CHARLESTON HARBOR DREDGING PROJECT

ENVIRONMENTAL ASSESSMENT:

BIOLOGICAL AND SEDIMENT COMPOSITION SAMPLING

FINAL REPORT

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

Prepared by:
Marine Resources Research Institute

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EXECUTIVE SUMMARY

The United States Army Corps of Engineers (USACE) is preparing a Draft Environmental Impact Statement (DEIS) on the feasibility of navigation improvements within the Charleston Harbor Estuary (USACE 2011). One of the environmental effects of the proposed channel deepening is the potential for increased salt water intrusion within the estuary. This change in the salinity regime has the potential to impact the biological communities in the three river systems. As a result, the USACE partnered with the South Carolina Department of Natural Resources (SCDNR) through a Cooperative Agreement to assess the existing macrobenthic community, sediment, and water quality conditions in the Charleston Harbor system as part of the DEIS for Charleston Harbor Deepening.

This assessment provides results from quarterly sampling of the macrobenthic community, sediment grain size, and water quality at sites in the Cooper, Ashley, and Wando Rivers that have not been adequately sampled by the South Carolina Estuarine and Coastal Assessment Program (SCECAP) and are in proximity to historical sampling sites from the 1980's Charleston Harbor Characterization Study (CHCS; Van Dolah et al. 1990). These additional data will help to more accurately assess the existing conditions in the Cooper, Ashley, and Wando Rivers as well as support in the Habitat Suitability Index (HSI) models.

The sampling of the upper Cooper River provides the most recent spatially distributed data collection of the sediment composition and macrobenthic community since the 1980s CHCS. The sediment composition was found to be highly variable along the length and across the width of the upper Cooper River system. The sand content varied throughout the river system from 13 to 99% . The sediment composition across the river at an individual site was also found to be variable with 40 to 60% differences in sand content observed across the river. In addition, the sediment composition of the Back River was found to be variable along the length but generally similar across the

width of the system. The sand content in the Back River on average ranged from 10 to 95% depending on site. The salinity levels within the upper Cooper River were found to be 0.1 ppt on average at the two sites above the Cooper River Tee (CBH, CBK) to a maximum average of 14 ppt at the lowest most site (CBA).

The macrobenthic community in the upper Cooper River was found to be most influenced by the highly variable sediment composition . The salinity was not as biologically influential when the entire community was assessed. The macrobenthic community at the three freshwater sites (CBG, CBH, CBK) was comprised of both freshwater and estuarine species. The two oligohaline to mesohaline sites, CBA and CBD, respectively, were comprised of primarily estuarine species. The communities were variable depending on the season. The highest abundances were generally observed in the winter or spring in comparison to the abundances in the summer or fall. The highest number of species were generally observed in the spring and generally found to increase from the summer to spring sampling events. However, the multivariate analysis did not find season to be an important factor in the similarity of sites at the macrobenthic community level. The macrobenthic communities were compared between the current study and the 1980s CHCS study. In general, the dominant species were either a component of the community or still one of the dominant species with approximately 10 species found in both studies.

The sampling of the Ashley River provides additional information in an area not sampled as part of the SCECAP monitoring and at two locations previously sampled as part of the 1980s CHCS. The sediment composition was found to be fairly homogeneous down the length and across the width of the sampled portion of the Ashley River. The sand content was generally >80% at all sites with a few seasonal exceptions at the most downstream site (ABA) having the sand content as low as approximately 70% in the summer and winter. These low values were generally driven by one station. The salinity levels within the sampled portion of the Ashley River were found to decrease from the lower to the upper site with the salinity highly variable by the season sampled. Higher rainfall during the winter and spring months probably accounts for this seasonal variability.

The macrobenthic community in the Ashley River was found to be most influenced by the difference in salinity levels at the lower most transect, ABA, in comparison to ABB and ABC. The macrobenthic community ABA was most similar to the community in the Harbor and Wando River. The two upstream sites were more similar to each other. The community at ABA was dominated by estuarine, opportunistic species. The communities at ABB and ABC were dominated by estuarine species, with some brackish species observed. No strong seasonal trends were apparent. The communities at the repeated sites were found to be generally similar between this study and the 1980s CHCS.

The sampling of the Wando River provides additional information in areas not sampled as part of the SCECAP monitoring. The sediment composition was found to be homogeneous down the length and across the width of the Wando River. The sand content was generally >85% at all sites. The salinity levels within the Wando River were found to decrease from the lower to the upper site with the salinity levels in the polyhaline zone (18-30 ppt).

The macrobenthic community in the Wando River was very diverse and abundant. No salinity or sediment composition influence on the communities was observed. The macrobenthic communities at all of the Wando River sites were generally similar to each other and to the SCECAP sites in the Harbor and lower Ashley River. The community was dominated by estuarine species. No strong seasonal trends were apparent.

The 1980s CHCS concluded that "salinity appears to be the most important determinant of benthic community structure, with sediment type playing a secondary, more localized role" (Van Dolah et al. 1990). In general, the findings of this study support this conclusion. Overall, the SCECAP sites clustered with the sites from this study along the salinity distribution within the estuary. The Cooper River exhibited a localized sediment composition effect on the macrobenthic community.

Future assessments related to the Charleston Harbor Deepening should be based on the findings from this study and the Feasibility Study. Additional information is needed on the interrelatedness of changes in water quality and sediment composition. In particular, the dependence of the macrobenthic community and the potential environmental changes involving sediment composition, salinity, and other water quality parameters. The final project impact area and the modeling results should be evaluated to determine what additional pre-assessment sampling should be conducted. The SCECAP monitoring program and the data collected for this study may provide a reasonable baseline assessment for evaluating post-deepening effects; however, this cannot be determined until the Feasibility Study is completed.

In addition, Van Dolah et al. (1990) noted the difficulty with determining potential impacts with only one year of pre-diversion data available. Multiple pre-assessment time periods will increase the likelihood of detecting a difference if one is present. Therefore, an assessment and discussion among the USACE and cooperating agencies should be conducted after the Feasibility Study is complete to determine if additional sites and time periods should be sampled for a pre-assessment. The findings of this study indicate the post-deepening assessment should be conducted in the summer and winter. The summer will allow for additional comparisons to SCECAP sites. The winter provides a season during which the abundances were the highest and potential biotic changes would be most apparent. The post-assessment should be conducted over a period of at least 3 years after dredging completion.

I. INTRODUCTION

The United States Army Corps of Engineers (USACE) is preparing a Draft Environmental Impact Statement (DEIS) on the feasibility of navigation improvements within the Charleston Harbor Estuary (USACE 2011). The Charleston Harbor Post 45 feasibility study will analyze and evaluate improvements to the Charleston Harbor Navigation Channel. During this phase of study, the Harbor will be evaluated to identify the extent to which the array of alternatives will be applied to each reach of the Federal Navigation Channel. This process will include the appropriate level of engineering, economic, and environmental analyses to identify the possible benefits and impacts associated with the projected navigational improvements. Improvements being considered will be additional depth and other channel modifications to increase transportation cost savings. The USACE is assessing potential impacts that the project may have on the resources in and around Charleston Harbor. A DEIS requires an analyses of economic, engineering, and environmental effects (USACE 2011) to help evaluate the impacts of a project as large as the Charleston Harbor Deepening.

One of the environmental effects with the proposed deepening is the potential for increased salt water intrusion within the estuary. Additional information is needed to better understand how a shift in salinity dynamics will affect available prey items for species of concern. This change in the salinity has the potential to impact the biological communities in the three river systems, particularly species of concern such as the shortnose sturgeon (*Acipenser brevirostrum*) which spawn in freshwater above the tidal influence (Crance 1986). The spawning activities of commercially harvested blue crabs (*Callinectes sapidus*) are also influenced by salinity and may also be affected by channel modifications. Therefore, environmental assessments must be conducted to determine if the navigation improvements, including deepening and widening channel reaches, would adversely impact fish and crustacean species. The USACE is proposing to use US Fish and Wildlife Service Habitat Suitability Index (HSI) models for species of concern to better understand the implications of deepening the harbor on fisheries and the ecosystem they use. HSI models were developed to provide habitat information for evaluating impacts on fish and wildlife habitat from water or land use changes (Schamberger et al. 1982). Their ultimate purpose will be to serve as a basis for improved decision making and increased understanding of habitat relationships under the various alternative analyses (Schamberger et al. 1982).

The Charleston Harbor Characterization Study (CHCS) completed by the South Carolina Department of Natural Resources (SCDNR) was focused on assessing the potential impacts from the Cooper River Rediversion Project which was completed in 1985 (Van Dolah et al. 1990). This study sampled the three river systems and lower harbor for hydrography, water quality, sediment composition, macrobenthic community, and fish and crustacean communities in the Charleston Harbor Estuary during the years from 1984 to 1988. The macrobenthic community portion of the CHCS had two main objectives including (1) assessing 10 sites seasonally in the Cooper River and Wando River and lower Harbor for one year pre-rediversion and three years' post-rediversion as well as three sites seasonally in the Ashley River post-rediversion; and (2) assessing 178 sites in the middle to lower portion of the Harbor during July of 1988 to understand the spatial variability in macrobenthos and sediment composition (Van Dolah et al. 1990). Overall, the study found only limited changes in select macrobenthic species which might have been related to the rediversion and difference in freshwater inflow; however, the short-term nature of the project might have precluded seeing larger differences (Van Dolah et al. 1990).

In addition, to the historical data from the Characterization Study, environmental data for the Charleston Harbor are available from the ongoing SCDNR and SC Department of Health and Environmental Control (SCDHEC) program called the South Carolina Estuarine and Coastal Assessment Program (SCECAP) (Van Dolah et al. 2002, Bergquist et al. 2011, Van Dolah et al. 2013). SCECAP is a state-wide coastal monitoring program initiated in 1999 which evaluates the environmental health of the state's estuarine habitats on a periodic basis (Van Dolah et al. 2013). SCECAP uses a random, stratified (by open water or tidal creek) probability-based sampling approach currently sampling 30 sites during the summer throughout coastal SC. Approximately 80 sites have been sampled from 1999 to 2011 in the Charleston Harbor area as defined by the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model grid (Figure 1).

Under Cooperative Agreement W912HP-12-2-0003, the USACE partnered with the SCDNR to assess the existing biological, sediment, and water quality conditions in the Charleston Harbor system in order to determine baseline conditions for the Charleston Harbor Deepening Study. The project is divided into three areas that could potentially be affected by a shift in the salinity levels: (1) an assessment of biological and environmental conditions in the upper Cooper River; (2) an assessment of biological and environmental conditions in the middle Ashley River; and (3) an assessment of biological and environmental conditions in the Wando River. This assessment provides results from quarterly sampling of the macrobenthic community, sediment grain size, and water quality at sites in the Cooper, Ashley, and Wando Rivers that have not been adequately sampled by SCECAP and in proximity to historical sampling sites from the 1980s CHCS (Van Dolah et al. 1990). This additional data collection will help to more accurately assess the existing conditions in the Cooper, Ashley, and Wando Rivers and has provided sediment composition data for use in the HSI models. Ultimately, this will help to understand the risk associated with a potential shift in salinity on these species.

II. METHODS

A. Sampling Sites

Eleven core sites were established in the Cooper, Ashley and Wando Rivers and sampled seasonally for a full suite of parameters (i.e., sediment composition, water quality, macrobenthic community). Eleven supplemental sites were established in the Cooper River (including the Back River) and sampled in the summer for sediment composition. A number of these sites were chosen to correspond to the sites established for the

1980s CHCS (Van Dolah et al. 1990) and/or in areas that have not been sampled as part of SCECAP.

A total of 16 sites were sampled in the upper Cooper River including three in the Back River. Six sites were sampled above the “Tee” with three in each branch (sites not previously sampled). In both branches, one was established 2.5 km above the Tee, one was established half way between the end of the EFDC model grid and the Tee, and one was established in the upper third of the model grid. Seven sites (CR04/COO1, COO, CON, COM, COL, COK, CR03/COO2 from CHCS) were sampled in approximately equal distances below the Tee ending adjacent to the Bushy Park landing on the Cooper River. Previous salinity data indicated this would cover the area which now is fresh (above the “Tee”) to mesohaline (approximately 15 ppt) (Van Dolah et al. 1990). Three sites, equally spaced throughout the Back River, were also sampled. Figure 2 provides the sampling sites. All of these sites were sampled in the summer (September) for sediment composition. In addition, the 5 core sites established in the Cooper River were sampled for the macrobenthic community, semi-continuous water quality, and sediment composition. The 5 core sites were located at the West Branch branch 2.5 km (CBH), East Branch 2.5 km (CBK),, and below the Tee - CR04 (CBG), COM (CBD), and CR03 (CBA) sites. All five of these core sites were assessed in each of the four seasons.

Three core sites were established in the middle Ashley River. Two of these sites corresponded to sites established for the 1980s CHCS (AR02, AR03, Van Dolah et al. 1990). One site was established above this area to provide data for an area previously not sampled by the SCECAP or the 1980s CHCS (Figure 2). Sediment composition, macrobenthic community, and semi-continuous water quality were collected at each core site.

Three core sites were established in the Wando River. Two of these sites correspond to water quality sites established for the 1980s CHCS (WRF, WRD, Van Dolah et al. 1990).

These two sites fill SCECAP data gap areas in the middle and lower Wando River. One site was established in the upper reaches of the Wando to provide data for an area previously not sampled by SCECAP or the 1980s CHCS (Figure 2). Sediment composition, macrobenthic community samples and semi-continuous water quality were collected at each core site.

At each site, three replicate stations were established across the river to ensure the samples collected are representative of the river at that site. The total width of the channel was divided to obtain three replicate stations across the width of the river (1-25%, 2-50%, 3-75% of the total river width) to ensure the data from the site represents the entire width. ArcMap v9 was used to identify sites and replicate station locations. Target latitude and longitude stations were identified and used to navigate to stations in the field using Garmin global positioning system (GPS) units (Table 1).

B. Field Sampling

The summer, fall, winter, and spring sampling events were conducted on September 11-13, 2012; November 19-21, 2012; February 12-14, 2013; May 14-16, 2013, respectively. At each core site, water quality, sediment composition, and macrobenthic community were sampled. Point water quality measurements were collected at the middle replicate station to measure salinity, dissolved oxygen, temperature, and pH throughout the water column (surface, mid, bottom) using a YSI 85 handheld unit. A YSI datasonde (model 6920) was deployed 0.5 m off the bottom using weights near each site with the final location dependent on the impact to navigation and instrument safety. The datasonde collected measurements of dissolved oxygen, temperature, salinity, depth, and pH every 15 minutes for a minimum of 25 hours. The Ashley River middle site (ABB) did not collect data during the summer sampling and the upper Cooper River mainstem site (CBG) was lost during the fall sampling thereby resulting in no data.

At each of the three stations for each site, one grab sample was collected using a 0.043 m^2 Young grab. Any sample in which the grab did not penetrate evenly to at least 8.0 cm depth (80% of the total depth of the grab) was discarded and re-collected for macrobenthic samples. A sub-sample (0.003 m^2) was placed in a labeled bag for processing of the surficial sediment composition (percent sand, silt, clay). At the core sites, the remainder of the grab sample (0.04m^2) was washed through a 0.5 mm-mesh sieve. Organisms and sediment retained on the sieve were preserved in a buffered solution of 10% formalin/seawater with rose bengal stain. The bottom scouring in the Cooper River and existence of Cooper Marl precluded sampling the macrobenthic community at all three stations across the channel. Numerous attempts were made within a 50 m distance around each target station to obtain a sample. If a benthic sample could not be collected then the limited material obtained was utilized for sediment processing. A sediment sample was not collected at CBA1 in the summer. Macrobenthic community samples were not collected at CBA1 (summer, fall, or winter), CBD2 (summer, fall, or spring), CBG1 (fall or winter), CBG3 (summer), and CBH1 (summer).

In addition, it was evident after the summer sampling that, in some cases the sediment composition data did not fully represent the structure of the material on the bottom. Therefore, pictures were taken of each grab for the sampling events in the remaining seasons. Pictures are provided with the digital data.

C. Laboratory Processing

The surficial sediment samples were processed using a modified Plumb et al. (1981) method. In addition, the sand fraction was further analyzed to obtain additional sand categorization for use in the Habitat Suitability Index (HSI) Models. The dry sand fraction was further processed by a Ro-tap mechanical shaker with a series of sieves (0.25, 2 mm) to obtain very fine to fine sand (0.063-0.25 mm), medium to coarse sand (0.25-2 mm), and gravel (>2 mm).

In the laboratory, macrobenthic community samples were sieved through a 0.5 mm sieve, the retained material was sorted and identified to the lowest possible taxonomic level. Benthic organisms were sorted from retained material under a magnifying lens, and each individual specimen was identified to the lowest possible taxonomic level using dissecting and/or compound microscopes as necessary. All analyses excluded meiofaunal species (such as nematodes and copepods that are not retained on a 0.5 mm sieve). A voucher collection of representative specimens of each taxon was created for the project and maintained by the Environmental Research Section at the SCDNR Marine Resources Research Institute (Charleston, SC).

All samples processed for sediment composition, benthic sorting and benthic identification were subjected to a strict quality assurance/quality control (QA/QC) process. For all three categories, samples were processed in batches of ten. One random sample out of the ten was re-processed by a second experienced staff member. For the sediment analyses, if there was a discrepancy of more than 10% between the original and QA/QC results for the dominant component, the batch was considered to have failed QA/QC and the entire batch of ten was re-processed. Similarly, for sorting and identification, if less than 90% of the organisms were retrieved from the preserved sample or more than 10% of the specimens were misidentified or miscounted, the entire batch was reprocessed. In the event that a batch was reanalyzed, additional QA/QC was conducted on those samples. In addition, YSI water quality dataloggers and hand-held sensors were subjected to QA/QC procedures prior to and following each deployment to ensure that the units functioned properly in the field and that all parameters were within the manufacturer's recommendations.

D. Data Summarization and Analysis

All data were entered into a Microsoft Access© project database. Data were manipulated in Microsoft Access or Excel©. Data summarization is focused on descriptive summaries of the sediment composition, water quality and macrobenthic community. The sediment composition from the summer core and supplemental sites are described at the site level (average of 2-3 replicate stations) with some discussion of the replicate station variability among sites. The seasonal core sites are primarily discussed at the site level for the sediment composition, water quality, and macrobenthic community with one exception for the multivariate analysis of the macrobenthic community.

A number of metrics were calculated to evaluate the macrobenthic community including number of species, species diversity, and species evenness. Number of species was calculated as the number of unique species per station. The Shannon-Wiener (H') diversity index was used to calculate species diversity and J' was used to calculate species evenness (reviewed in Krebs 1989). Data were log base 2 and natural log transformed for H' and J', respectively. All metrics were calculated on each individual station sample and averaged to obtain a number per site.

In addition, multivariate statistical analyses were performed on the macrobenthic community including hierarchical cluster analysis and non-metric Multidimensional Scaling (MDS) ordination using Primer v6 statistical package (Clark and Gorley 2006). The focus of this analysis was to examine the similarity of macrobenthic communitiesamong the input samples (i.e., station and season, site and season). The MDS analysis provides a graphical presentation of the similarity among the samples (Clarke and Warwick 2001). For example, if site A is found to be closer to site B than site C then site A is considered to be more similar to B than C. The cluster analysis was performed to provide the graphical image of samples that are considered to be clustering together on the MDS plots. All macrobenthic data were fourth root transformed. This transformation down-weights the abundance of dominant species to provide additional weight to the rarer species in the analysis (Clarke and Warwick 2001). A resemblance matrix was created using Bray-Curtis similarities upon which the cluster and MDS analyses were performed. Several different datasets were analyzed including: (1) station level data within each river system to evaluate the differences among stations, sites, and seasons; (2) site level data across the three river systems with and without the SCECAP data to evaluate across system and seasonal differences. Figure 3 provides a map of the SCECAP and study sites used for this analysis.

III. RESULTS and DISCUSSION

A. Summer Sediment Composition Assessment

a. Cooper River

The surficial sediment composition of the Cooper River was highly variable during the summer of 2012 sampling event. From a visual assessment during sampling, the sediments ranged from sandy-mud to a crumbly clay material to gravel, all of which could occur at one station across the width of a site. The sediment composition data are summarized by sand (>0.063 mm) and silt/clay or mud (< 0.063 mm) with some discussion of the further size fractionation of the sand component including gravel (>2 mm), medium to coarse sand (0.25-2 mm), and very fine to fine sand (0.063-0.25 mm).

The three Back River sites (BSA, BSB, BSC) ranged in sediment composition from the first site (BSA) having on average over 90% silt/clay content to the middle site (BSB) with less than 5% silt/clay content to the upper site (BSC) with on average 60% silt/clay content (Table 2, Figure 4). The clay percentages of the silt/clay fractions ranged from 58% to 77% of the total. The sand fraction of the Back River was composed of very fine to very coarse sand with only a small proportion (2%) at BSC being gravel size (Table 2). The among station variability at a site was generally low with the largest variance found at BSC (Figure 5).

The seven sites sampled in the mainstem Cooper River ranged from 2% (CBD3) to 99% (CBA2) sand content (Figure 6). The sediment composition at CBA was on average 97% sand content which was composed of primarily very fine to fine sands (Table 2, Figure

6). This was a consistent pattern observed across the two sampling stations at this site (note that one site was not collected due to the scoured nature of the river bed which precluded obtaining a complete benthic grab – subsequent core stations with the same issue were sampled for sediment only). At CSB, the sediment composition was more variable with one station having 64% sand content and the other two stations having greater than 90% sand content (Figure 4). Of the sand fraction, very fine to very coarse sands were found (Table 2, Figure 6). The sediment composition of the CSC site was greater than 85% sand content at the three stations with the sites only varying with regard to the sand composition which ranged from fine sand up to gravel size classes. In contrast to the lower sites, the CBD site had a predominately silt/clay content (with clay being the dominant fraction). The middle station (CBD2) was the only station at this site to have 30% of the fraction as sand, predominately very fine to fine in size class (Table 2, Figure 6). The sediment composition at the CSE site was primarily composed of sand with varying levels across the river from over 90% on the west side (CSE1) to only 54% on the east side (CSE3) (Table 2, Figure 6). The sediment composition at the CSF site was primarily silt/clay content (~60%) with approximately two-thirds of that being the clay fraction. The sand fraction was composed of very fine to fine size classes. The CBG site had varying sediment composition across the three stations with the middle station consisting of 98% sand content and the other two stations consisting of ~40% sand content. The middle station had predominately medium to coarse sand (>70%) and the east and west stations had very fine to fine sand size classes (Table 2, Figure 6).

The three sites sampled on the West Branch (CBH, CSI, CSJ) showed variable surficial sediment composition among the stations as well as across sites (Table 2, Figures 4 and 6). The site nearest the Tee (CBH) was composed of sand with varying gravel size class dominating (66%) at the west side station and medium to coarse sand dominating at the other two stations. At CSI, the sediment composition varied from over 95% sand (approximately half medium to coarse sand and half larger than granule size) on the east side compared to the middle and west sides with over 50% silt/clay content. The most upstream site, CSJ, showed a similar pattern to CSI; however, the middle station had the highest sand content (~98%) and the west and east stations were predominately silt/clay content (>60%) (Table 2, Figure 6).

The three sites sampled on the East Branch (CBK, CSL, CSM) were generally similar with regard to the sand content dominating (>98%) at all of the middle stations (Table 2, Figures 4 and 6). The primary sand fractions were very fine to fine and medium to very coarse sand sizes. Only one station, CSM3, was dominated by silt/clay content (>60%) (Table 2, Figure 6).

b. Ashley River

The surficial sediment composition of the three Ashley River sampling sites were generally less variable across stations and among sites compared to the Cooper River sites (Table 2, Figures 4 and 7). The sediment composition was the most variable across stations at ABA. Two of the stations were dominated by sand, predominately very fine to very coarse sand size classes, while the west station (ABA1) was dominated by silt/clay (~88%). At ABB, the sediment composition was fairly consistent across the three sites with >80% sand content. The sand fraction was primarily very fine to very coarse sand at two of the stations with gravel size class also present at one of the stations. At ABC, the sediment composition was very consistent among stations with greater than 90% sand fractions of which gravel size classes and medium to very coarse sand size class dominated (Table 2, Figures 4 and 7).

c. Wando River

The sediment composition of the three Wando River sampling sites, was relatively consistent across sites and among stations at each site (Table 2, Figures 4 and 8). At WBA, the sediment composition was sand (~89%), primarily very fine to fine sand size classes. At WBB, the sediment composition was consistent across the three sites with the sand fraction dominating (>95%). The sand fraction was primarily very fine to very coarse sand with some gravel present. At WBC, the sediment composition was consistent among stations with greater than 95% sand content of which very fine to very coarse sand fractions dominated (Table 2, Figures 4 and 8).

B. Seasonal Macrobenthic and Environmental Assessment

a. Cooper River

The sediment composition at the five Cooper River core sites showed an average sand content that ranged from 36% to 99% with some large variations among sites and seasons (Table 3, Figure 9). The sand fraction of the sediment composition at CBA ranged from an average of 72% (fall) to 97% (summer) which was composed of primarily very fine to fine sands. The higher sand content in the summer may be a result of the average being calculated from two instead of three replicates during this season. The average sand fraction at CBD ranged from 13% (summer) to 56% (fall) sand content. Of the sand content, the very fine to fine sand fractions dominated. The CBG site had varying sediment composition across the four seasons with an average sand content ranging from 61% (summer) to 98% (spring) with the medium to coarse sands dominating except in the summer when they were approximately equal (Table 3, Figure 9). At CBH (West Branch), the average sand content ranged from 70% (spring) to 99% (summer). The medium to coarse sand fractions dominated the sand content. This was the only site where a significant amount of gravel was obtained in one of the three replicate stations across the river in the summer only. However, it must be recognized that the Young grab used for the physical and biological sample collections is not designed to sample gravel bottom. Gravel often prevents the jaws from fully closing, thus losing a substantial portion of the sample. Questionable samples were not utilized; however, repeated attempts to retrieve a successful grab sample introduced a bias towards finer grain sediment that allowed the device to function within its limitations. The East Branch (CBK) had sand content which ranged from 36% (spring) to 92% (fall) on average. The sand fraction was variable and dependent on the season at this site (Table 3, Figure 9). Silt/clay content at all Cooper River sites among all seasons ranged from 1%

(CBA summer) to 87% (CBD summer) with clay being the dominant fraction in every station. The variability observed among seasons is likely due to the highly variable nature of the sediment composition within a site (defined as the three stations across the width of river).

A vertical profile of water quality was collected at the middle station just below the surface (0.3 m), at about mid-depth, and just above the bottom. The Cooper River had an average salinity difference between surface and bottom of 0.3 ppt. No difference was observed on average for DO between the surface and bottom. Only the two most downstream two sites (CBA, CSB) showed any difference between the surface and bottom salinity. CBA surface salinity was found to be 0.9 to 2.1 ppt lower than the bottom salinity for all four seasons. CSB was only sampled in the summer as part of the sediment assessment and a 0.9 ppt difference was observed between bottom and surface. These differences indicate a well mixed system and that the bottom continuous water quality sensor provided representative data for the entire water column.

The semi-continuous water quality data were collected over an approximately 40 hour period in the Cooper River; however, for comparative purposes only the first 25 hour period was used to obtain the average, minimum, and maximum (Table 4). The longer time periods for the Cooper River are shown in the continuous graphs (Figures 10, 11, 12, and 13). The depth varied among seasons within sites. Water quality datasondes were moved between sampling events to reduce the risk of loss. Some movement of the dataloggers appeared to occur during deployments due to the strong currents in these systems (Table 4). The CBA logger was placed outside of the channel for the summer and within the channel for the other sampling periods resulting in an average of 3.3 m for the summer and 5.2 to 5.6 m depth for the remaining sampling periods. On average across the four seasons, the depth ranged from 8.2 to 12.4 m, 1.3 to 9.2 m, 4.4 to 5.1 m, and 6.6 to 8.2 m at CBD, CBG, CBH, and CBK, respectively. The water depth followed the expected tidal pattern for all sampling events with a few unusual patterns observed at CBH in the summer, CBD in the winter, and CBK in the spring.

The temperature was consistent with expected levels across the four seasons sampled (Table 4). On average, the temperature was 27 to 28 ^{o}C , 13 to 14 ^{o}C, 12 to 13 ^{o}C, and 22 to 23 ^{o}C, respectively, from summer to spring. The pH levels were fairly consistent among the four seasons across the five sites. On average, the pH levels ranged from 6.8 to 7.6 with the higher values, as expected, at the higher salinity sites (Table 4). Across all seasons, the West Branch site (CBH) had a higher average pH values compared to the East Branch site (CBK).

As expected in the Cooper River for all four seasons, the salinity levels decreased with distance from the estuary; however, the salinity levels were different among the four seasons (Table 4). The largest differences were observed at the two most downstream sites (CBA and CBD). The salinity range at CBA was 5 to 20 ppt, 4 to 15 ppt, 1 to 13 ppt, and 2 to 18 ppt for the summer, fall, winter, and spring, respectively. The salinity range at CBD was 0 to 6 ppt, 0 to 5 ppt, 0 to 1 ppt, and 0 to 2 ppt for the summer, fall, winter, and spring, respectively. The three upstream sites were freshwater with all salinity levels less than 0.34 ppt. The rainfall amounts for the four seasons sampled reflect the observed changes in salinity with higher rainfall in February and May compared to September and November (Figure 14). In general, the salinity fluctuations followed a tidal pattern (Figures 10, 11, 12, and 13).

The dissolved oxygen (DO) concentrations in the Cooper River were lowest in the summer and highest in the winter with the fall very close to the winter levels. The average DO concentration was lowest at CBA compared to the other two mainstem sites (CBD and CBG) (Table 4). The DO concentration in the West Branch (CBH) was always higher than the DO concentration in the East Branch (CBK) in each season (Table 4). The cycling of DO concentration was variable among the five sites across the four seasons

(Figures 10, 11, 12, and 13). At CBA, the cyclical pattern of the DO concentration was generally inverse to the tidal signal with this being observed in the summer and winter, with very little pattern was observed in the spring. At CBD, CBG, and West Branch (CBH), the cycling of DO concentration was also inverse to the tidal signal with higher values observed at low tide in the summer. Very little pattern in DO concentration was observed at these two-three sites in the fall or winter. The spring pattern appears to be more diurnally driven rather than tidally influenced. The cycling of DO concentration at East Branch (CBK) was the most pronounced in comparison to the other sites for all four seasons sampled. In the summer, fall, and winter at CBK, the DO concentration showed a pattern of higher DO concentration at high tide and lower DO concentration at low tide. In the spring at CBK, there appears to be the same tidal influence. The differences in water quality between the two upper branches of the Cooper River are probably related to the very different freshwater inputs in the two systems. The West Branch is receiving continuous flow through the Pinopolis Dam and the East Branch is a headwater system in a forest dominated watershed.

A total of 9,428 organisms, representing 51 taxa, were identified from the 50 samples collected in the Cooper River. The abundance of a single species (*Corophium lacustre*) in a single sample (20132055, CBD2, winter) accounts for approximately 1/3 of these organisms. *Corophium lacustre* is a small tube-building amphipod that is found associated with vegetation in freshwater to brackish environments. *Corophium lacustre* was also found in the 1980s CHCS with a patchy distribution; however, the highest abundance observed was 31 individuals (~620 individuals/m^2). The macrobenthic community was dominated by three species which accounted for 77% of the total abundance including two amphipods (*Gammarus tigrinus* and *Corophium lacustre*) and one polychaete worm (*Scolecolepides viridis*) (Table 5). Six additional taxon were found to be present in more than 50% of the samples collected including one haustorid amphipod (*Lepidactylus dytiscus*), one tanaid (*Hargeria rapax*), the oligochate family

(Tubificidae), two isopods (*Chirodotea almyra*, *Cyathura burbancki*), one insect (*Axarus* sp.), and a mud crab (*Rhithropanopeus harrisii*) (Table 5).

The average total density for each site ranged from 225 individuals/ m^2 at CBH in the summer to 38,617 individuals/ m^2 at CBD in the winter (Table 5, Figure 15A). The second highest average total density was 6,958 individuals/ m^2. The average total density was highest in the winter or spring and lowest in the summer or fall, dependent on site. The West Branch site (CBH) was the only one that did not have significant increases in the winter and/or spring. The average total density at CBH remained more similar among seasons than the other sites. High variability was observed across the channel (among the 3 replicate stations). The average number of species ranged from 2 at CBH in the summer to 9 species at both CBD in the winter and East Branch (CBK) in the spring (Table 5, Figure 15B). The average number of species generally increased from the summer to the spring with the highest values observed in the spring at all sites except for CBD which had the highest average number of species in the winter (Figure 15B).

The species diversity (H') ranged from 0.72 at CBG in the summer to 2.11 at CBD in the summer (Figure 16A). The species evenness (J') ranged from 0.41 at CBD in the winter to 0.88 at CBG in the fall. Overall, no clear trends were observed for either species diversity or evenness across the seasons or sites in the Cooper River (Figure 16B).

The macrobenthic community data were categorized into major taxonomic groups to further evaluate the community including amphipoda, crustacea (minus amphipoda), mollusca, polychaeta, oligochaeta, and other. The other group included organisms such as nemertea, echinodermata, phoronida, and insecta. The distribution of major taxa was observed to be quite variable even across replicate stations at a single site. This is likely the result of the variability that was observed in the sediment composition data. At the site level, the major taxa varied within the Cooper River sites and across the four seasons. At CBA (the most downstream site), the community was dominated by amphipods in the summer, fall, and spring in comparison to polychaetes in the winter (Figure 17). At CBD, the community was dominated (~40%) by the other category with the rest of the community composed of amphipods, polychaetes, and oligochaetes in the summer in comparison to primarily amphipods dominating in the other three seasons (Figure 17). At CBG, the community was primarily composed of amphipods across all four seasons with varying proportions of crustaceans (minus amphipods), polychaetes, and other organisms contributing at varying levels dependent on which season. At the West Branch site (CBH), the community was dominated by amphipods in the summer with the other three seasons being more variable and including higher proportions of primarily polychaetes and oligochaetes (Figure 17). At the East Branch site (CBK), the community was primarily dominated by amphipods during all seasons with varying higher proportions of oligochaetes in the summer and fall (Figure 17).

