2.1). None of the species groups were highly faithful to any of the station groups.

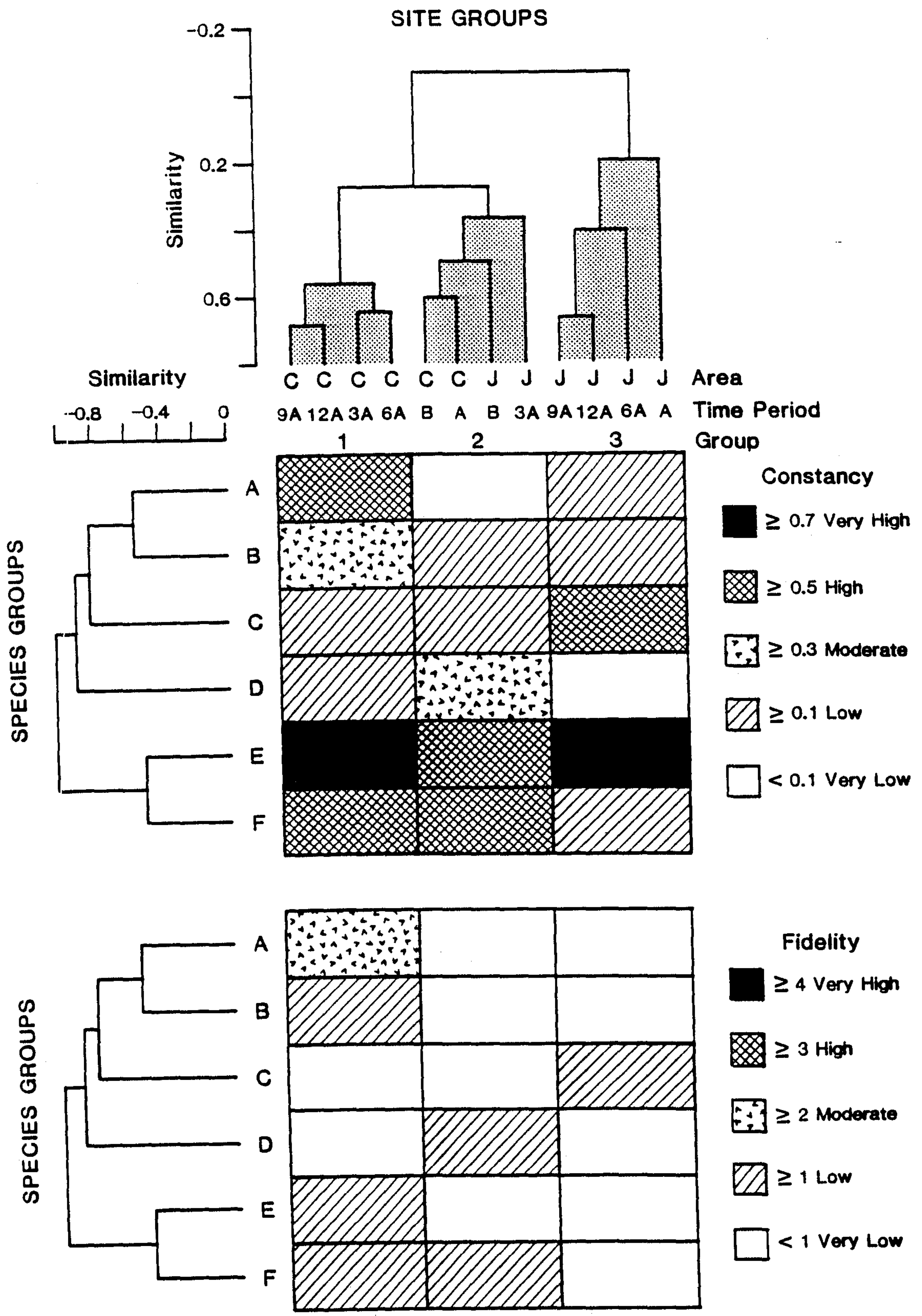


Figure 17. Normal (site groups) and inverse (species groups) cluster dendrograms with nodal constancy and fidelity diagrams for samples collected from Joiner Bank and the control area.

Table 12. Species groups formed by inverse cluster analysis of benthic fauna collected from Joiner Bank and the offshore control area. A = amphipod, An = anthozoan, C = cumacean, D = decapod, M = mollusk, My = mysid, P = polychaete, E = echinoderm, H = holothuroid.

Group A	Group B	Group C	Group D	Group E	Group F
Pinnixa chaetopterana (D)	*Terebra dislocata* (P)	*Carinomella lactea* (I)	*Lepidopa websteri* (D)	*Eudevenopus honduranus* (A)	*Pagurus longicarpus* (D)
Armandia agilis (P)	*Aricidea wassi* (P)	*Mangelia quadrata* (M)	*Pinnixa sayana* (D)	*Paraonis fulgens* (P)	*Cyclaspis bacescui* (C)
Aricidea suecica (P)	*Glycera americana* (P)	*Paraprionospia pinnata* (P)	*Oligochaeta*	*Rhepoxynius epistomus* (A)	*Aglaophamus verrilli* (P)
Nephtys bucera (P)	*Listriella barnardi* (A)	*Streblospio benedicti* (P)	*Anthuridae*	*Sphiophanes bombyx* (P)	*Thyonella gemmata* (H)
Callianassa biformis (D)	*Pagurus hendersoni* (D)	*Eteone heteropoda* (P)	*Nucula proxima* (M)	*Nemertinea*	*Metharpinia floridana* (A)
Cyclaspis varians (C)	*Ophiophragmus wurdemani* (O)	*Polinices duplicatus* (M)	*Magelona sp.* (P)	*Protohaustorius deichmannae* (A)	*Mancocuma sp.* (M)
Renilla reniformis (An)	*Tellina iris* (M)	*Neomysis americana* (My)	*Magelona papillicornis* (P)	*Mulinia lateralis* (M)	*Nematoda*
Pinnixa sp. (D)	*Axiothella mucosa* (P)	*Leucon sp.* (C)	*Leptosynapta sp.* (H)	*Mediomastus californiensis* (P)	*Synchelidium americanum* (A)
Listriella clymenella (A)	*Turbellaria*	*Caulleriella sp.* (P)	*Batea catharinensis* (A)	*Tellina texana* (M)	*Bowmaniella sp.* (C)
Magelona rosea (P)	*Phyllodoce arenae* (P)	*Scolelepis squamata* (P)		*Acteocina candei* (M)	*Amastigos caperatus* (P)
Glycinde solitaria (P)	*Ampharete americana* (P)	*Donax variabilis* (M)		*Nephtys picta* (P)	*Ogyrides hayi* (D)
Leptochela serratorbita (D)		*Maldanidae* (P)		*Scolelepis texana* (P)	*Dispio uncinata* (P)
				Leitoscoloplos fragilis (P)	*Dissodactylus mellitae* (D)
				Solen viridis (M)	*Mellita quinquesperforata* (E)
				Tharyx sp. (P)	*Olivella mutica* (M)
					Oxyurostylis smithi (C)
					Parvilucina multilineata (M)
					Abra aequalis (M)
					Bathyporeia parkeri (A)
					Nephtyidae (P)
					Acanthohaustorius millsi (A)
					Acanthohaustorius intermedius (A)

The major changes observed in faunal composition at Joiner Bank were most likely due to (1) the alteration of bottom sediments in this area following the dredging operation, and (2) the reduction in wave energy associated with creation of the dredged basin. The reduced wave energy, combined with the proximity of this borrow site to Port Royal Sound, were probably the primary causes for the accumulation of a thick layer of silt on the bottom that persisted throughout the study period. Muddy bottom habitats are not typically found in the nearshore zone off South Carolina beaches, and these bottom types tend to support a very different assemblage of benthic fauna than sandy bottoms. Thus, it is unlikely that the benthic communities in the Joiner Bank area will recover to pre-dredge conditions until the area fills back in with sand.

Studies conducted at a borrow site near Treasure Island, Florida also documented the accumulation of fine-grained sediments in a nearshore borrow pit created by dredging for beach nourishment, and impacts to the benthic communities in that area persisted for more than three years (Saloman, 1974). Taylor Biological Company (1978) studied the same site and predicted that it would take 10 years or more for the borrow area to completely recover to pre-dredge conditions. No data are available to predict the duration of impacts to the benthos at Joiner Bank, but based on our observations it may take several years for the original bottom sediment composition to be restored.

Gaskin Bank Borrow Site:

Impacts to benthic communities in the Gaskin Bank borrow site were detected immediately after dredging, but the effects were not as persistent as those observed at Joiner Bank. A complete listing of all fauna collected at these sites is provided in Appendix II.1.

Two-way analysis of variance tests indicated significant area and seasonal effects with respect to both mean faunal abundances and the mean number of species collected at Gaskin Bank and the control area ($P<.01$). Prior to dredging, there were no significant differences between sites with respect to either variable; however, faunal composition did differ between the two sites (Figures 18, 19). Polychaetes (primarily *Spiophanes bombyx*)

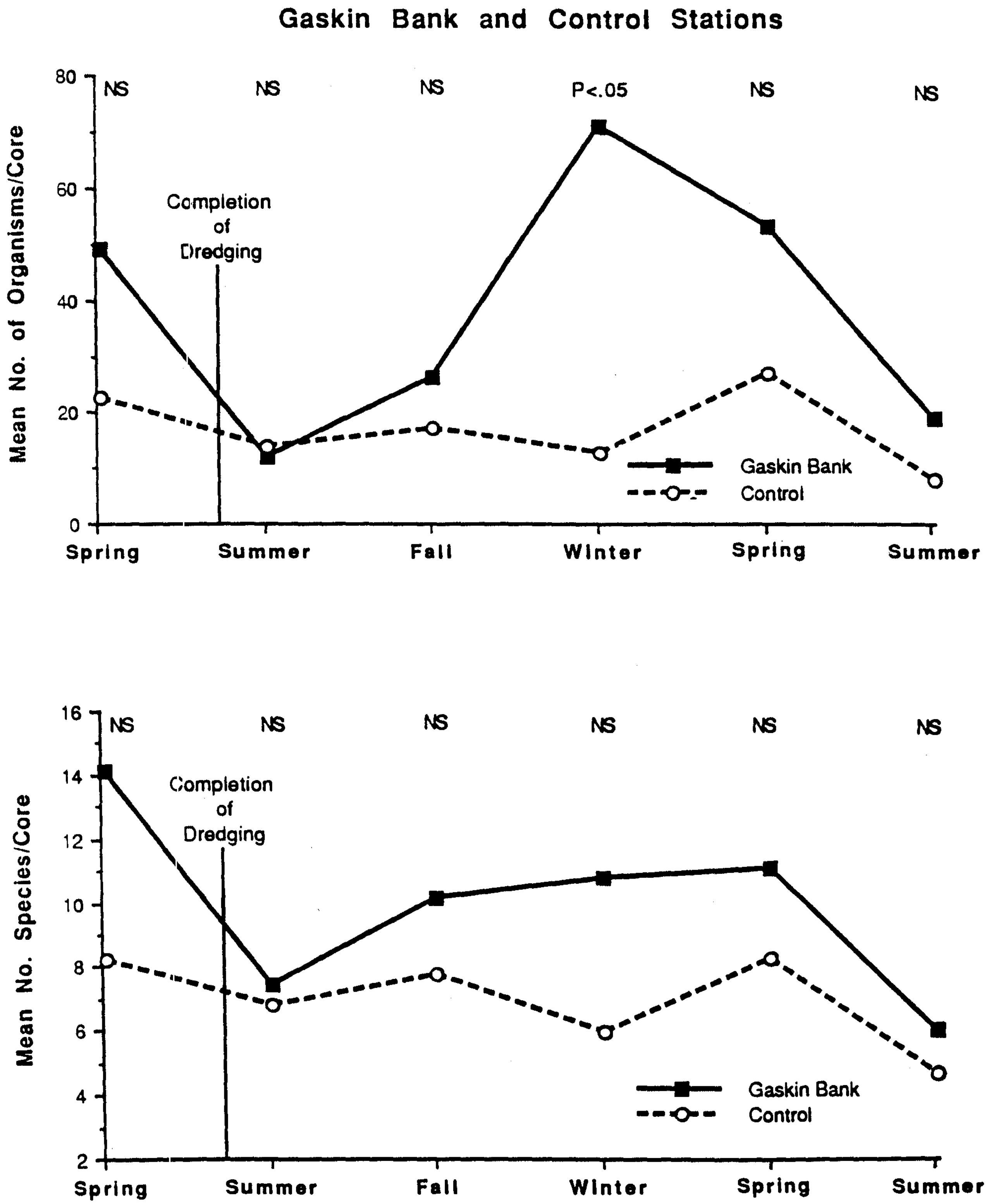


Figure 18. Mean number of organisms and species collected in core samples from the Gaskin Bank borrow site and the control area. Probabilities listed at the top of each graph indicate the results from Tukey pairwise comparisons of means observed in each area on the different sampling dates. NS indicates no significant difference (P > .05).

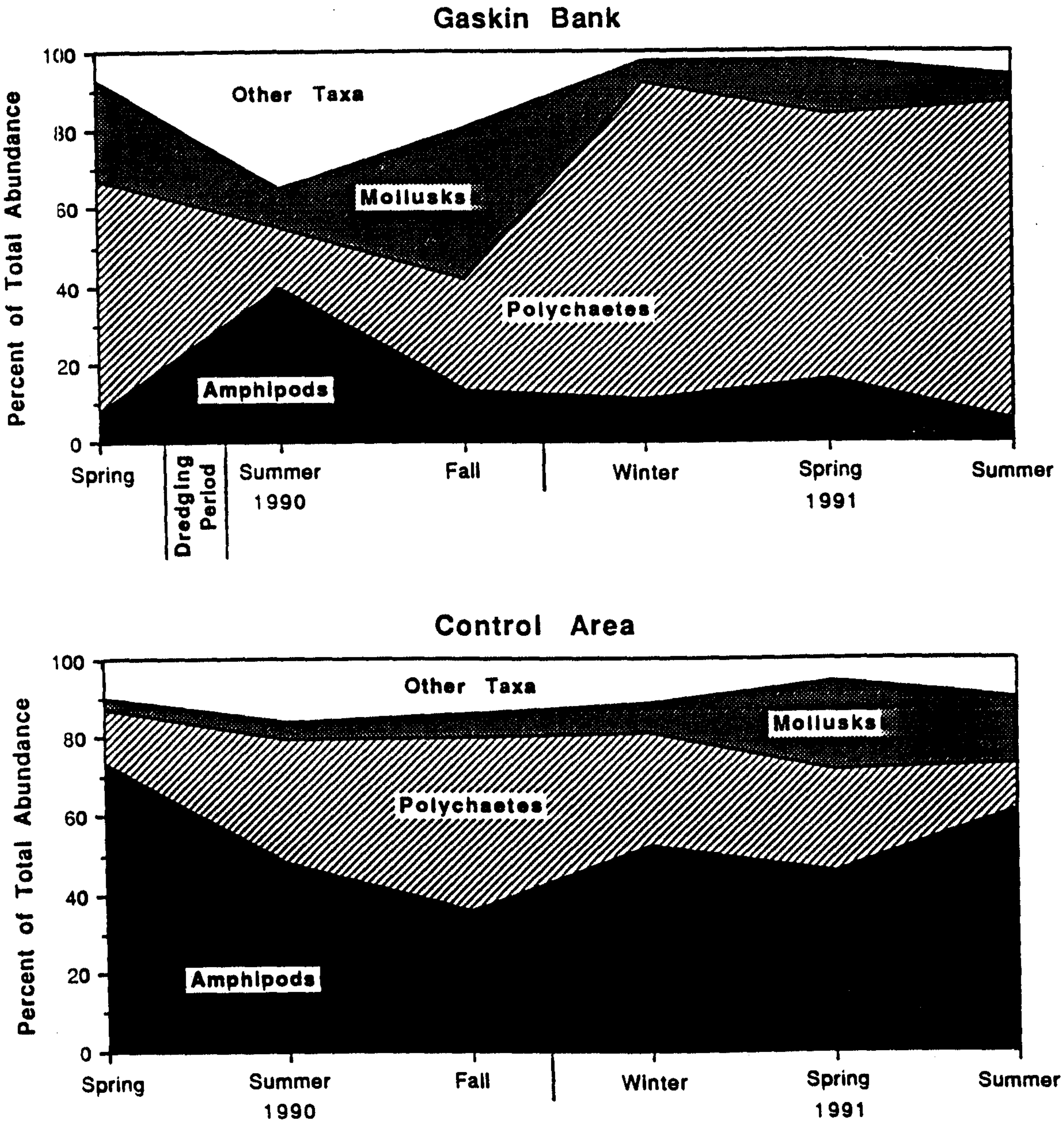


Figure 19. Percentages of total faunal abundance represented by the major taxonomic groups collected from at Gaskin Bank and the control area.

and mollusks (primarily *Tellina texana* and *Parvilucina multilineata*) were the dominant macrofauna in benthic cores from Gaskin Bank (Table 13). Amphipods comprised a relatively small percentage of the taxa at Gaskin Bank, whereas they were the dominant taxa in the control area at this time.

Shortly after Gaskin Bank had been dredged, there was a substantial reduction in both the number of species and density of organisms in that area, but the values were not significantly different from those at the control site (Figure 18). Faunal composition had also changed at the borrow site relative to the pre-dredge sampling period, with amphipods representing the greatest percentage of taxa collected (Figure 19). *Protohaustorius deichmannae* was the most abundant species at this time, as in the control area, but the density of this species at Gaskin Bank was only 35% of the density in the control area (Table 12). Additionally, many of the species that were initially abundant at the borrow site prior to dredging were either rare or absent shortly after dredging was completed.

By the fall of 1990 (approx. 4 mo. after dredging), faunal densities had increased at the borrow site, and by the winter of 1991, densities were significantly greater than those observed at the control site (Figure 18). Faunal abundances then declined over the remaining study period, with average densities at the borrow site approaching those at the control site during the last two sampling periods.

The mean number of species collected at the borrow site had also increased by the fall of 1990 (4 mo after dredging) compared to the immediate post-dredge sampling period (Figure 18). Species numbers remained higher at Gaskin Bank than at the control area on all subsequent sampling periods, although the differences between sites were not significant on any particular sampling date ($P>.05$, Tukey's test). Estimates of species diversity (H') at Gaskin Bank stations did not show any consistent patterns related to dredging effects (Table 11).

Species composition differed between Gaskin Bank and the control site, both before and after dredging (Figure 19). In the control area, the dominant species and major taxa forming the benthic communities did not change markedly throughout the study period. Major changes in species composition were observed at Gaskin Bank, but alterations related to the dredging operation appeared to be relatively short-term compared to the changes

Table 13. Listing of the ten most abundant species collected from Gaskin Bank and the offshore control area and the percent of total faunal abundance represented by these species during each season. A = amphipod, C = cumacean, O = decapod, M = mollusks, P = polychaete.

SPECIES	PERCENT OF TOTAL FAUNA					
	1990			1991		
	Spring	Summer	Fall	Winter	Spring	Summer
Gaskin Bank						
Spiophanes bombyx (P)	21.0	0.3	0.1	70.2	43.3	51.3
Tellina texana (M)	8.9	6.2	14.3	1.6	3.4	0.7
Caulleriella sp. (P)	8.0	---	0.3	---	2.8	2.3
Mediomastus californiensis (P)	5.5	0.8	11.3	1.2	14.8	19.3
Protohaustorius deichmannae (A)	1.8	12.1	2.4	7.9	11.6	---
Solen viridis (M)	0.3	---	7.0	0.3	4.4	2.7
Tellina iris (P)	---	---	4.6	2.8	2.8	---
Rhepoxynius epistomus (A)	3.6	9.0	3.0	0.9	0.1	0.5
Parvilucina multilineata (M)	7.1	---	0.6	0.1	0.7	0.7
Nepthys picta (P)	4.5	---	---	0.6	1.4	0.9
Control Area						
Protohaustorius deichmannae (A)	52.1	36.2	18.8	37.7	33.7	40.5
Eudevenopus honduranus (A)	7.9	5.1	12.0	8.2	1.8	---
Sphiophanes bombyx (P)	6.5	2.7	1.4	6.9	8.3	---
Paraonis fulgens (P)	2.8	15.2	29.2	14.5	12.3	1.3
Solen viridis (M)	0.4	1.0	0.8	0.5	18.3	4.3
Rhepoxynius epistomus (A)	0.9	5.6	3.3	3.7	8.0	10.8
Ogyrides hayi (D)	---	7.3	1.4	1.9	0.1	0.9
Bathyporeia parkeri (A)	6.6	0.7	0.2	0.5	0.3	0.4
Nemertinea	1.9	3.9	1.8	5.5	2.2	2.6
Tellina texana (M)	1.0	1.9	2.8	3.2	3.1	3.9

noted at Joiner Bank. By the winter of 1991 (7 mo. after dredging), the polychaete *S. bombyx* was again the dominant species at the borrow site stations and the percentages of all major taxa were similar to those observed prior to dredging (Figure 19). Samples collected in the spring of 1991 contained most of the same species that were initially collected during the spring of 1990 (prior to dredging), and densities of many of these species were comparable (Table 12, Appendix 2.1).

Cluster analysis provided additional evidence that species composition at the Gaskin Bank site had returned to pre-dredge conditions less than one-year after dredging (Figure 20). Three major site groups were identified in this analysis. Group 1 included all samples collected from the control area. Faunal similarity among these samples was relatively high compared to samples from Gaskin Bank. Site group 2 consisted of samples taken immediately after, and 3 months after dredging at Gaskin Bank. These samples were relatively dissimilar to the other Gaskin Bank samples, which formed a third site group consisting of cores taken before and 6 - 12 months after dredging.

Species groups formed by the inverse cluster analysis are listed in Table 14. Groups C and D showed relatively high constancy among samples in site group 3, but only moderate fidelity to that group (Figure 20) Species Group E contained most of the numerically dominant species found at both the control area and Gaskin Bank. Due to the ubiquitous distribution of these species among the stations sampled, this species group showed high constancy and low fidelity to all of the stations groups.

The relatively quick recovery of benthic communities at Gaskin Bank is probably due to the lack of major changes in bottom sediment characteristics in the borrow area. Unlike Joiner Bank, this area was located well away from the entrances to the two major sounds on each end of Hilton Head Island, and bottom sediments after dredging were predominantly fine sands with a very low percentages of silt and clay. Additionally, Gaskin Bank was located in deeper waters than Joiner Bank, which may have lessened the effects of wave energy on the bottom.

Table 14. Species groups formed by inverse cluster analysis of benthic fauna collected from Gaskin Bank and the offshore control area. A = amphipod, An = anthozoan, C = cumacean, D = decapod, E = echinoderm, H = holothuroid, I = isopod, M = mollusk, N = nemerkan, P = polychaete.

Group A	Group B	Group C	Group D	Group E
Acetes americanus (D)	*Thyonella gemmata* (H)	*Nematoda*	*Leptochela serratorbita* (D)	*Oxyurostylis smithi* (C)
Microprotopus raneyi (A)	*Olivella mutica* (M)	*Tharyx sp.* (P)	*Acteocina candei* (M)	*Abra aequalis* (M)
Notomastus sp. (P)	*Cyclaspis varians* (C)	*Batea catharinensis* (A)	*Sigambra tentaculata* (P)	*Aricidea suecica* (P)
Nereidae (P)	*Bowmaniella sp.* (M)	*Pseudeurythde ambigua* (P)	*Onuphis eremita* (P)	*Listriella barnardi* (A)
Amphiuridae (P)	*Pinnixa sayana* (D)	*Pagurus hendersoni* (D)	*Terebra dislocata* (P)	*Tellina iris* (M)
Sabellaria vulgaris (P)	*Pagurus longicarpus* (D)	*Aligena elevata* (M)	*Trachypenaeus constrictus* (D)	*Sphiophanes bombyx* (P)
Ensis directus (M)	*Cyclaspis bacescui* (C)	*Owenia fusiformis* (P)	*Paraprionospio pinnata* (P)	*Mediomastus californiensis* (P)
Armandia maculata (P)	*Pinnixa chaetopterana* (D)	*Nucula proxima* (M)	*Emerita talpoida* (D)	*Solen viridis* (M)
Notomastus hemipodus (P)	*Armandia agilis* (P)	*Turbonilla sp.* (P)	*Polinices duplicatus* (M)	*Parvilucina multilineata* (M)
Capitellidae (P)	*Pinnixa sp* (D)	*Clymenella torquata* (P)	*Brania wellfleetensis* (P)	*Nepthys picta* (P)
Notomastus lovatus (P)	*Turbellaria*	*Listriella clymenella* (A)	*Glycera oxycephala* (P)	*Amastigos caperatus* (P)
Phylodoce castanea (P)	*Scolelepis texana* (P)	*Glycera americana* (P)	*Axiothella mucosa* (P)	*Leitoscoloplos fragilis* (P)
Mulinia lateralis (M)	*Callianassa biformis* (D)	*Magelona rosea* (P)	*Strigilla mirabilis* (M)	*Caulleriella sp.* (P)
Prionospio dayi (P)	*Dispio uncinata* (P)	*Ampelisca verilli* (A)	*Scolelepis squamata* (P)	*Eudevenopus honduranus* (A)
Nereis succinea (P)	*Synchelidium americanum* (A)	*Edotea montosa* (I)	*Nephtys bucera* (P)	*Paraonis fulgens* (P)
Spio pettiboneae (P)	*Ogyrides hayi* (D)	*Prionospio cirrifera* (P)	*Carinomella lactea* (N)	*Rhepoxynius epistomus* (A)
	Renilla reniformis (An)		*Phyllodoce arenae* (P)	*Tellina texana* (M)
	Ogyrides alphaerostris (D)		*Magelona papillicornis* (P)	*Nemertinea*
	Neohaustorius schmitzi (A)		*Ampharete americana* (P)	*Protohaustorius deichmannae* (A)
	Polydora socialis (P)		*Ophiuroidea*	*Acanthohaustorius millsi* (A)
	Ogyrides sp. (D)		*Magelona sp.* (P)	*Acanthohaustorius intermedius* (A)
	Agalophamus verrilli (P)		*Nassarius albus* (M)	*Dissodactylus mellitae* (D)
	Nephtyidae (P)		*Glycera dibranchiata* (P)	*Mellita quinquesperforata* (E)
	Ophiophragmus wurdemani (E)		*Glycinde solitaria* (P)	*Bathyporeia parkeri* (A)
	Ancinus depressus (I)		*Glycera sphyrabrancha* (P)	
	Metharpinia floridana (A)		*Cistenides gouldii* (P)	
			Hemipodus roseus (P)	

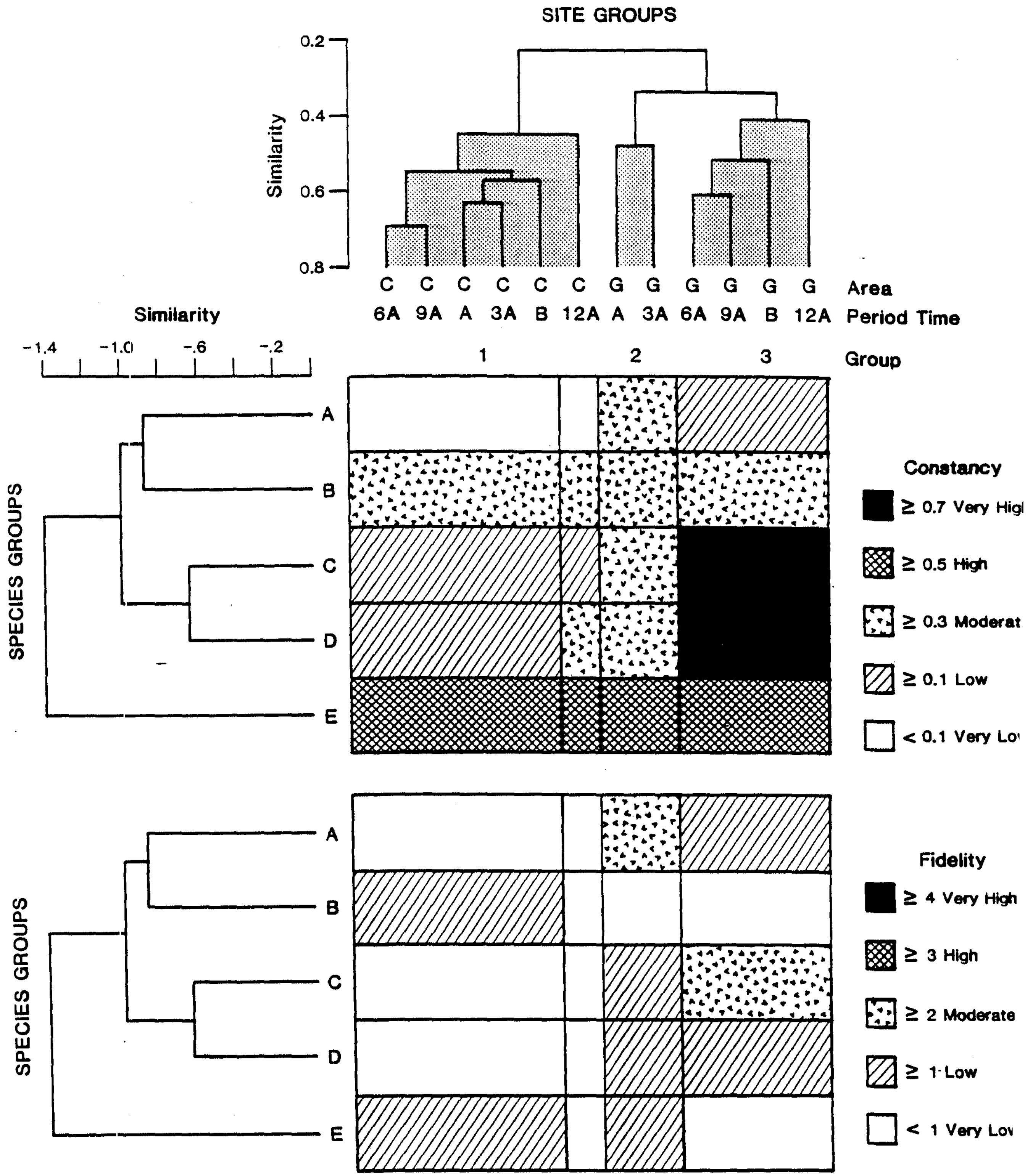


Figure 20. Normal (site groups) and inverse (species groups) cluster dendrograms with nodal constancy and fidelity diagrams for samples collected from Gaskin Bank and the control area.

