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An Assessment of the Charleston Ocean Dredged Material Disposal Site and Surrounding Areas Prior to the 2018 Harbor Deepening: Sediment Characteristics and Macrobenthic Infaunal Community Composition

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Table of Contents

Executive Summary

A two-part monitoring program of the physical and biological condition of bottom habitats within and surrounding the newly expanded Charleston Ocean Dredged Material Disposal Site (ODMDS) was completed prior to and following initiation of dredge material placements associated with the 2018 Charleston Harbor Post 45 Deepening Project. The first part of the monitoring program, addressed in this report, assessed baseline sediment characteristics and associated benthic infaunal communities in zones within and adjacent to the ODMDS. The second part of the monitoring program, which is addressed in a separate report (Arendt et al. 2020), evaluated changes to bottom habitat, associated epifaunal organisms, and fish assemblages associated with dredge material placement. This assessment of the Charleston ODMDS relies on a sampling design utilized in previous monitoring efforts which established three discrete zones: disposal area, inner boundary and outer boundary. However, the overall footprint of the monitored area was expanded for this assessment due to the enlargement of the disposal area. Each zone was divided into strata, 4 strata within the disposal zone and 8 strata within each of the inner and outer boundary zones, for a total of 20 strata. The general configuration of inner and outer boundary strata established in previous monitoring studies was maintained, but the layout of strata within the disposal zone has been modified for the current study.

A total of 140 stations were sampled in and around the expanded Charleston ODMDS prior to the 2018 Charleston Harbor Post 45 Deepening Project. Benthic grab samples for sediment characteristics and benthic community analysis were collected at 4-10 randomly selected locations within each of the 20 strata. Ten samples were collected in each of the inner and outer boundary strata considered more likely to be impacted by sediment migration based on previous benthic studies and monitoring of currents, 5 samples were collected in each of the inner and outer boundary strata considered less likely to be impacted by sediment migration, 6 samples were collected from each of the two disposal zone strata within the 1993 ODMDS, and 4 samples were collected from each of the two previously unused disposal zone strata. Sediment characteristics included percent silt/clay, percent sand, percent $CaCO_3$, organic matter content, and grain size of the sand fraction. Macrobenthic community parameters evaluated included total density, number of taxa, density of general taxonomic groups, and overall community analysis.

The placement of dredged material into the Charleston ODMDS from the 1999-2002 Charleston Harbor Deepening Project, and from ongoing maintenance dredging, resulted in a number of physical and biological impacts to the areas surrounding the disposal zone, as well as anticipated impacts within the disposal zone. An assessment of sediment characteristics in 2000, partway through the 1999-2002 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 attributed to migration of dredged material from the placement area,

unauthorized dumping outside the designated site, and trailings from barges entering or exiting the placement area. Dredged 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 dredging operation of such materials, higher silt/clay and shell hash content was found in the disposal zone than surrounding boundary areas. However, analyses of 2002 sediment composition data, after completion of the 1999-2002 Charleston Harbor Deepening Project, indicated that percentages of silt/clay within the disposal zone were not significantly different than values in most of the strata in the inner and outer boundary zones. Likewise, organic matter levels in many strata in boundary zones adjacent to the 1993 ODMDS were not significantly different than levels in strata within the disposal zone.

In 2018, there was a high level of spatial variability in sediment characteristics over the expanded Charleston ODMDS sampling area, although sand was the dominant component of the sediment in all strata. Variability in sediment parameters was observed at all spatial scales: throughout the study area, between strata within zones (disposal, inner boundary, and outer boundary), and between stations within strata. Applying cluster analysis to the 2018 sediment data from the 20 strata yielded four statistically significant groups. The first group of strata, consisting of both previously used disposal zone strata, had surficial sediment characteristics that were the most distinct from the other strata, driven primarily by relatively high silt/clay and TOM content. The second group, consisting of the two inner and outer strata directly to the west of the active disposal zone, also contained elevated silt/clay and TOM levels, but to a lesser extent than observed in the disposal zone, in addition to having the finest-grained sand among all strata. This second group of strata, although located outside of previous disposal zone boundaries, continues to show potential changes from prior placement activities due to the transport of dredged sediment from the disposal zone via waves and currents and/or due to unauthorized placement activity. The third and fourth sediment-based groups of strata had surficial sediments with low silt/clay levels and coarser sand than the impacted groups, but the third group had a higher sand content while the fourth group had higher calcium carbonate content. The third group of strata, consisting of inner and outer boundary strata to the northwest and southwest and inner boundary strata to the east, had more finely-grained sand than the fourth group. Both sets of boundary strata to the west and the inner boundary strata to the east had sediment characteristics more like each other than to the sediment characteristics of the north/south boundary strata and the outer boundary strata to the east.

In an analysis of Charleston ODMDS benthic communities conducted after completion of the 1999-2002 Charleston Harbor Deepening Project, temporal comparisons of macrobenthic infauna from the baseline (1993-1994), interim (2000), and post-placement (2002) assessments indicated significant effects on community structure related to placement operations completed as part of the 1999-2002 Charleston Harbor Deepening Project. A general trend of decreased benthic abundance and reduced taxonomic richness was observed in strata to the west and northwest of the ODMDS. In strata to the east of the ODMDS, many biological metrics were not significantly different from baseline assessments.

In the 140 benthic macroinvertebrate infauna samples collected in 2018, more than 17,900 organisms representing 249 distinct taxa were collected and identified. As noted in the assessment of sediment characteristics, high variability was observed in benthic community characteristics at all spatial scales. Applying cluster analysis to the 2018 benthic community data yielded eleven significantly different groups of strata that were simplified to five main groups for summarization. As observed in the 2018 sediment analysis, and consistent with patterns observed in previous assessments, the boundary strata in the western portion of the 2018 study area had benthic community characteristics more similar to each other, and more similar to the characteristics of the disposal strata located within the 1993 ODMDS, than to the strata to the east. One of the previously active disposal strata contained a benthic community most similar to a neighboring pair of inner/outer strata to the west, and the other previously active disposal stratum contained a benthic community most similar to that of a set of three inner and outer boundary strata to the north and west. The strata with the most distinct benthic community characteristics in 2018 were located in the northeastern corner (two strata in a previously unstudied area) and in the south; these three strata were characterized by high benthic infaunal densities and overall taxonomic richness (particularly polychaete richness), as well as relatively low amphipod densities. These benthic community results contrasted with the sediment results, where the strata most different from the others were the two previously active disposal zone strata.

The sediment characteristics and macrobenthic invertebrate infaunal community data presented in this report represent baseline data, for the purpose of characterizing these features in the newly expanded Charleston ODMDS prior to the beginning of the 2018 Charleston Harbor Post 45 Deepening Project. Based on the findings from the present assessment, sediment characteristics and benthic communities in the boundary areas surrounding the recently expanded ODMDS, particularly to the west of the disposal zone, continue to show sediment characteristics more similar to the disposal zone, likely from prior placement activities. The post-assessment, after the 2018 Charleston Harbor Post 45 Deepening Project is complete, will enable an evaluation of any additional changes to the sediment characteristics and macrobenthic infaunal community as a result of new dredged sediment placement, as well as detection of changes to inner or outer boundary strata as a result of potential drift of placed sediment out of the ODMDS.

Introduction

The Charleston, South Carolina, Ocean Dredged Material Disposal Site (ODMDS) is one of the most active and frequently used sites in the South Atlantic Bight. It has historically been used primarily by the U.S. Army Corps of Engineers (USACE) and the South Carolina State Ports Authority (SCSPA) to dispose of bottom sediments derived from maintenance dredging and deepening projects in the Charleston Harbor estuary and entrance channel (Charleston ODMDS Site Management and Monitoring Plan (SMMP) 2016). Since 1987, approximately 52 million cubic yards of dredged material have been placed within the Charleston ODMDS and it is estimated that an additional 65 million cubic yards of dredge material emanating from new work and maintenance dredging will be placed in the disposal site over the next twenty-five years (SMMP 2016).

The original Management Plan for ocean dredged material placement for the Charleston Harbor complex (1987) established a smaller permanent ODMDS 2.8 x 1.1 nautical miles in size, surrounded by a larger ODMDS 5.3 x 2.3 nautical miles in size (Figure 1). The smaller ODMDS was designated for continuous placement of bottom sediments from maintenance dredging in the harbor and entrance channel while the larger ODMDS was initially designated to be used for seven years (1987-1994) specifically to receive bottom sediments from the Charleston Harbor Deepening Project. However, placement activities within the smaller ODMDS were found to impact previously unidentified live bottom habitat present within the site resulting in a re-designation of the site boundaries to avoid impacting these critical areas (Winn et al. 1989).

The re-designated ODMDS was established in 1993 by an Interagency Task Force and consists of a four-square mile area contained within the larger ODMDS site, partially overlapping with the original smaller ODMDS (Figure 1). The 1993 ODMDS was also re-designated to receive all placement materials permitted for offshore placement including maintenance dredging and deepening materials. Additionally, the seven-year time limit was eliminated, and the site was promulgated for “continued use”. Baseline data for the 1993 ODMDS were collected to characterize conditions in and around the site prior to receiving dredged bottom sediments (Van Dolah et al. 1997). Additionally, the Task Force developed a Management Plan for the 1993 ODMDS, including comprehensive monitoring of the site, set forth in the Charleston ODMDS SMMP (SMMP 1993). This Management and Monitoring Plan established three discrete zones; Disposal, Inner Boundary and Outer Boundary, which have been used in subsequent monitoring efforts to examine impacts in and around the disposal zone. Implementation of this site plan also required the construction of an L-shaped berm on the western side of the 4 square mile disposal zone made up of harder and more cohesive materials intended to serve as a barrier against the transport of deposited dredge material away from the disposal zone. Monitoring efforts focused on tracking changes in sediment and benthic community composition within these zones as well as transport of deposited sediment away from the disposal zone.

Following the re-designation of the ODMDS and approval of the new SMMP in 1995, placement of new work dredge material from the Charleston Harbor Deepening Project within the 1993 ODMDS began in 1999 and continued through 2002. Monitoring of the site was initiated before placement of material began and continued at regular intervals through to the end of the project including both an interim and final assessment performed by SCDNR (Jutte et al. 2001, 2005). Results of these efforts are detailed below.

Following the improvements to navigation effected by the 1999-2002 Charleston Harbor Deepening Project, the USACE Charleston District proposed several additional modifications to accommodate the needs of future shipping traffic, specifically the deepening and widening of portions of the federal navigation channel. In anticipation of the larger volumes of dredge material derived from both the dredging and increases in maintenance dredging required by this project, to begin in 2018, the USACE requested modifications to the existing ODMDS and the development of a new SMMP. The newly established ODMDS has a total area of 9.8 mi^2; the western side of the current ODMDS contains the 1993 ODMDS, and the eastern side of the current ODMDS consists of an area not previously used for dredge material placement (Figure 2). The SMMP for the new ODMDS (SMMP 2016) requires monitoring that utilizes the same zone designations (Disposal, Inner Boundary, Outer Boundary) and similar strata configuration as previous monitoring efforts as well as the construction and monitoring of a new U-shaped berm consisting of consolidated material arising from new work dredging. The focus of this monitoring effort is to document baseline conditions within the newly expanded ODMDS, and the Inner and Outer Boundary areas, prior to new placement activities.

The Charleston ODMDS, due to its status as one of the most frequently used sites in the South Atlantic Bight, is consequently one of the most extensively monitored. Monitoring efforts have included bathymetric surveys, examination of sediment characteristics and contamination, gamma isotope mapping of bottom sediments, assessment of macrobenthic infaunal invertebrate communities, and hydrographic surveys.

The USACE has conducted bathymetric surveys of the Charleston ODMDS and surrounding area since 1972 (Winn et al. 1989). The purpose of these surveys has been to identify the location and shape of sediment mounds formed by the placement of dredged material within the site and to determine whether these mounds were stable.

Multiple monitoring studies of the Charleston ODMDS have examined sediment composition and chemistry, including gamma isotope mapping and chemical contaminants, as well as collection of surficial sediments in conjunction with macrobenthic infaunal community sampling. Nearshore sediments in the Charleston Harbor area primarily consist of fine-grained sands with some river-derived silts (USACE 1987). The earliest assessment of sediment characteristics and contamination was completed in 1978 by the South Carolina Wildlife and Marine Resources Department (SCWMRD 1979). This study provided baseline sediment composition data from 40 sites and contaminant data from 24 sites within the Charleston ODMDS (SCWMRD 1979, Van Dolah et al. 1983). Additional testing of sediments was conducted at a limited number of sites (10) by Interstate Electronic Corporation (IEC) in 1979 (USEPA 1983). Neither of these studies found elevated contaminant levels within the ODMDS.

A subsequent study of sediment composition and contamination conducted a decade later sampled 28 sites within the ODMDS and surrounding areas and found that contaminant levels were not elevated above the baseline range detected in the 1978 SCWMRD study (Winn et al. 1989). This study did identify minor changes in sediment characteristics resulting from movement of some deposited material away from the site, but surficial sediment composition outside the placement area appeared mostly unchanged.

A re-designation of the boundaries of the ODMDS in 1993, to form a new four-square-mile disposal zone, created the need for a new baseline assessment of sediment composition and contamination. In 1993 and 1994, a total of 200 sediment samples each year were collected in and around the disposal zone as part of the new baseline assessment (Van Dolah et al. 1996, 1997). Analysis of these samples showed that the dominant sediment type in the ODMDS was fine-grained sands with variable concentrations of silt/clay and shell hash. In 1993, relatively high concentrations of silt/clay (>10%) were found within the disposal zone. However, sampling in 1994 found that most of these muddy sediments had dispersed. Contaminant analysis of 40 composite sediment samples collected during the 1993-1994 assessment showed the presence of metal contaminants, but contaminant concentrations were generally below concentrations of concern (Van Dolah et al. 1996, 1997).

Additional sediment composition and contaminant assessments of the ODMDS were completed in 2000, approximately half-way through the 1999-2002 Charleston Harbor Deepening Project (Jutte et al. 2001), and again in 2002 following the completion of this project (Jutte et al. 2005). Comparison of results from the pre-impact (1993-1994) and interim (2000) assessments with results from the final post-impact assessment (2002) showed changes in the silt/clay and shell hash content of bottom sediments both within the placement area as well as in the inner and outer boundary zones, indicating that impacts from placement activities were not limited to the disposal zone. Possible drivers of this change include the migration of deposited sediments from the disposal site and unauthorized dumping of dredged material outside the disposal zone (Jutte et al. 2005). These assessments also found that contaminant levels within the disposal zone and surrounding areas were relatively low and fell below published concentrations of concern for PAHs, PCBs, pesticides, and metals, with the exception of cadmium which was found to be elevated above the concentration of concern threshold in one stratum within the disposal zone. Detection levels for six of the contaminants were higher than published bioeffects thresholds and therefore were not adequately assessed by this study.

Dredge material placed within the Charleston ODMDS consists primarily of fine-grained inner harbor sediments with higher amounts of shell hash in the entrance channel, which have a different chemical signature than the nearshore sediments that naturally occur in the area of the Charleston ODMDS. This difference allows the placement and movement of dredge material to be tracked using a gamma isotope mapping system (GIMS). The USEPA in partnership with the University of Georgia's Center for Applied Isotope Studies (CAIS) completed multiple surveys of the bottom sediment chemistry of the Charleston ODMDS between 1988 and 1994 (Noakes 1995). The results of this survey indicated the isotope chemistry of the bottom was relatively homogeneous within the smaller 1987 ODMDS disposal site. In addition, multiple surveys using this method conducted in 1991, 1993 and 1994 were able to track the dispersal of dredge material away from the site within the larger 1987 ODMDS (Noakes 1995). Based on the observed dispersal pattern an L-shaped berm around the smaller placement area was constructed with the goal of preventing movement of dredge material away from the replacement area.

The communities of macrobenthic infaunal invertebrates, which are important prey items for many fish and crustacean species as well as indicators of change in the benthic environment, have been monitored since 1978. The initial assessment of the ODMDS found no major differences in the benthic communities sampled within the larger ODMDS compared to adjacent areas (Van Dolah et al. 1983). An additional baseline assessment of benthic communities within the larger ODMDS was conducted by IEC (EPA 1983). This study also indicated no difference in benthic communities between the placement area and adjacent areas.

The SCWMRD completed an updated assessment in 1987 in response to proposed changes to the ODMDS intended to mitigate the effects of placement activities on previously unidentified live bottom habitats within the original site (Winn et al. 1989). Benthic sampling in this study was designed with sampling stations positioned to measure potential migration of dredge material from the disposal zone to surrounding areas and to assess potential changes in the benthos caused by movement of this material. This assessment detected some movement of dredge material away from the site and associated changes in benthic community structure (Winn et al. 1989); however, benthic communities surrounding the smaller ODMDS did not appear to be significantly impacted.

Baseline macrobenthic infaunal community data were collected in 1993 and 1994 following the re-designation of the boundaries of the ODMDS (Van Dolah et al. 1996, 1997). The benthic community sampling design included three zones – disposal, inner boundary, and outer boundary – established within the ODMDS by 1993 SMMP. A total of 200 stations, located within 20 strata arranged in and around the newly established placement site, were sampled each year. Taxonomic analysis of these benthic samples indicated variation in species composition, faunal density and number of species across zones and strata. The density of some taxonomic groups was found to be related to sediment type, indicating that changes in sediment composition caused by placement activities may result in changes to the benthic community.

More recent studies of Charleston ODMDS benthic communities were conducted in 2000, after partial completion of the 1999-2002 Charleston Harbor Deepening Project, and again in 2002 upon the completion of this project, to assess related impacts. Zimmerman and others (2002) conducted the interim assessment of ODMDS bottom habitats in 2000 using 20 strata divided among the previously established monitoring zones. Strata were classified as impacted or non-impacted based on their location in relation to the ODMDS and the dominant currents in the area which made them more or less likely to be impacted by placement activities. Impacted strata were identified west and northwest of the disposal zone while non-impacted strata were located to the east of the disposal zone. A comparison of benthic communities between impacted and non-impacted strata revealed differences in the numerically dominant species present, likely driven by a preference of these species for the different sediment types present in each strata type. Impacted strata were dominated by several species that prefer muddy sediments while non-impacted strata were not, indicating that the nearly continuous placement of fine-grain sediments that has occurred since 1988 within these impacted sites had changed the sediment composition of strata to the west and northwest of the disposal zone, and consequently their associated macrobenthic infaunal assemblages. However, Zimmerman and others (2002) characterized these changes as subtle.

The most recent post-impact assessment of the ODMDS benthic community was completed in 2002 following the completion of the 1999-2002 Charleston Harbor Deepening Project (Jutte et al. 2005). Comparisons between impacted and non-impacted strata found a significantly greater abundance and diversity of major taxonomic groups (mollusks, amphipods, polychaetes) in non-impacted areas relative to impacted areas. Cluster analysis showed that the benthic community structure, including species composition and relative abundance, was similar within impacted strata. This analysis also identified similarities in these metrics between some impacted and non-impacted strata indicating either recovery of benthic communities in some impacted strata or placement-related impacts occurring in “non-impacted” strata. Examination of the ten dominant taxa collected in the post-impact study revealed that five of these species were significantly less abundant in impacted strata than in non-impacted strata while only one species was found in greater abundance in impacted areas. The remaining four dominant species showed no variation in their abundance between impacted and non-impacted strata. This assessment concluded that patterns of abundance of individual species is likely a consequence of physiological or behavioral responses to changes in sediment characteristics related to placement activities.

Comparison of results from the 1993-1994 baseline assessment (Van Dolah et al. 1996, 1997), the 2000 interim assessment (Zimmerman et al. 2002), and the 2002 post-placement assessment (Jutte et al. 2005), indicate significant changes to benthic community composition related to placement of dredge sediment associated with the 1999-2002 Charleston Harbor Deepening Project. Decreased overall infaunal abundance, reduced abundance of individual species, and decreased overall diversity was observed in impacted strata to the west and northwest of the ODMDS. Strata east of the disposal zone, classified as non-impacted, did not display a significant change in these metrics between the post-impact assessment and the baseline study (Jutte et al. 2005). Analysis of macrobenthic infauna data in the monitored strata indicated that the abundance and diversity of benthic taxa were altered in both impacted strata and non-impacted strata over time, suggesting that not all observed changes in the communities can be attributed to placement activities. Analysis of the five dominant taxa collected in the 1993-1994 assessment revealed a decline in the abundance of two of the dominant species between 1993-1994 and 2000-2002, due to physiological/behavioral responses to changes in sediment composition from placement activities and/or natural population fluctuations. The remaining three dominant taxa showed no change in abundance over time.

Many assessments of the Charleston ODMDS and surrounding area have included hydrographic data including water quality (water temperature, salinity, and dissolved oxygen) as well as wave and current data. The earliest assessment of the ODMDS in 1978 collected water quality data at 40 sites (SCWMRD 1979) and the IEC study the following year provided additional data from the larger ODMDS (EPA 1983). Water quality data were also reported in Winn et al. (1989), the 1993-1994 baseline assessment (Van Dolah et al. 1996, 1997), and the 2000-2002 impact assessment (Jutte et al. 2005).

Ocean currents in the area of the Charleston ODMDS were studied by the Environmental Protection Agency (EPA) in 1991 (SMMP 2005). The National Oceanographic and Atmospheric Administration (NOAA) collected additional current data in the seaward reaches of the Charleston Harbor Entrance Channel (Wilmot 1988). These data showed a predominantly north-by-northeast current present during the summer with a westerly component in the winter months. Southerly currents were minimal during these sampling periods. Subsequently, the NOAA National Ocean Service (NOS) Coastal Estuarine and Oceanography Branch (CEOB) measured currents from January 1994 through September 1995 using an acoustic Doppler current profiler (ADCP) to identify tidal, wind-driven and density-driven currents present in the Charleston ODMDS and surrounding area. From these data, it was concluded that currents flowed from northeast-to-southwest which could potentially transport dredged material to the benthic communities present in the southwest corner of the larger ODMDS (Williams et al. 1997).

A more recent study of waves and currents at the Charleston ODMDS conducted by the EPA from November 2012 through February 2014 also identified a significant tidal component to currents at the site (EPA 2014). Near-bottom currents monitored by two ADCP units deployed near the Charleston ODMDS predominantly flowed westward, but also flowed in an eastward direction more than 25% of the time. Although the net vector of bottom currents over the full study period extended to the west-northwest, the strongest bottom currents (>20 cm/sec) were most frequently observed flowing to the west-southwest.

The goal of this report is to characterize the sediment characteristics and the macrobenthic infaunal community to establish baseline conditions for the ODMDS and surrounding strata that can be used to identify potential changes resulting from the placement of dredge material within the ODMDS. If sediment is transported by waves and currents out of the disposal zone and into surrounding areas, these baseline data, in combination with post-impact monitoring data, can be used to understand the magnitude and direction of potential sediment movement and associated changes to the macrobenthic infaunal community.

Methods

Study Design

The current pre-impact assessment of the Charleston ODMDS relies on a sampling design utilized in previous monitoring efforts which established three discrete zones; disposal, inner boundary and outer boundary (Figure 3; Van Dolah et al. 1996, 1997). However, the overall footprint of the monitored area was expanded due to the enlargement of the disposal zone. Each zone was divided into strata; 4 strata within the disposal zone and 8 strata within each of the inner and outer boundary zones, for a total of 20 strata. The general configuration of inner and outer boundary strata established in previous monitoring studies was maintained, but the layout of strata within the disposal zone has been modified for the current study. Previous monitoring efforts have partitioned this zone into four square quadrants of equal size. The monitoring strata of the disposal zone in the current study consist of two large rectangles arranged side by side on the western portion of the site and two smaller rectangles arranged above and below one another on the eastern portion of the site (Figure 3). This layout is based on placement areas designated by the USACE for the 2018 Charleston Harbor Post 45 Deepening Project; each disposal stratum will receive dredge material from a specific subsection of the shipping channel or harbor area. The disposal zones D1 and D2 (4.8 and 3.2 km^2 respectively) have received dredge material from previous events, whereas D3 and D4 (1.2 and 1.9 km^2 respectively) have not.

A total of 140 stations were sampled in and around the expanded Charleston ODMDS prior to the 2018 Charleston Harbor Post 45 Deepening project (Figure 3); station coordinates are provided in Appendix 1. Ten paired sediment and macrobenthic infauna community samples were collected in each of the inner and outer strata considered more likely to be impacted by sediment migration based on previous research (SCDNR 2005) and monitoring of currents (EPA 2014) (Figure 3; I1, I6, I7, I8, O1, O6, O7, O8; 80 samples). Five samples were collected in each of the inner and outer zones considered less likely to be impacted by sediment migration (Figure 3; I2, I3, I4, I5, O2, O3, O4, O5; 40 samples). Two of the disposal zone strata were located within the 1993 ODMDS (Figure 3; D1, D2) and the other two disposal zone strata were located outside of the 1993 boundary but within the newly expanded ODMDS (Figure 3; D3, D4). Six samples were collected from each of the strata within the 1993 ODMDS (D1, D2; 12 samples) and four samples were collected from each of the strata within the expanded ODMDS (D3, D4; 8 samples).

Station locations were selected using stratified random sampling after applying a 100 m buffer to the inner boundary of each stratum to reduce edge effects and the potential for drifting off target while the sampler was deployed. In order to minimize impacts to hardbottom habitat, and because these areas were surveyed in a separate effort, any randomly selected station locations that fell within likely hardbottom habitat (e.g., the southern portion of zone O7) were replaced with randomly selected non-hardbottom locations.

Sampling within the disposal zone was designed to provide a reference for any potential changes to surface sediments or biota in the inner or outer zones caused by drift of existing material or biota derived from maintenance dredging, and to quantify how this potential source material changes as new material is added. Future monitoring of this area will follow a similar design, as in previous ODMDS monitoring efforts (e.g., SCDNR 2005), such that pre-impact and post-impact benthic habitat characteristics can be compared to assess any potential impacts.

Field and Laboratory

Pre-impact field sampling of the Charleston ODMDS was conducted on January 16, 17, and 19, 2018 using the SCDNR R/V Silver Crescent. Within each stratum, a single near-surface (approximately 0.3 meters beneath the water surface) and near-bottom (approximately 0.3 meters above the bottom) measurement of dissolved oxygen concentration, salinity, and water temperature was made using a YSI multi-probe. At each station, a single benthic grab sample was collected and retained using a Young grab that captures 0.044 m^2 of bottom surface area. Samples in which the grab did not penetrate to at least 8.0 cm (80% of the maximum grab volume) were considered invalid and resulted in immediate resampling of the station. Each grab sample was sub-sampled for analysis of sediment characteristics using a 3.5 cm diameter plastic tube inserted through the top of each grab to the bottom of the sample (up to 10 cm deep). The remaining 0.040 m^2 of the grab sample was used for benthic community analysis.

Sediment samples were analyzed to determine percentage (by weight) of clay, silt, sand, and calcium carbonate ($CaCO_3$) using the procedures described in Folk (1980) and Pequegnat and others (1981). Together, clay, silt, sand, and $CaCO_3$ make up 100% of the weight of a sediment sample. The mean sand grain diameter in each sample was determined by dry-sieving the sand fraction of the sediment through fourteen 0.5 phi-interval screens (-2.0, pebble gravel and larger, to 4.0, very fine sand) to separate it into size fractions. According to the Udden-Wentworth Phi classification (Brown and McLachlan 1990), phi = $-\log_2$[grain diameter in mm]). Each sand size fraction was weighed, and then the percentile-based Folk and Ward (1957) method was used to calculate mean sand phi. Percent total organic matter (TOM) was determined by drying a sample of whole sediment overnight at 70°C to remove water, weighing the dried sediment, combusting the dry sediment at 550°C in a muffle furnace for two hours to burn off the organic matter, and re-weighing the remaining sediment, as described by Plumb (1981). TOM analysis was performed on two replicate samples and the results were averaged.

The benthic community sample, representing 0.040 m^2 of bottom area, was washed through a 0.5 mm mesh sieve on the day of collection. Organisms and sediment retained on the sieve were preserved in a buffered solution of 10% formalin/seawater containing rose bengal stain. Macrobenthic invertebrates were sorted from retained material under a magnifying lens, and each individual organism was identified to the lowest possible taxonomic level using dissecting and compound microscopes.

All samples processed for sediment characteristics, benthic community sorting and taxonomy were subjected to a rigorous quality assurance (QA) process. Sediment samples for sand, silt, and clay determination were processed in batches of 10 with one out of every 10 samples being re-processed for QA by a different lab technician. If the percentage of the dominant sediment component varied more than 10% between the original measurement and the QA run then the original results were invalidated and the entire batch of ten was re-processed. A similar QA process, with a 10% difference threshold, was followed for the sorting and identification of benthic community samples.

The sediment and benthic community data for this study were submitted to USACE and are located in a Microsoft Access relational database stored on a backed-up SCDNR server.

