Monitoring Effects of a Potential Increased Tidal Range in the Cape Fear River Ecosystem Due to Deepening Wilmington Harbor, North Carolina
Year 4: June 1, 2003 - May 31, 2004

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ABSTRACT

All twelve stations were operational during this reporting period with about the same loss of tides, maximum of 18.5%, experienced in previous years. Most stations lost less than 12% of tides. More than 1,400 tide ranges were measured between 1 June 2002 and 31 May 2004. The correlation of tidal range from the base station at Ft Caswell with the predicted tidal range remained very good. Tidal ranges at stations within the estuary were fairly constant and higher than tidal ranges measured at most upstream stations. Water levels in the most upstream sites were affected by discharge rates in the river. This reporting period was characterized by fewer high discharge events than in the 2002-2003 monitoring year. Significant differences in yearly mean tidal ranges between this reporting period and 2002-2003 were observed. Mean monthly maximum water levels for this reporting period were not significantly different from values reported for 2002-2003. With the exception of station P11, there was no significant difference in mean monthly minimum water level between this reporting period and last year. In contrast to previous reporting periods, comparisons of the regression slopes when tidal range at each site was regressed against P1 tidal range yielded significant differences between this reporting period and the previous reporting period for all stations except P3, P8, P12, and P13. When the slopes from this reporting period were compared to slopes calculated for Year 1 (2000-2001), all stations except P2, P8, and P13 yielded a significant difference between years.

Tidal lag times varied slightly during this reporting period for upstream stations in the Northeast Cape Fear River. In contrast, the high tide lag decreased in the mainstem and estuarine stations, while the low tide lag has consistently increased. The duration of the ebb tide continues to exceed the duration of flood at most stations as in previous monitoring periods. Flood and ebb durations showed little change from mean durations reported in 2002 - 2003. The relationship between tidal range at Ft Caswell and other stations differed from station to station, but was generally related to distance upstream and freshwater flow. Fewer high discharge events in 2003-2004 resulted in a reduction in variability of the tidal ranges observed during this monitoring period.

In general, mean tidal range decreased from downstream to upstream. The mean tidal range for every station except P1 and P14 was significantly higher this year. When the mean tidal ranges for the current year were compared to those reported for Year 1 (2000-2001), only stations P3 and P7 exhibited means that were not significantly different. These results have been complicated by the existence of lower water levels (drought-induced) and extreme flooding in the system over the last three years. Additional types of data analyses will be necessary to conclusively evaluate the effects of channel modification on tidal attributes.

This year represents a period of more typical flow conditions in the river, maximum salinities for P8 and P13 were 0.2 ppt and 4.7 ppt., respectively, compared to previous years where salinity was very high during droughts or very low during long periods of higher than normal rainfall.

River water flooded marshes and swamps adjacent to stations on most tides often to depths of a few feet during this more-normal 12-month period. During fall, saline water was largely confined to wetlands adjacent to estuarine stations or those at the lower reaches of the rivers. There were differences between fall and spring with respect to salinity, largely due to saline water reaching upstream stations in the Northeast Cape Fear River, but not in the mainstem Cape Fear River.

Floodwater on the wetland surface influenced the biogeochemistry of Eagle Island, which is analyzed monthly. There had been a steady decrease in salinity from June 2002 until June 2003. The salinity slightly rebounded during the current winter (2003-2004), however, it was still lower than previous years. This monthly pattern of salinity variation was in contrast to the previous two years where peaks in salinity were observed during November and May. Because of the lack of a salinity pulse during these times, several subsites at Eagle Island became largely methogenic for the first time in the five years of the study. Other Eagle Island subsites also became less sulfate reducing during this same period.

Low salinity conditions characterized the current project year, summer 2003, and winter 2004. In general, all sites experienced low salinity conditions compared to previous winters and summers. Town Creek, Indian Creek, Dollisons Landing, and Black River sites experienced the lowest salinity measured since initiation of the project. While all Northeast Cape Fear River sites had relatively fresher conditions during the current year, there was more variability in the extent to which they experienced low salinities. Fishing Creek had the freshest winter and summer on record, Prince George Creek had the freshest winter on record, and Rat Island had the freshest summer on record. Smith Creek had fresh conditions during both the summer and winter, but not the freshest on record.

Infaunal community patterns have been followed at nine sites from 1999-2003 and through three major potential system-level impacts: a developing drought in 2001-2002, a period of recovery and relatively higher freshwater input in 2003, as well as the initiation of channel deepening construction in 2001-2002. Infaunal species richness and diversity exhibited significant variation among years and sites. Diversity decreased from downstream to upstream sites for both the mainstem Cape Fear (P6-P8) and Northeast Cape Fear sites (P11-P13). However, this pattern did not hold for Northeast Cape Fear sites in 2002, possibly reflecting the influence of increased salinity during that year, or for the uppermost site (P8) in either 2002 or 2000. This upstream/downstream pattern was not observed for the Town Creek sites.

Among-year patterns in diversity for individual sites were less clear. Diversity was generally low in 2000 compared to other years, with 2000 representing the lowest or second lowest period for diversity in 8 of the 9 sites. There were no other consistent trends among the other years across the 9 sites. Much of the variation in diversity was due to changes in dominance. Species richness did not exhibit consistent patterns among sites and years, except for generally higher species richness at all sites in 1999. Multidimensional Scaling Analysis indicated that 2002 and 2003 represented distinct community assemblages based on species similarity compared to the base years (1999-2001). 2002 and 2003 (sampling years) were separated from each other statistically, but both were dramatically different from the previous three years. Examination of dominant species at each site indicated that many sites were initially dominated exclusively by tidal freshwater and oligohaline species including a significant number of oligohaline-mesohaline polychaetes by 2002, suggesting salinity effect caused by the drought.

In 2003, the upper estuarine stations were again dominated by oligohaline species, but the taxonomic composition differed from earlier years.

Five years of infaunal data indicate detectable long-term trends in community composition. One trend was consistent with salinity changes in the Cape Fear system associated with a drought during 2000-2002. The other trend is more obvious and involves a shift in community characteristics between 2002/2003 and the previous 3 years of sampling. While the difference between 2002 and other years might be explained by salinity, this would not explain the difference between 2003, which was not a drought year, and 1999-2001. Explanations may include community instability related to recovery from the previous drought year, a year-specific event in 2003, or a possible signature from channel deepening and widening activities. These various hypotheses can best be distinguished by examining consistency in patterns for 2004-2005 data with those of 2002-2003.

The epibenthic community (primarily fish and decapods found along the marsh and swamp boundary) has also been sampled using Breder and drop traps spring and fall, since 1999. Drop traps collected a total of 77 taxa while a total of 41 taxa have been collected using Breder traps. As in previous years, evaluation of species richness, diversity, and total fauna by season (spring-fall) for Breder trap data showed strong inter-annual and site differences. Patterns were consistent with developing drought conditions in 2001 and 2002 and further evaluation will be needed to determine if these community fluctuations are also indicative of river deepening impacts. Analysis of Similarity (ANOSIM) using all site season combinations indicated that 2002 was significantly different from all other years. Drop trap data showed similar results, with significant annual and site differences. Analysis of total abundance and ANOSIM both show 2002 as an outlier year. While 2003 seems to show some recovery toward a preconstruction condition, spring 2004 had the highest total abundances recorded since project initiation in 1999 for most stations in the main stem Cape Fear and Northeast Cape Fear Rivers. These stations were dominated by high recruitment of spot (*Leiostomus xanthurus)* and early juvenile flounder *Paralichthys* sp., both important commercial species.

There has been some recovery of salt-sensitive plant species, but generally these have not returned to initial conditions. High levels of flooding, especially in the upper stations in the mainstem Cape Fear drainage may also have limited growth and prevented plant growth early in the season. New species appeared in several sites and may have arrived in this floodwater that remained over some sites for long periods. In the Northeast Cape Fear River, there were several sites, notable Rat Island, where salt-tolerant species have invaded and continue to invade. There were also new salt tolerant and salt intolerant species noted.

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EXECUTIVE SUMMARY

Published studies have shown that previous widening and deepening projects in the Cape Fear River and Harbor increased the tidal amplitude upstream. Modeling prior to the current deepening effort projected an increase of as much as three inches in tidal height. Even small changes in flooding could have a large effect within forested wetlands adjacent to the lower Cape Fear River, especially if increased flooding was accompanied by more saline water. The Wilmington District of the U.S. Army Corps of Engineers initiated a large-scale monitoring project to determine impacts, if any, from the Harbor Widening and Deepening Project. Monitoring includes, 1) a preconstruction phase, which began in 1999, 2) a construction phase, currently ongoing, and 3) a final post construction period. The final phase will allow the determination, if any, of project effects.

Twelve monitoring stations are located from the river's mouth to sites 16 miles upstream of Wilmington in both the Cape Fear and Northeast Cape Fear Rivers. Salinity and water level are collected continuously from all stations. The greatest potential impact is expected near the current fresh water – saltwater interface and stations are clustered on both sides of this gradient. At nine stations, a variety of biological and biogeochemical data are collected both in the shallow water adjacent to wetlands and in wetlands themselves. These data include abundance and diversity of small animals living in or on the surface of the mud (benthic invertebrates) and small animals that move onto the marsh when it is inundated (epibenthic animals), which includes a number of commercially and environmentally important species. These data also include change in the abundance of salt-sensitive plants within wetlands, and change in the microbial community associated with wetland sediments. Gauging stations along the river and within wetlands allow monitoring of the tide, along with any saltwater it contains, within both branches of the Cape Fear River and a small tributary (Town Creek) and into wetland adjacent to nine of these stations.

The construction monitoring phase has been marked by extreme drought within the Cape Fear watershed leading to record low levels of discharge followed by record high levels of discharge. As a consequence significant differences between these periods and the pre-construction data cannot be assumed to be project related. Post-monitoring will allow the separation of drought/flood effects from construction effects.

Significant differences in tidal range were found in 2003-2004 from previous years, but no differences in maximum flood levels. Although not significant, the mean tidal range increased for all stations upstream of the base station, except for the background station located upstream at the confluence of the Black and Cape Fear Rivers. The relationship of oceanic tides to estuarine tidal range has changed at seven of the 11 stations. High tide lag has decreased while low tide lag has increased, but the duration of ebb tide always exceeds that of flood tide. More frequent flooding and higher water levels within wetlands adjacent to the river reflected changes in water level along the river.

The beginning of the current monitoring period was marked by increased upstream discharge. Saline water that had penetrated into wetland sediments at stations along the river was replaced by fresher water. As a consequence, of fresher conditions, a general shift in the major bacteria active in decomposing organic matter within wetland soils from sulfate-reducing forms to those that produce methane has been observed. The reactants and products of these bacteria have proven to be excellent indicators of major changes in the salinity of floodwater. Salt-sensitive vegetation growing within wetlands adjacent to the river have also responded and recovered to some extent from the effect of two years of drought. However, they have not returned to preconstruction levels. This may be due to latent effects of the drought or to high water levels early in the growing season.

Small polychaete worms and crustaceans within sediments adjacent to wetlands also responded to drought conditions with shifts in both abundance and composition of dominant forms. These are critical as food for important commercial fish, shrimp, and crabs. Some changes within this group of animals suggest that there has either been a permanent change in fauna or that the effects of a drought persist even after the drought has ended. Similarly, the more motile animals that feed on these organisms also responded to the drought, but returned to a more normal pattern in 2003-2004, demonstrating a high degree of resilience. However, the lag in the benthic response may have a more profound impact in future seasons because there is a direct relationship between these food resources and fish populations.

1.0 STATION OPERATION

1.1 Summary

Measurement of water levels in the main channel of the Cape Fear River, the Northeast Cape Fear River, and Town Creek continue to provide data necessary to determine the impact associated with the widening and deepening project (see Figure 1.1-1 for Station Location). Differences between the high and low points of each tide, referred to as ranges in this report, can be followed upstream from the base station at Ft Caswell (P1) to any individual station. Differences between stations with respect to tidal range, time to high or low tide, length of low and high tides were also determined. Comparisons of these variables before and after channel modifications will provide the statistical testing mechanism to examine whether the project has impacted wetlands adjacent to the lower Cape Fear River. In addition, the absolute elevation of floodwater when related to measurements of water levels at marsh/swamp substations allows the determination of both flood duration and flood depth for any tide. Problems of communication with instruments or minor instrument malfunction were solved as they occurred. As was the case in previous monitoring years, each tide has been examined for each station and a determination made as to whether the data collected were reliable.

Several major problems were solved during the past year. The Fort Caswell station (P1) still experiences periodic unidentified disturbances leading to data curves that are not smooth; however, the maximum and minimum water levels were unaffected. Thus, the range data required for yearly regression analyses were unaffected. Several of the pilings appear to be slightly off vertical causing the beaded cable to catch on the stilling well on occasion. Adjustments have and are being made to the water level recorders in the DCPs to increase the distance between the beaded cable and the edge of the stilling well.

Table 1.1-1 provides a general summary of data loss that affects statistical analysis for present and future comparisons.

Table 1.1-1. Percentages of tides unavailable for analysis and reasons for loss. Detailed descriptions of "loss" categories are listed in Section 1.2 above.

Station	% Loss At Station P1	% QA/QC	% Under-ranging Events	% Absence of Data	% Freezing	% Mechanical Errors	Total % Lost Tides
P1	N/A	0.0	0.0	0.6	0.0	7.4	8.0
P2	8.0	0.0	0.0	0.4	0.0	0.7	9.1
P3	8.0	0.0	0.0	3.6	0.0	1.6	13.2
P4	8.0	0.0	0.0	0.0	0.0	0.0	8.0
P6	8.0	0.0	0.0	0.0	0.0	0.6	8.6
P7	8.0	0.0	4.5	0.0	1.4	0.5	14.4
P8	8.0	0.5	0.1	0.0	0.0	1.8	10.4
P9	8.0	0.7	0.0	0.0	0.0	0.7	9.4
P11	8.0	0.0	6.4	0.0	0.0	4.1	18.5
P12	8.0	0.0	0.1	8.3	0.0	1.8	18.2
P13	8.0	0.0	0.0	0.0	0.0	0.2	8.2
P14	8.0	0.1	0.0	0.0	0.0	1.1	9.2

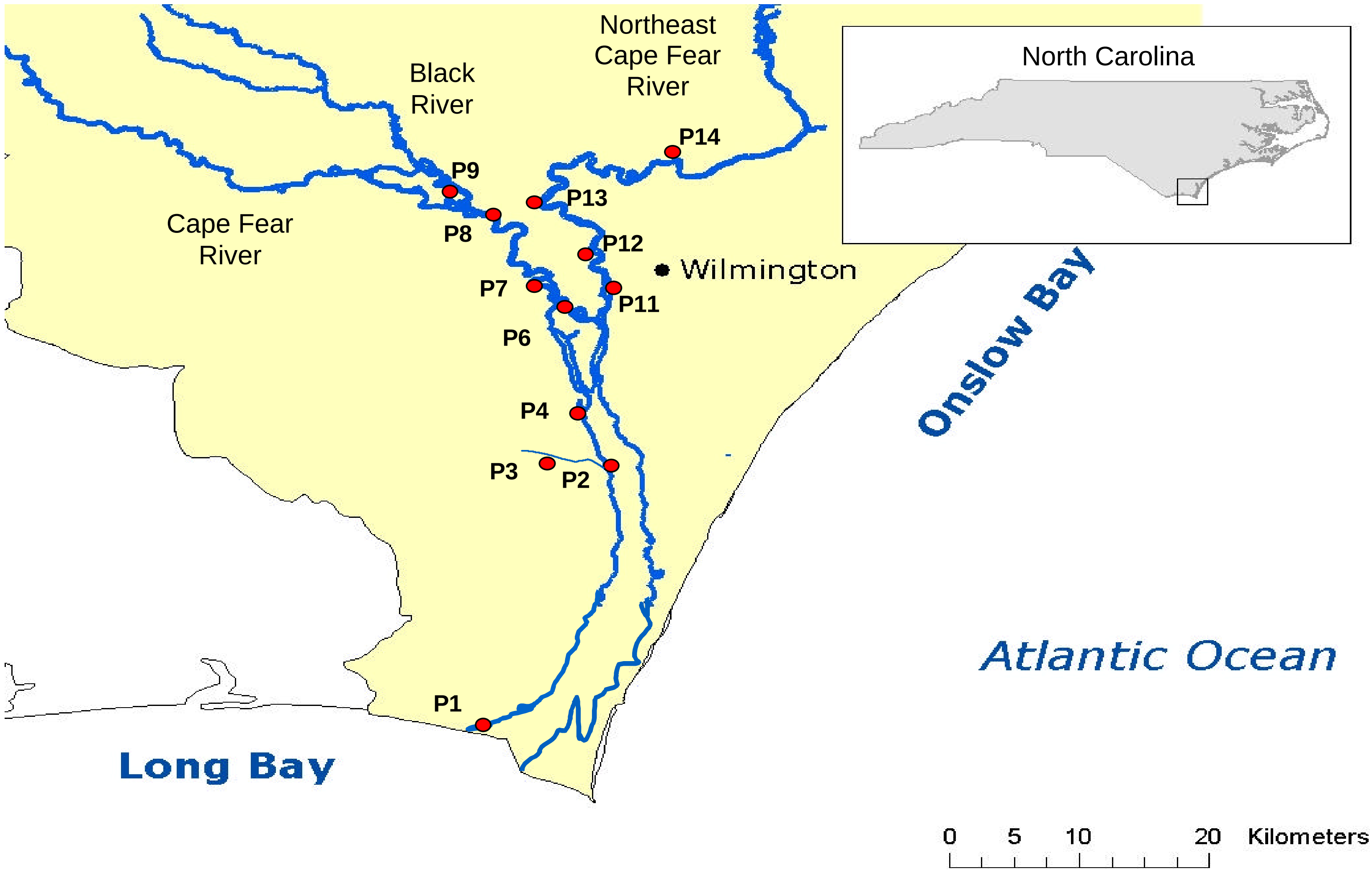


Figure 1.1-1. Location of permanent stations on the Cape Fear River estuary and tributaries.

1.2 Methodology

Water level was sampled by a UNIDATA shaft-encoded water level recorder housed in an aluminum stilling well at 1-second intervals. A UNIDATA Starlogger recorded the average, maximum, and minimum values every 3 minutes. Conductivity and temperature were also sampled by a UNIDATA conductivity instrument and recorded by the Starlogger every 3 minutes. Data were downloaded to a PC housed in the laboratory every 2 weeks via modem. In instances when the modem had not functioned properly, technicians on site downloaded data loggers using a laptop. Preliminary data quality review consisted of visually reviewing data for major problems (e.g. float hang-ups in the stilling well, data transmission errors, large jumps/shifts in water level, loss of data) within 2-3 days of download. This process is done so that any major problems identified can be rectified immediately. Data were then compiled into files each of which contains one month of data for each station. Data files were then sorted at 6 minutes intervals and the resulting data set stored for subsequent data analysis. Specific problems associated with the equipment and data acquisition were described below for each station. The following terms used in this section of the report describe general mechanisms through which data were lost or compromised. Any data point that has or may have been compromised is not used in analyses.

<u>Loss at Station P1</u>: Because the response of each variable upstream is related to the base station at Ft Caswell (P1), the loss of a variable from P1 during a particular tide means that there is no means of comparison with other stations. Reasons for data loss at P1 as well as other stations are: 1) <u>QA/QC Procedure</u>, which refers to tides that were removed from the data set when measurements coincided with QA/QC and equipment maintenance procedures. In these instances, recorded water levels were inaccurate due to cleaning the water level float, removing/replacing the water level recorder, replacing the beaded cable, or performing a field reset when in-situ observations of water level were inconsistent with water levels reported by the data logger; 2) <u>Under ranging events</u> refers to tides that were removed from the data set when the actual water level fell below the elevation of the stilling well cap. In these instances, the instruments were unable to detect the minimum water level; 3) <u>Absence of Data</u> refers to tides that were lost when the data were not recorded by the data logger or were not transmitted properly via the modem or PC download process; 4) <u>Freezing</u> of surface water in the stilling well prohibited the float from following the rise and fall of the tides and these tides were removed; 5) <u>Mechanical Errors</u> refer to tides removed from the data set during the data review process because of likely mechanical malfunction. Mechanical malfunctions were suspected when the plotted data exhibited misshapen curves, large jumps, and flat lines (i.e. hang-ups).

1.3 Ft Caswell (P1)

Ft Caswell is the most important station because this station experiences amplitude changes that are essentially oceanic tides. All upstream water levels are related to this station. This station functioned well during the reporting period. The total percentage of lost tides at this station from June 2003 to May 2004 (8.0%) was comparable to losses reported for previous reporting periods. Communication problems necessitated manual downloading on several occasions and the datalogger was replaced on two occasions in summer 2003. Data collected at this station still show irregularities in the shape of the water level curves periodically; however, the lack of a smooth curve usually does not affect the reported minimum and maximum water level values (i.e. reported tidal range). Biofouling continues to be a minor problem for the conductivity (salinity) probe, especially when larvae are recruiting into the estuary, and the growth of oysters inside the stilling well led to the loss of about 29 tides in June 2002. Monthly QA/QC checks and cleaning of probes and the well interior, however, limits and corrects these problems when they occur. Corrosion of the beaded cable also affects data quality; therefore, cable integrity is assessed each month and the cable replaced when necessary.

1.4 Town Creek Mouth (P2)

Water level curves at this station are not always as smooth as would be expected, although maximum and minimum water levels correspond well with P1. This site seems to be affected by passing ships/boats, which compromises the quality of data in some instances. The percentage of tides lost for this station during this reporting period was very low compared to the 2002-2003 period (<2%). Bird excrement covering the solar cell is still a problem at this site and must be removed to limit corrosion of the metal components of the structure. Biofouling is also a problem at this station, but is identified and corrected each month (if present) during monthly QA/QC checks. Water relatively high in salinity at this site continues to affect the beaded cables, necessitating their replacement on occasion.

1.5 Inner Town Creek (P3)

This station generally experiences few problems and continues to generate smooth tidal curves. The protected nature of this site continues to limit large waves and wakes. Although the loss of tides at this station was slightly higher than during previous reporting period, the total number of tides lost was still near 5%. Missing data were largely due to problems with the timer in the modem system. A new phone box was installed and reprogrammed in January 2004.

1.6 Corps Yard (P4)

NOAA operates the tidal gauge at this site and data are available at their website after curve-smoothing procedures are applied. The UNCW conductivity/salinity gauges located at this site have operated with no problems over the reporting period.

1.7 Eagle Island (P6)

This site experienced no significant operational difficulties during this monitoring period. However, the data logger was removed and replaced in October 2003.

1.8 Indian Creek (P7)

This DCP and associated stilling well are set higher than others along the Cape Fear River and therefore, this site continues to experience a relatively high percentage of lost tides due to under ranging (4.5% for this reporting period). This year, freezing during the winter months was also a problem that resulted in a loss of 1.4% of the tides. Less than 1% of the tides at this site were lost due to communication errors.

1.9 Dollisons Landing (P8)

This site has experienced no significant operational difficulties since the piling was replaced during the last reporting period. Small tide losses occurred during QA/QC, due to under-ranging events and a few mechanical/transmission errors.

1.10 Black River (P9)

This site experienced no significant operational difficulties during this monitoring period. Less than 1.5% of the tides were lost due to QA/QC and minor mechanical malfunctions that were immediately corrected.

1.11 Smith Creek (P11)

Data acquisition at this site was somewhat less than during the previous reporting period. Under ranging events have returned and mechanical problems associated with malfunctioning data loggers contributed to loss of data at this site. Further, the water level recorder failed QA/QC specifications on several occasions and needed to be reset. As a result, approximately 10.5% of the tides measured at this site were lost. New data loggers have been installed and appear to be properly functioning.

1.12 Rat Island (P12)

This site experienced a few minor operational difficulties during this monitoring period. Minor problems associated with failed batteries led to an absence of data (8.3%) and an offset cable resulted in the loss of approximately 1.8% of the tides at this station.

1.13 Fishing Creek (P13)

This site experienced no significant operational difficulties during this monitoring period.

1.14 Prince George Creek (P14)

There have been few problems at this site with respect to water level. The micrologger for the conductivity instrument was replaced after conductivity data was observed to flat line at this site in October 2003.

2.0 MONUMENT AND STATION SURVEY VERIFICATION

2.1 Summary

No surveys were scheduled for this reporting period and no problems were noted in the River Water Level monitoring, Section 3.0 or Swamp/Marsh Water Level monitoring.

3.0 RIVER WATER LEVEL/SALINITY MONITORING

3.1 Summary

More than 1,400 tide ranges measured between 1 June 2002 and 31 May 2004 comprise the database for water level comparisons during this monitoring period (Appendix A). The existing database allows for analyses of changes in tidal amplitude as well as changes of ebb and flood duration. The correlation of tidal range from the base station at Ft Caswell with the predicted tidal range remained very good; however, the slope of the regression was considerably lower than in previous years. Tidal ranges within the estuary were fairly constant, including the lowermost of the upstream stations, and were higher than tidal ranges measured at most upstream stations. Water levels in the most upstream sites and the inner Town Creek station continued to be affected by discharge rates in the river. This reporting period was characterized by fewer high discharge events than in the 2002-2003 reporting period and this is evident in the generally higher R^2 values for almost all stations this year compared to last year. Numerous significant differences in yearly mean tidal ranges between this reporting period and 2002-2003 were observed, but these do not appear to vary systematically. In general, tidal range at both of the most upstream sites in the mainstem, Northeast Cape Fear and at P1 was significantly lower than the mean ranges reported for these stations during the first year of monitoring. The observation, that mean tidal range observed at P1 (Ft. Caswell) has significantly decreased, complicates interpretation of the results as this station was initially expected to be unimpacted by river deepening activities. Mean monthly maximum water levels for this reporting period were not significantly different from the values reported for 2002-2003. With the exception of station P11, there was no significant difference in mean monthly minimum water level between this reporting period and last year. In contrast to previous reporting periods, comparisons of the regression slopes when tidal range at each site was regressed against P1 tidal range yielded significant differences between this reporting period and the previous reporting period for all stations except P3, P8, P12, and P13. When the slopes from this reporting period were compared to slopes calculated for Year 1 (2000-2001), P3 also yielded a significant difference between years. This infers that the tidal range has changed.

There was a very slight difference between tidal lag times measured during this reporting period and those measured in 2002-2003 for the upstream stations in the Northeast Cape Fear River. In contrast, for the mainstem stations and estuary stations, the high tide lag appears to have decreased while the low tide lag has consistently increased. The duration of the ebb tide continues to exceed the duration of flood at most stations as in previous monitoring periods. Flood and ebb durations show little change from mean durations reported in 2002-2003 for most stations (less than 3% change for both flood and ebb durations). The one exception was station P1 (4.5% decrease in ebb duration). The relationship between tidal range at Ft Caswell and other stations differed from station to station, but was generally related to distance from the ocean and freshwater flow. Fewer high discharge events in 2003-2004 resulted in a reduction in variability of the tidal ranges observed during this monitoring period.

In general, mean tidal range decreased at upstream stations. The mean tidal range for every station except P1and P14 was significantly higher this year than the mean tidal range reported in 2002-2003. At stations P1 and P14, there was no significant difference in mean tidal range between this year and last year's monitoring period. When the mean tidal ranges for the current year were compared to those reported for Year 1 (2000-2001), only stations P3 and P7 exhibited means that were not significantly different. At present, our observations are inconclusive and somewhat inconsistent with the expected effects of dredging. It is apparent that that our results have been complicated by the existence of both lower, drought-induced water levels and extreme flooding in the system over the last three years and that additional types of data analyses will be necessary to conclusively evaluate the effects of channel modification on tidal attributes. Further, the data suggest that the limited data set available for Year 1 (October-May), may be affecting the results of the statistical analyses.

In 2000-2001, salinity did not exceed 1 ppt at stations upstream of Eagle Island on the Cape Fear River because of the continuous release of freshwater upstream. In 2001-2002, upstream releases in the Cape Fear River had been reduced and salinities as high as 3.5 ppt were measured at P8 while salinities exceeding 14 ppt were measured at Fishing Creek, 8 miles north of Point Peter in the Northeast Cape Fear River. In 2002-2003, maximum salinities reported for these sites were 5.8 ppt and 16.4 ppt, respectively, and were measured in summer 2002 when drought conditions still existed in the region. This year, a period of more typical flow conditions in the river, maximum salinities for P8 and P13 were 0.2 ppt and 4.7 ppt, respectively.

3.2 Database

Water level, conductivity, and temperature data collected at DCP stations from June 2003 through May 2004 are incorporated in this report. This year's database includes approximately 1400 tides of sufficient quality to be used in the analyses of each of the 11 DCP stations. Specific problems associated with each station have been described in Section 1.0 of this report. Table 1.1-1 summarizes the percentage of tides unavailable for analysis due to the various reasons cited above.

3.3 Data Analyses Methods

Maximum, minimum, and mean water level and conductivity/ temperature were recorded every 3 minutes. The final data set used for analyses consists of 3-minute averages of water level and conductivity collected every 6 minutes. The 6-minute means were plotted after each two-week interval and the resulting curves visually inspected by a senior analyst for quality control purposes. Suspect data, such as outliers or data points that deviate from a smooth curve, were discarded. Unreliable data, such as those collected during periods of mechanical malfunction, equipment maintenance, under-ranging events, and freezing events, were also removed. The remaining data were then filtered to extract the maximum and minimum water levels associated with each tidal event. For this report, a tidal event consists of one high water/low water pair.

The high and low water values contained in the final data set were used to determine the mean tidal range and to compute tidal lags between sites. The mean tidal range was computed from the difference in water level between each high and low tide event for each station. With the exception of stations P3 and P7, the mean tidal ranges measured during this reporting period were significantly different ($P<0.05$) than the means reported during the first year of monitoring (2000-2001). There was no consistent pattern to these differences, ranges were greater at some stations and lower at others. It is important to note, however, that the Year 1 reporting period only included the period of October to May and all subsequent period have included a complete calendar year. Ranges at P3 and P7 were, however, significantly greater than mean tidal ranges reported for those stations in 2003-2004.

Table 3.3-1. Monthly maximum, minimum, and range of salinity values for each station. Monthly maximum, minimum, and range of water level for each station are also given. All water levels are relative to NAVD88 with the exception of P4 (USACE yard), which is relative to MSL.

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P1	Jun-03	23.4	10.0	13.4	2.45	-4.21	6.66
	Jul-03	23.3	7.7	35.6	3.05	-4.53	7.58
	Aug-03	24.1	8.2	35.9	2.01	-4.03	6.04
	Sep-03	28.1	9.2	39.0	3.32	-3.76	7.08
	Oct-03	28.2	7.4	40.4	3.15	-4.14	7.29
	Nov-03	13.0	-0.2	13.2	3.04	-4.13	7.17
	Dec-03	30.3	8.7	21.6	2.50	-4.35	6.85
	Jan-04	32.1	9.7	22.3	2.30	-4.23	6.53
	Feb-04	28.0	9.3	18.7	2.00	-4.75	6.75
	Mar-04	27.4	8.4	19.0	2.55	-5.37	7.92
	Apr-04	30.2	11.3	18.9	2.55	-3.99	6.54
	May-04	32.8	8.7	24.1	2.80	-4.25	7.05
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P2	Jun-03	2.8	0.1	2.7	3.71	-2.57	6.28
	Jul-03	6.7	0.1	6.6	3.49	-2.85	6.34
	Aug-03	4.5	0.0	4.5	3.30	-2.62	5.92
	Sep-03	12.4	2.2	10.2	4.22	-2.15	6.37
	Oct-03	13.8	7.5	6.3	3.79	-2.53	6.32
	Nov-03	10.5	0.1	10.4	3.86	-2.69	6.55
	Dec-03	10.2	0.1	10.1	3.56	-2.74	6.30
	Jan-04	10.9	0.1	10.8	3.13	-2.70	5.83
	Feb-04	8.7	0.1	8.6	3.27	-2.68	5.95
	Mar-04	11.0	0.1	10.9	3.14	-2.77	5.91
	Apr-04	12.4	1.4	11.0	3.20	-2.76	5.96
	May-04	13.2	0.2	13.0	3.59	-2.78	6.37
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P3	Jun-03	1.8	0.1	1.7	1.98	-1.77	3.75
	Jul-03	4.0	0.1	3.9	1.42	-5.45	6.87
	Aug-03	3.5	0.1	3.4	1.86	-2.12	3.98
	Sep-03	9.8	0.1	9.7	2.52	-1.90	4.42
	Oct-03	10.7	0.1	10.6	2.67	-1.38	4.05
	Nov-03	7.6	0.0	7.6	2.49	-2.03	4.52
	Dec-03	9.5	0.0	9.5	2.20	-2.10	4.30
	Jan-04	8.7	0.0	8.7	1.85	-2.06	3.91
	Feb-04	2.3	0.0	2.3	2.14	-2.37	4.51
	Mar-04	3.7	0.0	3.7	1.93	-2.21	4.14
	Apr-04	11.6	0.1	11.5	1.94	-2.30	4.24
	May-04	9.3	0.1	9.2	2.26	-2.05	4.31
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P4	Jun-03	0.7	0.0	0.7	3.24	-2.89	6.13
	Jul-03	1.6	0.1	1.5	3.04	-3.30	6.34
	Aug-03	3.7	0.1	3.6	2.90	-3.04	5.94
	Sep-03	16.5	0.4	16.1	3.81	-3.21	7.02
	Oct-03	11.7	0.1	11.6	3.34	-3.01	6.35
	Nov-03	9.4	0.1	9.3	3.31	-3.54	6.85
	Dec-03	7.9	0.1	7.8	3.13	-3.45	6.58

Table 3.3-1. continued

Site	Month	Salinity (ppt) Maximum	Minimum	Range	Water Level (ft) Maximum	Minimum	Range
	Jan-04	9.2	0.0	9.2	2.65	-3.58	6.23
	Feb-04	6.5	0.1	6.4	2.80	-3.94	6.74
	Mar-04	10.4	0.1	10.3	2.70	-3.86	6.56
	Apr-04	9.9	0.1	9.8	2.73	-3.54	6.27
	May-04	9.3	0.1	9.2	3.16	-3.36	6.52
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P6	Jun-03	1.1	0.0	1.1	3.38	-2.48	5.86
	Jul-03	2.0	0.0	2.0	3.21	-2.91	6.12
	Aug-03	2.3	0.0	2.3	3.14	-2.69	5.83
	Sep-03	14.9	0.0	14.9	3.85	-3.02	6.87
	Oct-03	10.0	0.0	10.0	3.41	-2.70	6.11
	Nov-03	8.9	0.1	8.8	3.36	-3.10	6.46
	Dec-03	9.6	0.0	9.6	3.24	-3.05	6.29
	Jan-04	10.2	0.0	10.2	2.80	-3.03	5.83
	Feb-04	11.8	0.0	11.8	2.88	-3.06	5.94
	Mar-04	14.6	0.0	14.6	2.76	-3.21	5.97
	Apr-04	13.0	0.1	12.9	2.65	-3.24	5.89
	May-04	11.3	0.0	11.3	3.12	-3.18	6.30
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P7	Jun-03	0.1	0.0	0.1	3.29	-1.91	5.20
	Jul-03	0.1	0.0	0.1	3.17	-2.11	5.28
	Aug-03	0.1	0.0	0.1	3.18	-2.15	5.33
	Sep-03	0.1	0.1	0.0	3.75	-2.23	5.98
	Oct-03	0.1	0.0	0.1	3.27	-2.18	5.45
	Nov-03	0.1	0.0	0.1	3.16	-2.32	5.48
	Dec-03	0.1	0.0	0.1	3.14	-2.33	5.47
	Jan-04	0.1	0.0	0.1	2.66	-2.36	5.02
	Feb-04	0.1	0.0	0.1	2.97	-2.36	5.33
	Mar-04	0.1	0.0	0.1	2.85	-2.34	5.19
	Apr-04	0.1	0.0	0.1	2.76	-2.36	5.12
	May-04	0.1	0.0	0.1	3.24	-2.38	5.62
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P8	Jun-03	0.1	0.0	0.1	3.57	-1.42	4.99
	Jul-03	0.1	0.0	0.1	3.35	-1.57	4.92
	Aug-03	0.1	0.0	0.1	3.51	-1.53	5.04
	Sep-03	0.1	0.0	0.1	3.84	-1.87	5.71
	Oct-03	0.1	0.0	0.1	3.31	-1.66	4.97
	Nov-03	0.1	0.0	0.1	3.20	-2.44	5.64
	Dec-03	0.1	0.0	0.1	3.26	-2.14	5.40
	Jan-04	0.1	0.0	0.1	3.15	-1.83	4.98
	Feb-04	0.1	0.0	0.1	3.10	-1.85	4.95
	Mar-04	0.1	0.0	0.1	2.83	-2.47	5.30
	Apr-04	0.2	0.1	0.1	2.73	-2.76	5.49
	May-04	0.2	0.0	0.2	2.71	-2.44	5.15
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P9	Jun-03	0.1	0.0	0.1	4.00	-1.14	5.14
	Jul-03	0.1	0.0	0.1	3.28	-1.28	4.56
	Aug-03	0.0	0.0	0.0	3.72	-1.03	4.75
	Sep-03	0.1	0.0	0.1	3.76	-1.57	5.33
	Oct-03	0.1	0.0	0.1	3.17	-1.42	4.59
	Nov-03	0.1	0.0	0.1	3.12	-1.75	4.87
	Dec-03	0.1	0.0	0.1	3.28	-2.04	5.32
	Jan-04	0.1	0.0	0.1	2.79	-1.84	4.63
	Feb-04	0.1	0.0	0.1	3.03	-1.84	4.87
	Mar-04	0.1	0.0	0.1	3.19	-1.95	5.14
	Apr-04	0.1	0.0	0.1	2.99	-1.68	4.67
	May-04	0.1	0.0	0.1	3.08	-1.74	4.82

Table 3.3-1. concluded

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P11	Jun-03	4.4	0.0	4.4	3.27	-3.70	6.97
	Jul-03	4.3	0.0	4.3	3.79	-2.39	6.18
	Aug-03	3.0	0.0	3.0	4.92	-1.76	6.68
	Sep-03	13.8	0.1	13.7	4.38	-3.66	8.04
	Oct-03	11.5	0.1	11.4	3.05	-4.82	7.87
	Nov-03	10.9	0.0	10.9	2.23	-4.16	6.39
	Dec-03	10.9	0.0	10.9	2.97	-4.00	6.97
	Jan-04	9.9	0.1	9.8	1.97	-4.40	6.37
	Feb-04	9.3	0.0	9.2	2.50	-3.50	6.00
	Mar-04	11.9	0.0	11.9	2.58	-3.57	6.15
	Apr-04	14.1	0.1	14.0	2.41	-4.49	6.90
	May-04	11.3	0.0	11.3	2.03	-3.39	5.42
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P12	Jun-03	0.2	0.0	0.2	2.96	-2.13	5.09
	Jul-03	1.2	0.0	1.2	3.28	-2.44	5.72
	Aug-03	1.6	0.0	1.6	4.04	-2.35	6.39
	Sep-03	17.3	0.1	17.2	4.52	-1.46	5.98
	Oct-03	9.0	0.0	9.0	3.07	-2.18	5.25
	Nov-03	7.2	0.0	7.2	2.93	-2.95	5.88
	Dec-03	9.3	0.0	9.3	2.87	-2.82	5.69
	Jan-04	9.9	0.1	9.8	2.42	-2.93	5.35
	Feb-04	13.1	0.0	13.1	2.60	-3.27	5.87
	Mar-04	15.6	0.0	15.6	2.53	-2.87	5.40
	Apr-04	13.1	0.0	13.1	2.49	-2.96	5.45
	May-04	10.2	0.0	10.2	2.87	-2.61	5.48
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P13	Jun-03	0.1	0.0	0.1	2.52	-1.81	4.33
	Jul-03	0.1	0.0	0.1	2.44	-1.99	4.43
	Aug-03	0.1	0.0	0.1	2.35	-1.90	4.25
	Sep-03	3.9	0.0	3.9	2.90	-2.22	5.12
	Oct-03	0.5	0.0	0.5	2.76	-1.71	4.47
	Nov-03	0.1	0.0	0.1	2.54	-2.65	5.19
	Dec-03	0.5	0.0	0.5	2.54	-2.54	5.08
	Jan-04	0.9	0.0	0.9	2.09	-2.56	4.65
	Feb-04	0.7	0.0	0.7	2.30	-2.93	5.23
	Mar-04	4.5	0.0	4.5	2.19	-2.56	4.75
	Apr-04	3.3	0.0	3.3	2.17	-2.60	4.77
	May-04	4.7	0.0	4.7	2.57	-2.32	4.89
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P14	Jun-03	0.1	0.0	0.1	2.70	-1.43	4.13
	Jul-03	0.1	0.0	0.1	1.74	-1.58	3.32
	Aug-03	0.1	0.0	0.1	2.12	-1.52	3.64
	Sep-03	0.1	0.0	0.1	2.42	-1.51	3.93
	Oct-03	0.1	0.0	0.1	2.52	-1.15	3.67
	Nov-03	0.1	0.0	0.1	2.47	-1.54	4.01
	Dec-03	0.1	0.0	0.1	2.36	-1.95	4.31
	Jan-04	0.1	0.0	0.1	1.73	-1.81	3.54
	Feb-04	0.1	0.0	0.1	2.04	-2.22	4.26
	Mar-04	0.1	0.0	0.1	1.84	-2.12	3.96
	Apr-04	0.1	0.0	0.1	1.73	-1.98	3.71
	May-04	0.1	0.0	0.1	2.21	-1.80	4.01

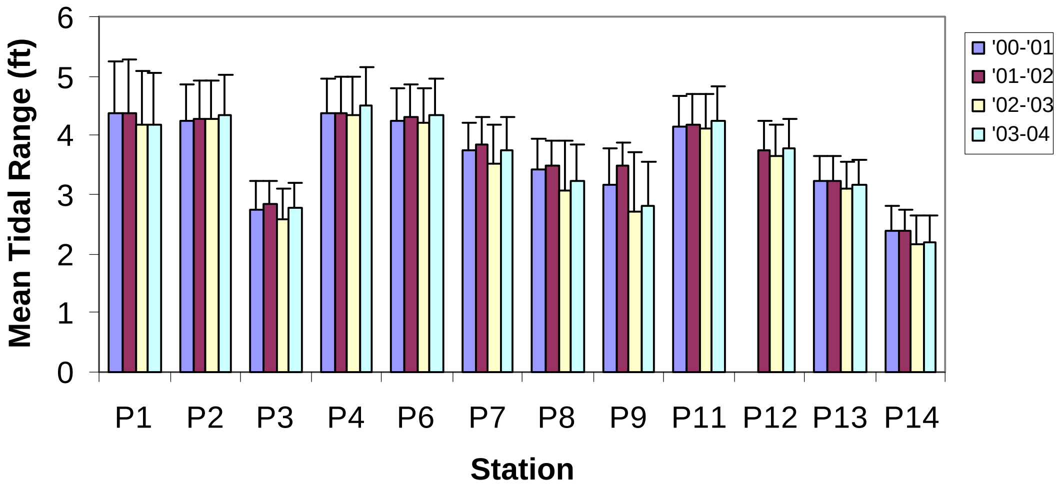


Figure 3.3-1. Mean water level for each station for all monitoring years. All water levels are relative to NAVD88 with the exception of P4 (USACE yard), which is relative to MSL. Error bars show one standard deviation. Significant differences between yearly means ($p<0.05$) for one or more monitoring periods are shown in Table 3-3.2.

Table 3.3-2. Summary of statistical analyses of mean annual water level comparisons for each of the 11 DCP stations. Yearly mean tidal ranges were compared using Tukey-Kramer highest significant difference ($p<0.05$). Asterisks denote where significant differences occurred among years. Years with different letter superscripts were significantly different. Years with two letter super scripts were not different from either year. No data (NA) were available for year 1 for station P12.

Station	Significant	Effect (Year)
P1	*	1^{a} 2^{a} 3^{b} 4^{b}
P2	*	1^{a} 2^{ab} 3^{a} 4^{b}
P3	*	1^{a} 2^{b} 3^{c} 4^{a}
P4	*	1^{a} 2^{a} 3^{a} 4^{b}
P6	*	1^{a} 2^{b} 3^{a} 4^{b}
P7	*	1^{a} 2^{b} 3^{c} 4^{a}
P8	*	1^{a} 2^{a} 3^{b} 4^{c}
P9	*	1^{a} 2^{b} 3^{c} 4^{d}
P11	*	1^{ab} 2^{ac} 3^{b} 4^{c}
P12	*	NA 2^{a} 3^{b} 4^{a}
P13	*	1^{a} 2^{a} 3^{b} 4^{c}
P14	*	1^{a} 2^{a} 3^{b} 4^{b}

Table 3.3-3. Summary of statistical tests for yearly data collected at the 11 DCP stations. Yearly means of tidal ranges were compared. Also shown are yearly differences in the slopes of the best-fit lines generated by regressing each tidal range for each station on the corresponding tidal range for P1. These were compared using analysis of covariance. NS indicates no significant difference at $P < 0.05$. Asterisks denote significant differences between years and p values are given. N/A indicates insufficient data to complete analyses.

Station	Y1/Y2 Regression Slope	Y1/Y3 Regression Slope	Y1/Y4 Regression Slope	Y3/Y4 Regression Slope
P1	---	---	---	---
P2	*(<0.0001)	NS	NS	* (0.0011)
P3	* (<0.0001)	NS	* (0.0227)	NS
P4	NS	NS	* (<0.0001)	* (<0.0001)
P6	NS	NS	* (<0.0001)	* (<0.0001)
P7	*(0.0247)	NS	* (0.0064)	* (0.0007)
P8	NS	NS	NS	NS
P9	NS	NS	* (0.0001)	* (<0.0001)
P11	NS	NS	* (<0.0001)	* (<0.0001)
P12	N/A	N/A	N/A	NS
P13	NS	NS	NS	NS
P14	* (0.0088)	NS	* (<0.0001)	* (0.0002)

Tidal lags were determined by measuring the difference in time for high (or low) tide at 2 different stations as described in the Year 1 report. All tidal lags were calculated relative to station P1 and are being used to evaluate the impact of dredging on the propagation of the tidal wave upriver. Mean tidal range, flood duration, ebb duration and tidal lags for each station are given in Table 3.3-4. During this reporting period, high tide lag values decreased at all stations relative to last year's values with the exception of station P11. Both increases and decreases in low tide lag were noted among stations relative to the 2002-2003 values. Consistent with previous reporting periods, mean flood durations were lower than mean ebb durations with the exception of stations P1 and P3. Flood and ebb durations varied little from those values reported in the last monitoring period (<2%) except for P1 which showed a 4.5% decrease in ebb duration.

Table 3.3-4. Summary of tidal data generated from data collection platforms (DCP) at eleven stations along the Cape Fear River and tributaries. Values in italicized parens are the percent change between the current monitoring interval and the previous reporting period. Positive values indicate an increase and negative values a decrease. ND indicates that a change was not measurable. N/A indicates that data were insufficient to measure a reliable change. Mean lag times are also given in parentheses for both high and low tide.

Station Number	**Mean Tidal Range (ft)**	**Mean Flood Duration (hr) *(% change)***	**Mean Ebb Duration (hr) *(%change)***	**Mean High Tide Lag From P1 (hr) ('02-'03 lag time)**	**Mean Low Tide Lag From P1 (hr) ('02-'03 lag time)**
P1	4.17 ± 21.5%	6.35 (-2.7)	6.03 (-4.48)	---	---
P2	4.33 ± 15.67%	5.87 (+2.4)	6.53 (-2.91)	1.27 (1.70)	2.05 (1.88)
P3	2.71 ± 15.60%	6.30 (-1.1)	6.05 (+0.33)	2.92 (3.40)	2.95 (2.92)
P4	4.49 ± 14.6%	5.65 (-0.4)	6.75 (+0.30)	1.32 (1.73)	2.14 (2.42)
P6	4.33 ± 14.14%	5.80 (-0.5)	6.55 (-0.76)	2.00 (2.70)	2.57 (2.18)
P7	3.74 ± 15.0%	5.73 (-0.7)	6.65 (+0.30)	2.45 (3.17)	3.07 (2.60)
P8	3.22 ± 19.9%	5.75 (-1.2)	6.62 (+0.60)	2.85 (3.53)	3.47 (3.00)
P9	2.81 ± 26.8%	5.75 (-2.2)	6.63 (+1.50)	3.27 (3.93)	3.88 (3.77)
P11	4.19 ± 14.44%	5.73 (-0.9)	6.57 (-0.76)	2.15 (2.15)	2.75 (2.68)
P12	3.77 ± 13.4%	5.78 (-1.5)	6.62 (+1.10)	2.40 (2.60)	2.97 (3.00)
P13	3.16 ± 13.9%	5.82 (-1.0)	6.60 (+1.20)	2.92 (3.12)	3.47 (3.48)
P14	2.19 ± 20.4%	5.82 (-2.2)	6.58 (+2.00)	4.00 (4.20)	4.53 (4.52)

Table 3.3-5. Yearly comparisons of mean monthly maximum and minimum water levels collected at the 11 DCP stations. Significant differences were identified using a Wilcoxon Rank Sum test. NS indicates no significant difference at P <0.05. Asterisks denote significant differences between years and p values are given. N/A indicates insufficient data to complete analyses. Yr1/Yr2 and Yr2/Yr3 results are available in the Year 3 Annual Report.

Station	**Yr1/Yr4 Mean Monthly Maximum WL**	**Yr3/Yr4 Mean Monthly Maximum WL**	**Yr1/Yr4 Mean Monthly Minimum WL**	**Yr3/Yr4 Mean Monthly Minimum WL**
P1	NS	*(0.0032)	NS	NS
P2	*(0.0205)	NS	*(0.0043)	NS
P3	NS	NS	*(0.0276)	NS
P4	NS	NS	NS	NS
P6	NS	NS	*(0.0449)	NS
P7	NS	NS	*(0.0015)	NS
P8	NS	NS	*(0.0167)	NS
P9	*(0.0007)	NS	*(0.0007)	NS
P11	NS	NS	NS	*(0.0027)
P12	N/A	NS	N/A	NS
P13	*(0.0448)	NS	NS	NS
P14	NS	NS	NS	NS

3.4 Upstream Tidal Effects

Stations upstream of Point Peter are increasingly influenced by river flow in both branches of the Cape Fear Estuary and are considered separately from estuarine stations P1, P2, and P4, and from each other.

3.41 Ft Caswell (P1) and Outer Town Creek (P2)

The tidal ranges observed at the Ft Caswell base station show good agreement with the predicted tides for the area (Figure 3.41-1). When observed tidal ranges are regressed against the predicted tidal ranges, the R^2 value is similar to those documented in previous reports, however, the slope shows a slight flattening compared to previous years (slopes ~ 1.08 for years 1-3). The mean tidal range at P1 was significantly lower than the mean reported for years 1 and 2, but not different from year 3 (Table 3.3-2, Figure 3.3-1). The mean tidal range at the Outer Town Creek (P2) site was also significantly higher than the ranges reported for all previous monitoring periods with the exception of year 2. Further, both the mean monthly maximum and minimum water levels were significantly different from those reported for the Year 1 monitoring period (Table3.3-5). As seen in Figure 3.41-2, the tidal range at P2 is strongly and positively correlated with observed tidal ranges at P1. The slope of the P1 versus P2 regression for this monitoring period was significantly higher ($p<0.0001$) than the slope reported during the most recent reporting period (Table 3.3-3), but not significantly different from the slope measured in the first monitoring period. One possible explanation for the difference in statistical significance among years may be the greater variability in tidal ranges at P2 during this year compared to year 1 (R^2 = 0.96). Another possibility may be that the dredging and realignment of the offshore shipping channel has affected tidal ranges at P1. While the observed deviations from the predicted tides at P2 (and P1 for that matter) may be associated with wind events, upland run-off events, and to a lesser degree, periods of increased river discharge; the overall impact of these events on water level is much less than other up river sites.

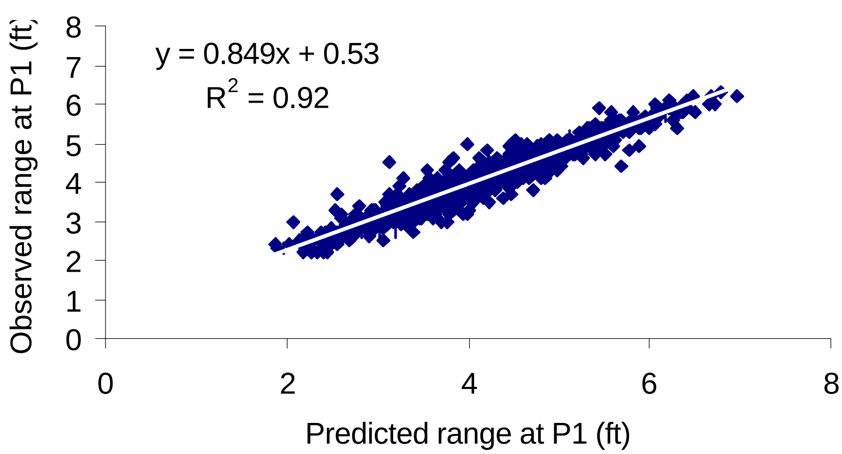


Figure 3.41-1. Plot of predicted tidal range at P1 relative to measured tidal range at P1 for June 2003 to May 2004.

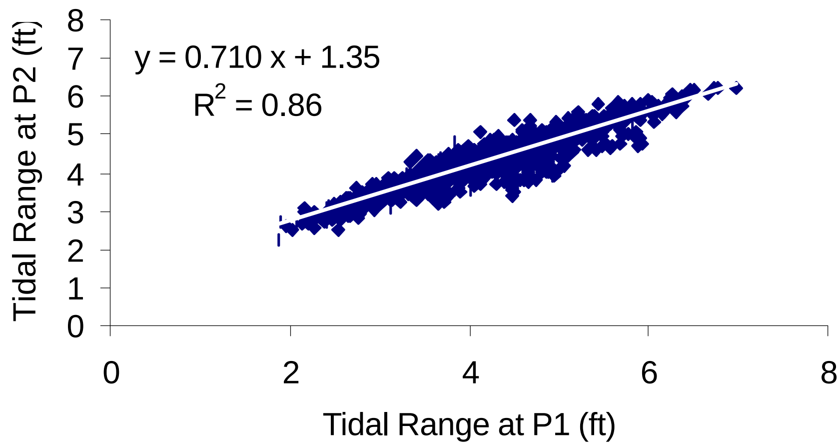


Figure 3.41-2. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Outer Town Creek (P2).

The water level curve at P1 has remained generally symmetrical and continues to show less evidence of the time asymmetries (Table 3.3-3) measured at other stations. These asymmetries, as evidenced by the unequal flood and ebb durations shown in Table 3.3-3, begin at site P2 and continue up river to all monitoring sites. The duration of flooding tide at P2 increased slightly during this reporting while the ebb tide duration decreased slightly. Consistent with the previous reporting period, the mean high tide lag between P2 and P1 decreased and the mean low tide lag increased. These changes, however, are much greater for this reporting period than those documented in the 2002-2003 report. These data may suggest a change in the rate of the tidal wave propagation up-estuary that is consistent with an increase in tidal range; as predicted by USACE models.

3.42 Inner Town Creek (P3)

For this reporting period, the mean tidal range observed at this site was approximately 1.6 feet less than the tidal range observed at the creek mouth. The mean tidal range from June 2003 to May 2004 was significantly greater (by 0.14 ft) than the mean tidal range reported for June 2002 to May 2003, but was not significantly different for the mean tidal range reported for October 2000 to May 2001. This difference may be due to elevated rainfall and runoff at P3 in spring 2003 combined with lower than normal rainfall and river discharge in spring 2004 (Figure 3.5-1 and Figure 3.5-2). As shown in previous reports, large runoff events often cause a decrease in the magnitude of the tidal range, thereby lowering the mean when they occur. Water level curves generated for this station and computed tidal ranges continue to exhibit a wide range of variability and to depend on flow conditions in the creek. Mean ebb and flood durations at this site have changed little since last reporting period.

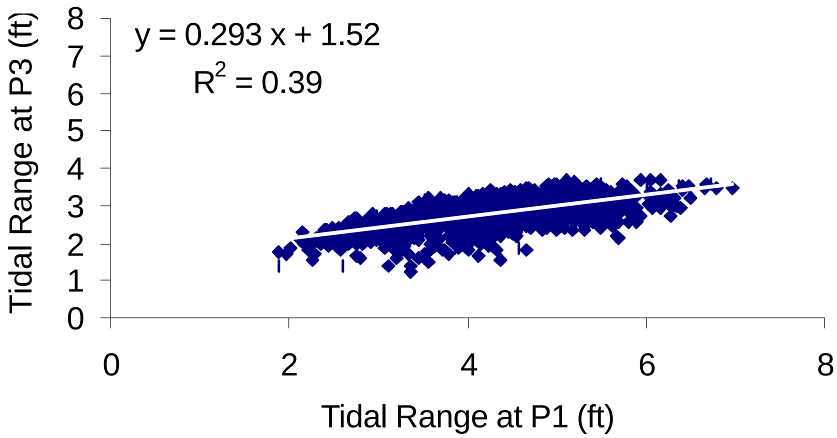


Figure 3.42-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Inner Town Creek (P3).

The correlation between tides at P3 and P1 this year was higher than that reported for the previous two monitoring periods (R^2 = 0.32 and R^2 = 0.26 for years 2 and 3, respectively). The slope of the P1 versus P3 regression for this monitoring period was significantly steeper (p = 0.0011) than the slope reported in 2002-2003 (Table 3.3-2), but not significantly different from the slope reported for year 1. Again, this may be due to a combination of high rainfall/runoff affecting the creek in spring 2003 compared to the effects of a period of low rainfall in spring 2004. This result is consistent with our observation that low flow conditions in the creek may have a profound effect on tidal range relationships for those sites susceptible to periodically high runoff.

3.43 Corps Yard (P4)

The tidal range observed at P4 continues to approximate the range observed at the P1 base station (Figure 3.42-2). The slope (0.70) of the P1/P4 regression was, for the first time, significantly greater than the slopes reported for the previous monitoring period and for the first monitoring period (Table 3.3-3). The mean tidal range for this reporting period was significantly greater than the means measured at this station during all previous monitoring periods (Figure 3.3-1). Water level curves generated for P4 continue to show a slight time asymmetry that does not occur at P1. The mean ebb and flood durations of 6.75 and 5.65 hours, respectively, have not changed since the previous reporting periods. Both the mean high and low tide lags at this station, however, are less than those reported in 2002-2003 (Table 3.3-4). These data suggest that the tidal wave is propagating more quickly upriver. Mean maximum and minimum water levels at this station, however, were not significantly different from those reported in 2002-2003 or 2000-2001 (Table 3.3-5). Water levels at the Corps Yard continue to be impacted by changes in river discharge, but to a much lesser degree than stations further upstream.

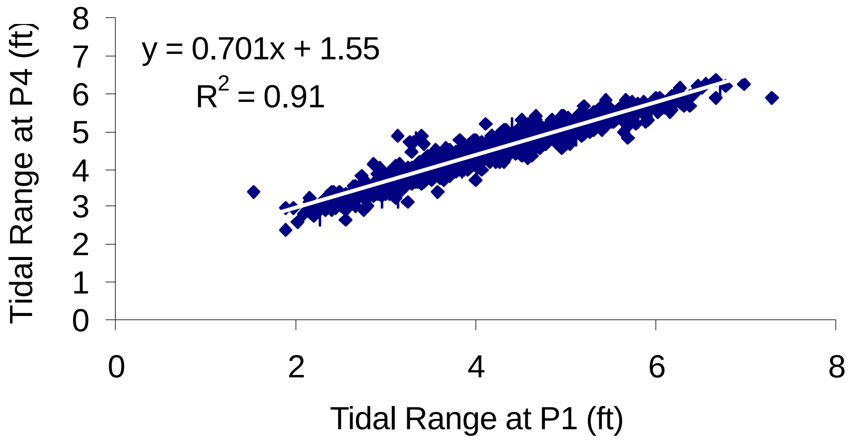


Figure 3.43-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and the Corps Yard station (P4).

3.44 Cape Fear River: Eagle Island (P6), Indian Creek (P7), Dollisons Landing (P8), and Black River (P9)

With the exception of P6, mean tidal ranges computed for mainstem river sites were comparable to or lower than the mean determined for P1. The mean tidal range for P6, however, was comparable to the range reported for P2 (Table 3.3-4). Consistent with previous years, tidal range decreased with distance upriver (Table 3.3-4) with P9 exhibiting the lowest tidal range of these sites. Figures 3.44-1, 3.44-2, 3.44-3, and 3.44-4 illustrate the relationship between tidal range at these Cape Fear River sites and tidal range at Ft. Caswell. In general, tidal range at each upriver site is positively correlated with tidal range at the mouth, however, the degree of correlation decreases upriver. The R^2 values at sites P6, P7, and P8 were much higher for this reporting period compared to the 2002-2003 reporting period when record rainfall and runoff impacted the system. The R^2 value for P9 was comparable to that reported in the previous year's report. During this reporting period, base flow conditions prevailed in the river and there was greater consistency in upriver discharge. Both of these factors are recognized to control water level at these sites. At these stations, the mean tidal ranges measured over this reporting period were significantly higher than those measured during 2002-2003. With the exception of P7, mean tidal ranges at these sites also were significantly different from ranges reported for the first year of monitoring (Figure 3.3-1, Table 3.3-2). Mean tidal range at site P6 was significantly greater than the range reported for year 1, while sites P8 and P9 exhibited mean ranges significantly lower than those reported for year 1. Neither the mean monthly maximum nor minimum water levels for these stations differed significantly from the values reported in 2002-2003 (Table 3.3-2). When compared to year 1 values, however, mean monthly minimum values for all stations were significantly different from year 1 as was the mean maximum value reported for P9. In contrast to the most recent reporting period, comparisons of the regression slopes between years yielded significant differences at all sites with the exception of P8 (Table 3.3-3). For all sites that showed significant differences, slopes were steeper except for P9. When regression slopes for this reporting period were compared to year 1, significant differences existed for all sites with the exception of P8.

The mainstem upriver sites continue to exhibit pronounced time asymmetries as shown in previous reports. The duration of flooding and ebbing tide at these stations has changed little (~2% or less) since the last reporting period (Table 3.3-4). In contrast to the 2001-2002 reporting period, the mean high tide lab from P1 appears to have decreased during this reporting period for these stations. The mean low tide lag appears to have increased at all mainstem stations. These results are not consistent with last year's observations and may reflect a change from the high flow conditions in 2002-2003 to lower flow conditions in 2003-2004.

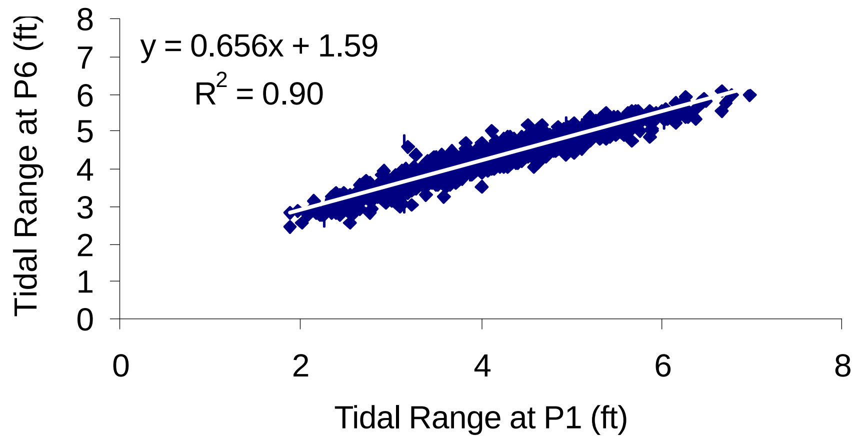


Figure 3.44-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Eagle Island (P6).

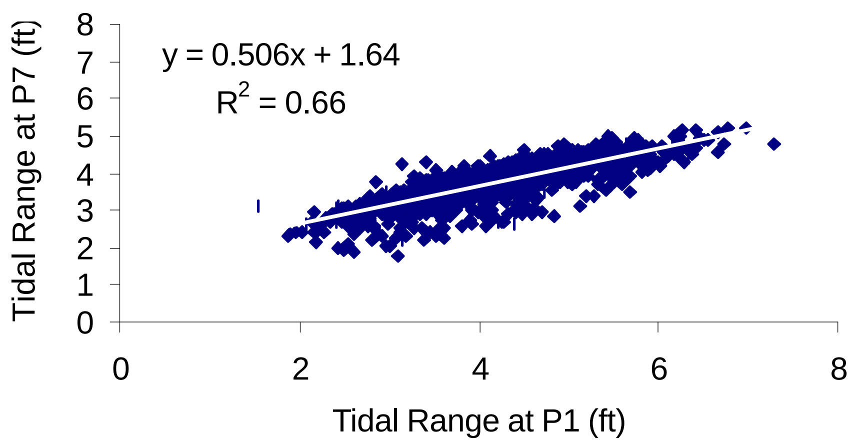


Figure 3.44-2**.** Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Indian Creek (P7).

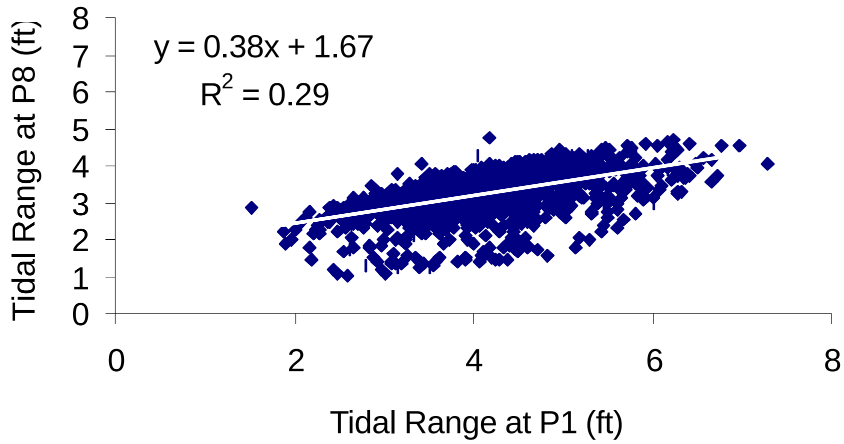


Figure 3.44-3. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Dollisons Landing (P8).

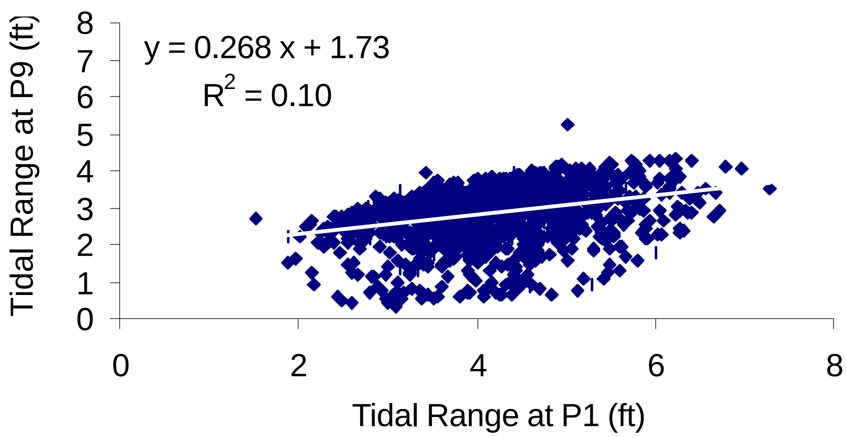


Figure 3.44-4. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Black River (P9).

3.45 Northeast Cape Fear: Smith Creek (P11), Rat Island (P12), Fishing Creek (P13), and Prince George Creek (P14)

With the exception of P14, mean tidal ranges computed for northeast Cape Fear sites over the current reporting period were significantly greater than those reported in 2002-2003 (Figure 3.3-1). These differences again may reflect a transition from high flow conditions, which suppress tidal range during the last reporting period to lower flow conditions during this reporting period. This year's values were also significantly different than the ranges reported in 2000-2001. For the two most upstream stations (Table 3.3-2) ranges were significantly lower, but for the most downstream station the range was significantly greater than Year 1. Mean tidal ranges computed for these stations since June 2003 are lower than the mean determined for P1

(Table 3.3-3) except for station P11. Further, as observed in the mainstem, tidal ranges decrease with distance upriver. Tidal ranges at upstream stations in the Northeast Cape Fear are positively correlated with the tidal range at P1 (Figures 3.45-1, 3.45-2, 3.45-3, and 3.45-4). The mean tidal range at P14 on the Northeast Cape Fear River continues to be less than the mean range measured at P9, 12 mi from convergence on the Cape Fear River. Consistent with previous years, tidal ranges at stations P11 and P12 are more strongly correlated to tidal ranges observed at P1 than the tidal ranges at P13 and P14. Water levels at these upriver stations continue to be impacted strongly by other types of events; especially increased rainfall and upriver discharge. The influence of these types of events is evident by the lower R^2 values for the most upstream stations and higher R^2 values during this reporting period when high flow events were less frequent than in 2002-2003 (Figures 3.5-1 and 3.5-2). Comparisons of the regression slopes between this reporting period and last year yielded no significant differences for sites P12 and P13 (Table 3.3-2). A significantly steeper regression slope occurred at P11, while the slope was lower for site P14. Significant differences in regression slope between this reporting period and 2000-2001 were also detected. No year one data were available for P12 with which to make a similar comparison. With the exception of site P11, the mean monthly minimum water levels for this reporting period were not significantly different than those reported for year 3 (Table 3.3-5). This result is consistent with last year's report where no significant difference in minimum water level was noted between 2002 and 2003 and the previous reporting period. No significant difference in maximum water level was noted between this year and 2002-2003 for these stations. This result differs from last year where significant increases in monthly maximum water level relative to the prior year were observed, but is consistent with comparisons between years 1 and 2.

All of the sites in the Northeast Cape Fear River continue to exhibit time asymmetries. There was very little difference in either flood or ebb duration compared to last reporting period (Table 3.3-4). As observed for the mainstem, flood durations appear to have decreased minimally while ebb durations have slightly increased. Similarly, there was very little change between the mean high and low tide lags observed during this reporting period and those reported for 2002-2003. This observation is consistent with last year's report.

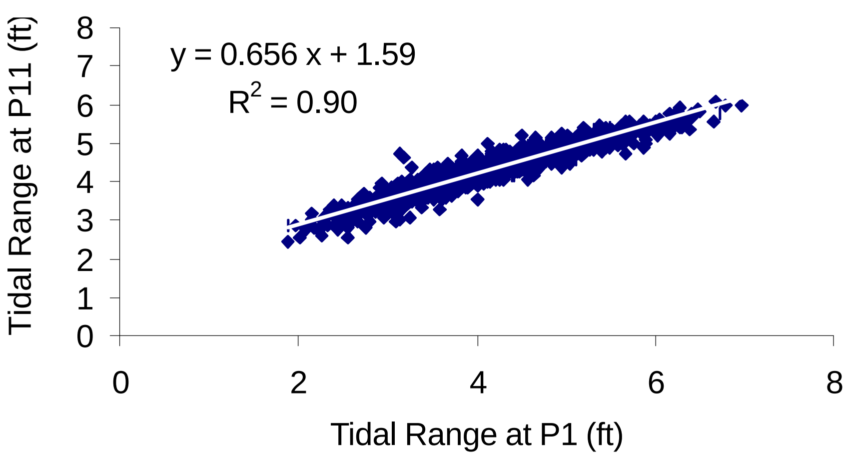


Figure 3.45-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Smith Creek (P11).

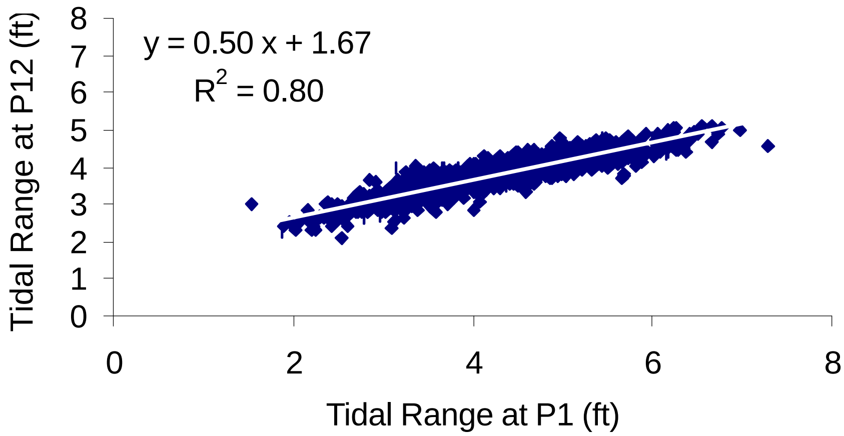


Figure 3.45-2. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Rat Island (P12).

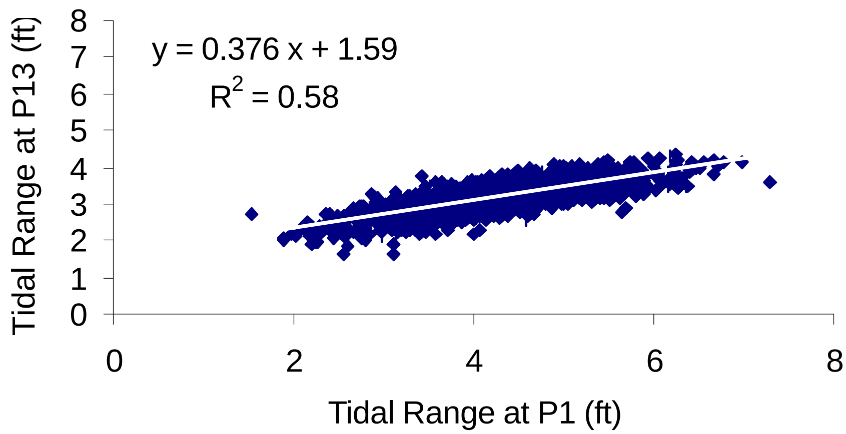


Figure 3.45-3. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Fishing Creek (P13).

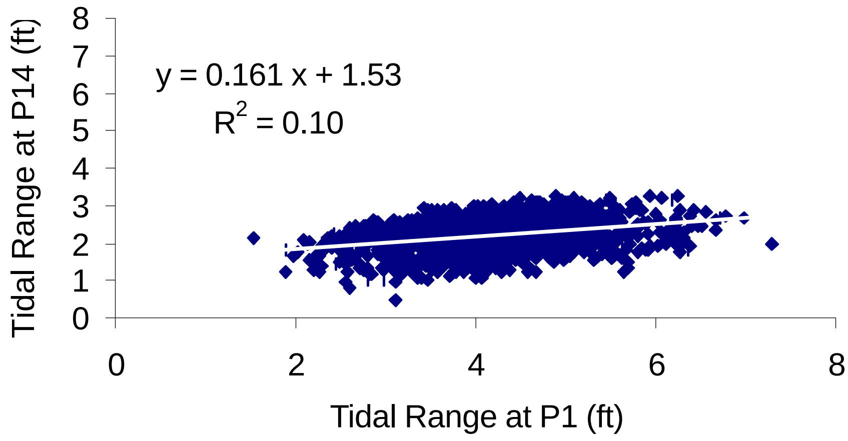


Figure 3.45-4. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Prince George Creek (P14).

3.5 Influence of Upstream Flow

Periods of lower, drought-induced water levels and extreme flooding in the system over the last 3 years have contributed to differing tidal conditions in the Cape Fear and Northeast Cape Fear Rivers between monitoring years. These effects are confounded by the shortened data set for Year 1 which included data collected from October to June, only, and covered a period when monthly river discharge was below the long-term average (~5531 ft^3/s) reported by the USGS at Lock and Dam 1 on the Cape Fear mainstem (Figure 3.5-1). The higher tidal ranges observed for P1 for the first two monitoring periods may reflect these lower than average flows in the river, which have a tendency to produce higher tidal ranges. In contrast, the above average discharges recorded during monitoring years 3 and 4, may explain the lower mean tidal ranges observed at P1 and other stations during those years. The year 4 discharge data include fewer high flow events and more closely approximate mean conditions for the river (Figure 3.5-2). These data may help account for the high R^2 values reported this year. The discharge data do not, however, fully account for the significant differences in regression slope that existed between this year and previous reporting period for most stations. As indicated in last year's report, additional analyses should be undertaken to account for or correct for the effects of streamflow. One possibility is to filter the data to remove scatter associated with periods of high discharge (see last years report). However, given the limited "pre-dredging" data for year 1, a second possibility is to group data not by monitoring year, but by dredging project milestones. In this way, the effects of specific tasks associated with the dredging project on tidal range might be more clearly discerned.

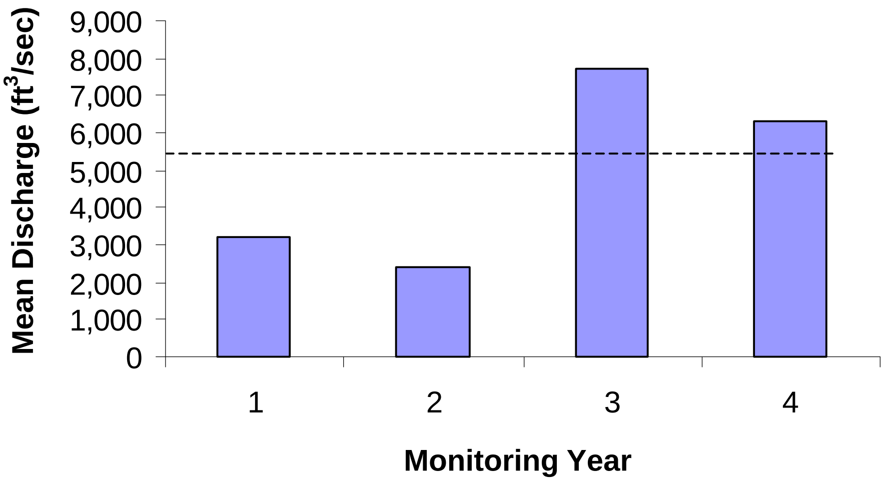


Figure 3.5-1. Mean discharge for each monitoring period. Monitoring year 1 is October 2000 to May 2001; monitoring year 2 in June 2001 to May 2002; monitoring year 3 is June 2002 to May 2003; and monitoring year 4 is June 2003 to May 2004.

Streamflow on the Cape Fear River at Lock 1 for the 2003-2004 Reporting Period

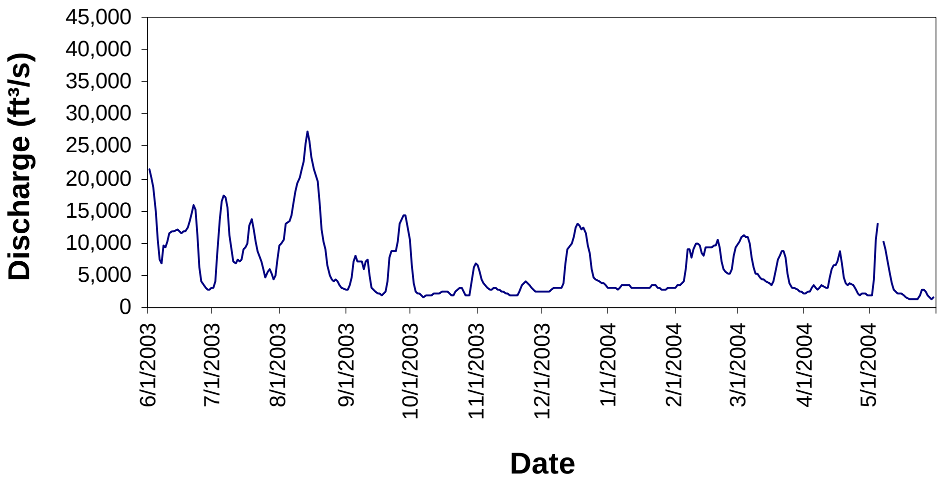


Figure 3.5-2. Plot showing discharge in the Cape Fear River at Lock 1 for the current monitoring period. Data available at http://nwis.waterdata.usgs.gov/nc/nwis site number 02105769.

4.0 MARSH/SWAMP FLOOD AND SALINITY LEVELS

4.1 Summary

Water levels and conductivity (salinity) within marshes and swamps adjacent to stations were collected on time during two-week intervals in fall and spring with few missing data. Most subsites within stations flooded regularly in the period of the study, which represented a more normal 12-month period than previous years. During fall, saline water was largely confined to estuarine stations or those at the lower reaches of the rivers. There were some differences noted between fall and spring with respect to salinity when saline water reached upstream in the Northeast Cape Fear River, but did not in the mainstem Cape Fear River.

4.2 Data Base

Despite high water levels fall 2003 and concern over Hurricane Isabel, few problems were encountered with respect to water level data. Bear "vandalism" occurred again at Black River (P9) at the beginning of deployment requiring additional time at that site. One instrument was destroyed at that time and two others damaged. No water level instruments were lost to excessive flooding during either season of collecting resulting in a 100% complete data set (Tables 4.2-1 and 4.2-2).

Conductivity instruments also functioned perfectly during both seasons and minor malfunctions did not lead to any data loss (Tables 4.2-3 and 4.2-4). The only exception was the loss of conductivity data at P9 because of the aforementioned bear attack. Fortunately, this was a period of fresh water and no saline water was found below this station.