In summary, our data show differential effects between the two borrow sites that appear to be related to the degree of physical change within each site following the dredging operation. Changes observed in the benthic communities at Joiner Bank persisted throughout the study, and were probably the result of changes in bottom type. Although major changes were also observed in the benthic communities at Gaskin Bank, the decline in numbers of species and organisms was not as great as at Joiner Bank, and benthic communities appeared to have largely recovered within 6-9 months after the dredging operation. The lack of major changes in sediment characteristics may explain the relatively rapid recolonization of the borrow site with similar fauna. Future dredging operations for nourishment purposes should carefully consider site location and configuration in order to minimize long-term changes in sediments, which create an atypical physical environment for the benthos.

Planktonic Communities:

A total of 135 plankton tows were made throughout the six-month period, capturing 2220 priority organisms (Table 15). Most abundant of these were megalopae of the common blue crab, *Callinectes sapidus*, representing almost 55% of the total number. The lesser blue crab, *Callinectes similis*, was also collected, as were post-larvae of the penaeid shrimps, *Penaeus duorarum*, *P. setiferus*, and *P. aztecus*. Fishes classified as priority species included larval forms of whiting (*Menticirrhus* sp.), Atlantic croaker (*Micropogonias undulatus)*, red drum (*Sciaenops ocellata)*, spot (*Leiostomus xanthurus)*, spotted seatrout (*Cynoscion nebulosus)*, and seabass of the family Serranidae. Although targeted for collection, no flounder (*Paralichthys* sp.) or mackerel (*Scomberomorus* sp.) were captured. Peak abundance of larval paralichthid flounder is known to occur earlier in the year (January) than when our sampling took place (Bozeman and Dean, 1980; Ginsburg, 1952; Powell and Schwartz, 1977) and, although the spawning season for king and spanish mackerel coincided with our sampling dates, larvae of these species are generally found high in the water column and are, therefore, not often collected by bottom sled (B.W. Stender, S.C. Marine Resources Research Institute, pers. comm.).

Table 15. Total numbers and percent of total catch for priority plankton species.

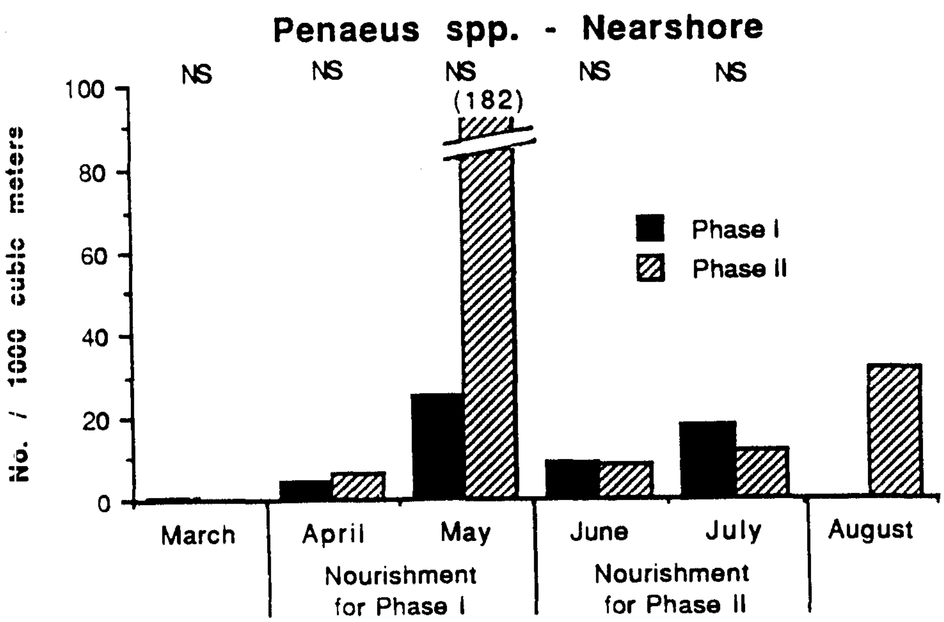
	#	%
Callinectes sapidus	1219	54.91
Menticirrhus sp.	337	15.18
Micropogonias undulatus	254	11.44
Penaeus duorarum	142	6.40
Penaeus setiferus	81	3.65
Sciaenops ocellata	73	3.29
Callinectes similis	73	3.29
Penaeus aztecus	23	1.04
Leiostomus xanthurus	8	0.36
Cynoscion nebulosus	7	0.32
Serranidae	2	0.09
Penaeus sp.	1	0.04
Total	2220	100.00

In addition to these priority species, several other planktonic organisms were collected. Most abundant were the crustaceans *Acetes americanus* and Mysidacea, and larval fishes including gobies (Gobiidae), anchovies (Engraulidae), jacks (Carangidae), weakfish (*Cynoscion regalis*) and star drum (*Stellifer lanceolatus*). Non-priority species greatly outnumbered priority species at all stations.

Of the three main groups of organisms collected (shrimp, crab and fish), the most important economically are the shrimp (*Penaeus* spp.), which constitute South Carolina's largest commercial fishery. Any impact to these species would be of major concern. None of our data indicate, however, that there were significant impacts to larval shrimp from any aspect of the nourishment operation. Penaeid shrimp were much more numerous in the surf zone than at the borrow sites (Figure 21). At the nearshore sites, numbers were highly variable, but statistical tests indicated no significant differences between dredge outfall sites and the non-impacted reference sites (Table 16). Numbers of shrimp collected at the offshore borrow sites were consistently low. Statistical comparisons of shrimp densities showed no significant differences between the two dredged areas or between the dredged areas and the control site.

Blue crab were far more abundant than shrimp and were caught in varying numbers at both the inshore and offshore sites (Figure 22). The only significant difference in abundance was found at the nearshore stations in July when collections at Phase I, where nourishment had already been completed, were much greater than at Phase II, where nourishment was actively occurring (Table 16). Although nourishment may have been a contributing factor, it is unlikely that this difference in numbers was a direct result of the nourishment operation. During the previous months, blue crab megalopae were collected only at Phase I, even while nourishment was occurring in this area, indicating a possible affinity for this area unrelated to the nourishment operation. At the offshore sites, no significant differences were detected among any of the areas.

Among the priority fishes, differences in abundance between the nearshore areas occurred in March, before nourishment began at either site (Figure 23). This illustrates a basic difference in distribution unrelated to the operation, and emphasizes the difficulty in making comparisons between sites based on a single event such as beach nourishment.



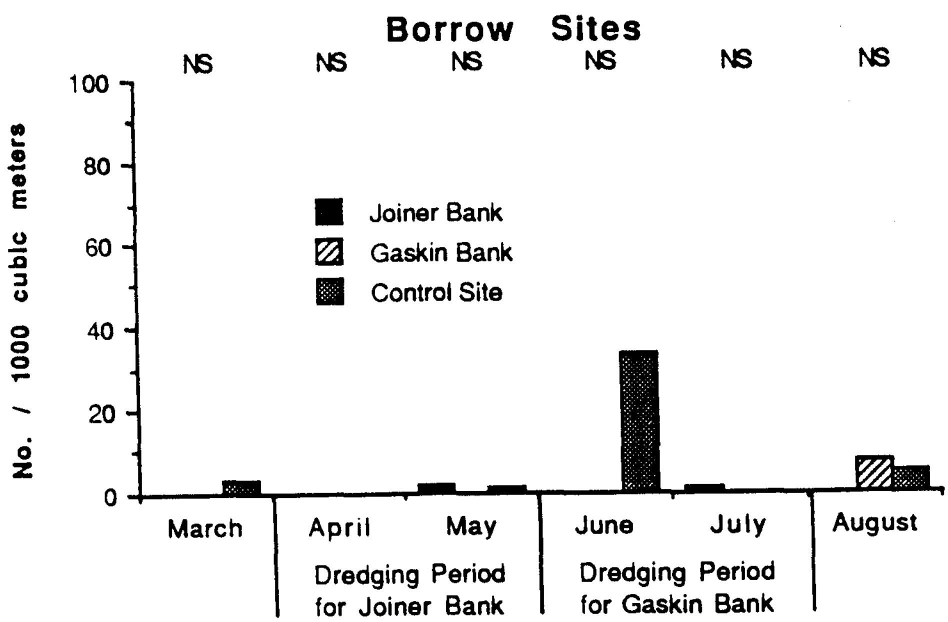
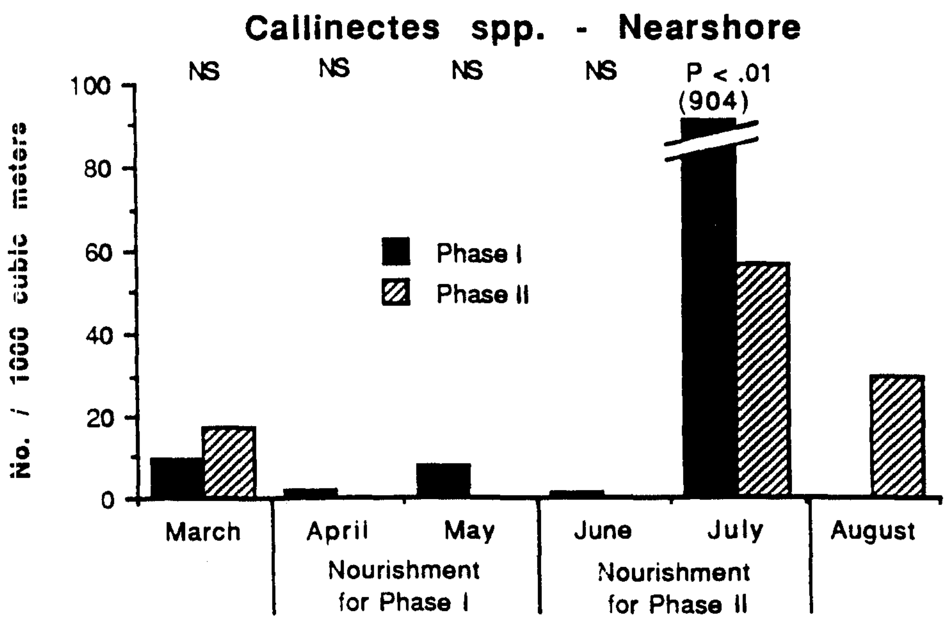


Figure 21. Number of penaeid shrimp collected per 1000 cubic meters of water filtered for nearshore and offshore sites. NS = no significant difference in abundance between sites.

Table 16. Results of analysis of variance tests for differences between outfall and reference sites (inshore) and between dredged and non-dredged areas (offshore). ND = not significantly different; * = significantly different at $\alpha < 0.01$ level.

	Inshore		Offshore	
	Significance	P	Significance	P
Penaeus sp.				
March	ND	0.3466	ND	0.1411
April	ND	0.8233	ND	1.0000
May	ND	0.1117	ND	0.6186
June	ND	1.0000	ND	0.0702
July	ND	0.4346	ND	0.3966
August	-	-	ND	0.3659
Callinectes sp.				
March	ND	0.7672	ND	0.2227
April	ND	0.1411	ND	0.1535
May	ND	0.1513	ND	0.2911
June	ND	0.3466	ND	1.0000
July	*	0.0024	ND	0.9045
August	-	-	ND	0.3466
Priority Fishes				
March	*	0.0025	ND	0.2129
April	ND	0.3466	ND	0.2193
May	ND	0.3632	*	0.0058
June	ND	0.8618	ND	0.1894
July	ND	0.1411	ND	0.0989
August	-	-	ND	0.1450



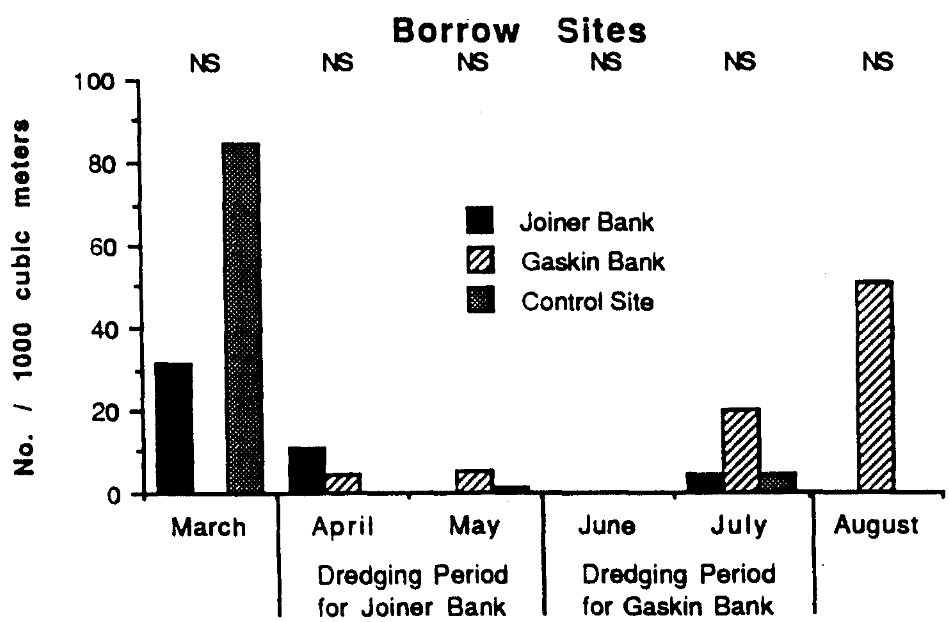
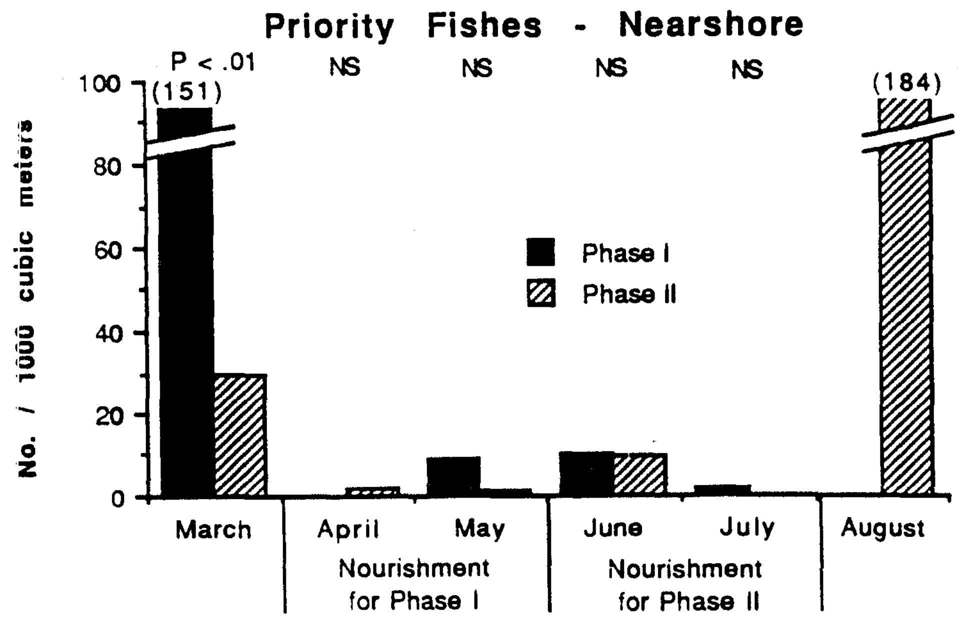


Figure 22. Number of blue crab collected per 1000 cubic meters of water filtered for nearshore and offshore sites. NS = no significant difference in abundance between sites. P = significant difference detected at level specified.



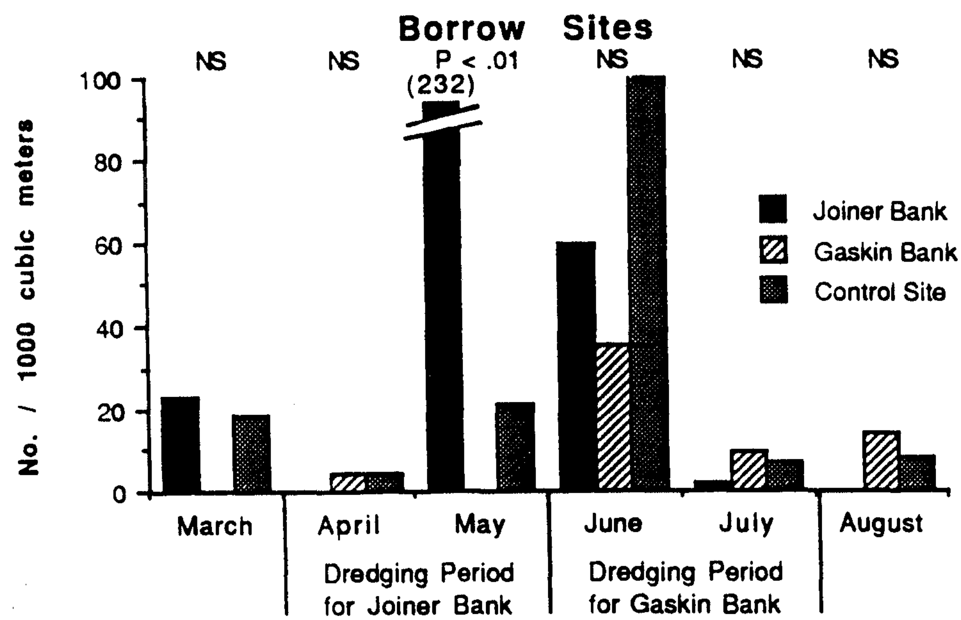


Figure 23. Number of priority fishes collected per 1000 cubic meters of water filtered for nearshore and offshore sites. NS = no significant difference in abundance between sites. P = significant difference detected at level specified.

In subsequent months, numbers of larval fishes were low in both nourished and unnourished areas until August, after sampling at Phase I had been completed. During this sampling period, the seasonal recruitment of red drum resulted in a large increase in numbers at Phase II, suggesting that there were no lasting effects on larval recruitment related to nourishment at this site. At the offshore sites, the only significant difference between sites occurred in May when dredging was taking place at Joiner Bank. During this time, greater numbers of larval fishes were collected at Joiner Bank than at either Gaskin Bank or the control site, indicating that dredging may have had a positive effect on larval fish recruitment. It has been suggested that fish may be attracted to areas of active dredging by the large amounts of organic matter extracted from the benthos and suspended into the water column by the dredge (Coastal Science Associates, Inc., 1990). Turbidity data indicate that turbidity levels at Joiner Bank were much higher at this time than levels at the other sites or during any other season (*see* Turbidity Concentrations).

The results of normal cluster analysis on all plankton data combined showed the importance of seasonality and station location in forming site groups, but gave no indication that dredging or nourishment operations affected these groups in any way. Five station groups were formed, each of which contained both impacted and reference sites (Table 17). Groups 1 and 2 consisted exclusively of offshore sites, while groups 3 and 4 were composed primarily of nearshore sites. This grouping indicates that station location was more important than dredging or nourishment activities in determining station similarity. The fifth group contained both nearshore and offshore stations, but only samples from the month of March. Although these were all pre-nourishment samples, their grouping together was based more on the seasonality of the species caught at these stations during this month. With one exception, this was the only month in which larval spot and croaker were collected. This seasonal pattern in larval abundance is well documented for these species throughout the southeast (Bearden, 1964; Dawson, 1958; Kobylinski and Sheridan, 1979; Shealy *et al.*, 1974; Warlen and Chester, 1985) and not a result of nourishment activities.

Inverse cluster analysis, again, emphasized station location and seasonality in forming species groups (Table 18). Group A (*Micropogonias undulatus*, *Leiostomus xanthurus*, *Callinectes similis*) contained species which were caught primarily during the month of

Table 17. Site groups resulting from normal cluster analysis based on data pooled by station and season. JB = Joiner Bank, GB = Gaskin Bank, CS = Offshore control site, H1 = Nourished beach at Phase I, H2 = Nourished beach at Phase II.

Group 1		Group 2		Group 3		Group 4		Group 5	
CS	July	GB	June	H1	June	H1	April	CS	March
GB	April	JB	June	H2	June	H2	April	JB	March
JB	July	JB	May	CS	June	H1	July	H1	March
CS	May	CS	April	H2	May	H2	July	H2	March
GB	July	CS	August			GB	August		
GB	May					H1	May		
JB	April					H2	August		

Table 18. Species groups resulting from inverse cluster analysis based on data pooled by station and season.

Group A	Group B	Group C	Group D
Micropogonias undulatus	Serranidae	*Cynoscion nebulosus*	*Menticirrhus sp.*
Leiostomus xanthurus		*Penaeus sp.*	*Callinectes sapidus*
Callinectes similis			

Group E	Group F
Penaeus duorarum	*Sciaenops ocellata*
Penaeus setiferus	
Penaeus aztecus	

March. This was also evident in the nodal analysis where species group A showed very high constancy and fidelity to site group 5, indicating that species in this group were found at all stations but only during March (Figure 24).

Groups B (Serranidae) and C (*Cynoscion nebulosus*, *Penaeus* sp.) contained species that were infrequently collected; therefore, their occurrence at a particular station or at a particular time made them highly faithful to that station or season.

Group D (*Menticirrhus* sp., *Callinectes sapidus*) consisted of taxa which were collected over a wide range of stations and seasons. This was confirmed in nodal analysis where this species group showed high or very high constancy, but low or very low fidelity with all site groups.

Group E contained only the penaeid shrimps (*Penaeus duorarum*, *P. setiferus*, *P. aztecus*), which grouped together because of their occurrence primarily at nearshore stations. Nodal analysis showed this station preference with high constancy values for site groups 3 and 4, the groups made up of nearshore stations. Low fidelity values indicate that, while found primarily at inshore sites, shrimp were not exclusive to them.

Group F contained only the red drum, *Sciaenops ocellata*, which was highly seasonal in its occurrence.

Separate analyses of plankton samples from the surf zone, which was impacted by nourishment, and from the offshore sites, which were impacted by dredging, reveals that neither of these activities were as important as natural seasonal variability in determining station similarity. Normal cluster analyses consistently grouped impacted and non-impacted sites together based on season. This was especially evident in the surf zone where samples from outfall and reference sites clustered together during every season (Figure 25). Though not as strongly evident at the borrow sites, dredged and non-dredged areas still clustered together seasonally. The one exception to this occurred in May when Joiner Bank, which was being actively dredged at the time, grouped separately from Gaskin Bank and the control site. This, however, was the month when Joiner Bank had a significantly greater abundance of larval fishes than either of the other sites.

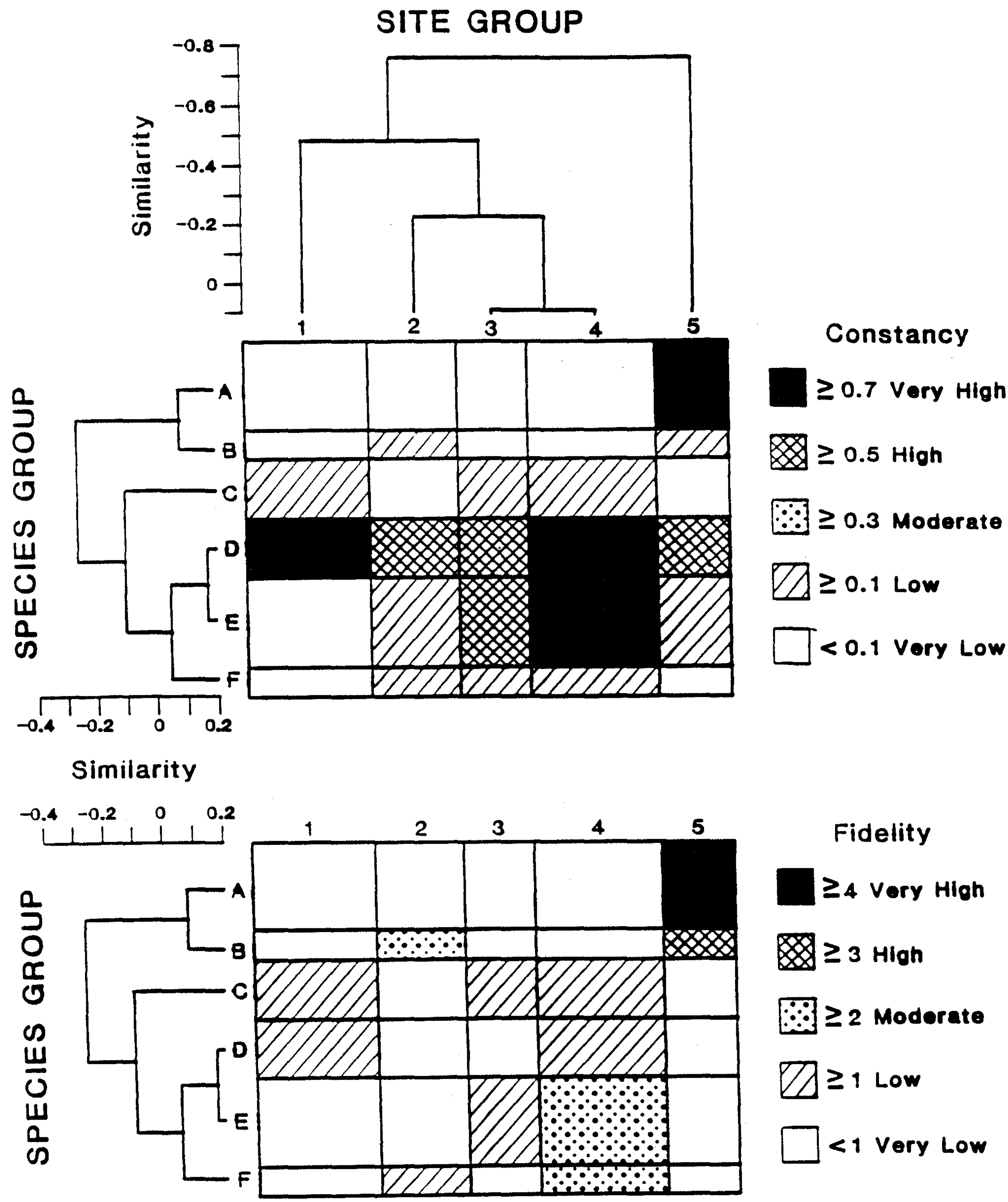


Figure 24. Constancy and fidelity tables generated from nodal analysis of all plankton data.