Data Analyses: Sediment Characteristics

To test for the presence of groups of strata with sediment characteristics similar to each other and significantly different from the sediment characteristics of other groups, hierarchical cluster analysis was applied. The sediment data were transformed at the station-level to achieve a more normal distribution for sediment parameters with long-tail raw distributions. The data were subsequently averaged at the stratum level and then normalized; a Euclidean distance-based resemblance matrix was generated; and a similarity profile (SIMPROF) permutation test was applied. Because % silt and % clay were strongly correlated ($r = 0.98$), they were analyzed as a combined parameter (% silt/clay) instead of separately. To visualize relative similarity in sediment characteristics among strata, a non-metric Multi-Dimensional Scaling (nMDS) plot was constructed using 50 iterations from the same resemblance matrix used in the cluster analysis. The hierarchical cluster, similarity profile, and nMDS analyses were all run using the statistical analysis software PRIMER, version 7.

The results of station-level sediment characteristics were averaged across the stations within each stratum and within each sediment cluster to determine the mean (± SE) percent composition of each sediment component and the mean (± SE) sand phi. While previous monitoring studies have analyzed sediment characteristics and across zones (Disposal, Inner Boundary, Outer Boundary; Jutte et al. 2001), such comparisons were not made here due to the lack of similarity among strata within each zone observed in the cluster, similarity profile, and nMDS analyses. These within-zone differences are likely attributable to past sediment placements in the ODMDS, non-random current-driven movement of placed sediments, and the expansion of the disposal zone such that only two of the four disposal zone strata in this study have previously been used for placement of dredged sediment.

To visualize the spatial distribution of each sediment component within and between strata, station-level sediment characteristics results were mapped and interpolated over the full sampling area. The inverse distance weighting interpolation method (ArcGIS 10.3.1) was applied, which uses a 12-neighbor variable search radius to estimate values in between sample locations. In addition to sediment data from 2018, sediment data from 1993, 1994, 2000, and 2002 were also mapped to enable a visual assessment of the changes in the distribution of each sediment parameter over time. In 1993, 1994, 2000, and 2002, samples were collected at 200 stations each year; in 1994, however, the sediment parameters for seven stations did not add up to 100%, so the maps for 1994 are based on data from only 193 stations.

Data Analyses: Benthic Community

The original benthic community data set for this study was reviewed to exclude taxa not considered representative of the macrobenthic infaunal community. Excluded taxa included epifaunal species that require hard substrate and meiofaunal species (such as nematodes, copepods, and ostracods) that are not well quantified using a 0.5 mm sieve. After exclusion, epifaunal and meiofaunal species were not considered further in any of the data analyses.

To test for the presence of groups of strata with macrobenthic infaunal communities similar to each other and significantly different from the benthic communities of other groups, hierarchical cluster analysis was applied to stratum-averaged square-root transformed community data (transformation was used in order to down-weight numerically dominant taxa so that moderately abundant taxa would also contribute to community comparisons); a Bray-Curtis similarity-based resemblance matrix was generated; and similarity profile (SIMPROF) permutation tests were applied. To visualize relative similarity in benthic communities among strata, an nMDS plot was constructed using 50 iterations from the same resemblance matrix used in the cluster analysis. The hierarchical cluster, similarity profile, and nMDS analyses were all run using the statistical analysis software PRIMER, version 7.

Macrobenthic infaunal communities were also summarized using several different metrics: total organism density (number of individual organisms/m^2), taxonomic richness (number of unique taxa per station), proportional abundance of each taxonomic group, and density of each taxonomic group. These metrics and their standard errors were calculated at the stratum level and at the benthic community cluster level. For the purpose of calculating taxonomic richness, taxa which could not be identified to the lowest possible taxonomic level (due to damage or because they were in an early developmental stage) were merged with related taxa in the same sample (unless the organism clearly represented a unique taxon), in order to avoid overestimating the total number of taxa.

To visualize spatial patterns in total organism density, taxonomic richness, proportional abundance by taxonomic group, and density of each taxonomic group within and between strata, station-level benthic community results were mapped and interpolated over the full sampling area. The inverse distance weighting interpolation method (ArcGIS 10.3.1) was applied, which uses a 12-neighbor variable search radius to estimate values in between sample locations.

Results

Water Quality

Water quality measurements were taken at near-surface and near-bottom levels at a single location within each stratum at the time of benthic sampling (Appendix 2). Bottom water temperatures (10.8-14.5°C) tended to be slightly warmer than surface water temperatures (8.3-14.5°C), bottom salinities (36.4-37.5 psu) tended to be slightly higher than surface salinities (34.6-37.5 psu), and dissolved oxygen concentrations near the bottom (7.64-8.76 mg/L) tended to be slightly lower than near the surface (7.68-9.48 mg/L) but were not physiologically limiting in any strata. At the zone level, the mean near-bottom dissolved oxygen concentration was highest in the disposal zone (8.36 mg/L) and lowest in the outer boundary zone (8.21 mg/L).

Sediment Characteristics

Sediment analysis was performed on core samples extracted from the benthic grabs collected at all 140 stations (Appendix 3). Pooling data across all samples indicates that, in general, bottom sediments were dominated by sand (82.4%) mixed with moderate amounts of shell hash/$CaCO_3$ (14.6%), with smaller proportions of silt (1.2%) and clay (1.9%). Silt and clay levels were highly correlated (r=0.98), and therefore were analyzed throughout this report in combined form (% silt/clay). The mean TOM content was 3.3%.

To identify groups of strata with sediment characteristics similar to those of other strata within the group and significantly different from the sediment characteristics of other groups of strata, hierarchical cluster analysis and similarity profile permutation tests were applied to a multi-parameter sediment dataset averaged at the stratum level which included % sand, mean sand phi, and log(x+1) transformed % silt/clay, % $CaCO_3$, and % TOM. Four significantly different clusters of strata were identified (Figures 4-5): D1/D2 (cluster S1; shaded in dark green on the map); I7/O7 (S2; light green); D4, I3, I4, I6/O6, and I8/O8 (S3; yellow); and D3, I1/O1, I2/O2, O3, O4, and I5/O5 (S4; red). Cluster S1 included two strata in the western portion of the disposal zone, cluster S2 included one inner boundary and one outer boundary stratum to the west of the previously active disposal zone, cluster S3 included two strata each in the northwestern and southwestern inner and outer boundary zones as well as a disposal stratum and two inner boundary strata to the east of the disposal zone, and cluster S4 included eight strata in the eastern portion of the monitoring area, representing both inner and outer boundary zone strata in the north and south, and two outer boundary strata in the east (Figure 5). Sediment cluster S1 included both disposal zone strata used for dredged sediment placement prior to this study (D1 and D2). The other two disposal zone strata, which have not previously been used for sediment placement, were grouped into two separate clusters (D3 into cluster S4, and D4 into cluster S3). Given the distribution of strata across sediment-based clusters, with disposal zone strata categorized into three separate clusters (S1, S3, S4), inner boundary zone strata categorized into three separate clusters (S2, S3, S4), and outer boundary zone strata categorized into three separate clusters (S2, S3, S4), there is not a sound basis to pool data at the zone level (disposal, inner boundary, outer boundary) for baseline assessment purposes.

The Pearson correlation-based vectors on the sediment nMDS plot (Figure 4) indicate that the strata in cluster S1 (D1/D2) generally had higher silt/clay and TOM content as well as higher mean sand phi (finer sand) in comparison to other strata, and that the strata in cluster S2 (I7/O7) had higher silt/clay, finer sand, and lower $CaCO_3$ than the strata in clusters S3 and S4. Pooling sediment data at the sediment cluster level showed that cluster S1 (D1, D2; both previously active disposal zone strata) had the highest % silt/clay content (15.8%) and the lowest % sand content (64.4%) among the four clusters, as well as a high % $CaCO_3$ content (19.8%), comparable to the $CaCO_3$ level in cluster S4 (19.4%; Figure 6). Cluster S2 (two adjacent west-southwest inner and outer boundary strata; Figure 5), had the second-highest silt/clay content (4.1%). Clusters S1 and S2 also had the highest TOM content (4.4%, 4.0%, 3.6%, and 2.1% for S1, S2, S4, and S3, respectively) and the finest sand (mean sand phi was 2.69, 2.50, 2.38, and 1.90 for S2, S1, S3, and S4, respectively).

Stratum-level mean sand content ranged from 62.9% to 89.7% (Figures 7-8). The strata with the lowest mean sand content were located within the previously active disposal zone (D1= 62.9%; D2= 65.9%); all other strata had a sand content of >70% (Figure 8). Sand content at individual stations ranged from a low of 18.0% at disposal zone station D104, to a high of 95.8% at inner boundary station I810 (Appendix 3). While sediment characteristics summarized at the stratum level show the dominance of sand in all strata, seven stations were dominated by other sediment types; D104 and D206 consisted primarily of silt/clay (52% and 74%, respectively) and stations D106, I102, I202, O201, and O303 contained 54-71% $CaCO_3$. Strata that had a high degree of variability in sand content across stations, as reflected by a greater standard error (SE), include disposal strata D1 and D2, inner boundary stratum I2, and outer boundary strata O2 and O3 (Figure 8). These strata include stations that had either an elevated silt/clay content (D205, D206), an elevated $CaCO_3$ content (D101, D106, I102, I202, O201, O303), or a mix of both (D104). In some cases, stations that had unusually large proportions of non-sand sediment components were located only a short distance from each other, such as D104 and D206 or I202 and O201, on different sides of a stratum boundary (Figure 9). This illustrates the high degree of variability in sediment characteristics within some strata as well as similarities that exist in neighboring stations across strata boundaries.

The mean sand grain size (phi) of sampled strata ranged from 1.3 to 2.8, with an average of 2.2 which is classified as fine sand (Figure 10). The sand component of most strata fell in the fine sand category (mean phi 2.0-3.0), with the exception of three strata (I5, O3, and O5) which were classified as medium-grained (mean phi 1.0-2.0). Mean sand phi calculated at individual stations ranged from coarse sand (0.16; O305) to very fine sand (3.09; O705). While the sand component of a few stations was classified as coarse (phi < 1.0; Appendix 3), no strata fell into this category. The boundary area strata with the most variability in mean sand phi among stations (I2, I5, O3, O5), as indicated by a higher standard error (Figure 10), were all located in the eastern and southern portions of the study area (Figure 11).

The $CaCO_3$ content at the stratum level ranged from 8.5% to 25.3% (Figure 12). The $CaCO_3$ content at individual stations ranged between 2.6% (D206) and 70.7% (O201). Multiple strata displayed a high degree of variability in $CaCO_3$ content across stations (D1, I2, O2, O3), as indicated by high standard error (Figure 12); all four of these strata included a single station with a $CaCO_3$ content of greater than 50% (D106, I202, O201 and O303) as well as multiple stations with much lower proportions of $CaCO_3$ which generally occurred in the northern strata as well as the D1 stratum (Figure 13).

Silt and clay, overall, were the smallest components of the sediment (Figures 7, 14). Averaged across all 140 stations, silt and clay made up 1.2% and 1.9% of the sediment, respectively, for a combined total of 3.0%. Silt/clay content was highly variable at the station level (Appendix 3), ranging from 0.1% (I105) to 74% (D206). Mean silt/clay was relatively high in two strata (D1=11.8%; D2=19.8%; Figure 14), both located within the portion of the current disposal zone that contains the 1993 ODMDS disposal zone (Figure 2). However, both strata showed a high degree of variability; the elevated mean silt/clay value at the stratum level was driven by only one or two stations in each stratum (D104, D205 and D206) where the silt/clay content was very high (Figure 15).

Mean total organic matter (TOM) content at the stratum level ranged from 1.3% to 7.3%, with an average of 3.2% (Figure 16). Mean TOM content of individual stations ranged from 0.7% (O504) to 16.2% (O108). The stratum with the highest TOM (O1) is located in the outer boundary zone, adjacent to the Charleston shipping channel (Figure 17, Figure 1). Other outer boundary strata that had relatively high TOM included O2 (also adjacent to the shipping channel), O4, and O7 (Figure 16). Strata in the inner boundary zone with higher TOM content included I1 and I7, both of which were immediately adjacent to outer boundary zone strata that also had a higher TOM content (Figure 17). Mean TOM was also relatively high in the two previously active disposal strata (D1 and D2), as well as in D3.

Macrobenthic Community

A total of 17,928 individual organisms representing 249 distinct taxa were identified in the 140 benthic macroinvertebrate infauna samples collected in 2018 (Appendix 4). Polychaetes, mollusks, and amphipods were the most numerous taxonomic groups (Figure 18). The distinct macrobenthic taxa consisted of 94 polychaete, 70 mollusk, 27 amphipod, 31 non-amphipod crustacean, 11 echinoderm and 16 other unique taxa. The “other” category accounted for 5% of total abundance; the most abundant taxa in this category included lancelet worms in the genus *Branchiostoma*, oligochaetes in the family Tubificidae, sipunculid worms, and nemertean worms (Appendix 4).

To identify groups of strata with macrobenthic infauna communities similar to those of other strata within the group and different from the benthic communities of other groups of strata, hierarchical cluster analysis and similarity profile permutation tests were applied to, and an nMDS plot was generated based on, a density-by-taxon dataset averaged at the stratum level. Eleven significantly different clusters of strata were identified: D2; I8/O8; I1; I7/O7; D1; D4; I4/O4; I6/O6; D3, O1, I2, I3, and O5; O2; and I5/O3 (Figure 19). The four clusters with the highest similarity consisted of paired neighboring inner and outer boundary strata (I8/O8 at 79.5%; I7/O7 at 75.8%; I4/O4 at 73.9%; and I6/O6 at 73.2%). As in the sediment characteristics analysis, strata within each zone (disposal, inner boundary, and outer boundary) did not generally group together and therefore comparisons were not made across zones.

To streamline comparisons across benthic community strata, an intermediate level of clusters was selected: five significantly different groups of strata based on similarity profile permutation tests (Figure 20). Benthic community cluster A1 includes strata D2, I1, and I8/O8; cluster A2 includes strata D1 and I7/O7; cluster A3 includes strata D4, I4/O4, and I6/O6; cluster A4 includes strata D3, O1, I2, I3, and O5; and cluster B1 includes strata O2, O3, and I5 (Figures

20-21). The Pearson-correlation-based vectors on the nMDS plot indicate that in general, the strata in benthic community clusters A1, A2, and A3 have sediments with higher silt/clay content, finer sand, and lower $CaCO_3$ content than clusters A4 and B1 (Figure 20). The primary taxa driving the similarity among strata within each cluster are presented in Appendix 5. The similarity among the strata in cluster A1 is primarily driven by similar densities of specific amphipod and polychaete taxa, as well as two mollusk taxa, echinoid echinoderms, and nemertean worms (Appendix 5; Table 1). The similarity among strata within cluster A2, and within A3, is driven by similar densities of specific polychaete, amphipod, and mollusk taxa. The similarity among strata within cluster A4 is driven by similar densities of specific polychaete taxa, as well as amphipods, mollusks, echinoderms and sipunculid worms. Cluster B2 is unique in that amphipods were not an important driver of similarity among its taxa; instead, diverse polychaetes, mollusks, other worms (lancelets, sipunculids, and tubificids), and echinoderms are the key drivers (Appendix 5; Table 1).

At the station level, the density of macrobenthic invertebrate infauna ranged from approximately 300 to 20,500 individuals/m^2. At the stratum level, mean density ranged from 1,354 (D2) to 7,445 (O3) individuals/m^2 (Figure 22). Densities (and variability) were highest in the outer boundary strata located in the northeastern corner of the study area (Figure 22). Stratum O3, which had the highest mean density of infauna, also displayed a high degree of variability and included three high density stations (O302, O303 and O305) with benthic samples that contained between four and nine times as many individuals than the two lower density stations (O301 and O304). In stratum O2, the high mean density was driven by a single station (O201) that had more than twelve times as many individuals per square meter than the station with the next highest density (O204). Among the inner boundary and disposal zone strata, I5 and D4 had the highest mean densities, respectively.

Taxonomic richness, the number of distinct taxa identified per station, ranged from 8 to 74. At the stratum level, D2 had the lowest mean taxonomic richness (19.5 taxa/station) and O3 had the highest (51.0 taxa/station; Figure 23), in accordance with the organismal density results (Figure 22). Taxonomic richness was consistently low in stratum D2, but highly variable in O2 and O3, where the higher richness stations contained two to three times more taxa than the lower richness stations. Among the inner boundary and disposal zone strata, I5 and D4 had the highest mean taxonomic richness, respectively, which was also the case for organismal density.

Polychaetes, mollusks, amphipods, echinoderms, non-amphipod crustaceans, and "other" taxa were present in all 20 strata in varying proportions (Figure 24). The most abundant (dominant) taxonomic group varied by stratum. In the disposal zone, polychaetes contributed the most to infaunal abundance in two strata (D1 and D2), mollusks were dominant in D3, and amphipods were dominant in D4 (Figure 24). In the inner boundary zone, polychaetes were the most abundant taxonomic group in five strata (I1, I2, I4, I6, I7), and the remaining strata were dominated by either mollusks (I3, I5) or amphipods (I8). In the outer boundary zone, six strata were dominated by polychaetes (O1, O2, O3, O5, O6, O7), mollusks were the most abundant organisms in stratum O4, and amphipods were dominant in O8.

Polychaetes were the most diverse and abundant taxonomic group, contributing 42% to overall macrobenthic infaunal abundance and appearing as the dominant group in thirteen of the twenty strata. Station-level polychaete densities ranged from 100 to 11,575 individuals/m^2, stratum-level polychaete densities ranged from 580 (O8) to 4,400 (O3) individuals/m^2, and stratum-level percent composition ranged from 24% (O8) to 59% (O3; Figure 25). The highest densities of polychaetes were observed in the northern and northeastern outer boundary strata. The most abundant polychaete taxa included *Prionospio* sp., which was present at high densities in benthic community clusters A2 and A3 as well as in strata O1 and O5; Polygordiidae, which was present at high densities in clusters A2 and A3 as well as the I5/O3 cluster within cluster B1; and *Spiophanes bombyx* and *Glycera* sp., which were most abundant in clusters B1 and A4 (Table 1). Strata O2 and O3 contained high densities of multiple polychaete taxa that were either not present, or present at much lower densities, in other strata.

Mollusks accounted for 23% of total macrobenthic infaunal abundance and were the dominant taxonomic group in four strata (D3, I3, I5, and O4). Station-level mollusk densities ranged from 0 to 3,800 individuals/m^2, stratum-level mollusk densities ranged from 217 (D2) to 1,965 (I5) individuals/m^2, and stratum-level percent composition ranged from 12% (I8) to 46% (I5; Figure 26). The highest densities of mollusks were observed in the inner and outer boundary strata in the eastern portion of the study area. The most abundant mollusk taxa included *Crassinella martinicensis*, which was present at high densities in benthic community clusters B1, A4, and A3; *Parvilucina crenella*, which was present at high densities in clusters A2 and A3; and *Caecum* sp., which was most abundant in stratum O2 (Table 1).

Amphipods contributed 21% to total macrobenthic infaunal abundance and were the dominant taxonomic group in three strata (D4, I8, and O8). Station-level amphipod densities ranged from 0 to 4,525 individuals/m^2, stratum-level amphipod densities ranged from 70 (I5) to 1,994 (D4) individuals/m^2, and stratum-level percent composition ranged from 1.6% (I5) to 46% (O8 and I8; Figure 27). Amphipod densities were highest at some stations in I8/O8, D4, and I4/O4, in a band running from the west-northwest to the east-southeast through the study area with lower densities occurring in the previously used disposal strata (D1 and D2). The most abundant amphipod taxa included *Rhepoxynius epistomus*, which was present at high densities in strata I7/O7 as well as in D4 and I4/O4; *Bathyporeia parkeri*, which was present at high densities in D4, I4, D1, I7, and I8; and *Protohaustorius wigleyi*, which was most abundant in I8/O8 and D4 (Table 1).

Echinoderms accounted for 6% of macrobenthic infaunal abundance and did not dominate any strata. Station-level echinoderm densities ranged from 0 to 3,900 individuals/m^2, stratum-level echinoderm densities ranged from 60 (I3) to 840 (O2) individuals/m^2, and stratum-level percent composition ranged from 1.9% (I7) to 17.4% (I1; Figure 28). The highest echinoderm densities were observed in the inner and outer boundary strata in the north-northeastern portion of the study area. The majority of echinoderms were identified only to the class level. Brittle stars (class Ophiuroidea) were the most abundant echinoderms and were present at the highest densities in strata I1/O1, O2, O3, and D1. Sea urchins (class Echinoidea) were present at the highest densities in strata I8/O8 and I1 (Table 1).

Non-amphipod crustaceans were the least abundant taxonomic group, contributing only 2.5% to the total abundance of macrobenthic infauna. Station-level non-amphipod crustacean densities ranged from 0 to 525 individuals/m^2, stratum-level densities ranged from 25 (I2) to 183 (D1) individuals/m^2, and stratum-level percent composition ranged from 0.7% (I2) to 7.1% (D1; Figure 29). The most abundant non-amphipod crustacean taxa included the tanaid *Tanaissus psammophilus*, which was present at moderate densities in strata I3, I5, and D3; and the cumacean *Cyclaspis varians*, which was present at a moderate density in stratum D1 (Table 1).

Taxa belonging to all other taxonomic groups contributed 5.3% to the abundance of macrobenthic infauna. Station-level densities of “other” taxa ranged from 0 to 2,400 individuals/m^2, stratum-level densities ranged from 42 (D1) to 985 (O3) individuals/m^2, and stratum-level percent composition ranged from 1.6% (D1) to 13.8% (I5; Figure 30). The most abundant “other” taxa included the lancelet *Branchiostoma* sp. as well as tubificid worms and sipunculid worms, all of which were present at the highest densities in strata O3/I5, a cluster within cluster B1 (Table 1).

Discussion

The Charleston ODMDS 2018 study area fully contained the areas studied in 1993 and 1994 for a baseline assessment, and in 2000 and 2002 after the partial and full completion of the 1999-2002 Charleston Harbor Deepening Project. However, due to the recent expansion of the ODMDS, the 2018 study area is larger than that covered in previous studies, with the enlarged portion extending primarily to the east. Within the overlapping area, the spatial distribution of individual sediment parameters in 2018 tended to be similar to distributions observed in previous years, with a clear signal of past dredged sediment placements showing up in the strata previously used for disposal and the strata to the west of the active disposal zone.

The 1993-1994 baseline assessment of sediment characteristics within the then-configuration of the Charleston ODMDS found that sand dominated most of the monitored area (Figure 9), with small patches of bottom with low sand content located in the central-western area, which overlaps with the 1987 ODMDS (Figure 1), and in the north-northeastern monitored boundary area. Assessments of sediment characteristics in the ODMDS and boundary zones were next conducted after partial completion (2000) and again after the full completion (2002) of the 1999-2002 Charleston Harbor Deepening Project. These surveys indicated that the patches of surface sediment with low sand content were mostly restricted to the then-active disposal zone (corresponding to current strata D1 and D2), with a small number of northeastern boundary area stations also having low sand content (Figure 9). The current (2018) baseline study assessed an expanded study area with a reduced density of sampling in the disposal zone and eastern boundary strata. The 2018 assessment of surface sediment characteristics within the ODMDS revealed a continuation of the pattern of sand content observed in earlier surveys. All boundary strata continued to be dominated by sand, with most stations exhibiting fine material being restricted to the previously active portion of the disposal zone (strata D1 and D2) as well as a few isolated stations in the boundary zones to the north and northeast of the disposal zone (Figure 9), including areas which represent an expansion of the ODMDS boundary zones beyond the area surveyed in earlier assessments.

Surveys of sand grain size (phi) within and around the Charleston ODMDS showed the consistent presence of relatively fine-grained sand (higher phi) in the western portion of the site, corresponding to the 1987 ODMDS disposal zone, from 1993 through 2018 (Figure 11). The baseline survey conducted in 1993 found relatively coarse sands in the northern, eastern, and southern boundary areas as well as in the southwestern and northeastern portions of the current disposal zone. A survey the following year (1994) found fewer areas with relatively coarse sand, primarily concentrated in the northeastern and southern boundary zones. Surveys in 2000 and 2002, during and after the 1999-2002 Charleston Harbor Deepening Project, continued to show relatively finer sand in the western and northwestern portions of the study area, with a persistent area of relatively coarse sediment in the southwestern corner of stratum O7 and in the northeastern and southern portions of the study area. In 2018, the disposal zone and western boundary strata were dominated by relatively fine sand, including the southwestern corner of stratum O7, which in 2000 and 2002 contained relatively coarse sand. Strata D3 and D4, which had not previously been used for sediment placement, transitioned from having a mix of differently textured sand in all four preceding surveys to being dominated by fine-grained sand in 2018, although in part this may be due to reduced sampling density, particularly the lack of 2018 samples collected in the southwestern corner of stratum D4. Similar to previous surveys, patches of relatively coarse sand were observed in 2018 in the southern boundary zones and in the northern and northeastern boundary strata, although areas with the coarsest sand in 2018 tended to correspond to boundary areas located outside of the previously monitored area.

In all surveys of surface sediment characteristics in and around the Charleston ODMDS from 1993-2018, the proportion of $CaCO_3$ in the surface sediment was highly variable throughout the study area (Figure 13). A few stations with relatively high $CaCO_3$ content were consistently observed across all the surveys. Two of the historical areas that showed high $CaCO_3$ content in the past were not surveyed in 2018 due to those areas falling within the western and northeastern portions of the footprint of the planned sediment containment berm.

In three of the four previous Charleston ODMDS sediment characteristics surveys (1993, 2000, and 2002), the combined silt/clay content was quite low in most of the study area, with hotspots within previously active disposal zones (D2 in 1993 and D1 and D2 in 2000 and 2002) as well as areas west of the active disposal zones (O7 in 1993 and I7 and O7 in 2000 and 2002; Figure 15). In 1994, silt/clay content across the study area was higher than in other years, although the distribution of hotspots was similar. In 2018, the spatial distribution of high and low silt/clay content sediments was similar to that observed in 2002, after the 1999-2002 Charleston Harbor Deepening Project, with slightly lower silt/clay content in strata I7 and O7 of the current study (Figure 15).

The distribution of TOM hotspots within the Charleston ODMDS study area from 1993-2002 (Figure 17) was similar to the distribution of silt/clay hotspots over the same time period (Figure 15). As with silt/clay, TOM levels throughout the study area in 1994 were higher than they were in 1993, 2000, and 2002. The highest TOM levels were observed in disposal stratum D2 and areas west in 1993 and 1994, and in disposal strata D1 and D2 as well as inner and outer strata of zone 7 (I7/O7) in 2000 and 2002. In 2018, similar to 2002, the previously utilized areas of the disposal zone and zone 7 showed relatively high TOM relative to the rest of the study area, but the highest TOM content was found in sediments in the previously unmonitored O1 stratum.

As observed in the sediment analysis, the 2018 macrobenthic community analysis showed that the previously active disposal strata and the boundary strata in the western portion of the study area had benthic community characteristics more similar to each other than to the strata to the east. Previously active disposal stratum D1 contained a benthic community most similar to a neighboring pair of inner/outer strata to the west, and previously active disposal stratum D2 contained a benthic community most similar to that of a set of three inner and outer boundary strata to the north and west. The group of strata with the most distinct benthic community characteristics in 2018 were located in the northeastern corner (O2, O3) and in the south (I5) of the study area; this group of three strata was characterized by high benthic infaunal densities and overall taxonomic richness (particularly polychaete richness), as well as relatively low amphipod densities. These benthic community results contrasted with the sediment results, where the strata most different from the others were the two previously active disposal zone strata.

As observed in the sediment samples, spatial variability was observed across strata in the macrobenthic community. Overall, polychaetes were the most abundant taxonomic group, but mollusks and amphipods were the dominant taxa at a subset of stations and strata. The previously active disposal stratum farthest to the west had the lowest macrobenthic density and the lowest taxonomic richness among all 20 strata, and the outer boundary stratum to the east-northeast of the previously active disposal zone had the highest macrobenthic density and taxonomic richness. In general, higher densities and richness were observed in the northern and eastern boundary zones (and in the previously unused southeastern disposal stratum), and lower densities and richness were observed in the western portion of the study area, including the two previously active disposal strata.

In both the sediment and benthic community analyses, the previously active disposal zone strata (corresponding to the 1993 ODMDS) shared features with the inner and outer boundary strata to the west and shared less similarity with the boundary strata to the east and south. One possible driver of the similarity between the previously active disposal zone strata and the strata to the west may be the influence of occasional strong bottom currents flowing over the disposal zone to the west-southwest, and more frequent lower-speed bottom currents flowing to the west-northwest, carrying dredged sediment placed in the disposal strata into adjacent strata to the west. As part of the ongoing harbor deepening project, a berm is being constructed along the western, southern, and eastern boundaries of the expanded ODMDS with the goal of restricting the transport of placed sediment from the ODMDS to adjacent areas.

