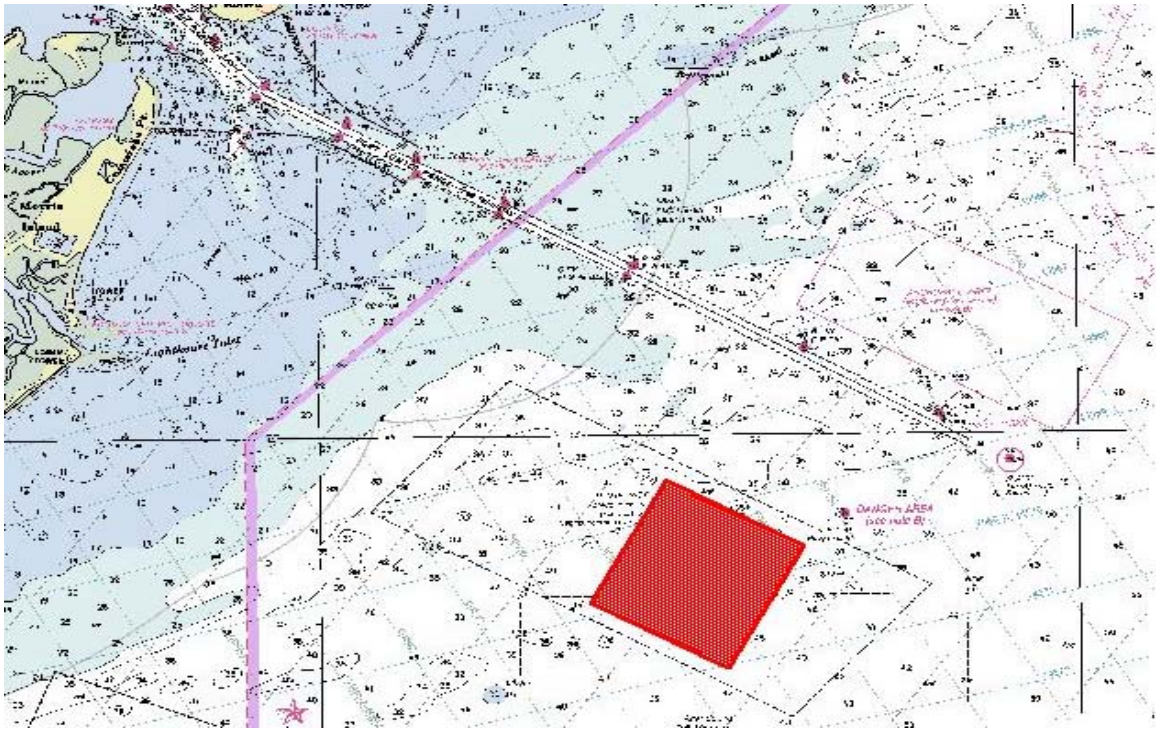
# An Environmental Assessment of the Charleston Ocean Dredged Material Disposal Site And Surrounding Areas:

Physical and Biological Conditions after Partial Completion of the Charleston Harbor Deepening Project

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U.S. Corps of Engineers
Charleston District

# FINAL REPORT

An Environmental Assessment
of the
Charleston Ocean Dredged Material Disposal Site
and Surrounding Areas:

*Physical and Biological Conditions*
*After Partial Completion of the*
*Charleston Harbor Deepening Project*

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# EXECUTIVE SUMMARY

This report evaluates the physical and biological condition of bottom habitats within and surrounding the Charleston Offshore Dredge Material Disposal Site (ODMDS) approximately halfway through the 1999-2002 Charleston Harbor Deepening Project. Physical and biological conditions summarized in this report include sediment characteristics, sediment contaminants, and benthic assemblages in the disposal zone, inner boundary zone, and outer boundary zone. These results represent a portion of an ongoing, long-term monitoring program. The larger monitoring program also included side scan sonar surveys, sediment mapping surveys, assessments of hard bottom reef communities, and measurements of disposal sediment mobility and transport in the region. Detailed findings from the other portions of the monitoring program are reported elsewhere.

The ODMDS disposal zone and surrounding boundary areas were divided into 20 discrete strata of comparable size, approximately one square mile. Benthic grab samples for sediment characteristics, sediment contaminants, and benthic assemblage analysis were collected at ten randomly selected locations within each of the twenty strata. Sediment characteristics included percent silt/clay, percent sand, percent $CaCO_3$, organic matter content, and grain size of the sand fraction. Sediment contaminants measured were trace metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides. Benthic assemblage parameters evaluated included total density, number of species, density of general taxonomic groups, and density of numerically dominant taxa. A cluster analysis based on benthic species composition and density was also conducted.

The disposal of fine-grained inner harbor sediments into the Charleston offshore disposal zone has resulted in a number of physical and biological impacts to the area surrounding the disposal zone. Sediment characteristics to the west of the disposal zone are altered relative to typical levels in nearshore South Carolina waters. These changes in sediment characteristics have, in turn, impacted the benthic community living to the west of the disposal zone. Mean density, number of species, density of certain taxon groups, and density of several dominant taxa have been altered in those strata located to the west and northwest of the disposal zone.

The current disposal activities resulted in the placement of fine-grained inner harbor materials in the western and central portions of the disposal zone, while shelly sands from the entrance channel were used to build upon the eastern berm of the disposal zone. As expected, sediment characteristics within the disposal zone were significantly different from those in the boundary zones. Sediment characteristics were also significantly different from earlier baseline sampling conducted in 1993 and 1994. Although disposal effects were intended to be limited to the disposal zone, silt/clay content in the inner and outer boundary zones was significantly higher in 2000 than in baseline studies. This increase in muddy sediments was most evident in the areas to the west of the disposal zone. The probable source of elevated silt/clay levels in the

boundary zones is migration of materials from the disposal site or unauthorized dumping of disposal material.

Sediment contaminant levels were low within the disposal zone and surrounding areas. Trace metal, PAH, PCB, and pesticide concentrations were all below published bioeffects guidelines. Contaminant concentrations above the detection limit were found in a number of strata, but highest levels were consistently found in disposal zone sediments. This suggests that the presence of contaminated sediments was low and limited to within the disposal zone.

This report focuses on the condition of benthic infaunal assemblages in the inner and outer boundary zones. Although biological effects within the disposal zone were anticipated, analyses in these areas were limited to sediment characteristics and contaminants in an effort to lower study costs. Cluster analyses revealed that the benthic community structure at impacted areas was distinct from the benthic community structure at non-impacted areas. Benthic infaunal populations within the boundary areas impacted by disposal of dredge materials (i.e. to the west of the disposal zone) showed decreased faunal densities and number of species. Other benthic parameters, such as the density of certain taxonomic groups and the density of dominant taxa, were also altered in areas impacted by disposal activities. Declines in the density of organisms within the disposal area, as well as in surrounding areas, may cause long-term effects due to reduced local recruitment.

Monitoring activities at the disposal site should not cease upon the completion of large-scale disposal operations because these monitoring efforts are needed to document the duration and fate of disposed sediments and long-term trends at the site. Therefore, SCDNR recommends that the planned post-assessment and three-year post-assessment of the Charleston ODMDS and surrounding areas be completed using the same sampling strategies used for the baseline and 2000 surveys. In addition, the continuation of monitoring efforts at hard bottom reef sites, planned through at least spring 2005, is warranted to document the status of biological resources, habitat condition, and areal extent.

Continued monitoring of the Charleston disposal zone and surrounding areas is particularly critical in the face of ongoing disposal operations, future disposal operations, and possible site expansion requests. Based on the data collected during the post-assessment studies, specific recommendations for monitoring in subsequent years of the program may change, and findings may warrant an extension in the length of the monitoring program.

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# INTRODUCTION

## Site History

The Charleston, South Carolina, Ocean Dredged Material Disposal Site (ODMDS) is actively used by the U.S. Army Corps of Engineers to receive bottom sediments dredged from channel maintenance and deepening projects in the Charleston Harbor estuary. The configuration of this ODMDS has changed over the past 15 years with respect to the location and size of the areas where recent disposal operations have occurred (Van Dolah *et al.* 1996, 1997; Winn *et al.* 1989). Authorized disposal activities have taken place within a larger area that encompassed approximately 5.3 x 2.3 nautical miles (Figure 1, labeled "larger ODMDS"). Prior to the current location, a 2.8 x 1.1 nautical mile site (Figure 1, labeled "old disposal area") was used until it was discovered that dumping operations were impacting a live bottom area within the western quarter of that area. In 1993, an interagency Task Force identified a new location four square miles in size that was located in the outer portion of the larger ODMDS for disposal of future materials. A Management Plan for this ODMDS included a comprehensive monitoring plan for the site that is described in the Charleston ODMDS Site Management and Monitoring Plan (1993). The four square mile disposal zone and surrounding areas were divided into three zones representing the disposal zone, inner boundary zone, and outer boundary zone (Figure 2), which were further subdivided into 20 discrete strata of comparable size (one square mile). Based on the Site Management and Monitoring Plan, the U.S. Army Corps of Engineers (USACE) began building an L-shaped berm on the western side of the four square mile disposal zone using material from the 1991-1996 deepening project. The berm was to be constructed of harder materials and was designed

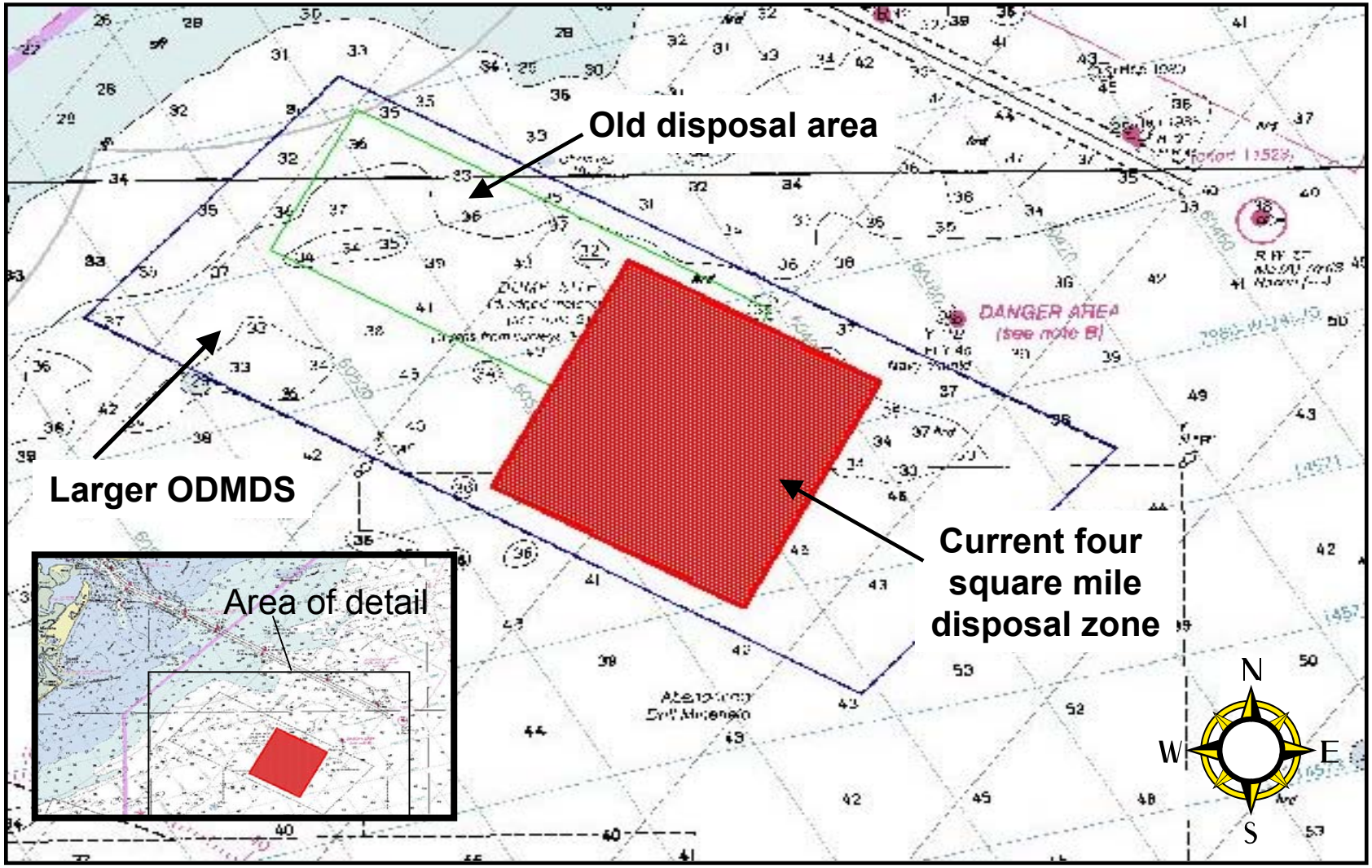



Figure 1. Location of the larger ODMDS (blue box), old disposal area (green box), and current four square mile disposal zone (red box). See text for details.

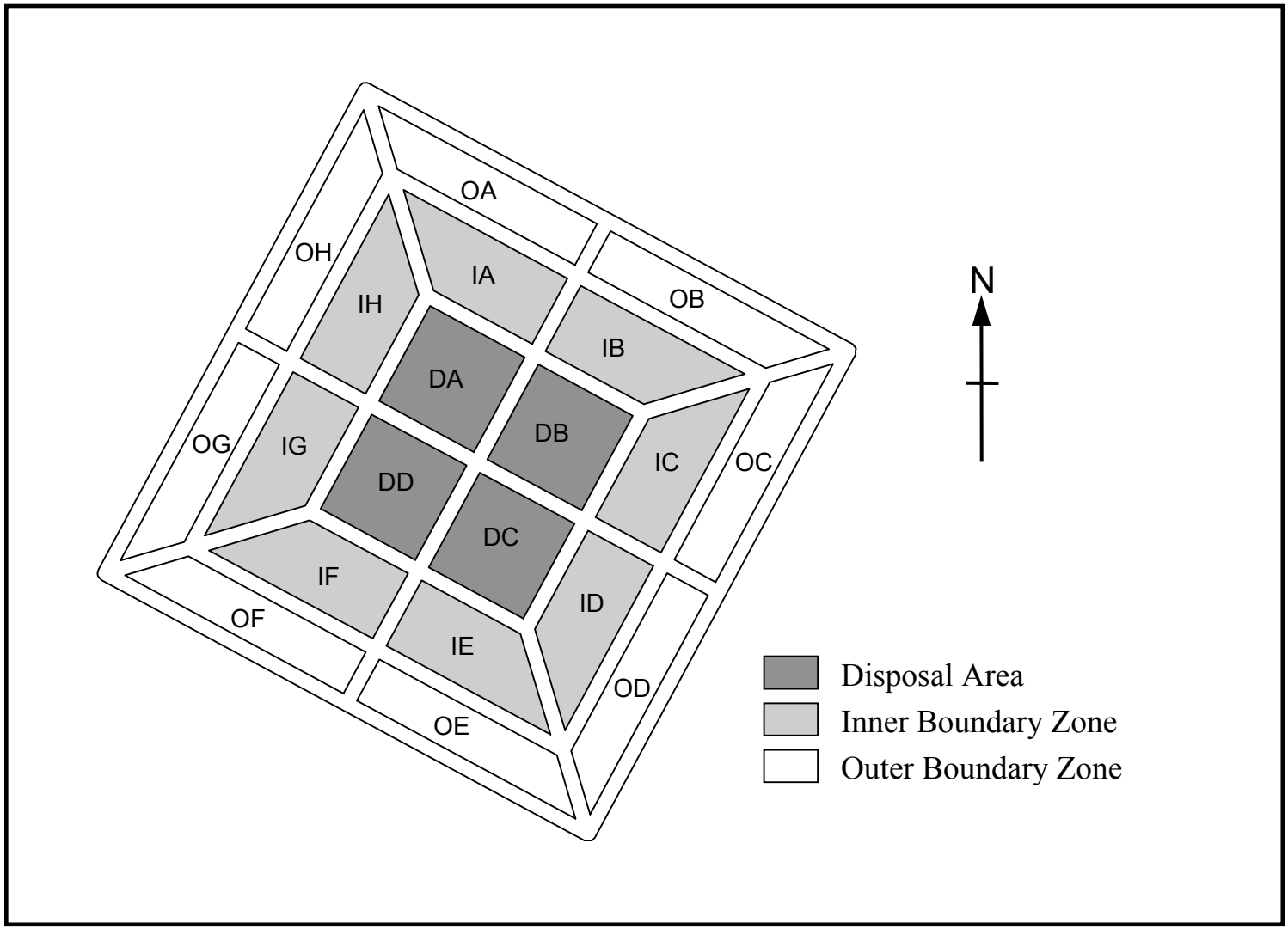



Figure 2. Permitted disposal zone within the Charleston ODMDS and the surrounding boundary zones.

to serve as a barrier, with finer materials to be placed to the east of the barrier.

The U.S. Congress authorized the most recent Charleston Harbor Deepening Project in 1996. The project was initiated in July 1999, and completed in April 2002. The project was planned to deepen the entrance channel from 42 ft to 47 ft, and the inner harbor channel from 40 ft to 45 ft. Approximately 20-25 million cubic yards of sediments were planned for disposal in the four square mile disposal zone selected by the Task Force in 1993.

## Past Monitoring Activities

Extensive monitoring of the Charleston ODMDSs has occurred throughout the years. These efforts have included bathymetric surveys, analyses of sediment characteristics and sediment contaminant levels, assessments of biological communities, hydrographic surveys, and areal mapping of sediment chemistry. The following sections describe these efforts by type.

### *Bathymetry*

Detailed bathymetric monitoring of the smaller ODMDS and surrounding area has been conducted by the USACE at periodic intervals since 1972 to: (1) document the location and configuration of mounds created by placing dredged material along narrow corridors within the smaller ODMDS, and (2) determine whether these mounds were remaining stable (Winn *et al.* 1989).

### *Sediment Characteristics and Sediment Contaminants*

Monitoring of bottom sediment characteristics and sediment contaminant levels in the area was first completed in 1978 (Winn *et al.* 1989) by the South Carolina

Department of Wildlife and Marine Fisheries (SCWMRD, now the South Carolina Department of Natural Resources). That study provided sedimentological data at 40 sites, and contaminant data at 24 sites in and around the larger ODMDS (SCWMRD 1979, Van Dolah *et al.* 1983). Interstate Electronic Corporation (IEC) sampled sediments at 10 sites and contaminant levels at 10 sites in the area of the larger ODMDS during 1979 (EPA 1983). These studies did not find elevated levels of contaminants. The SCWMRD study found higher levels of mercury and cadmium than the IEC study, which may have been due to analytical methodology (EPA 1983).

Winn *et al*. (1989) collected sediment and sediment contaminant samples at 28 sites in the larger ODMDS and surrounding areas. None of the stations displayed contaminant levels above the range observed in the 1978 SCWMRD study. Minor changes in sediment characteristics were detected, with some movement of material away from the disposal site. Surficial sediment characteristics outside the disposal site did not appear to be altered.

As part of the baseline assessment of the current four square mile disposal zone, 200 sediment samples were collected in both 1993 and 1994 in and around the disposal zone (Van Dolah *et al*. 1996, 1997). Bottom sediments in the area were comprised primarily of medium to fine-grained sands, with variable concentrations of silt/clay and shell hash. Relatively high concentrations of mud (>10%) were found within the disposal area in 1993. By 1994, most of the muddy sediments had dispersed. Forty composite sediment contaminant samples were also collected during the 1993-1994 assessment. Metal contaminants were detected in several strata, but concentrations were generally below known bioeffects levels.

### *Biological Communities*

Benthic assemblages in the vicinity of the larger ODMDS have been monitored since 1978. SCWMRD (1979) completed an assessment in 1978. No major differences were found in the benthic communities collected within the larger ODMDS compared to adjacent areas (Van Dolah *et al.* 1983). The IEC sampled the benthos at 10 sites during March and December 1979 in the vicinity of the larger ODMDS (EPA 1983). Their findings also did not indicate any differences in the benthic communities present, which could be attributed to previous disposal operations.

An updated assessment was completed in 1987 by the SCWMRD due to the changes in the site designation that occurred at that time (Winn *et al.* 1989). The benthic sampling program was designed around the corridor disposal concept with a network of stations positioned to intercept the migration of material over the bottom, if it occurred, and to assess changes in the benthic communities resulting from the movement of dredged material. The 1987 baseline survey detected minor changes in benthic community structure related to a disposal operation completed in 1986, and some movement of the material was detected away from the disposal site (Winn *et. al*. 1989). However, this movement did not appear to significantly alter benthic communities outside the smaller ODMDS.

The South Carolina Department of Natural Resources (SCDNR) completed intensive benthic infaunal sampling in the four square mile disposal zone and surrounding boundary areas in 1993-94 as part of a baseline assessment of the area (Van Dolah *et al*. 1996, 1997). During this period, they collected benthic samples at 200 stations each year in 20 zones located within and around the current disposal site. Species composition,

faunal density, and number of species varied among zones and strata. The density of some general taxonomic groups was found to be related to sediment type, a finding which suggests that future large scale disposal operations could lead to disposal-related changes in the benthic communities.

Several additional studies of demersal fishes and decapods have been conducted in the South Atlantic Bight since the early 1970's. Some of these studies have included one or more sites in the vicinity of the ODMDSs (Wenner *et al.* 1979, 1980; Wenner and Read 1981).

In July 1992, EPA, in conjunction with the University of Georgia's Department of Ecology, undertook a study on the physiological effects of dredged material on the oxygen metabolism of *Oculina arbuscula* (scleractinian) and *Lophogorgia hebes* (gorgonian). The results of the study suggest that while coral recovery from single episodes of low-level sediment exposure is likely, recovery from repeated low level exposures or single episodes of high-level exposure becomes more difficult (Porter 1993). Both long-term responsiveness and immediate short-term productivity rates were inhibited by exposure to sediment concentrations above 100 mg/l (15 NTU) (Porter 1993).

### *Hydrographic Data*

Hydrographic data has been collected as part of most assessments of the Charleston ODMDSs. In 1978, SCWMRD collected hydrographic data at 40 sites during their August sampling effort (SCWMRD 1979). The IEC assessment in 1979 provided additional hydrographic data for the larger ODMDS in the March and December sampling seasons (EPA 1983). Water quality data were collected by SCWMRD in 1987

during the summer and winter (Winn *et al.* 1989). Hydrographic data were also collected by SCDNR during summer sampling periods in 1993 and 1994 (Van Dolah *et al*. 1996, 1997).

Data on ocean currents at the Charleston ODMDSs were collected by EPA in summer and winter 1991, and NOAA also collected a limited number of observations in the seaward reaches of the Charleston Harbor Entrance Channel (Wilmot 1988). The ocean current data were used by the Corps of Engineers, Waterways Experiment Station (WES) for input into a model simulating sediment plume dispersion for a dumping episode at the site. Ocean current data revealed a predominant NNE component during the summer. While the strong NNE component was also present during the winter, a westerly component was evident during that season as well. Currents toward the southern, and neighboring sectors, were minimal during these sampling periods.

The National Ocean Service (NOS), Coastal Estuarine and Oceanography Branch (CEOB) deployed a 1200 kHz acoustic Doppler current profiler (ADCP) in the larger ODMDS from January 1994 through September 1995 in an effort to measure ocean currents in the vicinity of the site. The results of this study found that the currents in the vicinity of the Charleston ODMDSs consist of tidal, wind-driven, and density-driven currents. The currents flowing toward the southwest or west could potentially transport dredged material to the benthic communities in the southwest corner of the larger ODMDS (Williams *et al.* 1997).

### *Sediment Mapping Surveys*

To assist in defining dredged material placement and migration within the Charleston Harbor ODMDSs, real time mapping of the seafloor sediments in the

Charleston ODMDS and surrounding areas has been conducted by the USEPA and the Center for Applied Isotope Studies at the University of Georgia (Noakes 1995). The gamma isotope mapping system (GIMS) tows a sled with gamma radiation detection capability and uses these data to map identify the chemical signature and distribution of sediments. The continuous sediment sampling system ($CS^3$) uses a sled-mounted submersible pump to collect surficial sediments, which are later analyzed using x-ray fluorescence spectroscopy. Sites were mapped along transects spaced approximately 1,000 feet apart.

The EPA, in conjunction with the University of Georgia's Center for Applied Isotope Studies (CAIS), completed a survey within the smaller ODMDS site in July 1988, and within the larger ODMDS site in March 1990. Survey results indicated the seafloor within the smaller site was relatively homogeneous, from a selected gamma isotope perspective, and relatively void of fine sediments since the $CS^3$ sled, which is selective to sediments generally smaller than 400 microns, did not retrieve any material. The larger site was mapped again in August 1991, May 1993, and June 1994. Each of these surveys was successful in tracking and documenting the dispersion of the dredged material deposited at the disposal site. The construction of the L-shaped berm was clearly indicated, as well as other areas of elevated silt/clay concentrations due to historical disposal operations or unidentified origins (Noakes 1995).

## Unauthorized Disposal Activity

Based on reports from commercial shrimpers (January 2000), SCDNR staff investigated muddy areas found outside the four square mile disposal zone in 2000.

SCDNR sampling confirmed that sediments high in silt/clay content were present in areas surrounding the four square mile disposal zone, and identified this problem to the USACE, who reviewed logs and found unauthorized dumps made outside the four square mile disposal zone. Reconnaissance of about 50 unauthorized dump sites was completed by a subcontractor to the dredging company and reviewed by SCDNR staff. At least one of the unauthorized dump sites appeared to have occurred over live bottom, and other dumps may also have occurred over other live bottom areas. If so, the bottom and evidence of reef growth were completely buried by the unauthorized dumps. A report summarizing these findings (Jutte *et al.* 2001) was sent to USACE, the contractor (Norfolk Dredging Company), and USEPA.

During the March 2000 Site Management and Monitoring Plan (SMMP) meeting, the USACE noted that the berms under construction at the disposal zone were being built with a mixture of materials, rather than the more consolidated materials as originally planned. It was agreed that future barge loads of material would be assessed by the subcontractor, with more consolidated materials (e.g. cooper marl, rocky material) being placed on the berm, and finer, unconsolidated, materials placed to the southeast of the berm. The SMMP Team also discussed the path of barge traffic over live bottom reef habitat en route to the disposal zone. Team members agreed that by traveling a northerly track to the shipping channel, the potential for accidental dumps over live bottom reefs could be reduced or eliminated.

## Interim Monitoring Efforts

An interim assessment of the disposal area and surrounding boundary areas was planned to occur approximately halfway through the current Charleston Harbor Deepening Project. This report summarizes the findings of the biological, sediment, and sediment contaminant conditions which were sampled in 2000 as part of this interim assessment.

In March 2000, Coastal Carolina University's Center for Marine and Wetland Studies (CMWS), in cooperation with the U.S. Geological Survey (USGS), completed a side scan sonar survey, swath bathymetry survey, and CHIRP sub-bottom profiling of the disposal zone and surrounding areas. Bathymetry data from the CMWS-USGS survey is presented in this report (see Gayes 2001 for details). Additional closely spaced side scan sonar surveys and bottom video tows were completed in August 2000 at hard bottom reef areas. These data, in addition to direct diver observations, were used to identify areas where disposal material deposited in the disposal zone had been reworked and transported away from the site (Gayes 2001). The side scan imagery detected evidence of curvilinear bands of high backscatter sediments indicative of sediment trailing out of the disposal dredges as they entered or exited the disposal zone, as well as numerous dredge dump deposits in the boundary areas outside the designated disposal zone.

The second survey season (July-August 2001) produced an updated regional side scan sonar mosaic that extended further offshore than the March 2000 survey (Gayes *et al.* 2002). When these two side scan sonar mosaics were compared, new unauthorized dumps outside the boundaries of the disposal zone were apparent that must have occurred since the March 2000 survey was conducted. During the same research cruises, detailed

video and side scan sonar surveys at the index reef sites were also collected. A new application of a textural analysis routine and neural network classifier developed by CMWS staff indicated that approximately 53% of the surface area of each of the six 1-$km^2$ index reef sites was composed of hard bottom. Temporal data were available for only one reef site, located in the outer boundary zone southwest of the disposal zone. The analysis technique indicated that this reef site may have experienced a loss in hard bottom habitat between March 2000 and July 2001 (Gayes *et al.* 2002). Additional sampling will further investigate change in hard bottom at these sites, and refine estimates of hard bottom loss. The change in areal extent of the reef habitat at this site appears to be caused by some combination of the effects of disposal activities and natural variability, but the relative effects of each causal factor cannot be identified until additional data are collected. Further information on these research cruises and details on the remainder of the geophysical data are presented in Gayes *et al*. (2002).

Areal mapping of sediment chemistry was conducted by the University of Georgia's Center for Applied Isotope Studies in October 2000 (Noakes 2001). The goal of the mapping survey was to track sediment and sediment movement patterns in and around the disposal zone using the gamma isotope mapping system (GIMS) and the continuous sediment sampling system ($CS^3$). Noakes (2001) reported that misplaced dredged material was clearly indicated in the western region outside the disposal area (Figure 3). In addition, a trail of probable dredged material was observed leaving the western disposal cell (strata DA, Figure 2) heading towards the northwest; the trail observed was most likely the result of dredged material falling from disposal barges as they entered or existed the disposal zone (Noakes 2001).