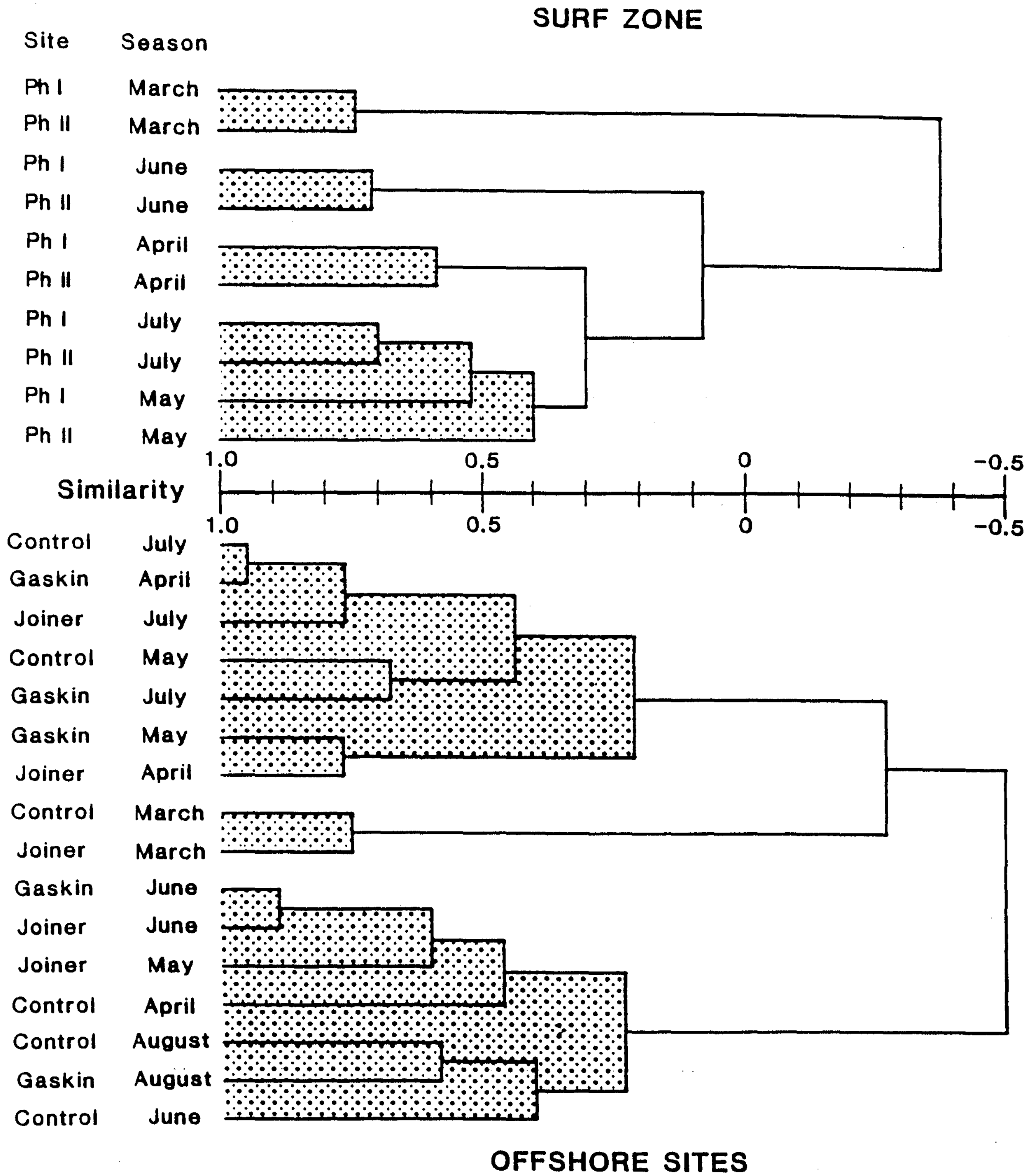


Figure 25. Normal cluster dendrograms of monthly plankton data from surf zone and offshore sites separately.

discuss in sentence w/ concluding remark on next page

The number of animals entrained in the dredge pipeline cannot be accurately measured and there are certain inconsistencies in estimating these numbers based on tows of a plankton sled. While the sled was towed across the bottom with current flowing through it, the dredge head was largely buried in the sediment. Although flow rates through the dredge may be much greater, a plankton sled may actually cover more bottom area while being towed. Nonetheless, based on the number of animals caught per standard volume of water strained, the maximum number of animals that may have been entrained by the dredge can be estimated. Using the conversion factor of one cubic meter = 264.2 gallons (LeMaraic and Ciaramella, 1973), and an estimated average of 15 million gallons of water pumped per day by the dredge (Richard T. Jackson, Great Lakes Dredge & Dock Company, pers. comm.), the following estimates can be made:

The maximum number of post-larval shrimp (total *Penaeus* spp.) caught during any one month at an offshore site was 33.3 per 1000 m^3 of water (June, 1990). This density would equate to a rate of 1883 shrimp postlarvae entrained per day. Since mean numbers for the other months were much lower, the average number of shrimp entrained per day over the entire period of dredge operation would be considerably lower. Given the fact that one female white shrimp produces 500,000 to 1 million eggs per spawn (Anderson *et al.*, 1949) entrainment of postlarvae at this rate should be of little concern. It should also be noted that natural mortality of post-larval penaeid shrimp has been estimated at greater than 60% (Gunter, 1956; Minello et al., 1989), indicating that the number of post-larvae entrained by the dredge would not represent an equal number of adult shrimp available for harvesting.

The most blue crab (total *Callinectes* spp.) caught at one time, 84.6 per 1000 m^3, occurred in March. This equates to 4783 crab megalopae entrained per day. Since mesalopae mortality rates are greater than 99% (Van Engel, 1987), the loss of megalopae to the dredging operation would be inconsequential. Furthermore, spawning of *Callinectes sapidus* has been estimated at 700,000 to more than 2 million eggs per female per spawn (Williams, 1984).

Maximum abundance for priority fishes occurred in May (232.2 per 1000 m^3). This would result in an estimated entrainment of 13,135 fish larvae per day. Fecundity rates for several of these fishes have been reported as 500,000 eggs per spawn for spot (Sheridan *et al.*, 1984), 1 to 1.7 million eggs per spawn for Atlantic croaker (Morse, 1980), and 500,000 to 2 million eggs per spawn for red drum (Arnold *et al.*, 1977; Roberts *et al.*, 1978). Since natural mortality rates for some of these species have been estimated at about 80% (Rutherford, 1982) the effects of entraining fish larvae by the dredge would be relatively insignificant.

In summary, dredging and nourishment appeared to have minimal effect on planktonic communities in the Hilton Head area. Natural seasonal fluctuations continued to be the controlling factor in community composition throughout the dredging period. Overall numbers of economically and recreationally important species were low, further reducing the possibility of negative impacts due to entrainment by the dredge.

Beach Seine Survey:

A total of 80 animals representing 14 species were collected by the seine (Table 19). The most abundant species was the burrowing shrimp, *Callichirus major*, which was found in all five samples. The sea pansy, *Renilla reniformis*, and the sand dollar, *Mellita quinquesperforata* were also found in every collection. Other frequently caught species, collected in 4 of the 5 samples, were the mole crab, *Lepidopa websteri*, and the sea catfish, *Ariopsis felis*, which was also the most common fish encountered by the finfish surveys (*see* Finfish Communities).

Although captured consistently, none of these species were collected in large numbers. No species of commercial or recreational importance were collected despite the fact that brown shrimp (*Penaeus aztecus*) are known to inhabit nearshore areas such as this during this month (D. Whitaker, MRRI, Pers. comm.). In general, the species entrained by the dredge were more sedentary, bottom dwelling organisms. Penaeid shrimps and most fishes and crabs appear to be able to avoid the dredge head. The noise and vibration created by the dredge probably gave sufficient warning to these more motile species.

Table 19. Total numbers of all species collected and frequency of capture (FRQ) for 5 seine hauls.

	#	%	FRQ
Callichirus major	23	28.75	5
Renilla reniformis	14	17.50	5
Mellita quinquesperforata	9	11.25	5
Ariopsis felis	9	11.25	4
Strigilla mirabilis	6	7.50	3
Lepidopa websteri	5	6.25	4
Sphaeroma quadridentatum	5	6.25	2
Panopeus herbstii	3	3.75	1
Anchoa mitchilli	1	1.25	1
Chloroscombrus chrysurus	1	1.25	1
Trachypenaeus constrictus	1	1.25	1
Stomolophus meleagris	1	1.25	1
Nemertinea	1	1.25	1
Corbula sp.	1	1.25	1
Total	80	100.00	

Finfish Communities:

Borrow Site Survey:

Forty-one species were captured by gill net and hook and line at the borrow sites, with nine of these found in large enough numbers, or considered recreationally important to fisherman, to warrant further investigation. These included sea catfish (*Ariopsis felis*), gafftopsail catfish (*Bagre marinus*), spotted seatrout (*Cynoscion nebulosus*), whiting (*Menticirrhus* spp.), bluefish (*Pomatomus saltatrix*), atlantic sharpnose shark (*Rhizoprionodon terraenovae*), red drum (*Sciaenops ocellata*), spanish mackerel (*Scomberomorus maculatus*), and bonnethead shark (*Sphyrna tiburo*). A complete listing of all species captured is provided in Appendix IV.1. Analyses of relative abundance were conducted by season and sampling area. The 10 in mesh gill net was found to sample fishes ineffectively; therefore the few specimens entrapped by this gear were excluded from analyses.

When the faunal assemblages from the two borrow sites were compared, a discernable difference was noted in both species composition and species diversity. Gaskin Bank yielded only about 25% of the specimens collected, and the species composition was markedly different from that at Joiner Bank. Most noticeable was the fact that sharks, bluefish, and spanish mackerel were found to be more abundant over this shoal, which was completely submerged, compared to the emergent Joiner Bank, which was partially exposed (Table 20). Schooling bait-fishes were also observed at Gaskin Bank as spanish mackerel and bluefish were being caught (but too small to be sampled by our gear), and may have accounted for the abundance of these more active piscivorous fishes at that time. The more frequent occurrence of the two sharks (Atlantic sharpnose and bonnethead) is less easily explained. The fact that Gaskin Bank is farther away from an inlet than Joiner Bank, and is always submerged may account for this difference, but the environmental factors that influence the distribution of these species is not well understood.

Joiner Bank is a more complex area having both submerged and emergent regions, a surf zone and a protected lagoon. This gradation of habitat, together with its proximity to Port Royal Inlet, were probably responsible for the greater abundance of all fishes found there (Table 20). The overall species diversity was also greater at Joiner Bank, where 37 species were taken (70 % of the total number). Only 16 species were captured at Gaskin Bank.

Table 20. Abundance of selected fishes taken off the front beach of Hilton Head Island during 1990, with percentages of specimens captured at each of the sand borrow sites.

Species	Gaskin Bank (%)	Joiner Bank (%)	Total No.
All Fish	23.9	76.1	1008
Sea Catfish	16.7	83.3	204
Gafftop Catfish	14.5	85.5	55
Spotted Seatrout	0.0	100	24
Whiting	3.0	97.0	33
Bluefish	61.9	38.1	97
Atlantic Sharpnose	77.3	22.7	44
Red Drum	0.0	100	29
Spanish Mackerel	76.9	23.1	65
Bonnethead	78.6	21.4	28

Table 21. Contribution of each selected species to the overall catch by gear type taken from the front beach of Hilton Head Island during 1990. All are listed as percentage of fishes in each category.

Species	All Fishes (%)	H&L (%)	Gill (%)
Sea Catfish	20.3	29.7	19.1
Gafftop Catfish	5.4	5.4	5.5
Spotted Seatrout	2.4	0.0	2.7
Whiting	3.3	8.1	2.9
Bluefish	9.6	18.0	8.6
Atlantic Sharpnose	4.4	12.6	3.4
Red Drum	2.9	23.4	0.3
Spanish Mackerel	6.5	0.0	7.3
Bonnethead	2.8	0.0	3.1
Menhaden	33.6	0.0	37.8
Other Fishes	8.8	2.8	9.3
Total Numbers	1008	111	897

Nine of the most abundant fishes seen regularly in our sampling efforts were considered to be of recreational interest. Their abundances are presented as percentages all fishes taken in Table 21. Menhaden (two species found) are also listed in Table 21 to show their abundance in relation to the total numbers of fishes captured. Because these fishes form large schools, great numbers were encountered only twice. Their prevalence, measured in frequency of encounter, was low.

Sea catfish were most numerous in both hook and line and gill net catches. These and gafftopsail catfish were captured in 13 of 22 samples. Gafftopsail catfish ranked fourth in overall numbers, sixth in hook and line samples, and fourth in gill net catches. Bluefish occurred in 10 collections, ranked second in overall abundance, second in the gill net sets, and third in hook and line samples. Atlantic sharpnose sharks were found in 8 of 22 collections, ranked fourth in abundance by hook and line, and sixth in abundance in the gill net catches. Spanish mackerel were the fourth most frequently encountered (7 of 22 collections), and were taken only in the gill nets. Whitings were the fifth most frequently encountered (6 of 22 collections), ranked fourth in number of fishes taken by hook and line, and fifth most abundant in gill net catches. Although no bonnethead sharks or spotted seatrout were caught by hook and line (probably because the surf fishing technique used in this study selected against the capture of these species), they were found to be sixth and seventh most abundant in the gill net catches. Red drum were found in 4 of 22 collections. They were the second most abundant species captured by hook and line sampling, but were found infrequently in gill net sets. The assemblage of fish species collected off Hilton Head Island is similar in composition to that found in preliminary gill net sets in front beach waters of a barrier island north of Charleston, SC in 1985 (C.A. Wenner, personal communication).

There is only one published account of surveys in South Carolina which used gill nets to capture fishes off the front beach (Van Dolah et al, 1987). That study utilized 3 m mesh sets to capture fish near the Murrells Inlet jetties. Their catch per unit effort (CPUE) for this gear was much higher than we found at the Hilton Head study, probably because the species composition and abundances were positively affected by the presence of the jetty rocks in their study. Table 22 lists CPUE data for our selected species in each sampled area and for each season using the 3 in mesh gill nets (Table 22). Sea catfish and gafftopsail

Table 22. Catch per unit effort (CPUE) expressed as fishes caught/hour using 3" gill nets set at the borrow sites in 1990.

Species	Sampling Locations			Season		
	Gaskin	Joiner	Both	May	August	October
Sea Catfish	2.5	6.6	5.1	6.4	5.2	1.2
Gafftop Catfish	0.5	1.7	1.2	1.7	1.1	0.2
Spotted Seatrout	0.0	1.1	0.7	1.0	0.0	1.0
Whiting	0.1	1.1	0.7	1.2	0.0	1.0
Bluefish	4.9	0.8	2.3	0.6	0.7	9.8
Atlantic Sharpnose	2.0	0.2	0.8	0.2	2.8	0.0
Red Drum	0.0	0.1	0.1	0.0	0.5	0.3
Spanish Mackerel	4.0	0.7	1.9	0.6	0.5	8.2
Bonnethead	1.8	0.3	0.8	0.5	1.9	0.0

catfish were found most abundantly in the spring. Bluefish and spanish mackerel were second and third in total CPUE, and as noted earlier, each were found more often over Gaskin than Joiner Bank. Red drum and spotted seatrout catch rates were relatively low, and each were captured at Joiner Bank only. No sharks were found during October, and no spotted seatrout or whiting were taken in August. The absence of sharks in the fall was also noted by Van Dolah et al. (1987).

Diet studies suggested that Joiner Bank was much richer in prey species, but only a few of the fishes captured from the borrow sites contained prey items in their stomachs. Therefore, specimens collected from both areas during all seasons were pooled for the diet analyses (Table 23). The diet of sea catfish was comprised primarily of non-commercial crabs and shrimps (42%), worms (38%), very few fishes (1.6%), and a variety of sessile or slow-moving bottom dwelling invertebrates (18.4%). Stomachs of gafftopsail catfish contained fishes (36%), with menhaden the most common of these. Non-commercial crabs and shrimp made up 33% of their diet, and the remainder of the stomach contents were sessile or slow-moving bottom dwelling invertebrates (31%). The diet of spotted seatrout was comprised entirely of fishes, dominated by the rough silverside, menhaden, and croaker. The diet of whiting consisted of worms (50%), non-commercial crabs and shrimp (41%), and fishes (9%). Bluefish ate mostly fishes (94%), with star drum and anchovies making up most of the diet. Red drum ate a variety of decapod crustaceans (78%), and most of these were penaeid shrimp. Fishes contributed only 22% of their diet. Spanish mackerel ate fish only. Most (79%) of these were anchovies, and most of their remaining diet was menhaden.

The diet contents observed in this study are similar to the results obtained from diet studies done elsewhere in South Carolina with respect to the major prey categories (Van Dolah et al. 1987). Four species studied by us were also examined by Van Dolah et al. (1987). They found that bluefish consumed an abundance of menhaden and very few invertebrates. Food items in whitings included non-commercial crabs and shrimp. Spotted seatrout ate mostly fishes (spots and anchovies). Red drum was the only species examined by both studies which ate large amounts of commercial shrimps.

Table 23. Food items consumed by the more common fishes taken from off the front beach of Hilton Head Island in 1990, expressed as percentage of total number of prey taxa.

Predator Species	Prey Item	% of Diet
Sea Catfish	Decapod Crustaceans	42.1
	Nemertines & Polychaetes	38.1
	Mollusks	11.1
	Fishes	1.6
	Other	7.1
Gafftopsail Catfish	Decapod Crustaceans	33.0
	Fishes	36.1
	Mollusks	9.9
	Mantis Shrimp	6.6
	Holothuroidea	6.6
	Others	7.8
Spotted Seatrout	Fishes	100.0
	Silversides	(35.3)
	Atlantic menhaden	(23.5)
	Croaker	(17.6)
	Anchovies	(11.8)
	Others	(11.8)
Whiting	Decapod Crustaceans	43.7
	Polychaetes	47.7
	Fishes	8.6
Bluefish	Fishes	93.8
	Star drum	(22.9)
	Anchovies	(20.8)
	Atlantic menhaden	(8.3)
	Atlantic bumper	(8.3)
	Silver perch	(6.2)
	other fishes	(33.5)
	Decapod Crustaceans	6.2
Red Drum	Decapod Crustaceans	78.0
	Commercial shrimp	(50.0)
	other decapods	(28.0)
	Fishes	22.0
Spanish Mackerel	Fishes	100.0
	Anchovies	(78.8)
	Atlantic menhaden	(10.5)
	other fishes	(10.7)

Fish length data are presented in Appendix IV.2 by season, and represent a combination of both areas sampled. The length data for successive seasons are not meant to represent growth trends, but are used to illustrate size of fishes encountered on the front beach using surf fishing techniques and gill nets as sampling gear.

Based on the data collected by both hook and line and gill nets during this study, it is apparent that of the larger, more abundant fishes found off of the front beach of Hilton Head, only the catfishes and whitings may be immediately impacted by sediment displacement. These were the only fishes whose diets were comprised largely of non-motile or slowly moving bottom inhabiting prey items. Because of the ubiquitous occurrence of the sea catfish and gafftopsail catfish, removal of small shoals probably would not radically alter their overall abundance. Other predatory fishes encountered had diets composed mostly of fishes or highly motile invertebrates and may not be affected by sand dredging operations.

Turbidity Concentrations:

Turbidity values were highly variable among stations throughout the study, but mean values were fairly consistent for most stations over time (variation of <40 NTU). Among the offshore sites, Joiner Bank had the highest seasonal means and the widest range of values (Appendix V.1). Turbidity levels there were exceptionally high during the first three seasons of sampling; however, this cannot be attributed entirely to the dredging that took place there since initial turbidity values for Joiner Bank were well above levels for other areas before dredging began (Figure 26). The high turbidities at Joiner Banks were most likely related to the proximity of the site to the entrance of Port Royal Sound heavy silt loads which flow out of the sound. After dredging, these finer sediments began accumulating in the dredged pit (*see* Physical Setting), contributing to the high turbidity levels found there. At Gaskin Bank and the offshore control area, turbidity levels remained relatively low and stable throughout the study. Dredging at Gaskin Bank appeared to have little effect on turbidity values there.

Nourishment was expected to have a greater effect on turbidity levels in the nearshore areas since sediment would flow directly into the surf zone through the dredge effluent. These effects, however, appeared to be very limited. Seasonal data from

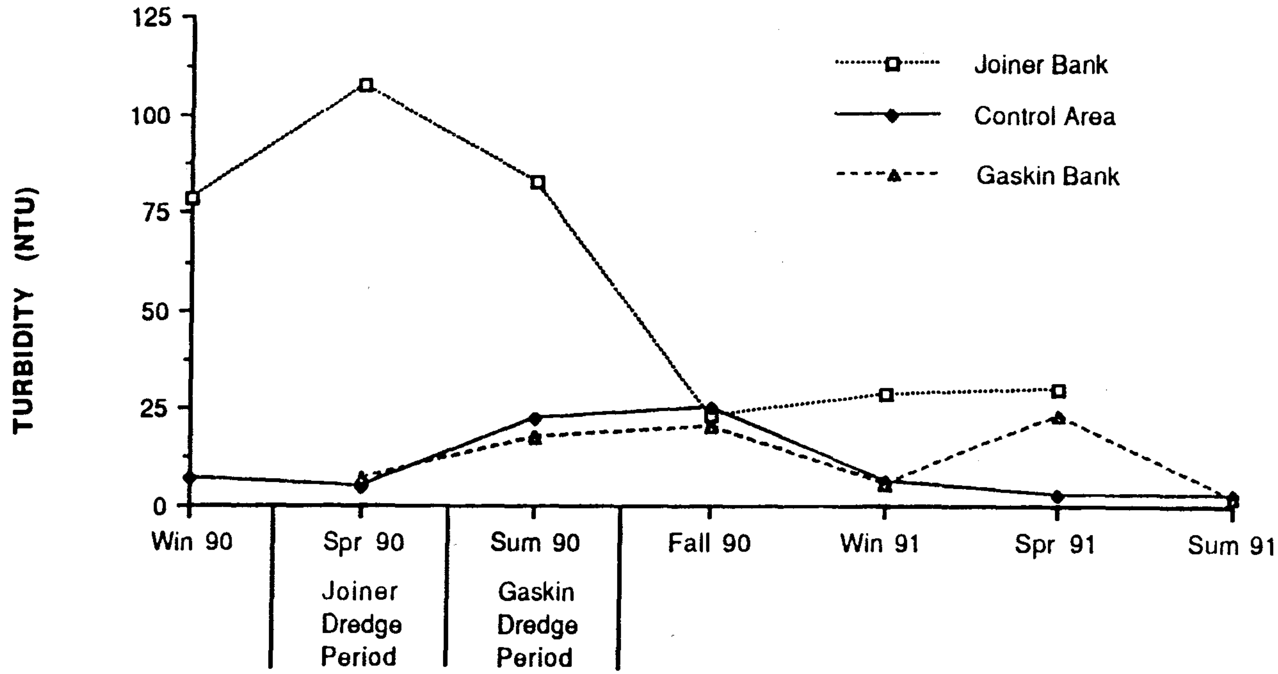


Figure 26. Mean turbidity values for offshore sites.

Phases I and II, as well as the control beach, showed only minor fluctuations in turbidity values, none of which corresponded to nourishment activities (Figure 27). The only elevated levels found inshore were those taken directly in or very near the sediment plume. While background levels around most of Hilton Head Island ranged from about 25 to 50 NTU, samples taken 50 feet from shore directly in the plume approached 200 NTU (Figure 28). These elevated levels continued 100 m south of the plume as longshore current carried silt in this direction. At 200 and 300 m south, turbidity values began decreasing and within 500 m turbidity had declined to mean levels found elsewhere. A slight increase found 1000 m south of the plume was apparently unrelated to the outfall. North of the outfall, turbidity values dropped to near background levels almost immediately, as longshore current carried sediment in the opposite direction. Measurements taken 200 feet from shore suggested that the sediment plume did not reach this distance. Directly out from the plume, turbidity values were less than 50 NTU (Figure 28). Increased values were observed at only one location to the north of the outfall.

Limited dispersal of suspended sediments from dredge effluent is not unusual. In specific investigations of turbidity generated by pipeline disposal, Schubel *et al.* (1978) found that 97-99% of discharged slurry settled to the bottom within a few tens of meters from the discharge point. Nichols *et al.* (1978) also concluded that distribution of turbidity was confined to the environs of the discharge point. They also stated that when discharge stopped, sediment plumes disappeared within 2 hours. Our findings confirm that when fill material consists of less than 10% silt and clay, turbidity effects from beach restoration are very short-lived.

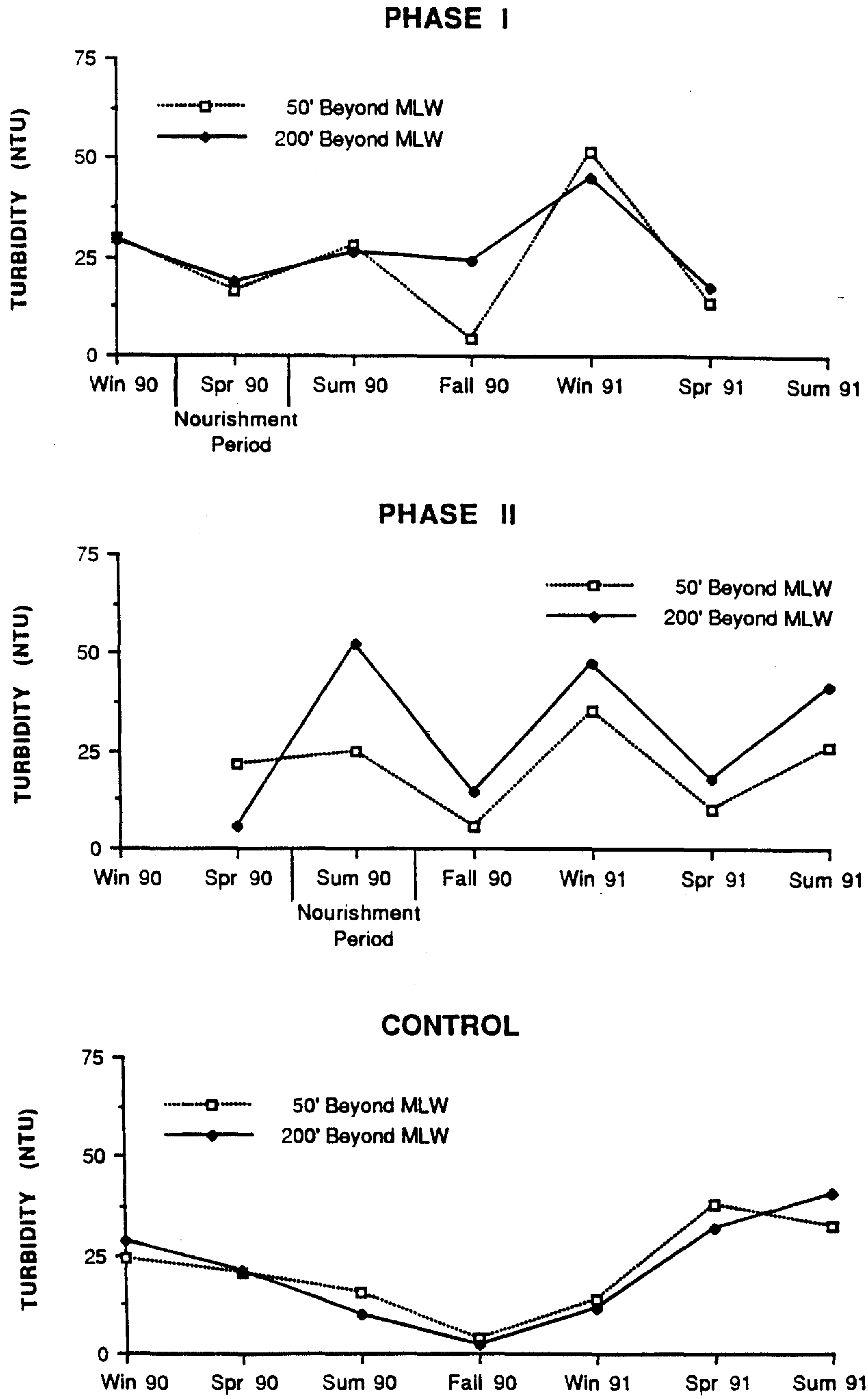


Figure 27. Mean turbidity values for nearshore sites.