The sediment and macrobenthic invertebrate infaunal community characteristics presented in this report represent baseline data, for the purpose of characterizing these features in the newly expanded Charleston ODMDS prior to the initiation of the 2018 Charleston Harbor Post 45 Deepening Project. A companion study underway by SCDNR is monitoring hardbottom habitats in the ODMDS boundary zones and has deployed sediment traps to explore spatially explicit sedimentation rates. The post-assessment of the Charleston Harbor Post 45 Deepening Project will enable an evaluation of changes to the benthic habitat and infaunal community in the disposal zone as a result of dredged sediment placement, as well as detection of changes to inner or outer boundary strata as a result of potential drift of placed sediment out of the ODMDS.

Figures

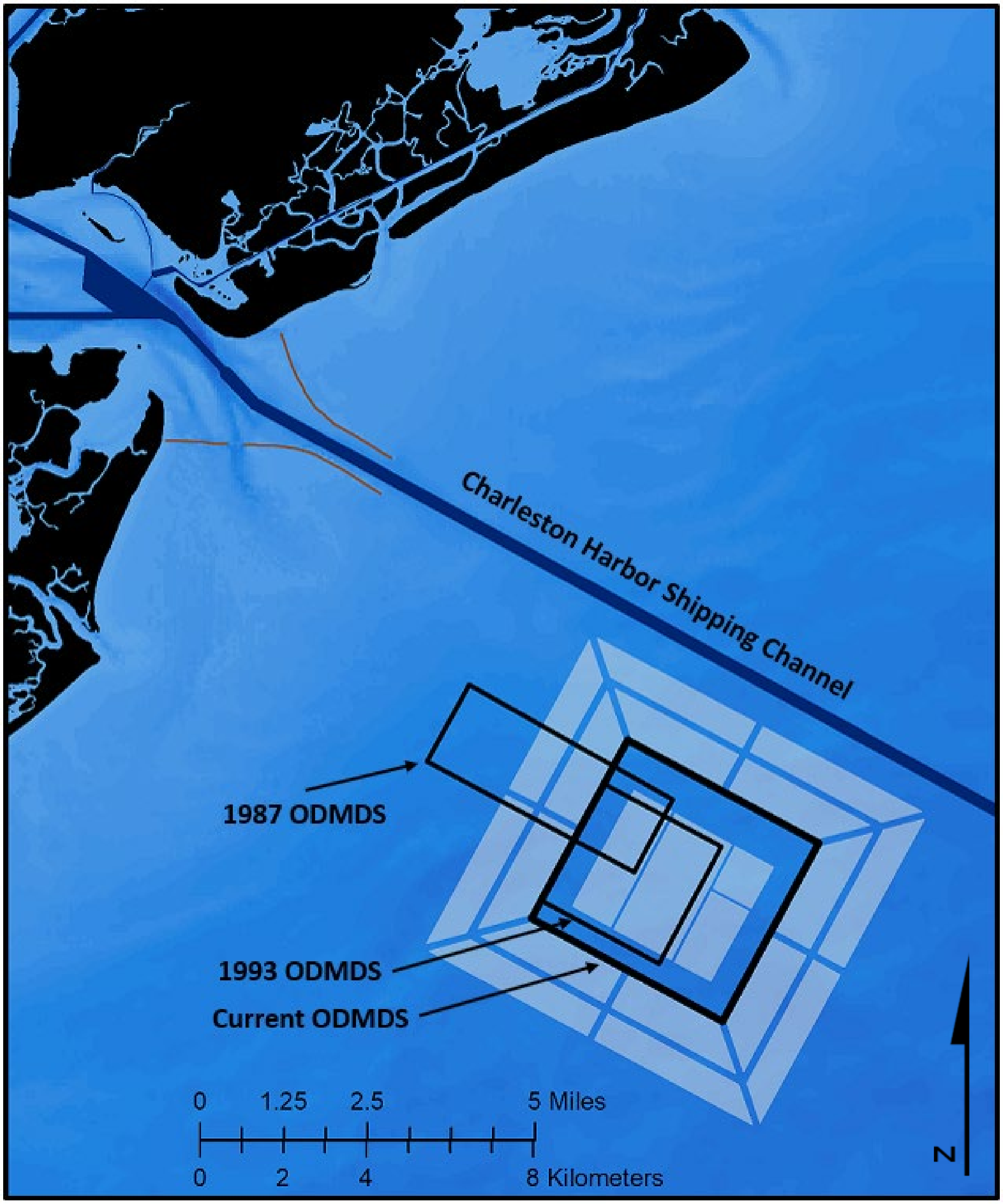

Figure 1. Location of the original "smaller" ODMDS, established in 1987 (approximate boundary; digitized from an image); the ODMDS established in 1993; the current ODMDS; and the Charleston Harbor Shipping Channel. The black rectangles represent the designated disposal zones, and the gray shaded areas represent the Disposal, Inner Boundary, and Outer Boundary strata used in the present study.

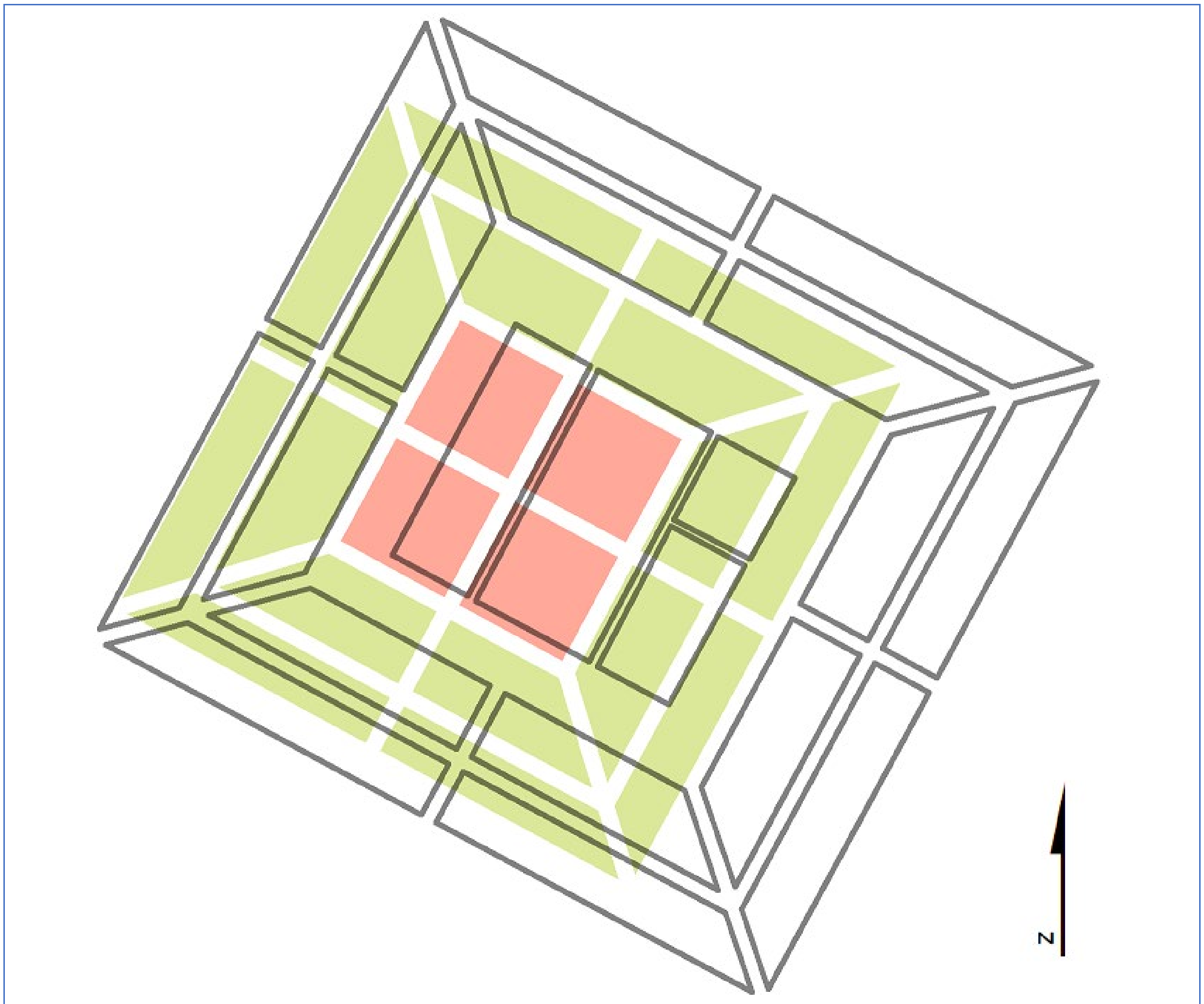

Figure 2. Current ODMDS study area and monitoring strata (polygons outlined in gray), overlapping with the 1993 ODMDS monitoring strata: disposal zone (red-shaded squares) and inner and outer boundary strata (green-shaded polygons).

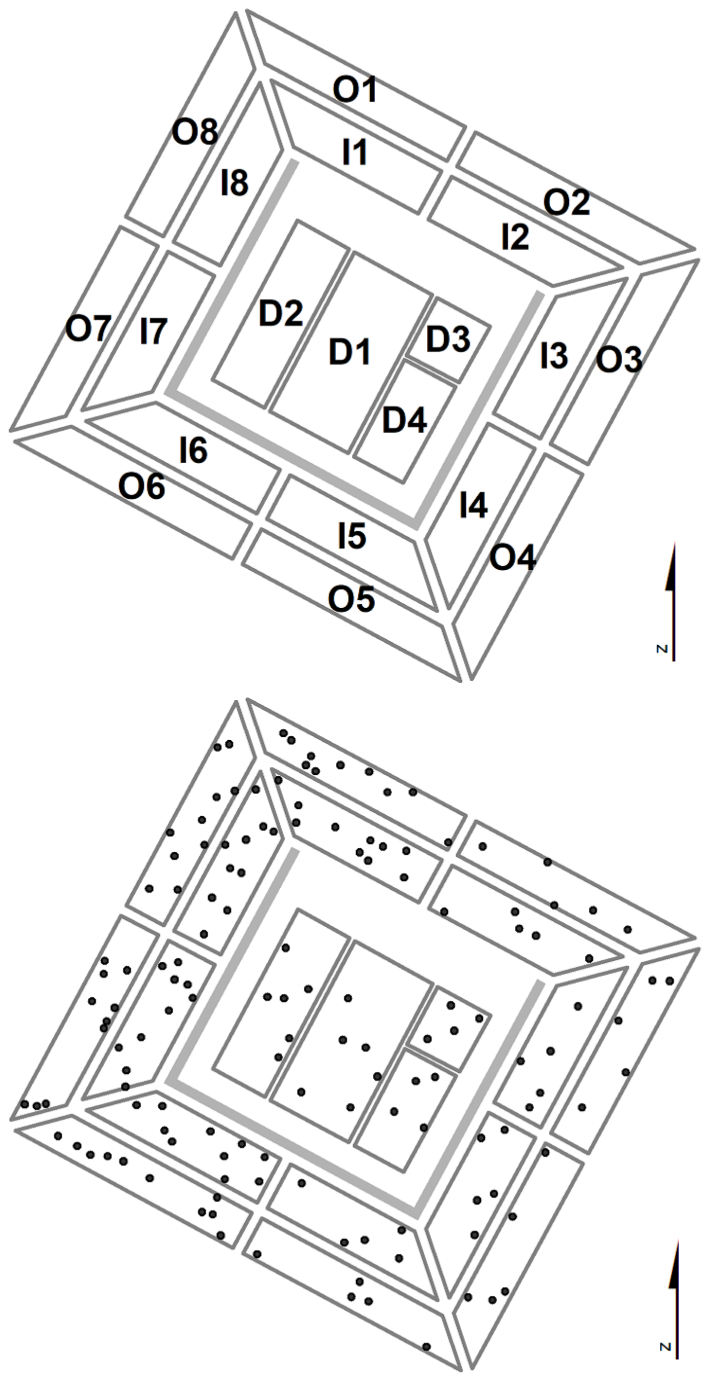

Figure 3. 2018 ODMDS study area with strata labeled within monitoring zones – Disposal (D), Inner Boundary (I) and Outer Boundary (O) – and proposed U-shaped berm location (thick gray line). Locations of stations sampled within each stratum (bottom). Boundary strata in the west-northwest portion of the study area were sampled more densely than boundary strata in the east-southeast portion of the study area.

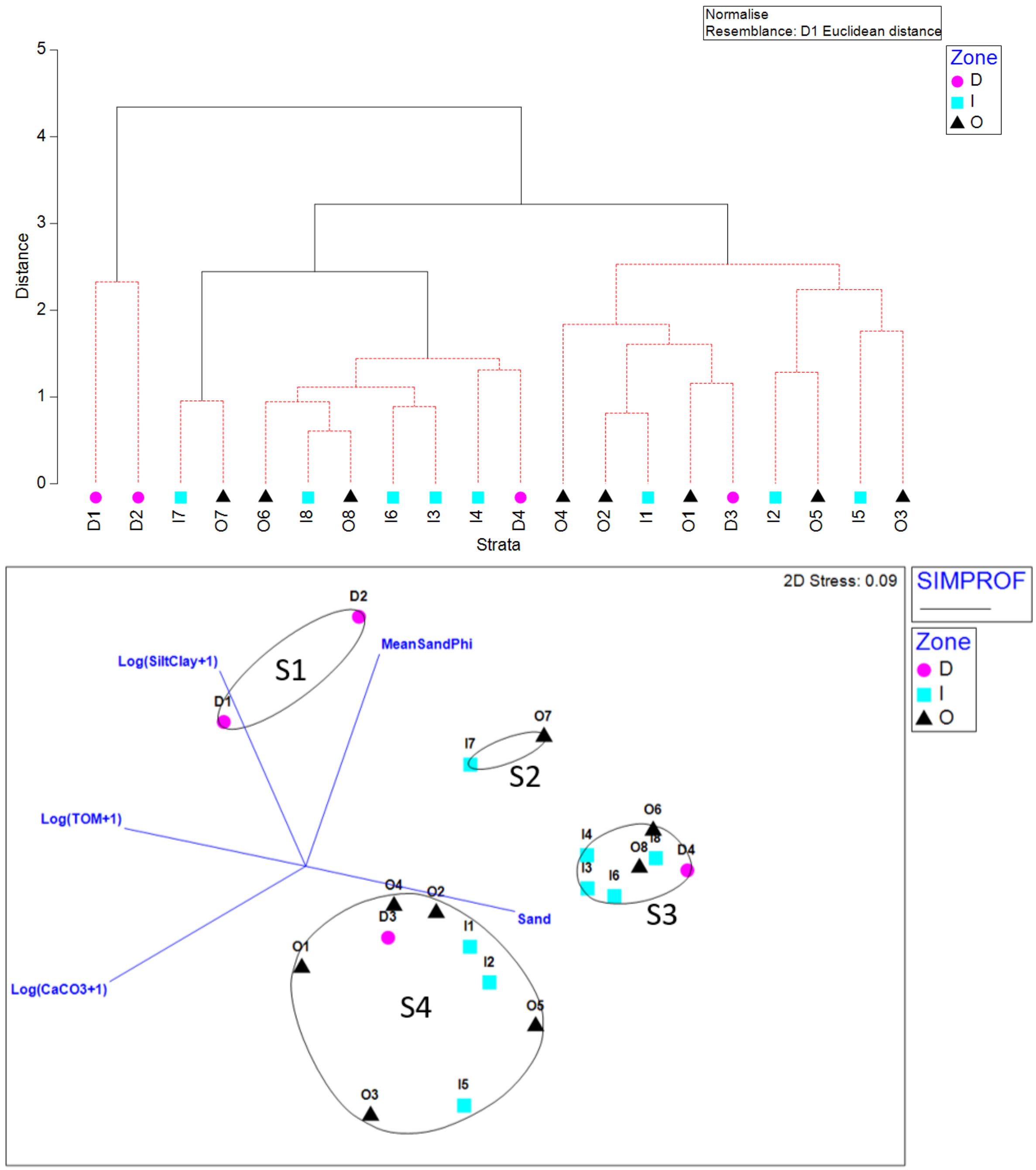

Figure 4. Hierarchical cluster tree (top) and nMDS plot (bottom) representing Euclidean distance for multivariate sediment characteristics across strata. In the tree, each vertical black line represents a cluster of strata that had sediment characteristics in 2018 that were significantly different from the other clusters, as determined by similarity profile (SIMPROF) permutation tests. The encircling black lines on the nMDS plot also represent SIMPROF clusters, and the vectors represent associations between each sediment parameter (a subset of which were transformed to more closely approximate normality assumptions) and the plotted positions of the strata.

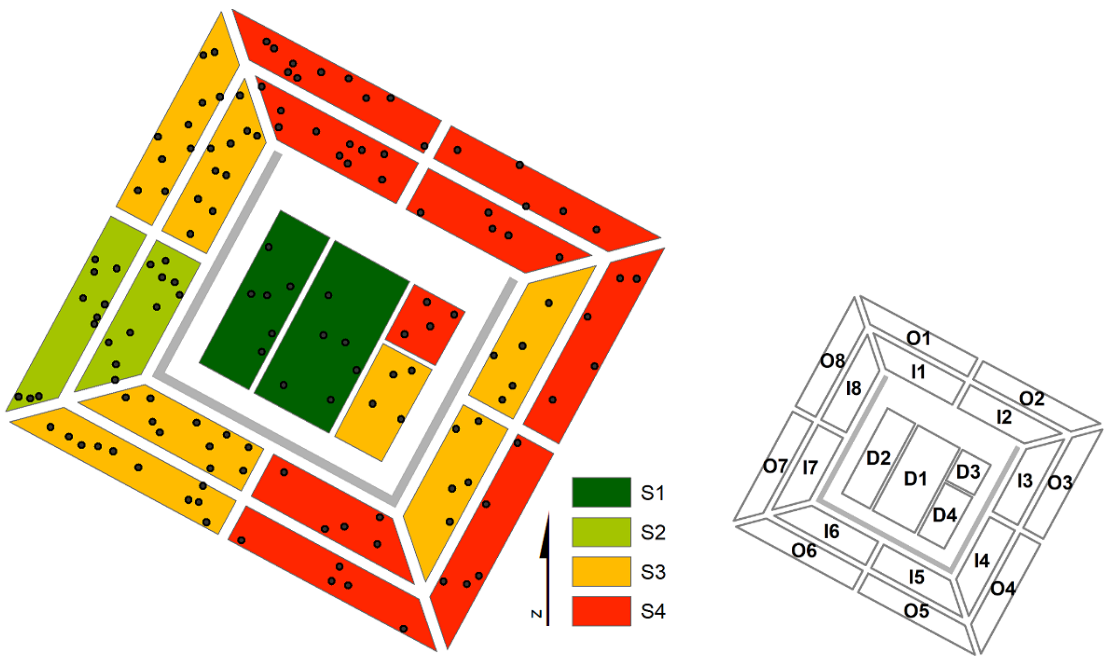

Figure 5. Sediment characteristic-based clusters of strata identified by hierarchical cluster analysis and similarity profile (SIMPROF) permutation tests.

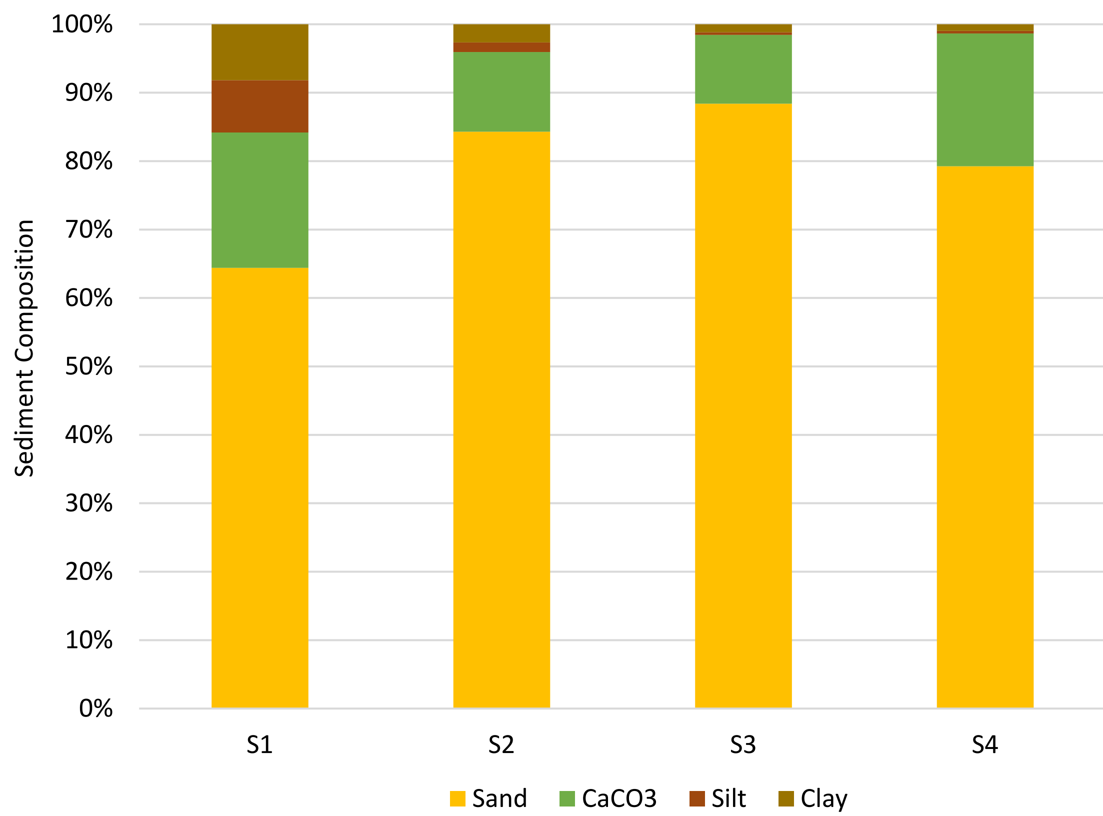

Figure 6. Mean sediment characteristics (% sand, % $CaCO_3$, % silt, and % clay) by sediment cluster in 2018.

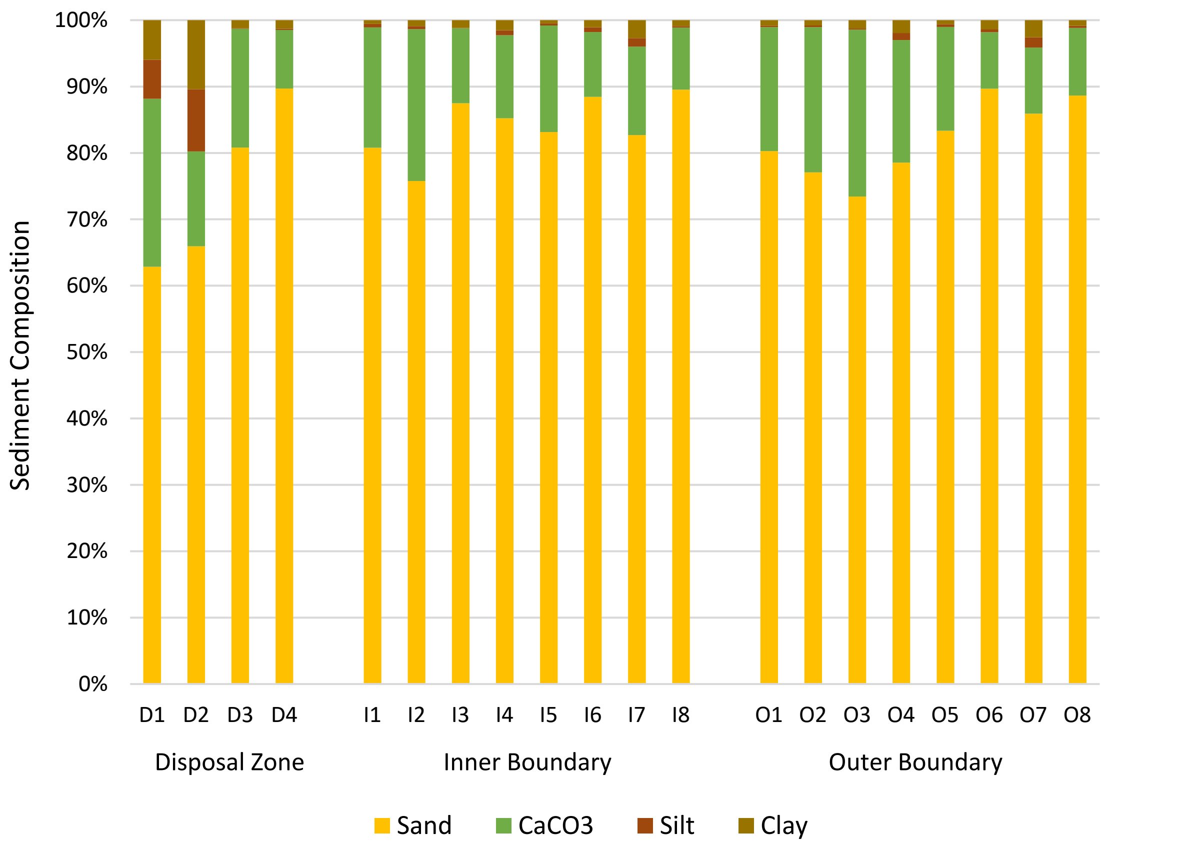

Figure 7. Mean sediment characteristics (% sand, % $CaCO_3$, % silt, and % clay) by stratum sampled in 2018.

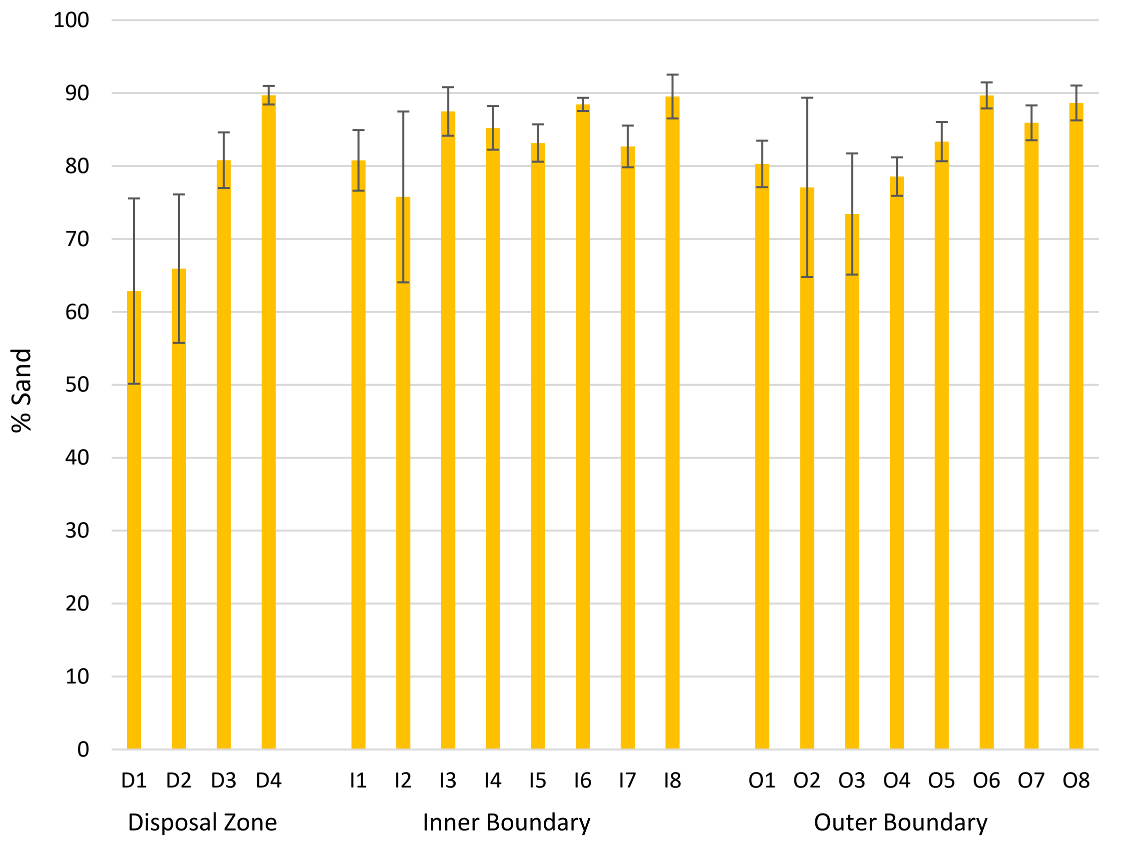

Figure 8. Mean % sand (± 1 SE) by stratum sampled in 2018.

