Monitoring Effects of a Potential Increased Tidal Range in the Cape Fear River Ecosystem Due to Deepening Wilmington Harbor, North Carolina
Year 1: August 1, 2000 – July 31, 2001

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ABSTRACT

A monitoring system along the Cape Fear River, the Northeast Cape Fear River, and Town Creek has provided data on 1) natural tidal flux and salinity change in the main stem of these rivers and creeks, 2) the degree to which floodwater with its salt load reaches into swamps and marshes adjacent to nine of the 11 sites, 3) variations in fundamental decompositional process caused by the sulfate in seawater on these wetland soils, and 4) effects of the saline water and flooding on salt-sensitive vegetation. Small animals (benthos) living in sediments along the water's edge and small motile fish and crustaceans that inhabit the shallow intertidal and shallow subtidal habitats (epibenthos) likely to be impacted by a change in salinity or flooding have also been monitored. Initial data were collected summer 1999. Data collected represent conditions before channel reconfiguration from the current widening and deepening project likely impacted upstream marsh/swamp habitats.

Each data collection platform has experienced problems ranging from lightning strikes that destroyed circuit boards in instruments to unstable support pilings. Only one station, Rat Island, in the Northeast Cape Fear River, has not provided enough data to support before versus after analyses. This station became operational at the end of the reporting period (May 2001) after a new piling design was installed. We expect to develop an adequate database for this station before any impacts of the project are noted upstream. If not, interpolation from adjacent stations along with data already available for this site should provide an adequate database with which to work.

Tides at the base station (Ft. Caswell) follow predicted tides. Stations lower in the river experience tidal ranges similar to the base station. Correlation of the tidal range at the base station with upstream stations is high except at stations farthest upstream when high flow conditions occur. Tidal amplitude decreases upstream; as does the relationship between tide range at Ft. Caswell and upstream stations, i.e. slope changes from 1:1 to 1:<1. The farther upstream a site, the closer the slope is to 0, although linear relationships exist between all stations and the base station. The two main branches of the river behave differently. A programmed release from Jordan Dam of fresh water into the Cape Fear River appears to prevent saline water from moving upstream during drought periods. In the Northeast Cape Fear River saline conditions reach all but the background site at Prince George Creek approximately 16 miles upstream of Wilmington, NC.

Water level, flooding duration, and salinity were measured at 54 substations (6 at each of 9 stations) located along belt transects perpendicular to the main channel. Most of these substations flooded to some degree with each tide except for a station located near Indian Creek (P7) on the Cape Fear River. Elevations at this site were higher and this site flooded only on the highest range tides. Flooding depth and duration were generally greatest at

substations closest to the channel edge, except where berms were present. Salinity in water flooding the marsh or swamp generally reflected what was measured in the main channel at substations close to the channel edge and then decreased between the channel edge and the upland. Exceptions occurred when small channels carried either river water directly into the interior of the wetland or freshwater from the upland to the channel edge.

Saline water moving onto the marsh or swamp surface will have the greatest impact if it becomes incorporated into wetland soils. The degree to which this occurred during the monitoring period was evaluated by determining the sulfate and chloride content (derived mainly from seawater) in soil porewater. Typically, wetland soils not impacted by saline water are dominated by methane producing bacteria. The presence of methane in soils at each of the 54 substations was determined. There was clear evidence of sulfate derived from seawater in most of the substations at sites when saline water was measured at the surface. Two stations (Town Creek P3 and Smith Creek P11) contained substations generally classified as sulfate reducing all year long, while Eagle Island was sulfate reducing when salinity was high, especially in summer. Intrusions of saline water at river monitoring stations are reflected by the import of saltwater onto the marsh surface, which eventually becomes incorporated into soil porewater. Hydrogen sulfide, the metabolic byproduct when sulfate is reduced in sediments, is toxic to both plants and animals not adapted to saline water.

Between 27 and 61 benthic taxa were collected per station in 1999 and 2000. The species present were representative of estuaries in the Southeastern U.S. Stations were dominated by polychaetes, oligochaetes, amphipods, and insect larvae with polychaetes dominating at more saline stations and oligochaetes at freshwater stations. There were some differences among the three drainages. There were some taxonomic shifts at some stations between years, but no change in functional guilds. Guilds were relatively stable. There were more species in 1999 than in 2000, mostly due to the presence of rare species. Relatively low similarity values between years reflects the gain and loss of rare species. There was also relatively low similarity among stations.

Motile fish and crustacea entering the marsh/swamp edge were comprised of 23 taxa with lower species richness in fall 1999 because of Hurricane Floyd and the flooding that followed. Dominant resident species were gobies, fiddler crabs, grass shrimp, top minnow, and sunfish. Non-resident species entering the marsh included spot, croaker, and flounder. Lower in the intertidal zone 35 taxa were collected and were dominated by non-resident species already noted. There was greater among year similarity for spring sampling than for fall, likely due to hurricane flooding in the fall.

Salt-sensitive vegetation has been identified in seven of the nine transects and a representative portion nearest the river or channel mapped, either through the production of polygons using GPS technology to map the vegetative stand or in large quadrats within which cover and condition are evaluated. Pre-impact change was identified and likely related to natural ecological variation of salinity and pedestrian impacts. GPS technology allows relatively precise measurements of position in non-forested stations and hence polygon size, but is limited in forested transects by multipath scatter.

Based on current conditions (pre-project), vegetation and faunal change may eventually occur in the Northeast Cape Fear River as far upstream as Fishing Creek. These effects are not anticipated in the Cape Fear River upstream of Indian Creek. Changes that occur as a result of the project may both increase the penetration of saline water into the interior of marshes and swamps, increase the duration of saline events, and/or increase the movement of saline water upstream. The potential also exists that channel reconfiguration may decrease saline excursions and therefore decrease future impacts.

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EXECUTIVE SUMMARY

Models depicting tidal flooding levels and salinity of the Cape Fear River system predict as much as a four inch increase in tidal amplitude near Wilmington, NC. While the same model predict no increase in salinity, increased flooding of tidal wetlands would allow existing saline water to impact wetlands adjacent to the Cape Fear River. A monitoring study was designed to determine: 1) if a change in tidal amplitude occurs as a result of the widening and deepening of the Cape Fear River and Wilmington Harbor, 2) the aerial extent of any tidal change in the major branches of the river, and 3) impacts of any change on critical biotic component of the upper Cape Fear estuary.

Twelve data collection platforms were established in the Cape Fear system that measure water level, temperature, and salinity. A variety of biological variables are also evaluated at 10 of these stations. Stations became fully operational in 2000, although several components of the biological sampling began in 1999. An adequate pre-impact database has been developed for all stations except the Rat Island station where the data collection platform failed because of sediment instability in that part of the river. The platform has been reinstalled and data collected since May 2001. The expectation is that a sufficient database will be collected before dredging activities impact the upper estuary.

The mean tidal range during 2000-2001 was similar to the ocean at Ft. Caswell (4.37 ft). Tidal range was essentially the same upriver as far as the Wilmington Harbor - Eagle Island area and then gradually decreased upstream in both branches reaching only 3.19 ft at the confluence of the Cape Fear and Black Rivers and 2.38 ft near Prince George Creek on the Northeast Cape Fear River. Town Creek, a tributary of the lower Cape Fear River downstream of Wilmington exhibited the same phenomenon with a tidal range at the mouth of 4.29 ft and upstream range of 2.76 ft. Lower in the estuary flood and ebb tide duration were essentially the same, but further upstream ebb tide exceeded the duration of flood tide.

Saline water did not reach wetlands upstream of Eagle Island in the Cape Fear River. In the Northeast Cape Fear River, quarter strength seawater extended between eight and sixteen miles upstream of Wilmington, during periods when rainfall was low. Most wetlands adjacent to the river flooded with each tide with the duration and depth generally greater near the water's edge. Saline water in the river generally penetrated into wetlands, but was diluted by freshwater near upland edges.

Saline water entering these tidal wetlands contains sulfate that penetrates into soils and produces toxic hydrogen sulfide through the reduction of sulfate by anaerobic bacteria. Soils in wetlands near Eagle Island had sulfate reduction for large portions of the year, while wetlands adjacent to stations far upstream generally did not and were instead dominated by bacteria that produced methane. Wetland study sites that experienced pulses of saline water exhibited different conditions depending on the availability of sulfate and would alternate between sulfate reduction and methane production. Oceanic salt driven production of hydrogen sulfide extended upstream only as far as Indian Creek (4 miles upstream of Wilmington) on the Cape Fear River. In the Northeast Cape Fear River sulfate reduction occurred at least eight miles upstream of Wilmington and at higher levels for longer periods of duration. There was no evidence that ocean derived sulfate extended as far as 16 miles upstream in the Northeast Cape Fear River.

The production of hydrogen sulfide by bacteria in marsh soils when exposed to ocean derived saltwater is extremely significant because hydrogen sulfide has a high toxicity to both plants and animals characteristic of freshwater wetlands. Salt sensitive plant species are monitored in all wetlands adjacent to monitoring where they currently occur. Long-lived woody species, trees and shrubs, are also sensitive to hydrogen sulfide, but may require decades before a response can be measured. Salt sensitive species monitored should respond within a short time span, i.e. months. Comparisons of stands of designated species did identify some change in salt sensitive plants species attributed to natural variations in salinity and pedestrian traffic. Global Positioning Technology worked well to identify vegetation position in open marshes, but was limited by multipath scatter in wooded transects.

Small animals, mostly worms and small crustacea, living in the mud along the river's edge and on the wetland edge are extremely important food for aquatic organisms including many commercially important fish and crustacea. Significant change in number and/or species composition could have positive or negative impacts on higher trophic levels and ecosystem function. Sampling was designed to determine both significant changes of species composition and abundance and important shifts in community composition that could indicate change in food available for fish. In general, animals inhabiting stations lower in the Cape Fear River resembled similar sites in other estuaries and are typically dominated by spionid polychaetes. Those in freshwater sites were dominated by oligochaetes and insect larvae. The number of species was generally lower at stations in the Northeast Cape Fear River as compared to the Cape Fear River. In general, there were more species found at stations in 1999 than in 2000. There were differences in species composition among sites and among years, but the overall functional groups (guilds) remained relatively persistent.

The impact of hurricane induced flooding in fall 1999 was apparent in the abundance and species composition of small fish and epibenthos. By May 2001, 35 species of these animals had been collected adjacent to wetlands near monitoring stations and 23 species collected as they entered or exited wetlands with tidal flooding. Many of these species are important non-resident, commercial species such as spot, croaker, flounder, and blue crabs. There was greater among year (1999 vs. 2000) similarity for spring relative to fall collections due to the hurricane-induced flooding in fall 1999.

An adequate database exists to determine project impacts. Because there is no way to determine what portion of the project will lead to hydrologic change, the database will remain open for new data until the project is completed.

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 provides several critical data bases that will allow a determination of impact from 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 ebb and flood tides were determined. Comparisons of these variables before the channel is widened and deepened versus after the channel is widened and deepened will provide the statistical testing mechanism that will determine whether the project has impacted the tidal characteristics of adjacent wetlands. In addition, the absolute elevation of floodwater when related to measurements of water levels at marsh/swamp substations allows for the determination of both flood duration and flood depth for any tide. Thus, water level is a critical measure. Stations began to be brought on line in May 2000 and were technically operational in July even though all facets were not always operating continually. Problems of communication with instruments were solved as they occurred, but persistent problems continued with rapid water level changes, e.g. boat wakes, that exceeded the ability of the water level instrumentation to follow over very short time spans. This was especially a problem at low water levels and at low tide. Consistent, reliable data were not available from all instruments until stilling wells were capped in August and September. Data collected before this time can be used, but each tide must be examined for each station and a determination made as to whether an artificial jump in water level occurred.

Several major problems were solved during the past year and minor problems solved as they occurred. The instability of the Rat Island data collection platform was a safety concern since initial installation. Soft, fluid-like sediments led to the pile leaning at an angle sufficient to cause the float attached to the water level recorder to hang on the stilling well. Reinstallation of the Rat Island piling 50 feet upstream was not successful in eliminating the sway and it eventually leaned. The same pile was driven into place instead of jetted into position 10 feet further upstream with the same result as the previous two attempts. After the pile system was redesigned and two batter pilings attached to the vertical piling the data collection platform (DCP) was stable. This station is now fully functioning, but yielded no significant data (only May 2001 data collected) for this reporting period.

A second major problem was rapid vertical water level movements that exceeded the water level instrument’s recording capability. This typically resulted in dramatic increases of water level and QA/QC failures. The problem was solved with the installation of stilling well caps, which limit the rate of entry and egress of water. To insure that conductivity (salinity) measures were accurately reflecting ambient water, the conductivity probes and their PVC protection were moved to the piling at the same elevation. There has also been corrosion of the beaded cables at high salinity stations. These cables were replaced.

A final problem was the failure of salinity (conductivity) instruments to meet QA/QC criteria for temperature during winter. This is significant because the calculation of salinity from conductivity requires an accurate temperature measurement. The problem was intermittent and did not occur at every station at all times. After extensive laboratory testing we discovered that one group of probes from the company supplying the probes (Unidata Inc.) was made by a different manufacturer and that the Unidata software did not calculate the proper temperature and hence salinity at low temperatures. Our discovery of this software error instituted a worldwide notification by Unidata. While this was a significant problem that required many hours to solve, data loss was minimal since it did not affect freshwater stations.

By the end of the first full year of operation, problems with instrumentation have greatly diminished and those that have occurred are ones we have seen before and are solved quickly. Table 1.1-1 provides a general summary of data loss that affects statistical analysis for present and future comparisons.

Table 1.1-1. Percentages of tides unavailable for analysis and reasons for loss. No comparison can be made when data from this station is lost. Detailed descriptions of "loss" categories are listed in Section 1.2 below.

STATION NUMBER	% TIDES LOST to LOSS AT STATION P1	% TIDES LOST due to QA/QC PROCEDURE	% TIDES LOST to UNDER-RANGING EVENTS	% TIDES LOST to ABSENCE OF DATA	% TIDES LOST to FREEZING	% TIDES LOST to MECHANICAL ERRORS	TOTAL % LOST TIDES
P1	N/A	0.9	0.0	0.0	N/A	8.0	8.9
P2	8.9	0.6	9.8	0.0	N/A	3.3	22.6
P3	8.9	0.5	0.0	0.0	0.6	1.2	11.2
P4	8.9	N/A	N/A	0.0	N/A	N/A	8.9
P6	8.9	0.7	0.6	0.0	N/A	0.1	10.3
P7	8.9	0.5	6.2	3.7	N/A	0.0	19.3
P8	8.9	1.3	0.0	0.2	N/A	0.1	10.5
P9	8.9	0.5	0.0	0.1	2.2	0.2	11.9
P11	8.9	1.1	0.0	0.2	N/A	1.7	11.9
P12	N/A	N/A	N/A	100.0	N/A	N/A	100.0
P13	8.9	0.3	0.0	1.4	N/A	0.1	10.7
P14	8.9	0.1	0.0	0.0	N/A	0.0	9.0

1.2 Methodology

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

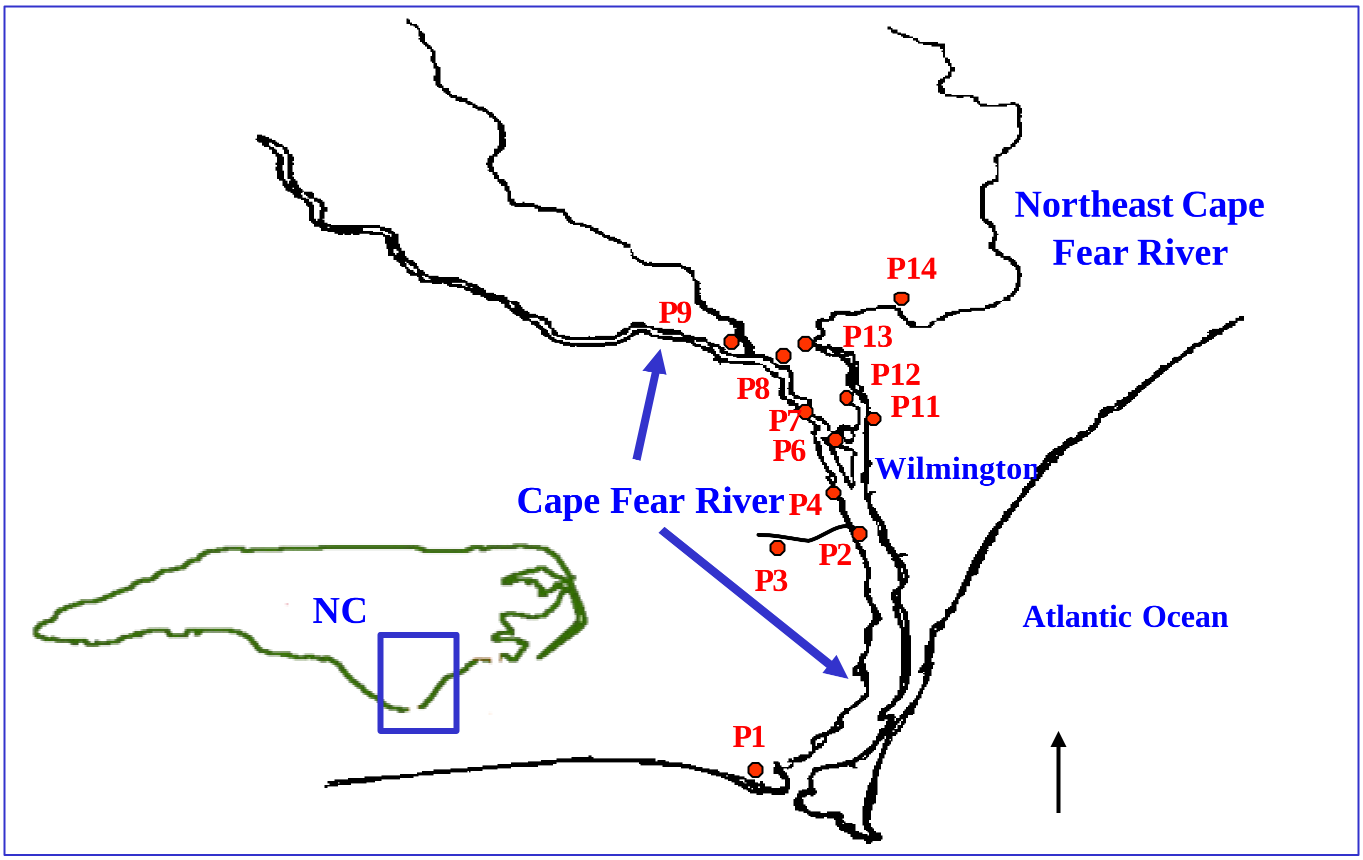
QA/QC procedures have been constantly evaluated during this first year of data collection to insure that they will quickly and accurately indicate all problems that could affect data. The following are terms used to describe data loss throughout this report.

<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) <u>Absence of Data</u> refers to tides that were lost when the data were not recorded by the data logger or were not transmitted properly via the modem or PC download process. 4) <u>Freezing</u> of surface water in the stilling well prohibited the float from following the rise and fall of the tides and these tides were removed. 5) <u>Mechanical Errors</u> refer to tides removed from the data set during the data review process because of likely mechanical malfunction. Mechanical malfunctions were suspected when the plotted data exhibited misshapen curves, large jumps, and flat lines (i.e. hang-ups).

1.3 Ft. Caswell (P1)

Ft. Caswell is the most important station because this station experiences amplitude changes that essentially reflect oceanic tides. All tidal fluctuations at stations upstream are related to this station. Initially, this station functioned well when other stations were not; thus this station has provided a good database with which to work. Communication problems necessitated manual downloading on several occasions with no loss of data. During spring, the monthly QA/QC checks required resetting the water level recorder. This was necessitated because of irregular rapid jumps in water level that were deemed mechanical. Most of these were obvious and did not occur during high or low tide so range data were not lost. Nevertheless, the problem has been perplexing. In an attempt to isolate the cause of these fluctuations, all components were switched with other stations to determine if it was an equipment problem. Corroded cable was replaced. The water level float cable was replaced to insure that the weight was not entering the water at high tide, and the stilling well was capped. The instrument was also observed for periods when the rapid departure or entrance of Coast Guard vessels produced large waves that resonated within the canal basin. None of these efforts has led to a solution. This station has a very long stilling well and is solidly attached to the Coast Guard pier. Excessive sway of the stilling well remains a problem because the well has only one support brace on a very long stilling well. A second brace was proposed in the 2001-2002 budget. There is also the potential that vibrations from heavy equipment on the concrete pier could set up a standing wave in the well. While unresolved, these are all minor problems that have not led to any major data losses.

Figure 1.2-1. General location of stations in the Cape Fear Basin watershed. Stations are designated as follows: P1 - Fort Caswell, P2 - Outer Town Creek, P3 - Inner Town Creek, P4 - Corps Yard, P6 - Eagle Island, P7 - Indian Creek, P8 - Dollisons Landing, P9 - Black River, P11 - Smith Creek, P12 - Rat Island, P13 - Fishing Creek, and P14 - Prince George Creek.



Biofouling has also been a minor problem for the conductivity (salinity) probe, especially when larvae are recruiting into the estuary. Monthly QA/QC checks and cleaning of probes, when needed, has limited the effects of this problem on data quality.

1.4 Town Creek Mouth (P2)

Water level curves at this station are not always as smooth as would be expected, although maximum and minimum water levels correspond well with P1. This site has shoaled greatly since the initial installation of the DCP requiring occasional excavation around the stilling well to insure water flow into and out of the well. Until a cap was placed on the stilling well, long waves from passing ships exceeded the capacity of the water level instrument to respond. This resulted in some data loss. When water levels in the river are low, water is not present at this station (low tide flat line) and so amplitude is not accurately recorded. This type of under ranging occurred during some tides in December, January, February, and April. Such data loss will occur whenever normal water levels are low. Data for these tides are omitted in analyses. This area is also a feeding area for pelicans, terns, and gulls that sit on the piling and solar cell. Excrement covering the solar cell must be removed and the caustic nature of the excrement has caused increased corrosion of the metal components of the structure. Lightning in August resulting in some data loss and also damaged the water level recorder and other instrumentation.

Relatively high salinity water at this site has had some effects on beaded cables, which will need to be replaced in the near future. Biofouling is also a problem at this station, but is identified and corrected each month (if present) during monthly QA/QC checks. The conductivity probe was covered with barnacles in October 2001 and was replaced during routine monthly QA/QC inspection.

1.5 Inner Town Creek (P3)

This station has had few problems and continues to generate smooth tidal curves. This station provided excellent data even before caps were placed on stilling wells because the stilling well's bottom is well below the surface at low tide. The restricted and protected nature of this site also minimizes impacts of large waves and wakes. There were some flat lines (no apparent change in water level) during January when the surface of the water froze the float in position and did not follow the tide. This site is subjected to rapid increases in the average water level during local rain events, which quickly return to normal because of the restricted drainage basin of Town Creek. No conductivity data were collected here in December 2000 and January 2001 because of a malfunctioning micrologger.

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. UNCW has installed a conductivity/salinity gauge at this site. The only problems encountered here were related to the incompatibility of the conductivity probes and software discussed previously that resulted in incorrect temperature measurements at very low temperatures. This problem has been corrected.

1.7 Eagle Island (P6)

While this station is located along the main river channel there have been minimal problems with boat wakes once stilling caps were installed. Extremely low tides in December 2000, January 2001, and February 2001 led to some under ranging events with the concomitant data loss that occurs when river levels fall lower than the stilling well. A lightning strike in summer 2000 led to some data loss.

1.8 Indian Creek (P7)

This DCP and associated stilling well are set higher than others along the Cape Fear River. During low water periods this site flat lines because the water is below the bottom of the stilling well. This is a major problem when the river stage is low because of low discharge upstream. As a result, we have lost a significant percentage (10.4%) of all potential range values for statistical analyses. Loss of either a high tide or low tide point results in the loss of two range values (preceding and following range).

1.9 Dollisons Landing (P8)

On many QA/QC visits there was a discrepancy in the measured water level versus the instrument level and the water level recorder was reset. On each occasion the direction of the error was the same, i.e. water level was higher on the water level instrument. This DCP was resurveyed in June and found to be 1.47 feet lower than the original survey. In addition, numerous tides were lost at this site probably due to waves (wind and boat) prior to installing the stilling well cap.

1.10 Black River (P9)

Located on a quiet slough at the confluence of the Cape Fear and Black Rivers, this station had few problems from waves and has provided one of the most complete data sets. A winter freeze in December 2000 and January 2001 froze the surface water at this site and caused some loss of data because the float was frozen to the stilling well.

1.11 Smith Creek (P11)

There have been several problems at this site, notably the rapid shoaling adjacent to the DCP. In addition, there has been some sagging of the stilling well. The cell phone communication system was not operating in April because of a malfunction of the timer and this station was downloaded manually until the communicator was returned from the manufacturer. This station does not record the lowest low tides (flat lines) and is affected by waves on occasion. There have also been several float hang-ups. As a result, the bracket supporting the water level recorder has been adjusted and the problem has diminished.

1.12 Rat Island (P12)

This has been the most problematic station in the study because of the nature of sediments here. The initial installation resulted in a piling that was not vertical despite attempts to straighten it (see discussion in CZR Part B report 2001). This led to almost constant float problems resulting in almost complete data loss. In November at new piling was installed approximately 50 feet upstream of the initial location and instruments reinstalled. After several weeks, this piling also began to lean and instruments were removed. In December, the piling was reinstalled using a pile driver instead of the jetting procedure used previously, but by January the piling was again leaning. After discussion with Corps personnel and local piling drivers, a new design was developed that used two batter piles placed alongside a vertical pile. This was installed in May and resulted in a stable platform. These problems plus a lightning strike in August 2000 have limited data to only a small period in May 2001.

1.13 Fishing Creek (P13)

There have been few problems at this site.

1.14 Prince George Creek (P14)

Less than 0.1% of tide ranges were lost from this site once stilling well caps were added. Prior to the installation of the cap on the stilling well, boat wakes and short wind driven waves led to numerous incidents where water level change exceeded the water level instrument's design capabilities. The problem with temperature measurements of conductivity probes in cold conditions, mentioned earlier in this section, was first noted at this station. Fortunately, this is always a freshwater site and there was no significant data loss here.

2.0 MONUMENT AND STATION SURVEY VERIFICATION

2.1 Summary

A vertical survey of substations at Eagle Island (P6) with optical survey equipment found that all six substations were within 0.06 feet of the original survey with a mean variation of 0.03 feet. The elevation of the Water Level Recorder in the river was within 0.04 feet. This was within the precision of the survey instruments. The Water Level Recorder at the Dollisons Landing site (P8) was 1.47 feet lower than the original survey and the first substation 0.87 feet lower than the original survey.

2.2 Survey at Rat Island (P12)

Resetting pilings at Rat Island twice left this station without a NAVD88 elevation. Standard optical equipment was used to establish new vertical points on the new piling using the benchmark on the marsh edge previously surveyed ($\pm$0.01 feet) at 5.21 feet NAVD88. A level line was shot to the piling and elevations established for the water level instrument. The elevation of the instrument is 10.63 feet. This elevation was verified by comparing to water levels measured at substation 1 during flood tide.

2.3 Survey at Dollisons Landing (P8)

This site was selected for resurvey because monthly QA/QC checks required constant resetting of the water level gauge to the surveyed elevation. This suggested either the piling was sinking or the water level instrument was not operating properly. The survey transit was placed on a relatively firm hummock at the river's edge and the previously established benchmark used as the basis of elevation. A level line was shot to the piling, which holds the DCP, and to substation 1, both within 40 feet of the transit. A stadia rod was placed on the PVC benchmark at Substation 1, and a yardstick on the piling was subtracted from the level line elevation. Both the piling and substation were significantly lower than the original survey. The piling was 1.47 feet lower and the substation 0.87 feet lower. Other explanations for this discrepancy are that the benchmark had risen or the original survey was in error.

An independent verification of elevation was obtained from QA/QC procedures. When all QA/QC resetting was added together they indicated that the DCP was 1.51 feet lower in elevation than when the instrument was first installed, which is very close to the surveyed 1.47 feet elevation deviation actually measured based on the benchmark. Thus, we concluded that the benchmark is stable and the problem is that the static points represented by the piling and PVC is not static at this site.

2.4 Survey at Eagle Island (P6)

This site was chosen for a complete survey because monthly biogeochemistry collections are made here and the additional traffic has the potential for compacting sediments and altering elevations if substation PVC benchmarks are susceptible to compaction. All six substations plus the DCP piling were surveyed at this site. Surveyed elevations are as follows with previously established elevations in parentheses; substation 1, 3.15' (3.18'), substation 2, 2.72' (2.71'), substation 3, 1.56' (1.58'), substation 4, 3.39' (3.36'), substation 5, 4.16' (4.08'), and substation 6, 4.81' (4.75). The DCP was 7.16' compared to the previous measure of 7.12'. The original precision was $\pm$ 0.01' using laser survey equipment and the precision of the optical instrument was $\pm$ 0.025 based on repeated measures of the benchmark. Thus, there was little movement of any of the substations or critical instrumentation at this station.

2.5 Resetting Elevations on DCP Pilings

Monthly QA/QC procedures require that the water level measured by the instrument be checked against established elevations on the piling. This requires that a tape measure be employed and that the observer be able to determine the exact water level adjacent to the piling. While the procedure has worked well and not resulted in significant error, the measurement error is on the order of 0.04', which is in excess of the 0.01' survey error. In addition, when the water level recorder is reset, the corresponding change must be added or subtracted to the database. We have experimented with a second method of checking instrument that became obvious when comparing water levels at marsh substations with the water level at the DCP (see Section 4.3). The proximity of substation 1 to the DCP provides an excellent check as water levels should be the same ± 0.01', the error of our survey data. In addition, the instrument averaging eliminates any effect of small waves and interpolation required by the observer in our current QA/QC procedure.

2.6 Current Elevations of Water Level Instruments and Substations

Table 2.6-1 shows all surveyed data points and indicate those that have been verified as well as those for which new elevations have been established.

Table 2.6-1. Surveyed NAVD88 elevation for all stations in feet. New elevations are emboldened, while verified elevations are underlined. NA indicates that this variable does not exist at a particular transect.

			Substations					
Station	**Benchmark**	**DCP**	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
P1	NA	12.39	NA	NA	NA	NA	NA	NA
P2	NA	16.36	NA	NA	NA	NA	NA	NA
P3	5.43	13.09	2.18	3.58	2.93	2.31	1.91	3.62
P6	<u>5.17</u>	<u>15.44</u>	<u>3.18</u>	<u>2.71</u>	<u>1.58</u>	<u>3.36</u>	<u>4.08</u>	<u>4.75</u>
P7	6.1	15.2	3.6	3.96	4.13	4.17	5.09	4.92
P8	5.44	**14.64**	**3.59**	4.39	4.48	6.49	4.05	6.99
P9	6.3	15.44	3.68	4.43	3.97	5.06	4.59	4.26
P11	5.99	17.16	2.80	3.98	3.2	3.18	3.59	2.7
P12	5.21	10.63	3.23	3.55	3.37	5.13	3.69	4.37
P13	4.95	13.26	3.58	4.6	3.11	2.79	3.13	3.25
P14	5.12	12.31	2.61	3.91	3.16	3.34	3.09	3.04

3.0 RIVER WATER LEVEL/SALINITY MONITORING

3.1 Summary

More than 900 tide ranges measured between 1 October 2000 and 31 May 2001 provide an excellent database with which to compare future data at 10 of the 11 stations. Rat Island (P12) was brought on line in May 2001. The database developed is extremely flexible and will allow detection of changes in tidal amplitude as well as detection of changes of ebb and flood duration. The correlation of tidal range from the base station at Ft. Caswell with stations lower in the river was excellent and better than the correlation of actual Ft. Caswell tidal range with the predicted tidal range, demonstrating that importance of unpredictable local events, which alter tides the entire length of the river. Tidal range downstream was similar to that upstream in the lower basin, but decreased further upstream. The most upstream sites and the inner Town Creek station were markedly affected by freshwater flow, local in nature at Town Creek. There was also an increased asymmetry of the ebb and flood of tides as the distance from the river mouth increased. The duration of the ebb tide increased with distance upstream, while the duration of flooding decreased. The tidal range of the tide was altered upstream. When tides were above the mean NAVD88 elevation tidal range was lower upstream, but when tides were lower than mean NAVD88 elevation tidal range increased. The relationship of tidal range between Ft. Caswell and other stations was different for each station, but was generally related to distance from the ocean, freshwater flow, and dependent on which branch of the Cape Fear River a station was located. There is a steady release of freshwater down the Cape Fear River, while freshwater flow in the Northeastern Cape Fear River is dependent on local rainfall and season.

Salinity of floodwaters did not exceed 1 ppt at stations upstream of Eagle Island on the Cape Fear River because of the large drainage basin and continuous release upstream, while significant pulses of saline water reached farther upstream in the Northeast Cape Fear River, exceeding 9 ppt at Fishing Creek, 8 miles north of Point Peter. This site is dominated by woody vegetation not tolerant of any saline water. Note that these measurements were made in water in the surface 3-5 feet of the water column, water that would likely go onto marshes and swamps. Salinity lower in the water column in the river would be expected to exceed these values.

3.2 Database

Water level, conductivity, and temperature data collected at DCP stations from August 2000 through May 2001 are incorporated in this report. To date, approximately 900 tides have been analyzed for the 10 operational 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. While data for August and September 2000 were collected, some stations experienced many problems with rapid water level change from the lack of caps on stilling wells. To correct these data requires a data manager to reset water level in the database, which adds an additional error to these data. Because some stations required many resets and others few, these data are omitted from the database to insure that all data have the same degree of all types of error. Also, the robust database includes enough data for analyses using data listed.

3.3 Data Analyses Methods

Maximum, minimum, and average 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, the duration of flooding, and the duration of ebbing for each site. These data are also used 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 tidal range for each of the 900 measured tides for each station during the study period is provided in Appendix D. Statistical differences between the range values for stations upstream before versus after channel deepening for a specified tidal change at the river mouth (P1) will be used to determine if the project has altered the flooding regimen upstream. Monthly tidal ranges, maximum/minimum water level and maximum/minimum salinity values for each station are given in Table 3.3-1.

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. ND = No data available.

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P1	Oct-00	33	16	17	2.33	-3.63	5.96
	Nov-00	34	22	13	2.82	-4.16	6.98
	Dec-00	34	21	13	2.71	-4.58	7.29
	Jan-01	34	22	12	2.28	-5.03	7.31
	Feb-01	34	23	11	1.80	-5.10	6.90
	Mar-01	32	12	21	3.45	-4.15	7.60
	Apr-01	34	12	22	2.26	-4.38	6.64
	May-01	45	26	19	2.69	-3.81	6.50
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P2	Oct-00	13	0	13	3.20	-2.43	5.63
	Nov-00	21	0	21	3.35	-3.17	6.52
	Dec-00	13	0	13	3.14	-3.07	6.21
	Jan-01	18	1	17	2.78	-3.07	5.85
	Feb-01	11	0	11	2.50	-3.06	5.56
	Mar-01	9	0	8	3.78	-3.02	6.80
	Apr-01	15	0	15	3.11	-3.11	6.22
	May-01	34	5	29	3.12	-3.05	6.17
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P3	Oct-00	2	0	2	1.54	-2.26	3.80
	Nov-00	2	0	2	1.73	-2.51	4.24
	Dec-00	ND	ND	ND	1.46	-3.16	4.62
	Jan-01	ND	ND	ND	3.37	-2.92	6.29
	Feb-01	2	0	2	1.29	-2.88	4.17
	Mar-01	5	0	5	2.57	-2.03	4.60
	Apr-01	8	0	8	1.65	-2.88	4.53
	May-01	20	0	20	1.29	-2.88	4.17

Table 3.3-1. Continued

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P4**	Oct-00	7	0	7	3.24	-2.30	5.54
	Nov-00	10	5	5	3.34	-3.10	6.44
	Dec-00	7	4	3	3.11	-3.77	6.88
	Jan-01	8	4	4	2.65	-3.60	6.25
	Feb-01	8	0	8	2.48	-3.78	6.26
	Mar-01	11	0	11	3.75	-3.06	6.81
	Apr-01	12	0	12	3.17	-3.42	6.59
	May-01	18	3	15	3.05	-3.08	6.13
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P6	Oct-00	13	0	13	2.47	-2.98	5.45
	Nov-00	13	2	11	2.91	-3.17	6.08
	Dec-00	14	0	14	2.75	-3.83	6.58
	Jan-01	11	0	11	2.45	-3.75	6.20
	Feb-01	9	0	8	2.34	-3.58	5.92
	Mar-01	12	0	12	3.70	-3.00	6.70
	Apr-01	11	0	11	3.29	-3.30	6.59
	May-01	18	0	17	2.81	-3.15	5.96
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P7	Oct-00	0	0	0	2.77	-2.27	5.04
	Nov-00	1	0	1	3.06	-2.90	5.96
	Dec-00	1	0	1	2.67	-2.87	5.54
	Jan-01	0	0	0	2.42	-2.86	5.28
	Feb-01	0	0	0	2.29	-2.86	5.15
	Mar-01	0	0	0	3.45	-2.51	5.96
	Apr-01	0	0	0	3.14	-2.78	5.92
	May-01	0	0	0	2.69	-2.75	5.44
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P8	Oct-00	0	0	0	2.90	-1.91	4.81
	Nov-00	0	0	0	2.85	-2.27	5.12
	Dec-00	0	0	0	2.67	-2.80	5.47
	Jan-01	0	0	0	2.67	-2.68	5.35
	Feb-01	0	0	0	2.45	-2.67	5.12
	Mar-01	0	0	0	3.49	-1.88	5.37
	Apr-01	0	0	0	3.93	-2.90	6.83
	May-01	0	0	0	2.72	-2.42	5.14
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P9	Oct-00	0	0	0	2.57	-1.83	4.40
	Nov-00	0	0	0	2.49	-2.45	4.94
	Dec-00	0	0	0	2.30	-3.75	6.05
	Jan-01	0	0	0	7.40	-3.78	11.18
	Feb-01	0	0	0	2.08	-3.70	5.78
	Mar-01	0	0	0	2.94	-2.10	5.04
	Apr-01	0	0	0	2.89	-3.26	6.15
	May-01	0	0	0	2.22	-2.69	4.91

Table 3.3-1. Concluded

		Salinity (ppt)			Water Level (ft)		
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P11	Oct-00	13	0	13	2.95	-2.55	5.50
	Nov-00	16	0	16	2.79	-3.34	6.13
	Dec-00	9	0	9	2.55	-3.54	6.09
	Jan-01	10	0	10	3.01	-5.48	8.49
	Feb-01	7	0	7	2.39	-3.35	5.74
	Mar-01	13	0	13	3.45	-2.85	6.30
	Apr-01	10	0	10	3.11	-3.40	6.51
	May-01	13	0	13	2.74	-3.08	5.82
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P13	Oct-00	4	0	4	2.21	-1.89	4.10
	Nov-00	9	0	9	2.25	-2.76	5.01
	Dec-00	0	0	0	1.99	-3.44	5.43
	Jan-01	2	0	2	1.70	-3.28	4.98
	Feb-01	0	0	0	1.72	-3.07	4.79
	Mar-01	2	0	2	2.82	-2.31	5.13
	Apr-01	3	0	3	2.27	-3.15	5.42
	May-01	9	1	8	2.18	-2.54	4.72
Site	Month	Maximum	Minimum	Range	Maximum	Minimum	Range
P14	Oct-00	0	0	0	2.27	-1.31	3.58
	Nov-00	1	0	1	1.87	-2.10	3.97
	Dec-00	0	0	0	1.71	-2.70	4.41
	Jan-01	0	0	0	1.44	-2.55	3.99
	Feb-01	0	0	0	1.49	-2.42	3.91
	Mar-01	0	0	0	2.67	-1.49	4.16
	Apr-01	0	0	0	1.95	-2.66	4.61
	May-01	1	0	1	1.75	-2.00	3.75

Tidal lags were determined by measuring the difference in time for high (or low) tide at 2 different stations (Figure 3.3-1). All tidal lags were calculated relative to station P1. Data presented herein comprise the baseline (pre-project) conditions against which all future data will be compared. Quantification of changes in tidal lag and tidal asymmetry (flood/ebb durations--see Figure 3.3-2) are critical to the determination of dredging impact 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 3.3-2.

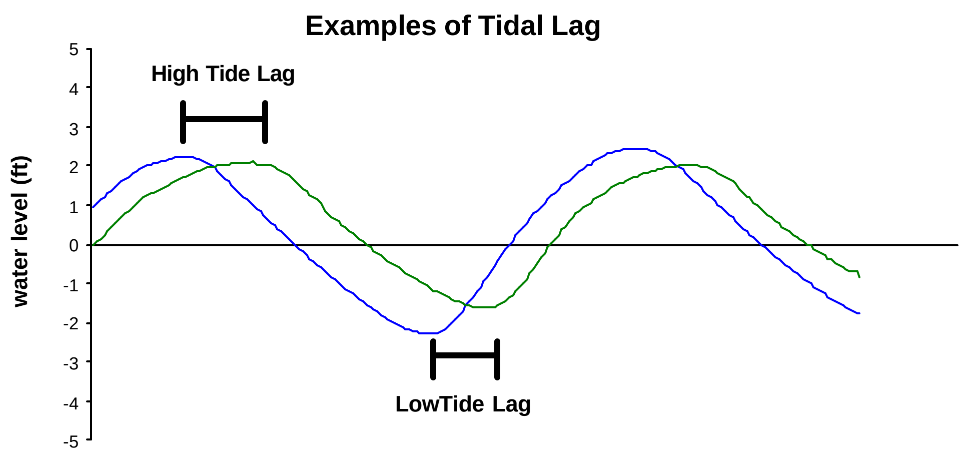


Figure 3.3-1. Theoretical example of time lag between stations. Note that the lag between stations during ebb versus flood tide may be different.

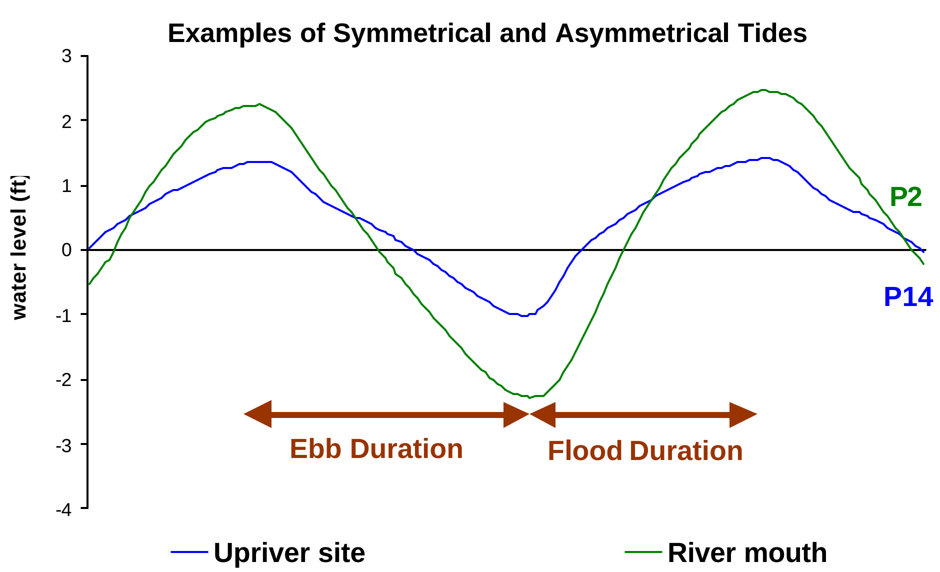


Figure 3.3-2. Illustration of flood and ebb duration at two different river sites. Site P2 exemplifies a symmetrical tidal curve; minimal impact by riverine parameters. Site P14 exemplifies an asymmetrical tidal curve; maximum impact by riverine parameters.

Table 3.3-2. Summary of tidal data generated from data collection platforms (DCP) at eleven stations along the Cape Fear River and tributaries.

Station Number	Mean Tidal Range (ft)	Mean Flood Duration (hr)	Mean Ebb Duration (hr)	Mean High Tide Lag From P1 (hr)	Mean Low Tide Lag From P1 (hr)
P1	4.37 ± 20.4%	6.27	6.15	------	------
P2	4.29 ± 14.0%	5.63	6.68	2.11	1.42
P3	2.76 ± 17.4%	6.25	6.13	3.00	3.00
P4	4.39 ± 13.7%	5.66	6.77	2.39	1.78
P6	4.26 ± 12.9%	5.77	6.59	2.71	2.21
P7	3.78 ± 12.4%	5.72	6.66	3.07	2.62
P8	3.45 ± 15.1%	5.71	6.64	3.54	3.01
P9	3.19 ± 19.4%	5.74	6.63	3.85	3.40
P11	4.17 ± 12.9%	5.71	6.69	2.84	2.24
P13	3.25 ± 13.5%	5.78	6.62	3.51	3.08
P14	2.38 ± 18.5%	5.83	6.55	4.53	4.10

3.4 Upstream Tidal Effects

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

The tidal ranges observed at the Ft. Caswell base station generally agree with the predicted tides for the area (Figure 3.41-1). The same is true for the Outer Town Creek (P2) site. As seen in Figure 3.41-2, the tidal range at P2 is highly positively correlated with observed tidal ranges at P1. The observed deviations from the predicted tides at both sites are likely due to wind events, upland run-off events, and to a lesser degree, periods of increased river discharge. The most important forcing mechanisms at this site (aside from astronomical forcing) are wind and localized, intense rain events. The overall impact of these events on water level, however, is minimal relative to other up river sites. As expected, the water level curve at P1 is symmetrical and shows little evidence of the time-velocity asymmetries (Table 3.3-2) measured at other stations. These asymmetries, as evidenced by the unequal flood and ebb durations shown in Table 3.3-2, begin at site P2 and continue up river to all monitoring sites.

3.42 Inner Town Creek (P3)

The mean tidal range observed at this site is approximately 1.5 feet less than the tidal ranged observed at the creek mouth (approximately 4.3 feet). The shape of the water level curves generated for this station and the computed tidal ranges vary widely and appear to depend on flow conditions in the creek. In general, higher water levels and lower tidal ranges occur during periods of increased creek discharge. Although tidal range at P3 generally increases with increased tidal range at P1, non-tidal forcing mechanisms are very important (Figure 3.42-1). Water levels at this site are strongly affected by upland runoff and rain as evidenced by variation of water levels for a specified tidal range at P1 (Figure 3.42-1).

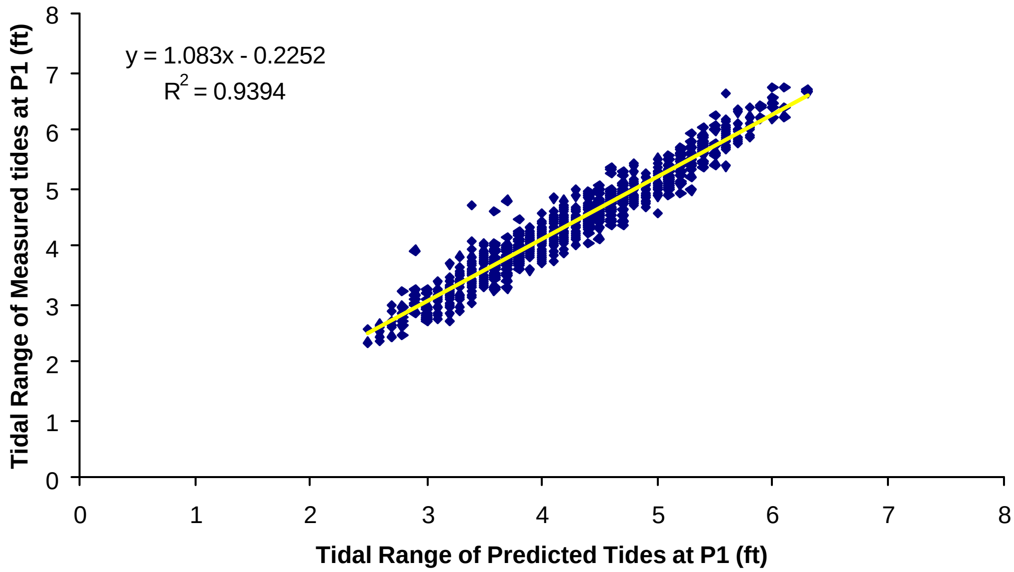


Figure 3.41-1. Plot of predicted tidal range at P1 relative to measured tidal range at P1 for the study period.

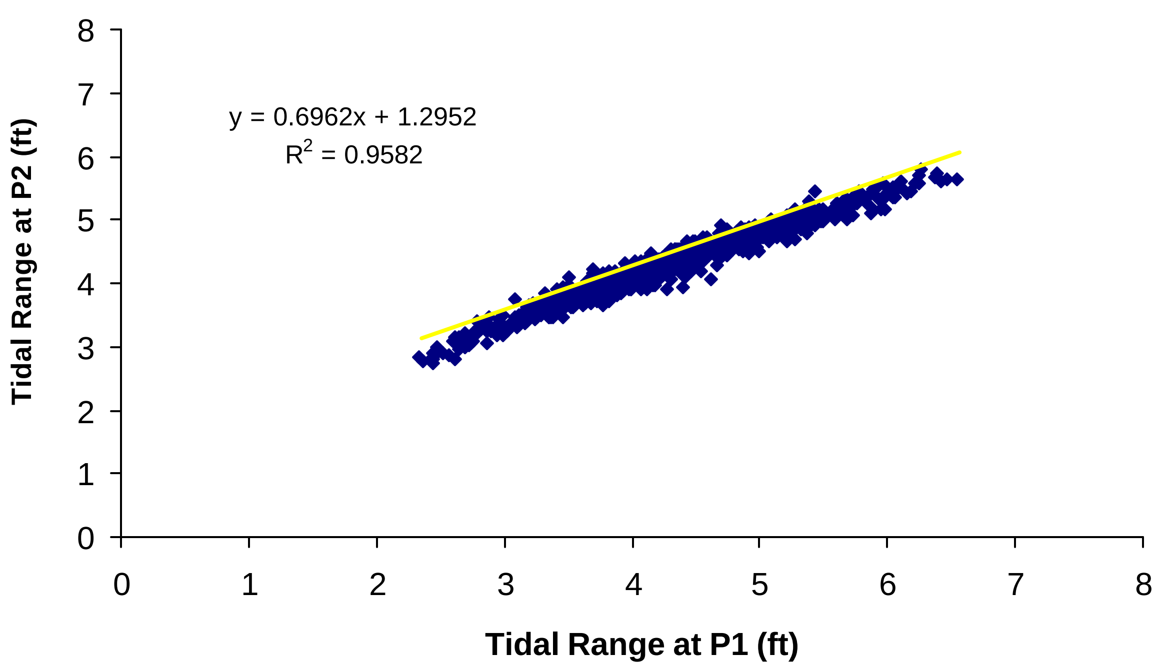


Figure 3.41-2. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Outer Town Creek (P2).

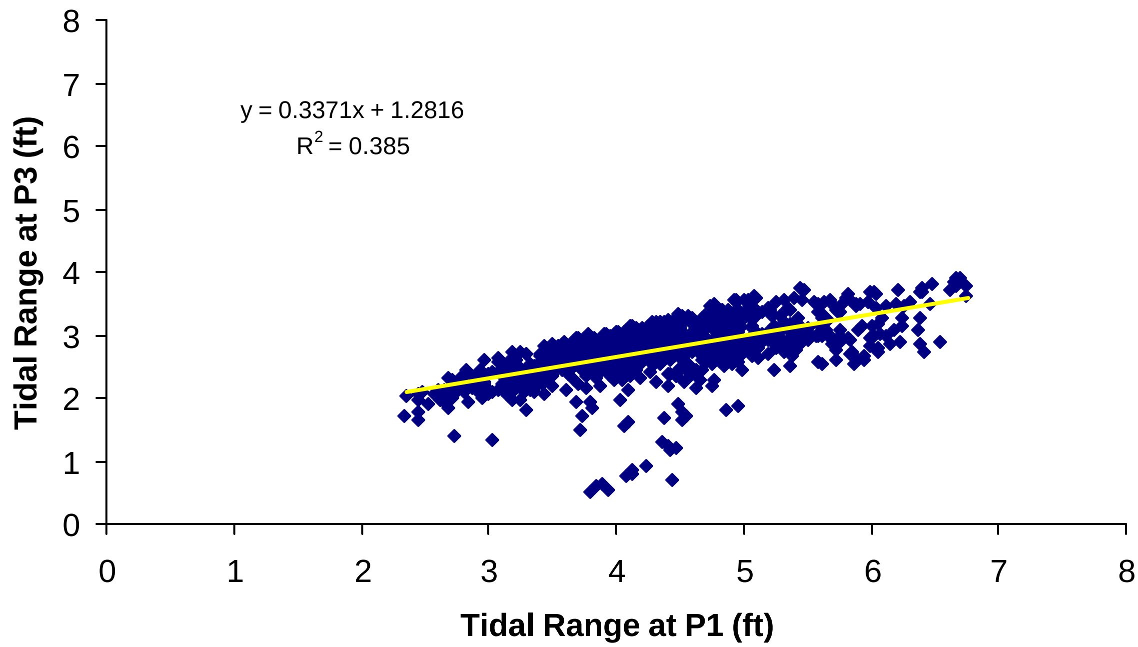


Figure 3.42-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Inner Town Creek (P3).

3.43 Corps Yard (P4)

The tidal range observed at P4 approximates the range observed at the P1 base station (Figure 3.43-1). The difference in mean tidal range between this station and Ft. Caswell shown in Table 3.3-2 is negligible. For all practical purposes, tidal range at this station is consistent with tides observed at the river mouth. Water level curves generated for P4, however, show a slight time asymmetry that does not occur at P1. Water levels at the Corps yard appear to be only minimally impacted by changes in river discharge. Water levels observed at P4 do not appear to be impacted by non-tidal forcing mechanisms any more or any less than those observed at sites P1 and P2.

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

Mean tidal ranges computed for these sites were lower than the mean determined for P1. In general, tidal range decreased with distance upriver (Table 3.3-2). Water levels at all of these stations appear to be impacted by run-off events. Qualitative analyses suggest that while maximum and minimum water levels increase relative to datum during periods of high river discharge, tidal range is minimally affected. These sites are also subject to pronounced time asymmetries as would be expected for estuarine systems. Figures 3.44-1, 3.44-2, and

3.44-3 illustrate the relationship between tidal range at these Cape Fear River sites and tidal range at Ft. Caswell. In general, tidal range at each upriver site is positively correlated with tidal range at the mouth, however, the degree of correlation decreases upriver. As was the case for P3, water levels at the upriver sites are more susceptible to variations in upland runoff and meteorological forcing.