In order to examine the replicate variability within sites and across seasons as well as examine possible effects from sediment composition and salinity on the macrobenthic community, multivariate statistics were used. The MDS ordination analysis provides a spatial representation of the similarity (closeness) of each pair of samples collected. Very little distinction was observed among the five Cooper River core sites (Figure 18A). Overall, very little seasonal differences were observed between the stations or sites (Figure 18B). The lack of distinction among the five sites may be surprising given the salinity gradient that exists in the Cooper River; however, the average salinity does not appear to be a large factor in the similarity among samples (Figure 18C). Instead, the sediment composition (shown as silt/clay percentage) appears to be a more important factor in the similarity among samples as seen in the MDS plot where the samples on the left are higher in silt/clay content than the samples on the right half (Figure 18D). Sediment composition has been found to have a significant influence of the macrobenthic community in the 1980s CHCS, particularly at the local scale (Van Dolah et al. 1990).

Two of the sites sampled for this project were also sampled during the 1980s CHCS (Van Dolah et al. 1990). The two sites were CBA and CBG which correspond to CR03 and CR04, respectively. CBA and CR03 showed generally similar sediment composition with >90% of the sediment content as sand for both studies and similar salinity levels, ranging from 0 to 24 ppt (from point measures) in the 1980s CHCS and 5 to 20 ppt (from semi-continuous dataset) in this study. Overall, the benthic communities were similar with ten of the same species found in both studies including *Lepidactylus dysticus* (amphipod), *Scolecolepides virdis* (polychaete), *Chiridotea almyra* (*Chiridotea stenops*) (isopod), *Monoculodes sp*. or *Monoculodes edwardsi* (amphipod), *Corophium lacustre* (amphipod), *Gammarus tigrinus* (amphipod), *Nereis succinea* (polychaete), *Cyathura burbancki* or *Cyathura polita* (isopod), *Streblospio benedicti* (polychaete), and Nemertea (Table 6). These species are a mix of common estuarine species such as *S. benedicti*, *C. burbancki*, *C. almyra*, *G. tigrinus*, *S. viridis*, Nemertea, and more commonly freshwater to brackish water species such as *C. lacustre*. In addition, *Hargeria rapax* (tanaid) was found in high abundances in this study but only in the spring sampling event at the same station (CBA1) that was only observed in the spring at the same site with high abundances of *C. lacustre*.

CBG and CR04 showed generally similar sediment composition with 80 to 95% of the sediment content as sand and similar salinity levels with salinity levels at ~0 ppt for both studies. Overall, the benthic communities at this location were similar with 11 of the same species found in both studies including *Chiridotea almyra* (includes *Chiridotea stenops*) (isopod), Gammarus tigrinus (amphipod), *Lepidactylus dysticus* (amphipod), *Melita nitida* (amphipod), *Scolecolepides virdis* (polychaete), *Cyathura polita* (isopod), Chironomidae (insect), Ceratopogonidae (insect), Oligochaeta or Tubificidae (oligochaete), Gastropoda (mollusk), and *Rhithropanopeus harrisii* (decapod) (Table 6). In addition, two other insect groups, *Axarus Sp*. and Tipulidae, were found in this study.

These species are more freshwater to brackish species with a few common estuarine species.

b. Ashley River

The surficial sediment composition of the three Ashley River core sites was generally consistent across the four seasons (Table 7, Figure 19). At ABA, the sand content on average for the site ranged from 69% (summer) to 89% (winter). The sand fraction was generally split between very fine to fine sand and medium to coarse sand. At ABB, the sediment composition was 88% sand content in the summer and >96% sand content in the other three seasons. The sand fraction was generally split between very fine to fine sand and medium to coarse sand with the proportion of gravel ranging from 5% to 15%. At ABC, the sand content ranged from 71% (spring) to 97% (winter). ABC showed higher proportions of gravel compared to ABA and ABB with the gravel ranging from 21% to 58% of the sand fraction. The remaining sand fraction was primarily medium to coarse sand (Table 7, Figure 19). The variability observed among seasons is likely due to the highly variable nature of the sediment composition within a site.

A vertical profile of water quality showed the difference in salinity from the bottom to surface was 1.1 ppt and the difference in dissolved oxygen from the bottom to the surface was 0.1 mg/L in the Ashley River. The largest difference in salinity was generally found at the most downstream site (ABA). This indicates that the river is well-mixed.

The semi-continuous water quality data were collected over a 25 hour period in the Ashley River for the four seasons (Table 8, Figures 20, 21, 22, and 23). The ABB datasonde did not collect data during the summer deployment. The average depth ranged from 1.7 to 3.4 m at ABA, 3.8 to 6.9 m at ABB, and 1.3 to 6.1 m at ABC across all four seasons. The temperature was consistent among the four seasons and across the three sites. On average, the temperature was 27 ^{o}C, 13 ^{o}C, 14 ^{o}C, and 23 ^{o}C, respectively, in summer, fall, winter, and spring (Table 8). The pH levels were fairly consistent among the four seasons across the three sites. On average, the pH levels ranged from 6.8 to 7.7 ^{o}C with the higher values, as expected, generally at the higher salinity sites (Table 8).

As expected in the Ashley River for all four seasons, the salinity levels decreased with distance from the mouth of the estuary; however, the salinity levels were different among the four seasons (Table 8, Figures 20, 21, 22, and 23). Similar to the Cooper River, the salinity values coincide with the amount of rainfall that occurred during the month of sampling (Figure 14). The highest salinity values were observed in the fall when low rainfall was recorded for the previous three months (Figure 14). The salinity range at ABA was 15-23 ppt, 23-27 ppt, 6-23 ppt, and 11-19 ppt for the summer, fall, winter, and spring, respectively. The salinity range at ABB was not calculated due to a malfunctioning logger in the summer. The salinity range for the remaining seasons was 12-25 ppt, 0.5-12 ppt, and 3-12 ppt for the fall, winter, and spring, respectively. The salinity range at ABC was 1-14 ppt, 12-20 ppt, 0.2-5 ppt, and 0.4-6 ppt for the summer, fall, winter, and spring, respectively (Figures 20, 21, 22, and 23).

The dissolved oxygen (DO) concentrations in the Ashley River followed the expected DO concentration pattern with the lowest levels at all three sites in the summer and the highest values in the winter with the fall very close to the winter levels at ABA and ABB. The DO concentration at ABC in the winter was similar to the spring. The decreased DO concentration may be related to the high rainfall during the winter sampling. Over all seasons, the average DO concentration was lowest at ABC (most upstream site) compared to the other two downstream sites (ABA and ABB) (Table 8, Figures 20, 21, 22, and 23). An unusual increase in the DO data was observed at the ABA site in the summer at the beginning of the deployment. It is unknown if this is an equipment issue or a real phenomena (Figures 20). The instrument calibrated and post-calibrated at 100.1% and 100.3%, respectively, indicating the instrument was functioning properly during the deployment. The average DO concentration without these higher values was

4.56 mg/l. A second unusual set of observations were made at the ABC site in the winter deployment with DO concentrations hypoxic (< 2 mg/l) and nearly anoxic (0 mg/l) for both low tide periods sampled. The instrument calibrated and post-calibrated at 100.5% and 97.5%, respectively, indicating the instrument was functioning properly during the deployment. However, we do not believe the data represents the water quality in the river. It is likely that something blocked the sensors during the low tide periods such as mud or leaves. Therefore, these data were removed. The cycling of DO concentration was not very pronounced at any of the sites for any season (Figures 20, 21, 22, and 23). Slight tidal signals were observed at ABC in the summer and spring and at ABB in the spring. A slight inverse DO concentration pattern was observed at ABA in the winter.

The Ashley River had the fewest organisms collected with a total of 3,141 organisms, representing 66 taxa, identified from the 36 samples collected. One station replicate from ABB (ABB3) in the Ashley River in the summer did not contain any organisms (Table 9). Seven species were found to represent 75% of the abundance in the Ashley River including two polychaetes (*Parandalia* sp., *Streblospio benedicti*), two oligochaetes (*Tubificoides wasselli, Tubificoides brownae*), and three amphipods (*Corophium lacustre, Gammarus tigrinus, Melita nitida)*. Five additional taxa were found to be present in more than 50% of the total samples collected including one amphipod (*Monoculodes edwardsi)*, one isopod (*Cyathura burbancki*), the ribbon worms (Nemertea), and two polychaetes (*Nereis succinea, Polydora socialis*) (Table 9).

The average total density in the Ashley River ranged from 608 individuals/m^2 at ABB in the summer to 9,017 individuals/m^2 at ABC in the spring (Table 9, Figure 24A). This high value was dominated by one station (ABC1, spring) having a high density of *Corophium lacustre* similar to the high abundances of *C. lacustre* observed in the Cooper River. The next highest average total density was 2,342 individuals/m^2 at ABB in the fall. However, most of the average total densities in the Ashley River were in the 1,000 to 2,000 individuals/m^2 range. Very little seasonal difference was observed in the Ashley River for average total density (Figure 24A). The average number of species ranged from 3 to 10 species with most of the average number of species values in the 6 to 10 range (Table 9, Figure 24B). No consistent seasonal patterns across the three sites were observed related to the number of species (Figure 24B).

The species diversity (H') ranged from 0.58 at ABB in the summer to 2.71 at ABB in the spring (Figure 25A). The species evenness (J') ranged from 0.19 at ABB in the summer to 0.88 at ABB in the winter. Overall, no clear trends were observed for either species diversity or evenness across the seasons or sites in the Ashley River (Figure 25B).

The macrobenthic community data were categorized into major taxonomic groups to further evaluate the community. The lower site (ABA) was composed primarily of polychaetes and oligochaetes, with oligochaetes dominating in the summer and polychaetes dominating in the other three seasons (Figure 26). The middle site (ABB) was dominated by polychaetes in the summer which shifted to approximately equal amounts of polychaetes and amphipods in the fall and spring. ABB was dominated by amphipods in the winter. The upper site (ABC) was equally dominated by polychaetes and crustaceans (minus the amphipods) in the summer in comparison to the fall, winter and spring which was dominated by amphipods (Figure 26).

In order to examine the replicate variability among sites and seasons as well as possible physical effects (sediment composition and salinity) on the macrobenthic community, multivariate statistics were used. Two main groups were evident on the plot: (1) all of the ABA samples on the right and all of the ABB and ABC samples on the left (Figure 27A). Very few seasonal differences were observed (Figure 27B). The salinity was highest at ABA in comparison to ABB and ABC which was likely affecting the differences observed between the two groups (Figure 27C). The sediment composition (shown as silt/clay percentage) does not appear to be driving the similarity of stations or seasons for macrobenthic community distribution (Figure 27D).

Two of the sites sampled for this project were also sampled during the 1980s CHCS (Van Dolah et al. 1990). The two sites were ABA and ABB which correspond to AR02 and AR03, respectively. ABA and AR02 showed generally similar sediment composition with a range in sand content of ~80% in 1980s CHCS and 70-90% in this study. The salinity levels were similar and ranged from 16 to 35 ppt in the CHCS (point measurements) and 6 to 27 ppt in this study (semi-continuous measurements). Overall, the benthic communities were similar with ten of the same species found in both studies including *Paraprionospio pinnata* (polychaete); *Mulinia lateralis* (mollusk); Oligochaeta or *Tubificoides wasselli*, *Tubificoides brownae*, Tubificidae (oligochaete); *Mediomastus californiensis* (polychaeta); Nemertea; *Leucon americanus* (crustacean); *Monoculodes* sp. or *Monoculodes edwardsi* (amphipod); *Streblospio benedicti* (polychaete); *Prionospio* sp. (polychaete); and *Eteone heteropoda* (polychaete) (Table 10). All of these species are common estuarine species. *Streblospio benedicti*, *P. pinnata*, *M. californiensis*, and the oligochaetes are considered to be opportunistic species.

ABB and AR03 showed generally similar sediment composition with ~ 90% sand content and salinity levels ranged from 3 to 29 ppt in 1980s CHCS and 0 to 25 ppt in this study. Overall, the benthic communities were similar with 11 of the same species found in both studies including Oligochaeta or *Tubificoides wasselli*, *Tubificoides brownae*, Tubificidae (oligochaete); *Lepidactylus dysticus* (amphipod); *Scolecolepides virdis* (polychaete); *Monoculodes* sp. or *Monoculodes edwardsi* (amphipod); *Gammarus tigrinus* (amphipod); *Corophium lacustre* (amphipod); *Cyathura polita or C. burbancki* (isopod); *Edotia montosa* (isopod); *Neomysis americana* (crustacean); *Nereis succinea* (polychaete); and *Brachidontes exustus* (mollusk) (Table 10). These species are primarily estuarine species with a few freshwater to brackish species.

c. Wando River

The sediment composition of the three Wando River sampling sites was relatively consistent across seasons (Table 11, Figure 28). At WBA, the sediment composition was dominated by sand content, ranging from 85 to 89% across the four seasons. The sand fraction was primarily very fine to fine sand size classes for all four seasons with higher proportions of medium to coarse sand and gravel in the spring. At WBB, the sediment composition was very consistent across the four seasons with the sand fraction dominating (>96%). The sand fraction was primarily very fine to very coarse sand. The sediment composition at WBC was the most variable out of the three sites in the Wando River. The sand fraction was ~ 96% in the summer, fall, and winter with primarily very fine to very coarse fractions of sand. In the spring, the sand fraction was 85% sand with a higher proportion of very fine to fine sand (Table 11, Figure 28).

The vertical profile of water quality showed the average difference in salinity from the bottom to surface was 0.9 ppt and the average difference in dissolved oxygen from the bottom to the surface was 0.0 mg/L. The largest difference in salinity was generally found at the most downstream site (WBA). This indicates that the river is well-mixed.

The semi-continuous water quality data were collected over a 25 hour period in the Wando River for the four seasons (Table 12, Figures 29, 30, 31, and 32). The average depth ranged from 1.0 to 4.2 m at WBA, 2.4 to 3.3 m at WBB, and 2.4 to 3.2 m at WBC (Table 12). The temperature was consistent among the four seasons and across the three sites. On average, the temperature was 27 ^{o}C, 13 to 14 ^{o}C, 14 to 15 ^{o}C, and 22 to 24 ^{o}C in the summer, fall, winter, and spring, respectively (Table 12). The pH levels were fairly consistent among the four seasons across the three sites. On average, the pH levels ranged from 7.3 to 7.9 with the higher values, as expected, at the higher salinity sites.

As expected in the Wando River for all four seasons, the salinity levels decreased with distance from the estuary; however, the salinity levels were different among the four seasons (Table 12, Figures 29, 30, 31, and 32). The salinity range at WBA was 25 to 28 ppt, 26 to 28 ppt, 20 to 26 ppt, and 21 to 25 ppt for the summer, fall, winter, and spring, respectively. The salinity range at WBB was 19 to 26 ppt, 25 to 26 ppt, 22 to 24 ppt, and 20 to 23 ppt for the summer, fall, winter, and spring, respectively. The salinity range at WBC was 12 to 17 ppt, 24 to 25 ppt, 10 to 23 ppt, and 16 to 19 ppt for the summer, fall, winter, and spring, respectively (Table 12). The observed changes in salinity, especially at WBC, reflect the rainfall total observed in the four seasons (Figure 14). The salinity fluctuations at all sites generally followed a tidal pattern except in the winter at WBA and WBB and in the spring at WBA. During these sampling events, almost no consistent fluctuations in salinity were observed (Figures 29, 30, 31, and 32).

The dissolved oxygen (DO) concentrations in the Wando River followed the expected DO concentration pattern with the lowest levels at all three sites in the summer and the highest values for WBA and WBB in the winter with the fall DO concentration close to the winter concentrations (Table 12). At WBC, the pattern was similar but the fall DO concentration was slightly higher than winter DO concentration. Over all seasons, the average DO concentration was lowest at WBC (most upstream site) compared to the other two downstream sites (WBA and WBB) (Figures 29, 30, 31, and 32). In general, the DO concentration did not show a clear cyclical pattern across the four seasons or three sites (Figures 29, 30, 31, and 3).

A total of 4,340 organisms, representing 139 taxa, were identified from the 36 samples collected from the Wando River. Overall, the community was very diverse with two species, *Streblospio benedicti,* and *Paraprionospio pinnata,* representing the maximum proportion which was 14% and 15% of the total abundance. No other species accounted for more than 5% of the abundance (Table 13). Twenty-four other species were found to be present in more than 50% of the samples collected with most of these species being polychaetes (Table 11).

The average total density in the Wando River ranged from 833 individuals/m^2 to 4,675 individuals/m^2 (Table 13, Figure 33A). A lot of variability in the average total density was observed among the three sites and across the four seasons with no clear trends apparent. The average number of species ranged from 10 to 24 species (Table 13, Figure 33B). The number of species was generally higher in the two downstream sites (WBA, WBB) compared to the upstream site (WBC) with the levels lowest in the summer compared to the other seasons for WBA and WBB. Overall, the number of species was higher in the Wando River when compared to the Cooper and Ashley Rivers. The species diversity (H') ranged from 1.57 at WBA in the fall to 3.47 at WBB in the spring (Figure 34A). The species evenness (J') ranged from 0.35 at WBA in the fall to 0.88 at WBC in the summer. Overall, no clear trends were observed for either species diversity or evenness across the seasons or sites in the Wando River (Figure 34B).

The macrobenthic community data were categorized into major taxonomic groups to further evaluate the community. Polychaeta dominated the macrobenthic communities at WBA and WBB for all four seasons (Figure 35). The community at WBC was more variable across the four seasons with a shift in the dominant major taxa from polychaeta (51%) in the summer to amphipoda in the winter (57%) and spring (44%) (Figure 35). The fall had similar percentages with approximately 35% for each.

In order to examine the replicate variability among sites and seasons as well as possible effects from sediment composition and salinity on the macrobenthic community, multivariate statistics were used. The MDS ordination plot shows the WBB samples were grouped together in the center of the plot (Figure 36A). The WBA2 and WBA3 replicate stations grouped together below the WBB samples. The WBA1 replicate stations showed no clear grouping across the four seasons. This replicate station was located in the river channel which may be related to the fewer species and a different macrobenthic community composition than was observed at other Wando WBA stations. The WBC1 and WBC2 replicate stations were grouped in the lower right indicating a similar community among these stations. The WBC3 replicate stations for all four seasons grouped together on the left of the WBB samples. This station had a very different species composition than the other two stations at WBC. Shell material was frequently obtained in the grab samples which may have allowed a different community to inhabit this area. Overall, very little seasonal differences were observed in the community composition among the stations or sites (Figure 36B). Salinity does not appear to be a key factor in the community distributions (Figure 36C); however, the salinity gradient in the Wando River is not pronounced and would not be expected to overly influence the distribution of organisms. With the possible exception of the WBC3 station, the sediment composition (shown as silt/clay percentage) does not appear to be driving the similarity of samples for macrobenthic community (Figure 36D).

C. Macrobenthic Community Comparison across River Systems

Multivariate statistics was used to evaluate the macrobenthic community across the four seasons and three river systems; however, caution is warranted since the sample design was not developed to test the question as to whether the river systems are statistically different. However, some information can be obtained from comparing the communities among the three river systems. Site and season were used for this analysis to remove the potential affect of the station variability. Cooper River sites were not similar to the Wando River sites as evidenced by the grouping of each on different sides of the plot (Figure 37A). The most downstream Ashley River site (ABA) was similar to the Wando River sites. The other two Ashley River sites (ABB and ABC) were similar to both the Wando River sites and Cooper River sites as evidenced by their plotting between the two other rivers. Season did not appear to have an effect on the overall macrobenthic community (Figure 37B). Sediment composition and salinity levels appear to have some relationship to the macrobenthic community similarities among the sites

(Figure 37C and 37D). These findings are not unexpected given the sample design and differences observed in sediment composition and salinity levels among the sites in the river systems.

D. Macrobenthic Community Comparison with Historical/SCECAP Data

Multivariate statistical analysis was performed to assess if SCECAP data collected from the Charleston Harbor during the period from 1999-2011 would be appropriate to use to expand the spatial data available in the summer season as part of this study. Thirty-six SCECAP sites from the main stem of the three river systems and the Harbor were combined with the 11 core sites from this study. All sites were classified into major system including Harbor, Ashley, Wando and Cooper systems. Four sites in the lower Cooper River below the confluence with the Wando River, near the mouth of the Harbor were designated as Harbor sites due to their proximity to the Harbor.

The year the sample was collected was not found to be a prominent factor in the clustering of sites. The SCECAP Harbor sites were similar to each other and grouped on the middle right of the MDS plot (Figure 38A). Most of the Wando River sites (both SCECAP and this study) were found to be similar to the Harbor sites, grouping on the left of the Harbor sites. The farthest upstream Wando River site (a SCECAP site) was dissimilar to the other Wando sites and plotted away from all other sites. In general, the lower Cooper River (SCECAP) and lower Ashley River (SCECAP and ABA) were found to be similar to Wando River sites. These sites were all located in high salinity regions of the three systems. The upper Ashley River sites from this study (ABB and ABC) and SCECAP were generally most similar to each other as well as to the upper Cooper River sites from this study and SCECAP (Figure 38B). The sites on the right side of the plot had higher salinities than the sites on the left side of the plot (Figure 38C). The sediment composition was not found to be distributed differently on the MDS plot indicating sediment composition was not a strong influence on the macrobenthic community distribution (Figure 38D) for the SCECAP study.

IV. CONCLUSIONS

The sampling of the upper Cooper River provides the most recent spatially distributed data collection of the sediment composition and macrobenthic community since the 1980s CHCS. The sediment composition was found to be highly variable down the length and across the width of the upper Cooper River system. There was no consistent pattern across the river with regard to where the Cooper Marl was found. The high variability was probably the result of the high flow conditions in the Cooper River. In addition, variability was also observed among seasons which is likely the result of the patchy distribution and the sampling of multiple stations across the river to represent a site and not related to season specifically. The salinity levels within the upper Cooper River were found to be 0.1 ppt on average at the two sites above the Cooper River Tee (CBH, CBK) to a maximum average of 14 ppt at the lowest most site (CBA). The macrobenthic community in the upper Cooper River was found to be most influenced by the sediment composition which is not unexpected given the wide range of sediments found in the system. The salinity was not as strong of a factor when the entire community was assessed. The two sites sampled in both the current study and the 1980s CHCS were found to be generally similar with respect to the macrobenthic community composition. Further analysis is warranted of the macrobenthic communities between the two studies but this will require additional effort to merge the species lists throughout the estuary for comparability to be possible.

The sampling of the Ashley River provides additional information in an area not sampled as part of the SCECAP monitoring and at two locations previously sampled as part of the 1980s CHCS. The sediment composition was found to be fairly homogeneous down the length and across the width of the sampled portion of the Ashley River. The salinity levels within the sampled portion of the Ashley River were found to decrease from the lower to the upper site with the salinity highly variable by the season sampled, presumably related to the rainfall differences among seasons. The macrobenthic community in the Ashley River was found to be most influenced by the difference in salinity levels at ABA in comparison to ABB and ABC. The communities at the two sites sampled as part of the current study and the1980s CHCS were found to be generally similar with regard to the community composition.

The sampling of the Wando River provides additional information in areas not sampled as part of the SCECAP monitoring. The sediment composition was found to be homogeneous down the length and across the width of the Wando River. The salinity levels within the Wando River were found to decrease from the lower to the upper site with the salinity levels in the polyhaline zone (18-30 ppt). The macrobenthic community in the Wando River was very diverse and abundant. No salinity or sediment composition influence on the communities was observed.

The 1980s Charleston Harbor Characterization Study concluded that "salinity appears to be the most important determinant of benthic community structure, with sediment type playing a secondary, more localized role" (Van Dolah et al. 1990). The findings of this study support this conclusion particularly when the entire estuary is evaluated (i.e., SCECAP data are included to provide an assessment of the salinity and sediment composition throughout the Charleston Harbor Estuary). Overall, the SCECAP sites clustered with the sites from this study in a predictable fashion, primarily along the salinity gradients within the estuary. The salinity levels appear to be a dominant driver when the entire Charleston Harbor is evaluated. The Cooper River was the only system to exhibit a localized sediment composition effect on the macrobenthic community. The sediment composition covered a broad range of sediment types in the Cooper River in comparison to the Wando and Ashley Rivers which had more homogenous sediment composition.

The effect of season appears to be the most important in the Cooper River with little to no apparent seasonal differences in the other river systems. The limited dataset precludes robust statistical analysis of the data; however, the 1980s CHCS also found limited seasonal variability across the four study years. Sanger (1998) reported significant differences among the seasons with higher abundances and number of species in the winter and spring compared to the summer and fall in headwater tidal creeks and salt marshes in the Charleston Harbor Estuary similar to the findings in the upper Cooper River for this study. Therefore, the collection of seasonal data is critical to understanding the variability in the macrobenthic community and particularly in understanding the available prey items for species of concern, particularly in the upper Cooper River.

V. RECOMMENDATIONS

Future assessments related to the Charleston Harbor Deepening should be based on the findings from this study and the Feasibility Study. Additional information is needed on the interrelatedness of changes in water quality and sediment composition. In particular, the dependence of the macrobenthic community and the potential environmental changes involving sediment composition, salinity, and other water quality parameters. The final project impact area and the modeling results should be evaluated to determine what additional pre-assessment sampling should be conducted. The SCECAP monitoring program and the data collected for this study may provide a reasonable baseline assessment for evaluating post-deepening effects; however, this cannot be determined until the Feasibility Study is completed.

In addition, Van Dolah et al. (1990) noted the difficulty with determining potential impacts with only one year of pre-diversion data available. Multiple pre-assessment time periods will increase the likelihood of detecting a difference if one is present. Therefore, an assessment and discussion among the USACE and cooperating agencies should be conducted after the Feasibility Study is complete to determine if additional sites and time periods should be sampled for a pre-assessment. The findings of this study indicate the post-deepening assessment should be conducted in the summer and winter. The summer will allow for additional comparisons to SCECAP sites. The winter provides a season during which the abundances were the highest and potential biotic changes would be most apparent. The post-assessment should be conducted over a period of at least 3 years after dredging completion.

ACKNOWLEDGEMENT

This project was funded by the US Army Corps of Engineers (USACE) through cooperative agreement number W912HP-12-2-0003. The authors extend our sincere thanks to the staff of the USACE Charleston District, particularly Mark Messersmith, Alan Shirey, and Brian Williams, for their continued support. The hard work of the Environmental Research Section of the SCDNR Marine Resources Research Institute staff is greatly appreciated. Leona Forbes, Steve Burns, Mollie Reynolds, Dany Burgess, Catharine Parker, Nicole Wisniewski, and Mark Messersmith assisted with field sampling. Leona Forbes, Steve Burns, Catharine Parker, Nicole Wisenieski, Mollie Reynolds conducted all of the laboratory processing. Mark Messersmith provided critical peer-review that significantly improved the quality of the final report.

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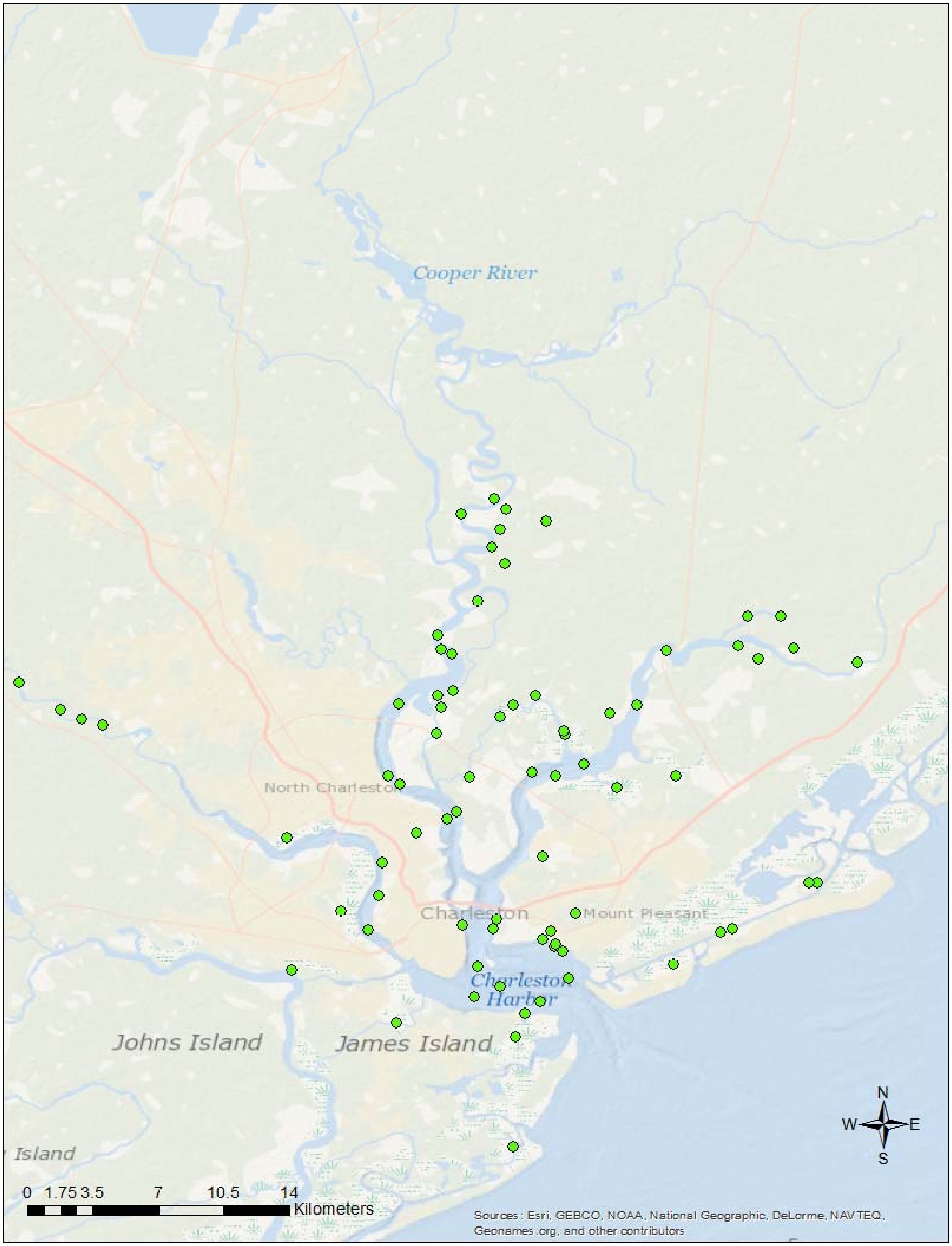


Figure 1. Map of the 77 SCECAP sites sampled from 1999-2011 collected in the Charleston Harbor Estuary. These sites include both tidal creek and open water sites.

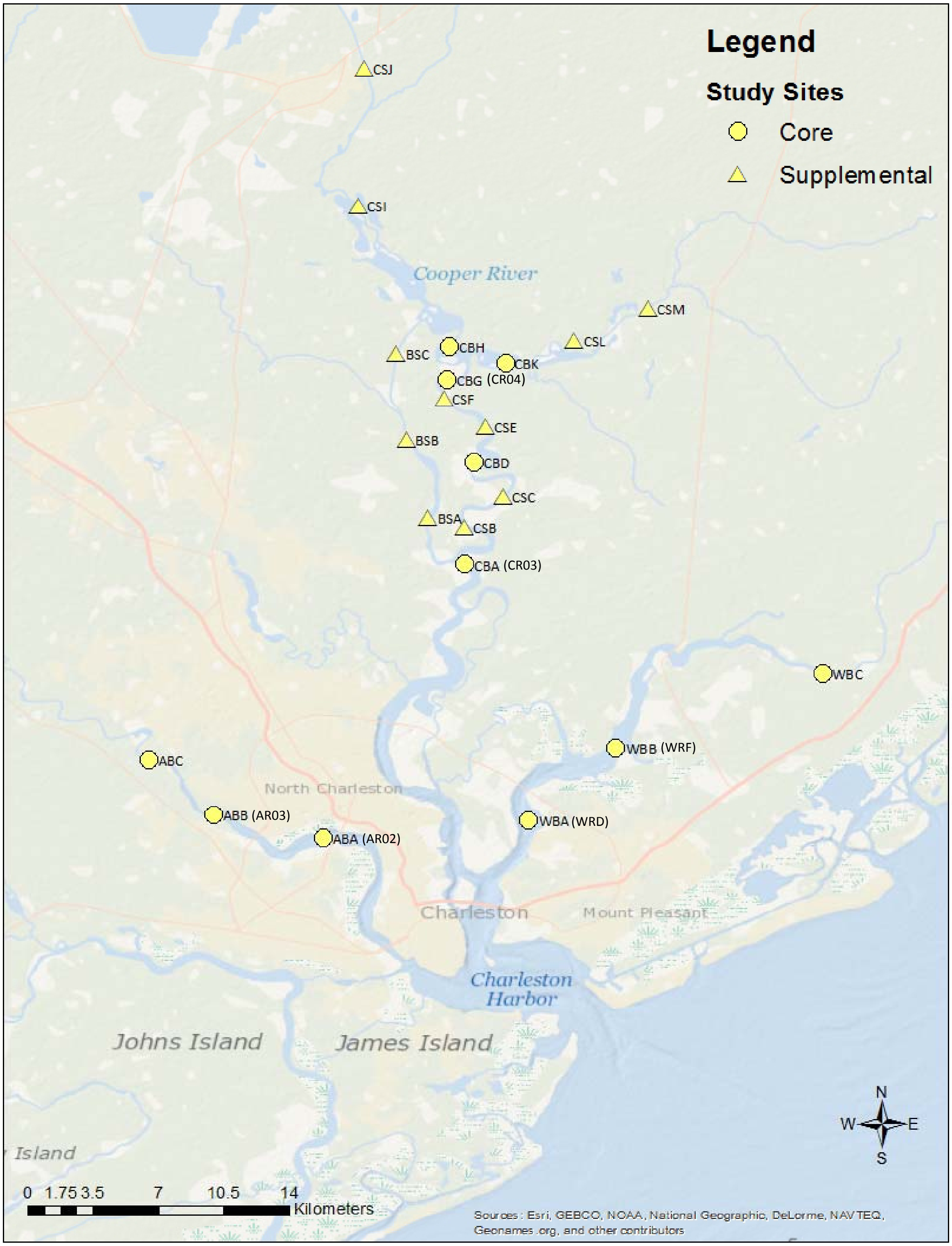


Figure 2. Map of the sampling sites for this study. The core sites are shown with the yellow circle. The supplemental sediment composition sampling sites are shown with the yellow triangle. The six sites sampled in the 1980s CHCS are provided in parentheses after the site code.