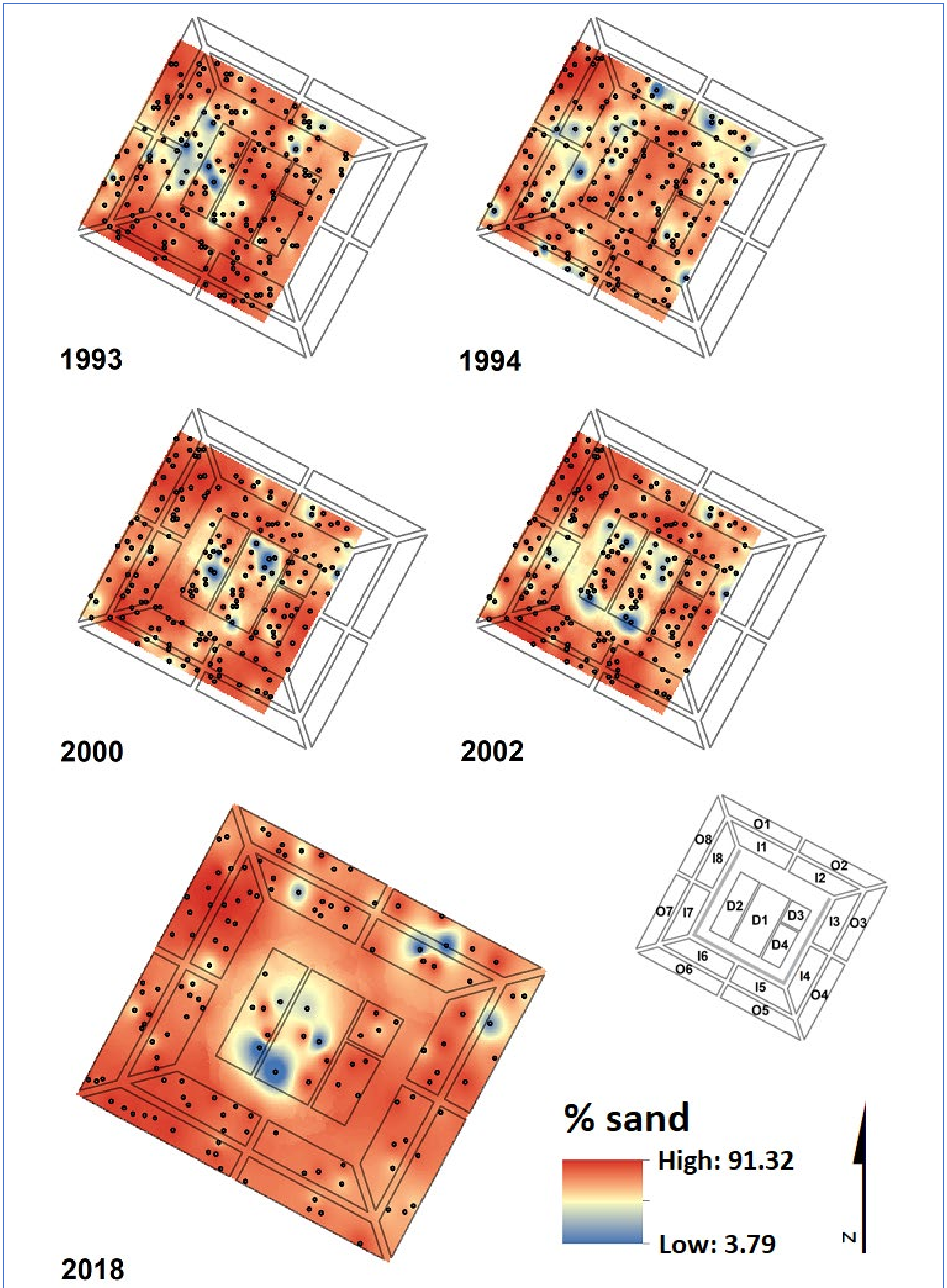

Figure 9. Interpolation of the relative contribution of sand to total sediment characteristics between stations sampled in 1993, 1994, 2000, 2002, and 2018.

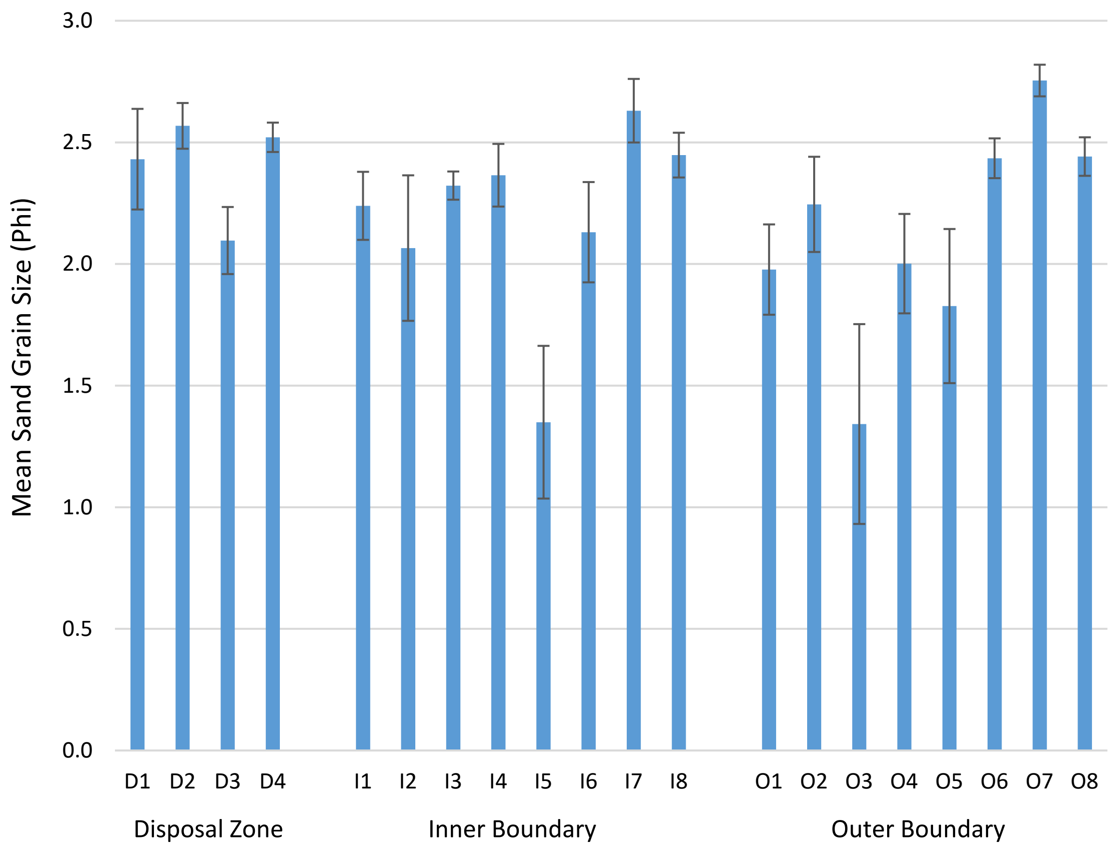

Figure 10. Mean sand grain size (± 1 SE) by stratum sampled in 2018. A phi of 0-1 corresponds to coarse sand, a phi of 1-2 corresponds to medium-grain sand, and a phi of 2-3 corresponds to fine-grain sand.

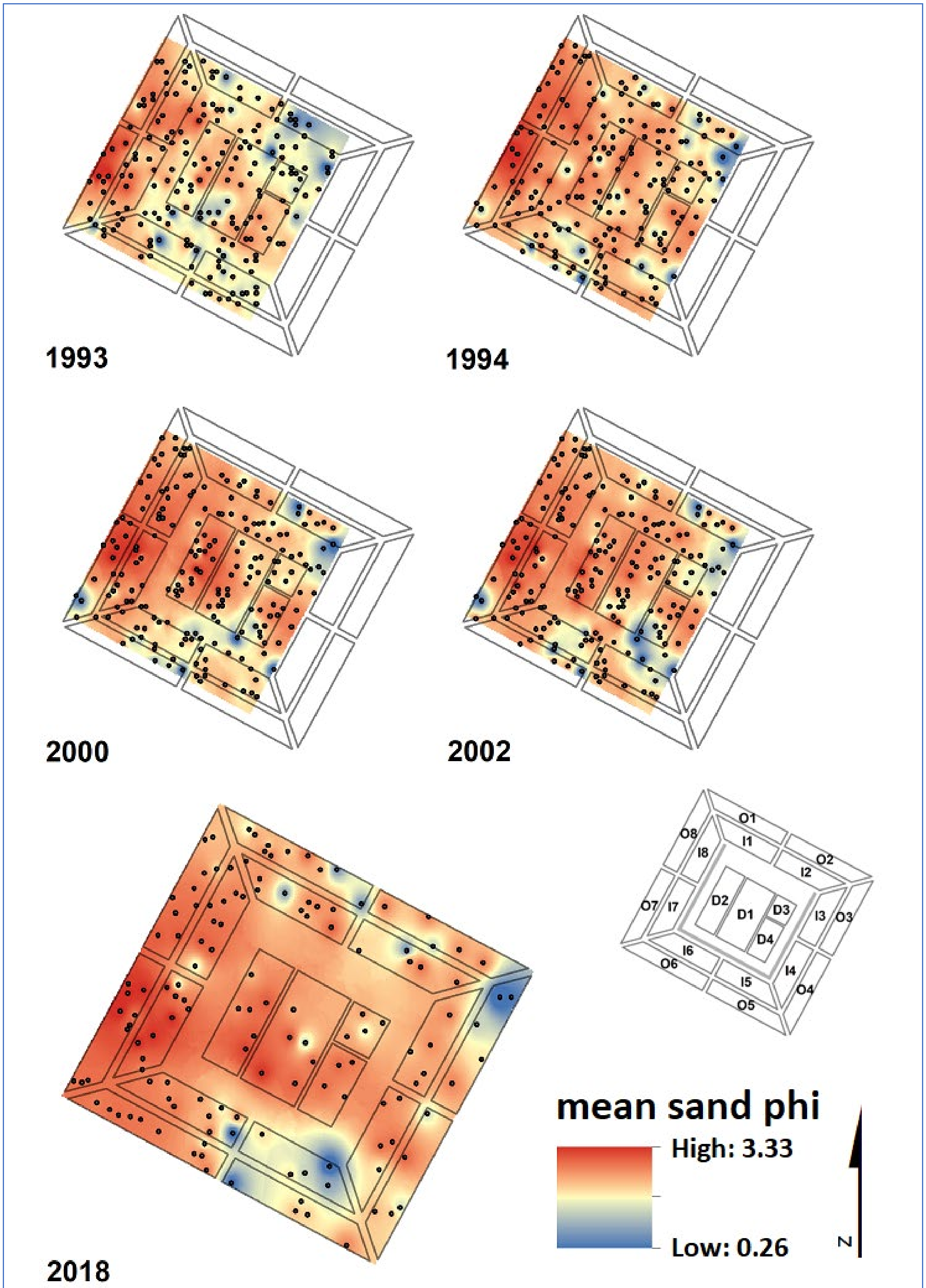

Figure 11. Interpolation of mean sand grain size (phi), ranging from coarse (0.26) to very fine (3.33) sand, between stations sampled in 1993, 1994, 2000, 2002, and 2018.

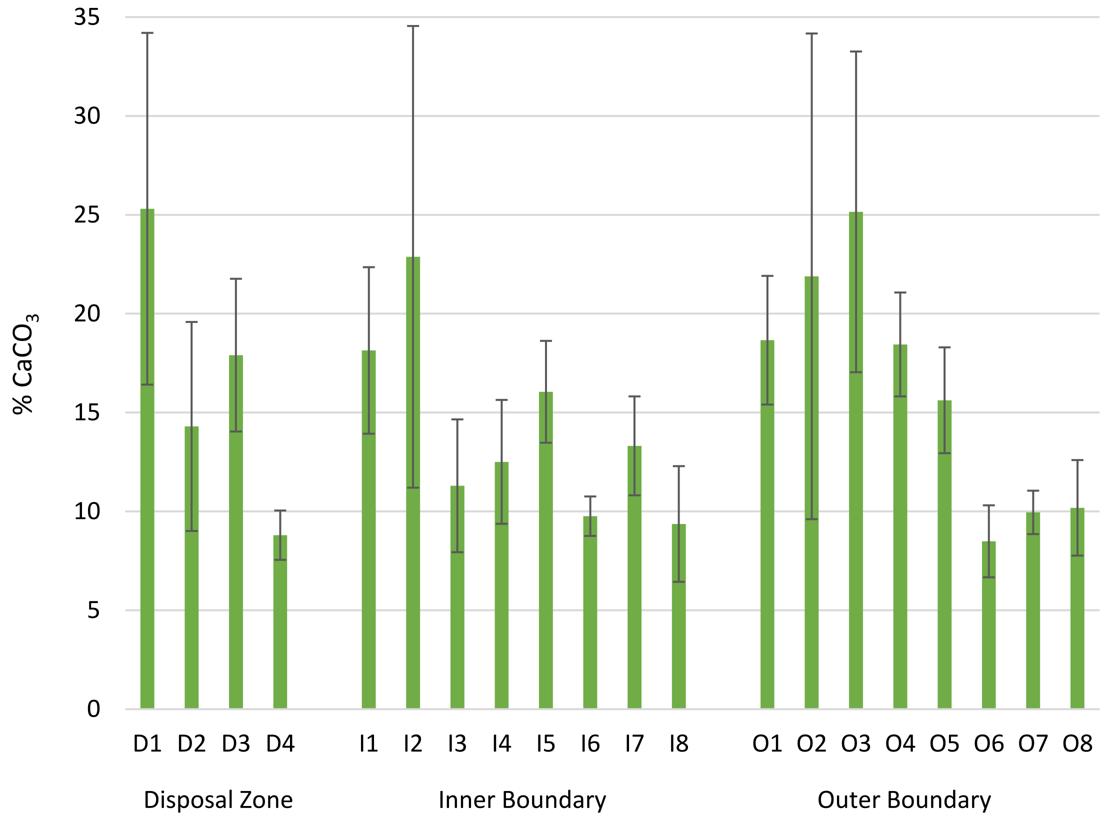

Figure 12. Mean % $CaCO_3$ (± 1 SE) by stratum sampled in 2018.

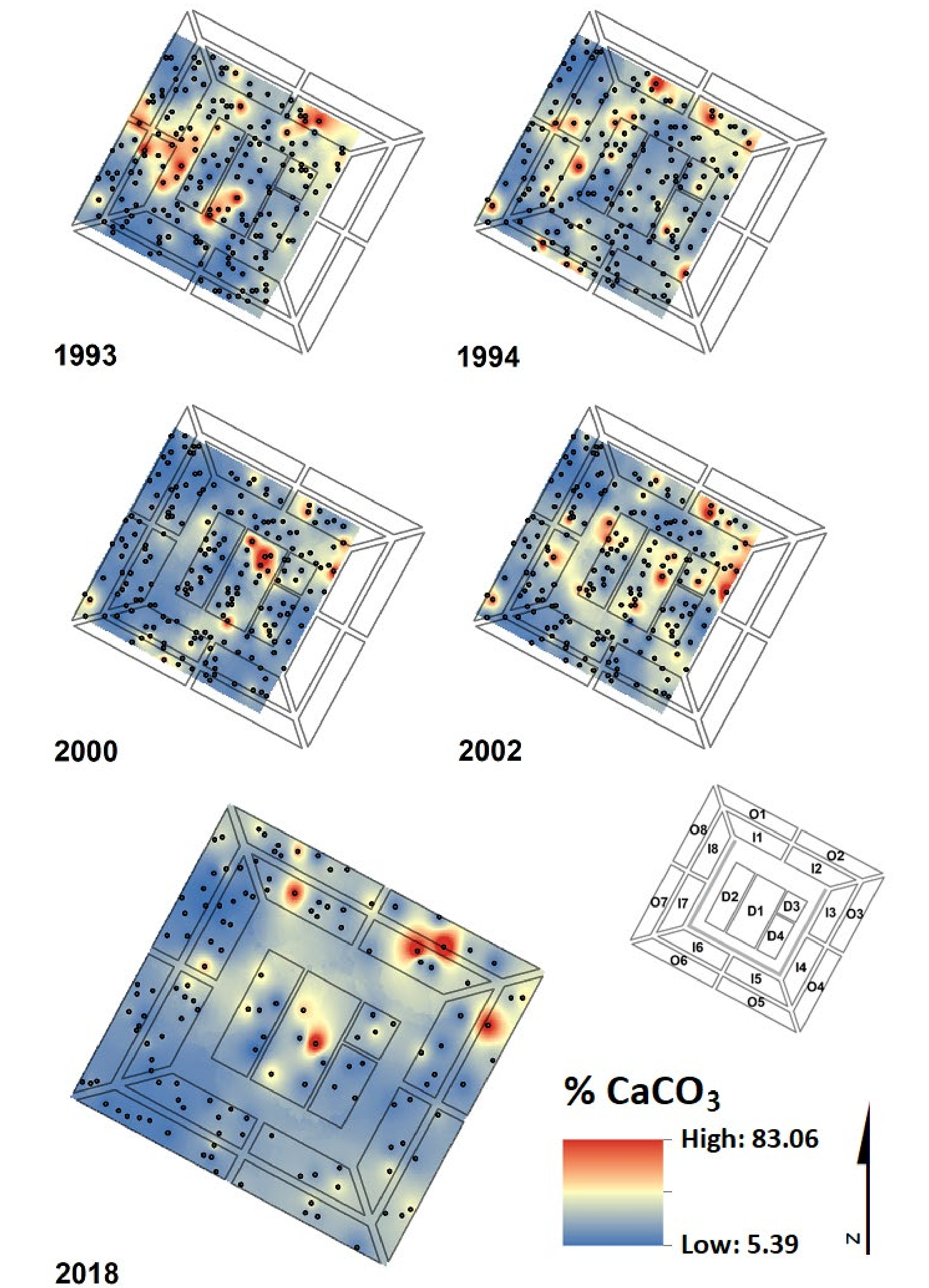

Figure 13. Interpolation of the relative contribution of $CaCO_3$ to total sediment characteristics between stations sampled in 1993, 1994, 2000, 2002, and 2018.

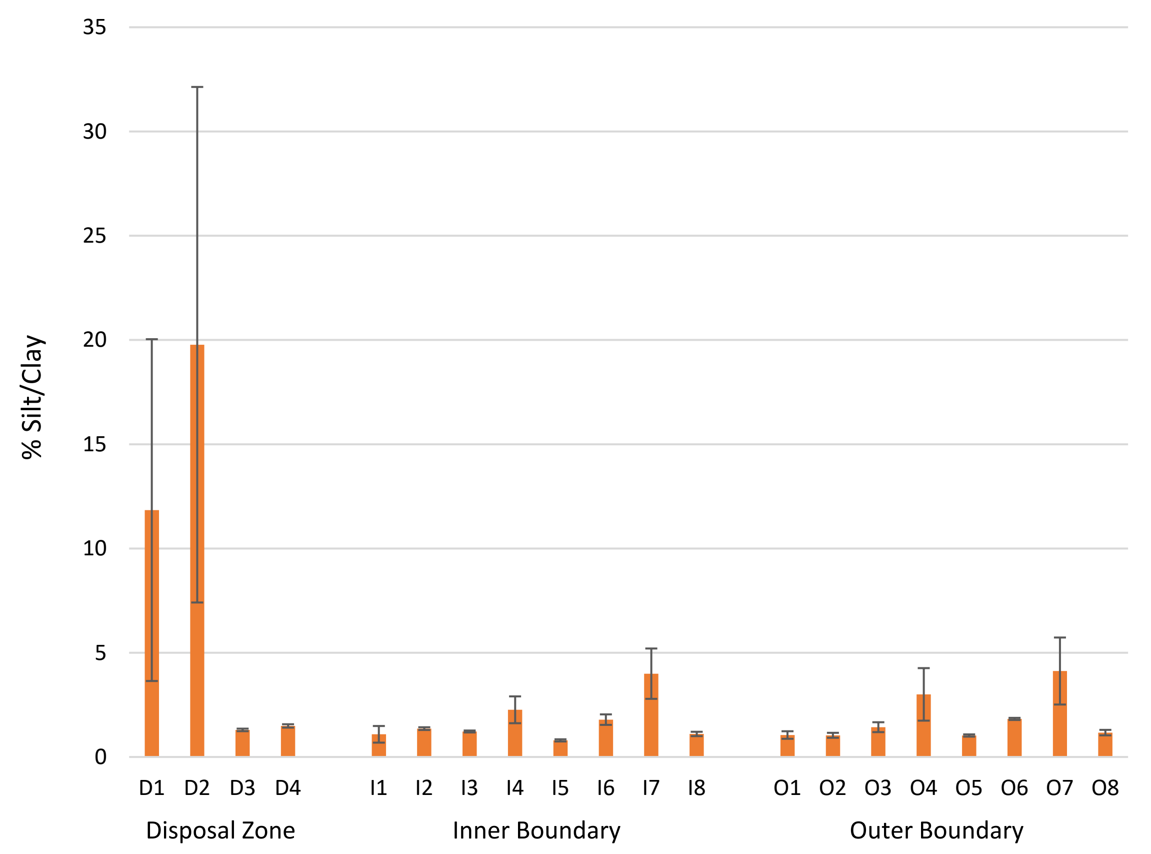

Figure 14. Mean % silt/clay (± 1 SE) by stratum sampled in 2018.

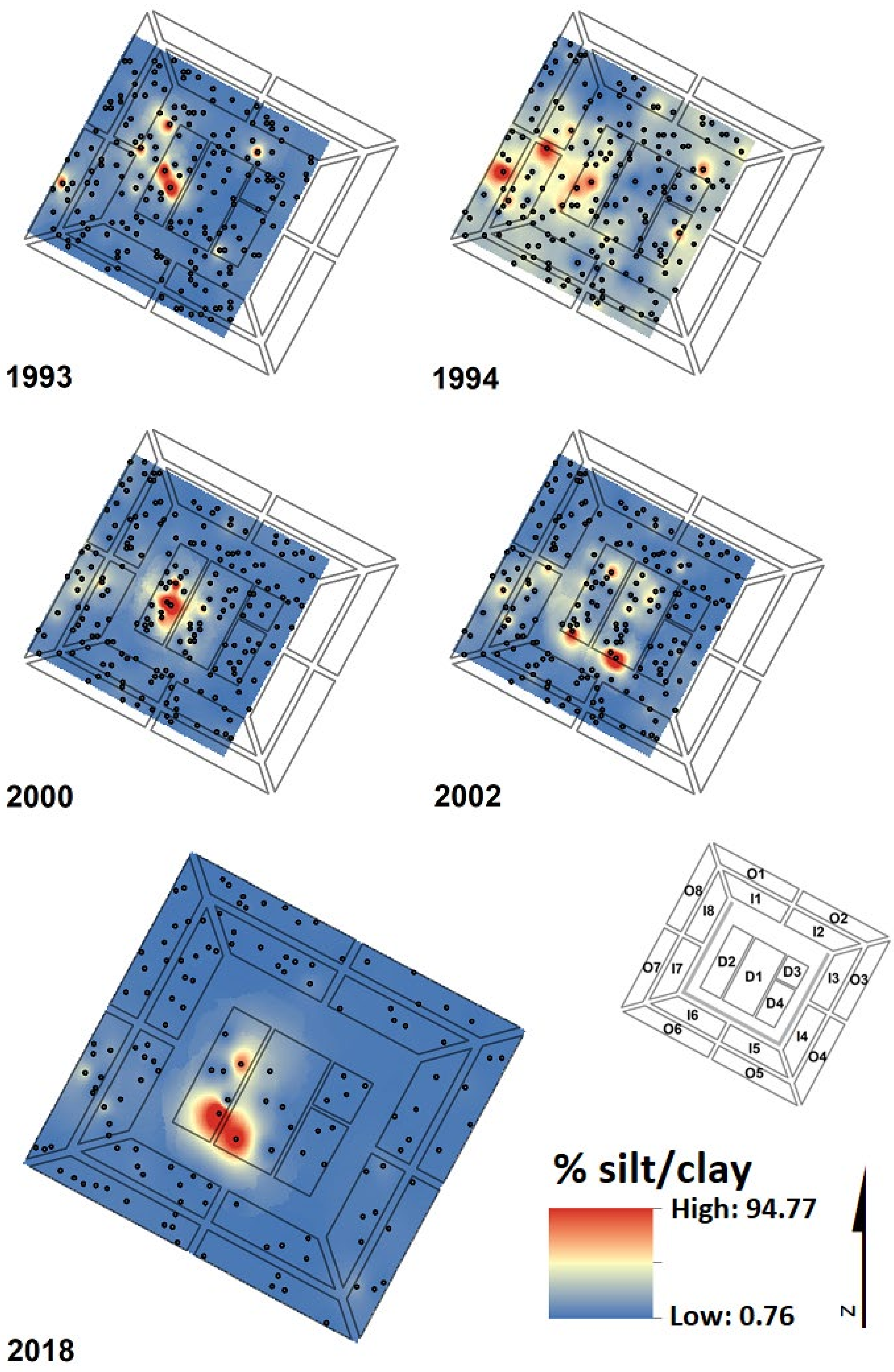

Figure 15. Interpolation of the relative contribution of combined silt and clay to total sediment characteristics between stations sampled in 1993, 1994, 2000, 2002, and 2018.

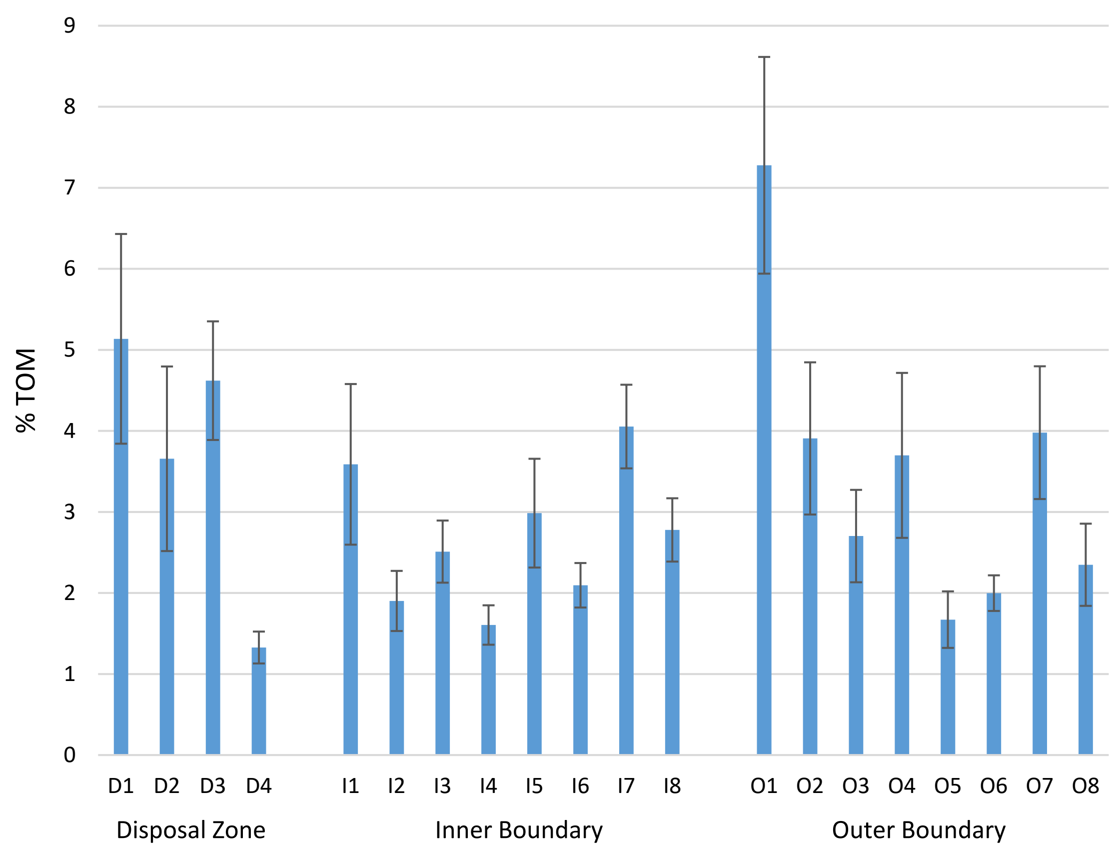

Figure 16. Mean % total organic matter (± 1 SE) by stratum sampled in 2018.

