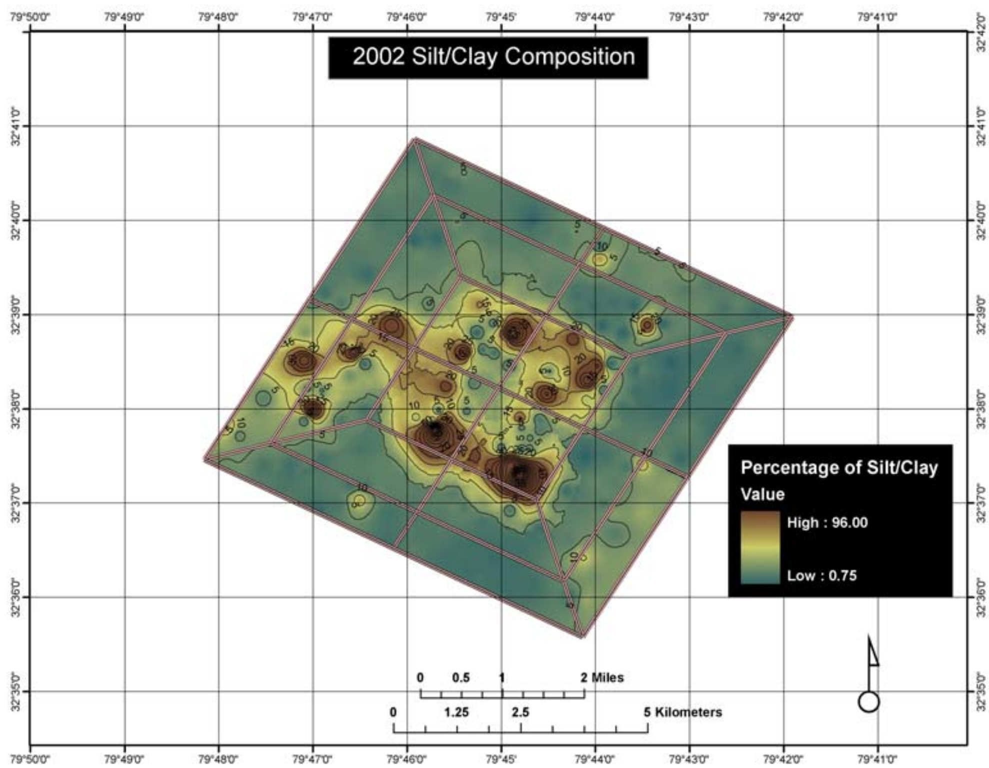
An Environmental Assessment of the Charleston Ocean Dredged Material Disposal Site And Surrounding Areas:

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



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Submitted to:
U.S. Corps of Engineers
Charleston District

FINAL REPORT

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of the
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and Surrounding Areas:

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January 2005

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EXECUTIVE SUMMARY

A monitoring program of the physical and biological condition of bottom habitats within and surrounding the Charleston Ocean Dredged Material Disposal Site (ODMDS) was completed after the conclusion of disposal activities associated with the 1999-2002 Charleston Harbor Deepening Project. Approximately 20-25 million cubic yards of inner harbor and entrance channel materials were placed at the ODMDS as part of the project. Findings presented here include analyses of sediment characteristics, sediment contaminants, and benthic assemblages in the disposal zone, inner boundary zone, and outer boundary zone. These results build on an ongoing, long-term monitoring program with several collaborating partners coordinated by the South Carolina Department of Natural Resources (SCDNR). 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 sampling design for this monitoring program divided the ODMDS into a disposal zone, inner boundary zone, and outer boundary zone which were further subdivided into a total of 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 contaminant analyses included the measurement of trace metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides. Benthic assemblage parameters that were evaluated included total density, number of species, diversity, density of general taxonomic groups, and density of numerically dominant taxa. A cluster analysis based on benthic species composition and density was also conducted. Analyses of the data collected included spatial comparisons of post-disposal data, and temporal comparisons among baseline, interim, and post-disposal assessments.

The placement of disposal material into the Charleston ODMDS from the Charleston Harbor Deepening Project, and from ongoing maintenance dredging, has resulted in a number of physical and biological impacts to the areas surrounding the disposal zone, as well as anticipated impacts within the disposal area. An Interim Assessment completed in 2000, midway through the Charleston Harbor Deepening Project, documented significant alterations of sediment characteristics, particularly silt/clay content and organic matter content, to the west and northwest of the disposal zone relative to typical bottom conditions found in the nearshore zone of South Carolina. These changes in sediment characteristics were caused by the migration of dredged material from the disposal site, unauthorized dumping outside the designated site, and trailings from barges entering or exiting the disposal area.

Disposal material placed in the Charleston ODMDS included fine-grained inner harbor materials and shelly sands from the entrance channel. As expected following a large-scale disposal operation of these materials, higher silt/clay and shell hash content was found in the disposal zone than surrounding boundary areas. However, statistical analyses of 2002 sediment composition data by strata indicated that percentages of silt/clay within the disposal area were not significantly different than values in most of the strata in the inner and outer boundary zones. Likewise, organic matter in many strata in boundary zones adjacent to the ODMDS was not significantly different than levels in strata within the disposal site. These findings suggest that previous, and likely ongoing, effects from sediment migration are affecting sediment characteristics in the monitoring zones surrounding the ODMDS.

Temporal comparisons of sediment characteristics show clear evidence of disposal activities within the designated disposal area, and a strong pattern of continued and increased effects in the surrounding boundary areas. Silt/clay and shell hash contents were significantly higher in the post-disposal assessment in the inner and outer boundary zones than during previous assessments. Similarly, significantly higher levels of organic matter were documented in 2002 than baseline and interim assessments, not only for the disposal area, but for the inner and outer boundary zones as well. Although disposal effects were intended to be limited to the disposal zone, post-disposal assessment findings clearly document that these impacts are also occurring in the inner and outer monitoring zones surrounding the Charleston ODMDS. The probable source of these materials in the boundary zones is migration of materials from the disposal site and unauthorized dumping of disposal material.

Levels of sediment contaminants within the disposal zone and surrounding areas were low. Trace metal, PAH, PCB, and pesticide concentrations were below published bioeffects guidelines, with the exception of cadmium levels in one stratum within the disposal area. These findings suggest that the presence of contaminated sediments was low and limited to within the designated disposal zone. It should be noted that contaminant concentrations were above published bioeffects guidelines (effects range low, or ER-L levels) for six contaminants, which were therefore not adequately assessed as part of this study and could potentially be present at levels that could adversely affect biological resources.

More than 18,600 organisms representing 448 taxa were collected and identified from a subset of ten strata in the inner and outer boundary zones to assess impacts to the benthic community related to dredge disposal operations. 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. Spatial comparisons of 2002 benthic community data included a variety of metrics and statistical techniques and documented patterns in the benthic community structure indicating that disposal related effects are still present and detectable in the boundary areas surrounding the Charleston ODMDS. Comparisons between non-impacted (east of disposal area) and impacted strata (west and northwest of disposal area) found significantly greater overall abundance and diversity, abundance of mollusks, abundance of amphipods, and numbers of species of polychaetes, amphipods, mollusks, and other taxa in non-impacted than impacted strata. Cluster analyses revealed that the benthic community structure in most impacted strata was similar based on species composition and relative abundance. A second strata group resulted from the cluster analysis, and was composed of both impacted and non-impacted strata, suggesting either recovery of benthic communities in some impacted strata, or the occurrence of disposal-related effects in non-impacted strata. Analyses of the ten dominant taxa collected in 2002 indicated that five of these species were found in significantly fewer numbers in impacted strata than non-impacted strata, and one species was found in significantly greater numbers in impacted strata than non-impacted strata. The remaining species showed no significant differences among strata types. Patterns in the abundance of individual species are likely consequences of physiological or behavioral responses to alterations in sediment characteristics caused by disposal operations.

Temporal comparisons of benthic assemblages from the baseline assessment (1993-1994), interim assessment (2000), and post-disposal assessment (2002) indicate significant effects on benthic community structure related to disposal operations completed as part of the 1999-2002 Charleston Harbor Deepening Project. A general trend of decreased benthic abundance, reduced species numbers, and decreased diversity was observed in impacted strata to the west and northwest of the ODMDS. In strata classified as non-impacted, many biological metrics were not significantly different from baseline assessments or did not exhibit a significant trend over time. Temporal analyses of general taxonomic structure suggested that these community metrics showed alterations in the impacted strata following disposal operations; however, since many differences were also observed in non-impacted strata, differences cannot be attributed directly to disposal activities. Additional analyses were completed on the abundance of the five dominant taxa collected in 1993, 1994, and 2002. In most impacted strata, two species showed significant declines in abundance in 2002 when compared to the baseline assessment, a response that is likely due to physiological or behavioral responses to changes in sediment composition from disposal operations. The other three dominant taxa showed either no significant change over time, or shifts in abundance that appear related to natural population fluctuations.

Based on the findings from the post-disposal assessment conducted upon completion of the 1999-2002 Charleston Harbor Deepening Project, sediment characteristics and biological communities in the boundary areas surrounding the ODMDS have sustained impacts related to disposal operations. Therefore, SCDNR recommends the completion of a five year post-assessment of the Charleston ODMDS and surrounding areas using sampling strategies similar to those used for the baseline, interim, and post-disposal surveys. Such an assessment was previously approved by the interagency Task Force during the development of an updated Site Management and Monitoring Plan for the Charleston ODMDS. Monitoring activities at ocean disposal areas should not cease upon the completion of large-scale disposal operations if full recovery has not occurred in areas outside the ODMDS that should not have been adversely impacted. In the case of the Charleston ODMDS, it is critical to continue these efforts to understand the duration and fate of disposed sediments and document long-term trends, particularly in light of ongoing disposal operations, future disposal operations, and possible site expansion requests. Further discussion among Task Force members is warranted to determine possible mechanisms for reducing costs of a five year post-assessment.

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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 (USACE) to receive bottom sediments dredged from channel maintenance and deepening projects in the Charleston Harbor estuary and entrance channel. Modifications to the configuration of this ODMDS have occurred during the past two decades with respect to location and size of the areas where recent disposal operations have occurred (Van Dolah *et al.* 1996, 1997; Winn *et al.* 1989). The ODMDS currently designated for use (Figure 1, shown in red) is four square miles in size, and falls within a larger disposal area that encompasses approximately 5.3 x 2.3 nautical miles (Figure 1, labeled “larger ODMDS”). The current ODMDS overlaps a smaller ODMDS (2.8 x 1.1 nautical mile site) that was previously used for authorized disposal activities (Figure 1, labeled “old disposal area”) until impacts to hard bottom reef areas from dumping operations were identified within the western quarter of the area (Winn *et al.* 1989). The current ODMDS was designated for use in 1993 by an interagency Task Force. This relocation of the ODMDS required the collection of new baseline data to determine conditions in and around this site, especially since this area had recently received disposal material (Van Dolah *et al.* 1996, 1997), and was slated for the placement of large-scale disposal from the Charleston Harbor Deepening project.

The interagency Task Force developed a Management Plan for this ODMDS including a comprehensive monitoring plan for the site that is described in the Charleston ODMDS Site Management and Monitoring Plan (1993). Based on this plan, the four

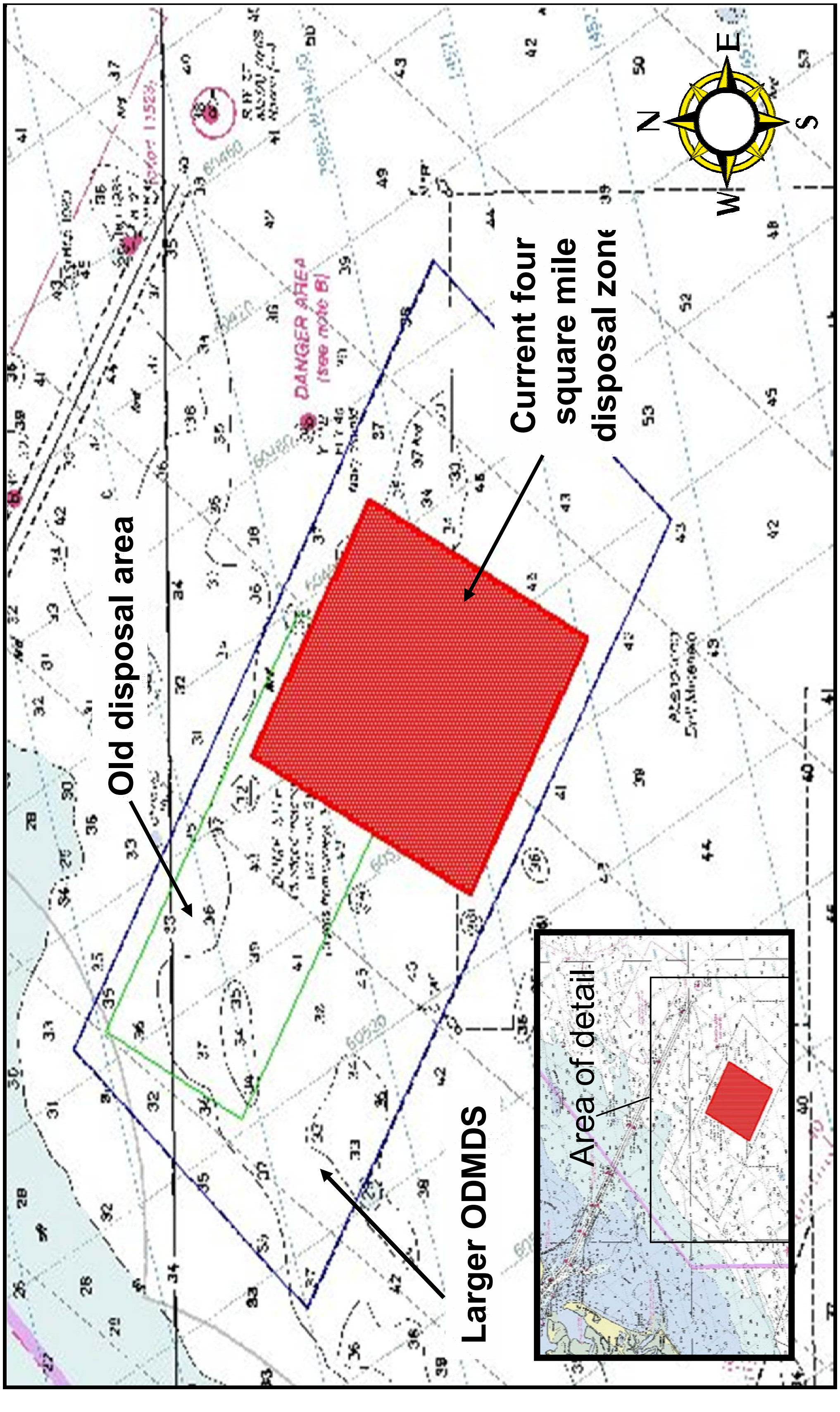

Figure 1. Location of the larger ODMDS (blue box), smaller ODMDS (green box), and currently designated four square mile disposal zone (red box). See text for details.

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 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 to serve as a barrier, with finer materials to be placed to the east of the barrier. An updated Management and Monitoring Plan is currently being developed by the interagency Task Force that monitors activities at the ODMDS (Gary Collins, USEPA, pers. comm.).

The most recent Charleston Harbor Deepening Project was authorized by the U.S. Congress 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

The Charleston ODMDSs have a history of extensive monitoring. 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. These historical efforts are described in more detail in the following section. Monitoring activities that have occurred in response to

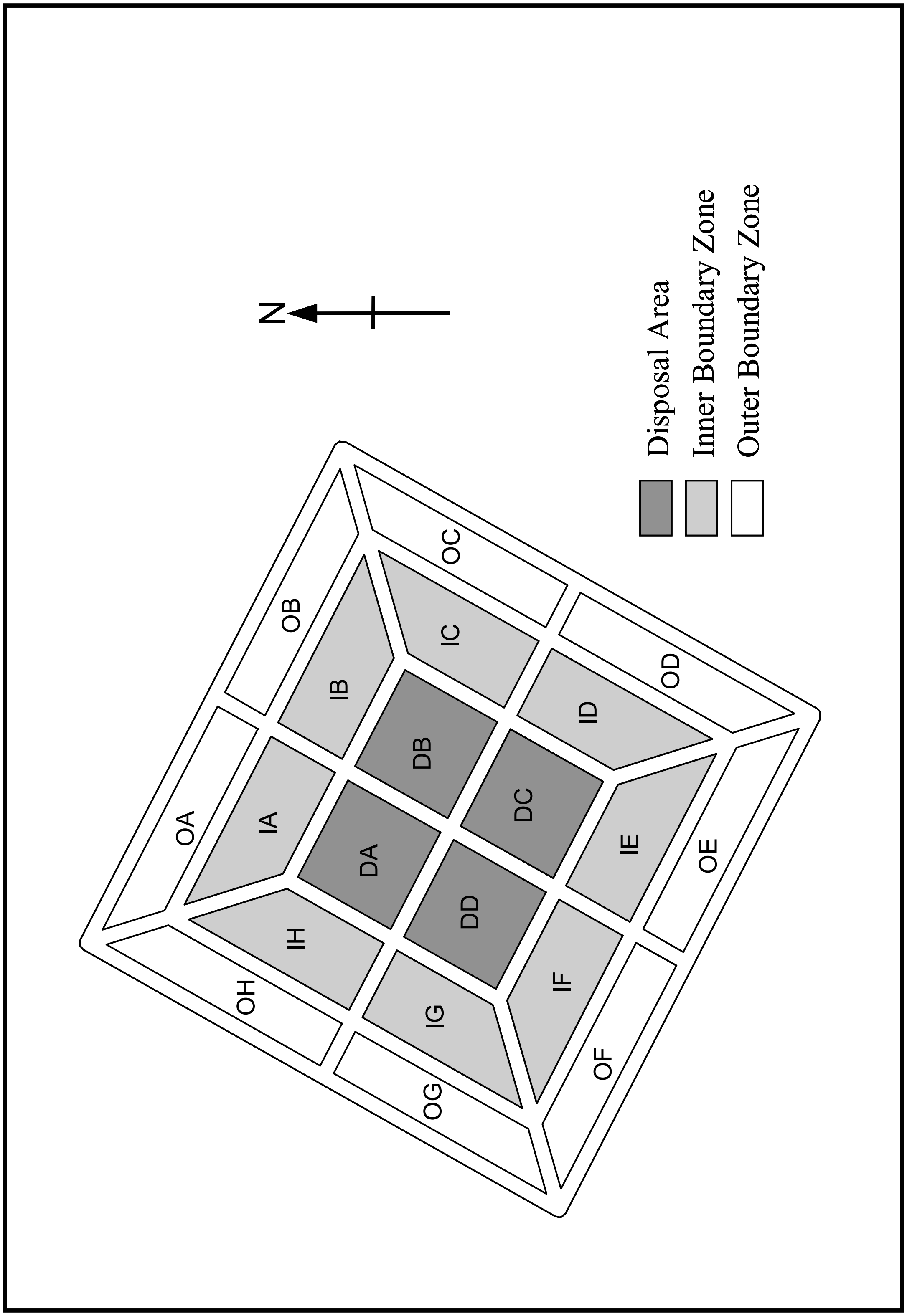

Figure 2. Designated disposal zone within the Charleston ODMDS and the surrounding boundary zones.

the 1999-2002 Charleston Harbor Deepening project are also presented in the following two sections (unauthorized disposal activity and interim monitoring efforts).

Bathymetry

The smaller ODMDS and surrounding area have been surveyed by the USACE at periodic intervals since 1972 to obtain bathymetric data. The purpose of these surveys are 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

An assessment of bottom sediment characteristics and sediment contaminant levels in the area was first completed in 1978 by the South Carolina Department of Wildlife and Marine Fisheries (SCWMRD 1979, now the South Carolina Department of Natural Resources). The SCWMRD study collected sedimentological data at 40 sites, and contaminant data at 24 sites in and around the larger ODMDS (SCWMRD 1979, Van Dolah *et al.* 1983). An additional 10 sites were sampled for sediment and contaminant levels in the area of the larger ODMDS by Interstate Electronic Corporation (IEC) during 1979 (EPA 1983). Neither of these studies found 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 (SCWMRD 1979). Minor changes in sediment characteristics were detected, with some movement of material away from the disposal site. However, surficial sediment characteristics outside the disposal site did not appear to be altered.

A baseline assessment of the current four square mile disposal zone was completed in 1993 and 1994, and 200 sediment samples were collected in and around the disposal zone during both years (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. In 1993, relatively high concentrations of mud (>10%) were found within the disposal area, although most of the muddy sediments had dispersed by the 1994 assessment. 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, common prey items for many fish and crustacean species, have been monitored since 1978 in the vicinity of the larger ODMDS. SCWMRD (1979) found no major differences in the benthic communities collected within the larger ODMDS compared to adjacent areas (Van Dolah *et al.* 1983) in a study conducted in 1978. The IEC sampled the benthos at 10 sites during March and December 1979 in the vicinity of the larger ODMDS (EPA 1983). No differences in the benthic communities were detected between the ODMDS and surrounding areas, which could be attributed to previous disposal operations or recovery of the benthic communities within the ODMDS.

The SCWMRD completed an updated assessment in 1987 due to the changes in the site designation (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. Minor changes in the benthic community were detected in response to the movement of disposal material away from the disposal site following a 1986 disposal operation; however, this movement did not appear to significantly alter benthic communities outside the smaller ODMDS (Winn *et. al*. 1989).

An intensive assessment of benthic communities was completed by the South Carolina Department of Natural Resources (SCDNR) in the four square mile disposal zone and surrounding boundary areas in 1993-1994 as part of a baseline assessment of the area (Van Dolah *et al*. 1996, 1997). Benthic samples were collected at 200 stations each year. Species composition, faunal density, and number of species varied among zones (disposal zone, inner boundary zone, and outer boundary zone) and strata (twenty one-square mile areas located in one of the three zones). The density of some general taxonomic groups was found to be related to sediment type, a finding that suggests that future large-scale disposal operations could lead to disposal-related changes in benthic community structure.

Hard bottom reef communities, naturally occurring hard or rocky formations that support dense assemblages of sponges, corals, and other invertebrates, are found in the vicinity of the Charleston ODMDS. These areas attract many recreationally and commercially important fishes such as black seas bass, porgies, snappers, and groupers (SCWMRD 1984). Due to the close proximity of the Charleston ODMDS to hard bottom reef habitats, the potential exists for long-term loss of sessile biota and associated finfishes through burial by fine-grained sediments dispersed from the ODMDS.

Therefore, hard bottom reef communities near the disposal area have been monitored to assess the impacts of disposal activities. Meier and Porter (1993) completed a statistical assessment of changes in epifaunal invertebrate cover between 1990 and 1991 based on field data collected by the USEPA. A reference area and a site impacted by disposal placed in 1989 were evaluated based on color photographs of invertebrate cover to determine mortality, settlement, and general growth patterns of individual organisms during the survey period. No significant changes in the numbers of selected taxa were observed at the reference area, while significant declines in abundance of two taxa (a sponge and gorgonian octocoral) were observed at the impacted site (Meier and Porter 1993).

A study of the physiological effects of dredged material on the oxygen metabolism of two hard bottom reef organisms (the scleractinian coral *Oculina arbuscula* and the gorgonian octocoral *Lophogorgia hebes*) was completed in 1992 by the EPA in conjunction with the University of Georgia's Department of Ecology. The results of the study suggested 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 is more difficult. 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).

In addition to assessments of benthic assemblages and hard bottom reef communities, several 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).

Hydrographic Data

Hydrographic data have 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 in early 2000, SCDNR staff investigated muddy areas found outside the four square mile disposal zone. SCDNR sampling and a USGS survey confirmed the presence of discrete mounds of disposal material and sediments high in silt/clay content in areas surrounding the four square mile disposal zone, and identified this problem to the USACE The USACE reviewed logs and also found unauthorized dumps made outside the four square mile disposal zone. Reconnaissance of about 50 unauthorized dumpsites was completed by a subcontractor to the dredging company and reviewed by SCDNR staff. At least one of the unauthorized dumpsites 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.* 2001a) 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 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 western berm, and finer, unconsolidated, materials placed elsewhere in the disposal site. 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 completed in 2000 approximately halfway through the 1999-2002 Charleston Harbor Deepening Project. Several collaborating research teams were involved with these monitoring programs, including SCDNR, Coastal Carolina's Center for Marine and Wetland Studies, U.S. Geological Survey, University of Georgia's Center for Applied Isotope Studies, and University of South Carolina's Coastal Processes and Sediment Dynamics Laboratory. Analyses included assessments of bathymetry, sediment characteristics (through analysis of grab samples, side scan sonar surveys, and sub-bottom profiling), surficial sediment chemistry, disposal material mobility and transport, sediment contaminants, biological communities, and hydrographic conditions (Zimmerman *et al.* 2002, 2003, Jutte *et al.* 2003).

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 (Gayes 2001, Zimmerman *et al.* 2002). 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. Additional closely spaced side scan sonar surveys and bottom video tows were completed in 2000 at hard bottom reef areas. These surveys, in addition to direct diver observations, were used to identify areas where disposal material had been reworked and transported away from the site (Gayes 2001).

A second regional side scan sonar mosaic was collected in July-August 2001 that extended further offshore than the March 2000 survey (Gayes *et al.* 2002). When the 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 2000 survey was conducted. During the same research cruises, detailed video and side scan sonar surveys at the reef sites were also collected. These data 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, likely caused by some combination of the effects of disposal activities and natural variability (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. In addition, a trail of probable dredged material was observed leaving a 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).

The University of South Carolina Coastal Processes and Sediment Dynamics Laboratory completed an assessment of disposal material mobility and transport in the vicinity of the disposal site (Voulgaris 2002) by measuring the combined action of waves and currents 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). The platform was equipped with an acoustic doppler current profiler and optical backscatter sensor. Findings indicated that the combined shear stress caused by the waves and currents is much larger than the mean shear stress of the currents alone. Comparison of mean stresses with the settling characteristic of the sediments suggest that the finer-grained dredged material can create flocculates that have reduced settling velocities. The implication of this study is that finer-grained dredged material can be transported even with the slightest wave conditions (Voulgaris 2002).

The interim assessment included the collection of 200 sediment samples and twenty composite sediment contaminant samples in the four square mile disposal zone and surrounding boundary areas (Zimmerman *et al.* 2002). The majority of sediments collected during the interim assessment were medium to fine-grained sands with moderate amounts of shell hash. Significantly lower sand content was found within the disposal zone, as expected due to the extensive dumping of fine-grained inner harbor materials at the site. Temporal comparisons found that silt/clay content was significantly higher in 2000 than 1994 not only in the disposal zone, but also in the inner boundary and outer boundary zones (Zimmerman *et al*. 2002). The strata with the largest increases in silt/clay content were located within the disposal zone and to the west of the disposal site, most likely due to migration of material from the disposal site and from unauthorized dumps made outside the disposal site (Jutte *et al.* 2001a). Sediment contaminant levels were low in all strata sampled, with trace metal, polyaromatic hydrocarbon (PAH), polychlorinated biphenyl (PCB), and pesticide concentrations below published bioeffects levels (Zimmerman *et al.* 2002).

Two hundred benthic samples were collected as part of the interim assessment, with a limited subset of samples (n = 100) in the areas surrounding the disposal site selected for analysis. Based on patterns in the abundance and composition of benthic taxa, three strata groups were identified: western boundary strata, northwestern boundary strata, and eastern boundary strata. These strata groupings supported the a *priori* classification of sites as impacted or non-impacted from disposal operations based on findings from previous side scan sonar and sediment mapping surveys (Noakes 2001, Gayes 2001, Gayes *et al.*2002). Temporal analyses, which compared 2000 data to a subset of 1993-1994 data that were selected because they best typified natural baseline conditions and eliminated influences of historical disposal activity (Zimmerman *et al.* 2002), also documented disposal related impacts on the benthic communities in the vicinity of the ODMDS. These analyses found that mean faunal density and number of species were significantly lower in 2000 than 1993 and 1994 in the majority of impacted strata, while most non-impacted strata showed no significant differences between years. In addition, general taxonomic structure was influenced by disposal operations. Significant declines in organisms in the "other taxa" category (predominately the cephalochordate *Branchiostoma* sp., ribbon worms in the phylum Nemertea, and Polygordiid annelids) appeared to be associated with disposal activities, although the declines in amphipod and mollusk abundances were likely linked to annual variability (Zimmerman *et al.* 2002).

A companion program to the monitoring activities at the ODMDS was developed in 2000 in response to the evidence of disposal material migration, dredge trailings outside the disposal site, and unauthorized disposal activities. The goal of this companion program was to identify impacts to hard bottom reef habitats in the vicinity of the Charleston ODMDS (Jutte *et al.* 2003), and biannual assessments will continue through spring 2005. The collaborative study, including researchers from SCDNR, Coastal Carolina University, and the University of Georgia Center for Applied Isotope Studies, includes sampling activities twice each year at two reference areas and four sites likely to be impacted by disposal activities. During each sampling period, video surveys of sponge/coral and fish communities, and measurements of surficial sediment depths, surficial sediment characteristics, and sedimentation rates are collected. In addition, a detailed side scan sonar survey with simultaneous underwater video is completed annually to determine changes in the areal extent of each reef site. To date, the trends observed in the hard bottom reef communities in the vicinity of the disposal site suggest that these organisms are experiencing natural fluctuations in community structure and suffering limited, if any, impacts from the large-scale disposal operations that occurred at the ODMDS. However, the lack of baseline data before the initiation of disposal activities related to the deepening project began makes definitive interpretation difficult.