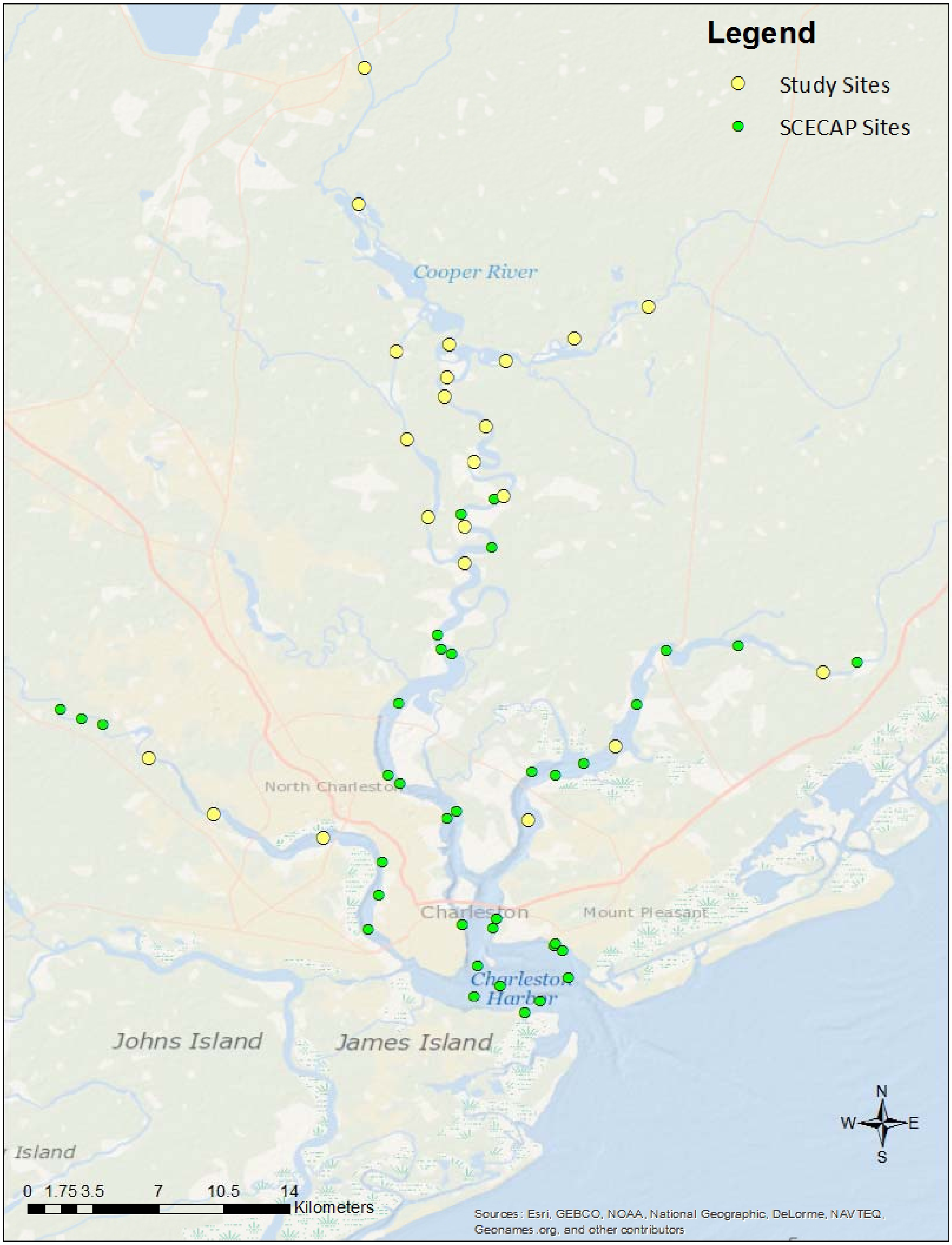


Figure 3. Map of the 36 SCECAP sites (green circles) sampled from 1999-2011 and the 11 core study sites (yellow circles) used in the MDS analysis.

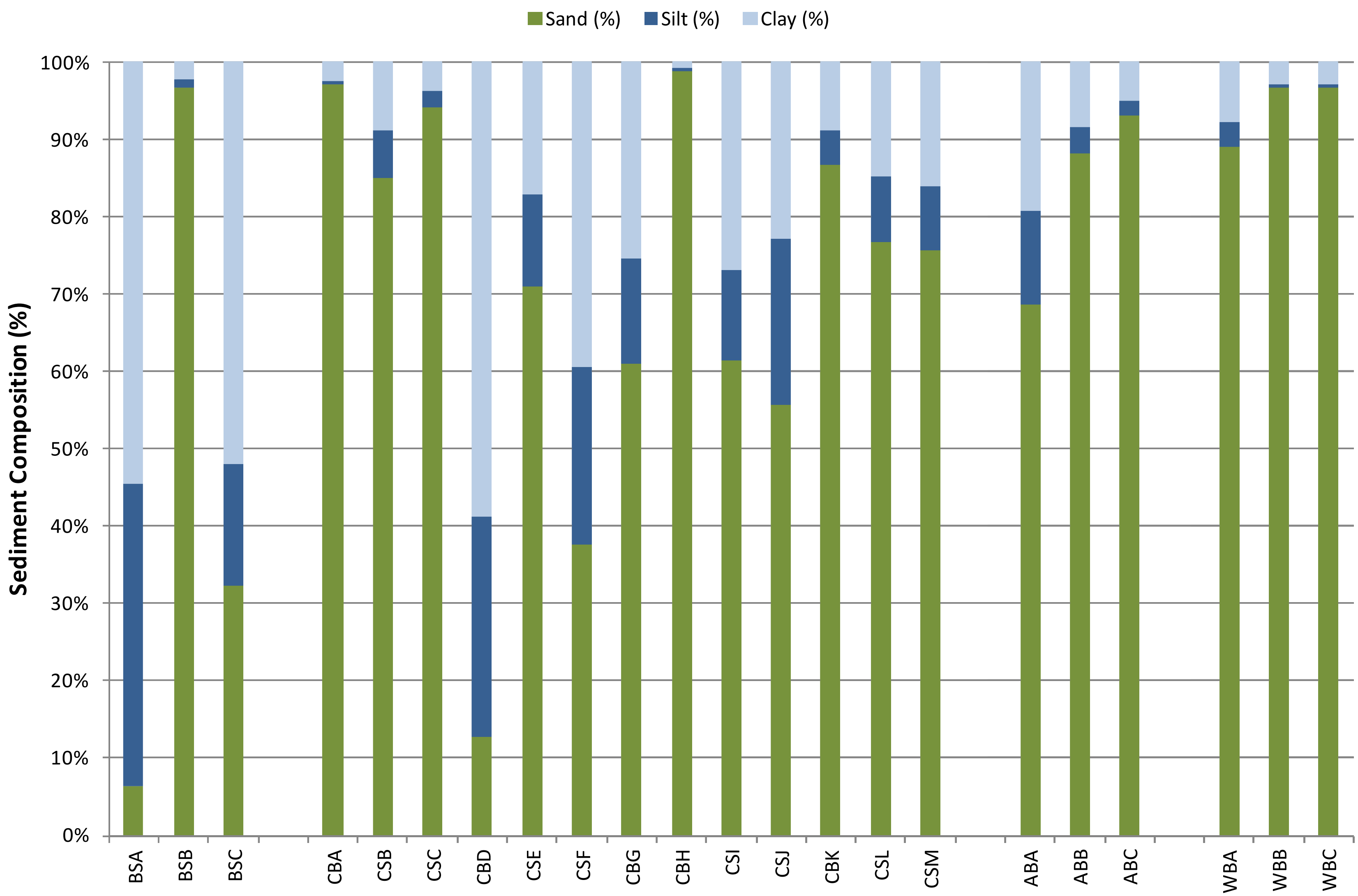


Figure 4. Average sediment composition (sand, silt, clay) for each site sampled during the Summer of 2012.

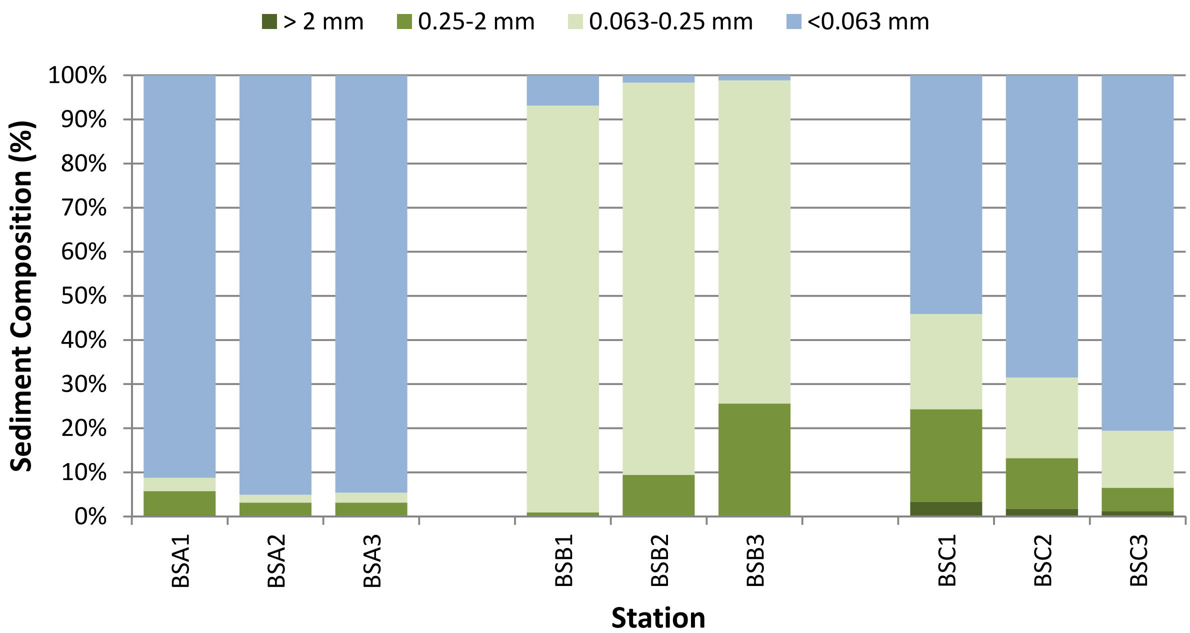


Figure 5. Sediment composition with additional sand fractions differentiated for each station sampled during the Summer of 2012 in the Back River. >2 mm=gravel, 0.25-2.0 mm=medium to coarse sand, 0.063-0.25=very fine to find sand, <0.063 mm=mud.

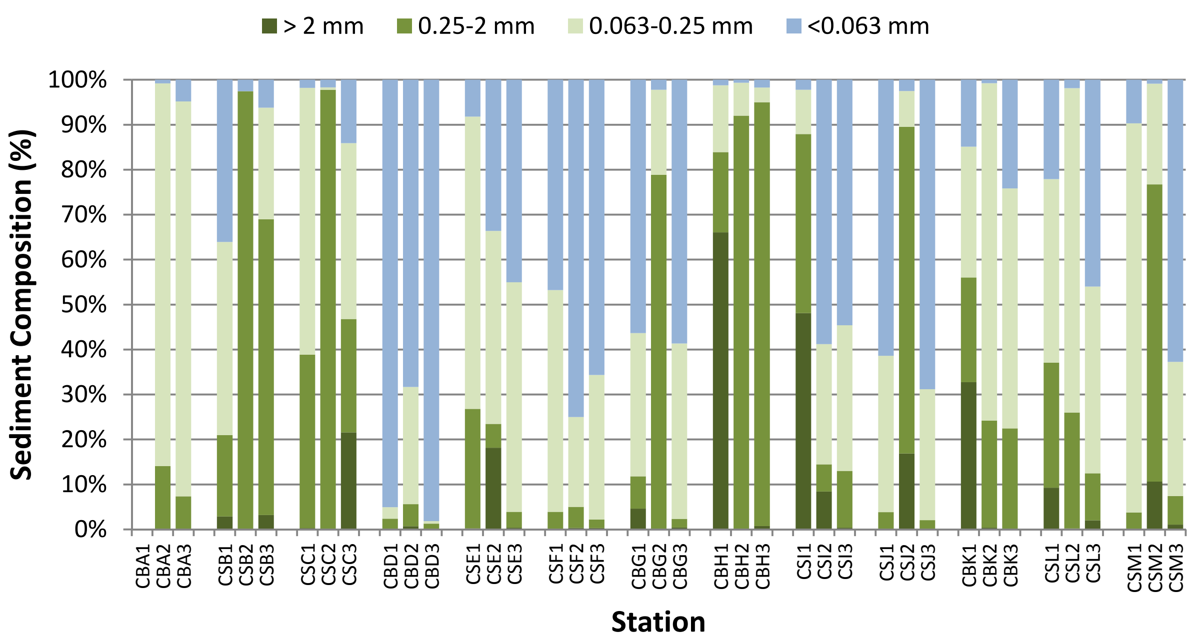


Figure 6. Sediment composition with additional sand fractions differentiated for each station sampled during the Summer of 2012 in the Cooper River. >2 mm=gravel, 0.25-2.0 mm=medium to coarse sand, 0.063-0.25=very fine to find sand, <0.063 mm=mud.

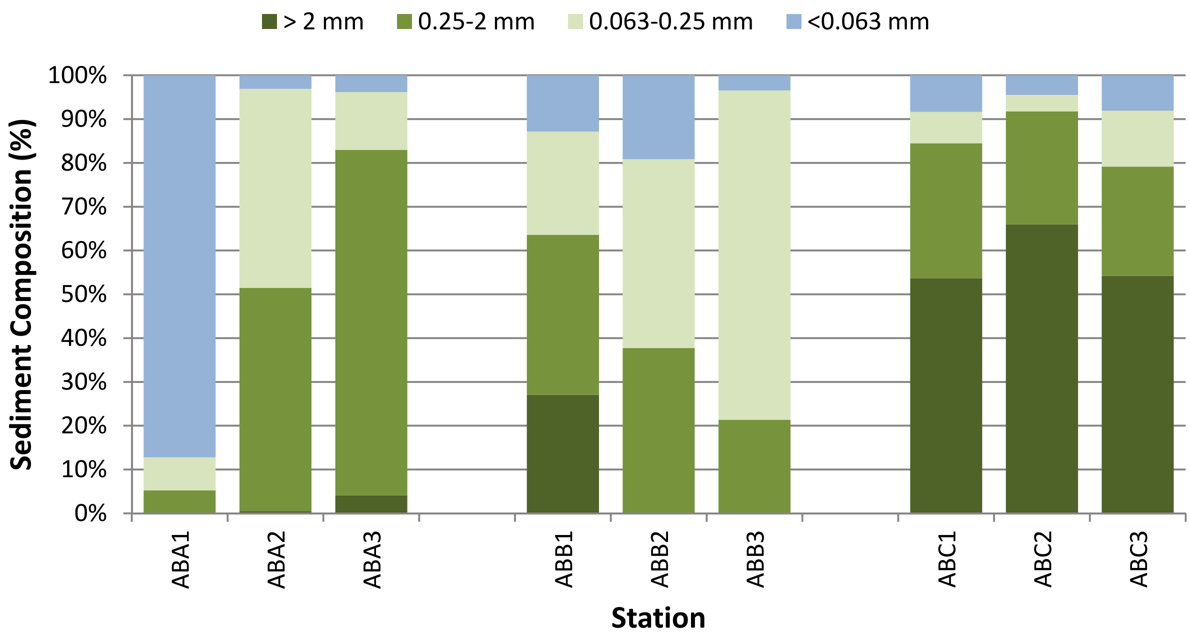


Figure 7. Sediment composition with additional sand fractions differentiated for each station sampled during the Summer of 2012 in the Ashley River. >2 mm=gravel, 0.25-2.0 mm=medium to coarse sand, 0.063-0.25=very fine to find sand, <0.063 mm=mud.

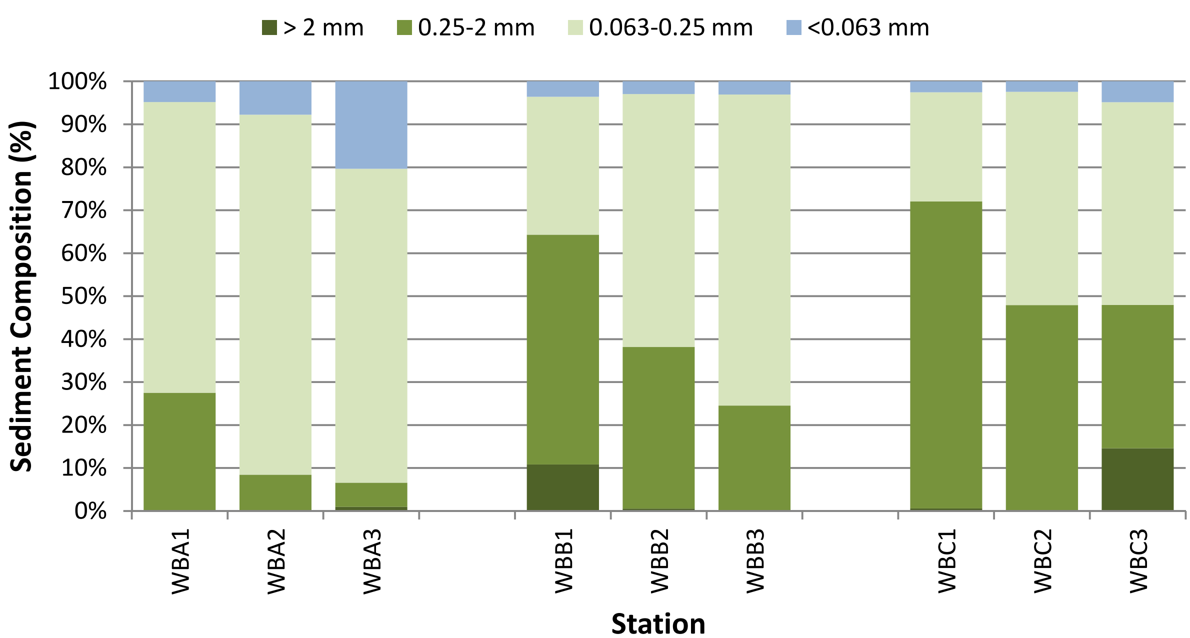


Figure 8. Sediment composition with additional sand fractions differentiated for each station sampled during the Summer of 2012 in the Wando River. >2 mm=gravel, 0.25-2.0 mm=medium to coarse sand, 0.063-0.25=very fine to find sand, <0.063 mm=mud.

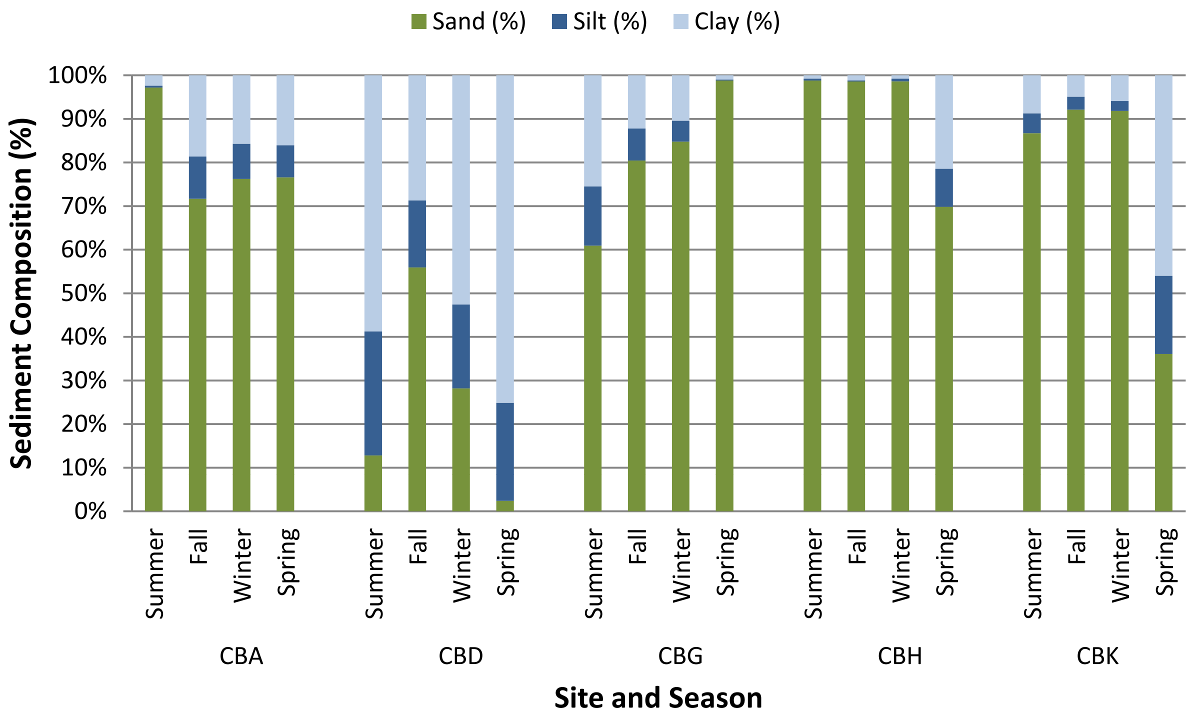


Figure 9. Sediment composition for each core site and season in the Cooper River. Site is an average of the 2-3 stations sampled at each site.

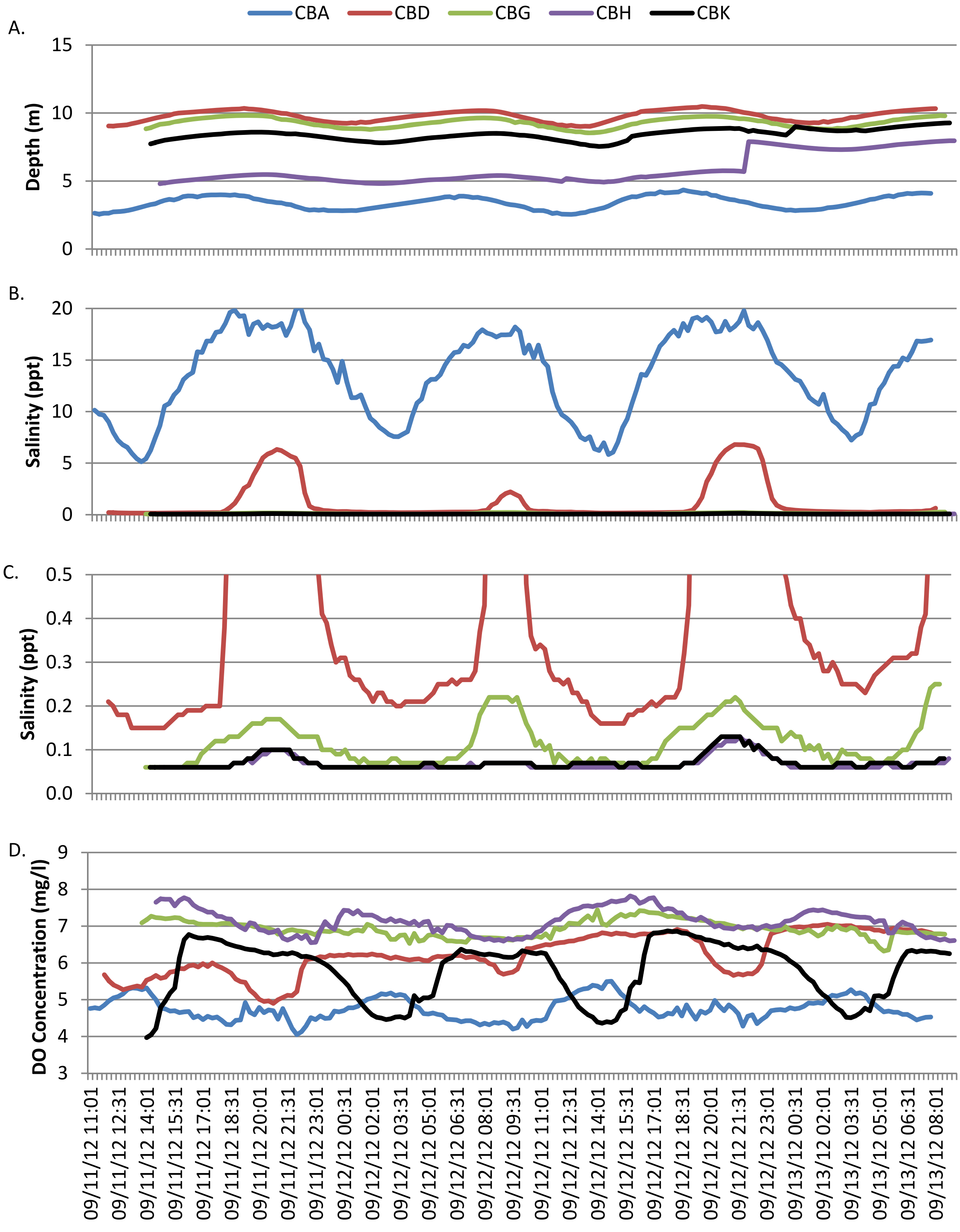


Figure 10. Semi-continuous water quality – depth (A), salinity (B and C), and DO concentration (D) – for the Cooper River sampling sites during the Summer of 2012.

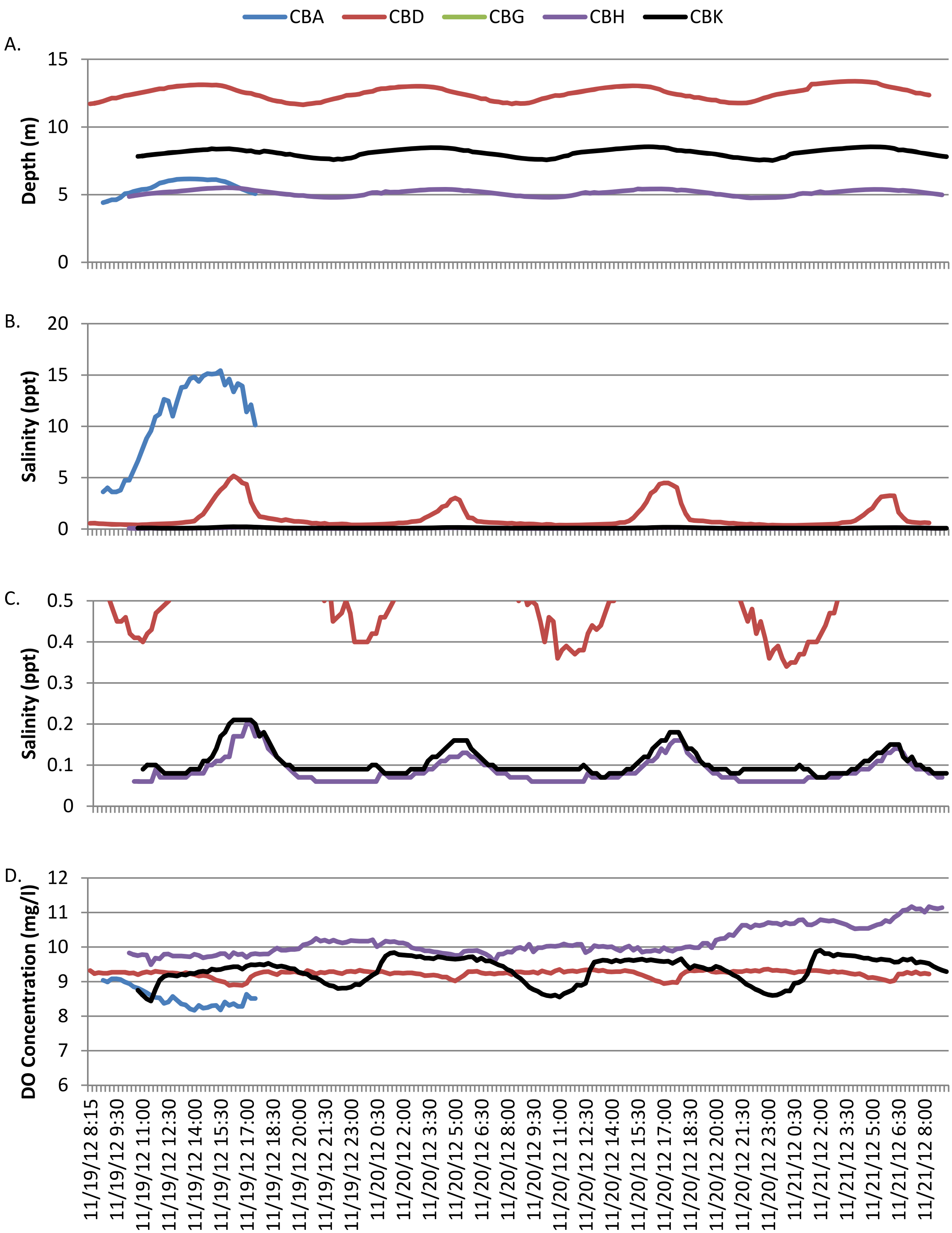


Figure 11. Semi-continuous water quality – depth (A), salinity (B and C), and DO concentration (D) – for the Cooper River sampling sites during the Fall of 2012.

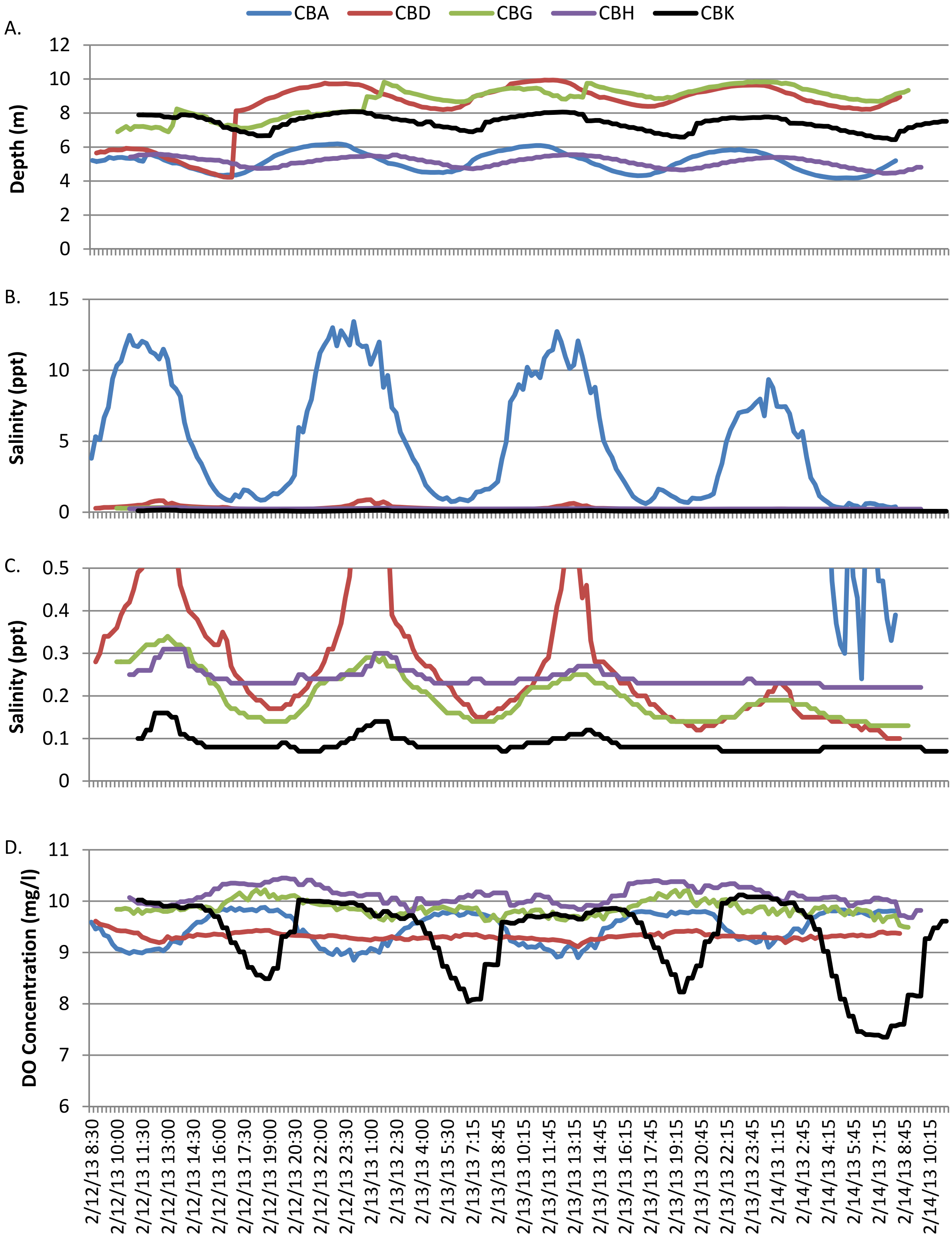


Figure 12. Semi-continuous water quality – depth (A), salinity (B and C), and DO concentration (D) – for the Cooper River sampling sites during the Winter of 2013.

