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Assessment of Macroinvertebrate Communities and Heavy Metal Contamination Along the Intracoastal Waterway in Fort Lauderdale, Florida

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ASSESSMENT OF MACROINVERTEBRATE COMMUNITIES AND HEAVY METAL CONTAMINATION ALONG THE INTRACOASTAL WATERWAY IN FORT LAUDERDALE, FLORIDA

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ABSTRACT

Sediments from four areas adjacent to marinas and a background site in the Intracoastal Waterway were assessed for macroinvertebrate composition and heavy metal contamination. Sediment core samples were collected in 2004 and 2005 for analyses of macroinvertebrate composition and sediment grain size. Additional sediment samples were collected in 2005 for chemical analyses of metals (Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni and Zn). MANOVA and dendograms using Bray-Curtis similarity matrices grouped the sites into two clusters: the 3 sites closest to the New River formed one group, and the two end sites formed the other. The sites nearest the New River were dominated by polychaetes, half of which were pollutant-tolerant species (e.g., *Capitella capitata*). The macroinvertebrate communities of the two end sites were dominated by tanaids, gastropods and sipunculids with fewer annelids than the other 3 sites. The influence of the New River on the study sites appeared to outweigh the sources of metal pollution found in marinas. The 3 sites closest to the New River had higher metal concentrations than the two end sites. The background site, nearest the mouth of the New River, exceeded the Florida sediment quality guideline probable effect level for cadmium and copper while three of the four marina sites exceeded at most one probable effect level and one or more threshold effect levels for cadmium and copper. The furthest site from the New River, which was the closest site to Port Everglades, had the lowest metal concentrations. Additional studies are needed to determine the level of pollutant loading from the New River and its effects on nearby biological communities.

Keywords: sediment contaminants, heavy metals, macroinvertebrate, marinas, stormwater, South Florida

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1. INTRODUCTION

Marinas and the small boats and yachts contained within can be very deleterious to nearby aquatic environment. Hazardous materials such as diesel fuel and illegally pumped out toilets are just a few of the sources of pollution that can affect the water and sediment quality within a marina. Less obvious sources of pollution from marinas are metal-enriched anti-fouling paints applied to the hull of a boat; cleaning solvents such as mineral spirits, polycyclic aromatic hydrocarbons and phenols; sacrificial anodes such as zinc used to prevent corrosion to a boat's metal components, and the untreated stormwater runoff from marina docks (Akanlar et al. 2011).

Studies have been conducted on the affects harbors have on the environment (Guerra-Garcia and Garcia-Gomez 2004, Ingole et al. 2009) but little research has been focused on the impacts discharge from marinas may have on the environment. Harbors and marinas differ in that harbors can shelter larger vessels such as commercial barges and vessels, often transporting pollutants such as fuels and chemicals that have a greater ability to impact the environment. Marinas are often thought of as having a lower impact on the environment but with its high transitory nature and little oversight of operations occurring upon each vessel the potential to affect the sediment and macroinvertebrate composition is great.

Within a 3-km stretch of Fort Lauderdale's Intracoastal Waterway (ICW) are four of the city's largest marinas: City of Fort Lauderdale/Las Olas Marina, Bahia Mar Marina, Lauderdale Marina, and the Pier 66 Marina. The close proximity of the marinas and the large volume of vessels the marinas dock and service have the potential to severely impact the underlying sediment quality and benthic macroinvertebrates communities.

In this study, benthic macroinvertebrate communities and sediment heavy metals were analyzed to assess the potential impact that point sources like marinas may have on the benthic community composition. Sediment cores were collected and analyzed for macroinvertebrate composition, sediment grain size and heavy metal concentrations, and water quality was measured at each of the sites. The marina sediments were compared to a background site located in the middle of the marina/ICW transect.

2. MATERIALS AND METHODS

a. Study sites

Five sites were chosen along the Intracoastal Waterway (ICW) in Ft. Lauderdale, Florida (Figure 1), running in a north-south direction from the City of Fort Lauderdale Marina to the 17th Street Causeway (Table 1): Site 1, the City of Fort Lauderdale Marina; site 2, Bahia Mar Marina; and site 3, the background site, are all located on the eastern side of the ICW, each separated by 800-900 m. Site 4, the Lauderdale Marina, is the only site on the western side of the ICW and is 800 m from the Background Site but only 400 m from site 5, the 17th Street Causeway site, which is on the eastern side of the ICW.

Site 3, the background site, was chosen based on the absence of commercial dockage and its location mid-way between the other four sites. This site is situated behind a residence along the ICW approximately 400 m from the mouth of the New River. At each of the five sites, biotic and abiotic samples were collected over a five-day period during two consecutive years. The samples in 2004 were collected between

October 11th and October 15th, and the samples in 2005 were collected between July 27th and August 1st.

Table 1. Sites with locations.

Site	Name	Latitude	Longitude
1	City of Fort Lauderdale Marina	26 07.172 N	80 06.524 W
2	Bahia Mar Marina	26 06.687 N	80 06.533 W
3	Background (private residence)	26 06.657 N	80 07.058 W
4	Lauderdale Marina	26 06.242 N	80 07.198 W
5	17th Street Causeway	26 05.477 N	80 06.708 W

b. Biological samples

The benthic macroinvertebrate communities were assessed by taking core samples. The corers, constructed from polyvinyl chloride (PVC) pipe, had an inside diameter of 7.62 cm and were pushed 15 cm into the sediment, taking a sediment sample of 684 cm^3 per core. Three replicates were taken per site for macroinvertebrate composition. Each core sample was emptied into a 1-gal sealable bag in the field and fixed with 10% buffered formalin with rose Bengal vital stain. Samples were sieved in the laboratory through a 0.5-mm mesh screen and transferred to 70% ethanol for future identification. Specimens were extracted from the sediment and sorted under a dissecting stereomicroscope, and identified under a dissecting or compound microscope to the lowest possible taxon.

c. Sediment samples – grain size

The same PVC corers were also used to sample sediments at all five sites to determine sediment grain size, with three replicates taken at each site. Sediment samples were frozen without any preservative. Sediment grain size distributions were determined for each of the 30 samples. The sieve sizes used were U.S. Standards 10 (>2mm, granule), 35 (>0.5 mm, coarse sand), 60 (>1/4mm, medium sand), 120 (>1/8mm, fine sand), 230 (>1/16mm, very fine sand) and >230 (<1/16mm, silt-clay). The standard operating procedure (SOP) used was a modification of the Environmental Protection Agency's *Procedures for Handling and Chemical Analysis of Sediment and Water Samples* (Plumb 1981).

d. Sediment samples – chemical analyses

Sediment samples were only collected in 2005 for chemical analysis. The samples were analyzed for metals, nutrients, and total and volatile solids. Multiple sediment core samples were taken at each site with high-density polyethylene (HDPE) core tubes. The tubes were pushed ~3 cm into the sediment, capped and brought to the surface where the water entrapped in each core was siphoned off the top and the sediment was composited to fill a 500-mL glass jar. Composite samples were collected to produce a mean value for each site's sediment chemistry. The samples were kept on ice and taken to Broward County's Environmental Monitoring Laboratory for analysis.

Sediment samples were analyzed for ten heavy metals: aluminum (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn). Aluminum and iron were measured by an inductively coupled plasma mass spectrometer (ICPMS) using *EPA method SW846 6010B GR9 NC*. Cadmium, chromium, copper, nickel, lead, and zinc were all measured by an ICPMS using *EPA method SW846 6010B GR9*. Arsenic was measured with a heated graphite

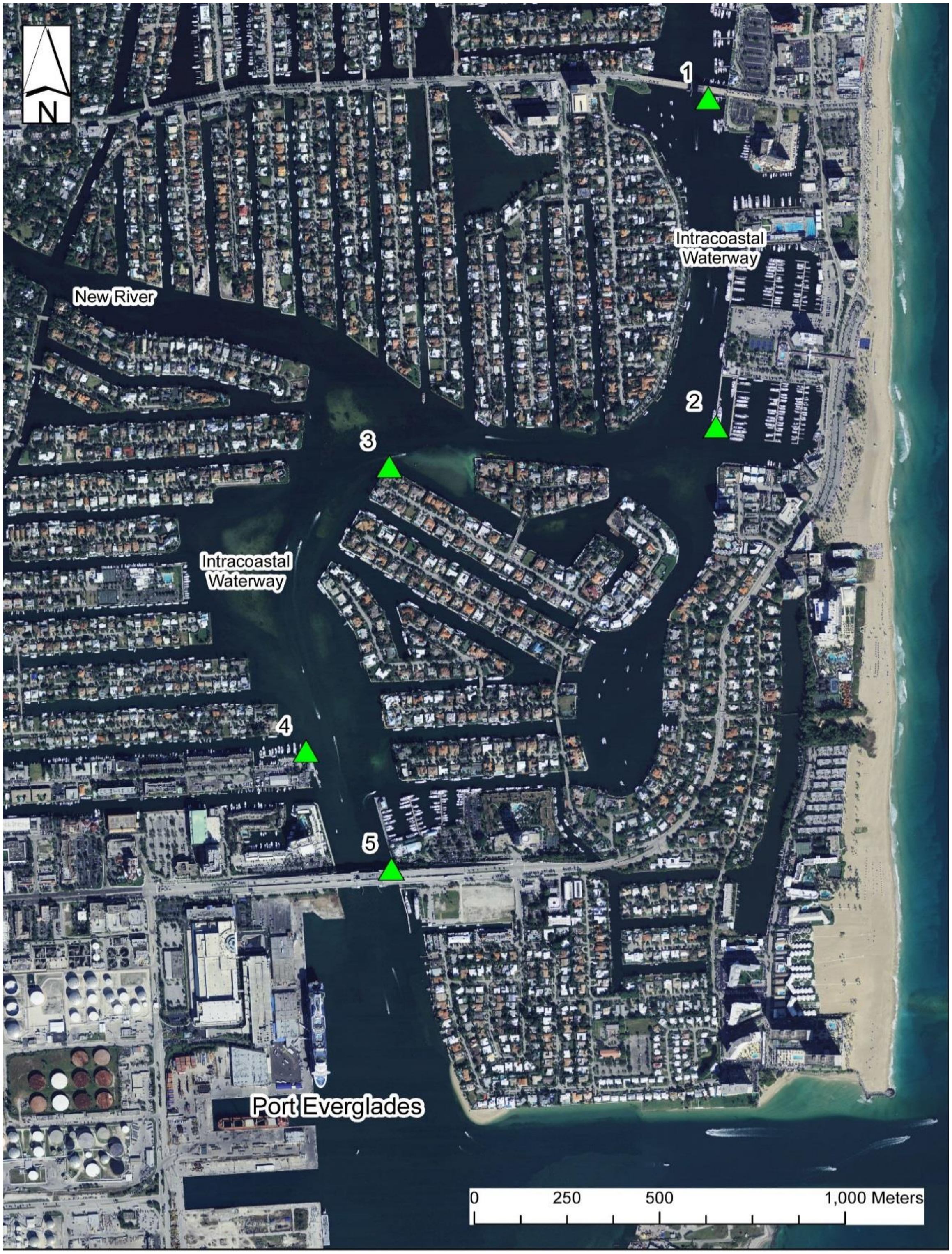

Figure 1. Study area along the Intracoastal Waterway in Fort Lauderdale, Florida, showing stations sampled in 2004-2005. Site 1 = City of Fort Lauderdale Marina, Site 2 = Bahia Mar Marina, Site 3 = Background site, Site 4 = Lauderdale Marina, Site 5 = 17th Street Causeway/Pier 66 Marina.

atomizer using *EPA method SW846 7060HB*. Mercury was measured with a chemical vapor transport using *EPA method SW 846 6010B GR9*.

The nutrient analysis consisted of Nitrite + Nitrate (NO_x), Total Kjeldahl Nitrogen (TKN), Total Nitrogen (TN) and Total Phosphorus (TP). Nitrite + Nitrate was measured using *EPA method 353.2; Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction)*. Total Kjeldahl Nitrogen was measured using *EPA method 351.2; Determination of Total Kjeldahl nitrogen by semi-automated colorimetry*. Total Nitrogen was calculated (TKN+NOx) by EPA methods 353.2+351.2. Total Phosphorus was measured using *EPA method 365.4; Phosphorus, Total (Colorimetric, Automated, Block Digestor AA II)*. The results for the sediment analysis are located in Table 25.

All of these methods are available online at www.epa.gov/fem/methcollectns.htm.

e. Water Quality

After the core samples were collected, a YSI 6600 multiparameter datasonde was deployed at each site ~10 cm from the bottom to record continuous water quality conditions through a minimum of one tidal cycle. Measurements of depth, temperature, specific conductivity, pH, dissolved oxygen, turbidity and chlorophyll were recorded every 15 minutes. To prevent theft or damage, the instrument was housed in a PVC casing. The casing had 1 cm holes drilled approximately 5 cm apart to let water flow freely through and pass by the sonde's probes. The PVC casing was secured with zip ties, a cable and lock.

The datasonde was calibrated following procedures used by Broward County's Environmental Monitoring Laboratory and the YSI 6-Series Multiparameter Water Quality Sonde's User Manual (YSI 2004). Both references used EPA methods for calibrating probes; dissolved oxygen (EPA method 360.1), pH (EPA method 150.1), specific conductivity (EPA method 120.1), temperature (EPA method 170.1). Measurements for turbidity *in situ* and chlorophyll *in vivo* were estimated.

f. Statistical analyses

i. Biological samples

Descriptive statistics were run on each of the replicates and the mean was calculated for each site and year. Density (m^{-2}), richness (S), diversity with base-2 logarithms (H'), and evenness (J') can be found in Table 2. ANOVA was run on each of the descriptive statistics, except evenness, to determine if there were significant differences among the sites and/or years.

Using all 105 taxa identified, a Bray-Curtis similarity matrix (Bray and Curtis 1957) was created with PRIMER statistical software. Prior to creating the similarity matrix, the data was fourth root transformed so the more abundant taxa did not bias results (Fields et al., 1982). A dendrogram using group average sorting was created from the similarity matrix. In addition to the dendrogram, PRIMER was used for non-metric multidimensional scaling (nMDS) analysis of the similarity matrix. Another statistical program, Statistica, was used for multivariate analysis of variance (MANOVA) to detect any significant differences among the collected species.

Once it was determined through multivariate analysis that significant differences existed among the sites' composition, Tukey's Honestly Significant Difference (HSD) was used to identify which species differed significantly ($p < 0.05$).

ii. Sediment samples – grain size

Sediment grain size composition (Table 22) was analyzed using multivariate analysis of variance from Statistica to identify possible significant differences for both site and year. Because significant differences were detected, Tukey's HSD was used to identify the grain size classes that differed among the samples.

iii. Sediment samples – chemical analyses

Due to the absence of data from 2004, chemical composition of the sediment samples could not be compared between the two years. The sediment samples collected in 2005 were compared to samples collected and analyzed by Broward County between 2005 and 2007 (Broward County 2005, Broward County 2006, Broward County 2007) and compared to the Florida Department of Environmental Protection's (FDEP) sediment quality guidelines for coastal waters. FDEP developed a system of sediment quality guidelines using an effects level approach (ELA) intended to permit determination of concentrations of contaminants in sediments that are either likely or unlikely to be associated with sediment toxicity or adverse effects on infauna (MacDonald 1994, p. 40). This approach includes two levels: the Threshold Effect Level (TEL) "is calculated as the geometric mean of the 15^{th} percentile of the effects data set and the 50^{th} percentile of the no effects data set, [and] represents the chemical concentration below which adverse effects are expected to occur infrequently. The [Probable Effect Level] (PEL) represents a second threshold value, above which adverse effects are expected to be frequently observed [and is] calculated as the geometric mean of the 50th percentile of the effects data set and the 85th percentile of the no effects data set” (MacDonald et al. 1996, p. 256).

iv. Water Quality

In 2004, the deployed multiparameter datasonde’s battery compartment flooded and all data was lost. The data recorded during the 2005 deployments were used to create scatter plots and box-whisker plots for tidal water quality comparisons among the five sites. Descriptive statistics were also run on the continuous monitoring data.

3. RESULTS

a. Biological samples

A total of 2,842 macroinvertebrate specimens was identified to 105 taxa from approximately 60 families in 7 phyla, with the majority identified to species level. Phylum Annelida exhibited the greatest species richness, with 49 species divided among tubificid oligochaetes (5 species) and representatives of 25 polychaete families dominated by Capitellidae, Cirratulidae, Sabellidae, Spionidae and Syllidae. Arthropoda was the second most speciose phylum and consists of 27 species of crustaceans from 17 families, chiefly tanaidaceans and ostracods. Mollusks ranked third with 20 species from 14 different families. Though 12 bivalve species from 9 families were identified, the 8 gastropod species from 5 families constituted the majority of specimens. Of the two species of sipunculans, most were one species of Aspidosiphonidae. The remaining species consisted of 4 Nemertea, 2 Ophiuroidea and 1 Hemichordata. Table 2 lists the mean densities, species richness and evenness of macroinvertebrates at the five sampling sites.

Table 2. Descriptive statistics of mean macroinvertebrate samples collected in 2004 and 2005 from all five sites.

Site Year	n	Density (m^{-2})	Richness (S)	Diversity (H' log2)	Evenness (J')
1 2004	108.33	23,755	15.33	2.80	0.71
1 2005	150.33	32,965	17.67	2.75	0.67
2 2004	121.33	26,606	21.67	3.62	0.82
2 2005	85	18,639	16.33	3.31	0.82
3 2004	85.33	18,712	18.00	3.49	0.84
3 2005	144	31,576	25.67	3.58	0.77
4 2004	42	9,210	16.67	3.67	0.92
4 2005	78	17,104	26.00	4.00	0.85
5 2004	99	21,709	14.67	2.29	0.59
5 2005	34	7,456	12.33	2.95	0.81

Mean ± standard deviation (SD) of macroinvertebrates in the 30 core samples were 94.7 ± 45.1 per sample, which extrapolates to 20,775 ± 9,881 macroinvertebrates m^{-2}. Mean species richness (S) of all 30 samples was 18.43, with a Shannon-Weaver diversity index (H', log2) of 3.25 and an evenness (J') of 0.78. The following section treats species composition by site and year.

i. Site 1 – City of Fort Lauderdale Marina

Table 3 lists abundances, percent composition and densities per replicate, and mean values and standard deviations for 2004. Macroinvertebrate abundance ranged from 105 to 115 specimens per replicate (mean 108.33 ± 5.77) for a density of 23,024-25,217 macroinvertebrates m^{-2} (mean 23,755 ± 1,266). Species richness ranged from 14 to 17 species (mean 15.33 ± 1.53). Mean higher taxonomic composition consisted of approximately 40% Crustacea, 27% Annelida, and 26% Sipuncula with the remaining 7% composed of Echinodermata, Mollusca and Nemertea.

Table 3. Site 1: City of Fort Lauderdale Marina. 2004 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 1 2004	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	count	%	n/m^2	count	%	n/m^2	count	%	n/m^2	count ± SD	% ± SD	n/m^2 ± SD
ANNELIDA	**21**	**18.26**	**4,605**	**18**	**17.14**	**3,947**	**50**	**47.62**	**10,964**	**29.67 ± 17.67**	**27.38 ± 16.31**	**6,505 ± 3875**
Oligochaeta												
Pectinodrilus sp.	4	3.48	877	13	12.38	2,851	17	16.19	3,728	11.33 ± 6.66	10.46 ± 6.15	2,485 ± 1,460
Polychaeta												
Arabella mutans	0	0.00	0	0	0.00	0	1	0.95	219	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
Capitella capitata	1	0.87	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
Ehlersia cornuta	2	1.74	439	3	2.86	658	1	0.95	219	2.00 ± 1.00	1.85 ± 0.92	439 ± 219
Fabriciola trilobata	3	2.61	658	0	0.00	0	6	5.71	1,316	3.00 ± 3.00	2.77 ± 2.77	658 ± 658
Minuspio sp.	0	0.00	0	0	0.00	0	1	0.95	219	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
Nematonereis hebes	0	0.00	0	0	0.00	0	2	1.90	439	0.67 ± 1.15	0.62 ± 1.07	146 ± 253
Notomastus daueri	3	2.61	658	2	1.90	439	1	0.95	219	2.00 ± 1.00	1.85 ± 0.92	439 ± 219
Paramphinome	3	2.61	658	0	0.00	0	0	0.00	0	1.00 ± 1.73	0.92 ± 1.60	219 ± 380
Polycirrus sp.	1	0.87	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
Polydora sp.	4	3.48	877	0	0.00	0	21	20.00	4,605	8.33 ± 11.15	7.69 ± 10.29	1,827 ± 2,445
CRUSTACEA	**42**	**36.52**	**9,210**	**56**	**53.33**	**12,280**	**33**	**31.43**	**7,236**	**43.67 ± 11.59**	**40.31 ± 10.70**	**9,575 ± 2542**
Amphipoda												
Grandidierella bonnieroides	0	0.00	0	0	0.00	0	3	2.86	658	1.00 ± 1.73	0.92 ± 1.60	219 ± 380
Isaeidae 1	0	0.00	0	1	0.95	219	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
Isaeidae 2	2	1.74	439	0	0.00	0	0	0.00	0	0.67 ± 1.15	0.62 ± 1.07	146 ± 253
Decapoda												
Pinnixa sp.	0	0.00	0	1	0.95	219	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
Pinnotheridae 2	0	0.00	0	1	0.95	219	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
Isopoda												
Malacanthura caribbica	1	0.87	219	1	0.95	219	0	0.00	0	0.67 ± 0.58	0.62 ± 0.53	146 ± 127
Xenanthura brevitelson	0	0.00	0	3	2.86	658	0	0.00	0	1.00 ± 1.73	0.92 ± 1.60	219 ± 380
Tanaidacea												
Leptochelia savignyi	3	2.61	658	8	7.62	1,754	6	5.71	1,316	5.67 ± 2.52	5.23 ± 2.32	1,243 ± 552
Mesokalliapseudes macsweenyi	36	31.30	7,894	41	39.05	8,991	24	22.86	5,263	33.67 ± 8.74	31.08 ± 8.06	7,382 ± 1,916
ECHINODERMATA	**0**	**0.00**	**0**	**1**	**0.95**	**219**	**0**	**0.00**	**0**	**0.33 ± 0.58**	**0.31 ± 0.53**	**73 ± 126.6**
Ophiurida												
Amphiodia sp.	0	0.00	0	1	0.95	219	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
HEMICHORDATA	**1**	**0.87**	**219**	**0**	**0.00**	**0**	**0**	**0.00**	**0**	**0.33 ± 0.58**	**0.31 ± 0.53**	**73 ± 126.6**
Enteropneusta 1	1	0.87	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
MOLLUSCA	**1**	**0.87**	**219**	**8**	**7.62**	**1,754**	**1**	**0.95**	**219**	**3.33 ± 4.04**	**3.08 ± 3.73**	**731 ± 886.2**
Gastropoda												
Caecum pulchellum	1	0.87	219	7	6.67	1,535	1	0.95	219	3.00 ± 3.46	2.77 ± 3.20	658 ± 760
Meioceras nitidum	0	0.00	0	1	0.95	219	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
NEMERTEA	**4**	**3.48**	**877**	**3**	**2.86**	**658**	**1**	**0.95**	**219**	2.67 ± **1.53**	**2.46 ± 1.41**	**585 ± 335**
Nemertea 1	3	2.61	658	0	0.00	0	0	0.00	0	1.00 ± 1.73	0.92 ± 1.60	219 ± 380
Nemertea 2	0	0.00	0	3	2.86	658	1	0.95	219	1.33 ± 1.53	1.23 ± 1.41	292 ± 335
Nemertea 3	1	0.87	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.31 ± 0.53	73 ± 127
SIPUNCULA	**46**	**40.00**	**10,087**	**19**	**18.10**	**4,166**	**20**	**19.05**	**4,386**	**28.33 ± 15.31**	**26.15 14.13**	**6,213 ± 3357**
Aspidosiphon sp.	46	40.00	10,087	19	18.10	4,166	20	19.05	4,386	28.33 ± 15.31	26.15 ± 14.13	6,213 ± 3,357
Total	**115**	**100.00**	**25,217**	**105**	**100.00**	**23,024**	**105**	**100.00**	**23,024**	**108.33 ± 5.77**	**100.00**	**23,755 ± 1,266**

Crustacea was the most abundant group in 2004 with a mean abundance of 43.67 ± 11.59 specimens per replicate and a density of 9,575 ± 2,542 crustaceans m^{-2}. Crustaceans were represented by 3 species of amphipod and 2 species each of decapod, isopod and tanaidacean. Of the 9 species identified, only the tanaidaceans, *Leptochelia savignyi* and *Mesokalliapseudes macsweenyi*, were found in all three replicates.

Mesokalliapseudes macsweenyi was the most abundant species in 2004 with 36, 41 and 24 specimens per replicate for a mean percent composition of 31.08 ± 8.06 %.

Annelida was the second most abundant group, with a mean abundance of 29.67 ± 17.67 specimens per replicate and a density of 6,505 ± 3,875 annelids m^{-2}. Eleven species of annelid were identified (mean richness 6.33 ± 2.89 per replicate), ten of which were polychaetes. The only oligochaete, *Pectinodrilus* sp., was the most abundant annelid (4, 13, 17) and the third most abundant species overall, with a mean percent composition of 10.46 ± 6.15%. Only three annelid species were found in all three replicates: *Pectinodrilus* sp. and 2 polychaetes, *Notomastus daueri* and *Ehlersia cornuta*.

Aspidosiphon sp. represented the third most abundant major taxon, Sipuncula, and was the second most abundant species, with 46, 19 and 20 specimens for a mean density of 6,213 ± 3,357 m^{-2} and percent composition of 26.15 ± 14.13%. The remaining species consisted of 1 ophiuroid and 3 nemerteans, which together accounted for ~7% of macroinvertebrate abundance.

Table 4 lists abundances, percent composition and densities per replicate, and mean values and standard deviations for 2005. Macroinvertebrate abundances ranged from 92 to 184 specimens per replicate (mean 150.33 ± 50.72) with a species richness of 14-20 species (mean 17.67 ± 3.21). Species richness remained approximately the same from the previous year, whereas mean abundance increased by nearly 50%. Densities ranged from 20,174 to 40,348 macroinvertebrates m^{-2} (mean 32,965 ± 11,121). Mean higher taxonomic composition consisted of approximately 47% Crustacea, 33%

Sipuncula, and 14% Annelida, with the remaining 6% represented by Mollusca and Nemertea.