Post-Disposal Monitoring Efforts

An assessment of physical and biological conditions in and around the disposal area was planned upon completion of the 1999-2002 Charleston Harbor Deepening project. As planned, the deepening project produced approximately 31.5 million cubic yards (mcy) of sediments that were placed in the Charleston ODMDS. The specific objectives of the proposed post-disposal monitoring project included assessments of surficial sediments, sediment contaminants, and benthic macrofaunal assemblages in the ODMDS and surrounding areas.

A regional side scan sonar and bathymetry survey of the ODMDS and surrounding areas was completed by USGS and Coastal Carolina University in June 2002. In addition, the third annual survey of reef sites in the vicinity of the disposal area was completed in fall 2002, using the same equipment, collection protocols, and analysis techniques used in previous years to maintain coherence between survey years (Gayes *et al*. 2003). A very limited number of unauthorized dumps (n = 5) were identified based on inspection of the USGS side scan sonar data and comparison with data from previous surveys. Textural analyses of the 2002 data indicated that the 1-km^2 window surrounding each of the six reef sites experienced net gains in hard bottom area relative to 2001 at all sites surveyed.

Post-disposal mapping of surficial sediment chemistry indicated that the ODMDS site and surrounding monitoring areas have a complex surficial sediment matrix due to the long history of disposal activities in the area and the large volume of material dumped at the site from the Charleston Harbor Deepening project (Noakes 2003). Gamma activity, slurry density, and elemental concentration maps were successfully used to clearly map the location of entrance channel and inner harbor materials recently placed in the site. In addition, evidence of disposal material outside the ODMDS was clearly identified, based on its unique isotopic signature, in a bulge to the west of the disposal area, and within the boundary zones to the north of the disposal site in a trail leading towards the ODMDS. While it is possible that some fraction of the sediments found outside the disposal area are from historical disposal operations, the detection of an isotope in grab samples (^{7}Be) with a very short half-life confirmed that sediments found outside the disposal area were recently deposited offshore.

The remainder of this report summarizes assessments of sediment characteristics, sediment contaminants, and benthic communities in and around the Charleston ODMDS upon completion of the 1999-2002 Charleston Harbor Deepening project.

METHODS

Field Sampling

Field sampling was completed 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 1993-1994 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). No samples were collected within a 100 m buffer inside the boundary of each stratum to avoid the inadvertent location of sampling sites in adjacent strata. The location of sampling sites was accomplished using a Geographic Positioning System (GPS) equipped with a differential beacon. Sampling was completed on September 23-24, 2002 using the SCDNR R/V Lady Lisa.

A benthic grab sample was collected at each of the ten sites within each of the 20 strata using a 0.043 m^2 Young grab. Stations sampled in 2002 were selected from the original random array of stations and alternate stations created for baseline sampling in 1993 and 1994. Station locations of 2002 samples are shown in Figure 3, and the latitude/longitude coordinates for each site (NAD83 datum) are provided in Appendix 1. Hydrographic data were collected at the location of the first grab sample in each zone. Salinity (‰), temperature (ºC), and dissolved oxygen (mg/L) were measured at surface and bottom levels (Table 1). Each grab sample was sub-sampled for analysis of sediment characteristics (% sand, silt/clay, and $CaCO_3$; 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

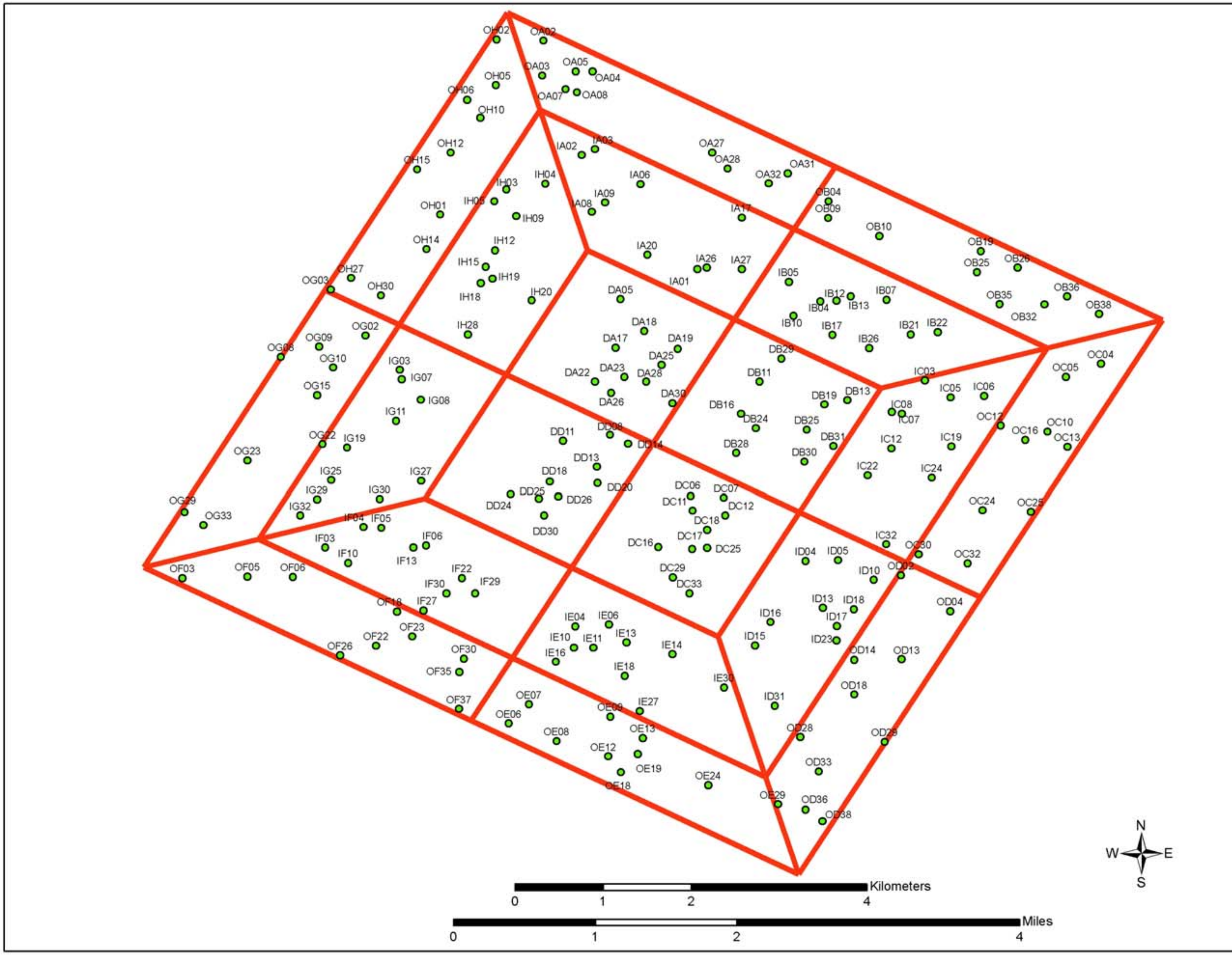

Figure 3. Location of stations sampled in the disposal zone and surrounding boundary zones as part of the post-disposal assessment in 2002.

Table 1. Bottom and surface hydrographic data in the strata located in the Charleston ODMDS and surrounding boundary zones. Data was collected September 23-24, 2002.

Strata	Bottom Dissolved Oxygen (mg/L)	Bottom pH	Bottom Salinity (ppt)	Bottom Temperature (^{o}C)	Surface Dissolved Oxygen (mg/L)	Surface pH	Surface Salinity (ppt)	Surface Temperature (^{o}C)
DA	6.86	8.0	36.7	27.7	6.94	7.9	36.7	27.8
DB	6.98	8.0	36.9	27.8	7.05	8.0	36.9	27.8
DC	6.62	8.0	36.9	27.7	6.68	8.0	37.0	27.7
DD	6.90	8.0	36.7	27.6	7.07	8.0	36.7	27.6
IA	6.07	7.9	36.6	27.6	6.07	7.9	36.6	27.6
IB	7.07	7.9	36.7	28.0	7.00	7.9	36.8	27.7
IC	6.06	7.9	36.9	27.6	6.07	7.9	36.8	27.6
ID	6.22	7.9	36.9	27.6	6.33	7.9	36.9	27.7
IE	6.72	7.7	36.8	27.6	6.80	7.7	36.8	28.1
IF	6.91	7.8	36.7	27.6	7.43	7.8	36.5	28.1
IG	6.38	7.9	36.4	27.6	6.40	7.8	34.5	27.6
IH	6.08	7.9	36.5	27.7	6.10	7.8	36.4	27.6
OA	6.04	7.9	36.5	27.6	6.08	7.9	35.8	27.6
OB	6.94	7.9	36.9	27.7	7.01	7.9	36.9	27.8
OC	6.07	7.9	36.9	27.6	6.09	7.9	36.9	27.6
OD	6.28	7.8	36.9	27.6	6.54	7.8	36.9	27.7
OE	7.40	7.7	36.8	27.8	7.54	7.7	36.6	28.0
OF	6.78	7.8	36.7	27.7	6.86	7.8	36.5	28.1
OG	6.18	7.9	36.5	27.7	6.19	7.9	36.4	27.6
OH	6.12	7.9	36.5	27.7	6.16	7.9	36.4	27.6

grab to the bottom of the sample. Samples for analysis of sediment characteristics were stored separately for each grab sample. A stainless steel core (2.5 cm dia.), first rinsed with acid (0.1 N HCl) and hexane, was used to collect sediment contaminant samples. The core was 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 the 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 organic matter content 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). Measurements of total organic matter were obtained by burning a portion of each sample at 550° C for two hours as described by Plumb (1981).

Contaminants measured in the sediments included 28 metals, 135 PAHs, 7 PCBs, and 27 pesticides. Sediment contaminant samples were transferred to the USEPA-Athens Laboratory for analysis of organic and inorganic contaminants using various USEPA approved protocols. Analyses were completed for all composite samples (n = 20). The analytical method detection limits for the various contaminant analytes were provided by the USEPA and are listed in Tables 2-5. Biological effects range-low (ER-L) and effects range-median (ER-M) values are those reported by Long *et al.* (1995) or Long and Morgan (1990). ER-L is defined as the concentration of a contaminant that resulted in adverse bioeffects in 10% of the studies examined, while ER-M is the concentration that resulted in adverse effects in 50% of the studies. Contaminants concentrations from 2002 data were compared whenever possible to these ER-M and ER-L values (Tables 2-5).

Due to funding constraints, sorting and taxonomic identification of benthic invertebrate samples was completed using the tiered approach developed for the interim assessment (Zimmerman *et al.* 2002). 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), and compared to 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

Table 2. Metals tested for in sediments collected from the disposal zone and surrounding areas. Effects range-low (ERL) and effects range-median (ERM) values were taken from Long *et al*. (1995) and Long and Morgan (1990).

Metals	**Minimum Detection Limit**	**ERL**	**ERM**
Aluminum			
Antimony		2	25
Arsenic		8.2	70
Barium			
Beryllium			
Cadmium		1.2	9.6
Calcium			
Chromium		81	370
Cobalt			
Copper		34	270
Iron			
Lead		46.7	218
Magnesium			
Manganese			
Molybdenum			
Nickel		20.9	51.6
Potassium			
Selenium			
Silver		1	3.7
Sodium			
Strontium			
Thallium			
Tin			
Titanium			
Total Mercury		0.2	0.7
Vanadium			
Yttrium			
Zinc		150	410

Table 3. Organic compounds tested for in sediments collected from the disposal zone and surrounding areas. Effects range-low (ERL) and effects range-medium (ERM) values were taken from Long *et al*. (1995) and Long and Morgan (1990). Units are reported as parts per billion dry weight.

Organic compound	Minimum Detection Limit	ERL	ERM
(3-and/or 4-) Methylphenol			
(m- and/or p-) Xylene			
1,1,1,2-Tetrachloroethane			
1,1,1-Trichloroethane			
1,1,2,2-Tetrachloroethane			
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)			
1,1,2-Trichloroethane			
1,1-Biphenyl			
1,1-Dichloroethane			
1,1-Dichloroethene (1,1-Dichloroethylene)			
1,1-Dichloropropene			
1,2,3-Trichlorobenzene			
1,2,3-Trichloropropane			
1,2,4-Trichlorobenzene_Ext			
1,2,4-Trichlorobenzene_Vol			
1,2,4-Trimethylbenzene			
1,2-Dibromo-3-Chloropropane (DBCP)			
1,2-Dibromoethane (EDB)			
1,2-Dichlorobenzene			
1,2-Dichloroethane			
1,2-Dichloropropane			
1,3,5-Trimethylbenzene			
1,3-Dichlorobenzene			
1,3-Dichloropropane			
1,4-Dichlorobenzene			
2,2-Dichloropropane			
2,3,4,6-Tetrachlorophenol			
2,4,5-Trichlorophenol			
2,4,6-Trichlorophenol			
2,4-Dichlorophenol			
2,4-Dimethylphenol			
2,4-Dinitrophenol			
2,4-Dinitrotoluene			
2,6-Dinitrotoluene			
2-Chloronaphthalene			
2-Chlorophenol			
2-Methyl-4,6-Dinitrophenol			
2-Methylnaphthalene		70	670
2-Methylphenol			
2-Nitroaniline			
2-Nitrophenol			
3,3'-Dichlorobenzidine			
3-Nitroaniline			
4_Nitroaniline			
4-Bromophenyl Phenyl Ether			

Organic compound	Minimum Detection Limit	ERL	ERM
4-Chloro-3-Methylphenol			
4-Chloroaniline			
4-Chlorophenyl Phenyl Ether			
4-Nitrophenol			
Acenaphthene		16	500
Acenaphthylene		44	640
Acetone			
Acetophenone			
Anthracene		85.3	1100
Atrazine			
Benzaldehyde			
Benzene			
Benzo(a)Anthracene		261	1600
Benzo(a)Pyrene		430	1600
Benzo(b)Fluoranthene			
Benzo(g,h,i)Perylene			
Benzo(k)Fluoranthene			
Benzyl Butyl Phthalate			
bis (2-Ethylhexyl) Phthalate			
bis(2-Chloroethoxy) Methane			
bis(2-Chloroethyl) Ether			
bis(2-Chloroisopropyl) Ether			
Bromobenzene			
Bromochloromethane			
Bromodichloromethane			
Bromoform			
Bromomethane			
Caprolactam			
Carbazole			
Carbon Disulfide			
Carbon Tetrachloride			
Chlorobenzene			
Chloroethane			
Chloroform			
Chloromethane			
Chrysene		384	2800
cis-1,2-Dichloroethene			
cis-1,3-Dichloropropene			
Cyclohexane			
Dibenzo (a,h) Anthracene		63.4	260
Dibenzofuran			
Dibromochloromethane			
Dibromomethane			
Dichlorodifluoromethane			
Diethyl Phthalate			
Dimethyl Phthalate			
Dimethyl Sulfide			
Di-n-Butylphthalate			
Di-n-Octylphthalate			
Ethyl Benzene			

Organic compound	Minimum Detection Limit	ERL	ERM
Fluoranthene		600	5100
Fluorene		19	540
Hexachloro-1,3-Butadiene			
Hexachlorobutadiene			
Hexachlorocyclopentadiene(HCCP)			
Hexachloroethane			
Indeno(1,2,3-cd)Pyrene			
Isophorone			
Isopropylbenzene			
Methyl Acetate			
Methyl Butyl Ketone			
Methyl Ethyl Ketone			
Methyl Isobutyl Ketone			
Methyl T-Butyl Ether (MTBE)			
Methylcyclohexane			
Methylene Chloride			
Naphthalene		160	2100
n-Butylbenzene			
Nitrobenzene			
n-Nitrosodi-n-Propylamine			
n-Nitrosodiphenylamine/Diphenylamine			
n-Propylbenzene			
o-Chlorotoluene			
o-Xylene			
p-Chlorotoluene			
Pentachlorophenol			
Phenanthrene		240	1500
Phenol			
p-Isopropyltoluene			
Pyrene		665	2600
sec-Butylbenzene			
Styrene			
tert-Butylbenzene			
Tetrachloroethene(Tetrachloroethylene)			
Toluene			
trans-1,2-Dichloroethene			
trans-1,3-Dichloropropene			
Trichloroethene(Trichloroethylene)			
Trichlorofluoromethane			
Vinyl Chloride			
Dibenzofuran			
Dibromochloromethane			
Dibromomethane			
Dichlorodifluoromethane			
Diethyl Phthalate			
Dimethyl Phthalate			
Dimethyl Sulfide			
Di-n-Butylphthalate			
Di-n-Octylphthalate			
Ethyl Benzene			

Table 4. PCBs tested for in sediments collected from the disposal zone and surrounding areas. Effects range-low (ERL) and effects range-medium (ERM) values were taken from Long *et al*. (1995) and Long and Morgan (1990). Units are reported as parts per billion dry weight.

PCB Congener	Minimum Detection Limit	ERL	ERM
PCB-1016 (Aroclor 1016)			
PCB-1221 (Aroclor 1221)			
PCB-1232 (Aroclor 1232)			
PCB-1242 (Aroclor 1242)			
PCB-1248 (Aroclor 1248)			
PCB-1254 (Aroclor 1254)			
PCB-1260 (Aroclor 1260)			
Total_PCB		22.7	180

Table 5. Pesticides tested for in sediments collected from the disposal zone and surrounding areas. Effects range-low (ERL) and effects range-medium (ERM) values were taken from Long *et al.* (1995) and Long and Morgan (1990). Units are reported as parts per billion dry weight.

Pesticide	Minimum Detection Limit	ERL	ERM
4,4'-DDD		2	20
4,4'-DDE		2.2	27
4,4'-DDT			
Aldrin			
alpha-BHC			
alpha-Chlordane /2		0.5	6
alpha-Chlordene /2			
beta-BHC			
beta-Chlordene /2			
Chlordene /2			
cis-Nonachlor /2			
delta-BHC			
Dieldrin		0.02	8
Endosulfan I			
Endosulfan II			
Endosulfan Sulfate			
Endrin			
Endrin Ketone			
gamma-Chlordane /2			
gamma-HCH (g-BHC, lindane)			
Heptachlor			
Heptachlor Epoxide			
Hexachlorobenzene			
Methoxychlor			
Oxychlordane (Octachlorepoxide) /2			
Toxaphene			
trans-Nonachlor /2			
Total_DDT		1.58	46.1

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

Analyses of sediment data (% sand, % silt/clay, % $CaCO_3$, organic matter content, and mean phi size) were conducted to identify any differences among the three zones (disposal, inner boundary and outer boundary) and between strata within 2002 samples (spatial comparisons). 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 from 2002 were statistically compared to 1993, 1994, and 2000 sediment data. Analyses were performed on rank-transformed data using SigmaStat for Windows version 2.03 (SPSS 1997).

Upon review of 1994 sediment composition data, it was determined that the total sediment composition for seven stations (DC02, DD30, ID10, IH14, IH18, IH26, OG14) did not equal one hundred percent. The original raw data files were no longer available, so it was impossible to identify the type of error that had occurred with respect to the sediment data for these stations. Therefore, sediment composition, grain size, and organic matter content data for these stations were not included when conducting spatial comparisons of 1994 data with other sampling periods.

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 *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.

The Sorensen/Bray Curtis proportional similarity coefficient, with a flexible group linkage method (ß value = -0.25), was used to conduct cluster analyses of 2002 data using PC-ORD Version 4.10 (McCune and Mefford 1999). The data analyzed were limited to taxa that comprised 98% of all taxa collected to eliminate rare taxa. The groups generated through this procedure displayed relative similarity between strata based on species composition and abundance.

Temporal analyses were conducted on all 2002 and 2000 data and a subset of 1993-1994 baseline data. The subset was selected in an effort to limit analyses to those samples which best typified natural, non-impacted, baseline conditions, and eliminated from analysis samples collected in 1993-1994 that may have been influenced by historical disposal activities. 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. 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 90th percentile of silt/clay (3.617%) and greater than the 90th percentile of $CaCO_3$ (24.368%) were likely affected by historical dumping activities and were excluded from analyses of temporal change.

To evaluate temporal changes in the benthic community, analysis of variance (ANOVA) was performed on various parameters in each stratum in 2002 to values from 2000 and to the reference subset from 1993 and 1994. The benthic parameters evaluated included: density, number of species, density of general taxonomic groups (polychaetes, amphipods, mollusks, and 'other taxa'), and density of dominant taxa. When necessary, data were transformed to meet the assumptions of parametric analyses. ANOVAs were performed using SigmaStat for Windows version 2.03 (SPSS 1997).

RESULTS AND DISCUSSION

Hydrographic Data

Hydrographic measurements collected in the Charleston ODMDS and surrounding boundary zones displayed no effects related to disposal activities (Table 1). Minor differences in surface and bottom temperature among stations was observed and most likely reflect tidal stage and the time of day that the site was sampled (bottom range = 27.6 – 28.0^{o}C, surface range = 27.6 – 28.1^{o}C). Salinity values ranged from 36.4 to 37.0 ppt, which are typical of nearshore waters of South Carolina during this time period. Dissolved oxygen values were high in all strata (bottom range = 6.04 – 7.40 mg/L, surface range = 6.07 – 7.54 mg/L).

Sediment Characteristics

Sediment Composition

In general, sediment composition in the study area in 2002 was dominated by sand (mean = 75.2%) mixed with moderate amounts of shell hash/$CaCO_3$ (mean = 18.1%). Detailed data on the sediment characteristics found at each station are provided in Appendix 2. When sediment composition is analyzed by zone (Figures 4-7), a trend of decreasing silt/clay content is observed when moving from the disposal area (mean silt/clay = 15.6%) and through the inner (mean = 4.6%) and outer boundary zones (4.5%). When analyzed at the level of zone, silt/clay content was significantly higher in the disposal zone than the inner and outer boundary zones in 2002 ($p < 0.001$). Sediments within the disposal area following the Charleston Harbor Deepening project

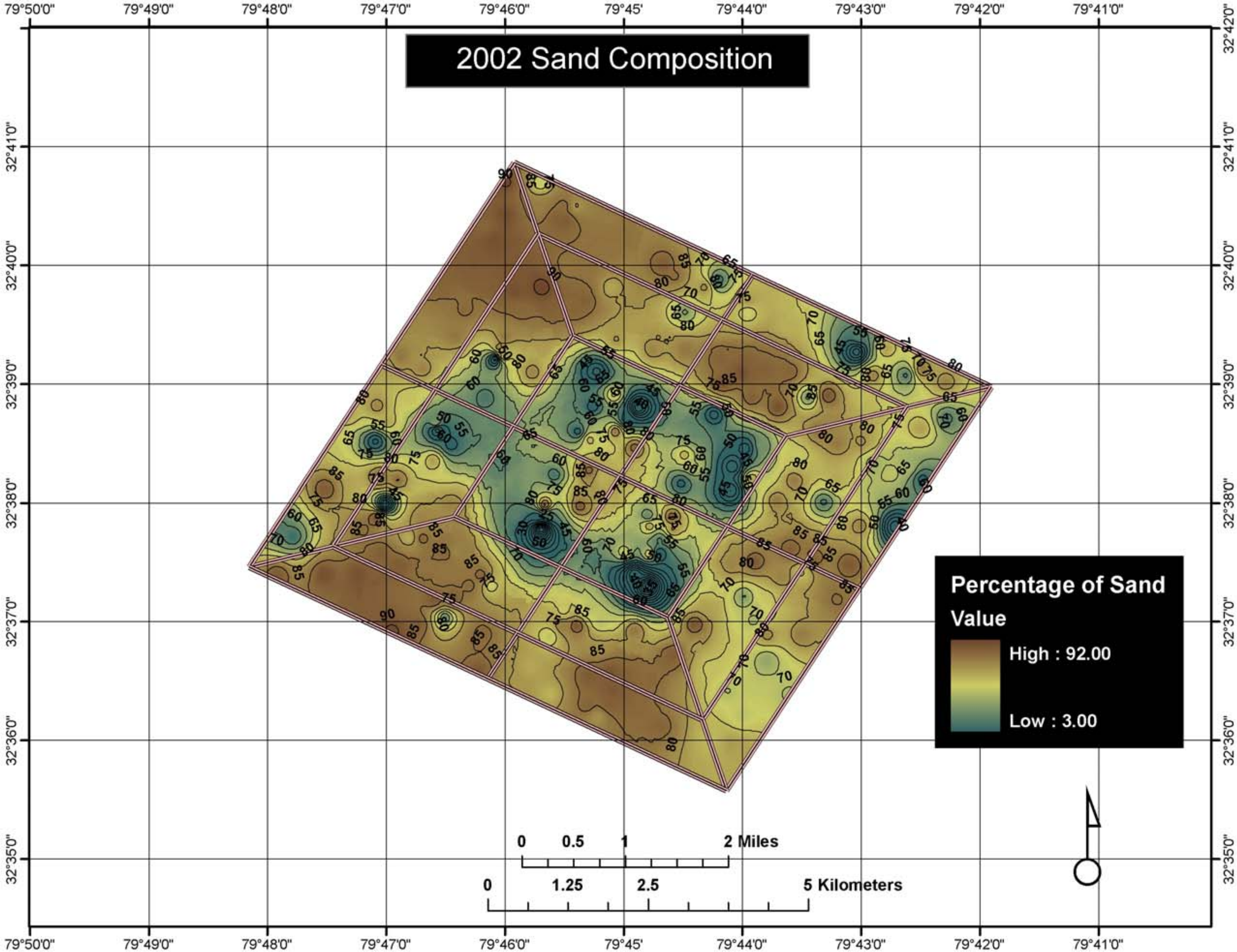

Figure 4. Contour map of the percentage of sand in surficial sediments in the disposal zone and surrounding monitoring zones. Results are based on sediment composition of 200 grab samples taken throughout the study area in September 2002 (see Appendix 2).

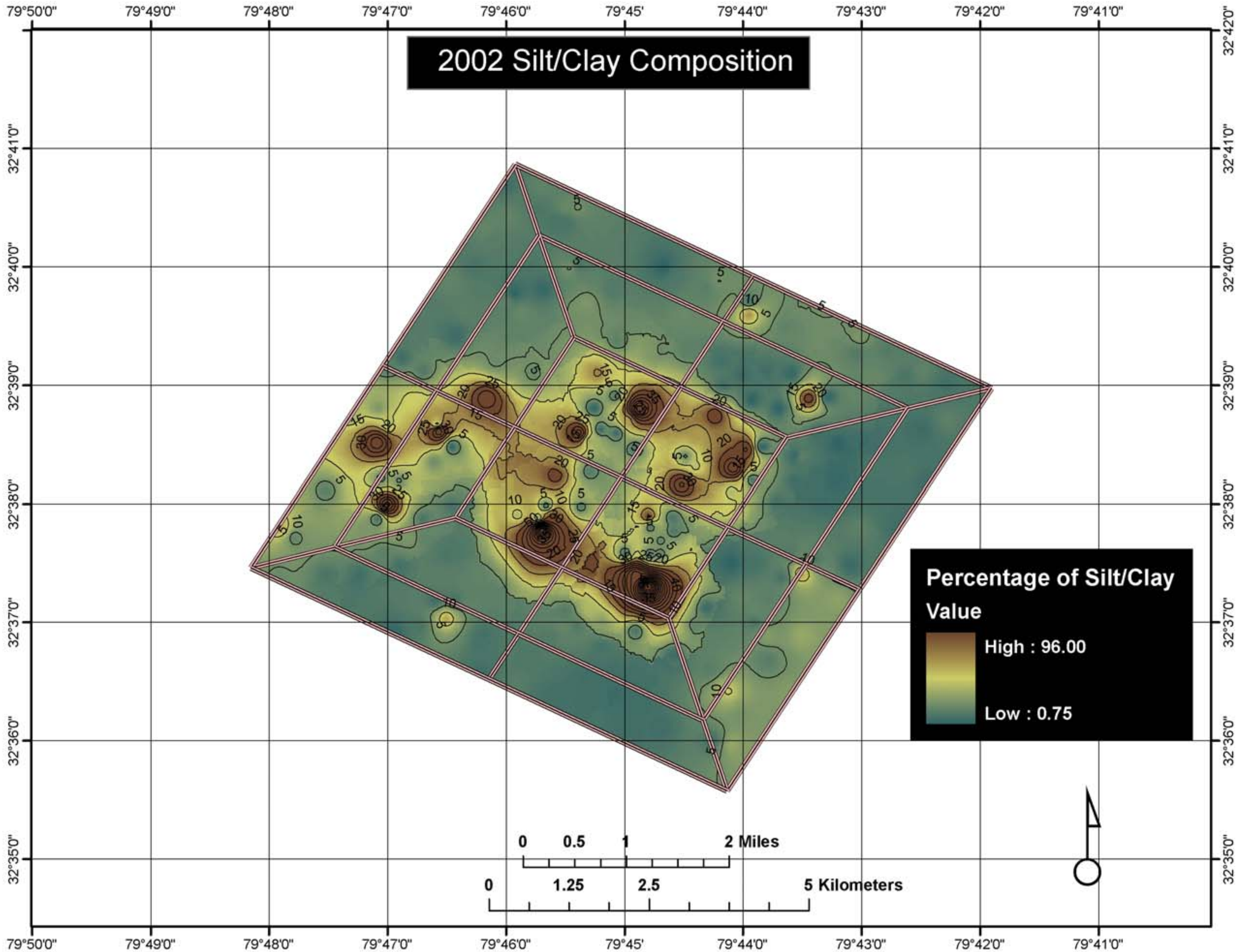

Figure 5. Contour map of the percentage of silt/clay in surficial sediments in the disposal zone and surrounding monitoring zones. Results are based on sediment composition of 200 grab samples taken throughout the study area in September 2002 (see Appendix 2).