Table 4.2-1. Flooding frequency, duration and depth, and actual water level of marsh/swamp substations during fall 2003. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P3	1	Fall 03	9/25/03	10/9/03	26/27	8.0	2.4	0.66	1.7
	2	Fall 03	9/25/03	10/9/03	26/27	7.5	2.4	0.83	1.6
	3	Fall 03	9/25/03	10/9/03	26/27	7.9	2.4	0.52	1.9
	4	Fall 03	9/25/03	10/9/03	26/27	7.7	2.5	1.49	1.0
	5	Fall 03	9/25/03	10/9/03	27/27	5.7	2.4	0.99	1.4
	6	Fall 03	9/25/03	10/9/03	23/27	5.6	4.4	3.31	1.1
P6	1	Fall 03	10/8/03	10/22/03	27/27	7.9	3.1	0.76	2.3
	2	Fall 03	10/8/03	10/22/03	26/27	5.2	3.0	1.56	1.4
	3	Fall 03	10/8/03	10/22/03	27/27	6.4	3.2	0.85	2.4
	4	Fall 03	10/8/03	10/22/03	23/27	6.2	3.1	1.13	2.0
	5	Fall 03	10/8/03	10/22/03	23/27	4.9	3.3	1.92	1.4
	6	Fall 03	10/8/03	10/22/03	19/27	4.4	3.0	1.74	1.3

Table 4.2-1. concluded

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P7	1	Fall 03	10/23/03	11/6/03	26/27	5.2	3.4	1.76	1.6
	2	Fall 03	10/23/03	11/6/03	21/27	4.4	3.5	2.23	1.3
	3	Fall 03	10/23/03	11/6/03	19/27	4.0	3.4	2.26	1.1
	4	Fall 03	10/23/03	11/6/03	17/27	4.2	3.5	2.43	1.1
	5	Fall 03	10/23/03	11/6/03	15/27	4.6	3.3	2.31	1.0
	6	Fall 03	10/23/03	11/6/03	13/27	5.0	3.4	2.37	1.0
P8	1	Fall 03	10/31/03	11/14/03	20/27	5.3	3.2	2.14	1.1
	2	Fall 03	10/31/03	11/14/03	25/27	5.7	3.2	1.54	1.7
	3	Fall 03	10/31/03	11/14/03	25/27	5.9	3.4	1.46	1.9
	4	Fall 03	10/31/03	11/14/03	20/27	5.3	3.1	1.98	1.1
	5	Fall 03	10/31/03	11/14/03	16/27	5.0	3.1	2.24	0.9
	6	Fall 03	10/31/03	11/14/03	11/27	5.6	3.0	2.38	0.0
P9	1	Fall 03	10/16/03	10/30/03	26/27	8.2	3.3	0.58	2.7
	2	Fall 03	10/16/03	10/30/03	27/27	5.8	3.2	2.21	1.0
	3	Fall 03	10/16/03	10/30/03	6/27	3.8	2.9	1.22	1.7
	4	Fall 03	10/16/03	10/30/03	4/27	4.8	3.2	2.06	1.1
	5	Fall 03	10/16/03	10/30/03	5/27	4.4	3.1	2.20	0.9
	6	Fall 03	10/16/03	10/30/03	12/27	4.8	3.0	1.92	1.1
P11	1	Fall 03	9/24/03	10/8/03	27/27	5.9	3.9	1.44	2.5
	2	Fall 03	9/24/03	10/8/03	27/27	5.3	4.0	1.82	2.2
	3	Fall 03	9/24/03	10/8/03	27/27	5.4	3.9	1.76	2.1
	4	Fall 03	9/24/03	10/8/03	26/27	5.5	3.9	1.85	2.1
	5	Fall 03	9/24/03	10/8/03	27/27	5.1	3.9	1.91	2.0
	6	Fall 03	9/24/03	10/8/03	21/27	5.2	3.9	2.04	1.9
P12	1	Fall 03	11/10/03	11/24/03	23/27	5.6	3.0	0.90	2.1
	2	Fall 03	11/10/03	11/24/03	13/27	5.5	3.0	1.62	1.4
	3	Fall 03	11/10/03	11/24/03	13/27	4.7	3.0	2.00	1.0
	4	Fall 03	11/10/03	11/24/03	12/27	6.9	3.0	1.90	1.1
	5	Fall 03	11/10/03	11/24/03	10/27	5.8	3.0	2.08	0.9
	6	Fall 03	11/10/03	11/24/03	5/27	7.6	2.9	2.44	0.5
P13	1	Fall 03	12/4/03	12/18/03	25/27	6.4	2.5	1.43	1.1
	2	Fall 03	12/4/03	12/18/03	26/27	5.9	2.5	1.08	1.4
	3	Fall 03	12/4/03	12/18/03	26/27	7.0	2.6	0.75	1.9
	4	Fall 03	12/4/03	12/18/03	26/27	7.3	3.1	1.00	2.1
	5	Fall 03	12/4/03	12/18/03	26/27	5.7	2.4	1.21	1.2
	6	Fall 03	12/4/03	12/18/03	13/27	4.6	2.4	1.64	0.8
P14	1	Fall 03	12/1/03	12/15/03	27/27	7.6	2.6	0.70	1.9
	2	Fall 03	12/1/03	12/15/03	25/27	6.7	2.1	0.87	1.2
	3	Fall 03	12/1/03	12/15/03	24/27	6.6	2.4	1.08	1.3
	4	Fall 03	12/1/03	12/15/03	22/27	6.1	2.3	1.22	1.1
	5	Fall 03	12/1/03	12/15/03	20/27	5.7	2.4	1.28	1.1
	6	Fall 03	12/1/03	12/15/03	16/27	6.2	2.7	1.49	1.2

Table 4.2-2. Flooding frequency, duration and depth, and actual water level of marsh/swamp substations during spring 2004. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P3	1	Spr 04	4/19/04	5/3/04	17/27	5.9	1.7	0.66	1.0
	2	Spr 04	4/19/04	5/3/04	17/27	5.5	1.7	0.83	0.9
	3	Spr 04	4/19/04	5/3/04	20/27	5.8	1.8	0.52	1.3
	4	Spr 04	4/19/04	5/3/04	18/27	4.9	1.7	1.49	0.2
	5	Spr 04	4/19/04	5/3/04	7/27	5.7	1.7	0.99	0.7
	6	Spr 04	4/19/04	5/3/04	9/27	6.5	3.8	3.31	0.5
P6	1	Spr 04	4/21/04	5/5/04	25/26	5.4	3.2	0.76	2.4
	2	Spr 04	4/21/04	5/5/04	16/26	6.0	3.2	1.56	1.6
	3	Spr 04	4/21/04	5/5/04	25/26	5.1	3.2	0.85	2.4
	4	Spr 04	4/21/04	5/5/04	16/26	4.9	3.2	1.13	2.1
	5	Spr 04	4/21/04	5/5/04	13/26	4.6	3.4	1.92	1.5
	6	Spr 04	4/21/04	5/5/04	9/26	4.9	3.0	1.74	1.3
P7	1	Spr 04	5/5/04	5/19/04	24/27	5.1	3.3	1.76	1.6
	2	Spr 04	5/5/04	5/19/04	9/27	5.6	3.5	2.23	1.3
	3	Spr 04	5/5/04	5/19/04	11/27	5.7	3.4	2.26	1.1
	4	Spr 04	5/5/04	5/19/04	8/27	4.9	3.4	2.43	1.0
	5	Spr 04	5/5/04	5/19/04	13/27	5.3	3.1	2.31	0.8
	6	Spr 04	5/5/04	5/19/04	14/27	4.5	3.4	2.37	1.0
P8	1	Spr 04	4/7/04	4/21/04	15/27	3.6	2.8	2.14	0.7
	2	Spr 04	4/7/04	4/21/04	24/27	4.4	2.9	1.54	1.4
	3	Spr 04	4/7/04	4/21/04	25/27	5.0	2.9	1.46	1.4
	4	Spr 04	4/7/04	4/21/04	22/27	4.9	2.9	1.98	0.9
	5	Spr 04	4/7/04	4/21/04	18/27	5.0	2.5	2.24	0.3
	6	Spr 04	4/7/04	4/21/04	6/27	5.1	2.7	2.38	0.0
P9	1	Spr 04	3/24/04	4/7/04	26/26	6.7	2.7	0.58	2.1
	2	Spr 04	3/24/04	4/7/04	18/26	5.1	2.5	2.21	0.3
	3	Spr 04	3/24/04	4/7/04	10/26	4.6	2.6	1.22	1.4
	4	Spr 04	3/24/04	4/7/04	4/26	5.4	2.5	2.06	0.4
	5	Spr 04	3/24/04	4/7/04	4/26	5.9	2.5	2.20	0.3
	6	Spr 04	3/24/04	4/7/04	2/26	4.2	2.5	1.92	0.6
P11	1	Spr 04	3/16/04	3/29/04	18/25	5.3	2.8	1.44	1.4
	2	Spr 04	3/16/04	3/29/04	11/25	4.9	2.8	1.82	1.0
	3	Spr 04	3/16/04	3/29/04	15/25	5.2	2.7	1.76	0.9
	4	Spr 04	3/16/04	3/29/04	10/25	5.9	2.7	1.85	0.9
	5	Spr 04	3/16/04	3/29/04	13/25	5.2	2.6	1.91	0.7
	6	Spr 04	3/16/04	3/29/04	9/25	6.0	2.8	2.04	0.8

Table 4.2-2. concluded

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P12	1	Spr 04	3/29/04	4/12/04	26/27	6.5	2.5	0.90	1.6
	2	Spr 04	3/29/04	4/12/04	20/27	6.1	2.5	1.62	0.9
	3	Spr 04	3/29/04	4/12/04	19/27	5.9	2.4	2.00	0.4
	4	Spr 04	3/29/04	4/12/04	16/27	5.2	2.4	1.90	0.5
	5	Spr 04	3/29/04	4/12/04	17/27	5.1	2.3	2.08	0.2
	6	Spr 04	3/29/04	4/12/04	5/27	6.8	2.4	2.44	0.0
P13	1	Spr 04	3/3/04	3/17/04	25/26	7.3	2.1	1.43	0.7
	2	Spr 04	3/3/04	3/17/04	23/26	5.2	2.1	1.08	1.0
	3	Spr 04	3/3/04	3/17/04	26/26	6.1	2.3	0.75	1.6
	4	Spr 04	3/3/04	3/17/04	25/26	6.9	3.0	1.00	2.0
	5	Spr 04	3/3/04	3/17/04	25/26	5.7	2.1	1.21	0.9
	6	Spr 04	3/3/04	3/17/04	10/26	4.4	2.1	1.64	0.5
P14	1	Spr 04	3/1/04	3/15/04	26/27	8.6	2.1	0.70	1.4
	2	Spr 04	3/1/04	3/15/04	26/27	6.1	2.0	0.87	1.1
	3	Spr 04	3/1/04	3/15/04	25/27	6.8	2.0	1.08	0.9
	4	Spr 04	3/1/04	3/15/04	22/27	6.6	1.9	1.22	0.7
	5	Spr 04	3/1/04	3/15/04	21/27	5.4	1.9	1.28	0.6
	6	Spr 04	3/1/04	3/15/04	13/27	5.6	1.9	1.49	0.4

4.3 Marsh/Swamp Flooding

Most subsites flooded with every tide (Tables 4.2-2 and 4.2-2) in patterns similar to previous years of this study (Hackney et al. 2002a, 2002b, 2003) generally reflecting the interaction of tidal height relative to NAVD88 with the elevation of the subsite. Differences among years are discussed in Section 9 of this report. Note that June 2003-May 2004 were a more normal year with respect to upstream discharge (Figures 3.5-1 and 3.5-2) than previous years where drought and high discharge during fall and spring marsh/swamp study periods affected flood levels. These patterns are discussed in Section 9.

4.4 Water Salinity in Marshes and Swamps

During fall's study saline water reached wetlands only within the estuarine stations of P3, P6, and P11 (Table 4.2-3). Subsite 1 at Rat Island (P12) was the only other subsite to receive saline water (Table 4.2-3). This pattern contrasts significantly from the previous year (Hackney et al. 2003) when saline water reached the uppermost station in the Northeast Cape Fear and further upstream in the main stem Cape Fear as well. Salinities were also lower this reporting year. The highest salinity recorded fall 2003 was 9 ppt, far less than the 21ppt and 18ppt recorded in wetlands at P3 and P18, in the upper reaches of Town Creek and the Northeast Cape Fear River, respectively, during fall 2002 (Hackney et al. 2003). Fall 2003 continued the trend observed spring that year when saline water almost never flooded any subsites (Hackney et al. 2003).

In spring 2004, an interesting dichotomy developed when the main stem of the Cape Fear River was fresh during the collecting period, while the Northeast Cape Fear River subsites were more saline. This reflects increased fresh water flow through lock and dam #1 and reduced rainfall in the drainage supporting the Northeast Cape Fear River (Table 4.2-4). Note that the Town Creek drainage received heavy runoff during the two-week collection period, while saline water, as concentrated as 1/3 seawater, reached into subsites at Rat Island (P12), penetrating far into the interior wetlands at this site.

Table 4.2-3. Summary of salinity data from nine substations collected along the Cape Fear River and its tributaries in fall 2003.

Station Number	Station Name	Substation Number	Fall 2003 Salinity Range (ppt)	Proportion of flood events containing >1 ppt salinity
P3	Town Creek	1	<1-8	26/27
		2	<1-3	27/27
		3	<1-7	26/27
		4	<1-6	25/27
		5	<1-6	25/27
		6	<1-6	23/27
P6	Eagle Island	1	<1-9	20/27
		2	<1-8	19/27
		3	<1-7	10/27
		4	<1-6	7/27
		5	<1-2	3/27
		6	<1-2	1/27
P7	Indian Creek	1	<1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P8	Dollisons Landing	1	<1	0/26
		2	<1	0/26
		3	<1	0/26
		4	<1	0/26
		5	<1	0/26
		6	<1	0/26
P9	Black River	1	<1	0/29
		2	<1	0/29
		3	<1	0/29
		4	<1	0/29
		5	<1	0/29
		6	ND	ND

Table 4.2-3. concluded

Station Number	Station Name	Substation Number	Fall 2003 Salinity Range (ppt)	Proportion of flood events containing >1 ppt salinity
P11	Smith Creek	1	<1-6	20/27
		2	<1-6	20/27
		3	<1-5	21/27
		4	<1-5	21/27
		5	<1-4	18/27
		6	<1-5	20/27
P12	Rat Island	1	<1-3	7/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P13	Fishing Creek	1	<1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P14	Prince George	1	<1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27

Table 4.2-4. Summary of salinity data from nine substations collected along the Cape Fear River and its tributaries in spring 2004.

Station Number	Station Name	Substation Number	Spring 2004 Salinity Range (ppt)	Proportion of flood events containing >1 ppt salinity
P3	Town Creek	1	<1-1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1-1	1/27
		5	<1	0/27
		6	<1	0/27
P6	Eagle Island	1	<1-6	10/26
		2	<1-5	5/26
		3	<1-3	5/26
		4	<1-2	2/26
		5	<1-5	5/26
		6	<1	0/26

Station Number | Station Name | Substation Number | Spring 2004 Salinity Range (ppt) | Proportion of flood events containing >1 ppt salinity

Table 4.2-4. concluded

P7	Indian Creek	1	<1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P8	Dollisons Landing	1	<1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P9	Black River	1	<1	0/26
		2	<1	0/26
		3	<1	0/26
		4	<1	0/26
		5	<1	0/26
		6	<1	0/26
P11	Smith Creek	1	<1-3	8/25
		2	<1-3	8/25
		3	<1-3	10/25
		4	<1-3	9/25
		5	<1-2	6/25
		6	<1-1	3/25
P12	Rat Island	1	<1-11	26/27
		2	<1-7	19/27
		3	<1-5	11/27
		4	<1-3	6/27
		5	<1-3	4/27
		6	<1	0/27
P13	Fishing Creek	1	<1	0/26
		2	<1	0/26
		3	<1	0/26
		4	<1	0/26
		5	<1	0/26
		6	<1	0/26
P14	Prince George	1	<1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27

5.0 MARSH/SWAMP BIOGEOCHEMISTRY

5.1 Summary

The data presented in the current report includes the winter of 2004 and the summer of 2003. The microbial modes of organic matter remineralization of the study sites range from sulfate reducing to methanogenic. Analysis of porewater chloride, sulfate, and methane was performed at six substations per station and at 6 sub-depths per substation. Samples were collected during the winter and summer at eight sites and monthly at P6 (Eagle Island). These data were used to classify the geochemical setting of each substation at each station as methanogenic (M), sulfate reducing (SR), methanogenic with evidence of past sulfate reduction (MPSR), and sulfate reducing with a non-seawater source of sulfate (SRNS). The classifications were compared to the previous data for these sites. Understanding the current and past geochemical conditions examined during the past 4 ½ years will be necessary to separate potential change caused by the dredging and deepening of the Cape Fear River from natural fluctuations.

Station P6's (Eagle Island) geochemistry was analyzed monthly and displayed a steady decrease in salinity from June of 2002 until June of 2003. The salinity slightly rebounded during the current winter (2004) however it was still lower than previous years. This monthly pattern of salinity variation was in contrast to the previous two years where peaks in salinity were observed during November and May (Hackney et al. 2002a; 2002b; 2003). Because of the lack of a salinity pulse during these times, several locations within Eagle Island converted to M geochemical classifications for the first time. This was particularly true during the spring and early summer of 2003. The majority of Eagle Island classifications during the current study are now MPSR classifications in contrast to previous years where more SR classifications were observed.

The remaining eight stations were sampled twice each year, during summer and winter. The patterns of variations for the current year and previous years follow.

Low salinity conditions characterized the current project year summer 2003 and winter 2004. In general, all sites experienced conditions that would be considered low salinity compared to previous winters and summers. Several sites had conditions that were the lowest in salinity since the project started. For the most seaward station, Town Creek, both the winter and summer were the freshest on record. The Cape Fear River sites (Indian Creek, Dollisons Landing, and Black River) had a relatively low salinity winter and a summer that was the freshest observed during this project. While all Northeast Cape Fear River sites had relatively fresher conditions during the current year, there was more variability in the extent to which they experienced low salinities. Fishing Creek had the freshest winter and summer on record, Prince George had the freshest winter on record, and Rat Island had the freshest summer on record. Smith Creek had fresh conditions during both the summer and winter, but not the freshest on record.

5.2 Geochemical Theory and Classification

Porewater sampling of the metabolic products of sulfate reducing and methanogenic bacteria help establish the frequency and duration of organic soil inundation by tidal water carrying ocean-derived salt versus inundation by fresh water. Changes in flooding frequency have a more significant impact if salts from seawater enter the pore space of wetland sediments. In the presence of sufficient seawater sulfate, organic matter is remineralized via sulfate reducing bacteria in anaerobic environments generating hydrogen sulfide. In freshwater environments, organic matter is usually remineralized via methanogens that generate methane as a byproduct. In the presence of high levels of sulfate from seawater, sulfate reducers out compete methanogens and methanogenesis is inhibited. Hydrogen sulfide is toxic and limits both plants and animal species that do not have a behavioral or physiological mechanism to tolerate this bacterial metabolite. Thus, a shift in remineralization pathway can lead to different communities of plants and animals.

Chloride concentrations are a direct measure of salinity as it occurs in a constant proportion in seawater and has no substantial sinks or sources in wetland sediments. Therefore, the term salinity used in the biogeochemistry section of this report will refer to salinity based on measured chloride concentrations.

Chloride and sulfate concentrations are in a constant ratio in seawater (approximately 20:1). Unlike sulfate, which can decrease due to sulfate reduction, there are no common removal mechanisms (biotic or abiotic) for chloride from seawater. Therefore, chloride concentrations can be used as an indicator of the amount of sulfate originally supplied to a site by seawater. Changes in the ratio of chloride to sulfate are an indicator of sulfate reduction. In the presence of sulfate reduction, methanogenic bacteria are out competed and methane production is inhibited. Therefore, low concentrations of methane are another indicator of sulfate reduction. When sulfate concentrations decrease sufficiently, sulfate-reducing bacteria are no longer able to function and methane production dominates. Thus, a sulfate reducing threshold concentration can be identified in sulfate concentration versus depth profiles, where sulfate concentrations no longer decrease with increasing depth and methane concentrations increase. Data from including all nine marsh/swamp stations from previous reports place the level where the shift occurs at approximately 300 µM sulfate. This corresponds to sulfate being supplied by salinities of approximately 0.4 parts per thousand.

Using this sulfate reducing threshold (300 µM sulfate), stations and substations were classified as sulfate reducing or methanogenic. Methanogenic substations that had a chloride to sulfate ratio significantly greater than seawater (>30:1) were classified as methanogenic sites with evidence of past sulfate reduction. Sulfate reducing sites with ratios less than seawater (5:1) were classified as sulfate reducing with a non-seawater source of sulfate. The four main classifications are: 1) sulfate reducing (SR), 2) methanogenic (M), 3) methanogenic with evidence of past sulfate reduction (MPSR) and sulfate reducing with a non-seawater source of sulfate (SRNS). Changes in these classifications will be used to determine changes in biogeochemical setting associated with river dredging, drought, or other factors.

5.3 Geochemical Methodology

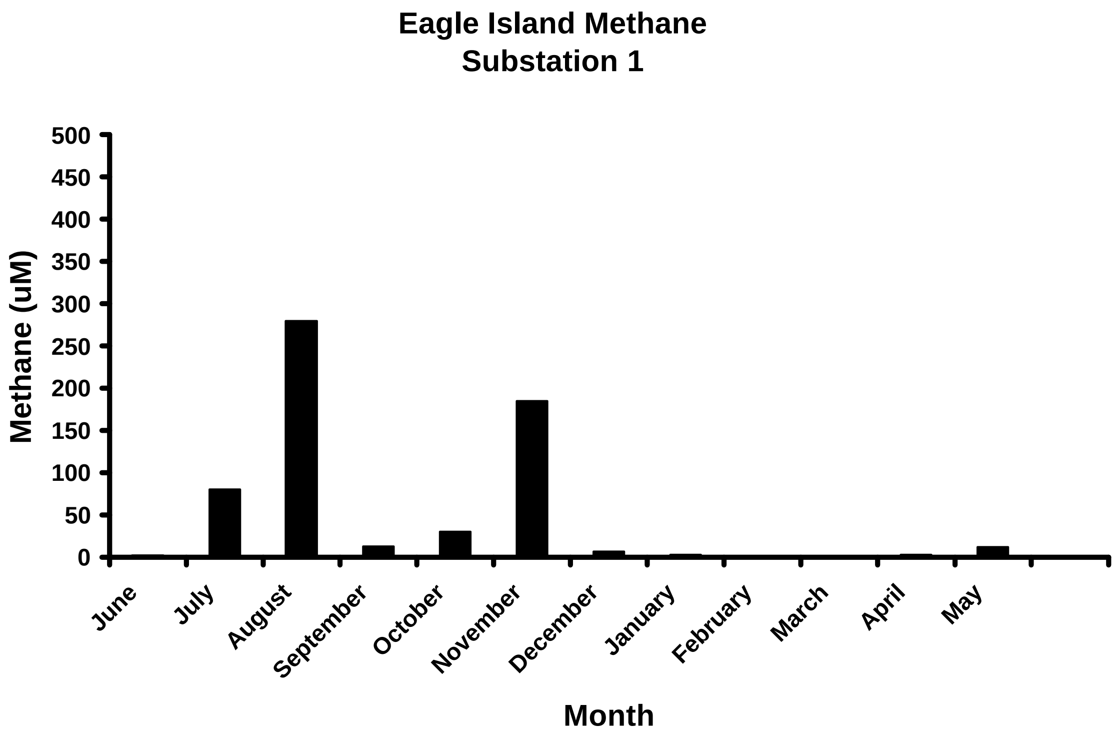
Biogeochemical monitoring was established in close proximity to shallow water well/conductivity/temperature substations. Six substations are distributed along the length of each of nine monitoring belt transects with number one near the river or channel and number 6 adjacent to uplands. Substations are roughly perpendicular to the segment of the stream along which they have been established. Sampling devices, peepers, are constructed of thick acrylic with wells (1-cm deep grooves) located at six different depths that sample 1, 6, 11, 16, 21, and 26 cm below the soil surface. Semipermeable membranes allow methane, sulfate, and chlorine to equilibrate with distilled water in wells. Peepers are inserted into the substrate and left for 1 week, which is ample time for equilibration. Peepers have been shown to be reliable collection devices for these types of dissolved substances (Hesslein 1976). The concentrations of all parameters are determined after removing samples from peeper cells with a syringe equipped with a needle. Sulfate and chloride concentrations are stable under oxic conditions and can be stored in serum vials until analysis. Sulfate and chloride concentrations are determined with an ion chromatograph (Hoehler et al. 1994). Salinity is calculated from the chloride concentrations of the equilibrated peeper chamber water based on the constant ratio of chloride to total dissolved salts in seawater. Samples for porewater methane analysis are prepared by extraction of porewater methane into an inert helium headspace within a gas-tight syringe. The headspace gas is then injected into a gas chromatograph equipped with a flame ionization detector (Kelley et al. 1995) for quantitative determination of methane concentration.

Porewater is collected and analyzed at all 54 substations in all nine transect stations during mid-summer and mid-winter, the coldest and warmest parts of the year. This provides data during periods of maximum and minimum bacterial metabolism. In addition, porewater is collected from the Eagle Island station (P6) every month using the same procedures. This station represents a transition between saline and fresh-dominated stations. In addition, the six substations represent a transition from well-flooded to less flooded.

5.4 Eagle Island (P6) Annual Cycles of Sulfate, Chloride, and Methane

Prior to spring of 2003, Eagle Island had been classified primarily as SR and MPSR classification because both methanogenesis and sulfate reduction occur at this station (Hackney et al. 2002a; 2002b; 2003). The occurrence of methanogenic, geochemical classifications increased during the spring of 2003 and continued to increase through the winter of 2004. Eagle Island’s general classifications are based on the following observations: 1) Methane is present at depth in all substations, but is often at very low concentrations at the surface during times of high sulfate input (Figures 5.4-1); 2) Sulfate concentrations range from below the sulfate reducing threshold of 300 µM indicating methane production, to as high as 6000 µM indicating sufficient sulfate to drive sulfate reduction (Figure 5.4-2). The ratios of sulfate to chloride range from those found in seawater to ratios indicating a depletion of sulfate due to sulfate reduction (Figure 5.4-3).

Salinity input to Eagle Island varies during the year. Generally the salinity is higher during summer months when the flow rate of the river is lower, however, a massive input of salt was observed during November of 2000 and 2001 and May of 2001 and 2002 (Hackney et al. 2002b). These events overshadowed seasonal trends and dominated geochemical conditions



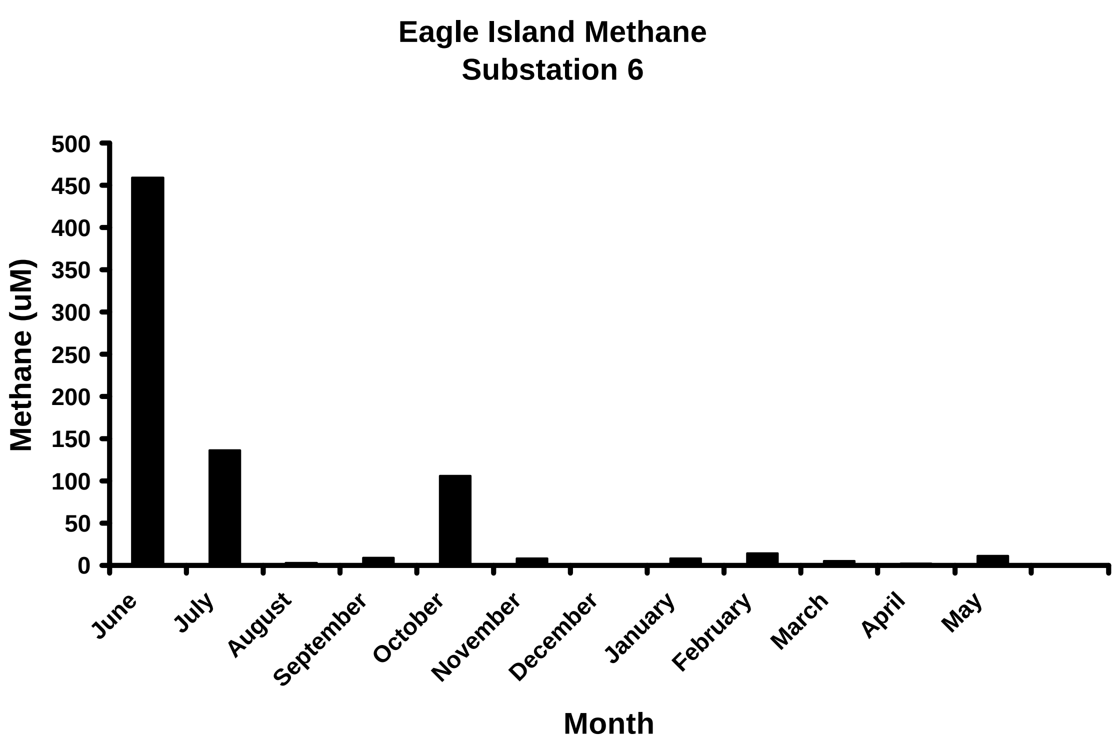
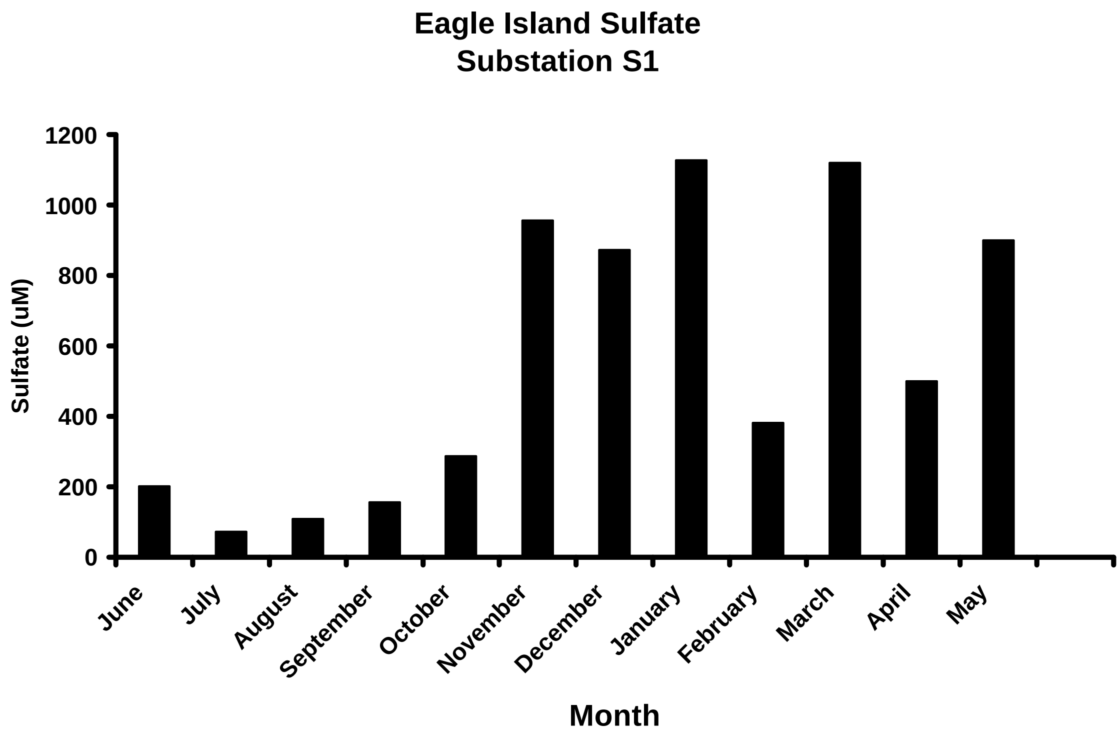


Figure 5.4-1. Methane concentrations of Eagle Island porewaters vs. month. Top shows nearshore site (S1) and bottom shows most upland site (S6).



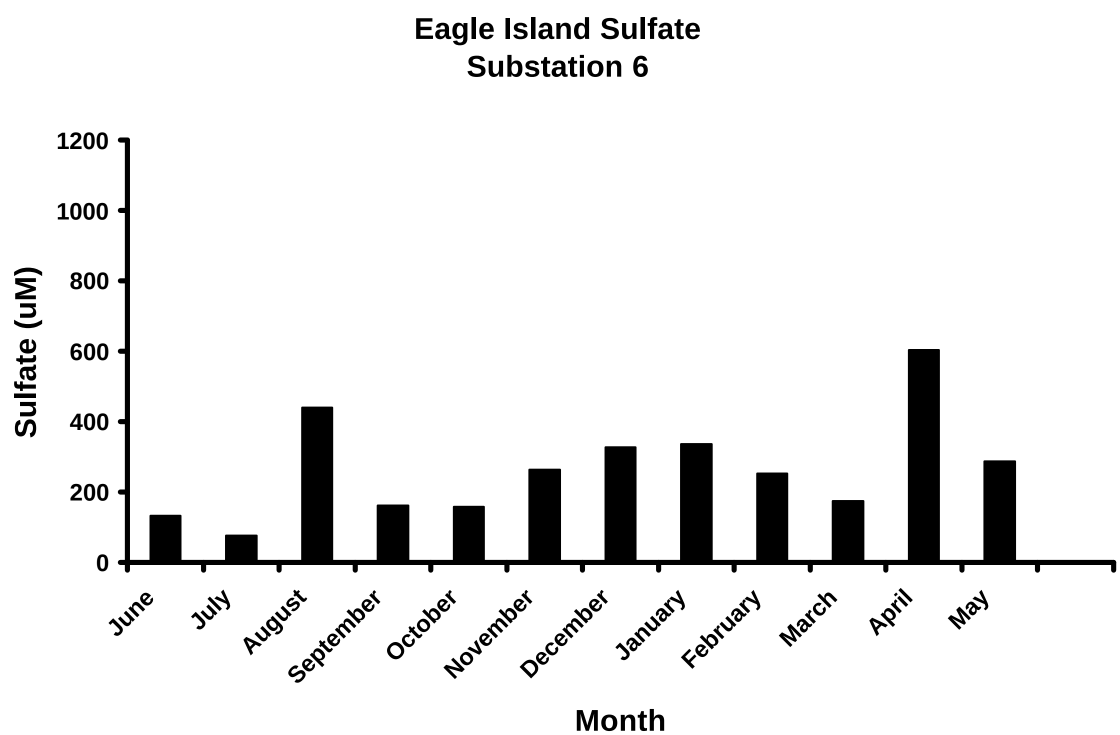
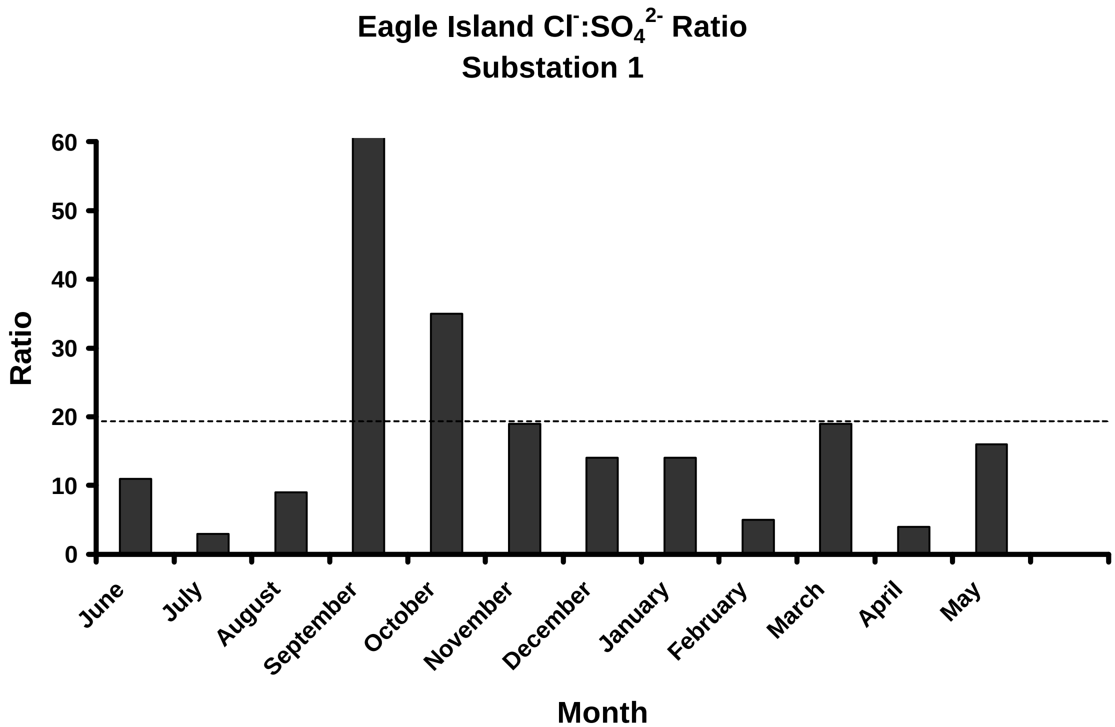


Figure 5.4-2. Sulfate concentrations of Eagle Island porewaters vs. month. Top shows nearshore site (S1) and bottom shows most upland site (S6).



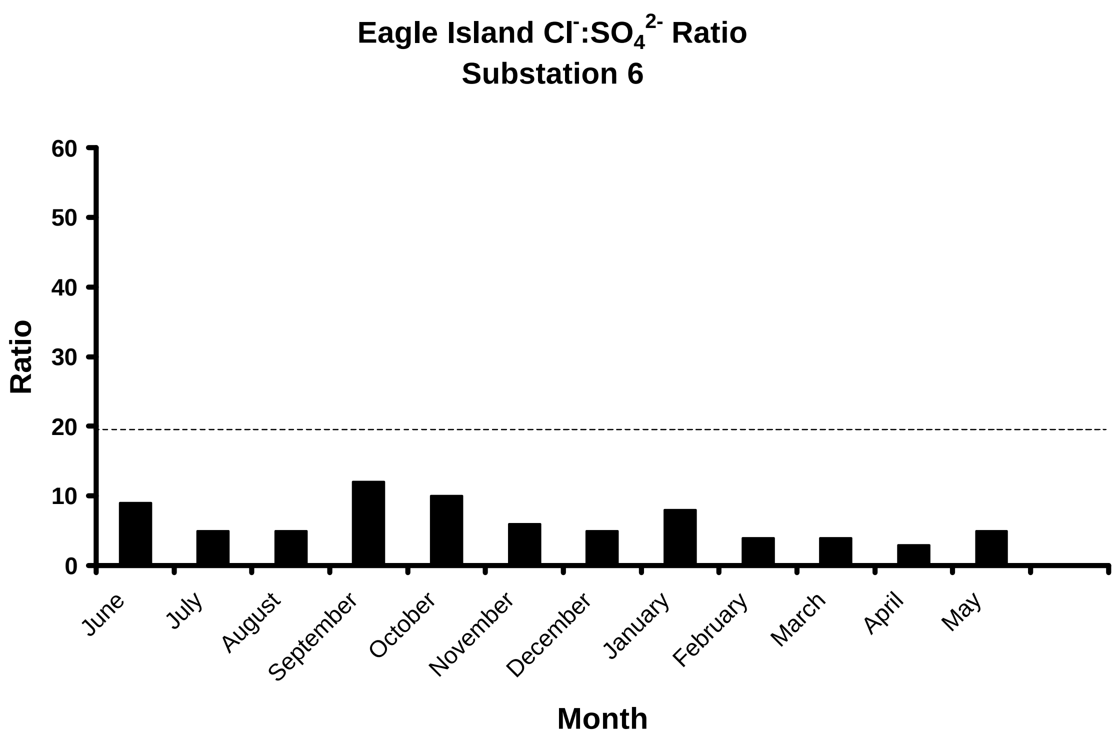


Figure 5.4-3. Chloride to sulfate ratios of Eagle Island porewaters vs. month. Dashed line shows ratio for seawater. Top shows nearshore site (S1) and bottom shows most upland site (S6).

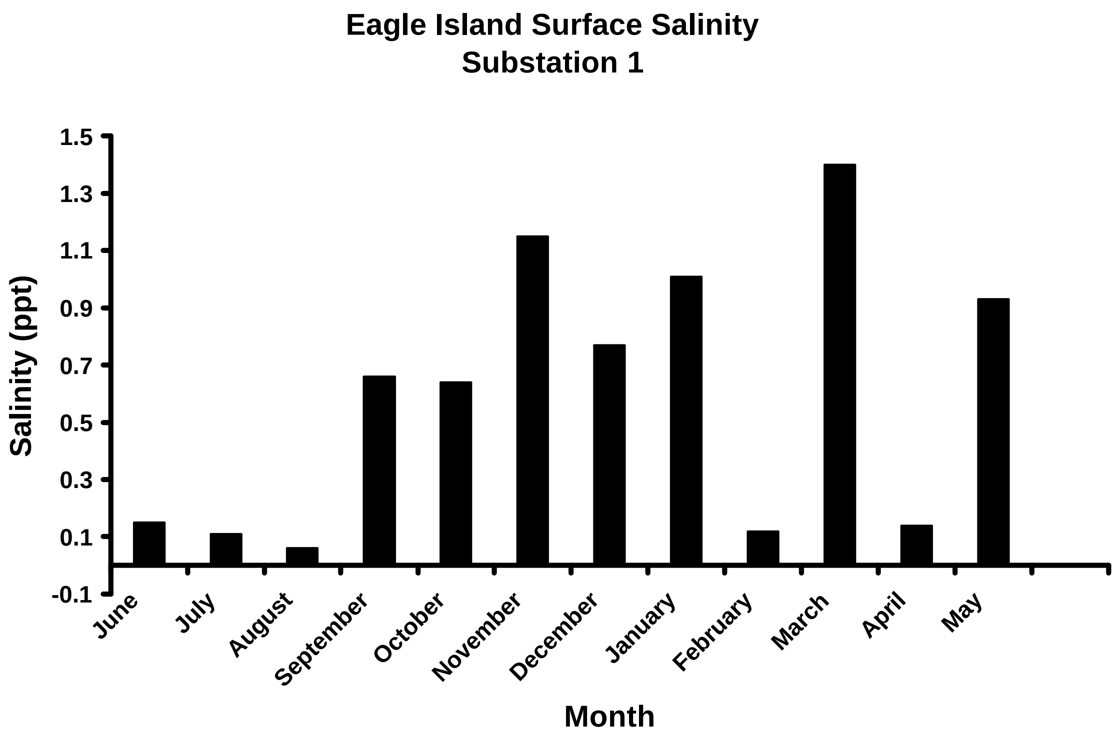
during these years (Hackney et al. 2002a; 2002b). During the previous year (winter 2003, summer 2002) the pattern of salinity variations was different (Hackney et al. 2003). Instead of salinity peaks during November and May, the salinity steadily decreased from the summer of 2002 until the spring of 2003. Salinities during the current year have remained low with only a slight increase in the near-shore stations beginning fall of 2003 (Figure 5.4-4). The continued fresh conditions were reflected in the geochemical parameters and classifications during the 2003-2004 reporting period (Table 5.4-1). This demonstrates that trends, such as more saline water during summer and less saline water during winter, are only general patterns and individual years may vary.

Salinities at the subsite adjacent to the river (S1) were approximately 10-15 ppt. during the summer of 2002 (Hackney et al. 2003). By November 2002 they had dropped below 0.5 ppt and remained there until the fall of 2003 when there was a slight increase with salinity values approaching 1 ppt (Figure 5.4-4). With the exception of low salinity values in February and April, the salinities though the winter of 2004 have remained at approximately 1 ppt. At the most inland subsite (S6), salinities dropped from about 8 ppt during the summer of 2002 to below 0.5 ppt by March 2003 (Hackney et al. 2003). They have remained at approximately 0.1 ppt through the winter and spring of 2004.

Sulfate concentrations at Eagle Island essentially parallel the pattern of salinity (Figure 5.4-2). Sulfate concentrations at S1 remained low during the summer of 2003 and rebounded slightly during the fall of 2003. With the exception of February and April, values have remained at approximately 1000 µM, much lower than the 8,000 – 10,000 µM values seen during the summer of 2002 prior to the drop in salinity (Hackney et al. 2003). Sulfate values at subsite six remained low throughout the current study period staying close to sulfate reducing threshold values (Figure 5.4-2).

Geochemical classifications of Eagle Island show the expected trend for a system experiencing lower salinity conditions. Prior to the decrease in salinity that began during the fall of 2002, the majority of classifications were SR and MPSR (Hackney et al., 2002a, 2002b, 2003). Currently the majority of sites are methanogenic with only a few sub-stations having SR classifications primarily resulting from the slight rebound in salt input which began during the winter of 2004 (Table 5.4-1).

The chloride to sulfate ratios ($Cl^-:SO_4^{2-}$) reflect salinity variations observed during the current year (Figure 5.4-3). At S1, the ratios were below that expected for seawater indicating that the sulfate present was likely from oxidation of H_2S rather than re-supply from seawater. During the fall, as salinities began to increase slightly, signs of sulfate reduction were evident with ratios greater than seawater. From November 2003 to May 2004, values remained close to that expected for seawater indicating a re-supply was occurring without rapid sulfate reduction during the colder months. Interestingly, during February and April when salinities were low, the ratios once again suggest a non-seawater source of sulfate, likely from the oxidation of H_2S. For Eagle Island subsite 6, where salinities and sulfate supply was low, ratios display a similar pattern with values indicating H_2S oxidation and not seawater was the source of sulfate.



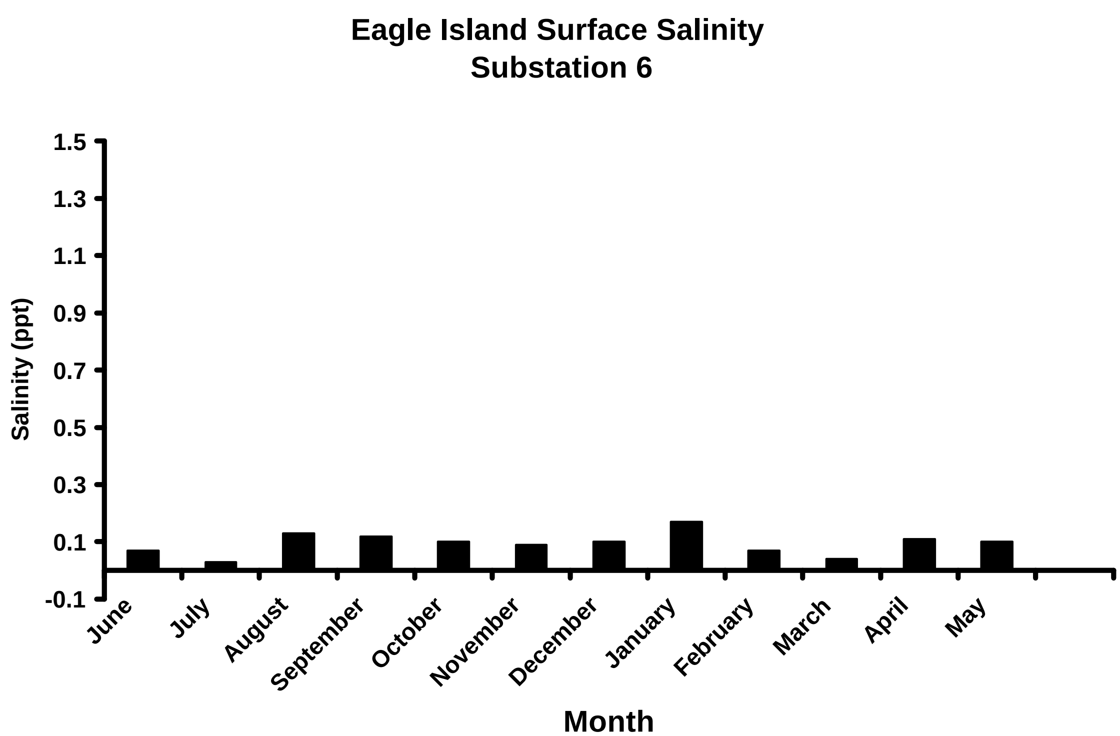


Figure 5.4-4. Salinities of Eagle Island porewaters vs. month. Top shows nearshore site (S1) and bottom shows most upland site (S6).

Table 5.4-1. Eagle Island (P6) Geochemical Classifications by month. Site classifications are as follows: Methanogenic I, Sulfate Reducing II, Methanogenic with evidence of past sulfate reduction I*, Sulfate reducing non-seawater source of sulfate II*.

Sites	June 03	July	August	September	October	November	December	January	February
S1-1	I	I	I	I*	I*	II	II	II	II*
S1-2	I	ns	I	I*	I*	II	II	II	II
S1-3	I	ns	I	I*	I*	I*	II	II	II
S1-4	I*	I*	I	I*	I*	I*	II	II	II
S1-5	I*	I*	I*	I*	I*	I*	II	II	II
S1-6	I*	I*	I*	I	I*	I*	II	II	II
S2-1	I	I	I	I	I*	II	II	II	I*
S2-2	I	I	I	I	I*	I*	II	II	I*
S2-3	I	I	I	I	I*	I*	II	II	I*
S2-4	I*	I	I	I*	I*	I*	I*	I*	I*
S2-5	I*	I*	I	I*	I*	I*	I*	I*	I*
S2-6	I*	I*	I	I*	I*	I*	I*	I*	I*
S3-1	I*	I*	I*	I*	I*	II	II	II	I
S3-2	I*	I*	I*	I*	I*	II	II	II	I*
S3-3	I*	I*	I*	I*	I*	I*	I*	II	I*
S3-4	I*	I*	I*	I*	I*	I*	I*	II	I*
S3-5	I*	I*	I*	I*	I*	I*	I*	I*	I*
S3-6	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-1	I	I*	I	II	I	I*	I*	II	I*
S4-2	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-3	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-4	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-5	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-6	I*	I*	I*	I*	I*	I*	I*	I*	I*
S5-1	I	I*	I*	I*	I*	I	II	II	I
S5-2	I	I*	I*	I*	I*	I	I*	II	I*
S5-3	I*	I*	I*	I*	I*	I*	I*	II	I*
S5-4	I*	I*	I*	I*	I*	I*	I*	II	I*
S5-5	I*	I*	I*	I*	I*	I*	I*	I	I*
S5-6	I*	I*	I*	I*	I*	I*	I*	II	I*
S6-1	I	I	II*	I	ns	I	II*	II	I
S6-2	I	I	II	I	I	I	I	II	I
S6-3	I*	I	I	I	I	I	I	I	I
S6-4	I*	I*	I	I	I*	I	I	I	I
S6-5	I*	I*	I	I	I*	I	I	I	I
S6-6	I*	I*	I	I*	I*	I	I	I	I

Table 5.4-1. concluded

Sites	March	April	May
S1-1	II	II*	II
S1-2	II	II*	II
S1-3	II	I	II
S1-4	II	I	I*
S1-5	II	I*	I*
S1-6	I	I*	I*
S2-1	I*	I*	ns
S2-2	I*	I*	I*
S2-3	I*	I*	I*
S2-4	I*	I*	I*
S2-5	I*	I*	I*
S2-6	I*	I*	II*
S3-1	II	II	II
S3-2	I*	I*	I*
S3-3	I*	I*	I*
S3-4	I*	I*	I*
S3-5	I*	I*	I*
S3-6	I*	I*	I*
S4-1	I*	I	I*
S4-2	I*	I*	I*
S4-3	I*	I*	I*
S4-4	I*	I*	I*
S4-5	I*	I*	I*
S4-6	I*	I*	I*
S5-1	I	II*	II
S5-2	I*	II	I*
S5-3	I*	I	I*
S5-4	I*	I	I*
S5-5	I*	I*	I*
S5-6	I*	I*	I*
S6-1	I	II*	I
S6-2	I	II	I
S6-3	II	I	II*
S6-4	I	I	I
S6-5	I	I	I
S6-6	I*	I	I

Methane concentrations at Eagle Island were generally higher during the low salinity conditions and decreased dramatically during the winter of 2004 as salinities increased (Figure 5.4-1). The decrease in methane at S1 after November of 2003 likely resulted from the increase in sulfate concentrations and inhibition of methanogenesis when sulfate concentrations increased above the sulfate reduction threshold of approximately 300 µM. The lack of high methane concentrations at S6 is harder to explain. With values of sulfate staying close to the sulfate-reducing threshold, it was expected that methanogenesis would occur. However, methane concentrations remained low during this period of time. Considering the $Cl^{-}:SO_4^{2-}$ ratio data, and the indication that oxidation of H_2S was occurring at this site, it is possible that the methane was also being oxidized. This can occur in any non-methanogenic zone where an oxidant is present.

5.5 Marsh/Swamp Transect Stations Geochemistry, Annual Variability

The following section compares the geochemistry of substations from the previous years 2000-2001 (Hackney et al. 2002a), 2001-2002 (Hackney et al. 2002b), and 2002-2003 (Hackney et al. 2003) to the current year. The current report includes the winter of 2004 and the summer of 2003.

5.51 Town Creek (P3)

Town Creek is the most seaward station monitored for geochemistry, although it is situated upstream in a separate drainage basin. The average summer salinities showed no obvious changes over the previous 3 years of summer data [(summer 2000 = 4.3 $\pm$ 1.7 (Hackney et al. 2002a); summer 2001 = 3.4 $\pm$ 0.8 (Hackney et al. 2002b); summer 2002 = 4.8 $\pm$ 2.2 (Hackney et al. 2003). Average porewater salinities are usually higher during summers compared to winters, reflecting the general trend towards higher winter freshwater river flow. The current summer salinities ranged from approximately 0.4 ppt to 3.0 ppt (Table 5.51-1) in contrast to the previous summer 2002 where the majority of salinities were greater than 3.0 ppt (Hackney et al. 2003). Summer 2003 classifications reflected the fresher conditions with the majority of sites having MPSR conditions for the first time (Table 5.51-2).

The average winter porewater salinities increased steadily throughout the first four years of this study [winter 2000 = 0.8 $\pm$ 0.4 ppt; winter 2001 = 1.4 $\pm$ 0.8 ppt (Hackney et al. 2002a); winter 2002 = 3.8 ppt $\pm$ 1.9 (Hackney et al. 2002b); winter 2003 = 7.2 $\pm$ 4.9 ppt]. Porewater salinities during the previous winter (2003) reached values as high as 17 ppt, roughly twice the highest winter salinities ever observed (Hackney et al. 2003). During the current winter (2004) there was a dramatic shift towards lower salinity conditions (Table 5.51-1). Salinities ranged from approximately 0.5 ppt to 3.0 ppt whereas during the previous winter of 2003 the majority of the salinities were greater than 3 ppt (Hackney et al. 2003). In the past 4 winters, the majority of geochemical classifications have been SR (Hackney et al. 2002a, 2002b, 2003). The current winter (2004) geochemical classifications reflected the lower salinities with the majority of substations now showing MPSR conditions indicating a lack of re-supply of sulfate to the porewaters after depletion.

Methane concentrations increases, which would indicate fresher conditions, were not observed (Hackney et al. 2003; Table 5.51-3) even though the salinity at this site decreased during winter 2004 and summer 2003. Methane concentrations at Town Creek are generally high even though it is typically a SR classification, which indicates that the methane present in the porewaters likely results from upward transport from sulfate depleted zones below our sampling depth and therefore methane concentrations are not a good indicator of salinity regime at this site.

Table 5.51-1. Salinity of sites. Salinity in parts per thousand calculated from chloride concentrations in porewaters. A "---" indicates no data.

			Salinity	
Station	Substation	Depth (cm)	Summer 2003	Winter 2004
Town Creek	1	1	0.45	0.47
P3	1	6	0.43	0.83
	1	11	0.62	0.94
	1	16	0.95	0.91
	1	21	1.27	1.02
	1	26	1.43	1.13
	2	1	0.39	0.54
	2	6	0.77	1.18
	2	11	1.38	2.02
	2	16	2.08	2.53
	2	21	2.72	2.80
	2	26	2.54	3.05
	3	1	0.39	0.20
	3	6	0.36	0.25
	3	11	0.39	0.30
	3	16	0.79	0.55
	3	21	1.46	0.94
	3	26	2.26	1.43
	4	1	0.36	0.97
	4	6	0.46	1.27
	4	11	0.61	1.60
	4	16	0.89	1.94
	4	21	1.22	1.89
	4	26	1.60	1.65
	5	1	0.28	0.27
	5	6	0.27	0.28
	5	11	0.41	0.37
	5	16	0.54	0.48
	5	21	0.71	0.61
	5	26	0.88	1.63
	6	1	0.26	0.41
	6	6	0.37	0.59
	6	11	0.49	0.65
	6	16	0.75	0.78
	6	21	1.19	1.05
	6	26	2.34	1.38

Table 5.51-1. continued

Station	Substation	Depth (cm)	Salinity	
			Summer 2003	Winter 2004
Eagle Island	1	1	ns	1.01
P6	1	6	ns	1.12
	1	11	ns	1.60
	1	16	0.11	1.86
	1	21	0.40	1.54
	1	26	0.59	1.15
	2	1	0.01	2.44
	2	6	0.03	1.01
	2	11	0.08	0.77
	2	16	0.13	0.50
	2	21	0.22	0.46
	2	26	0.41	0.51
	3	1	1.19	0.96
	3	6	1.39	1.22
	3	11	1.53	1.25
	3	16	1.65	1.14
	3	21	1.88	1.16
	3	26	2.13	1.19
	4	1	0.17	0.87
	4	6	0.16	1.23
	4	11	0.20	1.40
	4	16	0.28	1.59
	4	21	0.43	1.64
	4	26	0.70	1.68
	5	1	0.11	0.53
	5	6	0.22	0.64
	5	11	0.29	0.61
	5	16	0.36	0.46
	5	21	0.45	0.32
	5	26	0.70	0.57
	6	1	0.03	0.17
	6	6	0.04	0.16
	6	11	0.08	0.11
	6	16	0.11	0.13
	6	21	0.16	0.14
	6	26	0.23	0.11
Indian Creek	1	1	0.03	0.03
P7	1	6	0.03	0.04
	1	11	0.07	0.04
	1	16	0.18	0.06
	1	21	0.39	0.12
	1	26	0.62	0.18
	2	1	0.03	0.07
	2	6	0.04	0.07
	2	11	0.05	0.07
Indian Creek	2	16	0.08	0.08
(continued)	2	21	0.14	0.06
	2	26	0.30	0.06
	3	1	0.01	0.06

Table 5.51-1. continued

Station	Substation	Depth (cm)	Salinity Summer 2003	Salinity Winter 2004
	3	6	0.02	0.06
	3	11	0.02	0.05
	3	16	0.03	0.05
	3	21	0.04	0.05
	3	26	0.05	0.05
	4	1	0.03	0.05
	4	6	0.03	0.05
	4	11	0.03	0.05
	4	16	0.04	0.04
	4	21	0.03	0.04
	4	26	0.04	0.04
	5	1	0.02	ns
	5	6	0.02	0.03
	5	11	0.03	0.03
	5	16	0.03	0.03
	5	21	0.03	0.03
	5	26	0.02	0.03
	6	1	0.01	0.02
	6	6	0.01	0.02
	6	11	0.01	0.02
	6	16	0.01	0.02
	6	21	0.01	0.02
	6	26	0.01	0.02
Dollisons	1	1	0.02	0.03
Landing P8	1	6	0.02	0.03
	1	11	0.02	0.02
	1	16	0.02	0.02
	1	21	0.02	0.02
	1	26	0.02	0.02
	2	1	0.03	0.04
	2	6	0.03	0.03
	2	11	0.04	0.03
	2	16	0.05	0.05
	2	21	0.04	0.05
	2	26	0.04	0.04
	3	1	0.04	0.04
	3	6	0.04	0.04
	3	11	0.05	0.04
	3	16	0.05	0.03
	3	21	0.04	0.04
	3	26	0.04	0.03
Dollisons	4	1	0.02	0.03
Landing	4	6	0.02	0.04
(continued)	4	11	0.03	0.03
	4	16	ns	0.03
	4	21	0.03	0.03
	4	26	0.03	0.03
	5	1	0.03	0.07
	5	6	0.03	0.07

Table 5.51-1. continued

Station	Substation	Depth (cm)	Salinity Summer 2003	Salinity Winter 2004
	5	11	0.03	0.06
	5	16	0.04	0.06
	5	21	0.03	0.05
	5	26	0.03	0.06
	6	1	0.03	0.06
	6	6	0.03	0.06
	6	11	0.03	0.06
	6	16	0.04	0.05
	6	21	0.03	0.05
	6	26	0.04	0.05
Black River	1	1	0.01	0.27
P9	1	6	0.02	0.36
	1	11	0.02	0.09
	1	16	0.03	0.23
	1	21	0.04	0.05
	1	26	0.04	0.04
	2	1	0.02	0.03
	2	6	0.01	0.03
	2	11	0.02	0.03
	2	16	0.02	0.03
	2	21	0.02	0.03
	2	26	0.03	0.03
	3	1	0.02	0.03
	3	6	0.04	0.02
	3	11	ns	0.02
	3	16	0.05	0.03
	3	21	0.03	0.03
	3	26	0.04	0.03
	4	1	0.01	0.03
	4	6	0.02	0.03
	4	11	0.03	0.03
	4	16	0.02	0.02
	4	21	0.03	0.03
	4	26	0.04	0.03
	5	1	0.01	0.03
	5	6	0.02	0.03
	5	11	0.02	0.03
Black River	5	16	0.03	0.03
(continued)	5	21	0.02	0.03
	5	26	0.03	0.05
	6	1	0.01	0.03
	6	6	0.02	0.04
	6	11	0.01	0.03
	6	16	0.02	0.03
	6	21	0.02	0.06
	6	26	0.02	0.04
Smith Creek	1	1	0.78	4.83
P11	1	6	0.78	4.88
	1	11	2.05	2.03

Table 5.51-1. continued

Station	Substation	Depth (cm)	Salinity	
			Summer 2003	Winter 2004
	1	16	2.64	3.15
	1	21	3.57	3.03
	1	26	4.28	4.08
	2	1	0.38	5.14
	2	6	0.33	3.97
	2	11	0.83	2.39
	2	16	1.83	1.88
	2	21	2.40	1.64
	2	26	4.39	1.74
	3	1	0.39	4.98
	3	6	0.56	4.47
	3	11	0.89	3.91
	3	16	1.25	3.46
	3	21	1.69	3.48
	3	26	2.21	3.26
	4	1	0.53	ns
	4	6	1.32	3.34
	4	11	1.27	2.13
	4	16	1.74	2.21
	4	21	3.75	2.82
	4	26	3.61	3.17
	5	1	ns	3.63
	5	6	1.54	2.05
	5	11	2.19	3.67
	5	16	3.11	3.84
	5	21	3.59	4.06
	5	26	3.72	4.16
	6	1	0.40	3.31
	6	6	0.51	1.75
	6	11	0.60	1.05
	6	16	1.09	0.93
	6	21	1.55	1.57
	6	26	2.08	2.02
Rat Island	1	1	0.28	0.98
P12	1	6	0.11	0.75
	1	11	0.17	0.68
	1	16	0.24	0.67
	1	21	0.17	0.69
	1	26	0.32	0.72
	2	1	0.09	0.38
	2	6	0.17	0.31
	2	11	0.24	0.27
	2	16	0.33	0.23
	2	21	0.58	0.19
	2	26	0.77	0.21
	3	1	0.08	0.64
	3	6	0.08	0.57
	3	11	0.12	0.53
	3	16	0.17	0.42

Table 5.51-1. continued

Station	Substation	Depth (cm)	Salinity	
			Summer 2003	Winter 2004
	3	21	0.14	0.38
	3	26	0.21	0.37
	4	1	0.13	0.34
	4	6	0.15	0.22
	4	11	0.14	0.25
	4	16	0.18	0.22
	4	21	0.20	0.23
	4	26	0.29	0.28
	5	1	0.37	0.46
	5	6	0.44	0.45
	5	11	0.40	1.90
	5	16	0.37	0.44
	5	21	0.44	0.44
	5	26	0.50	0.45
	6	1	0.30	0.16
	6	6	0.28	0.20
	6	11	0.30	0.23
	6	16	0.37	0.23
	6	21	0.43	0.27
	6	26	0.53	0.27
Fishing Creek	1	1	0.02	0.02
P13	1	6	0.02	0.03
	1	11	0.02	0.03
	1	16	0.02	0.03
	1	21	0.03	0.04
	1	26	0.06	0.04
	2	1	0.06	ns
	2	6	0.07	0.09
	2	11	0.07	0.08
Fishing Creek	2	16	0.07	0.08
(continued)	2	21	0.08	0.09
	2	26	0.08	0.09
	3	1	0.14	0.24
	3	6	0.18	0.24
	3	11	0.19	0.25
	3	16	0.24	0.28
	3	21	0.32	0.30
	3	26	0.43	0.33
	4	1	0.10	0.08
	4	6	0.11	0.07
	4	11	0.10	0.06
	4	16	0.12	0.06
	4	21	0.10	0.05
	4	26	ns	0.06
	5	1	0.13	0.04
	5	6	0.09	0.04
	5	11	0.10	0.04
	5	16	0.10	0.04
	5	21	0.10	0.04

Table 5.51-1. continued

Station	Substation	Depth (cm)	Salinity Summer 2003	Salinity Winter 2004
	5	26	0.09	0.03
	6	1	0.03	0.02
	6	6	0.04	0.02
	6	11	0.02	0.02
	6	16	0.02	0.02
	6	21	0.02	0.03
	6	26	0.02	0.03
Prince George	1	1	0.02	ns
P14	1	6	0.02	0.03
	1	11	0.02	0.03
	1	16	0.03	0.03
	1	21	0.03	0.03
	1	26	0.04	0.04
	2	1	0.13	0.05
	2	6	0.23	0.06
	2	11	0.24	0.08
	2	16	0.25	0.07
	2	21	0.25	0.08
	2	26	0.26	0.09
	3	1	0.03	ns
	3	6	0.03	0.03
	3	11	0.03	0.04
	3	16	0.03	0.04
	3	21	0.03	0.04
	3	26	0.06	0.05
Prince George	4	1	0.05	0.05
(continued)	4	6	0.07	0.06
	4	11	0.09	0.06
	4	16	0.12	0.07
	4	21	0.17	0.07
	4	26	0.19	0.07
	5	1	0.02	0.03
	5	6	0.03	0.03
	5	11	0.03	0.03
	5	16	0.03	0.03
	5	21	0.03	0.03
	5	26	0.03	0.03
	6	1	0.02	0.02
	6	6	0.02	0.03
	6	11	0.03	0.02
	6	16	0.03	0.02
	6	21	0.02	0.02
	6	26	0.04	0.02

Table 5.51-1. continued

Table 5.51-2. Classification of Sites Summer 2003. Site classifications are as follows: Methanogenic I, Sulfate Reducing II, Methanogenic with evidence of past sulfate reduction I*, Sulfate reducing non-seawater source of sulfate II*.

			Classification			
Station	Substation	Depth (cm)	Summer 2000	Summer 2001	Summer 2002	Summer 2003
Town Creek	1	1	II	II	II	I*
P3	1	6	II	II	II	I*
	1	11	II	II	II	I*
	1	16	II	II	II	I*
	1	21	II	II	II	I*
	1	26	I*	II	II	I*
	2	1	II	II	II	II
	2	6	II	II	II	II
	2	11	II	II	I*	II
	2	16	II	II	I*	II
	2	21	II	II	I*	I*
	2	26	II	II	I*	II
	3	1	II	II	II	I*
	3	6	II	II	II	I*
	3	11	II	II	II	I*

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification			
			Summer 2000	Summer 2001	Summer 2002	Summer 2003
Town Creek (continued)	3	16	II	II	II	I*
	3	21	II	II	II	I*
	3	26	II	II	II	I*
	4	1	II	II	II	I
	4	6	II	II	II	I*
	4	11	II	II	II	I*
	4	16	II	II	II	I*
	4	21	II	II	II	I*
	4	26	II	II	II	I*
	5	1	II	II	I*	I*
	5	6	II	II	II	I*
	5	11	II	II	II	I
	5	16	II	II	II	I*
	5	21	II	II	II	I*
	5	26	II	II	II	I*
	6	1	II	II	II	I
	6	6	II	II	II	I*
	6	11	II	II	II	I*
	6	16	II	II	II	I*
	6	21	II	II	II	I*
	6	26	I*	II	II	I*
Eagle Island P6	1	1	II	II	II	I
	1	6	II	II	II	ns
	1	11	II	II	II	ns
	1	16	II	II	II	I*
	1	21	II	II	II	I*
	1	26	II	II	I*	I*
	2	1	II	II	II	I
	2	6	II	II	II	I
	2	11	II	II	II	I
	2	16	II	I*	II	I
	2	21	II	I*	II	I*
	2	26	II	I*	I*	I*
	3	1	I*	II	II	I*
	3	6	I*	I*	II	I*
	3	11	I*	I*	II	I*
	3	16	I*	I*	II	I*
	3	21	I*	I*	II	I*
	3	26	I*	I*	II	I*
	4	1	II	II	I*	I*
	4	6	II	I*	I*	I*
Eagle Island (continued)	4	11	II	I*	I*	I*
	4	16	II	I*	I*	I*
	4	21	II	I*	I*	I*

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification Summer 2000	Summer 2001	Summer 2002	Summer 2003
	4	26	I*	I*	I*	I*
	5	1	II	I*	II	I*
	5	6	I*	I*	II	I*
	5	11	II	I*	I*	I*
	5	16	I*	I*	I*	I*
	5	21	I*	I*	I*	I*
	5	26	I*	I*	I*	I*
	6	1	II	I*	II	I
	6	6	I*	I*	II	I
	6	11	---	I*	II	I
	6	16	II	I*	II	I*
	6	21	I*	I*	II	I*
	6	26	I*	I*	I*	I*
Indian Creek P7	1	1	II	II	II	I
	1	6	II	II	II	I*
	1	11	II	II	II	I*
	1	16	II	II	II	I*
	1	21	II	II	II	I*
	1	26	I	I*	II	I*
	2	1	I	II	II	I
	2	6	I	I	II	I*
	2	11	I	I	II	I
	2	16	I	I*	II	I*
	2	21	I	I*	II	I*
	2	26	I	I	II	I*
	3	1	II	II	I*	I
	3	6	II	I	I*	I
	3	11	I	I*	I*	I
	3	16	I	I	I*	I
	3	21	II	I	I*	I
	3	26	I	II	I*	I*
	4	1	I	I	II	I
	4	6	II	I	II	I
	4	11	II	I	II	I
	4	16	I	I	II	I
	4	21	I	I	II	I
	4	26	I	I	II	I
	5	1	II	I	I*	I
Indian Creek (continued)	5	6	I	I	I*	I
	5	11	II	I	I*	I
	5	16	II	---	I*	I
	5	21	I	I*	I*	I
	5	26	I	I	I*	I
	6	1	II	---	I	I

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification			
			Summer 2000	Summer 2001	Summer 2002	Summer 2003
	6	6	I	---	I	I
	6	11	I	I	I	I
	6	16	I	I	I	I
	6	21	I	---	I	I
	6	26	II	I	I	I
Dollisons	1	1	I		II	I
Landing P8	1	6	II*	II	II	I
	1	11	II*	II	I	I
	1	16	II*	II	I	I
	1	21	II	I	II	I
	1	26	II	I	I	I
	2	1	II*	II	I	I
	2	6	II	I	I*	I
	2	11	I	II	I*	I*
	2	16	I	I*	I*	I*
	2	21	I	II	I*	I*
	2	26	I	I	I*	I*
	3	1	II	I	I	I
	3	6	I		I*	I
	3	11	I	I	I*	I*
	3	16	I	I	I*	I
	3	21	I	I	I*	I*
	3	26	I	II	I*	I
	4	1	I	I	II*	I
	4	6	I	I	I	I
	4	11	I	II	I*	I
	4	16	I	I	ns	I
	4	21	I	II	I*	I
	4	26	I	II	I*	I*
	5	1	I	I	I	I
	5	6	I	I	I	I
	5	11	I	I	I*	I
	5	16	I	I*	I*	I
	5	21	I	II	I*	I
	5	26	I	II	I*	I
Dollisons	6	1	I	I	I	I
Landing	6	6	I	I*	I	I
(continued)	6	11	I	I*	I*	I
	6	16	I	I*	I*	I
	6	21	I	I	I*	I
	6	26	I	I	I*	I
Black River	1	1	I	---	I*	I
P9	1	6	---	---	I*	I
	1	11	I	---	I	I

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification Summer 2000	Summer 2001	Summer 2002	Summer 2003
	1	16	I	---	II*	I
	1	21	II	---	I*	I
	1	26	I	II	I*	I
	2	1	I	I*	I*	I
	2	6	I	I*	I*	I
	2	11	I	I	I*	I
	2	16	I	I	II*	I
	2	21	I	I	I	I
	2	26	I	I*	I*	I
	3	1	I	II	I*	I
	3	6	I	II*	I*	I
	3	11	I	I	I	ns
	3	16	I	I	II*	I
	3	21	I	I	I	I
	3	26	I	I	I	I
	4	1	I	II	I*	I
	4	6	II	II*	I	I
	4	11	I	II	II*	I
	4	16	I	I	II*	I
	4	21	I	I	II*	I
	4	26	I	I	II*	ns
	5	1	II*	II*	I	I
	5	6	II	II	I	I
	5	11	I	II	II*	I
	5	16	I	I	II*	I*
	5	21	II	I	II*	I
	5	26	II	I	I	I
	6	1	II*	---	I	I
	6	6	II*	II	II*	I
	6	11	II*	I	II*	I
	6	16	I	I*	II*	I
	6	21	I	I	I	I
Black River	6	26	I	I	I	I
Smith Creek	1	1	II	II	II	II
P11	1	6	II	I*	II	II
	1	11	---	II	II	II
	1	16	II	II	II	II
	1	21	---	II	II	II
	1	26	---	II	II	II
	2	1	II	II	II	II*
	2	6	---	I*	II	II
	2	11	II	II	II	II
	2	16	II	II	II	II
	2	21	II	II	II	II

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification Summer 2000	Summer 2001	Summer 2002	Summer 2003
	2	26	II	II	II	II
	3	1	II	II	II	II
	3	6	II	II	II	I*
	3	11	II	II	II	I*
	3	16	II	II	II	II
	3	21	II	II	II	I*
	3	26	II	II	II	II
	4	1	II	II	II	II
	4	6	II	II	II	II
	4	11	II	II	II	II
	4	16	II	II	II	II
	4	21	II	II	II	II
	4	26	II	II	II	II
	5	1	II	I*	II	ns
	5	6	II	II	II	II
	5	11	II	II	II	II
	5	16	II	II	II	II
	5	21	II	II	II	II
	5	26	II	II	II	II
	6	1	II	II	II	I
	6	6	II	I*	II	I
	6	11	II	I*	II	I*
	6	16	II	I*	II	II
	6	21	II	---	II	II
	6	26	II	II	II	II
Rat Island	1	1	II	II	II	I
P12	1	6	II	II	II	I
	1	11	II	II	II	I
	1	16	II	II	II	I
Rat Island	1	21	II	II	II	I*
(continued)	1	26	I	II	II	I*
	2	1	II	I*	II	I
	2	6	II	I*	II	II
	2	11	II	I*	II	II
	2	16	II	II	II	II
	2	21	II	II	I*	I*
	2	26	I*	---	II	I*
	3	1	II	II	II	I
	3	6	II	I	II	I
	3	11	II	I	II	I
	3	16	II	I	II	I
	3	21	II	I*	II	I
	3	26	II	I*	II	I
	4	1	II	I*	II	I

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification Summer 2000	Summer 2001	Summer 2002	Summer 2003
	4	6	I*	II	II	I
	4	11	I*	I*	II	I
	4	16	II	I*	II	I*
	4	21	II	I*	I*	I*
	4	26	I*	I*	I*	I*
	5	1	II	I	II	I*
	5	6	II	I	II	I*
	5	11	I	I*	II	I*
	5	16	II	I*	II	I*
	5	21	II	I*	II	I*
	5	26	I*	I*	II	I*
	6	1	I	---	II	II
	6	6	I	I	II	II
	6	11	I	I	II	I*
	6	16	I	I*	II	I*
	6	21	I	I	II	I*
	6	26	I	I	II	I*
Fishing Creek P13	1	1	II	---	II	I
	1	6	II	---	II	I
	1	11	II	I*	II	I
	1	16	II	II	II	I
	1	21	II	I*	II	I
	1	26	I*	II	II	I
	2	1	II	I	II	I
	2	6	II	I	II	I
	2	11	II	I	II	I
Fishing Creek (continued)	2	16	II	II	II	I
	2	21	II	II	II	I
	2	26	I*	II	II	I
	3	1	II	II	II	I
	3	6	I	I*	II	I
	3	11	II	I*	II	I
	3	16	II	I*	II	I
	3	21	II	II	II	I*
	3	26	I	I*	II	I*
	4	1	I	I	II	I
	4	6	I	II	II	I
	4	11	I	I	II	I
	4	16	I	I	II	I
	4	21	I	I	II	I
	4	26	I	I	NS	I
	5	1	II	I	II	II
	5	6	II	I	II	I
	5	11	II	I	II	I

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification			
			Summer 2000	Summer 2001	Summer 2002	Summer 2003
	5	16	II	I	II	I
	5	21	II	II	II	I*
	5	26	II	I	II	I
	6	1	I	II	II	I
	6	6	II*	I	I	II*
	6	11	I	I	I	I
	6	16	II	II	I	I
	6	21	I	I*	I	I
	6	26	I	I	I	I
Prince George P14	1	1	I	I	II	I
	1	6	I	I	II	I
	1	11	I	I*	II	I
	1	16	I	I	II	I
	1	21	I	I	I*	I
	1	26	I	I*	I*	I
	2	1	I	I	II	I*
	2	6	I	I	II	I*
	2	11	I	I	II	I*
	2	16	I	I	I*	I*
	2	21	I	I*	I*	I*
	2	26	I	I*	I*	I*
	3	1	I	I	II	I
	3	6	I	II*	II	I
Prince George (continued)	3	11	I	I	II	I
	3	16	I	I*	II	I
	3	21	I	I	I*	I
	3	26	I	I	I*	I
	4	1	I	I	II	I
	4	6	I	I	II	I*
	4	11	I*	I	II	I*
	4	16	I	I	II	I*
	4	21	I	I	I*	I*
	4	26	I	I	I*	I*
	5	1	I	II	II	I
	5	6	II	II	II	I
	5	11	I	I	II	I
	5	16	I	I	II	I
	5	21	I	I	II	I
	5	26	I	I*	I*	I
	6	1	I	I	I	I
	6	6	I	I	II	I
	6	11	I	I	I*	I
	6	16	I	I	I*	I
	6	21	I	I	I*	I

Table 5.51-2. continued

Station	Substation	Depth (cm)	Classification			
			Summer 2000	Summer 2001	Summer 2002	Summer 2003
	6	26	I	II	I*	I

Table 5.51-3. Classification of sites in winter 2004. Site classifications are as follows: Methanogenic I, Sulfate Reducing II, Methanogenic with evidence of past sulfate reduction I*, Sulfate reducing non-seawater source of sulfate II*.

			Classification				
Station	Substation	Depth (cm)	Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
Town Creek	1	1	---	II	II	II	I
P3	1	6	---	II	II	II	I*
	1	11	---	II	II	II	I*
	1	16	---	I*	II	II	I*
	1	21	---	I*	II	I*	I*
	1	26	I*	I*	II	I*	I*
	2	1	II	II	II	II	I*
	2	6	II	II	II	I*	I*
	2	11	I*	II	II	I*	I*
	2	16	I	II	II	I*	I*
	2	21	I*	II	II	I*	I*
	2	26	I*	II	II	II	I*
	3	1	II	I	II	II	II
	3	6	I	II	II	II	I
	3	11	I	II	II	II	I*
	3	16	I*	I*	II	II	I*
	3	21	I*	II	II	II	I*
	3	26	I*	II	II	II	I*
	4	1	I	II	II	II	II
	4	6	I*	I*	II	II	I*
	4	11	II	I*	II	II	I*
	4	16	II	I*	II	II	I*
	4	21	II	II	II	II	I*
	4	26	II	II	II	II	II
	5	1	---	II	II	II	I
	5	6	I	II	II	II	I
	5	11	I	II	II	II	I*
	5	16	II	II	II	II	I*
	5	21	---	II	II	II	I*
	5	26	II	II	II	II	II
	6	1	II	II	II	II	II
	6	6	II	II	II	II	I*
	6	11	II	II	II	II	I*
	6	16	II	II	II	II	I*
	6	21	II	II	II	II	I*
	6	26	II	II	II	II	I*
Eagle Island	1	1	---	II	II	II	II
P6	1	6	---	II	II	II	II

Table 5.51-3. continued

Station	Substation	Depth (cm)	Classification Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
	1	11	---	II	II	II	II
	1	16	I	II	II	I	II
	1	21	I	II	II	I	II
	1	26	I*	II	II	I*	II
	2	1	I	II	II	II	II
	2	6	I	II	II	II	II
	2	11	---	II	II	II	II
	2	16	---	II	II	II	I*
	2	21	I	II	II	II	I*
	2	26	I	II	II	II	I*
	3	1	I	II	II	II	II
	3	6	---	II	II	II	II
	3	11	I*	II	II	II	II
	3	16	I*	I*	II	II	II
	3	21	I*	II	II	I*	I*
	3	26	II	II	II	I*	I*
	4	1	I	II	II	II	II
	4	6	I*	II	II	I*	I*
	4	11	I*	II	II	I*	I*
	4	16	II	I*	II	I*	I*
	4	21	I*	II*	II	I*	I*
	4	26	I*	II	II	I*	I*
	5	1	I	II	II	II	II
	5	6	I*	II	I*	I*	II
	5	11	I	II	I*	I*	II
	5	16	I*	II	I*	I*	II
	5	21	I*	II	II	I*	I
	5	26	I*	II	I*	I*	II
	6	1	I	I*	I*	II	II
	6	6	I*	I*	I*	I*	II
	6	11	I	I*	I*	I*	I
	6	16	I	I*	I*	I*	I
	6	21	I	I*	I*	I*	I
	6	26	I	I*	I*	I*	I

Indian	1	1	I	I	I	I	I
Creek P7	1	6	I	I	I	II*	II*
	1	11	I	I	I	II	II*
	1	16	---	I	I	II	II*
	1	21	I	I	I	II	I
	1	26	I	I	I	II	I

Table 5.51-3. continued

Station	Substation	Depth (cm)	Classification Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
	2	1	I	I	I*	I*	I
	2	6	I	I	I*	I*	I
	2	11	I	I	I*	I*	I
	2	16	I	I	I*	I*	I*
	2	21	I*	I	I*	I*	I*
	2	26	I*	I	I*	I*	I*
	3	1	I	I	I	I*	I
	3	6	I*	I	I	I*	I
	3	11	I*	I	I*	I*	I*
	3	16	I	I	I*	I*	I*
	3	21	I*	I	I*	I*	I
	3	26	I	I	I*	I*	I
	4	1	I	I	I	I	I
	4	6	I	I	I	I*	I
	4	11	I	I	I	I*	I*
	4	16	I*	I	I	I*	I*
	4	21	I*	I	I	I*	I*
	4	26	I	I	I	I*	I*
	5	1	I	I	I	NS	I
	5	6	I	I	I	I	I
	5	11	I	I	I	I	I
	5	16	I*	I	I	I	I
	5	21	I	I	I	I	I
	5	26	I*	I	I	I	I
	6	1	I	I	I	I	I
	6	6	I	I	I	I	I
	6	11	I	I	I	I	I
	6	16	I	I	I	I	I
	6	21	I	I	I	I	I
	6	26	II*	I	I	I	I

Dollisons	1	1	---	II*	I	I	I
Landing P8	1	6	I	II*	II*	I	II
	1	11	II	II*	II*	I	II
	1	16	I	II*	II*	I	I
	1	21	I*	II	II*	I	I
	1	26	II*	II*	I	I	I
	2	1	---	I	I	I	I
	2	6	---	I	I	I	I
	2	11	II	I	I	I	I

Table 5.51-3. continued

Station	Substation	Depth (cm)	Classification Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
	2	16	II	I	I	I	II*
	2	21	I	I	I	I*	II*
	2	26	I	I	I	I	I
	3	1	II	I	I	I	I
	3	6	I	I	I	I	I
	3	11	II*	II*	I	I	I
	3	16	I	II*	I	I	I
	3	21	II	I	I	I	II*
	3	26	I	I	I	I	I
	4	1	II	I	I	I	I
	4	6	I	I	I	I	I
	4	11	I*	I	I	I	I
	4	16	---	I	I	I	I
	4	21	---	I	I	I	I
	4	26	I	I	I	I*	I
	5	1	I	I	I	I	I
	5	6	II	I	I	I	I
	5	11	---	I	I	I	I
	5	16	II	I	I	I	I
	5	21	I	II*	I	I	I
	5	26	II	I	I	I	II*
	6	1	I*	I	I	I	I
	6	6	I	I	I	I	I
	6	11	II*	I	I*	I	I
	6	16	II	I	I	I*	I
	6	21	---	I	I	I	I
	6	26	I	I	I	I	I
Black River P9	1	1	---	I	I	I*	II
	1	6	I	I	I	I	II
	1	11	I	I	I	I	I
	1	16	I	I	I	I	I
Black River (continued)	1	21	I	II	I	I	I
	1	26	I*	II	I	I	I
	2	1	I	II*	I	I	I
	2	6	I	II*	I	I	I
	2	11	I	I	I	I	I
	2	16	I*	I	I	I	I
	2	21	I	II	I	I	I
	2	26	I	I	I	I*	I
	3	1	I	II*	I	I	I
	3	6	I	II*	I	I	I
	3	11	I	II*	I	I	I
	3	16	I	I	I	I	I

Table 5.51-3. continued

Station	Substation	Depth (cm)	Classification Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
	3	21	I	II	I	I	I
	3	26	I	II*	I	I	I
	4	1	I	II*	I	I	I
	4	6	I*	I	I	I	I
	4	11	I*	II*	I	I	I
	4	16	I*	II*	I	I	I
	4	21	I*	II*	I	I	I
	4	26	I*	II*	I	I	I
	5	1	I*	II*	I	I	I
	5	6	I	II*	I	I	I
	5	11	I	II*	I	I*	I
	5	16	I*	II*	I	I*	I
	5	21	I*	II*	I*	I	I
	5	26	I*	II*	I	I*	I
	6	1	I	I	I	I	I
	6	6	I	I	I	I	I
	6	11	I*	I	I	I	I
	6	16	I*	I	I	I	I
	6	21	I	II*	I	I	I
	6	26	I	II*	I	I	I
Smith Creek P11	1	1	I	II	II	II	II
	1	6	I*	I*	II	II	II
	1	11	---	II	II	II	II
	1	16	I*	II	II	II	II
	1	21	I*	II	II	II	II
	1	26	---	II	II	II	II
	2	1	II	II	---	II	II
	2	6	I*	II	II	II	II
Smith Creek (continued)	2	11	I*	II	II	II	II
	2	16	I*	II	II	II	II
	2	21	I*	II	II	II	II
	2	26	---	II	II	II	II
	3	1	---	II	II	II	II
	3	6	I*	II	II	II	II
	3	11	I*	II	II	II	II
	3	16	I*	II	II	II	II
	3	21	I*	II	II	II	II
	3	26	I*	II	II	II	II
	4	1	I	II	II	II	II
	4	6	II	I	II	II	II
	4	11	II	II	II	II	II
	4	16	II	II	II	II	II
	4	21	II	II	II	II	II

Table 5.51-3. continued

Station	Substation	Depth (cm)	Classification Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
	4	26	II	II	II	II	II
	5	1	II	II	II	II	II
	5	6	II	II	II	II	II
	5	11	I*	II	II	II	II
	5	16	I*	II	II	II	I*
	5	21	I*	II	II	II	I*
	5	26	---	II	II	II	I*
	6	1	---	II	II	II	II
	6	6	---	II	II	II	II
	6	11	---	II	II	II	II
	6	16	---	II	II	II	I*
	6	21	---	II	II	II	II
	6	26	---	II	II	II	II
Rat Island	1	1	---	II	II	II	II
P12	1	6	---	II	II	II	II
	1	11	I*	II	II	II	II
	1	16	I*	II	II	II	II
	1	21	I*	II	II	II	I*
	1	26	I*	II	II	II	II
	2	1	I*	II	II	II	II
	2	6	I*	I	II	II	II
	2	11	I*	II	II	II	II
	2	16	I*	II	II	II	II
	2	21	I*	II	II	II	II
	2	26	I*	II	II	II	II
Rat Island	3	1	II	II	II	II	II
(continued)	3	6	I	II	II	II	II
	3	11	I*	II	II	II	II
	3	16	I	II	II	II	II
	3	21	I	II	II	II	I
	3	26	I	II	II	II	I*
	4	1	I*	II	II	II	II
	4	6	I*	I*	II	II	II
	4	11	I*	I*	II	II	II
	4	16	I*	I*	II	I*	I
	4	21	I*	I*	II	I*	I
	4	26	I*	I*	II	II	I
	5	1	I	II	II	II	I*
	5	6	I	I*	I	II	I*
	5	11	I	I*	II	II	II
	5	16	I	I*	II	II	I*
	5	21	I	I*	I*	II	I*
	5	26	I	I*	I*	II	I*

Table 5.51-3. continued

Station	Substation	Depth (cm)	Classification Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
	6	1	I	I	---	II	II*
	6	6	I	I	---	II	II*
	6	11	I	I	II	II	II*
	6	16	I	II	II	II	II
	6	21	I	I	II	II	I
	6	26	I	I	II	II	I
Fishing Creek P13	1	1	II	II	I	I	I
	1	6	II	II	I	I	I
	1	11	I	II	II	II*	I
	1	16	I	II	II	II*	II*
	1	21	I	II	II	II*	I
	1	26	I	II	II	II*	I
	2	1	---	II	I	II*	I
	2	6	I	II	II	I	I
	2	11	I	II	II	I	I
	2	16	I	I	II	I	I
	2	21	I*	I	II	I	I
	2	26	I*	I	II	I*	I*
	3	1	I	I	II	I*	I*
	3	6	I	I	II	II	I*
	3	11	I*	I	II	I*	I*
	3	16	I	I	II	I*	I*
Fishing Creek (continued)	3	21	I*	I	II	I*	I*
	3	26	I	II	II	I*	I*
	4	1	II*	II	II	I	I
	4	6	I	II	II	II	I
	4	11	I	II	II	II	I
	4	16	I	II	II	II	I
	4	21	I	I	II	II	I
	4	26	I	I	II	II	I
	5	1	I	I	---	I	I
	5	6	I	I	II	I	I
	5	11	I	I	II	I	I
	5	16	I	I	II	I	I
	5	21	I	I	I*	I*	I
	5	26	I	I	---	I*	I
	6	1	II	I	I	I	I
	6	6	I*	I	I*	I	I
	6	11	II	I	I	I	I
	6	16	---	I	I	I	I
	6	21	II	I	I	I	I
	6	26	I	I	I	I	I
Prince	1	1	I	II*	II*	NS	I

Table 5.51-3. continued

Station	Substation	Depth (cm)	Classification Winter 2000	Winter 2001	Winter 2002	Winter 2003	Winter 2004
George P14	1	6	I	I	II*	II*	I
	1	11	I	I	II	II*	I
	1	16	I	I	II	II*	I
	1	21	I	I	II	II*	I
	1	26	I	I	II*	II*	I
	2	1	I	I	II*	I	I
	2	6	I	I	II*	I	I*
	2	11	I	I	II*	I	I*
	2	16	I	II	II*	I	I*
	2	21	I	I*	II*	I	I*
	2	26	I*	I	II	I	I*
	3	1	II	I	II*	NS	I
	3	6	II	I	II*	II*	I
	3	11	I	I	II	I	I
	3	16	I	I	II*	I	I
	3	21	I	I	II	I	I*
	3	26	I	I	II	I	I*
	4	1	I	I	II*	I	I
	4	6	I	II*	II*	I	I
Prince George (continued)	4	11	I	I	II	I*	I*
	4	16	I	I	II*	I*	I*
	4	21	I	I	II	I*	I*
	4	26	I	I	II	I*	I*
	5	1	I	I	II	II*	I
	5	6	I	I	II*	I	I*
	5	11	I	I	II	I	I
	5	16	I	II	II	I	I*
	5	21	I	I	II	I	I
	5	26	I	I	II	I	I
	6	1	II*	II	II*	II*	I
	6	6	I	I	II	II*	I
	6	11	I	I	II	II*	I
	6	16	I	I	II	II*	I
	6	21	I	I	I	II*	I
	6	26	I	I	I	I	I

Table 5.51-4. Methane Concentrations of Sites. Porewater methane concentrations are μM.