Table 4. Site 1: City of Fort Lauderdale Marina. 2005 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 1 2005	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	**count**	**%**	**n/m²**	**count**	**%**	**n/m²**	**count**	**%**	**n/m²**	**count ± SD**	**% ± SD**	**n/m² ± SD**
ANNELIDA	**21**	**11.41**	**4,605**	**28**	**30.43**	**6,140**	**13**	**7.43**	**2,851**	**20.67 ± 7.51**	**13.75 ± 4.99**	**4,532 ± 1,646**
Oligochaeta												
Pectinodrilus sp.	9	4.89	1,974	0	0.00	0	2	1.14	439	3.67 ± 4.73	2.44 ± 3.14	804 ± 1,036
Tubificidae 1	1	0.54	219	6	6.52	1,316	3	1.71	658	3.33 ± 2.52	2.22 ± 1.67	731 ± 552
Polychaeta												
Chaetozone setosa	0	0.00	0	1	1.09	219	0	0.00	0	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Diopatra sp.	0	0.00	0	1	1.09	219	0	0.00	0	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Ehlersia cornuta	6	3.26	1,316	1	1.09	219	3	1.71	658	3.33 ± 2.52	2.22 ± 1.67	731 ± 552
Fabriciola trilobata	1	0.54	219	2	2.17	439	0	0.00	0	1.00 ± 1.00	0.67 ± 0.67	219 ± 219
Glycera sp.	0	0.00	0	0	0.00	0	1	0.57	219	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Nematonereis hebes	0	0.00	0	1	1.09	219	1	0.57	219	0.67 ± 0.58	0.44 ± 0.38	146 ± 127
Polycirrus sp.	1	0.54	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Polydora sp.	3	1.63	658	14	15.22	3,070	1	0.57	219	6.00 ± 7.00	3.99 ± 4.66	1,316 ± 1,535
Sphaerosyllis sp.	0	0.00	0	0	0.00	0	2	1.14	439	0.67 ± 1.15	0.44 ± 0.77	146 ± 253
Tharyx dorsobranchialis	0	0.00	0	2	2.17	439	0	0.00	0	0.67 ± 1.15	0.44 ± 0.77	146 ± 253
CRUSTACEA	**83**	**45.11**	**18,200**	**30**	**32.61**	**6,578**	**97**	**55.43**	**21,270**	**70.00 ± 35.34**	**46.56 ± 23.51**	**15,350 ± 7,750**
Amphipoda												
Ampelisca bicarinata	6	3.26	1,316	0	0.00	0	3	1.71	658	3.00 ± 3.00	2.00 ± 2.00	658 ± 658
Caprella pentantis	1	0.54	219	0	0.00	0	7	4.00	1,535	2.67 ± 3.79	1.77 ± 2.52	585 ± 830
Grandidierella bonnieroides	3	1.63	658	0	0.00	0	2	1.14	439	1.67 ± 1.53	1.11 ± 1.02	365 ± 335
Isaeidae 2	10	5.43	2,193	0	0.00	0	6	3.43	1,316	5.33 ± 5.03	3.55 ± 3.35	1,169 ± 1,104
Cumacea												
Cyclaspis sp.	1	0.54	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Decapoda												
Pinnotheridae 1	0	0.00	0	0	0.00	0	1	0.57	219	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Pinnotheridae 2	0	0.00	0	0	0.00	0	1	0.57	219	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Isopoda												
Malacanthura caribbica	0	0.00	0	1	1.09	219	1	0.57	219	0.67 ± 0.58	0.44 ± 0.38	146 ± 127
Xenanthura brevitelson	0	0.00	0	1	1.09	219	0	0.00	0	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Tanaidacea												
Leptochelia savignyi	14	7.61	3,070	1	1.09	219	13	7.43	2,851	9.33 ± 7.23	6.21 ± 4.81	2,047 ± 1,586
Mesokalliapseudes macsweenyi	48	26.09	10,525	27	29.35	5,921	63	36.00	13,815	46.00 ± 18.08	30.60 ± 12.03	10,087 ± 3,965
HEMICHORDATA	**5**	**2.72**	**1,096**	**0**	**0.00**	**0**	**1**	**0.57**	**219**	**2.00 ± 2.65**	**1.33 ± 1.76**	**439 ± 580**
Enteropneusta 1	5	2.72	1,096	0	0.00	0	1	0.57	219	2.00 ± 2.65	1.33 ± 1.76	439 ± 580
MOLLUSCA	**3**	**1.63**	**658**	**1**	**1.09**	**219**	**16**	**9.14**	**3,508**	**6.67 ± 8.14**	**4.43 ± 5.42**	**1,462 ± 1,786**
Bivalvia												
Geukensia granosissima	0	0.00	0	0	0.00	0	1	0.57	219	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Gastropoda												
Caecum pulchellum	3	1.63	658	1	1.09	219	15	8.57	3,289	6.33 ± 7.57	4.21 ± 5.04	1,389 ± 1,660
NEMERTEA	**3**	**1.63**	**658**	**0**	**0.00**	**0**	**0**	**0.00**	**0**	**1.00 ± 1.73**	**0.67 ± 1.15**	**219 ± 380**
Nemertea 1	2	1.09	439	0	0.00	0	0	0.00	0	0.67 ± 1.15	0.44 ± 0.77	146 ± 253
Nemertea 3	1	0.54	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
SIPUNCULA	**69**	**37.50**	**15,130**	**33**	**35.87**	**7,236**	**48**	**27.43**	**10,525**	**50.00 ± 18.08**	**33.26 ± 12.03**	**10,964 ± 3,965**
Aspidosiphon sp.	68	36.96	14,911	33	35.87	7,236	48	27.43	10,525	49.67 ± 17.56	33.04 ± 11.68	10,891 ± 3,850
Sipuncula 1	1	0.54	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.22 ± 0.38	73 ± 127
Total	**184**	**100.00**	**40,348**	**92**	**100.00**	**20,174**	**175**	**100.00**	**38,374**	**150.33 ± 50.72**	**100.00**	**32,965 ± 11,122**

Crustacea remained the most abundant group in 2005 with a mean abundance of 70 ± 35.34 specimens per replicate and density of 15,350 ± 7,750 crustaceans m^{-2}. Abundance and diversity increased from 2004. Crustacea included 11 species in 2005: 4

amphipods, 2 species each of decapod, isopod and tanaidacean, and 1 cumacean. The two tanaidacean species from 2004, *L. savignyi* and *M. macsweenyi*, remained the only crustacean species found in all three replicates in 2005. The latter was the second most abundant species in 2005 (mean abundance 46.00 ± 18.08 per replicate), and accounted for ~30% of macroinvertebrate composition.

Annelida was the third most abundant group in 2005 with a mean abundance of 20.67 ± 7.50 specimens per replicate and a density of 4,532 ± 1,646 annelids m^{-2}. Annelid abundance decreased from 2004 to 2005 by approximately one-third. Twelve species were identified in 2005 (mean richness 7 ± 1): 2 oligochaetes and 10 polychaetes. A tubificid oligochaete and 2 polychaetes, *E. cornuta* and *Polydora* sp., were the only annelids identified in all three replicates.

Sipuncula was the second most abundant group in 2005 with a mean abundance of 50 ± 18.08 specimens per replicate, an increase of ~75% from the previous year. Two sipunculan species were identified, but 99.34% were *Aspidosiphon* sp., the most abundant species in 2005, with a mean percent composition of 33.04 ± 11.68%. The remaining species consisted of 2 species each of mollusks (1 bivalve and 1 gastropod) and nemerteans.

ii. Site 2 - Bahia Mar Marina

Table 5 lists abundances, percentage composition and densities per replicate, and mean values and standard deviation for 2004. Macroinvertebrate abundances ranged from 106 to 134 specimens per replicate (mean 121.33 ± 14.19) with a richness of 20-24 species (mean 21.67 ± 2.08). Extrapolated densities range from 23,244 to 29,384 macroinvertebrates m^{-2} with a mean of 26,606 ± 3,111. Mean higher taxonomic composition consisted of ~63% Annelida, 22% Mollusca, and 8% Sipuncula with the remaining 7% consisting of Crustacea, Ophiuroidea and Nemertea.

Table 5. Site 2: Bahia Mar Marina. 2004 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 2 2004	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	count	%	n/m²	count	%	n/m²	count	%	n/m²	count ± SD	% ± SD	n/m² ± SD
ANNELIDA	**74**	**69.81**	**16,227**	**78**	**62.90**	**17,104**	**77**	**57.46**	**16,885**	**76.33 ± 2.08**	**62.91 ± 1.72**	**16,738 ± 456**
Oligochaeta												
Pectinodrilus sp.	4	3.77	877	2	1.61	439	2	1.49	439	2.67 ± 1.15	2.20 ± 0.95	585 ± 253
Tubificidae 1	7	6.60	1,535	8	6.45	1,754	12	8.96	2,631	9.00 ± 2.65	7.42 ± 2.18	1,974 ± 580
Tubificidae 2	3	2.83	658	3	2.42	658	7	5.22	1,535	4.33 ± 2.31	3.57 ± 1.90	950 ± 506
Tubificidae 3	0	0.00	0	1	0.81	219	0	0.00	0	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
Tubificoides sp.	24	22.64	5,263	18	14.52	3,947	17	12.69	3,728	19.67 ± 3.79	16.21 ± 3.12	4,313 ± 830
Polychaeta												
Axiothella sp.	3	2.83	658	2	1.61	439	1	0.75	219	2.00 ± 1.00	1.65 ± 0.82	439 ± 219
Capitella capitata	6	5.66	1,316	7	5.65	1,535	0	0.00	0	4.33 ± 3.79	3.57 ± 3.12	950 ± 830
Chaetozone setosa	1	0.94	219	1	0.81	219	0	0.00	0	0.67 ± 0.58	0.55 ± 0.48	146 ± 127
Ehlersia cornuta	0	0.00	0	1	0.81	219	3	2.24	658	1.33 ± 1.53	1.10 ± 1.26	292 ± 335
Fabriciola trilobata	4	3.77	877	11	8.87	2,412	20	14.93	4,386	11.67 ± 8.02	9.62 ± 6.61	2,558 ± 1,759
Lumbrineris sp.1	0	0.00	0	2	1.61	439	0	0.00	0	0.67 ± 1.15	0.55 ± 0.95	146 ± 253
Minuspio sp.	1	0.94	219	0	0.00	0	1	0.75	219	0.67 ± 0.58	0.55 ± 0.48	146 ± 127
Nematonereis hebes	1	0.94	219	1	0.81	219	0	0.00	0	0.67 ± 0.58	0.55 ± 0.48	146 ± 127
Notomastus sp.	1	0.94	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
Pisionidae 1	1	0.94	219	2	1.61	439	0	0.00	0	1.00 ± 1.00	0.82 ± 0.82	219 ± 219
Polydora sp.	1	0.94	219	5	4.03	1,096	1	0.75	219	2.33 ± 2.31	1.92 ± 1.90	512 ± 506
Prionospio sp.	1	0.94	219	2	1.61	439	0	0.00	0	1.00 ± 1.00	0.82 ± 0.82	219 ± 219
Tharyx dorsobranchialis	16	15.09	3,508	12	9.68	2,631	11	8.21	2,412	13.00 ± 2.65	10.71 ± 2.18	2,851 ± 580
Tharyx sp.2	0	0.00	0	0	0.00	0	2	1.49	439	0.67 ± 1.15	0.55 ± 0.95	146 ± 253
CRUSTACEA	**0**	**0.00**	**0**	**2**	**1.61**	**439**	**2**	**1.49**	**439**	**1.33 ± 1.15**	**1.10 ± 0.95**	**292 ± 253**
Decapoda												
Pinnotheridae 2	0	0.00	0	1	0.81	219	0	0.00	0	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
Isopoda												
Xenanthura brevitelson	0	0.00	0	0	0.00	0	1	0.75	219	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
Ostracoda												
Sarsiellidae 2	0	0.00	0	1	0.81	219	1	0.75	219	0.67 ± 0.58	0.55 ± 0.48	146 ± 127
ECHINODERMATA	**0**	**0.00**	**0**	**1**	**0.81**	**219**	**0**	**0.00**	**0**	**0.33 ± 0.58**	**0.27 ± 0.48**	**73 ± 127**
Ophiurida												
Amphiodia sp.	0	0.00	0	1	0.81	219	0	0.00	0	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
MOLLUSCA	**17**	**16.04**	**3,728**	**26**	**20.97**	**5,701**	**38**	**28.36**	**8,333**	**27.00 ± 10.54**	**22.25 ± 8.68**	**5,921 ± 2,310**
Bivalvia												
Abra/Ervilia sp.	0	0.00	0	0	0.00	0	1	0.75	219	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
Timoclea pygmaea	1	0.94	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
Gastropoda												
Acteocina sp.	0	0.00	0	3	2.42	658	2	1.49	439	1.67 ± 1.53	1.37 ± 1.26	365 ± 335
Caecum pulchellum	15	14.15	3,289	22	17.74	4,824	33	24.63	7,236	23.33 ± 9.07	19.23 ± 7.48	5,117 ± 1,990
Meioceras nitidum	0	0.00	0	0	0.00	0	1	0.75	219	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
Turbonilla sp. 1	1	0.94	219	1	0.81	219	1	0.75	219	1.00 ± 0.00	0.82 ± 0.00	219 ± 0
NEMERTEA	**4**	**3.77**	**877**	**8**	**6.45**	**1,754**	**6**	**4.48**	**1,316**	**6.00 ± 2.00**	**4.95 ± 1.65**	**1,316 ± 439**
Nemertea 2	4	3.77	877	8	6.45	1,754	5	3.73	1,096	5.67 ± 2.08	4.67 ± 1.72	1,243 ± 456
Nemertea 3	0	0.00	0	0	0.00	0	1	0.75	219	0.33 ± 0.58	0.27 ± 0.48	73 ± 127
SIPUNCULA	**11**	**10.38**	**2,412**	**9**	**7.26**	**1,974**	**11**	**8.21**	**2,412**	**10.33 ± 1.15**	**8.52 ± 0.95**	**2,266 ± 253**
Sipuncula 1	11	10.38	2,412	9	7.26	1,974	11	8.21	2,412	10.33 ± 1.15	8.52 ± 0.95	2,266 ± 253
Total	**106**	**100.00**	**23,244**	**124**	**100.00**	**27,191**	**134**	**100.00**	**29,384**	**121.33 ± 14.19**	**100.00**	**26,606 ± 3,111**

Annelida was the most abundant group in 2004, with a mean abundance of 76.33 ± 2.08 specimens per replicate and density of 16,738 ± 456 annelids m^{-2}. They were represented by 5 oligochaetes and 14 polychaetes (mean richness 14 ± 2.64 species per replicate). Four polychaetes (*Axiothella* sp., *Tharyx dorsobranchialis*, *Fabriciola trilobata* and *Polydora* sp.), and four oligochaetes (*Pectinodrilus* sp., *Tubificoides* sp. and 2 unidentified tubificid species) were found in all three replicates. *Tubificoides* sp. was the second most abundant species in 2004 with 17-24 specimens per replicate, accounting for mean percent composition and density of 16.21 ± 3.12% and 4,313 ± 830 m^{-2}, respectively. *T. dorsobranchialis* was the third most abundant species, accounting for 10.71 ± 2.18% of specimens.

Mollusca was the second most common group, with a mean abundance of 27 ± 10.54 specimens per replicate and density of 5,921 ± 2,310 mollusks m^{-2}. The 6 mollusk species (mean species richness 3.67 ± 1.15) included 2 bivalves and 4 gastropods. The gastropod *Caecum pulchellum* was the most abundant species in 2004 with 15-33 specimens per replicate (mean 23.33 ± 9.07), which accounted for a mean percent composition of 19.23 ± 7.48% and density of 5,117 ± 1,990 m^{-2}. *C. pulchellum* was also the only mollusk found in all three replicates.

Of the remaining 15% of mean macroinvertebrate composition, over half (8.52 ± 0.95%) consisted of an unidentified sipunculan species found in all three replicates. Three crustacean (1 decapod, 1 isopod and 1 ostracod), 1 ophiuroid and 2 nemertean species accounted for the remaining 6.5%.

Table 6 lists abundances, percent composition and densities per replicate, and mean values and standard deviations for 2005. Macroinvertebrate abundances of 46-109 specimens (mean 85 ± 34.07) and richness of 15-19 species (mean 16.33 ± 2.30) per replicate decreased from the previous year. Densities ranged from 10,087 to 23,902 macroinvertebrates m^{-2}, with a mean of 18,639 ± 7,472. Mean composition of higher taxa was ~75% Annelida, 14% Mollusca, and 5% Crustacea, with Ophiuroidea, Nemertea and Sipuncula accounting for the remaining 6%.

Table 6. Site 2: Bahia Mar Marina. 2005 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 2 2005	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	**count**	**%**	**n/m^2**	**count**	**%**	**n/m^2**	**count**	**%**	**n/m^2**	**count ± SD**	**% ± SD**	**n/m^2 ± SD**
ANNELIDA	**39**	**84.78**	**8,552**	**85**	**85.00**	**18,639**	**66**	**60.55**	**14,473**	**63.33 ± 23.12**	**74.51 ± 27.19**	**13,888 ± 5,069**
Oligochaeta												
Tubificidae 1	5	10.87	1,096	6	6.00	1,316	5	4.59	1,096	5.33 ± 0.58	6.27 ± 0.68	1,169 ± 127
Tubificidae 2	2	4.35	439	8	8.00	1,754	4	3.67	877	4.67 ± 3.06	5.49 ± 3.59	1,023 ± 670
Tubificidae 3	0	0.00	0	1	1.00	219	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Tubificoides sp.	9	19.57	1,974	24	24.00	5,263	18	16.51	3,947	17.00 ± 7.55	20.00 ± 8.88	3,728 ± 1,656
Polychaeta												
Axiothella sp.	1	2.17	219	0	0.00	0	2	1.83	439	1.00 ± 1.00	1.18 ± 1.18	219 ± 219
Capitella capitata	2	4.35	439	0	0.00	0	1	0.92	219	1.00 ± 1.00	1.18 ± 1.18	219 ± 219
Chaetozone setosa	0	0.00	0	2	2.00	439	0	0.00	0	0.67 ± 1.15	0.78 ± 1.36	146 ± 253
Ehlersia cornuta	0	0.00	0	1	1.00	219	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Fabriciola trilobata	11	23.91	2,412	19	19.00	4,166	20	18.35	4,386	16.67 ± 4.93	19.61 ± 5.80	3,655 ± 1,082
Lumbrineris sp.2	0	0.00	0	1	1.00	219	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Pseudopolydora sp.	1	2.17	219	2	2.00	439	2	1.83	439	1.67 ± 0.58	1.96 ± 0.68	365 ± 127
Sphaerosyllis sp.	0	0.00	0	3	3.00	658	2	1.83	439	1.67 ± 1.53	1.96 ± 1.80	365 ± 335
Tharyx dorsobranchialis	5	10.87	1,096	18	18.00	3,947	7	6.42	1,535	10.00 ± 7.00	11.76 ± 8.24	2,193 ± 1,535
Tharyx sp.1	3	6.52	658	0	0.00	0	5	4.59	1,096	2.67 ± 2.52	3.14 ± 2.96	585 ± 552
CRUSTACEA	**2**	**4.35**	**439**	**2**	**2.00**	**439**	**8**	**7.34**	**1,754**	**4.00 ± 3.46**	**4.71 ± 4.08**	**877 ± 760**
Amphipoda												
Grandidierella bonnieroides	1	2.17	219	2	2.00	439	4	3.67	877	2.33 ± 1.53	2.75 ± 1.80	512 ± 335
Decapoda												
Clibanarius sp.	0	0.00	0	0	0.00	0	1	0.92	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Isopoda												
Xenanthura brevitelson	1	2.17	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Tanaidacea												
Leptochelia savignyi	0	0.00	0	0	0.00	0	2	1.83	439	0.67 ± 1.15	0.78 ± 1.36	146 ± 253
Ostracoda												
Cytherididae 1	0	0.00	0	0	0.00	0	1	0.92	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
ECHINODERMATA	**0**	**0.00**	**0**	**0**	**0.00**	**0**	**1**	**0.92**	**219**	**0.33 ± 0.58**	**0.39 ± 0.68**	**73 ± 127**
Ophiurida												
Amphioplus sp.	0	0.00	0	0	0.00	0	1	0.92	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
MOLLUSCA	**3**	**6.52**	**658**	**6**	**6.00**	**1,316**	**27**	**24.77**	**5,921**	**12.00 ± 13.08**	**14.12 ± 15.38**	**2,631 ± 2,867**
Bivalvia												
Tagelus sp.	1	2.17	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Gastropoda												
Caecum pulchellum	2	4.35	439	6	6.00	1,316	27	24.77	5,921	11.67 ± 13.43	13.73 ± 15.80	2,558 ± 2,945
NEMERTEA	**1**	**2.17**	**219**	**2**	**2.00**	**439**	**1**	**0.92**	**219**	**1.33 ± 0.58**	**1.57 ± 0.68**	**292 ± 127**
Nemertea 2	1	2.17	219	2	2.00	439	1	0.92	219	1.33 ± 0.58	1.57 ± 0.68	292 ± 127
SIPUNCULA	**1**	**2.17**	**219**	**5**	**5.00**	**1,096**	**5**	**4.59**	**1,096**	**3.67 ± 2.31**	**4.31 ± 2.72**	**804 ± 506**
Sipuncula 1	1	2.17	219	5	5.00	1,096	5	4.59	1,096	3.67 ± 2.31	4.31 ± 2.72	804 ± 506
Total	**46**	**100.00**	**10,087**	**100**	**100.00**	**21,928**	**109**	**100.00**	**23,902**	**85.00 ± 34.07**	**99.61**	**18,639 ± 7,472**

Annelida was the most abundant group in 2005, though abundances varied considerably among replicates (39, 85 and 67), due in large part to larger numbers of the oligochaete *Tubificoides* sp. (9, 24, 18) and the polychaete *F. trilobata* (11, 19, 20) in the second and third replicates, with mean percent compositions of 20 ± 8.88% and 19.61 ± 5.8%, respectively. These two species were the first and second most abundant species in 2005, respectively, and accounted for over half of annelid abundance in each replicate. However, the 16 annelid species identified in 2005 (4 oligochaetes and 12 polychaetes) were dispersed evenly, with 9-11 species per replicate. Three oligochaete species (Tubificidae sp. 1 and sp. 2, and *Tubificoides* sp.) and 3 polychaete species (*T. dorsobranchialis*, *F. trilobata* and *Pseudopolydora* sp.) were found in all three replicates.

Mollusca remained the second most abundant group in 2005, but richness decreased from the previous year by about two-thirds. Only 2 species remained present: the bivalve *Tagelus* sp. and the gastropod *C. pulchellum*. The abundance of *C. pulchellum* in the third replicate (2, 6, 27) was the largest of any species at Site 2 in 2005, constituting the majority of mollusk specimens and making it the third most abundant species (mean percent composition 13.73 ± 15.8%).

Crustacea experienced a slight increase in species richness in 2005 with 5 species (1 amphipod, decapod, isopod, tanaidacean and ostracod each). The amphipod *Grandidierella bonnieroides* was the only crustacean in all three replicates (1, 2, 4). One species each of Nemertea and Sipuncula were also found in all three replicates. Lastly, one ophiuroid species (*Amphioplus* sp.) accounted for the remaining macroinvertebrate composition in 2005.

iii. Site 3 - Background Site

Table 7 lists abundances, percentage composition, and densities per replicate, and mean values and standard deviations for in 2004. Abundances ranged from 71 to 93 specimens per replicate (mean 85.33 ± 12.42) with a richness of 15-20 species (mean 18 ± 2.64). Densities ranged from 15,569 to 20,393 macroinvertebrates m^{-2} per replicate with a mean of 18,712 ± 2,724. The mean higher taxon composition consisted of ~70% Annelida and 22% Crustacea, with Gastropoda, Nemertea and Sipuncula comprising the rest.

Table 7. Site 3: Background. 2004 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 3 2004	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	**count**	**%**	**n/m²**	**count**	**%**	**n/m²**	**count**	**%**	**n/m²**	**count ± SD**	**% ± SD**	**n/m² ± SD**
ANNELIDA	**46**	**64.79**	**10,087**	**66**	**71.74**	**14,473**	**66**	**70.97**	**14,473**	**59.33 ± 11.55**	**69.53 ± 13.53**	**13,011 ± 2,532**
Oligochaeta												
Tubificidae 1	4	5.63	877	12	13.04	2,631	10	10.75	2,193	8.67 ± 4.16	10.16 ± 4.88	1,900 ± 913
Tubificidae 2	1	1.41	219	4	4.35	877	4	4.30	877	3.00 ± 1.73	3.52 ± 2.03	658 ± 380
Tubificoides sp.	3	4.23	658	13	14.13	2,851	14	15.05	3,070	10.00 ± 6.08	11.72 ± 7.13	2,193 ± 1,334
Polychaeta												
Axiothella sp.	2	2.82	439	3	3.26	658	2	2.15	439	2.33 ± 0.58	2.73 ± 0.68	512 ± 127
Brania sp.	0	0.00	0	0	0.00	0	1	1.08	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Capitella capitata	2	2.82	439	4	4.35	877	1	1.08	219	2.33 ± 1.53	2.73 ± 1.79	512 ± 335
Fabriciola trilobata	19	26.76	4,166	4	4.35	877	17	18.28	3,728	13.33 ± 8.14	15.63 ± 9.54	2,924 ± 1,786
Lumbrineris sp.1	0	0.00	0	1	1.09	219	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Lumbrineris sp.2	3	4.23	658	3	3.26	658	1	1.08	219	2.33 ± 1.15	2.73 ± 1.35	512 ± 253
Nematonereis hebes	1	1.41	219	1	1.09	219	0	0.00	0	0.67 ± 0.58	0.78 ± 0.68	146 ± 127
Orbinia riseri	0	0.00	0	1	1.09	219	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Pisionidae 1	0	0.00	0	1	1.09	219	0	0.00	0	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Polydora sp.	0	0.00	0	0	0.00	0	1	1.08	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Prionospio sp.	2	2.82	439	0	0.00	0	1	1.08	219	1.00 ± 1.00	1.17 ± 1.17	219 ± 219
Sphaerosyllis sp.	0	0.00	0	0	0.00	0	1	1.08	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Terebellides stroemi	1	1.41	219	1	1.09	219	0	0.00	0	0.67 ± 0.58	0.78 ± 0.68	146 ± 127
Tharyx dorsobranchialis	4	5.63	877	13	14.13	2,851	7	7.53	1,535	8.00 ± 4.58	9.38 ± 5.37	1,754 ± 1,005
Tharyx sp.1	4	5.63	877	5	5.43	1,096	6	6.45	1,316	5.00 ± 1.00	5.86 ± 1.17	1,096 ± 219
CRUSTACEA	**15**	**21.13**	**3,289**	**18**	**19.57**	**3,947**	**23**	**24.73**	**5,043**	**18.67 ± 4.04**	**21.88 ± 4.74**	**4,093 ± 886**
Cumacea												
Cyclaspis sp.	0	0.00	0	0	0.00	0	1	1.08	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
Isopoda												
Xenanthura brevitelson	0	0.00	0	1	1.09	219	4	4.30	877	1.67 ± 2.08	1.95 ± 2.44	365 ± 456
Ostracoda												
Cytherididae 1	14	19.72	3,070	16	17.39	3,508	13	13.98	2,851	14.33 ± 1.53	16.80 ± 1.79	3,143 ± 335
Sarsiellidae 2	1	1.41	219	1	1.09	219	5	5.38	1,096	2.33 ± 2.31	2.73 ± 2.71	512 ± 506
MOLLUSCA	**0**	**0.00**	**0**	**0**	**0.00**	**0**	**1**	**1.08**	**219**	**0.33 ± 0.58**	**0.39 ± 0.68**	**73 ± 127**
Gastropoda												
Turbonilla sp. 2	0	0.00	0	0	0.00	0	1	1.08	219	0.33 ± 0.58	0.39 ± 0.68	73 ± 127
NEMERTEA	**0**	**0.00**	**0**	**1**	**1.09**	**219**	**1**	**1.08**	**219**	**0.67 ± 0.58**	**0.78 ± 0.68**	**146 ± 127**
Nemertea 2	0	0.00	0	1	1.09	219	1	1.08	219	0.67 ± 0.58	0.78 ± 0.68	146 ± 127
SIPUNCULA	**10**	**14.08**	**2,193**	**7**	**7.61**	**1,535**	**2**	**2.15**	**439**	**6.33 ± 4.04**	**7.42 ± 4.74**	**1,389 ± 886**
Sipuncula 1	10	14.08	2,193	7	7.61	1,535	2	2.15	439	6.33 ± 4.04	7.42 ± 4.74	1,389 ± 886
Total	**71**	**100.00**	**15,569**	**92**	**100.00**	**20,174**	**93**	**100.00**	**20,393**	**85.33 ± 12.42**	**100.00**	**18,712 ± 2,724**

Annelida was the most abundant group in 2004 with a mean abundance of 59.33 ± 11.55 specimens per replicate and mean density of 13,011 ± 2,532 annelids m^{-2}. Eighteen annelid species were identified (mean richness of 13 ± 1 species per replicate): three tubificid oligochaetes and 15 polychaetes. Half of the annelid species were found in all three replicates: 3 oligochaetes (Tubificidae 1, Tubificidae 2 and Tubificoides sp.) and 6 polychaetes (*Capitella capitata*, *Axiothella* sp. 2, *T. dorsobranchialis*, *Tharyx* sp., *Lumbrineris* sp. 2 and *F. trilobata*). *F. trilobata* was the second most abundant species in 2004 with 19, 4 and 17 specimens per replicate (mean abundance 13.33 ± 8.14; mean percent composition 15.63 ± 9.54%). *Tubificoides* sp. was the third most abundant species with a mean abundance of 10 ± 6.08 specimens per replicate (3, 13, 14) and a mean percent composition of 11.72 ± 7.13%.