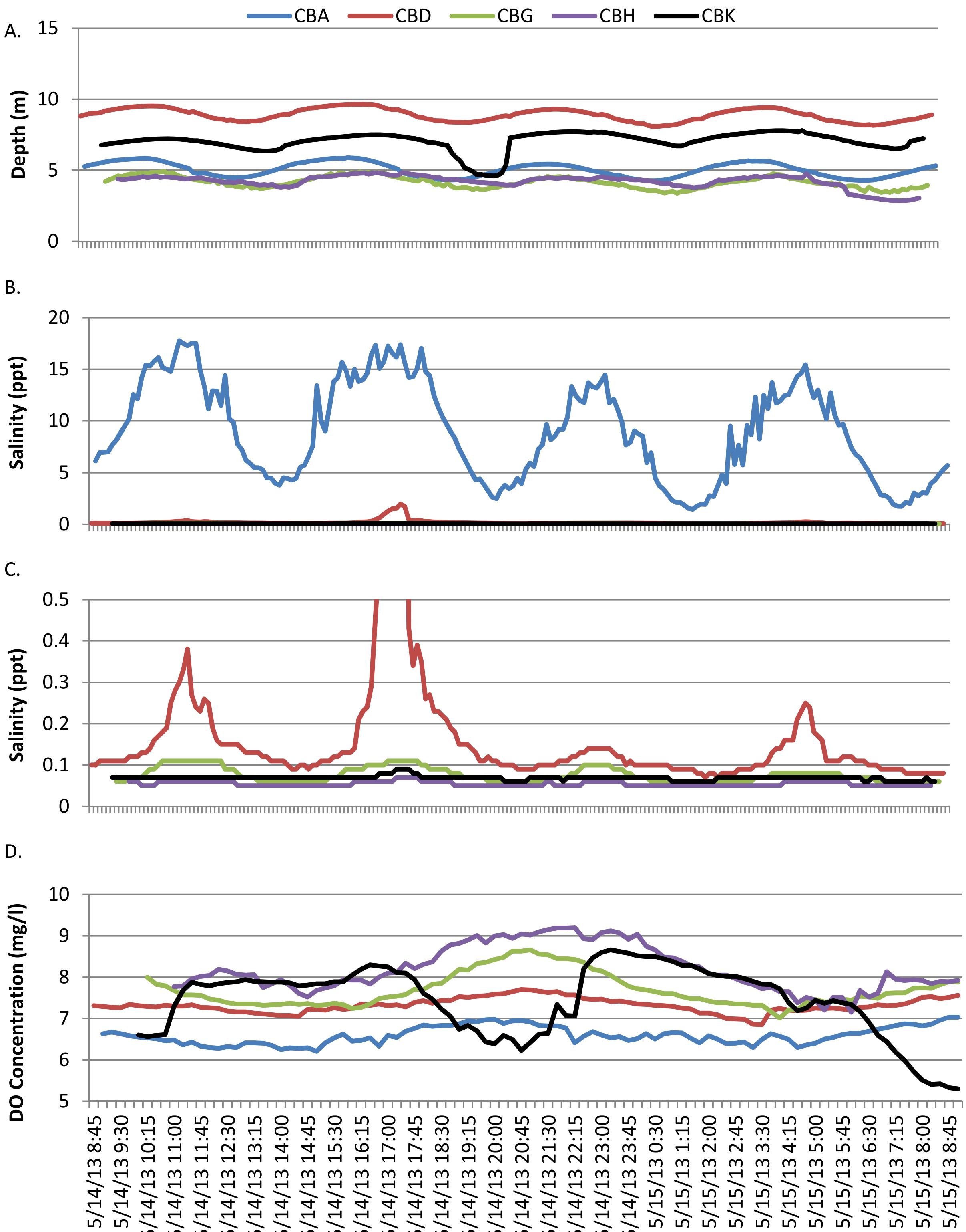


Figure 13. Semi-continuous water quality – depth (A), salinity (B and C), and DO concentration (D) – for the Cooper River sampling sites during the Spring of 2013.

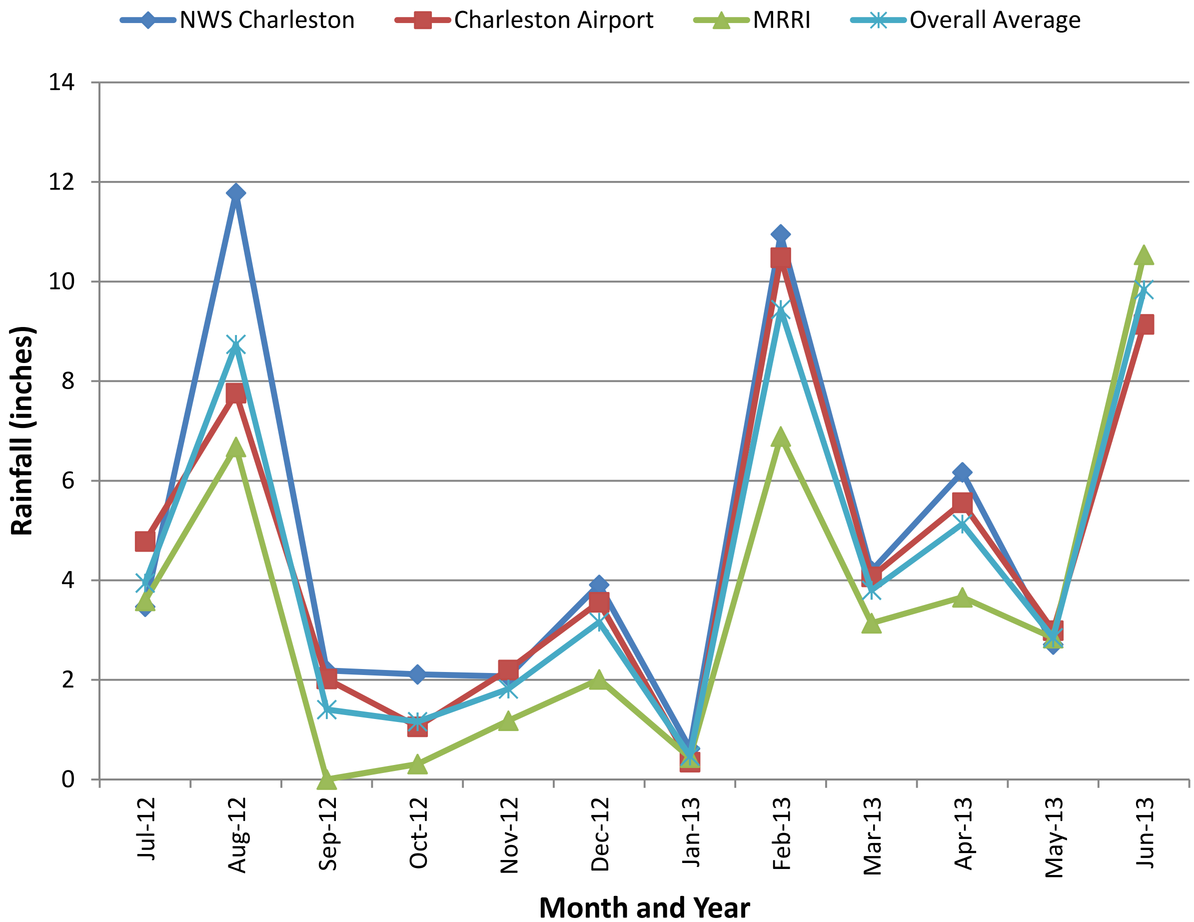
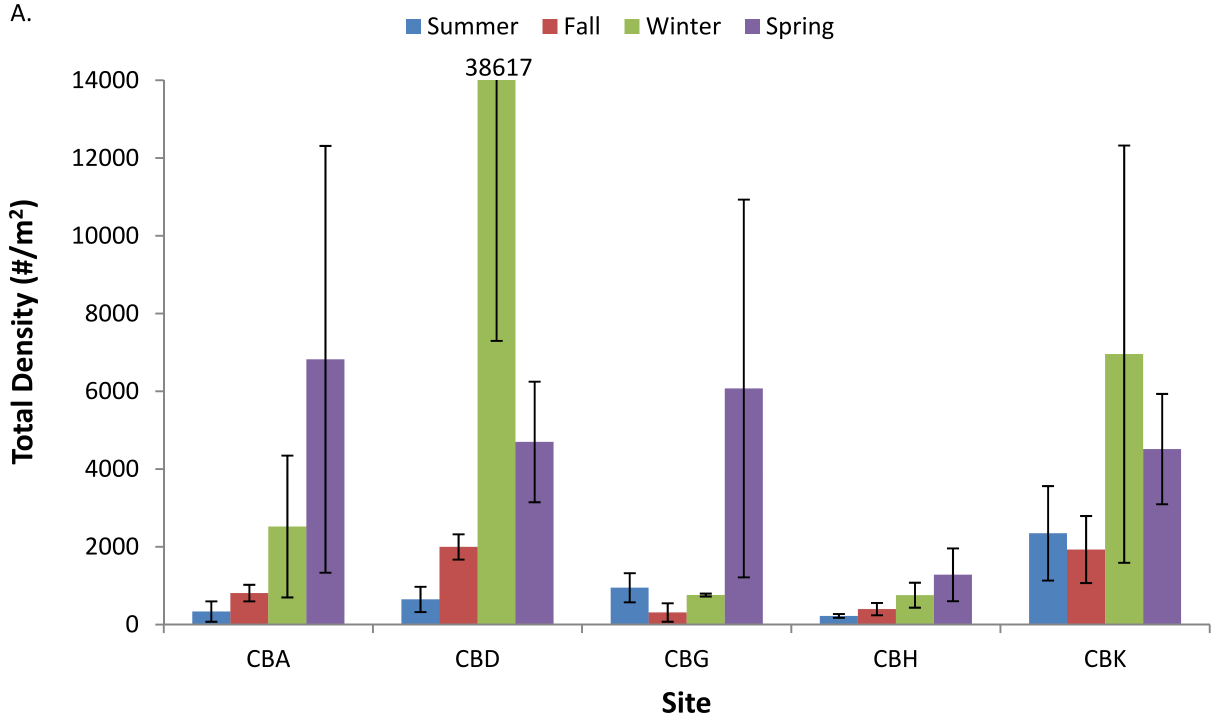


Figure 14. Rainfall by month for three sites located around Charleston County from July 2012 to June 2013. Rainfall data for the Naval Weapons Station (NWS) and Charleston Airport were obtained from the NOAA National Climatic Data Center (http://www.ncdc.noaa.gov/cdo-web/).

A.



B.

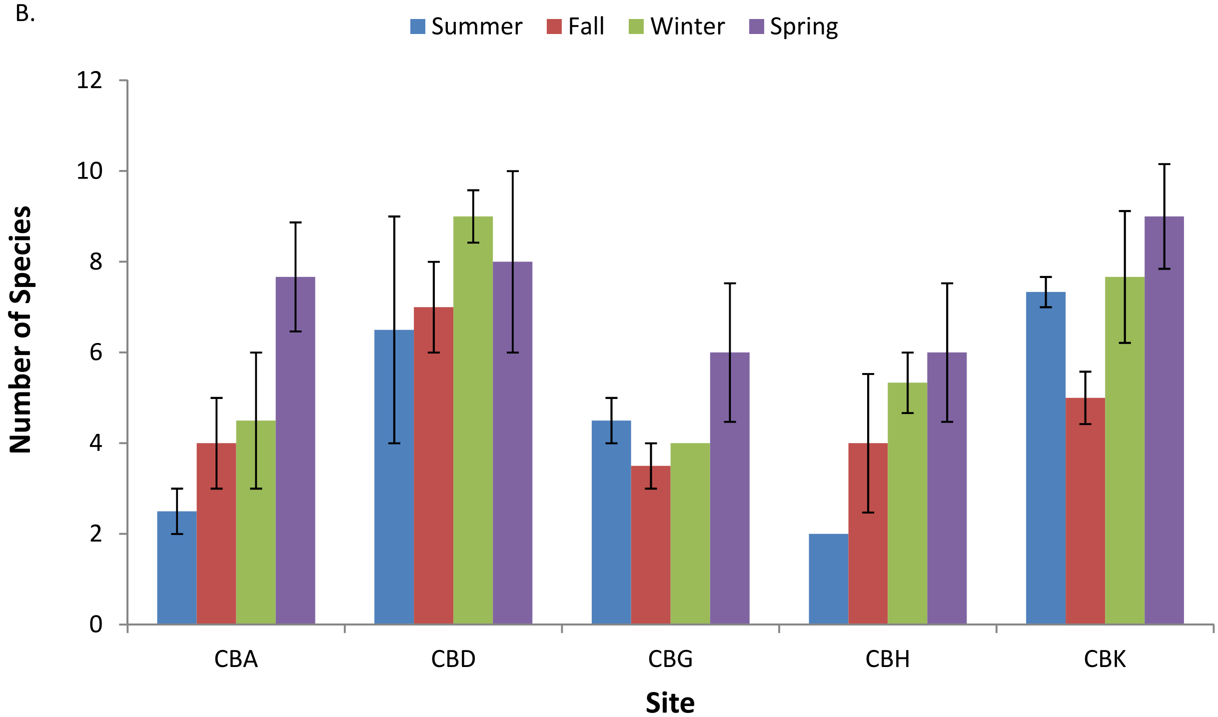


Figure 15. The average total density (A) and number of species (B) of the macrobenthic community for each site sampled in the Cooper River during each season. Error bars represent ± 1 standard error.

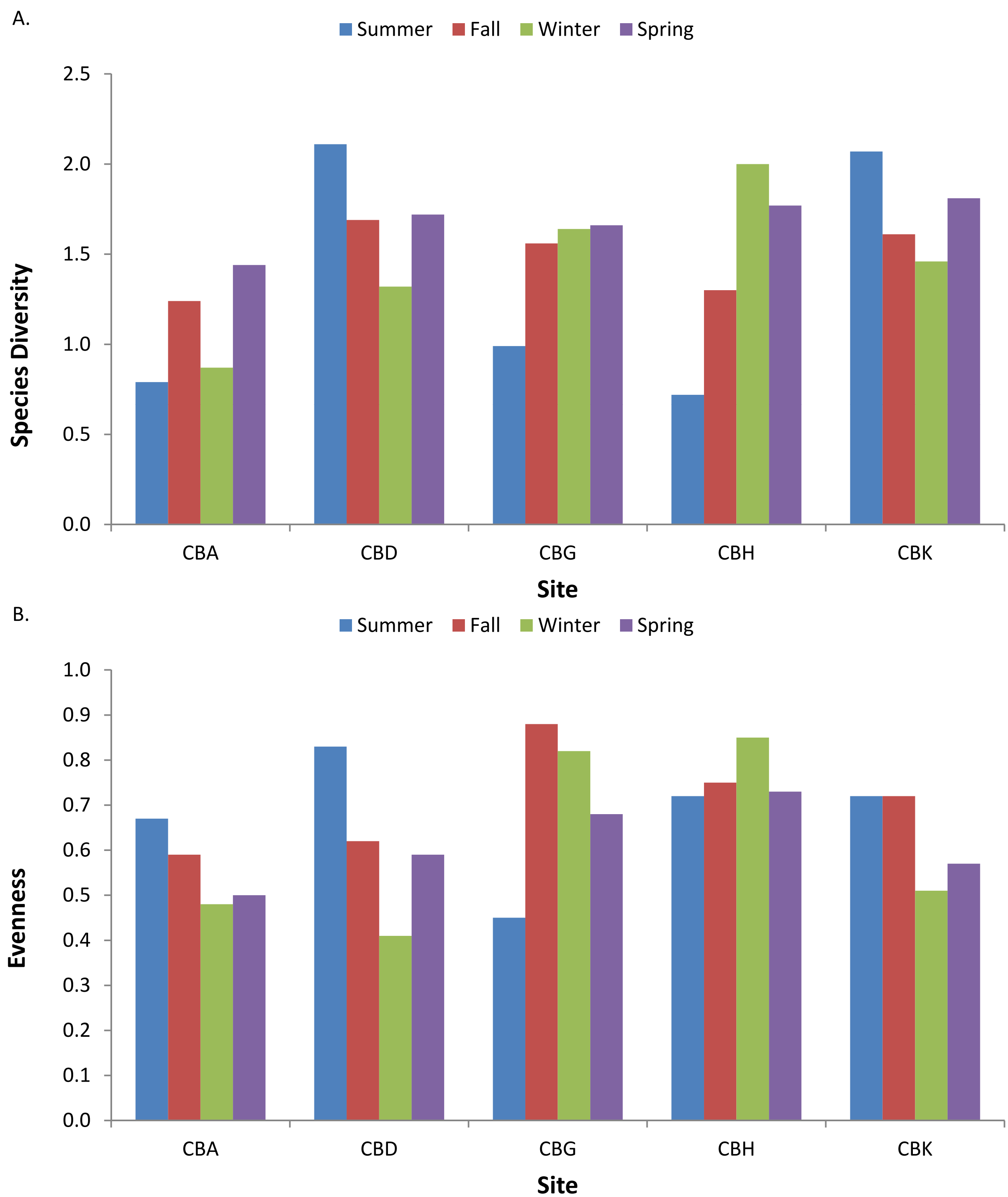


Figure 16. The species diversity (A) and evenness(B) of the macrobenthic community for each site sampled in the Cooper River during each season.

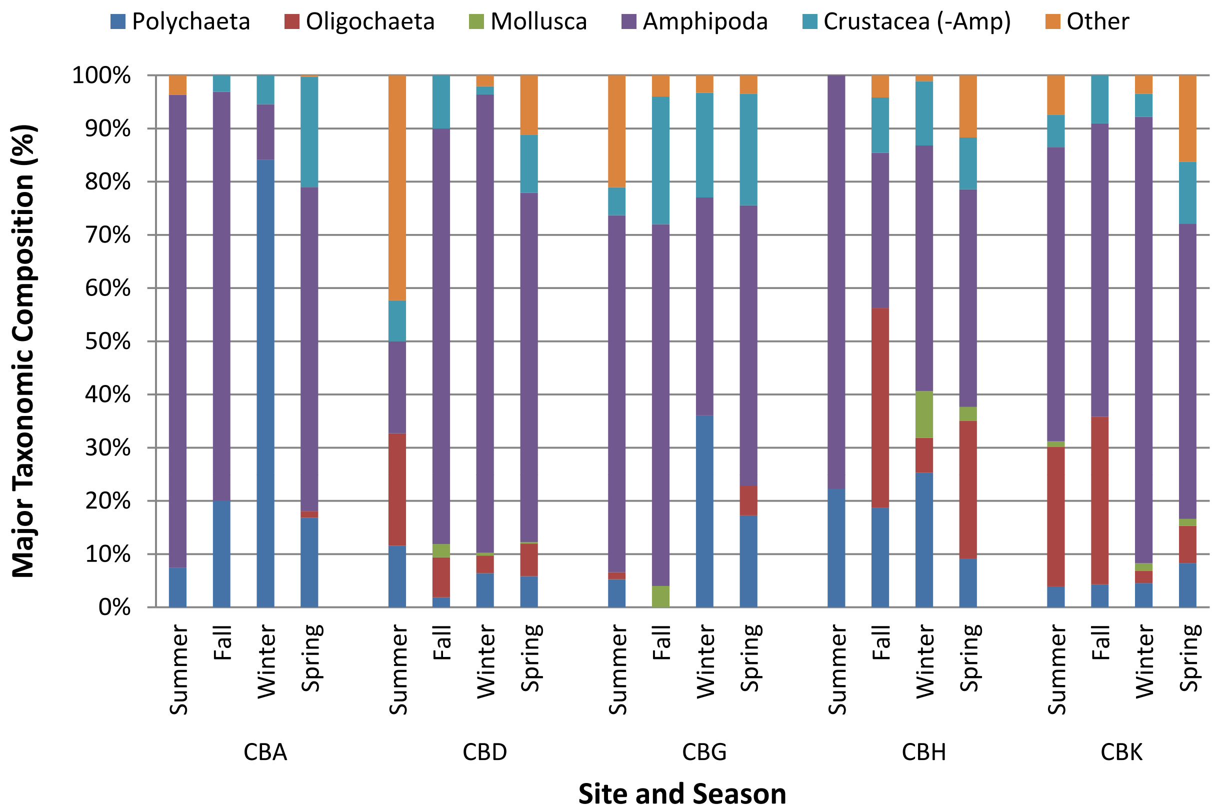


Figure 17. The major taxonomic composition of the macrobenthic community for each site sampled in the Cooper River during each season.

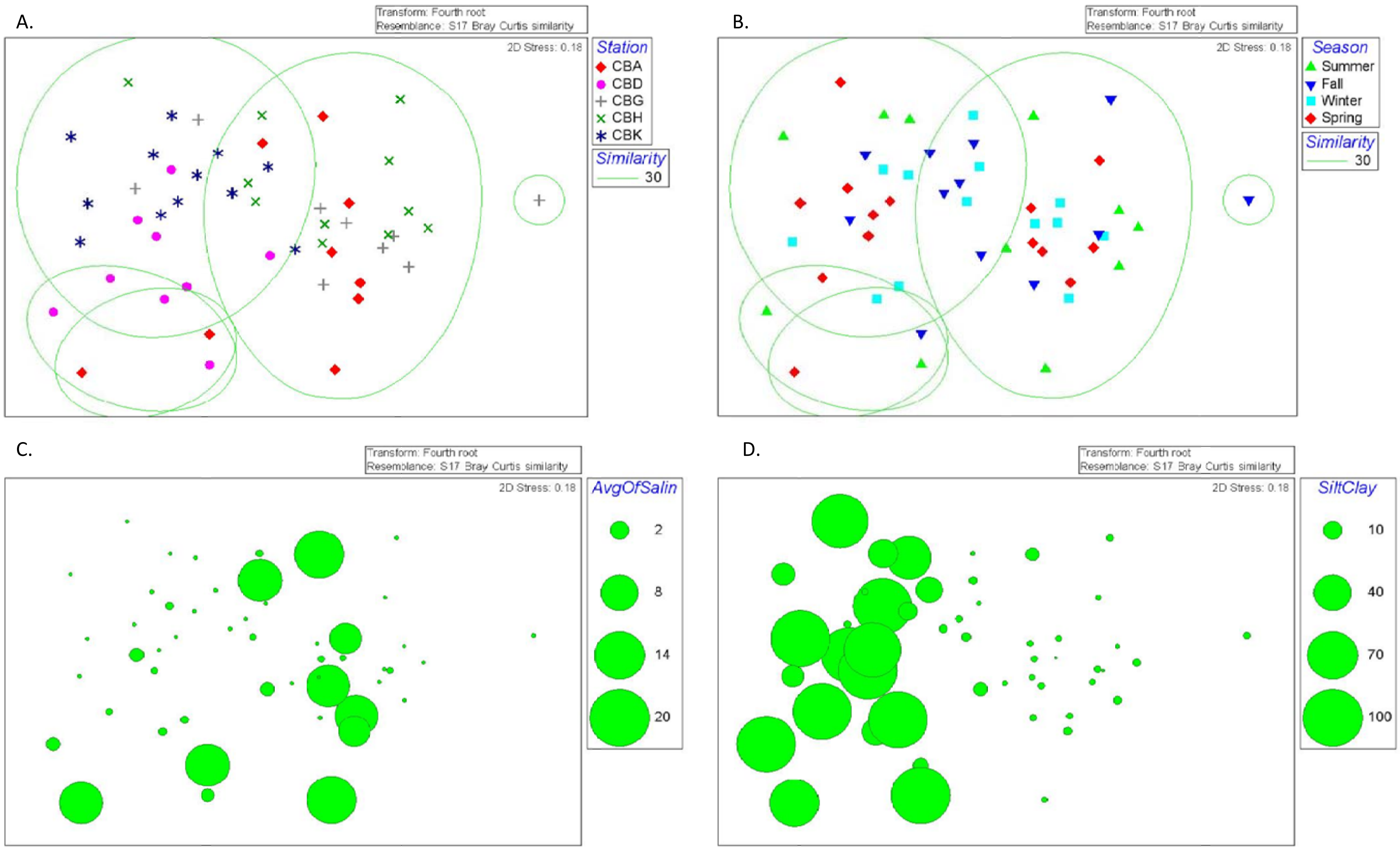


Figure 18. The MDS ordination plot of the macrobenthic community for each station sampled in the Cooper River during each season. The samples are the same in all four plots but the symbols are coded differently to help identify patterns in the similarity of samples. (A) is coded by system and (B) is coded by year. The similarity groupings are based on the cluster analysis to indicate the major groupings of the sites. (C) is the average salinity (ppt) and (D) is the average silt/clay percentage for each sample.

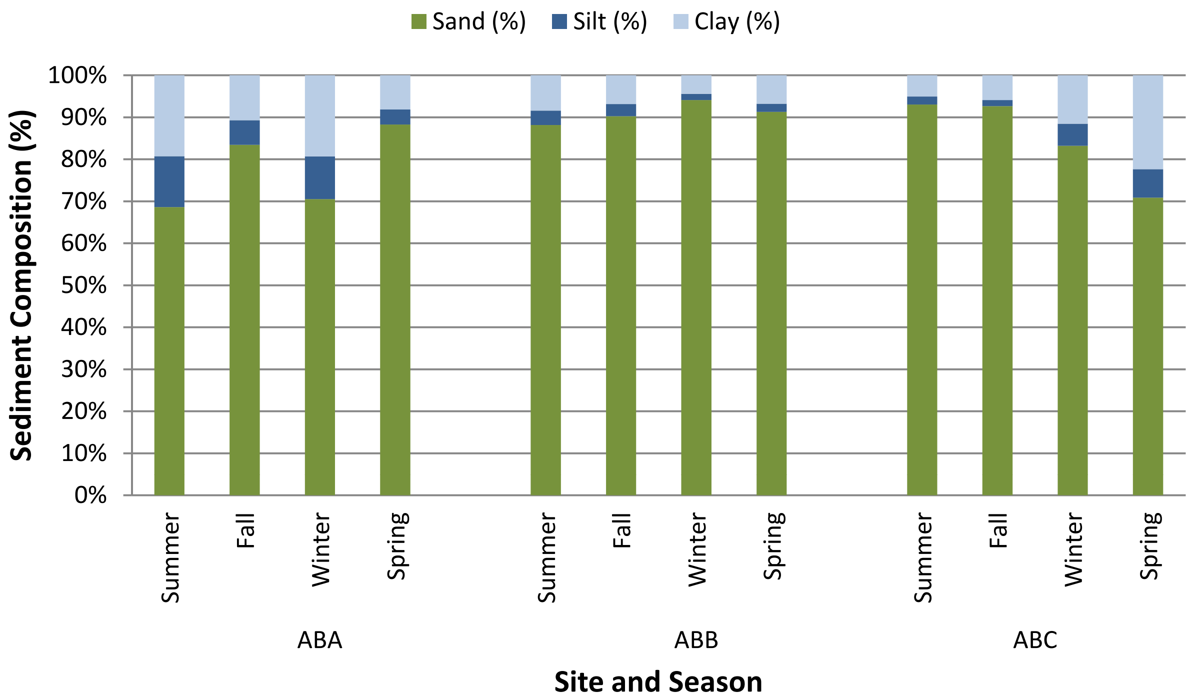


Figure 19. Sediment composition for each site and season in the Ashley River. Site is an average of the 3 stations sampled at each site for each season.

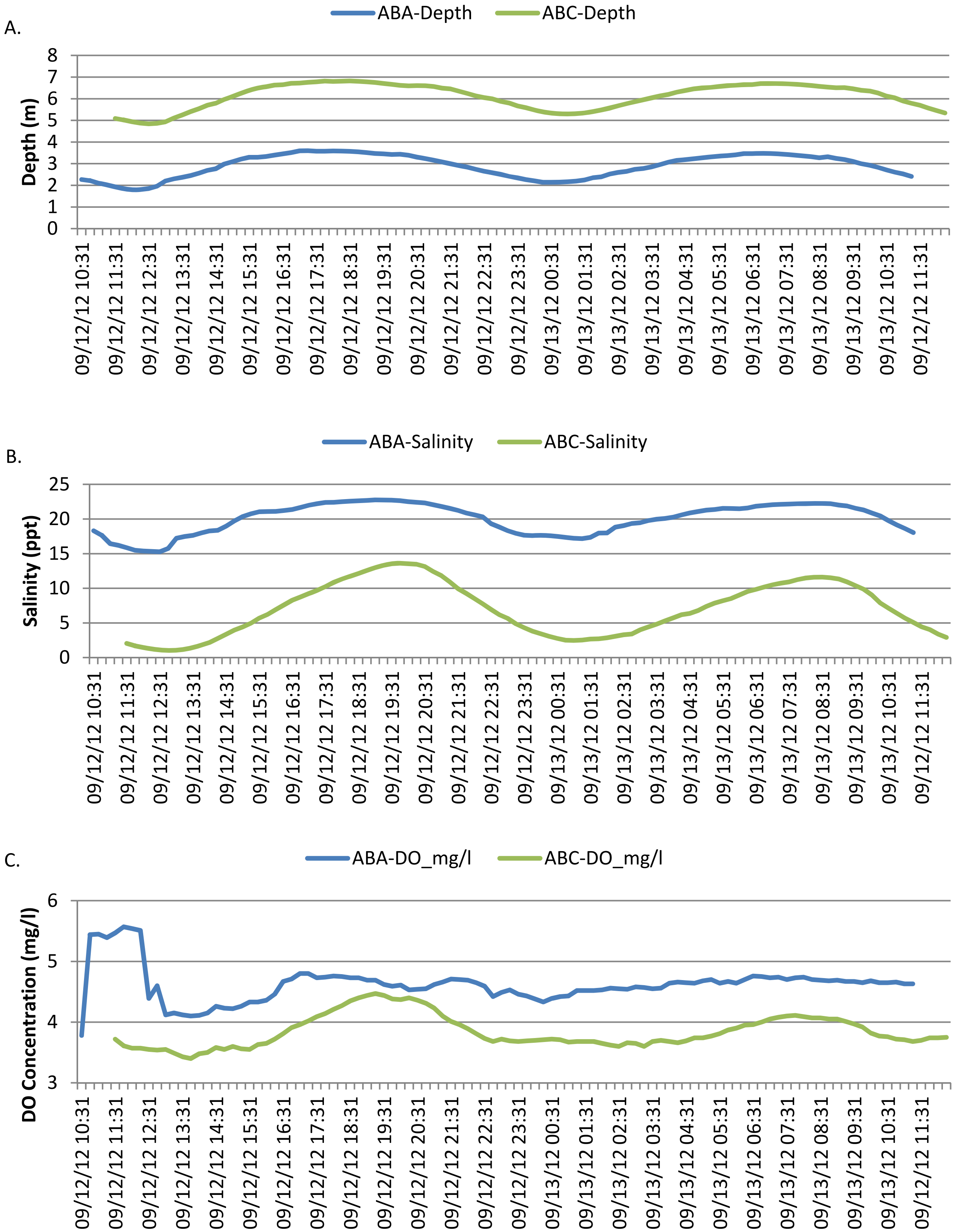
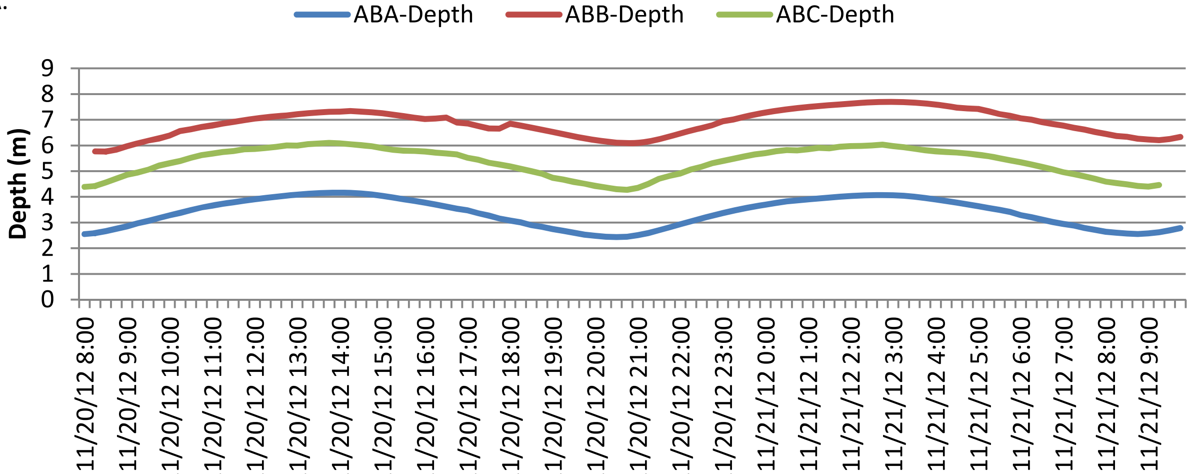
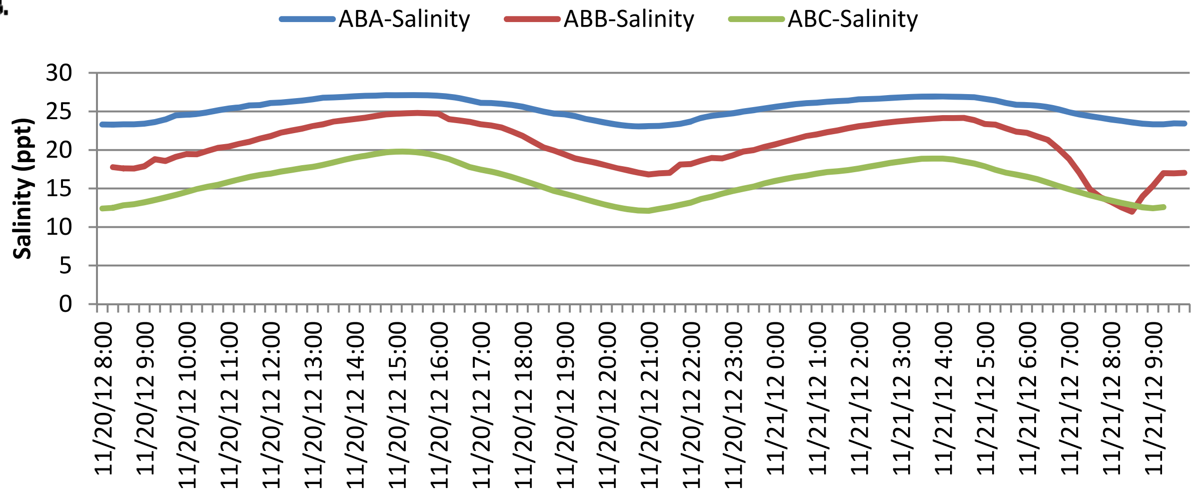


Figure 20. Semi-continuous water quality (depth, salinity, and DO concentration) for the Ashley River sampling sites during the Summer of 2012.