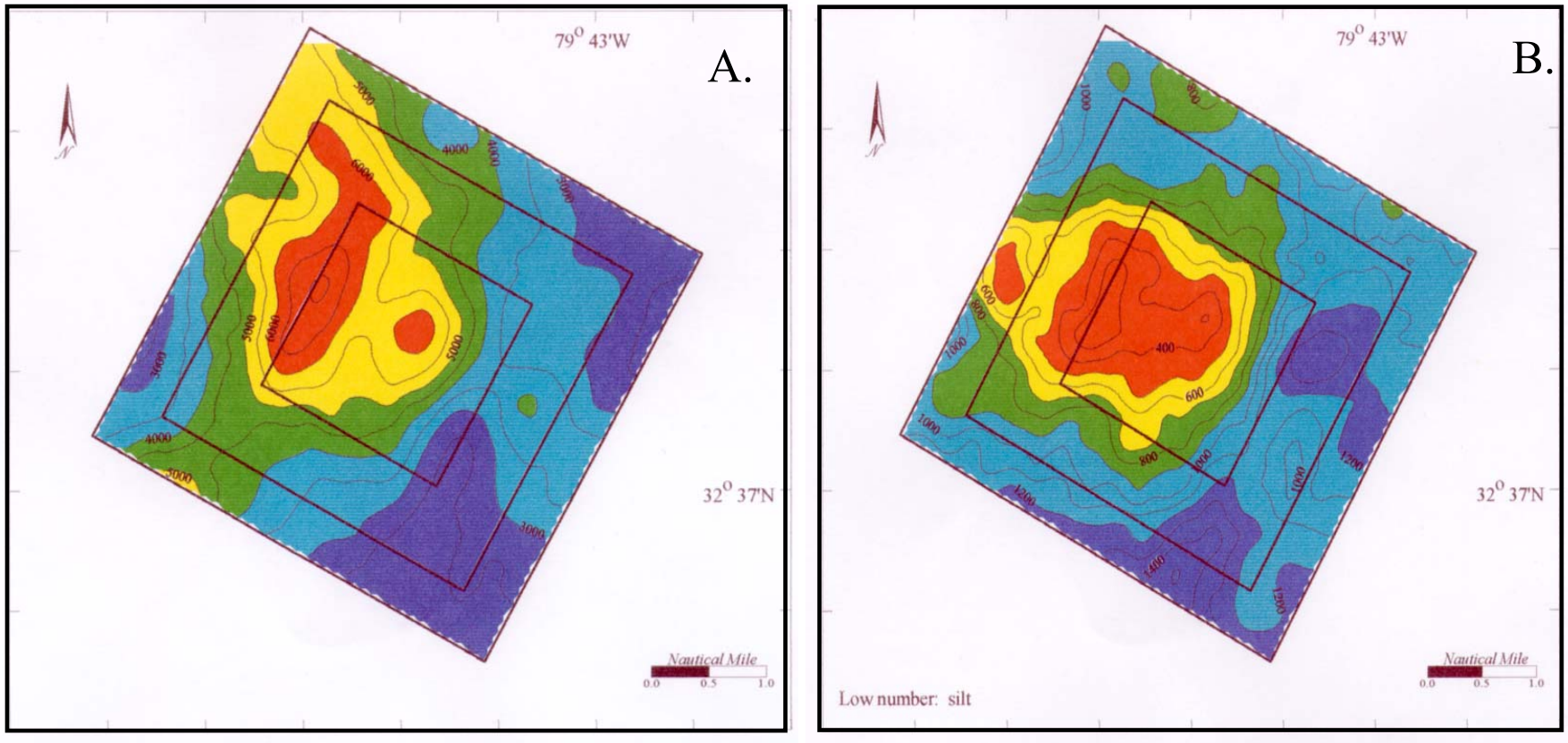



Figure 3. Contour maps of (A) total gamma activity and (B) sediment slurry density (light intensity) for the disposal zone and surrounding areas. Total gamma activity is reflecting the marl being dredged from the harbor which is high in $^{214}Bi$ (phosphate) and $^{40}K$ (clay). There is extremely good agreement between the harbor dredged material placed in the western berm area and the total gamma activity. Sediment slurry density gives a good quantitative evaluation of the amounts of surficial fine-grained sediment on the seafloor. Figures from Noakes (2001).

An assessment of disposal material mobility and transport in the vicinity of the disposal site was conducted by the University of South Carolina Coastal Processes and Sediment Dynamics Laboratory (Voulgaris 2002). The combined action of waves and currents were measured for 35 days using a bottom-mounted platform deployed to the west of the western berm of the disposal site (strata IG, see Figure 2 for location) and equipped with an acoustic doppler current profiler and optical backscatter sensor. In general, it was found that the combined shear stress by the waves and currents is much larger than the mean currents alone. Comparison of the mean stresses with the settling characteristic of the sediments suggest that the finer-grained dredged material can create flocculates that have reduced settling velocities. Therefore, finer-grained dredged material can be transported even with the slightest wave conditions.

Four hard bottom reef study sites and two control reefs have been surveyed three times to date (fall 2000, spring 2001, fall 2001). During each sampling period, video surveys of sponge/coral communities, video surveys of fish communities, and measurements of surficial sediment depths, surficial sediment characteristics, and sedimentation rates were collected. In addition, a detailed side scan sonar survey with simultaneous underwater video was completed annually to determine changes in the areal extent of each reef site (details in previous section). Biannual assessments of these index hard bottom reef sites will continue through at least spring 2005.

## Present Conditions

The monitoring efforts conducted in the vicinity of the permitted disposal zone within the Charleston ODMDS clearly document a trend of fine materials migrating from

the disposal zone in a predominately westerly direction, compounded by unauthorized disposal activities in the west/southwest region of the boundary areas, and dredge trailings to the northwest of the site. Based on these findings, we cannot differentiate whether the disposal material is moving from the disposal site over the berms, from the berms, from unauthorized disposal activities that occurred in 1999-2001, from the dispersion of the material during disposal activities at the site, or some combination of all four possibilities. In addition, due to the long-term use of the site, it is difficult to distinguish between the effects of recent and historical disposal activity. Regardless, for the purposes of this report, data collected to date strongly support the contention that existing conditions to the west, southwest, and northwest of the disposal zone have been impacted. The boundary zones east of the disposal site remain similar to conditions before dredging began.

# METHODS

## Field Sampling

Sampling efforts took place within the permitted disposal zone in the Charleston ODMDS (Federal Register 67 FR 30597) and the inner and outer boundary zones defined as part of the 1993-94 baseline assessment of the Charleston ODMDS (Van Dolah *et al*. 1997). These three zones (disposal, inner, and outer) are composed of a total of 20 discrete strata of comparable size, approximately one square mile (Figure 2). A 100 m buffer was created inside the boundary of each stratum to avoid the inadvertent location of sampling sites in adjacent strata. Positioning at sites sampled within each strata was accomplished using a Geographic Positioning System (GPS) equipped with a differential beacon. Sampling was completed on September 11-12, 2000 using the SCDNR R/V Lady Lisa.

One benthic grab sample was collected at 10 sites within each of the 20 strata using a 0.043 $m^2$ Young grab. Stations sampled in 2000 were selected from the original random array of 400 stations sampled in 1993 and 1994. The location of sites sampled in 2000 is shown in Figure 4, and the latitude/longitude coordinates for each site (NAD83 datum) are provided in Appendix 1. Each grab sample was sub-sampled for analysis of sediment characteristics (% sand, silt, clay, $CaCO_3$; organic matter content; sand grain size distribution), and for the presence of contaminants. The core used to characterize sediments was collected using a plastic tube (3.5 cm dia.) inserted through the top of each grab to the bottom of the sample. Sediment characteristics samples were stored separately for each grab sample. The sediment contaminant core was collected using a stainless steel tube (2.5 cm dia.) first rinsed with acid (0.1 N HCl) and hexane, and then

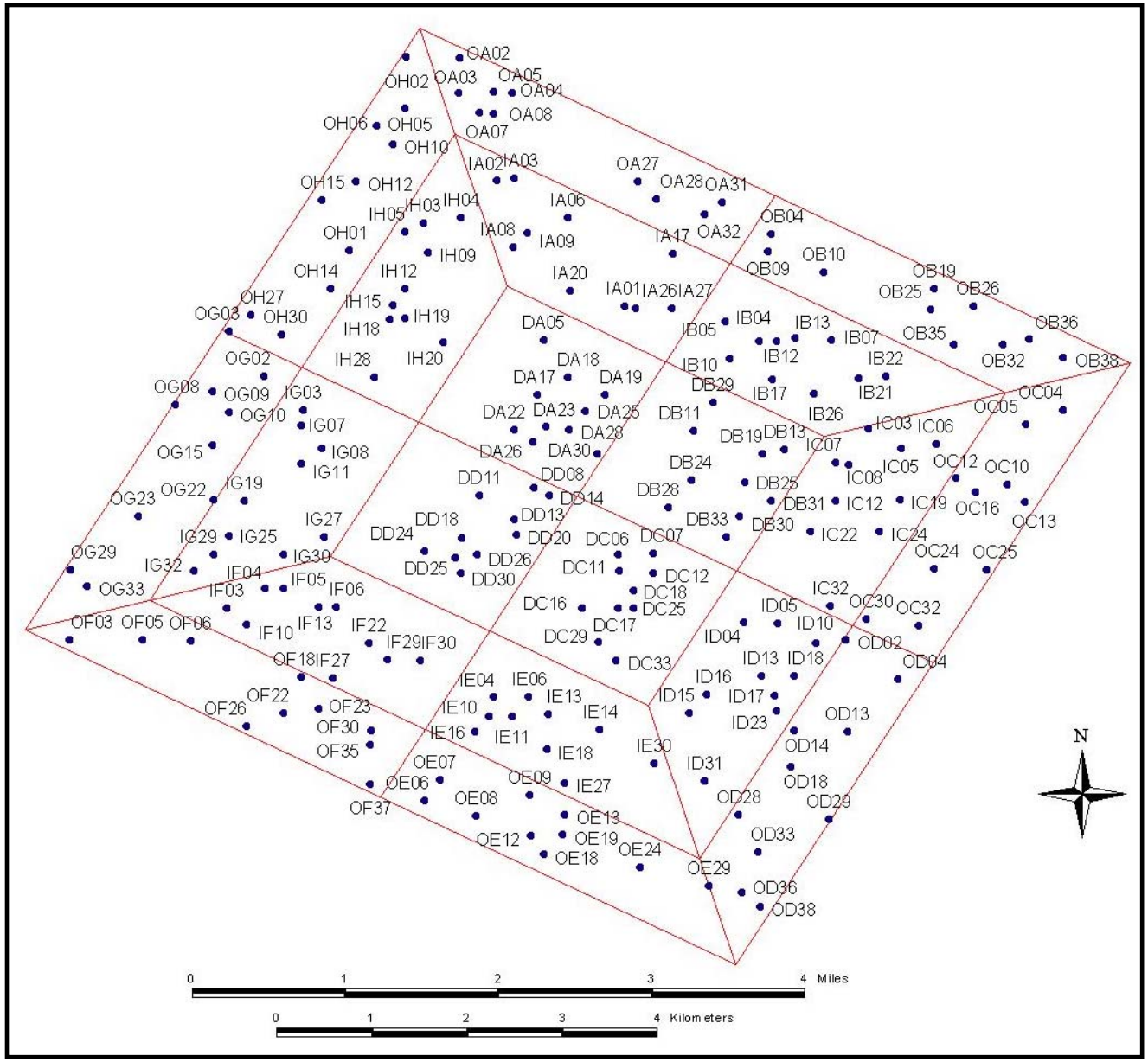



Figure 4. Location of stations sampled in the disposal zone and surrounding boundary areas as part of the interim assessment. Samples were collected on September 11-12, 2000. See text for details.

inserted through the top of the grab sample at least 1 cm away from the sides of the grab. Contaminant cores collected from each of the 10 sites sampled within a stratum were composited and transferred to pre-cleaned glass jars with Teflon lids. All contaminant samples were stored on ice or at 4$^{o}$C until they were processed in the laboratory. The remainder of the grab sample, representing approximately 0.04 $m^2$ of bottom surface area, was washed through a 0.5 mm-mesh sieve. Organisms and sediment retained on the sieve were preserved in a buffered solution of 10% formalin/seawater with rose bengal stain.

## Laboratory Processing

Sediment composition, mean grain size, and total organic carbon (TOC) were analyzed in all samples collected (n = 200). The sediment composition samples were analyzed for percentages (by weight) of sand, silt, clay, and calcium carbonate ($CaCO_3$) using procedures described by Folk (1980) and Pequegnat *et al.* (1981). Sand fractions were dry-sieved using a Ro-tap mechanical shaker and grain size was determined using fourteen 0.5 phi-interval screens, where phi = $-\log_2$ (grain diameter in mm) according to the Udden-Wentworth Phi classification (Brown and McLachlan 1990). TOC was measured on a Perkin Elmer Model 2400 CHNS Analyzer. The CHNS Analyzer determines the percent organic matter present in a subsample of sediment.

Contaminants measured in the sediments included 14 metals, 25 PAHs, 27 PCBs, and 22 pesticides. Sediment contaminant analyses were completed for all composite samples (n = 20). All contaminants were analyzed by the NOAA-NOS Coastal Center for Environmental Health and Biomolecular Research (CCEHBR) using the following

protocols. Extraction and sample preparation for organic compounds were similar to those described by Krahn *et al*.(1988) and Fortner *et al.* (1996). Samples were then extracted with $CH_2Cl_2$ using accelerated solvent extraction, concentrated by nitrogen blow-down, and cleaned by gel permeation chromotography where necessary. PAHs were quantified by capillary GC-ion trap mass spectrophotometry. Organochlorine pesticides and PCBs were analyzed using dual column gas chromatography with electron capture detection using methods described by Kucklick *et al*. (1997). Trace metals were analyzed using methods similar to those described by Long *et al.* (1998) using inductively coupled plasma spectroscopy for Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Sn, Zn and by graphite furnace atomic absorption for Ag and Se. Mercury was analyzed by cold-vapor atomic absorption. The analytical method detection limits as well as bioeffects limits for the various contaminant analytes are listed in Tables 1-4.

Benthic infaunal sample sorting and taxonomic identification were completed using a tiered approach. Samples were processed from a selected subset of strata collected in boundary areas known to be impacted based on findings from other studies conducted as part of the interim assessment (Noakes 2001, Gayes 2001, Gayes *et al*. 2002). These samples were then compared with samples from another subset of strata collected from the boundary zones where there was no evidence of change in sediment condition. Impacted strata included IA, OA, IG, OG, IH, and OH (n = 60 grab samples), and non-impacted strata included IC, OC, ID, and OD (n = 40 grab samples). Benthic samples were sorted in the laboratory to remove the organisms from sediments remaining in the sample. All organisms were then identified to the species level, or the lowest practical level possible if the specimen was damaged or incomplete. A master voucher

collection was created for the project and will be maintained by the Environmental Research Section at SCDNR.

## Data Analyses

### *Sediment Characteristics*

The analytical techniques used to process organic carbon measures in 2000 were different from those used in 1993-1994 baseline studies. As described above, sediments collected in 2000 were analyzed using a CHNS analyzer. In 1993 and 1994, sediments were analyzed for organic matter content by burning a portion of each sample at 550$^{o}$C for two hours as described by Plumb (1981). These techniques both determine the percent of a subsample of the core sediment sample that is comprised of organic matter. Although, both techniques provide a measure of how much organic matter occurs in the sediments, the different analytical techniques mean that these data are not directly comparable. Previous work conducted by Ringwood *et al.* (1995) analyzing estuarine sediment samples collected in the Carolinian Province (Virginia, North Carolina, South Carolina, Georgia, and Florida) showed that there was a strong correlation ($r^2 = 0.98$, $p < 0.001$) between the two analytical techniques. To determine if a similar correlation existed for offshore sediments, a subset of the sediment samples collected in 2000 for the present study were reanalyzed using the same technique used for 1993-1994 samples. A subset of 50 sediment samples collected in 2000, including samples with high silt/clay content (n = 17), moderate silt/clay content (n = 16), and low silt/clay content (n = 17), were analyzed. The comparison resulted in a high level of correlation ($r^2 = 0.96$, $p <$

0.0001) between results generated from the two analytical techniques, and the resulting linear regression was used as a conversion tool for the 2000 data.

Sediment characteristics were analyzed to determine differences among the three zones (disposal, inner boundary and outer boundary) as well as between strata. One-way analyses of variance (ANOVA) were performed on rank-transformed data using Sigmastat for Windows version 2.03 (SPSS 1997). To evaluate temporal changes in sediment characteristics, two-way ANOVAs comparing either year and zone or year and strata were performed. Sediment characteristics (% sand, % silt/clay, % $CaCO_3$, organic matter content, and mean phi size) from 2000 were statistically compared to 1993 and 1994 sediment data. Analyses were performed on rank-transformed data using Sigmastat for Windows version 2.03 (SPSS 1997).

### *Sediment Contaminants*

Sediment contaminant data from 2000 were summarized in tabular form. For many of these contaminants, Long *et al.* (1995) published bioeffects guidelines that reflect the concentration of a contaminant that resulted in adverse bioeffects in 10% of the studies examined (defined as Effects Range-Low or ER-L) as well as the concentration that resulted in adverse effects in 50% of the studies (defined as Effects Range-Median or ER-M). MacDonald *et al*. (1996) also published bioeffects guidelines designated as threshold effects level (TEL) and probable effects level (PEL). "A TEL was derived by calculating the geometric mean of the 15$^{th}$ percentile of the effects data set and the 50$^{th}$ percentile of the no effects data set. Similarly, a PEL was developed for each chemical by determining the geometric mean of the 50$^{th}$ percentile of the effects data set and the 85$^{th}$ percentile of the no effects data set" (MacDonald *et al*. 1996).

Contaminants concentrations from 2000 data were compared whenever possible to these TEL, PEL, ER-M and ER-L values (Tables 1-4).

As part of the quality assurance for the laboratory analyses of sediment contaminants, standards for each contaminant were analyzed for percent recovery. The majority of contaminants had percent recoveries within the accepted range (70-130%). However, three pesticides (Hexachlorobenzene, 2,4-DDE, and 4,4-DDE), one PAH (Fluorene) and five PCB's (congeners 18, 105, 138, 187, and 195) had percent recoveries below the accepted range, and the pesticide 2,4-DDD and PCB 128 had percent recoveries above the accepted range. Results for these contaminants should be viewed with caution because reported values may not be an accurate estimate of the actual concentrations.

### *Benthic Infaunal Assemblages*

The original benthic infaunal data set for this study was reviewed to eliminate taxa that were not considered representative of the infaunal community. These included epifaunal species that require hard substrate, taxa that are typically considered to be meiofauna, and taxa that are colonial life forms. This deletion applied across all stations, and these species were not considered further in any of the data analyses.

The data set was further reviewed by grab to identify taxa that may potentially over-represent the number of species found in a grab sample. Organisms identified at the family level as well as at the species level within that family, or species identified at a known species level and an unknown species level in the same genus, might represent an inflation of species diversity indices (e.g. Ampeliscidae and *Ampelisca abdita,* or

Table 1. Metals tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al*. (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported in parts per million dry weight for all metals except aluminum and lead which are reported in percent.

| Metals | Minimum Detection Limit* | ERL | TEL | ERM | PEL |
|---|---|---|---|---|---|
| Aluminum | 0.00002 | | | | |
| Arsenic | 0.003 | 8.2 | 7.2 | 70 | 41.6 |
| Cadmium | 0.001 | 1.2 | 0.7 | 9.6 | 4.2 |
| Chromium | 0.03 | 81 | 52.3 | 370 | 160 |
| Copper | 0.01 | 34 | 18.7 | 270 | 108 |
| Iron | 0.00005 | | | | |
| Lead | 0.002 | 46.7 | 30.2 | 218 | 112 |
| Manganese | 0.01 | | | | |
| Mercury | 0.004 - 0.006 | 0.15 | 0.13 | 0.7 | 0.7 |
| Nickel | 0.002 | 20.9 | 15.9 | 51.6 | 42.8 |
| Selenium | 0.03 | | | | |
| Silver | 0.02 | 1 | 0.7 | 3.7 | 1.8 |
| Tin | 0.0040 - 0.005 | | | | |
| Zinc | 0.3 | 150 | 124 | 410 | 271 |

* Some minimum detection limits vary over a range of values due to variability in sample volume.

Table 2. Organic compounds tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al*. (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported as parts per billion dry weight.

| Organic compound | Minimum Detection Limit* | ERL | TEL | ERM | PEL |
|---|---|---|---|---|---|
| 1,6,7 Trimethylnaphthalene | 1.58 - 1.86 | | | | |
| 1-Methylnaphthalene | 3.39 - 3.99 | | | | |
| 1-Methylphenanthrene | 3.13 - 3.68 | | | | |
| 2,6 Dimethylnaphthalene | 3.16 - 3.71 | | | | |
| 2-Methylnaphthalene | 4.66 - 5.48 | 70 | 20.2 | 670 | 201 |
| Acenaphthene | 5.46 - 6.42 | 16 | 6.71 | 500 | 88.9 |
| Acenaphthylene | 1.42 - 1.67 | 44 | 5.87 | 640 | 128 |
| Anthracene | 2.92 - 3.44 | 85.3 | 46.9 | 1100 | 245 |
| Benzo(a)anthracene | 6.44 - 7.58 | 261 | 74.8 | 1600 | 693 |
| Benzo(a)pyrene | 8.18 - 9.62 | 430 | 88.8 | 1600 | 763 |
| Benzo(b)fluoranthene | 4.99 - 5.87 | | | | |
| Benzo(e)pyrene | 3.78 - 4.44 | | | | |
| Benzo(g,h,i)perylene | 5.12 - 6.03 | | | | |
| Benzo(j+k)fluoranthene | 4.27 - 5.02 | | | | |
| Biphenyl | 5.33 - 6.27 | | | | |
| Chrysene+Triphenylene | 1.84 - 2.16 | | | | |
| Dibenz(a,h+a,c)anthracene | 1.37 - 1.61 | | | | |
| Dibenzothiophene | 2.09 - 2.46 | | | | |
| Fluoranthene | 3.60 - 4.23 | 600 | 113 | 5100 | 1494 |
| Fluorene | 2.36 - 2.77 | 19 | 21.2 | 540 | 144 |
| Indeno(1,2,3-cd)pyrene | 7.95 - 9.34 | | | | |
| Naphthalene | 8.49 - 9.98 | 160 | 34.6 | 2100 | 391 |
| Perylene | 4.76 - 5.60 | | | | |
| Phenanthrene | 2.82 - 3.32 | 240 | 86.7 | 1500 | 544 |
| Pyrene | 2.64 - 3.10 | 665 | 153 | 2600 | 1398 |
| Total_PAH | | 4022 | 1684 | 44792 | 16770 |

* Minimum detection limits vary over a range of values due to variability in sample volume.

Table 3. PCBs tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al*. (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported as parts per billion dry weight.

| PCB Congener | Minimum Detection Limit* | ERL | TEL | ERM | PEL |
|---|---|---|---|---|---|
| PCB 101 | 0.1 | | | | |
| PCB 104 | 0.1 | | | | |
| PCB 105 | 0.12 | | | | |
| PCB 118 | 0.07 | | | | |
| PCB 126 | 0.13 | | | | |
| PCB 128 | 0.07 | | | | |
| PCB 138 | 0.18 | | | | |
| PCB 153 | 0.1 | | | | |
| PCB 154 | 0.1 | | | | |
| PCB 170 | 0.16 | | | | |
| PCB 18 | 0.15 | | | | |
| PCB 180 | 0.11 | | | | |
| PCB 187 | 0.05 | | | | |
| PCB 188 | 0.1 | | | | |
| PCB 195 | 0.12 | | | | |
| PCB 201 | 0.1 | | | | |
| PCB 206 | 0.098 | | | | |
| PCB 209 | 0.1 | | | | |
| PCB 28 | 0.19 | | | | |
| PCB 29 | 0.1 | | | | |
| PCB 44 | 0.05 | | | | |
| PCB 50 | 0.1 | | | | |
| PCB 52 | 0.07 | | | | |
| PCB 66 | 0.06 | | | | |
| PCB 77 | 1.5 | | | | |
| PCB 8 | 0.13 | | | | |
| PCB 87 | 0.1 | | | | |
| Total_PCB | | 22.7 | 21.6 | 180 | 189 |

Table 4. Pesticides tested for in sediments collected from the disposal zone and surrounding areas. Minimum detection limits were provided by NOAA-NOS. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et. al.* (1995) and Long and Morgan (1990). Threshold effects level (TEL) and probable effects level (PEL) values were taken from McDonald *et al*. (1996). Units are reported as parts per billion dry weight.

| Pesticide | Minimum Detection Limit | ERL | TEL | ERM | PEL |
|---|---|---|---|---|---|
| 2,4'-DDD | 0.06 | | | | |
| 2,4'-DDE | 0.06 | | | | |
| 2,4'-DDT | 0.14 | | | | |
| 4,4'-DDD | 0.24 | 2 | 1.22 | 20 | 7.81 |
| 4,4'-DDE | 0.03 | 2.2 | 2.07 | 27 | 374 |
| 4,4'-DDT | 0.02 | | | | |
| Aldrin | 0.01 | | | | |
| Chlorpyrifos | 0.1 | | | | |
| Cis-chlordane (alpha-chlordane) | 0.08 | 0.5 | 2.26 | 6 | 4.79 |
| Dieldrin | 0.18 | 0.02 | 0.72 | 8 | 4.3 |
| Endosulfan ether | 0.1 | | | | |
| Endosulfan I | 0.1 | | | | |
| Endosulfan II | 0.1 | | | | |
| Endosulfan Lactone | 0.1 | | | | |
| Endosulfan Sulfate | 0.1 | | | | |
| Gamma-HCH (g-BHC, lindane) | 0.08 | | | | |
| Heptachlor | 0.04 | | | | |
| Heptachlor epoxide | 0.1 | | | | |
| Hexachlorobenzene | 0.06 | | | | |
| Mirex | 0.16 | | | | |
| Total_DDT | | 1.58 | 3.89 | 46.1 | 51.7 |
| Total_Pest | | | | | |
| Trans-nonachlor | 0.09 | | | | |

*Ampelisca abdita* and *Ampelisca* sp.). In these situations, species lists were modified to eliminate the possibility of duplication in species counts.

Standard ecological parameters of diversity (H' – calculated with log base 2), evenness ($J' = H'/H_{max}$, where $H_{max}$= ln (# of taxa in sample)), and richness (SR = S-1/lnN) were calculated for each station using the abundance of each species collected per grab.

### Spatial Changes

The Bray-Curtis proportional similarity coefficient was used to conduct cluster analyses on faunal density data, with a flexible sorting strategy and a cluster intensity coefficient of ß= -0.25 (Bloom 1994). The groups generated through this procedure displayed relative similarity between zones based on species composition and density. Rare taxa were eliminated from analysis when running the cluster analysis. Only taxa that comprised 98% of all taxa collected were included in these analyses.

### Temporal Changes

In an effort to separate the effects of historical disposal activities from natural annual variability when analyzing temporal changes in the benthic community structure, a subset of samples selected from the 1993 and 1994 studies was used to best represent typical, non-impacted samples from the area surrounding the disposal zone. Sampling in 1993-1994 was conducted over a two-year period to identify baseline conditions and annual variability in sediment characteristics and benthic infaunal assemblages. However, strata on the western edge of the disposal area (IG, IH, OG, OH) and within the disposal zone (DA, DB, DC, DD) had already been impacted by historical dumping at the time of the baseline study. Therefore, samples from these strata were excluded from

temporal analyses. Sediments that have high silt/clay or $CaCO_3$ content are not representative of the benthic habitat typically found off the coast of South Carolina. Therefore, samples from 1993 and 1994 that had greater than the 90$^{th}$ percentile of silt/clay (3.617%) and greater than the 90$^{th}$ percentile of $CaCO_3$ (24.368%) were likely affected by historical dumping activities and were also excluded from analyses of temporal change.

To evaluate temporal change, analysis of variance (ANOVA) was performed to compare the benthic community in each strata processed in 2000 to the reference subset from 1993 and 1994. The benthic parameters evaluated included: density, number of species, density of general taxonomic groups (polychaetes, amphipods, molluscs, and 'other taxa'), and density of dominant taxa. When necessary, data were either $\log_{10}$ or rank transformed to meet assumptions of parametric analyses. ANOVAs were performed using Sigmastat for Windows version 2.03 (SPSS 1997).

# RESULTS AND DISCUSSION

## Sediment Characteristics

### *Spatial Comparisons*

Detailed data on the sediment characteristics at each station are provided in Appendix 2. The majority of sediments collected in 2000 were composed of medium to fine-grained sands (mean = 78.0% sand content) mixed with moderate amounts of shell hash (mean = 17.4% $CaCO_3$). A contour map of sand content revealed that the sediments with the lowest percent sand content were primarily located within the disposal zone and in the northwestern outer boundary area (Figure 5). There was significantly less sand in disposal zone sediments than in inner or outer boundary zone sediments ($p < 0.001$), as would be expected following large-scale disposal of fine-grained inner harbor materials. There were few significant differences in sand content among strata; although strata OD, IA, and IF had significantly more sand than stratum DB ($p < 0.001$). A contour map of shell hash showed that $CaCO_3$ reached highest concentrations primarily along the eastern edge of the disposal zone (Figure 6). Shell hash was statistically less variable than sand content in the areas within and surrounding the disposal zone. There were no significant differences among zones or among strata with respect to shell hash content (Figure 7).

