Monitoring Effects of a Potential Increased Tidal Range in the Cape Fear River Ecosystem Due to Deepening Wilmington Harbor, North Carolina
Year 10: June 1, 2009 – May 31, 2010

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Acronyms Used in this Report

ANOSIM	Analysis of Similarity
ANOVA	Analysis of Variance
DCP	Data Collection Platform
ECSU	Elizabeth City State University
M	Methanogenic
MPSR	Methanogenic with evidence of past sulfate reduction
MSL	Mean Sea Level
NA	Insufficient Data
ND	No Data Recorded
NS	No Significant Difference
PPT	Parts Per Thousand
SR	Sulfate Reducing
SRNS	Sulfate reducing with non-seawater source of sulfate
UNCW	University of North Carolina Wilmington
UNF	University of North Florida
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
XXX	Data Loss
--	Species absent

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ABSTRACT

This report includes data collected from June 2009 through May 2010. During this period, problems of communication with instruments or minor instrument malfunction were solved as they occurred. Mechanical errors were slightly higher at some sites this year than during previous reporting periods This may reflect the age of some of the equipment. However, 8 out of 12 stations had a decrease in total tides lost. The station with the greatest loss of tidal range data was P2 (Town Creek), which lost 23.5% of tides due to under-ranging events (most likely a result of under-ranging events due to local ship traffic and associated large wakes) and equipment failures. This was a slight increase from last years 20.1% of total tides lost. Data loss at P7 (Indian Creek) was relatively low (7.8%) compared to last year's loss of 17.5%. Overall, there were more than 1,400 tide ranges measured between June 1, 2009 and May 31, 2010.

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. Higher discharge rates this year appear to have influenced water level and tidal range; similar to what was observed in 2006-2007. A good correlation between measured tidal range from the base station at Ft Caswell and the predicted tidal range for this station continued to exist. The mean tidal range at P1 was not significantly different from the mean reported in the previous monitoring period, but was significantly lower than the range reported in year 1. Water levels in the most upstream sites and the inner Town Creek station continued to be affected by precipitation and discharge rates in the river. Higher discharge rates this year appear to have influenced water level and tidal range this year; similar to what was observed in 2006-2007. All of the sites upstream of P4 exhibited a significant difference in yearly mean tidal ranges between this reporting period and 2008-2009. 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 at all sites except P2, P7, P8 and P9). When the slopes from this reporting period were compared to slopes calculated for Year 1 (2000-2001), all sites exhibited a significantly different slope except for stations P3, P13, and P14.

Periods of lower, drought-induced water levels and extreme flooding in the system over the last 5 years have contributed to differing tidal conditions in the Cape Fear and Northeast Cape Fear Rivers between monitoring years. During this reporting period, the mean discharge in the Cape Fear mainstem was higher than during year 9 (2008-2009) and considerably above the 30 year average. The mean discharge for this reporting period was comparable to the mean discharge that existed during 2006-2007(monitoring year 7). The differences in discharge rates between this project year and the previous year, may explain the number of differences in salinity, flooding frequency, and duration.

The flooding frequency within swamps and marshes at a majority of the DCP stations was higher this year when compared to last year. This effect was more pronounced in the fall 2010 when the river discharge rates were below long-term mean discharge for the Cape Fear River (as measured at Lock 1 by a USGS gauging station). During spring 2010, flooding conditions were still greater than last year with 6 out of 9 stations exhibiting an increased number of flood events compared to the 2008-2009 monitoring period. Salinity levels in the fall also reflected the lower flow regimen. In fall 2009, salinity was detected at 5 out of the 9 stations. This pattern is similar to the previous fall (2008) sampling period during low flow conditions. Also similar to flood patterns, salinity measured in spring 2010 returned to levels comparable to previous years. The pattern of slightly increased salinities during swamp sampling was also seen throughout the year in the porewater samples.

In general, salinities this year were slightly elevated compared to the average year, but not as saline as the low flow year at Indian Creek (P7), Black River (P9), Rat Island (P12), Town Creek (P3), and Eagle Island (P6). Fishing Creek (P13) and Prince George (P14) had conditions that were similar to those observed during the low flow year. Dollisons Landing (P8) and Smith Creek (P11) did not exhibit any trends towards either saltier or fresher conditions. Monthly sampling at Eagle Island (P6), indicated that classifications at this site are consistent with an average year where the majority of classifications were methanogenic with evidence of past sulfate reduction (MPSR). During the low flow year, classifications were evenly divided between sulfate reducing and MPSR.

In general, site species diversity was low (less than 1) and overall species richness was also low with only 65 taxa recovered (excluding 5 terrestrial taxa). This is only half the species recovered in peak years (Hackney et al. 2005, Hackney et al. 2006). Unlike the hydrology and chemistry measurements, the species diversity and richness measurements indicate that there is not an immedicate community response to increased river discharge and precipitation.

The 2009 benthic infaunal sampling season showed a distinct shift in faunal patterns with a general reduction in both the number of taxa present per site and a reduction in mean total abundance as compared to 1999-2008. Previous sampling years have shown signs of species replacement, especially during periods of increasing drought and recovery; however, 2009 showed an overall decline in species richness, much as was reported for the 2008 sampling year. Relative abundance patterns among functional guilds remained relatively stable reflecting a greater conservatism in trophic structure compared to individual taxa abundances. The shift in insect taxa reported in the 2007 sampling year and the continued decline of certain infaunal taxa in 2008 and 2009 could be explained by the reduced river discharges and increases in salinity at some sites. Patterns observed in 2009 are very similar to those reported in 2008 and show a steady decline in number of taxa and in abundance of many taxa.

While benthic infauna respond more slowly to changes in physical factors, the epibenthic community responds quickly to physical changes due to their highly motile nature and need for refuge and forage habitat. Breder traps (a passive sampling device) deployed at multiple tidal positions within the marsh and Drop traps (an active density-based sampling method) used along the shallow subtidal marsh edge habitat, measured the presence of the epibenthos in various portions of the estuary. Evaluations of total abundance among years show that more fish utilized the fringing marshes in fall 2007 compared to the fall 2008 and fall 1999 periods. For the spring sampling periods, 2008 total abundances were higher than the 2009 and 2000 periods. With a few exceptions, the fall and spring richness and diversity data displayed similar patterns, with the fall 2007 period exhibiting higher levels than fall 2008 and 1999 periods and the spring 2008 period being higher than the 2009 and 2000 periods.

Sensitive vegetation in the Cape Fear River estuary continues to be affected by exposure to the elevated salinity as seen during this monitoring year. During 2009, effects on sensitive vegetation were most evident at Inner Town Creek and Rat Island. Inner Town Creek and Rat Island were exposed to high salinity waters during the spring and summer of 2009, and previously documented trends towards dominance by salt-tolerant species continued at both of these sites. Following two consecutive years of decline, sensitive vegetation at Fishing Creek exhibited signs of recovery during 2009. Although significant changes were observed at Indian Creek, vegetation at this site continues to be heavily influenced by recent disturbance. The remaining three sites (Dollisons Landing, Black River, and Prince George Creek) had minimal shifts in sensitive vegetations. Most likely due to the lack of exposure to high salinity during 2009.

This report includes data from project year June 1, 2009 – May 31, 2010. Previous year's data may be obtained from USACE or the project webpage (http://people.uncw.edu/culbertsonj). Comparisons will be made among and between data from all project years following project construction.

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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 the data necessary to assess the impact associated with the widening and deepening project. 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 adjacent wetlands. 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. This report includes data collected from June 2009 through May 2010. During this period, problems of communication with instruments or minor instrument malfunction were solved as they occurred. Mechanical errors were slightly higher at some sites this year than during previous reporting periods. This may reflect the age of some of the equipment. 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.

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 logged 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 did 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 was followed so that any major problem identified could be rectified immediately. Data were then compiled into files, each of which contained 1 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. As in previous reporting periods, the terms used to describe general mechanisms through which data are lost or compromised are defined below:

<u>Loss at Station P1</u>: Because the response of each variable upstream (Figure 1.2-1) 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) Absence of Data 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) Freezing 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) Mechanical Errors 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).

Table 1.2-1. 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	0.5	0	0	0	6.0	6.5
P2	6.5	0.6	0	0	0	16.4	23.5
P3	6.5	0	0	0	0	0	6.5
P4	6.5	0	0	0	0	0	6.5
P6	6.5	0.1	0	0.3	0	0.3	7.2
P7	6.5	0	0.3	0.6	0	0.4	7.8
P8	6.5	0.3	0	0.0	0	1.2	8.0
P9	6.5	0.4	0	5.7	0	4.8	17.4
P11	6.5	1.1	0	5.7	0	4.1	17.4
P12	6.5	0.1	0	2.8	0	0	9.4
P13	6.5	0.2	0	0	0	0.1	6.8
P14	6.5	0.2	0	0.0	0	1.8	8.5

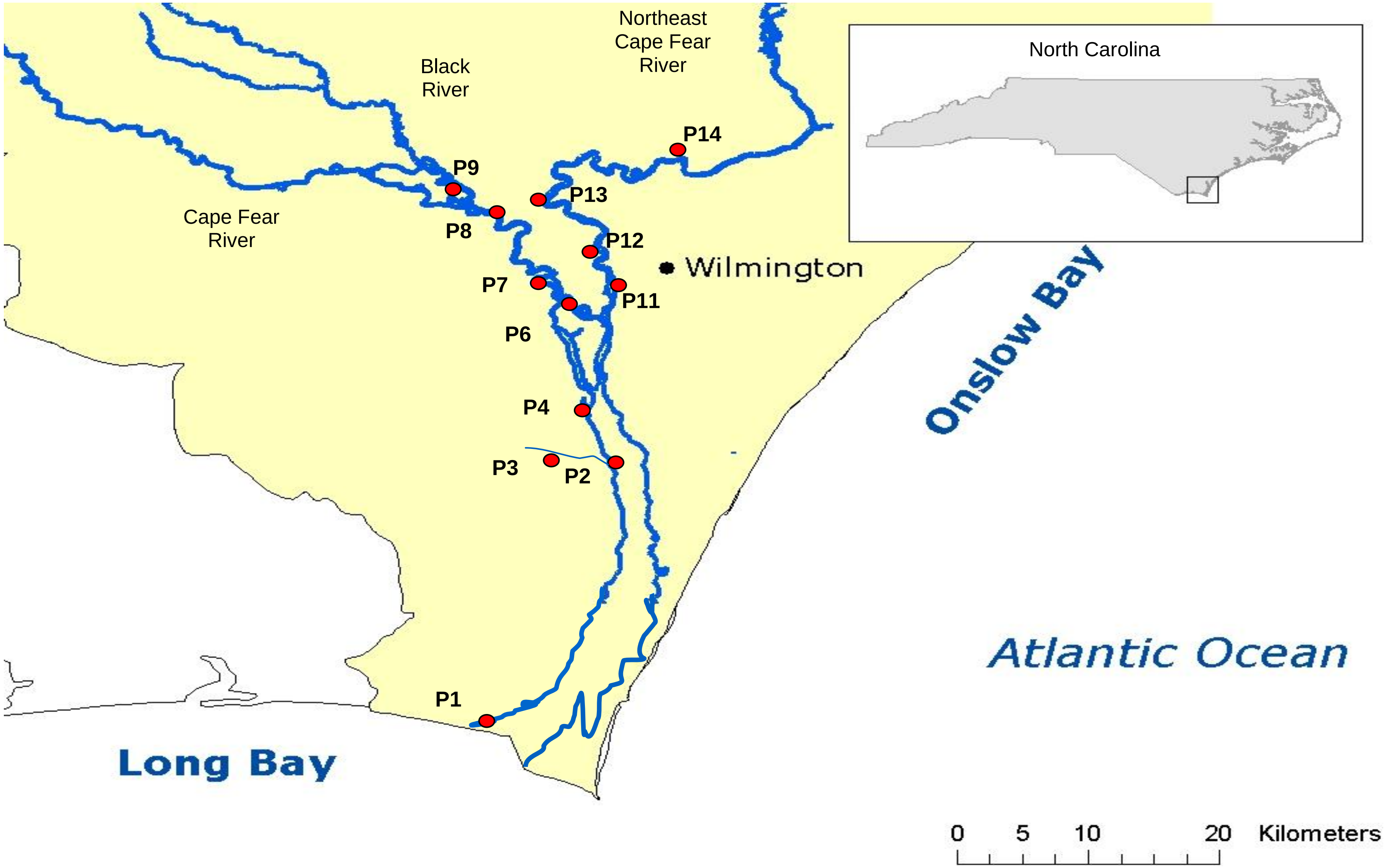
1.3 Ft Caswell (P1)

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. The total percentage of lost tides at this station (6.5 %) was lower than during the 2008-2009 reporting period (8.2%). Data collected at this station still show occasional irregularities in the shape of the water level curves, but these variations do not affect the reported minimum and maximum water level values (i.e. reported tidal range). The station was mostly affected by passing weather systems that caused erroneous data collection during high wind and wave action. These issues accounted for 6.0% of the lost tides. Monthly QA/QC checks and cleaning of probes and the well interior seem to prevent most minor problems before 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 can be noisy due to periods of what appear to be high frequency variations in water level. These episodes do not occur with any regular periodicity and are believed to be associated with nearby ship traffic. Nonetheless, maximum and minimum

Figure 1.2-1. Location of permanent stations on the Cape Fear River estuary and tributaries.



water levels can be identified and these data correspond well with data from P1. The percentage of lost tides at this station (23.5 %) was consistent with the previous reporting period (20.1%). During this reporting period, the majority of losses were associated with mechanical problems (16.4%), most likely caused by accretion of sediment around the stilling well. This DCP is located at the mouth of town creek and this has been an on-going problem for the last several years. The problem was particularly an issue in summer 2009; however, a stilling well cap installed in Sept 2009 solved the problem. Failure of the water level instrument and beaded cable also played a role in some of the mechanical problems. .

1.5 Inner Town Creek (P3)

This station typically exhibits few problems and this year was no exception. No data loss occurred due to station performance and all of the lost tides (6.5%) were due to lost tides at P1.

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 only a few problems over the reporting period.

1.7 Eagle Island (P6)

During this reporting period, data loss at this station improved over the 2008-2009 reporting period. This year's data loss is consistent with losses during the 2006-2007 and 2007-2008 reporting periods. The station exhibited few problems with the only losses occurring from mechanical issues (0.3%), lost data (0.3%), and QA/QC loss (0.1%),

1.8 Indian Creek (P7)

The under-ranging problem that has plagued this station over the last couple of years was a minor issue. Lost tides due to under-ranging accounted for only 0.3%, which is a vast improvement over previous years. The previous two reporting periods exhibited a large number of under-ranging events presumably due to clear cutting that occurred on the adjacent river edge and the accumulation of sediment around the well. This site continued to experience infrequent mechanical problems and QAQC water level resets, which resulted in a loss of less than 0.5% of total tides.

1.9 Dollisons Landing (P8)

The total loss of tides for this reporting period was 8.0%. The primary causes of data loss were mechanical errors and QAQC water level resets. These resulted in a loss of 1.5% of total tides.

1.10 Black River (P9)

Site P9 experienced a loss of 17.4% of total tides for the 2009-2010 reporting period, which is a slight increase over the last several reporting periods. Similar to previous years, data loss at the station was associated with mechanical errors (4.8%) associated with periodic river flooding that interrupted operation of the water level recorder. Data absences also were a major problem during this reporting period and caused a loss of 5.7% of total tides. During this reporting period (like all previous years), this station required many water level resets due to a gradual drift in the water level recorder (0.4%). However, the number of water level resets needed was less than the previous reporting period.

1.11 Smith Creek (P11)

The problems which were first seen in the 2008-2009 reporting period continue to affect station operation and the site experiences a high percentage of mechanical losses (4.1%). Data absences also were a problem and accounted for 5.7% of total tides. In addition, several QA/QC visits were needed to correct mechanical and data loss issues and these resulted in 1.1% of lost tides.

1.12 Rat Island (P12)

This station operated well during this reporting period. The total percentage of lost tides was only 9.4%, and most of these losses were associated with data loss (2.8%) due to the failure of the water level recorder on two separate occasions. A small number of QA/QC visits, required to reset failed equipment, also resulted in a small percentage (0.1%) of lost tides.

1.13 Fishing Creek (P13)

The percentage of lost tides at this site was comparable to the previous reporting period. This site continues to operate exceedingly well with a 0.3% loss of tides due to mechanical or other problems.

1.14 Prince George Creek (P14)

This station experienced few problems and showed a slight improvement over the 2008-2009 period. The total percentage of lost tides was only 8.5% compared to the previous period (11.5%). Similar to P9, this site is prone to water level equipment failures during major flooding events causing mechanical errors. However, mechanical errors during this reporting period (1.8%) were lower than the previous reporting period (3.2%). QA/QC visits at this site resulted in only a 0.2% loss of tides.

2.0 MONUMENT AND STATION SURVEY VERIFICATION

2.1 Summary

All of the elevation monuments are intact and stable. The subsite elevation monuments and primary monument at P7 appear to be intact following the 2008 extensive vegetation clearing by adjacent development. All of the sites, including P7, require future resurveying at the end of the project by professional surveyors to ensure we are relying on accurate NAVD88 elevations determined at the beginning of the study.

3.0 RIVER WATER LEVEL/SALINITY MONITORING

3.1 Summary

More than 1,400 tide ranges measured between 1 June 2009 and 31 May 2010 (Appendix A) were used to conduct analyses of changes in tidal amplitude as well as changes of ebb and flood duration. A good correlation between measured tidal range from the base station at Ft Caswell and the predicted tidal range for this station continues to exist. The mean tidal range at P1 was not significantly different from the mean reported in the previous monitoring period, but was significantly lower than the range reported in year 1. 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. Higher discharge rates appear to have influenced water level and tidal range this year; similar to what was observed in 2006-2007. All of the sites upstream of P4 exhibited a significant difference in yearly mean tidal ranges between this reporting period and 2008-2009. Mean tidal range at all of the sites except for P7 were significantly different from the mean tidal range reported in year one of monitoring. The observation that mean tidal range observed at P1 (Ft. Caswell) is again significantly less than in year 1 continues to complicate interpretation of the results as this station was initially expected to be unimpacted by river widening activities. Mean monthly maximum water levels were significantly different from the values reported for the previous monitoring period at six of the stations (P3, P7, P9, P12, P13, P14). Mean monthly minimum water levels also differed significantly from 2008-2009 at six stations (P3, P4, P11, P12, P13, and P14). 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 at all sites except P2, P7, P8 and P9). When the slopes from this reporting period were compared to slopes calculated for Year 1 (2000-2001), all sites exhibited a significantly different slope except for stations P3, P13, and P14.

With the exception of site P11 (which remained unchanged), the mean high tide lags changed at all sites this reporting period. P2, P4 and P6 exhibited decreases and the remaining stations exhibited increases. Changes in mean low tide lag were typically small, but usually reflected increases. Only site P11 showed a decrease, albeit very small, in low tide lag compared to values reported last year. During this reporting period, mean flood duration changed by less than 1% with some stations showing increases and others showing decreases. Mean ebb duration also changed very little and reflected decreases at all sites except for P2, P4, P6 and P12.

Periods of lower, drought-induced water levels and extreme flooding in the system over the last 5 years have contributed to differing tidal conditions in the Cape Fear and Northeast Cape Fear Rivers between monitoring years. As reported by Hackney et al (2001-2007), 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. This reporting period, the mean discharge was greater than the 30 year mean and was comparable to the mean discharge that existed during 2006-2007 (monitoring year 7). The differences in discharge rates between this project year and the previous year, may explain the larger number of differences in tidal attributes reported here.

Harmonic analysis of tidal constituents has continued during this reporting period. For all of the stations, the M2 component is the dominant constituent as expected. A longer water level time series exists at station P4, allowing for examination of tidal harmonics for several years prior to the initiation of dredging. Over the 13 year period between 1994 and 2009, however, neither the amplitude nor the phase of the M2 constituent has changed appreciably. For the most part, the amplitude of the M2 constituent at P4 has varied between 2.03 and 2.1 with this year's value being 2.1. As expected, the M2 amplitude at sites just upstream and downstream of P4 (e.g. P2, P6, and P11) are more similar to P4 than to other sites in the river. Like mean water level, changes in harmonic amplitude appear to be linked to variations in discharge.

For much of this reporting period, river discharge was higher than in the previous 2 years. Because drought conditions no longer existed, the higher salinities reported for upstream stations in previous reported were not observed. At the most upstream sites (P9 and P14) salinities were usually less than 0.2ppt. Only on two occasions (July 2009 and May 2010) did salinity meet or exceed 1ppt. These events occurred in the Northeast Cape Fear River. Interestingly, both of these months followed periods of slightly higher discharge recorded in the mainstem, however, the elevated salinities did not persist even though discharge presumably remained low. As described in the following sections, discharge data are not available for the Northeast Cape Fear to enable a direct comparison of salinity to discharge in the Cape Fear mainstem.

3.2 Database

Water level, conductivity, and temperature data collected at DCP stations from June 2009 through May 2010 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 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. 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), or pre-dredging, at every station except P7 and P12 where no year 1 data are available (Table 3.3-2). At eight of the twelve stations (all of which are upstream stations), the mean tidal range measured during this reporting period also was significantly different ($P<0.05$) than the means reported during the previous reporting period. This result differs from the 2008-2009 reporting period when one half of the stations showed such differences.

Yearly comparisons of mean monthly maximum and minimum water levels collected at the 11 DCP stations are shown in Table 3.3-3. Significant differences in mean monthly maximum water level between this reporting period and year 1 only were observed at all stations except P1 and P4. However, when mean monthly maximum water levels from this reporting period were compared to the 2008-2009 reporting period, water levels were significantly higher at stations P3, P7, P9, P12, P13 and P14. These results are very different than 2008-2009, when such differences were noted at only one site. When mean monthly minimum water levels for this reporting period were compared to year 1, the means also were significantly higher at stations P2, P3, P7, P9, P11, P13 and P14.

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. "XXX" indicates periods of extended data loss due to mechanical failure of water level instrument

		Salinity (ppt)			**Water Level (ft)**		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P1	Jun-09	33.4	0.6	32.8	3.81	-3.51	7.32
	Jul-09	45.2	28.3	16.9	2.89	-4.25	7.14
	Aug-09	40.0	10.4	29.6	2.42	-4.47	6.89
	Sep-09	34.2	0.3	33.9	3.37	-2.65	6.02
	Oct-09	33.8	13.1	20.7	2.84	-2.93	5.77
	Nov-09	34.4	0.6	33.8	3.55	-4.10	7.65
	Dec-09	32.0	0.3	31.7	3.05	-4.13	7.18
	Jan-10	35.1	5.7	29.4	2.17	-4.27	6.44
	Feb-10	27.1	0.1	27.0	2.83	-3.73	6.56
	Mar-10	29.7	0.4	29.3	2.44	-3.91	6.35
	Apr-10	45.7	1.3	44.4	2.26	-3.99	6.25
	May-10	42.6	0.3	42.3	1.92	-4.23	6.15

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P2	Jun-09	14.9	0.4	14.5	4.79	-1.92	6.71
	Jul-09	26.5	8.7	17.8	3.96	-1.43	5.39
	Aug-09	19.5	10.1	9.4	2.64	-2.90	5.54
	Sep-09	18.6	0.1	18.5	3.38	-1.22	4.60
	Oct-09	13.2	2.6	10.6	4.01	-2.23	6.24
	Nov-09	13.5	0.6	12.9	2.76	-3.97	6.73
	Dec-09	6.3	0.1	6.2	4.42	-2.58	7.00
	Jan-10	3.9	0.4	3.5	3.94	-2.67	6.61
	Feb-10	3.7	0.1	3.6	3.77	-2.71	6.48
	Mar-10	9.8	0.1	9.7	3.82	-2.77	6.59
	Apr-10	26.7	0.1	26.6	3.57	-2.71	6.28
	May-10	21.2	0.1	21.1	3.69	-2.83	6.52
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P3	Jun-09	9.8	0.2	9.6	2.37	-1.81	4.18
	Jul-09	15.2	0.1	15.1	2.01	-2.27	4.28
	Aug-09	13.7	0.2	13.5	2.03	-2.3	4.33
	Sep-09	19.0	0.1	18.9	2.34	-1.25	3.59
	Oct-09	15.8	0.3	15.5	2.25	-1.68	3.93
	Nov-09	17.3	0.1	17.2	2.87	-1.47	4.34
	Dec-09	2.5	0.1	2.4	2.61	-1.89	4.50
	Jan-10	10.0	0.4	9.6	2.40	-2.23	4.63
	Feb-10	0.1	0.0	0.1	2.36	-1.72	4.08
	Mar-10	3.6	0.1	3.5	2.18	-1.88	4.06
	Apr-10	9.3	0.1	9.2	2.09	-2.40	4.49
	May-10	11.7	0.2	11.5	2.01	-2.52	4.53
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P4	Jun-09	12.8	1.0	11.8	3.95	-2.72	6.67
	Jul-09	16.7	5.6	11.1	3.09	-3.24	6.33
	Aug-09	15.0	1.7	13.3	3.26	-2.99	6.25
	Sep-09	17.2	5.9	11.3	3.57	-2.05	5.62
	Oct-09	17.5	4.9	12.6	3.47	-2.64	6.11
	Nov-09	17.5	0.1	17.4	4.12	-2.50	6.62
	Dec-09	6.4	0.0	6.4	3.86	-3.29	7.15
	Jan-10	5.9	0.0	5.9	3.49	-3.27	6.76
	Feb-10	2.2	0.0	2.2	3.21	-3.36	6.57
	Mar-10	4.5	0.1	4.4	3.28	-3.46	6.74
	Apr-10	12.0	0.1	11.9	3.03	-3.33	6.36
	May-10	15.1	1.5	13.6	3.22	-3.34	6.56
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P6	Jun-09	12.6	0.1	12.5	3.48	-3.08	6.56
	Jul-09	17.5	0.1	17.4	3.08	-3.11	6.19
	Aug-09	17.9	0.1	17.8	3.26	-2.82	6.08
	Sep-09	19.6	0.1	19.5	3.45	-1.74	5.19
	Oct-09	18.7	0.1	18.6	3.34	-2.55	5.89
	Nov-09	18.5	0.1	18.4	3.99	-2.39	6.38
	Dec-09	4.8	0.0	4.8	3.75	-3.21	6.96
	Jan-10	5.8	0.0	5.8	3.49	-3.15	6.64
	Feb-10	1.3	0.0	1.3	3.20	-3.19	6.39
	Mar-10	5.2	0.0	5.2	2.90	-3.46	6.36
	Apr-10	11.2	0.0	11.2	2.72	-3.50	6.22
	May-10	15.5	0.1	15.4	2.90	-3.54	6.44
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
	Jun-09	3.3	0.1	3.2	3.83	-2.07	5.90
P7	Jul-09	10.4	0.1	10.3	3.11	-2.36	5.47
	Aug-09	4.2	0.1	4.1	3.22	-2.36	5.58
	Sep-09	9.4	0.1	9.3	3.46	-1.35	4.81
	Oct-09	11.9	0.1	11.8	3.35	-1.96	5.31
	Nov-09	12.3	0.1	12.2	4.21	-1.79	6.00
	Dec-09	0.1	0.0	0.1	4.04	-2.32	6.36
	Jan-10	0.1	0.0	0.1	3.90	-2.39	6.29
	Feb-10	0.1	0.0	0.1	4.16	-2.00	6.16
	Mar-10	0.1	0.0	0.1	3.48	-2.24	5.72
	Apr-10	1.2	0.0	1.2	3.39	-2.32	5.71
	May-10	6.6	0.0	6.6	3.28	-2.71	5.99

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P8	Jun-09	0.1	0.1	0.0	3.59	-1.64	5.23
	Jul-09	0.1	0.1	0.0	3.32	-1.97	5.29
	Aug-09	0.1	0.1	0.0	3.49	-1.76	5.25
	Sep-09	0.2	0.0	0.2	3.33	-1.76	5.09
	Oct-09	0.2	0.1	0.1	3.62	-1.52	5.14
	Nov-09	0.2	0.1	0.1	4.77	-0.95	5.72
	Dec-09	0.1	0.0	0.1	4.36	-1.38	5.74
	Jan-10	0.1	0.0	0.1	3.78	-2.15	5.93
	Feb-10	0.1	0.0	0.1	4.69	-1.32	6.01
	Mar-10	0.1	0.0	0.1	3.59	-1.51	5.10
	Apr-10	0.1	0.0	0.1	3.59	-1.96	5.55
	May-10	0.3	0.1	0.2	3.41	-2.32	5.73
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P9	Jun-09	0.1	0.1	0.0	3.82	-1.34	5.16
	Jul-09	0.1	0.1	0.0	3.26	-1.92	5.18
	Aug-09	0.1	0.1	0.0	3.23	-1.54	4.77
	Sep-09	0.1	0.1	0.0	3.63	-0.57	4.20
	Oct-09	0.1	0.1	0.0	3.75	-0.56	4.31
	Nov-09	0.1	0.1	0.0	3.76	-1.40	5.16
	Dec-09	0.1	0.0	0.1	3.93	-1.42	5.35
	Jan-10	0.1	0.0	0.1	3.91	0.14	3.77
	Feb-10	0.0	0.0	0.0	3.84	-0.58	4.42
	Mar-10	0.0	0.0	0.0	3.49	-1.26	4.75
	Apr-10	0.1	0.0	0.1	3.40	-1.73	5.13
	May-10	0.1	0.1	0.0	3.62	-1.85	5.47
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P11	Jun-09	9.5	0.1	9.4	3.95	-2.02	5.97
	Jul-09	15.4	1.0	14.4	3.68	-2.27	5.95
	Aug-09	12.5	0.1	12.4	3.12	-2.83	5.95
	Sep-09	14.4	0.1	14.3	3.80	-1.59	5.39
	Oct-09	16.5	0.1	16.4	3.49	-2.08	5.57
	Nov-09	15.8	0.1	15.7	4.31	-2.12	6.43
	Dec-09	2.6	0.1	2.5	3.36	-2.96	6.32
	Jan-10	17.1	0.2	16.9	3.35	-2.23	5.58
	Feb-10	0.1	0.0	0.1	2.99	-2.33	5.32
	Mar-10	3.3	0.0	3.3	3.12	-1.98	5.10
	Apr-10	8.6	0.1	8.5	2.61	-3.25	5.86
	May-10	20.0	0.1	19.9	3.85	-2.45	6.30
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P12	Jun-09	10.5	0.1	10.4	3.44	-2.12	5.56
	Jul-09	15.4	0.2	15.2	2.83	-2.65	5.48
	Aug-09	14.6	0.1	14.5	2.98	-2.48	5.46
	Sep-09	15.7	0.1	15.6	3.27	-1.53	4.80
	Oct-09	17.4	0.1	17.3	3.11	-2.03	5.14
	Nov-09	17.0	0.1	16.9	3.82	-1.88	5.70
	Dec-09	6.4	0.1	6.3	3.54	-2.47	6.01
	Jan-10	4.8	0.1	4.7	3.38	-2.58	5.96
	Feb-10	1.5	0.1	1.4	3.03	-2.42	5.45
	Mar-10	4.1	0.1	4.0	2.99	-2.50	5.49
	Apr-10	13.0	0.1	12.9	2.84	-2.69	5.53
	May-10	18.7	1.0	17.7	2.95	-2.75	5.70

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P13	Jun-09	4.9	0.1	4.8	2.96	-1.82	4.78
	Jul-09	11.5	0.2	11.3	2.46	-2.39	4.85
	Aug-09	1.8	0.1	1.7	2.61	-2.3	4.91
	Sep-09	6.7	0.1	6.6	2.87	-1.25	4.12
	Oct-09	9.0	0.1	8.9	2.73	-1.77	4.50
	Nov-09	9.8	0.0	9.8	3.38	-1.58	4.96
	Dec-09	0.4	0.0	0.4	3.20	-1.99	5.19
	Jan-10	0.1	0.0	0.1	3.15	-2.22	5.37
	Feb-10	0.1	0.0	0.1	2.92	-1.93	4.85
	Mar-10	1.3	0.0	1.3	2.61	-2.11	4.72
	Apr-10	5.0	0.1	4.9	2.41	-2.56	4.97
	May-10	10.1	0.2	9.9	2.43	-2.60	5.03
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P14	Jun-09	0.2	0.1	0.1	2.34	-1.26	3.60
	Jul-09	1.0	0.1	0.9	2.01	-1.86	3.87
	Aug-09	0.2	0.1	0.1	2.02	-1.84	3.86
	Sep-09	0.1	0.0	0.1	2.42	-0.83	3.25
	Oct-09	0.1	0.0	0.1	2.21	-1.25	3.46
	Nov-09	0.2	0.0	0.2	3.16	-1.00	4.16
	Dec-09	0.1	0.0	0.1	2.87	-1.04	3.91
	Jan-10	0.1	0.0	0.1	3.04	-1.37	4.41
	Feb-10	0.1	0.0	0.1	3.15	-0.46	3.61
	Mar-10	0.1	0.0	0.1	2.63	-0.86	3.49
	Apr-10	0.2	0.0	0.2	2.37	-1.62	3.99
	May-10	1.5	0.1	1.4	2.28	-1.76	4.04

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 ($P<0.05$). Years with different letter superscripts were significantly different. Asterisks denote where significant differences occurred between this reporting period and year 1 (2000-2001). Ampersands denote where significant differences exist between this reporting period and the previous reporting period (2008-2009). Note that the year 1 reporting period only included the period of October to May and all subsequent periods have included a complete calendar year (June-May). No data (NA) were available for year 1 for station P12.

Station	Significant	Effect (Year)
P1	*	1^{a} 9^{b} 10^{b}
P2	*	1^{a} 9^{b} 10^{b}
P3	*	1^{a} 9^{b} 10^{b}
P4	*	1^{a} 9^{b} 10^{b}
P6	*@	1^{a} 9^{b} 10^{c}
P7	@	1^{ab} 9^{a} 10^{b}
P8	*@	1^{a} 9^{a} 10^{b}
P9	*@	1^{a} 9^{b} 10^{c}
P11	*@	1^{a} 9^{b} 10^{c}
P12	@	NA 9^{a} 10^{b}
P13	*@	1^{a} 9^{a} 10^{b}
P14	*@	1^{a} 9^{a} 10^{b}

Table 3.3-3. 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. Additional yearly comparisons are available in previous reports (Culbertson et al., 2009; Hackney et al., 2008, 2007 etc.).

Station	Yr1/Yr10 Mean Monthly Maximum WL	Yr9/Yr10 Mean Monthly Maximum WL	Yr1/Yr10 Mean Monthly Minimum WL	Yr9/Yr10 Mean Monthly Minimum WL
P1	NS	NS	NS	NS
P2	*(0.0206)	NS	*(0.0108)	NS
P3	*(0.0447)	*(0.0179)	*(0.0033)	*(0.0404)
P4	NS	NS	NS	*(0.0303)
P6	*(0.0372)	NS	NS	NS
P7	*(0.0012)	*(0.0141)	*(0.0015)	NS
P8	*(0.0060)	NS	*(0.0026)	NS
P9	*(0.0055)	*(0.0350)	*(0.0004)	NS
P11	*(0.0069)	NS	*(0.0012)	*(0.0067)
P12	N/A	*(0.0376)	N/A	*(0.0261)
P13	*(0.0012)	*(0.0433)	*(0.0069)	*(0.0495)
P14	*(0.0043)	*(0.0022)	*(0.0026)	*(0.0111)

Tidal lags were determined by measuring the difference in time for high (or low) tide at 2 different stations as described in Hackney et al., (2001). All tidal lags were calculated relative to station P1 and are 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, both the high tide and low tide lag values were comparable to those reported in 2008-2009. The greatest difference between years occurred at station P9 where the mean high tide lag increased by 0.16 hr. During this reporting period, the mean flood duration and the mean ebb duration varied little ($\leq$ 0.26 %) from the previous reporting period (Table 3.3-4). Unlike the previous reporting period, changes in flood and ebb duration did not exhibit any consistent pattern.

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 (Hackney et al., 2007). 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 for the previous reporting period 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) ('08-'09 lag time)	Mean Low Tide Lag From P1 (hr) ('08-'09 lag time)
P01	4.22 ± 20.58%	6.28 (+0.02)	6.11 (-0.05)	N/A	N/A
P02	4.39 ± 15.39%	5.66 (-0.05)	6.73 (+0.05)	1.33 (1.38)	1.95 (1.93)
P03	2.68 ± 17.48%	6.66 (+0.26)	5.93 (-0.07)	3.15 (3.04)	2.96 (2.95)
P04	4.44 ± 15.57%	5.70 (-0.03)	6.70 (+0.04)	1.61 (1.65)	2.18 (2.02)
P06	4.31 ± 14.24%	5.88 (-0.03)	6.51 (+0.01)	2.18 (2.21)	2.56 (2.53)

Station Number	Mean Tidal Range (ft)	Mean Flood Duration (hr) *(% change)*	Mean Ebb Duration (hr) *(%change)*	Mean High Tide Lag From P1 (hr) ('08-'09 lag time)	Mean Low Tide Lag From P1 (hr) ('08-'09 lag time)
P07	3.72 ± 16.30%	5.86 (+0.05)	6.53 (-0.02)	2.63 (2.60)	3.05 (3.03)
P08	3.21 ± 21.14%	5.88 (+0.05)	6.51 (-0.05)	3.06 (3.00)	3.46 (3.45)
P09	2.82 ± 28.76%	5.91 (+0.10)	6.50 (-0.08)	3.51 (3.35)	3.90 (3.81)
P11	4.20 ± 14.41%	5.83 (-0.02)	6.55 (0.00)	2.21 (2.21)	2.63 (2.65)
P12	3.71 ± 14.04%	5.86 (-0.04)	6.53 (+0.03)	2.60 (2.57)	3.01 (2.95)
P13	3.07 ± 15.20%	5.93 (+0.02)	6.46 (-0.02)	3.12 (3.01)	3.47 (3.46)
P14	2.03 ± 25.52%	6.00 (+0.07)	6.40 (-0.06)	4.26 (4.18)	4.55 (4.53)

Statistical differences between tidal range values for upstream stations, before versus after channel deepening for specified tidal changes at the river mouth (P1) comprise one key approach to determining if the project has resulted in detectable changes in tidal range upstream. One assumption of this approach is that the tidal range at the base station at Ft Caswell (P1) is in equilibrium with open ocean tides and not subject to changes associated with dredging activities. To verify this condition, the observed tidal range at P1 for each reporting period is regressed against the predicted (astronomical) range. Analysis of Covariance (ANCOVA) is then used to determine if significant differences exist between the each yearly regression (i.e. slope). The tidal ranges observed at each upstream station are then regressed on the corresponding tidal range for P1. Comparisons of the resultant regression slopes are then conducted between subsequent reporting periods using ANCOVA ($P<0.05$). These results are shown in Table 3.3-4.

Table 3.3-5. 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/Y10 Regression Slope	Y9/Y10 Regression Slope

P2	*(0.0007)	NS
P3	NS	* (0.0002)
P4	* (<0.0001)	* (<0.0001)
P6	* (<0.0001)	* (0.0002)
P7	* (<0.0001)	NS
P8	* (0.0127)	NS
P9	* (0.0395)	NS
P11	* (<0.0001)	* (0.0196)
P12	N/A	* (<0.0001)
P13	NS	* (<0.0001)
P14	NS	* (0.0064)

3.4 Upstream Tidal Effects

Stations upstream of Point Peter are influenced more 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. The mean tidal range at P1 was not significantly different from the mean reported in the previous monitoring period, but was significantly lower than the range reported in year 1 (Table 3.3-2). There was no significant difference in either the mean monthly maximum and minimum water levels relative to last year's reporting period or relative to year 1 (Table 3.3-5). The mean tidal range at the Outer Town Creek (P2) site was also not significantly different from the mean reported in the previous monitoring period, but was significantly higher than the range reported in year 1 (Table 3.3-2). Figure 3.41-2 demonstrates that 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 not significantly different from the slope reported during the 2008-2009 reporting period (Table 3.3-5), but was significantly different from the slope measured in the first monitoring period ($P<0.0001$) at the $P<0.05$ significance level. Although tidal fluctuations at this station are strongly impacted by drought and flood events, P2 was not appreciably affected by climatological events this year as evidenced by the low range in water level variability ($r^2 = 0.93$).

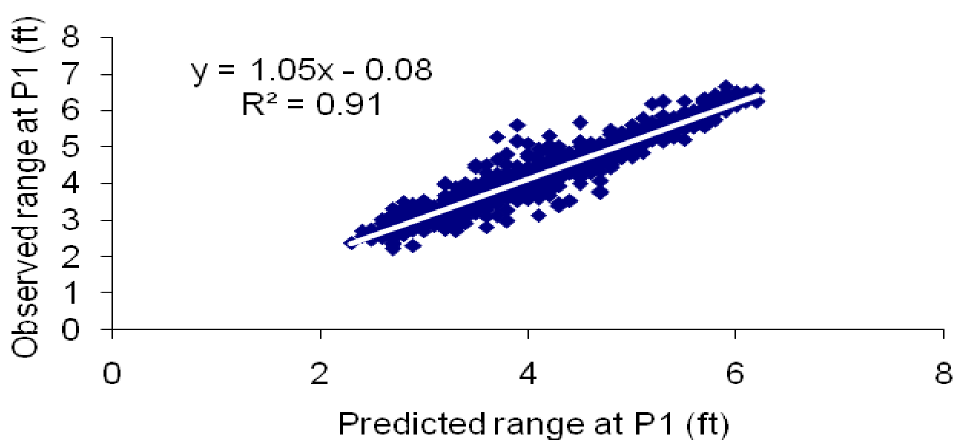


Figure 3.41-1. Plot of predicted tidal range at P1 relative to measured tidal range at P1 for June 2009 to May 2010.

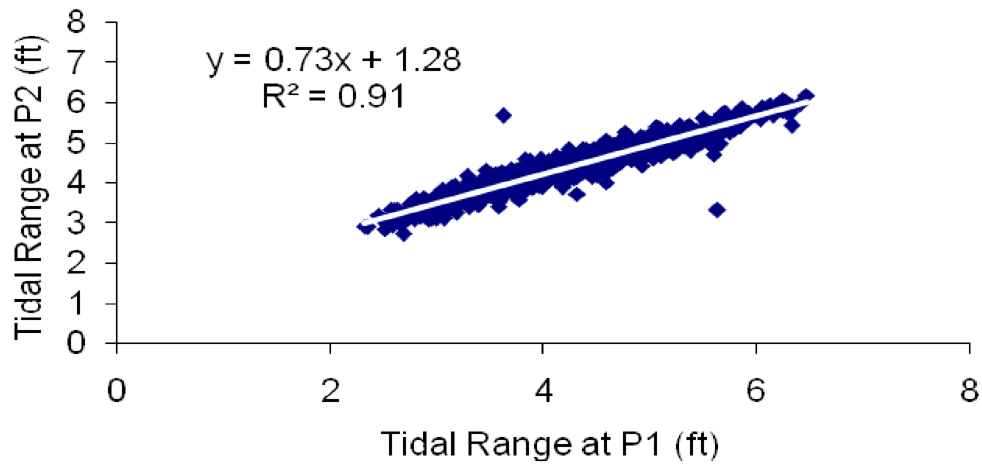


Figure 3.41-2. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Outer Town Creek (P2).

The water level curve at P1 continues to show less evidence of the time asymmetries measured at other stations based on the flood and ebb durations shown in Table 3.3-3. These asymmetries begin at site P2 and continue up river to all monitoring sites. Relative to the previous reporting period, the duration of flood tide decreased by 0.05% and the duration of ebb tide increased by 0.05% at site P2. Tidal lag at P2 changed little compared to the previous reporting period.

3.42 Inner Town Creek (P3)

The mean tidal range observed at P3 during this reporting period was approximately 1.3 feet less than the tidal range observed at the creek mouth (Table 3.3-4) and lower than the mean tidal ranges of all other sites except P14. This result is consistent with the results of the previous 5 reporting periods. The mean tidal range during this reporting period was significantly lower than the mean tidal range reported for year 1, but not different from the previous reporting period. The duration of mean flood increased slightly this reporting period whereas the mean ebb duration decreased slightly relative to the previous reporting period (Table 3.3-4). Both the mean monthly maximum water level and mean monthly minimum water level were significantly higher than year 1 and the previous reporting period (Table 3.3-3).

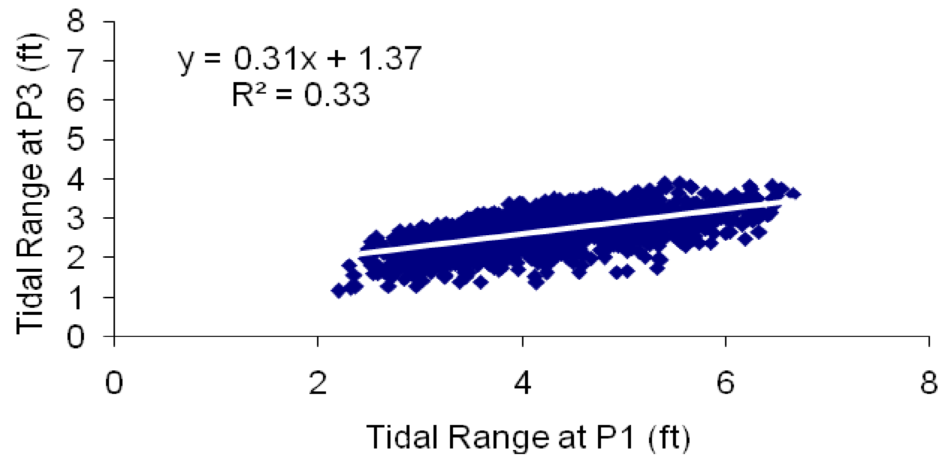


Figure 3.42-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Inner Town Creek (P3).

The correlation between tides at P3 and P1 this year was lower than the values reported in 2008-2009 ($r^2 < 0.57$). The slope of the P1 versus P3 regression for this monitoring period was significantly different from the slope reported in 2008-2009, but not significantly different from the slope reported for year 1 (Table 3.3-5).

3.43 Corps Yard (P4)

The mean tidal range observed at P4 is higher than the mean tidal range at the P1 base station (Table 3.3-4). The mean tidal range during this reporting period was not significantly different from the mean reported for 2008-2009, but significantly higher than the mean reported in year 1 (Hackney et al., 2001). The slope of the P1 versus P4 regression was significantly greater than the slope reported for the first monitoring period (Table 3.3-3), but significantly less than the slope reported last year. 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, 6.7 and 5.7 hours, respectively, are comparable to those reported previously. These durations have changed by less than 0.05% since the previous reporting period. The mean low tide lag has increased by approximately 7 minutes since the last reporting period and the mean high tide lag decreased slightly (Table 3.3-4). Mean maximum water levels at this station were not significantly different from those reported in 2008-2009 or year 1 (Table 3.3-3). Mean minimum water levels at this station were not different from year 1, but higher than the previous reporting period.

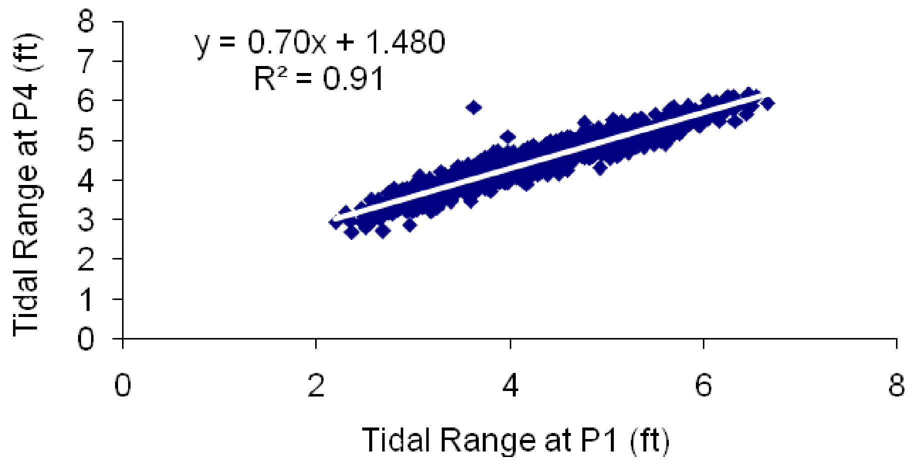


Figure 3.43-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and the Corps Yard station (P4).

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 lower than the mean determined for P1. Consistent with previous years, tidal range decreased with distance upriver (Table 3.3-4), with P9 exhibiting the lowest tidal range of these sites. Mean tidal range at mainstem stations were higher than the range observed at counterpart stations in the Northeast Cape Fear tributary. For all of the mainstem stations, the mean tidal range for this reporting period was significantly lower than the mean reported in 2008-2009 (Table 3.3-2). With the exception of site P7, the mean tidal ranges for this reporting period also were significantly different than means reported for these sites in year 1 (Table 3.3-2). Site P6 was significantly higher, while the remaining sites were significantly lower. There were no significant differences in mean monthly minimum water levels between this reporting period and 2008-2009 for any of the mainstem stations. The mean monthly minimum water level was significantly higher than year 1 values at all stations except P6. This result is consistent with previous reports. The mean monthly maximum water level for this reporting period was significantly higher than the year 1 value at all of the mainstem stations. When mean monthly maximum water levels for this year were compared to 2008-2009, significant differences existed only at sites P7 and P9 (Table 3.3-3).

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 mainstem stations and tidal range at Ft. Caswell (P1). In general, tidal range at each upriver site is positively correlated with tidal range at the mouth. During this reporting period, the r^2 values were appreciably lower than those reported in 2008-2009. This pattern likely reflected more periods of increased precipitation and generally higher discharge (Figure 3.5-1). Comparisons of the regression slopes between this reporting period and year 1 were significantly different at all of the mainstem sites (Table 3.3-5). This result is consistent with 2007-2008. With the exception of P6, which was significantly lower, all regression slopes for this reporting period were not significantly different from 2008-2009 (Table 3.3-5).

The mainstem upriver sites continue to exhibit pronounced time asymmetries as described in previous reports (e.g. Hackney et al., 2001, 2002, etc). In general, mean flood duration is less than mean ebb duration. The duration of a flood tide at these stations has changed little (by less than 0.1%), since the last reporting period. These changes reflect increases at all sites except P6 where flood tide duration decreased (Table 3.3-4). The duration of ebb tide also changed very little during this reporting period (also less than 0.1%). With the exception of P6, the duration of ebb tide decreased, *albeit* minimally, at all stations. The mean high tide lag from P1 increased slightly at all stations relative to the 2008-2009 reporting period except for P6, where a slight decrease was noted. Changes in mean low tide lag relative to the previous reporting period also reflected minimal increases (Table 3.3-4).

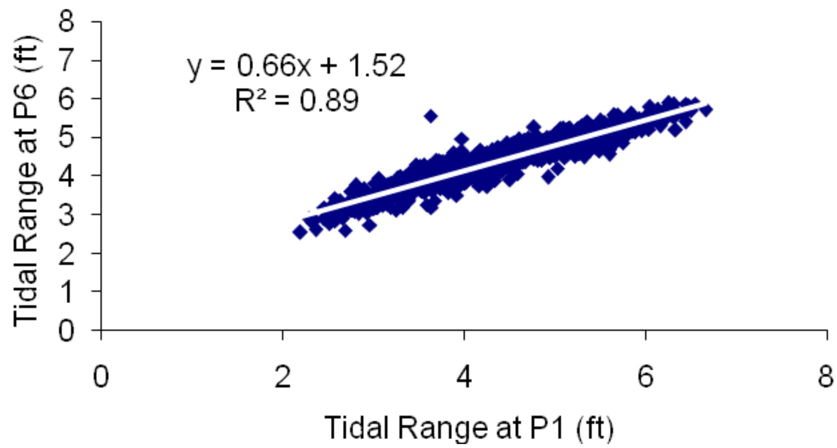


Figure 3.44-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Eagle Island (P6).

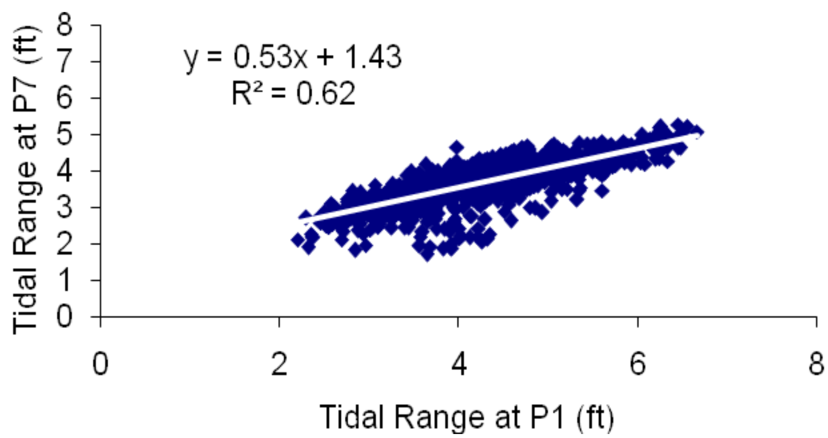


Figure 3.44-2**.** Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Indian Creek (P7).

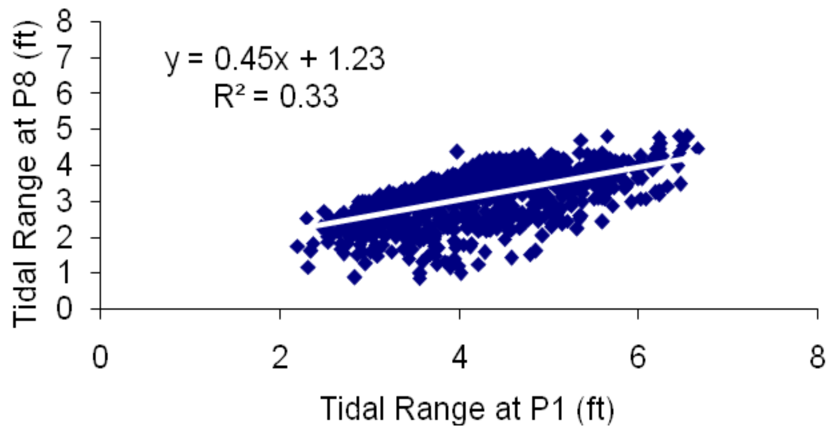


Figure 3.44-3. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Dollisons Landing (P8).

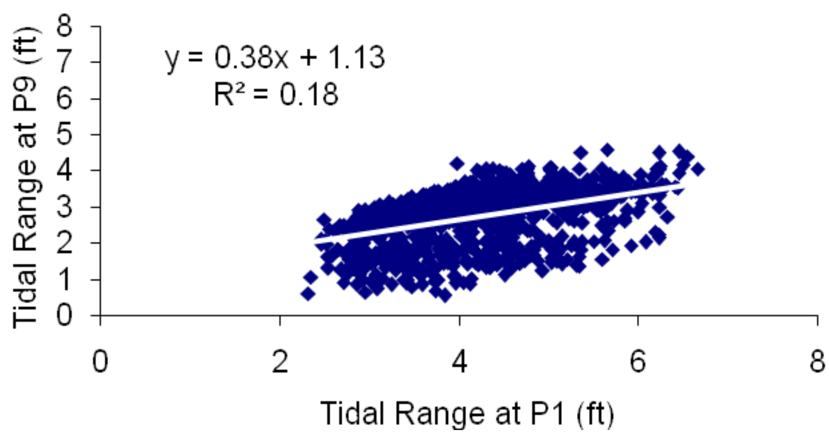


Figure 3.44-4. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Black River (P9).

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

The mean tidal ranges computed for Northeast Cape Fear River stations over the current reporting period were significantly different from those reported in 2008-2009 at all sites (Table 3.3-2). The mean tidal ranges also were significantly different than values reported in year 1 at all of these sites. The mean tidal range at site P11 was significantly higher, whereas the mean tidal range at sites P13 and P14 were significantly lower. A similar year 1 comparison is unavailable for site P12 due to an incomplete data set at that station during the first year of monitoring (see Hackney et al., 2001). These results are different from the previous annual report and may reflect higher discharge in the river. Although discharge data are no longer publically available for the Northeast Cape Fear, data collected on the Cape Fear mainstem indicates that, unlike last year, discharge increased to a mean exceeding the 30 year average

(Figure 3.5-1). Mean tidal ranges for all of the Northeast Cape Fear River stations decreased upstream and continued lower than the mean determined for P1 (Table 3.3-4). Both the mean monthly maximum and minimum water levels were significantly higher than year 1 values at all stations with available data (Table 3.3-3). The mean monthly maximum water levels at all sites were significantly higher than those reported in 2008-2009 at all sites except for P11 where no difference was measured. The mean monthly minimum water levels during this reporting period were significantly higher than 2008-2009 at all sites in the Northeast Cape Fear. All of the sites in the Northeast Cape Fear River continue to exhibit time asymmetries. Mean flood durations are shorter than ebb durations and show little change compared to 2008-2009 (Table 3.3-4). During this monitoring period, mean flood duration decreased slightly at P11 and P12, but increased slightly at P13 and P14 relative to the previous reporting period. Mean ebb duration did not change at P11, increased slightly at P12 and decreased slightly (<0.1%) at P13 and P14 during this reporting period (Table 3.3-4).

Tidal ranges at upstream stations in the Northeast Cape Fear were positively correlated with the tidal range at P1 (Figure 3.45-1, Figure 3.45-2, Figure 3.45-3, and Figure 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 miles from convergence on the Cape Fear River. Consistent with previous reports, 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 as suggested by the lower r^2 values for the most upstream stations and the lower r^2 values for this reporting period compared to last year's when discharge was lower (Figure 3.5-1 and Figure 3.5-2). Comparisons of the regression slopes between this reporting period and last year yielded significant differences at all sites. With the exception of the most upstream site (P11), no significant differences in slope existed when this reporting period was compared to year 1 (Table 3.3-4). As noted earlier and in previous reports, no year 1 data were available for P12 with which to make a similar comparison.

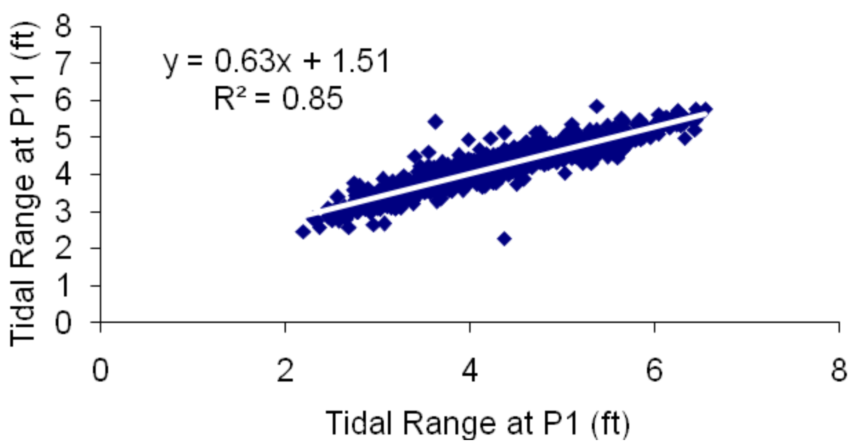


Figure 3.45-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Smith Creek (P11).

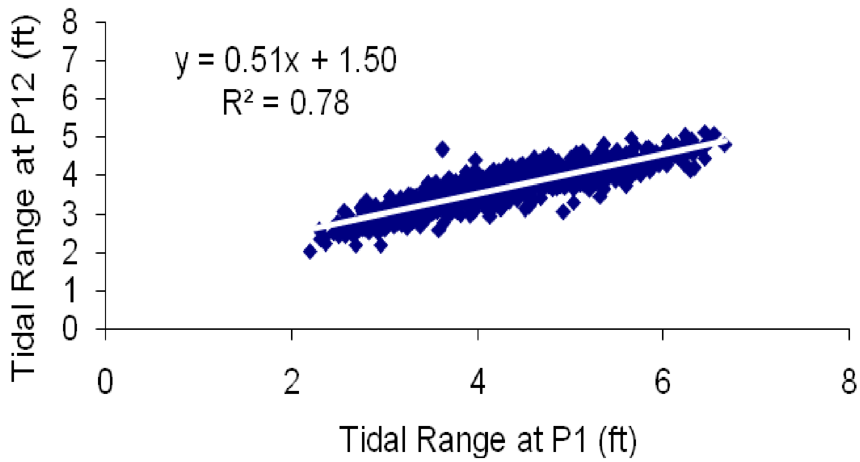


Figure 3.45-2. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Smith Creek (P12).

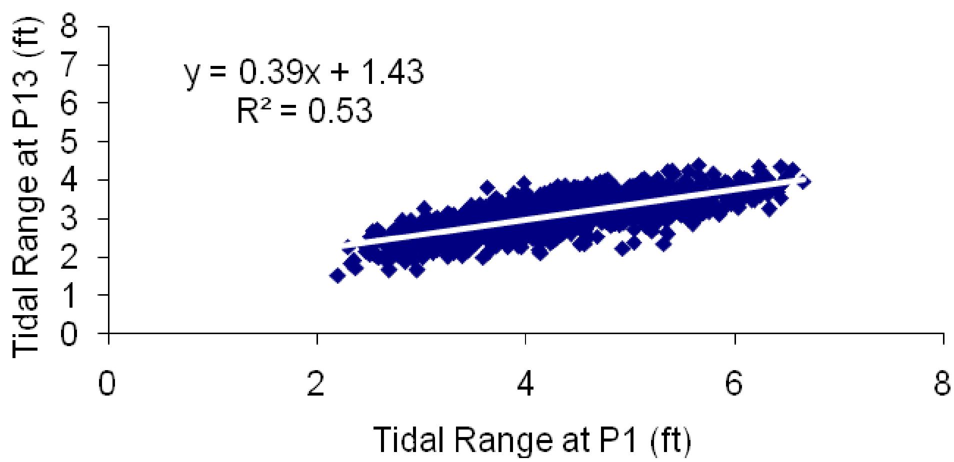


Figure 3.45-3. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Fishing Creek (P13).

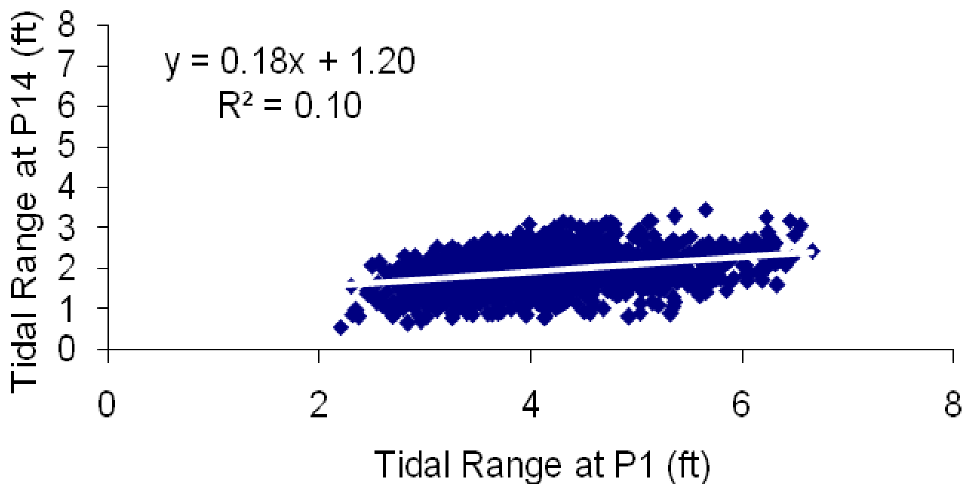


Figure 3.45-4. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Prince George Creek (P14).

3.5 Influence of Upstream Flow

Periods of lower, drought-induced water levels and extreme flooding in the system over the duration of this project 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). Interpretations related to discharge are also complicated by the fact that the discharge time series for the Northeast Cape Fear River is no longer available. During this reporting period, the mean discharge in the Cape Fear mainstem was higher than the 30 year average. These conditions contrast with the previous two reporting periods when discharge was less than the 30 year mean. The mean discharge for this reporting period is similar to the mean discharge reported for 2003-2004 and 2006-2007. These patterns in discharge may account for the number of differences in tidal characteristics noted between this reporting period and the previous reporting period. When only mean tidal ranges are considered, values reported during this period show better agreement with 2006-2007 (a similar discharge year) than with 2008-2009 (Table 3.5-1).

Table 3.5-1. Mean tidal ranges for upriver stations in both the Cape Fear River and Northeast Cape Fear River for this reporting period as well as 2008-2009 and 2006-2007.

Station Number	Mean Tidal Range (ft) This period	Mean Tidal Range (ft) 2008-2009	Mean Tidal Range (ft) 2006-2007
P6	4.31 ± 14.24%	4.38 ± 14.84%	4.29 ± 15.00%
P7	3.72 ± 16.30%	3.81 ± 14.03%	3.72 ± 16.53%
P8	3.21 ± 21.14%	3.50 ± 15.98%	3.21 ± 22.42%
P9	2.82 ± 28.76%	3.13 ± 20.83%	2.93 ± 24.35%
P11	4.20 ± 14.41%	4.28 ± 14.63%	4.17 ± 15.91%
P12	3.71 ± 14.04%	3.82 ± 14.80%	3.72 ± 14.46%
P13	3.07 ± 15.20%	3.24 ± 15.05%	3.13 ± 15.85%
P14	2.03 ± 25.52%	2.33 ± 19.26%	2.24 ± 20.06%

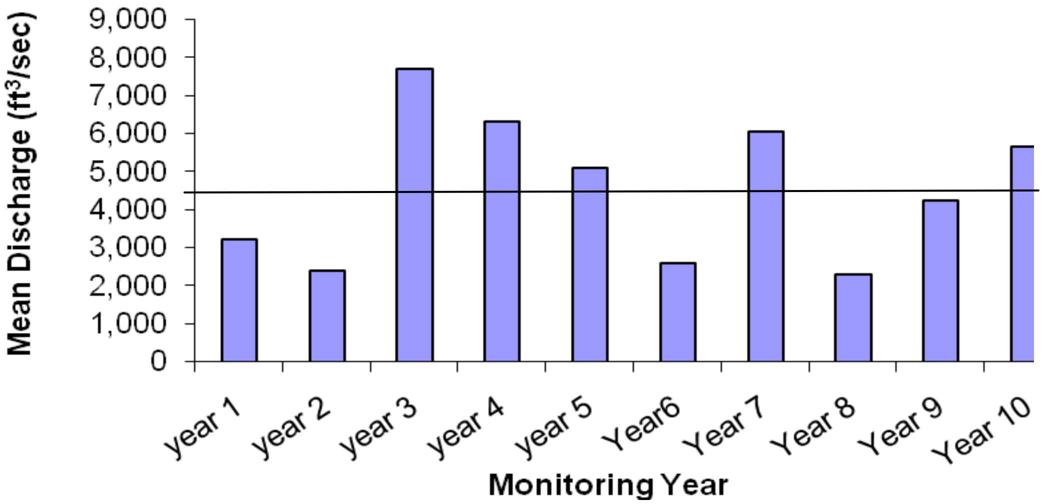


Figure 3.5-1. Mean discharge for each monitoring period. Monitoring year 1 is October 2000 to May 2001; monitoring year 2 in June 2001 to May 2002; monitoring year 3 is June 2002 to May 2003; monitoring year 4 is June 2003 to May 2004; monitoring year 5 is June 2004 to May 2005; monitoring year 6 is June 2005 to May 2006; and monitoring year 7 is June 2006 to May 2007. The line denotes the long-term mean discharge for the Cape Fear River as measured at Lock 1 by a USGS gauging station.

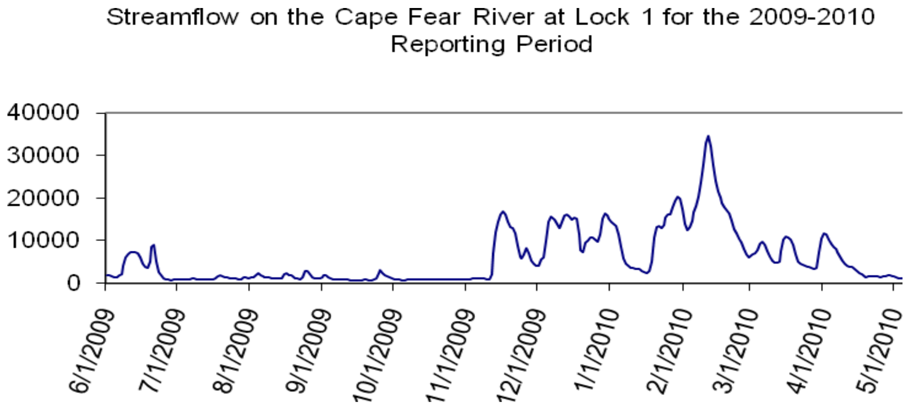


Figure 3.5-2. Plot showing discharge in the Cape Fear River at Lock 1 for the current monitoring period. Data available at http://nwis.waterdata.usgs.gov/nc/nwis site number 02105769.

3.6 Tidal Harmonics

Because tides are resonance phenomena, any changes in cross sectional area will affect propagation frequency such that some harmonic components may be altered to a greater or lesser degree. In the Cape Fear River, it is anticipated that the tidal amplitudes and phases of the six primary harmonics, as monitored and defined by the National Ocean Service of the National Oceanic and Atmospheric Administration, will change after dredging. By focusing on the primary harmonics for the Lower Cape Fear, we are attempting to resolve differences in water levels resulting from tides versus upstream inputs.

A classical tidal harmonics analysis was performed on each of the individual stations of the Cape Fear River Project using the MATLAB version of T-Tide (Pawlowicz *et al*., 2002). The relative phase and amplitude of the major frequencies in the measured 6-minute water level data have been determined with error estimates and a 95% confidence level. Constituents were considered significant if the signal-to-noise ratio was greater than 1. As in previous reports, the M2 component is the dominant constituent at every station (Table 3.6-1). These phase/amplitude data provide a compression of the data in the complete time series and will eventually be used to identify differences in tidal dynamics between the stations along the river that have been impacted by channel modification activities. Table 3.6-2 shows tidal harmonics for station P4 in 2009 and Figure 3.6-1 shows the tidal amplitude for years 1994 to present. Station P4 was selected because water level time series data were available for several years prior to the initiation of dredging activities and because harmonic constituents have been well-established. T-tide was used to determine the phase and amplitude of the dominant tidal constituents by year. While the relative dominance of the lesser constituents varied among years, the M2 component was the dominant constituent every year. Neither the amplitude nor the phase of the M2 constituent has changed appreciably. For the most part, the amplitude has varied between 2.03 and 2.09. Higher amplitudes were noted in 1997 (pre-dredging) and in 2003 and 2004 (during dredging modifications). Lower amplitudes occurred in 1994, 1995 and 1998 (prior to dredging activities) and again in 2001 and 2002 after dredging had been initiated. We have not yet established a pattern in amplitude change over the 11 year period examined; however, higher amplitudes tend to coincide with periods of higher river discharge. As expected, the M2 amplitude at sites P2, P6 and P11 (sites just upstream and downstream of P4) are more similar to the P4 M2 amplitude than other monitoring sites.

Table 3.6.1 Summary of tidal harmonics for reporting period 2009-2010. Errors shown represent the standard error association with each respective data set.

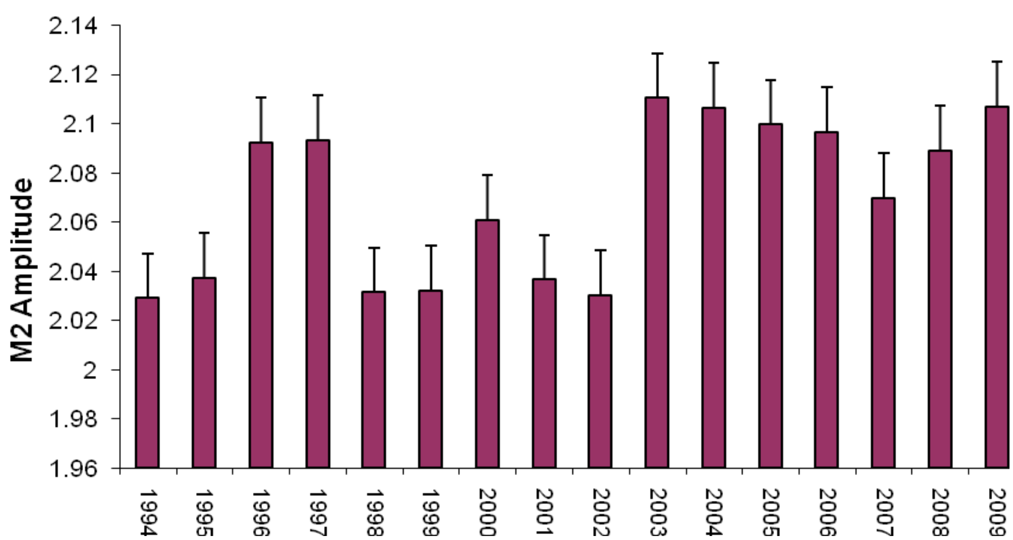
site	tide	amp	amp_err	pha	pha_err
P01	M2	1.9279	0.11	189.35	3.38
	N2	0.4214	0.085	172.94	12.44
	K1	0.3995	0.022	105.42	3.72
	S2	0.3884	0.103	224.27	16.75
	O1	0.2337	0.027	118.38	5.35
P02	M2	2.0328	0.032	34.89	1.06
	N2	0.4661	0.04	232.28	4.84
	K1	0.3192	0.044	351.04	7.32
	S2	0.2727	0.036	294.63	7.71
	O1	0.2131	0.045	91.16	11.46
P03	M2	1.2325	0.065	291.72	2.83
	K1	0.2581	0.021	173.7	3.86
	N2	0.2555	0.062	287.58	14.48
	O1	0.1798	0.02	194.16	6.51
	S2	0.0999	0.059	346.22	39.93
P06	M2	1.9982	0.04	279.97	1.16
	N2	0.4673	0.04	269.55	5.14
	K1	0.3716	0.025	155.75	3.42
	O1	0.2345	0.023	176.83	5.94
	S2	0.2059	0.038	324.16	9.98
P07	M2	1.7241	0.101	265.13	3.39
	K1	0.3483	0.022	152.28	4.83
	N2	0.294	0.098	248.22	18.86
	S2	0.2228	0.097	306.48	26.88
	O1	0.2193	0.026	173.38	7.14
P08	M2	1.5521	0.037	302.48	1.38
	N2	0.3384	0.041	293.16	7.08
	K1	0.3208	0.023	174.86	4.42
	O1	0.2225	0.024	196.16	6
	S2	0.1347	0.045	350.94	16.38
P09	M2	1.3561	0.105	293.08	4.03
	N2	0.3146	0.101	283.88	17.26
	K1	0.3096	0.03	173	5.04
	O1	0.2049	0.025	194.14	7.61
	S2	0.1345	0.088	339.71	45.05
P11	M2	1.8713	0.041	282.83	1.17
	N2	0.3139	0.04	273.08	5.97
	S2	0.2635	0.036	307.16	8.79
	K1	0.2512	0.04	153.4	8.63
	O1	0.2148	0.035	175.13	9.42
P12	M2	1.7006	0.077	281.92	2.91
	N2	0.3795	0.076	267.15	12.15
	K1	0.3272	0.024	160.25	4.58
	O1	0.209	0.024	180.97	7.93
	S2	0.1774	0.072	330.25	23.98
P13	M2	1.388	0.068	284.82	2.69
	K1	0.2848	0.023	167.03	4.9
	N2	0.2155	0.068	275.31	18.89
	O1	0.1843	0.022	188.51	7.9
	S2	0.1612	0.074	324.88	27

site	tide	amp	amp_err	pha	pha_err
P14	M2	0.7199	0.05	329.68	4.3
	K1	0.128	0.02	203.4	8
	O1	0.1103	0.018	216.33	9.09
	N2	0.1071	0.056	329.55	27.96
	S2	0.06	0.045	7.8	50.93

Table 3.6.2 Summary of yearly tidal harmonics for station P4 in 2009. Errors shown represent the standard error association with each respective data set.

year	tide	amp	amp_err	pha	pha_err
2009	M2	2.1072	0.018	273.55	0.48
	N2	0.4313	0.016	262.31	2.53
	K1	0.2959	0.016	144.12	3.24
	S2	0.2893	0.018	305.4	2.99
	O1	0.234	0.015	169.19	3.92

Figure 3.6-1. Plot of the amplitude of the M2 tidal constituent at station P4 from 1994 to present. Error bars represent the amplitude error.



4.0 MARSH/SWAMP FLOOD AND SALINITY LEVELS

4.1 Summary

Periods of lower, drought-induced water levels and extreme flooding in the system over the last 5 years have contributed to differing tidal conditions in the Cape Fear and Northeast Cape Fear Rivers between monitoring years. During this reporting period, the mean discharge in the Cape Fear mainstem was higher than during year 9 (2008-2009) and considerably above the 30 year average. The mean discharge for this reporting period was comparable to the mean discharge that existed during 2006-2007(monitoring year 7). The differences in discharge rates between this project year and the previous year, may explain the number of differences in salinity, flooding frequency, and duration.

The flooding frequency within swamps and marshes at a majority of the DCP stations was higher this year when compared to last year. This effect was more pronounced in the fall 2010 when the river discharge rates were below long-term mean discharge for the Cape Fear River (as measured at Lock 1 by a USGS gauging station). During spring 2010, flooding conditions were still greater than last year with 6 out of 9 stations exhibiting an increased number of flood events compared to the 2008-2009 monitoring period. Salinity levels in the fall also reflected the lower flow regimen. In fall 2009, salinity was detected at 5 out of the 9 stations. This pattern is similar to the previous fall (2008) sampling period during low flow conditions. Also similar to flood patterns, salinity measured in spring 2010 returned to levels comparable to previous years.

4.2 Data Base

Flood data collections went very smoothly this reporting year with only two exceptions, P6 (Eagle Island) and P13 (Fishing Creek) (Tables 4.2-1 and 4.2-2). Historically, station P6 has experienced erosion due to increased boat traffic from a boat manufacturing operation in Leland, North Carolina, as noted in last year’s report. Boats are tested at high speeds adjacent to P6 by a local manufacturer. The placement of instruments at subsite 1 at P6 has been abandoned due to this erosion, therefore no data (flood or salinity) were collected from fall 2007 to the present. At P13, subsite 6, equipment malfunction during the fall 09 sampling period caused loss of data.