A.



B.



C.

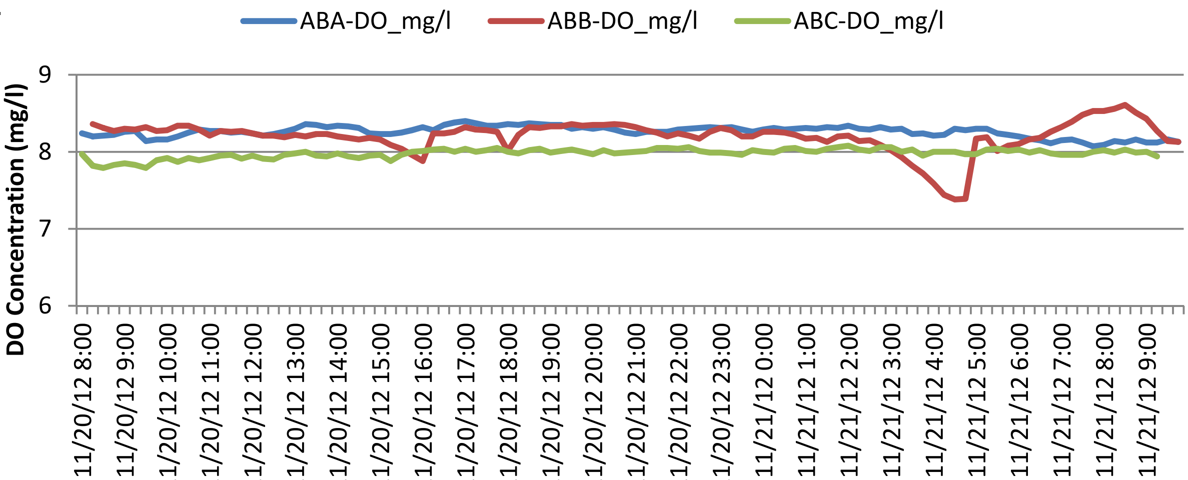


Figure 21. Semi-continuous water quality (depth, salinity, and DO concentration) for the Ashley River sampling sites during the Fall of 2012.

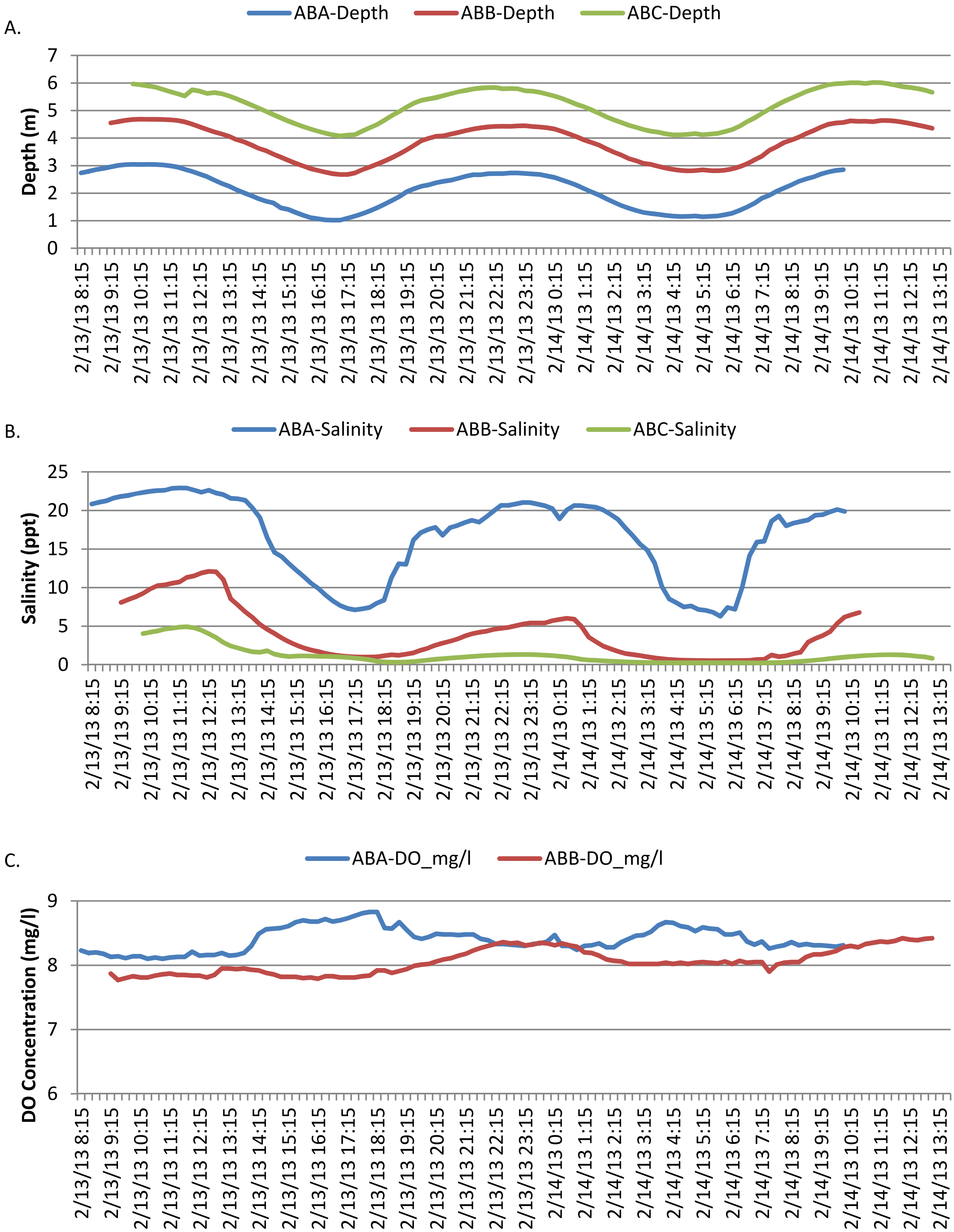


Figure 22. Semi-continuous water quality (depth, salinity, and DO concentration) for the Ashley River sampling sites during the Winter of 2013.

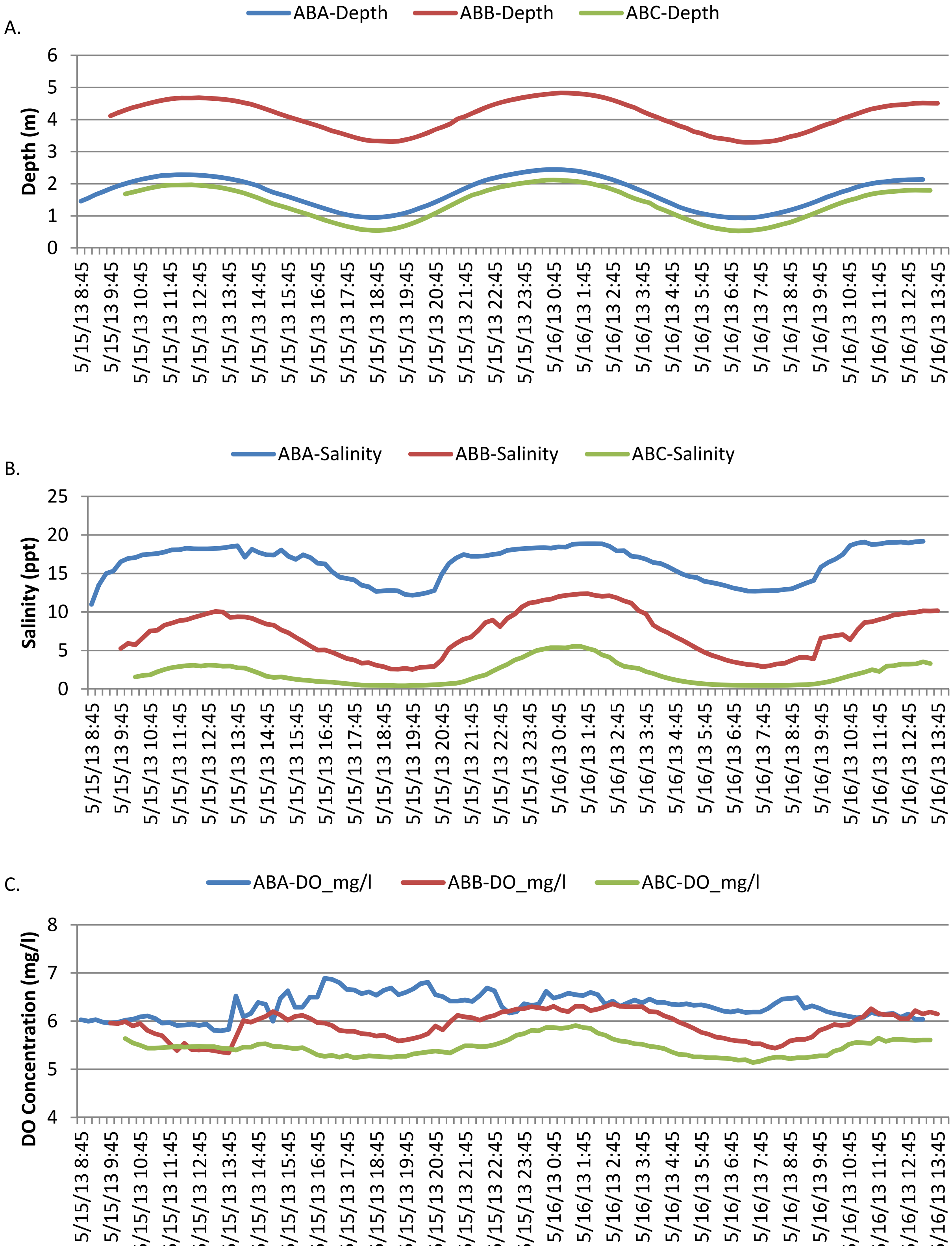


Figure 23. Semi-continuous water quality (depth, salinity, and DO concentration) for the Ashley River sampling sites during the Spring of 2013.

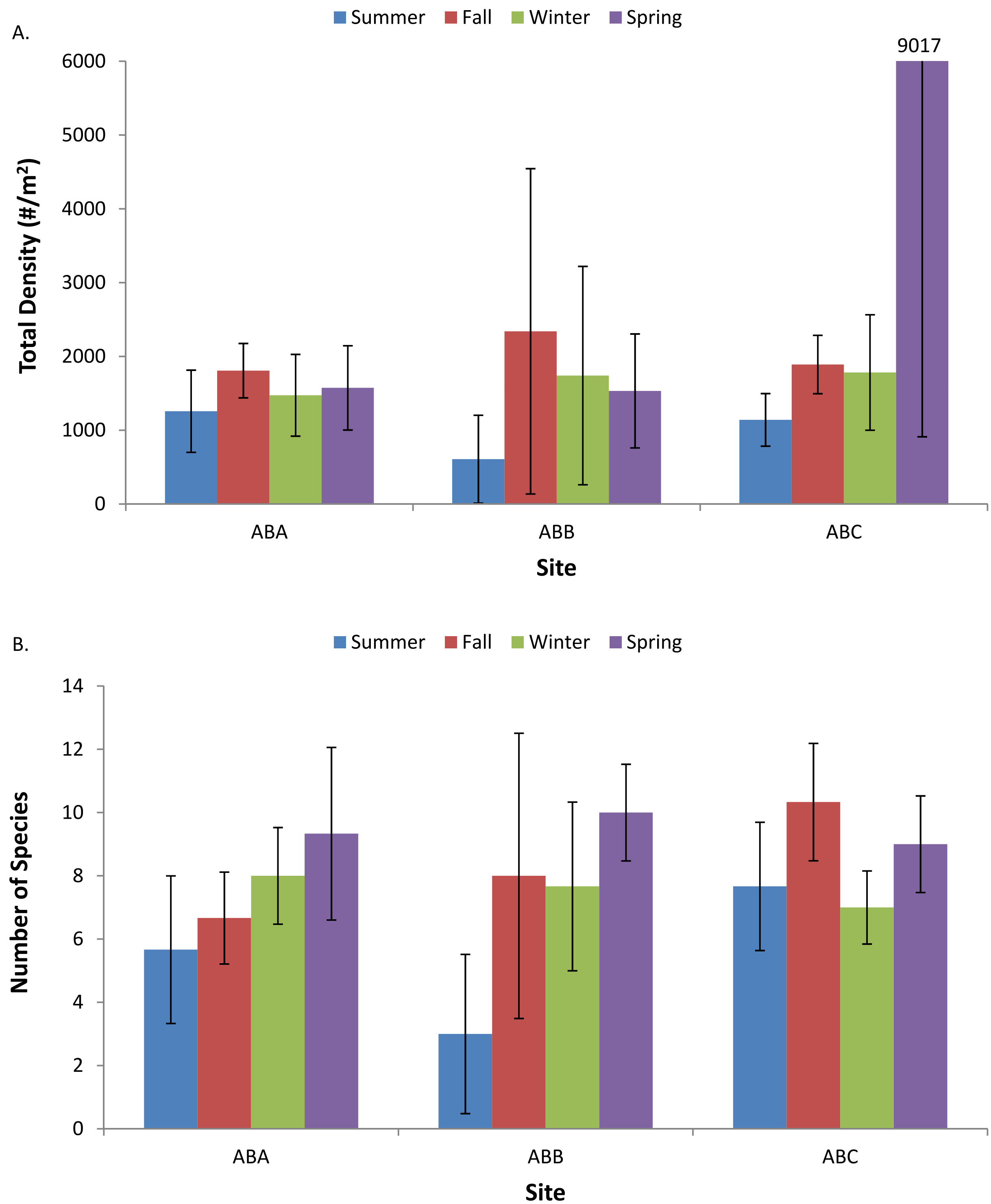


Figure 24. The average total density (A) and number of species (B) of the macrobenthic community for each site sampled in the Ashley River during each season. Error bars represent ± 1 standard error.

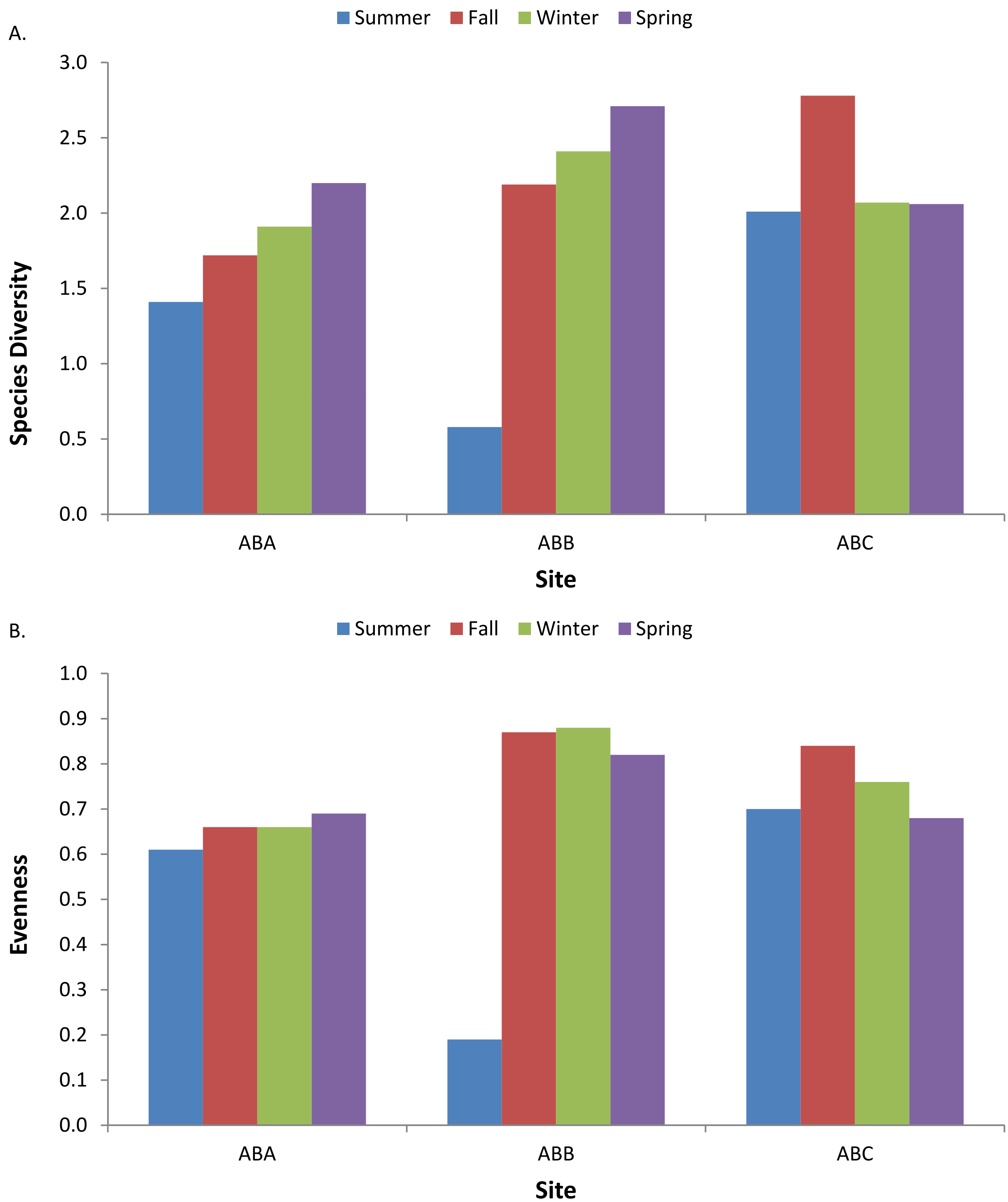


Figure 25. The species diversity (A) and evenness (B) of the macrobenthic community for each site sampled in the Ashley River during each season.

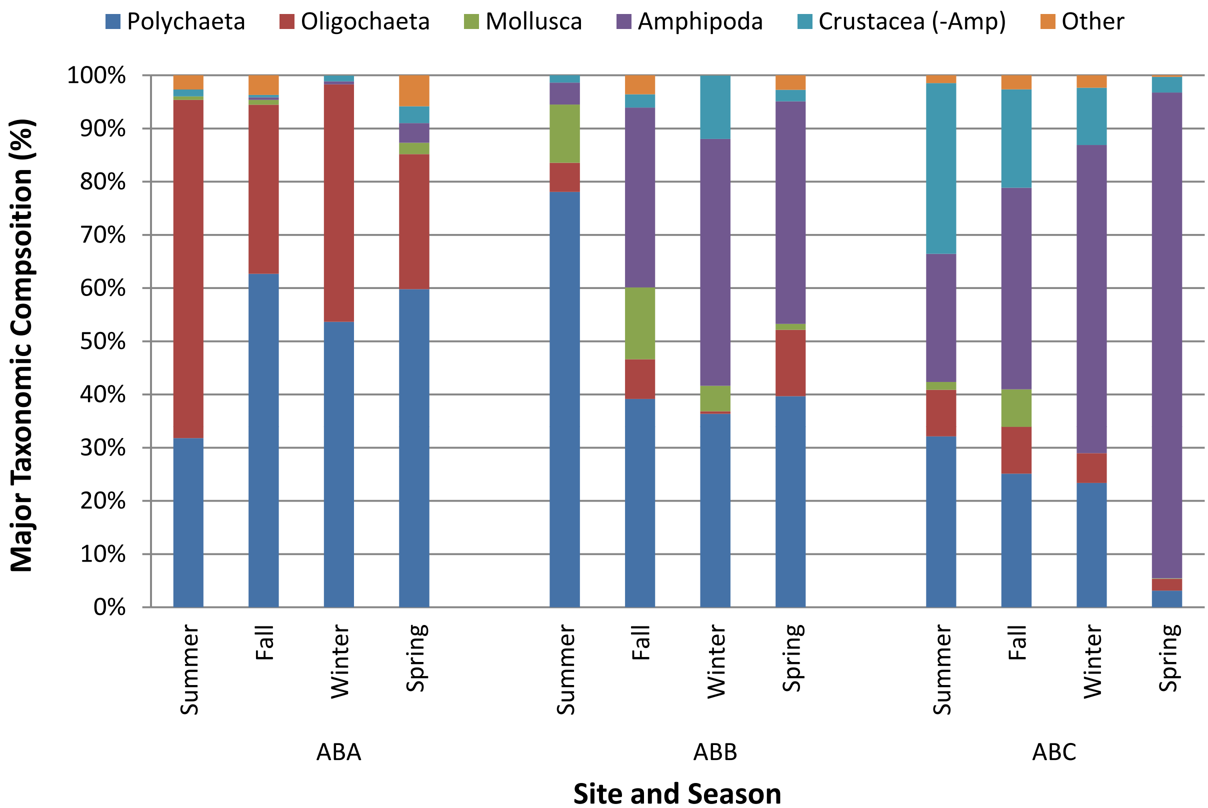


Figure 26. The major taxonomic composition of the macrobenthic community for each site sampled in the Ashley River during each season.

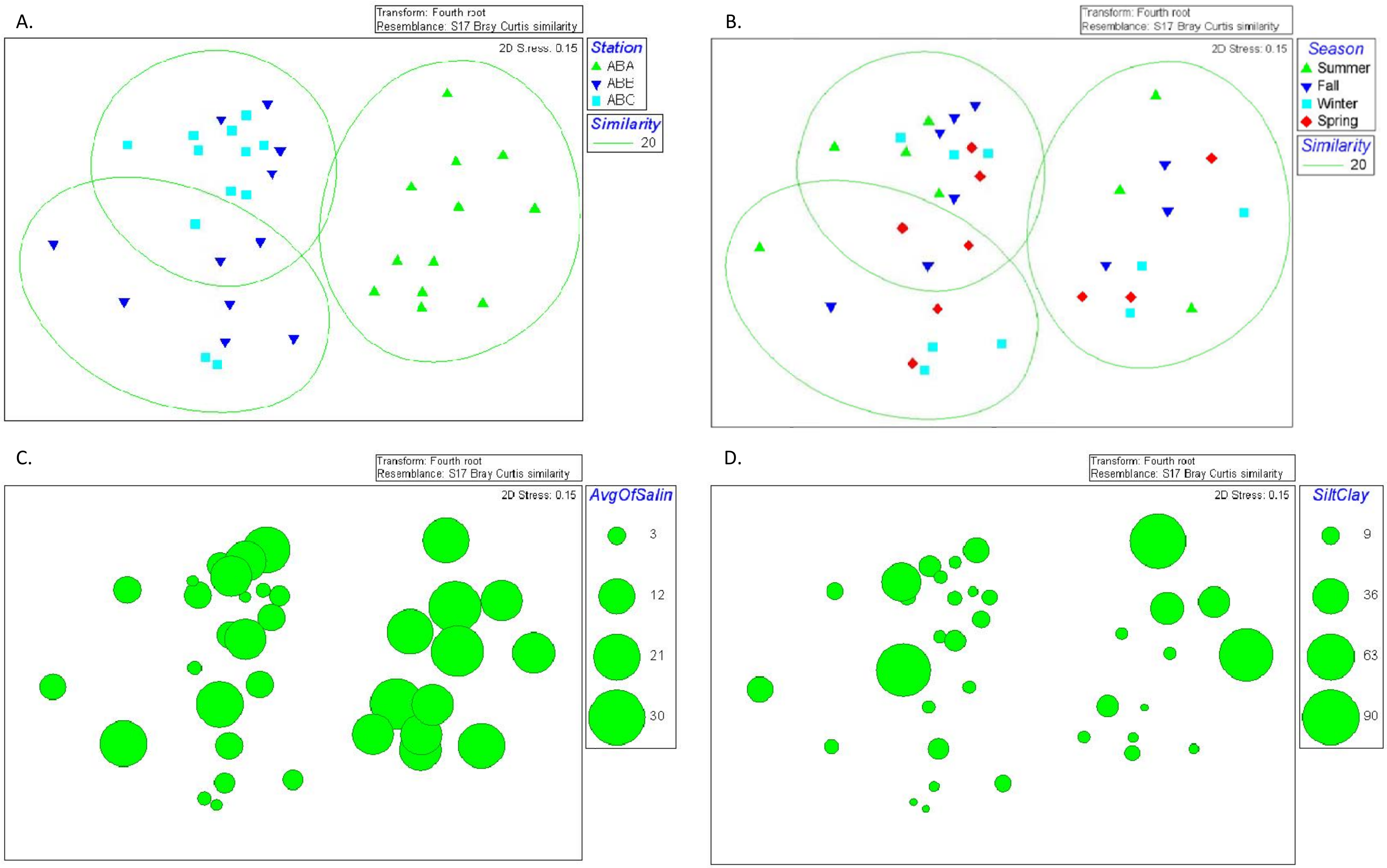


Figure 27. The MDS ordination plot of the macrobenthic community for each station sampled in the Ashley River during each season. The samples are the same in all four plots but the symbols are coded differently to help identify patterns in the similarity of samples. (A) is coded by system and (B) is coded by year. The similarity groupings are based on the cluster analysis to indicate the major groupings of the sites. (C) is the average salinity (ppt) and (D) is the average silt/clay percentage for each sample.

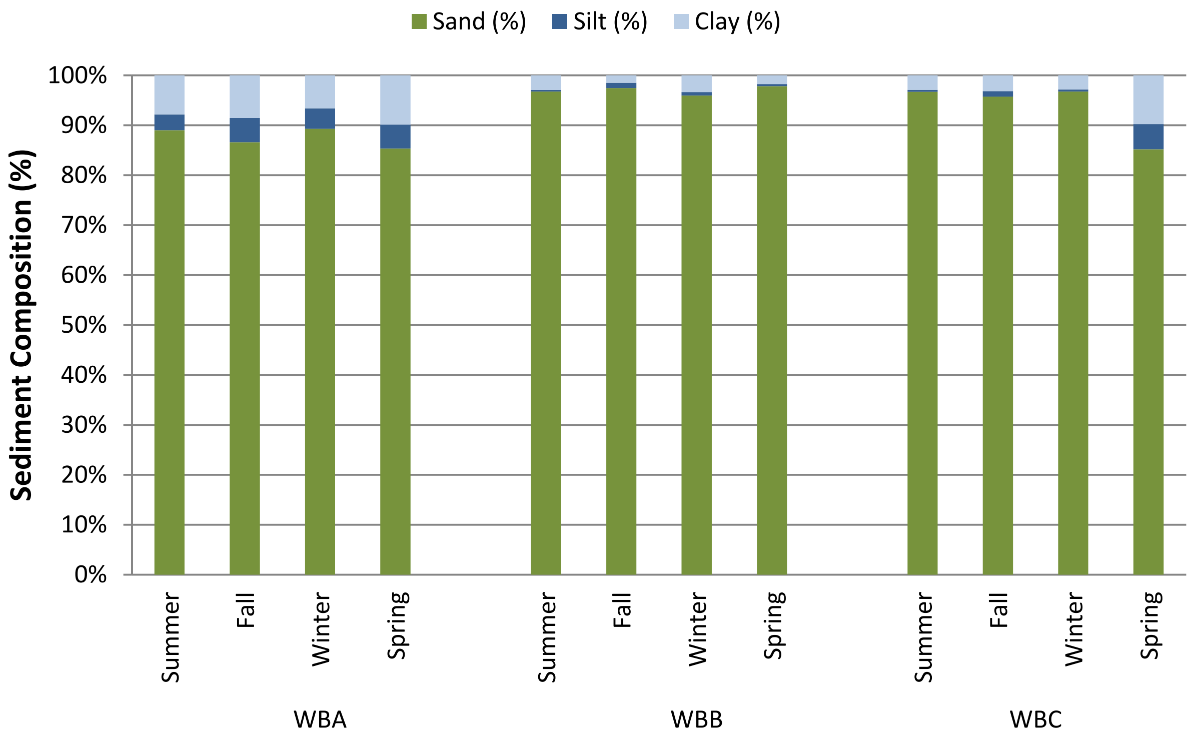
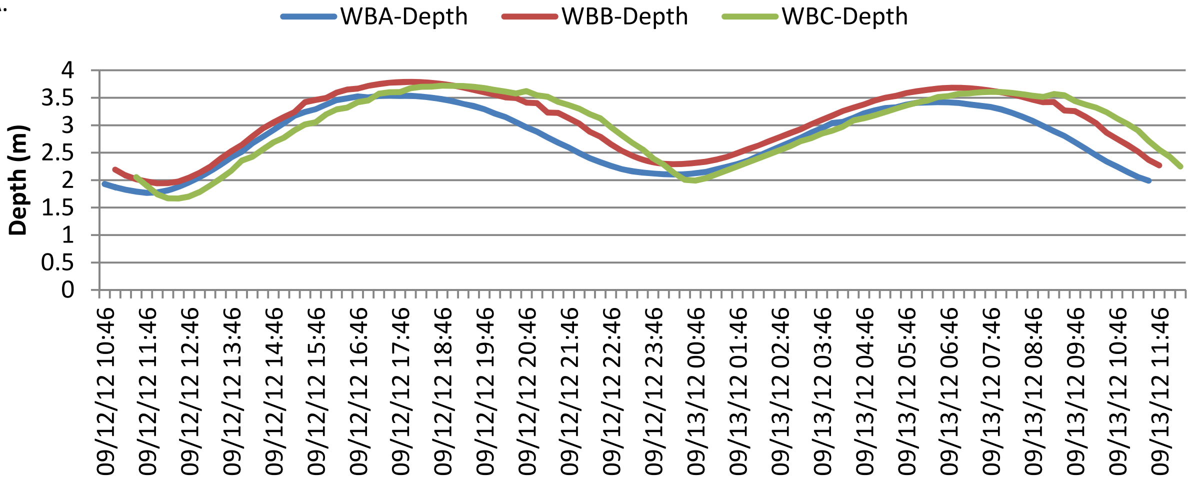
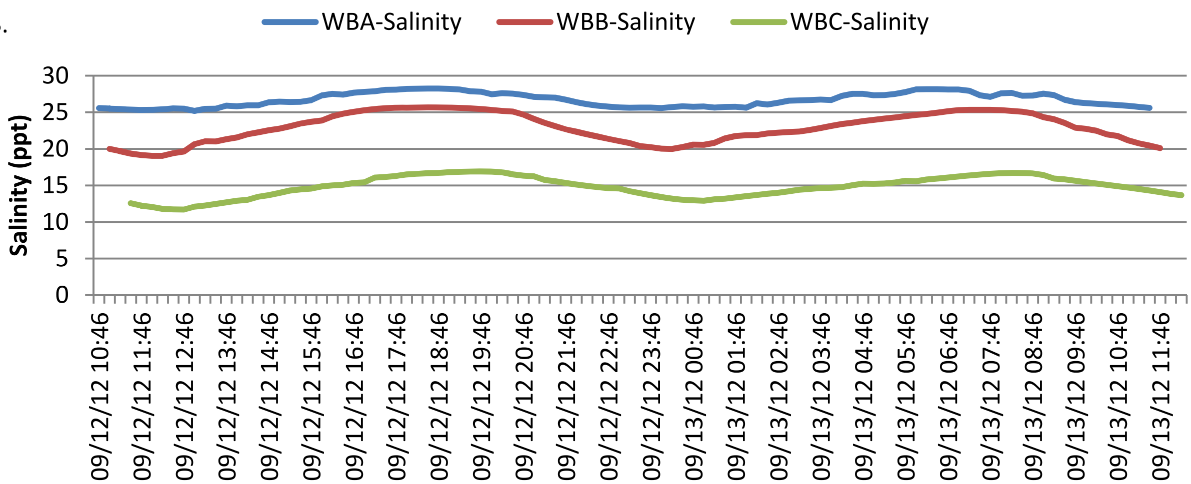


Figure 28. Sediment composition for each site and season in the Wando River. Site is an average of the 3 stations sampled at each site.

A.



B.



C.

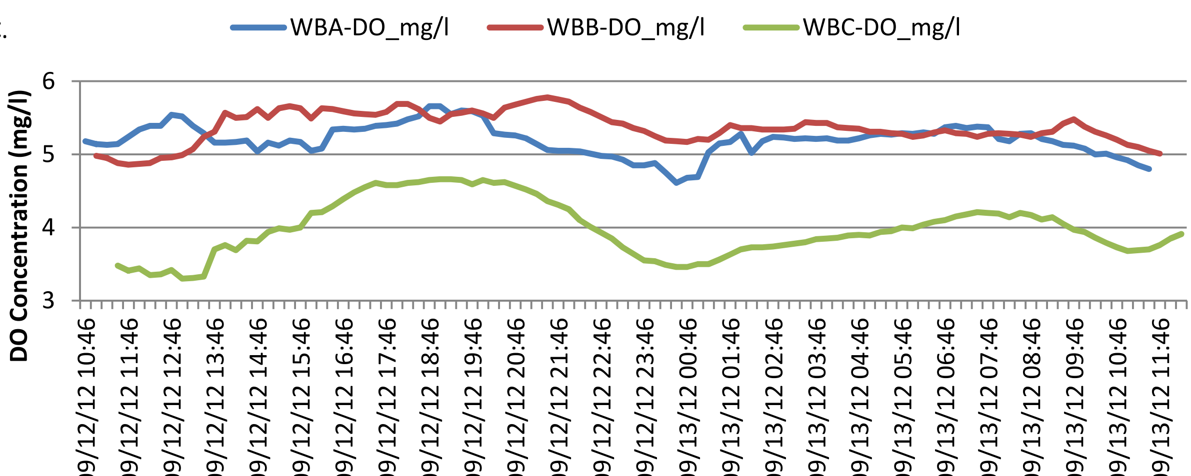


Figure 29. Semi-continuous water quality (depth, salinity, and DO concentration) for the Wando River sampling sites during the Summer of 2012.