Silt/clay content in 2000 ranged from 0.1 to 67.8% with a mean of 4.6%. A contour map of silt/clay content revealed that muddy sediments were most common within the disposal zone as well as along the western boundary area (Figure 8). Disposal zone sediments had significantly more silt/clay than the inner or outer boundary zones (p

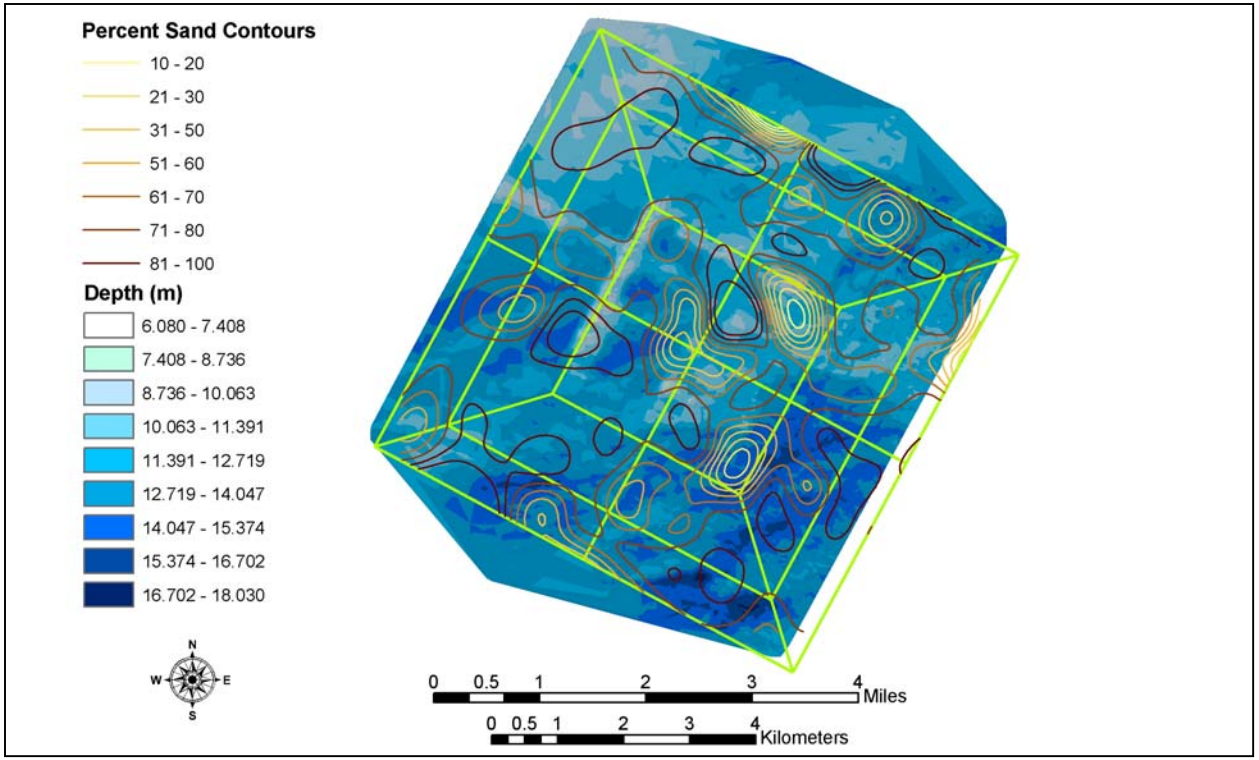



Figure 5. Contour map of the percentage of sand for surficial sediments in the disposal zone and surrounding areas. Map is based on the sediment composition of 200 grab samples taken throughout the study area. Bathymetry data are from Gayes (2001).

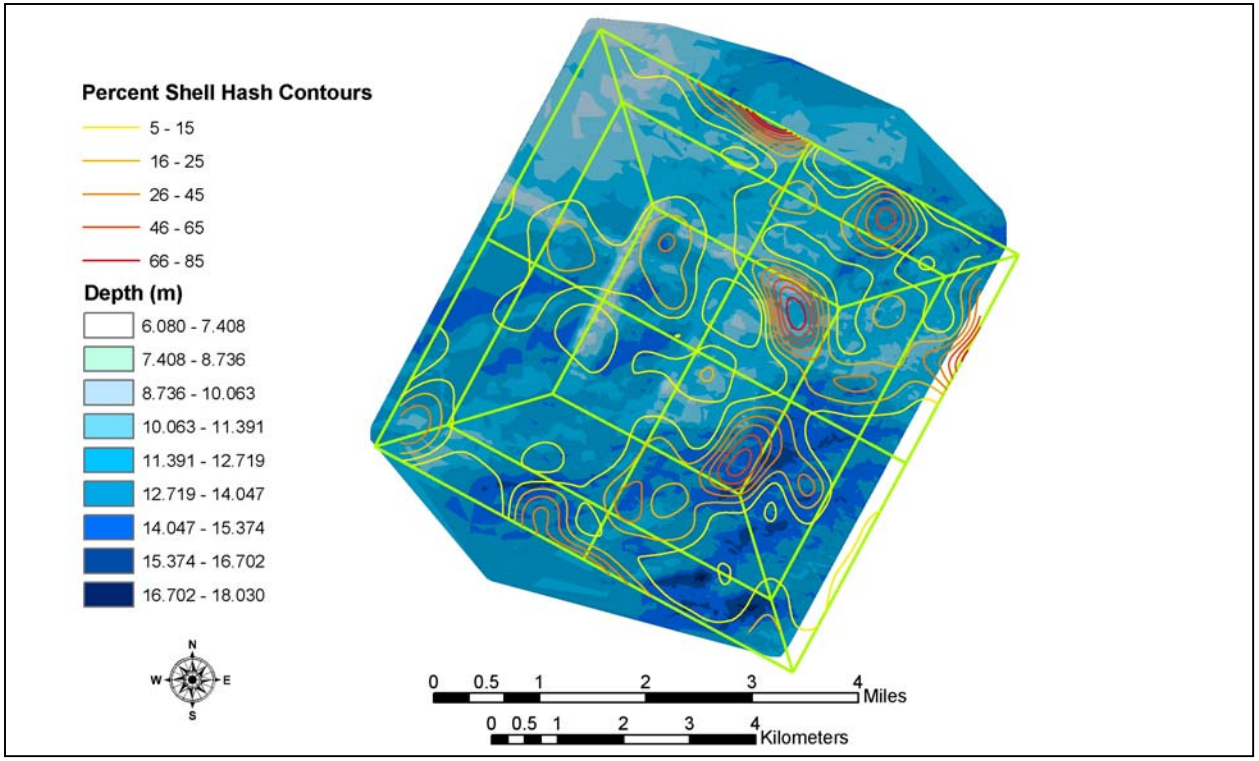



Figure 6. Contour map of the percentage of shell hash for surficial sediments in the disposal zone and surrounding areas. Map is based on the sediment composition of 200 grab samples taken throughout the study area. Bathymetry data are from Gayes (2001).

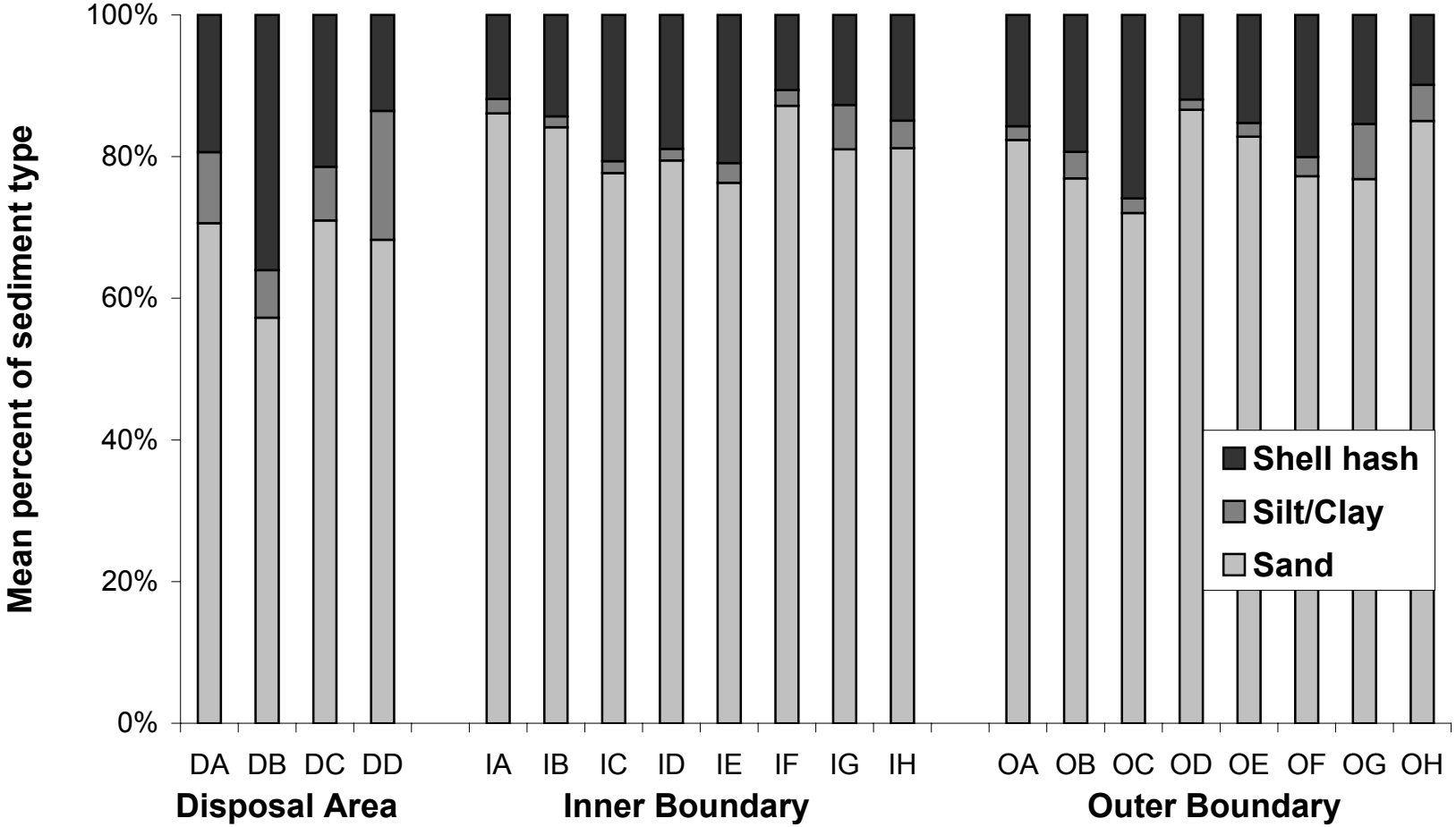



Figure 7. Sediment composition of strata. Data are based on the average of ten grab samples per stratum collected in 2000.

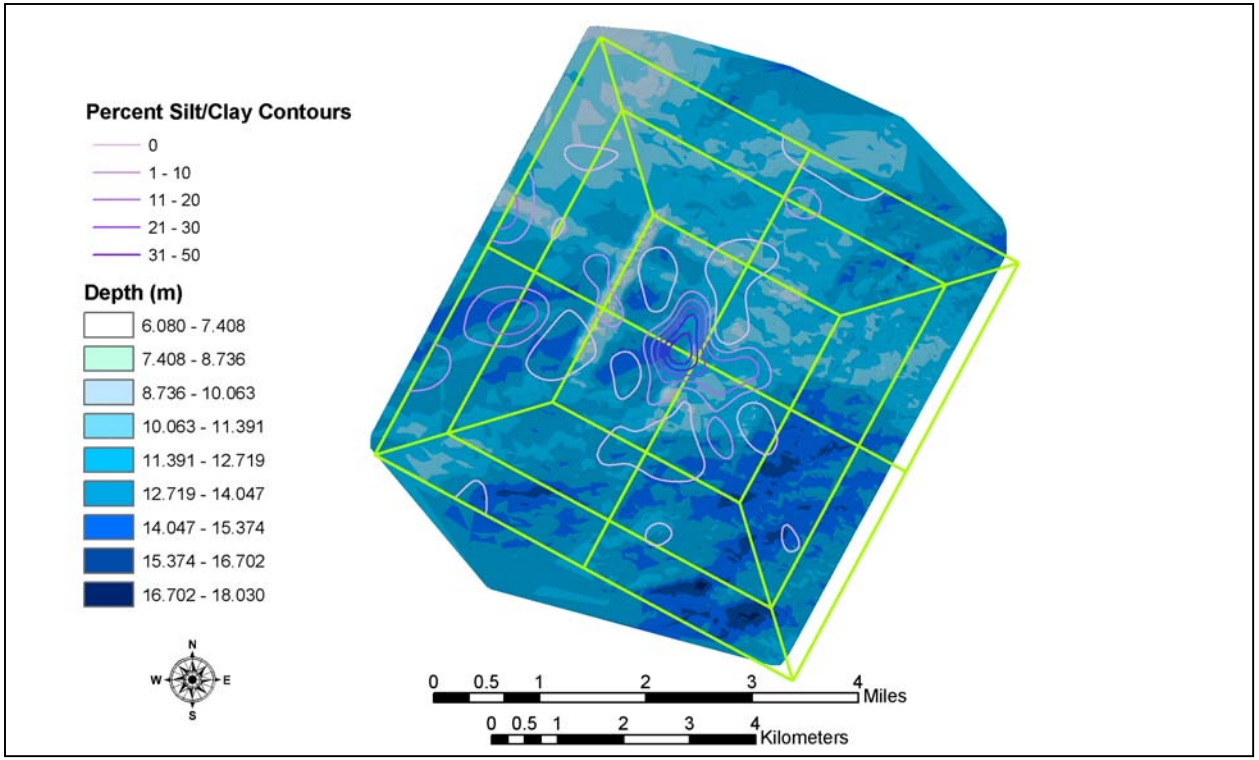



Figure 8. Contour map of the percentage of silt/clay for surficial sediments in the disposal zone and surrounding areas. Map is based on the sediment composition of 200 grab samples taken throughout the study area. Bathymetry data are from Gayes (2001).

< 0.001) due to the placement of fine-grained inner harbor material in the area. Silt/clay content in strata OG, DD, DB, OB, and OH was significantly greater than a number of other strata, namely OD, IB, IC, IA, and OA ($p < 0.001$, Figure 7). In 2000, organic matter content in the vicinity of the disposal zone ranged from 0.62 to 8.67% with a mean of 1.09%. Disposal zone sediments had significantly more organic matter than both the inner and outer boundary zones (Figure 9). Numerous significant differences in organic matter content occurred among strata. In general, sediments on the western side and within the disposal zone (i.e. DA, DB, DC, OH, IH, OG, IG) had higher organic matter content than those on the eastern side (IC, OC, ID, OD).

Mean phi size of the sand content was 2.25 (range = 0.25 - 3.35). There were no significant differences in grain size among zones ($p = 0.121$) but differences did occur among strata ($p < 0.001$). Strata within the disposal zone (DA) and on the western side (OG, IG, OH, IH) had smaller grain size of the sand fraction than strata IE, OE, IC and OC which are located on the eastern and southern sides of the disposal area (Figure 10).

### *Temporal Comparisons*

In general, sediments collected in 2000 had lower sand content and higher shell hash content than sediments in 1993 and 1994. The sand content in sediments collected in 2000 was significantly lower than sediments collected in 1993 and 1994 ($p < 0.001$), largely due to an increase in percent silt/clay content. The percentage of shell hash in 2000 sediments was significantly higher than values found for 1994 sediments ($p = 0.023$). Although no significant differences among zones occurred with respect to shell hash content, disposal zone sediments sampled in 2000 had greater shell hash content

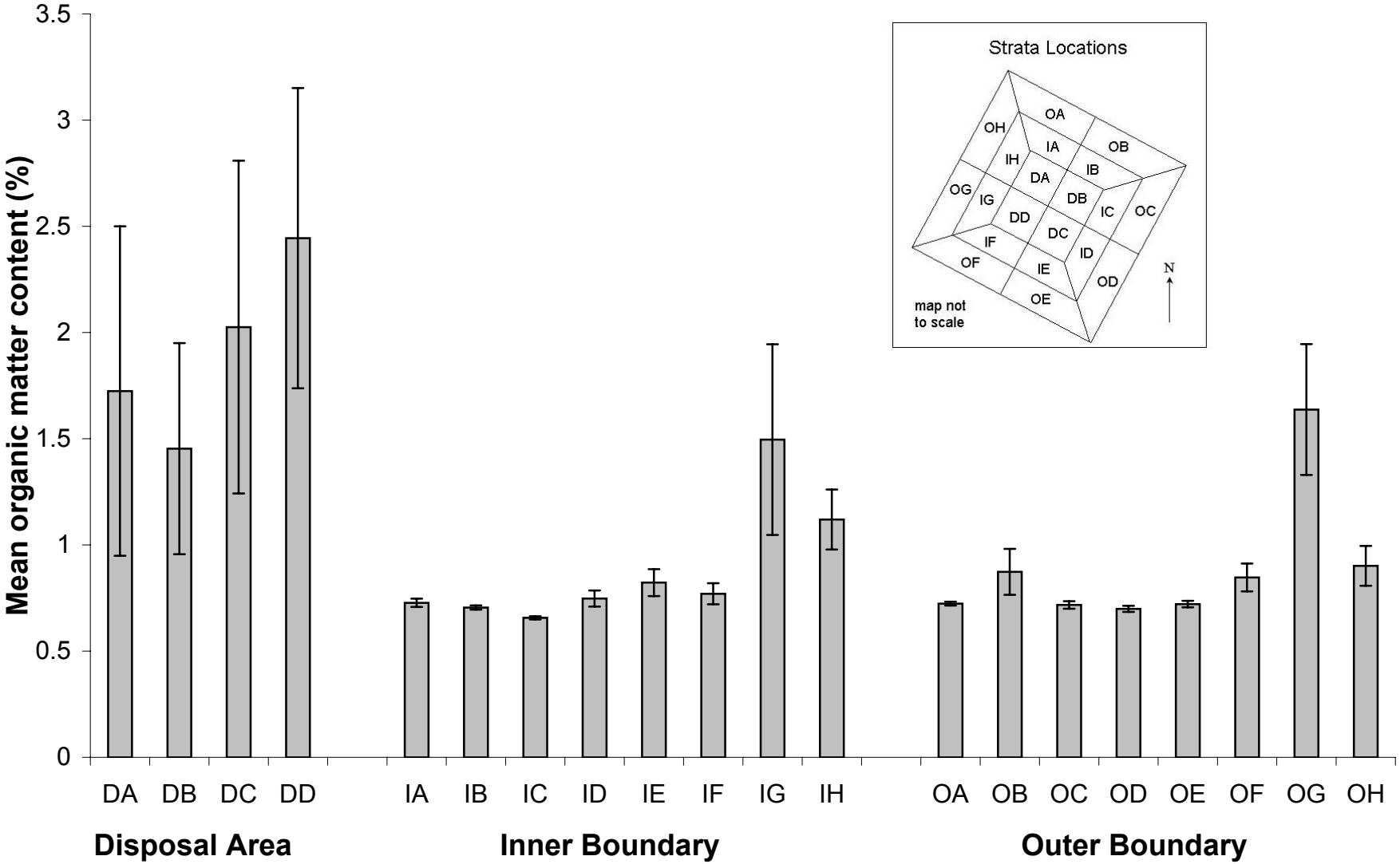



Figure 9. Mean organic matter content in each stratum sampled in 2000. Data are based on the average of ten grab samples per stratum collected in 2000. Error bars represent ±1standard error.

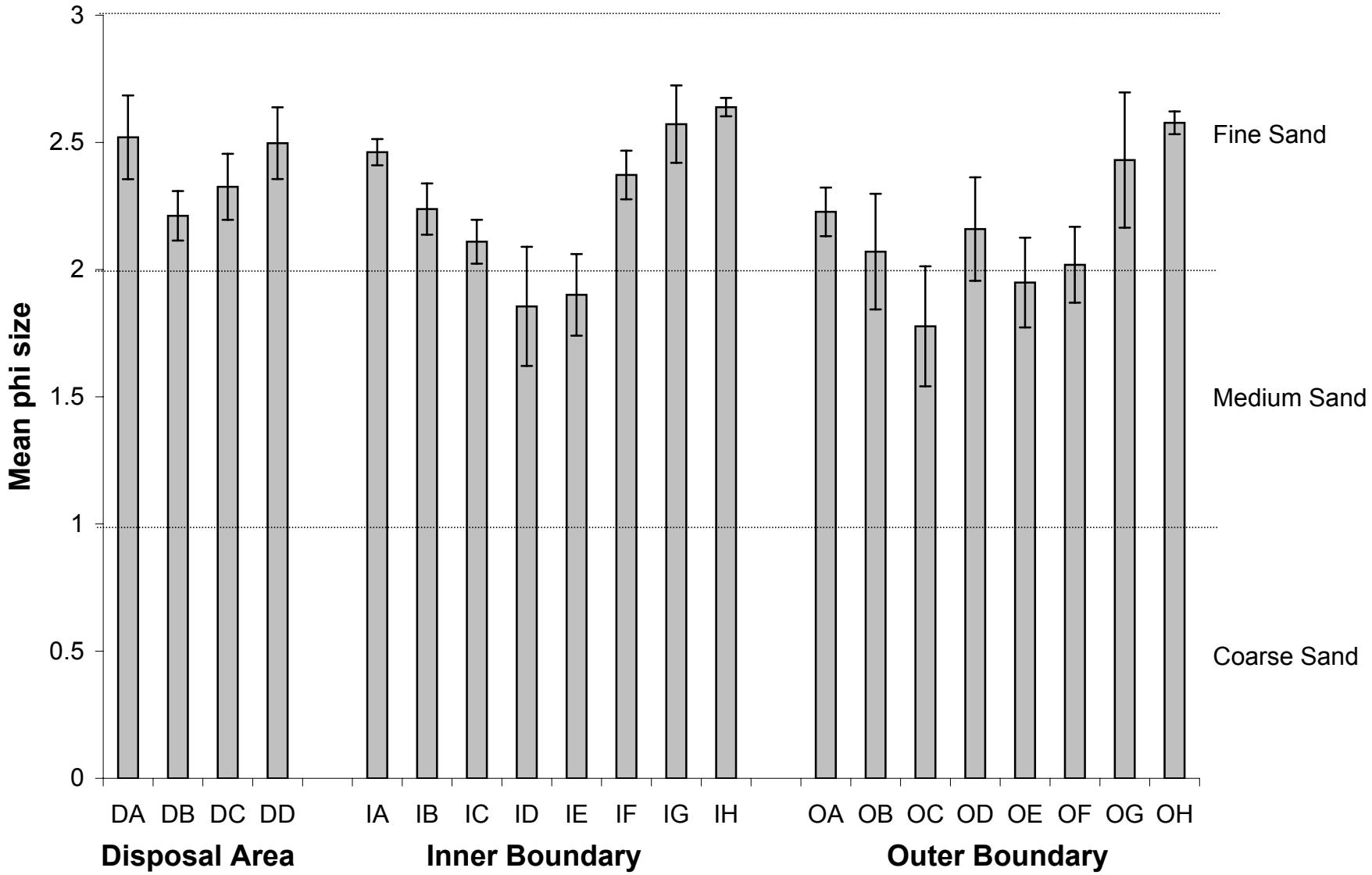



Figure 10. Mean grain size of sand for each stratum. Data are based on the average of ten grab samples per stratum collected in 2000. Error bars represent ±1 standard error.

than in 1994. Sediments dredged from the entrance channel were disposed on the eastern berm of the disposal area, and were generally high in shell hash content (USACE personal communication, Noakes 2001). Organic matter content and mean phi size showed no significant differences between the baseline 1993-1994 surveys and the 2000 survey ($p > 0.05$).

Overall, silt/clay content in 2000 was similar to 1993 values (mean = 4.60% in both years), but 2000 values were consistently higher than 1994 silt/clay content (mean = 2.15%). The difference observed in silt/clay content between 2000 and 1994 sediments was statistically significant for each of the three zones ($p < 0.001$, Figure 11). Van Dolah *et al*. (1997) reported that muddy sediments encountered in 1993 at the disposal area had dispersed by 1994 when only three stations, located in strata DC, DD, and OG, had greater than 10% silt/clay content. Fourteen stations sampled in 2000 had greater than 10% silt/clay content. These stations were located in each of the disposal area strata as well as in strata IG, OG, IB, and IH. Elevated silt/clay levels in the disposal zone were expected since millions of cubic yards of fine-grained materials were disposed at the site as part of the current Charleston Harbor Deepening Project. However, the elevated silt/clay content in strata outside the disposal zone, particularly to the west of the disposal zone, is likely a result of the movement of fines from the disposal zone, in addition to the material placed there as a result of unauthorized dumps.

Sampling efforts conducted by SCDNR in February-March 2000 as a response to unauthorized disposal activity (Jutte *et al.* 2001) documented a similar trend in increased silt/clay content, identifying a migration of fines in a predominately southwest direction from the disposal zone. Based on total gamma activity records from the 2000 sediment

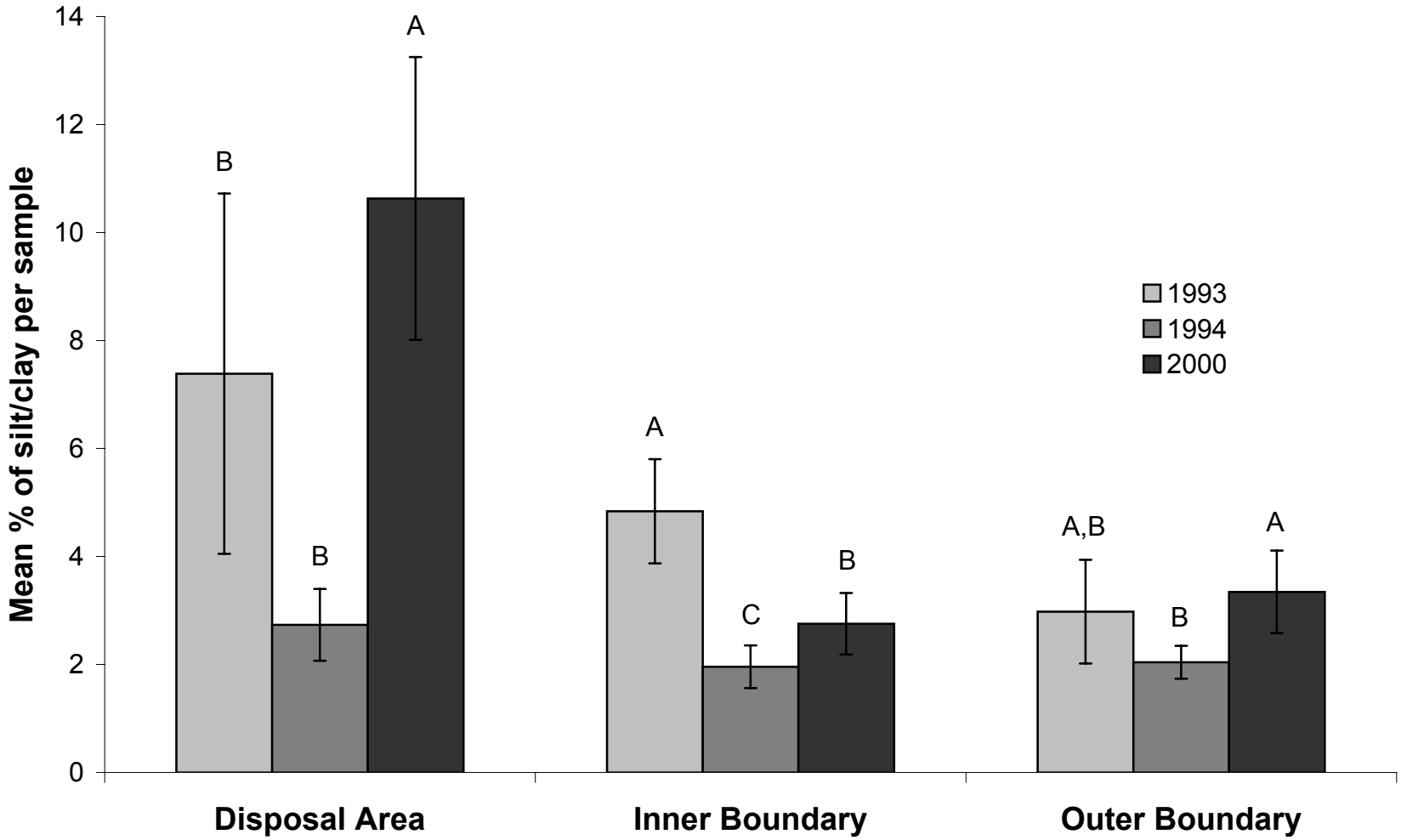



Figure 11. Mean percentage of silt/clay per sample in each zone. Differences between years were determined within each zone. Bars that do not share letters with each other are significantly different ($p < 0.05$). Error bars represent $\pm 1$ standard error.

mapping survey, Noakes (2001) noted that the signature of disposal material on the western berm bulged in a westward direction (strata IH and IG) and also extended in a northwestern direction from the western berm (strata IA and IH). The western peak in gamma activity could be due in part to historical disposal activities or unauthorized disposal activity, while the northwestern peak in gamma activity appeared to be evidence of dredged material leaving barges as they entered or exited the disposal site. Noakes (2001) also mapped aluminum concentrations in the vicinity of the Charleston ODMDS. Aluminum is a good indicator of clay in surficial sediments, and high aluminum levels can be used to trace the dispersion of fine-grained sediments at the disposal site. Elevated aluminum levels were found within the disposal site, and also in strata OG and IA, reflecting dredged material from either recent or past disposal activities.

### Sediment Contaminants

The concentrations of various trace metals detected in the samples collected during 2000 in the disposal zone and surrounding areas are summarized in Table 5. Trace metal concentrations were low throughout the entire study area, with all values below published bioeffects guidelines (Long *et al.* 1995, McDonald *et al.* 1996). In strata IA, IF, IE, IG, IH, OA, OB, OD, OE, OG, and OH, metal concentrations fell within the range of disposal zone concentrations for at least one metal. All the metals tested for in 2000 had their highest levels within the disposal zone except cadmium, which had highest concentrations in stratum OG. This is somewhat contradictory to the results from 1993 and 1994, when highest concentrations of metals were found in stratum IH, not the disposal zone. However, stratum IH had greater silt/clay content in 1993 and 1994 than

in 2000. Contaminants often bind to fine-grained sediments (Olsen *et al.* 1982, Luoma 1989, Barrick and Prahl 1987) and it is not unexpected that strata with elevated silt/clay content would also have elevated sediment contaminants. Silt/clay content in 2000 was greatest in the disposal zone where inner harbor materials were placed, therefore, it stands to reason that contaminant concentrations would be highest in these strata.