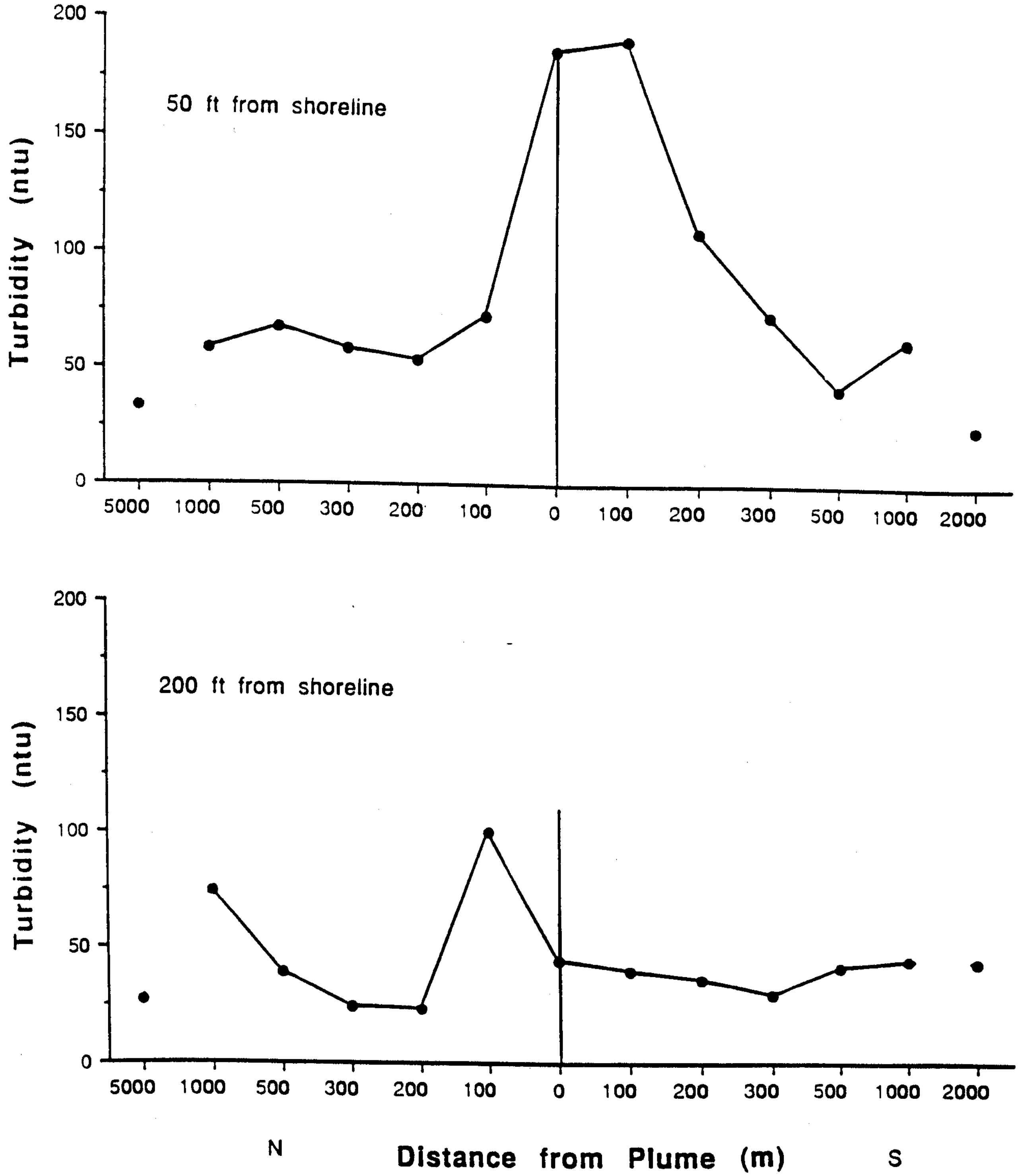


Figure 28. Turbidity values taken from the sediment plume and at fixed distances to the north and south.

SUMMARY AND CONCLUSIONS

This study provided considerable additional data regarding the physical and biological changes that resulted from the largest beach nourishment operation that has been completed in South Carolina. General conclusions derived from this study are summarized below.

1. Beach profiles following nourishment indicated that the fill material at the Phase I study site appeared to be fairly stable during the post-nourishment study period. Profile surveys at the Phase II study site showed evidence of greater erosion.

2. The fill material deposited on the beach was similar to the pre-existing surficial sediments at most of the intertidal levels sampled. Subtidal sediments were also similar before and after nourishment.

3. Macrofaunal communities in the lower intertidal zone and subtidal areas of the beach showed some evidence of degradation, but recovery appeared to be relatively rapid. There were no major changes in macrofaunal species composition at either the Phase I or Phase II study sites. The rapid recovery of benthic communities in these areas was probably due to the similarity of fill material to existing sediments, and the fact that the nourishment material was placed high on the beach, well above mean sea level. Therefore, burial of organisms in the lower intertidal zone as a result of sediment redistribution may have been gradual enough to allow most organisms to burrow up through the overburden.

4. Sediments within the Gaskin Bank borrow site were similar to those observed prior to nourishment. At the Joiner Bank borrow site, however, bottom sediments changed substantially after dredging, as silts and clays accumulated in the dredged pit. These sediments were probably exported from Port Royal Sound and deposited in the borrow area as a result of altered hydrography in the borrow area. Muddy sediments persisted at the borrow site throughout the 1-yr post-nourishment study period.

5. Benthic communities at both borrow sites were significantly altered by the dredging operation. Macrofaunal assemblages in the Gaskin Bank borrow site appeared to have recovered within the 1-yr post-nourishment sampling period. Benthic communities recolonizing the Joiner Bank borrow site were very different from those observed prior to nourishment, and species composition remained dissimilar throughout the post-nourishment survey period. Further sampling is recommended to determine when this area has recovered to pre-dredge conditions. Based on the physical and biological changes observed at Joiner Bank, this shoal should only be used as a borrow site if it can be dredged in a manner that would preclude the accumulation of muddy sediments.

6. Planktonic organisms collected throughout the study area included several species that are commercially or recreationally important. No significant differences in the abundance of any of these species were observed between reference sites and sites affected by the dredging/nourishment operation. The effects of season and site location (i.e., distance from shore, proximity to Port Royal Sound) appeared to be the major factors influencing faunal similarity among sites. Estimates of fish, crab, and shrimp present in the areas where the dredge was working were very low compared to the number of larvae typically produced by each species of concern. Relatively few larger organisms were entrained by the dredge, but not in high numbers and no economically important species were observed in the dredge effluent.

7. Recreationally important fish species were abundant at the shoals used as borrow sites, with more species and higher densities of fish observed at Joiner Bank. Diet analysis suggested that most of these species would not be directly affected by the loss of benthic fauna in the borrow areas.

8. Dredging and nourishment appeared to have little effect on average turbidity levels observed at the borrow sites or in the surf zone adjacent to newly nourished beach, except in the immediate vicinity of the pipeline effluent where turbidities were very high. The high turbidity plume did not extend very far from the outfall, however.

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APPENDICES

Appendix I.1. Data results of granulometric analyses of sediment samples.

STATION	Sampling Date	Sand %	Silt %	Clay %	CaCO3 %	Organic Matter	Sand Grain Size ø: X̄	Size Class	SD	Sorting Descr.	Skewness	Mode
JB01	03/14/90	94.117	0.26	2.597	3.026	0.146	2.43	FS	0.637	MW	-1.205	3
JB01	05/18/90	59.048	33.269	6.256	1.427	5.812	2.952	FS	0.337	VW	0.206	3
JB01	08/08/90	92.092	0.641	1.796	5.471	4.799	2.507	FS	0.6	MW	-1.16	3
JB01	11/07/90	96.013	0.933	1.199	1.855	12.771	2.753	FS	0.34	VW	-0.415	3
JB01	03/05/91	93.275	0.416	4.02	2.29	0.906	2.71	FS	0.523	MW	-1.137	3
JB01	05/07/91	86.987	1.45	9.278	2.286	2.065	2.856	FS	0.346	VW	-1.278	3
JB02	03/14/90	93.539	1.957	2.236	2.268	0.231	ND	MS	0.707	M	0.49	1
JB02	05/18/90	80.902	7.789	7.511	3.797	4.003	2.945	FS	0.389	W	-0.2	3
JB02	08/08/90	84.955	2.333	5.599	7.113	1.251	3.083	VFS	0.479	W	-0.634	3.5
JB02	11/07/90	52.339	37.423	4.881	5.357	ND	2.885	FS	0.774	M	-1.122	3
JB02	03/05/91	53.494	36.772	7.649	2.086	6.483	3.055	VFS	0.384	W	-0.111	3
JB02	05/07/91	56.264	29.23	10.406	4.1	6.906	3.195	VFS	0.38	W	-8.626	3.5
JB03	03/14/90	97.454	0	1.6	0.946	0.033	2.598	FS	0.49	W	-0.65	3
JB03	05/18/90	52.320	25.571	9.699	12.411	12.414	2.188	FS	0.991	M	-5.4	3
JB03	08/08/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
JB03	11/07/90	56.685	31.044	6.036	6.235	8.333	2.823	FS	0.684	MW	-0.638	3
JB03	03/05/91	56.398	29.443	10.733	3.426	5.534	3.122	VFS	0.426	W	-9.842	3
JB03	05/07/91	56.184	30.435	10.345	3.036	5.47	3.11	VFS	0.4	W	-7.939	3
BC01	03/15/90	95.262	0.851	0.851	3.037	ND	2.693	FS	0.516	MW	-0.485	3
BC01	05/18/90	95.071	1.687	0.843	2.399	0.785	2.609	FS	0.557	MW	-0.658	3
BC01	08/08/90	96.099	0.659	1.846	1.396	0.719	2.702	FS	0.344	VW	-0.567	3
BC01	11/07/90	92.989	0.836	1.393	4.782	0.531	2.819	FS	0.43	W	-0.699	3
BC01	03/05/91	95.033	0	3.365	1.602	0.464	2.831	FS	0.361	W	-0.721	3
BC01	05/07/91	93.330	0	4.825	1.825	0.75	2.632	FS	0.398	W	-0.745	3
BC01	08/06/91	95.389	0.333	2.664	1.615	0.61	2.747	FS	0.372	W	-8.567	3

Appendix I.1. Continued

BC02	03/15/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BC02	05/18/90	96.474	0.556	1.668	1.301	0.365	2.662	FS	0.36	W	-0.493	3
BC02	08/08/90	96.620	0.535	2.139	0.706	0.457	2.539	FS	0.407	W	-0.291	3
BC02	11/07/90	95.463	0.539	2.155	1.843	1.552	2.711	FS	0.373	W	-0.693	3
BC02	03/05/91	95.166	0	3.313	1.521	1.133	2.773	FS	0.289	VW	-0.812	3
BC02	05/07/91	95.028	0	3.553	1.42	1.29	2.508	FS	0.364	W	-0.41	3
BC02	08/06/91	96.534	1.063	0.456	1.947	0.544	2.71	FS	0.398	W	-0.629	3
BC03	03/15/90	94.679	0.565	1.695	3.061	0.585	2.862	FS	0.377	W	0.523	3
BC03	05/18/90	94.557	2.411	2.411	0.62	0.903	2.621	FS	0.495	MW	-0.597	3
BC03	08/08/90	90.726	0.543	2.17	6.561	0.349	3.295	VFS	0.175	VW	0.518	3.5
BC03	11/07/90	96.259	0.53	1.856	1.355	0.767	2.784	FS	0.377	W	-0.839	3
BC03	03/05/91	94.983	0	3.328	1.689	0.738	2.631	FS	0.46	W	-0.746	3
BC03	05/07/91	95.285	1.233	2.055	1.428	0.993	2.486	FS	0.449	W	-0.714	3
BC03	08/06/91	96.426	0.875	0.583	2.116	0.669	2.541	FS	0.475	W	-0.508	3
GB01	05/18/90	96.505	0.539	1.617	1.338	0.455	2.176	FS	0.393	W	0.193	2.5
GB01	08/08/90	91.617	0.252	3.27	4.862	0.062	2.763	FS	0.277	VW	-0.471	3
GB01	11/07/90	86.683	2.604	6.168	4.545	1.894	1.675	MS	0.486	W	0.629	1.5
GB01	03/05/91	93.622	0.273	3.546	2.559	0.874	2.853	FS	0.406	W	5.939	3
GB01	05/07/91	91.405	0.563	4.925	3.107	2.112	2.832	FS	0.464	W	-0.832	3
GB01	08/06/91	92.008	0	4.073	3.918	1.545	2.883	FS	0.36	W	8.755	3
GB02	05/18/90	90.838	1.224	3.128	4.81	2.191	2.996	VFS	0.329	VW	0.307	3
GB02	08/08/90	94.272	1.318	2.108	2.302	0.832	2.742	FS	0.397	W	9.921	3
GB02	11/07/90	96.095	0.135	2.893	2.013	0.344	2.725	FS	0.406	W	0.347	3
GB02	03/05/91	94.115	0.555	3.045	2.276	0.235	2.759	FS	0.388	W	-0.382	3
GB02	05/07/91	94.861	0	3.356	1.783	0.544	2.507	FS	0.461	W	-0.796	3
GB02	08/06/91	82.304	2.247	10.595	4.854	3.114	2.995	VFS	0.446	W	-3.348	3
GB03	05/18/90	96.003	0.725	4.203	2.07	0.766	2.829	FS	0.305	VW	0.215	3

Appendix I.1. Continued

GB03	08/08/90	92.623	1.728	3.744	1.905	2.034	2.97	VFS	0.375	W	0.142	3
GB03	11/07/90	94.595	0.526	2.893	1.987	0.679	2.702	FS	0.385	W	-4.325	3
GB03	03/05/91	93.295	0	3.881	2.823	0.668	2.787	FS	0.432	W	-0.308	3
GB03	05/07/91	93.191	0	4.111	2.697	0.958	2.73	FS	0.403	W	0.111	3
GB03	08/06/91	91.119	1.41	4.074	3.397	1.586	2.788	FS	0.475	W	-0.106	3
HA11	02/21/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA11	05/07/90	91.066	4.742	3.497	0.698	0.4	2.621	FS	0.353	W	-0.528	3
HA11	08/07/90	91.249	0.55	2.477	5.724	0.657	2.712	FS	0.357	W	-0.424	3
HA11	11/13/90	95.317	0.136	2.047	2.5	0.653	2.543	FS	0.557	MW	-0.776	3
HA11	02/26/91	95.234	0	3.207	1.559	0.587	2.643	FS	0.482	W	-0.679	3
HA11	05/08/91	94.058	0.674	2.158	3.109	1.437	2.549	FS	0.656	MW	-1.201	3
HB11	02/21/90	90.306	0	1.391	8.302	0.403	2.708	FS	0.559	MW	-1.279	3
HB11	05/07/90	96.544	0.271	1.9	1.285	0.53	2.658	FS	0.451	W	-0.891	3
HB11	08/07/90	90.904	0.547	2.46	6.089	0.647	2.672	FS	0.485	MW	-0.99	3
HB11	11/13/90	90.692	0.9	1.8	6.608	0.722	2.084	FS	0.42	W	6.461	2.5
HB11	02/26/91	92.808	0.138	2.907	4.146	0.388	2.576	FS	0.64	MW	-1.175	3
HB11	05/08/91	86.892	2.514	3.44	7.143	0.768	2.317	FS	0.843	M	-0.862	3
HC11	02/21/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HC11	05/07/90	89.440	0.574	2.868	7.119	0.984	3.13	VFS	0.585	MW	-0.239	3
HC11	08/07/90	94.175	0.907	2.462	2.457	0.329	2.61	FS	0.471	W	-1.435	3
HC11	11/13/90	94.671	1.897	1.084	2.348	0.875	2.881	FS	0.441	W	-4.272	3
HC11	02/26/91	94.161	1.523	2.631	1.684	0.329	2.63	FS	0.531	MW	-1.088	3
HC11	05/08/91	95.788	0.868	1.302	2.042	2.395	2.57	FS	0.342	VW	-0.696	3
HD11	02/21/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HD11	05/07/90	87.116	2.454	6.543	3.887	2.126	2.99	VFS	0.558	MW	-0.48	3.5
HD11	08/07/90	85.366	3.678	4.991	5.965	2.092	3.06	VFS	0.522	MW	-0.818	3.5
HD11	11/13/90	76.320	3.733	14.665	5.282	2.643	3.049	VFS	0.507	MW	-0.528	3.5
HD11	02/26/91	87.712	0.932	6.214	5.142	2.143	3.096	VFS	0.552	MW	-0.653	3.5

Appendix I.1. Continued

HD11	05/08/91	86.515	2.374	6.676	4.436	1.311	3.062	VFS	0.485	W	-0.981	3.5
HA12	02/21/91	95.294	0.407	0.136	4.163	0.196	1.893	MS	0.882	M	-0.126	3
HA12	05/07/90	94.835	0.269	2.417	2.48	1.496	2.433	FS	0.696	MW	-0.898	3
HA12	08/07/90	96.831	0.544	1.087	1.539	0.467	2.573	FS	0.507	MW	-0.941	3
HA12	11/13/90	92.157	2.874	2.09	2.879	0.409	2.464	FS	0.603	MW	-0.654	3
HA12	02/26/91	96.761	0	1.558	1.681	0.228	2.587	FS	0.542	MW	-0.597	3
HA12	05/08/91	94.368	0	2.895	2.737	0.625	2.613	FS	0.551	MW	-1.05	3
HB12	02/21/90	89.173	0.571	2.282	7.974	0.431	2.4	FS	1.057	P	-0.619	3
HB12	05/07/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HB12	08/07/90	89.939	0.408	2.584	7.07	0.93	2.701	FS	0.514	MW	-0.77	3
HB12	11/13/90	97.007	0.839	1.399	0.755	0.617	2.529	FS	0.443	W	-0.414	3
HB12	02/26/91	94.896	0	3.399	1.705	0.484	2.582	FS	0.448	W	-0.705	3
HB12	05/08/91	90.863	0	2.705	6.432	1.23	2.259	FS	0.873	M	-0.567	3
HC12	02/21/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HC12	05/07/90	92.120	0.55	2.201	5.129	0.808	2.508	FS	0.606	MW	-1.063	3
HC12	08/07/90	94.878	0.528	2.377	2.217	0.804	2.619	FS	0.587	MW	-0.798	3
HC12	11/13/90	97.316	0.84	1.4	0.444	1.712	2.795	FS	0.288	VW	-0.226	3
HC12	02/26/91	91.853	0	3.102	5.045	1.109	2.433	FS	0.809	M	-0.885	3
HC12	05/08/91	95.114	0	3.105	1.781	1.565	2.636	FS	0.362	W	-0.168	3
HD12	02/21/90	81.094	10.915	2.469	5.522	3.519	3.309	VFS	0.391	W	-0.676	3.5
HD12	05/07/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HD12	08/07/90	87.046	4.387	4.661	3.907	1.583	2.845	FS	0.546	MW	-0.12	3
HD12	11/13/90	95.846	0.564	1.128	2.463	1.801	2.726	FS	0.42	W	-0.341	3
HD12	02/26/91	89.005	2.111	5.428	3.456	1.677	3.021	VFS	0.52	MW	-0.354	3.5
HD12	05/08/91	87.443	2.55	5.667	4.34	1.096	3.156	VFS	0.457	W	-0.453	3.5
HA21	05/08/90	94.674	0.817	1.643	2.875	1.46	2.655	FS	0.611	MW	-1.117	3
HA21	06/20/90	91.839	1.343	2.954	3.864	0.568	2.833	FS	0.427	W	-0.556	3

Appendix I.1. Continued

HA21	08/06/90	95.627	0.267	1.87	2.235	0.267	2.836	FS	0.396	W	-0.352	3
HA21	11/15/90	95.880	0.268	2.142	1.711	0.736	2.601	FS	0.405	W	-0.06	3
HA21	02/27/91	95.457	0	2.003	2.54	0.487	2.772	FS	0.471	W	-0.144	3
HA21	05/09/91	93.490	0	2.528	3.982	0.398	2.772	FS	0.381	W	-1.264	3
HA21	08/08/91	95.763	0	0.733	3.504	0.034	2.613	FS	0.539	MW	-0.889	3
HB21	05/08/90	95.363	0.271	2.44	1.926	1.232	2.571	FS	0.621	MW	-0.683	3
HB21	06/20/90	94.710	0.548	1.917	2.826	0.613	2.83	FS	0.409	W	-0.365	3
HB21	08/06/90	93.949	1.873	1.07	3.108	0.754	2.592	FS	0.58	MW	-0.639	3
HB21	11/15/90	96.399	1.329	0.886	1.385	0.7	2.513	FS	0.493	W	-1.345	3
HB21	02/27/91	95.721	0	2.718	1.561	0.227	2.707	FS	0.364	W	-1.465	3
HB21	05/09/91	94.702	1.663	1.385	2.25	0.931	2.514	FS	0.445	W	-0.666	3
HB21	08/08/91	97.401	0	0.729	1.87	0.36	2.491	FS	0.42	W	-0.421	3
HC21	05/08/90	96.894	0.271	1.897	0.938	0.365	2.501	FS	0.634	MW	-0.563	3
HC21	06/20/90	96.428	1.377	0.555	1.645	0.135	2.801	FS	0.418	W	-0.375	3
HC21	08/06/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HC21	11/15/90	95.621	0.545	1.772	2.062	0.53	2.802	FS	0.27	VW	0.318	3
HC21	02/27/91	95.047	0	2.81	2.143	0.398	2.819	FS	0.396	W	-0.549	3
HC21	05/09/91	94.906	0	2.561	2.534	0.598	2.644	FS	0.432	W	-1.079	3
HC21	08/08/91	96.483	0.307	0.922	2.286	0.378	2.647	FS	0.573	MW	-1.079	3
HD21	05/08/90	87.367	5.95	2.587	4.095	1.895	2.758	FS	0.439	W	-0.826	3
HD21	06/20/90	91.181	1.895	2.977	3.947	0.926	2.948	FS	0.408	W	-8.656	3
HD21	08/06/90	86.350	3.216	5.628	4.806	1.244	2.867	FS	0.481	W	-0.13	3
HD21	11/15/90	89.927	2.925	3.901	3.247	1.724	2.871	FS	0.365	W	4.761	3
HD21	02/27/91	88.182	0	8.113	3.704	2.054	2.682	FS	0.656	MW	-1.028	3
HD21	05/09/91	88.771	1.781	5.641	3.807	1.812	2.855	FS	0.397	W	-0.116	3
HD21	08/08/91	87.405	0.487	6.012	6.095	1.28	3.055	VFS	0.437	W	-7.352	3
HA22	05/08/90	93.060	1.114	1.671	4.154	0.551	3.047	VFS	0.72	M	-1.168	3.5
HA22	06/20/90	96.438	0.405	1.485	1.672	0.64	2.674	FS	0.366	W	-0.309	3

Appendix I.1. Continued

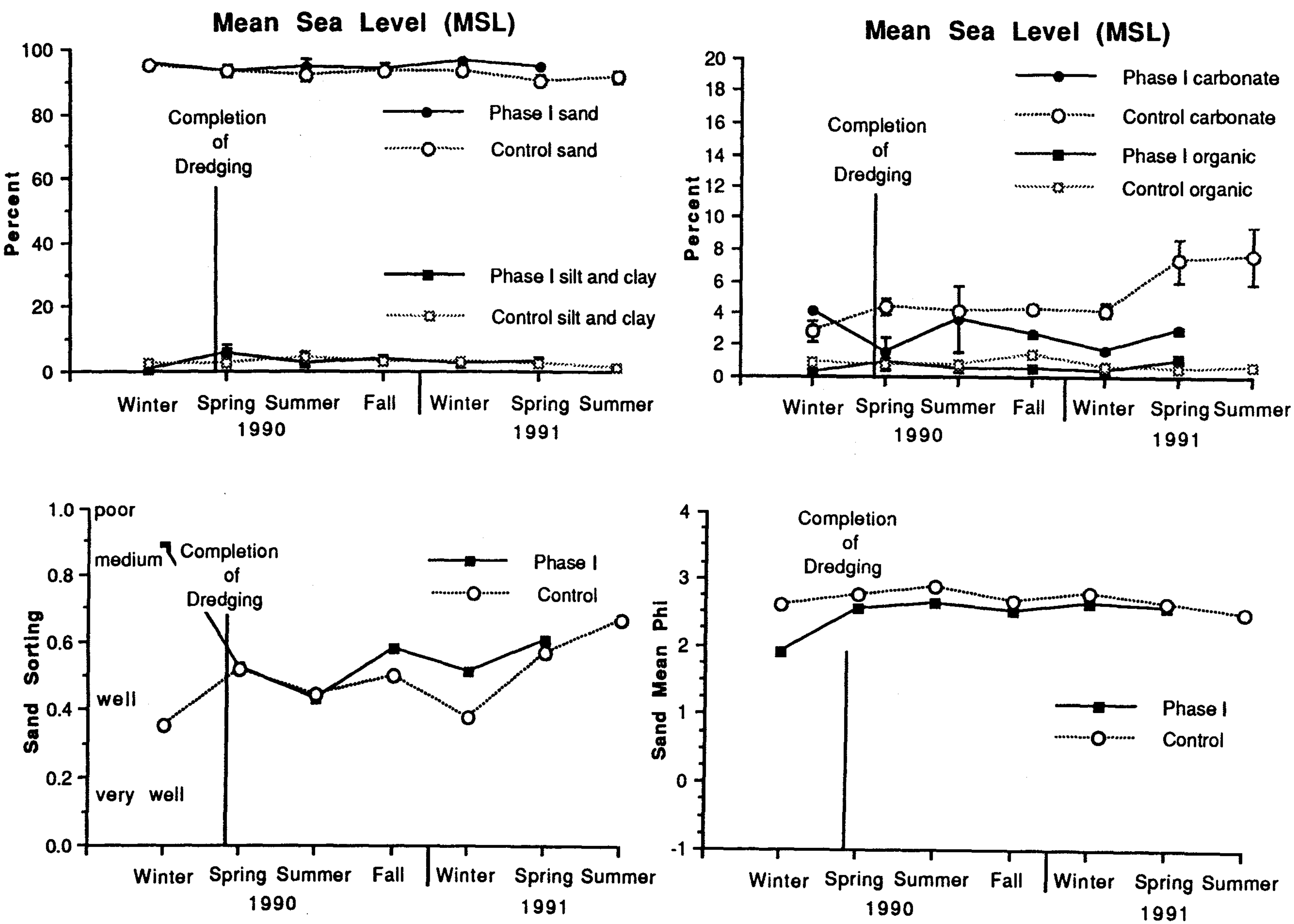
HA22	08/06/90	96.180	1.319	1.847	0.653	0.887	2.684	FS	0.407	W	-3.331	3
HA22	11/15/90	90.525	0.253	1.011	8.211	0.822	2.662	FS	0.407	W	5.426	3
HA22	02/27/91	94.892	0	3.541	1.566	0.681	2.737	FS	0.282	VW	-0.473	3
HA22	05/09/91	95.279	0	3.213	1.508	1.525	2.649	FS	0.375	W	-8.255	3
HA22	08/08/91	97.438	0	0.869	1.694	0.613	2.605	FS	0.427	W	-0.306	3
HB22	05/08/90	94.439	1.359	1.903	2.299	0.743	2.389	FS	0.676	MW	-0.545	3
HB22	06/20/90	97.479	0.829	1.105	0.587	11.995	2.704	FS	0.413	W	-0.168	3
HB22	08/06/90	78.599	11.223	3.832	6.346	1.179	3.073	VFS	0.54	MW	-0.389	3
HB22	11/15/90	96.919	0.531	1.061	1.789	0.263	2.454	FS	0.439	W	-0.34	3
HB22	02/27/91	95.492	0	2.779	1.73	0.132	2.347	FS	0.586	MW	-1.043	3
HB22	05/09/91	94.813	0.731	2.339	2.117	0.827	2.562	FS	0.483	W	-0.37	3
HB22	08/08/91	97.992	0	0	2.008	0.833	2.543	FS	0.431	W	-0.61	3
HC22	05/08/90	94.371	0.55	1.925	3.155	0.592	2.588	FS	0.502	MW	-0.209	3
HC22	06/20/90	94.822	0.266	2.655	2.257	0.339	2.688	FS	0.374	W	-0.336	3
HC22	08/06/90	94.399	0.949	1.492	3.16	0.579	2.825	FS	0.517	MW	-0.435	3
HC22	11/15/90	97.332	0.402	0.803	1.463	0.331	2.614	FS	0.36	W	-6.998	3
HC22	02/27/91	94.340	0	3.899	1.761	0.456	2.741	FS	0.387	W	-0.212	3
HC22	05/09/91	94.523	0	4.036	1.441	0.198	2.525	FS	0.351	W	-0.345	3
HC22	08/08/91	97.205	0	0.593	2.205	0.132	2.485	FS	0.557	MW	-0.662	3
HD22	05/08/90	87.653	2.978	4.331	5.039	1.146	3.036	VFS	0.545	MW	-0.422	3
HD22	06/20/90	86.933	5.97	1.899	5.198	1.484	2.973	VFS	0.46	W	-0.343	3
HD22	08/06/90	84.909	4.229	6.485	4.377	5.626	3.146	VFS	0.401	W	-0.203	3.5
HD22	11/15/90	86.129	3.995	4.852	5.024	2.241	3.036	VFS	0.539	MW	1.288	3
HD22	02/27/91	73.824	4.801	16.557	4.818	4.722	3.035	VFS	0.497	MW	-0.187	3
HD22	05/09/91	89.590	0.417	5.747	4.247	1.341	2.941	FS	0.485	W	-9.545	3
HD22	08/08/91	91.873	1.143	2.287	4.697	1.397	2.958	VFS	0.467	W	-4.284	3
FA31	03/07/90	95.161	0.269	2.419	2.151	1	2.591	FS	0.468	W	-0.713	3
FA31	05/09/90	92.426	0.678	2.034	4.863	0.759	2.658	FS	0.566	MW	-0.733	3