			Methane	
Station	Substation	Depth (cm)	Summer 2003	Winter 2004
Town Creek	1	1	87	11
P3	1	6	148	37
	1	11	126	67
	1	16	148	64
	1	21	147	78
	1	26	181	102
	2	1	5	97
	2	6	44	136
	2	11	44	182
	2	16	62	205
	2	21	66	212
	2	26	89	264
	3	1	162	23
	3	6	190	153
	3	11	273	183
	3	16	244	221
	3	21	239	258
	3	26	115	305
	4	1	34	161
	4	6	267	336
	4	11	352	349
	4	16	362	268
	4	21	326	286
	4	26	327	333
	5	1	127	17
	5	6	189	63
	5	11	206	138
	5	16	241	188
	5	21	241	239
	5	26	204	264
	6	1	175	8
	6	6	268	142
	6	11	331	391
	6	16	254	435
	6	21	287	520
	6	26	244	463

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane Summer 2003	Methane Winter 2004
Eagle Island	1	1	80	3
P6	1	6	72	2
	1	11	94	2
	1	16	258	6
	1	21	241	24
	1	26	276	154
	2	1	74	102
	2	6	237	269
	2	11	319	361
	2	16	378	400
	2	21	390	498
	2	26	498	466
	3	1	238	6
	3	6	173	21
	3	11	249	45
	3	16	264	116
	3	21	252	318
	3	26	230	463
	4	1	8	136
	4	6	220	211
	4	11	322	203
	4	16	328	358
	4	21	357	317
	4	26	381	431
	5	1	61	6
	5	6	272	20
	5	11	252	66
	5	16	342	125
	5	21	294	249
	5	26	245	336
	6	1	136	8
	6	6	219	17
	6	11	230	110
	6	16	256	199
	6	21	218	313
	6	26	278	347

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane	
			Summer 2003	Winter 2004
Indian Creek	1	1	98	ns
P7	1	6	277	2
	1	11	298	2
	1	16	242	3
	1	21	274	14
	1	26	180	36
	2	1	213	33
	2	6	300	108
	2	11	216	139
	2	16	267	151
	2	21	236	151
	2	26	212	151
	3	1	75	11
	3	6	240	43
	3	11	313	34
	3	16	306	42
	3	21	304	70
	3	26	319	115
	4	1	215	43
	4	6	237	105
	4	11	208	132
	4	16	196	158
	4	21	194	83
	4	26	244	78
	5	1	34	2
	5	6	67	4
	5	11	87	9
	5	16	118	12
	5	21	134	25
	5	26	130	32
	6	1	29	2
	6	6	63	2
	6	11	129	3
	6	16	185	3
	6	21	195	3
	6	26	287	4

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane Summer 2003	Methane Winter 2004
Dollisons Landing P8	1	1	129	1
	1	6	303	1
	1	11	226	4
	1	16	266	13
	1	21	224	53
	1	26	194	65
	2	1	93	86
	2	6	247	20
	2	11	361	129
	2	16	385	130
	2	21	266	106
	2	26	305	55
	3	1	75	46
	3	6	117	36
	3	11	154	30
	3	16	130	23
	3	21	125	26
	3	26	95	21
	4	1	66	11
	4	6	279	38
	4	11	333	54
	4	16	282	58
	4	21	281	80
	4	26	242	71
	5	1	94	18
	5	6	226	50
	5	11	250	74
	5	16	271	74
	5	21	272	74
	5	26	347	53
	6	1	45	2
	6	6	154	9
	6	11	122	33
	6	16	160	30
	6	21	302	41
	6	26	248	42

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane	
			Summer 2003	Winter 2004
Black River	1	1	124	0
P9	1	6	136	ns
	1	11	156	61
	1	16	210	119
	1	21	155	141
	1	26	218	129
	2	1	140	0
	2	6	252	0
	2	11	210	2
	2	16	271	0
	2	21	271	0
	2	26	327	ns
	3	1	20	4
	3	6	57	32
	3	11	39	94
	3	16	50	126
	3	21	54	113
	3	26	54	89
	4	1	2	1
	4	6	102	47
	4	11	265	132
	4	16	350	206
	4	21	380	249
	4	26	391	297
	5	1	43	22
	5	6	154	91
	5	11	341	126
	5	16	367	109
	5	21	256	114
	5	26	305	119
	6	1	2	2
	6	6	336	110
	6	11	309	154
	6	16	338	215
	6	21	379	229
	6	26	388	230

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane	
			Summer 2003	Winter 2004
Smith Creek	1	1	5	10
P11	1	6	94	22
	1	11	294	51
	1	16	263	105
	1	21	352	188
	1	26	321	219
	2	1	263	4
	2	6	305	61
	2	11	430	188
	2	16	374	290
	2	21	367	308
	2	26	221	341
	3	1	141	4
	3	6	263	33
	3	11	239	97
	3	16	275	171
	3	21	291	243
	3	26	340	327
	4	1	162	3
	4	6	149	168
	4	11	190	405
	4	16	121	502
	4	21	148	328
	4	26	141	487
	5	1	na	10
	5	6	208	328
	5	11	371	368
	5	16	347	416
	5	21	253	304
	5	26	329	289
	6	1	192	3
	6	6	400	82
	6	11	356	173
	6	16	361	190
	6	21	256	172
	6	26	188	172

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane Summer 2003	Methane Winter 2004
Rat Island	1	1	26	61
P12	1	6	15	86
	1	11	121	123
	1	16	238	152
	1	21	240	192
	1	26	252	174
	2	1	64	4
	2	6	85	3
	2	11	192	20
	2	16	217	30
	2	21	210	26
	2	26	252	19
	3	1	47	130
	3	6	135	178
	3	11	153	285
	3	16	271	342
	3	21	321	394
	3	26	340	467
	4	1	301	20
	4	6	303	171
	4	11	313	320
	4	16	339	311
	4	21	371	491
	4	26	408	525
	5	1	164	366
	5	6	204	442
	5	11	255	482
	5	16	274	481
	5	21	223	416
	5	26	227	386
	6	1	2	6
	6	6	14	9
	6	11	34	22
	6	16	75	129
	6	21	73	211
	6	26	25	209

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane Summer 2003	Methane Winter 2004
Fishing Creek	1	1	2	1
P13	1	6	5	1
	1	11	70	1
	1	16	101	1
	1	21	162	2
	1	26	266	8
	2	1	68	1
	2	6	134	4
	2	11	175	19
	2	16	233	53
	2	21	290	156
	2	26	254	179
	3	1	227	90
	3	6	259	217
	3	11	277	252
	3	16	336	264
	3	21	292	275
	3	26	341	228
	4	1	2	3
	4	6	8	3
	4	11	14	2
	4	16	17	1
	4	21	19	1
	4	26	76	2
	5	1	103	1
	5	6	153	1
	5	11	164	3
	5	16	212	5
	5	21	168	5
	5	26	183	12
	6	1	6	ns
	6	6	12	2
	6	11	22	6
	6	16	31	8
	6	21	53	8
	6	26	48	5

Table 5.51-4. continued

Station	Substation	Depth (cm)	Methane Summer 2003	Methane Winter 2004
Prince George P14	1	1	181	3
	1	6	251	11
	1	11	273	26
	1	16	246	55
	1	21	232	100
	1	26	170	128
	2	1	213	47
	2	6	274	138
	2	11	268	208
	2	16	283	185
	2	21	261	203
	2	26	242	182
	3	1	65	1
	3	6	147	11
	3	11	242	68
	3	16	279	179
	3	21	333	244
	3	26	314	262
	4	1	188	182
	4	6	238	211
	4	11	292	273
	4	16	249	328
	4	21	224	345
	4	26	175	378
	5	1	147	27
	5	6	223	43
	5	11	298	59
	5	16	282	67
	5	21	267	82
	5	26	230	119
	6	1	154	160
	6	6	314	326
	6	11	311	357
	6	16	336	371
	6	21	373	396
	6	26	363	320

5.52 Indian Creek (P7)

Porewaters of Indian Creek were essentially fresh during the winters of 2000, 2001, and 2002, with highest salinities never reaching above 0.2 ppt (Table 5.51-1). Winter porewater salinities increased substantially at this station during the winter of 2003 with salinities as high as 1.3 ppt at the near shore substation S1 and averaged 0.4 $\pm$ 0.3 ppt at substations 1, 2, 3, and 4 combined. Substations 5 and 6 were still fresh and likely not influenced as much by tidal floodwaters (Hackney et al. 2003). During the current winter (2004), salinities returned to low values with only 2 substations reaching values above 0.2 ppt (Table 5.51-1). Classifications were generally MP and MPSR, similar to the winters of 2000, 2002, and 2003 but not as fresh as the winter of 2001 where all classifications were MP (Table 5.51-3). Only substation S1 had sulfate concentrations sufficient to sustain sulfate reduction (Table 5.52-1).

An increase in salinity was also observed during summer 2002. During the previous 2 summers, the majority of substations had values below 0.5 ppt. During the summer of 2002 most values at substations farthest from the river had salinities in the 2.0 ppt range, clearly showing an increase in salinity. During the current summer (2003), all but 3 substations sub-depths had salinities below 0.2 ppt indicating very low salinity conditions for this site. For the first time, this site had all methanogenic summer classifications with the majority being M and only a few MPSR (Table 5.51-2). Generally, methane concentrations were higher during the current winter (2004) and summer (2003) (Table 5.51-4) compared to the previous winter (2003) and summer (2002) (Hackney et al. 2003) reflecting the lower sulfate input and higher rates of methane production.

Table 5.52-1. Sulfate Concentrations of Sites. Porewater sulfate concentrations are μM. A "---" indicates no data.

			Sulfate	
Station	Substation	Depth (cm)	Summer 2003	Winter 2004
Town Creek	1	1	169	268
P3	1	6	201	217
	1	11	119	162
	1	16	91	172
	1	21	108	244
	1	26	129	118
	2	1	344	176
	2	6	391	145
	2	11	482	109
	2	16	450	147
	2	21	258	121
	2	26	561	137
	3	1	184	305
	3	6	174	193
	3	11	139	136
	3	16	120	234
	3	21	82	154
Town Creek	3	26	212	165

Table 5.52-1. continued

Station	Substation	Depth (cm)	Sulfate	
			Summer 2003	Winter 2004
(continued)	4	1	207	422
	4	6	231	281
	4	11	215	253
	4	16	191	275
	4	21	165	287
	4	26	125	318
	5	1	81	238
	5	6	134	164
	5	11	222	162
	5	16	92	147
	5	21	111	135
	5	26	105	341
	6	1	166	308
	6	6	110	247
	6	11	121	157
	6	16	126	247
	6	21	76	177
	6	26	43	179
Eagle Island	1	1	73	1129
P6	1	6	41	1154
	1	11	12	1512
	1	16	8	1610
	1	21	14	1289
	1	26	20	863
	2	1	156	1821
	2	6	192	818
	2	11	185	480
	2	16	155	184
	2	21	109	152
	2	26	120	158
	3	1	21	837
	3	6	11	681
	3	11	15	582
	3	16	12	338
	3	21	21	231
	3	26	18	122
	4	1	72	514
	4	6	19	148
	4	11	17	130
	4	16	16	221
	4	21	12	117
Eagle Island	4	26	8	72
(continued)	5	1	50	661
	5	6	56	802
	5	11	30	592

Table 5.52-1. continued

Station	Substation	Depth (cm)	Sulfate Summer 2003	Sulfate Winter 2004
	5	16	24	410
	5	21	12	283
	5	26	28	473
	6	1	76	336
	6	6	54	357
	6	11	45	195
	6	16	25	111
	6	21	26	133
	6	26	19	171
Indian Creek	1	1	42	233
P7	1	6	16	322
	1	11	9	353
	1	16	9	341
	1	21	16	245
	1	26	21	193
	2	1	54	116
	2	6	20	67
	2	11	30	42
	2	16	23	32
	2	21	22	19
	2	26	16	20
	3	1	62	41
	3	6	27	33
	3	11	20	25
	3	16	22	24
	3	21	21	33
	3	26	21	31
	4	1	40	45
	4	6	28	27
	4	11	29	21
	4	16	32	6
	4	21	30	18
	4	26	24	18
	5	1	40	44
	5	6	26	44
	5	11	24	37
	5	16	21	39
	5	21	17	22
Indian Creek	5	26	25	22
(continued)	6	1	36	48
	6	6	31	50
	6	11	26	39
	6	16	22	36
	6	21	28	43
	6	26	23	36

Table 5.52-1. continued

Station	Substation	Depth (cm)	Sulfate	
			Summer 2003	Winter 2004
Dollisons Landing P8	1	1	40	270
	1	6	38	573
	1	11	33	516
	1	16	39	296
	1	21	31	131
	1	26	30	105
	2	1	40	114
	2	6	33	81
	2	11	19	71
	2	16	15	643
	2	21	17	434
	2	26	10	221
	3	1	34	243
	3	6	33	254
	3	11	19	266
	3	16	28	253
	3	21	18	432
	3	26	38	242
	4	1	51	269
	4	6	28	281
	4	11	20	232
	4	16	21	232
	4	21	14	220
	4	26	13	224
	5	1	41	59
	5	6	33	52
	5	11	30	54
	5	16	33	36
	5	21	23	45
	5	26	19	336
	6	1	55	76
	6	6	42	82
	6	11	49	64
	6	16	52	63
	6	21	21	45
Dollisons Landing	6	26	33	64
Black River P9	1	1	22	386
	1	6	25	444
	1	11	24	182
	1	16	32	274
	1	21	36	117
	1	26	28	110
	2	1	50	253
	2	6	17	246

Table 5.52-1. continued

Station	Substation	Depth (cm)	Sulfate	
			Summer 2003	Winter 2004
	2	11	22	216
	2	16	29	177
	2	21	25	154
	2	26	16	134
	3	1	26	194
	3	6	29	128
	3	11	23	60
	3	16	28	57
	3	21	33	43
	3	26	31	37
	4	1	23	140
	4	6	24	106
	4	11	21	51
	4	16	19	57
	4	21	13	52
	4	26	ns	31
	5	1	24	288
	5	6	17	149
	5	11	17	94
	5	16	7	85
	5	21	14	74
	5	26	16	51
	6	1	66	164
	6	6	25	89
	6	11	15	66
	6	16	14	45
	6	21	43	43
	6	26	20	45
Smith Creek	1	1	1201	3776
P11	1	6	1083	4117
	1	11	596	1879
	1	16	400	2535
Smith Creek	1	21	385	1377
(continued)	1	26	578	1097
	2	1	3814	4099
	2	6	402	3406
	2	11	350	1787
	2	16	477	908
	2	21	500	376
	2	26	618	545
	3	1	586	4210
	3	6	215	3223
	3	11	270	2459
	3	16	1259	1842
	3	21	266	1581

Table 5.52-1. continued

Station	Substation	Depth (cm)	Sulfate	
			Summer 2003	Winter 2004
	3	26	348	1144
	4	1	796	3500
	4	6	1948	2288
	4	11	682	708
	4	16	2439	358
	4	21	4934	327
	4	26	1488	340
	5	1	#DIV/0!	2387
	5	6	707	609
	5	11	501	370
	5	16	582	206
	5	21	482	112
	5	26	418	280
	6	1	289	2663
	6	6	269	1264
	6	11	265	473
	6	16	335	178
	6	21	469	644
	6	26	1498	456
Rat Island	1	1	242	914
P12	1	6	171	602
	1	11	152	423
	1	16	134	386
	1	21	51	297
	1	26	145	328
	2	1	292	684
	2	6	359	615
	2	11	404	485
	2	16	302	402
Rat Island	2	21	160	402
(continued)	2	26	118	369
	3	1	191	618
	3	6	143	595
	3	11	137	492
	3	16	120	381
	3	21	94	227
	3	26	118	163
	4	1	162	559
	4	6	216	366
	4	11	99	312
	4	16	68	172
	4	21	50	165
	4	26	62	198
	5	1	111	103
	5	6	83	133

Table 5.52-1. continued

Station	Substation	Depth (cm)	Sulfate	
			Summer 2003	Winter 2004
	5	11	113	840
	5	16	63	125
	5	21	71	159
	5	26	102	150
	6	1	547	993
	6	6	334	882
	6	11	109	846
	6	16	143	478
	6	21	137	295
	6	26	180	294
Fishing Creek	1	1	87	101
P13	1	6	77	156
	1	11	84	226
	1	16	58	306
	1	21	45	285
	1	26	35	283
	2	1	80	130
	2	6	89	118
	2	11	88	110
	2	16	82	94
	2	21	94	72
	2	26	115	39
	3	1	122	80
	3	6	162	38
	3	11	134	32
	3	16	130	49
Fishing Creek	3	21	144	33
(continued)	3	26	140	31
	4	1	124	109
	4	6	149	110
	4	11	123	91
	4	16	199	92
	4	21	158	85
	4	26	146	91
	5	1	312	99
	5	6	108	104
	5	11	81	80
	5	16	70	84
	5	21	46	89
	5	26	52	99
	6	1	253	113
	6	6	356	126
	6	11	114	116
	6	16	79	123
	6	21	96	130

Table 5.52-1. continued

Station	Substation	Depth (cm)	Sulfate Summer 2003	Sulfate Winter 2004
	6	26	93	163
Prince George P14	1	1	77	116
	1	6	50	123
	1	11	31	121
	1	16	38	100
	1	21	26	85
	1	26	26	105
	2	1	42	58
	2	6	38	26
	2	11	31	19
	2	16	49	15
	2	21	40	17
	2	26	48	21
	3	1	54	117
	3	6	49	94
	3	11	42	68
	3	16	35	33
	3	21	30	20
	3	26	42	27
	4	1	43	40
	4	6	33	35
	4	11	27	21
	4	16	31	26
Prince George (continued)	4	21	36	30
	4	26	31	26
	5	1	50	21
	5	6	31	14
	5	11	31	22
	5	16	32	9
	5	21	38	24
	5	26	45	36
	6	1	54	26
	6	6	61	22
	6	11	61	25
	6	16	66	18
	6	21	34	26
	6	26	40	24

5.53 Dollisons Landing (P8)

Winter porewaters at Dollisons Landing have been essentially fresh with only a few substation sub-depths with sulfate concentrations able to support sulfate reduction, mainly during the winter of 2000 (Hackney et al. 2002a). During the winters of 2000 and 2001, the site had porewater salinities in the 0.1 to 0.3 ppt range (Hackney et al. 2002a) and were below 0.1 ppt in the winters of 2002, 2003, and 2004 (Table 5.51-1, Hackney et al. 2002b, Hackney et al. 2003).

Salinities during the current summer (2003) (Table 5.51-1) were all at or below 0.05 ppt. resulting in the lowest salinities observed at this site since the projects inception. For the first time all substations had methanogenic conditions (Table 5.51-2). The majority of substations had M classifications and only a few had MPSR classifications.

5.54 Black River (P9)

Winter porewaters of the Black River station continued to display fresh conditions that have been observed since the winter of 2002. All substations were methanogenic except for the two surface sub-depths at substation S1 (Table 5.51-3). During the previous two winters, a few of the substations were MPSR classifications, however none were MPSR classifications during the current winter (2004) suggesting slightly fresher conditions. Salinities remained low with the majority of values below 0.04 ppt (Table 5.51-1).

Summer 2003 salinities were similar to the winter 2004 values and ranged from approximately 0.01- 0.05 ppt (Table 5.51-1). All but 5 of the substations had salinities at or below 0.03 ppt, which is lower than the previous summer of 2002, which had the majority of salinities above 0.03 ppt. (Hackney et al. 2003). Fresh conditions were evident in the classifications of this station during the current summer of 2003. All substations had M classifications except for one sub-depth, which had a MPSR classification (Table 5.51-2). On the basis of classifications and salinities, the summer of 2003 was the freshest summer since monitoring began for this site.

5.55 Smith Creek (P11)

Porewater salinities during winter at Smith Creek steadily increased from 2000 (Hackney et al. 2002a) to 2002 (Hackney et al. 2002b). However, salinities during the previous winter (2003) [av. = 4.4 $\pm$ 1.1 ppt; (Hackney et al. 2003)] and the current winter (2004) [av. = 3.3 $\pm$ 1.1 ppt; (Table 5.51-1)] were lower than the winter of 2002 [(av. = 7.2 $\pm$ 2.1 ppt; (Hackney et al. 2003)]. The slightly fresher conditions during the current winter are reflected in classifications, which for the first time since the winter of 2000 show a few substations with methanogenic (MPSR) conditions (Table 5.51-3).

All summer 2003 salinities were lower than the previous summer of 2002 (Hackney et al. 2003). The highest values for the current summer were approximately 4 ppt (Table 5.51-1), whereas all salinities from the previous summer (2002) were greater than 4 ppt and reached values as high as 14 ppt. A few of the classifications during the current summer show methanogenic conditions following sulfate depletion, whereas all classifications were SR during the previous summer (Table 5.51-2). Conditions during the current summer are very similar to those observed during summer 2001 (Hackney et al. 2002b).

5.56 Rat Island (P12)

Vegetation along this transect is strongly transitional, from saline tolerant species near the river to salt intolerant species toward the upland boundary. Porewater salinity reflects the gradient with higher salinity at substations near the river and fresher conditions toward the uplands. Winter salinities steadily increased during the past three years (Hackney et al. 2002a, 2002b) with last winter (2003) showing a dramatic salinity increase in upland sites for the first time (Hackney et al. 2003). Average substation S6 salinities were never above 0.2 ppt until winter 2003 when they were 2.7 $\pm$ 0.2 ppt, representing more than a ten-fold increase. Salinities during the current winter (2004) returned to lower values similar to those observed during winters of 2001-2003 with the majority of salinities at the upland sites below 0.3 ppt (Table 5.51-1). Winter classifications reflected lower salinities with several upland sites returning to methanogenic conditions (Table 5.51-3).

A similar pattern was observed during summer of 2002. Previous average salinities at near-shore station S1 have always been below 2 ppt (Hackney et al. 2002a, 2002b) however, during the summer of 2002 the average value at substation S1 was 6.3 $\pm$ 0.7 ppt (Hackney et al. 2003). Salinities at substation 6 increased as well during the summer of 2002. Average salinities at this upland site (1.9 $\pm$ 0.2 ppt, Hackney et al. 2003b) increased almost tenfold from previous average salinities (0.2 + 0.1 ppt, Hackney et al. 2002a; 2002b). The salinities during the current summer of 2003 were lower than that of the previous summer (2002) with the majority of salinities below 0.4 ppt. (Table 5.51-1). On the basis of classifications, the summer of 2003 was the freshest observed during this project. All but 5 substations were methanogenic (Table 5.51-2) whereas during the second freshest summer (2001), 10 substations had sulfate reducing conditions (Hackney at al. 2002a). Methane concentrations during the current winter (2004) and summer (2003) were generally higher than the previous winter (2003) and summer (2002) providing a good example of inhibition of methanogenesis during higher salinity conditions (Table 5.51-4, Hackney et al. 2003).

5.57 Fishing Creek (P13)

Winter porewater salinities at Fishing Creek peaked during winter 2002 and returned to values similar to the winters of 2000 and 2001 during the winter of 2003. Salinities of approximately 1 ppt. were observed during the winter of 2002 (Hackney et al. 2002b). During the winter of 2003 salinities were all less than 0.5 ppt (Hackney et al.

2003). Winter 2004 salinities displayed a freshening trend with all salinities below 0.1 ppt except for substation 3 (Table 5.51-1). On the basis of classifications, the winter of 2004 was the freshest on record with only one site having sulfate concentrations high enough to maintain sulfate reduction (Table 5.52-1, Table 5.51-3). The lowest salinity winter (2000) prior to 2004 had 6 sub-depths with sulfate reducing conditions.

Porewater salinities measured during the previous summer (2002) were the highest ever obtained for Fishing Creek since the beginning of the project with values of approximately 5-7 ppt. at the near-bank substation, 3 ppt at the mid substations, and essentially fresh conditions at stations adjacent the upland (Hackney et al. 2003). Porewater salinities during summer 2003 were the lowest observed during the project for Fishing Creek with values less than 0.1 ppt at the near-bank substation, less than 0.5 ppt at the mid substations (Table 5.51-1). Summer 2003 classifications reflected the fresher conditions with all but 2 sub-depths with methanogenic conditions. In previous summers, at least 1/3 of the sub-depths were sulfate reducing (Table 5.51-2). Higher methane concentrations during the current summer (2003) (Table 5.51-4) compared to the previous summer (2002) (Hackney et al. 2003) reflect the fresher conditions observed during the current summer.

5.58 Prince George Creek (P14)

Winter salinities peaked in 2002 and decreased during the winter 2004. Salinities during the previous winter (2003) ranged from 0.05 to 0.26 ppt (Hackney et al. 2003). Current salinities for the winter of 2004 were all below 0.1 ppt. (Table 5.51-1). For the first time all substation sub-depths were methanogenic (Table 5.51-3) with none having sulfate concentrations able to support sulfate reduction due to lower chloride (Table 5.58-1) and salinities levels (Table 5.51-1).

Summer salinities returned to values similar to those observed before the peak in salinity during the summer of 2002. Summer 2002 salinity values were approximately 1 ppt (Hackney et al. 2003), roughly twice previous values (Hackney et al. 2002a; 2002b). The majority of summer 2003 values were below 0.04 ppt. Prior to the summer of 2002, summer geochemical classifications were essentially all (M). Due to the increase in salinity at this site during the summer 2002, the majority of substations were converted to (SR) (Table 5.51-2). None of the summer 2003 classifications were sulfate reducing and were similar to the previous summers of 2000 and 2001.

Table 5.58-1. Chloride Concentrations of Sites. Chloride concentrations of porewaters in µM.

			Chloride	
Station	Substation	Depth (cm)	Summer 2003	Winter 2004
Town Creek	1	1	7069	7389
P3	1	6	6778	12979
	1	11	9708	14647
	1	16	14857	14154
	1	21	19838	15911
	1	26	22414	17724
	2	1	6138	8399
	2	6	12066	18446
	2	11	21485	31627
	2	16	32475	39599
	2	21	42511	43777
	2	26	39725	47584
	3	1	6081	3166
	3	6	5643	3896
	3	11	6076	4760
	3	16	12288	8554
	3	21	22859	14682
	3	26	35358	22395
	4	1	5700	15159
	4	6	7256	19874
	4	11	9578	25054
	4	16	13921	30284
	4	21	19073	29472
	4	26	25030	25858
	5	1	4422	4178
	5	6	4179	4421
	5	11	6469	5778
	5	16	8411	7460
	5	21	11128	9494
	5	26	13809	25512
	6	1	4138	6426
	6	6	5714	9247
	6	11	7617	10233
	6	16	11770	12136
	6	21	18569	16376
	6	26	36522	21561

Table 5.58-1. continued

Station	Substation	Depth (cm)	Chloride Summer 2003	Chloride Winter 2004
Eagle Island	1	1	191	15750
P6	1	6	ns	17489
	1	11	ns	25041
	1	16	1692	29109
	1	21	6297	24014
	1	26	9272	17962
	2	1	183	38058
	2	6	527	15771
	2	11	1194	12069
	2	16	1982	7756
	2	21	3490	7144
	2	26	6452	7964
	3	1	18587	15077
	3	6	21652	19071
	3	11	23934	19526
	3	16	25763	17805
	3	21	29298	18055
	3	26	33209	18658
	4	1	2581	13590
	4	6	2475	19192
	4	11	3167	21799
	4	16	4433	24849
	4	21	6655	25655
	4	26	10997	26180
	5	1	1725	8345
	5	6	3438	10046
	5	11	4580	9564
	5	16	5635	7111
	5	21	7062	5033
	5	26	10912	8869
	6	1	393	2616
	6	6	693	2488
	6	11	1227	1642
	6	16	1725	2069
	6	21	2578	2126
	6	26	3564	1661

Table 5.58-1. continued

			Chloride	
Station	Substation	Depth (cm)	Summer 2003	Winter 2004
Indian Creek	1	1	420	494
P7	1	6	499	581
	1	11	1101	690
	1	16	2823	956
	1	21	6054	1930
	1	26	9740	2821
	2	1	497	1071
	2	6	645	1049
	2	11	827	1144
	2	16	1212	1296
	2	21	2143	998
	2	26	4761	995
	3	1	216	959
	3	6	317	899
	3	11	343	827
	3	16	435	796
	3	21	565	827
	3	26	750	724
	4	1	414	806
	4	6	505	763
	4	11	522	738
	4	16	561	568
	4	21	533	585
	4	26	582	583
	5	1	243	398
	5	6	352	494
	5	11	406	419
	5	16	410	414
	5	21	400	418
	5	26	383	409
	6	1	137	254
	6	6	134	253
	6	11	142	250
	6	16	166	255
	6	21	214	269
	6	26	159	285

Table 5.58-1. continued

Station	Substation	Depth (cm)	Chloride	
			Summer 2003	Winter 2004
Dollisons	1	1	250	441
Landing P8	1	6	282	437
	1	11	250	330
	1	16	341	306
	1	21	338	350
	1	26	302	385
	2	1	463	582
	2	6	485	485
	2	11	588	513
	2	16	761	823
	2	21	635	728
	2	26	631	623
	3	1	576	616
	3	6	685	638
	3	11	718	629
	3	16	728	513
	3	21	684	621
	3	26	669	486
	4	1	315	523
	4	6	338	550
	4	11	433	501
	4	16	410	488
	4	21	414	462
	4	26	398	430
	5	1	407	1041
	5	6	512	1016
	5	11	495	955
	5	16	566	910
	5	21	504	852
	5	26	541	883
	6	1	440	962
	6	6	427	922
	6	11	458	871
	6	16	561	808
	6	21	486	728
	6	26	598	711

Table 5.58-1. continued

Station	Substation	Depth (cm)	Chloride	
			Summer 2003	Winter 2004
Black River	1	1	220	4185
P9	1	6	266	5603
	1	11	373	1442
	1	16	459	3640
	1	21	555	756
	1	26	615	691
	2	1	238	526
	2	6	204	455
	2	11	267	425
	2	16	325	409
	2	21	379	412
	2	26	437	525
	3	1	301	494
	3	6	556	386
	3	11	ns	380
	3	16	757	399
	3	21	536	432
	3	26	559	419
	4	1	220	467
	4	6	265	454
	4	11	393	424
	4	16	353	383
	4	21	453	439
	4	26	555	451
	5	1	218	484
	5	6	290	404
	5	11	391	421
	5	16	404	408
	5	21	377	440
	5	26	422	705
	6	1	171	442
	6	6	244	564
	6	11	206	433
	6	16	242	514
	6	21	288	921
	6	26	319	631

Table 5.58-1. continued

Station	Substation	Depth (cm)	Chloride	
			Summer 2003	Winter 2004
Smith Creek	1	1	12146	75496
P11	1	6	12235	76227
	1	11	32026	31789
	1	16	41307	49210
	1	21	55840	47394
	1	26	66901	63701
	2	1	5909	80356
	2	6	5108	62016
	2	11	12935	37390
	2	16	28629	29313
	2	21	37463	25567
	2	26	68649	27225
	3	1	6114	77879
	3	6	8698	69832
	3	11	13833	61155
	3	16	19517	54115
	3	21	26347	54328
	3	26	34488	50920
	4	1	8279	73634
	4	6	20649	52221
	4	11	19869	33274
	4	16	27129	34498
	4	21	58523	44011
	4	26	56417	49546
	5	1	ns	56702
	5	6	23998	31974
	5	11	34230	57298
	5	16	48601	60039
	5	21	56049	63504
	5	26	58069	65016
	6	1	6194	51650
	6	6	8037	27406
	6	11	9330	16385
	6	16	17035	14550
	6	21	24276	24534
	6	26	32548	31508

Table 5.58-1. continued

Station	Substation	Depth (cm)	Chloride	
			Summer 2003	Winter 2004
Rat Island P12	1	1	4299	15354
	1	6	1665	11778
	1	11	2664	10624
	1	16	3718	10527
	1	21	2695	10776
	1	26	5052	11241
	2	1	1427	5943
	2	6	2696	4860
	2	11	3741	4266
	2	16	5134	3586
	2	21	9022	2965
	2	26	12088	3340
	3	1	1293	9934
	3	6	1251	8890
	3	11	1848	8227
	3	16	2710	6489
	3	21	2233	5874
	3	26	3355	5738
	4	1	1968	5281
	4	6	2336	3381
	4	11	2160	3859
	4	16	2856	3381
	4	21	3097	3589
	4	26	4609	4349
	5	1	5844	7172
	5	6	6854	7028
	5	11	6322	29678
	5	16	5747	6834
	5	21	6824	6842
	5	26	7858	6999
	6	1	4637	2505
	6	6	4451	3058
	6	11	4673	3538
	6	16	5754	3657
	6	21	6713	4156
	6	26	8329	4218

Table 5.58-1. continued

Station	Substation	Depth (cm)	Chloride Summer 2003	Chloride Winter 2004
Fishing Creek	1	1	361	338
P13	1	6	358	422
	1	11	347	447
	1	16	351	482
	1	21	415	609
	1	26	884	617
	2	1	997	1311
	2	6	1100	1368
	2	11	1081	1317
	2	16	1143	1250
	2	21	1232	1391
	2	26	1326	1422
	3	1	2242	3771
	3	6	2831	3719
	3	11	3021	3948
	3	16	3790	4442
	3	21	5046	4617
	3	26	6752	5148
	4	1	1551	1251
	4	6	1647	1039
	4	11	1603	985
	4	16	1943	910
	4	21	1517	835
	4	26	1717	892
	5	1	1956	617
	5	6	1335	635
	5	11	1500	566
	5	16	1525	652
	5	21	1563	632
	5	26	1377	543
	6	1	505	325
	6	6	677	242
	6	11	357	386
	6	16	279	354
	6	21	305	406
	6	26	350	460

Table 5.58-1. continued

Station	Substation	Depth (cm)	Chloride	
			Summer 2003	Winter 2004
Prince George P14	1	1	356	516
	1	6	381	535
	1	11	347	529
	1	16	418	512
	1	21	444	523
	1	26	599	578
	2	1	2081	772
	2	6	3534	930
	2	11	3714	1177
	2	16	3912	1171
	2	21	3905	1295
	2	26	4022	1409
	3	1	440	583
	3	6	443	517
	3	11	404	577
	3	16	444	635
	3	21	527	634
	3	26	983	846
	4	1	765	779
	4	6	1025	913
	4	11	1355	943
	4	16	1923	1097
	4	21	2585	1104
	4	26	3016	1129
	5	1	383	436
	5	6	415	437
	5	11	454	412
	5	16	487	429
	5	21	460	510
	5	26	505	484
	6	1	281	298
	6	6	334	431
	6	11	413	317
	6	16	445	279
	6	21	375	309
	6	26	558	313

6.0 BENTHIC INFAUNA COMMUNITIES

6.1 Summary

This report summarizes infaunal community patterns at 9 sites distributed among the Cape Fear River, Northeast Cape Fear River, and Town Creek from 1999-2003. This period covered three major potential system-level impacts: a developing drought in 2001-2002, a period of recovery and relatively higher freshwater input in 2003, as well as the initiation of channel deepening construction in 2001-2002. Diversity was generally lowest in 2000 and species richness was generally highest in 1999, but both showed variable patterns among sites for the other 4 years. Multidimensional Scaling Analysis indicated that 2002 and 2003 represented distinct community assemblages based on species similarity compared to 1999-2001. These 2 years differed from each other, but more dramatic was a separation of these 2 years from the previous 3 years of sampling. Examination of dominant species at each site indicates that many sites initially dominated exclusively by tidal freshwater and oligohaline species included a significant proportion of oligohaline-mesohaline polychaetes by 2002, suggesting a potential salinity affect related to the drought at that time. In 2003 the upper estuarine stations were again dominated by oligohaline species, but the taxonomic composition differed from that sampled in earlier years. Further analysis of community trends after the drought has ended and the community has experienced several years of post-drought conditions will be needed to distinguish climatic from channel deepening impacts.

6.2 Background

Infaunal communities associated with tidal wetlands are critical to support the nursery function of the estuarine system. Because of the location of these communities as well as the tidal patterns and relatively narrow physical conditions needed to support them, these groups are predicted to be among the prime indicators of ecosystem impacts. As part of the U.S. Army Corps of Engineers project to deepen and widen the Cape Fear River shipping channel from the mouth of the river to Wilmington Harbor, benthic infaunal communities have been monitored at stations predicted to have the greatest potential impacts. The focus of this sampling effort is on the fringing wetlands that border the river and represent critical habitat and nursery areas for a number of commercially and ecologically important taxa. Changes in the composition and abundance of organisms living within or directly on the sediments of the fringing marsh (infauna) may result from changes in salinity, flow, and tidal inundation. Benthic infaunal community patterns integrate environmental changes at a specific site over time. Most infauna have limited post-larval mobility or dispersal, with abundances at a site reflecting a combination of recruitment patterns and site-specific processes. Infauna may be relatively long-lived, with lifespans of months to years for some taxa, and they occupy intermediate trophic positions, consuming detrital or planktonic food sources and being prey for larger fish and decapods. As a result, the community present in an area represents cumulative impacts of varying environmental factors over a several month period, both biotic and abiotic. Changes in the composition of the infaunal community in response to changing environmental conditions may occur more slowly than for more motile organisms that can migrate to optimal locations. However, changes in this group may also have fundamental importance for local ecosystem functioning because of their key position in nearshore estuarine food webs.

While many benthic species are resilient to short-term disturbances, long-term change associated with fluctuations in water quality, changes in tidal inundation or amplitude, changes in current flow or local hydrology, changes in salinity regime, or other physical factors may alter species composition and abundance. These physical changes may impact the infaunal community through direct mortality, reduced dispersal, food web alteration, and impacts related to increased stress (e.g. reduced feeding, competition). The monitoring effort reported here is designed to detect possible changes in the infaunal communities at selected sites that may be coincident with the timing of widening and deepening of the Cape Fear River shipping channel. This design should provide the ability to distinguish potential long-term changes related to these anthropogenic impacts from year-to-year variability related to climatic fluctuations. Current working hypotheses are: 1) Changes in salinity and/or tidal amplitude and/or inundation period will lead to changes in intertidal and shallow subtidal benthic community composition. 2) If alterations of the Cape Fear River shipping channel change estuarine flow characteristics, a change in community composition and function reflecting altered recruitment patterns may follow.

Polychaetes, oligochaetes, amphipods, and insect larvae are the dominant taxonomic groups of the Cape Fear estuary. The pattern of specific species that dominate a site changes along the estuarine gradient from polyhaline to oligohaline and tidal freshwater conditions. Bivalves and gastropods, though common in other estuaries, are not abundant in the Cape Fear system and are generally represented primarily by juveniles (<1-4 mm shell length). Polychaetes (segmented worms bearing specialized appendages) are common throughout the estuary and are generally the numerically dominant taxa in euhaline to mesohaline environments. Polychaetes have a variety of living modes including free-living, burrowing, and sedentary forms. Burrowing and tube dwelling species dominate in most of the intertidal and shallow subtidal areas and are common prey for fish, shrimp, and crabs. Oligochaetes are another group of segmented worms, but they generally lack specialized appendages, have a burrowing habit, and exhibit direct development. Direct development in this group often results in locally dense patches and the ability to respond quickly to local environmental changes. Their deeper burrowing habit often makes them less available as a prey resource for fish and decapods than tube dwelling polychaetes or amphipods. Amphipods are a diverse group of brooding crustaceans. This group can exhibit explosive population growth under optimal conditions, and serves as a critical food resource in fringing wetlands during at least certain time periods. Although many are free-living or pelagic, a large proportion of estuarine amphipods are tube builders that can be highly mobile over small spatial scales and may quickly colonize disturbed habitats. Insect larvae are among the most numerous and diverse groups that inhabit the oligohaline and tidal freshwater regions of the estuary, but are generally absent from lower mesohaline and more saline areas. Insect larvae exploit virtually every habitat type in the upper estuary and are distinct from other groups in having aerial dispersal. However, many insects are very sensitive to salt intrusions and are indicators of changing salinity conditions.

6.3 Methodology

Infaunal core samples were collected at nine stations along the Cape Fear River estuarine gradient. Three benthic stations are located in Town Creek (P2 at the mouth of Town Creek, P3A and P3B inner Town Creek), three stations in the main stem Cape Fear above the city of

Wilmington (P6- Eagle Island, P7- Indian Creek, and P8- Dollisons Landing), and three stations in the North East Cape Fear River (P11- Smith Creek, P12- Rat Island, and P13- Fishing Creek). These stations are the same as those being monitored for epifauna patterns (Chapter 7) and represent a subset of those stations being monitored for changes in physical factors that may be causal for possible biotic changes (including tidal elevation, inundation, and biogeochemical composition among other variables).

Infaunal core samples (10 cm diameter X 15 cm deep) were collected at two upper intertidal sub-sites and two lower intertidal sub-sites at each station. These sub-sites are fixed stations that were originally marked (and positions recorded using GPS) in 1999. Three replicate core samples were collected within a one-meter area around these points. Core samples are collected at all stations in June of each year. All samples are fixed in a 10% formalin solution (~4% formaldehyde), with rose Bengal dye added, and later sieved through a 500 micron screen to remove excess sediment and preserved in 50% isopropanol. All organisms are separated from the remaining sediment by sorting under a dissecting microscope and identified to lowest reasonable taxon, in most cases this is genus or species.

The major deepening and widening efforts for the Cape Fear River channel began in winter 2001 and are expected to be complete in 2008. Since the current report summarizes data from infaunal samples taken through June 2003, these data represent primarily background conditions (pre-dredging; 1999-2001) and possible initial impacts related to the actual sediment removal activities (2002-2003). Full effects of the deepening project cannot be assessed until 2-3 years of post-dredging data are available to compare to pre-dredging conditions. However, interim community patterns at each site over the 5 years of sampling are being assessed by examining patterns of species diversity, species richness, species dominance, and community similarity as described by multi-dimensional scaling. Per site diversity was calculated using the Shannon-Weiner Diversity Index and was compared along with per site species richness among sites and years. To assess patterns of species dominance over time, all species comprising at least 3% of the total fauna at a site on a given sampling date were recorded. Community similarity was compared among site/year combinations using the ANOSIM and multidimensional scaling data analysis procedures of the PRIMER statistical package (Clarke and Gorley 2001). These procedures examine community similarity based on a Bray-Curtis Similarity matrix. All species were included in this analysis and abundances were square root transformed to reduce dominating effects of common taxa on analyses. Abundances of major taxanomic groups (polychaetes, oligochaetes, amphipods and insects) and major functional guilds (sedentary/tube dwellers, surface/mobile taxa, deep burrowing taxa, and surface burrowing taxa) were compared among years separately for each site using analysis of variance. Abundances were log-transformed before analyses to meet assumptions of homogeneity of variances.

6.4 Faunal Patterns

Species richness and diversity exhibited significant variation among years and sites (ANOVA; $p<0.0001$). Diversity decreased from downstream to upstream sites for both the mainstem Cape Fear (P6-P8) and Northeast Cape Fear sites (P11-P13) (Figure 6.4-1). However, this pattern did not hold for Northeast Cape Fear sites in 2002, possibly reflecting the influence of increased salinity during that year, or for the uppermost site (P8) in either 2002 or 2000. This upstream/downstream pattern was not present for the Town Creek sites. Among-year patterns in diversity were less clear. Diversity was generally low in 2000 compared to other years, with 2000 representing the lowest or second lowest period for diversity in 8 of the 9 sites. There were no other consistent trends among the other years across the 9 sites sampled. Much of the variation in diversity was due to changes in dominance. Species richness did not exhibit consistent patterns among sites and years, except for generally higher species richness at all sites in 1999 (1999 represented the time of highest or second highest diversity for all 9 sites) (Figure 6.4-2).

Analysis of community similarity and the associated graphical representation of those patterns, multidimensional scaling (MDS), are increasingly being used to discriminate infaunal community patterns among years or sites. We compared community assemblages among years and sites and found the strongest patterns related to among year differences (Figure 6.4-3; ANOSIM: $R=0.724$; $p<0.001$). Two patterns were most apparent: The first involves strong differences between 2002/2003 (both circled) and previous years. Although there is a gradient among the 1999-2001 samples (indicated with 1999 site samples graphing lower on the y-axis and grading into 2000 and then 2001 samples moving up the y-axis), these sites do not differentiate strongly from each other. However, there is a clear break between these earlier samples and the later 2 years. The second pattern is apparent as a difference between 2002 and 2003 samples. Although MDS does not have specific factors associated with each axis, the differences along the y-axis are consistent with salinity (lower salinity years lower on the y-axis, higher salinity higher on the y-axis); while the 2002/2003 split from earlier sample years dominates the x-axis separation. Differences among sites were not strong relative to among-year patterns.

This difference among years is also reflected in ANOVA comparisons of among-year abundances for major taxonomic groups and functional guilds. Where significant differences occurred, 2003 represented extreme levels for at least one taxonomic group for all but one site (Table 6.4-1). General patterns included higher abundances of insect larvae (except for P8) and moderate to lower numbers of amphipods and polychaetes during 2003 where significant differences occurred. Functional guild changes also reflected these patterns, with among-year variations in surface/mobile (often dominated by insect larvae and amphipods) and sedentary/tube builders.

More pronounced than variations in abundance of taxonomic groups was their relative composition. For example, insect larvae and certain amphipods were among the dominant taxa at several sites during both 1999 and 2003 (Table 6.4-2). However, in 1999 the dominant insect larvae were *Bezzia/Palpomyia* at one site, *Parandalia* at one site, and *Procladius* at another site. The dominant amphipods were *Gammarus* spp. In 2003 the dominant insect larvae were *Polypedilium* at 6 sites, *Dicrotendipes* at 3 sites and *Cryptochironomus* and *Paratindipes* at 1 site each. Where amphipods dominated, *Corophium* was usually the most common genera in 2003 samples. As noted in last year's progress report, 2002 was distinguished by greater dominance of several polychaete species, consistent with a drought signature, and decline of insects at most sites. Variations in abundances of less common taxa are also apparent among years for most sites (Tables 6.4-3 through 6.4-11).

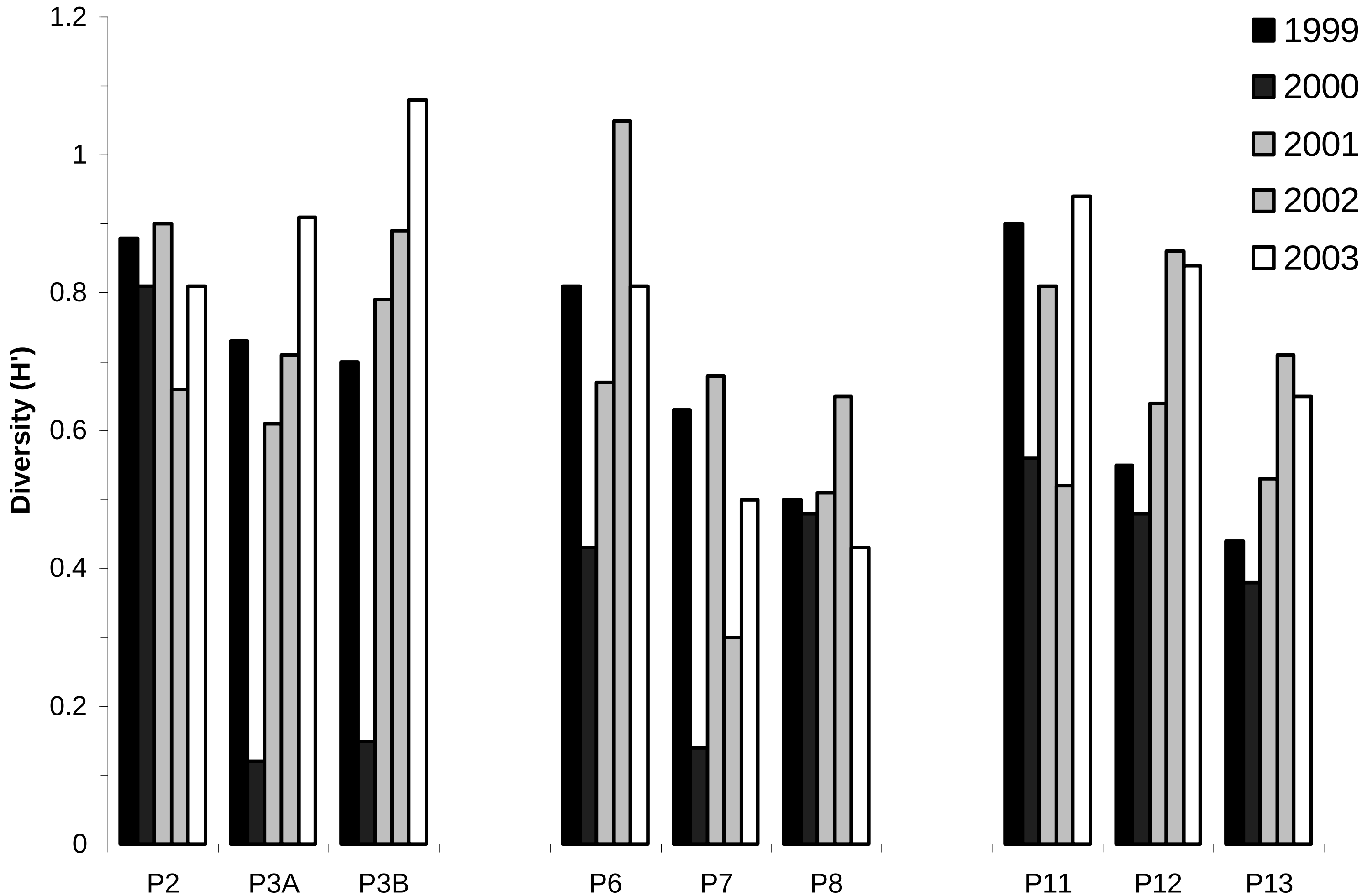


Figure 6.4-1: Diversity (H’, Shannon-Weiner Index) at Town Creek (P2-P3), mainstem Cape Fear River (P6-P8) and Northeast Cape Fear River (P11-P13) sampling stations from 1999-2003.

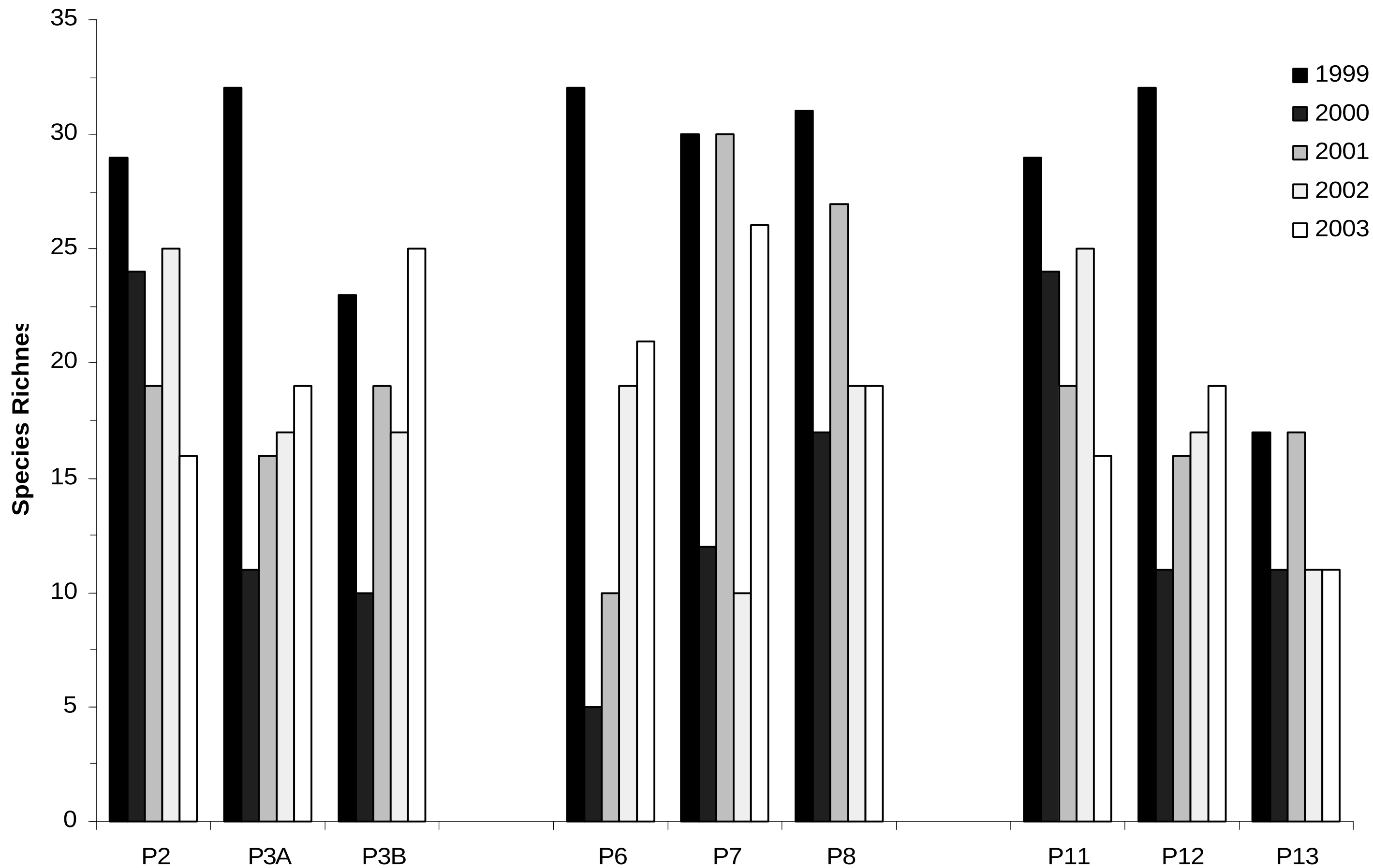


Figure 6.4-2: Species Richness (total number species sampled) at Town Creek (P2-P3), mainstem Cape Fear River (P6-P8) and Northeast Cape Fear River (P11-P13) sampling stations from 1999-2003.

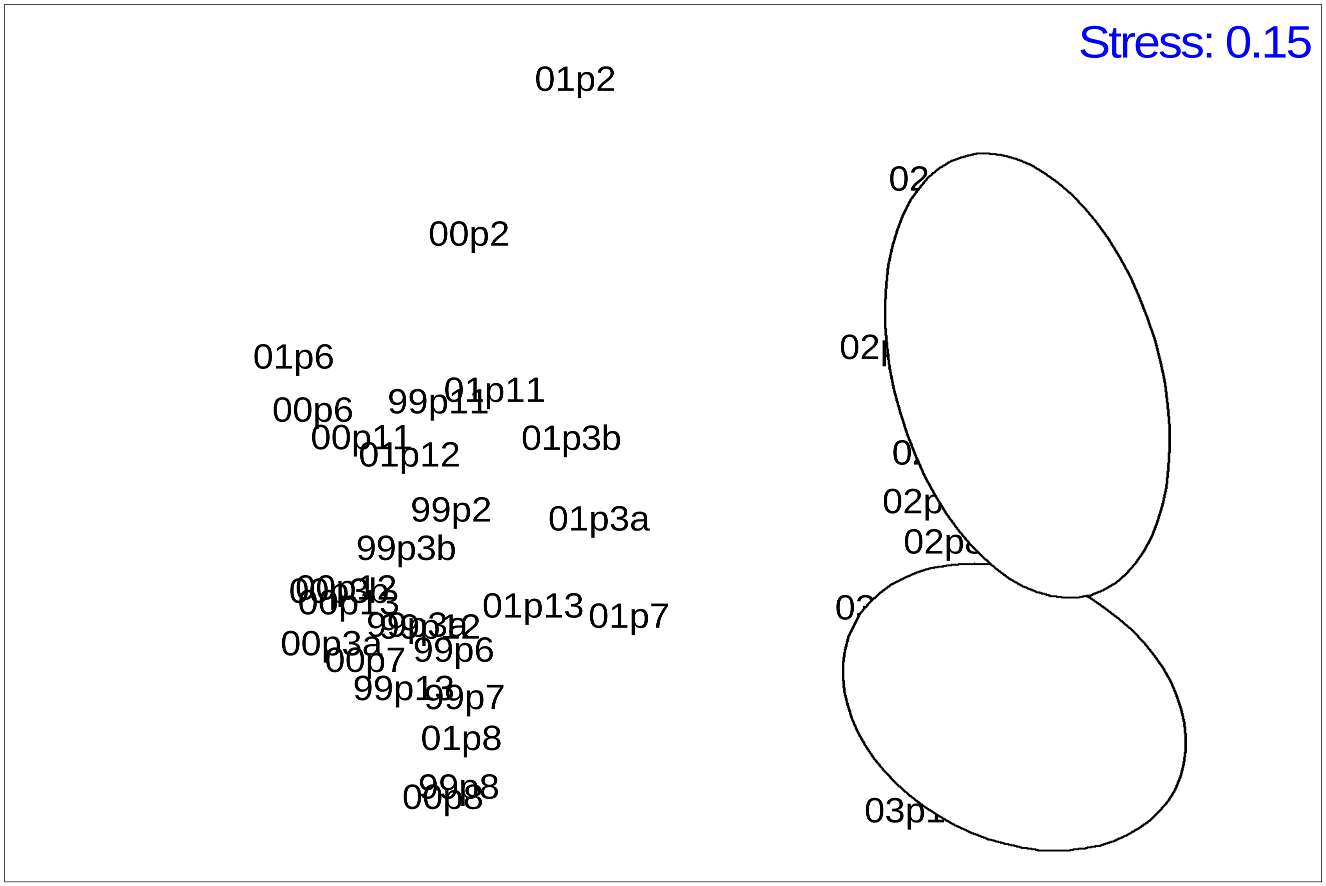


Figure 6.4-3. Multidimensional Scaling plot for infaunal community similarity. Samples are identified as year (99, 00, 01, 02, 03) / site (p2, p3a. p3b, p6, p7, p8, p11, p12, p13) combinations. 2002 and 2003 samples are indicated within circles.

Table 6.4-1. Among-year differences in density of major taxonomic groups and major functional groups for each site. F (and p) values are from Analysis of Variance. Where ANOVA indicated a significant year effect, year differences were tested with an SNK post-hoc test. Years with the same superscript do not differ significantly (p<0.05). Years with two letter superscripts were not different from either year.

Site	Group	F (p)	SNK (where ANOVA significant)
P2	Sedentary/tube builder	4.44 (0.005)	00^{a} 02^{a} 99^{ab} 01^{ab} 03^{b}
	Surface/mobile	4.20 (0.006)	03^{a} 99^{ab} 00^{ab} 01b 02^{b}
	Deep burrowing	5.33 (0.002)	99^{a} 00^{b} 02^{b} 03^{b} 01^{b}
	Surface burrower	3.88 (0.01)	02^{a} 99^{a} 01^{ab} 00^{ab} 03^{b}
	Oligochaete	6.17 (0.0005)	99^{a} 00^{b} 03^{b} 02^{b} 01^{b}
	Polychaete	15.34 (0.0001)	02^{a} 00^{ab} 99^{b} 01^{c} 03^{c}
	Amphipoda	7.18 (0.0002)	00^{a} 01^{a} 02^{b} 99^{b} 03^{b}
	Insecta	1.62 (0.203)	
P3A	Sedentary/tube builder	1.82 (0.16)	
	Surface/mobile	0.78 (0.51)	
	Deep burrowing	9.79 (0.0001)	00^{a} 01^{b} 02^{bc} 03^{c}
	Surface burrower	2.92 (0.05)	01^{a} 00^{a} 02^{a} 03^{a}
	Oligochaete	9.39 (0.0001)	00^{a} 01^{b} 02^{bc} 03^{c}
	Polychaete	0.77 (0.52)	
	Amphipoda	1.36 (0.27)	
	Insecta	0.77 (0.48)	
P3B	Sedentary/tube builder	3.39 (0.07)	
	Surface/mobile	3.65 (0.015)	03^{a} 99^{b} 00^{b} 02^{b} 01^{b}
	Deep burrowing	6.41 (0.0004)	00^{a} 99^{b} 01^{b} 03^{b} 02^{b}
	Surface burrower	1.49 (0.22)	
	Oligochaete	5.39 (0.002)	00^{a} 99^{b} 01^{b} 03^{b} 02^{b}
	Polychaete	1.90 (0.13)	
	Amphipoda	0.98 (0.43)	
	Insecta	4.45 (0.015)	03^{a} 99^{b} 01^{b} 00^{b}
P6	Sedentary/tube builder	2.06 (0.011)	
	Surface/mobile	3.28 (0.021)	99^{a} 03^{ab} 01^{b} 02^{b} 00^{b}
	Deep burrowing	4.59 (0.0004)	99^{a} 03^{ab} 00^{ab} 02^{b} 01^{b}
	Surface burrower	0.83 (0.51)	
	Oligochaete	4.60 (0.004)	99^{a} 03^{ab} 00^{ab} 02^{b} 01^{b}
	Polychaete	1.73 (0.16)	
	Amphipoda	5.89 (0.0008)	99^{a} 03^{b} 01^{b} 02^{b} 00^{b}
	Insecta	7.19 (0.0008)	99^{a} 03^{a} 01^{b} 00^{b}

Table 6.4-1. continued

Site	Group	F (p)	SNK (where ANOVA significant)
P7	Sedentary/tube builder	1.82 (0.14)	
	Surface/mobile	9.94 (0.0001)	03^{a} 01^{ab} 00^{b} 99^{b} 02^{c}
	Deep burrowing	6.14(0.0005)	03^{a} 00^{ab} 99^{abc} 01^{bc} 02^{c}
	Surface burrower	1.25 (0.30)	
	Oligochaete	6.34 (0.0004)	03^{a} 00^{a} 99^{ab} 01^{ab} 02^{b}
	Polychaete	1.02 (0.41)	
	Amphipoda	5.04 (0.002)	01^{a} 99^{ab} 03^{b} 02^{b} 00^{b}
	Insecta	7.01 (0.0008)	03^{a} 99^{b} 00^{b} 01^{b}
P8	Sedentary/tube builder	5.89 (0.0007)	00^{a} 01^{ab} 99^{ab} 03^{bc} 02^{c}
	Surface/mobile	6.74 (0.0003)	00^{a} 99^{b} 03^{b} 01^{b} 02^{b}
	Deep burrowing	14.72 (0.0001)	00^{a} 99^{ab} 03^{ab} 01^{b} 02^{c}
	Surface burrower	9.90 (0.0001)	01^{a} 02^{b} 00^{b} 03^{b} 99^{b}
	Oligochaete	14.73 (0.0001)	00^{a} 99^{ab} 03^{ab} 01^{b} 02^{c}
	Polychaete	1.95 (0.12)	
	Amphipoda	7.82 (0.0001)	01^{a} 99^{ab} 00^{bc} 02^{bc} 03^{c}
	Insecta	3.31 (0.035)	00^{a} 99^{b} 01^{b} 03^{b}
P11	Sedentary/tube builder	4.2 (0.007)	01^{a} 03^{ab} 99^{b} 00^{b} 02^{b}
	Surface/mobile	9.17 (0.0001)	03^{a} 01^{b} 00^{b} 99^{b} 02^{b}
	Deep burrowing	0.76 (0.56)	
	Surface burrower	14.40 (0.0001)	01^{a} 02^{b} 03^{b} 00^{b} 99^{b}
	Oligochaete	0.76 (0.56)	
	Polychaete	5.01 (0.003)	01^{a} 03^{b} 99^{b} 00^{b} 02^{b}
	Amphipoda	1.04 (0.40)	
	Insecta	6.81 (0.002)	03^{a} 01^{b} 00^{b} 99^{b} 02^{b}
P12	Sedentary/tube builder	1.59 (0.19)	
	Surface/mobile	9.02 (0.0001)	03^{a} 01^{b} 00^{b} 99^{b} 02^{b}
	Deep burrowing	2.47 (0.06)	
	Surface burrower	1.33 (0.28)	
	Oligochaete	2.44 (0.063)	
	Polychaete	1.13 (0.36)	
	Amphipoda	0.54 (0.70)	
	Insecta	5.38 (0.005)	03^{a} 99^{b} 01^{b} 00^{b}

Table 6.4-1. continued

Site	Group	F (p)	SNK (where ANOVA significant)
P13	Sedentary/tube builder	1.73 (0.16)	
	Surface/mobile	5.98 (0.0008)	03^{a} 01^{b} 00^{b} 99^{b} 02^{b}
	Deep burrowing	6.87 (0.0003)	99^{a} 01^{ab} 00^{ab} 03^{bc} 02^{c}
	Surface burrower	1.53 (0.21)	
	Oligochaete	6.86 (0.0003)	99^{a} 01^{ab} 00^{ab} 03^{bc} 02^{c}
	Polychaete	2.15 (0.095)	
	Amphipoda	2.43 (0.064)	
	Insecta	1.61 (0.21)	

Table 6.4-2. Numerically dominant taxa by site and year, 1999-2003. Mobility guilds: SM-surface mobile, SB-surface burrowing, DB-deep burrowing, ST-sedentary or tube building; Feeding guilds: D-deposit feeders, S-suspension feeders, H-grazers, shredders, detritivores, P-predators.

				Guild Type
Year	Site	Dominant Taxa	% abundance	mobility/feeding
1999	P2	Bivalve juv.	3.1	ST / S
		Hobsonia florida	5.1	ST / D
		Oligochaeta	47.1	DB / D
		Parandalia sp.	3.4	SB / ?
		Polydora ligni	14.1	ST / D
		Polydora socialis	6.0	ST / D
		Streblospio benedicti	4.2	ST / D
1999	P3A	*Dolichopus*	3.3	SM / P
		Gammarus tigrinus	4.5	SM / H,D
		Hobsonia florida	4.8	ST / D
		Oligochaeta	71.7	DB / D
		Procladius sp.	3.8	SM / H
1999	P3B	*Gammarus laurencianus*	3.6	SM / H
		Gammarus tigrinis	8.0	SM / H
		Hobsonia florida	10.9	ST / D
		Oligochaeta	54.3	DB / D
1999	P6	*Cyathura polita*	6.8	SM / H
		Laeonereis culveri	3.5	SM / D,H
		Oligochaeta	64.5	DB / D
1999	P7	Oligochaeta	86.2	DB / D
1999	P8	bivalve juv.	5.3	ST / S
		Oligochaeta	83.9	DB / D

Table 6.4-2. continued

Year	Site	Dominant Taxa	Guild Type % abundance	 mobility/feeding
1999	P11	*Hobsonia florida*	19.6	ST / D
		insect pupae	5.4	SM / ?
		Oligochaeta spp.	35.7	DB / D
		Tubificoides heterochaetus	18.5	DB / D
1999	P12	*Bezzia*/*Palpomyia*	3.4	SM / H,P
		Oligochaeta	83.2	DB / D
1999	P13	Oligochaeta	93.0	DB / D
2000	P2	*Boccardiella* sp.	51.0	ST / D
		Corophium acherasicum	8.3	ST,SM / H
		Hobsonia florida	8.3	ST / D
		Oligochaeta	13.4	DB / D
2000	P3A	Dolichopodid larvae	3.0	SM / ?
		Oligochaeta	94.9	DB / D
2000	P3B	Oligochaeta	94.0	DB / D
2000	P6	*Laeonereis culveri*	13.2	SM / D,H
		Maranzellaria virdis	11.8	ST / D
		Namalycastis abiuma	5.3	SM / ?
		Oligochaeta	68.4	DB / D
2000	P7	Oligochaeta	94.8	DB / D
2000	P8	bivalve juv.	7.6	ST / S
		Nematoda*	6.8	(varied)
		Oligochaeta	74.7	DB / D
2000	P11	*Boccardiella* sp.	5.5	ST / D
		Dicrotandipes sp.	4.4	SM / ?
		Maranzellaria virdis	16.5	ST / D
		Oligochaeta	63.7	DB / D
		Polypedilum sp.	3.3	SM / H
2000	P12	Nematoda*	31.6	(varied)
		Oligochaeta	62.1	DB / D
2000	P13	Dolichopodid	3.0	SM / P
		Laeonereis culveri	4.0	SM / D,H
		Nematoda*	5.1	(varied)
		Oligochaeta	82.3	DB / D
2001	P2	*Corophium acherasicum*	54.0	ST,SM / H
		Oligochaeta	4.2	DB / D
		Polydora socialis	5.4	ST / D
		Tanais sp.	28.0	ST, SM / H
2001	P3A	*Eukiefferiella* sp.	7.3	SM / ?
		Oligochaeta	76.1	DB / D
		Orchestia sp.	3.6	SM / H
2001	P3B	*Corophium acherasicum*	3.7	ST,SM / H
		Hobsonia florida	4.6	ST / D

Table 6.4-2. continued

Year	Site	Dominant Taxa	Guild Type % abundance	Guild Type mobility/feeding
		Oligochaeta	52.8	DB / D
		Orchestia sp.	27.8	SM / H
2001	P6	Amphipod sp. (juv)	3.2	SM / ?
		Dolichopodid larvae	6.5	SM / P
		Hemipodus roseus	11.3	SM / D,P
		Maranzellaria virdis	29.0	ST / D
		Oligochaeta	41.9	DB / D
2001	P7	*Dolichopus* sp.	3.7	SM / P
		Gammarus daiberi	4.9	SM / H
		Oligochaeta	82.4	DB / D
2001	P8	bivalve juv.	4.9	ST / S
		Oligochaeta	76.3	DB / D
		Orchestia sp.	4.2	SM / H
2001	P11	Nereidae juv.	20.4	SB / D,H
		Hobsonia florida	6.7	ST / D
		Maranzellaria virdis	35.6	ST / D
		Oligochaeta	23.1	DB / D
		Polypedilum sp.	4.9	SM / H
2001	P12	*Boccardiella* sp.	36.0	ST / D
		Oligochaeta	46.0	DB / D
2001	P13	Oligochaeta	92.4	DB / D
2002	P2	*Mediomastus* sp.	4.1	DB / D
		Parandalia sp. A	3.9	SB / ?
		Streblospio benedicti	57.0	ST / D
		Fabriciola sp.	20.4	ST / D
		Fabriciola trilobata	3.2	ST / D
2002	P3A	Collembola	34.0	SM / H
		Streblospio benedicti	6.9	ST / D
		Tubificoides heterochaetus	8.2	DB / D
		Tubificidae	42.1	DB / D
2002	P3B	*Bezzia*/*Palpomyia*	4.3	SM / H,P
		Streblospio benedicti	21.5	ST / D
		Tubificoides heterochaetus	4.3	DB / D
		Enchytraeidae sp.	16.1	DB / D
		Tubificidae	39.8	DB / D
2002	P6	Collembola	5.0	SM / H
		Laeonereis culveri	16.3	SM / D,H
		Streblospio benedicti	13.8	ST / D
		Tubificoides heterochaetus	16.3	DB / D
		Uca sp.	16.3	SB,SM / D,H
		Tubificidae	18.8	DB / D
2002	P7	Tubificidae	96.8	DB / D

Table 6.4-2. continued

Year	Site	Dominant Taxa	% abundance	Guild Type mobility/feeding
2002	P8	*Orchestia uhleri*	3.3	SM / H
		Tubificoides heterochaetus	3.3	DB / D
		Tubificoides sp.	79.9	DB / D
2002	P11	*Streblospio benedicti*	5.6	ST / D
		Tubificoides heterochaetus	67.5	DB / D
		Tubificidae	17.8	DB / D
2002	P12	*Bezzia*/*Palpomyia*	7.4	SM / H,P
		Streblospio benedicti	4.2	ST / D
		Tubificidae	26.3	DB / D
2002	P13	*Bezzia*/*Palpomyia*	14.6	SM / H,P
		Laeonereis culveri	4.9	SM / D,H
		Tubificidae	65.9	DB / D
2003	P2	*Polypedilium* sp.	41.5	SM / H
		Dicrotendipes sp.	23.1	SM / H
		Tubificidae	9.2	DB / D
		Bezzia/*Palpomyia*	7.7	SM / H,P
2003	P3A	Tubificidae	37.2	DB / D
		Polypedilium sp.	23.3	SM / H
		Cassidimidea lunifrons	8.1	SM / ?
		Cyathura madelinae	4.7	SM / H,P
		Bezzia/*Palpomyia*	3.5	SM / H,P
		Cryptochironomus sp.	3.5	SM / H
		Lumbriculidae	3.5	?
2003	P3B	Tubificidae	27.3	DB / D
		Procladius sp.	15.4	SM / H
		Polypedilium sp.	11.2	SM / H
		Axarus sp.	7.0	SM / ?
		Dicrotendipes sp.	7.0	SM / H
		Ablabesmyia sp.	5.6	SM / ?
		Limnodrilus hoffmeisteri	4.9	DB / D
		Corophium volutator	3.5	ST,SM / H
		Corophium lacustra	3.5	ST,SM / H
2003	P6	Tubificidae	49.4	DB / D
		Bezzia/*Palpomyia*	16.1	SM / H,P
		Monopylephorus irroratus	9.2	DB / D
		Nematoda*	4.6	(varied)
		Collembola	4.0	SM / D
2003	P7	Tubificidae	75.3	DB / D
		Limnodrilus hoffmeisteri	6.9	DB / D
		Polypedilium sp.	4.2	SM / H
		Bezzia/*Palpomyia*	3.2	SM / H,P
2003	P8	Tubificidae	68.8	DB / D
		Nematoda*	23.0	(varied)

Table 6.4-2. continued

Year	Site	Dominant Taxa	Guild Type % abundance	mobility/feeding
2003	P11	*Maranzellaria viridis*	29.2	ST / D
		Tubificoides heterochaetus	16.8	DB / D
		Polypedilium sp.	13.2	SM / H
		Tubificidae	10.4	DB / D
		Axarus sp.	8.8	SM / ?
		Cryptochironomus sp.	7.6	SM / H
		Bivalve juv.	3.2	ST / S
		Procladius sp.	3.2	SM / H
2003	P12	Tubificidae	53.2	DB / D
		Polypedilium sp.	11.1	SM / H
		Nematoda*	9.3	(varied)
		Ablabesmyia sp.	3.7	?
		Dicrotendipes sp.	3.2	SM / H
2003	P13	Tubificidae	52.1	DB / D
		Polypedilium sp.	25.0	SM / H
		Paratendipes sp.	4.2	SM / H
		Cryptochironomus sp.	4.2	SM / H
		Bezzia/*Palpomyia*	4.2	SM / H, P
		Limnodrilus hoffmeisteri	3.2	DB / D

*sampling protocol not designed for nematoda. This taxa only appears when unusually large individuals are present.

Table 6.4-3 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected on the Town Creek mouth site (P2) during June 1999, June 2000, June 2001 and June 2002. The means presented here represent the combination of two sub-sites for both high and low intertidal areas.

	Town Creek mouth (P 2)				
High Intertidal	June 99	June 00	June 01	June 02	June 03
amphipod sp.	0.17(0.17)	0.5(0.23)	0(0)	0(0)	0(0)
Bezzia/palpomia	0.5(0.5)	0(0)	0(0)	2.0(2.0)	2.5(0.86)
juv. Bivalve	1.0(0.37)	0.5(0.29)	0(0)	0(0)	0.25(0.25)
Boccardiella sp.	0(0)	26.5(18.62)	0(0)	0.25(0.25)	0.75(0.48)
Capitellidae sp.	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Cassidimidea lunifrons	0.17(0.17)	0.5(0.5)	0(0)	0(0)	0.5(0.5)
Caulleriella killariensis	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Chironomid larvae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Corophium acherasicum	0(0)	0(0)	12.5(8.72)	0(0)	0(0)
Corophium acutum	0(0)	0(0)	7.75(7.75)	0(0)	0(0)
Corophium lacustre	0(0)	4.25(0.85)	0(0)	0(0)	0.5(0.29)
Corophium sp.	0.17(0.17)	0(0)	11.75(7.81)	0(0)	0(0)
Crangonyx psudogracilis	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Cyathura polita	0(0)	0.75(0.75)	0(0)	0(0)	0(0)
Dicrotendipes sp.	2.0(0.93)	1.0(1.0)	0.25(0.25)	0(0)	7.5(6.85)
Eteone heteropoda	0(0)	1.0(0.41)	0(0)	0(0)	0(0)
Eteone sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Fabriciola sp.	0(0)	0(0)	0(0)	37.0(37.0)	0(0)
Fabriciola trilobata	0(0)	0(0)	0(0)	5.75(5.42)	0(0)
Gammarus sp.	0(0)	0.75(0.48)	0(0)	0.25(0.25)	0(0)
Gammarus tigrinus	0(0)	2.25(2.25)	0(0)	0(0)	0(0)
Hageria rapax	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Hobsonia florida	3.67(2.01)	3.0(2.68)	0.5(0.5)	0(0)	0.5(0.5)
insect pupae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
insect sp.	0.17(0.17)	0(0)	0.25(0.25)	0(0)	0(0)
insect sp. e	0(0)	0(0)	0(0)	0(0)	0(0)
Nereidae sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Laeonereis culveri	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Marenzellaria virdis	1.67(1.67)	0(0)	0(0)	0(0)	0(0)
Nereis falsa	0(0)	1.25(1.25)	0(0)	0(0)	0(0)
Nereis riisei	0.67(0.49)	0(0)	0(0)	0(0)	0(0)
Nereis succinea	0(0)	0.25(0.25)	1.5(0.96)	0(0)	0(0)
Oligochaeta	36.5(11.55)	8.75(6.79)	2.25(1.31)	0(0)	0(0)
Orchestia uhleri	0(0)	0(0)	0(0)	0.75(0.75)	0(0)
Owenia sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Palaemonetes pugio	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Parandalia sp.	1.0(0.63)	0(0)	0.5(0.29)	2.75(1.11)	0(0)
Polydora ligni	12.17(10.83)	0.25(0.25)	0.25(0.25)	0.75(0.48)	0(0)
Polydora socialis	5.5(4.11)	0(0)	3.25(3.25)	0.25(0.25)	0(0)
Polypedilum sp.	1.5(0.72)	0.3(0.3)	0(0)	0(0)	13.5(11.51)
Streblospio benedicti	0.83(0.31)	0.75(0.25)	0.25(0.25)	8.25(4.77)	0(0)
Tanais sp.	0.33(0.33)	0(0)	16.75(9.46)	0(0)	0(0)
Tanytarus sp.	0(0)	0(0)	0(0)	0(0)	0.75(0.75)
Tubificidae sp.	0(0)	0(0)	0(0)	2.25(1.93)	2.75(1.55)
Tubificoides heterochaetus	0(0)	0(0)	0(0)	0.5(0.5)	0(0)
Uca minax	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Uca sp.	0(0)	0(0)	0(0)	0.25(0.25)	0(0)

Table 6.4-3. continued

Low Intertidal	Town Creek mouth (P 2) June 99	June 00	June 01	June 02	June 03
amphipod sp.	0.17(0.17)	0.25(0.25)	0(0)	0(0)	0(0)
Belanus improvisus	0(0)	0(0)	4.8(4.8)	0(0)	0(0)
Bezzia/*palpomia*	0(0)	0(0)	0(0)	0(0)	0(0)
juv. Bivalve	0(0)	0.25(0.25)	0(0)	0.29(0.18)	0(0)
Boccardiella sp.	0(0)	16.5(5.17)	0(0)	0(0)	0(0)
Capitella capitata	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Chironomus sp.	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Collembola sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Corophium sp.	0(0)	0.25(0.25)	0.2(0.2)	0(0)	0(0)
Corophium lacustre	0(0)	2.5(1.19)	0(0)	0(0)	0(0)
crab megalopae	0(0)	0(0)	0(0)	0(0)	0(0)
Cyathura madelinae	0(0)	0(0)	0(0)	0(0)	0(0)
Cyclaspis varians	0(0)	0(0)	0(0)	0.14(0.14)	0(0)
Dicrotendipes sp.	0(0)	0.5(0.5)	0(0)	0(0)	0(0)
Eteone heteropoda	0(0)	0(0)	0(0)	0.71(0.42)	0(0)
Gammarus tigrinus	0.33(0.33)	0(0)	0.2(0.2)	0(0)	0(0)
Edotea (*muntosa*)	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Gammarus sp.	0(0)	0.25(0.25)	0.2(0.2)	0.14(0.14)	0(0)
gastropod juv.	0(0)	0(0)	0(0)	0(0)	0(0)
Hobsonia florida	0.83(0.83)	4.0(2.74)	0(0)	0(0)	0.25(0.25)
Laeonereis culveri	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Mediomastus ambiseta	1.17(0.83)	0(0)	0(0)	2.86(2.54)	0(0)
Mediomastus sp.	1.67(0.99)	0(0)	0(0)	4.29(2.3)	0.25(0.25)
Melita nitida	0(0)	0.5(0.5)	0.2(0.2)	0(0)	0(0)
Mucrogammarus mucronata	0(0)	0(0)	0(0)	0.14(0.14)	0(0)
Nemertean	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Nereis acuminata	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Neanthes succinea	0(0)	1.25(0.95)	0.2(0.2)	0.14(0.14)	0(0)
Oligochaeta	4.83(2.21)	2.5(1.19)	0.2(0.2)	0(0)	0(0)
Parandalia sp.	2.5(0.85)	1.0(0.71)	0.8(0.37)	2.43(1.49)	0(0)
Paraprionospio pinnata	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Polydora ligni	0.83(0.83)	1.5(1.5)	0(0)	0.43(0.43)	0(0)
Polypedilum sp.	0(0)	0(0)	0(0)	0(0)	0(0)
Porcladius sp.	0(0)	0(0)	0(0)	0(0)	0.75(0.25)
Spisula solidessima	0(0)	0(0)	0(0)	0.29(0.18)	0(0)
Streblospio benedicti	3.0(1.69)	0(0)	1.6(1.03)	54.29(11.27)	0(0)
Syllidae sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Tanais sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Tubificoides heterochaetus	0(0)	0(0)	0.2(0.2)	0.86(0.7)	0(0)
Tubificidae sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)

Table 6.4-4 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at P3A upper Town Creek sites during June 1999, June 2000, June 2001 and June 2002. The means presented here represent the combination of two sub-sites for both high and low intertidal areas.