The concentrations of various polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), and pesticides that were detected in samples collected during 2000 in the disposal zone and surrounding areas are summarized in Tables 6-8. These sediment contaminants were found in low concentrations throughout the study area, with no values exceeding published bioeffects levels (Long *et al*. 1995, McDonald *et al.* 1996). PAH concentrations above the detection limit were identified in strata DA, DB, DD, IG, and OG. These detected PAHs were chrysene+triphenylene, fluoranthene, perylene, and pyrene. PCB congeners 187, 29,44, 52, and 8 were found in concentrations above the detection limit in strata IA, IF, and OG. The pesticides chlorpyrifos, endosulfan ether, and endosulfan sulfate were found in concentrations above the detection limit in strata IA, IF, and OB.

## Benthic Infaunal Assemblages

### *Overview—2000 Benthic Data*

More than 15,700 organisms representing 402 taxa were collected from the 10 strata analyzed in 2000. A complete list of all taxa collected in these 10 strata is provided in Appendix 3, and a list of the dominant taxa collected is provided in Table 9. Mean density in these strata ranged from 1,415 to 9,323 individuals per $m^2$ with an average of

Table 5. Metal concentrations detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. None of the values exceeded published ERL or TEL levels. Values are expressed as parts per million except for aluminum and iron which are expressed as percent.

| | Disposal Area | | | | Inner Zone | | | | | | | | Outer Zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | DA | DB | DC | DD | IA | IB | IC | ID | IE | IF | IG | IH | OA | OB | OC | OD | OE | OF | OG | OH |
| Aluminum | 0.51 | 0.89 | 0.55 | 1.39 | 0.19 | 0.18 | 0.19 | 0.21 | 0.09 | 0.29 | 0.47 | 0.47 | 0.16 | 0.21 | 0.15 | 0.15 | 0.12 | 0.14 | 0.28 | 0.68 |
| Arsenic | 3.25 | 4.25 | 3.90 | 3.51 | 2.16 | 2.24 | 2.30 | 2.58 | 2.60 | 2.27 | 2.64 | 3.28 | 2.35 | 2.13 | 1.99 | 2.03 | 1.90 | 1.72 | 2.58 | 3.55 |
| Cadmium | 0.13 | 0.20 | 0.37 | 0.11 | 0.13 | 0.04 | * | 0.01 | * | 0.06 | 0.28 | 0.37 | 0.11 | 0.07 | 0.03 | 0.02 | * | 0.02 | 0.44 | 0.20 |
| Chromium | 6.70 | 14.90 | 24.60 | 12.10 | 2.35 | 1.52 | 1.23 | 1.71 | * | 2.50 | 6.04 | 7.15 | 4.11 | 2.99 | * | * | * | * | 4.72 | 7.08 |
| Copper | 0.81 | 0.37 | 1.61 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Iron | 0.56 | 0.53 | 0.37 | 0.81 | 0.31 | 0.24 | 0.23 | 0.28 | 0.31 | 0.39 | 0.53 | 0.55 | 0.36 | 0.40 | 0.33 | 0.34 | 0.32 | 0.34 | 0.45 | 0.68 |
| Lead | 2.55 | 3.45 | 1.51 | 4.34 | 1.74 | 1.34 | 1.17 | 1.46 | 0.74 | 1.63 | 2.59 | 2.37 | 1.89 | 2.10 | 1.07 | 1.34 | 1.23 | 1.21 | 2.74 | 3.17 |
| Manganese | 57.40 | 90.50 | 42.00 | 80.10 | 53.90 | 37.50 | 31.30 | 35.40 | 21.60 | 51.95 | 53.40 | 67.80 | 50.90 | 38.80 | 25.70 | 30.80 | 23.20 | 33.50 | 62.10 | 68.80 |
| Mercury | 0.01 | * | 0.01 | 0.01 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | 0.01 | * |
| Nickel | 3.40 | 6.55 | 12.70 | 4.51 | 1.80 | 2.19 | 2.83 | 2.71 | 3.43 | 2.50 | 3.07 | 3.64 | 2.96 | 2.04 | 2.89 | 3.49 | 1.76 | 3.37 | 2.30 | 4.42 |
| Selenium | * | 0.31 | 1.08 | * | * | * | * | * | 0.05 | * | * | * | * | 0.13 | * | * | 0.21 | * | 0.06 | 0.11 |
| Silver | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Tin | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Zinc | 12.30 | 11.30 | 11.80 | 13.80 | * | * | * | * | * | 5.60 | 9.98 | 7.17 | * | * | * | * | * | 3.48 | 4.92 | * |

* Metal was analyzed for but not detected

Table 6. PCBs detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. Values are reported as parts per billion. None of the values exceeded published ERL or TEL levels.

| PCB | Disposal Area | | | | Inner Zone | | | | | | | | Outer Zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Congener | DA | DB | DC | DD | IA | IB | IC | ID | IE | IF | IG | IH | OA | OB | OC | OD | OE | OF | OG | OH |
| PCB 101 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 104 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 105 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 118 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 126 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 128 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 138 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 153 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 154 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 170 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 18 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 180 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 187 | * | * | * | * | 0.069 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 188 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 195 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 201 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 206 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 209 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 28 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 29 | * | * | * | * | * | * | * | * | * | 0.102 | * | * | * | * | * | * | * | * | * | * |
| PCB 44 | * | * | * | * | 0.093 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 50 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 52 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | 0.069 | * |
| PCB 66 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 77 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 8 | * | * | * | * | 0.366 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| PCB 87 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Total_PCB | * | * | * | * | 0.529 | * | * | * | * | 0.102 | * | * | * | * | * | * | * | * | 0.069 | * |

* PCB was analyzed for but not detected

Table 7. Organic compounds detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. Values are reported as parts per billion. None of the values exceeded published ERL or TEL levels.

| | Disposal Area | | | | Inner Zone | | | | | | | | Outer Zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Organic compound | DA | DB | DC | DD | IA | IB | IC | ID | IE | IF | IG | IH | OA | OB | OC | OD | OE | OF | OG | OH |
| 1,6,7 Trimethylnaphthalene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 1-Methylnaphthalene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 1-Methylphenanthrene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 2,6 Dimethylnaphthalene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 2-Methylnaphthalene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Acenaphthene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Acenaphthylene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Anthracene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Benzo(a)anthracene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Benzo(a)pyrene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Benzo(b)fluoranthene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Benzo(e)pyrene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Benzo(g,h,i)perylene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Benzo(j+k)fluoranthene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Biphenyl | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Chrysene+Triphenylene | * | 2.3 | * | 2.2 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Dibenz(a,h+a,c)anthracene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Dibenzothiophene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Fluoranthene | 4.7 | 8.3 | * | * | * | * | * | * | * | * | 4.6 | * | * | * | * | * | * | * | * | * |
| Fluorene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Indeno(1,2,3-cd)pyrene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Naphthalene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Perylene | 36.0 | 11.5 | * | 24.5 | * | * | * | * | * | * | 6 | * | * | * | * | * | * | * | 6.1 | * |
| Phenanthrene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Pyrene | 4.7 | 6.0 | * | * | * | * | * | * | * | * | 3.6 | * | * | * | * | * | * | * | 3.3 | * |
| Total_PAH | 45.4 | 28.0 | * | 26.7 | * | * | * | * | * | * | 14.2 | * | * | * | * | * | * | * | 9.4 | * |

* PAH was analyzed for but not detected

Table 8. Pesticide concentrations detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2000. Values are reported as parts per billion. None of the values exceeded published ERL or TEL levels.

| | Disposal Area | | | | Inner Zone | | | | | | | | Outer Zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pesticide | DA | DB | DC | DD | IA | IB | IC | ID | IE | IF | IG | IH | OA | OB | OC | OD | OE | OF | OG | OH |
| 2,4'-DDD | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 2,4'-DDE | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 2,4'-DDT | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 4,4'-DDD | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 4,4'-DDE | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 4,4'-DDT | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Aldrin | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Chlorpyrifos | * | * | * | * | 0.59 | * | * | * | * | 0.15 | * | * | * | 0.10 | * | * | * | * | * | * |
| Cis-chlordane (alpha-chlordane) | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Dieldrin | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Endosulfan ether | * | * | * | * | 0.07 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Endosulfan I | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Endosulfan II | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Endosulfan Lactone | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Endosulfan Sulfate | * | * | * | * | 0.13 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Gamma-HCH (g-BHC, lindane) | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Heptachlor | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Heptachlor epoxide | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Hexachlorobenzene | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Mirex | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Total_DDT | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Total_Pest | * | * | * | * | 0.79 | * | * | * | * | 0.15 | * | * | * | 0.10 | * | * | * | * | * | * |
| Trans-nonachlor | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

* Pesticide was analyzed for but not detected

Table 9. The twenty-five numerically dominant taxa collected from the disposal zone and surrounding area in 2000. Values are mean number of organisms per $m^2$. P = Polychaete, A = Amphipod, M = Mollusc, O = Other.

| | | | Non-Impacted Strata | | | | Impacted Strata | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Inner | | Outer | | Inner | | | Outer | | |
| Species Name | | Total | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
| *Prionospio dayi* | P | 3078 | 128 | 338 | 148 | 453 | 350 | 415 | 465 | 105 | 353 | 325 |
| *Prionospio cristata* | P | 2413 | 83 | 750 | 773 | 88 | 30 | 23 | 85 | 80 | 480 | 23 |
| *Branchiostoma* sp. | O | 1840 | 323 | 605 | 450 | 238 | 28 | 30 | 10 | 120 | 28 | 10 |
| *Rhepoxynius epistomus* | A | 1818 | 175 | 78 | 318 | 438 | 180 | 83 | 185 | 143 | 43 | 178 |
| *Sabellaria vulgaris* | P | 1728 | 0 | 938 | 0 | 33 | 3 | 0 | 60 | 5 | 690 | 0 |
| Nemertinea | O | 1633 | 123 | 240 | 133 | 135 | 45 | 320 | 150 | 38 | 340 | 110 |
| *Prionospio* sp. | P | 1163 | 23 | 580 | 203 | 13 | 8 | 13 | 20 | 43 | 258 | 5 |
| Sabellariidae | P | 1103 | 0 | 1038 | 5 | 0 | 0 | 28 | 0 | 30 | 3 | 0 |
| *Magelona* sp. | P | 1018 | 8 | 13 | 8 | 5 | 23 | 333 | 38 | 13 | 523 | 58 |
| Polygordiidae | O | 1008 | 58 | 203 | 68 | 248 | 45 | 133 | 70 | 8 | 135 | 43 |
| *Mediomastus* sp. | P | 870 | 18 | 283 | 55 | 8 | 3 | 0 | 8 | 5 | 480 | 13 |
| *Eudevenopus honduranus* | A | 835 | 48 | 163 | 135 | 205 | 30 | 38 | 90 | 38 | 20 | 70 |
| *Protohaustorius deichmannae* | A | 800 | 73 | 35 | 65 | 75 | 75 | 50 | 168 | 83 | 10 | 168 |
| *Myriochele oculata* | P | 633 | 3 | 165 | 25 | 53 | 0 | 43 | 90 | 5 | 143 | 108 |
| *Bhawania heteroseta* | P | 578 | 3 | 98 | 13 | 0 | 0 | 0 | 0 | 3 | 463 | 0 |
| *Mediomastus californiensis* | P | 555 | 35 | 360 | 53 | 0 | 5 | 0 | 0 | 5 | 98 | 0 |
| *Mellita* sp. | O | 555 | 205 | 3 | 163 | 28 | 55 | 8 | 5 | 43 | 0 | 48 |
| *Goniada littorea* | P | 495 | 15 | 28 | 23 | 30 | 33 | 55 | 95 | 15 | 105 | 98 |
| Ophiuroidea | O | 493 | 20 | 25 | 243 | 50 | 3 | 45 | 13 | 5 | 75 | 15 |
| *Acanthohaustorius intermedius* | A | 455 | 68 | 25 | 53 | 63 | 90 | 25 | 10 | 90 | 0 | 33 |
| Oligochaeta | O | 453 | 30 | 125 | 75 | 93 | 13 | 20 | 5 | 3 | 70 | 20 |
| *Synelmis ewingi* | P | 435 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 425 | 0 |
| *Armandia maculata* | P | 380 | 38 | 105 | 85 | 18 | 10 | 20 | 35 | 20 | 40 | 10 |
| *Natica pusilla* | M | 370 | 28 | 50 | 48 | 30 | 23 | 58 | 60 | 18 | 40 | 18 |
| *Crassinella martinicensis* | M | 343 | 83 | 90 | 110 | 15 | 3 | 8 | 3 | 30 | 3 | 0 |
| Percent of total abundance | | | 66 | 71 | 61 | 68 | 69 | 68 | 70 | 69 | 66 | 72 |
| Mean density per strata | | | 2475 | 9323 | 5480 | 3505 | 1580 | 2975 | 2720 | 1415 | 7853 | 2063 |
| Mean number of species | | | 29 | 51 | 42 | 37 | 24 | 32 | 32 | 22 | 43 | 26 |
| Mean H' - Diversity | | | 4.01 | 4.19 | 4.22 | 4.27 | 3.85 | 3.96 | 4.21 | 3.88 | 4.12 | 3.98 |
| Mean Evenness - J' | | | 0.84 | 0.76 | 0.79 | 0.82 | 0.84 | 0.80 | 0.84 | 0.88 | 0.78 | 0.85 |
| Mean Species Richness | | | 6.21 | 9.03 | 7.75 | 7.40 | 5.65 | 6.47 | 6.67 | 5.36 | 7.68 | 5.71 |

3,939 individuals per $m^2$. The number of species per grab ranged from 22 to 51 species per grab with a mean of 34 species per grab. Diversity (H') ranged from 3.85 to 4.27 per strata with a mean of 4.07; mean diversity values for each strata are listed in Table 9.

Polychaetes were the most abundant taxonomic group, comprising 56% of all organisms identified in samples collected during 2000. Organisms falling in the category 'other taxa' (e.g. Nemertina, *Branchiostoma* sp., Polygordiidae) made up 21% of the total abundance. Amphipods and molluscs comprised 13% and 10% of the total abundance, respectively (Figure 12).

Fourteen taxa made up 50% of the total number of individuals. In decreasing order of abundance these taxa were *Prionospio dayi*, *Prionospio cristata, Branchiostoma* sp., *Rhepoxynius epistomus*, *Sabellaria vulgaris*, Nemertina, *Prionospio* sp., Sabellaridae, *Magelona* sp., Polygordiidae, *Mediomastus* sp., *Eudevenopus honduranus*, *Protohaustorius deichmannae*, and *Myriochele oculatus.* Although Sabellaridae and *Sabellaria vulgaris* were numerically dominant, the majority (> 85%) of these organisms were found in one (in the case of Sabellaridae) or two (in the case of *S. vulgaris*) samples. Therefore, these two taxa are not representative of the overall benthic community. If these two taxa are excluded, the remaining twelve numerically dominant taxa comprise 47% of the total abundance for 2000 data.

### *Spatial Changes—2000 Benthic Data*

The benthic assemblages found in the strata that showed major changes in sediment composition (impacted) were somewhat different from those collected in areas with no evidence of change related to disposal activities (non-impacted). The eleven numerically dominant taxa in the non-impacted strata (IC, ID, OC, OD), in order of

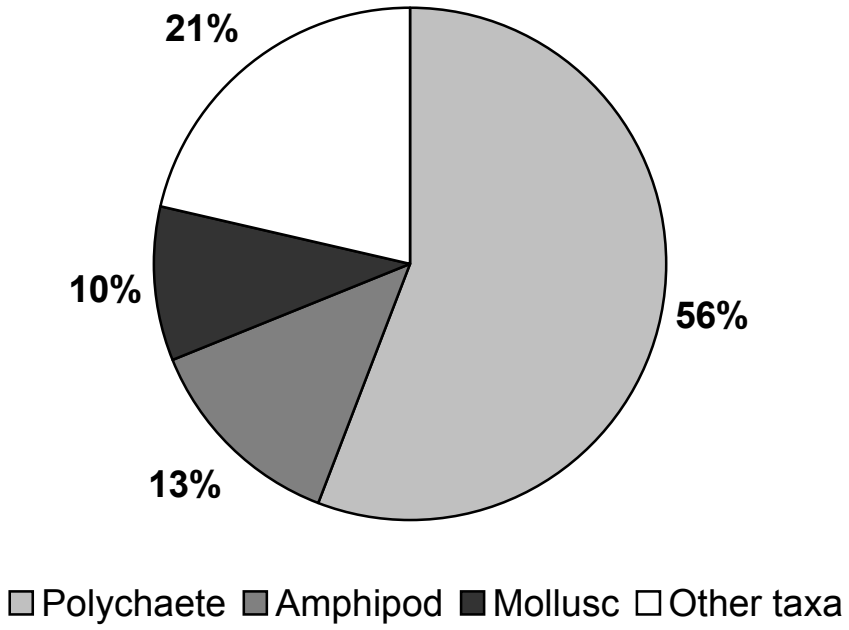



Figure 12. Percent abundance of general taxonomic groups from samples collected in 2000.

decreasing abundance, were: *Prionospio cristata*, *Branchiostoma* sp., *P. dayi*, Sabellaridae, *Rhepoxynius epistomus*, *Sabellaria vulgaris*, *Prionospio* sp., Nemertina, Polygordiidae, *Eudevenopus honduranus*, and *Mediomastus californiensis*. These taxa comprised 50% of the total abundance in the non-impacted strata. The eleven numerically dominant taxa in the impacted strata (IA, IG, IH, OA, OG, OH), in order of decreasing abundance, were: *P. dayi*, Nemertina, *Magelona* sp., *Rhepoxynuis epistomus*, *S. vulgaris*, *P. cristata*, *P. deichmannae*, *Mediomastus* sp., *Bhawania heteroseta*, *Synelmis ewingi*, and Polygordiidae. These taxa comprised 47% of the total abundance in the impacted strata.

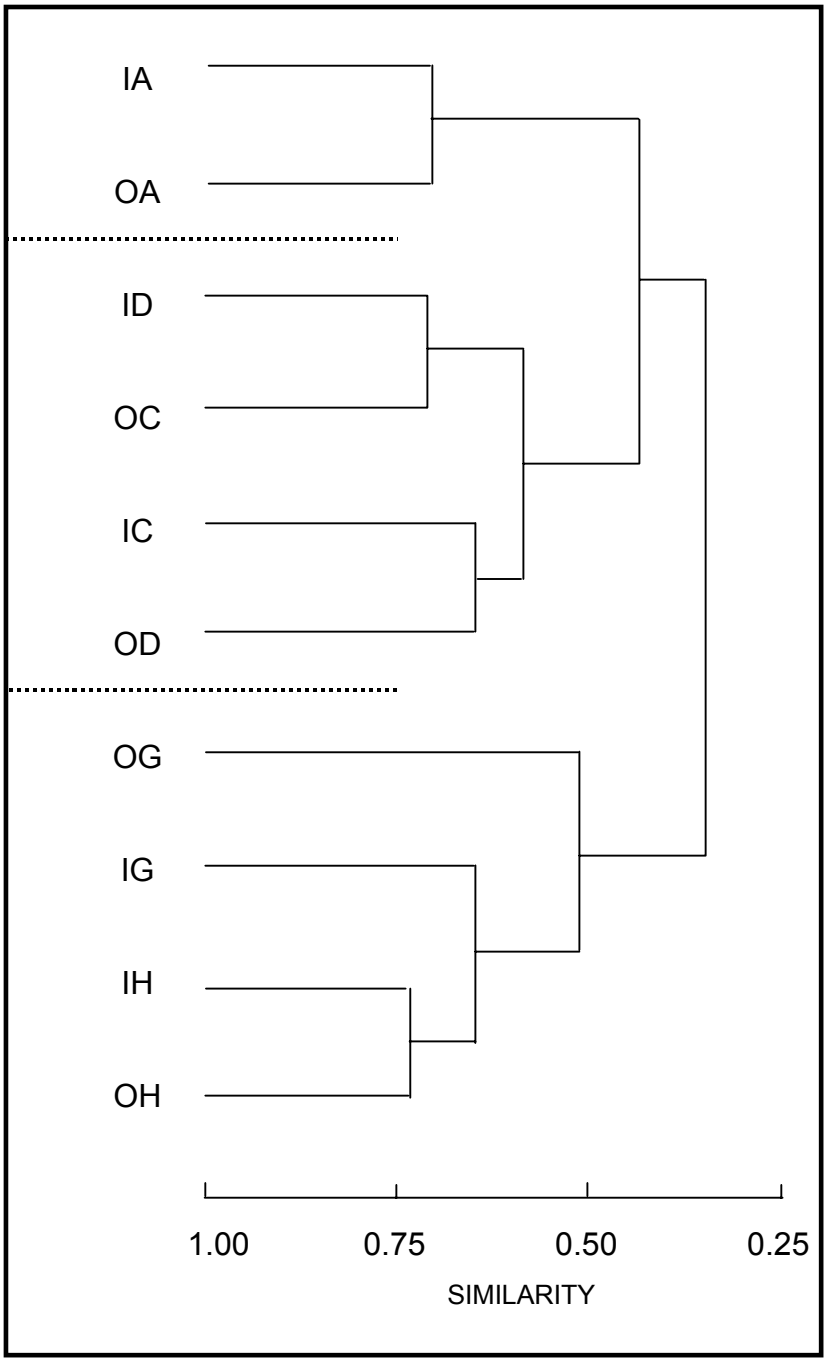
Seven of these taxa were common between the impacted and non-impacted strata. However, a number of these common taxa were more abundant in one or the other of the two strata groups. For example, *P. cristata* and Polygordiidae were more abundant in non-impacted strata while *P. dayi* and Nemertina were more abundant in impacted strata. The taxa *Branchiostoma* sp. and *Eudevenopus honduranus* were among the top eleven taxa for the non-impacted strata but were not part of the dominant taxa list for the impacted strata. *Branchiostoma* sp. are rarely found in muddy sediments (Cory and Pierce 1967, Boschung and Gunter 1962). *Eudevenopus honduranus* is a sand-dwelling platyischnopid amphipod (Thomas and Barnard 1983, Cary 1996) that has been observed to exhibit declines in abundance following physical disruptions such as dredging activities (Jutte *et al*. 2001). Conversely, *Magelona* sp. and *Protohaustorius deichmannae* were dominant in the impacted strata but were not members of the eleven numerically dominant taxa in the non-impacted strata. The abundance of tentaculate feeding polychaetes, such as *Magelona* sp., were found to be positively correlated with

silt/clay content and organic matter content following dredging activities in Myrtle Beach (Jutte *et al.* 1999). These findings suggest patterns in animal-sediment relationships that may be indicative of non-impacted versus impacted strata.

To further evaluate spatial differences in the benthic community inhabiting the disposal zone and surrounding areas, a cluster analysis of the data was conducted. Cluster analysis grouped the strata analyzed in 2000 based on the composition and density of the benthic infaunal community (Figure 13). The density and composition of the benthos in strata OG, IG, IH, and OH (impacted areas) were most similar to one another. Strata in the boundary areas to the east of the disposal zone in IC, OC, ID, and OD (non-impacted areas) formed a second distinct cluster. The third data cluster was composed of strata IA and OA, which are located to the northwest of the disposal area and are subjected to dredge trailings based on side scan sonar surveys (Gayes *et al.* 2002) and sediment mapping data (Noakes 2001). These findings suggest that the western, eastern, and northwestern boundary strata support distinct faunal assemblages. The higher level of similarity between the northwestern and eastern strata suggests that the northwestern strata have been less impacted by disposal activities than the western strata. This could be due to the identification and correction of the trailing problem following the 2000 side scan survey, while ongoing migration of disposal material continues to impact the western strata.

### *Temporal Changes*

To evaluate temporal changes in the benthic communities, data from 1993 and 1994 were divided into those stations within strata IA, IB, IC, ID, IE, IF, OA, OB, OC,



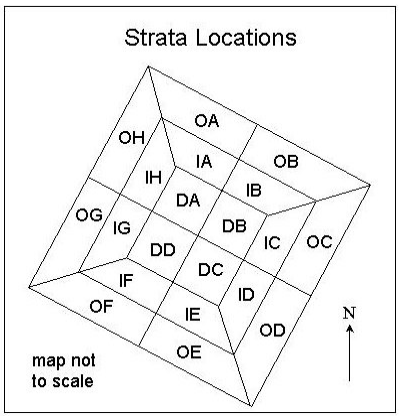




Figure 13. Results of normal cluster analysis using Bray-Curtis similarity coefficient on benthic data collected in 2000.

OD, OE, and OF that also had less than the 90th percentile silt/clay and the 90th percentile $CaCO_3$. This subset of reference data was then used for comparison to the 2000 data.

Analyses of benthic community metrics between the three years revealed significant effects of disposal activities on both mean density and number of species. Mean density was significantly lower in 2000 than in 1993 or 1994 in four of the six impacted strata while there were no significant differences between mean density in 2000 and the earlier years in three of the four non-impacted strata (Figure 14). The number of species was significantly lower in 2000 than in 1993 or 1994 at five of the six impacted strata, while three of the four non-impacted strata had no significant differences among years (Figure 15). These effects on the number of species and the density of benthic organisms were apparent in both the areas adjacent to the disposal zone (i.e. inner zone) as well as in the areas farther away from the disposal zone (i.e. outer zone). The non-impacted stratum IC had significantly lower faunal density and number of species in 2000 than in 1993 or 1994, although the cause of these trends is unclear. A number of benthic organisms, including the amphipod *Bathyporeia parkeri*, the pelecypod *Parvilucina multilineata*, and the archiannelid Polygordiidae had significantly higher densities in the 1993-1994 references stations than in stratum IC in 2000.

The general taxonomic composition in the boundary zones were altered following disposal activities, however, most of these differences cannot be attributed to the disposal of dredge material. Densities of the most abundant taxonomic groups, the polychaetes, showed no discernible pattern related to disposal activities. The density of molluscs was significantly lower in 2000 than in 1993 or 1994 in nine of the strata (all the impacted strata and three of four non-impacted strata). Also, the density of amphipods was

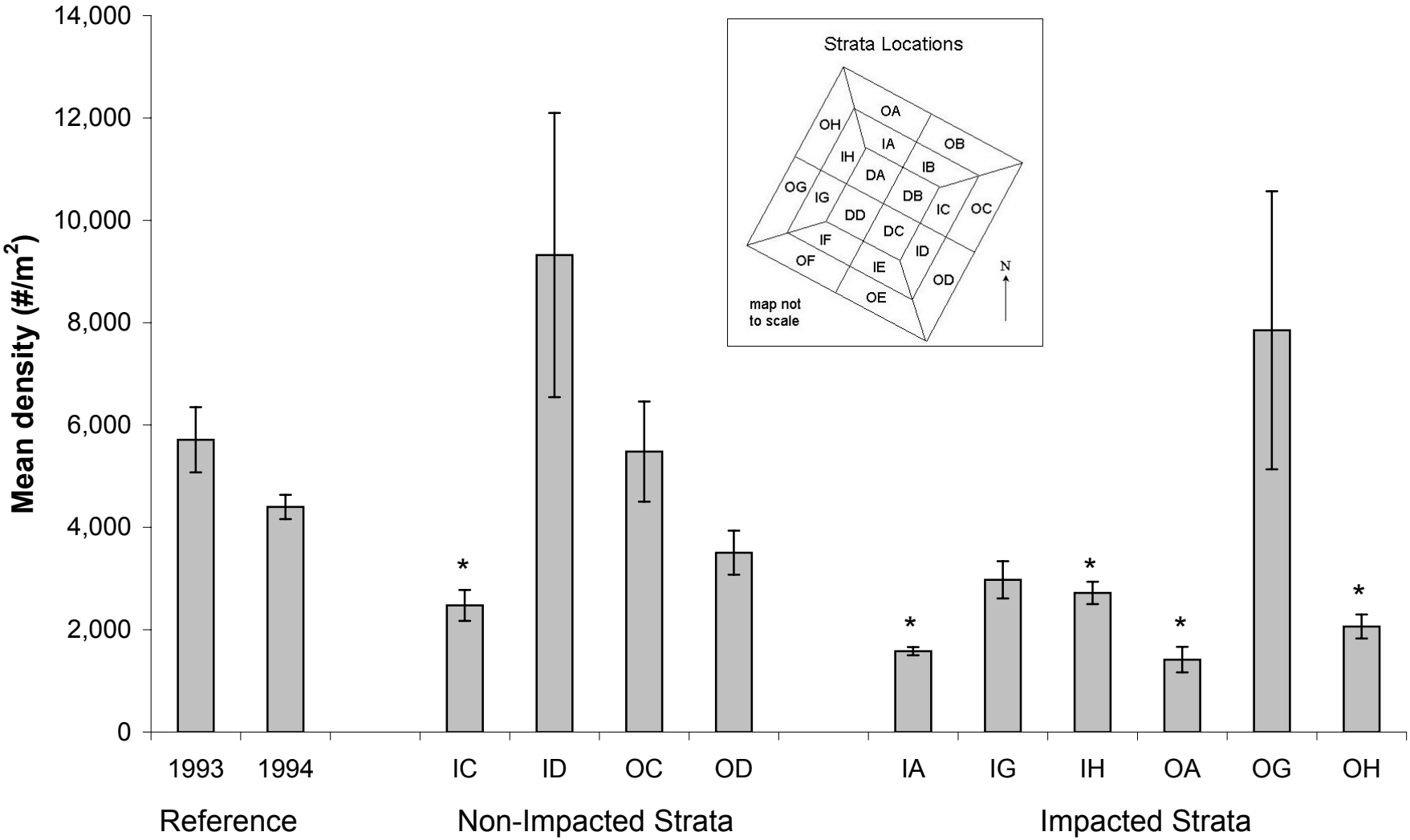



Figure 14. Mean density at 1993/1994 reference stations and strata from 2000. Error bars represent ±1 standard error. Asterisk represent strata in which 2000 < 1993 and 1994 (significant difference at $p < 0.05$).