Crustacea was the second most common group in 2004 with a mean abundance of 18.67 ± 4.04 specimens per replicate and density of 4,093 ± 886 crustaceans m^{-2}. Four species were identified in 2004: 1 cumacean, 1 isopod, and 2 ostracods. The two ostracod species, Cytherididae 1 and Sarsiellidae 2, were found in all three replicates and accounted for approximately 90% of crustacean abundance. The cytheridid was the most abundant species with a mean abundance of 14.33 ± 1.53 specimens per replicate and mean percent composition of 16.80 ± 1.79%.

The gastropod *Turbonilla* sp. 2, one nemertean and one sipunculan species accounted for the remaining 8% composition in 2004. The sipunculan occurred in all three replicates.

Table 8. Site 3: Background. 2005 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 3 2005	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	**count**	**%**	**n/m^2**	**count**	**%**	**n/m^2**	**count**	**%**	**n/m^2**	**count ± SD**	**% ± SD**	**n/m^2 ± SD**
ANNELIDA	**67**	**75.28**	**14,692**	**131**	**82.91**	**28,726**	**161**	**87.03**	**35,304**	**119.67 ± 48.01**	**83.10 ± 33.34**	**26,241 ± 10,529**
Oligochaeta												
Tubificidae 1	13	14.61	2,851	28	17.72	6,140	13	7.03	2,851	18.00 ± 8.66	12.50 ± 6.01	3,947 ± 1,899
Tubificidae 2	6	6.74	1,316	6	3.80	1,316	5	2.70	1,096	5.67 ± 0.58	3.94 ± 0.40	1,243 ± 127
Tubificidae 3	0	0.00	0	1	0.63	219	2	1.08	439	1.00 ± 1.00	0.69 ± 0.69	219 ± 219
Tubificoides sp.	4	4.49	877	17	10.76	3,728	5	2.70	1,096	8.67 ± 7.23	6.02 ± 5.02	1,900 ± 1,586
Polychaeta												
Aricidea catherinae	0	0.00	0	0	0.00	0	1	0.54	219	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Axiothella sp.	4	4.49	877	1	0.63	219	1	0.54	219	2.00 ± 1.73	1.39 ± 1.20	439 ± 380
Brania sp.	1	1.12	219	4	2.53	877	1	0.54	219	2.00 ± 1.73	1.39 ± 1.20	439 ± 380
Capitella capitata	8	8.99	1,754	6	3.80	1,316	11	5.95	2,412	8.33 ± 2.52	5.79 ± 1.75	1,827 ± 552
Fabriciola trilobata	17	19.10	3,728	19	12.03	4,166	95	51.35	20,832	43.67 ± 44.47	30.32 ± 30.88	9,575 ± 9,751
Glycera sp.	1	1.12	219	0	0.00	0	1	0.54	219	0.67 ± 0.58	0.46 ± 0.40	146 ± 127
Goniadidae 1	0	0.00	0	0	0.00	0	1	0.54	219	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Lumbrineris sp.2	0	0.00	0	4	2.53	877	2	1.08	439	2.00 ± 2.00	1.39 ± 1.39	439 ± 439
Magelona sp.	0	0.00	0	0	0.00	0	1	0.54	219	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Minuspio sp.	0	0.00	0	3	1.90	658	0	0.00	0	1.00 ± 1.73	0.69 ± 1.20	219 ± 380
Nematonereis hebes	0	0.00	0	1	0.63	219	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Orbinia riseri	0	0.00	0	0	0.00	0	1	0.54	219	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Pettibonia duofurca	2	2.25	439	3	1.90	658	0	0.00	0	1.67 ± 1.53	1.16 ± 1.06	365 ± 335
Pisionidae 1	0	0.00	0	1	0.63	219	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Polynoidae 1	0	0.00	0	2	1.27	439	0	0.00	0	0.67 ± 1.15	0.46 ± 0.80	146 ± 253
Prionospio sp.	3	3.37	658	0	0.00	0	0	0.00	0	1.00 ± 1.73	0.69 ± 1.20	219 ± 380
Pseudopolydora sp.	0	0.00	0	6	3.80	1,316	8	4.32	1,754	4.67 ± 4.16	3.24 ± 2.89	1,023 ± 913
Sphaerosyllis sp.	2	2.25	439	4	2.53	877	7	3.78	1,535	4.33 ± 2.52	3.01 ± 1.75	950 ± 552
Tharyx dorsobranchialis	3	3.37	658	22	13.92	4,824	6	3.24	1,316	10.33 ± 10.21	7.18 ± 7.09	2,266 ± 2,240
Tharyx sp.1	3	3.37	658	3	1.90	658	0	0.00	0	2.00 ± 1.73	1.39 ± 1.20	439 ± 380
CRUSTACEA	**18**	**20.22**	**3,947**	**19**	**12.03**	**4,166**	**13**	**7.03**	**2,851**	**16.67 ± 3.21**	**11.57 ± 2.23**	**3,655 ± 705**
Amphipoda												
Ampelisca bicarinata	0	0.00	0	1	0.63	219	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Cumacea												
Cyclaspis sp.	1	1.12	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Vaunthompsonia sp.	1	1.12	219	0	0.00	0	1	0.54	219	0.67 ± 0.58	0.46 ± 0.40	146 ± 127
Isopoda												
Xenanthura brevitelson	0	0.00	0	1	0.63	219	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Mysida												
Mysidae 2	2	2.25	439	0	0.00	0	0	0.00	0	0.67 ± 1.15	0.46 ± 0.80	146 ± 253
Ostracoda												
Cytherididae 1	11	12.36	2,412	16	10.13	3,508	9	4.86	1,974	12.00 ± 3.61	8.33 ± 2.50	2,631 ± 791
Eusarsiella sp.	2	2.25	439	0	0.00	0	1	0.54	219	1.00 ± 1.00	0.69 ± 0.69	219 ± 219
Harbansus paucichelatus	1	1.12	219	1	0.63	219	1	0.54	219	1.00 ± 0.00	0.69 ± 0.00	219 ± 0
Sarsiellidae 2	0	0.00	0	0	0.00	0	1	0.54	219	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
ECHINODERMATA	**1**	**1.12**	**219**	**2**	**1.27**	**439**	**0**	**0.00**	**0**	**1.00 ± 1.00**	**0.69 ± 0.69**	**219 ± 219**
Ophiurida												
Amphioplus sp.	1	1.12	219	2	1.27	439	0	0.00	0	1.00 ± 1.00	0.69 ± 0.69	219 ± 219
MOLLUSCA	**2**	**2.25**	**439**	**2**	**1.27**	**439**	**2**	**1.08**	**439**	**2.00 ± 0.00**	**1.39 ± 0.00**	**439 ± 0**
Bivalvia												
Ctena orbiculata	0	0.00	0	0	0.00	0	1	0.54	219	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Diplodonta punctata	1	1.12	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Macoma sp.	0	0.00	0	1	0.63	219	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Parvilucina crenella	1	1.12	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Gastropoda												
Acteon candens	0	0.00	0	1	0.63	219	0	0.00	0	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
Caecum pulchellum	0	0.00	0	0	0.00	0	1	0.54	219	0.33 ± 0.58	0.23 ± 0.40	73 ± 127
NEMERTEA	**0**	**0.00**	**0**	**3**	**1.90**	**658**	**6**	**3.24**	**1,316**	**3.00 ± 3.00**	**2.08 ± 2.08**	**658 ± 658**
Nemertea 2	0	0.00	0	3	1.90	658	4	2.16	877	2.33 ± 2.08	1.62 ± 1.45	512 ± 456
Nemertea 3	0	0.00	0	0	0.00	0	2	1.08	439	0.67 ± 1.15	0.46 ± 0.80	146 ± 253
SIPUNCULA	**1**	**1.12**	**219**	**1**	**0.63**	**219**	**3**	**1.62**	**658**	**1.67 ± 1.15**	**1.16 ± 0.80**	**365 ± 253**
Sipuncula 1	1	1.12	219	1	0.63	219	3	1.62	658	1.67 ± 1.15	1.16 ± 0.80	365 ± 253
Total	**89**	**100.00**	**19,516**	**158**	**100.00**	**34,646**	**185**	**100.00**	**40,567**	**144.00 ± 49.51**	**100.00**	**31,576 ± 10,856**

Table 8 lists abundances, percentage composition, and densities per replicate, and mean values and standard deviation for 2005. Replicate abundances varied from 89 to 185 specimens (mean 144 ± 49.51), but species richness ranged only between 23 and 27 species per replicate (mean 25.67 ± 2.31). Densities ranged from 19,516 to 40,567 macroinvertebrates m^{-2} (mean 31,576 ± 10,856). Mean higher taxon composition was ~83% Annelida and 12% Crustacea with the remaining 5% consisting of Ophiuroidea, Mollusca, Nemertea and Sipuncula.

Annelida remained the most abundant group in 2005 with a mean abundance and density of 119.67 ± 48.01 specimens per replicate and 26,241 ± 10,529 annelids m^{-2}, respectively. Mean abundance doubled from the previous year. Four species of tubificid oligochaete and 20 species of polychaete were identified in 2005 (mean richness 16 ± 2.65 species per replicate). Of these, 9 were found in all three replicates: 3 oligochaetes (Tubificidae 1, Tubificidae 2 and *Tubificoides* sp.) and 6 polychaetes (*C. capitata*, *Axiothella* sp., *T. dorsobranchialis*, *Brania* sp., *Sphaerosyllis* sp. and *F. trilobata*). *F. trilobata* was the most abundant species in 2005 with mean abundance of 43.67 ± 44.47 specimens per replicate and mean percent composition of 30.32 ± 30.88%, though its numbers were skewed by one replicate (17, 19 and 95). The unidentified tubificid oligochaete, Tubificidae 1, was the second most abundant species in 2005 and, like *F. trilobata*, it also varied in abundance among the replicates (13, 28, 13; mean 18 ± 8.66 specimens per replicate) with a mean percent composition of 12.5 ± 6.01%.

Crustacea remained the second most abundant group in 2005, but mean percent composition decreased to half that of the previous year, while richness more than doubled. Mean abundance and density were 16.67 ± 3.21 specimens per replicate and

3,655 ± 705 crustaceans m^{-2}, respectively. Species richness was relatively even, with a mean of 5 ± 1 species per replicate, two of which were ostracods found in each replicate: Cytherididae 1 and *Harbansus paucichelatus*. The former was the most abundant non-annelid in 2005, with a mean abundance of 12 ± 3.61 specimens per replicate and a mean percent composition of 8.33 ± 2.5%.

Ten species made up the remaining 5% of macroinvertebrates in 2005: 1 ophiuroid, 4 bivalves, 2 gastropods, 2 nemerteans and 1 sipunculan. Of these, only the sipunculan were found in all three replicates.

iv. Site 4 - Lauderdale Marina

Table 9 lists abundances, percent compositions, and densities per replicate, and mean values and standard deviations for 2004. Abundances ranged from 20 to 72 specimens per replicate (mean 42 ± 26.91) with a richness of 13-23 species (mean 16.67 ± 5.51). Densities ranged from 4,386 to 15,788 macroinvertebrates m^{-2} with a mean of 9,210 ± 5,900. The mean composition of the higher taxa was approximately 79% Annelida, 10% Mollusca and 8% Crustacea, with the remainder consisting of Nemertea and Sipuncula.

Annelida was the most abundant group in 2004 with a mean abundance and density of 33 ± 19.67 specimens per replicate and 7,236 ± 4,314 annelids m^{-2}, respectively. In all, 18 species of annelid were identified in 2004 (mean richness 10.67 ± 3.06 species per replicate); 3 oligochaetes and 15 polychaetes. Only 4 species were found in all three replicates; a tubificid oligochaete and 3 polychaetes, *Tharyx* sp., *Lumbrineris* sp. 2 and *Aricidea catherinae*. *A. catherinae* was the most abundant species in 2004 with a mean percent composition and density of 11.11 ± 4.96% and 1,023 ± 456 m^{-2}, respectively. *Tubificoides* sp. and *F. trilobata* were the second most abundant species with equal mean abundances but differing standard deviations, 8.73 ± 7.65% and 8.73 ± 15.12%, respectively.

Table 9. Site 4: Lauderdale Marina. 2004 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 4 2004	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	count	%	n/m^2	count	%	n/m^2	count	%	n/m^2	count ± SD	% ± SD	n/m^2 ± SD
ANNELIDA	**15**	**75.00**	**3,289**	**54**	**75.00**	**11,841**	**30**	**88.24**	**6,578**	**33.00 ± 19.67**	**78.57 ± 46.84**	**7,236 ± 4,314**
Oligochaeta												
Pectinodrilus sp.	0	0.00	0	7	9.72	1,535	0	0.00	0	2.33 ± 4.04	5.56 ± 9.62	512 ± 886
Tubificidae 1	2	10.00	439	2	2.78	439	5	14.71	1,096	3.00 ± 1.73	7.14 ± 4.12	658 ± 380
Tubificoides sp.	0	0.00	0	6	8.33	1,316	5	14.71	1,096	3.67 ± 3.21	8.73 ± 7.65	804 ± 705
Polychaeta												
Anaspio sp.	0	0.00	0	0	0.00	0	2	5.88	439	0.67 ± 1.15	1.59 ± 2.75	146 ± 253
Aricidea catherinae	3	15.00	658	4	5.56	877	7	20.59	1,535	4.67 ± 2.08	11.11 ± 4.96	1,023 ± 456
Axiothella sp.	2	10.00	439	1	1.39	219	0	0.00	0	1.00 ± 1.00	2.38 ± 2.38	219 ± 219
Chaetozone setosa	0	0.00	0	3	4.17	658	2	5.88	439	1.67 ± 1.53	3.97 ± 3.64	365 ± 335
Fabriciola trilobata	0	0.00	0	11	15.28	2,412	0	0.00	0	3.67 ± 6.35	8.73 ± 15.12	804 ± 1,393
Lumbrineris sp.1	1	5.00	219	2	2.78	439	0	0.00	0	1.00 ± 1.00	2.38 ± 2.38	219 ± 219
Lumbrineris sp.2	1	5.00	219	3	4.17	658	2	5.88	439	2.00 ± 1.00	4.76 ± 2.38	439 ± 219
Minuspio sp.	0	0.00	0	0	0.00	0	1	2.94	219	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Phyllodoce arenae	0	0.00	0	0	0.00	0	1	2.94	219	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Polydora sp.	0	0.00	0	1	1.39	219	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Prionospio sp.	0	0.00	0	2	2.78	439	3	8.82	658	1.67 ± 1.53	3.97 ± 3.64	365 ± 335
Sphaerosyllis sp.	3	15.00	658	0	0.00	0	0	0.00	0	1.00 ± 1.73	2.38 ± 4.12	219 ± 380
Spio/Microspio sp.	0	0.00	0	1	1.39	219	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Tharyx dorsobranchialis	2	10.00	439	6	8.33	1,316	0	0.00	0	2.67 ± 3.06	6.35 ± 7.27	585 ± 670
Tharyx sp.1	1	5.00	219	5	6.94	1,096	2	5.88	439	2.67 ± 2.08	6.35 ± 4.96	585 ± 456
CRUSTACEA	**4**	**20.00**	**877**	**4**	**5.56**	**877**	**2**	**5.88**	**439**	**3.33 ± 1.15**	**7.94 ± 2.75**	**731 ± 253**
Amphipoda												
Grandidierella bonnieroides	1	5.00	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Synchelidium americanum	0	0.00	0	1	1.39	219	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Cumacea												
Cyclaspis sp.	0	0.00	0	1	1.39	219	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Decapoda												
Clibanarius sp.	1	5.00	219	1	1.39	219	0	0.00	0	0.67 ± 0.58	1.59 ± 1.37	146 ± 127
Isopoda												
Xenanthura brevitelson	1	5.00	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Mysida												
Mysidae 1	0	0.00	0	0	0.00	0	1	2.94	219	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Ostracoda												
Harbansus paucichelatus	1	5.00	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Sarsiellidae 2	0	0.00	0	1	1.39	219	1	2.94	219	0.67 ± 0.58	1.59 ± 1.37	146 ± 127
MOLLUSCA	**0**	**0.00**	**0**	**11**	**15.28**	**2,412**	**1**	**2.94**	**219**	**4.00 ± 6.08**	**9.52 ± 14.48**	**877 ± 1,334**
Bivalvia												
Chione elevata	0	0.00	0	1	1.39	219	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Gouldia cerina	0	0.00	0	0	0.00	0	1	2.94	219	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Solemya occidentalis	0	0.00	0	1	1.39	219	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Gastropoda												
Caecum pulchellum	0	0.00	0	9	12.50	1,974	0	0.00	0	3.00 ± 5.20	7.14 ± 12.37	658 ± 1,139
NEMERTEA	**1**	**5.00**	**219**	**2**	**2.78**	**439**	**1**	**2.94**	**219**	**1.33 ± 0.58**	**3.17 ± 1.37**	**292 ± 127**
Nemertea 2	1	5.00	219	2	2.78	439	1	2.94	219	1.33 ± 0.58	3.17 ± 1.37	292 ± 127
SIPUNCULA	**0**	**0.00**	**0**	**1**	**1.39**	**219**	**0**	**0.00**	**0**	**0.33 ± 0.58**	**0.79 ± 1.37**	**73 ± 127**
Sipuncula 1	0	0.00	0	1	1.39	219	0	0.00	0	0.33 ± 0.58	0.79 ± 1.37	73 ± 127
Total	**20**	**100.00**	**4,386**	**72**	**100.00**	**15,788**	**34**	**100.00**	**7,456**	**42.00 ± 26.91**	**100.00**	**9,210 ± 5,900**

Mollusca was slightly more abundant than Crustacea, with mean abundances of 4 ± 6.08 and 3.33 ± 1.15 specimens per replicate and mean densities of 877 ± 1,334 m^{-2} and 731 ± 253 m^{-2}, respectively. Four species of mollusk were identified: 3 bivalve and 1 gastropod, and eight species of crustacean: 2 species of amphipod and ostracod, and one species each of cumacean, decapod, isopod and mysid. The large standard deviation for mollusks was caused by the abundance of *C. pulchellum* in one replicate (0, 9, 0), which also made it the most abundant non-annelid in 2004, with a mean percent composition of 7.14 ± 12.37%. Between these two major taxa, the remaining 11 species never accounted for more than one specimen per replicate, and no molluscan or crustacean species were found in all three replicates. One nemertean and one sipunculan species contributed the remaining 3% of macroinvertebrate composition. The nemertean was found in all three replicates.

Table 10 lists abundances, percent compositions and densities per replicate, with mean values and standard deviations for 2005. Abundances ranged from 72 to 85 specimens per replicate (mean 78 ± 6.56) with mean richness of 26 ± 1 species per replicate. Densities ranged from 15,788 to 18,639 macroinvertebrates m^{-2} (mean 17,104 ± 1,438). Both mean abundance and richness increased from the previous year: ~185% and 150%, respectively. Mean higher taxon composition was ~81% Annelida, 8% Crustacea and 6% Mollusca, with the remaining 5% consisting of Ophiuroidea, Nemertea and Sipuncula.

Annelida remained the most abundant group in 2005 with a mean abundance and density of 63.33 ± 7.64 specimens per replicate and 13,888 ± 1,675 annelids m^{-2}, respectively. Three species of oligochaete and 21 species of polychaetes were identified

Table 10. Site 4: Lauderdale Marina. 2005 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 4 2005	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	count	%	n/m²	count	%	n/m²	count	%	n/m²	count ± SD	% ± SD	n/m² ± SD
ANNELIDA	**70**	**82.35**	**15,350**	**65**	**84.42**	**14,253**	**55**	**76.39**	**12,060**	**63.33 ± 7.64**	**81.20 ± 9.79**	**13,888 ± 1,675**
Oligochaeta												
Tubificidae 1	5	5.88	1,096	5	6.49	1,096	3	4.17	658	4.33 ± 1.15	5.56 ± 1.48	950 ± 253
Tubificidae 2	2	2.35	439	1	1.30	219	0	0.00	0	1.00 ± 1.00	1.28 ± 1.28	219 ± 219
Tubificoides sp.	10	11.76	2,193	4	5.19	877	2	2.78	439	5.33 ± 4.16	6.84 ± 5.34	1,169 ± 913
Polychaeta												
Ampharetidae 1	1	1.18	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Aricidea catherinae	0	0.00	0	1	1.30	219	2	2.78	439	1.00 ± 1.00	1.28 ± 1.28	219 ± 219
Axiothella sp.	1	1.18	219	3	3.90	658	6	8.33	1,316	3.33 ± 2.52	4.27 ± 3.23	731 ± 552
Brania sp.	1	1.18	219	0	0.00	0	1	1.39	219	0.67 ± 0.58	0.85 ± 0.74	146 ± 127
Capitella capitata	3	3.53	658	1	1.30	219	3	4.17	658	2.33 ± 1.15	2.99 ± 1.48	512 ± 253
Chaetozone setosa	11	12.94	2,412	3	3.90	658	9	12.50	1,974	7.67 ± 4.16	9.83 ± 5.34	1,681 ± 913
Ehlersia cornuta	0	0.00	0	0	0.00	0	1	1.39	219	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Fabriciola trilobata	10	11.76	2,193	32	41.56	7,017	6	8.33	1,316	16.00 ± 14.00	20.51 ± 17.95	3,508 ± 3,070
Glycera sp.	1	1.18	219	2	2.60	439	1	1.39	219	1.33 ± 0.58	1.71 ± 0.74	292 ± 127
Lumbrineris sp.2	4	4.71	877	1	1.30	219	1	1.39	219	2.00 ± 1.73	2.56 ± 2.22	439 ± 380
Minuspio sp.	0	0.00	0	1	1.30	219	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Nematonereis hebes	0	0.00	0	1	1.30	219	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Pettibonia duofurca	0	0.00	0	0	0.00	0	2	2.78	439	0.67 ± 1.15	0.85 ± 1.48	146 ± 253
Pisionidae 1	0	0.00	0	2	2.60	439	0	0.00	0	0.67 ± 1.15	0.85 ± 1.48	146 ± 253
Poecilochaetus sp.	0	0.00	0	1	1.30	219	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Polydora sp.	0	0.00	0	0	0.00	0	3	4.17	658	1.00 ± 1.73	1.28 ± 2.22	219 ± 380
Prionospio sp.	2	2.35	439	1	1.30	219	0	0.00	0	1.00 ± 1.00	1.28 ± 1.28	219 ± 219
Sphaerosyllis sp.	2	2.35	439	2	2.60	439	3	4.17	658	2.33 ± 0.58	2.99 ± 0.74	512 ± 127
Tharyx dorsobranchialis	6	7.06	1,316	2	2.60	439	5	6.94	1,096	4.33 ± 2.08	5.56 ± 2.67	950 ± 456
Tharyx sp.1	11	12.94	2,412	2	2.60	439	6	8.33	1,316	6.33 ± 4.51	8.12 ± 5.78	1,389 ± 989
Tharyx sp.2	0	0.00	0	0	0.00	0	1	1.39	219	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
CRUSTACEA	**7**	**8.24**	**1,535**	**5**	**6.49**	**1,096**	**7**	**9.72**	**1,535**	**6.33 ± 1.15**	**8.12 ± 1.48**	**1,389 ± 253**
Amphipoda												
Grandidierella bonnieroides	1	1.18	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Synchelidium americanum	0	0.00	0	0	0.00	0	1	1.39	219	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Cumacea												
Cyclaspis sp.	1	1.18	219	2	2.60	439	2	2.78	439	1.67 ± 0.58	2.14 ± 0.74	365 ± 127
Decapoda												
Penaeida 1	1	1.18	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Pinnixa sp.	0	0.00	0	0	0.00	0	1	1.39	219	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Isopoda												
Xenanthura brevitelson	0	0.00	0	0	0.00	0	1	1.39	219	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Ostracoda												
Eusarsiella sp.	4	4.71	877	3	3.90	658	0	0.00	0	2.33 ± 2.08	2.99 ± 2.67	512 ± 456
Harbansus paucichelatus	0	0.00	0	0	0.00	0	2	2.78	439	0.67 ± 1.15	0.85 ± 1.48	146 ± 253
ECHINODERMATA	**1**	**1.18**	**219**	**0**	**0.00**	**0**	**0**	**0.00**	**0**	**0.33 ± 0.58**	**0.43 ± 0.74**	**73 ± 127**
Ophiurida												
Amphioplus sp.	1	1.18	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
MOLLUSCA	**5**	**5.88**	**1,096**	**4**	**5.19**	**877**	**6**	**8.33**	**1,316**	**5.00 ± 1.00**	**6.41 ± 1.28**	**1,096 ± 219**
Bivalvia												
Macoma sp.	1	1.18	219	0	0.00	0	1	1.39	219	0.67 ± 0.58	0.85 ± 0.74	146 ± 127
Nucula proxima	1	1.18	219	0	0.00	0	1	1.39	219	0.67 ± 0.58	0.85 ± 0.74	146 ± 127
Gastropoda												
Acteocina sp.	1	1.18	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Acteon candens	2	2.35	439	1	1.30	219	0	0.00	0	1.00 ± 1.00	1.28 ± 1.28	219 ± 219
Caecum pulchellum	0	0.00	0	3	3.90	658	4	5.56	877	2.33 ± 2.08	2.99 ± 2.67	512 ± 456
NEMERTEA	**2**	**2.35**	**439**	**2**	**2.60**	**439**	**4**	**5.56**	**877**	**2.67 ± 1.15**	**3.42 ± 1.48**	**585 ± 253**
Nemertea 1	0	0.00	0	1	1.30	219	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Nemertea 2	0	0.00	0	1	1.30	219	2	2.78	439	1.00 ± 1.00	1.28 ± 1.28	219 ± 219
Nemertea 3	1	1.18	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Nemertea 4	1	1.18	219	0	0.00	0	2	2.78	439	1.00 ± 1.00	1.28 ± 1.28	219 ± 219
SIPUNCULA	**0**	**0.00**	**0**	**1**	**1.30**	**219**	**0**	**0.00**	**0**	**0.33 ± 0.58**	**0.43 ± 0.74**	**73 ± 127**
Sipuncula 1	0	0.00	0	1	1.30	219	0	0.00	0	0.33 ± 0.58	0.43 ± 0.74	73 ± 127
Total	**85**	**100.00**	**18,639**	**77**	**100.00**	**16,885**	**72**	**100.00**	**15,788**	**78.00 ± 6.56**	**100.00**	**17,104 ± 1,438**

in 2005. Eleven of the 24 annelid species were found in all three replicates; 2 oligochaetes (Tubificidae 1 and *Tubificoides* sp.) and 9 polychaetes (*Capitella capitata*, *Axiothella* sp., *C. setosa*, *T. dorsobranchialis*, *Tharyx* sp.1, *Lumbrineris* sp. 2, *Glycera* sp., *Sphaerosyllis* sp. and *F. trilobata*). The three most abundant species in 2005 were polychaetes. *F. trilobata*, was the most abundant (10, 32, 6) with a mean percent composition of 20.51 ± 17.95% and a density of 3,508 ± 3,070 m^{-2}. *C. setosa* was second with 11, 3, 9 specimens per replicate for a mean percent composition of 9.83 ± 5.34%, followed closely by *Tharyx* sp. 1 with 11, 2, 6 specimens per replicate for a mean percent composition of 8.12 ± 5.78%.