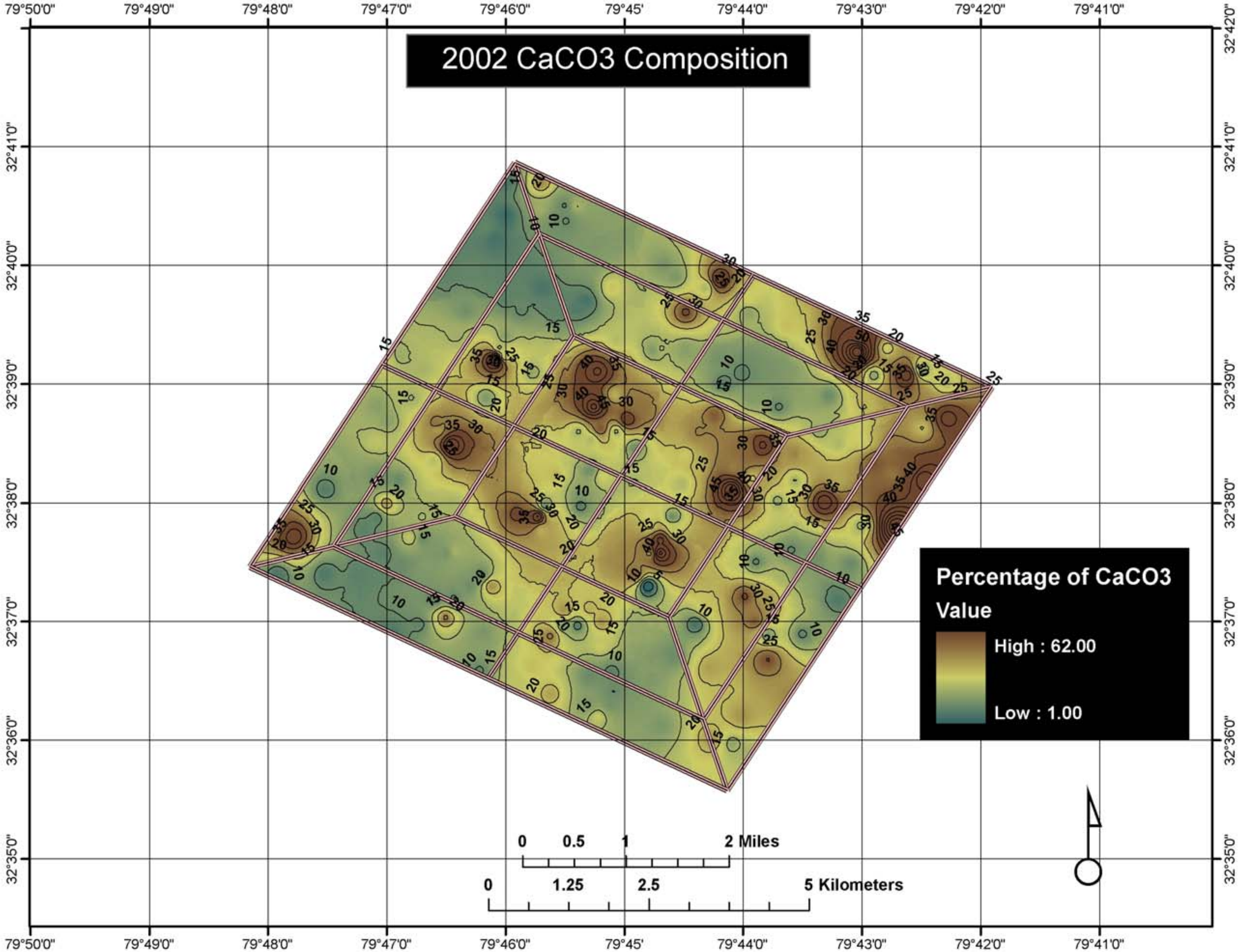

Figure 6. Contour map of the percentage of calcium carbonate (shell hash) in surficial sediments in the disposal zone and surrounding monitoring zones. Results are based on sediment composition of 200 grab samples taken throughout the study area in September 2002 (see Appendix 2).

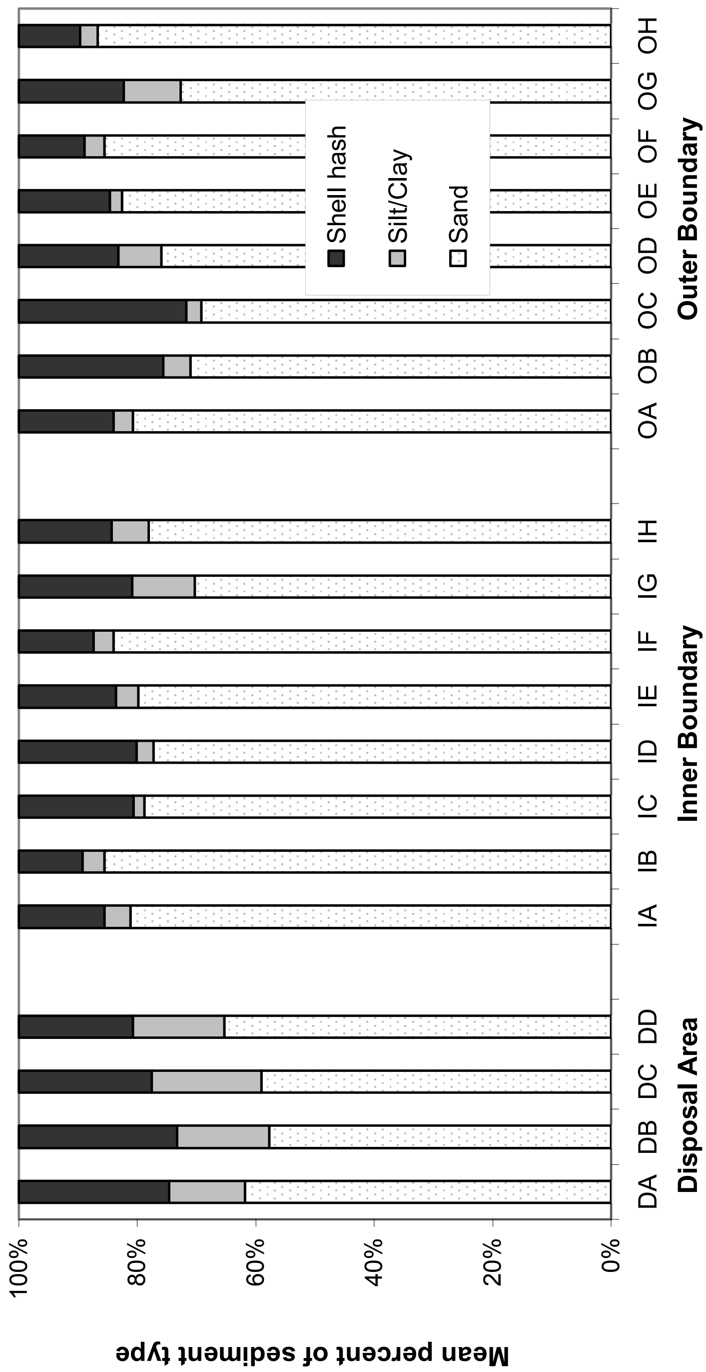

Figure 7. Sediment composition of each strata. Data are based on the average of ten grab samples per stratum collected in 2002.

were also significantly higher in shell hash and significantly lower in sand content than inner and outer boundary zones ($p < 0.001$). These findings correspond to the disposal of large amounts of inner harbor material high in fines within the disposal area, as well as the placement of dredged entrance channel materials that are typically higher in $CaCO_3$ content than surficial nearshore sediments (Noakes 2001, 2003).

When statistical comparisons are completed on the strata level, results indicate that several boundary zone strata were not significantly different than disposal area strata with respect to silt/clay content. Silt/clay content between the disposal area strata and strata in the inner and outer boundary zone were generally not statistically different, with the exception of significantly higher silt/clay content only in two disposal area strata (DB and DD) and two outer boundary strata (OD and OG) than strata IB, IC, and OE ($p < 0.001$). The lack of statistical differences in silt/clay content between many strata in the boundary zone and disposal zone indicates continued movement of silt/clay materials from the disposal area to monitoring areas outside the disposal area. With respect to sand content, comparisons among strata found that strata IB, IF, OF, and OH had significantly more sand than one or more disposal area strata ($p < 0.001$).

Temporal comparisons of sediment composition from the baseline and interim assessments with the 2002 post-disposal assessment show clear evidence of the disposal activities within the designated disposal area, and also a strong pattern of continued effects related to disposal activities in the surrounding monitoring zones (Figures 8-10). Maps of change in silt/clay content between 1994 and 2000 show levels greater than 5% (dark green) throughout much of the disposal area, as well as in strata to the west of the disposal area (Figure 8). Continued increases in silt/clay (dark green) are documented

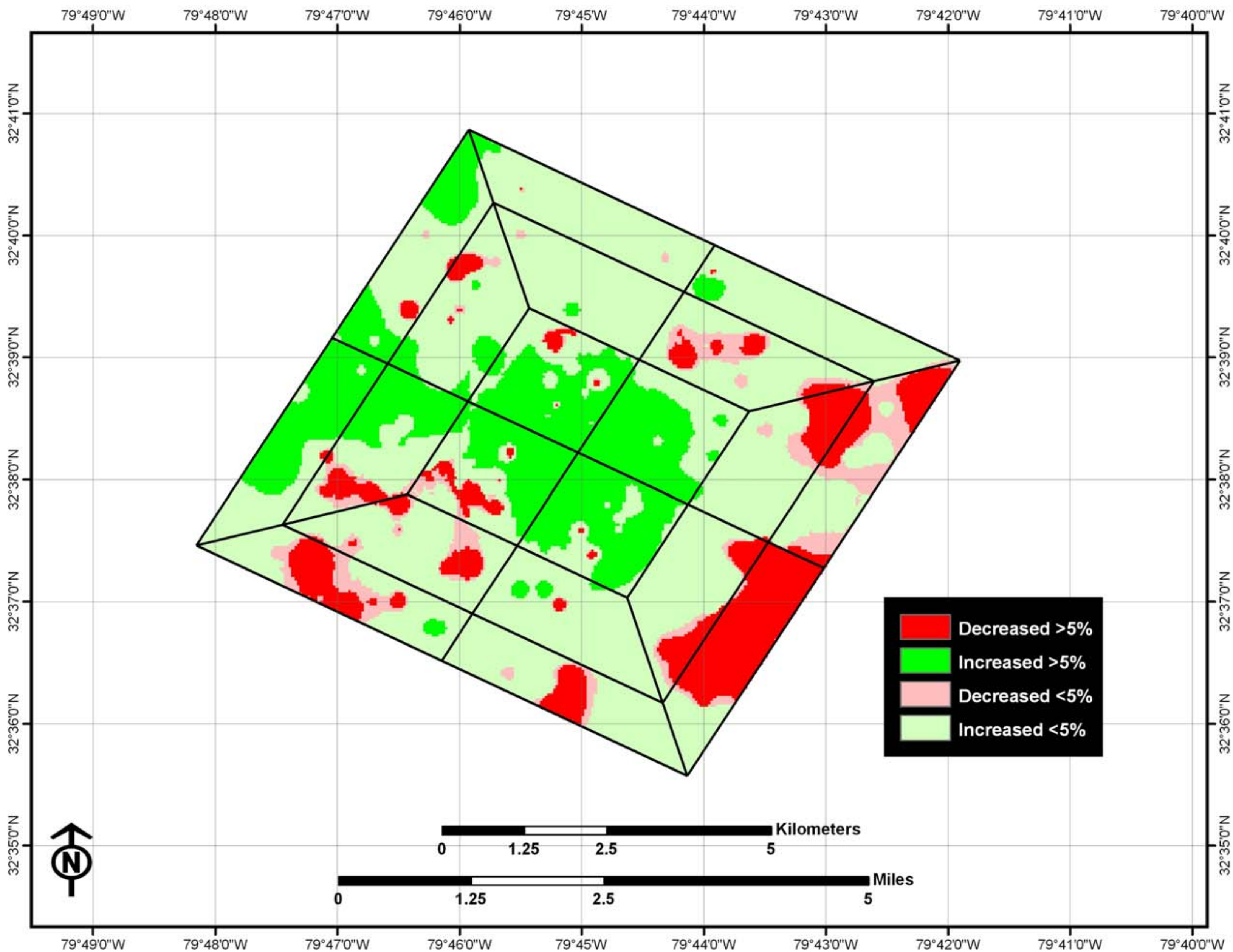

Figure 8. Change analysis of silt/clay content in surficial sediments between 1994 and 2000 assessments. Dark green indicates an increase of greater than 5% silt/clay, light green indicates an increase of less than 5%, dark red indicates a decrease of greater than 5%, and pink indicates a decrease of less than 5%.

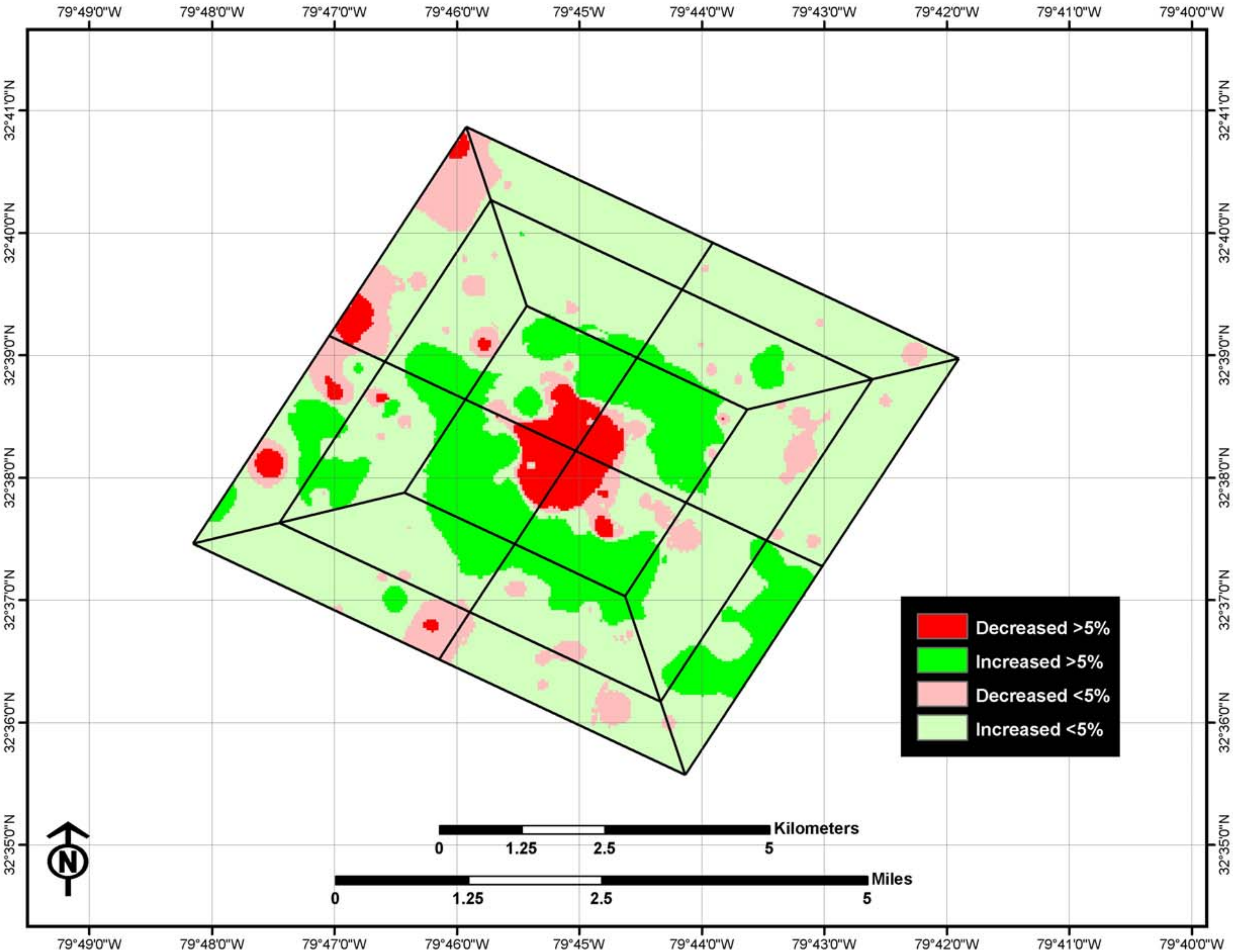

Figure 9. Change analysis of silt/clay content in surficial sediments between 2000 and 2002 assessments. Dark green indicates in increase of greater than 5% silt/clay, light green indicates an increase of less than 5%, dark red indicates a decrease of greater than 5%, and pink indicates a decrease of less than 5%.

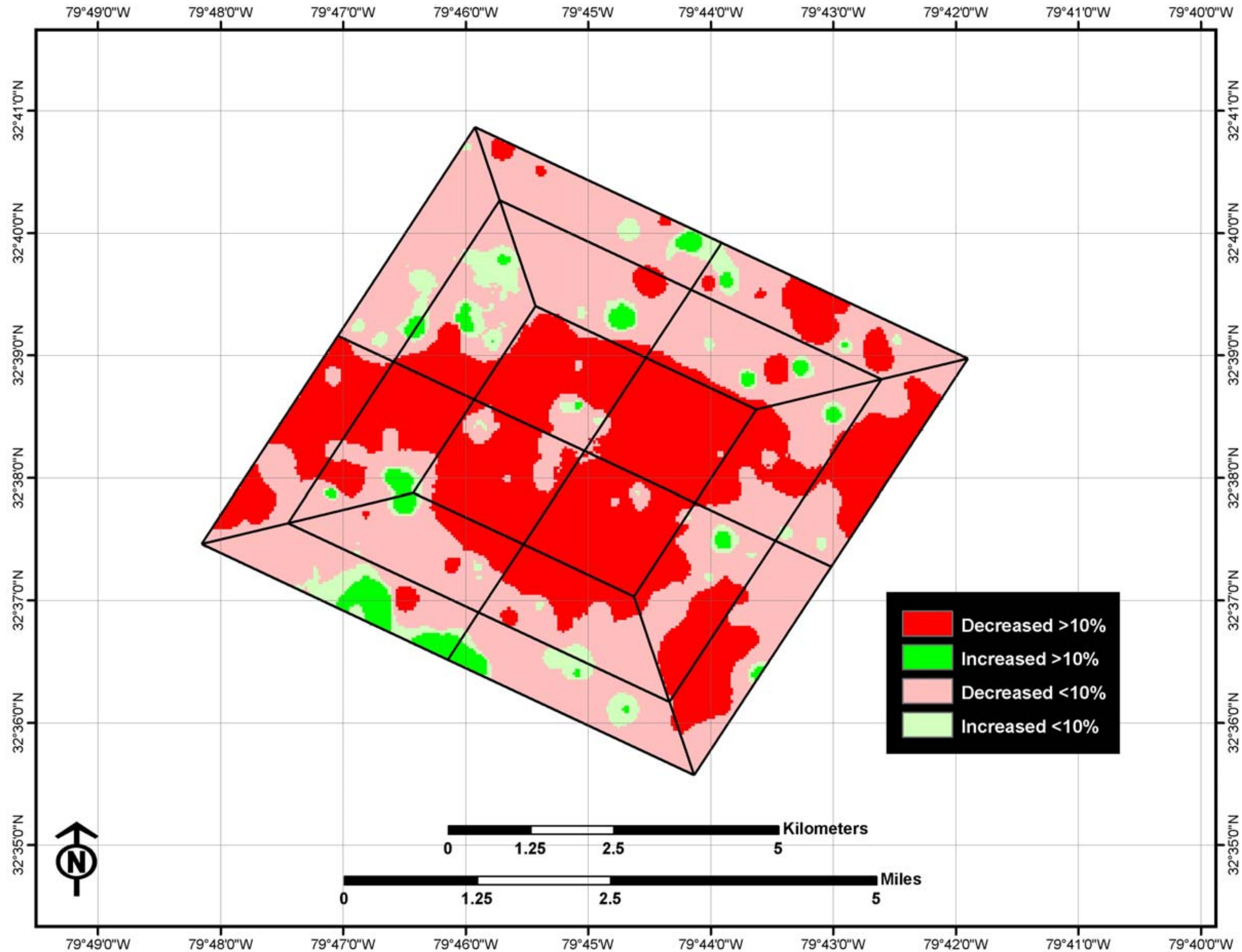

Figure 10. Change analysis of sand content in surficial sediments between 1994 and 2002 assessments. Dark green indicates in increase of greater than 10% sand, light green indicates an increase of less than 10%, dark red indicates a decrease of greater than 10%, and pink indicates a decrease of less than 10%.

between 2000 and 2002 within the disposal area and strata to the west and northwest of the site (Figure 9).

An analysis of change in sand content from the 1994 baseline assessment through the 2002 post-disposal assessment shows a similar trend; decreasing sand content (red and pink) within the disposal zone and in the monitoring strata to the west of the disposal zone (Figure 10). Statistical analyses of sediment composition over time found that silt/clay and shell hash content within the disposal area were significantly greater, and sand content was significantly lower, in 2002 than 1993 and 1994 ($p < 0.05$). Sediments collected in the inner boundary zone in 2002 had significantly lower sand content and higher silt/clay content than sediments collected in 1994 ($p = 0.003$). Likewise, outer boundary sediments collected in 2002 had significantly lower sand content and higher silt/clay content than sediments from the baseline assessment ($p < 0.001$). In addition, significantly higher levels of silt/clay were observed in 2002 in the inner and outer boundary zones than were observed in the interim assessment in 2000. No significant differences in the percent composition of shell hash ($CaCO_3$) was observed between years ($p > 0.05$).

Organic Matter Content

Organic matter content in 2002 ranged from 0.60 to 11.70%, with a mean of 1.75%. Organic matter content within the disposal area (Appendix 2, Figures 11 and 12) was significantly greater than values in the surrounding monitoring zones during this sampling period ($p < 0.001$), as was expected following a large-scale disposal operation. Mean organic matter values in the disposal area ranged from 0.83 to 11.7%, with a mean value of 3.7%. In the inner boundary areas, the mean organic matter content was 1.37%,

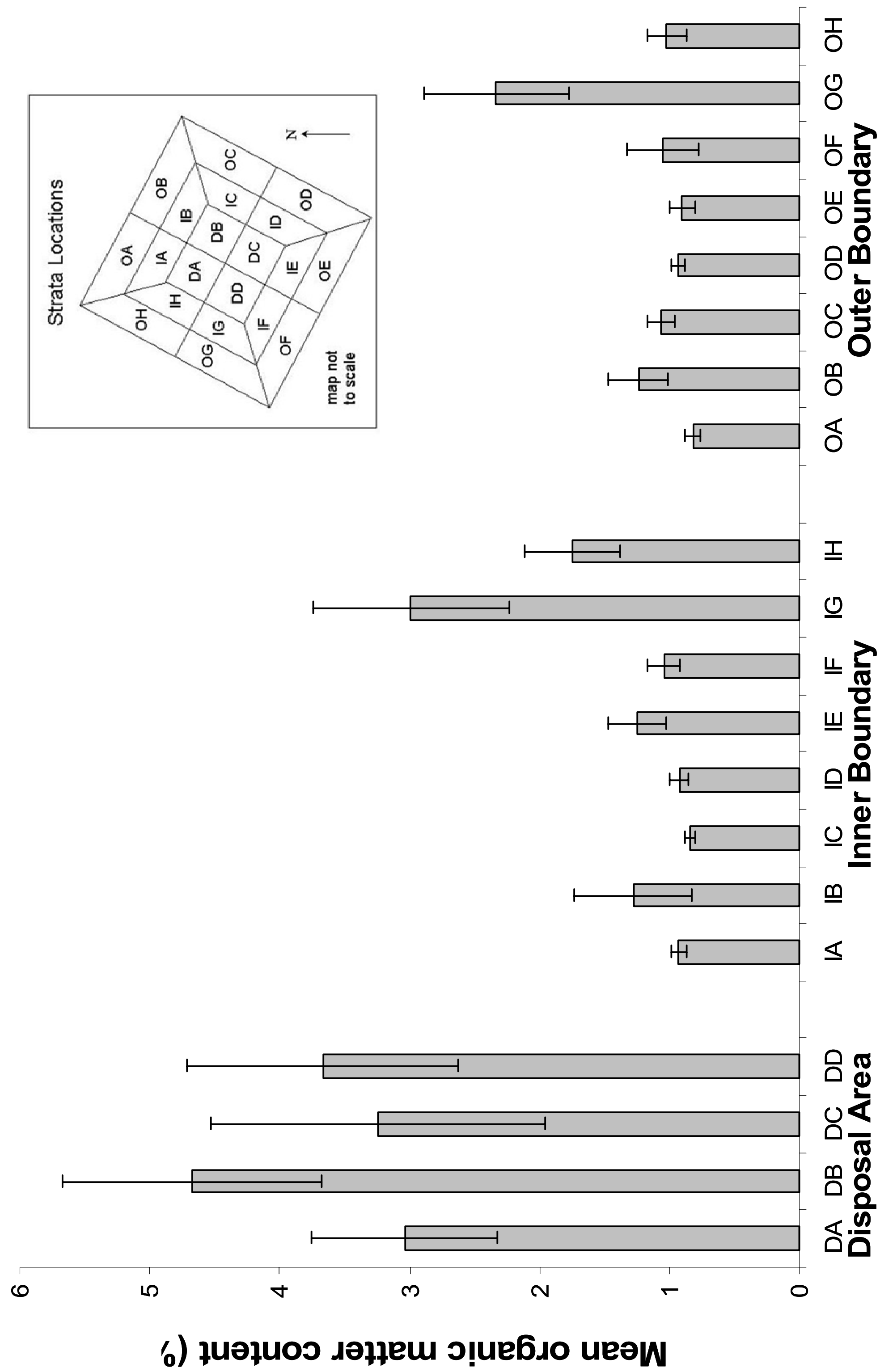

Figure 11. Mean organic matter content in each stratum sampled in 2002. Data are based on the average of ten grab samples per stratum collected in 2002. Error bars represent ± 1 standard error.

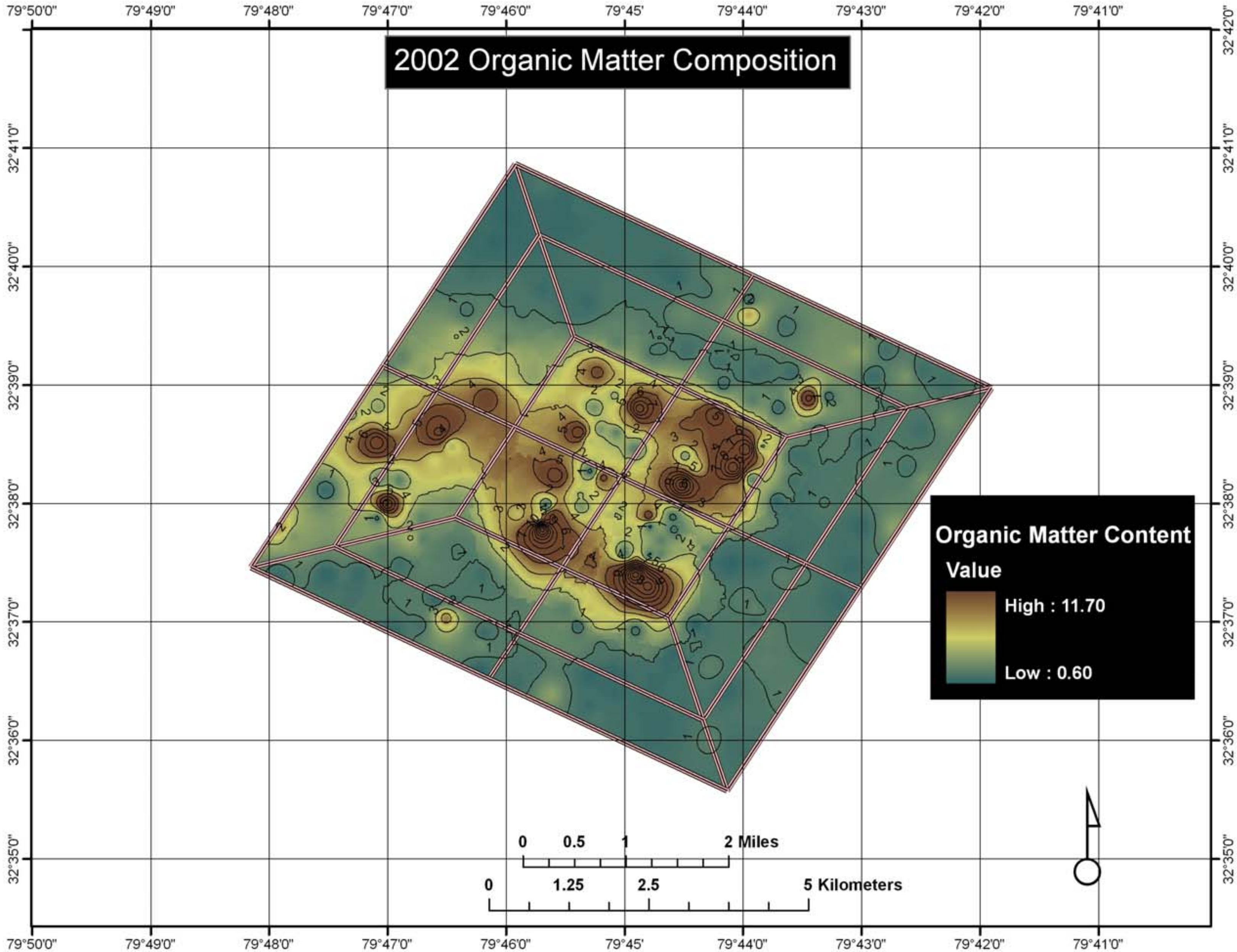

Figure 12. Contour map of the organic matter content in surficial sediments in the disposal zone and surrounding monitoring zones.

and ranged from 0.60 to 7.11%, while the outer boundary areas had a slightly lower mean value of 1.17%, with values ranging from 0.62 to 6.89%.