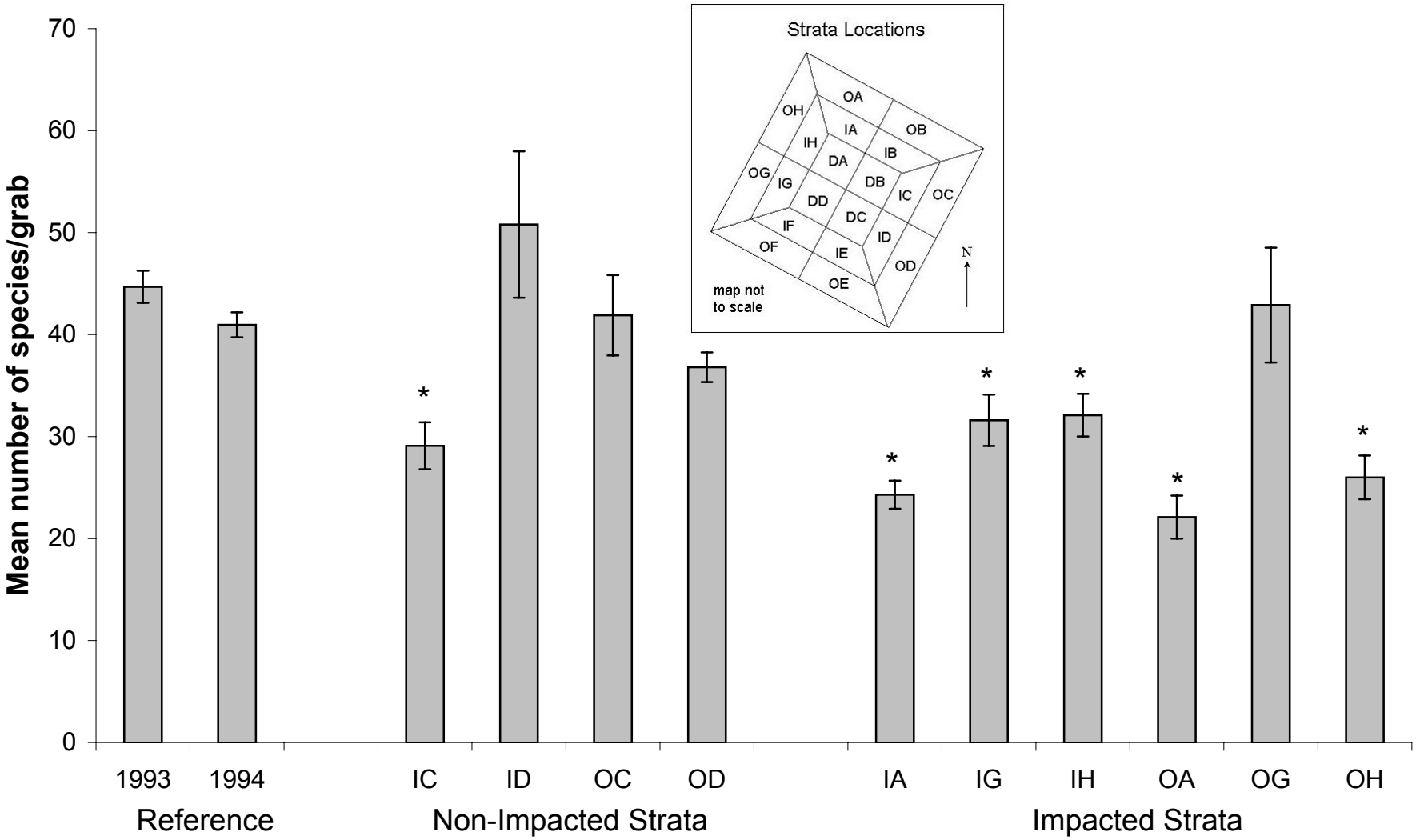



Figure 15. Number of species at 1993/1994 reference stations and strata from 2000. Error bars represent ±1 standard error. Asterisk represent strata in which 2000 < 1993 and 1994 (significant difference at $p < 0.05$).

significantly lower in 2000 than in 1993 and 1994 in seven of the strata (five of six impacted strata and two of four non-impacted strata). Because differences between the baseline assessment and the 2000 assessment were encountered in both the impacted and non-impacted strata with respect to mollusc and amphipod densities, these effects appear to be related to year-to-year variability and not to disposal activities. However, the density of organisms in the 'other taxa' category does appear to have been altered by disposal activities. Organisms in the 'other taxa' category had significantly lower densities in 2000 than in 1993 or 1994 in four of the six impacted strata, whereas none of the non-impacted strata had significant differences among years (Figure 16).

An overall species list for the 1993, 1994, and 2000 surveys included the following top ten dominant taxa: the polychaetes *Prionospio cristata* and *Prionospio dayi*; the amphipods *Rhepoxynius epistomus* and *Bathyporeia parkeri*; the molluscs *Parvilucina multilineata, Crassinella martinicensis* and *Tellina* sp.; and Nemertina, *Branchiostoma* sp. and Polygordiidae in the 'other taxa' category. To examine impacts of disposal activities on these taxa, ANOVAs were performed to compare the 2000 data by strata to the reference samples from 1993 and 1994. Eight of the ten dominant taxa had no discernible differences in faunal densities among the three years. The density of two taxa, *Prionospio dayi* and *Crassinella martinicensis*, appeared to be significantly altered by changes related to disposal activities.

In five of the six impacted strata, *P. dayi* had significantly higher densities in 2000 than in 1993 or 1994, while three of the four non-impacted strata had no significant differences in *P. dayi* density among years (Figure 17). *P. dayi* is a spionid polychaete classified as both a deposit feeder and a suspension feeder (Fauchald and Jumars 1979,

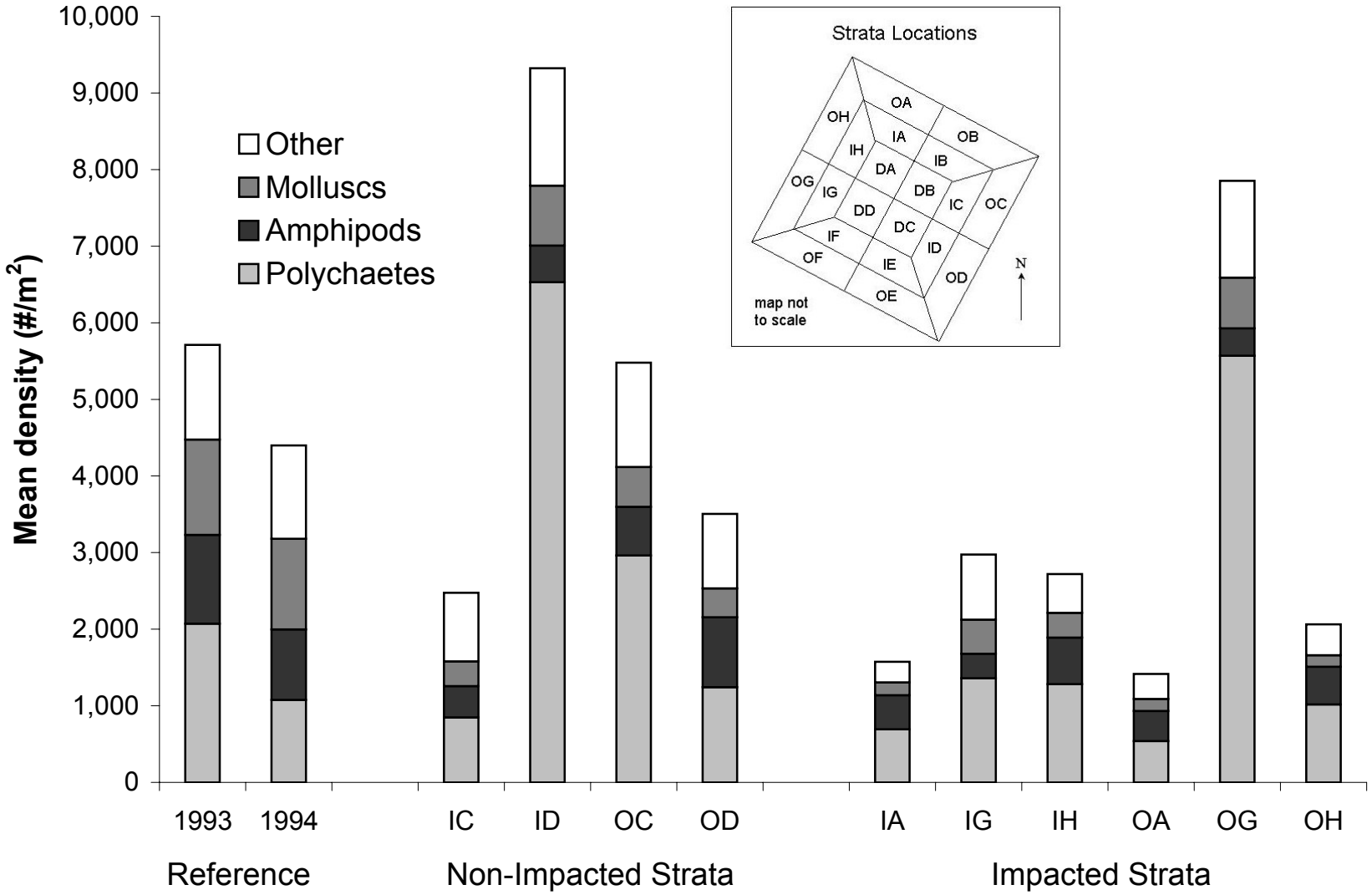



Figure 16. Mean density of general taxonomic groups at 1993/1994 reference stations and strata from 2000.

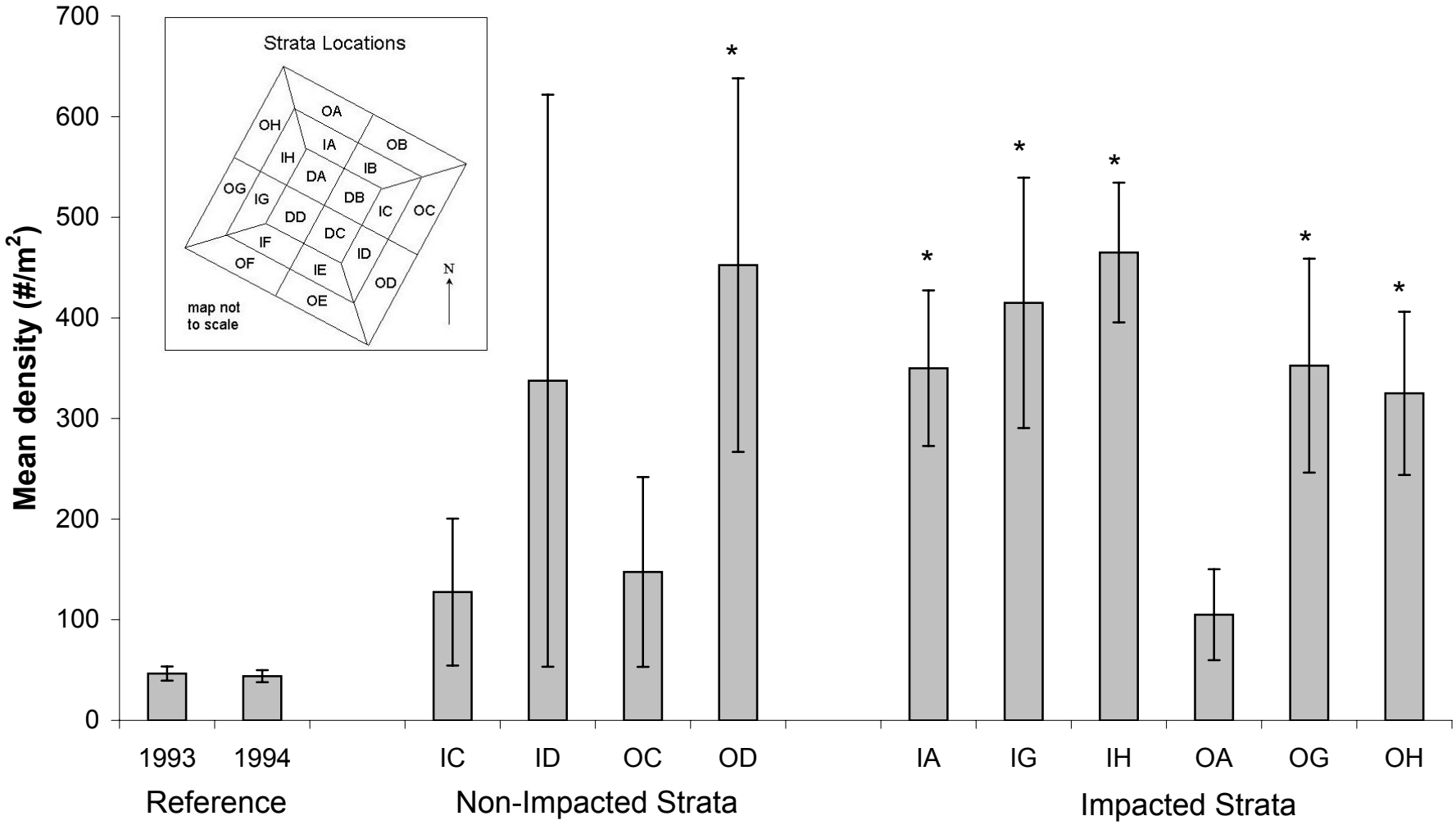



Figure 17. Mean density of *P. dayi* at 1993/1994 reference stations and strata from 2000. Error bars represent ±1 standard error. Asterisk represent strata in which 2000 > 1993 and 1994 (significant difference at $p < 0.05$).

Dauer *et al.* 1981), depending on the availability of suspended and deposited particles. Large abundances of this species might be expected with increased levels of surficial sediments with relatively high organic matter content or with deposition of sediments high in organic matter composition. Spionid polychaetes, when filter-feeding, depend on particles making direct contact with their elongate, flexible feeding palps ('impingement-feeders', Steele-Petrovic 1975). This feeding technique, which captures larger size particles and allows smaller particles to pass through, makes these organisms tolerant of high turbidity water conditions. This is not the case for filter-feeding bivalves, which filter water through an organ that traps all particles larger than a certain size (see below), and becomes clogged in turbid waters (Dauer *et al.* 1981).

*C. martinicensis* had significantly lower densities in 2000 than in 1993 or 1994 in all of the impacted strata, but three of the four non-impacted strata had no significant differences among years (Figure 18). This mollusc is commonly found in shelly or sandy sediments (Harry 1966) and the presence of disposal materials in the impacted strata may have reduced the abundance of this species. Suspension-feeding bivalves such as *C. martinicensis* can suffer disorders caused by the abrasive action of silt/clay, the exposure of toxicants absorbed to the fine materials (Blake *et al.* 1996), or the clogging of gills (Dauer *et al.* 1981). While the responses to these physical conditions are often sublethal, the severity of the response depends on the species, life stage, time of year, duration of exposure, and natural habitat of the species. Clarke and Miller-Way (1992) found that molluscs were absent from disposal-affected areas in Mobile Bay, Alabama. Future assessments of biological impacts from disposal activities at the Charleston disposal area

may further elucidate relationships between alterations in sediment composition and certain feeding types (e.g suspension/filter feeders).

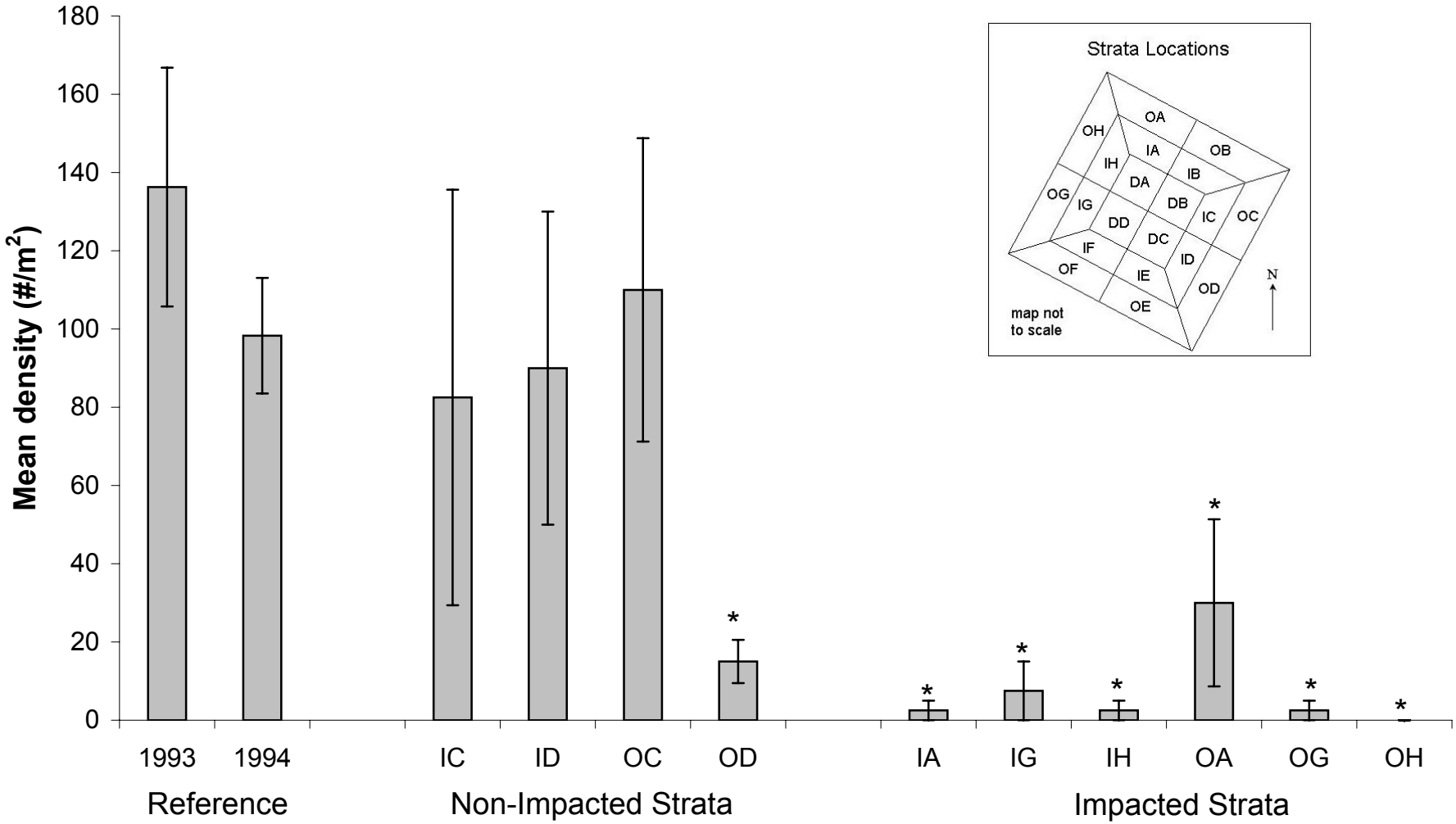



Figure 18. Mean density of *C. martinicensis* at 1993/1994 reference stations and strata from 2000. Error bars represent ±1 standard error. Asterisk represent strata in which 2000 < 1993 and 1994 (significant difference at $p < 0.05$).

# CONCLUSIONS AND RECOMMENDATIONS

The disposal of fine-grained inner harbor sediments into the Charleston offshore disposal zone has resulted in a number of physical and biological impacts to the area surrounding the disposal zone. Silt/clay and organic matter content to the west of the disposal zone are elevated above typical levels in nearshore South Carolina waters. These changes in sediment characteristics have, in turn, impacted the benthic community living to the west of the disposal zone.

Disposal operations placed fine-grained inner harbor materials in the western and central portions of the disposal zone, and shelly sands from the entrance channel on the eastern berm of the disposal zone. Some unauthorized dumping also occurred in areas to the west and south (mostly within the inner boundary zone) of the disposal zone. As expected, sediment characteristics within the disposal zone were significantly different from earlier baseline sampling in 1993 and 1994. These effects were intended to be limited to the disposal zone, however, the significantly increased levels of silt/clay in the inner and outer boundary zones in 2000 when compared to baseline levels clearly show the effects were more pervasive. The likely source of the elevated silt/clay levels in the boundary zones is material migrating from the disposal site or unauthorized dumps.

The benthic community structure in the boundary areas impacted by disposal activities showed decreased faunal densities and number of species. In addition, effects were observed in particular taxonomic groups and several dominant species. The condition of the benthic infaunal assemblages in the boundary zones was the focus of this report; while biological effects within the disposal zone were obviously anticipated, analyses in these areas was limited to sediment characteristics and sediment contaminants

in an effort to lower study costs. Declines in the densities of organisms in the boundary zones and disposal zone may cause longer-term effects due to reduced local recruitment.

Based on these findings, SCDNR recommends that the planned post-assessment and three-year post-assessment of the Charleston ODMDS and surrounding areas be completed using the same sampling strategies used for the baseline and 2000 surveys. In addition, the continuation of monitoring efforts at hard bottom reef sites, planned through at least spring 2005, is warranted to document status of biological resources, habitat condition, and areal extent.

Monitoring activities should not cease upon the completion of large-scale disposal operations because these monitoring efforts are needed to document the duration and fate of disposed sediments and long-term trends at the site. Continued monitoring of the site is particularly critical in the face of ongoing disposal operations, future disposal operations, and possible site expansion requests. Based on the data collected during the post-assessment studies, specific recommendations for monitoring in subsequent years of the program may change, and findings may warrant an extension in the length of the monitoring program.

# SUMMARY

- Disposal operations have occurred in the general vicinity of the Charleston Ocean Dredged Material Disposal Site (ODMDS) since 1896. The area currently permitted for disposal activities is a four square mile disposal zone approved by an interagency team in 1993.
- Extensive monitoring efforts to assess sediment characteristics, sediment contaminants, water current and wave conditions, and benthic assemblages have been conducted in the area, in addition to side scan sonar surveys, and sediment mapping surveys.
- In anticipation of the 1999-2002 Charleston Harbor deepening project, baseline monitoring activities at the disposal zone and surrounding areas (inner and outer boundary zones) took place in 1993 and 1994. These studies were conducted to better understand natural variability in sediment characteristics and benthic infaunal assemblages in the area. The effects of historical dumping activities in the area were acknowledged.
- Unauthorized disposal activities occurred in 1999 and 2000 as part of the 1999-2002 Charleston Harbor deepening project. Sediments high in silt/clay content were found in areas surrounding the disposal zone, likely due to the movement of fines from the disposal site, combined with the disposal of fine-grained materials from unauthorized dumps.
- This report provides an interim assessment of the sediment characteristics, sediment contaminants, and benthic infaunal assemblages in the disposal area and surrounding boundary areas. These efforts, in addition to sediment mapping

surveys, side scan sonar surveys, hard bottom reef assessments, and measurements of disposal material mobility and transport were planned to occur approximately halfway through the 1999-2002 Charleston Harbor deepening project.

- Benthic grab samples were collected at 200 sites within the disposal zone, inner boundary zone, and outer boundary zone using a GPS positioning system and were selected from the original random array of 400 stations sampled in 1993-1994. Each grab sample was sub-sampled for analysis of sediment characteristics and sediment contaminants. The remainder of the grab sample was sieved to remove benthic organisms for identification in the laboratory. Sediment and benthic infaunal samples were processed by SCDNR, and contaminant samples were processed by NOAA-NOS-CCEHBR. Benthic sample processing followed a tiered approach with a subset of 10 of the total 20 strata being analyzed. Strata were classified as impacted or non-impacted based on findings from the sediment mapping survey (Noakes 2001), side scan sonar survey (Gayes 2001), and sediment analyses.
- The majority of sediments collected in 2000 were composed of medium to fine-grained sands mixed with moderate amounts of shell hash. Due to the extensive dumping of fine-grained inner harbor material in the disposal site, there was significantly higher silt/clay content and organic matter content and significantly lower sand content in the disposal zone than in the inner and outer boundary areas. There were no significant differences among zones with respect to shell hash ($CaCO_3$) content or the mean grain size of sand.

- Silt/clay content was significantly higher in the disposal zone, inner boundary, and outer boundary zones in 2000 than in 1994. The most impacted areas were the disposal zone and strata IG, IH, OG, and IB, likely due to migration of material from the disposal site and unauthorized disposal material. Temporal comparisons of other sediment characteristics indicated that sand content was significantly lower in the disposal zone in 2000 than in baseline surveys, and shell hash content in the disposal zone was significantly higher in 2000 than in 1994.
- Sediment contaminant levels were low in all strata sampled in 2000. All trace metal, polyaromatic hydrocarbon (PAH), polychlorinated biphenyl (PCB), and pesticide concentrations were below published bioeffects levels.
- Over 15,700 organisms representing 402 taxa were identified in the 10 strata analyzed in 2000. The average number of species per grab was 34, with an overall mean diversity (H') of 4.07. Polychaetes were the most dominant taxonomic group (56%), followed by organisms in the 'other taxa' category (21%), amphipods (13%), and molluscs (10%).
- There was some overlap in the dominant benthic organisms found in the impacted and non-impacted strata. Several species exhibited higher dominance at either the impacted or the non-impacted sites; the patterns in the density of these species was most likely due to differences in sediment characteristics.
- A cluster analysis of the 2000 data resulted in three groupings based on the density and composition of organisms: the western boundary strata, the eastern boundary strata, and the northwestern boundary strata. The faunal assemblage in the northwestern strata was more similar to the eastern strata than the western

strata. This suggests that the measures taken to eliminate dredge trailings over the northwestern region in 2000 may have minimized benthic impacts or allowed for greater faunal recovery, while ongoing migration of disposal material continues to impact the western strata.

- Temporal analyses of benthic community structure compared 2000 data to a subset of 1993-1994 data. The subset selected best typified natural, baseline conditions, and eliminated from analysis samples collected in 1993-1994 that may have been influenced by historical disposal activities.
- Mean faunal density and the mean number of species were significantly lower in 2000 than 1993 or 1994 in the majority of impacted strata, while most non-impacted strata showed no significant differences between years. General taxonomic structure was also affected by disposal activities. Organisms in the 'other taxa' category had significant declines in the majority of impacted strata in 2000, but no difference among years was observed in non-impacted strata. The consistent declines in amphipods and molluscs in all strata in 2000 are most likely due to annual variability.
- Two dominant organisms, the polychaete *Prionospio dayi* and the bivalve *Crassinella martinicensis*, showed significant shifts in faunal densities that appeared to be associated with disposal operations. Increased silt/clay content in surficial sediments may be beneficial to *P. dayi*, due to its feeding mode, while fine sediments may lead to sublethal effects or mortality in *C. martinicensis*.
- Based on these findings, SCDNR recommends that the planned post-assessment and three-year post-assessment of the disposal zone and surrounding boundary

areas be completed using the same sampling strategies used for the baseline and 2000 surveys. Continued monitoring of hard bottom reef sites is also warranted. These monitoring efforts are needed to document the duration and fate of disposed sediment and long-term trends at the site.

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# LITERATURE CITED

Barrick, R.C. and P.G. Prahl. 1987. Hydrocarbon geochemistry of the Puget Sound regions-III. Polycyclic aromatic hydrocarbons in sediments. Estuarine, Coastal, and Shelf Science. 25:175-191.

Blake, N.J., L.J. Doyle, and J.J. Culter. 1996. Impacts and direct effects of sand dredging for beach renourishment on the benthic organisms and geology of the west Florida shelf. Final report prepared by the Florida Institute of Oceanography for the U.S. Department of the Interior, Minerals Management Service. 109 pp + appendices.

Bloom, S.A. 1994. The community analyses system 4.2. Ecological Data Consultants, Inc., Archer, Florida.

Boschung, H.V. and G. Gunter. 1962. Distribution and variation of *Branchiostoma caribaeum* in Mississippi Sound. Tulane Studies in Zoology. 9: 245-257.

Brown, A.C. and A. McLachlan. 1990. Ecology of Sandy Shores. Elsevier, Amsterdam, The Netherlands. 328 pp.

Cary, L.A. 1996. The natural history of a sand dwelling amphipod, Eudevenopus honduranus Thomas & Barnard, 1983, from high energy beaches of east central Florida. Master Thesis, Florida Institute of Technology. 85 pp.

Charleston ODMDS Site Management and Monitoring Plan, 1993. Site Management and Monitoring Team (SMMP); U.S. Environmental Protection Agency, Region IV; the Charleston District U.S. Army Corps of Engineers; the U.S. Fish and Wildlife Service; the South Carolina Wildlife and Marine Resources Department; the South Carolina Ports Authority. Approved by LCDR Mark E. Vincent, USACE, and W. Ray Cunningham, Director, Water Management Division, USEPA, Region IV, March 10, 1993, 15 pp.

Clarke, D. and T. Miller-Way. 1992. An environmental assessment of the effects of open-water disposal of maintenance dredged material on benthic resources in Mobile Bay, Alabama. Final Report submitted to US Army Engineer District, Mobile. Misc. Paper D-92-1.

Cory, R.L. and E.L. Pierce. 1967. Distribution and ecology of lancelets (Order Amphioxi) over the continental shelf of the Southeastern United States. Limnology and Oceanography 12: 650-656.

Dauer, D.M., C.A. Maybury, and R.M. Ewing. 1981. Feeding behavior and general ecology of several spionid polychaetes from the Chesapeake Bay. Journal of Experimental Marine Biology and Ecology 54: 21-38.

Environmental Protection Agency. 1983. Final Environmental Impact Statement for Savannah, GA; Charleston, SC; and Wilmington, NC. Ocean Dredged Material Disposal Sites Designation. EPA Report. 440/2-83-014. 131 pp.

Fauchald, K. and P.A. Jumars. 1979. The diet of worms: a study of polychaete feeding guilds. Oceanography and Marine Biology Annual Reveiw. 17: 193-284.

Folk, R.L. 1980. Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, Texas. 185 pp.