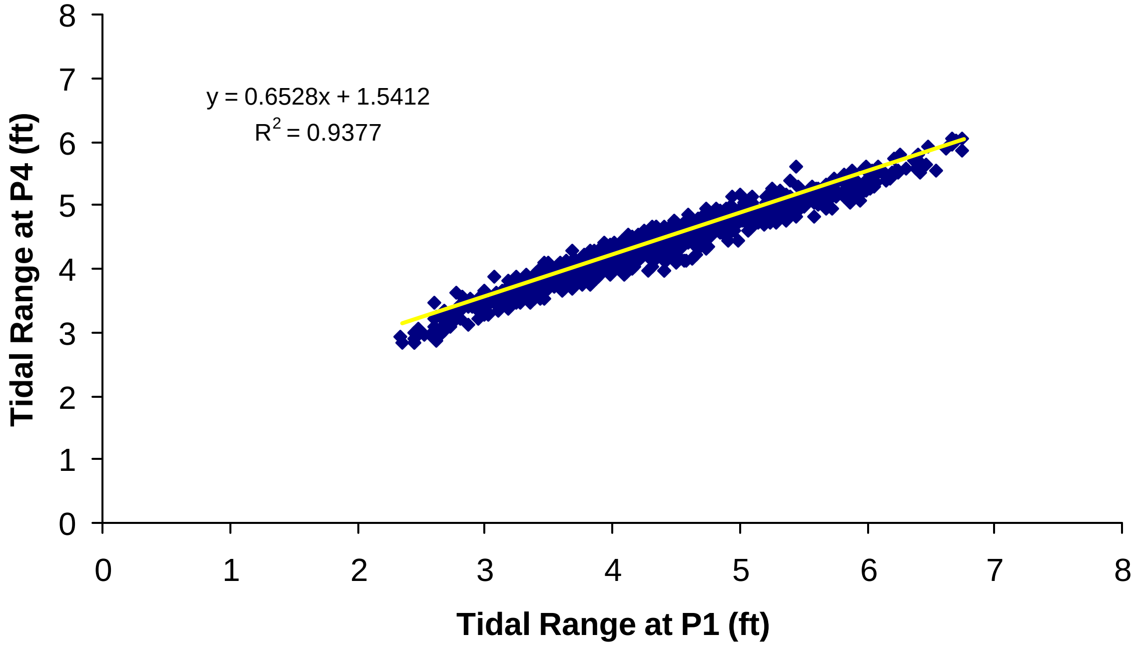


Figure 3.43-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and the Corps Yard station (P4).

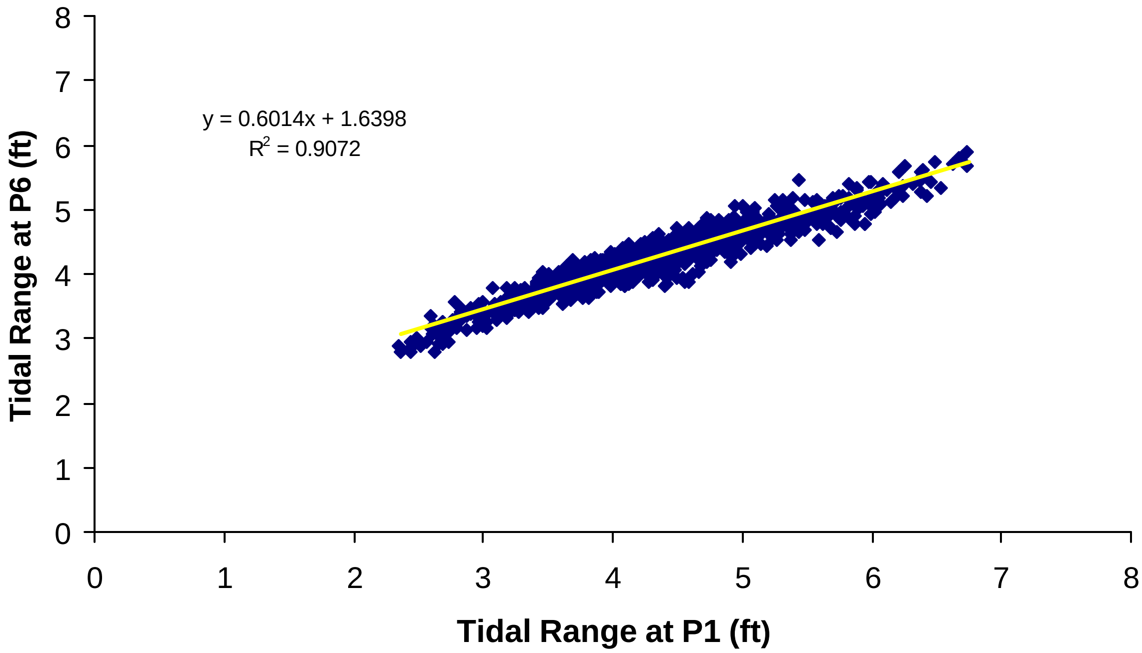


Figure 3.44-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Eagle Island (P6).

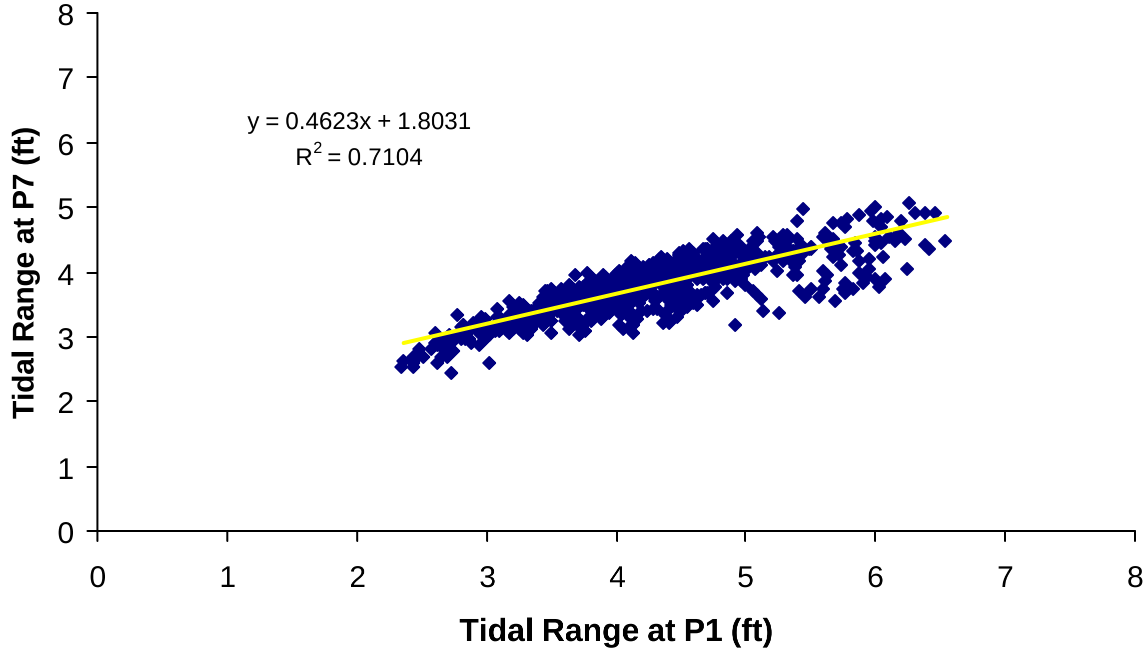


Figure 3.44-2**.** Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Indian Creek (P7).

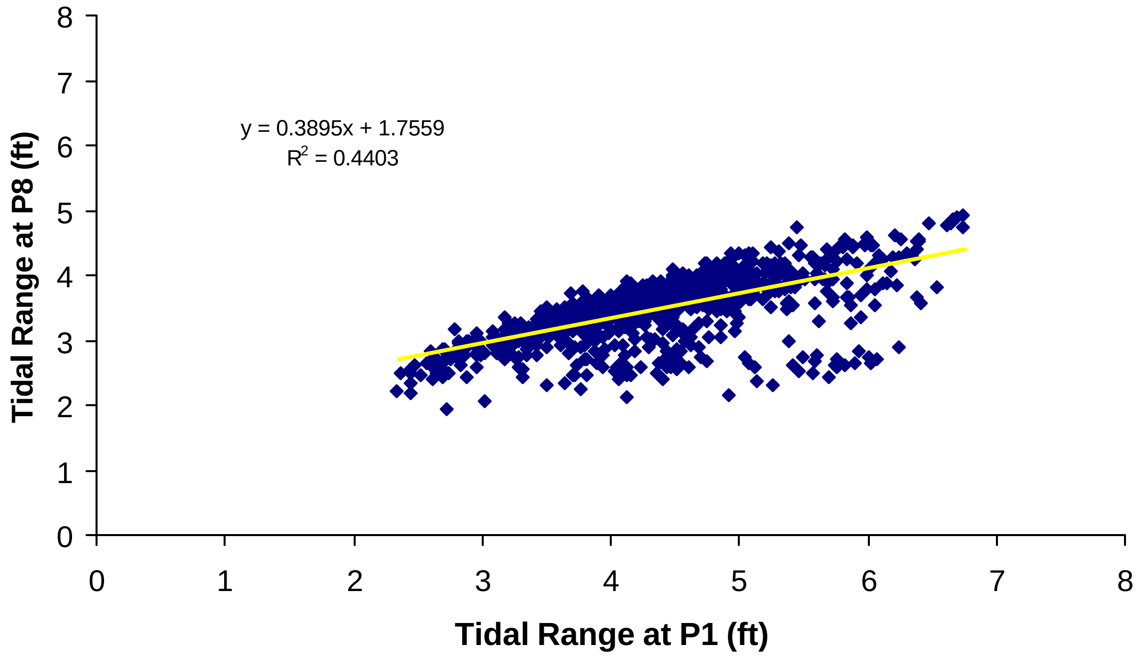


Figure 3.44-3. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Dollisons Landing (P8).

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

Mean tidal ranges computed for these sites were also lower than the mean determined for P1 (Table 3.3-2). In general, tidal ranges decrease with distance upriver and were positively correlated with the tidal range at P1 (Figure 3.45-1 and 3.45-2). At P11, tidal range variability was similar to that observed at P1; therefore, suggesting that astronomical forcing mechanisms are the primary control over water level at this station. Tidal range at P12 and P13 are more weakly correlated with P1, suggesting that water levels at this upriver station were impacted by other types of events such as wind, rain, and river discharge. All of these sites in the Northeast Cape Fear exhibit pronounced time asymmetries typical of estuarine systems.

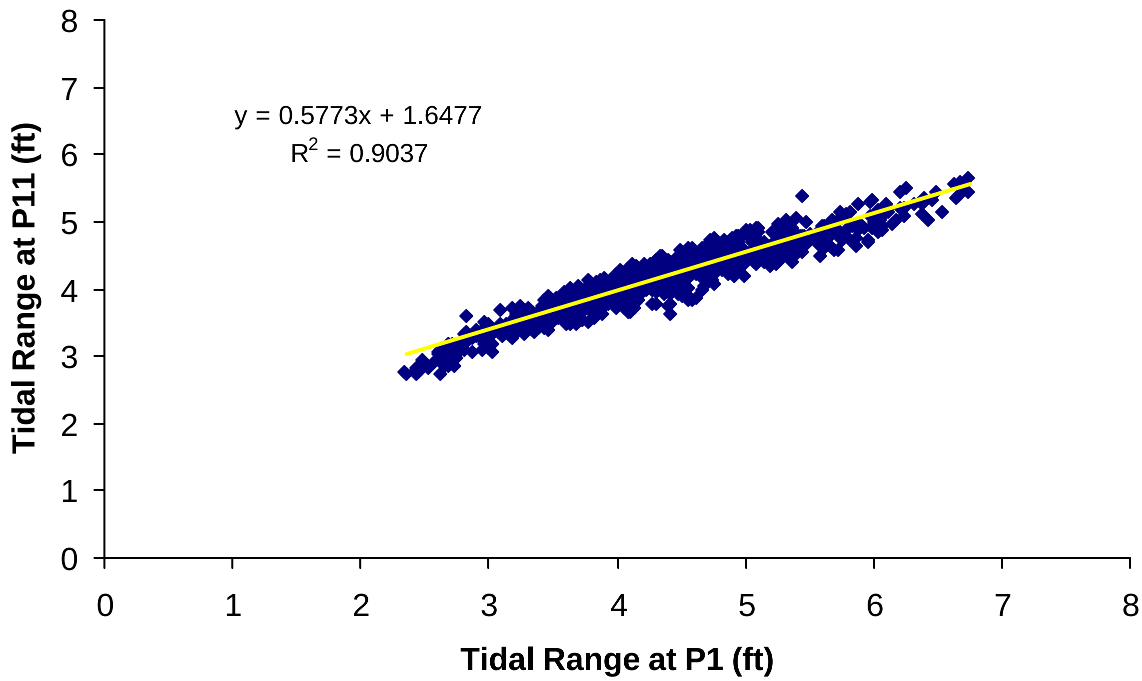


Figure 3.45-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Smith Creek (P11).

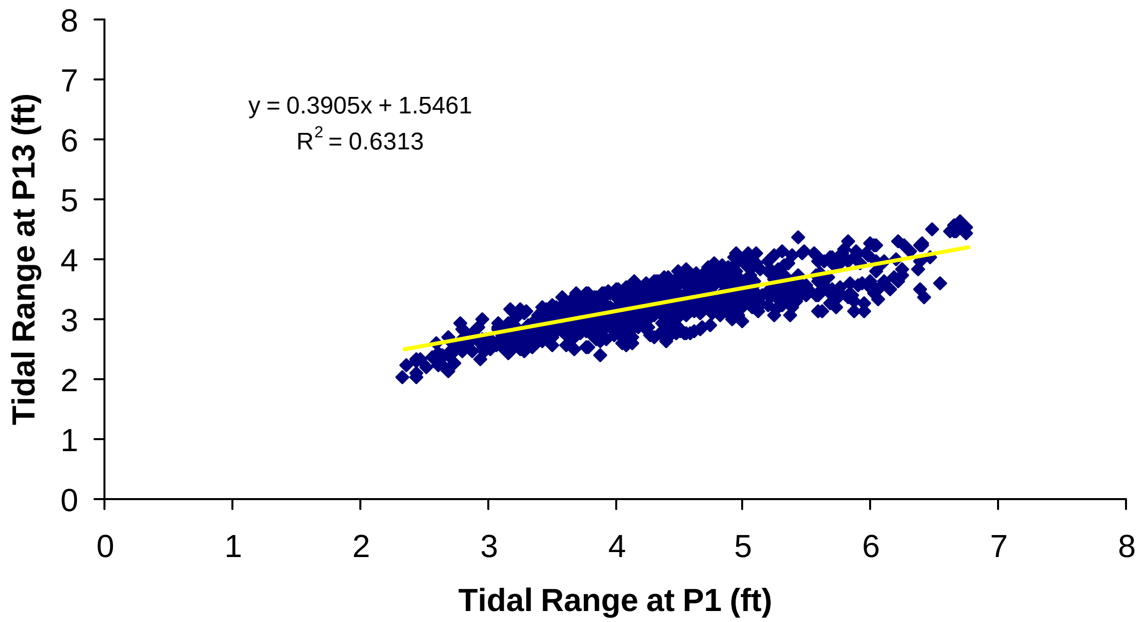


Figure 3.45-2. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Fishing Creek (P13).

3.46 Upriver Stations: Black River (P9) and Prince George Creek (P14)

The mean tidal ranges for P9 and P14 are much lower than those observed at the base stations (e.g. P1/P2) and less than the ranges computed for the other lower stations because of the distance between these stations and the mouth of the river. The mean tidal range at P14 on the Northeast Cape Fear River (16 miles from convergence of the Cape Fear and Northeast Cape Fear Rivers near Wilmington) is less than the mean range measured at P9, 12 miles from convergence on the Cape Fear River. Tidal curves for these stations show very pronounced time asymmetries (Figure 3.3-2). Despite their distance from the river mouth, tidal ranges at P9 and P14 still demonstrate a weak, but positive correlation with tidal range at P1 (Figures 3.46-1 and 3.46-2). Water levels at these stations appear to be more strongly impacted by changes in river discharge than at the other monitoring stations. Changes in river discharge and periods of high precipitation appear to be as important a control of water level as are the tides at these sites. Water levels at P14 in the Northeast Cape Fear River and at P9 in the Cape Fear River vary differently because the Corps maintains a specified discharge of fresh water from the Jordan Dam into the Cape Fear River even during periods of drought. This practice will differentially impact water levels in these systems.

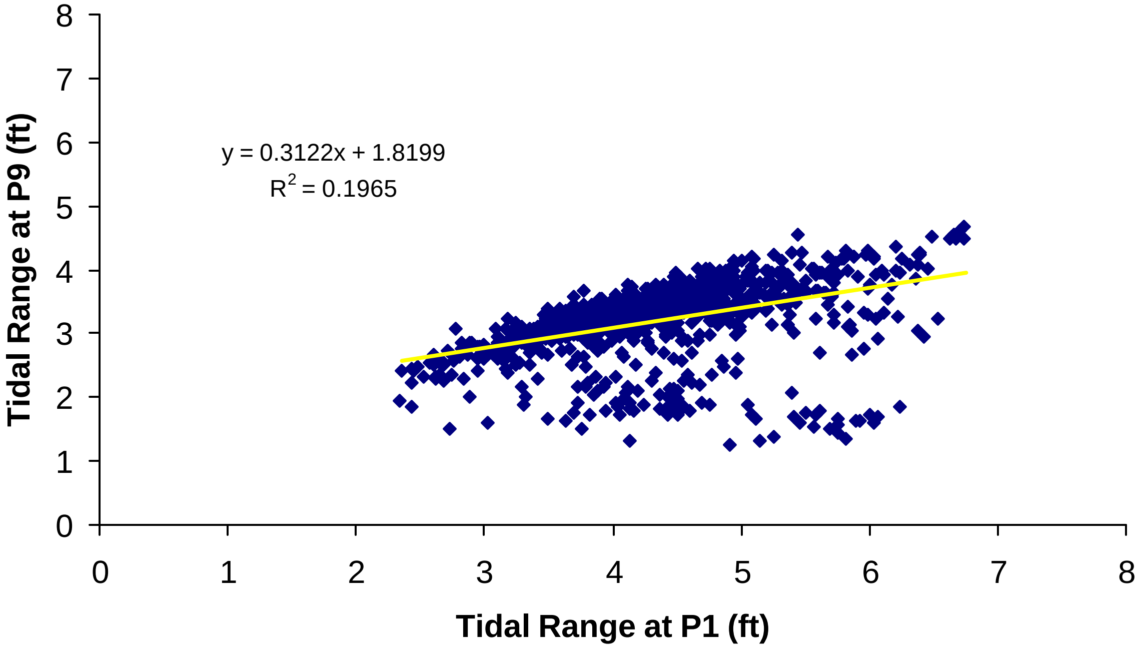


Figure 3.46-1. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Black River (P9).

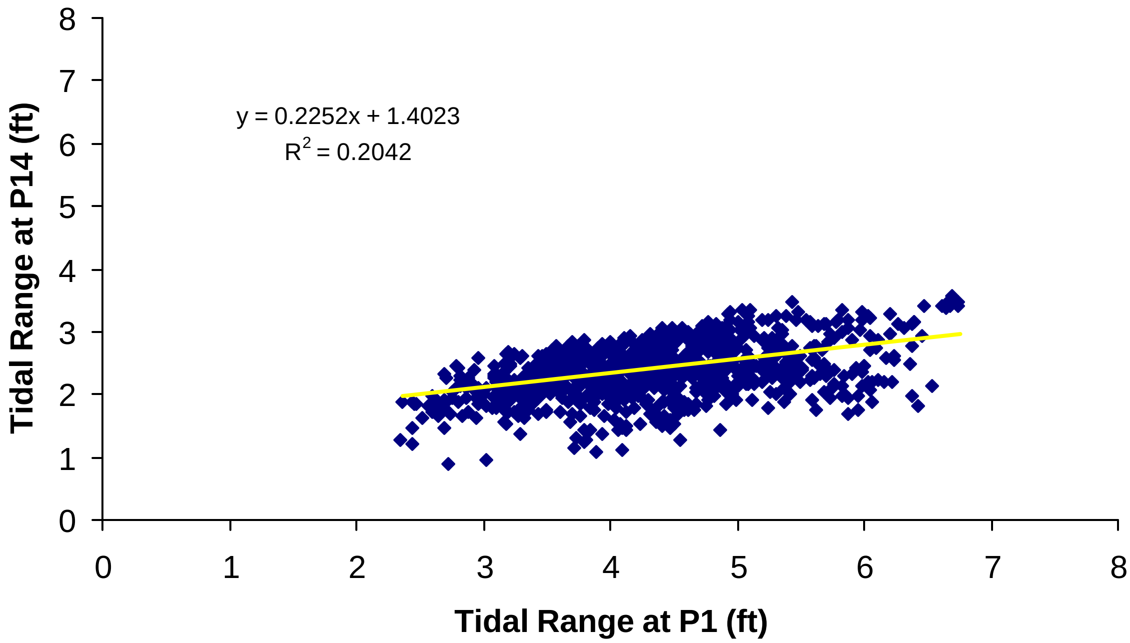


Figure 3.46-2. Plot showing relationship between tidal ranges observed at Ft. Caswell (P1) and Prince George Creek (P14).

4.0 MARSH/SWAMP FLOODING AND SALINITY LEVELS

4.1 Summary

The degree of flooding at 54 substations located within nine belt transects (6 per station) was measured spring 2000, summer 2000, fall 2000, and spring 2001. The summer data collection was added because instruments measuring salinity of floodwater on the marsh/swamp surface were not operational during spring 2000. Salinity of floodwater was collected summer 2000, fall 2000, and spring 2001. Most substations flooded when the high tide was above the mean high tide or when river and ocean levels were higher than average. In general, substations nearest the watercourse flooded more frequently, for longer periods of time, and at greater depth than substations near the uplands, although there were exceptions. Dollisons Landing (P8) and Fishing Creek (P13) had berms along the river's edge and flooded less than the more interior substations. The Indian Creek (P7) belt transect, on the Cape Fear River, was relatively high and many of the interior substations flooded infrequently and would not be considered tidally flooded. Saline water measured at the DCP moved onto the marsh/swamp surface at substations close to the water's edge and was measurably diluted as distance from the watercourse increased at most stations. Elevations of the marsh/swamp surface (relative to NAVD88 datum) ranged from 0.66-2.43 feet with the lowest average elevations found at Prince George Creek (P14) in the Northeast Cape Fear River farthest from Point Peter (confluence of the Cape Fear and Northeast Cape Fear Rivers). Data suggest that there is a gradient in the surface levels of the marsh/swamp such that a net movement of saline water could move into the Northeast Cape Fear River during low or no flow conditions when swamps along this branch of the river evapotranspirate large quantities of water. In the Northeast Cape Fear River, saline water was measured in swamps and marshes 2, 4, and 8 miles upstream of Point Peter and likely reaches further upstream, but not as far as Prince George Creek (P14) which is approximately 16 miles upstream. Saline water was not found in swamps and marshes of the Cape Fear River at stations located 4 miles or greater upstream.

4.2 Data Base

Study protocol required collection of water levels and salinities on the marsh surface at all six substations at each of nine stations (P3, P6, P7, P8, P9, P11, P12, P13, and P14) during fall and spring each year. This report also includes an additional reporting period, summer 2000 because conductivity instruments were not operational during spring 2000, thus limiting the salinity database. Water levels for spring 2000 are included in the same format for comparative purposes. Sampling protocol requires that data are collected at all six substations at a station simultaneously for at least a two-week period during each season so that high tides associated with either a full or new moon are measured as well as a low tidal amplitude associated with a neap tide. Note, however, that data for all stations are not collected simultaneously making comparisons between stations inappropriate for any one season. Instead, marsh flooding/salinity data are related to water levels and salinity at the DCP located at the water's edge, which allows interpretation of flooding levels on the marsh/swamp surface for a given flood level of the river. Tables 4.2-1, 4.2-2, 4.2-3, and 4.2-4 summarize the proportion of tides that flood each substation, the average duration of flooding per tide, the maximum water level (relative to NAVD88 datum), and the height of the marsh surface for Spring 2000, Summer 2000, Fall 2000, and Spring 2001, respectively.

The salinity of flooding water in the marsh/swamp is a critical element in determining if a potential increase in tidal amplitude will lead to community change in adjacent wetlands. Limited equipment availability during spring 2000 produced no substantial salinity database so an additional, equivalent data collection was made summer 2000. When the number of operational conductivity units or probes was limited, those that were operational were placed at substations that were most likely to flood based on previous data. Equipment problems were largely solved by fall 2000 and few data were lost in either fall 2000 or spring 2001 collections. The proportion of flood events that contained significant salinity (> 1 ppt) and the range of salinity for summer 2000, fall 2000, and spring 2001 are contained in Tables 4.2-5, 4.2-6, and 4.2-7.

4.3 Marsh/Swamp Flooding

The degree to which a substation floods depends on its absolute elevation (measured relative to NAVD88), the amplitude of the tide, the river level or freshwater input, and the water level of the ocean adjacent to the river's mouth. All of these variables, except elevation, fluctuate independently. All 54 substations flooded during at least one tide. Most,

Table 4.2-1. Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Spring 2000. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P3	1	Spr 00	3/17/00	3/31/00	24/28	6.6	2.1	0.66	1.5
	2	Spr 00	3/17/00	3/31/00	23/28	6.6	2.1	0.83	1.3
	3	Spr 00	3/17/00	3/31/00	27/28	7.6	2.1	0.52	1.6
	4	Spr 00	3/17/00	3/31/00	27/28	7.5	2.9	1.49	1.4
	5	Spr 00	3/17/00	3/31/00	20/28	6.0	2.1	0.99	1.1
	6	Spr 00	3/17/00	3/31/00	14/28	5.1	4.3	3.31	1.0
P6	1	Spr 00	2/4/00	2/18/00	27/28	7.4	2.5	0.76	1.7
	2	Spr 00	2/4/00	2/18/00	26/28	5.2	2.8	1.56	1.3
	3	Spr 00	2/4/00	2/18/00	27/28	6.4	2.7	0.85	1.9
	4	Spr 00	2/4/00	2/18/00	27/28	5.9	2.8	1.13	1.6
	5	Spr 00	2/4/00	2/18/00	24/28	4.5	3.2	1.92	1.3
	6	Spr 00	2/4/00	2/18/00	15/28	3.9	2.8	1.74	1.1
P7	1	Spr 00	2/23/00	3/8/00	14/28	3.5	2.5	1.76	0.7
	2	Spr 00	2/23/00	3/8/00	1/28	4.1	2.5	2.23	0.3
	3	Spr 00	2/23/00	3/8/00	1/28	4.1	2.8	2.26	0.5
	4	Spr 00	2/23/00	3/8/00	1/28	5.4	2.6	2.43	0.1
	5	Spr 00	2/23/00	3/8/00	0/28	0.0	0.0	2.31	0.0
	6	Spr 00	2/23/00	3/8/00	0/28	0.0	0.0	2.37	0.0
P8	1	Spr 00	3/8/00	3/22/00	17/28	6.0	3.5	2.14	1.3
	2	Spr 00	3/8/00	3/22/00	22/28	6.2	3.4	1.54	1.9
	3	Spr 00	3/8/00	3/22/00	22/28	6.0	3.4	1.46	1.9
	4	Spr 00	3/8/00	3/22/00	17/28	5.4	3.4	1.98	1.4
	5	Spr 00	3/8/00	3/22/00	8/28	6.3	3.3	2.24	1.1
	6	Spr 00	3/8/00	3/22/00	7/28	5.1	3.4	2.38	1.0
P9	1	Spr 00	3/1/00	3/16/00	29/30	7.6	2.6	0.58	2.0
	2	Spr 00	3/1/00	3/16/00	28/30	4.8	3.6	2.21	1.4
	3	Spr 00	3/1/00	3/16/00	16/30	3.8	1.8	1.22	0.6
	4	Spr 00	3/1/00	3/16/00	4/30	5.6	2.6	2.06	0.6
	5	Spr 00	3/1/00	3/16/00	3/30	5.9	2.8	2.20	0.6
	6	Spr 00	3/1/00	3/16/00	3/30	4.3	2.7	1.92	0.8
P11	1	Spr 00	3/22/00	4/5/00	23/28	4.7	2.7	1.44	1.3
	2	Spr 00	3/24/00	4/5/00	14/25	3.3	2.5	1.82	0.7
	3	Spr 00	3/22/00	4/5/00	18/28	4.3	2.7	1.76	1.0
	4	Spr 00	3/22/00	4/5/00	14/28	3.1	2.7	1.85	0.9
	5	Spr 00	3/22/00	4/5/00	14/28	4.1	2.7	1.91	0.8
	6	Spr 00	3/22/00	4/5/00	13/28	3.4	2.8	2.04	0.8

Table 4.2-1 (concluded). Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Spring 2000. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P12	1	Spr 00	4/12/00	4/26/00	27/28	6.0	2.5	0.90	1.6
	2	Spr 00	4/12/00	4/26/00	21/28	5.1	3.0	1.62	1.4
	3	Spr 00	4/12/00	4/26/00	11/28	4.1	2.9	2.00	0.9
	4	Spr 00	4/12/00	4/26/00	7/28	4.9	2.8	1.90	0.9
	5	Spr 00	4/12/00	4/26/00	4/28	6.9	2.8	2.08	0.8
	6	Spr 00	4/12/00	4/26/00	4/28	6.8	2.9	2.44	0.5
P13	1	Spr 00	5/2/00	5/18/00	17/32	3.5	2.1	1.43	0.7
	2	Spr 00	5/2/00	5/18/00	30/32	5.0	2.1	1.08	1.1
	3	Spr 00	5/2/00	5/18/00	30/32	6.3	2.1	0.75	1.4
	4	Spr 00	5/2/00	5/18/00	30/32	7.1	2.2	1.00	1.2
	5	Spr 00	5/2/00	5/18/00	30/32	5.9	2.2	1.21	1.0
	6	Spr 00	5/2/00	5/18/00	17/32	3.5	2.1	1.64	0.5
P14	1	Spr 00	4/14/00	4/28/00	26/28	7.8	2.2	0.70	1.5
	2	Spr 00	4/20/00	4/28/00	15/16	7.6	2.3	0.87	1.4
	3	Spr 00	4/14/00	4/28/00	26/28	6.5	2.4	1.08	1.3
	4	Spr 00	4/14/00	4/28/00	25/28	5.6	2.3	1.22	1.1
	5	Spr 00	4/14/00	4/28/00	25/28	5.9	2.2	1.28	0.9
	6	Spr 00	4/14/00	4/28/00	22/28	6.1	2.3	1.49	0.8

Table 4.2-2. Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Summer 2000. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P3	1	Sum 00	8/18/00	9/1/00	26/28	7.8	2.1	0.66	1.5
	2	Sum 00	8/18/00	9/1/00	26/28	7.2	2.1	0.83	1.3
	3	Sum 00	8/18/00	9/1/00	26/28	7.9	2.2	0.52	1.7
	4	Sum 00	8/18/00	9/1/00	26/28	7.9	3.4	1.49	2.0
	5	Sum 00	8/18/00	9/1/00	27/28	6.7	2.0	0.99	1.0
	6	Sum 00	8/18/00	9/1/00	24/28	5.1	4.5	3.31	1.1
P6	1	Sum 00	8/17/00	8/30/00	24/26	7.7	3.1	0.76	2.3
	2	Sum 00	8/17/00	8/30/00	24/26	6.4	3.1	1.56	1.6
	3	Sum 00	8/17/00	8/30/00	24/26	6.0	3.1	0.85	2.3
	4	Sum 00	8/17/00	8/30/00	24/26	5.7	2.8	1.13	1.6
	5	Sum 00	8/17/00	8/30/00	24/26	5.3	3.5	1.92	1.5
	6	Sum 00	8/17/00	8/30/00	21/26	5.2	2.9	1.74	1.1
P7	1	Sum 00	6/15/00	6/28/00	17/26	5.2	2.5	1.76	0.8
	2	Sum 00	6/15/00	6/28/00	3/26	2.7	2.6	2.23	0.3
	3	Sum 00	6/15/00	6/28/00	4/26	4.6	2.7	2.26	0.4
	4	Sum 00	6/15/00	6/28/00	4/26	6.9	2.1	2.43	0.0
	5	Sum 00	6/15/00	6/28/00	4/26	4.2	2.0	2.31	0.0
	6	Sum 00	6/15/00	6/28/00	2/26	10.7	2.5	2.37	0.1
P8	1	Sum 00	7/7/00	7/20/00	12/26	4.0	3.5	2.14	1.3
	2	Sum 00	7/7/00	7/20/00	22/26	4.8	3.4	1.54	1.9
	3	Sum 00	7/7/00	7/20/00	22/26	4.9	3.4	1.46	1.9
	4	Sum 00	7/7/00	7/20/00	13/26	4.5	3.4	1.98	1.4
	5	Sum 00	7/7/00	7/20/00	6/26	2.5	2.5	2.24	0.3
	6	Sum 00	7/14/00	7/20/00	0/12	0.0	0.0	2.38	0.0
P9	1	Sum 00	8/1/00	8/8/00	14/14	8.5	2.7	0.58	2.1
	2	Sum 00	8/1/00	8/8/00	13/14	5.8	3.8	2.21	1.6
	3	Sum 00	8/1/00	8/15/00	20/28	4.7	2.2	1.22	1.0
	4	Sum 00	8/1/00	8/15/00	18/28	4.9	2.9	2.06	0.9
	5	Sum 00	8/1/00	8/15/00	17/28	5.5	3.0	2.20	0.8
	6	Sum 00	8/1/00	8/15/00	16/28	6.0	2.9	1.92	1.0
P11	1	Sum 00	6/15/00	7/1/00	19/30	5.8	2.7	1.44	1.3
	2	Sum 00	6/15/00	6/29/00	6/27	3.8	2.7	1.82	0.9
	3	Sum 00	6/15/00	6/29/00	12/27	6.9	2.7	1.76	0.9
	4	Sum 00	6/15/00	6/29/00	8/27	8.4	2.6	1.85	0.8
	5	Sum 00	6/15/00	6/29/00	8/27	6.9	2.7	1.91	0.8
	6	Sum 00	6/15/00	6/29/00	9/27	9.2	2.6	2.04	0.5

Table 4.2-2 (concluded). Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Summer 2000. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P12	1	Sum 00	6/28/00	7/12/00	25/27	6.8	3.0	0.90	2.1
	2	Sum 00	6/28/00	7/12/00	19/27	5.4	2.9	1.62	1.3
	3	Sum 00	7/6/00	7/12/00	3/11	5.8	2.3	2.00	0.3
	4	Sum 00	6/28/00	7/12/00	6/27	6.5	2.8	1.90	0.9
	5	Sum 00	6/28/00	7/12/00	6/27	6.1	2.8	2.08	0.8
	6	Sum 00	6/28/00	7/12/00	6/27	8.9	3.0	2.44	0.5
P13	1	Sum 00	7/20/00	8/2/00	15/25	5.6	2.5	1.43	1.1
	2	Sum 00	7/26/00	8/2/00	13/14	6.8	2.5	1.08	1.4
	3	Sum 00	7/19/00	8/2/00	26/27	6.2	1.8	0.75	1.1
	4	Sum 00	7/19/00	8/2/00	25/27	7.8	2.7	1.00	1.7
	5	Sum 00	7/19/00	8/2/00	25/27	6.7	2.5	1.21	1.3
	6	Sum 00	7/19/00	8/2/00	13/27	4.5	2.6	1.64	1.0
P14	1	Sum 00	8/2/00	8/16/00	26/27	8.8	2.1	0.70	1.4
	2	Sum 00	8/2/00	8/16/00	26/27	8.3	2.1	0.87	1.2
	3	Sum 00	8/2/00	8/16/00	26/27	7.0	2.2	1.08	1.1
	4	Sum 00	8/2/00	8/16/00	26/27	6.3	2.1	1.22	0.9
	5	Sum 00	8/2/00	8/16/00	26/27	5.6	2.2	1.28	0.9
	6	Sum 00	8/2/00	8/16/00	18/27	5.3	1.9	1.49	0.4

Table 4.2-3. Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Fall 2000. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P3	1	Fall 00	10/25/00	11/7/00	25/28	7.1	1.8	0.66	1.2
	2	Fall 00	10/25/00	11/7/00	25/28	6.8	1.8	0.83	1.0
	3	Fall 00	10/25/00	11/7/00	25/28	7.4	1.9	0.52	1.4
	4	Fall 00	10/25/00	11/7/00	25/28	7.5	2.8	1.49	1.3
	5	Fall 00	10/25/00	11/7/00	23/28	5.7	1.8	0.99	0.8
	6	Fall 00	10/25/00	11/7/00	21/28	4.6	4.1	3.31	0.8
P6	1	Fall 00	10/23/00	11/6/00	26/28	9.1	2.9	0.76	2.2
	2	Fall 00	10/23/00	11/6/00	25/28	5.1	3.0	1.56	1.4
	3	Fall 00	10/23/00	11/6/00	24/28	6.1	3.1	0.85	2.3
	4	Fall 00	10/23/00	11/6/00	26/28	5.4	3.0	1.13	1.9
	5	Fall 00	10/23/00	11/6/00	24/28	4.8	3.3	1.92	1.4
	6	Fall 00	10/23/00	11/6/00	20/28	4.0	2.9	1.74	1.1
P7	1	Fall 00	10/17/00	10/23/00	11/12	5.6	2.8	1.76	1.1
	2	Fall 00	10/9/00	10/23/00	7/29	4.2	2.8	2.23	0.6
	3	Fall 00	10/9/00	10/23/00	6/29	4.0	2.7	2.26	0.4
	4	Fall 00	10/9/00	10/23/00	5/29	3.8	3.1	2.43	0.7
	5	Fall 00	10/9/00	10/23/00	6/29	3.6	2.7	2.31	0.4
	6	Fall 00	10/9/00	10/23/00	4/29	5.0	2.6	2.37	0.2
P8	1	Fall 00	11/8/00	11/21/00	17/26	4.3	3.0	2.14	0.8
	2	Fall 00	11/8/00	11/21/00	23/26	5.8	2.9	1.54	1.4
	3	Fall 00	11/8/00	11/21/00	25/26	5.5	3.0	1.46	1.6
	4	Fall 00	11/8/00	11/21/00	16/26	4.5	2.9	1.98	0.9
	5	Fall 00	11/8/00	11/21/00	11/26	3.6	3.0	2.24	0.7
	6	Fall 00	11/8/00	11/21/00	3/26	4.9	3.0	2.38	0.6
P9	1	Fall 00	11/29/00	12/12/00	24/25	8.1	2.6	0.58	2.0
	2	Fall 00	11/29/00	12/12/00	21/25	4.5	3.4	2.21	1.2
	3	Fall 00	11/29/00	12/12/00	2/25	1.8	1.8	1.22	0.6
	4	Fall 00	11/29/00	12/12/00	2/25	4.2	2.5	2.06	0.5
	5	Fall 00	11/29/00	12/12/00	1/25	4.2	2.5	2.20	0.3
	6	Fall 00	11/29/00	12/12/00	1/25	5.8	2.6	1.92	0.7
P11	1	Fall 00	9/28/00	10/11/00	23/26	5.6	3.2	1.44	1.8
	2	Fall 00	9/28/00	10/11/00	17/26	4.6	3.3	1.82	1.5
	3	Fall 00	9/28/00	10/11/00	17/26	5.1	3.2	1.76	1.5
	4	Fall 00	9/28/00	10/11/00	16/26	5.1	3.2	1.85	1.3
	5	Fall 00	9/28/00	10/11/00	16/26	4.7	3.1	1.91	1.2
	6	Fall 00	9/28/00	10/11/00	16/26	4.3	3.2	2.04	1.2

Table 4.2-3 (concluded). Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Fall 2000. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P12	1	Fall 00	10/11/00	10/24/00	25/28	6.5	2.6	0.90	1.7
	2	Fall 00	10/11/00	10/24/00	20/28	4.4	2.5	1.62	0.9
	3	Fall 00	10/11/00	10/22/00	12/28	5.1	2.5	2.00	0.5
	4	Fall 00	10/11/00	10/23/00	6/28	3.7	2.5	1.90	0.6
	5	Fall 00	10/11/00	10/24/00	3/28	6.0	2.4	2.08	0.3
	6	Fall 00	10/11/00	10/24/00	0/28	0.0	0.0	2.44	0.0
P13	1	Fall 00	11/13/00	11/27/00	19/28	4.7	2.4	1.43	0.9
	2	Fall 00	11/13/00	11/27/00	12/28	4.2	2.3	1.08	1.2
	3	Fall 00	11/13/00	11/27/00	26/28	5.6	2.4	0.75	1.7
	4	Fall 00	11/13/00	11/27/00	26/28	6.8	2.1	1.00	1.1
	5	Fall 00	11/13/00	11/27/00	26/28	5.7	2.4	1.21	1.2
	6	Fall 00	11/13/00	11/24/00	6/28	3.7	2.4	1.64	0.8
P14	1	Fall 00	11/27/00	12/11/00	26/28	6.5	1.9	0.70	1.2
	2	Fall 00	11/27/00	12/11/00	26/28	5.7	2.1	0.87	1.2
	3	Fall 00	11/27/00	12/11/00	25/28	5.5	1.8	1.08	0.7
	4	Fall 00	11/27/00	12/11/00	23/28	6.6	1.8	1.22	0.6
	5	Fall 00	12/4/00	12/11/00	12/16	4.5	1.8	1.28	0.5
	6	Fall 00	11/27/00	12/11/00	7/28	4.3	1.8	1.49	0.3

Table 4.2-4. Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Spring 2001. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P3	1	Spr 01	4/19/01	5/3/01	21/28	3.8	1.5	0.66	0.9
	2	Spr 01	4/19/01	5/3/01	14/28	3.5	1.5	0.83	0.7
	3	Spr 01	4/19/01	5/3/01	23/28	1.2	1.5	0.52	1.0
	4	Spr 01	4/19/01	5/3/01	20/28	4.1	2.5	1.49	1.0
	5	Spr 01	4/19/01	5/3/01	6/28	6.2	1.5	0.99	0.5
	6	Spr 01	4/19/01	5/3/01	1/28	4.0	3.6	3.31	0.3
P6	1	Spr 01	3/7/01	3/21/01	27/28	10.0	3.2	0.76	2.4
	2	Spr 01	3/7/01	3/21/01	21/28	5.0	3.2	1.56	1.7
	3	Spr 01	3/7/01	3/21/01	27/28	6.0	3.3	0.85	2.4
	4	Spr 01	3/8/01	3/21/01	20/26	5.5	3.7	1.13	2.6
	5	Spr 01	3/7/01	3/20/01	13/28	5.2	3.5	1.92	1.6
	6	Spr 01	3/7/01	3/21/01	15/28	4.8	3.0	1.74	1.2
P7	1	Spr 01	2/21/01	3/7/01	22/28	5.8	2.3	1.76	0.6
	2	Spr 01	2/21/01	3/7/01	0/28	0.0	0.0	2.23	0.0
	3	Spr 01	2/21/01	3/7/01	0/28	0.0	0.0	2.26	0.0
	4	Spr 01	2/21/01	3/7/01	0/28	0.0	0.0	2.43	0.0
	5	Spr 01	2/21/01	3/7/01	0/28	0.0	0.0	2.31	0.0
	6	Spr 01	2/21/01	3/7/01	0/28	0.0	0.0	2.37	0.0
P8	1	Spr 01	3/21/01	4/4/01	21/28	4.7	3.0	2.14	0.8
	2	Spr 01	3/21/01	4/4/01	26/28	6.2	2.9	1.54	1.4
	3	Spr 01	3/21/01	4/4/01	26/28	6.5	2.9	1.46	1.5
	4	Spr 01	3/21/01	4/4/01	24/28	4.6	2.9	1.98	0.9
	5	Spr 01	3/21/01	4/4/01	13/28	4.3	2.9	2.24	0.7
	6	Spr 01	3/21/01	3/31/01	3/28	4.0	2.8	2.38	0.5
P9	1	Spr 01	4/4/01	4/18/01	26/26	9.6	3.2	0.58	2.6
	2	Spr 01	4/4/01	4/18/01	25/26	8.7	4.0	2.21	1.8
	3	Spr 01	4/4/01	4/18/01	19/26	6.6	2.3	1.22	1.1
	4	Spr 01	4/4/01	4/18/01	16/26	8.4	3.1	2.06	1.0
	5	Spr 01	4/4/01	4/18/01	16/26	7.3	3.2	2.20	1.0
	6	Spr 01	4/4/01	4/18/01	16/26	7.0	3.0	1.92	1.1
P11	1	Spr 01	4/6/01	4/20/01	16/26	4.0	2.9	1.44	1.5
	2	Spr 01	4/6/01	4/20/01	15/26	3.9	2.9	1.82	1.1
	3	Spr 01	4/6/01	4/20/01	16/26	4.3	2.9	1.76	1.2
	4	Spr 01	4/6/01	4/20/01	15/26	4.8	2.9	1.85	1.1
	5	Spr 01	4/6/01	4/20/01	14/26	4.5	3.0	1.91	1.1
	6	Spr 01	4/6/01	4/20/01	14/26	3.8	2.9	2.04	0.9

Table 4.2-4 (concluded). Flooding frequency, duration and depth and actual water level of marsh/swamp substations during Spring 2001. Actual water level is calculated using the maximum depth and marsh/swamp surface elevation relative to NAVD88 datum.

Station Number	Substation Number	Season	Start Date	End Date	# Flood Events	Mean Flood Duration (hr)	Maximum Depth (ft)	Marsh/Swamp Elevation (ft)	Actual water level (ft)
P12	1	Spr 01	4/12/01	4/26/01	25/26	6.0	2.7	0.90	1.8
	2	Spr 01	4/12/01	4/26/01	21/26	4.6	2.6	1.62	1.0
	3	Spr 01	4/12/01	4/26/01	12/26	3.8	2.8	2.00	0.8
	4	Spr 01	4/12/01	4/26/01	7/26	4.6	2.4	1.90	0.5
	5	Spr 01	4/12/01	4/26/01	1/26	5.2	2.5	2.08	0.4
	6	Spr 01	4/12/01	4/26/01	1/26	6.0	2.5	2.44	0.1
P13	1	Spr 01	4/25/01	5/10/01	21/28	8.4	2.1	1.43	0.7
	2	Spr 01	4/25/01	5/10/01	25/28	7.0	2.1	1.08	1.0
	3	Spr 01	4/25/01	5/10/01	27/28	6.5	2.1	0.75	1.3
	4	Spr 01	4/25/01	5/10/01	26/28	9.7	2.1	1.00	1.1
	5	Spr 01	4/25/01	5/10/01	25/28	5.1	2.1	1.21	0.9
	6	Spr 01	4/25/01	5/10/01	5/28	5.4	2.1	1.64	0.4
P14	1	Spr 01	3/3/01	3/19/01	30/32	8.3	2.3	0.70	1.6
	2	Spr 01	3/3/01	3/19/01	29/32	8.0	1.9	0.87	1.1
	3	Spr 01	3/3/01	3/19/01	28/32	8.0	2.3	1.08	1.2
	4	Spr 01	3/3/01	3/19/01	24/32	7.6	2.2	1.22	1.0
	5	Spr 01	3/3/01	3/19/01	22/32	6.3	2.3	1.28	1.1
	6	Spr 01	3/3/01	3/19/01	16/32	8.4	2.3	1.49	0.8

however, flooded regularly with the duration of each flood event lasting longer than half each tidal cycle (Tables 4.2-1 through 4.2-4). One station, Indian Creek (P7), was the exception to this general statement. Elevations of substations at this site were the highest of all transects. All but substation 1 rarely flooded during February 2001 (Table 4.2-4). Note that substations 5 and 6 flooded only once, but the duration was relatively long, because of river flooding. Indian Creek is the only station where substations, except substation 1, were not tidal during part of the year.

Inner Town Creek (P3) flooded almost every tide during all seasons (Tables 4.2-1 through 4.2-4) although less frequent flooding was noted April 2001. Substation 6, adjacent to the uplands, is relatively high and consequently floods less, about half of the tides that occurred during the study. The local drainage of this creek and the distance of the station from the main channel of the river are such that local rainfall events produce freshets that both lower salinity to 0 ppt and raise water levels (Figure 4.3-1). Consequently, the salinity that reaches the marsh surface varied greatly during a given two-week period depending on both local rainfall and river salinity. In spring 2001, all substations, except substation 6, flooded regularly, but salt content was relatively low (Table 4.2-7). Fall 2000 contrasted greatly with floodwater salinity always above 2 ppt, except at substation 6, and as high as 13 ppt (Table 4.2-6). Flooding occurred during almost every tide for an average duration of 1.2 - 6.2 hours. Consequently, this station has sediments classified as sulfate reducing (see Section 5.51) and lacks salt sensitive vegetation (CZR 2001). Summer 2000 illustrates an intermediate condition when high salinity (10 ppt) was interrupted by rain events that reduced salinity to near 0 ppt (Table 4.2-5) and the increased water level in Town Creek increased the flooding duration (Table 4.2-2).

Eagle Island (P6) is located on the Cape Fear River, but is also affected by the Brunswick River to the south that carries saline water to this part of the estuary. It is also the one station from which monthly porewater samples are collected and analyzed at all six substations. All substations, except substation 6, flood almost every tide for an average of about 4-10 hours (Table 4.2-1 through 4.2-4). The downstream location of this station and its proximity to the Brunswick River allow dilute seawater access. Floodwater salinity as high as 12 ppt occurred in October 2000 (Table 4.2-6). Even when salinity in the estuary was lower most substations were subjected to increased floodwater salinity after which salinity declined to near fresh conditions (Tables 4.2-5 and 4.2-7). The salt tolerant nature of vegetation at this site (CZR 2001) and high sulfate reduction levels (see Section 5 below and CZR 2001) strongly argue that this site is normally flooded by saline water.

Indian Creek (P7) substations are the highest in elevation of all substations and consequently flood the least. During February 2000 and February 2001, all but substation 1 flooded less than one time during the two-week study period (Tables 4.2-1 and 4.2-4). Even during other seasons, flooding frequency was low as was flooding depth. There is a berm between substations 1 and 2 and consequently when flooding does occur, it is often of longer duration (Tables 4.2-1 through 4.2-4) because floodwater has no easy exit from the swamp.

Indian Creek shows no indication of impacts from salt and contains several species of salt sensitive herbaceous vegetation in addition to woody trees and shrubs that dominate the

Table 4.2-5 Summary of salinity data from nine substations collected along the Cape Fear River and its tributaries in Summer of 2000.

Station Number	Station Name	Substation Number	Summer 2000 Salinity Range (ppt)	No. of flood events containing > 1 ppt salinity
P3	Town Creek	1	<1 - 10	13
		2	<1 - 10	11
		3	<1 - 10	11
		4	<1 - 8	10
		5	ND	ND
		6	ND	ND
P6	Eagle Island	1	3 - 8	23
		2	2 - 7	22
		3	ND	ND
		4	<1 - 7	15
		5	ND	ND
		6	ND	ND
P7	Indian Creek	1	<1	0
		2	<1	0
		3	<1	0
		4	ND	ND
		5	<1	0
		6	<1	0
P8	Dollison's Landing	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	ND	ND
		6	ND	ND
P9	Black River	1	<1	0
		2	ND	ND
		3	<1	0
		4	<1	0
		5	ND	ND
		6	ND	ND
P11	Smith Creek*	1	<1 - 11	14
		2	<1 - 12	20
		3	6 - 12	22
		4	<1 - 11	16
		5	<1 - 12	13
		6	ND	ND
P12	Rat Island	1	6 - 9	25
		2	<1 - 9	22
		3	<1 - 7	18
		4	<1 - 6	8
		5	ND	ND
		6	ND	ND
P13	Fishing Creek	1	<1 - 5	7
		2	<1 - 4	9
		3	<1 - 4	8
		4	<1 - 4	6
		5	ND	ND
		6	ND	ND
P14	Prince George	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	ND	ND
		6	ND	ND

ND=No data available

* data collected 06/04/00 through 06/19/00

Table 4.2-6 Summary of salinity data from nine substations collected along the Cape Fear River and its tributaries in Fall 2000.

Station Number	Station Name	Substation Number	Fall 2000 Salinity Range (ppt)	No. of flood events containing > 1 ppt salinity
P3	Town Creek	1	7 - 13	25
		2	6 - 12	25
		3	6 - 13	25
		4	5 - 10	25
		5	2 - 8	25
		6	<1 - 8	17
P6	Eagle Island	1	2 - 10	26
		2	4 - 11	25
		3	4 - 12	24
		4	4 - 12	26
		5	2 - 7	24
		6	<1 - 6	20
P7	Indian Creek	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0
P8	Dollison's Landing	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0
P9	Black River	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0
P11	Smith Creek	1	<1 - 8	3
		2	<1 - 8	4
		3	<1 - 8	1
		4	<1 - 7	2
		5	<1 - 4	2
		6	<1 - 3	2
P12	Rat Island	1	3 - 6	25
		2	<1 - 3	16
		3	<1 - 2	6
		4	<1	0
		5	<1	0
		6	<1	0
P13	Fishing Creek	1	<1 - 5	10
		2	<1	1
		3	<1	2
		4	<1 - 5	10
		5	<1 - 4	7
		6	<1 - 2	2
P14	Prince George	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0

Table 4.2-7 Summary of salinity data from nine substations collected along the Cape Fear River and its tributaries in Spring 2001.

Station Number	Station Name	Substation Number	Spring 2001 Salinity Range (ppt)	No. of flood events containing > 1 ppt salinity
P3	Town Creek	1	<1	0
		2	<1 - 4	3
		3	<1 - 5	6
		4	<1 - 1	1
		5	<1	0
		6	<1	0
P6	Eagle Island	1	<1 - 11	2
		2	<1 - 10	1
		3	<1 - 10	2
		4	<1 - 9	1
		5	<1	0
		6	<1	0
P7	Indian Creek	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0
P8	Dollison's Landing	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0
P9	Black River	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0
P11	Smith Creek	1	<1	0
		2	<1 - 3	1
		3	<1 - 3	14
		4	<1 - 1	1
		5	<1	0
		6	<1	0
P12	Rat Island	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0
P13	Fishing Creek	1	<1 - 3	3
		2	<1 - 3	3
		3	<1 - 2	3
		4	<1 - 2	3
		5	<1 - 2	2
		6	<1	0
P14	Prince George	1	<1	0
		2	<1	0
		3	<1	0
		4	<1	0
		5	<1	0
		6	<1	0

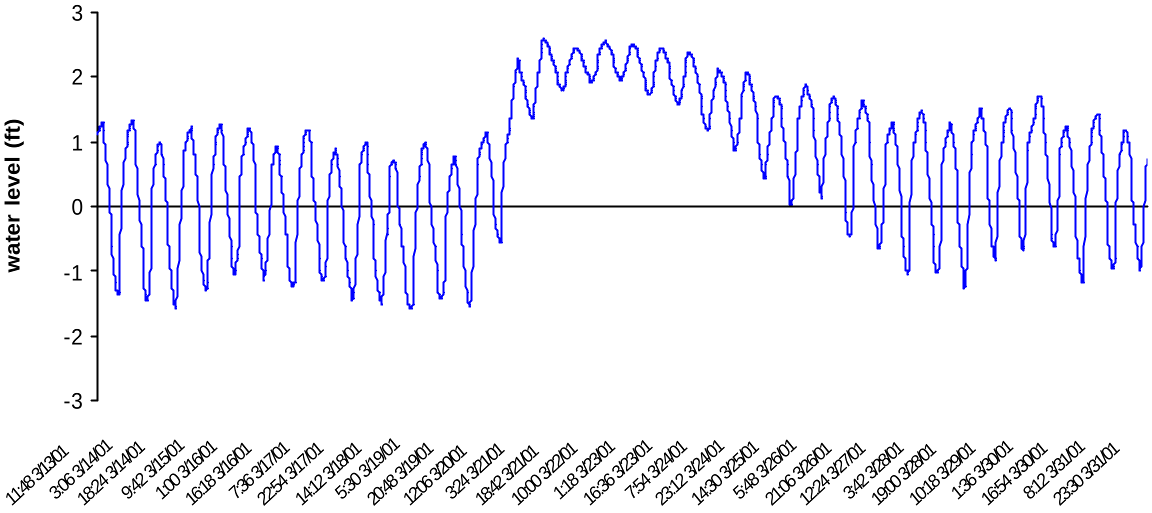


Figure 4.3-1. Water level for Inner Town Creek (P3).

station. On no occasion was salt detected on the marsh surface (Tables 4.2-5 through 4.2-7), although this may happen during extreme events. The constant release of freshwater upstream from Jordan Lake likely prevents any long-term salinity increase in surface water. The elevation of the site also limits potential salt impacts as low flow conditions in the Cape Fear River, which coincide with high salinity in the upper estuary, limit the tides from reaching the relatively high elevation swamp where substations are located.