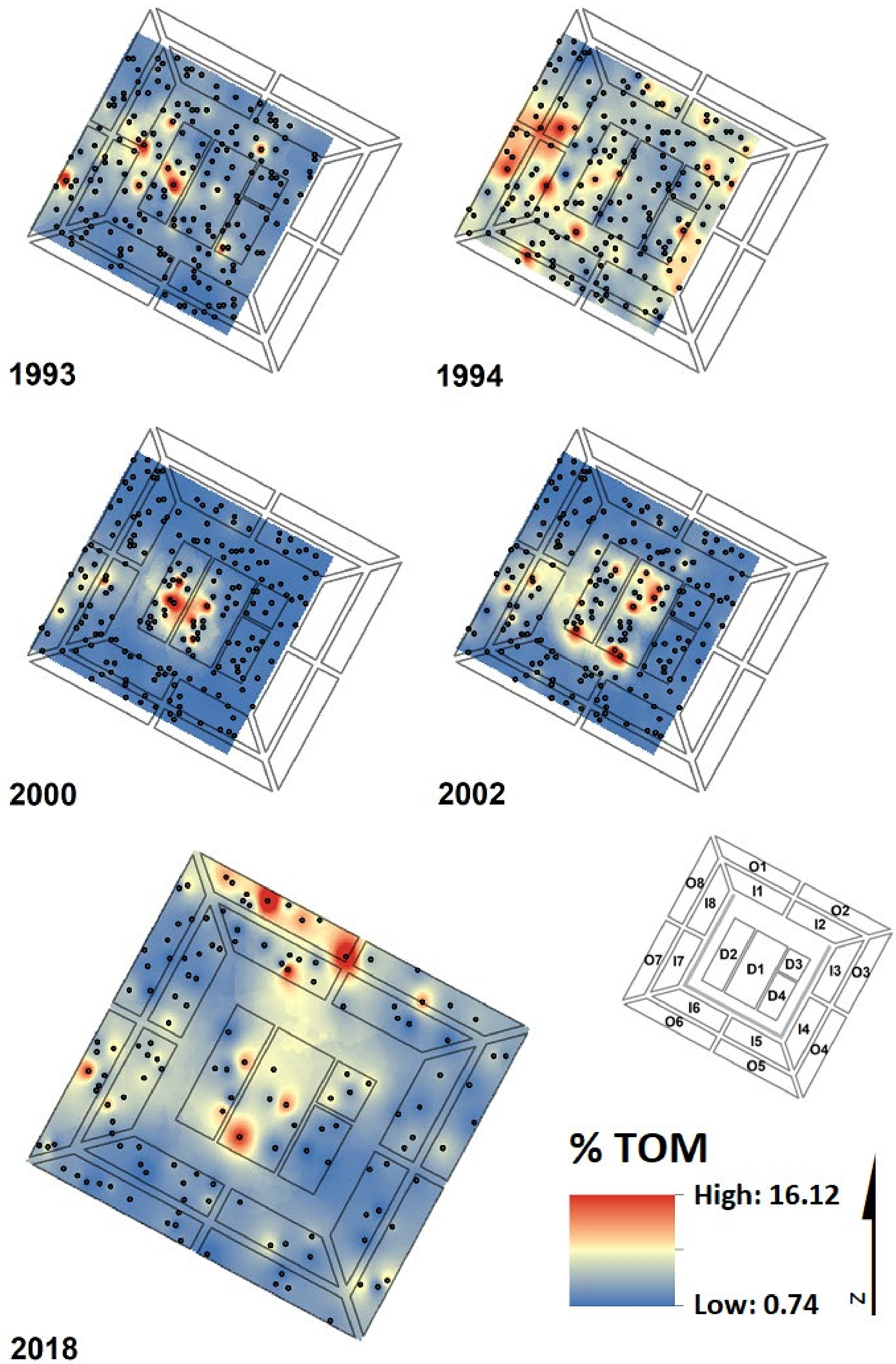

Figure 17. Interpolation of contribution of total organic matter (TOM) to total sediment characteristics between stations sampled in 1993, 1994, 2000, 2002, and 2018.

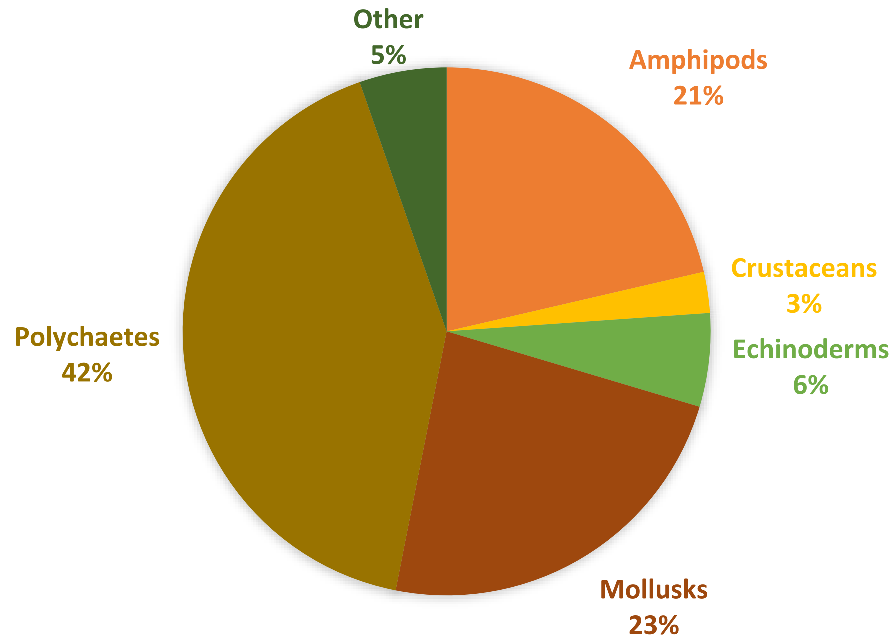

Figure 18. Percent abundance of each taxonomic group observed, pooled across all 140 macrobenthic infaunal community samples collected in the Disposal, Inner Boundary, and Outer Boundary zones in and around the Charleston ODMDS in 2018. "Crustaceans" represents non-amphipod crustaceans.

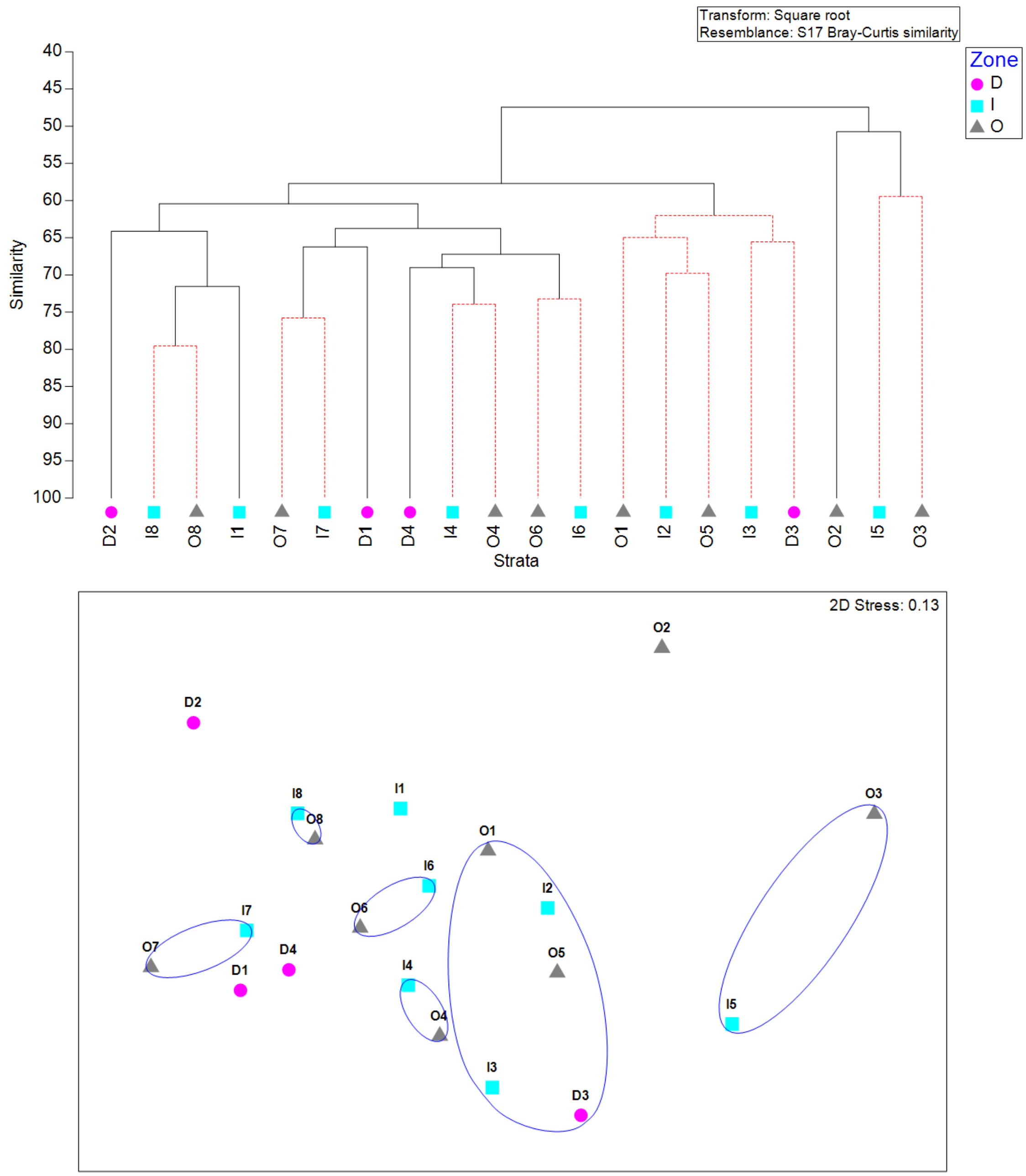

Figure 19. Macrobenthic infaunal community hierarchical cluster tree (top) and nMDS plot (bottom). In the cluster tree, each vertical black line represents a stratum or group of strata (cluster) that had a community in 2018 significantly different from communities in other strata based on similarity profile permutation tests. On the nMDS plot, each multi-stratum cluster is encircled in blue.

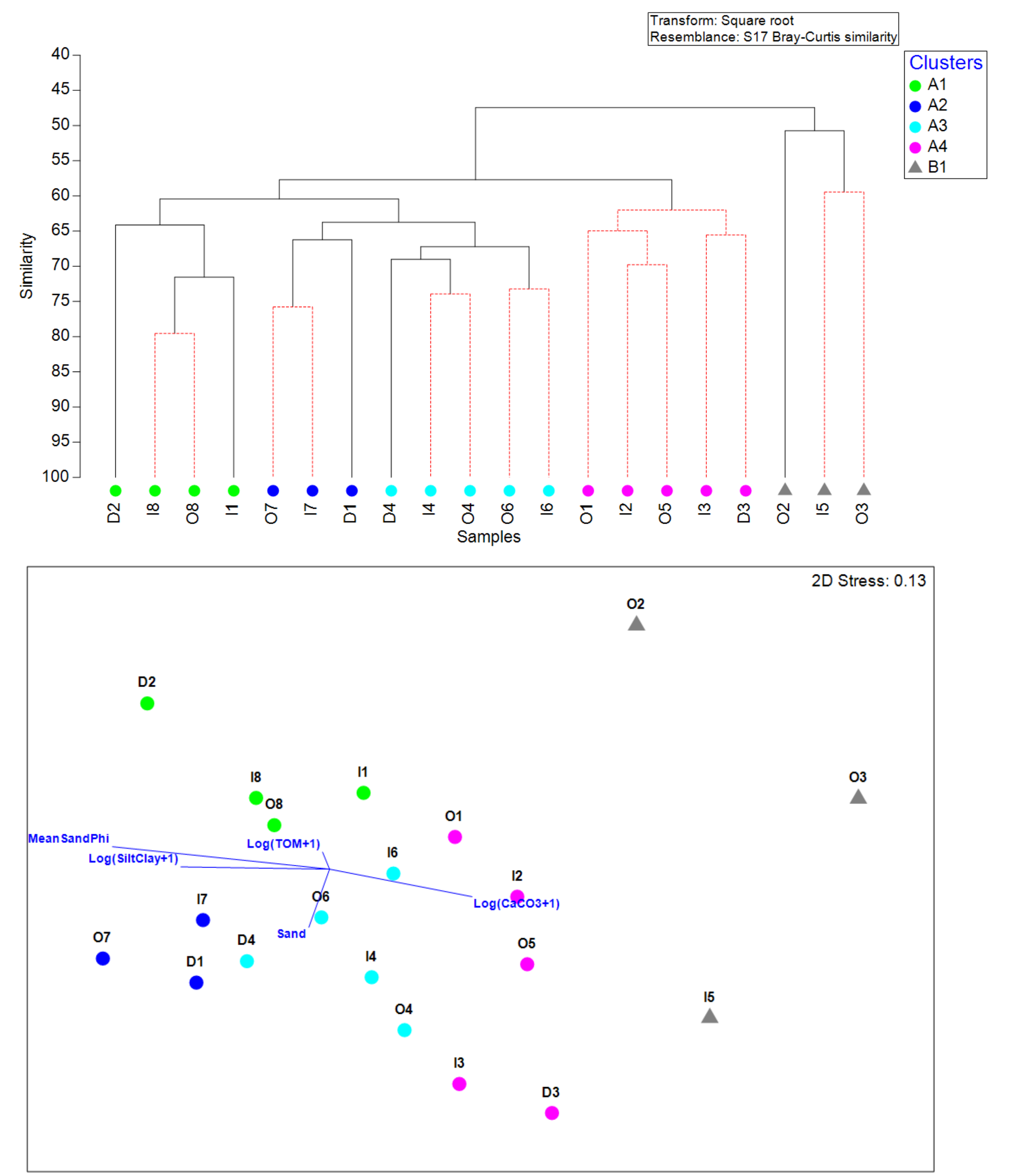

Figure 20. Macrobenthic infaunal community hierarchical cluster tree (top), and nMDS plot (bottom). Strata were divided into five statistically significant clusters (color-coded) for further analysis. The nMDS plot, color-coded by cluster, represents relative similarity in macrobenthic infauna community across strata.

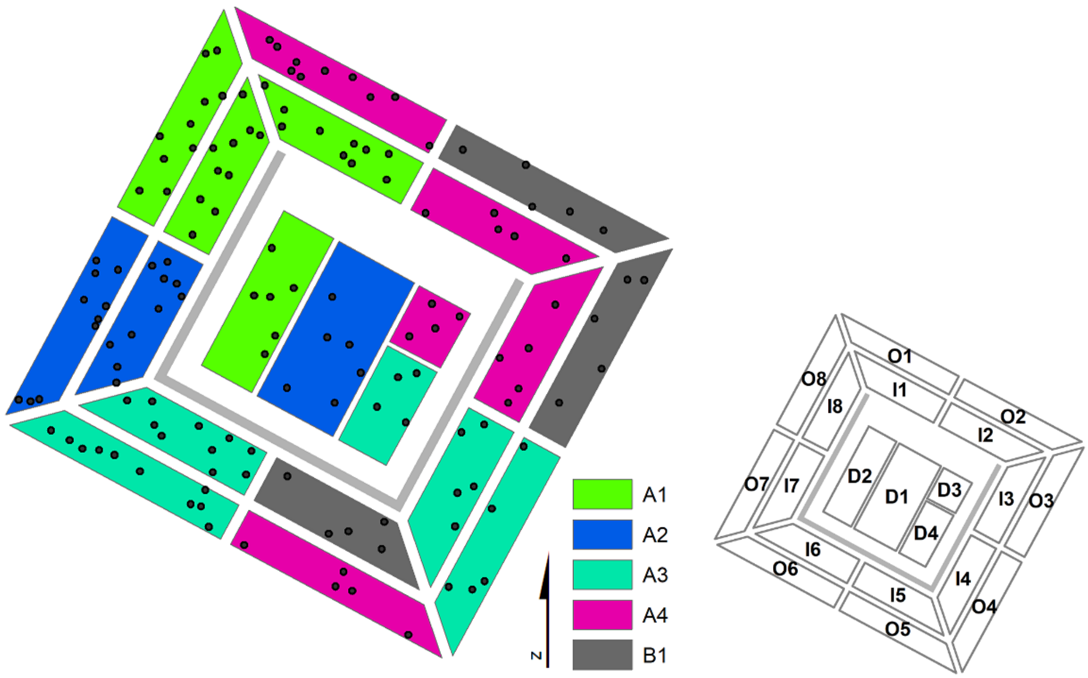

Figure 21. Macrobenthic infauna community-based clusters of strata, identified by hierarchical cluster analysis and similarity profile (SIMPROF) permutation tests.

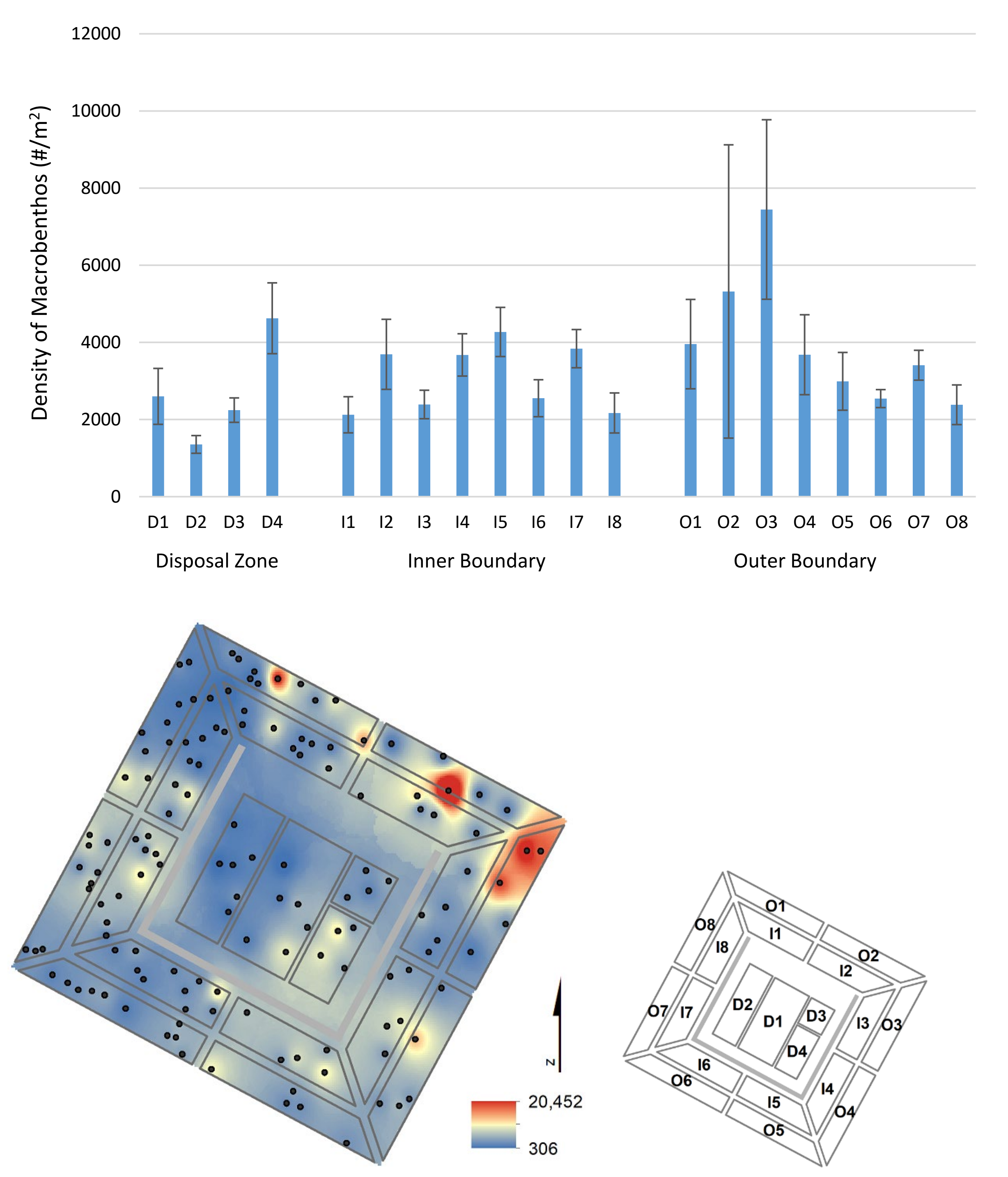

Figure 22. Mean density (# individuals/m^2; ± 1 SE) of macrobenthic infauna by stratum (top) and interpolated density between stations sampled in 2018 (bottom).

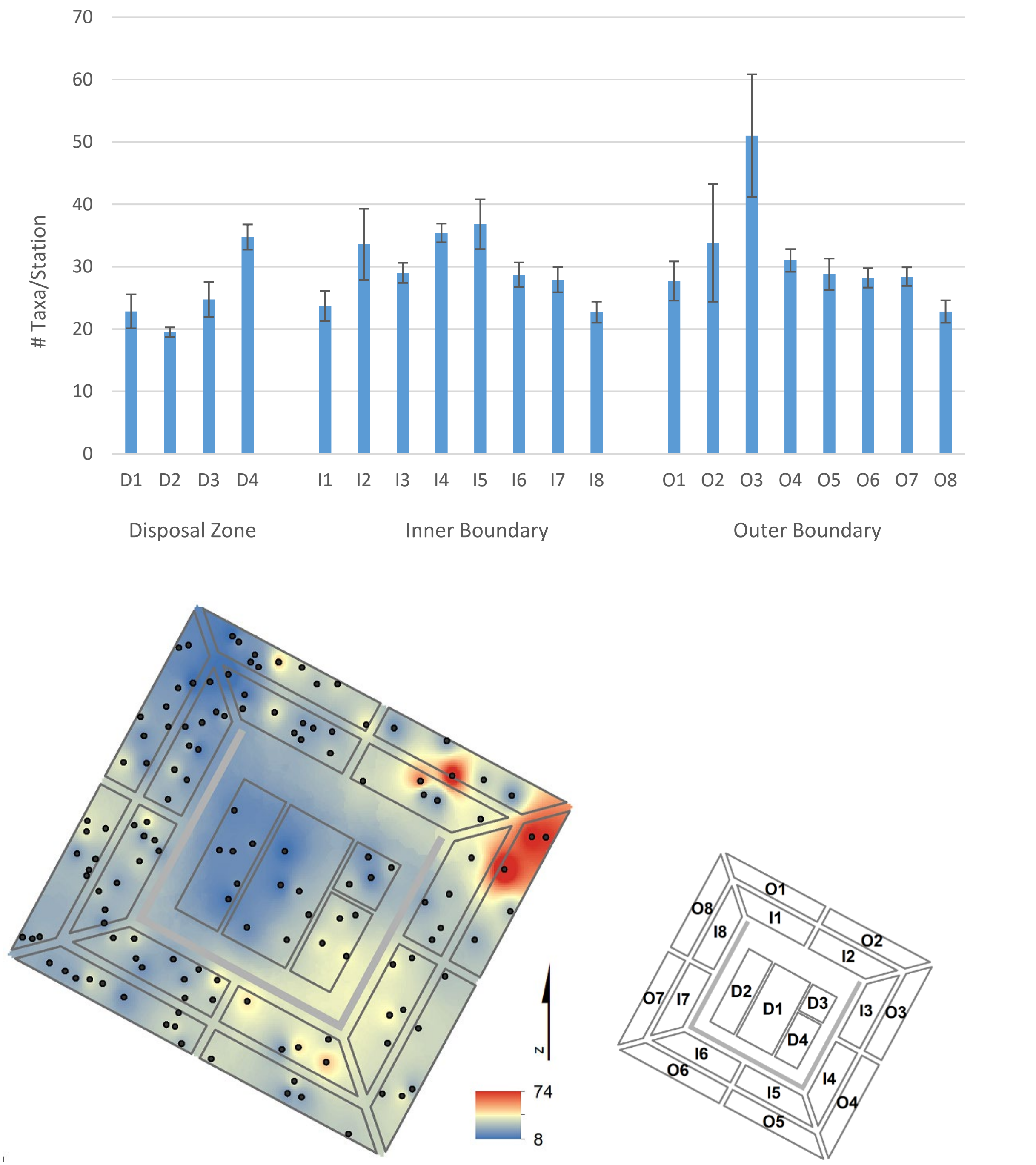

Figure 23. Mean taxonomic richness (# distinct taxa/station; ± 1 SE) by stratum (top), and interpolated taxonomic richness between stations sampled in 2018 (bottom).

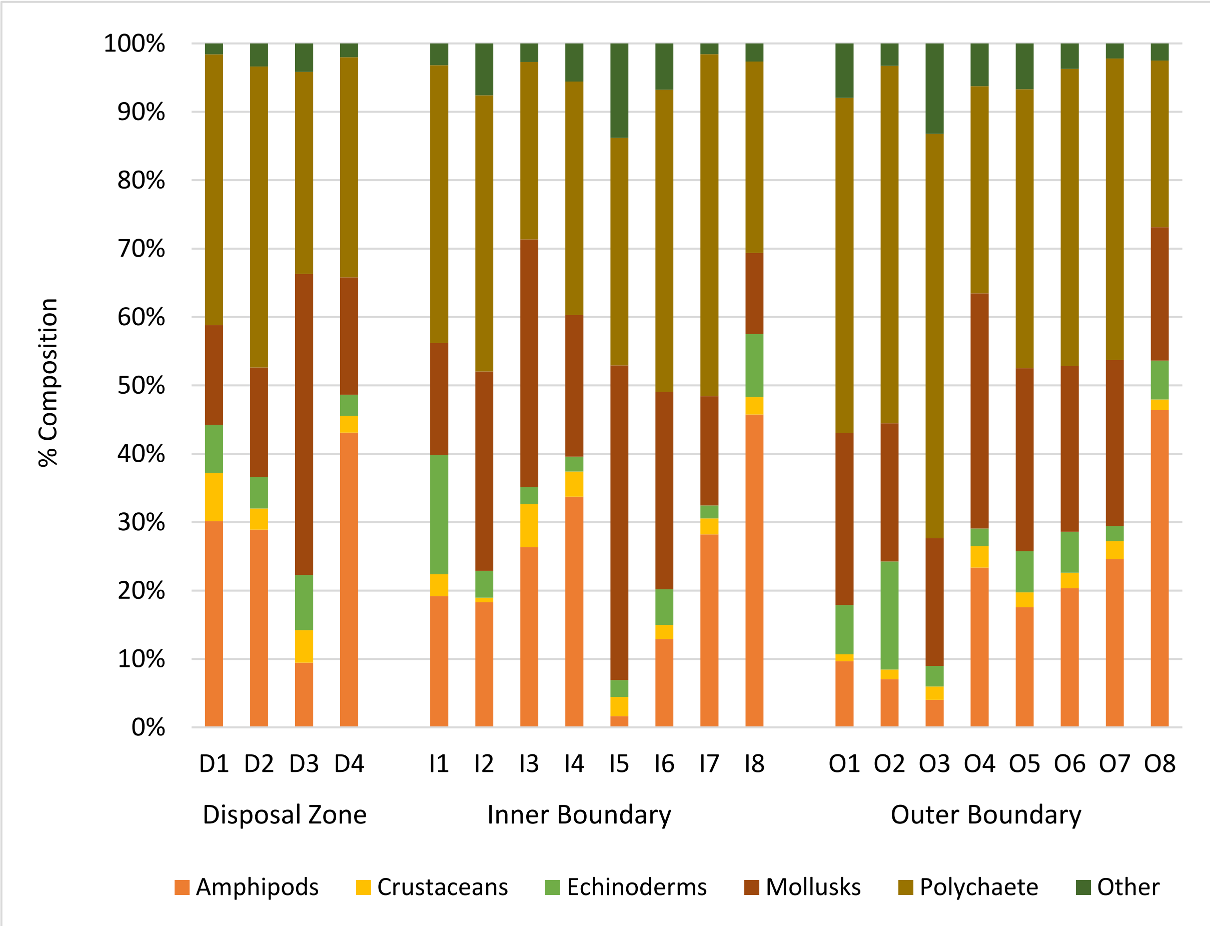

Figure 24. Mean percent composition of each taxonomic group of macrobenthic infauna in each stratum sampled in 2018. "Crustaceans" represents non-amphipod crustaceans.