	Town Creek inner a (P3A)				
High Intertidal	June 99	June 00	June 01	June 02	June 03
Bezzia/palpomia	0(0)	0(0)	0.4(0.24)	0.17(0.17)	0.75(0.47)
juv. bivalve	0.17(0.17)	0(0)	0(0)	0.17(0.17)	0(0)
Cassidimidea lunifrons	0(0)	0(0)	1.0(0.32)	0(0)	1.25(0.63)
Collembola sp.	0.33(0.21)	0(0)	0(0)	8.67(7.09)	0(0)
Chironomidae sp	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cryptochironomous sp	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Cyathura (madelinae)	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cyathura polita	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Dicrotendipes sp.	0(0)	0(0)	0(0)	0.17(0.41)	0(0)
Dicrotendipes (lobus)	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Dolichopodid larvae	0(0)	3.75(1.38)	0.6(0.4)	0(0)	0.25(0.25)
Dolichopus sp.	1.83(0.6)	0(0)	0.2(0.2)	0(0)	0(0)
Elasmopus sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Enchytraeidae sp	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Eukiefferiella sp.	0(0)	0(0)	1.8(1.56)	0(0)	0(0)
Gammarus tigrinus	0.33(0.33)	0(0)	0(0)	0(0)	0(0)
Hemipodus roseus	0(0)	0.5(0.5)	0.4(0.24)	0(0)	0(0)
insect pupae	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
insect sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
insect sp.b	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
insect sp. g	0.33(0.33)	0(0)	0(0)	0(0)	0(0)
juv. Nereid	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Laeonereis culveri	0.67(0.67)	0.5(0.5)	0(0)	0(0)	0(0)
Lumbriculidae sp	0(0)	0(0)	0.2(0.2)	0(0)	0.75(0.75)
Megalopae	0(0)	0(0)	0(0)	0.17(0.17)	0.25(0.25)
Mite	0.17(0.17)	0(0)	0(0)	0.17(0.17)	0(0)
Nais sp	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Oligochaeta	36.67(24.02)	42.0(12.81)	9.6(3.98)	0(0)	0(0)
Olivella sp.	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Orchestia sp.	0(0)	0(0)	0.8(0.58)	0(0)	0(0)
Orchestia uhleri	0(0)	0(0)	0.4(0.4)	0.17(0.17)	0(0)
Polypedilum sp.	0(0)	0.25(0.25)	0(0)	0(0)	3.5(2.36)
Procladius sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Solenopsis sp	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Spionidae sp.	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Streblospio benedicti	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Tabanus sp	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Tubificidae sp.	0(0)	0(0)	2.4(2.4)	6.67(3.26)	6.0(0.25)
Uca minax	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Uca pugilator	0.5(0.34)	0(0)	0(0)	0(0)	0(0)
Uca pugnax	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Uca sp.	0(0)	0.25(0.25)	0(0)	0.33(0.21)	0.25(0.25)

Table 6.4-4. continued

Low Intertidal	Town Creek inner a (P3A) June 99	June 00	June 01	June 02	June 03
Ampharetidae sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Amphipoda sp.	0.67(0.33)	0.25(0.25)	0(0)	0(0)	0(0)
*Bezzia/palpomi*a	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
juv. bivalve	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Boccardiella sp.	0(0)	0(0)	0(0)	0.33(0.21)	0(0)
Cassidisca lunifrons	0.17(0.17)	0(0)	0.2(0.2)	0(0)	0.5(0.29)
Collembola sp.	0(0)	0(0)	0(0)	0.33(0.21)	0(0)
Corophium volutator	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cryptochironomous sp	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cyathura (madelinae)	0(0)	0(0)	0(0)	0(0)	0.5(0.29)
Cyathura polita	0(0)	0(0)	0.4(0.4)	0(0)	0(0)
Dolichopodid larvae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Gammarus plumosa	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Eukiefferiella sp.	0(0)	0(0)	0.4(0.4)	0(0)	0(0)
Gammarus tigrinus	2.67(2.12)	0(0)	0(0)	0(0)	0(0)
gastropod juv.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Hobsonia florida	3.17(1.33)	0(0)	0.6(0.4)	0(0)	0.5(0.29)
Hydrophilidae larvae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Insect pupae	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
insect larva b	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Marenzellaria virdis	0.33(0.33)	0(0)	0(0)	0(0)	0(0)
Mediomastus ambiseta	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Mediomastus califoriensis	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Melita nitida	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Monopylephores sp.	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Munna sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Oligochaeta	5.0(3.85)	83.0(35.67)	12.4(3.91)	0(0)	0(0)
Orchestia sp.	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Polydora ligni	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Polydora sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Polypedilum sp.	1.0(0.37)	0(0)	0(0)	0(0)	1.5(1.19)
Procladius sp	2.5(0.34)	0(0)	0(0)	0(0)	0(0)
Streblospio benedicti	0.17(0.17)	0(0)	0.2(0.2)	1.67(1.12)	0(0)
Tanytarsus sp.	0.5(0.34)	0(0)	0(0)	0(0)	0.25(0.25)
Tubificidae sp.	0(0)	0(0)	0(0)	4.5(1.34)	2.0(1.08)
Tubificoides heterochaetus	0(0)	0(0)	0(0)	0.67(0.33)	0(0)
Uca pugilator	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Uca sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)

Table 6.4-5 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at P3B upper Town Creeksites during June 1999, June 2000, June 2001, and June 2002. The means presented here represent the combination of two sub-sites for both high and low intertidal areas.

	Town Creek inner b (P3B)				
High Intertidal	June 99	June 00	June 01	June 02	June 03
juv. bivalve	0.4(0.24)	0(0)	0(0)	0(0)	0.25(0.25)
juv. Nereidae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Ablabesmyia sp.	0(0)	0(0)	0(0)	0(0)	2(2)
Axarus sp.	0(0)	0(0)	0(0)	0(0)	2.5(2.5)
Bezzia/palpomyia	(0)	0(0)	0(0)	0.8(0.58)	0.25(0.25)
Boccardiella sp A	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cassidimidea lunifrons	0(0)	0(0)	0.6(0.24)	0(0)	0.5(0.5)
Collembola sp.	0.4(0.24)	0(0)	0(0)	0.2(0.2)	0.25(0.25)
Corophium lacustre	0(0)	0(0)	0(0)	0(0)	1.25(0.95)
Corophium volutator	0(0)	0(0)	0.4(0.2)	0(0)	1.25(0.95)
Cryptochironomous sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cyathura (madelinae)	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Dero sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Dicrotendipes sp.	0(0)	0(0)	0(0)	0(0)	2.5(2.5)
Diptera sp.	0(0)	0(0)	0(0)	0.2(0.2)	0.25(0.25)
Dolichopodid larvae	0(0)	0.5(0.5)	0.4(0.24)	0(0)	0(0)
Dolichopus sp	0.4(0.4)	0(0)	0.2(0.2)	0(0)	0(0)
Enchytraeidae sp.	0(0)	0(0)	0(0)	3(3)	0(0)
Eukiefferiella sp.	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
*Hobsonia flori*da	0(0)	0(0)	0.8(0.8)	0.2(0.2)	0(0)
Hydrothassa sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
insect larva c	0.4(0.24)	0(0)	0(0)	0(0)	0(0)
Laeonereis culveri	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Marenzellaria virdis	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Munna sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Nereidae sp.	0(0)	0.75(0.75)	0(0)	0(0)	0(0)
Oligochaeta	16.4(6.24)	27.3(6.8)	3(1.84)	0(0)	0(0)
Orchestia sp.	0.2(0.2)	0.25(0.25)	4.2(3.95)	0(0)	0(0)
Orchestia uhleri	0(0)	0.75(0.48)	0.2(0.2)	0(0)	0(0)
Platyhelminthes sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Polypedilum sp.	0(0)	0.25(0.25)	0(0)	0(0)	2.5(2.18)
Procladius sp.	0(0)	0(0)	0(0)	0(0)	1(1)
Streblospio benedicti	0(0)	0(0)	0.2(0.2)	0.4(0.4)	0(0)
Tanytarsus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Tubificidae sp.	0(0)	0(0)	1(1)	0.8(0.58)	8(4.74)
Uca sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)

Table 6.4-5. continued

Low Intertidal	Town Creek inner b (P3B) June 99	June 00	June 01	June 02	June 03
Amphipoda sp.	0.33(0.21)	(0)	0(0)	0(0)	0(0)
Cassidisca lunifrons	0.17(0.17)	0(0)	0(0)	0.2(0.2)	0(0)
Chironomidae sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Collembola sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Coelotanypus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Corophium acutum	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Corophium lacustre	0(0)	0(0)	0.5(0.5)	0(0)	0(0)
Cryptochironomous sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cyathura polita	0(0)	0.5(0.29)	0(0)	0.8(0.8)	0(0)
Dicrotendipes sp.	0.17(0.17)	0(0)	0(0)	0.2(0.2)	0(0)
Dolichopodid larvae	0(0)	0.25(0.25)	0.25(0.25)	0(0)	0(0)
Gammarus sp.	0.17(0.17)	0(0)	0(0)	0.4(0.4)	0(0)
Gammarus lawrencianus	0.83(0.83)	0(0)	0(0)	0(0)	0(0)
Gammarus tigrinus	1.83(1.83)	0(0)	0(0)	0(0)	0(0)
Gastropoda sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Heteromastus filiformis	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Hobsonia florida	2.5(0.89)	0(0)	0.25(0.25)	0(0)	0(0)
insect sp. a	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
insect pupae	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Laeonereis culveri	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Limnodrilus hoffmeisteri	0(0)	0(0)	0(0)	0(0)	1.75(1.75)
Marenzellaria virdis	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Marinogammarus sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Melita dentata	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Mite	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Munna sp.	0.5(0.34)	0(0)	0(0)	0(0)	0(0)
Namalycastis sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Nimbocera sp.	0.5(0.5)	0(0)	0(0)	0(0)	0(0)
Oligochaeta	4.83(2.36)	39.3(13.9)	10.5(3.23)	0(0)	0(0)
Polydora sp.	0.33(0.33)	0(0)	0(0)	0(0)	0(0)
Polydora ligni	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Polydora socialis	0(0)	0(0)	0(0)	0.4(0.4)	0(0)
Polypedilum sp.	0.67(0.49)	0(0)	0(0)	0(0)	1.5(0.96)
Procladius sp.	0.5(0.34)	0(0)	0(0)	0(0)	4.5(2.6)
Rhithropanapeus harisii	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Stictochironomus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Streblospio benedicti	0(0)	0(0)	0(0)	3.6(1.03)	0(0)
Tharyx sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Tubificidae sp.	0(0)	0(0)	0(0)	6.6(2.01)	1.75(0.63)
Tubificoides heterochaetus	0(0)	0(0)	0(0)	0.8(0.58)	0.5(0.5)

Table 6.4-6 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at the lowest main-stem Cape Fear site P6 during June 1999, June 2000, June 2001, and June 2002. The means presented here represent the combination of two sub-sites for both high and low intertidal areas.

	Eagle Island (P6)				
High Intertidal	June 99	June 00	June 01	June 02	June 03
Bezzia/palpomia	0.6(0.24)	0.25 (0.25)	0(0)	0.5(0.29)	6.75(4.01)
juv. bivalve	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
juv. Gastropod	0.2(0.2)	0(0)	0(0)	0(0)	0.25(0.25)
Cassidisca lunifrons	1(1)	0(0)	0(0)	0(0)	0(0)
Chrysops sp.	0(0)	0(0)	0(0)	0.25(0.25)	1(1)
Collembola sp.	1.6(0.75)	0(0)	0(0)	1(0.41)	1.75(0.63)
Curculionidae sp.	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
Cyathura (*madelinae*)	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
Cyathura polita	0.8(0.58)	0(0)	0(0)	0(0)	0(0)
Delphacidae sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Dero sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Diptera sp.	0(0)	0(0)	0(0)	0(0)	0.75(0.48)
Dolichopodid larvae	0(0)	0(0)	1(0.41)	0.25(02.5)	1(0.58)
Dolichopus sp.	0.8(0.8)	0(0)	0(0)	0(0)	0(0)
Enchytraeidae sp.	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Eukiefferiella (*claripennis*)	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Hemipodus roseus	0.8(0.8)	0(0)	1.75(0.85)	0(0)	0(0)
insect larva c	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
insect sp h	1(1)	0(0)	0(0)	0(0)	0(0)
insect sp I	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
Laeonereis culveri	3.2(2.03)	2.5(1.66)	0(0)	1(0.58)	0(0)
Lumbriculidae sp.	0(0)	0(0)	0(0)	2.25(2.25)	0(0)
Marrenzellaria virdis	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Microvelia sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Monopylephorus irroratus	0(0)	0(0)	0(0)	0(0)	4(3.67)
Namalycastis abiuma	0(0)	1(0.41)	0(0)	0(0)	0(0)
Nereidae sp.	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Oligochaeta	9.6(4.84)	9.5(2.9)	6(4.06)	0(0)	0(0)
Orchestia uhleri	1(0.55)	0(0)	0(0)	0.25(02.5)	0(0)
Orchestia sp.	1.2(0.97)	0(0)	0(0)	0(0)	0(0)
Paratendipes sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Polypedilum sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Procladius sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Sabellaria vulgaris beauforteasis	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Sthenelais sp. A	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Syphidae	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Tubificidae sp.	0(0)	0(0)	0(0)	1.5(0.29)	19.75(6.34)
Tubificoides heterochaetus	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Uca minax	0(0)	0(0)	0.25(0.25)	0.25(0.25)	0(0)
Uca pugilator	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
Uca pugnax	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Uca sp.	0.2(0.2)	0(0)	0(0)	1(0.41)	0(0)

Table 6.4-6. continued

Low Intertidal	Eagle Island (P6) June 99	June 00	June 01	June 02	June 03
amphipod sp.	0.8(0.58)	0(0)	0.4(0.4)	0(0)	0(0)
Bezzia/*palpomia*	0.6(0.4)	0(0)	0.2(0.2)	0(0)	0.25(0.25)
juv. bivalve	0.6(0.4)	0(0)	0(0)	0(0)	0(0)
Capitellidae sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Cassidisca lunifrons	1(0.77)	0(0)	0(0)	0(0)	0(0)
Coelotanypus sp.	0(0)	0(0)	0(0)	0(0)	0.75(0.75)
Collembola sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Cyathura polita	5.0(5.0)	0(0)	0(0)	0(0)	0(0)
Dolichopus sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Eukiefferiella (*claripennis*)	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
Gammarus daiberi	0.2(0.2)	0(0)	0.2(0.2)	0(0)	0(0)
gastropod juv.	0.4(0.24)	0(0)	0(0)	0(0)	0(0)
Hobsonia florida	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
insect pupae	1.8(1.11)	0(0)	0(0)	0(0)	0(0)
insect sp.	0.2(0.2)	0(0)	0(0	0(0)	0(0)
Maranzellaria virdis	0(0)	2(0.91)	3.8(1.16)	0(0)	0(0)
Melita sp.	1.0(1.0)	0(0)	0(0)	0(0)	0(0)
Mite sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Munna sp.	1.0(1.0)	0(0)	0(0)	0(0)	0(0)
Nemertean	0(0)	0(0)	0(0)	0.4(0.4)	0(0)
Oligochaeta	49.6(18.89)	3.5(1.94)	1(0.55)	0(0)	0(0)
Parandalia sp.	0(0)	0(0)	0(0)	0.4(0.24)	0.25(0.25)
Pectinaria gouldii	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Polydora socialis	2.6(2.6)	0(0)	0(0)	0(0)	0(0)
Polydora sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Polypedilum sp.	0.4(0.4)	0(0)	0(0)	0(0)	0.5(0.29)
Procladius sp.	0.6(0.6)	0(0)	0(0)	0(0)	0(0)
Streblospio benedicti	0(0)	0(0)	0(0)	0.4(0.4)	0(0)
Sirosperma sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Tubificidae sp.	0(0)	0(0)	0(0)	0(0)	1.75(0.25)
Tubificoides heterochaetus	0(0)	0(0)	0(0)	3.8(2.33)	0(0)
Uca sp.	0.4(0.4)	0(0)	0(0)	0(0)	0(0)

Table 6.4-7 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at P7 on the main-stem Cape Fear during June 1999, June 2000, June 2001, and June 2002. The means presented here represent the combination of two sub-sites for both high and low intertidal areas.

	Indian Creek (P7)				
High Intertidal	June 99	June 00	June 01	June 02	June 03
Bezzia/palpomia	0.2(0.2)	0(0)	0.17(0.17)	0(0)	2.25(1.03)
juv. bivalve	0(0)	0.2(0.2)	0.17(0.17)	0(0)	2(0.82)
*Cassidisca luni*frons	0(0)	0(0)	1(0.52)	0(0)	0.25(0.25)
Celina sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Chironomus sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Chrysops sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Collembola sp.	0.4(0.24)	1.2(0.8)	0(0)	0.17(0.17)	0(0)
Corophium acherasicum	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Corophium sp.	0(0)	0(0)	0.5(0.5)	0(0)	0(0)
Corophium volutator	0(0)	0(0)	0.67(0.67)	0(0)	0(0)
Cryptochironomus sp.	0.2(0.2)	0(0)	0(0)	0(0)	1(0.58)
Cyathura (*madelinae*)	0.4(0.4)	0(0)	0(0)	0(0)	0.25(0.25)
*Cyathura poli*ta	0(0)	0.2(0.2)	3.67(1.02)	0(0)	0(0)
Dolichopodid larvae	0(0)	1.6(0.24)	0.5(0.5)	0(0)	0(0)
Dolichopus sp.	1.6(0.51)	0(0)	0.5(0.5)	0(0)	0(0)
*Gammarus diabe*ri	0(0)	0(0)	4(4)	0(0)	0(0)
Gammarus sp.	0(0)	0(0)	0.67(0.67)	0(0)	0(0)
gastropod juv.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Hobsonia florida	0(0)	0(0)	0.17(0.17)	0.17(0.17)	0(0)
insect larvae	0(0)	0.4(0.4)	0(0)	0(0)	0(0)
insect pupae	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
insect sp.	0(0)	0(0)	0.67(0.49)	0(0)	0(0)
insect sp. b	0(0)	0(0)	0(0)	0(0)	0(0)
Isopod sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Lirceus sp.	1.4(1.2)	0(0)	0.67(0.67)	0(0)	0(0)
Limnodrilus hoffmeisteri	0(0)	0(0)	0(0)	0(0)	11.5(3.75)
Lumbriculidae sp.	7.4(3.33)	0(0)	0.33(0.21)	0.17(0.17)	0(0)
Micropsectra sp.	0.8(0.37)	0(0)	0(0)	0(0)	0(0)
Microtendipes (rydalensis group)	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Mite	0(0)	0.2(0.2)	0(0)	0(0)	0(0)
Nemertea	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Oligochaete	52.2(15.47)	64.2(23.7)	20.17(10.29)	0(0)	0.5(0.5)
Omisus sp.	0(0)	0(0)	1.83(1.83)	0(0)	0(0)
Orchestia (plantesis)	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Orchestia sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Orchestia uhleri	0.6(0.6)	0(0)	0(0)	0(0)	0(0)
Paratendipes sp.	0(0)	0(0)	1.83(1.64)	0(0)	0(0)
Polypedilum sp.	0(0)	0(0)	0.17(0.17)	0(0)	6.75(2.84)
Pristinella sp.	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
Sirosperma sp.	0(0)	0(0)	0(0)	0(0)	1(0.58)
Spirosperma carolinensis	0(0)	0(0)	0.83(0.83)	0(0)	0(0)
Spionidae sp.	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Staphylinidae	0(0)	0(0)	0(0)	0.17(0.17)	0(0)
Stictochironomus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Tabanus sp.	0.2(0.2)	0(0)	0(0)	0(0)	0.3(0.3)
Tubificidae sp.	0(0)	0(0)	3.17(2.01)	24.5(5.36)	104(30.6)
Tubificoides heterochaetus	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Uca pugilator	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
Uca sp.	0(0)	0(0)	0.33(0.33)	0(0)	104(30.6)

Table 6.4-7. continued

Low Intertidal	Indian Creek (P7) June 99	June 00	June 01	June 02	June 03
Arcteonais lomondi	0(0)	0(0)	0(0)	0(0)	0.4(0.24)
Aulodrilus pluriseta	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Batea cathariensis	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
juv. bivalve	0.6(0.4)	0.25(0.25)	0(0)	0.17(0.17)	0.4(0.4)
Bezzia/Palpomyia	0.2(0.2)	0(0)	0(0)	0.17(0.17)	3.8(2.58)
Cassidisca lunifrons	0.6(0.24)	0(0)	0(0)	0(0)	0(0)
Chironomidae sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Chironomus sp.	0.2(0.2)	0(0)	0(0)	0(0)	0.2(0.2)
Cladotanytarsus sp.	0(0)	0(0)	0(0)	0(0)	0.4(0.4)
Coelotanypus sp.	0(0)	0(0)	0(0)	0.17(0.17)	2(1.05)
Corophium volutator	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Crab megalopae	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Cryptochironomous sp.	0.6(0.6)	0(0)	0(0)	0(0)	2(0.89)
Cryptotendipes sp.	0(0)	0(0)	0(0)	0(0)	0.4(0.4)
Cyathura polita	0(0)	0.5(0.29)	0.67(0.49)	0(0)	0(0)
Cyathura (*madelinae*)	0.4(0.24)	0(0)	0(0)	0(0)	0(0)
Dero sp.	0(0)	0(0)	0(0)	0(0)	0.8(0.8)
Dispio unicata	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Dolichopodid larvae	0(0)	0.25(0.25)	0.67(0.67)	0(0)	0(0)
Dolichopus sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Gammarus daiberi	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Gammarus tigrinus	0.6(0.4)	0(0)	0(0)	0(0)	0(0)
gastropod juv.	1.0(0.45)	0(0)	0(0)	0(0)	0(0)
insect larvae	0(0)	0(0)	0.33(0.33)	0(0)	0(0)
insect pupae	0.4(0.24)	0(0)	0(0)	0(0)	0(0)
insect species	0(0)	0(0)	0.33(0.21)	0(0)	0(0)
insect sp. a	0.4(0.24)	0(0)	0(0)	0(0)	0(0)
insect sp.b	0(0)	0(0)	0(0)	0(0)	0(0)
insect sp. f	0(0)	0(0)	0(0)	0(0)	0(0)
insect sp. g	0(0)	0(0)	0(0)	0(0)	0(0)
Isochaetides sp.	0(0)	0(0)	0.5(0.5)	0(0)	0(0)
Isopoda (unknown)	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Laeonereis culveri	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Limnodrilus hoffmeisteri	0(0)	0(0)	0.5(0.5)	0(0)	2.8(1.16)
Lumbriculidae sp.	0(0)	0(0)	0.83(0.54)	0(0)	0(0)
Munna sp.	0(0)	0(0)	0(0)	0(0)	0(0)
Oligochaeta	17.8(4.55)	64(19.63)	46.83(25.24)	0(0)	0(0)
Orchestia sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Paratendipes sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Polypedilum sp.	1.0(1.0)	1.25(0.48)	0.33(0.33)	0(0)	2(0.84)
Procladius sp.	0.2(0.2)	0(0)	0(0)	0(0)	1.6(0.4)
Saetheria sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Spionidae sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Spirosperma carolinensis	0(0)	0(0)	0.33(0.33)	0(0)	0(0)
Tanytarsus sp.	0(0)	0(0)	0(0)	0(0)	0.4(0.24)
Tubificidae sp.	0(0)	0(0)	8.5(5.38)	11.0(3.34)	48.2(6.85)

Table 6.4-8. Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at P8 on the main-stem Cape Fear during June 1999, June 2000, June 2001, and June 2002. The means presented here represent the combination of two sub-sites for both high and low intertidal areas.

	Dollisons Landing (P8)				
High Intertidal	June 99	June 00	June 01	June 02	June 03
Bezzia/palpomia	0.33(0.33)	0.75 (0.25)	0.33(0.21)	0(0)	0(0)
juv. bivalve	11.17(4.32)	23.5(8.51)	5.17(1.82)	0.6(0.4)	2(1.15)
Branchiura sowerbyi	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cassidisca lunifrons	0(0)	0(0)	0(0)	0.4(0.24)	0(0)
Coelotanypus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Coleoptera larvae	0.33(0.33)	0(0)	0(0)	0(0)	0(0)
Collembola sp.	1.5(0.43)	6.5(2.53)	0.33(0.21)	0(0)	0(0)
Cryptochironomus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cyathura polita	0(0)	0(0)	0(0)	0.6(0.4)	0(0)
Dero sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Dolichopodid larvae	0(0)	6.5(2.33)	0.67(0.49)	0.4(0.4)	0.5(0.5)
Dolichopus sp.	2.17(.75)	0(0)	0(0)	0(0)	0(0)
Enchytraeidae sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Gammarus tigrinus	1.33(1.33)	0(0)	0(0)	0(0)	0(0)
gastropod juv.	0.5(0.34)	0(0)	0(0)	0(0)	0(0)
Hydaticus larvae	0.33(0.21)	0(0)	0(0)	0(0)	0(0)
Hydrobia sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Hydrophilidae larvae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
insect larvae	0(0)	0(0)	1.33(0.88)	0(0)	0(0)
insect pupae	0(0)	0(0)	0.83(0.31)	0(0)	0(0)
insect sp. a	0(0)	0(0)	0(0)	0(0)	0(0)
insect sp. b	0(0)	0(0)	0.5(0.5)	0(0)	0(0)
insect sp. C	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
insect sp. D	0(0)	0(0)	0.33(0.33)	0(0)	0(0)
insecta sp.	0.17(0.17)	0(0)	0.17(0.17)	0(0)	0(0)
Limnodrilus hoffmeisteri	0(0)	0(0)	0(0)	0(0)	1.0(0.71)
Lumbriculidae sp.	5(2.89)	2(2)	0(0)	1.4(0.75)	0.25(0.25)
Micropsectra sp.	3.17(3.17)	0(0)	0(0)	0(0)	0(0)
Mite	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Neanthes succinea	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Nemertea	0(0)	0(0)	0.33(0.21)	0(0)	0.25(0.25)
Notomierus capricornis	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Oligochaeta	73.5(14.07)	180.25(37.14)	44.17(11.32)	0(0)	0(0)
Omisus sp.	0(0)	0(0)	0(0)	0.6(0.6)	0(0)
Orchestia sp.	0(0)	0(0)	5.5(1.57)	0.2(0.2)	0(0)
Orchestia uhleri	3.5(1.48)	2.5(1.5)	0(0)	1 (1)	0(0)
Oribatei sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Paratendipes sp.	0(0)	5.75(2.69)	0(0)	0.2(0.2)	1.5(1.19)
Polypedilum sp.	0.17(0.17)	2.75(2.43)	0.17(0.17)	0.2(0.2)	3(1.41)
Rheotanytarsus sp.	0.33(0.33)	0.5(0.5)	0(0)	0(0)	0(0)
Sirosperma sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Stratiomya sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Tabanus sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Tanais sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Tanytarsus sp.	1(1)	7.5(2.99)	0.17(0.17)	0(0)	0(0)
Tipula sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Tubificidae sp.	0(0)	0(0)	0(0)	19.4(9.14)	128(39.51)
Tubificoides heterochaetus	0.17(0.17)	0(0)	0(0)	1(1)	0.25(0.25)
Uca pugilator	0.17(0.17)	0.5(0.5)	0(0)	0(0)	0(0)
Uca pugnax	0(0)	0(0)	0.17(0.17)	0(0)	0(0)

Table 6.4-8. continued

Low Intertidal	Dollisons Landing (P8) June 99	June 00	June 01	June 02	June 03
Armadillidium quadrifrons	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Bezzia/*palpomia*	0.33(0.33)	0(0)	0.33(0.21)	0.75(0.48)	1(0.58)
juv. bivalve	1.67(0.56)	5.75(4.46)	1.83(0.31)	0.25(0.25)	1(0.71)
Branchiura sowerbyi	0(0)	0(0)	0(0)	0(0)	1(0.71)
Cassidisca lunifrons	0.83(0.83)	0(0)	0(0)	0(0)	0(0)
Coelotanypus sp.	0(0)	0(0)	0(0)	0.25(0.25)	0.75(0.48)
Collembola sp.	0.17(0.17)	0.25(0.25)	1(1)	0(0)	0(0)
Corophium acherasicum	0(0)	0(0)	3.33(0.99)	0(0)	0(0)
Corophium sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
crab megalopae	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Cryptochironomous sp.	0.33(0.33)	0(0)	0(0)	0(0)	0(0)
Cyathura polita	0(0)	0(0)	1.5(0.56)	0.25(0.25)	0(0)
Cyathura (*madelinae*)	0.67(0.67)	0.75(0.75)	0(0)	0(0)	0(0)
Dolichopodid larvae	0(0)	0.75(0.25)	0.67(0.33)	0(0)	0(0)
Dolichopus sp.	1(0.82)	0(0)	0(0)	0(0)	0.25(0.25)
Gammarus tigrinus	1.5(1.15)	0(0)	0(0)	0(0)	0(0)
gastropod juv.	0.17(0.17)	0.5(0.5)	1(0.68)	0.5(0.5)	0(0)
insect pupae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
insect sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
insect sp.b	0.17(0.17)	0(0)	0.17(0.17)	0(0)	0(0)
Isopoda (unknown)	0(0)	0(0)	0.83(0.65)	0(0)	0(0)
Limnodrilus hoffmeisteri	0(0)	0(0)	0(0)	0(0)	6.25(5.92)
Lumbriculidae sp.	3(1.61)	1.5(1.19)	0(0)	0(0)	0(0)
Micropsectra sp.	0.17(0.17)	0(0)	0(0)	0.25(0.25)	0(0)
Munna sp.	0(0)	0(0)	0(0)	0(0)	0(0)
Namalycastis sp.	0(0)	0(0)	0.8(1)	0(0)	0(0)
Oligochaeta	122.83(31.34)	103(16.91)	63(67.6)	0(0)	0(0)
Orchestia sp.	0(0)	0(0)	57(21.7)	0(0)	0(0)
Orchestia uhleri	0(0)	0.75(0.48)	0(0)	0(0)	0(0)
Paratendipes sp.	0.17(0.17)	1(0.58)	0(0)	0(0)	0(0)
Polypedilum haterale group	2.33(2.33)	0(0)	0(0)	0(0)	0(0)
Polypedilum sp.	1.33(0.56)	3(1.58)	2.5(2.4)	0(0)	0(0)
Pristinella sp.	0.67(0.67)	0(0)	0(0)	0(0)	0(0)
Procladius sp.	0(0)	0(0)	0.3(0.5)	0(0)	1(0.71)
Rheotanytarsus sp.	0.17(0.17)	0(0)	0(0)	0(0)	0(0)
Sirosperma sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Tanytarsus sp.	0.33(0.33)	1(1)	0(0)	0(0)	0(0)
Tribelos sp.	0.33(0.33)	0(0)	0(0)	0(0)	0(0)
Tubificoides sp.	0(0)	0(0)	0(0)	6.5(2.06)	57.25(32.77)

Table 6.4-9 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at P11 on the NE Cape Fear River during June 1999, June 2000, June 2001, June 2002, and June 2003. The means presented here represent the combination of two sub-site for both high and low intertidal areas at each station.

	Smith Creek (P11)				
High Intertidal	June 99	June 00	June 01	June 02	June 03
amphipod sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Bezzia/palpomia	0(0)	0(0)	0.5(0.5)	0.5(0.29)	0.25(0.25)
juv. bivalve	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
Boccardiella sp.	0(0)	1.25(1.25)	0(0)	0(0)	0(0)
Cassidisca lunifrons	1(0.71)	0.25(0.25)	1.25(0.48)	0(0)	0(0)
Chironomus sp.	0.5(0.5)	0(0)	0(0)	0(0)	0(0)
Cladotanytarsus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Cryptochironomus sp.	0(0)	0(0)	0(0)	0(0)	1.75(1.44)
Curculionidae sp.	0.75(0.75)	0(0)	0(0)	0(0)	0(0)
Cyathura madelina	0(0)	0.25(0.25)	0(0)	0.25(0.25)	0(0)
Dicrotendipes lobus	1(1)	0(0)	0(0)	0(0)	0(0)
Dicrotendipes nirvosus	0.5(0.5)	0(0)	0(0)	0(0)	0(0)
Dicrotendipes sp.	0(0)	1(0.71)	0.5(0.29)	0.25(0.25)	0(0)
Edotea triloba	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Gammarus diaberi	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Gammarus tigrinus	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Gammarus mucronatus	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
Gammarus sp.	0(0)	0(0)	0(0)	1.5(1.5)	0(0)
Hobsonia florida	7.5(4.33)	0(0)	3.25(1.11)	0(0)	0(0)
Hydrobia sp.	0(0)	0(0)	0(0)	0(0)	0(0)
Insect larvae (Elimidae)	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
insect pupae	1(1)	0.25(0.25)	0(0)	0(0)	0(0)
Insect sp.	1.25(1.25)	0(0)	0(0)	0.5(0.5)	0(0)
Laeonereis culveri	0(0)	0(0)	0(0)	0.5(0.5)	0(0)
Megalopae (*Uca*)	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Megalops	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Nemertea	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Nereidae sp.	0(0)	0(0)	1(0.71)	0(0)	0(0)
Oligochaeta	10.5(3.69)	14.25(7.7)	1.75(0.85)	0(0)	0(0)
Paratendipes sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Polydora ligni	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
Polydora socialis	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
Polydora sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Polypedilium sp.	0.5(.5)	0.25(0.25)	0.5(0.5)	0(0)	3.75(1.49)
Stictochironomus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Streblospio benedicti	0(0)	0(0)	0(0)	0.75(0.49)	0(0)
Tubificidae sp.	0(0)	0(0)	0(0)	9.75(8.76)	4.75(2.59)
Tubificidae heterochaetus	0(0)	0(0)	0(0)	1(0.71)	0.75(0.48)
Uca sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)

Table 6.4-9. continued

Low Intertidal	Smith Creek (P11) June 99	June 00	June 01	June 02	June 03
amphipod sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Armadillidium vulgare	0(0)	0(0)	0(0)	0(0)	0.33(0.33)
Axarus sp.	0(0)	0(0)	0(0)	0(0)	3.67(1.52)
Bivalve sp.	0(0)	0(0)	0(0)	0.2(0.2)	1.17(0.4)
Boccardiella sp.	0(0)	0(0)	0.17(0.17)	0(0)	0(0)
Cladotanytarsus sp.	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Collembola sp.	0(0)	0(0)	0(0)	0(0)	0.17(0.17)
Corophium acherasicum	0(0)	0(0)	0.33(0.33)	0(0)	0(0)
Corophium sp.	0(0)	0(0)	0.33(0.33)	0(0)	0(0)
crab megalopae	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Cryptochironomous (*fulvens*)	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Cryptochironomous sp.	0(0)	0(0)	0(0)	0(0)	2(0.58)
Cyathura (madelinae)	0(0)	0(0)	0(0)	0(0)	0.17(0.17)
Cyathura polita	0(0)	0(0)	0(0)	0(0)	0.17(0.17)
Diplopoda (millipede)	0(0)	0(0)	0(0)	0(0)	0.17(0.17)
Eteone heteropoda	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Gammarus tigrinus	0.6(0.4)	0(0)	0(0)	0(0)	0(0)
Hobsonia florida	0.6(0.24)	0(0)	0.33(0.21)	0(0)	0(0)
Laeonereis culveri	0(0)	0(0)	5(4.43)	0.2(0.2)	0(0)
Marenzellaria virdis	1(0.77)	3.75(1.93)	22.83(5.72)	0(0)	12.17(3.51)
nemertea	0.2(0.2)	0(0)	0.5(0.22)	0.2(0.2)	0(0)
Nereidae	0(0)	0(0)	7(2.5)	0(0)	0(0)
Oligochaeta	3.6(1.86)	0.25(0.25)	7.5(4.63)	0(0)	0(0)
Parandalia sp A	0(0)	0(0)	0(0)	0.2(0.2)	0.17(0.17)
Paratanytarsus sp.	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Pentatomidae	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Polypedilum sp.	0.4(0.4)	0.5(0.5)	1.67(0.61)	0(0)	3(0.93)
Procladius sp.	0(0)	0(0)	0(0)	0(0)	1.33(1.33)
Streblospio benedicti	0(0)	0(0)	0(0)	2.0(1.38)	0(0)
Tanytarsus sp.	0(0)	0(0)	0(0)	0(0)	0.17(0.17)
Tubificidae sp.	0(0)	0(0)	0(0)	0.4(0.4)	1.17(1.17)
Tubificoides heterochaetus	6.2(6.2)	0(0)	1.5(1.31)	30.4(18.98)	6.5(2.86)

Table 6.4-10 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at P12 on the NE Cape Fear River during June 1999, June 2000, June 2001, June 2002, and June 2003. The means presented here represent the combination of two sub-site for both high and low intertidal areas at each station.

Rat Island (P12)

High Intertidal	June 99	June 00	June 01	June 02	June 03
Bezzia/*palpomia*	1.8(0.37)	0(0)	0.25(0.25)	1.4(0.93)	0.6(0.24)
Cassidisea lunifrons	0.2(0.2)	0.25(0.25)	0.25(0.25)	0.4(0.4)	0(0)
Collembola sp.	0.2(0.2)	1(0.41)	0(0)	0(0)	0(0)
Corophium (*lacustre*)	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Cricotopus sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Delphacidae sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Dicrotendipes sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Diptera sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Dispio unicata	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Dolichopodidae sp.	0(0)	0(0)	0(0)	0.2(0.2)	0.4(0.24)
Dolichopodid larvae	0(0)	0.25(0.25)	0.75(0.75)	0(0)	0(0)
Dolichopus sp.	0.6(0.4)	0(0)	0(0)	0(0)	0(0)
Donacia sp.	0.2(0.2)	0(0)	0(0)	0.2(0.2)	0(0)
Donaciinae sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Endochironomus sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Gammarus sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
gastropod juv.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Hemiptera sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Heterothissocladius sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Hydrobia sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Insect sp.	0(0)	0(0)	0.75(0.48)	0(0)	0(0)
insect sp. g	0.4(0.4)	0(0)	0(0)	0(0)	0(0)
insect sp. h	1.2(1.2)	0(0)	0(0)	0(0)	0(0)
insect sp. f	0(0)	0(0)	0(0)	0(0)	0(0)
Laeonereis culveri	1.4(0.51)	0.25(0.25)	0(0)	0(0)	0(0)
Lumbriculid sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Mesomelia mulsanti	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Mite	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Monopylephorus irroratus	1(1)	0(0)	0(0)	0(0)	0.4(0.4)
Namalycastis sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Nereidae sp.	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Nereidae sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Ocypode quadrata	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Oligochaeta	47.8(15.93)	30(9.61)	13.25(7.11)	0(0)	0(0)
Orchestia sp.	0(0)	0(0)	0(0)	0(0)	0(0)
Orchestia uhleri	0.2(0.2)	0.5(0.29)	0(0)	0(0)	0(0)
Orthocladinae sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Paratandipes sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Polypedilium sp.	0(0)	0(0)	0.5(0.5)	0(0)	1.8(1.11)
Pristinella sp	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Spiophanes bombyx	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Streblospio benedicti	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Tubificidae sp.	0(0)	0(0)	0(0)	3.2(1.16)	17.6(4.15)
Uca minax	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Uca pugilator	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Uca sp.	0(0)	0(0)	0(0)	0.4(0.4)	0(0)

Table 6.4-10. continued

Low Intertidal	Rat Island (P12) June 99	June 00	June 01	June 02	June 03
Ablabesmyia sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.71)
amphipod sp. B	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Axarus sp.	0(0)	0(0)	0(0)	0(0)	0.75(0.75)
Bezzia/*palpomia*	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Boccardiella sp.	0(0)	0(0)	12.5(12.5)	7.6(4.43)	0.75(0.48)
Cassidinidea lunifrons	0(0)	0(0)	0(0)	0(0)	0.75(0.48)
Chyrsops sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Collembola sp.	0(0)	0(0)	0.5(0.5)	0(0)	0(0)
Corophium acherasicum	0(0)	0(0)	1(1)	0(0)	0(0)
Crangonyx sp.	0(0)	0(0)	0(0)	0.4(0.4)	0(0)
Cricotopus sp.	0(0)	0(0)	0(0)	0(0)	0.5(0.5)
Cryptochironomus sp.	0(0)	0(0)	0(0)	0(0)	0.75(0.75)
Dicrotendipes lucifer	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Dicrotendipes sp.	0(0)	0(0)	0(0)	0(0)	1.75(1.75)
Edotea juv sp.	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Enchytraeidae sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Gammarus tigrinus	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Gammarus sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
juv. Gastropod	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Hobsonia florida	0(0)	0(0)	0(0)	0.4(0.4)	0.25(0.25)
Insect sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
insect larvae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Laeonereis culveri	0(0)	0(0)	0(0)	0.4(0.4)	0(0)
Lumbriculid sp.	0(0)	1.75(1.44)	0(0)	0(0)	0(0)
Mediomastus sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Megalops	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Naididae sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Namalycastis sp.	0(0)	0(0)	0.5(0.5)	0(0)	0(0)
Nereis lamellosa	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Oligochaeta	1.6(0.51)	7.25(4.4)	2.75(1.49)	0(0)	0(0)
Paracladopelma sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Polydora ligni	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Polydora socialis	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Polydora sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Polypedilum sp.	0.2(0.2)	0(0)	0(0)	0(0)	3.75(1.11)
Procladius sp.	0(0)	0(0)	0(0)	0(0)	0.25(0.25)
Rhithropanopeus harrisii	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Spiophanes bombyx	0(0)	0(0)	0(0)	0.2(0.2)	0(0)
Streblospio benedicti	0(0)	0(0)	0(0)	0.8(0.58)	0(0)
Tanypodinae sp.	0(0)	0(0)	0(0)	0(0)	1.25(1.25)
Tubificidae sp.	0(0)	0(0)	0(0)	1.8(1.36)	0.5(0.29)
Tubificoides heterochaetus	0(0)	0(0)	0(0)	0.4(0.4)	6.75(3.90)

Table 6.4-11 Mean (no. per 0.01 m^2) and (standard deviation) for all taxa collected at P13 on the NE Cape Fear River during June 1999, June 2000, June 2001, June 2002, and June 2003. The means presented here represent the combination of two sub-site for both high and low intertidal areas at each station.

Fishing Creek (P13)

High Intertidal	June 99	June 00	June 01	June 02	June 03
Aricidea suecica	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Bezzia/palpomyia	0(0)	0(0)	0.2(0.2)	0.75(0.75)	1(0.71)
juv. bivalve	0(0)	0.75(0.48)	0(0)	0(0)	0(0)
Collembola sp.	0.2(0.2)	0(0)	0.8(0.8)	0(0)	0.5(0.5)
Cyathura polita	0.2(0.2)	0(0)	0(0)	0(0)	0.5(0.5)
Dolichopodid larvae	0(0)	0.5(0.5)	0.2(0.2)	0.25(0.25)	0(0)
Dolichopus sp.	0.4(0.24)	0.75(0.75)	0(0)	0(0)	0(0)
Halipldae sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Helophorus linearis	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Hydrobia sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Insect sp.	0(0)	0(0)	0.4(0.4)	0.25(0.25)	0(0)
insect pupae	0.2(0.2)	0(0)	0.2(0.2)	0(0)	0(0)
Laeonereis culveri	0.4(0.24)	2(1.08)	0(0)	0.25(0.25)	0(0)
Lumbriculid sp.	1.4(1.4)	0.5(0.29)	18.4(18.4)	1(0.58)	0(0)
Mediomastus sp.	0.2(0.2)	0(0)	0(0)	0(0)	0(0)
Megalopae (Uca)	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Namalycastis sp.	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Nereidae sp.	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Oligochaeta	29.4(6.9)	11(3.72)	37.2(14.04)	0(0)	0(0)
Orchestia sp.	0(0)	0(0)	0.4(0.24)	0(0)	0(0)
Orchestia uhleri	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Oribatei sp.	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Paratendipes sp.	0(0)	0.5(0.5)	0.6(0.4)	0(0)	1(0.71)
Polichopodidae sp.	0(0)	0(0)	0.2(0.2)	0(0)	0(0)
Polypedilium sp.	0.6(0.4)	0(0)	0.4(0.24)	0(0)	5(1.22)
Tubificidae sp	0(0)	0(0)	0(0)	2.75(2.43)	6.25(1.97)

	Fishing Creek (P13)				
Low Intertidal	June 99	June 00	June 01	June 02	June 03
Amphididae sp.	0(0)	0(0)	0(0)	0(0)	0.2(0.2)
Bezzia/palpomia	0(0)	0(0)	0.25(0.25)	0.75(0.48)	0(0)
Cassidimidea lunifrons	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Chirodotea caeca	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
Cryptochironomous (*fulvens*)	0.5(0.5)	0(0)	0(0)	0(0)	0(0)
Cryptochironomous sp.	0(0)	0(0)	0(0)	0(0)	0.8(0.37)
Dolichopodid larvae	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Hobsonia florida	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Limnodrilus hoofmeisteri	0(0)	0(0)	0(0)	0(0)	0.6(0.24)
insect pupae	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
insect sp.d	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
Insect sp e	0.5(0.5)	0(0)	0(0)	0(0)	0(0)
larval fish	0.25(0.25)	0(0)	0(0)	0(0)	0(0)
Laeonereis culveri	0(0)	0(0)	0(0)	0.25(0.25)	0(0)
Megalopa (Uca)	0(0)	0(0)	0.25(0.25)	0(0)	0(0)
Namalycastis sp.	0(0)	0.25(0.25)	0(0)	0(0)	0(0)
Oligochaeta	34.25(11.13)	29.3(15.37)	8.25(4.97)	0(0)	0(0)
Polypedilum sp.	0.25(0.25)	1(0.71)	1.25(0.95)	0(0)	0.8(0.2)
Procladius sp.	0.75(0.48)	0(0)	0(0)	0(0)	0.2(0.2)
Tubificidae sp.	0(0)	0(0)	0(0)	4(3.08)	5(2.65)

Five years of infaunal data indicate detectable long-term trends in community composition. One trend is consistent with salinity changes. In the Cape Fear system, this involved a drought developing during 2000-2002, with peak salinity levels prior to our June 2002 sampling. The other trend is more obvious but not as easily explained. This involved a dramatic change in community characteristics between 2002/2003 and the previous 3 years of sampling. While the difference between 2002 and previous years might be explained by salinity, this would not explain the difference between 2003, which was not a drought year, and 1999/2000. Possible explanations might include community instability related to recovery from the previous drought year, a year-specific event, or a possible signature from channel deepening and widening activities. These various hypotheses can best be distinguished by examining consistency in patterns for 2004-2005 data with those of 2002-2003.

7.0 EPIBENTHIC STUDIES: DECAPODS AND EPIBENTHIC FISH

7.1 Summary

As part of the long-term project to monitor potential changes in the communities that depend on tidal marsh and swamp, we are examining the epibenthic community (primarily fish and decapods) found along the marsh and swamp boundary. Drop trap sampling collected a total of 77 taxa while a total of 41 taxa have been collected using Breder traps. As in previous years, evaluation of species richness, diversity, and total fauna by season (spring-fall) for Breder trap data showed strong inter-annual and site differences. Patterns were consistent with developing drought conditions in 2001 and 2002 and further evaluation will be needed to determine if these community fluctuations are also indicative of river deepening impacts. Analysis of Similarity (ANOSIM) using all site season combinations indicated that 2002 was significantly different from all other years. Drop trap data showed similar results, with significant annual and site differences. Analysis of total abundance and ANOSIM both show 2002 as an outlier year. Spring 2004 was dominated by high recruitment of spot *Leiostomus xanthurus* and early juvenile flounder *Paralichthys* sp. Highest total abundances were recorded for most sites in the main-stem Cape Fear and North East Cape Fear tributaries during spring 2004.

7.2 Background

Since September of 1999, the UNCW Benthic Ecology Lab has conducted a long term evaluation of the epibenthic organisms utilizing the tidal marshes along the Cape Fear River, Northeast Cape Fear River, and Town Creek. This section examines the distribution and abundance patterns for epifauna. This group of organisms is, by definition, highly mobile and capable of demonstrating rapid changes in patterns of utilization across sites and seasons. Here we focus on temporal and spatial trends in community level factors such as diversity, species richness, and species groupings. These are measures that might indicate change if dredging and deepening the lower Cape Fear River altered flow or tidal effects. Here we present data from Breder traps and drop traps for fall and spring. Breder traps were used to evaluate faunal use of lower, mid, and upper intertidal areas, while drop traps were used to evaluate use of shallow subtidal habitats. While fall 1999 through 2000 reflect pre-dredge or background conditions, dredging activities began spring 2001 and various aspects are expected to continue through 2005.

This study focuses on the epibenthic community utilizing the fringing marsh and swamp habitats across the estuarine gradient. This group of organisms may be sensitive to potential changes associated with shifts in salinity and/or tidal inundation. The sampling window for this monitoring effort is spring and fall, periods of high recruitment into the estuary (primary recruitment in the spring and a smaller pulse in the fall of the year, with differences in species composition between seasons). This level of effort is necessary to detect potential impacts to higher trophic levels. Fringing marshes and swamps are the most prominent structural habitats within the upper Cape Fear estuarine system and provide both refuge and forage for epifaunal organisms. These habitats, primarily tidal wetlands and swamps, are critical in terms of providing refuge and foraging habitat for a number of commercially and environmentally important transient and resident species.

As part of the long-term project to monitor potential changes in the communities that depend on these habitats we are examining the epibenthic community (primarily fish and decapods) found along the marsh and swamp boundary. Aside from resident fish and decapods, epibenthos include juveniles of transient fish, crabs and shrimp as well as larger snails, amphipods, and isopods. These organisms tend to be highly motile, are often able to utilize a variety of habitats, and may respond rapidly to environmental cues. Many species have larval stages that leave the upper estuary, while others immigrate to the estuary as larvae making recruitment, and subsequent impacts on population levels, potentially responsive to changes in river hydrology. Examples of epibenthos in the Cape Fear system include important fisheries species such as the blue crab, *Callinectes sapidus*, the spot, *Leiostomus xanthurus*, flounder *Paralichthys dentatus* and commercial shrimp, (*Farfantepanaeus* sp. and *Litopanaeus* sp.). Many epibenthos often occupy critical intermediate trophic roles, being predators on benthos or plankton and prey for larger fish (e.g. grass shrimp, *Palaemonetes* spp., killifish, *Fundulus* spp., and bay anchovy, *Anchoa* sp.). Evaluation of epibenthos provides direct information on possible year class strength of target fishery and indicator species as well as indications of resource and ecosystem responses. Epibenthos may respond quickly to changing conditions because of their ability to move away from unfavorable conditions as well as their dependence on annual recruitment events.

Epibenthic taxa may represent indicators of ecosystem level changes for three reasons: 1) their motile lifestyles allows them to quickly respond to physical changes in the environment, 2) many of the species are juveniles that represent a critical “bottleneck” in year class strength that is sensitive to hydrodynamic factors affecting larval ingress, and 3) the intermediate trophic role of many epibenthos may lead to greater responsiveness to both changes in primary consumer abundances (e.g. benthos) and higher predator abundances. Changes in tidal amplitude or salinity regimes may be first detected as a change in the distribution of certain epifaunal organisms, including shifts in dominance at a site or along the upstream/downstream gradient. Epifauna are sensitive to changes in many physical conditions and may show behavioral avoidance depending on the factor (i.e. rapid shift in dissolved oxygen, temperature or salinity). Conversely, they may show consistency on the longer temporal scale (i.e. timing of ingress/egressing into the estuary and dominance patterns). For many epifauna, especially the juveniles of transient fish, a critical factor may be resource limitation. The presence of a consistent and abundant food resource (including benthic fauna) and refuge (structural habitat within the marsh system) are important for determining population levels and survivorship.

The objective here is to evaluate long-term trends in abundance, species composition, and habitat utilization of epibenthos and to detect shifts (if any) in these patterns concordant with river deepening activities and any associated physical changes. The primary objective of the first 2 years of sampling (fall 1999-spring 2001) was to establish a baseline for species composition and abundance patterns. The third and fourth year of monitoring represents a construction phase. Potential impacts to hydrology may start to become apparent at this time. Potential long-term impacts of the river deepening project would be detected by comparison of patterns in multiple years after channel deepening has been completed to pre-construction and during construction patterns. As with the benthic infaunal sampling, some of the potential impacts to these communities are similar to those predicted for rapid sea level rise and so may indicate long-term community changes expected naturally in other systems over the next several decades.

There are three primary working hypotheses:

1) Shifts in salinity, tidal inundation, or tidal amplitude may cause shifts in the epibenthic community composition and /or abundance.

2) Changes in the benthic community resulting from the deepening and widening of the river channel may cause a trophic cascading effect that will change the dominance patterns and distribution of some epibenthic species.

3) Hydrologic alterations may affect annual recruitment patterns into the estuary, especially for transient species.

7.3 Methodology

Marshes and boundary wetlands in the Cape Fear River estuary provide a variety of habitats, especially in the tidally influenced areas that have both intertidal and shallow subtidal edge habitats. We use two sampling methods, Breder traps and drop traps, to target fauna with different utilization patterns. Breder trap sampling targets bottom-oriented organisms that utilize the intertidal marsh habitat during the period of inundation. Breder traps are a passive form of sampling that average use patterns over a several hour period. This method has the advantage of being reliably deployed among a variety of structures. Drop trap sampling targets those organisms that utilize the shallow subtidal or “edge” habitat. It is an instantaneous method that provides reliable estimates for both bottom oriented and pelagic species, with the advantage of allowing high replication, but it is difficult to deploy within heavily structured environments such as marshes.

Breder traps are used to sample small fish and crustaceans utilizing areas within the vegetated marsh or wooded swamp and were described in previous reports (Hackney et al. 2002a; 2002b; 2003). When submerged, these traps are transparent and catch epibenthic fish and crustaceans passively, as they move into the tidal marshes. At each station traps are placed at three tidal heights; lower intertidal (near mean low water), mid intertidal (submerged ~1m depth at mean high water), and upper intertidal (submerged ~ 0.5m at mean high water). Two sets of five traps are set at each tidal height with the opening oriented toward the channel or downstream. The orientation of the traps is based on preliminary study that indicated this positioning is optimal for obtaining highest catches. Each trap is secured to the substrate to ensure it maintains proper orientation. All traps are set on the rising tide and traps are allowed to “fish” for two hours. This time period is based on previous work and represents a compromise between obtaining higher catches and reducing possible loss due to escape or to predation or cannibalism among organisms within the traps. All organisms caught are identified to lowest possible taxon and representative specimens are preserved for verification. All organisms caught are measured for total length. Breder trap sampling is conducted at 9 sites: P11, P12 and P13 in the mainstem Cape Fear River, P6, P7 and P8 in the Northeast Cape Fear, and P2 and 2 sites at P3 in Town Creek.

Drop traps sample those epibenthos utilizing the lower marsh edge or shallow subtidal regions adjacent to the marsh. The drop trap is an aluminum square that is 1m on a side and 1m high with mesh netting and floats attached to the top edge to prevent organisms from escaping. The trap is deployed from a boat using a large boom that suspends the trap 6-8 feet above the water surface. When the trap is released its weight drives it into the substrate and seals the bottom to prevent organisms from escaping beneath the trap (each drop is checked for an adequate bottom seal upon deployment, on the trap with a complete bottom seal are samples). Eighteen replicate drops are made in the shallow subtidal areas at each station. Replicate samples are taken at least 10m apart and at least 20 minutes is allowed between each sample. Once the trap is secured the contents are removed using a steel frame sweep net with a 2mm mesh. The trap is considered empty when five consecutive sweeps of the entire trap yield no organisms. All organisms caught are identified, enumerated, and measured (total length). Representatives of each species caught are preserved for verification. Drop sampling is conducted at the same sites as Breder trap sampling, except that the two P3 subsites are sampled as one site.

Drop trap and Breder trap sampling was conducted during the same time window for all stations. However a minimum of two days was allowed between sampling methods for any station. This time period reduces possible interference between sampling methods and reduces possible impacts at the sampling stations.

For this report, we present mean abundance of epibenthos for each station by year and season (reflecting seasonal variation in faunal abundances) (Tables 7.4.1-7.4.17). To evaluate potential trends and community level responses, analyses for this report focus on differences in diversity, and total fauna by season across years. Site comparisons were made on common taxa (Table 7.4.18) (taxa comprising 5% or more of the total number of individuals in any year season combination). Breder trap data was analyzed with year/season/site/set (upper, mid, or lower intertidal) as main effects, along with the appropriate interactions, using an analysis of variance approach. Results of that analysis indicated strong interactions, with season (reflecting differential recruitment patterns for different species), so these data were analyzed separately for each season. This analysis detected some interactions, however, these interactions were attributed to sites and sets with low abundances or no fauna captured during one or more sampling events. To evaluate overall community trends, an Analysis of Similarity (ANOSIM) was used on data collected from Breder trap and drop trap methods to detect overall differences among years. This analysis uses a similarity matrix and compares all years pairwise. Data was square root transformed to reduce the influence of common species, allowing patterns of secondary species to be evaluated.

Table 7.4-1a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P2 (Mouth of Town Creek).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.20 (0.20)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia affinis	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0.30 (0.15)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.30 (0.21)	0.40 (0.22)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0.70 (0.33)	0.90 (0.28)	0.60 (0.27)	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)
Symphurus plagiusa	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)
Syngnathidae	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I insect	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugilator	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-1b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P2 (Mouth of Town Creek).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0.30 (0.15)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	010 (0.10)	0 (0)	0.10 (0.10)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.60 (0.31)	0.80 (0.42)	0.30 (0.15)	0 (0)	0 (0)	0 (0)
Paralichthys lethostigma	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	3.50 (0.82)	4.50 (1.18)	3.70 (1.68)	0 (0)	0 (0)	0 (0)
Symphurus plagiusa	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Syngnathidae	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I insect	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugilator	0 (0)	0 (0)	1.5 (1.19)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0.80 (0.80)	0.10 (0.10)	0 (0)	0 (0)	0 (0)

Table 7.4-1c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P2 (Mouth of Town Creek).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0.10 (0.10)	0.10 (0.10)	0 (0)
Fundulus heteroclitus	0.10 (0.10)	0.10 (0.10)	0 (0)	0.20 (0.13)	0.20 (0.13)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.10 (0.10)	0.20 (0.13)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hirudinea	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Leiostomas xanthurus	9.90 (2.66)	5.00 (1.62)	5.30 (2.33)	0 (0)	0 (0)	0.50 (0.22)	1.00 (0.54)	0.50 (0.27)	0.30 (0.21)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)
Palaemonetes pugio	1.50 (0.43)	1.40 (0.52)	2.30 (1.04)	2.00 (0.82)	1.10 (0.53)	1.30 (0.68)	1.00 (0.45)	1.00 (0.47)	0.10 (0.10)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-1d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P2 (Mouth of Town Creek).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Fundulus heteroclitus	0 (0)	0 (0)	0.10 (0.10)	0.30 (0.15)	0.20 (0.13)	1.00 (0.33)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.40 (0.27)	0.30 (0.30)	0.10 (0.10)
Hirudinea	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)
Leiostomas xanthurus	0 (0)	0 (0)	0 (0)	2.60 (1.64)	2.20 (0.44)	1.40 (0.40)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.80 (0.44)	0.80 (0.51)	1.70 (0.96)	1.60 (0.67)	1.80 (0.36)	1.30 (0.50)
Paralichthys dentatus	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
U/I larval fish	0.20 (0.13)	0.80 (0.59)	0.10 (0.10)	0.30 (0.30)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)

Table 7.4-2a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P3A (Town Creek).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0.20 (.20)	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)	0.20 (0.13)	0.40 (0.16)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.20)	0 (0)	0.50 (0.31)	1.10 (0.41)	0.50 (0.31)
Ctenogobius shufeldti	0 (0)	0.10 (0.10)	0.10 (0.10)	0 (0)	0.80 (0.47)	0 (0)	0 (0)	0 (0)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0.10 (0.10)	0.10 (0.10)	0.20 (0.20)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.70 (0.52)	0.40 (0.31)	0.50 (0.31)	0.30 (0.15)	0.40 (0.22)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.20 (0.20)	0.40 (0.22)	0.80 (0.25)	0 (0)	0.20 (0.20)	0.30 (0.21)	0.20 (0.20)	0.10 (0.10)	0 (0)

Table 7.4-2b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P3A (Town Creek).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)	0 (0)
Fundulus heteroclitus	0.22 (0.15)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)	0.70 (0.40)
Gambusia holbrooki	0.11 (0.11)	0.20 (0.20)	0.20 (0.20)	0.60 (0.50)	1.60 (0.85)	1.20 (0.57)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.30 (0.21)	0.10 (0.10)	0.40 (0.22)
Gobiosoma sp.	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.33 (0.24)	0.80 (0.61)	0.90 (0.69)	0.20 (0.133)	0.40 (0.16)	0 (0)
Farfantepenaeus aztecus	0.33 (0.33)	0.20 (0.13)	0.70 (0.50)	0 (0)	0 (0)	0 (0)
Uca minax	0.33 (0.17)	0.50 (0.31)	0.50 (0.40)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-2c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P3A (Town Creek).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Fundulus heteroclitus	0 (0)	0 (0)	0.10 (0.10)	1.00 (0.54)	1.00 (0.89)	1.50 (0.82)	0.10 (0.10)	0.30 (0.15)	0.80 (0.51)
Gambusia affinis	0.10 (0.10)	0.50 (0.27)	0.50 (0.31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.10 (0.10)	0.30 (0.21)	0.60 (0.43)	0.90 (0.69)
Ctenogobius shufeldti	0 (0)	0.10 (0.10)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Uca pugnax	1.50 (0.62)	2.10 (0.57)	2.00 (0.67)	0.10 (0.10)	1.40 (0.56)	1.80 (0.53)	0 (0)	0 (0)	0 (0)
Uca pugilator	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)	1.00 (0.30)	1.10 (0.48)

Table 7.4-2d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P3A (Town Creek).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Fundulus heteroclitus	0.20 (0.20)	0.50 (0.27)	0.89 (0.35)	0 (0)	0 (0)	0 (0)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0.10 (0.10)	0.60 (0.34)	0 (0)	1.70 (0.86)	0.80 (0.29)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	1.30 (0.60)	1.50 (0.52)	2.70 (1.75)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	0.70 (0.60)	0.70 (0.60	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.90 (0.35)	0.80 (0.33)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.30 (0.15)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Uca minax	0.60 (0.31)	0.80 (0.29)	1.11 (0.31)	0 (0)	0 (0)	0.20 (0.13)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugilator	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-3a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P3B (Town Creek).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Fundulus confluentus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.10 (0.10)	0 (0)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	1.00 (0.56)	0.20 (0.13)	1.00 (0.49)	0 (0)	0.30 (0.15)	0 (0)
Ctenogobius shufeldti	0 (0)	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)	0.50 (0.22)	0 (0)	0 (0)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	1.60 (0.40)	1.50 (0.76)	1.20 (0.59)	0.20 (0.13)	0.10 (0.10)	0.10 (0.10)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.50 (0.22)	0.20 (0.13)	0.40 (0.16)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-3b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P3B (Town Creek).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Fundulus confluentus	0 (0)	0 (0)	0.20 (0.20)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0.10 (0.10)	0 (0)	0.20 (0.13)	0 (0)	0 (0)	0 (0)
Fundulus majalis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Gambusia holbrooki	0.50 (0.40)	0 (0)	0.10 (0.10)	0 (0)	0.20 (0.16)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.50 (0.50)
Gobiosoma sp.	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.10 (0.10)	0.80 (0.49)	0.90 (0.41)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)
Farfantepenaeus aztecus	0.40 (0.22)	0.40 (0.27)	0.80 (0.51)	0.10 (0.10)	0.15 (0.08)	0 (0)
Uca minax	0 (0)	1.20 (0.49)	1.80 (0.61)	0 (0)	0.10 (0.10)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)

Table 7.4-3c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P3B (Town Creek).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Dormitator maculatus	0 (0)	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)	0 (0)
Gambusia affinis	0.10 (0.10)	0.20 (0.13)	0.30 (0.15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0.40 (0.31)	1.10 (0.67)	0.60 (0.40)	2.30 (0.83)	2.30 (1.04)	0.60 (0.34)
Ctenogobius shufeldti	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0.10 (0.10)	0 (0)	0 (0)	0.10 (0.10)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.20 (0.20)	0.10 (0.10)	0.10 (0.10)	1.20 (0.53)	0.30 (0.15)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.70 (0.26)	1.20 (0.49)	0.60 (0.34)	0.20 (0.13)	0.60 (0.40)	0.90 (0.50)	0 (0)	0 (0)	0 (0)
Uca pugilator	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.40 (0.22)	0.30 (0.15)	2.60 (0.73)

Table 7.4-3d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P3B (Town Creek).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0.60 (0.27)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0.20 (0.20)	0.30 (0.21)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	030 (0.15)	1.80 (0.92)	0.10 (0.10)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.20 (0.13)	0.10 (0.10)
Paralichthys dentatus	0.20 (0.20)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)
Uca minax	0 (0)	0.80 (0.47)	1.40 (0.60)	0 (0)	0 (0)	0.20 (0.20)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugilator	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-4a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P6 (Eagle Island).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.10 (0.10)	0.11 (0.11)
Dormitator maculatus	0 (0)	0.10 (0.10)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)	0 (0)	0.10 (0.10)	0 (0)	0 (0)
Lutjanus griseus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	1.00 (0.60)	0.80 (0.44)	0.20 (0.13)	1.90 (1.49)	1.40 (0.45)	2.89 (1.74)
Paralichthys albigutta	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)
U/I fish	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-4b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P6 (Eagle Island).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	1.50 (0.50)	0.90 (0.55)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0.60 (0.50)	0.10 (0.10)
Fundulus majalis	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0 (0)	0.10 (0.10)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)
Lutjanus griseus	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.50 (0.22)	0.50 (0.31)	4.22 (4.10)	0 (0)	0 (0)	0 (0)
Paralichthys albigutta	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0.90 (0.23)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Sygnathidae	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.50 (0.22)
U/I fish	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-4c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P6 (Eagle Island).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0.10 (0.10)	0.10 (0.10)	0 (0)	0.10 (0.10)	0 (0)	0.20 (0.13)	0 (0)	0 (0)
Diving beetle	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.90 (0.59)	1.00 (0.89)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Ctenogobius shufeldti	0 (0)	0.10 (0.10)	0.10 (0.10)	0.20 (0.13)	0.30 (0.21)	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0.10 (0.10)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0.20 (0.13)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)	0.20 (0.20)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0.30 (0.30)	0.10 (0.10)	0.20 (0.20)	0 (0)	0 (0)	0.20 (0.20)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)
Paralichthys dentatus	0.30 (0.30)	0.40 (0.22)	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugilator	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Uca pugnax	0 (0)	0 (0)	0 (0)	0.30 (0.21)	0 (0)	0.60 (0.31)	0 (0)	0 (0)	0 (0)

Table 7.4-4d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P6 (Eagle Island).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0 (0)
Diving beetle	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0.50 (0.27)	0.10 (0.10)	0.20 (0.13)	0 (0)	0.10 (0.10)	0.20 (0.13)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.30 (0.15)	0.50 (0.22)	0.10 (0.10)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	8.70 (2.87)	14.30 (4.37)	32.90 (12.60)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0.60 (0.31)	0.70 (0.40)	2.30 (1.08)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0 (0)	0 (0)
Paralichthys dentatus	2.30 (0.67)	1.80 (0.63)	0.80 (0.59)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0.20 (0.20)	0.20 (0.20)	0 (0)
Uca pugilator	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-5a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P7 (Indian Creek).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eucinostomus argenteus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.20 (0.13)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropterus salmoides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.60 (0.34)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-5b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P7 (Indian Creek).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eucinostomus argenteus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.50 (0.22)	0.10 (0.10)	0.40 (0.22)
Gobiosoma sp.	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropterus salmoides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.11 (0.11)	1.56 (0.56)	0.56 (0.34)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-5c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P7 (Indian Creek).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.50 (0.31)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.40 (0.16)	1.10 (0.28)	4.33 (3.85)	0.40 (0.22)	0.60 (0.22)	0.30 (0.21)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	6.60 (2.35)	8.20 (3.57)	2.80 (0.66)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0.40 (0.22)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.10 (0.10)
Paralichthys lethostigma	0 (0)	0.30 (0.15)	0.67 (0.44)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rhithropanopeus herbstii	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)

Table 7.4-5d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P7 (Indian Creek).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.70 (0.42)	0.70 (0.30)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	1.60 (0.78)	0.90 (0.31)	1.10 (0.35)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0.40 (0.16)	0.30 (0.21)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	1.20 (0.33)	0.70 (0.37)	0.50 (0.17)
Rhithropanopeus herbstii	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0.10 (0.10)	0.33 (0.17)	0 (0)	0 (0)	0 (0)

Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-6a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P8 (Dollisons Landing).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cambarus robustus	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus confluentus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	1.0 (1.0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0.20 (0.13)	0.20 (0.20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-6b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P8 (Dollisons Landing).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)
Callinectes sapidus	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cambarus robustus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus confluentus	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.20)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	1.10 (0.60)	0.50 (0.27)	0.20 (0.13)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.78 (0.66)	0.30 (0.21)	1.10 (0.31)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0.20 (0.20)	0.10 (0.10)

Table 7.4-6c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P8 (Dollisons Landing).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Amphipoda	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.60 (0.31)	0.30 (0.15)	0.30 (0.21)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.20 (0.13)	1.00 (0.80)	0 (0)	0 (0)	0 (0)

Table 7.4-6d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P8 (Dollisons Landing).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Amphipoda	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0.30 (0.21)	0.30 (0.15)	0.10 (0.10)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0.10 (0.10)	0.11 (0.11)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	1.20 (0.61)	0.20 (0.13)	0 (0)

Table 7.4-7a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P11 (Smith Creek).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)
Dormitator maculatus	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus majalis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0 (0)	0.30 (0.21)
Ctenogobius shufeldti	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Lepomis macrochirus	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lutjanus griseus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.80 (0.80)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.60 (0.27)	0.50 (0.22)	0.20 (0.13)
Symphorus plagiusa	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.10 (0.10)	0.20 (0.13)	8.50 (4.17)	0 (0)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-7b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P11 (Smith Creek).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus majalis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	2.10 (0.85)	0.70 (0.40)	0.30 (0.21)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lutjanus griseus	0.10 (0.10)	0.10 (0.10)	0.20 (0.13)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.40 (0.31)	0.40 (0.22)	0.40 (0.16)	0.10 (0.10)	0.10 (0.10)	0 (0)
Paralichthys dentatus	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys lethostigma	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	1.20 (0.70)	1.80 (0.61)	1.20 (0.36)	0 (0)	0 (0)	0 (0)
Symphorus plagiusa	0.10 (0.10)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish	0.10 (0.10)	0 (0)	0.40 (0.40)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-7c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P11 (Smith Creek).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.30 (0.15)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.20)	0 (0)	0.10 (0.10)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.60 (0.31)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	1.30 (0.76)	0.30 (0.21)	1.0 (0.39)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.80 (0.61)	0.50 (0.22)	1.10 (0.60)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.20 (0.20)	0 (0)	0 (0)	0.10 (0.10)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.40 (0.16)	0.40 (0.31)	1.20 (0.63)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)

Table 7.4-7d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P11 (Smith Creek).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.10 (0.10)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0.10 (0.10)	0 (0)	6.80 (2.08)	9.70 (3.85)	25.90 (11.83)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.33 (0.17)	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0.89 (0.56)	0.10 (0.10)	0.30 (0.21)	0 (0)	0 (0)	0 (0)

Table 7.4-8a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P12 (Rat Island).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0.60 (0.34)	0 (0)	0.40 (0.22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.20 (0.20)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Lepomis macrochirus	0 (0)	0.20 (0.13)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.10 (0.10)	0 (0)	0 (0)	0.40 (0.31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.10 (0.10)
Syngnathidae	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0.20 (0.13)	0.10 (0.10)	0.10 (0.10)	0 (0)	1.70 (0.53)	0 (0)	0 (0)	0 (0)

Table 7.4-8b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P12 (Rat Island).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia affinis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.60 (0.43)	0.60 (0.40)	0.60 (0.31)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0.44 (0.24)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0.30 (0.21)	0.30 (0.15)	0.89 (0.26)	0 (0)	0 (0)	0 (0)
Syngnathidae	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-8c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P12 (Rat Island).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0.30 (0.15)
Fundulus heteroclitus	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.20 (0.20)	0.80 (0.49)	0 (0)	0 (0)	0.30 (0.21)
Ctenogobius shufeldti	0.60 (0.31)	0.60 (0.31)	0.10 (0.10)	0 (0)	0.20 (0.20)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0.20 (0.13)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)
Leiostomas xanthurus	0.20 (0.20)	0.20 (0.13)	0.10 (0.10)	0.50 (0.31)	0.60 (0.27)	0.80 (0.49)	0 (0)	0.20 (0.13)	0 (0)
Lepomis macrochirus	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0.20 (0.20)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.20 (0.20)	0.30 (0.21)	0.50 (0.22)	0 (0)	1.00 (0.39)	0.50 (0.27)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys lethostigma	0 (0)	0.30 (0.21)	0.30 (0.15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.20)
Rhithropanopeus herbstii	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.10 (0.10)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4.8-d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P12 (Rat Island).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0.90 (0.41)	0.55 (0.25)	0.90 (0.50)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Leiostomas xanthurus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropogonias undulatus	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.67 (0.55)	1.60 (0.93)	3.50 (3.06)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0.22 (0.15)	1.40 (1.09)	0.40 (0.22)	0 (0)	0 (0)	0 (0)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rhithropanopeus herbstii	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.81 (0.55)	1.50 (0.43)

Table 7.4-9a. Mean abundance (SE) for epibenthic fauna collected during fall (1999-2001) breder trap samples at station P13 (Fishing Creek).

	Fall 1999			Fall 2000			Fall 2001		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Dormitator maculatus	0.10 (0.10)	0.20 (0.20)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0.60 (0.60)	0.30 (0.30)	0 (0)	0.20 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lutjanus griseus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0.40 (0.31)	0.40 (0.31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-9b. Mean abundance (SE) for epibenthic fauna collected during fall (2002-2003) breder trap samples at station P13 (Fishing Creek).

	Fall 2002			Fall 2003		
	Low	Mid	Upper	Low	Mid	Upper
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.13)	0 (0)
Dormitator maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gobiosoma sp.	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis macrochirus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lutjanus griseus	0.10 (0.10)	0.10 (0.10)	0.10 (0.10)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0.30 (0.30)	0 (0)	0.40 (0.40)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0.20 (0.20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0 (0)

Table 7.4-9c. Mean abundance (SE) for epibenthic fauna collected during spring (2000-2002) breder trap samples at station P13 (Fishing Creek).

	Spring 2000			Spring 2001			Spring 2002		
	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0.10 (0.10)	0.80 (0.42)	0.40 (0.22)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.30 (1.10)	0.60 (0.34)	0.20 (0.13)
Lepomis macrochirus	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.30 (0.30)	0.10 (0.10)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0.10 (0.10)	0.20 (0.13)	0.60 (0.43)	0.80 (0.33)	0 (0)	0 (0)	0 (0)

Table 7.4-9d. Mean abundance (SE) for epibenthic fauna collected during spring (2003-2004) breder trap samples at station P13 (Fishing Creek).

	Spring 2003			Spring 2004		
	Low	Mid	Upper	Low	Mid	Upper
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0.30 (0.21)	0.70 (0.33)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	1.30 (0.47)	1.00 (0.49)	1.50 (0.70)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	2.00 (1.31)	2.20 (1.04)	5.50 (2.87)
Lepomis macrochirus	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0.30 (0.21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0.30 (0.30)	0.20 (0.20)	0.40 (0.22)
Uca minax	0.20 (0.13)	0.40 (0.16)	0.90 (0.31)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-10. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P2 (Mouth of Town Creek).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Alpheus heterochelis	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Anchoa mitchelli	0.44 (0.44)	0 (0)	1.39 (1.33)	0.28 (0.23)	0 (0)	0 (0)	0 (0)	2.00 (1.94)	0 (0)	0 (0)
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0.28 (0.14)	0 (0)	0 (0)
Anthinnae	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Bivalve	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)
Brevoortia tyrannus	0 (0)	0 (0)	0.17 (0.17)	0 (0)	0 (0)	0 (0)	0 (0)	21.67 (20.80)	0 (0)	0 (0)
Callinectes sapidus	0.33 (0.14)	0.67 (0.23)	0.78 (0.42)	0.11 (0.11)	0 (0)	0.06 (0.06)	0.06 (0.06)	0.50 (0.15)	0.17 (0.09)	0.17 (0.09)
Gambusia holbrooki	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Gerreidae	0 (0)	0 (0)	0 (0)	0 (0)	0.22 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gobiesox punctulatus	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.44 (0.20)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0.17 (0.09)	0.06 (0.06)	0.11 (0.08)	0 (0)	0.06 (0.06)
Lagodon rhomboides	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0.44 (0.23)	0 (0)	0 (0)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7.0 (2.41)	62.89 (40.60)	0.22 (0.17)	0 (0)	4.61 (1.39)
Lutjanus griseus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0.39 (0.24)	0 (0)	0 (0)	5.61 (3.20)	1.28 (0.75)	1.39 (1.13)	0 (0)	0 (0)
Menidia menidia	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0.33 (0.24)	0 (0)	0 (0)	0 (0)	4.56 (4.38)	0.89 (0.35)
Menticirrhus saxatilis	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropogonias undulatus	0 (0)	0 (0)	0.44 (0.27)	0 (0)	0 (0)	0 (0)	0 (0)	9.06 (1.89)	16.56 (4.12)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	1.39 (0.78)	0.89 (0.35)	0 (0)	0 (0)
Palaemonetes pugio	1.39 (0.88)	0.78 (0.61)	2.11 (0.81)	0.06 (0.06)	3.06 (0.73)	5.56 (1.35)	20.22 (10.05)	37.94 (16.39)	1.33 (0.55)	1.33 (0.53)
Panopeus herbstii	0.06 (0.06)	0.50 (0.31)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0.06 (0.06)	0 (0)	0.06 (0.06)	0 (0)	0.11 (0.08)	0 (0)	0.11 (0.08)	0.17 (0.12)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.61 (0.57)	0.06 (0.06)
Penaeid	0 (0)	0.17 (0.12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0.17 (0.09)	0.17 (0.12)	3.50 (1.35)	0.44 (0.23)	0 (0)	0 (0)	3.06 (2.37)	0 (0)	1.22 (0.75)
Penaeus setiferus	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rangia cuneata	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rhithropanopeus harrisii	0.06 (0.06)	0 (0)	0.06 (0.06)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0.22 (0.10)	0 (0)	0 (0)
Sciaenidae sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sesarma reticulatum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)
Smphurus plagiusa	0 (0)	0 (0)	0 (0)	1.00 (0.44)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Syngnathid sp.	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trachinotus falcatus	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish sp A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.09)	0 (0)
Uca pugnax	0.06 (0.06)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-11. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P3 (Town Creek).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Anchoa mitchelli	1.36 (0.63)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Anguilla rostrata	0.06 (0.04)	0 (0)	0 (0)	0 (0)	0 (0)	0.09 (0.07)	0.28 (0.16)	0 (0)	0 (0)	0.06 (0.06)
Brevoortia tyrannus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4.00 (2.50)	0 (0)	0 (0)
Callinectes sapidus	0.11 (0.10)	0 (0)	0.11 (0.08)	0 (0)	0.39 (0.18)	0.20 (0.11)	0.28 (0.16)	0.56 (0.27)	0 (0)	0.56 (0.22)
Cambarus robustus	(0.03) (0.03)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eucinostomus argenteus	0 (0)	0 (0)	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Evorthodus lyricus	0 (0)	0 (0)	0 (0)	0 (0)	2.44 (0.89)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0.12 (.08)	0 (0)	0 (0)	0.17 (0.12)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0.11 (0.11)
Fundulus majalis	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0.81 (0.72)	1.83 (0.62)	3.39 (1.72)	0.11 (0.08)	1.00 (0.58)	2.00 (1.28)	0.06 (0.06)	0.22 (0.13)	0 (0)	1.11 (0.54)
Ctenogobius shufeldti	0.53 (0.34)	0.33 (0.16)	0.17 (0.09)	0 (0)	1.22 (0.45)	0.28 (0.12)	0.73 (0.39)	0.22 (0.17)	0 (0)	5.78 (1.79)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.34 (0.19)	0 (0)	0.22 (0.10)	0 (0)	0.11 (0.11)
Leiostomus xanthurus	0 (0)	0 (0)	0.28 (0.14)	0 (0)	0 (0)	0 (0)	0.28 (0.17)	0 (0)	0 (0)	36.39 (13.62)
Lepomis macrochirus	0.09 (0.07)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	1.59 (1.70)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0.06 (0.04)	0 (0)	0.06 (0.06)	0 (0)	2.89 (2.38)	0.06 (0.06)	0 (0)	4.33 (2.22)	0 (0)	0 (0)
Menidia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Micropogonias undulatus	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	50.44 (21.43)	0 (0)	0 (0)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2.89 (1.19)	0 (0)	0.06 (0.06)
Notropis petersoni	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.22 (0.22)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0 (0)	1.39 (0.83)	0.56 (0.30)	0.17 (0.12)	0 (0)	0.17 (0.09)	7.17 (3.23)	0 (0)	10.39 (5.52)
Panopeus herbstii	0.06 (0.06)	0.17 (0.12)	0.06 (0.06)	0 (0)	0 (0)	0.06 (0.04)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0.45 (0.16)	1.17 (0.59)	0 (0)	0.11 (0.08)	0 (0)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0 .06 (0.06)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.12)	0 (0)	0 (0)	0 (0)	0 (0)	0.44 (0.35)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	2.33 (0.67)	3.56 (2.05)	0 (0)	0 (0)	0 (0)	0 (0)	1.39 (1.16)
Rhithropanopeus harrisii	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sesarma cinereum	0 (0)	0.28 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sesarma reticulatum	0 (0)	0 (0)	0 (0)	0.17 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Symphurus plagiusa	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Sygnathidae	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	2.14 (1.05)	0.06 (0.06)	0 (0)	0 (0)	0.06 (0.06)	0.31 (0.17)	0.39 (0.22)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0.17 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0.50 (0.22)	0 (0)
Uca pugnax	0.92 (0.47)	5.06 (0.96)	0 (0)	0 (0)	0 (0)	0.03 (0.03)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.78 (0.46)	0 (0)	0.39 (0.39)

Table 7.4-12. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P6 (Eagle Island).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Anchoa mitchelli	0 (0)	1.00 (0.37)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0.05 (0.05)	0.50 (0.25)	0.11 (0.08)
Callinectes sapidus	0.22 (0.10)	0.06 (0.06)	0 (0)	0.06 (0.06)	0.39 (0.16)	0 (0)	0.06 (0.06)	0.53 (0.18)	0.22 (0.10)	0.61 (0.18)
Clupeidae	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.21 (0.21)	0 (0)	0 (0)
Corbicula fluminea	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.32 (0.27)	0.06 (0.06)	0 (0)
Gerres cinereus	0 (0)	0.28 (0.16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.06 (0.06)	0.22 (0.15)	0 (0)	0 (0)	1.61 (0.51)	0.11 (0.11)	0.11 (0.08)	0 (0)	0 (0)	1.78 (0.33)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0.11 (0.08)
Leiostomus xanthurus	0 (0)	0 (0)	0.22 (0.13)	0 (0)	0 (0)	0 (0)	1.72 (0.72)	1.00 (0.52)	0 (0)	25.61 (9.85)
Lepomis sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Menidia beryllina	0.11 (0.08)	0 (0)	0.17 (0.09)	0.72 (0.42)	0 (0)	0 (0)	20.83 (10.04)	0 (0)	0 (0)	0 (0)
Menidia menidia	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0.28 (0.28)	0 (0)
Menidia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.32 (0.32)	0 (0)	3.44 (2.55)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.22 (0.17)	0.16 (0.16)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	5.44 (3.28)	1.00 (1.00)	0 (0)	0 (0)	0 (0)	1.78 (0.60)	8.21 (2.52)	0.22 (0.13)	0.22 (0.13)
Panopeus herbstii	0 (0)	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.12)	1.17 (0.56)	0.11 (0.11)	0.44 (0.23)	0 (0)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.26 (0.13)	10.83 (3.68)	11.00 (3.82)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0.83 (0.35)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rhithropanopeus harrisii	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.05 (0.05)	0 (0)	0.06 (0.06)
Sesarma reticulatum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.05 (0.05)	0 (0)	0 (0)
Symphurus plagiusa	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0.44 (0.20)	0.11 (0.08)	0 (0)	0 (0)	0.50 (0.25)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0.06 (0.06)
U/I larval fish	0 (0)	0 (0)	0 (0)	2.44 (1.72)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-13. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P7 (Indian Creek).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0.33 (0.14)	0.71 (0.34)	0.11 (0.11)	0 (0)	0.39 (0.28)	1.06 (0.41)
Callinectes sapidus	0.06 (0.06)	0 (0)	0.17 (0.09)	0 (0)	0.11 (0.07)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)
Clupeidae	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dorosoma cepedianum	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dorosoma pretense	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Esox lucius	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eucinostomus argenteus	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fundulus heteroclitus	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0.06 (0.06)	0.17 (0.17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gerres cinereus	0 (0)	0.22 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.06 (0.06)	0.28 (0.18)	0.22 (0.10)	0 (0)	2.11 (0.38)	0.29 (0.14)	0 (0)	0 (0)	0 (0)	1.72 (0.53)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.35 (0.35)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Leiostomus xanthurus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	38.78 (21.08)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.28 (0.18)	0 (0)	0 (0)	0 (0)
Menidia menidia	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)
Menidia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0.28 (0.23)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Mugil cephalus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.28 (0.28)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	0.28 (0.23)	0 (0)	0.33 (0.28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0.06 (0.06)	0.47 (0.29)	1.56 (0.56)	0 (0)	1.50 (0.48)	0 (0)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0 (0)	9.50 (2.14)
Rangia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0.06 (0.06)	0.44 (0.15)	0 (0)	2.06 (0.60)	0 (0)	0 (0)	0 (0)	0.61 (0.22)	0 (0)
U/I juvenile fish	0 (0)	0.39 (0.33)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.06 (0.06)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.8-14. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P8 (Dollisons Landing).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0.33 (0.18)	0.39 (0.14)	0.06 (0.06)	0.11 (0.08)
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.22 (0.10)	0 (0)	0.06 (0.06)
Clupeidae	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	69.78 (45.05)
Cyprinidae	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Esox niger	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.12 (0.08)	0 (0)
Fundulus heteroclitus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)
Gambusia holbrooki	0.22 (0.22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)
Ctenogobius shufeldti	0.11 (0.08)	0 (0)	0.06 (0.06)	0 (0)	2.56 (0.67)	0 (0)	0 (0)	0 (0)	0 (0)	2.17 (0.62)
Gambusia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.33 (0.23)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0.17 (0.12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lepomis gibbensis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.76 (1.76)	0 (0)
Lepomis macrochirus	0.06 (0.06)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.61 (0.39)	0 (0)	0 (0)	0.12 (0.12)	0 (0)
Menidia menidia	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Notropis chalybaeus	2.94 (1.98)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Notropis petersoni	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0.11 (0.11)	0.06 (0.06)	0 (0)	1.35 (0.34)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.72 (0.40)
Penaeid	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.22 (0.13)	0 (0)	0 (0)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rhithorpanopeus harrisii	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sesarma cinereum	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)
Trinectes maculatus	0.17 (0.12)	0 (0)	0.11 (0.11)	0.06 (0.06)	4.00 (1.40)	0 (0)	0 (0)	0.06 (0.06)	0.18 (0.13)	0 (0)
U/I larval fish sp A	0 (0)	0 (0)	0 (0)	1.17 (0.74)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish sp B	0 (0)	0 (0)	0 (0)	0.17 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0 (0)	0.17 (0.12)	0.17 (0.09)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-15. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P11 (Smith Creek).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Anchoa mitchelli	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0.39 (0.33)
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.33 (0.16)	0 (0)	0.06 (0.06)	0.11 (0.08)	0 (0)
Callinectes sapidus	0 (0)	0.06 (0.06)	0.50 (0.25)	0.17 (0.09)	0.22 (0.10)	0.11 (0.08)	0 (0)	1.17 (0.56)	0.28 (0.11)	0.72 (0.33)
Eucinostomus argenteus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0.22 (0.13)	0 (0)	0.06 (0.06)	0 (0)	0.28 (0.16)	0.17 (0.12)	0 (0)	0 (0)	0 (0)	0.72 (0.23)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.33 (0.20)	0 (0)	0 (0)
Ictalurus furcatus	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.72 (0.50)	0 (0)	0.11 (0.08)	0 (0)	0 (0)
Leiostomus xanthurus	0 (0)	0 (0)	0.11 (0.08)	0 (0)	0 (0)	14.83 (9.79)	9.56 (2.30)	1.94 (0.60)	0.39 (0.23)	64.11 (14.63)
Logodon rhomboides	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lutjanus griseus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	1.89 (0.64)	0.83 (0.61)	0 (0)	0 (0)	0.22 (0.17)	1.0 (0.76)	0.06 (0.06)	0 (0)	0 (0)
Menidia menidia	0 (0)	0 (0)	0 (0)	0 (0)	1.50 (1.44)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2.67 (1.11)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.89 (0.87)
Mugil cephalus	0 (0)	0 (0)	0.28 (0.28)	0.06 (0.06)	0 (0)	0 (0)	0.94 (0.79)	0.17 (0.12)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	1.56 (0.41)	0.17 (0.17)	0.17 (0.17)	0 (0)	0.06 (0.06)	0.17 (0.09)	5.20 (2.38)	0.22 (0.13)	0.06 (0.06)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	1.17 (0.44)	0.06 (0.06)	0 (0)	16.11 (3.31)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.28 (0.14)	0 (0)	14.78 (3.73)
Farfantepenaeus aztecus	0 (0)	0.83 (0.49)	6.28 (4.30)	3.56 (1.16)	0 (0)	0 (0)	0 (0)	0.28 (0.18)	0 (0)	0 (0)
Penaeus setiferus	0 (0)	1.89 (0.85)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rangia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.12)	0 (0)	0 (0)	0 (0)	0 (0)
Rhithropanopeus harrisii	0.06 (0.06)	0.06 (0.06)	0.17 (0.12)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)
Sesarma cinereum	0 (0)	0.72 (0.38)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Symphurus plagiusa	0 (0)	0 (0)	0 (0)	0.22 (0.13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0.22 (0.17)	0.06 (0.06)	0 (0)	0 (0)	0.33 (0.14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish sp A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)

Table 7.4-16. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P12 (Rat Island).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Alosa aestivalis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2.56 (2.44)
Anchoa mitchilli	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.67 (1.05)
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.33 (0.28)	0 (0)	0 (0)	0.17 (0.12)
Brevoortia tyrannus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)
Callinectes sapidus	0 (0)	0.11 (0.08)	0.56 (0.27)	0.06 (0.06)	0.11 (0.08)	0 (0)	0 (0)	0.78 (0.26)	0 (0)	0.17 (0.09)
Ctenogobius shufeldti	0.11 (0.08)	0.06 (0.06)	0.06 (0.06)	0 (0)	0.72 (0.40)	0.06 (0.06)	0.56 (0.23)	0 (0)	0 (0)	1.83 (0.69)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.22 (0.10)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Leiostomus xanthurus	0 (0)	0 (0)	0.28 (0.23)	0 (0)	0 (0)	0.11 (0.08)	0 (0)	17.56 (15.35)	0 (0)	16.94 (8.08)
Lepomis macrochirus	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lutjanus griseus	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropogonias undulatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8.22 (4.56)
Menidia beryllina	0 (0)	0 (0)	0.33 (0.23)	0 (0)	0 (0)	0.17 (0.12)	0.39 (0.39)	0 (0)	0 (0)	0 (0)
Palaemonetes pugio	0 (0)	1.22 (0.66)	1.56 (0.89)	0.33 (0.16)	0.11 (0.11)	0.06 (0.06)	1.61 (0.93)	1.50 (0.41)	5.94 (2.60)	0 (0)
Paralichthys albigutta	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.12)	0.33 (0.16)	0 (0)	11.44 (3.57)	0 (0)
Paralichthys lethostigma	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.17 (0.68)	2.22 (1.19)
Farfantepenaeus aztecus	0 (0)	0 (0)	0.06 (0.06)	0.22 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rhithropanopeus harrisii	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)
Sesarma cinereum	0 (0)	0.17 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trinectes maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0.06 (0.06)	0 (0)
U/I larval fish	0 (0)	0 (0)	0 (0)	0.22 (0.22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca minax	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.06 (0.06)	1.11 (0.54)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)

Table 7.4-17. Mean abundance (SE) for epibenthic fauna collected in drop trap sampling at station P13 (Fishing Creek).