Mollusca and Crustacea continued to have relatively equal mean abundances: 5 ± 1 and 6.33 ± 1.15 specimens per replicate for extrapolated densities of 1,096 ± 219 m^{-2} and 1,389 ± 253 m^{-2}, respectively. Molluscan and crustacean species richness remained approximately the same from the previous year, with 5 species of mollusk: 2 bivalve and 3 gastropods, and 8 species of crustacean: 2 amphipods, decapods and ostracods, and 1 cumacean and isopod each. The cumacean *Cyclaspis* sp., was the only non-annelid found in all three replicates. The remaining 5% mean composition consisted of 6 species: 1 ophiuroid, 1 sipunculan and 4 nemerteans.

v. Site 5 - 17th Street Causeway

Table 11 lists abundances, percent composition and densities per replicate, and mean values and standard deviations for 2004. Abundances ranged from 71 to 149 specimens (mean 99 ± 43.41) and richness 13-16 species per replicate (mean 14.67 ± 1.53). Densities ranged from 15,569 to 32,673 macroinvertebrates m^{-2} (mean 21,709 ± 9,518). Mean composition of the higher taxa was ~56% Gastropoda, 22% Sipuncula and

16% Annelida, with Crustacea and Nemertea contributing the rest.

Table 11. Site 5: 17th Street Causeway. 2004 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 5 2004	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	**count**	**%**	**n/m^2**	**count**	**%**	**n/m^2**	**count**	**%**	**n/m^2**	**count ± SD**	**% ± SD**	**n/m^2 ± SD**
ANNELIDA	**14**	**18.18**	**3,070**	**23**	**32.39**	**5,043**	**12**	**8.05**	**2,631**	**16.33 ± 5.86**	**16.50 ± 5.92**	**3,582 ± 1,285**
Oligochaeta												
Tubificidae 3	1	1.30	219	1	1.41	219	0	0.00	0	0.67 ± 0.58	0.67 ± 0.58	146 ± 127
Polychaeta												
Ampharetidae 2	0	0.00	0	2	2.82	439	0	0.00	0	0.67 ± 1.15	0.67 ± 1.17	146 ± 253
Capitella capitata	1	1.30	219	3	4.23	658	2	1.34	439	2.00 ± 1.00	2.02 ± 1.01	439 ± 219
Ehlersia cornuta	0	0.00	0	0	0.00	0	1	0.67	219	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Nematonereis hebes	0	0.00	0	1	1.41	219	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Notomastus daueri	7	9.09	1,535	3	4.23	658	0	0.00	0	3.33 ± 3.51	3.37 ± 3.55	731 ± 770
Pectinaria gouldi	0	0.00	0	0	0.00	0	1	0.67	219	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Phyllodocidae 1	1	1.30	219	1	1.41	219	0	0.00	0	0.67 ± 0.58	0.67 ± 0.58	146 ± 127
Polydora sp.	1	1.30	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Pseudopolydora sp.	1	1.30	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Sabellidae 1	0	0.00	0	0	0.00	0	4	2.68	877	1.33 ± 2.31	1.35 ± 2.33	292 ± 506
Sphaerosyllis sp.	0	0.00	0	1	1.41	219	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Spio/Microspio sp.	0	0.00	0	1	1.41	219	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Tharyx sp.1	2	2.60	439	8	11.27	1,754	4	2.68	877	4.67 ± 3.06	4.71 ± 3.09	1,023 ± 670
Typosyllis sp.	0	0.00	0	2	2.82	439	0	0.00	0	0.67 ± 1.15	0.67 ± 1.17	146 ± 253
CRUSTACEA	**1**	**1.30**	**219**	**4**	**5.63**	**877**	**5**	**3.36**	**1,096**	**3.33 ± 2.08**	**3.37 ± 2.10**	**731 ± 456**
Amphipoda												
Ampeliscidae 1	0	0.00	0	0	0.00	0	1	0.67	219	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Decapoda												
Caridae 1	0	0.00	0	0	0.00	0	2	1.34	439	0.67 ± 1.15	0.67 ± 1.17	146 ± 253
Mysida												
Mysidae 1	1	1.30	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Tanaidacea												
Leptochelia savignyi	0	0.00	0	1	1.41	219	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Ostracoda												
Rutiderma darbyi	0	0.00	0	3	4.23	658	1	0.67	219	1.33 ± 1.53	1.35 ± 1.54	292 ± 335
Sarsiellidae 1	0	0.00	0	0	0.00	0	1	0.67	219	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
MOLLUSCA	**52**	**67.53**	**11,403**	**29**	**40.85**	**6,359**	**84**	**56.38**	**18,420**	**55.00 ± 27.62**	**55.56 ± 27.90**	**12,060 ± 6,057**
Gastropoda												
Caecum imbricatum	0	0.00	0	1	1.41	219	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Caecum pulchellum	50	64.94	10,964	28	39.44	6,140	82	55.03	17,981	53.33 ± 27.15	53.87 ± 27.43	11,695 ± 5,954
Mathilda sp.	0	0.00	0	0	0.00	0	1	0.67	219	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Meioceras nitidum	2	2.60	439	0	0.00	0	1	0.67	219	1.00 ± 1.00	1.01 ± 1.01	219 ± 219
NEMERTEA	**1**	**1.30**	**219**	**2**	**2.82**	**439**	**4**	**2.68**	**877**	**2.33 ± 1.53**	**2.36 ± 1.54**	**512 ± 335**
Nemertea 1	1	1.30	219	2	2.82	439	1	0.67	219	1.33 ± 0.58	1.35 ± 0.58	292 ± 127
Nemertea 2	0	0.00	0	0	0.00	0	3	2.01	658	1.00 ± 1.73	1.01 ± 1.75	219 ± 380
SIPUNCULA	**9**	**11.69**	**1,974**	**13**	**18.31**	**2,851**	**44**	**29.53**	**9,648**	**22.00 ± 19.16**	**22.22 ± 19.35**	**4,824 ± 4,201**
Aspidosiphon sp.	8	10.39	1,754	13	18.31	2,851	44	29.53	9,648	21.67 ± 19.50	21.89 ± 19.70	4,751 ± 4,276
Sipuncula 1	1	1.30	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.34 ± 0.58	73 ± 127
Total	**77**	**100.00**	**16,885**	**71**	**100.00**	**15,569**	**149**	**100.00**	**32,673**	**99.00 ± 43.41**	**100.00**	**21,709 ± 9,518**

Mollusca was the most abundant group in 2004 with a mean abundance of 55 ± 27.62 specimens per replicate and a density of 12,060 ± 6,057 mollusks m^{-2}. The four species identified in 2004 were all gastropods. *C. pulchellum* was the only mollusk found in all three replicates and contributed 97% of molluscan abundance and approximately

53.87 ± 27.43% of mean macroinvertebrate composition, making it the most abundant species in 2004.

Sipuncula was the second most abundant group with a mean abundance of 22 ± 19.16 specimens per replicate and density of 4,824 ± 4,201 sipunculans m^{-2}. *Aspidosiphon* sp., one of the two sipunculan species identified, accounted for 98.5% of sipunculan abundance and 21.89 ± 19.70% of mean macroinvertebrate composition. The large standard deviation was caused by the abundance of *Aspidosiphon* sp. in the third replicate (8, 13, 44), making it the second most abundant species in 2004.

Annelida was the third most abundant group in 2004 with a mean abundance of 16.33 ± 5.86 specimens per replicate and density of 3,582 ± 1,285 annelids m^{-2}. Fifteen species of annelid were identified in 2004: 1 tubificid oligochaete and 14 polychaetes. Only two species, *Capitella capitata* and *Tharyx* sp., were found in all three replicates. The latter was the third most abundant species, but contributed a mean percent composition of only 4.71 ± 3.09%.

The remaining 5% of mean macroinvertebrate composition consisted of Crustacea and Nemertea. Six species of crustacean: 2 ostracods and 1 each of amphipod, decapod, mysid and tanaidacean, contributed a mean abundance of 3.33 ± 2.08 crustaceans per replicate. The two nemertean species identified in 2004 contributed a mean abundance of 2.33 ± 1.53 specimens per replicate.

Table 12 lists abundances, percentage composition and densities per replicate, and mean values and standard deviations for 2005. Abundances ranged from 19 to 44

Table 12. Site 5: 17th Street Causeway. 2005 macroinvertebrate replicate and mean abundances (count), percent composition and density.

Site 5 2005	Replicate 1			Replicate 2			Replicate 3			Mean		
Species	count	%	n/m²	count	%	n/m²	count	%	n/m²	count ± SD	% ± SD	n/m² ± SD
ANNELIDA	**23**	**58.97**	**5,043**	**26**	**59.09**	**5,701**	**10**	**52.63**	**2,193**	**19.67 ± 8.50**	**57.84 ± 25.01**	**4,313 ± 1,865**
Oligochaeta												
Tubificidae 1	1	2.56	219	9	20.45	1,974	5	26.32	1,096	5.00 ± 4.00	14.71 ± 11.76	1,096 ± 877
Tubificidae 2	0	0.00	0	0	0.00	0	1	5.26	219	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Tubificidae 3	3	7.69	658	1	2.27	219	0	0.00	0	1.33 ± 1.53	3.92 ± 4.49	292 ± 335
Tubificoides sp.	0	0.00	0	2	4.55	439	1	5.26	219	1.00 ± 1.00	2.94 ± 2.94	219 ± 219
Polychaeta												
Aricidea catherinae	0	0.00	0	2	4.55	439	0	0.00	0	0.67 ± 1.15	1.96 ± 3.40	146 ± 253
Capitella capitata	13	33.33	2,851	1	2.27	219	2	10.53	439	5.33 ± 6.66	15.69 ± 19.58	1,169 ± 1,460
Chaetozone setosa	0	0.00	0	7	15.91	1,535	1	5.26	219	2.67 ± 3.79	7.84 ± 11.14	585 ± 830
Lumbrineris sp.2	0	0.00	0	1	2.27	219	0	0.00	0	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Pettibonia duofurca	3	7.69	658	0	0.00	0	0	0.00	0	1.00 ± 1.73	2.94 ± 5.09	219 ± 380
Poecilochaetus sp.	1	2.56	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Prionospio sp.	1	2.56	219	1	2.27	219	0	0.00	0	0.67 ± 0.58	1.96 ± 1.70	146 ± 127
Sphaerosyllis sp.	1	2.56	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Tharyx dorsobranchialis	0	0.00	0	1	2.27	219	0	0.00	0	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Tharyx sp.1	0	0.00	0	1	2.27	219	0	0.00	0	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
CRUSTACEA	**3**	**7.69**	**658**	**1**	**2.27**	**219**	**7**	**36.84**	**1,535**	**3.67 ± 3.06**	**10.78 ± 8.99**	**804 ± 670**
Amphipoda												
Grandidierella bonnieroides	0	0.00	0	0	0.00	0	2	10.53	439	0.67 ± 1.15	1.96 ± 3.40	146 ± 253
Synchelidium americanum	0	0.00	0	0	0.00	0	1	5.26	219	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Decapoda												
Penaeida 1	1	2.56	219	1	2.27	219	0	0.00	0	0.67 ± 0.58	1.96 ± 1.70	146 ± 127
Pinnotheridae 2	0	0.00	0	0	0.00	0	1	5.26	219	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Mysida												
Mysidae 2	1	2.56	219	0	0.00	0	2	10.53	439	1.00 ± 1.00	2.94 ± 2.94	219 ± 219
Tanaidacea												
Mesokalliapseudes macsweenyi	1	2.56	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Ostracoda												
Sarsiellidae 1	0	0.00	0	0	0.00	0	1	5.26	219	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
MOLLUSCA	**12**	**30.77**	**2,631**	**17**	**38.64**	**3,728**	**2**	**10.53**	**439**	**10.33 ± 7.64**	**30.39 ± 22.46**	**2,266 ± 1,675**
Bivalvia												
Chione elevata	0	0.00	0	1	2.27	219	1	5.26	219	0.67 ± 0.58	1.96 ± 1.70	146 ± 127
Gastropoda												
Caecum pulchellum	12	30.77	2,631	16	36.36	3,508	1	5.26	219	9.67 ± 7.77	28.43 ± 22.85	2,120 ± 1,703
SIPUNCULA	**1**	**2.56**	**219**	**0**	**0.00**	**0**	**0**	**0.00**	**0**	**0.33 ± 0.58**	**0.98 ± 1.70**	**73 ± 127**
Aspidosiphon sp.	1	2.56	219	0	0.00	0	0	0.00	0	0.33 ± 0.58	0.98 ± 1.70	73 ± 127
Total	**39**	**100.00**	**8,552**	**44**	**100.00**	**9,648**	**19**	**100.00**	**4,166**	**34.00 ± 13.23**	**100.00**	**7,456 ± 2,901**

specimens per replicate (mean 34 ± 13.23) for an extrapolated density of 4,166 to 9,648 macroinvertebrates m^{-2} (mean 7,456 ± 2,901). Abundance was half that in the previous year due to reduced molluscan abundance. Species richness declined only slightly, to 12-13 species per replicate (mean 12.33 ± 0.58). Mean higher taxonomic composition consisted of ~58% Annelida, 30% Mollusca and 11% Crustacea.

Annelida was the most abundant group in 2005 with a mean abundance of 19.67 ± 8.50 specimens per replicate and a density of 4,313 ± 1,865 annelids m^{-2}. Fourteen species of annelid were identified in 2005: 4 oligochaetes and 10 polychaetes. *Capitella capitata* and an unidentified tubificid were the only annelids found in all three replicates. These two species were also the second and third most abundant species in 2005 with mean percent compositions of 15.69 ± 19.58% and 14.71 ± 11.76%, respectively.

Mollusca was the second most abundant group with a mean abundance of 10.33 ± 7.64 specimens per replicate and a mean density of 2,266 ± 1,675 mollusks m^{-2}, only ~20% of the abundance of 2004. Two species were present in 2005, the bivalve *Chione elevata* and the gastropod *C. pulchellum,* with the latter accounting for ~94% of specimens. *C. pulchellum* was also the only mollusk in all three replicates, and the most abundant species in 2005 with a mean percent composition of 28.43 ± 22.85%.

Crustacea and Sipuncula comprised the remaining 10% of mean macroinvertebrate composition in 2005. Crustacean abundance and species richness differed little from the previous year; the 7 crustacean species in 2005 were 2 amphipods and decapods, and 1 mysid, tanaidacean and ostracod for a mean abundance of 3.67 ± 3.06 specimens per replicate. One specimen of the sipunculan *Aspidosiphon* sp. was found in one replicate, approximately a 95% reduction from the previous year's abundance.

vi. Macroinvertebrate Density

Despite what appear to be major interannual differences in invertebrate densities, (e.g., 9,210 ± 5,900 (2004) to 17,107 ± 1,438 (2005) at site 4, and 21,709 ± 9,518 (2004) to 7,456 ± 2,901 (2005) at site 5), mean macroinvertebrate densities did not differ significantly in a two-tailed t-test between the 2004 and 2005 samplings at any of the five sites (Table 13). Because the densities did not differ between the two years for any of the sites, the mean and standard deviation of the six replicates (3 in each of the 2 years) were calculated in Table 14 for each site. The macroinvertebrate densities between the sites were determined to be significantly different with ANOVA ($F(4,25) = 3.73$, $p = 0.016$) (Table 14). Tukey's HSD was run to determine which sites were significantly different (Table 15). The only sites with a significant difference of densities were Sites 1 ($\bar{x}$ = 28,360 m^{-2}, SD = 8,693) and 4 ($\bar{x}$ = 13,174 m^{-2}, SD = 5,783), the most and least dense sites, respectively.

Table 13. Comparison of mean macroinvertebrate densities ($\bar{x}$ m^{-2}) and standard deviations (SD) by sample site between years 2004 and 2005. Significant differences analyzed with two tailed t-Test (α =0.05, df = 2). Site with p <0.05 are significantly different.

Site	2004 $\bar{x}$ m^{-2}	2004 SD	2005 $\bar{x}$ m^{-2}	2005 SD	$t_{0.05(2)2}$	p
1	23,755	1,266	32,965	11,122	1.42	0.290
2	26,606	3,111	18,639	7,472	1.70	0.163
3	18,712	2,724	31,756	10,856	1.99	0.117
4	9,210	5,900	17,107	1,438	2.25	0.087
5	21,709	9,518	7,456	2,901	2.48	0.068

Table 14. Comparison of mean macroinvertebrate densities ($\bar{x}$ m^{-2}) and standard deviations (SD) among sample sites.

Site	$\bar{x}$ m^{-2}	SD
1	28,360	8,693
2	22,623	6,727
3	25,144	9,988
4	13,175	5,783
5	14,582	10,028

Table 15. Approximate probabilities of post-hoc test (Tukey HSD) comparison of mean macroinvertebrate densities among sites. Sites with values < 0.05 (shaded cells) are significantly different (Error: Between MS = 7,091x104, df = 25).

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Site 1		0.762	0.963	0.033	0.062
Site 2	0.762		0.985	0.320	0.479
Site 3	0.963	0.985		0.131	0.223
Site 4	0.033	0.320	0.131		0.998
Site 5	0.062	0.479	0.223	0.998	

vii. Macroinvertebrate Richness

At two of the five sites, sites 2 and 3, mean species richness was significantly different from 2004 to 2005 (Table 16). Because species richness differed within a site, Tukey HSD was used to determine which sites' species richness differed among the other sites and years (Table 17).

Table 16. Comparison of mean species richness ($\bar{x}$) and standard deviations (SD) by sample site between years 2004 and 2005. Significant differences analyzed with two tailed t-Test (α =0.05, df = 2). Sites with p <0.05 are significantly different.

	2004		**2005**			
Site	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$t_{0.05(2)4}$	***p***
1	15	2	18	3	1.14	0.320
2	22	2	16	2	2.97	0.041
3	18	3	26	2	3.78	0.019
4	17	6	26	1	2.89	0.102
5	15	2	12	1	2.47	0.069

Table 17. Approximate probabilities of post-hoc test (Tukey HSD) comparison of mean species richness by site and year. Sites with values < 0.05 (shaded cells) are significantly different (Error: Between MS = 6.87, df = 20).

	Site 1 2004	**Site 1 2005**	**Site 2 2004**	**Site 2 2005**	**Site 3 2004**	**Site 3 2005**	**Site 4 2004**	**Site 4 2005**	**Site 5 2004**	**Site 5 2005**
Site 1 2004		0.980	0.153	1.000	0.955	0.003	1.000	0.002	1.000	0.913
Site 1 2005	0.980		0.688	1.000	1.000	0.033	1.000	0.024	0.913	0.329
Site 2 2004	0.153	0.688		0.329	0.776	0.688	0.409	0.593	0.085	0.009
Site 2 2005	1.000	1.000	0.329		0.998	0.009	1.000	0.006	0.998	0.688
Site 3 2004	0.955	1.000	0.776	0.998		0.046	1.000	0.033	0.853	0.259
Site 3 2005	0.003	0.033	0.688	0.009	0.046		0.012	1.000	0.002	0.000
Site 4 2004	1.000	1.000	0.409	1.000	1.000	0.012		0.009	0.993	0.593
Site 4 2005	0.002	0.024	0.593	0.006	0.033	1.000	0.009		0.001	0.000
Site 5 2004	1.000	0.913	0.085	0.998	0.853	0.002	0.993	0.001		0.980
Site 5 2005	0.913	0.329	0.009	0.688	0.259	0.000	0.593	0.000	0.980	

iix. Macroinvertebrate Diversity

The mean Shannon-Wiener diversity indices did not differ significantly between the two years for any of the sites (Table 18), so the mean and standard deviation of the six replicates (3 in each of the 2 years) were calculated in Table 19 for each site. A one-way analysis of variance did yield a significant difference between mean diversity indices among sites ($F(4,20) = 14.38$, $p < 0.001$) (Table 19). Tukey's HSD was used to determine which sites were significantly different (Table 20). Mean diversity indices at sites 1 and 5 ($\bar{x} = 2.77$, SD = 0.155 and $\bar{x} = 2.62$, SD = 0.551, respectively) were significantly different from the indices at sites 2, 3 and 4 ($\bar{x}$ = 3.46, SD = 0.234; $\bar{x}$ = 3.53, SD = 0.351 and $\bar{x}$ = 3.84, SD = 0.385, respectively).

Table 18. Comparison of mean Shannon-Wiener diversity indices ($\bar{x}$) and standard deviations (SD) by sample site between years 2004 and 2005. Significant differences analyzed with two tailed t-Test (α =0.05, df = 2). Sites with p <0.05 are significantly

	2004		2005			
Site	**$\bar{x}$ *H'***	**SD**	**$\bar{x}$ *H'***	**SD**	**$t_{0.05(2)4}$**	***p***
1	2.80	0.15	2.75	0.19	0.38	0.721
2	3.62	0.22	3.31	0.10	2.21	0.091
3	3.49	0.22	3.57	0.50	0.25	0.814
4	3.68	0.31	4.00	0.44	1.05	0.350
5	2.29	0.57	2.95	0.32	1.74	0.157

Table 19. Comparison of mean Shannon-Wiener diversity indices ($\bar{x}$) and standard deviations (SD) among sample sites.

Site	**$\bar{x}$ *H'***	**SD**
1	2.77	0.155
2	3.46	0.234
3	3.53	0.351
4	3.84	0.385
5	2.62	0.551

Table 20. Approximate probabilities of post-hoc test (Tukey HSD) comparison of mean diversity indices among sites. Sites with values < 0.05 (shaded cells) are significantly different (Error: Between MS = 0.13078, df = 25).

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Site 1		0.022	0.010	0.000	0.946
Site 2	0.022		0.997	0.398	0.004
Site 3	0.010	0.997		0.591	0.002
Site 4	0.000	0.398	0.591		0.000
Site 5	0.946	0.004	0.002	0.000	

ix. Macroinvertebrate Composition Comparison

Wilks' lambda multivariate ANOVA was used to determine if the site and/or year significantly affected the macroinvertebrate compositions. The macroinvertebrate composition was significantly different between the sites (Wilks' $\lambda = 0.000$, $F(80, 6.37) = 11.59$, $p < 0.005$). Sample year did not significantly affect species composition (Wilks' $\lambda = 0.013$, $F(20, 1) = 3.82$, $p = 0.385$). Due to the significant difference between macroinvertebrate compositions among sites, Tukey's HSD test was used to determine which species differed.

Of the 105 species identified, 36 differed significantly among sites and/or sample years. Over half of the significantly different species were annelids: 4 oligochaetes and 15 polychaetes. The second largest group were 10 species of crustaceans: 4 ostracods, 2 amphipods, 2 cumaceans and 2 tanaidaceans. The remaining significantly different species consisted of 3 molluscs (1 bivalve and 2 gastropod), 2 nemerteans and 2 sipunculans. Appendix A shows the results of the Tukey HSD test for the 36 species. Because the sites' macroinvertebrate compositions differed, ordination was used to cluster the replicates into groups of similar macroinvertebrate composition.

A dendrogram (Figure 2) and nMDS (Figure 3) of the 30 replicates' macroinvertebrate abundances, root-root transformed, using the Bray-Curtis similarity matrix and group-average sorted depicts two main groups; sites 2, 3 and 4, and sites 1 and 5. Henceforth, sites 2, 3 and 4 shall be referred together as group A and sites 1 and 5 group B. For each of the sites 1-4, the replicate samples collected in 2004 and 2005 clustered together. Five of the six replicates collected at site 5 were clustered together, while one collected in 2005, S5-05b, was grouped with the samples collected at site 4.

The macroinvertebrate composition of S5-05b was more similar to site 4 than site 5 due to the abundance of a few polychaete species; *Aricidea catherinae*, *Chaetozone setosa and Lumbrineris* sp. 2. The three polychaetes above comprised one-fifth of the significantly different species of polychaetes (Appendix A) and were found mostly in greater abundances at site 4 than any other site.

MANOVA was applied to the two groups separately to determine if the macroinvertebrate compositions within groups A and B were significantly different. The macroinvertebrate compositions were marginally different between sites in group A (Wilks' $\lambda = 0.00$, $F(60, 8.46) = 2.78$, $p = 0.057$) but were not significantly different between the sites in group B (Wilks' $\lambda = 0.001$, $F(24, 3.50) = 1.38$, $p = 0.43$).

MANOVA was reapplied to the 30 replicates' macroinvertebrate abundances though at a higher taxonomic classification (i.e., oligochaetes, polychaetes, amphipods, decapods, isopods, tanaidaceans, mysids, ostracods, cumaceans, bivalves, gastropods and sipunculans). Significant differences still appeared among the five sites (Wilks' $\lambda = 0.00$, $F(108, 78.04) = 3.37$, $p < 0.005$). A MANOVA on higher classification abundances found no significant differences between sites in either group A (Wilks' $\lambda = 0.00$, $F(60, 8.46) = 1.65$, $p = 0.22$) or group B (Wilks' $\lambda = 0.00$, $F(24, 3.50) = 0.89$, $p = 0.64$). Table 21 summarizes mean densities and standard deviations of the higher taxonomic groups at each of the five sites.

Table 21. Mean density (x m^{-2}) and standard deviation of the higher taxonomic groups at each of the five sites. Groups A and B refer to the clustering of sites found in Figures 2 and 3.