Appendix I.1. Continued

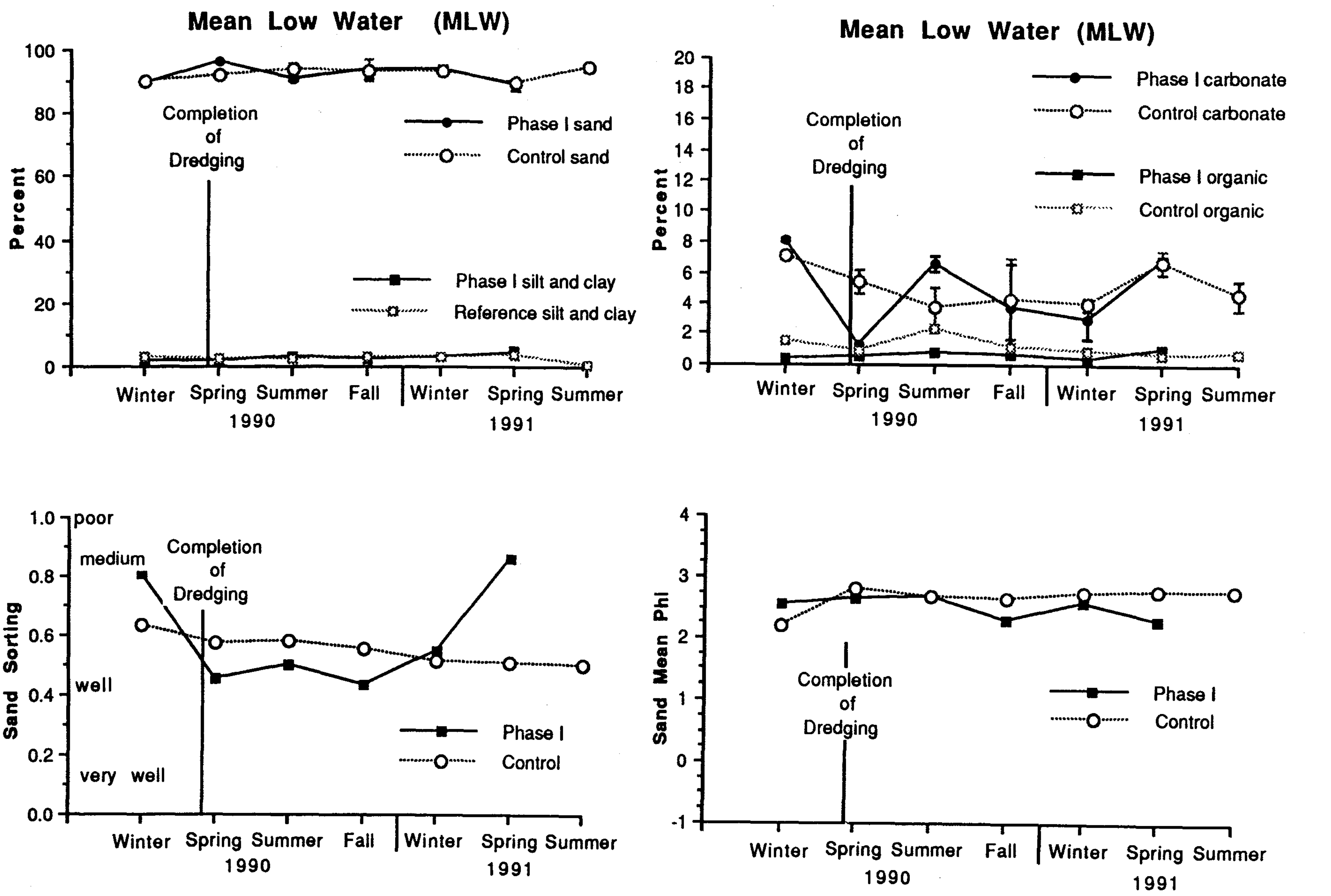
FA31	08/02/90	93.296	0.271	2.438	3.995	0.433	2.555	FS	0.538	MW	-0.516	3
FA31	11/14/90	93.414	0.828	1.38	4.378	1.709	2.522	FS	0.588	MW	-0.58	3
FA31	02/25/91	91.486	0	3.881	4.663	0.755	2.791	FS	0.343	VW	-0.992	3
FA31	05/10/91	88.514	0.283	2.549	8.653	0.532	2.721	FS	0.6	MW	-1.206	3
FA31	08/07/91	93.134	0.674	0.337	5.855	0.719	2.497	FS	0.619	MW	-0.556	3
FB31	03/07/90	89.873	1.335	1.626	7.147	1.542	2.18	FS	0.631	MW	-0.573	2.5
FB31	05/09/90	92.372	2.428	0.539	4.661	0.833	2.696	FS	0.527	MW	-0.897	3
FB31	08/02/90	92.503	0.821	1.641	5.035	4.56	2.648	FS	0.636	MW	-0.549	3
FB31	11/14/90	90.207	1.136	1.704	6.953	1.221	2.513	FS	0.698	MW	-0.501	3
FB31	02/25/91	92.321	0	3.26	4.419	0.768	2.547	FS	0.656	MW	-0.612	3
FB31	05/10/91	89.573	0	2.974	7.453	0.645	2.694	FS	0.61	MW	-1.026	3
FB31	08/07/91	93.548	0	0.905	5.547	0.783	2.859	FS	0.48	W	-1.106	3
FC31	03/07/90	94.310	0.555	0.833	4.301	0.301	2.775	FS	0.502	MW	-0.719	3
FC31	05/09/90	91.964	0.272	1.634	6.129	1.09	2.436	FS	0.823	M	-0.643	3
FC31	08/02/90	92.300	0.276	1.656	5.769	0.814	2.874	FS	0.525	MW	-1.049	3.5
FC31	11/14/90	93.833	0.138	2.07	3.958	3.083	2.84	FS	0.472	W	-0.765	3
FC31	02/25/91	94.185	0	2.104	3.711	0.682	2.792	FS	0.49	W	-0.79	3
FC31	05/10/91	91.202	0	2.184	6.615	0.737	2.765	FS	0.554	MW	-0.773	3
FC31	08/07/91	95.587	0	0.873	3.54	0	2.654	FS	0.441	W	-0.682	3
FD31	03/07/90	92.883	1.383	1.245	4.49	0.506	2.9	FS	0.347	W	-0.214	3
FD31	05/09/90	90.373	0.818	1.363	7.446	1.132	2.882	FS	0.41	W	-0.902	3
FD31	08/02/90	89.108	1.849	4.226	4.817	0.84	3.239	VFS	0.36	W	-0.428	3.5
FD31	11/14/90	90.581	0.555	1.664	7.201	1.124	2.489	FS	0.641	MW	-0.688	3
FD31	02/25/91	91.971	0	3.597	4.432	0.623	2.84	FS	0.361	W	-0.924	3
FD31	05/10/91	91.042	0	3.023	5.935	0.536	2.638	FS	0.53	MW	-0.9	3
FD31	08/07/91	92.632	0	2.505	4.863	0.539	2.875	FS	0.372	W	-1.179	3
FA32	03/07/90	94.656	0.417	1.39	3.537	0.686	ND	FS	0.24	VW	-0.541	3
FA32	05/09/90	93.207	1.073	1.878	3.842	0.9	2.831	FS	0.467	W	-0.982	3

Appendix I.1. Continued

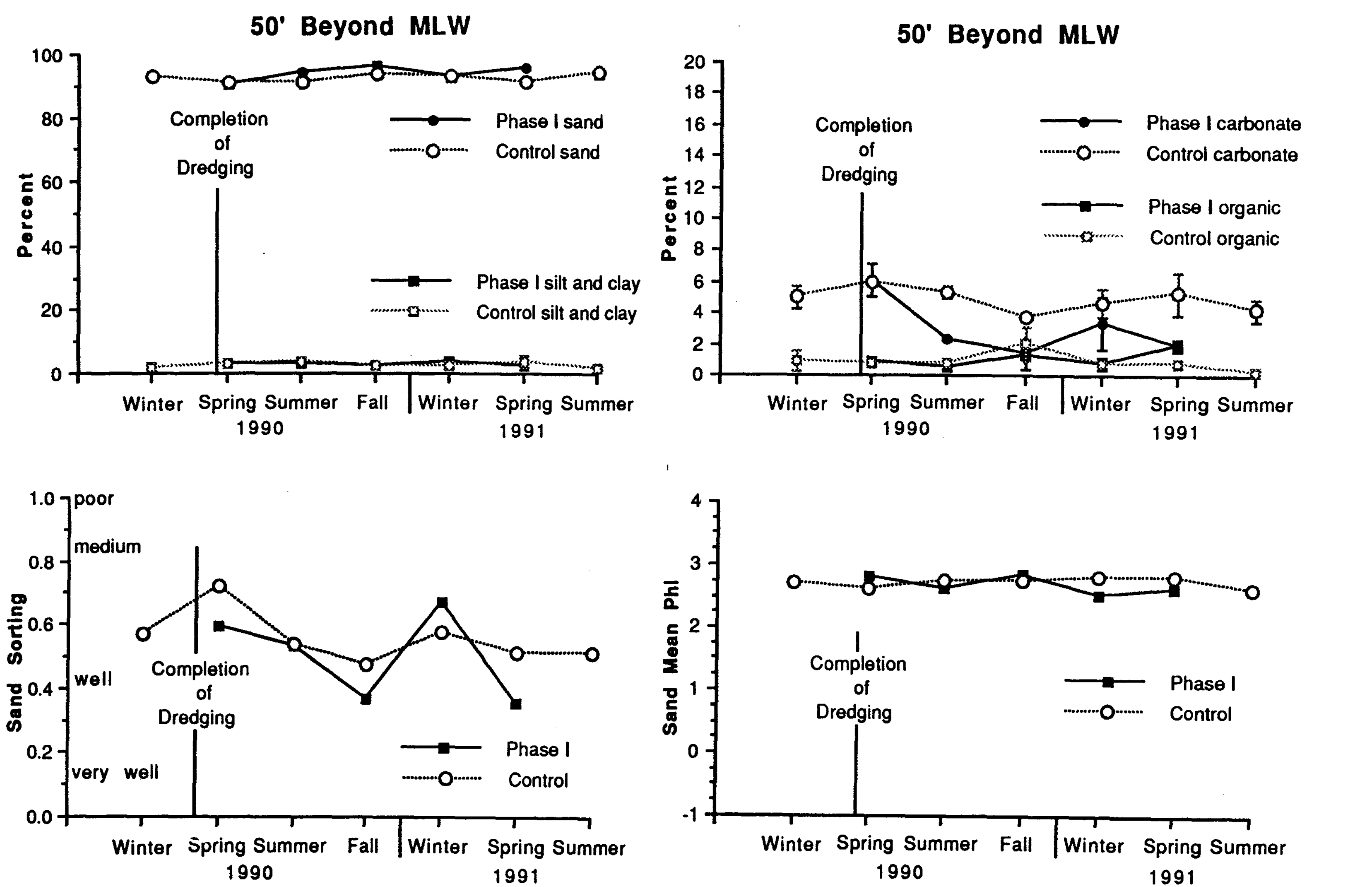
FA32	08/02/90	89.752	0.528	5.544	4.176	1.034	3.184	VFS	0.353	W	-0.244	3.5
FA32	11/14/90	92.203	1.064	2.659	4.074	1.187	2.793	FS	0.409	W	-0.901	3
FA32	02/25/91	94.045	0	2.267	3.688	0.431	2.772	FS	0.414	W	-0.866	3
FA32	05/10/91	91.718	0	2.324	5.959	0.464	2.542	FS	0.54	MW	-0.75	3
FA32	08/07/91	88.992	0.634	0.951	9.423	0.699	2.456	FS	0.709	M	-0.706	3
FB32	03/07/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FB32	05/09/90	91.545	0.832	1.387	6.235	0.923	2.578	FS	0.623	MW	-0.797	3
FB32	08/02/90	95.659	0.843	1.125	2.373	0	2.704	FS	0.519	MW	-0.454	3
FB32	11/14/90	96.604	0.556	2.223	1.617	1.156	2.786	FS	0.414	W	-0.644	3
FB32	02/25/91	93.447	0	3.027	3.525	1.038	2.924	FS	0.367	W	-0.435	3
FB32	05/10/91	89.534	1.944	2.592	5.93	0.695	2.857	FS	0.44	W	-0.66	3
FB32	08/07/91	95.774	0	0.602	3.623	0.753	2.662	FS	0.514	MW	-0.531	3
FC32	03/07/90	92.173	0.959	1.096	5.773	1.602	2.676	FS	0.635	MW	-0.794	3
FC32	05/09/90	90.141	0.8	3.2	5.859	0.568	2.774	FS	0.62	MW	-0.805	3
FC32	08/02/90	89.752	1.25	4.029	4.969	0.778	2.613	FS	0.551	W	-0.714	3
FC32	11/14/90	94.039	1.885	0.538	3.538	0.948	2.666	FS	0.476	W	-0.893	3
FC32	02/25/91	91.429	0.272	2.724	5.574	0.86	2.812	FS	0.666	MW	-0.688	3
FC32	05/10/91	90.540	2.257	3.298	3.906	0.94	2.882	FS	0.47	W	-0.592	3
FC32	08/07/91	92.718	0	2.317	4.965	0.446	2.604	FS	0.58	MW	-0.615	3
FD32	03/07/90	92.799	0.697	1.532	4.972	0.467	ND	FS	0.486	W	-0.136	3
FD32	05/09/90	91.805	0.941	3.763	3.49	1.235	3.046	VFS	0.337	VW	-0.38	3.5
FD32	08/02/90	93.570	0.139	1.534	4.757	0.774	2.847	FS	0.644	MW	-0.743	3
FD32	11/14/90	92.182	0.818	1.363	5.637	0.951	2.823	FS	0.647	MW	-0.878	3
FD32	02/25/91	89.784	0.815	3.532	5.869	0.94	2.798	FS	0.614	MW	-0.838	3
FD32	05/10/91	89.289	0	2.761	7.95	1.116	2.536	FS	0.707	M	-0.775	3
FD32	08/07/91	89.314	0	3.985	6.701	1.695	3.072	VFS	0.504	MW	-1.164	3.5



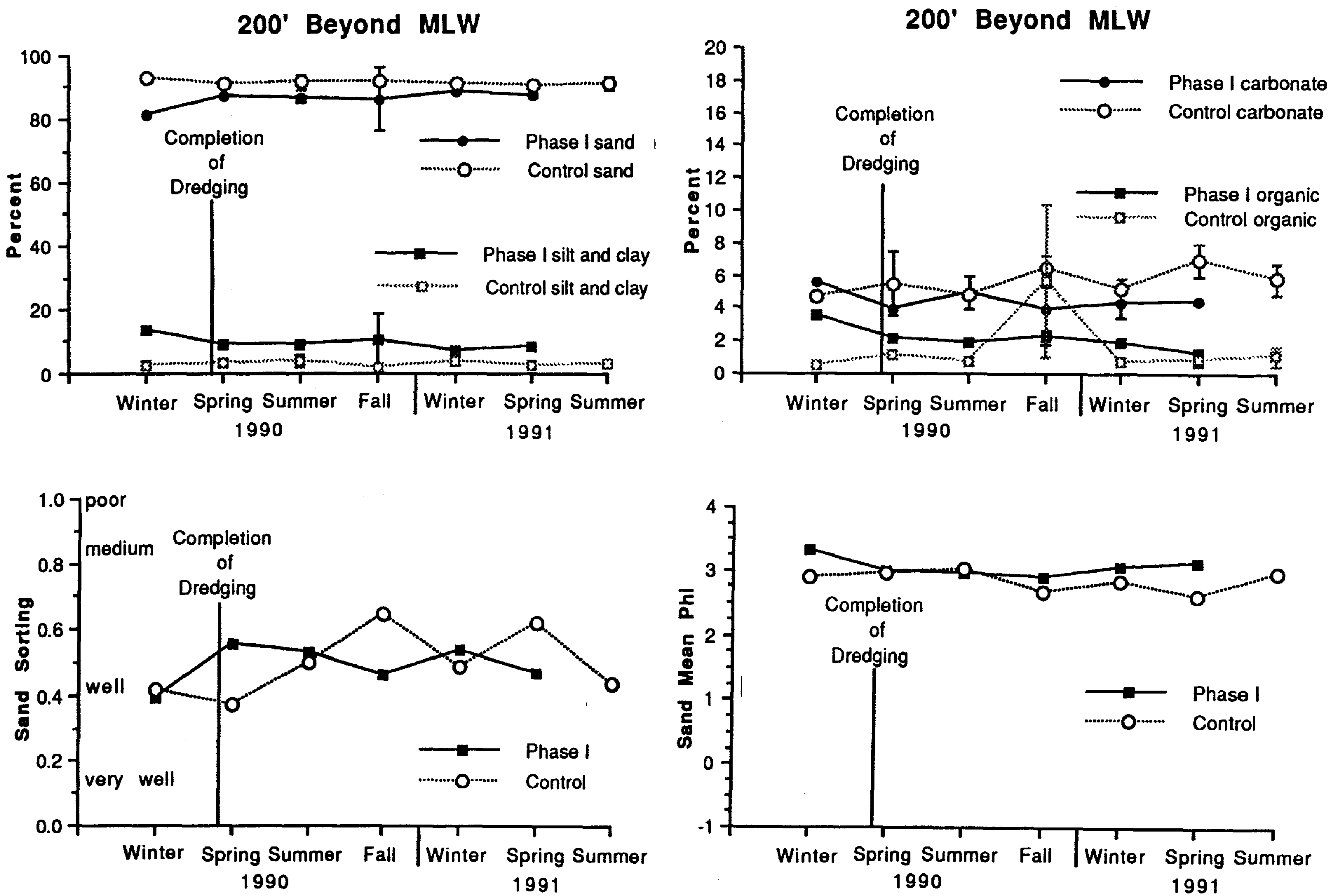
Appendix I.2.a. Sedimentological results of sampling at Phase I, mean sea level.



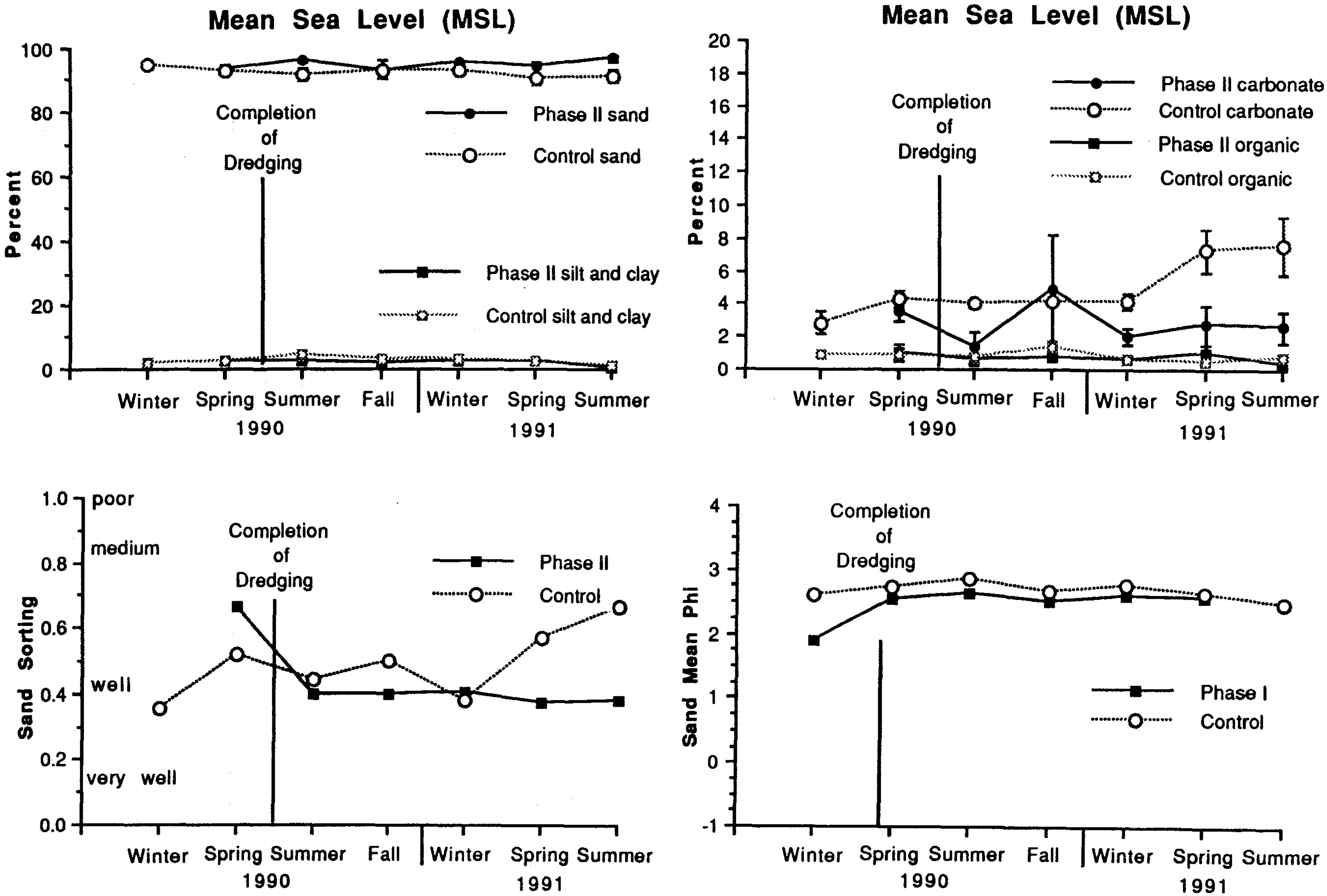
Appendix I.2.b. Sedimentological results of sampling at Phase I, mean low water.



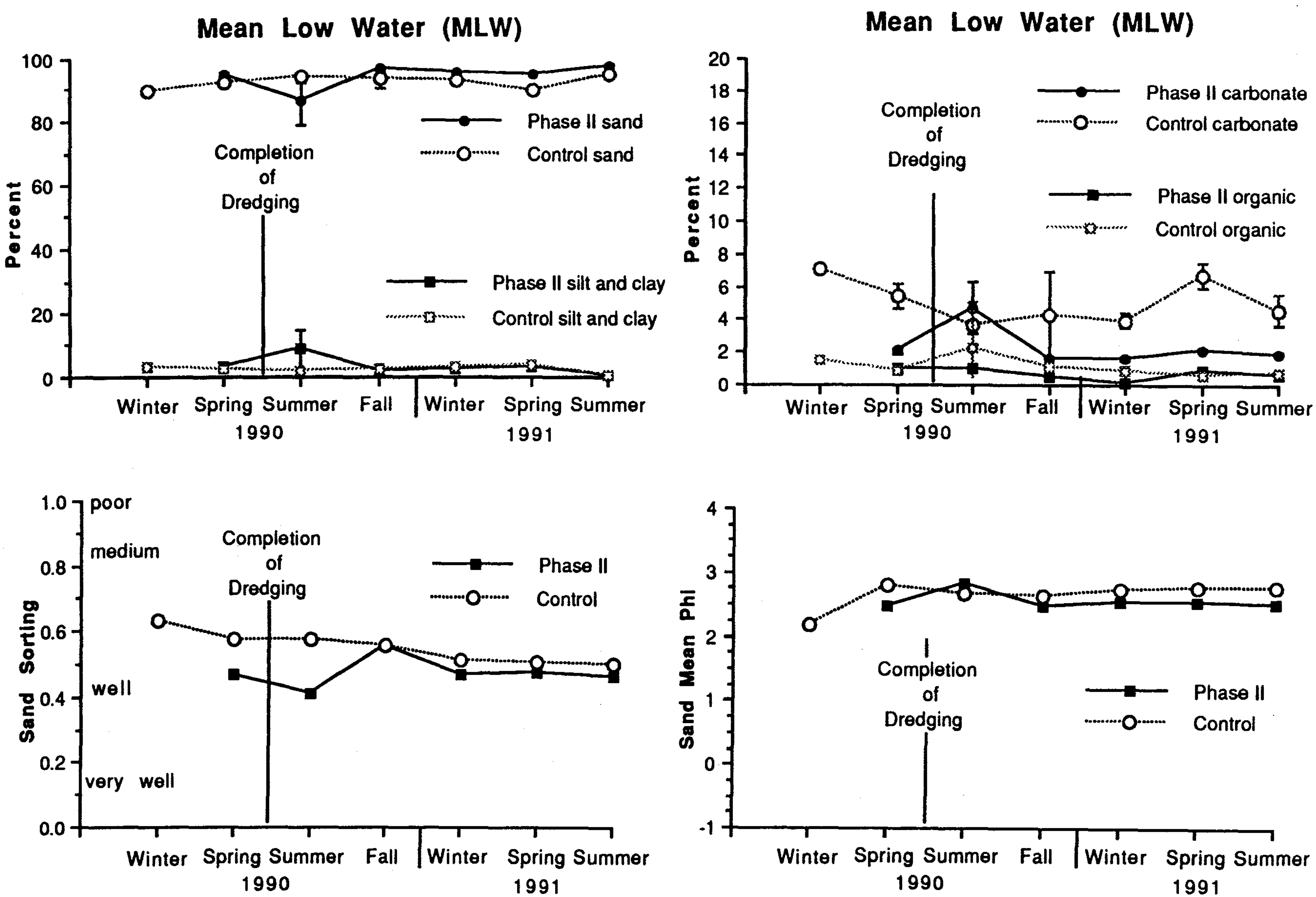
Appendix I.2.c. Sedimentological results of sampling at Phase I, 50 feet beyond mean low water.



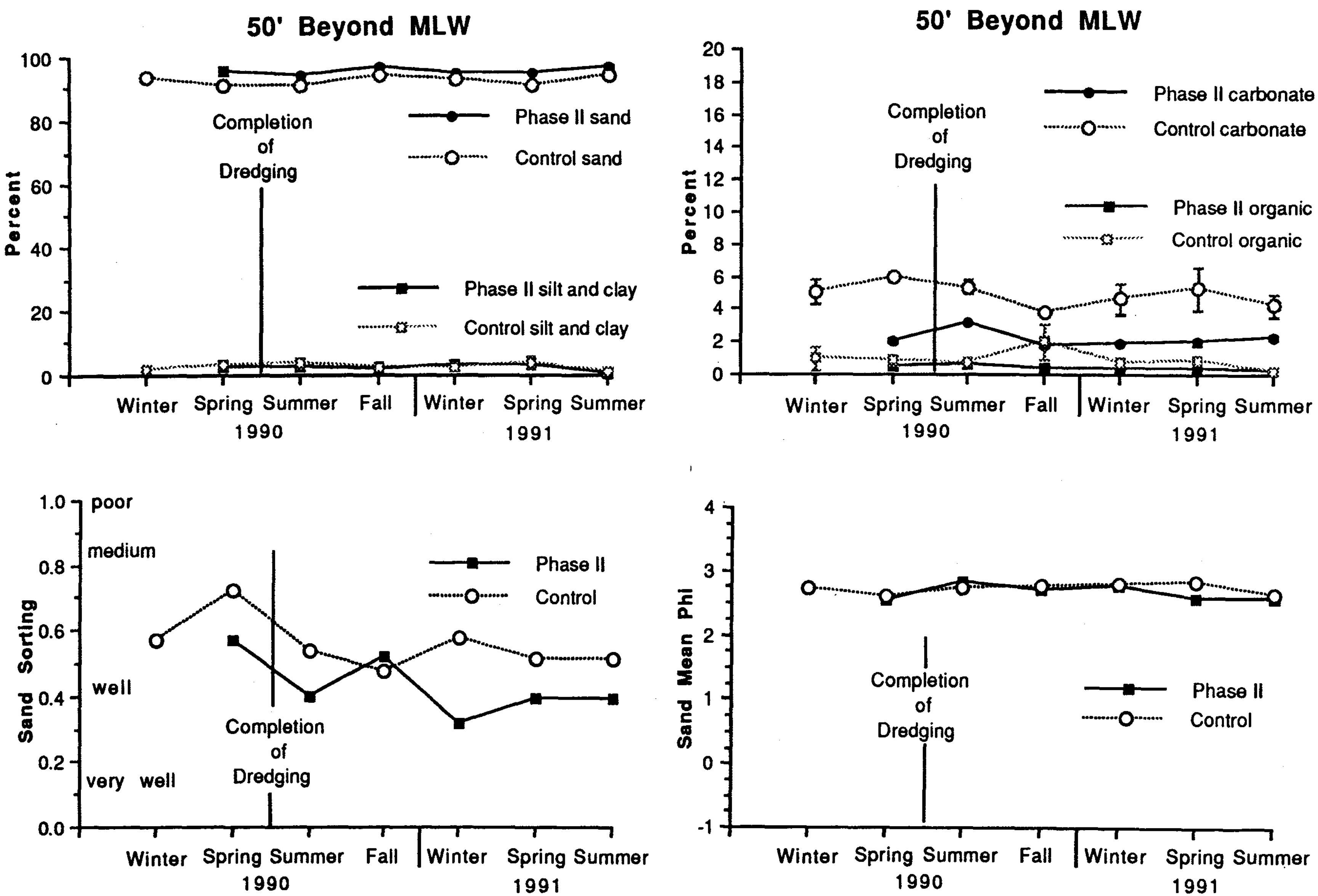
Appendix I.2.d. Sedimentological results of sampling at Phase I, 200 feet beyond mean low water.