	Fall					Spring				
	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Alosa aestivalis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Anchoa mitchelli	0 (0)	0 (0)	0 (0)	0.28 (0.28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)
Anguilla rostrata	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.17)	0.28 (0.14)	0 (0)	0.06 (0.06)	0.11 (0.08)
Callinectes sapidus	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0.17 (0.12)	0.06 (0.06)	0 (0)	0.11 (0.08)
Cambarus robustus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)
Dorosoma petenense	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Esox americanus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)
Gambusia holbrooki	0 (0)	0.33 (0.18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ctenogobius shufeldti	0 (0)	0 (0)	0 (0)	0 (0)	1.39 (0.74)	0.22 (0.15)	0.17 (0.09)	0.11 (0.08)	0 (0)	1.17 (0.40)
Gobiosoma sp.	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lagodon rhomboides	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.09)
Leiostomus xanthurus	0 (0)	0 (0)	0.39 (0.27)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	27.22 (5.68)
Lepomis macrochirus	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia beryllina	0 (0)	0 (0)	0.72 (0.46)	0 (0)	0 (0)	1.39 (0.97)	0.22 (0.22)	6.89 (6.54)	0 (0)	0 (0)
Menidia menidia	0 (0)	0 (0)	0 (0)	4.28 (2.51)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Menidia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)	7.28 (3.11)
Palaemonetes pugio	0 (0)	0 (0)	0 (0)	0.44 (0.29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Panopeus herbstii	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Panopeus sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Paralichthys dentatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.33 (0.16)	0.56 (0.23)	0 (0)	1.29 (0.50)	0 (0)
Paralichthys sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.56 (0.20)
Farfantepenaeus aztecus	0 (0)	0 (0)	0 (0)	0.33 (0.16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Procambarus robostus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)
Rhithropanopeus harrisii	0 (0)	0.22 (0.10)	0 (0)	0 (0)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0.24 (0.14)	0 (0)
Trinectes maculatus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.33 (0.20)	0 (0)	0 (0)	0 (0)	0 (0)
U/I larval fish	0 (0)	0 (0)	0 (0)	0.89 (0.89)	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uca pugnax	0.11 (0.11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Table 7.4-18. Common taxa and relative percent of total abundance by year season for Breder trap sampling. Common taxa are defined as species that comprise 5% or more of the total fauna.

	Fall					Spring				
Species	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004
Ctenogobius shufeldti	--	--	--	--	54.1	15.1	8.5	--	--	--
Dormitator maculatus	10.7	--	--	--	--	--	--	--	--	--
Fundulus heteroclitus	--	--	--	--	7.7	--	13.4	12.7	8.2	5.4
Gambusia holbrooki	--	--	14.8	--	18.7	--	--	22.8	--	--
Leiostomus xanthurus	--	--	--	--	--	46.1	39.7	8.1	--	73.9
Lepomis macrochirus	8.6	--	--	--	--	--	--	--	--	--
Micropogonias undulates	--	--	--	--	--	--	--	6.5	--	--
Paleomonetes pugio	--	--	53.1	33.4	--	10.2	11.4	23.1	31.0	--
Paralichthys dentatus	--	--	--	--	--	--	--	--	28.4	--
Farfantepenaeus aztecus --	--	11.7	42.8	--	--	--	--	--	--	
Uca minax	--	--	--	8.6	--	--	--	--	21.6	--
Uca pugilator	--	--	--	--	--	--	--	18.6	--	--
Uca pugnax	67.5	--	--	--	--	16.5	14.5	--	--	--
Uca sp.	--	91.3	--	--	--	--	--	--	--	--

Table 7.4-19. Common taxa and relative percent of total abundance for drop trap samples by year and season. Common taxa are defined as those species that comprise 5% or more of the total abundance during any sampling season.

	Fall					Spring					
Species	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	
Anchoa mitchilli	14.9	--	5.6	--	--	--	--	--	--	--	
Brevoortia tyranus	--	--	--	--	--	--	--	12.9	--	--	
Callinectes Sapidus	--	--	7.9	--	--	--	--	--	--	--	
Clupeidae	--	--	--	--	--	--	--	--	--	17.9	
Ctenogobius shufeldti	9.7	--	--	--	27.1	--	--	--	--	--	
Evorthodus lyricus	--	--	--	--	6.5	--	--	--	--	--	
Fundulus heteroclitus	--	--	--	--	--	--	--	12.7	--	--	
Gambusia holbrooki	8.9	7.9	12.9	--	--	7.5	--	22.8	--	--	
Lagodon rhomboides	--	--	--	--	--	--	--	9.2	--	--	
Leiostomus xanthurus	--	--	--	--	--	46.9	55.4	--	--	54.8	
Menidia beryllina	--	6.4	9.1	--	7.7	15.1	17.9	6.3	--	--	
Menidia menidia	--	--	--	--	5.3	--	--	--	6.0	--	
Micropogonias undulates		--	--	--	--	--	--	--	29.9	20.3	--
Notropis chalybaeus	13.9	--	--	--	--	--	--	--	--	--	
Paleomonetes pugio	6.5	31.2	23.3	--	8.9	10.6	17.8	30.4	9.5	--	
Paralichthys dentatus	--	--	--	--	--	6.3	--	--	39.6	--	
Paralichthys sp.	--	--	--	--	--	--	--	--	16.7	10.3	
Farfaneopenaeus aztecus		--	--	24.3	--	10.7	--	--	--	--	--
Litopenaeus setiferus	--	6.5	--	--	--	--	--	--	--	--	
Trinectes maculatus	24.1	--	--	--	18.7	--	--	--	--	--	
U.I. fish	--	--	--	97.7	--	--	--	--	--	--	
Uca minax	--	--	--	--	--	--	--	--	--	--	
Uca pugilator	--	--	--	--	--	--	--	--	--	--	
Uca pugnax	9.9	21.7	--	--	--	16.5	--	--	--	--	
Uca sp.	--	91.3	--	--	--	--	--	--	--	--	

Data collected from drop trap sampling was also analyzed for community level responses, examining per sample species richness, total fauna abundance, and diversity by year/site/season. As with the Breder trap data, interactions related to site differences seem to reflect the patchy nature of the epibenthos and magnitude effects. We also compared abundances of common fauna (taxa comprising greater than 5% of the total individuals caught within a given sampling period) among years for each station (Table 7.4.19). Abundances of all fauna were log transformed before analyses to meet assumptions of non-heterogeneity of variances. For drop traps a 1-way Analysis of Variance was used to compare abundances among years at each site within a season type. Where significant year affects were found, an SNK test was used to distinguish among years.

7.4 Faunal patterns

After verification of all identifications a total of 41 taxa have been collected using Breder traps since the initiation of this project in fall 1999. The mean abundance along with standard errors for each taxa by site/season/year is presented in Tables 7.4.1-7.4.9. Drop trap sampling collected a total of 77 taxa. Likewise the mean abundance and standard error of each taxa present at a site is presented in tables 7.4.10-7.4.17. These data clearly show the variable nature of individual taxa but they also highlight the consistent nature of certain groups of taxa.

The Analysis of Similarity showed similar patterns for both drop trap and breeder trap data in that 2002 was clearly different from all other years. However in the case of the drop trap data most years did show some degree of difference, although 2000 was not different from 1999, 2001, or 2003. Breder Trap data on the other hand showed a greater degree of similarity between 2001 and the 2003 and 2004 seasons.

Diversity and total abundance showed both temporal and site differences for both Breder and drop trap methods (Figure 7.4.1-7.4.8). Most interesting of all these data is the clear increase in total abundance for spring 2004 throughout most of the estuary (P2-Mouth of Town Creek is an exception). This pattern is much clearer in the drop trap data than in the Breder trap data (Figure 7.4.1 and 7.4.5). The spring 2004 increase in total abundance can be attributed mainly to the recruitment of two taxa (*Leiostomus xanthurus* and juvenile *Paralichthys* sp.). This also explains the apparent lack of response in diversity measurements over the same time period (Figure 7.4.4 and 7.4.6).

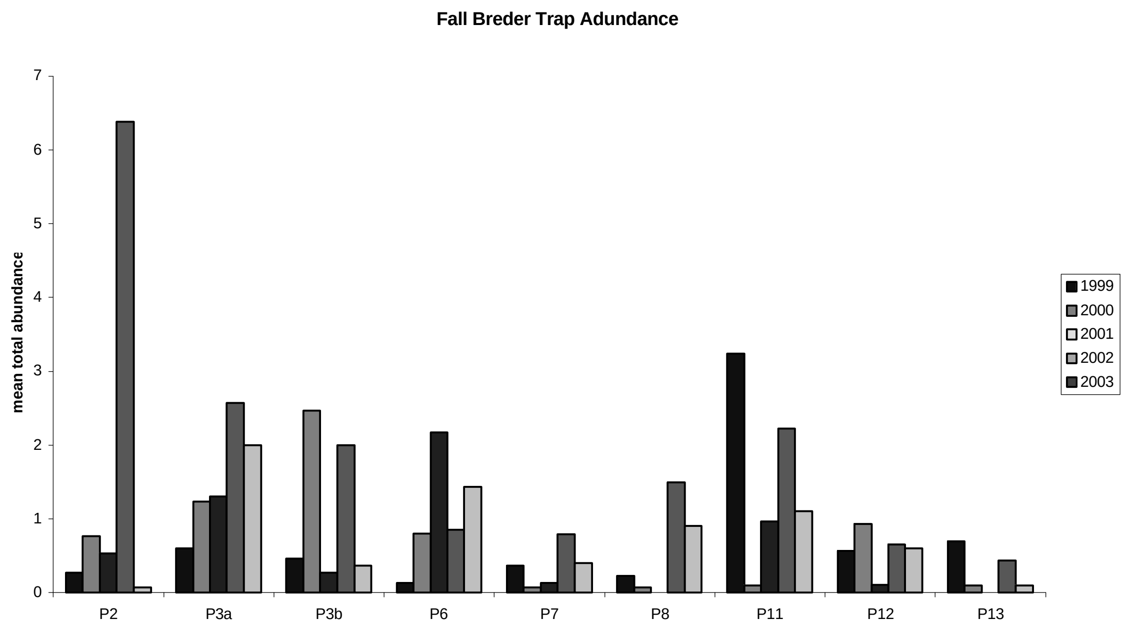


Figure 7.4.1. Mean total abundance per sample for fall Breder trap samples 1999-2003

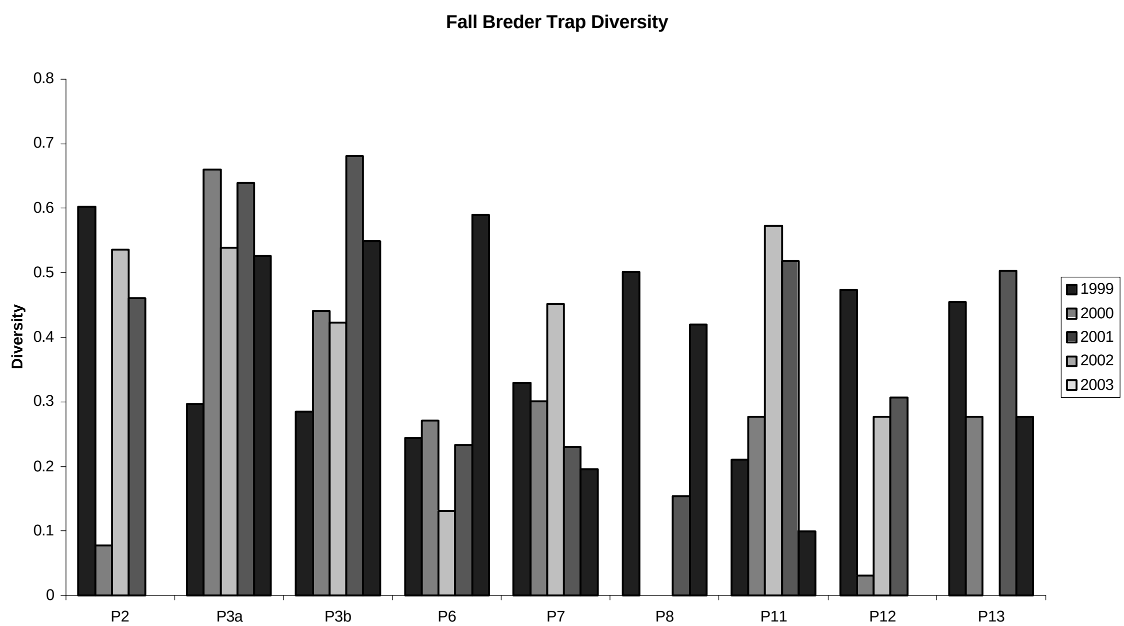


Figure 7.4.2. Mean diversity per sample for fall Breder trap samples 1999-2003

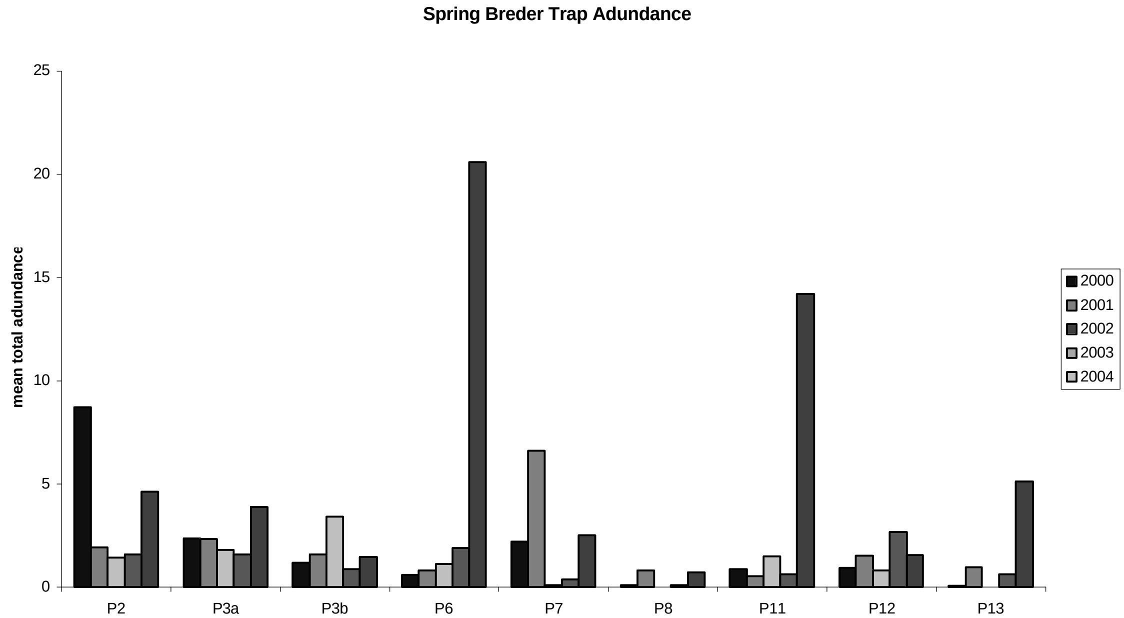


Figure 7.4.3. Mean total abundance per sample for fall Breder trap samples 1999-2004

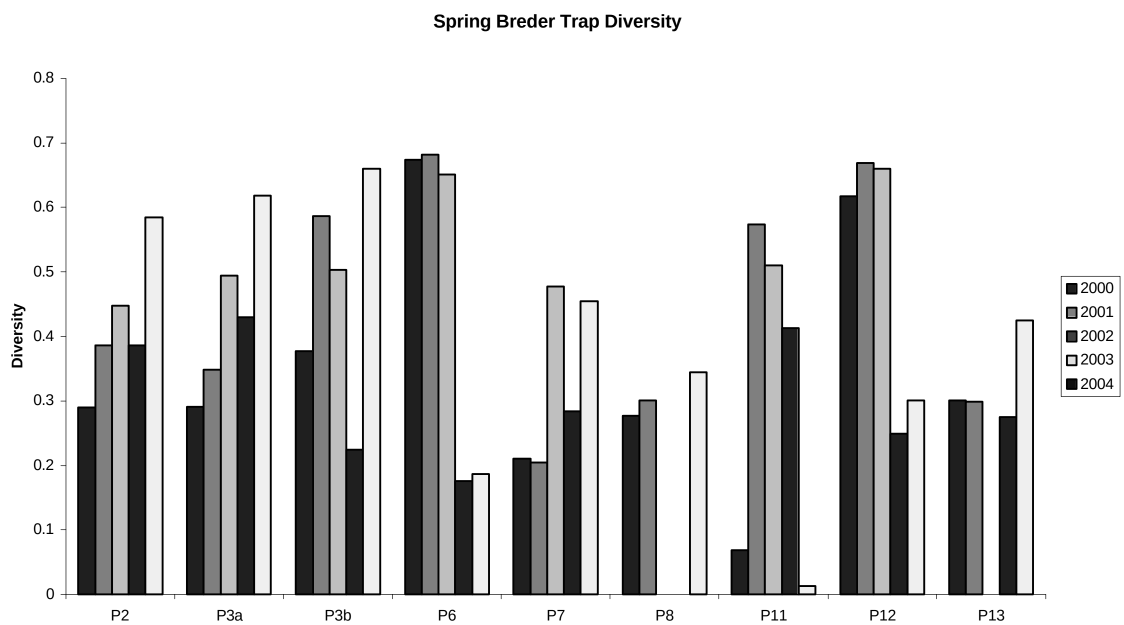


Figure 7.4.4. Mean diversity by site for spring sampling periods 2000-2004

Spring Drop Trap Abundance

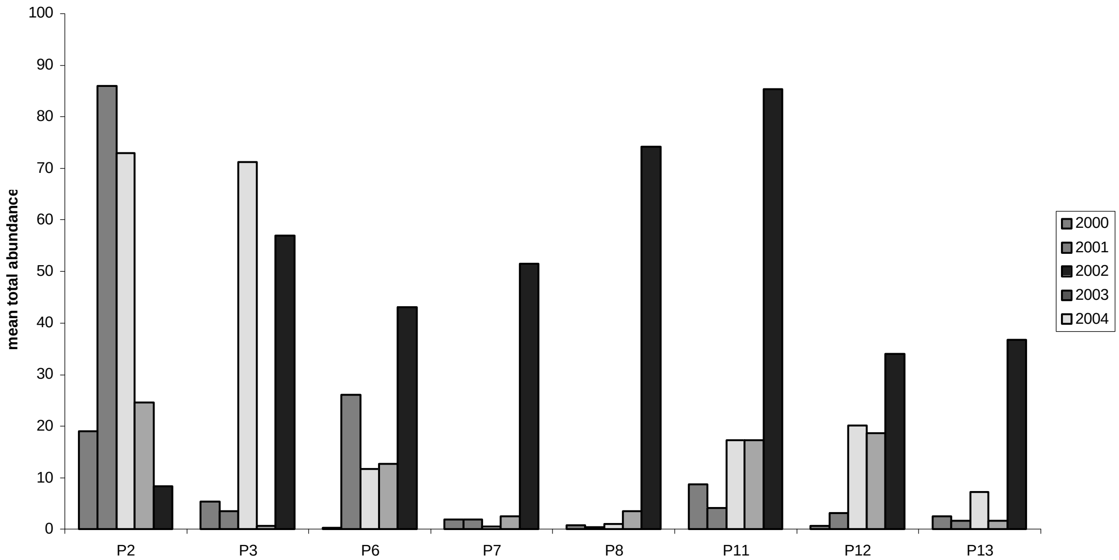


Figure 7.4.5 Mean total abundance per sample for drop traps taken in spring samplings 2000-2004

Spring Drop Trap Diversity

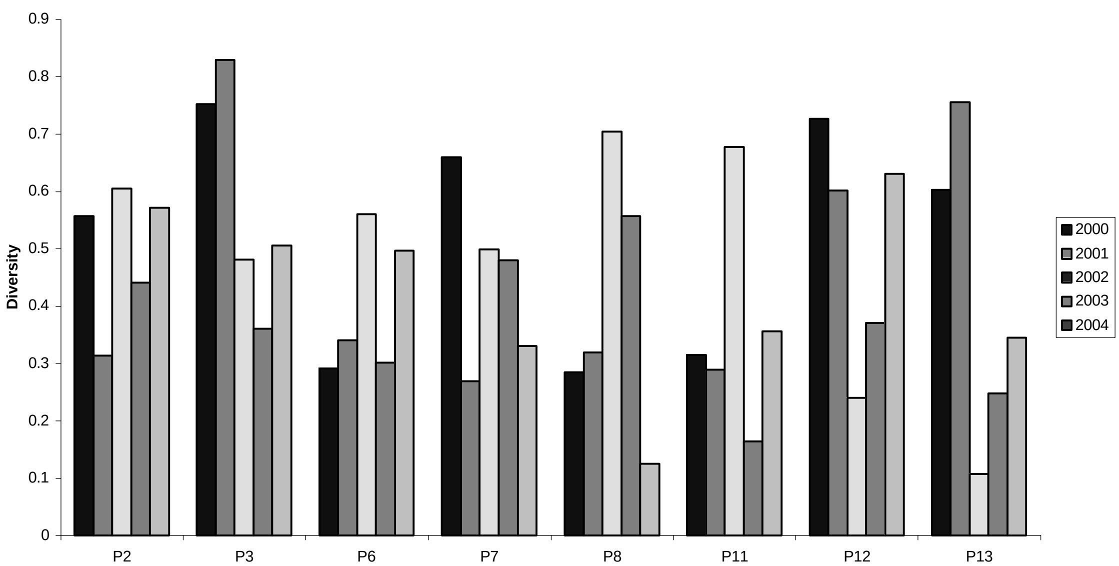


Figure 7.4.6. Mean diversity for all spring drop trap samplings 2000-2004

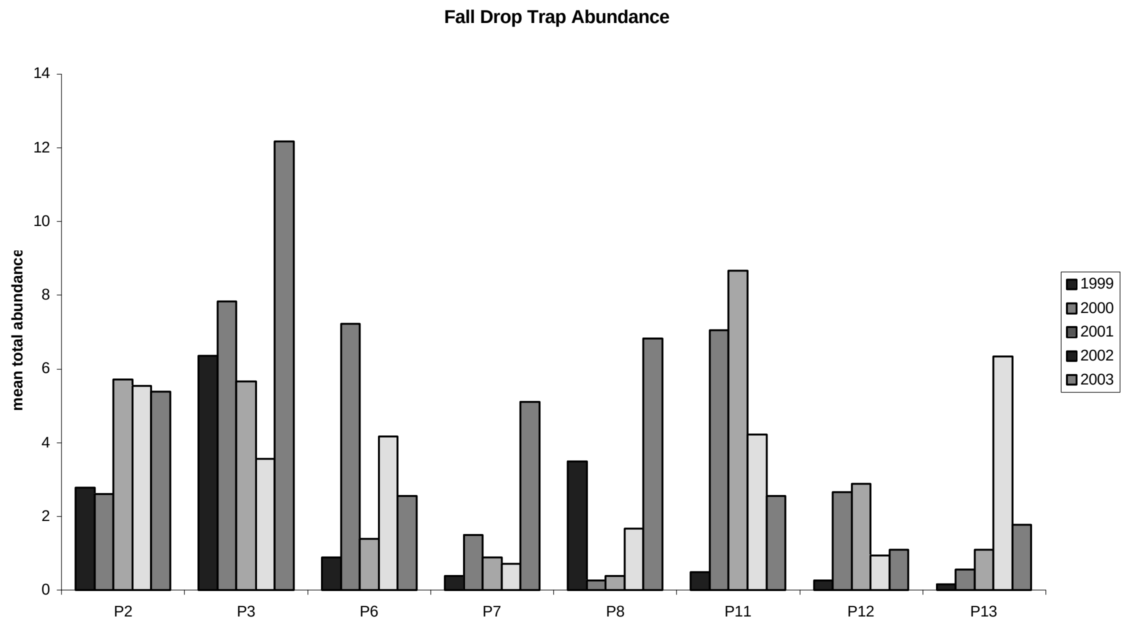


Figure 7.4.7 Mean total abundance per sample from all fall drop trap samplings 1999-2003

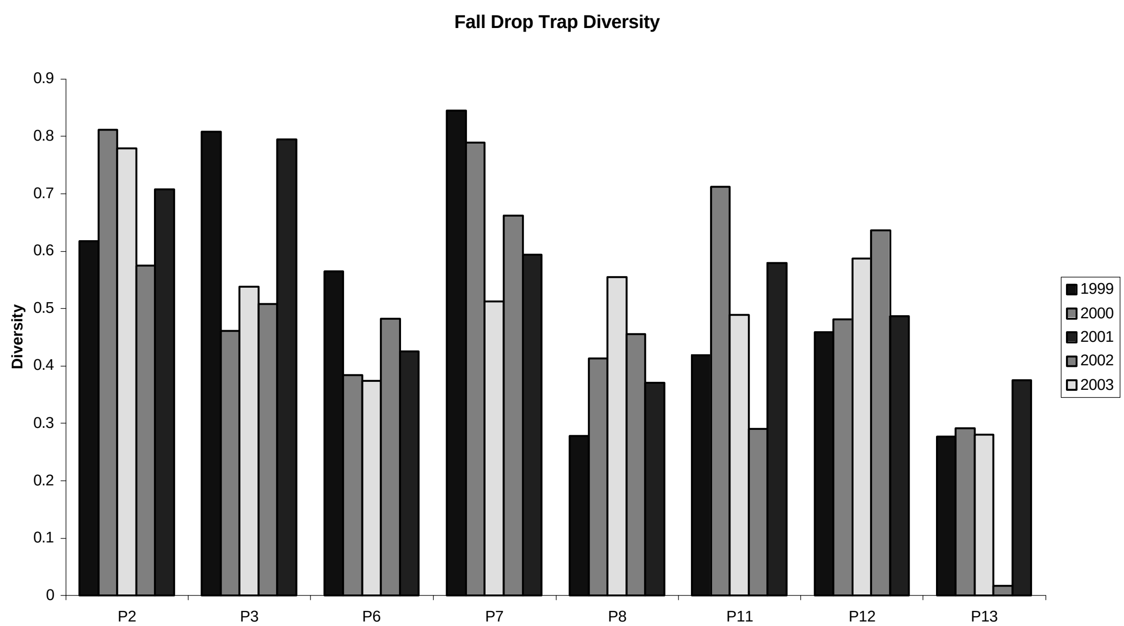


Figure 7.4.8. Mean diversity from fall drop trap samplings 1999-2003

8.0 SENSITIVE HERBACEOUS VEGETATION SAMPLING

8.1 Summary

Summer 2003 marked a reversal of highly saline conditions that had occurred the previous year and a return to fresher conditions. There has been some recovery of salt-sensitive species, but generally these have not returned to initial conditions. High levels of flooding, especially in the upper stations in the mainstem Cape Fear drainage may also have limited growth and prevented plant growth early in the season. New species appeared in several sites and may have arrived in this floodwater that remained over some sites for long periods. In the Northeast Cape Fear River, there were several sites, notable Rat Island, where salt-tolerant species have invaded and continue to invade. There were also new salt tolerant and salt intolerant species noted.

8.2 Introduction and Background

As a part of the on-going Wilmington Harbor monitoring program in the Cape Fear River Estuary, seven stations are examined annually for content and cover by salt-sensitive herbaceous vegetation (Table 8.2-1). The seven stations, all within the lower Cape Fear River estuarine system, experience exposure to ocean-derived salt as well as freshwater tidal flooding. Generalized vegetation zones have been defined along 50-meter wide transects at each station and described in an earlier report (CZR Incorporated 2001). Sampling methods and results of previous sampling at these stations during 2001 are covered in earlier reports (CZR Incorporated 2001, CZR Incorporated 2002, Hackney et al. 2002a, Hackney et al. 2002b, Hackney et al. 2003).

Table 8.2-1. Locations, names and numbers of sensitive herbaceous vegetation monitoring stations in the Wilmington Harbor monitoring project, Cape Fear River Estuary, North Carolina.

Stream Name	Station Name	Station Number
Town Creek	Inner Town Creek	P3
Cape Fear River	Indian Creek	P7
Cape Fear River	Dollisons Landing	P8
Cape Fear River (near Black River)	Black River	P9
Northeast Cape Fear River	Rat Island	P12
Northeast Cape Fear River	Fishing Creek	P13
Northeast Cape Fear River	Prince George Creek	P14

Vegetation conditions and soil geochemistry data from substations located near main streams strongly suggest that characteristics of tidal waters are largely responsible for plant species composition of adjacent wetland habitats (Hackney et al. 2002a, Hackney et al. 2002b, Hackney et al. 2003). Plant species vary in their sensitivity to variations in water chemistry in surface as well as subsurface substrates. In the more saline environments, sulfides help create an environment that is toxic to most obligate freshwater plant species. It is likely that varying degrees of sensitivity exist among, and perhaps within, species. Herbaceous plants may display opportunistic growth in varying sediment regimes where maturation of some species is favored by methanogenic conditions and full development of others is favored by the byproducts of sulfate reduction. Ability to survive adverse biogeochemical conditions is likely to have a profound bearing on opportunistic growth.

Many estuarine systems along the southeastern coast of the United States are subject to irregular changes in salinity due to variations in hydrologic regimes governed by regional meteorological events. Rainfall events, hurricanes, droughts, and floods all can temporarily or permanently alter the biogeochemistry of estuarine substrates. There is reason to speculate that plants have, through evolutionary modifications, developed methods of dealing with such relatively sudden habitat perturbations. Survival abilities may involve root system characteristics, diaspore mobility, resistant structures, germination characteristics, as well as other adaptive strategies.

8.3 Methodology

Data collection methods remain largely the same as those used during previous iterations of sensitive herbaceous vegetation sampling (CZR Incorporated 2002, Hackney et al. 2002a, Hackney et al. 2002b, Hackney et al. 2003). Data for plant species presence and percent cover were gathered from permanently fixed or variable plots. Five stations, Inner Town Creek (P3), Black River (P9), Rat Island (P12), Fishing Creek (P13), and Prince George Creek (P14) have sensitive herbaceous vegetation plots that have been used to demonstrate yearly size and shape variations of polygons. These areas exhibited discrete sensitive herbaceous vegetation elements that were easily defined at the beginning of the project. During the second week of August 2003, when herbaceous vegetation reached its full seasonal development, species were listed and their contributed cumulative cover percentages recorded. At that time, PVC (polyvinyl chloride) stakes were added, removed or shifted to mark variations in polygon boundaries. Position data were recorded using GPS (Global Positioning System) instruments during the first week of January 2004 at each of the five stations. Winter GPS data collection avoids some of the problems related to multipath encountered during summer when heavy canopy foliage conditions present problems (Hackney et al. 2002a, Hackney et al. 2002b).

Polygons with fixed four-sided plots were originally chosen to represent larger, more widespread sensitive herbaceous vegetation assemblages at P7 and P8 (CZR Incorporated 2001). Data for species content and percent cover were recorded for these plots also during August 2003. Since corners of these figures are not changed annually, additional GPS data were not necessary.

Field personnel responsible for gathering data for sensitive herbaceous vegetation and GPS have remained the same for this reporting period.

8.4 Hydrologic Events and Sensitive Herbaceous Vegetation

Sensitive herbaceous sample data are presented below for each of the sampling stations (Tables 8.41-1through 8.47-1). Polygon shapes from previous as will as from current data are presented for each station (Figures 8.41-1 through 8.47-1). Variables considered important during collection and presentation of the data include (1) changes in sensitive herbaceous species, (2) abrupt shifts in dominance of sensitive herbaceous species, (3) changes in cover contributions of sensitive herbaceous species within delineated polygons, and (4) variations of shapes and sizes of polygons. Hydrologic events coming before the present sampling period have been characteristic of drought conditions within the watershed resulting in increased ocean-derived salt concentrations accompanied by shifts in basic biogeochemical regimes (Hackney et al. 2002a, Hackney et al. 2002b, Hackney et al. 2003).

Streamflow data from three main tributaries of the lower Cape Fear River watershed show wide variation during the last four years (Figure 8.4-1). Mean flow in the Cape Fear for the period of the record since January 1, 2000 (not including data from the last 18 months of drought) at the Lock and Dam No. 1 gauging station was 11,070 cfs (cubic feet per second). Minimum daily flow for the same period was recorded at 1,730 cfs, while maximum daily flow has reached 27,500 cfs [(Us Geological Survey (3)]. Between 4/16/2002 and 8/27/2002 daily flow at Lock and Dam No. 1 did not exceed the minimum set earlier for the period of the record. Again, during the same year from 9/6/2002 until 10/11/2002 flows were well below the minimum previously recorded [(US Geological Survey (2)]. Both maximum and minimum records for daily flow appear to have been broken within the last 18 months along the Cape Fear (Figure 8.4-1A). By the middle of October 2002 a distinct change in flow had occurred (Figure 8.4-1A).

Flow data from the Black and Northeast Cape Fear Rivers show much the same trend, reflecting a period of record-breaking drought followed by a period of record-breaking precipitation within the watershed [US Geological Survey (1, 2, 3)] (Figure 8.4-1B and C). The sudden change from high salinities within the normally mildly brackish portions of the lower Cape Fear estuary to freshwater conditions becomes understandable when the nearly synchronous, record discharges of freshwater from three major rivers in the watershed are considered, even though the gauging stations for these portions of the tributaries are well above the project area (Table 8.4-1).

A trend of diminishing salinities in response to increased freshwater flows is exemplified by data from three monitoring stations within the project area (Table 8.4-1). Stream salinity monitoring data from the Inner Town Creek station apply to an isolated watershed, for which there are no gauged streamflow data. These data show that by November 2002 considerably fresher water conditions prevailed and remain only slightly brackish into winter and the following (2003) growing season. At Inner Town Creek, minimum values are not particularly instructive. However, both maximum and minimum mean values demonstrate similar trends from midway along the two main branches within the project area, the Cape Fear and the Northeast Cape Fear Rivers. Note that at both Indian Creek and Rat Island salinity remained low through the growing season of 2003.

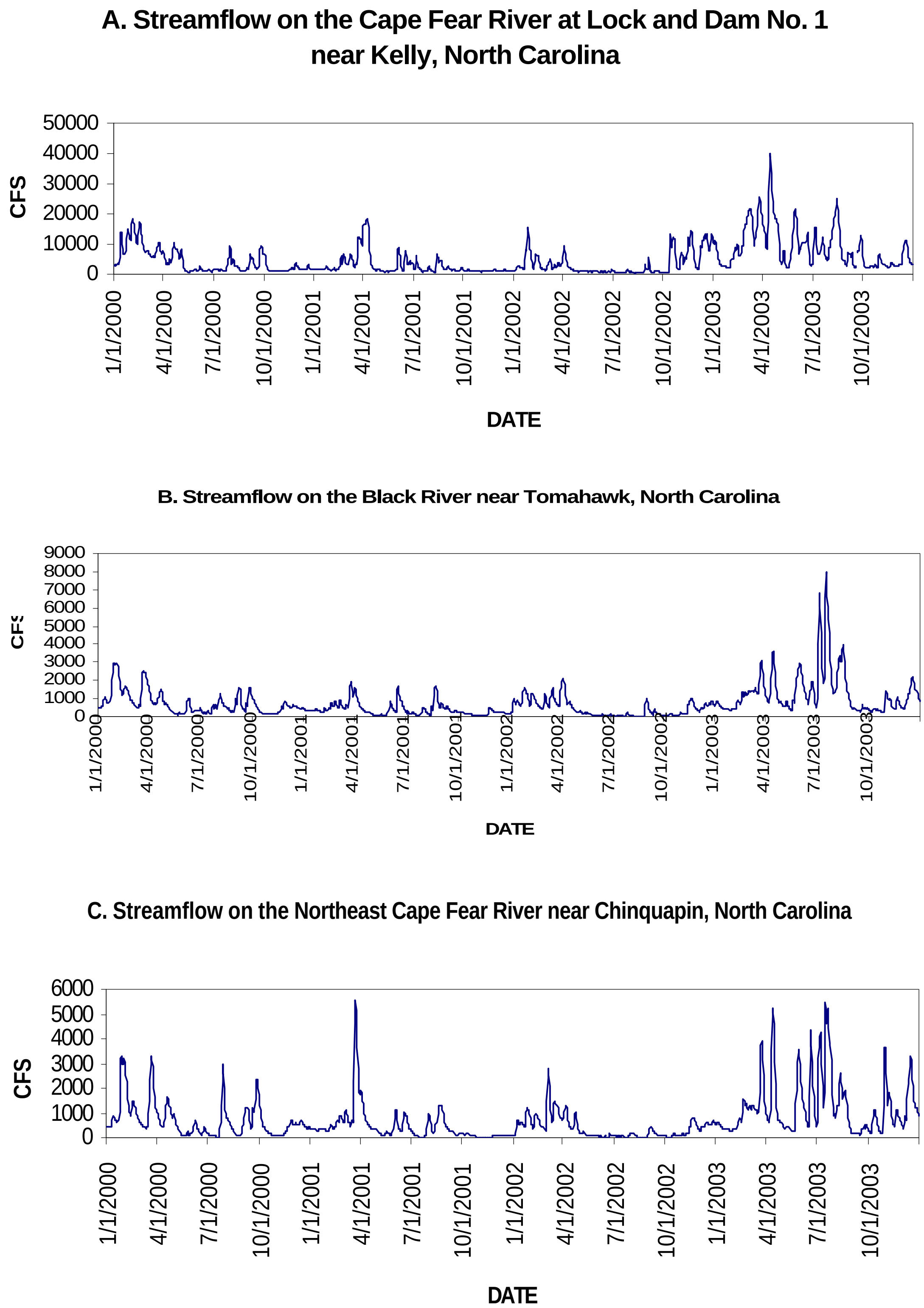


Figure 8.4-1. Stream flow (cubic feet/second) for years 2000-2003 at US Geological Survey gauging stations above the Wilmington Harbor monitoring project area, Cape Fear River, North Carolina.

Table 8.4-1. Monthly mean maximum and minimum stream water salinity values for the year August 2002 through August 2003 at Inner Town Creek, Indian Creek and Rat Island stations, Wilmington Harbor monitoring project, Cape Fear River, North Carolina.

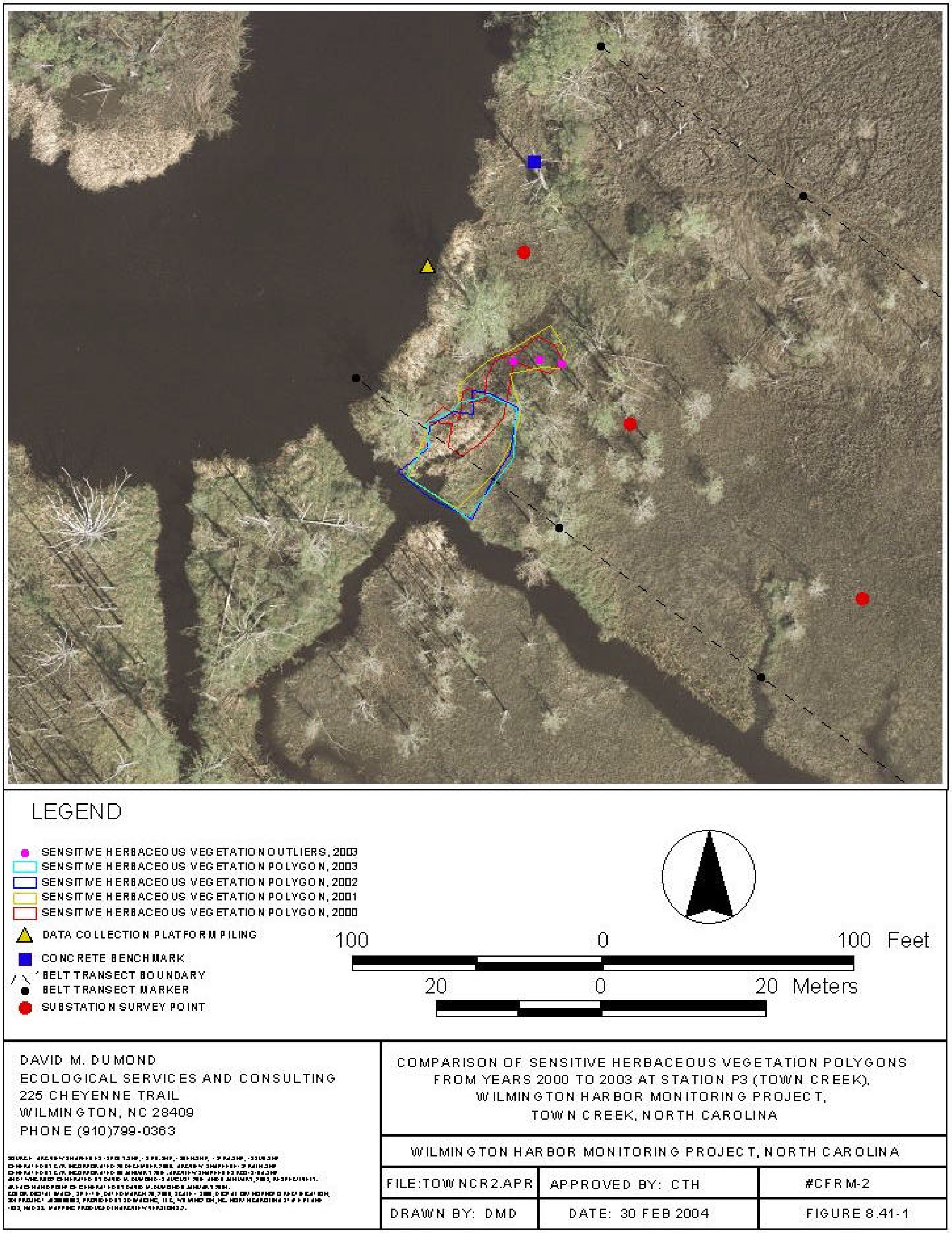
	Station Name/Number					
Date	Inner Town Creek/P3		Indian Creek/P7		Rat Island/ P12	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Aug/2002	19.3	0.1	10.0	0.1	16.9	2.7
Sep	11.9	0.1	0.3	0.1	11.4	0.3
Oct	19.9	0.1	1.8	0.1	17.8	0.6
Nov	8.8	0.1	0.1	0.0	9.5	0.1
Dec	7.5	0.1	0.1	0.1	6.9	0.1
Jan/2003	2.7	0.1	0.3	0.0	8.9	0.1
Feb	3.3	0.1	0.1	0.1	8.5	0.1
Mar	1.0	0.0	0.1	0.0	0.1	0.1
Apr	0.1	0.0	0.1	0.0	1.5	0.0
May	8.1	0.0	0.1	0.0	8.3	0.0
Jun	1.9	0.0	0.1	0.0	0.2	0.0
Jul	1.4	0.0	0.1	0.0	1.2	0.0
Aug	1.9	0.0	0.1	0.0	1.6	0.0

8.41 Inner Town Creek

Sensitive herbaceous vegetation at Inner Town Creek may have shown signs of a partial rebound from previous seasons of inundation by high salinity brackish water. Cover values for *Zizaniopsis miliacea* and *Peltandra virginica* are significantly higher than for last year. Three outlier clumps of *Zizaniopsis miliacea* have reappeared east of the main polygon where this species was dominant in 2000 and 2001 (Table 8.41-1, Figure 8.41-1). The relative sizes of the 2002 polygon and main 2003 polygon, however, are similar. The increase this year in cover by *Carex hyalinolepis* may be attributable to proliferation of rhizomes of this species among the somewhat weakened rhizomes of *Zizaniopsis miliacea*. It is also possible the rhizomes of the two species were already mixed within the polygon and the diminished cover of last year's *Zizaniopsis miliacea* gave an advantage to a somewhat more tolerant *Carex hyalinolepis*.

Sagittaria lancifolia was blooming this year and there were old inflorescence axes from earlier flowering of *Zizaniopsis miliacea* during spring. Last year inflorescences of *Zizaniopsis miliacea* had died prior to maturing, presumably as a result of salt water, while *Sagittaria lancifolia* had produced no flowers. This year *Typha latifolia* also showed scattered flowering. In general the vegetation in the polygon was much more luxuriant this year than last. Browned stems and leaves and stunting of stems were not noted as they were last year. Some *Acer rubrum* along the levee near the northwest side of the polygon bore leaves this year. Last year all woody species on the levee appeared dead. The amount of above-water vegetation this year is an indication of greater production of plant biomass. However, *Spartina cynosuroides*, a more salt-tolerant species, has continued to invade the denser stands of *Zizaniopsis miliacea* along the stream bank. Knees and stems of *Taxodium ascendens* on the levee still appear dead.

The above observations of plant material are consistent with data from stream monitoring on Town Creek (Table 8.4-1) and data from substations (not shown here). Both show abrupt


LEGEND
SENSITIVE HERBACEOUS VEGETATION OUTLIERS, 2003
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2003
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2002
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2001
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2000
DATA COLLECTION PLATFORM PILING
CONCRETE BENCHMARK
BELT TRANSECT BOUNDARY
BELT TRANSECT MARKER
SUBSTATION SURVEY POINT
100
0
100 Feet
20
0
20 Meters
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS
FROM YEARS 2000 TO 2003 AT STATION P3 (TOWN CREEK),
WILMINGTON HARBOR MONITORING PROJECT,
TOWN CREEK, NORTH CAROLINA
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
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DRAWN BY: DMD
DATE: 30 FEB 2004
FIGURE 8.41-1

decreases in salinity during the fall of 2002 (Table 3.3-1 and Table 4.4-2 in Hackney et al. 2003). Although there are no streamflow gauging stations along Town Creek, it is likely that increased precipitation in this watershed as well as fresher tidal flooding from the Cape Fear combined to reduce salinities prevalent in this smaller system during the growing season of 2002 (See Section 4 in Hackney et al. 2003). Because this watershed is isolated from that of the lower Cape Fear River, it should be determined whether or not severe precipitation deficits localized in Town Creek watershed along with average summer, freshwater flow in the lower Cape Fear could return salinity regimes to their late 2002 levels in Town Creek.

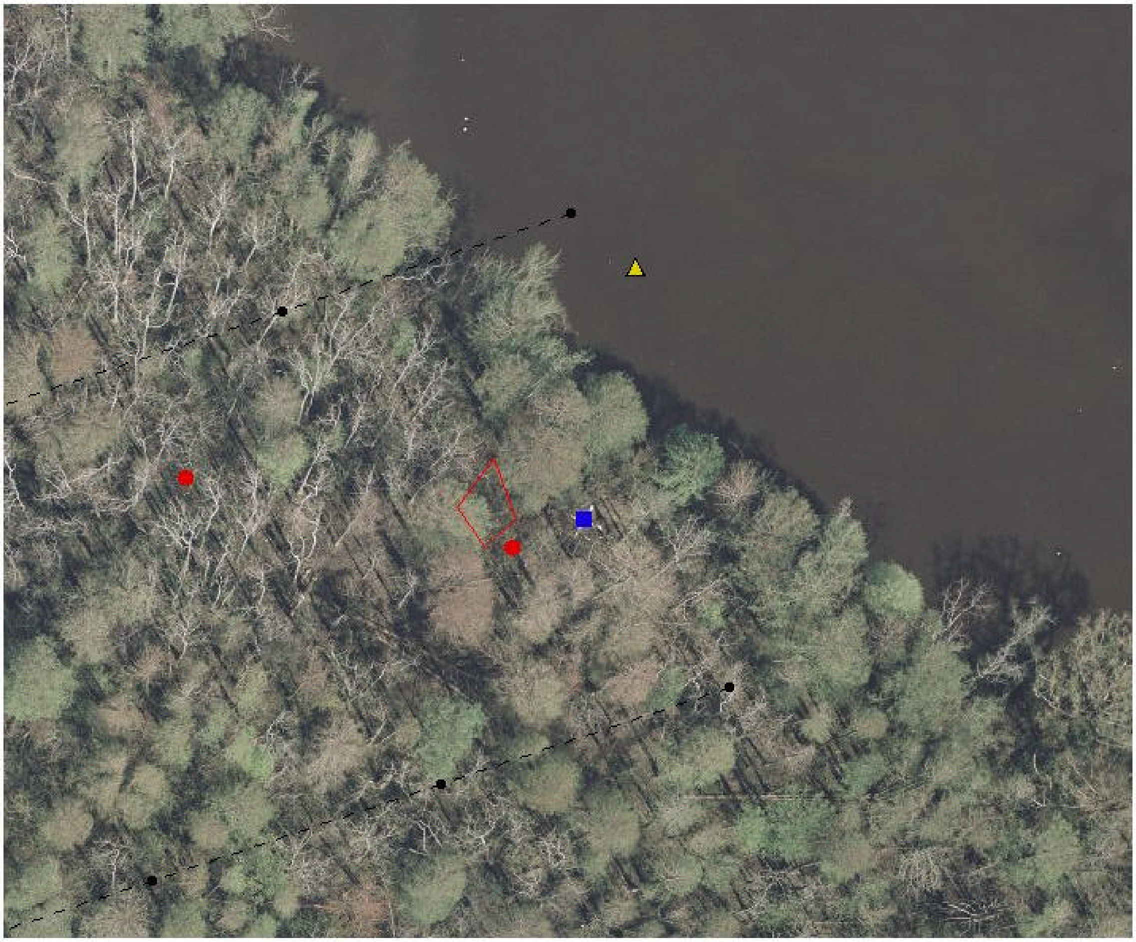
Table 8.41-1. Comparisons of polygon size and percent cover contributions by sensitive herbaceous species in polygons from years 2000, 2001, 2002, and 2003 at the Inner Town Creek Station (P3), Wilmington Harbor monitoring project, Town Creek, North Carolina.

Species	Year							
	2000		2001		2002		2003	
	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)
Zizaniopsis miliacea	70	710	60	1772.5	20	1311	50	1326
Sagittaria lancifolia	5		20		5		10	
Peltandra virginica	3		<1		<1		10	
Carex hyalinolepis	1		10		10		40	
Typha latifolia	--		10		10		10	
Schoenoplectus americanus	--		--		10		10	

8.42 Indian Creek

As in previous years the sensitive herbaceous vegetation polygon at Indian Creek is a simple four-sided figure marked by flagged trees located at each corner (Figure 8.42-1). The apparent change in size of the configuration last year (Table 8.42-1) is a reflection only of the use of new GPS data gathered under leafless canopy conditions (Hackney et al. 2003).

There have been no great changes from the cover data gathered last year (Table 8.42-1). Not unexpectedly, *Polygonum arifolium*, *Carex hyalinolepis* and *Saururus cernuus* have recovered to a small extent from rhizome material within the substrate. Further increases in biomass of these two species can be expected in the coming year. Two species, *Polygonum virginianum* and *Chasmanthium latifolium*, more characteristic of brown water river floodplains, have appeared this year. These species were likely deposited as seeds or fruits by floodwaters or possibly animals. *Peltandra virginica* and *Carex crinita* have disappeared, possibly due to scouring by floodwaters. An additional species not considered a sensitive herbaceous species due to its annual habit, *Impatiens capensis*, has reappeared in the area. Above ground material of *Hymenocallis* (likely *H. floridana*) has not been seen before at this station. Generally, the



LEGEND

- SENSITIVE HERBACEOUS VEGETATION POLYGON
- DATA COLLECTION PLATFORM PILING
- CONCRETE BENCHMARK
- BELT TRANSECT BOUNDARY
- BELT TRANSECT MARKER
- SUBSTATION SURVEY POINT

100 0 100 Feet

20 0 20 Meters

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SENSITIVE HERBACEOUS VEGETATION POLYGON FROM YEAR 2003
AT STATION P7 (INDIAN CREEK),
WILMINGTON HARBOR MONITORING PROJECT,
CAPE FEAR RIVER, NORTH CAROLINA

WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA

FILE: INDIANC2.APR	APPROVED BY: CTH	#CFRM-2
DRAWN BY: DMD	DATE: 30 FEBRUARY 2004	FIGURE 8.42-1

vegetation conditions are more luxuriant than those seen last year, but the site has in no way regained its pre-salt disturbance biomass.

A small drainage way has formed over the last year along the gentle slope near the middle of the plot. It joins a drainage line already in place along the south side of the plot. This new, drainage feature may have been caused by scouring, as higher than normal tidal floodwaters receded. Habitat that once was available for one set of species along the route of this new tributary may now favor a different set of species. Plant material as well as habitat space may have been lost as a result of the formation of this feature.

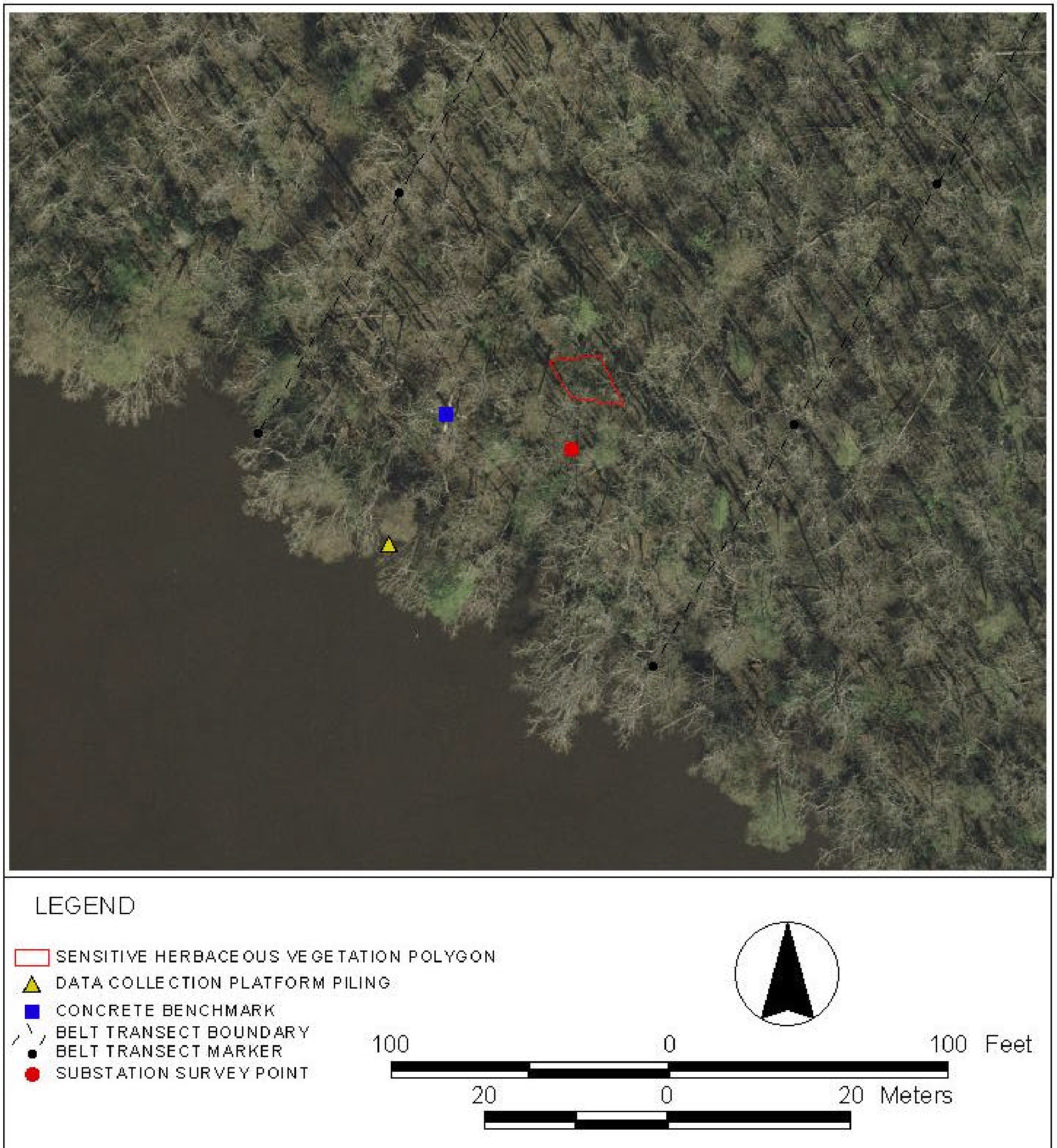
Table 8.42-1. Comparisons of percent cover contributions by sensitive herbaceous species in polygons from years 2000, 2001, 2002, and 2003 at the Indian Creek Station (P7), Wilmington Harbor monitoring project, Cape Fear River, North Carolina.

Species	Year							
	2000		2001		2002		2003	
	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)
Saururus cernuus	2	129.78	1	129.78	--	281.88	2	281.88
Polygonum arifolium	2		10		--		1	
Cicuta maculata	5		2		<1		2	
Polygonum punctatum	<1		<1		--		--	
Commelina virginica	<1		2		1		<1	
Carex crinita var. *brevicrinus*	<1		<1		10		--	
Carex hyalinolepis	<1		2		--		1	
Symphyotrichum elliottii	<1		--		--		--	
Triadenum walteri	<1		<1		--		--	
Lycopus virginicus	<1		--		--		--	
Galium sp.	<1		--		--		--	
Phanopyrum gymnocarpum	--		<1		2		1	
Peltandra virginica	--		--		<1		--	
Boehmeria cylindrica	--		<1		--		--	
Polygonum virginianum	--		--		--		1	
Chasmanthium latifolium	--		--		--		1	
Hymenocallis sp.	--		--		--		<1	

8.43 Dollisons Landing

The polygon at Dollisons Landing also is a fixed, four-sided figure marked by flagged trees at each corner (Figure 8.43-1). Data for GPS locations of the corners were recollected during the winter of 2002 during leafless canopy conditions.

Six sensitive herbaceous plant species have disappeared from the plot at Dollisons Landing since last year (Table 8.43.1). Most notable among these are *Polygonum arifolium*,



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SENSITIVE HERBACEOUS VEGETATION POLYGON FROM YEAR 2003
AT STATION P8 (DOLLISONS LANDING),
WILMINGTON HARBOR MONITORING PROJECT,
CAPE FEAR RIVER, NORTH CAROLINA

WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA

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DRAWN BY: DMD	DATE: 30 FEBRUARY 2004	FIGURE 8.43-1

Polygonum punctatum, *Rumex verticillatus* and *Cicuta maculata*. *Polygonum arifolium* and *Polygonum punctatum* have been present in the plot since inception of sampling in 2000. The dominant species, *Saururus cernuus*, has been reduced and now contributes 10 percent cover within the plot.

Methanogenic conditions had returned to this site by the time of the winter geochemistry sampling (Hackney et al. 2003, Table 5.51-3), and chloride levels were relatively low (Hackney et al. 2003, Table 5.58-1). Some of the plant material may have been scoured or gouged out by higher flood tides and/or water-born debris. Possible debris tracks were noted within the sample plot. Several plant stems were crushed or broken as if something had settled on them and then had been removed by the rising tide. Like Indian Creek (P7), the plot may not yet have recovered from the salinity events during the growing season of 2002.

Woody plant species in the vicinity of the plot have exhibited few visible symptoms of past exposures to salt or sulfide. Stems and knees of *Taxodium ascendens* show normal external signs of growth. The bark at the growing tips of knees has split to revealing inner bark layers, a sign of normal growth in response to flooding. The fruit load on *Nyssa aquatica* is heavy, which may be an indication of last year's stress. Stems, branches and leaves of *Nyssa aquatica* appeared healthy.

Table 8.43.1. Comparisons of polygon size and percent cover contributions by sensitive herbaceous species in polygons from the years 2000, 2001, 2002 and 2003 at the Dollisons Landing Station (P8), Wilmington Harbor monitoring project, Cape Fear River, North Carolina.

Species	Year							
	2000		2001		2002		2003	
	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)
Saururus cernuus	30	404.52	20	404.52	35	286.12	10	286.12
Polygonum arifolium	10		25		3		--	
Boehmeria cylindrica	<1		--		<1		--	
Rumex verticillatus	<1		--		2		--	
Cicuta maculata	2		--		2		--	
Carex sp.	1		--		--		--	
Polygonum punctatum	1		1		3		--	
Peltandra virginica	2		1		3		1	
Carex crinita	<1		2		--		--	
Dulichium arundinaceum	<1		--		--		--	
Triadenum walteri	<1		--		--		--	
Eryngium aquaticum	--		3		1		<1	
Pontederia cordata	--		<1		--		<1	
Hymenocallis floridana	--		--		<1		<1	
Alternanthera philoxeroides	--		--		<1		--	

8.44 Black River

Previous changes in the shapes of sensitive herbaceous vegetation polygons at the Black River station represented normal changes in patterns of growth of *Ludwigia palustris*. This year, 2003, growth established during the early part of the growing season had been perturbed by the effects of flooding (Table 8.44-1, Figure 8.44-1). *Ludwigia palustris* has a prostrate habit that must be visible for definition of the bounds of the annual polygon. Sampling was delayed until the substrate was visible at low tide (August 29). As indicated in earlier evaluations of this site, the wetland forest can be characterized as a combination of swamp forest and flood plain. During much of the period of high water (Figure 8.4-1B) this mix of habitat was flooded by as much as two feet at low tide.

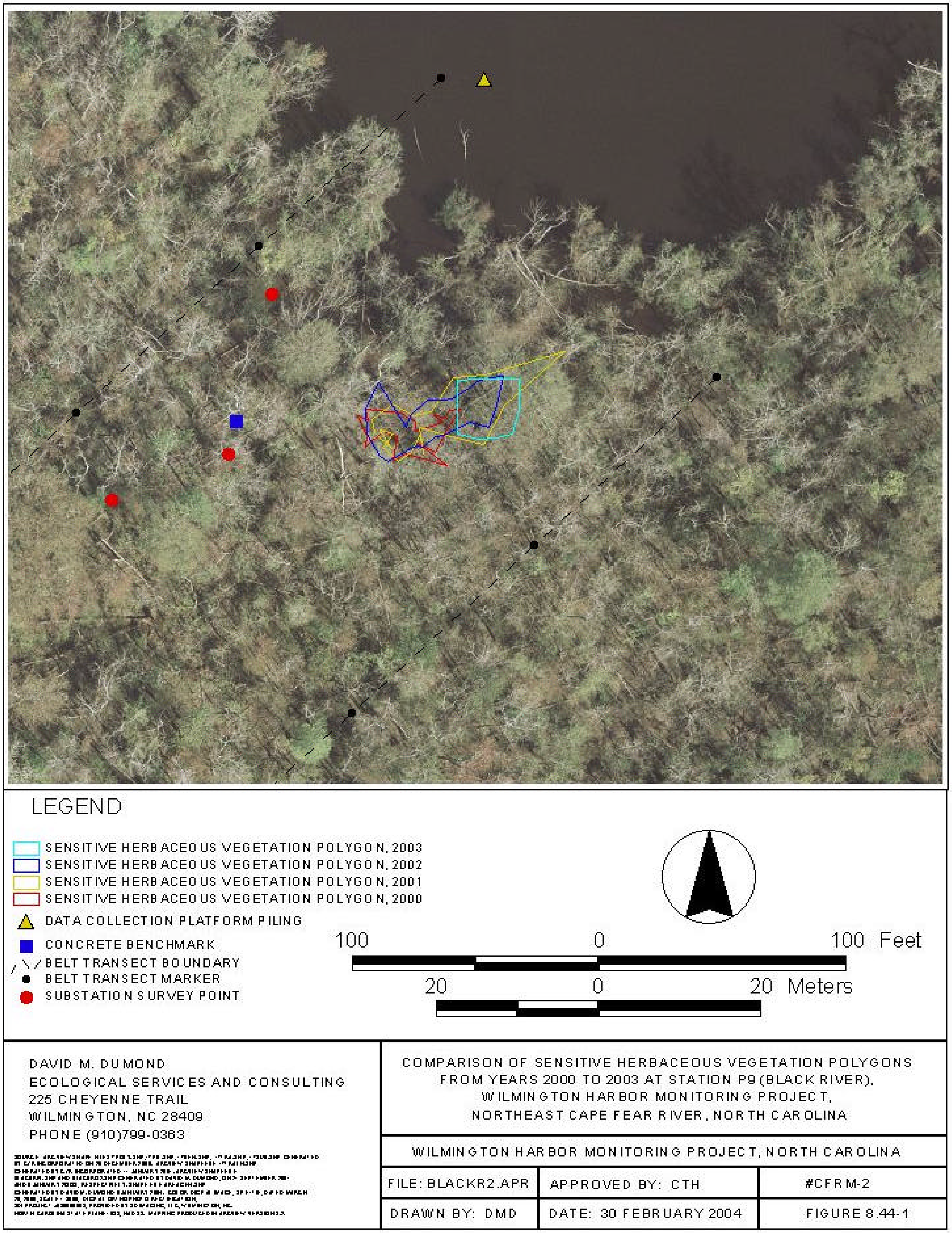
By late August growth of *Ludwigia palustris* appeared to have been compromised by flooding. With the combined effects of oxygen depletion and siltation, plants had been fragmented and most had washed out of the western portions of the polygon established in 2002. Some of those fragments may have been deposited in the area of the polygon established for this year, 2003. All material of *Ludwigia palustris* seen in the 2003 polygon was represented by tenuously rooted plant fragments. Of the few fragments examined, none showed signs of effective root growth and seemed to be anchored more by sediment deposition than by roots. This year seedlings of *Symphyotrichum elliottii* were lightly scattered through the 2002 polygon, and were a bit more numerous in the 2003 polygon (Table 8.44-1).

Boundary markers for the 2002 polygon were not moved this season to accommodate the shift of the plant material. Instead, a new polygon was marked so that a full evaluation of the new distribution could be made during the following year (Figure 8.44-1).

Table 8.44-1. Comparisons of polygon size and percent cover contributions by sensitive herbaceous species in polygons from years 2000, 2001, 2002 and 2003 at the Black River (P9), Wilmington Harbor monitoring project, Cape Fear River, North Carolina.

Species	Year							
	2000		2001		2002		2003	
	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)
Ludwigia palustris	50	431	20	1120	20	913.02	(<1) [a] 1	(913.02) [a] 567.78
Polygonum punctatum	--		15		1		--	
Polygonum arifolium	--		1		<1		--	
Symphyotrichum elliottii	--		2		<1		(<1) [a] 1	
Scutellaria lateriflora	--		--		<1		--	
Boehmeria cylindrica	--		--		<1		--	

[a]Values in parentheses apply to the 2002 polygon in 2003. Cover values in parenthese for 2003 apply to the 2003 polygon.


LEGEND
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2003
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2002
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2001
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2000
DATA COLLECTION PLATFORM PILING
CONCRETE BENCHMARK
BELT TRANSECT BOUNDARY
BELT TRANSECT MARKER
SUBSTATION SURVEY POINT
100 0 100 Feet
20 0 20 Meters
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS
FROM YEARS 2000 TO 2003 AT STATION P9 (BLACK RIVER),
WILMINGTON HARBOR MONITORING PROJECT,
NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
FILE: BLACKR2.APR
APPROVED BY: CTH
#CFRM-2
DRAWN BY: DMD
DATE: 30 FEBRUARY 2004
FIGURE 8.44-1

8.45 Rat Island

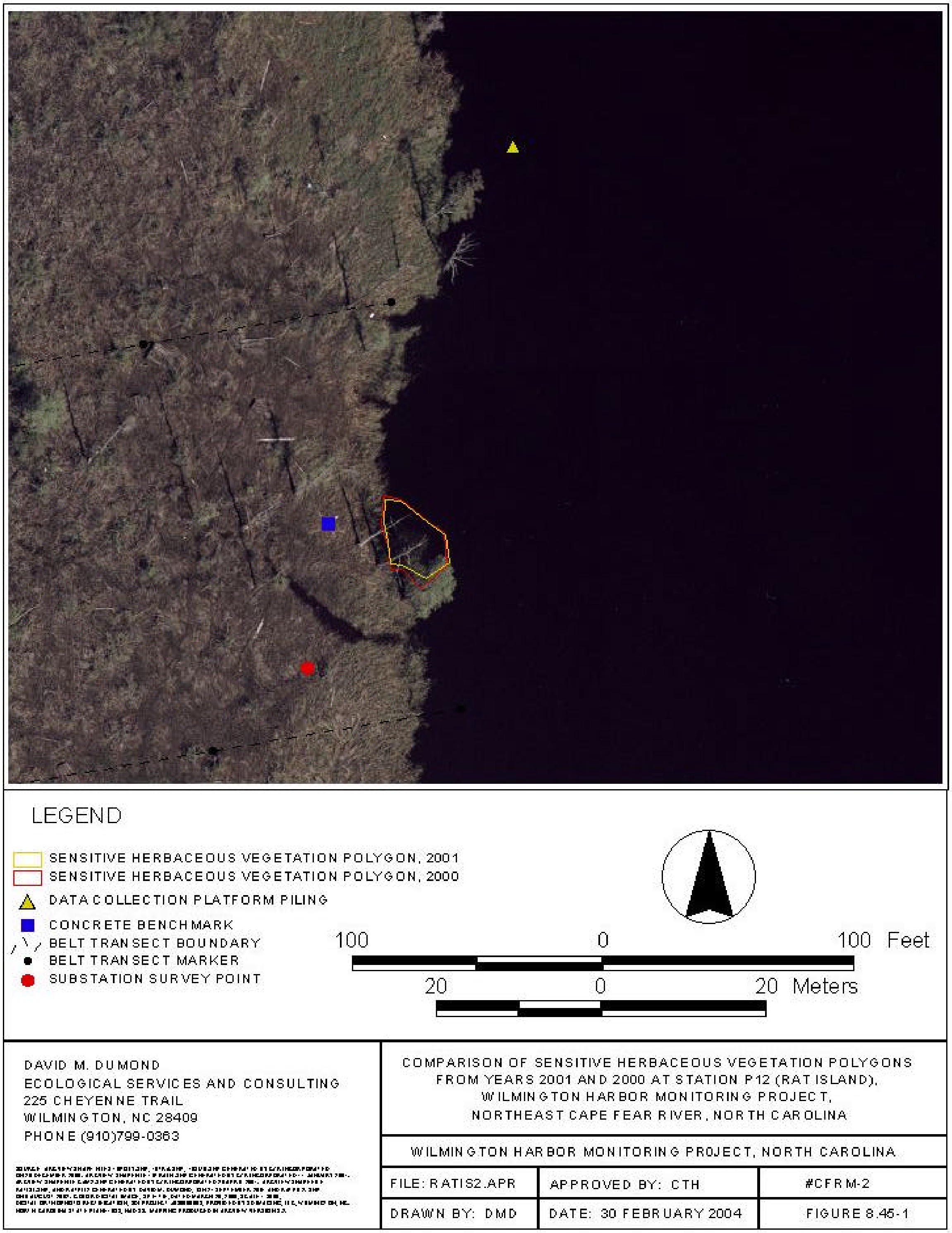
Data from the Rat Island sensitive herbaceous species polygon remain much the same for this year as for last (Table 8.45-1, Figure 8.45-1). *Schoenoplectus americanus* dominates the area, but is being invaded by the non-sensitive species *Spartina cynosuroides* particularly along the eastern edge of the polygon. Increase in density of *Schoenoplectus americanus* stems this year was most probably related to the freshwater conditions prevalent during this year's stems arose. It is doubtful the density of rhizomes has increased below the surface of the substrate. More nodes along the rhizomes were able to give rise to more above-ground stems this year than last likely because of the decrease in salinity of the water. For perhaps the same reason, *Sagittaria lancifolia* reappeared from subsurface structures. It is likely that *Hymenocallis crassifolia* material was below the substrate and so not obvious last year. Rhizomes or bulbs of this species appear now along the edge of the eroding bank. An annual freshwater wetland species new to the polygon, *Bidens laevis*, has likely been washed in from some other area. *Lilaeopsis chinensis*, a pioneer on brackish, muddy substrate surfaces, was noted for the first time in the polygon this year.

The *Taxodium ascendens* near the southern end of the polygon, previously hit by lightening or broken by wind, is producing several adventitious shoots.

Table 8.45-1. Comparisons of polygon size and percent cover contributions by sensitive herbaceous species in polygons from years 2000, 2001, 2002 and 2003 at the Rat Island (P12), Wilmington Harbor monitoring project, Northeast Cape Fear River, North Carolina.

Species	Year							
	2000		2001		2002		2003	
	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)
Schoenoplectus americanus	100	532.94	20	532.94	30	532.94	50	532.94
Carex hyalinolepis	20		8		10		<1	
Sagittaria lancifolia	10		30		--		5	
Alternanthera philoxeroides	<1		--		<1		--	
Polygonum arifolium	<1		--		--		--	
Ludwigia grandiflora	<1		--		--		--	
Polygonum punctatum	<1		1		--		--	
Boltonia asteroids	<1		<1		--		--	
Symphyotrichum subulatum	<1		<1		<1		<1	
Peltandra virginica	--		1		--		--	
Rumex verticillatus	--		1		--		--	
Hymenocallis crassifolia[a]	--		<1		--		1	

[a]Taxonomic name change from 2002, this does not represent a species change.


LEGEND
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2001
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2000
DATA COLLECTION PLATFORM PILING
CONCRETE BENCHMARK
BELT TRANSECT BOUNDARY
BELT TRANSECT MARKER
SUBSTATION SURVEY POINT
100 0 100 Feet
20 0 20 Meters
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS
FROM YEARS 2001 AND 2000 AT STATION P12 (RAT ISLAND),
WILMINGTON HARBOR MONITORING PROJECT,
NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
FILE: RATIS2.APR
APPROVED BY: CTH
#CFRM-2
DRAWN BY: DMD
DATE: 30 FEBRUARY 2004
FIGURE 8.45-1

8.46 Fishing Creek

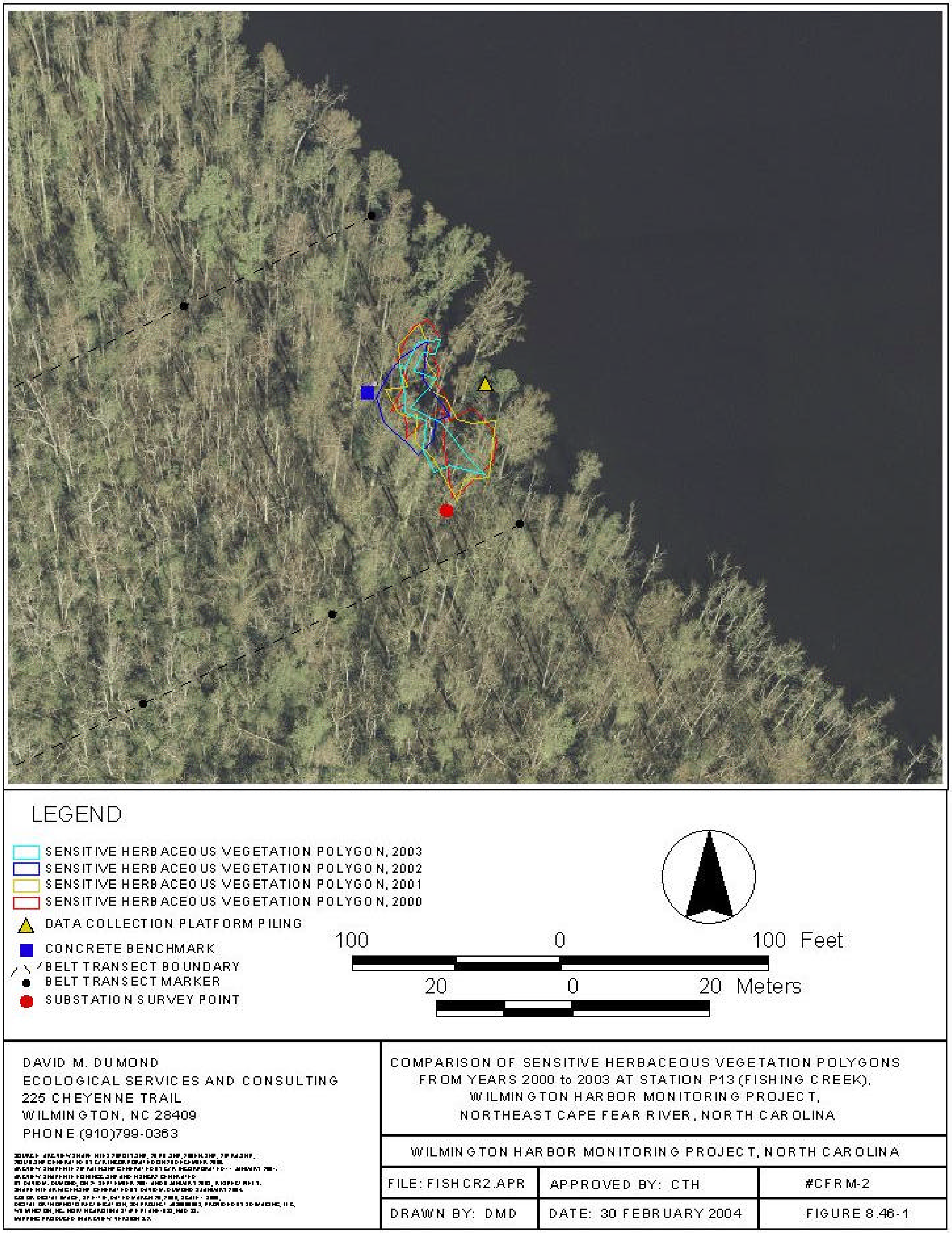
The Fishing Creek sensitive herbaceous polygon again decreased in size this year, diminishing to slightly more than 682 square feet (Table 8.46-1, Figure 8.46-1). *Pontederia cordata*, the main sensitive herbaceous species used in definition of the polygon, has rebounded partially from the previous salinity event. However, it occupies a larger portion of a smaller polygon than last year. *Polygonum arifolium* has reappeared, while *Zizania aquatica* and *Sagittaria lancifolia* are significantly more important this year than in last year's polygon. *Zizaniopsis miliacea* persists and may continue to expand, at least intermittently, within the polygon as the tree canopy thins as a result of salinity events. *Peltandra virginica* has increased remarkably since last year, possibly in response to sudden opening of the substrate to more light.

Four new species that may be of value as sensitive herbaceous species were documented for the first time this year, *Carex hyalinolepis*, *Apios americana*, *Ludwigia palustris*, and *Hymenocallis crassifolia*. Both *Apios* and *Ludwigia* were probably transported recently to the site. *Carex* and *Hymenocallis* may have been present for more than one growing season, but not visible.

New to the polygon, but not considered sensitive herbaceous species are *Lilaeopsis chinensis*, indicating increasingly brackish conditions, *Impatiens capensis*, indicating increasingly fresh conditions, and *Bidens laevis*, which also indicates fresh conditions. Appearance of these species may be attributable to the profound salinity event followed by flooding. All three species are pioneers in wetland systems. *Lilaeopsis chinensis* is a pioneer on exposed muddy shores in brackish systems and likely spreads from propagula deposited by water. Water, or possibly animals, may be responsible for deposition of the seeds of *Bidens* and *Impatiens capensis*. Both, along with *Peltandra virginica*, are pioneers of exposed substrates in freshwater wetlands.

It is clear that salinity events followed by unusual freshwater flows can be responsible for creation of habitat that favors recruitment of plant species in both pioneering and non-pioneering situations.

Taxodium ascendens in the swamp forest canopy does not show any apparent symptoms relative to a salinity event. However, 25-50 feet to the west of the shoreline, *Nyssa biflora* trees show some stem and branch death that may be related to salt water effects.


LEGEND
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2003
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2002
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2001
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2000
DATA COLLECTION PLATFORM PILING
CONCRETE BENCHMARK
BELT TRANSECT BOUNDARY
BELT TRANSECT MARKER
SUBSTATION SURVEY POINT
100 0 100 Feet
20 0 20 Meters
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS
FROM YEARS 2000 to 2003 AT STATION P13 (FISHING CREEK),
WILMINGTON HARBOR MONITORING PROJECT,
NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
FILE: FISHCR2.APR
APPROVED BY: CTH
#CFRM-2
DRAWN BY: DMD
DATE: 30 FEBRUARY 2004
FIGURE 8.46-1

Table 8.46-1. Comparisons of polygon size and percent cover contributions by sensitive herbaceous species in polygons from years 2000, 2001, 2002 and 2003 at the Fishing Creek Station (P13), Wilmington Harbor monitoring project, Northeast Cape Fear River, North Carolina.