Both Dollisons Landing (P8) and Black River (P9) were above all salt incursions in the upper estuary (Tables 4.2-5 through 4.2-7) and no salt (<0.5ppt) was detected at these substations; a condition consistent with both vegetation and biogeochemistry characteristics of these sites. Both stations, however, were clearly tidal despite their distance from the ocean (Tables 4.2-1 through 4.2-4) and flooded a high percentage of tides. Note the less frequently flooded condition of substation 6 at Dollisons Landing. Substation 6 at Black River was located in a depression and longer flooding duration at this substation is related to this characteristic, not the elevation of the substation.

Stations located along the Northeast Cape Fear River, P11-P14, do not have the benefit of a constant release of water upstream from a dam and so low flow conditions in the basin have the potential to allow more saltwater farther upstream, especially during summer conditions when the lush vegetation of the river swamp system can evapotranspirate huge amounts of water that would normally exit into the near shore environment through the river mouth.

Smith Creek (P11) substations are located at least partially on old dredge disposal material. Sites farther from the watercourse are relatively high, but still flood. During June 2000, most substations flooded only a third of the tides, but typically flooding occurs during more than half of the tides. Flood events were significant in duration lasting from 3.1 to 8.4 hours average duration per tide (Tables 4.2-1 through 4.2-4). Most tides contained water with significant saline content, maximum of 12 ppt (Tables 4.2-5 through 4.2-7). The proximity of this station to Ness Creek and Smith Creek allows freshwater runoff from suburban/urban Wilmington to lower salinity after heavy rainfalls, a condition noted on more than one occasion.

Rat Island (P12) is one of the most interesting stations because vegetation has clearly been impacted by what appears to be salt incursions. Indeed, salt was detected (maximum of 9 ppt) in floodwater at the three or four lowest substations during summer and fall 2000 (Tables 4.2-5 and 4.2-6), but was near 0 ppt during spring 2001 (Table 4.2-7). The two substations closest to the river flooded most of the time, while the remaining substations were flooded by fewer than 25% of the tides (Tables 4.2-1 through 4.2-4). When flooded, however, the duration of flooding was about the same for all substations because the irregular surface of this station serves to trap floodwater. This has the potential to trap any salt that reaches deep into the swamp. Proof of this phenomenon would be exhibited by significant sulfate reduction in sediments, which is noted in Section 5.56 of this report.

Fishing Creek (P13), which is about the same distance from the ocean as Dollisons Landing (P8) flooded regularly (Tables 4.2-1 though 4.2-4) except for substation 6 furthest from the river. Substation 1 was different than other stations in that it was higher in elevation as it was located on a slight berm. Consequently, drainage channels innervate the swamp and cross the transect bringing floodwater to interior substations before flooding at substation 1. Substations 2-4 are located near these channels and substation 5 in the middle of a drainage channel. These drainage channels also funnel water from local rain events from the swamp into the river. On one occasion this phenomenon was directly observed when a local thunderstorm flooded substations in the swamp with over 1 foot of water even though the tide level in the river was low. It took several hours for water levels to return to normal levels in the swamp.

Vegetation at Fishing Creek appears to be consistent with communities associated with fresh water. However, saline floodwaters as salty as 5 ppt were detected at all substations including the one immediately adjacent the upland. Sediments in this swamp are notable in that they are very unconsolidated, a condition consistent with organic degradation in soils. It is important to recall that salinity and flooding are recorded at substations for only two weeks each season so higher salinity may have occurred when instruments were not present. Saline levels detected in soils at some substations during porewater sampling provide evidence that such events occur (see Section 5.57).

The background station for this branch of the river is station P14, Prince George Creek. Despite its distance from the ocean and the low tidal range (see Section 3) most substations flood with every tide, but do not receive any ocean derived salt (Tables 4.2-1 through 4.2-7). The elevation of these substations (relative to NAVD88) is relatively low and as a consequence flood duration was on average the longest of all stations except for Fishing Creek (Tables 4.2-1 through 4.2-4).

4.4 Basin Elevation

Absolute elevation of the surface of marsh and swamp at all 54 substations varies from 0.66 to 2.43 feet NAVD88, if most substations adjacent to uplands (substation 6) are excluded. Some of the lowest absolute elevations are farthest from the ocean, especially in the Northeast Cape Fear River at P12, P13, & P14 (Table 4.2-1). Substations 5 and 6 at Rat Island (P12) are located in what was once pocosin habitat that is now tidally flooded on many occasions. The long-term implication of this topographic feature is that during low or no flow conditions there is the potential for a net flow of saline water upstream in the Northeast Cape Fear River. This was documented by the presence of saline water upstream of Point Peter at only one station (P6 – Eagle Island) in the Cape Fear River, while saline water was noted at three stations (P11 – Smith Creek, P12 – Rat Island, and P13 – Fishing Creek) in the Northeast Cape Fear River. Upstream flow is limited in the Cape Fear River by higher flow rates in the river and a much larger drainage basin.

4.5 Main Channel Salinity versus Marsh/Swamp Salinity

The degree to which salinity in the river or creeks affect the marsh or swamp surface depends on the ability of the saline water to move onto the marsh/swamp surface. Because fresh water typically flows over more saline water in the upper portions of estuaries, the marsh/swamp surface may be insulated from excursions of salt water upstream unless the saline water is near the surface. The conductivity probe located at each DCP platform was placed at a level that would correspond to the lowest water levels of low tide. Initially, these probes were within the stilling wells, but the limited exchange of surface water with the stilling well during a falling tide and later the necessity to limit water exchange in the stilling wells forced the placement of the conductivity probe on the piling adjacent to the stilling well.

Tables 4.5-1 and 4.5-2 show the maximum salinity measured in floodwaters at marsh/swamp substations and the corresponding maximum levels of salinity found at the DCP during that tide. In general, the highest salinity water measured at the DCP did not move onto the surface of the marsh or swamp except at substation 1 closest to the river. The short (two-week) duration of the salinity and water levels on the marsh/swamp surface misses intrusions of salt during other times of the year. Based on the relationship between salinity at the DCP and salinity of the water flooding the marsh swamp at a specific water level, inference can be made regarding the degree of salt reaching the marsh/swamp. During November 2000 salinity was as high as13 ppt at the Eagle Island (P6) DCP (Table 4.5-1). Substation 1 floods on almost every tide with water containing the same amount of salt at the DCP measured, so we infer that salinity also was 13 ppt on the marsh. Correlating water level at the DCP with marsh elevation allows a determination of both depth of flooding and a reliable estimate of salinity for any substation.

5.0 Marsh/Swamp Biogeochemistry

5.1 Summary

Geochemical data were collected at nine stations in the Cape Fear River Estuary beginning in winter 2000. The microbial modes of organic matter remineralization of these sites ranged from sulfate reducing to methanogenic. Analysis of porewater chloride, sulfate, and methane was performed at six substations per station and at six depths per substation. Samples were collected during winter and summer at eight stations and monthly at Eagle Island (P6). The database interpreted in this section includes two winter collections (winter 2000 and 2001) and one summer collection (2000). These data were used to classify the geochemical setting of each substation at each station as methanogenic, sulfate reducing, methanogenic with evidence of past sulfate reduction, or sulfate reducing with a non-seawater source of sulfate. Understanding the current and past geochemical conditions will be necessary to separate potential changes caused by the dredging and widening of the Cape Fear River from natural fluctuations.

The geochemistry at Eagle Island (P6) is analyzed monthly and is characterized by a mix of sulfate reduction and methane production. Sulfate reduction is the dominant microbial pathway for the breakdown of organic material during most of the year with the exception of early fall, when methanogenesis dominates. During fall (September and October), sulfate concentrations and inputs are lowered due to the summer depletion of sulfate stocks and decreases in floodwater salinities, resulting in the highest rates of methane production. Methane production rates are low during the remainder of the year due to competition by sulfate reducing bacteria. A major feature of the Eagle Island geochemical data was a pulse

Table 4.5-1. Maximum salinity at all swamp stations and corresponding DCP salinity for the same tide for Fall 2000.

Station Number	Station Name	Substation Number	Season	Date	Time	Maximum Swamp Salinity (ppt)	Corresponding DCP Salinity
P3	Town Creek	1	Fall 00	10/28/00	13:54	13	ND
		2	Fall 00	10/28/00	13:48	12	ND
		3	Fall 00	10/28/00	14:06	13	ND
		4	Fall 00	10/28/00	15:00	10	ND
		5	Fall 00	10/29/00	23:48	8(6 on 10/28)	ND
		6	Fall 00	10/30/00	1:36	8(6 on 10/28)	ND
P6	Eagle Island	1	Fall 00	10/26/00	11:00	10 (6 on 11/5)	11
		2	Fall 00	11/5/00	18:48	11	13
		3	Fall 00	11/5/00	18:18	12	13
		4	Fall 00	11/5/00	18:42	12	13
		5	Fall 00	11/5/00	18:24	7	13
		6	Fall 00	11/5/00	18:06	6	13
P7	Indian Creek	1	Fall 00	10/18/00	N/A	<1	<1
		2	Fall 00	10/18/00	N/A	<1	<1
		3	Fall 00	10/18/00	N/A	<1	<1
		4	Fall 00	10/18/00	N/A	<1	<1
		5	Fall 00	10/18/00	N/A	<1	<1
		6	Fall 00	10/18/00	N/A	<1	<1
P8	Dollison's Landing	1	Fall 00	11/12/00	N/A	<1	<1
		2	Fall 00	11/12/00	N/A	<1	<1
		3	Fall 00	11/12/00	N/A	<1	<1
		4	Fall 00	11/12/00	N/A	<1	<1
		5	Fall 00	11/12/00	N/A	<1	<1
		6	Fall 00	11/12/00	N/A	<1	<1
P9	Black River	1	Fall 00	11/28/00	N/A	<1	<1
		2	Fall 00	11/28/00	N/A	<1	<1
		3	Fall 00	11/28/00	N/A	<1	<1
		4	Fall 00	11/28/00	N/A	<1	<1
		5	Fall 00	11/28/00	N/A	<1	<1
		6	Fall 00	11/28/00	N/A	<1	<1
P11	Smith Creek	1	Fall 00	10/10/00	21:18	8	*3
		2	Fall 00	10/10/00	21:30	8	*3
		3	Fall 00	10/10/00	21:24	8	*3
		4	Fall 00	10/10/00	21:24	7	*3
		5	Fall 00	10/10/00	20:54	4	*3
		6	Fall 00	10/10/00	20:54	3	*3

ND=No data due to conductivity meter malfunction

* DCP conductivity probe contained within stilling well

Table 4.5-1(concluded). Maximum salinity at all swamp stations and corresponding DCP salinity for the same tide for Fall 2000.

Station Number	Station Name	Substation Number	Season	Date	Time	Maximum Swamp Salinity (ppt)	Corresponding DCP Salinity
P12	Rat Island	1	Fall 00	10/19/00	16:36	6	*ND
		2	Fall 00	10/19/00	16:36	3	*ND
		3	Fall 00	10/19/00	16:36	2	*ND
		4	Fall 00	10/19/00	N/A	<1	*ND
		5	Fall 00	10/19/00	N/A	<1	*ND
		6	Fall 00	10/19/00	N/A	<1	*ND
P13	Fishing Creek	1	Fall 00	11/13/00	12:30	5	8
		2	Fall 00	11/13/00	12:30	1	8
		3	Fall 00	11/13/00	12:30	1	8
		4	Fall 00	11/13/00	12:30	5	8
		5	Fall 00	11/13/00	13:00	4	8
		6	Fall 00	11/13/00	12:30	3	8
P14	Prince George	1	Fall 00	11/27/00	N/A	<1	<1
		2	Fall 00	11/27/00	N/A	<1	<1
		3	Fall 00	11/27/00	N/A	<1	<1
		4	Fall 00	11/27/00	N/A	<1	<1
		5	Fall 00	11/27/00	N/A	<1	<1
		6	Fall 00	11/27/00	N/A	<1	<1

*ND = DCP equipment absent

Table 4.5-2. Maximum salinity at all swamp stations and corresponding DCP salinity for the same tide for Spring 2001.

Station Number	Station Name	Substation Number	Season	Date	Time	Maximum Swamp Salinity (ppt)	Corresponding DCP Salinity
P3	Town Creek	1	Spring 01	4/28/01	N/A	<1	8
		2	Spring 01	4/28/01	2:54	4	8
		3	Spring 01	4/28/01	2:42	5	8
		4	Spring 01	4/28/01	2:54	1	8
		5	Spring 01	4/28/01	N/A	<1	8
		6	Spring 01	4/28/01	N/A	<1	8
P6	Eagle Island	1	Spring 01	3/20/01	21:54	11	11
		2	Spring 01	3/20/01	21:30	10	11
		3	Spring 01	3/20/01	21:30	10	11
		4	Spring 01	3/20/01	22:00	9	11
		5	Spring 01	3/20/01	22:00	<1	11
		6	Spring 01	3/20/01	22:00	1	11
P7	Indian Creek	1	Spring 01	2/21/01	N/A	<1	<1
		2	Spring 01	2/21/01	N/A	<1	<1
		3	Spring 01	2/21/01	N/A	<1	<1
		4	Spring 01	2/21/01	N/A	<1	<1
		5	Spring 01	2/21/01	N/A	<1	<1
		6	Spring 01	2/21/01	N/A	<1	<1
P8	Dollison's Landing	1	Spring 01	3/22/01	N/A	<1	<1
		2	Spring 01	3/22/01	N/A	<1	<1
		3	Spring 01	3/22/01	N/A	<1	<1
		4	Spring 01	3/22/01	N/A	<1	<1
		5	Spring 01	3/22/01	N/A	<1	<1
		6	Spring 01	3/22/01	N/A	<1	<1
P9	Black River	1	Spring 01	4/17/01	N/A	<1	<1
		2	Spring 01	4/17/01	N/A	<1	<1
		3	Spring 01	4/17/01	N/A	<1	<1
		4	Spring 01	4/17/01	N/A	<1	<1
		5	Spring 01	4/17/01	N/A	<1	<1
		6	Spring 01	4/17/01	N/A	<1	<1
P11	Smith Creek	1	Spring 01	4/17/01	N/A	<1	5
		2	Spring 01	4/17/01	5:42	3	5
		3	Spring 01	4/17/01	5:42	3	5
		4	Spring 01	4/17/01	4:48	2	5
		5	Spring 01	4/17/01	N/A	<1	5
		6	Spring 01	4/17/01	N/A	<1	5

ND=No data due to conductivity meter malfunction

Table 4.5-2 (concluded). Maximum salinity at all swamp stations and corresponding DCP salinity for the same tide for Spring 2001.

Station Number	Station Name	Substation Number	Season	Date	Time	Maximum Swamp Salinity (ppt)	Corresponding DCP Salinity
P12	Rat Island	1	Spring 01	3/23/01	N/A	<1	*ND
		2	Spring 01	3/23/01	N/A	<1	*ND
		3	Spring 01	3/23/01	N/A	<1	*ND
		4	Spring 01	3/23/01	N/A	<1	*ND
		5	Spring 01	3/23/01	N/A	<1	*ND
		6	Spring 01	3/23/01	N/A	<1	*ND
P13	Fishing Creek	1	Spring 01	5/10/01	1:00	3	7
		2	Spring 01	5/10/01	1:00	3	7
		3	Spring 01	5/10/01	1:00	2	7
		4	Spring 01	5/10/01	1:00	2	7
		5	Spring 01	5/10/01	1:00	2	7
		6	Spring 01	5/10/01	N/A	<1	<1
P14	Prince George	1	Spring 01	3/5/01	N/A	<1	<1
		2	Spring 01	3/5/01	N/A	<1	<1
		3	Spring 01	3/5/01	N/A	<1	<1
		4	Spring 01	3/5/01	N/A	<1	<1
		5	Spring 01	3/5/01	N/A	<1	<1
		6	Spring 01	3/5/01	N/A	<1	<1

*ND = DCP equipment absent

of high salinity floodwaters that occurred during November 2000 and May 2001. The high levels of sulfate that occurred during May 2001 likely reflect seasonal patterns associated with river flow; however, the event in November 2000 may be an anomaly. This event altered the normally fresh fall/winter conditions and produced higher rates of sulfate reduction. By January 2001, the station returned to more typical conditions. The occurrence of this type of event may or may not be a typical feature in the Cape Fear River, yet it dominated the geochemistry of Eagle Island during November and the months that followed. Future monitoring will determine whether or not these events are rare or if they occur with high frequency. If they occur with high frequency, they may contribute significantly to geochemical variations in addition to those caused by seasonal cycles.

The remaining eight stations are sampled twice each year, during winter and summer. Two of these stations were primarily sulfate reducing year-round (P3 Town Creek 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, and P13 Fishing Creek). There were also some within-site patterns of variation observed. Salinities, and therefore the input of sulfate, are typically higher at substation 1, which is usually closest to the flooding source when compared with substations further inland. Thus, some stations may have both sulfate reducing and methanogenic sediments at different substations during the same time of the year. Essentially this is an indication of how far from the water's edge the impact of sea derived salt reaches in the marsh/swamp. Rat Island was a good example of this type of geochemical setting. Sulfate reduction also tends to be dominant at the surface of sediments compared to deeper ones because there is a resupply of sulfate from floodwaters. Deeper sediments are more isolated from the floodwater source of sulfate and can rapidly deplete their sulfate stocks resulting in a shift to methanogenic remineralization processes with depth.

The geochemical settings of the stations in this project have been classified and described. The diversity of these sites (methanogenic and sulfate reducing) will allow both increases and decreases in salinity to be detected with the current monitoring scheme. An increase in salinity will shift methanogenic sites to sulfate reducing sites, especially in summer and mixed sites (with sulfate reduction in summer and methanogenesis in winter) to year-round sulfate reducing sites. Year-round sulfate reducing sites will experience increased inhibition of methanogenesis with an increase in salinity. In the case of a freshening of the estuary, the opposite should occur.

5.2 Geochemical Theory and Classification

Porewater sampling of the metabolic products of sulfate reducing and methanogenic bacteria helps establish the frequency and duration of organic soil inundation by tidal water carrying ocean-derived salt containing sulfate 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. In the presence of high levels of sulfate from seawater, methanogens are out competed by sulfate reducing bacteria and methanogenesis is inhibited. Hydrogen sulfide is toxic and limits both plant and animal species that do not have a behavioral or physiological mechanism to tolerate this bacterial metabolite. Thus, a shift in the dominant remineralization pathway can lead to different communities of plants and animals.

Sulfate and chloride concentrations are in a constant ratio in seawater (approximately 0.05:1 sulfate to chloride). Unlike sulfate, which can decrease in concentration due to sulfate reduction, there are no common removal mechanisms (biotic or a biotic) for chloride from seawater. Therefore, chloride concentration can be used to calculate the amount of sulfate originally supplied to a site by seawater. A porewater sulfate to chloride ratio that is lower than the seawater sulfate to chloride ratio is 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 are exhausted, sulfate-reducing bacteria are no longer able to function and methane production dominates. This 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 the nine-marsh/swamp stations of the present study place this value at approximately 300 µM sulfate. This concentration of sulfate corresponds to a salinity of approximately 0.4 parts per thousand.

Using this sulfate reducing threshold (300 µM sulfate), substations were classified as either methanogenic or sulfate-reducing. Methanogenic substations that had a sulfate to chloride ratio significantly less than the ratio of seawater (<0.05:1) were classified as methanogenic sites with evidence of past sulfate reduction. Sulfate reducing substations with ratios greater than seawater (>0.2:1) were classified as sulfate reducing sites with a non-seawater source of sulfate. The four main classifications are: 1) sulfate reducing (SR), 2) methanogenic (M), 3) methanogenic with evidence of past sulfate reduction (MPSR) and 4) sulfate reducing with a non-seawater source of sulfate (SRNS). Changes in these classifications will be used to determine changes in the biogeochemical setting. Such changes would be expected to be associated with increased tidal water and/or increased salinity measured at DCP stations or at substations on the marsh or swamp.

5.3 Geochemical Methodology

Biogeochemical monitoring was established in close proximity to shallow water well/conductivity/temperature substations. Sampling devices, referred to as peepers, are constructed of thick acrylic with wells located at six different depths, every 5 cm and sample 1, 6, 11, 16, 21, and 26 cm below the soil surface. Semi-permeable membranes allow methane, sulfate, and chloride to equilibrate with deionized water in wells. Peepers are inserted into the substrate and allowed to equilibrate for one week. 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 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 54 substations in 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 fom the Eagle Island (P6) every month using the same procedures. This station represents a transition between saline and fresh-dominated stations. In addition, the six substations represent the same transition along a different scale, well flooded to less flooded.

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

Eagle Island contains substations with SR and MPSR classifications meaning that both methanogenesis and sulfate reduction occur at this station (Table 5.4-1). These classifications are based on the following observations: 1) Sulfate concentrations ranged from less than 300 µM (the sulfate reducing threshold), indicating the presence of methane production, to as high as 6000 µM, indicating the presence of sufficient levels of sulfate to drive sulfate reduction, 2) Sulfate to chloride ratios ranged from those found in seawater to lowered ratios indicating a depletion of sulfate due to sulfate reduction, and 3) Methane was present at depth in all substations, but was often at very low concentrations at the surface during times of high sulfate input.

Chloride concentrations are a direct measure of salinity since chloride 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. Salinity input to Eagle Island varied during the year. Generally, salinity was higher during summer months when the flow rate of the river was low. However, two massive inputs of salt were observed during November 2000 and May 2001 (Figure 5.4-1), which overshadowed seasonal trends and dominated geochemical conditions during this report period (January 2000 - May 2001).

Within the Eagle Island station, as well as within the other stations in this study, the general trend was a decrease in salinity with distance from the river or creek (Figure 5.4-2). This trend is probably due to upland sources of freshwater, i.e. runoff and subsurface seepage. Within each substation at Eagle Island, the salinity versus depth profiles demonstrated either little variation of salinity with depth, indicating good mixing within the sediment porewaters, or higher salinities at the surface, indicating a recent input of high salinity water (Figure 5.4-3a-f). These profiles suggest a relatively rapid exchange of porewaters with floodwaters, which is also evident in the months following the high salinity event in November 2000. In November 2000 and May 2001, the flux of high salinity water from the surface was obvious from decreasing chloride concentrations with depth (Figure 5.4-3a-f) for all substations except substation 2. A closer look at the months that followed the November 2000 event suggests

Table 5.4-1. 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*.

Station	Substation	Depth (cm)	Summer 2000	Winter 2000	Winter 2001
Town Creek			Classification	Classification	Classification
P3					
	1	1	II	---	II
	1	6	II	---	II
	1	11	II	---	II
	1	16	II	---	I*
	1	21	II	---	I*
	1	26	I*	I*	I*
	2	1	II	II	II
	2	6	II	II	II
	2	11	II	I*	II
	2	16	II	I	II
	2	21	II	I*	II
	2	26	II	I*	II
	3	1	II	II	I
	3	6	II	I	II
	3	11	II	I	II
	3	16	II	I*	I*
	3	21	II	I*	II
	3	26	II	I*	II
	4	1	II	I	II
	4	6	II	I*	I*
	4	11	II	II	I*
	4	16	II	II	I*
	4	21	II	II	II
	4	26	II	II	II
	5	1	II	---	II
	5	6	II	I	II
	5	11	II	I	II
	5	16	II	II	II
	5	21	II	---	II
	5	26	II	II	II
	6	1	II	II	II
	6	6	II	II	II
	6	11	II	II	II
	6	16	II	II	II
	6	21	II	II	II
	6	26	I*	II	II

Table 5.4-1. Continued

Station	Substation	Depth (cm)	Summer 2000	Winter 2000	Winter 2001
Eagle Island			Classification	Classification	Classification
P6					
	1	1	II	---	II
	1	6	II	---	II
	1	11	II	---	II
	1	16	II	I	II
	1	21	II	I	II
	1	26	II	I*	II
	2	1	II	I	II
	2	6	II	I	II
	2	11	II	---	II
	2	16	II	---	II
	2	21	II	I	II
	2	26	II	I	II
	3	1	I*	I	II
	3	6	I*	---	II
	3	11	I*	I*	II
	3	16	I*	I*	I*
	3	21	I*	I*	II
	3	26	I*	II	II
	4	1	II	I	II
	4	6	II	I*	II
	4	11	II	I*	II
	4	16	II	II	I*
	4	21	II	I*	II*
	4	26	I*	I*	II
	5	1	II	I	II
	5	6	I*	I*	II
	5	11	II	I	II
	5	16	I*	I*	II
	5	21	I*	I*	II
	5	26	I*	I*	II
	6	1	II	I	I*
	6	6	I*	I*	I*
	6	11	---	I	I*
	6	16	II	I	I*
	6	21	I*	I	I*
	6	26	I*	I	I*

Table 5.4-1. Continued

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

Table 5.4-1. Continued

Station	Substation	Depth (cm)	Summer 2000	Winter 2000	Winter 2001
Dollisons Landing			Classification	Classification	Classification
P8					
	1	1	I	---	II*
	1	6	II*	I	II*
	1	11	II*	II	II*
	1	16	II*	I	II*
	1	21	II	I*	II
	1	26	II	II*	II*
	2	1	II*	---	I
	2	6	II	---	I
	2	11	I	II	I
	2	16	I	II	I
	2	21	I	I	I
	2	26	I	I	I
	3	1	II	II	I
	3	6	I	I	I
	3	11	I	II*	II*
	3	16	I	I	II*
	3	21	I	II	I
	3	26	I	I	I
	4	1	I	II	I
	4	6	I	I	I
	4	11	I	I*	I
	4	16	I	---	I
	4	21	I	---	I
	4	26	I	I	I
	5	1	I	I	I
	5	6	I	II	I
	5	11	I	---	I
	5	16	I	II	I
	5	21	I	I	II*
	5	26	I	II	I
	6	1	I	I*	I
	6	6	I	I	I
	6	11	I	II*	I
	6	16	I	II	I
	6	21	I	---	I
	6	26	I	I	I

Table 5.4-1. Continued

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

Table 5.4-1. Continued

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

Table 5.4-1. Continued

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

Table 5.4-1. Continued

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

Table 5.4-1. Concluded

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

Figure 5.4-1. Monthly comparison of surface chloride porewater concentrations at substations 1 and 6 in Eagle Island (P6) from March 2000 through May 2001. Red bars are substation 6 blue bars are substation 1.

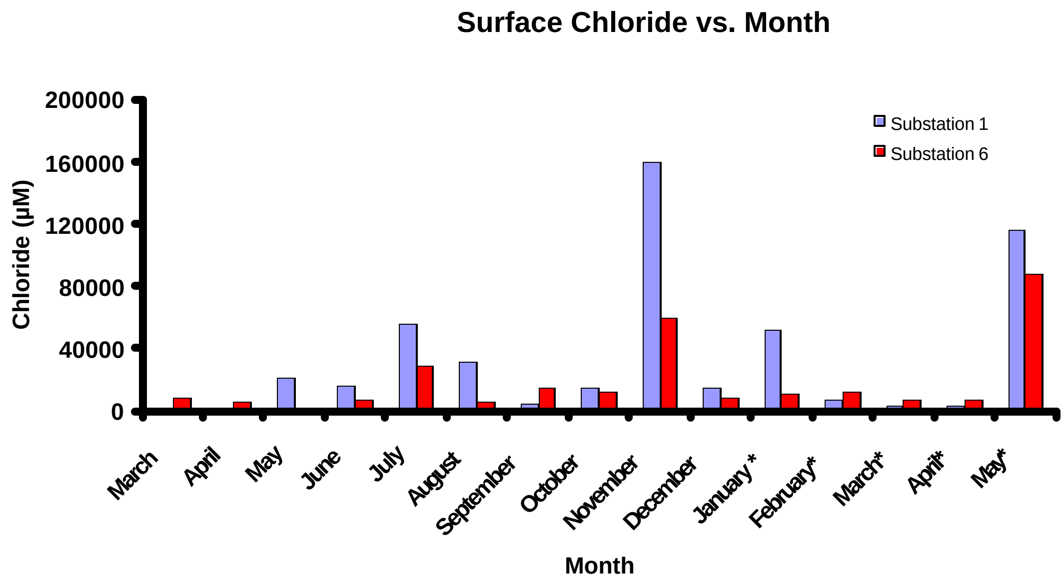


Figure 5.4-2. Comparison of chloride porewater concentrations in May 2000 (blue bars) versus November 2000 (red bars) at Eagle Island substations. Chloride concentrations are µM.

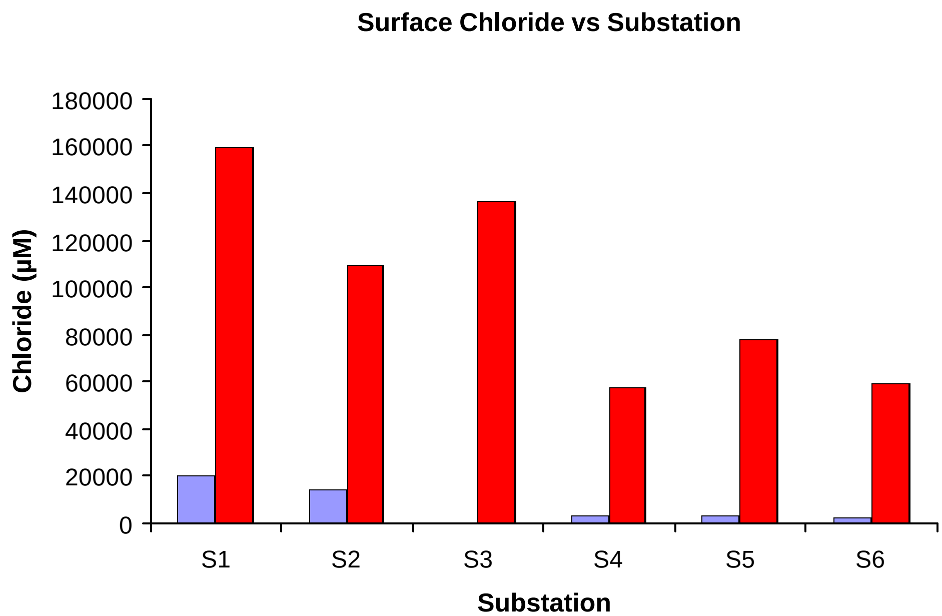
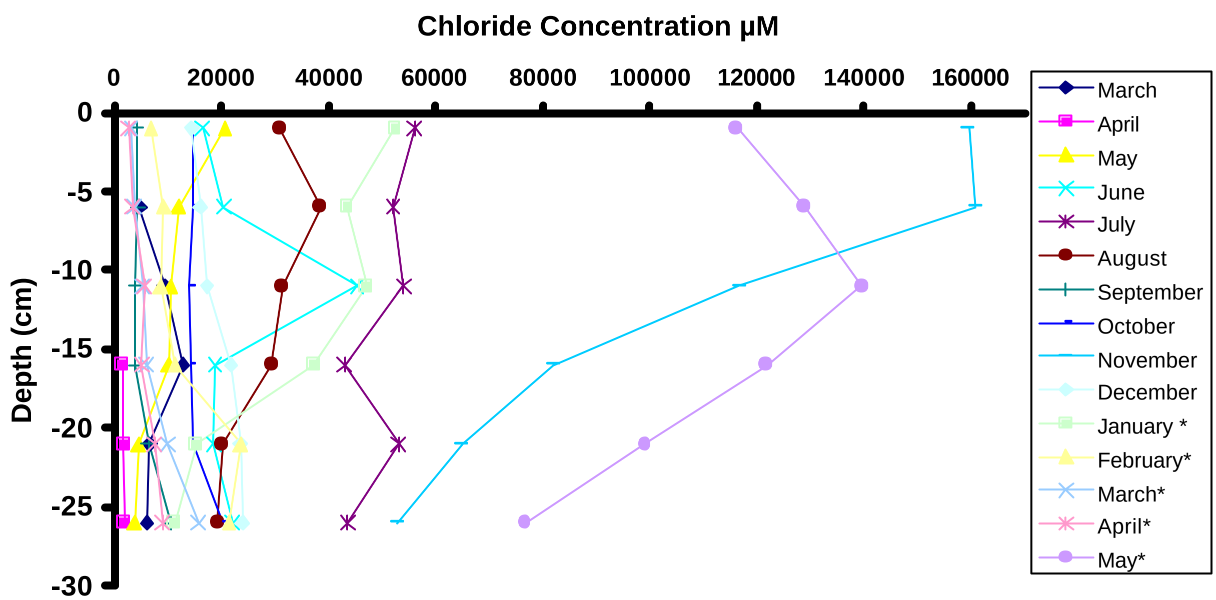
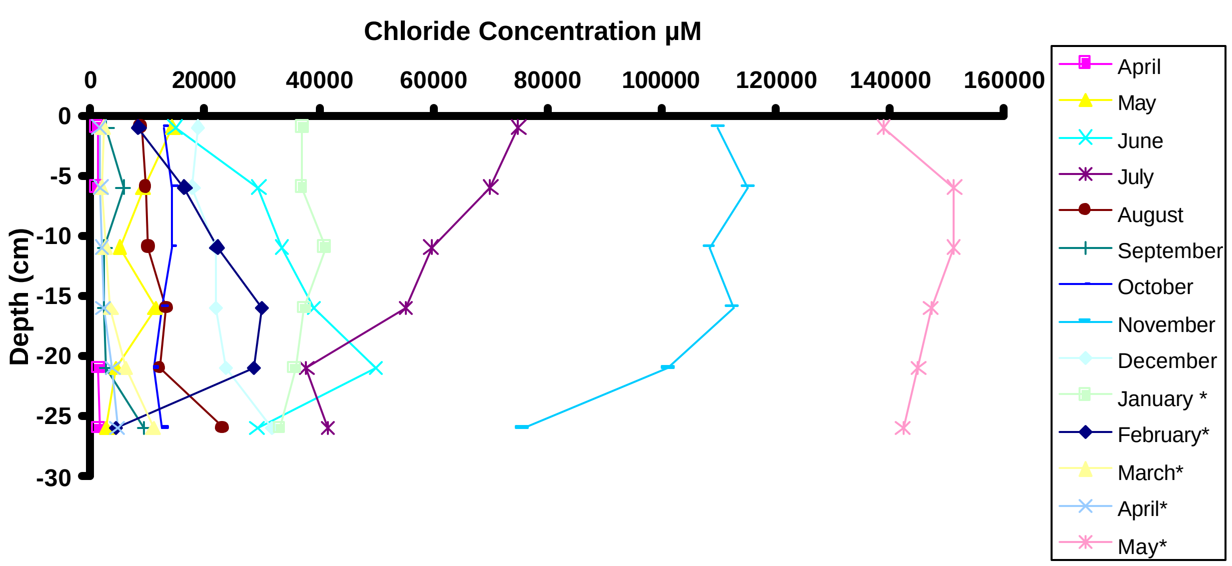


Figure 5.4-3. Eagle Island chloride porewater concentrations for substation 1-6 versus depth for various months. Months with an asterisk are from 2001, all others are from 2000. Chloride concentrations are µM.

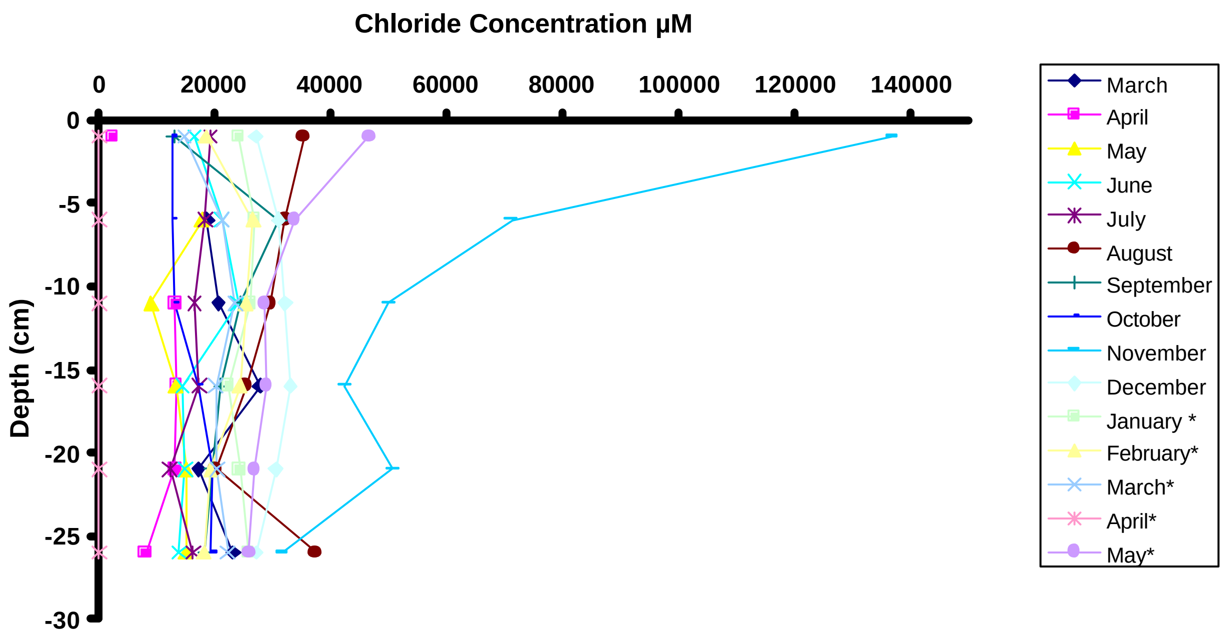
a. Substation 1



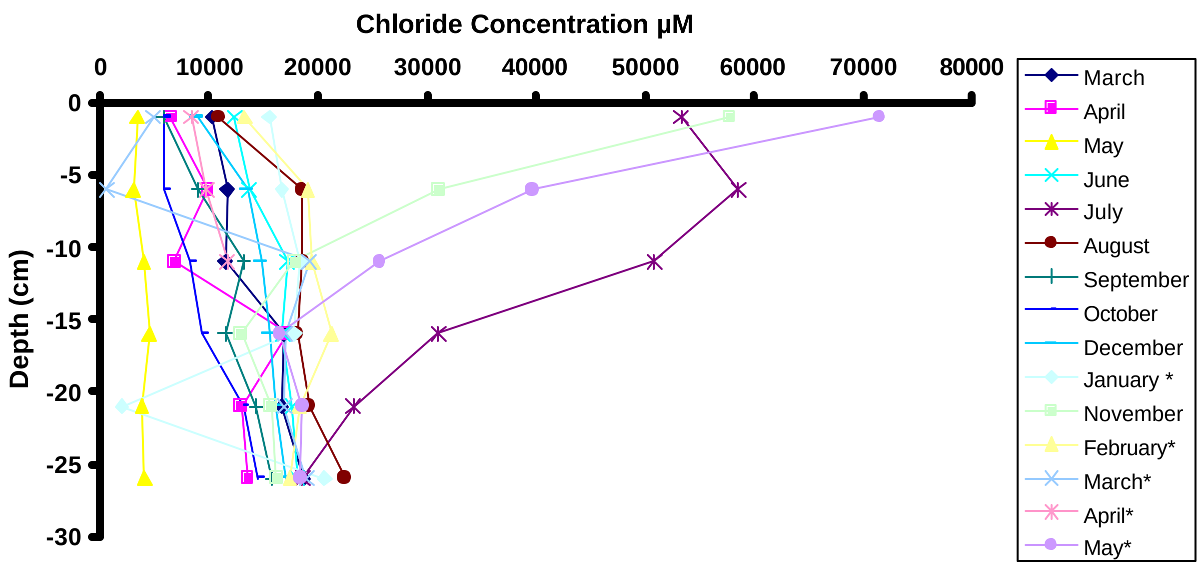
b. Substation 2



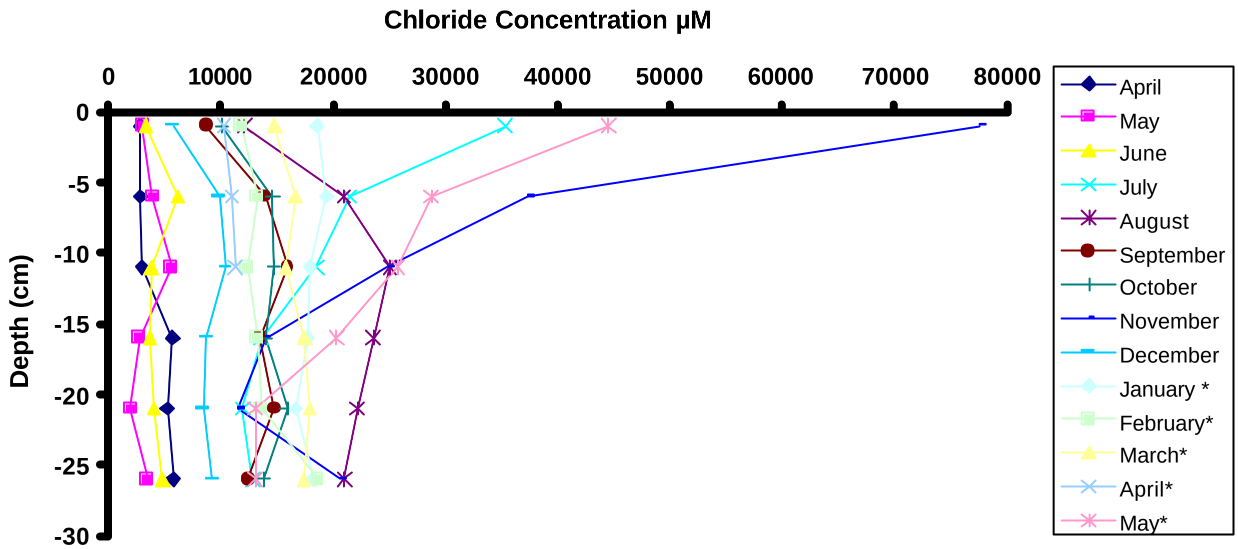
c. Substation 3



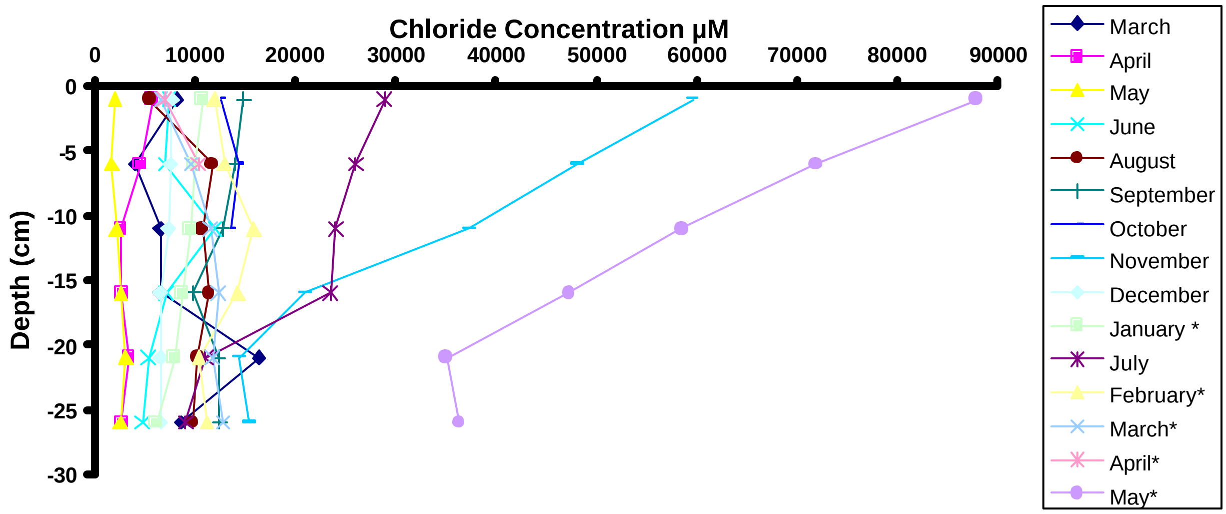
d. Substation 4



e. Substation 5



f. Substation 6



that the flushing of sediments may be rapid. In December and January, salinity profiles showed little variation with depth indicating dilution of the high salinity water with fresher water (Figure 5.4-4a, b). The rapid rate of sulfate addition to sediment is important as it demonstrates that sediments are not insulated to any degree from even short incursions of salinity.

Sulfate concentrations must be at sufficient levels for organic matter to breakdown via sulfate reduction. Preliminary observations in this study indicate that this threshold is approximately 300 µM. The occurrence of sulfate reduction can be identified by a sulfate concentration versus depth profile where sulfate concentrations decrease with depth until a threshold value is reached and sulfate concentrations no longer decrease with depth. Below this zone, the less competitive methane-producing bacteria are responsible for the breakdown of organic matter. The presence of sulfate reduction can also be confirmed by a sulfate to chloride ratio lower than the ratio found in seawater, indicating a depletion of sulfate.

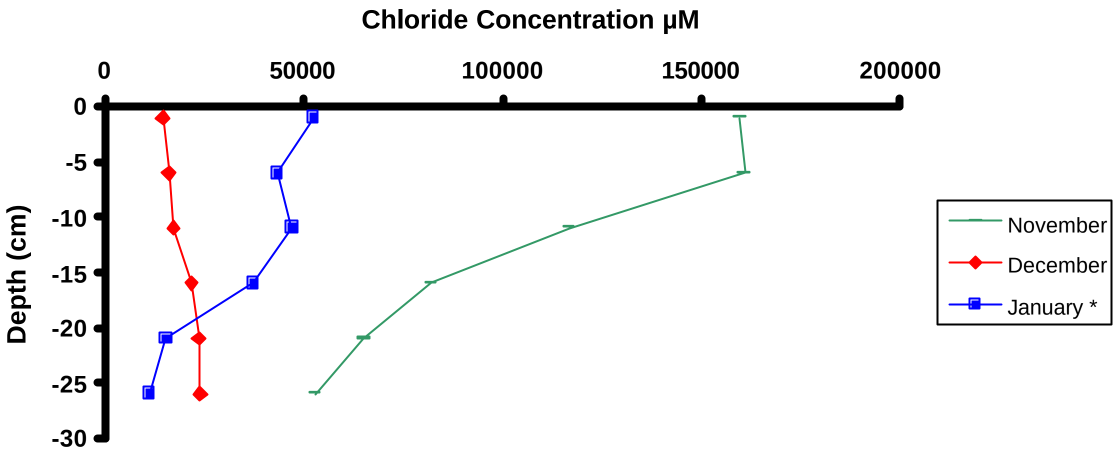
Sulfate concentrations ranged from below sulfate reducing threshold values to well above threshold values. Sulfate concentration versus depth profiles indicated the existence of both sulfate reducing and methanogenic sediments at Eagle Island. Generally, sulfate concentration depth profiles showed little variation with depth and were close to threshold concentrations during early spring (March-May 2000) and late fall (September-October 2000), indicating the absence of sulfate reduction (Figure 5.4-5a-f). During summer and after the high input of sulfate during November 2000 and May 2001, sulfate concentration versus depth profiles showed higher concentrations at the surface and a decrease with depth approaching threshold concentrations, indicating the presence of sulfate reduction.

Sulfate to chloride ratios further indicate the presence of sulfate reduction at some Eagle Island substations during the year. The patterns of variation in sulfate to chloride ratios follow a general trend with sulfate depleted ratios at depth in highly flooded substations (Figure 5.4-6a,b) and at surface and depth in the less flooded, upland substations (Figure 5.4-6c-f) supporting the idea that sulfate reduction occurs at Eagle Island and that the resupply of salt is greater at near-river stations. Eagle Island also is subject to periods of low salinity that flushes chloride from sediments. When such an event follows a high salinity event, remineralization of hydrogen sulfide into sulfate can increase the sulfate to chloride ratio. This phenomenon was observed, especially at substations 1 and 2 (Figures 5.4-6a, b).

Breakdown of organic matter by methanogens is inhibited by the more competitive sulfate reducing bacteria. Therefore, in the presence of sulfate reduction, methane concentrations are usually lowered. However, while methane production was inhibited during the summer at Eagle Island in surface sediments when salinities were higher, high summer temperatures allowed for maximum rates of methane production below the zone of sulfate reduction. These high rates of methane production below the zone of sulfate reduction can produce methane that migrates towards the surface giving a false indication of methane production in surface sediments. Therefore, methane concentrations should only be interpreted in conjunction with sulfate concentration data and sulfate to chloride ratio data. Eagle Island sulfate concentrations and sulfate to chloride ratios indicate that sulfate reduction was greatest near the surface of the sediments during summer and after the pulses of high

Figure 5.4-4. Eagle Island Substations 1 and 6 Porewater Chloride Concentrations for November, December, and January. Chloride concentrations are µM.

a. Substation 1



b. Substation 6

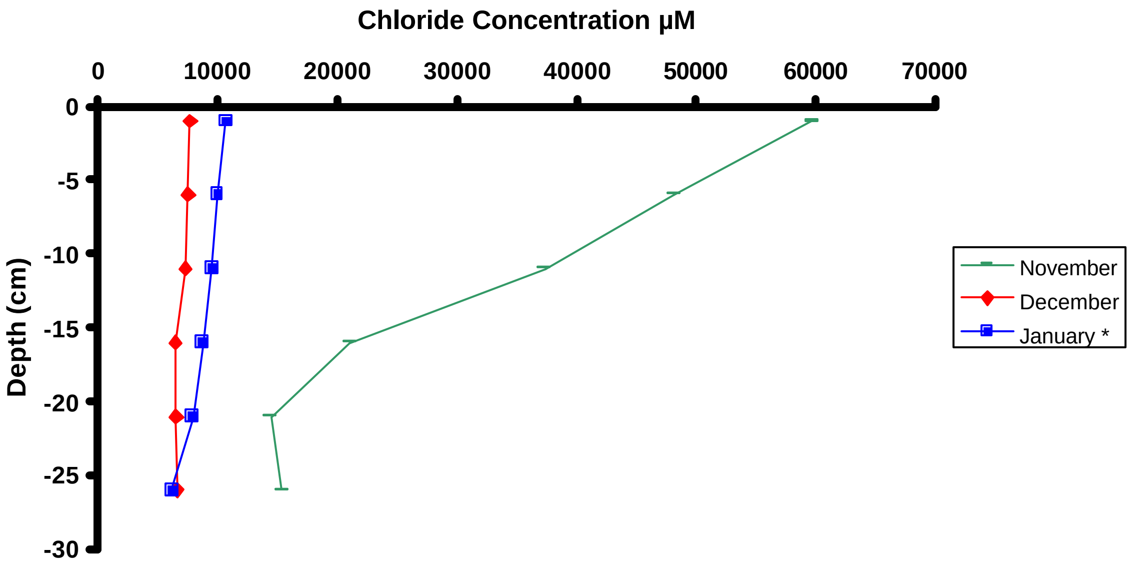
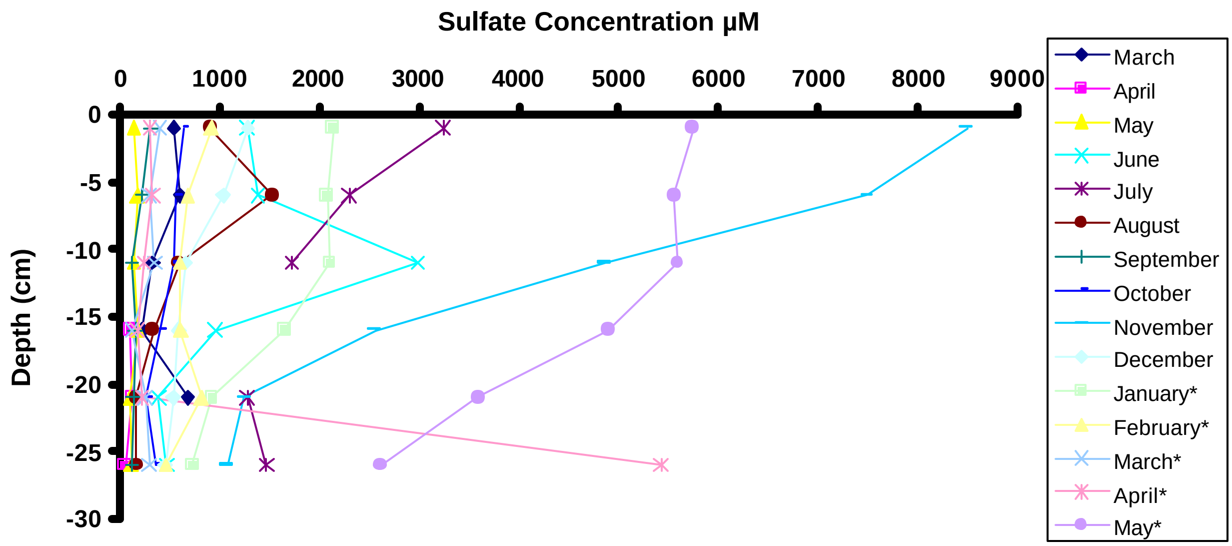
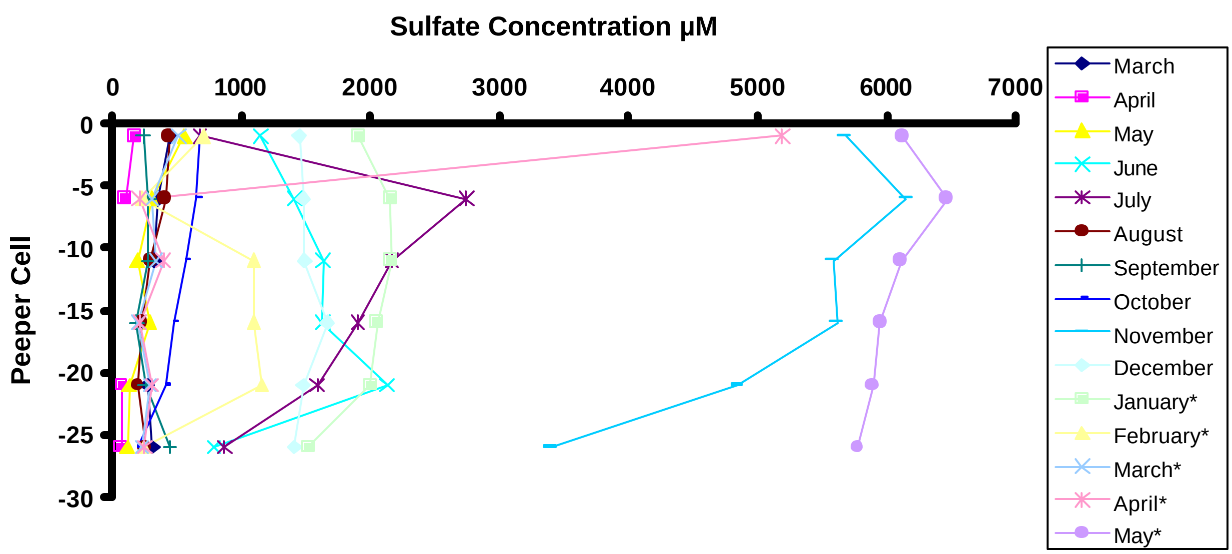


Figure 5.4-5. Eagle Island Substations 1-6 Porewater Sulfate Concentrations Versus Depth. Months with asterisk are from 2001, all others are 2000. Sulfate concentrations are µM.