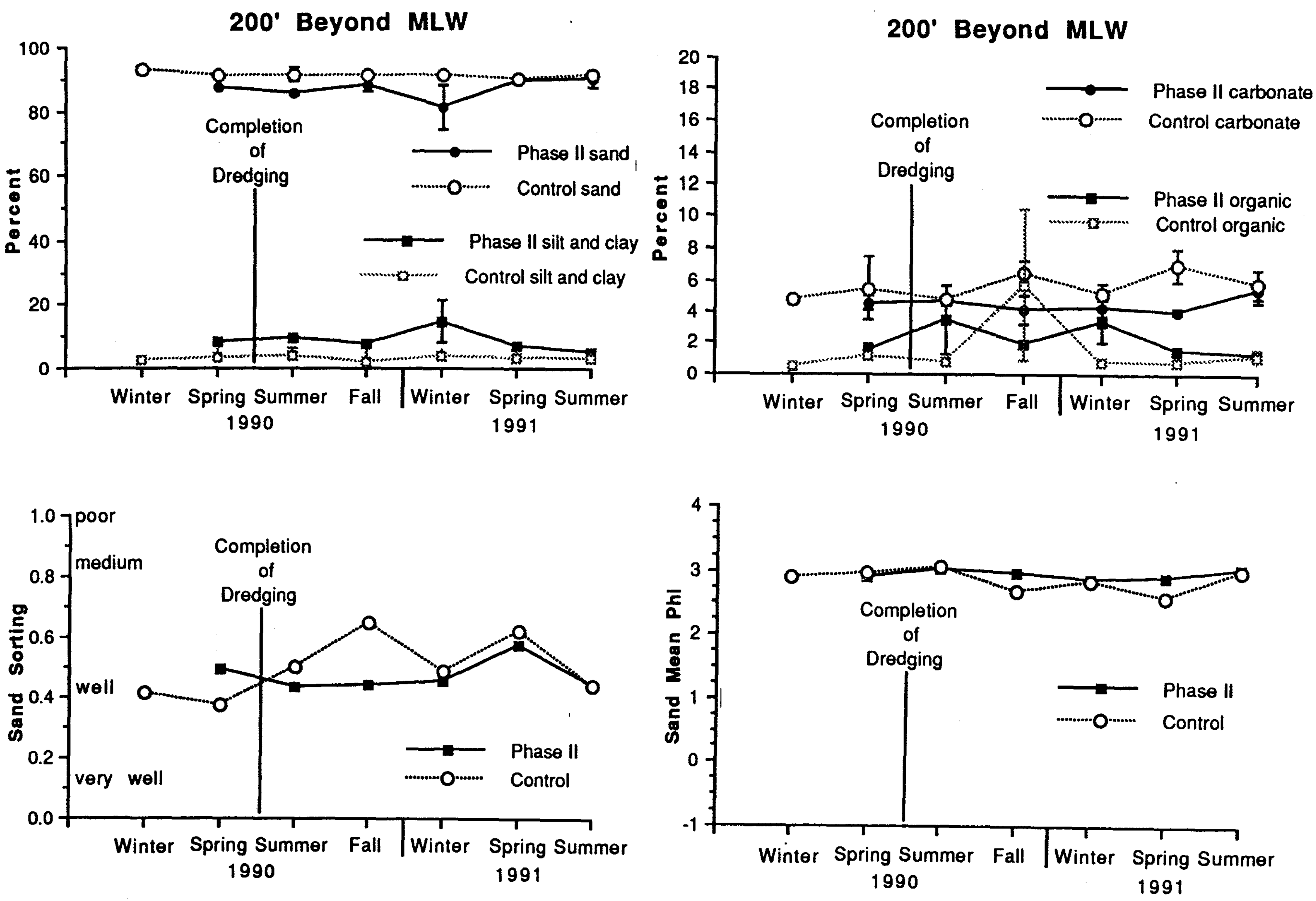
Appendix I.3.a. Sedimentological results of sampling at Phase II, mean sea level.



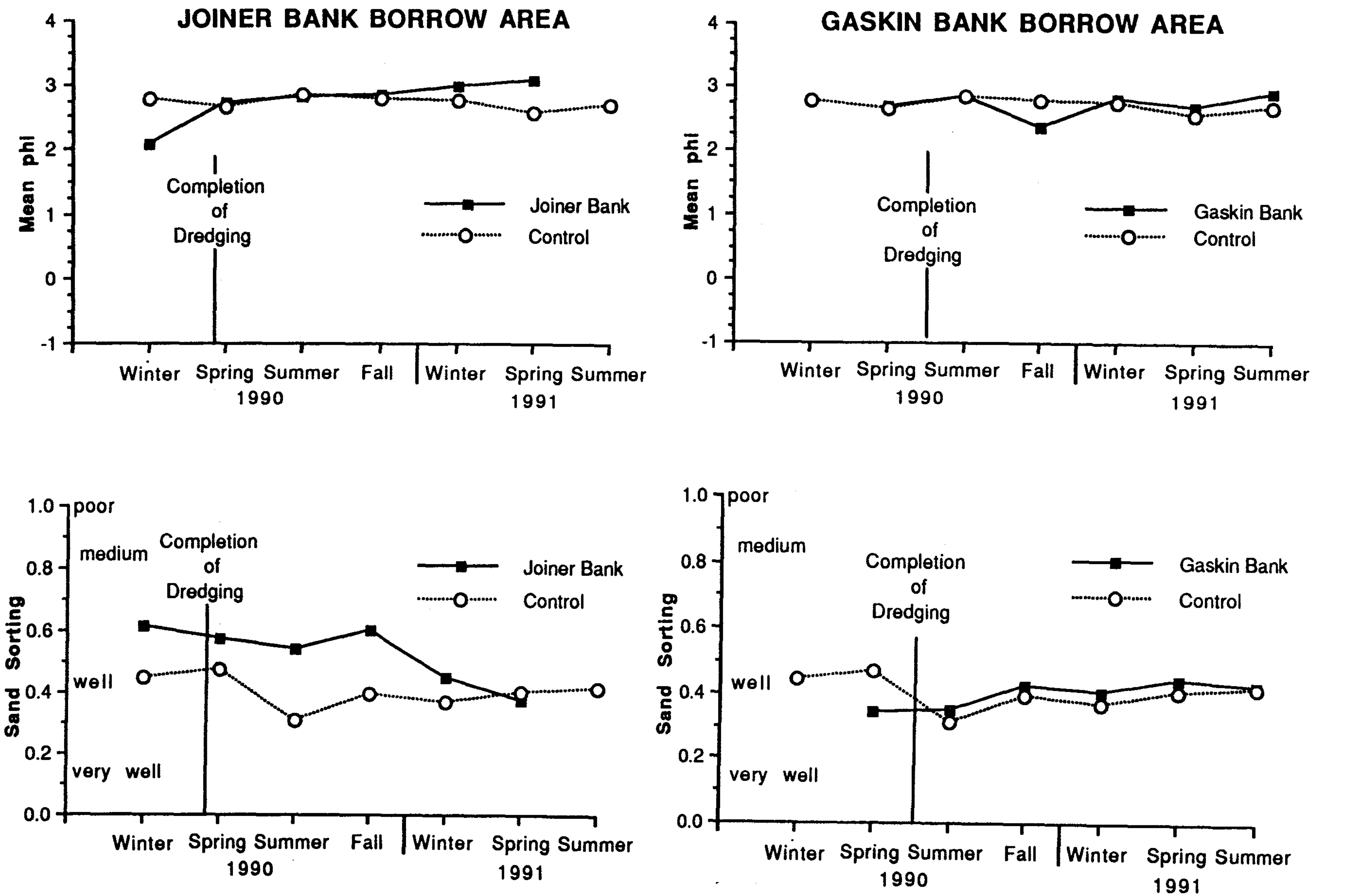
Appendix I.3.b. Sedimentological results of sampling at Phase II, mean low water.



Appendix I.3.c. Sedimentological results of sampling at Phase II, 50 feet beyond mean low water.



Appendix I.3.d. Sedimentological results of sampling at Phase II, 200 feet beyond mean low water.



Appendix 1.4. Sand grain size and sorting descriptions for Joiner Bank and Gaskin Bank.

Appendix II.1 Total number of each species collected at each station, by season. Station designations are as follows.

Beach and Nearshore Stations

	Phase I	Phase II	Control
Mean Sea Level (MSL)	HA01	HA02	FA03
Mean Low Water (MWL)	HB01	HB02	FB03
50' from MLW	HC01	HC02	FC03
200' from MLW	HD01	DD02	FD03

Offshore Stations

Joiner Bank Borrow Site	JB01, JB02, JB03
Gaskin Bank Borrow Site	GB01, GB02, GB03
Offshore Control Site	BC01, BC02, BC03

The total number of collections at each beach and neartshore station was 20, total number of collections at offshore stations is 10, with the following exceptions.

Win 90: HD02 = 19: JB01, BC01, n = 9

Spr 90: FA03 n = 19

Sum 90: HB01, HC02, HD01 n = 19

Fall 90: HA01 n = 19

FA03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
DONAX VARIABILIS	190		47	106	157	36	18
NEOHAUSTORIUS SCHMITZI	13	162	32	16	20	120	32
PARAHAUSTORIUS LONGIMERUS	65	47	6	4	12	14	1
SCOLELEPIS SQUAMATA	9	17	12	1		1	4
PROTOHAUSTORIUS DEICHMANNAE	1	19		3		3	
HAUSTORIUS CANADENSIS	2				4	5	
NEMATODA		5	2				
PARAONIS FULGENS	1		2	1	1		1
CHIRIDOTEA COECA		1	1		1	2	
MULINIA LATERALIS				4	1		
EXOSPHAEROMA DIMINUTUM			2			2	
BOPYRIDAE				3			
CHIRIDOTEA ALMYRA						3	
MANCOCUMA SP.		3					
NEMERTINEA		1			1		1
SPHAEROMA QUADRIDENTATUM	2						1
ETEONE HETEROPODA					2		
ISOTOMA DISPAR	2						
LEITOSCOLOPLOS FRAGILIS						1	1
LEPIDOPA WEBSTERI			2				
TELLINA TEXANA		2					
CORBULA SP.		1					
CUMACEA				1			
ENTOMOBRYA ARULA			1				
OLIGOCHAETA	1						
PARVILUCINA MULTILINEATA	1						
PINNIXA CRISTATA	1						
SPIONIDAE			1				
SPIOPHANES BOMBYX					1		
TURBELLARIA				1			

FB03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE	107	396	58	35	114	269	81
DONAX VARIABILIS	212	5	81	30		1	8
SCOLELEPIS SQUAMATA	18	8	1	1	158	20	5
PARAHAUSTORIUS LONGIMERUS	60	4			2	32	
MANCOCUMA SP.		41			16	15	
ACANTHOHAUSTORIUS MILLSI		27	2	8	4	2	10
PARAONIS FULGENS	3	10	5	4	5	8	2
PINNIXA CRISTATA	4	2	3	1		1	13
NEMERTINEA	2	5	1	1	6	3	2
BOWMANIELLA SP.		10	3			2	4
ANCINUS DEPRESSUS		2	1	2	3	7	
NEMATODA		9	1	2			
MULINIA LATERALIS	6	1		3			
CYCLASPIS BACESCUI			1			6	
NEOHAUSTORIUS SCHMITZI		4		2	1		
ETEONE HETEROPODA	1	1			4		
ISOTOMA DISPAR	2	1	2				
SOLEN VIRIDIS	1			3		1	
CYCLASPIS SP.						4	
DISPIO UNCINATA	1	1	1				1
NEPHTYS BUCERA						3	1
NEREIS SP.		2				2	
CYCLASPIS VARIANS				1		2	
OGYRIDES HAYI			1	1	1		
SCOLELEPIS TEXANA						1	2
AGLAOPHAMUS VERRILLI		1	1				
BOPYRIDAE				2			
CAULLERIELLA SP.						2	
CHIRIDOTEA STENOPS				1		1	
EMERITA TALPOIDA							2
HAUSTORIUS CANADENSIS	1					1	
LEITOSCOLOPLOS FRAGILIS			1				1
MAGELONA PAPILLICORNIS					1	1	
PINNIXA SP.			2				
SPIOPHANES BOMBYX		1			1		
SYNCHELIDIUM AMERICANUM					1	1	
TURBELLARIA						1	1
ARABELLIDAE	1						
CHIRIDOTEA COECA	1						
CUMACEA	1						
LISTRIELLA CLYMENELLAE				1			
LUMBRINERIDAE						1	
MICROPROTOPUS RANEYI						1	
MANNOSQUILLA GRAYI		1					
NEPHTYIDAE	1						
PAGURUS LONGICARPUS					1		

FB03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PINNOTHERIDAE		1					
SABELLARIA VULGARIS				1			
TELLINA TEXANA				1			
VAUNTHOMPSONIA SP.				1			

FC03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE	189	672	119	23	138	603	131
DONAX VARIABILIS	2	307	53	26		2	5
SCOLELEPIS SQUAMATA	12	2		3	49	21	
PARAHAUSTORIUS LONGIMERUS	59			3	5	9	
ACANTHOHAUSTORIUS MILLSI	3	25		4	7	18	8
PARAONIS FULGENS	2	23	14	2	4	5	8
NEMERTINEA	1	2	2			12	6
PINNIXA CRISTATA	3	2	2	4	1	1	8
MANCOCUMA SP.	4	8		1	2	3	2
NEOHAUSTORIUS SCHMITZI		19					1
LEITOSCOLOPLOS FRAGILIS			5			7	1
NEMATODA		7	5				
BOWMANIELLA SP.			5			1	5
OGYRIDES HAYI			4		1		5
CYCLASPIS BACESCUI		1	1			2	2
CYCLASPIS VARIANS						5	1
MULINIA LATERALIS	3	1	1		1		
NEPHTYS BUCERA						5	
TURBELLARIA				1	1	3	
CYCLASPIS SP.		2	2				
MICROPROTOPUS RANEYI					4		
NEREIS SP.		2				2	
PINNIXA SP.			2	1		1	
SCOLELEPIS TEXANA							4
ABRA AEQUALIS	3						
DISPIO UNCINATA	2	1					
NEPHTYS PICTA			2				1
SOLEN VIRIDIS						3	
VAUNTHOMPSONIA SP.					3		
ACETES AMERICANUS			2				
AGLAOPHAMUS VERRILLI		2					
ANCINUS DEPRESSUS				1	1		
CHIRIDOTEA COECA	2						
CHIRIDOTEA STENOPS			1			1	
HAUSTORIUS CANADENSIS		2					
LEPIDOPA WEBSTERI			1				1
NEPHTYIDAE	2						
NEPHTYS SP.			1			1	
OLIGOCHAETA		2					
RHEPOXYNIUS EPISTOMUS						2	
SPHAEROMA QUADRIDENTATUM				1	1		
SYNCHELIDIUM AMERICANUM			2				
AMPHARETE AMERICANA				1			
AMPITHOE VALIDA		1					
CALLIANASSA BIFORMIS							1
ENTOMOBRYA ARULA		1					

FC03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
ETEONE HETEROPODA						1	
GLYCINDE SOLITARIA							1
LISTRIELLA BARNARDI							1
ODOSTOMIA SP.				1			
ONUPHIS EREMITA			1				
OXYUROSTYLIS SMITHI					1		
PHYLLODOCE ARENAE			1				
PINNOTHERIDAE		1					
POLYDORA SOCIALIS					1		
SPIONIDAE				1			
SPIOPHANES BOMBYX						1	
TELLINA TEXANA			1				
TRACHYPENAEUS CONSTRICTUS			1				

FD03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE	208	821	54	44	119	182	51
MULINIA LATERALIS	5	5	9	815	3		
NEMERTINEA	8	15		7	24	9	7
LEITOSCOLOPLOS FRAGILIS			26			32	3
SYNCHELIDIUM AMERICANUM		20	17	3	1	7	1
MANCOCUMA SP.	14	3		1		22	
PARAONIS FULGENS	3	13			4	7	2
TELLINA TEXANA	2	8	10		3	1	2
ONUPHIS EREMITA	2	1	9 .	3	2		7
CYCLASPIS BACESCUI		14				9	
TURBELLARIA				15	3	5	
NEPHTYS PICTA		3	17	1			1
SCOLELEPIS TEXANA		2	1	3	9	2	4
DISPIO UNCINATA	2	1	8			7	2
TELLINA IRIS							20
SPIOPHANES BOMBYX	2	4	4		4	5	
MAGELONA PAPILLICORNIS	5	5	2	1			4
SCOLELEPIS SQUAMATA	3	3		1	4	5	
SOLEN VIRIDIS			7	3		5	1
ACANTHOHAUSTORIUS MILLSI	3	3	1		4	4	
CYCLASPIS SP.		14	1				
PARAHAUSTORIUS LONGIMERUS	15						
OXYUROSTYLIS SMITHI	3	2			3	6	
BOWMANIELLA SP.	1	5	4			1	
NEMATODA	2	3	5				
CHIRIDOTEA STENOPS		2			2	2	3
NEREIS SP.						9	
PINNIXA CRISTATA				2	1	1	4
RHEPOXYNIUS EPISTOMUS		4		1		2	1
NEPHTYS BUCERA						5	2
OGYRIDES HAYI			2	2	2		1
AGLAOPHAMUS VERRILLI		6					
TEREBRA DISLOCATA		3			1		2
CALLIANASSA BIFORMIS			5				
CYCLASPIS VARIANS				1		4	
DONAX VARIABILIS	1		4				
NEOHAUSTORIUS SCHMITZI		1				2	2
DISSODACTYLUS MELLITAE				3	1		
EDOTEA MONTOSA		2				2	
ETEONE HETEROPODA		1				2	1
ACETES AMERICANUS			3				
ARABELLIDAE		1	1			1	
LEPIDOPA WEBSTERI	1		1			1	
MEDIOMASTUS CALIFORNIENSIS		1	1				1
MICROPROTOPUS RANEYI		2				1	
NEPHTYIDAE	2					1	

FD03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
RENILLA RENIFORMIS			1				2
SABELLARIA VULGARIS	3						
TELLINA SP.	3						
ARMANDIA AGILIS			2				
GLYCINDE SOLITARIA							2
LEITOSCOLOPLOS FRAGILIS							2
OLIGOCHAETA				1		1	
ONUPHIS EREMITA			2				
PAGURUS HENDERSONI			1	1			
PHYLLODOCE ARENAE		2					
SPIO PETTIBONEAE					2		
ABRA AEQUALIS						1	
ACTEOCINA CANDEI					1		
ACTINIARIA			1				
AMASTIGOS CAPERATUS	1						
AMPHARETE AMERICANA						1	
BATHYPOREIA PARKERI		1					
BOWMANIELLA SP.	1						
BRACHIDONTES EXUSTUS							1
CARINOMELLA LACTEA				1			
CERAPUS TUBULARIS	1						
COLLEMBOLA		1					
CRASSINELLA LUNULATA	1						
ISOPODA			1				
LEMBOS WEBSTERI		1					
LEUCON AMERICANUS		1					
MAGELONA SP.			1				
MARGINELLIDAE	1						
MELLITA QUINQUESPERFORATA					1		
MANNOSQUILLA GRAYI						1	
NEOMYSIS AMERICANA						1	
NEPHTYS SP.						1	
NOTOMASTUS SP.							1
PAGURUS LONGICARPUS		1					
PHYLLODOCE SP.		1					
PINNIXA SP.		1					
PINNIXA CHAETOPTERANA					1		
POLYDORA SOCIALIS						1	
SPHAEROMA QUADRIDENTATUM					1		
TELLINA AGILIS	1						
TIRON TRIOCELLATUS						1	
TRACHYPENAEUS CONSTRICTUS		1					
TURBONILLA SP.	1						

HA01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
NEOHAUSTORIUS SCHMITZI	180	18	88	3	38	296	
DONAX VARIABILIS	467	38	38	90	5	10	
NEMATODA	64						
PARAHAUSTORIUS LONGIMERUS		22	1	4	3	27	
HAUSTORIUS CANADENSIS	12	4			2	26	
ACANTHOHAUSTORIUS MILLSI		1	5	9	3	5	
MULINIA LATERALIS	1			20			
PARAONIS FULGENS	3	1	1	3		9	
SCOLELEPIS SQUAMATA	5	2	2	1		3	
LEPIDACTYLUS DYTISCUS						10	
LEITOSCOLOPLOS FRAGILIS	2			4	1	1	
NEMERTINEA		3		1		4	
PINNIXA CRISTATA		2	1	4		1	
OLIGOCHAETA	4		1				
CHIRIDOTEA COECA		2				1	
ISOTOMA DISPAR	3						
NEREIS SP.		1				2	
PINNIXA SP.						3	
PROTOHAUSTORIUS DEICHMANNAE		2		1			
ARABELLIDAE					1	1	
GASTROPODA		2					
SPHAEROMA QUADRIDENTATUM		2					
ACANTHOHAUSTORIUS INTERMEDIUS			1				
AMPHARETE AMERICANA	1						
MANCOCUMA SP.					1		
MELITIDAE				1			
MONOCULODES EDWARDSI						1	
NEREIDAE		1					
NEREIS SUCCINEA						1	
ORBINIIDAE				1			
OXYUROSTYLIS SMITHI	1						
PARVILUCINA MULTILINEATA					1		
SPIOPHANES BOMBYX	1						
SYNCHELIDIUM AMERICANUM	1						
TELLINA TEXANA					1		
TELLINIDAE	1						
TURBELLARIA						1	
TURBONILLA SP.	1						

HA02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
DONAX VARIABILIS		239	9	139	131	60	48
NEOHAUSTORIUS SCHMITZI		376		4	39	87	67
MULINIA LATERALIS				139			
PARAHAUSTORIUS LONGIMERUS		1	9	6	20	16	1
HAUSTORIUS CANADENSIS		30			5	7	
SCOLELEPIS SQUAMATA		14	7	4		3	
LEPIDACTYLUS DYTISCUS					11	1	
NEMATODA		9	2				
CHIRIDOTEA COECA		9	1				
ACANTHOHAUSTORIUS MILLSI		1		1	1		5
PINNIXA CRISTATA				3			4
MEDIOMASTUS CALIFORNIENSIS		5					
OLIGOCHAETA		4					
NEMERTINEA		3					
PARAONIS FULGENS		1		2			
EMERITA TALPOIDA				2			
LEITOSCOLOPLOS FRAGILIS					2		
LUMBRINERIDAE						2	
MANCOCUMA SP.		2					
ASTYRIS LUNATA						1	
BOWMANIELLA SP.			1				
CAPRELLA EQUILIBRA						1	
ETEONE HETEROPODA					1		
GLYCINDE SOLITARIA							1
MICROPROTOPUS RANEYI					1		
MONOCULODES EDWARDSI		1					
NEOPANOPE SAYI			1				
OSTRACODA				1			
OXYUROSTYLIS SMITHI		1					
SABELLARIA VULGARIS			1				
SPHAEROMA QUADRIDENTATUM		1					
TELLINA TEXANA					1		
TURBELLARIA					1		
TURBONILLA SP.						1	

HB01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
SCOLELEPIS SQUAMATA	60	11			29	75	
PARAONIS FULGENS	11	5	12	9	7	74	
NEOHAUSTORIUS SCHMITZI	73	2					
DONAX VARIABILIS	38		9	1		3	
CYCLASPIS VARIANS		37				1	
NEMATODA	21	1	1	2			
PROTOHAUSTORIUS DEICHMANNAE		19	1			2	
ACANTHOHAUSTORIUS MILLSI		12			2	5	
HAUSTORIUS CANADENSIS	4	10					
DISPIO UNCINATA		1	9	1			
NEMERTINEA		1	2			6	
SYNCHELIDIUM AMERICANUM		4	3	1	1		
MULINIA LATERALIS	1			6			
ISOTOMA DISPAR	4	1					
AMPHARETE AMERICANA	4						
BOWMANIELLA SP.		4					
OLIGOCHAETA		1	2		1		
PINNIXA CRISTATA				4			
BOWMANIELLA SP.		2				1	
ETEONE HETEROPODA			2		1		
LEITOSCOLOPLOS FRAGILIS	2				1		
NEREIS SP.		3					
PARAHAUSTORIUS LONGIMERUS		1	1	1			
ACTEOCINA CANDEI					2		
CERAPUS TUBULARIS					2		
LUMBRINERIDAE				1		1	
MANCOCUMA SP.		1	1				
MEDIOMASTUS CALIFORNIENSIS			2				
OXYUROSTYLIS SMITHI		2					
BATEA CATHARINENSIS			1				
CHIRIDOTEA STENOPS		1					
CYCLASPIS SP.		1					
LEITOSCOLOPLOS SP.			1				
LEPIDOPA WEBSTERI	1						
MICROPROTOPUS RANEYI					1		
NEPHTYS SP.		1					
NEPHTYS PICTA				1			
NEREIDAE						1	
ORGYIA DETRITA	1						
PAGURUS HENDERSONI				1			
PELECYPODA	1						
PINNIXA SAYANA			1				
POLYNOIDAE		1					
SCOLELEPIS TEXANA			1				
TELLINA TEXANA				1			
THARYX SP.		1					

HB01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
TURBELLARIA					1		
TURRIDAE					1		
VAUNTHOMPSONIA SP.						1	

HB02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PARAHAUSTORIUS LONGIMERUS		95	48	1	54	68	56
SCOLELEPIS SQUAMATA		55	7		110	116	17
MANCOCUMA SP.		81		1	1	5	1
PROTOHAUSTORIUS DEICHMANNAE		8	9		1	41	16
PARAONIS FULGENS		13	26	2		15	3
DONAX VARIABILIS			21	6		7	7
BOWMANIELLA SP.		10	17	1		1	3
NEMERTINEA		1				13	2
ACANTHOHAUSTORIUS MILLSI		1	3	3		4	1
NEMATODA		12					
CYCLASPIS VARIANS		9					
OGYRIDES HAYI			1	1	1		3
OXYUROSTYLIS SMITHI		5			1		
LEPIDOPA WEBSTERI		1	1	1			2
NEPHTYS PICTA		2	1			2	
NEREIS SP.		1				3	1
PINNIXA SP.		3	2				
PINNIXA CRISTATA		1	1				3
MICROPROTOPUS RANEYI		1			3		
NEPHTYS BUCERA		3				1	
PINNIXA CHAETOPTERANA			2	2			
TELLINA TEXANA		1			3		
ATYLUS SP.				3			
LEUCON SP.		2				1	
PINNOTHERIDAE		3					
SPIOPHANES BOMBYX					1	2	
TURBELLARIA						1	2
VAUNTHOMPSONIA SP.					3		
CERAPUS TUBULARIS		1			1		
CYCLASPIS BACESCUI						1	1
DISPIO UNCINATA		1				1	
EDOTEA MONTOSA		1			1		
ETEONE HETEROPODA		2					
OGYRIDES SP.			2				
SPIO PETTIBONEAE						2	
AMPHARETE AMERICANA					1		
BOWMANIELLA SP.		1					
CAULLERIELLA SP.						1	
CHIRIDOTEA STENOPS		1					
CYCLASPIS SP.		1					
EMERITA BENEDICTI					1		
ENTOMOBRYA ARULA							1
ISOTOMA DISPAR				1			
METAMYSIDOPSIS SWIFTI						1	
MULINIA LATERALIS				1			
NEOHAUSTORIUS SCHMITZI		1					

HB02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
NEPHTYS SP.						1	
NUDIBRANCHIA					1		
OGYRIDES ALPHAEROSTRIS						1	
OLIGOCHAETA				1			
PINNIXA SAYANA			1				
PORTUNUS GIBBESII			1				
SCOLELEPIS TEXANA						1	
SOLEN VIRIDIS						1	
SYNCHELIDIUM AMERICANUM						1	

HC01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
MULINIA LATERALIS	11			1428		2	
PROTOHAUSTORIUS DEICHMANNAE	42	87	31	51	28	73	
PARAONIS FULGENS	43	2	18	33	12	36	
SCOLELEPIS TEXANA			2	3		57	
ACANTHOHAUSTORIUS MILLSI		14		6	29	10	
SCOLELEPIS SQUAMATA	4	1		4	37	4	
DISPIO UNCINATA	10	3	13	11	1	6	
HAUSTORIUS CANADENSIS	10	33					
NEMATODA	36	5		1			
TELLINA TEXANA	6		2	4	6	12	
LEITOSCOLOPLOS FRAGILIS	9	5	1	1		11	
NEMERTINEA	6	3		7	3	7	
PAGURUS HENDERSONI					1	21	
SYNCHELIDIUM AMERICANUM	2	11		2	5		
AMPHARETE AMERICANA	17			1			
OXYUROSTYLIS SMITHI		14		3		1	
PARAHAUSTORIUS LONGIMERUS		1			16		
ACTEOCINA CANDEI				8	6	1	
CYCLASPIS VARIANS	1	8		2		3	
OGYRIDES HAYI	1	1	3	4	3		
SOLEN VIRIDIS	5			3		3	
AGLAOPHAMUS VERRILLI						9	
DONAX VARIABILIS		1	5			2	
SPIOPHANES BOMBYX	4					4	
BOWMANIELLA SP.		1	6				
NEPHTYS BUCERA			1			6	
ONUPHIS EREMITA	3			3	1		
TELLINA AGILIS	7						
NEOHAUSTORIUS SCHMITZI	4				1	1	
PINNIXA CRISTATA	1			5			
OLIGOCHAETA		1	1		1	2	
CHIRIDOTEA STENOPS	3	1					
EDOTEA MONTOSA		3					
ETEONE HETEROPODA	1				2		
NEPHTYS PICTA	1	1				1	
RHEPOXYNIUS EPISTOMUS			1			2	
ABRA AEQUALIS	1				1		
ARMANDIA AGILIS				2			
EUDEVENOPUS HONDURANUS		1				1	
LEPIDOPA WEBSTERI	2						
MICROPROTOPUS RANEYI		1			1		
NEPHTYS SP.				1		1	
NEREIS SP.		2					
OGYRIDES SP.			2				
TELLINA IRIS					2		
ACANTHOHAUSTORIUS INTERMEDIUS				1			