While several significant differences in organic matter content occurred among strata, in many cases organic matter content within the disposal area was not statistically different than levels in strata located in the adjacent monitoring zones. These findings point to continued effects with respect to organic matter content in the boundary zone as a result of disposal related activities, particularly to the west of the disposal site. Organic matter content in the two strata in the disposal zone (DA and DD) that received fine-grained inner harbor materials almost exclusively, did not have significantly different organic matter content than several strata in the inner and outer boundary zones, including IA, IE, IF, IG, IH, OB, and OG. The disposal of entrance channel materials, typically high in shell hash content and low in organic matter content were concentrated in disposal area strata DB and DC, although these areas still received a limited volume of inner harbor sediments, and exhibited high variability among silt/clay and organic matter content (Appendix 2). Significantly higher organic matter content was found in stratum DB than most other strata, with the exception of several strata located to the west of the disposal area (IG, IH, OG) where values were not statistically different. Levels of organic matter in disposal stratum DC were not significantly different than any other strata, including other disposal area strata.

When trends in organic matter between the baseline assessment, interim assessment, and post-disposal assessment were analyzed, a significant increase in organic matter content is found in 2002 relative to the other sampling periods ($p < 0.001$). A change analysis of organic matter content between 1994 and 2002 shows increases in organic matter content greater than two percent throughout the disposal area and in many of the boundary area strata (Figure 13). This trend was expected within disposal area due to the large amount of inner harbor material placed at the site as part of the Charleston Harbor Deepening project, and organic matter content in 2002 was significantly higher than 1993, 1994, and 2000 samples ($p < 0.001$). However, a similar trend was observed in the inner and outer boundary areas. In the inner boundary area, post-disposal assessment samples had significantly higher organic matter content than 1994 and 2000 samples ($p < 0.05$), and outer boundary samples collected in 2002 had significantly higher organic matter content than 1993 and 2000 samples ($p < 0.001$). These results indicate that disposal material, whether through migration from the disposal site, unauthorized dumps, or trailings from barges, has resulted in increased organic matter content in the monitoring zones surrounding the designated disposal area.

Sand Grain Size

Detailed data on the mean phi size of the sand fraction by station is presented in Appendix 2, and mean values for each stratum in 2002 are shown in Figure 14. The mean phi size of the sand fraction was 2.25 (range = 0.35 to 3.34). There were no significant differences among zones ($p = 0.170$), but differences were found among strata ($p < 0.001$). The mean phi size of the sand fraction in strata IH and OG on the western side of the ODMDS was significantly greater (i.e., the sand grain size was significantly finer) than the phi size in strata OC and ID on the eastern side of the disposal area.

When temporal comparisons of the mean phi size of the sand fraction were completed, significant differences between zones were observed ($p = 0.048$), with the disposal zone having a significantly larger phi size (i.e., finer grain size) than the outer

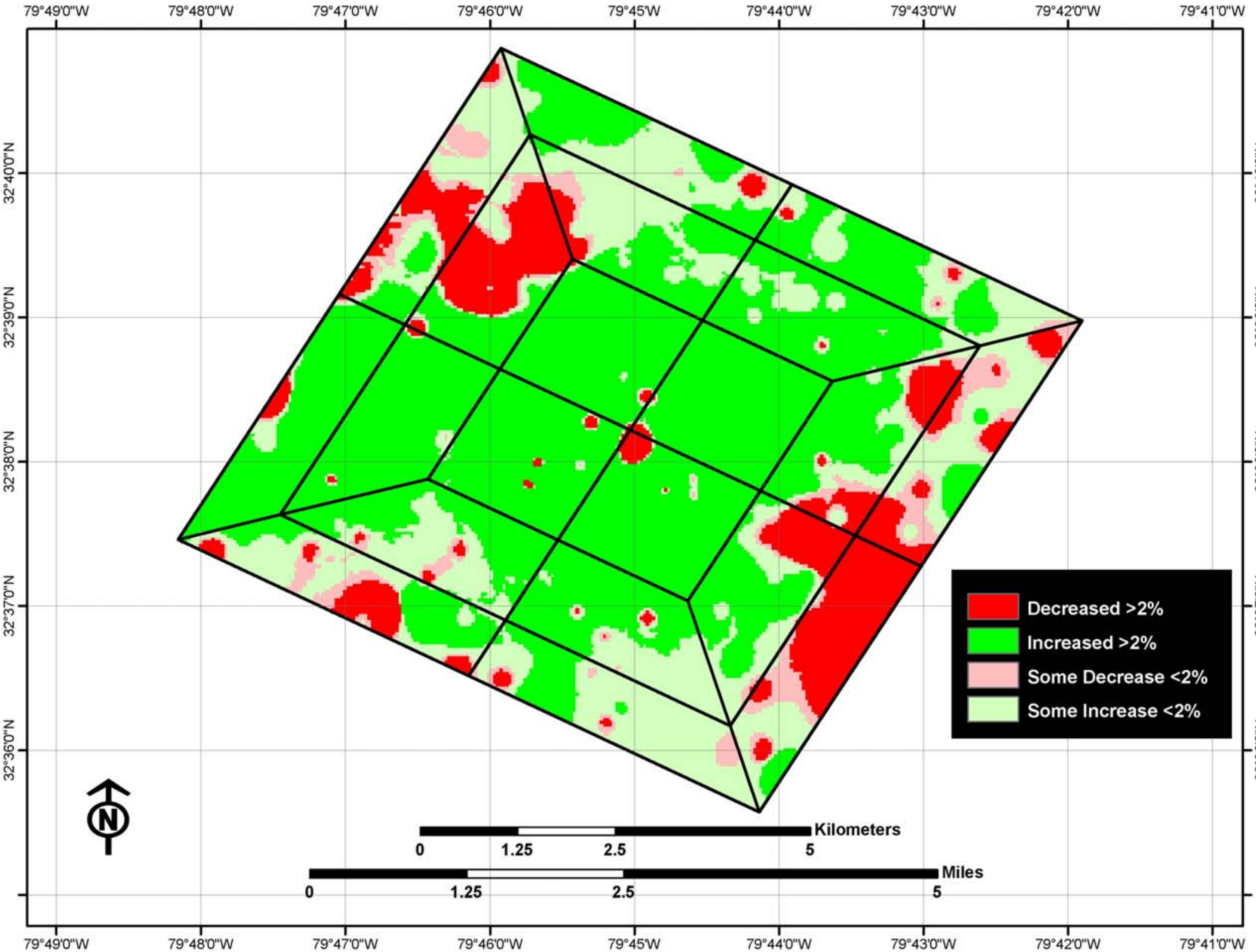

Figure 13. Change analysis of organic matter content in surficial sediments between 1994 and 2002 assessments. Dark green indicates in increase of greater than 2% organic matter, light green indicates an increase of less than 2%, dark red indicates a decrease of greater than 2%, and pink indicates a decrease of less than 2%.

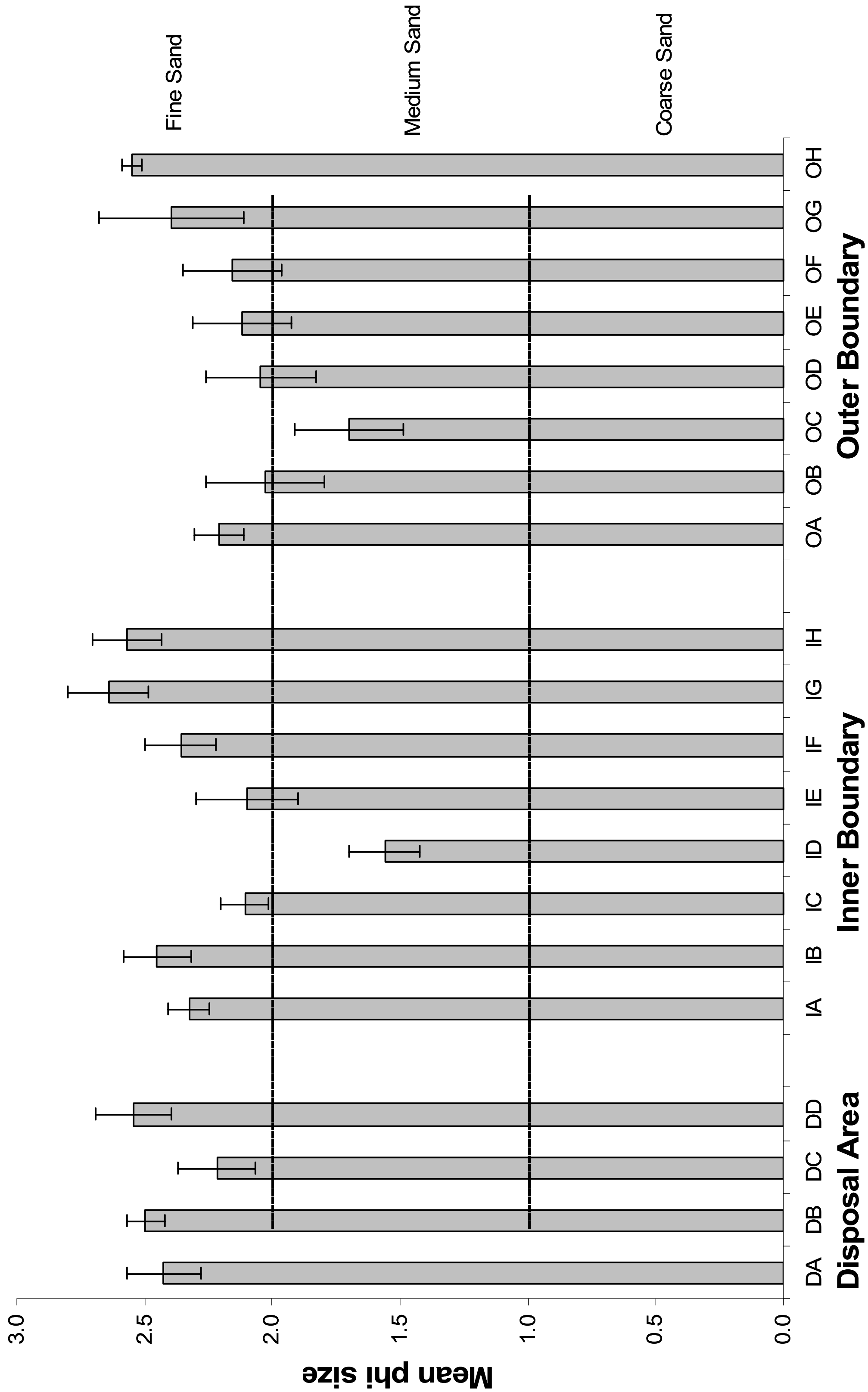

Figure 14. Mean grain size of sand for each stratum. Data are based on the average of ten grab samples per stratum collected in 2002. Error bars represent ± 1 standard error.

boundary zone. However, no significant differences were observed between years, and no significant year/zone interactions were observed (Figure 14).

Sediment Contaminants

The concentrations of various trace metals detected in the 2002 samples in the disposal zone and surrounding areas are summarized in Table 6. Trace metal concentrations were generally low throughout the study area, with values below published bioeffects guidelines (Long and Morgan 1990, Long *et al.* 1995). The only exception was cadmium, which had levels in one stratum within the disposal area (DB) that exceeded bioeffects guidelines. For most metals, the highest levels were found in the disposal area, with the exception of cobalt and iron, which were higher in strata IH and OG, respectively. The presence of higher levels of trace metals in the disposal area than surrounding boundary areas follows the general trend observed in 2000 (Zimmerman *et al*. 2002). Silt/clay content in 2000 and 2002 was higher in the disposal area than surrounding boundary zones, and contaminants often bind to these fine-grained sediments (Olsen *et al.* 1982, Luoma 1989, Barrick and Prahl 1987). During the baseline assessment conducted in 1993-1994, the highest number of trace metals detected was found in stratum IH (Van Dolah *et al.* 1997). Muddy sediments from historical disposal activities were detected in this stratum during this period and may explain the elevated trace metal levels.

Concentrations of various polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides that were detected in 2002 samples are presented in Tables 7-9. These contaminants were found in low concentrations throughout the

Table 6. Metal concentrations detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2002. The cadmium value in stratum DB exceeded published ERL levels. Values are expressed as parts per million except for aluminum, calcium, iron, magnesium, and sodium 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	0.18	0.28	0.17	0.26	0.07	0.06	0.04	0.05	0.05	0.06	0.13	0.16	0.04	0.05	0.05	0.04	0.04	0.05	0.15	0.08
Antimony	0.07	0.30	*	0.21	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Arsenic	4.05	5.50	3.80	4.30	2.70	2.90	2.30	2.70	2.80	2.20	3.60	3.10	3.30	2.60	2.20	2.10	1.75	1.60	3.40	2.50
Barium	6.70	11.00	6.60	6.40	3.60	3.00	4.50	4.40	4.50	3.10	6.60	4.60	6.00	5.00	3.60	4.40	4.00	2.60	4.40	3.80
Beryllium	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cadmium	0.53	5.40	0.38	0.49	0.15	*	*	*	*	*	0.36	0.48	*	*	*	*	*	*	0.21	0.32
Calcium	7.95	11.00	8.50	8.80	5.30	5.40	9.30	7.00	6.00	5.00	8.30	4.80	8.00	11.00	6.60	7.50	6.30	4.40	7.00	5.00
Chromium	11.00	40.00	15.00	21.00	6.30	6.40	4.10	0.00	4.90	6.80	11.00	11.00	5.30	*	5.10	5.30	2.30	4.80	8.50	6.90
Cobalt	*	*	1.00	*	*	*	*	*	*	*	*	1.30	1.10	*	*	1.20	*	*	*	*
Copper	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Iron	0.34	0.32	0.30	0.38	0.23	0.21	0.14	0.20	0.20	0.20	0.30	0.35	0.19	0.21	0.18	0.16	0.16	0.17	0.39	0.24
Lead	1.80	1.60	1.40	2.30	1.20	0.94	0.61	0.90	1.00	0.96	1.60	1.80	0.71	0.87	0.88	0.78	0.79	0.82	1.80	1.30
Magnesium	0.26	1.10	0.32	0.38	0.17	0.16	0.14	0.17	0.15	0.17	0.33	0.25	0.12	0.17	0.15	0.15	0.14	0.16	0.31	0.18
Manganese	58.50	64.00	35.00	61.00	50.00	28.00	27.00	30.00	24.00	29.00	52.00	56.00	39.00	27.00	29.00	26.00	23.00	21.00	57.00	54.00
Molybdenum	*	3.40	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Nickel	*	12.00	*	8.50	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Potassium	470	750	520	730	*	*	*	*	*	*	430	460	*	*	*	*	*	*	550	*
Selenium	*	1.40	*	1.00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Silver	*	0.47	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sodium	0.50	0.69	0.50	0.70	0.39	0.39	0.44	0.39	0.38	0.40	0.47	0.46	0.28	0.38	0.42	0.37	0.37	0.52	0.69	0.34
Strontium	400	590	440	400	260	280	490	380	340	250	390	240	400	550	360	440	370	240	350	240
Thallium	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Tin	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Titanium	29.50	63.00	26.00	42.00	15.00	12.00	6.40	9.90	11.00	14.00	24.00	25.00	7.60	10.00	9.30	6.90	8.35	11.00	26.00	16.00
Total Mercury	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Vanadium	6.80	14.00	7.80	13.00	3.90	4.20	2.60	3.20	3.70	3.50	7.20	6.20	4.00	3.50	2.70	2.80	2.45	2.80	7.50	4.20
Yttrium	27.50	68.00	20.00	56.00	8.90	6.10	4.80	4.10	4.30	8.10	14.00	21.00	7.20	3.90	4.60	3.90	3.40	4.20	9.00	12.00
Zinc	12.00	62.00	15.00	20.00	*	*	*	*	*	*	12.00	14.00	*	*	*	*	*	*	10.00	8.40

*Metal was analyzed for but not detected

Table 7. PCBs detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2002. Values are reported as parts per billion. None of the values exceeded published ERL 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-1016 (Aroclor 1016)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB-1221 (Aroclor 1221)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB-1232 (Aroclor 1232)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB-1242 (Aroclor 1242)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB-1248 (Aroclor 1248)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB-1254 (Aroclor 1254)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PCB-1260 (Aroclor 1260)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

*PCB was analyzed for but not detected

Table 8. Organic compounds detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2002. Values are reported as parts per billion. None of the values exceeded published ERL 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
(3-and/or 4-) Methylphenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
(m- and/or p-) Xylene	0.9	*	*	*	0.8	1.9	*	*	1.0	*	1.1	*	1.6	*	*	1.7	0.9	*	*	
1,1,1,2-Tetrachloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,1,1-Trichloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,1,2,2-Tetrachloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,1,2-Trichloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,1-Biphenyl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
1,1-Dichloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,1-Dichloroethene (1,1-Dichloroethylene)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,1-Dichloropropene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2,3-Trichlorobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2,3-Trichloropropane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2,4-Trichlorobenzene_Ext	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
1,2,4-Trichlorobenzene_Vol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2,4-Trimethylbenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2-Dibromo-3-Chloropropane (DBCP)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2-Dibromoethane (EDB)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2-Dichlorobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2-Dichloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,2-Dichloropropane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,3,5-Trimethylbenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,3-Dichlorobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,3-Dichloropropane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1,4-Dichlorobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
2,2-Dichloropropane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
2,3,4,6-Tetrachlorophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4,5-Trichlorophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4,6-Trichlorophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4-Dichlorophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4-Dimethylphenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4-Dinitrophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,4-Dinitrotoluene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2,6-Dinitrotoluene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Chloronaphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Chlorophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Methyl-4,6-Dinitrophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Methylnaphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Methylphenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Nitroaniline	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2-Nitrophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Organic compound	Disposal Area				Inner Zone								Outer Zone							
	DA	DB	DC	DD	IA	IB	IC	ID	IE	IF	IG	IH	OA	OB	OC	OD	OE	OF	OG	OH
3,3'-Dichlorobenzidine	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3-Nitroaniline	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4_Nitroaniline	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4-Bromophenyl Phenyl Ether	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4-Chloro-3-Methylphenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4-Chloroaniline	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4-Chlorophenyl Phenyl Ether	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4-Nitrophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Acenaphthene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Acenaphthylene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Acetone	*	*	*	*	270.0	*	*	*	*	*	51.0	*	*	*	*	*	*	*	*	
Acetophenone	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Anthracene	2.8	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Atrazine	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzaldehyde	6.2	*	*	*	5.0	*	12.0	*	*	*	6.9	7.1	5.2	*	6.1	*	2.5	*	8.5	5.0
Benzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Benzo(a)Anthracene	5.5	*	*	5.9	*	5.0	*	*	*	*	*	8.4	*	*	*	*	*	*	*	*
Benzo(a)Pyrene	5.5	*	*	5.9	*	5.5	*	*	*	*	*	7.9	*	*	*	*	*	*	*	*
Benzo(b)Fluoranthene	5.0	*	*	*	*	*	*	*	*	*	*	5.6	*	*	*	*	*	*	*	*
Benzo(g,h,i)Perylene	3.9	*	*	*	*	*	*	*	*	*	*	5.8	*	*	*	*	*	*	*	*
Benzo(k)Fluoranthene	3.9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Benzyl Butyl Phthalate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	5.1	*
bis (2-Ethylhexyl) Phthalate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
bis(2-Chloroethoxy) Methane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
bis(2-Chloroethyl) Ether	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
bis(2-Chloroisopropyl) Ether	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bromobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Bromochloromethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Bromodichloromethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Bromoform	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Bromomethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Caprolactam	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Carbazole	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Carbon Disulfide	*	9.2	*	*	*	*	*	3.1	*	*	6.9	1.4	*	1.1	*	1.3	*	*	*	
Carbon Tetrachloride	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Chlorobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Chloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Chloroform	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Chloromethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Chrysene	5.0	*	*	5.9	*	*	*	*	*	*	*	6.1	*	*	*	*	*	*	*	*
cis-1,2-Dichloroethene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
cis-1,3-Dichloropropene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cyclohexane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dibenzo (a,h) Anthracene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dibenzofuran	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Organic compound	Disposal Area				Inner Zone								Outer Zone							
	DA	DB	DC	DD	IA	IB	IC	ID	IE	IF	IG	IH	OA	OB	OC	OD	OE	OF	OG	OH
Dibromochloromethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dibromomethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dichlorodifluoromethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Diethyl Phthalate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dimethyl Phthalate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dimethyl Sulfide	15.0		30.0	50.0	20.0		60.0	40.0	30.0	60.0	200.0	100.0		20.0	30.0	40.0	30.0	90.0	50.0	
Di-n-Butylphthalate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Di-n-Octylphthalate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ethyl Benzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0.2	*	*	
Fluoranthene	15.9	*	*	13.0	*	13.0	*	*	*	*	8.7	19.0	*	*	*	*	*	*	*	*
Fluorene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hexachloro-1,3-Butadiene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Hexachlorobutadiene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hexachlorocyclopentadiene(HCCP)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hexachloroethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Indeno(1,2,3-cd)Pyrene	3.2	*	*	*	*	*	*	*	*	*	*	5.3	*	*	*	*	*	*	*	*
Isophorone	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Isopropylbenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Methyl Acetate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Methyl Butyl Ketone	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Methyl Ethyl Ketone	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Methyl Isobutyl Ketone	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Methyl T-Butyl Ether (MTBE)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Methylcyclohexane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Methylene Chloride	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Naphthalene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
n-Butylbenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Nitrobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
n-Nitrosodi-n-Propylamine	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
n-Nitrosodiphenylamine/Diphenylamine	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
n-Propylbenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
o-Chlorotoluene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
o-Xylene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
p-Chlorotoluene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Pentachlorophenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Phenanthrene	5.0	*	*	*	*	6.7	*	*	*	*	*	10.0	*	*	*	*	*	*	*	*
Phenol	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
p-Isopropyltoluene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Pyrene	14.8	*	*	10.0	*	10.0	*	*	*	*	6.7	15.0	*	*	*	*	*	*	6.9	*
sec-Butylbenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Styrene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
tert-Butylbenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Tetrachloroethene(Tetrachloroethylene)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Toluene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
trans-1,2-Dichloroethene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
trans-1,3-Dichloropropene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Trichloroethene(Trichloroethylene)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Trichlorofluoromethane	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Vinyl Chloride	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	

*PAH was analyzed but not detected

Table 9. Pesticide concentrations detected in sediment samples collected from the Charleston ODMDS and surrounding areas in September 2002. Values are reported as parts per billion. None of the values exceeded published ERL 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**
4,4'-DDD	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4,4'-DDE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4,4'-DDT	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Aldrin	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
alpha-BHC	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
alpha-Chlordane /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
alpha-Chlordene /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
beta-BHC	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
beta-Chlordene /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Chlordene /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
cis-Nonachlor /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
delta-BHC	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dieldrin	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan I	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan II	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulfan Sulfate	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endrin	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endrin Ketone	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
gamma-Chlordane /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
gamma-HCH (g-BHC, lindane)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Heptachlor	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Heptachlor Epoxide	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hexachlorobenzene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Methoxychlor	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Oxychlordane (Octachlorepoxide) /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Toxaphene	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
trans-Nonachlor /2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

*Pesticide was analyzed for but not detected disposal area and surrounding boundary areas, with no values exceeding published bioeffects levels (Long and Morgan 1990, Long *et al.* 1995). The detection limits for the PAHs acenapthene, acenapthylene, and fluorene were greater than ERL values. In addition, the reported detection limits of three pesticides, 4,4-DDD, alpha-chlordane, and dieldrin, were above ERL values. As a result, the ODMDS and surrounding boundary areas were not adequately assessed for these six contaminants, which could potentially be present at levels that could adversely affect biological resources.

Benthic Infaunal Assemblages

Overview—2002 Benthic Data

The benthic assessment for this study included the collection and identification of more than 18,600 organisms representing 448 taxa. A subset of ten strata, five selected from the inner boundary (strata with an "I" prefix, see Figure 2) and five selected from the outer boundary area (strata with an "O" prefix), were analyzed in this component of the study. Following Zimmerman *et al.* (2002), strata IA, IG, IH, OA, OG, and OH (n = 60 grab samples) were classified *a priori* as "impacted" based on findings from previous studies (Noakes 2001, Gayes 2001, Gayes *et al.*2002). Strata IC, ID, OC, and OD (n= 40 grab samples) were classified *a priori* as "non-impacted."

A complete list of all taxa collected in these ten strata is provided in Appendix 3. The dominant 25 taxa collected in 2002 in these ten strata comprised 58% of the total abundance, and are presented in Table 10, in addition to summary statistics for each stratum. The ten numerically dominant taxa collected in 2002 (38% of the total abundance), in order of decreasing abundance, were the annelid Polygordiidae, the

Table 10. The twenty-five numerically dominant taxa collected from selected strata in the inner and outer boundary zones surrounding the Charleston ODMDS in 2002. Values in body of the table are mean number of organisms per m^2. P = polychaete, A = amphipod, M = mollusk, and O = other taxa.

			Non-impacted strata				Impacted Strata					
			Inner		*Outer*		*Inner*			*Outer*		
Species Name	Taxon	Sum	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Polygordiidae	O	4785	178	658	503	393	605	415	695	258	348	735
Crassinella martinicensis	M	2180	470	198	458	140	315	53	53	455	3	38
Prionospio cristata	P	2078	0	538	348	195	68	188	123	88	455	78
Rhepoxynius epistomus	A	2005	133	160	150	333	215	80	433	138	90	275
Nemertea	O	1560	85	123	158	133	73	303	118	38	463	70
Parvilucina multilineata	M	1260	53	178	5	350	65	210	168	0	93	140
Crassinella lunulata	M	1233	170	385	40	78	35	100	43	38	343	3
Eudevenopus honduranus	A	1030	85	178	78	240	60	65	145	23	55	103
Branchiostoma sp.	O	913	203	133	258	73	95	13	8	105	3	25
Caecum pulchellum	M	865	3	140	130	563	0	8	13	0	5	5
Microspio pigmentata	P	825	3	8	775	0	0	0	0	40	0	0
Prionospio dayi	P	788	20	20	18	120	128	83	158	5	68	170
Tellinidae	M	758	5	105	0	258	0	53	95	0	65	178
Strigilla mirabilis	M	720	93	13	13	45	120	55	83	85	5	210
Cylichnella bidentata	M	663	0	0	0	10	0	378	30	0	233	13
Prionospio sp.	P	663	3	203	0	53	5	115	38	8	235	5
Sipuncula	O	628	8	65	233	70	0	33	13	8	200	0
Mediomastus sp.	P	590	0	18	0	3	3	188	43	15	323	0
Oligochaeta	O	568	30	88	195	95	8	8	15	0	105	25
Myriochele oculata	P	560	0	88	8	25	0	220	28	0	190	3
Tellina agilis	M	553	90	13	43	0	85	15	53	248	8	0
Bhawania heteroseta	P	540	10	48	28	10	3	20	0	0	423	0
Pelecypoda	M	523	38	60	30	45	3	18	70	30	40	190
Aspidosiphon gosnoldi	O	485	0	155	0	70	0	30	8	0	215	8
Magelona sp.	P	450	3	28	0	10	13	125	23	0	243	8
Percent of total abundance			52	51	53	56	66	69	69	65	56	69
Mean density per strata (#/m^2)			3208	7108	6578	5918	2878	4028	3568	2418	7568	3323
Mean number of species (#/0.04m^2)			28	60	44	51	25	34	34	22	50	30
Mean H' - Diversity			3.86	4.78	4.30	4.64	3.68	4.02	4.08	3.63	4.40	3.93
Mean J' - Evenness			0.80	0.82	0.79	0.83	0.80	0.80	0.80	0.82	0.79	0.80
Mean Species Richness			5.68	10.55	7.82	9.24	5.09	6.76	6.80	4.69	8.85	6.05

bivalve *Crassinella martinicensis*, the polychaete *Prionospio cristata*, the amphipod *Rhepoxynius epistomus*, ribbon worms in the phylum Nemertea, the bivalve *Parvilucina multilineata*, the bivalve *C. lunulata*, the amphipod *Eudevenopus honduranus*, the cephalochordate *Branchiostoma* sp., and the gastropod *Caecum pulchellum*. Mean density per strata ranged from 2,418 to 7,568 individuals per m^2, with an average of 4,659 individuals per m^2. The mean number of species per grab ranged from 22 to 60, with a mean value of 38 species per grab. Diversity (H') ranged from 3.63 to 4.78 per strata, with a mean value of 4.13.

The general taxonomic structure of the benthic assemblage collected in 2002 was dominated by polychaetes, which comprised 35% of the total number of individuals collected. Dominant polychaetes included *Prionospio cristata*, *Microspio pigmentata*, *P. dayi*, *Prionospio* sp., *Mediomastus* sp., *Myriochele oculata*, *Bhawania heteroseta*, and *Magelona* sp. Amphipods composed approximately 14% of the total abundance, with mollusks and other taxa contributing 26% and 25% of the total number of individuals collected, respectively.