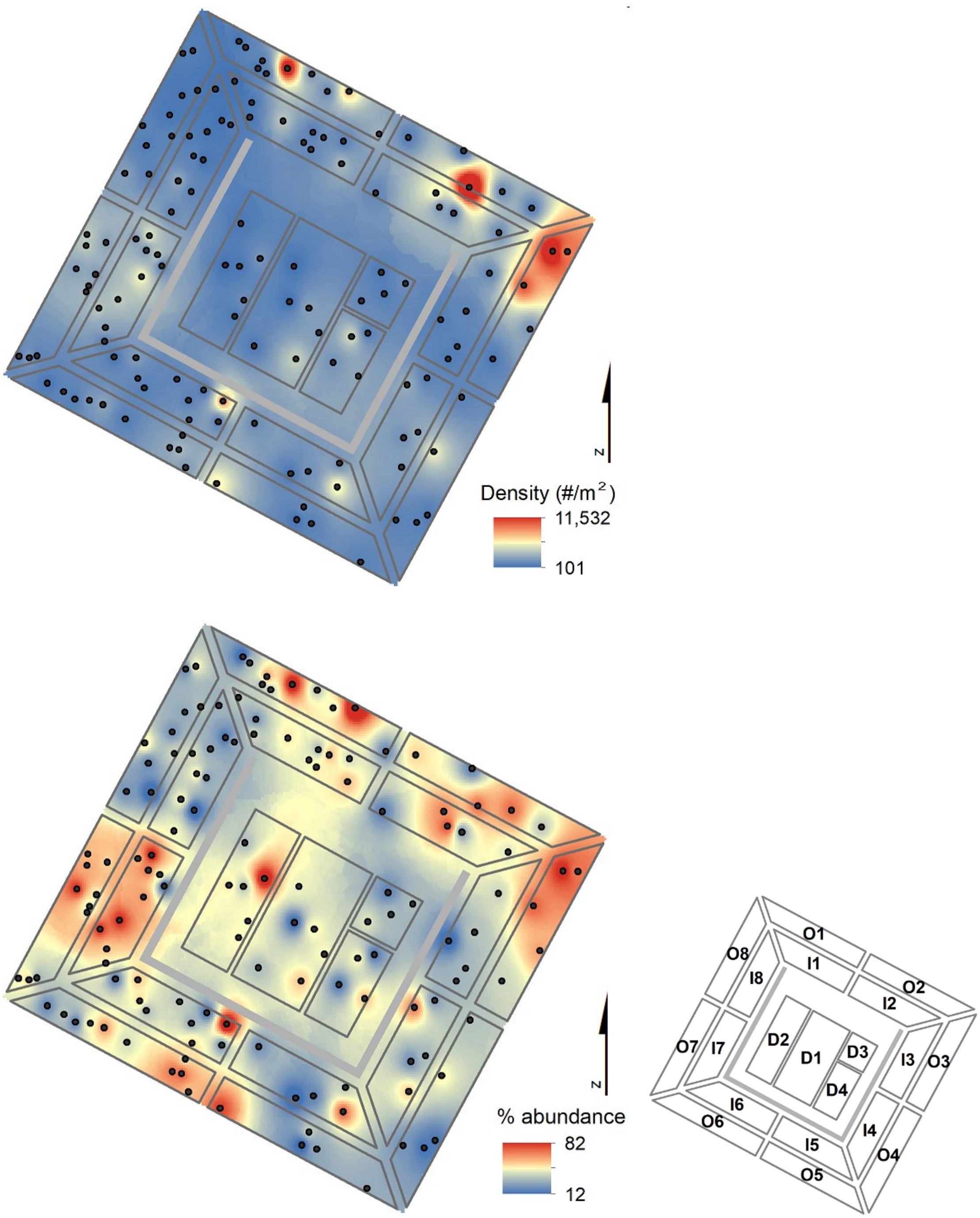

Figure 25. Interpolated total density (# individuals/m^2; top) and percent abundance (bottom) of polychaetes between stations sampled in 2018.

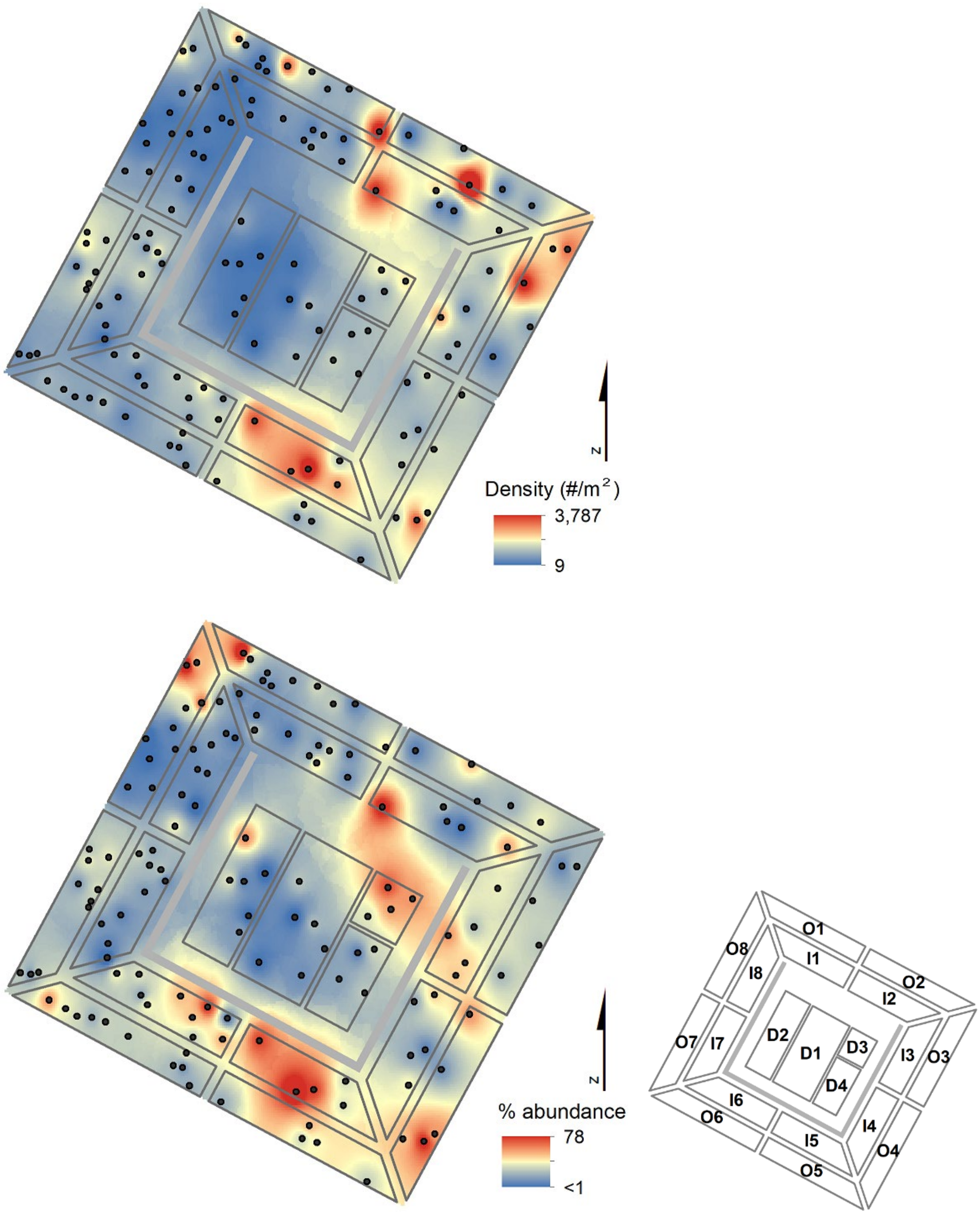

Figure 26. Interpolated total density (# individuals/m^2; top) and percent abundance (bottom) of mollusks between stations sampled in 2018.

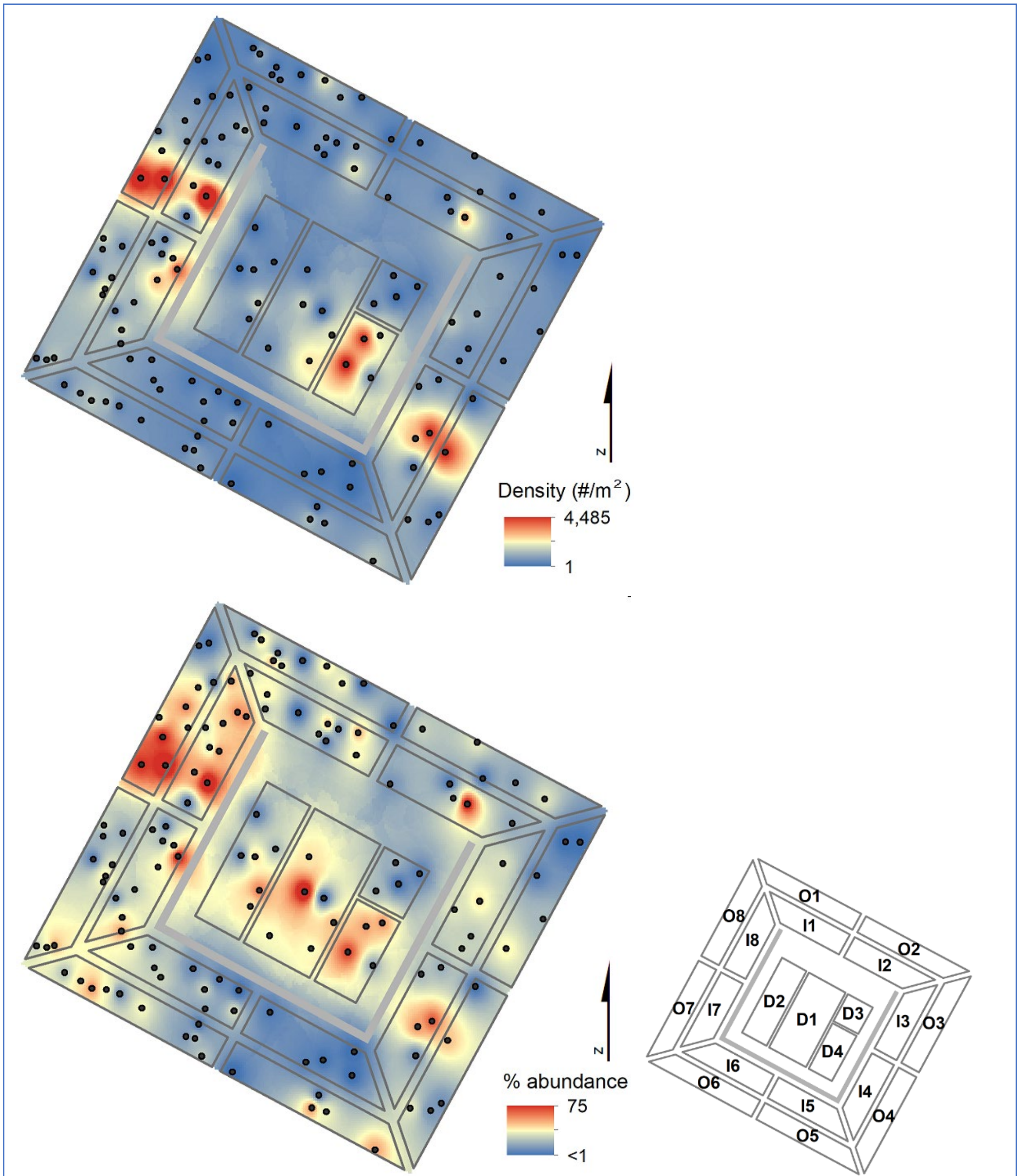

Figure 27. Interpolated total density (# individuals/m^2; top) and percent abundance (bottom) of amphipods between stations sampled in 2018.

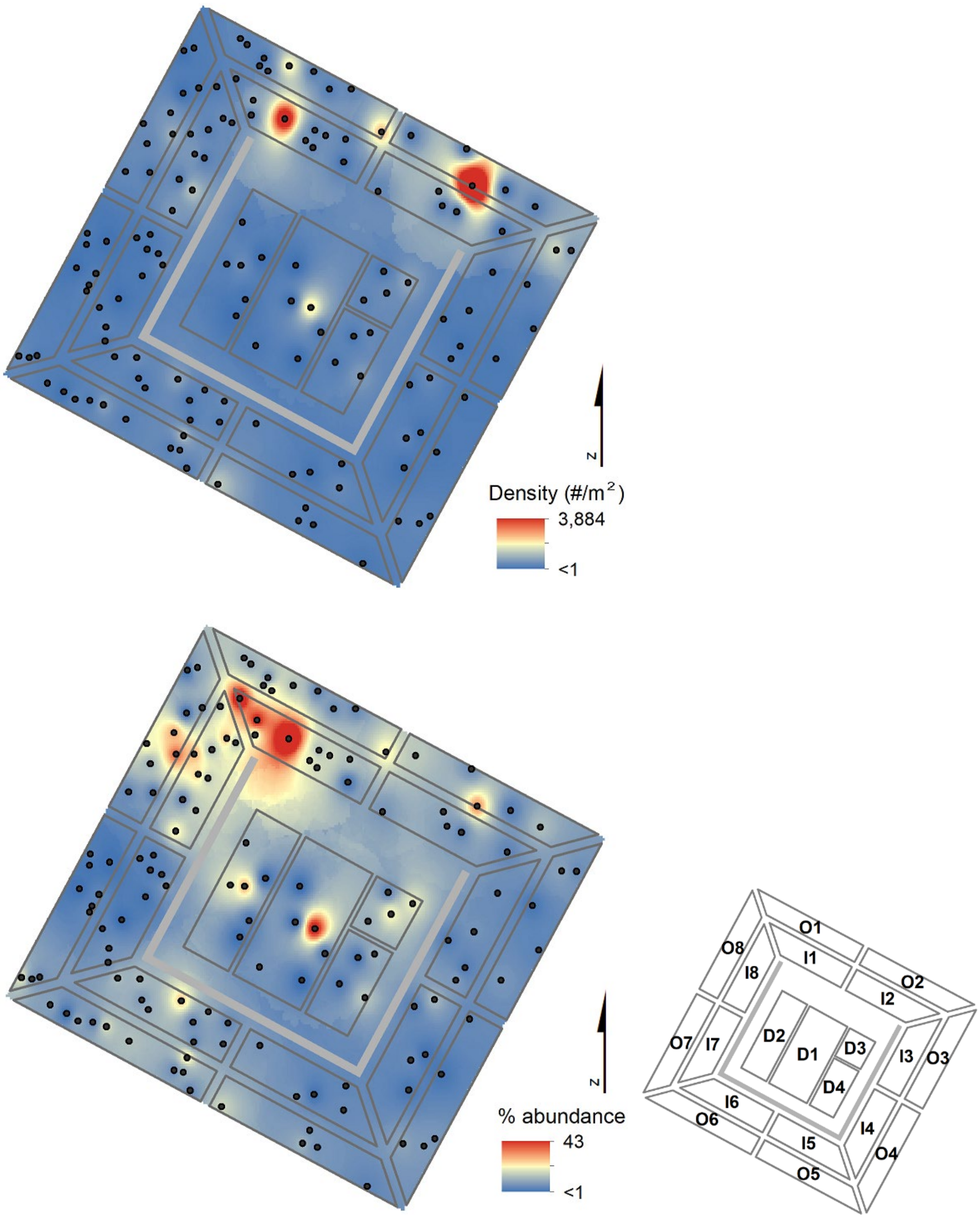

Figure 28. Interpolated total density (# individuals/m^2; top) and percent abundance (bottom) of echinoderms between stations sampled in 2018.

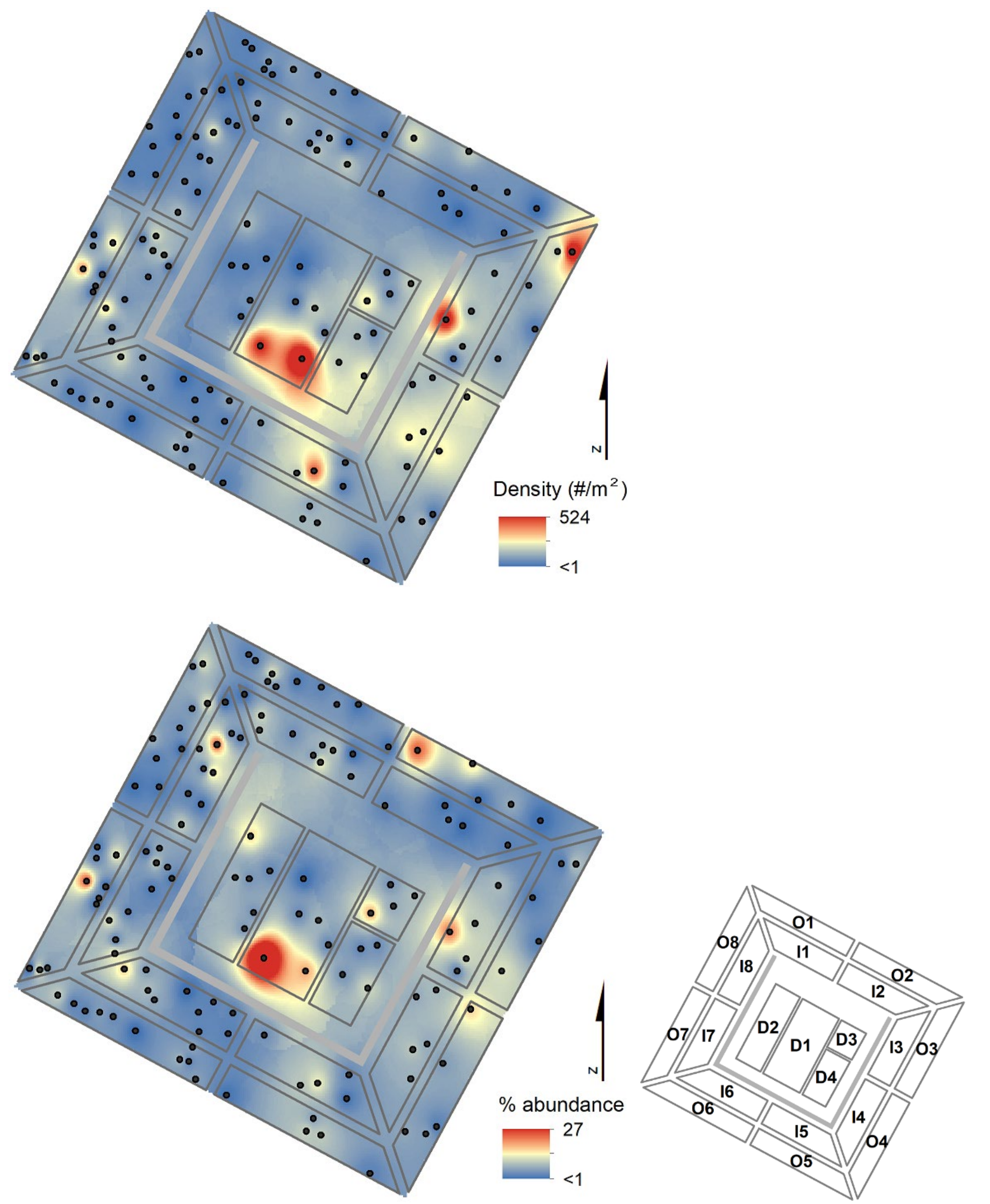

Figure 29. Interpolated total density (# individuals/m^2; top) and percent abundance (bottom) of non-amphipod crustaceans between stations sampled in 2018.

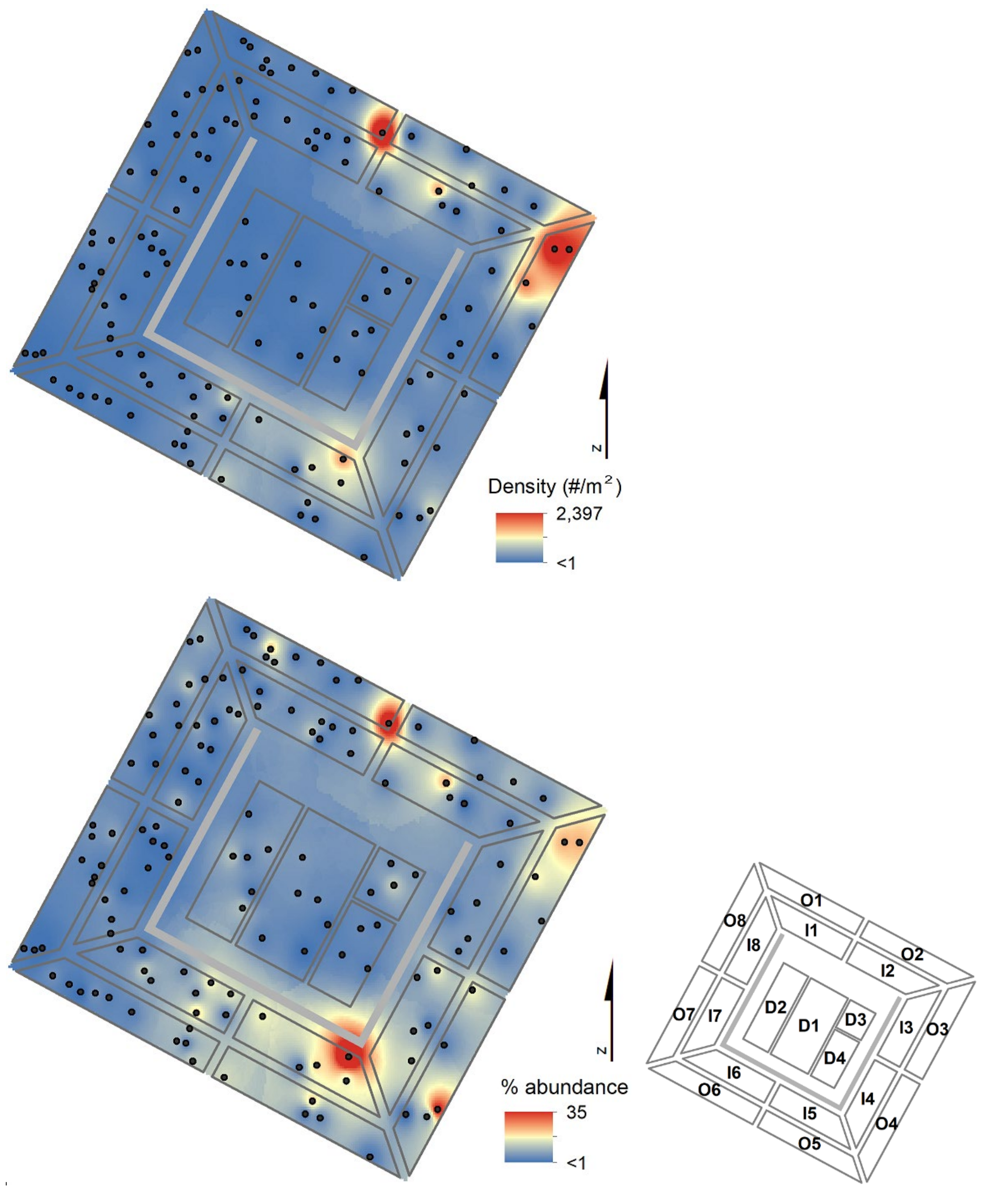

Figure 30. Interpolated total density (# individuals/m^2; top) and percent abundance (bottom) of all "other" macrobenthic infaunal taxa between stations sampled in 2018.

Table 1: The mean density (# individuals/m ^{2}) of selected macrobenthic infauna taxa in each stratum in 2018, sorted by taxonomic category and then relative abundance within that category. Taxonomic categories ("Tax. Cat.") include amphipods (A), non-amphipod crustaceans (C), echinoderms (E), mollusks (M), polychaetes (P), and other taxa (O). Taxa were selected for inclusion in this table based on either high mean density across strata (≥ 20 individuals/m ^{2}), or high mean density within at least one stratum (≥ 50 individuals/m ^{2}). Strata in this table are arranged in the same order as in the hierarchical cluster tre e in Figure 20. Fine-scale clusters (11) are outlined in bold borders, and coarse-scale clusters (5) are named and color-coded.

Taxon Name	Tax.	A1				A2			A3					A4					B1		
	Cat.	D2	I8	O8	I1	O7	I7	D1	D4	I4	O4	O6	I6	O1	I2	O5	I3	D3	O2	I5	O3
Rhepoxynius epistomus	A	167	215	223	98	440	523	179	394	325	340	228	83	60	130	50	50	0	40	5	5
Bathyporeia parkeri	A	117	138	293	43	178	308	333	813	605	205	40	15	103	125	40	5	31	10	5	15
Protohaustorius wigleyi	A	33	398	410	125	70	90	67	344	50	140	70	30	83	140	200	295	94	85	10	35
Eudevenopus honduranus	A	38	93	90	33	103	70	42	238	125	65	68	70	38	50	45	85	19	20	5	5
Acanthohaustorius intermedius	A	8	133	68	93	8	35	17	100	30	0	68	88	68	90	145	150	19	70	0	80
Melita nitida	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
Tanaissus psammophilus	C	4	10	5	13	3	3	0	0	20	45	10	8	8	5	40	90	63	0	80	25
Cyclaspis varians	C	8	8	5	8	23	15	71	19	40	20	0	5	0	0	10	0	6	5	0	0
Anthuridae	C	0	0	0	5	0	0	4	0	10	5	0	0	0	0	0	5	0	0	0	60
Ophiuroidea	E	13	23	8	245	10	25	175	25	10	25	58	20	218	65	120	15	88	780	55	185
Echinoidea	E	46	160	113	120	48	30	8	94	35	40	70	80	60	55	40	30	69	60	45	35
Crassinella martinicensis	M	79	60	255	160	23	105	88	144	230	585	163	260	558	630	255	500	719	260	1165	260
Parvilucina crenella	M	38	30	58	35	385	258	113	325	155	100	200	148	58	35	10	30	0	0	30	5
Caecum sp.	M	4	10	3	25	0	0	4	56	50	65	38	10	68	30	75	0	31	485	85	115
Semelina nuculoides	M	4	3	5	5	0	0	0	31	70	180	15	30	10	20	205	125	131	45	125	115
Tellina sp.	M	4	25	23	13	135	100	42	50	65	80	23	43	18	30	30	10	13	20	120	15
Abra aequalis	M	0	28	20	15	63	23	13	106	30	15	65	65	28	75	15	75	19	35	15	45
Acteocina candei	M	0	13	10	15	8	5	8	13	35	65	20	20	13	25	35	30	0	0	210	120
Bivalvia	M	17	18	8	28	23	8	38	6	15	30	3	18	43	20	30	25	19	10	85	105
Crassinella lunulata	M	4	5	3	10	0	10	13	6	15	30	5	15	35	105	20	5	6	50	35	110
Solenidae	M	13	30	50	25	53	15	13	6	0	0	13	20	88	15	0	0	6	15	10	20
Gastropoda	M	4	0	0	5	3	0	0	6	15	5	8	3	10	0	0	5	0	15	5	170
Polyplacophora	M	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5	0	60
Odostomia sp.	M	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	65
Prionospio sp.	P	158	63	53	113	348	735	292	350	240	290	275	323	895	120	360	20	19	105	85	90
Polygordiidae	P	13	45	38	45	318	230	163	381	175	200	260	108	103	110	30	65	25	20	325	270
Spiophanes bombyx	P	29	58	50	70	43	93	54	38	115	120	80	60	80	215	230	50	181	295	155	530
Glycera sp.	P	21	48	60	93	10	10	25	69	90	90	68	73	118	145	125	135	125	155	90	165
Aglaophamus verrilli	P	21	18	18	38	105	128	196	238	130	110	105	58	40	75	50	5	44	45	115	145
Spio pettiboneae	P	29	33	20	18	13	48	42	31	155	5	23	48	148	70	55	40	31	10	50	235
Maldanidae	P	0	30	5	55	0	13	0	0	15	0	28	65	35	50	80	5	19	450	10	115
Armandia agilis	P	8	28	45	63	100	115	29	56	45	60	33	20	108	20	20	20	25	20	40	15
Onuphis eremita	P	33	55	28	50	20	123	25	38	60	30	48	45	18	55	15	75	0	20	0	10
Fabricia sp.	P	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	240	5	405
Owenia fusiformis	P	63	5	3	35	5	18	4	6	15	0	5	33	58	20	25	0	0	150	5	65
Serpulidae	P	0	0	0	0	0	0	0	0	5	0	0	0	20	0	0	0	0	190	20	210
Amphicteis gunneri	P	25	83	23	25	38	63	17	69	5	10	0	30	8	0	0	5	0	5	0	30
Goniada littorea	P	13	33	43	10	88	48	33	38	0	0	23	33	28	25	0	0	0	0	0	0
Scolelepis sp.	P	13	10	10	18	20	33	4	31	25	50	38	25	8	25	5	40	6	25	5	20
Sigalion sp.	P	0	8	28	65	3	0	21	0	0	0	0	0	65	20	20	5	69	15	30	50
Magelona sp.	P	50	10	20	13	150	80	8	6	0	0	8	8	8	15	0	0	6	10	0	5
Aricidea sp.	P	17	5	3	5	108	75	8	6	5	5	0	0	3	20	5	5	13	0	30	10
Exogone dispar	P	0	0	0	0	0	0	0	0	15	10	0	0	0	60	0	5	0	0	20	190
Terebellidae	P	4	0	0	0	0	0	0	0	0	0	0	8	3	5	5	0	0	5	0	245
Goniadides carolinae	P	0	0	0	0	0	0	0	0	0	0	0	25	3	60	10	0	0	0	45	130
Dorvilleidae	P	0	0	0	0	0	5	8	0	0	10	3	13	5	50	0	5	0	0	35	105
Parapionosyllis sp.	P	0	0	3	5	0	3	4	6	5	15	3	0	0	10	20	10	6	20	40	75
Pholoe sp.	P	0	0	0	0	0	0	4	0	0	0	0	0	0	5	0	0	0	0	5	180
Mediomastus sp.	P	38	0	0	50	5	5	0	0	0	0	0	8	28	20	0	0	0	10	5	10
Pisione remota	P	0	0	0	3	0	0	0	0	0	0	0	8	3	15	5	0	0	10	0	135
Bhawania heteroseta	P	0	0	0	0	0	0	0	0	0	5	0	1	11	53	0	0	0	23	3	63

Taxon Name	Tax.	A1				A2			A3					A4					B1		
	Cat.	D2	I8	O8	I1	O7	I7	D1	D4	I4	O4	O6	I6	O1	I2	O5	I3	D3	O2	I5	O3
Polycirrus sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	110	0	45
Kinbergonuphis sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	145	0	0
Exogone sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0
Sphaerosyllis sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	75	0	45
Eunice vittata	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125
Petaloproctus sp.	P	0	0	3	5	0	0	0	13	5	5	0	0	10	0	0	0	6	0	60	5
Onuphis sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	0	19	0	0	65
Brania sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	0	0
Prosphaerosyllis longicauda	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	60
Branchiostoma sp.	O	0	5	0	5	3	0	13	0	30	180	28	30	13	115	120	5	31	50	205	440
Tubificidae	O	4	8	20	8	10	5	0	38	35	20	8	40	15	80	5	5	19	10	100	295
Sipuncula	O	0	0	3	5	23	20	4	25	40	15	25	43	50	50	25	25	25	35	150	155
Nemertea	O	42	45	23	23	38	25	25	25	45	10	33	40	50	20	5	15	13	45	20	20
Cupuladria doma	O	0	0	3	3	0	0	0	0	35	5	0	3	145	0	0	0	0	0	45	0
Enchytraeidae	O	0	0	3	0	0	0	0	0	5	0	0	10	0	15	30	0	6	0	20	50

Acknowledgments

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References

Arendt, M., Evans, C., Shea, N., Tweel, A., Sanger, D., 2020. Charleston Harbor Post 45: Biological Monitoring and Sediment Sampling at the Charleston ODMDS; 2017-2019 Final Report (Job 2). 2017-2019 Final Report (Job 2) Submitted to the U.S. Army Corps of Engineers, Charleston District.