Fortner, A.R., M. Sanders, and S.W. Lemire. 1996. Polynuclear aromatic hydrocarbons and trace metal burdens in sediment and the oyster, Crassostrea virginica (Gmelin), from two high salinity estuaries in South Carolina. In: Sustainable Development in the Southeast Coastal Zone. F.J. Vernberg, W.B. Vernberg and T. Siewicki, eds. University of South Carolina Press, Columbia, SC, USA, pp. 445-477.

Gayes, P.T. 2001. Geophysical characterization of the seafloor within the Charleston ocean dredged material disposal site, March-September 2000. Final report prepared by the Center for Marine and Wetland Studies for the South Carolina Department of Natural Resources. 49 pp.

Gayes, P.T., G.Y. Ojeda, P.C. Jutte, and R.F. Van Dolah. 2002. Geophysical characterization of the seafloor: Charleston ocean dredged material disposal site—July 2001. Final report prepared by the Center for Marine and Wetland Studies and the South Carolina Department of Natural Resources for the U.S. Army Corps of Engineers, Charleston District. 54 pp.

Harry, H.W. 1966. Studies on bivalve molluscs of the genus Crassinella in the Northwestern Gulf of Mexico: anatomy, ecology, and systematics. Publications of the Institute of Marine Science, University of Texas. 11:65-89.

Jutte, P.C., R.F. Van Dolah, M.V. Levisen, P. Donovan-Ealy, P.T. Gayes, and W.E. Baldwin. 1999. An environmental monitoring study of the Myrtle Beach renourishment project: physical and biological assessment of offshore sand borrow site, Phase I—Cherry Grove borrow area. Final report prepared by the South Carolina Department of Natural Resources for the U.S. Army Corps of Engineers, Charleston District. 79 pp.

Jutte, P.C., M.V. Levisen, and R.F. Van Dolah. 2001. Analysis of sediments and habitat in the areas surrounding the Charleston ocean dredged material disposal site, including unauthorized disposal operations. Final report prepared by the South Carolina Department of Natural Resources for the Norfolk Dredging Company and the U.S. Army Corps of Engineers. 21 pp.

Krahn, M.M., C.A. Wigren, R.W. Pearce, L.K. Moore, R.G. Boger, W.D. McLeod, Jr., S.L. Chan, and D.W. Brown. 1988. New HPLC cleanup and revised extraction procedures for organic contaminants, National Oceanic and Atmospheric Administration Technical Memorandum NMFS F/NWC-153: 23-47.

Kucklick, J.R., S. Sivertsen, M. Sanders and G. Scott. 1997. Factors influencing polycyclic aromatic hydrocarbon concentrations and patterns in South Carolina sediments. Journal of Experimental Marine Biology and Ecology. 213: 13-29.

Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memo. NOS OMA 52. US National Oceanic and Atmospheric Administration, Seattle, Washington. 175pp.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management. 19(1): 81-97.

Long, E.R. G.I. Scott, J. Kucklick, M. Fulton, B. Thompson, R.S. Carr, K.J. Scott, G.B. Thursby, G.T. Chandler, J.W. Anderson, G.M. Sloane. 1998. Final Report. Magnitude and extent of sediment toxicity in selected estuarines of South Carolina and Georgia. NOAA Technical Memorandum NOS ORCA: 178pp.

Luoma, S.N. 1989. Can we determine the biological availability of sediment-bound trace metals. Hydrobiologica. 176/177:379-396.

McDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology. 5:253-278.

Noakes, S. 1995. Postdisposal areal mapping of sediment chemistry at the Charleston, South Carolina ODMDS's. Final Report, submitted to U.S. Environmnental Protection Agency, Office of Wetlands, Oceans, and Watersheds. Prepared by the Center for Applied Isotope Studies, Athen GA. 56 pp.

Noakes, S. 2001. Postdisposal areal mapping of sediment chemistry at the Charleston, South Carolina ODMDS. Final report prepared by the Center for Applied Isotope Studies for the South Carolina Department of Natural Resources. 60 pp. + appendices.

Olsen, C.R., N.H. Cutshall, I.L. Larsen. 1982. Pollutant-particle associations and dynamics in coastal marine environments: a review. Marine Chemistry. 11:501-533.

Pequegnat, W.E., L.H. Pequegnat, B.M. James, E.A. Kennedy, R.R. Fay, and A.D. Fredericks. 1981. Procedural guide for designation surveys of ocean dredged

material disposal sites. Final Report prepared by TerEce Corp. for U.S. Army Engineer Waterways Experiment Station, Technical Report EL-81-1, 268 pp.

Plumb, R.H., Jr. 1981. Procedures for handling and chemical analysis of sediment and water samples. Tech. Rept. EPA ICE-81-1, prepared by Great Lakes Laboratory, State University College at Buffalo, NY, for the U.S. Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredge and Fill Material. Published by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Porter, James W. 1993. The Physiological Effects of Dredge-Spoil on the Oxygen Metabolism of Charleston Harbor, SC, Marine Benthic Invertebrates. Final Report, submitted to the United States Environmental Protection Agency, Region 4. Prepared by the Institute of Ecology, University of Georgia. 33 pp.

Ringwood, A.H., R.F. Van Dolah, A.F. Holland, and M.E. DeLorenzo. 1995. Year one demonstration project studies conducted in the Carolinian Province by Marine Resources Research Institute: results and summaries. Final Report submitted to National Oceanic and Atmospheric Administration.

South Carolina Wildlife and Marine Resources Division (SCWMRD). 1979. Benthic and sedimentological studies on the Charleston Harbor ocean disposal area, Charleston Harobr deepening project. Final report prepared for the U.S. Army Corps of Engineers, Charleston District.

Statistical Product and Software Solutions (SPSS). 1997. SigmaStat 2.0 for Windows. SPSS, Inc. Chicago, Illinois.

Steele-Petrovic, H.M. 1975. An explanation for the tolerance of brachipods and relative intolerance of bivalves for soft muddy bottoms. Journal of Paleontology. 49: 552-556.

Thomas, J.D. and J.L. Barnard. 1983. The Platyischnopidae of North America (Crustacea: Amphipoda). Smithsonian Contributions to Zoology. Number 375. Smithsonian Institution Press, City of Washington.

Van Dolah, R.F., D.R. Calder, and D.M. Knott. 1983. Assessment of benthic macrofauna in an ocean disposal area near Charleston, South Carolina. South Carolina Marine Resources Center Technical Report No. 56. 97 pp.

Van Dolah, R.F., P.H. Wendt, D.A. Goldman, and M.V. Levisen. 1996. Survey of benthic infaunal assemblages and sediment characteristics in and around the Charleston Ocean Dredged Material Disposal Area. Interim Report submitted to the U.S. Army Corps of Engineers, Charleston District. 57 pp. + appendices.

Van Dolah, R.F., P.H. Wendt, D.A. Goldman, A.B. Wrona, R.A. Pardieck, and M.V.

Levisen. 1997. An assessment of benthic infaunal assemblages and sediments in the vicinity of the Charleston Ocean Dredged Material Disposal Area. Final Report submitted to U.S. Army Corps of Engineers, Charleston District. 59pp.

Voulgaris, G. 2002. Disposal material mobility and transport in the vicinity of the Charleston Ocean Dredged Material Disposal Site. Final Report submitted to South Carolina Department of Natural Resources. 21 pp.

Wenner, C.A., C.A. Barans, B.W. Stender, F.H. Berry. 1979. Results of MARMAP otter trawl investigations in the South Atlantic Bight. III. Summer 1974. Technical Report –S.C. Marine Resources Center. 1979. 62 pp. Technical Report No. 41.

Wenner, C.A. C.A. Barans, B.W. Stender, F.H. Berry. 1980. Results of MARMAP otter trawls investigations in the South Atlantic Bight. V. Summer, 1975. S.C. Marine Resources Center Technical Report 45. 57 pp.

Wenner, E.L. and T.H. Read. 1981. Distribution and assemblages of decapod crustaceans from the continental shelf of the South Atlantic Bight: 1977-1979 MARMAP investigations. South Carolina Marine Resources Research Institute, Technical Report No. 49. 41 pp.

Williams, R., C. Sun, R. Bourgerie. 1997. Collection of ocean current data at the Charleston, South Carolina Ocean Dredged Material Disposal Site. Final Report submitted to the U.S. Environmental Protection Agency. Prepared by the National Oceanic and Atmospheric Administration, National Ocean Service, Coastal and Estuarine Oceanography Branch. 13 pp.

Wilmot, W.H. 1988. Charleston Harbor oceanography project phase 2 plan. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Oceanography and Marine Assessment.

Winn, R.H. R.F. Van Dolah, A. Frankenburg, and T. Kanna. 1989. Benthic and sedimentological studies of the ocean dredged material disposal site for Charleston, South Carolina. Vol. I-II. Final Report submitted to the U.S. Army Corps of Engineers, Charleston District.

# APPENDICES

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

| Station | Collection # | Date | Depth | Latitude | Longitude |
|---|---|---|---|---|---|
| DA05 | 9601 | 09/12/2000 | 12.8 | 32.6518 | 79.7536 |
| DA17 | 9602 | 09/12/2000 | 11.3 | 32.6466 | 79.7543 |
| DA18 | 9603 | 09/12/2000 | 13.2 | 32.6483 | 79.7514 |
| DA19 | 9604 | 09/12/2000 | 12.6 | 32.6466 | 79.7479 |
| DA22 | 9605 | 09/12/2000 | 13.7 | 32.6433 | 79.7564 |
| DA23 | 9606 | 09/12/2000 | 12.7 | 32.6436 | 79.7534 |
| DA25 | 9607 | 09/12/2000 | 13.1 | 32.6450 | 79.7497 |
| DA26 | 9608 | 09/12/2000 | 12.6 | 32.6421 | 79.7547 |
| DA28 | 9609 | 09/12/2000 | 13.4 | 32.6433 | 79.7512 |
| DA30 | 9610 | 09/12/2000 | 12.7 | 32.6410 | 79.7485 |
| DB11 | 9611 | 09/12/2000 | 13.1 | 32.6432 | 79.7395 |
| DB13 | 9612 | 09/12/2000 | 12.2 | 32.6414 | 79.7309 |
| DB19 | 9613 | 09/12/2000 | 11.3 | 32.6411 | 79.7330 |
| DB33 | 9614 | 09/12/2000 | 12.3 | 32.6332 | 79.7364 |
| DB24 | 9615 | 09/12/2000 | 13.1 | 32.6386 | 79.7397 |
| DB25 | 9616 | 09/12/2000 | 12.4 | 32.6383 | 79.7347 |
| DB28 | 9617 | 09/12/2000 | 13.9 | 32.6360 | 79.7419 |
| DB29 | 9618 | 09/12/2000 | 12.3 | 32.6458 | 79.7377 |
| DB30 | 9619 | 09/12/2000 | 12.0 | 32.6351 | 79.7351 |
| DB31 | 9620 | 09/12/2000 | 11.9 | 32.6366 | 79.7321 |
| DC06 | 9621 | 09/12/2000 | 11.3 | 32.6315 | 79.7466 |
| DC07 | 9622 | 09/12/2000 | 10.9 | 32.6316 | 79.7433 |
| DC11 | 9623 | 09/12/2000 | 11.5 | 32.6300 | 79.7465 |
| DC12 | 9624 | 09/12/2000 | 12.1 | 32.6298 | 79.7433 |
| DC16 | 9625 | 09/12/2000 | 11.8 | 32.6265 | 79.7500 |
| DC17 | 9626 | 09/12/2000 | 12.8 | 32.6265 | 79.7466 |
| DC18 | 9627 | 09/12/2000 | 12.5 | 32.6282 | 79.7451 |
| DC25 | 9628 | 09/12/2000 | 12.5 | 32.6265 | 79.7451 |
| DC29 | 9629 | 09/12/2000 | 14.6 | 32.6233 | 79.7484 |
| DC33 | 9630 | 09/12/2000 | 13.4 | 32.6216 | 79.7468 |
| DD08 | 9631 | 09/12/2000 | 13.1 | 32.6378 | 79.7545 |
| DD11 | 9632 | 09/12/2000 | 13.9 | 32.6371 | 79.7597 |
| DD20 | 9633 | 09/12/2000 | 11.5 | 32.6334 | 79.7562 |
| DD13 | 9634 | 09/12/2000 | 13.3 | 32.6349 | 79.7564 |
| DD14 | 9635 | 09/12/2000 | 10.7 | 32.6371 | 79.7531 |
| DD18 | 9636 | 09/12/2000 | 12.6 | 32.6331 | 79.7613 |
| DD24 | 9637 | 09/12/2000 | 13.3 | 32.6318 | 79.7648 |
| DD25 | 9638 | 09/12/2000 | 11.6 | 32.6313 | 79.7620 |
| DD26 | 9639 | 09/12/2000 | 13.5 | 32.6316 | 79.7600 |
| DD30 | 9640 | 09/12/2000 | 12.4 | 32.6298 | 79.7615 |
| IA01 | 9641 | 09/11/2000 | 12.0 | 32.6549 | 79.7460 |
| IA02 | 9642 | 09/11/2000 | 12.0 | 32.6668 | 79.7580 |
| IA03 | 9643 | 09/11/2000 | 11.9 | 32.6670 | 79.7564 |
| IA06 | 9644 | 09/11/2000 | 11.1 | 32.6633 | 79.7513 |
| IA08 | 9645 | 09/11/2000 | 12.0 | 32.6605 | 79.7565 |
| IA09 | 9646 | 09/11/2000 | 11.3 | 32.6618 | 79.7551 |
| IA17 | 9647 | 09/11/2000 | 11.4 | 32.6599 | 79.7414 |
| IA20 | 9648 | 09/11/2000 | 12.0 | 32.6564 | 79.7512 |
| IA26 | 9649 | 09/11/2000 | 11.9 | 32.6547 | 79.7449 |
| IA27 | 9650 | 09/11/2000 | 11.7 | 32.6547 | 79.7416 |

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

| Station | Collection # | Date | Depth | Latitude | Longitude |
|---|---|---|---|---|---|
| IB04 | 9651 | 09/11/2000 | 13.1 | 32.6517 | 79.7333 |
| IB05 | 9652 | 09/11/2000 | 12.8 | 32.6535 | 79.7365 |
| IB07 | 9653 | 09/11/2000 | 12.0 | 32.6518 | 79.7265 |
| IB10 | 9654 | 09/11/2000 | 12.0 | 32.6500 | 79.7361 |
| IB12 | 9655 | 09/11/2000 | 12.3 | 32.6516 | 79.7316 |
| IB13 | 9656 | 09/11/2000 | 12.8 | 32.6519 | 79.7299 |
| IB17 | 9657 | 09/11/2000 | 12.0 | 32.6480 | 79.7321 |
| IB21 | 9658 | 09/11/2000 | 15.1 | 32.6481 | 79.7239 |
| IB22 | 9659 | 09/11/2000 | 13.1 | 32.6484 | 79.7214 |
| IB26 | 9660 | 09/11/2000 | 13.1 | 32.6467 | 79.7282 |
| IC03 | 9661 | 09/11/2000 | 12.2 | 32.6434 | 79.7230 |
| IC05 | 9662 | 09/11/2000 | 11.0 | 32.6415 | 79.7199 |
| IC06 | 9663 | 09/11/2000 | 11.7 | 32.6420 | 79.7167 |
| IC07 | 9664 | 09/11/2000 | 11.4 | 32.6402 | 79.7261 |
| IC08 | 9665 | 09/11/2000 | 10.9 | 32.6400 | 79.7248 |
| IC12 | 9666 | 09/11/2000 | 11.2 | 32.6366 | 79.7261 |
| IC19 | 9667 | 09/11/2000 | 12.3 | 32.6367 | 79.7200 |
| IC22 | 9668 | 09/11/2000 | 11.2 | 32.6337 | 79.7285 |
| IC24 | 9669 | 09/11/2000 | 10.7 | 32.6338 | 79.7220 |
| IC32 | 9670 | 09/12/2000 | 13.9 | 32.6267 | 79.7266 |
| ID04 | 9671 | 09/12/2000 | 13.1 | 32.6252 | 79.7348 |
| ID05 | 9672 | 09/12/2000 | 13.7 | 32.6250 | 79.7316 |
| ID10 | 9673 | 09/12/2000 | 15.5 | 32.6232 | 79.7280 |
| ID13 | 9674 | 09/12/2000 | 14.3 | 32.6200 | 79.7331 |
| ID15 | 9675 | 09/12/2000 | 14.4 | 32.6166 | 79.7399 |
| ID16 | 9676 | 09/12/2000 | 14.7 | 32.6184 | 79.7383 |
| ID17 | 9677 | 09/12/2000 | 14.7 | 32.6183 | 79.7318 |
| ID18 | 9678 | 09/12/2000 | 13.9 | 32.6201 | 79.7300 |
| ID23 | 9679 | 09/12/2000 | 13.4 | 32.6168 | 79.7317 |
| ID31 | 9680 | 09/12/2000 | 15.1 | 32.6102 | 79.7384 |
| IE04 | 9681 | 09/12/2000 | 15.3 | 32.6181 | 79.7584 |
| IE06 | 9682 | 09/12/2000 | 15.1 | 32.6181 | 79.7550 |
| IE10 | 9683 | 09/12/2000 | 14.1 | 32.6163 | 79.7588 |
| IE11 | 9684 | 09/12/2000 | 14.4 | 32.6163 | 79.7566 |
| IE13 | 9685 | 09/12/2000 | 14.7 | 32.6165 | 79.7532 |
| IE14 | 9686 | 09/12/2000 | 15.4 | 32.6150 | 79.7483 |
| IE16 | 9687 | 09/12/2000 | 14.5 | 32.6148 | 79.7602 |
| IE18 | 9688 | 09/12/2000 | 14.0 | 32.6132 | 79.7533 |
| IE27 | 9689 | 09/12/2000 | 13.0 | 32.6100 | 79.7516 |
| IE30 | 9690 | 09/12/2000 | 13.2 | 32.6118 | 79.7432 |
| IF03 | 9691 | 09/12/2000 | 12.7 | 32.6265 | 79.7835 |
| IF04 | 9692 | 09/12/2000 | 13.5 | 32.6283 | 79.7799 |
| IF05 | 9693 | 09/12/2000 | 13.4 | 32.6283 | 79.7782 |
| IF06 | 9694 | 09/12/2000 | 12.3 | 32.6266 | 79.7733 |
| IF10 | 9695 | 09/12/2000 | 13.5 | 32.6249 | 79.7816 |
| IF13 | 9696 | 09/12/2000 | 12.6 | 32.6266 | 79.7749 |
| IF22 | 9697 | 09/12/2000 | 12.3 | 32.6231 | 79.7701 |
| IF27 | 9698 | 09/12/2000 | 13.1 | 32.6199 | 79.7735 |
| IF29 | 9699 | 09/12/2000 | 12.6 | 32.6217 | 79.7683 |
| IF30 | 9700 | 09/12/2000 | 13.5 | 32.6216 | 79.7653 |

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

| Station | Collection # | Date | Depth | Latitude | Longitude |
|---|---|---|---|---|---|
| IG03 | 9701 | 09/12/2000 | 15.5 | 32.6451 | 79.7763 |
| IG08 | 9702 | 09/12/2000 | 13.4 | 32.6416 | 79.7745 |
| IG11 | 9703 | 09/12/2000 | 14.3 | 32.6400 | 79.7765 |
| IG07 | 9704 | 09/12/2000 | 13.8 | 32.6438 | 79.7765 |
| IG19 | 9705 | 09/12/2000 | 14.1 | 32.6366 | 79.7818 |
| IG25 | 9706 | 09/12/2000 | 15.5 | 32.6333 | 79.7833 |
| IG27 | 9707 | 09/12/2000 | 13.1 | 32.6332 | 79.7743 |
| IG29 | 9708 | 09/12/2000 | 14.5 | 32.6316 | 79.7848 |
| IG30 | 9709 | 09/12/2000 | 12.9 | 32.6316 | 79.7781 |
| IG32 | 9710 | 09/12/2000 | 14.4 | 32.6300 | 79.7867 |
| IH03 | 9711 | 09/12/2000 | 12.2 | 32.6628 | 79.7650 |
| IH04 | 9712 | 09/12/2000 | 12.5 | 32.6633 | 79.7614 |
| IH05 | 9713 | 09/12/2000 | 12.3 | 32.6619 | 79.7667 |
| IH20 | 9714 | 09/12/2000 | 13.3 | 32.6515 | 79.7631 |
| IH09 | 9715 | 09/12/2000 | 13.1 | 32.6600 | 79.7645 |
| IH12 | 9716 | 09/12/2000 | 13.2 | 32.6566 | 79.7667 |
| IH15 | 9717 | 09/12/2000 | 14.1 | 32.6551 | 79.7678 |
| IH18 | 9718 | 09/12/2000 | 13.8 | 32.6537 | 79.7681 |
| IH19 | 9719 | 09/12/2000 | 13.7 | 32.6538 | 79.7667 |
| IH28 | 9720 | 09/12/2000 | 14.0 | 32.6483 | 79.7696 |
| OA02 | 9721 | 09/11/2000 | 10.5 | 32.6784 | 79.7616 |
| OA03 | 9722 | 09/11/2000 | 11.6 | 32.6750 | 79.7617 |
| OA04 | 9723 | 09/11/2000 | 10.4 | 32.6750 | 79.7566 |
| OA05 | 9724 | 09/11/2000 | 10.7 | 32.6751 | 79.7584 |
| OA07 | 9725 | 09/11/2000 | 10.9 | 32.6732 | 79.7597 |
| OA08 | 9726 | 09/11/2000 | 10.8 | 32.6730 | 79.7584 |
| OA27 | 9727 | 09/11/2000 | 11.5 | 32.6667 | 79.7448 |
| OA28 | 9728 | 09/11/2000 | 12.1 | 32.6651 | 79.7430 |
| OA31 | 9729 | 09/11/2000 | 10.9 | 32.6648 | 79.7368 |
| OA32 | 9730 | 09/11/2000 | 11.2 | 32.6636 | 79.7385 |
| OB04 | 9731 | 09/11/2000 | 11.4 | 32.6617 | 79.7321 |
| OB09 | 9732 | 09/11/2000 | 13.1 | 32.6601 | 79.7324 |
| OB10 | 9733 | 09/11/2000 | 12.7 | 32.6582 | 79.7272 |
| OB19 | 9734 | 09/11/2000 | 14.0 | 32.6566 | 79.7168 |
| OB25 | 9735 | 09/11/2000 | 12.3 | 32.6546 | 79.7171 |
| OB26 | 9736 | 09/11/2000 | 13.1 | 32.6550 | 79.7131 |
| OB32 | 9737 | 09/11/2000 | 13.0 | 32.6514 | 79.7103 |
| OB35 | 9738 | 09/11/2000 | 12.5 | 32.6514 | 79.7149 |
| OB36 | 9739 | 09/11/2000 | 12.3 | 32.6519 | 79.7078 |
| OB38 | 9740 | 09/11/2000 | 14.0 | 32.6501 | 79.7046 |
| OC04 | 9741 | 09/11/2000 | 12.6 | 32.6451 | 79.7046 |
| OC05 | 9742 | 09/11/2000 | 13.0 | 32.6438 | 79.7081 |
| OC10 | 9743 | 09/11/2000 | 12.0 | 32.6382 | 79.7100 |
| OC12 | 9744 | 09/11/2000 | 12.2 | 32.6388 | 79.7148 |
| OC13 | 9745 | 09/11/2000 | 11.6 | 32.6365 | 79.7082 |
| OC16 | 9746 | 09/11/2000 | 11.4 | 32.6374 | 79.7129 |
| OC24 | 9747 | 09/11/2000 | 11.9 | 32.6302 | 79.7168 |
| OC25 | 9748 | 09/11/2000 | 11.9 | 32.6301 | 79.7118 |
| OC30 | 9749 | 09/11/2000 | 13.8 | 32.6255 | 79.7232 |
| OC32 | 9750 | 09/11/2000 | 14.5 | 32.6248 | 79.7183 |

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston disposal zone during September 2000. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