Group	Site	Oligochaete	Polychaete	Tanaid	Ostracod	Bivalve	Gastropod	Sipunculid
A	2	6,944 ± 1,965	8,406 ± 1,864	73 ± 179	110 ± 120	110 ± 120	4,166 ±2,948	1,535 ± 877
	3	6,030 ± 3,116	13,595 ± 8,697	0 ± 0	3,399 ± 495	146 ± 179	110 ±120	877 ± 809
	4	2,156 ± 1,251	8,406 ± 3,932	0 ± 0	439 ± 277	256 ± 216	731 ±729	73 ± 113
B	1	2010 ± 1,122	3,508 ± 2,270	10,379 ± 4,141	0 ± 0	37 ± 90	1,060 ±1,244	8,588 ± 4,191
	5	914 ± 1,014	3,033 ± 1,437	73 ± 113	219 ± 277	73 ± 113	7,090 ±6,744	2,449 ± 3,720

Group	Site	Amphipod	Cumacean	Decapod	Isopod	Mysid	Ophiurid	Nemertean
A	2	256 ± 351	0 ± 0	73 ± 113	73 ± 113	0 ± 0	73 ± 113	804 ± 630
	3	37 ± 97	146 ± 179	0 ± 0	219 ± 340	73 ± 179	110 ± 183	402 ± 508
	4	146 ± 113	219 ± 196	146 ± 113	73 ± 113	37 ± 90	37 ± 90	439 ± 240
B	1	1,608 ± 1,999	37 ± 90	146 ± 226	292 ± 330	0 ± 0	37 ± 90	402 ± 378
	5	146 ± 266	0 ± 0	183 ± 165	0 ± 0	146 ± 179	0 ± 0	256 ± 351

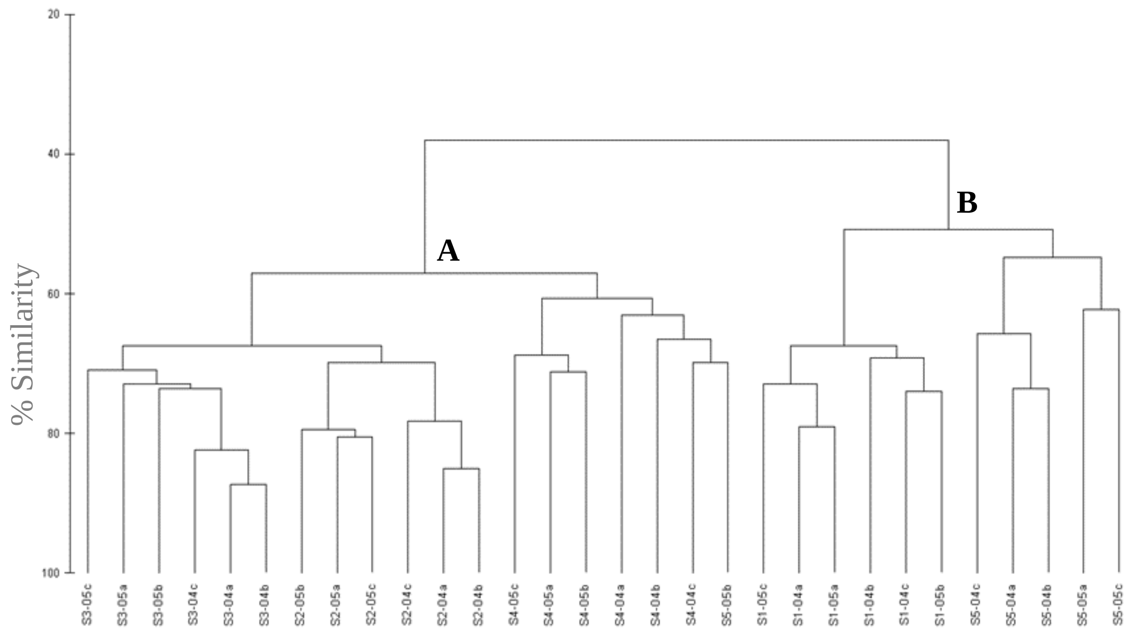

Figure 2. Dendrogram showing classification of the 30 replicates based on species abundance. Abundances were root-root transformed before using Bray-Curtis similarity matrix with group average sorting. Groups A and B are distinguished at similarity level

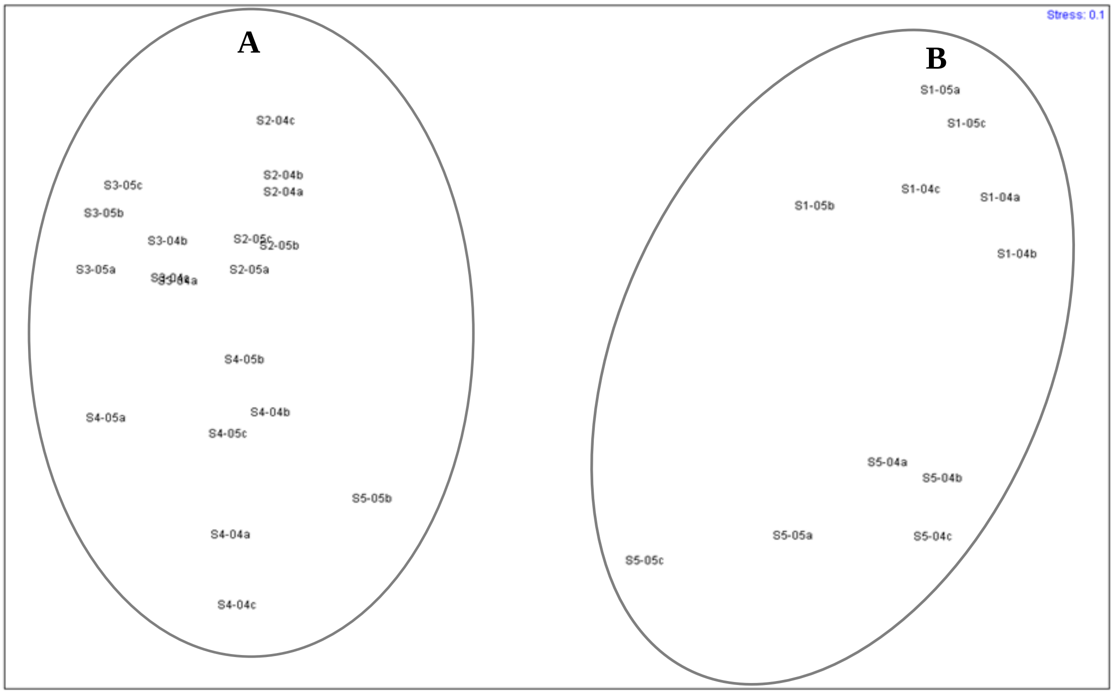

Figure 3. Ordination of the 30 macroinvertebrate replicates using non-metric multi-dimensional scaling on the same similarity matrix as in Fig. 2. Clusters were distinguished in the dendrogram and superimposed by encircling each cluster of replicates.

b. Sediment samples – grain size

The percent dry weights of the 6 grain sizes (i.e., granule, coarse sand, medium sand, fine sand, very fine sand and silt-clay) from the 30 sediment samples are listed in Table 22. Multivariate analysis determined that grain size distributions differed significantly among sites (Wilks' $\lambda = 0.001$, $F(20, 54.01) = 16.8$, $p < 0.005$). A dendrogram (Figure 4) of grain size distributions of the 30 replicates, using the Bray-Curtis similarity matrix and group-average sorted, again distinguishes two main groups; sites 2, 3 and 4, and sites 1 and 5. The sediment grain size distributions in the two main groups were not as clearly separated by site as was seen in Figure 2 for the macroinvertebrate composition. The grain size distributions were more mixed among the sites. Some sediment samples from site 3 were grouped with sites 2 and 4, and one sediment sample from site 2, 2-2005b, was grouped with those from site 1.

Table 22. 2004 and 2005 grain size distributions, based on percent dry weight.

Site	Year	U.S. Standard	Φ	U.S. Standard	Φ	U.S. Standard	Φ	U.S. Standard	Φ	U.S. Standard	Φ	U.S. Standard	Φ
		10	-1	35	1	60	2	120	3	230	4	>230	>4
		Granule		Coarse Sand		Medium Sand		Fine Sand		Very Fine Sand		Silt-Clay	
1	2004	4.18		31.53		30.08		23.54		5.12		5.55	
1	2004	7.80		26.14		31.23		22.57		5.58		6.68	
1	2004	6.29		34.54		32.99		18.17		3.52		4.50	
1	2005	6.65		30.91		30.73		22.86		4.93		3.92	
1	2005	13.49		43.85		25.06		12.32		2.46		2.82	
1	2005	7.89		39.73		29.07		17.31		3.18		2.82	
2	2004	4.26		13.36		30.80		36.79		6.60		8.19	
2	2004	2.12		7.51		17.96		51.57		10.72		10.12	
2	2004	3.64		5.89		19.80		51.91		9.79		8.97	
2	2005	4.96		16.34		37.80		31.90		4.02		4.98	
2	2005	12.46		23.55		32.78		24.36		3.06		3.78	
2	2005	10.06		17.01		32.75		31.79		4.23		4.17	
3	2004	3.93		8.97		27.90		41.22		7.66		10.32	
3	2004	4.54		10.29		30.13		35.43		8.56		11.06	
3	2004	3.21		11.40		28.79		37.92		7.70		10.98	
3	2005	6.95		11.73		30.19		36.35		7.74		7.04	
3	2005	17.71		12.07		28.66		26.88		7.01		7.68	
3	2005	9.26		14.10		33.39		32.43		5.35		5.47	
4	2004	7.92		10.05		19.22		49.03		8.46		5.32	
4	2004	8.24		8.14		16.98		49.22		9.83		7.58	
4	2004	4.24		5.72		15.06		56.96		11.38		6.64	
4	2005	10.33		14.26		28.51		36.84		6.09		3.96	
4	2005	3.17		10.13		26.95		46.84		8.05		4.85	
4	2005	5.33		11.26		27.08		45.19		6.88		4.27	
5	2004	19.90		43.21		27.67		4.21		0.93		4.07	
5	2004	32.30		40.37		17.83		4.02		0.69		4.78	
5	2004	12.37		49.80		31.67		4.32		0.51		1.34	
5	2005	27.42		36.31		26.71		5.59		1.13		2.85	
5	2005	18.16		39.70		33.07		5.67		0.66		2.74	
5	2005	22.97		47.88		23.87		2.98		0.46		1.84	

Folk's (1965) classification of grain size distributions was used to describe the mean distributions for each of the sites in 2004 and 2005. Mean percent composition and standard deviation of gravel (x >2mm), sand (1/16mm< x <2mm) and silt-clay (x<1/16mm) were calculated for each of the sites in each year (Table 23). The majority of the sites were classified as gravelly sand (sand: silt+clay ratio > 9:1, gravel = 2-30%)

for both years. The only site classified differently, Site 3 in 2004, was slightly gravelly muddy sand (sand: silt+clay ratio = 1:1 to 9:1, gravel = 2-30%).

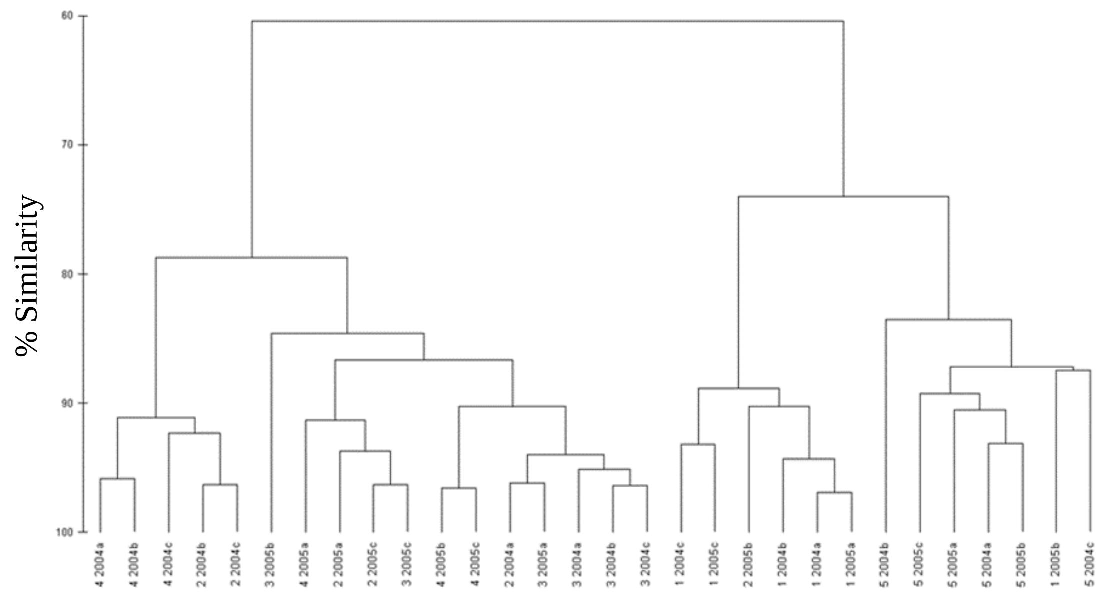

Figure 4. Dendrogram showing classification of the 30 replicates based on sediment grain size distributions using Bray-Curtis similarity matrix with group average sorting.

Table 23. Mean percent sediment composition ± standard deviation as well as Folk's sediment classification for 2004 and 2005.

Grain Size	Site 1 2004	Site 2 2004	Site 3 2004	Site 4 2004	Site 5 2004
Gravel	6.09 ± 1.82	3.34 ± 1.10	3.89 ± 0.67	6.80 ± 2.23	21.52 ± 10.07
Sand	88.33 ± 2.49	87.57 ± 0.18	85.32 ± 0.80	86.68 ± 2.47	75.08 ± 11.71
Silt-Clay	5.58 ± 1.09	9.09 ± 0.97	10.79 ± 0.40	6.52 ± 1.13	3.40 ± 1.81
Folk's Classification	Gravelly Sand	Gravelly Sand	Slightly Gravelly Muddy Sand	Gravelly Sand	Gravelly Sand

Grain Size	Site 1 2005	Site 2 2005	Site 3 2005	Site 4 2005	Site 5 2005
Gravel	9.34 ± 3.64	9.16 ± 3.83	11.30 ± 5.66	6.28 ± 3.67	22.85 ± 4.63
Sand	87.47 ± 3.27	86.53 ± 3.21	81.96 ± 6.38	89.36 ± 3.26	74.67 ± 4.70
Silt-Clay	3.19 ±0.64	4.31 ± 0.61	6.73 ± 1.14	4.36 ± 0.45	2.48 ± 0.55
Folk's Classification	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand

MANOVA was used to determine if the sites and years were significantly different based on the percent composition of gravel, sand and silt-clay. Sediment compositions were significantly different between the sites and years (Wilks' $\lambda = 0.44$, $F(8, 38) = 2.4$, $p = 0.033$). Tukey HSD was applied to each of the three grain size classes to determine which sites and years differed (Table 24).Dendrogram showing classification of the 30 replicates based on the sediment grain size distributions using Bray-Curtis similarity matrix with group average sorting.

c. Sediment samples – chemical analyses

In 2005, composite sediment samples were collected at each site and analyzed for metals, nutrients, and percent volatile solids (Table 25). The results of the metals analyses does not follow the groupings of sites 2-4, and 1 and 5 as closely as is seen for the macroinvertebrate composition (Figure 2) and sediment grain size distributions (Figure 4). Seven of the ten metals analyzed had the highest concentrations at sites 2 and 3. Site 3 had the highest concentrations for aluminum, cadmium, copper, iron and lead. Site 2 had the highest concentrations of chromium and mercury. Zinc was the only metal that had higher concentrations at site 1 than sites 2-4. The two remaining metals in Table 25, arsenic and nickel, were found below the method detection limit at all five sites. Site 5 had the lowest concentrations for all metals analyzed.

Of the metals that have toxicity level guidelines developed by FDEP (i.e., As, Cd, Cr, Cu, Pb, Hg, Ni and Zn)Zi), only cadmium and copper were detected at levels exceeding either the threshold effects level (TEL) or probable effects level (PEL). Cadmium was detected in exceedance of the 4.21 mg/kg dw PEL at sites 2, 3 and 4 while site 1, 3.79 mg/kg dw, exceeded the TEL of 0.676 mg/kg dw. Copper exceeded the

Table 24. Approximate probabilities of post-hoc test (Tukey HSD) comparison of grain size percent composition among sites. Sites with values < 0.05 (shaded cells) are significantly different.

Gravel (Error: Between MS = 20.620, df = 20)

	Site 1 2004	Site 1 2005	Site 2 2004	Site 2 2005	Site 3 2004	Site 3 2005	Site 4 2004	Site 4 2005	Site 5 2004	Site 5 2005
Site 1 2004		0.996	0.999	0.997	1.000	0.912	1.000	1.000	0.014	0.006
Site 1 2005	0.996		0.824	1.000	0.889	1.000	0.999	0.997	0.083	0.041
Site 2 2004	0.999	0.824		0.847	1.000	0.518	0.993	0.998	0.003	0.001
Site 2 2005	0.997	1.000	0.847		0.907	1.000	1.000	0.998	0.075	0.037
Site 3 2004	1.000	0.889	1.000	0.907		0.609	0.998	1.000	0.004	0.002
Site 3 2005	0.912	1.000	0.518	1.000	0.609		0.961	0.927	0.217	0.115
Site 4 2004	1.000	0.999	0.993	1.000	0.998	0.961		1.000	0.020	0.010
Site 4 2005	1.000	0.997	0.998	0.998	1.000	0.927	1.000		0.015	0.007
Site 5 2004	0.014	0.083	0.003	0.075	0.004	0.217	0.020	0.015		1.000
Site 5 2005	0.006	0.041	0.001	0.037	0.002	0.115	0.010	0.007	1.000	

Sand (Error: Between MS = 24.475, df = 20)

	Site 1 2004	Site 1 2005	Site 2 2004	Site 2 2005	Site 3 2004	Site 3 2005	Site 4 2004	Site 4 2005	Site 5 2004	Site 5 2005
Site 1 2004		1.000	1.000	1.000	0.999	0.844	1.000	1.000	0.084	0.069
Site 1 2005	1.000		1.000	1.000	1.000	0.925	1.000	1.000	0.125	0.104
Site 2 2004	1.000	1.000		1.000	1.000	0.917	1.000	1.000	0.120	0.099
Site 2 2005	1.000	1.000	1.000		1.000	0.975	1.000	0.999	0.190	0.159
Site 3 2004	0.999	1.000	1.000	1.000		0.997	1.000	0.989	0.308	0.264
Site 3 2005	0.844	0.925	0.917	0.975	0.997		0.969	0.710	0.781	0.725
Site 4 2004	1.000	1.000	1.000	1.000	1.000	0.969		0.999	0.178	0.149
Site 4 2005	1.000	1.000	1.000	0.999	0.989	0.710	0.999		0.051	0.041
Site 5 2004	0.084	0.125	0.120	0.190	0.308	0.781	0.178	0.051		1.000
Site 5 2005	0.069	0.104	0.099	0.159	0.264	0.725	0.149	0.041	1.000	

Silt-Clay (Error: Between MS = .94499, df = 20)

	Site 1 2004	Site 1 2005	Site 2 2004	Site 2 2005	Site 3 2004	Site 3 2005	Site 4 2004	Site 4 2005	Site 5 2004	Site 5 2005
Site 1 2004		0.139	0.008	0.837	0.000	0.895	0.966	0.864	0.221	0.024
Site 1 2005	0.139		0.000	0.907	0.000	0.007	0.013	0.885	1.000	0.995
Site 2 2004	0.008	0.000		0.000	0.527	0.149	0.090	0.000	0.000	0.000
Site 2 2005	0.837	0.907	0.000		0.000	0.130	0.209	1.000	0.972	0.424
Site 3 2004	0.000	0.000	0.527	0.000		0.002	0.001	0.000	0.000	0.000
Site 3 2005	0.895	0.007	0.149	0.130	0.002		1.000	0.146	0.013	0.001
Site 4 2004	0.966	0.013	0.090	0.209	0.001	1.000		0.232	0.022	0.002
Site 4 2005	0.864	0.885	0.000	1.000	0.000	0.146	0.232		0.961	0.390
Site 5 2004	0.221	1.000	0.000	0.972	0.000	0.013	0.022	0.961		0.971
Site 5 2005	0.024	0.995	0.000	0.424	0.000	0.001	0.002	0.390	0.971	

108 mg/kg dw PEL at site 3 with a concentration of 153 mg/kg dw, while sites 1, 2 and 4 exceeded the TEL (18.7 mg/kg dw) at concentrations of 22.2, 66.5 and 31.8 mg/kg dw, respectively.

The results of the nutrients analyses do not follow any pattern or trend. The percent solids were similar at all five sites with a narrow range of 72.9-76.4 % solids. The lowest value for percent solids, 72.9, occurred at site 3, which was also the highest percent volatile solids at 2.11%. The other four sites had percent volatile solids < 2%.

Table 25. Chemical analysis of composite sediment samples collected in 2005. Analysis includes metals, nutrients, percent solids and volatile solids. mdl = method detection limit, mdl* = differing mdl, dw = dry weight, FDEP SQG = Florida Department of Environmental Protection sediment quality guideline, TEL = threshold effect level, PEL = probable effect level.

Analyte	Units	mdl	Site 1	Site 2	Site 3	Site 4	Site 5	FDEP SQG	
Metals								TEL	PEL
Aluminum	mg/kg dw	0.954	15.125	40.36	1,195.10	836.25	1.49	n/a	n/a
Arsenic	mg/kg dw	2.43	<2.43	<2.43	<2.43	<2.43	<2.43	7.24	41.6
Cadmium	mg/kg dw	1.53	3.79	12.1	15.7	15.1	<1.53	0.676	4.21
Chromium	mg/kg dw	1.64	1.905	3.17	2.79	2.38	<1.64	52.3	160
Copper	mg/kg dw	1.27	22.2	66.5	153	31.8	6.05	18.7	108
Iron	mg/kg dw	0.792	1,107.80	731.43	4,214.30	372.65	187.27	n/a	n/a
Lead	mg/kg dw	2.24	15.1	13.5	18.4	12.7	<2.24	30.2	112
Mercury	mg/kg dw	0.053	0.0642	0.126	0.123	0.0636	<.0530	0.13	0.696
Nickel	mg/kg dw	2.39	<2.39	<2.39	<2.39	<2.39	<2.39	15.9	42.8
Zinc	mg/kg dw	6.04	45.6	29.8	41.8	20.6	18.7	124	271
Nutrients									
Nitrite & Nitrate	mg/kg	12.5	<12.5	<12.5	<12.5	<12.5	<12.5		
Total Kjeldahl Nitrogen	mg/kg	2, 2.25*	98.65	159	49.6*	849	399		
Total Nitrogen	mg/kg	2.5, 3.12*	101.5	162	58.5*	850	403		
Total Phosphates	mg/kg	2, 2.5*	54	35.1	59.5*	31.4	86.9		
Miscellaneous									
Percent Solids	%	0.012	73.9	73.8	72.9	76.4	75.1		
Volatile Solids	%	0.1	1.77	1.72	2.11	1.17	1.24		

d. Water Quality

YSI 6600 multiparameter datasondes were deployed in 2004 and 2005 at each site to measure specific conductivity (salinity), temperature, dissolved oxygen, pH, chlorophyll and turbidity through a minimum of one tidal cycle with readings taken in 15 minute intervals. The sonde used in 2004 flooded during its deployment and as a result the data was lost. Another sonde was redeployed a month later but the data was not representative of the conditions during which the macroinvertebrate samples were collected and thus not used for comparison. Appendix B lists all water quality data collected in 2005**.** Table 26 summarizes the data and is illustrated in Figure 5.

The specific conductivity levels at Sites 1, 2, 4 and 5 range from 30,637 to 54,609 uS/cm throughout the tidal cycle. At Site 3, the effect of the freshwater discharge from the mouth of the New River produces a larger range of specific conductivity, 16,404 to 48,770 uS/cm. pH levels correspond well with the specific conductivity. Sites 1, 2, 4 and 5 have pH levels between 7.75 and 8.06; site 3 has a slightly lower range: 7.63 to 7.99. The range of temperatures at Sites 1, 2 and 3 are slightly elevated in comparison to those of Sites 4 and 5, 30.84-32.88ºC and 29.04-31.45ºC, respectively. Dissolved oxygen varies little between low and high tide (4.93-5.94 mg/L) at Sites 1, 4 and 5 with the higher concentrations occurring at high tide. Sites 2 and 3 experience wider ranges of dissolved oxygen as the result of the freshwater discharge lowering dissolved oxygen concentrations at low tide, (3.87-6.13 mg/L and 4.32-6.74 mg/L, respectively). The turbidity levels at all five sites are less than 4.5 NTUs, with levels <1.5 NTUs at Sites 1, 3 and 5. Chlorophyll levels are greater at Sites 1, 2 and 3 (2-12 ug/L) compared to those at Sites 4 and 5 (0-9 ug/L).

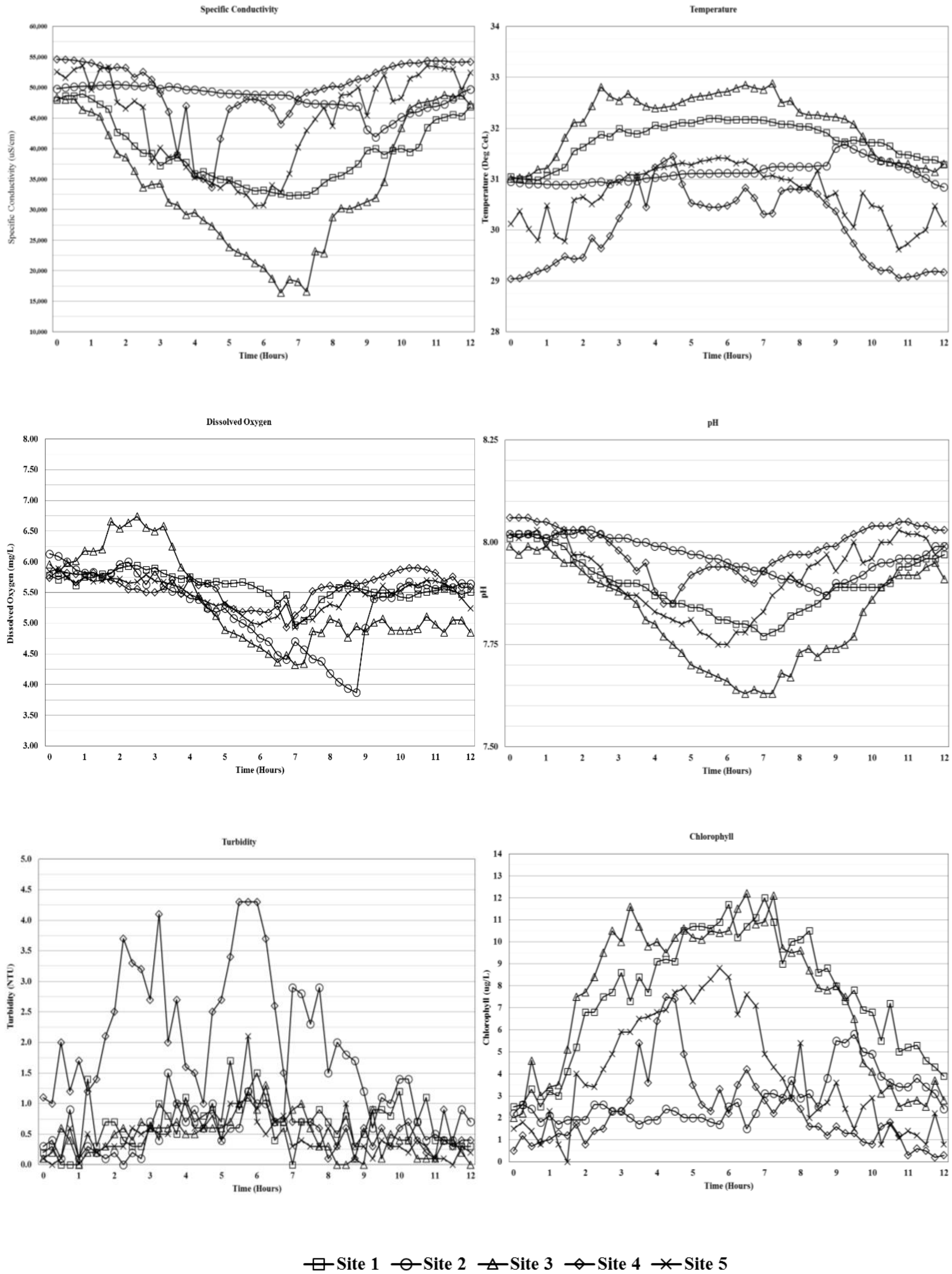

Figure 5. Water quality parameters: specific conductivity (uS/cm), temperature (degrees Celsius), dissolved oxygen (mg/L), pH, turbidity (NTU) and chlorophyll (μg/L), measured in 15-min intervals throughout one tidal cycle during the 2005 sampling.

Table 26. Descriptive statistics for specific conductivity, temperature, dissolved oxygen, pH, turbidity and chlorophyll measured during one tidal cycle in 2005.