Spatial Patterns in Benthic Community Structure—2002 Assessment

Based on spatial comparisons of 2002 data, patterns in the benthic community structure suggest that disposal related effects are still present and detectable in the boundary areas surrounding the Charleston ODMDS. Comparisons between non-impacted strata (IC, ID, OC, and OD) and impacted strata (IA, IG, IH, OA, OG, and OH) found significantly greater abundance, diversity, abundance of mollusks, abundance of amphipods, and numbers of species of polychaetes, amphipods, mollusks, and other taxa in non-impacted strata than impacted strata ($p < 0.05$). Greater abundances of mollusks and organisms falling in the "other taxa" category were also found in non-impacted than impacted strata, although these differences were not significantly different ($p > 0.05$). The only exception to this trend was the mean number of species per grab, which was significantly higher in impacted strata than non-impacted strata ($p < 0.001$). When differences among individual strata are analyzed, the trend in species numbers appears to be driven by strata IA and OA, which consistently had significantly higher species counts than non-impacted strata. These spatial analyses indicate that the response of the benthic community to increased silt/clay content in impacted strata appears to be reductions in overall abundance, declining diversity, and reductions in abundance and species counts of most general taxonomic groups.

A cluster analysis of the 2002 benthic community data was completed to evaluate relative similarity on a spatial scale based on differences in abundance and composition (Figure 15). The benthic community structure found in strata IA, IC, and OA were most similar to one another, and weakly similar to the abundance and composition of the benthos in strata IH and OH. With the exception of stratum IC, these strata were designated as impacted, and the clustering pattern suggests that some of the similarity in benthic community structure may be linked to disposal related activities. A second cluster was formed by strata ID, OD, and OC (non-impacted strata), which also displayed a weak similarity in benthic community abundance and composition with strata IG and OG (impacted strata). The similarity in faunal assemblages between these non-impacted and impacted strata could indicate (1) recovery of benthic communities in strata IG and OG since the completion of the interim assessment in 2000 when cluster analyses grouped these strata as most similar to impacted strata IH and OH, although sediment

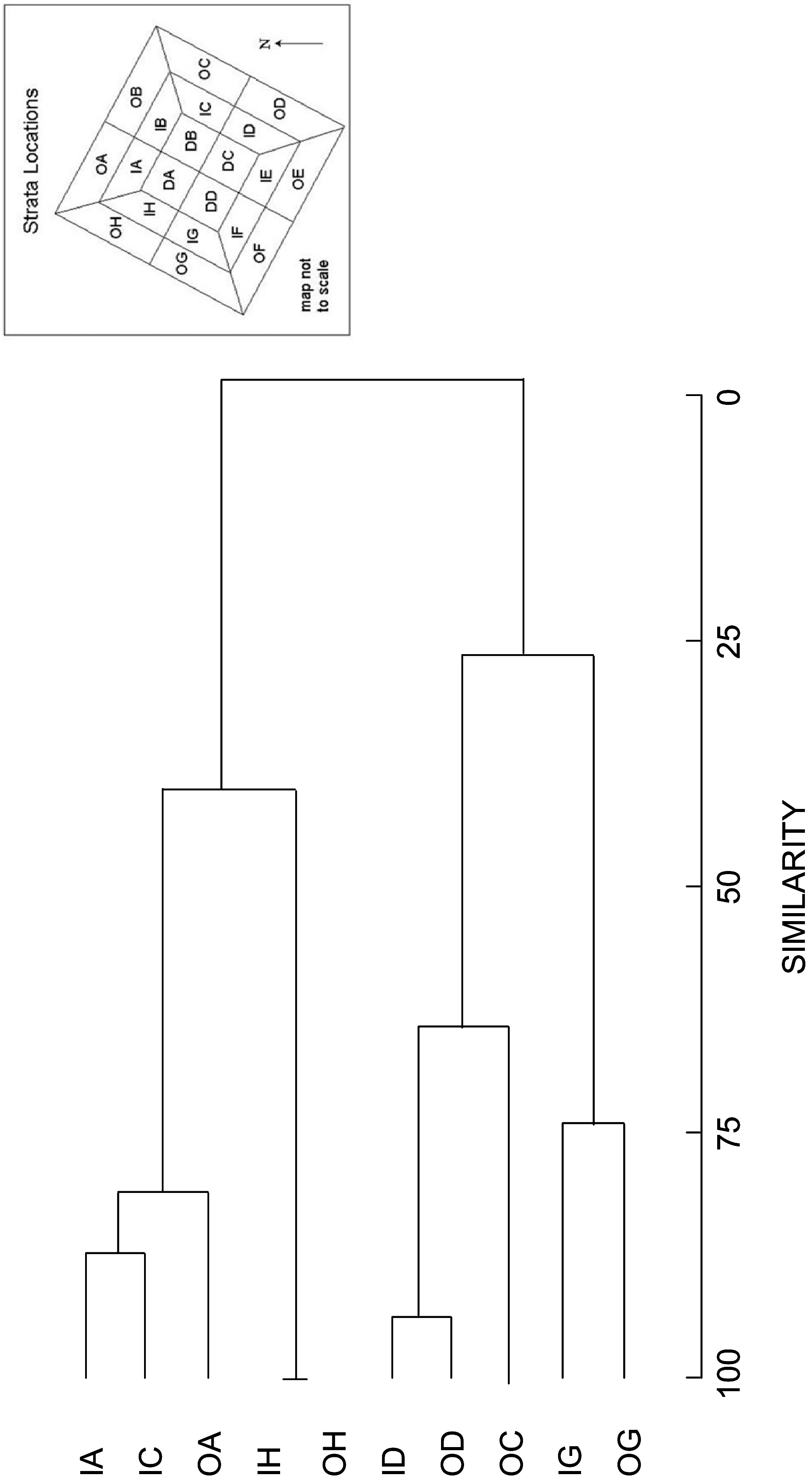

Figure 15. Results of normal cluster analyses using Sorensen/Bray Curtis proportional similarity coefficient with a flexible group linkage method.

characteristics have not recovered (see above; Noakes 2003, Gayes *et al.* 2002), or (2) potential impacts to the benthic community structure in the eastern boundary areas related to disposal activities.

The ten numerically dominant taxa in the non-impacted strata (IC, ID, OC, OD), in order of decreasing abundance, were: Polygordiidae, *Crassinella martinicensis*, *Prionospio cristata*, *Caecum pulchellum*, *Microspio pigmentata*, *Rhepoxynius epistomus*, *Crassinella lunulata*, *Branchiostoma* sp., *Parvilucina multilineata*, and *Eudevenopus honduranus*. These taxa composed 39% of the total abundance in the non-impacted strata. The ten dominant taxa in the impacted strata (IA, IG, IH, OA, OG, OH), in order of decreasing abundance were: Polygordiidae, *R. epistomus*, Nemertea, *P. cristata*, *Crassinella martinicensis*, *P. multilineata*, *Cylichnella bidentata*, *Prionospio dayi*, *Mediomastus* sp., and *Crassinella lunulata*. These taxa composed 43% of the overall abundance in impacted strata.

Of the taxa that were numerically dominant in non-impacted and impacted strata, six were common between the two strata groups. However, several of the dominant taxa were more abundant in one or the other of the two strata groups. Therefore, the ten most dominant taxa collected in 2002 were analyzed to determine if significant differences in abundance were found between impacted and non-impacted strata (see Table 10). Five of these species, including three mollusks (*Crassinella lunulata*, *C. martinicensis*, and *Caecum pulchellum*), the amphipod *Eudevenopus honduranus*, and the cepahlochordate *Branchiostoma* sp. were found in significantly fewer numbers in impacted strata than non-impacted strata ($p < 0.05$). Significantly greater abundances of the bivalve mollusk *Parvilucina multilineata* were found in impacted strata than non-impacted strata (p <

0.05). No significant difference in the abundance of the remaining taxa were found between impacted and non-impacted strata ($p > 0.05$).

The increased amounts of fine-grained materials found in the impacted strata as a result of this large-scale disposal operation could lead to physiological problems in suspension-feeding bivalves such as *Crassinella*. These organisms can suffer disorders caused by the abrasive action of silts and clays, the exposure to toxicants absorbed to fine materials (Blake *et al*. 1996), or clogging of the gills (Dauer *et al.* 1981). As part of the interim assessment of the Charleston ODMDS completed in 2000, significantly lower abundances of *C. martinicensis* were found than when compared to baseline values (Zimmerman *et al.* 2002). This bivalve is commonly found in sandy or shelly habitats (Harry 1966), and the increased amount of fine-grained disposal materials in the impacted boundary strata may have led to the reduced numbers observed. Variable responses of *Crassinella* to habitat disturbance have been reported. Following two beach nourishment projects in Myrtle Beach (Jutte *et al.* 2001b, c), no significant changes in the abundance of *C. martinicensis* or *C. lunulata* were observed following dredging. However, the physical effects of dredging are not directly comparable to the disposal of large amounts of fine-grained materials; in one of the studies, sediment composition remained sandy throughout the study period (Jutte *et al.* 2001c), which would likely lead to less physiological stress in mollusks. The gastropod *C. pulchellum*, while a detritivore rather than a suspension feeder, prefers sandy habitats (Rehder 1996, Ruppert and Fox 1988) and may be behaviorally or physiologically not well suited for the increased silt/clay content in the impacted areas.

A similar trend of lower densities in impacted areas was observed for *E. honduranus* as part of the interim assessment conducted approximately midway through the harbor deepening project (Zimmerman *et al.* 2002). This platyischnopid amphipod is described as a sand-dweller, with reported burrowing depths to approximately 3 cm (Thomas and Barnard 1983, Cary 1996). Declines in abundance of *E. honduranus* following physical disturbances such as dredging activities that alter sediment composition have also been documented as part of the Myrtle Beach renourishment project (Jutte *et al*. 2001b, c). The reduction in numbers observed in impacted strata as part of the current study is likely a physiological or behavioral response to changes in sediment characteristics caused by disposal operations.

The bivalve mollusk *Parvilucina multilineata* was also a dominant species found as part of the interim assessment conducted at the Charleston ODMDS in 2000. However, significant alterations in the overall abundance of this species were not observed in response to disposal related activities (Zimmerman *et al*. 2002). *P. multilineata* also displayed no significant alterations in abundance following dredging activities associated with the third phase of the Myrtle Beach renourishment project (Jutte *et al*. 2001c). Short-term declines were observed following the second phase of the Myrtle Beach renourishment project (Jutte *et al.* 2001b), and sharp declines in abundance were found after dredging activities associated with a beach nourishment project in Tampa Bay (Blake *et al.*1996). The higher abundances of *P. multilineata* in impacted strata than non-impacted strata in the current study may be explained by the sediment preference of this species. *P. multilineata* are commonly found in muddy or silty sands, (Rehder 1996, Ruppert and Fox 1988), which may make *P. multilineata* better adapted for the higher silt/clay conditions found in impacted strata than many other bivalve species.

Temporal Changes in Benthic Community Structure

Changes in benthic community structure over time were analyzed to assess the impacts resulting from the large-scale disposal activities that occurred during the Charleston Harbor Deepening project. Data analyzed from 1993 and 1994 were limited to a subset of reference stations (see Methods section) that best typified natural baseline conditions and eliminated from analysis the samples that may have been influenced by historical disposal activities. In addition, as with the spatial analyses of 2002 data described in the previous section, data from 2002 in the boundary zones surrounding the ODMDS were classified *a priori* as impacted or non-impacted based on findings from previous studies (Noakes 2001, Gayes 2001, Gayes *et al.*2002).

Analyses of the four years of benthic community data revealed significant effects related to disposal activities. A general trend over time of decreased benthic abundance and reduced species numbers and diversity was observed in the impacted boundary zones, while in the boundary zones classified as non-impacted, many metrics were not significantly different from baseline assessments, or did not exhibit a consistent trend across strata.

Mean abundance was significantly lower in 2002 than 1993 and/or 1994 in three of the six impacted strata (IA, OA, and OH), while values were significantly higher in three of the four non-impacted strata (ID, OC, and OD) and significantly lower in strata IC (Figure 16). The mean number of species per grab (Figure 17) was significantly lower in 2002 than 1993 and/or 1994 in five of the six impacted strata (IA, IG, IH, OA, and

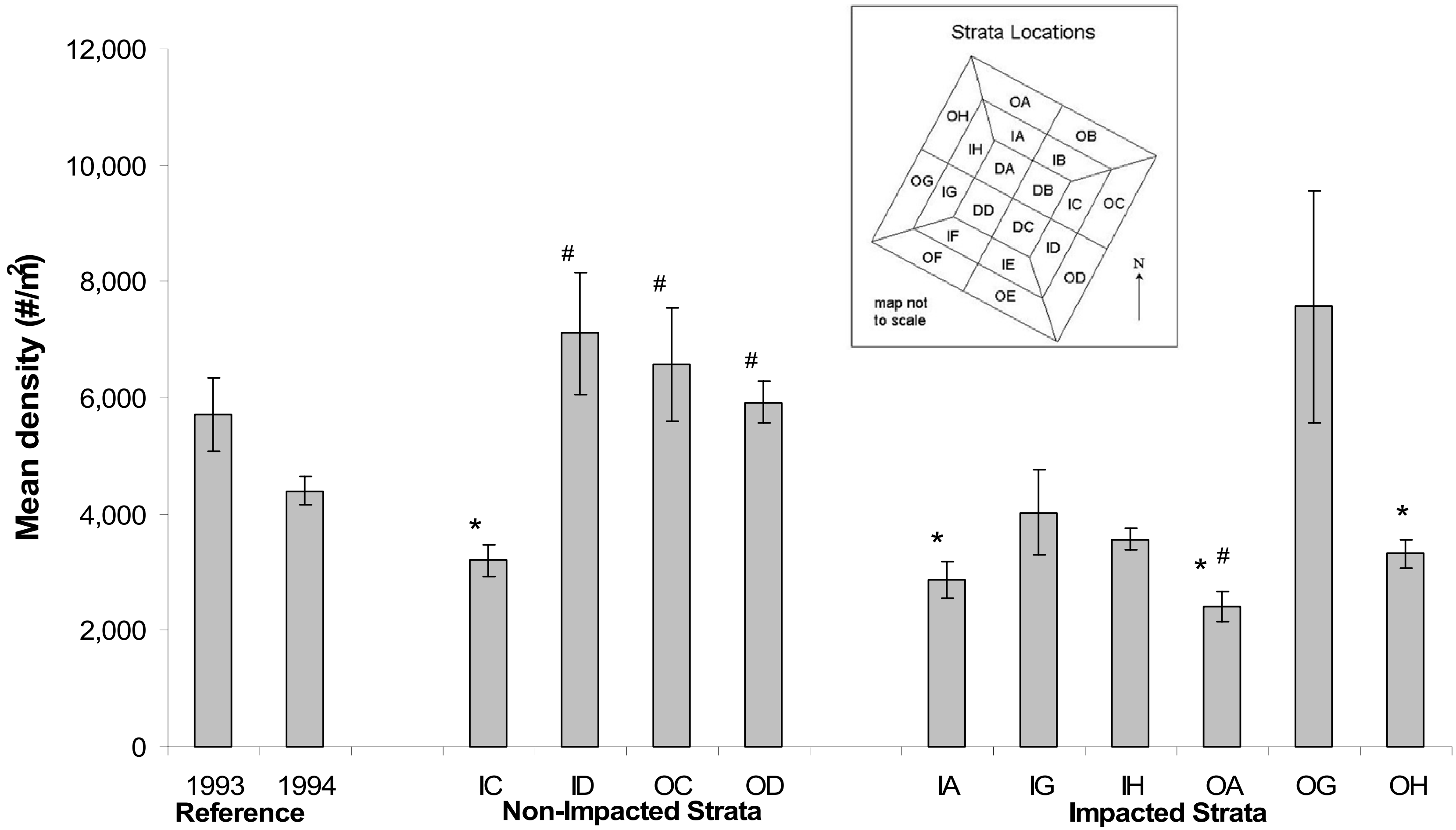

Figure 16. Mean density at 1993/1994 reference stations and strata from 2002. Error bars represent ±1 standard error. An asterisk (*) represents strata in which 2002 were significantly different than 1993, and a pound sign (#) represents strata in which 2002 were significantly different than 1994.

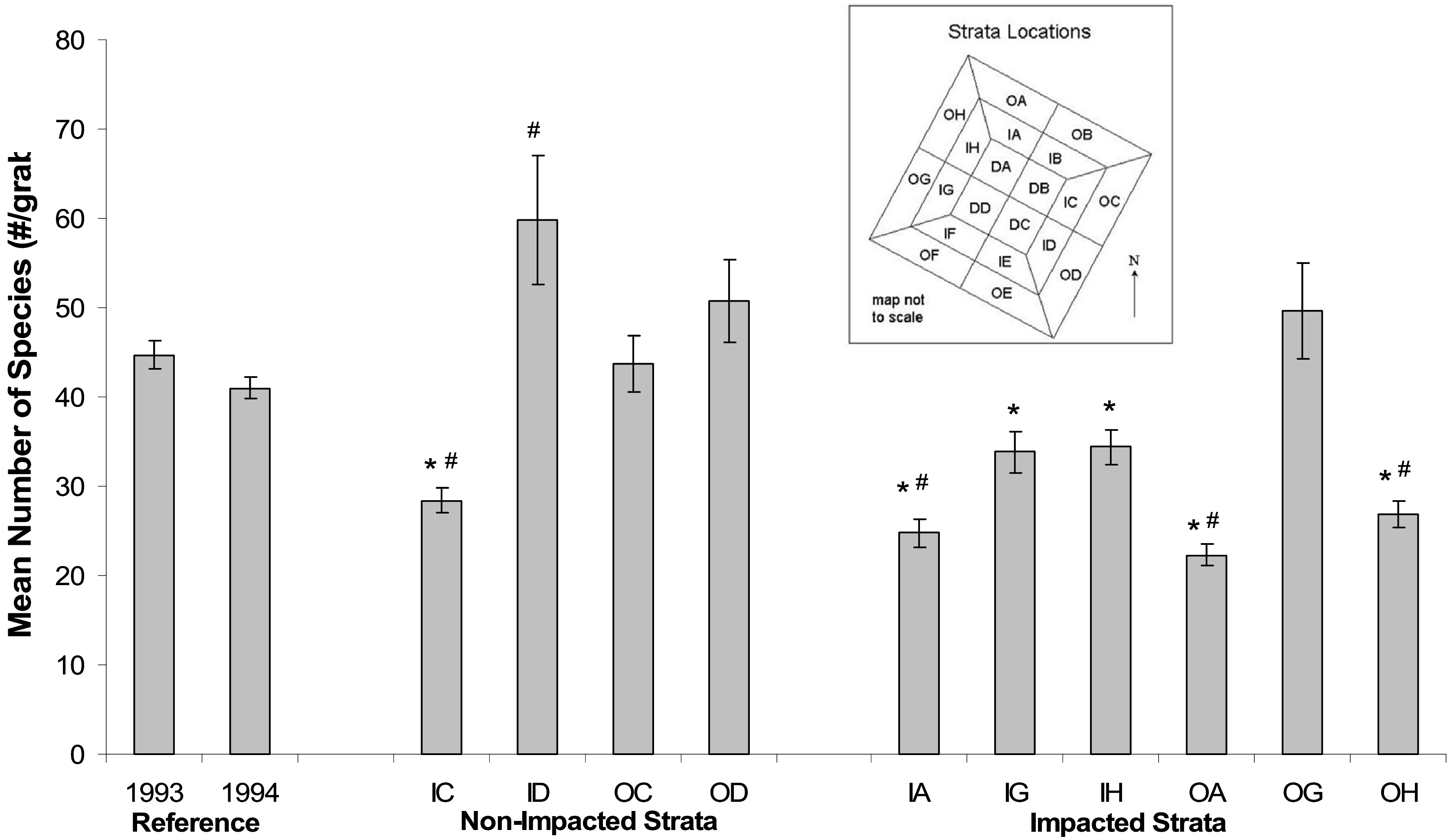

Figure 17. Mean number of species at 1993/1994 reference stations and strata from 2002. Error bars represent +1 standard error. An asterisk (*) represents strata in which 2002 were significantly different than 1993, and a pound sign (#) represents strata in which 2002 were significantly different than 1994.

OH). No consistent pattern was observed with respect to the mean number of species in non-impacted strata; values were higher in 2002 than 1993 and/or 1994 in one of the four non-impacted strata (ID), significantly lower in one stratum (IC), and not significantly different in strata OC and OD. Diversity (H') was significantly lower in 2002 than 1993 and/or 1994 in three of the six impacted strata (IA, OA, and OH), while values were significantly lower in only one non-impacted strata (IC).

The general taxonomic structure in the impacted boundary zones was altered following disposal operations, but many differences were also observed in the non-impacted zones when compared to baseline data (Figure 18). Therefore, differences in taxonomic structure cannot be attributed directly to disposal related activities. Amphipod abundances were significantly lower in all six of the impacted strata in 2002 than in 1993 and/or 1994, and in two of the four non-impacted strata (IC and OC). Densities of the most abundant overall taxonomic group, polychaetes, were significantly lower in three of the six impacted strata (IA, OA, and OH) and one of the four non-impacted strata (IC) in 2002 than 1993 and/or 1994, and significantly higher in one impacted strata (OG) and two of the four non-impacted strata (ID and OC). Abundances of organisms falling in the "other taxa" category were significantly lower in 2002 than 1993 and/or 1994 in one of the six impacted strata (OA), significantly higher in one of the six impacted strata (OG), and displayed no significant differences from the baseline assessment for the remaining four non-impacted strata (IA, IG, IH, and OH). In non-impacted strata, significantly lower values for organisms in the "other taxa" category were observed in 2002 in one of the four strata (IC) and significantly higher values in strata ID. No significant differences in the abundance of mollusks was observed over time in any of the impacted strata, while

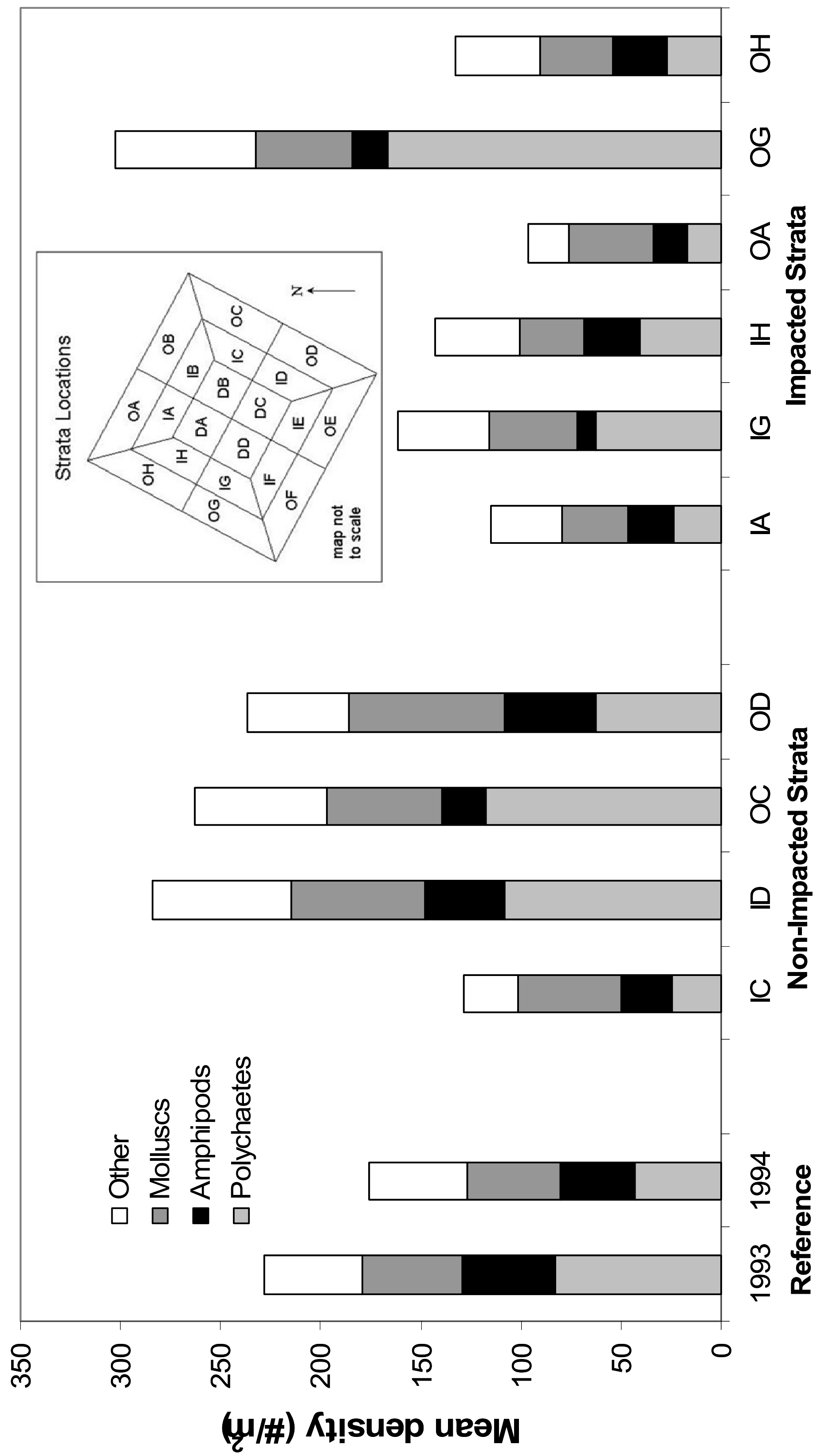

Figure 18. Mean density of general taxonomic groups at 1993/1994 reference stations and strata from 2002.

significantly greater values were seen in 2002 than 1993 in one of the four non-impacted strata (OD).

An overall species list was generated for the 1993, 1994, and 2002 surveys, and included the following ten dominant taxa in order of decreasing abundance: annelids in the family Polygordiidae, the polychaete *Prionospio cristata*, the amphipod *Rhepoxynius epistomus*, the bivalve *Parvilucina multilineata*, the cephalochordate *Branchiostoma* sp., the bivalves *Crassinella martinicensis* and *Tellina probrina*, the amphipod *Bathyporeia parkeri*, ribbon worms in the phylum Nemertea, and the gastropod *Caecum pulchellum*. To examine potential effects of disposal activities on numerically dominant taxa, ANOVAs were performed on the five most dominant species to compare 2002 abundances to reference samples collected in 1993 and 1994.

The abundances of *Branchiostoma* sp. and *P. cristata* appeared to be significantly altered by changes related to disposal activities (Figures 19 and 20). No significant differences in the abundances of Polygordiid annelids were found between years in any of the strata ($p > 0.05$), and although changes in the abundances of *R. epistomus* and *P. multilineata* were seen across years, these changes were observed in both impacted and non-impacted strata, and do not appear to be directly related to disposal operations, but likely natural population fluctuations. Abundances of *Branchiostoma* sp. were lower in 2002 than 1993 and/or 1994 in all six of the impacted strata, while only one of the four non-impacted strata (OD) had significantly lower abundances than baseline values (Figure 19). *Branchiostoma* sp. are uncommon in muddy sediments (Cory and Pierce 1967, Boschung and Gunter 1962), and their low numbers in impacted strata are likely a physiological or behavioral response to changes in sediment characteristics. Four of the

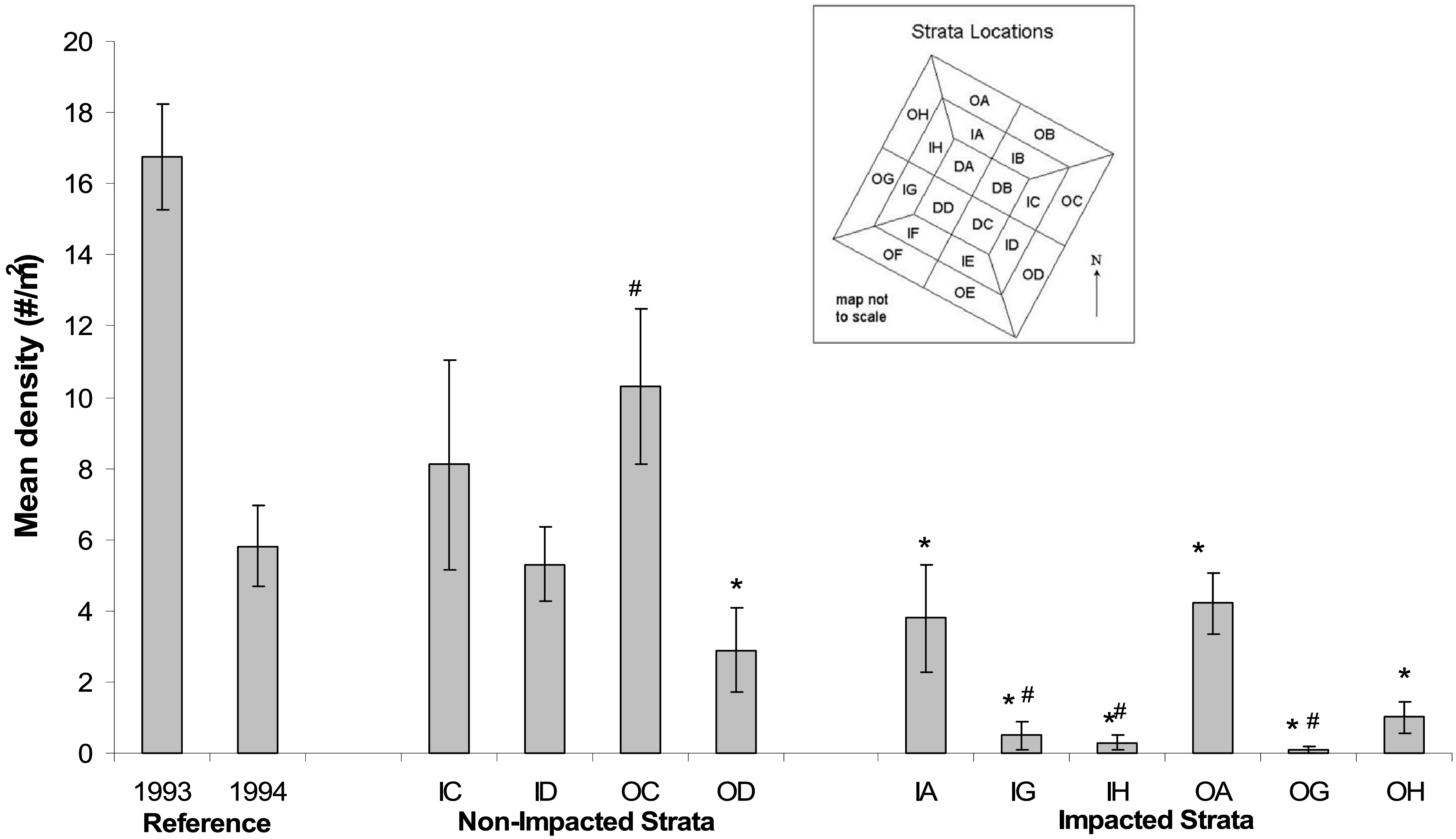

Figure 19. Mean density of Branchiostoma sp. at 1993/1994 reference stations and strata from 2002. Error bars represent +1 standard error. An asterisk (*) represents strata in which 2002 were significantly different than 1993, and a pound sign (#) represents strata in which 2002 were significantly different than 1994.