| Station | Collection # | Date | Depth | Latitude | Longitude |
|---|---|---|---|---|---|
| OD02 | 9751 | 09/11/2000 | 15.4 | 32.6235 | 79.7251 |
| OD04 | 9752 | 09/11/2000 | 15.0 | 32.6198 | 79.7202 |
| OD13 | 9753 | 09/11/2000 | 14.8 | 32.6148 | 79.7250 |
| OD14 | 9754 | 09/11/2000 | 15.1 | 32.6149 | 79.7300 |
| OD18 | 9755 | 09/11/2000 | 14.5 | 32.6115 | 79.7303 |
| OD28 | 9756 | 09/11/2000 | 14.3 | 32.6069 | 79.7353 |
| OD29 | 9757 | 09/11/2000 | 14.3 | 32.6066 | 79.7267 |
| OD33 | 9758 | 09/11/2000 | 14.1 | 32.6035 | 79.7334 |
| OD36 | 9759 | 09/11/2000 | 13.8 | 32.5996 | 79.7350 |
| OD38 | 9760 | 09/11/2000 | 13.7 | 32.5984 | 79.7332 |
| OE06 | 9761 | 09/11/2000 | 13.4 | 32.6083 | 79.7649 |
| OE07 | 9762 | 09/11/2000 | 13.0 | 32.6103 | 79.7634 |
| OE08 | 9763 | 09/11/2000 | 14.6 | 32.6069 | 79.7600 |
| OE09 | 9764 | 09/11/2000 | 13.6 | 32.6088 | 79.7550 |
| OE12 | 9765 | 09/11/2000 | 14.4 | 32.6050 | 79.7549 |
| OE13 | 9766 | 09/11/2000 | 13.7 | 32.6070 | 79.7516 |
| OE18 | 9767 | 09/11/2000 | 15.1 | 32.6032 | 79.7537 |
| OE19 | 9768 | 09/11/2000 | 15.1 | 32.6051 | 79.7518 |
| OE24 | 9769 | 09/11/2000 | 14.2 | 32.6021 | 79.7446 |
| OE29 | 9770 | 09/11/2000 | 15.9 | 32.6003 | 79.7380 |
| OF03 | 9771 | 09/11/2000 | 13.7 | 32.6235 | 79.7984 |
| OF05 | 9772 | 09/11/2000 | 13.4 | 32.6235 | 79.7915 |
| OF06 | 9773 | 09/11/2000 | 11.6 | 32.6234 | 79.7869 |
| OF18 | 9774 | 09/11/2000 | 13.0 | 32.6200 | 79.7765 |
| OF22 | 9775 | 09/11/2000 | 14.5 | 32.6166 | 79.7781 |
| OF23 | 9776 | 09/11/2000 | 15.1 | 32.6170 | 79.7749 |
| OF26 | 9777 | 09/11/2000 | 13.7 | 32.6153 | 79.7817 |
| OF30 | 9778 | 09/11/2000 | 13.6 | 32.6150 | 79.7699 |
| OF35 | 9779 | 09/11/2000 | 14.5 | 32.6135 | 79.7700 |
| OF37 | 9780 | 09/11/2000 | 13.0 | 32.6099 | 79.7700 |
| OG02 | 9781 | 09/11/2000 | 14.8 | 32.6483 | 79.7801 |
| OG03 | 9782 | 09/11/2000 | 13.9 | 32.6525 | 79.7833 |
| OG09 | 9783 | 09/11/2000 | 14.3 | 32.6469 | 79.7849 |
| OG10 | 9784 | 09/11/2000 | 14.9 | 32.6450 | 79.7833 |
| OG15 | 9785 | 09/11/2000 | 16.0 | 32.6418 | 79.7848 |
| OG22 | 9786 | 09/11/2000 | 14.1 | 32.6367 | 79.7848 |
| OG23 | 9787 | 09/11/2000 | 14.9 | 32.6352 | 79.7919 |
| OG08 | 9788 | 09/11/2000 | 14.0 | 32.6456 | 79.7883 |
| OG29 | 9789 | 09/11/2000 | 14.9 | 32.6301 | 79.7983 |
| OG33 | 9790 | 09/11/2000 | 13.8 | 32.6286 | 79.7967 |
| OH01 | 9791 | 09/11/2000 | 12.8 | 32.6602 | 79.7720 |
| OH02 | 9792 | 09/11/2000 | 10.7 | 32.6784 | 79.7666 |
| OH05 | 9793 | 09/11/2000 | 11.9 | 32.6736 | 79.7667 |
| OH06 | 9794 | 09/11/2000 | 12.2 | 32.6720 | 79.7694 |
| OH10 | 9795 | 09/11/2000 | 11.2 | 32.6702 | 79.7678 |
| OH12 | 9796 | 09/11/2000 | 11.7 | 32.6667 | 79.7713 |
| OH14 | 9797 | 09/11/2000 | 12.2 | 32.6566 | 79.7737 |
| OH15 | 9798 | 09/11/2000 | 11.9 | 32.6649 | 79.7745 |
| OH27 | 9799 | 09/11/2000 | 13.4 | 32.6541 | 79.7812 |
| OH30 | 9800 | 09/11/2000 | 14.4 | 32.6522 | 79.7783 |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| DA05 | 9/12/2000 | 62.9 | 0.8 | 36.3 | 0.7 | 2.1 | F | 0.682 | MW | 2.5 |
| DA17 | 9/12/2000 | 70.2 | 1.4 | 28.4 | 0.8 | 2.1 | F | 0.530 | MW | 2.5 |
| DA18 | 9/12/2000 | 77.5 | 4.4 | 18.1 | 1.0 | 2.8 | F | 0.577 | MW | 3.0 |
| DA19 | 9/12/2000 | 90.7 | 2.4 | 6.9 | 0.7 | 2.8 | F | 0.415 | W | 3.0 |
| DA22 | 9/12/2000 | 72.5 | 8.4 | 19.1 | 1.6 | 2.8 | F | 0.579 | MW | 3.0 |
| DA23 | 9/12/2000 | 53.6 | 1.7 | 44.7 | 0.9 | 1.4 | M | 1.029 | P | 1.5 |
| DA25 | 9/12/2000 | 85.3 | 3.1 | 11.6 | 0.9 | 2.7 | F | 0.541 | MW | 3.0 |
| DA26 | 9/12/2000 | 77.8 | 5.8 | 16.5 | 1.1 | 2.6 | F | 0.630 | MW | 3.0 |
| DA28 | 9/12/2000 | 26.9 | 67.8 | 5.3 | 8.7 | 3.2 | VF | 0.480 | W | 3.5 |
| DA30 | 9/12/2000 | 88.6 | 4.5 | 6.9 | 0.8 | 2.8 | F | 0.480 | W | 3.0 |
| **Mean** | | **70.6** | **10.0** | **19.4** | **1.7** | **2.5** | | | | |
| | | | | | | | | | | |
| DB11 | 9/12/2000 | 80.4 | 9.2 | 10.4 | 2.2 | 2.5 | F | 0.485 | W | 3.0 |
| DB13 | 9/12/2000 | 53.0 | 4.5 | 42.5 | 0.9 | 2.2 | F | 0.707 | MW | 3.0 |
| DB19 | 9/12/2000 | 12.8 | 3.1 | 84.1 | 0.9 | 1.9 | M | 1.055 | P | 2.0 |
| DB24 | 9/12/2000 | 88.6 | 2.3 | 9.1 | 0.8 | 2.5 | F | 0.478 | W | 3.0 |
| DB25 | 9/12/2000 | 33.8 | 3.9 | 62.3 | 0.7 | 1.8 | M | 0.652 | MW | 2.0 |
| DB28 | 9/12/2000 | 59.9 | 29.1 | 11.1 | 5.7 | 2.6 | F | 0.520 | MW | 3.0 |
| DB29 | 9/12/2000 | 32.1 | 3.2 | 64.7 | 0.7 | 1.9 | M | 0.780 | M | 2.0 |
| DB30 | 9/12/2000 | 81.7 | 1.1 | 17.1 | 0.6 | 1.9 | M | 0.707 | MW | 2.5 |
| DB31 | 9/12/2000 | 53.3 | 4.3 | 42.4 | 1.2 | 2.2 | F | 0.754 | M | 2.5 |
| DB33 | 9/12/2000 | 76.9 | 6.7 | 16.4 | 0.8 | 2.5 | F | 0.532 | MW | 3.0 |
| **Mean** | | **57.3** | **6.7** | **36.0** | **1.5** | **2.2** | | | | |
| | | | | | | | | | | |
| DC06 | 9/12/2000 | 52.9 | 24.4 | 22.7 | 6.3 | 2.9 | F | 0.744 | M | 3.0 |
| DC07 | 9/12/2000 | 92.4 | 1.7 | 5.9 | 0.7 | 2.6 | F | 0.404 | W | 3.0 |
| DC11 | 9/12/2000 | 83.9 | 3.3 | 12.8 | 0.8 | 2.5 | F | 0.536 | MW | 3.0 |
| DC12 | 9/12/2000 | 80.3 | 1.4 | 18.2 | 1.4 | 2.4 | F | 0.557 | MW | 2.5 |
| DC16 | 9/12/2000 | 87.5 | 1.3 | 11.2 | 0.8 | 2.5 | F | 0.550 | MW | 3.0 |
| DC17 | 9/12/2000 | 59.7 | 28.8 | 11.5 | 7.1 | 2.5 | F | 0.559 | MW | 3.0 |
| DC18 | 9/12/2000 | 80.0 | 2.4 | 17.6 | 0.7 | 2.4 | F | 0.528 | MW | 3.0 |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| DC25 | 9/12/2000 | 60.6 | 3.4 | 36.1 | 0.8 | 1.8 | M | 1.029 | P | 2.5 |
| DC29 | 9/12/2000 | 79.7 | 1.1 | 19.2 | 0.8 | 1.7 | M | 0.862 | M | 1.5 |
| DC33 | 9/12/2000 | 32.9 | 8.0 | 59.1 | 0.8 | 1.8 | M | 0.669 | MW | 2.0 |
| **Mean** | | **71.0** | **7.6** | **21.4** | **2.0** | **2.3** | | | | |
| | | | | | | | | | | |
| DD08 | 9/12/2000 | 36.4 | 58.1 | 5.5 | 6.5 | 3.2 | VF | 0.540 | MW | 3.5 |
| DD11 | 9/12/2000 | 82.4 | 3.0 | 14.5 | 1.1 | 2.7 | F | 0.644 | MW | 3.0 |
| DD13 | 9/12/2000 | 69.6 | 6.4 | 24.0 | 1.4 | 2.2 | F | 1.555 | P | 3.0 |
| DD14 | 9/12/2000 | 27.6 | 63.4 | 8.9 | 6.1 | 2.9 | F | 0.651 | MW | 3.0 |
| DD18 | 9/12/2000 | 77.1 | 2.2 | 20.7 | 0.8 | 1.6 | M | 0.891 | M | 2.0 |
| DD20 | 9/12/2000 | 56.2 | 36.8 | 7.0 | 3.6 | 2.7 | F | 0.611 | MW | 3.0 |
| DD24 | 9/12/2000 | 87.6 | 3.0 | 9.4 | 1.0 | 2.4 | F | 0.615 | MW | 3.0 |
| DD25 | 9/12/2000 | 82.2 | 1.7 | 16.1 | 0.7 | 2.1 | F | 0.732 | M | 2.5 |
| DD26 | 9/12/2000 | 77.6 | 6.6 | 15.8 | 2.3 | 2.7 | F | 0.650 | MW | 3.0 |
| DD30 | 9/12/2000 | 85.9 | 0.7 | 13.4 | 0.9 | 2.5 | F | 0.588 | MW | 3.0 |
| **Mean** | | **68.3** | **18.2** | **13.5** | **2.4** | **2.5** | | | | |
| | | | | | | | | | | |
| IA01 | 9/11/2000 | 87.5 | 2.7 | 9.8 | 0.8 | 2.6 | F | 0.526 | MW | 3.0 |
| IA02 | 9/11/2000 | 92.3 | 0.5 | 7.2 | 0.7 | 2.5 | F | 0.446 | W | 3.0 |
| IA03 | 9/11/2000 | 90.2 | 1.1 | 8.7 | 0.7 | 2.4 | F | 0.507 | MW | 2.5 |
| IA06 | 9/11/2000 | 90.0 | 2.3 | 7.7 | 0.6 | 2.4 | F | 0.496 | W | 2.5 |
| IA08 | 9/11/2000 | 88.5 | 2.4 | 9.2 | 0.7 | 2.7 | F | 0.414 | W | 3.0 |
| IA09 | 9/11/2000 | 88.5 | 1.5 | 10.0 | 0.7 | 2.5 | F | 0.520 | MW | 3.0 |
| IA17 | 9/11/2000 | 83.7 | 1.8 | 14.5 | 0.8 | 2.4 | F | 0.481 | W | 3.0 |
| IA20 | 9/11/2000 | 77.7 | 4.7 | 17.6 | 0.8 | 2.6 | F | 0.669 | MW | 3.0 |
| IA26 | 9/11/2000 | 85.9 | 2.1 | 12.0 | 0.8 | 2.5 | F | 0.478 | W | 3.0 |
| IA27 | 9/11/2000 | 76.8 | 1.5 | 21.8 | 0.7 | 2.1 | F | 0.662 | MW | 2.5 |
| **Mean** | | **86.1** | **2.0** | **11.9** | **0.7** | **2.5** | | | | |
| | | | | | | | | | | |
| IB04 | 9/11/2000 | 90.4 | 1.6 | 7.9 | 0.7 | 2.4 | F | 0.441 | W | 2.5 |
| IB05 | 9/11/2000 | 87.0 | 1.7 | 11.2 | 0.7 | 2.4 | F | 0.498 | W | 3.0 |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| IB07 | 9/11/2000 | 74.2 | 0.7 | 25.1 | 0.7 | 1.5 | M | 0.764 | M | 1.5 |
| IB10 | 9/11/2000 | 92.3 | 0.6 | 7.0 | 0.7 | 2.5 | F | 0.427 | W | 3.0 |
| IB12 | 9/11/2000 | 78.4 | 1.0 | 20.6 | 0.7 | 1.8 | M | 0.752 | M | 2.5 |
| IB13 | 9/11/2000 | 87.4 | 1.4 | 11.2 | 0.7 | 2.3 | F | 0.497 | W | 2.5 |
| IB17 | 9/11/2000 | 85.5 | 1.7 | 12.8 | 0.7 | 2.3 | F | 0.472 | W | 2.5 |
| IB21 | 9/11/2000 | 83.9 | 3.4 | 12.7 | 0.7 | 2.4 | F | 0.662 | MW | 3.0 |
| IB22 | 9/11/2000 | 78.7 | 1.8 | 19.5 | 0.7 | 2.4 | F | 0.502 | MW | 3.0 |
| IB26 | 9/11/2000 | 83.5 | 1.5 | 15.0 | 0.7 | 2.3 | F | 0.457 | W | 2.5 |
| **Mean** | | **84.1** | **1.5** | **14.3** | **0.7** | **2.2** | | | | |
| | | | | | | | | | | |
| IC03 | 9/11/2000 | 82.1 | 2.0 | 15.8 | 0.6 | 2.3 | F | 0.555 | MW | 2.5 |
| IC05 | 9/11/2000 | 68.1 | 1.5 | 30.4 | 0.7 | 2.0 | F | 0.490 | W | 2.5 |
| IC06 | 9/11/2000 | 73.9 | 1.6 | 24.5 | 0.6 | 2.2 | F | 0.530 | MW | 2.5 |
| IC07 | 9/11/2000 | 91.9 | 1.2 | 6.9 | 0.6 | 2.3 | F | 0.363 | W | 2.5 |
| IC08 | 9/11/2000 | 77.7 | 1.2 | 21.1 | 0.6 | 1.9 | M | 0.511 | MW | 2.0 |
| IC12 | 9/11/2000 | 88.7 | 1.3 | 10.0 | 0.6 | 2.3 | F | 0.465 | W | 2.5 |
| IC19 | 9/11/2000 | 82.7 | 1.9 | 15.5 | 0.6 | 2.2 | F | 0.516 | MW | 2.5 |
| IC22 | 9/11/2000 | 62.2 | 1.9 | 35.9 | 0.6 | 1.8 | M | 0.604 | MW | 2.0 |
| IC24 | 9/11/2000 | 63.0 | 1.7 | 35.3 | 0.7 | 1.6 | M | 0.677 | MW | 2.0 |
| IC32 | 9/12/2000 | 86.6 | 2.4 | 11.0 | 0.7 | 2.5 | F | 0.421 | W | 3.0 |
| **Mean** | | **77.7** | **1.7** | **20.6** | **0.7** | **2.1** | | | | |
| | | | | | | | | | | |
| ID04 | 9/12/2000 | 73.2 | 1.9 | 24.9 | 0.8 | 1.5 | M | 0.813 | M | 2.0 |
| ID05 | 9/12/2000 | 90.5 | 1.6 | 7.8 | 0.7 | 2.6 | F | 0.390 | W | 3.0 |
| ID10 | 9/12/2000 | 89.4 | 0.8 | 9.8 | 0.8 | 2.7 | F | 0.371 | W | 3.0 |
| ID13 | 9/12/2000 | 63.9 | 1.7 | 34.5 | 0.7 | 1.1 | M | 1.080 | P | 1.0 |
| ID15 | 9/12/2000 | 89.0 | 1.9 | 9.2 | 0.6 | 0.3 | C | 0.945 | M | 0.5 |
| ID16 | 9/12/2000 | 89.7 | 1.5 | 8.8 | 0.7 | 2.2 | F | 0.711 | M | 3.0 |
| ID17 | 9/12/2000 | 51.1 | 2.5 | 46.5 | 1.0 | 1.8 | M | 1.047 | P | 3.0 |
| ID18 | 9/12/2000 | 87.7 | 1.9 | 10.3 | 0.7 | 2.4 | F | 0.486 | W | 3.0 |
| ID23 | 9/12/2000 | 69.5 | 2.4 | 28.1 | 0.7 | 2.0 | M | 0.609 | MW | 2.5 |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| ID31 | 9/12/2000 | 90.5 | 0.2 | 9.2 | 0.6 | 2.0 | F | 0.705 | MW | 2.5 |
| **Mean** | | **79.5** | **1.6** | **18.9** | **0.7** | **1.9** | | | | |
| | | | | | | | | | | |
| IE04 | 9/12/2000 | 60.7 | 6.2 | 33.1 | 1.1 | 1.3 | M | 0.991 | M | 1.0 |
| IE06 | 9/12/2000 | 69.0 | 5.9 | 25.0 | 1.1 | 1.0 | C | 1.677 | P | 3.0 |
| IE10 | 9/12/2000 | 89.0 | 2.5 | 8.4 | 0.7 | 2.5 | F | 0.499 | W | 3.0 |
| IE11 | 9/12/2000 | 91.3 | 1.4 | 7.3 | 0.7 | 2.5 | F | 0.503 | MW | 3.0 |
| IE13 | 9/12/2000 | 78.7 | 0.6 | 20.7 | 0.8 | 2.1 | F | 1.176 | P | 3.0 |
| IE14 | 9/12/2000 | 81.6 | 3.0 | 15.4 | 0.8 | 1.8 | M | 1.339 | P | 2.5 |
| IE16 | 9/12/2000 | 56.6 | 2.2 | 41.2 | 1.1 | 1.9 | M | 0.789 | M | 2.5 |
| IE18 | 9/12/2000 | 61.9 | 0.7 | 37.4 | 0.8 | 1.5 | M | 1.325 | P | 2.5 |
| IE27 | 9/12/2000 | 88.4 | 3.1 | 8.5 | 0.6 | 2.3 | F | 0.494 | W | 2.5 |
| IE30 | 9/12/2000 | 85.9 | 2.2 | 11.9 | 0.6 | 2.3 | F | 0.494 | W | 2.5 |
| **Mean** | | **76.3** | **2.8** | **20.9** | **0.8** | **1.9** | | | | |
| | | | | | | | | | | |
| IF03 | 9/12/2000 | 89.0 | 2.4 | 8.6 | 0.7 | 2.6 | F | 0.486 | W | 3.0 |
| IF04 | 9/12/2000 | 85.0 | 2.7 | 12.3 | 1.2 | 2.6 | F | 0.527 | MW | 3.0 |
| IF05 | 9/12/2000 | 86.2 | 3.2 | 10.6 | 0.8 | 2.6 | F | 0.540 | MW | 3.0 |
| IF06 | 9/12/2000 | 88.3 | 2.9 | 8.8 | 0.7 | 2.4 | F | 0.483 | W | 2.5 |
| IF10 | 9/12/2000 | 86.4 | 1.8 | 11.7 | 0.8 | 2.5 | F | 0.595 | MW | 3.0 |
| IF13 | 9/12/2000 | 86.2 | 1.4 | 12.4 | 0.7 | 2.2 | F | 0.648 | MW | 2.5 |
| IF22 | 9/12/2000 | 87.8 | 2.7 | 9.6 | 0.7 | 2.4 | F | 0.542 | MW | 2.5 |
| IF27 | 9/12/2000 | 89.1 | 3.2 | 7.6 | 0.7 | 2.4 | F | 0.554 | MW | 2.5 |
| IF29 | 9/12/2000 | 84.7 | 0.9 | 14.5 | 0.6 | 1.6 | M | 0.792 | M | 2.0 |
| IF30 | 9/12/2000 | 89.1 | 0.9 | 10.0 | 0.7 | 2.5 | F | 0.514 | MW | 3.0 |
| **Mean** | | **87.2** | **2.2** | **10.6** | **0.8** | **2.4** | | | | |
| | | | | | | | | | | |
| IG03 | 9/12/2000 | 73.0 | 11.0 | 16.0 | 2.2 | 2.9 | F | 0.547 | MW | 3.0 |
| IG07 | 9/12/2000 | 49.2 | 30.4 | 20.4 | 5.4 | 3.4 | VF | 0.449 | W | 4.0 |
| IG08 | 9/12/2000 | 88.5 | 1.9 | 9.6 | 0.8 | 2.5 | F | 0.541 | MW | 3.0 |
| IG11 | 9/12/2000 | 82.1 | 4.4 | 13.4 | 1.0 | 2.8 | F | 0.491 | W | 3.0 |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| IG19 | 9/12/2000 | 88.1 | 2.6 | 9.2 | 0.8 | 2.7 | F | 0.521 | MW | 3.0 |
| IG25 | 9/12/2000 | 82.5 | 4.1 | 13.4 | 1.2 | 2.6 | F | 0.618 | MW | 3.0 |
| IG27 | 9/12/2000 | 84.1 | 2.2 | 13.6 | 1.1 | 2.7 | F | 0.627 | MW | 3.0 |
| IG29 | 9/12/2000 | 81.8 | 2.9 | 15.3 | 0.9 | 1.5 | M | 0.983 | M | 2.0 |
| IG30 | 9/12/2000 | 88.3 | 1.6 | 10.0 | 0.8 | 2.3 | F | 0.588 | MW | 2.5 |
| IG32 | 9/12/2000 | 92.8 | 1.3 | 6.0 | 0.9 | 2.4 | F | 0.495 | W | 2.5 |
| **Mean** | | **81.0** | **6.2** | **12.7** | **1.5** | **2.6** | | | | |
| | | | | | | | | | | |
| IH03 | 9/12/2000 | 90.3 | 0.8 | 8.9 | 0.8 | 2.5 | F | 0.422 | W | 3.0 |
| IH04 | 9/12/2000 | 87.5 | 1.4 | 11.2 | 0.8 | 2.5 | F | 0.502 | MW | 3.0 |
| IH05 | 9/12/2000 | 89.7 | 1.0 | 9.3 | 0.7 | 2.6 | F | 0.408 | W | 3.0 |
| IH09 | 9/12/2000 | 82.1 | 6.3 | 11.6 | 0.9 | 2.6 | F | 0.424 | W | 3.0 |
| IH12 | 9/12/2000 | 84.1 | 2.3 | 13.6 | 1.0 | 2.7 | F | 0.408 | W | 3.0 |
| IH15 | 9/12/2000 | 84.4 | 2.0 | 13.6 | 0.9 | 2.8 | F | 0.403 | W | 3.0 |
| IH18 | 9/12/2000 | 65.7 | 5.2 | 29.1 | 1.5 | 2.5 | F | 0.704 | MW | 3.0 |
| IH19 | 9/12/2000 | 84.4 | 3.4 | 12.2 | 1.0 | 2.8 | F | 0.426 | W | 3.0 |
| IH20 | 9/12/2000 | 76.4 | 8.8 | 14.8 | 2.2 | 2.7 | F | 0.578 | MW | 3.0 |
| IH28 | 9/12/2000 | 67.4 | 7.7 | 24.9 | 1.5 | 2.6 | F | 0.912 | M | 3.0 |
| **Mean** | | **81.2** | **3.9** | **14.9** | **1.1** | **2.6** | | | | |
| | | | | | | | | | | |
| OA02 | 9/11/2000 | 79.9 | 3.7 | 16.4 | 0.8 | 2.2 | F | 0.541 | MW | 2.5 |
| OA03 | 9/11/2000 | 87.2 | 3.1 | 9.7 | 0.7 | 2.5 | F | 0.475 | W | 3.0 |
| OA04 | 9/11/2000 | 80.9 | 2.8 | 16.3 | 0.7 | 2.1 | F | 0.613 | MW | 2.5 |
| OA05 | 9/11/2000 | 77.1 | 2.8 | 20.1 | 0.7 | 2.0 | M | 0.573 | MW | 2.0 |
| OA07 | 9/11/2000 | 82.4 | 2.7 | 14.9 | 0.7 | 2.2 | F | 0.573 | MW | 2.5 |
| OA08 | 9/11/2000 | 92.7 | 0.5 | 6.8 | 0.7 | 2.3 | F | 0.431 | W | 2.5 |
| OA27 | 9/11/2000 | 86.3 | 0.9 | 12.8 | 0.7 | 2.5 | F | 0.474 | W | 3.0 |
| OA28 | 9/11/2000 | 91.5 | 0.8 | 7.7 | 0.7 | 2.6 | F | 0.422 | W | 3.0 |
| OA31 | 9/11/2000 | 56.7 | 1.5 | 41.9 | 0.8 | 1.5 | M | 0.840 | M | 1.5 |
| OA32 | 9/11/2000 | 88.8 | 0.5 | 10.7 | 0.7 | 2.4 | F | 0.461 | W | 2.5 |
| **Mean** | | **82.4** | **1.9** | **15.7** | **0.7** | **2.2** | | | | |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| OB04 | 9/11/2000 | 89.4 | 2.1 | 8.5 | 0.7 | 2.4 | F | 0.439 | W | 2.5 |
| OB09 | 9/11/2000 | 60.8 | 11.5 | 27.7 | 1.8 | 2.4 | F | 0.698 | MW | 3.0 |
| OB10 | 9/11/2000 | 84.1 | 3.8 | 12.2 | 0.8 | 2.5 | F | 0.429 | W | 3.0 |
| OB19 | 9/11/2000 | 60.9 | 3.5 | 35.7 | 0.8 | 0.4 | C | 0.856 | M | 0.5 |
| OB25 | 9/11/2000 | 45.5 | 3.3 | 51.2 | 1.0 | 1.2 | M | 0.953 | M | 1.0 |
| OB26 | 9/11/2000 | 86.7 | 3.2 | 10.2 | 0.7 | 2.6 | F | 0.468 | W | 3.0 |
| OB32 | 9/11/2000 | 86.0 | 2.3 | 11.7 | 0.7 | 2.2 | F | 0.519 | MW | 2.5 |
| OB35 | 9/11/2000 | 83.3 | 2.6 | 14.1 | 0.8 | 2.2 | F | 0.568 | MW | 2.5 |
| OB36 | 9/11/2000 | 85.1 | 2.6 | 12.2 | 0.7 | 2.4 | F | 0.453 | W | 3.0 |
| OB38 | 9/11/2000 | 87.5 | 2.6 | 10.0 | 0.7 | 2.5 | F | 0.457 | W | 3.0 |
| **Mean** | | **76.9** | **3.7** | **19.3** | **0.9** | **2.1** | | | | |
| OC04 | 9/11/2000 | 54.3 | 1.5 | 44.2 | 0.7 | 0.3 | C | 1.166 | P | 0.5 |
| OC05 | 9/11/2000 | 75.4 | 1.7 | 22.9 | 0.7 | 1.0 | C | 1.025 | P | 1.0 |
| OC10 | 9/11/2000 | 77.6 | 1.9 | 20.5 | 0.6 | 1.4 | M | 0.897 | M | 2.5 |
| OC12 | 9/11/2000 | 77.6 | 2.1 | 20.3 | 0.7 | 2.2 | F | 0.476 | W | 2.5 |
| OC13 | 9/11/2000 | 36.3 | 1.7 | 62.0 | 0.8 | 1.6 | M | 0.792 | M | 2.5 |
| OC16 | 9/11/2000 | 64.8 | 2.1 | 33.1 | 0.8 | 1.6 | M | 0.804 | M | 2.5 |
| OC24 | 9/11/2000 | 78.2 | 2.2 | 19.6 | 0.7 | 2.3 | F | 0.496 | W | 2.5 |
| OC25 | 9/11/2000 | 81.6 | 1.7 | 16.7 | 0.7 | 2.3 | F | 0.418 | W | 2.5 |
| OC30 | 9/11/2000 | 86.8 | 3.8 | 9.4 | 0.7 | 2.5 | F | 0.503 | MW | 3.0 |
| OC32 | 9/11/2000 | 87.8 | 2.0 | 10.2 | 0.7 | 2.5 | F | 0.367 | W | 3.0 |
| **Mean** | | **72.0** | **2.1** | **25.9** | **0.7** | **1.8** | | | | |
| OD02 | 9/11/2000 | 88.5 | 0.8 | 10.7 | 0.8 | 2.6 | F | 0.427 | W | 3.0 |
| OD04 | 9/11/2000 | 89.9 | 1.2 | 8.9 | 0.7 | 2.6 | F | 0.394 | W | 3.0 |
| OD13 | 9/11/2000 | 89.9 | 1.1 | 9.0 | 0.7 | 2.6 | F | 0.388 | W | 3.0 |
| OD14 | 9/11/2000 | 88.1 | 0.9 | 11.0 | 0.8 | 2.5 | F | 0.480 | W | 3.0 |
| OD18 | 9/11/2000 | 88.5 | 0.1 | 11.4 | 0.7 | 2.2 | F | 0.605 | MW | 0.5 |
| OD28 | 9/11/2000 | 87.9 | 0.6 | 11.5 | 0.6 | 2.1 | F | 0.585 | MW | 2.5 |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| OD29 | 9/11/2000 | 82.0 | 0.6 | 17.4 | 0.7 | 0.4 | C | 1.109 | P | 0.5 |
| OD33 | 9/11/2000 | 87.7 | 0.9 | 11.4 | 0.7 | 2.2 | F | 0.471 | W | 2.5 |
| OD36 | 9/11/2000 | 83.8 | 4.7 | 11.4 | 0.7 | 2.2 | F | 0.531 | MW | 2.5 |
| OD38 | 9/11/2000 | 79.9 | 3.5 | 16.6 | 0.7 | 2.1 | F | 0.617 | MW | 2.5 |
| **Mean** | | **86.6** | **1.4** | **11.9** | **0.7** | **2.2** | | | | |
| | | | | | | | | | | |
| OE06 | 9/11/2000 | 66.2 | 2.8 | 31.0 | 0.8 | 1.6 | M | 0.969 | M | 2.5 |
| OE07 | 9/11/2000 | 83.2 | 2.5 | 14.3 | 0.7 | 2.2 | F | 0.485 | W | 2.5 |
| OE08 | 9/11/2000 | 80.7 | 1.6 | 17.7 | 0.7 | 0.6 | C | 1.156 | P | 0.5 |
| OE09 | 9/11/2000 | 87.0 | 2.0 | 11.0 | 0.7 | 2.1 | F | 0.624 | MW | 2.5 |
| OE12 | 9/11/2000 | 89.4 | 1.9 | 8.6 | 0.7 | 2.4 | F | 0.456 | W | 2.5 |
| OE13 | 9/11/2000 | 86.0 | 0.9 | 13.2 | 0.7 | 2.2 | F | 0.481 | W | 2.5 |
| OE18 | 9/11/2000 | 85.9 | 1.5 | 12.6 | 0.8 | 1.8 | M | 1.246 | P | 3.0 |
| OE19 | 9/11/2000 | 90.5 | 1.0 | 8.5 | 0.7 | 2.5 | F | 0.437 | W | 3.0 |
| OE24 | 9/11/2000 | 87.5 | 2.6 | 9.9 | 0.7 | 2.3 | F | 0.471 | W | 2.5 |
| OE29 | 9/11/2000 | 71.8 | 2.6 | 25.6 | 0.8 | 1.8 | M | 0.925 | M | 2.5 |
| **Mean** | | **82.8** | **1.9** | **15.2** | **0.7** | **1.9** | | | | |
| | | | | | | | | | | |
| OF03 | 9/11/2000 | 70.3 | 4.2 | 25.5 | 1.2 | 2.1 | F | 1.372 | P | 3.0 |
| OF05 | 9/11/2000 | 90.9 | 1.6 | 7.5 | 0.7 | 2.4 | F | 0.482 | W | 2.5 |
| OF06 | 9/11/2000 | 93.0 | 0.5 | 6.5 | 0.7 | 2.3 | F | 0.486 | W | 2.5 |
| OF18 | 9/11/2000 | 89.8 | 2.6 | 7.7 | 0.7 | 2.3 | F | 0.552 | MW | 2.5 |
| OF22 | 9/11/2000 | 62.4 | 2.3 | 35.3 | 1.1 | 1.5 | M | 1.129 | P | 1.0 |
| OF23 | 9/11/2000 | 58.2 | 1.8 | 40.0 | 1.1 | 1.4 | M | 1.106 | P | 1.0 |
| OF26 | 9/11/2000 | 91.8 | 1.1 | 7.1 | 0.7 | 2.5 | F | 0.505 | MW | 3.0 |
| OF30 | 9/11/2000 | 81.3 | 2.8 | 15.9 | 0.7 | 2.1 | F | 0.732 | M | 3.0 |
| OF35 | 9/11/2000 | 81.8 | 7.2 | 11.0 | 0.7 | 2.3 | F | 0.572 | MW | 2.5 |
| OF37 | 9/11/2000 | 52.8 | 3.1 | 44.1 | 0.8 | 1.2 | M | 1.198 | P | 2.0 |
| **Mean** | | **77.2** | **2.7** | **20.1** | **0.8** | **2.0** | | | | |
| | | | | | | | | | | |
| OG02 | 9/11/2000 | 83.8 | 5.2 | 11.0 | 1.0 | 2.9 | F | 0.414 | W | 3.0 |

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2000. VF = very fine sand, F = fine sand, M = medium sand, C = coarse sand. MW = medium well, W = well, P = poor, M = medium. SD = standard deviation. Organic matter content reported as percent.