	Site 1	Site 2	Site 3	Site 4	Site 5
Specific Conductivity (uS/cm)					
Min	32,272	41,904	16,404	33,624	30,637
Max	48,956	50,460	48,770	54,609	53,554
Mean	39,320	48,290	34,126	49,761	44,457
Median	38,981	48,901	31,914	51,353	46,766
Std Dev	5,252	2,112	10,582	5,317	7,693
Temperature (Deg. Cel)					
Min	30.98	30.84	31.01	29.04	29.62
Max	32.19	31.69	32.88	31.45	31.42
Mean	31.76	31.12	32.09	30.03	30.69
Median	31.88	31.11	32.26	30.23	30.73
Std Dev	0.38	0.21	0.62	0.74	0.54
Dissolved Oxygen (mg/L)					
Min	4.97	3.87	4.32	4.93	4.93
Max	5.94	6.13	6.74	5.90	5.89
Mean	5.60	5.28	5.35	5.59	5.47
Median	5.61	5.50	5.05	5.64	5.53
Std Dev	0.21	0.61	0.73	0.24	0.25
pH					
Min	7.77	7.87	7.63	7.85	7.75
Max	8.02	8.03	7.99	8.06	8.03
Mean	7.89	7.97	7.82	7.99	7.92
Median	7.89	7.97	7.83	7.99	7.94
Std Dev	0.07	0.05	0.12	0.06	0.09
Turbidity (NTU)					
Min	0.0	0.0	0.0	0.1	0.0
Max	1.7	2.9	1.3	4.3	2.1
Mean	0.7	0.9	0.5	1.6	0.5
Median	0.7	0.7	0.5	1.2	0.4
Std Dev	0.4	0.7	0.3	1.3	0.4
Chlorophyll (ug/L)					
Min	2.5	1.5	2.0	0.2	0.0
Max	12.0	5.8	12.2	7.5	8.8
Mean	7.5	2.8	7.5	2.2	4.0
Median	7.7	2.5	8.4	1.6	3.5
Std Dev	2.8	1.1	3.3	1.7	2.6

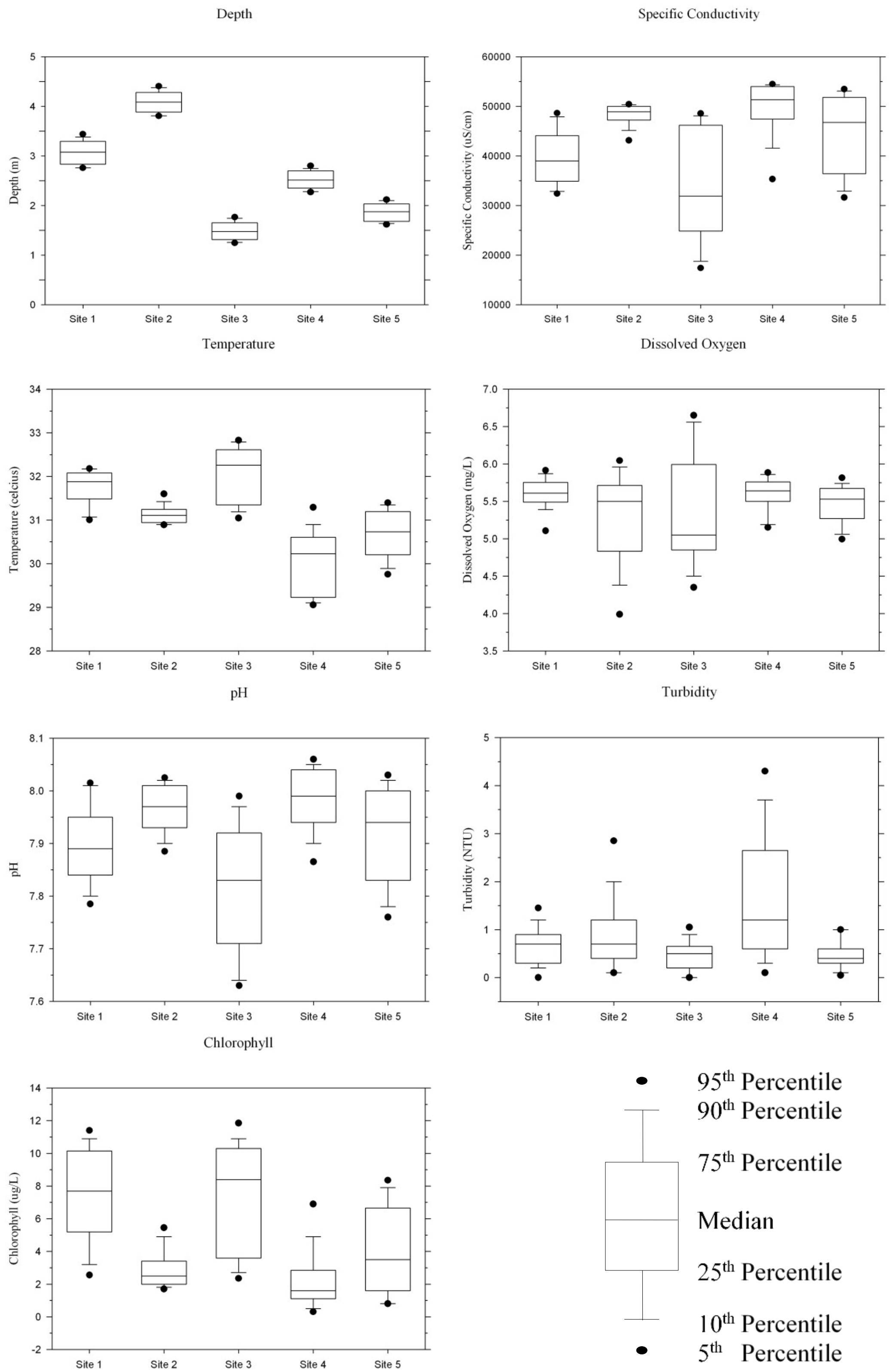

Figure 6. Water quality conditions (i.e., depth, specific conductivity, temperature, dissolved oxygen, pH, turbidity and chlorophyll) during one tidal cycle at each site in 2005.

4. DISCUSSION

Macroinvertebrate densities were not significantly different between the years at any of the five sites. Amongst the sites macroinvertebrate densities were only significantly different between sites 1 and 4 ($p = 0.033$), all other sites' densities were not significantly different. Two sites' species richness were significantly different between 2004 and 2005. Species richness declined at site 2 with a mean richness and standard deviation of 22 ± 2 and 16 ± 2 for 2004 and 2005, respectively, ($p = 0.041$) while the species richness at site 3 increased from 18 ± 3 to 26 ± 2, respectively, ($p = 0.019$). The higher species richness at sites 3 and 4 in 2005 (S = 26) were significantly different from most other sites and years (S = 12-22). The diversity indices were not significantly different between the years at any of the five sites. Between the sites the mean diversity indices at sites 1 and 5 (2.72 and 2.62, respectively) were significantly different than the indices at sites 2, 3 and 4 (3.46, 3.53 and 3.84, respectively). The comparison of macroinvertebrate communities between the sites were significantly different ($p < 0.005$). The marina sites 1 and 5 differed significantly from the background (non-marina) site 3 as well as marina sites 2 and 4. From year to year the entirety of the macroinvertebrates present did not differ significantly ($p = 0.385$).

Marina sites 1 and 5 did not differ significantly from each other either at the species level ($p = 0.43$) or higher taxonomic level (e.g., oligochaete, polychaete, amphipod, tanaidacean, gastropod) ($p = 0.64$). At the species level, marina sites 2 and 4 and background site 3, were marginally different ($p = 0.057$). However, the three sites did not differ significantly at the higher taxonomic level ($p = 0.22$). This study follows Ferraro and Cole (1990), Gray et al. (1990), Warwick et al. (1990), Sommerfield and

Clarke (1995), Olsgard et al. (1997), and Sanchez-Moyano et al. (2010) in using higher taxa to compare macroinvertebrate communities' responses to environmental factors such as pollutants (e.g., heavy metals) that may reflect stressful conditions. Variables such as sediment grain size and depth can affect more specific taxonomic levels such as species composition (Warwick 1988).

The annual mean of each site's higher taxonomic macroinvertebrate composition as well as the two-year mean were calculated (Table 27) in order to summarize the macroinvertebrate communities. Group A (sites 2, 3 and 4) was dominated by oligochaetes and polychaetes while group B (sites 1 and 5) had lower abundances of annelids but higher percentages of sipunculids.

Table 27. Annual and mean percent composition of higher taxonomic groups.

Taxonomic Group	Group A									Group B					
	Site 2			Site 3			Site 4			Site 1			Site 5		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
Oligochaeta	29.7	32.2	30.95	25.4	23.2	24.3	21.4	13.7	17.55	10.5	4.7	7.6	0.7	22.5	11.6
Polychaeta	33.2	42.3	37.75	44.1	59.9	52	57.2	67.5	62.35	16.9	9.1	13	15.8	35.3	25.55
Amphipoda	0	2.8	1.4	0	0.2	0.1	1.6	0.8	1.2	1.8	8.4	5.1	0.3	2.9	1.6
Cumacea	0	0	0	0.4	0.7	0.55	0.8	2.1	1.45	0	0.2	0.1	0	0	0
Decapoda	0.3	0.4	0.35	0	0	0	1.6	0.8	1.2	0.6	0.4	0.5	0.7	2.9	1.8
Isopoda	0.3	0.4	0.35	2	0.2	1.1	0.8	0.4	0.6	1.5	0.7	1.1	0	0	0
Mysida	0	0	0	0	0	0	0.8	0	0.4	0	0	0	0.3	2.9	1.6
Ostracoda	0.6	0.4	0.5	19.5	9.9	14.7	2.4	3.8	3.1	0	0	0	1.7	1	1.35
Tanaidacea	0	0.8	0.4	0	0	0	0	0	0	36.3	36.8	36.55	0.3	1	0.65
Ophiurida	0.3	0.4	0.35	0	0.7	0.35	0	0.4	0.2	0.3	0	0.15	0	0	0
Bivalvia	0.5	0.4	0.45	0	0.9	0.45	2.4	1.7	2.05	0	0.2	0.1	0	2	1
Gastropoda	21.7	13.7	17.7	0.4	0.4	0.4	7.1	4.7	5.9	3.1	4.2	3.65	55.6	28.4	42
Nemertea	5	1.6	3.3	0.8	2.1	1.45	3.2	3.4	3.3	2.5	0.7	1.6	2.4	0	1.2
Sipuncula	8.5	4.3	6.4	7.4	1.2	4.3	0.8	0.4	0.6	26.2	33.3	29.75	22.2	1	11.6

Site 1 had a mean macroinvertebrate composition of 36% tanaidacean, 30% sipunculan, 13% polychaete, 8% oligochaete and 5% ostracod (Table 27). The mean composition at site 5 was comprised of 42% gastropods, 26% polychaete, 12% oligochaete and 12% sipunculan. The macroinvertebrate communities at sites 1 and 5 were similar in having a low mean percent composition of annelids, ~20% and ~37%, respectively. Sites 1 and 5 also had a high mean percent composition of sipunculans, ~30% and ~11%, respectively, relative to the other sites.

Site 2 had a mean macroinvertebrate composition of 38% polychaete, 31% oligochaete and 18% gastropod. The mean composition of macroinvertebrates at site 3 was 52% polychaete, 24% oligochaete and 15% ostracod. Site 4 had a mean composition of 62% polychaete, 18% oligochaete and 6% gastropod. The dominance of annelids, in particular polychaetes, as the most abundant of the higher taxa (mean composition >65%) contributed to the similarity in macroinvertebrate communities at these three sites.

Some of the more abundant polychaetes observed at the group A sites and less abundant at group B sites were capitellids (e.g., *Capitella capitata*), spionids (e.g., *Prionospio* sp., *Polydora* sp.), cirratulids (e.g., *Tharyx* sp.) and fabriciine sabellids (e.g., *Fabriciola trilobata*). At sites 2-4 capitellids, spionids, cirratulids and fabriciine sabellids polychaetes accounted for a mean composition of 29-50% of all macroinvertebrates, while at sites 1 and 5 the percent composition was much lower: 6-28%. The dominance of the above mentioned species at sites 2-4 is characteristic of a stressed environment (Pearson and Rosenberg 1978, Messing 1990, Ingole et al. 2009).

Differences in sediment grain size distributions may be a factor underlying the significant differences between the macroinvertebrate communities at the two groups of sites: group A (sites 2, 3 and 4), and group B (sites 1, 5). Of the three components used to classify a sediment (i.e., gravel, sand, and silt-clay), the amount of silt-clay (= percent fines) most influences sediment chemistry. Organic contaminants and trace metals have a strong affinity for fine-grained particles and are therefore often found in greater concentrations in sediments with higher amounts of silt-clay (Velinsky et al. 1994). Mean percent fines ranged from 6.5-10.8% in 2004 and 4.3-6.7% in 2005 at group A sites 2, 3, and 4. The mean percent fines were less in group B with a range of 3.4-5.5% in 2004 and 2.5-3.2% in 2005 (Table 23). The higher percentage of fines at the three group A sites may explain the higher concentrations of metals detected in the sediments and the dominance of more stress-tolerant species.

Swifter currents at site 5 (Bernhard, personal observation) most likely accounts for the coarser grain size of sediments. The higher velocity flows observed at site 5 could result in winnowing of fine grain particles and would explain the shift dominant fauna away from deposit feeders common at sites 2, 3 and 4. Site 1 likely sees similar current velocities as at sites 2, 3 and 4 (Bernhard, personal observation) but the distance from the source, New River, may allow for the development of benthic communities dominated by suspension feeder (e.g., *Mesokalliapseudes macsweenyi*) over deposit feeders. Site 1 is far enough from the source to not receive as much polluted material which may be determining macroinvertebrate composition.

The concentrations of aluminum, cadmium, chromium and copper were higher at group A sites 2-4 than group B sites 1 and 5, in keeping with the higher percentages of fine sediment grains at the former. The exceedance of the cadmium PEL at sites 2-4 in addition to the exceedance of copper PEL at site 3 and TEL exceedance at sites 2 and 4 may explain the higher abundance of more stress-tolerant species at the three sites. MacDonald (1996) evaluated the results of the TEL and PEL levels for metals as they related to field studies conducted in Tampa Bay, Pensacola Bay, and coastal and offshore

Gulf of Mexico. The results of those studies were in agreement with the levels of adverse biological effects set by the TEL and PEL. Compounding TEL or PEL exceedances reflect a greater stress on the biological communities. In this study, all three group A sites had more than one exceedance of a sediment quality guideline.

The water quality measured during the tidal cycle revealed a potentially significant source of contaminants to the background site 3. This site experiences large fluxes in specific conductivity (Figures 4 and 5) as a result of freshwater, and mesohaline and oligohaline waters discharged from the New River to the Intracoastal Waterway. The South Florida Water Management District (SFWMD) operates and maintains a series of canals throughout south Florida to control surface water, recharge groundwater supplies and prevent flooding. Large amounts of water discharged from the New River originate upstream at the North New River Canal and the C-12 Canal, which are a part of SFWMD's surface water conveyance system. A major component of the surface water in the conveyance system is stormwater, which is the product of precipitation that flows over impervious land. As stormwater travels across impervious land and enters municipal separate storm sewer systems (MS4), it accumulates pollutants such fertilizers, pesticides, oils, metals and sediments. The stormwater and pollutants are then discharged from the MS4 to nearby surface waters. The stormwater discharged to the SFWMD canals crosses lands supporting many different uses, including residential, commercial, agricultural and industrial (Figure 7). Each land use generates different types and concentrations of pollutants (Miller and Mattraw 1982), that stormwater runoff may introduce into Intracoastal Waterway and coastal surface waters and sediments.

Broward County's Environmental Monitoring Laboratory (BCEML) measured the levels of metals in samples of surface sediments collected throughout the County between 2005 and 2007 as a part of its NDPES permit monitoring requirements (Table 28). The Figure ID column in Table 28 corresponds to the sediment sampling sites on Figure 7; study sites 1-5 correspond to the sediment sampling sites 16-20. The concentrations of metals in the marine sediments are less than those found in freshwater sediments, likely due to the accumulation of pollutants in sediments as a result of stormwater loading. Concentrations of pollutants in sediments are often higher where either water flow is lessened, allowing deposition of particulate matter (e.g., site 11 in Figure 7; Bernhard, personal observations), or where the water chemistry changes rapidly, such as along an estuarine gradient (Kennish 2002) (e.g., site 4 and 8 in Figure 7; Bernhard, personal observation); site 3 falls into the latter category.

Figure 7. Land use and sediment sampling site locations for metals analysis by Broward County.

Between 1995 and 1996, Long et al. (2002) conducted a survey of sediment quality and benthic communities in coastal Miami-Dade County, Florida, including the

Miami River and Biscayne Bay, and found greater sediment contamination along the Miami River than in Biscayne Bay and a higher dominance of polychaetes in the more polluted areas. As with the New River, the Miami River receives substantial stormwater discharge and pollutant loading from both point and non-point sources, and, as consistent with the findings in Fort Lauderdale, the upstream pollutant loading appears to be more of a determining factor for benthic community composition than local sources such as the marinas located throughout the ICW.

Cooksey and Hyland (2007) assessed the benthic community and sediment-associated stressors along the Lower St. Johns River, Jacksonville, Florida, and, again as in the current study, chemical contamination of sediments was greater near the center of the metropolitan area, where different types of land use discharged the stormwater to nearby surface waters. The most abundant species observed at the contaminated sites was a spionid polychaete, *Streblospio benedicti*, a species indicative of polluted environments.

In addition to the two local studies conducted in Florida assessing benthic macroinvertebrate communities as a response to stress, many studies have been carried out across the world. Giangrande et al. (2005) reviewed the use of polychaetes as environmental indicators. They concluded that capitellid, cirratulid and spionid polychaetes were opportunistic species often dominating environments exposed to pollution. A study conducted by Shen et al. (2010) found that *Tharyx* sp., *Capitella capitata* and *Prionospio* sp. were present in estuarine sediments that received pollutant loading from upstream Hong Kong. Sanchez-Moyano et al. (2010) assessed the

Table 28. Results of 2005-2007 sediment sampling by BCEML. Bold values exceed Florida's coastal sediment quality guideline threshold effects level (TEL) and bold/underline exceed probable effects level (PEL). Figure IDs 16-20 correspond with study sites 1-5, respectively. Results below the mdl are reported <mdl.

Metal (mg/kg dw)			Al	As	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
method detection limit (mg/kg dw)			0.954	2.43	1.53	1.64	1.27	0.792	0.053	2.39	2.24	6.04
Figure ID	**Basin**	**Aqueous Medium**										
1	Hillsboro Canal	Freshwater	290.5	0.556	7.005	0.9635	5.97	145.15	<0.053	<2.39	6.81	6.16
2	Hillsboro Canal	Marine	35.5	3.76	<1.53	9.18	**26.9**	1810	<0.053	3.14	12.6	35.5
3	Hillsboro Canal	Marine	2030	0.703	<1.53	4.53	11.5	962	<0.053	<2.39	17.2	19.2
4	Intracoastal	Marine	6985	**13.15**	<1.53	**61.25**	**<u>424</u>**	14650	**<u>0.8805</u>**	15	**90.55**	**<u>463.5</u>**
5	C-13	Freshwater	7330	3.74	10.6	18.2	14.2	6380	0.0812	15	17.1	45.9
6	C-13	Freshwater	21600	4.68	6.68	44.1	109	11500	0.151	19.5	48.7	123
7	C-13	Marine	2905	3.81	<1.53	14.85	**46.55**	2655	**0.1555**	7.23	**60.55**	122.5
8	C-13	Marine	4640	**8.71**	<1.53	33	**<u>160</u>**	10100	**0.444**	11.1	**104**	**253**
9	Intracoastal	Marine	2240	0.796	<1.53	5.93	**28.3**	1120	0.0753	3.54	17.1	33.8
10	C-12/NNRC	Freshwater	4840	5.355	7.565	128.95	182.5	4355	<0.053	16.75	515	585
11	C-12/NNRC	Marine	6440	**10.5**	**<u>11.4</u>**	**56.2**	**<u>250</u>**	10100	**<u>0.799</u>**	**21.3**	**<u>216</u>**	**<u>755</u>**
12	C-12/NNRC	Marine	3710	**12.8**	**<u>13</u>**	43.5	**<u>413</u>**	10000	**<u>0.768</u>**	13.7	**<u>139</u>**	**<u>612</u>**
13	C-12/NNRC	Marine	1850	1.96	<1.53	14	**68.8**	2030	**0.218**	11.7	**32.4**	77.4
14	Intracoastal	Marine	21.5	2.98	<1.53	3.47	18.2	1960	0.0593	3.8	18.1	40.6
15	Intracoastal	Marine	1455	2.745	<1.53	8.315	**56.6**	2170	**0.1375**	4	16.95	54.15
16	Intracoastal	Marine	17.85	2.52	**3.79**	1.905	**22.2**	1111	0.06415	<2.39	15.1	45.55
17	Intracoastal	Marine	44.3	<2.43	**<u>12.1</u>**	3.17	**66.5**	736	0.126	<2.39	13.5	29.8
18	Intracoastal	Marine	1200	<2.43	**<u>15.7</u>**	2.79	**<u>153</u>**	4220	0.123	<2.39	18.4	41.8
19	Intracoastal	Marine	840	<2.43	**<u>15.1</u>**	2.38	**31.8**	377	0.0636	<2.39	12.7	20.6
20	Intracoastal	Marine	3.84	<2.43	<1.53	<1.64	6.05	190	<0.053	<2.39	2.24	18.7
21	C-12/NNRC	Freshwater	1174	1.175	10.045	8.23	8.115	2390	<0.053	1.0645	10.15	22.75
22	C-12/NNRC	Marine	1230	1.23	<1.53	4.14	**31.8**	1970	<0.053	2.86	8.84	35.2
23	C-11	Freshwater	3490	0.623	8.645	6.115	10.24	1090.5	<0.053	<2.39	12.05	11.95
24	C-11	Freshwater	2900	19.4	6.88	0.287	30.5	40200	0.101	14.7	24.2	80.9
25	C-11	Freshwater	2070	3.27	8.49	2.64	12	3430	<0.053	<2.39	12.8	26.9
26	C-11	Freshwater	515	0.9425	5.32	0.7045	3.3	834.5	<0.053	<2.39	5.64	8.275
27	C-11	Marine	780.5	0.75	<1.53	2.8	**30.4**	734	<0.053	3.175	13.3	17.25
Coastal Florida Sediment Quality Assessment Guidelines		TEL	n/a	7.24	0.676	52.3	18.7	n/a	0.13	15.9	30.2	124
		PEL		41.6	4.21	160	108		0.696	42.8	112	271

macroinvertebrate communities along a heavy-metal-rich estuary in southwestern Spain, downstream of mining activity. Spionid polychaetes were found in greater abundance upstream where metal concentrations were higher than the near coastal sediments. In India, Ingole et al. (2009) assessed benthic macroinvertebrate communities within harbors and found spionids and capitellids more abundant in organic-enriched sediments and polychaetes in general dominant among all harbor sediments. Guerra-Garcia and Garcia-Gomez (2004) found that polychaete abundance decreases within a less stressful environment in North Africa.

5. CONCLUSION

In this study it appears that the activities in marinas may be less of a determining factor for benthic macroinvertebrate composition than the potential effects of upland stormwater discharge. Urbanized estuaries and coastal embayments often have higher concentrations of chemicals in their sediments as a result of upstream stormwater discharge (Kennish 2002, Birch ad Rochford 2010). Municipal and industrial facilities produce stormwater with elevated levels of cadmium, copper and zinc (Kennish 2002). The highest concentrations of cadmium and copper were seen at the background site, nearest the mouth of the New River. While copper is heavily used in marine paints for its anti-fouling properties, it is often used as a algaecide at golf courses, retention ponds and surface water conveyance system, all of which eventually discharge directly or indirectly (as a result of stormwater) downstream to the coastal system (Crawford et al. 2010).

To better understand the effects of pollutants from stormwater discharge in the marine environment, future studies within Broward County's waterways could focus on benthic macroinvertebrate communities near the convergence of SFWMD's conveyance systems and the Intracoastal Waterway.

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APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years shaded (p<0.05).

Ampelisca bicarinata, Approximate Probabilities for Post Hoc TestsError: Between MS = .10406, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	.96039	0.0000	0.0000	0.0000	.33333	0.0000	0.0000	0.0000	0.0000
1	2004		0.0404	1.0000	1.0000	1.0000	0.9506	1.0000	1.0000	1.0000	1.0000
1	2005	0.0404		0.0404	0.0404	0.0404	0.3854	0.0404	0.0404	0.0404	0.0404
2	2004	1.0000	0.0404		1.0000	1.0000	0.9506	1.0000	1.0000	1.0000	1.0000
2	2005	1.0000	0.0404	1.0000		1.0000	0.9506	1.0000	1.0000	1.0000	1.0000
3	2004	1.0000	0.0404	1.0000	1.0000		0.9506	1.0000	1.0000	1.0000	1.0000
3	2005	0.9506	0.3854	0.9506	0.9506	0.9506		0.9506	0.9506	0.9506	0.9506
4	2004	1.0000	0.0404	1.0000	1.0000	1.0000	0.9506		1.0000	1.0000	1.0000
4	2005	1.0000	0.0404	1.0000	1.0000	1.0000	0.9506	1.0000		1.0000	1.0000
5	2004	1.0000	0.0404	1.0000	1.0000	1.0000	0.9506	1.0000	1.0000		1.0000
5	2005	1.0000	0.0404	1.0000	1.0000	1.0000	0.9506	1.0000	1.0000	1.0000	

Aricidea catherinae, Approximate Probabilities for Post Hoc TestsError: Between MS = .12383, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	0.0000	.33333	1.4523	.72974	0.0000	.39640
1	2004		1.0000	1.0000	1.0000	1.0000	0.9707	0.0021	0.3062	1.0000	0.9199
1	2005	1.0000		1.0000	1.0000	1.0000	0.9707	0.0021	0.3062	1.0000	0.9199
2	2004	1.0000	1.0000		1.0000	1.0000	0.9707	0.0021	0.3062	1.0000	0.9199
2	2005	1.0000	1.0000	1.0000		1.0000	0.9707	0.0021	0.3062	1.0000	0.9199
3	2004	1.0000	1.0000	1.0000	1.0000		0.9707	0.0021	0.3062	1.0000	0.9199
3	2005	0.9707	0.9707	0.9707	0.9707	0.9707		0.0241	0.9199	0.9707	1.0000
4	2004	0.0021	0.0021	0.0021	0.0021	0.0021	0.0241		0.3179	0.0021	0.0381
4	2005	0.3062	0.3062	0.3062	0.3062	0.3062	0.9199	0.3179		0.3062	0.9707
5	2004	1.0000	1.0000	1.0000	1.0000	1.0000	0.9707	0.0021	0.3062		0.9199
5	2005	0.9199	0.9199	0.9199	0.9199	0.9199	1.0000	0.0381	0.9707	0.9199	

Aspidosiphon sp ., Approximate Probabilities for Post Hoc TestsError: Between MS = .06915, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	2.2689	2.6335	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.0520	.33333
1	2004		0.7845	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.9881	0.0002
1	2005	0.7845		0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.2349	0.0002
2	2004	0.0002	0.0002		1.0000	1.0000	1.0000	1.0000	1.0000	0.0002	0.8551
2	2005	0.0002	0.0002	1.0000		1.0000	1.0000	1.0000	1.0000	0.0002	0.8551
3	2004	0.0002	0.0002	1.0000	1.0000		1.0000	1.0000	1.0000	0.0002	0.8551
3	2005	0.0002	0.0002	1.0000	1.0000	1.0000		1.0000	1.0000	0.0002	0.8551
4	2004	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000		1.0000	0.0002	0.8551
4	2005	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000	1.0000		0.0002	0.8551
5	2004	0.9881	0.2349	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002		0.0002
5	2005	0.0002	0.0002	0.8551	0.8551	0.8551	0.8551	0.8551	0.8551	0.0002	

Axiothella sp., Approximate Probabilities for Post Hoc TestsError: Between MS = .09847, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	1.1684	.72974	1.2315	1.1381	.72974	1.2937	0.0000	0.0000
1	2004		1.0000	0.0058	0.1858	0.0034	0.0075	0.1858	0.0021	1.0000	1.0000
1	2005	1.0000		0.0058	0.1858	0.0034	0.0075	0.1858	0.0021	1.0000	1.0000
2	2004	0.0058	0.0058		0.7769	1.0000	1.0000	0.7769	1.0000	0.0058	0.0058
2	2005	0.1858	0.1858	0.7769		0.6340	0.8364	1.0000	0.4866	0.1858	0.1858
3	2004	0.0034	0.0034	1.0000	0.6340		1.0000	0.6340	1.0000	0.0034	0.0034
3	2005	0.0075	0.0075	1.0000	0.8364	1.0000		0.8364	0.9997	0.0075	0.0075
4	2004	0.1858	0.1858	0.7769	1.0000	0.6340	0.8364		0.4866	0.1858	0.1858
4	2005	0.0021	0.0021	1.0000	0.4866	1.0000	0.9997	0.4866		0.0021	0.0021
5	2004	1.0000	1.0000	0.0058	0.1858	0.0034	0.0075	0.1858	0.0021		1.0000
5	2005	1.0000	1.0000	0.0058	0.1858	0.0034	0.0075	0.1858	0.0021	1.0000	

Brania sp., Approximate Probabilities for Post Hoc TestsError: Between MS = .07239, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	.33333	1.1381	0.0000	.66667	0.0000	0.0000
1	2004		1.0000	1.0000	1.0000	0.8700	0.0016	1.0000	0.1333	1.0000	1.0000
1	2005	1.0000		1.0000	1.0000	0.8700	0.0016	1.0000	0.1333	1.0000	1.0000
2	2004	1.0000	1.0000		1.0000	0.8700	0.0016	1.0000	0.1333	1.0000	1.0000
2	2005	1.0000	1.0000	1.0000		0.8700	0.0016	1.0000	0.1333	1.0000	1.0000
3	2004	0.8700	0.8700	0.8700	0.8700		0.0390	0.8700	0.8700	0.8700	0.8700
3	2005	0.0016	0.0016	0.0016	0.0016	0.0390		0.0016	0.5195	0.0016	0.0016
4	2004	1.0000	1.0000	1.0000	1.0000	0.8700	0.0016		0.1333	1.0000	1.0000
4	2005	0.1333	0.1333	0.1333	0.1333	0.8700	0.5195	0.1333		0.1333	0.1333
5	2004	1.0000	1.0000	1.0000	1.0000	0.8700	0.0016	1.0000	0.1333		1.0000
5	2005	1.0000	1.0000	1.0000	1.0000	0.8700	0.0016	1.0000	0.1333	1.0000	

APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years are shaded (p<0.05).