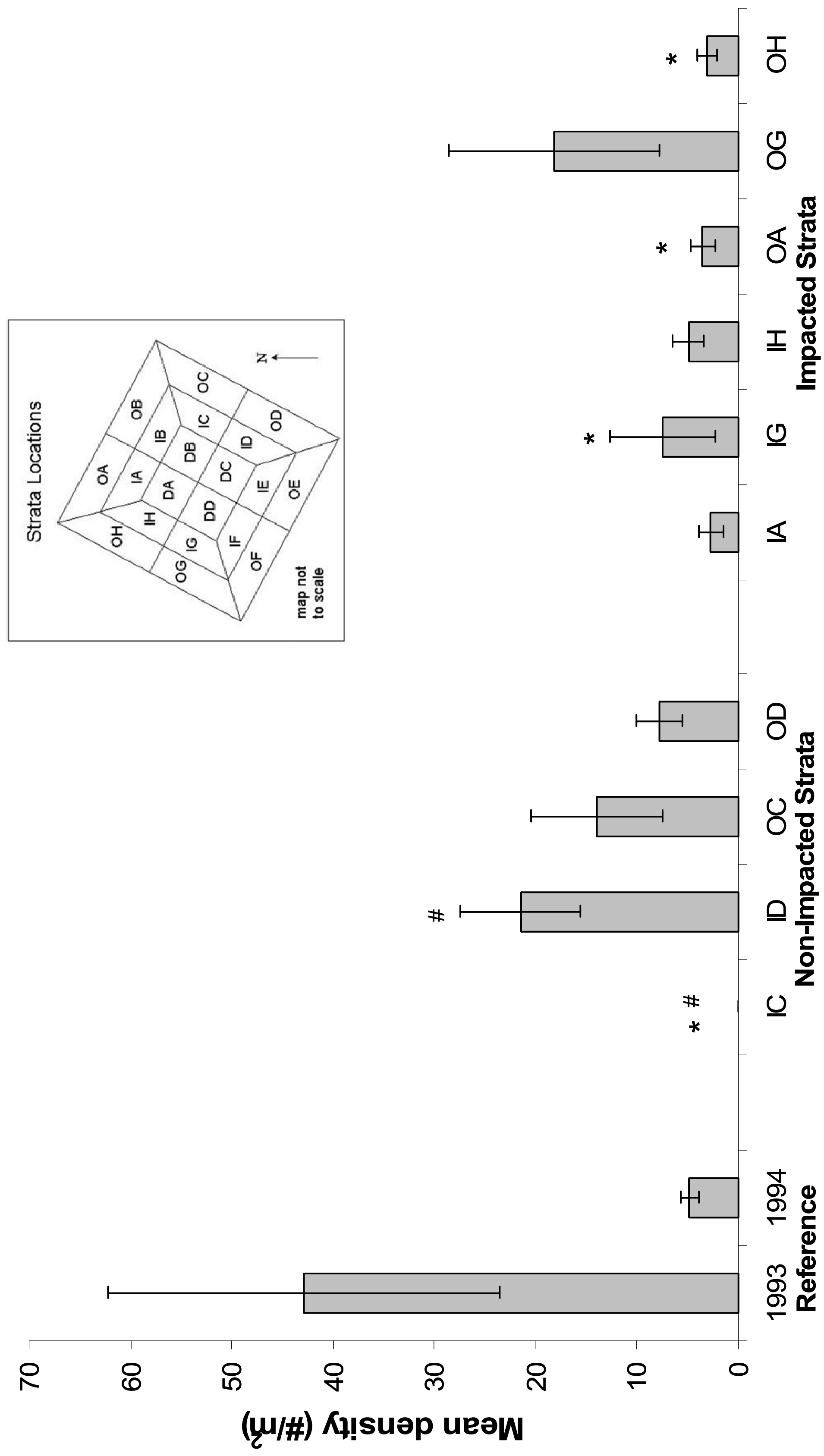

Figure 20. Mean density of Prionospio cristata at 1993/1994 reference stations and strata from 2002. Error bars represent +1 standard error. An asterisk (*) represents strata in which 2002 were significantly different than 1993, and a pound sign (#) represents strata in which 2002 were significantly different than 1994.

six impacted strata had reduced abundances of *P. cristata* when compared to 1993 data, while only one of the four non-impacted strata (IC) had significantly lower abundances of this polychaete (Figure 20). Reduced abundances of *P. cristata* were not observed during the interim assessment of the Charleston ODMDS conducted in 2000, although this species was one of the numerically dominant species sampled (Zimmerman *et al.* 2002). *P. cristata* prefers silty sand, and uses grooved peristomal palps to selectively extract food from the sediment surface (Uebelacker and Johnson 1984).

The ecological implications related to the significant changes in community composition, the abundance of several dominant taxa, the number of species, and the overall density of organisms cannot be readily identified, but it is likely that these changes could have an adverse effect on the finfish and crustacean species that consume these organisms. Many of the dominant taxa assessed in this study are known food items for several fish and crustacean species.

CONCLUSIONS AND RECOMMENDATION

Disposal operations associated with the Charleston Harbor Deepening Project resulted in the placement of fine-grained inner harbor material and entrance channel material high in shell hash in the Charleston ODMDS. A baseline assessment of the Charleston ODMDS and surrounding monitoring zones in 1993-1994, an interim assessment in 2000, and the current post-disposal assessment have documented physical and biological effects in the monitoring zones surrounding the disposal area. The current report summarizes physical and biological conditions upon the completion of dumping activities related to the Charleston Harbor Deepening Project. Our findings document a strong pattern of continued impacts in the surrounding boundary areas with respect to levels of silt/clay and organic matter, and the condition of benthic communities.

Based on these findings, SCDNR recommends the completion of a five year post-assessment of the Charleston ODMDS and surrounding areas using sampling strategies similar to those used for the baseline, interim, and post-disposal surveys. Such an assessment was previously approved by the interagency Task Force during the development of an updated Site Management and Monitoring Plan for the Charleston ODMDS. Monitoring activities at ocean disposal areas should not cease upon the completion of large-scale disposal operations. In the case of the Charleston ODMDS, it is critical to continue these efforts to understand the duration and fate of disposed sediments and document long-term trends, particularly in light of ongoing disposal operations, future disposal operations, and possible site expansion requests. Further discussion among Task Force members is warranted to determine possible mechanisms for reducing costs of a three or five year post-assessment.

SUMMARY

- The 1999-2002 Charleston Harbor Deepening Project produced approximately 20-25 million cubic yards of inner harbor and entrance channel materials that were placed in the Charleston Ocean Dredged Material Disposal Site (ODMDS).
- A baseline assessment of the Charleston ODMDS was completed in 1993-1994, and an interim assessment was completed in 2000 approximately midway through the deepening project.
- The current report presents findings from the post-disposal assessment of physical and biological conditions in the disposal zone and surrounding monitoring zones upon completion of the 1999-2002 Charleston Harbor Deepening Project. These results build on an ongoing, long-term monitoring program with several collaborating partners coordinated by the South Carolina Department of Natural Resources (SCDNR). Detailed findings from the other portions of the monitoring program are reported elsewhere.
- As expected following a disposal operation on the scale of the Charleston Harbor Deepening project, higher silt/clay and shell hash content were observed in the disposal zone than inner or outer boundary zones, which corresponds to the placement of fine-grained inner harbor material and entrance channel materials high in $CaCO_3$ content.
- However, the analysis of sediments on the strata level found that most boundary area strata were not significantly different with respect to silt/clay content than strata within the disposal zone. The lack of statistical differences in silt/clay content between many strata in the boundary zone and disposal zone is a clear

indicator of continued impacts from disposal activities on sediment composition in the monitoring zones.

- Temporal comparisons of sediment composition from the 1993-1994 baseline and 2000 interim assessment with the 2002 post-disposal assessment show clear evidence of the disposal activities within the designated disposal area, and also a strong pattern of continued and increased changes in sediment composition in the surrounding monitoring zones related to disposal activities. Silt/clay and shell hash levels in the inner and outer boundary zones were significantly higher than during previous assessments.
- Percentages of silt/clay content in sediments found in strata within the disposal area and strata located in the inner and outer boundary zone were generally not statistically different, indicating that continued effects from disposal activities are occurring in the boundary zones. These effects are the result of previous, and likely ongoing, migration of materials from the disposal zone, in addition to impacts that occurred during the Charleston Harbor Deepening Project related to unauthorized dumping and trailings of dredge materials as barges entered and exited the disposal area.
- Analyses of organic matter content from 2002 samples indicated that levels within the disposal zone were significantly greater than surrounding monitoring zones.
- Temporal comparisons of organic matter content found significantly higher levels in 2002 than the baseline and interim assessments in the disposal zone, inner boundary zone, and outer boundary zone.

- No long-term effects on the mean grain size of the sand fraction were observed within 2002 or between years.
- Trace metal concentrations were generally below published bioeffects guidelines, with the exception of one metal (cadmium) within the disposal area. Concentrations of various polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides detected in 2002 samples were low throughout the disposal area and monitoring zones, with none exceeding published bioeffects guidelines. Five analytes (two PAHs and three pesticides) were found in concentrations that exceeded detection limits.
- More than 18,600 organisms representing 448 taxa were collected and identified from ten strata analyzed in 2002. The dominant 25 taxa comprised 58% of the total abundance, with the majority of the benthic community composed of polychaete worms (35% of the total abundance).
- Spatial comparisons of 2002 benthic community data indicate that disposal related effects are present and detectable in the boundary areas surrounding the Charleston ODMDS. These effects include a consistent response of the benthic community to the increased silt/clay content including reductions in overall abundance, declines in diversity, and reductions in abundance and species counts of most general taxonomic groups.
- Among the ten dominant taxa collected in 2002, five species were found in significantly fewer numbers in the impacted strata than the non-impacted strata, and included two bivalves, a gastropod, an amphipod, and a cephalochordate. One bivalve species was found in significantly greater abundances in impacted strata

than non-impacted strata. The response of these taxa was likely a physiological or behavioral response to changes in sediment composition resulting from disposal operations.

- A cluster analysis of 2002 benthic data evaluated relative similarity on a spatial scale based on differences in abundance and composition. One cluster consisted primarily of impacted strata, suggesting that some of the similarity in benthic community structure may be linked to disposal related activities. A second cluster was composed of both impacted and non-impacted strata, which could indicate recovery in some impacted strata or disposal-related effects in non-impacted strata.
- Analyses of the four years of benthic community data revealed significant effects related to disposal activities. A general trend of decreased benthic abundance and reduced species numbers and diversity was observed in impacted strata to the west and northwest of the disposal zone. In strata classified as non-impacted, many metrics were not significantly different from baseline assessments, or did not exhibit a consistent trend across strata.
- An examination of general taxonomic structure during the baseline assessment, interim assessment, and post-disposal assessment indicated that the impacted boundary zones were altered following disposal operations, but that many differences were also observed in the non-impacted zones with respect to baseline data. Therefore, differences in taxonomic structure cannot be attributed directly to disposal related activities.

- The five numerically dominant taxa across 1993, 1994, and 2002 were analyzed to determine if significant changes in abundance were found over time. Two of these species (the cephalochordate *Branchiostoma* sp. and the polychaete *Prionospio cristata*) were significantly lower in 2002 than during the baseline assessment in most impacted strata. The response of these taxa was likely a physiological or behavioral response to changes in sediment composition resulting from disposal operations. The other three species showed either no significant differences among years or natural population fluctuations that could not be directly attributed to disposal operations.
- Based on these findings, SCDNR recommends the completion of a five year post-assessment of the Charleston ODMDS and surrounding areas using sampling strategies similar to those used for the baseline, interim, and post-disposal surveys. Long-term monitoring is critical to understand the duration and fate of disposed sediments and document long-term trends, particularly in light of ongoing disposal operations, future disposal operations, and possible site expansion requests. Further discussion among Task Force members is warranted to determine possible mechanisms for reducing costs of a three or five year post-assessment.

ACKNOWLEDGEMENTS

Special thanks to the many SCDNR staff who assisted with sample collection and laboratory processing for this project: Marty Levisen, Lynn Zimmerman, Leona Forbes, Lisa McLean, George Riekerk, Steve Burns, Mike Schwarz, and Jeff Jacobs. We also extend our thanks to Mary Ellen Williams and Christine Martinelli for their administrative support.

Thank you to staff at the U.S. Army Corps of Engineers, Charleston District. In particular, we greatly appreciate the efforts of Robin Coller-Socha for her patience and ongoing assistance in dealing with this long-term project. Lincoln Blake and Kevin Widner also provided general assistance throughout the project. The U.S. Army Corps of Engineers funded these monitoring efforts through Cooperative Agreement SAC0007.

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APPENDICES

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston ODMDS in September 2002. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
DA05	4001	23-Sep-02	8.8	32.6518	79.7538
DA17	4002	23-Sep-02	10.7	32.6468	79.7543
DA18	4003	23-Sep-02	12.5	32.6485	79.7514
DA19	4004	23-Sep-02	9.8	32.6467	79.7479
DA22	4005	23-Sep-02	13.1	32.6433	79.7565
DA23	4006	23-Sep-02	11.9	32.6438	79.7534
DA25	4007	23-Sep-02	8.5	32.6450	79.7496
DA26	4008	23-Sep-02	12.5	32.6422	79.7548
DA28	4009	23-Sep-02	11.6	32.6433	79.7512
DA30	4010	23-Sep-02	8.8	32.6411	79.7485
DB11	4011	23-Sep-02	11.9	32.6433	79.7396
DB13	4012	23-Sep-02	9.8	32.6414	79.7306
DB16	4014	24-Sep-02	11.0	32.6400	79.7415
DB19	4013	23-Sep-02	8.2	32.6410	79.7330
DB24	4015	23-Sep-02	11.3	32.6386	79.7400
DB25	4016	23-Sep-02	8.8	32.6384	79.7347
DB28	4017	23-Sep-02	12.5	32.6360	79.7420
DB29	4018	23-Sep-02	8.8	32.6457	79.7373
DB30	4019	23-Sep-02	9.1	32.6351	79.7350
DB31	4020	23-Sep-02	8.5	32.6367	79.7320
DC06	4021	24-Sep-02	10.4	32.6316	79.7466
DC07	4022	24-Sep-02	10.7	32.6314	79.7433
DC11	4023	24-Sep-02	10.7	32.6301	79.7464
DC12	4024	24-Sep-02	11.6	32.6297	79.7431
DC16	4025	24-Sep-02	11.0	32.6264	79.7499
DC17	4026	24-Sep-02	11.6	32.6262	79.7465
DC18	4027	24-Sep-02	12.2	32.6282	79.7450
DC25	4028	24-Sep-02	11.9	32.6263	79.7450
DC29	4029	24-Sep-02	11.9	32.6233	79.7485
DC33	4030	24-Sep-02	11.6	32.6217	79.7467
DD08	4031	24-Sep-02	10.1	32.6379	79.7549
DD11	4032	24-Sep-02	12.2	32.6373	79.7597
DD13	4034	24-Sep-02	10.7	32.6346	79.7563
DD14	4035	24-Sep-02	9.6	32.6370	79.7530
DD18	4036	24-Sep-02	11.0	32.6331	79.7611
DD20	4033	24-Sep-02	9.5	32.6330	79.7562
DD24	4037	24-Sep-02	8.5	32.6318	79.7650
DD25	4038	24-Sep-02	7.3	32.6314	79.7622
DD26	4039	24-Sep-02	11.6	32.6316	79.7602
DD30	4040	24-Sep-02	9.8	32.6297	79.7616
IA01	4041	23-Sep-02	10.8	32.6549	79.7459
IA02	4042	23-Sep-02	9.6	32.6665	79.7578
IA03	4043	23-Sep-02	10.5	32.6671	79.7565
IA06	4044	23-Sep-02	9.6	32.6636	79.7518
IA08	4045	23-Sep-02	10.2	32.6607	79.7568
IA09	4046	23-Sep-02	9.9	32.6617	79.7554
IA17	4047	23-Sep-02	9.8	32.6601	79.7414

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston ODMDS in September 2002. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
IA20	4048	23-Sep-02	10.5	32.6563	79.7511
IA26	4049	23-Sep-02	10.5	32.6550	79.7450
IA27	4050	23-Sep-02	10.8	32.6548	79.7414
IB04	4051	23-Sep-02	11.9	32.6515	79.7334
IB05	4052	23-Sep-02	11.6	32.6535	79.7366
IB07	4053	23-Sep-02	11.3	32.6517	79.7266
IB10	4054	23-Sep-02	11.3	32.6501	79.7361
IB12	4055	23-Sep-02	11.6	32.6516	79.7317
IB13	4056	23-Sep-02	12.2	32.6521	79.7302
IB17	4057	23-Sep-02	11.3	32.6481	79.7321
IB21	4058	23-Sep-02	13.4	32.6482	79.7241
IB22	4059	23-Sep-02	13.4	32.6484	79.7214
IB26	4060	23-Sep-02	11.9	32.6468	79.7284
IC03	4061	23-Sep-02	12.5	32.6434	79.7227
IC05	4062	23-Sep-02	11.3	32.6417	79.7200
IC06	4063	23-Sep-02	11.3	32.6419	79.7166
IC07	4064	23-Sep-02	11.0	32.6402	79.7261
IC08	4065	23-Sep-02	10.1	32.6400	79.7250
IC12	4066	23-Sep-02	11.0	32.6365	79.7261
IC19	4067	23-Sep-02	11.9	32.6367	79.7200
IC22	4068	23-Sep-02	11.6	32.6337	79.7285
IC24	4069	23-Sep-02	10.7	32.6335	79.7219
IC32	4070	23-Sep-02	14.0	32.6267	79.7266
ID04	4071	23-Sep-02	14.0	32.6250	79.7349
ID05	4072	23-Sep-02	13.7	32.6251	79.7316
ID10	4073	23-Sep-02	15.5	32.6231	79.7279
ID13	4074	23-Sep-02	14.3	32.6202	79.7331
ID15	4075	23-Sep-02	14.3	32.6164	79.7401
ID16	4076	23-Sep-02	14.3	32.6187	79.7385
ID17	4077	23-Sep-02	14.6	32.6183	79.7317
ID18	4078	23-Sep-02	14.6	32.6201	79.7299
ID23	4079	23-Sep-02	13.4	32.6169	79.7317
ID31	4080	23-Sep-02	15.2	32.6102	79.7380
IE04	4081	23-Sep-02	14.3	32.6183	79.7584
IE06	4082	23-Sep-02	14.0	32.6185	79.7550
IE10	4083	23-Sep-02	13.6	32.6161	79.7586
IE11	4084	23-Sep-02	13.1	32.6161	79.7566
IE13	4085	23-Sep-02	13.7	32.6167	79.7532
IE14	4086	23-Sep-02	14.6	32.6155	79.7485
IE16	4087	23-Sep-02	13.4	32.6147	79.7604
IE18	4088	23-Sep-02	13.0	32.6132	79.7534
IE27	4089	23-Sep-02	12.8	32.6096	79.7519
IE30	4090	23-Sep-02	12.5	32.6121	79.7432
IF03	4091	23-Sep-02	10.7	32.6264	79.7840
IF04	4092	23-Sep-02	11.4	32.6285	79.7801
IF05	4093	23-Sep-02	11.3	32.6284	79.7783
IF06	4094	23-Sep-02	10.7	32.6266	79.7737

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston ODMDS in September 2002. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
IF10	4095	23-Sep-02	11.3	32.6248	79.7817
IF13	4096	23-Sep-02	10.7	32.6264	79.7750
IF22	4097	23-Sep-02	10.2	32.6232	79.7700
IF27	4098	23-Sep-02	11.7	32.6199	79.7740
IF29	4099	23-Sep-02	11.0	32.6217	79.7687
IF30	4100	23-Sep-02	11.4	32.6217	79.7716
IG03	4101	22-Sep-02	13.9	32.6445	79.7764
IG07	4104	22-Sep-02	14.2	32.6436	79.7762
IG08	4102	22-Sep-02	12.0	32.6415	79.7743
IG11	4103	22-Sep-02	12.7	32.6393	79.7768
IG19	4105	22-Sep-02	13.2	32.6366	79.7818
IG25	4106	23-Sep-02	13.4	32.6332	79.7834
IG27	4107	23-Sep-02	11.3	32.6332	79.7742
IG29	4108	23-Sep-02	12.8	32.6313	79.7848
IG30	4109	23-Sep-02	10.7	32.6313	79.7784
IG32	4110	23-Sep-02	12.5	32.6297	79.7866
IH03	4111	23-Sep-02	9.9	32.6630	79.7655
IH04	4112	23-Sep-02	9.6	32.6636	79.7615
IH05	4113	23-Sep-02	9.8	32.6618	79.7667
IH09	4115	23-Sep-02	9.8	32.6603	79.7645
IH12	4116	23-Sep-02	11.1	32.6568	79.7667
IH15	4117	23-Sep-02	11.4	32.6551	79.7676
IH18	4118	23-Sep-02	11.3	32.6534	79.7681
IH19	4119	23-Sep-02	11.6	32.6539	79.7669
IH20	4114	23-Sep-02	11.6	32.6517	79.7629
IH28	4120	23-Sep-02	11.9	32.6482	79.7694
OA02	4121	23-Sep-02	9.8	32.6782	79.7617
OA03	4122	23-Sep-02	10.4	32.6747	79.7618
OA04	4123	23-Sep-02	9.8	32.6751	79.7567
OA05	4124	23-Sep-02	9.8	32.6751	79.7584
OA07	4125	23-Sep-02	9.5	32.6733	79.7594
OA08	4126	23-Sep-02	9.5	32.6730	79.7583
OA27	4127	23-Sep-02	9.8	32.6668	79.7445
OA28	4128	23-Sep-02	10.4	32.6652	79.7429
OA31	4129	23-Sep-02	10.4	32.6647	79.7367
OA32	4130	23-Sep-02	10.1	32.6636	79.7387
OB04	4131	23-Sep-02	11.0	32.6618	79.7325
OB09	4132	23-Sep-02	13.1	32.6601	79.7326
OB10	4133	23-Sep-02	12.5	32.6582	79.7273
OB19	4134	23-Sep-02	13.7	32.6567	79.7169
OB25	4135	23-Sep-02	12.2	32.6545	79.7173
OB26	4136	23-Sep-02	12.8	32.6550	79.7132
OB32	4137	23-Sep-02	12.2	32.6512	79.7104
OB35	4138	23-Sep-02	12.2	32.6513	79.7150
OB36	4139	23-Sep-02	12.5	32.6521	79.7081
OB38	4140	23-Sep-02	14.0	32.6503	79.7048
OC04	4141	23-Sep-02	13.1	32.6452	79.7046

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston ODMDS in September 2002. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
OC05	4142	23-Sep-02	12.8	32.6438	79.7082
OC10	4143	23-Sep-02	12.2	32.6382	79.7101
OC12	4144	23-Sep-02	12.5	32.6388	79.7149
OC13	4145	23-Sep-02	12.5	32.6366	79.7081
OC16	4146	23-Sep-02	11.9	32.6374	79.7124
OC24	4147	23-Sep-02	12.5	32.6302	79.7168
OC25	4148	23-Sep-02	11.9	32.6300	79.7118
OC30	4149	23-Sep-02	14.3	32.6257	79.7233
OC32	4150	23-Sep-02	14.3	32.6248	79.7183
OD02	4151	23-Sep-02	14.9	32.6235	79.7251
OD04	4152	23-Sep-02	14.3	32.6199	79.7201
OD13	4153	23-Sep-02	14.6	32.6149	79.7251
OD14	4154	23-Sep-02	15.2	32.6149	79.7299
OD18	4155	23-Sep-02	14.0	32.6113	79.7299
OD28	4156	23-Sep-02	14.0	32.6070	79.7354
OD29	4157	23-Sep-02	13.7	32.6065	79.7268
OD33	4158	23-Sep-02	13.7	32.6034	79.7335
OD36	4159	23-Sep-02	14.0	32.5995	79.7349
OD38	4160	23-Sep-02	13.7	32.5983	79.7332
OE06	4161	23-Sep-02	12.2	32.6084	79.7653
OE07	4162	23-Sep-02	11.3	32.6103	79.7632
OE08	4163	23-Sep-02	13.0	32.6065	79.7604
OE09	4164	23-Sep-02	12.2	32.6091	79.7549
OE12	4165	23-Sep-02	12.7	32.6050	79.7551
OE13	4166	23-Sep-02	12.2	32.6069	79.7515
OE18	4167	23-Sep-02	13.9	32.6033	79.7538
OE19	4168	23-Sep-02	13.7	32.6052	79.7521
OE24	4169	23-Sep-02	13.1	32.6020	79.7448
OE29	4170	23-Sep-02	14.8	32.6001	79.7377
OF03	4171	23-Sep-02	11.4	32.6232	79.7986
OF05	4172	23-Sep-02	11.1	32.6234	79.7920
OF06	4173	23-Sep-02	10.7	32.6234	79.7873
OF18	4174	23-Sep-02	11.0	32.6198	79.7767
OF22	4175	23-Sep-02	13.0	32.6163	79.7788
OF23	4176	23-Sep-02	13.9	32.6173	79.7751
OF26	4177	23-Sep-02	11.9	32.6153	79.7825
OF30	4178	23-Sep-02	12.3	32.6150	79.7698
OF35	4179	23-Sep-02	13.1	32.6136	79.7703
OF37	4180	23-Sep-02	11.7	32.6098	79.7703
OG02	4181	23-Sep-02	12.5	32.6481	79.7799
OG03	4182	23-Sep-02	11.6	32.6528	79.7835
OG08	4188	23-Sep-02	11.9	32.6459	79.7886
OG09	4183	23-Sep-02	11.9	32.6469	79.7846
OG10	4184	23-Sep-02	13.1	32.6448	79.7832
OG15	4185	23-Sep-02	13.7	32.6419	79.7849
OG22	4186	23-Sep-02	12.5	32.6369	79.7843
OG23	4187	23-Sep-02	12.5	32.6353	79.7920

Appendix 1. List of station locations and depths for sites sampled in and around the Charleston ODMDS in September 2002. Depth is reported in meters. Latitude and longitude are reported in decimal degrees.