Table 4.2-1. Flooding frequency, duration, depth, and actual water level of marsh/swamp stations during fall 2009. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to the NAVD88 datum. ND = No data

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 09	9/15/2009	9/29/2009	27/27	7.1	2.4	0.66	1.8
	2	Fall 09	9/15/2009	9/29/2009	27/27	7.3	2.3	0.83	1.5
	3	Fall 09	9/15/2009	9/29/2009	27/27	8.2	2.7	0.52	2.2
	4	Fall 09	9/15/2009	9/29/2009	27/27	7.9	2.2	1.49	0.7
	5	Fall 09	9/15/2009	9/29/2009	27/27	6.1	2.3	0.99	1.3
	6	Fall 09	9/15/2009	9/29/2009	24/27	4.6	4.6	3.31	1.2
P6	1	Fall 09	ND	ND	ND	ND	ND	ND	ND
	2	Fall 09	9/10/2009	9/24/2009	27/27	5.4	3.5	1.56	2.0
	3	Fall 09	9/10/2009	9/24/2009	27/27	7.2	3.6	0.85	2.7
	4	Fall 09	9/10/2009	9/24/2009	27/27	5.8	3.6	1.13	2.5
	5	Fall 09	9/10/2009	9/24/2009	27/27	4.9	3.8	1.92	1.9
	6	Fall 09	9/10/2009	9/24/2009	27/27	4.6	3.3	1.74	1.6
P7	1	Fall 09	10/8/2010	10/22/2009	25/27	5.2	3.4	1.76	1.6
	2	Fall 09	10/8/2010	10/22/2009	15/27	4.8	3.4	2.23	1.2
	3	Fall 09	10/8/2010	10/22/2009	13/27	3.9	3.3	2.26	1.0
	4	Fall 09	10/8/2010	10/22/2009	16/27	3.9	3.4	2.43	1.0
	5	Fall 09	10/8/2010	10/22/2009	11/27	4.6	3.2	2.31	0.8
	6	Fall 09	10/8/2010	10/22/2009	13/27	5.2	3.2	2.37	0.8
P8	1	Fall 09	12/1/2009	12/15/2009	26/27	5.2	3.7	2.14	1.6
	2	Fall 09	12/1/2009	12/15/2009	22/27	6.3	3.7	1.54	2.2
	3	Fall 09	12/1/2009	12/15/2009	25/27	6.9	3.7	1.46	2.2
	4	Fall 09	12/1/2009	12/15/2009	25/27	5.7	3.9	1.98	1.9
	5	Fall 09	12/1/2009	12/15/2009	20/27	4.9	3.6	2.24	1.3
	6	Fall 09	12/1/2009	12/15/2009	16/27	4.4	3.7	2.38	1.3
P9	1	Fall 09	10/22/2009	11/5/2009	27/27	7.4	3.0	0.58	2.4
	2	Fall 09	10/22/2009	11/5/2009	27/27	4.3	2.9	2.21	0.7
	3	Fall 09	10/22/2009	11/5/2009	16/27	3.1	2.2	1.22	1.0
	4	Fall 09	10/22/2009	11/5/2009	14/27	4.1	2.9	2.06	0.8
	5	Fall 09	10/22/2009	11/5/2009	7/27	5.7	2.8	2.20	0.6
	6	Fall 09	10/22/2009	11/5/2009	6/27	5.3	2.9	1.92	1.0
P11	1	Fall 09	9/24/2009	10/8/2009	27/27	4.9	3.3	1.44	1.9
	2	Fall 09	9/24/2009	10/8/2009	24/27	4.2	3.1	1.82	1.3
	3	Fall 09	9/24/2009	10/8/2009	27/27	4.0	3.5	1.76	1.8
	4	Fall 09	9/24/2009	10/8/2009	27/27	4.3	3.2	1.85	1.3
	5	Fall 09	9/24/2009	10/8/2009	25/27	4.1	3.1	1.91	1.2
	6	Fall 09	9/24/2009	10/8/2009	21/27	4.6	3.3	2.04	1.3

Table 4.2-1 (continued)

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	Fall 09	10/29/2010	11/12/2009	27/27	6.1	3.2	0.90	2.3
	2	Fall 09	10/29/2010	11/12/2009	27/27	4.8	2.7	1.62	1.1
	3	Fall 09	10/29/2010	11/12/2009	23/27	4.4	3.1	2.00	1.1
	4	Fall 09	10/29/2010	11/12/2009	21/27	5.0	2.5	1.90	0.6
	5	Fall 09	10/29/2010	11/12/2009	16/27	4.3	2.7	2.08	0.6
	6	Fall 09	10/29/2010	11/12/2009	13/27	4.3	3.0	2.44	0.5
P13	1	Fall 09	12/17/2009	12/31/2009	27/27	6.4	2.5	1.43	1.1
	2	Fall 09	12/17/2009	12/31/2009	27/27	6.0	2.7	1.08	1.6
	3	Fall 09	12/17/2009	12/31/2009	27/27	7.4	2.9	0.75	2.2
	4	Fall 09	12/17/2009	12/31/2009	27/13	7.5	3.4	1.00	2.4
	5	Fall 09	12/17/2009	12/31/2009	27/27	6.7	2.8	1.21	1.6
	6	Fall 09	ND	ND	ND	ND	ND	ND	ND
P14	1	Fall 09	12/16/2009	12/30/2009	27/27	8.7	3.0	0.70	2.3
	2	Fall 09	12/16/2009	12/30/2009	27/27	8.2	2.6	0.87	1.8
	3	Fall 09	12/16/2009	12/30/2009	27/27	7.7	2.6	1.08	1.5
	4	Fall 09	12/16/2009	12/30/2009	27/27	7.7	2.6	1.22	1.4
	5	Fall 09	12/16/2009	12/30/2009	27/27	6.9	2.6	1.28	1.3
	6	Fall 09	12/16/2009	12/30/2009	18/27	5.9	2.3	1.49	0.8

Table 4.2-2. Flooding frequency, duration, depth, and actual water level of marsh/swamp stations during spring 2010. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to the NAVD88 datum. ND indicates no data

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 10	3/2/2010	3/16/2010	27/27	5.8	2.0	0.66	1.3
	2	Spr 10	3/2/2010	3/16/2010	27/27	5.4	1.9	0.83	1.1
	3	Spr 10	3/2/2010	3/16/2010	27/27	6.0	1.9	0.52	1.4
	4	Spr 10	3/2/2010	3/16/2010	27/27	6.1	1.9	1.49	0.4
	5	Spr 10	3/2/2010	3/16/2010	27/27	4.7	1.8	0.99	0.9
	6	Spr 10	3/2/2010	3/16/2010	21/27	3.7	4.2	3.31	0.8
P6	1	Spr 10	ND	ND	ND	ND	ND	ND	ND
	2	Spr 10	4/28/2010	5/12/2010	20/27	4.9	3.0	1.56	1.4
	3	Spr 10	4/28/2010	5/12/2010	27/27	4.6	3.1	0.85	2.3
	4	Spr 10	4/28/2010	5/12/2010	19/27	6.0	3.1	1.13	1.9
	5	Spr 10	4/28/2010	5/12/2010	13/27	4.6	3.4	1.92	1.4
	6	Spr 10	4/28/2010	5/12/2010	10/27	6.1	2.9	1.74	1.2
P7	1	Spr 10	4/29/2010	5/13/2010	19/27	5.9	2.9	1.76	1.1
	2	Spr 10	4/29/2010	5/13/2010	4/27	7.5	2.7	2.23	0.5
	3	Spr 10	4/29/2010	5/13/2010	4/27	4.8	2.7	2.26	0.5
	4	Spr 10	4/29/2010	5/13/2010	6/27	5.6	2.8	2.43	0.4

Table 4.2-2 (continued)

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	5	Spr 10	4/29/2010	5/13/2010	5/27	4.6	2.8	2.31	0.5
(continued)	6	Spr 10	4/29/2010	5/13/2010	6/27	4.4	2.7	2.37	1.9
P8	1	Spr 10	5/12/2010	5/26/2010	19/27	4.2	3.0	2.14	0.9
	2	Spr 10	5/12/2010	5/26/2010	26/27	5.2	2.9	1.54	1.3
	3	Spr 10	5/12/2010	5/26/2010	27/27	5.2	3.1	1.46	1.6
	4	Spr 10	5/12/2010	5/26/2010	19/27	5.3	2.9	1.98	0.9
	5	Spr 10	5/12/2010	5/26/2010	12/27	5.6	2.9	2.24	0.6
	6	Spr 10	5/12/2010	5/26/2010	5/27	4.1	2.8	2.38	0.4
P9	1	Spr 10	5/13/2010	5/27/2010	27/27	6.4	3.0	0.58	2.5
	2	Spr 10	5/13/2010	5/27/2010	24/27	4.9	3.0	2.21	0.8
	3	Spr 10	5/13/2010	5/27/2010	19/27	4.7	3.0	1.22	1.7
	4	Spr 10	5/13/2010	5/27/2010	13/27	4.3	3.0	2.06	1.0
	5	Spr 10	5/13/2010	5/27/2010	3/27	5.8	2.9	2.20	0.7
	6	Spr 10	5/13/2010	5/27/2010	10/27	5.1	3.1	1.92	1.1
P11	1	Spr 10	3/25/2010	4/8/2010	27/27	4.1	2.7	1.44	1.2
	2	Spr 10	3/25/2010	4/8/2010	22/27	3.8	3.4	1.82	1.6
	3	Spr 10	3/25/2010	4/8/2010	22/27	4.2	3.5	1.76	1.8
	4	Spr 10	3/25/2010	4/8/2010	23/27	3.9	3.2	1.85	1.4
	5	Spr 10	3/25/2010	4/8/2010	19/27	3.7	3.1	1.91	1.2
	6	Spr 10	3/25/2010	4/28/2010	20/27	3.8	3.3	2.04	1.2
P12	1	Spr 10	4/8/2010	4/22/2010	27/27	4.2	2.3	0.90	1.4
	2	Spr 10	4/8/2010	4/22/2010	20/27	4.9	2.3	1.62	0.7
	3	Spr 10	4/8/2010	4/22/2010	8/27	3.4	2.3	2.00	0.3
	4	Spr 10	4/8/2010	4/22/2010	6/27	5.0	2.3	1.90	0.4
	5	Spr 10	4/8/2010	4/22/2010	5/27	6.2	1.9	2.08	-0.2
	6	Spr 10	4/8/2010	4/22/2010	2/27	5.7	2.2	2.44	-0.2
P13	1	Spr 10	4/7/2010	4/21/2010	27/27	5.8	1.9	1.43	0.5
	2	Spr 10	4/7/2010	4/21/2010	25/27	4.0	2.0	1.08	0.9
	3	Spr 10	4/7/2010	4/21/2010	27/27	4.4	2.0	0.75	1.3
	4	Spr 10	4/7/2010	4/21/2010	27/27	5.4	3.1	1.00	2.1
	5	Spr 10	4/7/2010	4/21/2010	27/27	4.2	1.5	1.21	0.3
	6	Spr 10	4/7/2010	4/21/2010	21/27	4.1	1.9	1.64	0.2
P14	1	Spr 10	3/18/2010	4/1/2010	27/27	7.7	2.5	0.70	1.8
	2	Spr 10	3/18/2010	4/1/2010	27/27	6.1	2.1	0.87	1.2
	3	Spr 10	3/18/2010	4/1/2010	27/27	5.8	2.3	1.08	1.3
	4	Spr 10	3/18/2010	4/1/2010	27/27	5.4	2.4	1.22	1.1
	5	Spr 10	3/18/2010	4/1/2010	27/27	4.9	2.3	1.28	1.0
	6	Spr 10	3/18/2010	4/1/2010	22/27	5.0	2.3	1.49	0.8

Table 4.2-3. Summary of salinity data from nine stations collected along the Cape Fear River and its tributaries in fall 2009. ND indicates no data

Station Number	Station Name	Substation Number	Fall 2009 Salinity Range (ppt)	Proportion of flood events containing > 1 ppt salinity
P3	Town Creek	1	<1 - 21	27/27
		2	<1 - 13	27/27
		3	<1 - 15	27/27
		4	<1 - 19	27/27
		5	<1 - 15	27/27
		6	<1 - 17	27/27
P6	Eagle Island	1	ND	ND
		2	<1 - 14	27/27
		3	<1 - 15	27/27
		4	<1- 14	27/27
		5	<1 - 12	27/27
		6	<1 - 10	27/27
P7	Indian Creek	1	<1 - 5	14/27
		2	<1	0/27
		3	<1 - 2	2/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P9	Black River	1	<1	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P11	Smith 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
P12	Rat Island	1	<1 - 10	18/27
		2	<1 - 8	20/27
		3	<1 - 6	19/27
		4	<1 - 7	18/27
		5	<1 - 7	18/27
		6	<1 - 6	20/27
P13	Fishing Creek	1	<1 - 17	27/27
		2	<1 - 13	26/27
		3	<1 - 11	23/27
		4	<1 - 9	18/27
		5	<1 - 7	12/27
		6	<1 - 7	12/27

Station Number	Station Name	Substation Number	Fall 2009 Salinity Range (ppt)	Proportion of flood events containing > 1 ppt salinity
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 stations collected along the Cape Fear River and its tributaries in spring 2010. ND indicates no data.

Station Number	Station Name	Substation Number	Spring 2010 Salinity Range (ppt)	Proportion of flood events containing > 1 ppt salinity
P3	Town Creek	1	<1 - 2	1/27
		2	<1	0/27
		3	<1 - 1	0/27
		4	<1 - 1	0/27
		5	<1 - 1	0/27
		6	<1 - 1	0/27
P6	Eagle Island	1	ND	ND
		2	<1 - 7	14/27
		3	<1 - 12	18/27
		4	<1 - 8	18/27
		5	<1 - 8	11/27
		6	<1 - 5	4/27
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	Dollison's 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	0/27
		2	<1	0/27
		3	<1	0/27
		4	<1	0/27
		5	<1	0/27
		6	<1	0/27
P11	Smith Creek	1	<1 - 4	10/27
		2	<1 - 4	10/27
		3	<1 - 4	10/27
		4	<1 - 4	10/27

Table 4.2-4 (continued)

Station Number	Station Name	Substation Number	Spring 2010 Salinity Range (ppt)	Proportion of flood events containing > 1 ppt salinity
		5	<1 - 4	10/27
		6	<1 - 4	10/27
P12	Rat Island	1	<1 - 6	10/27
		2	<1 - 4	7/27
		3	<1 - 3	6/27
		4	<1 - 2	1/27
		5	<1	0/27
		6	<1 - 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

4.3 Marsh/Swamp Flooding

A majority of the stations showed an increase in the number of flood events this year when compared to last year (Figures 4.3-1 and 4.3-2). This effect was more pronounced in the fall sampling season (when all 9 stations had an increased number of flood events) than in the spring (Tables 4.2-1 and 4.2-2). For example, at station P6 the number of flood events at all subsites reached 27/27 during the fall 2009 season (Table 4.2-1). During the spring sampling season, subsite P6 reached the maximum number of flood events (27/27) at only one of the subsites (Table 4.2-2). The overall average number of flood events per sampling period was greater in fall 2009 (23/27) than in fall 09 (19/27). During spring 2010, six out of nine stations recorded a higher mean number of flooding events than the previous year, spring 2008. Overall, the average number of flood events was similar during spring 2009 and spring 2008 with approximately 19 flood events per 27 possible.

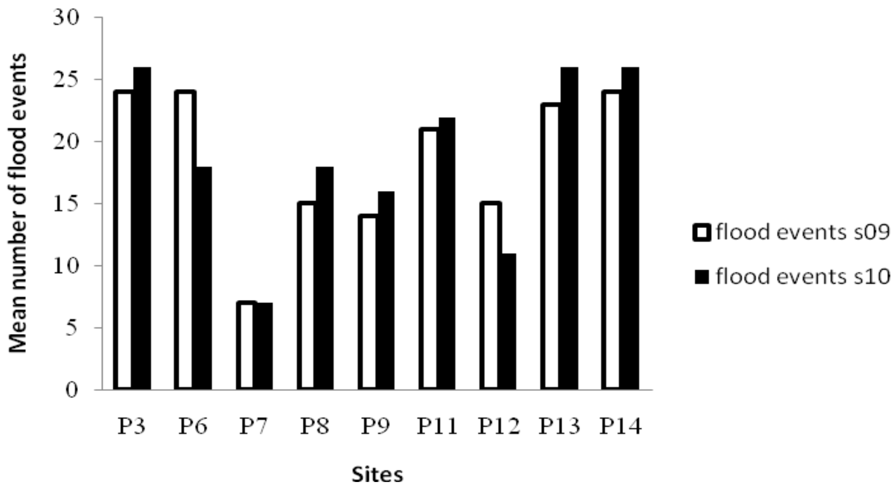


Figure 4.3-1 Average number of flood events (27 max) for spring 2010 and spring 2009

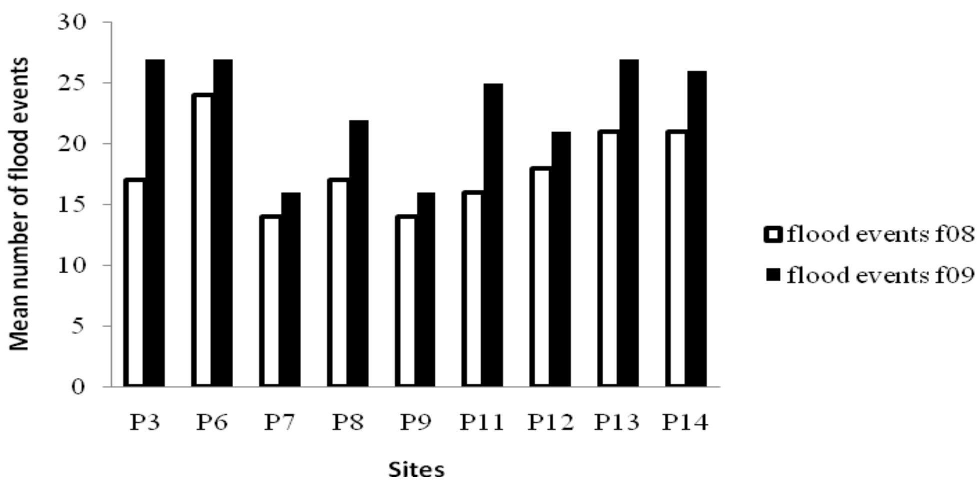


Figure 4.3-2 Average number of flood events (27 max) for fall 2009 and fall 2008

The mean discharge rate from Lock and Dam #1 appreciably increased during the monitoring period, from February-March 2010. This spike in river flow occurred just prior to our spring sampling season. The mean flood duration (of all subsites) increased during the spring 2010 season at all but one station (P11) (Figure 4.3-3). The mean flood duration of all stations and subsites in spring 2010 was 5.2 hours, which is greater than the mean flood duration for the previous year, spring 2009, which was 4.7 hours. This increase in flood duration was also seen in the fall sampling period (fall 2009) with seven out of nine stations recording either the same or an increase in the mean flood duration (Figure 4.3-4). The mean flood duration of all stations and subsites in fall 2009 was 5.7 hours, which is greater than the mean flood duration for the previous year, fall 2008, which was 5.1 hours.

These data are collected for two-week periods, but all stations are not collected during the same two-week time frame. Typically, each two-week period includes either a new moon or full moon tide, which usually produced water levels higher than the mean water level at each site. There was no attempt to schedule these two-week collection periods with high or low river flow so it is not unusual for any one station to have a lower frequency of flooding from chance alone.

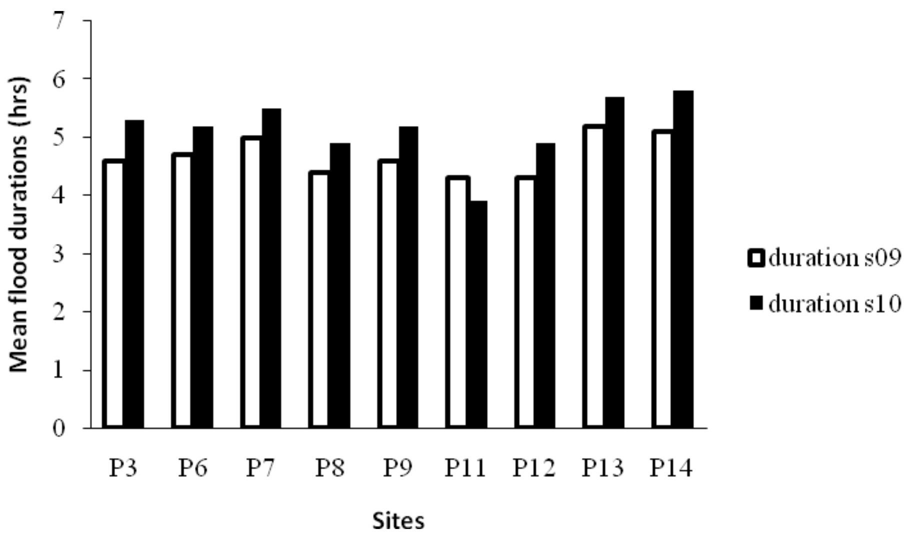


Figure 4.3-3 Mean flood durations (hours) for spring 2010 and spring 2009

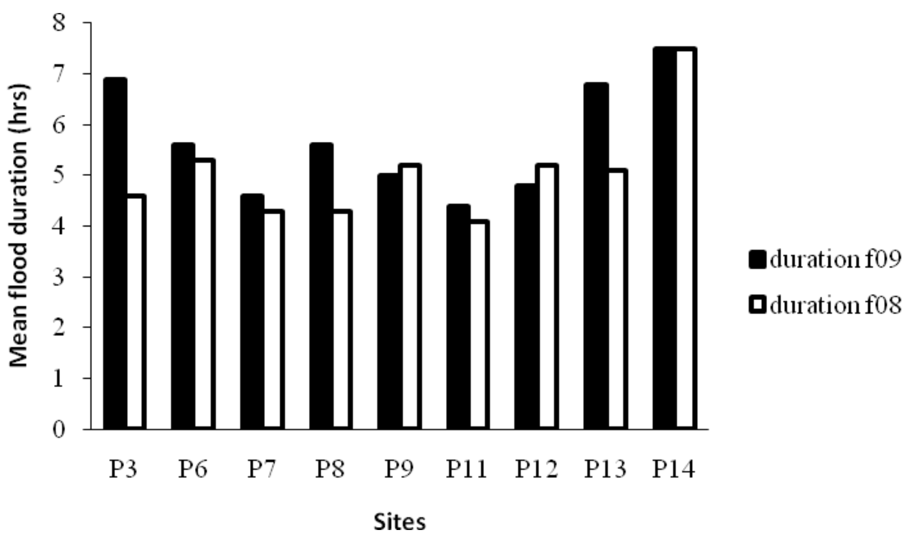


Figure 4.3-4 Mean flood durations (hours) for fall 2009 and fall 2008

4.4 Water Salinity in Marshes and Swamps

Salinity of surface water flooding swamps and marshes reflected the overall state of river flows relative to previous reporting periods. The mean discharge at Lock and Dam 1 for this reporting period is similar to the mean discharge reported for 2003-2004 and 2006-2007. The discharge for the monitoring period was higher than the overall mean discharge for the past 10 years and higher than last reporting year's (2008-2009) mean discharge. In fall 09, when the discharge was lower than the yearly average, saline water was detected on the marsh/swamp surface at five of the nine sampling stations (P3, P6, P7, P12, and P13) (Table 4.2-3). The highest salinity measured during this time period was 21 ppt at station P3 (Table 4.2-3). By spring 2010, saline water was only measured at four of the nine stations, with a lower salinity max of 12 ppt at station P6 (Table 4.2-4). This decrease in salinity along the marsh surface could be attributed to the spike in river discharge that occurred early in the spring (February – March 2010) (Figure 3.5-2).

5.0 MARSH/SWAMP BIOGEOCHEMISTRY

5.1 Summary

Geochemical data were collected at nine stations along the Cape Fear River Estuary beginning in winter of 2000. Data from the winters of 2000-2008 and the summers of 2000-2007 was presented in the previous annual reports for this project (CZR Incorporated 2001; Hackney et al. 2002a, 2002b, 2003, 2005, 2006, 2007; and Culbertson et al., 2008, 2009, 2010). Data presented in the current report includes winter 2010 and summer 2009. 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). Classifications were compared to the previous data for these sites.

The current year was generally slightly saltier compared to the average year, but not as salty as the low flow year at Indian Creek (P7), Black River (P9), Rat Island (P12), Town Creek (P3), and Eagle Island (P6). Fishing Creek (P13) and Prince George (P14) had conditions that were similar to the low flow year. Dollisons Landing (P8) and Smith Creek (P11) did not show any trends towards either saltier of fresher conditions.

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, methanogens are replaced by sulfate reducing bacteria 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 all nine marsh/swamp stations of the present study 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, which may also indicate oxidation of hydrogen sulfide in the porewaters. The four main classifications are: 1) sulfate reducing (SR), 2) methanogenic (M), 3) methanogenic with evidence of past sulfate reduction (MPSR) and 4) 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 chloride 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. The six substations along each transect represent a transition along a different scale, well-flooded to less flooded.

The first seven reports of this monitoring project provided enough information to establish what will be referred to as an "average year". On the basis of the first seven reports and river flow data, the authors have established the report year four (Hackney et al., 2005) as a year representing average conditions. This year will be referred to as the "average year" in this report. Year three (Hackney et al., 2004) has been identified as a low river flow year representing a year with high salinity intrusion into the monitoring sites and will be referred to as the "low river flow year" in the current report. The current year's data will be compared to the average year and the low river flow year to put the current year's data in perspective.

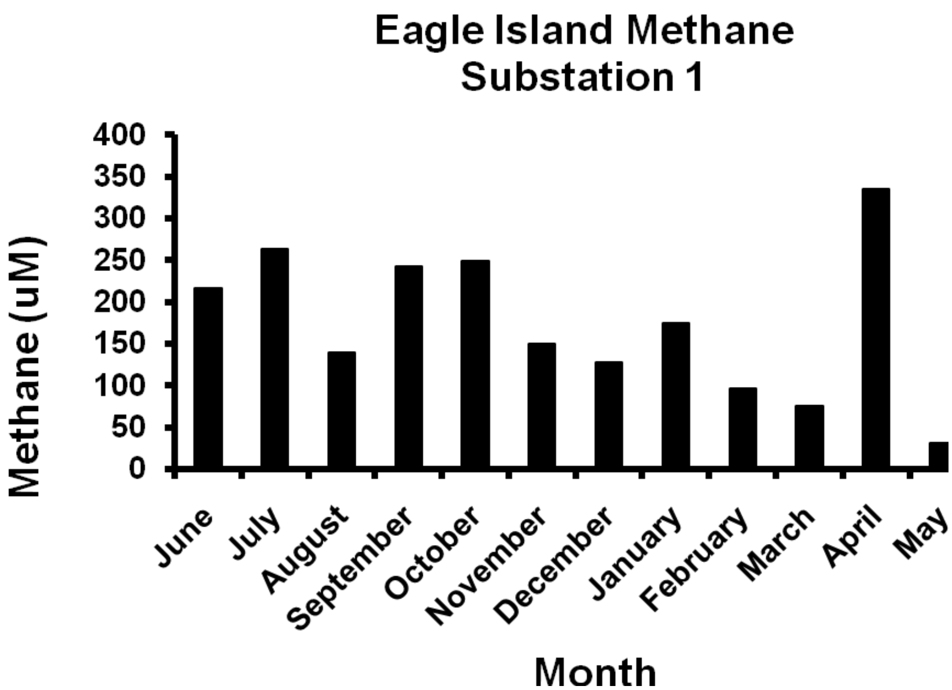
5.4 Eagle Island (P6) Annual Cycles of Sulfate, Chloride, and Methane

Eagle Island's previous and current general classifications are based on the following observations: 1) Methane is typically present at depth in all substations, but is often at very low concentrations at the surface during times of high sulfate input (Figure 5.4-1), 2) Sulfate concentrations range from below the sulfate reducing threshold of 300 µM indicating methane production, to as high as 1500 µM indicating sufficient sulfate to support sulfate reduction (Figure 5.4-2). The ratio of chloride to sulfate range from those found in seawater to ratios indicating a depletion of sulfate due to sulfate reduction (Figure 5.4-3). Some lower ratios also occur, possibly indicating oxidation of hydrogen sulfide from previous sulfate reduction.

Salinity values at Eagle Island during the average year (Hackney et al., 2005) were typically less than 1.5 ppt at the creekbank location S1 and less than 0.1 ppt at the upland site S6. The low river flow high salinity year (Hackney et al., 2004) had salinity values as high as 14 ppt at S1 and 8 ppt at S6. The salinity values observed during the current year were similar to the average year at S1 ranging from approximately 0.02 – 1.6 ppt and slightly above average at S6 ranging from 0.1 to 0.6 ppt S6 (Figure 5.4-4). Sulfate concentrations during the current year (approximately 30 -1000 µM at S1 and 0 – 500 µM at S6) were similar to those measured during the average year at S1 (200-1000 µM) and values obtained for S6 during the average year (100-500 µM). The Chloride to sulfate ratios were at or above those expected for seawater for the majority of the months at S1 and above at S6. Ratios near that of seawater indicate a recent resupply of sea salts, while those above the chloride to sulfate ratio indicate active sulfate reduction.

Average year methane concentrations vary, but typically reach values approaching 400µM. During the low river flow year, methane concentrations were <70µM. During the current year methane concentrations were approximately 30-340 µM at S1 and ranged between 140 – 400 µM at S6 (Figure 5.4-1). The higher levels of methane at S1 and S6 are consistent with less resupply of sulfate and an average river flow year. The sulfate was not resupplied often by subsequent floodwaters resulting in the shift to methanogenesis following depletion of sulfate to the threshold concentration.

The classifications of Eagle Island during the current year (Table 5.4-1) are consistent with an average year where the majority of the classifications were methanogenic with evidence of past sulfate reduction (MPSR) (Hackney et al., 2005). This is consistent with an occasional pulse of relatively low salinity water followed by temporary sulfate reducing conditions until the sulfate is reduced to threshold concentration. After the low levels of sulfate are depleted, the site returns to methanogenic conditions recording in the sediments evidence of the prior sulfate reduction in the chloride to sulfate ratios. During the low flow year, classifications were evenly divided between sulfate reducing and MPSR (Hackney et al., 2004).



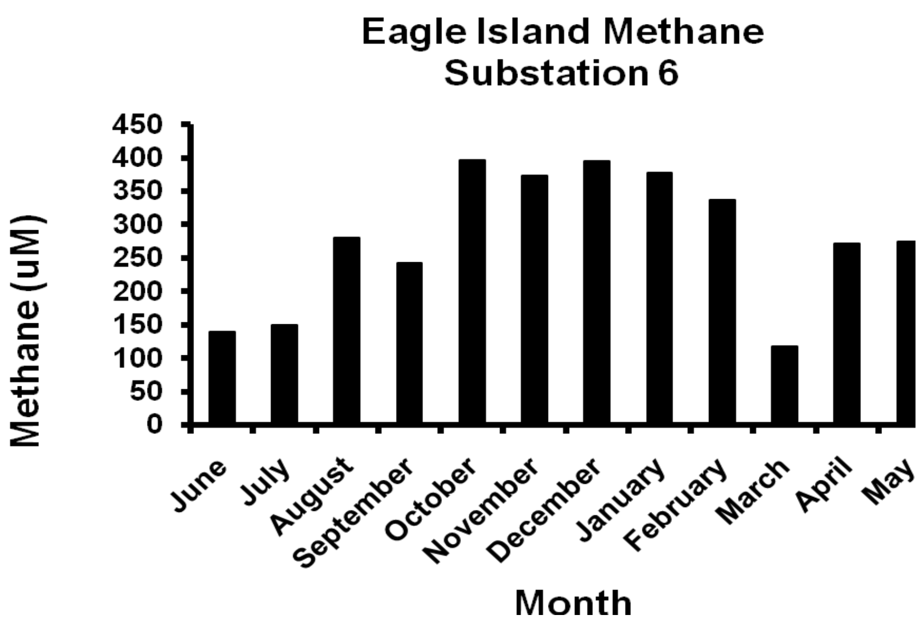


Figure 5.4-1. Methane concentrations of Eagle Island porewaters vs. month. Top shows nearshore site (S1) and bottom shows most upland site (S6).

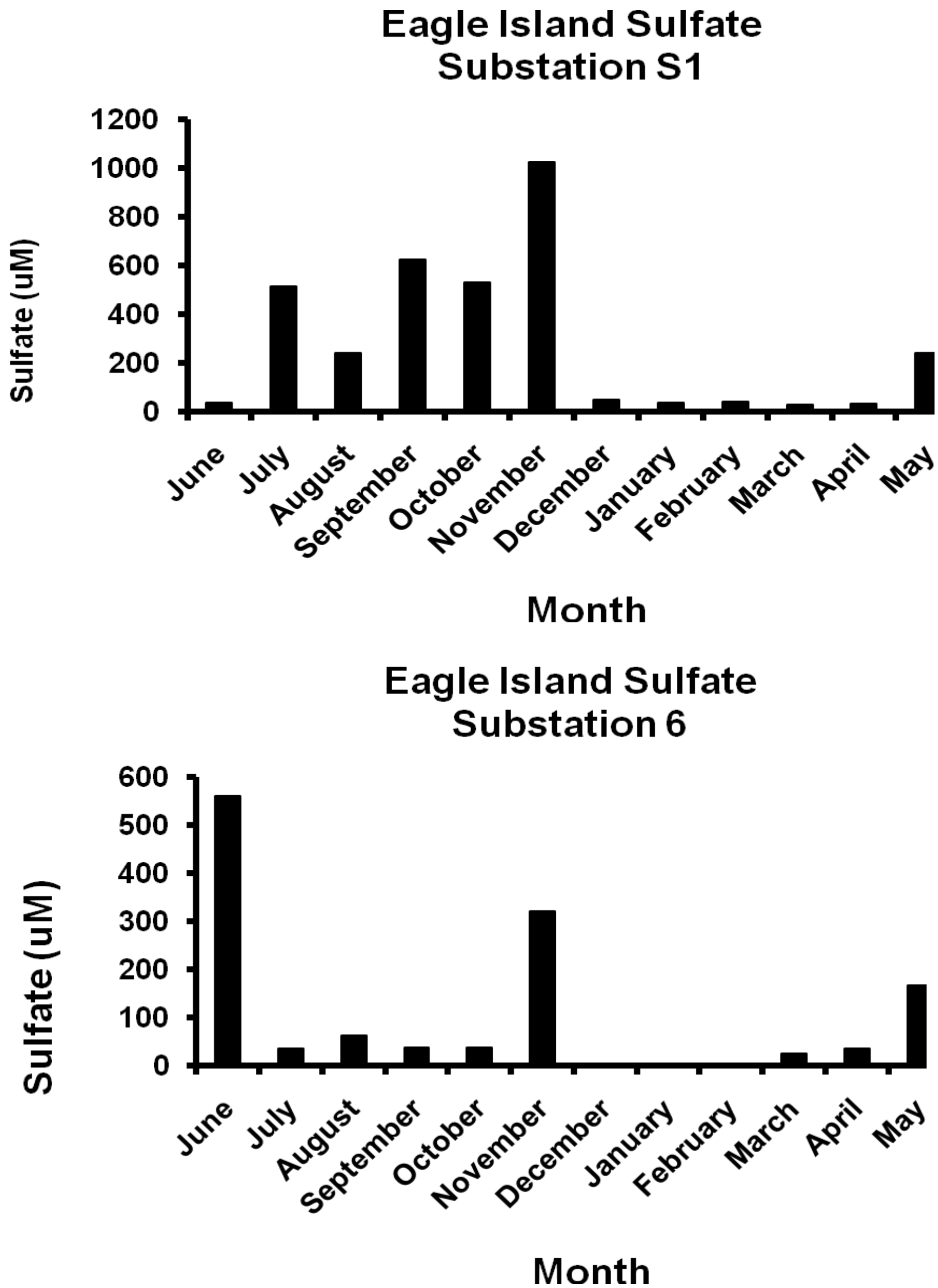
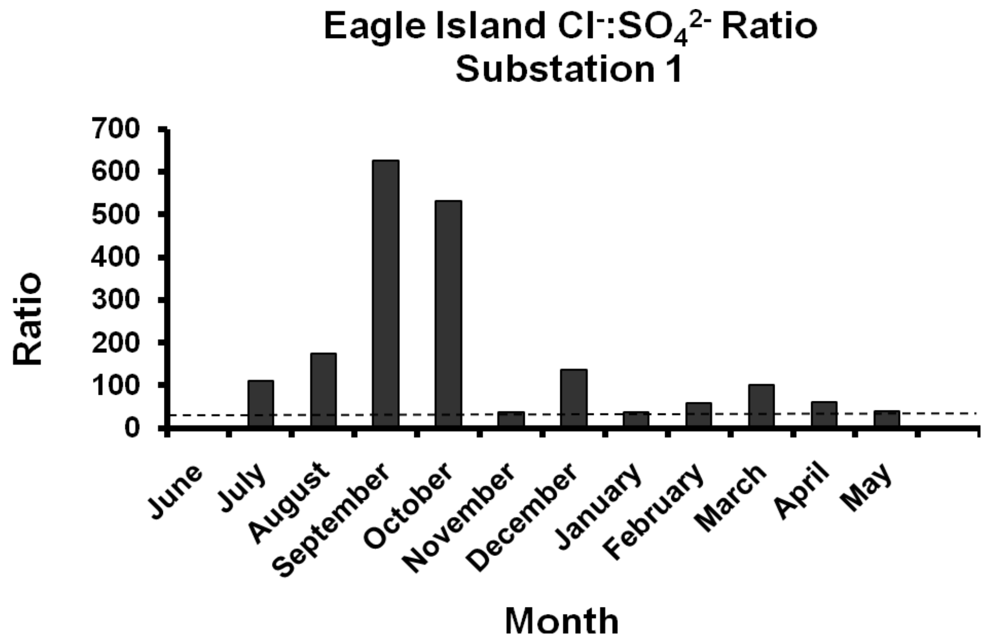


Figure 5.4-2. Sulfate concentrations of Eagle Island porewaters vs. month. Top shows nearshore site (S1) and bottom shows the sub-site closest to uplands (S6).



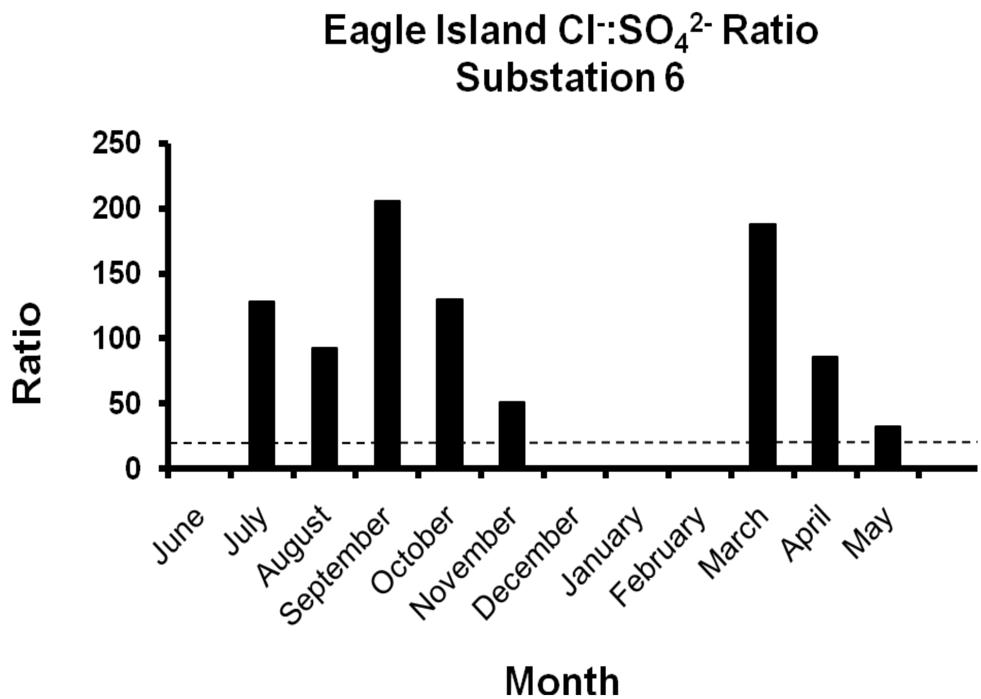
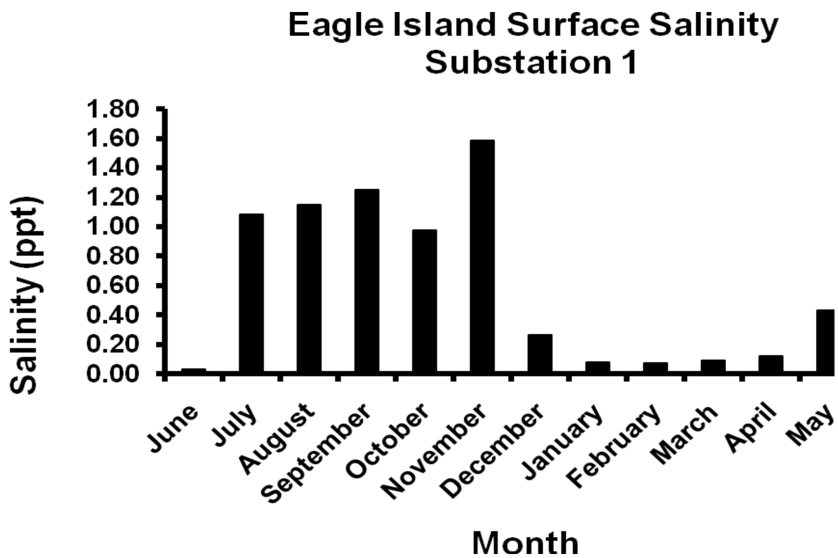


Figure 5.4-3. Chloride to sulfate ratios of Eagle Island porewaters vs. month. Dashed line shows ratio for seawater. Top shows nearshore site (S1) and bottom shows subsite closest to uplands (S6).



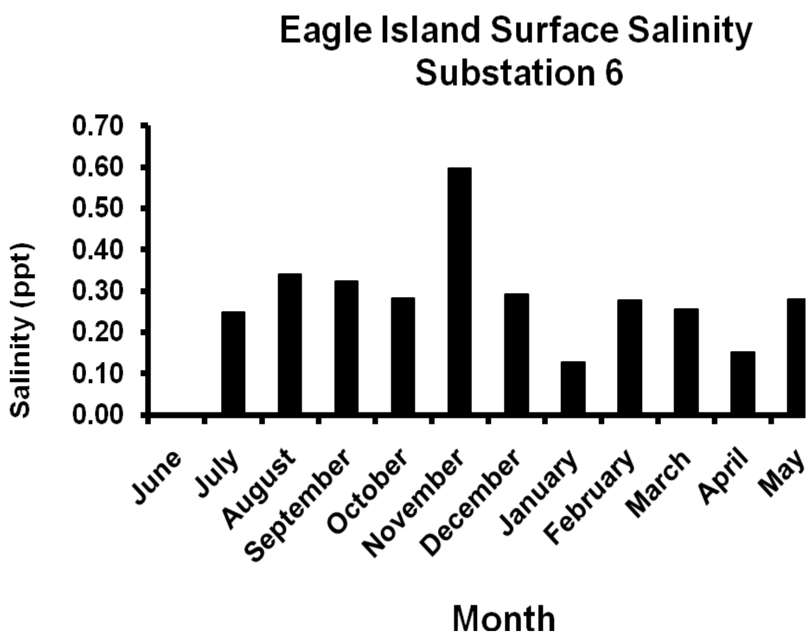


Figure 5.4-4. Salinities of Eagle Island porewaters vs. month. Top shows nearshore site (S1) and bottom shows subsite closest to uplands (S6).

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 09	July	August	September	October	November	December	January	February	March	April	May 10
S1-1	I*	II	II	II	II	II	I*	I	I	I	I	I
S1-2	I	II	II	II	II	II	I	I	I	I*	I*	II
S1-3	I	II	I*	II	II	II	I*	I	I	I*	I*	I*
S1-4	I	I*	I*	II	II	II	I*	I*	I*	I*	I*	I*
S1-5	I	I*	I*	I*	I*	II	I*	I*	I*	I*	I*	I*
S1-6	I	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S2-1	I	II	I*	II	I*	I*	I*	I*	I*	I*	I	II
S2-2	I	II	I*	I*	I*	I*	I*	I*	I*	I*	I*	II
S2-3	I	II	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S2-4	I	II	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S2-5	I	II	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S2-6	I	II	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S3-1	I	I*	I*	I*	II	II	I*	I*	I*	I*	I*	I*
S3-2	I*	I*	I*	I*	I*	II	I*	I*	I*	I*	I*	I*
S3-3	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S3-4	I	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S3-5	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S3-6	I	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-1	I*	I*	I*	I*	II	I*	I*	I*	I*	I*	I*	I*
S4-2	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-3	I	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-4	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-5	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S4-6	I	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S5-1	I*	I*	I*	I*	I	I*	I*	I*	I*	I*	I*	I*
S5-2	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S5-3	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I
S5-4	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I
S5-5	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S5-6	I	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*
S6-1	I	I*	I*	I*	I*	II	I*	I*	I*	I*	I*	I
S6-2	I	I*	I*	I*	I*	II	I*	I*	I*	I*	I*	II
S6-3	II*	I*	I*	I*	I*	II	I*	I*	I*	I*	I*	I
S6-4	II*	I*	I*	I*	I*	II	I*	I*	I*	I*	I*	I
S6-5	II*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I
S6-6	II*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I*	I

5.5 Marsh/Swamp Transect Stations Geochemistry, Annual Variability

5.51 Town Creek (P3)

Salinity at Town Creek during the average year ranged between 0.5 and 2.5 ppt. (Hackney et al., 2005). During the low river flow year, salinities reached as high as 17 ppt. (Hackney et al., 2004). The current year salinities (Table 5.51-1), based on chloride concentrations (Table 5.51-2), were similar to the average year (0.1-2 ppt). The majority of sulfate concentrations were in the 30 – 1,600 μM range (Table 5.51-3) in between the average year concentrations of 100 – 300 μM and the low river flow year concentrations of 500 – 3,000 μM. Methane concentrations during the current year ranged from approximately 20 - 400 μM (Table 5.51-4). During both the low river flow year and the average year methane concentrations were similar at this site with concentrations generally in the 10-300 μM range. There is little distinction between classifications at this site between the average and low flow years. During the summer, classifications tend to be SR and during the winter MPSR. During the current summer, classifications fluctuated between SR and MPSR (Table 5.51-1).

Table 5.51-1. Salinity of Sites. Salinity in parts per thousand calculated from chloride concentrations in porewaters. A [---] indicates no data. A [nd] means not determined.

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Town Creek	1	1	1.86	0.06
P3	1	6	1.84	0.54
	1	11	1.84	0.66
	1	16	1.73	0.84
	1	21	1.34	0.98
	1	26	1.62	1.06
	2	1	1.17	1.12
	2	6	2.09	0.22
	2	11	2.09	0.41
	2	16	1.98	0.66
	2	21	1.90	1.06
	2	26	1.86	1.26
	3	1	1.87	1.37
	3	6	2.11	0.33
	3	11	2.26	0.65
	3	16	2.31	1.08
	3	21	1.45	1.45
	3	26	1.41	1.54

Table 5.51-1 (continued)

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Town Creek (continued)	4	1	1.34	1.53
	4	6	1.44	0.22
	4	11	1.42	0.26
	4	16	1.46	0.46
	4	21	1.47	0.73
	4	26	1.45	0.97
	5	1	1.44	1.25
	5	6	1.44	0.15
	5	11	1.58	0.27
	5	16	1.52	0.41
	5	21	2.04	0.56
	5	26	1.93	0.72
	6	1	1.76	0.79
	6	6	1.74	1.42
	6	11	1.94	1.59
	6	16	2.02	1.76
	6	21	1.96	1.85
	6	26	2.00	1.88
Eagle Island P6	1	1	2.02	1.87
	1	6	1.66	0.02
	1	11	1.56	0.02
	1	16	1.34	0.03
	1	21	1.07	0.08
	1	26	0.86	0.04
	2	1	0.66	0.13
	2	6	1.72	0.09
	2	11	1.80	0.27
	2	16	1.77	0.16
	2	21	1.59	0.38
	2	26	1.23	0.24
	3	1	0.77	0.19
	3	6	0.70	0.47
	3	11	0.67	0.22
	3	16	0.64	0.43
	3	21	0.65	0.24
	3	26	0.65	0.15
	4	1	0.67	0.25
	4	6	0.81	0.28
	4	11	0.81	0.50
	4	16	0.82	0.15
	4	21	0.79	0.14
	4	26	0.78	0.26
	5	1	0.75	0.24

Table 5.51-1 (continued)

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Eagle Island (continued)	5	6	0.75	0.15
	5	11	0.54	0.28
	5	16	0.38	0.23
	5	21	0.32	0.49
	5	26	0.30	0.18
	6	1	0.28	0.10
	6	6	0.29	0.17
	6	11	0.27	0.14
	6	16	0.25	0.13
	6	21	0.21	0.09
	6	26	0.18	0.13
Indian Creek P7	1	1	0.17	0.07
	1	6	2.86	0.03
	1	11	3.02	0.05
	1	16	2.60	0.09
	1	21	1.97	0.17
	1	26	1.32	0.43
	2	1	0.86	0.31
	2	6	1.03	0.07
	2	11	0.95	0.09
	2	16	0.93	0.18
	2	21	0.97	0.46
	2	26	1.16	0.64
	3	1	1.50	0.68
	3	6	0.29	0.05
	3	11	0.28	0.04
	3	16	0.27	0.07
	3	21	0.30	0.10
	3	26	0.31	0.13
	4	1	0.35	0.14
	4	6	0.10	0.04
	4	11	0.07	0.03
	4	16	0.05	0.04
	4	21	0.05	0.05
	4	26	0.05	0.05
	5	1	0.05	0.06
	5	6	0.04	0.01
	5	11	0.04	0.01
	5	16	0.03	0.02
	5	21	0.03	0.02
	5	26	0.04	0.02
	6	1	0.04	0.01
	6	6	0.01	0.01
	6	11	0.01	0.01

Table 5.51-1 (continued)

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Indian Creek (continued)	6	16	0.01	0.01
	6	21	0.02	0.01
	6	26	0.02	0.01
Dollisons Landing P8	1	1	0.01	0.02
	1	6	0.04	0.02
	1	11	0.04	0.02
	1	16	0.04	0.02
	1	21	0.03	0.02
	1	26	0.03	0.03
	2	1	0.03	0.03
	2	6	0.04	0.04
	2	11	0.04	0.03
	2	16	0.04	0.05
	2	21	0.05	0.03
	2	26	0.04	0.03
	3	1	0.04	0.04
	3	6	0.05	0.04
	3	11	0.08	0.03
	3	16	0.05	0.04
	3	21	0.05	0.03
	3	26	0.05	0.04
	4	1	0.05	0.04
	4	6	0.05	0.06
	4	11	0.05	0.05
	4	16	0.05	0.03
	4	21	0.06	0.04
	4	26	0.13	0.03
	5	1	0.05	0.05
	5	6	0.07	0.05
	5	11	0.07	0.06
	5	16	0.07	0.05
	5	21	0.06	0.06
	5	26	0.06	0.07
	6	1	0.06	0.07
	6	6	0.08	0.04
	6	11	0.09	0.06
	6	16	0.09	0.05
	6	21	0.08	0.05
	6	26	0.08	0.05
Black River P9	1	1	0.09	0.05
	1	6	0.04	0.04
	1	11	0.03	0.03
	1	16	0.03	0.02
	1	21	0.03	0.03

Table 5.51-1 (continued)

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Black River (continued)	1	26	0.03	0.03
	2	1	0.03	0.03
	2	6	0.03	0.02
	2	11	0.03	0.01
	2	16	0.03	0.03
	2	21	0.03	0.02
	2	26	0.03	0.02
	3	1	0.03	0.02
	3	6	0.04	0.05
	3	11	0.04	0.02
	3	16	0.33	0.02
	3	21	0.04	0.03
	3	26	0.05	0.02
	4	1	0.06	0.03
	4	6	0.03	0.02
	4	11	0.03	0.02
	4	16	0.03	0.02
	4	21	0.02	0.02
	4	26	0.03	0.02
	5	1	0.03	0.02
	5	6	0.03	0.02
	5	11	0.04	0.02
	5	16	0.03	0.02
	5	21	0.03	0.03
	5	26	0.03	0.03
	6	1	0.04	0.03
	6	6	0.03	0.02
	6	11	0.03	0.02
	6	16	0.03	0.03
	6	21	0.03	0.03
	6	26	0.03	0.03
Smith Creek P11	1	1	0.04	0.02
	1	6	2.35	0.26
	1	11	2.25	0.34
	1	16	1.66	0.23
	1	21	1.29	0.25
	1	26	1.22	0.70
	2	1	1.26	0.81
	2	6	2.89	0.14
	2	11	2.80	0.32
	2	16	2.28	0.32
	2	21	1.78	0.34
	2	26	1.52	0.49
	3	1	1.47	0.43

Table 5.51-1 (continued)

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Smith Creek (continued)	3	6	2.93	0.13
	3	11	2.51	0.16
	3	16	2.06	0.27
	3	21	1.60	0.19
	3	26	1.13	0.26
	4	1	1.18	0.29
	4	6	2.49	0.12
	4	11	2.03	0.06
	4	16	1.67	0.12
	4	21	1.54	0.26
	4	26	1.53	0.17
	5	1	1.37	0.22
	5	6	2.67	0.10
	5	11	2.48	0.13
	5	16	1.90	0.10
	5	21	1.41	0.10
	5	26	1.11	0.06
	6	1	1.00	0.11
	6	6	2.02	0.03
	6	11	2.25	0.05
	6	16	1.77	0.04
	6	21	1.51	0.09
	6	26	1.40	0.06
Rat Island P12	1	1	1.29	0.07
	1	6	0.57	0.08
	1	11	0.77	0.10
	1	16	1.00	0.15
	1	21	1.03	0.15
	1	26	0.90	0.17
	2	1	0.70	0.19
	2	6	0.67	0.05
	2	11	0.91	0.15
	2	16	1.01	0.14
	2	21	1.31	0.19
	2	26	0.69	0.22
	3	1	0.50	0.26
	3	6	0.67	0.33
	3	11	0.79	0.17
	3	16	0.80	0.22
	3	21	0.73	0.22
	3	26	0.66	0.19
	4	1	0.49	0.26
	4	6	0.78	0.02
	4	11	0.85	0.02

Table 5.51-1 (continued)

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Rat Island (continued)	4	16	0.84	0.03
	4	21	0.72	0.03
	4	26	0.60	0.05
	5	1	0.49	0.09
	5	6	0.41	0.06
	5	11	0.64	0.06
	5	16	0.82	0.03
	5	21	0.89	0.08
	5	26	0.89	0.07
	6	1	0.92	0.07
	6	6	0.14	0.03
	6	11	0.17	0.04
	6	16	0.16	0.02
	6	21	0.19	0.04
	6	26	0.17	0.04
Fishing Creek P13	1	1	0.18	0.03
	1	6	0.10	0.02
	1	11	0.11	0.02
	1	16	0.14	0.02
	1	21	0.17	0.05
	1	26	0.30	0.03
	2	1	0.61	0.04
	2	6	0.11	0.08
	2	11	0.13	0.09
	2	16	0.22	0.11
	2	21	0.42	0.12
	2	26	0.81	0.12
	3	1	1.18	0.13
	3	6	0.51	0.38
	3	11	0.42	0.43
	3	16	0.59	0.47
	3	21	0.66	0.53
	3	26	0.73	0.55
	4	1	0.80	0.57
	4	6	0.18	0.10
	4	11	0.18	0.08
	4	16	0.18	0.08
	4	21	0.21	0.08
	4	26	0.28	0.08
	5	1	0.36	0.08
	5	6	0.18	0.06
	5	11	0.26	0.05
	5	16	0.40	0.04
	5	21	0.51	0.04

Table 5.51-1 (continued)

Station	Substation	Depth (cm)	Salinity	
			Summer 2009	Winter 2010
Fishing Creek (continued)	5	26	0.60	0.04
	6	1	0.50	0.05
	6	6	0.02	0.02
	6	11	0.02	0.02
	6	16	0.02	0.02
	6	21	0.03	0.02
	6	26	0.04	0.02
Prince George P14	1	1	0.04	0.02
	1	6	0.09	0.02
	1	11	0.08	0.03
	1	16	0.09	0.02
	1	21	0.09	0.02
	1	26	0.09	0.03
	2	1	0.07	0.04
	2	6	0.05	0.10
	2	11	0.07	0.09
	2	16	0.11	0.12
	2	21	0.13	0.13
	2	26	0.17	0.13
	3	1	0.19	0.13
	3	6	0.04	0.04
	3	11	0.05	0.03
	3	16	0.06	0.04
	3	21	0.08	0.03
	3	26	0.08	0.03
	4	1	0.05	0.02
	4	6	0.08	0.08
	4	11	0.08	0.05
	4	16	0.10	0.07
	4	21	0.11	0.08
	4	26	0.14	0.08
	5	1	0.16	0.06
	5	6	0.08	0.03
	5	11	0.09	0.04
	5	16	0.09	0.03
	5	21	0.10	0.04
	5	26	0.10	0.03
	6	1	0.09	0.03
	6	6	0.08	0.02
	6	11	0.10	0.03
	6	16	0.10	0.03
	6	21	0.08	0.04
	6	26	0.07	0.03

Table 5.51-2. Chloride Concentrations of Sites. Chloride concentrations of porewaters in µM.

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Town Creek	1	1	29137	8363
P3	1	6	28685	10325
	1	11	27099	13157
	1	16	20939	15295
	1	21	25293	16484
	1	26	18265	17475
	2	1	32595	3417
	2	6	32632	6441
	2	11	30999	10255
	2	16	29720	16527
	2	21	29134	19718
	2	26	29142	21352
	3	1	32951	5220
	3	6	35252	10109
	3	11	36040	16813
	3	16	22658	22707
	3	21	21971	24119
	3	26	20920	23917
	4	1	22480	3383
	4	6	22259	4125
	4	11	22804	7250
	4	16	22935	11436
	4	21	22581	15201
	4	26	22562	19532
	5	1	22531	2274
	5	6	24750	4259
	5	11	23691	6397
	5	16	31861	8742
	5	21	30156	11210
	5	26	27501	12403
	6	1	27186	22200
	6	6	30345	24805
	6	11	31493	27501
	6	16	30656	28948
	6	21	31283	29320
	6	26	31524	29168

Table 5.51-2. (continued)

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Eagle Island	1	1	25943	327
P6	1	6	24343	255
	1	11	20873	466
	1	16	16787	1175
	1	21	13406	697
	1	26	10259	2043
	2	1	26901	1456
	2	6	28094	4265
	2	11	27632	2528
	2	16	24898	5981
	2	21	19272	3725
	2	26	12083	2950
	3	1	10972	7280
	3	6	10542	3513
	3	11	9982	6751
	3	16	10179	3722
	3	21	10162	2398
	3	26	10459	3933
	4	1	12684	4423
	4	6	12614	7845
	4	11	12766	2357
	4	16	12299	2260
	4	21	12258	4081
	4	26	11708	3809
	5	1	11682	2311
	5	6	8506	4315
	5	11	5875	3632
	5	16	5068	7581
	5	21	4687	2782
	5	26	4376	1560
	6	1	4595	2687
	6	6	4201	2162
	6	11	3937	2098
	6	16	3353	1374
	6	21	2874	1980
	6	26	2728	1066

Table 5.51-2. (continued)

Station	**Substation**	**Depth (cm)**	**Chloride**	
			Summer 2009	**Winter 2010**
Indian Creek	1	1	44668	416
P7	1	6	47195	728
	1	11	40559	1457
	1	16	30809	2655
	1	21	20647	6792
	1	26	13391	4788
	2	1	16122	1161
	2	6	14915	1333
	2	11	14548	2737
	2	16	15124	7190
	2	21	18175	9926
	2	26	23382	10668
	3	1	4520	802
	3	6	4445	598
	3	11	4293	1072
	3	16	4725	1632
	3	21	4779	2045
	3	26	5475	2198
	4	1	1636	601
	4	6	1037	515
	4	11	770	649
	4	16	708	754
	4	21	769	755
	4	26	821	990
	5	1	624	215
	5	6	634	221
	5	11	482	266
	5	16	455	249
	5	21	694	246
	5	26	651	188
	6	1	190	217
	6	6	189	189
	6	11	220	226
	6	16	266	207
	6	21	262	211
	6	26	209	237

Table 5.51-2. (continued)

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Dollisons	1	1	663	267
Landing P8	1	6	683	313
	1	11	629	332
	1	16	544	365
	1	21	477	397
	1	26	513	434
	2	1	668	616
	2	6	697	497
	2	11	682	710
	2	16	849	541
	2	21	693	546
	2	26	661	615
	3	1	822	567
	3	6	1284	526
	3	11	793	601
	3	16	847	523
	3	21	811	699
	3	26	752	621
	4	1	824	898
	4	6	809	743
	4	11	858	520
	4	16	913	548
	4	21	2033	431
	4	26	814	777
	5	1	1080	735
	5	6	1047	916
	5	11	1045	841
	5	16	991	992
	5	21	957	1033
	5	26	939	1113
	6	1	1309	686
	6	6	1397	889
	6	11	1388	836
	6	16	1279	855
	6	21	1306	752
	6	26	1450	757

Table 5.51-2. (continued)

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Black River	1	1	695	579
P9	1	6	508	403
	1	11	486	380
	1	16	500	447
	1	21	486	410
	1	26	506	518
	2	1	523	272
	2	6	527	215
	2	11	529	532
	2	16	540	322
	2	21	425	351
	2	26	479	366
	3	1	590	773
	3	6	574	309
	3	11	5131	357
	3	16	665	424
	3	21	796	370
	3	26	885	422
	4	1	459	280
	4	6	419	317
	4	11	416	362
	4	16	355	357
	4	21	426	316
	4	26	412	335
	5	1	499	380
	5	6	597	288
	5	11	540	367
	5	16	484	431
	5	21	491	424
	5	26	550	545
	6	1	418	311
	6	6	529	328
	6	11	430	397
	6	16	415	398
	6	21	498	445
	6	26	595	366

Table 5.51-2. (continued)

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Smith Creek	1	1	36770	3985
P11	1	6	35088	5341
	1	11	26015	3591
	1	16	20230	3834
	1	21	19136	10910
	1	26	19753	12626
	2	1	45174	2198
	2	6	43721	5039
	2	11	35671	5028
	2	16	27835	5249
	2	21	23782	7694
	2	26	23002	6660
	3	1	45794	2017
	3	6	39277	2480
	3	11	32167	4154
	3	16	25006	3005
	3	21	17728	4116
	3	26	18437	4608
	4	1	38845	1871
	4	6	31678	945
	4	11	26033	1814
	4	16	24083	4091
	4	21	23945	2601
	4	26	21433	3464
	5	1	41735	1551
	5	6	38766	2034
	5	11	29744	1597
	5	16	22057	1557
	5	21	17392	994
	5	26	15581	1755
	6	1	31571	527
	6	6	35231	769
	6	11	27698	652
	6	16	23589	1351
	6	21	21852	1012
	6	26	20121	1085

Table 5.51-2. (continued)

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Rat Island	1	1	8906	1212
P12	1	6	12075	1640
	1	11	15698	2313
	1	16	16167	2315
	1	21	14090	2669
	1	26	10942	3002
	2	1	10462	856
	2	6	14222	2420
	2	11	15707	2222
	2	16	20542	2942
	2	21	10837	3465
	2	26	7888	4118
	3	1	10476	5091
	3	6	12348	2628
	3	11	12467	3479
	3	16	11356	3446
	3	21	10238	2928
	3	26	7608	4140
	4	1	12161	311
	4	6	13273	251
	4	11	13090	469
	4	16	11214	487
	4	21	9447	735
	4	26	7637	1390
	5	1	6377	984
	5	6	10012	887
	5	11	12878	469
	5	16	13834	1226
	5	21	13841	1076
	5	26	14297	1093
	6	1	2255	425
	6	6	2628	656
	6	11	2554	356
	6	16	2927	632
	6	21	2670	598
	6	26	2766	394

Table 5.51-2. (continued)

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Fishing Creek	1	1	1626	377
P13	1	6	1795	357
	1	11	2210	387
	1	16	2705	850
	1	21	4712	483
	1	26	9585	692
	2	1	1793	1208
	2	6	2047	1408
	2	11	3381	1716
	2	16	6582	1802
	2	21	12581	1864
	2	26	18502	2057
	3	1	8005	5861
	3	6	6523	6727
	3	11	9194	7358
	3	16	10262	8263
	3	21	11391	8662
	3	26	12502	8904
	4	1	2775	1487
	4	6	2763	1309
	4	11	2791	1282
	4	16	3301	1307
	4	21	4359	1317
	4	26	5669	1315
	5	1	2854	901
	5	6	4049	732
	5	11	6212	697
	5	16	7961	600
	5	21	9346	646
	5	26	7850	743
	6	1	318	327
	6	6	319	275
	6	11	389	273
	6	16	516	276
	6	21	613	244
	6	26	690	351

Table 5.51-2. (continued)

Station	Substation	Depth (cm)	Chloride	
			Summer 2009	Winter 2010
Prince George	1	1	1426	351
P14	1	6	1235	435
	1	11	1463	360
	1	16	1466	368
	1	21	1383	524
	1	26	1124	699
	2	1	813	1498
	2	6	1161	1445
	2	11	1694	1860
	2	16	2016	2016
	2	21	2606	1988
	2	26	3035	2053
	3	1	699	612
	3	6	810	540
	3	11	966	590
	3	16	1295	525
	3	21	1261	510
	3	26	854	366
	4	1	1228	1259
	4	6	1322	825
	4	11	1548	1081
	4	16	1773	1198
	4	21	2205	1197
	4	26	2518	1015
	5	1	1296	502
		6	1373	568
	5	11	1418	480
	5	16	1564	565
	5	21	1531	465
	5	26	1470	449
	6	1	1296	377
	6	6	1625	437
	6	11	1489	448
	6	16	1320	548
	6	21	1077	439
	6	26	889	461

Table 5.51-3. Sulfate Concentrations of Sites. Porewater sulfate concentrations are µM. A [---] indicates no data. A [nd] means not determined.

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Town Creek	1	1	1628	70
P3	1	6	1623	71
	1	11	1233	100
	1	16	250	121
	1	21	735	116
	1	26	141	108
	2	1	703	45
	2	6	309	51
	2	11	235	113
	2	16	133	72
	2	21	114	71
	2	26	91	29
	3	1	1333	27
	3	6	964	22
	3	11	927	50
	3	16	357	123
	3	21	335	148
	3	26	243	95
	4	1	358	66
	4	6	287	98
	4	11	223	115
	4	16	164	146
	4	21	188	184
	4	26	290	237
	5	1	237	35
	5	6	304	43
	5	11	256	41
	5	16	975	43
	5	21	654	38
	5	26	345	66
	6	1	507	64
	6	6	278	109
	6	11	325	117
	6	16	259	147
	6	21	339	136
	6	26	392	134
Eagle Island	1	1	1200	61
P6	1	6	830	40
	1	11	403	31
	1	16	94	20
	1	21	48	nd

Table 5.51-3. (continued)

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Eagle Island	1	26	nd	nd
P6 (continued)	2	1	1580	17
	2	6	1518	11
	2	11	1368	nd
	2	16	1272	nd
	2	21	1029	nd
	2	26	564	nd
	3	1	80	nd
	3	6	37	nd
	3	11	0	nd
	3	16	0	nd
	3	21	15	nd
	3	26	0	nd
	4	1	0	nd
	4	6	0	nd
	4	11	0	nd
	4	16	0	nd
	4	21	0	nd
	4	26	0	nd
	5	1	169	nd
	5	6	68	nd
	5	11	0	nd
	5	16	18	nd
	5	21	0	nd
	5	26	25	nd
	6	1	72	nd
	6	6	19	nd
	6	11	23	nd
	6	16	nd	nd
	6	21	35	nd
	6	26	27	nd
Indian Creek	1	1	3150	18
P7	1	6	3206	138
	1	11	2743	20
	1	16	2008	26
	1	21	1207	18
	1	26	437	40
	2	1	665	104
	2	6	236	81
	2	11	61	148
	2	16	45	49
	2	21	nd	25
	2	26	21	36
	3	1	28	25

Table 5.51-3. (continued)

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Indian Creek	3	6	nd	12
(continued)	3	11	nd	18
	3	16	nd	26
	3	21	17	13
	3	26	nd	21
	4	1	56	106
	4	6	25	81
	4	11	nd	176
	4	16	27	0
	4	21	21	0
	4	26	19	11
	5	1	61	36
	5	6	31	0
	5	11	26	13
	5	16	15	18
	5	21	23	nd
	5	26	nd	10
	6	1	37	19
	6	6	25	9
	6	11	21	nd
	6	16	30	nd
	6	21	nd	nd
	6	26	25	nd
Dollisons	1	1	403	47
Landing P8	1	6	265	52
	1	11	144	28
	1	16	59	13
	1	21	nd	nd
	1	26	nd	nd
	2	1	30	45
	2	6	nd	29
	2	11	nd	22
	2	16	40	38
	2	21	18	29
	2	26	19	81
	3	1	33	42
	3	6	nd	25
	3	11	nd	56
	3	16	nd	20
	3	21	nd	22
	3	26	nd	32
	4	1	179	63
	4	6	71	36
	4	11	35	43

Table 5.51-3. (continued)

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Dollisons Landing	4	16	32	39
(continued)	4	21	nd	27
	4	26	nd	39
	5	1	20	29
	5	6	28	25
	5	11	26	28
	5	16	nd	24
	5	21	nd	36
	5	26	nd	37
	6	1	68	33
	6	6	31	21
	6	11	23	14
	6	16	37	12
	6	21	29	12
	6	26	39	16
Black River	1	1	93	18
P9	1	6	36	40
	1	11	41	20
	1	16	55	26
	1	21	42	18
	1	26	27	40
	2	1	96	104
	2	6	126	81
	2	11	66	148
	2	16	29	49
	2	21	26	20
	2	26	85	40
	3	1	41	25
	3	6	nd	12
	3	11	335	18
	3	16	nd	26
	3	21	24	46
	3	26	nd	29
	4	1	33	106
	4	6	nd	81
	4	11	207	nd
	4	16	nd	nd
	4	21	20	nd
	4	26	nd	11
	5	1	19	36
	5	6	22	nd
	5	11	16	21
	5	16	nd	nd
	5	21	nd	nd

Table 5.51-3. (continued)

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Black River	5	26	16	10
P9	6	1	nd	13
(continued)	6	6	nd	9
	6	11	nd	nd
	6	16	nd	nd
	6	21	nd	nd
	6	26	nd	nd
Smith Creek	1	1	1977	162
P11	1	6	1328	171
	1	11	546	77
	1	16	223	122
	1	21	216	83
	1	26	148	78
	2	1	844	13
	2	6	745	nd
	2	11	563	nd
	2	16	320	nd
	2	21	134	nd
	2	26	199	nd
	3	1	1670	135
	3	6	1102	69
	3	11	737	105
	3	16	363	44
	3	21	260	86
	3	26	275	22
	4	1	1624	9
	4	6	785	nd
	4	11	437	nd
	4	16	355	14
	4	21	306	nd
	4	26	313	nd
	5	1	2659	26
	5	6	2117	nd
	5	11	1063	nd
	5	16	472	nd
	5	21	205	nd
	5	26	190	nd
	6	1	1822	nd
	6	6	1157	nd
	6	11	538	nd
	6	16	246	nd
	6	21	211	nd
	6	26	188	nd

Table 5.51-3. (continued)

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Rat Island	1	1	29	36
P12	1	6	32	30
	1	11	21	19
	1	16	nd	20
	1	21	nd	16
	1	26	nd	23
	2	1	22	nd
	2	6	45	11
	2	11	58	nd
	2	16	24	nd
	2	21	28	nd
	2	26	36	nd
	3	1	343	12
	3	6	282	nd
	3	11	281	23
	3	16	229	nd
	3	21	223	nd
	3	26	155	nd
	4	1	762	12
	4	6	543	33
	4	11	467	28
	4	16	294	14
	4	21	198	nd
	4	26	98	13
	5	1	126	nd
	5	6	131	nd
	5	11	107	nd
	5	16	164	nd
	5	21	376	nd
	5	26	170	nd
	6	1	15	17
	6	6	47	21
	6	11	28	200
	6	16	36	10
	6	21	40	nd
	6	26	41	10
Fishing Creek	1	1	31	140
P13	1	6	28	147
	1	11	nd	153
	1	16	nd	137
	1	21	nd	153
	1	26	27	108
	2	1	566	40
	2	6	647	35

Table 5.51-3. (continued)

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Fishing Creek (continued)	2	11	945	nd
	2	16	626	nd
	2	21	152	13
	2	26	57	15
	3	1	298	68
	3	6	145	46
	3	11	38	38
	3	16	28	34
	3	21	54	42
	3	26	nd	25
	4	1	52	101
	4	6	74	101
	4	11	127	99
	4	16	58	93
	4	21	54	107
	4	26	1117	100
	5	1	346	139
	5	6	247	121
	5	11	118	112
	5	16	44	96
	5	21	45	103
	5	26	82	85
	6	1	67	90
	6	6	83	90
	6	11	97	88
	6	16	104	95
	6	21	48	81
	6	26	43	86
Prince George P14	1	1	313	94
	1	6	310	170
	1	11	101	112
	1	16	57	54
	1	21	61	68
	1	26	65	103
	2	1	60	49
	2	6	55	nd
	2	11	36	77
	2	16	21	nd
	2	21	17	14
	2	26	nd	18
	3	1	108	95
	3	6	60	75
	3	11	37	97
	3	16	nd	20

Table 5.51-3. (continued)

Station	Substation	Depth (cm)	Sulfate	
			Summer 2009	Winter 2010
Prince George	3	21	nd	15
(continued)	3	26	15	13
	4	1	58	54
	4	6	68	96
	4	11	55	36
	4	16	42	16
	4	21	36	14
	4	26	25	14
	5	1	26	44
	5	6	nd	90
	5	11	27	24
	5	16	nd	22
	5	21	17	23
	5	26	nd	24
	6	1	182	56
	6	6	65	87
	6	11	17	37
	6	16	28	86
	6	21	22	16
	6	26	nd	25

Table 5.51-4. Methane Concentrations of Sites. Porewater methane concentrations are µM. A [nd] means not determined.

Station	**Substation**	**Depth (cm)**	**Methane**	
			Summer 2009	**Winter 2010**
Town Creek	1	1	3	142
P3	1	6	25	153
	1	11	112	179
	1	16	113	149
	1	21	79	174
	1	26	161	161
	2	1	147	110
	2	6	209	238
	2	11	193	310
	2	16	192	354
	2	21	278	426
	2	26	27	352
	3	1	14	89
	3	6	45	181
	3	11	73	242
	3	16	123	281
	3	21	106	280
	3	26	106	373
	4	1	230	11
	4	6	175	44
	4	11	198	74
	4	16	170	90
	4	21	159	132
	4	26	90	122
	5	1	137	96
	5	6	114	215
	5	11	131	242
	5	16	92	329
	5	21	88	404
	5	26	182	362
	6	1	72	212
	6	6	55	249
	6	11	53	212
	6	16	75	181
	6	21	38	169
	6	26	42	142

Table 5.51-4. (continued)

Station	Substation	Depth (cm)	Methane	
			Summer 2009	Winter 2010
Eagle Island	1	1	0	0
P6	1	6	1	1
	1	11	82	82
	1	16	248	248
	1	21	375	375
	1	26	347	347
	2	1	78	78
	2	6	341	341
	2	11	550	550
	2	16	624	624
	2	21	789	789
	2	26	787	787
	3	1	148	148
	3	6	367	367
	3	11	455	455
	3	16	536	536
	3	21	495	495
	3	26	485	485
	4	1	158	158
	4	6	269	269
	4	11	444	444
	4	16	405	405
	4	21	351	351
	4	26	452	452
	5	1	352	352
	5	6	334	334
	5	11	361	361
	5	16	526	526
	5	21	396	396
	5	26	354	354
	6	1	236	236
	6	6	351	351
	6	11	381	381
	6	16	395	395
	6	21	455	455
	6	26	442	442

Table 5.51-4. (continued)

Station	**Substation**	**Depth (cm)**	**Methane**	
			Summer 2009	**Winter 2010**
Indian Creek	1	1	4	0
P7	1	6	0	0
	1	11	10	0
	1	16	28	1
	1	21	39	13
	1	26	67	18
	2	1	58	22
	2	6	411	46
	2	11	393	254
	2	16	392	238
	2	21	293	181
	2	26	284	230
	3	1	173	96
	3	6	168	218
	3	11	192	290
	3	16	231	415
	3	21	191	431
	3	26	173	450
	4	1	244	2
	4	6	496	30
	4	11	364	39
	4	16	93	34
	4	21	297	38
	4	26	238	39
	5	1	134	19
	5	6	134	36
	5	11	156	75
	5	16	155	54
	5	21	191	63
	5	26	163	58
	6	1	36	15
	6	6	37	3
	6	11	98	1
	6	16	116	3
	6	21	191	3
	6	26	105	21

Table 5.51-4. (continued)

Station	Substation	Depth (cm)	Methane	
			Summer 2009	Winter 2010
Dollisons	1	1	1	1
Landing P8	1	6	2	39
	1	11	47	36
	1	16	66	35
	1	21	68	27
	1	26	80	45
	2	1	98	20
	2	6	98	49
	2	11	58	31
	2	16	77	3
	2	21	49	25
	2	26	77	ND
	3	1	108	45
	3	6	125	56
	3	11	168	54
	3	16	128	59
	3	21	126	84
	3	26	100	126
	4	1	ND	2
	4	6	149	73
	4	11	176	81
	4	16	131	124
	4	21	126	194
	4	26	95	175
	5	1	164	46
	5	6	217	71
	5	11	194	84
	5	16	158	131
	5	21	209	134
	5	26	208	6
	6	1	226	55
	6	6	218	111
	6	11	19	90
	6	16	255	116
	6	21	204	144
	6	26	294	108

Table 5.51-4. (continued)

Station	Substation	Depth (cm)	Methane	
			Summer 2009	Winter 2010
Black River	1	1	90	110
P9	1	6	40	344
	1	11	132	365
	1	16	288	409
	1	21	279	472
	1	26	253	446
	2	1	5	0
	2	6	27	ND
	2	11	91	1
	2	16	242	19
	2	21	291	24
	2	26	97	10
	3	1	45	104
	3	6	77	147
	3	11	258	164
	3	16	212	148
	3	21	213	127
	3	26	213	116
	4	1	124	ND
	4	6	197	65
	4	11	197	409
	4	16	208	566
	4	21	176	504
	4	26	233	464
	5	1	107	92
	5	6	179	181
	5	11	186	192
	5	16	203	191
	5	21	168	246
	5	26	195	134
	6	1	12	432
	6	6	252	633
	6	11	193	783
	6	16	141	775
	6	21	316	684
	6	26	178	781

Table 5.51-4. (continued)

Station	Substation	Depth (cm)	Methane	
			Summer 2009	Winter 2010
Smith Creek	1	1	17	31
P11	1	6	61	44
	1	11	125	125
	1	16	100	238
	1	21	113	359
	1	26	131	370
	2	1	131	97
	2	6	132	277
	2	11	203	406
	2	16	95	447
	2	21	135	589
	2	26	191	585
	3	1	99	139
	3	6	134	145
	3	11	125	220
	3	16	210	265
	3	21	183	455
	3	26	209	441
	4	1	133	301
	4	6	132	479
	4	11	253	590
	4	16	177	482
	4	21	175	545
	4	26	127	472
	5	1	8	46
	5	6	123	429
	5	11	207	524
	5	16	157	478
	5	21	183	404
	5	26	184	342
	6	1	ND	156
	6	6	189	198
	6	11	346	204
	6	16	309	299
	6	21	320	369
	6	26	391	505

Table 5.51-4. (continued)

Station	Substation	Depth (cm)	Methane	
			Summer 2009	Winter 2010
Rat Island	1	1	85	125
P12	1	6	122	194
	1	11	148	353
	1	16	99	380
	1	21	168	399
	1	26	72	419
	2	1	151	95
	2	6	159	86
	2	11	222	101
	2	16	195	163
	2	21	214	187
	2	26	198	160
	3	1	64	203
	3	6	98	192
	3	11	85	243
	3	16	98	251
	3	21	118	222
	3	26	120	237
	4	1	78	3
	4	6	78	2
	4	11	99	32
	4	16	97	110
	4	21	131	147
	4	26	136	156
	5	1	49	84
	5	6	80	100
	5	11	73	147
	5	16	92	157
	5	21	89	148
	5	26	82	186
	6	1	163	0
	6	6	288	np
	6	11	233	np
	6	16	237	np
	6	21	242	np
	6	26	259	np

Table 5.51-4. (continued)

Station	Substation	Depth (cm)	Methane	
			Summer 2009	Winter 2010
Fishing Creek	1	1	82	np
P13	1	6	102	16
	1	11	116	48
	1	16	167	53
	1	21	216	52
	1	26	178	72
	2	1	260	200
	2	6	273	253
	2	11	204	375
	2	16	324	343
	2	21	362	433
	2	26	275	358
	3	1	214	67
	3	6	199	106
	3	11	208	121
	3	16	184	156
	3	21	159	188
	3	26	138	130
	4	1	48	16
	4	6	80	26
	4	11	141	33
	4	16	146	29
	4	21	161	41
	4	26	145	45
	5	1	69	37
	5	6	108	53
	5	11	107	59
	5	16	131	65
	5	21	166	57
	5	26	139	57
	6	1	14	1
	6	6	26	0
	6	11	32	0
	6	16	18	np
	6	21	45	0
	6	26	45	0

Table 5.51-4. (continued)

Station	Substation	Depth (cm)	Methane	
			Summer 2009	Winter 2010
Prince George	1	1	4	16
P14	1	6	131	17
	1	11	320	24
	1	16	325	43
	1	21	268	59
	1	26	235	44
	2	1	94	220
	2	6	98	313
	2	11	114	327
	2	16	143	340
	2	21	167	352
	2	26	96	359
	3	1	168	15
	3	6	209	71
	3	11	240	176
	3	16	248	268
	3	21	237	270
	3	26	280	234
	4	1	174	288
	4	6	3	311
	4	11	299	447
	4	16	357	371
	4	21	331	239
	4	26	326	223
	5	1	120	61
	5	6	168	95
	5	11	111	109
	5	16	178	155
	5	21	115	211
	5	26	120	194
	6	1	7	230
	6	6	165	539
	6	11	176	543
	6	16	231	521
	6	21	232	462
	6	26	186	284

Table 5.51-5. Classification of Sites. 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*. A [---] indicates no data. A [nd] means not determined.

Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Town Creek P3	1	1	II	I*
	1	6	II	I*
	1	11	II	I*
	1	16	I*	I*
	1	21	II	I*
	1	26	I*	I*
	2	1	II	I*
	2	6	II	I*
	2	11	I*	I*
	2	16	I*	I*
	2	21	I*	I*
	2	26	I*	I*
	3	1	II	I*
	3	6	II	I*
	3	11	II	I*
	3	16	II	I*
	3	21	II	I*
	3	26	I*	I*
	4	1	II	I*
	4	6	I*	I*
	4	11	I*	I*
	4	16	I*	I*
	4	21	I*	I*
	4	26	I*	I*
	5	1	I*	I*
	5	6	II	I*
	5	11	I*	I*
	5	16	II	I*
	5	21	II	I*
	5	26	II	I*
	6	1	II	I*
	6	6	I*	I*
	6	11	II	I*
	6	16	I*	I*
	6	21	II	I*
	6	26	II	I*
Eagle Island P6	1	1	II	I
	1	6	II	I
	1	11	II	I
	1	16	I*	I*

Table 5.51-5. (continued)

Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Eagle Island (continued)	1	21	I*	I*
	1	26	I*	I*
	2	1	II	I*
	2	6	II	I*
	2	11	II	I*
	2	16	II	I*
	2	21	II	I*
	2	26	II	I*
	3	1	I*	I*
	3	6	I*	I*
	3	11	I*	I*
	3	16	I*	I*
	3	21	I*	I*
	3	26	I*	I*
	4	1	I*	I*
	4	6	I*	I*
	4	11	I*	I*
	4	16	I*	I*
	4	21	I*	I*
	4	26	I*	I*
	5	1	I*	I*
	5	6	I*	I*
	5	11	I*	I*
	5	16	I*	I*
	5	21	I*	I*
	5	26	I*	I*
	6	1	I*	I*
	6	6	I*	I*
	6	11	I*	I*
	6	16	I*	I*
	6	21	I*	I*
	6	26	I*	I*
Indian Creek P7	1	1	II	I
	1	6	II	I
	1	11	II	I*
	1	16	II	I*
	1	21	II	I*
	1	26	II	I*
	2	1	II	I
	2	6	I*	I
	2	11	I*	I
	2	16	I*	I*
	2	21	I*	I*
	2	26	I	I*

Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Indian Creek (continued)	3	1	I*	I*
	3	6	I*	I*
	3	11	I*	I*
	3	16	I*	I*
	3	21	I*	I*
	3	26	I*	I*
	4	1	I	I
	4	6	I*	I
	4	11	I*	I
	4	16	I	I*
	4	21	I*	I*
	4	26	I*	I*
	5	1	I	I
	5	6	I	I*
	5	11	I	I
	5	16	I*	I
	5	21	I*	I*
	5	26	I*	I
	6	1	I	I
	6	6	I	I
	6	11	I	I*
	6	16	I	I*
	6	21	I*	I*
	6	26	I	I*
Dollisons Landing P8	1	1	II*	I
	1	6	I	I
	1	11	I	I
	1	16	I	I
	1	21	I*	I*
	1	26	I*	I*
	2	1	I	I
	2	6	I*	I
	2	11	I*	I*
	2	16	I	I
	2	21	I*	I
	2	26	I*	I
	3	1	I	I
	3	6	I*	I
	3	11	I*	I
	3	16	I*	I
	3	21	I*	I*
	3	26	I*	I
	4	1	I	I
	4	6	I	I
	4	11	I	I
	4	16	I	I
	4	21	I*	I
	4	26	I*	I

Table 5.52-1. (continued)

Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Dollisons Landing (continued)	5	11	I*	I
	5	16	I*	I*
	5	21	I*	I
	5	26	I*	I*
	6	1	I	I
	6	6	I*	I*
	6	11	I*	I*
	6	16	I*	I*
	6	21	I*	I*
	6	26	I*	I*
Black River P9	1	1	I	I*
	1	6	I	I
	1	11	I	I
	1	16	I	I
	1	21	I	I
	1	26	I	I
	2	1	I	I
	2	6	I	I
	2	11	I	I
	2	16	I	I
	2	21	I	I
	2	26	I	I
	3	1	I	I*
	3	6	I*	I
	3	11	I	I
	3	16	I*	I
	3	21	I*	I
	3	26	I*	I
	4	1	I	I
	4	6	I*	I
	4	11	I	I*
	4	16	I*	I*
	4	21	I	I*
	4	26	I*	I*
	5	1	I	I
	5	6	I	I*
	5	11	I*	I
	5	16	I*	I*
	5	21	I*	I*
	5	26	I*	I*
	6	1	I*	I
	6	6	I*	I*
	6	11	I*	I*
	6	16	I*	I*
	6	21	I*	I*
	6	26	I*	I*

Table 5.52-1. (continued)

Station	Substation	Depth (cm)	Summer	Winter
Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Smith Creek	1	1	II	I
P11	1	6	II	I*
	1	11	II	I*
	1	16	I*	I*
	1	21	I*	I*
	1	26	I*	I*
	2	1	II	I*
	2	6	II	I*
	2	11	II	I*
	2	16	II	I*
	2	21	II	I*
	2	26	II	I*
	3	1	II	I
	3	6	II	I*
	3	11	II	I*
	3	16	II	I*
	3	21	I*	I*
	3	26	I*	I*
	4	1	II	I*
	4	6	II	I*
	4	11	II	I*
	4	16	II	I*
	4	21	II	I*
	4	26	II	I*
	5	1	II	I*
	5	6	II	I*
	5	11	II	I*
	5	16	II	I*
	5	21	I*	I*
	5	26	I*	I*
	6	1	II	I*
	6	6	II	I*
	6	11	II	I*
	6	16	I*	I*
	6	21	I*	I*
	6	26	I*	I*
Rat Island	1	1	I*	I*
P12	1	6	I*	I*
	1	11	I*	I*
	1	16	I*	I*
	1	21	I*	I*
	1	26	I*	I*
	2	1	I*	I*
	2	6	I*	I*
	2	11	I*	I*
	2	16	I*	I*

Table 5.52-1. (continued)

Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Rat Island P12 (continued)	2	21	I*	I*
	2	26	I*	I*
	3	1	II	I*
	3	6	I*	I*
	3	11	I*	I*
	3	16	I*	I*
	3	21	I*	I*
	3	26	I*	I*
	4	1	II	I
	4	6	II	I
	4	11	II	I
	4	16	I*	I*
	4	21	I*	I*
	4	26	I*	I*
	5	1	I*	I*
	5	6	I*	I*
	5	11	I*	I*
	5	16	I*	I*
	5	21	II	I*
	5	26	I*	I*
	6	1	I*	I
	6	6	I*	I*
	6	11	I*	I
	6	16	I*	I*
	6	21	I*	I*
	6	26	I*	I*
Fishing Creek P13	1	1	I*	I
	1	6	I*	I
	1	11	I*	I
	1	16	I*	I
	1	21	I*	I
	1	26	I*	I
	2	1	II*	I
	2	6	II*	I*
	2	11	II*	I*
	2	16	II	I*
	2	21	I*	I*
	2	26	I*	I*
	3	1	I	I*
	3	6	I*	I*
	3	11	I*	I*
	3	16	I*	I*
	3	21	I*	I*
	3	26	I*	I*
	4	1	I*	I
	4	6	I*	I
	4	11	I	I
	4	16	I*	I

Table 5.52-1. (continued)

Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Fishing Creek (continued)	4	21	I*	I
	4	26	II	I
	5	1	II	I
	5	6	I	I
	5	11	I*	I
	5	16	I*	I
	5	21	I*	I
	5	26	I*	I
	6	1	I	I
	6	6	I	I
	6	11	I	I
	6	16	I	I
	6	21	I	I
	6	26	I	I
Prince George P14	1	1	II	I
	1	6	II*	I
	1	11	I	I
	1	16	I	I
	1	21	I	I
	1	26	I	I
	2	1	I	I*
	2	6	I	I*
	2	11	I*	I
	2	16	I*	I*
	2	21	I*	I*
	2	26	I*	I*
	3	1	I	I
	3	6	I	I
	3	11	I	I
	3	16	I*	I
	3	21	I*	I*
	3	26	I*	I
	4	1	I	I
	4	6	I	I
	4	11	I	I*
	4	16	I*	I*
	4	21	I*	I*
	4	26	I*	I*
	5	1	I*	I
	5	6	I*	I
	5	11	I*	I
	5	16	I*	I
	5	21	I*	I
	5	26	I*	I
	6	1	I	I
	6	6	I	I
	6	11	I*	I
	6	16	I*	I

Table 5.52-1. (continued)

Station	Substation	Depth (cm)	Summer 2009	Winter 2010
Prince George	6	21	I*	I
P14	6	26	I*	I

5.52 Indian Creek (P7)

Salinity at Indian Creek during the average year ranged between 0.01 and 1 ppt. (Hackney et al., 2005). During the low river flow year, salinities reached values as high as 3 ppt. (Hackney et al., 2004). The current year salinities (Table 5.51-1), based on chloride concentrations (Table 5.51-2), were elevated, ranging between 1 – 3 ppt near the creekbank during summer collection. The creek bank sites were similar to an average year during winter 2010 collection with salinities less than 1 ppt. Upland sites did not appear to be as highly impacted with values less than 1 ppt. The majority of summer sulfate concentrations were in the 1,000 – 3,000 μM range near the creekbank and generally <100 μM at the upland sites (Table 5.51-3). These values were well above the average year concentrations of 10 – 350 μM and the low river flow year concentrations of 50 – 2,000 μM. The current winter sulfate concentrations were generally <100 μM and in the range of the average year values. Methane concentrations ranged between approximately 10 - 400 μM. These methane concentrations were similar to the low river flow year and average year concentrations (50 – 300 μM). The current year's classifications were similar to both average year and low river flow year classifications, with a combination of SR and MPSR at river bank sites, and MPSR and M at the upland station.

5.53 Dollisons Landing (P8)

Salinity at Dollisons Landing during the average year and the low river flow year ranged between 0.02 and 1 ppt. (Hackney et al., 2005; Hackney et al., 2004). The current year salinities (Table 5.51-1), based on chloride concentrations (Table 5.51-2), were all <0.1 ppt. The majority of sulfate concentrations were in the 10 – 50 μM range with a few in the 100-400 μM range (Table 5.51-3). These values were similar to the average year concentrations of 10 – 600 μM and the low river flow year concentrations of 10 – 400 μM. Methane concentrations were similar for the current year, the low river flow year and the average year (1 – 350 μM). Average year, low river flow year, and the current year classifications were a combination of M and MPSR. The current year had relatively more MPSR than most previous years. The similarity in the biogeochemical conditions and classifications for Dollison's Landing during various years indicates this site may not be as susceptible to salinity intrusions as other locations along the river.

5.54 Black River (P9)

Salinity at Black River during the average year, low river flow year, and the current year were consistently low and range between 0.02 – 0.09 ppt. (Table 5.51-1; Hackney et al., 2004; Hackney et al., 2005). Sulfate concentrations were approximately 10-200 μM during the average year and slightly higher 10-300 μM during the low flow year. During the current year concentrations of sulfate were (10 – 100 μM) with the exception of a few elevated concentration in the (200 – 300 μM) range. These sulfate concentrations reflect low flow and average flow years conditions. Methane concentrations at this site in the current, average and low flow year range between (0 – 300 μM) were observed during summer 2009. Methane concentrations ranged between (0-700 μM) during winter collection. During the average year classifications were mainly M and some MPSR. During the low river flow year classifications were mainly MPSR and some M. During the current year classifications were M and MPSR.

5.55 Smith Creek (P11)

Salinity at Smith Creek during the average year ranged between 1 - 4 ppt. (Hackney et al., 2005). During the low river flow year, salinities ranged between 8 - 14 ppt. (Hackney et al., 2004). The current year salinities (Table 5.51-1) ranged between approximately 0.1 - 2 ppt. Sulfate concentrations were in the 100 – 2,000 μM range (Table 5.51-3), slightly lower than average year concentrations of 200 – 5,000 μM and below the low river flow year concentrations of 2,000 – 12,000 μM. Methane concentrations ranged between 10-500 μM during the current year. Most methane concentrations in the low river flow year and average year were 10 – 400 μM while those during the average year were similar, ranging between approximately 100-500 μM. The biogeochemical conditions at Smith Creek during the average year were mostly SR due to the influence of salinity at this site. Classifications during the low river flow year were essentially all SR. During the current year the summer was dominated by SR with a few M classifications, while the winter had mainly MPSR classifications. This may indicate high levels of sulfate reduction possibly due to high levels of organic material deposited at this site during the fall resulting in rapid consumption of sulfate. It does not appear that the MPSR classifications were due to a lack of sulfate supply since salinities capable of maintaining sulfate reduction were observed during this year.

5.56 Rat Island (P12)

Salinity at Rat Island during the average year ranged between 0.2 – 0.8 ppt. (Hackney et al., 2005). During the low river flow year, salinities ranged between 1 – 8 ppt. (Hackney et al., 2004). The current year salinities (Table 5.51-1), were similar to an average year ranging between 0.02 – 1.0 ppt. Sulfate concentrations were in the 10 – 400 μM range during the current year with the exception of a few values of in the 500 - 700 μM range at S4 during the summer (Table 5.51-3). These values were below that of the low river flow year (100 – 6,000 μM) and similar to the 100-300 μM range observed during the average year. Average year methane concentrations reached values of 500 μM. Methane concentrations were in the 10 -300 μM range during the current year. The biogeochemical conditions at Rat Island during the average year and the current year were a combination of SR, MPSR and M classifications. During the low flow year classifications were mostly SR reflecting the impact of higher sulfate concentrations during that year.

5.57 Fishing Creek (P13)

Salinity at Fishing Creek during the average year ranged between 0.02 – 1.0 ppt. (Hackney et al., 2005). During the low river flow year, salinities reached values of 2 - 7 ppt. (Hackney et al., 2004). The current year salinities (Table 5.51-1), were similar to an average year with values ranging from 0.02 – 1.0 ppt. The majority of sulfate concentrations were in the 50 – 300 μM range during the average year. Sulfate concentrations during the current year fluctuated between an average and above average year concentrations, with values ranging between 20 – 1,000 μM (Table 5.51-3), but lower than those observed during the low river flow year (1,000 – 5000 μM). Methane concentrations in the average and current year were 10 – 400 μM (Table 5.51-4). Average year and current year classifications were mainly M, with a few MPSR, SR and SRNS.

5.58 Prince George Creek (P14)

Salinity at Prince George during the average year ranged between 0.02 – 0.2 ppt. (Hackney et al., 2005). During the low river flow year salinities reached values of 1 ppt. (Hackney et al., 2004). The current year salinities (Table 5.51-1), were similar to the average year with salinities ranging between 0.02 – 0.2 ppt. The majority of sulfate concentrations were in the 30 – 120 μM range during the average year. Sulfate concentrations during the current year were similar and slightly above an average year with values ranging between 10 – 300 μM (Table 5.51-3). Methane concentrations in the average year were 100 – 400 μM. The majority of methane concentrations during the low river flow year were less than 100 μM, reflecting the dominance of sulfate reduction. The current year's methane concentrations were in the range of 10-500 μM, reflective of a fluctuation between low and average flow. Average year classifications were mainly M with a few MPSR, SR and a few SRNS. Low flow years produce SR with some MPSR. The classifications at most sites during the current year were M, MPSR and a few SRNS, similar to an average year.

5.6 Long Term Trends and Change

Year 1 (winter 2000, 2001, summer 2000):

During the first year of the study general geochemical classifications were established for the sites in order to compare with future conditions. In the first report, which included the winters of 2000, 2001, and the summer of 2000 (Hackney et al. 2002), 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. 2002).

Year 2 (winter 2002, summer 2001):

In the second report, which included the summer of 2001 and the winter of 2002 (Hackney et al. 2002a, 2002b), 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 resulting from an increase in salinity. The other two sites 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 methanogenic classifications converted to sulfate reducing. Smith Creek (P11), which was already a sulfate reducing system, recorded higher salinities in porewaters.

The summer geochemical classifications on the Cape Fear River showed the opposite trend with evidence of a slight freshening of the porewaters. Changes in classifications of the Cape Fear River sites were not as dramatic as those observed on the Northeast Cape Fear River. The general trend for Cape Fear River sites was a slight freshening of the porewaters in winter 2002 and saltier conditions in summer 2001 compared to the data contained in the previous report. 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 the winter.

Year 3 (winter 2003, summer 2002):

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 the continued increase in summer salinities, all four sites 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 sites had a summertime sulfate reducing geochemical classifications. A similar increase in summertime porewater salinity was noted in the Cape Fear River sites immediately above the City of Wilmington (Indian Creek, Eagle Island), while the sites further upstream on the Cape Fear River (Black River, Dollisons Landing) had peak salinities occurring during the previous summer (2001). The salinities of

Town Creek, 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 and Eagle Island) all had lower winter porewater salinities than previous winters. For the upper Cape Fear River stations (Black River and Dollisons Landing), winter conditions showed a steady decrease in salinity since 2000. Fresher 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, and Smith Creek), winter (2003) porewater salinities returned to lower values after peaking during the previous winter (2002). The decrease in salinities for 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 and Prince George), several substations that previously converted to sulfate reducing returned to a methanogenic geochemical classification in 2003. Porewater salinities of Town Creek, Indian Creek, and Eagle Island increased during the winter (2003). The changes in geochemical classifications were relatively small for these sites with only slight changes towards higher salinity classifications.

Year 4: (winter 2004, summer 2003)

Low salinity conditions characterize Year 4, 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 were the lowest in salinity since the study began in 2000. 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 study. 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.

Year 5: (winter 2005, summer 2004)

Low salinity conditions characterize Year 5 of the study, summer 2004 and winter 2005. In general, all sites experienced conditions that would be considered low salinity on the basis of previous winters and summers. However, conditions were not as fresh as the previous year. Five stations experienced slightly saltier conditions during the current summer (2004) compared to last summer (Town Creek, Indian Creek, Black River, Smith Creek, and Fishing Creek), while Prince George experienced slightly fresher conditions. The remainder of sites either had no change or a mix of fresher and saltier conditions within the site. Two stations experienced slightly saltier conditions during the current winter (2005) compared to last winter (Town Creek and Rat Island), while Indian Creek experienced slightly fresher conditions. Five sites were essentially the same as the previous winter (Eagle Island, Black River, Smith Creek, Fishing

Creek, and Prince George) and Dollisons Landing had both saltier and fresher conditions within the site.

Year 6: (winter 2006, summer 2005)

In general, fresher conditions continued though Year 6 of this monitoring study, although slight differences were noted between the current year and the previous one. During the current winter, these slight changes in salinity and mode of organic matter remineralization varied systematically with river location. NECF river sites (Prince George, Fishing Creek, Rat Island, and Smith Creek) displayed a slight freshening, while all, but one (Indian Creek) main stream CFR sites showed slightly saltier conditions (Eagle Island, Black River, and Dollisons Landing). Town Creek, which is the most sea ward location monitored for geochemistry was noticeable fresher.

During the summer there were no consistent patterns with some sites showing slightly saltier conditions (Rat Island creek bank, Smith Creek, Eagle Island, and Town Creek) and some showing slightly fresher conditions (Fishing Creek, Rat Island upland, and Indian Creek). Generally conditions remained fairly fresh during this summer.

Year 7: (winter 2007, summer 2006)

Fresher conditions continued throughout both the winter and summer of year seven of the monitoring project. Classifications at most sites were essentially the same as year six with the exception of very slightly fresher conditions.

Year 8: (winter 2008, summer 2007)

The current year proved to be the saltiest year since the beginning of the monitoring project. All stations except the ones located most upstream (P8 Dollison's Landing; P9 Black River; P13 Fishing Creek; P14 Prince George) experienced the highest salinities and subsequent effects since monitoring began. The most upstream stations had elevated salinities similar to the summer of 2002 when previous low river flow conditions were present. The high salinities resulted in a shift towards classifications expected for higher salinities and input of sulfate. Generally methanogenic conditions were replaced by sulfate reducing conditions.

Year 9: *(winter 2009, summer 2008)*

The current year was generally slightly saltier compared to the average year, but not as salty as the low flow year at Indian Creek (P7), Black River (P9), Rat Island (P12), Town Creek (P3), and Eagle Island (P6). Fishing Creek (P13) and Prince George (P14) had conditions similar to the low flow year. Dollisons Landing (P8) and Smith Creek (P11) did not show any trends towards either salty of fresher conditions.

Year 10: *(winter 2010, summer 2009)*

The current year was very similar to the average year with only one possible exception, Indian Creek (P7), which displayed conditions typical of slightly elevated salinities.

6.0 BENTHIC INFAUNA COMMUNITIES

6.1 Summary

This report covers the June 2009 sampling period and presents data on selected community characteristics including comparison of diversity, species richness, and mean abundances of all taxa recovered by station during the 2009 sampling season. For illustrative purposes, current mean total abundance by taxa are presented with analogous data from both 1999 (the first year of sampling) and from the 2008 sampling period (Culbertson et. al. 2009). In general, site diversity was low (less than 1) and overall species richness was also low with only 65 taxa represented in the June 2009 sampling (excluding 5 terrestrial taxa). This is only half the species collected in peak years (Hackney et al. 2005, Hackney et al. 2006).

This chapter summarizes infaunal community patterns at nine sites distributed along the Cape Fear River, Northeast Cape Fear River and Town Creek for the 2009 collection. The nine stations have all been continuously monitored as part of a long-term effort to evaluate potential impacts of deepening and widening the Cape Fear River since 1999 (Hackney et al. 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, Culbertson et al 2008, 2009). Twenty-Five taxa were considered common in the 2009 sampling season, comprising 5% or more of the total abundance of organisms recovered from at least one site. These common taxa represent polychaetes, oligochaetes, crustaceans and insects.

6.2 Background

The ship traffic into and out of the Cape Fear River port is essential to the economic development of the Cape Fear region. Trends over the last two decades have been to reduce costs by building larger ships. These ships require deeper channels to operate safely; therefore, the U.S. Army Corps of Engineers initiated a project to deepen the Cape Fear River shipping channel from the mouth of the river to Wilmington Harbor (as discussed in the executive summary of this report). This deepening activity has several potential impacts including the shifting of the tidal salt wedge upstream, changes in tidal amplitude, subsequent shifts in wetland flooding intensity and extent, and changes in inundation time. The consequences of any of these changes could have far reaching impacts to the flora and fauna of the Cape Fear River estuary. Alterations in salinity, flow, and tidal currents are the most likely impacts predicted by numeric models of the Cape Fear River system. Any of these changes would have significant effects on the critical nursery habitats in the Cape Fear River estuary, potentially altering physical and chemical characteristics of the sediment, or the inundation period leading to alterations in the vegetation along the fringing marsh, shifts in dominant infauna, and utilization habits by resident and transient fishes.

As part of the U.S. Army Corps of Engineers project to deepen 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 for 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 currents. Benthic infaunal community patterns integrate environmental changes at a specific site over time. Many infaunal groups 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. These organisms occupy an intermediate trophic position, consuming detrital or planktonic food sources (although some species are predatory or omnivorous) and being prey for larger fish and decapods. As a result, the infaunal community present in an area represents cumulative impacts of varying environmental factors over a several month period. Changes in the composition of the infaunal community in response to changing environmental conditions may occur more rapidly than for more motile organisms that can migrate among optimal locations. However, changes in this group may also have fundamental importance for local ecosystem functioning because of their key intermediate 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, or changes in salinity regime and 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, osmotic stress, etc.). The monitoring effort reported here is designed to detect changes in the infaunal communities at selected sites that may be coincident with the timing of deepening of the Cape Fear River shipping channel. This study was designed 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) If changes in salinity, tidal amplitude and/or inundation period occur, it will be evidenced by changes in intertidal and shallow subtidal benthic community composition, 2) If alterations of the Cape Fear River shipping channel significantly changes 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 infaunal taxonomic groups in the Cape Fear estuary. Bivalves, gastropods, and isopods are consistently present in the system, but are not numerically dominant at most sites. Polychaetes and amphipods tend to dominate mesohaline sits in the river, while oligochaetes and insects dominate the oligohaline sites, although site-specific responses may vary among years and may vary in specific taxonomic composition. The relative importance of the specific species that dominate a site changes along the estuarine gradient from polyhaline to oligohaline and tidal freshwater conditions. Infaunal groups demonstrate a variety of reproductive, dispersal, and functional strategies that can directly relate to timing and magnitude of their response to shifting environmental conditions. As noted in previous evaluations of the Cape Fear River estuary, both bivalves and gastropods have conspicuously low abundances in estuarine portions of the river both in the intertidal and subtidal habitats (Mallin et al. 1999 and 2001). Polychaetes (segmented worms bearing specialized appendages) occur 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 near surface and tube-dwelling species are common prey for fish, shrimp, and crabs. Oligochaetes are another group of segmented worms that generally lack specialized appendages, have a burrowing habit, and exhibit direct development. Direct development in this group can result 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. Like other infaunal groups, this group includes a number of living strategies including surface, tube-dwelling and free-living species that would be susceptible to predation especially by juvenile fish that recruit into the system heavily in the spring and to a lesser extent in the fall of each year.

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 mainstem Cape Fear above the city of Wilmington (P6-Eagle Island, P7-Indian Creek, and P8-Dollisons's Landing), and three stations in the Northeast 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 (Section 7.0) 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 subsites and two lower intertidal subsites at each station. These subsites 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, 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 efforts for the Cape Fear River channel began in winter 2001 and were ongoing at various areas within the Cape Fear system into 2006. Since the current report summarizes data from infaunal samples taken in June 2009 with comparison to 2008 and initial samples, differences among years may represent changes from background conditions (pre-dredging; 1999-2001), possible initial impacts related to the actual sediment removal activities (2002-2006) and any developing hydrologic impacts of channel alterations. Full effects of the deepening project cannot be assessed until 2-3 years of post-dredging data are available and are fully compared to pre-dredging conditions and patterns occurring while dredging was ongoing. However, annual community patterns at each site are assessed in this report by examining patterns of species diversity, species richness, taxonomic and guild dominance, and community similarity. Per site diversity was calculated using the Shannon Diversity Index and was compared along with per sample taxonomic richness among years by site. For comparison of taxonomic richness, taxa were combined where there was uncertainty among years. Abundances of major taxonomic 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

While four locations (two upper intertidal and two lower intertidal subsites) were sampled at each station, mean total abundances for all infaunal species present at a specific station are given by tidal position. In order to more easily compare the relative abundance and shifts in composition among years and tidal positions, abundance data is presented in three year blocks: 1999 (initial sampling year), 2008 (previous sampling year) and 2009 (current sampling year), by tidal position (high intertidal and low intertidal) and only for taxa that were present at that site/substation combination. In all cases the tables with the subscript “a” represents the high intertidal subsites and tables with the subscript “b” represent the low intertidal subsites. Tables 6.4-1a and 6.4-1b represent the mouth of Town Creek (P2) located in the mesohaline region of the Cape Fear River, while Tables 6.4-2a and 6.4-2b and Tables 6.4-3a and 6.4-3b represent the two inner Town Creek sites, P3A and P3B, respectively. The main stem Cape Fear sites represent the salinity gradient from the lower mesohaline to generally oligohaline conditions: Eagle Island (P6) (Tables 6.4-4a and 6.4-4b), Indian Creek (P7) (Tables 6.4-5a and 6.4-5b), and Dollison’s Landing (P8) (Tables 6.4-6a and 6.4-6b). The Smith Creek site (P11) (Table 6.4.7a and 6.4.7b), Rat Island site (P12) (Tables 6.4.7a and 6.4.8b), and Fishing Creek site (P13) (Tables 6.4.9a and 6.4.9b) represent analogous conditions on the NE Cape Fear River. The 2009 sampling season showed a distinct shift in faunal patterns with a general reduction in both the number of taxa present at a site and a reduction in mean total abundance as compared to 1999 2008. Previous sampling years have shown signs of species replacement, especially during periods of increasing drought and recovery; however, 2009 showed an overall decline in species richness, much as was reported for the 2008 sampling year (Culbertson et al. 2009).

Any taxa that represented 5% of the total abundance at a given site were considered common. In the current analysis 25 taxa were considered common. Oligochaetes were still the most abundant taxa for most sites (Table 6.4.10), with Lumbriculidae, Tubificidae, and *Tubificoides heterochaetus* among the common oligochaete groups. There was little change in the proportion of the oligochaete family Tubificidae between this reporting period and the previous. Tubificidae spp. represented between 25% and 60% of the number of individuals present at most sites (compared to 10-90% in 2008). This grouping was comprised of several species, since many of the individuals placed within the Tubificidae family were too small to reliably identify or incomplete. The remaining common taxa were *Apocorophium lacustre* (amphipod), *Bezzia/Palpomyia* (insect), bivalve sp., *Boccardiella sp A* (polychaete), *Chironomus* sp. (insect), *Dicrotendipes nervosus* (insect), , Dolichopodidae sp. (insect), *Edotea* sp. (isopoda), *Hobsonia florida* (polychaete), *Laeonereis culveri* (polychaete), *Marenzelleria viridis* (polychaete), *Parachironomous* sp. (insect), *Parandalia* sp A. (polychaete), *Polydora socialis* (polychaete), *Polypedilium* sp. (insect), *Procladius* sp. (insect), Spionidae sp. (polychaete), *Streblospio benedicti* (polychaete), Tipulidae sp. (insect), and *Uca* sp. (decapod) (Figure 6.4.1). Most of these taxa were represented among the dominant fauna in the previous sampling year, however, several fauna that have been dominant in previous years such as *Capitella capitata*, *Mediomastus* sp. and *Hargeria rapax* were not present in this listing (Culbertson et al. 2010).

Comparison of total abundance among sites during 2009 shows only one significant difference with the Dollison Landing site (P8) having greater mean abundance than the Fishing Creek (P13) site (Figure 6.4.2) [ANOVA on log transformed data: $F (8, 61) = 2.87$, $P = 0.0089$. SNK: P8=A, P7=BA, P11=BA, P2=BA, P3A=BA, P3B=BA, P12=BA, P6=BA, P13=B. Sites with the same letter are not significantly different based on the SNK]. This difference is driven almost exclusively by the oligochaetes present at P8. All other sites showed intermediate abundances. This is most likely due to the high degree of variability among sites. It is worth noting that overall mean total abundance reported here were lower than mean total abundance reported in the previous report (Culbertson et al 2010). However with the exception of P2 the general pattern is similar between years. Mean species richness shows the same pattern as the mean total abundance with P8 demosntrating significantly greater richness than all sites except Indian Creek (P7) and the upper Town Creek site (P3) (Figure 6.4.4) [ANOVA: $F (8, 61) = 4.79$, $P = 0.0001$. SNK: P8=A, P2=BA, P7=BAC, P3A=BAC, P3B=BC, P12=BC, P6=BC, P11=BC, P13=C. Sites with the same letter are not significantly different based on the SNK]. Comparison of mean diversity indicated an overall difference ($F=2.50, P<0.02$), but the SNK pairwise comparison could not detect any specific differences among sites (Figure 6.4.5).

Relative abundance patterns among functional guilds remained relatively stable (Table 6.4.11), reflecting the greater conservatism in trophic structure compared to individual taxa abundances. Surface/mobile taxa dominated at the most saline site and were co-dominants at P3, reflecting the influence of polychaete and amphipod taxa. Deep burrowing taxa dominated at other sites.

Some of the patterns observed here may be a response to drought conditions that continued since late 2007. During the 2007 sampling year, rainfall in the Cape Fear River basin was ~27 inches below average. Rainfall levels for 2008 reached nearly the same levels. Below average precipitation fell in late 2008 and 2009 had below average rainfall for the year. Although there was a increase in river flow recorded near the end of 2009, overall 2009 still ended with a rainfall deficit and all infaunal samples were collected earlier in 2009 prior to any potential impacts from increasing flows that may have been observed in the 2009-2010 sampling year. The shift in insect taxa reported in the 2007 sampling year (Culbertson et al. 2009) and the continued decline of certain infaunal taxa in 2008 and 2009 (Culbertson et al. 2009 and 2010) could be explained by the reduced river discharges and increases in salinity at some sites. The patterns observed in 2009 are very similar to those reported in 2008 and show a steady decline in number of taxa and in abundance of many taxa. It is not surprising to observe low diversity measurement at this time or find few differences among sites, even those spread across such a large spatial area. Infaunal communities are patchy be nature and with changes in key physical parameters it may take several recruitment periods for some taxa to colonize or re-colonize select areas.

Table 6.4-1a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected on the Town Creek mouth site (P2) during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
amphipod sp.	0.17(0.17)	0(0)	0(0)
Apocorophium lacustre	0(0)	0.25(0.25)	1.75(0.85)
Boccardiella sp.	0(0)	0(0)	1.00(1.00)
Boccardiella sp. A	0(0)	0(0)	0.50(0.50)
juv. Bivalve	1.00(0.36)	0.25(0.25)	0(0)
Capitella capitata	0(0)	2.50(2.50)	0(0)
Cassidinidea lunifrons	0.17(0.17)	0(0)	0.25(0.25)
Corophium sp.	0.17(0.17)	0(0)	0(0)
Dicrotendipes nervosus	0(0)	0(0)	0.25(0.25)
Dicrotendipes sp.	2.00(0.93)	0(0)	0(0)
Dolichopodidae sp.	0(0)	0(0)	0.25(0.25)
Gammarus palustris	0(0)	0(0)	0.25(0.25)
Gammarus sp.	0(0)	0(0)	0.25(0.25)
Gammarus tigrinus	0(0)	0.25(0.25)	0(0)
Hargeria rapax	0(0)	23.75(12.29)	0.25(0.25)
Hobsonia florida	3.67(2.01)	0(0)	0(0)
Hydracarina sp.	0(0)	0(0)	0.25(0.25)
insect sp.	0.17(0.17)	0(0)	0(0)
Laeonereis culveri	0.17(0.17)	0(0)	0(0)
Marenzelleria viridis	1.67(1.67)	0(0)	0(0)
Neanthes succinea	0(0)	3.50(1.19)	1.00(0.58)
Nereis riisei	0.67(0.49)	0(0)	0(0)
Oligochaeta sp.	36.50(11.55)	0(0)	0(0)
Orchestia uhleri	0(0)	0.25(0.25)	0(0)
Owenia sp.	0.17(0.17)	0(0)	0(0)
Palaemonetes pugio	0.17(0.17)	0(0)	0(0)
Parandalia sp.	1.00(0.63)	0(0)	0(0)
Polydora ligni/cornuta	12.17(10.83)	0(0)	0(0)
Polydora socialis	5.50(4.11)	0(0)	0(0)
Polypedilum sp.	1.50(0.72)	0(0)	0(0)
Pseudonototanais sp. B	0(0)	0(0)	33.25(15.35)
Streblospio benedicti	0.83(0.31)	12.5(11.84)	0(0)
Tanais sp.	0.33(0.33)	0(0)	0(0)
Tubificidae spp.	0(0)	4.75(3.47)	1.00(0.71)
Tubificoides heterochaetus	0(0)	4.50(4.50)	0(0)

Table 6.4-1b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected on the Town Creek mouth site (P2) during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
amphipod sp.	0.17(0.17)	0(0)	0(0)
Boccardiella sp.	0(0)	0(0)	0.25(0.25)
Collembola sp.	0.17(0.17)	0(0)	0(0)
Edotea (*montosa*)	0.17(0.17)	0(0)	0.75(0.48)
Gammarus tigrinus	0.33(0.33)	0(0)	0(0)
Geukensia demissa	0(0)	0(0)	0.25(0.25)
Hobsonia florida	0.83(0.83)	0(0)	0(0)
Laeonereis culveri	0.17(0.17)	0(0)	0(0)
Lumbriculidae sp.	0(0)	0(0)	0.25(0.25)
Mediomastus ambiseta	1.17(0.83)	5.25(2.78)	0(0)
Mediomastus sp.	1.67(0.99)	3.25(1.70)	0.25(0.25)
Neanthes succinea	0(0)	0(0)	1.75(0.85)
Nemertea sp.	0.17(0.17)	0.50(0.29)	0(0)
Oligochaeta sp.	4.83(2.21)	0(0)	0(0)
Palaemonetes pugio	0(0)	0(0)	0.25(0.25)
Parandalia sp.	2.50(0.85)	0(0)	0(0)
Parandalia sp. A	0(0)	1.50(0.50)	1.75(0.75)
Paraprionospio pinnata	0.17(0.17)	0(0)	0(0)
Polydora ligni/cornuta	0.83(0.83)	0(0)	0(0)
Pseudonototanais sp. B	0(0)	0(0)	2.00(1.15)
Streblospio benedicti	3.00(1.69)	7.00(3.49)	0.75(0.48)
Syllidae sp.	0.17(0.17)	0(0)	0(0)

Table 6.4-2a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P3A upper Town Creek sites during June 1999, 2008 and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
Acarina sp.	0.17(0.17)	0(0)	0(0)
Bezzia/Palpomyia sp.	0(0)	0(0)	2.00(0.91)
Bivalvia sp.	0(0)	0(0)	0.50(0.29)
juv. Bivalve	0.17(0.17)	0(0)	0.75(0.48)
Collembola sp.	0.33(0.21)	0(0)	0(0)
Cyathura (madelinae)	0(0)	0.25(0.25)	0(0)
Dolichopus sp.	1.83(1.83)	0(0)	0(0)
Ephydridae sp.	0(0)	0(0)	0.50(0.50)
Gammarus tigrinus	0.33(0.33)	0(0)	0(0)
Hydracarina sp.	0(0)	0.25(0.25)	0(0)
insect pupae	0.17(0.17)	0(0)	0(0)
insect sp.	0.17(0.17)	0(0)	0(0)
insect sp. b	0.17(0.17)	0(0)	0(0)
insect sp. g	0.33(0.33)	0(0)	0(0)
Laeonereis culveri	0.67(0.67)	0(0)	0(0)
Oligochaeta sp.	36.67(24.02)	0(0)	0(0)
Orchestia uhleri	0(0)	1.25(0.63)	0.75(0.48)
Orthocladiinae sp.	0(0)	0.25(0.25)	0(0)
Tubificidae spp.	0(0)	9.25(4.13)	8.75(4.27)
Uca minax	0.17(0.17)	0(0)	0(0)
Uca pugilator	0.50(0.34)	0(0)	0(0)
Uca pugnax	0.17(0.17)	0(0)	0(0)
Uca sp.	0(0)	0(0)	0.50(0.29)

Table 6.4-2b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P3A upper Town Creek sites during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
Ampharetidae sp.	0.17(0.17)	0(0)	0(0)
amphipod sp.	0.67(0.33)	0(0)	0(0)
Apocorophium lacustre	0(0)	0.50(0.29)	4.75(3.30)
Apocorophium louisianum	0(0)	0.25(0.25)	0(0)
Apocorophium sp.	0(0)	0.50(0.50)	0(0)
Bezzia/Palpomyia sp.	0(0)	0.50(0.50)	0(0)
Boccardiella sp.	0(0)	0.25(0.25)	0(0)
juv. Bivalve	0.17(0.17)	0(0)	0(0)
Cassidinidea lunifrons	0.17(0.17)	0(0)	0(0)
Cyathura (madelinae)	0(0)	0.75(0.75)	0.25(0.25)
Cyathura (polita)	0(0)	0.25(0.25)	0(0)
Dasyhelea sp.	0(0)	0(0)	0.25(0.25)
Dicrotendipes nervosus	0(0)	10.50(10.50)	4.00(3.67)
Dolichopodidae sp.	0(0)	0.25(0.25)	0(0)
Gammarus plumosa	0.17(0.17)	0(0)	0(0)
Gammarus tigrinus	2.67(2.12)	0(0)	0(0)
juv. Gastropod	0.17(0.17)	0(0)	0(0)
Hargeria rapax	0(0)	0.50(0.50)	0(0)
Hobsonia florida	3.17(1.33)	0.50(0.50)	0.25(0.25)
insect larva b	0.17(0.17)	0(0)	0(0)
insect pupae	0.17(0.17)	0(0)	0(0)
juv. Isopod	0(0)	0(0)	0.75(0.75)
Laeonereis culveri	0(0)	0(0)	0.25(0.25)
Marenzelleria viridis	0.33(0.33)	0(0)	0(0)
Mediomastus ambiseta	0.17(0.17)	0(0)	0(0)
Mediomastus califoriensis	0.17(0.17)	0(0)	0(0)
Munna sp.	0.17(0.17)	0(0)	0(0)
Neanthes succinea	0(0)	0(0)	0.25(0.25)
Oligochaeta sp.	5.00(3.85)	0(0)	0(0)
Polydora ligni/cornuta	0.17(0.17)	0(0)	0(0)
Polydora sp.	0.17(0.17)	0(0)	0(0)
Polypedilum sp.	1.00(0.36)	0(0)	2.00(1.68)
Procladius sp.	2.50(0.92)	0(0)	0(0)
Streblospio benedicti	0.17(0.17)	0(0)	0(0)
Tanytarsus sp.	0.50(0.34)	0(0)	0(0)
Tubificidae spp.	0(0)	12.25(8.62)	3.50(1.55)

Table 6.4-3a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P3B upper Town Creek sites during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
Anurida maritima	0(0)	1.00(0.71)	0(0)
Bezzia/Palpomyia sp.	0(0)	0.75(0.48)	2.25(0.95)
juv. Bivalve	0.40(0.24)	0(0)	0.75(0.48)
Collembola sp.	0.40(0.24)	0(0)	0(0)
Cyathura (madelinae)	0(0)	0.25(0.25)	0.25(0.25)
Dolichopodidae sp.	0(0)	1.00(0.58)	0(0)
Dolichopus sp.	0.40(0.40)	0(0)	0(0)
Ephydra sp.	0(0)	0.50(0.50)	0(0)
Gammarus tigrinus	0(0)	0.50(0.50)	0(0)
insect larvae c	0.40(0.24)	0(0)	0(0)
Laeonereis culveri	0(0)	0(0)	0.25(0.25)
Marenzelleria viridis	0.20(0.20)	0(0)	0(0)
Megalops sp.	0(0)	0.25(0.25)	0(0)
Munna sp.	0.20(0.20)	0(0)	0(0)
Oligochaeta sp.	16.40(6.24)	0(0)	0(0)
Orchestia sp.	0.20(0.20)	0(0)	0(0)
Orchestia uhleri	0(0)	1.50(1.19)	0(0)
Tubificidae spp.	0(0)	5.50(1.55)	3.25(0.95)
Uca sp.	0.20(0.20)	0(0)	0.50(0.29)

Table 6.4-3b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P3B upper Town Creek sites during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
amphipod sp.	0.33(0.21)	0(0)	0(0)
Apocorophium lacustre	0(0)	8.25(8.25)	0(0)
Bezzia/Palpomyia sp.	0(0)	0.25(0.25)	0(0)
Cassidinidea lunifrons	0.17(0.17)	0.25(0.25)	0(0)
Cyathura (madelinae)	0(0)	1.25(0.95)	0.25(0.25)
Dicrotendipes nervosus	0(0)	8.00(8.00)	0.25(0.25)
Dicrotendipes sp.	0.17(0.17)	0(0)	0(0)
Dolichopodidae sp.	0(0)	0.75(0.75)	0(0)
Gammarus lawrencianus	0.83(0.83)	0(0)	0(0)
Gammarus sp.	0.17(0.17)	0(0)	0(0)
Gammarus tigrinus	1.83(1.83)	0.50(0.29)	0(0)
Helophorus sp.	0(0)	0(0)	0.25(0.25)
Heteromastus filiformis	0.17(0.17)	0(0)	0(0)
Hobsonia florida	2.50(0.88)	0(0)	0(0)
Hydracarina spp.	0(0)	0.50(0.50)	0(0)
Laeonereis culveri	0(0)	1.25(0.63)	0.50(0.29)
Marenzelleria viridis	0.17(0.17)	0(0)	0(0)
Marinogammarus sp.	0.17(0.17)	0(0)	0(0)
Munna sp.	0.50(0.34)	0(0)	0(0)
Nimbocera sp.	0.50(0.50)	0(0)	0(0)
Oligochaeta sp.	4.83(2.36)	0(0)	0.25(0.25)
Parachironomus sp.	0(0)	0(0)	0.25(0.25)
Polydora sp.	0.33(0.33)	0(0)	0(0)
Polypedilum sp.	0.67(0.49)	0(0)	0(0)
Procladius sp.	0.50(0.34)	0(0)	0(0)
Tubificidae spp.	0(0)	3.50(1.50)	5.00(3.39)

Table 6.4-4a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at the lowest main-stem Cape Fear site P6 during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
Bezzia/Palpomyia sp.	0.60(0.24)	0.50(0.50)	1.25(0.63)
juv. Bivalve	0.20(0.20)	0(0)	0(0)
Cassidinidea lunifrons	1.00(1.00)	0(0)	0(0)
Collembola sp.	1.60(0.75)	0(0)	0(0)
Curculionidae sp.	0.40(0.40)	0(0)	0(0)
Cyathura (*madelinae*)	0.40(0.40)	0.50(0.29)	0(0)
Cyathura polita	0.80(0.58)	0(0)	0(0)
Diptera sp. (pupae)	0(0)	0.25(0.25)	0(0)
Dolichopodidae sp.	0(0)	0.25(0.25)	0.75(0.48)
Dolichopus sp.	0.80(0.80)	0(0)	0(0)
Ephydra sp.	0(0)	0(0)	0.50(0.50)
Eukiefferiella (*claripennis*)	0.20(0.20)	0(0)	0(0)
juv. Gastropod	0.20(0.20)	0(0)	0(0)
Hemipodus roseus	0.80(0.80)	0(0)	0(0)
insect larva c	0.20(0.20)	0(0)	0(0)
insect sp. h	1.00(1.00)	0(0)	0(0)
insect sp. i	0.40(0.40)	0(0)	0(0)
Laeonereis culveri	3.20(2.03)	0.25(0.25)	0(0)
Melita nitida	0(0)	0.25(0.25)	0(0)
Neanthes succinea	0(0)	0.25(0.25)	0(0)
Oligochaeta sp.	9.60(4.84)	0(0)	0(0)
Orchestia sp.	1.20(0.97)	0(0)	0(0)
Orchestia uhleri	1.00(0.55)	0(0)	0(0)
Procladius sp.	0.20(0.20)	0(0)	0(0)
Tubificidae spp.	0(0)	8.25(5.79)	13.25(6.54)
Uca pugilator	0.40(0.40)	0(0)	0(0)
Uca sp.	0.20(0.20)	1.00(0.41)	0.50(0.29)

Table 6.4-4b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at the lowest main-stem Cape Fear site P6 during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
Acarina sp.	0.20(0.20)	0(0)	0(0)
amphipod sp.	0.80(0.58)	0.25(0.25)	0(0)
Anurida maritima	0(0)	0(0)	0.25(0.25)
Bezzia/Palpomyia sp.	0.60(0.40)	0.25(0.25)	0(0)
juv. Bivalve	0.60(0.40)	0(0)	0(0)
Boccardiella sp. A	0(0)	0(0)	0.50(0.29)
Cassidinidea lunifrons	1.00(0.77)	0(0)	0(0)
Collembola sp.	0.20(0.20)	0(0)	0(0)
Cyathura polita	5.00(5.00)	0(0)	0(0)
Dolichopus sp.	0.20(0.20)	0(0)	0(0)
Edotea sp.	0(0)	0(0)	0.25(0.25)
Eukiefferiella (*claripennis*)	0.40(0.40)	0(0)	0(0)
Gammarus daiberi	0.20(0.20)	0(0)	0(0)
juv. Gastropod	0.40(0.24)	0(0)	0(0)
Hobsonia florida	0.20(0.20)	0(0)	0(0)
insect pupae	1.80(1.11)	0(0)	0(0)
insect sp.	0.20(0.20)	0(0)	0(0)
Melita sp.	1.00(1.00)	0(0)	0(0)
Munna sp.	1.00(1.00)	0(0)	0(0)
Oligochaeta sp.	49.60(18.88)	0(0)	0(0)
Polydora socialis	2.60(2.60)	0(0)	0.50(0.50)
Polypedilum sp.	0.40(0.40)	0(0)	0(0)
Procladius sp.	0.60(0.60)	0(0)	0(0)
Spionidae sp.	0(0)	0.25(0.25)	0(0)
Streblospio benedicti	0(0)	0.25(0.25)	0(0)
Tubificidae spp.	0(0)	0.25(0.25)	0.75(0.25)
Tubificoides heterochaetus	0(0)	0.50(0.50)	0(0)
Uca sp.	0.40(0.40)	0(0)	0(0)

Table 6.4-5a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P7 on the main-stem Cape Fear during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
Bezzia/Palpomyia sp.	0.20(0.20)	0(0)	0.25(0.25)
Celina sp.	0.20(0.20)	0(0)	0(0)
Chrysops sp.	0.20(0.20)	0(0)	0(0)
Coleoptera sp. (larva)	0(0)	0.25(0.25)	0(0)
Collembola sp.	0.40(0.24)	0(0)	0(0)
Cryptochironomus sp.	0.20(0.20)	0(0)	0(0)
Cyathura (*madelinae*)	0.40(0.40)	0(0)	0(0)
Dolichopodidae sp.	0(0)	0(0)	1.50(0.96)
Dolichopus sp.	1.60(0.51)	0(0)	0(0)
juv. Gastropod	0.20(0.20)	0(0)	0.25(0.25)
insect pupae	0.20(0.20)	0(0)	0(0)
Laeonereis culveri	0(0)	0(0)	1.00(0.00)
Lirceus sp.	1.40(1.17)	0(0)	0(0)
Lumbriculidae sp.	7.40(3.32)	0.25(0.25)	6.75(3.45)
(Lumbriculidae sp.)	0(0)	1.25(1.25)	0(0)
Micropsectra sp.	0.80(0.37)	0(0)	0(0)
Nemertea sp.	0(0)	0(0)	0.50(0.50)
Oligochaeta sp.	52.20(15.47)	0(0)	0(0)
Orchestia (platensis)	0.20(0.20)	0(0)	0(0)
Orchestia uhleri	0.60(0.60)	1.25(0.95)	0.25(0.25)
Pristinella sp.	0.40(0.40)	0(0)	0(0)
Tabanus sp.	0.20(0.20)	0(0)	0.25(0.25)
Tipula sp.	0(0)	0(0)	0.50(0.50)
Tipulidae sp.	0(0)	0.75(0.75)	0.75(0.48)
Tubificidae spp.	0(0)	14.00(9.67)	0.25(0.25)
Tubificoides heterochaetus	0.20(0.20)	0(0)	0(0)
Uca pugilator	0.40(0.40)	0(0)	0(0)
Uca sp.	0(0)	0.50(0.50)	0(0)

Table 6.4-5b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P7 on the main-stem Cape Fear during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
Bezzia/Palpomyia sp.	0.20(0.20)	0(0)	0.25(0.25)
juv. Bivalve	0.60(0.40)	0(0)	0.25(0.25)
Cassidinidea lunifrons	0.60(0.24)	0(0)	0(0)
Chironomus sp.	0.20(0.20)	0(0)	0(0)
Collembola sp.	0(0)	0.25(0.25)	0(0)
Cryptochironomous sp.	0.60(0.60)	0(0)	2.25(1.03)
Cyathura (*madelinae*)	0.40(0.24)	0(0)	0(0)
Dolichopus sp.	0.20(0.20)	0(0)	0(0)
Gammarus daiberi	0.20(0.20)	0(0)	0(0)
Gammarus tigrinus	0.60(0.40)	0(0)	0(0)
juv. Gastropod	1.00(0.45)	0(0)	0(0)
insect pupae	0.40(0.24)	0(0)	0(0)
insect sp. a	0.40(0.24)	0(0)	0(0)
Laeonereis culveri	0(0)	0.25(0.25)	0(0)
Limnodrilus hoffmeisteri	0(0)	0(0)	0.25(0.25)
Lumbriculidae sp.	0(0)	0.25(0.25)	0(0)
Megalops sp.	0.20(0.20)	0(0)	0(0)
Oligochaeta sp.	17.80(4.55)	0(0)	0(0)
Paratendipes sp.	0.20(0.20)	0(0)	0(0)
Polypedilum sp.	1.00(1.00)	0(0)	1.25(0.48)
Procladius sp.	0.20(0.20)	0(0)	0(0)
Tubificidae spp.	0(0)	4.75(1.75)	44.00(12.81)

Table 6.4-6a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P8 on the main-stem Cape Fear during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
Acarina sp.	0.17(0.17)	0(0)	0(0)
Anurida maritima	0(0)	1.25(0.75)	0.50(0.29)
Bezzia/Palpomyia sp.	0.33(0.33)	0(0)	0.75(0.75)
juv. Bivalve	11.17(4.32)	0(0)	0.75(0.75)
Coleoptera sp.	0.33(0.33)	0(0)	0(0)
Collembola sp.	1.50(0.43)	0(0)	0(0)
Copelatus sp.	0(0)	0(0)	0.25(0.25)
Dolichopodidae sp.	0(0)	0.50(0.50)	0(0)
Dolichopus sp.	2.17(0.75)	0(0)	0(0)
Ephydridae sp.	0(0)	0.50(0.50)	0(0)
Gammarus tigrinus	1.33(1.33)	0(0)	0(0)
juv. Gastropod	0.50(0.34)	0(0)	0.25(0.25)
Helophorus linearis	0(0)	0.25(0.25)	0(0)
Hirudinea sp.	0(0)	0(0)	0.25(0.25)
Hydaticus sp. (larvae)	0.33(0.21)	0(0)	0(0)
insect sp.	0.17(0.17)	0(0)	0(0)
insect spp. (larvae)	0(0)	0(0)	0.50(0.50)
Isochaetides sp.	0(0)	0(0)	4.75(4.11)
Lumbriculidae sp.	5.00(2.89)	0(0)	9.75(0.85)
(Lumbriculidae sp.)	0(0)	0.75(0.75)	0(0)
Micropsectra sp.	3.17(3.17)	0(0)	0(0)
Naididae sp.	0(0)	0(0)	0.75(0.48)
Noterus (*capricornis*)	0.17(0.17)	0(0)	0(0)
Oligochaeta sp.	73.50(14.07)	0(0)	0(0)
Orchestia uhleri	3.50(1.48)	0.50(0.50)	1.00(0.41)
Paratendipes sp.	0(0)	0(0)	1.75(1.03)
Polypedilum sp.	0.17(0.17)	0(0)	0(0)
Rheotanytarsus sp.	0.33(0.33)	0(0)	0(0)
Spirosperma carolinensis	0(0)	0.50(0.29)	2.75(1.49)
Stratiomya sp.	0.17(0.17)	0(0)	0(0)
Tabanidae sp.	0(0)	0(0)	0.50(0.50)
Tanytarsus sp.	1.00(1.00)	0(0)	0(0)
Tubificidae spp.	0(0)	2.50(0.50)	42.25(23.62)
Tubificoides heterochaetus	0.17(0.17)	0(0)	0(0)
Uca pugilator	0.17(0.17)	0(0)	0(0)

Table 6.4-6b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P8 on the main-stem Cape Fear during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
Anurida maritima	0(0)	0(0)	0.25(0.25)
Bezzia/Palpomyia sp.	0.33(0.33)	0.50(0.29)	0(0)
Bivalvia sp.	0(0)	0(0)	0.50(0.50)
juv. Bivalve	1.67(0.56)	0(0)	0.50(0.50)
Cassidinidea lunifrons	0.83(0.83)	0(0)	0(0)
Collembola sp.	0.17(0.17)	0(0)	0(0)
Cryptochironomous sp.	0.33(0.33)	0.25(0.25)	0.50(0.29)
Cyathura (*madelinae*)	0.67(0.67)	0(0)	0(0)
Dolichopodidae sp.	0(0)	0.25(0.25)	0.75(0.48)
Dolichopodidae sp. (pupae)	0(0)	0(0)	0.25(0.25)
Dolichopus sp.	1.00(0.82)	0(0)	0(0)
Ephydridae sp.	0(0)	0.50(0.50)	0(0)
Gammarus tigrinus	1.50(1.15)	0(0)	0.25(0.25)
juv. Gastropod	0.17(0.17)	0(0)	0(0)
Hydracarina sp.	0(0)	0(0)	0.25(0.25)
insect sp. b	0.17(0.17)	0(0)	0(0)
Limnodrilus hoffmeisteri	0(0)	0.25(0.25)	0(0)
Lumbriculidae sp.	3.00(1.61)	0.25(0.25)	1.75(1.44)
(Lumbriculidae sp.)	0(0)	0.25(0.25)	0(0)
Megalops sp.	0.17(0.17)	0(0)	0(0)
Micropsectra sp.	0.17(0.17)	0(0)	0(0)
Oligochaeta sp.	122.83(31.34)	0(0)	0(0)
Orchestia uhleri	0(0)	0(0)	0.25(0.25)
Paratendipes sp.	0.17(0.17)	0(0)	0.50(0.29)
Polypedilum/Haterale sp.	2.33(2.33)	0(0)	0(0)
Polypedilum spp.	1.33(0.56)	1.50(0.87)	0(0)
Pristinella sp.	0.67(0.67)	0(0)	0(0)
Rheotanytarsus sp.	0.17(0.17)	0(0)	0(0)
Spirosperma carolinensis	0(0)	0(0)	0.75(0.48)
Tanytarsus sp.	0.33(0.33)	0(0)	0(0)
Tribelos sp.	0.33(0.33)	0(0)	0(0)
Tubificidae spp.	0(0)	5.25(2.02)	39.50(25.76)

Table 6.4-7a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P11 on the NE Cape Fear River during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
Bezzia/Palpomyia sp.	0(0)	0.50(0.50)	0(0)
Boccardiella sp.	0(0)	0.25(0.25)	0(0)
juv. Bivalve	0.25(0.25)	0(0)	0(0)
Cassidinidea lunifrons	1.00(0.71)	0(0)	0(0)
Chironomus sp.	0.50(0.50)	0(0)	0.25(0.25)
Curculionidae sp.	0.75(0.75)	1.00(1.00)	0(0)
Curculionidae sp. (larvae)	0(0)	0.50(0.50)	0(0)
Dicrotendipes lobus	1.00(1.00)	0(0)	0(0)
Dicrotendipes nervosus	0.50(0.50)	0(0)	0.25(0.25)
Gammarus mucronatus	0.25(0.25)	0(0)	0(0)
Hobsonia florida	7.50(4.33)	0(0)	0.25(0.25)
insect larvae	1.25(1.25)	0(0)	0(0)
insect pupae	1.00(1.00)	0(0)	0(0)
Oligochaeta sp.	10.50(3.68)	0(0)	0(0)
Parandalia sp. A	0(0)	0.25(0.25)	0.25(0.25)
Polydora ligni/cornuta	0.25(0.25)	0(0)	0(0)
Polydora socialis	0.25(0.25)	0(0)	0(0)
Polypedilum sp.	0.50(.50)	0(0)	0(0)
Tubificidae spp.	0(0)	56.25(28.36)	31.00(12.90)
Tubificoides heterochaetus	0(0)	0.25(0.25)	9.00(9.00)
Uca sp.	0(0)	0.25(0.25)	0(0)

Table 6.4-7b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P11 on the NE Cape Fear River during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
amphipod sp.	0.20(0.20)	0(0)	0(0)
Cryptochironomous (*fulvens*)	0.20(0.20)	0(0)	0(0)
Gammarus tigrinus	0.60(0.40)	0(0)	0(0)
Hobsonia florida	0.60(0.24)	0(0)	0(0)
Laeonereis culveri	0(0)	0.25(0.25)	0(0)
Marenzelleria viridis	1.00(0.77)	0(0)	7.50(7.50)
Megalops sp.	0.20(0.20)	0(0)	0(0)
Nemertea sp.	0.20(0.20)	0(0)	0(0)
Oligochaeta sp.	3.60(1.86)	0(0)	0(0)
Parandalia sp. A	0(0)	0.75(0.25)	0(0)
Polypedilum sp.	0.40(0.40)	0(0)	0(0)
Spionidae sp.	0(0)	0(0)	4.00(4.00)
Tubificidae spp.	0(0)	0.25(0.25)	0(0)
Tubificoides heterochaetus	6.20(6.20)	6.75(3.94)	14.50(14.50)

Table 6.4-8a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P12 on the NE Cape Fear River during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for high intertidal areas.

High Intertidal	**June 99**	**June 08**	**June 09**
Anurida maritime	0(0)	1.25(1.25)	1.00(1.00)
Apocorophium lacustre	0(0)	0.25(0.25)	0(0)
Bezzia/Palpomyia sp.	1.80(0.37)	0.25(0.25)	6.00(1.78)
Boccardiella sp.	0(0)	0.50(0.50)	0(0)
Cassidinidea lunifrons	0.20(0.20)	0(0)	0.25(0.25)
Chironomus sp.	0.20(0.20)	0(0)	0(0)
Collembola sp.	0.20(0.20)	0(0)	0.75(0.48)
Corophidae sp.	0(0)	0.25(0.25)	0(0)
Corophium (*lacustre*)	0.20(0.20)	0(0)	0(0)
Cricotopus sp.	0.20(0.20)	0(0)	0(0)
Dolichopodidae sp.	0(0)	0(0)	0.25(0.25)
Dolichopus sp.	0.60(0.40)	0(0)	0(0)
Donacia sp.	0.20(0.20)	0(0)	0(0)
Ephydra sp.	0(0)	0(0)	0.50(0.50)
juv. Gastropod	0.20(0.20)	0(0)	0(0)
Hargeria rapax	0(0)	0.50(0.50)	0(0)
Helophorus linearis	0(0)	0(0)	0.25(0.25)
Hydracarina sp.	0(0)	0.25(0.25)	0(0)
insect larvae g	0.40(0.40)	0(0)	0(0)
insect larvae h	1.20(1.20)	0(0)	0(0)
Laeonereis culveri	1.40(0.51)	0.50(0.50)	0.25(0.25)
Megalops sp.	0(0)	0.50(0.50)	0(0)
juv. *Merragata* sp.	0(0)	0(0)	0.25(0.25)
Monopylephorus irroratus	1.00(1.00)	0(0)	0(0)
Neanthes succinea	0(0)	0.50(0.29)	0(0)
Ocypode quadrata	0.20(0.20)	0(0)	0(0)
Oligochaeta sp.	47.80(9.60)	0(0)	0(0)
Orchestia uhleri	0.20(0.20)	0.25(0.25)	0(0)
Orthocladiinae sp.	0(0)	0(0)	1.00(1.00)
Parandalia sp. A	0(0)	0.25(0.25)	0(0)
Polydora socialis	0(0)	0.25(0.25)	0(0)
Prionospio sp.	0(0)	0.25(0.25)	0(0)
Pristinella sp.	0.20(0.20)	0(0)	0(0)
Tubificidae spp.	0(0)	2.00(1.22)	20.25(6.06)
Uca minax	0.20(0.20)	0(0)	0(0)
Uca pugilator	0.20(0.20)	0(0)	0(0)

Table 6.4-8b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P12 on the NE Cape Fear River during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-sites for low intertidal areas.

Low Intertidal	**June 99**	**June 08**	**June 09**
amphipod sp.	0.20(0.20)	0(0)	0(0)
Anurida maritima	0(0)	1.25(0.95)	0(0)
Apocorophium lacustre	0(0)	0.25(0.25)	0(0)
Bezzia/Palpomyia sp.	0.20(0.20)	0.25(0.25)	0(0)
Diptera sp. (pupae)	0(0)	0.25(0.25)	0(0)
Gammarus tigrinus	0.20(0.20)	0(0)	0(0)
Hobsonia florida	0(0)	0(0)	0.25(0.25)
Hydracarina sp.	0(0)	0.50(0.50)	0(0)
Mediomastus sp.	0.20(0.20)	0(0)	0(0)
Oligochaeta sp.	1.60(0.51)	0(0)	0(0)
Orchestia uhleri	0(0)	0.25(0.25)	0(0)
Paracladopelma sp.	0.20(0.20)	0(0)	0(0)
Polydora ligni/cornuta	0.20(0.20)	0(0)	0(0)
Polydora sp.	0.20(0.20)	0(0)	0(0)
Polypedilum sp.	0.20(0.20)	0(0)	0.25(0.25)
Procladius sp.	0(0)	0(0)	0.25(0.25)
Tubificidae spp.	0(0)	11.25(3.42)	0(0)
Uca sp.	0(0)	0.75(0.48)	0(0)

Table 6.4-9a. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P13 on the NE Cape Fear River during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-site for high intertidal areas at each station.

High Intertidal	**June 99**	**June 08**	**June 09**
Collembola sp.	0.20(0.20)	0(0)	0(0)
Cyathura polita	0.20(0.20)	0(0)	0(0)
Diptera sp.	0(0)	0.25(0.25)	0(0)
Dolichopodidae sp.	0(0)	0.75(0.48)	0.25(0.25)
Dolichopus sp.	0.40(0.24)	0(0)	0(0)
Haliplidae sp.	0.20(0.20)	0(0)	0(0)
Hydracarina sp.	0(0)	0.25(0.25)	0(0)
insect pupae	0.20(0.20)	0(0)	0(0)
Laeonereis culveri	0.40(0.24)	0(0)	0.25(0.25)
Lumbriculidae sp.	1.40(1.40)	0.50(0.50)	0(0)
Mediomastus sp.	0.20(0.20)	0(0)	0(0)
Oligochaeta sp.	29.40(6.90)	0(0)	0(0)
Polypedilum sp.	0.60(0.40)	0(0)	0(0)
Tubificidae spp.	0(0)	3.50(1.44)	14.50(6.65)

Table 6.4-9b. Mean (no. per 0.01 m^2) and (standard error) for all taxa collected at P13 on the NE Cape Fear River during June 1999, 2008, and 2009. The means presented here represent the combination of two sub-site for low intertidal areas at each station.

Low Intertidal	**June 99**	**June 08**	**June 09**
juv. Bivalve	0(0)	0(0)	0.25(0.25)
Chiridotea caeca	0.25(0.25)	0(0)	0(0)
Collembola sp.	0(0)	0.25(0.25)	0(0)
Cryptochironomous (*fulvens*)	0.50(0.50)	0(0)	0(0)
Cryptochironomous sp.	0(0)	0(0)	0.25(0.25)
insect pupae	0.25(0.25)	0(0)	0(0)
insect sp. d	0.25(0.25)	0(0)	0(0)
insect sp. e	0.50(0.50)	0(0)	0(0)
Larval fish	0.25(0.25)	0(0)	0(0)
Marenzelleria viridis	0(0)	0(0)	0.25(0.25)
Megalops sp.	0(0)	0(0)	0.25(0.25)
Oligochaeta sp.	34.25(11.13)	0(0)	0(0)
Polypedilum sp.	0.25(0.25)	0(0)	0.50(0.50)
Procladius sp.	0.75(0.48)	0(0)	0(0)
Tubificidae spp.	0(0)	1.75(0.75)	0.25(0.25)

Table 6.4-10. Mean (no. per 0.01 m^2) and (standard error) for eight major taxonomic groups by each site on the NE Cape Fear River during Summer 2009. The means presented here represent both upper intertidal and lower subtidal substations.

TAXA	P2	P3A	P3B	P6	P7	P8	P11	P12	P13
Amphipoda	1.13 (0.67)	2.75 (1.72)	0 (0)	0 (0)	0.13 (0.13)	0.75 (0.31)	0 (0)	0 (0)	0 (0)
Bivalvia	0.13 (0.13)	0.63 (0.26)	0.38 (0.26)	0 (0)	0.13 (0.13)	0.88 (0.44)	0 (0)	0 (0)	0.13 (0.13)
Decapoda	0.13 (0.13)	0.25 (0.16)	0.25 (0.16)	0.25 (0.16)	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (0.13)
Gastropoda	0 (0)	0 (0)	0 (0)	0 (0)	0.13 (0.13)	0.13 (0.13)	0 (0)	0 (0)	0 (0)
Insecta	0.25 (0.16)	4.38 (2.75	1.50 (0.53)	1.38 (0.75)	3.50 (0.65)	3.25 (1.39)	0.33 (0.21)	5.25 (2.69)	0.50 (0.38)
Isopoda	0.50 (0.27)	0.50 (0.50)	0.25 (0.16)	0.13 (0.13)	0 (0)	0 (0)	0 (0)	0.13 (0.13)	0 (0)
Oligochaeta	0.63 (0.38)	6.13 (2.33)	4.25 (1.78)	7.00 (3.84)	25.63 (9.35)	51.13 (18.51)	31.50 (10.74)	10.13 (4.75)	7.88 (4.22)
Polychaeta	3.63 (1.21)	0.38 (0.18)	0.38 (0.18)	0.50 (0.27)	0.50 (0.19)	0 (0)	4.17 (2.50)	0.25 (0.16)	0.25 (0.16)

Table 6.4-11. Mean (no. per 0.01 m^2) and (standard error) for three major functional groups by each site on the NE Cape Fear River during Summer 2009. The means presented here represent both upper intertidal and lower subtidal substations.

TAXA	P2	P3A	P3B	P6	P7	P8	P11	P12	P13
Deep burrowing	1.62 (0.56)	6.12 (2.32)	4.25 (1.78)	7.00 (3.84)	25.88 (9.26)	51.12 (18.51)	31.67 (10.82)	10.12 (4.74)	7.88 (4.22)
Surface/mobile	18.88 (9.24)	5.62 (3.18)	2.38 (0.62)	1.75 (0.90)	4.25 (0.62)	4.38 (1.21)	0.33 (0.21)	5.50 (2.73)	0.75 (0.49)
Sedentary/tube builder	3.75 (0.88)	3.25 (1.76)	0.38 (0.26)	0.50 (0.27)	0.12 (0.12)	0.88 (0.44)	4.00 (2.54)	0.12 (0.12)	0.25 (0.16)

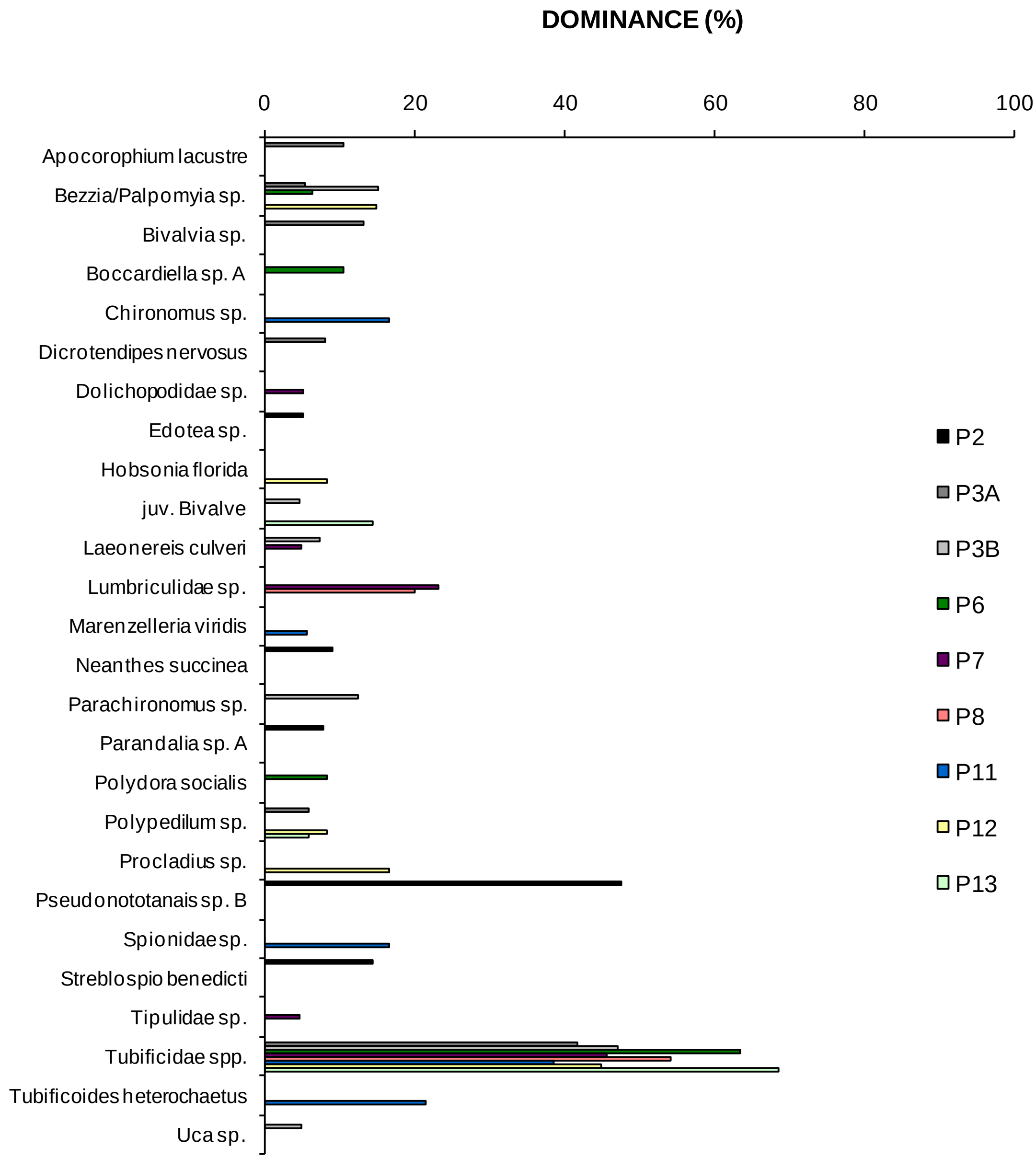


Figure 6.4-1. Common species representing ≥ 5% of the total abundance among sites sampled in Summer 2009. This data represents both upper intertidal and lower subtidal substations.

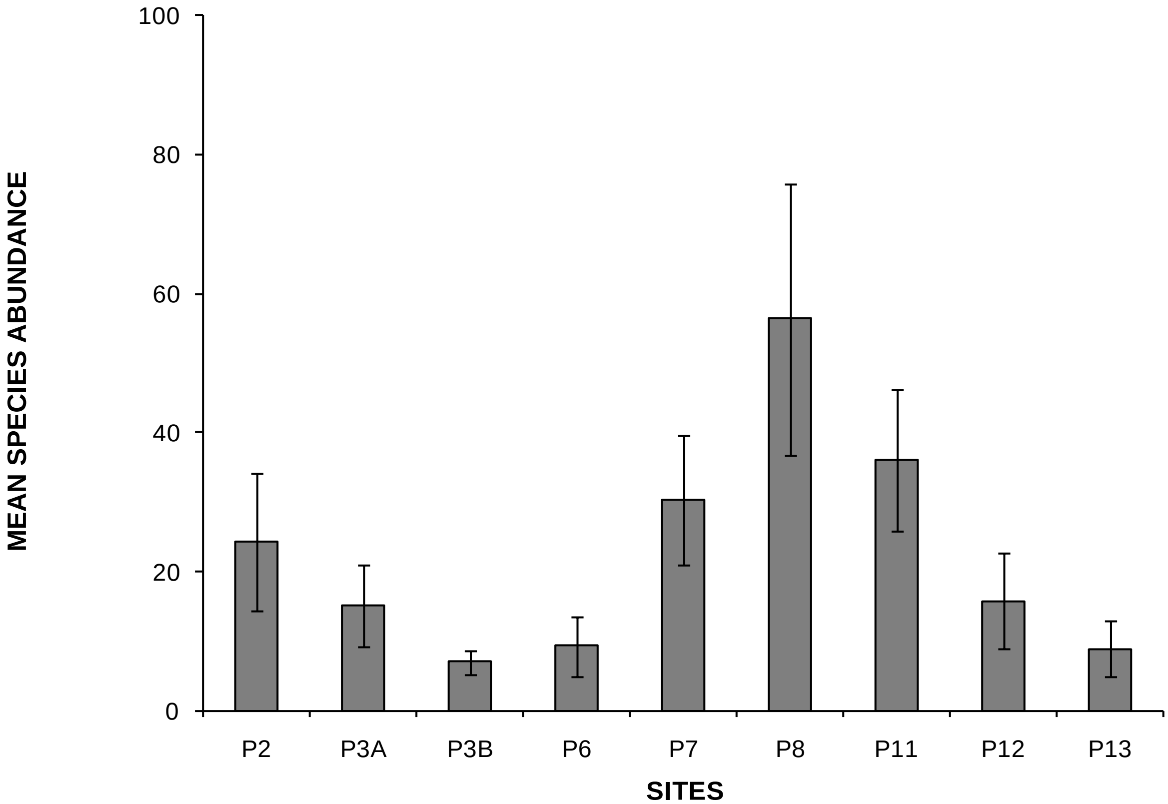


Figure 6.4-2. Mean species abundance among sites sampled in Summer 2009. This data represents both upper intertidal and lower subtidal substations. Bars represent standard error of the mean. ANOVA (represents log transformed data): F (8, 61) = 2.87, P= 0.0089. SNK: P8=A, P7=BA, P11=BA, P2=BA, P3A=BA, P3B=BA, P12=BA, P6=BA, P13=B. Sites with the same letter are not significantly different based on the SNK.

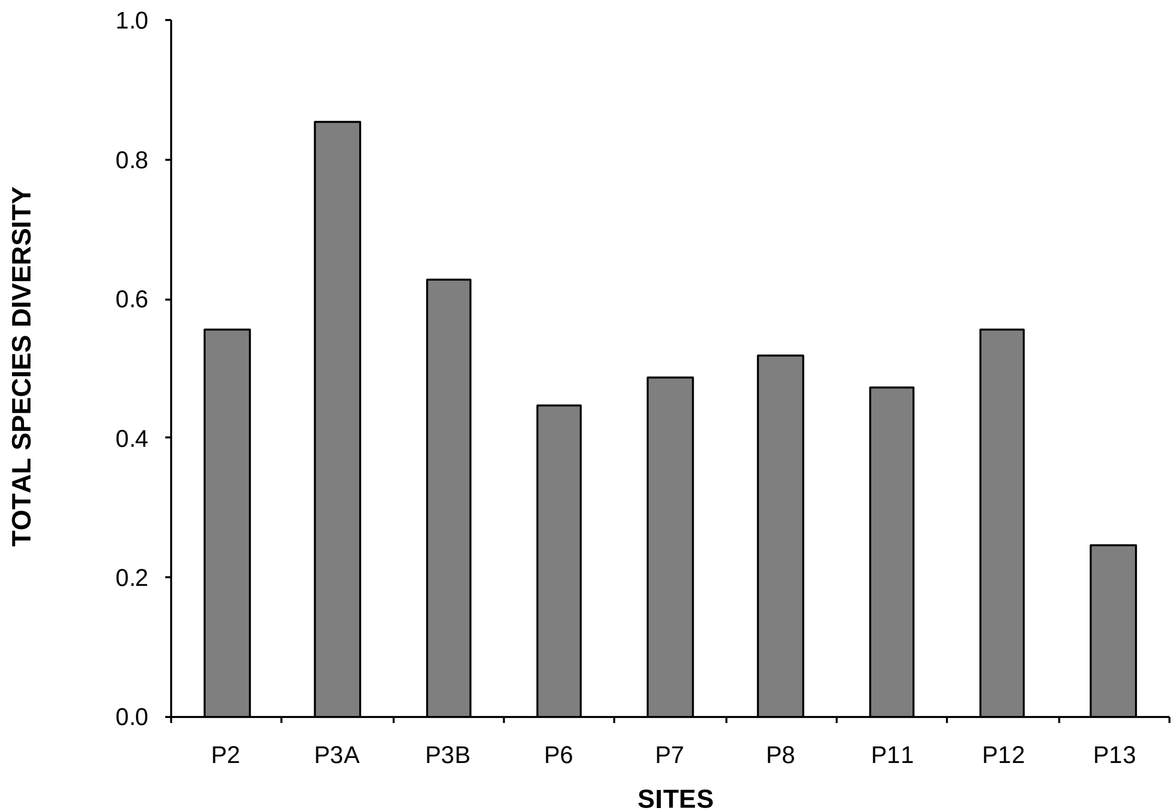


Figure 6.4-3. Total species diversity among sites sampled in Summer 2009. This data represents both high and low intertidal substations. Diversity was calculated using the Shannon diversity index

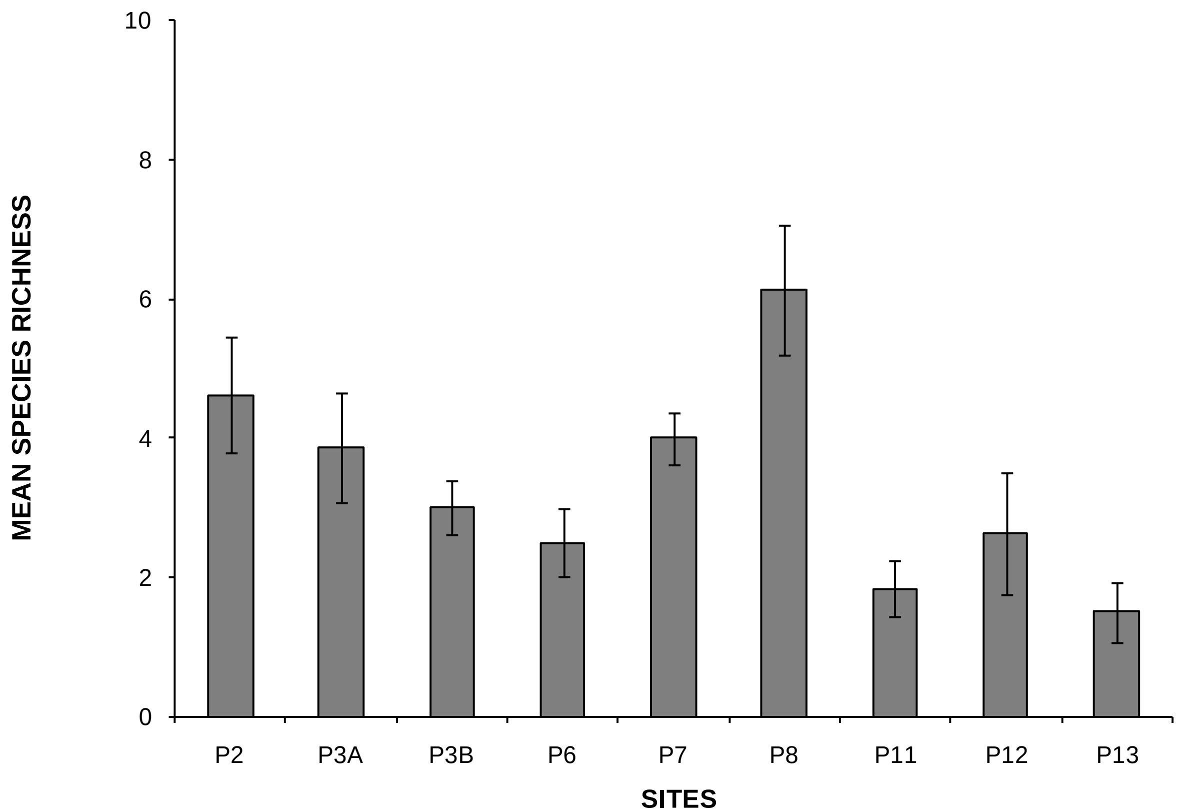


Figure 6.4-4. Mean species richness among sites sampled in Summer 2009. This data represents both upper intertidal and lower subtidal substations. Bars represent standard error of the mean. ANOVA: F (8, 61) = 4.79, P = 0.0001. SNK: P8=A, P2=BA, P7=BAC, P3A=BAC, P3B=BC, P12=BC, P6=BC, P11=BC, P13=C. Sites with the same letter are not significantly different based on the SNK.