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

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

EPA, Environmental Protection Agency. 2014. Charleston Harbor ODMDS / Regional Sediment Management Current and Wave Measurements. Atlanta, GA.

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

Folk, R.L. and Ward, W.C., 1957. Brazos River Bar: A Study in the Significance of Grain Size Parameters. Journal of Sedimentary Petrology: 27(1).

Jutte, P.C., Levinsen, M.V., Van Dolah, R.F., 2001. Analysis of Sediments and Habitat in the Areas Surrounding the Charleston ODMDS, Including Unauthorized Disposal Operations. Final Report Submitted to the Norfolk Dredging Company and the U.S. Army Corps of Engineers, Charleston District.

Jutte, P.C., Crowe, S.E., Van Dolah, R.F., Weinbach, P.R., 2005. An Environmental Assessment of the Charleston ODMDS and Surrounding Areas: Physical and Biological Conditions after Completion of the Charleston Harbor Deepening Project. Final Report to the Charleston District, U.S. Army Corps of Engineers.

Noakes, S. 1995. Post-disposal areal mapping of sediment chemistry at the Charleston, South Carolina ODMDS's. Final Report, submitted to U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. Prepared by the Center for Applied Isotope Studies, Athens GA.

Pequegnat, W.E., L.H. Pequegnat, B.M. James, E.A. Kennedy, R.R. Fay, and A.D. Fredericks. 1981. Procedural guide for designation surveys of ocean dredged material disposal sites. Final Report prepared by TerEce Corp. for U.S. Army Engineer Waterways Experiment Station, Technical Report EL-81-1.

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

SCDNR, South Carolina Department of Natural Resources. 2005. 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.

SCWMRD, South Carolina Wildlife and Marine Resources Dept. 1979. Benthic and sedimentologic studies on the Charleston Harbor ocean disposal area, Charleston Harbor Deepening Project. SCWMRD Marine Division for the Charleston District, U.S. Army Corps of Engineers.

SMMP. 1993. Site Management and Monitoring Plan for the Charleston ODMDS.

SMMP. 2016. Site Management and Monitoring Plan for the Charleston ODMDS.

Van Dolah, R.F., Calder, D.R., Knott, D.M., 1983. Assessment of Benthic Macroinfauna in an Ocean Disposal Area Near Charleston, SC. South Carolina Marine Resources Center Technical Report No. 56.

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

Van Dolah, R.F., P.H. Wendt, D.A. Goldman, A.B. Wrona, R.A. Pardieck, and M.V. Levisen. 1997. An assessment of benthic infaunal assemblages and sediments in the vicinity of the Charleston Ocean Dredged Material Disposal Area. Final Report submitted to U.S. Army Corps of Engineers, Charleston District.

Williams, R., Sun, C., Bourgerie, R., 1997. Collection of ocean current data at the Charleston, South Carolina ODMDS. Final Report Prepared by the National Oceanic and Atmospheric Administration, National Ocean Service, Coastal and Estuarine Oceanography Branch for the U.S. Environmental Protection Agency.

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

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

Zimmerman, L.E., P.C. Jutte, and R.F. Van Dolah. 2002. An environmental assessment of the Charleston ocean dredged material disposal site and surrounding areas. Final Report submitted to the U.S. Army Corps of Engineers, Charleston District.

Zimmerman, L.E., Jutte, P.C., Van Dolah, R.F., 2003. An Environmental Assessment of the Charleston ODMDS and Surrounding Areas: Physical and Biological Conditions after Partial Completion of the Charleston Harbor Deepening Project. Marine Pollution Bulletin 46 (11), 1408-1419.

Appendix 1: Sampling date, station depth, and coordinates of each station sampled in 2018. Station depth was not corrected for tidal stage.

Station	Date	Station Depth (m)	Latitude	Longitude
D101	1/17/2018	11.2	32.64069	-79.74055
D102	1/17/2018	14.9	32.62358	-79.74033
D103	1/17/2018	14.0	32.62846	-79.73535
D104	1/17/2018	11.9	32.62611	-79.74944
D105	1/17/2018	11.9	32.63424	-79.74162
D106	1/17/2018	9.4	32.63297	-79.73744
D201	1/19/2018	14.0	32.64877	-79.75201
D202	1/19/2018	12.8	32.64107	-79.75555
D203	1/19/2018	13.1	32.63453	-79.75152
D204	1/19/2018	12.5	32.64083	-79.75243
D205	1/19/2018	13.4	32.64225	-79.74791
D206	1/19/2018	13.4	32.63162	-79.75362
D301	1/17/2018	13.1	32.63733	-79.71625
D302	1/17/2018	12.8	32.63546	-79.72098
D303	1/17/2018	12.2	32.63944	-79.72153
D304	1/17/2018	11.9	32.63422	-79.72595
D401	1/17/2018	15.2	32.62759	-79.72823
D402	1/17/2018	15.2	32.62290	-79.73222
D403	1/17/2018	14.3	32.62825	-79.72459
D404	1/17/2018	15.2	32.62036	-79.72681
I101	1/19/2018	14.0	32.66371	-79.72936
I102	1/19/2018	13.4	32.66761	-79.74250
I103	1/19/2018	12.5	32.66355	-79.73811
I104	1/19/2018	13.4	32.66447	-79.73373
I105	1/19/2018	13.1	32.66838	-79.74985
I106	1/19/2018	13.7	32.67100	-79.74930
I107	1/19/2018	15.8	32.65956	-79.72992
I108	1/19/2018	12.5	32.67501	-79.75296
I109	1/19/2018	13.4	32.66536	-79.73602
I110	1/19/2018	13.1	32.66223	-79.73655
I201	1/17/2018	11.0	32.65131	-79.70860
I202	1/17/2018	14.0	32.65400	-79.70938
I203	1/17/2018	15.2	32.65022	-79.70557
I204	1/17/2018	14.0	32.65409	-79.72251
I205	1/17/2018	14.0	32.64650	-79.69574
I301	1/17/2018	15.2	32.62323	-79.70718
I302	1/17/2018	14.9	32.63204	-79.70314
I303	1/17/2018	15.2	32.63902	-79.69791
I304	1/17/2018	13.7	32.62553	-79.70514
I305	1/17/2018	14.0	32.63055	-79.70868

Station	Date	Station Depth (m)	Latitude	Longitude
I401	1/17/2018	14.9	32.61981	-79.71179
I402	1/17/2018	17.1	32.60345	-79.71767
I403	1/17/2018	18.0	32.60886	-79.71712
I404	1/17/2018	18.3	32.60983	-79.71389
I405	1/17/2018	15.8	32.61858	-79.71619
I501	1/16/2018	16.1	32.59989	-79.73168
I502	1/16/2018	16.4	32.60422	-79.73117
I503	1/16/2018	14.0	32.61187	-79.74950
I504	1/16/2018	14.6	32.60245	-79.74183
I505	1/16/2018	14.6	32.60278	-79.73801
I601	1/16/2018	12.8	32.62415	-79.77522
I602	1/16/2018	14.6	32.61857	-79.77353
I603	1/16/2018	13.4	32.62438	-79.78002
I604	1/16/2018	14.3	32.62038	-79.77485
I605	1/16/2018	14.9	32.61620	-79.76389
I606	1/16/2018	14.9	32.61262	-79.76378
I607	1/16/2018	14.0	32.61218	-79.75751
I608	1/16/2018	15.8	32.61593	-79.75632
I609	1/16/2018	14.0	32.62012	-79.76636
I610	1/16/2018	14.6	32.61805	-79.76054
I701	1/16/2018	12.5	32.62725	-79.78210
I702	1/16/2018	13.4	32.64105	-79.76930
I703	1/16/2018	13.4	32.64667	-79.77196
I704	1/16/2018	14.9	32.64402	-79.77277
I705	1/16/2018	14.0	32.63908	-79.77382
I706	1/16/2018	14.0	32.64315	-79.77034
I707	1/16/2018	14.6	32.63494	-79.77898
I708	1/16/2018	14.3	32.64606	-79.77496
I709	1/16/2018	13.4	32.62977	-79.78183
I710	1/16/2018	15.5	32.63343	-79.78316
I801	1/19/2018	12.5	32.66062	-79.76007
I802	1/19/2018	13.7	32.65470	-79.76273
I803	1/19/2018	13.1	32.66131	-79.76214
I804	1/19/2018	13.1	32.65100	-79.76717
I805	1/19/2018	13.1	32.66696	-79.75402
I806	1/19/2018	12.8	32.66581	-79.75919
I807	1/19/2018	12.2	32.67365	-79.75726
I808	1/19/2018	12.8	32.66780	-79.75587
I809	1/19/2018	13.7	32.65677	-79.76556
I810	1/19/2018	12.5	32.66496	-79.76292

Station	Date	Station Depth (m)	Latitude	Longitude
O101	1/19/2018	13.7	32.67293	-79.73277
O102	1/19/2018	11.9	32.67736	-79.74793
O103	1/19/2018	11.0	32.67867	-79.74693
O104	1/19/2018	13.7	32.67618	-79.73615
O105	1/19/2018	12.5	32.66490	-79.72161
O106	1/19/2018	11.9	32.68236	-79.75201
O107	1/19/2018	11.0	32.68126	-79.75052
O108	1/19/2018	12.5	32.67727	-79.74149
O109	1/19/2018	14.0	32.67284	-79.72813
O110	1/19/2018	11.6	32.67631	-79.74608
O201	1/17/2018	13.7	32.65485	-79.70213
O202	1/17/2018	15.5	32.66429	-79.71525
O203	1/17/2018	13.7	32.66173	-79.70325
O204	1/17/2018	14.9	32.65089	-79.68852
O205	1/17/2018	15.5	32.65408	-79.69489
O301	1/17/2018	15.5	32.62312	-79.69745
O302	1/17/2018	16.8	32.64286	-79.68092
O303	1/17/2018	15.2	32.63667	-79.69044
O304	1/17/2018	15.2	32.62855	-79.68922
O305	1/17/2018	16.5	32.64293	-79.68404
O401	1/17/2018	18.3	32.60616	-79.71057
O402	1/17/2018	15.5	32.59455	-79.71211
O403	1/17/2018	15.2	32.61618	-79.70431
O404	1/19/2018	15.5	32.59369	-79.71894
O405	1/19/2018	14.9	32.59313	-79.71442
O501	1/17/2018	15.8	32.59395	-79.74059
O502	1/17/2018	15.2	32.59632	-79.73904
O503	1/17/2018	16.8	32.58593	-79.72684
O504	1/19/2018	16.2	32.60075	-79.75797
O505	1/19/2018	15.2	32.59318	-79.73740
O601	1/16/2018	13.7	32.60755	-79.76809
O602	1/16/2018	14.6	32.61669	-79.78870
O603	1/16/2018	14.0	32.60978	-79.76526
O604	1/16/2018	14.9	32.60713	-79.76609
O605	1/16/2018	13.7	32.61285	-79.77776
O606	1/16/2018	14.0	32.61803	-79.79111
O607	1/16/2018	13.7	32.61560	-79.78258
O608	1/16/2018	14.9	32.60381	-79.76474
O609	1/16/2018	12.5	32.61969	-79.79465
O610	1/16/2018	15.2	32.61637	-79.78545

Station	Date	Station Depth (m)	Latitude	Longitude
O701	1/16/2018	13.7	32.62473	-79.80074
O702	1/16/2018	14.0	32.63754	-79.78535
O703	1/16/2018	13.7	32.62442	-79.79857
O704	1/16/2018	14.9	32.64552	-79.78146
O705	1/16/2018	15.8	32.64074	-79.78802
O706	1/16/2018	14.6	32.63967	-79.78390
O707	1/16/2018	14.0	32.64701	-79.78556
O708	1/16/2018	14.6	32.64494	-79.78581
O709	1/16/2018	14.3	32.63651	-79.78593
O710	1/16/2018	13.1	32.62478	-79.79684
O801	1/19/2018	12.5	32.66334	-79.77249
O802	1/19/2018	14.0	32.65802	-79.77189
O803	1/19/2018	13.7	32.65820	-79.77726
O804	1/19/2018	10.7	32.68025	-79.76418
O805	1/19/2018	11.6	32.66695	-79.77322
O806	1/19/2018	12.5	32.66499	-79.76682
O807	1/19/2018	11.9	32.67248	-79.76453
O808	1/19/2018	11.3	32.67344	-79.76109
O809	1/19/2018	10.4	32.68080	-79.76205
O810	1/19/2018	11.6	32.66887	-79.76721

Appendix 2: 2018 water quality by stratum: Dissolved oxygen (DO), salinity, and water temperature (Temp) measured approximately 0.3 meters above the bottom (near-bottom) and approximately 0.3 beneath the water surface (near-surface).

Stratum	Date	Near-bottom measurements			Near-surface measurements		
		DO (mg/L)	Salinity (psu)	Temp (°C)	DO (mg/L)	Salinity (psu)	Temp (°C)
D1	1/17/2018	8.53	37.1	13.0	8.91	36.8	12.0
D2	1/19/2018	8.42	36.6	11.3	9.43	34.9	8.4
D3	1/17/2018	8.20	37.4	14.0	8.21	37.4	14.0
D4	1/17/2018	8.30	37.4	13.9	8.60	37.1	13.0
Zone D mean		8.36	37.1	13.1	8.79	36.6	11.9
I1	1/19/2018	8.21	37.0	12.0	9.48	34.6	8.3
I2	1/17/2018	8.22	37.4	13.9	8.26	37.4	13.9
I3	1/17/2018	8.17	37.5	14.4	8.16	37.5	14.4
I4	1/17/2018	8.10	37.5	14.5	8.10	37.4	14.4
I5	1/16/2018	8.23	36.7	12.6	8.34	36.6	12.4
I6	1/16/2018	8.20	36.6	12.4	8.41	36.5	12.0
I7	1/16/2018	8.76	36.4	11.1	8.99	36.2	10.5
I8	1/19/2018	8.51	36.5	11.1	9.37	35.2	8.8
Zone I mean		8.30	37.0	12.8	8.64	36.4	11.8
O1	1/19/2018	8.65	36.4	10.8	9.45	34.8	8.6
O2	1/17/2018	8.17	37.5	14.0	8.31	37.5	13.8
O3	1/17/2018	8.24	37.5	14.3	8.24	37.5	14.3
O4	1/17/2018	7.75	37.5	14.5	7.74	37.5	14.5
O5	1/17/2018	7.64	37.5	14.5	7.68	37.4	14.3
O6	1/16/2018	8.36	36.5	12.4	8.55	36.4	12.1
O7	1/16/2018	8.27	36.6	12.4	8.53	36.4	12.1
O8	1/19/2018	8.60	36.4	10.8	9.30	35.1	8.8
Zone O mean		8.21	37.0	13.0	8.48	36.6	12.3

Appendix 3: 2018 sediment characteristics by station. (% clay + % silt + % $CaCO_3$ + % sand = 100%)

Station	Date	% clay	% silt	% $CaCO_3$	% sand	Mean sand phi	Sand classification	% TOM
D101	1/17/2018	4.3	5.7	32.3	57.7	2.25	fine	5.2
D102	1/17/2018	1.0	0.1	8.3	90.6	2.63	fine	1.6
D103	1/17/2018	1.2	0.1	7.7	91.0	2.58	fine	3.0
D104	1/17/2018	25.2	27.1	29.8	18.0	2.91	fine	9.6
D105	1/17/2018	3.3	2.0	10.1	84.7	2.72	fine	3.2
D106	1/17/2018	0.8	0.4	63.7	35.2	1.51	medium	8.1
D201	1/19/2018	1.2	0.3	29.2	69.4	2.21	fine	1.2
D202	1/19/2018	1.3	0.3	32.2	66.3	2.38	fine	3.2
D203	1/19/2018	1.9	0.3	5.7	92.2	2.69	fine	1.8
D204	1/19/2018	1.3	0.1	10.2	88.4	2.59	fine	1.5
D205	1/19/2018	21.3	16.7	5.9	56.0	2.70	fine	7.5
D206	1/19/2018	35.4	38.6	2.6	23.4	2.84	fine	6.8
D301	1/17/2018	1.4	0.0	20.6	78.0	2.09	fine	5.5
D302	1/17/2018	1.1	0.0	26.9	72.0	1.71	medium	2.5
D303	1/17/2018	1.2	0.1	8.7	89.9	2.31	fine	4.9
D304	1/17/2018	1.3	0.0	15.4	83.3	2.28	fine	5.6
D401	1/17/2018	1.1	0.3	6.7	91.8	2.63	fine	1.8
D402	1/17/2018	1.6	0.2	9.8	88.5	2.56	fine	0.8
D403	1/17/2018	1.2	0.2	6.8	91.8	2.55	fine	1.4
D404	1/17/2018	1.2	0.2	11.9	86.7	2.35	fine	1.3
I101	1/19/2018	0.7	0.1	10.3	88.9	2.42	fine	2.5
I102	1/19/2018	0.5	0.1	53.8	45.6	1.06	medium	2.0
I103	1/19/2018	0.5	0.1	17.3	82.1	2.20	fine	1.3
I104	1/19/2018	0.6	0.2	18.7	80.6	2.47	fine	5.0
I105	1/19/2018	0.1	0.0	20.4	79.5	2.18	fine	2.2
I106	1/19/2018	0.5	0.3	9.4	89.9	2.42	fine	0.9
I107	1/19/2018	1.8	2.8	13.0	82.4	2.67	fine	4.7
I108	1/19/2018	0.3	0.6	10.4	88.7	2.32	fine	1.9
I109	1/19/2018	0.2	0.6	8.5	90.6	2.46	fine	3.8
I110	1/19/2018	0.3	0.6	19.7	79.4	2.19	fine	11.6
I201	1/17/2018	0.6	0.6	9.1	89.7	2.41	fine	2.1
I202	1/17/2018	0.7	0.9	68.6	29.9	0.94	coarse	2.5
I203	1/17/2018	1.2	0.1	6.0	92.6	2.60	fine	0.9
I204	1/17/2018	0.9	0.5	10.4	88.1	1.99	medium	2.8
I205	1/17/2018	1.0	0.3	20.3	78.5	2.39	fine	1.2
I301	1/17/2018	1.1	0.1	7.2	91.6	2.37	fine	3.1
I302	1/17/2018	1.2	0.1	7.2	91.5	2.41	fine	1.5
I303	1/17/2018	1.3	0.1	8.1	90.6	2.44	fine	3.1
I304	1/17/2018	1.2	0.0	9.4	89.4	2.27	fine	3.2
I305	1/17/2018	1.1	0.0	24.6	74.2	2.12	fine	1.6

Station	Date	% clay	% silt	% $CaCO_3$	% sand	Mean sand phi	Sand classification	% TOM
I401	1/17/2018	1.5	3.3	9.5	85.7	2.35	fine	2.3
I402	1/17/2018	1.4	0.0	24.7	73.9	1.88	medium	1.2
I403	1/17/2018	1.8	0.1	9.6	88.5	2.58	fine	2.0
I404	1/17/2018	1.6	0.2	11.4	86.7	2.57	fine	1.0
I405	1/17/2018	1.3	0.1	7.2	91.3	2.46	fine	1.5
I501	1/16/2018	0.4	0.3	26.0	73.3	1.13	medium	1.4
I502	1/16/2018	0.5	0.2	13.0	86.3	0.36	coarse	3.6
I503	1/16/2018	0.8	0.2	14.2	84.8	1.94	medium	2.2
I504	1/16/2018	0.7	0.2	15.4	83.7	1.95	medium	5.3
I505	1/16/2018	0.0	0.7	11.6	87.7	1.47	medium	2.5
I601	1/16/2018	1.2	0.7	9.0	89.0	2.34	fine	1.8
I602	1/16/2018	1.9	0.6	6.3	91.2	2.56	fine	0.8
I603	1/16/2018	1.3	0.6	7.2	90.8	2.50	fine	1.9
I604	1/16/2018	1.9	1.8	7.4	89.0	2.40	fine	1.2
I605	1/16/2018	1.0	0.4	12.1	86.5	2.27	fine	2.7
I606	1/16/2018	0.9	0.8	14.4	83.9	2.46	fine	1.9
I607	1/16/2018	1.0	0.5	11.2	87.4	0.41	coarse	3.8
I608	1/16/2018	0.5	0.7	8.3	90.5	2.33	fine	1.5
I609	1/16/2018	0.8	0.4	6.8	91.9	2.29	fine	2.9
I610	1/16/2018	0.3	0.7	14.7	84.3	1.80	medium	2.2
I701	1/16/2018	1.4	0.1	4.8	93.7	2.46	fine	1.6
I702	1/16/2018	1.0	0.1	9.3	89.6	2.65	fine	3.1
I703	1/16/2018	1.8	1.1	32.5	64.6	1.60	medium	3.5
I704	1/16/2018	3.0	2.0	10.9	84.2	2.69	fine	3.2
I705	1/16/2018	3.8	1.7	11.2	83.3	2.97	fine	5.0
I706	1/16/2018	1.7	0.5	20.2	77.6	2.46	fine	6.0
I707	1/16/2018	2.4	1.2	10.5	85.9	2.93	fine	4.3
I708	1/16/2018	2.0	0.5	12.4	85.2	2.88	fine	3.6
I709	1/16/2018	1.7	0.1	7.1	91.1	2.66	fine	3.1
I710	1/16/2018	8.4	5.7	14.3	71.6	3.00	very fine	7.2
I801	1/19/2018	0.4	0.2	9.0	90.4	2.57	fine	1.2
I802	1/19/2018	1.0	0.3	9.4	89.3	2.68	fine	3.5
I803	1/19/2018	0.7	0.2	4.9	94.2	2.58	fine	2.0
I804	1/19/2018	1.0	0.8	35.0	63.2	1.75	medium	5.5
I805	1/19/2018	1.1	0.0	7.7	91.2	2.42	fine	3.2
I806	1/19/2018	0.9	0.1	4.7	94.4	2.46	fine	1.9
I807	1/19/2018	0.8	0.1	6.9	92.3	2.35	fine	3.1
I808	1/19/2018	1.0	0.0	4.8	94.3	2.49	fine	2.5
I809	1/19/2018	1.3	0.1	8.4	90.2	2.71	fine	3.2
I810	1/19/2018	0.8	0.3	3.1	95.8	2.53	fine	1.7

Station	Date	% clay	% silt	% $CaCO_3$	% sand	Mean sand phi	Sand classification	% TOM
O101	1/19/2018	0.8	0.3	20.0	78.9	2.25	fine	7.5
O102	1/19/2018	0.3	0.4	7.7	91.6	2.46	fine	2.6
O103	1/19/2018	0.5	0.1	16.0	83.4	2.01	fine	6.8
O104	1/19/2018	1.3	0.0	7.3	91.4	2.59	fine	4.2
O105	1/19/2018	0.3	0.2	28.7	70.8	1.03	medium	12.7
O106	1/19/2018	0.7	0.1	29.5	69.7	1.60	medium	7.6
O107	1/19/2018	0.6	0.0	15.2	84.2	2.31	fine	6.2
O108	1/19/2018	0.6	0.3	37.5	61.6	2.07	fine	16.2
O109	1/19/2018	1.2	0.4	16.6	81.8	1.13	medium	5.5
O110	1/19/2018	1.9	0.4	8.2	89.5	2.49	fine	3.3
O201	1/17/2018	0.9	0.2	70.7	28.3	1.47	medium	7.6
O202	1/17/2018	1.0	0.2	8.0	90.7	2.46	fine	3.3
O203	1/17/2018	1.1	0.2	8.6	90.2	2.47	fine	2.3
O204	1/17/2018	0.2	0.4	6.9	92.5	2.46	fine	3.5
O205	1/17/2018	0.9	0.2	15.3	83.7	2.38	fine	2.9
O301	1/17/2018	1.2	0.1	7.0	91.7	2.46	fine	4.2
O302	1/17/2018	0.8	0.3	30.1	68.8	0.79	coarse	2.4
O303	1/17/2018	2.2	0.1	54.1	43.5	1.45	medium	1.6
O304	1/17/2018	1.2	0.1	17.2	81.5	1.92	medium	1.5
O305	1/17/2018	0.9	0.2	17.3	81.5	0.24	coarse	3.9
O401	1/17/2018	1.8	1.0	10.5	86.8	2.63	fine	3.1
O402	1/17/2018	1.2	0.3	26.8	71.7	1.56	medium	6.2
O403	1/17/2018	1.1	0.1	17.2	81.6	1.55	medium	1.8
O404	1/19/2018	4.3	3.6	17.5	74.6	2.17	fine	5.9
O405	1/19/2018	1.3	0.4	20.2	78.1	2.09	fine	1.4
O501	1/17/2018	0.8	0.2	14.6	84.4	2.15	fine	1.9
O502	1/17/2018	0.7	0.4	25.2	73.7	1.88	medium	1.0
O503	1/17/2018	0.3	0.7	8.8	90.2	2.44	fine	2.2
O504	1/19/2018	0.5	0.4	16.0	83.1	0.64	coarse	0.7
O505	1/19/2018	0.9	0.4	13.5	85.3	2.05	fine	2.5
O601	1/16/2018	1.1	0.5	10.4	87.9	2.34	fine	2.9
O602	1/16/2018	1.3	0.4	5.7	92.6	2.60	fine	1.1
O603	1/16/2018	1.2	0.3	24.0	74.5	1.72	medium	2.5
O604	1/16/2018	1.1	0.8	4.9	93.2	2.55	fine	0.9
O605	1/16/2018	0.9	1.0	5.4	92.7	2.50	fine	1.7
O606	1/16/2018	1.9	0.1	6.4	91.6	2.56	fine	2.6
O607	1/16/2018	1.6	0.3	6.4	91.7	2.54	fine	2.6
O608	1/16/2018	1.7	0.0	9.8	88.5	2.49	fine	2.2
O609	1/16/2018	1.5	0.4	5.1	93.0	2.49	fine	2.2
O610	1/16/2018	1.6	0.4	6.8	91.1	2.54	fine	1.3

Station	Date	% clay	% silt	% $CaCO_3$	% sand	Mean sand phi	Sand classification	% TOM
O701	1/16/2018	0.7	0.3	6.4	92.5	2.57	fine	2.6
O702	1/16/2018	1.5	0.9	4.0	93.6	2.68	fine	2.4
O703	1/16/2018	1.3	0.5	13.1	85.1	2.58	fine	6.2
O704	1/16/2018	4.4	2.8	11.5	81.3	2.96	fine	6.1
O705	1/16/2018	10.1	7.2	14.4	68.3	3.09	very fine	9.8
O706	1/16/2018	0.6	0.3	6.1	93.0	2.51	fine	2.7
O707	1/16/2018	1.5	0.6	9.9	88.0	2.89	fine	2.7
O708	1/16/2018	4.0	1.7	11.5	82.8	2.98	fine	3.1
O709	1/16/2018	1.3	0.6	13.2	84.8	2.67	fine	3.1
O710	1/16/2018	0.6	0.3	9.4	89.7	2.62	fine	1.2
O801	1/19/2018	0.9	0.9	7.0	91.1	2.61	fine	1.6
O802	1/19/2018	1.1	0.2	6.3	92.4	2.71	fine	0.9
O803	1/19/2018	1.3	0.6	8.2	89.8	2.70	fine	3.7
O804	1/19/2018	0.8	0.2	20.1	78.9	2.22	fine	1.9
O805	1/19/2018	0.7	0.2	5.9	93.2	2.54	fine	2.3
O806	1/19/2018	0.9	0.0	3.8	95.2	2.57	fine	1.0
O807	1/19/2018	0.4	0.4	3.5	95.7	2.42	fine	1.8
O808	1/19/2018	0.7	0.2	20.3	78.8	1.99	medium	1.8
O809	1/19/2018	0.7	0.3	22.6	76.4	2.12	fine	6.4
O810	1/19/2018	1.0	0.1	4.1	94.8	2.53	fine	2.2

Appendix 4: The mean density (# individuals/m^2) of each macrobenthic infauna taxon at each stratum in 2018, sorted by taxonomic category and then taxon name. Taxonomic categories ("Cat.") include amphipods (A), non-amphipod crustaceans (C), echinoderms (E), mollusks (M), polychaetes (P), and other taxa (O).