Species	Year							
	2000		2001		2002		2003	
	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)
Pontederia cordata	20	1522.20	40	1646.10	5	971.91	30	682.14
Symphyotrichum elliottii	<1		--		--		--	
Polygonum punctatum	2		1		--		<1	
Sium suave	<1		2		5		1	
Polygonum arifolium	1		3		--		10	
Zizaniopsis miliacea	2		<1		<1		5	
Saururus cernuus	2		2		--		1	
Cicuta maculata	<1		2		--		--	
Sagittaria lancifolia	2		20		5		20	
Orontium aquaticum	<1		--		--		--	
Peltandra virginica	<1		1		5		30	
Rhynchospora corniculata	<1		<1		--		--	
Carex sp.	<1		--		--		--	
Alternanthera philoxeroides	--		5		<1		<1	
Zizania aquatica	--		2		<1		50	
Boltonia asteroides	--		1		--		--	
Rumex verticillatus	--		<1		2		1	
Cinna arundinacea	--		<1		--		<1	
Eryngium aquaticum	--		<1		5		2	
Schoenoplectus americanus	--		--		<1		--	
Carex hyalinolepis	--		--		--		1	
Apios americana	--		--		--		<1	
Hymenocallis crassifolia	--		--		--		2	
Ludwigia palustris	--		--		--		<1	

8.47 Prince George Creek

The sensitive herbaceous species of primary importance at the Prince George Creek sampling area is *Saururus cernuus*. Salinity events last year at this site resulted in visible damage to sensitive herbaceous species as noted in a previous report (Hackney et al. 2003). This year, however, recovery of *Saururus cernuus* is evidenced by an increase in cover from 20 percent last year to 40 percent this year (Table 8.47-1). In addition, the size of the sensitive herbaceous species polygon has increased slightly this year (Table 8.47-1, Figure 8.47-1).

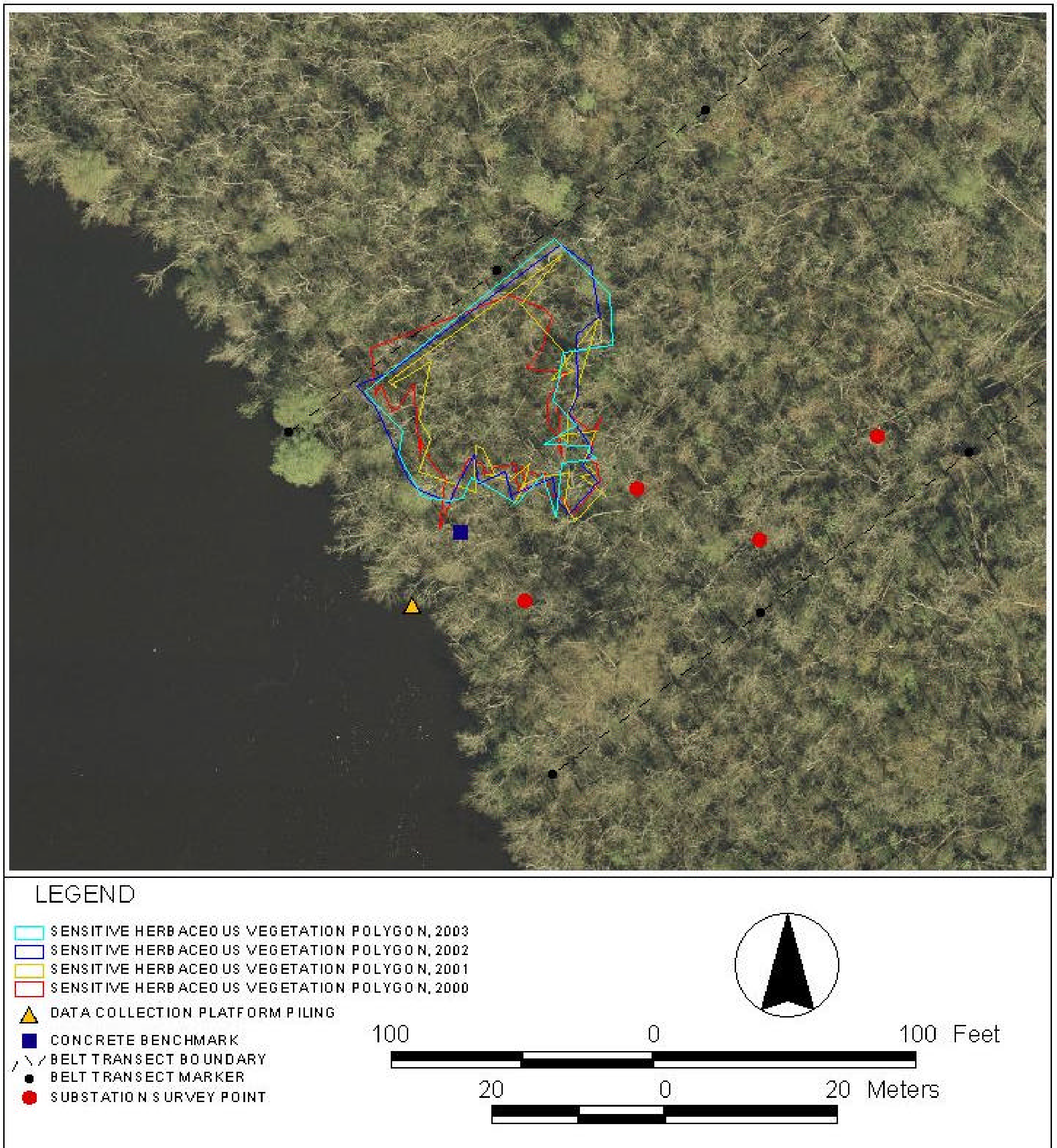
Four species, *Boehmeria cylindrical*, *Carex lupulina*, *Alternanthera philoxeroides* and *Mikania scandens*, were not seen in the polygon this year and three additional species have appeared, *Zizaniopsis miliacea*, *Osmunda regalis* and *Triadenum walteri*. Of the first set of four species, *Alternanthera philoxeroides* is a highly mobile species and can be quickly gained and lost from wetland habitats subject to river flooding. The other three species usually root permanently in habitats elevated on hummocks above tidally flooded muck substrates. These habitats may include rotten stumps, root mats and tree bases. These plants may send out stolons or runners that adventitiously root in different substrates. Occasionally they take root in mucky soils between hummocks.

Table 8.47-1. Comparisons of polygon size and percent cover contributions by sensitive herbaceous species in polygons from years 2000, 2001, 2002 and 2003 at the Prince George Creek Station (P14), Wilmington Harbor monitoring project, Northeast Cape Fear River, North Carolina.

Species	Year							
	2000		2001		2002		2003	
	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)	Cover (%)	Size (ft^2)
Saururus cernuus	35	3931.15	60	3669.31	20	5190.20	40	5265.43
Polygonum hydropiper	20		15		--		<1	
Peltandra virginica	10		8		1		5	
Pontederia cordata	--		5		--		--	
Polygonum arifolium	--		5		1		<1	
Cicuta maculata	--		<1		<1		<1	
Zizania aquatica	--		<1		--		--	
Cinna arundinacea	--		<1		--		--	
Boehmeria cylindrical	--		<1		<1		--	
Carex lupulina	--		<1		<1		--	
Alternanthera philoxeroides	--		--		<1		--	
Decodon verticillatus	--		--		<1		<1	
Hymenocallis crassifolia[a]	--		--		<1		<1	
Zizaniopsis miliacea	--		--		--		<1	
Triadenum walteri	--		--		--		<1	

[a]Taxonomic name change from 2002 does not represent a species change.

The second set of three-species that have appeared for the first time this year also demonstrate mixed habitat optima in tidal river habitats. *Osmunda regalis* and *Triadenum walteri* are usually supported in hummocks often with other species. Occasionally the latter will appear, atypically, to be rooted in tidal muck. *Zizaniopsis miliacea*, however, is a true sensitive herbaceous species in that it roots directly in tidal muck.



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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2000 TO 2003 AT STATION P14 (PRINCE GEORGE CREEK), WILMINGTON HARBOR MONITORING PROJECT, NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA

WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA

FILE: PRGEO2.APR	APPROVED BY: CTH	#CFRM-2
DRAWN BY: DMD	DATE: 30 FEBRUARY 2004	FIGURE 8.47-1

Appearance and, perhaps, disappearance of species from the Prince George Creek polygon result from a complex of human disturbance (searchers and hunters), flooding and salinity-related changes. Human disturbance within the polygon has been excessive. Such perturbations result in fragmentation of rhizomes, introduction of species from adjacent habitats and modification of polygon habitats. When accompanied by more natural perturbations, these changes can be responsible for local variations in distribution and abundance.

8.5 Conclusions

It is clear from examination of gauging station streamflow data that freshwater flow conditions have changed drastically since the fall of 2002 in the lower Cape Fear River estuary (Figure 8.4-1). It is also apparent from the monitoring data significant salinity events preceded flooding at most of the stations containing sensitive herbaceous vegetation polygons (Hackney et al. 2003 and Table 8.4-1). The large volumes of freshwater coming from all major tributaries in the watershed have now effectively flushed the upper estuarine system and diluted river and swamp water salinities prevalent during the growing season of 2002. A period of record low flow has been followed by a period of record flooding.

The most apparent biological effect noted following flooding involved recovery of above-ground plant material when fresh conditions returned. Recovery has varied from station to station and the reasons for this variance are not immediately clear. It can be assumed that sub-surface plant structures, roots, rhizomes, corms, etc. were able to provide a modicum of protection to meristematic tissues from the various effects of salinity events, at least for a time. The degree of protection provided doubtless varies from structure to structure, tissue to tissue and species to species. Of course, the strength of the salinity events varied from station to station as has the degree of flushing by freshwater.

The range of additional biological effects from close temporal association of these two record events could not be monitored using current facilities. Important among these effects are deposition of plant propagula by flooding, which has been enormous. Recent debris racks seen at several sites deposited by tidal ebb and flow are rich with seeds and other plant parts capable of taking root. Many new surfaces are available in systems perturbed by high salinity tides, scouring of old surface substrates and deposition of new substrate materials. In addition, low oxygen environments have been induced by long-term flooding in the upper reaches of the project area. These environments have further contributed to plant fragmentation, death and dispersal. New substrates have been made available for new plant recruitment and new sediments have been added to many of these substrates. Just how profound the interplay of these events has been and what part the initial salinity events have played should be considered in future studies.

9.0 INTER-ANNUAL TRENDS

9.1 Summary

Three phenomena have been identified since the study began in 1999 that have the potential to impact the Cape Fear River at the ecosystem level. First is the large-scale dredging, which includes deepening the ocean bar channel outside the estuary, deepening and widening the river channel upstream to Wilmington, and widening and deepening upstream of the State Port in the Northeast Cape Fear River. Second, the natural system has also been subjected to a record drought within the Cape Fear River watershed, and third by record rainfall and runoff that followed the drought. The ultimate goal of monitoring various biotic and abiotic components is to separate natural variation from project-related impacts.

Monitoring components have successfully documented the drought, which had an impact on almost every monitoring component. The three drainage systems (Town Creek, mainstem Cape Fear River, and Northeast Cape Fear River) responded to different degrees because each has a different source of freshwater. Impacts of drought were greatest in the Northeast Cape Fear River stations. Recovery following the drought has occurred, but is not complete in that several components have not returned to initial conditions. There has only been one year since the flood conditions ended and communities may not have had time to recover. Alternatively, there may be impacts of the project that have changed the entire ecosystem and no recovery to previous conditions may occur. The database being developed is proving to adequately determine changes in various important ecological variables. When post-dredging monitoring is completed, impacts of natural versus project-related will be possible.

9.2 Background

This portion of the report is designed to summarize overall trends from the previous eight sections and to identify patterns common to various monitoring components. It is anticipated that this section of the report will increase in length and complexity as the monitoring continues, as there are more years available for comparison. Ultimately, these comparisons will be divided into pre-construction, construction, and post-construction periods.

9.3 River Water Levels and Salinity

In general, tidal range at the most upstream sites (P9 and P14) in both the mainstem and Northeast Cape Fear and at P1 were significantly lower than the mean ranges reported for these stations during the first year of monitoring. The observation, that tidal range at P1 (Ft. Caswell) has significantly decreased, complicates interpretation of results as this station was initially expected to be unimpacted by river deepening activities. In contrast to previous reporting periods, comparisons of regression slopes generated by regressing tidal range at each site against P1 tidal range yielded significant differences between this reporting period and the previous reporting period for all stations except P3, P8, P12, and P13. When the slopes from this reporting period were compared to slopes calculated for Year 1 (2000-2001), P3 also yielded a significant difference between years.

There was a very slight difference between tidal lag times measured during this reporting period and those measured in 2002-2003 for the upstream stations in the Northeast Cape Fear River. In contrast, for the mainstem stations and estuary stations, the high tide lag appears to have decreased while the low tide lag has consistently increased. The duration of the ebb tide continues to exceed the duration of flood at most stations as in previous monitoring periods. Flood and ebb durations show little change from mean durations reported in 2002-2003 for most stations (less than 3% change for both flood and ebb durations). The one exception was station P1 (4.5% decrease in ebb duration). The relationship between tidal range at Ft Caswell and other stations differed from station to station, but was generally related to distance from the ocean and freshwater flow. Fewer high discharge events in 2003-2004 resulted in a reduction in variability of the tidal ranges observed during this monitoring period.

In general, mean tidal range decreased at upstream stations. The mean tidal range for every station except P1and P14 was significantly higher this year than the mean tidal range reported in 2002-2003. When the mean tidal ranges for the current year were compared to those reported for Year 1 (2000-2001), only stations P3 and P7 exhibited means that were not significantly different. At present, our observations are inconclusive and somewhat inconsistent with the expected effects of dredging. It is apparent that our results have been complicated by the existence of both lower, drought-induced water levels and extreme flooding in the system over the last 3 years. These effects will be more easily evaluated if more normal conditions continue.

In 2000-2001, salinity did not exceed 1 ppt at stations upstream of Eagle Island on the Cape Fear River because of the continuous release of freshwater upstream. In 2001-2002, upstream releases in the Cape Fear River were reduced and saline water as high as 3.5 ppt were measured at P8, while water exceeding 14 ppt was found at Fishing Creek, 8 miles north of Point Peter in the Northeast Cape Fear River. The next year (2002-2003), maximum salinities reported for these sites were 5.8 ppt and 16.4 ppt, respectively. This year, a period of more typical flow conditions in the river, maximum salinities for P8 and P13 were 0.2 ppt and 4.7 ppt, respectively.

9.4 Swamp/Marsh Flooding

The initial duration of tidal flooding within marshes and swamps is based upon monitoring during four two-week periods in spring, summer, and fall 2000 and spring 2001. The expectation is that on average about half the sites would flood more and half less if there were no consistent patterns of increased or decreased flooding over time. There could also be a distinctive seasonal effect where one season would flood longer than another, a pattern that would also be obvious. Surprisingly, the drought of 2002-2003 resulted in swamps and marshes flooding for a longer periods (Table 9.4-1). Fall 2001 and spring 2002 also flooded longer at 28/54 and 23/54 subsites. During fall 02, 37 of 54 subsites flooded longer, while the next season (spring 2003) every subsite flooded longer. By fall 2004 flooding duration was still longer at 36 subsites, but returned to a pattern of flooding similar to the initial period during spring 04. As more seasonal data become available seasonal and annual differences will be evaluated using non-parametric statistics.

Table 9.4-1 Deviation of flood duration over time.

			Deviation from Initial					
Station	Subsite	**Initial Avg. Tidal Duration (hrs.)[1] (Spr. 2000-Spr.2001)**	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
P3	1	**6.3**	-0.6	0.1	1.3	0.8	1.7	-0.4
	2	**6.0**	-0.7	-0.7	1.2	0.8	1.5	-0.5
	3	**6.0**	0.2	0.0	1.9	1.3	1.9	-0.2
	4	**6.8**	-0.8	-1.7	1.7	0.5	1.0	-1.9
	5	**6.2**	-0.2	-1.4	0.9	0.4	-0.4	-0.4
	6	**4.7**	2.8	-0.2	1.6	0.4	0.9	1.8
P6	1	**8.6**	-1.7	-2.2	-0.3	-1.9	-0.7	-3.2
	2	**5.4**	1.1	0.3	0.8	0.0	-0.2	0.6
	3	**6.1**	0.4	-0.5	-0.1	0.5	0.3	-1.0
	4	**5.6**	0.8	-0.1	0.1	0.1	0.6	-0.7
	5	**5.0**	0.0	0.0	0.9	0.1	0.0	-0.4
	6	**4.5**	-0.1	-0.1	0.5	0.2	-0.1	0.4
P7	1	**5.0**	1.6	0.6	1.3	2.2	0.2	0.1
	2	**2.8**	3.2	3.4	1.2	3.7	1.7	2.9
	3	**3.2**	2.9	2.8	0.7	2.9	0.8	2.5
	4	**4.0**	2.1	1.5	0.8	1.6	0.2	0.9
	5	**2.0**	4.2	2.5	4.1	3.9	2.7	3.4
	6	**3.9**	2.1	1.4	2.4	2.1	1.1	0.6
P8	1	**4.8**	-0.3	0.4	0.0	-1.1	0.6	-1.2
	2	**5.8**	-0.9	-0.2	0.2	-0.7	0.0	-1.4
	3	**5.7**	-0.1	-0.9	0.0	-0.2	0.2	-0.7
	4	**4.8**	-0.6	0.5	0.3	-0.4	0.6	0.2
	5	**4.2**	-0.2	1.2	0.1	-0.5	0.8	0.8
	6	**3.5**	-0.1	1.5	0.8	0.1	2.1	1.6
P9	1	**8.5**	-0.5	-2.2	-2.1	-1.6	-0.3	-1.8
	2	**6.0**	1.2	-1.7	-0.6	-1.2	-0.1	-0.9
	3	**4.2**	1.5	1.7	0.5	-0.6	-0.4	0.4
	4	**5.8**	0.3	0.2	-0.4	-1.3	-1.0	-0.4
	5	**5.7**	0.2	-1.4	-0.2	-1.2	-1.3	0.2
	6	**5.8**	0.4	-1.2	-0.6	-0.9	-1.0	-1.6
P11	1	**5.0**	1.0	0.1	1.3	1.5	0.9	0.3
	2	**3.9**	1.5	0.3	1.0	1.5	1.4	1.0
	3	**5.2**	0.9	0.0	0.2	0.8	0.3	0.1
	4	**5.4**	-0.1	-0.2	0.6	0.1	0.1	0.6
	5	**5.1**	0.3	-0.1	0.3	0.7	0.0	0.2
	6	**5.2**	-0.2	-0.5	0.5	-0.3	0.0	0.8

			Deviation from Initial					
Station	Subsite	**Initial Avg. Tidal Duration (hrs.)[1] (Spr. 2000-Spr.2001)**	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004

P12	1	**6.3**	0.7	-0.1	0.8	-0.5	-0.7	0.2
	2	**4.9**	0.3	-0.2	-0.1	1.2	0.6	1.2
	3	**4.7**	0.9	-0.2	1.7	-0.4	0.0	1.2
	4	**4.9**	-0.2	0.1	0.6	0.8	2.0	0.3
	5	**6.1**	0.3	-0.6	0.2	-0.1	-0.3	-1.0
	6	**5.4**	2.0	-0.6	-0.3	1.4	2.2	1.4
P13	1	**5.6**	1.9	1.6	1.2	0.0	0.9	1.8
	2	**5.8**	-1.1	-0.8	0.4	0.6	0.2	-0.6
	3	**6.2**	-0.9	-0.9	0.1	0.4	0.9	-0.1
	4	**7.9**	-1.8	-1.1	-2.5	-0.9	-0.6	-0.9
	5	**5.9**	-0.3	0.1	-0.9	-0.3	-0.1	-0.1
	6	**4.3**	-2.1	0.0	-0.3	-0.6	0.3	0.1
P14	1	**7.9**	-1.4	-2.7	0.1	0.8	-0.3	0.7
	2	**7.4**	-2.7	-2.3	-1.2	0.6	-0.7	-1.3
	3	**6.8**	-0.5	-1.5	-0.3	0.4	-0.2	0.0
	4	**6.5**	-0.6	-1.7	0.4	0.1	-0.4	0.1
	5	**5.6**	-0.1	-0.9	-0.2	0.7	0.1	-0.2
	6	**6.0**	0.9	-0.4	0.0	-0.5	0.2	-0.4

The depth of floodwater over the marsh or swamp surface also increased during the drought (Table 9.4-2). In fall 02, spring 03, and fall 03 seasons, floodwater depth increased at 44 of 54, 46 of 54, and 51 or 54 subsites, respectively. Flooding frequency also increased, following a similar pattern (Table 9.4-3). In spring 03, 51 of the 54 subsites flooded more frequently. Thus, more frequent flooding, at greater depths, and for longer durations corresponded with lower river discharge. Initially, this does not seem to be related to the dredging project as all three variable returned to near normal in spring 2004.

Table 9.4-2 Deviation of maximum flood depths over time.

Station	Subsite	**Initial Avg. Max. Tidal Depth (ft) (Spr. 2000-Spr.2001)**	Deviation from Initial: Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
P3	1	1.9	-0.2	-0.4	0.6	0.2	0.5	-0.2
	2	1.9	-0.3	-0.5	0.6	0.1	0.5	-0.2
	3	1.9	-0.3	-0.5	0.5	0.2	0.5	-0.1
	4	2.9	-1.3	-1.6	-0.3	-0.8	-0.4	-1.2
	5	1.9	-0.3	-0.5	0.7	0.5	0.6	-0.2
	6	4.1	-0.3	-0.4	0.4	0.1	0.3	-0.3
Station	Subsite	**Initial Avg. Max. Tidal Depth (ft) (Spr. 2000-Spr.2001)**	Deviation from Initial: Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
P6	1	2.9	-1.0	-0.4	0.2	0.8	0.2	0.3
	2	3.0	-0.2	-0.7	-0.1	0.6	0.0	0.2

Station	Subsite	**Initial Avg. Max. Tidal Depth (ft) (Spr. 2000-Spr.2001)**	Deviation from Initial					
			Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
	3	3.1	-0.7	-0.7	0.0	0.2	0.2	0.2
	4	3.1	-0.7	-0.7	-0.1	0.5	0.0	0.1
	5	3.4	-0.6	-0.8	-0.2	0.2	-0.1	0.0
	6	2.9	-0.1	-0.6	-0.1	0.3	0.1	0.1
P7	1	2.5	0.5	0.1	0.6	2.0	0.9	0.8
	2	2.0	1.0	0.5	1.2	2.5	1.5	1.5
	3	2.1	0.9	0.5	1.0	2.3	1.4	1.4
	4	2.0	1.0	0.6	1.3	2.6	1.6	1.5
	5	1.2	1.7	1.2	1.8	3.1	2.1	1.9
	6	1.3	1.5	1.4	1.8	3.1	2.1	2.1
P8	1	3.3	-0.5	-0.5	-0.4	-0.3	0.0	-0.5
	2	3.2	-0.4	-0.2	-0.2	-0.2	0.1	-0.3
	3	3.2	-0.2	-0.2	-0.1	-0.1	0.2	-0.3
	4	3.2	-0.4	-0.4	-0.3	-0.3	0.0	-0.3
	5	2.9	-0.2	-0.2	0.0	0.0	0.2	-0.4
	6	2.3	0.5	0.4	0.6	0.5	0.7	0.4
P9	1	2.8	0.0	-0.3	0.0	-0.3	0.5	-0.1
	2	3.7	-0.7	-1.0	-1.0	-0.9	-0.5	-1.2
	3	2.0	1.1	0.3	0.7	0.7	0.9	0.6
	4	2.8	0.2	-0.5	-0.1	0.0	0.4	-0.3
	5	2.9	-0.1	-0.5	-0.3	-0.1	0.2	-0.4
	6	2.8	0.1	-0.4	0.1	0.0	0.2	-0.3
P11	1	2.9	0.1	0.7	0.5	0.7	1.0	-0.1
	2	2.9	0.2	0.7	0.7	0.8	1.2	-0.1
	3	2.9	0.1	0.3	0.3	0.7	1.0	-0.2
	4	2.9	0.0	0.5	0.7	0.8	1.1	-0.2
	5	2.9	0.0	0.2	0.4	0.7	1.0	-0.3
	6	2.9	0.2	0.2	0.1	0.7	1.0	-0.1
P12	1	2.7	0.2	0.4	0.3	0.0	0.3	-0.2
	2	2.8	0.0	0.4	0.2	0.0	0.3	-0.3
	3	2.6	0.1	0.5	0.2	0.0	0.4	-0.2
	4	2.6	0.2	0.3	0.3	0.1	0.4	-0.2
	5	2.6	0.1	0.4	-0.2	0.0	0.4	-0.3
	6	2.1	0.8	1.1	1.2	0.5	0.8	0.3
P13	1	2.3	-0.3	0.0	0.0	0.1	0.2	-0.2
	2	2.3	-0.3	0.0	0.0	0.0	0.3	-0.2
	3	2.1	0.0	0.4	0.2	0.4	0.5	0.2
	4	2.3	-0.3	0.1	0.7	0.8	0.8	0.7
	5	2.3	-0.3	-0.1	0.0	0.1	0.1	-0.2
	6	2.3	0.0	-0.1	0.0	0.0	0.1	-0.2
P14	1	2.1	-0.2	-0.2	0.1	0.2	0.5	0.0
	2	2.1	-0.2	-0.4	-0.1	0.1	0.0	-0.1

3	2.2	-0.4	-0.5	0.0	0.0	0.2	-0.2
4	2.1	-0.3	-0.4	0.2	0.1	0.2	-0.2
5	2.1	-0.2	-0.4	0.2	0.0	0.3	-0.2
6	2.1	-0.3	-0.5	0.1	0.1	0.6	-0.2

Not only did flooding depth and flood duration increase during the drought years, but frequency of flooding increased as well during fall 02, spring 03, and fall 03 (Table 9.4-3). Increased flooding frequency has profound effects on wetland communities. It limits the degree of aeration of the soil between flood events. This can be important with respect to decomposition within the soil and at the soil's surface. Increased flooding lowers the decomposition rate of plant materials as it limits aerobic mineralization. Increased flooding also insures that seawater, including the important oxidant sulfate, is constantly replenished in soils. This fuels sulfate reduction within soil producing the toxic metabolite hydrogen sulfide that limits growth of many plant species. Increased frequency of flooding allows more frequent feeding forays by epifaunal and allows larval benthic organisms to access these wetlands.

Table 9.4-3. Deviation of flood event frequency over time.

			Deviation from Initial					
Station	Subsite	**Initial Frequency % (Spr. 2000-Spr.2001)**	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
P3	1	**85.7**	+14.3	-4.9	+14.3	+14.3	+10.6	-22.8
	2	**78.6**	+2.9	-13.2	+21.4	+17.7	+17.7	-15.6
	3	**90.2**	+9.8	-13.3	+6.1	+9.8	+6.1	-16.1
	4	**87.5**	+12.5	-10.6	+8.8	+12.5	+8.8	-20.8
	5	**67.9**	-19.7	-44.8	+28.4	+28.4	+32.1	-41.9
	6	**53.6**	-27.6	+4.1	+39.0	+39.0	+31.6	-20.2
P6	1	**94.5**	-6.1	+5.5	+1.8	+1.8	+5.5	+1.6
	2	**87.3**	-10.3	-2.1	+9.0	+9.0	+9.0	-25.7
	3	**92.7**	+3.4	+7.3	+3.6	+3.6	+7.3	+3.4
	4	**88.2**	+8.0	+8.1	+8.1	+8.1	-3.0	-26.6
	5	**77.3**	-8.0	-14.3	+15.3	+19.0	+7.9	-27.3
	6	**64.5**	-10.7	-16.4	+13.2	+31.7	+5.8	-29.9
P7	1	**68.1**	+16.5	+17.1	+24.5	+20.8	+28.2	+20.8
			Deviation from Initial					
Station	Subsite	**Initial Frequency % (Spr. 2000-Spr.2001)**	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
	2	**9.9**	+13.2	+1.2	+41.9	+64.2	+67.9	+23.4
	3	**9.9**	+13.2	-2.5	+30.8	+56.8	+60.5	+30.8
	4	**9.0**	+14.1	+2.1	+24.3	+57.7	+54.0	+20.6
	5	**9.0**	+14.1	+5.8	+31.7	+57.7	+46.5	+39.1
	6	**5.4**	+6.1	+20.5	+20.5	+57.6	+42.7	+46.4
P8	1	**47.2**	+22.0	-6.5	+23.1	+38.0	+26.9	+8.3
	2	**86.1**	+2.4	+2.8	-4.6	+10.2	+6.5	+2.8

	3	**63.0**	+25.5	+29.6	+25.9	+33.3	+29.6	+29.6
	4	**64.8**	-3.3	-20.4	+5.6	+16.7	+9.3	+16.7
	5	**35.2**	+11.0	+1.9	+24.1	+24.1	+24.1	+31.5
	6	**12.0**	+7.1	+17.6	+25.0	+32.4	+28.7	+10.2
P9	1	**97.9**	+2.1	+2.1	+2.1	+2.1	-1.6	+2.1
	2	**91.6**	+8.4	-32.3	+8.4	+8.4	+8.4	-22.3
	3	**52.3**	+25.6	-22.7	-0.4	+18.1	-30.1	-13.8
	4	**36.7**	+22.6	-18.2	+18.9	-3.4	-21.9	-21.3
	5	**33.9**	+6.8	-22.8	-0.6	-4.3	-15.4	-18.6
	6	**34.9**	+20.7	-20.0	+2.2	-1.5	+9.6	-27.2
P11	1	**73.6**	-18.1	-0.6	+26.4	+22.7	+26.4	-1.6
	2	**50.0**	-1.9	+7.7	+42.6	+38.9	+50.0	-6.0
	3	**58.9**	-10.7	+6.5	+37.4	+33.7	+41.1	+1.1
	4	**49.5**	-5.1	+4.3	+31.9	+39.6	+46.8	-9.5
	5	**48.6**	-4.2	+9.1	+36.6	+40.3	+51.4	+3.4
	6	**48.6**	-7.9	+5.2	+36.6	+36.6	+29.2	-12.6
P12	1	**93.6**	-4.7	+6.4	+6.4	+6.4	-8.4	+2.7
	2	**74.3**	-3.9	-0.2	-3.9	+3.5	-26.2	-0.2
	3	**34.9**	-8.9	+24.4	+31.8	+17.0	+13.3	+35.5
	4	**23.9**	+2.1	+28.0	+50.2	+16.9	+20.6	+35.4
	5	**12.8**	+9.4	+24.2	+31.6	+42.7	+24.2	+50.1
	6	**10.1**	-2.7	+12.1	+64.0	+41.8	+8.4	+8.4
P13	1	**63.7**	-4.5	+28.9	+25.2	+28.9	+28.9	+32.4
	2	**71.7**	+2.4	+20.9	+20.9	+24.6	+24.6	+16.8
	3	**96.5**	-0.2	-3.9	-7.6	+3.5	-0.2	+3.5
	4	**94.7**	-2.1	-2.1	-46.5	+5.3	+1.6	+1.5
	5	**93.8**	-1.2	-1.2	-4.9	+6.2	+2.5	+2.3
	6	**38.9**	-13.0	+1.8	+5.5	+9.2	+9.2	-0.5
P14	1	**93.9**	+2.4	+6.1	+2.4	+2.4	+6.1	+2.4
	2	**93.2**	+3.1	-4.3	+3.1	+3.1	-0.6	+3.1
	3	**91.3**	+5.0	-6.1	+5.0	+5.0	-2.4	+1.3
	4	**85.2**	+7.4	0.0	+11.1	+11.1	-3.7	-3.7
	5	**82.5**	-23.3	-12.2	+2.7	+10.1	-8.5	-4.7
	6	**54.8**	-32.6	-21.4	+15.6	+30.4	+4.5	-6.6

The significance of more frequent flooding, of longer duration, and greater flood depth is magnified if this is accompanied by higher salinity floodwater. The pattern with respect to salinity of floodwater (Table 4.4-4) is different in that salinity of floodwater has generally been the same or higher than salinity measured the initial year (summer 2000, fall 2000, and spring 2001). This is a misleading statistic in one sense in that four of the stations (P7, P8, P9, and P14) are typically freshwater so no deviation was expected in these predominately fresh sites. Based on the manner in which salinity was determined it is impossible for sites with an initial salinity of less than 1 to become less saline. Maximum salinity during a two-week period is not a good indicator of long-term trends at a station. The quantity of seawater required to initiate sulfate reduction is slightly less than 0.5 ppt. An increase in the frequency of tidal flooding by water containing 1 ppt seawater is extremely important to this process. Only four subsites flooded with water containing greater than 1 ppt seawater more than 50% of the time during the initial three two-week studies in 2000-02 and those were mostly at Station P6 (Table 9.4-5). Flooding by saline water generally increased during the study (Table 9.4-5), especially stations in the Northeast Cape Fear River. Note that there has been very little change with respect to flooding by saline water in the upper Cape Fear Stations (P7, P8, & P9) even during the drought of 02-03, but the Northeast Cape Fear River stations were clearly different from year to year.

Table 9.4-4 Deviation of maximum salinities over time.

			Deviation from Initial					
Station	Subsite	**Initial Avg. Max Salinities (ppt) (Sum. 2000-Spr.2001)**	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
P3	1	**8.0**	11.0	-7.0	13.0	-8.0	0.0	-7.0
	2	**8.7**	10.3	-8.7	10.3	-8.7	-5.7	-8.7
	3	**9.3**	9.7	-9.3	ND	-9.3	-2.3	-9.3
	4	**6.3**	10.7	-5.3	-0.3	-6.3	-0.3	-5.3
	5	**4.5**	9.5	-2.5	7.5	-4.5	1.5	-4.5
	6	**4.0**	10.0	-3.0	2.0	-4.0	2.0	-4.0
P6	1	**9.7**	5.3	-4.7	-0.7	-9.7	-0.7	-3.7
	2	**9.3**	2.7	-9.3	3.7	ND	-1.3	-4.3
	3	**11.0**	2.0	-7.0	1.0	ND	-4.0	-8.0
	4	**9.3**	1.7	-7.3	-4.3	ND	-3.3	-7.3
	5	**4.0**	3.0	-4.0	2.0	-3.0	-2.0	1.0
	6	**3.5**	2.5	-1.5	3.5	-3.5	-1.5	-3.5
P7	1	**0.0**	5.0	0.0	2.0	ND	0.0	0.0
	2	**0.0**	1.0	3.0	1.0	0.0	0.0	0.0
	3	**0.0**	1.0	0.0	1.0	0.0	0.0	0.0
	4	**0.0**	0.0	0.0	2.0	0.0	0.0	0.0
	5	**0.0**	0.0	0.0	1.0	0.0	0.0	0.0
	6	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
P8	1	**0.3**	ND	-0.3	-0.3	-0.3	-0.3	-0.3
	2	**0.0**	0.0	2.0	0.0	0.0	0.0	0.0
	3	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	4	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	5	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	6	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
P9	1	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	2	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	3	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	4	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	5	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	6	**0.0**	0.0	0.0	0.0	0.0	ND	0.0

P11	1	**6.7**	7.3	-3.7	11.3	-6.7	-0.7	-3.7
	2	**7.7**	4.3	-4.7	3.3	-7.7	-1.7	-4.7
	3	**7.7**	7.3	-2.7	1.3	-7.7	-2.7	-4.7
	4	**6.3**	8.7	-3.3	6.7	-6.3	-1.3	-3.3
	5	**5.7**	8.3	-2.7	12.3	-4.7	-1.7	-3.7
	6	**1.5**	11.5	1.5	16.5	0.5	3.5	-0.5
P12	1	**5.0**	6.0	-3.0	7.0	-5.0	-2.0	6.0
	2	**4.0**	9.0	-3.0	8.0	-3.0	-4.0	3.0
	3	**3.0**	9.0	-2.0	8.0	-1.0	-3.0	2.0
	4	**2.3**	8.7	0.7	8.7	-1.3	-2.3	0.7
	5	**0.0**	10.0	1.0	11.0	1.0	0.0	3.0
	6	**0.0**	2.0	1.0	7.0	2.0	1.0	0.0
P13	1	**4.3**	4.7	-4.3	-2.3	-4.3	-4.3	-4.3
	2	**2.7**	8.3	-2.7	-0.7	-2.7	-2.7	-2.7
	3	**2.3**	6.7	-2.3	-0.3	-1.3	-2.3	-2.3
	4	**3.7**	4.3	-3.7	-1.7	-2.7	-3.7	-3.7
	5	**3.0**	4.0	-3.0	-1.0	-3.0	-3.0	-3.0
	6	**1.0**	0.0	-1.0	0.0	-1.0	-1.0	-1.0
P14	1	**0.0**	2.0	0.0	1.0	0.0	0.0	0.0
	2	**0.0**	2.0	1.0	1.0	0.0	0.0	0.0
	3	**0.0**	2.0	0.0	1.0	0.0	0.0	0.0
	4	**0.0**	2.0	0.0	1.0	0.0	0.0	0.0
	5	**0.0**	2.0	0.0	1.0	0.0	0.0	0.0
	6	**0.0**	1.0	0.0	1.0	0.0	0.0	0.0

Table 9.4-5. Deviation of number of flood events containing >1 ppt salinity over time.

Station	Subsite	Initial Frequency % (Sum. 2000-Spr.2001)	Deviation from Initial Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
P3	1	**45.2**	54.8	-45.2	39.9	-45.2	51.1	-45.2
	2	**46.4**	38.8	-46.4	27.6	-46.4	53.6	-46.4
	3	**50.0**	50.0	-50.0	ND	-50.0	46.3	-50.0
	4	**42.9**	57.1	3.3	49.7	-42.9	49.7	-39.2
	5	**44.6**	14.6	1.5	47.9	-44.6	47.9	-44.6
	6	**30.4**	-0.7	0.4	69.6	-30.4	54.8	-30.4
P6	1	**62.2**	37.8	-62.2	37.8	-62.2	11.9	-23.7
	2	**58.5**	33.8	-28.9	41.5	ND	11.8	-39.3
	3	**46.4**	49.7	-35.3	53.6	ND	-9.4	-27.2
	4	**51.2**	44.9	-51.2	48.8	ND	-25.3	-43.5
	5	**42.9**	34.1	-5.8	42.3	-42.9	-31.7	-23.6
	6	**35.7**	25.8	23.5	64.3	-35.7	-32.0	-35.7
P7	1	**0.0**	30.8	3.7	77.8	ND	0.0	0.0
	2	**0.0**	0.0	3.7	0.0	0.0	0.0	0.0
	3	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	4	**0.0**	0.0	0.0	63.0	0.0	0.0	0.0
	5	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	6	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
P8	1	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	2	**0.0**	0.0	3.7	0.0	0.0	0.0	0.0
	3	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	4	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	5	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	6	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
P9	1	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	2	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	3	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	4	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	5	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0
	6	**0.0**	0.0	0.0	0.0	0.0	ND	0.0
P11	1	**21.5**	26.6	32.3	74.8	-21.5	52.6	10.5
	2	**31.6**	16.5	22.2	64.7	-31.6	42.4	0.4
	3	**46.8**	1.3	18.5	53.2	-46.8	30.9	-6.8
	4	**24.1**	27.8	49.0	75.9	-24.1	53.7	11.9
	5	**19.0**	25.5	7.9	73.6	-15.3	47.7	5.0
	6	**3.8**	36.9	61.5	77.6	59.1	70.2	8.2

Station	Subsite	Initial Avg. Max Salinities (ppt) (Sum. 2000-Spr.2001)	Deviation from Initial

			Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
P12	1	**61.7**	38.3	-43.2	34.6	-61.7	-35.8	34.6
	2	**46.9**	30.9	-39.5	34.6	-46.9	-46.9	23.5
	3	**29.6**	33.3	-25.9	37.0	-7.4	-29.6	11.1
	4	**9.9**	30.9	-6.2	53.1	-6.2	-9.9	12.3
	5	**0.0**	11.1	0.0	51.9	74.1	0.0	14.8
	6	**0.0**	11.1	0.0	33.3	11.1	0.0	0.0
P13	1	**24.1**	5.5	-24.1	5.5	-24.1	-24.1	-24.1
	2	**15.7**	54.7	-15.7	28.8	-15.7	-15.7	-15.7
	3	**15.7**	84.3	-15.7	76.9	-15.7	-15.7	-15.7
	4	**22.9**	77.1	-22.9	69.7	-22.9	-22.9	-22.9
	5	**16.1**	32.1	-16.1	-12.4	-16.1	-16.1	-16.1
	6	**3.6**	0.1	-3.6	0.1	-3.6	-3.6	-3.6
P14	1	**0.0**	100.0	0.0	3.7	0.0	0.0	0.0
	2	**0.0**	85.2	0.0	0.0	0.0	0.0	0.0
	3	**0.0**	85.2	0.0	11.1	0.0	0.0	0.0
	4	**0.0**	74.1	0.0	37.0	0.0	0.0	0.0
	5	**0.0**	44.4	0.0	0.0	0.0	0.0	0.0
	6	**0.0**	22.2	0.0	0.0	0.0	0.0	0.0

9.5 Biogeochemistry

During the first year, now considered the "Base Year" (winter 2000, 2001, and summer 2000) of the project, general geochemical classifications were established for all subsites. In the first report (Hackney et al. 2002a), subsites at three of these stations were primarily sulfate reducing year-round (P3 - Town Creek, P12 - Rat Island, and P11- Smith Creek), two were primarily methanogenic year round (P8 - Dollisons Landing, and P14 - Prince George) and four exhibited mixed conditions with sulfate reduction typically dominating the geochemistry during the summer and methanogenesis dominating during the winter (P7- Indian Creek , P9 - Black River, P12 - Rat Island, P13 - Fishing Creek) (Hackney et al. 2002b).

In the second report, which included the summer of 2001 and the winter of 2002 (Hackney et al. 2003), two Northeast Cape Fear River sites, Prince George (P14) and Fishing Creek (P13), displayed a dramatic change in winter classification from methanogenic in the winters of 2000 and 2001 to sulfate reducing in the Winter of 2002 corresponding to increased salinity at these stations. The other two stations on the Northeast Cape Fear River, Rat Island (P12) and Smith Creek (P11), also showed signs of increased salinity although their general classification did not change. Rat Island (P12) had several subsites change from methanogenic classifications to sulfate reducing. Smith Creek (P11), which was already a sulfate reducing system, recorded higher salinities in porewaters.

The summer geochemical classifications on the mainstem Cape Fear River showed the opposite trend with evidence of a slight freshening of porewaters. Changes in classifications of the Cape Fear River subsites were not as dramatic as those observed on the Northeast Cape Fear River. The general trend for Cape Fear River stations was a slight freshening of porewaters in winter 2002 and more saline conditions in summer 2001 compared to the Base Year. Town Creek (P3), which is located below the confluence of the Northeast Cape Fear River and the Cape Fear River, displayed a similar trend as that of the Cape Fear River sites with slightly saltier conditions during the summer and slightly fresher conditions during winter.

The increases in porewater salinities observed during previous summers continued through the summer of 2002 in the Northeast Cape Fear River (Fishing Creek, Prince George, Rat Island, and Smith Creek). Due to even higher summer salinities in year three, all four stations were classified as sulfate reducing geochemical classifications for the first time. With the exception of Smith Creek, which already had a sulfate reducing geochemical classification, this was the first time the upper Northeast Cape Fear stations were classified as sulfate reducing in summer. A similar increase in summertime porewater salinity was noted in the Cape Fear River stations immediately above the City of Wilmington (Indian Creek, Eagle Island), while stations further upstream on the mainstem Cape Fear River (Black River, Dollisons Landing) had peak salinities occurring during the previous summer (2001). The salinities of the Town Creek station, the only site below the City of Wilmington monitored for geochemical classification, showed no obvious change in summer porewater salinity.

With the exception of Town Creek, which is below the city of Wilmington, and the Cape Fear River sites immediately above the City of Wilmington (Indian Creek, Eagle Island) all sites in 2003 had lower winter porewater salinities than previous winters. For the upper Cape Fear River stations (Black River, Dollisons Landing), winter salinity continued the steady decrease that began in 2000. Less saline conditions did not cause a shift in geochemical classification for these sites since they were already methanogenic. In the Northeast Cape Fear River (Fishing Creek, Prince George, Rat Island, Smith Creek), winter (2003) porewater salinities returned to lower values after peaking the previous winter (2002). The decrease in salinity at the more seaward stations (Rat Island and Smith Creek) was not enough to convert these systems from sulfate reducing geochemical classification. For upstream stations (Fishing Creek, Prince George), several subsites that were converted to sulfate reducing during the previous winter returned to methanogenic geochemical classification during winter (2003). Porewater salinities of Town Creek, Indian Creek, and Eagle Island increased during the winter (2003). Changes in geochemical classifications were relatively small for these sites with only slight changes towards higher salinity classifications.

Low salinity conditions characterize the current project year, summer 2003 and winter 2004. In general, all sites experienced conditions that would be considered low salinity on the basis of previous winters and summers. Several sites had conditions that wer the lowet in salinity since the project started. For the most seawartd station, Town Creek, both the winter and summer were the freshest on record. The Cape Fear River sites (Indian Creek, Dollisons Landing, and Black River) had a relatively low salinity winter and a summer that was the freshest observed during this project. While all Northeast Cape Fear River sites had relatively fresher conditions during the current year, there was more variability in the extent to which they experienced low salinities. Fishing Creek had the freshest winter and summer on record. Smith Creek had fresh conditions during both the summer and winter, but not the freshest on record.

9.6 Benthic Community

Since this study began sampling nine sites distributed among the Cape Fear River, Northeast Cape Fear River, and Town Creek from 1999-2003, three major potential system-level impacts have occurred. A developing drought in 2001-2002 led to distinctly different infaunal communities than the initial collections found in summer 1999 and 2000. This difference was most pronounced towards the end of the drought in 2002. This was followed by a period of recovery and relatively higher freshwater input in 2003. Finally, channel deepening construction was initiated in 2001-2002 and continues through the current study period (2003-2004).

Diversity of benthic invertebrates was generally lowest in 2000 and species richness generally highest in 1999, but both showed variable patterns among sites for the other 4 years. Multidimensional Scaling Analysis indicated that 2002 and 2003 represented distinct community assemblages based on species similarity compared to 1999-2001. These 2 years were different from each other, but more dramatic was a separation of these 2 years from the previous 3 years of sampling. The separation of 2002 can be attributed to drought effects. However, the distinct nature of 2003 samples cannot be attributed to salinity, as salinity that year was similar to 1999, and suggests some other system-wide phenomenon affecting benthic communities in all 3 tributaries. Examination of dominant species at each site indicated that many sites were initially dominated exclusively by tidal freshwater and oligohaline species, but shifted towards a significant proportion of oligohaline-mesohaline polychaetes by 2002. This could be interpreted as a salinity effect related to the drought. By 2003, upper estuarine stations were again dominated by oligohaline species, but the taxonomic composition differed from earlier years. Further analysis of community trends after the drought has ended and the community has experienced several years of post-drought conditions will be needed to distinguish climatic from channel deepening impacts.

9.7 Epibenthic Community

A total of 41 taxa have been collected using Breder traps since fall 1999. Drop trap sampling collected more taxa (77). These data clearly show the variable nature of these mostly motile taxa, but also reveal the consistent nature of certain taxonomic groups.

An Analysis of Similarity showed similar patterns for both drop trap and breeder trap data in that 2002 was clearly different from all other years when using pairwise comparisons. However, the drop trap data did show some degree of difference between years, although 2000 was not different from 1999, 2001, or 2003. Breder Trap data on the other hand showed a greater degree of similarity between 2001, 2003, and 2004 seasons.

Diversity and total abundance showed both temporal and site differences for both Breder and drop trap collections. Most interesting of all these data was the clear increase in total abundance for spring 2004 throughout most of the estuary. This pattern was much clearer for drop trap data than in Breder trap data. The spring 2004 increase in total abundance was attributed mainly to the recruitment of two taxa (*Leiostomus xanthurus* and juvenile *Paralichthys* sp.), a phenomenon that masked a response in diversity measurements at the end of the drought period.

9.8 Salt-Sensitive Herbaceous Vegetation Trends

Salt sensitive species appear and disappeared since the study was initiated summer 2000, but overall their total extent has increased with respect to overall size of the polygon containing sensitive vegetation (Table 9.8-1). The number of sensitive plant species per station has also fluctuated and about half of the stations were more species and half less (Table 9.8-3). This reflects the relatively large pool of species that exist in the lower reaches of the river and upper estuary, where propagules from species upriver are constantly introduced. Some of these propagules undoubtedly germinate. Also some species apparently disappear during high saline conditions, but remain as rhizomes. These appear again when conditions become favorable. There was an overall decline in percent cover (Table 9.8-3) that appears to be related to drought. It is difficult to relate this decline to drought in summer 2003 as fresh conditions returned to most of these stations early in the year. High water levels, increased flooding duration, and increased frequency of flooding the previous years may require more than one year for full recovery of salt-sensitive vegetation. Salt-sensitive vegetation may remain in a state of flux along this environmental fresh/saline gradient and each year reflect the effect of multiple years, not just the previous growing season

Table 9.8-1. Variation in size (ft^2) of sensitive vegetation areas at each site compared to a base year.

Station	Base Year (2000)	2001	2002	2003
P3	**710.00**	+1062.50	+601.00	+616.00
P7	**129.78**	0.00	+152.10	+152.10
P8	**404.52**	0.00	-118.40	-118.40
P9	**431.00**	+689.00	+482.02	+136.78
P12	**532.94**	0.00	0.00	0.00
P13	**1522.20**	+123.90	-550.29	-840.06
P14	**3931.15**	-261.84	+1259.05	+1334.28

Table 9.8-2. Variation in the number of species found at each site compared to a base year (2000).

Station	Base Year (2000)	2001	2002	2003
P3	**4**	+ 1	+ 2	+2
P7	**11**	-1	-6	-2
P8	**11**	-4	-1	-6
P9	**1**	+3	+5	+1
P12	**9**	0	-5	-4
P13	**13**	+3	-3	+4
P14	**3**	+7	+7	+6

Table 9.8-3. Variation in the percent of sensitive vegetation cover at each site compared to a base year.

Station	Base Year (2000)	2001	2002	2003
P3	**79**	+22	-23	+51
P7	**18**	+4	-3	-7
P8	**51**	+2	+1	-37
P9	**50**	-12	-25	-48
P12	**136**	-72	-94	-78
P13	**36**	+48	-5	+122
P14	**65**	+33	-36	-13

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APPENDIX A

LIST OF TIDAL RANGE DATA FOR ALL 14 STATIONS USED TO GENERATE FIGURES AND TABLES IN SECTION 3.0

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1	3.1	3.42	1.92	3.35	2.97	1.76	0.91	0.93	2.97	2.37	1.62	xxx
2	2.8	3.49	2.48	3.52	3.21	2.21	1.31	xxx	3.26	2.85	2.31	xxx
3	4.53	4.72	2.97	4.76	4.43	3.1	1.9	0.68	4.41	3.86	3.18	xxx
4	4.12	4.35	2.64	4.35	4.04	2.77	1.67	0.98	4	3.42	2.71	1.85
5	3.15	3.6	2.31	3.63	3.31	2.2	1.25	0.81	3.3	2.83	2.24	1.41
6	3.19	3.64	2.43	3.68	3.38	2.31	1.37	0.55	3.37	2.96	2.4	1.12
7	4.41	4.56	2.85	4.55	4.27	3.01	1.88	0.69	4.22	3.68	2.97	1.39
8	4.13	4.3	2.46	4.26	3.98	2.66	1.62	0.99	3.93	3.32	2.56	1.75
9	2.97	3.5	2.1	3.49	3.21	2.04	1.17	0.79	3.21	2.71	2.1	1.27
10	3.09	3.64	2.37	3.62	3.36	2.29	1.4	0.55	3.34	2.91	2.37	1
11	4.38	4.55	2.72	4.49	4.24	3	1.89	0.72	4.15	3.58	2.87	1.35
12	4.6	4.55	2.52	4.47	4.19	2.9	1.77	0.97	4.1	3.47	2.69	1.6
13	3.39	3.69	2.19	3.62	3.32	2.21	1.25	0.87	3.14	2.82	2.2	1.33
14	3.61	3.89	2.45	3.83	3.54	2.51	1.54	0.55	3.4	3.06	2.5	1.06
15	4.41	4.51	2.69	4.47	4.17	2.96	1.83	0.84	4.1	3.53	2.84	1.43
16	4.42	4.65	2.77	4.62	4.33	3.16	2.04	0.92	4.24	3.65	2.92	1.59
17	3.13	3.68	2.35	3.71	3.39	2.37	1.37	1.18	3.46	2.89	2.31	xxx
18	2.98	3.56	2.5	3.69	3.42	2.61	1.82	0.64	3.4	3.02	2.57	xxx
19	3.93	4.16	2.77	4.22	3.96	2.99	2.02	1.21	3.91	3.46	2.9	1.63
20	3.77	4.25	2.68	4.21	3.97	3.13	2.32	1.2	3.9	3.41	2.79	1.81
21	3.25	3.75	2.44	3.73	3.49	2.66	1.87	1.65	3.44	3.03	2.49	1.67
22	3.03	3.51	2.43	3.58	3.46	2.86	2.27	1.19	3.38	3.02	2.57	1.45
23	3.84	4.23	2.74	4.27	4.13	3.44	2.73	1.77	4.02	3.54	2.96	1.65
24	4.12	4.46	2.77	4.44	4.24	3.56	2.83	2.09	4.1	3.54	2.88	1.89
25	3.45	4.11	2.65	4.15	3.97	3.3	2.58	2.21	3.81	3.35	2.75	1.69
26	3.61	4.1	2.64	4.16	4.01	3.39	2.73	1.97	3.88	3.39	2.8	1.62
27	3.71	4.03	2.62	4.08	3.92	3.31	2.65	2.15	3.78	3.3	2.71	1.67
28	3.88	4.34	2.84	4.4	4.23	3.58	2.86	2.07	4.08	3.6	3.02	1.6
29	4.03	4.54	2.87	4.54	4.39	3.74	3.01	2.25	4.14	3.73	3.13	1.93
30	3.89	4.23	2.65	4.21	4.07	3.41	2.68	2.38	4.32	3.41	2.77	1.99
31	3.8	4.1	2.62	4.1	3.94	3.28	2.56	2.04	3.84	3.32	2.69	1.64
32	4.4	4.78	3.13	4.85	4.67	3.92	3.15	1.93	4.56	4.01	3.36	1.61
33	4.93	5.14	3.24	5.19	4.97	4.2	3.41	2.47	4.9	4.22	3.51	2.12
34	4.22	4.54	2.79	4.56	4.36	3.68	2.92	2.73	4.23	3.66	2.99	2.17
35	3.84	4.29	2.71	4.29	4.13	3.45	2.7	2.3	4	3.48	2.86	1.79
36	4.42	4.77	3.02	4.78	4.57	3.84	3.06	2.07	3.2	3.89	3.23	1.71
37	5.25	5.44	3.27	5.41	5.16	4.38	3.58	2.38	xxx	4.36	3.58	2.05
38	4.95	5.03	2.84	4.98	4.74	3.86	2.99	2.89	4.6	3.92	3.12	2.25
39	4.15	4.34	2.62	4.36	4.17	3.35	2.51	2.22	4.05	3.48	2.8	1.75

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
40	4.74	4.86	3.06	4.81	4.61	3.83	2.97	1.77	4.5	3.94	3.3	1.57
41	5.73	5.77	3.38	5.64	5.42	4.53	3.61	2.23	5.24	4.53	3.73	2.1
42	5.53	5.39	2.95	5.32	5.06	4.06	3.08	2.84	4.91	4.16	3.28	2.33
43	4.45	4.42	2.62	4.47	4.24	3.33	2.43	2.25	4.12	3.53	2.82	1.84
44	5	4.96	3.15	4.94	4.72	3.86	2.97	1.65	4.6	4.04	3.38	1.57
45	6.41	6.09	3.54	5.93	5.65	4.68	3.71	2.21	5.49	4.75	3.89	2.2
46	6.02	5.63	3.03	5.52	5.22	4.17	3.14	2.89	5.07	4.3	3.38	2.47
47	4.81	4.72	2.7	4.73	4.5	3.56	2.58	2.27	4.37	3.75	2.98	1.9
48	5.39	5.08	3.09	5.01	4.78	3.91	2.95	1.75	4.68	4.06	3.36	1.67
49	6.66	6.05	3.46	5.87	5.57	4.58	3.56	2.17	5.31	4.66	3.8	2.11
50	6.28	5.84	3.12	5.74	5.41	4.28	3.22	2.74	5.26	4.44	3.51	2.36
51	4.66	4.59	2.67	4.6	4.34	3.35	2.39	2.3	4.23	3.61	2.87	1.98
52	5.12	5.03	3.17	4.99	4.77	3.9	2.97	1.56	4.67	4.13	3.47	1.6
53	6.72	6.24	3.59	6.07	5.78	4.78	3.75	2.23	5.62	4.88	4.04	2.35
54	6.32	5.9	3.2	5.81	5.49	4.38	3.31	2.92	5.34	4.55	3.65	2.65
55	4.72	4.7	2.77	4.76	4.5	3.51	2.52	2.37	4.34	3.78	3.03	2.13
56	4.93	4.93	3.11	4.96	4.73	3.88	2.99	1.65	4.61	4.09	3.45	1.75
57	6.37	6.01	3.5	5.91	5.62	4.66	3.7	2.25	5.47	4.78	3.98	2.41
58	6.07	5.83	3.2	5.73	5.44	4.37	3.36	2.89	5.3	4.56	3.67	2.71
59	4.6	4.56	2.71	4.59	4.35	3.4	2.48	2.25	4.25	3.68	2.97	2.28
60	4.49	4.7	2.97	4.8	4.61	3.81	3.03	1.45	4.52	4.05	3.47	1.82
61	5.85	5.7	3.36	5.68	5.44	4.57	3.72	2.34	5.32	4.71	3.99	2.55
62	5.36	5.31	3.04	5.3	5.04	4.11	3.23	2.97	4.92	4.25	3.48	2.88
63	xxx	4.43	2.71	4.55	4.34	3.46	2.61	2.46	4.24	3.7	3.05	2.27
64	xxx	4.47	2.87	4.58	4.4	3.65	2.88	1.86	4.29	3.81	3.24	2.03
65	xxx	5.44	3.24	5.44	5.22	4.4	3.59	2.21	5.08	4.47	3.76	2.34
66	xxx	5.16	2.84	5.19	4.92	3.99	3.11	2.89	4.79	4.12	3.33	2.65
67	xxx	4.47	2.61	4.59	4.37	3.53	2.69	2.32	4.28	3.74	3.09	2.04
68	3.76	4.5	2.53	4.29	4.14	3.43	2.64	1.89	4.02	3.5	2.86	1.98
69	4.58	5.09	2.82	4.82	4.62	3.83	3.01	1.93	4.49	3.88	3.16	1.8
70	4.93	4.99	2.68	5.03	4.74	3.81	2.88	2.32	4.6	3.92	3.1	2.01
71	4.1	4.33	2.44	4.45	4.2	3.33	2.43	2.08	4.34	3.51	2.8	1.75
72	3.34	3.59	2.14	3.71	3.56	2.88	2.16	1.65	3.41	2.98	2.41	1.56
73	3.69	3.77	2.24	3.87	3.71	3.01	2.28	1.48	3.61	3.13	2.53	1.39
74	4.32	4.51	2.63	4.64	4.42	3.53	2.64	1.58	4.3	3.71	3	1.51
75	3.92	4.35	2.54	4.48	4.33	3.43	2.54	1.87	4.19	3.6	2.91	1.77
76	3.37	3.78	2.26	3.88	3.78	3.08	2.31	1.78	3.65	3.17	2.59	1.7
77	3.87	4.07	2.36	4.16	3.99	3.29	2.52	1.61	3.86	3.35	2.74	1.55
78	3.86	4.2	2.41	4.31	4.12	3.32	2.52	1.8	3.99	3.44	2.79	1.65
79	3.87	4.25	2.43	4.34	4.17	3.37	2.56	1.72	4.02	3.49	2.84	1.6

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
80	3.29	3.71	2.06	3.76	3.64	2.91	2.15	1.76	3.49	3.01	2.38	1.66
81	3.14	3.53	2.01	3.6	3.49	2.78	2.06	1.42	3.37	2.91	2.33	1.29
82	3.6	3.98	2.27	4.09	3.91	3.07	2.28	1.36	3.8	3.25	2.61	1.3
83	3.66	4.1	2.33	4.2	4.04	3.19	2.38	1.47	3.91	3.35	2.69	1.43
84	3.34	3.78	2.14	3.83	3.72	2.94	2.13	1.57	3.59	3.08	2.43	1.49
85	2.83	3.35	1.95	3.44	3.3	2.57	1.84	1.32	3.21	2.77	2.19	1.31
86	3.41	3.95	2.38	4.03	3.85	3.07	2.17	1.12	3.78	3.29	2.69	1.18
87	3.74	4.29	2.5	4.36	4.18	3.36	2.38	1.47	4.08	3.52	2.86	1.57
88	3.45	3.96	2.29	4.02	3.85	3.05	2.19	1.6	3.79	3.21	2.56	1.66
89	2.84	3.39	2.02	3.48	3.29	2.55	1.79	1.4	3.27	2.77	2.2	1.41
90	xxx	3.84	2.54	4.02	3.82	3.07	2.31	1.12	3.74	3.3	2.77	1.19
91	xxx	4.34	2.78	4.49	4.32	3.5	2.62	1.64	4.2	3.67	3.05	1.76
92	xxx	4.03	2.47	4.14	4.02	3.33	2.55	1.84	3.88	3.34	2.7	1.9
93	xxx	3.31	2.15	3.46	3.31	2.67	1.96	1.88	3.23	2.8	2.28	1.55
94	xxx	3.82	2.65	4	3.86	3.34	2.79	1.36	3.76	3.33	2.86	1.28
95	3.98	4.43	2.89	4.55	4.42	3.85	3.23	2.31	4.29	3.77	3.19	1.86
96	3.59	4.01	2.58	4.11	4.02	3.54	3.05	2.73	3.88	3.37	2.75	2.06
97	2.7	3.27	2.22	3.42	3.33	2.88	2.42	2.65	3.23	2.81	2.29	1.66
98	3.11	3.66	2.61	3.85	3.76	3.43	3.06	2.04	3.64	3.25	2.79	1.34
99	4.21	4.62	3.04	4.74	4.61	4.19	3.75	2.78	4.55	3.94	3.35	1.88
100	4.05	4.37	2.62	4.27	4.17	3.68	3.2	3.45	4.01	3.44	2.77	2.24
101	2.98	3.45	2.21	3.4	3.34	2.92	2.5	2.88	3.21	2.77	2.24	1.64
102	3.32	3.79	2.7	3.96	3.87	3.55	3.22	2.22	3.75	3.36	2.9	1.29
103	4.49	4.76	3.12	4.87	4.73	4.32	3.92	2.96	4.89	4.05	3.44	1.99
104	4.16	4.43	2.74	4.46	4.36	3.86	3.38	3.64	4.21	3.62	2.94	2.33
105	2.96	3.41	2.28	3.48	3.42	3	2.58	3.04	3.3	2.85	2.31	1.77
106	3.31	3.82	2.71	3.91	3.81	3.48	3.16	2.29	3.73	3.34	2.88	1.33
107	4.55	4.75	3.12	4.81	4.64	4.23	3.86	2.93	4.54	4	3.4	2.08
108	4.24	4.53	2.83	4.58	4.43	3.93	3.49	3.6	4.3	3.7	3.04	2.41
109	3.08	3.64	2.4	3.73	3.65	3.21	2.79	3.17	3.53	3.04	2.48	1.93
110	3.39	3.93	2.82	4.09	3.99	3.67	3.35	2.5	3.89	3.5	3.07	1.5
111	4.65	4.88	3.26	4.98	4.83	4.44	4.08	3.15	4.7	4.17	3.63	2.28
112	4.69	4.84	2.97	4.77	4.64	4.13	3.62	3.85	4.52	3.89	3.21	2.66
113	3.43	3.85	2.55	3.86	3.79	3.37	2.93	3.28	3.7	3.2	2.62	2.06
114	3.42	3.76	2.73	3.88	3.83	3.54	3.24	2.64	3.72	3.36	2.82	1.65
115	4.73	4.77	3.14	4.79	4.68	4.29	3.92	3.06	4.55	4.1	3.39	2.04
116	4.73	4.87	3.03	4.86	4.75	4.21	3.73	3.7	4.6	4	3.35	2.41
117	3.47	3.81	2.58	3.9	3.83	3.38	2.98	3.42	3.7	3.23	2.68	2.30
118	3.73	4.06	2.86	4.23	4.17	3.8	3.47	2.72	4.05	3.64	3.18	1.81
119	4.8	4.84	xxx	4.94	4.84	4.42	4.05	3.29	4.69	4.18	3.64	2.49

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
120	4.39	4.44	xxx	4.5	4.36	3.88	3.48	3.84	4.23	3.70	3.13	2.78
121	3.72	4.26	2.8	4.42	4.34	3.89	3.51	3.20	4.11	3.68	3.12	2.21
122	4.05	4.24	2.73	4.17	4.09	3.63	3.18	3.24	3.93	3.45	2.89	2.24
123	4.92	4.79	3	4.66	4.55	4.06	3.58	2.86	4.12	3.85	3.25	2.00
124	4.94	4.84	2.96	4.95	4.77	4.1	3.44	3.22	4.82	3.99	3.29	2.25
125	3.65	3.88	2.51	4.02	3.89	3.31	2.72	2.91	3.76	3.26	2.67	2.09
126	3.93	4.19	2.9	4.3	4.19	3.65	3.07	2.23	4.09	3.63	3.10	1.69
127	4.55	4.61	3.07	4.7	4.59	4.05	3.45	2.58	4.44	3.92	3.35	2.22
128	4.63	4.81	3.2	4.96	4.79	4.01	3.25	2.94	4.64	4.06	3.40	2.42
129	4	4.47	3.02	4.67	4.42	3.72	2.98	2.55	4.48	3.82	3.20	2.33
130	3.55	3.93	2.73	4.08	3.87	3.28	2.56	2.33	3.83	3.36	2.83	2.20
131	4.33	4.47	2.99	4.54	4.41	3.73	2.98	1.92	4.27	3.76	3.17	1.99
132	4.62	4.8	3.12	4.87	4.67	3.79	2.87	2.31	4.54	3.95	3.28	2.23
133	4.02	4.42	2.94	4.56	4.35	3.5	2.61	2.03	4.51	3.69	3.06	2.16
134	3.9	4.28	2.91	4.4	4.22	3.4	2.5	1.82	4.12	3.61	3.02	2.02
135	4.12	4.41	2.99	4.5	4.32	3.49	2.61	1.72	4.21	3.69	3.10	2.04
136	4.48	4.85	3.25	4.94	4.69	3.72	2.69	1.84	4.6	4.04	3.40	2.10
137	4.34	4.81	3.18	4.94	4.68	3.72	2.71	1.81	4.75	4.01	3.37	2.32
138	4.01	4.38	2.95	4.5	4.27	3.34	2.37	1.87	4.19	3.66	3.07	2.28
139	3.93	4.3	2.95	4.39	4.17	3.27	2.34	1.53	4.09	3.59	3.02	2.05
140	4.42	4.76	3.25	4.84	4.57	3.52	2.46	1.57	4.5	3.97	3.38	2.04
141	4.62	5.01	3.34	5.09	4.82	3.75	2.67	1.59	5.26	4.17	3.53	2.34
142	4.34	4.71	3.1	4.78	4.53	3.45	2.36	1.76	4.44	3.87	3.21	2.44
143	3.91	4.27	2.89	4.35	4.11	3.11	2.11	1.44	4.06	3.53	2.93	2.07
144	4.22	4.68	3.3	4.79	4.51	3.44	2.36	1.31	4.49	4.01	3.46	1.86
145	4.97	5.31	3.57	5.41	5.11	3.96	2.77	1.49	xxx	xxx	3.83	2.48
146	4.44	4.71	3.07	4.79	4.53	3.45	2.33	1.83	4.4	3.83	3.15	2.73
147	3.74	4.14	2.86	4.24	3.99	2.99	1.99	1.40	3.93	3.43	2.84	1.99
148	4.03	4.48	3.17	4.57	4.31	3.32	2.31	xxx	4.27	3.82	3.28	1.81
149	xxx	5.65	3.58	5.62	5.36	4.25	3.06	xxx	7.45	4.73	3.94	2.30
150	xxx	5.07	2.82	5.03	4.75	3.66	2.56	2.02	4.66	3.95	3.13	2.71
151	xxx	4.17	2.57	4.2	3.95	2.92	1.93	1.61	3.89	3.36	2.70	1.77
152	xxx	4.92	3.18	4.92	4.68	3.7	2.73	1.14	4.58	4.02	3.37	1.54
153	xxx	5.91	3.55	5.86	5.58	4.48	3.37	1.97	5.7	4.73	3.91	2.16
154	xxx	5.43	2.99	5.38	5.1	4.09	3.07	2.45	4.94	4.20	3.30	2.49
155	xxx	4.46	2.66	4.52	4.23	3.3	2.34	2.21	4.05	3.56	2.83	1.82
156	xxx	4.9	3.16	4.95	4.71	3.88	2.99	1.58	4.87	4.04	3.35	1.55
157	xxx	5.95	3.53	5.84	5.59	4.64	3.66	2.30	5.56	4.70	3.84	2.10
158	xxx	5.58	3.08	5.47	5.2	4.21	3.21	2.87	5.04	4.25	3.33	2.38
159	xxx	4.3	2.64	4.36	4.13	3.25	2.35	2.39	3.97	3.40	2.68	1.83

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
160	xxx	5.01	3.27	5.11	4.91	4.09	3.28	1.63	4.77	4.25	3.62	1.44
161	xxx	6.08	3.61	5.98	5.73	4.81	3.92	2.62	5.56	4.87	4.08	2.46
162	xxx	5.6	3.17	5.5	5.25	4.3	3.4	3.18	5.07	4.33	3.49	2.70
163	xxx	4.47	2.75	4.52	4.34	3.49	2.65	2.66	4.2	3.62	2.92	2.09
164	xxx	4.77	3.18	4.74	4.6	3.92	3.23	1.97	4.46	3.96	3.37	1.73
165	xxx	6.03	3.61	5.78	5.56	4.76	3.98	2.68	5.4	4.72	3.96	2.37
166	xxx	5.65	3.2	5.41	5.16	4.27	3.47	3.36	5	4.30	3.47	2.72
167	xxx	4.58	2.84	4.58	4.35	3.58	2.85	2.80	4.22	3.67	2.98	2.11
168	xxx	5.19	3.4	5.33	5.11	4.33	3.59	2.21	4.98	4.43	3.76	1.80
169	xxx	5.97	3.68	5.99	5.76	4.89	4.11	2.95	5.58	4.89	4.10	2.61
170	5.57	5.41	3.21	5.41	5.18	4.3	3.46	3.45	5.02	4.32	3.55	2.81
171	xxx	4.6	2.85	4.71	4.52	3.72	2.92	2.77	4.38	xxx	3.13	2.26
172	xxx	4.83	3.11	4.92	4.73	4	3.24	2.24	4.59	xxx	3.44	1.99
173	xxx	5.61	xxx	5.59	5.38	4.59	3.81	2.57	5.22	xxx	3.87	2.43
174	xxx	4.19	xxx	5.39	5.18	4.23	3.35	3.14	5.01	xxx	3.52	2.71
175	xxx	3.53	xxx	4.84	4.66	3.76	2.9	2.59	4.51	xxx	3.19	2.22
176	4.07	4.55	2.95	4.62	4.47	3.75	2.98	2.16	4.3	xxx	3.18	2.01
177	4.81	5.1	3.17	5.1	4.93	4.16	3.37	2.33	4.77	xxx	3.49	2.16
178	4.98	5.2	3.13	5.25	5.04	4.13	3.24	2.72	4.87	xxx	3.43	2.38
179	xxx	4.46	2.86	4.6	4.39	3.55	2.7	2.49	xxx	xxx	3.03	2.17
180	xxx	4.36	2.98	4.49	4.34	3.62	2.84	1.99	xxx	xxx	3.19	1.91
181	xxx	4.72	3.1	4.8	4.65	3.92	3.11	2.20	xxx	xxx	3.36	2.23
182	xxx	4.79	3.06	4.88	4.68	3.84	2.92	2.44	xxx	xxx	3.25	2.36
183	xxx	4.55	2.93	4.67	4.48	3.66	2.78	2.14	xxx	xxx	3.15	2.13
184	xxx	4.04	2.64	4.05	3.89	3.18	2.38	2.05	3.74	xxx	2.78	2.07
185	xxx	4.27	2.75	4.23	4.08	3.35	2.55	1.69	3.93	xxx	2.92	1.82
186	xxx	4.69	2.9	4.74	4.51	3.53	2.54	1.86	4.39	xxx	3.10	1.93
187	xxx	4.3	2.77	4.45	4.21	3.33	2.44	1.69	4.19	xxx	2.93	2.00
188	xxx	4.02	2.76	4.13	3.93	3.1	2.21	1.70	3.91	xxx	2.91	1.89
189	xxx	4.18	2.77	4.22	4.05	3.16	2.23	1.46	3.93	xxx	2.90	1.96
190	xxx	4.32	2.87	4.41	4.21	3.24	2.29	1.46	4.09	xxx	3.03	1.93
191	xxx	4.24	2.83	4.36	4.15	3.2	2.28	1.47	4.07	xxx	3.04	2.05
192	xxx	3.68	2.47	3.78	3.62	2.82	2	1.66	3.54	xxx	2.62	2.07
193	xxx	3.55	2.46	3.64	3.45	2.69	1.9	1.29	3.39	xxx	2.52	1.73
194	xxx	3.9	2.7	4.01	3.76	2.96	2.11	1.22	3.72	xxx	2.81	1.68
195	xxx	4.21	2.86	4.33	4.11	3.26	2.34	1.40	4.76	xxx	3.06	1.90
196	xxx	3.65	2.43	3.73	3.58	2.83	2.02	1.57	3.49	xxx	2.51	2.08
197	xxx	3.51	2.32	3.54	3.4	2.67	1.89	1.33	3.34	xxx	2.43	1.56
198	xxx	4.27	2.8	4.11	3.85	3.06	2.22	1.23	3.84	xxx	2.85	1.51
199	xxx	4.49	2.93	4.41	4.15	3.32	2.43	1.50	4.18	xxx	3.08	1.83

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
200	xxx	4.1	2.65	4.19	4	3.15	2.31	1.67	3.9	xxx	2.73	2.00
201	xxx	3.35	2.27	3.39	3.22	2.46	1.71	1.59	3.15	xxx	2.19	1.59
202	xxx	3.88	2.88	3.95	3.78	3.11	2.4	1.10	3.74	xxx	3.01	1.21
203	xxx	4.35	3.08	4.43	4.22	3.46	2.66	1.84	4.03	xxx	3.25	xxx
204	xxx	4.13	2.82	4.19	4.03	3.33	2.57	1.98	3.9	xxx	2.87	xxx
205	xxx	3.28	2.34	3.29	3.12	xxx	xxx	1.92	3.06	xxx	2.24	1.84
206	xxx	3.99	3	4.04	3.85	xxx	xxx	1.32	3.82	xxx	3.11	1.33
207	xxx	4.61	3.31	4.7	4.53	3.83	3.05	2.08	4.46	4.03	3.56	xxx
208	xxx	4.01	2.87	4.11	4	3.42	2.76	2.39	3.89	3.45	2.96	2.65
209	xxx	3.26	2.36	3.36	3.25	2.71	xxx	2.20	3.2	2.85	2.43	2.02
210	xxx	3.83	2.75	3.91	3.76	3.2	xxx	1.60	3.73	3.37	2.95	1.62
211	xxx	4.66	3.24	4.68	4.53	3.93	3.29	2.12	4.46	4.01	3.51	2.13
212	xxx	4.05	2.84	4.12	4.02	3.46	2.87	2.83	3.92	xxx	2.99	2.58
213	xxx	3.42	2.53	3.62	3.53	3	2.45	2.32	3.45	3.08	2.65	2.05
214	xxx	3.87	2.89	4.07	3.95	3.41	2.8	1.92	3.88	3.52	3.09	1.75
215	xxx	4.78	3.39	4.92	4.78	4.2	3.54	2.23	4.64	4.17	3.64	2.20
216	xxx	4.44	3.04	4.57	4.44	3.79	3.06	2.96	4.28	3.73	3.11	2.62
217	xxx	3.67	2.66	3.85	3.72	3.1	2.42	2.44	3.64	3.21	2.69	1.97
218	xxx	3.98	2.94	4.15	3.98	3.41	2.78	1.87	3.92	3.54	3.08	1.67
219	xxx	5.04	3.47	5.14	4.96	4.34	3.65	2.24	4.84	4.32	3.73	2.14
220	xxx	4.83	3.14	4.93	4.74	3.99	3.25	3.05	4.57	3.95	3.23	2.61
221	xxx	4	2.78	4.16	4	3.29	2.58	2.61	3.89	3.38	2.77	1.94
222	xxx	4.38	3.13	4.56	4.41	3.84	3.18	1.97	4.32	3.85	3.29	1.63
223	xxx	5.23	3.52	5.31	5.13	4.5	3.8	2.61	4.99	4.41	3.74	2.18
224	xxx	4.87	3.09	4.84	4.68	4.01	3.32	3.19	4.51	3.88	3.18	2.48
225	xxx	4.06	5.8	4.09	3.97	3.34	2.68	2.74	3.85	3.33	2.74	1.92
226	xxx	4.32	3.05	4.4	4.3	3.81	3.25	2.13	4.19	3.74	3.21	1.62
227	xxx	5.44	3.55	5.44	5.26	4.67	4.05	2.74	5.11	4.51	3.82	2.17
228	xxx	5.15	3.2	5.19	4.99	4.26	3.55	3.54	4.82	4.15	3.36	2.55
229	xxx	4.23	2.85	4.32	4.17	3.51	xxx	3.02	4.04	3.49	2.84	2.00
230	xxx	4.45	3.1	4.59	4.4	3.77	xxx	2.36	4.27	3.70	3.07	1.69
231	xxx	5.19	3.4	5.29	5.09	4.42	3.75	2.65	4.91	4.25	3.52	1.92
232	xxx	5.15	3.26	5.19	5.01	4.25	3.51	3.24	4.84	4.17	3.42	2.21
233	xxx	4.61	3.03	4.72	4.55	3.85	3.15	2.92	4.4	3.79	3.11	2.06
234	xxx	4.66	3.14	4.73	4.57	3.9	3.22	2.56	4.45	3.90	3.28	1.83
235	xxx	5.25	3.39	5.26	5.08	4.37	3.65	2.65	4.93	4.30	3.58	2.13
236	xxx	5.1	3.21	5.14	4.95	4.1	3.28	3.07	4.79	4.13	3.37	2.32
237	xxx	4.73	3.08	4.82	4.66	3.84	3.04	2.6	5.61	3.91	3.2	2.07
238	xxx	4.62	3.02	4.69	4.55	3.75	2.98	2.35	4.37	3.81	3.13	1.98
239	xxx	4.99	3.17	5.01	4.84	4.01	3.24	2.31	4.66	4.06	3.34	1.93

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
240	xxx	5.14	3.21	5.18	4.96	4.08	3.24	2.57	4.82	4.18	3.41	2.06
241	xxx	4.81	3.09	4.87	4.68	3.82	2.98	2.51	4.54	3.93	3.21	2.07
242	xxx	4.7	3	4.73	4.57	3.78	3.02	2.24	xxx	3.87	3.22	1.91
243	4.52	4.79	3.05	4.81	4.63	3.84	3.07	2.35	xxx	3.91	3.23	2.05
244	4.75	5.02	3.24	5.08	4.88	4.11	3.28	2.41	4.75	4.17	3.49	2.05
245	4.68	5.01	3.19	5.08	4.84	4.1	3.27	2.59	4.71	4.12	3.44	2.33
246	4.24	4.6	2.95	4.66	4.44	3.72	2.95	2.58	4.32	3.78	3.16	2.27
247	3.72	4.39	2.91	4.46	4.29	3.54	2.79	2.28	4.17	3.65	3.05	2.11
248	4.32	4.96	3.31	5.05	4.83	3.96	3.11	2.13	4.73	4.19	3.57	2.03
249	4.67	5.22	3.35	5.29	5.08	4.22	3.36	2.39	4.99	4.36	3.69	2.56
250	4.05	4.59	2.96	4.62	4.45	3.64	2.82	2.63	4.33	3.8	3.2	2.59
251	3.67	4.15	2.83	4.22	4.05	3.25	2.46	2.1	3.97	3.47	2.92	2.18
252	4.24	4.86	3.28	4.9	4.68	3.82	2.96	1.77	4.61	4.09	3.53	2
253	4.67	5.39	3.49	5.38	5.15	4.27	3.37	2.23	5.32	4.46	3.84	2.65
254	4.16	4.69	2.99	4.72	4.55	3.73	2.86	2.61	4.42	3.87	3.26	2.83
255	3.51	4.1	2.75	4.18	4.01	3.23	2.42	2.11	3.92	3.44	2.89	2.23
256	3.96	4.59	3.16	4.7	4.49	3.71	2.86	1.71	4.41	3.95	3.43	1.98
257	5.16	5.42	3.51	5.45	5.22	4.38	3.49	2.14	5.1	4.56	3.93	2.56
258	4.68	4.84	2.96	4.85	4.63	3.74	2.83	2.71	4.59	3.91	3.22	2.9
259	3.46	3.89	2.73	3.97	3.78	3	2.17	2	3.73	3.26	2.7	2.13
260	3.95	4.4	2.92	4.48	4.27	3.46	2.59	1.49	4.21	3.74	3.19	1.87
261	5.16	5.37	3.26	5.42	5.18	4.26	3.31	1.88	5.05	4.45	3.79	xxx
262	4.68	4.91	2.88	4.96	4.72	3.73	2.74	2.45	4.77	3.97	3.26	2.67
263	3.61	4.12	2.56	4.13	3.93	3.04	2.14	1.83	3.86	3.34	2.76	2.04
264	4.01	4.5	2.93	4.43	4.23	3.32	2.39	1.4	4.18	3.7	3.17	1.75
265	5.37	5.51	3.31	5.46	5.22	4.2	3.16	1.64	5.09	4.47	3.78	2.28
266	5.03	5.11	2.75	5.13	4.85	3.7	2.57	2.23	4.76	4.02	3.22	2.64
267	3.67	4	2.36	4.07	3.82	2.83	1.87	1.57	xxx	3.23	2.58	1.95
268	4.29	4.54	2.92	4.52	4.26	3.24	2.2	1.13	xxx	3.71	3.1	1.61
269	5.6	5.69	3.36	5.61	5.34	4.19	3	1.39	5.22	4.55	3.8	2.15
270	5.49	5.44	3.02	5.43	5.12	3.87	2.59	1.93	5	4.26	3.43	2.56
271	3.99	4.29	2.54	4.32	4.06	2.96	1.88	1.44	3.98	3.43	2.76	1.99
272	4.44	4.8	3.08	4.77	4.5	3.33	2.2	1.04	4.48	3.99	3.37	1.55
273	6	5.93	3.52	5.87	5.56	4.27	2.95	1.31	5.46	4.8	4.03	2.33
274	5.46	5.33	3	5.32	5	3.67	2.38	1.8	4.85	4.15	3.33	2.77
275	4.17	4.33	2.63	4.37	4.05	2.87	1.81	1.23	4.01	3.47	2.79	1.9
276	4.48	4.76	3.06	4.76	4.42	3.2	2.04	0.96	4.42	3.91	3.29	1.59
277	5.81	5.79	3.43	5.73	5.41	4.04	2.69	1.04	5.31	4.63	3.85	2.16
278	5.42	5.42	3.05	5.4	5.05	3.57	2.23	1.56	4.95	4.2	3.34	2.5
279	4.33	4.61	2.73	4.57	4.24	2.9	1.77	1.09	4.22	3.61	2.91	1.89