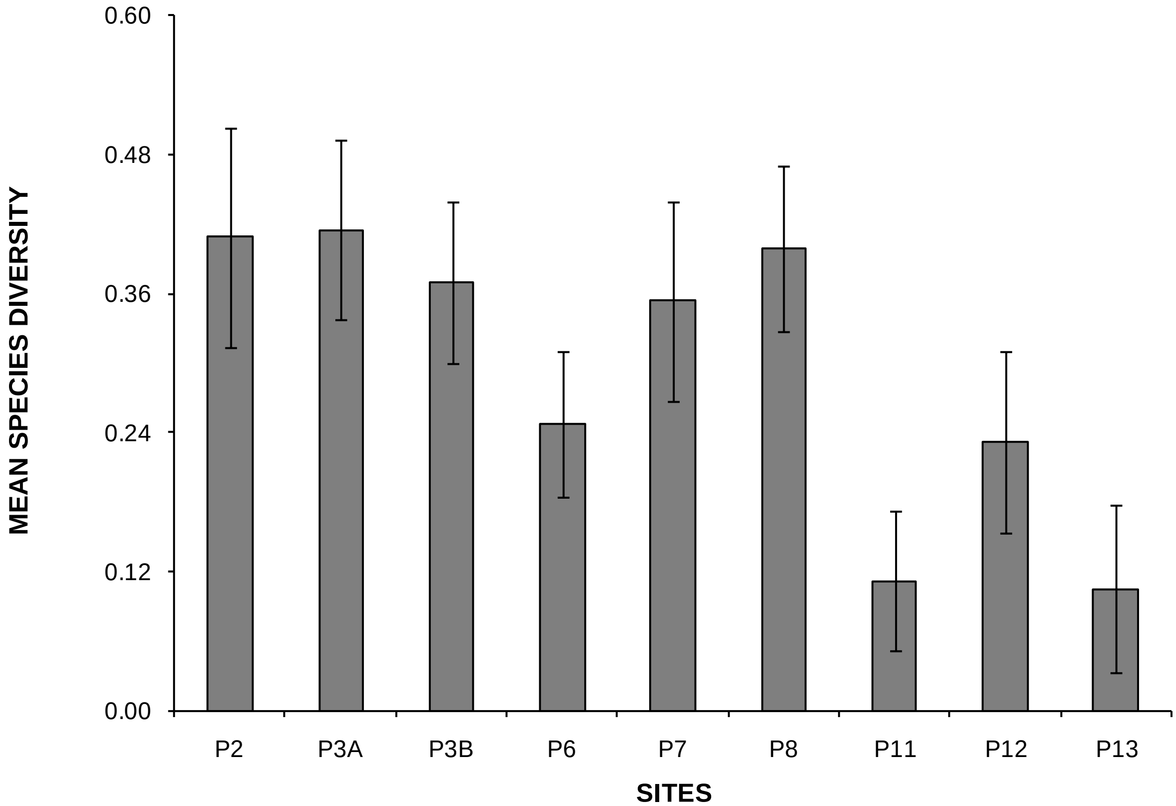


Figure 6.4-5. Mean species diversity among sites sampled in Summer 2009. Diversity was calculated using the Shannon diversity index. This data represents both upper intertidal and lower subtidal substations. Bars represent standard error of the mean. ANOVA: $F(8, 61) = 2.50$, $P < 0.0202$. SNK is not significant between sites.

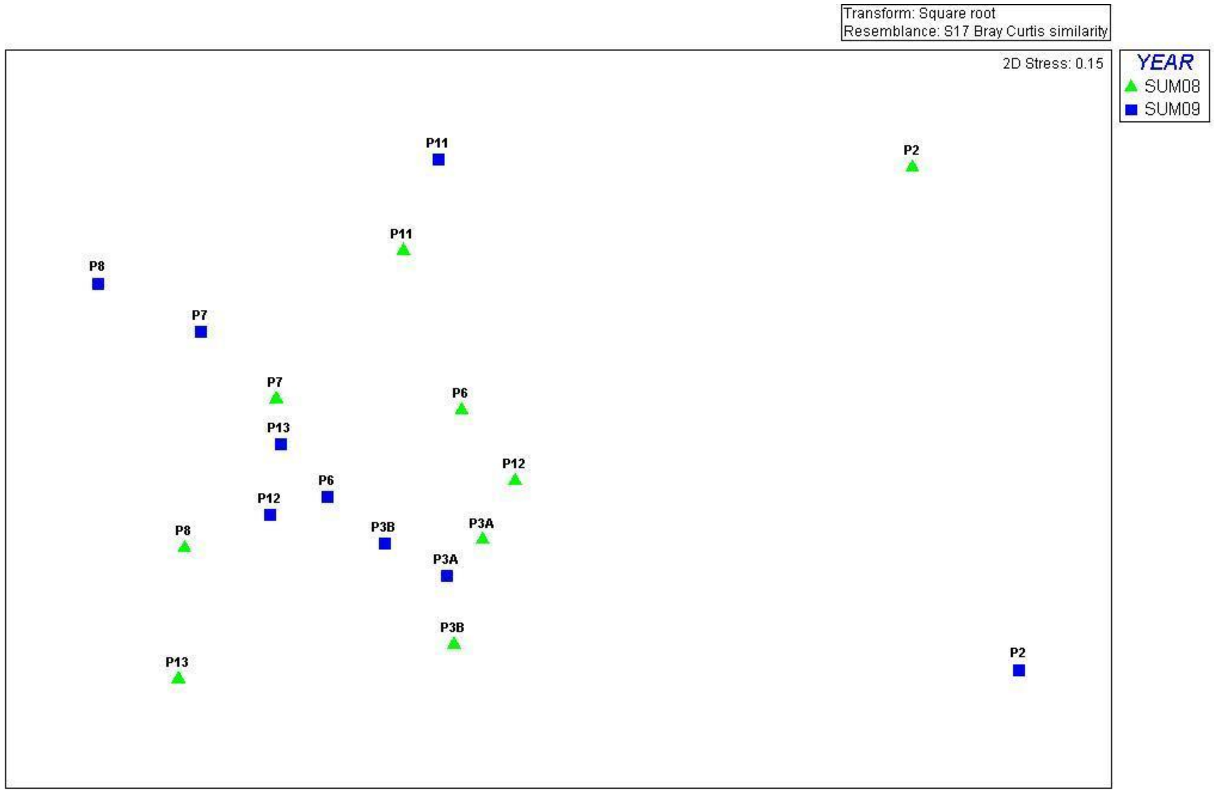


Figure 6.4-6. Multi-Dimensional Scaling Plot (MDS) (Primer v6) of community similarity among sites for 2008 and 2009. Each year site community set is indicated by colored site marker (green=2008 blue=2009). Markers that are grouped close together have a greater degree of similar between years

7.0 EPIBENTHIC STUDIES: DECAPODS AND EPIBENTHIC FISH

7.1 Summary

Tidal marshes and swamps represent a critical habitat for a number of species within river dominated estuaries. Predictions for sea level rise over the next century suggest these areas may also be at risk of significant impacts. Many species, including many finfish and crustaceans of commercial importance, utilize marsh and tidal swamp habitats as refuge and forage areas. Their use can span across several life stages, including vulnerable early developmental stages, juveniles and in some cases adult forms.Many spend at least a portion of their lives either living on or associated with the bottom (benthic) habitats. These organisms represent a vital link between benthic secondary production and higher trophic levels. Factors that alter or influence these benthic habitats have the potential to cause upward cascade effects. This study focuses on evaluating the utilization of these habitats by epibenthic species during critical recruitment periods in the spring and fall to detect potential impacts from deepening activities in the lower ~30 kilometers of the Cape Fear River estuary. Factors in this analysis include abundance, diversity, and species richness.

While benthic infauna respond more slowly to the changes in physical factors (mainly due to limited dispersal rates and longer establishment time), the epibenthic community can respond quickly to physical changes as they mature, due to their highly motile nature and responsiveness to the presence of refuge and forage habitat. The distribution and abundance of epibenthic organisms is affected by the distribution, dominance patterns, and species composition of the benthic infauna (critical prey for most of the taxa collected as part of this study), as discussed in Section 6.0.

Two methods were employed to sample epibenthos, Breder traps (a passive sampling device) deployed at multiple tidal positions within the marsh and Drop traps (an active density based sampling method) deployed along the shallow subtidal marsh edge habitat. Previous findings indicated changes in species patterns consistent with developing drought conditions in 2001 and 2002, though this period was also coincident with the initial construction activity (Hackney et al. 2004). The period from 2007 to early 2009 was characterized by lower than average precipitation amounts (State Climate Office Website 2009) and this may have contributed to the lower abundances noted in the spring 2009 data. The majority of the channel deepening of the Cape Fear River was downstream of Wilmington between 2002 and 2004. Planned construction upstream has not been completed. This annual report presents data from current, initial, and immediate previous years' sampling to evaluate annual patterns. This evaluation is intended to provide a quick summary of short-term responses in the highly motile epi-benthic community. Evaluations of total abundance among years show that more fish utilized the fringing marshes in fall 2007 compared to the fall 2008 and fall 1999 periods. For the spring sampling periods, 2008 total abundances were higher than the 2009 and 2000 periods. With a few exceptions, the fall and spring richness and diversity data displayed similar patterns, with the fall 2007 period exhibiting higher levels than fall 2008 and 1999 periods and the spring 2008 period being higher than the 2009 and 2000 periods.

7.2 Background

The presence of refuges and sufficient forage habitat are critical to maintaining community diversity and ecosystem function. Shifts in salinity or tidal inundation period have been shown to affect community dynamics and could have an upward cascade effect on prey composition and density. An increase or decrease in tidal inundation periods or changes in salinity could lead to shifts in vegetation type, dominance, or habitat coverage directly altering habitat quality. Tidal fringing marsh and swamps provide essential habitat for juvenile fishes and crustaceans across the estuarine gradient. The maintenance of these habitats supports commercial and recreational shrimp fisheries (both *Farfantepanaeus aztecus* and *Litopanaeus setiferus)* in the lower Cape Fear River and provides essential refuge for juvenile blue crabs, *Callinectes sapidus*, several species of scianids, and a large number of prey fishes. These are critical fisheries for the Cape Fear region. Changes in the epibenthic organisms (either composition or abundance) could both cause significant impacts to these fisheries and be an indicator of changing species distributions, either through direct impacts to juvenile stages or through a shift in available forage species. Epibenthos are sensitive to changes associated with shifts in salinity and/or tidal inundation. The ingress of juvenile stages of many fishery species is closely dependent on the recruitment of prey species. In general, benthic fauna such as annelids and amphipods tend towards highest abundances in early spring, following a winter relatively free of predator influence and abundant benthic production. Juvenile fish and crustaceans that depend on this benthic resource start invading the estuary by mid February with full recruitment of multi-species assemblages by early March. There is also a slightly smaller recruitment of benthos in the fall of each year and this too is closely followed by benthic feeding fishes and crustaceans. These annual cycles of species recruitment were the basis for our focus on spring and fall sampling events.

As part of the long-term project to monitor potential changes in the communities that depend on these habitats, we examined 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, 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 fishery species such as the blue crab (*Callinectes sapidus*), spot (*Leiostomus xanthurus*), flounder (*Paralichthys* spp.), and commercial shrimp (*Farfantepanaeus* sp. and *Litopanaeus* sp). Many epibenthos 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 represent indicators of ecosystem level changes for three reasons: 1) their motile lifestyles allow them to quickly respond to physical changes in the environment, 2) juvenile stages of many species 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 the distribution of certain epifaunal organisms, including shifts in dominance at a site or along the upstream/downstream gradient, may indicate changes in tidal amplitude or salinity regimes. 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/egress 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 of this section of the monitoring project is to evaluate abundance of organisms utilizing the fringing tidal marshes and wetlands at the stations along the Cape Fear River estuary where benthic infaunal assemblages are being monitored. This report covers sampling in fall 2009 and spring 2010. Data from previous reporting periods (2008-2009 and the initial sampling period 1999-2000) is included here for comparative purposes (Culbertson et. al., 2010).

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 used two sampling methods, Breder traps and Drop traps, to target epifauna with different utilization patterns. Breder trap sampling targets bottom oriented organisms that utilize the intertidal marsh or swamp habitat during the period of tidal 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 and within 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 and more understandable relation to actual density, but it is difficult to deploy within heavy structure.

Breder traps are constructed of clear acrylic (31 cm length X 16 cm height X 15 cm width). When submerged, these traps are transparent and catch epibenthic fish and crustaceans, passively, as they move into the tidal wetlands. At each station, traps are placed at three tidal heights; lower intertidal (near mean low water), mid intertidal (submerged ~ 1 m depth at mean high water), and upper intertidal (submerged ~ 0.5 m at mean high water). Two sets of five traps are set at each tidal height with the opening oriented towards the channel or downstream. The orientation of the traps is based on preliminary data that indicates this channel or downstream 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, predation, or cannibalism among organisms within the traps. All organisms caught are measured for total length, identified to lowest possible taxon, and representative specimens are preserved for verification. Breder trap sampling is conducted at nine sites: P11 (Smith Creek), P12 (Rat Island) and P13 (Fishing Creek) in the mainstem Cape Fear River; P6 (Eagle Island), P7 (Indian Creek), and P8 (Dollison's Landing) in the Northeast Cape Fear; and P2 (at the mouth of Town Creek), and two 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 1 m on a side and 1 m 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 to ensure that organisms cannot escape). Eighteen replicate drops are made in the shallow subtidal areas at each station. Replicate samples are taken at least 10 m apart, and at least 20 minutes are allowed between each sample. Once the trap is secured, the contents are removed using a steel frame sweep net with a 2 mm 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 for 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 at one site because of edge area limitations.

Drop trap and Breder trap sampling was conducted during the same time window for all stations. At least 24 hours separated the use of each method at a site. While Breder traps were deployed on a single day per site, drop trap samples were collected over a 3+ day period for each site. The collection of drop trap data over a multi-day sampling period gives a more accurate evaluation of the use of the subtidal areas adjacent to each site.

Epibenthos were monitored from two distinct sub-habitats with methods specific for each habitat. Mean abundance data is presented by sampling methodology. Breder trap data that targets those species that move into the fringing marsh with the flooding tide is presented with fall and spring data concurrent for each site (Table 7.4-1a-7.4-9b). Drop trap data that targets lower marsh edge or shallow sub-tidal habitats is presented likewise (Table 7.4-10a-7.4-17b). Analyses for this report focused on differences in diversity, species richness, and total epifauna by season,and across years for both Breder and Drop trap data separately, to evaluate potential trends and community level responses. Because of interactions between seasons and among sites, the data was analyzed among years by site for each season on log transformed data using a One-way Analysis of Variance to meet the assumptions of homogeneous variances. Where significant year effects were found, an SNK test was used to distinguish among years by site. The Shannon diversity index was used to describe diversity patterns at each site. The Shannon diversity index accounts for both species abundance and evenness among species. Overall community comparisons, including all species present, were analyzed using an Analysis of Similarity with Primer 6.0, a multivariate statistical package.

Table 7.4-1a. Mean abundance per trap (SE) for epibenthic fauna collected in fall Breder trap sampling at station P2 (Mouth of Town Creek).

	Fall 1999			**Fall 2008**			**Fall 2009**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0.10(0.10)	0(0)
Ctenogobius shufeldti	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Eucinostomus sp.	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)
Farfantepenaeus aztecus	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0.10(0.10)	0.20(0.13)	0(0)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.90(0.38)
Gambusia affinis	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Gobiosoma bosc	0(0)	0(0)	0(0)	0.20(0.13)	0(0)	0(0)	0(0)	0(0)	0(0)
Litopenaeus setiferus	0(0)	0(0)	0(0)	1.90(0.38)	1.20(0.36)	3.90(1.39)	0(0)	0(0)	0.20(0.13)
Lutjanus synagris	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Palaemonetes intermedius	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Palaemonetes pugio	0(0)	0.30(0.15)	0.10(0.10)	0.30(0.21)	0(0)	0.60(0.22)	0(0)	0(0)	0.20(0.13)
Palaemonetes vulgaris	0(0)	0(0)	0(0)	0.30(0.15)	0.80(0.29)	0.10(0.10)	0(0)	0.10(0.10)	0.10(0.10)
Paralichthys lethostigma	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)
Symphurus plagiusa	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.30(0.21)	0(0)
Syngathus fuscus	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.10(0.10)	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)

Table 7.4-1b. Mean abundance per trap (SE) for epibenthic fauna collected in spring Breder trap sampling at station P2 (Mouth of Town Creek).

	Spring 2000			Spring 2009			Spring 2010		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.20(0.20)	0(0)	0.10(0.10)	0(0)
Ctenogobius shufeldti	0.10(0.10)	0.20(0.13)	0(0)	0(0)	0.10(0.10)	0(0)	0.10(0.10)	0(0)	0(0)
Fundulus heteroclitus	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)	0.60(0.50)	0(0)	0(0)	0.60(0.31)
Hirudinea sp.	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)	0.80(0.29)	1.30(0.26)	0.30(0.21)
Leiostomas xanthurus	9.90(2.66)	5.00(1.62)	5.30(2.33)	0.20(0.13)	0(0)	0.50(0.27)	2.00(0.37)	1.00(0.26)	3.10(0.94)
Lucania parva	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)
Mugil cephalus	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.20)	0(0)	0(0)	0(0)
Palaemonetes pugio	1.50(0.43)	1.40(0.52)	2.30(1.04)	0.10(0.10)	0.40(0.31)	3.60(1.41)	0(0)	0.60(0.22)	1.40(0.45)
Palaemonetes vulgaris	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.10(0.10)	0(0)
Paralichthys albigutta	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.10(0.10)
Paralichthys sp.	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0.10(0.10)
Penaeidae sp. (postlarvae)	0(0)	0(0)	0(0)	0.80(0.36)	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)
Rhithropanopeus harrisii	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)

Table 7.4-2a. Mean abundance per trap (SE) for epibenthic fauna collected in fall Breder trap sampling at station P3A (Town Creek).

	Fall 1999			**Fall 2008**			**Fall 2009**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenobobius boleosoma	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Ctenogobius shufeldti	0(0)	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Eucinostomus sp.	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)
Farfantepenaeus aztecus	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)
Lepomis macrochirus	0(0)	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Litopenaeus setiferus	0(0)	0(0)	0(0)	0(0)	1.20(0.44)	1.10(0.53)	0.40(0.22)	0.67(0.29)	0.10(0.10)
Lutjanus cyanopterus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.11(0.11)	0(0)
Palaemonetes pugio	0(0)	0(0)	0(0)	0.89(0.61)	0.80(0.44)	1.70(0.97)	0.30(0.21)	0(0)	0(0)
Palaemonetes vulgaris	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.33(0.24)	0(0)
Uca pugnax	0.20(0.20)	0.40(0.22)	0.80(0.25)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

Table 7.4-2b. Mean abundance per trap (SE) for epibenthic fauna collected in spring Breder trap sampling at station P3A (Town Creek).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Ctenogobius shufeldti	0(0)	0.10(0.10)	0.20(0.13)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0.10(0.10)	1.30(0.70)	0(0)	0(0)
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)
Lagodon rhomboides	0(0)	0(0)	0(0)	0.20(0.13)	0.10(0.10)	0(0)	3.90(1.59)	11.40(2.58)	5.70(1.71)
Leiostomus xanthurus	0(0)	0(0)	0(0)	1.60(0.97)	5.00(2.30)	0.70(0.30)	12.50(6.42)	13.00(3.56)	1.00(0.33)
Mugil cephalus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Palaemonetes pugio	0(0)	0(0)	0(0)	3.60(0.81)	5.20(2.22)	15.20(8.91)	2.60(1.34)	1.20(0.53)	0.90(0.41)
Paralichthys sp.	0(0)	0(0)	0(0)	0.10(0.10)	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(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)	0.10(0.10)	0(0)	0(0)

Table 7.4-3a. Mean abundance per trap (SE) for epibenthic fauna collected in fall Breder trap sampling at station P3B (Town Creek).

	Fall 1999			**Fall 2008**			**Fall 2009**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Archosargus probatocephalus	0(0)	0(0)	0(0)	0(0)	0.11(0.11)	0(0)	0(0)	0(0)	0(0)
Bairdiella chrysoura	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.20)	0(0)
Callinectes sapidus	0(0)	0(0)	0(0)	0.11(0.11)	0.11(0.11)	0.10(0.10)	0(0)	0.10(0.10)	0(0)
Ctenogobius shufeldti	0(0)	0.10(0.10)	0.10(0.10)	0.11(0.11)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)
Lagodon rhomboides	0(0)	0(0)	0(0)	0(0)	0.11(0.11)	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)
Litopenaeus setiferus	0(0)	0(0)	0(0)	0.11(0.11)	0.33(0.24)	0.20(0.13)	0.30(0.21)	1.40(0.34)	0.90(0.50)
Palaemonetes pugio	0(0)	0(0)	0(0)	0.11(0.11)	0.11(0.11)	1.70(0.47)	0(0)	0.10(0.10)	0.50(0.31)
Paralichthys lethostigma	0(0)	0(0)	0(0)	0.11(0.11)	0(0)	0(0)	0(0)	0(0)	0(0)
Symphurus plagiusa	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Syngnathus fuscus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)
Uca pugnax	0.50(0.22)	0.20(0.13)	0.40(0.16)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

Table 7.4-3b. Mean abundance per trap (SE) for epibenthic fauna collected in spring Breder trap sampling at station P3B (Town Creek).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0.10(0.10)	0(0)
Ctenogobius boleosoma	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Ctenogobius shufeldti	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
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(0)	0(0)	0.10(0.10)	0.50(0.31)	0.10(0.10)	0.75(0.25)
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(0)	0(0)	0(0)	0(0)	0(0)	0.13(0.13)
Lagodon rhomboides	0(0)	0(0)	0(0)	0.50(0.22)	0.30(0.15)	0(0)	0.80(0.29)	2.10(0.59)	0.13(0.13)
Leiostomus xanthurus	0(0)	0(0)	0(0)	2.90(1.35)	30.70(22.82)	10.50(4.77)	5.40(1.93)	27.80(14.47)	0.50(0.38)
Micropogonias undulatus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)
Mugil cephalus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1.90(1.20)	0(0)	0(0)
Palaemonetes pugio	0(0)	0(0)	0(0)	0.80(0.36)	0.40(0.31)	1.30(0.45)	0.30(0.15)	3.30(1.05)	2.25(1.01)
Paralichthys albigutta	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.60(0.16)	0.30(0.15)	0(0)
Uca minax	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)
Uca pugnax	0.70(0.26)	1.20(0.49)	0.60(0.34)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

Table 7.4-4a. Mean abundance per trap (SE) for epibenthic fauna collected during fall Breder trap sampling at station P6 (Eagle Island).

	Fall 1999			**Fall 2008**			**Fall 2009**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0.10(0.10)	0.10(0.10)
Citharichthys spilopterus	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)
Ctenogobius shufeldti	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0(0)	0.10(0.10)	0(0)
Dormitator maculatus	0(0)	0.10(0.10)	0.20(0.13)	0(0)	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)
Eucinostomus sp.	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.50(0.31)	0(0)	0(0)	0(0)
Litopenaeus setiferus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	3.50(0.43)	3.10(0.50)	1.70(0.33)
Palaemonetes pugio	0(0)	0(0)	0(0)	1.20(0.63)	0.90(0.59)	1.30(0.65)	0.30(0.21)	0.60(0.43)	0.10(0.10)
Paralichthys albigutta	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Symphurus plagiusa	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Uca minax	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)

Table 7.4-4b. Mean abundance per trap (SE) for epibenthic fauna collected during spring Breder trap sampling at station P6 (Eagle Island).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Ctenogobius shufeldti	0(0)	0.10(0.10)	0.10(0.10)	0.20(0.13)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Lagodon rhomboides	0(0)	0.10(0.10)	0.20(0.13)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)
Leiostomus xanthurus	0(0)	0(0)	0.20(0.13)	0.60(0.34)	0.60(0.34)	1.40(0.56)	0(0)	0(0)	0(0)
Menidia beryllina	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)
Micropogonias undulatus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Paralichthys dentatus	0.30(0.30)	0.40(0.22)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Paralichthys sp.	0(0)	0(0)	0(0)	1.30(0.37)	0.80(0.25)	0.20(0.13)	22.30(5.49)	17.20(3.55)	1.75(0.94)

Table 7.4-5a. Mean abundance per trap (SE) for epibenthic fauna collected during fall Breder trap sampling at station P7 (Indian Creek).

	Fall 1999			Fall 2008			Fall 2009		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenogobius shufeldti	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Dormitator maculatus	0(0)	0.20(0.13)	0(0)	0(0)	0.11(0.11)	0(0)	0(0)	0(0)	0(0)
Gambusia holbrooki	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)
Palaemonetes pugio	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)
Paralichthys lethostigma	0(0)	0(0)	0(0)	0(0)	0.22(0.15)	0(0)	0(0)	0(0)	0(0)
Uca minax	0(0)	0(0)	0(0)	0(0)	0.11(0.11)	0.70(0.33)	0(0)	0.10(0.10)	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 per trap (SE) for epibenthic fauna collected during spring Breder trap sampling at station P7 (Indian Creek).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenogobius shufeldti	0.40(0.16)	1.10(0.28)	4.33(3.85)	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)	0.10(0.10)
Lagodon rhomboides	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.90(0.41)	2.20(1.37)	0.70(0.50)
Lepomis macrochirus	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Paralichthys lethostigma	0(0)	0.30(0.15)	0.67(0.44)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Paralichthys sp.	0(0)	0(0)	0(0)	0.60(0.43)	0.20(0.13)	0(0)	3.50(1.21)	1.70(0.54)	0.80(0.42)
Uca minax	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.40(0.16)	0.60(0.31)

Table 7.4-6a. Mean abundance per trap (SE) for epibenthic fauna collected during fall Breder trap sampling at station P8 (Dollison Landing).

	Fall 1999			**Fall 2008**			**Fall 2009**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Cambarus robustus	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Ctenogobius shufeldti	0.10(0.10)	0(0)	0(0)	0.20(0.13)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Dormitator maculatus	0(0)	0(0)	0.10(0.10)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Eleotris amblyopsis	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Eucinostomus sp.	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.20)	0(0)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Gambusia holbrooki	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)
Larimus fasciatus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Lepomis macrochirus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Sesarma cinereum	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Trinectes maculatus	0.20(0.13)	0.20(0.20)	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)	0.10(0.10)	0(0)	0.30(0.15)

Table 7.4-6b. Mean abundance per trap (SE) for epibenthic fauna collected during spring Breder trap sampling at station P8 (Dollison Landing).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenogobius shufeldti	0(0)	0(0)	0(0)	0.10(0.10)	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.40(0.27)	0.20(0.20)	0.20(0.20)
Lepomis macrochirus	0(0)	0(0)	0(0)	0.50(0.31)	0(0)	0.20(0.20)	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 sp.	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)
Uca minax	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)

Table 7.4-7a. Mean abundance per trap (SE) for epibenthic fauna collected during fall Breder trap sampling at station P11 (Smith Creek).

	Fall 1999			**Fall 2008**			**Fall 2009**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.10(0.10)	0.10(0.10)	0(0)	0(0)
Ctenogobius shufeldti	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Dormitator maculatus	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0(0)	0.10(0.10)
Fundulus heteroclitus	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Lepomis macrochirus	0.10(0.10)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Litopenaeus setiferus	0(0)	0(0)	0(0)	1.50(0.31)	1.10(0.46)	1.20(0.36)	3.50(0.79)	0.70(0.26)	2.70(0.72)
Menidia beryllina	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)	0.20(0.13)	0(0)	0(0)	0(0)
Palaemonetes pugio	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0.10(0.10)	0.40(0.22)	0.70(0.21)	0(0)
Palaemonetes vulgaris	0(0)	0(0)	0(0)	0.10(0.10)	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)
Uca pugnax	0.10(0.10)	0.20(0.13)	8.50(4.17)	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)	0.10(0.10)

Table 7.4-7b. Mean abundance per trap (SE) for epibenthic fauna collected during spring Breder trap sampling at station P11 (Smith Creek).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Callinectes sapidus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0.10(0.10)
Ctenogobius shufeldti	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0(0)	0.40(0.16)	0.40(0.16)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.30(0.21)
Lagodon rhomboides	0.10(0.10)	0(0)	0(0)	0.20(0.13)	0(0)	0.10(0.10)	0.40(0.16)	0.10(0.10)	0.10(0.10)
Leiostomus xanthurus	1.30(0.76)	0.30(0.21)	1.00(0.39)	0.80(0.29)	2.40(1.27)	21.40(5.35)	11.60(5.87)	14.70(3.78)	10.50(4.36)
Palaemonetes pugio	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0.30(0.21)	0.70(0.33)
Paralichthys albigutta	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.50(0.34)	0.20(0.13)
Paralichthys sp.	0(0)	0(0)	0(0)	1.00(0.37)	0.50(0.27)	0(0)	1.40(0.60)	0.50(0.22)	0.10(0.10)

Table 7.4-8a. Mean abundance per trap (SE) for epibenthic fauna collected during fall Breder trap sampling at station P12 (Rat Island).

	Fall 1999			Fall 2008			Fall 2009		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenogobius shufeldti	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.20(0.13)
Dormitator maculatus	0.60(0.34)	0(0)	0.40(0.22)	0.10(0.10)	0(0)	0.10(0.10)	0(0)	0(0)	0.30(0.21)
Eleotris amblyopsis	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)
Leiostomus xanthurus	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)
Lepomis macrochirus	0(0)	0.20(0.13)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Litopenaeus setiferus	0(0)	0(0)	0(0)	0.40(0.16)	0.10(0.10)	0.30(0.21)	0(0)	0(0)	0.10(0.10)
Palaemonetes pugio	0.10(0.10)	0 (0)	0 (0)	0(0)	0(0)	0.10(0.10)	0(0)	0.10(0.10)	0(0)
Syngnathus fuscus	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)
Uca minax	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0.20(0.13)
Uca pugnax	0(0)	0.20(0.13)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

Table 7.4-8b. Mean abundance per trap (SE) for epibenthic fauna collected during spring Breder trap sampling at station P12 (Rat Island).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenogobius shufeldti	0.60(0.31)	0.60(0.31)	0.10(0.10)	0.30(0.21)	0.30(0.15)	0.10(0.10)	0(0)	0(0)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0.10(0.10)	0.10(0.10)	0.11(0.11)	0.10(0.10)
Lagodon rhomboides	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1.80(0.90)	1.22(0.43)	0.10(0.10)
Leiostomas xanthurus	0.20(0.20)	0.20(0.13)	0.10(0.10)	0.40(0.16)	2.00(1.18)	0.10(0.10)	1.40(0.70)	1.78(0.43)	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)
Palaemonetes pugio	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.40(0.22)	0(0)	0.11(0.11)	0(0)
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)	2.30(0.67)	2.33(0.75)	0(0)
Uca minax	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.20)	0(0)	0(0)	0.10(0.10)
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 7.4-9a. Mean abundance per trap (SE) for epibenthic fauna collected during fall Breder trap sampling at station P13 (Fishing Creek).

	Fall 1999			**Fall 2008**			**Fall 2009**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenogobius boleosoma	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)
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)
Leiostomus xanthurus	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)
Lepomis macrochirus	0.60(0.60)	0.30(0.30)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Litopenaeus setiferus	0(0)	0(0)	0(0)	0.30(0.21)	0.20(0.13)	0.40(0.22)	0(0)	0(0)	0(0)
Palaemonetes pugio	0(0)	0(0)	0(0)	0(0)	0.30(0.21)	0.50(0.31)	0(0)	0(0)	0(0)
Sesarma cinereum	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)	0.50(0.27)
Uca pugnax	0(0)	0.40(0.30)	0.40(0.30)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Uca sp.	0(0)	0(0)	0(0)	0(0)	0(0)	0.20(0.13)	0(0)	0(0)	0(0)

Table 7.4-9b. Mean abundance per trap (SE) for epibenthic fauna collected during spring Breder trap sampling at station P13 (Fishing Creek).

	Spring 2000			**Spring 2009**			**Spring 2010**		
	Low	**Mid**	**Upper**	**Low**	**Mid**	**Upper**	**Low**	**Mid**	**Upper**
Ctenogobius shufeldti	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0(0)	0(0)	0(0)	0.25(0.16)	0(0)	0(0)	0(0)
Lagodon rhomboides	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0.40(0.22)	0(0)
Leiostomus xanthurus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	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 sp.	0(0)	0(0)	0(0)	0(0)	0.10(0.10)	0(0)	0.20(0.20)	0.20(0.13)	0.10(0.10)
Uca pugnax	0(0)	0(0)	0.10(0.10)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

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

	1999	**2008**	**2009**
Anchoa mitchilli	0.44(0.44)	1.89(1.25)	0.33(0.28)
Bairdiella chrysoura	0(0)	0(0)	0.17(0.09)
Callinectes sapidus	0.33(0.14)	1.55(0.36)	0.89(0.37)
Ctenogobius shufeldti	0.44(0.20)	0(0)	0(0)
Eucinostomus sp.	0(0)	0.72(0.61)	0(0)
Farfantepenaeus aztecus	0(0)	0.28(0.14)	0.17(0.12)
Gobiosoma bosc	0(0)	0.06(0.06)	0.17(0.12)
Litopenaeus setiferus	0(0)	1.00(0.44)	8.28(2.68)
Menidia beryllina	0(0)	0.22(0.22)	0(0)
Palaemonetes intermedius	0(0)	0(0)	0.83(0.83)
Palaemonetes pugio	1.39(0.88)	3.61(1.62)	0.44(0.25)
Palaemonetes vulgaris	0(0)	3.17(1.37)	0.28(0.28)
Panopeus herbstii	0.06(0.06)	0(0)	0(0)
Rhithropanopeus harrisii	0.06(0.06)	0.11(0.08)	0.17(0.12)
Sciaenops ocellata	0(0)	0(0)	0.06(0.06)
Symphurus plagiusa	0(0)	0.06(0.06)	0(0)
Syngnathus scovelli	0(0)	0.06(0.06)	0(0)
Uca pugnax	0.06(0.06)	0(0)	0(0)

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

	2000	**2009**	**2010**
Anchoa mitchilli	0(0)	0(0)	3.28(3.10)
Callinectes sapidus	0.06(0.06)	0.44(0.15)	0.78(0.29)
Clupeidae	0(0)	1.11(0.58)	0.67(0.37)
Ctenogobius shufeldti	0.17(0.09)	0(0)	0(0)
Lagodon rhomboides	0.44(0.23)	0(0)	3.17(1.74)
Leiostomus xanthurus	7.00(2.41)	2.83(0.60)	17.22(6.76)
Menidia beryllina	5.61(3.20)	0(0)	0(0)
Micropogonias undulatus	0(0)	0(0)	4.89(2.68)
Mugil cephalus	0(0)	0.06(0.06)	0.50(0.40)
Palaemonetes pugio	5.56(1.35)	7.28(2.81)	2.67(1.15)
Palaemonetes vulgaris	0(0)	0(0)	0.06(0.06)
Panopeus herbstii	0.06(0.06)	0(0)	0(0)
Paralichthys albigutta	0(0)	0(0)	0.11(0.11)
Paralichthys dentatus	0.11(0.08)	0(0)	0(0)
Paralichthys lethostigma	0(0)	0(0)	0.06(0.06)
Paralichthys sp.	0(0)	0.22(0.15)	0.33(0.20)
Rhithropanopeus harrisii	0(0)	0.33(0.18)	0.28(0.19)

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

	1999	**2008**	**2009**
Anchoa mitchilli	1.36(0.66)	0(0)	0(0)
Anguilla rostrata	0.06(0.04)	0(0)	0(0)
Callinectes sapidus	0.11(0.07)	0.17(0.09)	0.28(0.14)
Cambarus robustus	(0.03)(0.03)	0(0)	0(0)
Citharichthys spilopterus	0(0)	0.06(0.06)	0(0)
Ctenogobius boleosoma	0(0)	0.28(0.18)	0(0)
Ctenogobius shufeldti	0.53(0.24)	0.06(0.06)	0(0)
Eucinostomus sp.	0(0)	1.44(1.00)	0.17(0.12)
Farfantepenaeus aztecus	0(0)	0.06(0.06)	0.06(0.06)
Fundulus heteroclitus	0.11(.05)	0.06(0.06)	0(0)
Gambusia holbrooki	0.80(0.60)	0(0)	0.06(0.06)
Gobionellus oceanicus	0(0)	0.22(0.13)	0(0)
Gobiosoma bosc	0(0)	0.06(0.06)	0(0)
Lepomis macrochirus	0.08(0.05)	0(0)	0(0)
Litopenaeus setiferus	0(0)	4.00(1.34)	8.11(2.62)
Menidia beryllina	0.06(0.04)	0.44(0.39)	1.61(1.20)
Micropogonias undulatus	0.11(0.05)	0(0)	0(0)
Palaemonetes pugio	0(0)	136.22(58.93)	5.28(3.69)
Panopeus herbstii	0.06(0.06)	0(0)	0(0)
Paralichthys lethostigma	0(0)	0.06(0.06)	0(0)
Symphurus plagiusa	0(0)	0.44(0.23)	0.33(0.14)
Trinectes maculatus	2.14(0.76)	0(0)	0(0)
Uca pugnax	0.92(0.46)	0(0)	0(0)

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

	2000	**2009**	**2010**
Anguilla rostrata	0.08(0.05)	0(0)	0.17(0.12)
Callinectes sapidus	0.19(0.08)	0.89(0.25)	1.06(0.36)
Clupeidae	0(0)	5.67(5.61)	0(0)
Ctenogobius boleosoma	0(0)	0.17(0.12)	0(0)
Ctenogobius shufeldti	0.28(0.08)	0.28(0.23)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0.22(0.13)
Gambusia holbrooki	2.00(0.93)	0.17(0.17)	0.11(0.08)
Lagodon rhomboides	0.33(0.14)	0.61(0.28)	1.94(0.86)
Leiostomus xanthurus	0(0)	75.50(26.16)	5.56(2.55)
Lepomis macrochirus	1.58(0.84)	0(0)	0(0)
Menidia beryllina	0.06(0.06)	0(0)	0(0)
Micropogonias undulatus	0(0)	0.06(0.06)	0(0)
Mugil cephalus	0(0)	1.78(0.87)	2.61(1.25)
Mugil curema	0(0)	0(0)	0.06(0.06)
Palaemonetes pugio	0(0)	48.83(14.01)	11.22(4.38)
Panopeus herbstii	0.06(0.04)	0(0)	0(0)
Paralichthys dentatus	0.45(0.12)	0(0)	0(0)
Paralichthys sp.	0(0)	0.06(0.06)	5.17(1.35)
Rhithropanopeus harrisii	0(0)	0.06(0.06)	0(0)
Trinectes maculatus	0.30(0.14)	0(0)	0(0)
Uca pugnax	0.03(0.03)	0(0)	0(0)

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

	1999	**2008**	**2009**
Anchoa mitchilli	0(0)	0.11(0.11)	1.56(0.97)
Bairdiella chrysoura	0(0)	0(0)	0.06(0.06)
Callinectes sapidus	0.22(0.10)	0.17(0.12)	0.22(0.10)
Citharichthys spilopterus	0(0)	0.06(0.06)	0(0)
Corbicula fluminea	0.06(0.06)	0(0)	0(0)
Ctenogobius shufeldti	0.06(0.06)	0.06(0.06)	0.06(0.06)
Eucinostomus sp.	0(0)	0.06(0.06)	0(0)
Gobiosoma bosc	0(0)	0.06(0.06)	0(0)
Leiostomus xanthurus	0(0)	0(0)	0.44(0.23)
Litopenaeus setiferus	0(0)	0.06(0.06)	3.06(0.70)
Menidia beryllina	0.11(0.08)	0.39(0.22)	0.06(0.06)
Palaemonetes pugio	0(0)	0.83(0.36)	1.11(0.47)
Palaemonetes vulgaris	0(0)	0(0)	0.06(0.06)
Paralichthys lethostigma	0(0)	0.06(0.06)	0(0)
Rhithropanopeus harrisii	0(0)	0.33(0.14)	0.28(0.28)
Symphurus plagiusa	0(0)	0(0)	0.17(0.12)
Trinectes maculatus	0.44(0.20)	0.17(0.09)	0(0)

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

	2000	**2009**	**2010**
Anguilla rostrata	0(0)	0(0)	0.56(0.56)
Callinectes sapidus	0(0)	0.17(0.09)	0(0)
Clupeidae	0(0)	6.22(3.70)	2.11(1.05)
Ctenogobius shufeldti	0.11(0.11)	0.39(0.14)	0(0)
Lagodon rhomboides	0(0)	0(0)	1.17(0.53)
Leiostomus xanthurus	0(0)	2.06(1.07)	61.33(42.35)
Micropogonias undulatus	0(0)	0.22(0.17)	0.56(0.41)
Mugil cephalus	0(0)	0.72(0.50)	0.44(0.30)
Palaemonetes pugio	0(0)	1.61(0.57)	0.22(0.13)
Paralichthys albigutta	0(0)	0(0)	0.11(0.08)
Paralichthys dentatus	0.17(0.12)	0(0)	0(0)
Paralichthys sp.	0(0)	3.39(0.72)	22.94(4.68)
Trinectes maculatus	0(0)	0(0)	0.06(0.06)

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

	1999	**2008**	**2009**
Callinectes sapidus	0.06(0.06)	0(0)	0.06(0.06)
Citharichthys spilopterus	0(0)	0.06(0.06)	0(0)
Ctenogobius shufeldti	0.06(0.06)	0.06(0.06)	0.28(0.11)
Dorosoma pretense	0.06(0.06)	0(0)	0(0)
Esox lucius	0.06(0.06)	0(0)	0(0)
Eucinostomus sp.	0(0)	0.11(0.08)	0(0)
Evorthodus lyricus	0(0)	0.06(0.06)	0.06(0.06)
Fundulus heteroclitus	0.06(0.06)	0(0)	0(0)
Gambusia holbrooki	0.06(0.06)	0(0)	0(0)
Gobionellus oceanicus	0(0)	0(0)	0.06(0.06)
Leiostomus xanthurus	0(0)	0(0)	0.17(0.12)
Litopanaeus setiferus	0(0)	0(0)	0.17(0.12)
Macrobrachium acanthurus	0(0)	0(0)	0.56(0.40)
Menidia beryllina	0(0)	0(0)	0.06(0.06)
Palaemonetes pugio	0(0)	0.67(0.50)	0(0)
Trinectes maculatus	0(0)	0.11(0.08)	0(0)
Uca pugnax	0.06(0.06)	0(0)	0(0)

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

	2000	**2009**	**2010**
Anguilla rostrata	0.71(0.34)	0(0)	0.06(0.06)
Callinectes sapidus	0(0)	0.06(0.06)	0(0)
Clupeidae	0(0)	0(0)	1.72(1.41)
Ctenogobius shufeldti	0.29(0.14)	0.17(0.12)	0(0)
Lagodon rhomboides	0.35(0.35)	0(0)	0(0)
Menidia beryllina	0(0)	0.06(0.06)	0(0)
Paralichthys albigutta	0(0)	0(0)	0.06(0.06)
Paralichthys dentatus	0.47(0.28)	0(0)	0(0)
Paralichthys sp.	0(0)	10.72(2.88)	15.78(4.62)
Rangia sp.	0.06(0.06)	0(0)	0(0)
Uca minax	0(0)	0.11(0.08)	0(0)
Uca pugnax	0.06(0.06)	0(0)	0(0)

Table 7.8-14a. Mean abundance per trap (SE) for epibenthic fauna collected in fall Drop trap sampling at station P8 (Dollison Landing).

	1999	2008	2009
Ctenogobius shufeldti	0.11(0.08)	1.06(0.27)	0.44(0.22)
Dorosoma petenense	0(0)	0.44(0.25)	0(0)
Eucinostomus sp.	0(0)	0.06(0.06)	0(0)
Evorthodus lyricus	0(0)	0(0)	0.06(0.06)
Gambusia holbrooki	0.22(0.22)	0(0)	0(0)
Gobionellus oceanicus	0(0)	0.06(0.06)	0(0)
Lepomis macrochirus	0.06(0.06)	0.17(0.12)	0(0)
Menidia beryllina	0(0)	0.06(0.06)	0(0)
Notropis chalybaeus	2.94(1.98)	0(0)	0(0)
Palaemonetes pugio	0(0)	0.06(0.06)	0(0)
Paralichthys lethostigma	0(0)	0(0)	0.06(0.06)
Trinectes maculatus	0.17(0.12)	1.00(0.34)	0.28(0.14)

Table 7.8-14b. Mean abundance per trap (SE) for epibenthic fauna collected in spring Drop trap sampling at station P8 (Dollison Landing).

	2000	**2009**	**2010**
Anguilla rostrata	0(0)	0.11(0.08)	0(0)
Callinectes sapidus	0(0)	0(0)	0(0)
Clupeidae	0(0)	0.11(0.08)	1.50(0.99)
Ctenogobius shufeldti	0(0)	0.89(0.28)	0.06(0.06)
Esox americanus	0(0)	0(0)	0.06(0.06)
Menidia beryllina	0.61(0.39)	0(0)	0(0)
Mugil cephalus	0(0)	0(0)	0(0)
Paralichthys dentatus	0.11(0.11)	0(0)	0(0)
Paralichthys sp.	0(0)	3.39(1.14)	11.11(3.80)
Trinectes maculatus	0(0)	0.06(0.06)	0(0)
Uca pugnax	0.06(0.06)	0(0)	0(0)

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

	1999	**2008**	**2009**
Anchoa mitchilli	0(0)	0.89(0.56)	2.22(0.83)
Bairdiella chrysoura	0(0)	0(0)	0.06(0.06)
Callinectes sapidus	0(0)	0.39(0.14)	0.17(0.09)
Ctenogobius shufeldti	0.22(0.13)	0.06(0.06)	0(0)
Eucinostomus sp.	0(0)	0.28(0.18)	0(0)
Farfantepenaeus aztecus	0(0)	0(0)	0.06(0.06)
Leiostomus xanthurus	0(0)	0.06(0.06)	0.06(0.06)
Litopenaeus setiferus	0(0)	2.78(1.58)	6.67(2.13)
Menidia beryllina	0(0)	0.06(0.06)	0(0)
Palaemonetes pugio	0(0)	0.50(0.36)	0.06(0.06)
Rhithropanopeus harrisii	0.06(0.06)	0(0)	0(0)
Selene vomer	0(0)	0(0)	0.06(0.06)
Symphurus plagiusa	0(0)	0.22(0.13)	0.56(0.50)
Trinectes maculatus	0.22(0.17)	0(0)	0(0)

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

	2000	**2009**	**2010**
Anchoa mitchilli	0(0)	0.17(0.17)	0(0)
Anguilla rostrata	0.33(0.16)	0(0)	0(0)
Callinectes sapidus	0.11(0.08)	0.22(0.10)	0.11(0.08)
Clupeidae	0(0)	2.33(1.27)	1.83(1.00)
Ctenogobius shufeldti	0.17(0.12)	0.06(0.06)	0.11(0.08)
Lagodon rhomboides	0.72(0.50)	0(0)	0.17(0.09)
Leiostomus xanthurus	14.83(9.79)	6.44(2.52)	16.83(6.52)
Menidia beryllina	0.22(0.17)	0(0)	0(0)
Micropogonias undulatus	0(0)	0(0)	0.06(0.06)
Mugil cephalus	0(0)	0(0)	0.28(0.28)
Palaemonetes pugio	0.06(0.06)	0.11(0.08)	0.83(0.57)
Paralichthys albigutta	0(0)	0(0)	0.06(0.06)
Paralichthys dentatus	1.17(0.44)	0(0)	0(0)
Paralichthys lethostigma	0(0)	0(0)	0.06(0.06)
Paralichthys sp.	0(0)	0.89(0.36)	2.78(0.63)
Rangia sp.	0.17(0.12)	0(0)	0(0)
Trinectes maculatus	0(0)	0(0)	0.06(0.06)

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

	1999	**2008**	**2009**
Anchoa mitchilli	0(0)	0.39(0.39)	0(0)
Callinectes sapidus	0(0)	0.11(0.08)	0.06(0.06)
Ctenogobius shufeldti	0.11(0.08)	0(0)	0.33(0.14)
Dormitator maculatus	0(0)	0(0)	0.17(0.09)
Eucinostomus sp.	0(0)	0.11(0.11)	0(0)
Fundulus heteroclitus	0(0)	0(0)	0.06(0.06)
Leiostomus xanthurus	0(0)	0.22(0.15)	0(0)
Lepomis macrochirus	0.11(0.08)	0(0)	0(0)
Litopenaeus setiferus	0(0)	5.39(1.88)	4.22(2.41)
Menidia beryllina	0(0)	0(0)	1.22(1.05)
Menidia menidia	0(0)	0.06(0.06)	0(0)
Palaemonetes pugio	0(0)	3.44(2.32)	7.28(3.13)
Rhithropanopeus harrisii	0(0)	0.06(0.06)	0(0)
Symphurus plagiusa	0(0)	0.06(0.06)	0(0)
Uca pugnax	0.06(0.06)	0(0)	0(0)

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

	2000	**2009**	**2010**
Anchoa mitchilli	0(0)	1.89(1.39)	0(0)
Callinectes sapidus	0(0)	0.11(0.08)	0(0)
Clupeidae	0(0)	25.44(16.11)	0(0)
Ctenogobius shufeldti	0.06(0.06)	0.33(0.14)	0.22(0.13)
Fundulus heteroclitus	0(0)	0(0)	0.06(0.06)
Gambusia holbrooki	0(0)	0(0)	0.17(0.12)
Lagodon rhomboides	0(0)	0.06(0.06)	0.11(0.08)
Leiostomus xanthurus	0.11(0.08)	23.78(6.84)	7.94(3.41)
Micropogonias undulatus	0(0)	2.00(0.95)	0(0)
Menidia beryllina	0.17(0.12)	0(0)	0(0)
Mugil cephalus	0(0)	1.83(0.98)	0.44(0.28)
Palaemonetes pugio	0.06(0.06)	9.06(3.35)	1.56(0.72)
Paralichthys dentatus	0.17(0.12)	0(0)	0(0)
Paralichthys sp.	0(0)	1.17(0.41)	3.33(2.54)

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

	1999	**2008**	**2009**
Callinectes sapidus	0(0)	0.06(0.06)	0(0)
Ctenogobius shufeldti	0(0)	0(0)	0.22(0.10)
Eleotris amblyopsis	0(0)	0(0)	0.06(0.06)
Eucinostomus sp.	0(0)	0.06(0.06)	0.06(0.06)
Gobiosoma bosc	0(0)	0(0)	0.06(0.06)
Lepomis macrochirus	0.06(0.06)	0(0)	0(0)
Litopenaeus setiferus	0(0)	0.17(0.12)	0(0)
Menidia beryllina	0(0)	0.33(0.14)	0.11(0.11)
Palaemonetes pugio	0(0)	0.11(0.08)	0(0)
Paralichthys lethostigma	0(0)	0.06(0.06)	0(0)
Rhithropanopeus harrisii	0(0)	0.06(0.06)	0.06(0.06)
Trinectes maculatus	0(0)	0(0)	0.39(0.22)
Uca pugnax	0.11(0.11)	0(0)	0(0)

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

	2000	**2009**	**2010**
Anguilla rostrata	0.17(0.17)	0.06(0.06)	0(0)
Callinectes sapidus	0(0)	0.06(0.06)	0(0)
Clupeidae	0(0)	1.50(1.33)	0(0)
Ctenogobius boleosoma	0(0)	0.06(0.06)	0(0)
Ctenogobius shufeldti	0.22(0.15)	0.28(0.19)	0.06(0.06)
Leiostomus xanthurus	0(0)	1.22(0.72)	4.06(2.74)
Lepomis macrochirus	0.11(0.11)	0(0)	0(0)
Menidia beryllina	1.39(0.97)	0.06(0.06)	0(0)
Micropogonias undulatus	0(0)	0.11(0.08)	0(0)
Palaemonetes pugio	0(0)	0.06(0.06)	0(0)
Paralichthys dentatus	0.33(0.16)	0(0)	0(0)
Paralichthys sp.	0(0)	2.17(0.72)	2.61(1.33)
Trinectes maculatus	0.33(0.20)	0(0)	0.06(0.06)

7.4 Community Evaluation

Dominance Patterns

The 2009- 2010 sampling year showed a similar pattern as observed in previous years with a decline in species present compared to the previous (in this case 2008-2009) sampling year (Culbertson et al 2010). Previous reporting periods show that species number peaked in 2002-2004 (Hackney et.al. 2004, 2005). Total species richness for the Drop traps and Breder traps were 35 and 26, respectively. During the fall 2009 to spring 2010 sampling period, drop traps captured 26 and 20 taxa, respectively; whereas, Breder traps captured 18 and 15 taxa over the same time period. Several species were numerically dominant (comprising > 5% of the total number of individuals collected), and consistently appeared among sites and/or seasons, among years, and across habitats. During the fall 2009 period, *Ctenogobius shufeldti* (freshwater goby), *Palaemonetes pugio* (grass shrimp) and *Litopenaeus setiferus* (commercial white shrimp) were the most common taxa collected in both shallow subtidal habitats (drop trap) and intertidal marsh habitats (Breder trap) across most sites (Figure 7.4-1 and Figure 7.4-3). In the spring, *Leiostomus xanthurus* (spot) and *Paralichthys* sp. (flounder) were dominant at most sites although *Palaemonetes pugio* was still common in some sites in both habitats (Figure 7.4-2 and Figure 7.4-4). *Ctenogobius shufeldti* (freshwater goby), *Fundulus heteroclitus* and *Lagodon rhomboides* were also common at a number of sites in the intertidal marsh habitats (Figure 7.4-2 and Figure 7.4-4).

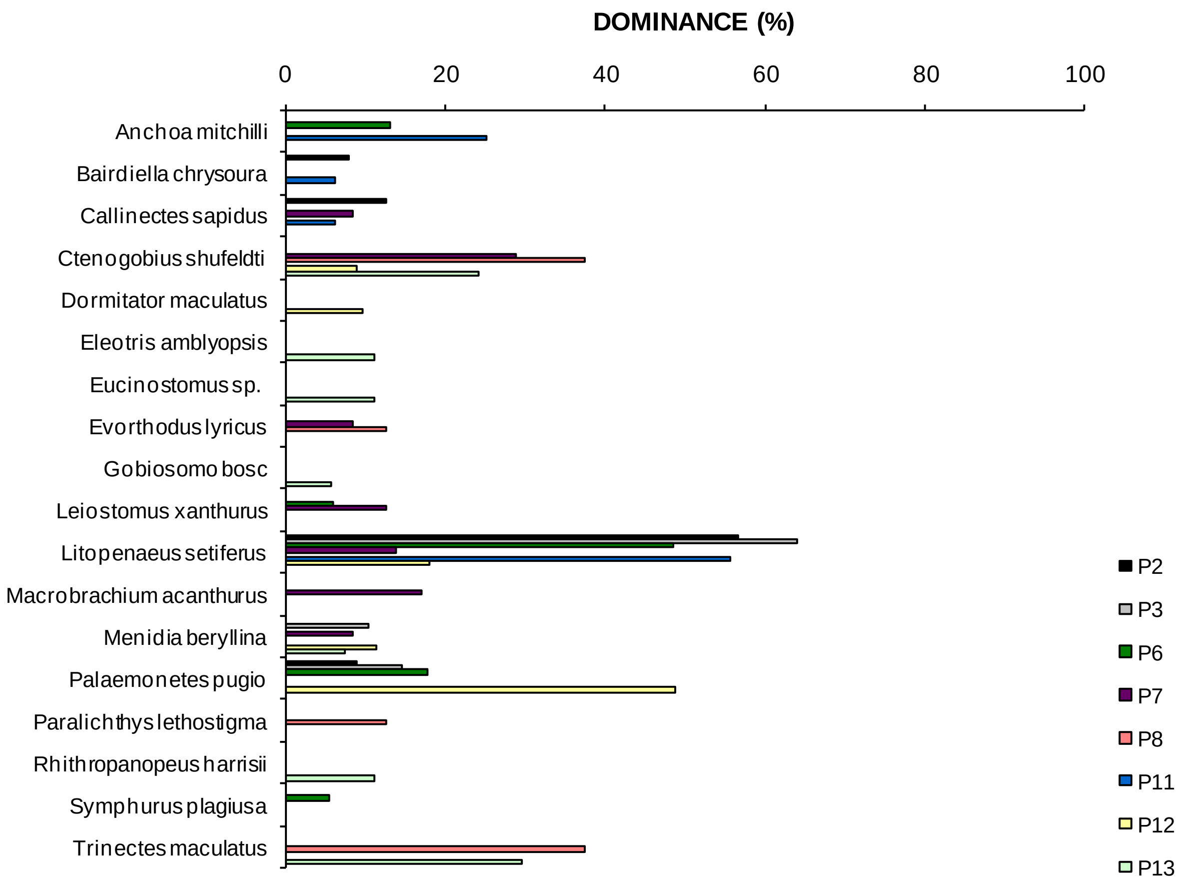


Figure 7.4-1. Common species representing ≥ 5% of the total abundance among sites sampled by Drop trap in fall 2009.

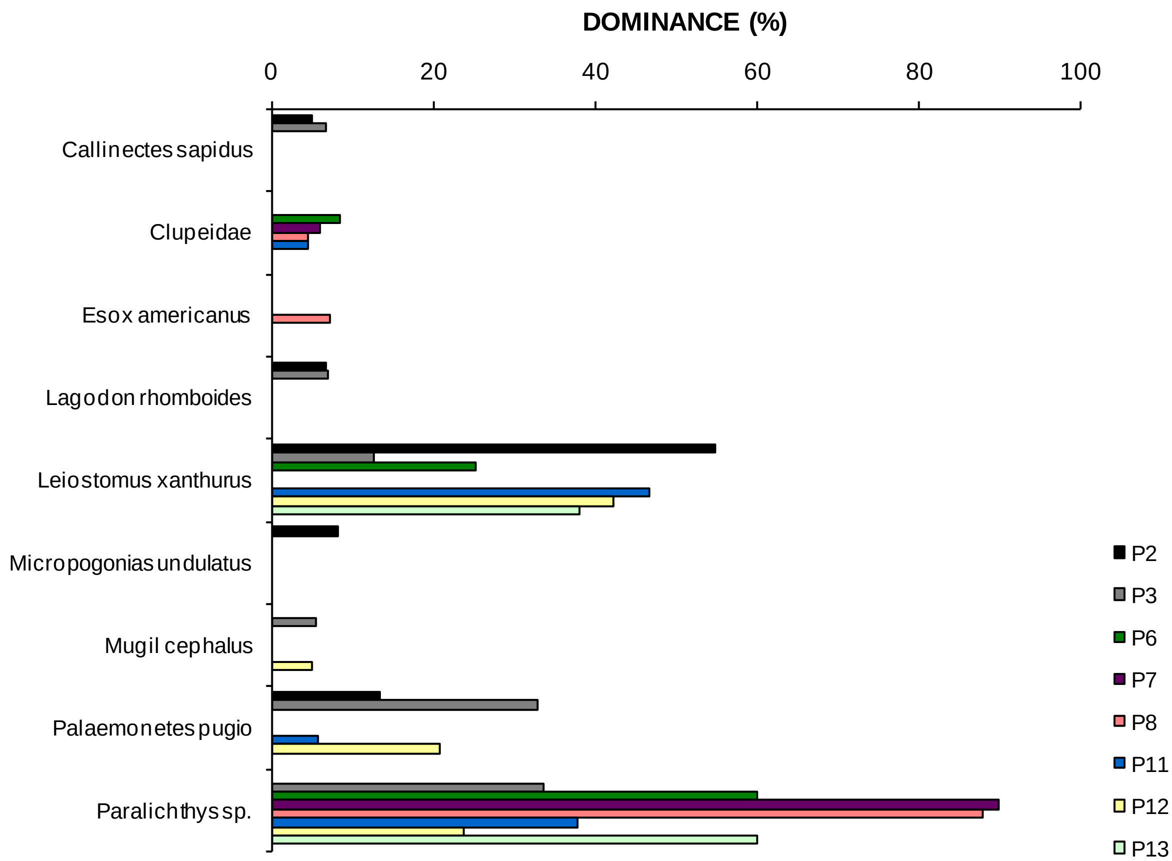


Figure 7.4-2. Common species representing ≥ 5% of the total abundance among sites sampled by Drop trap in spring 2010.

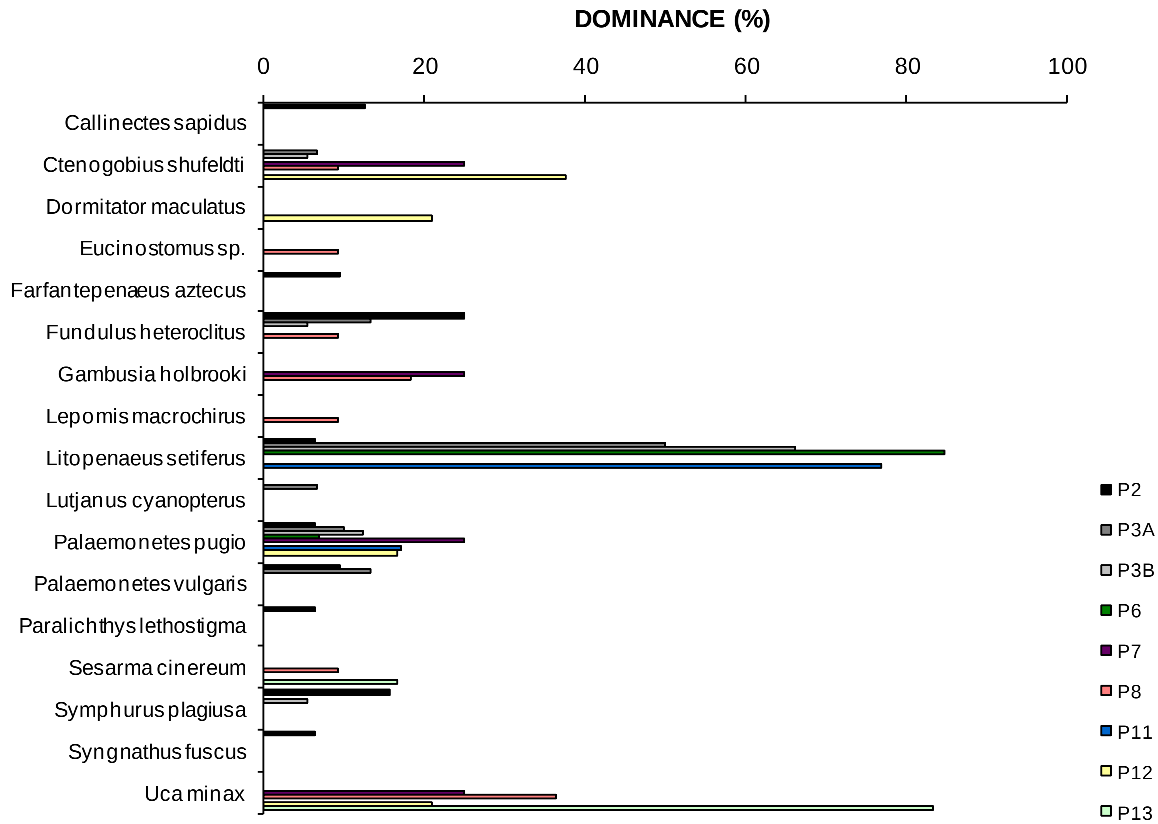


Figure 7.4-3. Common species representing ≥ 5% of the total abundance among sites sampled by Breder trap in fall 2009.

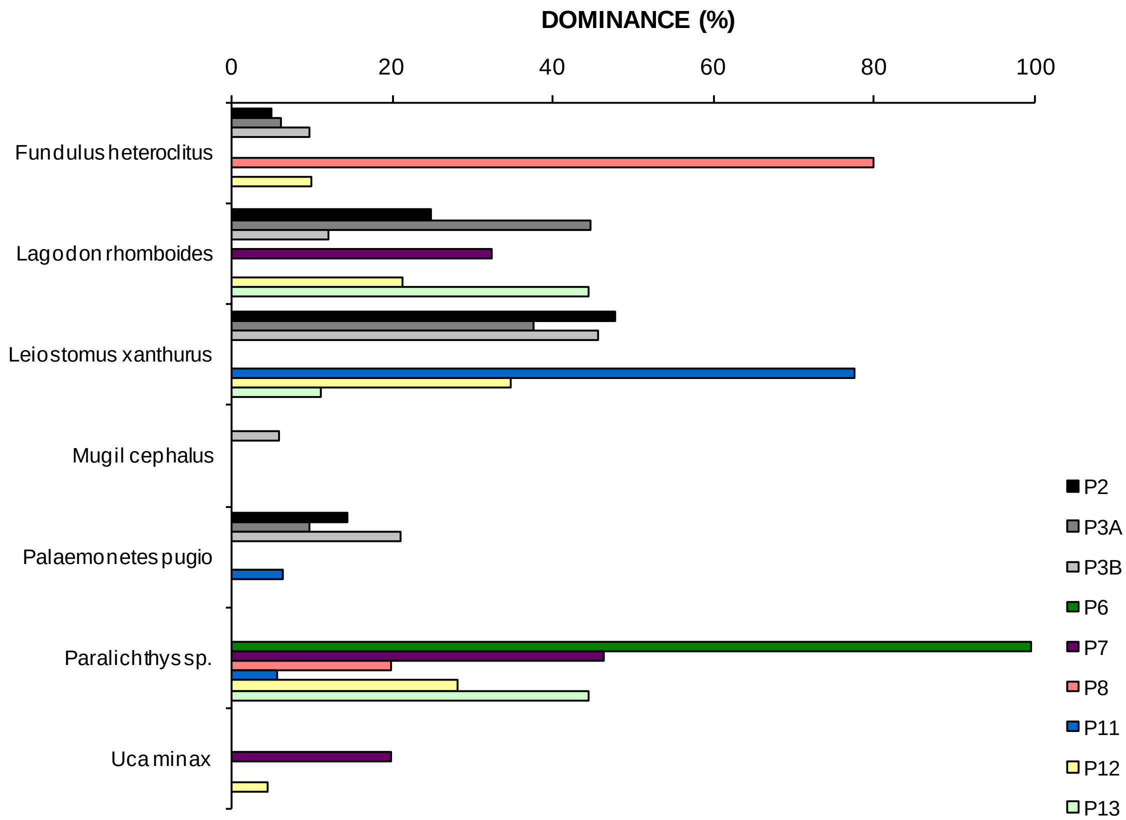


Figure 7.4-4. Common species representing ≥ 5% of the total abundance among sites sampled by Breder trap in spring 2010.

Community Measures

Species Richness

For the purpose of this report species richness is defined as the total number of species present within a given habitat as any time. Species richness was low overall (Figure 7.4-9, 7.4-14, 7.4-19, 7.4-24), although nearly twice as many species were collected in spring samples compared to those collected in the fall. Likewise there seemed to be more species represented in the shallow subtidal marsh edge habitats (drop trap) (Figure 7.4-19, 7.4-20, and 7.4-24) compared to the intertidal marsh interior habitats (Breder traps) (Figures 7.4-9, 7.4-10 and 7.4-14). Although richness was low, there were significant differences noted in 4 out of 4 comparisons based on mean species richness by season and habitat. The upper sites for the mainstem and NE Cape Fear tributaries showed significantly lower species richness for both habitat types for both fall 2009 (Figure 7.4.5,and, 7.4-15) and spring 2010 (Figure 7.4-10 and 7.4-20). The lower sites on each of the main tributaries showed higher species richness (compared to the other sites) for the fall 2009 marsh interior samples (Figure 7.4-5) [ANOVA: F (8, 260) = 14.92, P < 0.0001. SNK: P6=A, P11=A, P3B=B, P2=B, P3A=CB, P8=CB, P12=C, P7=C, P13=C. Sites with the same letter are not significantly different based on the SNK] and for the shallow subtidal marsh edge samples (Figure 7.4-15)[(ANOVA (log transformed data): F (7, 136) = 7.24, P < 0.0001. SNK: P6=A, P3=A, P11=A, P2=A, P12=A, P7=B, P13=B, P8=B. Sites with the same letter are not significantly different based on the SNK]. While the spring sampling season showed a slightly different pattern with greater numbers of species in the Town Creek tributary for marsh interior (Figure 7.4.10)[ANOVA (non-transformed data): F (8, 256) = 34.52, P < 0.0001. SNK: P3B=A, P11=A, P3A=A, P2=A, P12=B, P7=CB, P6=C, P13=D, P8=D. Sites with the same letter are not significantly different based on the SNK.] and the shallow marsh edge (Figure 7.4-20)[ANOVA (log transformed data): F (7, 136) = 16.76, P < 0.0001. SNK: P2=A, P3=A, P6=BA, P12=B, P11=B, P8=C, P7=C, P13=C. Sites with the same letter are not significantly different based on the SNK].

Species Abundance

As with mean species richness, total abundance is used to indicate a degree of habitat utilization. Comparisons of mean total abundance showed consistent differences among sites in the current sampling year. Marsh interior sampling (Breder trap) showed significant differences in the fall 2009 with higher mean total abundance at the lower tributary sites P6 and P11(Figure 7.4-6)[ANOVA (non-transformed data): F (8, 260) = 25.53, P < 0.0001. SNK: P6=A, P11=A, P3B=B, P2=CB, P3A=CB, P8=C, P12=C, P13=C, P7=C. Sites with the same letter are not significantly different based on the SNK], and a similar pattern in spring 2010 with the addition that the upper Town Creek site P3 was also significantly higher than all other sites (Figure 7.4-11) [ANOVA(log transformed data): F (8, 256) = 8.04, P < 0.0001. SNK: P3A=A, P3B=A, P6=A, P11=A, P2=B, P12=B, P7=B, P13=B, P8=B. Sites with the same letter are not significantly different based on the SNK]. The pattern for the shallow subtidal sampling (drop trap) in fall 2009 did not match the utilization pattern of the marsh interior sampling or the patterns observed with species richness with greater abundances in the Town Creek tributary sites (P2 an P3) and Rat Island (P12) the mid site on the NE Cape Fear tributary (Figure 7.4-16)[

ANOVA (non-transformed data): $F (7, 136) = 5.11$, $P < 0.0001$. SNK: P3=A, P12=A, P2=A, P11=BA, P6=BA, P7=B, P13=B, P8=B. Sites with the same letter are not significantly different based on the SNK]. The comparison for spring 2010 showed consistent catches among most sites with the exception of Eagle Island (P6), the lower site on the mainstem Cape Fear (Figure 7.4-21) [ANOVA (log transformed data): $F (7, 136) = 2.66$, $P = 0.0131$. SNK: P6=A, P2=B, P3=B, P11=B, P7=B, P12=B, P8=B, P13=B. Sites with the same letter are not significantly different based on the SNK].This pattern was driven mainly by high catches of *Leiostomus xanthurus* and *Paralichthys* spp. (Table 7.4-12b).

Mean Diversity

The Shannon diversity calculation takes into account both the evenness of a species within a site and the relative proportion each species comprises of the total number within a sample set. Presented here are comparisons of mean diversity among sites for the current sampling year. In general, diversity measures below 1 are considered low, although it should be noted that these measures are similar to many river dominated estuaries and characteristic of areas with low to moderate species richness that are dominated by a few species. The marsh interior sampling (Breder trap) reflected the same pattern as richness and abundance for spring 2009 (Figure 7.4-7) [ANOVA (non-transformed data): $F (8, 260) = 5.55$, $P < 0.0001$. SNK: P6=A, P11=A, P2=BA, P3B=BA, P12=B, P3A=B, P13=B, P7=B, P8=B. Sites with the same letter are not significantly different based on the SNK] and for spring 2010 (Figure 7.4-12) [ANOVA (non-transformed data): $F (8, 256) = 21.57$, $P < 0.0001$. SNK: P3B=A, P2=A, P3A=A, P11=BA, P12=B, P7=C, P6=C, P13=C, P8=C. Sites with the same letter are not significantly different based on the SNK]. The pattern for the shallow subtidal sampling reflects species richness and abundance pattern in general with higher catches at Eagle Island (P6) and low catches at the mid and upper sites on the mainstem and NE Cape Fear tributaries driving the patterns for fall 2009 (Figure 7.4-17) [ANOVA (log transformed data): $F (7, 136) = 5.27$, $P < 0.0001$. SNK: P6=A, P3=BA, P11=BAC, P2=BAC, P12=BC, P7=BC, P13=BC, P8=C. Sites with the same letter are not significantly different based on the SNK] and spring 2010 patterns being dominated by relatively higher catches in the Town Creek tributary and lower catches in the mid and upper portions of the other tributaries (Figure 7.4-22) [ANOVA (log transformed data): $F (7, 136) = 14.81$, $P < 0.0001$. SNK: P2=A, P3=A, P6=B, P12=B, P11=B, P7=C, P13=C, P8=C. Sites with the same letter are not significantly different based on the SNK].

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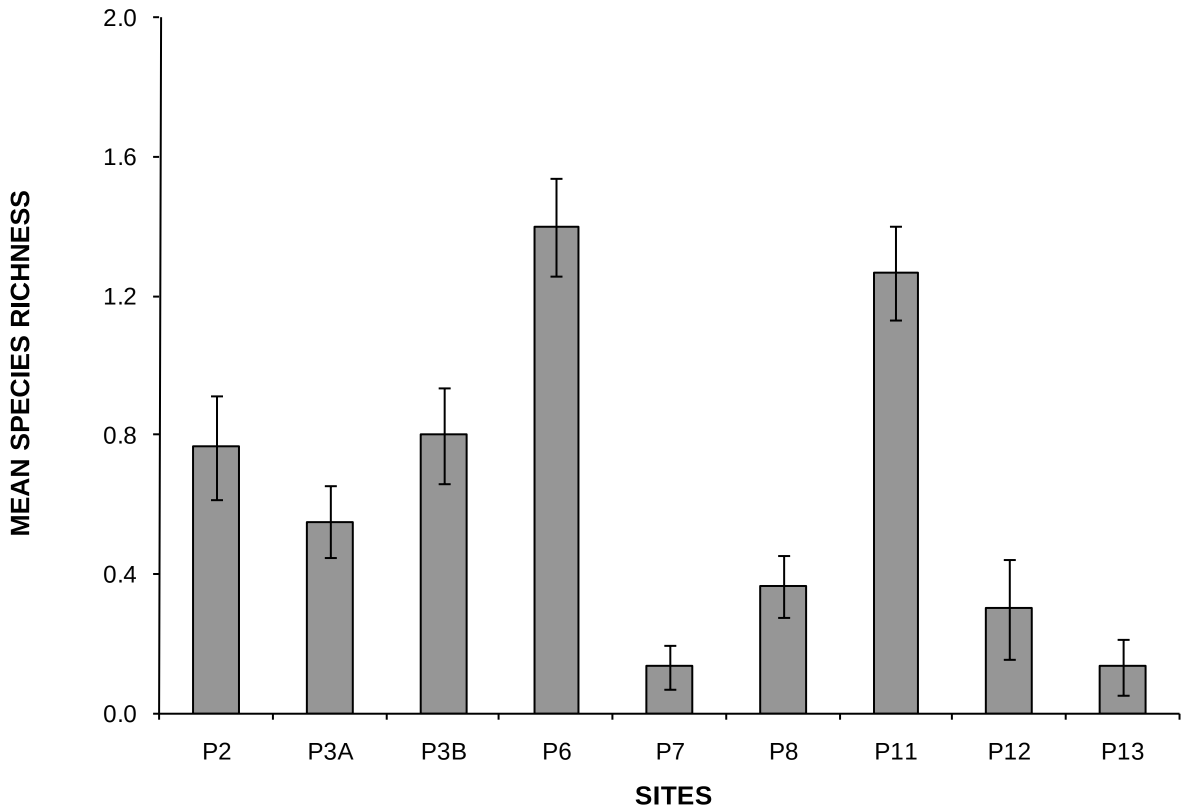


Figure 7.4-5. Mean species richness (Breder trap) among sites sampled in fall 2009. Bars represent standard error of the mean. ANOVA: $F(8, 260) = 14.92$, $P < 0.0001$. SNK: P6=A, P11=A, P3B=B, P2=B, P3A=CB, P8=CB, P12=C, P7=C, P13=C. Sites with the same letter are not significantly different based on the SNK.

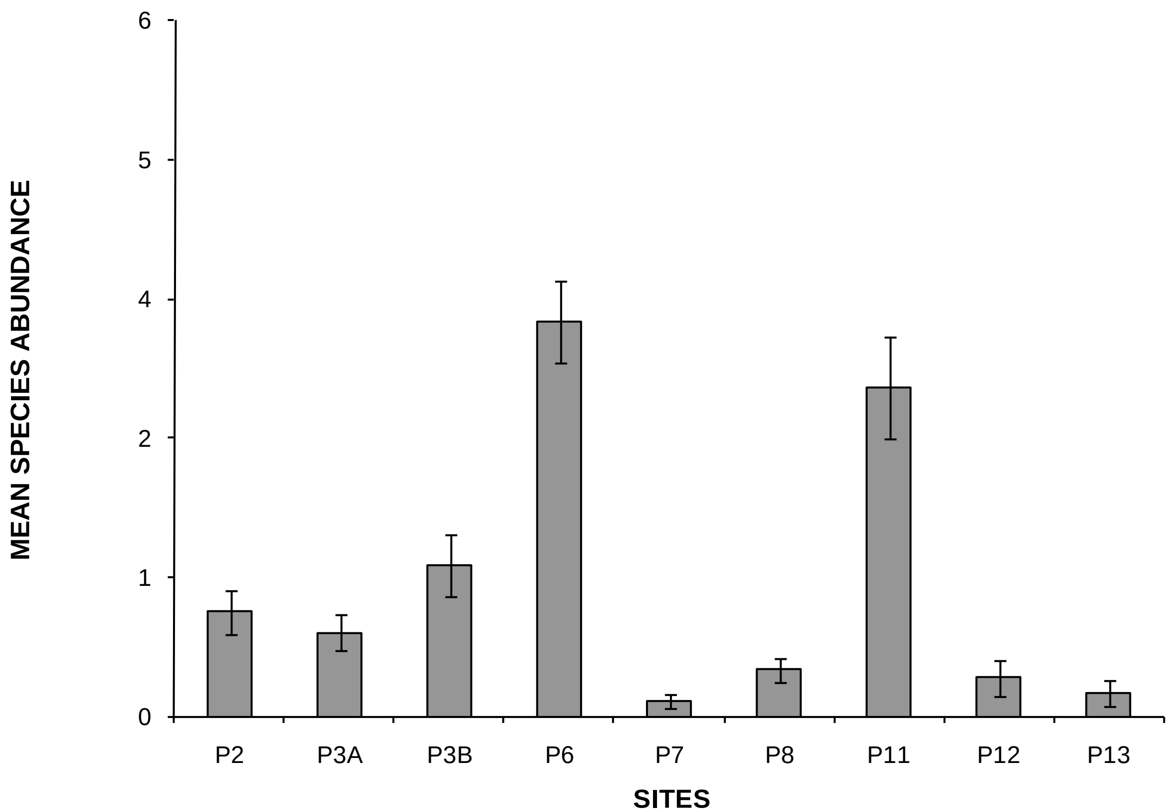


Figure 7.4-6. Mean species abundance (Breder trap) among sites sampled in fall 2009. Bars represent standard error of the mean. The assumption of Homogeneity of Variance was not met, even when data was log transformed. ANOVA (represents non-transformed data): $F (8, 260) = 25.53$, $P < 0.0001$. SNK: P6=A, P11=A, P3B=B, P2=CB, P3A=CB, P8=C, P12=C, P13=C, P7=C. Sites with the same letter are not significantly different based on the SNK.