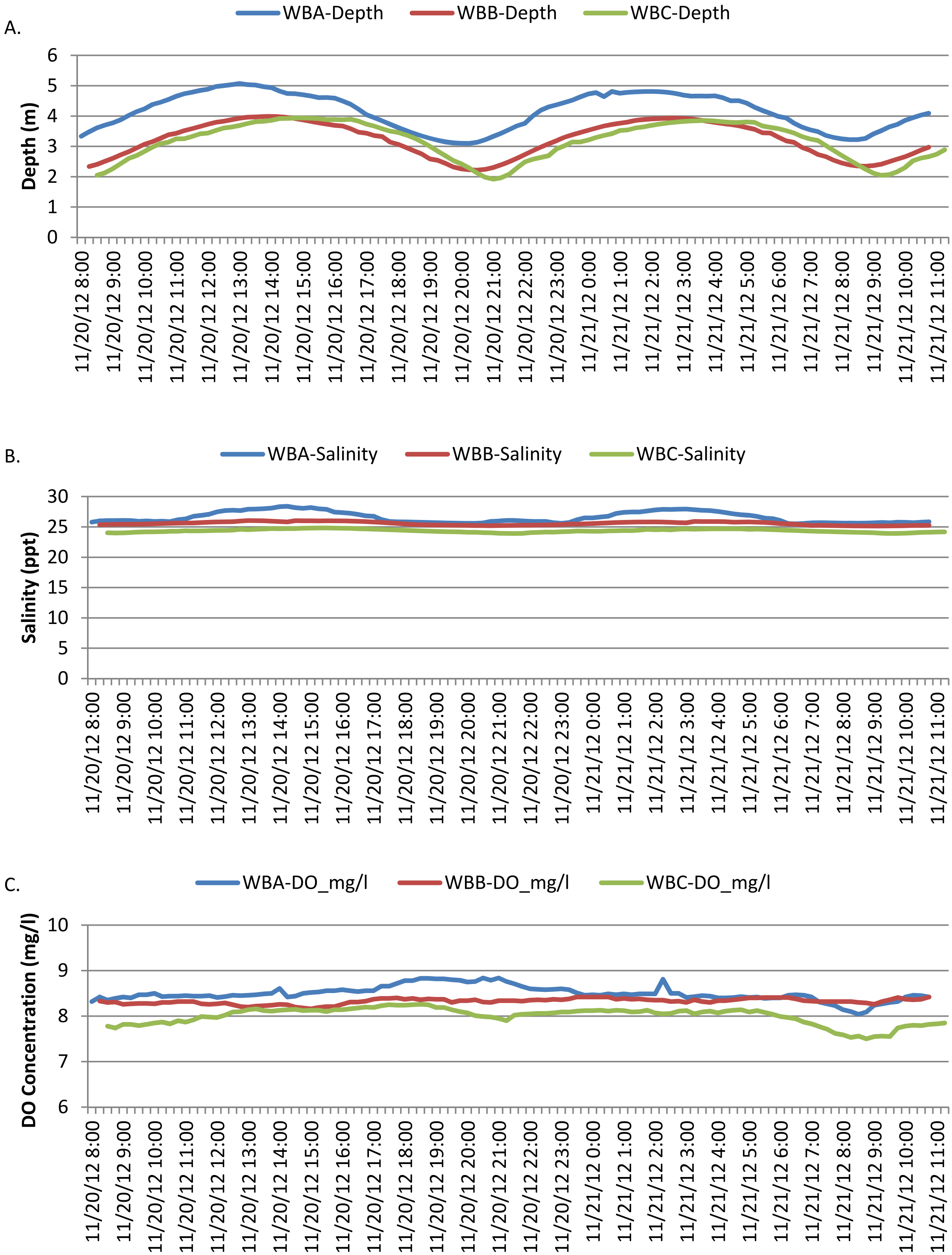


Figure 30. Semi-continuous water quality (depth, salinity, and DO concentration) for the Wando River sampling sites during the Fall of 2012.

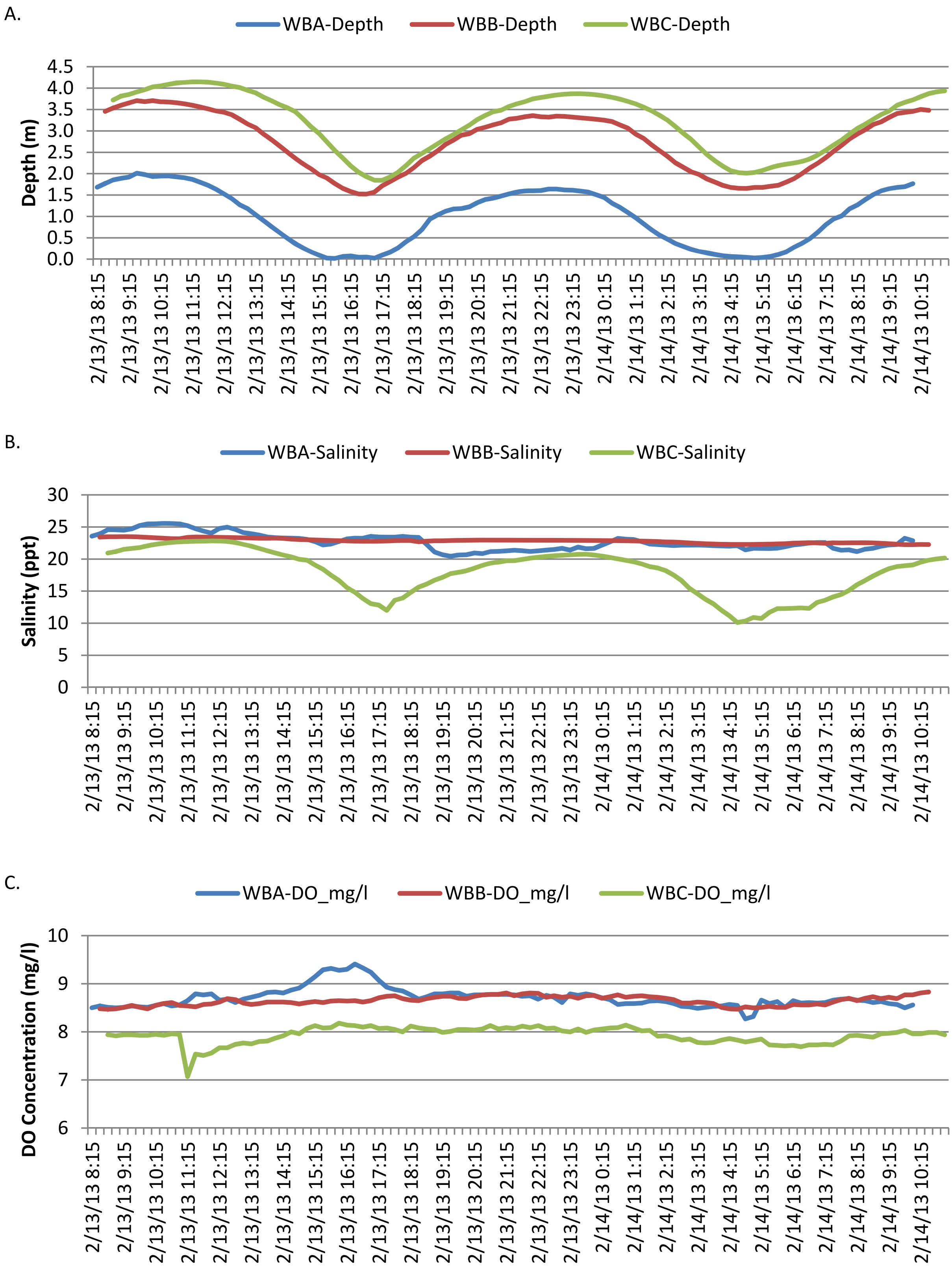


Figure 31. Semi-continuous water quality (depth, salinity, and DO concentration) for the Wando River sampling sites during the Winter of 2013.

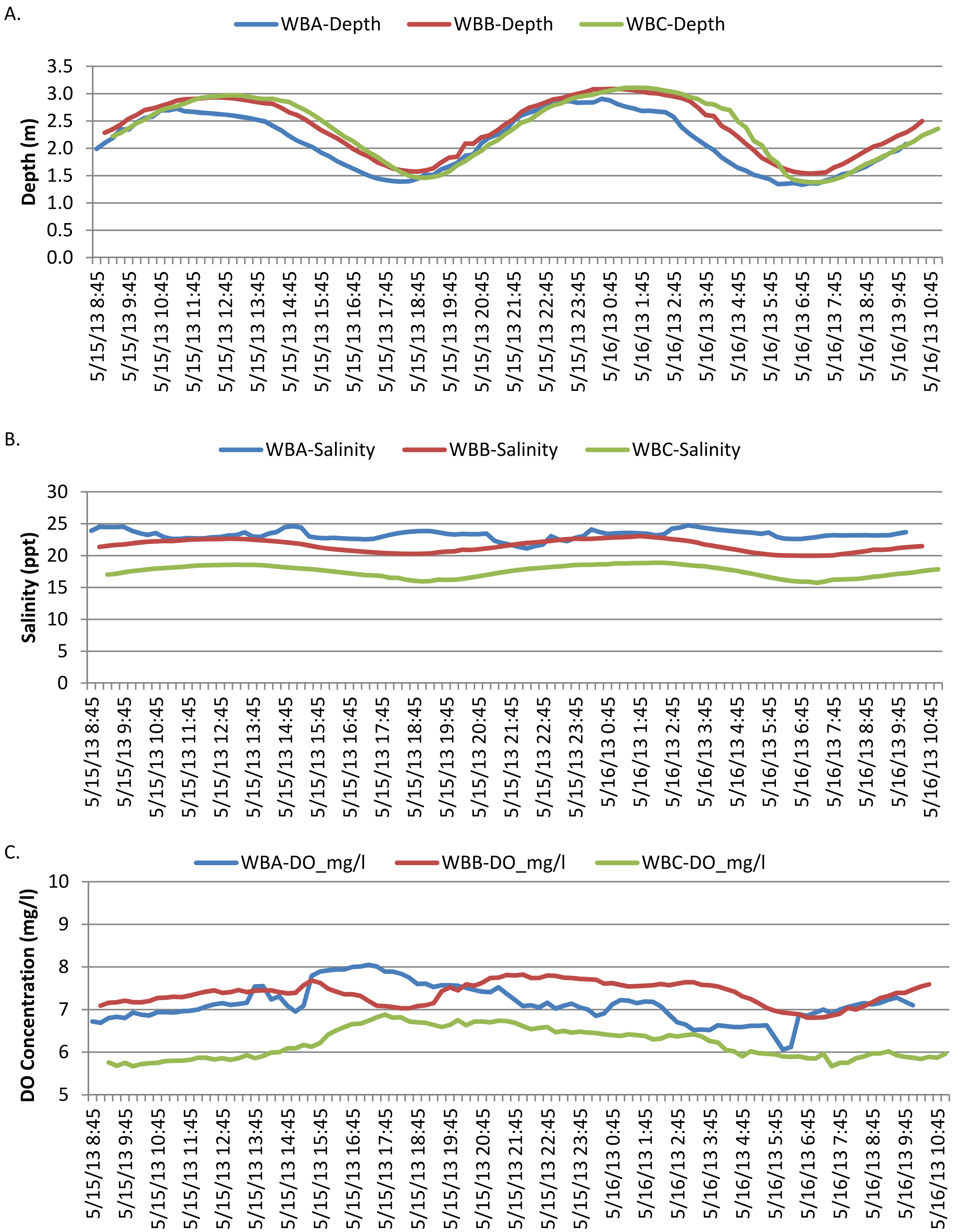
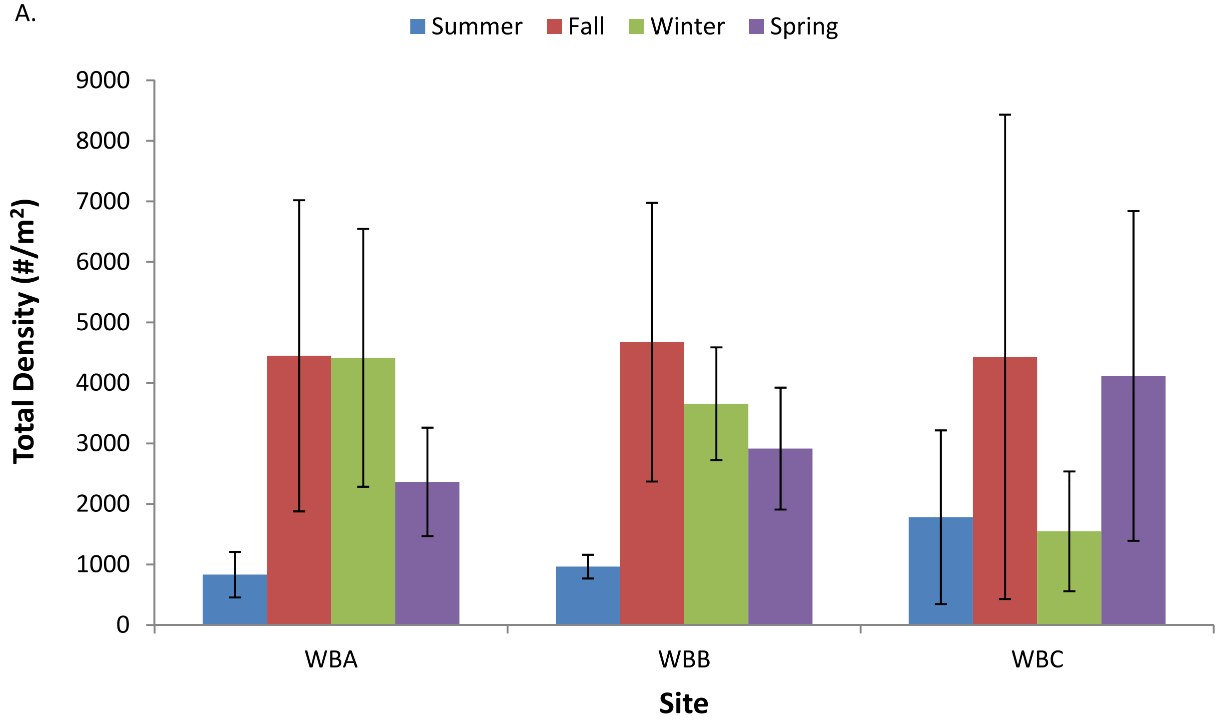


Figure 32. Semi-continuous water quality (depth, salinity, and DO concentration) for the Wando River sampling sites during the Spring of 2013.

A.



B.

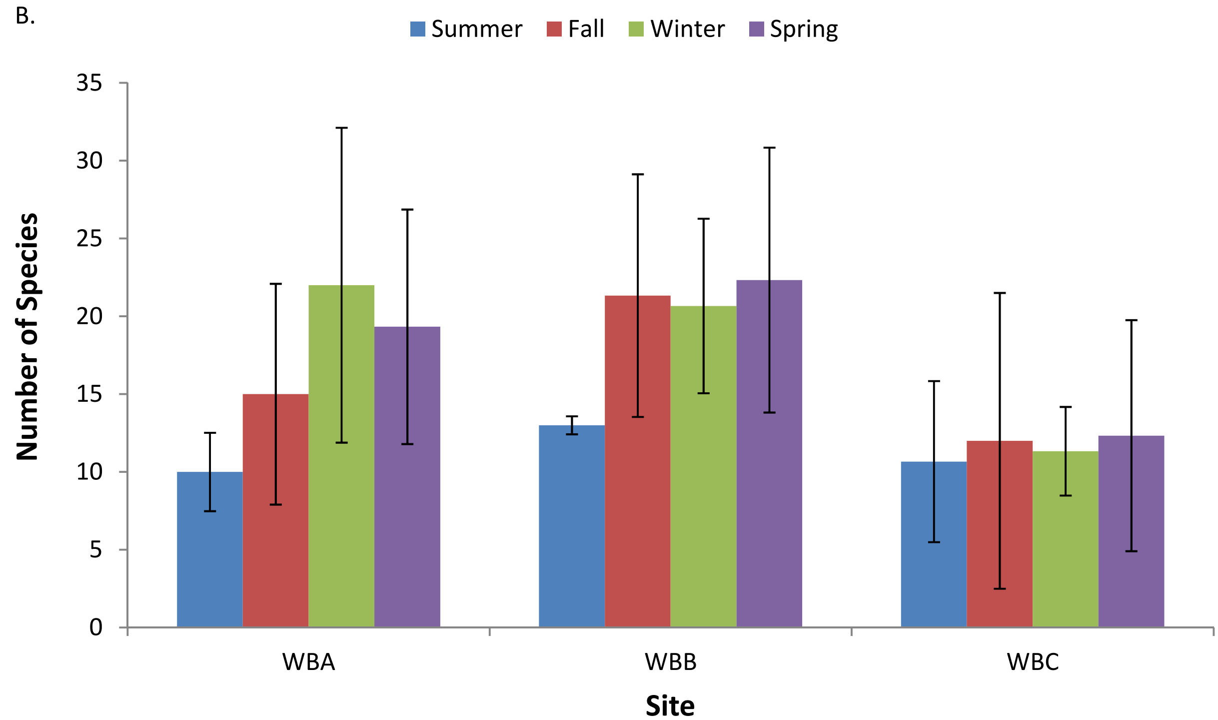


Figure 33. The average total density (A) and number of species (B) of the macrobenthic community for each site sampled in the Wando River during each season. Error bars represent ± 1 standard error.

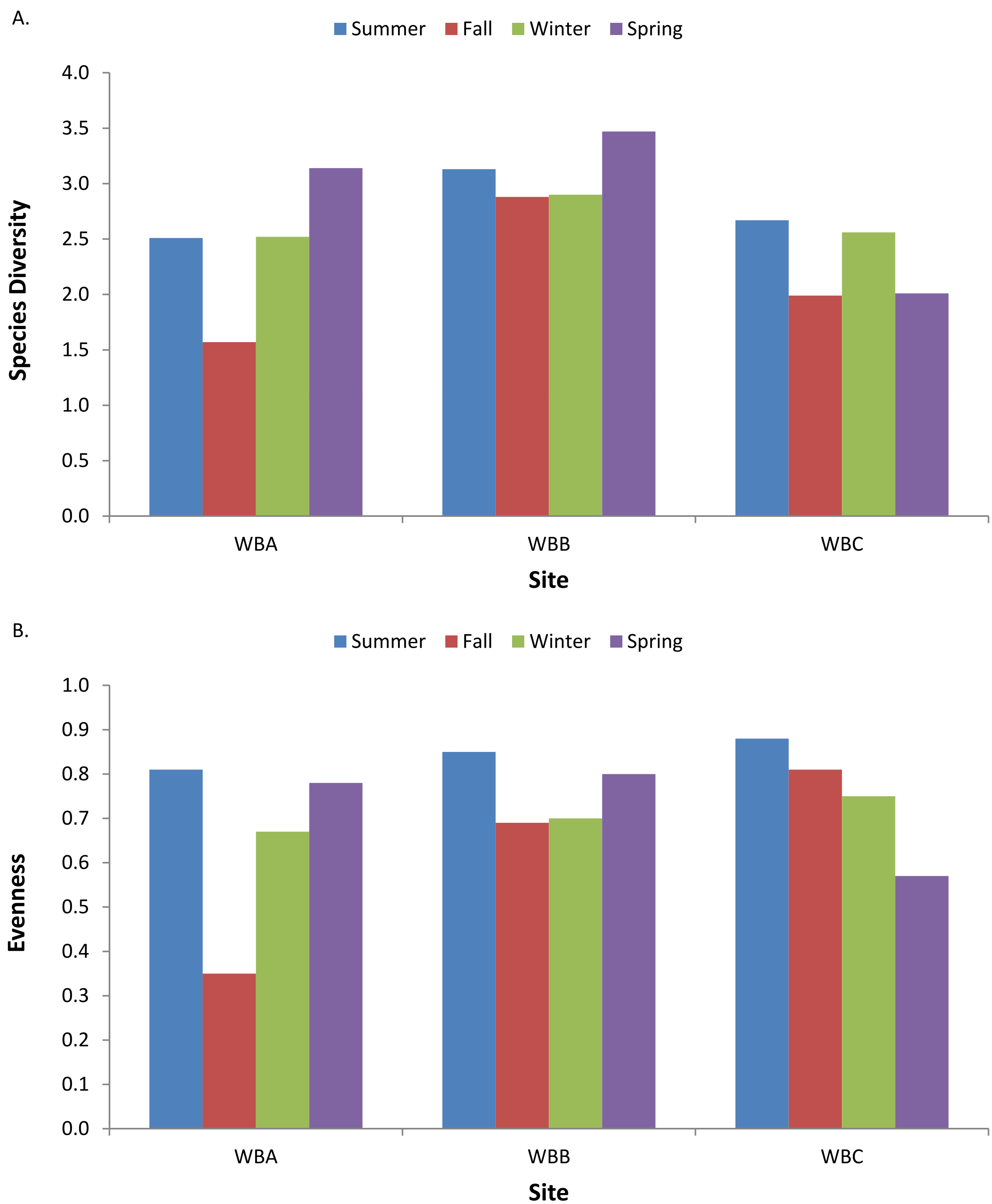


Figure 34. The species diversity (A) and evenness (B) of the macrobenthic community for each site sampled in the Wando River during each season.

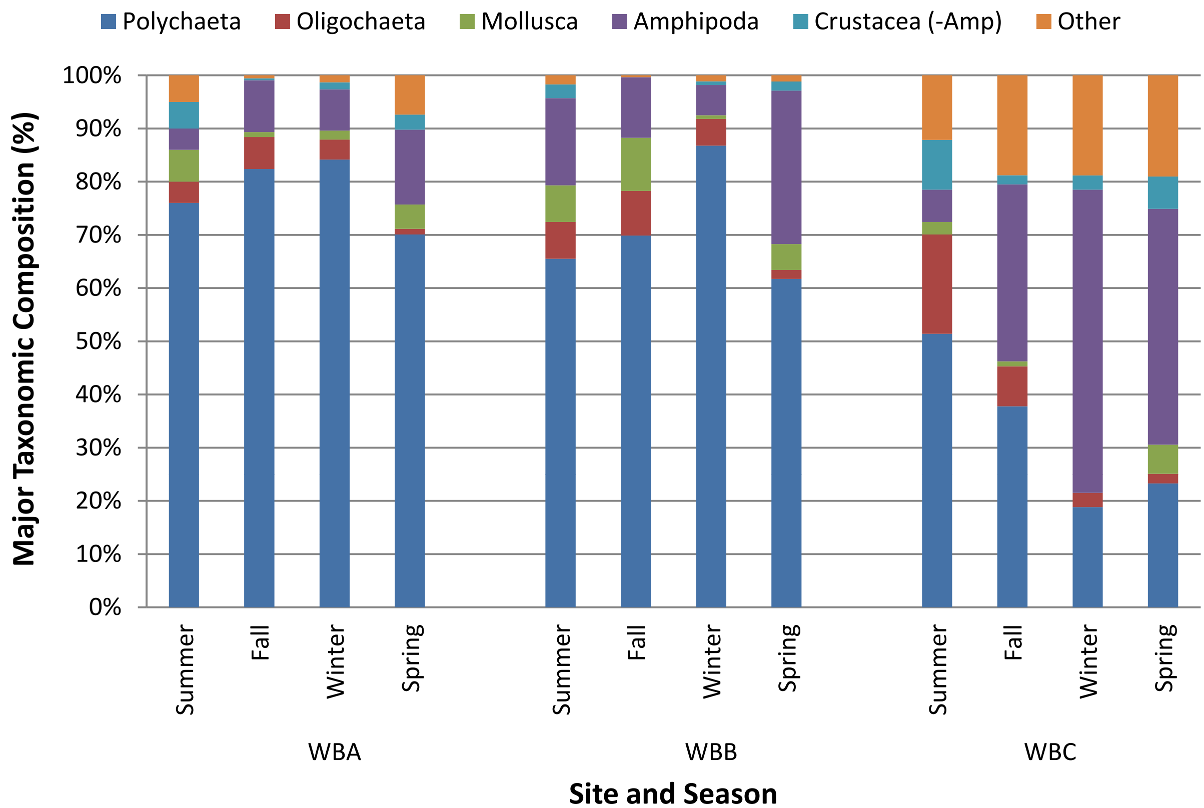


Figure 35. The major taxonomic composition of the macrobenthic community for each site sampled in the Wando River during each season.

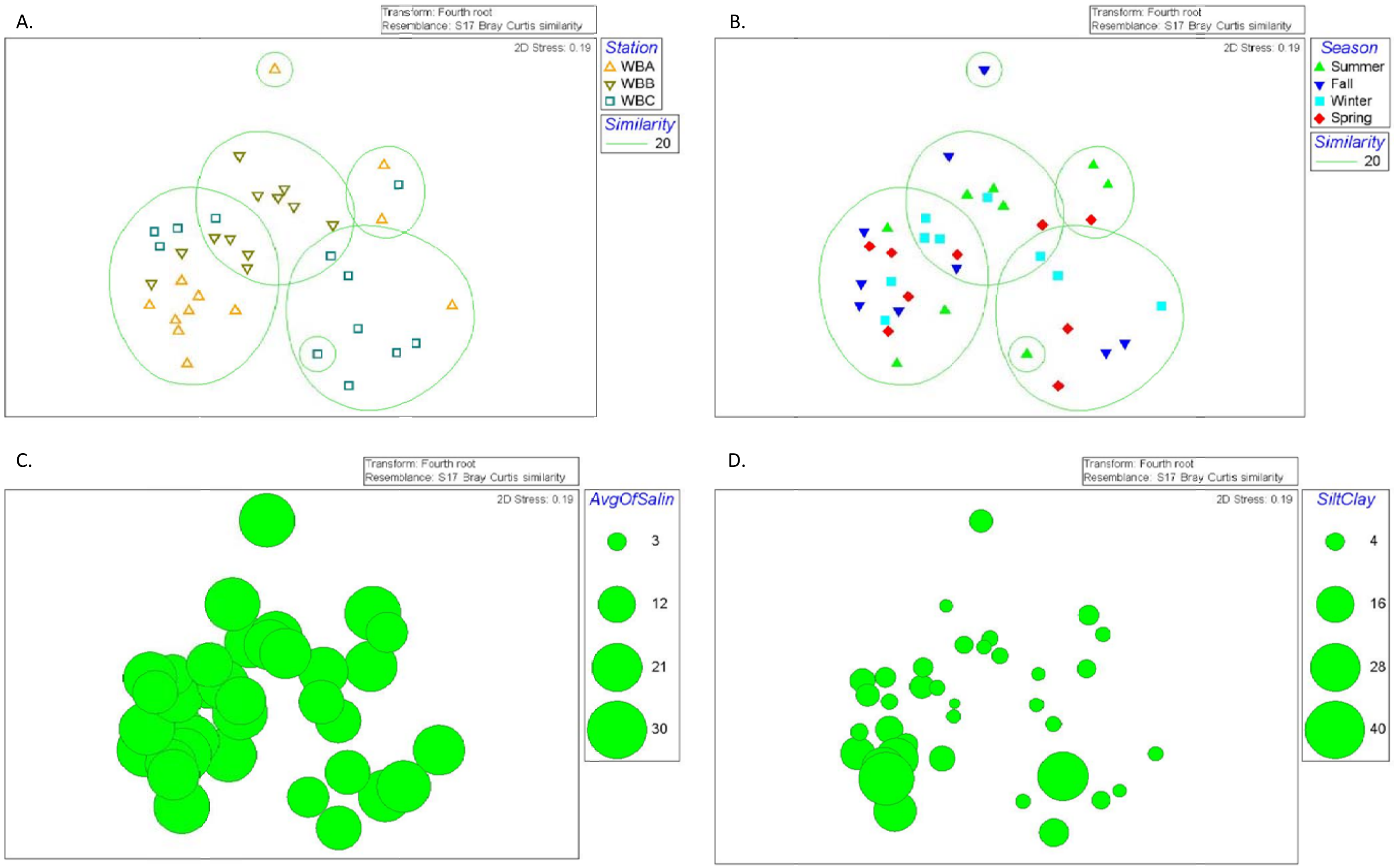


Figure 36. The MDS ordination plot of the macrobenthic community for each station sampled in the Wando River during each season. The samples are the same in all four plots but the symbols are coded differently to help identify patterns in the similarity of samples. (a) is coded by system and (B) is coded by year. The similarity groupings are based on the cluster analysis to indicate the major groupings of the sites. (C) is the average salinity (ppt) and (D) is the average silt/clay percentage for each sample.

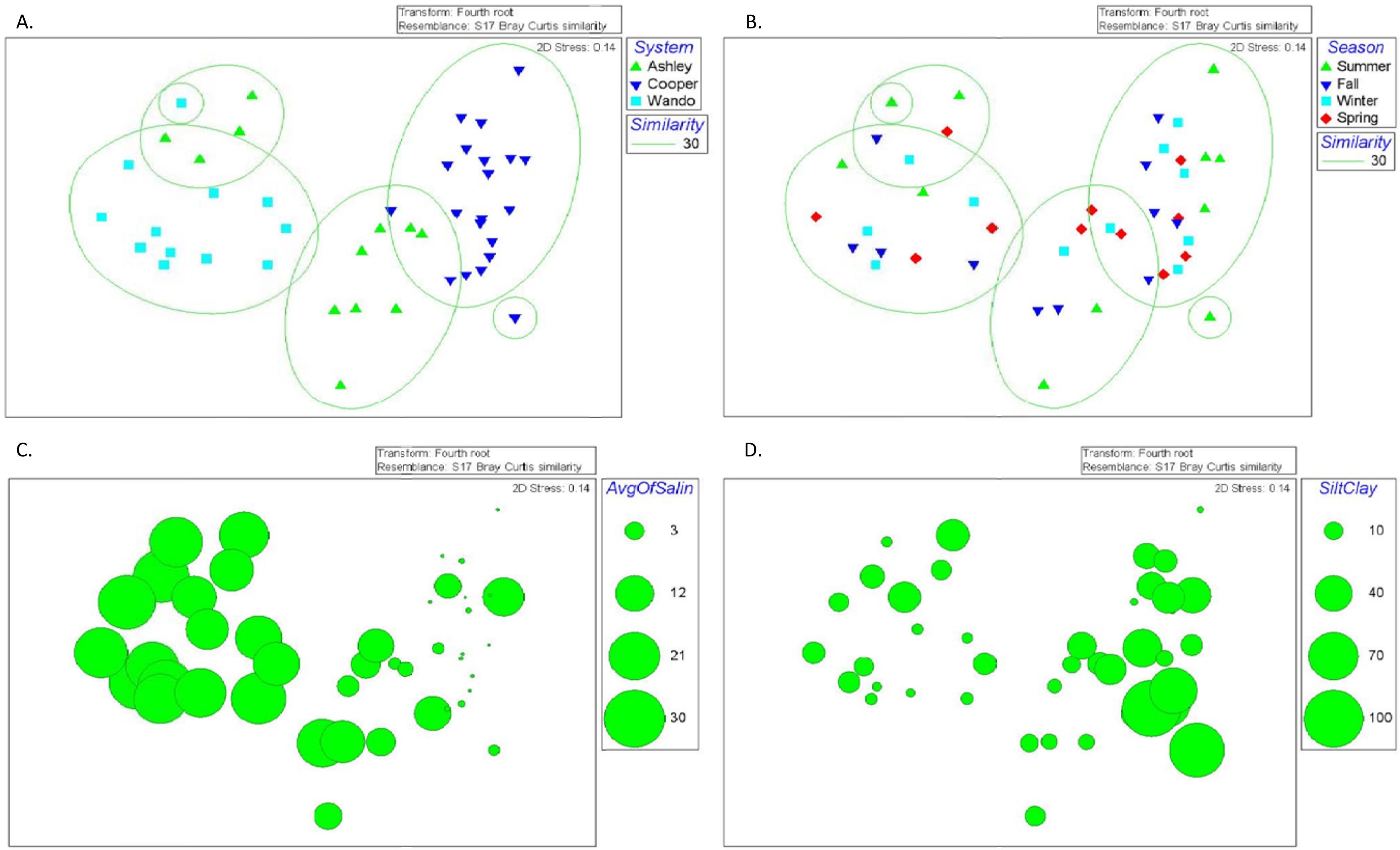


Figure 37. The MDS ordination plots of the macrobenthic community for each core site and season (sample) in all three river systems sampled for this study during each season. The samples are the same in all four plots but the symbols are coded differently to help identify patterns in the similarity of samples. (A) is coded by system and (B) is coded by year. The similarity groupings are based on the cluster analysis to indicate the major groupings of the samples. (C) is the average salinity (ppt) and (D) is the average silt/clay percentage for each sample.