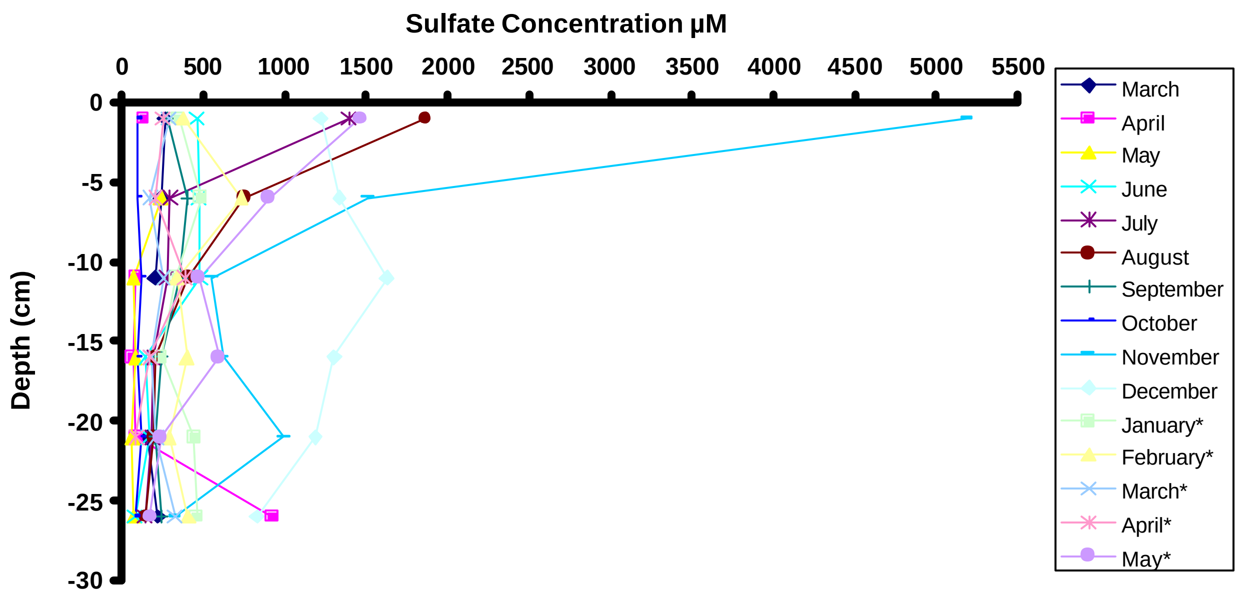
a. Substation 1



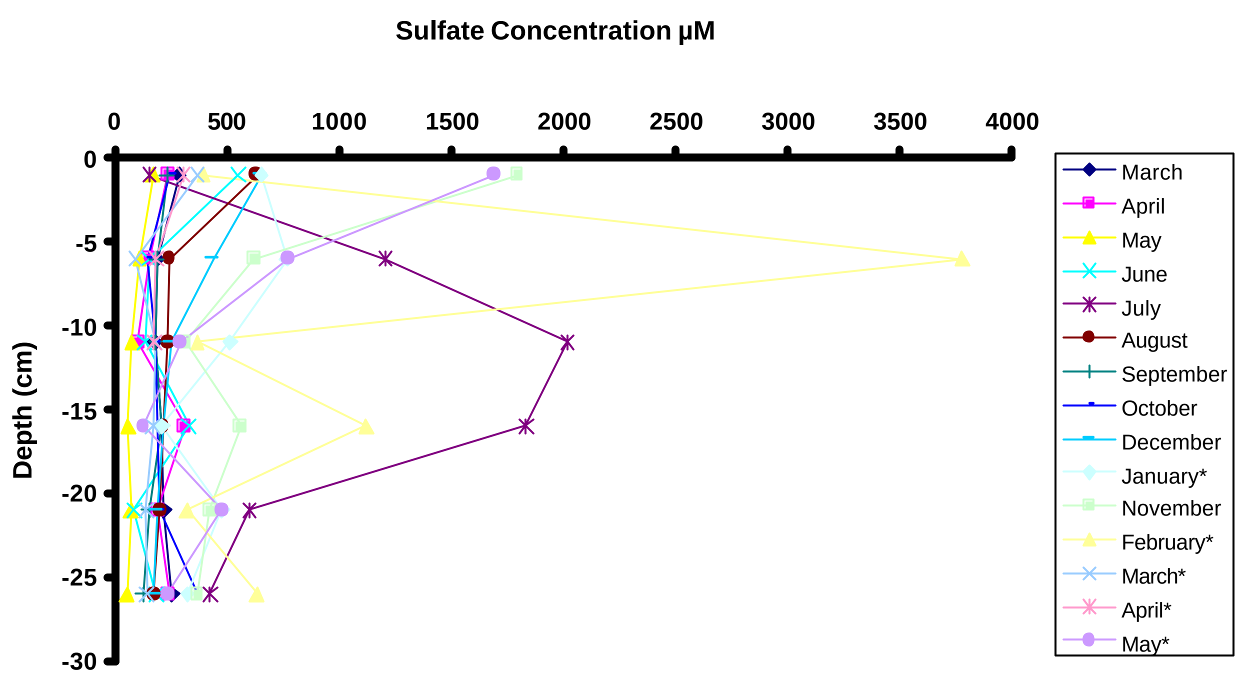
b. Substation 2



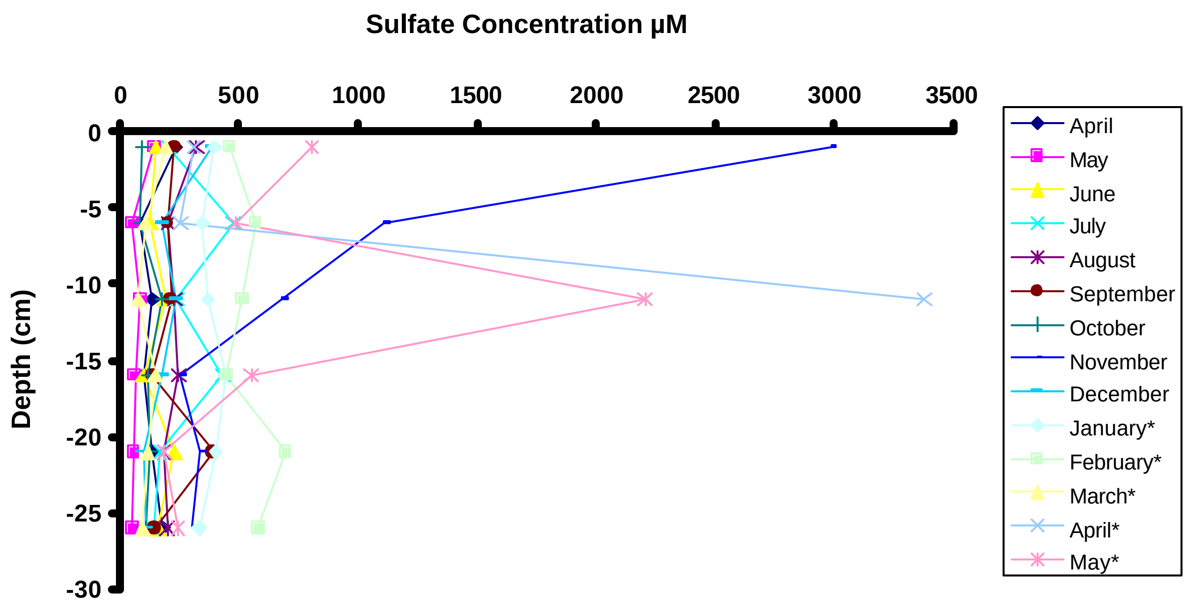
c. Substation 3



d. Substation 4



e. Substation 5



f. Substation 6

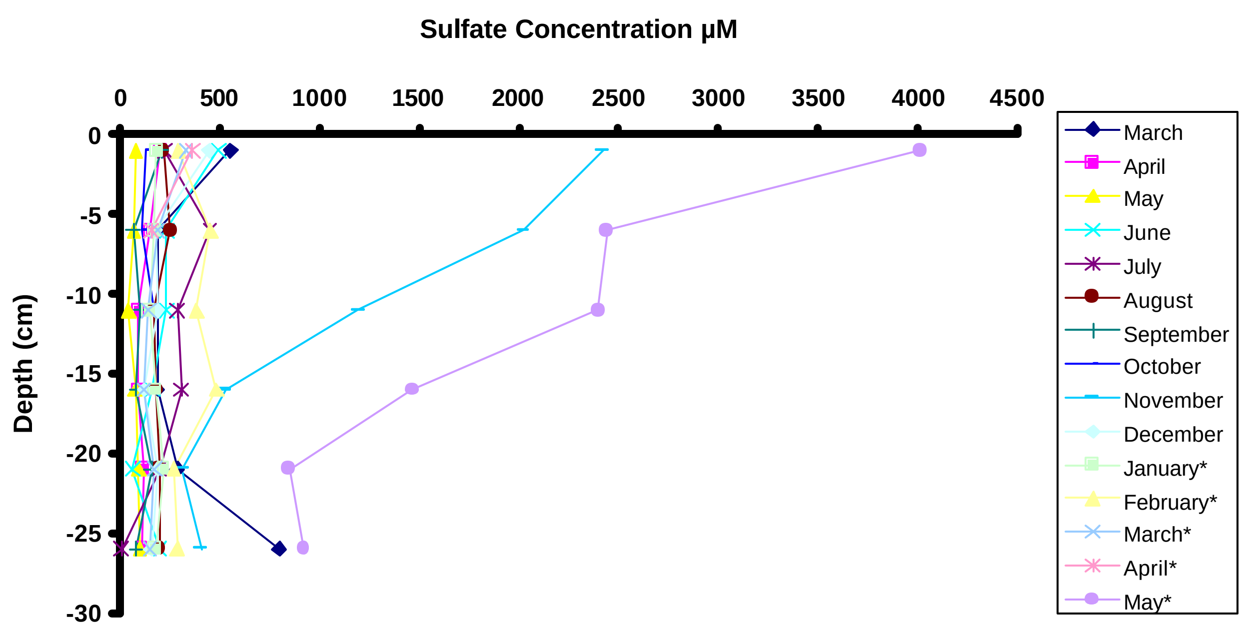
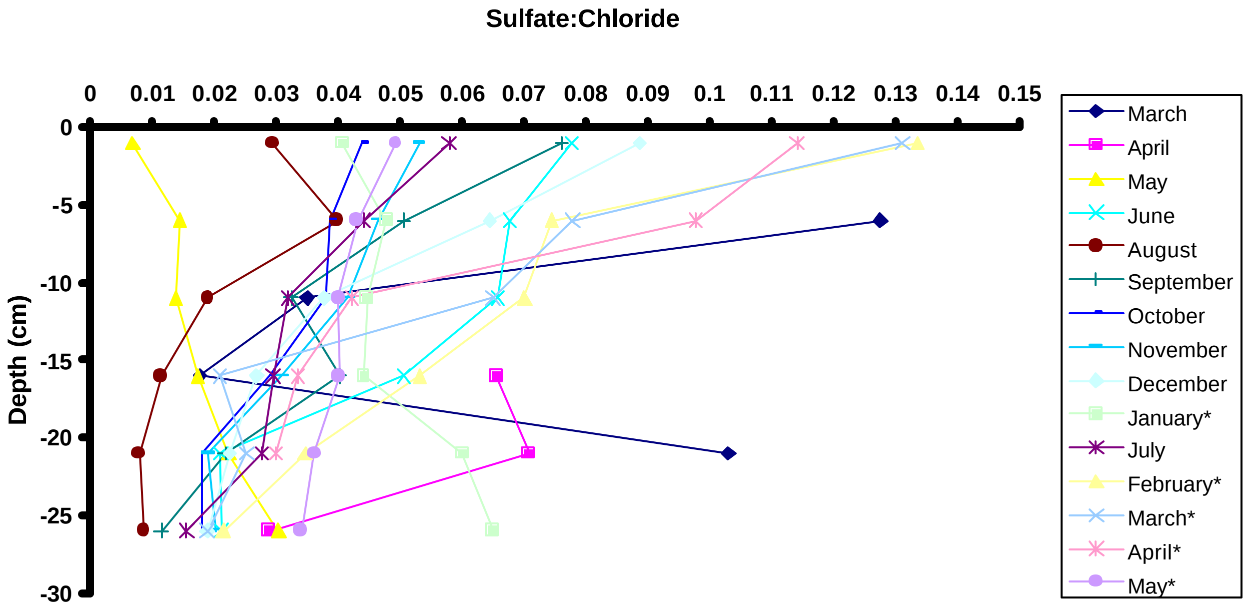
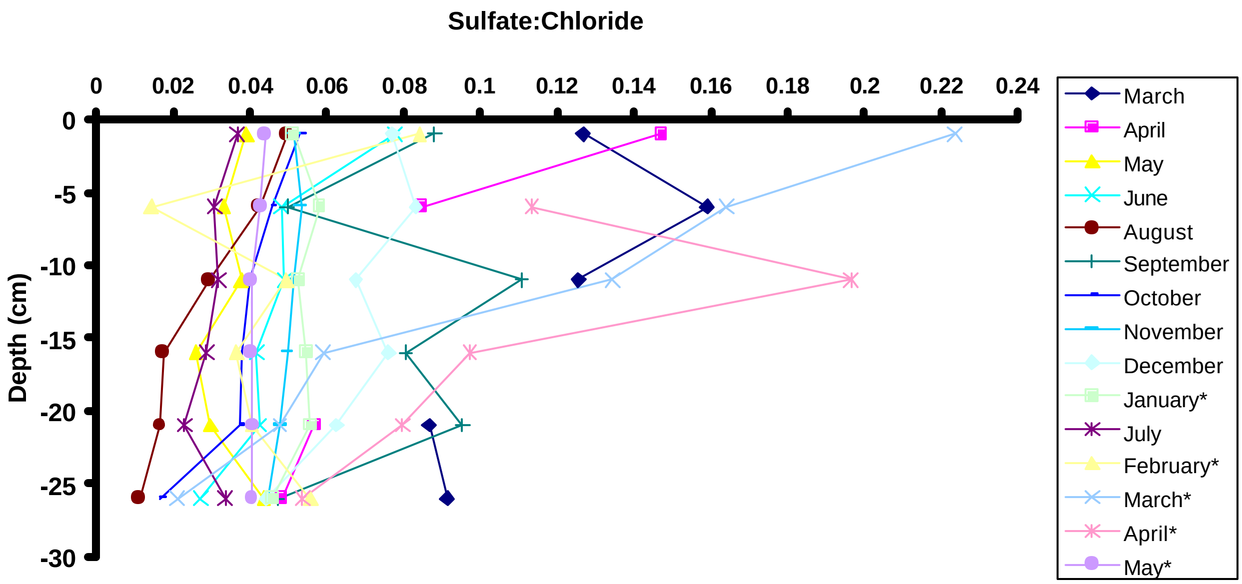


Figure 5.4-6. Sulfate to Chloride Ratios for Eagle Island Porewaters Substations 1-6. Months with asterisk are from 2001, all others are 2000.

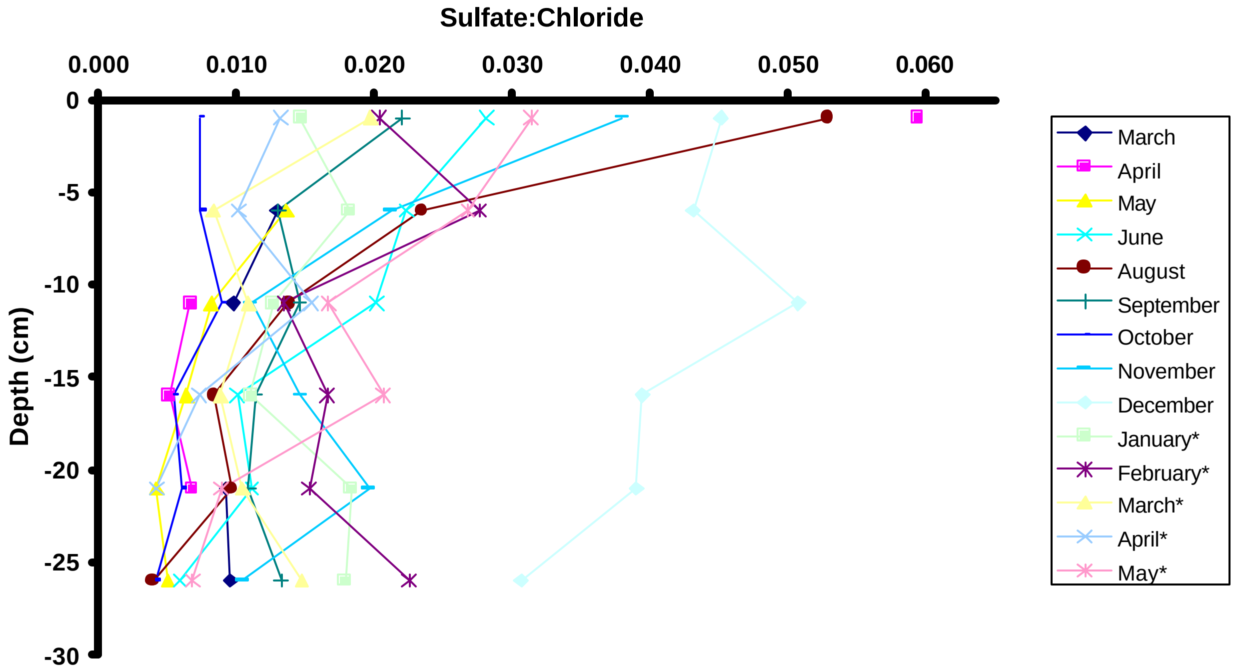
a. Substation 1



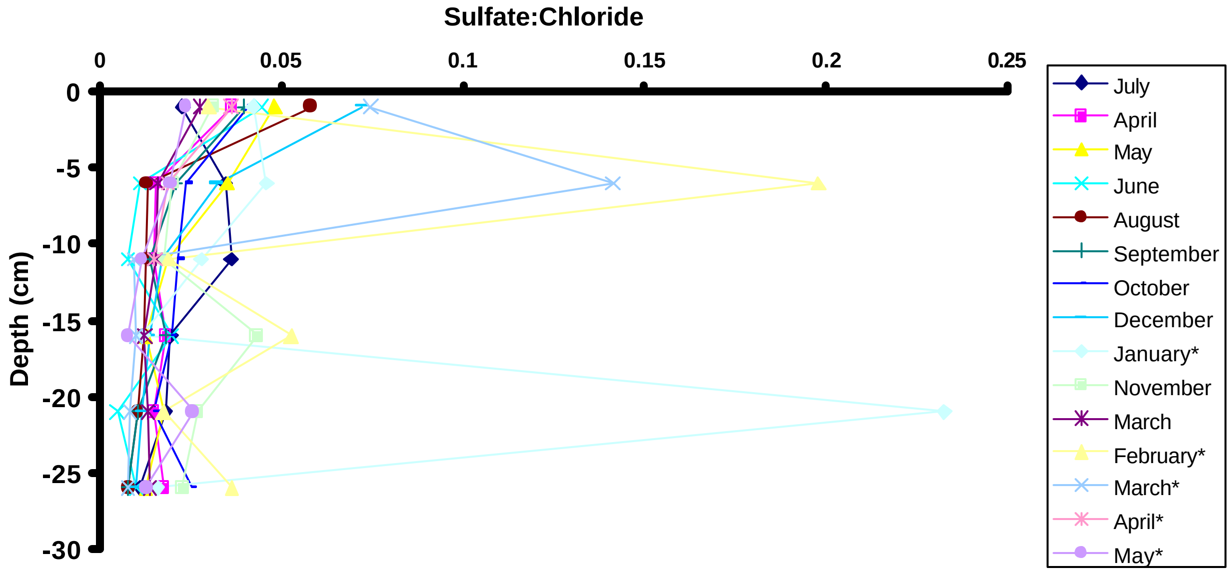
b. Substation 2



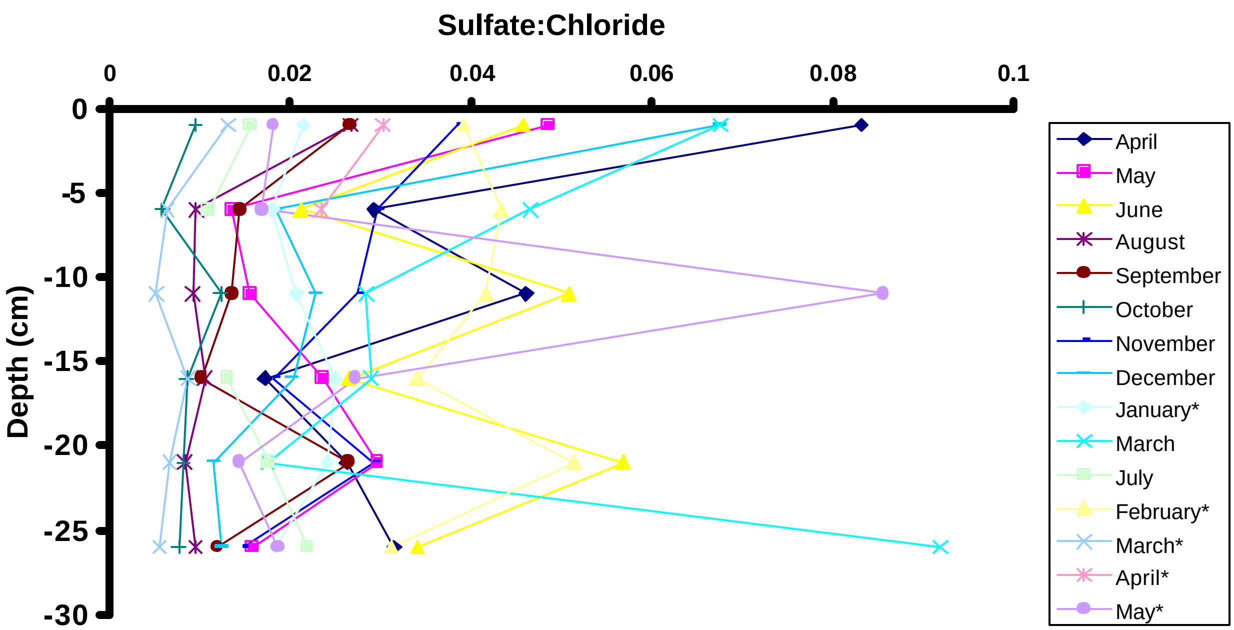
c. Substation 3



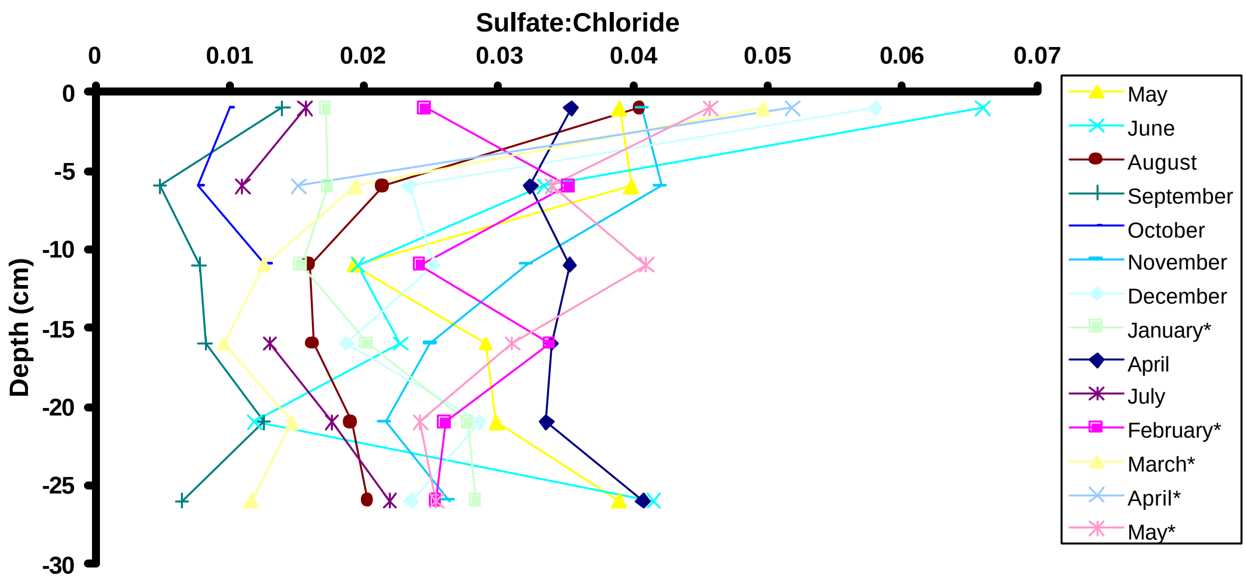
d. Substation 4



e. Substation 5



f. Substation 6



salinity water in November 2000 and May 2001. The presence of sulfate reduction at the surface during these times is also supported by the lowered methane concentrations during late summer and spring and following the November 2000 and May 2001 pulses of high salinity water (Figure 5.4-7a-f). The highest concentrations of methane occurred during September and October after the summertime sulfate reduction period had depleted the sulfate stocks. During these two months, sulfate concentrations at most depths were consistently below the threshold concentration for sulfate reduction.

5.5 Winter versus Summer Geochemistry for all Marsh/Swamp Transect Stations

The following section contrasts salinity regimes and geochemistries of substations between warm summer conditions versus cold winter conditions. These descriptions and geochemical classifications can be used to determine seasonal, interannual and post dredging variations. Three separate seasons are discussed including the winters of 2000 and 2001 and the summer of 2000. It should be noted that the winter 2000 data represent an extended sampling period, which includes data collected when soil conditions were not at the winter extreme. Therefore, these data largely represent late winter/early spring conditions. Sampling protocols now allow the collection of data from all stations during a five-week period.

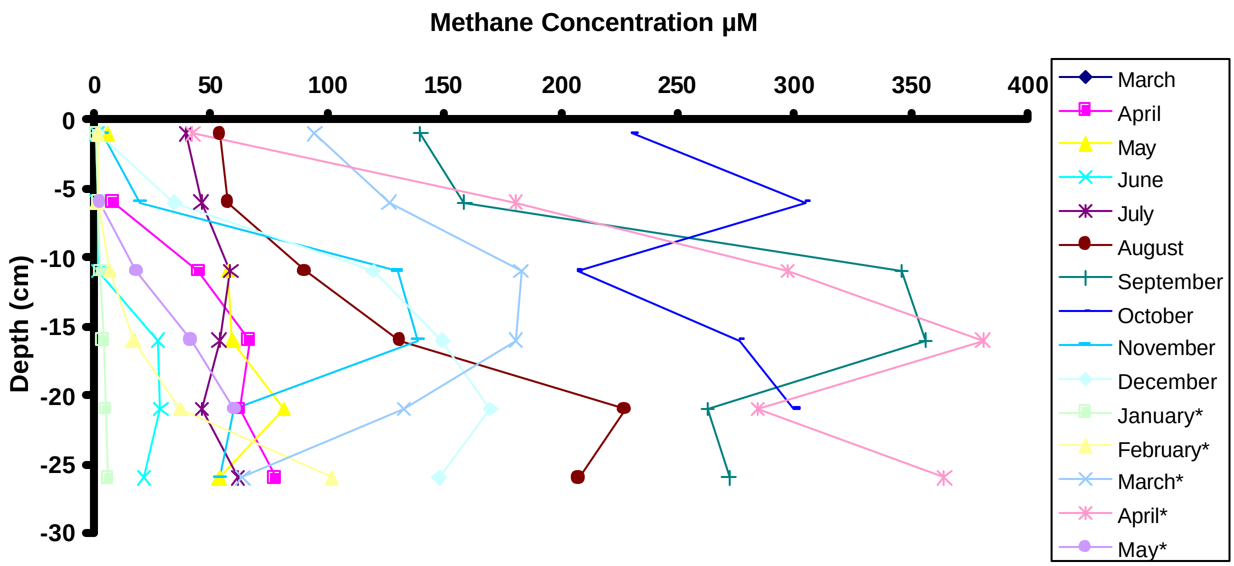
5.51 Town Creek (P3)

Town Creek is the most seaward station monitored for geochemistry. The salinity of porewaters at this site ranged from 0.1–4 ppt during winter and 2–8 ppt during summer (Tables 5.51-1)**.** Corresponding chlorinity is shown in Table 5.51-2. The station is classified exclusively as a sulfate reducing system (SR) during the summer with the exception of deep samples at substations 1 and 6 which are classified as methanogenic with evidence of past sulfate reduction (MPSR) (Table 5.4-1). This biogeochemical zonation is typical of estuarine sediments which are often sulfate reducing at the surface and methanogenic at depth due to depletion of sulfate which cannot be easily resupplied at depth. Since the quantity and quality of organic matter drives the rates of organic matter breakdown, it is likely that substations 1 and 6 contain more labile organic material than the other substations within this station. It is also possible that these substations have lower water/sediment exchange rates and therefore are not resupplied with sulfate during flood tides as well as the other substations.

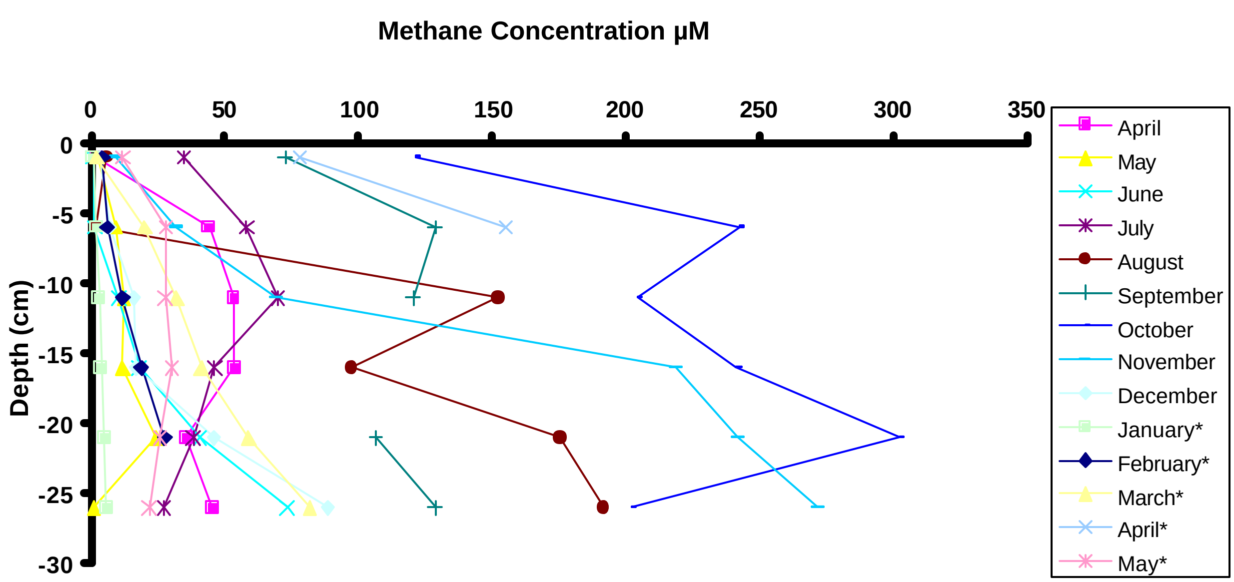
During the winter, this station was primarily classified as SR with just a few MPSR classifications (Table 5.4-1). The increase in MPSR classifications likely results from lower winter salinity of floodwaters and/or from the depletion of sulfate during the warmer months. Winter 2000 classifications are similar to those of winter 2001, except that there were some methanogenic sites that did not show evidence of past sulfate reduction in their sulfate to chloride ratios (Table 5.4-1). Because winter 2000 samples were collected later in the winter, and therefore further removed from the influence of the summer geochemical processes, it is likely that they no longer record the previous summertime geochemical conditions in their porewaters. Porewater methane concentrations were generally low at this site with the exception of substations 4 and 6 which were slightly elevated reflecting methane production at depth below the zone of sulfate reduction (Table 5.51-3)

Figure 5.4-7. Methane Concentrations for Eagle Island Porewaters Substations 1-6. Months with asterisk are from 2001, all others are 2000. Methane concentrations are µM.

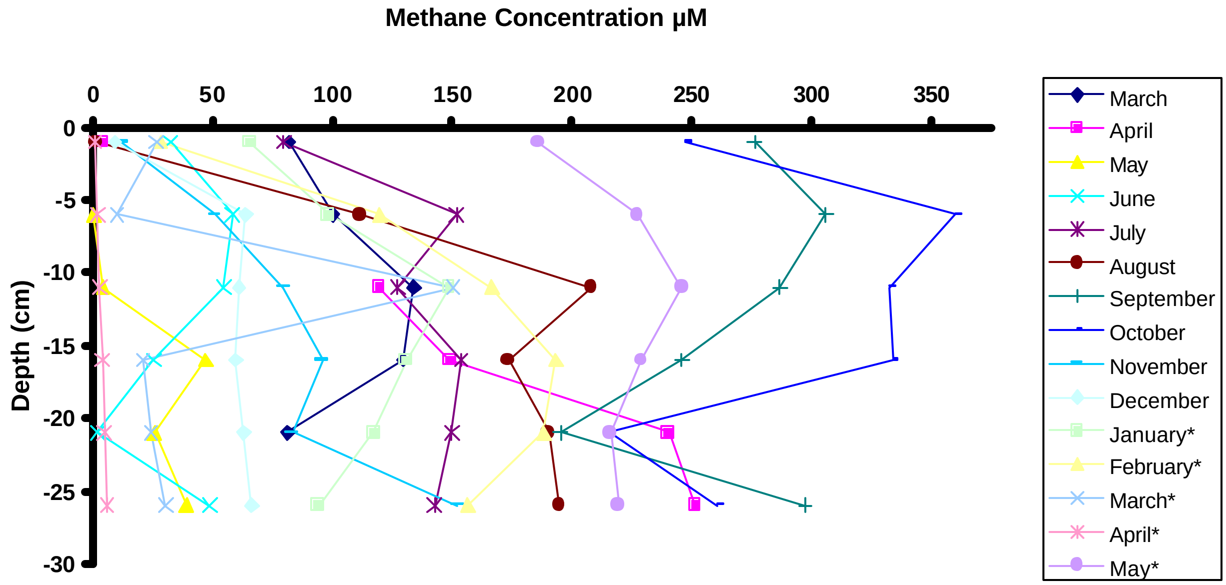
a. Substation 1



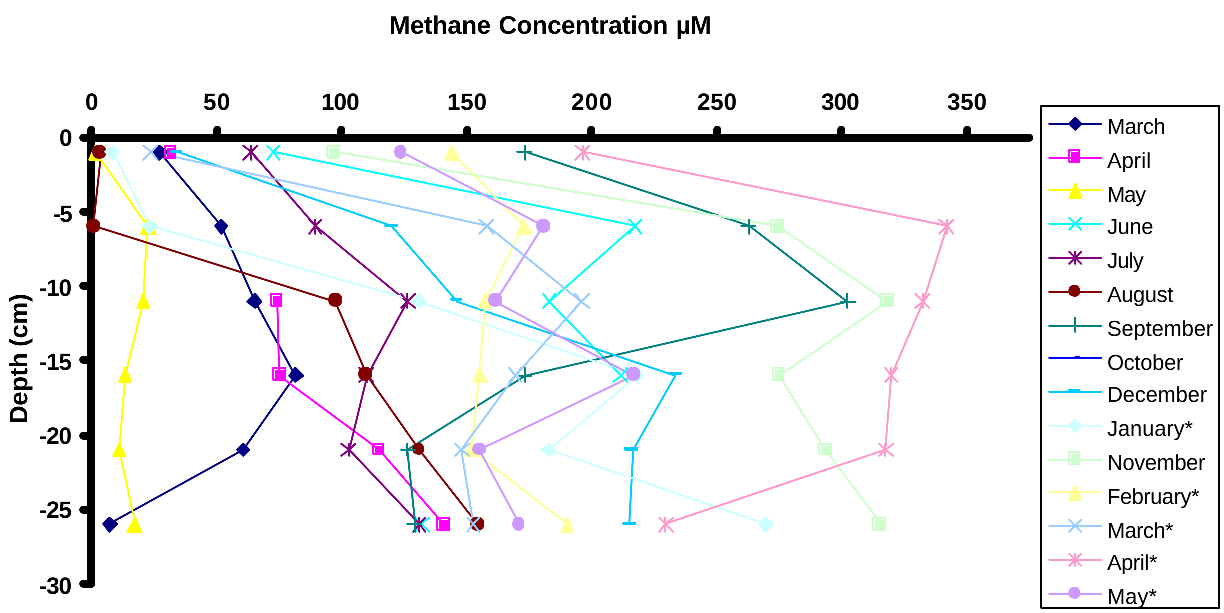
b. Substation 2



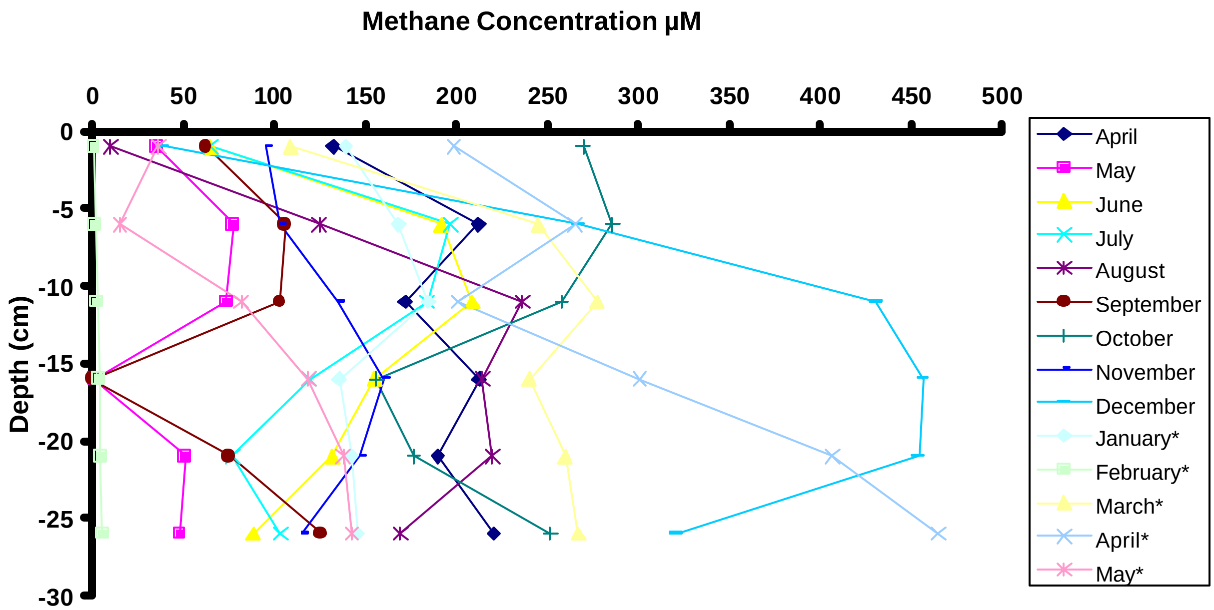
c. Substation 3



d. Substation 4



e. Substation 5



f. Substation 6

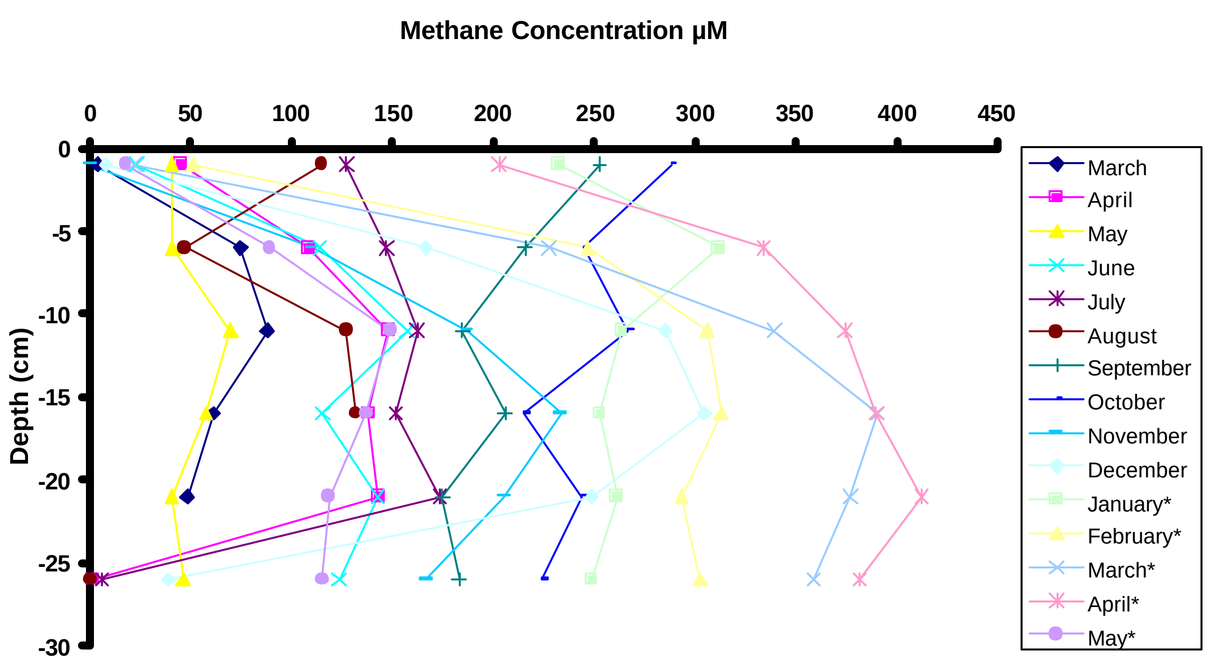


Table 5.51-1. Salinity of Sites. Salinity in parts per thousand calculated from chloride concentrations in porewaters.

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Town Creek			Salinity	Salinity	Salinity
P3	1	1	0.55		2.55
	1	6	0.84		5.50
	1	11	1.41		6.56
	1	16	2.51		6.17
	1	21	1.98	0.95	4.00
	1	26	2.43	1.04	2.89
	2	1	0.59	0.50	6.11
	2	6	1.28	0.49	8.09
	2	11	1.69	0.69	7.77
	2	16	2.07	0.10	6.72
	2	21	2.28	1.06	5.24
	2	26	1.04	1.27	4.27
	3	1	0.32	0.36	4.66
	3	6	0.79	0.45	5.99
	3	11	0.76	0.34	6.56
	3	16	0.77	0.48	5.97
	3	21	1.06	0.74	4.20
	3	26	1.43	1.12	3.69
	4	1	0.55	0.46	3.03
	4	6	0.82	0.62	2.85
	4	11	0.99	1.16	2.62
	4	16	1.29	1.13	2.74
	4	21	0.83	1.46	2.68
	4	26	1.34	1.74	2.69
	5	1	0.66		2.42
	5	6	0.73	0.46	4.60
	5	11	0.83	0.37	4.08
	5	16	1.08	0.58	3.36
	5	21	1.04		2.95
	5	26	1.51	0.52	2.48
	6	1	1.76	0.57	4.76
	6	6	2.32	0.82	4.28
	6	11	2.61	1.15	3.46
	6	16	2.72	1.18	2.88
	6	21	2.85	1.40	2.45
	6	26	3.60	1.94	2.14

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Eagle Island			Salinity	Salinity	Salinity
P6	1	1	3.28		3.50
	1	6	2.72		3.25
	1	11	2.94		3.38
	1	16	2.33	0.10	2.69
	1	21	0.96	0.11	3.32
	1	26	0.70	0.12	2.73
	2	1	2.32	0.07	4.68
	2	6	2.32	0.08	4.38
	2	11	2.57		3.73
	2	16	2.34		3.45
	2	21	2.24	0.09	2.36
	2	26	2.07	0.10	2.60
	3	1	1.50	0.14	1.20
	3	6	1.68		1.14
	3	11	1.63	0.82	1.03
	3	16	1.39	0.83	1.08
	3	21	1.52	0.82	0.77
	3	26	1.61	0.50	1.01
	4	1	0.97	0.41	3.33
	4	6	1.05	0.62	3.66
	4	11	1.15	0.43	3.18
	4	16	1.12	1.07	1.94
	4	21	0.13	0.81	1.45
	4	26	1.29	0.85	1.16
	5	1	1.16	0.18	2.21
	5	6	1.21	0.18	1.34
	5	11	1.12	0.19	1.16
	5	16	1.10	0.36	0.85
	5	21	1.04	0.33	0.75
	5	26	1.14	0.36	0.80
	6	1	0.67	0.36	1.81
	6	6	0.63	0.29	1.63
	6	11	0.60	0.17	
	6	16	0.55	0.17	1.47
	6	21	0.50	0.21	0.70
	6	26	0.39	0.17	0.57

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Indian Creek			Salinity	Salinity	Salinity
P7	1	1	0.08	0.08	0.28
	1	6	0.06	0.09	0.35
	1	11	0.06	0.09	0.34
	1	16	0.10		0.27
	1	21	0.10	0.15	0.30
	1	26	0.15	0.20	0.34
	2	1	0.10	0.11	0.13
	2	6	0.07	0.08	0.33
	2	11	0.10	0.10	0.27
	2	16	0.07	0.10	0.15
	2	21	0.12	0.10	0.33
	2	26	0.14	0.07	0.25
	3	1	0.11	0.14	0.13
	3	6	0.13	0.10	0.32
	3	11	0.07	0.09	0.24
	3	16	0.19	0.07	0.13
	3	21	0.10	0.08	0.44
	3	26	0.06	0.06	0.16
	4	1	0.06	0.11	0.12
	4	6	0.11	0.07	0.19
	4	11	0.05	0.07	0.21
	4	16	0.21	0.07	0.13
	4	21	0.17	0.06	0.12
	4	26	0.24	0.09	0.16
	5	1	0.09	0.08	0.20
	5	6	0.06	0.07	0.23
	5	11	0.04	0.07	0.18
	5	16	0.09	0.09	0.33
	5	21	0.09	0.10	0.16
	5	26	0.09	0.08	0.13
	6	1	0.06	0.10	0.16
	6	6	0.12	0.06	0.14
	6	11	0.09	0.06	0.11
	6	16	0.05	0.06	0.12
	6	21	0.15	0.05	0.12
	6	26	0.08	0.06	0.20

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Dollisons Landing			Salinity	Salinity	Salinity
P8	1	1	0.15		0.08
	1	6	0.16	0.37	0.20
	1	11	0.11	0.24	0.14
	1	16	0.09	0.21	0.11
	1	21	0.19	0.57	0.15
	1	26	0.08	0.22	0.15
	2	1	0.08		0.14
	2	6	0.18		0.18
	2	11	0.09	0.31	0.15
	2	16	0.13	0.27	0.15
	2	21	0.12	0.25	0.12
	2	26	0.15	0.21	0.12
	3	1	0.11	0.41	0.11
	3	6	0.14	0.19	0.12
	3	11	0.15	0.15	0.12
	3	16	0.14	0.21	0.11
	3	21	0.09	0.22	0.11
	3	26	0.05	0.19	0.13
	4	1	0.06	0.31	0.07
	4	6	0.05	0.18	0.09
	4	11	0.06	0.29	0.07
	4	16	0.04	0.26	0.08
	4	21	0.07	0.22	0.09
	4	26	0.06	0.21	0.09
	5	1	0.10	0.22	0.10
	5	6	0.07	0.22	0.07
	5	11	0.03		0.08
	5	16	0.08	0.59	0.08
	5	21	0.09	0.25	0.10
	5	26	0.12	0.33	0.09
	6	1	0.10	0.47	0.12
	6	6	0.10	0.14	0.12
	6	11	0.09	0.43	0.12
	6	16	0.07	0.19	0.12
	6	21	0.04	0.37	0.10
	6	26	0.13	0.27	0.13

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Black River			Salinity	Salinity	Salinity
P9	1	1	0.11		0.14
	1	6	0.07	0.12	
	1	11	0.06	0.15	0.08
	1	16	0.09	0.17	0.11
	1	21	0.19	0.16	0.29
	1	26	0.20	0.26	0.10
	2	1	0.06	0.30	0.16
	2	6	0.04	0.09	0.15
	2	11	0.04	0.10	0.08
	2	16	0.09	0.10	0.15
	2	21	0.19	0.07	0.23
	2	26	0.12	0.10	0.19
	3	1	0.07	0.08	0.11
	3	6	0.09	0.08	0.11
	3	11	0.06	0.12	0.17
	3	16	0.05	0.11	0.17
	3	21	0.19	0.14	0.20
	3	26	0.11	0.18	0.30
	4	1	0.05	0.25	0.11
	4	6	0.07	0.16	0.34
	4	11	0.07	0.21	0.13
	4	16	0.05	0.20	0.12
	4	21	0.07	0.61	0.10
	4	26	0.15	0.17	0.11
	5	1	0.05	0.49	0.12
	5	6	0.07	0.10	0.13
	5	11	0.06	0.17	0.17
	5	16	0.09	0.12	0.12
	5	21	0.07	0.07	0.12
	5	26	0.13	0.16	0.14
	6	1	0.07	0.26	0.13
	6	6	0.07	0.13	0.09
	6	11	0.05	0.09	0.08
	6	16	0.08	0.16	0.13
	6	21	0.10	0.15	0.10
	6	26	0.13	0.26	0.07

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Smith Creek			Salinity	Salinity	Salinity
P11	1	1	3.77	0.31	5.67
	1	6	2.84	0.40	4.32
	1	11	3.06		
	1	16	2.43	0.88	3.42
	1	21	2.85	1.48	
	1	26	2.96		
	2	1	3.32	0.66	3.50
	2	6	2.49	0.88	
	2	11	2.79	1.04	3.28
	2	16	2.85	1.52	2.29
	2	21	2.83	2.16	1.64
	2	26	2.63		2.33
	3	1	4.67		3.58
	3	6	4.49	0.36	4.97
	3	11	4.54	0.85	4.59
	3	16	3.59	1.47	2.41
	3	21	3.34	1.44	1.68
	3	26	3.00	1.74	2.52
	4	1	4.07	0.27	7.41
	4	6	0.10	0.66	6.46
	4	11	4.55	1.11	7.66
	4	16	4.48	1.96	6.87
	4	21	4.27	1.70	7.57
	4	26	4.24	1.63	7.11
	5	1	2.47	0.39	6.87
	5	6	2.29	0.63	6.05
	5	11	2.13	0.56	7.65
	5	16	2.08	0.63	4.17
	5	21	2.07	0.46	3.07
	5	26	1.88		3.46
	6	1	2.47		2.99
	6	6	1.10		6.76
	6	11	1.01		3.71
	6	16	1.17		5.01
	6	21	1.70		6.35
	6	26	1.67		4.60

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Rat Island			Salinity	Salinity	Salinity
P12	1	1	.91		2.57
	1	6	1.3		2.20
	1	11	.87	0.64	1.73
	1	16	.96	0.68	1.16
	1	21	.69	0.73	1.08
	1	26	1.16	0.87	0.27
	2	1	1.17	0.27	2.35
	2	6	0.06	0.40	2.11
	2	11	0.98	0.45	2.06
	2	16	0.98	0.62	1.51
	2	21	0.96	0.86	0.92
	2	26	0.80	0.75	0.54
	3	1	1.03	0.24	1.96
	3	6	1.25	0.26	2.38
	3	11	1.14	0.18	2.42
	3	16	1.34	0.21	1.88
	3	21	1.07	0.26	1.29
	3	26	1.42	0.24	1.33
	4	1	0.59	0.20	0.63
	4	6	0.60	0.21	0.81
	4	11	0.74	0.22	0.79
	4	16	0.72	0.27	0.58
	4	21	0.87	0.25	0.87
	4	26	0.87	0.28	0.60
	5	1	0.55	0.09	0.82
	5	6	0.70	0.10	0.92
	5	11	0.81	0.13	0.33
	5	16	0.94	0.12	0.64
	5	21	0.99	0.11	0.38
	5	26	1.21	0.12	0.41
	6	1	0.15	0.06	0.30
	6	6	0.14	0.08	0.24
	6	11	0.16	0.09	0.16
	6	16	0.11	0.08	0.19
	6	21	0.09	0.07	0.14
	6	26	0.08	0.08	0.13

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Fishing Creek			Salinity	Salinity	Salinity
P13	1	1	0.20	0.57	4.27
	1	6	0.14	0.20	3.07
	1	11	0.15	0.16	2.35
	1	16	0.19	0.20	1.53
	1	21	0.20	0.19	0.73
	1	26	0.19	0.27	0.76
	2	1	0.04		1.72
	2	6	0.09	0.08	1.12
	2	11	0.05	0.13	1.07
	2	16	0.05	0.11	1.02
	2	21	0.05	1.71	0.88
	2	26	0.05	0.60	0.78
	3	1	0.10	0.22	0.55
	3	6	0.09	0.29	0.36
	3	11	0.09	0.48	0.35
	3	16	0.10	0.25	0.57
	3	21	0.10	0.43	0.41
	3	26	0.11	0.37	0.29
	4	1	0.05	0.28	0.23
	4	6	0.05	0.15	0.19
	4	11	0.06	0.22	0.11
	4	16	0.07	0.12	0.10
	4	21	0.05	0.10	0.07
	4	26	0.04	0.19	0.05
	5	1	0.04	0.09	0.51
	5	6	0.08	0.17	0.72
	5	11	0.09	0.28	0.61
	5	16	0.05	0.14	0.56
	5	21	0.07	0.17	0.41
	5	26	0.06	0.21	0.57
	6	1	0.03	0.17	0.13
	6	6	0.06	0.53	0.07
	6	11	0.08	0.44	0.07
	6	16	0.05	0.31	0.76
	6	21	0.06	0.45	0.14
	6	26	0.06	0.46	0.15

Table 5.51-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Prince George			Salinity	Salinity	Salinity
P14	1	1	0.14	0.06	0.15
	1	6	0.10	0.05	0.16
	1	11	0.08	0.06	0.15
	1	16	0.10	0.06	0.12
	1	21	0.09	0.06	0.13
	1	26	0.07	0.06	0.11
	2	1	0.07	0.08	0.16
	2	6	0.08	0.06	0.15
	2	11	0.11	0.07	0.12
	2	16	0.21	0.06	0.08
	2	21	0.30	0.05	0.09
	2	26	0.22	0.06	0.08
	3	1	0.17	0.05	0.25
	3	6	0.31	0.05	0.24
	3	11	0.14	0.05	0.20
	3	16	0.14	0.05	0.22
	3	21	0.13	0.05	0.17
	3	26	0.12	0.05	0.16
	4	1	0.06	0.04	0.13
	4	6	0.06	0.05	0.14
	4	11	0.06	0.04	0.57
	4	16	0.07	0.04	0.14
	4	21	0.05	0.05	0.10
	4	26	0.05	0.07	0.12
	5	1	0.05	0.05	0.13
	5	6	0.18	0.05	0.10
	5	11	0.06	0.07	0.10
	5	16	0.41	0.05	0.07
	5	21	0.10	0.04	0.10
	5	26	0.07	0.04	0.10
	6	1	0.21	0.06	0.05
	6	6	0.20	0.04	0.06
	6	11	0.16	0.04	0.07
	6	16	0.05	0.04	0.07
	6	21	0.05	0.04	0.07
	6	26	0.05	0.06	0.07

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

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Town Creek			Chloride	Chloride	Chloride
P3	1	1	8849		40722
	1	6	13361		88006
	1	11	22629		104975
	1	16	40138		98784
	1	21	31681	15197	64069
	1	26	38923	16669	46168
	2	1	9427	7970	97740
	2	6	20462	7885	129410
	2	11	26996	10994	124371
	2	16	33131	1529	107597
	2	21	36409	16888	83833
	2	26	16710	20388	68253
	3	1	5159	5822	74498
	3	6	12681	7229	95841
	3	11	12116	5425	104939
	3	16	12349	7627	95449
	3	21	16972	11915	67275
	3	26	22844	17899	59032
	4	1	8741	7388	48475
	4	6	13105	9850	45524
	4	11	15868	18526	41962
	4	16	20625	18042	43782
	4	21	13208	23282	42914
	4	26	21440	27780	43018
	5	1	10592		38702
	5	6	11611	7328	73586
	5	11	13233	5952	65325
	5	16	17251	9297	53687
	5	21	16607		47136
	5	26	24202	8325	39712
	6	1	28097	9119	76112
	6	6	37091	13101	68501
	6	11	41781	18382	55366
	6	16	43478	18944	46051
	6	21	45618	22343	39144
	6	26	57593	31080	34289