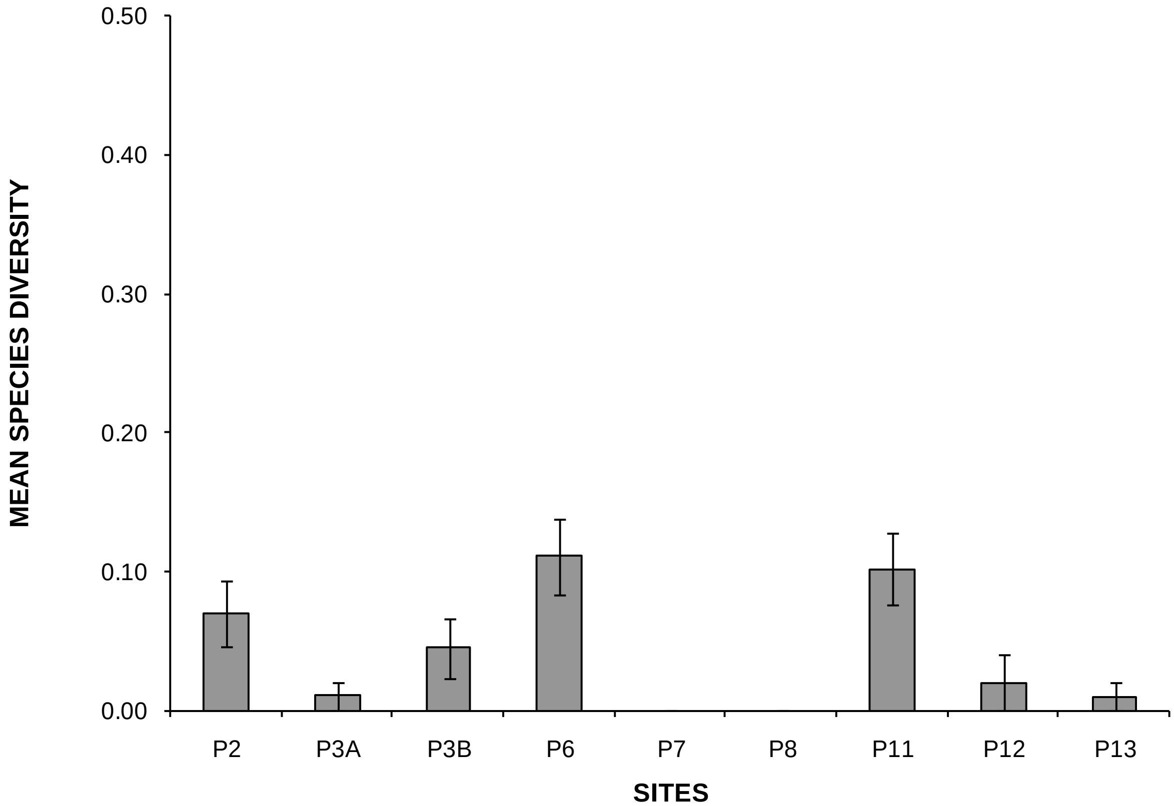


Figure 7.4-7. Mean species diversity (Breder trap) among sites sampled in fall 2009. The calculation of diversity for P7 and P8 is extremely low so the bar appear absent. Diversity was calculated using the Shannon diversity index. Bars represent standard error of the mean. The assumption of Homogeneity of Variance was not met, even when data was log transformed. ANOVA (represents non-transformed data): $F (8, 260) = 5.55$, $P < 0.0001$. SNK: P6=A, P11=A, P2=BA, P3B=BA, P12=B, P3A=B, P13=B, P7=B, P8=B. Sites with the same letter are not significantly different based on the SNK.

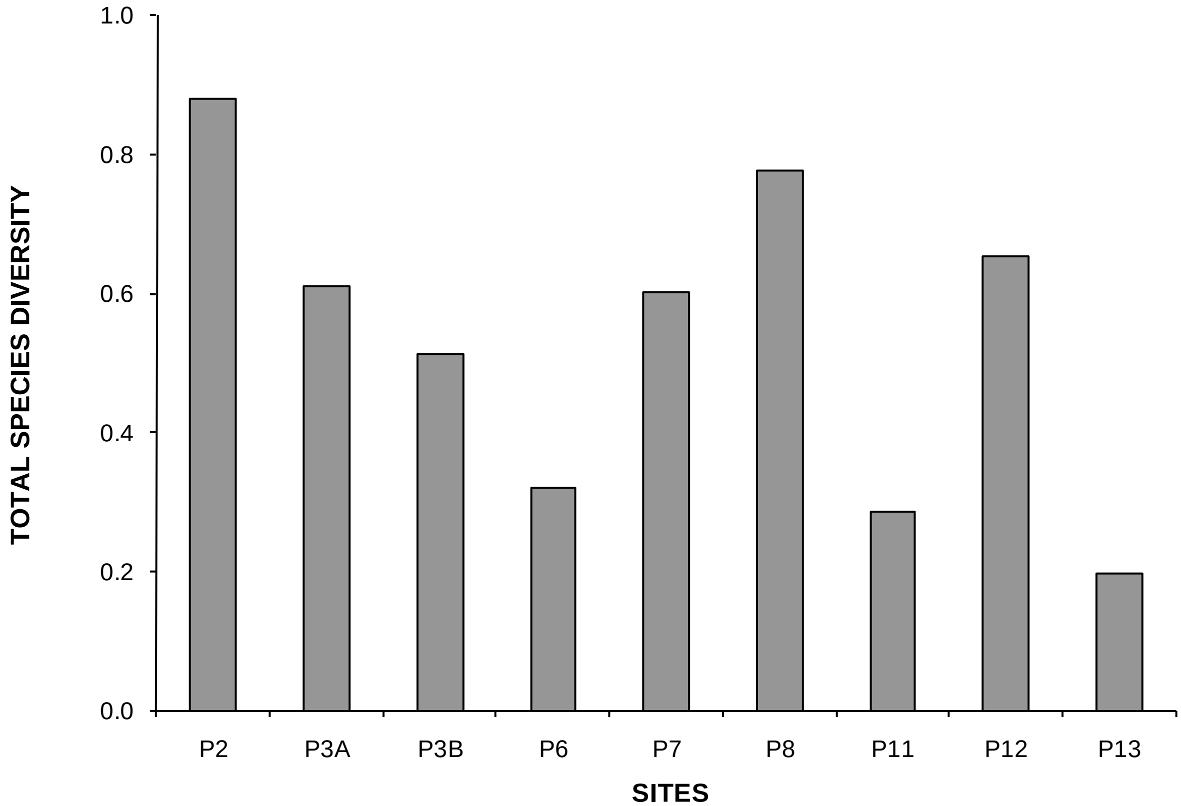


Figure 7.4-8. Overall diversity (Breder trap) by site in fall 2009. Diversity was calculated using the Shannon diversity index.

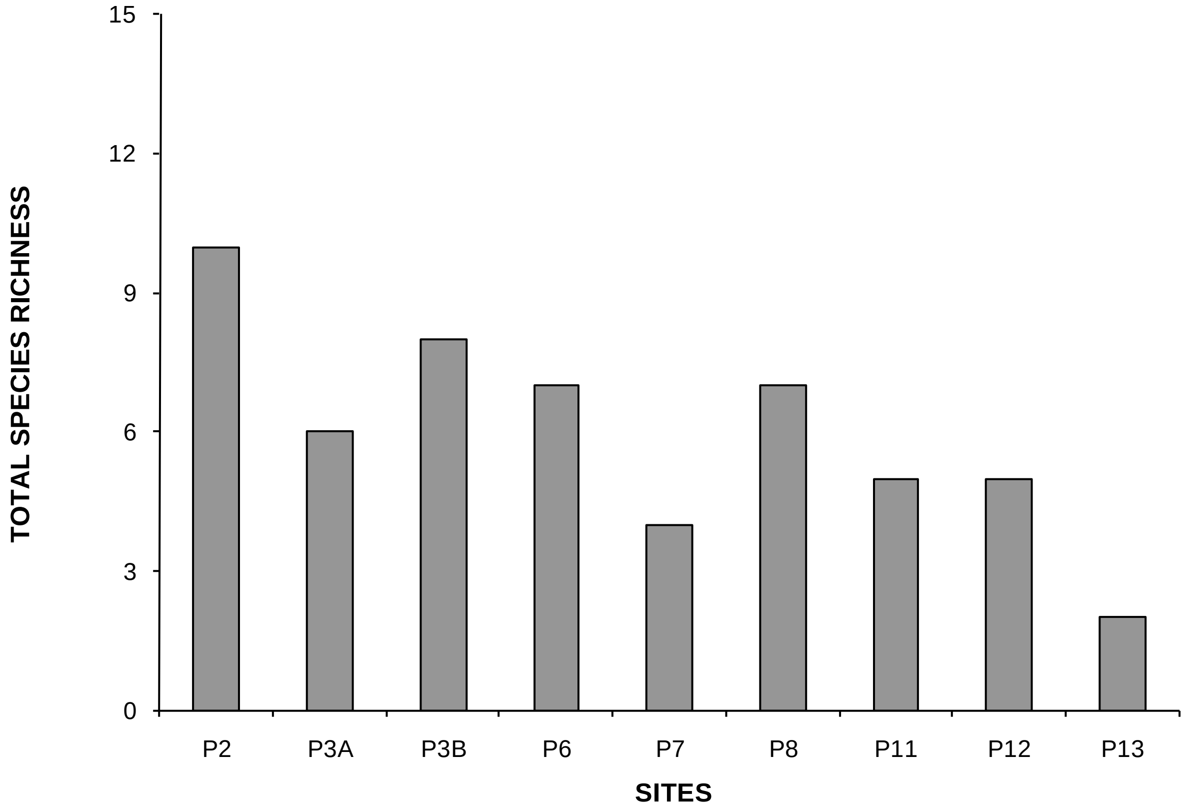


Figure 7.4-9. Total species richness (Breder trap) among sites sampled in fall 2009.

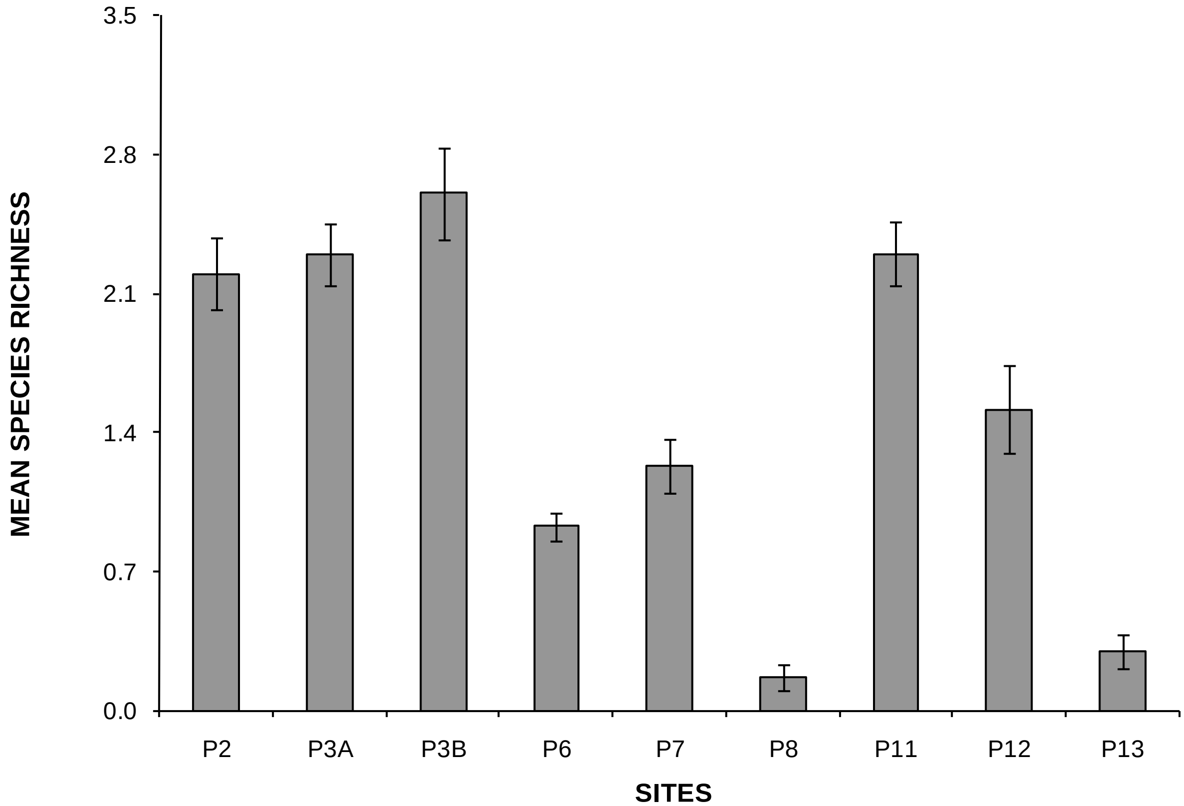


Figure 7.4-10. Mean species richness (Breder trap) among sites sampled in spring 2010. Bars represent standard error of the mean. The assumption of Homogeneity of Variance was not met, even when data was log transformed. ANOVA (represents non-transformed data): $F(8, 256) = 34.52$, $P < 0.0001$. SNK: P3B=A, P11=A, P3A=A, P2=A, P12=B, P7=CB, P6=C, P13=D, P8=D. Sites with the same letter are not significantly different based on the SNK.

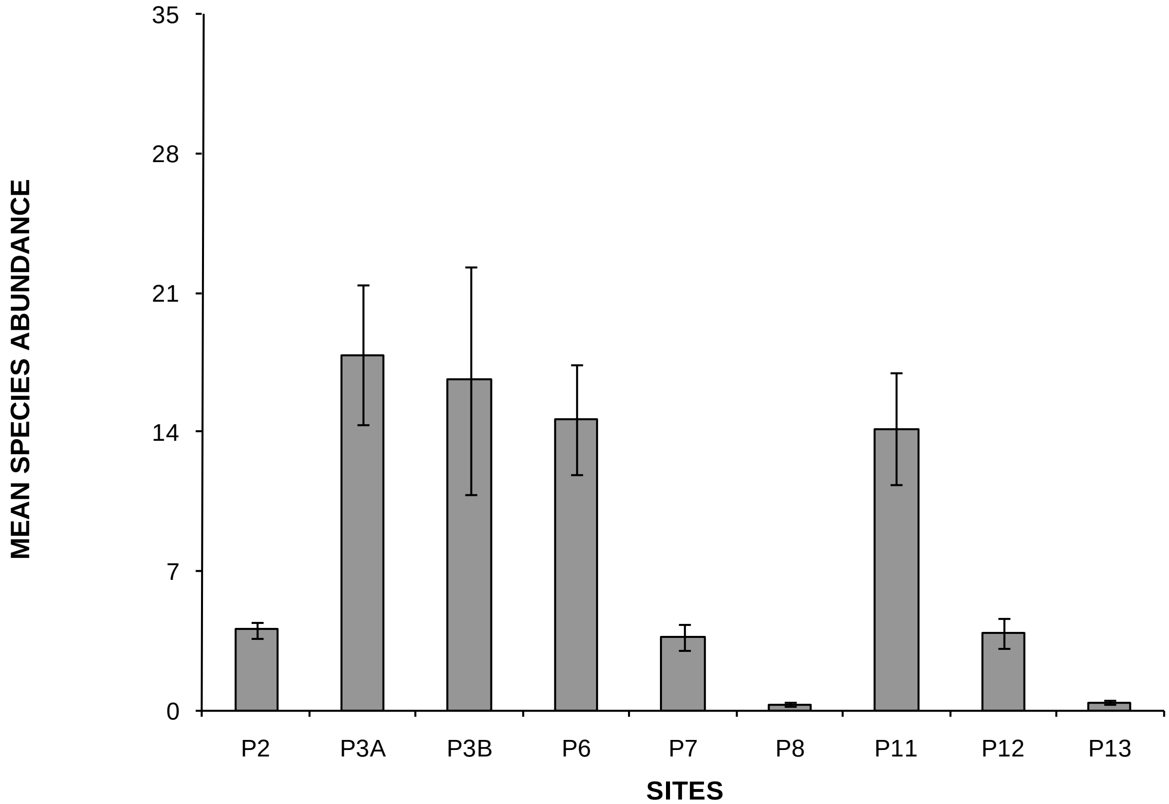


Figure 7.4-11. Mean species abundance (Breder trap) among sites sampled in spring 2010. Bars represent standard error (SE) of the mean. ANOVA: $F (8, 256) = 8.04$, $P < 0.0001$. SNK: P3A=A, P3B=A, P6=A, P11=A, P2=B, P12=B, P7=B, P13=B, P8=B. Sites with the same letter are not significantly different based on the SNK.

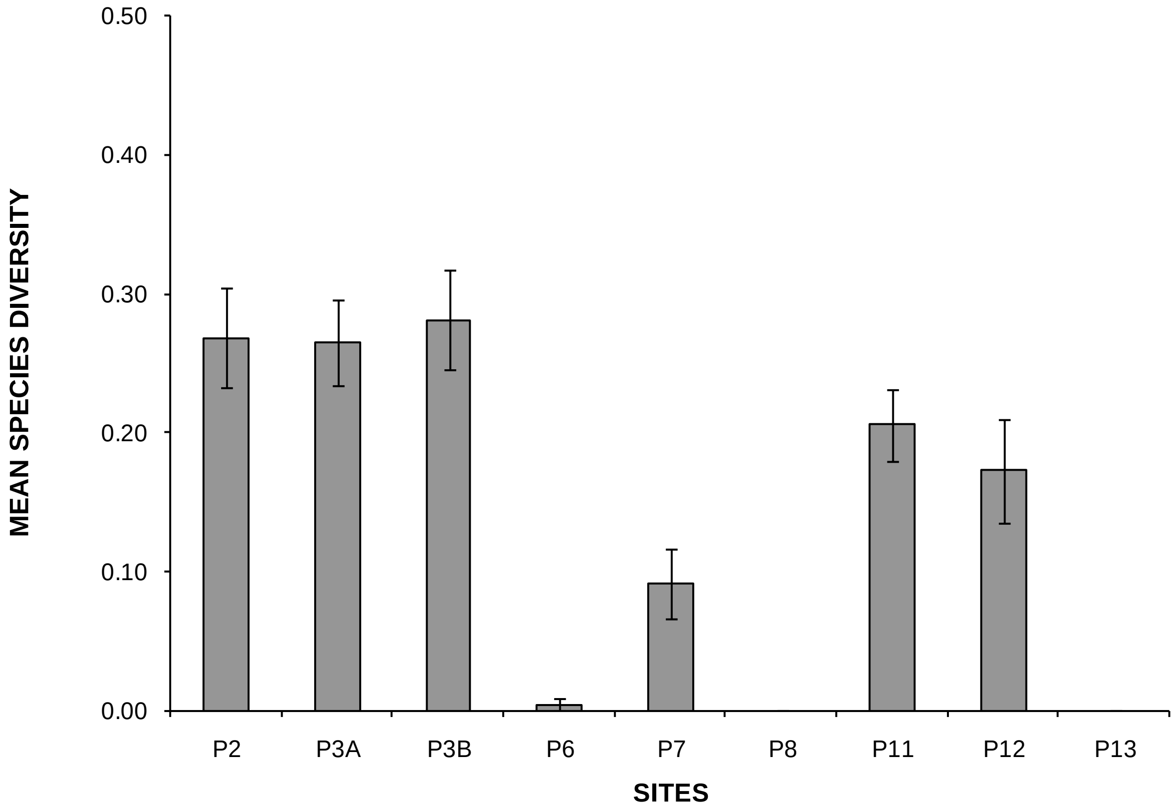


Figure 7.4-12. Mean species diversity (Breder trap) among sites sampled in spring 2010. The calculation of diversity for P8 and P13 was so low that it the bar appears absent. Diversity was calculated using the Shannon diversity index. Bars represent standard error of the mean. The assumption of Homogeneity of Variance was not met, even when data was log transformed. ANOVA (represents non-transformed data): $F (8, 256) = 21.57$, $P < 0.0001$. SNK: P3B=A, P2=A, P3A=A, P11=BA, P12=B, P7=C, P6=C, P13=C, P8=C. Sites with the same letter are not significantly different based on the SNK.

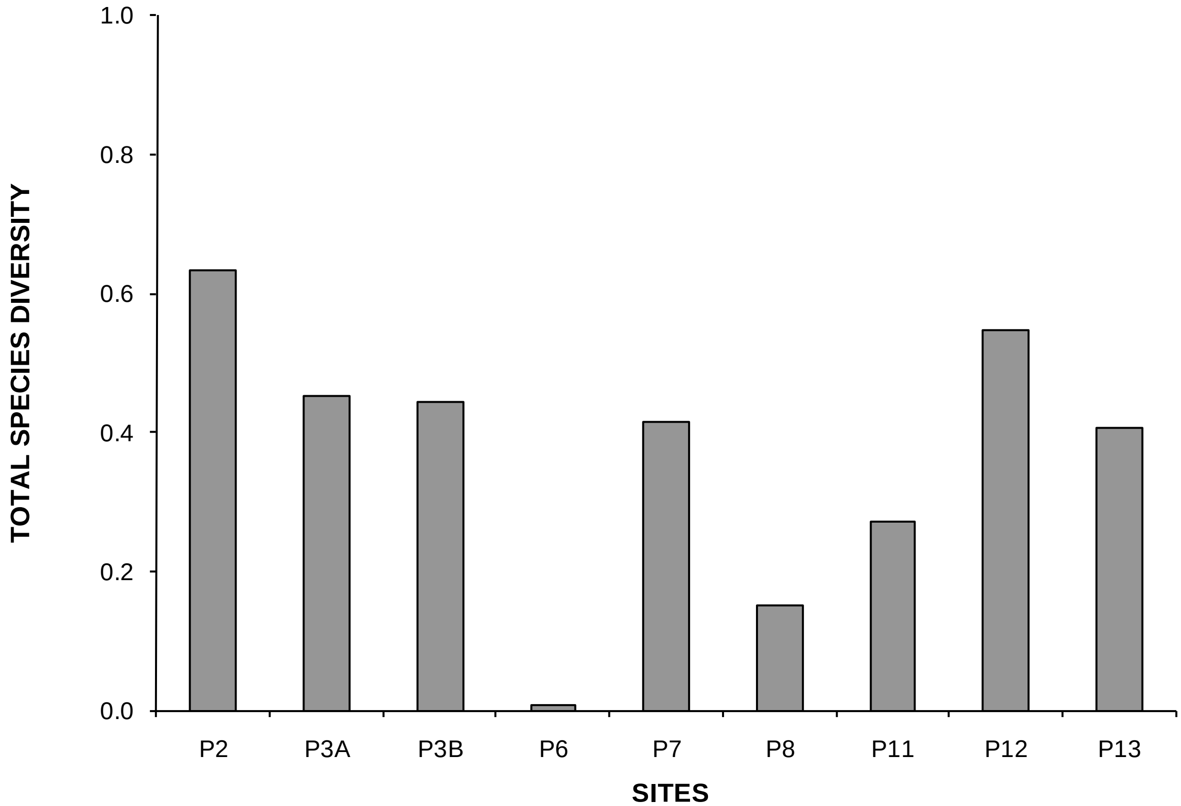


Figure 7.4-13. Overall diversity by sites (Breder trap) in spring 2010. Diversity was calculated using the Shannon diversity index.

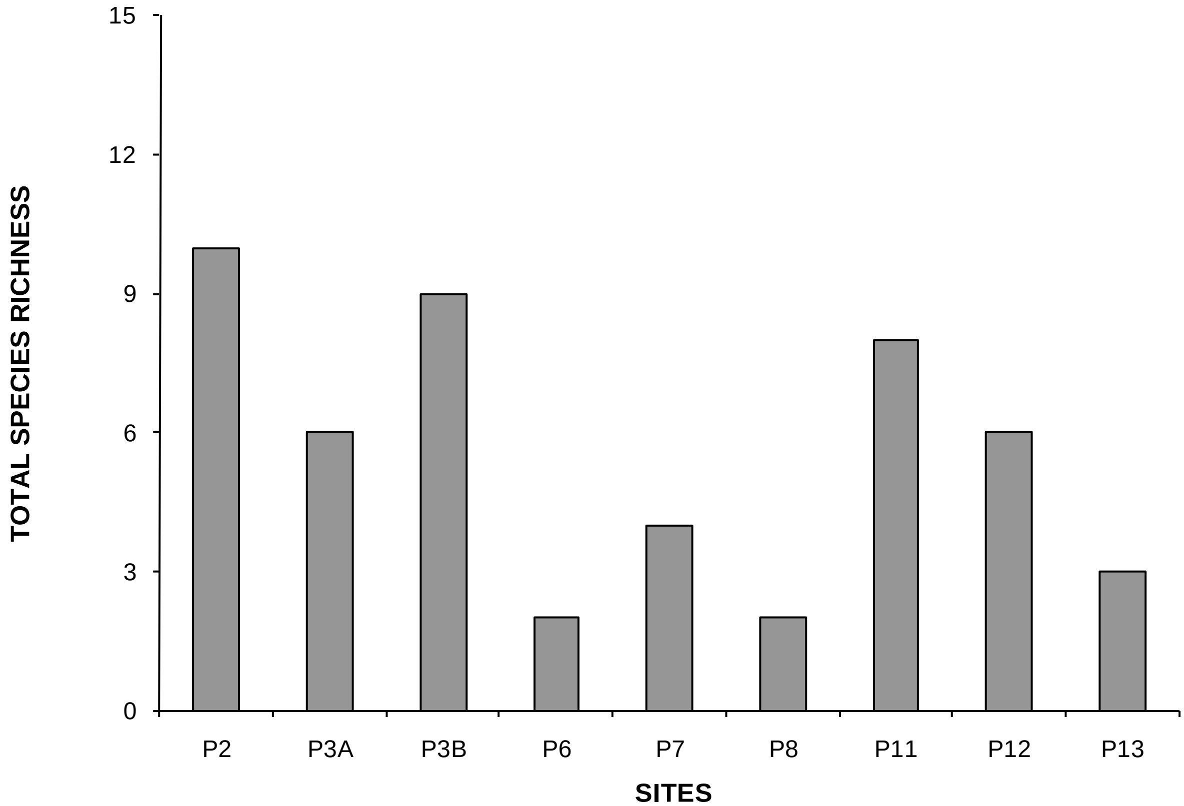


Figure 7.4-14. Total species richness (Breder trap) among sites sampled in spring 2010.

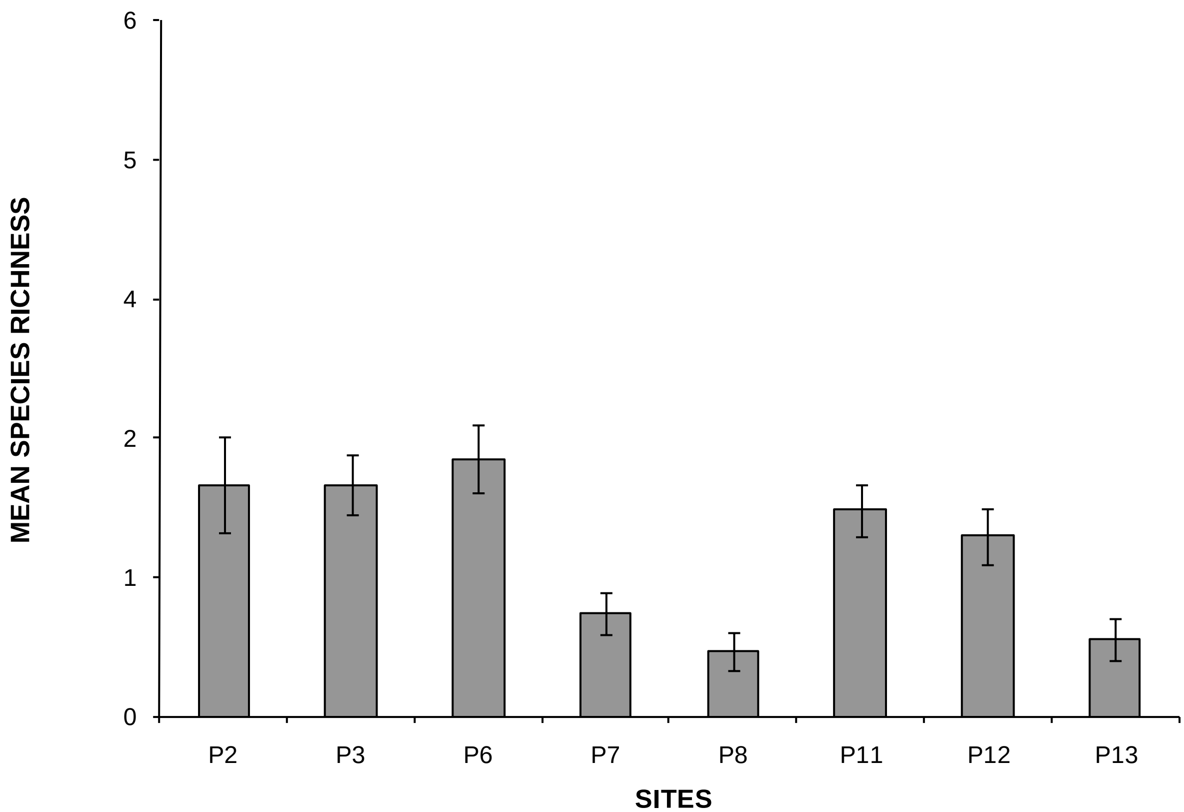


Figure 7.4-15. Mean species richness (Drop trap) among sites sampled in fall 2009. Bars represent standard error of the mean. ANOVA (represents log transformed data): F (7, 136) = 7.24, P < 0.0001. SNK: P6=A, P3=A, P11=A, P2=A, P12=A, P7=B, P13=B, P8=B. Sites with the same letter are not significantly different based on the SNK.

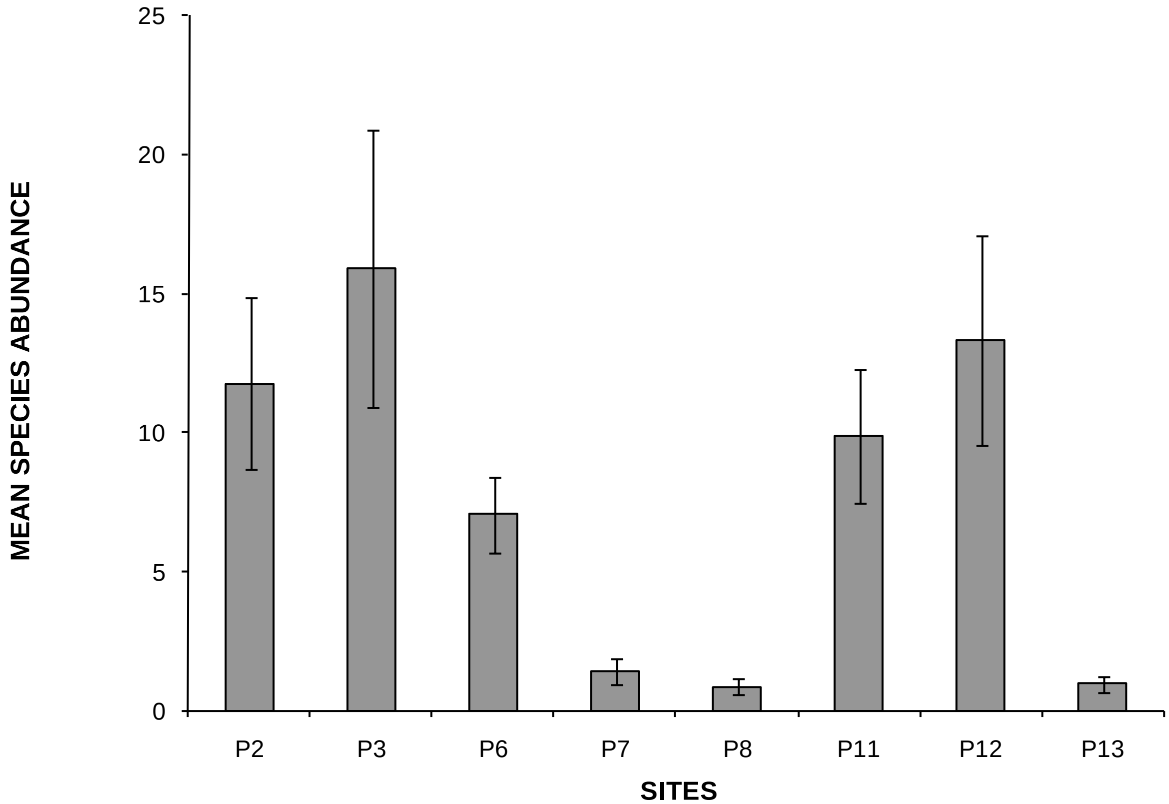


Figure 7.4-16. Mean species abundance (Drop trap) among sites sampled in fall 2009. Bars represent standard error of the mean. The assumption of Homogeneity of Variance was not met, even when data was log transformed. ANOVA (represents non-transformed data): $F(7, 136) = 5.11$, $P < 0.0001$. SNK: P3=A, P12=A, P2=A, P11=BA, P6=BA, P7=B, P13=B, P8=B. Sites with the same letter are not significantly different based on the SNK.

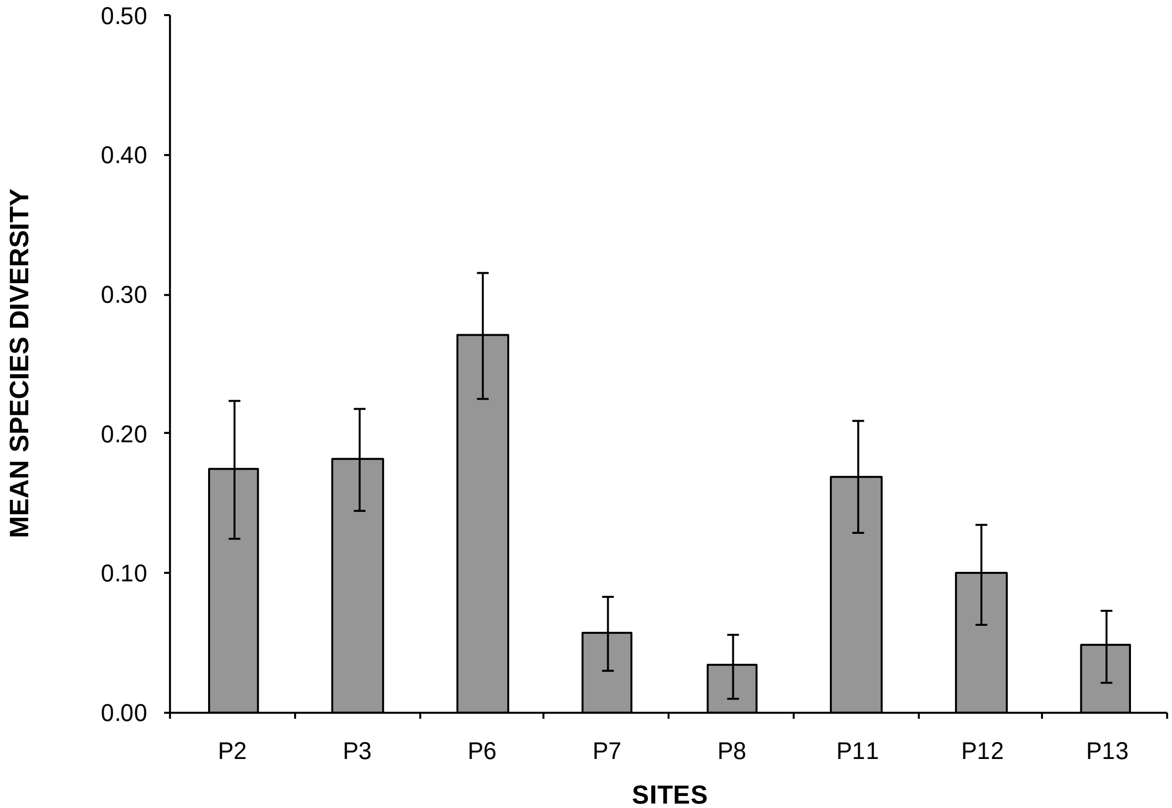


Figure 7.4-17. Mean species diversity (Drop trap) among sites sampled in fall 2009. Diversity was calculated using the Shannon diversity index. Bars represent standard error of the mean. Log transformed data met the assumption of Homogeneity of Variance better than non-transformed data; however, the assumption of Homogeneity of Variance was still not met. ANOVA (represents log transformed data): $F (7, 136) = 5.27$, $P < 0.0001$. SNK: P6=A, P3=BA, P11=BAC, P2=BAC, P12=BC, P7=BC, P13=BC, P8=C. Sites with the same letter are not significantly different based on the SNK.

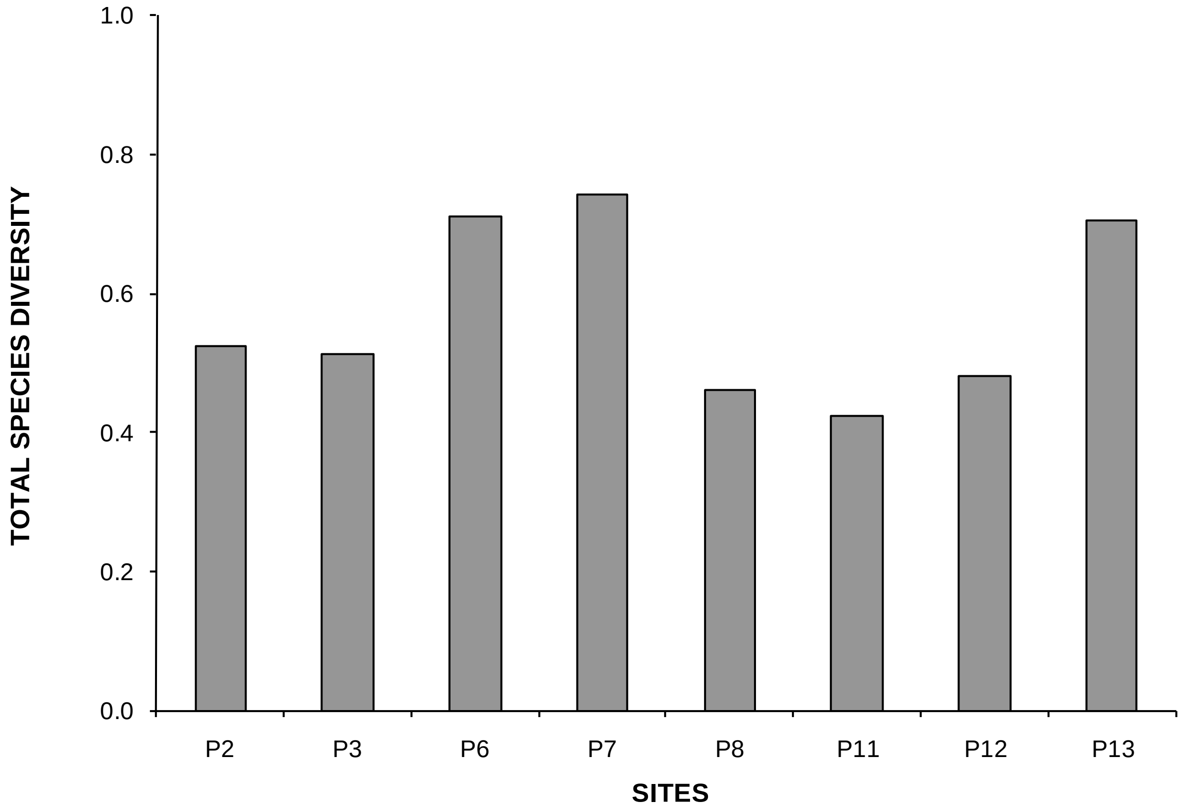


Figure 7.4-18. Overall diversity (Drop trap) by site in fall 2009. Diversity was calculated using the Shannon diversity index.

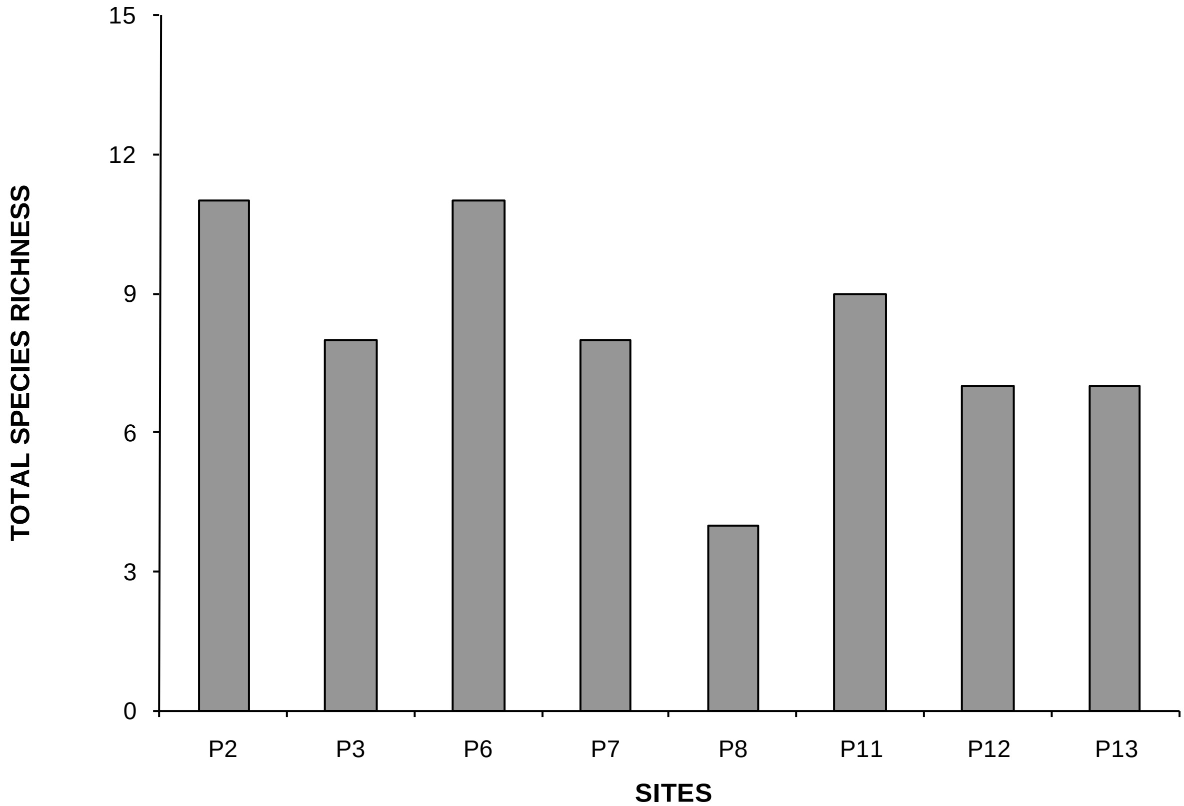


Figure 7.4-19. Total species richness (Drop trap) among sites sampled in fall 2009.

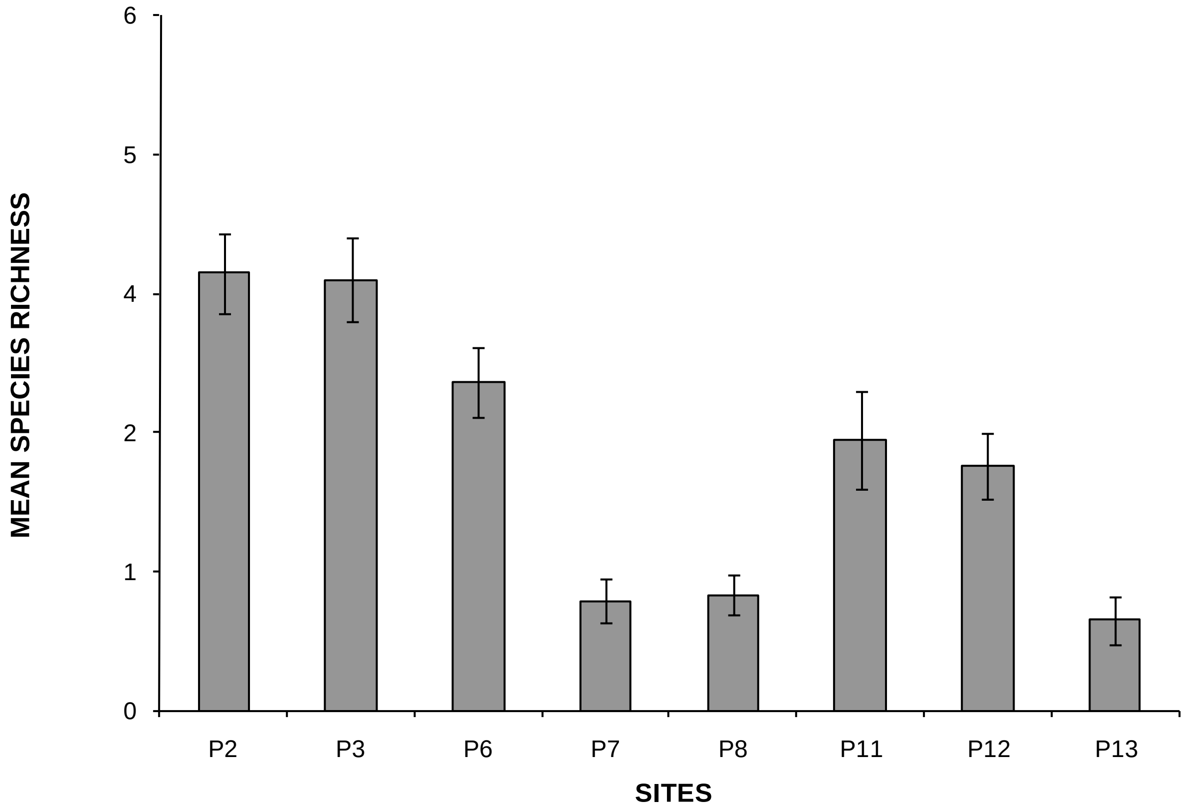


Figure 7.4-20. Mean species richness (Drop trap) among sites sampled in spring 2010. Bars represent standard error of the mean. ANOVA (represents log transformed data): F (7, 136) = 16.76, P < 0.0001. SNK: P2=A, P3=A, P6=BA, P12=B, P11=B, P8=C, P7=C, P13=C. Sites with the same letter are not significantly different based on the SNK.

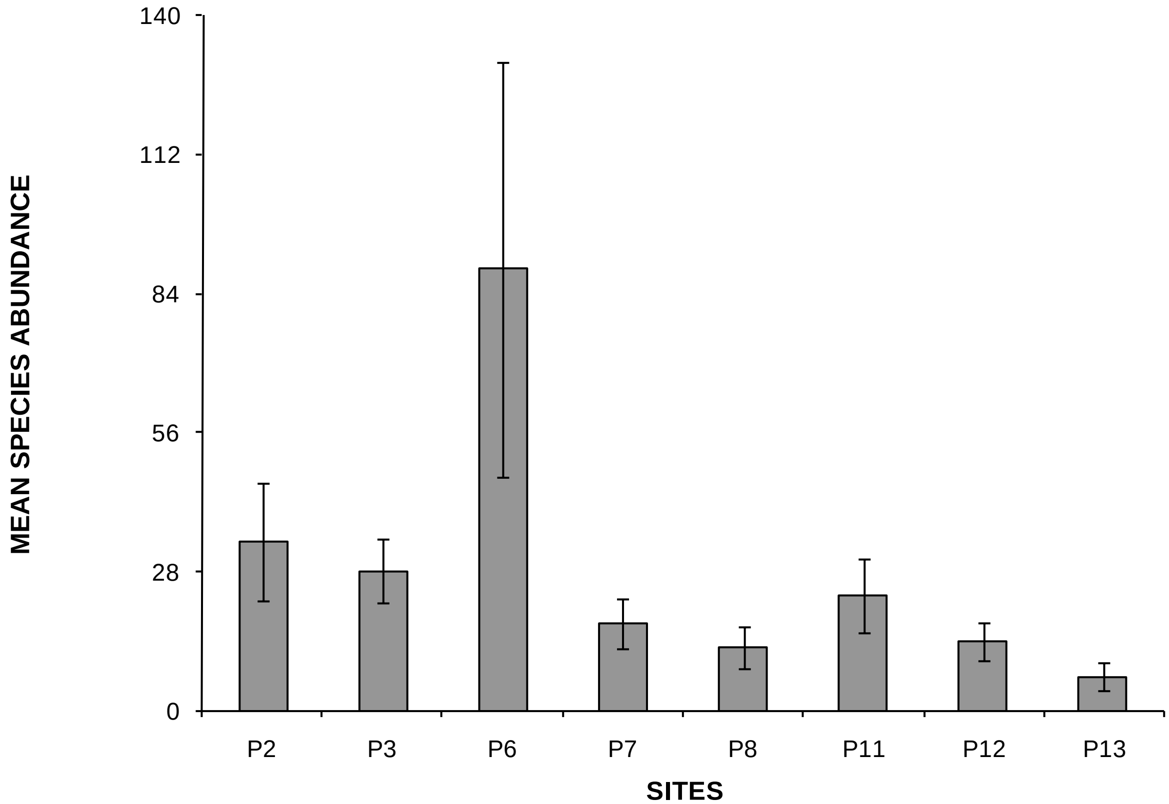


Figure 7.4-21. Mean species abundance (Drop trap) among sites sampled in spring 2010. Bars represent standard error of the mean. ANOVA: $F(7, 136) = 2.66$, $P = 0.0131$. SNK: P6=A, P2=B, P3=B, P11=B, P7=B, P12=B, P8=B, P13=B. Sites with the same letter are not significantly different based on the SNK.

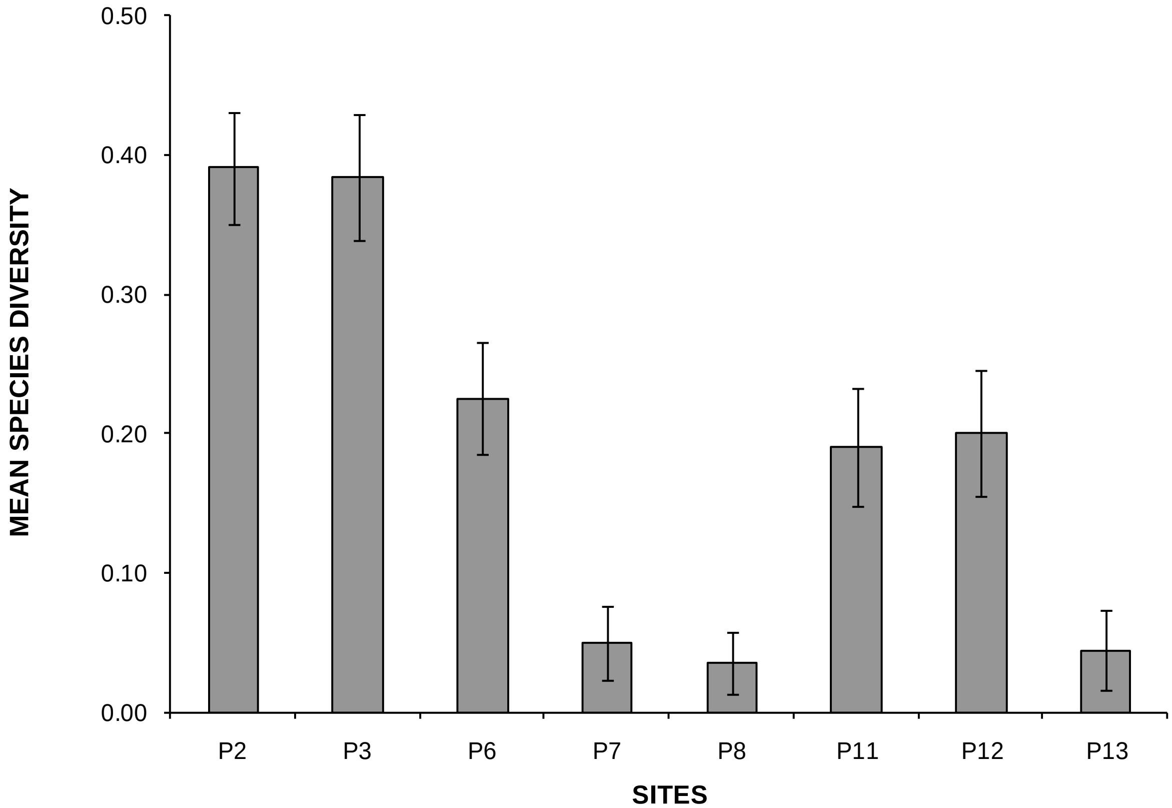


Figure 7.4-22. Mean species diversity (Drop trap) among sites sampled in spring 2010. Diversity was calculated using the Shannon diversity index. Bars represent standard error of the mean. ANOVA: $F (7, 136) = 14.81$, $P < 0.0001$. SNK: P2=A, P3=A, P6=B, P12=B, P11=B, P7=C, P13=C, P8=C. Sites with the same letter are not significantly different based on the SNK.

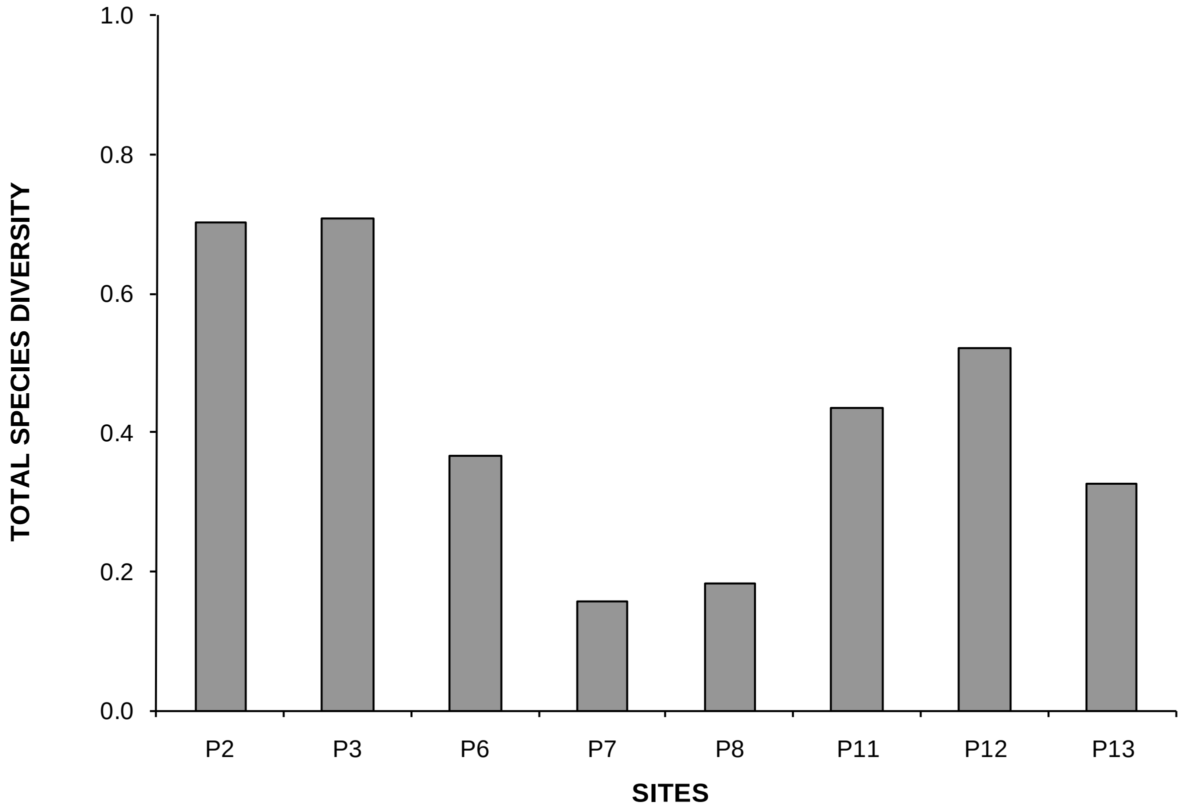


Figure 7.4-23. Overall diversity (Drop trap) by site in spring 2010. Diversity was calculated using the Shannon diversity index.

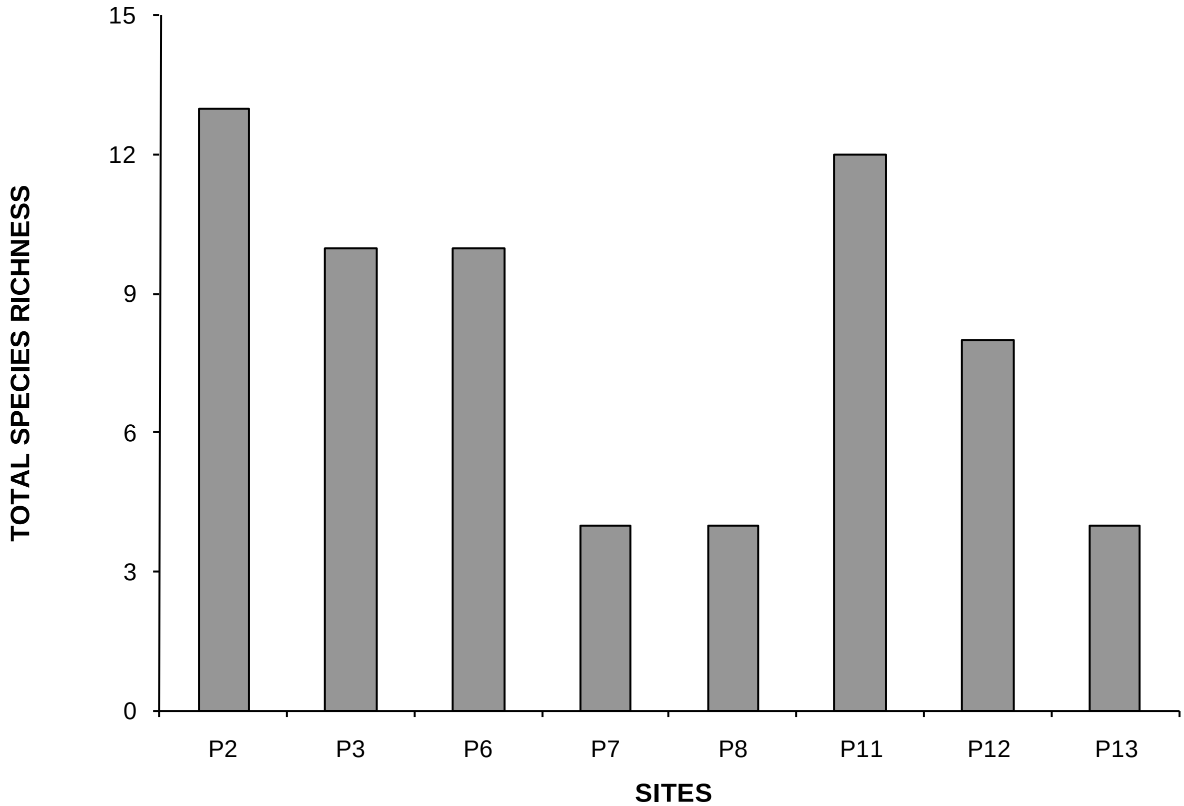


Figure 7.4-24. Total species richness (Drop trap) among sites sampled in spring 2010.

8.0 SENSITIVE HERBACEOUS VEGETATION SAMPLING, YEAR TEN

8.1 Summary

This report presents the results of the tenth consecutive year (2009) of vegetation monitoring within the Cape Fear River estuary. Salt-sensitive plant species have been monitored at seven sampling stations distributed along Town Creek (P3-Inner Town Creek), the Cape Fear River (P7-Indian Creek, P8-Dollisons Landing, and P9-Black River), and the Northeast Cape Fear River (P12-Rat Island, P13-Fishing Creek, and P14-Prince George Creek). The results of past monitoring efforts (2000-2008) have revealed significant changes in sensitive vegetation at Inner Town Creek, Rat Island, and Fishing Creek. Changes at these sites have occurred coincidentally with exposure to high salinity waters. Although Indian Creek has experienced moderately high salinities over the past several years, vegetation changes have been heavily influenced by severe site disturbance and polygon relocation. The remaining three sites (Dollisons Landing, Black River, and Prince George Creek) have experienced little or no exposure to high salinity waters. Past changes in sensitive vegetation at these three sites have been minimal.

During the summer of 2009, four sites (Inner Town Creek, Indian Creek, Rat Island, and Fishing Creek) were exposed to high salinity waters. However, compared to the previous two years (2007 and 2008), maximum river salinity levels at these four stations were lower and of shorter duration. Maximum salinity levels were highest at Inner Town Creek (18.5 ppt) and Rat Island (15.4 ppt). Vegetation monitoring data for the current year (2009) reveal additional losses of sensitive vegetation at Inner Town Creek and Rat Island. Sensitive species at these sites are being replaced by species that are more tolerant of saline conditions. The Indian Creek site experienced a moderate (10.4 ppt), short-duration spike in salinity during June 2009. Although significant changes in sensitive vegetation were observed at Indian Creek during 2009, this site has been severely impacted by timber clearing operations. Furthermore, the sensitive herbaceous polygon at Indian Creek was relocated during 2008. Although salinity-induced changes may be occurring at Indian Creek, the ability to identify such changes is confounded by the limited data set for the current polygon and the effects of recent timber clearing at the site. High salinity levels at the Fishing Creek site during 2007 and 2008 were accompanied by significant declines in sensitive herbaceous vegetation. Although the Fishing Creek site experienced a moderate (11.5 ppt), short-duration spike in salinity during 2009, sensitive vegetation exhibited signs of recovery from the events of 2007 and 2008.

The remaining three sites (Dollisons Landing, Black River, and Prince George Creek) were not exposed to high salinity waters during 2009. Maximum river salinity levels at these three sites were all ≤ 1 ppt throughout the portion of 2009 leading up to August monitoring event. Consistent with previous years, changes in sensitive vegetation at these sites were minimal during 2009.

8.2 Introduction and Background

Annual monitoring of vegetation within the Cape Fear River estuary has been conducted since 2000 in an effort to evaluate potential impacts associated with the deepening of the Cape

Fear River channel. Potential impacts of channel deepening include alterations in salinity, flow, and tidal currents. These changes have the potential to affect the health, distribution, and composition of plant species within fringing tidal marshes and swamp forests. Vegetation monitoring efforts were focused on plant species that are sensitive to changes in salinity. As fringing marshes and swamps are increasingly exposed to high salinity waters, salinity stress may adversely affect the growth of salt-sensitive species. Changing conditions may favor the growth of more salt-tolerant species, leading to changes in community composition. Salt-sensitive plant species were monitored at seven sampling stations distributed along Town Creek (P3-Inner Town Creek), the Cape Fear River (P7-Indian Creek, P8-Dollisons Landing, and P9-Black River), and the Northeast Cape Fear River (P12-Rat Island, P13-Fishing Creek, and P14-Prince George Creek) (Figure 1.2-1). All of the sampling stations are located within fringing marshes or swamp forests that experience daily tidal inundation. This report presents the results of vegetation monitoring during 2009. Vegetation monitoring data from previous years were presented in a series of earlier annual reports (CZR Incorporated 2001, 2002; Hackney et al. 2002, 2003, 2004, 2005, 2006, 2007, 2008; Culbertson et al. 2009, 2010).

In addition to vegetation monitoring data, river salinity data and marsh/swamp biogeochemical data were evaluated as indicators of exposure to saline waters. Maximum river salinity levels at the seven monitoring stations were used as indicators of marsh/swamp exposure to high salinity waters. As river salinity levels increase, adjacent marshes and swamps are increasingly exposed to saline waters through tidal flooding. Elevated river salinity levels typically occur coincidentally with periods of low river flow during the summer and fall. As river discharge rates decrease during the summer and early fall, ocean-derived high salinity waters are carried further upstream by tidal currents. Conversely, increasing river discharge rates during the late fall and winter are accompanied by decreasing river salinity levels. Soil biogeochemical classifications were also used as an indicator of marsh/swamp exposure to high salinity waters. High salinity floodwaters alter soil biogeochemical processes within the marshes and swamps. Methanogenic soil conditions are replaced by sulfate reducing conditions. Sulfate reduction produces hydrogen sulfide, a compound that inhibits the growth of sensitive plant species. Salinity and biogeochemical monitoring data from previous years were presented in earlier reports (CZR Incorporated 2001, 2002; Hackney et al. 2002, 2003, 2004, 2005, 2006, 2007, 2008; Culbertson et al. 2009, 2010). Salinity and biogeochemical monitoring data for the current year are presented in Section 3.0 and Section 5.0, respectively.

During the first nine years of monitoring (2000-2008), exposure to saline waters was documented at six of the seven stations. Stations at Inner Town Creek, Rat Island, and Fishing Creek were exposed to high salinity waters repeatedly during this period. Sensitive vegetation at these three sites has been strongly affected by increasing salinity. Although Indian Creek experienced moderately high salinities during 2007 and 2008, vegetation changes have been heavily influenced by severe site disturbance and polygon relocation. Early vegetation changes at Indian Creek were attributed to changes in salinity; however, more recent vegetation changes have been primarily attributed to disturbance. The remaining three sites (Dollisons Landing, Black River, and Prince George Creek) have experienced little or no exposure to high salinity waters. Past changes in sensitive vegetation at these three sites have been minimal.

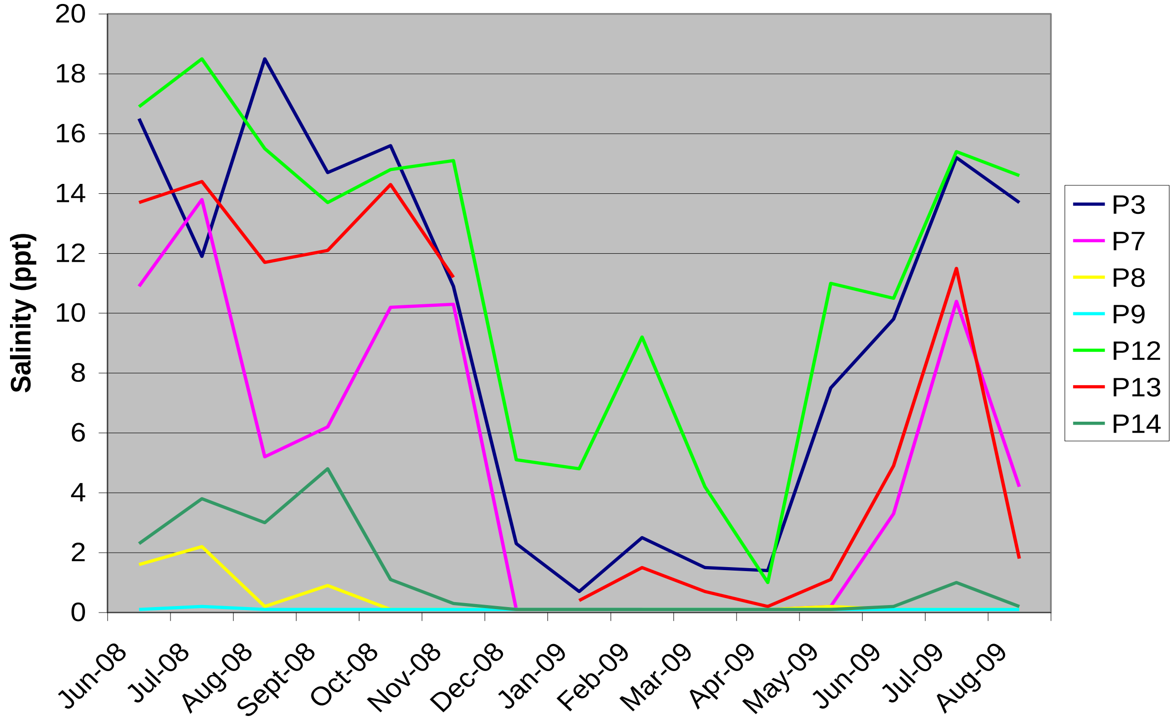


Figure 8.2-1. Monthly maximum salinity values recorded at seven river sampling substations (June 2008-August 2009). Data for P7 does not include March 2009. Data for P13 does not include December 2008.

Salinity and river discharge data covering the period from June 2008 through August 2009 are presented in Figure 8.2-1 and Figure 8.2-2, respectively. Compared to the previous two years (2007 and 2008), maximum river salinity levels at the seven stations were lower and of shorter duration. During the summer of 2009, four sites (Inner Town Creek, Indian Creek, Rat Island, and Fishing Creek) were exposed to high salinity waters. Maximum salinity levels were highest at Inner Town Creek (18.5 ppt) and Rat Island (15.4 ppt), whereas the Indian Creek and Fishing Creek sites experienced moderate, short-duration spikes in salinity. River discharge rates during 2009 were generally higher than those recorded during 2007 and 2008. Comparatively high discharge rates during the month of June were apparently responsible for the maintenance of relatively low salinity levels through the month of June. A strong decrease in river discharge rates during July was accompanied by high salinity levels at the four stations. Maximum salinities at all four sites subsequently declined during August. Although maximum August salinity levels were only slightly lower at Inner Town Creek and Rat Island, maximum salinities at Indian Creek and Fishing Creek were greatly reduced. The remaining three sites (Dollisons Landing, Black River, and Prince George Creek) were not exposed to high salinity waters during 2009. Maximum river salinity levels at these three sites were all ≤1 ppt throughout the portion of 2009 leading up to August monitoring event.

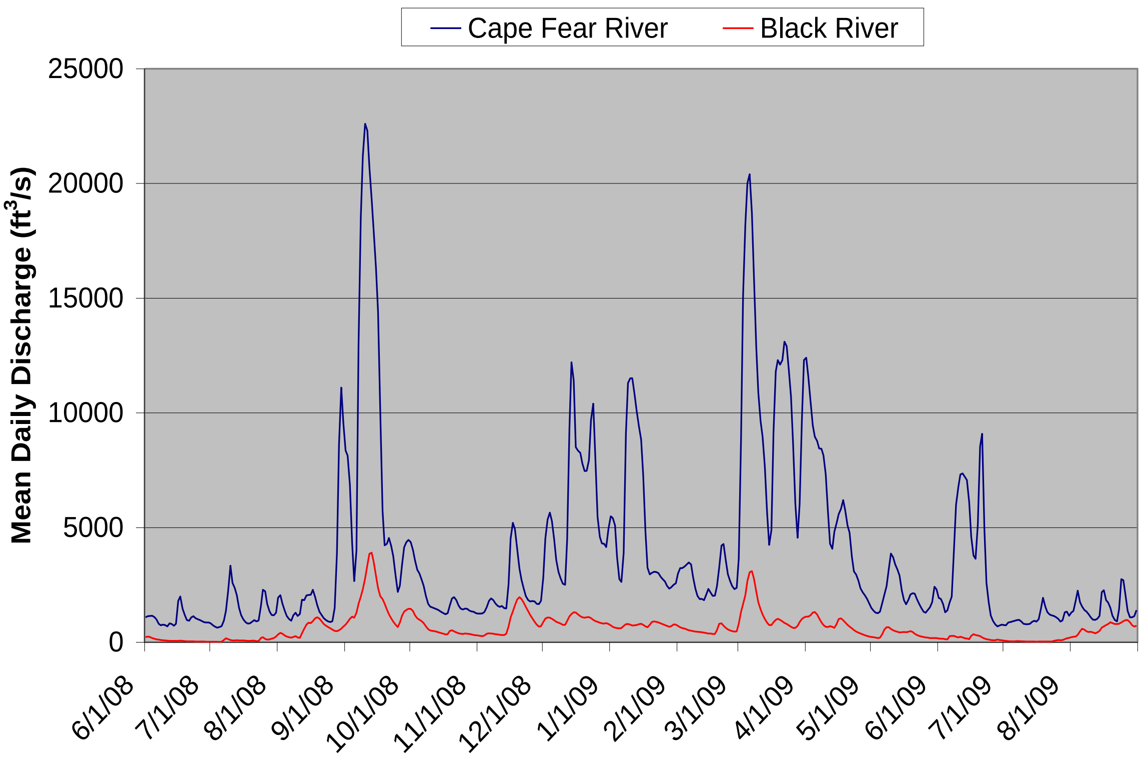


Figure 8.2-2. Mean daily discharge rates (June 2008-August 2009) for the Cape Fear River (Lock and Dam #1 near Kelly, NC) and the Black River (Tomahawk, NC) (http://waterdata.usgs.gov/nc/nwis/current/?type=flow).

8.3 Methodology

Sensitive herbaceous vegetation polygons were originally established at the seven sampling stations during 2000. Variable polygons were established at Inner Town Creek (P3), Black River (P9), Rat Island (P12), Fishing Creek (P13), and Prince George Creek (P14); whereas fixed, four-sided polygons were established at Indian Creek (P7) and Dollisons Landing (P8). Variable polygons are used to delineate distinct, recognizable assemblages of sensitive species. The configurations of variable polygons were modified annually to reflect changes in the distribution of sensitive vegetation. Fixed polygons were used to represent larger, widespread assemblages of sensitive species. The configurations of fixed polygons remain constant from year to year. The original variable polygon at Black River was abandoned and replaced by a fixed polygon in 2005, and the fixed polygon at Indian Creek was relocated in 2008. Although the Rat Island polygon is a variable plot, its configuration has not changed since its establishment in 2000. Annual polygon areas for years 2000 through 2009 are presented in Table 8.3-1.

Annual vegetation monitoring was conducted on the 24th and 25th of August 2009. Methods of data collection during 2009 were the same as those used during previous years. At each station, the percent cover of each sensitive herbaceous species within the polygon was estimated and recorded. The configurations of variable polygons at Inner Town Creek and

Fishing Creek were modified to reflect changes in the distribution of sensitive vegetation assemblages. PVC stakes marking the polygon boundaries at these sites were repositioned to mark the new boundaries of the modified polygons. PVC stakes were renumbered and their new positions were recorded with a GPS unit. Variable polygons at Rat Island and Prince George Creek were not modified during 2009; and the fixed polygons at Indian Creek, Dollisons Landing, and Black River remain unchanged.

Appendix B contains a cumulative list of scientific names, common names, and authorities for all plant species that have appeared in monitoring reports from 2000-2010. Appendix C contains metadata for GIS features that appear on figures within this report. Coordinates for newly (2009) modified polygons are contained in Appendix D.

Table 8.3-1. Sensitive herbaceous vegetation polygon areas (ft^2) 2000-2009.

Station	**Year**									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Inner Town Creek (P3)	710.0	1552.5	1311.0	1326.0	1518.1	3619.2	5595.4	3403.3	266.8 (A) 21.2 (B)	1691.0
Indian Creek (P7)	129.8	129.8	281.9 [a]	281.9	281.9	281.9	281.9	281.9	254.3 [b]	254.3 [b]
Dollisons Landing (P8)	404.5	404.5	286.1 [a]	286.1	286.1	286.1	286.1	286.1	286.1	286.1
Black River (P9)	431.0	1120.0	913.0	567.8	69.5	251.8[b]	251.8	251.8	251.8	251.8
Rat Island (P12)	532.9	532.9	532.9	532.9	532.9	532.9	532.9	532.9	532.9	532.9
Fishing Creek (P13)	1522.2	1646.1	971.9	682.1	2506.3	2272.8	2305.3	1813.1	0	620.0
Prince George Creek (P14)	3931.2	3669.3	5190.2	5265.4	5227.2	5245.9	4654.3	4607.1	4702.7	4702.7

[a] Changes in area are an artifact of shift to winter GPS data collection.
[b] Polygon moved to new location.

8.4 Sensitive Herbaceous Vegetation Monitoring

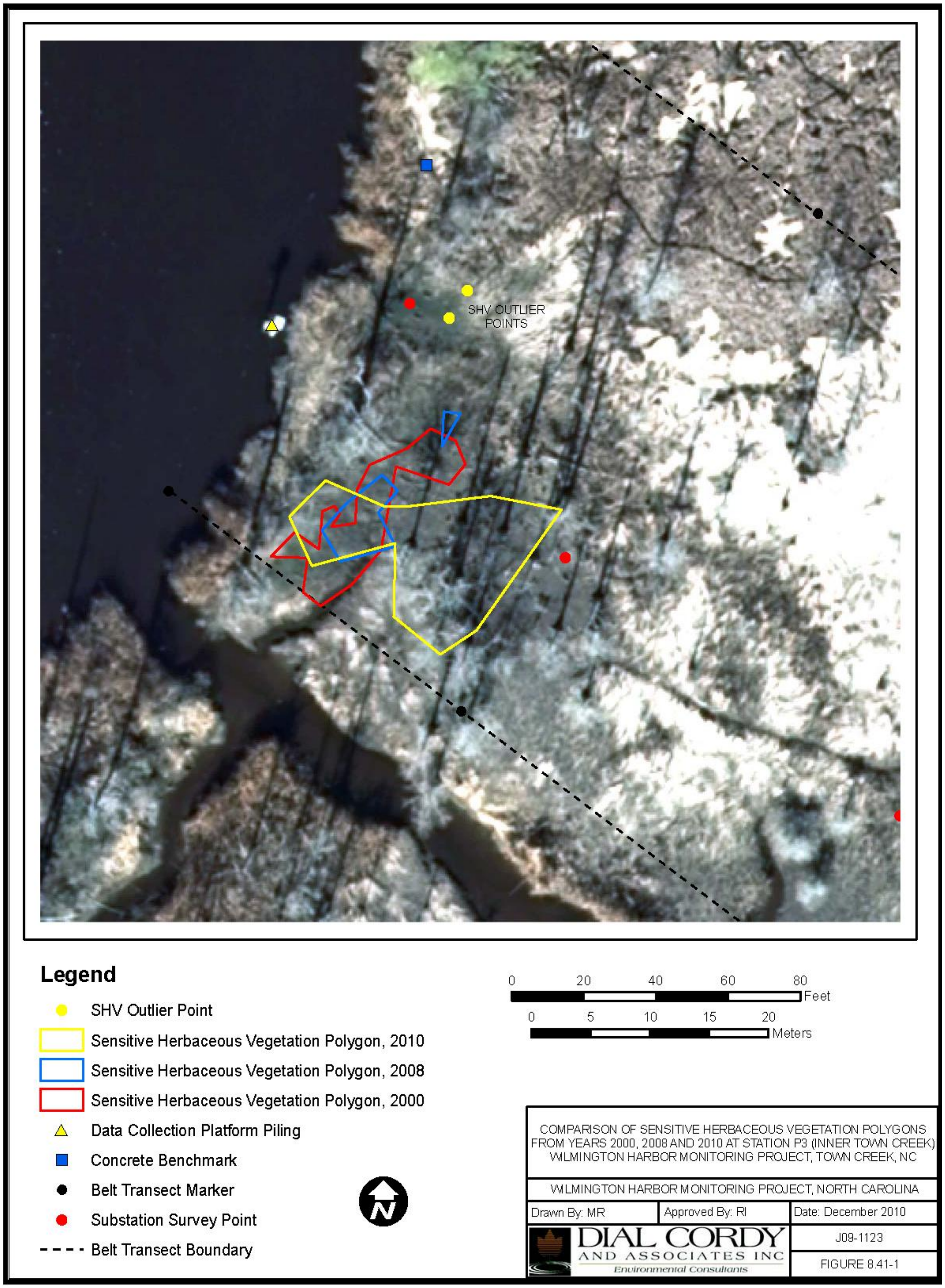
8.41 Town Creek

The configuration of the variable polygon at Town Creek has changed significantly over the course of the ten-year monitoring period. Changes in the size and shape of the polygon have been driven primarily by fluctuations in the distribution of the long-time dominant sensitive species, *Zizaniopsis miliacea*. The polygon reached a maximum area of 5,595 square feet during 2006, at which time *Zizaniopsis miliacea* had a percent cover value of 50 percent. Prolonged high salinity levels during the 2007 growing season were accompanied by the rapid decline of *Zizaniopsis miliacea*. The decline continued into 2008, at which time the polygon was reduced to two small plots (A and B) with a combined area of 288 square feet (Figure 8.41-1). Sensitive species were also present at two outlying point locations to the north of the polygons.

Significant changes in sensitive vegetation during 2009 were accompanied by further modifications to the Town Creek polygons. Polygon A was expanded, whereas polygon B and the two outlying point features were deleted. The single 2009 polygon has an area of 1,691 square feet (Figure 8.41-1). Vegetation monitoring data for 2009 are presented in Table 8.41-1. *Zizaniopsis miliacea*, the long-time dominant, has completely disappeared from the Town Creek site, whereas *Schoenoplectus americanus* has undergone significant expansion. *Schoenoplectus americanus*, which had a 2008 percent cover value of 1 percent in polygon A, has expanded to the southeast beyond the boundaries of the 2008 polygon. The newly occupied areas represent former patches of bare organic substrate. *Schoenoplectus americanus* had a percent cover value of 20 percent within the expanded polygon. The only other sensitive species that were present in the 2009 polygon, *Sagittaria lancifolia* and *Zizania aquatica*, each had percent cover values of <1 percent. Thus, the configuration of the 2009 polygon is based almost entirely on the distribution of *Schoenoplectus americanus*. As indicated by their deletion, Polygon B and the two outlying point features no longer contain any sensitive herbaceous species.

Table 8.41-1. Percent cover values of sensitive herbaceous species within the Inner Town Creek (P3) polygon during years 2000 through 2009.

Species	**Year**									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Zizaniopsis miliacea	70	60	20	50	60 (20)	55 (5)	50	2	5(A) 2OP	--
Sagittaria lancifolia	5	20	5	10	10	10 (30)	2	<1	1(A) <1(B)	<1
Peltandra virginica	3	<1	<1	10	<1 (--)	<5 (<1)	1	<1	--	--
Carex hyalinolepis	1	10	10	40	1	<5	2	<1	--	--
Schoenoplectus americanus	--	--	10	10	10	>1 (<1)	1	1	1(A)	20
Zizania aquatica	--	--	--	--	--	-- (<1)	1	<1	--	<1


SHV OUTLIER POINTS
Legend
SHV Outlier Point
Sensitive Herbaceous Vegetation Polygon, 2010
Sensitive Herbaceous Vegetation Polygon, 2008
Sensitive Herbaceous Vegetation Polygon, 2000
Data Collection Platform Piling
Concrete Benchmark
Belt Transect Marker
Substation Survey Point
Belt Transect Boundary
0 20 40 60 80 Feet
0 5 10 15 20 Meters
N
COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2000, 2008 AND 2010 AT STATION P3 (INNER TOWN CREEK) WILMINGTON HARBOR MONITORING PROJECT, TOWN CREEK, NC
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
Drawn By: MR
Approved By: RI
Date: December 2010
DIAL CORDY AND ASSOCIATES INC
Environmental Consultants
J09-1123
FIGURE 8.41-1

Typha angustifolia, not a sensitive species, is now the dominant species over much of the area that formerly supported *Zizaniopsis miliacea*. *Typha angustifolia* is encroaching into the current polygon from the north and west, and it appears that conditions at the Town Creek site now favor this species. The continuation of high salinity levels and sulfate reducing conditions may lead to the eventual dominance of this species within all of the former and current polygon areas. Other non-sensitive herbaceous species that are present include *Spartina cynosuroides*, *Schoenoplectus tabernaemontani*, and *Pluchea odorata*. *Spartina cynosuroides* continues to dominate the shoreline of Town Creek; however, it does not appear to be advancing landward towards the polygon. *Schoenoplectus tabernaemontani* culms are scattered throughout the dense stands of *Typha angustifolia*. *Pluchea odorata* is present at scattered locations along the margins of the old rice ditch.