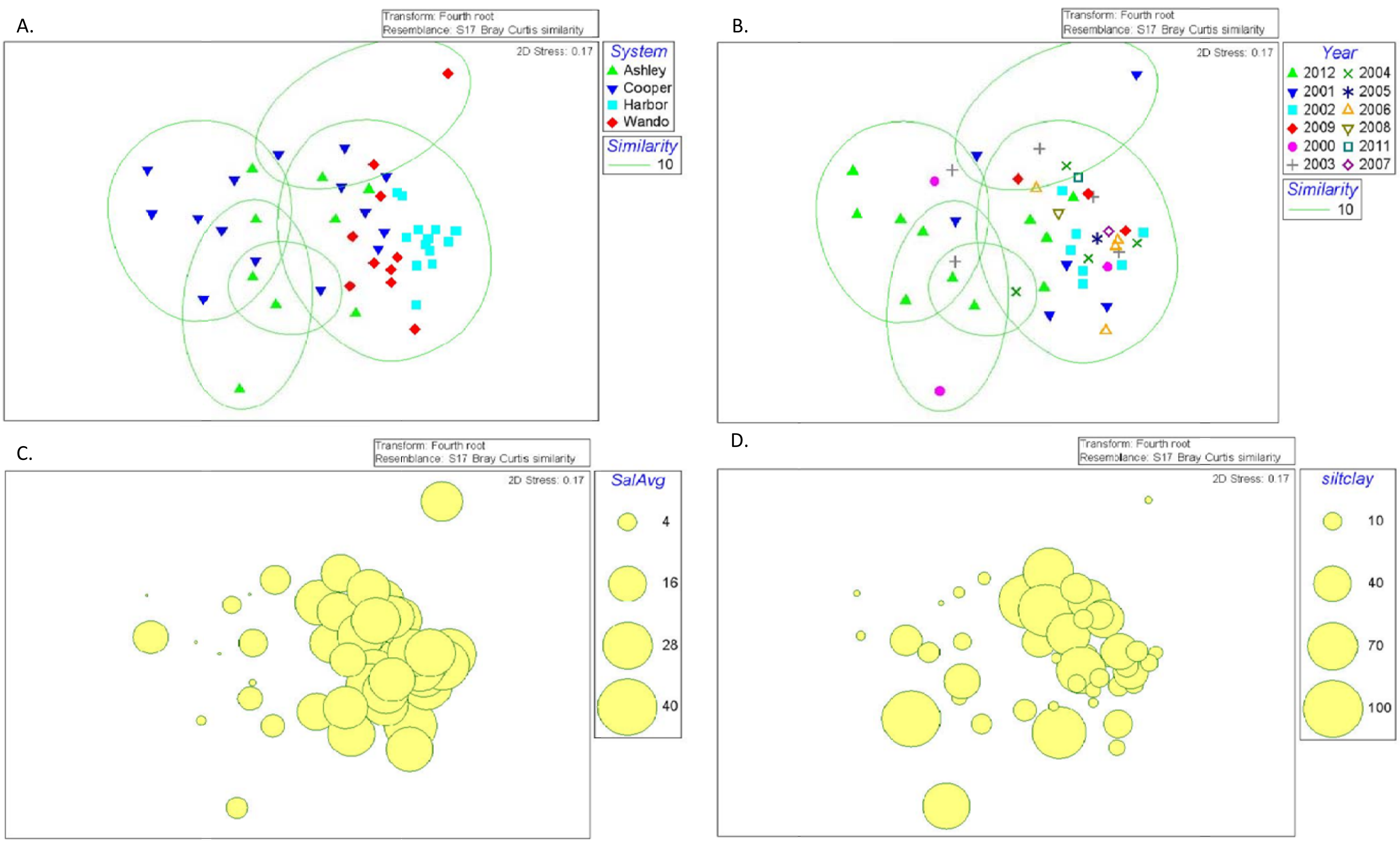


Figure 38. The MDS ordination plots of the macrobenthic community for each core site from this study in the summer and the 36 SCECAP sites in the Charleston Harbor Estuary (see Figure 3 for locations). The data (samples) are the same in all four plots but the symbols are coded differently to help identify patterns in the similarity of samples. (A) is coded by system and (B) is coded by year. The similarity groupings are based on the cluster analysis to indicate the major groupings of the sites. (C) is the average salinity (ppt) and (D) is the average silt/clay percentage for each sample.

Table 1. List of target stations for the sampling in the Ashley, Cooper, and Wando Rivers.

River System	Station	Station Type	Sample Type	Latitude	Longitude
Cooper Main Stem	CBA1	Core	Benthic, Sediment	32.96612	79.92494
	CBA2	Core	Benthic, Sediment, Water Quality	32.96698	79.92426
	CBA3	Core	Benthic, Sediment	32.96787	79.92359
	CBD1	Core	Benthic, Sediment	33.01684	79.91941
	CBD2	Core	Benthic, Sediment, Water Quality	33.01618	79.91946
	CBD3	Core	Benthic, Sediment	33.01556	79.91949
	CBG1	Core	Benthic, Sediment	33.05667	79.93253
	CBG2	Core	Benthic, Sediment, Water Quality	33.05611	79.93282
	CBG3	Core	Benthic, Sediment	33.05559	79.93313
	CSB1	Supplemental	Sediment	32.98437	79.92452
	CSB2	Supplemental	Sediment	32.98481	79.92415
	CSB3	Supplemental	Sediment	32.98524	79.92377
	CSC1	Supplemental	Sediment	32.99996	79.90558
	CSC2	Supplemental	Sediment	32.99963	79.9052
	CSC3	Supplemental	Sediment	32.99927	79.90484
	CSE1	Supplemental	Sediment	33.03231	79.91431
	CSE2	Supplemental	Sediment	33.03286	79.9138
	CSE3	Supplemental	Sediment	33.03343	79.91333
	CSF1	Supplemental	Sediment	33.04675	79.9344
	CSF2	Supplemental	Sediment	33.04694	79.93395
	CSF3	Supplemental	Sediment	33.04715	79.93351
Cooper East Branch	CBK1	Core	Benthic, Sediment	33.0642	79.90453
	CBK2	Core	Benthic, Sediment, Water Quality	33.06393	79.9044
	CBK3	Core	Benthic, Sediment	33.06366	79.90427
	CSL1	Supplemental	Benthic, Sediment	33.07497	79.87117
	CSL2	Supplemental	Sediment	33.07482	79.87122
	CSL3	Supplemental	Benthic, Sediment	33.07467	79.87128
	CSM1	Supplemental	Benthic, Sediment	33.09044	79.83601
	CSM2	Supplemental	Sediment	33.09026	79.83595
	CSM3	Supplemental	Benthic, Sediment	33.0901	79.8359
Cooper West Branch	CBH1	Core	Benthic, Sediment	33.07236	79.93188
	CBH2	Core	Benthic, Sediment, Water Quality	33.07229	79.93138
	CBH3	Core	Benthic, Sediment	33.07222	79.93087
	CSI1	Supplemental	Sediment	33.13916	79.97531
	CSI2	Supplemental	Sediment	33.1392	79.97491
	CSI3	Supplemental	Sediment	33.13926	79.97449
	CSJ1	Supplemental	Sediment	33.20507	79.97224
	CSJ2	Supplemental	Sediment	33.20515	79.972
	CSJ3	Supplemental	Sediment	33.20524	79.97176

River System	Station	Station Type	Sample Type	Latitude	Longitude
Cooper Back River	BSA1	Supplemental	Sediment	32.98951	79.94201
	BSA2	Supplemental	Sediment	32.9892	79.94156
	BSA3	Supplemental	Sediment	32.9889	79.9411
	BSB1	Supplemental	Sediment	33.02647	79.9523
	BSB2	Supplemental	Sediment	33.02657	79.95206
	BSB3	Supplemental	Sediment	33.02669	79.95181
	BSC1	Supplemental	Sediment	33.06845	79.95683
	BSC2	Supplemental	Sediment	33.06845	79.9567
	BSC3	Supplemental	Sediment	33.06846	79.95657
Ashley River	ABA1	Core	Benthic, Sediment	32.83326	79.99191
	ABA2	Core	Benthic, Sediment, Water Quality	32.83525	79.99205
	ABA3	Core	Benthic, Sediment	32.83722	79.99216
	ABB1	Core	Benthic, Sediment	32.84625	80.04428
	ABB2	Core	Benthic, Sediment, Water Quality	32.84684	80.04457
	ABB3	Core	Benthic, Sediment	32.84742	80.04483
	ABC1	Core	Benthic, Sediment	32.87306	80.07567
	ABC2	Core	Benthic, Sediment, Water Quality	32.87326	80.07558
Wando River	WBA1	Core	Benthic, Sediment	32.84289	79.89638
	WBA2	Core	Benthic, Sediment, Water Quality	32.84386	79.89332
	WBA3	Core	Benthic, Sediment	32.84486	79.89028
	WBB1	Core	Benthic, Sediment	32.88004	79.85309
	WBB2	Core	Benthic, Sediment, Water Quality	32.87886	79.85133
	WBB3	Core	Benthic, Sediment	32.87762	79.84988
	WBC1	Core	Benthic, Sediment	32.91482	79.75186
	WBC2	Core	Benthic, Sediment, Water Quality	32.91454	79.75207
	WBC3	Core	Benthic, Sediment	32.91425	79.75225

Table 2. The average sediment composition for each core and supplemental site sampled during the Summer of 2012. The sand size fractions were obtained from the sand component.

Site	Silt (%)	Clay (%)	Sand (%)	Sand Fraction >2 mm (%)	Sand Fraction 0.25-2 mm (%)	Sand Fraction 0.063-0.25 mm (%)
CBA	0.4	2.4	97.2	0.1	10.7	86.5
CSB	6.1	8.8	85.0	2.1	60.4	22.6
CSC	2.2	3.7	94.1	7.3	53.9	33.0
CBD	28.5	58.7	12.8	0.3	2.8	9.7
CSE	11.8	17.1	71.1	6.3	11.8	53.0
CSF	23.0	39.5	37.5	0.2	3.5	33.8
CBG	13.6	25.5	60.9	1.7	29.3	29.9
CBH	0.5	0.7	98.8	22.3	68.1	8.5
CSI	11.6	27.0	61.5	19.0	19.5	23.0
CSJ	21.5	22.8	55.8	5.7	26.1	24.0
CBK	4.5	8.7	86.7	11.0	23.2	52.5
CSL	8.5	14.8	76.7	3.8	21.4	51.5
CSM	8.4	16.1	75.6	3.9	25.4	46.3
BSA	39.3	54.4	6.3	0.2	3.8	2.3
BSB	1.0	2.3	96.8	0.0	12.0	84.8
BSC	15.7	52.1	32.3	2.1	12.6	17.6
ABA	12.1	19.3	68.6	1.6	45.0	22.1
ABB	3.4	8.4	88.2	9.0	31.9	47.3
ABC	1.9	5.1	93.0	57.9	27.2	7.9
WBA	3.2	7.8	89.0	0.3	13.9	74.8
WBB	0.3	2.9	96.8	3.9	38.5	54.5
WBC	0.4	2.9	96.7	5.1	50.8	40.7

Table 3. The average sediment composition for each core site sampled by each season for the Cooper River. The sand size fractions were obtained from the sand component.

Site	Season	Silt (%)	Clay (%)	Sand (%)	Sand Fraction >2 mm (%)	Sand Fraction 0.25-2 mm (%)	Sand Fraction 0.063-0.25 mm (%)
CBA	Summer	0.4	2.4	97.2	0.1	10.7	86.5
	Fall	9.7	18.6	71.7	0.4	8.5	62.8
	Winter	8.1	15.7	76.2	0.1	10.7	65.4
	Spring	7.4	16.0	76.6	0.0	9.4	67.2
CBD	Summer	28.5	58.7	12.8	0.3	2.8	9.7
	Fall	15.4	28.7	55.9	10.7	15.2	30.0
	Winter	19.2	52.6	28.2	0.0	4.1	24.0
	Spring	22.5	75.1	2.4	0.0	0.6	1.9
CBG	Summer	13.6	25.5	60.9	1.7	29.3	29.9
	Fall	7.3	12.2	80.4	0.3	60.2	19.9
	Winter	4.8	10.4	84.8	0.0	62.4	22.4
	Spring	0.2	1.0	98.8	22.4	53.3	23.1
CBH	Summer	0.5	0.7	98.8	22.3	68.1	8.5
	Fall	0.3	1.2	98.6	3.8	66.4	28.4
	Winter	0.6	0.8	98.6	0.6	72.3	25.8
	Spring	8.7	21.4	69.9	0.7	62.5	6.7
CBK	Summer	4.5	8.7	86.7	11.0	23.2	52.5
	Fall	3.0	4.9	92.1	29.8	37.6	24.7
	Winter	2.3	5.9	91.8	23.4	22.5	45.9
	Spring	17.9	46.0	36.1	0.2	24.4	11.4

Table 4. The average, maximum, and minimum [avg (max, min)] for each semi-continuous water quality deployment collected over a 25 hour period in the Cooper River during the four seasons. * Logger was not recovered.

Site	Season	Collection Number	Temperature (°C)	pH	Sp. Cond. (mS/cm)	Salinity (ppt)	DO (% sat)	DO (mg/l)	Depth (m)
CBA	Summer	20122065	28.32 (28.6, 28.04)	7.53 (7.67, 7.38)	22.76 (32.61, 9.24)	13.75 (20.29, 5.14)	64.7 (71.1, 58.3)	4.67 (5.32, 4.05)	3.33 (3.99, 2.56)
CBA	Fall	20122198	14.2 (14.27, 14.1)	7.61 (7.72, 7.38)	18.35 (25.25, 6.57)	10.98 (15.43, 3.61)	88.93 (90.4, 87.3)	8.53 (9.08, 8.17)	5.61 (6.17, 4.41)
CBA	Winter	20132044	13.33 (13.54, 13.07)	7.44 (7.67, 7.23)	9.85 (22.25, 1.49)	5.72 (13.44, 0.75)	93.48 (95.2, 91.8)	9.44 (9.88, 8.85)	5.21 (6.19, 4.33)
CBA	Spring	20132121	21.97 (22.65, 21.41)	7.39 (7.58, 7.18)	17.8 (28.73, 4.64)	10.64 (17.76, 2.48)	80.26 (82.6, 77.5)	6.6 (7.03, 6.21)	5.14 (5.88, 4.32)
CBD	Summer	20122086	28.11 (28.7, 27.67)	7.39 (7.47, 7.28)	1.94 (11.20, 0.31)	1.04 (6.33, 0.15)	75.72 (83.9, 65.7)	5.89 (6.59, 4.9)	9.74 (10.34, 9.04)
CBD	Fall	20122205	13.73 (14.09, 13.22)	7.39 (7.58, 7.32)	2.15 (9.18, 0.80)	1.13 (5.17, 0.4)	89.5 (90.5, 87.9)	9.22 (9.33, 8.89)	12.4 (13.12, 11.64)
CBD	Winter	20132051	13.39 (13.67, 13.0)	7.32 (8.02, 7.25)	0.71 (1.73, 0.31)	0.35 (0.88, 0.15)	89.49 (91.8, 88.4)	9.33 (9.61, 9.19)	7.76 (9.76, 4.22)
CBD	Spring	20132128	22.66 (23.01, 22.07)	7.13 (7.19, 7.09)	0.51 (3.74, 0.2)	0.25 (1.97, 0.09)	84.92 (88.7, 80.2)	7.32 (7.7, 6.85)	9.03 (9.66, 8.36)
CBG	Summer	20122107	27.47 (28.16, 27.01)	7.3 (7.57, 7.1)	0.23 (0.47, 0.13)	0.11 (0.22, 0.06)	87.22 (93.5, 82.2)	6.89 (7.44, 6.53)	9.25 (9.83, 8.54)
CBG	Fall	2012*							
CBG	Winter	20132058	13.03 (13.36, 12.61)	7.22 (7.48, 7.13)	0.45 (0.70, 0.29)	0.22 (0.34, 0.14)	93.86 (96.7, 90.6)	9.87 (10.22, 9.62)	8.22 (9.82, 6.90)
CBG	Spring	20132135	22.02 (22.69, 21.27)	7.2 (7.37, 7.1)	0.17 (0.24, 0.12)	0.08 (0.11, 0.06)	88.14 (98.8, 80.3)	7.7 (8.66, 7.01)	4.29 (4.93, 3.64)
CBH	Summer	20122114	27.29 (27.72, 26.93)	7.43 (7.72, 7.24)	0.14 (0.22, 0.13)	0.07 (0.1, 0.06)	89.76 (98.6, 82.7)	7.11 (7.77, 6.55)	5.14 (5.48, 4.80)
CBH	Fall	20122219	13.09 (13.28, 12.86)	7.25 (7.52, 7.13)	0.19 (0.42, 0.13)	0.09 (0.2, 0.06)	94.29 (97.7, 89.9)	9.91 (10.25, 9.49)	5.13 (5.52, 4.79)
CBH	Winter	20132065	12.37 (12.74, 12.0)	7.23 (7.59, 7.17)	0.51 (0.67, 0.47)	0.25 (0.33, 0.23)	94.88 (98.3, 92.1)	10.12 (10.52, 9.8)	5.19 (5.59, 4.72)
CBH	Spring	20132142	21.58 (20.72, 22.02)	7.13 (7.46, 6.88)	0.12 (0.16, 0.11)	0.06 (0.07, 0.05)	92.92 (105.3, 80.8)	8.19 (9.2, 7.15)	4.36 (4.83, 3.81)
CBK	Summer	20122135	27.12 (27.75, 26.51)	7.13 (7.39, 6.84)	0.15 (0.22, 0.13)	0.07 (0.1, 0.06)	71.56 (85.9, 49.9)	5.68 (6.77, 3.97)	8.19 (8.60, 7.55)
CBK	Fall	20122226	13 (13.28, 12.63)	7.13 (7.3, 6.93)	0.23 (0.44, 0.16)	0.11 (0.21, 0.08)	88.01 (93.7, 79.7)	9.27 (9.84, 8.44)	8.06 (8.48, 7.58)
CBK	Winter	20132072	13.18 (14.19, 12.56)	7.06 (7.22, 6.88)	0.2 (0.35, 0.15)	0.09 (0.17, 0.07)	89.96 (95.3, 77)	9.44 (10.08, 8.04)	7.55 (8.08, 6.61)
CBK	Spring	20132149	21.9 (22.83, 21.04)	6.8 (7.54, 6.32)	0.15 (0.19, 0.14)	0.07 (0.09, 0.06)	83.23 (99.2, 58.9)	7.29 (8.66, 5.16)	6.76 (7.50, 4.60)

Table 5. Macrobenthic community data for each core site (average of 2-3 station replicates) in the Cooper River during each season.

Species Name	% of stns where present	% of total by species	CBA Summer	CBA Fall	CBA Winter	CBA Spring	CBD Summer	CBD Fall	CBD Winter	CBD Spring	CBG Summer	CBG Fall	CBG Winter	CBG Spring	CBH Summer	CBH Fall	CBH Winter	CBH Spring	CBK Summer	CBK Fall	CBK Winter	CBK Spring
Number of Species			**2.5**	**4**	**4.5**	**7.7**	**6.5**	**7**	**9**	**8**	**4.5**	**3.5**	**4**	**6**	**2**	**4**	**5.3**	**6**	**7.3**	**5**	**7.7**	**9**
Total Density (avg of 2-3 reps)			**337**	**812**	**2525**	**6824**	**650**	**2000**	**38616**	**4700**	**950**	**312**	**762**	**6074**	**225**	**399**	**758**	**1283**	**2349**	**1933**	**6958**	**4516**
Gammarus tigrinus	95	20.73	12.5	462.5	12.5	8.33	37.5	337.5	1900	37.5	12.5	37.5	12.5	3008.33	0	16.66	275	408.33	1258.33	1066.66	5833.33	2466.66
Scolecolepides viridis	90	9.54	25	100	2112.5	608.33	0	37.5	2425	25	50	0	275	1050	50	75	191.66	116.66	91.66	83.33	233.33	366.66
Chiridotea almyra	75	1.43	0	0	137.5	41.66	12.5	50	25	0	12.5	62.5	150	408.33	0	25	66.66	125	25	25	16.66	0
Lepidactylus dytiscus	65	3.16	262.5	0	225	175	0	250	0	0	612.5	175	300	141.66	175	91.66	75	116.66	25	0	0	0
Tubificidae	65	4.79	0	0	0	83.33	0	137.5	1275	287.5	12.5	0	0	341.66	0	150	50	333.33	241.66	600	150	316.66
Cyathura burbancki	60	3.42	0	25	0	16.66	0	137.5	466.66	450	0	12.5	0	825	0	16.66	25	0	0	125	266.66	475
Corophium lacustre	55	47.69	25	162.5	12.5	3966.66	75	962.5	31258	3037.5	0	0	0	41.66	0	0	0	0	0	0	8.33	25
Axarus sp.	50	3.52	12.5	0	0	8.33	262.5	0	783.33	525	187.5	0	0	0	0	0	0	16.66	175	0	225	725
Rhithropanopeus harrisii	50	0.37	0	0	0	0	12.5	12.5	100	50	37.5	0	0	25	0	0	0	0	8.33	8.33	16.66	33.33
Nemertea	25	0.09	0	0	0	8.33	0	0	0	0	0	12.5	25	0	0	8.33	0	16.66	0	0	0	0
Pelecypoda	25	0.10	0	0	0	0	0	0	16.66	12.5	0	0	0	0	0	0	25	0	16.66	0	8.33	0
Polydora socialis	25	0.59	0	37.5	0	75	75	0	50	250	0	0	0	0	0	0	0	0	0	0	0	0
Cassidinidea lunifrons	20	0.10	0	0	0	0	0	0	0	12.5	0	0	0	16.66	0	0	0	0	33.33	16.66	0	0
Chironomidae	20	0.26	0	0	0	0	0	0	16.66	0	0	0	0	183.33	0	0	8.33	8.33	0	0	0	0
Melita nitida	20	0.17	0	0	0	0	0	0	108.33	12.5	0	0	0	8.33	0	0	0	0	0	0	0	8.33
Monoculodes edwardsi	20	0.05	0	0	12.5	8.33	0	0	0	0	0	0	0	0	0	8.33	0	0	0	0	0	8.33
Tubificoides brownae	20	0.05	0	0	0	0	0	12.5	0	0	0	0	0	0	0	0	0	0	8.33	8.33	8.33	0
Corbicula fluminea	15	0.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33.33	0	0	75	58.33
Cyathura polita	10	0.12	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	75	0	0	0
Gastropoda	10	0.04	0	0	0	0	0	0	0	0	0	12.5	0	0	0	0	0	0	0	0	16.66	0
Hyalla azteca	10	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33	0	50	0	0	0	0
Leitoscoloplos fragilis	10	0.03	0	0	12.5	8.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nereis succinea	10	0.47	0	25	0	366.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paranais litoralis	10	0.13	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	8.33	0	0	0
Aligena elevata	5	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33	0	0	0
Ceratopogonidae	5	0.02	0	0	0	0	0	0	0	0	12.5	0	0	0	0	0	0	0	0	0	0	0
Dasyhelea sp.	5	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0
Edotia triloba	5	0.01	0	0	0	8.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammarus sp.	5	0.02	0	0	0	0	0	0	0	0	12.5	0	0	0	0	0	0	0	0	0	0	0
Hargeria rapax	5	1.63	0	0	0	1350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hirudinea	5	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33	0	0	0	0
Isopoda	5	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.66

Species Name	% of stns where present	% of total by species	CBA Summer	CBA Fall	CBA Winter	CBA Spring	CBD Summer	CBD Fall	CBD Winter	CBD Spring	CBG Summer	CBG Fall	CBG Winter	CBG Spring	CBH Summer	CBH Fall	CBH Winter	CBH Spring	CBK Summer	CBK Fall	CBK Winter	CBK Spring
Jasminiera sp.	5	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0
Melita sp.	5	0.02	0	0	0	0	0	12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melitidae	5	0.01	0	0	0	0	0	0	8.33	0	0	0	0	0	0	0	0	0	0	0	0	0
Monopylephorus irroratus	5	0.43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	358.33	0	0	0
Musculium sp.	5	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.66	0
Mytilopsis leucophaeata	5	0.22	0	0	0	0	0	0	183.33	0	0	0	0	0	0	0	0	0	0	0	0	0
Parandalia sp.	5	0.08	0	0	0	66.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelecorhynchidae	5	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33
Platyhelminthes	5	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.66	0	0	0	0
Protohaustorius sp.	5	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.66	0	0	0
Rangia cuneata	5	0.06	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sabellidae	5	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33
Scolelepis sp.	5	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58.33	0
Seira sp.	5	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33	0	0	0	0
Simuliidae	5	0.02	0	0	0	0	12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Streblospio benedicti	5	0.03	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tipulidae	5	0.03	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0
Tubificoides heterochaetus	5	0.05	0	0	0	0	37.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vitrinellidae	5	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41.66	0	0	0	0	0

Table 6. A comparison of the two Cooper River sites sampled for the 1980s Charleston Harbor Characterization Study (Van Dolah et al. 1990) and this study.

Site Names	Species Name CHCS	CHCS Rank	Species Name This Study	This Study Rank
CR03/CBA	*Lepidactylus dytiscus*	1	*Lepidactylus dytiscus*	4
CR03/CBA	*Scolecolepides viridis*	2	*Scolecolepides viridis*	2
CR03/CBA	*Chiridotea almyra*	3	*Chiridotea almyra*	7
CR03/CBA	*Chiridotea stenops*	4		
CR03/CBA	*Monoculodes* sp.	5	*Monoculodes edwardsi*	14
CR03/CBA	Haustoriidae	6		
CR03/CBA	Nemertea	7	Nemertea	16
CR03/CBA	*Melita nitida*	8		
CR03/CBA	*Gammarus tigrinus*	9	*Gammarus tigrinus*	5
CR03/CBA	*Chiridotea* sp.	10		
CR03/CBA	*Heteromastus filiformis*	10		
CR03/CBA	*Corophium lacustre*	12	*Corophium lacustre*	1
CR03/CBA	*Cyathura polita*	13	*Cyathura burbancki*	11
CR03/CBA	*Cyclaspis varians*	18		
CR03/CBA	*Eteone heteropoda*	18		
CR03/CBA	Mysida	18		
CR03/CBA	*Neomysis americana*	18		
CR03/CBA	*Nephtys simoni*	18		
CR03/CBA	*Nereis succinea*	18	*Nereis succinea*	6
CR03/CBA	Pelecypoda	18		
CR03/CBA	Spionidae	18		
CR03/CBA	*Streblospio benedicti*	18	*Streblospio benedicti*	12
CR03/CBA			*Hargeria rapax*	3
CR03/CBA			*Polydora socialis*	8
CR03/CBA			Tubificidae	9
CR03/CBA			*Parandalia* sp.	10
CR03/CBA			*Axarus* sp.	14
CR03/CBA			*Leitoscoloplos fragilis*	14
CR03/CBA			*Edotia triloba*	16
CR04/CBG	*Chiridotea almyra*	1	*Chiridotea almyra*	5
CR04/CBG	*Gammarus tigrinus*	2	*Gammarus tigrinus*	1
CR04/CBG	*Lepidactylus dytiscus*	3	*Lepidactylus dytiscus*	3
CR04/CBG	*Melita nitida*	4	*Melita nitida*	17
CR04/CBG	*Scolecolepides viridis*	5	*Scolecolepides viridis*	2
CR04/CBG	*Cyathura polita*	6		
CR04/CBG	Chironomidae	7	Chironomidae	8
CR04/CBG	*Chiridotea stenops*	8		
CR04/CBG	Vitrinellidae	9		
CR04/CBG	Ceratopogonidae	10	Ceratopogonidae	15
CR04/CBG	*Monoculodes* sp.	11		
CR04/CBG	*Protohaustorius deichmannae*	12		
CR04/CBG	Oligochaeta	13	Tubificidae	6
CR04/CBG	*Corbicula manilensis*	14		
CR04/CBG	*Odostomia* sp.	14		
CR04/CBG	*Cyathura burbancki*	17	*Cyathura burbancki*	4
CR04/CBG	Gastropoda	17	Gastropoda	15
CR04/CBG	*Rhithropanopeus harrisii*	17	*Rhithropanopeus harrisii*	9
CR04/CBG	*Mulinia lateralis*	21.5		
CR04/CBG	*Musculus* sp.	21.5		
CR04/CBG	Ostracoda	21.5		
CR04/CBG	Pelecypoda	21.5		
CR04/CBG	*Polydora* sp.	21.5		
CR04/CBG	Syllidae	21.5		
CR04/CBG			*Axarus* sp.	7
CR04/CBG			*Corophium lacustre*	10
CR04/CBG			Nemertea	11
CR04/CBG			Tipulidae	12
CR04/CBG			*Cassidinidea lunifrons*	13
CR04/CBG			*Gammarus* sp.	15

Table 7. The average sediment composition for each site sampled by each season for the Ashley River. The sand size fractions were obtained from the sand component.

Site	Season	Silt (%)	Clay (%)	Sand (%)		Sand Fraction >2 mm (%)	Sand Fraction 0.25-2 mm (%)	Sand Fraction 0.063-0.25 mm (%)
ABA	Summer	12.1	19.3	68.6		1.6	45.0	22.1
	Fall	5.9	10.7	83.4		2.7	36.7	44.1
	Winter	10.2	19.3	70.5		1.1	43.1	26.3
	Spring	3.6	8.1	88.3		0.4	50.6	37.3
ABB	Summer	3.4	8.4	88.2		9.0	31.9	47.3
	Fall	2.9	6.9	90.3		4.5	19.6	66.2
	Winter	1.5	4.4	94.1		14.5	36.4	43.2
	Spring	1.9	6.8	91.3		14.4	18.0	58.8
ABC	Summer	1.9	5.1	93.0		57.9	27.2	7.9
	Fall	1.4	5.9	92.7		40.6	36.6	15.5
	Winter	5.3	11.5	83.2		21.0	49.2	13.0
	Spring	6.8	22.4	70.9		23.2	38.5	9.3

Table 8. The average, maximum, and minimum [avg (max, min)] for each semi-continuous water quality deployment collected in the Ashley River over a 25 hour period during the four seasons. *indicates equipment malfunction.

Site	Season	Collection Number	Temperature (°C)	pH	Sp. Cond. (mS/cm)	Salinity (ppt)	DO (% sat)	DO (mg/l)	Depth (m)
ABA	Summer	20122002	27.11 (27.77, 26.43)	7.42 (7.57, 7.27)	32.16 (36.13, 25.16)	20.02 (22.75, 15.27)	64.98 (76.6, 52.6)	4.62 (5.57, 3.78)	2.9 (3.60, 1.80)
ABA	Fall	20122156	13.24 (13.52, 12.75)	7.66 (7.75, 7.52)	39.81 (42.22, 36.45)	25.41 (27.12, 23.05)	92.4 (94.9, 88.6)	8.27 (8.4, 8.07)	3.4 (4.16, 2.43)
ABA	Winter	20132002	14.23 (14.63, 13.84)	7.53 (7.63, 7.35)	26.64 (36.25, 11.03)	16.46 (22.92, 6.29)	90.72 (93.7, 85.9)	8.41 (8.83, 8.1)	2.05 (3.04, 1.02)
ABA	Spring	20132079	22.68 (24.19, 21.74)	7.44 (7.56, 7.28)	26.11 (30.39, 18.51)	16 (18.87, 10.98)	80.62 (89.5, 73.1)	6.34 (6.89, 5.8)	1.69 (2.44, 0.93)
ABB	Summer	*							
ABB	Fall	20122163	13.05 (13.32, 12.72)	7.41 (7.51, 7.19)	33.13 (38.94, 20.01)	20.78 (24.8, 11.97)	88.7 (91.9, 81.7)	8.2 (8.61, 7.38)	6.89 (7.69, 5.76)
ABB	Winter	20132009	13.93 (14.24, 13.4)	7.34 (7.46, 7.21)	6.9 (20.22, 1.08)	3.91 (12.11, 0.54)	79.61 (84.1, 76.5)	8.02 (8.36, 7.77)	3.75 (4.69, 2.68)
ABB	Spring	20132086	22.62 (23.51, 22.08)	7.17 (7.31, 6.99)	12.1 (20.68, 4.75)	6.99 (12.38, 2.54)	71.05 (78.8, 63.9)	5.89 (6.36, 5.34)	4.07 (4.83, 3.29)
ABC	Summer	20122016	26.92 (27.67, 26.13)	6.97 (7.19, 6.79)	12.12 (22.66, 2.05)	7 (13.61, 1.04)	50.18 (61.1, 42.7)	3.84 (4.47, 3.4)	6.11 (6.82, 4.84)
ABC	Fall	20122170	12.95 (13.16, 12.51)	7.47 (7.55, 7.27)	26.11 (31.73, 20.22)	16.01 (19.79, 12.11)	83.61 (86, 79.6)	7.98 (8.08, 7.79)	5.37 (6.10, 4.27)
ABC	Winter	20132016	14.15 (14.62, 13.5)	7.16 (7.3, 7.04)	2.29 (8.78, 0.50)	1.22 (4.92, 0.24)			5.11 (6.01, 4.08)
ABC	Spring	20132093	22.64 (23.39, 22.13)	6.99 (7.09, 6.93)	3.54 (9.84, 0.87)	1.9 (5.55, 0.43)	63.68 (70.6, 59.4)	5.44 (5.91, 5.14)	1.34 (2.12, 0.53)

Table 9. Macrobenthic community data for each core site (average of 3 station replicates) in the Ashley River during each season.