Station	Collection #	Date	Depth	Latitude	Longitude
OG29	4189	23-Sep-02	12.8	32.6300	79.7984
OG33	4190	23-Sep-02	12.2	32.6287	79.7965
OH01	4191	23-Sep-02	10.2	32.6604	79.7723
OH02	4192	23-Sep-02	8.7	32.6784	79.7665
OH05	4193	23-Sep-02	9.9	32.6737	79.7666
OH06	4194	23-Sep-02	9.6	32.6722	79.7695
OH10	4195	23-Sep-02	9.0	32.6704	79.7681
OH12	4196	23-Sep-02	9.1	32.6668	79.7712
OH14	4197	23-Sep-02	11.1	32.6569	79.7737
OH15	4198	23-Sep-02	9.5	32.6651	79.7746
OH27	4199	23-Sep-02	11.6	32.6539	79.7814
OH30	4200	23-Sep-02	11.9	32.6521	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 2002. 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	X	Size Class	SD	Sorting Descr.	Mode
DA05	9/23/2002	43.3	15.5	41.2	4.3	2.0	M	1.053	P	3.0
DA17	9/23/2002	52.1	0.9	46.9	1.4	1.5	M	0.908	M	2.5
DA18	9/23/2002	76.1	3.2	20.7	1.9	2.8	F	0.444	W	3.0
DA19	9/23/2002	24.8	48.8	26.4	7.7	2.5	F	0.969	M	2.5
DA22	9/23/2002	53.0	32.5	14.5	6.0	3.1	VF	0.502	MW	3.5
DA23	9/23/2002	69.3	1.6	29.2	1.5	2.3	F	1.107	P	3.0
DA25	9/23/2002	51.8	13.5	34.7	3.2	2.1	F	1.084	P	2.5
DA26	9/23/2002	76.4	7.9	15.7	2.2	2.9	F	0.429	W	3.0
DA28	9/23/2002	84.2	1.6	14.2	1.1	2.5	F	0.595	MW	3.0
DA30	9/23/2002	86.9	2.7	10.4	1.1	2.6	F	0.503	MW	3.0
Mean		**61.8**	**12.8**	**25.4**	**3.0**	**2.4**				
DB11	9/23/2002	60.9	13.8	25.2	3.9	2.6	F	0.594	MW	3.0
DB13	9/23/2002	62.7	0.9	36.4	1.9	2.2	F	0.511	MW	2.5
DB16	9/24/2002	77.1	4.5	18.4	8.0	2.6	F	0.615	MW	3.0
DB19	9/23/2002	47.1	25.8	27.1	1.6	2.6	F	0.523	MW	3.0
DB24	9/23/2002	70.5	9.4	20.1	2.5	2.4	F	0.545	MW	3.0
DB25	9/23/2002	40.5	34.3	25.1	8.9	2.6	F	0.643	MW	3.0
DB28	9/23/2002	53.3	31.1	15.6	9.4	2.9	F	0.369	W	3.0
DB29	9/23/2002	47.4	23.6	29.0	6.0	2.6	F	0.606	MW	3.0
DB30	9/23/2002	39.9	9.0	51.1	3.3	2.0	F	0.780	M	2.5
DB31	9/23/2002	78.2	2.6	19.2	1.2	2.4	F	0.470	W	3.0
Mean		**57.8**	**15.5**	**26.7**	**4.7**	**2.5**				
DC06	9/24/2002	61.5	20.8	17.7	4.6	2.7	F	0.672	MW	3.0
DC07	9/24/2002	87.3	2.5	10.2	0.9	2.5	F	0.451	W	3.0
DC11	9/24/2002	78.1	2.9	19.0	0.9	2.3	F	0.513	MW	3.0
DC12	9/24/2002	80.5	2.8	16.7	0.8	2.2	F	0.590	MW	2.5
DC16	9/24/2002	73.1	2.5	24.4	1.0	1.5	M	0.808	M	1.5
DC17	9/24/2002	73.8	2.2	24.0	0.9	1.7	M	0.809	M	2.0

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2002. 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 %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
DC18	9/24/2002	59.1	4.2	36.6	1.1	1.8	M	0.731	M	2.0
DC25	9/24/2002	49.6	3.6	46.8	1.1	1.9	M	0.638	MW	2.0
DC29	9/24/2002	24.4	47.8	27.7	11.7	2.7	F	0.776	M	3.0
DC33	9/24/2002	2.9	96.1	1.0	9.5	2.9	F	1.322	P	3.5
Mean		**59.0**	**18.6**	**22.4**	**3.2**	**2.2**				
DD08	9/24/2002	86.4	3.0	10.6	0.8	2.3	F	0.640	MW	3.0
DD11	9/24/2002	57.5	22.4	20.1	5.7	3.2	VF	0.415	W	3.5
DD13	9/24/2002	81.5	7.2	11.3	1.5	2.5	F	0.598	MW	3.0
DD14	9/24/2002	76.4	5.2	18.3	1.9	2.5	F	0.613	MW	3.0
DD18	9/24/2002	86.3	3.2	10.5	4.2	2.3	F	0.805	M	3.0
DD20	9/24/2002	87.8	3.6	8.6	0.8	2.3	F	0.643	MW	3.0
DD24	9/24/2002	59.5	8.6	31.9	2.7	2.3	F	0.540	MW	2.5
DD25	9/24/2002	53.1	6.1	40.8	2.0	1.8	M	1.103	P	3.0
DD26	9/24/2002	58.8	21.1	20.1	5.2	3.1	VF	0.395	W	3.5
DD30	9/24/2002	5.3	74.1	20.6	11.6	3.2	VF	0.586	MW	4.0
Mean		**65.3**	**15.5**	**19.3**	**3.7**	**2.5**				
IA01	9/23/2002	82.1	6.0	11.9	1.0	2.5	F	0.463	W	3.0
IA02	9/23/2002	83.8	5.1	11.1	0.8	2.4	F	0.445	W	2.5
IA03	9/23/2002	84.8	2.6	12.7	0.9	2.4	F	0.471	W	3.0
IA06	9/23/2002	78.0	3.0	19.0	1.0	2.0	F	0.570	MW	2.5
IA08	9/23/2002	86.6	5.3	8.1	0.8	2.6	F	0.436	W	3.0
IA09	9/23/2002	87.2	5.9	6.9	0.7	2.5	F	0.397	W	2.5
IA17	9/23/2002	64.4	4.6	31.0	1.3	1.7	M	0.739	M	2.0
IA20	9/23/2002	80.3	3.6	16.1	1.1	2.6	F	0.507	MW	3.0
IA26	9/23/2002	80.3	4.4	15.2	0.9	2.4	F	0.544	MW	3.0
IA27	9/23/2002	83.9	3.5	12.6	0.8	2.3	F	0.487	W	2.5
Mean		**81.1**	**4.4**	**14.5**	**0.9**	**2.3**				

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2002. 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 %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
IB04	9/23/2002	89.8	1.4	8.8	0.9	2.4	F	0.431	W	3.0
IB05	9/23/2002	86.8	2.1	11.1	0.8	2.6	F	0.466	W	3.0
IB07	9/23/2002	86.6	1.2	12.2	0.7	2.3	F	0.481	W	2.5
IB10	9/23/2002	89.2	2.1	8.7	0.8	2.4	F	0.504	MW	3.0
IB12	9/23/2002	87.1	2.5	10.4	0.7	2.3	F	0.507	MW	2.5
IB13	9/23/2002	86.9	1.8	11.2	0.8	2.3	F	0.520	MW	2.5
IB17	9/23/2002	87.2	0.7	12.1	1.1	2.4	F	0.500	MW	3.0
IB21	9/23/2002	64.0	22.9	13.1	5.3	2.8	F	0.353	W	3.0
IB22	9/23/2002	88.5	1.2	10.4	0.8	2.5	F	0.438	W	3.0
IB26	9/23/2002	89.6	1.0	9.5	0.8	2.4	F	0.487	W	2.5
Mean		**85.6**	**3.7**	**10.8**	**1.3**	**2.5**				
IC03	9/23/2002	84.9	1.6	13.5	0.8	2.3	F	0.573	MW	3.0
IC05	9/23/2002	83.6	0.7	15.7	1.0	2.2	F	0.457	W	2.5
IC06	9/23/2002	80.5	1.6	18.0	0.8	2.2	F	0.556	MW	3.0
IC07	9/23/2002	73.9	1.3	24.8	0.8	2.0	F	0.486	W	2.5
IC08	9/23/2002	73.9	3.8	22.3	0.8	1.9	M	0.621	MW	2.0
IC12	9/23/2002	83.5	1.6	14.8	0.8	2.2	F	0.498	W	2.5
IC19	9/23/2002	77.5	1.2	21.3	1.0	1.7	M	0.702	MW	2.5
IC22	9/23/2002	83.7	2.2	14.1	0.7	2.2	F	0.539	MW	2.5
IC24	9/23/2002	59.0	1.7	39.4	1.0	1.7	M	0.639	MW	2.0
IC32	9/23/2002	87.4	3.1	9.6	0.7	2.6	F	0.404	W	3.0
Mean		**78.8**	**1.9**	**19.3**	**0.8**	**2.1**				
ID04	9/23/2002	82.1	0.8	17.2	0.6	1.8	M	0.816	M	2.5
ID05	9/23/2002	88.4	2.2	9.4	0.7	2.6	F	0.428	W	3.0
ID10	9/23/2002	82.5	2.3	15.2	1.1	2.5	F	0.739	M	3.0
ID13	9/23/2002	64.6	4.4	31.0	1.1	1.1	M	0.957	M	1.0
ID15	9/23/2002	88.7	4.1	7.2	0.6	0.5	C	0.908	M	0.5
ID16	9/23/2002	78.6	1.7	19.7	1.1	0.9	C	1.171	P	0.5

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Station	Sampling Date	Sand %	Silt/Clay %	$CaCO_3$ %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
ID17	9/23/2002	70.3	4.3	25.3	1.2	1.8	M	1.158	P	3.0
ID18	9/23/2002	74.2	3.4	22.4	0.9	2.3	F	0.663	MW	3.0
ID23	9/23/2002	68.7	2.6	28.7	0.8	1.7	M	0.791	M	2.5
ID31	9/23/2002	74.5	3.4	22.2	1.1	0.5	C	1.356	P	0.5
Mean		**77.3**	**2.9**	**19.8**	**0.9**	**1.6**				
IE04	9/23/2002	73.3	3.3	23.5	1.1	0.7	C	1.028	P	0.5
IE06	9/23/2002	70.3	8.9	20.8	2.7	2.9	F	0.424	W	3.0
IE10	9/23/2002	83.3	4.3	12.3	1.3	2.6	F	0.475	W	3.0
IE11	9/23/2002	89.1	2.9	8.0	0.7	2.5	F	0.483	W	3.0
IE13	9/23/2002	70.7	6.2	23.1	2.3	2.3	F	1.055	P	3.0
IE14	9/23/2002	83.8	2.7	13.6	0.8	2.1	F	0.849	M	3.0
IE16	9/23/2002	71.2	3.0	25.8	1.2	1.5	M	0.956	M	1.5
IE18	9/23/2002	80.2	2.2	17.6	0.9	1.9	M	0.635	MW	2.5
IE27	9/23/2002	89.2	1.9	8.9	0.7	2.3	F	0.564	MW	3.0
IE30	9/23/2002	87.9	1.7	10.4	0.7	2.2	F	0.582	MW	2.5
Mean		**79.9**	**3.7**	**16.4**	**1.2**	**2.1**				
IF03	9/23/2002	87.6	3.7	8.8	1.0	2.6	F	0.480	W	3.0
IF04	9/23/2002	76.9	5.7	17.4	2.1	2.5	F	0.627	MW	3.0
IF05	9/23/2002	86.2	3.7	10.0	1.1	2.6	F	0.494	W	3.0
IF06	9/23/2002	82.2	2.8	14.9	1.0	2.3	F	0.576	MW	2.5
IF10	9/23/2002	87.9	2.1	10.0	0.8	2.3	F	0.615	MW	3.0
IF13	9/23/2002	86.2	2.6	11.2	1.0	2.4	F	0.561	MW	2.5
IF22	9/23/2002	86.2	4.0	9.8	0.8	2.3	F	0.608	MW	3.0
IF27	9/23/2002	88.1	2.3	9.6	0.8	2.3	F	0.588	MW	2.5
IF29	9/23/2002	72.8	3.6	23.6	1.0	1.8	M	0.837	M	2.5
IF30	9/23/2002	85.8	3.7	10.5	0.9	2.4	F	0.576	MW	3.0
Mean		**84.0**	**3.4**	**12.6**	**1.0**	**2.4**				

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2002. 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 %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
IG03	9/22/2002	64.7	8.8	26.5	5.2	3.2	VF	0.411	W	3.5
IG07	9/22/2002	42.2	35.4	22.5	2.1	1.7	M	0.776	M	2.0
IG08	9/22/2002	53.0	1.1	45.9	2.4	2.7	F	0.424	W	3.0
IG11	9/22/2002	78.7	5.0	16.2	6.7	3.1	VF	0.346	VW	3.5
IG19	9/22/2002	85.3	4.6	10.1	1.2	2.6	F	0.518	MW	3.0
IG25	9/23/2002	39.8	37.5	22.6	7.1	3.3	VF	0.371	W	3.5
IG27	9/23/2002	82.4	2.5	15.1	1.4	2.6	F	0.506	MW	3.0
IG29	9/23/2002	89.3	2.3	8.5	0.9	2.1	F	0.577	MW	2.5
IG30	9/23/2002	82.1	2.7	15.2	1.2	2.4	F	0.603	MW	3.0
IG32	9/23/2002	85.5	5.7	8.8	1.7	2.6	F	0.448	W	3.0
Mean		**70.3**	**10.6**	**19.1**	**3.0**	**2.6**				
IH03	9/23/2002	89.9	0.8	9.3	1.0	2.5	F	0.402	W	3.0
IH04	9/23/2002	91.4	1.3	7.3	0.7	2.5	F	0.425	W	3.0
IH05	9/23/2002	87.1	4.0	8.9	1.0	2.6	F	0.411	W	3.0
IH09	9/23/2002	85.9	4.5	9.6	1.7	2.5	F	0.482	W	3.0
IH12	9/23/2002	83.8	3.9	12.3	0.9	2.6	F	0.386	W	3.0
IH15	9/23/2002	81.6	4.4	14.0	1.2	2.7	F	0.386	W	3.0
IH18	9/23/2002	42.5	4.5	53.0	1.4	2.7	F	0.387	W	3.0
IH19	9/23/2002	78.9	5.0	16.1	2.7	2.1	F	0.815	M	3.0
IH20	9/23/2002	81.9	4.3	13.8	2.2	2.8	F	0.444	W	3.0
IH28	9/23/2002	58.0	29.9	12.0	4.6	2.7	F	0.670	MW	3.0
Mean		**78.1**	**6.3**	**15.6**	**1.7**	**2.6**				
OA02	9/23/2002	72.0	3.9	24.2	1.0	2.1	F	0.559	MW	2.5
OA03	9/23/2002	82.9	2.6	14.6	0.8	2.4	F	0.531	MW	2.5
OA04	9/23/2002	79.7	5.2	15.1	0.8	2.1	F	0.499	W	2.5
OA05	9/23/2002	85.8	4.5	9.7	0.7	2.3	F	0.510	MW	3.0
OA07	9/23/2002	87.3	2.2	10.4	0.7	2.3	F	0.447	W	2.5
OA08	9/23/2002	87.9	2.5	9.7	0.7	2.3	F	0.481	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 2002. 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 %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
OA27	9/23/2002	87.8	0.9	11.3	0.7	2.3	F	0.454	W	2.5
OA28	9/23/2002	85.5	2.8	11.6	0.7	2.4	F	0.444	W	3.0
OA31	9/23/2002	57.7	5.0	37.3	1.3	1.4	M	0.801	M	1.5
OA32	9/23/2002	81.0	3.4	15.6	0.9	2.4	F	0.468	W	3.0
Mean		**80.8**	**3.3**	**15.9**	**0.8**	**2.2**				
OB04	9/23/2002	79.7	2.2	18.1	0.7	2.1	F	0.539	MW	2.5
OB09	9/23/2002	72.7	14.4	12.9	3.0	2.7	F	0.470	W	3.0
OB10	9/23/2002	76.7	4.0	19.3	0.9	2.4	F	0.518	MW	3.0
OB19	9/23/2002	58.9	5.8	35.3	1.4	0.4	C	1.159	P	0.5
OB25	9/23/2002	37.0	3.0	60.0	1.8	1.2	M	0.954	M	1.0
OB26	9/23/2002	78.7	3.2	18.1	0.8	2.6	F	0.440	W	3.0
OB32	9/23/2002	59.2	2.6	38.2	1.5	1.6	M	0.798	M	2.5
OB35	9/23/2002	82.2	4.5	13.3	0.7	2.4	F	0.513	MW	3.0
OB36	9/23/2002	83.5	3.9	12.6	0.8	2.3	F	0.464	W	2.5
OB38	9/23/2002	82.3	2.0	15.6	0.8	2.6	F	0.438	W	3.0
Mean		**71.1**	**4.6**	**24.4**	**1.2**	**2.0**				
OC04	9/23/2002	58.6	3.7	37.8	1.3	0.4	C	1.047	P	1.0
OC05	9/23/2002	78.6	1.6	19.8	0.8	1.8	M	0.867	M	2.0
OC10	9/23/2002	68.9	2.8	28.3	0.9	1.2	M	0.952	M	1.0
OC12	9/23/2002	67.6	2.8	29.6	1.2	1.8	M	0.721	M	2.0
OC13	9/23/2002	53.4	1.9	44.8	1.4	1.9	M	0.537	MW	2.0
OC16	9/23/2002	71.6	2.5	25.9	1.0	1.1	M	0.852	M	1.0
OC24	9/23/2002	82.1	3.8	14.2	0.7	2.1	F	0.570	MW	2.5
OC25	9/23/2002	36.4	1.9	61.7	1.7	1.6	M	0.779	M	2.0
OC30	9/23/2002	86.7	2.7	10.6	0.9	2.5	F	0.447	W	3.0
OC32	9/23/2002	88.3	1.5	10.2	0.7	2.6	F	0.386	W	3.0
Mean		**69.2**	**2.5**	**28.3**	**1.1**	**1.7**				

Appendix 2. Characteristics of surficial sediment cores collected from grab samples taken at stations in and around the Charleston disposal area during September 2002. 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	X	Size Class	SD	Sorting Descr.	Mode
OD02	9/23/2002	74.2	13.3	12.4	1.1	2.6	F	0.427	W	3.0
OD04	9/23/2002	85.3	6.8	7.9	0.7	2.6	F	0.375	W	3.0
OD13	9/23/2002	83.2	7.4	9.4	0.9	2.6	F	0.461	W	3.0
OD14	9/23/2002	81.8	6.3	11.9	1.1	2.4	F	0.532	MW	3.0
OD18	9/23/2002	66.4	3.3	30.2	1.1	1.8	M	0.885	M	3.0
OD28	9/23/2002	69.8	10.4	19.8	0.7	2.1	F	0.695	MW	2.5
OD29	9/23/2002	69.5	6.3	24.2	1.1	0.5	C	1.059	P	0.5
OD33	9/23/2002	71.4	5.3	23.3	0.9	1.4	M	0.846	M	2.5
OD36	9/23/2002	79.2	7.4	13.4	0.8	2.2	F	0.587	MW	2.5
OD38	9/23/2002	78.5	6.3	15.2	0.8	2.3	F	0.482	W	2.5
Mean		**75.9**	**7.3**	**16.8**	**0.9**	**2.0**				
OE06	9/23/2002	79.7	3.4	16.9	0.8	2.5	F	0.437	W	3.0
OE07	9/23/2002	77.4	3.0	19.6	0.9	2.1	F	0.655	MW	3.0
OE08	9/23/2002	76.2	2.0	21.9	1.7	0.4	C	1.071	P	0.5
OE09	9/23/2002	88.2	1.8	10.0	0.6	2.3	F	0.547	MW	3.0
OE12	9/23/2002	86.5	1.8	11.7	0.7	2.4	F	0.476	W	2.5
OE13	9/23/2002	88.6	1.5	9.9	0.7	2.4	F	0.491	W	3.0
OE18	9/23/2002	80.0	2.5	17.5	0.9	2.2	F	0.729	M	2.5
OE19	9/23/2002	87.4	1.7	10.9	0.8	2.5	F	0.477	W	3.0
OE24	9/23/2002	86.5	1.7	11.8	0.7	2.4	F	0.425	W	2.5
OE29	9/23/2002	75.3	1.9	22.9	1.1	2.1	F	0.978	M	3.0
Mean		**82.6**	**2.1**	**15.3**	**0.9**	**2.1**				
OF03	9/23/2002	88.0	4.7	7.3	0.7	2.5	F	0.475	W	3.0
OF05	9/23/2002	89.5	2.6	7.9	0.7	2.4	F	0.506	MW	3.0
OF06	9/23/2002	89.4	1.9	8.8	0.7	2.3	F	0.490	W	2.5
OF18	9/23/2002	88.7	2.0	9.4	0.6	2.3	F	0.628	MW	3.0
OF22	9/23/2002	88.2	2.5	9.3	0.8	2.5	F	0.577	MW	3.0
OF23	9/23/2002	60.8	13.4	25.8	3.5	2.4	F	0.951	M	3.0

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Station	Sampling Date	Sand %	Silt/Clay %	CaCO3 %	Organic Matter	X	Size Class	SD	Sorting Descr.	Mode
OF26	9/23/2002	90.7	1.2	8.1	0.7	2.4	F	0.561	MW	3.0
OF30	9/23/2002	86.4	2.1	11.4	0.7	1.8	M	0.798	M	2.0
OF35	9/23/2002	85.3	2.2	12.5	1.4	0.5	C	1.135	P	0.5
OF37	9/23/2002	88.6	1.8	9.6	0.6	2.5	F	0.512	MW	3.0
Mean		**85.6**	**3.4**	**11.0**	**1.0**	**2.2**				
OG02	9/23/2002	74.5	10.6	14.8	2.7	2.9	F	0.439	W	3.0
OG03	9/23/2002	78.9	3.2	17.9	1.1	2.7	F	0.445	W	3.0
OG08	9/23/2002	77.1	8.1	14.8	1.7	2.8	F	0.484	W	3.0
OG09	9/23/2002	81.7	5.8	12.6	2.5	2.9	F	0.342	VW	3.0
OG10	9/23/2002	77.7	9.3	12.9	6.9	3.2	VF	0.441	W	3.5
OG15	9/23/2002	48.6	34.4	17.0	1.2	2.7	F	0.441	W	3.0
OG22	9/23/2002	85.8	4.0	10.2	0.7	2.5	F	0.576	MW	3.0
OG23	9/23/2002	87.9	3.6	8.5	1.9	2.8	F	0.470	W	3.0
OG29	9/23/2002	58.7	12.7	28.6	3.0	0.7	C	1.163	P	1.0
OG33	9/23/2002	56.0	4.1	39.9	1.5	0.7	C	1.423	P	0.5
Mean		**72.7**	**9.6**	**17.7**	**2.3**	**2.4**				
OH01	9/23/2002	85.6	3.5	10.9	0.9	2.6	F	0.405	W	3.0
OH02	9/23/2002	90.6	1.9	7.4	0.7	2.5	F	0.438	W	3.0
OH05	9/23/2002	90.0	4.2	5.8	0.6	2.5	F	0.445	W	3.0
OH06	9/23/2002	86.2	4.3	9.6	0.8	2.4	F	0.476	W	2.5
OH10	9/23/2002	89.7	3.3	7.0	0.6	2.4	F	0.435	W	2.5
OH12	9/23/2002	88.0	2.5	9.5	0.7	2.5	F	0.408	W	3.0
OH14	9/23/2002	83.9	1.6	14.5	2.0	2.4	F	0.731	M	3.0
OH15	9/23/2002	86.7	4.1	9.2	0.9	2.6	F	0.360	W	3.0
OH27	9/23/2002	83.9	1.8	14.3	1.2	2.7	F	0.365	W	3.0
OH30	9/23/2002	82.0	2.9	15.1	1.7	2.7	F	0.403	W	3.0
Mean		**86.7**	**3.0**	**10.3**	**1.0**	**2.5**				

Appendix 3. Total abundance (#/ 0.4m^2) of each species in all strata sampled in and around the Charleston ODMDS during September 2002. P = polychaete, M = mollusk, A = amphipod, and O = other taxa.

Species Name	Taxon	Sum	IC	ID	OC	OD	IA	IG	IH	OA	OG	OH
Abra aequalis	M	87	5	18	3	6	28	6	3	0	12	6
Acanthohaustorius intermedius	A	67	2	0	0	12	6	0	3	13	0	31
Acanthohaustorius millsi	A	93	55	0	11	0	20	0	0	7	0	0
Acteocina canaliculata	M	8	8	0	0	0	0	0	0	0	0	0
Acteocina candei	M	179	29	25	20	54	9	5	9	11	6	11
Acteon candens	M	4	0	0	0	0	0	3	1	0	0	0
Actiniaria	O	11	0	2	0	1	3	0	2	1	1	1
Aglaophamus verrilli	P	12	0	0	0	0	1	1	6	0	4	0
Aligena elevata	M	7	2	0	0	0	5	0	0	0	0	0
Amastigos caperatus	P	4	0	0	0	0	0	0	1	1	1	1
Ampelisca abdita	A	10	0	1	1	0	0	0	0	0	8	0
Ampelisca agassizi	A	1	0	1	0	0	0	0	0	0	0	0
Ampelisca macrocephala	A	1	0	0	0	1	0	0	0	0	0	0
Ampelisca sp.	A	5	2	0	0	0	2	0	0	0	1	0
Ampelisca vadorum	A	23	0	8	0	0	0	0	0	15	0	0
Ampelisca verrilli	A	31	0	17	5	9	0	0	0	0	0	0
Ampharetidae	P	5	0	3	0	0	0	0	0	0	1	1
Amphicteis gunneri	P	1	0	0	1	0	0	0	0	0	0	0
Amphiodia sp.	O	1	0	0	0	0	1	0	0	0	0	0
Amphipholis sp.	O	1	0	0	0	0	0	0	1	0	0	0
Amphipoda	A	8	0	0	7	0	0	0	0	1	0	0
Anachis obesa	M	1	0	0	0	0	0	1	0	0	0	0
Anadara transversa	M	46	0	28	0	6	0	0	0	0	11	1
Ancinus depressus	O	15	4	0	5	1	2	0	0	3	0	0
Ancistrosyllis sp.	P	15	0	1	2	6	2	1	0	0	1	2
Anomia simplex	M	4	0	2	0	1	0	0	0	0	1	0
Anoplodactylus petiolatus	O	2	0	0	0	0	0	0	0	0	2	0
Anthuridae	O	4	0	2	0	0	0	0	0	0	2	0
Aonides mayaguezensis	P	6	0	6	0	0	0	0	0	0	0	0
Aonides paucibranchiata	P	5	0	3	0	1	0	1	0	0	0	0
Aonides sp.	P	1	0	0	0	0	0	1	0	0	0	0
Aoridae	A	12	0	10	0	1	0	1	0	0	0	0
Apanthura magnifica	O	1	0	0	0	0	0	0	0	1	0	0
Aphelochaeta sp.	P	53	0	5	0	1	0	9	7	1	28	2
Aphroditidae	P	1	0	0	1	0	0	0	0	0	0	0
Arabella mutans	P	3	0	0	0	0	1	0	0	0	2	0
Arbacia punctulata	O	19	2	0	3	0	14	0	0	0	0	0
Arcidae	M	3	0	0	3	0	0	0	0	0	0	0
Argissa hamatipes	A	8	0	0	1	2	0	2	0	0	3	0
Aricidea cerrutii	P	1	0	0	1	0	0	0	0	0	0	0
Aricidea lopezi	P	120	0	13	0	0	0	25	6	0	75	1
Aricidea philbinae	P	5	0	0	0	4	0	1	0	0	0	0
Aricidea sp.	P	37	27	2	4	0	3	0	0	1	0	0
Aricidea suecica	P	50	0	11	0	2	1	1	0	0	35	0
Aricidea taylori	P	1	0	0	0	1	0	0	0	0	0	0
Aricidea wassi	P	80	2	6	1	4	14	1	27	2	1	22
Armandia agilis	P	44	1	0	3	0	4	6	10	7	4	9
Armandia maculata	P	103	0	18	0	18	2	3	11	0	43	8
Aspidosiphon albus	O	33	0	2	0	20	0	3	0	0	8	0
Aspidosiphon gosnoldi	O	194	0	62	0	28	0	12	3	0	86	3

Appendix 3. Total abundance (#/ $0.4m^2$) of each species in all strata sampled in and around the Charleston ODMDS during September 2002.
P = polychaete, M = mollusk, A = amphipod, and O = other taxa.