Table 5.51-2. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Eagle Island			Chloride	Chloride	Chloride
P6	1	1	52469		56059
	1	6	43473		52074
	1	11	47113		54054
	1	16	37300	1558	43012
	1	21	15378	1711	53083
	1	26	11204	1915	43601
	2	1	37123	1200	74891
	2	6	37057	1232	70018
	2	11	41135		59632
	2	16	37516		55244
	2	21	35825	1411	37799
	2	26	33160	1540	41530
	3	1	24011	2273	19182
	3	6	26812		18303
	3	11	26144	13091	16454
	3	16	22318	13336	17231
	3	21	24327	13075	12249
	3	26	25784	8067	16149
	4	1	15540	6500	53310
	4	6	16729	9922	58557
	4	11	18377	6905	50862
	4	16	17851	17196	31017
	4	21	2056	12992	23216
	4	26	20627	13583	18613
	5	1	18578	2849	35336
	5	6	19424	2863	21517
	5	11	17919	2972	18559
	5	16	17674	5733	13583
	5	21	16699	5202	11953
	5	26	18200	5774	12841
	6	1	10731	5763	28889
	6	6	10007	4618	26042
	6	11	9591	2646	
	6	16	8791	2698	23544
	6	21	7946	3433	11122
	6	26	6217	2711	9065

Table 5.51-2. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Indian Creek			Chloride	Chloride	Chloride
P7	1	1	1286	1321	4517
	1	6	919	1384	5652
	1	11	942	1449	5380
	1	16	1665		4386
	1	21	1581	2407	4765
	1	26	2440	3245	5424
	2	1	1530	1721	2031
	2	6	1046	1358	5336
	2	11	1633	1664	4242
	2	16	1086	1535	2357
	2	21	1913	1521	5358
	2	26	2219	1160	4030
	3	1	1814	2272	2101
	3	6	2041	1591	5151
	3	11	1162	1362	3833
	3	16	3033	1188	2009
	3	21	1628	1234	6988
	3	26	983	994	2635
	4	1	926	1705	1898
	4	6	1735	1134	3025
	4	11	844	1173	3299
	4	16	3357	1098	2108
	4	21	2722	1013	1991
	4	26	3773	1500	2507
	5	1	1440	1339	3221
	5	6	890	1080	3688
	5	11	677	1182	2883
	5	16	1370	1502	5344
	5	21	1519	1546	2509
	5	26	1500	1333	2035
	6	1	945	1624	2547
	6	6	1999	998	2195
	6	11	1498	919	1839
	6	16	851	884	1974
	6	21	2348	754	1866
	6	26	1270	921	3245

Table 5.51-2. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Dollisons Landing			Chloride	Chloride	Chloride
P8	1	1	2469		1351
	1	6	2629	5908	3258
	1	11	1705	3815	2198
	1	16	1366	3299	1820
	1	21	3010	9141	2354
	1	26	1264	3558	2373
	2	1	1270		2271
	2	6	2812		2813
	2	11	1485	4913	2377
	2	16	2071	4275	2435
	2	21	1926	4062	1982
	2	26	2405	3335	1939
	3	1	1812	6492	1733
	3	6	2249	3071	1861
	3	11	2434	2440	1920
	3	16	2226	3404	1795
	3	21	1415	3599	1815
	3	26	741	2972	2012
	4	1	944	5017	1178
	4	6	850	2864	1384
	4	11	1004	4667	1108
	4	16	598	4230	1353
	4	21	1142	3530	1370
	4	26	890	3354	1408
	5	1	1649	3499	1557
	5	6	1051	3454	1189
	5	11	516		1240
	5	16	1329	9516	1280
	5	21	1497	4016	1574
	5	26	1938	5323	1519
	6	1	1576	7593	1860
	6	6	1524	2275	1967
	6	11	1481	6955	1970
	6	16	1181	2999	1885
	6	21	608	5935	1655
	6	26	2142	4398	2008

Table 5.51-2. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Black River			Chloride	Chloride	Chloride
P9	1	1	1760		2190
	1	6	1104	1999	
	1	11	935	2444	1337
	1	16	1396	2787	1686
	1	21	3034	2639	4650
	1	26	3228	4191	1588
	2	1	960	4770	2494
	2	6	682	1378	2461
	2	11	677	1544	1274
	2	16	1382	1524	2454
	2	21	2976	1086	3661
	2	26	1997	1544	3093
	3	1	1050	1219	1690
	3	6	1511	1332	1810
	3	11	1024	1957	2645
	3	16	847	1748	2776
	3	21	3052	2242	3212
	3	26	1775	2924	4804
	4	1	736	3956	1763
	4	6	1194	2533	5389
	4	11	1060	3375	2069
	4	16	862	3150	1996
	4	21	1111	9771	1572
	4	26	2336	2657	1693
	5	1	802	7839	1916
	5	6	1051	1669	2018
	5	11	927	2703	2671
	5	16	1430	1934	1868
	5	21	1158	1191	1984
	5	26	2077	2627	2274
	6	1	1120	4096	2065
	6	6	1133	2057	1446
	6	11	792	1464	1307
	6	16	1290	2579	2118
	6	21	1523	2336	1673
	6	26	2084	4096	1179

Table 5.51-2. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Smith Creek			Chloride	Chloride	Chloride
P11	1	1	60390	4940	90689
	1	6	45375	6377	69054
	1	11	48940		
	1	16	38804	14026	54792
	1	21	45605	23702	
	1	26	47412		
	2	1	53053	10489	55939
	2	6	39820	14087	
	2	11	44592	16598	52410
	2	16	45674	24269	36717
	2	21	45299	34566	26167
	2	26	42109		37357
	3	1	74664		57347
	3	6	71825	5755	79485
	3	11	72649	13618	73488
	3	16	57390	23466	38559
	3	21	53409	22983	26805
	3	26	48052	27878	40296
	4	1	65168	4266	118630
	4	6	1612	10561	103285
	4	11	72860	17684	122547
	4	16	71759	31394	109984
	4	21	68359	27248	121119
	4	26	67760	26116	113812
	5	1	39560	6192	109938
	5	6	36590	10118	96843
	5	11	34016	9003	122325
	5	16	33286	10045	66665
	5	21	33179	7423	49152
	5	26	30106		55418
	6	1	39555		47865
	6	6	17729		108093
	6	11	16239		59434
	6	16	18677		80168
	6	21	27210		101530
	6	26	26771		73567

Table 5.51-2. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Rat Island			Chloride	Chloride	Chloride
P12	1	1	14611		41122
	1	6	22005		35144
	1	11	13874	10315	27758
	1	16	15321	10819	18515
	1	21	11072	11695	17343
	1	26	18506	13970	4316
	2	1	18678	4303	37666
	2	6	930	6411	33823
	2	11	15665	7169	32931
	2	16	15655	9943	24094
	2	21	15386	13836	14659
	2	26	12871	11939	8679
	3	1	16437	3771	31322
	3	6	20071	4198	38094
	3	11	18210	2936	38658
	3	16	21422	3280	30143
	3	21	17115	4226	20562
	3	26	22691	3789	21239
	4	1	9458	3249	10086
	4	6	9545	3421	12997
	4	11	11842	3492	12705
	4	16	11463	4383	9226
	4	21	13904	3956	13940
	4	26	13904	4517	9637
	5	1	8828	1449	13076
	5	6	11146	1585	14751
	5	11	13003	2019	5210
	5	16	15061	1921	10226
	5	21	15816	1781	6031
	5	26	19387	1910	6520
	6	1	2339	1021	4862
	6	6	2244	1210	3797
	6	11	2537	1397	2533
	6	16	1774	1209	3118
	6	21	1427	1104	2213
	6	26	1213	1345	2067

Table 5.51-2. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Fishing Creek			Chloride	Chloride	Chloride
P13	1	1	3166	9083	68304
	1	6	2240	3207	49083
	1	11	2461	2511	37667
	1	16	3016	3138	24488
	1	21	3136	2969	11677
	1	26	3066	4379	12158
	2	1	658		27482
	2	6	1490	1338	17966
	2	11	793	2131	17101
	2	16	727	1768	16349
	2	21	764	27372	14151
	2	26	806	9631	12549
	3	1	1568	3451	8781
	3	6	1470	4592	5735
	3	11	1486	7674	5611
	3	16	1616	3970	9040
	3	21	1580	6905	6634
	3	26	1727	5901	4576
	4	1	830	4411	3653
	4	6	731	2347	3056
	4	11	890	3478	1760
	4	16	1125	1908	1585
	4	21	785	1543	1123
	4	26	698	3013	735
	5	1	719	1417	8236
	5	6	1241	2701	11534
	5	11	1429	4453	9726
	5	16	802	2252	8975
	5	21	1108	2719	6523
	5	26	888	3436	9136
	6	1	445	2657	2063
	6	6	898	8433	1170
	6	11	1215	6996	1092
	6	16	837	5004	12212
	6	21	941	7266	2165
	6	26	995	7293	2378

Table 5.51-2. Concluded

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Prince George			Chloride	Chloride	Chloride
P14	1	1	2244	1018	2413
	1	6	1662	850	2509
	1	11	1337	924	2456
	1	16	1627	900	1987
	1	21	1441	890	2038
	1	26	1128	917	1836
	2	1	1198	1237	2528
	2	6	1283	1040	2367
	2	11	1736	1058	1857
	2	16	3333	956	1338
	2	21	4774	846	1423
	2	26	3491	888	1231
	3	1	2787	873	3939
	3	6	4935	822	3795
	3	11	2286	811	3215
	3	16	2164	875	3480
	3	21	2073	740	2683
	3	26	1891	798	2603
	4	1	1031	659	2069
	4	6	1021	763	2296
	4	11	937	641	9164
	4	16	1040	703	2310
	4	21	854	821	1658
	4	26	740	1060	1906
	5	1	877	820	2104
	5	6	2833	784	1629
	5	11	949	1075	1559
	5	16	6562	805	1200
	5	21	1571	652	1631
	5	26	1079	669	1521
	6	1	3416	881	771
	6	6	3272	621	1032
	6	11	2608	592	1077
	6	16	856	671	1114
	6	21	800	689	1073
	6	26	861	895	1068

Table 5.51-3. Methane Concentrations of Sites. Porewater methane concentrations are µM.

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Town Creek			Methane	Methane	Methane
P3	1	1	7	22	3
	1	6	22	46	29
	1	11	70	58	124
	1	16	158	39	64
	1	21	162	75	77
	1	26	142	56	67
	2	1	10	3	31
	2	6	44	51	54
	2	11	49	33	38
	2	16	48	70	39
	2	21	49	62	76
	2	26	71	57	61
	3	1	35	2	56
	3	6	89	66	29
	3	11	117	36	33
	3	16	130		42
	3	21	152	103	36
	3	26	144	96	59
	4	1	114	29	113
	4	6	302	110	121
	4	11	313	127	121
	4	16	348	114	119
	4	21	302	66	101
	4	26	325	135	150
	5	1	55	58	41
	5	6	91	78	61
	5	11	129	17	57
	5	16	200	100	62
	5	21	228	57	85
	5	26	270	60	95
	6	1	73	23	38
	6	6	124	165	62
	6	11	163	124	122
	6	16	207	139	52
	6	21	194	157	57
	6	26	178	106	145

Table 5.51-3. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Eagle Island			Methane	Methane	Methane
P6	1	1	4		39
	1	6	6	8	46
	1	11	8	45	59
	1	16	7	67	54
	1	21	18	62	46
	1	26	0	78	62
	2	1	0	2	35
	2	6	6	44	58
	2	11	9	53	70
	2	16	12	54	46
	2	21	24	36	38
	2	26	46	45	27
	3	1	66	4	80
	3	6	99		152
	3	11	149	120	127
	3	16	131	149	154
	3	21	117	241	150
	3	26	94	251	143
	4	1	9	32	64
	4	6	23		90
	4	11	131	74	127
	4	16	218	75	110
	4	21	183	115	103
	4	26	270	141	131
	5	1	139	132	65
	5	6	168	212	197
	5	11	185	172	184
	5	16	136	213	119
	5	21	143	190	77
	5	26	146	221	104
	6	1	233	45	127
	6	6	312	108	147
	6	11	264	148	162
	6	16	253	138	152
	6	21	261	143	173
	6	26	249	2	100

Table 5.51-3. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Indian Creek			Methane	Methane	Methane
P7	1	1		1	
	1	6	6	1	
	1	11	10	1	
	1	16	7	5	
	1	21	19	10	
	1	26	14	22	36
	2	1	121	1	30
	2	6	364	24	119
	2	11	256	29	167
	2	16	300	54	231
	2	21	310	57	150
	2	26	168	45	98
	3	1	181	48	48
	3	6	236	90	51
	3	11	244	77	141
	3	16	241	66	64
	3	21	264	64	52
	3	26	27	58	102
	4	1	38	16	109
	4	6	74	15	98
	4	11	64	24	104
	4	16	107	22	19
	4	21	119	18	70
	4	26	78	25	53
	5	1	5	13	80
	5	6	10	3	99
	5	11	13	4	150
	5	16	9	12	183
	5	21	11	22	136
	5	26	NC	26	36
	6	1	14	10	11
	6	6	18	33	36
	6	11	33	55	63
	6	16	23	55	27
	6	21	27	80	16
	6	26	22	94	144

Table 5.51-3. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Dollisons Landing			Methane	Methane	Methane
P8	1	1	3	2	
	1	6	3	4	3
	1	11	9	23	10
	1	16	4	16	8
	1	21	8	11	14
	1	26	17	3	58
	2	1		4	16
	2	6	28	31	73
	2	11	33	27	97
	2	16	42	29	61
	2	21	41	37	104
	2	26	40	30	125
	3	1	80	24	28
	3	6	84	75	29
	3	11	67	103	81
	3	16	58	103	3
	3	21	65	108	76
	3	26	45	8	182
	4	1	19	78	101
	4	6	31	88	161
	4	11	58	75	146
	4	16	94	62	38
	4	21	98	50	77
	4	26	98	52	85
	5	1	55	21	
	5	6	85	38	156
	5	11	123	63	191
	5	16	107	59	104
	5	21	85	58	57
	5	26	103	7	67
	6	1	96	12	36
	6	6	118	98	86
	6	11	126	82	133
	6	16	110	98	184
	6	21	54	83	122
	6	26	33	131	116

Table 5.51-3. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Black River			Methane	Methane	Methane
P9	1	1	76	33	47
	1	6	196	52	
	1	11	384	82	101
	1	16	411	59	131
	1	21	445	85	64
	1	26	472	122	109
	2	1	6	8	79
	2	6	12	37	65
	2	11	45	26	56
	2	16	31	43	18
	2	21	21	31	60
	2	26	21	39	36
	3	1	5	26	163
	3	6	9	76	154
	3	11	16	77	118
	3	16	18	62	145
	3	21	19	79	125
	3	26	26	61	54
	4	1	14	7	24
	4	6	79	67	24
	4	11	110	109	36
	4	16	171	68	73
	4	21	269	108	71
	4	26	201	132	88
	5	1	NC	44	4
	5	6	25	118	23
	5	11	280	127	46
	5	16	265	109	60
	5	21	181	65	67
	5	26	176	46	69
	6	1	13	5	1
	6	6	219	105	10
	6	11	282	131	32
	6	16	266	74	29
	6	21	243	25	28
	6	26	215	18	17

Table 5.51-3. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Smith Creek			Methane	Methane	Methane
P11	1	1	13	3	
	1	6	39	48	
	1	11	78	59	
	1	16	80	43	
	1	21	95	87	
	1	26	88	61	
	2	1	19	6	
	2	6	43	39	62
	2	11	141	62	148
	2	16	143	112	153
	2	21	240	72	103
	2	26	250	70	
	3	1	7	76	60
	3	6	70	65	98
	3	11	184	81	74
	3	16	212	104	122
	3	21	232	98	164
	3	26	264	123	9
	4	1	15	10	48
	4	6	109	92	13
	4	11	234	73	52
	4	16	227	79	
	4	21	184		
	4	26	129	48	
	5	1	6	2	2
	5	6	11	17	45
	5	11	40	54	61
	5	16	49	48	54
	5	21	33	58	28
	5	26	27	38	56
	6	1	7	3	2
	6	6	34	59	12
	6	11	38	50	22
	6	16	60	55	12
	6	21	35	49	17
	6	26	52	24	29

Table 5.51-3. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Rat Island			Methane	Methane	Methane
P12	1	1	2	45	1
	1	6	6	107	77
	1	11	25	145	124
	1	16	34	143	143
	1	21	16	160	116
	1	26	15	157	109
	2	1	1	22	6
	2	6	29	69	20
	2	11	6	131	15
	2	16	54	173	37
	2	21	46	168	75
	2	26	95		85
	3	1	1		
	3	6	9		35
	3	11	28		87
	3	16	45		35
	3	21	167		70
	3	26	239		107
	4	1	8	71	18
	4	6	61	153	100
	4	11	107	168	90
	4	16	179	216	77
	4	21	271	190	
	4	26	283	163	73
	5	1	22	69	91
	5	6	210	69	91
	5	11	258	98	91
	5	16	445	85	66
	5	21	453	85	79
	5	26	354	73	87
	6	1	2	1	2
	6	6	18	6	73
	6	11	62	28	21
	6	16	148	50	60
	6	21	132	48	108
	6	26	174	63	88

Table 5.51-3. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Fishing Creek			Methane	Methane	Methane
P13	1	1			1
	1	6	2		1
	1	11	1		12
	1	16	1		56
	1	21	2		33
	1	26	4		32
	2	1	1		53
	2	6	3		5
	2	11	3		60
	2	16	9		95
	2	21	11		25
	2	26	9		80
	3	1	28		136
	3	6	39		172
	3	11	47		160
	3	16	64		107
	3	21	78		139
	3	26	51		91
	4	1	NC		23
	4	6	3		10
	4	11	5		52
	4	16	11		39
	4	21	8		66
	4	26	7		64
	5	1	1		8
	5	6	1		75
	5	11	9		92
	5	16	30		65
	5	21	35		93
	5	26	29		87
	6	1	1		8
	6	6	1		14
	6	11	2		14
	6	16	2		25
	6	21			32
	6	26			50

Table 5.51-3. Concluded

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Prince George			Methane	Methane	Methane
P14	1	1	2	9	111
	1	6	1	50	122
	1	11	2	54	231
	1	16	4	145	190
	1	21	13	216	155
	1	26	12	190	128
	2	1	5	79	63
	2	6	63	196	216
	2	11	113	308	260
	2	16	171	312	236
	2	21	244	287	164
	2	26	202	280	134
	3	1	8	0	126
	3	6	18	5	226
	3	11	86	38	278
	3	16	122	52	204
	3	21	156	65	268
	3	26	181	83	326
	4	1	1	25	96
	4	6	1	114	149
	4	11	34	160	150
	4	16	105	187	204
	4	21	121	198	52
	4	26	160	204	30
	5	1	12	4	80
	5	6	137	39	148
	5	11	256	95	214
	5	16	283	123	185
	5	21	390	173	176
	5	26	298	159	83
	6	1	4	62	108
	6	6	81	194	172
	6	11	178	170	152
	6	16	149	201	130
	6	21	147	203	107
	6	26	102	179	156

5.52 Indian Creek (P7)

Porewaters of Indian Creek were essentially fresh with salinities ranging from 0.04 – 0.2 ppt in winter to 0.1 – 0.4 ppt during summer (Tables 5.51-1 and 5.51-2). In winter, substations were exclusively methanogenic due to the low salinities (Table 5.4-1). At some substations, summer salinities reach levels sufficient for sulfate reduction (Table 5.52-1). For the most part, the SR classification is a surface phenomenon at these substations, but some sulfate reduction occurs sporadically at depth (Table 5.4-1). The lack of any SR classifications at this station during winter makes it particularly sensitive to salinity increases and provides an ideal location to monitor salinity variations and their impact on geochemical processes.

5.53 Dollisons Landing (P8)

Porewaters of Dollisons Landing average around 0.1 ppt and show no obvious seasonal variations (Tables 5.51-1 and 5.51-2). Small pockets of porewater sulfate concentrations approaching those required for sulfate reduction were randomly distributed at this site. Classifications of substations close to the uplands were methanogenic and reflect low salinities (Table 5.4-1). At near shore substations and at various random depths at this site, sulfate concentrations were almost high enough to support sulfate reduction (Tables 5.51-1 and 5.51-2). However, direct input of sulfate via seawater is not likely because the sulfate to chloride ratios is higher than those of seawater in some cases suggesting other sources of sulfate. Seepage enters this site along the upland boundary from adjoining uplands. A cool-fired power generating plant nearby may have deposited ash into this area before anti-pollution devices were added.

5.54 Black River (P9)

Porewaters of the Black River station averaged 0.1 ppt salinity (Tables 5.51-1 and 5.51-2). No obvious seasonal variations were observed. This station displays high variability in its seasonal classifications. During the late winter sampling of 2000 the site was primarily a MPSR classification. During the summer of 2000 the site was mainly methanogenic with the exception of the upland sites that were SRNS. During the winter of 2001 the classification was primarily sulfate reducing with several non-seawater sources of sulfate classifications. The presence of a non-seawater source of sulfate makes it difficult to explain the geochemistry of this site with our classification scheme however future monitoring of this site may reveal a more predictable pattern of geochemical variation.

5.55 Smith Creek (P11).

Porewater salinities ranged from 0.5 – 5 ppt during winter to 2 – 8 ppt during summer (Tables 5.51-1 and 5.51-2). Because of the high salinity at this station it was classified as SR year round (Table 5.4-1). Some MPSR classifications were observed during the late sampling in winter 2000, indicating that methane production may dominate some stations during early spring when rates of remineralization increase and higher salinity summer conditions have not replenished porewater sulfate.

Table 5.52-1. Sulfate Concentrations of Sites. Porewater sulfate concentrations are µM.

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Town Creek			Sulfate	Sulfate	Sulfate
P3	1	1	512	262	990
	1	6	431	251	1277
	1	11	465		1302
	1	16	198	177	796
	1	21	231		425
	1	26	238	167	187
	2	1	561	432	1571
	2	6	415	310	837
	2	11	449	235	1110
	2	16	507	72	1213
	2	21	488	251	872
	2	26	300	228	551
	3	1	274	367	2087
	3	6	371	257	3028
	3	11	367	237	3369
	3	16	295	245	2967
	3	21	399	265	1428
	3	26	586	231	874
	4	1	332	271	522
	4	6	210	264	427
	4	11	208	426	355
	4	16	159	489	467
	4	21	500	3027	373
	4	26	536	379	479
	5	1	413		737
	5	6	472	291	908
	5	11	565	221	875
	5	16	730	416	873
	5	21	378		874
	5	26	337	946	811
	6	1	407	314	832
	6	6	428	687	485
	6	11	431	1894	528
	6	16	547	3564	521
	6	21	441	1132	367
	6	26	705	898	289

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Eagle Island			Sulfate	Sulfate	Sulfate
P6	1	1	2142		3246
	1	6	2078		2300
	1	11	2107		1726
	1	16	1651	102	1275
	1	21	924	121	1475
	1	26	729	56	683
	2	1	1909	177	2746
	2	6	2158	104	2168
	2	11	2165		1905
	2	16	2054		1590
	2	21	2002	80	871
	2	26	1526	74	1395
	3	1	352	135	299
	3	6	487		277
	3	11	332	87	195
	3	16	246	68	187
	3	21	445	89	144
	3	26	461	923	153
	4	1	654	236	1206
	4	6	768	150	2017
	4	11	513	102	1834
	4	16	208	310	600
	4	21	478	192	422
	4	26	324	239	204
	5	1	398	237	475
	5	6	349	84	238
	5	11	370	137	432
	5	16	442	98	168
	5	21	403	136	141
	5	26	334	182	222
	6	1	184	204	451
	6	6	173	149	286
	6	11	147	93	
	6	16	178	92	306
	6	21	220	115	196
	6	26	176	110	198

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Indian Creek			Sulfate	Sulfate	Sulfate
P7	1	1	259	147	798
	1	6	192	226	1021
	1	11	56	105	456
	1	16	182		319
	1	21	162	162	645
	1	26	153	161	299
	2	1	83	98	277
	2	6	111	83	204
	2	11	123	61	223
	2	16	0	110	140
	2	21	150	25	184
	2	26	138	28	198
	3	1	185	86	325
	3	6	74	27	573
	3	11	0	35	207
	3	16	138	43	194
	3	21	115	37	703
	3	26	123	34	214
	4	1	100	111	254
	4	6	128	46	482
	4	11	108	40	352
	4	16	190	32	176
	4	21	164	30	208
	4	26	272	220	285
	5	1	166	112	541
	5	6	108	43	124
	5	11	70	48	463
	5	16	165	41	625
	5	21	119	57	248
	5	26	143	44	213
	6	1	76	203	499
	6	6	129	45	254
	6	11	127	35	178
	6	16	53	44	226
	6	21	211	27	171
	6	26	248	353	327

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Dollisons Landing			Sulfate	Sulfate	Sulfate
P8	1	1	678	252	259
	1	6	831	211	868
	1	11	717	696	454
	1	16	584	215	410
	1	21	540	208	451
	1	26	323	1081	327
	2	1	100		521
	2	6	210		437
	2	11	206	571	266
	2	16	215	561	272
	2	21	143	201	221
	2	26	195	219	263
	3	1	130	1008	319
	3	6	110	194	268
	3	11	1288	658	255
	3	16	1328	185	227
	3	21	128	652	248
	3	26	131	174	264
	4	1	133	795	229
	4	6	165	108	186
	4	11	103	146	155
	4	16	186		145
	4	21	125		166
	4	26	132	166	231
	5	1	152	152	219
	5	6	114	624	175
	5	11	20		196
	5	16	156	1131	170
	5	21	356	163	184
	5	26	94	615	205
	6	1	133	236	220
	6	6	86	155	226
	6	11	96	4654	249
	6	16	102	486	246
	6	21	46		237
	6	26	178	188	238

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Black River			Sulfate	Sulfate	Sulfate
P9	1	1	274		271
	1	6	210	108	
	1	11	185	105	133
	1	16	231	138	131
	1	21	349	113	586
	1	26	474	116	124
	2	1	344	183	154
	2	6	342	58	169
	2	11	285	62	121
	2	16	287	41	178
	2	21	406	42	247
	2	26	270	66	198
	3	1	536	142	224
	3	6	414	57	167
	3	11	381	72	182
	3	16	283	88	186
	3	21	472	138	171
	3	26	384	107	214
	4	1	327	181	221
	4	6	258	84	462
	4	11	345	108	205
	4	16	451	104	201
	4	21	375	223	121
	4	26	829	81	189
	5	1	359	97	522
	5	6	345	67	306
	5	11	405	93	265
	5	16	610	63	292
	5	21	529	37	379
	5	26	594	83	311
	6	1	278	210	416
	6	6	118	69	469
	6	11	129	47	304
	6	16	223	76	273
	6	21	414	103	289
	6	26	519	200	298

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Smith Creek			Sulfate	Sulfate	Sulfate
P11	1	1	4182	270	4019
	1	6	2483	178	3587
	1	11	2275	184	
	1	16	1928	191	2441
	1	21	1837	156	
	1	26	1892		
	2	1	2852	316	1644
	2	6	1476	151	
	2	11	1779	136	1968
	2	16	1325	126	1852
	2	21	1097	200	518
	2	26	892		715
	3	1	4398	148	3520
	3	6	3408	149	3152
	3	11	2526	115	3065
	3	16	1512	144	1377
	3	21	991	215	673
	3	26	929	158	1296
	4	1	3553	282	2368
	4	6	88	365	2544
	4	11	727	987	2230
	4	16	565	2353	3265
	4	21	744	1296	4513
	4	26	724	874	5165
	5	1	2852	388	5637
	5	6	1695	333	4170
	5	11	674	175	4751
	5	16	672	126	2389
	5	21	774	124	2316
	5	26	806	211	3109
	6	1	2389	184	2231
	6	6	963	54	2247
	6	11	489	75	1345
	6	16	382		2400
	6	21	979	46	2691
	6	26	945	124	1727

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Rat Island			Sulfate	Sulfate	Sulfate
P12	1	1	869		1810
	1	6	1073		1060
	1	11	682	91	730
	1	16	730	281	522
	1	21	395	91	554
	1	26	679	132	268
	2	1	1187	123	1714
	2	6	151	121	1400
	2	11	851	111	1449
	2	16	563	91	968
	2	21	636	193	489
	2	26	543	132	258
	3	1	1082	318	1377
	3	6	1237	148	1268
	3	11	954	86	1051
	3	16	1029	118	763
	3	21	674	237	505
	3	26	828	140	536
	4	1	762	74	421
	4	6	287	77	292
	4	11	244	51	229
	4	16	156	61	692
	4	21	211	76	347
	4	26	147	54	267
	5	1	353	62	313
	5	6	216	81	370
	5	11	295	88	238
	5	16	259	81	426
	5	21	177	62	331
	5	26	287	70	215
	6	1	225	161	247
	6	6	248	116	208
	6	11	221	68	184
	6	16	335	78	196
	6	21	85	66	221
	6	26	105	72	199

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Fishing Creek			Sulfate	Sulfate	Sulfate
P13	1	1	746	302	2869
	1	6	852	397	1992
	1	11	896	245	1321
	1	16	1051	150	664
	1	21	941	161	305
	1	26	828	233	261
	2	1	413	387	1091
	2	6	467	108	578
	2	11	306	103	560
	2	16	296	88	506
	2	21	261	214	345
	2	26	246	214	252
	3	1	140	133	492
	3	6	168	228	199
	3	11	113	180	668
	3	16	168	135	314
	3	21	118	198	341
	3	26		217	247
	4	1	416	960	291
	4	6	352	127	192
	4	11	309	200	173
	4	16	285	188	147
	4	21	332	153	110
	4	26	223	157	143
	5	1	255	130	672
	5	6	220	173	976
	5	11	214	226	1320
	5	16	217	105	529
	5	21	198	191	407
	5	26	242	128	478
	6	1	204	309	208
	6	6	126	279	382
	6	11	203	300	227
	6	16	159		511
	6	21	210	580	155
	6	26	221	278	178

Table 5.52-1. Continued

Station	Substation	Depth (cm)	Winter 2001	Winter 2000	Summer 2000
Prince George			Sulfate	Sulfate	Sulfate
P14	1	1	564	95	206
	1	6	221	75	242
	1	11	208	66	155
	1	16	227	57	145
	1	21	188	32	103
	1	26	193	36	125
	2	1	264	175	222
	2	6	192	43	187
	2	11	239	47	218
	2	16	367	32	113
	2	21	49	36	160
	2	26	251	28	189
	3	1	411	107	229
	3	6	346	72	160
	3	11	273	129	160
	3	16	240	43	165
	3	21	217	46	140
	3	26	215	40	129
	4	1	228	97	201
	4	6	608	69	154
	4	11	202	42	282
	4	16	196	43	157
	4	21	123	33	136
	4	26	69	74	160
	5	1	302	137	199
	5	6	262	70	310
	5	11	265	66	134
	5	16	1307	41	174
	5	21	126	30	127
	5	26	78	43	139
	6	1	449	560	226
	6	6	168	160	170
	6	11	90	38	145
	6	16	246	40	140
	6	21	270	41	138
	6	26	210	49	146

5.56 Rat Island (P12)

Porewater salinities at Rat Island record a strong gradient with higher values at the near shore substations and almost freshwater conditions toward the upland. Salinity ranged from 0.1 – 1 ppt during winter and 0.2 – 2 ppt during summer (Tables 5.51-1 and 5.51-2). Because of the strong salinity gradient along the belt transect, this station contains both SR and M classifications during both summer and winter (Table 5.4-1). Generally the 3 near shore substations were SR and those closer to the upland were M or MPSR. More M and MPSR classifications are observed during winter when salinities are lower. Winter of 2000 was exclusively MPSR and M classifications. This phenomenon is similar to that described for Smith Creek where late winter/ early spring sampling detected methane production when rates of remineralization increase and the higher salinity summer floodwaters had not replenished the sulfate supply.

5.57 Fishing Creek (P13)

Porewater ranged from 0.1 –0.2 ppt during winter to 0.2 – 5 ppt during summer (Tables 5.51-1 and 5.51-2). Because of the seasonal variations in salinity, the site is essentially a SR classification during the summer with the exception of substation 4. Substation 4 is located in an ephemeral creek that acts as a conduit for both rain and river water. During winter, the station is essentially an M classification with the exception of substations near the river edge, that like other stations, receive the highest salinity floodwaters.

5.58 Prince George Creek (P14)

Prince George is an M classification due to its low salinities that average 0.1 –0.2 ppt (Tables 5.51-1 and 5.51-2), well below that required for sulfate reduction (Table 5.4-1). Slight seasonal variations were observed at this station with higher salinities during the summer; but still too low for sulfate reduction.

6.0 BENTHIC STUDIES

Benthic communities represent an important link in estuarine trophic dynamics. Infaunal communities are composed of organisms that act as both primary consumers and prey for fish and decapods. Many species directly or indirectly consume algal production, while others are obligate or facultative detritivores (feeding on decaying plant material to obtain a portion of their nutrients). Many taxa, especially near-surface species, are prey for epifaunal fish and decapods. This benthic coupling is critical to resident and estuarine dependent species that either spawn in the estuary or who spawn offshore with juveniles that move into the estuary and remain until maturity. Spot (Leiostomus xanthurus) and croaker (Micropogonus undulates) are excellent examples of the latter, spawning in late winter and early spring in offshore waters, but with larvae that move into the estuary in large numbers while still only a few millimeters long.

Their intermediate trophic position, relatively sedentary nature (most adults not moving more than a few meters), and varied responses to differing environmental factors are characteristics that make benthic fauna good indicators of anthropogenic effects. While many benthic species are resilient to relatively short-term perturbations in the system, many taxa may be susceptible to long-term changes, especially fluctuations in water quality, changes in tidal inundation or amplitude, changes in current flow or local hydrology, changes in salinity regime, or other physical factors. Possible effects of the Wilmington Harbor Deepening and Widening Project are changes in flow regimes at key portions of the estuary, changes in tidal inundation regimes along wetland areas, and possible shifts in salinity zones. The current effort is focused on evaluating long-term trends in benthic community composition and abundance with a long range goal of separating natural variation, due primarily to inter-annual variability (normal fluctuations in community composition and abundance across years and seasons), from potential effects due to deepening and widening the Cape Fear River.

The benthos in the Cape Fear River system is dominated primarily by four major taxonomic groups: polychaetes, oligochaetes, amphipods, and insect larvae. Each of these groups is represented by species that are consistently present at most stations (with the exception of insects in the lower estuary). Bivalves and gastropods, though common in other estuaries, are not abundant in the shallow habitats of the Cape Fear system. Polychaetes (segmented worms bearing specialized appendages) are common throughout the marine and estuarine environments. These organisms have a variety of living modes including free-living, burrowing, and sedentary forms. Burrowing and tube-dwelling species dominate most of the intertidal and shallow subtidal areas and are common prey items for many fish. Oligochaetes are another group of annelids mainly lacking specialized appendages with a deep-burrowing habit. This group has direct development and may be locally dense with potentially rapid responses to local conditions. However, they also tend to be less available as a prey resource because of their deep burrowing habit. Amphipods are a diverse group of brooding crustaceans. Many of the species within this group tend to have boom and bust population cycles and are an important resource for juvenile fish during certain time periods. Insect larvae are among the most numerous and diverse groups that inhabit the upper mesohaline and oligohaline regions of the river, but are generally absent from more saline areas. Insect larvae exploit virtually every habitat type available within the fresher portions of the upper estuarine system and are distinct from other dominant groups by having aerial dispersal.

6.1 Summary of Current Monitoring Effort

In order to evaluate infaunal communities in the intertidal and shallow subtidal regions of the Cape Fear River that may be impacted by the widening and deepening project, benthic core samples were collected from nine stations along the Cape Fear River from the mouth of Town Creek to eight miles above Wilmington on both the main stem and Northeast Cape Fear River (Figure 1.2-1). The first sampling was conducted in June 1999 with subsequent sampling taking place in June 2000 and June 2001. This report will summarize major faunal patterns for only the 1999 and 2000 sampling years (sample processing is ongoing for the June 2001 period). The sampling stations used in this study are representative of mesohaline, oligohaline regions adjacent to mesohaline habitats, oligohaline, and tidal freshwater wetlands. Samples were collected at replicate upper and lower intertidal sub-sites at each station to allow observations of potential differential responses that may occur with changes in tidal inundation regimes or with changes in larval availability.

The overall objective of this sampling effort is to evaluate the long-term impact (if any) from the deepening and widening of the Cape Fear River. The specific objectives of benthic sampling during 1999 and 2000 was to develop a baseline data set for comparison and detection of possible changes that may occur during dredging or after the channel widening has been completed. The hypotheses that will be tested are: 1) Changes in salinity and /or tidal amplitude will lead to changes in intertidal and shallow subtidal benthic community composition and abundance patterns. If changes in tidal amplitude or salinity occur, shifts in faunal dominance patterns will occur that reflect these environmental changes. 2) If alterations of the Cape Fear River shipping channel change estuarine flow characteristics a change in community composition and function reflecting altered recruitment patterns is expected.

6.2 Methodology

Infaunal core samples were collected at nine stations along the Cape Fear River estuarine gradient. Three benthic stations are located in Town Creek (P2 at the mouth of Town Creek, P3A and P3B inner Town Creek), three stations in the main stem of the Cape Fear River (P6 Eagle Island, P7 Indian Creek, and P8 Dollisons Landing), and three stations in the Northeast Cape Fear River (P11 Smith Creek, P12 Rat Island, and P13 Fishing Creek) (Figure 1.2-1). These stations represent a subset of the 12 stations being monitored.

Infaunal core samples (10 cm diameter X 15 cm deep) were collected at two upper intertidal sub-sites and two lower intertidal sub-sites at each station. These sub-sites are fixed stations that were originally marked (and positions recorded using GPS) in 1999 (CZR 1999). Three replicate core samples were collected within a one-meter area around these points. Core samples were collected at all stations in June 1999 and 2000. All samples were fixed in a 10% formalin solution (~4% formaldehyde), with rose Bengal dye added, and sieved through a 500 micron screen to remove excess sediment and preserved in 50% isopropanol. All organisms were separated from the remaining sediment by sorting under a dissecting microscope and identified to lowest reasonable taxonomic level, in most cases this is genus or species. Preliminary comparisons among stations and seasons were made using a presence/absence similarity analysis (Sorensen Index). Ultimate analyses will involve ANOVA comparisons of samples collected before and after dredging and multivariate analyses to indicate sample groupings based on faunal patterns and associated physical parameters.

6.3 Faunal patterns

In 1999 and 2000, between 49-61 infaunal taxa were collected from the Town Creek stations (Table 6.3-1), while during the same time period 41-51 taxa were collected at the three main stem Cape Fear stations (Table 6.3-2), and 27-47 taxa collected at stations on the Northeast Cape Fear River (Table 6.3-3). The species composition overall tends to be representative of communities found in other mid size, river dominates estuaries experiencing anthropogenic impacts, although there is some variation among the three tributary systems.

Overall, stations in Town Creek had 21 polycheate taxa, 9 amphipods, and 12 insect taxa, the mainstem stations had 6 polychaete taxa, 7 amphipods, and 28 insect taxa, and the Northeast Cape Fear stations had 10 polycheate taxa, 6 amphipods, and 19 insect taxa. Some of these numbers represent higher taxonomic categories, so the exact numbers may change as identifications are verified. Because the 3 tributaries (Town Creek system, mainstem Cape Fear, and Northeast Cape Fear) exhibit some distinct community attributes, each system will be discussed separately in the following community descriptions.

The Town Creek mouth station includes the most saline areas sampled (P2) while the 2 upper stations (P3A & 3B) are isolated from the low salinity stations of the upper Cape Fear and Northeast Cape Fear Rivers. P2 was dominated by spionid polychaetes, including the closely related Polydora in 1999 and Boccardiella in 2000. Both taxa are functionally similar in feeding and motility aspects. Oligochaetes were also dominant in 1999 and a major subdominant in 2000. At the 2 inner stations (P3A and P3B), oligochaetes were the dominant taxa in both years. In the low intertidal of P2, dominant taxa included oligochaetes in both years, the spionid polycheate Streblospio and the pilargid polychaete Parandalia in 1999 and the spionid Boccardiella in 2000. Although some of the specific species changed between years, guild level patterns were more conservative. Polydora and Boccariella are both considered to be tube dwelling and both are surface deposit feeders. This living mode and feeding type make both of these taxa more available to juvenile fish and decapods predators. Likewise the spionid polycheate Streblospio is tube dwelling and has been observed to switch between surface deposit feeding and suspension feeding. Streblospio, in particular, has been noted for its ability to establish itself following physical disturbances. Oligochaetes are considered to be deep burrowing (borrows generally >2 cm), subsurface deposit feeding taxa. Although abundant at some sites, this group of organisms is less possibly available as a prey resource to most of the epibenthic predators within the estuary.

All of the high intertidal mainstem Cape Fear River stations were dominated by oligochaetes during both years. The most downstream station, P6, included several mesohaline species that were not present at more oligohaline to tidal freshwater sites. Samples from 2000 were notable for lower species richness, with many insect larvae and amphipod species present in 1999 absent in 2000. Insect larvae are sensitive to weather conditions and their variability among years is characteristic of other estuarine systems. Amphipods are brooders and their populations may be indicative of local conditions. Low intertidal samples were also dominated by oligochaetes during both years. Once again, 2000 low intertidal samples were notable for lower species richness when compared to 1999 low intertidal samples. As with the Town Creek stations, guild level evaluations were consistent between years. Many insect larvae found at these stations live at the substrate surface and most tend to be a combination of deposit feeders and predators. Oligochaetes are deep burrowing/deposit feeders.

The high intertidal Northeast Cape Fear stations were also dominated by oligochaetes, though their abundance was less than at the mainstem stations. Low intertidal stations were also dominated by oligochaetes in both years, with insect larvae and the spionid polychaetes Marenzellaria common at some stations. The spionid polychaete Marenzellaria is a near surface burrowing taxon that forms vertical burrows and is also considered a deposit feeder. The Northeast Cape Fear stations were distinguished from the mainstem sites by generally having lower overall total density, especially in 1999, and greater evenness in abundance patterns.

In general, an evaluation of the infaunal community based on functional guilds provides a more conservative measure of community dominance. While individual taxa that are dominant at any given site may change from one sampling period to the next, the dominant functional guilds tended to be more stable. One good example of this stability is reflected in the dominant polychaete taxa at the Town Creek stations, a shift in one year from Polydora to Boccardiella the next year most likely does not represent a biologically significant change to the juvenile fish and decapods dependent on the benthic community because both of these related taxa are functionally similar. On the other hand, a functional shift from a community dominated by surface oriented taxa to one dominated by deep burrowers would represent a major change in the trophic dynamics at a station.

Preliminary evaluation of species richness at each station indicated greater species richness at all stations in 1999 versus 2000. This is true for both the high and low intertidal sub-sites in all three tributaries sampled, although stations in the NE Cape Fear consistently had the lowest number of species during either sampling period. Most of this between year variation in species richness is due to the occurrence of rare or uncommon taxa (some represented by only a single individual) that appeared in 1999 but not in 2000. Similarity analysis conducted using Sorensen indices reveals several patterns. Generally there was lower similarity among years for the Town Creek stations and the mainstem Cape Fear stations (with the exception of Dollisons Landing), and higher similarity among years for the NE Cape Fear stations (Table 6.3-4). However, much of the low similarity is explained by rare taxa, especially the greater presence of rare insect larvae in 1999. Inclusion of only common taxa for a site/year combination (species representing at least [1%] of the total individuals on any one sample date/site combination) yields much greater similarity among years. Among-site comparisons for 1999 showed low similarity, with only a couple of stations having similarities greater than 0.4 for either the high intertidal or low intertidal sub-sites (Table 6.3-5). Likewise, the same comparisons for 2000 also indicate low similarity (Table 6.3-6). This is expected since the stations were designed to span a gradient of salinity and wetland community zones.

7.0 EPIBENTHIC STUDIES DECAPODS AND EPIBENTHIC FISH

The epibenthic decapod and fish community located along the intertidal and shallow subtidal wetland fringe are being monitored. Aside from resident fish and decapods, epibenthos include juveniles of transient fish, crabs, and shrimp as well as larger snails, amphipods, and isopods. Epibenthos tend to be highly motile, are often able to utilize a variety of habitats, and may respond rapidly to environmental cues. Examples of epibenthos in the Cape Fear system include important fisheries species such as the blue crab, Callinectes sapidus, and the spot, Leiostomus xanthurus, as well as common prey items for larger species (e.g. grass shrimp, Palaemonetes spp., and killifish, Fundulus spp.). Sampling epibenthos provides direct information on year class strength of target fishery and indicator species, as well as indications of resource and ecosystem responses. Epibenthos respond quickly to changing environmental conditions and generally leave when conditions become unfavorable

This study is focused on the epibenthic community utilizing the fringing marsh habitats at nine stations along the estuarine gradient. Sampling is conducted spring and fall, which coincides with periods of recruitment of juveniles into the estuary. The primary recruitment, in terms of numbers, occurs in the spring and a smaller, but important recruitment pulse occurs in the fall. There are distinct differences in species composition between seasons that may prove important for detection of higher trophic level impacts. The habitats sampled in this monitoring effort represent the most prominent structural habitats (edge) within the upper Cape Fear estuarine system and provide both refuge and forage for epifaunal organisms, specifically juveniles of many fish species.

Many epibenthic taxa are good, first level indicators of ecosystem level impacts because their motile lifestyles allows them to quickly respond to physical changes in the environment. Many of the epibenthic species are juveniles and this life stage represents a critical “bottleneck” in year class strength. Recruitment is often extremely sensitive to any hydrodynamic factors affecting larval ingress. Changes in tidal amplitude, water salinity, or reduced/increased tidal asymmetry could change the distribution of certain epifaunal organisms by altering recruitment patterns. These changes would be expected to change species composition and abundance and lead to upstream/ downstream shifts in dominance. Epibenthos are also sensitive to changes in many physical factors and may avoid, to some degree, rapid fluctuations of dissolved oxygen, temperature, or salinity. At the same time, epibenthos may be consistent relative to the timing of ingress/egress into the estuary and with respect to dominant species. For many of the taxa in this group transport into this edge habitat ensures an abundant food resource (presumably benthic fauna) and refuge (structural habitat within the marsh system).

Loss of prey, i.e. food supply, could also lead to changes in the epibenthic community. Prey items are discussed in Section 6 (Benthic Sampling) of this report. Shifts in the pattern and or abundance of epibenthos are also likely to occur if there is a major change in recruitment and survival of the benthic component of the community. Evidence of the trophic connection between the benthic and epibenthic communities is clear. Juvenile flounder Paralichthys (~25-40mm total length), caught in the shallow subtidal areas of the Cape Fear Estuary contained remnants of copepods and amphipods in their stomachs, but these were mostly digested. Other specimens caught in the intertidal marsh edge contained fragments or entire spionid polychaetes (unpublished data Alphin and Posey) demonstrating that these intertidal and marsh habitats are the feeding areas for these fish.

The ultimate goal of the Epibenthic Monitoring is to evaluate long-term trends in habitat utilization (based on abundance, distribution and composition of epibenthic fauna) and to detect shifts (if any) in these patterns. For this reason the emphasis of the analysis of the first collections from 1999, 2000, and 2001 is to establish a reliable baseline data set. Comparisons of epibenthic community composition, distribution, and dominance during and following completion of the deepening and widening project will be used to evaluate possible impacts. As with the benthic sampling, some potential impacts to these communities are similar to those predicted for eustatic sea level rise and so may indicate long-term community changes expected in other estuaries during the next century.

7.1 Summary of Current Monitoring Efforts

The most important structural habitat within the upper Cape Fear River estuary is the fringing marsh/swamp edge. These habitats were sampled for epibenthic fish and crustaceans using Breder and drop traps. Breder traps were used to sample organisms moving into the fringing marsh during high tide, which they leave as the tide ebbs. Drop traps targeted those organisms that primarily utilize the lower marsh edge, and the shallow subtidal areas.

Epibenthos were sampled at nine stations across the estuarine gradient. These stations correspond to the benthic monitoring stations and are a subset of the 12 stations monitored for physical factors (Figure 1.2-1). Epibenthic samples were collected in September-October 1999 (following Hurricane Floyd), in April-May 2000, in September-October 2000, and in April-May 2001. (These sampling periods reflect the major recruitment pulses for many estuarine dependent species.) As with the benthic monitoring, these stations cover the mesohaline to oligohaline regions within Town Creek, the mainstem Cape Fear River and the Northeast Cape Fear River.

7.2 Methodology

Epibenthic organisms were sampled using both Breder traps and drop traps. These methods sample different subsets of the epibenthos. Each trap is highly effective within their respective habitats for certain species.

Breder traps were used to sample small fish and crustaceans moving into vegetated marsh or wooded swamp edge. Traps are constructed of clear acrylic (31 cm length X 16 cm height X 15 cm width). When submerged Breder traps catch epibenthic fish and crustaceans passively. At each station, traps were placed in the lower intertidal (near mean low water), mid intertidal (submerged ~1m depth at mean high water), and upper intertidal (submerged ~ .5m at mean high water) zones. Two sets of five traps were set at each tidal height with the opening oriented toward the channel or down stream. Trap orientation was based on preliminary data that indicates this positioning best for obtaining the highest catch. Each trap is secured to the substrate to ensure it maintains proper orientation. All traps were set on the rising tide. Traps were allowed to "fish" for two hours. This time period was based on previous work as a compromise between obtaining higher catches and reducing possible loss due to predation or cannibalism among organisms within the traps. All organisms caught were identified to lowest possible taxon and representative specimens preserved for verification. All organisms caught were measured for total length.

Drop traps were used to sample epibenthic fish and crustaceans utilizing the lower marsh edge or shallow subtidal regions of the marsh. The drop trap is an aluminum square that is 1m on a side and 1m high with mesh netting and floats attached to the top edge to prevent organisms from escaping. The trap was 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. Bottom contact is verified for each deployment to ensure that organisms could not escape from the trap. Eighteen replicate drops were made in the shallow subtidal areas at each station. Replicate samples were taken at least 32 feet apart with a minimum 20 minutes between samples. Once the trap was secured the contents were removed using a steel frame sweep net with a 2mm mesh. The trap was considered empty when five consecutive sweeps of the entire trap yield no organisms. All organisms caught were identified, enumerated, and measured (total length). Representatives of each species caught were preserved for species verification.

Drop trap and Breder trap sampling was conducted during the same time window for all stations. However a minimum of two days was allowed between sampling methods for any given station. This time period limits possible interference between sampling methods and reduces possible impacts at the sampling stations. Preliminary site and time period comparisons were made using Sorenson's similarity index as described for the benthos (Section 6.2).

7.3 Faunal Patterns

Breder trap sampling (1999-2001) yielded a total of 23 taxa across all stations sampled (Tables 7.3-1 – 7.3-3). Breder traps indicate the relative number of organisms that pass a particular point (i.e. the mouth of the trap) over a two-hour time period and so catches are a function of the mobility of the organisms caught as well as their distributional patchiness. Numbers of species collected per sampling period were low, with the fewest number of taxa collected during fall 1999 at the Town Creek stations (Table 7.3-1) and the highest number of taxa collected during that same time period at the Smith Creek station (Table 7.3-2). Fall 1999 samples were collected after the passage of Hurricane Floyd and flooding from that hurricane may have had some impact on the taxa recovered from this first sampling period. Although abundances are often low for passive sampling approaches such as Breder traps, the consistency of taxa at a site over repeated sampling periods combined with relative abundance measures is the key to evaluating these habitats using this method.

Similarity indices for Breder traps were calculated for each station for fall (September/October 1999 vs. September/October 2000) and spring (April/May2000 vs. April/May 2001). Similarity indices show two distinct patterns: 1) spring samplings tend to be more similar than fall sampling, and 2) some stations show no similarity or very low similarity (Table 7.3-4). The overall lower similarity between fall 1999 and fall 2000 samples may be a result of Hurricane Floyd in September 1999. In 1999 most sites were dominated by a few resident species such as Gobionellus shufeldti, Uca pugnax, Palaemonetes pugio and to a lesser extent Lepomis macrochirus. Fall 2000 samples had slightly higher species richness,

Table 7.3-1. Mean per trap and standard deviation for catches of epibenthic fish and crustaceans at each station in Town Creek using Breder traps. Samples were collected in three intertidal zones at each station; in the lower intertidal (at the lower edge of the marsh near mean low water), in the mid intertidal and upper intertidal zone.

Low intertidal	Town Creek mouth (P2)				Town Creek inner (P3A)				Town Creek inner (P3B)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0.1(0.3)	0	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0	0	0	0	0	0	0	0	0	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0	0.1(0.3)	0	0.2(0.4)	0	0	0.2(0.6)	1(1.7)	0	0	0	0.1(0.3)
Gambusia affinis	0	0	0	0	0	0.1(0.3)	0	0	0	0.1(0.3)	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0.1(0.3) 0	0	0	1(1.8)	0
Gobionellus shufeldti	0.1(0.3)	0.1(0.3)	0	0.1(0.3)	0	0	0	0	0	0.1(0.3)	0.1(0.3)	0.4(1)
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0.2(0.4)	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	9.9(8.4)	0	0	0	0	0	0	0	0	0	0
Lepomis macrochirus	0	0	0	0	0	0	0.2(0.6)	0	0	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	0	0	0	0	0.1(0.3)
Palaemonetes pugio	0	1.5(1.4)	0	2(2.6)	0	0	0.7(1.6)	0	0	0	1.6(1.3)	0.2(0.6)
Paralichthys dentatus	0	0	0	0	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0.7(1.1)	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0	0	0	0
U/I insect	0	0	0	0	0	0	0	0	0	0	0	0
U/I larval fish	0	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	0	0	0	0	0.2(0.6)	1.5(2)	0	0.1(0.3)	0.5(0.7)	0.7(0.8)	0.1(0.3)	0.2(0.4)

Table 7.3-1. Continued

Mid intertidal	Town Creek mouth (P2)				Town Creek inner (P3A)				Town Creek inner (P3B)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0	0	0	0	0	0	0	0	0	0.1(0.3)	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0	0.1(0.3)	0	0.2(0.4)	0	0	0.1(0.3)	1(2.8)	0	0	0	0
Gambusia affinis	0.1(0.3)	0	0	0	0	0.5(0.8)	0	0	0	0.2(0.40	0	0
Gambusia holbrooki	0	0	0	0	0	0	0.2(0.6)	0	0	0	0.2(0.4)	1.1(2.1)
Gobionellus shufeldti	0	0.2(0.4)	0	0	0.1(0.3)	0.1(0.3)	0.8(1.5)	0	0.1(0.3)	0.1(0.3)	0.1(0.3)	0.1(0.3)
Hirudinea	0	0.1(0.3)	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	5(5.1)	0	0	0	0	0	0	0	0	0	0.2(0.4)
Lepomis macrochirus	0	0	0	0	0.1(0.3)	0	0	0	0.1(0.3)	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	0	0	0	0	0
Palaemonetes pugio	0.3(0.5)	1.4(1.6)	0	1.1(1.7)	0	0	0.4(1)	0	0	0	1.5(2.4)	0.1(0.3)
Paralichthys dentatus	0	0	0	0	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0.9(0.9)	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0	0	0	0
U/I insect	0.1(0.3)	0	0	0	0	0	0	0	0	0	0	0
U/I larval fish	0	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	0	0	0	0	0.4(0.7)	2.1(1.8)	0.2(0.6)	1.4(1.8)	0.2(0.4)	1.2(1.5)	0	0.6(1.3)

Table 7.3-1. Concluded

Upper intertidal	Town Creek mouth (P2)				Town Creek inner (P3A)				Town Creek Inner (P3B)			
Species	Fall 99	Spr 00	Fall 0s0	pr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0.2(0.4)	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0	0	0	0	0	0	0	0	0	0.1(0.3)	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0	0	0	0.1(0.3)	0	0.1(0.3)	0.1(0.3)	1.5(2.6)	0	0	0.1(0.3)	0
Gambusia affinis	0	0	0	0	0	0.5(1)	0	0	0	0.3(0.5)	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0.1(0.3)	0	0	1(1.6)	0.6(1.3)
Gobionellus shufeldti	0	0	0	0	0.1(0.3)	0.2(0.4)	0	0	0.1(0.3)	0	0.5(0.7)	0
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	5.3(7.4)	0	0.5(0.7)	0	0	0	0	0	0	0	0.1(0.3)
Lepomis macrochirus	0	0	0	0	0.1(0.3)	0	0	0	0	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	0	0	0	0	0
Palaemonetes pugio	0.1(0.3)	2.3(3.3)	0	1.3(2.2)	0	0	0.5(1)	0	0	0	1.2(1.9)	0.1(0.3)
Paralichthys dentatus	0	0	0	0	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0.6(0.8)	0	0	0	0	0	0	0	0	
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0	0	0	0
U/I insect	0	0	0	0	0	0	0	0	0	0	0	0
U/I larval fish	0	0	0	0.1(0.3)	0	0	0	0	0	0	0	0
Uca pugnax	0.1(0.3)	0	0	0	0.8(0.8)	2(2.1)	0.3(0.7)	1.8(1.7)	0.4(0.5)	0.6(1.1)	0	0.9(1.6)

Table 7.3-2. Mean per trap and standard deviation for catches of epibenthic fish and crustaceans at each station on the main stem Cape Fear River using Breder traps. Samples were collected in three intertidal zones at each station; in the lower intertidal, in the mid intertidal and upper intertidal zone.