Species Name	% of stns where present	% of total by species	ABA Summer	ABA Fall	ABA Winter	ABA Spring	ABB Summer	ABB Fall	ABB Winter	ABB Spring	ABC Summer	ABC Fall	ABC Winter	ABC Spring
Number of Species			**5.7**	**6.7**	**8.0**	**9.3**	**3.0**	**8.0**	**7.7**	**10.0**	**7.7**	**10.3**	**7.0**	**9.0**
Total Density (avg of 3 reps)			**1258**	**1808**	**1475**	**1575**	**608**	**2342**	**1742**	**1533**	**1142**	**1892**	**1783**	**9017**
Monoculodes edwardsi	75	1.66	0	8.33	8.33	41.66	0	8.33	133.33	41.66	8.33	58.33	0	125
Parandalia sp.	75	9.68	0	0	0	25	400	400	283.33	283.33	200	366.66	366.66	208.33
Tubificoides brownae	75	5.83	266.66	575	125	0	33.33	175	0	141.66	33.33	166.66	0	8.33
Corophium lacustre	67	32.54	0	0	0	0	8.33	291.66	608.33	150	225	250	691.66	6291.66
Cyathura burbancki	67	4.78	16.66	0	0	0	8.33	25	158.33	0	350	333.33	150	208.33
Nemertea	58	0.73	8.33	0	0	75	0	8.33	0	41.66	0	8.33	41.66	8.33
Nereis succinea	58	2.32	0	0	0	0	66.66	191.66	25	125	108.33	66.66	25	0
Gammarus tigrinus	50	5.99	0	0	0	0	0	0	16.66	108.33	8.33	8.33	66.66	1358.33
Melita nitida	50	6.27	0	0	0	0	0	475	8.33	241.66	0	391.66	191.66	333.33
Polydora socialis	50	1.24	0	8.33	8.33	0	0	175	75	0	16.66	41.66	0	0
Tubificoides wasselli	50	6.43	533.33	0	516.66	341.66	0	0	0	50	0	0	100	141.66
Leitoscoloplos fragilis	42	0.54	0	0	41.66	33.33	0	8.33	50	8.33	0	0	0	0
Lepidactylus dytiscus	42	1.27	0	0	0	0	0	8.33	41.66	100	0	0	83.33	100
Scolecolepides viridis	42	1.18	0	0	0	0	0	0	8.33	183.33	25	0	25	66.66
Streblospio benedicti	42	7.99	200	783.33	591.66	400	0	0	116.66	0	0	0	0	0
Amygdalum papyrium	33	1.21	0	0	0	0	66.66	75	83.33	0	0	91.66	0	0
Cirrophorus sp.	33	0.38	16.66	33.33	8.33	41.66	0	0	0	0	0	0	0	0
Paraprionospio pinnata	33	2.04	75	250	25	183.33	0	0	0	0	0	0	0	0
Rhithropanopeus harrisii	33	0.25	0	0	0	0	0	25	0	16.66	16.66	0	0	8.33
Brachidontes recurvus	25	0.16	0	0	0	0	0	16.66	0	0	16.66	8.33	0	0
Chiridotea almyra	25	0.25	0	0	0	8.33	0	0	0	0	0	0	8.33	50
Mulinia lateralis	25	0.22	8.33	16.66	0	33.33	0	0	0	0	0	0	0	0
Tubificidae	25	0.32	0	0	16.66	58.33	0	0	8.33	0	0	0	0	0
Actiniaria	17	0.13	0	16.66	0	16.66	0	0	0	0	0	0	0	0
Ampelisca abdita	17	0.10	0	0	0	16.66	0	8.33	0	0	0	0	0	0
Axarus sp.	17	0.13	16.66	0	0	0	0	0	0	0	0	0	0	16.66
Brachidontes exustus	17	0.70	0	0	0	0	0	150	0	0	0	33.33	0	0
Cassidinidea lunifrons	17	0.16	0	0	0	0	0	0	0	0	0	16.66	25	0
Cleantis planicauda	17	0.06	0	0	0	0	0	8.33	0	8.33	0	0	0	0
Crassostrea virginica	17	0.41	0	0	0	0	0	91.66	0	16.66	0	0	0	0
Drilonereis longa	17	0.10	0	16.66	8.33	0	0	0	0	0	0	0	0	0
Edotia triloba	17	0.22	0	0	0	0	0	0	50	0	0	0	8.33	0
Eteone heteropoda	17	0.48	0	0	8.33	116.66	0	0	0	0	0	0	0	0
Hyalla azteca	17	0.32	0	0	0	0	0	50	0	0	0	33.33	0	0
Leucon americanus	17	0.22	0	0	16.66	41.66	0	0	0	0	0	0	0	0
Mediomastus californiensis	17	0.29	66.66	0	0	8.33	0	0	0	0	0	0	0	0
Melita dentata	17	0.22	0	0	0	0	0	0	0	0	33.33	0	0	25
Phoronida	17	0.22	8.33	50	0	0	0	0	0	0	0	0	0	0
Polydora cornuta	17	0.06	0	0	0	0	8.33	0	0	0	8.33	0	0	0
Sabellaria vulgaris	17	0.83	0	0	0	0	0	141.66	75	0	0	0	0	0
Scoloplos rubra	17	0.16	0	33.33	8.33	0	0	0	0	0	0	0	0	0
Tubificoides heterochaetus	17	0.45	0	0	0	0	0	0	0	0	66.66	0	0	50

Species Name	% of stns where present	% of total by species	ABA Summer	ABA Fall	ABA Winter	ABA Spring	ABB Summer	ABB Fall	ABB Winter	ABB Spring	ABC Summer	ABC Fall	ABC Winter	ABC Spring
Cirratulidae	8	0.13	0	0	0	33.33	0	0	0	0	0	0	0	0
Clymenella torquata	8	0.03	0	0	8.33	0	0	0	0	0	0	0	0	0
Corbiculidae	8	0.03	0	0	0	0	0	0	0	0	8.33	0	0	0
Cumacea	8	0.03	0	8.33	0	0	0	0	0	0	0	0	0	0
Exogone dispar	8	0.06	0	0	16.66	0	0	0	0	0	0	0	0	0
Exogone sp.	8	0.03	0	0	0	0	0	0	0	0	0	0	0	8.33
Glycera dibranchiata	8	0.03	0	0	8.33	0	0	0	0	0	0	0	0	0
Goniadides carolinae	8	0.13	33.33	0	0	0	0	0	0	0	0	0	0	0
Mediomastus sp.	8	0.03	0	0	8.33	0	0	0	0	0	0	0	0	0
Microdeutopus sp.	8	0.06	0	0	0	0	16.66	0	0	0	0	0	0	0
Modiolus modiolus squamosus	8	0.03	0	0	0	0	0	0	0	0	0	8.33	0	0
Mytilidae	8	0.03	0	0	0	0	0	0	0	0	8.33	0	0	0
Neomysis americana	8	0.03	0	0	0	0	0	0	0	8.33	0	0	0	0
Nereididae	8	0.03	0	0	0	0	0	0	0	0	8.33	0	0	0
Orbiniidae	8	0.03	0	0	0	0	0	0	0	8.33	0	0	0	0
Paracaprella tenuis	8	0.03	0	0	0	0	0	0	0	0	0	8.33	0	0
Pelecypoda	8	0.03	0	0	0	0	0	0	0	0	0	0	0	8.33
Platyhelminthes	8	0.03	0	0	0	0	0	8.33	0	0	0	0	0	0
Prionospio sp.	8	0.03	8.33	0	0	0	0	0	0	0	0	0	0	0
Scolelepis squamata	8	0.06	0	0	16.66	0	0	0	0	0	0	0	0	0
Sphaerosyllis sp.	8	0.06	0	0	0	16.66	0	0	0	0	0	0	0	0
Spiochaetopterus costarum oculatus	8	0.03	0	8.33	0	0	0	0	0	0	0	0	0	0
Streptosyllis pettiboneae	8	0.13	0	0	33.33	0	0	0	0	0	0	0	0	0
Tharyx acutus	8	0.32	0	0	0	83.33	0	0	0	0	0	0	0	0

Table 10. A comparison of the two Ashley River sites sampled for the 1980s Charleston Harbor Characterization Study (Van Dolah et al. 1990) and this study.

Site Name	Species Name CHCS	CHCS Rank	Species Name This Study	This Study Rank
AR02/ABA	*Paraprionospio pinnata*	1	*Paraprionospio pinnata*	4
AR02/ABA	*Heteromastus filiformis*	2		
AR02/ABA	*Mulinia lateralis*	3		
AR02/ABA	Oligochaeta	4	*Tubificoides wasselli*	2
AR02/ABA			*Tubificoides brownae*	3
AR02/ABA			Tubificidae	10
AR02/ABA	*Mediomastus californiensis*	5	*Mediomastus californiensis*	10
AR02/ABA			*Mediomastus* sp.	33
AR02/ABA	Nemertea	6	*Nemertea*	7
AR02/ABA	*Leucon americanus*	8	*Leucon americanus*	13.5
AR02/ABA	*Nereis succinea*	8		
AR02/ABA	*Monoculodes* sp.	8	*Monoculodes edwardsi*	13.5
AR02/ABA	*Edotia montosa*	10		
AR02/ABA	*Streblospio benedicti*	10	*Streblospio benedicti*	1
AR02/ABA	Phyllodocidae	12		
AR02/ABA	*Capitella capitata*	13		
AR02/ABA	Mysida	14		
AR02/ABA	*Prionospio* sp.	15	*Prionospio* sp.	33
AR02/ABA	Capitellidae	16		
AR02/ABA	Ostracoda	16		
AR02/ABA	*Eteone heteropoda*	22	*Eteone heteropoda*	5
AR02/ABA	*Ilyanassa obsoleta*	22		
AR02/ABA	*Mancocuma* sp.	22		
AR02/ABA	Mytilidae	22		
AR02/ABA	*Ogyrides alphaerostris*	22		
AR02/ABA	*Oxyurostylis smithi*	22		
AR02/ABA	*Podarkeopsis levifuscina*	22		
AR02/ABA	*Rhithropanopeus harrisii*	22		
AR02/ABA	*Sabellaria vulgaris*	22		
AR02/ABA			*Cirrophorus* sp.	6
AR02/ABA			*Tharyx acutus*	7
AR02/ABA			*Leitoscoloplos fragilis*	10
AR02/ABA			Phoronida	13.5
AR02/ABA			*Mulinia lateralis*	13.5
AR02/ABA			*Scoloplos rubra*	16
AR02/ABA			*Streptosyllis pettiboneae*	18.5
AR02/ABA			Cirratulidae	18.5
AR02/ABA			*Goniadides carolinae*	18.5
AR02/ABA			Actiniaria	18.5
AR02/ABA			*Parandalia* sp.	21
AR02/ABA			*Drilonereis longa*	22
AR02/ABA			*Scolelepis squamata*	26
AR02/ABA			*Polydora socialis*	26
AR02/ABA			*Exogone dispar*	26
AR02/ABA			*Sphaerosyllis* sp.	26
AR02/ABA			*Axarus* sp.	26
AR02/ABA			*Ampelisca abdita*	26
AR02/ABA			*Cyathura burbancki*	26
AR02/ABA			Cumacea	33
AR02/ABA			*Clymenella torquata*	33
AR02/ABA			*Chiridotea almyra*	33
AR02/ABA			*Glycera dibranchiata*	33
AR02/ABA			*Spiochaetopterus costarum oculatus*	33

Site Name	Species Name CHCS	CHCS Rank	Species Name This Study	This Study Rank
AR03/ABB	Oligochaeta	1	*Tubificoides brownae*	5
AR03/ABB			*Tubificoides wasselli*	19
AR03/ABB			Tubificidae	28.5
AR03/ABB	*Lepidactylus dytiscus*	2	*Lepidactylus dytiscus*	13
AR03/ABB	*Scolecolepides viridis*	3	*Scolecolepides viridis*	9
AR03/ABB	*Heteromastus filiformis*	4		
AR03/ABB	Turbellaria	5		
AR03/ABB	*Chiridotea almyra*	6		
AR03/ABB	*Monoculodes* sp.	7	*Monoculodes edwardsi*	11
AR03/ABB	*Gammarus tigrinus*	8	*Gammarus tigrinus*	14
AR03/ABB	Nemertea	9	Nemertea	21
AR03/ABB	*Corophium lacustre*	10	*Corophium lacustre*	2
AR03/ABB	Phyllodocidae	10		
AR03/ABB	*Cyathura polita*	12	*Cyathura burbancki*	10
AR03/ABB	*Cyclaspis varians*	13		
AR03/ABB	*Edotia montosa*	14	*Edotia triloba*	19
AR03/ABB	*Neomysis americana*	15		
AR03/ABB	*Nereis succinea*	15		
AR03/ABB	*Chiridotea stenops*	17		
AR03/ABB	*Mancocuma* sp.	17		
AR03/ABB	*Brachidontes exustus*	19	*Brachidontes exustus*	12
AR03/ABB			*Brachidontes recurvus*	24
AR03/ABB	*Mulinia lateralis*	19		
AR03/ABB	Mysida	19		
AR03/ABB			*Parandalia* sp.	1
AR03/ABB			*Nereis succinea*	4
AR03/ABB			*Melita nitida*	3
AR03/ABB			*Polydora socialis*	6
AR03/ABB			*Amygdalum papyrium*	7
AR03/ABB			*Sabellaria vulgaris*	8
AR03/ABB			*Streblospio benedicti*	15
AR03/ABB			*Crassostrea virginica*	16
AR03/ABB			*Leitoscoloplos fragilis*	17
AR03/ABB			*Hyalla azteca*	19
AR03/ABB			*Rhithropanopeus harrisii*	22
AR03/ABB			*Microdeutopus* sp.	24
AR03/ABB			*Cleantis planicauda*	24
AR03/ABB			Platyhelminthes	28.5
AR03/ABB			*Polydora cornuta*	28.5
AR03/ABB			Orbiniidae	28.5
AR03/ABB			*Ampelisca abdita*	28.5
AR03/ABB			*Neomysis americana*	28.5

Table 11. The average sediment composition for each site sampled by each season for the Wando River. The sand size fractions were obtained from the sand component.

Site	Season	Silt (%)	Clay (%)	Sand (%)		Sand Fraction >2 mm (%)	Sand Fraction 0.25-2 mm (%)	Sand Fraction 0.063-0.25 mm (%)
WBA	Summer	3.2	7.8	89.0		0.3	13.9	74.8
	Fall	4.8	8.5	86.6		2.1	12.4	72.1
	Winter	4.1	6.6	89.3		2.5	13.9	72.9
	Spring	4.8	9.9	85.4		3.8	28.2	53.3
WBB	Summer	0.3	2.9	96.8		3.9	38.5	54.5
	Fall	1.1	1.5	97.4		3.7	41.4	52.3
	Winter	0.7	3.3	96.0		1.6	38.4	56.0
	Spring	0.4	1.8	97.8		0.3	53.4	44.1
WBC	Summer	0.4	2.9	96.7		5.1	50.8	40.7
	Fall	1.1	3.2	95.7		3.2	43.8	48.7
	Winter	0.4	2.8	96.8		5.6	43.6	47.5
	Spring	5.1	9.8	85.2		5.9	17.3	62.0

Table 12. The average, maximum, and minimum [avg (max, min)] for each semi-continuous water quality deployment collected in the Wando River over a 25 hour period during the four seasons.

Site	Season	Collection Number	Temperature (^{o}C)	pH	Sp. Cond. (mS/cm)	Salinity (ppt)	DO (% sat)	DO (mg/l)	Depth (m)
WBA	Summer	20122023	27.34 (27.68, 26.59)	7.81 (7.91, 7.66)	41.74 (43.93, 39.59)	26.71 (28.26, 25.18)	76.21 (84, 66.6)	5.2 (5.66, 4.61)	2.77 (3.54, 1.77)
WBA	Fall	20122177	13.5 (13.93, 13)	7.94 (8.01, 7.73)	41.52 (44.01, 39.95)	26.62 (28.39, 25.51)	96.35 (100.5, 89.5)	8.51 (8.84, 8.04)	4.18 (5.07, 3.10)
WBA	Winter	20132023	13.8 (16.21, 13.03)	7.91 (7.99, 7.8)	35.92 (40.04, 32.65)	22.7 (25.57, 20.44)	96.99 (109, 89.8)	8.72 (9.41, 8.27)	0.95 (2.01, 0.0)
WBA	Spring	20132100	21.76 (23.18, 20.9)	7.9 (8.02, 7.75)	36.72 (38.83, 33.66)	23.27 (24.75, 21.13)	93.12 (107.2, 77.6)	7.14 (8.05, 6.06)	2.12 (2.90, 1.33)
WBB	Summer	20122030	27.48 (27.8, 26.89)	7.65 (7.81, 7.46)	36.35 (40.30, 30.76)	22.91 (25.67, 19.04)	77.27 (83.4, 68.8)	5.37 (5.78, 4.86)	3.04 (3.8, 1.94)
WBB	Fall	20122184	13.63 (13.87, 13.35)	7.77 (7.87, 7.59)	40.07 (40.68, 39.43)	25.6 (26.04, 25.14)	93.89 (95.3, 92.4)	8.32 (8.42, 8.16)	3.26 (3.98, 2.22)
WBB	Winter	20132030	14.12 (14.51, 13.52)	7.78 (7.85, 7.72)	36.17 (37.08, 35.33)	22.87 (23.5, 22.29)	96.84 (99.1, 94.2)	8.64 (8.81, 8.47)	2.7 (3.71, 1.52)
WBB	Spring	20132107	22.37 (22.89, 21.87)	7.57 (7.69, 7.48)	34.22 (36.43, 32.01)	21.52 (23.06, 19.98)	96.22 (102.8, 88.4)	7.38 (7.82, 6.81)	2.39 (3.09, 1.54)
WBC	Summer	20122037	26.51 (27.52, 25.78)	7.27 (7.44, 7.09)	24.42 (27.61, 19.69)	14.81 (16.91, 11.7)	53.85 (64.8, 43.4)	3.98 (4.66, 3.3)	2.97 (3.72, 1.66)
WBC	Fall	20122191	13.24 (13.71, 12.28)	7.57 (7.63, 7.36)	38.36 (38.98, 37.67)	24.39 (24.83, 23.9)	89.06 (92.6, 81.5)	8.02 (8.26, 7.5)	3.22 (3.94, 1.92)
WBC	Winter	20132037	14.69 (15.8, 13.87)	7.39 (7.51, 7.14)	28.77 (36.11, 17.13)	17.84 (22.83, 10.12)	87.19 (91.5, 78.8)	7.93 (8.18, 7.07)	3.16 (4.14, 1.84)
WBC	Spring	20132114	23.92 (26.1, 22.75)	7.34 (7.42, 7.22)	28.44 (30.43, 25.74)	17.53 (18.89, 15.73)	81.62 (93.3, 72.7)	6.22 (6.88, 5.67)	2.36 (3.10, 1.38)

Table 13. Macrobenthic community data for each core site (average of 3 station replicates) in the Wando River during each season.

Species Name	% of stns where present	% of total per species	WBA Summer	WBA Fall	WBA Winter	WBA Spring	WBB Summer	WBB Fall	WBB Winter	WBB Spring	WBC Summer	WBC Fall	WBC Winter	WBC Spring
Number of Species (avg of 3 reps)			**10.0**	**15.0**	**22.0**	**19.3**	**13.0**	**21.3**	**20.7**	**22.3**	**10.7**	**12.0**	**11.3**	**12.3**
Total Density (avg of 3 reps)			**833**	**4450**	**4416**	**2367**	**967**	**4675**	**3658**	**2916**	**1783**	**4433**	**1550**	**4117**
Mediomastus sp.	92	4.08	25	116.66	208.33	125	0	208.33	108.33	66.66	41.66	133.33	66.66	375
Scoloplos rubra	92	2.88	8.33	8.33	16.66	0	25	158.33	58.33	83.33	341.66	141.66	66.66	133.33
Streblospio benedicti	92	13.69	108.33	808.33	1000	316.66	58.33	800	1066.66	550	116.66	8.33	0	116.66
Nereis succinea	83	1.15	0	8.33	16.66	0	8.33	16.66	16.66	33.33	41.66	175	8.33	91.66
Nemertea	75	0.78	16.66	0	0	33.33	8.33	0	33.33	16.66	58.33	16.66	50	50
Podarkeopsis levifuscina	75	1.24	0	41.66	8.33	8.33	0	0	33.33	25	75	158.33	33.33	66.66
Spiochaetopterus costarum oculatus	75	2.97	8.33	41.66	50	41.66	0	775	0	33.33	41.66	66.66	0	16.66
Tubificoides brownae	75	3.23	33.33	258.33	150	25	0	58.33	0	0	283.33	325	8.33	25
Ampelisca abdita	67	1.82	0	58.33	50	133.33	0	0	66.66	83.33	0	16.66	150	100
Cirrophorus sp.	67	2.72	50	0	0	0	150	50	516.66	25	91.66	66.66	33.33	0
Ericthonius brasiliensis	67	0.53	8.33	41.66	66.66	16.66	0	16.66	16.66	16.66	0	8.33	0	0
Eteone heteropoda	67	0.60	0	66.66	33.33	0	0	8.33	41.66	25	16.66	0	8.33	16.66
Paracaprella tenuis	67	1.31	0	25	58.33	33.33	0	25	25	141.66	0	158.33	8.33	0
Tubificidae	67	0.55	0	8.33	16.66	0	0	16.66	0	16.66	50	8.33	33.33	50
Americhelidium americanum	58	0.83	0	25	8.33	8.33	91.66	16.66	41.66	0	0	0	108.33	0
Corophium acherusicum	58	3.09	0	25	25	41.66	0	0	0	66.66	0	8.33	441.66	508.33
Edotia triloba	58	0.78	0	0	25	0	16.66	0	8.33	8.33	108.33	0	33.33	83.33
Glycinde solitaria	58	0.53	8.33	33.33	16.66	25	16.66	58.33	33.33	0	0	0	0	0
Leitoscoloplos fragilis	58	0.53	25	0	0	0	0	41.66	41.66	8.33	33.33	25	16.66	0
Tharyx acutus	58	1.27	0	0	8.33	91.66	66.66	8.33	8.33	241.66	0	0	0	33.33
Carinomella lactea	50	0.41	25	16.66	25	58.33	0	8.33	0	16.66	0	0	0	0
Diopatra cuprea	50	0.35	0	41.66	41.66	8.33	0	16.66	8.33	8.33	0	0	0	0
Ilyanassa obsoleta	50	0.37	16.66	8.33	0	8.33	8.33	0	0	0	16.66	0	0	75
Paraprionospio pinnata	50	14.75	358.33	2333.33	1891.66	575	0	158.33	0	16.66	0	0	0	0
Polydora socialis	50	0.88	0	33.33	33.33	0	0	83.33	16.66	8.33	0	141.66	0	0
Sabellaria vulgaris	50	4.38	0	0	8.33	0	0	541.66	608.33	8.33	0	400	0	16.66
Aricidea bryani	42	0.67	8.33	16.66	91.66	108.33	0	0	0	0	0	0	0	16.66
Leucon americanus	42	0.48	16.66	8.33	0	33.33	0	0	0	0	0	25	0	91.66
Monoculodes edwardsi	42	0.30	0	0	0	0	16.66	33.33	0	25	0	0	16.66	16.66
Scoletoma tenuis	42	0.69	8.33	25	41.66	166.66	0	0	0	8.33	0	0	0	0
Acteocina canaliculata	33	0.60	0	0	8.33	16.66	0	166.66	25	0	0	0	0	0
Caulleriella sp.	33	2.28	0	0	0	0	250	125	275	175	0	0	0	0
Corophium lacustre	33	2.81	0	0	0	0	0	0	8.33	100	0	850	0	58.33
Cyathura burbancki	33	0.37	0	0	0	0	0	0	0	16.66	0	50	8.33	58.33
Drilonereis longa	33	0.28	0	0	0	0	33.33	25	16.66	25	0	0	0	0
Exogone dispar	33	0.48	0	8.33	50	0	0	0	16.66	100	0	0	0	0
Glycera americana	33	0.14	0	8.33	16.66	0	0	8.33	16.66	0	0	0	0	0
Grandidierella sp.	33	3.30	0	0	0	0	0	0	0	0	83.33	566.66	241.66	300
Lepidactylus dytiscus	33	3.06	0	0	33.33	0	0	0	0	0	0	141.66	141.66	791.66
Macoma tenta	33	0.55	0	0	8.33	41.66	0	0	0	141.66	0	0	0	8.33
Melita nitida	33	0.94	0	0	0	0	0	25	0	0	0	291.66	8.33	16.66
Monticellina sp.	33	0.30	0	41.66	16.66	8.33	0	0	41.66	0	0	0	0	0

Species Name	% of stns where present	% of total per species	WBA Summer	WBA Fall	WBA Winter	WBA Spring	WBB Summer	WBB Fall	WBB Winter	WBB Spring	WBC Summer	WBC Fall	WBC Winter	WBC Spring
Oxyurostylis smithi	33	0.12	0	0	16.66	8.33	0	0	8.33	8.33	0	0	0	0
Paraonis fulgens	33	0.41	0	0	0	0	0	0	0	8.33	8.33	125	0	8.33
Phoronida	33	0.65	0	0	33.33	66.66	0	0	0	0	75	0	0	58.33
Streptosyllis pettiboneae	33	0.55	0	0	0	0	0	0	150	8.33	33.33	0	8.33	0
Tubificoides wasselli	33	1.66	0	0	0	0	66.66	316.66	183.33	33.33	0	0	0	0
Unciola serrata	33	0.30	0	0	33.33	16.66	0	0	50	8.33	0	0	0	0
Batea catharinensis	25	1.06	0	241.66	25	0	0	116.66	0	0	0	0	0	0
Capitella capitata	25	0.25	0	0	0	0	0	0	0	0	8.33	16.66	0	66.66
Cirratulidae	25	0.12	0	0	8.33	0	0	16.66	0	16.66	0	0	0	0
Dispio uncinata	25	0.09	0	0	0	8.33	0	0	8.33	16.66	0	0	0	0
Hesionidae	25	0.07	0	8.33	0	0	0	8.33	8.33	0	0	0	0	0
Mulinia lateralis	25	0.21	16.66	0	16.66	0	0	41.66	0	0	0	0	0	0
Nassarius vibex	25	0.18	8.33	0	0	0	0	50	0	0	8.33	0	0	0
Nephtys picta	25	0.14	8.33	0	33.33	8.33	0	0	0	0	0	0	0	0
Notomastus latericeus	25	0.21	0	8.33	16.66	50	0	0	0	0	0	0	0	0
Ogyrides alphaerostris	25	0.07	8.33	8.33	8.33	0	0	0	0	0	0	0	0	0
Ophiuroidea	25	0.07	0	0	0	8.33	0	8.33	0	0	0	8.33	0	0
Potamilla reniformis	25	0.18	0	0	0	0	0	41.66	16.66	0	0	8.33	0	0
Protohaustorius wigleyi	25	0.39	8.33	0	0	75	0	0	0	0	58.33	0	0	0
Rhepoxynius hudsoni	25	0.62	0	0	0	8.33	41.66	0	0	175	0	0	0	0
Tellinidae	25	0.28	0	8.33	0	41.66	50	0	0	0	0	0	0	0
Abra aequalis	17	0.05	8.33	0	8.33	0	0	0	0	0	0	0	0	0
Ampelisca verrilli	17	1.22	0	0	0	0	0	258.33	0	183.33	0	0	0	0
Amygdalum papyrium	17	0.39	0	0	0	0	0	8.33	0	0	0	0	0	133.33
Aricidea sp.	17	0.16	0	0	16.66	0	0	0	0	0	0	0	41.66	0
Aricidea wassi	17	0.05	0	8.33	0	0	0	8.33	0	0	0	0	0	0
Autolytus sp.	17	0.28	0	0	0	0	0	8.33	0	91.66	0	0	0	0
Cirriformia sp.	17	0.28	0	0	0	0	0	41.66	0	58.33	0	0	0	0
Clymenella torquata	17	0.25	0	0	0	41.66	0	0	0	50	0	0	0	0
Corophium aquafuscum	17	0.07	0	0	0	0	0	16.66	0	0	0	0	8.33	0
Gammarus sp.	17	0.07	0	0	0	0	8.33	0	0	0	16.66	0	0	0
Magelona sp.	17	0.05	0	0	8.33	8.33	0	0	0	0	0	0	0	0
Molgula manhattensis	17	1.61	0	0	0	0	0	0	0	0	0	208.33	0	375
Neomysis americana	17	0.05	8.33	0	8.33	0	0	0	0	0	0	0	0	0
Nereididae	17	0.12	0	0	0	8.33	0	0	0	0	33.33	0	0	0
Pagurus longicarpus	17	0.09	0	0	0	25	8.33	0	0	0	0	0	0	0
Parandalia sp.	17	0.05	0	0	0	0	0	0	0	0	8.33	8.33	0	0
Polydora cornuta	17	0.07	0	0	0	0	8.33	0	0	0	16.66	0	0	0
Protohaustorius deichmannae	17	0.12	16.66	0	0	0	0	0	0	0	25	0	0	0
Scolelepis squamata	17	0.14	0	0	0	0	0	8.33	41.66	0	0	0	0	0
Sigambra tentaculata	17	0.07	16.66	0	0	8.33	0	0	0	0	0	0	0	0
Sphaerosyllis sp.	17	0.05	0	0	8.33	0	0	8.33	0	0	0	0	0	0
Spiophanes bombyx	17	0.07	0	0	8.33	16.66	0	0	0	0	0	0	0	0
Syllides sp.	17	0.55	0	0	0	0	0	0	0	0	0	191.66	8.33	0
Tellina sp.	17	0.23	0	0	16.66	0	0	66.66	0	0	0	0	0	0
Ampelisca vadorum	8	0.02	0	0	8.33	0	0	0	0	0	0	0	0	0
Amphictes gunneri	8	0.05	0	0	0	16.66	0	0	0	0	0	0	0	0

Species Name	% of stns where present	% of total per species	WBA Summer	WBA Fall	WBA Winter	WBA Spring	WBB Summer	WBB Fall	WBB Winter	WBB Spring	WBC Summer	WBC Fall	WBC Winter	WBC Spring
Aphelochaeta sp.	8	0.05	0	0	0	16.66	0	0	0	0	0	0	0	0
Aricidea suecica	8	0.09	0	0	33.33	0	0	0	0	0	0	0	0	0
Ascidiacea	8	0.07	0	0	0	0	0	0	0	0	0	25	0	0
Astyris lunata	8	0.02	0	0	0	0	0	8.33	0	0	0	0	0	0
Brania sp.	8	0.02	0	0	0	0	0	0	0	8.33	0	0	0	0
Campylaspis sp.	8	0.14	0	0	0	0	0	0	0	0	50	0	0	0
Caprella sp.	8	0.02	0	0	8.33	0	0	0	0	0	0	0	0	0
Cerapus tubularis	8	0.07	0	0	25	0	0	0	0	0	0	0	0	0
Cerianthidae	8	0.02	0	0	0	0	0	0	8.33	0	0	0	0	0
Chiridotea almyra	8	0.02	0	0	0	0	0	0	0	0	8.33	0	0	0
Corophium sp.	8	0.02	0	0	0	0	0	0	0	0	8.33	0	0	0
Costoanachis avara	8	0.02	0	0	8.33	0	0	0	0	0	0	0	0	0
Crassostrea virginica	8	0.05	0	0	0	0	0	0	0	0	0	16.66	0	0
Crepidula fornicata	8	0.02	0	0	0	0	0	0	0	0	0	0	0	8.33
Doriopsilla pharpa	8	0.07	0	0	0	0	0	0	0	0	0	25	0	0
Eulalia sanguinea	8	0.02	0	0	0	0	0	0	0	0	0	8.33	0	0
Exogone sp.	8	0.05	0	0	0	0	0	16.66	0	0	0	0	0	0
Gammarus tigrinus	8	0.92	0	0	0	0	0	0	0	0	0	0	0	333.33
Hargeria rapax	8	0.05	0	0	0	0	0	0	0	0	0	0	0	16.66
Hemipholis elongata	8	0.02	0	8.33	0	0	0	0	0	0	0	0	0	0
Heteromastus filiformis	8	0.05	0	0	0	0	0	16.66	0	0	0	0	0	0
Holothuroidea	8	0.02	0	0	0	8.33	0	0	0	0	0	0	0	0
Hyalla azteca	8	0.02	0	0	0	0	0	0	0	0	0	8.33	0	0
Leucothoe sp.	8	0.12	0	0	0	0	0	0	0	41.66	0	0	0	0
Listriella clymenellae	8	0.05	0	16.66	0	0	0	0	0	0	0	0	0	0
Maldanidae	8	0.07	0	0	0	0	0	0	25	0	0	0	0	0
Mediomastus ambiseta	8	0.02	0	0	0	0	0	0	0	0	8.33	0	0	0
Mytilidae	8	0.05	0	0	0	0	0	0	0	0	16.66	0	0	0
Natica pusilla	8	0.02	0	0	0	0	0	8.33	0	0	0	0	0	0
Neopanope sayi	8	0.02	0	0	0	0	0	0	8.33	0	0	0	0	0
Notomastus sp.	8	0.09	0	0	33.33	0	0	0	0	0	0	0	0	0
Nudibranchia	8	0.02	0	0	0	0	8.33	0	0	0	0	0	0	0
Odontosyllis enopla	8	0.02	0	0	0	0	0	8.33	0	0	0	0	0	0
Parapionosyllis sp.	8	0.02	0	0	0	0	8.33	0	0	0	0	0	0	0
Pelecypoda	8	0.23	0	0	0	0	0	83.33	0	0	0	0	0	0
Pista sp.	8	0.02	0	0	0	0	0	0	0	8.33	0	0	0	0
Polycirrus sp.	8	0.07	0	0	0	0	0	0	0	25	0	0	0	0
Portunus spinimanus	8	0.02	0	0	0	0	0	0	0	8.33	0	0	0	0
Rhepoxynius epistomus	8	0.02	0	0	0	0	0	8.33	0	0	0	0	0	0
Rhithropanopeus harrisii	8	0.02	0	0	0	0	0	0	0	8.33	0	0	0	0
Sabella microphthalma	8	0.07	0	0	0	0	0	0	0	25	0	0	0	0
Sclerodactyla briareus	8	0.02	0	0	0	0	8.33	0	0	0	0	0	0	0
Scolelepis texana	8	0.02	0	0	0	0	8.33	0	0	0	0	0	0	0
Scoloplos texana	8	0.02	0	8.33	0	0	0	0	0	0	0	0	0	0
Solen viridis	8	0.02	0	0	8.33	0	0	0	0	0	0	0	0	0
Sphenia antillensis	8	0.07	0	25	0	0	0	0	0	0	0	0	0	0

Species Name	% of stns where present	% of total per species	WBA Summer	WBA Fall	WBA Winter	WBA Spring	WBB Summer	WBB Fall	WBB Winter	WBB Spring	WBC Summer	WBC Fall	WBC Winter	WBC Spring
Tagelus divisus	8	0.09	0	0	0	0	0	33.33	0	0	0	0	0	0
Terebellidae	8	0.12	0	0	0	0	0	0	0	41.66	0	0	0	0
Trachypenaeus constrictus	8	0.02	8.33	0	0	0	0	0	0	0	0	0	0	0
Unciola sp.	8	0.05	0	0	0	0	0	16.66	0	0	0	0	0	0