HC01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
ANCINUS DEPRESSUS		1					
ASPIDOSIPHON SP.	1						
BATEA CATHARINENSIS			1				
BATHYPOREIA PARKERI					1		
BOPYRIDAE	1						
CALLIANASSA BIFORMIS			1				
CARRAZZIELLA SP.	1						
CHIRIDOTEA COECA					1		
CYCLASPIS SP.						1	
ISOPODA	1						
ISOTOMA DISPAR		1					
LEUCON SP.					1		
MANNOSQUILLA GRAYI	1						
NEPHTYIDAE	1						
OPHIUROIDEA	1						
PELECYPODA			1				
POLINICES DUPLICATUS						1	
RENILLA RENIFORMIS				1			
STRIGILLA MIRABILIS				1			
TELLINA SP.	1						
TURBELLARIA					1		
TURRIDAE					1		

HC02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE		11	42	30	33	83	10
PARAHAUSTORIUS LONGIMERUS		31	6	1	35	15	31
SCOLELEPIS SQUAMATA		7			61	8	5
PARAONIS FULGENS		34	5	3	1	9	13
SOLEN VIRIDIS				39	2	2	
BOWMANIELLA SP.		6	21				8
NEMERTINEA		10	5	5	8	3	4
DISPIO UNCINATA		3	1			17	7
NEMATODA		17	9	2			
SCOLELEPIS TEXANA			7	7		10	
MULINIA LATERALIS				20		1	
TELLINA TEXANA		1	9		5	3	
SPIOPHANES BOMBYX		1	2			14	
DONAX VARIABILIS			3	1		2	5
MANCOCUMA SP.		8			1	1	1
NEPHTYS PICTA		4	4				2
OGYRIDES HAYI		1	2	3	3		1
ONUPHIS EREMITA		1		7	2		
ACANTHOHAUSTORIUS MILLSI		3		2	3		
SYNCHELIDIUM AMERICANUM		7				1	
CHIRIDOTEA STENOPS		5	2				
NEPHTYS BUCERA				1		5	
OXYUROSTYLIS SMITHI		5			1		
DISSODACTYLUS MELLITAE				5			
MELLITA QUINQUESPERFORATA				2	1	2	
PINNIXA SP.		1	4				
ACANTHOHAUSTORIUS INTERMEDIUS			4				
PINNOTHERIDAE		4					
EDOTEA MONTOSA		3					
LEITOSCOLOPLOS FRAGILIS			1			2	
ABRA AEQUALIS					2		
AGLAOPHAMUS VERRILLI		2					
CALLIANASSA BIFORMIS			1				1
LEPIDOPA WEBSTERI			1			1	
MAGELONA PAPILLICORNIS				2			
NEREIS SP.		1				1	
NOTOMASTUS SP.			1	1			
RHEPOXYNIUS EPISTOMUS			1	1			
STRIGILLA MIRABILIS				2			
TURBELLARIA						2	
AMPHARETIDAE			1				
AMPITHOE LONGIMANA		1					
ARICIDEA SUECICA					1		
CORBULA BARRATTIANA		1					
CYCLASPIS VARIANS						1	
ENTOMOBRYA ARULA							1

HC02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
ETEONE HETEROPODA					1		
MAGELONA SP.				1			
MEDIOMASTUS CALIFORNIENSIS				1			
MICROPROTOPUS RANEYI		1					
MONOCULODES EDWARDSI				1			
NEOMYSIS AMERICANA		1					
NEPHTYIDAE				1			
OLIGOCHAETA				1			
OPHIUROIDEA					1		
PAGURUS HENDERSONI						1	
PARVILUCINA MULTILINEATA					1		
PINNIXA CHAETOPTERANA							1
POLYDORA CORNUTA							1

HD01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
MULINIA LATERALIS	232	6	36	1392	13	9	
MEDIOMASTUS CALIFORNIENSIS	107	108	611	48	73	57	
TELLINA TEXANA	89	44	94	18	9	18	
AMPHARETE AMERICANA	165	59	1			1	
OXYUROSTYLIS SMITHI	32	169	9	5	1	8	
ABRA AEQUALIS	142	7	5	1	6	3	
NEMATODA	57	46	32	7	3		
SCOLELEPIS TEXANA		7	14	9	13	78	
SYNCHELIDIUM AMERICANUM	35	47	1	2	6	9	
SOLEN VIRIDIS	38	5	44	2	4	4	
OLIGOCHAETA	30	15	6	12	12	8	
ACTEOCINA CANDEI	7	5	8	26	16	5	
LEITOSCOLOPLOS FRAGILIS	8	13	8	14	7	14	
TELLINA AGILIS	62						
CAULLERIELLA SP.		60					
RHEPOXYNIUS EPISTOMUS	1	7	19	5	2	22	
SPIOPHANES BOMBYX	17	5	3	1	3	15	
SCOLELEPIS SQUAMATA	16	11		1	8	5	
THARYX SP.	2	19	13	2	1	4	
NEMERTINEA	15	6	1	6	7	3	
DRILONEREIS LONGA			4	9	12	6	
CALLIANASSA BIFORMIS	4	1	14	6	3	1	
PRIONOSPIO CIRRIFERA	9	18		1	1		
PARAONIS FULGENS	15				8	4	
CYCLASPIS VARIANS	2	13	1		2	1	
GLYCERA AMERICANA	2	2	9	3	1	2	
ARICIDEA SUECICA	3		3	1	6	5	
PROTOHAUSTORIUS DEICHMANNAE		16	2				
ETEONE HETEROPODA	9	4			3		
PAGURUS HENDERSONI	1		12	3			
ARABELLIDAE	2	3	2	3	5		
EDOTEA MONTOSA		7	4			4	
DISPIO UNCINATA		7	3	1	3		
TURBELLARIA			1		8	4	
CARINOMELLA LACTEA	1	2	6			3	
MICROPROTOPUS RANEYI	10	1		1			
MONOCULODES EDWARDSI	1	9			1	1	
ONUPHIS EREMITA				1	6	5	
NEREIS SP.		8				3	
ONUPHIDAE			11				
GLYCINDE SOLITARIA	3	1	4	1			
NUCULA PROXIMA	5	3		1			
PINNIXA SP.			6	2		1	
SCOLOPLOS RUBRA	1		8				
LISTRIELLA CLYMENELLAE			8				
PINNIXA CHAETOPTERANA	2		5	1			

HD01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
DRILONEREIS MAGNA	2	1				4	
TELLINA SP.		7					
GLYCERA SPHYRABRANCHA	5					1	
LISTRIELLA BARNARDI	1			1		4	
PHYLLODOCE ARENAE		2				4	
AMASTIGOS CAPERATUS	2				2	1	
BOWMANIELLA SP.			3			2	
STREBLOSPIO BENEDICTI	3	2					
AMPHIURIDAE	2	2					
BATEA CATHARINENSIS		1	1	2			
MALMGRENIELLA SP.	2	1	1				
MANCOCUMA SP.		4					
MICROPHIOPHOLIS GRACILLIMA	3			1			
OPHIUROIDEA			1	2		1	
PARVILUCINA MULTILINEATA	1		1			2	
TELLINA IRIS	4						
ACANTHOHAUSTORIUS MILLSI		2				1	
CISTENIDES GOULDII	2		1				
DIOPATRA CUPREA	1				2		
NOTOMASTUS SP.		1		1		1	
OSTRACODA	2					1	
ARMANDIA AGILIS					1	1	
ASTHENOTHAERUS HEMPHILLI				1	1		
CERAPUS TUBULARIS		2					
CIRRIFORMIA GRANDIS				2			
CIRROPHORUS LYRIFORMIS	2						
CLYMENELLA TORQUATA			2				
CYATHURA BURBANCKI	2						
CYCLASPIS SP.			1			1	
DOSINIA DISCUS				1		1	
GLYCERA OXYCEPHALA						2	
HAUSTORIUS CANADENSIS	1	1					
LEITOSCOLOPLOS ROBUSTUS						2	
MAGELONA ROSEA	1					1	
NOTOMASTUS LATERICEUS		2					
PARAONIDAE	2						
SCLERODACTYLA BRIAREUS		1				1	
SYNAPTULA HYDROFORMIS	2						
THYONELLA GEMMATA			2				
TURBONILLA SP.			2				
AGLAOPHAMUS VERRILLI				1			
ANCINUS DEPRESSUS		1					
ARABELLA IRICOLOR			1				
ARICIDEA FRAGILIS	1						
CALLINECTES SAPIDUS	1						
CORBULA BARRATTIANA	1						

HD01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
CYCLASPIS BACESCUI			1				
DRILONEREIS SP.						1	
EMERITA SP.						1	
GLYCERA SP.						1	
HARPACTICOIDA						1	
HETEROMASTUS FILIFORMIS	1						
INGOLFIELLA SP.						1	
ISOTOMA DISPAR	1						
LEPTOCHELA SERRATORBITA				1			
LEUCON SP.	1						
LEUCOSIIDAE			1				
LUMBRINERIS TENUIS		1					
MACOMA SP.						1	
MALMGRENIA SP.	1						
MELLITA QUINQUESPERFORATA					1		
NEOMYSIS AMERICANA	1						
NEPHTYS PICTA	1						
NOTOMASTUS LOBATUS				1			
OGYRIDES HAYI			1				
ORBINIIDAE			1				
OWENIA FUSIFORMIS	1						
PAGURUS LONGICARPUS	1						
PARAPRIONOSPIO PINNATA	1						
PELECYPODA					1		
PINNOTHERIDAE		1					
POLINICES DUPLICATUS						1	
PORTUNUS SP.			1				
SABELLARIA VULGARIS				1			
SIGAMBRA TENTACULATA				1			
SIPUNCULA	1						
TELLINACEA	1						

HD02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
MULINIA LATERALIS		5	5	1216	165	60	
MEDIOMASTUS CALIFORNIENSIS		195	86	131	262	210	77
SOLEN VIRIDIS		2	1	280	19	9	
TELLINA TEXANA		40	52	55	100	23	6
OLIGOCHAETA		64	33	16	2	60	20
RHEPOXYNIUS EPISTOMUS		69	44	19	10	16	7
PINNIXA CHAETOPTERANA		18	32	22	8	1	51
OXYUROSTYLIS SMITHI		72		22	13	14	1
PRIONOSPIO CIRRIFERA		54	40		1	1	
THARYX SP.		25	12		2	36	
CAULLERIELLA SP.		45		2		18	8
SPIOPHANES BOMBYX		48	4	1	4	11	2
APANTHURA MAGNIFICA		69					
NEPHTYS PICTA		32	7		9	10	9
CALLIANASSA BIFORMIS		7	5	15	15	6	13
EDOTEA MONTOSA		54		5	2		
CARINOMELLA LACTEA		11	15	7	4	6	15
NEMERTINEA		5	3	5	21	14	3
ARICIDEA SUECICA		19	7	2	2	7	13
NEMATODA		15	27	3		1	
SYNCHELIDIUM AMERICANUM		13	6	9	12	2	2
ABRA AEQUALIS		16	10	2	9	3	2
TURBELLARIA		2	1	5	18	11	4
SCOLELEPIS TEXANA		3	6	7	12	11	
AMPHARETE AMERICANA		20	3	3	8	1	1
PINNIXA SP.		4	7	16	2	2	
LEITOSCOLOPLOS FRAGILIS		2	4	7	12	3	1
LISTRIELLA BARNARDI		5		5		5	14
DRILONEREIS LONGA			2	8	5	2	10
TELLINA IRIS				24			2
PARAPRIONOSPIO PINNATA			2	2			21
NOTOMASTUS LATERICEUS		18	5			1	
ONUPHIS EREMITA				5	12	1	6
GLYCINDE SOLITARIA			5	1	3		13
ANTHURIDAE		20					
ACTEOCINA CANDEI			3	6	5	3	2
GLYCERA AMERICANA		4	7	1		3	
ARABELLIDAE			3	3	2	5	
ETEONE HETEROPODA		1			10	1	
NUCULA PROXIMA		6	5	1			
PARVILUCINA MULTILINEATA		7	3	1	1		
HEMICHORDATA				1			9
ARMANDIA AGILIS				7			2
DRILONEREIS MAGNA		8					
GLYCERA OXYCEPHALA		1			4	2	
DRILONEREIS SP.			6				

HD02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
GLYCERA DIBRANCHIATA		2			1	2	1
NEPHTYIDAE					6		
PINNIXA SAYANA			1	5			
HEMIPHOLIS ELONGATA			2		3		
SCOLELEPIS SQUAMATA		1	1		3		
AMASTIGOS CAPERATUS		1			3		
BATEA CATHARINENSIS			4				
BOCCARDIA SP.		4					
LEUCON SP.				3		1	
LISTRIELLA CLYMENELLAE			4				
MAGELONA PHYLLISAE			1	1			2
PINNOTHERIDAE		4					
STREBLOSPIO BENEDICTI			1	1		2	
CLYMENELLA TORQUATA		2	1				
CORBULA SP.		3					
CORBULA BARRATTIANA		3					
LEPTOCHELA SERRATORBITA				2			1
MALMGRENIA SP.							3
MICROPHIOPHOLIS GRACILLIMA		3					
MONOCULODES EDWARDSI		2	1				
PAGURUS LONGICARPUS		1		2			
ACETES AMERICANUS							2
AGLAOPHAMUS VERRILLI		1	1				
AMPHIURIDAE		1		1			
BOWMANIELLA SP.			1				1
BUSYCON CARICA				1	1		
CERAPUS TUBULARIS					2		
CYCLASPIS SP.			2				
DIOPATRA CUPREA			2				
DISPIO UNCINATA			1	1			
DIVARICELLA QUADRISULCATA			1			1	
GLYCERA SP.		1			1		
GLYCERA SPHYRABRANCHA					1	1	
MAGELONA ROSEA						1	1
MICROPROTOPUS RANEYI					2		
NEPHTYS BUCERA		2					
NEREIS SP.		1				1	
NOTOMASTUS LOBATUS			2				
OPHIUROIDEA				1	1		
ORBINIIDAE		2					
PARANAITIS SPECIOSA		2					
PHYLLODOCE ARENAE		1				1	
POLINICES DUPLICATUS					1	1	
PROTOHAUSTORIUS DEICHMANNAE			2				
RANGIA CUNEATA			2				
SCOLOPLOS RUBRA			1				1

HD02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
STREPTOSYLLIS PETTIBONEAE					2		
ACANTHOHAUSTORIUS MILLSI						1	
AMPHIODIA SP.							1
ANADARA TRANSVERSA			1				
ANCINUS DEPRESSUS		1					
ARABELLA IRICOLOR		1					
ASTHENOTHAERUS HEMPHILLI							1
AXIOGNATHUS SQUAMATUS		1					
CYCLASPIS BACESCUI		1					
CYCLASPIS VARIANS		1					
CYLICHNELLA BIDENTATA					1		
EPITONIUM ANGULATUM				1			
FIMBRIOSTHENELAIS SP.		1					
HEPATUS EPHELITICUS		1					
LEPTOSYNAPTA SP.		1					
MACOMA SP.			1				
MALMGRENIELLA SP.		1					
MANCOCUMA SP.				1			
MANGELIA QUADRATA							1
NEOHAUSTORIUS SCHMITZI					1		
NEOMYSIS AMERICANA		1					
NEREIS SUCCINEA				1			
NOTOMASTUS SP.						1	
OGYRIDES ALPHAEROSTRIS							1
OWENIA FUSIFORMIS		1					
PAGURUS HENDERSONI						1	
PARACAPRELLA TENUIS				1			
PARAHAUSTORIUS LONGIMERUS					1		
PARAONIDAE		1					
PARAONIS FULGENS			1				
POLYCHAETA		1					
POLYDORA SP.						1	
PRIONOSPIO DAYI		1					
PSEUDEURYTHOE SP.			1				
RENILLA RENIFORMIS			1				
SABELLARIA VULGARIS				1			
SIGAMBRA TENTACULATA			1				
SPIO PETTIBONEAE						1	
SYLLIDAE							1
TELLINA SP.		1					
TELLINA ALTERNATA							1
TEREBRA DISLOCATA				1			
THYONELLA GEMMATA					1		
TURRIDAE					1		

BC01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE	59	105	57	32	59	77	38
PARAONIS FULGENS	4	6	14	61	27	36	
EUDEVENOPUS HONDURANUS	1	26	4	32	14		
SOLEN VIRIDIS		1		3	1	58	3
SPIOPHANES BOMBYX	8	19	3	4	15	3	
TELLINA TEXANA		2	5	8	2	18	1
RHEPOXYNIUS EPISTOMUS	3		9	7	4	6	6
NEMERTINEA	1	4	4		13	8	2
OGYRIDES HAYI	5		10	1	3		2
ARICIDEA SUECICA				6	4	5	3
DISSODACTYLUS MELLITAE	2	7		2	1	4	
PARVILUCINA MULTILINEATA	2	4	1	3	1	2	2
ACANTHOHAUSTORIUS MILLSI	9					2	3
ARMANDIA AGILIS				11	1	2	
MEDIOMASTUS CALIFORNIENSIS				10	3		
AMASTIGOS CAPERATUS		2	1	6	3		
MELLITA QUINQUESPERFORATA	2	4		1	3	2	
OXYUROSTYLIS SMITHI	1	2		5	2	1	
PINNIXA CHAETOPTERANA				9	1		
SCOLELEPIS TEXANA		1	2	1		6	
BATHYPOREIA PARKERI	2	3	2		1		1
AXIOTHELLA MUCOSA					3	4	1
NEMATODA	1	6		1			
AGLAOPHAMUS VERRILLI		2	5				
BOWMANIELLA SP.		1	2	3			1
CALLIANASSA BIFORMIS				5	1	1	
SYNCHELIDIUM AMERICANUM		5		2			
OLIVELLA MUTICA	2			2	2		
CYCLASPIS VARIANS				4	1		
LEITOSCOLOPLOS FRAGILIS		1	2	1	1		
PINNIXA SP.			3	2			
THARYX SP.		3	1			1	
DISPIO UNCINATA					4		
METHARPINIA FLORIDANA		4					
NEPHTYS PICTA		3				1	
PINNIXA CRISTATA				4			
THYONELLA GEMMATA		1	1		2		
ACANTHOHAUSTORIUS INTERMEDIUS		2					1
CAULLERIELLA SP.	1			2			
NEPHTYIDAE	2		1				
NEPHTYS BUCERA				2			1
RENILLA RENIFORMIS				2	1		
SABELLARIA VULGARIS				3			
ABRA AEQUALIS		1				1	
BATEA CATHARINENSIS		1					1
EUDEVENOPUS HONDURANUS	2						

BC01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
LEPTOSYNAPTA SP.	2						
LISTRIELLA CLYMENELLAE			1	1			
MAGELONA PAPILLICORNIS	1	1					
MANGELIA QUADRATA						2	
PAGURUS LONGICARPUS		2					
TELLINA IRIS						2	
ACTEOCINA CANDEI				1			
AMPHARETE AMERICANA			1				
ANCINUS DEPRESSUS		1					
ANCISTROSYLLIS SP.			1				
ANTHURIDAE	1						
ARICIDEA WASSI					1		
ARMANDIA MACULATA	1						
BRANIA WELLFLEETENSIS						1	
CARINOMELLA LACTEA						1	
CAULLERIELLA SP.							1
CIRROPHORUS LYRIFORMIS				1			
CYCLASPIS SP.		1					
CYCLASPIS BACESCUI				1			
EMERITA TALPOIDA							1
GASTROPODA		1					
GLYCERA AMERICANA						1	
GLYCINDE SOLITARIA			1				
LEPIDOPA WEBSTERI	1						
MAGELONA SP.						1	
MANCOCUMA SP.		1					
MANCOCUMA SP.	1						
MULINIA LATERALIS				1			
NEPHTYS SP.						1	
OLIGOCHAETA	1						
OPHIOPHRAGMUS WURDEMANI		1					
OPHIUROIDEA						1	
PHYLLODOCE ARENAE						1	
PINNIXA FLORIDANA			1				
POLYDORA SOCIALIS		1					
SCOLELEPIS SQUAMATA						1	
SQUILLA EMPUSA						1	
STRIGILLA MIRABILIS							1
TELLINA AGILIS	1						
TEREBRA DISLOCATA							1
TURBELLARIA						1	

BC02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE	78	104	46	32	59	142	34
PARAONIS FULGENS	4	5	13	55		16	2
SOLEN VIRIDIS		2	2			48	6
RHEPOXYNIUS EPISTOMUS		3	1	4	5	31	11
EUDEVENOPUS HONDURANUS	1	12	6	6	8	7	
NEMERTINEA	2	6	7	7		4	3
SPIOPHANES BOMBYX		2	1			26	
NEPHTYS PICTA		9	16	3			
BATHYPOREIA PARKERI	4	20				1	
OGYRIDES HAYI			16	5	3	1	
TELLINA TEXANA		2	1	1	1	7	5
ACANTHOHAUSTORIUS MILLSI	2				2	3	6
BOWMANIELLA SP.		1	5	2			1
METHARPINIA FLORIDANA		7		1			
MANCOCUMA SP.	6						
SCOLELEPIS SQUAMATA		1		3		2	
OLIVELLA MUTICA				2	1	1	1
TELLINA IRIS					3	1	1
CALLIANASSA BIFORMIS						3	1
SCOLELEPIS TEXANA			3	1			
ACANTHOHAUSTORIUS INTERMEDIUS					1	2	
MANCOCUMA SP.		3					
OXYUROSTYLIS SMITHI	2					1	
PINNIXA CHAETOPTERANA						3	
SYNCHELIDIUM AMERICANUM				3			
AMPHARETE AMERICANA						2	
AXIOTHELLA MUCOSA						1	1
CLYMENELLA TORQUATA							2
ISOTOMA DISPAR	2						
LISTRIELLA BARNARDI					1		1
MAGELONA SP.	2						
MELLITA QUINQUESPERFORATA		1				1	
NEMATODA	1	1					
NEPHTYIDAE	1			1			
OPHIOPHRAGMUS WURDEMANI		1				1	
TURBELLARIA						2	
AMASTIGOS CAPERATUS				1			
BATEA CATHARINENSIS	1						
CAPITELLIDAE			1				
CYCLASPIS BACESCUI		1					
DISPIO UNCINATA							1
ETEONE HETEROPODA						1	
EXOGONE DISPAR		1					
GLYCERA OXYCEPHALA						1	
ISOTOMA DISPAR	1						
LEITOSCOLOPLOS FRAGILIS							1

BC02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
LEPTOSYNAPTA SP.				1			
LISTRIELLA CLYMENELLAE							1
MAGELONA PAPILLICORNIS	1						
MEDIOMASTUS CALIFORNIENSIS						1	
NEPHTYS BUCERA						1	
OGYRIDES ALPHAEROSTRIS		1					
PAGURUS LONGICARPUS			1				
PARVILUCINA MULTILINEATA							1
RENILLA RENIFORMIS				1			
STREBLOSPIO BENEDICTI						1	
STRIGILLA MIRABILIS							1

BC03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE	81	146	47	32	25	56	22
PARAONIS FULGENS	3	8	36	33	28	48	1
EUDEVENOPUS HONDURANUS	24	16	11	23	9	8	
SPIOPHANES BOMBYX	6	23	7	3	11	39	
RHEPOXYNIUS EPISTOMUS	6	3	13	6	5	28	8
SOLEN VIRIDIS			2	1	1	43	1
ACANTHOHAUSTORIUS INTERMEDIUS		10	1		2	4	10
BATHYPOREIA PARKERI	1	22	1	1	1	1	
NEMERTINEA	1	3	5	2	8	6	1
TELLINA TEXANA		3	2	5	9		3
ACANTHOHAUSTORIUS MILLSI	5	7	1		2	2	1
PARVILUCINA MULTILINEATA	1	1	4		1		6
ABRA AEQUALIS	1	1		2	5	1	
SCOLELEPIS TEXANA		2	1	4	1	1	1
AMASTIGOS CAPERATUS		1	5	2	1		
BOWMANIELLA SP.		1	2	4			2
DISPIO UNCINATA	2		2	1	2		2
OGYRIDES HAYI	2		4	1	1		
NEPHTYIDAE	3	4					
OLIVELLA MUTICA		2	1	2	1	1	
MELLITA QUINQUESPERFORATA			1	1	1		3
NEPHTYS BUCERA				3		3	
LEITOSCOLOPLOS FRAGILIS			4	1			
NEPHTYS PICTA			4				1
STRIGILLA MIRABILIS							5
SYNCHELIDIUM AMERICANUM	2	2		1			
AXIOTHELLA MUCOSA					3		1
BRANIA WELLFLEETENSIS							4
CYCLASPIS BACESCUI		2	2				
PINNIXA SAYANA			1				3
ARICIDEA SUECICA					1	2	
CARINOMELLA LACTEA		2				1	
MAGELONA PAPILLICORNIS				1		1	1
MANCOCUMA SP.		3					
NUCULA PROXIMA	1						2
OXYUROSTYLIS SMITHI	1	1					1
ARMANDIA AGILIS				2			
CYCLASPIS VARIANS				1	1		
GLYCERA AMERICANA			1		1		
GLYCERA OXYCEPHALA							2
LEPTOCHELA SERRATORBITA				2			
NEMATODA		2					
PAGURUS HENDERSONI		1				1	
PAGURUS LONGICARPUS		1					1
TELLINA IRIS						2	
THYONELLA GEMMATA		1		1			

BC03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
AMPHIURIDAE				1			
ANCINUS DEPRESSUS							1
ARMANDIA MACULATA	1						
CALLIANASSA BIFORMIS			1				
CAULLERIELLA SP.				1			
CHIRIDOTEA STENOPS		1					
CYCLASPIS SP.		1					
DISSODACTYLUS MELLITAE			1				
ETEONE HETEROPODA						1	
GLYCINDE SOLITARIA				1			
LEPIDOPA WEBSTERI			1				
LEPTOSYNAPTA SP.	1						
LISTRIELLA BARNARDI						1	
MAGELONA ROSEA			1				
METHARPINIA FLORIDANA		1					
NEOHAUSTORIUS SCHMITZI		1					
NEREIS SP.						1	
PHYLLODOCE ARENAE						1	
PINNIXA CHAETOPTERANA				1			
PRIONOSPIO CIRRIFERA			1				
RENILLA RENIFORMIS				1			
TELLINA AGILIS	1						
TIRON TRIOCELLATUS						1	
TRACHYPENAEUS CONSTRICTUS		1					
TURBELLARIA				1			

GB01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
SPIOPHANES BOMBYX		138			950	228	133
MEDIOMASTUS CALIFORNIENSIS		8		83	4	218	48
TELLINA TEXANA		57	6	103	8	18	3
THARYX SP.		95	2		2		
PROTOHAUSTORIUS DEICHMANNAE		2	29	2	55	2	
AMASTIGOS CAPERATUS		67			18		
OXYUROSTYLIS SMITHI		6		77			
SOLEN VIRIDIS		1		40	2	28	1
RHEPOXYNIUS EPISTOMUS		32	21	1	7	1	3
ABRA AEQUALIS		11		33	1	2	
CAULLERIELLA SP.		19		1		17	8
NEPHTYS PICTA		22				14	2
NEMERTINEA		6	4	5	15	2	1
OWENIA FUSIFORMIS		31				2	
MULINIA LATERALIS		1		27	2	1	
LISTRIELLA BARNARDI				9	4	12	5
NEMATODA		25	3		1		
PARVILUCINA MULTILINEATA		16		4		4	3
RENILLA RENIFORMIS			27				
TELLINA IRIS				1	22	2	
CYCLOSTREMELLA HUMILIS		24					
SPIO PETTIBONEAE					24		
PINNIXA SP.				22			
EUDEVENOPUS HONDURANUS			11	3	2	1	
PHYLLODOCE ARENAE		6			1	7	2
LEITOSCOLOPLOS FRAGILIS		2	1	2	3	6	1
ARMANDIA AGILIS				14			
ACANTHOHAUSTORIUS INTERMEDIUS			13				
ACANTHOHAUSTORIUS MILLSI			8		4		
AMPHARETE AMERICANA		1			6	3	
BATEA CATHARINENSIS		7	1		2		
NEOHAUSTORIUS SCHMITZI			10				
OLIGOCHAETA		9					
SCOLELEPIS TEXANA		2	4		3		
NUCULA PROXIMA		6		1		1	
ARICIDEA SUECICA		2		4	1		
CALLIANASSA BIFORMIS			3	3	1		
CARINOMELLA LACTEA				2	4	1	
DISPIO UNCINATA			1	2	3		
EDOTEA MONTOSA		5		1			
NOTOMASTUS LOBATUS					2	4	
ONUPHIS EREMITA		2		1	1		2
PRIONOSPIO DAYI				1	5		
AGLAOPHAMUS VERRILLI					5		
BOWMANIELLA SP.				1		2	2
LEMBOS WEBSTERI					5		