Low Intertidal	Eagle Island (P6)				Indian Creek (P7)				Dollisons Landing (P8)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0	0	0	0	0	0	0	0	0	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0.1(0.3)	0	0	0	0	0
Fundulus heteroclitus	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia affinis	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0	0	0	0	0
Gobionellus shufeldti	0	0	0.1(0.3)	0.2(0.4)	0	0.4(0.5)	0	0.4(0.7)	0.1(0.3)	0	0	0.6(1)
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	0	0	0	0	0	0	6.6(7.4)	0	0	0	0
Lepomis macrochirus	0	0	0	0	0	0.1(0.3)	0	0	0	0	0.1(0.3)	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0.1(0.3)	0	0
Mugil cephalus	0	0	0	0.3(0.9)	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0	1.1(1.9)	0.1(0.3)	0	0	0	0	0	0	0	0
Paralichthys dentatus	0	0.3(0.9)	0	0.1(0.3)	0	0	0	0.4(0.7)	0	0	0	0.1(0.3)
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0	0	0	0
Paralicthys albigutta	0	0	0.1(0.3)	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0.2(0.4)	0	0	0
U/I insect	0	0	0	0	0	0	0	0	0	0	0	0
U/I larval fish	0.1(0.3)	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	0	0	0	0.3(0.7)	0.6(1)	0	0	0	0	0	0	0

Table 7.3-2. Continued

Mid Intertidal	Eagle Island (P6)				Indian Creek (P7)				Dollisons Landing (P8)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0.1(0.3)	0	0
Callinectes sapidus	0	0.1(0.3)	0	0.1(0.3)	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0.1(0.3)	0	0	0	0.2(0.4)	0	0	0	0	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia affinis	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0	0	0	0	0
Gobionellus shufeldti	0	0.1(0.3)	0.1(0.3)	0.3(0.7)	0	1.1(0.9)	0.1(0.3)	0.6(0.7)	0	0	0	0.1(0.3)
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0.1(0.3)	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	0	0	0	0	0	0	8.2(11.3)	0	0	0	0
Lepomis macrochirus	0	0	0	0	0	0	0	0	0	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0.1(0.3)	0	0
Mugil cephalus	0	0	0	0.1(0.3)	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0	0.8(1.4)	0	0	0	0	0	0	0	0	0
Paralichthys dentatus	0	0.4(0.7)	0	0	0	0	0	0	0	0	0	0.2(0.4)
Paralichthys lethostigma	0	0	0	0	0	0.3(0.5)	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0.1(0.3)	0	0	0
U/I insect	0	0	0	0	0	0	0	0	0	0	0	0
U/I larval fish	0	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	0	0	0	0	0.2(0.4)	0	0	0	0	0	0	0

Table 7.3-2. Concluded

Upper Intertidal	Eagle Island (P6)				Indian Creek (P7)				Dollisons Landing (P8)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0.1(0.3)	0.1(0.3)	0	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0.1(0.3)	0	0	0
diving beetle	0	0.1(0.3)	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0.2(0.4)	0	0	0	0	0	0	0	0.1(0.3)	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0	0	0	0	0	0	0	0.5(1)	0	0	0	0
Gambusia affinis	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0	0	0	0	0
Gobionellus shufeldti	0	0.1(0.3)	0	0.1(0.3)	0.1(0.3)	4.3(11.5)	0	0.3(0.7)	0	0	0	0.3(0.7)
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0.2(0.4)	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	0.2(0.4)	0	0.1(0.3)	0	0	0	2.8(2)	0	0	0	0
Lepomis macrochirus	0	0	0	0	0	0	0	0	0	0	0.1(0.3)	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0.2(0.6)	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0	0.2(0.4)	0	0	0	0	0	0	0	0	0
Paralichthys dentatus	0	0.1(0.3)	0	0	0	0	0	0.1(0.3)	0	0	0	1(2.5)
Paralichthys lethostigma	0	0	0	0	0	0.7(1.3)	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0	0	0	0
U/I insect	0	0	0	0	0	0	0	0	0	0	0	0
U/I larval fish	0	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	0	0	0	0.6(1)	0	0	0	0	0	0	0	0

Table 7.3-3. Mean per trap and standard deviation for catches of epibenthic fish and crustaceans at each station on the Northeast Cape Fear River using Breder traps. Samples were collected in three intertidal zones at each station; in the lower intertidal, in the mid intertidal and upper intertidal zone.

Low Intertidal	Smith Creek (P11)				Rat Island (P12)				Fishing Creek (P13)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0.1(0.3)	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0.2(0.4)	0	0	0	1.5(1.3)	0	0	0	0.1(0.3)	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0	0	0.1(0.3)	0	0	0	0	0	0	0	0	0.1(0.3)
Gambusia affinis 0	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
Gobionellus shufeldti	0.2(0.4)	0	0	0.6(1)	0	0.6(1)	0.2(0.6)	0	0	0	0	0
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0.1(0.3)	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	1.3(2.4)	0	0	0	0.2(0.6)	0	0.5(1)	0	0	0	0
Lepomis macrochirus	0.2(0.4)	0	0	0	0	0.1(0.3)	0	0	0.6(1.9)	0.1(0.3)	0.2(0.4)	0
Menidia beryllina	0.2(0.4)	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0	0	0	0.3(0.5)	0	0.4(1)	0.2(0.6)	0	0	0	0
Paralichthys dentatus	0	0	0	0.2(0.4)	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0.1(0.3)	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0	0	0	0
U/I larval fish	0.2(0.4)	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	0.2(0.4)	0	0.2(0.4)	0	0	0.1(0.3)	0.1(0.3)	0	0	0	0	0.2(0.4)

Table 7.3-3. Continued

Mid Intertidal	Smith Creek (P11)				Rat Island (P12)				Fishing Creek (P13)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0	0	0	0	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0	0	0	0	0	0	0	0	0.2(0.6)	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0.1(0.4)	0	0	0	0	0	0	0.2(0.6)	0	0	0	0.8(1.3)
Gambusia affinis	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0	0	0	0	0
Gobionellus shufeldti	0.1(0.4)	0	0	0.2(0.4)	00	0.6(1)	0	0.2(0.6)	0	0	0	0
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	0.3(0.7)	0	0.1(0.3)	0	0.2(0.4)	0	0.6(0.8)	0	0	0	0
Lepomis macrochirus	0.1(0.4)	0	0	0	0.2(0.4)	0	0	0	0.3(0.9)	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0.1(0.3)	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0	0	0	0	0	0	0.3(0.7)	0	0	0	0
Paralichthys dentatus	0	0	0	0.1(0.3)	0	0	0	0.1(0.3)	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0.3(0.7)	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0.1(0.4)	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	0.2(0.7)	0	0	0	0.2(0.4)	0	0.3(0.5)	0	0.4(1)	0	0.6(1.3)	0

Table 7.3-3. Concluded

Upper Intertidal	Smith Creek (P11)				Rat Island (P12)				Fishing Creek (P13)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Amphipods	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0	0	0	0.1(0.3)	0.1(0.3)	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
diving beetle	0	0	0	0	0	0	0	0	0	0	0	0
Dormitator maculatus	0	0	0	0	0.4(0.7)	0	0	0	0.1(0.3)	0	0	0
Eucinostomus argenteus	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	0	0	0	0	0	0.1(0.3)	0	0.8(1.5)	0	0	0	0.4(0.7)
Gambusia affinis	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0	0	0	0.1(0.3)	0
Gobionellus shufeldti	0	0	0	0	0	0.1(0.3)	0	0.1(0.3)	0	0	0	0
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0	0	0	0	0	0	0	0	0	0	0
Leiostomus xanthuras	0	1(1.2)	0	0	0	0.1(0.3)	0	0.8(1.5)	0	0	0	0
Lepomis macrochirus	0	0	0	0	0.1(0.3)	0	0	0	0	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0.2(0.6)	0	0	0	0.1(0.3)	0	0	0	0
Paralichthys dentatus	0	0	0	0	0	0	0	0	0	0	0	0
Paralichthys lethostigma	0	0	0	0	0	0.3(0.5)	0	0	0	0	0	0
Paralicthys albigutta	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0	0	0	0	0	0	0	0	0	0
Rhithropanopaeus harrisii	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0	0	0	0	0	0
Uca pugnax	8.5(13.2)	0	0	0	0.1(0.3)	0	1.7(1.6)	0	0.4(1)	0.1(0.3)	0	0.8(1)

Table 7.3-4 Similarity indices for Breder trap data for all stations. Similarities presented for the fall reflect comparisons between September/October 1999 and September/October 2000 and similarities for spring reflect comparisons between April/May 2000 and April/May 2001. Similarities are presented by tidal height.

	Low Intertidal		Mid Intertidal		High Intertidal	
Station	Fall	Spring	Fall	Spring	Fall	Spring
Town Creek mouth (P2)	0	.75	0	.57	0	.57
Town Creek inner a (P3A)	0	.4	.5	.4	.33	.57
Town Creek inner b (P3B)	.4	.5	.33	.44	.33	.28
Eagle Island (P6)	0	.33	0	.57	0	.4
Indian Creek (P7)	0	.4	0	.5	0	.33
Dollisons Landing (P8)	0	0	0	0	0	0
Smith Creek (P11)	.25	0	0	.4	0	0
Rat Island (P12)	.4	.28	.66	.5	.4	.66
Fishing Creek (P13)	.66	0	.5	0	0	.66

including two species of Gambusia and Fundulus heteroclitus (Tables 7.3-1, 7.3-2 and 7.3-3). Higher similarity values among years for spring samples is a result of increased numbers of transient species including Lagodon rhomboides, Leiostomus xanthurus, and several species of Paralichthys, which were present during both years.

Unlike Breder traps, drop traps are active sampling devices and do not rely on movement of organisms. Catches using this method were considerably higher (Tables 7.3-5 – 7.3-7). A total of 35 taxa were collected with drop traps. Peak species richness occurred at most sites during spring and fall 2000. However, the inner Town Creek stations showed consistent species richness across almost all sampling periods, with persistence of resident species, but variation in the transient taxa caught among sampling periods (Table 7.3-5). This same pattern is also evident in most of the other stations, although to a lesser extent. One exception is the Dollisons Landing (P8) station, which had persistently low species richness and no taxa caught in more than two sampling periods (Table 7.3-6).

Calculation of similarity indices for drop trap data shows consistently high similarity between spring samples for the Town Creek stations and for the Northeast Cape Fear River stations (Table 7.3-8). Similarity between fall samplings was lower, possibly due to hurricane effects in fall 1999. Comparisons between stations for each sampling period also reveal

Table 7.3-5. Mean (per 1 m^2) and standard deviation for catches of epibenthic fish and crustaceans using subtidal drop traps at each station in Town Creek. Drop traps were deployed along the depth contour (approximately 1m depth at mean low water) below the fringing marsh at each station. The two inner Town Creek stations have been combined into a single column here because of possible non-independence and close proximity of these two stations. Drop traps target those species that utilize the lower marsh edge but that might not move into the marsh proper.

	Town Creek mouth (P2)				Town Creek inner (P3)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Anguilla rostrata	0	0	0	0.1(0.2)	0.1(0.2)	0.1(0.3)	0	0.3(0.5)
Anchoa mitchilli	0.4(1.9)	0	0	0	1.4(3.9)	0	0	0
Callinectes sapidus	0.3(0.6)	0.1(0.2)	0.7(1)	0.1(0.3)	0.1(0.4)	0.3(0.6)	0	0.3(0.5)
Cambrus robustus	0	0	0	0	0(0.2)	0	0	0
Sesarma cinereum	0	0	0	0	0	0	0.3(0.5)	0
Corbicula fluminea	0	0	0	0	0	0	0	0
Dorosoma pretense	0	0	0	0	0	0	0	0
Esox americanus	0	0	0	0	0	0	0	0
Esox lucius	0	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	1.5(3.9)	0.8(3.6)	2.5(6.9)	1.8(2.6)	0.1(0.2)
Gerres linereus	0	0	0	0	0	0	0	0
Gobionellus shufeldti	0.4(0.9)	0.2(0.4)	0	0.1(0.3)	0.5(1.4)	0.4(0.6)	0.3(0.7)	0.3(0.5)
Fundulus majalis	0	0	0	0	0	0	0.1(0.2)	0
Fundulus heteroclitus	0	0	0	0	0.1(0.3)	0	0	0
Lagodon rhomboides	0	0.4(1)	0.1(0.2)	0.2(0.5)	0	0.5(1)	0	0
Lepomis macrochirus	0	0	0	0	0.1(0.3)	0	0.1(0.2)	0
Leiostomas xanthuras	0	7(10.2)	0	0.1(0.3)	0	3(6.9)	0	0.2(0.4)
Menticirrhus saxitilus	0	0	0.1(0.2)	0	0	0	0	0
Menida beryllina	0	5.6(13.6)	0	0	0	0.1(0.5)	0	0
Micropongia undulatus	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0	0	0	0	0
Netropis petersoni	0	0	0	0	0	0	0	0.1(0.3)
Notropis chalybaeus	0	0	0	0	0	0	0	0
Palaemonetes pugio	1.4(3.7)	5.6(5.7)	0.8(2.6)	0	0	0	0	0.2(0.4)
Panopeus herbstii	0.1(0.2)	0.1(0.2)	0.5(1.3)	0.1(0.3)	0	0	0.2(0.5)	0
Paralichthys dentatus	0	0.1(0.3)	0.1(0.2)	0.2(0.5)	0	0.7(0.8)	0	0.5(0.5)
Penaeid	0	0	0.2(0.5)	0	0	0	0	0
Penaeus setiferus	0	0	0.1(0.20	0	0	0	0	0
Penaeus aztecus	0	0	0.2(0.4)	0	0	0	0	0
Rangia sp.	0	0	0.1(0.2)	0	0	0	0	0
Rhithropanopeus harrissi	0.1(0.2)	0	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0.1(0.3)	2.1(4.6)	0.5(1)	0.1(0.2)	0.5(0.5)
Uca pugnax	0.1(0.20	0	0	0	0.9(2.7)	0.1(0.2)	5.1(4.1)	0
U/I larval fish	0	0	0.1(0.2)	0	0	0	0	0

Table 7.3-6. Mean (per 1 m^2) and standard deviation for catches of epibenthic fish and crustaceans using subtidal drop traps at each station in the main stem Cape Fear. Drop traps were deployed along the depth contour (approximately 1m depth at mean low water) below the fringing marsh at each station. Drop traps target those species that might utilize the lower marsh edge but that might not move into the marsh proper.

	Eagle Island (P6)				Indian Creek (P7)				Dollisons Landing (P8)			
Species	Fall l99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Anguilla rostrata	0	0	0	0.3(0.7)	0	0.7(1.4)	0	0.1(0.5)	0	0	0	0.2(0.4)
Anchoa mitchilli	0	0	1(1.6)	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0.2(0.4)	0	0.1(0.2)	0.15(0.4)	0.1(0.2)	0	0	0	0	0	0	0
ambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0
Sesarma cinereum	0	0	0	0	0	0	0	0	0	0	0.1(0.2)	0
Corbicula fluminea	0.1(0.2)	0	0	0	0	0	0	0	0	0	0	0
Dorosoma pretense	0	0	0	0	0.1(0.2)	0	0	0	0	0	0	0
Esox lucius	0	0	0	0	0.1(0.2)	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	0	0.1(0.2)	00	0.2(0.7)	0	0.2(0.9)	0	0	0
Gerres linereus	0	0	0.3(0.7)	0	0	0	0.2(0.4)	0	0	0	0	0
Gobionellus shufeldti	0.1(0.2)	0.1(0.5)	0.2(0.6)	0.3(0.7)	0.1(0.2)	0.3(0.6)	0.3(0.8)	0	0.1(0.3)	0	0	0
Fundulus heteroclitus	0	0	0	0	0.1(0.2)	0	0	0	0	0	0	0
Lagodon rhomboides	0	0	0	0	0.4(1.5)	0.4(1.5)	0	0	0	0	0	0
Lepomis macrochirus	0	0	0	0	0	0	0	0	0.1(0.2)	0	0.1(0.2)	0
Leiostomas xanthuras	0	0	0	4.8(9.8)	0	0	0	0	0	0	0	0
Menida beryllina	0.1(0.3)	0	0	56.1(115.6)	0	0	0	0.3(0.8)	0.6(1.6)	0.6(1.6)	0	0
Micropongia undulatus	0	0	0	0	0	0	0	0	0	0	0	0
Netropis petersoni	0	0	0	0	0	0	0	0	0	0	0	0.1(0.2)
Notropis chalybaeus	0	0	0	0	0	0	0	0	2.9(8.4)	0	0	0
Palaemonetes pugio	0	0	5.4(13.9)	3.9(7)	0	0	0.3(1)	0	0	0	0	0
Panopeus Herbstii	0	0	0.1(0.3)	0	0	0	0	0	0	0	0	0
Paralichthys dentatus	0	0.2(0.5)	0	3.2(6.5)	0.5(1.2)	0.5(1.2)	0	1.6(2.4)	0	0.6(1.6)	0	0.1(0.2)
Rangia sp.	0	0	0	0	0.1(0.2)	0.1(0.20	0	0	0	0	0	0
Rhithropanopeus harrissi	0	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0.4(0.9)	0	0.1(0.3)	0	0	0	0.1(0.2)	0	0.2(0.5)	0	0	0
Uca pugnax	0	0	0	0	0.1(0.2)	0.1(0.2)	0.1(0.5)	0	0	0.6(1.6)	0.2(0.5)	0
U/I larval fish	0	0	0	0	0	0	0.4(1.4)	0	0	0	0	0

Table 7.3-7. Mean (per 1 m^2) and standard deviation for catches of epibenthic fish and crustaceans using subtidal sampling (drop traps) at each station in the NE Cape Fear River. Drop traps were deployed along the depth contour (approximately 1m depth at mean low water) below the fringing marsh at each station. Drop traps target those species that utilize the low marsh edge, but that might not move into the marsh proper.

	Smith Creek (P11)				Rat Island (P12)				Fishing Creek (P13)			
Species	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01	Fall 99	Spr 00	Fall 00	Spr 01
Anguilla rostrata	0	0.3(0.7)	0	0	0	0	0	0.3(1.2)	0	0.2(0.7)	0	0.3(0.6)
Anchoa mitchilli	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0.1(0.3)	0.1(0.2)	0	0	0	0.1(0.3)	0	0	0	0	0
Cambrus robustus	0	0	0	0	0	0	0	0	0	0	0	0.1(0.2)
Sesarma cinereum	0	0	0.7(1.6)	0	0	0	0.2(0.4)	0	0	0	0	0
Corbicula fluminea	0	0	0	0	0	0	0	0	0	0	0	0
Dorosoma pretense	0	0	0	0	0	0	0	0	0	0	0	0
Esox americanus	0	0	0	0	0	0	0	0	0	0	0	0.1(0.5)
Esox lucius	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	0	0	0	0	0	0	0	0	0	0	0.3(0.8)	0
Gerres linereus	0	0	0	0	0	0	0	0	0	0	0	0
Gobionellus shufeldti	0.2(0.5)	0.2(0.5)	0	0	0.1(0.3)	0.1(0.2)	0.1(0.2)	0.6(1)	0	0.2(0.6)	0	0.1(0.5)
Fundulus heteroclitus	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	0	0.7(2.1)	0	9.6(10)	0	0	0	0	0	0	0	0
Lepomis macrochirus	0	0	0	1(3.3)	0.1(0.3)	0	0	0	0.1(0.2)	0.1(0.5)	0	0
Leiostomas xanthuras	0	14.8(41.5)	0	0	0	0.1(0.3)	0	0	0	0	0	0
Menida beryllina	0	0.2(0.7)	1.9(2.7)	0	0	0.2(0.5)	0	0.4(1.7)	0	1.4(4.1)	0	0.2(0.9)
Micropongia undulatus	0	0	0	0	0	0	0	0	0	0	0	0
Mugil cephalus	0	0	0	0.9(3.4)	0	0	0	0	0	0	0	0
Netropis petersoni	0	0	0	0.2(0.4)	0	0	0	0	0	0	0	0
Notropis chalybaeus	0	0	0	0	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0.1(0.2)	1.6(1.7)	0.1(0.2)	0	0.2(0.5)	1.2(2.8)	1.6(3.7)	0	0	0	0
Panopeus Herbstii	0	0	0	0	0	0	0	0	0	0	0	0
Paralichthys dentatus	0	1.2(1.9)	0	0	0	0.2(0.5)	0	0.3(0.7)	0	0.3(0.7)	0	0.6(1)
Penaeus setiferus	0	0	0	0	0	0	0	0	0	0	0	0
Penaeus aztecus	0	0	0.1(0.2)	0	0	0	0	0	0	0	0.2(0.4)	0
Rangia sp.	0	0.2(0.5)	1.9(3.6)	0	0	0	0	0	0	0	0	0
Rhithropanopeus harrissi	0.1(0.2)	0	0	0	0	0	0	0	0	0	0	0
Trinectes maculatus	0.2(0.7)	0	0.1(0.2)	0	0	0	0	0	0	0.3(0.8)	0	0
Uca pugnax	0	0	0	0	0.1(0.2)	0	1.1(2.3)	0	0.1(0.5)	0	0	0
U/I larval fish	0	0	0	0	0	0.1(0.2)	0	0	0	0	0	0

Table 7.3-8. Similarity indices for epibenthos collected using drop traps. Similarity was calculated for samples taken in Fall (September and October 1999 and 2000) and Spring (April and May 2000 and 2001).

Station	Fall	Spring
Town Creek mouth (P2)	0.33	0.59
Town Creek inner B (P3)	0.7	0.7
Eagle Island (P6)	0.5	0.4
Indian Creek (P7)	0.43	0.44
Dollison Landing (P8)	0.25	0.33
Smith Creek (P11)	0.33	0.57
Rat Island (P12)	0.5	0.73
Fishing Creek (P13)	0	0.62

Table 7.3-9 Similarity among sampling stations for each sampling period using drop traps. Epibenthos are sampled during Spring (April/ May) and Fall (September/ October) of each year. Evaluation of similarity among stations allows us to detect possible shift in composition across the estuarine gradient. The alphanumeric designation at the head of each column corresponds to

Fall 99

Station	P3	P6	P7	P8	P11	P12	P13
Town Creek mouth (P2)	0.53	0.33	0.43	0.17	0.4	0.4	0.22
Town Creek inner B (P3)		0.47	0.53	0.47	0.27	0.4	0.29
Eagle Island (P6)			0.33	0.4	0.5	0.25	0
Indian Creek (P7)				0.33	0.2	0.4	0.22
Dollisons Landing (P8)					0.5	0.5	0.29
Smith Creek (P11)						0.33	0
Rat Island (P12)							0.67
Fishing Creek (P13)							

Fall 00

Station	P3	P6	P7	P8	P11	P12	P13
Town Creek mouth (P2)	0.11	0.33	0.22	0	0.4	0.25	0
Town Creek inner B (P3)		0.4	0.26	0.54	0.24	0.46	0.2
Eagle Island (P6)			0.43	0	0.38	0.5	0
Indian Creek (P7)				0.2	0.25	0.5	0.22
Dollisons Landing (P8)					0.16	0.5	0
Smith Creek (P11)						0.43	0.18
Rat Island (P12)							0
Fishing Creek (P13)							

Spring 00

Station	P3	P6	P7	P8	P11	P12	P13
Town Creek mouth (P2)	0.63	0.4	0.43	0.37	0.82	0.71	0.43
Town Creek inner B (P3)		0.31	0.59	0.43	0.7	0.47	0.59
Eagle Island (P6)			0.5	0.4	0.37	0.5	0.5
Indian Creek (P7)				0.44	0.67	0.33	0.5
Dollisons Landing (P8)					0.33	0.22	0.44
Smith Creek (P11)						0.67	0.53
Rat Island (P12)							0.5
Fishing Creek (P13)							

Spring 01

Station	P3	P6	P7	P8	P11	P12	P13
Town Creek mouth (P2)	0.56	0.82	0.33	0.16	0.57	0.57	0.5
Town Creek inner B (P3)		0.71	0.33	0.5	0.43	0.57	0.5
Eagle Island (P6)			0.54	0.36	0.77	0.77	0.67
Indian Creek (P7)				0.67	0.5	0.75	0.6
Dollisons Landing (P8)					0.25	0.5	0.4
Smith Creek (P11)						0.6	0.33
Rat Island (P12)							0.67
Fishing Creek (P13)							

interesting seasonal patterns. There is greater similarity among stations during spring sampling events than in either of the fall samplings (Table 7.3-9). This apparent similarity may be driven by a few estuarine resident species, including Gobionellus shufeldti and Uca sp, that were present at most stations, as well as the presence of Paralichthys dentatus, Palaemonetes pugio, and Leiostomus xanthurus at all but Fishing Creek (P13) and Dollisons Landing (P8) during spring sampling.

8.0 SALT SENSITIVE VEGETATION SURVEY

8.1 Introduction and Background

As a part of the on-going Wilmington Harbor monitoring program in the Cape Fear River Estuary, seven of the nine stations with belt transects contained salt-sensitive vegetation and were selected in 2000 as sites for sensitive herbaceous vegetation sampling. The remaining two stations supported vegetation indicative of past salinity events. Presence of such vegetation has been interpreted as a function of tidal hydrology, salinity, and soil biogeochemistry. The seven stations at which vegetation monitoring is taking place are reviewed below (Table 8.1-1). Generalized vegetation zones along each belt transect, including those containing sensitive herbaceous species, were described previously (CZR Incorporated 2001).

Table 8.1-1. Locations, names and numbers of sensitive herbaceous vegetation monitoring stations in the Cape Fear River Estuary, North Carolina.

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

A sensitive herbaceous species was defined as a non-woody, perennial plant species sensitive to brackish water flooding and rooted in basal substrate (not on hummocks, root mats, stumps, logs, etc.) subject to regular, fresh tidal inundation. Areas supporting sensitive herbaceous species close to the main stream were chosen because of proximity to the source of flood tide water.

Initial baseline sampling of sensitive herbaceous vegetation was accomplished in four steps. A polygonal area dominated by one or more sensitive herbaceous species was selected. The polygonal area was delineated and flagged. A visual estimate of cover contributed by each species within the polygon was recorded. Location data for points circumscribing each polygon were collected using global positioning system (GPS) technology. Annual sampling results subsequent to collection of initial baseline data were based on application of GPS waypoints to re-establish polygons at each of the stations.

Delineation of sensitive herbaceous species polygons was performed in two ways. The initial routine was to follow stand boundaries of the species in such a way as to exclude distant or unrelated stems from the polygon. A second routine was used when there were no clear discontinuities in distribution of the sensitive herbaceous species within the belt transect. In this latter case, a four-sided polygon was defined and marked for use in making visual cover estimates. Four-sided polygons were used at Indian Creek (P7) and Dollisons Landing (P8).

8.2 Methodology

In order to redefine polygons at each station, GPS field data files (Pathfinder Office 2.8, .ssf files) were obtained from CZR, Incorporated. From these files, data points were selected and converted to waypoint files (Pathfinder Office 2.8, .wpt files), which were transferred to a Trimble's Pro XRS TSC1 Asset Surveyor (Version 5.21) and used to assist in relocating polygons in the field. An elevation mask of 15 degrees and a position dilution of precision (PDOP) of six were configured on the rover. Use of beacon signals is necessary for the application of waypoints.

Successful use of GPS equipment in establishment of waypoints is dependent upon constant reception of information via beacon or commercial satellite signals for real-time differential GPS (DGPS) corrections. Without this flow of information, accurate application of waypoints is problematic. Presence of dense vegetation interferes strongly with reception of beacon signals. Vegetation (in this case, a thick, leafy canopy) at five of the seven sites promoted signal bounce and deflection (multipath) as well as variable signal strength.

Open habitats at Town Creek and Rat Island did not prove particularly difficult for application of waypoints. Re-establishment of polygons at these sites resulted in only minor variations. Re-establishment through use of waypoints at closed-canopy sites proved futile and resulted in crossing lines at angles with short sides and/or small angles and wide variations in point locations. Presence of last year's marked flagging tape assisted greatly at all sites, but was particularly useful at forested stations where only approximate locations were navigated to using waypoints. Waypoint positions were verified, where possible, by the presence of old tape (sometimes without visible numbers or retrieved from the surface of the mud).

All polygon points were re-marked using pink flagging tape. Changes in polygon configurations promoted by advance or recession of plants required stripping of old flagging and hanging of new. Location data for all polygons was retaken using GPS. Taking new GPS data required waiting at a point for conditions to favor reception of DGPS (differentially corrected GPS) beacon signals. New point data, like the original data, are subject to inaccuracies from multipath where thick canopy conditions prevail. Signals for GPS data were received from a DGPS beacon.

As with accumulation of baseline sensitive herbaceous species data, plant species present within each polygon were first listed. Individual species cover estimates were made visually and recorded. Total species cover could exceed or fall below 100 percent where more than one species of sensitive vegetation was found that occupied different strata. The substrate was generally visible where cover percentages were below 100 percent. Total cover estimates of 100 percent or greater would have obscured the surface of the soil.

The month of August is the optimum month for assessment of vegetation cover. Usually during the first of August, normal growth and development of the majority of herbaceous plant species in local riparian wetlands peaks. By the beginning of September, seasonal senescence has begun. During June and July, growth and development are still underway. Accumulation of baseline sensitive herbaceous species data, was completed during early August. Cover data were recorded between August 13 and 17, 2001. Additional GPS data, not seasonally sensitive, were taken September 21 and 23.

Copies of original GPS polygon point data taken in the field would have been preferred for accurate comparison with point files recorded during the current year. Only modified files were available. That is, only .ssf point files already converted to area files (polygons) were available (all points had been connected and some points had been deleted). Position data for the points in some of these files differ slightly from the data presented in the baseline report (CZR Incorporated 2001). It was not possible to determine which data set was correct. These modified files, though they are used in the present report, may differ from the original, unavailable field files.

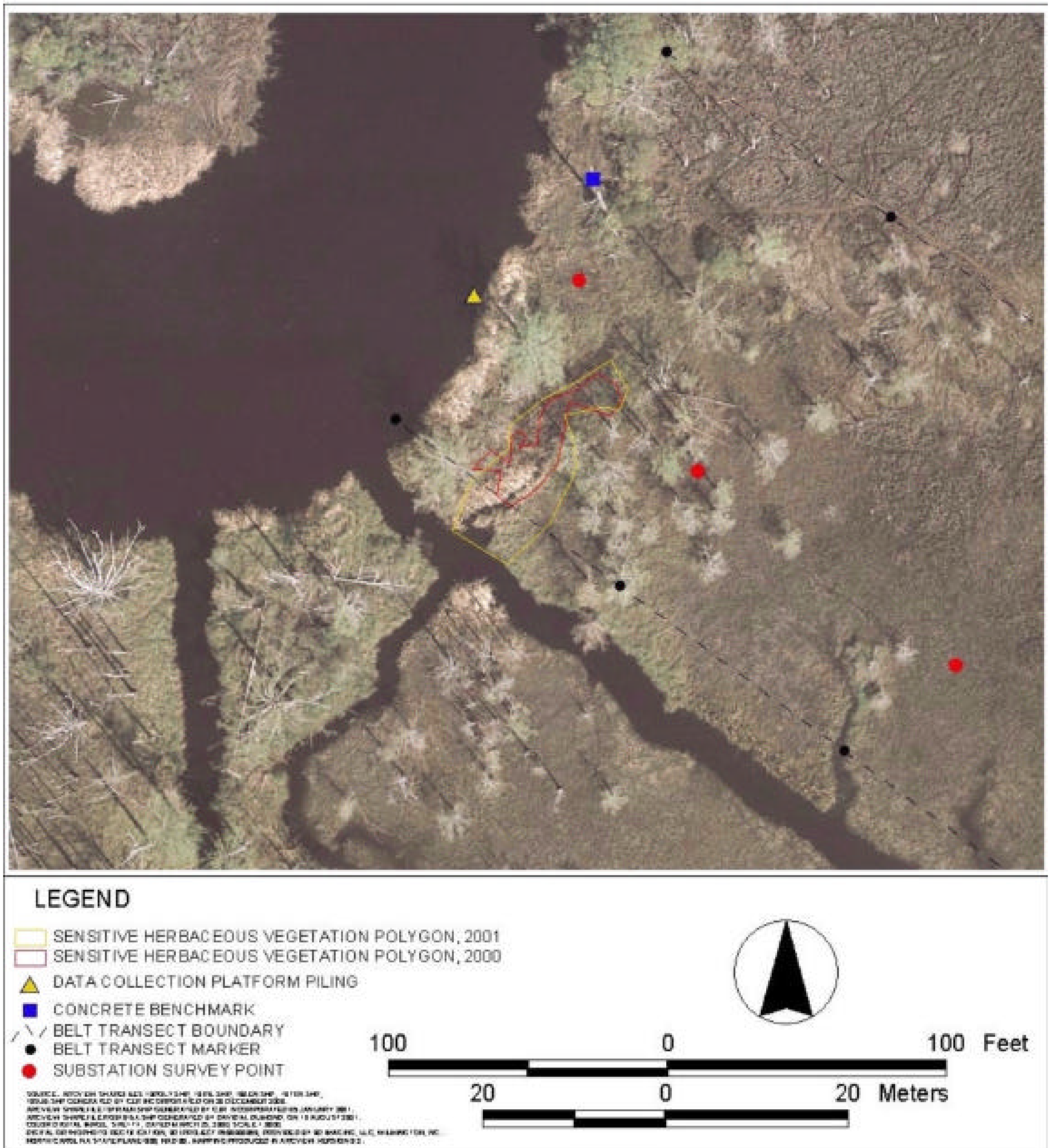
Common names and authorities for scientific names used in the text are listed in Appendix A. Metadata for GIS (Geographic Information System) and GPS files used in the preparation of the report are presented in Appendix B. Data for GPS positions of year 2001 polygons are presented in Appendix C. Similar data for year 2000 polygons have been presented in CZR Incorporated 2001, Appendix A.

8.3 Polygon Configuration and Sensitive Herbaceous Vegetation

Results of sensitive herbaceous vegetation data collection completed during initial baseline monitoring and similar data taken during the current year are presented below for each of the seven monitoring stations (Table 8.1-1). Field personnel and methodologies were consistent during both sample periods. Four potential variables were considered during collection of data: (1) presence/absence of sensitive herbaceous species, (2) abrupt shifts in dominance of sensitive herbaceous species (3) cover contributions of sensitive herbaceous species within delineated polygons, and (4) shape/size of polygon. Changes in these variables through time, when compared with chemical or physical monitoring, could signal shifting salinity/hydrology regimes.

8.31 Town Creek

Polygon size at Town Creek was enlarged from about 710 ft^2 (modified file obtained from CZR Incorporated) in year 2000 to about 1,772.5 ft^2 in year 2001 (polygon area determined from respective .ssf files using Trimble Pathfinder Office Version 2.8). The area was enlarged to incorporate additional plants of the dominant, *Zizaniopsis miliacea*, which had spread into the previous southeastern polygon boundaries (Figure 8.31-1, Table 8.31-1). The old boundary of the polygon had been marked naturally by a tidal gut. The *Zizaneopsis miliacea* had nearly obscured the tidal gut by 2001 and the boundaries of the polygon were



DAVID M. DUMOND ECOLOGICAL SERVICES AND CONSULTING 225 CHEYENNE TRAIL WILMINGTON, NC 28409 PHONE (910)799-0363	COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2001 AND 2000 AT STATION P3 (TOWN CREEK), WILMINGTON HARBOR MONITORING PROJECT, TOWN CREEK, NORTH CAROLINA	
	WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA	
	FILE: TOWNCR2.APR	APPROVED BY:	#CFRM-1
	DRAWN BY: DMD	DATE: 16 NOVEMBER 2001	FIGURE 8.31-1

Table 8.31-1. Comparison of percent cover contributions by sensitive herbaceous species in polygons from years 2000 and 2001 at the Town Creek Station (P3), Wilmington Harbor monitoring project, Town Creek, North Carolina.

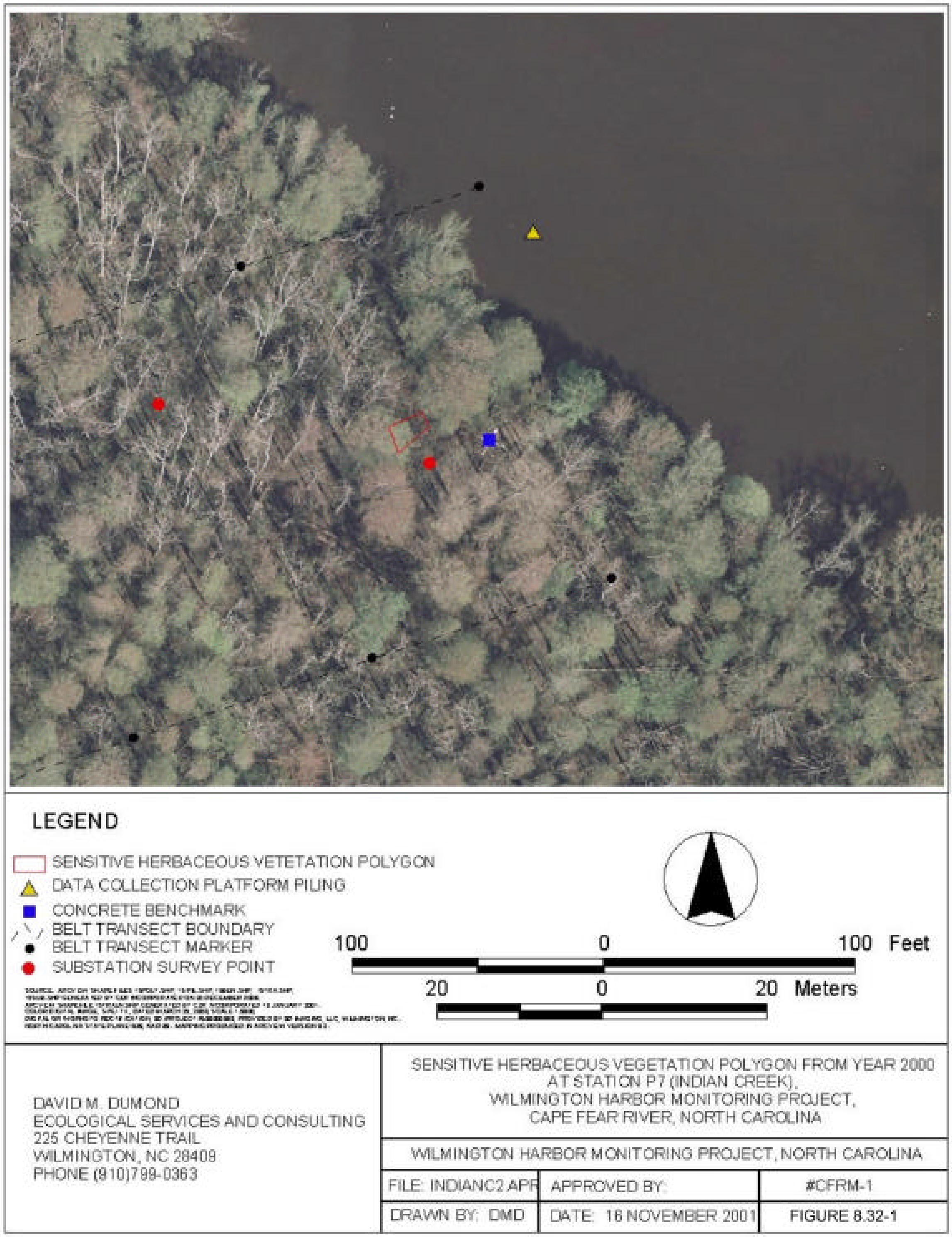
Sensitive Herbaceous Species	Percent Cover Year 2000	Percent Cover Year 2001
Zizaniopsis miliacea	70	60
Sagittaria lancifolia	5	20
Peltandra virginica	3	<1
Carex hyalinolepis	1	10
Typha latifolia	--	10

consequently enlarged. As a result, an additional plant species was included (*Typha latifolia*) and relative cover contributions of a previously sampled species (*Carex hyalinolepis*) increased somewhat as the new boundary shifted southeast. Increased abundance of *Sagittaria lancifolia* is notable and may represent rhizome extension of this brackish marsh species into substrate disturbed by pedestrian traffic as well as response to salinity events and increased area.

The original polygon established in the field in 2000, extended southwest beyond the limits of the belt transect to the old rice ditch (Figure 8.31-1), but was truncated in the report and limited only to the area inside the belt transect. An arbitrary decision was made during report preparation to terminate the polygon at the transect boundary. Sensitive herbaceous species cover estimates reported earlier (CZR Incorporated 2001) were based on the configuration of the original polygon, but results reported here use the adjusted configuration.

8.32 Indian Creek

The Indian Creek polygon is a simple four-sided figure marked by flagged trees located at each corner (Figure 8.32-1). It was not necessary to use waypoints for more than confirmation of the location of the flagged trees. Notable changes in cover by sensitive herbaceous species from last year are (1) an increase in *Polygonum arifolium;* (2) presence of two new species, *Carex* sp. *and Phanopyrum gymnocarpum;* and (3) loss of four species, *Carex crinita*, *Symphyotrichum elliottii*, *Lycopus virginicus*, and *Galium*; and a slight decrease in cover of *Cicuta maculata* (Table 8.32-1). *Carex* sp. is very likely sterile material of *Carex crinita* identified this year. *Symphyotrichum elliottii* and *Lycopus virginicus* are normally found above the regularly flooded substrate in swamp forests supported on stumps knees or logs. Their position in the substrate may simply have led to their failure to reappear this year. *Galium* is often small and easily missed. The change in *Cicuta maculata* cover is probably not significant at this point. *Phanopyrum gymnocarpum* was likely present last year, but not visible. It is strongly rhizomatous and may occur outside the plot.


LEGEND
SENSITIVE HERBACEOUS VETETATION POLYGON
DATA COLLECTION PLATFORM PILING
CONCRETE BENCHMARK
BELT TRANSECT BOUNDARY
BELT TRANSECT MARKER
SUBSTATION SURVEY POINT
100 0 100 Feet
20 0 20 Meters
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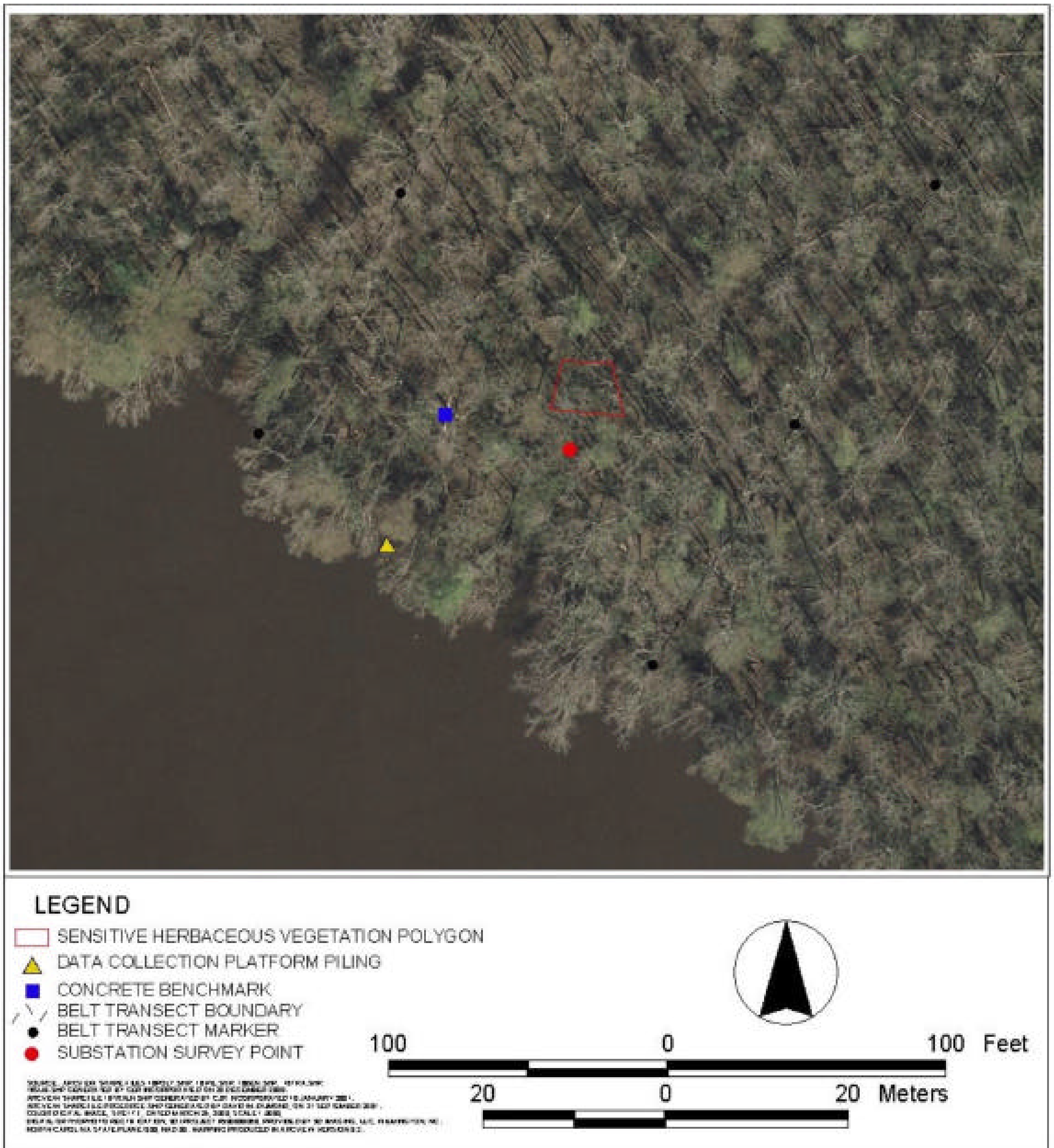
PHONE (910)799-0363
SENSITIVE HERBACEOUS VEGETATION POLYGON FROM YEAR 2000
AT STATION P7 (INDIAN CREEK),
WILMINGTON HARBOR MONITORING PROJECT,
CAPE FEAR RIVER, NORTH CAROLINA
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
FILE: INDIANC2.APR
APPROVED BY:
#CFRM-1
DRAWN BY: DMD
DATE: 16 NOVEMBER 2001
FIGURE 8.32-1

Table 8.32-1. Comparison of percent cover contributions by sensitive herbaceous species in a polygon from years 2000 and 2001 at the Indian Creek Station (P7), Wilmington Harbor monitoring project, Cape Fear River, North Carolina.

Sensitive Herbaceous Species	Percent Cover Year 2000	Percent Cover Year 2001
Saururus cernuus	2	1
Polygonum arifolium	3	10
Cicuta maculata	5	2
Polygonum punctatum	<1	<1
Commelina virginica	<1	2
Carex crinita	<1	--
Carex hyalinolepis	<1	2
Symphyotrichum elliottii	<1	--
Triadenum walteri	<1	<1
Lycopus virginicus	<1	--
Galium sp.	<1	--
Carex sp. (possibly *C. crinita*)	--	<1
Phanopyrum gymnocarpum	--	<1
Boehmeria cylindrical	--	1

8.33 Dollisons Landing

As at Indian Creek, the polygon at Dollisons Landing is a rectangular figure marked by flagged trees at each corner, and easy to verify using GPS waypoints (Figure 8.33-1). Changes since last year include: (1) decrease in cover by *Saururus cernuus* and a great increase in cover by *Polygonum arifolium;* (2) loss of five species, *Boehmeria cylindrica*, *Rumex verticillatus*, *Cicuta maculata*, *Carex* sp., *Dulichium arundinaceum*, and *Triadenum walteri*; and (3) gain of two species, *Eryngium aquaticum* and *Pontederia cordata* (Table 8.33-1). Though doubtfully significant, these changes could be interpreted as a slight trend toward brackishness. Species losses combined with decreased importance of *Saururus cernuus* could be the result of introduced or changing conditions favoring *Polygonum arifolium* (and possibly *Eryngium aquaticum*). *Impatiens capensis*, an annual and hence not strictly a sensitive herbaceous species, was removed from the 2000 list.



DAVID M. DUMOND ECOLOGICAL SERVICES AND CONSULTING 225 CHEYENNE TRAIL WILMINGTON, NC 28409 PHONE (910)799-0363	SENSITIVE HERBACEOUS VEGETATION POLYGON FROM YEAR 2000 AT STATION P8 (DOLLISON LANDING), WILMINGTON HARBOR MONITORING PROJECT, CAPE FEAR RIVER, NORTH CAROLINA		
	WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA		
	FILE: DOLLIS2.APR	APPROVED BY:	#CFRM-1
	DRAWN BY: DMD	DATE: 16 NOVEMBER 2001	FIGURE 8.33-1

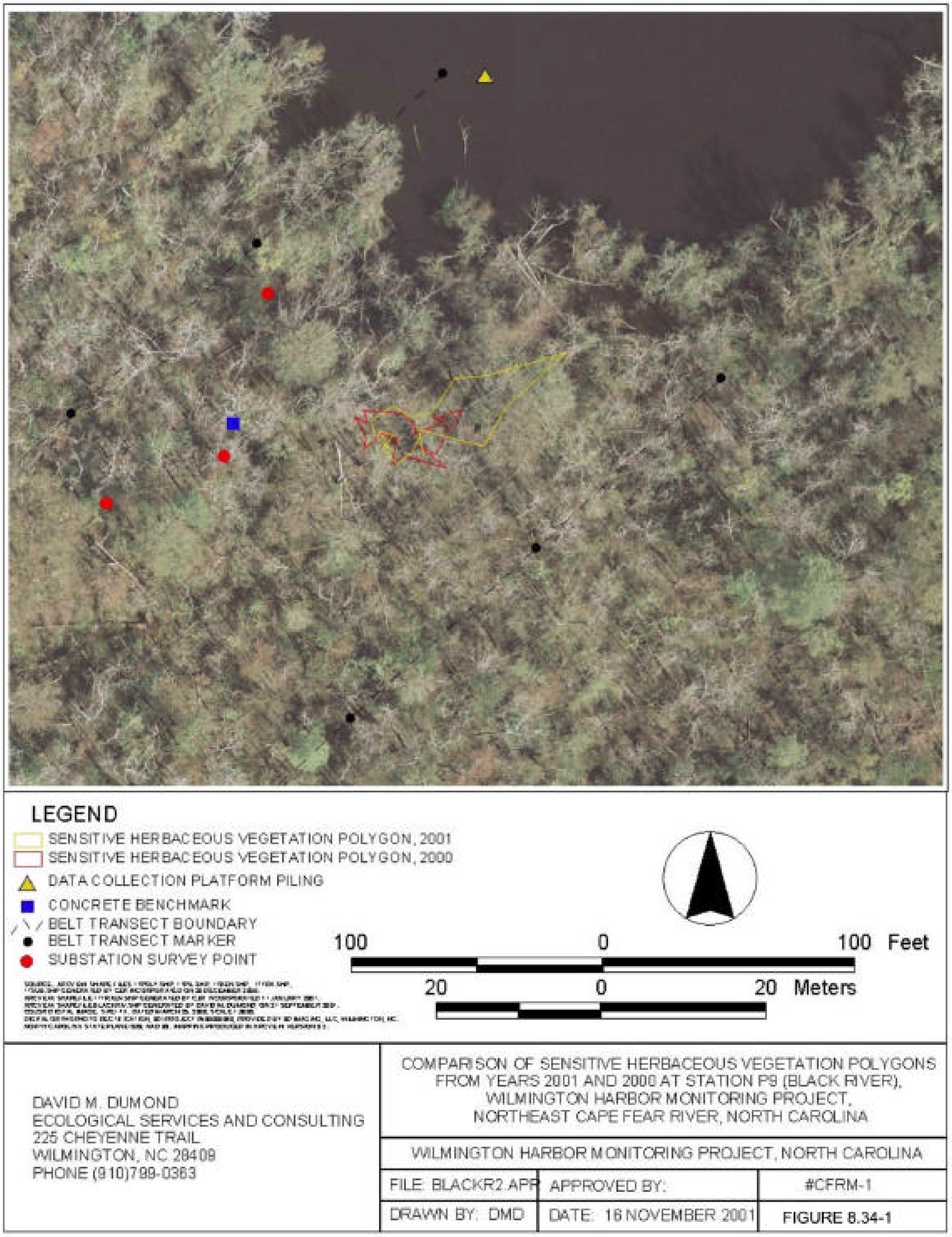
Table 8.33-1. Comparison of percent cover contributions by sensitive herbaceous species in a polygon from years 2000 and 2001 at the Dollisons Landing Station (P3), Wilmington Harbor monitoring project, Cape Fear River, North Carolina.

Sensitive Herbaceous Species	Percent Cover Year 2000	Percent Cover Year 2001
Saururus cernuus	30	20
Polygonum arifolium	10	25
Boehmeria cylindrica	<1	--
Rumex verticillatus	<1	--
Cicuta maculata	2	--
Carex sp.	1	--
Polygonum punctatum	1	1
Peltandra virginica	2	1
Carex crinita	<1	2
Dulichium arundinaceum	<1	--
Triadenum walteri	<1	--
Eryngium aquaticum	--	3
Pontederia cordata	--	<1

8.34 Black River

Polygon points flagged in 2000 at Black River Station were difficult to determine by 2001. Additionally, it was discovered that *Ludwigia palustris*, the primary species, had diminished in some areas and increased in others outside the old boundary. The boundaries of the polygon were expanded to include the new material (Figure 8.34-1). Some of the new boundary lines cross as a result of multipath effects. Most of the change in polygon size occurred following an expansion to the northeast. The area of the polygon changed from 431ft^2 to 1120 ft^2. As a result, *Ludwigia palustris* is now less dense and several additional species have been included (Table 8.34-1). *Polygonum punctatum* is present now in the old polygon as well as in the new one. *Polygonum arifolium* may increase by 2002 without river flooding. *Symphyotrichum elliottii* is not a characteristic part of the basal substrate flora.

Ludwigia palustris is a pioneer on saturated mineral silt/clay substrates in draw-down habitats. Tidal fresh water ebbing exposes such substrates at the Black River Station favoring spread of the species. Such conditions may develop during quiescent periods between significant river flood events. Floods affect erosion of old surfaces and deposition of new ones, which can, at the same time, disfavor and favor the species. Pedestrian traffic in these habitats may aid vegetative dispersal of the plants through fragmentation followed by dispersal.