Caecum pulchellum, Approximate Probabilities for Post Hoc TestsError: Between MS = .31034, df = 20.000

Site	Year	Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
		1.2089	1.4280	2.1768	1.6779	0.0000	.33333	.57735	.91010	2.6562	1.6204
1	2004		1.0000	0.5303	0.9863	0.2549	0.6543	0.9172	0.9995	0.1014	0.9945
1	2005	1.0000		0.8110	0.9999	0.1098	0.3717	0.6871	0.9739	0.2380	1.0000
2	2004	0.5303	0.8110		0.9794	0.0036	0.0172	0.0526	0.2068	0.9842	0.9595
2	2005	0.9863	0.9999	0.9794		0.0370	0.1537	0.3650	0.7897	0.5166	1.0000
3	2004	0.2549	0.1098	0.0036	0.0370		0.9989	0.9497	0.6080	0.0005	0.0479
3	2005	0.6543	0.3717	0.0172	0.1537	0.9989		0.9999	0.9500	0.0018	0.1917
4	2004	0.9172	0.6871	0.0526	0.3650	0.9497	0.9999		0.9989	0.0057	0.4334
4	2005	0.9995	0.9739	0.2068	0.7897	0.6080	0.9500	0.9989		0.0271	0.8510
5	2004	0.1014	0.2380	0.9842	0.5166	0.0005	0.0018	0.0057	0.0271		0.4424
5	2005	0.9945	1.0000	0.9595	1.0000	0.0479	0.1917	0.4334	0.8510	0.4424	

Capitella capitata , Approximate Probabilities for Post Hoc TestsError: Between MS = .18591, df = 20.000

Site	Year	Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
		.33333	0.0000	1.0639	.33333	1.2011	1.6893	0.0000	1.2107	1.1684	1.3627
1	2004		0.9924	0.5625	1.0000	0.3421	0.0264	0.9924	0.3288	0.3900	0.1627
1	2005	0.9924		0.1365	0.9924	0.0649	0.0035	1.0000	0.0615	0.0779	0.0253
2	2004	0.5625	0.1365		0.5625	1.0000	0.7415	0.1365	1.0000	1.0000	0.9965
2	2005	1.0000	0.9924	0.5625		0.3421	0.0264	0.9924	0.3288	0.3900	0.1627
3	2004	0.3421	0.0649	1.0000	0.3421		0.9177	0.0649	1.0000	1.0000	1.0000
3	2005	0.0264	0.0035	0.7415	0.0264	0.9177		0.0035	0.9260	0.8851	0.9934
4	2004	0.9924	1.0000	0.1365	0.9924	0.0649	0.0035		0.0615	0.0779	0.0253
4	2005	0.3288	0.0615	1.0000	0.3288	1.0000	0.9260	0.0615		1.0000	1.0000
5	2004	0.3900	0.0779	1.0000	0.3900	1.0000	0.8851	0.0779	1.0000		0.9999
5	2005	0.1627	0.0253	0.9965	0.1627	1.0000	0.9934	0.0253	1.0000	0.9999	

Caprella pentantis, Approximate Probabilities for Post Hoc TestsError: Between MS = .06731, df = 20.000

Site	Year	Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
		0.0000	.87553	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	2004		0.0145	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	2005	0.0145		0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145
2	2004	1.0000	0.0145		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	2005	1.0000	0.0145	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	2004	1.0000	0.0145	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000
3	2005	1.0000	0.0145	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000
4	2004	1.0000	0.0145	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000
4	2005	1.0000	0.0145	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000
5	2004	1.0000	0.0145	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000
5	2005	1.0000	0.0145	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

Chaetozone setosa, Approximate Probabilities for Post Hoc TestsError: Between MS = .24109, df = 20.000

Site	Year	Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
		0.0000	.33333	.66667	.39640	0.0000	0.0000	.83509	1.6231	0.0000	.87553
1	2004		0.9970	0.8027	0.9897	1.0000	1.0000	0.5577	0.0174	1.0000	0.4969
1	2005	0.9970		0.9970	1.0000	0.9970	0.9970	0.9537	0.0948	0.9970	0.9281
2	2004	0.8027	0.9970		0.9994	0.8027	0.8027	1.0000	0.3828	0.8027	0.9999
2	2005	0.9897	1.0000	0.9994		0.9897	0.9897	0.9798	0.1273	0.9897	0.9648
3	2004	1.0000	0.9970	0.8027	0.9897		1.0000	0.5577	0.0174	1.0000	0.4969
3	2005	1.0000	0.9970	0.8027	0.9897	1.0000		0.5577	0.0174	1.0000	0.4969
4	2004	0.5577	0.9537	1.0000	0.9798	0.5577	0.5577		0.6296	0.5577	1.0000
4	2005	0.0174	0.0948	0.3828	0.1273	0.0174	0.0174	0.6296		0.0174	0.6904
5	2004	1.0000	0.9970	0.8027	0.9897	1.0000	1.0000	0.5577	0.0174		0.4969
5	2005	0.4969	0.9281	0.9999	0.9648	0.4969	0.4969	1.0000	0.6904	0.4969	

Cyclaspis sp., Approximate Probabilities for Post Hoc TestsError: Between MS = .13453, df = 20.000

Site	Year	Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
		0.0000	.33333	0.0000	0.0000	.33333	.33333	.33333	1.1261	0.0000	0.0000
1	2004		0.9774	1.0000	1.0000	0.9774	0.9774	0.9774	0.0319	1.0000	1.0000
1	2005	0.9774		0.9774	0.9774	1.0000	1.0000	1.0000	0.2591	0.9774	0.9774
2	2004	1.0000	0.9774		1.0000	0.9774	0.9774	0.9774	0.0319	1.0000	1.0000
2	2005	1.0000	0.9774	1.0000		0.9774	0.9774	0.9774	0.0319	1.0000	1.0000
3	2004	0.9774	1.0000	0.9774	0.9774		1.0000	1.0000	0.2591	0.9774	0.9774
3	2005	0.9774	1.0000	0.9774	0.9774	1.0000		1.0000	0.2591	0.9774	0.9774
4	2004	0.9774	1.0000	0.9774	0.9774	1.0000	1.0000		0.2591	0.9774	0.9774
4	2005	0.0319	0.2591	0.0319	0.0319	0.2591	0.2591	0.2591		0.0319	0.0319
5	2004	1.0000	0.9774	1.0000	1.0000	0.9774	0.9774	0.9774	0.0319		1.0000
5	2005	1.0000	0.9774	1.0000	1.0000	0.9774	0.9774	0.9774	0.0319	1.0000	

APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years are shaded (p<0.05).

Cytherididae 1, Approximate Probabilities for Post Hoc TestsError: Between MS = .03546, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	.33333	1.9444	1.8511	0.0000	0.0000	0.0000	0.0000
1	2004		1.0000	1.0000	0.5063	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000
1	2005	1.0000		1.0000	0.5063	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000
2	2004	1.0000	1.0000		0.5063	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000
2	2005	0.5063	0.5063	0.5063		0.0002	0.0002	0.5063	0.5063	0.5063	0.5063
3	2004	0.0002	0.0002	0.0002	0.0002		0.9997	0.0002	0.0002	0.0002	0.0002
3	2005	0.0002	0.0002	0.0002	0.0002	0.9997		0.0002	0.0002	0.0002	0.0002
4	2004	1.0000	1.0000	1.0000	0.5063	0.0002	0.0002		1.0000	1.0000	1.0000
4	2005	1.0000	1.0000	1.0000	0.5063	0.0002	0.0002	1.0000		1.0000	1.0000
5	2004	1.0000	1.0000	1.0000	0.5063	0.0002	0.0002	1.0000	1.0000		1.0000
5	2005	1.0000	1.0000	1.0000	0.5063	0.0002	0.0002	1.0000	1.0000	1.0000	

Ehlersia cornuta , Approximate Probabilities for Post Hoc TestsError: Between MS = .15775, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	1.1684	1.2937	.77202	.33333	0.0000	0.0000	0.0000	.33333	.33333	0.0000
1	2004		1.0000	0.9597	0.2901	0.0441	0.0441	0.0441	0.2901	0.2901	0.0441
1	2005	1.0000		0.8293	0.1522	0.0197	0.0197	0.0197	0.1522	0.1522	0.0197
2	2004	0.9597	0.8293		0.9280	0.3854	0.3854	0.3854	0.9280	0.9280	0.3854
2	2005	0.2901	0.1522	0.9280		0.9866	0.9866	0.9866	1.0000	1.0000	0.9866
3	2004	0.0441	0.0197	0.3854	0.9866		1.0000	1.0000	0.9866	0.9866	1.0000
3	2005	0.0441	0.0197	0.3854	0.9866	1.0000		1.0000	0.9866	0.9866	1.0000
4	2004	0.0441	0.0197	0.3854	0.9866	1.0000	1.0000		0.9866	0.9866	1.0000
4	2005	0.2901	0.1522	0.9280	1.0000	0.9866	0.9866	0.9866		1.0000	0.9866
5	2004	0.2901	0.1522	0.9280	1.0000	0.9866	0.9866	0.9866	1.0000		0.9866
5	2005	0.0441	0.0197	0.3854	0.9866	1.0000	1.0000	1.0000	0.9866	0.9866	

Fabriciola trilobata , Approximate Probabilities for Post Hoc TestsError: Between MS = .30659, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	.96039	.72974	1.7834	2.0079	1.8442	2.4134	.60705	1.9073	0.0000	0.0000
1	2004		0.9999	0.7164	0.4200	0.6361	0.0954	0.9981	0.5507	0.5326	0.5326
1	2005	0.9999		0.4125	0.1926	0.3421	0.0344	1.0000	0.2772	0.8268	0.8268
2	2004	0.7164	0.4125		1.0000	1.0000	0.9155	0.2783	1.0000	0.0217	0.0217
2	2005	0.4200	0.1926	1.0000		1.0000	0.9948	0.1186	1.0000	0.0075	0.0075
3	2004	0.6361	0.3421	1.0000	1.0000		0.9520	0.2243	1.0000	0.0163	0.0163
3	2005	0.0954	0.0344	0.9155	0.9948	0.9520		0.0195	0.9765	0.0012	0.0012
4	2004	0.9981	1.0000	0.2783	0.1186	0.2243	0.0195		0.1770	0.9309	0.9309
4	2005	0.5507	0.2772	1.0000	1.0000	1.0000	0.9765	0.1770		0.0121	0.0121
5	2004	0.5326	0.8268	0.0217	0.0075	0.0163	0.0012	0.9309	0.0121		1.0000
5	2005	0.5326	0.8268	0.0217	0.0075	0.0163	0.0012	0.9309	0.0121	1.0000	

Glycera sp., Approximate Probabilities for Post Hoc TestsError: Between MS = .06786, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	.33333	0.0000	0.0000	0.0000	.66667	0.0000	1.0631	0.0000	0.0000
1	2004		0.8485	1.0000	1.0000	1.0000	0.1109	1.0000	0.0023	1.0000	1.0000
1	2005	0.8485		0.8485	0.8485	0.8485	0.8485	0.8485	0.0625	0.8485	0.8485
2	2004	1.0000	0.8485		1.0000	1.0000	0.1109	1.0000	0.0023	1.0000	1.0000
2	2005	1.0000	0.8485	1.0000		1.0000	0.1109	1.0000	0.0023	1.0000	1.0000
3	2004	1.0000	0.8485	1.0000	1.0000		0.1109	1.0000	0.0023	1.0000	1.0000
3	2005	0.1109	0.8485	0.1109	0.1109	0.1109		0.1109	0.6910	0.1109	0.1109
4	2004	1.0000	0.8485	1.0000	1.0000	1.0000	0.1109		0.0023	1.0000	1.0000
4	2005	0.0023	0.0625	0.0023	0.0023	0.0023	0.6910	0.0023		0.0023	0.0023
5	2004	1.0000	0.8485	1.0000	1.0000	1.0000	0.1109	1.0000	0.0023		1.0000
5	2005	1.0000	0.8485	1.0000	1.0000	1.0000	0.1109	1.0000	0.0023	1.0000	

Harbansus paucichelatus, Approximate Probabilities for Post Hoc TestsError: Between MS = .08047, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	.33333	.39640	0.0000	0.0000
1	2004		1.0000	1.0000	1.0000	1.0000	0.0098	0.9001	0.7773	1.0000	1.0000
1	2005	1.0000		1.0000	1.0000	1.0000	0.0098	0.9001	0.7773	1.0000	1.0000
2	2004	1.0000	1.0000		1.0000	1.0000	0.0098	0.9001	0.7773	1.0000	1.0000
2	2005	1.0000	1.0000	1.0000		1.0000	0.0098	0.9001	0.7773	1.0000	1.0000
3	2004	1.0000	1.0000	1.0000	1.0000		0.0098	0.9001	0.7773	1.0000	1.0000
3	2005	0.0098	0.0098	0.0098	0.0098	0.0098		0.1763	0.2766	0.0098	0.0098
4	2004	0.9001	0.9001	0.9001	0.9001	0.9001	0.1763		1.0000	0.9001	0.9001
4	2005	0.7773	0.7773	0.7773	0.7773	0.7773	0.2766	1.0000		0.7773	0.7773
5	2004	1.0000	1.0000	1.0000	1.0000	1.0000	0.0098	0.9001	0.7773		1.0000
5	2005	1.0000	1.0000	1.0000	1.0000	1.0000	0.0098	0.9001	0.7773	1.0000	

APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years are shaded ($p<0.05$).

Isaeidae 2, Approximate Probabilities for Post Hoc TestsError: Between MS = .14143, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	.39640	1.1145	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	2004		0.4082	0.9446	0.9446	0.9446	0.9446	0.9446	0.9446	0.9446	0.9446
1	2005	0.4082		0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418	0.0418
2	2004	0.9446	0.0418		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	2005	0.9446	0.0418	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	2004	0.9446	0.0418	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000
3	2005	0.9446	0.0418	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000
4	2004	0.9446	0.0418	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000
4	2005	0.9446	0.0418	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000
5	2004	0.9446	0.0418	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000
5	2005	0.9446	0.0418	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

Leptochelia savignyi, Approximate Probabilities for Post Hoc TestsError: Between MS = .11200, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	1.5210	1.6111	0.0000	.39640	0.0000	0.0000	0.0000	0.0000	.33333	0.0000
1	2004		1.0000	0.0008	0.0151	0.0008	0.0008	0.0008	0.0008	0.0092	0.0008
1	2005	1.0000		0.0005	0.0074	0.0005	0.0005	0.0005	0.0005	0.0045	0.0005
2	2004	0.0008	0.0005		0.8960	1.0000	1.0000	1.0000	1.0000	0.9602	1.0000
2	2005	0.0151	0.0074	0.8960		0.8960	0.8960	0.8960	0.8960	1.0000	0.8960
3	2004	0.0008	0.0005	1.0000	0.8960		1.0000	1.0000	1.0000	0.9602	1.0000
3	2005	0.0008	0.0005	1.0000	0.8960	1.0000		1.0000	1.0000	0.9602	1.0000
4	2004	0.0008	0.0005	1.0000	0.8960	1.0000	1.0000		1.0000	0.9602	1.0000
4	2005	0.0008	0.0005	1.0000	0.8960	1.0000	1.0000	1.0000		0.9602	1.0000
5	2004	0.0092	0.0045	0.9602	1.0000	0.9602	0.9602	0.9602	0.9602		0.9602
5	2005	0.0008	0.0005	1.0000	0.8960	1.0000	1.0000	1.0000	1.0000	0.9602	

Lumbrineris sp.2, Approximate Probabilities for Post Hoc TestsError: Between MS = .13599, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	.33333	1.2107	.86781	1.1684	1.1381	0.0000	.33333
1	2004		1.0000	1.0000	0.9782	0.0185	0.1751	0.0248	0.0307	1.0000	0.9782
1	2005	1.0000		1.0000	0.9782	0.0185	0.1751	0.0248	0.0307	1.0000	0.9782
2	2004	1.0000	1.0000		0.9782	0.0185	0.1751	0.0248	0.0307	1.0000	0.9782
2	2005	0.9782	0.9782	0.9782		0.1656	0.7424	0.2109	0.2488	0.9782	1.0000
3	2004	0.0185	0.0185	0.0185	0.1656		0.9739	1.0000	1.0000	0.0185	0.1656
3	2005	0.1751	0.1751	0.1751	0.7424	0.9739		0.9890	0.9948	0.1751	0.7424
4	2004	0.0248	0.0248	0.0248	0.2109	1.0000	0.9890		1.0000	0.0248	0.2109
4	2005	0.0307	0.0307	0.0307	0.2488	1.0000	0.9948	1.0000		0.0307	0.2488
5	2004	1.0000	1.0000	1.0000	0.9782	0.0185	0.1751	0.0248	0.0307		0.9782
5	2005	0.9782	0.9782	0.9782	1.0000	0.1656	0.7424	0.2109	0.2488	0.9782	

Mesokalliapseudes macsweenyi, Approximate Probabilities for Post Hoc TestsError: Between MS = .04351, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	2.3978	2.5763	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.33333
1	2004		0.9847	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
1	2005	0.9847		0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
2	2004	0.0002	0.0002		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.6347
2	2005	0.0002	0.0002	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	0.6347
3	2004	0.0002	0.0002	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.6347
3	2005	0.0002	0.0002	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.6347
4	2004	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.6347
4	2005	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.6347
5	2004	0.0002	0.0002	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		0.6347
5	2005	0.0002	0.0002	0.6347	0.6347	0.6347	0.6347	0.6347	0.6347	0.6347	

Nemertea 2, Approximate Probabilities for Post Hoc TestsError: Between MS = .24573, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	.77202	0.0000	1.5305	1.0631	.66667	.91010	1.0631	.72974	.43869	0.0000
1	2004		0.6649	0.6850	0.9990	1.0000	1.0000	0.9990	1.0000	0.9972	0.6649
1	2005	0.6649		0.0306	0.2678	0.8106	0.4588	0.2678	0.7265	0.9810	1.0000
2	2004	0.6850	0.0306		0.9715	0.5266	0.8636	0.9715	0.6218	0.2391	0.0306
2	2005	0.9990	0.2678	0.9715		0.9903	1.0000	1.0000	0.9972	0.8593	0.2678
3	2004	1.0000	0.8106	0.5266	0.9903		0.9998	0.9903	1.0000	0.9999	0.8106
3	2005	1.0000	0.4588	0.8636	1.0000	0.9998		1.0000	1.0000	0.9700	0.4588
4	2004	0.9990	0.2678	0.9715	1.0000	0.9903	1.0000		0.9972	0.8593	0.2678
4	2005	1.0000	0.7265	0.6218	0.9972	1.0000	1.0000	0.9972		0.9990	0.7265
5	2004	0.9972	0.9810	0.2391	0.8593	0.9999	0.9700	0.8593	0.9990		0.9810
5	2005	0.6649	1.0000	0.0306	0.2678	0.8106	0.4588	0.2678	0.7265	0.9810	

APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years are shaded (p<0.05).

Nemertea 4, Approximate Probabilities for Post Hoc TestsError: Between MS = .04083, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.72974	0.0000	0.0000
1	2004		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0078	1.0000	1.0000
1	2005	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	0.0078	1.0000	1.0000
2	2004	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.0078	1.0000	1.0000
2	2005	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.0078	1.0000	1.0000
3	2004	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.0078	1.0000	1.0000
3	2005	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.0078	1.0000	1.0000
4	2004	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		0.0078	1.0000	1.0000
4	2005	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078		0.0078	0.0078
5	2004	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0078		1.0000
5	2005	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0078	1.0000	

Notomastus daueri/americanus , Approximate Probabilities for Post Hoc TestsError: Between MS = .07710, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	1.1684	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.98088	0.0000
1	2004		0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.9971	0.0017
1	2005	0.0017		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0096	1.0000
2	2004	0.0017	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	0.0096	1.0000
2	2005	0.0017	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.0096	1.0000
3	2004	0.0017	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.0096	1.0000
3	2005	0.0017	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.0096	1.0000
4	2004	0.0017	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.0096	1.0000
4	2005	0.0017	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		0.0096	1.0000
5	2004	0.9971	0.0096	0.0096	0.0096	0.0096	0.0096	0.0096	0.0096		0.0096
5	2005	0.0017	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0096	

Nucula proxima , Approximate Probabilities for Post Hoc TestsError: Between MS = .03333, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.66667	0.0000	0.0000
1	2004		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000
1	2005	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000
2	2004	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000
2	2005	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.0070	1.0000	1.0000
3	2004	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.0070	1.0000	1.0000
3	2005	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.0070	1.0000	1.0000
4	2004	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		0.0070	1.0000	1.0000
4	2005	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070		0.0070	0.0070
5	2004	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070		1.0000
5	2005	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	

Pectinodrilus sp ., Approximate Probabilities for Post Hoc TestsError: Between MS = .17890, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	1.7812	.97375	1.2642	0.0000	0.0000	0.0000	.54219	0.0000	0.0000	0.0000
1	2004		0.4084	0.8783	0.0017	0.0017	0.0017	0.0455	0.0017	0.0017	0.0017
1	2005	0.4084		0.9968	0.1950	0.1950	0.1950	0.9541	0.1950	0.1950	0.1950
2	2004	0.8783	0.9968		0.0392	0.0392	0.0392	0.5530	0.0392	0.0392	0.0392
2	2005	0.0017	0.1950	0.0392		1.0000	1.0000	0.8473	1.0000	1.0000	1.0000
3	2004	0.0017	0.1950	0.0392	1.0000		1.0000	0.8473	1.0000	1.0000	1.0000
3	2005	0.0017	0.1950	0.0392	1.0000	1.0000		0.8473	1.0000	1.0000	1.0000
4	2004	0.0455	0.9541	0.5530	0.8473	0.8473	0.8473		0.8473	0.8473	0.8473
4	2005	0.0017	0.1950	0.0392	1.0000	1.0000	1.0000	0.8473		1.0000	1.0000
5	2004	0.0017	0.1950	0.0392	1.0000	1.0000	1.0000	0.8473	1.0000		1.0000
5	2005	0.0017	0.1950	0.0392	1.0000	1.0000	1.0000	0.8473	1.0000	1.0000	

Phyllodocidae 1, Approximate Probabilities for Post Hoc TestsError: Between MS = .03333, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.66667	0.0000
1	2004		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000
1	2005	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000
2	2004	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000
2	2005	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.0070	1.0000
3	2004	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.0070	1.0000
3	2005	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.0070	1.0000
4	2004	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.0070	1.0000
4	2005	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		0.0070	1.0000
5	2004	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070		0.0070
5	2005	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	

APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years are shaded (p<0.05).

Pseudopolydora sp ., Approximate Probabilities for Post Hoc TestsError: Between MS = .12272, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	1.1261	0.0000	1.0823	0.0000	0.0000	.33333	0.0000
1	2004		1.0000	1.0000	0.0220	1.0000	0.0304	1.0000	1.0000	0.9698	1.0000
1	2005	1.0000		1.0000	0.0220	1.0000	0.0304	1.0000	1.0000	0.9698	1.0000
2	2004	1.0000	1.0000		0.0220	1.0000	0.0304	1.0000	1.0000	0.9698	1.0000
2	2005	0.0220	0.0220	0.0220		0.0220	1.0000	0.0220	0.0220	0.2115	0.0220
3	2004	1.0000	1.0000	1.0000	0.0220		0.0304	1.0000	1.0000	0.9698	1.0000
3	2005	0.0304	0.0304	0.0304	1.0000	0.0304		0.0304	0.0304	0.2712	0.0304
4	2004	1.0000	1.0000	1.0000	0.0220	1.0000	0.0304		1.0000	0.9698	1.0000
4	2005	1.0000	1.0000	1.0000	0.0220	1.0000	0.0304	1.0000		0.9698	1.0000
5	2004	0.9698	0.9698	0.9698	0.2115	0.9698	0.2712	0.9698	0.9698		0.9698
5	2005	1.0000	1.0000	1.0000	0.0220	1.0000	0.0304	1.0000	1.0000	0.9698	

Rutiderma darbyi , Approximate Probabilities for Post Hoc TestsError: Between MS = .04720, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.77202	0.0000
1	2004		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0091	1.0000
1	2005	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0091	1.0000
2	2004	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	0.0091	1.0000
2	2005	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.0091	1.0000
3	2004	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.0091	1.0000
3	2005	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.0091	1.0000
4	2004	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.0091	1.0000
4	2005	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		0.0091	1.0000
5	2004	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091		0.0091
5	2005	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0091	

Sarsiellidae 2, Approximate Probabilities for Post Hoc TestsError: Between MS = .10818, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	.66667	0.0000	1.1651	.33333	.66667	0.0000	0.0000	0.0000
1	2004		1.0000	0.3335	1.0000	0.0094	0.9559	0.3335	1.0000	1.0000	1.0000
1	2005	1.0000		0.3335	1.0000	0.0094	0.9559	0.3335	1.0000	1.0000	1.0000
2	2004	0.3335	0.3335		0.3335	0.6955	0.9559	1.0000	0.3335	0.3335	0.3335
2	2005	1.0000	1.0000	0.3335		0.0094	0.9559	0.3335	1.0000	1.0000	1.0000
3	2004	0.0094	0.0094	0.6955	0.0094		0.1188	0.6955	0.0094	0.0094	0.0094
3	2005	0.9559	0.9559	0.9559	0.9559	0.1188		0.9559	0.9559	0.9559	0.9559
4	2004	0.3335	0.3335	1.0000	0.3335	0.6955	0.9559		0.3335	0.3335	0.3335
4	2005	1.0000	1.0000	0.3335	1.0000	0.0094	0.9559	0.3335		1.0000	1.0000
5	2004	1.0000	1.0000	0.3335	1.0000	0.0094	0.9559	0.3335	1.0000		1.0000
5	2005	1.0000	1.0000	0.3335	1.0000	0.0094	0.9559	0.3335	1.0000	1.0000	

Sipuncula 1, Approximate Probabilities for Post Hoc TestsError: Between MS = .15446, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	.33333	1.7915	1.3302	1.5314	1.1054	.33333	.33333	.33333	0.0000
1	2004		0.9856	0.0007	0.0142	0.0037	0.0608	0.9856	0.9856	0.9856	1.0000
1	2005	0.9856		0.0060	0.1168	0.0338	0.3722	1.0000	1.0000	1.0000	0.9856
2	2004	0.0007	0.0060		0.9008	0.9976	0.5243	0.0060	0.0060	0.0060	0.0007
2	2005	0.0142	0.1168	0.9008		0.9997	0.9992	0.1168	0.1168	0.1168	0.0142
3	2004	0.0037	0.0338	0.9976	0.9997		0.9351	0.0338	0.0338	0.0338	0.0037
3	2005	0.0608	0.3722	0.5243	0.9992	0.9351		0.3722	0.3722	0.3722	0.0608
4	2004	0.9856	1.0000	0.0060	0.1168	0.0338	0.3722		1.0000	1.0000	0.9856
4	2005	0.9856	1.0000	0.0060	0.1168	0.0338	0.3722	1.0000		1.0000	0.9856
5	2004	0.9856	1.0000	0.0060	0.1168	0.0338	0.3722	1.0000	1.0000		0.9856
5	2005	1.0000	0.9856	0.0007	0.0142	0.0037	0.0608	0.9856	0.9856	0.9856	

Terebellides stroemi , Approximate Probabilities for Post Hoc TestsError: Between MS = .03333, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	.66667	0.0000	0.0000	0.0000	0.0000	0.0000
1	2004		1.0000	1.0000	1.0000	0.0070	1.0000	1.0000	1.0000	1.0000	1.0000
1	2005	1.0000		1.0000	1.0000	0.0070	1.0000	1.0000	1.0000	1.0000	1.0000
2	2004	1.0000	1.0000		1.0000	0.0070	1.0000	1.0000	1.0000	1.0000	1.0000
2	2005	1.0000	1.0000	1.0000		0.0070	1.0000	1.0000	1.0000	1.0000	1.0000
3	2004	0.0070	0.0070	0.0070	0.0070		0.0070	0.0070	0.0070	0.0070	0.0070
3	2005	1.0000	1.0000	1.0000	1.0000	0.0070		1.0000	1.0000	1.0000	1.0000
4	2004	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000		1.0000	1.0000	1.0000
4	2005	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000		1.0000	1.0000
5	2004	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000	1.0000		1.0000
5	2005	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000	1.0000	1.0000	

APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years are shaded (p<0.05).