Taxon Name	Cat.	D1	D2	D3	D4	I1	I2	I3	I4	I5	I6	I7	I8	O1	O2	O3	O4	O5	O6	O7	O8
Acanthohaustorius intermedius	A	17	8	19	100	93	90	150	30	0	88	35	133	68	70	80	0	145	68	8	68
Acanthohaustorius millsi	A	0	0	6	0	0	10	0	0	25	0	0	0	3	0	0	15	5	0	3	0
Acanthohaustorius similis	A	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthohaustorius sp.	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0
Americhelidium americanum	A	46	4	6	38	3	20	35	30	0	18	3	0	3	10	5	20	5	5	3	3
Amphipoda	A	4	4	0	13	5	5	0	0	0	0	0	3	0	15	10	10	5	0	5	3
Argissa hamatipes	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Batea catharinensis	A	0	4	0	0	0	0	0	0	0	0	0	3	0	40	0	0	0	0	0	0
Batea sp.	A	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Bathyporeia parkeri	A	333	117	31	813	43	125	5	605	5	15	308	138	103	10	15	205	40	40	178	293
Caprella sp.	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Caprellidae	A	0	0	0	0	0	0	0	0	0	3	0	0	0	5	0	0	0	0	0	0
Cerapus tubularis	A	13	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	8	3	0
Ericthonius brasiliensis	A	38	8	0	0	0	0	0	20	5	3	8	0	5	10	0	5	5	13	0	0
Eudevenopus honduranus	A	42	38	19	238	33	50	85	125	5	70	70	93	38	20	5	65	45	68	103	90
Haustoriidae	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	3	0
Hippomedon serratus	A	0	0	0	6	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Idunella barnardi	A	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	10	0
Lembos websteri	A	0	0	6	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liljeborgia sp.	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	3	0
Melita dentata	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Melita nitida	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0
Melitidae	A	0	0	0	0	0	35	0	0	0	0	0	0	0	35	0	0	0	0	0	0
Metharpinia floridana	A	29	0	6	25	0	35	5	20	5	20	18	0	8	0	5	20	15	5	0	0
Microprotopus raneyi	A	0	8	0	0	0	0	0	0	0	3	5	5	0	0	0	5	0	0	0	3
Monocorophium acherusicum	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Neohaustorius sp.	A	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parametopella cypris	A	4	0	6	0	0	0	0	0	10	0	0	0	0	15	0	5	0	5	3	0
Photis sp.	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Phoxocephalidae	A	4	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protohaustorius wigleyi	A	67	33	94	344	125	140	295	50	10	30	90	398	83	85	35	140	200	70	70	410
Rhepoxynius epistomus	A	179	167	0	394	98	130	50	325	5	83	523	215	60	40	5	340	50	228	440	223
Tiron triocellatus	A	8	0	6	19	8	20	0	20	0	0	15	0	8	10	0	10	5	5	5	10
Tiron tropakis	A	0	0	0	6	0	10	0	10	0	0	5	8	8	5	10	15	5	3	0	5
Albunea paretii	C	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	3	3	0
Amakusanthura magnifica	C	4	0	0	0	5	10	5	0	0	0	3	3	5	5	0	0	0	3	0	10
Ancinus depressus	C	8	0	0	19	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Anthuridae	C	4	0	0	0	5	0	5	10	0	0	0	0	0	0	60	5	0	0	0	0
Apseudes sp.	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
Chiridotea excavata	C	0	0	0	0	3	0	0	0	0	0	10	15	0	5	0	0	0	8	0	0
Chlamydopleon dissimile	C	4	0	6	6	0	0	25	15	0	0	0	0	3	15	0	5	0	0	3	0
Cumacea	C	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclaspis pustulata	C	8	0	6	31	3	0	5	5	0	0	10	3	3	0	0	0	0	13	13	0
Cyclaspis sp.	C	0	0	0	0	0	0	0	0	5	5	3	0	0	15	0	0	5	0	0	0
Cyclaspis varians	C	71	8	6	19	8	0	0	40	0	5	15	8	0	5	0	20	10	0	23	5
Decapoda	C	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Diastylis sp.	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	0	0
Ebalia cariosa	C	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Emerita talpoida	C	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eurydice littoralis	C	0	0	6	0	0	0	0	0	0	0	0	0	0	0	5	5	5	0	0	0
Eurydice piperata	C	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0

Taxon Name	Cat.	D1	D2	D3	D4	I1	I2	I3	I4	I5	I6	I7	I8	O1	O2	O3	O4	O5	O6	O7	O8
Gibbesia neglecta	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Hepatus pudibundus	C	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	0	0	0	0	0
Heterocrypta granulata	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Kupellonura formosa	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Lepidopa websteri	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Leptochela serratorbita	C	4	4	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Leptochelia sp.	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0
Ogyrides alphaerostris	C	0	0	0	19	0	0	0	5	0	8	0	0	0	0	0	0	0	3	3	3
Ovalipes sp.	C	0	0	0	0	0	5	0	5	5	0	0	0	3	0	0	0	0	0	0	0
Ovalipes stephensoni	C	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Oxyurostylis lecroyae	C	0	0	6	0	0	0	10	0	0	3	0	0	3	5	5	0	0	0	0	0
Oxyurostylis smithi	C	42	17	6	19	15	0	10	25	20	20	35	18	10	20	10	30	0	10	25	13
Oxyurostylis sp.	C	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paguridae	C	25	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0
Pagurus arcuatus	C	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Pagurus longicarpus	C	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0
Pagurus pollicaris	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Pagurus sp.	C	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Panopeidae	C	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paranthura sp.	C	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	0	0	0	0	0
Pinnixa chaetopterana	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
Pinnixa sp.	C	0	0	0	0	5	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0
Pinnotheridae	C	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Tanaidacea	C	0	4	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0
Tanaissus psammophilus	C	0	4	63	0	13	5	90	20	80	8	3	10	8	0	25	45	40	10	3	5
Amphiuridae	E	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Asteroidea	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Astropecten articulatus	E	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Echinoidea	E	8	46	69	94	120	55	30	35	45	80	30	160	60	60	35	40	40	70	48	113
Holothuroidea	E	0	0	0	0	5	5	0	0	0	0	8	0	3	0	5	0	0	3	3	0
Leptosynapta tenuis	E	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Mellita sp.	E	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Moira atropos	E	0	4	25	25	0	20	15	35	5	28	5	15	5	0	0	30	20	23	10	15
Ophiolepis elegans	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Ophiuroidea	E	175	13	88	25	245	65	15	10	55	20	25	23	218	780	185	25	120	58	10	8
Thyonella gemmata	E	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Abra aequalis	M	13	0	19	106	15	75	75	30	15	65	23	28	28	35	45	15	15	65	63	20
Acteocina candei	M	8	0	0	13	15	25	30	35	210	20	5	13	13	0	120	65	35	20	8	10
Acteon candens	M	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
Acteonidae	M	0	0	0	0	0	10	0	0	5	0	0	0	0	0	10	0	0	0	10	0
Americoliva sayana	M	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0
Ameritella agilis	M	0	0	13	0	0	5	15	0	10	0	20	0	10	0	5	0	30	0	3	0
Ameritella versicolor	M	0	4	0	0	0	5	0	0	0	0	0	3	8	0	0	5	0	0	0	0
Anachis sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Anadara sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Anadara transversa	M	13	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Arcidae	M	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Astyris lunata	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Bivalvia	M	38	17	19	6	28	20	25	15	85	18	8	18	43	10	105	30	30	3	23	8
Cadulus sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Caecum carolinianum	M	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caecum imbricatum	M	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Caecum pulchellum	M	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	5	0	0	0	0
Caecum sp.	M	4	4	31	56	25	30	0	50	85	10	0	10	68	485	115	65	75	38	0	3
Calyptraea centralis	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0

Taxon Name	Cat.	D1	D2	D3	D4	I1	I2	I3	I4	I5	I6	I7	I8	O1	O2	O3	O4	O5	O6	O7	O8
Caryocorbula contracta	M	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Chaetopleura apiculata	M	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chione sp.	M	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chioneryx grus	M	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Columbellidae	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Costoanachis avara	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Crassinella lunulata	M	13	4	6	6	10	105	5	15	35	15	10	5	35	50	110	30	20	5	0	3
Crassinella martinicensis	M	88	79	719	144	160	630	500	230	1165	260	105	60	558	260	260	585	255	163	23	255
Crepidula fornicata	M	0	0	0	0	0	15	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Crepidula sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	5	10	0	0	0	0	0	0
Cylichna sp.	M	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Cylichnella bidentata	M	0	0	0	0	5	0	0	0	0	0	3	0	3	0	0	0	0	0	15	0
Cylichnidae	M	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Dentalium sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	5	0	3	0	0
Dosinia concentrica	M	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0
Ervilia concentrica	M	4	0	0	0	0	5	0	20	0	10	5	3	13	25	10	0	15	8	3	0
Eulima bilineata	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Eulimidae	M	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0
Gastropoda	M	0	4	0	6	5	0	5	15	5	3	0	0	10	15	170	5	0	8	3	0
Glycymeris sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Graptacme eborea	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	0
Haminoea solitaria	M	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kelliopsis elevata	M	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Limopsis cristata	M	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0
Limopsis sp.	M	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Lucinisca nassula	M	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Macoma sp.	M	17	0	0	0	0	0	0	0	0	0	0	0	13	5	0	0	0	23	18	0
Mangelia sp.	M	0	0	0	0	0	0	0	5	0	0	8	0	0	0	15	0	0	0	0	3
Marginellidae	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Melanella polita	M	0	0	0	0	0	0	0	0	5	3	0	0	8	30	0	5	0	3	0	0
Mercenaria mercenaria	M	0	4	6	0	0	5	5	0	20	0	3	0	3	0	20	40	15	0	0	0
Mysella planulata	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
Mytilidae	M	0	13	0	6	3	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Naticidae	M	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	0	0
Nucula proxima	M	0	4	0	0	0	5	0	0	0	5	0	0	0	0	0	0	0	0	3	0
Nucula sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
Nudibranchia	M	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	3	0
Odostomia sp.	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	65	0	0	0	0	0
Olivella mutica	M	0	8	0	13	0	5	0	0	5	5	5	3	0	5	0	0	0	0	8	3
Oudardia iris	M	0	0	0	6	0	0	0	0	0	0	15	5	0	0	0	0	0	5	10	3
Pandora sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Parvilucina crenella	M	113	38	0	325	35	35	30	155	30	148	258	30	58	0	5	100	10	200	385	58
Polyplacophora	M	0	0	0	0	0	0	0	5	0	0	0	0	0	5	60	0	0	0	0	0
Pteromeris perplana	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Pythinella cuneata	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0
Rissoidae	M	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Scaphopoda	M	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Semelina nuculoides	M	0	4	131	31	5	20	125	70	125	30	0	3	10	45	115	180	205	15	0	5
Sigatica sp.	M	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Sinum perspectivum	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Solariella lamellosa	M	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Solenidae	M	13	13	6	6	25	15	0	0	10	20	15	30	88	15	20	0	0	13	53	50
Strigilla mirabilis	M	4	4	0	6	5	0	10	20	5	30	8	23	5	5	0	5	15	20	0	23
Tectonatica pusilla	M	0	4	6	0	0	0	0	0	0	5	0	3	0	0	0	5	0	0	3	0
Tellina sp.	M	42	4	13	50	13	30	10	65	120	43	100	25	18	20	15	80	30	23	135	23

Taxon Name	Cat.	D1	D2	D3	D4	I1	I2	I3	I4	I5	I6	I7	I8	O1	O2	O3	O4	O5	O6	O7	O8
Tellinella listeri	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Tornatinidae	M	0	0	19	0	0	15	15	5	0	0	3	0	0	0	0	25	25	0	0	0
Trigonulina ornata	M	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Trochidae	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	3
Tucetona pectinata	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Turbonilla interrupta	M	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Turbonilla sp.	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Urosalpinx cinerea	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Vitrinellidae	M	0	0	0	13	0	0	0	0	5	40	0	0	0	5	10	0	5	0	0	0
Zebina browniana	M	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Aglaophamus verrilli	P	196	21	44	238	38	75	5	130	115	58	128	18	40	45	145	110	50	105	105	18
Alitta succinea	P	38	17	0	0	0	0	0	0	0	0	5	0	0	0	5	5	0	0	3	0
Amastigos caperatus	P	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Ampharetidae	P	0	0	6	6	3	20	5	30	5	5	3	8	10	10	0	0	5	13	3	5
Amphicteis gunneri	P	17	25	0	69	25	0	5	5	0	30	63	83	8	5	30	10	0	0	38	23
Ancistrosyllis sp.	P	0	0	0	0	0	0	0	0	10	0	0	3	5	0	0	0	0	0	0	0
Aphelochaeta sp.	P	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Aphroditidae	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Arabella mutans	P	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0
Aricidea sp.	P	8	17	13	6	5	20	5	5	30	0	75	5	3	0	10	5	5	0	108	3
Aricidea wassi	P	0	0	0	0	15	0	0	0	0	18	0	20	3	10	5	0	0	10	0	20
Armandia agilis	P	29	8	25	56	63	20	20	45	40	20	115	28	108	20	15	60	20	33	100	45
Bhawania goodei	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Bhawania heteroseta	P	0	0	0	0	0	53	0	0	3	1	0	0	11	23	63	5	0	0	0	0
Brania sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	70	0	0	0	0	0	0
Capitella capitata	P	0	0	0	6	0	15	0	0	10	0	10	0	0	0	0	0	0	5	3	0
Capitella sp.	P	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Capitellidae	P	4	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Caulleriella sp.	P	0	0	0	0	8	5	10	10	15	5	5	0	10	10	10	5	0	10	0	13
Ceratocephale oculata	P	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	10	0
Chone sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Cirratulidae	P	0	0	0	0	0	0	0	5	5	3	3	0	3	0	0	0	0	0	3	0
Cirrophorus sp.	P	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Clymenella torquata	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
Diopatra cuprea	P	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Diopatra sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Dipolydora socialis	P	0	0	0	0	0	0	0	0	20	0	3	0	0	15	0	0	0	0	0	3
Dorvilleidae	P	8	0	0	0	0	50	5	0	35	13	5	0	5	0	105	10	0	3	0	0
Drilonereis sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Echiura	P	0	0	0	0	3	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Eumida sanguinea	P	0	0	0	6	0	0	0	0	0	0	3	3	0	0	5	0	0	0	3	0
Eunice vittata	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0
Eunice websteri	P	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0
Eunicidae	P	0	0	0	0	0	0	0	0	10	0	0	0	0	0	15	0	0	0	0	0
Eurysyllis tuberculata	P	0	0	0	0	0	0	0	0	0	3	0	0	0	0	20	0	0	0	0	0
Exogone dispar	P	0	0	0	0	0	60	5	15	20	0	0	0	0	0	190	10	0	0	0	0
Exogone sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	0	0	0
Fabricia sp.	P	0	0	0	0	0	0	0	10	5	0	0	0	0	240	405	0	0	0	0	0
Galathowenia oculata	P	0	0	0	6	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Glycera sp.	P	25	21	125	69	93	145	135	90	90	73	10	48	118	155	165	90	125	68	10	60
Glycinde solitaria	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Goniada littorea	P	33	13	0	38	10	25	0	0	0	33	48	33	28	0	0	0	0	23	88	43
Goniadidae	P	0	0	0	0	0	0	0	5	0	0	0	0	0	10	0	0	0	0	0	0
Goniadides carolinae	P	0	0	0	0	0	60	0	0	45	25	0	0	3	0	130	0	10	0	0	0
Harmothoe sp.	P	0	0	0	0	0	5	0	0	0	0	0	0	0	0	10	0	0	0	0	0

Taxon Name	Cat.	D1	D2	D3	D4	I1	I2	I3	I4	I5	I6	I7	I8	O1	O2	O3	O4	O5	O6	O7	O8
Hesionidae	P	0	0	0	0	5	0	0	0	5	3	0	0	5	10	5	0	0	0	0	0
Heteropodarke heteromorpha	P	4	0	6	0	0	0	15	15	15	10	0	0	3	5	5	0	0	5	0	5
Heteropodarke sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Hydroides sp.	P	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypereteone lactea	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	0	0	3	0	0
Isolda pulchella	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	3	10
Kinbergonuphis sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	145	0	0	0	0	0	0
Kirkegaardia sp.	P	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0
Laeonereis culveri	P	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Leitoscoloplos fragilis	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
Leitoscoloplos sp.	P	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loimia viridis	P	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
Lumbrinerides dayi	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Lumbrinerides sp.	P	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Lumbrineris sp.	P	0	0	0	6	0	10	0	0	10	0	3	0	0	0	15	5	5	5	8	0
Lysidice ninetta	P	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Macroclymene sp.	P	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Magelona sp.	P	8	50	6	6	13	15	0	0	0	8	80	10	8	10	5	0	0	8	150	20
Maldanidae	P	0	0	19	0	55	50	5	15	10	65	13	30	35	450	115	0	80	28	0	5
Mediomastus californiensis	P	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	13	0
Mediomastus sp.	P	0	38	0	0	50	20	0	0	5	8	5	0	28	10	10	0	0	0	5	0
Mooreonuphis pallidula	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Mooreonuphis sp.	P	0	0	0	13	0	0	0	0	5	8	0	3	0	0	0	0	0	0	0	10
Myrianida sp.	P	0	0	0	0	3	10	0	0	5	3	0	0	0	40	15	0	0	0	0	0
Nephtyidae	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Nephtys picta	P	0	8	0	25	13	0	15	15	5	0	5	15	10	10	0	0	0	10	0	23
Nephtys squamosa	P	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Odontosyllis sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Oenonidae	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Onuphidae	P	0	0	0	6	0	0	0	0	0	0	0	0	3	5	0	5	0	0	3	0
Onuphis eremita	P	25	33	0	38	50	55	75	60	0	45	123	55	18	20	10	30	15	48	20	28
Onuphis sp.	P	0	0	19	0	0	0	0	0	0	0	0	0	3	0	65	0	5	0	0	0
Ophelia denticulata	P	0	0	0	0	0	0	0	0	5	0	0	0	3	0	20	0	0	0	0	0
Opheliidae	P	0	0	19	0	0	10	0	0	0	0	0	0	0	5	0	5	10	0	0	0
Orbiniidae	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Owenia fusiformis	P	4	63	0	6	35	20	0	15	5	33	18	5	58	150	65	0	25	5	5	3
Oweniidae	P	0	13	0	0	0	10	0	0	10	3	3	0	3	0	40	5	5	0	0	10
Paranaitis speciosa	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Paraonidae	P	0	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	8	0	0
Paraonis fulgens	P	0	0	13	25	8	30	40	25	35	8	0	5	5	10	5	10	35	0	0	10
Parapionosyllis sp.	P	4	0	6	6	5	10	10	5	40	0	3	0	0	20	75	15	20	3	0	3
Paraprionospio pinnata	P	4	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	8	0
Parasabella microphthalma	P	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petaloproctus sp.	P	0	0	6	13	5	0	0	5	60	0	0	0	10	0	5	5	0	0	0	3
Pholoe sp.	P	4	0	0	0	0	5	0	0	5	0	0	0	0	0	180	0	0	0	0	0
Phyllodocidae	P	4	0	0	0	0	20	0	5	0	3	3	3	8	45	40	0	15	0	0	0
Pilargidae	P	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pionosyllis sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Pisione remota	P	0	0	0	0	3	15	0	0	0	8	0	0	3	10	135	0	5	0	0	0
Pista sp.	P	0	0	0	0	13	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Plakosyllis brevipes	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Poecilochaetus johnsoni	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Polycirrus plumosus	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Polycirrus sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	3	110	45	0	0	0	0	0
Polydora cornuta	P	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0

Taxon Name	Cat.	D1	D2	D3	D4	I1	I2	I3	I4	I5	I6	I7	I8	O1	O2	O3	O4	O5	O6	O7	O8
Polydora sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Polygordiidae	P	163	13	25	381	45	110	65	175	325	108	230	45	103	20	270	200	30	260	318	38
Polynoidae	P	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0
Prionospio dayi	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Prionospio sp.	P	292	158	19	350	113	120	20	240	85	323	735	63	895	105	90	290	360	275	348	53
Prosphaerosyllis longicauda	P	0	0	0	0	0	0	0	0	5	0	0	0	0	0	60	0	0	0	0	0
Sabellaria sp.	P	0	0	0	0	0	0	0	0	15	0	3	0	3	10	15	0	0	0	5	0
Sabellaria vulgaris	P	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Sabellariidae	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Schistomeringos pectinata	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Schistomeringos sp.	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	30	0	0	0	0	0
Scolelepis sp.	P	4	13	6	31	18	25	40	25	5	25	33	10	8	25	20	50	5	38	20	10
Scoletoma tetraura	P	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	3
Scoloplos rubra	P	0	0	0	6	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	5
Scoloplos sp.	P	0	4	0	0	0	0	20	0	0	0	5	20	0	0	0	0	35	0	0	8
Serpulidae	P	0	0	0	0	0	0	0	5	20	0	0	0	20	190	210	0	0	0	0	0
Sigalion sp.	P	21	0	69	0	65	20	5	0	30	0	0	8	65	15	50	0	20	0	3	28
Sigalionidae	P	0	0	0	0	0	0	0	0	0	18	0	0	0	15	0	5	0	8	0	3
Sigambra tentaculata	P	0	13	0	0	3	0	0	0	0	0	10	0	8	0	0	0	0	0	30	0
Sphaerodoropsis sp.	P	4	0	0	6	0	0	0	5	5	3	3	0	5	0	5	10	0	10	13	0
Sphaerosyllis aciculata	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Sphaerosyllis piriferopsis	P	0	0	0	0	0	0	0	0	5	0	0	0	0	0	35	0	0	0	0	0
Sphaerosyllis sp.	P	0	0	0	0	0	5	0	0	0	0	0	0	3	75	45	0	0	0	0	0
Sphaerosyllis taylori	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Spio pettiboneae	P	42	29	31	31	18	70	40	155	50	48	48	33	148	10	235	5	55	23	13	20
Spionidae	P	8	0	0	0	0	0	5	0	0	0	3	0	5	20	0	0	5	3	3	5
Spiophanes bombyx	P	54	29	181	38	70	215	50	115	155	60	93	58	80	295	530	120	230	80	43	50
Streptosyllis sp.	P	21	0	25	0	0	0	5	15	0	5	8	0	5	15	15	15	10	8	8	0
Syllidae	P	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	0
Syllis gracilis	P	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Syllis sp.	P	0	0	0	0	0	0	0	5	10	0	0	0	0	20	30	15	5	0	0	0
Synelmis sp.	P	0	0	0	0	0	0	0	0	5	0	0	0	0	0	20	0	5	0	0	0
Terebellidae	P	0	4	0	0	0	5	0	0	0	8	0	0	3	5	245	0	5	0	0	0
Tharyx acutus	P	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tharyx sp.	P	0	0	0	0	0	0	5	0	10	0	0	0	3	0	10	0	0	0	0	0
Travisia parva	P	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	5	0	3	0
Westheidesyllis gesae	P	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0

Taxon Name	Cat.	D1	D2	D3	D4	I1	I2	I3	I4	I5	I6	I7	I8	O1	O2	O3	O4	O5	O6	O7	O8
Achelia sawayai	O	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Anoplodactylus petiolatus	O	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0
Branchiostoma sp.	O	13	0	31	0	5	115	5	30	205	30	0	5	13	50	440	180	120	28	3	0
Bryozoa	O	0	0	0	0	0	0	0	0	45	0	0	0	10	0	0	0	0	0	0	0
Cupuladria doma	O	0	0	0	0	3	0	0	35	45	3	0	0	145	0	0	5	0	0	0	3
Discoporella umbellata	O	0	0	0	0	3	0	0	0	5	5	3	0	25	5	0	0	5	0	0	0
Enchytraeidae	O	0	0	6	0	0	15	0	5	20	10	0	0	0	0	50	0	30	0	0	3
Eurythoe sp.	O	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Glottidia pyramidata	O	0	0	0	0	0	0	0	10	0	3	0	0	0	0	0	0	0	0	0	0
Heterodrilus sp.	O	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Monopylephorus irroratus	O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Nemertea	O	25	42	13	25	23	20	15	45	20	40	25	45	50	45	20	10	5	33	38	23
Oligochaeta	O	0	0	0	0	8	0	0	0	0	0	0	0	0	15	0	0	0	3	0	0
Phoronida	O	0	0	0	0	3	0	0	0	0	0	0	0	0	5	0	0	0	0	3	0
Platyhelminthes	O	0	0	0	0	3	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Sipuncula	O	4	0	25	25	5	50	25	40	150	43	20	0	50	35	155	15	25	25	23	3
Tubificidae	O	0	4	19	38	8	80	5	35	100	40	5	8	15	10	295	20	5	8	10	20
Tubificoides brownae	O	0	0	0	6	0	0	0	0	0	0	3	0	0	0	10	0	0	0	0	0
Tubificoides wasselli	O	0	0	0	0	10	0	10	0	0	0	5	0	0	0	0	0	10	0	0	10

Appendix 5. The primary macrobenthic infauna taxa driving the similarity among strata within each benthic community-based cluster. First column: Name of cluster, strata included in cluster, and average % Bray-Curtis similarity (AvSim) among strata. Top row: General taxonomic groups. Contents of each cell: % contribution of each taxon in each taxonomic group to the overall cluster AvSim. Note: None of the non-amphipod crustacean taxa were important drivers of within-cluster similarity.

	Amphipods	Mollusks	Polychaetes	Echinoderms	Other
A1 (D2,I1,I8/O8) 69.17% AvSim	*Rhepoxynius epistomus* (5.98%) *Protohaustorius wigleyi* (4.94%) *Bathyporeia parkeri* (4.53%) *Eudevenopus honduranus* (3.29%) *Acanthohaustorius intermedius* (2.85%)	*Crassinella martinicensis* (4.54%) *Parvilucina crenella* (2.92%)	*Prionospio* sp. (4.11%) *Spiophanes bombyx* (3.19%) *Glycera* sp. (2.95%) *Onuphis eremita* (2.92%) *Amphicteis gunneri* (2.49%)	Echinoidea (4.39%)	Nemertea (2.58%)
A2 (D1,I7/O7) 69.41% AvSim	*Rhepoxynius epistomus* (6.39%) *Bathyporeia parkeri* (5.97%) *Protohaustorius wigleyi* (3.33%) *Eudevenopus honduranus* (2.86%)	*Parvilucina crenella* (4.99%) *Tellina* sp. (3.07%) *Crassinella martinicensis* (2.54%)	*Prionospio* sp. (7.12%) Polygordiidae (5.47%) *Aglaophamus verrilli* (4.29%) *Armandia agilis* (2.78%) *Spiophanes bombyx* (2.76%)		
A3 (D4,I4/O4,I6/O6) 68.85% AvSim	*Rhepoxynius epistomus* (5.15%) *Bathyporeia parkeri* (3.26%) *Eudevenopus honduranus* (3.23%) *Protohaustorius wigleyi* (2.72%)	*Crassinella martinicensis* (5.06%) *Parvilucina crenella* (4.41%) *Tellina* sp. (2.30%)	*Prionospio* sp. (6.24%) Polygordiidae (4.78%) *Aglaophamus verrilli* (3.55%) *Glycera* sp. (3.21%) *Spiophanes bombyx* (2.92%) *Onuphis eremita* (2.31%)		
A4 (D3,O1,I2/I3,O5) 63.73% AvSim	*Protohaustorius wigleyi* (4.53%) *Acanthohaustorius intermedius* (3.14%) *Eudevenopus honduranus* (2.43%)	*Crassinella martinicensis* (8.92%) *Semelina nuculoides* (2.77%) *Abra aequalis* (2.08%)	*Glycera* sp. (4.87%) *Spiophanes bombyx* (4.21%) *Prionospio* sp. (2.99%) *Spio pettiboneae* (2.79%) Polygordiidae (2.70%) Aglaophamus verrilli (2.06%)	Ophiuroidea (2.98%) Echinoidea (2.77%)	Sipuncula (2.27%)
B1 (O2/O3,I5) 53.65% AvSim		*Crassinella martinicensis* (5.50%) *Caecum* sp. (3.30%) *Semelina nuculoides* (2.73%) *Crassinella lunulata* (2.14%)	*Spiophanes bombyx* (4.74%) *Glycera* sp. (3.54%) *Prionospio* sp. (3.17%) Polygordiidae (2.85%) *Aglaophamus verrilli* (2.73%) Serpulidae (2.48%) *Fabricia* sp. (2.13%) Maldanidae (1.86%)	Ophiuroidea (3.17%) Echinoidea (2.12%)	Branchiostoma sp. (3.21%) Sipuncula (2.72%) Tubificidae (1.83%)