LEGEND
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2001
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2000
DATA COLLECTION PLATFORM PILING
CONCRETE BENCHMARK
BELT TRANSECT BOUNDARY
BELT TRANSECT MARKER
SUBSTATION SURVEY POINT
100 0 100 Feet
20 0 20 Meters
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS
FROM YEARS 2001 AND 2000 AT STATION P9 (BLACK RIVER),
WILMINGTON HARBOR MONITORING PROJECT,
NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
FILE: BLACKR2.APR
APPROVED BY:
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DRAWN BY: DMD
DATE: 16 NOVEMBER 2001
FIGURE 8.34-1

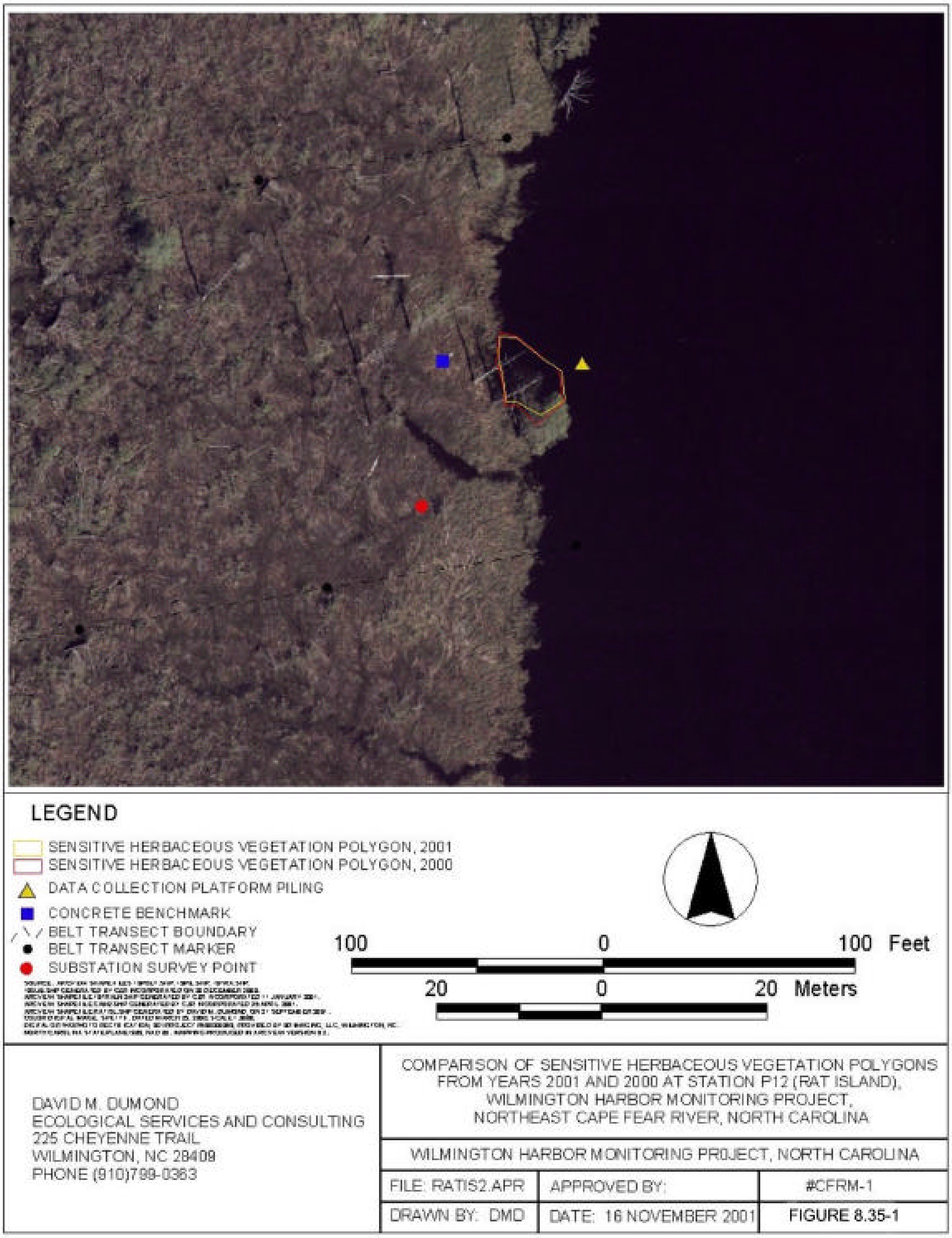
Table 8.34-1. Comparison of percent cover contributions by sensitive herbaceous species in polygons from years 2000 and 2001 at the Black River Station (P9), Wilmington Harbor monitoring project, Cape Fear River, North Carolina.

Sensitive Herbaceous Species	Percent Cover Year 2000	Percent Cover Year 2001
Ludwigia palustris	50	20
Polygonum punctatum	--	15
Polygonum arifolium	--	1
Symphyotrichum elliottii	--	2

8.35 Rat Island

The shape and size of the sensitive herbaceous polygon at Rat Island changed little as a result of reconstruction using GPS waypoints (Figure 8.35-1). In the absence of trees, beacon signals were largely unaffected by multipath scatter. However, vegetation at the Rat Island Station has apparently undergone a change since last year (Table 8.35-1). Diversity has increased from 9 to 12 species with some significant losses and gains. The most significant loss is *Schoenoplectus pungens*, which this year has become much thinner. *Spartina cynosuroides*, while not considered a sensitive herbaceous species because of its tendency to occupy relatively saline habitats, was present last year, but has become more abundant this year. *Carex hyalinolepis* also decreased considerably in cover, with an accompanying increase in *Sagittaria lancifolia.*

Appearance of the last two species in the 2001 list (Table 8.35-1) may be an artifact of the decrease in density of *Schoenoplectus pungens* and *Carex hyalinolepis*. *Hymenocallis floridana* and *Rumex verticillatus* may have been obscured during sampling in 2000. They characteristically bloom in spring. For the rest of their growing season they are relatively obscure, being limited to vegetative leaves that are easily hidden below strata dominated by other species.


LEGEND
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2001
SENSITIVE HERBACEOUS VEGETATION POLYGON, 2000
DATA COLLECTION PLATFORM PILING
CONCRETE BENCHMARK
BELT TRANSECT BOUNDARY
BELT TRANSECT MARKER
SUBSTATION SURVEY POINT
100
0
100 Feet
20
0
20 Meters
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COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2001 AND 2000 AT STATION P12 (RAT ISLAND), WILMINGTON HARBOR MONITORING PROJECT, NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA
WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
FILE: RATIS2.APR
APPROVED BY:
#CFRM-1
DRAWN BY: DMD
DATE: 16 NOVEMBER 2001
FIGURE 8.35-1

Table 8.35-1. Comparison of percent cover contributions by sensitive herbaceous species in polygons from years 2000 and 2001 at the Rat Island Station (P12), Wilmington Harbor monitoring project, Town Creek, North Carolina.

Sensitive Herbaceous Species	Percent Cover	
	Year 2000	Year 2001
Schoenoplectus pungens	100	20
Carex hyalinolepis	20	8
Sagittaria lancifolia	10	30
Alternanthera philoxeroides	<1	--
Polygonum arifolium	<1	--
Ludwigia grandiflora	<1	--
Polygonum punctatum	<1	1
Boltonia asteroids	<1	<1
Symphyotrichum subulatum	<1	<1
Peltandra virginica	--	1
Rumex verticillatus	--	1
Hymenocallis floridana	--	<1

Pluchea odorata, not considered a sensitive herbaceous species because of its annual habit, was a notable addition in 2001, possibly due to a salinity change as well as increased open substrate and light. It is a pioneer in such situations. *Amaranthus cannabinus*, also an annual pioneer on open muddy shores, probably was not present last year. It is also characteristic of open edges and muddy banks. Monitoring of such species would be useful in the interpretation of changes in the marsh.

Sensitive herbaceous species sample differences at Rat Island from 2000 to 2001 may have been influenced by one or more recent salinity events since the 2000 sampling. Salinity events occur when hydrologic conditions allow incursions of ocean-derived salinity (that exceed the mean salinity) during tidal flooding. Such events may be promoted during seasonal periods of fresh water low-flow, or during tidal extremes. The effects of salinity events are generally more pronounced where tidal flooding by fresh water is interspersed with occasional tidal flooding by brackish water. Presence of *Symphyotrichum subulatum* is indicative of recurrent salinity events, and probably should not be considered a sensitive herbaceous species. It is a regular member of brackish marshes and dredged material flats lower in the estuary.

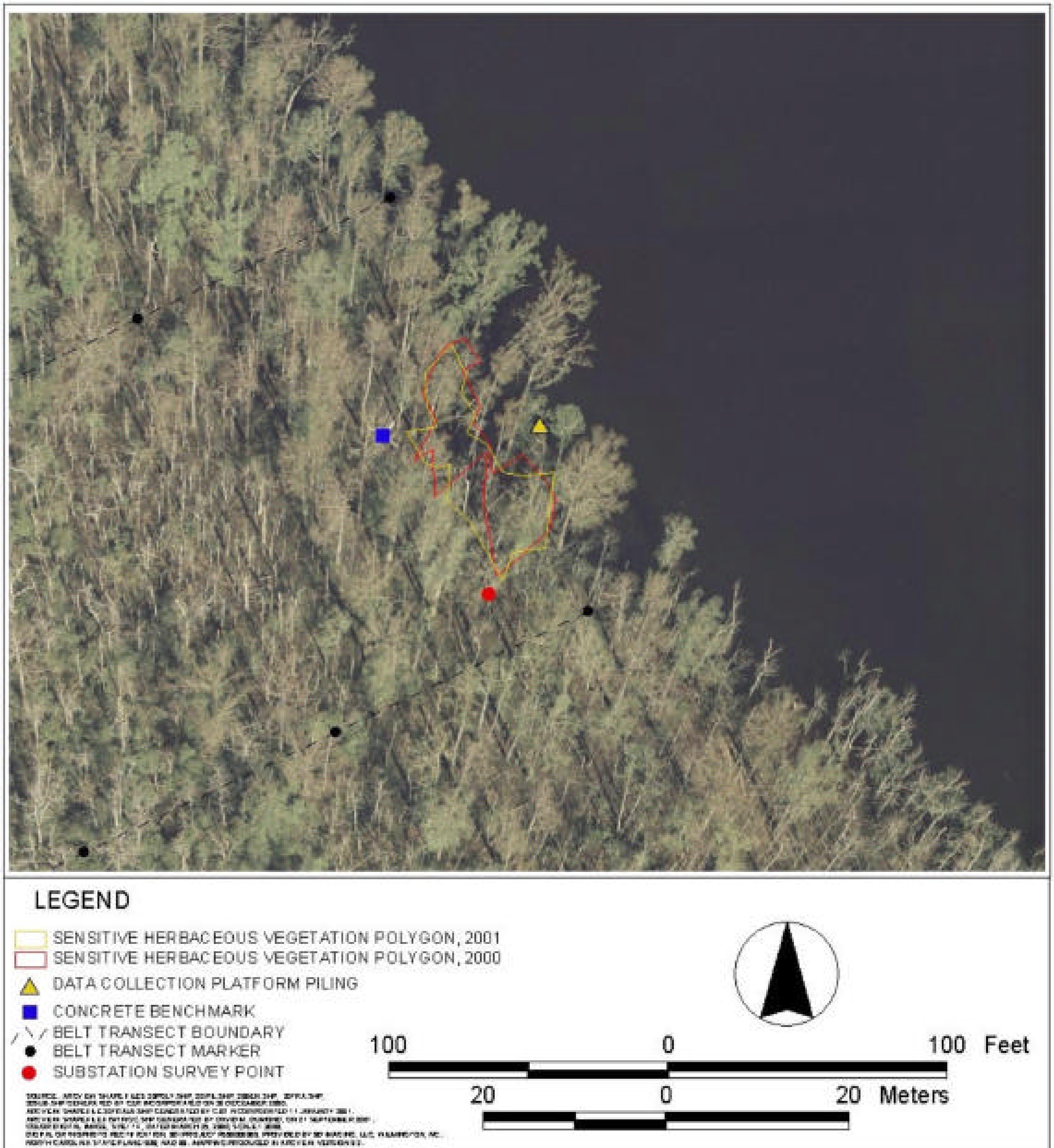
Rosa palustris, a woody species inadvertently included in the list of sensitive herbaceous species for this site in the previous report (CZR Incorporated 2001) is omitted here.

8.36 Fishing Creek

Waypoints and poorly preserved old flagging were used in an attempt to re-establish the sensitive herbaceous species polygon at Fishing Creek (Figure 8.36-1). Changes in extent of the primary sensitive herbaceous species, *Pontederia cordata*, resulted in partial polygon reconfiguration. The effects of multipath have caused additional changes. Configuration changes have resulted in inclusion of six additional species this year (Table 8.36-1). An additional notable difference is the increase in cover by *Pontederia cordata* from 20 to 40%, possibly an artifact of new growth combined with substrate disturbance. The increase in cover by *Sagittaria lancifolia* from 2 to 20% may be a result of polygon reconfiguration and/or pedestrian disturbance, or possibly salinity events. Since the 2000 sampling, a mat

Table 8.36-1. Comparison of percent cover contributions by sensitive herbaceous species in polygons from years 2000 and 2001 at the Fishing Creek Station (P13), Wilmington Harbor monitoring project, Town Creek, North Carolina.

Sensitive Herbaceous Species	Percent Cover Year 2000	Percent Cover Year 2001
Pontederia cordata	20	40
Aster sp.	<1	--
Polygonum punctatum	2	1
Sium suave	<1	2
Polygonum arifolium	1	3
Zizaneopsis miliacea	2	<1
Saururus cernuus	2	2
Cicuta maculata	<1	2
Sagittaria lancifolia	2	20
Orontium aquaticum	<1	--
Peltandra virginica	<1	1
Rhynchospora corniculata	<1	<1
Carex sp.	<1	--
Alternanthera philoxeroides	--	5
Zizania aquatica	--	2
Boltonia asteroides	--	1
Rumex verticillatus	--	<1
Cinna arundinacea	--	<1
Eryngium aquaticum	--	<1



DAVID M. DUMOND ECOLOGICAL SERVICES AND CONSULTING 225 CHEYENNE TRAIL WILMINGTON, NC 28409 PHONE (910)799-0363	COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2001 AND 2000 AT STATION P13 (FISHING CREEK), WILMINGTON HARBOR MONITORING PROJECT, NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA		
	WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA		
	FILE: FISHCR2.APR	APPROVED BY:	#CFRM-1
	DRAWN BY: DMD	DATE: 16 NOVEMBER 2001	FIGURE 8.36-1

of *Alternanthera philoxeroides* has developed along the northeastern edge of the polygon. Mats of this species break up in fall and disperse with the ebb and flood of tide. Mat fragments regularly become trapped along river margins and grow during the following summer.

There are few indications that events other than polygon reconfiguration and substrate disturbance are responsible for the apparent changes at Fishing Creek. Changes in *Sium suave*, *Polygonum arifolium*, *Sagittaria lancifolia* and *Orontium aquaticum* may partially reflect the effects of a salinity event.

Use of the name *Rhynchospora inundata* in year 2000 tables should be corrected to *Rhynchospora corniculata*.

8.37 Prince George Creek

Reconfiguration of the 2000 polygon at the Prince George Creek Station was very minor, and was accomplished using a combination of GPS waypoints and old flagging. In most cases the old flags were found in their original positions. Three points along the southwest side were modified due to spread of *Saururus cernuus* beyond the original boundary. A single point along the belt transect boundary was added back to the northeastern-most corner, having been omitted from the reported 2000 version. The majority of the variations apparent in the 2001 version are the results of GPS multipath effects (Figure 8.37-1). For instance, GPS Point 1, located at the northwestern-most corner of each configuration is on the belt transect line in the field. This point has remained fixed since the original point was flagged. These congruent points are roughly five meters apart in the two polygon versions shown. It appears that point variations of this magnitude or greater are commonplace between the two projections of this polygon.

Cover changes in sensitive herbaceous vegetation appear in the data in two ways: (1) there is a significant increase in the cover of *Saururus cernuus* from year 2000 to year 2001 and (2) seven species are new to the polygon in 2001 (Table 8.37-1). Stem and rhizome material of *Saururus cernuus* can be fragmented by occasional pedestrian traffic through the soft substrate. Rhizome fragmentation will effectively increase the number of propagules from which stems can arise the following year. Additionally, disturbance of the soil may promote invasion by other species.

There is no indication of a recent salinity event at the Prince George Creek Station.

LEGEND

- SENSITIVE HERBACEOUS VEGETATION POLYGON, 2001
- SENSITIVE HERBACEOUS VEGETATION POLYGON, 2000
- DATA COLLECTION PLATFORM PILING
- CONCRETE BENCHMARK
- BELT TRANSECT BOUNDARY
- BELT TRANSECT MARKER
- SUBSTATION SURVEY POINT

100 0 100 Feet

20 0 20 Meters

DAVID M. DUMOND ECOLOGICAL SERVICES AND CONSULTING 225 CHEYENNE TRAIL WILMINGTON, NC 28409 PHONE (910)799-0363	COMPARISON OF SENSITIVE HERBACEOUS VEGETATION POLYGONS FROM YEARS 2001 AND 2000 AT STATION P14 (PRINCE GEORGE CREEK), WILMINGTON HARBOR MONITORING PROJECT, NORTHEAST CAPE FEAR RIVER, NORTH CAROLINA
	WILMINGTON HARBOR MONITORING PROJECT, NORTH CAROLINA
	FILE: PRGEO2.APR · APPROVED BY: · #CFRM-1
	DRAWN BY: DMD · DATE: 16 NOVEMBER 2001 · FIGURE 8.37-1

Table 8.37-1. Comparison of percent cover contributions by sensitive herbaceous species in polygons from years 2000 and 2001 at the Prince George Creek Station (P14), Wilmington Harbor monitoring project, Town Creek, North Carolina.

Sensitive Herbaceous Species	Percent Cover Year 2000	Percent Cover Year 2001
Saururus cernuus	35	60
Polygonum hydropiper	20	15
Peltandra virginica	10	8
Pontederia cordata	--	5
Polygonum arifolium	--	5
Cicuta maculata	--	<1
Zizania aquatica	--	<1
Cinna arundinacea	--	<1
Boehmeria cylindrica	--	<1
Carex lupulina	--	<1

8.4 Hydrologic Events and Vegetation Change

Recent salinity events have occurred at Town Creek, Rat Island, and Fishing Creek. Maximum salinity data indicate that during fall 2000, events with maximum concentrations of 13.3, 5.7 and 5.1 ppt, respectively, occurred at substations closest to streams (substations 1) at each of these three sites after October 1 (Table 4.5-1). A maximum at Fishing Creek was not recorded until the middle of November. All these maximum readings were recorded at substations close to polygons at the sites. The Inner Town Creek Station (P3) appeared, as well, to experience salinity events during spring and summer but with maximum salinities generally below 10 ppt for the summer and less than or equal to 5 ppt for the spring (Tables 4.2-5 and 4.2-7). The number of flooding events carrying these salinities follows the same trend with a spring low (0), a summer mid-range (13) and a fall high (25).

Summer salinity events were recorded at Rat Island and Fishing Creek for the year 2000. Events with salinities of 6 to 9 ppt occurred at Rat Island substation 1 near the river in 2000. Salinity events occurred at a similar substation at Fishing Creek during the same period with concentrations of 1 to 5 ppt. Flooding events carrying these concentrations occurred as many as 25 times at Rat Island and only seven times at Fishing Creek (Table 4.2-5).

Town Creek experiences salinity events at greater rates and concentrations than either Rat Island or Fishing Creek. Rat Island is more likely to experience salinity events than is Fishing Creek and those events will carry somewhat greater salt concentrations. No other monitoring stations with sensitive herbaceous vegetation polygons experienced salinity incursions during 2000-2001. Vegetation changes at Town Creek and Fishing Creek do not strongly support these data. Vegetation changes at Rat Island seem to corroborate salinity event data.

Data recorded for depth, duration, and frequency of flooding at substations close to sensitive herbaceous polygons show no particular trends relative to vegetation, except that there is a possibility species diversity may be inversely related to flooding time at sites with recorded salinity events (Tables 4.2-1 through 4.2-4). Such a trend cannot be fully supported by the current data since complete species information is lacking.

8.5 GPS Data Variations

Point locations using GPS data, particularly at forested sensitive herbaceous polygons, are highly variable due to the effects of multipath deflections. Use of commercial satellite services (Omnistar, Landstar) to replace DGPS beacon use has been considered. In heavy canopy situations, these services are opined to be inferior to a DGPS beacon due to weak signals. Use of GPS tracking of variations in sensitive herbaceous distributions at forested sites will continue to generate polygon configurations more directly related to the effects of multipath rather than those of environmental parameters variations currently observed. Variations in shapes and sizes of polygons in forested habitats cannot be used as a dependable guide to the effects of salinity events on vegetation distributions, at least in the fine scale observed so far.

Copies of unmodified GPS data from year 2000 are not available for comparison with data from 2001. Combined with slight variations between text data and polygon point data of available configurations for 2000, it cannot be determined which, if any GPS data for that year are correct.

8.6 Ecological Sampling Strategy

It is apparent from salinity data, from qualitative assessment of vegetation changes, and from the inconsistent results of GPS data in forested situations that current sampling methods are failing to document vegetation change. Potential changes cannot be fully interpreted nor adequately monitored using selective lists of species. All species should be considered during the sampling process. Loss of species from an area is only one indication of change of potential concern in the monitoring process. Vegetation change, though slow and possibly not unidirectional, can best be monitored by establishment of permanent sampling areas at several locations across and along expected key gradients.

Sample plots to monitor herbaceous vegetation (including all herbaceous species) at each belt transect should be established randomly, marked and mapped using GPS technology. Since the plots would be visited only once each year, relocating each of them could become difficult. Plots should be kept to a minimum size thereby allowing access without intrusion into the plot. Current polygons must be traversed in the course of sampling, making pedestrian disturbance an unmanageable factor in assessment of change.

In addition, it would be valuable to annually establish the lower river/stream extents of one or more species of aquatic bryophytes (two species should be considered). This could be accomplished through the use of GPS at low water along both sides of the stream so that two shifting isohaline lines relative to bryophyte survival could be drawn annually across each stream (Town Creek, Cape Fear River, and Northeast Cape Fear River). One species of *Fontinalis* and one of *Fissidens* are appropriate and easily recognized in the field. A species of *Fontinalis* is currently being evaluated for salt sensitivity in an unrelated study and may be available in the near future.

8.7 Conclusions and Recommendations

The use of GPS technology to assess polygon shape and size through time is an unsatisfactory method for measure of potential vegetation change. The effects of multipath combined with insufficient sensitivity to track subtle changes, particularly within forested habitats is a serious impediment to use of this method. Sensitive herbaceous species do not allow sufficient plant diversity for monitoring potential biotic changes within sampling areas. Loss of species is only one potential indication of change due to variations in hydrology and salinity. All herbaceous species should be considered within randomly distributed, permanently marked sample plots throughout the belt transects, or at least near the sources of tidal water. Locations of these plots should be mapped along with other natural features (berms, dikes, ditches, channels, etc.) that can be used to interpret the movement of water into and out of the monitored areas. The size of the plots should be small so as to allow access without disturbance. Plots should not be placed in or near regularly traversed pedestrian routes.

A very simple use of aquatic bryophytes as monitors of potential salinity change should be considered. The lowest occurrences of *Fontinalis* and *Fissidens*, each with one representative species, should be marked on both shores of each waterway. Such occurrences are near Rat Island, Town Creek, and Indian Creek stations. The creation of two species-specific isohaline lines with four variable, salinity-sensitive points would be created and could be assessed annually, if not more frequently, using GPS.

9.0 LITERATURE CITED

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APPENDIX A:

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

List of Vascular Plant Species

A list of vascular plant species used in text and tables with accompanying authorities and common names follows. Both common and scientific names follow Kartesz and Meachum 1999.

Alternanthera philoxeroides (Mart.) Griseb. Alligator-Weed
Amaranthus cannabinus (L.) Sauer Tidal-Marsh Amaranth
Boehmeria cylindrica (L.) Sw. Small-Spike False Nettle
Boltonia asteroides (L.) L'Hér. White Doll's-Daisy
Carex crinita Lam. Fringed Sedge
Carex hyalinolepis Steud. Shoreline Sedge
Carex L. Sedge *Carex lupulina* Muhl. Ex Willd. Hop Sedge
Cicuta maculata L. Spotted Water-Hemlock
Cinna arundinacea L. Sweet Wood-Reed
Commelina virginica L. Virginia Dayflower
Dulichium arundinaceum (L.) Britt. Three-Way Sedge
Eryngium aquaticum L. Rattlesnake-Master
Galium L. Bedstraw
Hymenocallis floridana (Raf.) Morton Florida Spider-Lily
Impatiens capensis Meerb. Spotted Touch-Me-Not
Ludwigia grandiflora (M. Micheli) Greuter & Burdet Large-Flower Primrose-Willow
Ludwigia palustris (L.) Ell. Marsh Primrose-Willow
Lycopus virginicus L. Virginia Water-Horehound
Orontium aquaticum L. Goldenclub
Peltandra virginica (L.) Schott Green Arrow-Arum
Phanopyrum gymnocarpon (Ell.) Nash Savannah-Panic Grass
Pluchea odorata (L.) Cass. Sweetscent
Polygonum arifolium L. Halberd-Leaf Tearthumb
Polygonum hydropiper *L. Mild Water-Pepper*
Polygonum punctatum Ell. Dotted Smartweed
Pontederia cordata L. Pickerelweed
Rhynchospora corniculata (Lam.) Gray Short-Bristle Horned Beak Sedge
Rhynchospora inundata (Oakes) Fern. Narrow-Fruit Horned Beak Sedge
Rosa palustris Marsh. Swamp Rose
Rumex verticillatus L. Swamp Dock
Sagittaria lancifolia L. Bull-Tongue Arrowhead
Saururus cernuus L. Lizard's-Tail
Schoenoplectus pungens (Vahl) Palla Three-Square
Sium suave Walt. Hemlock Water-Parsnip
Spartina cynosuroides (L.) Roth Big Cord Grass
Symphyotrichum elliotii (Torr. & Gray) Nesom Marsh American-Aster
Symphyotrichum subulatum (Michx.) Nesom Seaside American-Aster
Triadenum walteri (J.G. Gmel.) Gleason Greater Marsh-St. John's-Wort
Typha latifolia L. Broad-Leaf Cat-Tail
Zizania aquatica L. Indian Wild Rice
Zizaniopsis miliacea (Michx.) Doell & Aschers. Marsh-Millet

Literature Cited

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

APPENDIX B:

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

METADATA

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

FIGURE 1

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

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

FILE NAMES:	**13pil.shp 13pil.dbf 13pil.shx**
DESCRIPTION OF LAYER:	Point depicting data collect platform piling
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Point
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
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POSITIONS OF MONITORING STATION COMPONENTS AND SENSITIVE HERBACEOUS PLANT SPECIES POLYGONS WITHIN THE BELT TRANSECT AT MONITORING STATON P3, TOWN CREEK

FIGURE 1

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

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

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

METADATA

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

FIGURE 1

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

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

METADATA

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

FIGURE 1

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

FILE NAMES:	**13tra.shp 13tra.dbf 13tra.shx**
DESCRIPTION OF LAYER:	Points depicting belt transect markers
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Points
SOFTWARE:	Pathfinder Office 2.1 and Arcview version 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	20 December 2000
SOURCE:	CZR Incorporated
SOURCE CONTACT:	Samuel Cooper
SOURCE ADDRESS:	4709 College Acres, Suite 2 Wilmington, NC 28403
SOURCE PHONE:	910/392-9253
SOURCE FAX:	910/392-9139
FILE NAMES:	**R081315A.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2001
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8 and Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	13 August, 2001
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

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

FIGURE 2

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

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

METADATA

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

FIGURE 2

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

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

METADATA

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

FIGURE 2

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

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

METADATA

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

FIGURE 2

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

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

METADATA

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

FIGURE 3

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

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

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

METADATA

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

FIGURE 3

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

METADATA

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

FIGURE 3

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

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

METADATA

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

FIGURE 3

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

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

METADATA

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

FIGURE 4

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

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

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

METADATA

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

FIGURE 4

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

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

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

METADATA

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

FIGURE 4

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

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

METADATA

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

FIGURE 4

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

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

METADATA

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

FIGURE 5

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

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

METADATA

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

FIGURE 5

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

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

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

METADATA

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

FIGURE 5

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

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

METADATA

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

FIGURE 5

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

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

METADATA

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

FIGURE 6

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

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

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

METADATA

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

FIGURE 6

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

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

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

METADATA

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

FIGURE 6

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

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

METADATA

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

FIGURE 6

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

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

FILE NAMES:	**FISHINGC.shp, .dbf, .shx**
DESCRIPTION OF LAYER:	Polygon depicting sensitive herbaceous plants, 2001
SOURCE:	Trimble PRO XRS GPS Unit
DATA TYPE:	Polygon from points
SOFTWARE:	Pathfinder Office 2.8, Arcview 3.2
DATUM:	North American Datum (NAD) 1983
COORDINATE SYSTEM:	U.S. State Plane 1983
REGION:	North Carolina 3200
UNITS OF MEASURE:	Feet
DATA COLLECTION:	23 August, 2001
SOURCE:	David M. DuMond
SOURCE CONTACT:	David M. DuMond
SOURCE ADDRESS:	225 Cheyenne Trail Wilmington, NC 28409
SOURCE PHONE:	910/799-0363

METADATA

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

FIGURE 7

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

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

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

METADATA

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

FIGURE 7

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

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

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

METADATA

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

FIGURE 7

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

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

METADATA

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

FIGURE 7

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

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

APPENDIX C:

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

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

Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft^2)	Easting* (ft^2)
Town Creek/ P3	1772.49	TC-1	140219.051	2304171.805
		TC-2	140207.082	2304191.344
		TC-3	140221.659	2304206.404
		TC-4	140227.839	2304209.772
		TC-5	140237.031	2304214.119
		TC-6	140242.445	2304215.836
		TC-7	140249.946	2304215.409
		TC-8	140270.182	2304212.486
		TC-9	140266.858	2304204.850
		TC-10	140256.540	2304191.699
		TC-11	140248.723	2304191.674
		TC-12	140236.591	2304178.099
		TC-13 (TC2-7a)	140260.872	2304211.829
		TC-14 (TC2-7b)	140263.278	2304227.086
		TC-15 (TC2-7c)	140262.762	2304231.769
		TC-16 (TC2-7d)	140260.772	2304234.450
		TC-17 (TC2-7e)	140280.231	2304228.285
Black River/P9	1119.58	1	216657.779	2286244.325
		2	216651.492	2286251.095
		3	216658.827	2286246.468
		4	216657.269	2286251.898
		5	216651.754	2286247.472
		6	216650.042	2286249.262
		7	216645.799	2286253.674
		8	216649.888	2286259.088
		9	216657.317	2286262.581
		10	216648.954	2286263.880
		11	216659.557	2286262.102
		12	216656.757	2286273.002
		13	216653.079	2286288.044
		14	216668.689	2286296.701
		15	216690.333	2286320.841
		16	216681.126	2286288.855
		17	216679.751	2286276.252
		18	216666.266	2286267.250
		19	216665.348	2286262.663
		20	216664.587	2286259.601
		21	216669.094	2286251.539
		22	216662.925	2286243.089
Rat Island/P12	532.94	1	203317.736	2313777.913
		2	203308.772	2313777.549
		3	203300.868	2313779.229
		4	203291.969	2313780.256
		5	203191.671	2313784.565
		6	203286.449	2313794.021
		7	203292.794	2313803.441
		8	203303.896	2313802.231

		9	203309.117	2313784.687
Station Name/Numb er	Polygon Area (ft^2)	Point Number	Northing* (ft^2)	Easting* (ft^2)
		10	203317.219	2313784.437
Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft^2) NAD 83	Easting* (ft^2) NAD 83
Fishing Creek/P13	1646.10	1	215434.539	2303604.659
		2	215433.148	2303593.142
		3	215422.842	2303588.528
		4	215443.926	2303577.863
		5	215451.578	2303569.614
		6	215464.474	2303570.360
		7	215463.540	2303566.543
		8	215464.940	2303561.667
		9	215476.415	2303554.937
		10	215477.821	2303565.921
		11	215485.052	2303562.581
		12	215497.650	2303561.666
		13	215507.769	2303571.186
		14	215496.683	2303576.106
		15	215490.616	2303574.817
		17(16 missed)	215482.008	2303579.455
		18	215476.137	2303576.585
		19	215471.856	2303583.992
		20	215461.894	2303589.648
		21	215460.313	2303596.880
		22	215461.579	2303608.001
Prince George Creek./P14	3669.31	1	227256.418	2320219.063
		2	227254.446	2320221.629
		3	227255.706	2320220.961
		4	227258.228	2320225.326
		5	227264.379	2320234.730
		6	227242.143	2320230.564
		7	227234.911	2320234.787
		8	227222.362	2320230.472
		9	227219.785	2320237.000
		10	227214.661	2320252.072
		11	227224.243	2320251.647
		12	227232.224	2320251.944
		13	227230.942	2320242.688
		14	227221.085	2320259.271
		15	227220.999	2320256.085
		16	227218.673	2320265.466
		17	227225.300	2320272.352
		18	227219.657	2320270.658
		19	227210.593	2320266.917
		20	227217.691	2320270.768
		21	227220.796	2320277.818
		22	227221.646	2320287.355
		23	227210.243	2320285.915
		24	227203.635	2320289.840
		25	227214.513	2320300.367
		26	227220.349	2320291.940

		27	227221.394	2320297.383
Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft^2)	Easting* (ft^2)
		28	227225.410	2320292.784
		Blank	227237.424	2320297.455
		29	227237.487	2320297.765
		30	227235.813	2303283.380
Station Name/Number	Polygon Area (ft^2)	Point Number	Northing* (ft^2) NAD 83	Easting* (ft^2) NAD 83
		31	227233.304	2320286.955
		32	227243.738	2320286.983
		33	227247.470	2320288.567
		34	227280.347	2320298.250
		35	227256.899	2320280.853
		36	227260.654	2320288.981
		37	227262.018	2320286.084
		38	227267.985	2320285.138
		39	227276.378	2320277.400
		40	227285.637	2320269.304
		41	227304.780	2320284.690

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

APPENDIX D:

LIST OF TIDAL RANGES AT ELEVEN STATIONS IN THE CAPE FEAR RIVER, NORTHEAST CAPE FEAR RIVER AND TOWN CREEK COLLECTED FROM OCTOBER 1, 2000 THROUGH MAY 31, 2001

tide	P1	P2	P3	P4	P6	P7	P8	P9	P11	P13	P14
1	4.86	4.60	1.82	4.59	4.38	3.68	3.05	2.49	4.22	xxx	1.44
2	4.55	4.42	1.73	4.39	4.16	3.45	2.83	2.27	4.01	xxx	1.29
3	3.72	3.78	1.50	3.86	3.68	3.04	2.45	1.91	3.54	xxx	1.15
4	3.73	3.77	1.71	3.83	3.69	3.13	2.63	2.16	3.54	xxx	1.31
5	4.48	4.47	1.91	4.47	4.28	3.64	3.09	2.60	4.11	xxx	1.47
6	4.10	4.03	1.62	4.00	3.80	3.14	2.56	2.07	3.65	xxx	1.12
7	3.02	3.31	1.33	3.29	3.17	2.60	2.07	1.60	3.05	xxx	0.96
8	3.29	3.67	1.80	3.66	3.57	3.08	2.58	2.15	3.44	xxx	1.37
9	3.79	4.09	1.93	4.10	3.96	3.42	2.91	2.47	3.80	xxx	1.44
10	3.81	3.96	1.83	3.99	3.82	3.23	2.70	2.24	3.67	xxx	1.26
11	2.73	3.02	1.41	3.09	2.96	2.44	1.94	1.51	2.85	xxx	0.90
12	2.84	3.37	1.95	3.45	3.37	2.98	2.62	2.30	3.27	xxx	1.65
13	3.44	3.81	2.07	3.89	xxx	3.39	3.02	2.70	xxx	xxx	1.69
14	3.18	3.52	1.97	3.61	3.53	3.10	2.71	2.39	3.39	2.46	1.54
15	2.44	2.91	1.64	3.00	2.94	2.53	2.17	1.85	2.82	2.02	1.21
16	2.62	3.15	1.96	3.24	3.19	2.86	2.57	2.30	3.09	2.42	1.73
17	3.42	3.77	2.22	3.84	3.75	3.39	3.07	2.79	3.61	2.80	1.98
18	3.16	3.46	2.03	3.55	3.45	3.08	2.74	2.46	3.30	2.44	1.57
19	2.34	2.83	1.72	2.94	2.87	2.52	2.21	1.95	2.77	2.03	1.28
20	2.60	3.10	2.04	3.22	3.16	2.90	2.67	2.50	3.05	2.39	1.73
21	3.20	3.66	2.26	3.76	3.66	3.35	3.07	2.89	3.55	2.74	1.95
22	3.19	3.62	2.20	3.70	3.59	3.27	2.98	2.79	3.47	2.58	1.73
23	xxx	2.70	1.74	2.76	2.66	2.37	2.11	1.92	2.58	1.89	1.18
24	xxx	2.94	2.11	3.01	2.97	2.78	2.62	2.52	2.92	2.42	1.93
25	3.55	3.84	2.53	3.90	3.85	3.63	3.42	3.30	3.77	3.06	2.41
26	xxx	3.53	2.18	3.61	3.52	3.19	2.92	2.76	3.41	2.53	1.78
27	xxx	2.88	1.86	2.92	2.85	2.53	2.28	2.14	2.74	2.00	1.40
28	2.75	3.10	2.18	3.16	3.12	2.92	2.76	2.67	3.03	2.50	2.05
29	3.46	3.46	2.35	3.54	3.48	3.29	3.12	3.01	3.39	2.79	2.23
30	3.82	3.72	2.42	3.74	3.64	3.34	3.08	2.91	3.56	2.74	1.99
31	3.18	3.39	2.29	3.48	3.38	3.07	2.82	2.67	3.30	2.52	1.85
32	3.11	3.42	2.41	3.52	3.48	3.26	3.06	2.96	3.38	2.75	2.21
33	3.95	4.18	2.68	4.18	4.08	3.85	3.58	3.43	4.00	3.19	2.47
34	4.18	4.27	2.58	4.22	4.07	3.69	3.32	3.10	4.02	2.96	2.07
35	3.72	3.98	2.48	3.99	3.87	3.49	3.17	2.97	3.81	2.84	2.00
36	3.75	3.94	2.50	4.02	3.89	3.58	3.26	3.09	3.82	2.92	2.11
37	4.26	4.32	2.65	4.39	4.25	3.92	3.56	3.35	4.17	3.17	2.26
38	4.50	4.48	2.65	4.43	4.32	3.91	3.50	3.25	4.24	3.11	2.13
39	3.88	3.95	2.46	3.96	3.90	3.51	xxx	xxx	3.81	2.80	1.94
40	4.08	4.10	2.70	4.25	4.13	3.81	xxx	xxx	4.03	3.14	2.36
41	4.57	4.51	2.82	4.58	4.41	4.08	3.72	3.50	4.31	3.31	2.43
42	4.72	4.60	2.84	4.57	4.46	4.08	3.68	3.42	4.36	3.28	2.34
43	4.47	4.38	2.78	4.38	4.29	3.92	3.55	3.31	4.19	3.17	2.28
44	4.52	4.46	2.85	4.53	4.41	4.03	3.69	3.45	4.30	3.31	2.42
45	4.74	4.60	2.88	4.69	4.55	4.14	3.77	3.51	4.44	3.37	2.43
46	4.80	4.67	2.92	4.66	4.56	4.15	3.76	3.50	4.44	3.38	2.45
47	4.83	4.75	2.96	4.64	4.56	4.17	3.79	3.53	4.44	3.41	2.49
48	xxx	4.67	2.88	4.62	4.48	4.07	3.69	3.43	4.36	3.30	2.36
49	4.77	4.66	2.86	4.67	4.51	4.08	3.68	3.43	4.39	3.31	2.34
50	4.81	4.68	2.89	4.67	4.56	4.14	3.73	3.50	4.45	3.36	2.40
51	5.07	4.87	2.99	4.83	4.72	4.29	3.87	3.62	4.61	3.48	2.50
52	5.00	4.79	2.89	4.77	4.62	4.18	3.76	3.49	4.51	3.36	2.36
53	4.65	4.55	2.77	4.54	4.40	3.97	3.57	3.32	4.29	3.20	2.25
54	4.81	4.72	2.89	4.64	4.56	4.13	3.73	3.48	4.43	3.36	2.43
55	5.29	5.09	3.05	4.98	4.88	4.42	3.99	3.70	4.73	3.58	2.57
56	5.08	4.83	2.84	4.83	4.64	4.17	3.72	3.41	4.50	3.32	2.26

57	4.43	4.35	2.67	4.42	4.26	3.83	3.43	3.17	4.15	3.08	2.12
58	4.51	4.52	2.86	4.54	4.45	4.06	3.70	3.47	4.35	3.33	2.43
59	5.40	5.16	3.10	5.12	4.96	4.51	4.07	3.79	4.83	3.65	2.62
60	5.00	4.75	2.72	4.75	4.53	4.05	3.57	3.26	4.41	3.19	2.12
61	4.19	4.22	2.54	4.24	4.09	3.67	3.27	3.01	4.00	2.94	2.00
62	4.32	4.37	2.69	4.37	4.26	3.85	3.50	3.28	4.16	3.13	2.22
63	5.19	5.01	2.93	4.92	4.76	xxx	3.85	3.58	4.63	3.45	2.40
64	4.82	4.62	2.58	4.61	4.39	3.90	3.45	3.15	4.28	3.07	1.98
65	3.85	3.88	2.33	3.96	3.82	3.40	3.05	2.80	3.72	2.72	1.80
66	4.06	4.14	2.57	4.14	4.04	3.68	3.37	3.17	3.95	3.00	2.14
67	5.03	4.87	2.86	4.80	4.62	4.19	3.79	3.54	4.53	3.37	2.36
68	4.68	4.37	2.43	4.33	4.13	3.68	3.26	2.98	4.03	2.87	1.86
69	3.77	3.74	2.17	3.75	3.62	3.24	2.89	2.65	3.52	2.55	1.67
70	4.02	4.23	2.56	4.24	4.11	3.75	3.43	3.22	4.02	3.04	2.15
71	4.77	4.77	2.78	4.74	4.57	4.15	3.76	3.51	4.48	3.32	2.31
72	4.26	4.30	2.42	4.24	4.10	3.68	3.28	3.02	4.01	2.88	1.90
73	3.50	3.64	2.18	3.69	3.59	3.23	2.90	2.68	3.50	2.56	1.71
74	4.00	xxx	2.52	4.14	4.02	3.67	3.35	3.15	3.93	2.97	2.12
75	4.37	xxx	xxx	4.40	4.23	3.87	3.52	3.31	4.15	3.11	2.19
76	4.44	4.43	2.68	4.41	4.30	3.95	3.59	3.38	4.22	3.18	2.26
77	3.82	3.95	2.45	3.96	3.88	3.54	3.21	3.01	3.80	2.85	2.02
78	4.06	4.10	2.67	4.26	4.10	3.76	3.46	3.27	4.01	3.10	2.33
79	4.55	4.54	2.85	4.67	4.48	4.13	3.79	3.59	4.38	3.37	2.51
80	4.43	4.48	2.78	4.48	4.37	4.03	3.67	3.46	4.28	3.27	2.38
81	3.98	4.15	2.58	4.11	4.02	3.68	3.35	3.14	3.93	2.99	2.17
82	4.26	4.45	2.79	4.40	4.26	3.90	3.59	3.40	4.15	3.24	2.46
83	4.62	4.66	2.90	4.65	4.48	4.12	3.78	3.58	4.36	3.39	2.56
84	4.61	4.68	2.98	4.72	4.60	4.24	3.88	3.67	4.49	3.48	2.62
85	4.49	4.45	2.86	4.48	4.36	4.00	3.64	3.44	4.26	3.29	2.46
86	4.49	4.44	2.91	4.49	4.39	4.05	3.71	3.51	4.30	3.38	2.60
87	4.96	4.83	3.07	4.86	4.79	4.39	4.03	3.81	4.65	3.63	2.77
88	4.82	4.67	2.86	4.64	4.48	4.08	3.69	3.47	4.39	3.33	2.41
89	4.77	4.65	2.88	4.63	4.47	4.08	3.70	3.48	4.38	3.36	2.45
90	4.88	4.57	2.81	4.61	4.44	4.04	3.65	3.40	4.34	3.28	2.33
91	4.99	4.74	2.89	4.78	4.62	4.20	3.79	3.53	4.51	3.40	2.42
92	5.02	4.76	2.84	4.76	4.61	4.16	3.74	3.47	4.50	3.34	2.32
93	5.23	4.92	2.90	4.86	4.68	4.22	3.80	3.52	4.58	3.41	2.37
94	5.12	4.83	2.79	4.79	4.59	4.11	3.69	3.40	4.49	3.30	2.25
95	5.03	4.79	2.77	4.77	4.56	4.09	3.66	3.37	4.45	3.27	2.24
96	5.01	4.80	2.79	4.78	4.60	4.15	3.72	3.44	4.48	3.32	2.28
97	5.34	4.95	2.89	4.93	4.75	4.27	3.83	3.54	4.63	3.42	2.35
98	5.43	5.01	2.83	4.99	4.78	4.27	3.81	3.49	4.67	3.38	2.26
99	5.09	4.76	2.72	4.74	4.55	4.07	3.64	3.34	4.45	3.24	2.17
100	4.88	4.63	2.72	4.64	4.47	4.05	3.64	3.41	4.38	3.25	2.27
101	5.40	5.04	2.88	4.94	4.74	4.28	3.83	3.57	4.65	3.42	2.38
102	5.38	4.91	2.67	4.82	4.61	4.07	3.60	3.30	4.50	3.20	2.07
103	4.76	4.50	2.54	4.57	4.40	3.90	3.47	3.19	4.30	3.09	2.02
104	4.67	4.52	2.60	4.51	4.34	3.90	3.50	3.26	4.26	3.10	2.11
105	5.35	5.10	2.81	4.96	4.75	4.23	3.79	3.52	4.65	3.36	2.27
106	5.37	4.85	2.52	4.75	4.54	3.96	3.47	3.14	4.40	3.08	1.89
107	4.31	4.05	2.24	4.04	3.91	3.44	3.03	2.76	3.79	2.71	1.69
108	xxx	4.55	2.71	4.58	4.46	4.05	3.68	3.45	4.37	3.28	2.31
109	xxx	5.07	2.89	5.06	4.88	4.40	3.96	3.68	4.78	3.49	2.40
110	4.99	4.50	2.46	4.44	4.30	3.79	3.36	3.05	4.18	2.96	1.90
111	3.88	3.81	2.20	3.83	3.73	3.32	2.97	2.73	3.63	2.64	1.74
112	3.94	3.99	2.48	4.05	3.94	3.61	3.31	3.13	3.87	2.94	2.14
113	4.73	4.53	2.69	4.54	4.39	3.99	3.64	3.41	4.30	3.20	2.27
114	4.42	4.32	2.39	4.20	4.06	3.64	3.24	2.98	3.97	2.86	1.88

115	3.28	3.51	2.08	3.48	3.40	3.06	2.74	2.55	3.33	2.46	1.66
116	3.48	3.70	2.41	3.75	3.68	3.40	3.15	3.02	3.62	2.82	2.10
117	4.35	4.31	2.63	4.27	4.17	3.84	3.52	3.34	4.10	3.12	2.25
118	3.99	3.92	2.30	3.91	3.81	3.45	3.10	2.89	3.73	2.75	1.86
119	2.95	3.18	2.00	3.22	3.17	2.87	2.60	2.43	3.09	2.33	1.63
120	2.96	3.33	2.22	3.34	3.32	3.10	2.90	2.79	3.25	2.59	2.01
121	3.94	4.07	2.52	4.03	3.95	3.67	3.41	3.26	3.89	3.02	2.25
122	3.61	3.66	2.14	3.65	3.54	3.23	2.92	2.73	3.47	2.57	1.73
123	2.69	3.00	1.83	3.01	2.93	2.68	2.42	2.27	2.85	2.15	1.48
124	2.80	3.26	2.10	3.22	3.17	2.96	2.75	2.64	3.10	2.46	1.88
125	3.63	3.80	2.37	3.75	3.69	3.45	3.19	3.05	3.63	2.83	2.10
126	3.35	3.48	2.11	3.48	3.40	3.15	2.86	2.71	3.35	2.53	1.75
127	2.44	2.80	1.79	2.85	2.80	2.58	2.34	2.22	2.75	2.09	1.47
128	2.65	3.03	2.04	3.07	3.04	2.83	2.63	2.54	2.97	2.38	1.89
129	3.24	3.53	2.27	3.52	3.49	3.26	3.04	2.94	3.41	xxx	2.07
130	3.29	3.54	2.22	3.54	3.48	3.24	2.99	2.85	3.40	2.64	1.93
131	2.52	2.91	1.91	2.95	2.89	2.68	2.46	2.32	2.83	2.20	1.61
132	2.44	2.83	1.97	2.90	2.85	2.70	2.54	2.46	2.80	2.32	1.87
133	3.25	3.49	2.26	3.53	3.45	3.27	3.07	2.98	3.39	2.76	2.17
134	3.21	3.49	2.16	3.51	3.40	3.18	2.94	2.79	3.35	2.60	1.90
135	2.65	2.97	1.94	2.97	2.91	2.70	2.48	2.34	2.86	2.23	1.65
136	2.69	3.00	2.02	3.04	3.03	2.83	2.64	2.54	2.96	2.40	1.91
137	3.40	3.62	2.28	3.62	3.57	3.35	3.14	3.02	3.49	2.79	2.18
138	3.38	3.60	2.19	3.54	3.48	3.25	3.00	2.84	3.41	2.64	1.90
139	3.02	3.25	2.09	3.31	3.26	3.04	2.80	2.66	3.19	2.50	1.81
140	2.99	3.17	2.07	3.28	3.18	2.96	2.77	2.66	3.13	2.49	1.88
141	xxx	3.41	2.16	3.49	xxx	3.16	2.96	2.83	xxx	2.63	1.98
142	xxx	3.80	2.35	3.86	4.46	3.48	3.19	3.00	3.67	2.81	2.00
143	3.34	3.49	2.21	3.54	3.43	3.21	2.95	2.78	3.40	2.61	1.87
144	3.36	3.53	xxx	3.58	3.46	3.29	3.07	2.94	3.45	2.73	2.09
145	xxx	3.73	xxx	3.77	3.59	3.42	3.17	3.03	3.58	2.81	2.12
146	xxx	4.08	2.51	4.02	3.83	3.60	3.30	3.12	3.82	2.94	2.19
147	3.98	4.04	2.49	3.99	3.83	3.59	3.29	3.11	3.81	2.92	2.17
148	3.78	3.95	2.50	3.94	3.74	3.56	3.29	3.14	3.74	2.94	2.21
149	4.02	4.11	2.58	4.11	3.91	3.71	3.43	3.26	3.90	3.05	2.27
150	4.20	4.13	2.57	4.15	3.98	3.72	3.39	3.18	3.96	3.01	2.15
151	4.59	4.45	2.72	4.42	4.23	3.95	3.59	3.37	4.21	3.20	2.29
152	4.41	4.15	2.38	3.96	3.84	3.54	3.17	2.94	3.78	2.76	1.88
153	4.50	4.24	2.43	4.09	3.94	3.64	3.26	3.03	3.89	2.86	1.97
154	4.58	xxx	2.34	4.13	3.88	3.55	3.15	2.90	3.83	2.76	1.76
155	4.56	xxx	2.40	4.13	3.89	3.56	3.17	2.92	3.84	2.77	1.82
156	4.80	4.60	2.65	4.61	4.36	4.04	3.63	3.35	4.33	3.14	2.08
157	4.48	4.30	2.45	4.30	4.07	3.74	3.34	3.07	4.03	2.90	1.88
158	4.81	4.62	2.76	4.66	4.43	4.13	3.75	3.52	4.42	3.33	2.37
159	5.48	4.98	2.92	4.95	4.69	4.35	3.94	3.69	4.67	3.48	2.45
160	4.91	4.48	2.54	4.44	4.20	3.85	3.45	3.18	4.18	3.03	2.04
161	4.50	4.33	2.48	4.37	4.17	3.82	3.44	3.17	4.14	3.03	2.04
162	4.78	4.53	2.63	4.56	4.40	3.98	3.58	3.31	4.33	3.15	2.14
163	5.73	5.25	2.91	5.14	4.90	4.39	3.95	3.64	4.84	3.48	2.35
164	5.59	5.01	2.57	4.83	4.52	4.03	3.56	3.22	4.49	3.12	1.91
165	4.66	4.29	2.30	4.23	4.03	3.63	3.20	2.90	3.98	2.82	1.75
166	5.07	4.65	2.67	4.61	4.41	4.05	3.63	3.36	4.39	3.21	2.17
167	5.99	5.38	2.94	5.23	4.94	4.48	4.01	3.70	4.92	3.54	2.35
168	5.73	5.08	2.59	4.93	4.64	4.11	3.61	3.28	4.59	3.19	1.93
169	4.54	4.18	2.26	4.15	3.95	3.56	3.13	2.88	3.92	2.77	1.70
170	4.90	4.59	2.67	4.55	4.32	4.00	3.62	3.38	4.32	3.21	2.20
171	6.00	5.43	3.00	5.32	5.01	4.55	4.10	3.78	4.99	3.64	2.45
172	5.95	5.18	2.66	5.06	4.76	4.21	3.69	3.32	4.72	3.28	1.99