High summer/fall salinity levels have been recorded in Town Creek repeatedly over the course of the ten-year monitoring period. Consistent with high salinity levels, summer marsh sampling substation classifications have been predominantly sulfate reducing over the course of the project. Prolonged high salinity levels during the 2007 growing season appear to have initiated the rapid decline of *Zizaniopsis miliacea*. Despite lower salinity levels during the spring and summer of 2009 (Figure 8.2-1), *Zizaniopsis miliacea* was unable to recover. The lack of recovery during 2009 indicates that this species is now severely limited by conditions at the Town Creek site. Although *Schoenoplectus americanus* has undergone some recovery, this species exhibited significant signs of salt stress (i.e., browning stems and leaves) during the 2009 monitoring event. Consequently, the future of *Schoenoplectus americanus* at the Town Creek site remains uncertain. Current trends indicate that high salinity conditions will continue to favor *Typha angustifolia*, thus leading to the eventual exclusion of the remaining sensitive species.

8.42 Indian Creek

The original fixed polygon at Indian Creek was monitored from 2000 through 2007. Elevated river salinity levels during the summer of 2002 were accompanied by significant declines in sensitive vegetation. Although sensitive vegetation exhibited signs of recovery during 2003 and 2004, most of the subsequent changes were attributed to severe erosion problems that developed within the polygon. During 2007, the Indian Creek site was heavily impacted by timber clearing operations. Impacts in the vicinity of the sensitive herbaceous polygon included removal of the swamp forest canopy, soil disturbance, and an increase in erosion rates. Based on these changes, the polygon was relocated during 2008. The 2008 fixed polygon is located approximately 50 feet northwest of the original location (Figure 8.42-1). Although the new polygon has also been affected by canopy removal and soil disturbance, erosion has not been a significant factor. The new 2008 polygon contained a total of 17 sensitive herbaceous species (Table 8.42-1). Prominent species included *Carex hyalinolepis* (10 percent cover), *Sagittaria lancifolia* (10 percent cover), *Typha latifolia* (5 percent cover), and *Rumex verticillatus* (5 percent cover). The remaining 13 species all had percent cover values of 2 percent or less.

A total of 13 sensitive herbaceous species were present in the Indian Creek polygon during the August 2009 monitoring event (Table 8.42-1). The percent cover value of *Carex* *hyalinolepis* increased significantly from 10 to 45 percent. *Sagittaria lancifolia* declined from 10 to 5 percent cover, and *Rumex verticillata* declined from 5 to <1 percent cover. *Typha latifolia*, which had a percent cover value of 5 percent during 2008, was absent from the polygon during 2009. The percent cover values of *Mikania scandens*, *Clematis ternifolia*, *Peltandra virginica*, and *Saururus cernuus* increased slightly during 2009. The remaining seven sensitive herbaceous species that were present during 2009 all had percent cover values of 1 percent or less. Of these additional species; *Alternanthera philoxeroides*, *Elymus virginicus*, var. *halophilus*, and *Polygonum punctatum* were new to the polygon. An additional six sensitive species disappeared from the polygon during 2009; however, all had been minor constituents with percent cover values of 2 percent or less during 2008.

Additional non-sensitive herbaceous species that were present in the polygon during 2009 include *Eupatorium capillifolium*, *Oenothera riparia*, and *Polygonum arifolium*. Woody vines that were present in the polygon include *Campsis radicans*, *Parthenocissus quinquefolia*, *Smilax rotundifolia*, and *Toxicdendron radicans*. The polygon also contains woody saplings representative of former swamp forest trees (i.e., *Fraxinus* sp., *Taxodium ascendens,* and *Nyssa aquatica*). Woody vines and saplings account for significant coverage within the polygon. Woody vines, saplings, and remnant mature *Taxodium ascendens* in the vicinity of the polygon appeared healthy at the time of the monitoring event.

Although river salinity levels at the Indian Creek station have remained low throughout most of the ten-year monitoring period, moderate elevations in salinity were recorded during 2007, 2008, and 2009 (Figure 8.2-1). Concurrent with elevated salinity levels, sulfate reduction has been detected at various outer marsh sampling substations since the summer of 2007. The detection of elevated river salinity levels and sulfate reduction indicate that sensitive vegetation at the Indian Creek site is vulnerable to salinity intrusions. However, the ability to identify salinity-induced changes is confounded by the limited data set for the current polygon and the effects of recent timber clearing at the site. It is difficult to distinguish the effects of salinity intrusions from the effects of severe disturbance. Canopy removal and soil disturbance are likely to favor shade-intolerant and/or opportunistic herbaceous species. The significant increase in coverage by *Carex hyalinolepis*, a shade intolerant species, may be related primarily to canopy removal and increasing light levels. Sensitive herbaceous vegetation is also being affected by the regeneration of woody species within the polygon.

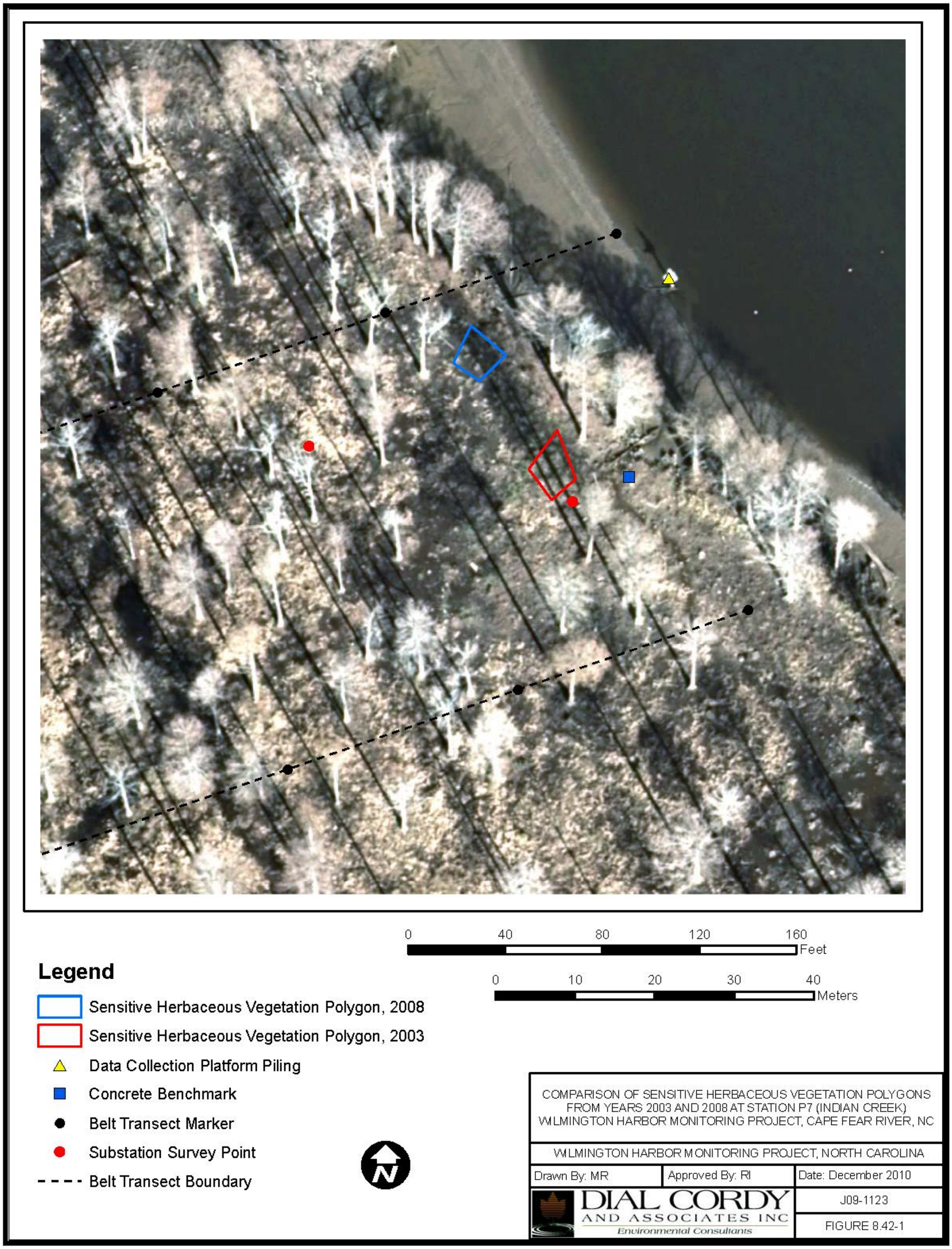
Table 8.42-1. Percent cover values of sensitive herbaceous species within the Indian Creek (P7) polygon during years 2000 through 2009.

Species	**Year**									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008[a]**	**2009[a]**
Saururus cernuus	2	1	--	2	20	1	5	2	<1	3
Cicuta maculata	5	2	<1	2	1	1	2	1	--	--
Polygonum punctatum	<1	<1	--	--	<1	<1	<1	3	<1	<1
Commelina virginica	<1	2	1	<1	--	<1	<1	<1	--	--
Carex crinita var. *brevicrinus*	<1	<1	10	--	--	<1	1	--	--	--
Carex hyalinolepis	<1	2	--	1	<1	<1	<1	<1	10	45
Symphyotrichum elliottii	<1	--	--	--	--	<1	<1	<1	--	--
Triadenum walteri	<1	<1	--	--	--	--	--	--	--	--
Lycopus virginicus	<1	--	--	--	--	--	<1	1	<1	--
Galium sp.	<1	--	--	--	--	--	--	--	--	--
Phanopyrum gymnocarpum	--	<1	2	1	1	1	2	5	--	--
Peltandra virginica	--	--	<1	--	--	--	--	--	1	3
Boehmeria cylindrica	--	<1	--	--	--	<1	<1	--	--	--
Polygonum virginianum	--	--	--	1	--	<1	--	--	--	--
Chasmanthium latifolium	--	--	--	1	--	<1	2	--	--	--
Hymenocallis crassifolia	--	--	--	--	<1	<1	2	--	--	--
Cinna arundinacea	--	--	--	--	<1	<1	--	--	<1	<1
Physostegia leptophylla	--	--	--	--	--	--	--	<1	--	--
Zizania aquatica	--	--	--	--	--	--	--	1	--	--
Mikania scandens	--	--	--	--	--	--	--	<1	1	5
Typha latifolia	--	--	--	--	--	--	--	--	5	--

Table 8.42-1 (continued)

Species	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Juncus effusus ssp. *solutus*	--	--	--	--	--	--	--	--	1	1
Clematis ternifolia	--	--	--	--	--	--	--	--	2	5
Rumex verticillatus									5	<1
Sagittaria lancifolia	--	--	--	--	--	--	--	--	10	5
Apios americana	--	--	--	--	--	--	--	--	1	--
Scutellaria lateriflora	--	--	--	--	--	--	--	--	<1	--
Sium suave	--	--	--	--	--	--	--	--	<1	--
Boltonia asteroides	--	--	--	--	--	--	--	--	<1	--
Pontederia cordata	--	--	--	--	--	--	--	--	2	--
Alternanthera philoxeroides	--	--	--	--	--	--	--	--	--	<1
Elymus virginicus var. *halophilus*	--	--	--	--	--	--	--	--	--	<1
Polygonum punctatum	--	--	--	--	--	--	--	--	--	<1

[a] Plot relocated in 2008



0 40 80 120 160 Feet
0 10 20 30 40 Meters
Legend
Sensitive Herbaceous Vegetation Polygon, 2008
Sensitive Herbaceous Vegetation Polygon, 2003
Data Collection Platform Piling
Concrete Benchmark
Belt Transect Marker
Substation Survey Point
Belt Transect Boundary
N
COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2003 AND 2008 AT STATION P7 (INDIAN CREEK) WILMINGTON HARBOR MONITORING PROJECT, CAPE FEAR RIVER, NC
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
Drawn By: MR
Approved By: RI
Date: December 2010
DIAL CORDY AND ASSOCIATES INC
Environmental Consultants
J09-1123
FIGURE 8.42-1

8.43 Dollisons Landing

The configuration of the fixed polygon at Dollisons Landing has remained constant since its establishment in 2000 (Figure 8.43-1). Annual monitoring efforts from 2000 through 2008 revealed few changes in sensitive herbaceous vegetation. *Saururus cernuus* remained the dominant sensitive species throughout this period. Consistent with previous years, observed changes in sensitive herbaceous vegetation were minimal during 2009 (Table 8.43-1). The percent cover value of *Saururus cernuus* increased slightly from 30 to 35 percent. *Peltandra virginica* increased from 1 to 5 percent cover, and *Cicuta maculata* decreased from 10 to <1 percent cover. The remaining three sensitive herbaceous species that were present during 2009 (*Boehmeria cylindrica*, *Polygonum punctatum*, and *Hymenocallis crassifolia*) all had percent cover values of <1 percent. *Impatiens capensis*, not a sensitive herbaceous species, continues to be a prominent species within the polygon. Other non-sensitive herbaceous species that were present within the polygon include *Polygonum arifolium* and *Cuscuta compacta*. *Cuscuta compacta*, a rootless parasitic annual vine, was present on most of the herbaceous plants within the polygon. Trees and shrubs in the vicinity of the polygon appeared healthy at the time of the monitoring event.

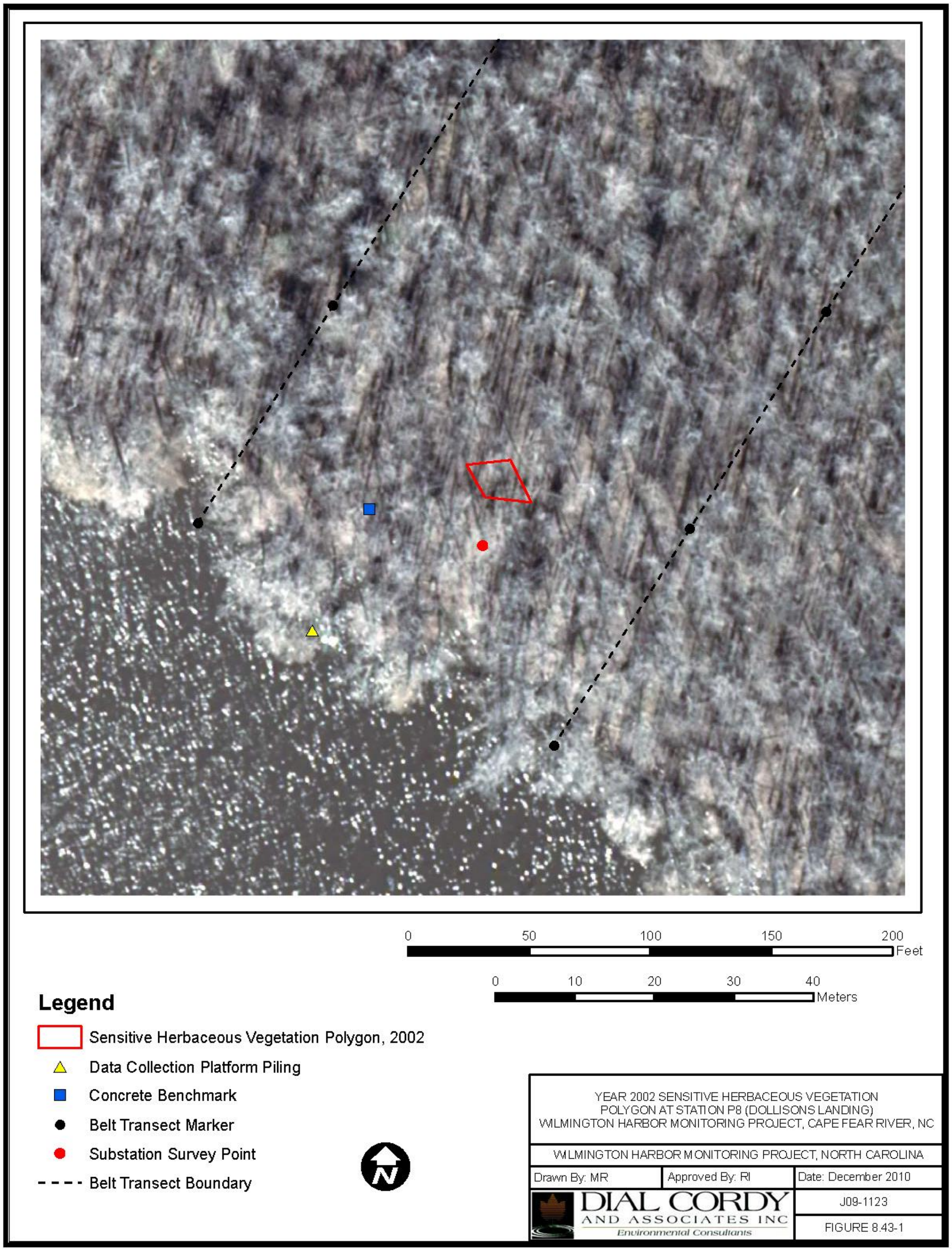
River salinity levels at the Dollisons Landing station have remained low throughout the ten-year monitoring period. Consistent with low river salinity levels, biogeochemical classifications at the swamp sampling substations have been strongly methanogenic over the course of the project. Although sulfate reduction was detected at the outermost swamp sampling substation (Substation 1 adjacent to the river) during the winter of 2009, this event has not had any obvious effect on sensitive vegetation. The lack of significant changes in polygon vegetation during 2009 is consistent with low river salinity levels (Figure 8.2-1) and the predominance of methanogenic conditions during the year leading up to the August 2009 sampling event. Currently, salinity intrusion does not appear to be a significant factor affecting vegetation at Dollisons Landing.

Table 8.43-1. Percent cover values of sensitive herbaceous species within the Dollisons Landing (P8) polygon during years 2000 through 2009.

Species	**Year**									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Saururus cernuus	30	20	35	35	40	50	30	30	30	35
Boehmeria cylinidrica	<1	--	<1	<1	1	<1	<1	<1	--	<1
Rumex verticillatus	<1	--	2	2	<1	<1	--	--	<1	--
Cicuta maculata	2	--	2	2	<1	<1	<1	<1	10	<1
Carex sp.	1	--	--	--	--	--	--	--	--	--
Polygonum punctatum	1	1	3	3	--	<1	1	>1	1	<1
Peltandra virginica	2	1	3	3	<1	1	1	>1	1	5

Table 8.43-1 (continued)

Species	Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carex crinita	<1	2	--	--	--	--	--	--	--	--
Dulichium arundinaceum	<1	--	--	--	--	--	--	--	--	--
Triadenum walteri	<1	--	--	--	--	--	--	--	--	--
Eryngium aquaticum	--	3	1	1	--	--	<1	--	--	--
Pontederia cordata	--	<1	--	--	--	<1	<1	5	--	--
Hymenocallis crassifolia	--	--	<1	<1	<1	--	--	<1	<1	<1
Alternanthera philoxeroides	--	--	<1	<1	--	--	--	--	--	--
Proserpinaca palustris	--	--	--	--	<1	--	--	--	--	--
Ipomoea sp.	--	--	--	--	<1	--	--	--	--	--
Hydrocotyle verticillata	--	--	--	--	--	--	1	<1	--	--
Lycopus virginicus	--	--	--	--	--	--	<1	--	--	--


0
50
100
150
200
Feet
0
10
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40
Meters
Legend
Sensitive Herbaceous Vegetation Polygon, 2002
Data Collection Platform Piling
Concrete Benchmark
Belt Transect Marker
Substation Survey Point
Belt Transect Boundary
N
YEAR 2002 SENSITIVE HERBACEOUS VEGETATION
POLYGON AT STATION P8 (DOLLISONS LANDING)
WILMINGTON HARBOR MONITORING PROJECT, CAPE FEAR RIVER, NC
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
Drawn By: MR
Approved By: RI
Date: December 2010
DIAL CORDY
AND ASSOCIATES INC
Environmental Consultants
J09-1123
FIGURE 8.43-1

8.44 Black River

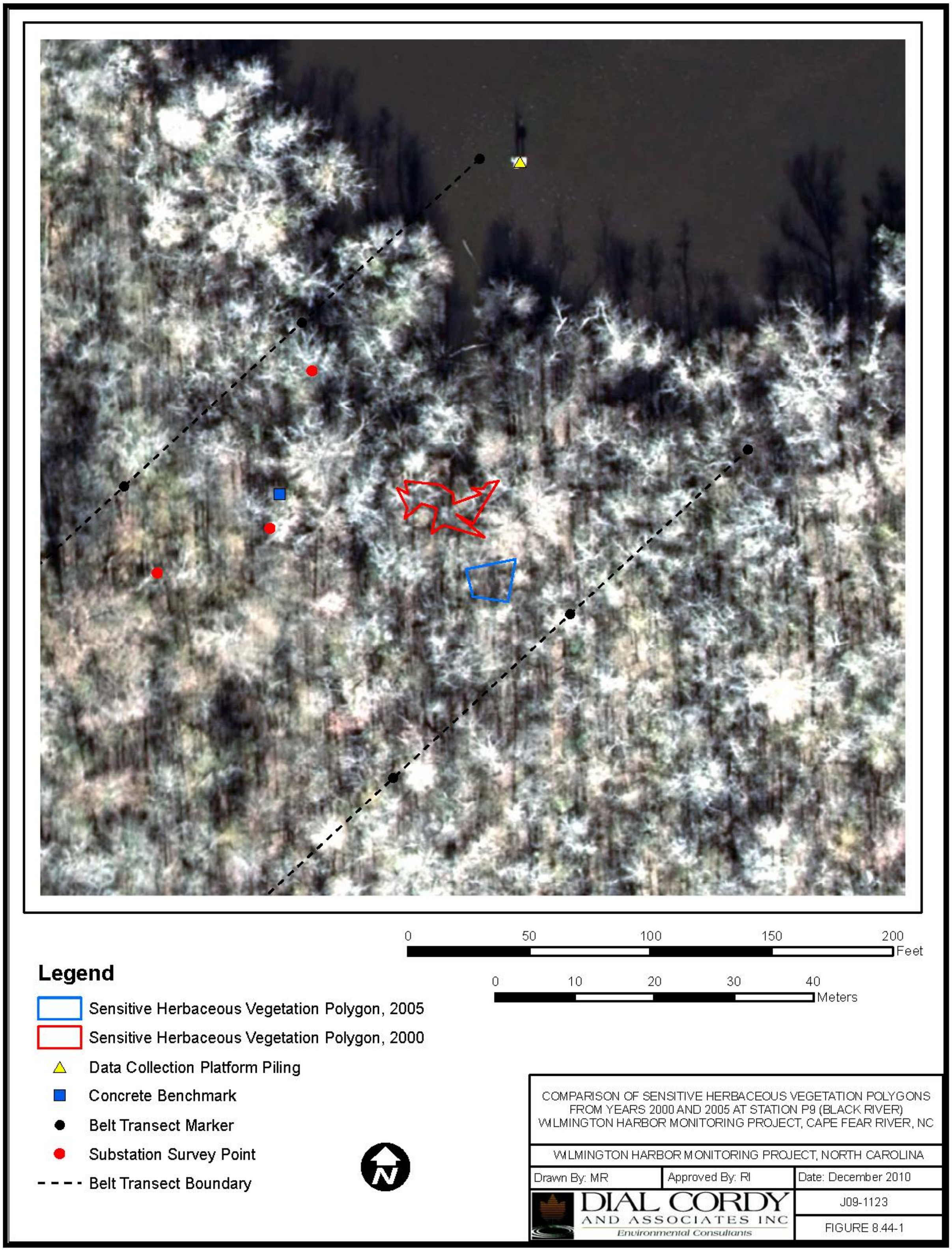
The original variable polygon at the Black River site was dominated by *Ludwigia palustris*. Due to the decline and eventual disappearance of the dominant sensitive species, the polygon was relocated in 2005. The configuration of the new fixed polygon has not changed since its establishment in 2005 (Figure 8.44-1). Annual monitoring efforts from 2005 through 2008 revealed few changes in sensitive herbaceous vegetation. *Saururus cernuus* remained the dominant sensitive species throughout this period. Consistent with previous years, observed changes in sensitive herbaceous vegetation were minimal during the August 2009 monitoring event (Table 8.44-1). The percent cover value of *Saururus cernuus* declined from 20 to 5 percent. *Apios americana* had the same percent cover value as 2008 (5 percent). *Polygonum punctatum* increased slightly from <1 to 3 percent cover, and *Peltandra virginica* reappeared in the polygon at a percent cover of 2 percent. The remaining two sensitive herbaceous species that were present during 2009, *Boehmeria cylindrica* and *Symphyotrichum elliottii*, had percent cover values of 1 and <1 percent, respectively. A total of five sensitive species disappeared from the plot during 2009; however, all had been minor constituents with percent cover values of 2 percent or less during 2008. Additional non-sensitive herbaceous species that were rooted in the substrate include *Impatiens capensis* and *Polygonum arifolium*. A number of other non-sensitive herbaceous species (*Carex deblis*, *Platanthera flava*, and *Osmunda regalis*) were rooted on hummocks and/or tree stumps within the polygon. *Toxicodendron radicans*, a woody vine, was also rooted on hummocks and/or tree stumps. Trees and shrubs in the vicinity of the polygon appeared healthy at the time of the monitoring event.

River salinity levels at the Black River station have remained low throughout the ten-year monitoring period. Maximum salinities during all years have been <1 ppt. Consistent with low river salinity levels, biogeochemical classifications at the swamp sampling substations have been predominantly methanogenic over the course of the project. The lack of significant changes in polygon vegetation during 2009 is consistent with low river salinity levels (Figure 8.2-1) and the predominance of methanogenic conditions during the year leading up to the August 2009 sampling event. Currently, salinity intrusion does not appear to be a significant factor affecting vegetation at the Black River station.

Table 8.44-1. Percent cover values of sensitive herbaceous species within the Black River (P9) polygon during years 2000 through 2009.

Species	Year									
	2000	**2001**	**2002**	**2003**	**2004**	**2005[a]**	**2006[a]**	**2007[a]**	**2008[a]**	**2009[a]**
Ludwigia palustris	50	20	20	1	5	5	--	<1	--	--
Polygonum punctatum	--	15	1	--	1	<1	<1	5	<1	3
Symphyotrichum elliottii	--	2	<1	1	<1	<1	<1	<1	<1	<1
Scutellaria lateriflora	--	--	<1	--	--	--	--	--	--	--
Boehmeria cylindrica	--	--	<1	--	<1	--	<1	1	1	1
Saururus cernuus	--	--	--	--	--	10	10	3	20	5
Physostegia leptophylla	--	--	--	--	--	<1	--	<1	<1	--
Peltandra virginica	--	--	--	--	--	<1	1	<1	--	2
Cicuta maculata	--	--	--	--	--	--	<1	2	2	--
Mikania scandens	--	--	--	--	--	--	--	<1	2	--
Lobelia cardinalis	--	--	--	--	--	--	--	<1	--	--
Apios americana	--	--	--	--	--	--	--	--	5	5
Hymenocallis crassifolia	--	--	--	--	--	--	--	--	<1	--
Lycopus virginicus	--	--	--	--	--	--	--	--	<1	--

[a] Plot relocated in 2005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Sensitive Herbaceous Vegetation Polygon, 2000
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Concrete Benchmark
Belt Transect Marker
Substation Survey Point
Belt Transect Boundary
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2000 AND 2005 AT STATION P9 (BLACK RIVER) WILMINGTON HARBOR MONITORING PROJECT, CAPE FEAR RIVER, NC
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
Drawn By: MR
Approved By: RI
Date: December 2010
DIAL CORDY AND ASSOCIATES INC
Environmental Consultants
J09-1123
FIGURE 8.44-1

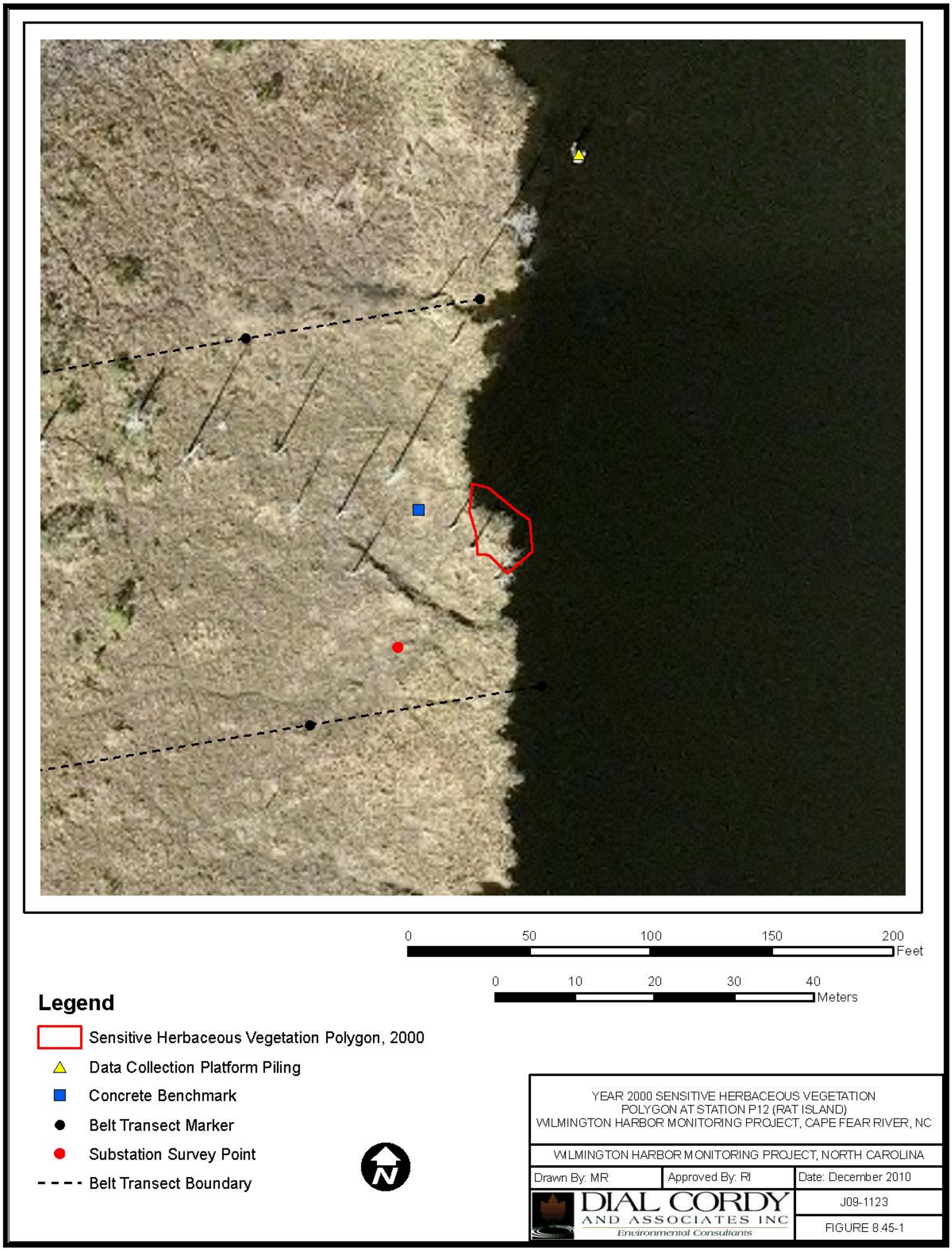
8.45 Rat Island

The configuration of the fixed polygon at Rat Island has remained constant since its establishment in 2000 (Figure 8.45-1). The polygon was originally dominated by *Schoenoplectus americanus*. Annual monitoring efforts from 2000 through 2008 documented significant fluctuations in the percent coverage of *Schoenoplectus americanus* (Table 8.45-1). These fluctuations were accompanied by the emergence of *Spartina cynosuroides*, not a sensitive species, as a co-dominant within the polygon. During 2008, *Schoenoplectus americanus* and *Spartina cynosuroides* had percent cover values of 60 and 50 percent, respectively. Significant changes in sensitive herbaceous vegetation were observed during the August 2009 monitoring event (Table 8.45-1). The most notable change was a sharp reduction in the percent coverage of *Schoenoplectus americanus* from 60 to 10 percent. *Spartina cynosuroides* is now the sole dominant species within the polygon. Several sensitive species that were absent from the polygon during 2008 (*Carex hyalinolepis*, *Rumex verticillatus*, and *Hymenocallis crassifolia*) reappeared during 2009. *Carex hyalinolepis* had a percent cover value of 5 percent, whereas *Rumex verticillatus* and *Hymenocallis crassifolia* each had percent cover values of <1 percent. The only other sensitive species that was present, *Symphyotrichum subulatum*, had the same percent cover value as 2008 (<1 percent).

Table 8.45-1. Percent cover values of sensitive herbaceous species within the Rat Island (P12) polygon during years 2000 through 2009.

Species	**Year**									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Schoenoplectus americanus	100	20	30	50	25	90	50	30	60	10
Carex hyalinolepis	20	8	10	<1	2	<1	2	10	--	5
Sagittaria lancifolia	10	30	--	5	10	<1	5	<1	<1	<1
Alternanthera philoxeroides	<1	--	<1	--	--	--	--	--	--	--
Boltonia asteroides	<1	<1	--	--	--	--	--	--	--	--
Symphyotrichum subulatum	<1	<1	<1	<1	--	--	--	--	<1	<1
Peltandra virginica	--	1	--	--	--	--	<1	--	--	--
Rumex verticillatus	--	1	--	--	--	--	--	<1	--	<1
Hymenocallis crassifolia	--	<1	--	1	<1	<1	<1	<1	--	<1
Polygonum punctatum	--	--	--	--	<1	--	--	--	--	--

High summer/fall salinity levels have been recorded at Rat Island repeatedly over the course of the ten-year monitoring period. Biogeochemical classifications at the marsh sampling substations have varied between predominantly sulfate reducing and a combination of methanogenic and sulfate reducing. It is apparent that salinity intrusions have had significant adverse effects on sensitive vegetation at Rat Island. Significant changes in polygon vegetation during 2009 are consistent with ongoing high river salinity levels (Figure 8.2-1) and sulfate reducing conditions during the year leading up to the August 2009 sampling event. *Schoenoplectus americanus* has demonstrated the ability to recover from sharp declines in the past; and consequently, it is difficult to predict the future of this species. However, it appears that conditions at Rat Island now favor *Spartina cynosuroides* as the dominant species.



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Sensitive Herbaceous Vegetation Polygon, 2000
Data Collection Platform Piling
Concrete Benchmark
Belt Transect Marker
Substation Survey Point
Belt Transect Boundary
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YEAR 2000 SENSITIVE HERBACEOUS VEGETATION
POLYGON AT STATION P12 (RAT ISLAND)
WILMINGTON HARBOR MONITORING PROJECT, CAPE FEAR RIVER, NC
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
Drawn By: MR
Approved By: RI
Date: December 2010
DIAL CORDY AND ASSOCIATES INC
Environmental Consultants
J09-1123
FIGURE 8.45-1

8.46 Fishing Creek

The configuration of the variable polygon at Fishing Creek has changed significantly since its establishment in 2000 (Figure 8.46-1). The original polygon was dominated by *Pontederia cordata* and *Saururus cernuus*. High river salinity levels during the summer of 2002 were accompanied by a sharp decline in sensitive vegetation and a significant reduction in the size of the polygon. Sensitive vegetation subsequently recovered and expanded, resulting in the redefinition of a much larger polygon. High river salinity levels during 2007 once again initiated a sharp decline in sensitive vegetation and a significant reduction in the size of the polygon. By 2008, the original dominant species were essentially absent from the Fishing Creek site, thus precluding redefinition of a sensitive herbaceous polygon. Consequently, the 2007 polygon configuration was retained for reevaluation in 2009.

Vegetation monitoring data for 2009 are presented in Table 8.46-1. *Pontederia cordata* reappeared within the Fishing Creek polygon during 2009. However, the distribution of culms has shifted south and west of the former 2007 polygon. Accordingly, the former 2007 polygon was modified to reflect the new distribution of this species (Figure 8.46-1). The 2009 polygon has a reduced area of 620 square feet. *Pontedaria cordata* had a percent cover value of 2 percent within the 2009 polygon. The other original dominant, *Saururus cernuus*, was not observed during 2009. An additional 14 sensitive herbaceous species were present in the 2009 polygon. *Sagittaria lancifolia* and *Carex hyalinolepis* each had percent cover values of 10 percent during 2009. All other species had percent cover values of 3 percent or less. Swamp forest trees at the Fishing Creek site continue to exhibit signs of severe salt stress. The majority of the trees appear to be dead or dying.

Maximum summer/fall river salinity levels have varied widely over the course of the ten-year monitoring period. High salinity levels during the summer of 2007 were accompanied by a shift from methanogenic to sulfate reducing conditions at the swamp sampling substations. High salinity levels were again recorded during the summer of 2008, and sulfate reducing conditions continued through the winter of 2009. The decline of sensitive vegetation during 2007 and 2008 is consistent with elevated salinity levels and sulfate reducing conditions. Lower salinities during the summer of 2009 (Figure 8.2-1) were accompanied by a return to methanogenic conditions at the swamp sampling substations. The reappearance of *Pontedaria cordata* during 2009 is consistent with lower salinities and a return to methanogenic conditions during the summer of 2009.

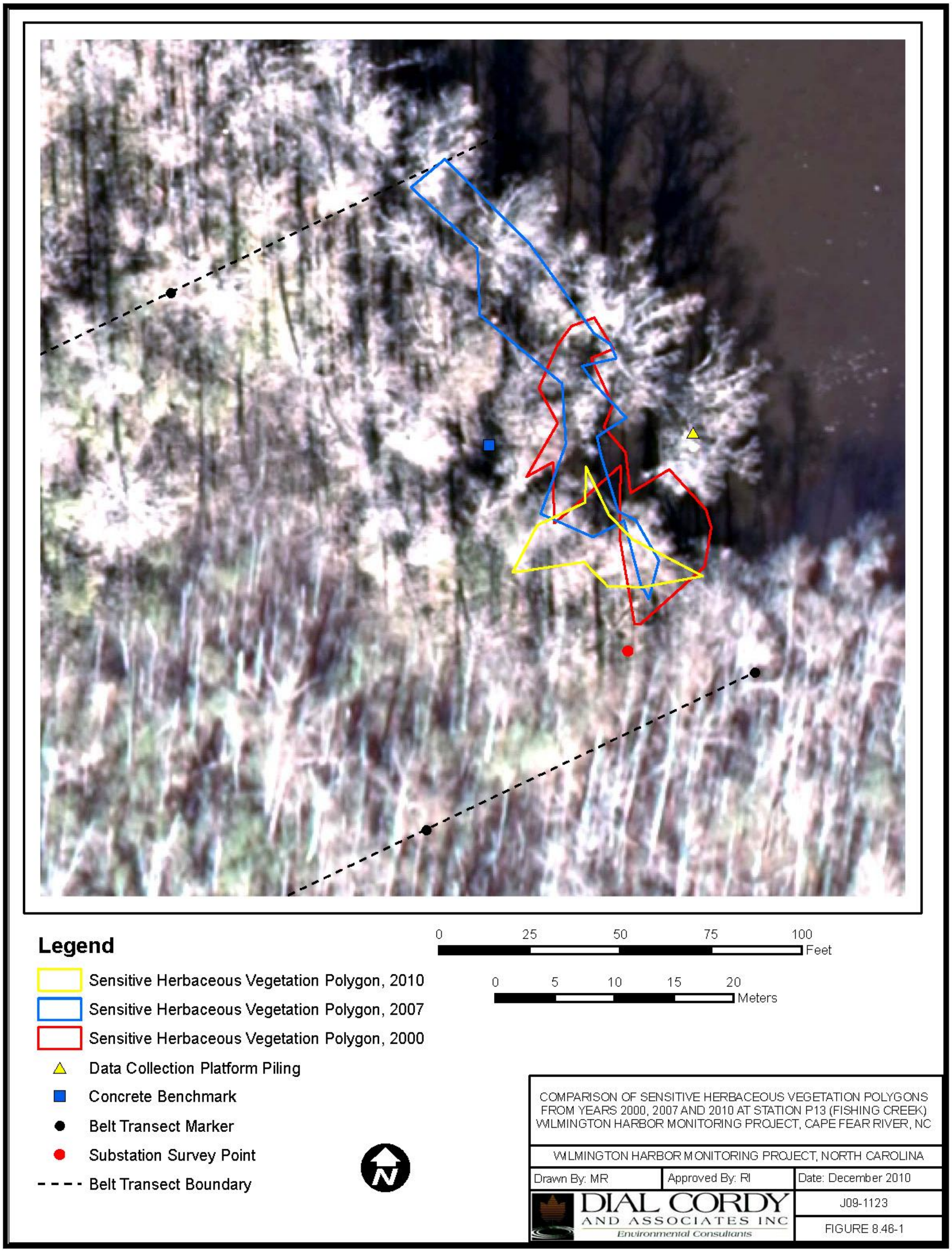
Table 8.46-1. Percent cover values of sensitive herbaceous species within the Fishing Creek (P13) polygon during years 2000 through 2009.

Species	**Year**									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Pontederia cordata	20	40	5	30	30	35	20	2[a]	<1 [a]	2
Symphyotrichum elliottii	<1	--	--	--	--	1	--	--	--	--
Polygonum punctatum	2	1	--	<1	10	2	3	1	--	3
Sium suave	<1	2	5	1	1	--	2	3[a]	2 [a]	1
Zizaniopsis miliacea	2	<1	<1	5	5	<1	--	--	1	--
Saururus cernuus	2	2	--	1	5	1	1	<1[a]	<1	--
Cicuta maculata	<1	2	--	--	1	1	<1	--	<1	--
Sagittaria lancifolia	2	20	5	20	5	1	3	3	2 [a]	10
Orontium aquaticum	<1	--	--	--	--	--	--	--	--	--
Peltandra virginica	<1	1	5	30	12	5	25	5[a]	2 [a]	3
Rhynchospora corniculata	<1	<1	--	--	<1	--	<1	<1	<1	2
Carex sp.	<1	--	--	--	--	--	--	--	--	--
Alternanthera philoxeroides	--	5	<1	<1	--	1	<1	1	20	2
Zizania aquatica	--	2	<1	50	<1	<1	<1	<1	10 [a]	1
Boltonia asteroides	--	1	--	--	<1	<1	<1	<1	<1	1
Rumex verticillatus	--	<1	2	1	--	<1	<1	<1	1 [a]	2

Table 8.46-1. (continued)

Species	Year									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Eryngium aquaticum	--	<1	5	2	2	5	2	<1[a]	<1	1
Schoenoplectus americanus	--	--	<1	--	--	--	--	--	--	--
Carex hyalinolepis	--	--	--	1	--	--	--	<1	1	10
Apios americana	--	--	--	<1	<1	<1	<1	--	--	--
Hymenocallis crassifolia	--	--	--	2	--	--	--	--	1	1
Ludwigia palustris	--	--	--	<1	<1	--	<1	--	--	--
Hypericum mutilum	--	--	--	--	<1	--	--	--	--	--
Boehmeria cylindrica	--	--	--	--	<1	<1	<1	--	--	--
Lycopus virginicus	--	--	--	--	--	<1	<1	--	--	--
Cyperus sp.	--	--	--	--	--	<1	--	--	--	--
Elymus virginicus var, *halophilus*	--	--	--	--	--	<1	--	<1	<1	<1
Lobelia cardinalis	--	--	--	--	--	--	<1	--	--	--
Carex crus-corvi	--	--	--	--	--	--	<1	--	--	--
Bidens laevis	--	--	--	--	--	--	<1	--	<1	--
Mikania scandens	--	--	--	--	--	--	<1	<1	--	--
Leersia oryzoides	--	--	--	--	--	--	--	<1	--	--

[a] Visible salt damage on plant materials



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Sensitive Herbaceous Vegetation Polygon, 2010
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2000, 2007 AND 2010 AT STATION P13 (FISHING CREEK) WILMINGTON HARBOR MONITORING PROJECT, CAPE FEAR RIVER, NC
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
Drawn By: MR
Approved By: RI
Date: December 2010
DIAL CORDY AND ASSOCIATES INC Environmental Consultants
J09-1123
FIGURE 8.46-1

8.47 Prince George Creek

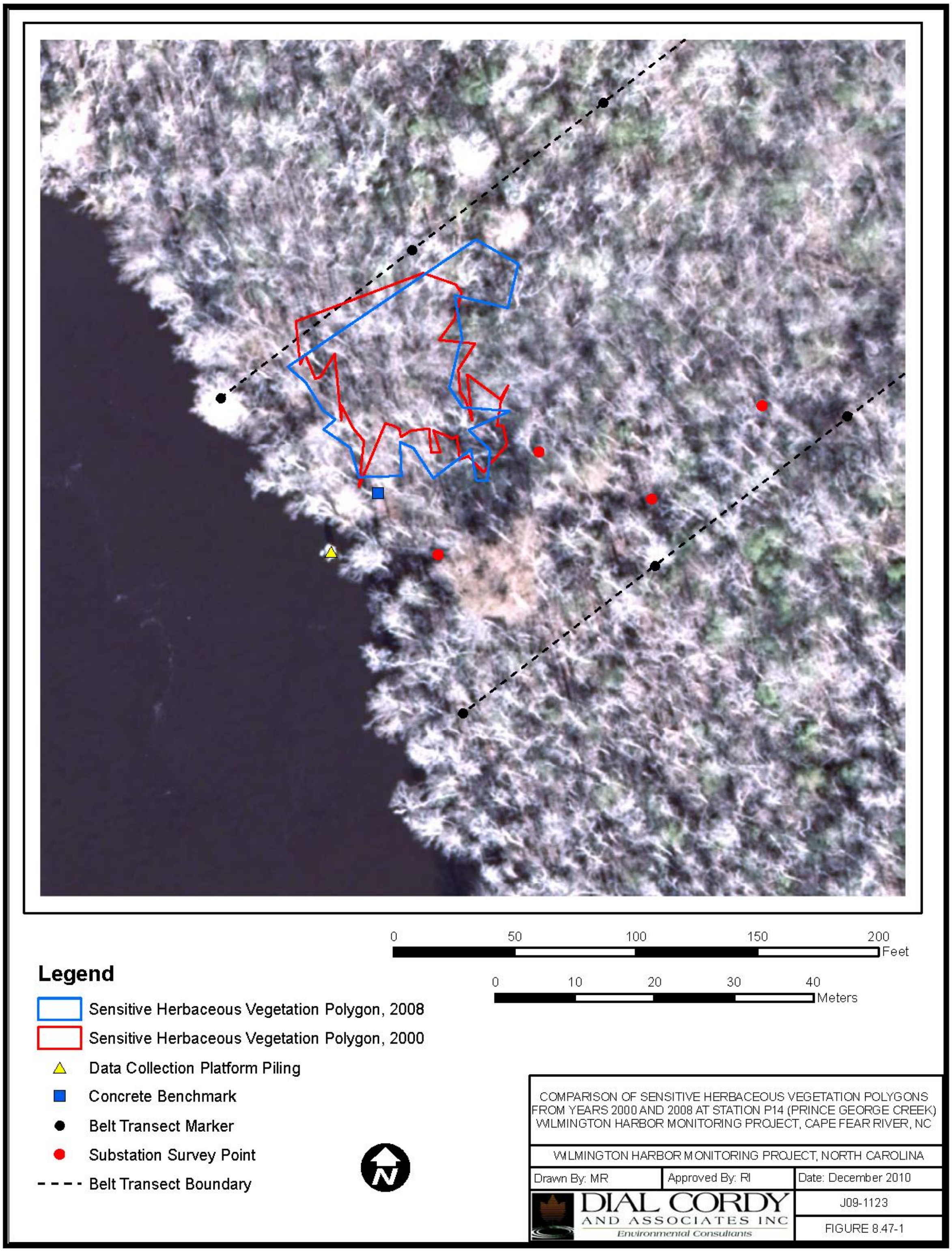
The configuration of the variable polygon at Prince George Creek has remained similar since its establishment in 2000 (Figure 8.47-1). Dominant species within the original polygon included *Saururus cernuus*, *Polygonum punctatum*, and *Peltandra virginica*. *Saururus cernuus* has remained a dominant species; whereas, the percent cover values of *Polygonum punctatum* and *Peltandra virginica* have fluctuated widely over the course of the project. Observed changes in sensitive herbaceous vegetation were minimal during the August 2009 monitoring event (Table 8.47-1), and no changes were made to the configuration of the variable polygon (Figure 8.47-1). The percent cover value of *Saururus cernuus* declined slightly from 30 to 25 percent, whereas the percent cover value of *Peltandra virginica* increased from 2 to 15 percent. *Polygonum punctatum* had the same percent cover value as 2008 (<1 percent). An additional seven sensitive herbaceous species were present during 2009; however, all had percent cover values of <1 percent. Of these additional species, *Phanopyrum gymnocarpum* and *Symphyotrichum elliottii* were new to the polygon. Additional non-sensitive herbaceous species that were rooted in the substrate include *Impatiens capensis*, *Polygonum arifolium*, and *Murdannia keisak*. *Cuscuta compacta*, a rootless parasitic annual vine, was also present on many of the herbaceous plants within the polygon. A number of other non-sensitive herbaceous species (*Carex* sp., *Osmunda regalis*, *Triadenum walteri*, and *Woodwardia areolata*) were rooted on hummocks and/or tree stumps within the polygon. *Toxicodendron radicans*, a woody vine, was also rooted on hummocks and/or tree stumps. Trees and shrubs in the vicinity of the polygon appeared healthy at the time of the monitoring event.

River salinity levels at Prince George Creek have remained low throughout the ten-year monitoring period. Although a minor spike in salinity (9.4 ppt) was recorded during October 2007, this event did not have any apparent effect on sensitive vegetation. River salinity levels remained low throughout 2008 and the portion of 2009 leading up to the August monitoring event (Figure 8.2-1). Biogeochemical classifications at the swamp sampling substations have been predominantly methanogenic over the course of the monitoring project; however, classifications were predominantly sulfate reducing during the winter of 2009. Classifications returned to strongly methanogenic during the summer of 2009. The lack of significant changes in polygon vegetation during 2009 is consistent with low river salinity levels over the course of the year leading up to August monitoring event. The increase in sulfate reduction during the winter of 2009 has not had any obvious effect on sensitive vegetation. Currently, salinity intrusion does not appear to be a significant factor affecting vegetation at Prince George Creek.

Table 8.47-1. Percent cover values of sensitive herbaceous species within the Prince George Creek (P14) polygon during years 2000 through 2009.

Species	**Year**									
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Saururus cernuus	35	60	20	40	40	20	50	35	30	25
Polygonum punctatum[a]	20	15	--	<1	20	30	10	2	<1	<1
Peltandra virginica	10	8	1	5	10	5	30	1	2	15
Pontederia cordata	--	5	--	--	<1	--	<1	--	1	<1
Cicuta maculata	--	<1	<1	<1	--	--	<1	<1	1	<1
Zizania aquatica	--	<1	--	--	--	--	--	--	--	--
Cinna arundinacea	--	<1	--	--	<1	<1	<1	<1	<1	<1
Boehmeria cylindrica	--	<1	<1	--	--	1	--	<1	--	<1
Carex lupulina	--	<1	<1	--	--	--	--	<1	--	--
Alternanthera philoxeroides	--	--	<1	--	--	--	--	--	<1	--
Decodon verticillatus	--	--	<1	<1	<1	<1	<1	<1	--	<1
Hymenocallis crassifolia	--	--	<1	<1	1	1	1	<1	<1	--
Zizaniopsis miliacea	--	--	--	<1	<1	<1	<1	--	<1	--
Triadenum walteri	--	--	--	<1	--	--	--	<1	--	--
Hydrocotyle sp.	--	--	--	--	<1	--	<1	--	--	--
Lobelia cardinalis	--	--	--	--	--	<1	--	--	--	--
Ludwigia palustris	--	--	--	--	--	--	<1	--	--	--
Lycopus virginicus	--	--	--	--	--	--	--	<1	--	--
Eryngium aquaticum	--	--	--	--	--	--	--	--	<1	--
Sium suave	--	--	--	--	--	--	--	--	<1	--
Apios americana	--	--	--	--	--	--	--	--	<1	--
Phanopyrum gymnocarpum	--	--	--	--	--	--	--	--	--	<1
Symphyotrichum elliottii	--	--	--	--	--	--	--	--	--	<1

[a] Previously identified as *Polygonum hydropiper* and *Polygonum hydropiperoides*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Sensitive Herbaceous Vegetation Polygon, 2000
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Substation Survey Point
Belt Transect Boundary
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS
FROM YEARS 2000 AND 2008 AT STATION P14 (PRINCE GEORGE CREEK)
WILMINGTON HARBOR MONITORING PROJECT, CAPE FEAR RIVER, NC
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
Drawn By: MR
Approved By: RI
Date: December 2010
DIAL CORDY
AND ASSOCIATES INC
Environmental Consultants
J09-1123
FIGURE 8.47-1

8.5 Discussion

Sensitive vegetation in the Cape Fear River estuary continues to be affected by exposure to saline floodwaters. During 2009, effects on sensitive vegetation were most evident at Inner Town Creek and Rat Island. Inner Town Creek and Rat Island were exposed to high salinity waters during the spring and summer of 2009, and previously documented trends towards dominance by salt-tolerant species continued at both of these sites. The magnitude and duration of salinity events at Fishing Creek and Indian Creek were reduced compared to the previous two years (2007 and 2008). Following two consecutive years of decline, sensitive vegetation at Fishing Creek exhibited signs of recovery during 2009. Although significant changes were observed at Indian Creek, vegetation at this site continues to be heavily influenced by recent disturbance. The remaining three sites (Dollisons Landing, Black River, and Prince George Creek) were not exposed to high salinity waters during 2009. Consistent with previous years, changes in sensitive vegetation at these sites were minimal during 2009.

Sensitive vegetation at Inner Town Creek has been strongly affected by repeated high salinity events over the course of the project. As of 2009, the original dominant sensitive species, *Zizaniopsis miliacea*, was no longer present at the site. Most of the areas that were formerly occupied by sensitive species are now dominated by the more salt-tolerant *Typha angustifolia*. Current trends indicate that high salinity conditions will continue to favor *Typha angustifolia*, thus leading to the eventual exclusion of the remaining sensitive species. Sensitive vegetation at Rat Island has also been strongly affected by repeated high salinity events over the course of the project. The long-time dominant sensitive species, *Schoenoplectus americanus*, experienced a dramatic decline during 2009. The sensitive herbaceous polygon is now dominated by the more salt-tolerant *Spartina cynosuroides*. Current trends indicate that high salinity conditions will continue to favor *Spartina cynosuroides*, resulting in the continued decline of the remaining sensitive species.

Although significant changes in sensitive vegetation were observed at Indian Creek during 2009, this site has been severely disturbed by recent timber clearing operations. Furthermore, the sensitive herbaceous polygon at Indian Creek was relocated during 2008. Exposure to moderately high salinity events over the past three years may have contributed to the observed changes in vegetation; however, the ability to identify such changes is confounded by the limited data set for the current polygon and the effects of recent timber clearing at the site.

High salinity levels at the Fishing Creek site during 2007 and 2008 were accompanied by significant declines in sensitive herbaceous vegetation. The original dominant sensitive species, *Pontedaria cordata*, was absent during 2008. Although the Fishing Creek site experienced a moderate, short-duration spike in salinity during 2009, sensitive vegetation exhibited signs of recovery from the high salinity events of 2007 and 2008. Recovery consisted primarily of the reappearance of *Pontedaria cordata*. Trees and shrubs at the site continue to exhibit signs of severe salt stress; however, these may be lingering effects of high salinity events during 2007 and 2008.

The remaining three sites (Dollisons Landing, Black River, and Prince George Creek) were not exposed to high salinity waters during 2009. Maximum river salinity levels at these three sites were all ≤ 1 ppt throughout the portion of 2009 leading up to August monitoring event. Consistent with previous years, changes in sensitive vegetation at these sites were minimal during 2009. Dollisons Landing and Prince George Creek have experienced low to moderately high salinity events during previous years. Increasing exposure to saline waters may eventually lead to changes in sensitive vegetation at these sites. The Black River site has not experienced any salinity events over the course of the project; and therefore, future changes in sensitive vegetation are not anticipated.

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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 (1 June 2008 – 31 May 2009)

Appendix A. List of tidal range data for all 14 stations used to generate figures and tables in Section 3.0. xxx indicates data loss.

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1	3.26	3.52	2.51	3.63	3.62	3.3	3	2.79	3.55	3.15	2.69	1.96
2	3.53	3.87	2.81	3.97	3.94	3.72	3.45	3.20	3.88	3.54	3.15	2.54
3	4.81	4.99	3.39	5.05	4.92	4.61	4.31	4.10	4.85	4.39	3.85	3.02
4	4.62	4.71	3.07	4.77	4.65	4.23	3.87	3.62	4.57	4.05	3.43	2.49
5	3.2	3.52	2.52	3.65	3.61	3.30	2.98	2.79	3.55	3.15	2.69	1.98
6	3.49	3.78	2.81	3.97	3.92	3.68	3.40	3.24	3.87	3.51	3.10	2.47
7	5.27	5.15	3.61	5.21	5.16	4.85	4.57	4.37	5.06	4.62	4.10	3.29
8	4.2	3.85	2.19	3.74	3.65	3.31	2.97	2.69	3.55	3.09	2.52	1.51
9	3.29	3.36	1.94	3.35	3.25	2.96	2.63	2.39	3.18	2.77	2.27	1.35
10	3.76	3.99	2.53	4.07	4.01	3.63	3.31	3.10	3.91	3.46	2.92	2.04
11	4.26	4.29	2.64	4.33	4.23	3.81	3.46	3.22	4.16	3.64	3.02	2.08
12	4.52	4.45	xxx	4.50	4.39	3.92	3.50	3.22	4.30	3.75	3.06	2.07
13	3.2	3.42	xxx	3.54	3.50	3.10	2.73	2.51	3.40	2.95	2.39	1.61
14	3.3	3.45	xxx	3.51	3.46	3.26	3.01	2.86	3.39	3.08	2.69	2.09
15	4.69	4.56	xxx	4.54	4.43	4.15	3.86	3.66	4.46	3.93	3.38	2.52
16	4.68	4.58	xxx	4.63	4.52	4.05	3.65	3.37	4.43	3.90	3.23	2.22
17	3.55	3.75	xxx	3.87	3.81	3.41	3.05	2.83	3.54	3.27	2.71	1.87
18	3.12	3.39	xxx	3.49	3.45	3.20	2.96	2.82	3.44	3.04	2.65	1.99
19	4.34	4.26	xxx	4.29	4.18	3.88	3.58	3.39	4.12	3.69	3.18	2.35
20	4.75	4.62	xxx	4.70	4.54	4.08	3.67	3.39	4.47	3.93	3.24	2.18
21	3.72	3.83	xxx	3.91	3.81	3.40	3.03	xxx	3.73	3.28	2.71	1.83
22	3.28	3.54	xxx	3.64	3.56	3.34	3.06	2.92	3.49	3.14	2.72	2.08
23	4.26	4.30	xxx	4.39	4.26	3.98	3.67	3.46	4.20	3.76	3.23	2.40
24	4.48	4.50	xxx	4.60	4.43	3.98	3.60	3.30	4.36	3.83	3.16	2.14
25	3.87	4.09	xxx	4.28	4.15	3.74	3.39	3.17	4.07	3.59	2.98	2.04
26	3.52	3.70	xxx	3.84	3.75	3.45	3.14	2.94	3.69	3.26	2.72	1.88
27	3.98	4.06	xxx	4.09	3.96	3.62	3.28	3.06	3.94	3.45	2.87	2.00
28	4.45	4.57	xxx	4.65	4.45	4.04	3.64	3.39	4.41	3.86	3.19	2.19
29	4.19	4.39	xxx	4.54	4.36	3.97	3.57	3.32	4.30	3.79	3.13	2.12
30	3.73	3.97	xxx	3.96	3.86	3.57	3.22	3.01	3.81	3.38	2.80	1.88

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
31	3.87	4.07	xxx	4.01	3.90	3.60	3.25	3.03	3.84	3.40	2.83	1.92
32	xxx	4.70	xxx	4.81	4.63	4.19	3.81	3.50	4.55	4.01	3.34	2.29
33	xxx	4.82	xxx	4.90	4.71	4.24	3.85	3.58	4.62	4.07	3.38	2.31
34	4.1	4.23	xxx	4.28	4.17	3.76	3.39	3.12	4.07	3.59	2.95	1.96
35	4.23	4.20	xxx	4.28	4.17	3.77	3.40	3.11	4.09	3.61	2.95	1.97
36	4.52	4.56	xxx	4.67	4.49	4.07	3.69	3.42	4.43	3.90	3.22	2.21
37	5.01	4.95	xxx	5.03	4.84	4.34	3.92	3.62	4.76	4.17	3.44	2.33
38	4.56	4.52	xxx	4.57	4.44	3.96	3.54	3.23	4.34	3.80	3.08	1.96
39	4.09	4.09	xxx	4.16	4.04	3.64	3.25	2.98	3.95	3.48	2.83	1.82
40	4.75	4.68	xxx	4.78	4.60	4.16	3.76	3.49	4.53	3.99	3.31	2.28
41	5.43	5.24	xxx	5.32	5.09	4.55	4.12	3.80	5.01	4.39	3.62	2.45
42	5.13	4.93	xxx	4.88	4.73	4.18	3.74	3.41	4.63	4.04	3.26	2.06
43	4.12	4.13	2.48	4.12	4.04	3.60	3.22	2.95	3.95	3.46	2.81	1.80
44	4.79	4.72	3.01	4.83	4.65	4.22	3.86	3.58	4.58	4.06	3.42	2.43
45	5.92	5.66	3.37	5.71	5.44	4.87	4.43	4.11	5.36	4.72	3.92	2.71
46	5.6	5.29	2.95	5.31	5.10	4.45	3.93	3.53	4.99	4.32	3.45	2.14
47	4.23	4.12	2.50	4.20	4.09	3.62	3.20	2.89	3.99	3.47	2.81	1.77
48	4.71	4.69	xxx	4.83	4.68	4.29	3.94	3.71	4.61	4.12	3.51	2.57
49	6.61	6.11	xxx	6.14	5.86	5.23	4.75	4.41	5.77	5.09	4.23	2.97
50	5.8	5.28	xxx	5.30	5.05	4.39	3.86	3.45	4.94	4.27	3.39	2.07
51	4.47	4.21	xxx	4.30	4.17	3.70	3.27	2.96	4.07	3.56	2.87	1.80
52	4.89	4.71	xxx	4.77	4.62	4.17	3.79	3.53	4.54	4.04	3.38	2.36
53	6.2	5.81	xxx	5.83	5.55	4.93	4.42	4.06	5.47	4.81	3.96	2.68
54	5.73	5.32	xxx	5.35	5.09	4.42	3.85	3.43	4.97	4.29	3.40	2.02
55	4.35	4.18	xxx	4.27	4.14	3.65	3.23	2.90	4.03	3.52	2.83	1.72
56	4.81	4.59	xxx	4.69	4.50	4.06	3.70	3.43	4.43	3.95	3.29	2.26
57	6.19	5.84	xxx	5.91	5.56	4.92	4.41	4.04	5.47	4.80	3.95	2.62
58	5.63	5.26	xxx	5.30	5.01	4.32	3.75	3.31	4.88	4.18	3.30	1.88
59	4.05	3.99	2.27	4.10	3.97	3.50	3.08	2.76	3.87	3.37	2.69	1.58
60	4.63	4.48	2.81	4.56	4.40	3.99	3.61	3.36	4.32	3.83	3.20	2.18
61	5.82	5.43	3.15	5.42	5.18	4.61	4.12	3.78	5.09	4.46	3.66	2.41

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
62	5.65	5.28	2.89	5.31	5.08	4.44	3.90	3.50	4.99	4.32	3.44	2.11
63	3.93	3.88	2.33	4.02	3.88	3.44	3.03	2.73	3.85	3.31	2.65	1.63
64	4.3	4.26	2.86	4.41	4.24	3.94	3.62	3.40	4.18	3.76	3.23	2.40
65	5.41	5.17	3.19	5.26	5.05	4.61	4.22	3.95	4.97	4.42	3.73	2.67
66	5.26	5.10	3.01	5.06	4.93	4.38	3.92	3.59	4.84	4.25	3.48	2.32
67	3.92	4.08	2.58	4.10	4.02	3.60	3.22	2.96	3.94	3.48	2.86	1.93
68	3.97	4.10	2.84	4.19	4.09	3.80	3.47	3.25	4.02	3.63	3.12	2.35
69	4.95	4.83	3.10	4.87	4.72	4.36	3.96	3.70	4.65	4.16	3.53	2.57
70	4.87	4.87	3.07	4.87	4.71	4.28	3.88	3.61	4.66	4.14	3.48	2.49
71	4.01	4.24	2.80	4.32	4.22	3.85	3.48	3.25	4.16	3.70	3.13	2.25
72	3.72	3.86	2.67	3.98	3.90	3.62	3.27	3.06	3.84	3.43	2.93	2.17
73	4.26	4.26	2.88	4.33	4.21	3.91	3.57	3.35	4.16	3.73	3.19	2.39
74	4.33	4.56	2.91	4.48	4.36	3.97	3.64	3.40	4.29	3.83	3.24	2.33
75	3.82	4.13	2.74	4.09	4.03	3.67	3.35	3.16	3.94	3.53	2.99	2.18
76	3.78	3.90	2.64	4.05	4.01	3.72	3.41	3.23	3.93	3.55	3.04	2.30
77	4.23	4.20	2.75	4.28	4.20	3.88	3.54	3.33	4.14	3.72	3.16	2.34
78	3.79	4.02	2.70	4.13	4.01	3.73	3.45	3.26	3.98	3.60	3.08	2.30
79	3.74	3.98	2.69	4.13	4.01	3.74	3.47	3.28	3.97	3.60	3.09	2.30
80	3.27	3.52	2.31	3.56	3.54	3.30	3.00	2.80	3.48	3.11	2.63	1.89
81	3.06	3.39	2.29	3.44	3.42	3.20	2.93	2.74	3.37	3.02	2.58	1.91
82	3.67	3.98	2.76	4.14	4.00	3.73	3.47	3.29	3.94	3.55	3.07	2.35
83	3.62	4.05	2.73	4.17	4.03	3.75	3.47	3.29	3.98	3.57	3.07	2.32
84	3.43	3.60	2.43	3.69	3.62	3.36	3.09	2.90	3.57	3.20	2.72	2.00
85	3.05	3.27	2.24	3.28	3.23	2.98	2.72	2.54	3.17	2.84	2.42	1.80
86	3.29	3.78	2.67	3.78	3.73	3.51	3.28	3.15	3.67	3.35	2.96	2.38
87	3.85	4.23	2.91	4.29	4.23	3.98	3.73	3.61	4.17	3.79	3.32	2.58
88	3.17	3.52	2.36	3.57	3.54	3.28	3.02	2.84	3.48	3.12	2.67	1.94
89	2.58	2.92	2.10	3.02	3.00	2.79	2.55	2.40	2.95	2.65	2.29	1.72
90	3.24	3.59	2.65	3.74	3.66	3.47	3.25	3.13	3.61	3.31	2.95	2.37
91	3.81	4.07	2.85	4.20	4.09	3.87	3.64	3.60	4.04	3.70	3.27	2.58
92	3.38	3.67	2.50	3.73	3.69	3.44	3.17	2.97	3.64	3.27	2.80	2.08

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
93	2.49	2.89	2.11	2.98	3.00	2.78	2.54	2.37	2.94	2.65	2.27	1.71
94	3.14	3.50	2.67	3.63	3.58	3.41	3.19	3.07	3.53	3.27	2.88	2.23
95	3.91	4.23	3.03	4.35	4.24	4.04	3.79	3.65	4.19	3.86	3.38	2.57
96	3.54	3.83	2.67	3.94	3.89	3.65	3.37	3.19	3.83	3.45	2.98	2.25
97	2.64	2.98	2.19	3.13	3.12	2.91	2.63	2.48	3.08	2.76	2.36	1.79
98	3	3.41	2.59	3.55	3.49	3.32	3.11	2.99	3.46	3.21	2.87	2.39
99	4.13	4.44	3.12	4.53	4.41	4.18	3.96	3.87	4.37	4.02	3.57	2.87
100	3.77	4.01	2.75	4.12	4.05	3.74	3.45	3.26	3.99	3.57	3.09	2.30
101	2.65	3.00	2.26	3.17	3.15	2.89	2.64	2.50	3.10	2.77	2.42	1.85
102	3.04	3.42	2.62	3.56	3.50	3.30	3.11	2.92	3.46	3.18	2.86	2.37
103	4.37	4.60	3.20	4.68	4.56	4.29	4.03	3.88	4.51	4.12	3.64	2.89
104	4.09	4.29	2.87	4.35	4.27	3.96	3.65	3.43	4.22	3.77	3.25	2.39
105	2.82	3.15	2.31	3.27	3.24	3.01	2.74	2.58	3.20	2.86	2.49	1.87
106	3.41	3.57	2.71	3.67	3.61	3.43	3.19	3.07	3.57	3.27	2.94	2.40
107	4.72	4.76	3.29	4.79	4.69	4.41	4.14	3.97	4.60	4.21	3.74	2.96
108	4.5	4.49	2.95	4.54	4.48	4.08	3.73	3.49	4.39	3.91	3.31	2.38
109	3.13	3.30	2.38	3.42	3.41	3.10	2.80	2.61	3.40	2.98	2.53	1.85
110	3.57	3.72	2.82	3.82	3.77	3.56	3.30	3.16	3.72	3.40	3.04	2.46
111	4.97	4.94	3.40	4.97	4.86	4.54	4.23	4.03	4.68	4.33	3.81	2.97
112	4.56	4.68	3.07	4.69	4.58	4.17	3.84	3.61	4.50	4.00	3.41	2.50
113	3.27	3.55	2.51	3.61	3.58	3.27	2.96	2.77	3.54	3.14	2.68	1.99
114	3.68	3.85	2.84	4.00	3.95	3.69	3.38	3.19	3.91	3.54	3.11	2.42
115	5.2	5.22	3.47	5.21	5.06	4.71	4.36	4.14	5.00	4.51	3.93	3.02
116	4.92	4.95	3.08	4.89	4.77	4.30	3.87	3.57	4.70	4.13	3.44	2.36
117	3.65	3.73	2.59	3.81	3.78	3.41	3.05	2.84	3.71	3.27	2.74	1.90
118	3.69	3.89	2.86	4.04	3.95	3.69	3.41	3.25	3.90	3.55	3.13	2.48
119	5.44	5.28	3.46	5.32	5.15	4.76	4.42	4.19	5.07	4.57	3.95	3.00
120	4.9	4.76	2.93	4.78	4.62	4.11	3.69	3.36	4.55	4.01	3.31	2.23
121	3.96	4.06	2.66	4.10	4.01	3.62	3.27	3.01	3.94	3.50	2.93	2.03
122	3.98	4.14	2.77	4.20	4.06	3.74	3.42	3.22	4.02	3.60	3.08	2.27
123	4.93	4.91	3.09	4.97	4.77	4.34	3.94	3.66	4.73	4.20	3.55	2.55

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
124	5.04	4.91	2.96	4.94	4.76	4.22	3.77	3.42	4.70	4.12	3.38	2.23
125	3.9	4.01	2.60	4.09	3.99	3.57	3.17	2.92	3.92	3.46	2.87	1.93
126	3.97	4.14	2.81	4.24	4.12	3.82	3.47	3.28	4.08	3.67	3.12	2.32
127	4.98	5.00	3.16	5.03	4.83	4.42	4.02	3.75	4.80	4.29	3.60	2.63
128	4.98	4.85	2.90	4.89	4.72	4.18	3.72	3.39	4.64	4.05	3.30	2.16
129	3.93	3.97	2.58	4.12	4.01	3.57	3.19	2.93	3.94	3.46	2.85	1.89
130	4	4.18	2.86	4.30	4.19	3.87	3.55	3.32	4.14	3.71	3.15	2.31
131	4.69	4.76	3.08	4.83	4.66	4.29	3.90	3.64	4.63	4.12	3.46	2.49
132	4.99	4.88	3.08	4.99	4.80	4.33	3.91	3.63	4.74	4.18	3.46	2.39
133	4.2	4.30	2.84	4.49	4.35	3.92	3.54	3.32	4.27	3.78	3.15	2.18
134	3.96	4.09	2.84	4.22	4.11	3.83	3.51	3.34	4.06	3.64	3.12	2.30
135	4.37	4.37	2.93	4.45	4.30	3.99	3.64	3.43	4.27	3.80	3.23	2.36
136	4.73	4.79	3.18	4.92	4.73	4.32	3.95	3.71	4.68	4.16	3.52	2.54
137	4.42	4.67	3.12	4.82	4.64	4.24	3.87	3.64	4.59	4.09	3.46	2.48
138	4.05	4.29	2.88	4.37	4.27	3.96	3.59	3.37	4.22	3.77	3.18	2.30
139	4.08	4.14	2.81	4.20	4.11	3.81	3.47	3.24	4.06	3.63	3.07	2.24
140	4.62	4.65	3.18	4.84	4.65	4.27	3.93	3.69	4.59	4.12	3.51	2.62
141	4.88	4.89	3.31	5.05	4.85	4.43	4.08	3.87	4.65	4.29	3.66	2.73
142	4.09	4.26	2.84	4.32	4.23	3.88	3.55	3.33	4.16	3.72	3.15	2.28
143	3.98	4.18	2.78	4.23	4.15	3.82	3.47	3.24	4.12	3.66	3.07	2.23
144	4.36	4.43	2.96	4.51	4.41	4.01	3.63	xxx	4.36	3.85	3.22	2.37
145	4.9	4.92	3.17	4.98	4.87	4.41	4.01	xxx	4.78	4.24	3.56	2.59
146	xxx	4.32	2.67	4.36	4.28	3.88	3.48	3.21	4.19	3.68	3.02	2.02
147	xxx	3.71	2.46	3.82	3.76	3.43	3.08	2.85	3.67	3.24	2.68	1.84
148	4.36	4.32	2.93	4.46	4.35	3.99	3.64	xxx	4.27	3.81	3.21	2.34
149	5.28	5.20	3.25	5.23	5.21	4.61	4.19	xxx	4.99	4.42	3.69	2.62
150	4.72	4.63	2.74	4.58	4.48	4.03	3.60	3.30	4.39	3.83	3.11	2.02
151	3.67	3.64	2.35	3.68	3.65	3.32	2.95	2.70	3.58	3.14	2.55	1.68
152	4.57	4.55	xxx	4.66	4.49	4.20	3.87	3.69	4.47	4.02	3.45	2.58
153	5.54	5.45	3.50	5.55	5.35	4.87	4.48	4.24	5.23	4.68	3.98	2.88
154	5.22	4.86	2.97	4.91	4.77	4.28	3.84	3.53	4.67	4.08	3.36	2.27

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
155	3.59	3.47	2.38	3.61	3.54	3.20	2.84	2.62	3.47	3.04	2.52	1.73
156	4.15	xxx	2.99	4.37	4.25	3.88	3.67	3.50	4.21	3.81	3.35	2.60
157	5.92	xxx	3.66	5.85	5.62	5.08	4.78	4.54	xxx	4.98	4.28	3.19
158	xxx	5.15	3.02	5.11	4.95	4.33	3.84	3.48	4.87	4.22	3.40	2.20
159	xxx	3.40	2.26	3.47	3.42	3.00	2.58	2.33	3.34	2.91	2.35	1.55
160	xxx	4.23	3.12	4.41	4.28	xxx	3.68	3.51	4.21	3.85	3.20	2.71
161	5.93	5.73	3.76	5.80	5.59	xxx	4.76	4.51	5.50	4.96	4.28	3.23
162	5.32	5.09	3.18	5.16	4.99	4.45	3.99	3.68	4.89	4.31	3.55	2.42
163	4.17	4.14	2.79	4.29	4.18	3.76	3.35	3.09	4.09	3.62	3.01	2.09
164	4.46	4.41	3.09	4.54	4.41	4.06	3.72	3.51	4.35	3.91	3.38	2.57
165	5.84	5.52	3.53	5.51	5.31	4.82	4.42	4.14	5.24	4.67	3.97	2.93
166	5.48	5.36	3.28	5.38	5.18	4.60	4.15	3.81	5.09	4.49	3.69	2.51
167	4.25	4.29	2.85	4.44	4.31	3.87	3.47	3.20	4.22	3.76	3.11	2.14
168	xxx	4.56	3.17	4.73	4.63	4.22	3.85	3.55	4.52	4.08	3.49	2.61
169	xxx	5.42	3.53	5.52	5.36	4.84	4.43	4.16	5.24	4.69	3.98	2.93
170	xxx	5.06	3.18	5.13	4.96	4.47	4.03	3.75	4.86	4.30	3.57	2.47
171	4.28	4.26	2.87	4.41	4.29	3.92	3.53	3.29	4.23	3.76	3.15	2.21
172	4.64	4.52	3.11	4.65	4.49	4.15	3.76	3.52	4.44	3.97	3.38	2.51
173	5.48	5.23	3.39	5.29	5.11	4.67	4.23	3.95	5.01	4.47	3.78	2.77
174	5.24	5.02	3.20	5.07	4.92	4.40	3.98	3.71	4.82	4.26	3.55	2.46
175	4.21	4.21	2.85	4.32	4.21	3.80	3.44	3.21	4.25	3.67	3.08	2.15
176	4.33	4.31	2.97	4.36	4.24	3.94	3.59	3.37	4.18	3.75	3.16	2.36
177	5.16	4.92	3.25	4.97	4.83	4.44	4.03	3.79	4.74	4.24	3.60	2.63
178	5.08	4.97	3.20	4.99	4.91	4.44	4.00	3.74	4.82	4.26	3.56	2.52
179	4.12	4.21	2.87	4.30	4.24	3.85	3.46	3.23	4.18	3.70	3.10	2.19
180	4.11	4.14	2.95	4.27	4.18	3.88	3.53	3.32	4.11	3.70	3.18	2.35
181	4.74	4.65	3.19	4.74	4.63	4.29	3.92	3.69	4.55	4.09	3.50	2.59
182	4.5	4.45	3.01	4.57	4.46	4.08	3.73	3.50	4.39	3.90	3.30	2.39
183	3.91	4.00	2.80	4.16	4.16	3.70	3.38	3.18	3.32	3.54	3.01	2.19
184	3.79	3.85	2.73	3.98	3.87	3.59	3.27	3.08	3.83	3.42	2.92	2.16
185	4.04	4.06	2.85	4.16	4.07	3.79	3.47	3.27	4.01	3.60	3.08	2.30

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
186	4.28	4.47	3.11	4.60	4.48	4.13	3.80	3.59	4.41	3.94	3.35	2.44
187	4.08	4.33	3.00	4.46	4.33	3.98	3.64	3.43	4.23	3.81	3.23	2.34
188	3.49	3.63	2.56	3.73	3.65	3.39	3.07	2.88	3.60	3.20	2.70	1.92
189	3.6	3.71	2.65	3.80	3.74	3.49	3.20	3.03	3.67	3.29	2.81	2.06
190	3.83	4.00	2.79	4.06	4.03	3.71	3.39	3.19	3.93	3.50	2.95	2.10
191	3.76	4.08	2.81	4.05	4.01	3.68	3.36	3.16	3.92	3.49	2.95	2.11
192	xxx	3.79	2.59	3.78	3.77	3.47	3.17	2.96	3.68	3.27	2.74	1.97
193	xxx	3.64	2.49	3.66	3.69	3.38	3.05	2.83	3.61	3.19	2.64	1.84
194	xxx	3.88	2.76	3.96	3.94	3.70	3.43	3.26	3.88	3.50	3.03	2.30
195	xxx	4.17	2.89	4.20	4.15	3.90	3.62	3.44	4.08	3.68	3.16	2.39
196	3.22	3.56	2.30	3.42	3.35	3.10	2.85	2.70	3.30	2.99	2.54	1.81
197	2.83	3.29	2.23	3.24	3.18	2.98	2.75	2.62	3.13	2.86	2.47	1.81
198	3.4	3.63	2.58	3.79	3.73	3.49	3.22	3.06	3.67	3.29	2.80	2.09
199	3.67	3.80	2.66	3.88	3.81	3.54	3.27	3.10	3.75	3.35	2.85	2.11
200	3.08	3.25	2.24	3.29	3.25	2.99	2.76	2.61	3.19	2.90	2.48	1.76
201	2.48	2.82	2.06	2.94	2.93	2.71	2.49	2.36	2.86	2.64	2.27	1.64
202	3.01	3.40	2.55	3.57	3.52	3.33	3.10	2.98	3.43	3.16	2.77	2.14
203	3.58	3.92	2.75	4.03	3.95	3.73	3.48	3.34	3.89	3.54	xxx	2.30
204	3.2	3.48	2.40	3.53	3.47	3.22	2.97	2.83	3.44	3.13	xxx	1.91
205	2.24	2.69	2.00	2.82	2.80	2.59	2.35	2.23	2.76	2.53	xxx	1.59
206	2.8	3.24	2.44	3.34	3.34	3.16	2.94	2.81	3.26	3.02	xxx	2.12
207	3.77	4.07	2.87	4.14	4.10	3.87	3.65	3.52	4.02	3.69	xxx	2.49
208	3.37	3.63	2.48	3.71	3.68	3.44	3.16	2.99	3.62	3.27	xxx	1.96
209	2.42	2.78	2.04	2.91	2.88	2.69	2.40	2.24	2.83	2.57	xxx	1.55
210	2.86	3.33	2.58	3.50	3.43	3.28	3.07	2.96	3.36	3.14	xxx	2.31
211	3.79	4.12	2.95	4.23	4.15	3.95	3.73	3.68	4.08	3.76	xxx	2.61
212	3.67	3.92	2.74	4.00	3.94	3.70	3.43	3.26	3.89	3.55	xxx	2.28
213	2.56	2.94	2.19	3.07	3.07	2.86	2.59	2.42	3.02	2.77	xxx	1.76
214	3.02	3.42	2.67	3.55	3.53	3.37	3.15	3.02	3.47	3.26	xxx	2.41
215	4.21	4.50	3.24	4.58	4.49	4.27	4.04	3.91	4.45	4.11	xxx	2.93
216	3.95	4.18	2.87	4.27	4.20	3.86	3.55	3.36	4.16	3.72	xxx	2.34