| Station | Sampling Date | Sand % | Silt/Clay % | $CaCO_3$ % | Organic Matter | $\bar{X}$ | Size Class | SD | Sorting Descr. | Mode |
|---|---|---|---|---|---|---|---|---|---|---|
| OG03 | 9/11/2000 | 83.8 | 4.6 | 11.7 | 0.9 | 2.8 | F | 0.475 | W | 3.0 |
| OG08 | 9/11/2000 | 84.9 | 4.5 | 10.6 | 0.9 | 2.8 | F | 0.477 | W | 3.0 |
| OG09 | 9/11/2000 | 80.9 | 9.0 | 10.0 | 1.6 | 2.8 | F | 0.444 | W | 3.0 |
| OG10 | 9/11/2000 | 71.7 | 15.6 | 12.8 | 3.3 | 3.0 | F | 0.461 | W | 3.0 |
| OG15 | 9/11/2000 | 67.6 | 18.5 | 13.9 | 2.5 | 3.1 | VF | 0.466 | W | 3.0 |
| OG22 | 9/11/2000 | 88.1 | 2.0 | 9.9 | 1.0 | 2.7 | F | 0.478 | W | 3.0 |
| OG23 | 9/11/2000 | 79.2 | 12.0 | 8.7 | 3.2 | 2.5 | F | 0.537 | MW | 3.0 |
| OG29 | 9/11/2000 | 74.3 | 3.8 | 21.9 | 0.8 | 0.9 | C | 1.060 | P | 1.0 |
| OG33 | 9/11/2000 | 53.9 | 2.8 | 43.3 | 1.1 | 0.8 | C | 1.239 | P | 0.5 |
| **Mean** | | **76.8** | **7.8** | **15.4** | **1.6** | **2.4** | | | | |
| | | | | | | | | | | |
| OH01 | 9/11/2000 | 87.1 | 4.0 | 8.8 | 0.8 | 2.7 | F | 0.433 | W | 3.0 |
| OH02 | 9/11/2000 | 84.8 | 7.4 | 7.8 | 0.7 | 2.4 | F | 0.503 | MW | 3.0 |
| OH05 | 9/11/2000 | 89.4 | 5.2 | 5.4 | 0.7 | 2.4 | F | 0.462 | W | 2.5 |
| OH06 | 9/11/2000 | 85.6 | 4.7 | 9.7 | 0.8 | 2.5 | F | 0.466 | W | 3.0 |
| OH10 | 9/11/2000 | 87.1 | 5.7 | 7.2 | 0.7 | 2.4 | F | 0.471 | W | 3.0 |
| OH12 | 9/11/2000 | 91.3 | 0.3 | 8.3 | 0.8 | 2.6 | F | 0.413 | W | 3.0 |
| OH14 | 9/11/2000 | 83.4 | 0.4 | 16.2 | 1.1 | 2.6 | F | 0.601 | MW | 3.0 |
| OH15 | 9/11/2000 | 88.0 | 3.0 | 9.0 | 0.8 | 2.7 | F | 0.355 | W | 3.0 |
| OH27 | 9/11/2000 | 70.2 | 16.1 | 13.8 | 1.6 | 2.8 | F | 0.427 | W | 3.0 |
| OH30 | 9/11/2000 | 83.4 | 4.1 | 12.5 | 1.1 | 2.8 | F | 0.468 | W | 3.0 |
| **Mean** | | **85.0** | **5.1** | **9.9** | **0.9** | **2.6** | | | | |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Abra aequalis* | M | 14 | 0 | 0 | 0 | 3 | 1 | 1 | 1 | 0 | 0 | 8 |
| *Acanthohaustorius intermedius* | A | 182 | 27 | 10 | 21 | 25 | 36 | 10 | 4 | 36 | 0 | 13 |
| *Acanthohaustorius millsi* | A | 10 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Acrocirridae | P | 12 | 0 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 4 | 0 |
| *Acteocina candei* | M | 64 | 2 | 8 | 8 | 17 | 2 | 6 | 9 | 8 | 1 | 3 |
| *Acteocina* sp. | M | 10 | 7 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Acteon candens* | M | 10 | 0 | 2 | 1 | 0 | 0 | 0 | 2 | 0 | 5 | 0 |
| *Acteon* sp. | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Actiniaria | O | 25 | 4 | 3 | 4 | 1 | 3 | 5 | 1 | 0 | 4 | 0 |
| *Aglaophamus verrilli* | P | 64 | 0 | 0 | 0 | 0 | 1 | 14 | 9 | 0 | 28 | 12 |
| *Albunea gibbesii* | O | 6 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 1 | 0 | 0 |
| *Albunea paretii* | O | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Albunea* sp. | O | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amastigos caperatus* | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ampelisca abdita* | A | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Ampelisca agassizi* | A | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ampelisca* sp. | A | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ampelisca verrilli* | A | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ampharetidae | P | 10 | 1 | 3 | 1 | 0 | 0 | 1 | 4 | 0 | 0 | 0 |
| *Amphicteis gunneri* | P | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiodia pulchella* | O | 46 | 1 | 8 | 3 | 0 | 0 | 2 | 0 | 0 | 32 | 0 |
| Amphipoda | A | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadara ovalis* | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Anadara* sp. | M | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadara transversa* | M | 35 | 0 | 21 | 0 | 0 | 0 | 0 | 4 | 3 | 7 | 0 |
| Anadarinae | M | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ancinus depressus* | O | 6 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| *Ancistrosyllis* sp. | P | 93 | 0 | 13 | 2 | 7 | 0 | 0 | 1 | 0 | 66 | 4 |
| *Anomia simplex* | M | 8 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| *Aonides paucibranchiata* | P | 41 | 0 | 16 | 24 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Aoridae | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Apanthura magnifica* | O | 9 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 6 | 0 |
| *Aphealochaeta* sp. | P | 3 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Arabella mutans* | P | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Arcidae | M | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arene* sp. | M | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aricidea* sp. A | P | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Aricidea lopezi* | P | 26 | 0 | 2 | 0 | 0 | 0 | 7 | 1 | 0 | 14 | 2 |
| *Aricidea philbinae* | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Aricidea* sp. | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aricidea suecica* | P | 24 | 1 | 17 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 1 |
| *Aricidea wassi* | P | 49 | 0 | 4 | 0 | 0 | 2 | 0 | 17 | 5 | 1 | 20 |
| *Armandia agilis* | P | 129 | 3 | 3 | 1 | 12 | 1 | 10 | 33 | 3 | 36 | 27 |
| *Armandia maculata* | P | 152 | 15 | 42 | 34 | 7 | 4 | 8 | 14 | 8 | 16 | 4 |
| *Armandia* sp. | P | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aspidosiphon albus* | O | 8 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Aspidosiphon gosnoldi* | O | 102 | 2 | 26 | 12 | 7 | 0 | 10 | 3 | 2 | 34 | 6 |
| *Aspidosiphon* sp. | O | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Asteroidea | O | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Astyris lunata* | M | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Autolytus* sp. | P | 14 | 0 | 10 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Axiognathus squamatus* | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Axiothella mucosa* | P | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Axiothella* sp. | P | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Batea catharinensis* | A | 12 | 0 | 2 | 0 | 3 | 0 | 0 | 5 | 0 | 2 | 0 |
| Bateidae | A | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bathyporeia parkeri* | A | 58 | 1 | 4 | 7 | 19 | 11 | 1 | 6 | 4 | 0 | 5 |
| *Bathyporeia* sp. | A | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bhawania heteroseta* | P | 231 | 1 | 39 | 5 | 0 | 0 | 0 | 0 | 1 | 185 | 0 |
| *Bhawania* sp. | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Biffarius biformis* | O | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 3 |
| Brachyura | O | 10 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 5 | 0 |
| *Branchiostoma* sp. | O | 736 | 129 | 242 | 180 | 95 | 11 | 12 | 4 | 48 | 11 | 4 |
| *Branchiosyllis exilis* | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Brania* sp. | P | 25 | 3 | 5 | 15 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| *Brania wellfleetensis* | P | 13 | 4 | 2 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bushia* sp. | M | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Cabira incerta* | P | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Caecum pulchellum* | M | 7 | 0 | 3 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Caecum* sp. | M | 8 | 0 | 4 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Callianassidae | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Calyptraea centralis* | M | 3 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Campylaspis* sp. | O | 28 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 20 | 2 |
| *Capitella capitata* | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Capitella jonesi* | P | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capitellidae | P | 24 | 1 | 12 | 2 | 0 | 0 | 5 | 2 | 0 | 2 | 0 |
| Capitellidae sp. A | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cardiomya ornatissima* | M | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Carinomella lactea* | O | 28 | 2 | 5 | 0 | 3 | 0 | 5 | 1 | 0 | 10 | 2 |
| *Caulleriella* sp. | P | 30 | 2 | 8 | 6 | 4 | 0 | 2 | 0 | 0 | 5 | 3 |
| *Cerapus tubularis* | A | 31 | 0 | 0 | 0 | 0 | 1 | 6 | 4 | 0 | 18 | 2 |
| *Ceratonereis irritabilis* | P | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 0 |
| *Chaetozone* sp. | P | 11 | 0 | 0 | 8 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Chione latilirata* | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chione* sp. | M | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chiridotea* sp. | O | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chiridotea stenops* | O | 16 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 2 | 0 | 5 |
| Chrysopetalidae | P | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cirratulidae | P | 27 | 2 | 5 | 3 | 1 | 2 | 3 | 0 | 1 | 9 | 1 |
| *Cirriformia* sp. | P | 50 | 7 | 5 | 15 | 4 | 2 | 4 | 2 | 2 | 6 | 3 |
| *Cirrophorus* sp. | P | 20 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 |
| *Corbula contracta* | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Corbula* sp. | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Corophiidae | A | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corophium* sp. | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Crangonidae | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Crassinella lunulata* | M | 128 | 0 | 76 | 9 | 2 | 1 | 19 | 2 | 4 | 15 | 0 |
| *Crassinella martinicensis* | M | 137 | 33 | 36 | 44 | 6 | 1 | 3 | 1 | 12 | 1 | 0 |
| *Crepidula fornicata* | M | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 |
| *Crepidula* sp. | M | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 |
| Crepidulidae | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cumacea | O | 13 | 1 | 3 | 1 | 2 | 0 | 1 | 2 | 1 | 2 | 0 |
| Cumacean sp. A | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cyathura burbancki* | O | 30 | 1 | 24 | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 0 |
| *Cyclaspis* sp. | O | 127 | 2 | 2 | 2 | 9 | 2 | 37 | 35 | 0 | 27 | 11 |
| *Cylichnella bidentata* | M | 32 | 0 | 0 | 0 | 0 | 0 | 11 | 5 | 0 | 12 | 4 |
| *Dentalium* sp. | M | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diogenidae | O | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Diopatra cuprea* | P | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Dipolydora* sp. | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dispio uncinata* | P | 15 | 0 | 0 | 0 | 3 | 0 | 0 | 5 | 1 | 6 | 0 |
| *Dissodactylus mellitae* | O | 21 | 0 | 0 | 0 | 0 | 2 | 0 | 8 | 11 | 0 | 0 |
| Dorvilleidae | P | 110 | 6 | 29 | 48 | 9 | 3 | 0 | 0 | 0 | 15 | 0 |
| *Dosinia elegans* | M | 7 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 |
| *Drilonereis* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Echinoidea | O | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Echiura | O | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Edotea montosa* | O | 5 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 2 | 0 |
| *Edotea triloba* | O | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Elasmopus levis* | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Emerita benedicti* | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ensis directus* | M | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eobrolgus spinosus* | A | 9 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 4 | 2 |
| Epitoniidae | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Epitonium* sp. | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ervilia concentrica* | M | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eteone lactea* | P | 3 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Euceramus praelongus* | O | 8 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Eudevenopus honduranus* | A | 334 | 19 | 65 | 54 | 82 | 12 | 15 | 36 | 15 | 8 | 28 |
| *Eulalia sanguinea* | P | 12 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| *Eulalia* sp. | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eunice vittata* | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eurydice littoralis* | O | 18 | 3 | 0 | 8 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eurydice piperata* | O | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Euryplax nitida* | O | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eurythoe* sp. | P | 6 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Exogone* sp. | P | 20 | 2 | 10 | 5 | 1 | 0 | 0 | 0 | 0 | 2 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gammaridea | A | 9 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 1 |
| *Gastrochaena hians* | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gastropoda | M | 20 | 3 | 7 | 0 | 2 | 2 | 0 | 1 | 2 | 3 | 0 |
| *Gibberosus myersi* | A | 4 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Glottidia pyramidata* | O | 29 | 2 | 10 | 1 | 3 | 2 | 5 | 0 | 0 | 5 | 1 |
| *Glycera americana* | P | 9 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 4 | 0 |
| *Glycera oxycephala* | P | 91 | 9 | 14 | 37 | 5 | 10 | 0 | 0 | 13 | 0 | 3 |
| *Glycera papillosa* | P | 8 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Glycera robusta* | P | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Glycera* sp. | P | 84 | 21 | 9 | 11 | 17 | 3 | 10 | 4 | 3 | 5 | 1 |
| Glycerea | P | 6 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Goneplacidae | O | 6 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Goniada littorea* | P | 198 | 6 | 11 | 9 | 12 | 13 | 22 | 38 | 6 | 42 | 39 |
| Goniadidae | P | 27 | 6 | 19 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Goniadides carolinae* | P | 115 | 0 | 34 | 20 | 0 | 0 | 0 | 0 | 1 | 60 | 0 |
| *Hargeria rapax* | O | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Harmothoe* sp. | P | 15 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 11 | 0 |
| Haustoriidae | A | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hepatus pudibundus* | O | 8 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 |
| Hesionidae | P | 38 | 5 | 11 | 11 | 0 | 0 | 0 | 0 | 4 | 7 | 0 |
| *Hesionura* sp. | P | 65 | 15 | 0 | 47 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Heterocrypta granulata* | O | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Heteropodarke heteromorpha* | P | 13 | 2 | 2 | 4 | 3 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Heteropodarke* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Hippomedon serratus* | A | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Holothuroidea | O | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Holothuroidea sp. A | O | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Hydroides microtis* | P | 59 | 0 | 37 | 18 | 2 | 0 | 0 | 0 | 2 | 0 | 0 |
| *Hydroides* sp. | P | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Idoteidae | O | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Isolda pulchella* | P | 11 | 0 | 5 | 1 | 2 | 0 | 1 | 0 | 0 | 2 | 0 |
| *Kinbergonuphis* sp. | P | 17 | 2 | 4 | 1 | 4 | 2 | 2 | 1 | 1 | 0 | 0 |
| *Laonice cirrata* | P | 9 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Latreutes parvulus* | O | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |

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| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Leitoscoloplos* sp. | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lembos* sp. | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Lepidopa websteri* | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Leptochela papulata* | O | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 1 |
| *Leptochela serratorbita* | O | 14 | 0 | 2 | 1 | 2 | 0 | 1 | 2 | 0 | 5 | 1 |
| *Leptognathia caeca* | O | 14 | 0 | 1 | 7 | 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Leptonacea* sp. | M | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| *Leptosynapta* sp. | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Leptosynapta tenuis* | O | 38 | 8 | 3 | 18 | 2 | 0 | 2 | 0 | 2 | 1 | 2 |
| Liljiborgiidae | A | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Limopsis* sp. | M | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Listriella barnardi* | A | 9 | 1 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 3 | 0 |
| *Listriella clymenellae* | A | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Loimia medusa* | P | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Lucifer faxoni* | O | 6 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Luconacia incerta* | A | 6 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 2 |
| *Luidia clathrata* | O | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Lumbrineridae | P | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| *Lumbrinerides* sp. | P | 9 | 0 | 0 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lumbrineris cruzensis* | P | 91 | 3 | 35 | 6 | 12 | 3 | 10 | 6 | 0 | 12 | 4 |
| *Lumbrineris* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Lysianassidae | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lysilla* sp. | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Macoma tenta* | M | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Macroclymene* sp. | P | 5 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Maera caroliniana* | A | 7 | 0 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Magelona* sp. | P | 407 | 3 | 5 | 3 | 2 | 9 | 133 | 15 | 5 | 209 | 23 |
| Majidae | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Malacoceros vanderhorsti* | P | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maldanidae | P | 9 | 0 | 4 | 3 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Marphysa sanguinea* | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mediomastus ambiseta* | P | 112 | 0 | 31 | 1 | 0 | 0 | 0 | 11 | 2 | 57 | 10 |
| *Mediomastus californiensis* | P | 222 | 14 | 144 | 21 | 0 | 2 | 0 | 0 | 2 | 39 | 0 |
| *Mediomastus* sp. | P | 348 | 7 | 113 | 22 | 3 | 1 | 0 | 3 | 2 | 192 | 5 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Megalomma lobiferum* | P | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Melanellidae | M | 14 | 0 | 0 | 8 | 0 | 0 | 0 | 2 | 0 | 1 | 3 |
| *Melita nitida* | A | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melita* sp. | A | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Melitidae | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Melitidae sp. A | A | 7 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Mellita quinquesperforata* | O | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| *Mellita* sp. | O | 222 | 82 | 1 | 65 | 11 | 22 | 3 | 2 | 17 | 0 | 19 |
| *Metapenaeopsis goodei* | O | 12 | 0 | 0 | 2 | 3 | 1 | 2 | 0 | 1 | 1 | 2 |
| *Metharpinia floridana* | A | 41 | 3 | 26 | 3 | 6 | 1 | 2 | 0 | 0 | 0 | 0 |
| *Microphthalmus* sp. | P | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microprotopus raneyi* | A | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 4 | 0 |
| *Microspio pigmentata* | P | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Moira atropos* | O | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Monoculodes edwardsi* | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Mooreonuphis nebulosa* | P | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Musculus lateralis* | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriochele oculata* | P | 253 | 1 | 66 | 10 | 21 | 0 | 17 | 36 | 2 | 57 | 43 |
| *Myriochele* sp. | P | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mystides borealis* | P | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Nassarina glypta* | M | 18 | 1 | 4 | 2 | 3 | 1 | 3 | 4 | 0 | 0 | 0 |
| *Natica pusilla* | M | 149 | 11 | 20 | 19 | 12 | 9 | 24 | 24 | 7 | 16 | 7 |
| Naticidae | M | 5 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 1 | 0 |
| *Nematonereis hebes* | P | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Nemertinea | O | 653 | 49 | 96 | 53 | 54 | 18 | 128 | 60 | 15 | 136 | 44 |
| *Neopanope sayi* | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Nephtyidae | P | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nephtys picta* | P | 93 | 4 | 7 | 7 | 21 | 15 | 6 | 6 | 8 | 3 | 16 |
| *Nephtys simoni* | P | 40 | 7 | 4 | 4 | 8 | 3 | 0 | 6 | 3 | 0 | 5 |
| *Nephtys* sp. | P | 13 | 0 | 0 | 1 | 0 | 8 | 0 | 0 | 4 | 0 | 0 |
| Nereidae | P | 41 | 1 | 20 | 1 | 0 | 0 | 6 | 5 | 0 | 8 | 0 |
| *Nereis acuminata* | P | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| *Nereis lamellosa* | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Nereis micromma* | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Nereis* sp. | P | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Nereis succinea* | P | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Notomastus hemipodus* | P | 2 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Notomastus latericeus* | P | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| *Notomastus* sp. | P | 5 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 |
| *Nucula* sp. | M | 11 | 0 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 6 | 0 |
| *Odontosyllis enopla* | P | 4 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ogyrides alphaerostris* | O | 13 | 2 | 0 | 0 | 2 | 1 | 1 | 3 | 0 | 3 | 1 |
| *Ogyrides hayi* | O | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Oligochaeta | O | 181 | 12 | 50 | 30 | 37 | 5 | 8 | 2 | 1 | 28 | 8 |
| *Olivella mutica* | M | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Olivella* sp. | M | 11 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 6 | 3 |
| Olividae | M | 12 | 2 | 0 | 0 | 3 | 1 | 3 | 0 | 1 | 2 | 0 |
| Onuphidae | P | 6 | 3 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Onuphis eremita* | P | 7 | 2 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 |
| *Ophelia denticulata* | P | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Opheliidae | P | 13 | 0 | 4 | 3 | 0 | 0 | 2 | 2 | 0 | 1 | 1 |
| *Ophelina denticulata* | P | 9 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophelina* sp. | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ophiuroidea | O | 197 | 8 | 10 | 97 | 20 | 1 | 18 | 5 | 2 | 30 | 6 |
| *Ovalipes stephensoni* | O | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Owenia fusiformis* | P | 107 | 4 | 15 | 13 | 15 | 5 | 13 | 6 | 3 | 28 | 5 |
| *Oxyurostylis smithi* | O | 120 | 0 | 1 | 4 | 7 | 0 | 19 | 29 | 4 | 35 | 21 |
| Paguridae | O | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Paguridea | O | 15 | 0 | 0 | 2 | 2 | 1 | 1 | 0 | 3 | 6 | 0 |
| *Pagurus hendersoni* | O | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pagurus longicarpus* | O | 17 | 1 | 10 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 0 |
| *Pagurus* sp. | O | 10 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 3 | 3 | 0 |
| *Paleanotus* sp. | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Paracaprella* sp. | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Paracaprella tenuis* | A | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Paraonidae | P | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Paraonis fulgens* | P | 32 | 13 | 0 | 6 | 2 | 7 | 0 | 0 | 1 | 0 | 3 |
| *Paraonis pygoenigmatica* | P | 4 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Parapionosyllis longicirrata* | P | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Parapionosyllis* sp. | P | 33 | 3 | 5 | 21 | 3 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Paraprionospio pinnata* | P | 41 | 0 | 4 | 0 | 2 | 1 | 15 | 6 | 0 | 10 | 3 |
| *Parvilucina multilineata* | M | 126 | 16 | 15 | 2 | 5 | 4 | 23 | 19 | 1 | 32 | 9 |
| Pelecypoda | M | 121 | 4 | 17 | 15 | 2 | 10 | 20 | 3 | 4 | 42 | 4 |
| Pelecypoda sp. A | M | 45 | 13 | 2 | 2 | 0 | 0 | 8 | 6 | 0 | 14 | 0 |
| Pelecypoda sp. B | M | 92 | 9 | 16 | 26 | 24 | 3 | 0 | 6 | 4 | 3 | 1 |
| Pelecypoda sp. C | M | 13 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pelecypoda sp. D | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pelecypoda sp. E | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pelecypoda sp. F | M | 5 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pelecypoda sp. G | M | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| Pelecypoda sp. H | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Pelecypoda sp. I | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Persephona mediterranea* | O | 6 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Petaloproctus* sp. | P | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pholoe minuta* | P | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phoronida | O | 7 | 2 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 |
| *Photis* sp. | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Phoxocephalidae | A | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Phyllodoce arenae* | P | 10 | 0 | 1 | 2 | 2 | 1 | 0 | 0 | 1 | 2 | 1 |
| *Phyllodoce groenlandica* | P | 8 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Phyllodoce* sp. | P | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phyllodocidae | P | 32 | 0 | 20 | 3 | 0 | 0 | 0 | 0 | 0 | 9 | 0 |
| *Phylo felix* | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Pilargidae | P | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Pinnixa sp. | O | 13 | 1 | 0 | 0 | 0 | 1 | 5 | 1 | 1 | 3 | 1 |
| *Pionosyllis gesae* | P | 83 | 19 | 11 | 47 | 3 | 2 | 0 | 0 | 0 | 1 | 0 |
| *Pionosyllis* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Pisione remota* | P | 51 | 0 | 2 | 23 | 10 | 0 | 0 | 0 | 0 | 16 | 0 |
| *Pista cristata* | P | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pitar* sp. | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Plakosyllis quadrioculata* | P | 14 | 0 | 0 | 13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plakosyllis* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Podarke* sp. | P | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Podarkeopsis levifuscina* | P | 13 | 0 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| *Poecilochaetus johnsoni* | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Polychaeta sp. A | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Polychaeta sp. B | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Polychaete sp. C | P | 18 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polycirrus* sp. | P | 10 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polydora cornuta* | P | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polydora socialis* | P | 16 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 0 |
| *Polydora* sp. | P | 3 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Polygordiidae | O | 404 | 23 | 81 | 27 | 99 | 18 | 54 | 28 | 3 | 54 | 17 |
| Polynoidae | P | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 3 |
| *Pomatoceros americanus* | P | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Portunidae | O | 6 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 1 |
| *Portunus sayi* | O | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Prionospio cirrifera* | P | 48 | 0 | 27 | 11 | 2 | 0 | 3 | 0 | 1 | 4 | 0 |
| *Prionospio cirrobranchiata* | P | 14 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 12 | 0 |
| *Prionospio cristata* | P | 965 | 33 | 300 | 309 | 35 | 12 | 9 | 34 | 32 | 192 | 9 |
| *Prionospio dayi* | P | 1231 | 51 | 135 | 59 | 181 | 140 | 166 | 186 | 42 | 141 | 130 |
| *Prionospio* sp. | P | 465 | 9 | 232 | 81 | 5 | 3 | 5 | 8 | 17 | 103 | 2 |
| *Prionospio* sp. A | P | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| *Processa* sp. | O | 10 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 1 | 4 | 1 |
| *Protohaustorius deichmannae* | A | 320 | 29 | 14 | 26 | 30 | 30 | 20 | 67 | 33 | 4 | 67 |
| *Ptilanthura tenuis* | O | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Pyramidellidae | M | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Rhepoxynius epistomus* | A | 727 | 70 | 31 | 127 | 175 | 72 | 33 | 74 | 57 | 17 | 71 |
| *Rhepoxynius hudsoni* | A | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Sabellaria* sp. | P | 13 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 4 | 1 |
| *Sabellaria vulgaris* | P | 691 | 0 | 375 | 0 | 13 | 1 | 0 | 24 | 2 | 276 | 0 |
| Sabellariidae | P | 441 | 0 | 415 | 2 | 0 | 0 | 11 | 0 | 12 | 1 | 0 |
| Saccocirridae | P | 10 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 6 | 0 |
| *Scolecolepides viridis* | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scolelepis* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Scolelepis squamata* | P | 7 | 1 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |

Appendix 3. Total abundance (#/ 0.04m$^2$) of each species in all strata sampled in and around the Charleston disposal area during September 2000. P = polychaete, M = mollusc, A = amphipod, O = other.

| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Scolelepis texana* | P | 6 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 0 |
| *Scoletoma ernesti* | P | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| *Scoletoma tenuis* | P | 49 | 0 | 29 | 0 | 6 | 0 | 2 | 0 | 0 | 11 | 1 |
| *Scoloplos rubra* | P | 10 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 3 |
| *Serpula vermicularis granulosa* | P | 45 | 0 | 9 | 35 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Serpulidae | P | 51 | 3 | 41 | 4 | 1 | 0 | 0 | 0 | 0 | 2 | 0 |
| Serpulidae sp. A | P | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sigambra bassi* | P | 8 | 0 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sigambra* sp. | P | 6 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Sigambra tentaculata* | P | 21 | 0 | 0 | 0 | 1 | 0 | 11 | 2 | 0 | 7 | 0 |
| *Simnia* sp. | M | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Sipuncula | O | 25 | 0 | 6 | 4 | 0 | 0 | 2 | 0 | 0 | 13 | 0 |
| Solenidae | M | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerosyllis aciculata* | P | 12 | 0 | 4 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerosyllis glandulata* | P | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerosyllis* sp. | P | 7 | 1 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerosyllis taylori* | P | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spio pettiboneae* | P | 9 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 1 | 4 | 0 |
| *Spiochaetopterus costarum oculatus* | P | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 |
| Spionidae | P | 18 | 2 | 3 | 1 | 0 | 0 | 1 | 0 | 1 | 10 | 0 |
| Spionidae sp. A | P | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spiophanes bombyx* | P | 36 | 1 | 7 | 2 | 4 | 10 | 4 | 3 | 1 | 2 | 2 |
| *Spiophanes missionensis* | P | 28 | 0 | 8 | 2 | 0 | 0 | 6 | 1 | 0 | 11 | 0 |
| *Spiophanes* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Spiophanes* sp. A | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Spisula solidissima* | M | 7 | 1 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| *Sthenelais boa* | P | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| *Sthenelais limicola* | P | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| *Sthenelais* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Streptosyllis* sp. | P | 15 | 2 | 1 | 7 | 4 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Strigilla mirabilis* | M | 75 | 12 | 7 | 17 | 9 | 13 | 6 | 3 | 6 | 0 | 2 |
| Syllidae | P | 38 | 8 | 8 | 20 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Syllidae sp. A | P | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Syllides floridanus* | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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| Species Name | Taxon | Total Abund. | IC | ID | OC | OD | IA | IG | IH | OA | OG | OH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Syllides fulvus* | P | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Syllides* sp. | P | 3 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Syllis prolifera* | P | 4 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Syllis* sp. | P | 4 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Synchelidium americanum* | A | 118 | 1 | 7 | 3 | 7 | 3 | 27 | 29 | 1 | 37 | 3 |
| *Synelmis ewingi* | P | 174 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 170 | 0 |
| Tanaidacea | O | 9 | 0 | 2 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tanaidacea sp. A | O | 4 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tanaissus psammophilus* | O | 14 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tellina agilis* | M | 48 | 3 | 14 | 2 | 5 | 1 | 15 | 2 | 3 | 1 | 2 |
| *Tellina alternata* | M | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| *Tellina iris* | M | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| *Tellina probrina* | M | 29 | 4 | 0 | 9 | 15 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Tellina* sp. | M | 64 | 2 | 13 | 9 | 26 | 5 | 0 | 4 | 3 | 0 | 2 |
| Tellinidae | M | 121 | 5 | 1 | 14 | 0 | 4 | 8 | 17 | 1 | 66 | 5 |
| Terebellidae | P | 5 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Tharyx acutus* | P | 52 | 3 | 34 | 2 | 3 | 3 | 1 | 2 | 3 | 1 | 0 |
| *Tiron* sp. | A | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 1 |
| *Tiron triocellatus* | A | 45 | 0 | 3 | 0 | 4 | 3 | 1 | 4 | 3 | 26 | 1 |
| *Tiron tropakis* | A | 34 | 8 | 5 | 2 | 1 | 6 | 3 | 2 | 4 | 3 | 0 |
| *Travisia* sp. | P | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Turbonilla* sp. | M | 38 | 0 | 2 | 7 | 8 | 2 | 3 | 8 | 1 | 5 | 2 |
| Turridae | M | 10 | 0 | 2 | 0 | 2 | 2 | 3 | 0 | 0 | 0 | 1 |
| *Typosyllis* sp. | P | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Unciola* sp. | A | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| *Upogebia affinis* | O | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Websterinereis tridentata* | P | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 24 | 0 |
| Total number of individuals | | 15759 | 990 | 3729 | 2192 | 1402 | 632 | 1194 | 1088 | 566 | 3141 | 825 |
| Total number of species | | 402 | 127 | 207 | 166 | 137 | 96 | 127 | 118 | 101 | 187 | 96 |