Aspidosiphon sp.	O	2	0	0	0	0	0	2	0	0	0	0
Asthenothaerus hemphilli	M	3	0	0	0	3	0	0	0	0	0	0
Astyris lunata	M	2	0	0	0	2	0	0	0	0	0	0
Autolytus sp.	P	8	0	1	2	1	1	0	0	0	3	0
Axiothella sp.	P	2	0	2	0	0	0	0	0	0	0	0
Batea catharinensis	A	64	0	26	0	26	0	0	0	0	12	0
Bathyporeia parkeri	A	156	5	10	10	26	42	4	16	13	0	30
Bhawania goodei	P	49	0	15	22	12	0	0	0	0	0	0
Bhawania heteroseta	P	216	4	19	11	4	1	8	0	0	169	0
Biffarius biformis	O	3	0	1	0	0	0	1	0	0	0	1
Brachiopoda	O	1	0	1	0	0	0	0	0	0	0	0
Brachyura	O	3	0	2	0	1	0	0	0	0	0	0
Branchiostoma sp.	O	365	81	53	103	29	38	5	3	42	1	10
Brania sp.	P	61	2	9	41	2	3	0	0	1	3	0
Brania wellfleetensis	P	35	4	8	9	4	0	0	0	10	0	0
Bushia sp.	M	2	2	0	0	0	0	0	0	0	0	0
Cabira incerta	P	42	1	8	0	1	0	0	5	0	26	1
Caecum cooperi	M	9	0	2	1	6	0	0	0	0	0	0
Caecum johnsoni	M	131	0	15	96	20	0	0	0	0	0	0
Caecum pulchellum	M	346	1	56	52	225	0	3	5	0	2	2
Caecum sp.	M	47	35	0	7	2	1	0	2	0	0	0
Callianassidae	O	2	0	1	0	0	0	1	0	0	0	0
Callianassidae sp. A	O	2	0	0	0	0	0	0	2	0	0	0
Calyptraea centralis	M	3	0	0	1	1	0	0	0	0	1	0
Campylaspis affinis	O	6	0	0	6	0	0	0	0	0	0	0
Campylaspis sp.	O	21	0	6	0	2	0	1	2	0	10	0
Capitella capitata	P	4	0	0	0	0	0	0	1	0	2	1
Capitellidae	P	23	0	21	0	0	0	1	1	0	0	0
Capitellidae sp. A	P	1	0	0	0	0	0	1	0	0	0	0
Capitellidae sp. B	P	4	0	0	0	0	0	0	0	0	4	0
Caridea	O	1	0	0	0	1	0	0	0	0	0	0
Carinomella lactea	O	134	3	3	3	0	0	73	23	0	29	0
Caulleriella sp.	P	25	1	5	1	7	2	0	1	4	0	4
Cerapus tubularis	A	1	0	0	0	0	0	0	0	0	1	0
Ceratocephale oculata	P	20	0	0	0	0	0	4	7	0	8	1
Ceratonereis irritabilis	P	1	0	1	0	0	0	0	0	0	0	0
Chaetognatha	O	1	0	0	1	0	0	0	0	0	0	0
Chaetopteridae	P	1	0	0	0	0	0	1	0	0	0	0
Chione grus	M	1	0	0	0	0	0	1	0	0	0	0
Chione sp.	M	1	0	0	0	0	0	1	0	0	0	0
Chiridotea stenops	O	3	0	0	0	0	0	0	0	1	0	2
Chone sp.	P	2	0	0	2	0	0	0	0	0	0	0
Cirolana polita	O	3	0	2	1	0	0	0	0	0	0	0
Cirratulidae	P	20	0	4	1	1	0	3	2	0	9	0
Cirriformia sp.	P	7	0	3	1	0	0	1	0	0	1	1
Cirrophorus sp.	P	28	0	3	4	5	0	2	1	1	12	0
Cistenides gouldii	P	1	0	0	0	0	0	0	0	0	1	0
Clymenella torquata	P	6	0	6	0	0	0	0	0	0	0	0
Columbellidae	M	5	0	4	0	1	0	0	0	0	0	0
Corbula contracta	M	3	0	1	0	0	0	0	0	0	2	0
Corophium acherusicum	A	1	0	0	0	0	0	0	0	0	1	0

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Crassinella lunulata	M	493	68	154	16	31	14	40	17	15	137	1
Crassinella martinicensis	M	872	188	79	183	56	126	21	21	182	1	15
Crassinella sp.	M	1	0	0	1	0	0	0	0	0	0	0
Crepidula fornicata	M	2	0	0	0	0	0	0	0	0	2	0
Crustacea	O	1	0	1	0	0	0	0	0	0	0	0
Cumacea	O	2	0	0	0	0	0	0	0	0	2	0
Cumacean sp. A	O	5	0	5	0	0	0	0	0	0	0	0
Cyathura burbancki	O	55	1	30	1	1	0	0	0	0	21	1
Cyclaspis sp.	O	88	3	14	5	44	2	3	5	0	6	6
Cylichnella bidentata	M	265	0	0	0	4	0	151	12	0	93	5
Dasybranchus lunulatus	P	1	0	0	0	0	0	0	1	0	0	0
Decamastus sp.	P	6	0	2	0	0	0	3	0	0	1	0
Decapoda	O	48	1	9	1	8	0	5	9	0	7	8
Dentalium eboreum	M	9	0	0	0	6	0	0	1	0	2	0
Dentalium sp.	M	14	0	2	0	0	0	1	5	0	6	0
Dentalium texasianum	M	4	1	0	0	0	0	0	0	0	3	0
Dialychone sp.	P	3	0	3	0	0	0	0	0	0	0	0
Diopatra cuprea	P	23	0	14	1	1	0	1	1	1	3	1
Dispio uncinata	P	8	0	2	0	0	0	5	1	0	0	0
Dissodactylus mellitae	O	7	0	0	0	0	0	5	2	0	0	0
Divaricella quadrisulcata	M	1	0	0	0	0	0	0	0	0	1	0
Dorvillea sp.	P	1	0	0	0	0	0	0	0	1	0	0
Dorvilleidae	P	86	3	21	30	15	0	3	3	2	8	1
Dosinia elegans	M	28	0	21	0	1	0	0	1	0	5	0
Drilonereis longa	P	3	0	1	1	0	0	1	0	0	0	0
Drilonereis sp.	P	3	0	0	2	0	0	0	0	1	0	0
Edotia montosa	O	9	0	0	0	0	0	3	2	0	4	0
Edotia triloba	O	1	0	0	0	0	1	0	0	0	0	0
Elasmopus levis	A	18	2	10	0	0	0	0	0	0	6	0
Emerita talpoida	O	1	0	0	0	0	0	0	0	1	0	0
Ensis directus	M	1	0	0	0	0	0	0	0	0	1	0
Eobrolgus spinosus	A	16	4	0	1	0	11	0	0	0	0	0
Epitomapta roseola	O	1	0	0	0	0	0	0	0	0	1	0
Epitonium sp.	M	1	0	0	0	0	0	0	1	0	0	0
Ericthonius brasiliensis	A	44	0	32	1	9	0	0	0	0	2	0
Ervilia concentrica	M	19	2	3	11	1	0	0	2	0	0	0
Eteone heteropoda	P	1	0	0	0	0	0	0	1	0	0	0
Eteone lactea	P	1	0	0	1	0	0	0	0	0	0	0
Euceramus praelongus	O	4	0	2	0	0	0	0	0	0	2	0
Euclymene sp.	P	17	0	13	0	4	0	0	0	0	0	0
Euclymene sp. B	P	2	0	2	0	0	0	0	0	0	0	0
Eudevenopus honduranus	A	412	34	71	31	96	24	26	58	9	22	41
Eulalia bilineata	P	3	0	0	0	0	1	0	0	0	2	0
Eulalia sanguinea	P	6	0	0	1	0	0	0	0	0	5	0
Eunice vittata	P	2	0	0	1	0	0	0	0	0	1	0
Eunice websteri	P	5	0	2	2	1	0	0	0	0	0	0
Eunicidae	P	3	0	1	2	0	0	0	0	0	0	0
Euprognatha rastellifera	O	1	0	1	0	0	0	0	0	0	0	0
Eurydice littoralis	O	15	1	7	2	5	0	0	0	0	0	0
Euryplax nitida	O	19	0	9	3	0	0	1	0	0	6	0
Eurythoe sp.	P	4	0	1	0	0	0	1	0	0	2	0

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Exogone lourei	P	11	0	0	11	0	0	0	0	0	0	0
Exogone sp.	P	69	0	26	0	23	0	1	0	0	19	0
Fabricia sp.	P	8	0	3	0	5	0	0	0	0	0	0
Filogranula sp.	P	3	0	0	3	0	0	0	0	0	0	0
Flabelligeridae	P	1	0	1	0	0	0	0	0	0	0	0
Gammaridae	A	1	0	0	0	0	1	0	0	0	0	0
Gammaridea	A	30	0	6	0	9	1	7	2	0	4	1
Gammaridea sp. A	A	2	0	1	0	0	0	0	0	0	0	1
Gammaridea sp. B	A	1	0	1	0	0	0	0	0	0	0	0
Gastrochaena hians	M	6	0	1	0	0	0	0	0	0	5	0
Gastropoda	M	58	3	24	21	6	0	1	0	2	1	0
Genetyllis castanea	P	1	0	0	1	0	0	0	0	0	0	0
Glottidia pyramidata	O	73	1	11	11	15	0	8	6	0	20	1
Glycera americana	P	86	14	12	22	0	15	0	0	23	0	0
Glycera asymmetrica	P	2	2	0	0	0	0	0	0	0	0	0
Glycera oxycephala	P	23	0	4	0	3	0	4	1	0	0	11
Glycera papillosa	P	157	39	2	102	0	7	0	0	7	0	0
Glycera robusta	P	1	0	0	1	0	0	0	0	0	0	0
Glycera sp.	P	58	1	18	0	18	0	11	6	0	3	1
Glycerea	P	3	0	0	0	0	0	2	1	0	0	0
Glycymeris americana	M	1	0	0	0	0	1	0	0	0	0	0
Glycymeris undata	M	1	0	0	0	0	0	0	0	0	1	0
Goneplacidae	O	1	0	0	0	0	0	0	0	0	1	0
Goniada littorea	P	48	1	7	0	3	6	8	4	0	11	8
Goniadidae	P	22	0	0	0	0	0	6	0	0	16	0
Goniadides carolinae	P	54	1	40	0	13	0	0	0	0	0	0
Grubeulepis sp.	P	1	0	1	0	0	0	0	0	0	0	0
Haminoea solitaria	M	2	2	0	0	0	0	0	0	0	0	0
Hargeria rapax	O	3	0	3	0	0	0	0	0	0	0	0
Harmothoe sp.	P	2	0	0	0	0	0	1	0	0	1	0
Haustoriidae	A	1	0	1	0	0	0	0	0	0	0	0
Hemipholis elongata	O	1	1	0	0	0	0	0	0	0	0	0
Hepatus pudibundus	O	1	0	0	0	0	0	0	0	0	1	0
Hesionidae	P	50	0	6	24	4	1	4	0	1	9	1
Hesionura sp.	P	18	0	0	15	3	0	0	0	0	0	0
Heterocrypta granulata	O	6	0	1	1	1	0	0	0	0	3	0
Heteropodarke heteromorpha	P	4	0	1	1	1	0	0	1	0	0	0
Heteropodarke sp.	P	6	0	0	1	4	1	0	0	0	0	0
Hippomedon serratus	A	2	0	0	0	2	0	0	0	0	0	0
Hippomedon sp.	A	1	0	0	1	0	0	0	0	0	0	0
Holothuroidea	O	1	0	0	0	0	0	0	0	0	1	0
Holothuroidea sp. A	O	1	0	0	0	0	0	0	1	0	0	0
Horoloanthura irpex	O	4	0	0	4	0	0	0	0	0	0	0
Hydroides dianthus	P	2	0	0	2	0	0	0	0	0	0	0
Hydroides microtis	P	1	0	1	0	0	0	0	0	0	0	0
Hydroides sp.	P	1	0	0	0	0	0	0	0	0	1	0
Hypsicomus phaeotaenia	P	1	0	0	0	0	0	0	0	0	1	0
Idoteidae	O	5	0	0	0	5	0	0	0	0	0	0
Isolda pulchella	P	33	0	22	0	4	0	1	0	0	6	0
Isopoda	O	2	0	0	1	1	0	0	0	0	0	0
Kinbergonuphis sp.	P	9	1	4	1	1	0	0	2	0	0	0

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Laonice cirrata	P	11	0	2	0	0	0	0	0	0	5	4
Latreutes parvulus	O	5	2	2	1	0	0	0	0	0	0	0
Leitoscoloplos fragilis	P	15	0	1	0	2	1	1	3	4	0	3
Leitoscoloplos robustus	P	1	0	1	0	0	0	0	0	0	0	0
Leitoscoloplos sp.	P	2	0	0	0	0	0	2	0	0	0	0
Lembos smithi	A	1	0	0	0	1	0	0	0	0	0	0
Lembos sp.	A	61	0	38	0	15	0	0	0	0	8	0
Lepidasthenia sp.	P	1	0	0	0	0	0	1	0	0	0	0
Lepidonotus sublevis	P	1	0	0	1	0	0	0	0	0	0	0
Leptochela papulata	O	2	0	0	2	0	0	0	0	0	0	0
Leptochela serratorbita	O	7	0	5	0	0	0	0	2	0	0	0
Leptochela sp.	O	3	0	0	1	0	0	0	0	2	0	0
Leptognathia caeca	O	66	19	2	37	3	1	0	0	4	0	0
Leucon sp.	O	1	0	0	0	0	0	0	0	1	0	0
Lijeborgidia sp. A	A	5	0	0	5	0	0	0	0	0	0	0
Liljeborgia sp.	A	1	0	0	0	1	0	0	0	0	0	0
Listriella barnardi	A	2	0	0	0	0	0	0	0	0	1	1
Litocorsa sp.	P	1	0	0	1	0	0	0	0	0	0	0
Loimia medusa	P	3	0	0	0	0	0	0	0	0	3	0
Lucifer faxoni	O	15	1	1	2	2	2	4	1	0	2	0
Lucina nassula	M	1	0	0	0	0	0	0	0	0	1	0
Luconacia incerta	A	6	0	0	0	2	0	0	0	0	4	0
Luidia clathrata	O	1	0	0	0	0	0	1	0	0	0	0
Lumbricalus dayi	P	2	0	0	0	0	0	0	0	0	2	0
Lumbrinerides sp.	P	1	1	0	0	0	0	0	0	0	0	0
Lumbrineris cruzensis	P	59	0	12	0	3	0	7	5	0	29	3
Lumbrineris sp.	P	2	0	0	2	0	0	0	0	0	0	0
Lyonsia hyalina	M	2	0	0	0	0	0	0	0	0	0	2
Lysianopsis alba	A	1	0	0	0	0	0	0	0	0	1	0
Lysilla sp.	P	1	0	0	0	0	0	0	0	0	1	0
Lytechinus variegatus	O	1	1	0	0	0	0	0	0	0	0	0
Macroclymene sp.	P	6	0	0	0	0	0	0	0	0	6	0
Maera caroliniana	A	53	0	12	0	9	0	0	0	0	32	0
Magelona sp.	P	180	1	11	0	4	5	50	9	0	97	3
Magelonidae	P	1	0	0	0	0	0	0	0	1	0	0
Majidae	O	1	0	0	0	0	0	0	0	0	1	0
Maldanidae	P	56	0	25	0	31	0	0	0	0	0	0
Mastobranchus sp.	P	5	0	5	0	0	0	0	0	0	0	0
Mediomastus ambiseta	P	5	0	0	0	0	0	0	0	0	5	0
Mediomastus californiensis	P	146	0	14	0	1	2	15	8	0	106	0
Mediomastus sp.	P	236	0	7	0	1	1	75	17	6	129	0
Megalomma sp.	P	2	0	2	0	0	0	0	0	0	0	0
Melinna maculata	P	5	0	0	0	0	0	0	0	0	5	0
Melita nitida	A	11	0	5	0	4	0	1	1	0	0	0
Melita sp.	A	8	2	0	0	0	0	6	0	0	0	0
Melitidae	A	18	0	3	0	3	1	0	0	0	10	1
Mellita sp.	O	112	6	4	1	10	9	4	11	22	2	43
Melphidippidae	A	66	32	2	24	0	2	0	0	6	0	0
Mercenaria mercenaria	M	3	0	1	1	0	0	1	0	0	0	0
Mesochaetopterus sp.	P	2	0	0	0	0	1	0	1	0	0	0
Mesorhoea sexspinosa	O	1	0	0	0	0	0	0	0	0	1	0

Appendix 3. Total abundance (#/ 0.4m^2) of each species in all strata sampled in and around the Charleston ODMDS during September 2002.
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Metapenaeopsis goodei	O	1	0	1	0	0	0	0	0	0	0	0
Metharpinia floridana	A	138	5	42	39	42	4	1	1	0	1	3
Microphthalmus sp.	P	2	0	2	0	0	0	0	0	0	0	0
Microprotopus raneyi	A	2	0	0	0	0	0	0	0	0	2	0
Microspio pigmentata	P	330	1	3	310	0	0	0	0	16	0	0
Mitrella sp.	M	7	0	7	0	0	0	0	0	0	0	0
Moira atropos	O	7	0	0	0	1	0	3	2	1	0	0
Monopylephorus rubroniveus	O	2	0	0	0	0	0	0	0	2	0	0
Monticellina sp.	P	37	0	13	0	1	0	2	0	0	21	0
Muricidae	M	1	1	0	0	0	0	0	0	0	0	0
Myriochele oculata	P	224	0	35	3	10	0	88	11	0	76	1
Mystides borealis	P	1	0	0	0	0	1	0	0	0	0	0
Mytilidae	M	9	0	1	0	2	0	0	0	0	6	0
Nassarina glypta	M	39	1	13	0	5	0	5	3	0	10	2
Nassarius trivittatus	M	1	1	0	0	0	0	0	0	0	0	0
Natica pusilla	M	170	5	13	12	22	6	33	20	0	46	13
Natica sp.	M	1	0	0	0	0	0	0	0	1	0	0
Naticidae	M	8	0	0	7	1	0	0	0	0	0	0
Nemertea	O	624	34	49	63	53	29	121	47	15	185	28
Neopanope sayi	O	3	0	0	0	1	0	0	0	0	2	0
Nephtys picta	P	73	7	8	7	16	8	9	4	5	1	8
Nephtys simoni	P	29	4	11	3	3	4	1	1	2	0	0
Nephtys sp.	P	1	0	0	0	0	0	0	0	0	0	1
Nephtys squamosa	P	9	0	6	0	3	0	0	0	0	0	0
Nereididae	P	32	0	6	1	5	0	4	4	0	11	1
Nereiphylla fragilis	P	5	0	2	0	1	0	0	1	1	0	0
Nereis acuminata	P	1	0	0	0	0	0	0	1	0	0	0
Nereis falsa	P	23	0	15	0	1	0	0	0	0	7	0
Nereis micromma	P	11	0	6	0	0	0	0	0	0	5	0
Nereis sp.	P	3	0	3	0	0	0	0	0	0	0	0
Nereis succinea	P	1	0	1	0	0	0	0	0	0	0	0
Notomastus hemipodus	P	2	0	1	0	0	0	0	0	0	1	0
Notomastus sp.	P	11	0	3	0	2	0	0	1	0	5	0
Nucula sp.	M	48	4	0	0	2	25	6	4	0	7	0
Nudibranchia	M	1	0	1	0	0	0	0	0	0	0	0
Odontosyllis enopla	P	2	0	0	0	0	0	0	0	0	2	0
Odostomia sp.	M	5	0	4	0	1	0	0	0	0	0	0
Oedicerotidae	A	1	1	0	0	0	0	0	0	0	0	0
Ogyrides alphaerostris	O	20	2	4	0	7	2	1	2	1	1	0
Oligochaeta	O	227	12	35	78	38	3	3	6	0	42	10
Olivella mutica	M	8	0	0	0	0	0	0	5	3	0	0
Olivella sp.	M	38	0	1	7	6	0	0	3	0	8	13
Onuphidae	P	2	0	1	0	1	0	0	0	0	0	0
Onuphis eremita	P	28	6	0	1	2	4	4	6	0	2	3
Opheliidae	P	5	0	1	0	2	0	2	0	0	0	0
Ophiolepis elegans	O	1	0	1	0	0	0	0	0	0	0	0
Ophiophragmus pulcher	O	1	0	0	1	0	0	0	0	0	0	0
Ophiophragmus septus	O	1	0	0	0	0	0	1	0	0	0	0
Ophiophragmus sp.	O	1	0	1	0	0	0	0	0	0	0	0
Ophiuroidea	O	44	9	5	12	5	3	1	3	0	4	2
Opisthodonta sp.	P	1	0	0	0	0	0	0	0	0	1	0

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Owenia fusiformis	P	118	2	3	19	2	3	16	21	3	40	9
Oxyurostylis smithi	O	64	8	10	6	22	3	5	1	1	2	6
Paguridae	O	3	0	2	0	0	1	0	0	0	0	0
Paguridea	O	16	0	2	1	5	1	2	0	0	3	2
Pagurus sp.	O	19	0	11	0	1	0	0	0	0	7	0
Palola siciliensis	P	17	0	0	17	0	0	0	0	0	0	0
Parametopella cypris	A	4	0	1	0	0	0	0	0	0	0	3
Paraonidae	P	30	0	4	7	1	0	1	1	9	5	2
Paraonis fulgens	P	11	0	0	9	0	1	0	0	1	0	0
Paraonis pygoenigmatica	P	1	0	1	0	0	0	0	0	0	0	0
Parapionosyllis sp.	P	47	0	3	28	14	0	0	0	0	2	0
Paraprionospio pinnata	P	29	1	2	0	1	0	8	12	0	5	0
Parvilucina multilineata	M	504	21	71	2	140	26	84	67	0	37	56
Pelecypoda	M	209	15	24	12	18	1	7	28	12	16	76
Pelecypoda sp. B	M	16	0	3	0	8	0	3	1	0	0	1
Pelecypoda sp. F	M	26	0	10	0	16	0	0	0	0	0	0
Pelecypoda sp. J	M	1	0	0	0	0	0	0	1	0	0	0
Pelecypoda sp. K	M	1	0	1	0	0	0	0	0	0	0	0
Penaeidae	O	2	0	0	0	1	0	0	0	0	1	0
Penaeoidea	O	1	0	0	0	1	0	0	0	0	0	0
Persephona mediterranea	O	2	0	2	0	0	0	0	0	0	0	0
Petaloproctus sp.	P	7	0	0	5	0	2	0	0	0	0	0
Pholoe minuta	P	8	0	0	4	4	0	0	0	0	0	0
Phoronida	O	2	0	0	0	0	0	2	0	0	0	0
Photis macrocoxa	A	20	0	3	0	0	1	0	0	0	16	0
Phoxocephalidae	A	4	0	2	1	0	0	0	1	0	0	0
Phyllodoce arenae	P	17	1	3	5	4	1	1	0	1	0	1
Phyllodoce longipes	P	1	0	1	0	0	0	0	0	0	0	0
Phyllodocidae	P	12	0	2	1	1	0	0	0	0	7	1
Pilargidae	P	7	0	0	7	0	0	0	0	0	0	0
Pilargis sp.	P	1	0	0	0	0	0	0	0	0	1	0
Pinnixa sp.	O	23	1	5	1	0	2	2	1	3	5	3
Pinnotheres ostreum	O	1	0	1	0	0	0	0	0	0	0	0
Pinnotheridae	O	3	0	0	1	1	0	0	1	0	0	0
Pionosyllis gesae	P	137	0	34	25	73	0	2	1	0	1	1
Pionosyllis sp.	P	2	1	0	0	0	0	0	0	0	1	0
Piromis roberti	P	3	0	0	1	0	0	0	0	0	2	0
Pisione remota	P	61	0	9	37	6	0	0	0	0	9	0
Pista sp.	P	1	1	0	0	0	0	0	0	0	0	0
Pitar sp.	M	1	0	0	0	0	0	1	0	0	0	0
Plakosyllis quadrioculata	P	40	0	7	15	18	0	0	0	0	0	0
Podarke sp.	P	2	0	0	0	2	0	0	0	0	0	0
Podarkeopsis levifuscina	P	36	0	10	16	0	0	2	0	6	2	0
Poecilochaetus johnsoni	P	4	0	0	0	0	0	3	0	1	0	0
Polinices duplicatus	M	6	1	0	3	1	0	0	0	1	0	0
Polychaeta	P	6	0	0	5	1	0	0	0	0	0	0
Polychaeta sp. D	P	1	0	0	0	0	0	0	1	0	0	0
Polychaeta sp. F	P	1	0	0	0	1	0	0	0	0	0	0
Polycirrus sp.	P	8	0	0	0	0	0	0	0	1	6	1
Polydora cornuta	P	21	1	8	0	2	0	1	0	0	9	0
Polydora socialis	P	20	7	1	6	0	0	0	0	0	6	0

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Polydora sp.	P	17	0	5	4	0	0	0	0	0	8	0
Polygordiidae	O	1914	71	263	201	157	242	166	278	103	139	294
Polynoidae	P	13	0	0	2	0	0	0	4	0	1	6
Polyodontes lupina	P	4	0	0	0	0	0	1	1	0	2	0
Polyplacophora	M	9	0	1	8	0	0	0	0	0	0	0
Portunus sp.	O	1	0	0	0	1	0	0	0	0	0	0
Prionospio cirrifera	P	133	38	12	28	3	47	0	0	2	2	1
Prionospio cirrobranchiata	P	13	0	1	0	1	0	2	0	0	9	0
Prionospio cristata	P	831	0	215	139	78	27	75	49	35	182	31
Prionospio dayi	P	315	8	8	7	48	51	33	63	2	27	68
Prionospio sp.	P	265	1	81	0	21	2	46	15	3	94	2
Prionospio sp. A	P	13	3	2	0	0	2	0	0	0	6	0
Processa sp.	O	19	1	15	0	2	0	1	0	0	0	0
Protohaustorius deichmannae	A	134	13	4	2	9	14	0	15	33	3	41
Pseudochama radians	M	2	0	0	0	0	0	0	0	0	2	0
Renilla reniformis	O	1	0	0	0	0	0	0	0	0	0	1
Rhepoxynius epistomus	A	802	53	64	60	133	86	32	173	55	36	110
Rhepoxynius hudsoni	A	23	23	0	0	0	0	0	0	0	0	0
Rudilemboides naglei	A	1	0	0	1	0	0	0	0	0	0	0
Sabellaria vulgaris	P	19	0	1	0	0	0	0	0	1	17	0
Sabellidae	P	4	0	2	1	0	0	0	1	0	0	0
Saccocirridae	P	2	0	0	2	0	0	0	0	0	0	0
Scaphopoda	M	1	1	0	0	0	0	0	0	0	0	0
Scolecolepides viridis	P	1	0	0	0	0	0	0	0	1	0	0
Scolelepis sp.	P	1	0	0	1	0	0	0	0	0	0	0
Scolelepis squamata	P	7	0	1	0	4	0	2	0	0	0	0
Scolelepis texana	P	6	0	0	1	2	0	0	0	0	0	3
Scoletoma ernesti	P	1	0	0	0	0	0	1	0	0	0	0
Scoletoma sp.	P	1	0	0	1	0	0	0	0	0	0	0
Scoletoma tenuis	P	101	0	27	0	0	0	1	0	0	73	0
Scoloplos rubra	P	18	1	2	0	3	2	1	3	0	5	1
Seila adamsi	M	1	0	0	0	0	0	1	0	0	0	0
Serpulidae	P	7	0	0	2	5	0	0	0	0	0	0
Sicyonia brevirostris	O	2	0	0	2	0	0	0	0	0	0	0
Sicyonia sp.	O	21	3	11	0	3	0	0	0	0	4	0
Sigalion sp.	P	1	1	0	0	0	0	0	0	0	0	0
Sigalionidae	P	1	0	0	0	0	0	0	0	0	1	0
Sigambra bassi	P	11	0	1	3	7	0	0	0	0	0	0
Sigambra sp.	P	8	0	0	0	1	0	1	1	0	0	5
Sigambra tentaculata	P	41	1	3	0	2	0	10	8	0	15	2
Sinum perspectivum	M	2	0	0	0	0	0	2	0	0	0	0
Sipuncula	O	251	3	26	93	28	0	13	5	3	80	0
Sphaeroma destructor	O	1	0	0	1	0	0	0	0	0	0	0
Sphaerosyllis aciculata	P	7	0	0	6	0	0	1	0	0	0	0
Sphaerosyllis glandulata	P	3	0	0	2	1	0	0	0	0	0	0
Sphaerosyllis longicauda	P	13	0	0	13	0	0	0	0	0	0	0
Sphaerosyllis piriferopsis	P	1	0	0	0	0	0	1	0	0	0	0
Sphaerosyllis sp.	P	14	0	5	2	4	0	0	0	0	3	0
Sphaerosyllis taylori	P	2	0	0	2	0	0	0	0	0	0	0
Spio pettiboneae	P	43	24	0	0	2	1	0	2	2	5	7
Spiochaetopterus costarum oculatus	P	7	0	0	0	0	0	1	1	0	4	1

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Spionidae	P	17	1	2	7	0	2	3	0	0	1	1
Spiophanes bombyx	P	113	11	15	14	17	5	15	13	1	7	15
Spiophanes missionensis	P	12	0	0	0	0	0	1	1	0	10	0
Sthenelais limicola	P	2	0	0	0	0	0	0	0	0	0	2
Streblospio benedicti	P	1	0	0	0	0	0	1	0	0	0	0
Streptospinigera heteroseta	P	1	0	0	1	0	0	0	0	0	0	0
Streptosyllis sp.	P	63	6	12	12	9	1	4	10	0	1	8
Strigilla mirabilis	M	288	37	5	5	18	48	22	33	34	2	84
Strombiformis bilineatus	M	20	0	4	0	1	0	2	1	0	11	1
Syllidae	P	38	4	4	19	4	0	2	0	1	4	0
Syllides bansei	P	2	0	0	1	1	0	0	0	0	0	0
Syllides floridanus	P	2	0	0	2	0	0	0	0	0	0	0
Syllides fulvus	P	1	0	1	0	0	0	0	0	0	0	0
Syllides sp.	P	5	0	0	4	1	0	0	0	0	0	0
Syllis prolifera	P	17	0	0	6	11	0	0	0	0	0	0
Syllis sp.	P	17	3	7	6	0	0	0	0	0	1	0
Syllis sp. B	P	2	0	0	0	0	0	0	0	0	2	0
Synchelidium americanum	A	52	7	8	4	3	4	9	10	0	2	5
Synelmis ewingi	P	59	0	5	15	0	0	0	0	0	39	0
Tanaidacea	O	6	0	2	4	0	0	0	0	0	0	0
Tellina aequistriata	M	2	0	0	0	0	0	2	0	0	0	0
Tellina agilis	M	221	36	5	17	0	34	6	21	99	3	0
Tellina alternata	M	5	5	0	0	0	0	0	0	0	0	0
Tellina iris	M	5	0	0	0	0	0	0	3	0	0	2
Tellina probrina	M	169	26	9	54	3	4	2	4	66	1	0
Tellina sp.	M	34	0	6	27	0	1	0	0	0	0	0
Tellinidae	M	303	2	42	0	103	0	21	38	0	26	71
Terebellidae	P	2	0	1	0	1	0	0	0	0	0	0
Terebra sp.	M	3	0	0	0	2	0	0	0	0	1	0
Tharyx acutus	P	6	0	0	0	0	0	2	0	2	0	2
Tiron sp.	A	2	0	0	0	2	0	0	0	0	0	0
Tiron triocellatus	A	71	17	12	12	17	3	0	0	10	0	0
Tiron tropakis	A	41	3	7	3	22	0	0	2	1	2	1
Trypanosyllis vittigera	P	5	0	0	5	0	0	0	0	0	0	0
Turbonilla sp.	M	30	7	6	2	0	1	2	5	0	6	1
Turridae	M	15	0	2	0	2	0	2	0	0	8	1
Unciola sp.	A	1	0	0	0	0	0	0	0	0	1	0
Upogebia affinis	O	18	0	9	0	1	0	4	0	0	4	0
Urosalpinx cinerea	M	2	2	0	0	0	0	0	0	0	0	0
Websterinereis tridentata	P	37	1	0	2	0	0	7	19	0	8	0
Xanthidae	O	2	0	0	2	0	0	0	0	0	0	0