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
217	2.76	3.13	2.34	3.31	3.28	2.99	2.71	2.54	3.22	2.90	xxx	1.87
218	3.23	3.52	2.71	3.63	3.60	3.41	3.18	3.01	3.53	3.29	xxx	2.39
219	4.72	4.80	3.35	4.81	4.73	4.45	4.18	3.99	4.64	4.26	xxx	2.95
220	4.42	4.48	2.97	4.49	4.42	4.03	3.70	3.44	4.35	3.86	xxx	2.34
221	3.21	3.49	2.53	3.57	3.54	3.23	2.94	2.74	3.49	3.12	xxx	1.94
222	3.74	3.80	2.81	4.01	3.91	3.63	3.34	2.78	3.83	3.46	xxx	2.37
223	5.05	4.90	3.33	5.02	4.87	4.50	4.17	3.99	4.77	4.28	xxx	2.86
224	4.84	4.83	3.14	4.85	4.74	4.29	3.91	3.65	4.66	4.12	xxx	2.42
225	3.6	3.75	2.64	3.86	3.83	3.46	3.10	2.87	3.75	3.32	xxx	1.95
226	3.89	4.10	3.06	4.24	4.21	3.89	3.64	3.39	4.12	3.75	xxx	2.63
227	5.23	5.21	3.53	5.27	5.14	4.72	4.42	4.19	5.05	4.55	xxx	3.04
228	5.07	4.96	3.20	5.04	4.88	4.39	3.97	3.69	4.79	4.22	xxx	2.49
229	4	4.09	2.86	4.24	4.13	3.74	3.37	3.15	4.06	3.60	xxx	2.19
230	4.36	4.41	2.96	4.55	4.44	4.07	3.72	3.01	4.35	3.91	xxx	2.54
231	5.41	5.25	3.33	5.32	5.17	4.70	4.31	4.03	5.05	4.51	3.87	2.86
232	5.24	5.11	3.29	5.21	5.04	4.56	4.13	xxx	4.95	4.38	3.69	2.58
233	4.64	4.56	3.04	4.68	4.54	4.13	3.73	xxx	4.46	3.97	3.34	2.34
234	4.44	4.45	3.02	4.59	4.45	4.09	3.71	xxx	4.37	3.93	3.36	2.49
235	5.4	5.30	3.38	5.37	5.20	4.73	4.30	xxx	5.11	4.56	3.87	2.83
236	5.4	5.19	3.16	5.23	5.05	4.51	4.04	xxx	4.96	4.35	3.58	2.38
237	4.78	4.65	2.96	4.76	4.60	4.15	3.73	3.46	4.52	3.98	3.30	2.23
238	4.53	4.63	2.97	4.61	4.46	4.06	3.70	3.46	4.38	3.90	3.31	2.36
239	5.14	5.16	3.21	5.10	4.92	4.45	4.05	4.02	4.83	4.29	3.63	2.56
240	5.51	5.21	3.18	5.28	5.09	4.52	4.05	3.71	4.99	4.39	3.60	2.40
241	4.92	4.67	2.95	4.79	4.63	4.14	3.71	3.44	4.52	3.99	3.29	2.21
242	4.63	4.57	2.98	4.67	4.52	4.11	3.71	3.44	4.43	3.93	3.31	2.37
243	4.7	4.69	3.03	4.78	4.64	4.20	3.80	3.78	4.55	4.03	3.38	2.41
244	5.3	5.06	3.25	5.18	5.01	4.51	4.08	3.71	4.91	4.35	3.63	2.52
245	5.04	4.90	3.17	5.05	4.87	4.40	3.96	3.41	4.78	4.23	3.53	2.44
246	4.67	4.61	3.04	4.71	4.58	4.20	3.80	3.38	4.49	3.99	3.38	2.42
247	4.56	4.38	2.93	4.49	4.36	4.01	3.63	3.53	4.29	3.81	3.23	2.32

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
248	5.1	4.72	3.22	4.88	4.73	4.34	3.97	3.77	4.66	4.17	3.55	2.64
249	5.21	4.91	3.27	5.04	4.84	4.49	4.09	3.66	4.82	4.31	3.65	2.67
250	4.53	4.55	3.06	4.62	4.48	4.20	3.81	3.54	4.46	3.99	3.41	2.48
251	3.99	4.22	2.88	4.25	4.15	3.85	3.49	3.37	4.08	3.67	3.15	2.32
252	4.44	4.65	3.24	4.76	4.59	xxx	3.91	3.72	4.52	4.09	3.56	2.72
253	5	5.07	3.47	5.27	5.12	xxx	4.33	3.84	5.02	4.51	3.91	2.93
254	4.28	4.32	2.90	4.42	4.34	4.00	3.63	3.56	4.26	3.77	3.23	2.32
255	3.6	3.75	2.66	3.86	3.80	3.53	3.20	3.28	3.74	3.33	2.87	2.11
256	4.07	4.24	3.05	4.41	4.31	4.00	3.68	3.69	4.25	3.85	3.34	2.56
257	4.79	4.82	3.29	4.93	xxx	4.43	4.09	4.11	4.74	4.26	3.66	2.77
258	4.33	4.44	2.96	4.47	4.41	4.05	3.69	3.40	4.34	3.86	3.29	2.40
259	3.38	3.66	2.58	3.71	3.68	3.40	3.06	2.99	3.62	3.23	2.78	2.04
260	3.87	4.13	3.02	4.30	4.18	3.92	3.61	3.49	4.12	3.75	3.30	2.61
261	4.87	4.92	3.42	5.07	4.92	4.58	4.25	xxx	4.85	4.39	3.82	2.97
262	4.35	4.37	2.90	4.41	4.35	4.00	3.65	xxx	4.27	3.80	3.24	2.37
263	3.24	3.50	2.50	3.61	3.59	3.31	2.99	2.80	3.52	3.15	2.71	2.01
264	3.93	4.13	3.05	4.32	4.22	3.91	3.64	3.45	4.16	3.78	3.30	2.64
265	5	5.04	3.45	5.16	5.03	4.65	4.33	4.11	4.28	4.48	3.91	3.02
266	4.5	4.57	3.04	4.61	4.54	4.19	3.82	3.58	4.47	3.98	3.39	2.47
267	3.31	3.54	2.55	3.66	3.63	3.35	3.02	2.81	3.57	3.18	2.72	1.99
268	4.09	4.23	3.16	4.39	4.32	3.85	3.74	3.55	4.26	3.88	3.45	2.74
269	5.21	5.19	3.59	5.30	5.16	4.61	4.26	4.24	4.37	4.61	4.05	3.14
270	4.81	4.68	3.15	4.74	4.64	4.26	3.65	3.65	4.55	4.06	3.48	2.55
271	3.76	3.89	2.77	3.97	3.92	3.62	3.07	3.06	3.88	3.44	2.97	2.19
272	4.31	4.41	3.22	4.57	4.47	3.97	xxx	3.62	4.44	4.01	3.54	2.76
273	5.53	5.35	3.71	5.47	5.29	4.74	xxx	4.36	4.65	4.71	4.12	3.20
274	xxx	4.96	3.17	5.10	4.90	4.45	xxx	3.67	4.78	4.24	3.53	2.47
275	xxx	4.19	2.84	4.38	4.24	3.83	xxx	3.12	4.16	3.67	3.07	2.17
276	xxx	4.48	3.17	4.67	4.54	4.12	xxx	3.63	4.48	4.05	3.53	2.75
277	xxx	5.28	3.49	5.37	5.21	4.70	xxx	4.15	5.11	4.61	3.98	3.02
278	5.07	4.80	3.09	4.88	4.74	4.32	xxx	3.64	4.65	4.15	3.51	2.50

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
279	4.36	4.24	2.88	4.37	4.24	3.90	xxx	3.30	4.19	3.75	3.19	2.32
280	4.33	4.35	3.02	4.49	4.33	4.03	xxx	3.47	4.29	3.86	3.34	2.55
281	5.21	5.21	3.38	5.30	5.11	4.70	xxx	4.03	5.04	4.52	3.88	2.89
282	4.93	4.82	3.00	4.86	4.72	4.27	xxx	3.52	4.63	4.08	3.39	2.31
283	4.09	4.17	2.77	4.28	4.18	3.83	xxx	3.20	4.11	3.65	3.07	2.15
284	4.42	4.33	2.88	4.43	4.28	3.95	xxx	3.34	4.21	3.76	3.20	2.30
285	5.04	4.82	3.08	4.87	4.70	4.30	xxx	3.62	4.61	4.10	3.47	2.48
286	4.93	4.82	3.04	4.91	4.76	4.31	xxx	3.59	4.67	4.13	3.43	2.33
287	4.35	4.33	2.83	4.43	4.31	3.94	xxx	3.28	4.23	3.76	3.14	2.14
288	4.3	4.33	2.88	4.41	4.29	3.96	xxx	3.35	4.22	3.76	3.18	2.29
289	4.72	4.70	3.03	4.77	4.64	4.25	xxx	3.59	4.57	4.05	3.40	2.43
290	4.63	4.62	2.98	4.69	4.58	4.18	xxx	3.52	4.50	3.99	3.33	2.33
291	4.22	4.33	2.86	4.43	4.33	3.98	xxx	3.38	4.24	3.78	3.18	2.24
292	4.39	4.19	2.74	4.24	4.14	3.83	xxx	3.17	4.05	3.58	3.00	2.09
293	4.43	4.24	2.77	4.27	4.18	3.86	xxx	3.22	4.10	3.62	3.02	2.13
294	4.47	4.49	2.98	4.53	4.47	4.10	xxx	3.50	4.39	3.90	3.28	2.36
295	3.96	4.13	2.80	4.21	4.16	3.83	xxx	3.25	4.06	3.64	3.06	2.19
296	3.98	3.97	2.76	3.99	3.94	3.71	xxx	3.15	3.87	3.48	2.97	2.20
297	3.93	3.89	2.72	3.92	3.87	3.64	xxx	3.10	3.80	3.41	2.92	2.16
298	4.16	4.22	2.97	4.25	4.19	3.92	xxx	3.43	4.12	3.71	3.23	2.47
299	4.15	4.23	2.97	4.31	4.23	3.96	xxx	3.46	4.19	3.75	3.26	2.46
300	3.86	3.89	2.75	3.98	3.92	3.67	xxx	3.13	3.86	3.44	2.98	2.21
301	3.33	3.42	2.47	3.46	3.46	3.23	xxx	2.71	3.47	3.01	2.60	1.96
302	3.67	4.30	3.07	4.22	4.21	xxx	xxx	3.55	4.15	3.80	3.37	2.73
303	3.9	4.30	3.04	4.24	4.20	xxx	xxx	3.52	4.14	3.77	3.31	2.60
304	3.31	3.58	2.72	3.72	3.68	3.47	xxx	3.05	3.63	3.32	2.95	2.34
305	3.33	3.75	2.78	3.83	3.79	3.56	xxx	3.13	3.73	3.41	3.04	2.40
306	3.11	3.46	2.56	3.55	3.53	3.30	xxx	2.88	3.46	3.16	2.81	2.22
307	3.47	3.78	2.82	3.93	3.91	3.70	xxx	3.41	3.84	3.53	3.15	2.52
308	3.19	3.46	2.51	3.57	3.54	3.32	xxx	2.89	3.47	3.12	2.73	2.07
309	2.53	2.84	2.17	2.96	2.95	2.76	xxx	2.35	2.91	2.61	2.30	1.78

Appendix A. (continued)

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
310	2.83	3.21	2.49	3.37	3.36	3.18	xxx	2.84	3.31	3.05	2.76	2.25
311	3.42	3.82	2.82	3.95	3.92	3.72	xxx	3.36	3.81	3.55	3.18	2.53
312	3.02	3.31	2.38	3.37	3.36	3.16	xxx	2.73	3.31	2.99	2.59	1.94
313	2.23	2.63	1.95	2.65	2.67	2.51	xxx	2.12	2.64	2.37	2.08	1.60
314	2.8	3.30	2.54	3.44	3.38	3.25	xxx	2.95	3.35	3.10	2.85	2.37
315	3.56	3.97	2.96	4.17	4.07	3.90	xxx	3.58	4.03	3.73	3.37	2.71
316	2.95	3.31	2.38	3.41	3.39	3.20	xxx	2.83	3.35	3.04	2.67	2.06
317	2.2	2.42	1.83	2.53	2.56	2.42	xxx	2.02	2.51	2.28	2.01	1.57
318	2.47	2.82	2.27	3.00	2.99	2.89	xxx	2.63	2.95	2.80	2.61	2.21
319	3.65	3.95	2.91	4.05	3.98	3.80	3.63	3.54	3.94	3.66	3.35	2.74
320	3.13	3.46	2.42	3.54	3.47	3.26	3.01	2.87	3.43	3.09	2.71	2.05
321	2.21	2.64	2.03	2.77	2.73	2.57	2.37	2.25	2.70	2.46	2.19	1.72
322	2.69	3.05	2.37	3.20	3.19	3.04	2.89	2.76	3.15	2.93	2.66	2.14
323	3.85	4.05	2.89	4.13	4.09	3.88	3.69	3.55	4.04	3.73	3.33	2.62
324	3.54	3.75	2.54	3.82	3.76	3.50	3.20	3.01	3.70	3.30	2.84	2.06
325	2.53	2.87	2.13	3.01	2.97	2.77	2.51	2.36	2.92	2.62	2.28	1.70
326	2.96	3.30	2.53	3.45	3.40	3.22	3.02	2.89	3.36	3.09	2.78	2.24
327	4.06	4.32	3.01	4.42	4.34	4.08	3.82	3.68	4.28	3.89	3.44	2.68
328	3.88	4.05	2.69	4.13	4.07	3.77	3.43	3.21	3.99	3.54	3.03	2.15
329	2.93	3.24	2.29	3.32	3.30	3.07	2.75	2.55	3.23	2.87	2.47	1.76
330	3.36	3.69	2.71	3.73	3.68	3.47	3.22	3.06	3.64	3.31	2.95	2.35
331	4.59	4.74	xxx	4.76	4.65	4.33	4.04	3.88	4.59	4.14	3.64	2.81
332	4.48	4.46	2.82	4.49	4.41	4.00	3.59	3.31	4.32	3.78	3.17	2.14
333	3.42	3.50	2.43	3.61	3.57	3.26	2.92	2.69	3.50	3.07	2.61	1.81
334	4.07	4.04	2.94	4.17	4.09	3.84	3.56	3.37	4.02	3.63	3.21	2.47
335	5.38	5.15	3.38	5.18	5.04	4.65	4.28	4.03	4.91	4.42	3.82	2.83
336	5.07	4.96	3.12	5.01	4.84	4.34	3.90	3.60	4.74	4.18	3.48	2.34
337	xxx	3.93	2.69	4.07	3.96	3.57	3.19	2.94	3.88	3.43	2.87	1.96
338	xxx	4.47	xxx	4.60	4.49	4.16	3.86	3.65	4.39	3.99	3.50	2.70
339	5.53	5.23	xxx	5.29	5.12	4.71	4.35	4.11	5.00	4.51	3.91	2.91
340	5.34	5.19	3.27	5.28	5.12	4.64	4.20	3.89	5.03	4.46	3.76	2.67

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
341	4.55	4.54	2.99	4.69	4.55	4.15	3.75	3.47	4.46	3.98	3.38	2.43
342	4.59	4.70	3.29	4.89	4.72	4.26	4.01	3.76	4.65	4.22	3.67	2.79
343	5.96	5.78	3.67	5.86	5.62	5.01	4.68	4.39	5.55	4.98	4.25	3.14
344	5.51	5.23	3.16	5.28	5.08	4.55	4.05	3.70	4.98	4.37	3.60	2.41
345	4.97	4.83	3.05	4.92	4.78	4.32	3.88	3.56	4.68	4.13	3.45	2.37
346	5.12	4.97	3.16	5.06	4.89	4.41	3.99	3.69	4.79	4.25	3.56	2.50
347	5.62	5.41	3.32	5.47	5.24	4.70	4.22	3.90	5.15	4.56	3.80	2.64
348	5.61	5.27	3.13	5.31	5.11	4.55	4.02	3.66	5.00	4.39	3.58	2.32
349	5.46	5.14	3.12	5.19	5.03	4.49	4.00	xxx	4.90	4.33	3.55	2.35
350	5.26	5.01	3.01	5.08	4.87	4.35	3.86	xxx	4.76	4.18	3.41	2.22
351	5.25	5.03	3.01	5.10	4.89	4.36	3.87	xxx	4.80	4.20	3.44	2.24
352	5.43	5.16	3.07	5.21	5.02	4.43	3.93	xxx	4.92	4.31	3.52	2.26
353	5.5	5.19	3.11	5.24	5.04	4.46	3.96	xxx	4.93	4.33	3.54	2.28
354	5.33	5.01	2.99	5.05	4.86	4.31	3.82	xxx	4.75	4.16	3.39	2.17
355	4.7	4.53	2.78	4.61	4.46	3.97	3.52	xxx	4.35	3.82	3.11	2.01
356	5.35	5.28	3.23	5.14	5.01	4.48	4.06	xxx	4.92	4.36	3.63	2.52
357	5.82	5.58	3.32	5.39	5.25	4.67	4.20	xxx	5.15	4.55	3.76	2.55
358	5.08	4.83	2.95	4.90	4.73	4.25	3.77	xxx	4.62	4.09	3.35	2.21
359	4.48	4.36	2.76	4.44	4.30	3.91	3.48	xxx	4.20	3.73	3.07	2.06
360	4.64	4.65	3.05	4.73	4.60	4.18	3.80	xxx	4.52	4.04	3.40	2.44
361	5.37	5.15	3.27	5.23	5.06	4.56	4.13	xxx	4.97	4.43	3.70	2.61
362	4.77	4.58	2.81	4.62	4.49	4.08	3.63	xxx	4.40	3.90	3.19	2.13
363	3.95	4.11	2.55	4.04	3.95	3.64	3.25	xxx	3.88	3.45	2.84	1.93
364	4.36	4.50	2.91	4.47	4.34	3.98	3.63	xxx	4.28	3.83	3.24	2.34
365	4.91	4.82	3.11	4.92	4.78	4.35	3.97	xxx	4.70	4.19	3.54	2.51
366	4.3	4.32	2.73	4.37	4.27	3.91	3.52	xxx	4.18	3.71	3.09	2.12
367	3.5	3.69	2.46	3.81	3.72	3.44	3.09	xxx	3.66	3.26	2.71	1.89
368	4.09	4.22	2.92	4.40	xxx	3.94	3.62	xxx	4.21	3.79	3.24	2.40
369	4.78	4.81	3.15	4.91	xxx	4.39	4.02	xxx	4.69	4.21	3.58	2.60
370	4.06	4.21	2.66	4.18	4.13	3.79	3.41	xxx	4.04	3.60	3.00	2.09
371	3.04	3.44	2.30	3.43	3.39	3.14	2.82	xxx	3.32	2.97	2.49	1.76

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
372	3.88	4.17	2.95	4.29	4.18	3.93	3.62	xxx	4.12	3.75	3.25	2.51
373	4.62	4.70	3.19	4.83	4.70	4.39	4.04	xxx	4.65	4.20	3.60	2.71
374	4.1	4.22	2.82	4.26	4.20	3.93	3.58	xxx	4.14	3.71	3.16	2.29
375	3.29	3.52	2.51	3.64	3.60	3.38	3.04	xxx	3.54	3.17	2.71	1.98
376	3.69	3.96	2.92	4.13	4.02	3.78	3.51	xxx	3.97	3.62	3.19	2.51
377	4.52	4.68	3.22	4.78	4.63	4.35	4.06	xxx	4.58	4.17	3.63	2.79
378	4.12	4.21	2.82	4.29	4.19	3.92	3.57	xxx	4.14	3.70	3.16	2.30
379	3.42	3.64	2.58	3.76	3.68	3.45	3.14	xxx	3.64	3.26	2.81	2.08
380	3.85	4.24	2.95	4.25	4.14	3.90	3.61	xxx	4.13	3.74	3.26	2.50
381	4.67	4.93	3.24	4.85	4.73	4.42	4.08	xxx	4.69	4.22	3.66	2.77
382	4.34	4.35	2.84	4.36	4.29	3.98	3.59	xxx	4.21	3.74	3.16	2.26
383	3.65	3.73	2.60	3.81	3.77	3.53	3.17	xxx	3.70	3.31	2.81	2.04
384	4.03	4.24	3.01	4.37	4.26	3.99	3.68	xxx	4.21	3.82	3.31	2.52
385	4.89	4.98	3.32	5.04	4.89	4.53	4.19	xxx	4.84	4.36	3.74	2.80
386	4.37	4.35	2.79	4.39	4.29	3.94	3.56	xxx	4.21	3.73	3.11	2.14
387	3.88	3.95	2.65	4.06	3.99	3.68	3.33	xxx	3.91	3.48	2.93	2.05
388	4.43	4.39	2.94	4.54	4.41	4.04	3.65	xxx	4.31	3.84	3.23	2.29
389	4.75	4.74	3.08	4.87	4.73	4.32	3.92	xxx	4.49	4.12	3.46	2.45
390	4.91	4.82	3.12	4.91	4.80	4.38	3.97	xxx	4.70	4.18	3.48	2.43
391	3.98	4.00	2.74	4.14	4.06	3.71	3.32	xxx	3.98	3.53	2.94	2.04
392	4.32	4.30	3.07	4.41	4.32	4.03	3.68	xxx	4.26	3.83	3.31	2.53
393	4.93	4.80	3.27	4.88	4.75	4.41	4.04	xxx	4.54	4.20	3.60	2.71
394	4.51	4.46	3.04	4.55	4.46	4.12	3.75	xxx	4.37	3.92	3.33	2.43
395	4.24	4.27	2.97	4.36	4.30	3.99	3.63	xxx	4.22	3.79	3.23	2.36
396	4.37	4.22	2.90	4.19	4.11	3.84	3.48	xxx	xxx	3.60	3.09	2.25
397	4.65	4.52	3.04	4.51	4.39	4.09	3.72	xxx	4.30	3.84	3.29	2.41
398	4.57	4.68	3.15	4.82	4.68	4.29	3.93	xxx	4.59	4.11	3.47	2.51
399	4.2	4.26	2.97	4.40	4.28	3.93	3.58	xxx	4.19	3.76	3.18	2.31
400	4.27	4.30	2.99	4.46	4.34	4.00	3.63	3.40	4.26	3.83	3.26	2.41
401	4.32	4.35	3.01	4.49	4.37	4.02	3.65	3.42	4.29	3.85	3.27	2.41
402	4	4.15	2.94	4.27	4.19	3.90	3.49	1.39	4.12	3.70	3.15	2.22

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
403	4.2	4.29	3.01	4.41	4.33	4.07	3.67	xxx	4.27	3.85	3.30	2.35
404	4.28	4.36	3.00	4.51	4.40	4.08	3.73	xxx	4.33	3.89	3.30	2.39
405	4.11	4.23	2.92	4.36	4.28	3.94	3.59	xxx	4.21	3.78	3.19	2.28
406	3.88	4.11	2.88	4.20	4.13	3.88	3.57	3.36	4.09	3.69	3.18	2.37
407	4.3	4.51	3.07	4.55	4.48	4.21	3.89	3.69	4.42	3.99	3.45	2.57
408	4.01	3.96	2.61	3.94	3.90	3.61	3.26	3.03	3.80	3.38	2.83	1.96
409	3.54	3.62	2.52	3.71	3.66	3.41	3.11	2.92	3.58	3.20	2.70	1.95
410	xxx	4.12	2.83	4.21	4.15	3.84	3.54	3.33	4.09	3.67	3.11	2.20
411	xxx	4.11	2.79	4.14	4.07	3.77	3.44	3.22	4.02	3.59	3.03	2.10
412	3.99	4.03	2.76	4.07	4.05	3.77	3.42	3.18	3.99	3.58	3.03	2.20
413	3.48	3.52	2.51	3.57	3.60	3.35	3.03	2.83	3.53	3.16	2.67	1.93
414	3.14	3.46	2.52	3.43	3.46	3.24	3.00	2.84	3.46	3.13	2.74	2.12
415	4.13	4.29	2.93	4.23	4.21	3.95	3.70	3.52	4.18	3.78	3.28	2.51
416	3.39	3.50	2.30	3.59	3.51	3.23	2.93	2.73	3.43	3.05	2.57	1.78
417	2.69	3.00	2.11	3.10	3.07	2.83	2.56	2.39	3.00	2.68	2.29	1.64
418	3.07	3.34	2.38	3.41	3.40	3.17	2.95	2.81	3.35	3.02	2.62	1.99
419	3.65	3.76	2.54	3.80	3.77	3.52	3.27	3.10	3.72	3.35	2.87	2.12
420	3.2	3.33	2.19	3.39	3.34	3.08	2.80	2.62	3.29	2.94	2.47	1.71
421	2.46	2.68	1.93	2.79	2.76	2.53	2.30	2.16	2.71	2.44	2.09	1.50
422	2.77	3.05	2.23	3.14	3.13	2.91	2.73	2.62	3.08	2.80	2.45	1.89
423	3.45	3.66	2.51	3.70	3.67	3.41	3.19	3.33	3.61	3.27	2.83	2.13
424	2.93	3.11	2.07	3.17	3.14	2.88	2.71	2.57	3.09	2.77	2.36	1.70
425	2.3	2.59	1.80	2.66	2.66	2.43	2.27	2.13	2.63	2.35	2.00	1.45
426	2.43	2.75	2.00	2.86	2.84	2.64	2.50	2.40	2.80	2.55	2.24	1.74
427	3.31	3.43	2.36	3.51	3.45	3.23	3.07	2.95	3.39	3.09	2.71	2.07
428	3.07	3.21	2.10	3.28	3.22	3.00	2.83	2.67	3.16	2.83	2.42	1.70
429	2.16	2.48	1.75	2.63	2.58	2.39	2.26	2.12	2.54	2.27	1.95	1.38
430	2.57	2.60	1.86	2.72	2.72	2.55	2.45	xxx	2.68	2.47	2.17	1.71
431	3.45	3.40	2.21	3.41	3.41	3.22	3.05	xxx	3.36	3.07	2.65	2.02
432	3.35	3.44	2.18	3.46	3.44	3.23	3.01	2.79	3.37	3.01	2.55	1.79
433	2.42	2.65	1.84	2.79	2.77	2.58	2.41	2.23	2.71	2.43	2.08	1.48

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
434	2.68	2.99	2.20	3.10	3.10	2.90	2.77	2.65	3.03	2.79	2.47	1.92
435	3.55	3.78	2.54	3.83	3.80	3.55	3.38	3.23	3.73	3.40	2.96	2.22
436	3.65	3.82	2.50	3.89	3.83	3.57	3.35	3.14	3.75	3.36	2.87	2.00
437	2.84	3.14	2.17	3.25	3.23	3.00	2.79	2.60	3.15	2.82	2.42	1.70
438	3.17	3.48	2.51	3.62	3.54	3.35	3.13	2.98	3.49	3.17	2.78	2.15
439	3.89	4.16	2.83	4.27	4.16	3.92	3.70	3.57	4.11	3.72	3.25	2.48
440	4.18	4.25	2.77	4.31	4.27	3.95	3.58	3.33	4.20	3.69	3.09	2.12
441	3.31	3.49	2.41	3.61	3.59	3.31	2.97	xxx	3.52	3.09	2.59	1.78
442	3.56	3.86	2.82	4.00	3.93	3.71	3.47	xxx	3.88	3.53	3.11	2.43
443	4.46	4.60	3.13	4.67	4.57	4.29	3.99	3.79	4.52	4.08	3.53	2.67
444	4.47	4.50	2.95	4.57	4.49	4.14	3.75	3.48	4.41	3.92	3.27	2.27
445	4.15	4.16	2.81	4.26	4.18	3.86	3.49	3.24	4.09	3.64	3.06	2.15
446	4.05	4.18	2.88	4.30	4.18	3.91	3.60	3.38	4.14	3.70	3.19	2.37
447	5.17	5.10	3.25	5.15	4.96	4.56	4.17	3.90	4.92	4.37	3.71	2.67
448	5.18	4.86	2.89	4.92	4.73	4.26	3.76	3.40	4.63	4.05	3.29	2.08
449	4.57	4.38	2.74	4.47	4.33	3.94	3.51	3.20	4.23	3.73	3.07	2.01
450	5.02	4.84	3.07	4.95	4.76	4.33	3.94	3.63	4.67	4.16	3.44	2.36
451	5.51	5.22	3.18	5.30	5.07	4.56	4.11	3.79	4.98	4.41	3.61	2.42
452	5.58	5.19	3.12	5.23	5.04	4.51	4.00	3.66	4.93	4.33	3.53	2.29
453	5.36	5.05	3.09	5.11	4.93	4.44	3.95	3.63	4.83	4.25	3.49	2.29
454	5.48	5.12	3.10	5.19	4.96	4.45	3.97	3.43	4.87	4.29	3.51	2.30
455	5.64	5.19	3.11	5.25	5.01	4.48	4.00	3.65	4.92	4.33	3.53	2.30
456	5.79	5.25	3.11	5.31	5.10	4.56	4.05	3.68	5.02	4.40	3.59	2.32
457	5.9	5.36	3.18	5.41	5.20	4.64	4.11	3.74	5.11	4.48	xxx	2.38
458	5.82	5.31	3.12	5.35	5.13	4.56	4.03	3.67	5.02	4.39	xxx	2.29
459	5.43	5.02	3.00	5.11	4.90	4.37	3.87	3.53	4.80	4.20	3.42	2.20
460	5.77	5.23	3.23	5.33	5.14	4.59	4.11	3.78	5.04	4.44	3.66	2.44
461	6.19	5.52	3.32	5.56	5.35	4.75	4.24	3.88	5.24	4.61	3.78	2.49
462	5.97	5.62	3.24	5.51	5.28	4.72	4.20	3.81	5.19	4.55	3.72	2.44
463	5	4.77	2.90	4.73	4.56	4.11	3.64	3.31	4.47	3.92	3.21	2.11
464	5.38	5.11	3.44	5.25	5.09	4.42	4.25	xxx	5.01	4.50	3.86	2.83

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
465	6.4	5.84	3.69	5.88	5.64	4.87	4.66	xxx	5.56	4.96	4.21	3.02
466	5.52	5.08	3.12	5.10	4.88	4.43	3.98	3.66	4.78	4.24	3.50	2.39
467	4.76	4.53	2.92	4.64	4.50	4.13	3.72	3.43	4.41	3.93	3.27	2.26
468	5.04	4.85	3.12	4.88	4.76	4.30	3.91	3.64	4.68	4.17	3.50	2.47
469	6.21	5.75	3.49	5.68	5.48	4.90	4.43	4.11	5.39	4.77	3.98	2.77
470	5.47	4.97	2.85	5.01	4.79	4.28	3.76	3.40	4.69	4.09	3.29	2.07
471	4.21	4.01	2.53	4.15	4.03	3.68	3.28	3.00	3.94	3.49	2.85	1.88
472	4.49	4.33	2.85	4.46	4.33	3.94	3.60	3.38	4.27	3.82	3.20	2.24
473	5.35	5.01	3.08	5.07	4.89	4.39	3.97	3.68	4.81	4.27	3.54	2.41
474	4.75	4.56	2.73	4.59	4.45	4.02	3.60	3.29	4.35	3.85	3.14	2.08
475	3.72	3.78	2.44	3.89	3.78	3.47	3.12	2.87	3.71	3.31	2.71	1.82
476	4.1	4.11	2.71	4.23	4.11	3.80	3.47	3.25	4.04	3.63	3.06	2.18
477	5.08	4.97	3.08	5.00	4.85	4.43	4.03	3.77	xxx	4.23	3.66	2.50
478	4.29	4.27	2.49	4.28	4.15	3.76	3.36	3.07	4.04	3.57	2.89	1.83
479	3.15	3.32	2.11	3.42	3.36	3.10	2.78	2.54	3.27	2.91	2.37	1.53
480	3.89	3.94	2.67	4.07	3.98	3.73	3.43	3.23	3.91	3.52	3.01	2.19
481	4.42	4.41	2.83	4.53	4.41	4.09	3.75	3.52	4.33	3.88	3.28	2.32
482	4.1	4.14	2.64	4.21	4.13	3.81	3.47	3.24	4.04	3.61	3.02	2.10
483	3.15	3.37	2.30	3.50	3.44	3.20	2.90	2.70	3.37	3.01	2.52	1.78
484	3.58	3.79	2.72	3.94	3.88	3.66	3.38	3.19	3.83	3.47	2.99	2.30
485	4.25	4.31	2.93	4.40	4.32	4.06	3.75	3.55	4.26	3.85	3.30	2.48
486	3.91	4.06	2.70	4.06	4.01	3.75	3.48	3.29	3.96	3.55	3.03	2.21
487	3.41	3.67	2.53	3.71	3.65	3.42	3.17	2.99	3.60	3.24	2.77	2.04
488	3.55	3.82	2.72	3.94	3.83	3.61	3.39	3.22	3.79	3.46	3.00	2.29
489	4.18	4.33	2.93	4.40	4.29	4.01	3.76	3.57	4.24	3.85	3.31	2.48
490	4.03	4.03	2.68	4.12	4.04	3.75	3.49	3.28	3.96	3.56	3.03	2.19
491	3.48	3.57	2.49	3.72	3.64	3.41	3.19	2.99	3.62	3.24	2.77	2.02
492	3.69	3.78	2.66	3.93	3.83	3.61	3.39	3.20	3.82	3.45	2.96	2.24
493	4.31	4.34	2.90	4.43	4.33	4.03	3.77	3.56	4.26	3.85	3.29	2.46
494	4.17	4.14	2.67	4.17	4.12	3.81	3.49	3.24	4.03	3.59	3.00	2.08
495	3.9	3.92	2.59	3.98	3.92	3.66	3.36	3.13	3.84	3.44	2.89	2.04

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
496	4.05	4.13	2.74	4.23	4.11	3.81	3.51	3.28	4.04	3.61	3.06	2.19
497	4.26	4.31	2.83	4.39	4.28	3.95	3.64	3.41	4.21	3.75	3.18	2.26
498	4.28	4.30	2.79	4.39	4.28	3.95	3.58	3.33	4.20	3.73	3.11	2.14
499	4.1	4.11	2.69	4.21	4.11	3.79	3.43	3.19	4.03	3.58	2.98	2.05
500	4.22	4.16	2.75	4.31	4.17	3.85	3.51	3.28	4.10	3.64	3.07	2.18
501	4.45	4.44	2.86	4.56	4.40	4.05	3.70	3.45	4.33	3.84	3.23	2.28
502	4.34	4.33	2.75	4.40	4.28	3.90	3.54	3.26	4.20	3.71	3.07	2.09
503	4.37	4.31	2.77	4.39	4.27	3.90	3.55	3.28	4.19	3.71	3.09	2.13
504	4.3	4.15	2.61	4.23	4.10	3.76	3.39	3.12	4.00	3.54	2.93	1.95
505	4.47	4.31	2.68	4.39	4.26	3.89	3.50	3.22	4.15	3.67	3.03	2.03
506	4.29	4.21	2.59	4.26	4.15	3.76	3.39	3.11	4.06	3.58	2.92	1.92
507	4.2	4.09	2.58	4.16	4.05	3.68	3.34	3.07	3.99	3.51	2.88	1.92
508	4.37	4.19	2.62	4.29	4.14	3.75	3.39	3.11	4.05	3.59	2.93	1.93
509	4.13	4.04	2.54	4.15	4.01	3.64	3.27	3.01	3.92	3.48	2.84	1.86
510	3.95	4.03	2.61	4.11	3.99	3.66	3.35	3.14	3.92	3.50	2.93	2.03
511	4.13	4.10	2.63	4.13	3.98	3.65	3.34	3.13	3.93	3.48	2.91	2.01
512	4.03	4.00	2.52	4.05	3.93	3.61	3.28	3.06	3.87	3.43	2.85	1.91
513	3.55	3.61	2.34	3.73	3.64	3.35	3.02	2.80	3.57	3.18	2.62	1.74
514	3.87	4.01	2.73	4.11	4.01	3.73	3.44	3.26	3.96	3.57	3.04	2.23
515	4.53	4.54	2.94	4.56	4.43	4.09	3.79	3.58	4.37	3.92	3.33	2.41
516	4.21	4.08	2.52	4.14	4.01	3.67	3.33	3.05	3.91	3.46	2.85	1.91
517	3.49	3.57	2.33	3.71	3.63	3.35	3.04	2.79	3.53	3.14	2.60	1.77
518	3.58	3.81	2.60	3.94	3.86	3.59	3.36	3.15	3.79	3.41	2.90	2.12
519	4.29	4.33	2.79	4.38	4.26	3.93	3.66	3.43	4.19	3.74	3.16	2.26
520	4.36	4.26	2.58	4.16	4.06	3.72	3.38	3.13	3.99	3.50	2.89	1.93
521	3.33	3.47	2.27	3.45	3.41	3.16	2.87	2.66	3.34	2.96	2.45	1.67
522	3.41	3.66	2.60	3.72	3.70	3.48	3.26	3.10	3.63	3.30	2.84	2.14
523	4.26	4.34	2.87	4.35	4.29	4.00	3.75	3.55	4.22	3.79	3.25	2.38
524	4.06	4.00	2.54	4.07	3.98	3.67	3.37	3.11	3.89	3.44	2.86	1.93
525	3.05	3.20	2.19	3.31	3.27	3.03	2.76	2.54	3.20	2.84	2.36	1.62
526	3.02	3.33	2.44	3.45	3.44	3.22	3.07	2.93	3.39	3.09	2.69	2.09

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
527	3.95	4.04	2.74	4.12	4.08	3.80	3.61	3.44	3.99	3.62	3.12	2.35
528	3.72	3.75	2.41	3.75	3.72	3.41	3.16	2.96	3.61	3.23	2.70	1.84
529	2.8	2.99	2.10	3.04	3.04	2.82	2.63	2.48	2.96	2.67	2.26	1.60
530	2.86	3.13	2.30	3.25	3.25	3.07	2.91	2.78	3.19	2.90	2.52	1.91
531	3.57	3.67	2.54	3.74	3.73	3.51	3.33	xxx	3.66	3.32	2.87	2.13
532	3.52	3.60	2.37	3.62	3.61	3.33	3.11	2.92	3.53	3.15	2.63	1.84
533	2.56	2.84	2.01	2.94	2.93	2.70	2.51	2.33	2.87	2.55	2.12	1.50
534	2.71	3.05	2.35	3.20	3.16	3.00	2.90	2.79	3.12	2.87	2.55	2.07
535	3.48	3.66	2.60	3.75	3.73	3.49	3.35	3.22	3.65	3.33	2.92	2.26
536	3.21	3.41	2.37	3.47	3.44	3.23	3.04	2.88	3.39	3.06	2.63	1.94
537	2.39	2.77	2.06	2.90	2.90	2.72	2.57	2.43	2.85	2.58	2.23	1.67
538	2.59	2.97	2.28	3.09	3.09	2.93	2.83	2.71	3.05	2.79	2.50	2.00
539	3.34	3.63	2.62	3.74	3.69	3.49	3.36	3.24	3.65	3.33	2.96	2.32
540	3.13	3.39	2.36	3.48	3.45	3.23	3.05	2.91	3.38	3.04	2.64	1.98
541	2.46	2.76	2.04	2.87	2.87	2.69	2.53	2.37	2.81	2.52	2.19	1.66
542	2.66	2.94	2.26	3.07	3.06	2.91	2.77	2.62	3.02	2.75	2.44	1.93
543	3.35	3.67	2.63	3.78	3.75	3.54	3.39	3.25	3.70	3.37	2.97	2.32
544	3.35	3.59	2.50	3.65	3.63	3.42	3.27	3.12	3.56	3.22	2.80	2.08
545	2.32	2.59	1.93	2.64	2.66	2.51	2.38	2.24	2.77	2.36	2.05	1.53
546	3.01	3.28	2.56	3.43	3.42	3.26	3.15	3.01	3.40	3.13	2.81	2.30
547	3.65	3.84	2.85	3.96	3.91	3.71	3.56	3.46	3.86	3.54	3.14	2.48
548	3.78	4.02	2.96	4.11	4.07	3.87	3.64	3.47	4.01	3.67	3.23	2.55
549	3.26	3.51	2.62	3.66	3.62	3.42	3.20	3.00	3.58	3.25	2.84	2.20
550	3.07	3.37	2.62	3.58	3.50	3.31	3.17	3.01	3.48	3.21	2.87	2.33
551	3.79	4.15	3.01	4.20	4.10	3.89	3.74	3.60	4.06	3.76	3.36	2.72
552	4.07	4.33	3.05	4.35	4.27	4.02	3.77	3.58	4.20	3.83	3.33	2.54
553	3.87	4.06	2.99	4.21	4.13	3.88	3.61	3.43	4.06	3.70	3.22	2.46
554	3.77	3.89	2.87	4.02	3.94	3.71	3.47	3.31	3.90	3.54	3.10	2.41
555	4.41	4.40	3.11	4.48	4.40	4.13	3.89	3.71	4.34	3.94	3.44	2.67
556	4.63	4.52	3.09	4.65	4.54	4.16	3.83	3.59	4.44	3.98	3.38	2.45
557	4.6	4.51	3.11	4.63	4.52	4.13	3.80	3.57	4.42	3.97	3.38	2.48

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
558	4.65	4.55	3.11	4.56	4.47	4.14	3.84	3.62	4.37	3.95	3.39	2.51
559	4.78	4.69	3.15	4.72	4.60	4.26	3.95	3.74	4.51	4.06	3.49	2.57
560	5	4.75	3.13	4.83	4.67	4.25	3.87	3.62	4.57	4.07	3.42	2.42
561	5.28	5.02	3.28	5.07	4.92	4.47	4.09	3.82	4.81	4.31	3.63	2.58
562	5.25	4.83	3.05	4.77	4.62	4.19	3.82	3.54	4.51	4.01	3.33	2.25
563	5.32	4.79	3.03	4.73	4.58	4.15	3.78	3.51	4.47	3.96	3.29	2.25
564	5.72	5.03	3.05	5.03	4.82	4.28	3.86	3.53	4.73	4.19	3.44	2.25
565	6.11	5.35	3.24	5.28	5.06	4.49	4.05	3.71	4.98	4.41	3.63	2.39
566	6.04	5.52	3.31	5.53	5.32	4.76	4.31	3.97	5.23	4.63	3.82	2.57
567	5.47	5.00	3.05	5.06	4.87	4.38	3.95	3.64	4.77	4.23	3.47	2.30
568	5.52	5.07	3.20	5.12	4.95	4.45	4.05	3.74	4.86	4.36	3.66	2.58
569	6.48	5.94	3.57	5.92	5.71	5.08	4.61	4.24	5.60	4.99	4.16	2.90
570	6.3	5.55	3.12	5.53	5.31	4.64	4.08	3.64	5.18	4.53	3.64	2.28
571	5.43	4.82	2.86	4.89	4.73	4.20	3.74	3.36	4.60	4.06	3.30	2.11
572	5.64	4.78	2.78	4.80	4.62	4.00	3.51	3.09	4.52	3.97	3.23	2.08
573	6.68	5.59	3.14	5.50	5.27	4.56	4.02	3.57	5.16	4.51	3.66	2.37
574	6.26	5.51	2.99	5.46	5.20	4.46	3.86	3.33	5.10	4.43	3.52	2.10
575	5.08	4.57	2.61	4.63	4.46	3.92	3.42	2.99	4.37	3.81	3.05	1.84
576	5.24	4.95	3.07	5.00	4.82	4.39	3.88	3.45	4.83	4.29	3.58	2.41
577	6.59	5.89	3.43	5.82	5.58	5.05	4.44	3.94	5.52	4.86	4.01	2.64
578	6.05	5.29	2.84	5.22	4.96	4.30	3.59	3.00	4.91	4.25	3.38	1.98
579	4.6	4.12	2.41	4.19	4.06	3.52	2.95	2.44	4.00	3.50	2.81	1.72
580	4.7	4.43	2.84	4.53	4.38	3.92	3.38	2.90	4.37	3.89	3.25	2.20
581	6.33	5.73	3.31	5.70	5.43	4.88	4.21	3.64	5.42	4.75	3.91	2.54
582	5.59	4.91	2.57	4.84	4.61	3.95	3.26	2.65	4.54	3.92	3.04	1.68
583	4.2	4.05	2.28	4.10	3.98	3.37	2.78	2.25	3.91	3.45	2.72	1.57
584	4.5	4.43	2.67	4.48	4.35	3.80	3.25	2.76	4.30	3.78	3.04	1.83
585	5.21	4.98	2.89	5.00	4.77	4.20	3.56	3.01	4.77	4.18	3.34	2.00
586	4.92	4.68	2.58	4.69	4.50	3.93	3.33	2.81	4.43	3.88	3.01	1.67
587	3.7	3.76	2.18	3.77	3.67	3.14	2.65	2.19	3.60	3.17	2.48	1.38
588	4.01	4.15	2.65	4.20	4.10	3.70	3.33	2.98	4.04	3.59	2.98	1.93

Appendix A. (continued)

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
589	4.95	4.75	2.88	4.77	4.59	4.16	3.71	3.33	4.55	4.03	3.31	2.09
590	4.36	4.29	2.52	4.31	4.16	3.73	3.30	2.95	4.09	3.62	2.89	1.74
591	3.32	3.57	2.22	3.69	3.57	3.16	2.78	2.49	3.52	3.12	2.48	1.50
592	3.76	3.95	2.58	4.10	3.97	3.61	3.27	3.04	3.90	3.48	2.87	1.93
593	4.35	4.38	2.74	4.46	4.29	3.92	3.53	3.25	4.23	3.75	3.08	2.01
594	3.94	4.11	2.58	4.18	4.05	3.72	3.37	3.11	3.98	3.54	2.92	1.96
595	3.53	3.55	2.35	3.63	3.51	3.16	2.86	2.64	3.44	3.06	2.51	1.69
596	3.64	3.84	2.62	4.00	3.89	xxx	3.33	3.16	3.81	3.44	2.94	2.18
597	4.12	4.10	2.69	4.08	3.93	xxx	3.36	3.17	3.87	3.46	2.94	2.14
598	4.01	3.99	2.62	3.97	3.87	xxx	3.32	3.14	3.80	3.40	2.90	2.13
599	4.15	4.39	2.78	4.44	4.30	xxx	3.70	3.46	4.29	3.82	3.23	2.32
600	3.59	3.69	2.20	3.66	3.52	xxx	2.91	2.65	3.52	3.12	2.60	1.63
601	3.78	4.02	2.42	4.04	3.93	xxx	3.26	2.98	3.89	3.49	2.94	1.90
602	4.1	4.18	2.40	4.13	4.05	xxx	3.26	2.95	3.98	3.48	2.86	1.70
603	3.83	3.91	2.30	3.91	3.86	xxx	3.11	2.81	3.81	3.32	2.74	1.65
604	3.63	3.77	2.19	3.81	3.73	xxx	3.01	2.71	3.69	3.21	2.63	1.58
605	3.74	3.93	2.29	3.96	3.86	xxx	3.12	2.82	3.79	3.32	2.74	1.66
606	4.28	4.27	2.42	4.30	4.18	xxx	3.30	2.97	4.08	3.56	2.86	1.66
607	4.17	4.12	2.37	4.19	4.08	xxx	3.20	2.88	3.96	3.46	2.78	1.62
608	3.96	4.17	2.40	4.07	3.99	xxx	3.25	2.96	3.94	3.45	2.80	1.69
609	3.73	4.06	2.33	3.94	3.86	xxx	3.17	2.89	3.83	3.35	2.72	1.64
610	3.96	4.10	2.44	4.11	4.03	xxx	3.26	2.99	3.94	3.47	2.80	1.77
611	3.95	4.06	2.45	4.13	4.06	xxx	3.27	3.00	3.97	3.48	2.81	1.76
612	4.23	4.12	2.52	4.20	4.12	xxx	3.37	xxx	4.02	3.54	2.90	1.85
613	3.36	3.19	2.07	3.24	3.20	xxx	2.50	2.29	3.11	2.73	2.20	1.35
614	4.39	4.51	3.19	4.65	4.55	xxx	3.96	3.78	4.49	4.09	3.60	2.79
615	4.74	4.86	3.24	4.99	4.84	xxx	4.20	3.97	4.79	4.32	3.73	2.77
616	4.01	4.23	2.91	4.36	4.26	xxx	3.64	xxx	4.20	3.79	3.26	2.42
617	3.56	3.83	2.69	4.02	3.95	3.68	3.33	3.13	3.88	3.51	3.01	2.21
618	3.87	4.07	2.98	4.22	4.15	3.92	3.58	3.42	4.09	3.74	3.29	2.55
619	4.59	4.62	3.24	4.71	4.61	4.35	4.02	3.83	4.55	4.16	3.65	2.81

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
620	4.39	4.42	3.03	4.54	4.44	4.08	3.72	3.48	4.37	3.94	3.38	2.47
621	3.75	4.03	2.81	4.14	4.07	3.73	3.38	3.16	4.00	3.60	3.10	2.26
622	3.83	4.15	2.97	4.24	4.15	3.89	3.58	3.39	4.09	3.74	3.27	2.49
623	4.54	4.70	3.26	4.78	4.67	4.38	4.06	3.85	4.61	4.20	3.66	2.79
624	4.43	4.48	3.01	4.55	4.46	4.10	3.74	3.49	4.38	3.92	3.36	2.40
625	3.56	3.80	2.71	3.98	3.90	3.59	3.24	3.02	3.83	3.44	2.97	2.12
626	3.57	3.79	2.80	3.94	3.89	3.66	3.36	3.18	3.84	3.49	3.08	2.36
627	4.06	4.13	2.94	4.18	4.10	3.85	3.53	3.32	4.06	3.67	3.21	2.45
628	4.08	4.38	3.10	4.51	4.37	4.14	3.85	3.64	4.33	3.96	3.48	2.68
629	3.45	3.79	2.77	4.01	3.91	3.69	3.40	3.21	3.85	3.53	3.10	2.34
630	3.4	3.65	2.76	3.85	3.81	3.57	3.27	3.10	3.74	3.43	3.03	2.38
631	4.46	4.58	3.25	4.65	4.58	4.30	4.01	3.83	4.51	4.13	3.65	2.89
632	4.27	4.34	2.92	4.38	4.30	3.96	3.63	3.41	4.22	3.78	3.27	2.36
633	3.23	3.56	2.55	3.70	3.67	3.39	3.05	2.84	3.60	3.23	2.81	2.03
634	3.36	3.72	2.77	3.82	3.82	3.61	3.32	3.16	3.76	3.46	3.08	2.41
635	4.33	4.50	3.14	4.53	4.49	4.23	3.95	3.76	4.43	4.05	3.57	2.77
636	4.38	4.36	2.92	4.40	4.33	3.99	3.65	3.40	4.25	3.80	3.26	2.35
637	3.14	3.35	2.43	3.49	3.46	3.17	2.86	2.65	3.38	3.04	2.63	1.91
638	3.28	3.62	2.77	3.74	3.75	3.54	3.30	3.15	3.68	3.41	3.07	2.46
639	4.26	4.47	3.16	4.53	4.49	4.24	3.97	3.79	4.41	4.05	3.60	2.07
640	4.08	4.20	2.90	4.28	4.22	3.91	3.59	3.37	4.14	3.73	3.23	xxx
641	2.61	2.89	2.15	3.02	3.02	2.79	2.53	2.37	2.95	2.67	2.34	xxx
642	2.76	3.18	2.50	3.32	3.32	3.19	3.00	2.91	3.26	3.07	2.83	xxx
643	4.05	4.33	3.18	4.46	4.39	4.19	3.94	3.80	4.33	4.02	3.61	xxx
644	3.8	3.93	2.77	4.03	3.99	3.72	3.41	3.20	3.93	3.54	3.07	xxx
645	2.71	3.01	2.24	3.13	3.15	2.94	2.70	2.52	3.25	2.81	2.49	xxx
646	2.74	3.10	2.41	3.22	3.21	3.06	2.88	2.76	3.16	2.96	2.71	xxx
647	3.89	4.16	3.05	4.25	4.18	3.92	3.68	3.53	4.35	3.79	3.39	xxx
648	xxx	4.86	3.34	4.92	4.90	4.44	4.09	3.83	4.83	4.33	3.71	xxx
649	xxx	2.91	1.96	2.91	3.07	xxx	xxx	xxx	2.98	xxx	2.21	xxx
650	xxx	2.76	2.24	2.85	2.96	xxx	xxx	xxx	2.90	xxx	2.65	xxx

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
651	xxx	4.42	3.39	4.57	4.47	4.17	4.09	3.98	4.43	4.18	3.85	xxx
652	3.67	3.82	2.79	3.91	3.85	3.63	3.34	3.16	3.83	3.50	3.09	xxx
653	2.9	3.33	2.54	3.44	3.43	3.26	3.02	2.88	3.40	3.15	2.84	xxx
654	2.78	3.20	2.43	3.36	3.32	3.13	2.90	2.76	3.28	3.04	2.72	xxx
655	3.39	3.77	2.82	3.93	3.90	3.70	3.49	3.34	3.85	3.57	3.20	xxx
656	3.79	4.04	2.89	4.13	4.10	3.82	3.56	3.39	4.04	3.67	3.23	xxx
657	2.93	3.22	2.39	3.34	3.32	3.06	2.79	2.63	3.28	2.95	2.60	xxx
658	2.97	3.38	2.67	3.59	3.52	3.36	3.15	3.03	3.48	3.24	2.97	xxx
659	3.55	3.89	2.95	4.08	3.99	3.81	3.57	3.43	3.95	3.67	3.31	xxx
660	4	4.30	3.19	4.48	4.40	4.05	3.85	3.65	4.35	3.99	3.53	xxx
661	3.66	3.96	2.96	4.14	4.07	3.72	3.52	3.32	4.01	3.68	3.25	xxx
662	3.48	3.81	2.90	4.02	3.93	3.71	3.45	3.28	3.87	3.59	3.22	xxx
663	3.65	4.02	3.04	4.24	4.15	3.94	3.66	3.49	4.09	3.79	3.40	1.42
664	4.09	4.39	xxx	4.59	4.51	3.96	3.94	3.75	4.46	4.11	3.67	2.88
665	4.4	4.61	xxx	4.77	4.67	4.09	4.07	3.86	4.61	4.23	3.77	2.96
666	3.94	4.16	3.07	4.34	4.23	4.00	3.67	3.46	4.16	3.80	3.38	2.63
667	4.01	4.25	3.13	4.43	4.33	4.10	3.77	3.57	4.17	3.90	3.48	2.71
668	4.61	4.67	3.36	4.82	4.73	4.19	4.04	3.82	4.65	4.24	3.73	2.82
669	5.06	5.00	3.52	5.13	5.00	4.42	4.27	4.04	4.91	4.47	3.92	2.97
670	4.69	4.66	3.24	4.72	4.61	4.28	3.93	3.70	4.52	4.09	3.57	2.69
671	4.44	4.52	3.17	4.60	4.51	4.21	3.87	3.65	4.42	4.01	3.52	2.68
672	4.82	4.74	3.31	4.88	4.73	4.33	4.00	3.75	4.65	4.20	3.65	2.75
673	5.66	5.48	3.61	5.45	5.26	4.78	4.43	4.15	5.18	4.65	4.02	3.01
674	5.38	5.18	3.31	5.09	4.91	4.47	4.20	3.79	4.80	4.28	3.64	2.58
675	4.63	4.46	3.05	4.53	4.42	4.06	3.68	3.43	4.30	3.87	3.31	2.38
676	5.28	5.00	3.45	5.24	5.11	4.40	4.27	3.99	5.02	4.52	3.87	2.85
677	6.11	5.51	3.63	5.58	5.38	4.61	4.46	4.15	5.32	4.74	4.04	2.94
678	5.74	5.39	3.51	5.45	5.25	4.62	4.37	4.06	5.19	4.64	3.96	2.86
679	xxx	4.91	3.30	5.09	4.91	4.32	4.07	3.78	4.83	4.34	3.69	2.65
680	xxx	5.04	3.47	5.19	5.03	4.32	4.22	3.94	4.94	4.46	3.85	2.88
681	6.55	5.91	3.87	5.95	5.77	4.96	4.82	4.50	5.68	5.10	4.37	3.25

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
682	6.19	5.54	3.47	5.54	5.34	4.80	4.32	3.99	5.25	4.66	3.86	2.69
683	5.08	4.71	3.13	4.85	4.69	4.26	3.83	3.54	4.62	4.12	3.44	2.42
684	5.43	5.09	3.47	5.25	5.08	xxx	4.26	3.98	5.02	4.51	3.88	2.87
685	6.45	5.89	3.81	5.96	5.73	xxx	4.76	4.44	5.64	5.05	4.32	3.16
686	6	5.54	3.48	5.57	5.35	4.81	4.35	4.01	5.25	4.68	3.89	2.72
687	4.86	4.73	3.14	4.86	4.71	4.28	3.86	3.55	4.61	4.14	3.46	2.44
688	5.31	4.95	3.36	5.01	4.87	4.42	4.06	3.77	4.78	4.30	3.68	2.71
689	6.24	5.75	3.70	5.74	5.54	4.99	4.60	4.29	5.45	4.88	4.15	3.03
690	6.33	5.65	3.54	5.67	5.45	4.89	4.40	4.09	5.34	4.73	3.94	2.73
691	4.63	4.29	2.94	4.45	4.33	3.92	3.47	3.22	4.24	3.77	3.15	2.19
692	4.99	4.76	3.51	5.04	4.94	xxx	4.22	3.99	4.82	4.43	3.91	3.02
693	6	5.55	3.81	5.73	5.53	xxx	4.68	4.39	5.40	4.92	4.28	3.22
694	5.69	5.44	3.69	5.52	5.36	xxx	4.47	4.18	5.26	4.76	4.10	3.05
695	3.88	3.81	2.70	3.96	3.91	xxx	3.17	2.95	3.84	3.44	2.97	2.18
696	3.97	xxx	3.13	4.29	4.24	xxx	3.71	3.52	4.13	3.88	3.49	2.88
697	5.48	xxx	3.93	5.51	5.37	xxx	4.75	4.50	5.23	4.90	4.36	3.49
698	5.14	4.93	3.54	5.09	4.95	xxx	4.21	3.94	4.87	4.45	3.90	2.97
699	4.24	4.19	3.11	4.36	4.31	xxx	3.65	3.41	4.25	3.89	3.43	2.64
700	4.17	4.19	3.17	4.38	4.32	xxx	3.75	3.56	4.26	3.95	3.54	2.81
701	4.94	4.91	3.59	5.08	4.95	xxx	4.29	4.08	4.87	4.51	4.01	3.16
702	4.81	4.77	3.46	4.88	4.77	xxx	4.10	3.88	4.70	4.31	3.82	2.98
703	3.81	4.08	2.92	4.12	4.13	xxx	3.46	3.24	4.08	3.71	3.24	2.54
704	4.02	4.34	3.18	4.47	4.48	xxx	3.83	3.60	4.42	4.08	3.60	2.89
705	4.54	4.54	3.46	4.77	4.69	xxx	4.12	3.91	4.63	4.31	3.86	3.10
706	3.89	3.96	3.04	4.10	4.07	3.83	3.56	3.37	4.02	3.72	3.35	2.67
707	3.48	3.67	2.83	3.79	3.82	3.60	3.34	3.15	3.76	3.49	3.16	2.53
708	3.58	3.77	2.89	3.94	3.94	3.61	3.45	3.27	3.88	3.61	3.27	2.62
709	3.84	4.01	3.10	4.19	4.14	3.81	3.66	3.49	4.08	3.80	3.46	2.79
710	3.86	3.91	3.02	4.10	4.03	3.80	3.60	3.44	3.98	3.72	3.41	2.77
711	4.03	4.03	3.08	4.22	4.13	3.89	3.66	3.49	4.09	3.81	3.47	2.79
712	3.59	3.75	2.85	3.92	3.87	3.64	3.34	3.15	3.82	3.52	3.15	2.46

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
713	3.21	3.55	2.77	3.74	3.73	3.51	3.26	3.09	3.67	3.41	3.08	2.49
714	3.54	3.78	2.95	3.91	3.86	3.68	3.46	3.32	3.81	3.58	3.26	2.70
715	3.7	4.00	3.04	4.16	4.09	3.91	3.65	3.49	5.03	3.78	3.42	2.77
716	3.9	4.15	3.12	4.29	4.22	4.00	4.11	3.56	4.18	3.86	3.50	2.79
717	2.9	3.01	2.21	3.02	2.98	2.77	2.50	2.38	2.95	2.69	2.39	1.87
718	4.05	xxx	3.07	4.29	4.26	xxx	3.65	xxx	3.80	3.91	xxx	2.89
719	4.61	xxx	3.51	4.98	4.94	xxx	4.31	xxx	4.48	4.54	xxx	3.31
720	3.28	3.52	2.70	3.68	3.70	3.43	xxx	xxx	3.66	3.43	3.14	xxx
721	3.33	3.58	2.82	3.78	3.79	3.54	xxx	3.21	xxx	3.52	3.23	xxx
722	3.25	3.56	2.77	3.75	3.74	3.53	3.31	3.16	3.69	3.45	3.15	2.55
723	4.32	4.55	3.40	4.70	4.61	4.35	4.12	3.96	4.56	4.25	3.87	3.14
724	3.62	3.71	2.68	3.83	3.68	3.46	3.25	3.10	3.65	3.33	2.98	2.35
725	3	3.28	2.51	3.43	3.35	3.19	3.02	2.90	3.32	3.07	2.79	2.28
726	3.99	4.16	3.08	4.33	4.36	4.08	3.80	3.64	4.30	3.94	3.51	2.73
727	3.81	3.61	2.71	3.68	3.72	3.46	3.21	3.07	3.66	3.34	3.00	2.36
728	3.49	3.57	2.73	3.63	3.61	3.42	3.20	3.07	3.56	3.30	3.00	2.47
729	3.37	3.74	2.78	3.81	3.81	3.59	3.32	3.15	3.78	3.45	3.10	2.47
730	3.27	3.62	2.75	3.74	3.72	3.51	3.29	3.13	3.69	3.40	3.11	2.52
731	4.39	4.50	3.29	4.62	4.54	4.28	4.04	3.86	4.47	4.15	3.74	3.01
732	4.07	4.15	2.94	4.24	4.16	3.91	3.62	3.42	4.08	3.71	3.28	2.52
733	3.2	3.46	2.61	3.64	3.61	3.40	3.13	2.95	3.54	3.22	2.88	2.24
734	3.85	3.79	2.87	3.96	3.95	3.71	3.43	3.23	3.88	3.55	3.15	2.49
735	4.59	4.44	3.22	4.55	4.49	4.23	3.94	3.73	4.42	4.05	3.58	2.84
736	4.53	4.44	3.15	4.59	4.46	4.17	3.84	3.63	4.38	3.98	3.48	2.67
737	3.38	3.47	2.56	3.66	3.60	3.35	3.03	2.83	3.54	3.20	2.80	2.11
738	xxx	3.77	2.92	3.93	3.92	3.60	3.47	3.30	3.87	3.60	3.27	2.66
739	xxx	4.70	3.44	4.80	4.73	4.36	4.20	4.01	4.65	4.31	3.87	3.09
740	4.62	4.63	3.30	4.71	4.62	4.33	4.00	3.78	4.53	4.14	3.64	2.81
741	3.3	3.48	2.58	3.64	3.60	3.37	3.07	2.87	3.54	3.22	2.84	2.20
742	3.53	3.78	2.93	3.95	3.93	3.40	3.50	3.31	3.89	3.61	3.28	2.69
743	4.55	4.66	3.50	4.78	4.72	4.14	4.21	4.01	4.66	4.33	3.89	3.15

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
744	4.64	4.65	3.39	4.71	xxx	4.14	4.06	3.84	4.59	4.22	3.73	2.91
745	3.35	3.51	2.58	3.63	xxx	3.15	3.10	2.91	3.56	3.25	2.88	2.23
746	3.53	3.81	2.97	3.99	xxx	xxx	3.56	3.41	3.92	3.67	3.36	2.81
747	4.55	4.73	3.63	4.87	xxx	xxx	4.33	4.14	4.77	4.46	4.05	3.32
748	4.59	4.66	3.40	4.69	xxx	3.95	4.01	3.78	4.57	4.20	3.73	2.92
749	3.55	3.77	2.69	3.79	xxx	3.15	3.21	3.00	3.75	3.40	2.99	2.34
750	3.3	3.65	2.79	3.72	xxx	3.15	3.32	3.17	3.72	3.46	3.16	2.64
751	4.59	4.78	3.64	4.87	xxx	4.15	4.33	4.16	4.76	4.46	4.07	3.37
752	4.65	4.65	3.41	4.78	xxx	4.15	4.09	3.84	4.63	4.24	3.76	2.91
753	3.32	3.56	2.57	3.61	xxx	3.19	3.11	2.91	3.68	3.30	2.94	2.23
754	3.36	3.71	2.81	3.77	xxx	3.19	3.42	3.27	3.86	3.56	3.27	2.69
755	4.63	4.74	3.61	4.89	3.57	4.11	4.34	4.17	4.77	4.45	4.06	3.34
756	4.46	4.39	3.21	4.49	4.44	4.09	3.78	3.55	4.36	3.96	3.49	2.69
757	3.39	3.53	2.61	3.62	3.64	3.35	3.08	2.88	3.59	3.25	2.89	2.29
758	3.37	3.63	2.76	3.79	3.80	3.37	3.36	3.20	3.77	3.46	3.16	2.59
759	4.19	4.27	3.27	4.46	4.39	3.94	3.90	3.71	4.33	4.00	3.63	2.93
760	4.21	4.31	3.24	4.49	4.41	3.93	3.81	3.60	4.34	3.99	3.56	2.81
761	3.55	3.69	2.80	3.84	3.83	3.36	3.25	3.07	3.76	3.44	3.08	2.44
762	3.21	3.58	2.78	3.76	3.74	3.36	3.32	3.18	3.69	3.44	3.17	2.61
763	4.44	4.45	3.36	4.58	4.49	4.08	4.02	3.84	4.45	4.14	3.76	3.05
764	4	4.09	2.96	4.14	4.08	3.82	3.53	3.32	4.03	3.68	3.26	2.55
765	3.98	4.51	3.29	4.64	4.57	4.28	4.00	3.82	4.50	4.13	3.70	3.00
766	xxx	3.69	2.50	3.63	xxx	3.26	3.27	2.77	2.84	3.07	2.64	1.85
767	xxx	2.84	2.02	2.75	xxx	2.55	2.23	2.04	3.42	2.39	2.04	1.39
768	xxx	4.56	3.52	4.87	xxx	xxx	4.43	4.20	xxx	4.51	4.10	3.47
769	xxx	3.93	2.92	4.23	4.23	xxx	3.74	3.55	4.11	3.85	3.43	2.74
770	3.8	3.94	3.11	4.18	4.19	xxx	3.66	3.49	4.12	3.87	3.48	2.86
771	4.51	4.55	3.52	4.77	4.71	xxx	4.20	4.02	4.64	4.35	3.92	3.22
772	4.14	4.16	3.13	4.27	4.20	xxx	3.62	3.40	4.18	3.84	3.43	2.71
773	4.41	4.52	3.43	4.68	4.60	xxx	4.06	3.85	4.56	4.23	3.81	3.08
774	4.06	4.21	3.10	4.39	4.28	4.04	3.69	3.45	4.24	3.89	3.46	2.70

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
776	4.39	4.53	3.37	4.65	4.63	xxx	4.03	3.82	4.58	4.22	3.77	2.99
777	4.81	4.84	3.53	4.96	4.88	xxx	4.22	3.98	4.83	4.44	3.93	3.08
778	4.33	4.46	3.24	4.60	4.48	4.19	3.86	3.65	4.44	4.07	3.60	2.81
779	3.58	3.86	2.88	4.05	3.99	3.71	3.38	3.18	3.94	3.60	3.21	2.52
780	4.45	4.42	3.41	4.74	4.70	xxx	4.04	3.81	4.59	4.26	3.81	3.02
781	5.34	5.10	3.80	5.37	5.25	xxx	4.57	4.31	5.15	4.78	4.24	3.33
782	4.72	4.68	3.38	4.82	4.67	4.26	4.03	3.78	4.63	4.24	3.74	2.87
783	3.91	4.02	2.97	4.19	4.12	3.71	3.50	3.27	4.08	3.72	3.30	2.54
784	4.45	4.43	3.32	4.68	4.61	xxx	3.96	3.71	4.55	4.19	3.73	2.92
785	5.92	5.54	3.98	5.65	5.49	xxx	4.77	4.50	5.42	5.00	4.42	3.47
786	4.83	4.90	3.31	5.01	4.85	4.54	4.11	3.86	4.81	4.36	3.78	2.87
787	4.69	4.40	3.08	4.57	4.41	4.12	3.68	3.44	4.37	3.96	3.43	2.59
788	4.95	4.64	3.25	4.85	4.68	4.15	3.89	3.61	4.62	4.18	3.63	2.74
789	6.21	5.76	3.77	5.88	5.68	5.06	4.78	4.44	5.62	5.06	4.39	3.33
790	5.67	5.24	3.24	5.30	5.09	4.60	4.07	3.68	5.00	4.42	3.66	2.50
791	4.51	4.39	2.89	4.53	4.39	4.00	3.54	3.21	4.31	3.85	3.22	2.26
792	4.76	4.66	3.12	4.73	4.57	4.25	3.82	3.53	4.52	4.08	3.48	2.57
793	6.33	5.97	3.70	5.92	5.68	5.19	4.65	4.28	5.61	5.02	4.24	3.06
794	6.15	5.39	3.04	5.24	5.03	4.48	3.87	3.41	4.90	4.24	3.41	2.10
795	4.61	4.23	2.59	4.23	4.11	3.73	3.25	2.87	4.00	3.49	2.86	1.83
796	5.55	5.21	3.40	5.32	5.15	4.64	4.26	3.94	5.08	4.53	3.84	2.74
797	6.66	5.97	3.68	5.97	5.73	5.10	4.64	4.27	5.64	4.99	4.17	2.90
798	5.89	5.41	3.25	5.40	5.18	4.66	4.11	3.73	5.08	4.47	3.67	2.44
799	4.79	4.54	2.90	4.65	4.49	4.09	3.59	3.27	4.41	3.90	3.22	2.15
800	5.22	5.00	3.33	5.10	4.94	4.51	4.12	3.82	4.89	4.38	3.74	2.72
801	6.31	5.87	3.65	5.81	5.60	5.05	4.61	4.25	5.52	4.91	4.15	2.96
802	5.89	5.43	3.26	5.40	5.20	4.64	4.10	3.73	5.10	4.47	3.67	2.42
803	4.95	4.54	2.95	4.63	4.48	4.04	3.58	3.27	4.41	3.89	3.22	2.18
804	4.55	4.32	2.81	4.45	4.32	3.97	3.53	3.23	4.25	3.78	3.18	2.23
805	xxx	5.64	3.37	5.69	5.45	4.93	4.37	3.98	5.37	4.73	3.93	2.70
806	xxx	5.62	3.11	5.62	5.34	4.67	4.00	3.52	5.24	4.53	3.59	2.18

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
808	4.41	4.38	2.94	4.50	4.41	4.11	3.70	3.44	4.34	3.91	3.33	2.40
809	5.29	5.05	3.17	5.11	4.95	4.61	4.12	3.80	4.89	4.37	3.66	2.55
810	5.16	4.84	2.97	4.86	4.69	4.30	3.79	3.44	4.62	4.11	3.39	2.28
811	4.4	4.28	2.75	4.35	4.24	3.89	3.45	3.15	4.16	3.72	3.09	2.11
812	4.17	4.30	2.81	4.35	4.24	3.95	3.56	3.29	4.19	3.77	3.18	2.25
813	4.87	4.84	3.04	4.85	4.70	4.37	3.93	3.62	4.65	4.16	3.50	2.44
814	4.51	4.41	2.73	4.47	4.34	3.94	3.47	3.13	4.27	3.76	3.09	2.01
815	3.91	4.03	2.60	4.16	4.06	3.71	3.29	2.99	3.99	3.55	2.95	1.98
816	4.14	4.10	2.65	4.20	4.11	3.78	3.36	3.07	4.02	3.58	2.95	1.97
817	4.07	4.03	2.60	4.15	4.05	3.71	3.28	2.99	4.20	3.53	2.90	1.93
818	3.94	4.04	2.70	4.18	4.04	3.74	3.37	3.13	3.99	3.58	3.00	2.13
819	3.87	3.92	2.62	4.06	3.90	3.60	3.22	2.99	3.85	3.44	2.87	2.02
820	3.63	3.82	2.57	3.93	3.85	3.56	3.18	2.94	3.76	3.36	2.82	1.98
821	3.51	3.78	2.53	3.84	3.80	3.52	3.15	2.92	3.70	3.31	2.78	1.95
822	3.39	3.62	2.50	3.71	3.62	3.38	3.08	2.90	3.56	3.22	2.76	2.13
823	3.67	3.83	2.58	3.92	3.81	3.56	3.24	3.04	3.76	3.40	2.88	2.19
824	4.02	4.18	2.81	4.34	4.19	3.87	3.47	3.20	4.12	3.71	3.13	2.19
825	3.4	3.61	2.55	3.79	3.71	3.40	3.06	2.85	4.09	3.28	2.80	1.97
826	3.09	3.36	2.45	3.44	3.44	3.22	2.94	2.77	3.84	3.10	2.71	2.06
827	3.6	3.79	2.65	3.84	3.79	3.58	3.29	3.10	3.74	3.42	2.96	2.22
828	3.71	3.83	2.60	3.92	3.84	3.53	3.11	2.80	3.81	3.44	2.90	2.03
829	2.76	3.14	2.22	3.28	3.25	2.98	2.61	2.32	3.22	2.86	2.40	1.71
830	3.76	4.19	3.17	4.33	4.22	3.93	3.52	3.22	4.15	3.87	3.47	2.85
831	3.84	4.16	3.07	4.35	4.23	3.97	3.58	3.29	4.16	3.86	3.42	2.69
832	3.24	3.66	2.73	3.85	3.77	3.48	3.21	2.72	3.71	3.44	3.04	2.33
833	2.09	2.47	1.73	2.53	2.50	2.18	1.75	1.42	2.44	2.20	1.90	1.40
834	3.45	xxx	2.91	3.89	3.88	xxx	3.18	2.89	xxx	3.56	xxx	2.77
835	4.36	xxx	3.45	4.73	4.67	xxx	4.00	3.70	4.42	4.29	xxx	3.19
836	3.16	3.68	2.78	3.83	3.79	3.52	3.23	3.00	3.74	3.46	3.09	2.48
837	2.75	3.33	2.62	3.55	3.51	3.27	2.98	2.77	3.49	3.27	2.96	2.43
838	3.05	3.38	2.61	3.55	3.55	3.29	3.08	2.90	3.49	3.26	2.92	2.34

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
840	3.7	4.10	2.97	4.21	4.10	3.82	3.49	3.27	4.08	3.71	3.27	2.50
841	2.65	3.31	2.43	3.39	3.36	3.08	2.77	2.55	3.34	3.05	2.72	2.08
842	3.43	3.92	2.91	4.01	3.99	3.64	3.43	3.24	3.95	3.62	3.22	2.55
843	4.2	4.44	3.33	4.60	4.50	4.13	3.88	3.71	4.49	4.14	3.66	2.88
844	4.01	4.35	3.21	4.49	4.36	4.07	3.74	3.56	4.32	3.97	3.51	2.73
845	3.09	3.56	2.62	3.72	3.65	3.36	3.04	2.84	3.61	3.29	2.90	2.22
846	3.33	3.85	2.91	4.02	3.98	xxx	3.42	3.24	3.93	3.63	3.24	2.60
847	4.22	4.59	3.44	4.72	4.63	xxx	4.03	3.84	4.58	4.25	3.79	3.03
848	4.28	4.52	3.31	4.64	4.56	xxx	3.87	3.64	4.49	4.13	3.62	2.79
849	3.36	3.73	2.73	3.89	3.85	xxx	3.17	2.95	3.79	3.46	3.01	2.29
850	3.68	3.98	3.07	4.21	4.15	xxx	3.60	3.45	4.09	3.84	3.41	2.73
851	4.68	4.83	3.66	5.01	4.89	xxx	4.30	4.11	4.83	4.52	4.01	3.18
852	4.53	4.75	3.47	4.87	4.74	xxx	4.00	3.77	xxx	4.28	3.76	2.89
853	3.37	3.82	2.73	3.92	3.84	xxx	3.11	2.91	3.82	3.42	2.99	2.28
854	3.68	xxx	3.11	4.29	4.24	xxx	3.65	3.49	4.16	3.87	3.46	2.82
855	4.86	xxx	3.86	5.29	5.17	xxx	4.54	4.34	5.09	4.76	4.24	3.41
856	4.7	4.87	3.52	5.02	4.87	xxx	4.05	3.79	4.82	4.41	3.82	2.87
857	3.82	4.04	2.96	4.26	4.17	xxx	3.36	3.13	4.09	3.74	3.24	2.44
858	3.68	4.04	3.07	4.25	4.18	xxx	3.58	3.42	4.12	3.81	3.42	2.76
859	4.92	5.15	3.80	5.33	5.17	xxx	4.53	4.32	5.12	4.73	4.23	3.39
860	5.06	5.03	3.50	5.18	4.98	4.40	4.10	3.80	4.92	4.39	3.81	2.82
861	3.79	3.95	2.84	4.12	4.02	3.45	3.18	2.93	3.96	3.55	3.05	2.26
862	3.82	xxx	3.22	4.42	4.35	xxx	3.75	3.59	4.29	3.99	3.58	2.90
863	4.98	xxx	3.84	5.35	5.20	xxx	4.56	4.36	5.13	4.76	4.25	3.38
864	4.97	4.99	3.56	5.07	4.96	4.30	4.13	3.88	4.88	4.44	3.87	2.90
865	4.28	4.37	3.19	4.48	4.43	3.76	3.60	3.40	4.35	3.95	3.45	2.60
866	4.07	4.16	3.09	4.27	4.22	3.76	3.54	3.38	4.16	3.79	3.36	2.62
867	4.86	4.99	3.57	5.04	4.93	xxx	4.23	4.02	5.02	4.45	3.94	3.08
868	4.99	5.01	3.43	5.08	4.92	xxx	4.05	3.78	4.86	4.36	3.75	2.77
869	4.12	4.22	3.07	4.40	4.29	xxx	3.47	3.24	4.23	3.80	3.29	2.46
870	4.27	4.43	3.25	4.65	4.55	xxx	3.84	3.65	4.48	4.08	3.63	2.84

Appendix A. (continued)