GB01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
MAGELONA PAPILLICORNIS		1			2	2	
OGYRIDES HAYI		1	4				
PINNIXA SAYANA			3	1			1
TURBELLARIA			1	2	1	1	
ALIGENA ELEVATA		4					
DONAX VARIABILIS		4					
GLYCERA OXYCEPHALA						4	
NEPHTYIDAE					4		
PINNIXA CHAETOPTERANA				3			1
AMPELISCA VERRILLI		3					
BATHYPOREIA PARKERI					2	1	
CLYMENELLA TORQUATA		3					
CYCLASPIS BACESCUI		1		2			
LISTRIELLA CLYMENELLAE		3					
NASSARIUS ALBUS						1	2
OGYRIDES ALPHAEROSTRIS		1	2				
OPHIUROIDEA		1				2	
PARAONIS FULGENS			1	1	1		
TEREBRA DISLOCATA		1	1				1
DIVARICELLA QUADRISULCATA		2					
GLYCINDE SOLITARIA						1	1
MICROPROTOPUS RANEYI				2			
NOTOMASTUS SP.				2			
SIGAMBRA TENTACULATA		1	1				
STRIGILLA MIRABILIS		1	1				
SYNCHELIDIUM AMERICANUM				2			
ACTEOCINA CANDEI				1			
AMPHIURIDAE				1			
AXIOTHELLA MUCOSA					1		
BARBATIA SP.		1					
CAPITELLIDAE				1			
CISTENIDES GOULDII						1	
CYCLASPIS SP.				1			
DORVILLEIDAE		1					
DRILONEREIS MAGNA		1					
GLYCERA AMERICANA		1					
GLYCERA SPHYRABRANCHA		1					
HEMIPHOLIS ELONGATA		1					
HEMIPODUS ROSEUS			1				
LEPTOCHELA SERRATORBITA							1
LOIMIA MEDUSA							1
LYONSIA HYALINA		1					
NEPHTYS BUCERA							1
NEREIDAE				1			
NEREIS SUCCINEA					1		
NOTOMASTUS HEMIPODUS				1			

GB01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
ODOSTOMIA LAEVIGATA							1
ORBINIIDAE		1					
PARAONIDAE		1					
PHYLLODOCE SP.		1					
PHYLLODOCE CASTANEA					1		
SCLERODACTYLA BRIAREUS					1		
THYONELLA GEMMATA		1					

GB02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
SPIOPHANES BOMBYX		149	1		217	107	6
PROTOHAUSTORIUS DEICHMANNAE			12	11	105	168	
MEDIOMASTUS CALIFORNIENSIS		74		2	12		55
TELLINA TEXANA		47	7	10	16	36	1
CAULLERIELLA SP.		95	2			4	1
PARVILUCINA MULTILINEATA		72			3	3	
ACANTHOHAUSTORIUS MILLSI			1		30	28	
TELLINA IRIS					28	15	
RHEPOXYNIUS EPISTOMUS		10	10	9	9	1	
NUCULA PROXIMA		35				1	
SPIO PETTIBONEAE				2	32		
NEPHTYS PICTA		29			2		1
ABRA AEQUALIS		10		10	1	9	
SOLEN VIRIDIS		2		5	1	21	1
TURBONILLA SP.		28				1	
CLYMENELLA TORQUATA		19			1		
EUDEVENOPUS HONDURANUS			3	14	1	2	
NEMATODA		18					
ARICIDEA SUECICA		4		2	7	4	
RENILLA RENIFORMIS			16	1			
PRIONOSPIO DAYI			3	9	4		
CARINOMELLA LACTEA		8			2	1	4
NEMERTINEA			4		9	2	
PARAONIS FULGENS			5	1	9		
LISTRIELLA CLYMENELLAE		11					3
ACANTHOHAUSTORIUS INTERMEDIUS			3	1		9	
LISTRIELLA BARNARDI		1		2		1	8
SCOLELEPIS TEXANA			1	3	5	2	
SYNCHELIDIUM AMERICANUM		1	4	2	3		
AMPELISCA VERRILLI		7		1		1	
PHYLLODOCE ARENAE		2				5	2
LEITOSCOLOPLOS FRAGILIS		2			1		5
MULINIA LATERALIS		2	3		1	1	1
OXYUROSTYLIS SMITHI			1	5	1	1	
OWENIA FUSIFORMIS		7					
PSEUDEURYTHOE AMBIGUA		5	1				1
NEPHTYS BUCERA						6	
ACTEOCINA CANDEI					1		4
AMASTIGOS CAPERATUS		1			1	3	
CALLIANASSA BIFORMIS			2	2			1
ONUPHIS EREMITA		1	1	2	1		
OPHELINA ACUMINATA			5				
PAGURUS HENDERSONI		4					1
DISPIO UNCINATA			3			1	
MELLITA QUINQUESPERFORATA			1	2		1	
BOWMANIELLA SP.			1	1			1

GB02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
GLYCERA AMERICANA		3					
GLYCERA SPHYRABRANCHA						3	
HEMIPODUS ROSEUS			1			2	
LEPTOCHELA SERRATORBITA			1				2
NOTOMASTUS LATERICEUS		3					
PINNIXA SAYANA				1			2
ALIGENA ELEVATA		1					1
AMPHARETE AMERICANA					1		1
ARMANDIA AGILIS					1		1
BATEA CATHARINENSIS							2
CHAETOGNATHA						2	
ENSIS DIRECTUS				1	1		
GLYCINDE SOLITARIA							2
MAGELONA PHYLLISAE		2					
MAGELONA ROSEA		2					
NOTOMASTUS SP.							2
OGYRIDES ALPHAEROSTRIS			2				
PARAPRIONOSPIO PINNATA							2
POLINICES DUPLICATUS					1		1
STHENELAIS BOA							2
STRIGILLA MIRABILIS					2		
AXIOTHELLA MUCOSA							1
BATHYPOREIA PARKERI							1
BRANCHIOSTOMA CARIBAEUM			1				
BRANIA WELLFLEETENSIS		1					
CABIRA INCERTA		1					
CAPITELLA CAPITATA		1					
CISTENIDES GOULDII		1					
DIOPATRA CUPREA							1
DISSODACTYLUS MELLITAE						1	
ERICHTHONIUS BRASILIENSIS						1	
GLYCERA DIBRANCHIATA						1	
LUMBRINERIS LATREILLI				1			
MAGELONA SP.							1
MAGELONA PAPILLICORNIS							1
MICROPROTOPUS RANEYI							1
MONOCULODES EDWARDSI					1		
NEREIDAE			1				
NOTOMASTUS HEMIPODUS		1					
NOTOMASTUS LOBATUS				1			
OLIGOCHAETA		1					
OSTRACODA					1		
PELECYPODA						1	
PHYLLODOCE CASTANEA						1	
PINNIXA SP.				1			
POLYDORA SOCIALIS		1					

GB02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PRIONOSPIO CIRRIFERA		1					
PYRAMIDELLA CRENULATA		1					
SCOLELEPIS SQUAMATA		1					
SIGAMBRA TENTACULATA		1					
SIPUNCULA						1	
TEREBRA CONCAVA		1					
TEREBRA DISLOCATA					1		
THARYX SP.							1
TRACHYPENAEUS CONSTRICTUS							1

GB03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
SPIOPHANES BOMBYX		24		1	329	357	151
TELLINA IRIS				35	9	27	
PROTOHAUSTORIUS DEICHMANNAE		25	2	6	8	15	
TELLINA TEXANA		28	9		10	4	
SOLEN VIRIDIS		2		10	3	21	13
MEDIOMASTUS CALIFORNIENSIS			3	4	10	19	6
NEPHTYS PICTA		15			10	8	2
NEREIS SUCCINEA				32	1		
CAULLERIELLA SP.		4		1		23	4
NEMERTINEA		8	1	4	6	10	3
RENILLA RENIFORMIS			32				
MULINIA LATERALIS		1	7	11	4	7	
LISTRIELLA BARNARDI				12		9	7
RHEPOXYNIUS EPISTOMUS		11	1	14	2		
PARVILUCINA MULTILINEATA		17		1		4	1
LEITOSCOLOPLOS FRAGILIS		4	1	5	2	5	2
PRIONOSPIO DAYI			1	8	7	2	
ARMANDIA AGILIS				13	2		
EUDEVENOPUS HONDURANUS				12		1	
SPIO PETTIBONEAE				2	11		
ABRA AEQUALIS		1		8		2	
PARAONIS FULGENS				1	9		
AMASTIGOS CAPERATUS		5		2		2	
ARICIDEA SUECICA		1		3	3	2	
CALLIANASSA BIFORMIS			5	1		1	2
OXYUROSTYLIS SMITHI		4		1	1	2	
PHYLLODOCE ARENAE		1				7	
DISPIO UNCINATA		2		2	3		
PRIONOSPIO CIRRIFERA		3	3	1			
SABELLARIA VULGARIS				7			
SCOLELEPIS TEXANA		1	3	3			
SYNCHELIDIUM AMERICANUM			5	1			1
ACANTHOHAUSTORIUS INTERMEDIUS			4	1		1	
GLYCERA AMERICANA					1	5	
PINNIXA SAYANA				2			4
GLYCERA DIBRANCHIATA							5
MAGELONA ROSEA		4			1		
PINNIXA SP.			1	2		1	1
CARINOMELLA LACTEA					3	1	
GLYCERA OXYCEPHALA		1				3	
NEMATODA		2	2				
OPHELINA ACUMINATA			4				
TURBONILLA SP.		1		2	1		
ALIGENA ELEVATA						3	
AXIOTHELLA MUCOSA		2				1	
BOWMANIELLA SP.			1	1			1

GB03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
MAGELONA PAPILLICORNIS			1			2	
NOTOMASTUS LOBATUS				1		1	1
PAGURUS LONGICARPUS				1			2
SIGAMBRA TENTACULATA				1	1		1
TEREBRA DISLOCATA						1	2
THARYX SP.		2	1				
TURBELLARIA			1	2			
ACANTHOHAUSTORIUS MILLSI			1		1		
ACETES AMERICANUS				1			1
ARMANDIA MACULATA				1	1		
CHAETOGNATHA						2	
LEPTOCHELA SERRATORBITA			1	1			
NEPHTYS BUCERA						2	
NEREIDAE				2			
NUCULA PROXIMA						2	
OGYRIDES SP.		1	1				
OGYRIDES ALPHAEROSTRIS			2				
OGYRIDES HAYI			2				
ONUPHIS EREMITA							2
OWENIA FUSIFORMIS						1	1
ACTINIARIA							1
AMPHARETE AMERICANA			1				
ANCINUS DEPRESSUS						1	
ASTHENOTHAERUS HEMPHILLI						1	
BATEA CATHARINENSIS			1				
BRANIA WELLFLEETENSIS							1
CLYMENELLA TORQUATA					1		
CYCLASPIS BACESCUI				1			
DRILONEREIS LONGA							1
ECHINOIDEA		1					
EMERITA TALPOIDA							1
ENSIS DIRECTUS		1					
GONIADA LITTOREA						1	
LISTRIELLA CLYMENELLAE		1					
MAGELONA SP.						1	
MYSIDOPSIS BIGELOWI				1			
NOTOMASTUS SP.				1			
OLIVELLA MUTICA		1					
OPHIUROIDEA							1
OVALIPES STEPHENSONI						1	
PARAPRIONOSPIO PINNATA			1				
PHYLLODOCE CASTANEA					1		
PINNIXA CHAETOPTERANA			1				
PSEUDEURYTHOE AMBIGUA			1				
SCOLELEPIS SQUAMATA						1	
SPIOPHANES MISSIONENSIS						1	

GB03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
STRIGILLA MIRABILIS			1				
TRACHYPENAEUS CONSTRICTUS							1
TURRIDAE				1			

JB01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PROTOHAUSTORIUS DEICHMANNAE	102		51		25	18	
TELLINA TEXANA		2	7	3	43	26	
SPIOPHANES BOMBYX	1				16	29	
SOLEN VIRIDIS	1		1			40	
LEITOSCOLOPLOS FRAGILIS		5	1	1	2	15	
THARYX SP.			2			21	
ACTEOCINA CANDEI				4	6	12	
SCOLELEPIS TEXANA		1			10	8	
PARAONIS FULGENS	5		3		4	3	
NEMERTINEA	1		3		4	5	
NEPHTYS PICTA	2					7	
AMASTIGOS CAPERATUS	1				6	1	
CARINOMELLA LACTEA		1			4	2	
EUDEVENOPUS HONDURANUS			3		1	3	
SYNCHELIDIUM AMERICANUM	1		3		2	1	
MEDIOMASTUS CALIFORNIENSIS		1	3		1	1	
NEMATODA	6						
RHEPOXYNIUS EPISTOMUS					1	5	
DISPIO UNCINATA			1		2	2	
LEUCON SP.		5					
AXIOTHELLA MUCOSA						4	
STREBLOSPIO BENEDICTI		2			2		
ABRA AEQUALIS			1	2			
ACANTHOHAUSTORIUS MILLSI					1	2	
CALLIANASSA BIFORMIS			1			2	
MANCOCUMA SP.	3						
MULINIA LATERALIS		1		2			
NEPHTYIDAE	1		1		1		
PARVILUCINA MULTILINEATA					1	2	
BOWMANIELLA SP.			1		1		
DONAX VARIABILIS	2						
GLYCINDE SOLITARIA		2					
MANGELIA QUADRATA					1	1	
OXYUROSTYLIS SMITHI		1	1				
PAGURUS HENDERSONI						2	
PARAPRIONOSPIO PINNATA				2			
ACANTHOHAUSTORIUS INTERMEDIUS			1				
BATHYPOREIA PARKERI			1				
CAULLERIELLA SP.	1						
EDOTEA MONTOSA		1					
ETEONE HETEROPODA		1					
GLYCERA SPHYRABRANCHA						1	
LEITOSCOLOPLOS FRAGILIS	1						
LEPTOCHELA SERRATORBITA				1			
LISTRIELLA CLYMENELLAE						1	
MAGELONA ROSEA						1	

JB01

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
MALDANIDAE					1		
MYSIDACEA	1						
NEOMYSIS AMERICANA	1						
NEREIS SUCCINEA						1	
OLIGOCHAETA			1				
PHYLLODOCE ARENAE						1	
RENILLA RENIFORMIS			1				
SCOLELEPIS SQUAMATA					1		
SIGAMBRA TENTACULATA	1						
STRIGILLA MIRABILIS	1						
TELLINA IRIS						1	
TEREBRA DISLOCATA	1						
TURBONILLA SP.	1						

JB02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
ACTEOCINA CANDEI				359	2	2	
MULINIA LATERALIS			51	4	29	214	
TELLINA TEXANA		2	59	4	81	1	
PROTOHAUSTORIUS DEICHMANNAE	107	1			3		
MEDIOMASTUS CALIFORNIENSIS				9	41	11	
LEUCON SP.		27			2		
LEITOSCOLOPLOS FRAGILIS		4		2	19	1	
SYNCHELIDIUM AMERICANUM	1			2	11		
PARAPRIONOSPIO PINNATA				5	3	4	
MANCOCUMA SP.			11				
NEPHTYS PICTA					8		
NEMATODA	3		4				
NEMERTINEA	5			1			
LEITOSCOLOPLOS FRAGILIS	5						
TELLINA SP.	5						
CARINOMELLA LACTEA				2	2		
MANGELIA QUADRATA				1	3		
ONUPHIS EREMITA			4				
SOLEN VIRIDIS		1		3			
DONAX VARIABILIS	2				1		
GLYCINDE SOLITARIA		1		1	1		
ABRA AEQUALIS					1	1	
ETEONE HETEROPODA					2		
GLYCERA AMERICANA	1			1			
MONOCULODES EDWARDSI					2		
NASSARIUS SP.						2	
RHEPOXYNIUS EPISTOMUS	2						
ACANTHOHAUSTORIUS MILLSI	1						
ALIGENA ELEVATA			1				
AMPHARETIDAE			1				
ARABELLIDAE					1		
ARICIDEA WASSI	1						
DISPIO UNCINATA	1						
HETEROMASTUS FILIFORMIS	1						
MALDANIDAE	1						
MELLITA QUINQUESPERFORATA	1						
MYSIDACEA	1						
NEOMYSIS AMERICANA	1						
NEREIS LAMELLOSA						1	
ODOSTOMIA SP.			1				
OGYRIDES SP.			1				
OLIGOCHAETA				1			
OXYUROSTYLIS SMITHI					1		
PARAHAUSTORIUS LONGIMERUS	1						
PINNIXA SAYANA			1				
POLINICES DUPLICATUS						1	

JB02

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
SCOLELEPIS SQUAMATA	1						
SCOLELEPIS TEXANA			1				
SPIOPHANES BOMBYX	1						
TEREBRA DISLOCATA	1						

JB03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
ACTEOCINA CANDEI				170	141	2	
MULINIA LATERALIS			53	3	1	120	
PROTOHAUSTORIUS DEICHMANNAE	110		1		2		
MEDIOMASTUS CALIFORNIENSIS			1	6	41	55	
TELLINA TEXANA		1	11	1	24		
LEUCON SP.		21					
ACANTHOHAUSTORIUS MILLSI	11	1					
PARAHAUSTORIUS LONGIMERUS	12						
PARAPRIONOSPIO PINNATA				7	2	3	
DONAX VARIABILIS	11						
LEITOSCOLOPLOS FRAGILIS		1			4	5	
NEPHTYS PICTA					9		
NEMERTINEA	6					2	
SYNCHELIDIUM AMERICANUM				3	5		
CARINOMELLA LACTEA				2	3	2	
SCOLELEPIS TEXANA					5	2	
STREBLOSPIO BENEDICTI					6		
ETEONE HETEROPODA					4	1	
NEOMYSIS AMERICANA		4					
CAULLERIELLA SP.		1			2		
MANCOCUMA SP.	3						
POLINICES DUPLICATUS					3		
ASTYRIS LUNATA			2				
GLYCINDE SOLITARIA				1		1	
MANGELIA QUADRATA				2			
NUCULA PROXIMA	1	1					
PALAEMONETES SP.		2					
PARAONIS FULGENS	2						
SPIOPHANES BOMBYX					2		
TURBELLARIA						2	
ABRA AEQUALIS						1	
AMPELISCA VERRILLI					1		
ANTHURIDAE	1						
BATHYPOREIA PARKERI	1						
BOWMANIELLA SP.			1				
HEMICHORDATA					1		
HOLOTHUROIDEA					1		
LEITOSCOLOPLOS FRAGILIS	1						
MACOMA TENTA				1			
MAGELONA ROSEA						1	
NEMATODA	1						
ODOSTOMIA SP.			1				
OGYRIDES HAYI	1						
OLIGOCHAETA			1				
OXYUROSTYLIS SMITHI		1					
PINNIXA SP.						1	

JB03

SPECIES	WIN90	SPR90	SUM90	FAL90	WIN91	SPR91	SUM91
PINNIXA CHAETOPTERANA				1			
RHEPOXYNIUS EPISTOMUS					1		
SIGALIONIDAE						1	
SOLEN VIRIDIS						1	
STHENELAIS BOA		1					

Appendix III.1. Mean number of animals caught per 1000 cubic meters of water filtered for each species at each station, by month. * Indicates active nourishment during this month.

Nearshore Stations

Phase 1

	March	April*	May*	June	July	Aug.
Penaeus aztecus	0.89	1.12	1.33	0	0.96	-
Penaeus duorarum	0	3.35	23.89	2.97	15.33	-
Penaeus setiferus	0	0	0	5.94	1.92	-
Callinectes sapidus	2.66	2.24	7.96	1.48	904.54	-
Callinectes similis	7.09	0	0	0	0	-
Cynoscion nebulosus	0	0	0	0	0.96	-
Leiostomus xanthurus	0	0	0	0	0	-
Menticirrhus sp.	0.89	0	9.29	10.39	0.96	-
Micropogonias undulatus	149.85	0	0	0	0	-
Sciaenops ocellata	0	0	0	0	0	-
Serranidae	0	0	0	0	0	-

Phase 2

	March	April	May	June*	July*	Aug.
Penaeus aztecus	0	3.36	13.72	0	0.88	4.23
Penaeus duorarum	0	3.36	103.68	0	3.54	25.40
Penaeus setiferus	0	0	65.56	8.39	7.07	2.12
Callinectes sapidus	3.81	0	0	0	56.59	16.93
Callinectes similis	13.32	0	0	0	0	12.70
Cynoscion nebulosus	0	0	0	1.40	0	2.12
Leiostomus xanthurus	1.90	0	0	0	0	0
Menticirrhus sp.	0	1.68	1.52	8.39	0	33.87
Micropogonias undulatus	27.59	0	0	0	0	0
Sciaenops ocellata	0	0	0	0	0	148.17
Serranidae	0	0	0	0	0	0

Appendix III.1. continued. * indicates active dredging during this month.

Offshore Borrow Sites

Joiner Bank

	March	April*	May*	June	July	Aug.
Penaeus aztecus	0	0	2.00	0	0	-
Penaeus duorarum	0	0	0	1.06	0	-
Penaeus setiferus	0	0	0	0	0	-
Callinectes sapidus	31.06	10.83	0	0	4.22	-
Callinectes similis	0.61	0	0	0	0	-
Cynoscion nebulosus	0	0	0	0	0	-
Leiostomus xanthurus	1.83	0	0	0	0	-
Menticirrhus sp.	0	0	228.23	59.85	2.11	-
Micropogonias undulatus	20.71	0	2.00	0	0	-
Sciaenops ocellata	0	0	0	0	0	-
Serranidae	0.61	0	2.00	0	0	-

Gaskin Bank

	March	April	May	June*	July*	Aug.
Penaeus aztecus	-	0	0	0	0	0
Penaeus duorarum	-	0	0	0	0	8.00
Penaeus setiferus	-	0	0	0	0	0
Callinectes sapidus	-	4.55	4.94	0	19.87	51.21
Callinectes similis	-	0	0	0	0	0
Cynoscion nebulosus	-	0	0	0	2.48	0
Leiostomus xanthurus	-	0	0	0	0	0
Menticirrhus sp.	-	4.55	0	35.55	7.45	12.80
Micropogonias undulatus	-	0	0	0	0	0
Sciaenops ocellata	-	0	0	0	0	1.60
Serranidae	-	0	0	0	0	0

Appendix III.1. continued.

Offshore Control Site

	March	April	May	June	July	Aug.
Penaeus aztecus	3.13	0	0	0	0	0
Penaeus duorarum	0	0	0	10.65	0	4.97
Penaeus setiferus	0	0	0	22.64	0	0
Callinectes sapidus	50.11	0	1.50	0	4.76	0
Callinectes similis	34.45	0	0	0	0	0
Cynoscion nebulosus	0	0	3.00	0	0	0
Leiostomus xanthurus	2.35	0	0	0	0	0
Menticirrhus sp.	0	4.47	18.02	105.19	7.15	4.97
Micropogonias undulatus	16.44	0	0	0	0	0
Sciaenops ocellata	0	0	0	0	0	3.31
Serranidae	0	0	0	0	0	0

Appendix IV.1 A listing of all fishes encountered off the front beach of Hilton Head Island in 1990. Ranking is by descending number of individuals.

Species		
Common Name	*Scientific Name*	Number
YELLOWFIN MENHADEN	*BREVOORTIA SMITHI*	214
SEA CATFISH	*ARIOPSIS FELIS*	204
ATLANTIC MENHADEN	*BREVOORTIA TYRANNUS*	124
BLUEFISH	*POMATOMUS SALTATRIX*	97
SPANISH MACKEREL	*SCOMBEROMORUS MACULATUS*	65
GAFFTOPSAIL CATFISH	*BAGRE MARINUS*	55
ATLANTIC SHARPNOSE SHARK	*RHIZOPRIONODON TERRAENOVAE*	44
RED DRUM	*SCIAENOPS OCELLATA*	29
BONNETHEAD SHARK	*SPHYRNA TIBURO*	28
SPOTTED SEATROUT	*CYNOSCION NEBULOSUS*	24
ATLANTIC BUMPER	*CHLOROSCOMBRUS CHRYSURUS*	20
GULF WHITING	*MENTICIRRHUS LITTORALIS*	17
SOUTHERN WHITING	*MENTICIRRHUS AMERICANUS*	16
STAR DRUM	*STELLIFER LANCEOLATUS*	9
SILVER SEATROUT	*CYNOSCION NOTHUS*	7
SPOT	*LEIOSTOMUS XANTHURUS*	7
CREVALLE JACK	*CARANX HIPPOS*	4
INSHORE LIZARDFISH	*SYNODUS FOETENS*	4
BLUE RUNNER	*CARANX CRYSOS*	3
WEAKFISH	*CYNOSCION REGALIS*	3
HARVESTFISH	*PEPRILUS ALEPIDOTUS*	3
POMPANO	*TRACHINOTUS CAROLINUS*	3
FINETOOTH SHARK	*CARCHARHINUS ISODON*	2
BLUNTNOSE STINGRAY	*DASYATIS SAYI*	2
STRIPED MULLET	*MUGIL CEPHALUS*	2
ATLANTIC THREAD HERRING	*OPISTHONEMA OGLINUM*	2
BUTTERFISH	*PEPRILUS TRIACANTHUS*	2
BLACK DRUM	*POGONIAS CROMIS*	2
SPOTTED EAGLE RAY	*AETOBATUS NARINARI*	1
BLACKTIP SHARK	*CARCHARHINUS LIMBATUS*	1
LADYFISH	*ELOPS SAURUS*	1
SMOOTH BUTTERFLY RAY	*GYMNURA MICRURA*	1
BANDED DRUM	*LARIMUS FASCIATUS*	1
TRIPLETAIL	*LOBOTES SURINAMENSIS*	1
CROAKER	*MICROPOGONIAS UNDULATUS*	1
BULLNOSE RAY	*MYLIOBATIS FREMINVILLEI*	1
KING MACKEREL	*SCOMBEROMORUS CAVALLA*	1
WINDOWPANE	*SCOPHTHALMUS AQUOSUS*	1
NORTHERN PUFFER	*SPHOEROIDES MACULATUS*	1
HOGCHOKER	*TRINECTES MACULATUS*	1

Appendix V.1 Means ($\bar{x}$) and standard errors (se) of quarterly bottom turbidities (NTU).

OFFSHORE	Joiner Bank		Control Area		Gaskin Bank	
	$\bar{x}$	se	$\bar{x}$	se	$\bar{x}$	se
Win 90	79.0	15.6	7.0	0.0	---	---
Spr 90	107.7	41.3	4.9	0.3	6.9	1.5
Sum 90	82.8	40.0	21.8	2.3	17.0	2.5
Fal 90	23.0	6.0	24.7	5.8	20.3	5.9
Win 91	28.6	3.2	6.0	0.5	5.5	0.3
Spr 91	29.8	16.3	2.8	0.4	23.1	4.3
Sum 91	---	---	2.6	1.6	1.8	0.3

NEARSHORE	50' Phase I		200' Phase I		50' Phase II		200' Phase II		50' Control		200' Control	
	$\bar{x}$	se	$\bar{x}$	se	$\bar{x}$	se	$\bar{x}$	se	$\bar{x}$	se	$\bar{x}$	se
Win 90	30.0	4.0	29.5	2.5	---	---	---	---	24.5	6.5	28.7	6.6
Spr 90	16.6	1.4	18.9	4.2	21.7	6.3	5.5	1.5	20.4	0.7	21.2	1.8
Sum 90	28.3	5.0	26.2	0.9	25.0	0.7	52.5	9.2	15.5	4.8	10.0	0.0
Fal 90	4.2	0.4	24.5	9.5	5.6	0.8	14.6	8.4	3.8	0.0	2.2	0.6
Win 91	52.0	15.0	45.0	9.0	35.3	5.8	47.2	8.4	14.0	0.0	11.5	0.5
Spr 91	13.8	0.8	17.8	0.2	10.0	0.0	17.5	6.5	38.0	4.4	32.0	3.0
Sum 91	---	---	---	---	26.0	0.0	41.1	27.3	32.5	6.5	40.8	8.2