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
280	4.61	4.8	3.01	4.68	4.36	3.04	1.84	0.91	4.37	3.82	3.17	1.66
281	5.6	5.54	3.29	5.45	5.11	3.69	2.34	0.94	5.03	4.37	3.59	2.01
282	5.29	5.31	3.05	5.28	4.92	3.37	2	1.3	4.84	4.13	3.3	2.25
283	4.49	4.68	2.8	4.66	4.31	2.9	1.7	0.93	4.3	3.7	2.98	1.87
284	4.46	4.78	3.01	4.78	4.4	2.98	1.71	0.84	4.42	3.88	3.21	1.69
285	5.19	5.29	3.2	5.27	4.89	3.39	2.04	0.8	4.86	4.22	3.45	2
286	5.13	5.16	3.02	5.11	4.74	3.09	1.77	1.07	4.72	4.04	3.26	2.13
287	3.9	4.54	2.8	4.53	4.17	2.68	1.54	0.76	4.2	3.62	2.95	1.89
288	3.91	4.55	2.96	4.54	4.2	2.75	1.53	0.73	4.24	3.72	3.13	1.7
289	4.71	4.83	3.05	4.82	4.47	2.96	1.71	0.68	4.47	3.89	3.24	2.01
290	4.83	4.93	3.01	4.89	4.48	2.86	1.58	0.83	4.52	3.93	3.25	2.07
291	4.39	4.6	2.88	4.55	4.14	2.64	1.44	0.67	4.21	3.66	3.03	2.02
292	4.07	4.35	2.8	4.32	3.95	2.56	1.38	0.64	4.02	3.52	2.97	1.88
293	4.21	4.54	2.89	4.51	4.15	2.71	1.51	0.61	4.19	3.68	3.09	1.98
294	4.28	4.6	2.88	4.57	4.19	2.67	1.46	0.7	4.23	3.71	3.09	2.05
295	4.25	4.58	2.88	4.57	4.18	2.66	1.45	0.66	4.81	3.71	3.09	1.99
296	3.56	3.94	2.47	3.95	3.62	2.35	1.28	0.64	xxx	3.19	2.64	1.99
297	3.51	3.89	2.47	3.88	3.56	2.31	1.24	0.59	xxx	3.16	2.62	1.68
298	3.92	4.33	2.77	4.34	3.96	2.61	1.46	0.54	4.01	3.54	2.97	1.67
299	3.82	4.32	2.74	4.35	3.96	2.59	1.41	0.7	4.06	3.52	2.94	1.95
300	3.45	3.9	2.5	3.91	3.61	2.41	1.37	0.61	3.64	3.22	2.7	1.91
301	3.01	3.47	2.3	3.44	3.17	2.05	1.09	0.66	3.22	2.84	2.39	1.76
302	3.57	4.02	2.75	4.01	3.71	2.5	1.42	xxx	3.76	3.37	2.91	1.56
303	4.08	4.41	2.9	4.43	4.12	2.78	1.57	xxx	4.17	3.69	3.14	2.13
304	3.08	3.62	2.33	3.66	3.44	2.25	1.33	xxx	3.45	3.03	2.53	2.25
305	2.6	3.13	2.12	3.16	2.95	1.88	1.05	0.65	2.99	2.62	2.2	1.77
306	2.8	3.44	2.41	3.45	3.23	2.19	1.3	0.45	3.29	2.95	2.58	1.54
307	3.36	3.93	2.62	3.96	3.76	2.52	1.5	0.69	xxx	xxx	2.91	1.98
308	2.93	3.49	2.23	3.54	3.34	2.31	1.41	0.75	xxx	2.91	2.45	2.22
309	2.49	3.04	2.05	3.08	2.88	1.94	1.1	0.74	2.9	2.57	2.16	1.71
310	2.88	3.53	2.38	3.59	3.35	2.37	1.51	0.47	3.36	3.01	2.6	1.5
311	3.27	3.8	2.55	3.89	3.62	2.54	1.57	0.86	3.63	3.25	2.83	1.95
312	3.11	3.34	2.22	3.46	3.25	2.41	1.6	0.8	3.22	2.85	2.45	2.14
313	2.44	2.83	1.94	2.95	2.76	1.97	1.21	0.97	2.76	2.44	2.06	1.73
314	2.67	3.33	2.38	3.49	3.29	2.52	1.78	0.61	3.31	3	2.65	1.42
315	3.25	3.87	2.64	4.04	3.82	2.89	1.99	1.2	3.87	3.47	3.03	2.06
316	3	3.55	2.39	3.69	3.52	2.78	2.01	1.24	3.46	3.08	2.64	2.35
317	2.18	2.81	2	2.97	2.82	2.17	1.48	1.38	2.8	2.5	2.13	1.9
318	2.63	3.31	2.44	3.49	3.34	2.7	2.03	0.92	3.33	3.03	2.69	1.49
319	3.48	4.2	2.84	4.31	4.16	3.36	2.51	1.52	4.86	3.7	3.27	2.11

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
320	3.29	3.95	2.62	4.05	3.92	3.24	2.52	1.8	3.79	3.38	2.89	2.55
321	2.16	2.97	2.11	3.14	3	2.4	1.77	1.91	2.98	2.64	2.24	2.07
322	2.73	3.61	2.67	3.81	3.68	3.13	2.57	1.24	3.65	3.31	2.94	1.56
323	3.94	4.49	3.13	4.63	4.5	3.86	3.17	2.12	4.44	4.01	3.57	2.29
324	3.74	4.16	2.76	4.28	4.19	3.62	3.04	2.59	4.06	3.57	3.03	2.81
325	2.92	3.44	2.38	3.57	3.48	2.92	2.37	2.56	3.37	2.97	2.5	2.12
326	3.05	3.73	2.38	3.9	3.83	3.39	2.95	1.92	3.74	3.4	2.99	1.71
327	4.4	4.71	3.2	4.84	4.74	4.26	3.78	2.58	4.63	4.17	3.65	2.29
328	3.84	4.13	2.63	4.22	4.11	3.62	3.11	3.38	3.98	3.46	2.88	2.78
329	3.1	3.65	2.43	3.79	3.69	3.22	2.74	2.69	3.59	3.13	2.61	1.91
330	3.66	4.19	2.82	4.33	4.22	3.74	3.31	2.33	4.12	3.65	3.11	1.71
331	4.73	5.01	3.17	5.1	4.94	4.37	3.88	2.87	4.81	4.24	3.6	2.21
332	4.5	4.74	2.85	4.82	4.64	4	3.39	3.46	4.48	3.87	3.16	2.54
333	3.57	4.01	2.56	4.14	4.02	3.45	2.9	2.9	3.89	3.38	2.76	1.97
334	4.12	4.44	2.94	4.58	4.45	3.96	3.47	2.44	4.34	3.82	3.24	1.71
335	5.12	5.24	3.26	5.31	5.12	4.55	3.98	3.06	5	4.47	3.68	2.25
336	4.92	5.02	2.99	5.08	4.89	4.22	3.55	3.55	4.73	4.07	3.33	2.53
337	4.11	4.35	2.72	4.45	4.31	3.73	3.12	3.06	4.18	3.6	2.95	2.08
338	4.68	4.8	3.1	4.88	4.75	4.2	3.64	2.67	4.63	xxx	3.42	1.83
339	5.41	5.39	3.32	5.47	5.28	4.65	4.03	3.21	5.12	xxx	3.73	2.36
340	5.38	5.31	3.2	5.43	5.22	4.51	3.8	3.57	5.06	4.36	3.57	2.55
341	4.62	4.69	2.95	4.82	4.66	4.02	3.37	3.3	4.51	3.89	3.19	2.32
342	4.89	4.89	3.2	4.97	4.83	4.29	3.75	2.91	4.69	xxx	3.51	2.06
343	5.55	5.41	3.39	5.49	5.28	4.68	4.07	3.37	5.13	xxx	3.79	2.51
344	5.36	5.37	3.31	5.48	5.28	4.63	3.98	3.68	5.12	4.46	3.7	2.66
345	4.99	5.08	3.2	5.18	5.01	4.38	3.78	3.54	4.86	4.23	3.51	2.52
346	4.98	4.92	3.14	5.02	4.84	4.28	3.75	3.36	4.7	4.11	3.44	2.4
347	5.45	5.29	3.29	5.39	5.16	4.55	3.97	3.36	5.02	4.39	3.67	2.4
348	5.31	5.33	3.25	5.44	5.23	4.55	3.96	3.56	5.08	4.42	3.69	2.52
349	5.14	5.19	3.19	5.3	5.12	4.46	3.88	3.55	4.96	4.32	3.6	2.51
350	5.12	5.06	3.12	5.15	4.96	4.36	3.79	3.48	4.81	4.19	3.5	2.44
351	4.89	4.88	3.07	4.97	4.78	4.21	3.65	3.41	4.66	4.06	3.39	2.38
352	5.14	5.2	3.34	5.33	5.17	4.54	4.07	3.29	5.03	4.44	3.77	2.32
353	5.12	5.17	3.3	5.31	5.15	4.51	4.03	3.72	4.99	4.39	3.73	2.73
354	5.01	5.05	3.24	5.18	5.01	4.45	3.92	3.72	4.86	4.27	3.62	2.65
355	4.5	3.5	3.04	4.74	4.59	4.06	3.56	3.59	4.46	3.92	3.32	2.58
356	4.73	xxx	3.34	5.04	4.92	xxx	4.01	3.26	4.79	4.28	3.74	2.38
357	5.27	xxx	3.48	5.42	5.27	xxx	4.28	3.77	5.13	4.56	3.97	2.88
358	4.72	xxx	3.17	4.94	4.79	4.28	3.82	4.04	4.66	4.11	3.54	2.99
359	4.02	xxx	2.95	4.45	4.35	3.88	3.43	3.54	4.26	3.73	3.21	2.58

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
360	4.29	xxx	3.22	4.77	4.65	xxx	3.82	3.19	4.57	4.07	3.58	2.38
361	5.03	xxx	3.48	5.37	5.22	xxx	4.33	3.61	5.09	4.57	4	2.81
362	4.51	xxx	3.08	4.81	4.68	4.18	3.71	xxx	4.55	4.03	3.46	3.07
363	3.61	xxx	2.75	4.08	3.99	3.57	3.15	3.44	3.89	3.45	2.96	2.53
364	3.94	xxx	3.1	4.5	4.41	xxx	3.68	2.91	4.31	3.9	3.46	2.2
365	4.95	xxx	3.52	5.38	5.24	xxx	4.41	3.49	5.11	4.59	4.05	2.75
366	4.44	4.52	2.91	4.61	4.48	3.95	3.44	4.18	4.37	3.83	3.25	3.14
367	3.63	3.84	2.66	3.96	3.89	3.43	3	3.11	3.77	3.33	2.84	2.33
368	3.75	4.12	2.85	4.23	4.14	3.69	3.31	2.7	4.03	3.62	3.18	2.08
369	4.85	5.09	3.25	5.14	5.01	4.47	4.01	3.01	5.18	4.35	3.78	2.46
370	4.45	4.64	xxx	4.71	4.58	3.95	3.33	3.68	4.44	3.85	3.19	2.86
371	3.16	3.52	xxx	3.63	3.55	3.02	2.47	2.85	3.45	3.01	2.51	2.1
372	3.63	4.08	2.91	4.26	4.18	3.73	3.29	2.02	4.09	3.71	3.29	1.69
373	4.95	5.04	3.28	5.12	5.01	4.51	4.01	2.94	4.87	4.37	3.82	2.62
374	4.65	4.74	2.94	4.81	4.7	4.08	3.5	3.64	4.56	4.01	3.38	2.93
375	3.78	4	2.64	4.12	4.04	3.47	2.96	3.04	3.92	3.46	2.93	2.37
376	3.98	4.18	2.83	4.31	4.25	3.81	3.39	2.52	4.13	3.7	3.23	2.09
377	5.24	5.14	3.24	5.19	5.08	4.55	4.04	3.04	4.95	4.4	3.8	2.47
378	4.78	4.7	2.77	4.74	4.6	3.99	3.43	3.64	4.47	3.87	3.21	2.84
379	3.94	4.01	2.53	4.12	4.02	3.48	2.99	2.97	3.91	3.42	2.87	2.14
380	4.15	4.26	2.77	4.39	4.31	3.83	3.38	2.56	4.19	3.73	3.22	1.95
381	5.19	5.06	3.09	5.11	4.97	4.42	3.9	3	4.84	4.27	3.66	2.37
382	4.74	4.64	2.63	4.68	4.5	3.86	3.26	3.49	4.39	3.78	3.11	2.64
383	4.03	4.16	2.47	4.24	4.12	3.53	2.97	2.77	4.01	3.49	2.88	1.99
384	4.29	4.4	2.69	4.49	4.39	3.84	3.34	2.5	4.26	3.75	3.16	1.88
385	5.34	5.23	3	5.25	5.04	4.41	3.81	2.89	4.93	4.29	3.57	2.22
386	5.15	5.02	2.66	5.03	4.8	4.09	3.41	3.31	4.7	4.02	3.23	2.45
387	4.27	4.33	2.44	4.39	4.26	3.61	3.01	2.88	4.15	3.6	2.94	1.95
388	4.56	4.53	2.64	4.62	4.53	3.93	3.4	2.53	4.38	3.81	3.16	1.82
389	5.42	5.27	2.9	5.32	5.13	4.44	3.81	2.98	4.98	4.28	3.5	2.1
390	5.34	5.15	2.65	5.17	4.93	4.19	3.49	3.32	4.83	4.13	3.31	2.27
391	4.6	4.47	2.44	4.54	4.39	3.73	3.14	2.94	4.28	3.71	3	1.96
392	4.65	4.57	2.62	4.65	4.5	3.88	3.32	2.65	4.38	3.81	3.15	1.82
393	5.28	5.06	2.79	5.12	4.91	4.26	3.64	2.83	4.79	4.13	3.39	2.05
394	4.96	4.76	2.52	4.82	4.59	3.91	3.26	3.12	4.49	3.85	3.1	2.17
395	4.66	4.58	2.47	4.63	4.43	3.76	3.15	2.71	4.33	3.73	3.03	1.86
396	4.71	4.63	2.49	4.7	4.5	3.82	3.21	2.62	4.39	3.79	3.07	1.84
397	5.02	4.83	2.57	4.87	4.66	3.95	3.31	2.67	4.55	3.92	3.16	1.88
398	4.88	4.68	2.41	4.71	4.51	3.83	3.21	2.75	4.4	3.77	3	1.94
399	4.5	4.46	2.34	4.52	4.33	3.66	3.05	2.69	4.25	3.66	2.92	1.76

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
400	4.78	4.71	2.51	4.74	4.55	3.95	3.39	2.54	4.44	3.83	3.08	1.72
401	4.24	4.36	2.37	4.46	4.28	3.71	3.16	2.94	4.18	3.61	2.91	1.86
402	4.47	4.52	2.59	4.62	4.47	3.97	3.49	2.73	4.36	3.79	3.11	1.75
403	4.4	4.44	2.52	4.51	4.35	3.85	3.37	3.14	4.25	3.69	3.01	2.03
404	4.3	4.42	2.58	4.46	4.32	3.89	3.47	3.04	4.23	3.7	3.06	1.95
405	4.04	4.19	2.48	4.28	4.14	3.71	3.31	3.2	4.04	3.53	2.91	2.08
406	4.11	4.31	2.66	4.41	4.29	3.87	3.52	3.05	4.18	3.67	3.09	1.97
407	4.39	4.51	2.72	4.57	4.45	4.04	3.65	3.28	4.34	3.8	3.2	2.19
408	4.17	4.33	2.6	4.34	4.21	3.82	3.42	3.39	4.12	3.61	3.01	2.24
409	3.59	3.85	2.39	3.9	3.79	3.4	3.05	3.17	3.71	3.24	2.71	2.08
410	3.59	3.96	2.6	4.09	4	3.65	3.36	2.83	3.91	xxx	2.98	1.89
411	3.97	4.24	2.69	4.34	4.23	3.88	3.57	3.19	4.14	xxx	3.14	2.21
412	3.68	3.87	2.39	3.94	3.79	3.44	3.12	3.38	3.71	xxx	2.75	2.29
413	3.12	3.47	2.23	3.58	3.46	3.13	2.83	2.95	3.39	xxx	2.52	1.95
414	3.42	3.8	2.57	3.97	3.88	3.56	3.29	2.68	3.81	xxx	2.94	1.82
415	3.88	4.11	2.67	4.16	4.08	3.73	3.43	2.76	4.02	xxx	3.06	2.23
416	3.23	3.52	2.23	3.53	3.49	3.18	2.9	2.33	3.46	xxx	2.56	2.29
417	2.66	2.89	2	3.02	2.95	2.67	2.45	3.14	2.92	xxx	2.21	1.85
418	2.86	3.16	2.26	3.31	3.23	3.03	2.87	3.28	3.18	xxx	2.56	1.64
419	3.84	3.91	2.57	3.94	3.85	3.62	3.4	2.79	3.77	xxx	2.98	2.06
420	3.34	3.57	2.29	3.66	3.57	3.3	3.05	3.27	3.53	xxx	2.73	2.31
421	2.56	2.79	1.93	2.89	2.79	2.52	2.3	2.91	2.76	xxx	2.11	2.06
422	3.19	3.68	2.53	3.83	4.6	3.49	3.24	2.16	xxx	xxx	3.03	1.61
423	3.42	4.45	2.91	4.67	4.2	4.3	4.07	3.11	xxx	xxx	3.76	2.39
424	2.76	2.84	1.68	2.93	2.83	2.59	2.35	3.95	2.89	xxx	2.05	2.96
425	2.27	2.57	1.57	2.63	2.61	2.43	2.16	2.17	2.37	xxx	1.97	1.26
426	3.06	3.63	2.33	3.67	3.59	3.36	3.07	1.99	xxx	xxx	2.84	1.21
427	3.21	3.59	2.29	3.67	3.58	3.35	3.08	2.9	xxx	xxx	2.72	2.07
428	3.07	3.57	2.4	3.68	3.61	3.4	3.16	2.95	3.58	xxx	2.82	1.98
429	2.27	2.81	1.96	2.93	2.89	2.67	2.48	3.04	2.85	xxx	2.2	2.18
430	2.52	3.04	2.18	3.11	3.05	2.86	2.69	2.36	3	xxx	2.46	1.67
431	3.55	3.99	2.65	3.97	3.89	3.7	3.5	2.6	3.83	xxx	3.13	2
432	3	3.45	2.23	3.49	3.42	3.16	2.9	3.39	3.39	xxx	2.64	2.53
433	2.5	3.03	2.03	3.1	3.04	2.82	2.6	2.7	3.01	xxx	2.34	1.95
434	2.82	3.4	2.28	3.44	3.33	3.05	2.77	2.41	3.31	xxx	2.58	1.75
435	3.8	4.21	2.66	4.22	4.11	3.8	3.45	2.52	4.06	xxx	3.15	2.01
436	3.49	3.79	2.28	3.84	3.73	3.31	2.84	3.2	3.68	xxx	2.71	2.39
437	3.03	3.38	2.17	3.48	3.41	3.01	2.58	2.46	3.33	xxx	2.51	1.84
438	3.15	3.44	2.21	3.48	3.39	3.01	2.59	2.19	3.32	xxx	2.5	1.74
439	4.1	4.32	2.62	4.34	4.17	3.71	3.24	2.22	4.13	xxx	3.06	1.78

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
440	4.32	4.37	2.37	4.42	4.22	3.59	2.97	2.84	4.12	xxx	2.82	2.16
441	3.66	3.85	2.16	3.92	3.79	3.2	2.61	2.43	3.3	xxx	2.57	1.62
442	4.24	4.51	2.66	4.64	4.5	3.84	3.22	2.1	4.39	xxx	3.16	1.51
443	4.81	4.91	2.79	5	4.81	4.11	3.48	2.67	4.68	4.06	3.31	2.01
444	4.47	4.53	2.49	4.61	4.45	3.78	3.12	2.92	4.33	3.73	2.98	2.07
445	4.19	4.26	2.39	4.34	4.22	3.58	2.93	2.56	4.09	3.53	2.84	1.8
446	4.36	4.49	2.57	4.62	4.46	3.79	3.17	2.37	4.33	3.76	3.07	1.73
447	5.1	5.09	2.79	5.21	4.97	4.23	3.55	2.62	4.85	4.16	3.36	1.95
448	4.86	4.84	2.56	4.89	4.69	3.94	3.2	2.96	4.57	3.89	3.08	2.1
449	4.68	4.73	2.53	4.77	4.6	3.87	3.16	2.56	4.47	3.83	3.06	1.78
450	5.21	4.91	2.55	4.98	4.75	3.91	3.13	2.54	4.62	3.92	3.1	1.79
451	5.63	5.26	2.69	5.32	5.07	4.19	3.36	2.44	4.93	4.17	3.29	1.74
452	5.53	5.25	2.59	5.25	5.02	4.05	3.12	2.66	4.89	4.12	3.2	1.87
453	5.39	5.13	2.56	5.15	4.94	3.99	3.09	2.34	4.79	4.06	3.17	1.72
454	5.53	5.2	2.59	5.27	xxx	3.97	3.03	2.32	xxx	4.12	3.23	1.72
455	5.47	5.16	2.58	5.24	4.98	3.95	3.03	2.2	4.84	4.1	3.21	1.74
456	5.45	5.18	2.6	5.25	4.99	3.93	2.97	2.2	xxx	4.13	3.23	1.73
457	5.84	5.53	2.74	5.58	5.29	4.18	3.19	2.12	xxx	4.34	3.41	1.78
458	5.62	5.28	2.45	5.34	5	3.84	2.81	2.34	4.88	4.08	3.15	1.87
459	5.32	5.03	2.37	5.09	4.81	3.7	2.69	1.96	4.68	3.94	3.05	1.6
460	5.32	5.09	2.46	5.16	4.89	3.81	2.76	1.84	4.75	4.03	3.14	1.57
461	5.9	5.6	2.68	5.69	5.3	4.15	3.06	1.88	5.16	4.36	3.39	1.66
462	5.68	5.11	2.17	5.14	4.73	3.51	2.52	2.18	4.6	3.82	2.89	1.8
463	4.58	4.22	1.88	4.29	4.04	2.96	2.05	1.69	3.93	3.32	2.54	1.33
464	5.06	4.97	2.56	5.09	4.87	3.8	2.8	1.21	4.75	4.08	3.24	1.21
465	5.91	5.55	2.72	5.62	5.28	4.12	3.06	1.88	5.14	4.33	3.4	1.83
466	5.5	5.19	2.39	5.24	4.9	3.74	2.75	2.15	4.77	4	3.1	1.84
467	4.14	4.17	2	4.28	4.05	2.99	2.09	1.91	3.96	3.38	2.62	1.6
468	4.52	4.66	2.55	4.8	4.61	3.63	2.79	1.29	4.5	3.92	3.21	1.34
469	5.49	5.34	2.78	5.39	5.13	4.07	3.17	2.02	4.99	4.28	3.46	1.96
470	4.99	4.81	2.37	4.88	4.63	3.74	2.9	2.36	4.49	3.81	3	2.05
471	4.06	4.06	2.09	4.2	4.01	3.18	2.36	2.18	3.91	3.35	2.64	1.66
472	4.16	4.25	2.37	4.4	4.27	3.57	2.93	1.64	4.13	3.6	2.92	1.47
473	5.1	5	2.67	5.07	4.86	4.07	3.37	2.35	4.72	4.07	3.29	1.82
474	4.5	4.5	2.23	4.52	4.33	3.67	3.04	2.77	4.19	3.56	2.8	2.01
475	3.28	3.51	1.83	3.59	3.47	2.89	2.33	2.53	3.37	2.9	2.28	1.54
476	3.91	4.24	2.53	4.41	4.33	3.86	3.44	1.87	4.18	3.71	3.12	1.24
477	4.86	4.92	2.76	5	4.85	4.29	3.8	3.1	4.69	4.09	3.4	2.11
478	4.46	4.46	2.44	4.49	4.34	3.82	3.37	3.42	4.21	3.62	2.96	2.22
479	3.31	3.53	2.04	3.63	3.51	3.08	2.68	3.03	3.43	2.96	2.4	1.85

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
480	3.32	3.64	2.35	3.76	3.64	3.36	3.09	2.4	3.56	3.18	2.74	1.49
481	4.59	4.71	2.77	4.78	4.59	4.2	3.83	2.92	4.49	3.97	3.38	2.03
482	4.23	4.26	2.27	4.36	4.13	3.62	3.15	3.59	4.03	3.45	2.76	2.42
483	3.14	3.45	1.97	3.63	3.47	3.04	2.65	2.83	3.37	2.93	2.37	1.66
484	3.56	3.89	2.4	4.04	3.9	3.54	3.21	2.4	3.8	3.36	2.85	1.45
485	4.15	4.44	2.61	4.55	4.36	3.97	3.59	3.02	4.25	3.74	3.14	1.96
486	4.49	4.68	2.67	4.76	4.56	4.08	3.63	3.34	4.48	3.87	3.16	2.12
487	3.37	3.67	2.23	3.83	3.69	3.26	2.87	3.31	3.61	3.13	2.53	2.03
488	3.64	4.09	2.81	4.27	4.19	3.87	3.58	2.63	4.08	3.7	3.26	1.61
489	4.4	4.67	2.97	4.78	4.65	4.29	3.96	3.46	4.54	4.05	3.53	2.54
490	4.54	4.67	2.92	4.75	4.61	4.19	3.78	3.78	4.51	3.98	3.37	2.64
491	3.92	4.17	2.69	4.3	4.19	3.78	3.39	3.54	4.07	3.61	3.06	2.4
492	3.93	4.19	2.86	4.33	4.23	3.9	3.61	3.19	4.12	3.73	3.27	2.19
493	4.6	4.73	3.07	4.83	4.68	4.34	4.02	3.45	4.59	4.11	3.58	2.53
494	4.59	4.68	2.97	4.78	4.61	4.19	3.77	3.81	4.52	3.98	3.38	2.73
495	4.22	4.36	2.85	4.48	4.34	3.94	3.55	3.52	4.25	3.76	3.2	2.43
496	4.21	4.33	2.87	4.43	4.32	3.95	3.63	3.33	4.23	3.77	3.25	2.32
497	4.62	4.61	3	4.68	4.56	4.17	3.82	3.46	4.46	3.97	3.41	2.45
498	4.49	4.59	2.81	4.67	4.51	4.08	3.66	3.63	4.42	3.89	3.27	2.56
499	4.45	4.7	2.93	4.75	4.62	4.19	3.77	3.42	4.51	3.99	3.38	2.33
500	4.55	4.63	2.21	4.59	4.49	4.05	3.64	3.52	4.38	3.88	3.24	2.44
501	4.56	4.52	2.28	4.51	4.41	4.01	3.63	3.36	4.34	3.87	3.3	2.17
502	4.68	4.57	2.46	4.6	4.45	4.02	3.62	3.37	4.3	3.74	3.08	2.32
503	4.65	4.6	2.49	4.63	4.48	4.02	3.62	3.35	4.33	3.78	3.11	1.89
504	4.31	4.43	2.42	4.52	4.37	3.95	3.58	3.36	4.22	3.67	2.99	1.95
505	4.53	4.51	2.44	4.59	4.43	3.98	3.58	3.34	4.29	3.73	3.04	1.77
506	4.49	4.42	2.27	4.48	4.34	3.87	3.46	3.33	4.18	3.63	2.94	1.81
507	4.56	4.51	2.36	4.55	4.4	3.95	3.56	3.21	4.24	3.7	3.01	1.74
508	4.52	4.47	2.27	4.48	4.32	3.86	3.46	3.3	4.17	3.62	2.92	1.81
509	4.18	4.28	2.2	4.33	4.18	3.73	3.34	3.18	4.03	3.5	2.83	1.72
510	4.21	4.35	2.27	4.44	4.3	3.86	3.47	3.09	4.16	3.62	2.97	1.65
511	4.7	4.67	2.4	4.68	4.54	4.07	3.65	3.23	4.39	3.8	3.11	1.81
512	4.37	4.4	2.17	4.38	4.28	3.75	3.33	3.38	4.08	3.49	2.82	1.89
513	3.91	4.13	2.06	4.18	4.09	3.59	3.19	3.06	3.9	3.35	2.7	1.65
514	3.93	4.11	2.09	4.18	4.03	3.6	3.23	2.95	3.9	3.39	2.74	1.59
515	4.46	4.57	2.29	4.58	4.41	3.93	3.54	2.97	4.27	3.7	3	1.63
516	4.28	4.38	2.11	4.38	4.2	3.71	3.25	3.23	4.05	3.47	2.74	1.79
517	3.64	3.88	1.92	3.95	3.81	3.38	2.97	2.92	3.67	3.18	2.52	1.51
518	3.64	3.89	2.05	3.97	3.86	3.46	3.1	2.68	3.73	3.25	2.64	1.4
519	4.22	4.37	2.21	4.38	4.23	3.79	3.37	2.87	4.09	3.54	2.86	1.56

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
520	4.03	4.22	2.06	4.19	4.03	3.57	3.13	3.11	3.9	3.35	2.64	1.68
521	3.18	3.51	1.79	3.57	3.46	3.05	2.69	2.84	3.34	2.88	2.28	1.46
522	3.25	3.57	1.98	3.69	3.59	3.22	2.93	2.45	3.47	3.04	2.49	1.26
523	4.22	4.4	2.3	4.41	4.27	3.83	3.44	2.74	4.14	3.59	2.93	1.51
524	3.72	3.83	1.81	3.79	3.65	3.18	2.75	3.19	3.54	2.98	2.31	1.78
525	2.79	3.18	1.59	3.25	3.16	2.75	2.42	2.44	2.94	2.62	2.04	1.14
526	3.94	4.23	2.32	4.29	4.19	3.73	3.36	2.15	4.04	3.52	2.84	1.04
527	3.91	3.92	2.14	3.95	3.83	3.41	3.06	3.09	3.68	3.18	2.54	1.66
528	3.42	3.65	2.13	3.65	3.57	3.28	3	xxx	3.46	3.05	2.52	1.43
529	2.57	3.08	1.81	3.14	3.07	2.78	2.5	xxx	2.98	2.6	2.12	1.6
530	2.62	3.17	2.19	3.27	3.26	3.03	2.84	2.34	3.2	2.89	2.54	1.25
531	3.67	3.99	2.48	4.04	3.98	3.71	3.47	2.73	3.9	3.48	3.01	1.89
532	3.23	3.54	2.14	3.59	3.42	3.13	2.88	3.34	3.34	2.92	2.45	2.19
533	2.25	2.8	1.76	2.87	2.75	2.49	2.26	2.75	2.66	2.33	1.94	1.67
534	2.74	3.32	2.3	3.41	3.37	3.1	2.85	2.13	3.27	2.94	2.54	1.28
535	3.26	3.7	2.5	3.78	3.75	3.5	3.27	2.7	3.63	3.28	2.86	1.89
536	2.93	3.36	2.23	3.46	3.4	3.14	2.88	3.14	3.3	2.93	2.46	2.16
537	2.21	2.69	1.82	2.78	2.75	2.45	2.18	2.76	2.67	2.31	1.89	1.78
538	2.6	3.17	2.37	3.32	3.29	3.07	2.89	2.05	3.22	2.94	2.64	1.3
539	3.35	3.64	2.62	3.77	3.69	3.48	3.3	2.81	3.59	3.3	2.94	2.13
540	2.79	2.95	2.14	3.01	2.95	2.78	2.62	3.23	2.85	2.61	2.32	2.37
541	2.5	2.91	2.11	3.03	2.96	2.8	2.61	2.58	2.87	2.64	2.33	1.84
542	2.59	3.04	2.15	3.22	3.1	2.87	2.65	2.56	3.03	2.73	2.34	1.82
543	3.32	3.72	2.49	3.83	3.7	3.47	3.24	2.54	3.64	3.28	2.85	1.77
544	3.46	3.84	2.41	3.89	3.85	3.5	3.19	3.11	3.73	3.28	2.75	2.15
545	2.56	3.05	2.04	3.17	3.16	2.81	2.51	3.02	3.05	2.67	2.2	1.86
546	3.13	3.63	2.57	3.81	3.69	3.43	3.18	2.35	3.59	3.27	2.86	1.45
547	3.65	4.07	2.72	4.19	4.05	3.76	3.5	3.06	3.94	3.56	3.09	2.2
548	3.55	3.99	2.68	4.04	3.94	3.66	3.37	3.38	3.87	3.46	2.98	2.34
549	3.41	3.83	2.63	3.94	3.83	3.57	3.28	3.24	3.77	3.38	2.92	2.22
550	3.45	3.77	2.57	3.86	3.72	3.44	3.14	3.15	3.67	3.28	2.8	2.17
551	4.11	4.46	2.93	4.5	4.35	4.05	3.72	2.99	3.59	3.82	3.28	2.04
552	4.44	4.54	2.77	4.59	4.46	4.02	3.58	3.53	xxx	3.77	3.1	2.4
553	3.72	3.77	2.43	3.88	3.77	3.36	2.99	3.31	xxx	3.18	2.6	2.01
554	3.92	4.22	2.89	4.33	4.24	3.93	3.6	2.78	xxx	3.73	3.24	1.68
555	4.78	4.93	3.13	4.95	4.83	4.47	4.08	3.44	4.7	4.18	3.59	2.42
556	4.63	4.81	3.02	4.84	4.69	4.27	3.84	3.88	4.58	4.03	3.42	2.6
557	4.91	4.95	3.09	5	4.86	4.42	3.97	3.59	4.73	4.15	3.52	2.41
558	4.89	4.64	2.77	4.71	4.54	4.04	3.55	3.7	4.43	3.82	3.15	2.46
559	5.1	4.92	2.94	5	4.82	4.29	3.79	3.24	4.69	4.07	3.38	2.04

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
560	5.11	4.95	2.85	5.03	4.83	4.23	3.72	3.46	4.7	4.05	3.31	2.22
561	5.32	4.98	2.87	5.03	4.83	4.22	3.72	3.34	4.7	4.05	3.31	2.05
562	5.49	5.24	2.98	5.28	5.05	4.42	3.89	3.33	4.91	4.23	3.45	2.06
563	5.2	4.99	2.86	5.04	4.83	4.23	3.71	3.49	4.69	4.04	3.27	2.21
564	5.28	5.08	2.97	5.13	4.96	4.39	3.89	3.34	4.8	4.18	3.46	2.08
565	5.82	5.62	3.22	5.65	5.43	4.78	4.2	3.56	5.27	4.57	3.77	2.29
566	6.16	5.55	2.96	5.5	5.23	4.55	3.92	3.82	5.1	4.36	3.5	2.46
567	5.12	4.75	2.64	4.77	4.56	3.97	3.44	3.49	4.46	3.83	3.09	2.11
568	5.57	5.29	3.15	5.38	5.21	4.62	4.16	3.08	5.05	4.44	3.71	1.88
569	6.22	5.76	3.3	5.8	5.58	4.92	4.39	3.87	5.39	4.7	3.91	2.53
570	6.17	5.6	3.16	5.67	5.41	4.76	4.18	4.04	5.23	4.52	3.72	2.61
571	5.39	4.94	2.89	5.06	4.85	4.26	3.74	3.79	4.7	4.07	3.34	2.4
572	5.23	4.93	2.95	5.02	4.88	4.39	3.94	3.41	4.73	4.18	3.53	2.16
573	6.42	5.97	3.39	6	5.76	5.15	4.59	3.69	5.6	4.91	4.12	2.49
574	5.58	5.52	2.87	5.56	4.91	4.53	3.88	4.26	5.12	4.35	3.48	2.87
575	4.2	4.43	2.49	4.55	xxx	3.79	3.27	3.46	4.24	3.65	2.95	2.07
576	3.98	4.68	2.88	4.79	xxx	4.21	3.8	2.95	4.52	4.02	3.4	1.8
577	5.44	5.8	3.31	5.81	xxx	4.98	4.45	3.57	5.41	4.74	3.97	2.4
578	5.81	5.22	2.54	5.25	xxx	4.19	3.53	4.12	4.8	4.05	3.2	2.73
579	4.5	4.28	2.33	4.36	xxx	3.58	3.1	3.07	4.07	3.5	2.83	1.76
580	5.69	4.78	2.15	4.82	xxx	3.92	3.34	2.78	4.4	3.74	2.9	1.76
581	xxx	5.87	2.69	5.88	5.58	4.77	4.04	2.93	5.35	xxx	3.58	1.51
582	xxx	4.98	1.75	4.97	4.67	3.86	3.12	3.5	4.48	3.7	2.76	1.96
583	xxx	3.92	1.51	3.98	3.83	3.16	2.56	2.54	3.64	3.06	2.31	1.22
584	xxx	4.22	1.55	4.27	4.17	3.53	2.95	2.07	4.01	3.42	2.65	1.06
585	xxx	4.87	1.94	4.88	4.72	4.02	3.4	2.46	4.54	xxx	2.99	1.36
586	xxx	4.66	1.43	4.62	4.43	3.68	2.97	2.87	4.26	xxx	2.71	1.53
587	xxx	3.81	1.05	3.83	3.7	3.02	2.36	2.36	3.54	xxx	2.25	1.24
588	3.57	3.92	1.47	4.08	3.95	3.34	2.79	1.78	3.8	xxx	2.62	0.99
589	4.67	4.7	1.8	4.79	4.61	3.94	3.35	2.3	4.45	xxx	2.98	1.44
590	4.37	4.4	1.53	4.39	4.26	3.56	2.9	2.84	4.11	xxx	2.64	1.58
591	3.36	3.69	1.21	3.74	3.64	3.01	2.39	2.33	3.51	xxx	2.28	1.26
592	3.45	3.81	1.61	3.96	3.81	3.26	2.75	1.84	3.68	xxx	2.54	1.09
593	4.32	4.47	1.8	4.56	4.39	3.77	3.22	2.27	4.25	xxx	2.87	1.40
594	4.13	4.31	1.68	4.3	4.18	3.53	2.91	2.73	4.03	xxx	2.60	1.56
595	3.36	3.73	1.4	3.76	3.66	3.07	2.48	2.40	3.52	xxx	2.31	1.26
596	3.35	3.72	1.72	3.86	3.72	3.22	2.74	1.99	3.58	xxx	2.46	1.14
597	4.03	4.17	1.85	4.28	4.12	3.56	3.06	2.34	3.97	xxx	2.70	1.33
598	4	4.12	1.84	4.2	4.06	3.47	2.96	2.63	3.91	xxx	2.56	1.45
599	3.78	3.96	1.73	4.04	3.91	3.34	2.84	2.50	3.77	xxx	2.50	1.25

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
600	3.58	3.83	1.83	3.95	3.8	3.29	2.84	2.39	3.67	xxx	2.45	1.25
601	3.91	4.04	1.88	4.14	3.98	3.43	2.95	2.46	3.85	xxx	2.56	1.26
602	4.29	4.26	1.94	4.31	4.17	3.58	3.04	2.56	4	xxx	2.60	1.33
603	3.86	4.06	1.86	4.13	4	3.44	2.92	2.59	3.84	xxx	2.52	1.25
604	3.83	4.1	2.03	4.15	4.03	3.52	3.05	2.48	3.88	xxx	2.59	1.24
605	3.97	4.19	2.01	4.25	4.1	3.56	3.08	2.66	3.95	xxx	2.62	1.32
606	4.22	4.4	2.13	4.46	4.3	3.72	3.19	2.69	4.14	xxx	2.72	1.31
607	4.02	4.23	2.06	4.3	4.16	3.61	3.08	2.78	4	xxx	2.62	1.36
608	4.07	4.23	2.15	4.28	4.15	3.63	3.15	2.68	3.99	xxx	2.67	1.29
609	3.97	4.16	2.07	4.21	4.07	3.54	3.07	2.79	3.91	xxx	2.61	1.40
610	4.07	4.34	2.29	4.43	4.29	3.77	3.31	2.72	4.14	xxx	2.84	1.32
611	4.25	4.45	2.32	4.52	4.37	3.84	3.37	2.96	4.22	xxx	2.87	1.55
612	4.31	4.41	2.34	4.42	4.26	3.74	3.29	3.01	4.11	xxx	2.83	1.53
613	4.05	4.24	2.25	4.28	4.12	3.62	3.18	2.93	3.98	xxx	2.73	1.52
614	4.18	4.39	2.41	4.51	4.35	3.83	3.35	2.84	4.21	xxx	2.92	1.45
615	4.31	4.44	2.41	4.51	4.36	3.84	3.36	3.01	4.2	xxx	2.89	1.64
616	4.31	4.61	2.56	4.63	4.49	3.97	3.52	3.00	4.33	xxx	3.05	1.60
617	4.18	4.41	2.44	4.47	4.32	3.8	3.35	3.19	4.17	xxx	2.91	1.78
618	3.85	4.09	2.38	4.19	4.09	3.61	3.2	3.05	3.95	xxx	2.81	1.64
619	4.64	4.68	2.63	4.7	4.57	4.03	3.58	2.93	4.41	xxx	3.11	1.68
620	4.46	4.55	2.46	4.59	4.45	3.87	3.4	3.25	4.29	xxx	2.94	1.87
621	3.82	3.87	2.17	3.98	3.87	3.36	2.94	3.02	3.73	xxx	2.57	1.66
622	4.06	4.13	2.5	4.27	4.17	3.72	3.33	2.62	4.04	xxx	2.95	1.42
623	4.49	4.36	2.56	4.44	4.33	3.86	3.46	3.07	4.19	xxx	3.00	1.86
624	4.61	4.48	2.64	4.53	4.4	3.92	3.52	3.18	4.26	xxx	3.08	1.86
625	3.79	3.98	2.4	4.08	3.99	3.54	3.15	3.22	3.87	xxx	2.77	1.93
626	3.77	3.9	2.59	4.05	3.98	3.6	3.26	2.87	3.86	xxx	2.91	1.69
627	4.59	4.58	2.87	4.67	4.56	4.14	3.77	3.04	4.42	xxx	3.32	1.97
628	4.45	4.38	2.57	4.4	4.25	3.76	3.34	3.50	4.1	xxx	2.91	2.25
629	3.41	3.67	2.27	3.79	3.68	3.24	2.86	3.02	3.53	xxx	2.53	1.79
630	3.43	3.79	2.51	3.91	3.82	3.46	3.14	2.60	3.7	xxx	2.81	1.54
631	4.23	4.49	2.75	4.44	4.31	3.92	3.57	2.95	4.21	2.98	3.15	1.92
632	4.32	4.52	2.66	4.37	4.25	3.81	3.39	3.34	xxx	3.3	2.97	2.14
633	3.05	3.55	2.27	3.6	3.52	3.13	2.74	3.11	xxx	xxx	2.44	1.87
634	3.18	3.68	2.58	3.81	3.75	3.44	3.14	2.50	3.66	xxx	2.85	1.49
635	4.06	4.37	2.86	4.45	4.35	4	3.68	2.96	3.84	3.80	3.27	2.06
636	3.84	4.07	2.52	4.07	3.99	3.57	3.19	3.47	xxx	3.37	2.77	2.34
637	2.71	3.27	2.17	3.34	3.31	2.92	2.58	2.93	xxx	2.78	2.28	1.77
638	2.94	3.52	2.43	3.49	3.45	3.19	2.94	2.36	3.39	3.04	2.65	1.44
639	3.65	3.82	2.51	3.7	3.58	3.29	3.03	2.81	3.52	3.13	2.66	1.96

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
640	3.98	4.24	xxx	4.28	4.18	3.87	3.58	2.88	4.11	3.70	3.21	1.96
641	2.23	2.75	xxx	2.84	2.79	2.53	2.27	3.42	2.71	2.41	2.04	2.47
642	2.08	2.66	xxx	2.79	2.76	2.61	2.48	2.15	2.73	xxx	2.32	1.47
643	3.74	4.12	xxx	4.16	4.09	3.9	3.71	2.46	4.06	xxx	3.41	2.06
644	3.31	3.69	2.6	3.68	3.63	3.37	3.09	3.63	3.57	3.20	2.78	2.92
645	2.48	3.02	2.23	3.1	3.12	2.88	2.64	2.95	3.04	2.74	2.39	2.17
646	2.97	3.43	2.54	3.56	3.56	3.3	3.07	2.51	3.47	3.17	2.81	1.85
647	3.67	3.98	2.93	4.07	4.05	3.79	3.54	2.95	3.97	3.64	3.23	2.26
648	3.3	3.68	2.66	3.78	3.72	3.46	3.21	3.43	3.64	3.30	2.90	2.60
649	2.3	2.9	2.11	3.05	3.04	2.77	2.51	3.09	2.93	2.62	2.27	2.29
650	2.55	3.14	2.4	3.32	3.31	3.1	2.89	2.38	3.22	2.96	2.64	1.76
651	3.45	3.95	2.9	4.07	3.98	3.76	3.54	2.79	xxx	3.61	3.23	2.25
652	3.26	3.81	2.75	3.84	3.73	3.5	3.28	3.44	xxx	3.38	3.04	2.68
653	2.43	3.02	2.24	3.1	3.05	2.85	2.64	3.18	xxx	2.74	2.45	2.47
654	2.86	3.41	2.6	3.62	3.53	3.29	3.08	2.55	3.46	3.20	2.88	1.99
655	3.36	3.84	2.9	4.04	3.91	3.66	3.46	2.98	3.85	3.57	3.21	2.40
656	3.33	3.73	2.8	3.86	3.79	3.58	3.36	3.40	3.73	3.46	3.12	2.65
657	3.35	4.29	2.79	3.9	3.81	3.57	3.31	3.25	3.75	3.46	3.09	2.60
658	3	3.37	2.58	3.64	3.56	3.31	3.05	3.19	3.51	3.23	2.86	2.54
659	3.67	4.39	2.95	4.14	4.06	3.83	3.58	2.93	4	3.70	3.32	2.30
660	3.66	3.93	2.76	3.98	3.87	3.6	3.31	3.46	3.82	3.45	3.03	2.70
661	3.89	4.29	xxx	4.26	4.13	3.85	3.54	3.17	4.07	3.67	3.23	2.35
662	3.14	3.27	xxx	3.1	3.01	2.74	2.47	3.39	xxx	2.59	2.18	2.51
663	3.24	3.22	xxx	3.1	3.06	2.76	2.47	2.32	xxx	2.65	2.23	1.54
664	4.49	4.76	3.1	4.82	4.79	xxx	xxx	2.30	xxx	xxx	3.75	xxx
665	4.12	4.36	2.9	4.5	4.38	4.07	3.74	3.90	4.28	3.90	3.40	xxx
666	3.74	4.01	2.67	4.11	4	3.62	3.29	3.60	3.91	3.53	3.02	2.59
667	4.44	4.65	2.96	4.64	4.59	4.2	3.86	3.12	4.46	4.03	3.48	2.23
668	3.83	4.81	2.86	4.78	4.67	4.18	3.72	3.65	4.52	3.97	3.31	2.58
669	4.51	5.38	3.13	5.32	5.17	4.62	4.1	3.40	5.01	4.40	3.66	2.22
670	5.07	4.94	2.66	4.93	4.72	4.1	3.54	3.74	4.59	3.94	3.17	2.46
671	4.57	4.57	2.58	4.63	4.48	3.92	3.41	3.13	4.35	3.77	3.07	1.87
672	5.16	5.2	2.82	5.06	4.93	4.29	3.73	3.03	4.75	4.11	3.34	1.85
673	5.68	5.61	2.98	5.42	5.27	4.57	3.96	3.32	5.08	4.37	3.54	2.04
674	5.72	5.35	2.81	5.39	5.16	4.42	3.77	3.51	4.96	4.24	3.39	2.16
675	4.97	4.74	2.57	4.87	4.65	3.99	3.42	3.28	4.47	3.84	3.08	1.96
676	5.31	5.13	2.94	5.2	5.05	4.43	3.87	2.98	4.87	4.25	3.50	1.78
677	6.22	5.85	3.19	5.81	5.62	4.9	4.26	3.46	5.42	4.68	3.83	2.24
678	6.08	5.62	2.93	5.62	5.36	4.58	3.87	3.80	5.17	4.42	3.53	2.41
679	4.99	4.75	2.58	4.87	4.65	3.98	3.37	3.35	4.48	3.86	3.08	2.04

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
680	5.36	5.1	3.06	5.19	5.04	4.47	3.93	2.91	4.89	4.31	3.60	1.78
681	6.78	6.24	3.49	6.2	5.95	5.23	4.54	3.57	5.79	5.03	4.16	2.43
682	6.38	5.73	2.91	5.68	5.36	4.52	3.77	4.10	5.2	4.39	3.46	2.74
683	5.04	4.73	2.53	4.78	4.58	3.88	3.25	3.23	4.42	3.78	3.00	1.92
684	5.63	5.45	3.22	5.62	5.47	4.79	4.23	2.78	5.29	4.64	3.87	1.68
685	6.97	6.21	3.46	6.25	6	5.19	4.54	3.80	5.81	5.02	4.14	2.54
686	6.17	5.72	2.98	5.56	5.32	4.53	3.89	4.06	5.14	4.39	3.53	2.66
687	4.81	4.82	2.66	4.78	4.63	3.96	3.41	3.41	4.47	3.85	3.11	2.14
688	4.78	4.73	2.9	4.83	4.71	4.19	3.74	3.00	4.57	4.02	3.39	1.90
689	6.23	5.96	3.36	5.92	5.68	4.99	4.4	3.42	5.52	4.80	3.99	2.32
690	5.67	5.44	2.75	5.34	5.05	4.27	3.59	3.97	4.91	4.15	3.27	2.66
691	4.35	4.36	2.4	4.41	4.22	3.61	3.07	3.10	4.12	3.54	2.83	1.83
692	4.65	4.68	2.78	4.78	4.61	4.07	3.61	2.68	4.48	3.93	3.26	1.62
693	5.76	5.51	3.1	5.51	5.28	4.64	4.07	3.27	5.13	4.45	3.66	2.11
694	5.44	5.12	2.65	5.12	4.86	4.17	3.52	3.66	4.73	4.02	3.18	2.32
695	4	4.07	2.25	4.17	4	3.43	2.91	3.07	3.9	3.35	2.66	1.80
696	4.19	4.32	2.64	4.41	4.29	3.85	3.43	2.55	4.17	3.68	3.07	1.51
697	5.21	5.21	2.96	5.32	5.1	4.53	4	3.17	4.97	4.32	3.55	2.07
698	4.71	4.46	2.46	4.56	4.34	xxx	3.22	3.65	xxx	xxx	2.89	2.33
699	2.55	2.53	xxx	2.64	2.56	xxx	xxx	xxx	xxx	xxx	xxx	xxx
700	4.38	4.21	xxx	4.69	4.47	xxx	3.94	xxx	xxx	4.23	3.82	xxx
701	4.94	4.66	xxx	5.15	4.82	xxx	4.23	3.73	4.79	4.46	3.96	3.00
702	4.25	4.44	xxx	4.54	4.82	xxx	3.65	4.06	4.34	3.89	3.40	3.08
703	3.92	4.21	2.96	4.33	4.27	xxx	3.52	3.47	4.17	3.75	3.28	2.64
704	3.37	3.74	2.73	3.92	3.85	3.51	3.21	3.32	3.76	3.40	2.98	2.52
705	4	4.49	3.11	4.57	4.47	4.13	3.82	3.04	4.3	3.97	3.51	2.34
706	4.06	4.49	2.98	4.52	4.42	4.01	3.65	3.65	4.34	3.85	3.33	2.76
707	3.54	3.92	2.73	4.06	3.98	3.58	3.24	3.44	3.88	3.48	3.00	2.47
708	3.62	4.04	2.9	4.25	4.12	3.77	3.46	3.05	4.03	3.65	3.20	2.24
709	3.67	4.03	xxx	4.22	4.08	3.73	3.41	3.30	4.01	3.62	3.16	2.49
710	4.21	4.55	xxx	4.71	4.6	xxx	3.9	3.25	4.52	4.12	3.66	2.44
711	3.48	3.76	2.7	3.91	4.3	xxx	3.17	3.73	3.7	3.36	2.95	2.88
712	3.09	3.56	2.7	3.82	xxx	xxx	3.26	2.99	3.64	3.38	3.07	2.29
713	3.7	4.08	3	4.33	xxx	xxx	3.67	3.16	4.15	3.82	3.46	2.61
714	3.88	4.19	3.1	4.33	4.24	xxx	3.59	3.55	4.17	3.81	3.41	2.83
715	4	4.32	3.3	4.44	4.37	xxx	3.73	3.41	4.29	3.94	3.54	2.71
716	3.68	4.09	3.1	4.26	4.15	xxx	3.57	3.56	4.1	3.77	3.38	2.86
717	3.37	3.77	2.8	3.95	3.88	xxx	3.3	3.42	3.82	3.50	3.12	2.73
718	3.46	3.76	2.8	4	3.94	xxx	3.31	3.14	3.87	3.52	3.11	2.52
719	4.15	4.23	3.2	4.46	4.36	xxx	3.72	3.14	4.3	3.93	3.50	2.48

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
720	3.59	3.78	2.8	3.98	3.89	3.59	3.32	3.57	3.85	3.52	3.15	2.77
721	4.05	4.16	3	4.32	4.23	3.94	3.66	3.21	4.17	3.84	3.44	2.48
722	4.22	4.07	2.8	4.18	4.05	3.69	3.35	3.54	3.99	3.59	3.12	2.75
723	4.32	4.36	3	4.46	4.32	3.95	3.62	3.16	4.28	3.84	3.36	2.30
724	4.12	4.2	2.7	4.27	4.11	3.73	3.38	3.42	4.08	3.62	3.09	2.54
725	3.49	3.75	2.5	3.89	3.75	3.39	3.05	3.18	3.71	3.31	2.82	2.27
726	3.8	4.06	2.7	4.19	4.06	3.68	3.32	2.87	3.99	3.57	3.06	2.08
727	4.32	4.39	2.8	4.44	4.3	3.91	3.54	3.11	4.24	3.78	3.24	2.25
728	4.32	4.58	3	4.69	4.55	4.14	3.77	3.32	4.47	4.02	3.47	2.39
729	3.61	4.05	2.8	4.26	4.13	3.74	3.37	3.56	4.04	3.63	3.11	2.57
730	3.57	3.92	2.8	4.06	3.98	3.63	3.29	3.17	3.91	3.53	3.06	2.27
731	4.48	4.66	3.1	4.71	4.6	4.23	3.89	3.11	4.53	4.09	3.56	2.35
732	4.12	4.29	2.7	4.39	4.21	3.8	3.41	3.68	4.15	3.66	3.09	2.75
733	3.45	3.81	2.5	3.98	3.84	3.45	3.08	3.15	3.77	3.34	2.83	2.16
734	3.54	3.87	2.6	3.99	3.89	3.56	3.22	2.85	3.81	3.41	2.93	2.00
735	4.57	4.66	3	4.68	4.54	4.18	3.79	3.02	xxx	3.98	3.42	2.16
736	4.44	4.43	2.7	4.45	4.27	3.81	3.35	3.55	xxx	3.66	3.00	2.50
737	3.61	3.87	2.4	3.93	3.78	3.34	2.92	3.04	3.71	3.24	2.66	1.94
738	3.54	3.88	2.5	3.94	3.84	3.48	3.13	2.66	3.77	3.34	2.83	1.71
739	4.46	4.54	2.9	4.57	4.45	4.05	3.65	2.92	4.38	3.86	3.27	2.02
740	4.49	4.51	2.7	4.56	4.37	3.85	3.37	3.46	4.31	3.72	3.02	2.34
741	3.38	3.66	2.3	3.79	3.67	3.19	2.77	3.02	3.59	3.12	2.52	1.88
742	3.27	3.75	2.5	3.9	3.81	3.46	3.15	2.48	3.71	3.33	2.85	1.54
743	4.71	5.03	3	5.09	4.91	4.43	3.98	2.95	4.75	4.23	3.58	2.06
744	4	3.85	xxx	3.71	3.52	2.93	2.44	3.67	3.45	2.87	2.20	2.51
745	3.58	3.51	xxx	3.41	3.26	2.76	2.36	2.09	3.03	2.77	2.20	1.09
746	4.24	4.33	2.4	4.34	4.18	3.67	3.17	2.06	4.06	3.53	2.85	1.25
747	3.78	3.95	2.2	3.91	3.76	3.28	2.84	2.82	3.66	3.16	2.53	1.63
748	4.34	4.48	2.4	4.48	4.33	3.81	3.33	2.51	4.21	3.66	2.95	1.44
749	3.08	3.45	2	3.57	3.47	3	2.58	2.94	3.34	2.88	2.30	1.75
750	3.24	3.82	2.5	3.93	3.86	3.49	3.13	2.22	3.77	3.39	2.93	1.27
751	4.36	4.57	2.8	4.66	4.55	4.17	3.77	2.84	4.43	3.95	3.38	2.12
752	4	4.13	2.5	4.25	4.1	3.59	3.09	3.47	3.97	3.48	2.87	2.41
753	3.1	3.53	2.2	3.67	3.58	3.11	2.63	2.68	3.46	3.02	2.47	1.86
754	3.07	3.57	2.4	3.76	3.68	3.22	2.78	2.24	3.6	3.20	2.72	1.58
755	4.27	4.26	2.7	4.37	4.27	3.78	3.32	2.41	4.16	3.70	3.14	1.95
756	3.86	4.09	2.4	4.21	4.08	3.51	2.98	2.91	3.96	3.47	2.86	2.23
757	3.77	4.16	2.5	4.28	4.15	3.57	3.05	2.49	4.04	3.58	2.99	1.87
758	3.12	3.1	1.4	3.23	3.07	2.52	2.02	2.57	2.94	2.50	1.92	2.04
759	3.52	3.59	1.7	3.71	3.55	2.95	2.43	1.55	3.43	2.96	2.34	xxx

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
760	4.23	4.39	1.9	4.39	4.22	3.43	2.74	1.94	4.06	3.46	2.67	xxx
761	2.61	3.08	1.4	3.18	3.02	2.34	1.75	2.13	2.9	2.43	1.83	xxx
762	3.24	3.75	2.1	3.9	3.75	3.14	2.55	1.26	3.68	3.23	2.67	xxx
763	3.96	4.29	2.3	4.44	4.27	3.61	2.95	2.06	4.17	3.64	2.98	1.64
764	3.59	4.01	2	4.13	3.98	3.34	2.68	2.37	3.88	3.39	2.75	1.79
765	3.25	3.85	1.9	3.92	3.81	3.16	2.5	2.09	3.7	3.23	2.61	1.63
766	3.29	3.81	1.9	3.92	3.8	3.14	2.51	1.92	3.71	3.24	2.67	1.52
767	3.67	4.09	2.1	4.22	4.08	3.43	2.79	1.92	3.98	3.48	2.87	1.62
768	3.63	4.06	1.9	4.17	4.02	3.31	2.63	2.18	3.92	3.42	2.79	1.75
769	3.85	4.32	2	4.45	4.3	3.58	2.89	1.98	4.16	3.64	2.98	1.65
770	3.75	4.12	1.8	4.22	4.07	3.28	2.53	2.24	3.91	3.36	2.65	1.79
771	3.21	3.5	1.6	3.61	3.4	xxx	xxx	1.83	3.31	xxx	2.27	1.39
772	4.37	4.66	2.5	4.76	4.52	xxx	xxx	xxx	4.44	xxx	3.23	1.23
773	4.68	5.01	2.5	5.13	4.92	4.01	3.11	xxx	4.78	4.16	3.41	2.00
774	3.65	4.03	2.1	4.21	4.01	3.25	2.5	2.33	3.89	3.36	2.72	2.02
775	3.45	4.01	2.1	4.17	3.98	3.22	2.48	1.83	3.87	3.37	2.74	1.59
776	4.53	4.79	2.6	4.93	4.7	3.77	2.91	1.82	4.57	3.97	3.21	1.65
777	5.04	5.1	2.7	5.2	4.98	4.03	3.16	2.14	4.82	4.17	3.37	1.87
778	4.73	4.95	2.7	5.09	4.86	3.94	3.04	2.36	4.71	4.06	3.28	1.94
779	4.01	4.4	2.4	4.57	4.34	3.47	2.61	2.23	4.23	3.66	2.96	1.83
780	4.3	4.63	2.7	4.76	4.56	3.7	2.91	1.88	4.46	3.92	3.26	1.65
781	4.99	5.12	2.9	5.21	4.99	4.09	3.25	2.22	4.86	4.25	3.50	2.01
782	5	5.11	2.8	5.18	4.97	4	3.1	2.49	4.81	4.16	3.35	2.15
783	4.23	4.52	2.5	4.65	4.47	3.53	2.69	2.30	4.33	3.75	3.03	1.91
784	4.96	4.88	3.1	5.24	5.04	4.08	3.21	1.95	4.92	4.36	3.65	1.69
785	6.25	5.79	3.4	6.06	5.82	4.8	3.87	2.46	5.64	4.94	4.10	2.33
786	5.38	5.35	3	5.42	5.13	4.17	3.24	3.05	4.97	4.27	3.44	2.58
787	4.6	4.86	2.8	5.01	4.74	3.83	2.91	2.44	4.62	4.01	3.24	1.98
788	5.06	5.17	3	5.27	5.03	4.13	3.24	2.12	4.9	4.27	3.48	1.87
789	6.05	5.88	3.3	5.87	5.62	4.64	3.72	2.46	5.47	4.73	3.84	2.09
790	6.1	5.76	3.1	5.77	5.46	4.45	3.48	2.92	5.3	4.52	3.59	2.31
791	4.9	4.84	2.8	4.96	4.67	3.74	2.82	2.66	4.55	3.91	3.12	1.99
792	5.33	5.09	3.3	5.46	5.24	4.37	3.52	2.05	5.1	4.49	3.73	1.71
793	6.67	6.09	3.6	6.34	6.07	5.11	4.18	2.83	5.89	5.12	4.19	2.36
794	6.22	5.87	3.1	5.89	5.55	4.56	3.6	3.43	5.39	4.59	3.60	2.60
795	5.22	5.15	2.9	5.24	4.96	4.04	3.13	2.82	4.83	4.14	3.27	2.00
796	5.29	5.24	3.1	5.29	5.08	4.29	3.52	2.38	4.93	4.29	3.51	1.82
797	6.47	6.16	3.5	6.18	5.85	4.94	4.08	2.88	5.7	4.93	4.00	2.14
798	6.35	5.82	3	5.9	5.54	4.55	3.66	3.39	5.37	4.52	3.49	2.43
799	4.86	4.66	2.5	4.8	4.55	3.68	2.89	2.94	4.39	3.72	2.90	1.83

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
800	5.12	5.13	3.1	5.31	5.15	4.46	3.84	2.23	4.99	4.39	3.67	1.51
801	6.16	5.71	3.3	5.8	5.57	4.82	4.14	3.31	5.41	4.70	3.85	2.36
802	5.79	5.47	3	5.54	5.28	4.56	3.85	3.59	5.13	4.43	3.59	2.40
803	4.41	4.56	2.7	4.73	4.53	3.89	3.26	3.31	4.4	3.81	3.08	2.18
804	4.49	4.81	3.1	4.98	4.87	4.26	3.86	2.77	4.74	4.26	3.63	1.83
805	5.72	5.64	3.4	5.74	5.55	4.85	4.38	3.47	5.39	4.79	4.05	2.57
806	5.35	5.28	3.1	5.4	5.16	4.48	3.86	3.94	5.01	4.35	3.57	2.81
807	4.07	4.4	2.7	4.6	4.43	3.83	3.28	3.37	4.3	3.75	3.08	2.28
808	4.04	4.51	3	4.67	4.57	4.11	3.68	2.84	4.44	3.98	3.43	1.96
809	5.31	5.4	3.3	5.51	5.33	4.78	4.26	3.36	5.19	4.60	3.93	2.50
810	4.92	4.98	2.9	5.11	4.9	4.27	3.69	3.90	4.76	4.13	3.40	2.80
811	3.75	4.14	2.6	4.32	4.18	3.63	3.13	3.27	4.06	3.55	2.93	2.22
812	3.95	4.32	2.9	4.52	4.4	3.96	3.53	2.74	4.28	3.82	3.26	1.93
813	4.67	4.79	3.1	4.95	4.79	4.31	3.84	3.21	4.67	4.14	3.51	2.36
814	4.45	4.68	3	4.79	4.63	4.13	3.64	3.52	4.52	3.99	3.36	2.51
815	3.78	4.19	2.8	4.32	4.2	3.73	3.27	3.31	4.1	3.62	3.05	2.36
816	3.73	4.14	2.9	4.3	4.19	3.77	3.41	2.96	4.1	3.66	3.16	2.15
817	3.87	4.24	2.9	4.41	4.3	3.86	3.48	3.15	4.19	3.74	3.20	2.37
818	3.88	4.35	2.9	4.45	4.34	3.9	3.53	3.21	4.21	3.78	3.26	2.36
819	3.87	4.38	2.9	4.5	4.38	3.94	3.58	3.28	4.25	3.81	3.30	2.49
820	3.59	3.96	2.7	4.11	3.99	3.6	3.25	3.33	3.85	3.45	2.96	2.52
821	2.53	3.16	2.2	3.24	3.15	2.81	2.64	3.03	3.01	2.72	xxx	2.19
822	3.46	4.12	3.1	4.34	4.23	xxx	3.7	2.30	4.19	3.88	xxx	1.71
823	4.17	4.58	3.3	4.86	4.71	xxx	4.05	3.52	4.65	4.26	3.78	2.90
824	3.42	3.68	2.6	3.91	3.78	3.45	3.13	3.86	3.69	3.32	2.90	3.03
825	3.09	3.35	xxx	3.6	3.51	3.19	2.91	2.96	3.42	3.10	2.74	2.29
826	3.28	3.77	xxx	3.99	3.93	xxx	3.39	2.74	3.85	3.54	3.19	2.20
827	3.6	4.11	xxx	4.31	4.21	xxx	3.63	3.23	4.14	3.80	3.40	2.63
828	3.33	3.83	xxx	4.09	3.94	3.59	3.29	3.47	3.85	3.49	3.07	2.76
829	2.64	3.33	xxx	3.54	3.45	3.12	2.84	3.12	3.36	3.03	2.67	2.42
830	3.12	3.82	xxx	3.97	3.94	xxx	3.36	2.68	3.87	3.54	3.17	2.09
831	3.97	4.41	xxx	4.6	4.52	xxx	3.9	3.21	4.44	4.09	3.65	2.58
832	3.41	3.8	xxx	3.99	3.87	3.56	3.25	3.75	3.78	3.44	3.01	2.97
833	2.5	3.14	xxx	3.31	3.24	2.95	2.71	3.09	3.17	2.88	2.52	2.38
834	3.08	3.67	xxx	3.85	3.81	3.45	3.26	2.53	3.74	3.43	3.04	2.02
835	3.99	4.34	xxx	4.52	4.43	4.06	3.82	3.09	4.34	4.00	3.56	2.48
836	3.56	3.94	xxx	4.05	3.97	3.66	3.37	3.66	3.88	3.56	3.15	2.86
837	2.91	3.44	xxx	3.59	3.54	3.24	2.96	3.21	3.44	3.16	2.79	2.46
838	3.45	3.88	xxx	4.1	4.02	3.64	3.38	2.80	3.93	3.59	3.17	2.18
839	4.25	4.48	xxx	4.64	4.53	4.15	3.87	3.21	4.45	4.08	3.61	2.52

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
840	3.85	4.14	xxx	4.17	4.11	3.79	3.45	3.70	4.02	3.68	3.23	2.86
841	3.08	3.6	xxx	3.71	3.67	3.34	3.03	3.31	3.53	3.25	2.83	2.52
842	3.55	3.98	xxx	4.12	4.06	3.69	3.39	2.85	4.14	3.61	3.19	2.19
843	4.44	4.71	xxx	4.82	4.71	4.34	4.02	3.22	4.14	4.22	3.74	2.53
844	4.25	4.38	xxx	4.41	4.24	3.92	3.55	3.85	5.33	3.77	3.27	2.97
845	3.39	3.68	xxx	3.75	3.68	3.32	2.97	3.33	3.49	3.20	2.76	2.44
846	3.54	3.95	xxx	4.15	4.11	3.74	3.48	2.74	3.97	3.66	3.26	2.03
847	4.36	4.3	xxx	4.36	4.27	3.88	3.6	3.29	4.14	3.78	3.36	2.60
848	4.17	4.27	xxx	4.38	4.28	3.87	3.6	3.42	4.16	3.81	3.39	2.66
849	3.76	4.17	xxx	4.39	4.29	3.88	3.6	3.41	4.18	3.83	3.37	2.70
850	3.95	4.33	xxx	4.57	4.48	3.92	3.75	3.40	4.37	4.01	3.55	2.65
851	4.66	4.81	xxx	4.95	4.84	4.27	4.08	3.54	4.74	4.32	3.84	2.80
852	4.12	4.34	xxx	4.45	4.31	3.92	3.55	3.89	4.23	3.81	3.33	3.04
853	3.54	3.92	xxx	4.11	4.02	3.64	3.29	3.36	3.94	3.56	3.10	2.57
854	3.75	4.13	xxx	4.25	4.21	3.86	3.52	3.09	4.12	3.77	3.32	2.38
855	4.67	4.89	xxx	4.93	4.85	4.5	4.15	3.33	4.76	4.36	3.86	2.63
856	4.58	4.71	xxx	4.78	4.62	4.17	3.74	3.95	4.53	4.03	3.45	3.07
857	3.78	4.13	xxx	4.23	4.09	3.66	3.24	3.47	4	3.56	3.04	2.56
858	4.02	4.39	xxx	4.53	4.42	4.03	3.66	2.99	4.32	3.92	3.44	2.23
859	5.04	5.11	xxx	5.22	5.06	4.64	4.24	3.45	4.97	4.48	3.93	2.67
860	4.88	4.94	xxx	5.05	4.87	4.35	3.88	4.01	4.79	4.22	3.57	3.04
861	3.55	3.72	xxx	3.87	3.77	3.3	2.92	3.56	3.66	3.24	2.73	2.56
862	3.61	3.58	xxx	4.15	4.1	xxx	3.55	2.62	4	3.72	3.35	1.97
863	5.07	4.52	xxx	4.95	4.82	xxx	4.12	3.39	4.74	4.33	3.84	2.76
864	4.7	4.24	xxx	4.58	4.42	4.03	3.64	3.94	4.35	3.91	3.42	3.02
865	3.47	3.46	xxx	3.96	3.87	3.51	3.2	3.43	3.79	3.46	3.06	2.61
866	3.84	3.56	xxx	4.22	4.16	3.82	3.52	3.01	4.06	3.73	3.32	2.40
867	4.76	4.41	xxx	4.99	4.88	4.52	4.16	3.34	4.8	4.37	3.87	2.65
868	4.49	4.26	xxx	4.58	4.43	4.02	3.61	3.96	4.39	3.91	3.37	3.04
869	3.73	3.76	xxx	4.17	4.06	3.68	3.31	3.36	4.01	3.60	3.14	2.46
870	3.93	3.76	xxx	4.17	4.09	3.74	3.4	3.09	4.04	3.64	3.17	2.35
871	4.17	4.05	xxx	4.45	4.34	3.97	3.61	3.21	3.93	3.87	3.35	2.42
872	4.48	4.16	xxx	4.76	4.6	4.21	3.81	3.39	4.61	4.08	3.53	2.53
873	3.59	3.36	xxx	3.98	3.89	3.51	3.14	3.59	3.81	3.42	2.94	2.66
874	3.78	3.43	xxx	4.14	4.13	3.73	3.48	2.93	4.03	3.71	3.28	2.19
875	4.48	3.94	xxx	4.62	4.55	4.14	3.84	3.31	4.46	4.09	3.59	2.61
876	3.93	3.88	2.94	4.28	4.19	3.85	3.49	3.68	4.14	3.76	3.28	2.83
877	3.74	3.72	2.87	4.16	4.06	3.73	3.4	3.33	4.03	3.66	3.21	2.58
878	3.97	4.24	3	4.44	4.29	3.93	3.58	3.23	4.24	3.86	3.38	2.55
879	4.19	4.45	3.1	4.59	4.46	4.08	3.73	3.38	4.37	3.99	3.50	2.62

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
880	3.75	4.04	2.82	4.13	4.04	3.7	3.38	3.55	3.96	3.60	3.17	2.71
881	4.24	4.56	3.08	4.64	4.51	4.17	3.82	3.22	4.43	4.03	3.55	2.48
882	4.47	4.76	3.12	4.92	4.75	4.35	3.95	3.62	4.66	4.21	3.66	2.76
883	3.59	3.88	2.66	4.03	3.94	3.54	3.18	3.70	3.82	3.46	2.99	2.72
884	3.75	3.5	2.93	4.16	4.12	3.79	3.48	2.94	4	3.69	3.28	2.22
885	4.37	4.04	3.24	4.71	4.62	4.29	3.96	3.30	4.53	4.15	3.69	2.63
886	4.26	4.06	3.03	4.64	4.49	4.08	3.71	3.78	4.4	3.96	3.44	2.94
887	3.9	3.76	2.87	4.36	4.23	3.82	3.44	3.49	4.14	3.73	3.22	2.60
888	4.03	3.84	3.1	4.47	4.38	4.04	3.71	3.22	4.3	3.95	3.51	2.42
889	4.72	4.39	3.36	5	4.85	4.51	4.15	3.52	4.79	4.36	3.88	2.82
890	4.29	4.23	2.95	4.61	4.36	3.98	3.59	3.96	4.33	3.87	3.35	3.08
891	3.54	3.68	2.71	4.14	3.96	3.58	3.21	3.37	3.9	3.51	3.04	2.51
892	4.11	3.85	3.07	4.59	4.48	4.08	3.69	3.00	4.38	3.97	3.49	2.32
893	5.48	4.96	3.57	5.59	5.41	4.94	4.49	3.48	5.31	4.78	4.18	2.72
894	4.95	4.63	2.77	4.53	4.38	3.89	xxx	4.22	4.29	3.75	3.14	3.19
895	3.13	3.29	2.26	3.32	3.24	2.86	xxx	3.11	2.99	xxx	2.40	2.09
896	4.46	3.74	3.29	4.97	4.67	xxx	4.06	2.30	4.63	xxx	3.82	1.69
897	xxx	4.47	3.53	5.59	5.22	xxx	4.46	3.82	5.21	4.74	4.11	3.02
898	4.8	4.29	3.21	4.94	4.76	4.31	3.9	4.19	4.68	4.20	3.65	3.09
899	4.16	3.88	3.03	4.6	4.46	4.02	3.64	3.66	4.36	3.94	3.43	2.77
900	4.85	4.03	3.36	5.12	4.91	xxx	4.1	3.42	4.86	4.44	3.86	2.61
901	5.93	4.77	3.66	5.73	5.47	xxx	4.58	3.85	5.43	4.91	4.27	2.95
902	5.33	4.58	3.2	5.16	4.95	4.42	3.93	4.28	xxx	4.29	3.66	3.24
903	4.4	4.01	2.98	4.69	4.54	4.04	3.59	3.63	xxx	3.95	3.38	2.64
904	5.05	4.16	3.36	5.14	5.02	xxx	4.08	3.33	xxx	4.42	3.84	2.46
905	xxx	5.06	3.74	5.95	5.77	xxx	4.69	3.80	xxx	5.04	4.36	2.90
906	5.9	4.93	3.26	5.49	5.25	4.6	4.01	4.35	xxx	4.48	3.73	3.25
907	4.82	4.08	2.94	4.75	4.57	4.01	3.49	3.62	xxx	3.93	3.28	2.55
908	5.19	4.96	3.37	5.23	5.09	xxx	4.13	3.17	xxx	4.47	3.87	2.28
909	6.17	5.74	3.67	5.93	5.75	xxx	4.64	3.85	xxx	5.00	4.30	2.91
910	6.03	5.57	3.27	5.52	5.32	4.65	4.05	4.29	xxx	4.53	3.76	3.17
911	4.78	4.61	2.87	4.67	4.51	3.93	3.4	3.66	xxx	3.87	3.21	2.57
912	5.18	4.8	3.49	5.34	5	xxx	4.3	3.08	xxx	4.65	4.06	2.20
913	6.06	5.34	3.66	5.74	5.34	xxx	4.54	4.04	xxx	4.91	4.25	3.12
914	5.4	5.18	3.33	5.21	5.01	4.49	4	4.26	xxx	4.37	3.74	3.21
915	4.75	4.83	3.2	4.97	4.81	4.32	3.85	3.71	xxx	4.21	3.61	2.75
916	4.94	4.95	3.28	5.02	4.88	4.38	3.96	3.55	xxx	4.29	3.70	2.67
917	5.26	5.25	3.41	5.24	5.09	4.58	4.15	3.70	xxx	4.49	3.88	2.78
918	5.26	5.07	3.28	5.16	4.97	4.46	4	3.89	xxx	4.34	3.70	2.94
919	4.57	4.53	3.04	4.64	4.49	3.98	3.53	3.72	xxx	3.90	3.32	2.72

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
920	4.3	4.62	3.31	4.93	4.84	xxx	4.02	3.27	xxx	4.32	3.80	2.44
921	5.48	5.06	3.5	5.32	5.17	xxx	4.34	3.80	xxx	4.61	4.05	2.99
922	4.92	4.6	3.05	4.69	4.51	4.09	3.69	4.11	xxx	3.98	3.44	3.13
923	4.7	4.81	3.18	4.89	4.71	4.28	3.88	3.46	xxx	4.19	3.64	2.58
924	4.55	4.58	2.75	4.7	4.48	4.01	3.57	3.63	xxx	3.90	3.30	2.77
925	4.3	4.32	2.76	4.48	4.33	3.89	3.5	3.29	xxx	3.82	3.25	2.33
926	4.66	4.16	2.71	4.65	4.51	4.05	3.64	3.24	xxx	3.96	3.35	2.36
927	4.48	3.94	2.66	4.43	4.28	3.82	3.43	3.36	xxx	3.74	3.18	2.36
928	3.66	3.7	2.34	3.81	3.69	3.38	3.11	3.17	xxx	3.28	2.87	2.26
929	3.56	3.86	2.42	4.01	3.86	3.56	3.27	2.94	xxx	3.45	3.01	2.17
930	3.99	4.17	2.49	4.27	4.13	xxx	3.36	3.10	4.08	3.65	3.10	2.26
931	3.43	3.71	2.31	3.83	3.72	xxx	3.01	3.15	3.67	xxx	2.79	2.21
932	3.54	3.89	2.48	4.02	3.92	3.6	3.31	2.81	3.84	xxx	3.08	2.01
933	2.76	3.14	1.97	3.24	3.19	2.86	2.58	3.14	3.08	2.77	2.40	2.37
934	3.26	3.69	2.48	3.72	3.69	3.34	3.2	2.40	3.6	3.34	3.00	1.80
935	3.71	4.17	2.78	4.26	4.18	3.83	3.66	3.05	4.11	3.82	3.41	2.48
936	3.24	3.67	2.53	3.87	3.76	3.46	3.16	xxx	3.7	3.39	2.97	2.75
937	2.74	3.42	2.34	3.62	3.55	3.26	2.97	xxx	3.49	3.19	2.80	2.31
938	2.78	3.49	2.54	3.64	3.61	3.39	3.15	xxx	3.55	3.29	2.94	2.20
939	3.48	3.94	2.74	4.09	4.01	3.77	3.5	3.01	3.94	3.67	3.27	2.43
940	3.26	3.58	2.5	3.7	3.63	3.38	3.1	3.37	3.57	3.30	2.92	2.66
941	2.41	2.95	2.08	3.06	3.05	2.82	2.59	2.97	2.99	2.75	2.45	2.28
942	2.76	3.39	2.52	3.56	3.54	3.31	3.1	2.47	3.47	3.24	2.93	1.95
943	3.53	3.82	2.72	3.91	3.86	3.59	3.33	2.99	3.79	3.49	3.12	2.44
944	2.69	3.1	2.26	3.21	3.16	2.9	2.68	3.20	3.12	xxx	2.54	2.56
945	2.41	2.93	2.19	3.11	3.1	2.86	2.66	2.61	3.04	xxx	2.53	2.13
946	2.86	3.39	2.51	3.54	3.54	3.29	3.04	2.58	3.46	3.20	2.86	2.11
947	3.44	3.78	2.78	3.95	3.87	3.63	3.4	2.89	3.81	3.54	3.18	2.33
948	3.09	3.5	2.59	3.71	3.61	3.37	3.18	3.28	3.6	3.31	2.99	2.61
949	2.29	2.81	2.08	2.98	2.97	2.75	2.56	3.08	2.9	2.68	2.40	2.45
950	2.68	2.9	2.39	3.36	3.36	3.12	2.89	2.45	3.2	3.03	2.70	1.94
951	3.89	3.88	3	4.32	4.23	3.96	3.68	xxx	4.1	3.84	3.43	2.21
952	3.54	3.84	2.65	4	3.9	3.57	3.24	xxx	3.9	3.51	3.05	2.80
953	2.49	3.2	2.32	3.4	3.37	3.05	2.78	3.08	3.4	3.01	2.64	2.37
954	3	3.17	2.47	3.55	3.49	3.19	2.93	2.62	3.4	3.10	2.77	2.07
955	4.33	4.44	3.16	4.77	4.63	4.32	3.97	2.77	4.5	4.17	3.69	2.22
956	4.71	4.48	2.98	4.94	4.75	4.28	3.77	3.78	4.7	4.17	3.51	2.93
957	2.81	3.01	2.21	3.56	3.45	3.02	2.62	3.46	3.4	3.00	2.49	2.44
958	3.65	3.2	3.07	4.42	4.26	xxx	3.74	2.34	4.2	3.99	3.58	1.64
959	4.62	3.82	3.36	5.01	4.79	xxx	4.18	3.53	4.8	4.45	3.96	2.86

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
960	4.13	3.73	3.06	4.59	4.45	4.06	3.69	3.98	4.4	4.01	3.53	3.13
961	3.42	3.3	2.77	4.16	4.07	3.7	3.37	3.48	4	3.63	3.18	2.75
962	3.65	3.34	2.99	4.37	4.31	xxx	3.6	3.15	4.3	3.88	3.43	2.48
963	4.88	4.02	3.42	4.99	4.89	xxx	4.17	3.38	4.8	4.42	3.92	2.72
964	4.48	3.96	3.06	4.67	4.52	4.07	xxx	3.94	4.4	4.04	3.51	3.11
965	4.05	3.68	2.91	4.44	4.34	3.91	xxx	3.35	4.2	3.85	3.33	2.69
966	3.87	3.62	2.87	4.26	4.18	3.72	xxx	3.24	4.1	3.72	3.22	2.55
967	4.52	4.38	3.28	5.01	4.91	4.44	xxx	2.98	4.8	4.37	3.83	2.47
968	4.77	4.37	2.99	4.77	4.62	4.01	xxx	xxx	4.5	3.99	3.37	2.93
969	4.16	3.96	2.8	4.48	4.36	3.77	xxx	xxx	4.2	3.75	3.17	2.33
970	4.42	3.96	2.85	4.6	4.5	3.89	xxx	2.72	4.5	3.89	3.30	2.23
971	4.65	3.99	2.86	4.49	4.37	3.75	xxx	2.77	4.3	3.79	3.19	2.36
972	4.87	4.05	3.1	4.82	4.69	4.08	3.48	2.60	4.6	4.11	3.50	2.29
973	3.72	3.23	2.64	4.07	3.96	3.36	2.8	2.96	3.9	3.42	2.87	2.57
974	4.49	3.4	3.43	5.07	4.47	xxx	xxx	2.31	4.5	4.41	3.91	2.09
975	xxx	3.59	3.46	5.22	4.61	xxx	xxx	3.49	4.6	4.52	4.02	3.19
976	4.47	3.57	3.23	4.71	4.56	xxx	3.67	3.62	4.5	4.10	3.63	3.18
977	4.39	3.74	3.31	4.87	4.71	xxx	3.82	3.32	4.6	4.23	3.73	2.82
978	4.52	3.74	3.34	4.99	4.72	xxx	3.82	3.47	4.7	4.30	3.77	2.90
979	4.94	3.94	3.48	5.17	4.91	xxx	4	3.41	4.9	4.47	3.95	2.89
980	4.93	3.92	3.32	4.99	4.87	4.25	3.71	3.57	4.8	4.28	3.75	3.06
981	4.71	3.85	3.28	4.96	4.85	4.24	3.71	3.26	4.8	4.25	3.70	2.86
982	4.56	3.84	3.32	4.97	4.86	4.24	3.69	3.26	4.8	4.29	3.76	2.81
983	4.54	3.83	3.3	4.96	4.85	4.23	3.68	3.21	4.8	4.28	3.73	2.90
984	4.74	3.83	3.31	4.97	4.85	4.22	3.64	3.21	4.8	4.26	3.71	2.86
985	4.66	3.79	3.33	4.96	4.83	4.2	3.62	3.16	4.8	4.27	3.75	2.83
986	4.61	3.8	3.38	5.04	4.88	4.22	3.68	3.12	4.8	4.35	3.82	2.90
987	4.49	3.62	3.22	4.85	4.56	4.07	3.31	3.19	4.6	4.15	3.61	2.96
988	4.17	4.41	3.16	4.63	4.54	4.02	xxx	3.08	4.5	4.02	3.54	2.74
989	4.69	4.87	3.45	5.07	4.94	4.41	3.85	3.08	4.9	4.41	3.92	2.78
990	4.25	4.57	3.01	4.82	4.69	4.07	3.49	3.41	4.6	4.11	3.56	3.09
991	4.02	4.18	2.9	4.41	4.29	3.66	3.09	3.00	4.2	3.80	3.31	2.63
992	4.02	3.57	2.81	4.37	4.28	3.73	3.21	2.62	4.2	3.79	3.32	2.53
993	4.47	4.11	3.13	4.93	4.81	4.25	3.71	2.79	4.7	4.25	3.72	2.54
994	4.26	4.04	2.85	4.69	4.51	3.93	3.37	3.25	4.4	3.90	3.34	2.84
995	3.51	3.51	2.6	4.19	4.05	3.49	2.96	2.88	4	3.52	2.99	2.43
996	3.7	3.55	2.78	4.24	4.17	3.73	3.28	2.51	4.1	3.72	3.24	2.18
997	4.57	4.26	3.08	4.87	4.78	4.3	3.8	2.93	4.7	4.21	3.68	2.56
998	4.42	4.24	2.86	4.82	4.69	4.1	3.55	3.43	4.6	4.03	3.41	2.86
999	3.48	3.49	2.58	4.09	4.01	3.46	2.97	3.10	3.9	3.47	2.93	2.43