Tharyx dorsobranchialis , Approximate Probabilities for Post Hoc TestsError: Between MS = .18581, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	.39640	1.8941	1.7272	1.6465	1.6823	.91810	1.4165	0.0000	.33333
1	2004		0.9756	0.0011	0.0028	0.0045	0.0036	0.2754	0.0183	1.0000	0.9924
1	2005	0.9756		0.0112	0.0306	0.0490	0.0398	0.8841	0.1701	0.9756	1.0000
2	2004	0.0011	0.0112		1.0000	0.9992	0.9998	0.2110	0.9268	0.0011	0.0076
2	2005	0.0028	0.0306	1.0000		1.0000	1.0000	0.4301	0.9954	0.0028	0.0210
3	2004	0.0045	0.0490	0.9992	1.0000		1.0000	0.5658	0.9995	0.0045	0.0339
3	2005	0.0036	0.0398	0.9998	1.0000	1.0000		0.5043	0.9986	0.0036	0.0274
4	2004	0.2754	0.8841	0.2110	0.4301	0.5658	0.5043		0.9081	0.2754	0.8034
4	2005	0.0183	0.1701	0.9268	0.9954	0.9995	0.9986	0.9081		0.0183	0.1232
5	2004	1.0000	0.9756	0.0011	0.0028	0.0045	0.0036	0.2754	0.0183		0.9924
5	2005	0.9924	1.0000	0.0076	0.0210	0.0339	0.0274	0.8034	0.1232	0.9924	

Tharyx sp.1 , Approximate Probabilities for Post Hoc TestsError: Between MS = .18074, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	.93714	1.4915	.87738	1.2282	1.5252	1.4284	.33333
1	2004		1.0000	1.0000	0.2382	0.0102	0.3119	0.0504	0.0083	0.0151	0.9916
1	2005	1.0000		1.0000	0.2382	0.0102	0.3119	0.0504	0.0083	0.0151	0.9916
2	2004	1.0000	1.0000		0.2382	0.0102	0.3119	0.0504	0.0083	0.0151	0.9916
2	2005	0.2382	0.2382	0.2382		0.8348	1.0000	0.9968	0.7866	0.9084	0.7622
3	2004	0.0102	0.0102	0.0102	0.8348		0.7456	0.9985	1.0000	1.0000	0.0753
3	2005	0.3119	0.3119	0.3119	1.0000	0.7456		0.9880	0.6896	0.8393	0.8485
4	2004	0.0504	0.0504	0.0504	0.9968	0.9985	0.9880		0.9963	0.9998	0.2889
4	2005	0.0083	0.0083	0.0083	0.7866	1.0000	0.6896	0.9963		1.0000	0.0622
5	2004	0.0151	0.0151	0.0151	0.9084	1.0000	0.8393	0.9998	1.0000		0.1067
5	2005	0.9916	0.9916	0.9916	0.7622	0.0753	0.8485	0.2889	0.0622	0.1067	

Tubificidae 1, Approximate Probabilities for Post Hoc TestsError: Between MS = .03886, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	1.2937	1.7232	1.5186	1.6846	2.0327	1.2913	1.4356	0.0000	1.4091
1	2004		0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	1.0000	0.0002
1	2005	0.0002		0.2507	0.9144	0.3607	0.0054	1.0000	0.9954	0.0002	0.9990
2	2004	0.0002	0.2507		0.9493	1.0000	0.6557	0.2445	0.7358	0.0002	0.6384
2	2005	0.0002	0.9144	0.9493		0.9863	0.0992	0.9094	0.9999	0.0002	0.9994
3	2004	0.0002	0.3607	1.0000	0.9863		0.5096	0.3529	0.8575	0.0002	0.7775
3	2005	0.0002	0.0054	0.6557	0.0992	0.5096		0.0053	0.0355	0.0002	0.0252
4	2004	0.0002	1.0000	0.2445	0.9094	0.3529	0.0053		0.9948	0.0002	0.9989
4	2005	0.0002	0.9954	0.7358	0.9999	0.8575	0.0355	0.9948		0.0002	1.0000
5	2004	1.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002		0.0002
5	2005	0.0002	0.9990	0.6384	0.9994	0.7775	0.0252	0.9989	1.0000	0.0002	

Tubificidae 2, Approximate Probabilities for Post Hoc TestsError: Between MS = .08934, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	1.4196	1.4284	1.2761	1.5418	0.0000	.72974	0.0000	.33333
1	2004		1.0000	0.0005	0.0005	0.0014	0.0003	1.0000	0.1446	1.0000	0.9242
1	2005	1.0000		0.0005	0.0005	0.0014	0.0003	1.0000	0.1446	1.0000	0.9242
2	2004	0.0005	0.0005		1.0000	0.9998	0.9999	0.0005	0.1927	0.0005	0.0074
2	2005	0.0005	0.0005	1.0000		0.9997	1.0000	0.0005	0.1811	0.0005	0.0068
3	2004	0.0014	0.0014	0.9998	0.9997		0.9804	0.0014	0.4644	0.0014	0.0258
3	2005	0.0003	0.0003	0.9999	1.0000	0.9804		0.0003	0.0766	0.0003	0.0025
4	2004	1.0000	1.0000	0.0005	0.0005	0.0014	0.0003		0.1446	1.0000	0.9242
4	2005	0.1446	0.1446	0.1927	0.1811	0.4644	0.0766	0.1446		0.1446	0.8219
5	2004	1.0000	1.0000	0.0005	0.0005	0.0014	0.0003	1.0000	0.1446		0.9242
5	2005	0.9242	0.9242	0.0074	0.0068	0.0258	0.0025	0.9242	0.8219	0.9242	

Tubificoides sp ., Approximate Probabilities for Post Hoc TestsError: Between MS = .15812, df = 20.000

		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	2.1012	2.0017	1.7164	1.6467	1.0201	1.4606	0.0000	.72974
1	2004		1.0000	0.0003	0.0003	0.0013	0.0020	0.1093	0.0066	1.0000	0.4594
1	2005	1.0000		0.0003	0.0003	0.0013	0.0020	0.1093	0.0066	1.0000	0.4594
2	2004	0.0003	0.0003		1.0000	0.9665	0.9135	0.0763	0.6249	0.0003	0.0120
2	2005	0.0003	0.0003	1.0000		0.9955	0.9799	0.1361	0.8007	0.0003	0.0230
3	2004	0.0013	0.0013	0.9665	0.9955		1.0000	0.5204	0.9980	0.0013	0.1323
3	2005	0.0020	0.0020	0.9135	0.9799	1.0000		0.6513	0.9998	0.0020	0.1935
4	2004	0.1093	0.1093	0.0763	0.1361	0.5204	0.6513		0.9269	0.1093	0.9949
4	2005	0.0066	0.0066	0.6249	0.8007	0.9980	0.9998	0.9269		0.0066	0.4574
5	2004	1.0000	1.0000	0.0003	0.0003	0.0013	0.0020	0.1093	0.0066		0.4594
5	2005	0.4594	0.4594	0.0120	0.0230	0.1323	0.1935	0.9949	0.4574	0.4594	

APPENDIX A – Significantly different macroinvertebrates. Significantly different sites and years are shaded ($p<0.05$).

Vaunthompsonia sp ., Approximate Probabilities for Post Hoc TestsError: Between MS = .03333, df = 20.000											
		Site 1 - 2004	Site 1 - 2005	Site 2 - 2004	Site 2 - 2005	Site 3 - 2004	Site 3 - 2005	Site 4 - 2004	Site 4 - 2005	Site 5 - 2004	Site 5 - 2005
Site	Year	0.0000	0.0000	0.0000	0.0000	0.0000	.66667	0.0000	0.0000	0.0000	0.0000
1	2004		1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000	1.0000	1.0000
1	2005	1.0000		1.0000	1.0000	1.0000	0.0070	1.0000	1.0000	1.0000	1.0000
2	2004	1.0000	1.0000		1.0000	1.0000	0.0070	1.0000	1.0000	1.0000	1.0000
2	2005	1.0000	1.0000	1.0000		1.0000	0.0070	1.0000	1.0000	1.0000	1.0000
3	2004	1.0000	1.0000	1.0000	1.0000		0.0070	1.0000	1.0000	1.0000	1.0000
3	2005	0.0070	0.0070	0.0070	0.0070	0.0070		0.0070	0.0070	0.0070	0.0070
4	2004	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070		1.0000	1.0000	1.0000
4	2005	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000		1.0000	1.0000
5	2004	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000		1.0000
5	2005	1.0000	1.0000	1.0000	1.0000	1.0000	0.0070	1.0000	1.0000	1.0000	

APPENDIX B – Site 1 continuous water quality data measured over a tidal cycle between 7/27/05 and 8/1/05.

Time (hours)	Temperature (deg C)	Specific Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)	Chlorophyll (ug/L)
0.25	31.05	47,925	5.78	8.01	0.2	2.5
0.5	31.00	48,645	5.71	8.02	0.3	2.6
0.75	31.01	48,616	5.77	8.02	0.0	3.3
1	30.98	48,956	5.61	8.01	0.0	2.5
1.25	31.07	48,166	5.75	8.01	0.0	3.2
1.5	31.15	47,259	5.74	8.00	1.4	3.0
1.75	31.23	46,465	5.80	7.99	0.3	4.1
2	31.55	42,689	5.82	7.96	0.7	5.2
2.25	31.63	42,043	5.90	7.95	0.7	6.8
2.5	31.75	40,431	5.93	7.93	0.4	6.8
2.75	31.88	39,265	5.94	7.92	0.3	7.5
3	31.83	39,211	5.87	7.91	0.3	7.7
3.25	31.99	37,197	5.90	7.90	0.6	8.6
3.5	31.91	38,069	5.81	7.90	1.0	7.3
3.75	31.89	38,548	5.76	7.90	0.8	8.4
4	31.94	37,779	5.72	7.89	0.5	7.7
4.25	32.06	35,869	5.76	7.87	1.1	9.1
4.5	32.02	36,272	5.67	7.87	0.7	9.2
4.75	32.07	35,509	5.65	7.85	0.8	9.1
5	32.11	34,979	5.68	7.85	0.9	10.5
5.25	32.10	34,844	5.64	7.84	0.7	10.7
5.5	32.15	34,216	5.65	7.84	1.7	10.7
5.75	32.19	33,505	5.67	7.83	0.9	10.6
6	32.19	33,072	5.62	7.81	1.2	10.9
6.25	32.16	33,220	5.55	7.81	1.5	11.7
6.5	32.17	32,832	5.49	7.80	1.1	10.2
6.75	32.17	32,601	5.32	7.80	0.4	10.7
7	32.17	32,272	5.46	7.79	0.6	11.1
7.25	32.16	32,374	4.97	7.77	0.0	12.0
7.5	32.12	32,415	5.04	7.78	0.7	10.9
7.75	32.08	33,115	5.17	7.79	0.7	9.0
8	32.08	34,399	5.39	7.82	0.9	10.0
8.25	32.03	35,291	5.46	7.83	0.7	10.1
8.5	32.03	35,575	5.58	7.84	0.5	10.5
8.75	31.97	36,451	5.61	7.85	0.8	8.6
9	31.91	37,502	5.57	7.87	0.3	8.8
9.25	31.76	39,678	5.54	7.89	0.5	8.0
9.5	31.73	40,016	5.50	7.89	0.9	7.3
9.75	31.77	38,981	5.49	7.89	0.9	7.8
10	31.73	39,722	5.50	7.89	0.8	6.9
10.25	31.72	40,024	5.43	7.89	1.2	6.8
10.5	31.72	39,402	5.41	7.89	0.4	5.5
10.75	31.65	40,191	5.48	7.90	0.7	7.2
11	31.49	43,482	5.51	7.94	1.1	5.0
11.25	31.48	44,748	5.53	7.94	0.4	5.2
11.5	31.44	45,099	5.56	7.95	0.4	5.3
11.75	31.38	45,588	5.53	7.96	0.3	4.6
12	31.38	45,289	5.47	7.96	0.3	4.3
12.25	31.29	46,868	5.51	7.97	0.3	3.9

APPENDIX B – Site 2 continuous water quality data measured over a tidal cycle between 7/27/05 and 8/1/05.

Time (hours)	Temperature (deg C)	Specific Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)	Chlorophyll (ug/L)
0.25	30.95	49,786	6.13	8.02	0.3	2.2
0.5	30.93	50,000	6.09	8.02	0.4	2.6
0.75	30.91	50,158	6.00	8.02	0.1	2.4
1	30.91	50,230	5.87	8.02	0.9	1.8
1.25	30.90	50,233	5.82	8.01	0.1	2.1
1.5	30.89	50,328	5.83	8.02	0.3	1.7
1.75	30.89	50,417	5.76	8.02	0.2	1.9
2	30.89	50,460	5.81	8.02	0.1	1.9
2.25	30.91	50,401	5.96	8.03	0.2	1.9
2.5	30.94	50,292	6.00	8.03	0.0	2.6
2.75	30.95	50,161	5.82	8.02	0.2	2.6
3	30.91	50,458	5.63	8.01	0.1	2.3
3.25	31.00	49,771	5.85	8.01	0.7	2.3
3.5	30.96	50,157	5.61	8.01	0.4	2.0
3.75	30.97	50,038	5.52	8.00	1.5	1.7
4	31.02	49,638	5.50	8.00	1.0	1.9
4.25	31.03	49,661	5.40	7.99	0.7	1.9
4.5	31.05	49,459	5.39	7.99	0.9	2.4
4.75	31.07	49,327	5.24	7.98	0.6	2.3
5	31.10	49,058	5.18	7.98	1.0	2.0
5.25	31.11	48,980	5.24	7.97	0.4	2.0
5.5	31.11	48,940	5.08	7.97	0.6	2.0
5.75	31.11	48,901	5.00	7.96	0.6	1.8
6	31.12	48,806	4.91	7.96	1.2	1.7
6.25	31.12	48,780	4.76	7.95	1.0	2.5
6.5	31.12	48,746	4.70	7.94	1.0	2.7
6.75	31.12	48,738	4.48	7.94	0.7	1.5
7	31.12	48,727	4.41	7.93	0.7	2.2
7.25	31.20	47,866	4.70	7.93	2.9	3.1
7.5	31.24	47,459	4.57	7.92	2.8	3.1
7.75	31.25	47,334	4.42	7.91	2.3	2.9
8	31.24	47,309	4.38	7.91	2.9	3.7
8.25	31.25	47,234	4.18	7.90	1.5	2.9
8.5	31.24	47,207	4.04	7.89	2.0	3.1
8.75	31.26	46,988	3.94	7.88	1.8	2.5
9	31.26	46,938	3.87	7.87	1.7	3.8
9.25	31.61	43,070	4.92	7.90	1.2	5.5
9.5	31.69	41,904	5.40	7.90	0.6	5.4
9.75	31.59	43,214	5.43	7.91	1.1	5.8
10	31.51	44,034	5.42	7.92	1.0	5.0
10.25	31.42	45,147	5.59	7.94	1.4	4.9
10.5	31.36	45,812	5.67	7.95	1.4	3.9
10.75	31.34	46,012	5.57	7.95	0.7	3.6
11	31.26	46,735	5.63	7.96	0.4	3.4
11.25	31.21	46,902	5.56	7.96	0.5	3.4
11.5	31.11	47,293	5.59	7.96	0.4	3.8
11.75	31.02	48,144	5.58	7.97	0.4	3.4
12	30.90	49,221	5.65	7.99	0.9	3.1
12.25	30.84	49,736	5.64	7.99	0.7	2.4

APPENDIX B – Site 3 continuous water quality data measured over a tidal cycle between 7/27/05 and 8/1/05.

Time (hours)	Temperature (deg C)	Specific Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)	Chlorophyll (ug/L)
0.25	31.01	48,386	5.96	7.99	0.1	2.0
0.5	31.03	48,022	5.83	7.97	0.2	2.2
0.75	31.06	48,089	5.98	7.99	0.6	4.6
1	31.19	46,365	6.01	7.98	0.4	3.0
1.25	31.21	46,003	6.18	7.99	0.0	3.4
1.5	31.44	45,292	6.17	7.97	0.2	3.5
1.75	31.82	42,259	6.20	7.95	0.2	5.1
2	32.11	39,158	6.66	7.95	0.3	7.5
2.25	32.12	38,594	6.54	7.93	0.5	7.7
2.5	32.44	36,347	6.64	7.91	0.6	8.4
2.75	32.81	33,627	6.74	7.90	0.4	9.5
3	32.62	34,102	6.56	7.89	0.7	10.5
3.25	32.54	34,275	6.50	7.88	0.6	10.0
3.5	32.68	31,193	6.58	7.87	0.6	11.6
3.75	32.53	30,750	6.25	7.85	0.6	10.7
4	32.43	29,151	5.91	7.81	0.7	9.8
4.25	32.39	29,530	5.74	7.80	0.5	10.0
4.5	32.41	28,292	5.44	7.77	0.5	9.5
4.75	32.44	27,348	5.26	7.75	0.6	10.2
5	32.52	25,787	5.12	7.73	0.6	10.6
5.25	32.60	23,883	4.89	7.70	0.6	10.2
5.5	32.63	23,021	4.83	7.69	0.7	10.1
5.75	32.65	22,494	4.77	7.68	1.0	10.5
6	32.70	21,257	4.67	7.67	1.1	10.4
6.25	32.72	20,458	4.60	7.66	0.9	10.5
6.5	32.79	18,732	4.50	7.64	1.3	11.5
6.75	32.85	16,404	4.36	7.63	0.7	12.2
7	32.79	18,565	4.48	7.64	0.7	10.8
7.25	32.76	18,179	4.32	7.63	0.9	10.9
7.5	32.88	16,570	4.34	7.63	1.0	12.1
7.75	32.50	23,208	4.87	7.68	0.6	9.7
8	32.54	22,870	4.84	7.67	0.3	9.5
8.25	32.31	28,761	5.07	7.73	0.3	9.6
8.5	32.26	30,253	5.01	7.74	0.0	8.7
8.75	32.26	30,094	4.77	7.72	0.0	7.9
9	32.23	30,693	4.95	7.74	0.1	7.8
9.25	32.22	31,299	4.87	7.74	0.0	8.0
9.5	32.18	31,914	5.01	7.75	0.9	7.5
9.75	32.08	34,572	5.07	7.77	0.1	6.5
10	31.84	40,132	4.88	7.83	0.5	4.5
10.25	31.54	43,393	4.88	7.86	0.4	4.1
10.5	31.37	46,626	4.88	7.89	0.4	3.1
10.75	31.33	47,425	4.91	7.91	0.1	3.5
11	31.31	47,672	5.11	7.92	0.1	2.5
11.25	31.30	47,983	4.98	7.92	0.1	2.7
11.5	31.21	48,770	4.85	7.92	0.4	2.8
11.75	31.21	48,455	5.05	7.94	0.4	2.5
12	31.14	48,715	5.05	7.95	0.2	3.7
12.25	31.30	47,191	4.85	7.91	0.0	2.8

APPENDIX B – Site 4 continuous water quality data measured over a tidal cycle between 7/27/05 and 8/1/05.

Time (hours)	Temperature (deg C)	Specific Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)	Chlorophyll (ug/L)
0.25	29.04	54,609	5.74	8.06	1.1	0.5
0.5	29.05	54,579	5.86	8.06	1.0	1.2
0.75	29.11	54,445	5.82	8.06	2.0	0.7
1	29.19	54,236	5.80	8.05	1.2	0.9
1.25	29.24	54,028	5.79	8.05	1.7	1.0
1.5	29.36	53,564	5.82	8.04	1.2	1.3
1.75	29.48	53,040	5.73	8.03	1.4	1.2
2	29.43	53,337	5.70	8.03	2.1	1.7
2.25	29.46	53,223	5.65	8.03	2.5	0.8
2.5	29.84	51,655	5.55	8.01	3.7	1.4
2.75	29.64	52,547	5.56	8.02	3.3	1.5
3	29.88	51,290	5.50	8.00	3.2	2.3
3.25	30.23	49,060	5.50	7.98	2.7	2.3
3.5	30.50	45,999	5.56	7.96	4.1	2.8
3.75	31.05	39,035	5.71	7.93	2.0	5.4
4	30.45	46,949	5.48	7.95	2.7	3.6
4.25	31.23	35,576	5.73	7.88	1.6	6.4
4.5	31.35	35,058	5.62	7.85	1.5	7.5
4.75	31.45	33,624	5.64	7.85	1.0	7.4
5	30.90	41,568	5.57	7.89	2.5	4.9
5.25	30.53	46,468	5.29	7.92	2.7	3.5
5.5	30.50	47,118	5.23	7.93	3.4	2.6
5.75	30.45	48,039	5.18	7.94	4.3	2.3
6	30.45	48,039	5.21	7.94	4.3	3.3
6.25	30.48	47,729	5.19	7.94	4.3	2.2
6.5	30.58	46,698	5.17	7.93	3.7	3.5
6.75	30.83	44,023	5.28	7.91	2.6	4.2
7	30.63	45,723	4.93	7.90	1.5	3.4
7.25	30.31	48,140	5.13	7.93	0.7	2.8
7.5	30.33	49,157	5.25	7.95	0.7	2.2
7.75	30.77	49,338	5.52	7.96	0.7	2.8
8	30.81	49,849	5.58	7.97	0.6	2.9
8.25	30.79	50,252	5.61	7.97	0.1	2.4
8.5	30.82	50,087	5.57	7.97	0.3	1.6
8.75	30.71	50,887	5.65	7.98	0.6	1.6
9	30.50	51,353	5.64	7.99	0.1	1.2
9.25	30.37	51,533	5.66	7.99	0.6	1.6
9.5	30.00	52,443	5.71	8.01	0.3	1.3
9.75	29.74	52,994	5.76	8.02	0.6	1.3
10	29.47	53,524	5.82	8.03	0.3	0.9
10.25	29.29	53,840	5.87	8.04	0.6	0.8
10.5	29.20	54,039	5.90	8.04	0.7	1.6
10.75	29.22	53,973	5.90	8.04	0.4	1.8
11	29.06	54,402	5.87	8.05	0.2	1.2
11.25	29.08	54,369	5.82	8.05	0.1	0.3
11.5	29.10	54,340	5.68	8.04	0.9	0.6
11.75	29.17	54,183	5.76	8.04	0.3	0.5
12	29.19	54,142	5.58	8.03	0.4	0.2
12.25	29.17	54,202	5.59	8.03	0.4	0.3

APPENDIX B – Site 5 continuous water quality data measured over a tidal cycle between 7/17/05 and 8/1/05.

Time (hours)	Temperature (deg C)	Specific Conductivity (uS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)	Chlorophyll (ug/L)
0.25	30.12	52,581	5.84	8.02	0.1	1.5
0.5	30.37	51,569	5.89	8.01	0.0	1.8
0.75	30.02	52,931	5.74	8.02	0.1	1.4
1	29.80	53,543	5.66	8.03	0.6	0.8
1.25	30.48	49,625	5.75	7.99	0.1	2.3
1.5	29.89	53,027	5.68	8.02	0.5	0.8
1.75	29.78	53,364	5.70	8.03	0.2	0.0
2	30.59	47,608	5.73	7.97	0.3	4.0
2.25	30.65	46,538	5.72	7.97	0.3	3.5
2.5	30.51	47,768	5.65	7.96	0.3	3.4
2.75	30.64	46,766	5.67	7.94	0.6	4.2
3	30.93	37,792	5.79	7.90	0.5	4.9
3.25	30.94	40,133	5.69	7.89	0.6	5.9
3.5	31.09	38,589	5.67	7.87	0.5	5.9
3.75	31.08	38,948	5.63	7.87	0.5	6.5
4	31.12	36,990	5.58	7.85	1.0	6.6
4.25	31.22	35,271	5.47	7.83	1.0	6.8
4.5	31.24	35,073	5.41	7.82	0.6	6.9
4.75	31.28	34,392	5.34	7.81	0.6	7.7
5	31.32	33,603	5.28	7.80	0.8	7.9
5.25	31.28	34,731	5.33	7.81	0.4	7.3
5.5	31.35	32,927	5.23	7.78	1.0	7.9
5.75	31.38	32,475	5.12	7.77	1.0	8.3
6	31.42	30,637	5.01	7.75	2.1	8.8
6.25	31.41	30,749	4.98	7.75	0.7	8.4
6.5	31.31	33,970	5.06	7.78	0.5	6.7
6.75	31.35	32,848	5.11	7.78	0.7	7.6
7	31.24	35,894	5.32	7.81	0.8	7.1
7.25	31.04	40,194	4.93	7.83	0.3	4.9
7.5	31.07	42,953	5.06	7.87	0.4	4.3
7.75	31.01	44,825	5.06	7.89	0.3	3.8
8	30.98	46,687	5.22	7.92	0.3	2.9
8.25	30.84	43,729	5.31	7.90	0.6	5.4
8.5	30.84	48,749	5.26	7.94	0.3	2.0
8.75	31.17	48,911	5.49	7.95	1.0	2.4
9	30.63	50,039	5.58	7.97	0.3	2.7
9.25	30.73	45,428	5.47	7.93	0.3	3.6
9.5	30.29	49,803	5.42	7.96	0.1	2.4
9.75	30.06	52,034	5.61	8.00	0.4	1.5
10	30.73	47,761	5.48	7.95	0.3	2.5
10.25	30.48	48,283	5.53	7.96	0.3	2.9
10.5	30.43	51,473	5.63	8.00	0.2	0.8
10.75	30.04	52,085	5.62	8.00	0.4	1.7
11	29.62	53,554	5.70	8.03	0.3	1.1
11.25	29.73	53,411	5.69	8.02	0.1	1.4
11.5	29.89	53,111	5.64	8.02	0.1	1.2
11.75	30.00	52,996	5.58	8.01	0.0	0.8
12	30.47	49,642	5.41	7.97	0.3	2.2
12.25	30.12	52,407	5.24	7.99	0.2	0.8