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
872	5.01	4.99	3.48	5.19	5.03	4.30	4.17	3.90	4.94	4.48	3.90	2.93
873	4.54	4.41	3.14	4.57	4.51	3.79	3.67	3.43	4.40	3.99	3.48	2.63
874	3.89	4.06	3.00	4.20	4.14	3.78	3.53	3.35	4.08	3.75	3.33	2.64
875	4.7	4.82	3.44	4.96	4.80	4.42	4.15	3.94	4.76	4.36	3.86	3.03
876	4.66	4.68	3.20	4.81	4.63	4.25	3.82	3.55	4.59	4.13	3.54	2.61
877	4.03	4.27	3.06	4.44	4.30	3.96	3.59	3.35	4.27	3.89	3.37	2.56
878	4.01	4.21	3.03	4.34	4.25	3.95	3.58	3.37	4.19	3.82	3.32	2.55
879	4.03	4.29	3.02	4.42	4.30	3.97	3.57	3.34	4.25	3.84	3.31	2.52
880	4.47	4.72	3.36	4.85	4.70	4.16	3.97	3.74	4.66	4.24	3.70	2.87
881	4.16	4.38	3.16	4.52	4.38	3.87	3.69	3.48	4.34	3.96	3.47	2.67
882	3.51	3.88	2.93	4.03	3.92	3.70	3.42	3.26	3.89	3.60	3.22	2.59
883	3.7	4.12	3.06	4.28	4.13	3.93	xxx	3.42	4.14	3.79	3.36	2.70
884	4.26	4.60	3.34	4.75	4.61	4.06	xxx	3.69	4.58	4.18	3.68	2.88
885	4.77	4.79	3.43	4.89	4.77	4.24	xxx	3.84	4.72	4.32	3.80	2.94
886	4.14	4.27	3.04	4.41	4.30	3.98	xxx	3.40	4.27	3.90	3.38	2.56
887	3.38	3.72	2.76	3.93	3.86	3.54	xxx	3.03	3.82	3.49	3.06	2.36
888	3.94	4.18	3.14	4.38	4.34	xxx	3.69	3.50	4.25	3.90	3.50	2.79
889	5.26	5.05	3.57	5.12	5.04	xxx	4.30	4.06	4.94	4.51	4.00	3.11
890	3.75	3.70	2.43	3.68	3.52	3.27	2.98	2.79	3.49	3.19	2.80	2.08
891	3.1	3.48	2.43	3.53	3.42	3.19	2.91	2.74	3.38	3.13	2.77	2.14
892	4.79	4.96	3.33	5.11	5.00	xxx	4.22	3.97	4.89	4.47	3.91	2.99
893	5.14	5.17	3.41	5.26	5.12	xxx	4.34	4.08	5.04	4.57	3.99	3.03
894	4.45	4.58	2.99	4.64	4.53	4.15	3.76	3.51	xxx	4.02	3.47	2.59
895	3.12	3.52	2.41	3.66	3.62	3.26	2.90	2.70	xxx	3.20	2.76	2.06
896	3.97	4.26	3.11	4.40	4.38	xxx	3.73	3.54	4.29	3.98	3.56	2.85
897	5.41	5.43	3.69	5.48	5.35	xxx	4.63	4.38	5.27	4.84	4.28	3.34
898	4.85	4.92	3.18	4.99	4.83	4.41	3.97	3.67	4.77	4.29	3.70	2.70
899	4.13	4.23	2.89	4.37	4.27	3.87	3.42	3.14	4.20	3.79	3.27	2.38
900	xxx	4.22	3.04	4.36	4.25	3.94	3.58	3.37	4.20	3.86	3.46	2.80
901	xxx	5.32	3.50	5.38	5.19	4.82	4.44	4.19	5.15	4.68	4.13	3.27
902	5.72	5.43	3.27	5.46	5.30	4.75	4.19	3.82	5.22	4.64	3.92	2.79

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
904	5.04	xxx	3.42	5.10	5.00	xxx	4.14	3.85	4.60	4.49	3.94	3.05
905	6.08	xxx	3.80	5.87	5.70	xxx	4.82	4.52	5.31	5.12	4.48	3.43
906	5.52	xxx	3.55	5.46	5.26	4.42	4.33	4.01	5.18	4.69	4.06	3.02
907	4.65	xxx	3.21	4.88	4.72	3.88	3.80	3.50	4.64	4.20	3.62	2.68
908	4.84	xxx	3.41	4.99	4.90	3.88	4.00	3.73	4.74	4.37	3.81	2.89
909	6.21	xxx	3.93	6.05	5.90	4.82	4.90	4.58	5.71	5.23	4.54	3.45
910	6.21	5.57	3.50	5.63	5.40	4.81	4.27	3.91	5.29	4.70	3.94	2.76
911	4.98	4.66	3.13	4.83	4.68	4.15	3.66	3.37	4.58	4.10	3.47	2.46
912	5.18	xxx	3.55	5.35	5.20	xxx	4.25	3.98	5.02	4.62	4.02	3.02
913	5.87	xxx	3.76	5.82	5.61	xxx	4.61	4.30	5.44	4.97	4.30	3.18
914	5.55	5.33	3.56	5.45	5.27	xxx	4.25	3.92	5.16	4.64	3.96	2.88
915	4.75	4.70	3.24	4.85	4.75	xxx	3.75	3.46	4.63	4.18	3.56	2.59
916	4.98	xxx	3.54	5.14	5.06	xxx	4.14	3.89	4.87	4.52	3.93	2.99
917	5.73	xxx	3.84	5.78	5.60	xxx	4.66	4.36	5.44	5.01	4.34	3.28
918	5.56	5.36	3.67	5.66	5.46	xxx	4.42	4.08	5.36	4.82	4.11	2.98
919	4.33	4.21	3.01	4.49	4.38	xxx	3.39	3.09	4.28	3.85	3.26	2.34
920	4.9	xxx	3.59	5.24	5.15	xxx	4.29	4.03	4.38	4.67	xxx	3.19
921	5.65	xxx	3.91	5.79	5.62	xxx	4.75	4.47	4.85	5.09	xxx	3.44
922	4.85	4.75	3.45	4.92	4.75	xxx	3.94	3.67	4.67	4.27	3.74	2.82
923	4.43	4.73	3.41	4.85	4.72	xxx	3.92	3.66	4.65	4.27	3.75	2.86
924	4.11	4.51	3.24	4.64	4.50	xxx	3.77	3.54	4.45	4.07	3.58	2.73
925	4.93	4.90	3.49	5.00	4.87	xxx	4.11	3.86	4.79	4.39	3.86	2.94
926	4.53	4.48	3.13	4.57	4.44	4.07	3.65	3.42	4.37	3.96	3.42	2.56
927	4.18	4.39	3.18	4.54	4.42	4.08	3.70	3.49	4.35	3.99	3.49	2.71
928	4.27	4.37	3.05	4.48	4.39	4.03	3.65	3.41	4.32	3.92	3.37	2.51
929	3.88	3.92	2.79	4.04	3.95	3.58	3.21	2.98	3.89	3.50	3.00	2.24
930	3.64	3.83	2.82	3.95	3.90	3.62	3.30	3.12	3.84	3.51	3.09	2.42
931	3.93	4.22	3.05	4.33	4.27	4.00	3.67	3.48	4.21	3.86	3.41	2.65
932	3.76	4.10	2.90	4.24	4.14	3.81	3.49	3.28	4.08	3.71	3.22	2.41
933	3.52	3.86	2.79	4.05	3.93	xxx	3.25	3.05	3.88	3.51	3.03	2.27
934	3.27	3.57	2.64	3.75	3.66	xxx	3.07	2.91	3.62	3.29	2.87	2.24

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
936	3.53	3.81	2.61	3.93	3.82	xxx	3.18	2.97	3.77	3.41	2.92	2.14
937	2.88	3.32	2.38	3.56	3.44	xxx	2.85	2.66	3.64	3.11	2.66	1.98
938	3.11	3.45	2.51	3.61	3.55	xxx	3.00	2.84	3.50	3.19	2.76	2.11
939	3.6	3.97	2.78	4.11	4.06	xxx	3.47	3.29	4.02	3.63	3.15	2.41
940	3.22	3.47	2.37	3.55	3.54	xxx	3.00	2.83	3.50	3.17	2.73	1.92
941	xxx	1.89	1.31	1.90	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
942	2.53	3.05	2.43	3.24	3.21	xxx	2.86	2.75	3.16	xxx	xxx	xxx
943	3.46	3.75	2.88	3.94	3.88	xxx	3.50	3.38	3.83	3.59	3.28	2.72
944	2.78	3.18	2.46	3.38	3.31	xxx	2.92	2.82	3.29	3.07	2.78	2.28
945	2.35	2.73	2.10	2.92	2.86	2.69	2.46	2.39	2.84	2.64	2.38	1.95
946	xxx	2.50	1.93	2.59	2.63	2.48	2.26	2.18	2.61	2.45	2.20	1.86
947	xxx	3.96	2.87	4.01	3.99	3.81	3.56	xxx	xxx	xxx	xxx	xxx
948	3.24	3.33	2.22	3.24	3.12	2.87	2.56	2.38	3.10	2.77	2.37	1.70
949	xxx	2.39	1.80	2.39	2.32	2.12	1.89	1.77	3.03	2.07	1.86	1.44
950	xxx	4.17	3.20	4.29	4.24	xxx	3.82	3.71	4.17	3.96	3.67	3.10
951	xxx	4.05	2.97	4.16	4.13	xxx	3.61	3.45	4.10	3.81	3.40	2.71
952	3.21	3.58	2.74	3.78	3.69	3.46	3.19	3.03	3.66	3.41	3.05	2.45
953	2.15	2.70	2.01	2.90	2.87	2.66	2.40	2.27	2.80	2.61	2.30	1.87
954	2.59	3.11	2.40	3.30	3.34	xxx	2.88	2.76	3.25	3.05	2.75	2.32
955	3.91	4.28	3.31	4.43	4.40	xxx	3.90	3.76	4.34	4.07	3.70	3.05
956	3.55	3.96	3.00	4.11	4.05	3.79	3.48	3.32	4.04	3.75	3.37	2.71
957	2.66	3.21	2.44	3.41	3.38	3.14	2.85	2.72	3.36	3.11	2.79	2.25
958	3.11	3.68	2.83	3.92	3.85	xxx	3.29	3.14	3.81	3.55	3.20	2.61
959	4.17	4.55	3.47	4.74	4.64	xxx	4.06	3.89	4.59	4.29	3.87	3.14
960	4.02	4.34	3.21	4.47	4.37	3.96	3.68	3.46	4.34	4.00	3.57	2.79
961	3.11	3.59	2.68	3.77	3.71	3.34	3.10	2.91	3.73	3.38	3.02	2.37
962	3.63	3.96	3.05	4.25	4.18	xxx	3.53	3.34	4.12	3.83	3.43	2.76
963	4.62	4.83	3.67	5.09	5.28	xxx	4.29	4.10	4.91	4.56	4.08	3.28
964	4.42	4.56	3.33	4.73	xxx	4.15	xxx	xxx	4.54	4.14	3.64	2.78
965	3.87	4.11	3.04	4.35	xxx	3.77	3.41	3.19	4.17	3.80	3.35	2.55
966	3.89	4.20	3.11	4.37	xxx	3.78	3.55	3.32	4.23	3.87	3.43	2.66

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
968	4.95	4.85	3.28	4.80	xxx	4.20	3.97	3.41	4.50	4.07	3.49	2.50
969	4.16	4.23	3.00	4.25	xxx	3.70	3.27	3.00	4.64	3.63	3.14	2.29
970	4.19	4.24	3.12	4.43	xxx	4.02	3.75	3.47	4.28	3.90	3.45	2.67
971	4.93	4.73	3.35	4.81	xxx	4.35	3.96	3.75	4.64	4.21	3.68	2.81
972	xxx	5.07	3.68	5.16	4.99	xxx	4.13	3.82	4.93	4.44	3.80	2.82
973	xxx	4.57	3.21	4.73	4.56	xxx	3.67	3.42	4.50	4.05	3.47	2.56
974	4.53	4.62	3.40	4.81	4.70	xxx	3.95	3.74	4.63	4.24	3.74	2.92
975	5.27	5.24	3.70	5.37	5.22	xxx	4.42	4.17	xxx	4.70	4.12	3.19
976	5.21	5.13	3.48	5.28	5.11	xxx	4.13	3.82	xxx	4.50	3.83	2.81
977	4.83	4.77	3.32	4.95	4.79	xxx	3.84	3.55	4.71	4.24	3.61	2.64
978	4.76	4.90	3.50	5.07	4.94	xxx	4.12	3.88	4.85	4.42	3.86	2.96
979	5.33	5.44	3.71	5.56	5.39	xxx	4.50	4.22	5.32	4.81	4.18	3.18
980	5.21	5.03	3.33	5.09	4.91	4.44	3.99	3.63	4.85	4.32	3.65	2.63
981	5.02	4.93	3.36	5.03	4.85	4.40	3.94	3.64	4.79	4.29	3.66	2.70
982	xxx	5.31	3.53	5.43	5.25	xxx	4.24	3.92	5.17	4.61	3.91	2.85
983	xxx	4.94	3.34	5.09	4.93	xxx	3.94	3.63	5.44	4.33	3.65	2.65
984	5.07	4.95	3.45	5.14	4.96	xxx	4.30	3.84	4.89	4.41	3.80	2.84
985	4.93	4.90	3.37	5.02	4.84	xxx	3.98	3.70	xxx	4.29	3.71	2.74
986	5.02	4.96	3.65	5.36	5.20	xxx	4.35	4.08	xxx	4.66	4.09	3.15
987	5.05	4.75	3.51	5.21	5.05	xxx	4.18	3.91	4.92	4.51	3.93	2.96
988	4.73	4.71	3.39	4.90	4.76	xxx	3.93	3.67	4.69	4.27	3.73	2.84
989	4.93	5.05	3.63	5.20	5.06	xxx	4.26	4.00	4.98	4.56	4.01	3.12
990	4.3	4.55	3.23	4.68	4.53	xxx	3.80	3.55	4.47	4.07	3.54	2.69
991	4.01	4.55	3.20	4.66	4.52	4.19	3.82	3.58	4.47	4.09	3.58	2.73
992	4.39	4.67	3.18	4.66	4.51	4.15	3.73	3.48	4.45	4.04	3.45	2.59
993	5.31	5.27	3.57	5.33	5.16	4.75	4.28	3.99	5.08	4.60	3.94	3.01
994	xxx	4.31	2.80	4.25	xxx	xxx	3.51	3.23	4.19	3.75	3.18	2.21
995	xxx	3.35	2.39	3.35	3.39	xxx	2.79	2.61	3.35	3.01	2.59	1.84
996	xxx	4.11	2.95	4.29	4.18	3.84	3.50	3.32	4.13	3.74	3.29	2.57
997	3.68	3.70	2.63	3.74	3.64	3.31	3.01	2.83	3.60	3.24	2.81	2.19
998	3.99	4.23	3.16	4.38	4.24	xxx	3.73	3.59	4.18	3.90	3.52	2.86

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1000	3.67	3.98	3.02	4.09	4.05	xxx	3.50	3.34	4.00	3.73	3.36	2.69
1001	4.7	4.92	3.62	5.01	4.92	xxx	4.30	4.11	4.88	4.53	4.04	3.22
1002	4.09	4.42	3.17	4.54	4.36	4.02	3.64	3.42	4.36	3.97	3.48	2.67
1003	2.98	3.56	2.60	3.71	3.65	3.31	2.98	2.77	3.62	3.27	2.86	2.23
1004	3.59	4.10	3.07	4.24	4.23	xxx	3.57	3.35	4.16	3.84	3.41	2.74
1005	4.85	5.14	3.70	5.18	5.06	xxx	4.38	4.17	4.99	4.63	4.12	3.27
1006	4.31	4.64	3.23	4.73	4.56	4.16	3.77	3.52	4.52	4.10	3.55	2.70
1007	3.12	3.45	2.49	3.65	3.58	3.20	2.85	2.63	3.52	3.17	2.73	2.10
1008	3.34	3.78	2.87	3.97	3.93	xxx	3.38	3.22	3.84	3.58	3.20	2.61
1009	5.18	5.35	3.82	5.42	5.27	xxx	4.62	4.40	5.19	4.81	4.27	3.40
1010	4.5	4.55	3.01	4.55	4.37	3.93	3.49	3.19	4.33	3.85	3.23	2.28
1011	3.48	3.92	2.79	4.05	3.94	3.53	3.14	2.89	3.90	3.51	2.99	2.18
1012	4.35	4.49	3.13	4.60	4.47	4.05	3.62	3.34	4.36	3.93	3.34	2.43
1013	5.53	5.69	3.75	5.69	5.51	5.00	4.45	4.08	5.53	4.82	4.07	2.92
1014	4.97	4.99	2.99	4.95	4.81	4.26	3.92	3.27	4.72	4.13	3.38	2.19
1015	3.57	3.57	2.34	3.64	3.59	3.13	2.67	2.36	3.50	3.07	2.52	1.64
1016	4.97	4.73	3.40	5.16	5.08	xxx	4.08	3.77	4.88	4.50	3.90	2.94
1017	5.49	5.10	3.49	5.49	5.35	xxx	4.32	4.00	5.17	4.71	4.02	2.93
1018	5.23	5.10	3.44	5.26	5.13	xxx	4.07	3.81	4.99	4.54	3.92	2.87
1019	4.42	4.44	3.07	4.64	4.55	xxx	3.61	3.31	4.40	4.00	3.45	2.53
1020	4.65	4.44	3.44	5.00	4.96	xxx	4.10	3.84	4.66	4.43	3.88	3.02
1021	5.33	4.94	3.68	5.47	5.37	xxx	4.44	4.15	5.08	4.80	4.18	3.20
1022	5.22	4.94	3.45	5.09	4.95	xxx	xxx	3.69	4.81	4.35	3.73	2.72
1023	5.01	4.93	3.45	5.13	4.99	xxx	4.04	3.74	5.17	4.40	3.80	2.82
1024	5.24	xxx	3.67	5.54	5.40	xxx	4.42	4.10	5.13	4.79	4.13	3.07
1025	5.24	xxx	3.40	5.05	4.93	xxx	3.96	3.65	4.66	4.34	3.74	2.76
1026	4.79	4.49	3.46	4.95	4.84	xxx	4.01	3.76	4.64	4.33	3.80	2.93
1027	5.07	4.71	3.62	5.21	5.06	xxx	4.23	4.00	4.86	4.55	4.00	3.11
1028	4.62	4.41	3.10	4.65	4.48	3.98	3.58	3.31	4.36	3.93	3.38	2.48
1029	5.25	5.20	3.53	5.35	5.18	4.65	4.24	3.93	5.05	4.56	3.93	2.92
1030	5.51	5.24	3.32	5.31	5.11	4.56	4.03	3.64	4.97	4.42	3.71	2.56

Appendix A. (continued)

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1032	4.75	4.79	3.14	4.90	4.78	4.30	3.81	3.47	4.65	4.17	3.52	2.51
1033	4.85	4.92	3.20	4.99	4.88	4.40	3.91	3.55	4.75	4.26	3.60	2.58
1034	4.79	4.82	3.18	4.94	4.82	4.34	3.89	3.53	4.68	4.23	3.59	2.55
1035	4.54	4.65	3.13	4.81	4.65	4.18	3.74	3.41	4.51	4.07	3.47	2.49
1036	4.45	4.60	3.11	4.77	4.64	4.19	3.77	3.43	4.52	4.09	3.49	2.56
1037	4.58	4.48	3.03	4.62	4.54	4.10	3.69	3.36	4.41	4.00	3.41	2.50
1038	3.98	4.16	2.85	4.27	4.21	3.78	3.40	3.09	4.09	3.67	3.13	2.26
1039	4.65	4.93	3.21	4.99	4.88	4.42	4.00	3.62	4.75	4.26	3.64	2.64
1040	4.29	4.46	2.76	4.51	4.35	3.85	3.39	2.96	4.22	3.71	3.04	1.95
1041	3.47	3.86	2.55	4.02	3.89	3.42	3.00	2.62	3.78	3.34	2.75	1.79
1042	3.71	4.10	2.70	4.08	4.04	3.62	3.20	2.89	3.89	3.48	2.94	2.04
1043	4.09	4.40	2.82	4.33	4.29	3.86	3.43	3.10	4.13	3.70	3.12	2.18
1044	3.77	4.10	2.68	4.21	4.10	3.67	3.23	2.86	3.97	3.54	2.92	1.96
1045	3.25	3.86	2.60	4.08	3.98	3.56	3.14	2.80	3.88	3.47	2.88	1.95
1046	xxx	3.87	2.57	4.06	3.96	3.52	3.09	2.75	3.85	3.42	2.82	1.85
1047	xxx	3.85	2.59	3.98	3.84	3.42	2.99	2.62	3.72	3.31	2.75	1.85
1048	xxx	3.89	2.73	4.08	3.90	3.54	3.19	2.88	3.80	3.42	2.94	2.11
1049	xxx	3.14	2.20	3.31	3.20	2.83	2.49	2.19	3.12	2.76	2.30	1.56
1050	2.86	3.34	2.49	3.48	3.46	3.15	2.85	2.57	3.40	3.10	2.70	2.11
1051	2.91	3.30	2.40	3.44	3.40	3.08	2.74	2.49	3.31	3.00	2.63	2.04
1052	2.99	3.40	2.58	3.58	3.56	3.25	2.94	2.72	3.46	3.17	2.81	2.22
1053	2.46	3.02	2.20	3.16	3.11	2.90	2.61	2.38	3.12	2.82	2.45	1.90
1054	2.22	2.88	2.23	2.98	3.04	2.84	2.59	2.40	2.99	2.74	2.44	2.04
1055	3.24	3.76	2.87	3.91	3.89	3.67	3.39	3.22	3.81	3.56	3.18	2.60
1056	2.92	3.39	2.48	3.56	3.49	3.20	2.88	2.65	3.40	3.11	2.66	2.01
1057	1.97	2.55	1.90	2.68	2.72	2.45	2.16	1.92	2.62	2.38	2.04	1.53
1058	2.15	2.80	2.16	2.84	2.90	2.70	2.47	2.27	2.82	2.63	2.37	1.95
1059	2.97	3.63	2.76	3.69	3.66	3.44	3.20	3.01	3.57	3.34	2.99	2.44
1060	3.1	3.61	2.68	3.76	3.68	3.38	3.17	2.86	3.55	3.27	2.86	2.22
1061	1.89	2.55	1.87	2.71	2.65	2.37	2.02	1.83	2.58	2.30	1.96	1.47
1062	2.13	2.96	2.33	3.12	3.09	2.91	2.67	2.50	3.04	2.83	2.57	2.21

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1064	2.6	3.26	2.48	3.45	3.36	3.11	2.88	2.74	3.28	3.04	2.68	2.19
1065	2.07	2.72	2.08	2.93	2.86	2.62	2.41	2.26	2.78	2.57	2.27	1.86
1066	2.36	2.98	2.32	3.15	3.12	2.93	2.73	2.60	3.03	2.84	2.54	2.13
1067	3.35	3.88	3.00	4.06	3.97	3.74	3.51	3.37	3.88	3.63	3.25	2.67
1068	3.35	3.75	2.77	3.86	3.74	3.42	3.15	2.98	3.68	3.36	2.93	2.26
1069	2.42	3.07	2.31	3.20	3.15	2.87	2.61	2.43	3.09	2.82	2.46	1.91
1070	3.04	3.60	2.74	3.78	3.75	3.51	3.25	3.08	3.64	3.40	3.03	2.43
1071	4.07	4.42	3.28	4.60	4.48	4.22	3.92	3.74	4.40	4.09	3.63	2.86
1072	3.82	4.02	2.90	4.05	3.88	3.57	3.26	3.06	3.80	3.46	2.98	2.25
1073	3.42	3.85	2.81	3.92	3.83	3.50	3.21	3.05	3.84	3.39	2.95	2.26
1074	3.38	3.33	2.39	3.31	3.32	3.04	2.95	2.59	xxx	2.92	2.50	1.78
1075	3.99	3.66	2.63	3.55	3.52	3.25	2.96	2.75	xxx	3.12	2.68	1.96
1076	4.53	4.60	3.16	4.76	4.64	4.22	3.82	3.53	xxx	4.05	3.46	2.52
1077	3.96	4.16	2.90	4.40	4.26	3.84	3.43	3.17	4.14	3.70	3.12	2.21
1078	4.02	4.37	3.18	4.60	4.50	4.06	3.75	3.52	4.40	4.02	3.52	2.72
1079	4.93	4.99	3.44	5.10	4.98	4.53	4.21	3.96	4.87	4.41	3.84	2.91
1080	5.11	5.07	3.35	5.16	4.93	4.41	3.88	3.47	4.86	4.34	3.68	2.66
1081	4.77	4.88	3.27	5.02	4.88	4.38	3.90	3.49	4.74	4.24	3.59	2.60
1082	4.89	4.99	3.40	5.08	4.97	4.36	3.78	3.27	4.85	4.37	3.75	2.74
1083	5.51	5.39	3.60	5.46	5.35	4.73	4.13	3.59	5.19	4.66	4.00	2.94
1084	4.95	4.68	2.90	4.53	4.38	3.71	3.05	2.45	4.25	3.65	3.00	2.03
1085	xxx	5.01	3.10	4.90	4.74	4.04	3.36	2.75	4.63	4.00	3.32	2.28
1086	xxx	5.18	3.10	5.19	5.03	4.21	3.37	2.69	4.89	4.26	3.46	2.25
1087	5.74	5.46	3.26	5.50	5.34	4.47	3.61	2.92	5.21	4.53	3.70	2.44
1088	6.09	5.36	3.12	5.39	5.21	4.33	3.45	2.69	5.08	4.40	3.54	2.07
1089	4.75	4.17	2.58	4.23	4.07	3.29	2.49	1.78	4.16	3.46	2.77	1.58
1090	5.57	xxx	3.62	5.70	5.55	xxx	3.79	3.08	5.28	4.90	4.20	3.07
1091	5.42	xxx	3.35	5.33	5.17	xxx	3.44	2.74	4.90	4.46	3.74	2.62
1092	5.4	4.67	3.58	5.42	5.21	xxx	3.56	2.89	4.92	4.61	3.97	2.95
1093	5.97	5.24	3.84	5.99	5.76	xxx	4.11	3.40	5.43	5.08	4.38	3.26
1094	5.45	xxx	3.68	5.62	5.44	4.59	3.66	2.87	5.29	4.78	4.06	2.96

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1096	5.3	xxx	3.67	5.55	5.33	4.36	3.49	2.70	5.15	4.69	4.02	2.93
1097	5.86	xxx	3.89	5.97	5.74	4.75	3.87	3.05	5.54	5.05	4.32	3.16
1098	5.35	5.40	3.64	5.61	5.41	4.48	3.55	2.74	5.28	4.71	3.99	2.85
1099	4.55	4.80	3.35	5.07	4.87	3.95	3.05	2.28	4.77	4.26	3.60	2.58
1100	4.72	4.82	3.50	5.14	4.95	4.18	3.37	2.69	4.84	4.38	3.76	2.79
1101	5.69	5.62	3.88	5.84	5.66	4.86	4.00	3.28	5.53	4.99	4.30	3.19
1102	4.98	5.18	3.36	5.28	5.14	4.37	3.56	2.86	4.99	4.42	3.68	2.55
1103	3.93	4.24	2.93	4.46	4.28	3.54	2.76	2.11	4.19	3.72	3.09	2.15
1104	4.1	4.40	3.16	4.61	4.45	3.88	3.26	2.75	4.36	3.93	3.39	2.56
1105	4.97	5.23	3.57	5.31	5.16	4.56	3.92	3.36	5.04	4.54	3.94	2.97
1106	4.47	4.85	3.21	4.96	4.79	4.14	3.48	2.87	4.67	4.14	3.47	2.40
1107	3.46	4.10	2.87	4.37	4.21	3.60	2.96	2.41	4.12	3.67	3.06	2.13
1108	3.65	4.25	3.07	4.49	4.35	3.82	3.23	2.73	4.26	3.85	3.31	2.47
1109	4.78	5.06	3.44	5.16	5.02	4.45	3.83	3.28	4.89	4.39	3.77	2.78
1110	4.15	4.55	3.01	4.65	4.51	3.94	3.32	2.78	4.39	3.89	3.26	2.29
1111	3.21	3.85	2.69	4.09	3.95	3.40	2.82	2.31	3.87	3.44	2.87	2.01
1112	3.35	3.79	2.74	3.99	3.90	3.45	2.99	2.56	3.80	3.42	2.91	2.14
1113	4.19	4.45	3.09	4.53	4.44	3.96	3.45	2.99	4.31	3.88	3.33	2.47
1114	4.15	4.70	2.94	4.62	4.49	3.90	3.33	2.84	4.36	3.83	3.18	2.17
1115	3.45	4.21	2.69	4.19	4.07	3.51	2.97	2.52	3.95	3.49	2.89	1.99
1116	xxx	3.44	2.34	3.48	3.52	3.16	2.76	2.40	3.40	3.09	2.65	1.93
1117	xxx	4.20	2.74	4.14	4.14	3.72	3.28	2.87	4.15	3.61	3.07	2.18
1118	5.05	5.14	3.11	5.24	5.09	4.35	3.68	3.09	4.94	4.33	3.59	2.39
1119	4.09	4.31	2.76	4.48	4.38	3.70	3.07	2.52	4.24	3.71	3.07	2.04
1120	3.59	3.99	2.73	4.14	4.06	3.58	3.09	2.63	3.96	3.54	3.03	2.21
1121	4.06	4.20	2.84	4.31	4.23	3.74	3.25	2.77	4.12	3.69	3.15	2.29
1122	4.25	4.46	2.98	4.57	4.49	3.94	3.38	2.87	4.38	3.94	3.37	2.50
1123	3.97	4.45	2.93	4.59	4.51	3.98	3.43	2.92	4.41	3.95	3.36	2.46
1124	3.96	4.38	2.91	4.53	4.41	3.86	3.26	2.70	4.31	3.85	3.25	2.35
1125	4.59	4.85	3.14	4.94	4.83	4.24	3.61	3.05	4.70	4.20	3.57	2.57
1126	4.37	4.60	2.88	4.70	4.52	3.85	3.17	xxx	4.41	3.89	3.22	2.18

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1128	4.36	4.62	2.90	4.74	4.58	3.90	3.15	2.51	4.46	3.94	3.25	2.18
1129	4.66	4.83	2.98	4.90	4.76	4.05	3.30	2.65	4.62	4.07	3.36	2.23
1130	4.76	4.86	2.99	4.75	4.58	3.88	3.16	2.52	4.04	3.90	3.19	2.08
1131	4.72	4.89	3.02	4.85	4.67	3.96	3.23	2.60	5.42	3.98	3.28	2.17
1132	4.93	4.67	2.82	4.79	4.64	3.90	3.18	2.55	4.48	3.91	3.18	1.96
1133	4.29	3.95	2.52	3.94	3.78	3.05	2.36	1.76	3.93	3.18	2.54	1.60
1134	5.06	4.94	3.41	5.34	5.19	4.28	3.80	3.26	4.99	4.55	3.89	2.88
1135	5.1	5.01	3.37	5.51	5.34	4.47	3.99	3.42	5.14	4.64	3.95	2.79
1136	4.72	5.01	3.37	5.19	5.06	4.45	3.88	3.40	4.91	4.40	3.77	2.77
1137	4.75	4.98	3.33	5.14	5.00	4.38	3.81	3.34	4.85	4.35	3.72	2.72
1138	4.38	4.63	3.15	4.73	4.57	4.09	3.60	3.21	4.44	3.99	3.42	2.55
1139	5.11	5.29	3.43	5.37	5.18	4.64	4.08	3.67	5.06	4.52	3.86	2.84
1140	5	5.12	xxx	5.24	5.06	4.44	3.84	3.36	4.92	4.33	3.61	2.47
1141	4.23	4.57	xxx	4.73	4.60	4.02	3.49	3.02	4.49	3.96	3.32	2.31
1142	4.52	4.72	3.16	4.78	4.66	4.18	4.20	3.31	4.54	4.04	3.44	2.47
1143	4.76	4.88	3.23	4.93	4.79	4.30	3.80	3.41	4.64	4.14	3.52	2.52
1144	4.97	5.25	3.58	5.61	5.47	xxx	4.34	3.92	5.31	4.77	4.11	3.06
1145	4.61	4.61	3.18	4.96	4.84	xxx	3.76	3.37	4.69	4.17	3.54	2.55
1146	4.12	4.29	3.05	4.48	4.38	3.95	3.56	3.26	4.26	3.84	3.30	2.48
1147	4.78	4.99	3.44	5.15	5.02	4.54	4.12	3.79	4.89	4.43	3.85	2.94
1148	4.36	4.71	3.07	4.72	4.64	4.15	3.71	3.35	4.50	4.02	3.42	2.47
1149	3.52	3.90	2.67	3.94	3.88	3.44	3.03	2.69	3.79	3.38	2.87	2.09
1150	3.39	3.73	2.76	3.91	3.83	3.52	3.24	3.01	3.74	3.40	3.00	2.38
1151	3.75	4.11	2.95	4.22	4.13	3.78	3.50	3.26	4.05	3.67	3.22	2.51
1152	3.96	4.36	3.15	4.47	4.36	3.99	3.70	3.46	4.28	3.89	3.42	2.68
1153	3.55	4.00	2.94	4.22	4.12	3.77	3.47	3.25	4.03	3.69	3.23	2.49
1154	3.6	3.86	2.87	4.01	3.93	3.58	3.30	3.10	3.84	3.50	3.06	2.34
1155	4.21	4.58	3.27	4.67	4.57	4.21	3.91	3.68	4.48	4.09	3.61	2.79
1156	4.13	4.53	3.08	4.60	4.52	4.11	3.72	3.43	4.41	3.96	3.41	2.52
1157	2.78	3.43	2.42	3.58	3.56	3.17	2.81	2.57	3.93	3.09	2.64	1.95
1158	3.29	3.70	2.80	3.84	3.85	3.57	3.32	3.14	3.68	3.46	3.07	2.47

Appendix A. (continued)

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1160	3.79	4.21	3.11	4.37	4.30	3.97	3.67	3.48	4.22	3.86	3.41	2.67
1161	2.7	3.39	2.43	3.60	3.59	3.27	2.99	2.80	3.71	3.18	2.77	2.14
1162	2.85	3.37	2.53	3.43	3.45	3.25	3.06	2.93	3.39	3.14	2.81	2.31
1163	3.73	4.05	3.09	4.06	4.03	3.82	3.60	3.47	4.19	3.69	3.33	2.74
1164	3.4	3.89	2.91	4.01	3.98	3.72	3.44	3.28	xxx	3.58	3.17	2.54
1165	2.3	3.02	2.21	3.19	3.22	2.97	2.73	2.58	xxx	2.87	2.51	1.98
1166	2.44	3.08	2.37	3.19	3.24	3.07	2.90	2.85	xxx	2.94	2.66	2.21
1167	3.35	3.71	2.88	3.76	3.74	3.56	3.37	3.31	3.69	3.42	3.09	2.57
1168	3.03	3.77	2.89	3.94	3.88	xxx	3.53	3.46	3.82	3.58	3.28	2.77
1169	2.21	2.72	2.00	2.87	2.87	xxx	2.54	2.47	2.80	2.58	2.34	1.91
1170	1.87	2.11	1.69	2.30	2.32	2.24	2.17	2.15	2.29	2.13	1.96	1.71
1171	3.29	3.45	2.78	3.60	3.56	3.44	3.32	3.28	3.52	3.33	3.07	2.66
1172	2.88	3.26	2.50	3.41	3.31	3.14	2.97	2.89	3.29	3.06	2.78	2.30
1173	2.24	2.62	2.04	2.78	2.73	2.58	2.42	2.34	2.70	2.52	2.28	1.88
1174	2.05	2.54	2.00	2.70	2.67	2.53	2.40	2.35	2.63	2.48	2.25	1.92
1175	3.21	3.81	2.87	3.92	3.80	3.65	3.50	3.44	3.76	3.56	3.24	2.75
1176	3.38	3.48	2.40	3.50	3.36	3.11	2.86	2.71	3.36	3.09	2.67	2.05
1177	2.3	2.67	2.00	2.82	2.75	2.53	2.31	2.18	2.71	2.54	2.24	1.78
1178	2.75	3.34	2.54	3.53	3.48	3.29	3.08	2.97	3.42	3.22	2.92	2.40
1179	3.32	3.94	2.81	4.00	3.89	3.68	3.47	3.35	3.86	3.59	3.20	2.58
1180	3.71	4.15	2.86	4.03	3.89	3.63	2.42	3.21	3.84	3.52	3.12	2.43
1181	2.94	3.47	2.49	3.52	3.45	3.21	2.96	2.80	3.46	3.11	2.75	2.16
1182	3.28	3.82	2.89	4.03	3.98	3.73	3.48	3.31	3.92	3.64	3.25	2.64
1183	3.84	4.17	3.09	4.31	4.22	3.97	3.71	3.55	4.17	3.85	3.42	2.72
1184	3.96	4.41	3.28	4.67	4.58	4.03	3.91	3.72	4.49	4.13	3.70	2.94
1185	4.07	4.27	3.18	4.51	4.47	3.92	3.83	3.63	4.34	3.99	3.56	2.80
1186	3.61	3.99	2.97	4.19	4.15	3.86	3.59	3.37	4.08	3.78	3.36	2.65
1187	4.4	4.46	3.25	4.64	4.54	4.25	3.96	3.73	4.48	4.13	3.69	2.91
1188	4.47	4.41	3.10	4.59	4.45	4.05	3.68	3.37	4.38	3.96	3.42	2.54
1189	4.55	4.88	3.36	5.04	4.90	4.49	4.09	3.76	4.81	4.36	3.78	2.87
1190	xxx	4.93	3.26	5.03	4.88	4.37	3.87	3.49	4.76	4.23	3.60	2.58

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1192	5.16	5.15	3.40	5.16	5.01	4.51	3.97	3.56	4.85	4.33	3.67	2.65
1193	5.19	5.26	3.45	5.28	5.13	4.61	4.07	3.66	4.94	4.42	3.76	2.72
1194	5.11	4.99	3.27	5.04	4.90	4.38	3.86	3.45	4.75	4.22	3.56	2.49
1195	5.21	5.00	3.30	5.08	4.93	4.42	3.90	3.49	5.14	4.25	3.60	2.54
1196	xxx	5.10	3.27	5.10	4.97	4.36	3.78	3.34	4.79	4.22	3.52	2.37
1197	xxx	5.55	3.45	5.49	5.37	4.71	4.11	3.67	5.42	4.53	3.78	2.59
1198	5.67	5.37	3.23	5.45	5.26	4.46	3.65	3.00	5.09	4.43	3.60	2.27
1199	5.16	4.99	3.08	5.09	4.93	4.19	3.41	2.75	4.79	4.17	3.40	2.20
1200	5.31	5.15	3.23	5.35	5.15	4.26	3.38	2.59	5.02	4.39	3.60	2.33
1201	6.28	5.85	3.52	5.98	5.75	4.81	3.91	3.08	5.56	4.87	3.99	2.58
1202	5.85	5.49	3.15	5.58	5.31	4.24	3.25	2.31	5.14	4.42	3.51	2.06
1203	5.3	5.02	3.01	5.16	4.92	3.88	2.91	2.00	4.79	4.14	3.33	1.99
1204	5.15	5.07	3.08	5.21	4.98	3.92	2.92	1.99	4.86	4.23	3.41	2.07
1205	6.5	6.15	3.52	6.21	5.89	4.74	3.67	2.72	5.73	4.94	3.98	2.41
1206	5.96	5.59	2.90	5.58	5.21	3.97	2.85	xxx	5.07	4.27	3.30	1.68
1207	4.93	4.87	2.66	4.95	4.69	3.55	2.52	xxx	4.57	3.90	3.05	1.62
1208	5.18	4.96	2.76	5.08	4.80	3.61	2.52	xxx	4.69	3.99	3.11	1.64
1209	6.07	5.71	3.12	5.77	5.45	4.20	3.04	xxx	5.30	4.50	3.51	1.91
1210	5.55	5.28	2.67	5.33	4.99	3.62	xxx	xxx	4.85	4.04	3.05	xxx
1211	4.47	4.45	2.33	4.59	4.30	3.02	xxx	xxx	4.21	3.55	2.72	xxx
1212	4.66	4.59	2.51	4.73	4.44	3.20	xxx	xxx	4.34	3.70	2.87	xxx
1213	5.9	5.65	2.98	5.72	5.35	4.02	xxx	xxx	5.19	4.38	3.38	xxx
1214	5.38	5.21	2.46	5.26	4.85	3.47	xxx	xxx	4.71	3.90	2.87	xxx
1215	3.93	4.03	1.99	4.17	3.85	2.60	xxx	xxx	3.78	3.18	2.38	xxx
1216	4.44	4.51	2.50	4.62	4.33	3.17	xxx	xxx	4.24	3.62	2.82	xxx
1217	5.25	5.25	2.80	5.28	4.95	3.72	xxx	xxx	4.81	4.06	3.13	xxx
1218	4.89	xxx	2.53	5.07	4.71	3.51	xxx	xxx	4.57	3.82	2.87	xxx
1219	3.5	xxx	2.07	4.12	3.79	2.67	xxx	xxx	3.72	3.15	2.36	xxx
1220	3.77	4.23	2.45	4.31	4.09	3.15	xxx	xxx	3.99	3.46	2.72	xxx
1221	4.74	4.97	2.77	5.01	4.76	3.73	xxx	xxx	4.61	3.95	3.07	xxx
1222	4.78	4.75	2.49	4.65	4.40	3.44	2.53	xxx	4.25	3.58	2.73	xxx

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1224	3.73	4.35	2.61	4.46	4.24	3.42	2.60	xxx	4.13	3.59	2.86	1.59
1225	4.43	4.58	2.65	4.61	4.39	3.53	2.65	xxx	4.29	3.66	2.88	1.52
1226	4.25	4.63	2.79	4.69	4.48	3.71	2.91	2.20	4.35	3.79	3.07	1.80
1227	3.39	4.25	2.57	4.32	4.10	3.35	2.56	1.88	4.06	3.46	2.78	1.56
1228	3.72	4.48	2.87	4.66	4.49	3.76	3.03	2.38	4.38	3.86	3.20	1.96
1229	4.02	4.36	2.80	4.54	4.36	3.63	2.89	2.23	4.25	3.74	3.06	1.83
1230	3.73	4.20	2.73	4.32	4.13	3.49	2.86	2.31	4.02	3.53	2.95	1.88
1231	3.73	4.15	2.70	4.27	4.11	3.47	2.83	2.27	3.98	3.48	2.90	1.83
1232	3.79	4.32	2.89	4.38	4.29	3.69	3.10	2.54	4.18	3.72	3.14	2.09
1233	4.03	4.31	2.89	4.37	4.25	3.65	3.07	2.51	4.15	3.68	3.10	2.07
1234	3.77	4.24	2.92	4.45	4.35	3.80	3.25	2.75	4.24	3.81	3.26	2.29
1235	4.11	4.37	2.93	4.54	4.44	3.88	3.33	2.81	4.32	3.86	3.28	2.24
1236	3.86	4.01	2.69	4.11	3.99	3.46	2.96	2.48	3.86	3.40	2.84	1.90
1237	4.04	4.33	2.85	4.42	4.30	3.74	3.21	2.72	4.18	3.69	3.09	2.08
1238	4.4	4.67	2.91	4.74	4.59	3.94	3.34	2.78	4.45	3.88	3.20	2.05
1239	4.53	4.95	3.03	5.00	4.83	4.15	3.54	2.97	4.69	4.10	3.38	2.15
1240	4.29	4.56	2.72	4.59	4.42	3.77	3.14	2.58	4.27	3.71	2.98	1.80
1241	3.86	4.19	2.60	4.26	4.14	3.53	2.91	2.36	4.00	3.50	2.81	1.69
1242	4.34	4.63	2.92	4.72	4.56	3.96	3.37	2.85	4.43	3.90	3.24	2.10
1243	4.64	4.90	3.02	5.02	4.81	4.17	3.55	3.03	4.66	4.07	3.36	2.15
1244	4.65	4.80	2.93	4.87	4.71	4.08	3.40	2.86	4.57	3.99	3.23	2.05
1245	3.85	4.15	2.65	4.23	4.13	3.54	2.91	2.37	4.00	3.49	2.82	1.77
1246	4.06	4.32	2.90	4.48	4.34	3.85	3.34	2.89	4.22	3.75	3.18	2.25
1247	4.81	4.93	3.15	5.07	4.87	4.33	3.77	3.32	4.73	4.16	3.50	2.44
1248	4.68	4.82	2.97	4.92	4.75	4.12	3.50	3.00	4.60	3.99	3.27	2.16
1249	3.99	4.22	2.72	4.36	4.23	3.65	3.08	2.60	4.09	3.57	2.92	1.92
1250	4.04	4.26	2.86	4.29	4.19	3.74	3.26	2.87	4.06	3.61	3.04	2.19
1251	5	5.07	3.19	5.06	4.89	4.36	3.80	3.38	4.75	4.19	3.51	2.48
1252	4.73	4.62	2.66	4.66	4.46	3.79	3.17	2.63	4.32	3.73	2.99	1.82
1253	3.82	3.91	2.43	3.93	3.83	3.24	2.70	2.19	3.71	3.23	2.61	1.63
1254	3.91	4.17	2.71	4.23	4.15	3.68	3.21	2.81	4.01	3.56	2.98	2.08

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1256	4.76	4.93	2.89	5.03	4.83	4.14	3.53	3.02	4.68	4.06	3.30	2.08
1257	3.75	4.09	2.52	4.19	4.05	3.45	2.91	2.43	3.93	3.40	2.76	1.74
1258	3.69	4.11	2.68	4.24	4.13	3.67	3.26	2.89	4.00	3.55	3.00	2.17
1259	4.66	4.82	2.97	4.90	4.75	4.21	3.74	3.34	4.60	4.06	3.41	2.40
1260	4.63	4.63	2.74	4.71	4.52	3.94	3.41	2.96	4.39	3.82	3.15	2.05
1261	3.83	4.01	2.47	4.09	3.94	3.44	2.97	2.54	3.84	3.36	2.78	1.81
1262	3.46	3.99	2.58	4.12	4.00	3.59	3.21	2.88	3.89	3.47	2.96	2.14
1263	4.41	4.57	2.85	4.67	4.53	4.05	3.62	3.27	4.38	3.89	3.29	2.36
1264	4.45	4.45	2.64	4.52	4.37	3.80	3.32	2.89	4.22	3.68	3.01	1.97
1265	3.33	3.54	2.26	3.71	3.59	3.10	2.67	2.32	3.47	3.05	2.51	1.65
1266	3.4	3.79	2.57	3.87	3.78	3.40	3.06	2.62	3.67	3.28	2.81	2.07
1267	4.14	4.53	2.88	4.55	4.43	4.01	3.63	3.29	4.32	3.85	3.27	2.38
1268	4.2	4.42	2.74	4.51	4.36	3.86	3.41	3.00	4.23	3.72	3.08	2.06
1269	2.92	3.51	2.23	3.58	3.50	3.03	2.64	2.27	3.39	2.96	2.42	1.55
1270	3.28	3.75	2.66	3.80	3.78	3.47	3.19	2.98	3.68	3.35	2.94	2.31
1271	4.06	4.30	2.96	4.43	4.34	4.02	3.71	3.48	4.23	3.85	3.36	2.62
1272	3.88	4.30	2.87	4.42	4.30	3.88	3.52	3.20	4.19	3.72	3.15	2.29
1273	2.69	3.37	2.34	3.54	3.49	3.11	2.77	2.50	3.37	2.98	2.51	1.79
1274	2.74	3.29	2.50	3.45	3.44	3.21	2.98	2.82	3.33	3.06	2.70	2.13
1275	3.72	4.12	2.95	4.22	4.14	3.88	3.63	3.42	4.05	3.71	3.28	2.59
1276	3.59	4.09	2.79	4.23	4.08	3.76	3.43	3.16	3.99	3.55	3.03	2.23
1277	2.53	3.24	2.32	3.46	3.35	3.03	2.73	2.50	3.32	2.88	2.44	1.79
1278	2.48	3.03	2.27	3.14	3.14	2.92	2.73	2.59	3.05	2.78	2.43	1.93
1279	3.43	3.94	2.71	3.82	3.78	3.55	3.33	3.16	3.69	3.38	2.96	2.33
1280	3.35	3.99	2.68	3.98	3.87	3.58	3.32	3.11	3.78	3.40	2.92	2.18
1281	2.69	3.36	2.42	3.55	3.48	3.19	2.92	2.73	3.39	3.05	2.60	1.94
1282	2.36	2.94	2.18	3.09	3.08	2.88	2.67	2.55	3.01	2.73	2.36	1.83
1283	3.31	3.61	2.55	3.69	3.63	3.42	3.20	3.05	3.56	3.23	2.81	2.17
1284	3.2	3.43	2.21	3.47	3.39	3.10	2.81	2.60	3.32	2.93	2.42	1.63
1285	2.7	3.28	2.18	3.35	3.30	3.01	2.74	2.55	3.25	2.87	2.39	1.64
1286	2.79	3.43	2.30	3.51	3.48	3.19	2.94	2.75	3.40	3.01	2.52	1.74

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1288	3.96	4.23	2.82	4.38	4.24	3.91	3.57	3.35	4.13	3.71	3.15	2.30
1289	3.3	3.59	2.48	3.73	3.64	3.34	3.01	2.83	3.54	3.15	2.69	1.91
1290	2.91	3.32	2.43	3.41	3.37	3.13	2.90	2.77	3.31	2.99	2.60	2.05
1291	3.43	3.74	2.63	3.84	3.78	3.53	3.32	3.16	3.69	3.35	2.90	2.26
1292	3.6	3.95	2.71	4.06	3.98	3.57	3.26	2.99	3.86	3.46	2.97	2.19
1293	3.57	4.09	2.79	4.23	4.14	3.79	3.49	3.20	4.03	3.62	3.12	2.30
1294	3.51	3.94	2.64	4.02	3.95	3.53	3.12	2.73	3.86	3.45	2.90	2.08
1295	3.5	3.90	2.65	3.99	3.93	3.52	3.12	2.74	3.83	3.42	2.89	2.09
1296	4.05	4.35	2.91	4.40	4.30	3.78	3.24	2.78	4.18	3.72	3.15	2.27
1297	4.22	4.61	2.99	4.67	4.57	4.05	3.48	3.02	4.44	3.94	3.33	2.37
1298	4.01	4.35	2.80	4.46	4.35	3.81	3.23	2.74	4.24	3.72	3.09	2.13
1299	3.93	4.19	2.75	4.29	4.17	3.63	3.07	2.57	4.07	3.57	2.96	2.05
1300	4.64	4.77	3.12	4.83	4.71	4.14	3.55	3.06	4.57	4.05	3.40	2.40
1301	4.89	5.07	3.23	5.13	4.98	4.38	3.76	3.26	4.85	4.27	3.58	2.52
1302	4.7	4.91	3.11	5.01	4.88	4.31	3.73	3.26	4.74	4.15	3.45	2.35
1303	4.44	4.57	2.96	4.67	4.56	3.98	3.43	2.97	4.41	3.87	3.21	2.18
1304	4.97	4.92	3.23	4.98	4.86	4.35	3.86	3.45	4.69	4.16	3.50	2.47
1305	5.77	5.64	3.53	5.67	5.48	4.89	4.29	3.86	5.34	4.69	3.94	2.75
1306	5.35	5.25	3.14	5.34	5.15	4.53	3.90	3.45	5.00	4.33	3.53	2.24
1307	4.75	4.71	2.90	4.77	4.62	4.06	3.50	3.08	4.50	3.90	3.19	2.03
1308	5.14	5.10	3.20	5.08	4.93	4.42	3.94	3.59	4.80	4.23	3.55	2.49
1309	6.37	6.08	3.61	6.04	5.77	5.11	4.49	4.07	5.62	4.91	4.08	2.80
1310	6	5.70	3.19	5.76	5.46	4.69	4.03	3.55	5.31	4.55	3.66	2.20
1311	4.91	4.78	2.85	4.90	4.70	4.05	3.50	3.13	4.57	3.97	3.21	1.97
1312	5.27	5.13	3.21	5.26	5.05	4.44	3.93	3.55	4.89	4.26	3.48	2.23
1313	6.66	6.20	3.64	6.23	5.90	5.16	4.52	4.04	5.74	4.95	4.03	2.57
1314	5.93	5.64	3.09	5.64	5.34	4.59	3.93	3.44	5.19	4.44	3.53	2.07
1315	4.73	4.67	2.72	4.75	4.56	3.93	3.38	2.99	4.43	3.82	3.07	1.81
1316	5.22	5.10	3.12	5.14	4.97	4.42	3.91	3.58	4.83	4.22	3.49	2.28
1317	6.58	6.20	3.54	6.15	5.87	5.16	4.50	4.05	5.71	4.93	4.03	2.58
1318	6.34	5.90	3.16	5.87	5.55	4.78	4.06	3.56	5.41	4.60	3.64	2.09

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1320	5.21	5.00	3.14	5.04	4.87	4.37	3.89	3.60	4.72	4.17	3.46	2.29
1321	6.52	6.07	3.55	6.03	5.75	5.10	4.48	4.08	5.59	4.87	3.99	2.59
1322	6	5.63	3.08	5.63	5.31	4.60	3.94	3.50	5.18	4.42	3.50	2.06
1323	4.28	4.33	2.57	4.47	4.26	3.71	3.21	2.89	4.15	3.58	2.86	1.69
1324	4.78	4.75	3.09	4.81	4.67	4.20	3.79	3.56	4.53	4.00	3.35	2.30
1325	6.14	5.84	3.52	5.81	5.59	4.99	4.45	4.12	5.44	4.75	3.94	2.64
1326	5.49	5.06	2.86	5.01	4.76	4.16	3.58	3.20	4.64	3.97	3.16	1.81
1327	4.03	4.02	2.45	4.08	3.92	3.45	3.01	2.70	3.97	3.30	2.64	1.54
1328	4.58	4.53	3.01	4.75	4.61	4.19	3.84	3.60	4.49	3.99	3.34	2.30
1329	5.44	4.96	3.13	5.07	4.88	4.40	3.98	3.70	4.75	4.17	3.44	2.29
1330	4.89	4.84	3.01	4.97	4.76	4.24	3.83	3.54	4.64	4.07	3.36	2.28
1331	4.1	4.29	2.77	4.44	4.25	3.78	3.41	3.18	4.14	3.64	2.99	2.03
1332	3.82	4.12	2.77	4.26	4.12	3.75	3.45	3.26	4.02	3.59	3.04	2.23
1333	4.96	4.80	3.09	4.87	4.71	4.31	3.96	3.73	4.61	4.09	3.47	2.51
1334	3.94	3.85	2.20	3.95	3.72	3.30	2.94	2.66	3.66	3.17	2.55	1.50
1335	3.92	4.13	2.47	4.21	4.04	3.62	3.25	3.00	3.99	3.54	2.94	1.87
1336	3.82	3.43	1.86	3.44	3.36	2.92	2.57	2.39	3.29	2.83	2.26	1.28
1337	3.37	2.85	1.60	2.91	2.82	2.41	2.11	1.94	2.75	2.37	1.86	1.04
1338	4.46	4.59	2.83	4.67	4.56	4.19	3.95	3.62	4.41	3.99	3.38	2.30
1339	3.97	4.10	2.56	4.14	4.02	3.65	3.31	3.11	3.91	3.46	2.86	1.85
1340	3.95	4.17	2.74	4.26	4.14	3.79	3.50	3.33	4.06	3.65	3.12	2.35
1341	4.24	4.40	2.81	4.51	4.36	4.04	3.75	3.56	4.28	3.84	3.27	2.43
1342	3.89	4.12	2.63	4.23	4.07	3.74	3.44	3.24	4.02	3.59	3.03	2.16
1343	4.36	4.60	2.85	4.66	4.50	4.15	3.81	3.59	4.43	3.94	3.35	2.38
1344	3.65	3.79	2.20	3.78	3.68	3.28	2.95	2.71	3.64	3.16	2.56	1.61
1345	3.67	3.94	2.32	3.97	3.88	3.48	3.15	2.89	3.84	3.38	2.76	1.79
1346	3.96	4.14	2.38	4.19	4.05	3.62	3.20	2.90	3.98	3.47	2.81	1.73
1347	4.09	4.29	2.46	4.40	4.23	3.78	3.34	3.06	4.16	3.61	2.94	1.82
1348	3.98	4.08	2.27	4.15	3.98	3.50	3.03	2.70	3.92	3.38	2.69	1.55
1349	3.37	3.56	2.06	3.63	3.56	3.13	2.75	2.45	3.47	3.01	2.40	1.40
1350	3.89	4.06	2.46	4.09	3.99	3.55	3.14	2.82	3.90	3.41	2.79	1.82

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1352	4.12	4.19	2.38	4.24	4.11	3.61	3.11	2.69	4.02	3.47	2.77	1.64
1353	3.51	3.83	2.23	3.89	3.83	3.35	2.88	2.48	3.73	3.23	2.59	1.55
1354	3.98	4.03	2.41	4.06	4.02	3.54	3.11	2.73	3.88	3.40	2.76	1.71
1355	4.5	4.40	2.59	4.42	4.33	3.82	3.23	2.99	4.20	3.67	2.98	1.84
1356	4.46	4.72	2.78	4.77	4.70	4.12	3.59	3.15	4.58	3.97	3.21	1.99
1357	3.25	3.66	2.17	3.60	3.60	3.05	2.56	2.18	3.49	2.99	2.35	1.35
1358	3.18	3.63	2.43	3.58	3.55	3.23	2.93	2.73	3.45	3.13	2.70	2.05
1359	4.72	4.86	3.02	4.88	4.74	4.35	3.97	3.69	4.62	4.12	3.52	2.58
1360	4.51	4.51	2.59	4.52	4.40	3.86	3.34	2.94	4.29	3.71	2.97	1.83
1361	3.41	3.66	2.24	3.73	3.68	3.22	2.79	2.44	3.58	3.14	2.52	1.58
1362	3.55	3.72	2.44	3.73	3.65	3.31	3.00	2.71	3.55	3.14	2.64	1.85
1363	4.52	4.55	2.82	4.54	4.38	3.96	3.54	3.22	4.23	3.74	3.13	2.16
1364	4.71	4.81	2.79	4.89	4.72	4.12	3.58	3.15	4.59	3.96	3.18	1.97
1365	3.31	3.51	2.17	3.60	3.53	3.02	2.58	2.21	3.42	2.95	2.34	1.40
1366	3.18	3.47	2.47	3.54	3.08	3.31	3.10	2.84	3.40	3.09	2.71	2.11
1367	4.64	4.71	3.00	4.73	4.60	4.25	3.95	4.02	4.48	4.00	3.45	2.57
1368	4.41	4.54	2.67	4.58	4.42	3.89	3.40	3.03	4.32	3.72	3.00	1.91
1369	3.1	3.59	2.30	3.73	3.65	3.20	2.80	2.47	3.56	3.09	2.50	1.63
1370	3.22	3.26	2.25	3.32	3.29	3.02	2.75	2.55	3.19	2.83	2.37	1.69
1371	4.53	4.22	2.67	4.15	4.04	3.71	3.37	3.14	3.95	3.50	2.93	2.08
1372	4.61	4.73	2.81	4.75	4.56	4.03	3.55	3.16	4.46	3.89	3.15	1.97
1373	3.22	3.59	2.27	3.68	3.60	3.14	2.73	2.39	3.51	3.05	2.44	1.46
1374	3.08	3.47	2.42	3.59	3.58	3.31	3.04	2.85	4.46	3.13	2.67	1.99
1375	4.34	4.46	2.85	4.52	4.41	4.08	3.73	3.49	4.29	3.82	3.22	2.34
1376	4.26	4.47	2.72	4.50	4.38	3.92	3.49	3.19	4.28	3.73	3.03	2.02
1377	3.13	3.49	2.27	3.59	3.51	3.10	2.73	2.47	3.43	3.00	2.43	1.61
1378	3.07	3.38	2.41	3.51	3.46	3.22	3.01	2.87	3.37	3.05	2.61	2.00
1379	4.07	4.26	2.80	4.33	4.21	3.93	3.65	3.47	4.13	3.71	3.16	2.37
1380	4.21	4.36	2.70	4.46	4.29	3.87	3.49	3.24	4.23	3.68	3.00	2.02
1381	2.94	3.30	2.23	3.47	3.38	2.98	2.65	2.46	3.31	2.87	2.34	1.57
1382	2.91	3.42	2.49	3.56	3.49	3.23	3.02	2.90	3.42	3.08	2.70	2.09

Appendix A. (continued)

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1384	3.85	4.16	2.53	4.24	4.10	3.71	3.37	3.14	4.06	3.55	2.91	1.98
1385	2.83	2.98	1.99	3.07	3.01	2.65	2.36	2.19	2.95	2.59	2.10	1.43
1386	2.96	3.17	2.39	3.27	3.22	3.01	2.84	2.76	3.14	2.89	2.55	2.07
1387	3.83	4.22	2.86	4.27	4.15	3.93	3.72	3.58	4.09	3.72	3.25	2.54
1388	4.08	4.48	2.84	4.42	4.29	3.96	3.68	3.46	4.24	3.78	3.19	2.26
1389	3.06	3.54	2.37	3.61	3.54	3.20	2.93	2.75	3.47	3.09	2.59	1.80
1390	2.82	3.25	2.43	3.39	3.32	3.12	2.92	2.83	3.27	2.99	2.64	2.12
1391	3.67	4.04	2.80	4.10	3.97	3.77	3.56	3.43	3.93	3.59	3.14	2.49
1392	3.97	4.30	2.85	4.39	4.26	3.91	3.61	3.40	4.19	3.74	3.15	2.30
1393	2.91	3.41	2.42	3.60	3.55	3.22	2.93	2.79	3.46	3.09	2.61	1.90
1394	2.78	3.17	2.40	3.32	3.31	3.11	2.91	2.83	3.26	2.97	2.61	2.07
1395	3.52	3.80	2.73	3.89	3.81	3.60	3.40	3.28	3.79	3.43	3.01	2.39
1396	3.85	4.17	2.88	4.30	4.15	3.85	3.58	3.41	4.10	3.67	3.16	2.40
1397	3.18	3.66	2.60	3.86	3.74	3.43	3.17	3.02	3.68	3.30	2.82	2.12
1398	3.06	3.45	2.55	3.60	3.56	3.34	3.12	3.02	3.51	3.19	2.78	2.19
1399	3.44	3.74	2.70	3.84	3.77	3.57	3.33	3.21	3.73	3.38	2.95	2.33
1400	4.04	4.34	3.09	4.51	4.36	4.10	3.83	3.69	4.30	3.89	3.40	2.67
1401	3.72	3.93	2.81	4.07	3.93	3.63	3.33	3.18	3.86	3.46	2.99	2.27
1402	3.45	3.91	2.83	4.04	3.97	3.73	3.50	3.39	3.92	3.61	3.21	2.60
1403	3.91	4.20	3.01	4.33	4.26	4.04	3.80	3.68	4.22	3.88	3.45	2.78
1404	3.88	4.17	3.02	4.32	4.19	3.94	3.66	3.51	4.14	3.77	3.32	2.62
1405	4.13	4.52	3.19	4.61	4.49	4.14	3.95	3.80	xxx	4.04	3.55	2.83
1406	3.74	4.08	2.83	4.13	4.08	3.80	3.51	3.35	xxx	3.63	3.14	2.41
1407	3.52	3.86	2.75	3.98	3.91	3.62	3.35	3.19	3.87	3.48	3.02	2.32
1408	4.4	4.65	3.29	4.79	4.67	4.18	4.03	xxx	4.59	4.15	3.63	2.85
1409	4.61	4.90	3.39	5.07	4.93	4.45	4.29	xxx	4.84	4.36	3.81	2.97
1410	xxx	4.54	3.12	4.63	4.56	4.22	3.87	3.68	4.48	4.00	3.46	2.63
1411	xxx	3.98	2.82	4.06	4.04	3.70	3.35	3.19	3.97	3.55	3.07	2.32
1412	4.45	4.56	3.32	4.69	4.59	3.94	3.97	3.76	4.51	4.09	3.62	2.84
1413	5.4	5.50	3.77	5.61	5.45	4.74	4.75	4.54	5.19	4.83	4.25	3.30
1414	5.06	4.94	3.25	4.77	4.86	4.43	4.05	3.74	4.77	4.21	3.59	2.61

Appendix A. (continued)

Station	P01	P02	P03	P04	P06	P07	P08	P09	P11	P12	P13	P14
1415	4.02											

APPENDIX B

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

Appendix B. (continued)

List of Plant Species

A list of plant species used in text and tables or specifically noted in the field with accompanying authorities and common names follows. Both common and scientific names for vascular plants generally follow Kartesz and Meachum (2005). Some species have been updated to follow Weakley (2008). Species considered sensitive herbaceous species are marked with an asterisk (*). The list is cumulative for the project.

Acer rubrum L. Red Maple
Alnus serrulata (Ait.) Wild. Tag Alder
**Alternanthera philoxeroides* (Mart.) Griseb. Alligator-Weed
Amaranthus cannabinus (L.)Sauer Tidal-Marsh Amaranth
Apios americana Medik. Groundnut
Arundinaria gigantea (Walter)Muhl. River Cane
**Aster* sp. Probably *Symphyotrichum elliottii*
Bidens cernua L. Bur-marigold
Bidens laevis (L.) B.S.P. Smooth Beggarticks
Bidens mitis (Michx.) Sherff. Small-fruit Beggarticks
Bidens sp. Beggarticks
**Boehmeria cylindrica* (L.) Sw. Small-Spike False Nettle
Bolboschoenus robustus (Pursh) J. Soják Salt-marsh Bulrush
**Boltonia asteroides* (L.) L'Hér. White Doll's-Daisy
Campsis radicans (L.) Seem. Ex Bureau Trumpet-Creeper
**Carex* L. Sedge
Carex albolutescens Schwein. Narrow-winged Sedge
Carex amphibole Steud. Eastern narrow-leaf Sedge
**Carex crinita* Lam. Fringed Sedge
**Carex crinita* var. *brevicrinis* Fern. Fringed Sedge
**Carex crus-corvi* Shuttlw. Ex Kunze Raven-Foot Sedge
Carex debilis Michx. White-Edge Sedge
Carex gigantea Rudge Giant Sedge
**Carex hyalinolepis* Steud. Shoreline Sedge
Carex leptalea Wahlenb. Bristly-stalk Sedge
**Carex lupulina* Muhl. Ex Willd. Hop Sedge
Carya aquatica (Michaux f.) Elliott, Water Hickory
**Chasmanthium latifolium* (Michx.) Yates Indian Wood-Oats
**Cicuta maculata* L. Spotted Water-Hemlock
**Cinna arundinacea* L. Sweet Wood-Reed
**Clematis crispa* L. Marsh Clematis
**Clematis ternifolia* DC. Sweet Autumn Clematis
**Commelina virginica* L. Virginia Dayflower
Cornus amomum P. Miller, Silky Dogwood
**Cyperus* L. Umbrella Sedge
**Decodon verticillatus* (L.) Ell. Swamp-Loosestrife
**Dulichium arundinaceum* (L.) Britt. Three-Way Sedge
Echinochloa walteri (Persh) Heller Barnyard Grass
**Elymus virginicus* var. *halophilus* (Bicknell) Wiegand Salt-marsh Wild Rye
Erechtites hieraciifolius (L.)Raf. ex DC. Fireweed
**Eryngium aquaticum* L. Rattlesnake-Master
Eupatorium capillifoliuim (Lam.) Small Dog-fennel
Fraxinus caroliniana P. Mill. Carolina Ash
Fraxinus pennsylvanica Marsh Green Ash
Fraxinus profunda (Bush) Bush Pumpkin Ash
**Galium* L. Bedstraw
Hydrocotyle L. Marsh-Pennywort
**Hydrocotyle verticillata* Thunb. Whorled Marsh-Pennywort
**Hymenocallis crassifolia* Herbert Swamp Spider-Lily

Hypericum walteri (Gmelin) Gleason Marsh St. John's-wort
Impatiens capensis Meerb. Spotted Touch-Me-Not
Ipomoea L. Morning-Glory
Juncus effusus ssp. *solutus* (Fernald & Wiegand) Hämet-ahti Soft Rush
Leersia lenticularis Michx. Catchfly Cutgrass
**Leersia oryzoides* (L.) Swartz Rice Cutgrass
Leucothoe racemosa (L.) Gray Swamp Doghobble
Lilaeopsis chinensis (L.) Kuntze Eastern Grasswort
**Lobelia cardinalis* L. Cardinal-Flower
*Ludwigia decurrens*Walter Wingstem Water Primrose
**Ludwigia grandiflora* (M. Micheli) Greuter & Burdet Large-Flower Primrose-Willow
Ludwigia leptocarpa (Nutt.) Hara Water-willow
**Ludwigia palustris* (L.) Ell. Marsh Primrose-Willow
**Lycopus virginicus* L. Virginia Water-Horehound
**Mikania scandens* (L.) Willd. Climbing Hempvine
Morella cerifera (L.) Small Common Wax-myrtle
Murdannia keisak (Hassk.) Hand.-Maz. Wart-Removing-Herb
Nyssa aquatica L. Water Tupelo
Nyssa biflora Walt. Swamp Tupelo
Oenothera riparia Nuttall Riverbank Evening-Primrose (was *O. fruticosa* ssp. *glauca*)
**Orontium aquaticum* L. Goldenclub
Osmunda regalis var. *spectabilis* Gray Royal Fern
Packera glabella (Poir.) C. Jeffrey Cress-Leaf Groundsel
**Peltandra virginica* (L.) Schott Green Arrow-Arum
Persea palustris (Raf.) Sarg. Swamp Bay
**Phanopyrum gymnocarpon* (Ell.) Nash Savannah-Panic Grass
**Physostegia leptophylla* Small Slender-Leaf False Dragonhead
Pilea pumila (L.) Gray Canadian Clearweed
Platanthera flava (L.) Lindley Rein Orchid
Pluchea odorata (L.) Cass. Sweetscent
Polygonum arifolium L. Halberd-Leaf Tearthumb
**Polygonum hydropiper* L. Mild Water-Pepper
**Polygonum hydropiperoides* Michx. Swamp Smartweed
**Polygonum punctatum* Ell. Dotted Smartweed
**Polygonum virginianum* L. Jumpseed
**Pontederia cordata* L. Pickerelweed
Porella pinnata L Leafy Liverwort
Proserpinaca palustris L. Marsh Mermaidweed
Quercus lyrata Walter, Overcup Oak
Quercus michauxii Nuttall, Basket Oak
Rotala ramosoir (L.)Koch. Toothcup
**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
Sagittaria latifolia Wild. Wapato
**Saururus cernuus* L. Lizard's-Tail
**Scutellaria lateriflora* L. Mad Dog Skullcap
**Schoenoplectus americanus* (Pers.) Volk. Ex Schinz & R. Keller Chairmaker's Club-Rush
Schoenoplectus robustus see *Bolboschoenus robustus*
Schoenoplectus tabernaemontani (K.C. Gmel.) Palla Soft-Stem Club-Rush
**Sium suave* Walt. Hemlock Water-Parsnip
Smilax rotundifolia L. Horsebrier

Solidago sempervirens var. *mexicana* (L.) Fern. Seaside Goldenrod
Spartina cynosuroides (L.) Roth Big Cord Grass
**Symphyotrichum elliottii* (Torr. & Gray) Nesom Marsh American-Aster
Symphyotrichum subulatum (Michx.) Nesom Seaside American-Aster
Symphyotrichum tenuifolium (L.) Nesom Perennial Saltmarsh American-Aster
Taxodium ascendens Brongn. Pond-Cypress
Toxicodendron radicans (L.) Kuntze Eastern Poison-Ivy
Toxicodendron vernix (L.) Kuntze Poison Sumac
**Triadenum walteri* (J.G. Gmel.) Gleason Greater Marsh-St. John's-Wort
**Typha latifolia* L. Broad-Leaf Cat-Tail
Typha angustifolia L. Narrow-Leaf Cat-Tail
Typha ×glauca Godr. (pro sp.)
Viburnum dentatum L. Southern Arrow-Wood
Woodwardia areolata (L.) T. Moore Netted Chain Fern
Woodwardia virginica (L.) E. Smith Virginia Chain Fern
**Zizania aquatica* L. Indian Wild Rice
**Zizaniopsis miliacea* (Michx.) Doell & Aschers. Marsh-Millet

Literature Cited

Kartesz, J.T., and C.A. Meacham. 2005. Synthesis of the North American Flora, Prepublication Version 2.0. Missouri Botanical Garden Press, St. Louis.

Weakley, A. S. 2008. Flora of the Carolinas, Virginia, Georgia, Northern Florida, and Surrounding Areas. Working Draft of 7 April 2008. University of North Carolina Herbarium, North Carolina Botanical Garden, University of North Carolina at Chapel Hill. Chapel Hill, NC.

APPENDIX C

METADATA COVERING GIS/GPS FILES USED IN TEXT FIGURES IN SENSITIVE HERBACEOUS VEGETATION POLYGONS: 2009 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 STATION P3, INNER 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 collection 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 STATION P3, INNER TOWN CREEK

FIGURE 8.41-1

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

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
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

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATION P3, INNER 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:	**TC08PO .shp, TC08PO.dbf, TC08PO.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2008
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.9 and Arcview 3.3
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	14 Jan 2009
SOURCE:	David M. DuMond
SOURCE ADDRESS:	1600 Hicks Road Broadway, NC 27505
SOURCE PHONE:	919/258-3032

METADATA

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

FIGURE 8.41-1

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

FILE NAMES:	**wilm_har_gps_data_nc-sp83-ft.shp, wilm_har_gps_data_nc-sp83-ft.dbf, wilm_har_gps_data_nc-sp83-ft.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2010
SOURCE:	Trimble Geo XT
DATA TYPE:	Polygon
SOFTWARE:	ArcMap 9.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	16 April 2010
SOURCE:	Dial Cordy & Associates Incorporated
SOURCE CONTACT:	Rahlff Ingle
SOURCE ADDRESS:	201 N. Front St. Suite 307 Wilmington, NC 28401
SOURCE PHONE:	910/251-9790
SOURCE FAX:	910/251-9409

METADATA

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

FIGURE 8.41-1

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

FILE NAME:	**78369251.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown during February, 2008 for Brunswick County, NC.
SOURCE:	Zeiss Digital Mapping Camera (DMC) Scale: 1” = 200’
DATA TYPE:	TIF, TFW, 6 inch pixel
SOFTWARE:	TIFF Image 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:	February 2008
SOURCE:	USGS
SOURCE CONTACT:	USGS Representative
SOURCE ADDRESS:	USGS Earth Resources Observation 47914 252nd Street Sioux Falls, SD
SOURCE PHONE:	800-252-4547

METADATA

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

FIGURE 8.42-1

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

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
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 STATION P7, INDIAN CREEK

FIGURE 8.42-1

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

FILE NAMES:	**Indcr .shp, Indcr.dbf, Indcr.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 February 2003
SOURCE:	David M. DuMond
SOURCE ADDRESS:	1600 Hicks Road Broadway, NC 27505
SOURCE PHONE:	919/258-3032
FILE NAMES:	**Indcrpo3.shp, Indcrpo3.dbf, Indcrpo3.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2008
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
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	4 August 2008
SOURCE:	David M. DuMond
SOURCE ADDRESS:	1600 Hicks Road Broadway, NC 27505
SOURCE PHONE:	919/258-3032

METADATA

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

FIGURE 8.42-1

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

FILE NAME:	**99188092.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown during February, 2008 for Brunswick County, NC.
SOURCE:	Zeiss Digital Mapping Camera (DMC) Scale: 1” = 200’
DATA TYPE:	TIF, TFW, 6 inch pixel
SOFTWARE:	TIFF Image 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:	February 2008
SOURCE:	USGS
SOURCE CONTACT:	USGS Representative
SOURCE ADDRESS:	USGS Earth Resources Observation 47914 252nd Street Sioux Falls, SD
SOURCE PHONE:	800-252-4547

METADATA

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

FIGURE 8.43-1

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

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

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 STATION P8, DOLLISONS 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 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 STATION P8, DOLLISONS LANDING

FIGURE 8.43-1

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

FILE NAME:	**41804839.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown during February, 2008 for Brunswick County, NC.
SOURCE:	Zeiss Digital Mapping Camera (DMC) Scale: 1” = 200’
DATA TYPE:	TIF, TFW, 6 inch pixel
SOFTWARE:	TIFF Image 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:	February 2008
SOURCE:	USGS
SOURCE CONTACT:	USGS Representative
SOURCE ADDRESS:	USGS Earth Resources Observation 47914 252nd Street Sioux Falls, SD
SOURCE PHONE:	800-252-4547

METADATA

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

FIGURE 8.44-1

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

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
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

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATION 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:	**briv.shp, briv.dbf, briv.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2005
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon
SOFTWARE:	Pathfinder Office 2.9, ArcView 3.3
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	21 January, 2006
SOURCE:	David M. DuMond
SOURCE ADDRESS:	1600 Hicks Road Broadway, NC 27505
SOURCE PHONE:	919/258-3032

METADATA

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

FIGURE 8.44-1

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

FILE NAME:	**62798558.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown during February, 2008 for Brunswick County, NC.
SOURCE:	Zeiss Digital Mapping Camera (DMC) Scale: 1” = 200’
DATA TYPE:	TIF, TFW, 6 inch pixel
SOFTWARE:	TIFF Image 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:	February 2008
SOURCE:	USGS
SOURCE CONTACT:	USGS Representative
SOURCE ADDRESS:	USGS Earth Resources Observation 47914 252nd Street Sioux Falls, SD
SOURCE PHONE:	800-252-4547

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATION 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, Ratpil2.dbf, Ratpil2.shx**
DESCRIPTION OF LAYER:	Point depicting new (2002) location of data collection platform piling
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 ADDRESS:	1600 Hicks Road Broadway, NC 27505
SOURCE PHONE:	919/258-3032

METADATA

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

FIGURE 8.45-1

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

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

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

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATION 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

METADATA

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

FIGURE 8.45-1

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

FILE NAME:	**3210-3.sid**
DESCRIPTION OF LAYER:	True color aerial photography was flown during March, 2006 for New Hanover County.
SOURCE:	Vexcel UltraCamD digital camera Scale: 1” = 200’
DATA TYPE:	MrSID Compressed Image, 6 inch pixel
SOFTWARE:	MrSID Image 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:	March 2006
SOURCE:	New Hanover County, NC
SOURCE CONTACT:	Leslie Stanfield, Director
SOURCE ADDRESS:	230 Government Center Drive Wilmington, NC 28403
SOURCE PHONE:	910-798-7107

METADATA

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

FIGURE 8.46-1

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

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

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

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATION 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:	**Fishcr07 .shp, Fishcr07.dbf, Fishcr07.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2007
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.9, Arcview 3.3
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 2008
SOURCE:	David M. DuMond
SOURCE ADDRESS:	1600 Hicks Road Broadway, NC 27505
SOURCE PHONE:	919/258-3032

METADATA

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

FIGURE 8.46-1

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

FILE NAMES:	**wilm_har_gps_data_nc-sp83-ft.shp, wilm_har_gps_data_nc-sp83-ft.shp.dbf, wilm_har_gps_data_nc-sp83-ft.shp.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2010
SOURCE:	Trimble Geo XT
DATA TYPE:	Polygon
SOFTWARE:	ArcMap 9.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	16 April 2010
SOURCE:	Dial Cordy & Associates Incorporated
SOURCE CONTACT:	Rahlff Ingle
SOURCE ADDRESS:	201 N. Front St. Suite 307 Wilmington, NC 28401
SOURCE PHONE:	910/251-9790
SOURCE FAX:	910/251-9409

METADATA

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

FIGURE 8.46-1

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

FILE NAME:	**48194475.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown during February, 2008 for Pender County, NC.
SOURCE:	Zeiss Digital Mapping Camera (DMC) Scale: 1” = 200’
DATA TYPE:	TIF, TFW, 6 inch pixel
SOFTWARE:	TIFF Image 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:	February 2008
SOURCE:	USGS
SOURCE CONTACT:	USGS Representative
SOURCE ADDRESS:	USGS Earth Resources Observation 47914 252nd Street Sioux Falls, SD
SOURCE PHONE:	800-252-4547

METADATA

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

FIGURE 8.47-1

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

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

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

METADATA

POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATION 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:	**PGR08PO.shp, PGR08PO.dbf, PGR08PO.shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2008
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.9, Arcview 3.3
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	4 January, 2008
SOURCE:	David M. DuMond
SOURCE ADDRESS:	1600 Hicks Road Broadway, NC 27505
SOURCE PHONE:	919/258-3032

METADATA

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

FIGURE 8.47-1

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

FILE NAME:	**34178736.tif**
DESCRIPTION OF LAYER:	True color aerial photography was flown during February, 2008 for Pender County, NC.
SOURCE:	Zeiss Digital Mapping Camera (DMC) Scale: 1” = 200’
DATA TYPE:	TIF, TFW, 6 inch pixel
SOFTWARE:	TIFF Image 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:	February 2008
SOURCE:	USGS
SOURCE CONTACT:	USGS Representative
SOURCE ADDRESS:	USGS Earth Resources Observation 47914 252nd Street Sioux Falls, SD
SOURCE PHONE:	800-252-4547

APPENDIX D

AREAS AND COORDINATES FOR NEWLY (YEAR 2009) MODIFIED SENSITIVE HERBACEOUS VEGETATION POLYGONS AT SAMPLING STATIONS IN THE CAPE FEAR RIVER ESTUARY, WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA

Appendix D. Areas and coordinates of newly (year 2009) modified sensitive herbaceous vegetation polygons 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	1691	1	140252	2304184
		2	140262	2304194
		3	140255	2304210
		4	140255	2304217
		5	140257	2304240
		6	140254	2304259
		7	140221	2304236
		8	140215	2304226
		9	140225	2304213
		10	140245	2304213
		11	140239	2304190
Fishing Creek/P13	620	1	215459	2303574
		2	215469	2303574
		3	215455	2303580
		4	215452	2303583
		5	215449	2303586
		6	215439	2303606
		7	215436	2303590
		8	215436	2303580
		9	215442	2303573
		10	215440	2303554
		11	215453	2303560

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