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1000	3.65	3.54	2.69	4.32	4.25	3.73	3.26	2.56	4.1	3.73	3.21	2.11
1001	4.92	4.46	3.16	5.24	5.09	4.53	4.01	2.86	4.9	4.48	3.89	2.42
1002	4.48	4.34	2.53	4.7	4.5	3.81	3.18	3.55	4.3	3.81	3.11	2.96
1003	3.4	3.38	2.13	3.69	3.59	2.92	2.35	2.62	3.5	3.04	2.47	1.99
1004	3.9	3.5	2.63	4.32	4.29	3.71	3.18	1.83	4.3	3.85	3.39	1.56
1005	4.82	4.04	2.91	4.83	4.74	4.16	3.58	2.70	4.7	4.20	3.67	2.55
1006	4.31	3.97	2.55	4.44	4.33	3.73	3.14	3.08	4.3	3.77	3.22	2.77
1007	3.62	3.66	2.4	4.25	4.15	3.56	3	2.62	4.1	3.64	3.09	2.32
1008	4.29	3.73	2.61	4.64	4.49	3.86	3.27	2.49	4.4	3.95	3.37	2.19
1009	5.6	4.7	3.03	5.52	5.32	4.64	4	2.75	5.2	4.65	3.97	2.44
1010	5.18	4.59	2.33	4.89	4.7	3.9	3.18	3.44	4.5	3.91	3.17	2.86
1011	4.15	3.88	2.06	4.17	4.02	3.24	2.55	2.52	3.9	3.37	2.75	1.91
1012	4.66	4.01	2.6	4.85	4.71	3.98	3.3	1.93	4.6	4.10	3.46	1.68
1013	5.59	4.7	2.87	5.5	5.32	4.58	3.87	2.72	5.2	4.60	3.84	2.41
1014	5.56	4.67	2.67	5.45	5.2	4.34	3.53	3.25	5.1	4.41	3.60	2.65
1015	4.65	4.21	2.45	5.07	4.87	4.03	3.24	2.84	4.7	4.13	3.40	2.26
1016	4.75	4.23	2.57	4.99	4.84	4.08	3.33	2.57	4.7	4.15	3.44	2.13
1017	5.87	5.05	2.93	5.76	5.57	4.74	3.94	2.68	5.4	4.75	3.93	2.25
1018	5.7	4.98	2.55	5.42	5.17	4.25	3.39	3.26	5	4.29	3.42	2.56
1019	4.85	4.38	2.34	4.92	4.69	3.82	3	2.65	4.6	3.93	3.16	1.96
1020	5.11	4.44	2.61	5.19	4.99	4.14	3.32	2.27	4.9	4.25	3.47	1.84
1021	5.83	4.98	2.79	5.64	5.42	4.52	3.67	2.59	5.3	4.57	3.71	2.16
1022	5.89	4.93	2.56	5.25	5	4.06	3.17	2.96	4.9	4.14	3.28	2.29
1023	5.09	4.47	2.38	4.89	4.66	3.77	2.9	2.43	4.4	3.90	3.10	1.84
1024	5.14	4.53	2.72	5.2	4.97	4.12	3.27	2.14	4.8	4.24	3.48	1.76
1025	5.52	4.75	2.78	5.38	5.13	4.25	3.39	2.52	4.8	4.35	3.54	2.14
1026	5.48	4.72	2.74	5.43	5.17	4.28	3.42	2.64	5	4.34	3.49	2.16
1027	4.8	4.14	2.5	4.88	4.64	3.79	2.94	2.69	4.5	3.91	3.16	2.07
1028	4.77	4.21	2.88	5.1	4.93	4.18	3.51	2.24	4.8	4.27	3.57	1.86
1029	5.41	4.6	2.99	5.41	5.21	4.45	3.78	2.91	5.1	4.47	3.71	2.39
1030	5.13	4.56	2.89	5.21	5	4.29	3.59	3.16	4.9	4.23	3.46	2.45
1031	4.67	4.26	2.78	4.96	4.76	4.06	3.37	3.01	4.7	4.04	3.32	2.20
1032	4.87	4.29	2.99	5.13	4.96	4.29	3.68	2.81	4.8	4.24	3.51	2.13
1033	4.91	4.18	2.92	5.02	4.86	4.2	3.6	3.17	4.7	4.15	3.42	2.37
1034	4.67	4.14	2.98	4.97	4.8	4.2	3.65	3.10	4.7	4.12	3.45	2.29
1035	5.01	4.39	3.04	5.19	5	4.37	3.8	3.18	4.9	4.28	3.57	2.36
1036	4.53	4.31	2.81	4.79	4.64	4.07	3.56	3.31	4.5	3.95	3.30	2.43
1037	4.34	4.13	2.74	4.63	4.48	3.92	3.42	3.11	4.3	3.82	3.20	2.23
1038	4.23	4.35	2.72	4.53	4.39	3.85	3.39	2.98	4.2	3.74	3.14	2.16
1039	4.52	4.57	2.83	4.71	4.59	4.03	3.54	2.98	4.4	3.92	3.31	2.15

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1040	4.13	4.37	2.67	4.54	4.43	3.89	3.4	3.12	4.3	3.76	3.14	2.28
1041	3.7	4	2.5	4.19	4.08	3.57	3.11	3.00	4	3.47	2.88	2.12
1042	3.56	3.8	2.46	3.95	3.8	3.39	3.02	2.73	3.7	3.28	2.78	1.92
1043	3.87	3.85	2.5	3.96	3.82	3.41	3.03	2.72	3.7	3.32	2.83	1.98
1044	3.47	3.73	2.35	3.85	3.77	3.41	3.06	2.72	3.7	3.29	2.84	2.04
1045	3.17	3.36	2.18	3.46	3.44	3.07	xxx	2.78	3.4	2.95	2.49	2.06
1046	2.82	3.36	2.25	3.41	3.4	3.14	xxx	2.47	3.4	3.01	2.71	1.67
1047	3.41	3.96	2.56	3.95	3.86	3.61	3.34	2.68	3.8	3.49	3.12	2.11
1048	3.59	3.78	2.17	3.77	3.65	3.31	2.92	3.10	3.5	3.20	2.67	2.52
1049	2.63	3.12	1.93	3.19	3.08	2.76	2.42	2.61	3	2.72	2.28	1.81
1050	3.35	3.54	2.21	3.73	3.61	3.22	2.85	2.14	3.5	3.14	2.67	1.56
1051	3.84	3.98	2.42	4.19	4.1	3.71	3.33	2.52	3.9	3.55	3.02	1.90
1052	3.06	3.38	1.85	3.43	3.36	2.97	2.59	2.98	3.2	2.88	2.39	2.15
1053	2.28	2.99	1.71	3.1	3.06	2.67	2.29	2.22	2.9	2.62	2.17	1.56
1054	2.56	3.26	1.86	3.31	3.27	2.89	2.45	1.93	3.1	2.84	2.40	1.39
1055	2.92	3.55	2.03	3.58	3.53	3.15	2.7	2.06	3.4	3.06	2.61	1.65
1056	3.26	3.73	2.02	3.9	3.75	3.24	2.72	2.30	3.6	3.21	2.69	1.84
1057	1.89	2.71	1.38	2.96	2.84	2.37	1.91	2.24	2.7	2.42	2.00	1.80
1058	2.36	2.89	1.99	3.29	3.27	2.88	2.46	1.51	3.2	3.00	2.71	1.23
1059	3.18	3.56	2.36	3.91	3.86	3.46	3	2.12	3.79	3.48	3.06	2.15
1060	3.01	3.55	2.31	3.8	3.68	3.23	2.75	2.61	3.6	3.25	2.80	2.42
1061	1.97	2.64	1.7	2.96	2.87	2.44	2.01	2.32	2.8	2.53	2.20	2.17
1062	2.39	2.7	2.18	3.41	3.36	2.91	2.47	1.64	3.31	3.06	2.73	1.64
1063	3.16	3.43	2.64	4.11	4.01	3.55	3.08	2.07	3.96	3.63	3.23	2.16
1064	3.32	3.43	2.66	3.86	3.76	3.28	2.77	2.63	3.69	3.35	2.96	2.57
1065	2.47	2.75	2.15	3.24	3.15	2.68	2.21	2.03	3.11	2.83	2.48	2.28
1066	2.93	3.57	2.77	4.03	3.93	3.37	2.81	1.79	3.91	3.58	3.18	1.87
1067	3.67	4.13	3.05	4.56	4.46	3.9	3.31	2.35	4.4	4.00	3.55	2.48
1068	3.46	4.09	2.93	4.36	4.22	3.64	3.05	2.80	4.16	3.75	3.29	2.80
1069	3.1	3.87	2.68	4.07	3.92	3.31	2.74	2.52	3.89	3.51	3.07	2.55
1070	3.16	3.88	2.79	4.14	4.02	3.42	2.83	2.25	3.99	3.60	3.16	2.36
1071	4.17	4.6	3.3	4.89	4.76	4.17	3.53	2.34	4.67	4.23	3.73	2.43
1072	4.05	4.5	3.05	4.62	4.45	3.81	3.14	2.98	4.34	3.88	3.32	2.88
1073	3.51	4.12	2.86	4.3	4.13	3.49	2.83	2.56	4.05	3.62	3.10	2.44
1074	3.84	4.3	3.1	4.69	4.53	3.85	3.15	2.27	4.45	3.99	3.44	2.28
1075	4.59	4.87	3.37	5.18	5.01	4.32	3.6	2.57	4.88	4.38	3.77	2.56
1076	4.41	4.8	3.14	4.86	4.68	3.95	3.21	2.98	4.53	4.02	3.39	2.80
1077	4.06	4.61	3.07	4.74	4.56	3.83	3.09	2.56	4.4	3.93	3.32	2.39
1078	xxx	4.65	3.11	4.76	4.59	3.87	3.14	2.45	4.46	3.97	3.36	2.34
1079	xxx	5.16	3.35	5.23	5.06	4.3	3.56	2.51	4.17	4.38	3.71	2.38

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1080	4.91	4.88	3.14	5.03	4.85	4.07	3.38	2.91	4.93	4.15	3.47	2.63
1081	4.4	4.38	2.9	4.49	4.32	3.56	2.81	2.64	4.21	3.70	3.09	2.34
1082	5.04	4.88	3.43	5.32	5.02	4.33	3.58	2.18	4.96	4.48	3.83	2.05
1083	5.34	5.06	3.51	5.46	5.18	4.5	3.74	2.96	5.1	4.59	3.91	2.76
1084	4.98	4.98	3.23	5.05	4.88	4.19	3.5	3.09	4.74	4.17	3.52	2.82
1085	5.51	5.5	3.46	5.57	5.33	4.57	3.83	2.93	5.02	4.53	3.74	2.51
1086	xxx	5.54	3.66	6.25	5.66	4.9	4.2	3.22	5.99	5.08	4.16	2.66
1087	5.88	4.73	3.28	5.42	4.86	4.18	3.56	3.51	4.8	4.41	3.64	2.85
1088	4.73	4.73	3.36	5.05	4.84	xxx	3.91	2.93	4.77	4.33	3.77	2.49
1089	5.44	5.31	3.59	5.66	5.4	xxx	4.28	3.40	5.3	4.78	4.15	2.95
1090	5	5.09	3.28	5.25	5.08	4.43	3.85	3.82	4.93	4.34	3.68	3.13
1091	5.16	5.22	3.37	5.38	5.21	4.55	3.95	3.38	xxx	4.49	3.82	2.67
1092	4.94	5.02	3.15	5.17	4.99	4.32	3.72	3.48	xxx	4.25	3.54	2.78
1093	5.11	5.03	3.24	5.15	4.98	4.32	3.73	3.24	4.84	4.28	3.61	2.46
1094	5.06	4.81	2.98	4.95	4.77	4.17	3.61	3.23	4.64	4.08	3.43	2.57
1095	4.63	4.26	2.74	4.36	4.16	3.58	3.04	3.13	4.07	3.55	2.94	2.33
1096	5.02	4.13	3.18	5	4.83	4.2	3.78	2.58	4.73	4.22	3.64	1.98
1097	5.38	4.71	3.38	5.63	5.47	4.8	4.34	3.36	5.34	4.75	4.08	2.78
1098	5.08	4.49	3.05	5.03	4.9	4.29	3.69	3.91	4.75	4.16	3.49	3.02
1099	4.54	4.16	2.95	4.74	4.64	4.06	3.5	3.24	4.52	3.99	3.35	2.44
1100	4.27	4.09	2.78	4.41	4.31	3.82	3.34	3.07	4.2	3.71	3.11	2.37
1101	4.91	4.72	3.1	5.01	4.89	4.34	3.8	2.98	4.75	4.20	3.56	2.19
1102	4.83	4.72	2.92	5.05	4.87	4.24	3.61	3.40	4.72	4.11	3.37	2.52
1103	3.6	3.73	2.48	4.12	3.98	3.43	2.87	3.13	3.84	3.36	2.72	2.19
1104	3.7	3.77	2.8	4.28	4.21	3.81	3.39	2.44	4.09	3.68	3.18	1.75
1105	4.75	4.48	3.07	4.92	4.8	4.34	3.87	3.08	4.65	4.16	3.59	2.43
1106	4.85	4.53	3.16	5.3	5.12	4.51	3.97	3.53	4.97	4.41	3.74	2.67
1107	3.55	3.44	2.63	4.29	4.19	3.66	3.19	3.55	4.06	3.59	3.02	2.68
1108	3.16	3.38	2.72	3.85	3.85	3.56	3.27	2.82	3.76	3.43	3.07	2.12
1109	4.47	4.38	3.16	4.77	4.68	4.31	3.95	3.06	4.58	4.14	3.68	2.49
1110	4.51	4.35	3.01	4.83	4.65	4.13	3.69	3.70	4.53	4.02	3.44	2.92
1111	2.97	3.24	2.4	3.83	3.71	3.25	2.87	3.37	3.63	3.21	2.70	2.53
1112	3.44	3.99	2.87	4.21	4.15	3.81	3.53	2.59	4.07	3.71	3.28	2.00
1113	4.46	4.78	3.29	4.89	4.8	4.41	4.09	3.34	4.69	4.27	3.79	2.67
1114	4.43	4.71	3.18	4.82	4.68	4.26	3.86	3.88	4.58	4.12	3.60	3.02
1115	3.38	3.97	2.75	4.17	4.09	3.7	3.32	3.62	4.01	3.59	3.11	2.80
1116	3.42	4	2.91	4.2	4.14	3.83	3.53	3.09	4.07	3.73	3.32	2.40
1117	4.88	5.08	3.53	5.21	5.07	4.71	4.34	3.34	4.58	4.56	4.06	2.68
1118	4.51	4.59	2.89	4.68	4.53	4.02	3.55	4.13	4.41	3.88	3.28	3.26
1119	3.52	3.87	2.62	3.97	3.85	3.4	3.01	3.25	3.77	3.33	2.85	2.33

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1120	3.76	4.21	2.88	4.37	4.29	3.9	3.57	2.73	4.2	3.78	3.31	2.10
1121	4.72	4.81	3.16	4.92	4.81	4.38	4.01	3.33	4.69	4.21	3.67	2.54
1122	4.47	4.6	2.92	4.67	4.55	4.07	3.65	3.75	4.42	3.91	3.35	2.77
1123	4.15	4.39	2.83	4.52	4.42	3.96	3.55	3.36	4.28	3.80	3.24	2.41
1124	4.37	4.59	2.99	4.71	4.62	4.14	3.71	3.27	4.49	4.01	3.43	2.34
1125	5.05	5.09	3.19	5.16	5.07	4.56	4.09	3.39	4.91	4.37	3.74	2.53
1126	5.11	4.92	2.93	4.92	4.76	4.2	3.62	3.73	4.59	4.04	3.36	2.74
1127	4.67	4.69	2.86	4.76	4.6	4.08	3.54	3.20	4.38	3.93	3.29	2.30
1128	4.72	4.78	2.95	4.87	4.72	4.14	3.6	3.13	5.04	4.04	3.40	2.28
1129	4.9	4.9	3	4.94	4.8	4.21	3.65	3.15	4.66	4.09	3.43	2.35
1130	5.17	5.09	3.08	5.27	5.08	4.42	3.77	3.19	4.94	4.34	3.63	2.38
1131	5.77	5.02	3.04	5.2	5.01	4.37	3.74	3.24	4.85	4.26	3.57	2.49
1132	4.45	4.54	2.82	4.62	4.5	3.95	3.41	3.23	4.37	3.85	3.26	2.43
1133	5.03	4.99	3.02	5.04	4.9	4.29	3.72	2.95	4.77	4.19	3.54	2.31
1134	5.35	5.13	2.97	5.14	4.94	4.21	3.52	3.24	4.8	4.14	3.40	2.48
1135	5.09	5.1	2.97	5.15	4.96	4.23	3.55	2.96	4.72	4.18	3.44	2.19
1136	5.05	4.96	2.83	4.97	4.79	4.06	3.38	2.99	xxx	4.00	3.26	2.25
1137	4.76	4.79	2.78	4.8	4.63	3.92	3.26	2.81	xxx	3.88	3.16	2.06
1138	5.29	5.07	2.96	5.22	5.02	4.25	3.55	2.68	xxx	4.26	3.49	2.02
1139	5.04	4.58	2.73	4.67	4.45	3.72	3.05	2.94	xxx	3.75	3.05	2.25
1140	5.07	4.98	3.19	5.15	4.99	4.35	3.71	2.45	xxx	4.32	3.70	1.94
1141	5.03	4.86	3.09	5.06	4.94	4.32	3.68	3.18	4.8	4.24	3.62	2.76
1142	4.52	4.48	2.93	4.61	4.5	3.94	3.41	3.17	4.36	3.89	3.33	2.65
1143	4.56	4.68	3.02	4.83	4.72	4.15	3.61	2.95	4.4	4.10	3.51	2.46
1144	4.47	4.61	3.01	4.73	4.62	4.06	3.52	3.14	4.4	4.00	3.41	2.58
1145	4.21	4.37	2.88	4.54	4.42	3.87	3.35	3.07	4.54	3.83	3.25	2.51
1146	4.4	4.59	3	4.66	4.51	4.01	3.48	2.92	4.75	3.92	3.33	2.39
1147	4.5	4.75	3.09	4.79	4.65	4.14	3.58	3.06	3.29	4.05	3.46	2.47
1148	4.72	4.9	3.23	4.98	4.9	4.4	3.9	3.15	3.75	4.24	3.65	2.58
1149	3.69	4.02	2.71	4.15	4.09	3.62	3.16	3.50	xxx	3.53	3.01	2.73
1150	4.04	4.31	3.18	4.62	4.49	xxx	3.85	2.80	xxx	4.06	3.60	2.20
1151	4.59	4.75	3.41	5.04	4.85	xxx	4.12	3.62	xxx	4.37	3.86	2.87
1152	4.14	4.52	3.2	4.63	4.55	xxx	3.87	3.87	xxx	4.04	3.56	3.05
1153	3.16	3.68	2.6	3.84	3.82	xxx	3.16	3.66	xxx	3.36	2.95	2.80
1154	3.51	3.9	2.9	4.14	4.1	xxx	3.56	2.97	xxx	3.68	3.29	2.28
1155	4.1	4.42	3.25	4.61	4.53	xxx	3.93	3.42	xxx	4.07	3.65	2.68
1156	3.76	4.22	3.08	4.38	4.33	xxx	3.73	3.77	xxx	3.84	3.46	2.97
1157	2.79	3.36	2.44	3.6	3.56	xxx	3.03	3.57	xxx	3.14	2.85	2.78
1158	3.14	3.53	2.63	3.76	3.74	xxx	3.27	2.90	xxx	3.33	3.02	2.25
1159	4.02	4.31	3.2	4.45	4.42	xxx	3.89	3.18	4.31	3.98	3.61	2.49

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1160	3.24	3.71	2.76	3.91	3.83	3.57	3.35	3.76	3.74	3.44	3.10	2.98
1161	2.43	3.15	2.36	3.38	3.33	3.1	2.9	3.22	xxx	2.99	2.69	2.54
1162	2.4	3.07	2.33	3.25	3.23	3.05	2.86	2.77	xxx	2.93	2.63	2.22
1163	3.24	3.67	2.82	3.83	3.76	3.57	3.36	2.75	xxx	3.45	3.11	2.19
1164	2.91	3.5	2.64	3.72	3.68	3.42	3.23	3.26	3.54	3.31	3.00	2.61
1165	2.4	2.71	2.04	2.91	2.85	2.66	2.49	3.14	2.77	2.56	2.30	2.49
1166	1.88	2.26	1.77	2.41	2.43	2.33	2.24	2.40	2.38	2.23	2.05	1.89
1167	3.08	3.48	2.66	3.58	3.53	3.41	3.27	2.21	3.48	3.29	3.03	1.81
1168	2.76	3.18	2.29	3.31	3.17	3.02	2.85	3.23	3.15	2.96	2.64	2.64
1169	2.34	2.84	2.13	2.94	2.85	2.71	2.58	2.79	3.9	2.65	2.41	2.16
1170	2.02	2.53	1.88	2.57	2.55	2.4	2.28	2.51	xxx	2.33	2.10	1.98
1171	2.9	3.28	2.3	3.34	3.26	3.1	2.94	2.22	xxx	2.99	2.69	1.75
1172	2.95	3.22	2.13	3.28	3.2	2.97	2.75	2.87	xx	2.91	2.56	2.22
1173	2.25	2.75	1.93	2.85	2.84	2.63	2.4	2.64	2.78	2.58	2.30	1.92
1174	2.61	3.1	2.18	3.18	3.14	2.96	2.73	2.31	3.08	2.87	2.57	1.72
1175	3.3	3.7	2.5	3.71	3.63	3.44	3.22	2.63	3.56	3.32	2.94	1.96
1176	3.78	3.95	2.46	3.97	3.91	3.61	3.85	3.09	3.81	3.44	2.96	2.29
1177	3.39	3.7	2.36	3.79	3.75	3.47	3.1	3.06	3.06	3.31	2.88	2.02
1178	3.7	3.98	2.58	4.09	4.03	3.73	3.44	2.97	xxx	3.54	3.05	1.98
1179	4.14	4.15	2.6	4.29	4.16	3.82	3.46	3.23	xxx	3.62	3.07	2.19
1180	4.02	4	2.62	4.04	3.92	3.69	xxx	3.23	3.9	3.52	3.11	2.14
1181	3.35	3.59	2.43	3.65	3.55	3.34	3.04	3.26	3.29	3.20	2.84	2.35
1182	3.76	4.13	2.88	4.25	4.12	3.84	3.55	2.97	4.09	3.70	3.27	2.13
1183	4.05	4.29	2.91	4.39	4.27	3.98	3.68	3.41	4.07	3.83	3.34	2.53
1184	4.05	4.24	2.86	4.41	4.28	3.95	xxx	3.51	4.97	3.81	3.30	2.58
1185	3.94	4.15	2.82	4.31	4.19	3.86	3.52	3.40	4.11	3.71	3.23	2.47
1186	4.17	4.44	3.05	4.56	4.44	4.14	3.79	3.34	4.37	3.97	3.47	2.42
1187	4.52	4.65	3.09	4.71	4.58	4.27	3.9	3.61	4.53	4.08	3.54	2.67
1188	4.37	4.4	2.91	4.51	4.37	4.03	3.89	3.70	4.31	3.87	3.34	2.68
1189	4.63	4.71	3.1	4.86	4.68	4.33	3.93	3.45	4.62	4.15	3.59	2.50
1190	4.88	4.85	3.09	4.97	4.76	4.33	3.86	3.73	4.7	4.16	3.52	2.70
1191	4.78	4.75	3.07	4.87	4.69	4.27	3.82	3.58	4.62	4.09	3.47	2.50
1192	4.9	5	3.2	5.16	4.96	4.55	xxx	3.54	4.87	4.35	3.72	2.49
1193	4.91	4.91	3.15	5.06	4.85	4.44	3.98	3.80	4.23	4.25	3.63	2.69
1194	5.3	5.1	3.38	5.28	5.1	4.56	4.2	3.71	4.48	4.47	3.86	2.61
1195	5.21	4.99	3.28	5.15	4.98	4.43	4.06	3.93	4.89	4.34	3.72	2.86
1196	5.06	4.95	3.29	5.12	4.94	4.43	xxx	3.79	xxx	4.33	3.75	2.72
1197	5.52	5.39	3.49	5.58	5.37	4.83	4.44	3.82	xxx	4.70	4.08	2.79
1198	5.57	5.32	3.32	5.39	5.18	4.65	4.13	4.18	xxx	4.49	3.79	3.03
1199	5.14	4.91	3.17	4.99	4.83	4.34	3.85	3.81	4.74	4.20	3.56	2.68

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1200	5.09	4.84	3.15	4.87	4.71	4.28	3.85	3.56	4.61	4.11	3.51	2.54
1201	5.82	5.53	3.44	5.54	5.31	4.8	4.31	3.62	5.21	4.61	3.93	2.59
1202	6.05	5.56	3.34	5.64	5.38	4.75	xxx	4.02	5.28	4.60	3.81	2.88
1203	4.78	4.63	2.97	4.77	4.6	4.05	xxx	3.80	4.41	3.96	3.29	2.61
1204	4.66	4.81	3.29	5.01	4.86	4.34	4.07	3.26	4.79	4.26	3.69	2.29
1205	5.73	5.59	3.58	5.75	5.53	4.94	4.54	3.78	3.8	4.81	4.12	2.77
1206	5.61	5.32	3.27	5.42	5.2	4.63	4.08	4.25	4.18	4.48	3.74	3.02
1207	4.72	4.68	3	4.87	4.71	4.21	3.72	3.74	4.3	4.07	3.42	2.61
1208	4.53	4.62	3.04	4.76	4.61	4.2	3.77	3.43	4.37	4.02	3.45	2.40
1209	5.52	5.36	3.39	5.38	5.18	4.69	4.21	3.52	5.06	4.49	3.84	2.53
1210	5.1	5.42	3.01	5.04	4.84	4.27	3.76	3.91	4.73	4.13	3.43	2.82
1211	4.01	4.49	2.63	4.19	4.04	3.56	3.13	3.44	3.94	3.47	2.89	2.36
1212	3.96	4.12	2.84	4.29	4.18	3.83	3.48	2.86	4.08	3.67	3.19	2.01
1213	5.11	5.16	3.29	5.22	5.05	4.62	4.19	3.28	4.97	4.42	3.80	2.43
1214	4.9	4.97	2.97	5.03	4.78	4.23	3.74	3.92	4.71	4.11	3.37	2.83
1215	3.61	3.94	2.55	4.17	4.03	3.57	3.19	3.39	3.91	3.48	2.95	2.26
1216	3.91	4.23	2.79	4.26	4.18	3.82	3.47	2.92	4.07	3.64	3.19	2.00
1217	4.28	4.88	3.06	4.8	4.64	4.24	3.82	3.26	4.55	4.05	3.46	2.35
1218	4.35	4.81	3.06	4.89	4.71	4.26	3.83	3.57	4.95	4.08	3.46	2.54
1219	3.46	3.83	2.56	4.02	3.9	3.48	3.1	3.56	3.45	3.35	2.82	2.52
1220	3.41	3.92	2.84	4.16	4.12	3.75	3.46	2.87	4.23	3.64	3.21	2.02
1221	4.47	4.58	3.15	4.71	4.63	4.25	3.95	3.28	4.47	4.07	3.57	2.52
1222	4.28	4.41	2.88	4.47	4.34	3.89	3.5	3.75	4.23	3.78	3.21	2.79
1223	3.98	4.29	2.82	4.48	4.39	3.96	3.57	3.22	4.02	3.82	3.25	2.40
1224	4	4.25	2.85	4.35	4.29	3.9	3.51	3.31	4.1	3.74	3.24	2.40
1225	4.35	4.49	2.98	4.52	4.41	4.02	3.62	3.27	3.94	3.85	3.33	2.44
1226	4.31	4.12	2.5	4.21	4.05	3.54	3.06	3.36	4.02	xxx	2.74	2.55
1227	3.44	3.6	2.31	3.82	3.72	3.23	2.81	2.73	3.31	xxx	2.55	1.86
1228	3.81	4.19	3	4.44	4.39	4.06	3.84	2.51	4.3	3.93	3.46	1.78
1229	3.91	4.13	2.95	4.23	4.19	3.86	3.45	3.50	3.93	3.73	3.31	2.65
1230	4.16	4.4	3.06	4.48	4.42	3.99	3.85	3.27	4.63	3.86	3.35	2.58
1231	3.57	3.81	2.64	3.92	3.86	3.47	3.07	3.24	3.75	3.35	2.88	2.52
1232	4.13	4.14	3.26	4.65	4.36	xxx	3.81	2.77	4.39	4.12	3.66	2.14
1233	4.99	4.81	3.56	5.3	4.97	xxx	4.36	3.51	4.97	4.60	4.02	2.92
1234	4.46	4.7	3.3	4.94	4.84	4.31	3.91	4.06	4.7	4.22	3.66	3.09
1235	4.37	4.67	3.31	4.85	4.78	4.26	3.88	3.59	4.64	4.21	3.70	2.71
1236	4.13	4.35	3.05	4.44	4.37	3.94	3.52	3.56	4.25	3.81	3.28	2.81
1237	4.57	4.77	3.29	4.88	4.79	4.34	3.89	3.19	4.67	4.19	3.61	2.45
1238	4.63	4.77	3.17	4.86	4.68	4.16	3.61	3.53	4.56	4.04	3.41	2.70
1239	4.66	4.82	3.2	4.95	4.77	4.24	3.69	3.33	4.63	4.12	3.48	2.41

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1240	4.87	4.92	3.25	5.04	4.91	4.28	3.64	3.24	4.77	4.22	3.53	2.48
1241	4.49	4.64	3.13	4.75	4.67	4.07	3.45	3.11	4.52	4.00	3.35	2.44
1242	4.84	4.84	3.27	4.87	4.76	4.13	3.51	2.92	xxx	4.09	3.47	2.34
1243	4.93	4.97	3.3	5	4.88	4.24	3.62	2.98	xxx	4.18	3.54	2.48
1244	4.92	5.07	3.43	5.2	5.07	4.4	3.73	3.08	5.73	4.36	3.68	2.53
1245	4.43	4.62	3.2	4.79	4.67	4.03	3.37	3.18	4.32	4.01	3.38	2.62
1246	4.67	4.68	3.34	4.87	4.75	4.21	3.65	2.85	4.27	4.11	3.53	2.40
1247	4.94	4.9	3.46	5.07	4.92	4.35	3.78	3.13	4.25	4.25	3.67	2.59
1248	5.12	4.9	3.47	5.14	5.02	4.41	3.96	3.35	4.31	4.33	3.71	2.70
1249	4.48	4.4	3.13	4.65	4.55	3.96	3.52	3.56	3.64	3.92	3.33	2.70
1250	4.53	4.41	3.35	4.8	4.61	xxx	3.82	3.15	3.6	4.10	3.55	2.40
1251	5.19	4.94	3.65	5.32	5.07	xxx	4.2	3.51	3.85	4.51	3.92	2.68
1252	4.92	4.94	3.5	5.19	5.04	4.38	4.04	3.88	4.03	4.35	3.74	2.95
1253	4.03	4.25	3.07	4.49	4.38	3.76	3.45	3.70	2.81	3.77	3.22	2.73
1254	4.18	4.26	3.22	4.62	4.42	3.77	3.75	3.11	2.61	3.96	3.47	2.34
1255	5.1	4.99	3.67	5.31	5.06	4.35	4.29	3.49	xxx	4.52	3.97	2.69
1256	4.58	4.83	3.36	4.96	4.81	4.32	3.88	4.04	xxx	4.15	3.55	3.06
1257	3.86	4.38	3.11	4.57	4.44	3.99	3.57	3.59	2.92	3.85	3.29	2.61
1258	3.81	4.25	3.06	4.42	4.3	3.92	3.53	3.29	2.96	3.73	3.22	2.42
1259	4.66	4.86	3.42	4.96	4.81	4.38	3.97	3.14	3.42	4.17	3.61	2.44
1260	4.49	4.78	3.27	4.93	4.77	4.27	3.85	3.70	4.26	4.11	3.50	2.74
1261	3.18	3.75	2.66	3.97	3.86	3.43	3.06	3.54	3.39	3.32	2.80	2.57
1262	3.48	3.99	2.97	4.15	4.08	xxx	3.47	2.78	2.52	3.62	3.22	2.03
1263	4.25	4.7	3.4	4.8	4.71	xxx	3.98	3.27	2.84	4.14	3.66	2.58
1264	4.01	4.65	3.31	4.77	4.68	xxx	3.88	3.77	2.85	4.07	3.56	2.88
1265	2.91	3.7	2.65	3.89	3.83	xxx	3.12	3.65	xxx	3.30	2.86	2.76
1266	2.76	3.5	2.65	3.62	3.6	3.35	3.13	2.90	xxx	3.18	2.86	2.18
1267	3.7	4.26	3.22	4.36	4.29	4.01	3.74	2.99	xxx	3.83	3.45	2.36
1268	3.7	4.3	3.16	4.51	4.4	4.04	3.76	3.61	xxx	3.89	3.44	2.81
1269	2.66	3.35	2.45	3.54	3.48	3.14	2.9	3.58	xxx	3.03	2.65	2.69
1270	2.67	3.31	2.55	3.56	3.55	xxx	3.13	2.84	xxx	3.18	2.87	2.06
1271	3.78	4.15	3.17	4.38	4.32	xxx	3.81	2.97	xxx	3.89	3.50	2.44
1272	3.1	3.67	2.77	3.85	3.77	3.5	3.27	3.70	xxx	3.35	2.99	2.88
1273	2.48	3.14	2.4	3.37	3.32	3.07	2.84	3.17	xxx	2.96	2.66	2.44
1274	2.42	2.99	2.28	3.21	3.18	2.95	2.74	2.75	xxx	2.83	2.53	2.20
1275	3.08	3.69	2.8	3.82	3.78	3.55	3.35	2.66	xxx	3.42	3.07	2.05
1276	2.97	3.72	2.71	3.78	3.7	3.47	3.25	3.25	xxx	3.31	2.93	2.51
1277	2.16	3.07	2.28	3.23	3.16	2.94	2.74	3.13	xxx	2.83	2.52	2.34
1278	2.13	2.69	2.09	2.89	2.86	2.7	2.57	2.65	xxx	2.61	2.37	2.03
1279	2.95	3.05	2.4	3.14	3.09	2.92	2.81	2.54	xxx	2.82	2.55	1.98

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1280	3.3	3.6	2.73	3.75	3.64	3.4	3.24	2.75	xxx	3.29	2.96	2.13
1281	2.68	3.05	2.3	3.24	3.16	2.95	2.79	3.13	xxx	xxx	2.56	2.39
1282	2.52	2.92	2.23	3.08	3.05	2.91	2.76	2.69	xxx	xxx	2.49	2.11
1283	2.76	3.06	2.31	3.24	3.18	3	2.8	2.69	xxx	xxx	2.53	2.09
1284	2.6	3.07	2.42	3.22	3.14	3.03	2.9	2.72	xxx	xxx	2.71	2.03
1285	2.92	3.48	2.67	3.62	3.54	3.44	3.28	2.87	xxx	3.30	3.04	2.39
1286	2.81	3.3	2.5	3.45	3.4	3.19	2.96	3.24	2.16	3.12	2.79	2.57
1287	2.94	3.54	2.68	3.67	3.6	3.4	3.17	2.86	2.12	3.32	2.99	2.23
1288	3.42	4.02	2.95	4.19	4.03	3.78	3.52	3.07	3.4	3.69	3.29	2.44
1289	2.94	3.49	2.6	3.7	3.59	3.35	3.13	3.39	3.1	3.27	2.92	2.63
1290	3.03	3.49	2.64	3.7	3.65	3.43	3.21	3.03	3.7	3.32	2.98	2.36
1291	3.36	3.81	2.84	4	3.91	3.67	3.43	3.12	4.08	3.57	3.18	2.43
1292	3.75	4.26	3.16	4.35	4.24	xxx	3.77	3.31	3.84	3.90	3.52	2.56
1293	3.57	4.34	3.18	4.46	4.35	xxx	3.76	3.65	3.89	3.97	3.58	2.89
1294	3.35	3.98	2.92	4.15	4.05	3.76	3.47	3.72	3.91	3.65	3.24	2.89
1295	3.51	4.27	3.17	4.41	4.33	4.06	3.81	3.33	4.19	3.91	3.50	2.54
1296	3.58	4.04	2.54	4	3.85	3.5	3.16	3.68	3.72	3.39	2.88	2.86
1297	4.26	4.26	2.79	4.2	4.05	3.7	3.37	2.93	3.39	3.61	3.12	2.12
1298	4.52	4.58	2.88	4.56	4.46	4.07	3.71	3.15	4.24	3.86	3.30	2.35
1299	3.28	xxx	2.81	4.44	4.35	3.92	3.52	3.51	4.16	3.74	3.18	2.35
1300	3.54	xxx	2.82	4.38	4.3	3.92	3.56	3.32	4.07	3.68	3.11	2.29
1301	5.21	xxx	3.09	4.95	4.81	4.41	4.04	3.37	4.07	4.15	3.53	2.23
1302	4.66	xxx	2.78	5.06	4.87	4.31	3.81	3.81	4.58	4.09	3.34	2.54
1303	3.14	xxx	2.75	4.88	4.73	4.24	3.78	3.44	4.11	4.00	3.30	2.07
1304	4.12	5.09	2.85	5.18	4.99	4.45	3.89	3.45	4.97	4.27	3.51	2.10
1305	5.9	5.38	2.94	5.32	5.09	4.52	3.96	3.51	4.85	4.31	3.52	2.22
1306	6.3	5.58	2.98	5.65	5.41	4.65	3.94	3.57	5.16	4.57	3.71	2.23
1307	5.26	4.84	2.7	4.98	4.85	4.16	3.52	3.39	4.61	4.06	3.29	2.31
1308	4.56	4.71	2.76	4.79	4.65	4.01	3.4	2.99	4.45	4.01	3.37	2.04
1309	6.27	6.08	3.32	6.16	5.91	5.15	4.44	2.88	5.67	5.04	4.21	2.35
1310	5.94	5.62	2.71	5.68	5.41	4.37	3.42	3.85	5.12	4.39	3.46	2.87
1311	4.67	4.85	2.44	4.95	4.77	3.81	2.91	2.64	4.22	3.93	3.15	1.90
1312	4.92	5.05	2.6	5.01	4.79	3.94	3.06	2.16	4.83	4.03	3.28	1.78
1313	6.27	5.98	2.99	5.91	5.62	4.68	3.75	2.32	5.42	4.68	3.77	1.92
1314	6.27	5.9	2.71	5.76	5.47	4.36	3.32	2.97	5.29	4.45	3.44	2.23
1315	4.54	4.64	2.2	4.57	4.35	3.36	2.41	2.44	4.18	3.59	2.81	1.78
1316	4.83	4.99	2.79	5.1	4.87	4.01	3.14	1.62	4.69	4.17	3.47	1.44
1317	6.5	6.15	3.2	6.15	5.84	4.87	3.92	2.44	5.62	4.91	4.00	2.15
1318	5.9	5.79	2.83	5.64	5.35	4.32	3.37	3.14	5.11	4.38	3.43	2.43
1319	4.53	4.79	2.44	4.74	4.53	3.59	2.68	2.55	4.31	3.76	2.98	1.84

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1320	4.62	4.78	2.78	4.87	4.69	3.93	3.12	1.90	4.49	3.98	3.29	1.61
1321	5.67	5.85	3.18	5.85	5.57	4.71	3.84	2.45	5.36	4.68	3.82	1.99
1322	5.39	5.51	2.81	5.55	5.24	4.25	3.34	3.13	5	4.28	3.33	2.29
1323	4.1	4.36	2.37	4.47	4.26	3.38	2.54	2.57	4.05	3.52	2.78	1.70
1324	4.01	4.56	2.8	4.66	4.5	3.81	3.13	1.82	4.3	3.84	3.18	1.42
1325	5.21	5.61	3.19	5.65	5.4	4.6	3.85	2.53	5.18	4.54	3.69	1.93
1326	4.58	5.12	2.74	5.21	4.93	4.12	3.32	3.20	4.71	4.04	3.15	2.21
1327	3.55	4.34	2.42	4.51	4.3	3.57	2.82	2.65	4.02	3.56	2.81	1.66
1328	3.57	4.29	2.56	4.41	4.27	3.66	3.06	2.21	3.97	3.57	2.91	1.48
1329	4.75	4.92	2.83	4.97	4.77	4.08	3.43	2.57	4.55	3.98	3.22	1.66
1330	4.91	5.15	2.76	5.16	4.87	4.09	3.38	2.91	4.63	4.00	3.12	1.85
1331	3.78	4.4	2.42	4.44	4.21	3.52	2.87	2.81	xxx	3.48	2.73	1.65
1332	3.63	4.28	2.61	4.32	4.17	3.65	3.14	2.34	xxx	3.52	2.89	1.41
1333	4.45	4.77	2.83	4.81	4.6	4.01	3.46	2.74	4.46	3.85	3.13	1.72
1334	4.61	4.8	2.79	4.94	4.7	4.05	3.47	3.02	4.55	3.89	3.13	1.85
1335	3.73	4.21	2.5	4.39	4.21	3.62	3.07	3.00	4.04	3.50	2.82	1.77
1336	3.48	4.06	2.62	4.19	4.09	3.67	3.24	2.65	3.93	3.51	2.93	1.54
1337	3.66	4.36	2.73	4.45	4.3	3.83	3.39	2.94	4.17	3.66	3.02	1.83
1338	4.17	4.76	2.92	4.84	4.63	4.1	xxx	3.06	4.49	3.91	3.22	1.88
1339	3.83	4.3	2.71	4.44	4.33	3.76	xxx	xxx	4.11	3.59	2.95	1.99
1340	3.6	4.14	2.8	4.33	4.2	3.82	3.43	2.98	4.05	3.63	3.08	1.79
1341	3.5	4.25	2.82	4.4	4.25	3.85	3.45	3.20	4.14	3.65	3.07	2.07
1342	3.87	4.6	3.01	4.65	4.49	4.03	3.64	3.21	4.37	3.85	3.23	2.04
1343	3.96	4.46	2.92	4.54	4.4	3.93	3.54	3.38	4.19	3.75	3.13	2.20
1344	3.82	4.35	2.97	4.5	4.4	4.01	3.65	3.28	4.22	3.82	3.26	2.11
1345	3.92	4.29	2.93	4.42	4.3	3.91	3.54	3.43	4.18	3.71	3.16	2.34
1346	4.27	4.57	3.13	4.66	4.52	4.09	3.72	3.32	4.4	3.92	3.38	2.24
1347	4.37	4.71	3.17	4.81	4.68	4.24	3.86	3.49	4.51	4.05	3.47	2.48
1348	3.94	4.35	2.96	4.48	4.38	3.97	3.62	3.63	4.22	3.79	3.24	2.52
1349	3.81	4.15	2.87	4.27	4.17	3.76	3.4	3.42	4.06	3.60	3.06	2.41
1350	4.23	4.57	3.17	4.71	4.59	4.16	3.8	3.20	4.46	3.99	3.47	2.24
1351	4.59	4.88	3.3	5.02	4.87	4.42	4.05	3.61	4.72	4.23	3.67	2.64
1352	4.23	4.59	3.11	4.71	4.59	4.17	3.8	3.85	4.46	4.00	3.45	2.75
1353	3.59	4.03	2.85	4.17	4.09	3.7	3.34	3.58	3.98	3.56	3.06	2.58
1354	4.07	4.43	3.18	4.56	4.46	4.02	3.75	3.15	4.36	3.95	3.49	2.27
1355	4.71	4.94	3.41	5.04	4.9	4.44	4.15	3.57	4.8	4.33	3.80	2.77
1356	4.48	4.75	3.25	4.87	4.73	4.32	3.93	3.95	4.62	4.15	3.60	2.97
1357	3.64	4.03	2.87	4.17	4.1	3.72	3.35	3.70	3.99	3.57	3.10	2.73
1358	4	4.34	3.17	4.5	4.41	xxx	3.72	3.14	4.32	3.91	3.48	2.35
1359	4.88	5.07	3.53	5.21	5.05	xxx	4.28	3.52	4.95	4.47	3.96	2.79

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1360	4.54	4.82	3.3	4.93	4.82	4.39	4	4.08	4.69	4.21	3.69	3.12
1361	3.69	4.14	2.93	4.28	4.23	3.82	3.43	3.78	4.05	3.69	3.21	2.82
1362	3.96	4.34	3.12	4.46	4.4	xxx	3.66	3.23	4.29	3.89	3.43	2.44
1363	4.91	5.13	3.56	5.21	5.09	xxx	4.31	3.49	4.97	4.52	4.01	2.71
1364	4.54	4.75	3.21	4.85	4.71	4.3	3.88	4.12	4.59	4.11	3.56	3.18
1365	3.47	3.93	2.78	4.05	3.96	3.59	3.22	3.66	3.52	3.46	3.00	2.68
1366	3.71	4.05	2.94	4.14	4.08	3.77	3.46	3.03	3.96	3.63	3.23	2.26
1367	4.74	4.85	3.39	4.92	4.81	4.46	4.11	3.32	4.7	4.27	3.79	2.56
1368	4.6	4.77	3.23	4.86	4.74	4.31	3.94	3.94	4.62	4.15	3.60	2.99
1369	3.21	3.58	2.53	3.72	3.65	3.27	2.94	3.73	3.41	3.20	2.75	2.75
1370	3.53	3.91	2.89	4	3.94	3.51	3.35	2.77	3.88	3.54	3.14	2.08
1371	4.59	4.81	3.43	4.86	4.76	4.3	4.11	3.19	4.67	4.27	3.80	2.47
1372	4.39	4.63	3.27	4.76	4.64	4.28	3.94	3.96	4.53	4.12	3.63	2.99
1373	3.26	3.67	2.64	3.85	4.03	3.44	3.1	3.77	3.7	3.33	2.90	2.82
1374	3.19	3.56	2.69	3.73	3.68	3.43	3.15	2.93	3.64	3.32	2.99	2.22
1375	4.42	4.62	3.37	4.75	4.64	4.37	4.07	3.04	4.55	4.19	3.78	2.45
1376	4.21	4.45	3.1	4.59	4.46	4.09	3.72	3.96	4.35	3.93	3.43	3.09
1377	2.93	3.4	2.46	3.58	3.49	3.15	2.85	3.54	3.46	3.07	2.68	2.67
1378	2.96	3.29	2.49	3.4	3.36	3.14	2.92	2.69	3.33	3.04	2.74	2.09
1379	4.15	4.26	3.1	4.32	4.26	4.02	3.75	2.82	xxx	3.85	3.46	2.26
1380	3.96	4.2	2.95	4.31	4.23	3.9	3.58	3.64	xxx	3.74	3.28	2.81
1381	2.71	3.19	2.34	3.39	3.34	3.03	2.78	3.42	xxx	2.95	2.60	2.55
1382	2.76	3.13	2.41	3.29	3.29	3.07	2.91	2.66	xxx	3.00	2.72	2.04
1383	3.82	3.95	2.92	4.02	4	3.76	3.54	2.69	xxx	3.63	3.25	2.24
1384	3.72	3.97	2.86	4.08	3.99	3.7	3.42	3.42	xxx	3.56	3.17	2.64
1385	2.62	3.17	2.34	3.34	3.29	3.04	2.8	3.27	xxx	2.94	2.63	2.54
1386	2.67	3.11	2.36	3.21	3.22	3.01	2.79	2.72	xxx	2.92	2.64	2.12
1387	3.62	3.87	2.87	3.97	3.92	3.7	3.47	2.72	xxx	3.55	3.20	2.20
1388	3.62	4.03	2.92	4.21	4.09	3.79	3.5	3.38	xxx	3.66	3.25	2.64
1389	2.76	3.27	2.41	3.45	3.4	3.12	2.85	3.34	xxx	3.01	2.67	2.62
1390	3.01	3.19	2.45	3.33	3.34	3.13	2.91	2.73	xxx	3.02	2.74	2.16
1391	3.82	3.88	2.9	3.99	3.94	3.71	3.46	2.82	xxx	3.57	3.22	2.27
1392	3.43	3.87	2.87	4.05	3.92	3.66	3.4	3.36	xxx	3.54	3.20	2.63
1393	3.06	3.63	2.69	3.82	3.74	3.48	3.18	3.30	xxx	3.39	3.04	2.62
1394	2.81	3.21	2.35	3.34	3.32	3.06	2.84	3.11	xxx	2.97	2.65	2.49
1395	3.15	3.41	2.56	3.55	3.48	3.23	3.03	2.72	xxx	3.16	2.84	2.13
1396	3.6	4.07	2.99	4.28	4.15	3.88	3.64	2.93	4.11	3.76	3.39	2.33
1397	3.47	4.06	2.93	4.24	4.12	3.82	3.55	3.52	5.06	3.71	3.32	2.76
1398	2.92	3.39	2.42	3.39	3.31	3.07	2.84	3.42	3.22	2.99	2.67	2.66
1399	3.51	3.82	2.67	3.8	3.7	3.46	3.21	2.75	3.7	3.35	2.99	2.12

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1400	3.7	4	2.81	4.09	3.95	3.68	xxx	3.10	3.97	3.55	3.16	2.39
1401	3.46	3.99	2.8	4.03	3.9	3.65	3.32	3.28	xxx	3.52	3.16	2.48
1402	3.57	4.07	2.79	4.15	4.04	3.73	3.43	3.27	xxx	3.58	3.14	2.50
1403	3.38	3.6	2.58	3.75	3.66	3.33	3.01	3.28	4.07	3.22	2.81	2.44
1404	3.83	4.11	2.99	4.32	4.22	3.89	3.59	2.87	3.64	3.76	3.36	2.16
1405	4.41	4.64	3.24	4.8	4.67	4.35	3.94	3.46	5.12	4.15	3.70	2.68
1406	3.78	4.05	2.78	4.17	4.06	3.73	3.33	3.86	3.87	3.58	3.12	2.94
1407	3.81	4.06	2.84	4.21	4.11	3.76	3.39	3.23	2.65	3.63	3.18	2.39
1408	4.09	4.22	2.89	4.31	4.2	3.88	3.47	3.29	4.12	3.69	3.23	2.45
1409	4.82	4.81	3.1	4.85	4.69	4.31	3.82	3.37	4.61	4.10	3.56	2.45
1410	4.67	4.61	2.87	4.65	4.51	4.02	3.5	3.69	4.41	3.86	3.26	2.66
1411	3.77	3.96	2.65	4.06	3.97	3.56	3.14	3.32	xxx	3.42	2.92	2.29
1412	4.71	4.71	3.2	4.84	4.69	4.31	3.85	2.99	xxx	4.10	3.57	2.11
1413	5.78	5.52	3.5	5.62	5.4	4.58	xxx	3.72	xxx	4.68	4.01	2.70
1414	5.54	5.31	3.27	5.39	5.17	2.67	xxx	4.17	xxx	4.43	2.13	2.95

Appendix A. List of Tidal Ranges.

Tide	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14

APPENDIX B

LIST OF VASCULAR PLANT SPECIES, COMMON NAMES AND AUTHORITIES FOR PLANTS APPEARING IN POLYGONS AT SAMPLING STATIONS IN THE CAPE FEAR RIVER ESTUARY, WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA

A list of vascular plant species used in text and tables with accompanying authorities and common names follows. Both common and scientific names follow Kartesz and Meachum 1999. Species considered sensitive herbaceous species are marked with an asterisk (*)

Acer rubrum L. Red Maple
**Alternanthera philoxeroides* (Mart.) Griseb. Alligator-Weed
Amaranthus cannabinus (L.) Sauer Tidal-Marsh Amaranth
Apios americana Medik. Groundnut
**Aster* sp. Probably *Symphyotrichum sp*
Bidens laevis (L.) B.S.P. Smooth Beggarticks .
**Boehmeria cylindrica* (L.) Sw. Small-Spike False Nettle
**Boltonia asteroides* (L.) L'Hér. White Doll's-Daisy
**Carex* L. Sedge
**Carex crinita* Lam. Fringed Sedge
**Carex crinita* var. *brevicrinis* Fern. Fringed Sedge
**Carex hyalinolepis* Steud. Shoreline Sedge
**Carex lupulina* Muhl. Ex Willd. Hop Sedge
Chasmanthium latifolium (Michx.) Yates Indian Wood-Oats
**Cicuta maculata* L. Spotted Water-Hemlock
**Cinna arundinacea* L. Sweet Wood-Reed
**Commelina virginica* L. Virginia Dayflower
**Decodon verticillatus* (L.) Ell. Swamp-Loosestrife
**Dulichium arundinaceum* (L.) Britt. Three-Way Sedge
**Eryngium aquaticum* L. Rattlesnake-Master
**Galium* L. Bedstraw
**Hymenocallis floridana* (Raf.) Morton Florida Spider-Lily
Impatiens capensis Meerb. Spotted Touch-Me-Not
Lilaeopsis chinensis (L.) Kuntze Eastern Grasswort
**Ludwigia grandiflora* (M. Micheli) Greuter & Burdet Large-Flower Primrose-Willow
**Ludwigia palustris* (L.) Ell. Marsh Primrose-Willow
**Lycopus virginicus* L. Virginia Water-Horehound
Mikania scandens (L.) Willd. Climbing Hempvine
Nyssa aquatica L. Water Tupelo
**Orontium aquaticum* L. Goldenclub
Osmunda regalis L. Gray Royal Fern
**Peltandra virginica* (L.) Schott Green Arrow-Arum
**Phanopyrum gymnocarpon* (Ell.) Nash Savannah-Panic Grass
Pluchea odorata (L.) Cass. Sweetscent
**Polygonum arifolium* L. Halberd-Leaf Tearthumb
**Polygonum hydropiper* L. Mild Water-Pepper
**Polygonum punctatum* Ell. Dotted Smartweed
Polygonum virginianum L. Jumpseed
**Pontederia cordata* L. Pickerelweed
**Rhynchospora corniculata* (Lam.) Gray Short-Bristle Horned Beak Sedge
**Rhynchospora inundata* (Oakes) Fern. Narrow-Fruit Horned Beak Sedge
Rosa palustris Marsh. Swamp Rose

**Rumex verticillatus* L. Swamp Dock
**Sagittaria lancifolia* L. Bull-Tongue Arrowhead
**Saururus cernuus* L. Lizard's-Tail
**Scutellaria lateriflora* L. Mad Dog Skullcap
**Schoenoplectus americanus* (Pers.) Volk. Ex Schinz & R. Keller Chairmaker's Club-Rush
**Sium suave* Walt. Hemlock Water-Parsnip
Spartina cynosuroides (L.) Roth Big Cord Grass
**Symphyotrichum elliottii* (Torr. & Gray) Nesom Marsh American-Aster
Symphyotrichum subulatum (Michx.) Nesom Seaside American-Aster
Taxodium ascendens Brongn. Pond-Cypress
**Triadenum walteri* (J.G. Gmel.) Gleason Greater Marsh-St. John's-Wort
**Typha latifolia* L. Broad-Leaf Cat-Tail
**Zizania aquatica* L. Indian Wild Rice
**Zizaniopsis miliacea* (Michx.) Doell & Aschers. Marsh-Millet

Literature Cited

Kartesz, J.T., and C.A. Meacham. 1999. Synthesis of the North American Flora, Version 1.0. North Carolina Botanical Garden, Chapel Hill, NC.

APPENDIX C

METADATA COVERING GIS/GPS FILES USED IN TEXT FIGURES IN SENSITIVE HERBACEOUS VEGETATION POLYGONS: FIRST AND SECOND YEAR ASSESSMENTS AT SEVEN STATIONS ESTABLISHED FOR THE WILMINGTON HARBOR MONITORING PROJECT IN THE CAPE FEAR RIVER ESTUARY, NORTH CAROLINA

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P3, TOWN CREEK

FIGURE 8.41-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**13ben.shp**	**13ben.dbf**	**13ben.shx**
DESCRIPTION OF LAYER:	Point depicting concrete benchmark		
SOURCE:	Trimble PRO XRS GPS Unit		
DATA TYPE:	Point		
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2		
DATUM:	North American Datum (NAD) 1983		
COORDINATE SYSTEM:	U.S. State Plane 1983		
REGION:	North Carolina 3200		
UNITS OF MEASURE:	Feet		
DATA COLLECTION:	20 December 2000		
SOURCE:	CZR Incorporated		
SOURCE CONTACT:	Samuel Cooper		
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403		
SOURCE PHONE:	910/392-9253		
SOURCE FAX:	910/392-9139		

FILE NAMES:	**13pil.shp**	**13pil.dbf**	**13pil.shx**
DESCRIPTION OF LAYER:	Point depicting data collect platform piling		
SOURCE:	Trimble PRO XRS GPS Unit		
DATA TYPE:	Point		
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2		
DATUM:	North American Datum (NAD) 1983		
COORDINATE SYSTEM:	U.S. State Plane 1983		
REGION:	North Carolina 3200		
UNITS OF MEASURE:	Feet		
DATA COLLECTION:	20 December 2000		
SOURCE:	CZR Incorporated		
SOURCE CONTACT:	Samuel Cooper		
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403		
SOURCE PHONE:	910/392-9253		
SOURCE FAX:	910/392-9139		

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P3, TOWN CREEK

FIGURE 8.41-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**13poly.shp 13poly.dbf 13poly.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2000 (13poly.ssf GPS file from CZR Incorporated)
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**13sub.shp 13sub.dbf 13sub.shx**
DESCRIPTION OF LAYER:	Points depicting substation survey points
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P3, TOWN CREEK

FIGURE 8.41-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**site9.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown on March 25, 2000 at an altitude of 1500 feet.
SOURCE:	Wild RC20 Aerial Mapping Camera Scale: 1" = 250' Resolution: 1100 DPI (23.1 microns)
DATA TYPE:	The image source consisted of color contact prints and diapositives were created and the negative film then digitally scanned on a Vexcell 4000 to create raw digital images to be rectified and produce digital orthophotos. This produced an original raw pixel size of .2272' based on the scale of the negative film.
SOFTWARE:	Tif/Tfw file format
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	25 March 2000
SOURCE:	3Di, LLC Wilmington NC, Office
SOURCE CONTACT:	Scott C. Williams, PLS
SOURCE ADDRESS:	2704-A Exchange Drive Wilmington, NC 28405
SOURCE PHONE:	910/392-1496
SOURCE FAX:	910/392-7326

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P3, TOWN CREEK

FIGURE 8.41-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**13tra.shp 13tra.dbf 13tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**R081315A.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2001
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	13 August 2001
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P3, TOWN CREEK

FIGURE 8.41-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**TWNCRK02.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2002
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	6 January 2003
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

FILE NAMES:	**AREA-GEN.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2003
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	5 January 2004
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P3, TOWN CREEK

FIGURE 8.41-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**POINTSGEN.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Points depicting sensitive herbaceous plant outliers, 2003
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	5 January 2004
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P7, INDIAN CREEK

FIGURE 8.42-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**15ben.shp**	**15ben.dbf**	**15ben.shx**

DESCRIPTION OF LAYER: Point depicting concrete benchmark

SOURCE: Trimble PRO XRS GPS Unit

DATA TYPE: Point

SOFTWARE: Pathfinder Office 2.1 and Arcview version 3.2
DATUM: North American Datum (NAD) 1983
COORDINATE SYSTEM: U.S. State Plane 1983
REGION: North Carolina 3200
UNITS OF MEASURE: Feet
DATA COLLECTION: 20 December 2000

SOURCE: CZR Incorporated
SOURCE CONTACT: Samuel Cooper
SOURCE ADDRESS: 4709 College Acres, Suite 2
Wilmington, NC 28403
SOURCE PHONE: 910/392-9253
SOURCE FAX: 910/392-9139

FILE NAMES:	**15pil.shp**	**15pil.dbf**	**15pil.shx**

DESCRIPTION OF LAYER: Point depicting data collect platform piling

SOURCE: Trimble PRO XRS GPS Unit
DATA TYPE: Point

SOFTWARE: Pathfinder Office 2.1 and Arcview version 3.2
DATUM: North American Datum (NAD) 1983
COORDINATE SYSTEM: U.S. State Plane 1983
REGION: North Carolina 3200
UNITS OF MEASURE: Feet
DATA COLLECTION: 20 December 2000

SOURCE: CZR Incorporated
SOURCE CONTACT: Samuel Cooper
SOURCE ADDRESS: 4709 College Acres, Suite 2
Wilmington, NC 28403
SOURCE PHONE: 910/392-9253
SOURCE FAX: 910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P7, INDIAN CREEK

FIGURE 8.42-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**Indcr2.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2002
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	6 January 2003
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

FILE NAMES:	**15sub.shp**	**15sub.dbf**	**15sub.shx**
DESCRIPTION OF LAYER:	Points depicting substation survey points		
SOURCE:	Trimble PRO XRS GPS Unit		
DATA TYPE:	Points		
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2		
DATUM:	North American Datum (NAD) 1983		
COORDINATE SYSTEM:	U.S. State Plane 1983		
REGION:	North Carolina 3200		
UNITS OF MEASURE:	Feet		
DATA COLLECTION:	20 December 2000		
SOURCE:	CZR Incorporated		
SOURCE CONTACT:	Samuel Cooper		
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403		
SOURCE PHONE:	910/392-9253		
SOURCE FAX:	910/392-9139		

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P7, INDIAN CREEK

FIGURE 8.42-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**site8.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown on March 25, 2000 at an altitude of 1500 feet.
SOURCE:	Wild RC20 Aerial Mapping Camera Scale: 1" = 250' Resolution: 1100 DPI (23.1 microns)
DATA TYPE:	The image source consisted of color contact prints and diapositives were created and the negative film then digitally scanned on a Vexcell 4000 to create raw digital images to be rectified and produce digital orthophotos. This produced an original raw pixel size of .2272' based on the scale of the negative film.
SOFTWARE:	Tif/Tfw file format
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	25 March 2000
SOURCE:	3Di, LLC Wilmington NC, Office
SOURCE CONTACT:	Scott C. Williams, PLS
SOURCE ADDRESS:	2704-A Exchange Drive Wilmington, NC 28405
SOURCE PHONE:	910/392-1496
SOURCE FAX:	910/392-7326

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P7, INDIAN CREEK

FIGURE 8.42-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**15tra.shp** **15tra.dbf** **15tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P8, DOLLISON LANDING

FIGURE 8.43-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**16ben.shp 16ben.dbf 16ben.shx**
DESCRIPTION OF LAYER:	Point depicting concrete benchmark
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Point
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**16pil.shp 16pil.dbf 16pil.shx**
DESCRIPTION OF LAYER:	Point depicting data collect platform piling
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Point
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P8, DOLLISON LANDING

FIGURE 8.43-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**16poly.shp 16poly.dbf 16poly.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2002
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	6 January 2003
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363
FILE NAMES:	**16sub.shp 16sub.dbf 16sub.shx**
DESCRIPTION OF LAYER:	Points depicting substation survey points
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P8, DOLLISON LANDING

FIGURE 8.43-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**site3.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown on March 25, 2000 at an altitude of 1500 feet.
SOURCE:	Wild RC20 Aerial Mapping Camera Scale: 1" = 250' Resolution: 1100 DPI (23.1 microns):
DATA TYPE:	The image source consisted of color contact prints and diapositives were created and the negative film then digitally scanned on a Vexcell 4000 to create raw digital images to be rectified and produce digital orthophotos. This produced an original raw pixel size of .2272' based on the scale of the negative film.
SOFTWARE:	Tif/Tfw file format
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	25 March 2000
SOURCE:	3Di, LLC Wilmington NC, Office
SOURCE CONTACT:	Scott C. Williams, PLS
SOURCE ADDRESS:	2704-A Exchange Drive Wilmington, NC 28405
SOURCE PHONE:	910/392-1496
SOURCE FAX:	910/392-7326

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P8, DOLLISON LANDING

FIGURE 8.43-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**16tra.shp 16tra.dbf 16tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P9, BLACK RIVER

FIGURE 8.44-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**17ben.shp 17ben.dbf 17ben.shx**
DESCRIPTION OF LAYER:	Point depicting concrete benchmark
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Point
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**17pil.shp 17pil.dbf 17pil.shx**
DESCRIPTION OF LAYER:	Point depicting data collect platform piling
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Point
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P9, BLACK RIVER

FIGURE 8.44-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**17poly.shp 17poly.dbf 17poly.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2000 (17poly.ssf GPS file from CZR Incorporated)
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**17sub.shp 17sub.dbf 17sub.shx**
DESCRIPTION OF LAYER:	Points depicting substation survey points
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P9, BLACK RIVER

FIGURE 8.44-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**site4.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown on March 25, 2000 at an altitude of 1500 feet.
SOURCE:	Wild RC20 Aerial Mapping Camera Scale: 1” = 250’ Resolution: 1100 DPI (23.1 microns)
DATA TYPE:	The image source consisted of color contact prints and diapositives were created and the negative film then digitally scanned on a Vexcell 4000 to create raw digital images to be rectified and produce digital orthophotos. This produced an original raw pixel size of .2272’ based on the scale of the negative film.
SOFTWARE:	Tif/Tfw file format
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	25 March 2000
SOURCE:	3Di, LLC Wilmington NC, Office
SOURCE CONTACT:	Scott C. Williams, PLS
SOURCE ADDRESS:	2704-A Exchange Drive Wilmington, NC 28405
SOURCE PHONE:	910/392-1496
SOURCE FAX:	910/392-7326

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P9, BLACK RIVER

FIGURE 8.44-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**17tra.shp 17tra.dbf 17tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139
FILE NAMES:	**BLACKRIV.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2001
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.8, Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	21 September, 2001
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P9, BLACK RIVER

FIGURE 8.34-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**Blackr02.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2002
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	6 January 2003
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

FILE NAMES:	**Area_gen.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2003
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	6 January 2004
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P12, RAT ISLAND

FIGURE 8.45-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**Cam2.shp Came2.dbf Cam2.shx**
DESCRIPTION OF LAYER:	Point depicting concrete benchmark
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Point
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139
FILE NAMES:	**Ratpil2.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2002
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	5 August 2002
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P12, RAT ISLAND

FIGURE 8.45-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**19poly.shp 19poly.dbf 19poly.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2000 (19poly.ssf GPS file from CZR Incorporated)
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**19sub.shp 19sub.dbf 19sub.shx**
DESCRIPTION OF LAYER:	Points depicting substation survey points
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P12, RAT ISLAND

FIGURE 8.45-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**site5.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown on March 25, 2000 at an altitude of 1500 feet.
SOURCE:	Wild RC20 Aerial Mapping Camera Scale: 1" = 250' Resolution: 1100 DPI (23.1 microns)
DATA TYPE:	The image source consisted of color contact prints and diapositives were created and the negative film then digitally scanned on a Vexcell 4000 to create raw digital images to be rectified and produce digital orthophotos. This produced an original raw pixel size of .2272' based on the scale of the negative film.
SOFTWARE:	Tif/Tfw file format
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	25 March 2000
SOURCE:	3Di, LLC Wilmington NC, Office
SOURCE CONTACT:	Scott C. Williams, PLS
SOURCE ADDRESS:	2704-A Exchange Drive Wilmington, NC 28405
SOURCE PHONE:	910/392-1496
SOURCE FAX:	910/392-7326

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P12, RAT ISLAND

FIGURE 8.45-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**19tra.shp 19tra.dbf 19tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139
FILE NAMES:	**RATISL.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2001
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8, Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	23 August, 2001
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P13, FISHING CREEK

FIGURE 8.46-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**20ben.shp**	**20ben.dbf**	**20ben.shx**

DESCRIPTION OF LAYER: Point depicting concrete benchmark

SOURCE: Trimble PRO XRS GPS Unit

DATA TYPE: Point

SOFTWARE: Pathfinder Office 2.1 and Arcview version 3.2
DATUM: North American Datum (NAD) 1983
COORDINATE SYSTEM: U.S. State Plane 1983
REGION: North Carolina 3200
UNITS OF MEASURE: Feet
DATA COLLECTION: 20 December 2000

SOURCE: CZR Incorporated
SOURCE CONTACT: Samuel Cooper
SOURCE ADDRESS: 4709 College Acres, Suite 2
Wilmington, NC 28403
SOURCE PHONE: 910/392-9253
SOURCE FAX: 910/392-9139

FILE NAMES:	**20pil.shp**	**20pil.dbf**	**20pil.shx**

DESCRIPTION OF LAYER: Point depicting data collect platform piling

SOURCE: Trimble PRO XRS GPS Unit

DATA TYPE: Point

SOFTWARE: Pathfinder Office 2.1 and Arcview version 3.2
DATUM: North American Datum (NAD) 1983
COORDINATE SYSTEM: U.S. State Plane 1983
REGION: North Carolina 3200
UNITS OF MEASURE: Feet
DATA COLLECTION: 20 December 2000

SOURCE: CZR Incorporated
SOURCE CONTACT: Samuel Cooper
SOURCE ADDRESS: 4709 College Acres, Suite 2
Wilmington, NC 28403
SOURCE PHONE: 910/392-9253
SOURCE FAX: 910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P13, FISHING CREEK

FIGURE 8.46-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**20poly.shp 20poly.dbf 20poly.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2000 (20poly.ssf GPS file from CZR Incorporated)
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**20sub.shp 20sub.dbf 20sub.shx**
DESCRIPTION OF LAYER:	Points depicting substation survey points
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P13, FISHING CREEK

FIGURE 8.46-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**site2b.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown on March 25, 2000 at an altitude of 1500 feet.
SOURCE:	Wild RC20 Aerial Mapping Camera Scale: 1” = 250’ Resolution: 1100 DPI (23.1 microns)
DATA TYPE:	The image source consisted of color contact prints and diapositives were created and the negative film then digitally scanned on a Vexcell 4000 to create raw digital images to be rectified and produce digital orthophotos. This produced an original raw pixel size of .2272’ based on the scale of the negative film.
SOFTWARE:	Tif/Tfw file format
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	25 March 2000
SOURCE:	3Di, LLC Wilmington NC, Office
SOURCE CONTACT:	Scott C. Williams, PLS
SOURCE ADDRESS:	2704-A Exchange Drive Wilmington, NC 28405
SOURCE PHONE:	910/392-1496
SOURCE FAX:	910/392-7326

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P13, FISHING CREEK

FIGURE 8.46-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**20tra.shp 20tra.dbf 20tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139
FILE NAMES:	**FISHINGC.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2001
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8, Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	23 August, 2001
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P13, FISHING CREEK

FIGURE 8.46-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**Fishcr2.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2002
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	7 January 2003
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

FILE NAMES:	**Area_gen.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2003
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	7 January 2004
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P14, PRINCE GEORGE CREEK

FIGURE 8.47-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**21ben.shp**	**21ben.dbf**	**21ben.shx**

DESCRIPTION OF LAYER: Point depicting concrete benchmark

SOURCE: Trimble PRO XRS GPS Unit

DATA TYPE: Point

SOFTWARE: Pathfinder Office 2.1 and Arcview version 3.2
DATUM: North American Datum (NAD) 1983
COORDINATE SYSTEM: U.S. State Plane 1983
REGION: North Carolina 3200
UNITS OF MEASURE: Feet
DATA COLLECTION: 20 December 2000

SOURCE: CZR Incorporated
SOURCE CONTACT: Samuel Cooper
SOURCE ADDRESS: 4709 College Acres, Suite 2
Wilmington, NC 28403
SOURCE PHONE: 910/392-9253
SOURCE FAX: 910/392-9139

FILE NAMES:	**21pil.shp**	**21pil.dbf**	**21pil.shx**

DESCRIPTION OF LAYER: Point depicting data collect platform piling

SOURCE: Trimble PRO XRS GPS Unit

DATA TYPE: Point

SOFTWARE: Pathfinder Office 2.1 and Arcview version 3.2
DATUM: North American Datum (NAD) 1983
COORDINATE SYSTEM: U.S. State Plane 1983
REGION: North Carolina 3200
UNITS OF MEASURE: Feet
DATA COLLECTION: 20 December 2000

SOURCE: CZR Incorporated
SOURCE CONTACT: Samuel Cooper
SOURCE ADDRESS: 4709 College Acres, Suite 2
Wilmington, NC 28403
SOURCE PHONE: 910/392-9253
SOURCE FAX: 910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P14, PRINCE GEORGE CREEK

FIGURE 8.47-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**21poly.shp 21poly.dbf 21poly.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2000 (21poly.ssf GPS file from CZR Incorporated)
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

FILE NAMES:	**21sub.shp 21sub.dbf 21sub.shx**
DESCRIPTION OF LAYER:	Points depicting substation survey points
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P14, PRINCE GEORGE CREEK

FIGURE 8.47-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**site1.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown on March 25, 2000 at an altitude of 1500 feet.
SOURCE:	Wild RC20 Aerial Mapping Camera Scale: 1" = 250' Resolution: 1100 DPI (23.1 microns)
DATA TYPE:	The image source consisted of color contact prints and diapositives were created and the negative film then digitally scanned on a Vexcell 4000 to create raw digital images to be rectified and produce digital orthophotos. This produced an original raw pixel size of .2272' based on the scale of the negative film.
SOFTWARE:	Tif/Tfw file format
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	25 March 2000
SOURCE:	3Di, LLC Wilmington NC, Office
SOURCE CONTACT:	Scott C. Williams, PLS
SOURCE ADDRESS:	2704-A Exchange Drive Wilmington, NC 28405
SOURCE PHONE:	910/392-1496
SOURCE FAX:	910/392-7326

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P14, PRINCE GEORGE CREEK

FIGURE 8.47-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**21tra.shp 21tra.dbf 21tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139
FILE NAMES:	**PRGEORGE.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2001
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8, Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	23 August 2001
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P14, PRINCE GEORGE CREEK

FIGURE 8.47-1

CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA

FILE NAMES:	**Prgeo2.shp, .dbf,.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2002
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8, Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	7 January 2003
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363P
FILE NAMES:	**Area_gen.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2003
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8, Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	7 January 2004
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363P

APPENDIX D

AREAS AND LOCATIONS OF YEAR 2001 SENSITIVE HERBACEOUS SPECIES POLYGONS AT SAMPLING STATIONS IN THE CAPE FEAR RIVER ESTUARY, WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA

Table D1. Areas and locations of year 2001 sensitive herbaceous species polygons at sampling stations in the Cape Fear River Estuary, Wilmington Harbor Monitoring Project, North Carolina.

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
Town Creek/ P3	1772.49	TC-1	140219.051	2304171.805
		TC-2	140207.082	2304191.344
		TC-3	140221.659	2304206.404
		TC-4	140227.839	2304209.772
		TC-5	140237.031	2304214.119
		TC-6	140242.445	2304215.836
		TC-7	140249.946	2304215.409
		TC-8	140270.182	2304212.486
		TC-9	140266.858	2304204.850
		TC-10	140256.540	2304191.699
		TC-11	140248.723	2304191.674
		TC-12	140236.591	2304178.099
		TC-13 (TC2-7a)	140260.872	2304211.829
		TC-14 (TC2-7b)	140263.278	2304227.086
		TC-15 (TC2-7c)	140262.762	2304231.769
		TC-16 (TC2-7d)	140260.772	2304234.450
		TC-17 (TC2-7e)	140280.231	2304228.285
Black River/P9	1119.58	1	216657.779	2286244.325
		2	216651.492	2286251.095
		3	216658.827	2286246.468
		4	216657.269	2286251.898
		5	216651.754	2286247.472
		6	216650.042	2286249.262
		7	216645.799	2286253.674
		8	216649.888	2286259.088
		9	216657.317	2286262.581
		10	216648.954	2286263.880
		11	216659.557	2286262.102
		12	216656.757	2286273.002
		13	216653.079	2286288.044
		14	216668.689	2286296.701
		15	216690.333	2286320.841
		16	216681.126	2286288.855
		17	216679.751	2286276.252
		18	216666.266	2286267.250
		19	216665.348	2286262.663
		20	216664.587	2286259.601
		21	216669.094	2286251.539
		22	216662.925	2286243.089

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
Rat Island/P12	**532.94**	**1**	**203317.736**	**2313777.913**
		2	**203308.772**	**2313777.549**
		3	**203300.868**	**2313779.229**
		4	**203291.969**	**2313780.256**
		5	**203191.671**	**2313784.565**
		6	**203286.449**	**2313794.021**
		7	**203292.794**	**2313803.441**
		8	**203303.896**	**2313802.231**
		9	**203309.117**	**2313784.687**
		10	**203317.219**	**2313784.437**
Fishing Creek/P13	**1646.10**	**1**	**215434.539**	**2303604.659**
		2	**215433.148**	**2303593.142**
		3	**215422.842**	**2303588.528**
		4	**215443.926**	**2303577.863**
		5	**215451.578**	**2303569.614**
		6	**215464.474**	**2303570.360**
		7	**215463.540**	**2303566.543**
		8	**215464.940**	**2303561.667**
		9	**215476.415**	**2303554.937**
		10	**215477.821**	**2303565.921**
		11	**215485.052**	**2303562.581**
		12	**215497.650**	**2303561.666**
		13	**215507.769**	**2303571.186**
		14	**215496.683**	**2303576.106**
		15	**215490.616**	**2303574.817**
		17(16 missed)	**215482.008**	**2303579.455**
		18	**215476.137**	**2303576.585**
		19	**215471.856**	**2303583.992**
		20	**215461.894**	**2303589.648**
		21	**215460.313**	**2303596.880**
		22	**215461.579**	**2303608.001**
Prince George Creek./P14	**3669.31**	**1**	**227256.418**	**2320219.063**
		2	**227254.446**	**2320221.629**
		3	**227255.706**	**2320220.961**
		4	**227258.228**	**2320225.326**
		5	**227264.379**	**2320234.730**
		6	**227242.143**	**2320230.564**
		7	**227234.911**	**2320234.787**
		8	**227222.362**	**2320230.472**
		9	**227219.785**	**2320237.000**
		10	**227214.661**	**2320252.072**

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
		11	227224.243	2320251.647
		12	227232.224	2320251.944
		13	227230.942	2320242.688
		14	227221.085	2320259.271
		15	227220.999	2320256.085
		16	227218.673	2320265.466
		17	227225.300	2320272.352
		18	227219.657	2320270.658
		19	227210.593	2320266.917
		20	227217.691	2320270.768
		21	227220.796	2320277.818
		22	227221.646	2320287.355
		23	227210.243	2320285.915
		24	227203.635	2320289.840
		25	227214.513	2320300.367
		26	227220.349	2320291.940
		27	227221.394	2320297.383
		28	227225.410	2320292.784
		Blank	227237.424	2320297.455
		29	227237.487	2320297.765
		30	227235.813	2303283.380
		31	227233.304	2320286.955
		32	227243.738	2320286.983
		33	227247.470	2320288.567
		34	227280.347	2320298.250
		35	227256.899	2320280.853
		36	227260.654	2320288.981
		37	227262.018	2320286.084
		38	227267.985	2320285.138
		39	227276.378	2320277.400
		40	227285.637	2320269.304
		41	227304.780	2320284.690

***North Carolina State Coordinate System, Region 3200, North American Datum, 1983.**

APPENDIX E

AREAS AND LOCATIONS OF YEAR 2002 SENSITIVE HERBACEOUS SPECIES POLYGONS AT SAMPLING STATIONS IN THE CAPE FEAR RIVER ESTUARY, WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA

Table E1. Areas and locations of year 2002 sensitive herbaceous species polygons at sampling stations in the Cape Fear River Estuary, Wilmington Harbor Monitoring Project, North Carolina.

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
Town Creek/ P3	1311.01	1	140252.686	2304204.104
		2	140254.152	2304197.128
		3	140244.393	2304197.276
		4	140245.755	2304189.728
		5	140240.050	2304180.419
		6	140230.819	2304179.261
		7	140228.050	2304175.749
		8	140221.507	2304167.644
		9	140211.476	2304179.568
		10	140202.664	2304196.661
		11	140218.225	2304205.072
		12	140228.702	2304211.839
		13	140247.158	2304215.087
Dollisons Landing/P8	286.12	1	210277.126	2299255.959
		2	210290.435	2299248.298
		3	210292.377	2299266.484
		4	210274.891	2299275.092
Indian Creek/P7	281.88	1	194595.542	2300236.821
		2	194579.530	2300225.021
		3	194566.542	2300234.136
		4	194575.429	2300244.082
Black River/P9	913.02	1	216667.899	2286240.311
		2	216677.570	2286245.829
		3	216659.736	2286257.199
		4	216664.763	2286258.607
		5	216671.147	2286265.555
		6	216670.676	2286272.045
		7	216671.660	2286275.310
		8	216675.642	2286282.450
		9	216678.195	2286285.375
		10	216680.007	2286290.628
		11	216680.371	2286296.350
		12	216668.975	2286293.748
		13	216659.906	2286290.127
		14	216661.969	2286283.178
		15	216656.654	2286272.461
		16	216656.043	2286268.834

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
		17	216651.652	2286263.978
		18	216652.404	2286260.882
		19	216646.134	2286049.723
		20	216648.344	2286246.192
		21	216657.318	2286240.877
Rat Island/P12	532.94	1	203317.736	2313777.913
		2	203308.772	2313777.549
		3	203300.868	2313779.229
		4	203291.969	2313780.256
		5	203191.671	2313784.565
		6	203286.449	2313794.021
		7	203292.794	2313803.441
		8	203303.896	2313802.231
		9	203309.117	2313784.687
		10	203317.219	2313784.437
Fishing Creek/P13	971.91	1	215480.924	2303573.291
		2	215469.118	2303582.956
		3	215464.119	2303586.013
		4	215461.200	2303579.128
		5	215452.716	2303578.166
		6	215444.820	2303570.668
		7	215449.926	2303566.497
		8	215456.337	2303558.989
		9	215460.816	2303554.507
		10	215473.015	2303550.923
		11	215483.803	2303556.877
		12	215491.487	2303562.723
		13	215499.891	2303575.165
		14	215491.352	2303573.664
Prince George Creek./P14	5290.20	1	227259.666	2320219.369
		2	227254.921	2320206.382
		3	227247.086	2320213.853
		4	227226.696	2320223.354
		5	227220.159	2320226.017
		6	227215.336	2320229.979
		7	227210.585	2320242.307
		8	227216.278	2320244.151
		9	227228.693	2320251.671
		10	227217.544	2320253.254
		11	227222.309	2320262.965
		12	227211.910	2320265.740

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
		13	**2272213.358**	**2320265.331**
		14	**227219.935**	**2320281.284**
		15	**227212.212**	**2320282.449**
		16	**227206.164**	**2320287.558**
		17	**227218.065**	**2320298.730**
		17A	**227224.615**	**2320292.219**
		18	**227230.453**	**2320296.470**
		19	**227244.458**	**2320287.539**
		20	**227251.662**	**2320290.879**
		21	**227274.103**	**2320290.256**
		22	**227281.403**	**2320299.301**
		23	**227300.279**	**2320295.953**
		24	**227308.281**	**2320284.334**

*****North Carolina State Coordinate System, Region 3200, North American Datum, 1983.

APPENDIX F

**AREAS AND LOCATIONS OF
YEAR 2003 SENSITIVE HERBACEOUS SPECIES POLYGONS AT
SAMPLING STATIONS IN THE CAPE FEAR RIVER ESTUARY,
WILMINGTON HARBOR MONITORING PROJECT,
NORTH CAROLINA**

Table F1. Areas and locations of year 2003 sensitive herbaceous species polygons at sampling stations in the Cape Fear River Estuary, Wilmington Harbor Monitoring Project, North Carolina

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
Town Creek/ P3	1326.0	1	140252.435	2304203.322
		2	140250.201	2304197.201
		3	140249.480	2304192.561
		4	140246.351	2304189.379
		5	140240.976	2304178.601
		6	140231.904	2304180.392
		7	140229.203	2304176.512
		8	140203.089	2304195.586
		9	140211.476	2304179.568
		10	140217.047	2304205.865
		11	140227.225	2304213.460
		12	140247.702	2304214.792
	Outlier Points	1	140265.496	2304213.394
		2	140265.789	2304223.878
		3	140264.332	2304233.119
Dollisons Landing/P8	286.12	1	210277.126	2299255.959
		2	210290.435	2299248.298
		3	210292.377	2299266.484
		4	210274.891	2299275.092
Indian Creek/P7	281.88	1	194595.542	2300236.821
		2	194579.530	2300225.021
		3	194566.542	2300234.136
		4	194575.429	2300244.082
Black River/P9 (2002 Polygon)	913.02	1	216667.899	2286240.311
		2	216677.570	2286245.829
		3	216659.736	2286257.199
		4	216664.763	2286258.607
		5	216671.147	2286265.555
		6	216670.676	2286272.045
		7	216671.660	2286275.310
		8	216675.642	2286282.450
		9	216678.195	2286285.375
		10	216680.007	2286290.628
		11	216680.371	2286296.350
		12	216668.975	2286293.748

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft)	Easting* (ft)
		13	216659.906	2286290.127
		14	216661.969	2286283.178
		15	216656.654	2286272.461
		16	216656.043	2286268.834
		17	216651.652	2286263.978
		18	216652.404	2286260.882
		19	216646.134	2286049.723
		20	216648.344	2286246.192
		21	216657.318	2286240.877
Black River/P9 (2003 Polygon)	567.78	a	216679.609	2286285.458
		b	216679.546	2286302.391
		c	216666.470	2286302.553
Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft) NAD 83	Easting* (ft) NAD 83
Black River/P9 (continued)		d	216657.202	2286300.044
		e	216655.582	2286293.361
		f	216655.278	2286286.533
		g	216657.317	2286277.507
		h	216678.864	2286277.768
Rat Island/P12	532.94	1	203317.736	2313777.913
		2	203308.772	2313777.549
		3	203300.868	2313779.229
		4	203291.969	2313780.256
		5	203191.671	2313784.565
		6	203286.449	2313794.021
		7	203292.794	2313803.441
		8	203303.896	2313802.231
		9	203309.117	2313784.687
		10	203317.219	2313784.437
Fishing Creek/P13	682.14	1	215481.759	2303579.465
		2	215467.610	2303566.746
		3	215460.252	2303581.959
		4	215453.357	2303588.014
		5	215444.057	2303594.754
		6	215435.693	2303603.133
		7	215440.204	2303586.074
		8	215436.828	2303578.192
		9	215447.310	2303573.406
		10	215461.671	2303574.378
		11	215465.346	2303564.336

Station Name/Number	Polygon Area (ft²)	Point Number	Northing* (ft)	Easting* (ft)
		12	215472.479	2303564.381
		13	215488.458	2303562.267
		14	215486.394	2303564.796
		15	215499.164	2303570.737
		16	215500.670	2303581.823
		17	215493.539	2303578.724
		18	215494.096	2303573.222
		19	215485.138	2303568.904
Prince George Creek./P14	5265.43	1	227252.563	2320209.691
		2	227246.060	2320216.038
		3	227237.486	2320224.149
		4	227229.049	2320222.615
		5	227222.628	2320226.080
		6	227212.996	2320231.430
		7	227211.000	2320241.469
		8	227212.057	2320246.824
		9	227220.004	2320250.453
		10	227215.900	2320257.780
		11	227209.899	2320267.446
		12	227221.005	2320277.358
		13	227204.816	2320282.444
		14	227225.556	2320284.883
		15	227227.171	2320297.904
		16	227229.417	2320294.957
		17	227232.120	2320295.379
		18	227232.498	2320278.077
		19	227239.781	2320289.938
		20	227249.071	2320281.545
		21	227255.121	2320282.823
		22	227267.321	2320285.303
		23	227270.460	2320304.038
		24	227289.492	2320302.777
		25	227310.520	2320281.611

*****North Carolina State Coordinate System, Region 3200, North American Datum, 1983.