173	4.40	3.95	2.20	3.97	3.80	3.39	2.96	2.69	3.75	2.64	1.61
174	4.53	4.45	2.77	4.52	4.33	4.06	3.72	3.52	4.32	3.34	2.44
175	5.59	5.16	3.01	5.13	4.85	xxx	xxx	xxx	4.84	3.63	2.56
176	5.19	4.76	2.69	4.69	4.44	xxx	3.64	3.37	4.43	3.23	2.20
177	4.06	3.97	2.37	4.00	3.85	3.52	3.17	2.96	3.84	2.83	1.95
178	4.24	4.14	2.65	4.18	4.04	3.79	3.48	3.32	4.04	3.16	2.40
179	5.26	4.93	2.95	4.90	4.70	4.38	4.00	3.78	4.68	3.60	2.65
180	4.87	4.59	2.63	4.57	4.35	3.95	3.53	3.26	4.32	3.16	2.15
181	3.67	3.73	2.28	3.74	3.61	3.30	2.96	2.75	3.59	2.67	1.87
182	3.84	3.89	2.49	3.90	3.75	3.56	3.29	3.14	3.77	2.99	2.29
183	4.73	4.53	2.73	4.49	4.28	4.03	3.69	3.51	4.29	3.32	2.48
184	4.79	4.69	2.82	4.64	4.42	4.11	3.73	3.50	4.43	3.36	2.44
185	3.89	3.88	2.47	3.88	3.71	3.42	3.10	2.90	3.72	2.83	2.06
186	3.89	3.94	2.65	4.00	3.85	3.62	3.34	3.18	3.87	3.09	2.42
187	4.68	4.66	2.87	4.66	4.45	4.20	3.88	3.68	4.46	3.52	2.70
188	4.72	4.45	2.70	4.43	4.20	3.91	3.55	3.33	4.20	3.20	2.36
189	xxx	4.13	2.58	4.12	3.94	3.66	3.31	3.11	3.93	3.01	2.25
190	xxx	4.20	2.61	4.23	4.05	3.75	3.40	3.19	4.04	3.09	2.26
191	xxx	4.12	2.69	4.17	4.02	3.73	3.42	3.23	3.99	3.12	2.35
192	xxx	3.82	2.44	3.85	3.71	3.52	3.27	3.12	3.69	2.95	2.25
193	xxx	3.98	2.47	4.03	3.84	3.63	3.35	3.19	3.86	3.02	2.24
194	4.28	4.14	2.54	4.20	3.98	3.68	3.34	3.14	4.00	3.06	2.22
195	4.03	4.23	2.55	4.27	4.07	3.78	3.45	3.25	4.08	3.14	2.30
196	4.73	4.61	2.77	4.61	4.39	4.08	3.70	3.48	4.40	3.37	2.46
197	4.13	3.99	2.50	4.07	3.88	3.58	3.22	3.03	3.88	2.96	2.15
198	4.39	4.43	2.88	4.44	4.29	4.02	xxx	3.49	4.29	3.44	2.61
199	4.24	4.27	2.73	4.22	4.17	3.81	3.48	3.28	4.10	3.25	2.42
200	4.74	4.70	3.26	4.76	4.69	4.34	4.06	3.88	4.62	3.83	3.07
201	5.10	4.90	3.30	5.05	4.91	4.53	4.21	4.00	4.84	3.94	3.07
202	4.42	4.46	3.03	4.50	4.37	4.04	3.69	3.50	4.34	3.52	2.73
203	4.37	4.54	3.06	4.52	4.44	4.13	3.78	3.61	4.39	3.60	2.83
204	4.75	4.61	3.12	4.67	4.57	4.20	3.81	3.59	4.49	3.58	2.73
205	4.96	4.78	3.20	4.78	4.68	4.32	3.94	3.72	4.59	3.69	2.85
206	4.96	4.78	3.14	4.80	4.67	4.29	3.91	3.68	4.57	3.62	2.74
207	4.54	4.37	2.95	4.48	4.36	3.97	3.59	3.37	4.27	3.37	2.52
208	4.63	4.53	3.14	4.61	4.53	4.18	3.83	3.65	4.44	3.61	2.85
209	5.32	5.09	3.36	5.07	4.95	4.57	4.20	3.99	4.84	3.90	3.05
210	4.99	4.86	xxx	4.83	4.68	4.30	3.92	3.69	4.59	3.63	2.77
211	4.39	4.38	xxx	4.40	4.27	3.91	3.56	3.35	4.20	3.34	2.56
212	4.44	4.39	3.02	4.47	4.35	3.99	3.66	3.45	4.27	3.44	2.65
213	5.78	5.46	3.50	5.38	5.22	4.82	4.43	4.17	5.13	4.09	3.16
214	xxx	4.31	2.27	4.15	3.94	3.39	2.83	2.48	3.84	2.56	1.31
215	xxx	3.87	2.33	3.93	3.78	3.29	2.80	2.52	3.72	2.66	1.58
216	xxx	4.53	2.55	4.51	4.39	3.93	3.49	3.21	4.25	3.06	1.88
217	5.31	5.02	2.73	4.88	4.73	4.23	3.75	3.44	4.56	3.25	2.00
218	5.24	4.84	2.45	4.72	4.55	4.01	3.50	3.15	4.38	3.06	1.80
219	4.09	3.99	2.12	3.91	3.81	3.33	2.91	2.62	3.65	2.56	1.48
220	4.10	4.24	2.39	4.17	4.13	3.75	3.38	3.15	3.99	3.08	2.15
221	4.86	4.77	2.64	4.68	4.58	4.17	3.77	3.51	4.44	3.34	2.27
222	4.75	4.44	2.19	4.34	4.21	3.73	3.29	2.98	4.06	2.91	1.81
223	3.68	3.68	1.93	3.70	3.63	3.20	2.80	2.52	3.48	2.51	1.56
224	4.13	4.32	2.55	4.42	4.38	4.02	3.66	3.43	4.26	3.36	2.47
225	5.09	5.00	2.76	4.99	4.89	4.47	4.06	3.81	4.75	3.64	2.60
226	4.47	4.43	2.36	4.43	4.31	3.85	3.43	3.16	4.16	3.07	2.09
227	3.25	3.47	1.96	3.57	3.51	3.11	2.75	2.50	3.38	2.51	1.72
228	3.40	3.71	2.36	3.82	3.79	3.47	3.20	3.01	3.69	2.94	2.27
229	4.36	4.44	2.65	4.52	4.44	4.08	3.77	3.58	4.32	3.41	2.58
230	4.15	4.21	2.44	4.23	4.12	3.71	3.34	3.11	3.98	2.97	2.05

231	3.11	3.50	2.14	3.56	3.50	3.13	2.81	2.59	3.39	2.55	1.80
232	3.64	4.04	2.70	4.13	4.11	3.81	3.52	3.36	4.01	3.24	2.52
233	4.35	4.35	2.72	4.33	4.25	3.90	3.56	3.38	4.14	3.24	2.45
234	3.58	3.77	2.46	3.78	3.70	3.37	3.08	2.92	3.59	2.81	2.17
235	2.76	3.20	2.14	3.31	3.28	2.98	2.72	2.56	3.17	2.50	1.93
236	2.96	3.31	2.36	3.41	3.38	3.15	2.91	2.78	3.30	2.67	2.11
237	3.89	4.11	2.74	4.14	4.08	3.82	3.56	3.43	3.98	3.25	2.55
238	3.27	xxx	xxx	3.77	3.68	3.35	3.06	2.90	3.55	2.73	1.99
239	2.74	3.05	2.09	3.15	3.09	2.77	2.50	2.34	2.98	2.28	1.68
240	2.87	3.24	2.34	3.40	3.36	3.09	2.88	xxx	3.27	2.65	2.11
241	3.54	3.62	2.52	3.73	3.66	3.39	3.15	3.03	3.57	2.87	2.26
242	3.52	3.63	2.48	3.78	3.70	3.39	3.16	3.02	3.60	2.86	2.19
243	xxx	3.28	2.30	3.41	3.34	3.07	2.85	2.72	3.23	2.59	2.01
244	xxx	2.66	1.89	2.78	2.72	2.53	2.38	2.30	2.64	2.15	1.72
245	xxx	3.09	2.10	3.09	3.02	2.79	2.60	2.47	2.94	2.36	1.85
246	3.63	3.68	2.49	3.68	3.58	3.31	3.08	2.94	3.48	2.83	2.25
247	3.17	3.44	2.37	3.51	3.42	3.17	2.93	2.81	3.32	2.71	2.13
248	2.62	2.81	1.98	2.87	2.79	2.59	2.40	2.32	2.73	2.23	1.77
249	3.24	3.49	2.33	3.56	3.44	3.24	3.04	2.95	3.39	xxx	2.18
250	3.43	3.58	2.24	3.54	3.46	3.19	2.92	2.77	3.42	2.65	1.94
251	3.23	3.52	2.22	3.54	3.46	3.20	2.93	2.80	3.42	2.66	1.96
252	3.18	3.46	2.10	3.55	3.42	3.10	2.80	2.64	3.37	2.54	1.73
253	3.07	3.40	2.14	3.49	3.40	3.10	xxx	2.67	3.35	2.57	1.80
254	3.91	4.11	2.59	4.14	4.07	3.74	3.41	3.21	3.99	3.04	2.13
255	3.78	3.84	2.42	3.90	3.82	3.46	3.11	2.92	3.74	2.79	1.92
256	3.17	3.44	2.28	3.56	3.46	3.19	2.94	2.84	3.39	2.68	2.04
257	3.31	3.60	2.35	3.72	3.60	3.34	xxx	xxx	3.55	2.79	2.10
258	3.96	4.05	2.61	4.13	4.04	3.70	3.36	3.18	3.97	3.04	2.17
259	4.06	4.08	2.68	4.26	4.16	3.82	3.47	3.28	4.09	3.14	2.25
260	3.96	3.97	2.57	4.13	4.02	3.69	3.35	3.16	3.95	3.00	2.13
261	3.72	3.89	2.48	3.94	xxx	3.53	3.21	3.03	xxx	2.88	2.06
262	4.22	4.27	2.75	4.32	4.25	3.87	3.53	3.31	4.13	3.18	2.28
263	4.60	4.55	2.85	4.57	4.48	4.08	3.71	3.47	4.35	3.33	2.37
264	4.46	4.31	2.68	4.31	4.20	3.84	3.47	3.27	4.10	3.10	2.19
265	4.05	3.96	2.50	4.00	3.91	3.54	3.18	2.98	3.80	2.86	2.00
266	4.95	4.71	3.07	4.77	4.71	4.29	3.90	3.67	4.56	3.54	2.60
267	5.30	4.92	3.14	4.91	4.83	4.41	4.03	3.78	4.68	3.61	2.63
268	4.77	4.79	3.08	4.82	4.71	4.32	3.97	3.74	4.58	3.58	2.69
269	4.71	4.67	2.96	4.70	4.57	4.16	3.77	3.54	4.42	3.41	2.51
270	4.86	4.64	3.03	4.71	4.59	4.17	3.77	3.55	4.45	3.47	2.55
271	5.97	5.57	3.52	5.58	5.42	4.95	4.50	4.23	5.29	4.11	3.03
272	5.70	5.20	2.93	5.18	4.96	4.42	3.91	3.57	4.82	3.50	2.29
273	4.92	4.59	2.67	4.62	4.44	3.94	3.48	3.19	4.32	3.16	2.08
274	5.38	4.90	2.93	4.91	4.76	4.28	3.84	3.58	4.62	3.50	2.47
275	6.38	5.72	3.27	5.67	5.46	4.90	4.39	4.07	5.29	3.96	2.77
276	6.15	5.43	2.87	5.38	5.11	4.47	3.89	3.54	4.96	3.49	2.19
277	4.96	4.56	2.57	4.61	4.43	3.89	3.41	3.13	4.30	3.08	1.96
278	5.28	4.84	2.87	4.88	4.76	4.28	3.85	3.58	4.61	3.48	2.41
279	6.24	5.58	3.15	5.55	5.35	xxx	4.27	3.94	5.19	3.84	2.61
280	6.37	5.66	3.09	5.70	5.45	xxx	4.24	3.85	5.29	3.83	2.50
281	4.62	4.06	2.43	4.16	4.01	3.50	3.04	2.70	3.87	2.79	1.74
282	4.92	xxx	3.14	4.79	4.73	xxx	3.99	3.76	4.54	3.76	2.93
283	6.74	xxx	3.62	6.05	5.88	xxx	4.92	4.66	5.65	4.53	3.46
284	6.18	5.44	3.09	5.43	5.18	4.59	4.07	3.75	5.03	3.71	2.57
285	4.91	4.66	2.83	4.78	4.62	4.10	3.66	3.39	4.49	3.37	2.40
286	5.28	4.70	2.94	4.73	4.61	4.16	3.74	3.51	4.46	3.41	2.49
287	6.05	5.36	3.16	5.37	5.18	4.68	4.19	3.92	5.04	3.81	2.72
288	6.09	5.54	3.27	5.62	5.40	4.84	4.31	4.00	5.25	3.93	2.75

289	4.46	4.20	2.67	4.33	4.20	3.72	3.27	3.00	4.07	3.03	2.09
290	4.89	xxx	3.27	4.93	4.85	xxx	4.08	3.88	4.56	3.86	3.01
291	5.88	xxx	3.47	5.42	5.29	xxx	4.44	4.21	4.97	4.13	3.18
292	5.07	4.73	3.14	4.81	4.67	4.24	3.84	3.61	4.54	3.56	2.72
293	4.86	4.71	3.14	4.82	4.69	4.25	3.87	3.65	4.55	3.60	2.76
294	4.67	4.50	3.01	4.60	4.48	4.05	3.68	4.03	4.34	3.41	2.56
295	5.28	5.15	3.29	5.18	5.01	4.57	4.18	3.95	4.88	3.85	2.91
296	5.10	4.91	2.95	4.83	4.64	4.16	3.74	3.47	4.49	3.38	2.40
297	4.48	4.55	2.89	4.69	4.59	4.16	3.77	3.53	4.45	3.43	2.49
298	xxx	4.01	2.48	3.89	3.77	3.38	2.79	2.79	3.56	2.68	1.78
299	xxx	3.82	2.42	3.59	3.45	3.04	2.79	2.51	3.55	2.46	1.71
300	4.75	4.84	3.29	4.90	4.85	4.50	4.20	4.02	4.76	3.85	3.03
301	4.41	4.16	2.81	4.25	4.22	3.87	3.51	3.32	4.08	3.21	2.39
302	4.20	4.12	2.93	4.33	4.22	3.84	3.48	3.29	4.11	3.32	2.59
303	4.25	4.40	3.07	4.61	4.49	4.12	3.80	3.62	4.38	3.54	2.75
304	4.35	4.54	3.21	4.67	4.61	4.23	3.86	3.69	4.50	3.65	2.88
305	4.68	4.71	3.28	4.79	4.73	4.33	3.95	3.77	4.61	3.72	2.92
306	4.25	4.30	2.96	4.42	4.31	3.90	3.54	3.33	4.19	3.30	2.53
307	3.80	4.03	2.86	4.19	4.08	3.71	3.38	3.20	3.98	3.18	2.51
308	4.43	xxx	3.17	4.61	4.53	4.15	3.80	3.61	4.40	3.58	2.78
309	4.46	xxx	3.02	4.47	4.39	3.99	3.61	3.40	4.26	3.39	2.56
310	4.32	xxx	3.21	4.63	4.54	xxx	3.83	3.64	4.44	3.65	2.93
311	3.81	xxx	2.85	4.22	4.13	xxx	3.49	3.31	4.02	3.28	2.59
312	4.11	xxx	3.08	4.46	4.39	xxx	3.73	3.55	4.14	3.54	2.90
313	4.94	xxx	3.57	5.12	5.05	xxx	4.33	4.14	4.79	4.09	3.32
314	4.05	4.17	2.98	4.31	4.23	3.86	3.52	3.31	4.14	3.34	2.59
315	3.59	3.92	2.88	4.10	4.03	3.69	3.38	3.19	3.95	3.25	2.58
316	4.20	4.32	3.09	4.48	4.42	4.06	3.71	3.52	4.31	3.50	2.74
317	4.70	4.70	3.33	4.81	4.74	4.36	4.00	3.81	4.63	3.77	2.96
318	4.92	xxx	3.32	4.94	4.82	4.41	4.05	3.86	4.68	3.81	2.96
319	3.81	xxx	2.57	3.89	3.79	3.39	3.05	2.84	3.67	2.89	2.20
320	4.31	xxx	3.14	4.54	xxx	xxx	3.84	3.65	3.96	3.63	2.98
321	5.19	xxx	3.43	4.97	xxx	xxx	4.18	3.99	4.35	3.97	3.18
322	4.36	xxx	3.07	4.34	4.23	xxx	3.62	3.48	4.15	3.46	2.79
323	3.90	xxx	3.00	4.32	4.20	xxx	3.56	3.39	4.14	3.40	2.71
324	4.07	xxx	3.06	4.37	4.28	xxx	3.63	3.45	4.21	3.46	2.77
325	5.10	xxx	3.60	5.12	5.02	xxx	4.35	4.16	4.92	4.10	3.34
326	4.73	4.65	3.22	4.80	4.62	4.22	3.86	3.65	4.53	3.64	2.82
327	3.85	4.02	2.85	4.23	4.09	3.71	3.36	3.15	4.02	3.23	2.50
328	4.30	xxx	3.14	4.49	4.42	4.05	3.76	3.57	4.34	3.59	2.86
329	4.74	xxx	3.13	4.31	4.21	3.84	3.58	3.42	4.13	3.43	2.75
330	4.43	4.22	3.11	4.35	4.24	xxx	3.66	3.51	4.16	3.51	2.86
331	3.85	3.95	2.87	4.23	4.14	xxx	3.50	3.33	4.07	3.36	2.67
332	3.93	xxx	2.97	4.23	4.16	xxx	3.55	xxx	4.10	3.42	2.79
333	5.04	xxx	3.56	5.05	4.95	xxx	4.32	xxx	4.87	4.10	3.34
334	4.75	4.58	3.17	4.69	4.52	4.16	3.78	3.56	4.46	3.59	2.76
335	3.72	3.89	2.80	4.12	3.98	3.63	3.29	3.11	3.94	3.18	2.49
336	3.96	4.07	2.99	4.28	4.19	3.87	3.57	3.41	4.13	3.43	2.78
337	4.83	4.72	3.39	4.85	4.74	4.43	4.11	3.93	4.67	3.89	3.13
338	4.70	4.56	3.17	4.65	4.53	4.17	3.81	3.60	4.48	3.60	2.78
339	3.65	3.74	2.66	3.89	3.82	3.47	3.14	2.96	3.78	3.02	2.35
340	3.60	3.82	2.80	4.00	3.95	3.67	3.34	3.24	3.90	3.26	2.66
341	4.50	4.50	3.20	4.53	4.39	4.10	3.76	xxx	4.34	3.63	2.94
342	4.22	4.26	2.95	4.32	4.18	3.86	3.54	3.37	4.14	3.39	2.66
343	xxx	3.79	2.76	3.90	3.84	3.54	3.27	3.12	3.77	3.14	2.50
344	xxx	3.28	2.48	3.41	3.36	3.17	2.99	2.90	3.31	2.86	2.39
345	xxx	4.40	3.08	4.50	4.41	4.19	3.93	3.81	4.36	3.68	3.02
346	4.38	4.32	2.67	4.26	4.08	3.71	3.33	3.11	4.03	3.08	2.22

347	3.21	3.52	2.36	3.57	3.44	3.11	2.82	2.63	3.39	2.66	1.99
348	3.61	3.78	2.67	3.90	3.85	3.55	3.29	3.13	3.77	3.06	2.42
349	3.91	4.03	2.71	4.11	4.02	3.68	3.35	3.16	3.97	3.12	2.40
350	4.22	4.33	2.99	4.42	4.31	4.00	3.66	3.49	4.28	3.46	2.72
351	2.71	3.02	2.00	3.16	3.09	2.76	2.52	xxx	3.04	2.40	1.87
352	2.69	3.14	2.32	3.27	3.25	3.00	2.85	xxx	3.19	2.70	2.33
353	3.67	3.90	2.91	4.03	3.96	3.75	3.52	xxx	3.92	3.33	2.77
354	3.82	3.97	2.88	4.12	4.02	3.73	3.43	3.27	4.00	3.30	2.65
355	3.10	3.36	2.45	3.52	3.48	3.22	2.97	2.84	3.45	2.86	2.33
356	2.93	3.25	2.45	3.43	3.41	3.19	2.98	xxx	3.37	2.86	2.39
357	3.51	3.77	2.81	3.93	3.88	3.63	3.36	xxx	3.84	3.23	2.66
358	3.73	3.94	2.89	4.03	3.97	3.72	3.42	xxx	3.94	3.31	2.69
359	3.17	3.47	2.51	3.56	3.52	3.27	3.00	xxx	3.50	2.90	2.37
360	2.96	3.42	2.59	3.57	3.55	3.32	3.11	xxx	3.52	2.99	2.57
361	3.16	3.42	2.58	3.54	3.50	3.27	3.06	xxx	3.47	2.94	2.49
362	3.54	xxx	2.83	3.86	3.81	xxx	3.33	xxx	3.78	3.21	2.70
363	3.30	xxx	2.70	3.81	3.76	xxx	3.27	xxx	3.73	3.14	2.61
364	2.81	3.30	xxx	3.44	3.33	3.16	2.97	xxx	3.32	2.85	2.41
365	3.20	3.58	xxx	3.73	3.64	3.46	3.25	xxx	xxx	3.14	2.68
366	3.21	3.48	xxx	3.59	3.57	3.36	3.09	xxx	xxx	2.99	2.50
367	3.79	4.06	xxx	4.15	4.10	3.87	3.61	xxx	4.09	3.45	2.88
368	3.58	3.77	xxx	3.97	3.82	3.51	3.25	xxx	3.78	3.10	2.48
369	3.16	3.37	xxx	3.56	3.44	3.15	2.92	xxx	3.39	2.83	2.31
370	3.78	3.95	2.92	4.06	4.04	3.76	3.49	xxx	3.98	3.36	2.76
371	4.56	4.63	3.31	4.74	4.65	4.36	4.03	xxx	4.61	3.82	3.06
372	3.70	3.77	2.69	3.83	3.68	3.44	3.15	2.99	3.67	3.00	2.40
373	xxx	3.72	2.71	3.83	3.72	3.48	3.22	3.08	3.68	3.08	2.52
374	4.77	4.70	3.27	4.87	4.77	4.39	4.00	3.78	4.68	3.79	2.92
375	4.79	4.57	3.19	4.67	4.57	4.21	3.83	3.62	4.50	3.64	2.81
376	4.23	4.30	2.98	4.38	4.32	3.99	3.66	3.49	4.27	3.50	2.74
377	4.06	4.12	2.92	4.25	4.21	3.86	3.51	3.33	4.14	3.37	2.61
378	4.51	xxx	3.23	4.65	4.60	xxx	3.89	3.68	4.50	3.72	2.95
379	5.31	xxx	3.57	5.24	5.15	xxx	4.38	4.15	5.03	4.13	3.25
380	4.84	4.76	xxx	4.79	4.64	4.27	3.88	3.66	4.55	3.66	2.80
381	4.25	4.28	xxx	4.39	4.27	3.91	3.54	3.34	4.20	3.38	2.61
382	4.83	xxx	3.24	4.76	4.68	4.28	3.89	3.67	4.59	3.70	2.88
383	5.99	xxx	3.67	5.60	5.44	5.01	4.57	4.31	5.33	4.27	3.30
384	5.44	5.06	3.14	5.05	4.85	4.40	3.93	3.68	4.75	3.65	2.65
385	4.17	3.97	2.67	4.04	3.93	3.51	3.10	2.89	3.85	2.97	2.18
386	5.07	xxx	3.35	4.91	4.84	xxx	4.05	3.85	4.62	3.88	3.07
387	6.74	xxx	3.78	5.85	5.68	xxx	4.75	4.50	5.43	4.44	3.40
388	6.31	xxx	3.52	5.58	5.39	4.90	4.35	4.09	5.26	4.12	3.07
389	4.86	xxx	3.12	4.79	4.67	4.22	3.73	3.51	4.58	3.61	2.70
390	5.55	xxx	3.53	5.25	5.13	xxx	4.27	4.02	4.79	4.11	3.18
391	6.70	xxx	3.90	6.01	5.84	xxx	4.90	4.61	5.48	4.62	3.56
392	6.20	xxx	3.48	5.52	5.30	4.79	4.29	3.98	5.20	4.01	2.96
393	5.43	xxx	3.27	5.06	4.88	4.42	3.95	3.66	4.79	3.74	2.78
394	5.70	xxx	3.49	5.29	5.18	xxx	4.28	4.01	5.01	4.05	3.11
395	6.67	xxx	3.79	5.94	5.79	xxx	xxx	4.48	5.60	4.47	3.40
396	6.46	5.65	3.48	5.64	5.43	4.90	xxx	4.02	5.32	4.05	2.93
397	5.21	4.65	3.09	4.79	4.63	4.16	3.69	3.40	4.54	3.50	2.57
398	5.57	xxx	3.50	5.29	5.14	xxx	4.28	4.02	4.86	4.07	3.15
399	6.48	xxx	3.81	5.93	5.74	xxx	4.79	4.51	5.43	4.49	3.42
400	5.76	5.30	3.36	5.35	5.17	4.68	4.21	3.92	5.06	3.94	2.90
401	4.95	4.60	3.06	4.67	4.51	4.06	3.63	3.36	4.42	3.47	2.58
402	5.06	xxx	3.30	4.96	4.85	xxx	4.06	3.83	4.71	3.87	3.01
403	6.62	xxx	3.73	5.90	5.72	xxx	4.78	4.50	5.57	4.47	3.42
404	5.68	5.01	2.98	4.96	4.72	4.22	3.75	3.44	4.62	3.48	2.48

405	4.84	4.52	2.91	4.61	4.45	4.03	3.63	3.38	4.36	3.40	2.52
406	4.96	4.67	2.96	4.73	4.58	4.15	3.73	3.48	4.47	3.46	2.53
407	5.09	4.82	3.02	4.91	4.73	4.28	3.84	3.57	4.63	3.56	2.59
408	5.28	4.95	3.08	5.02	4.82	4.38	3.94	3.69	4.73	3.66	2.70
409	4.62	4.49	2.88	4.57	4.43	4.01	3.62	3.39	4.32	3.37	2.50
410	4.68	4.49	xxx	4.60	4.48	4.08	3.71	3.48	4.38	3.46	2.63
411	4.45	4.35	2.89	4.49	4.35	3.97	3.59	xxx	4.28	3.37	2.55
412	4.44	4.44	3.04	4.54	4.42	4.08	3.72	3.52	4.36	3.51	2.73
413	4.41	4.43	3.00	4.50	4.39	4.04	3.69	3.48	4.31	3.48	2.69
414	4.26	4.35	3.00	4.46	4.34	4.01	3.68	3.49	4.27	3.49	2.72
415	3.76	3.86	2.74	4.03	3.92	3.58	3.26	3.09	3.85	3.13	2.44
416	3.75	3.97	2.95	4.13	4.08	3.78	3.50	3.37	3.98	3.37	2.77
417	4.39	4.52	3.19	4.58	4.49	4.20	3.90	3.75	4.42	3.69	3.00
418	4.02	4.14	2.83	4.23	4.09	3.76	3.42	3.24	4.05	3.24	2.52
419	3.32	xxx	2.53	3.68	3.60	3.28	2.99	2.84	3.55	2.89	2.28
420	3.62	3.77	2.80	3.92	3.87	3.61	3.38	3.26	3.81	3.25	2.69
421	4.61	4.57	3.18	4.64	4.53	4.24	3.94	3.78	4.47	3.72	3.00
422	3.90	4.02	2.69	4.11	3.95	3.63	3.30	3.12	3.93	3.12	2.41
423	3.09	xxx	2.46	3.62	3.52	3.22	xxx	2.77	3.49	2.83	2.25
424	3.77	4.01	2.88	4.17	4.08	3.78	3.48	3.32	4.01	3.34	2.68
425	4.68	4.68	3.19	4.80	4.65	4.34	4.00	3.81	4.58	3.75	2.96
426	4.15	4.07	2.70	4.01	3.87	3.59	3.27	3.10	3.82	3.05	2.34
427	3.14	3.46	2.41	3.54	3.45	3.20	2.92	2.78	3.45	2.79	2.20
428	3.63	3.69	2.64	3.74	3.67	3.40	3.11	2.96	3.62	2.95	2.34
429	4.34	4.24	2.90	4.16	4.07	3.80	3.51	3.38	4.02	3.26	2.60
430	4.46	4.35	xxx	4.37	4.26	3.88	3.49	3.29	4.18	3.24	2.46
431	xxx	3.35	xxx	3.47	3.39	3.00	2.61	2.38	3.31	2.49	1.83
432	xxx	xxx	3.36	4.76	4.69	xxx	4.11	3.94	4.42	3.95	3.23
433	4.63	xxx	3.18	4.68	4.56	xxx	3.95	3.78	4.32	3.77	2.98
434	4.23	xxx	xxx	4.45	4.35	xxx	3.63	3.43	4.24	3.50	2.75
435	3.95	xxx	xxx	4.30	4.23	xxx	3.59	3.42	4.10	3.46	2.77
436	3.80	xxx	2.95	4.14	4.11	xxx	3.51	3.35	4.03	3.37	2.73
437	4.77	xxx	3.49	4.89	4.81	xxx	4.13	3.96	4.71	3.92	3.16
438	4.41	4.60	3.18	4.66	xxx	4.13	3.78	3.60	xxx	3.61	2.85
439	4.07	3.90	2.79	4.13	4.01	3.65	3.29	3.08	xxx	3.16	2.47
440	3.77	3.65	2.66	3.92	3.86	3.54	3.22	3.04	3.79	3.10	2.46
441	4.79	4.55	3.25	4.63	4.53	4.21	3.89	3.74	4.46	3.71	3.00
442	4.68	4.52	3.06	4.62	4.46	4.09	3.71	3.50	4.39	3.51	2.66
443	3.90	4.11	2.88	4.31	4.19	3.83	3.48	3.26	4.13	3.33	2.52
444	3.73	3.81	2.74	3.92	3.83	3.53	3.24	3.06	3.79	3.10	2.44
445	4.92	4.87	3.24	4.90	4.76	4.44	4.11	3.90	4.71	3.82	2.98
446	4.85	4.59	2.80	4.57	4.39	3.92	3.49	3.19	4.35	3.25	2.22
447	3.72	3.72	2.48	3.81	3.71	3.27	2.89	2.65	3.66	2.77	1.94
448	4.10	4.19	2.88	4.29	4.23	3.87	3.51	3.31	4.15	3.31	2.53
449	4.53	4.34	2.92	4.32	4.22	3.86	3.49	3.29	4.15	3.27	2.49
450	4.65	4.58	3.12	4.66	4.54	4.17	3.81	3.62	4.46	3.57	2.78
451	3.58	3.77	2.62	3.98	3.89	3.52	3.18	2.98	3.81	3.02	2.32
452	3.70	3.88	2.87	4.01	3.97	3.68	3.40	3.26	3.91	3.24	2.64
453	4.94	4.88	3.41	4.93	4.86	4.57	4.26	4.09	4.80	xxx	xxx
454	4.70	4.43	2.96	4.43	4.32	3.98	3.62	3.39	4.26	3.33	2.44
455	3.89	3.92	2.75	4.01	3.92	3.57	3.20	2.99	3.86	3.04	2.27
456	4.16	4.08	2.91	4.22	4.14	3.84	3.51	3.35	4.08	3.32	2.62
457	4.49	4.35	2.99	4.42	4.31	4.01	3.68	3.50	4.28	3.44	2.70
458	4.48	4.52	3.10	4.59	4.46	4.13	3.76	3.58	4.42	3.52	2.73
459	3.52	3.69	2.58	3.82	3.72	3.40	3.04	2.88	3.67	2.91	2.24
460	3.46	3.74	2.77	3.88	3.85	3.59	3.30	3.18	3.79	3.17	2.62
461	4.16	4.21	3.09	4.31	4.28	4.00	3.72	3.59	4.21	3.52	2.87
462	4.31	4.30	3.08	4.39	4.32	3.98	3.65	3.47	4.25	3.48	2.72

463	3.58	3.79	2.72	3.93	3.87	3.55	3.23	3.07	3.81	3.11	2.45
464	3.29	3.63	2.69	3.77	3.74	3.49	3.24	3.12	3.70	3.11	2.58
465	4.00	4.16	3.06	4.30	4.24	3.97	3.69	3.55	4.19	3.51	2.84
466	4.10	4.17	3.00	4.36	4.24	3.89	3.56	3.38	4.18	3.41	2.66
467	3.70	3.92	2.86	4.12	4.03	3.71	3.42	3.25	3.97	3.28	2.62
468	3.45	3.60	2.65	3.64	3.57	3.31	3.05	2.92	3.49	2.89	2.33
469	3.55	3.88	2.83	3.94	3.86	3.60	3.33	3.20	3.89	3.14	2.52
470	3.66	3.94	2.86	4.03	3.97	3.71	3.43	3.29	3.93	3.25	2.60
471	3.52	xxx	2.67	3.74	3.69	3.41	3.15	3.01	3.64	3.01	2.42
472	3.62	xxx	2.76	3.93	3.88	3.58	3.32	3.17	3.82	3.17	2.54
473	3.22	3.53	2.59	3.72	3.67	3.41	3.16	3.03	3.63	3.04	2.45
474	3.58	3.74	2.76	3.93	3.89	3.63	3.37	3.26	3.84	3.23	2.63
475	3.75	3.74	2.73	3.88	3.84	3.55	3.27	3.14	3.77	3.12	2.50
476	3.58	3.84	2.86	4.05	4.00	3.73	3.49	3.38	3.94	3.36	2.78
477	3.37	3.45	2.51	3.68	3.64	3.36	3.09	2.96	3.56	2.96	2.39
478	xxx	3.54	2.66	3.75	3.70	3.47	3.21	3.08	3.64	3.07	2.54
479	xxx	4.24	3.19	4.43	4.32	4.09	3.83	3.71	4.28	3.66	3.03
480	3.73	3.85	xxx	4.01	3.91	3.64	3.36	3.23	3.86	3.21	2.58
481	3.08	3.38	xxx	3.53	3.45	3.18	2.92	2.78	3.42	2.82	2.30
482	xxx	xxx	2.97	4.13	4.07	xxx	3.61	3.48	4.02	3.45	2.94
483	4.41	xxx	3.24	4.53	4.44	xxx	3.87	3.72	4.37	3.69	3.05
484	3.91	xxx	2.98	4.26	4.10	3.81	3.49	3.34	4.07	3.39	2.75
485	3.25	3.62	2.72	3.88	3.78	3.52	3.27	3.16	3.74	3.18	2.63
486	3.70	xxx	2.95	4.17	4.13	xxx	3.57	3.44	4.05	3.45	2.85
487	4.93	xxx	3.54	4.98	4.88	xxx	4.24	4.06	4.80	4.03	3.29
488	4.60	4.52	3.19	4.66	4.52	4.17	3.84	3.65	4.46	3.66	2.91
489	4.02	4.11	3.00	4.26	4.15	3.84	3.56	3.41	4.11	3.43	2.80
490	4.07	4.13	2.99	4.29	4.19	3.87	3.56	3.40	4.15	3.44	2.76
491	5.08	4.98	3.43	5.10	4.96	4.61	4.23	4.04	4.90	4.01	3.17
492	5.22	4.98	3.29	5.03	4.86	4.47	4.05	3.82	4.81	3.82	2.91
493	3.85	3.97	2.78	4.14	4.04	xxx	3.31	3.10	3.99	3.21	2.48
494	4.80	xxx	3.21	4.76	4.70	xxx	3.90	3.67	4.49	3.76	2.96
495	5.82	xxx	3.66	5.48	5.39	xxx	4.55	4.31	5.15	4.29	3.36
496	5.20	4.96	3.39	5.03	4.88	xxx	4.04	3.80	xxx	3.80	2.87
497	4.95	4.73	3.18	4.83	4.70	xxx	3.86	3.63	4.62	3.66	2.76
498	5.35	xxx	3.42	5.11	5.02	xxx	4.15	3.90	4.89	3.92	2.97
499	6.21	xxx	3.71	5.73	5.58	xxx	4.63	4.37	5.43	4.31	3.27
500	6.11	5.52	3.45	5.54	5.32	xxx	4.25	3.93	5.19	3.96	2.88
501	5.06	xxx	3.10	4.79	4.64	xxx	3.68	3.37	4.51	3.48	2.54
502	5.80	xxx	3.60	5.42	xxx	xxx	4.43	4.16	4.90	4.18	3.20
503	6.65	xxx	3.83	5.94	xxx	xxx	4.80	4.51	5.35	4.48	3.38
504	6.38	xxx	3.68	5.75	5.57	xxx	4.52	4.22	5.30	4.22	3.12
505	5.72	xxx	3.41	5.27	5.12	xxx	4.10	3.81	4.87	3.89	2.85
506	6.04	xxx	3.66	5.55	xxx	xxx	4.46	4.18	4.93	4.24	3.22
507	6.66	xxx	3.90	6.05	xxx	xxx	4.86	4.55	5.38	4.58	3.48
508	xxx	xxx	3.65	5.69	5.50	xxx	4.46	4.15	5.28	4.15	3.02
509	5.91	xxx	3.48	5.32	5.17	xxx	4.18	3.89	4.95	3.92	2.88
510	5.83	xxx	3.56	5.31	5.18	xxx	4.24	3.97	4.94	3.98	3.00
511	6.40	xxx	3.74	5.70	5.53	xxx	4.53	4.26	5.30	4.24	3.17
512	6.40	xxx	3.69	5.79	5.60	xxx	4.54	4.24	5.36	4.26	3.14
513	5.58	xxx	3.35	5.09	4.94	xxx	3.94	3.66	4.70	3.74	2.75
514	5.46	xxx	3.57	5.29	xxx	xxx	4.31	4.07	4.78	4.11	3.20
515	6.03	xxx	3.67	5.47	xxx	xxx	4.46	4.20	4.93	4.22	3.25
516	5.63	xxx	3.52	5.19	5.06	xxx	4.18	3.94	4.86	3.98	3.10
517	5.59	xxx	3.50	5.16	5.04	xxx	4.17	3.93	4.85	3.97	3.10
518	5.14	4.71	3.36	4.92	4.82	xxx	4.02	3.79	4.70	3.82	2.94
519	5.03	4.73	3.42	4.97	4.86	xxx	4.11	3.90	4.75	3.90	3.04
520	4.98	4.56	3.10	4.68	4.52	xxx	3.71	3.48	4.42	3.54	2.67

521	4.98	4.69	3.22	4.78	4.65	xxx	3.84	3.61	4.56	3.66	2.81
522	5.36	xxx	3.39	5.16	5.04	xxx	4.17	3.92	4.91	3.95	3.03
523	4.31	xxx	2.84	4.36	4.27	xxx	3.44	3.22	4.14	3.30	2.49
524	xxx	xxx	3.01	4.31	4.23	xxx	3.59	3.43	4.15	3.48	2.83
525	xxx	xxx	3.39	4.91	4.79	xxx	4.13	3.97	4.71	3.96	3.19
526	4.26	4.20	2.92	4.34	4.21	xxx	3.51	3.33	4.15	3.36	2.60
527	3.74	3.89	2.78	4.07	3.98	xxx	xxx	xxx	3.92	3.19	2.52
528	3.53	3.83	2.76	3.98	3.93	3.62	3.32	3.16	3.86	3.17	2.53
529	4.11	4.34	3.06	4.45	4.38	4.07	3.77	3.62	4.31	3.55	2.84
530	3.93	4.13	2.80	4.23	4.12	3.77	3.42	3.24	4.05	3.20	2.45
531	2.95	3.34	2.34	3.51	3.42	3.07	2.77	2.60	3.36	2.65	2.05
532	3.18	3.63	2.74	3.82	3.78	3.55	3.34	3.23	3.72	3.18	2.66
533	4.15	4.47	3.12	4.51	4.38	4.14	3.88	3.74	4.33	3.63	2.94
534	3.75	4.07	2.74	4.09	3.90	3.59	3.27	3.10	3.86	3.09	2.38
535	2.82	xxx	2.42	3.57	3.47	3.18	2.90	2.76	3.60	2.79	2.22
536	2.82	3.28	2.46	3.44	3.40	3.17	2.95	2.84	3.35	2.80	2.31
537	4.17	4.31	3.06	4.36	4.28	4.03	3.76	3.63	4.23	3.48	2.83
538	4.59	4.73	3.06	4.85	4.72	4.27	3.86	3.62	4.61	3.58	2.62
539	3.93	3.87	2.55	3.99	3.90	3.45	3.05	2.80	3.78	2.88	2.00
540	xxx	3.57	2.65	3.73	3.70	3.44	3.18	3.04	3.62	3.06	2.53
541	xxx	3.97	2.89	4.11	4.04	3.79	3.56	3.44	3.98	3.36	2.80
542	3.79	3.75	2.64	3.84	3.75	3.43	3.15	2.99	3.70	2.97	2.32
543	2.79	3.20	2.33	3.34	3.31	3.02	2.76	2.62	3.24	2.63	2.10
544	3.40	3.66	2.71	3.78	3.78	3.49	3.21	3.06	3.69	3.06	2.47
545	4.25	4.41	3.13	4.46	4.43	4.12	3.84	3.70	4.34	3.59	2.86
546	3.98	4.10	2.80	4.16	4.07	3.68	3.34	3.12	4.00	3.16	2.38
547	3.00	3.32	2.37	3.49	3.45	3.12	2.83	2.61	3.37	2.65	2.02
548	3.43	3.80	2.81	3.96	3.94	3.62	3.32	3.10	3.85	3.21	2.61
549	4.08	4.33	3.09	4.44	4.40	4.07	3.75	3.53	4.30	3.54	2.80
550	4.10	4.25	3.00	4.35	4.18	3.88	3.51	3.27	4.16	3.39	2.65
551	3.51	3.78	2.72	3.92	3.87	3.50	3.18	2.93	3.76	3.06	2.40
552	3.71	3.95	2.90	4.13	4.13	3.76	3.45	3.22	4.01	3.28	2.60
553	4.29	4.43	3.21	4.58	4.53	4.14	3.78	3.54	4.40	3.61	2.86
554	4.16	4.26	3.03	4.43	4.35	3.98	3.65	3.42	4.22	3.41	2.62
555	3.74	3.87	2.78	4.05	3.99	3.61	3.30	3.07	3.88	3.11	2.39
556	3.83	xxx	2.95	4.24	4.22	3.89	3.63	3.44	4.11	3.36	2.70
557	5.05	4.86	3.42	4.98	4.87	4.48	4.15	3.95	4.75	3.87	3.10
558	xxx	4.39	2.87	4.47	4.34	3.87	3.47	3.23	4.20	3.20	2.31
559	xxx	4.06	2.75	4.19	4.11	3.66	3.29	3.05	3.98	3.04	2.23
560	4.38	4.43	3.07	4.54	4.47	4.07	3.71	3.47	4.35	3.49	2.75
561	4.67	xxx	3.20	4.79	4.72	4.35	4.00	3.76	4.60	3.69	2.85
562	4.62	xxx	2.94	4.47	4.34	3.88	3.47	3.16	4.23	3.27	2.38
563	4.07	4.14	2.81	4.23	4.12	3.69	3.31	3.00	4.00	3.12	2.33
564	4.10	4.30	2.98	4.41	4.36	3.93	3.55	3.22	4.24	3.35	2.55
565	4.41	xxx	3.04	4.55	4.50	4.06	3.66	3.34	4.36	3.44	2.60
566	4.37	xxx	3.05	4.61	4.51	4.05	3.63	3.30	4.38	3.45	2.61
567	4.20	4.37	2.98	4.49	4.40	3.95	3.55	3.22	4.27	3.33	2.51
568	4.24	4.15	2.85	4.22	4.16	3.77	3.41	3.12	4.04	3.17	2.40
569	4.62	4.57	3.06	4.69	4.60	4.18	3.77	3.46	4.48	3.55	2.68
570	4.77	4.59	2.95	4.64	4.53	4.03	3.56	3.20	4.37	3.30	2.29
571	4.27	4.19	2.80	4.24	4.15	3.67	3.24	2.90	4.00	3.04	2.16
572	4.38	4.42	3.04	4.59	4.50	4.08	3.69	3.40	4.36	3.44	2.61
573	4.30	4.25	2.92	4.36	4.28	3.85	3.46	3.17	4.14	3.22	2.42
574	4.42	4.43	3.10	4.57	4.49	4.08	3.70	3.42	4.37	3.47	2.69
575	4.32	4.35	3.04	4.52	4.44	4.04	3.66	3.39	4.31	3.41	2.62
576	3.99	4.23	3.03	4.37	4.33	3.96	3.64	3.42	4.21	3.40	2.69
577	4.21	4.38	3.10	4.54	4.47	4.09	3.76	3.54	4.36	3.52	2.76
578	3.96	4.13	2.88	4.28	4.19	3.79	3.43	3.17	4.07	3.18	2.40

579	4.34	4.55	3.11	4.65	4.52	4.10	3.73	3.45	4.40	3.48	2.67
580	3.96	4.09	2.66	4.20	4.07	3.66	3.31	3.03	3.94	3.02	2.18
581	3.35	3.45	2.39	3.57	3.50	3.11	2.78	2.51	3.39	2.59	1.88
582	3.68	3.86	2.76	3.99	3.94	3.62	3.35	3.14	3.84	3.09	2.43
583	4.50	4.61	3.12	4.71	4.63	4.26	3.95	3.72	4.52	3.62	2.80
584	3.86	4.07	2.61	4.17	4.06	3.63	3.29	3.03	3.93	2.94	2.09
585	3.13	3.51	2.36	3.66	3.57	3.17	2.83	2.60	3.47	2.58	1.84
586	3.70	3.94	2.71	3.99	3.94	3.64	3.31	3.12	3.87	3.03	2.31
587	4.11	4.27	2.86	4.27	4.21	3.91	3.59	3.39	4.12	3.26	2.49
588	3.90	4.03	2.69	4.09	4.01	3.67	3.34	3.14	3.88	3.02	2.24
589	3.09	3.45	2.37	3.60	3.54	3.21	2.90	2.69	3.44	2.64	1.96
590	3.47	3.86	2.78	4.02	3.97	3.71	3.43	3.26	3.88	3.15	2.52
591	4.15	4.33	3.00	4.40	4.32	4.03	3.71	3.55	4.20	3.39	2.64
592	3.66	3.92	2.67	4.02	3.92	3.57	3.28	3.11	3.81	3.00	2.28
593	3.13	3.44	2.47	3.59	3.50	3.17	2.91	2.74	3.40	2.70	2.08
594	xxx	3.95	2.77	4.08	4.01	3.68	3.40	3.22	3.89	3.15	2.46
595	xxx	4.96	3.28	5.02	4.88	4.49	4.17	3.97	4.75	3.81	2.97
596	xxx	4.19	2.47	4.27	4.08	3.60	3.21	2.92	3.96	2.88	1.89
597	xxx	xxx	2.21	3.64	3.55	3.12	2.78	2.52	3.47	2.53	1.67
598	xxx	xxx	2.35	3.62	3.58	3.29	3.04	2.87	3.51	2.75	2.06
599	xxx	4.26	2.65	4.29	4.17	3.84	3.53	3.32	4.08	3.15	2.32
600	xxx	5.03	2.99	5.11	4.97	4.48	4.05	3.75	4.84	3.69	2.53
601	3.84	4.12	2.64	4.23	4.17	3.74	3.38	3.11	4.03	3.10	2.14
602	3.86	4.09	2.69	4.27	4.25	3.85	3.50	3.24	4.13	3.22	2.37
603	4.82	4.83	2.99	4.93	4.85	4.44	4.06	3.76	4.71	3.66	2.70
604	5.26	5.09	3.05	5.16	5.04	4.50	4.00	3.62	4.90	3.74	2.59
605	4.83	4.57	2.81	4.68	4.58	4.06	3.60	3.26	4.40	3.34	2.26
606	5.33	4.84	3.11	4.89	4.79	4.26	3.82	3.48	4.67	3.60	2.66
607	6.26	5.80	3.47	5.81	5.67	5.07	4.56	4.16	5.51	4.24	3.12
608	4.96	4.76	2.65	4.83	4.63	4.00	3.45	2.99	4.46	3.18	2.02
609	4.99	4.84	2.74	4.92	4.74	4.12	xxx	3.12	4.57	3.33	2.16
610	5.41	5.06	2.76	5.04	4.86	4.17	3.55	3.02	4.71	3.31	2.02
611	6.11	5.61	3.00	5.52	5.30	4.55	3.87	3.31	5.15	3.62	2.23
612	5.95	5.29	2.61	5.15	4.77	4.05	3.35	2.75	4.71	3.14	1.74
613	5.62	5.10	2.55	5.01	4.76	3.96	3.30	2.71	4.60	3.12	1.76
614	6.06	5.36	2.72	5.30	5.07	4.24	3.53	2.93	4.89	3.35	1.88
615	6.38	5.66	2.86	5.56	5.28	4.42	3.67	3.05	5.11	3.49	1.97
616	6.42	5.61	2.73	5.51	5.21	4.34	3.57	2.94	5.04	3.38	1.83
617	5.87	5.09	2.53	5.03	4.79	3.97	3.26	2.66	4.63	3.13	1.69
618	6.22	5.56	2.88	5.53	5.32	4.51	3.84	3.26	5.16	3.65	2.19
619	6.54	5.63	2.88	5.54	5.32	4.49	3.81	3.23	5.15	3.60	2.12
620	5.87	5.21	2.66	5.14	4.89	4.16	3.54	3.04	4.75	3.30	1.94
621	5.85	5.40	2.73	5.36	5.08	4.32	3.66	3.14	4.93	3.41	2.01
622	6.05	5.52	2.80	5.45	5.24	4.46	3.78	3.23	5.06	3.51	2.07
623	5.83	5.30	2.71	5.25	5.06	4.31	3.65	3.12	xxx	3.40	1.98
624	5.99	5.42	2.83	5.39	5.15	4.43	3.79	3.30	xxx	3.52	2.13
625	5.72	5.21	2.75	5.18	4.95	4.26	3.65	3.16	xxx	3.38	2.05
626	5.84	5.35	2.91	5.31	5.11	4.46	3.88	3.41	xxx	3.59	2.30
627	5.37	4.94	2.72	4.93	4.75	4.14	3.58	3.15	4.59	3.32	2.10
628	5.37	5.03	2.94	5.01	4.85	4.31	3.82	3.46	4.71	3.54	2.45
629	5.60	5.27	3.14	5.25	5.08	4.53	4.04	3.68	4.95	3.76	2.58
630	xxx	4.69	2.53	4.63	4.46	3.91	3.44	3.07	4.31	3.14	1.96
631	xxx	4.06	2.26	4.06	3.93	3.42	2.99	2.62	3.79	2.73	1.72
632	4.54	4.51	2.67	4.55	4.46	4.06	3.65	3.41	4.34	3.39	2.46
633	4.78	4.59	2.70	4.60	4.48	4.05	3.66	3.39	4.36	3.35	2.39
634	4.85	4.89	2.78	4.90	4.76	4.31	3.91	3.65	4.63	3.56	2.62
635	4.04	4.25	2.47	4.30	4.18	3.75	3.36	3.10	4.06	3.08	2.23
636	3.86	4.14	2.60	4.24	4.15	3.83	3.55	3.37	4.05	3.27	2.57

637	4.50	4.65	2.83	4.72	4.62	4.26	3.96	3.78	4.50	3.65	2.82
638	xxx	4.28	2.52	4.41	4.31	3.89	3.57	3.37	4.19	3.25	2.40
639	xxx	4.45	2.55	4.58	4.44	3.98	3.63	3.43	4.31	3.30	2.43
640	xxx	xxx	2.31	4.15	4.02	3.63	3.32	2.57	3.90	3.01	2.18
641	xxx	3.69	2.25	3.81	3.72	3.39	3.12	2.38	xxx	2.85	2.13
642	xxx	3.90	2.35	4.05	3.96	3.60	3.32	3.15	3.86	3.03	2.29
643	xxx	3.37	2.05	3.56	3.51	3.17	2.89	2.73	3.41	2.66	1.96
644	2.90	3.23	2.14	3.40	3.39	3.15	2.92	2.81	3.30	2.71	2.20
645	3.48	3.77	2.42	3.93	3.86	3.59	3.34	3.23	3.77	3.06	2.48
646	3.41	3.78	2.33	3.91	3.79	3.47	3.20	3.09	3.71	2.93	2.26
647	2.60	xxx	2.03	3.46	3.35	3.06	2.83	2.68	xxx	2.59	1.99
648	2.78	3.40	2.33	3.61	3.56	3.35	3.16	3.06	xxx	2.94	2.44
649	3.42	3.58	2.41	3.66	3.62	3.39	3.18	3.06	3.53	2.93	2.40
650	3.36	3.64	2.50	3.77	3.66	3.41	3.20	3.08	3.59	2.97	2.43
651	2.88	xxx	xxx	3.49	3.40	3.16	2.97	2.85	3.34	2.76	2.26
652	2.71	3.12	2.30	3.26	3.24	3.02	2.85	2.74	3.17	2.65	2.26
653	3.55	3.65	xxx	3.76	3.74	3.52	3.34	3.24	3.67	3.08	2.60
654	3.30	3.65	2.40	3.65	3.58	3.30	3.06	2.92	xxx	2.82	2.27
655	2.82	3.35	2.20	3.36	3.30	3.05	2.84	2.71	3.22	2.62	2.13
656	2.90	3.30	2.33	3.51	3.47	3.20	2.99	2.85	3.39	2.73	2.21
657	3.92	3.84	2.70	3.97	3.92	3.62	3.40	3.25	3.84	3.14	2.59
658	xxx	2.68	1.69	2.73	2.64	2.42	2.28	2.17	2.61	2.04	1.51
659	xxx	xxx	2.84	4.62	4.40	4.09	3.74	3.51	4.34	3.44	2.59
660	xxx	xxx	0.91	3.97	3.63	2.91	2.30	1.80	3.53	2.20	0.81
661	xxx	3.15	1.19	3.16	3.00	2.34	1.90	1.48	2.92	2.01	1.04
662	xxx	4.03	0.76	3.95	3.80	3.15	2.57	2.04	3.57	2.27	0.95
663	xxx	3.19	0.61	3.19	3.03	2.45	1.92	1.45	2.84	1.73	0.60
664	3.79	4.01	0.50	4.08	3.93	3.32	2.70	2.18	3.79	2.52	1.23
665	3.89	3.99	0.62	4.04	3.89	3.27	2.64	2.10	3.73	2.41	1.07
666	3.85	4.09	0.59	4.21	4.05	3.37	xxx	2.03	3.89	2.67	1.43
667	3.93	4.18	0.55	4.30	4.12	3.44	2.76	2.15	3.94	2.67	1.36
668	4.08	4.23	0.75	4.31	4.12	3.37	2.65	1.97	3.98	2.78	1.54
669	4.44	4.47	0.69	4.50	4.31	3.55	2.82	2.13	4.15	2.86	1.55
670	4.13	4.10	0.87	4.06	3.86	3.18	2.46	1.81	3.73	2.61	1.45
671	4.13	4.23	0.80	4.19	3.97	3.30	2.57	1.92	3.85	2.69	1.50
672	4.43	4.59	1.18	4.56	4.36	3.56	2.74	2.00	4.24	2.95	1.65
673	4.24	4.41	0.92	4.35	4.19	3.40	2.60	1.88	4.06	2.83	1.54
674	4.41	4.37	1.25	4.13	3.95	3.21	2.41	1.81	3.62	2.70	1.50
675	4.47	4.46	1.20	4.26	4.06	3.32	2.57	1.89	3.94	2.76	1.54
676	4.51	4.63	1.64	4.67	4.46	3.63	2.85	2.11	4.33	3.07	1.77
677	4.36	4.22	1.29	4.23	4.02	3.21	2.49	1.82	3.92	2.76	1.56
678	4.37	4.29	1.69	4.29	4.11	3.34	2.66	2.03	4.01	2.93	1.77
679	4.96	4.90	1.88	4.87	4.69	3.87	3.13	2.40	4.54	3.28	1.98
680	4.51	4.46	1.77	4.40	4.21	3.45	2.72	1.99	4.07	2.80	1.52
681	4.06	4.13	1.55	4.06	3.86	3.11	2.39	1.71	3.73	2.59	1.42
682	4.62	xxx	2.15	4.66	4.45	3.64	2.91	2.23	4.30	3.13	1.86
683	xxx	4.81	2.11	4.80	4.61	3.80	3.06	2.35	4.46	3.22	1.89
684	4.77	4.74	2.30	4.75	4.59	3.78	3.04	2.34	4.45	3.21	1.91
685	4.03	4.08	1.96	4.11	3.95	3.19	2.52	1.90	3.86	2.78	1.60
686	4.11	4.21	2.34	4.22	4.05	3.37	2.76	2.18	3.98	3.02	1.91
687	4.85	4.78	2.52	4.79	4.62	3.90	3.23	2.57	4.49	3.36	2.13
688	4.58	4.58	2.51	4.58	4.44	3.68	3.00	2.34	4.29	3.12	1.88
689	4.19	4.30	2.32	4.29	4.15	3.41	2.84	2.11	4.02	2.95	1.77
690	4.30	4.40	2.54	4.39	4.24	3.54	2.89	2.27	4.11	3.07	1.91
691	4.98	4.86	2.76	4.82	4.66	3.94	3.25	2.61	4.52	3.36	2.12
692	4.47	4.34	2.34	4.31	4.13	3.42	2.75	2.12	3.99	2.78	1.58
693	3.95	4.30	2.34	4.37	4.21	3.51	2.86	2.22	4.07	2.90	1.67
694	xxx	4.11	2.19	3.99	3.82	3.16	2.49	1.85	3.70	2.54	1.35

695	xxx	xxx	2.39	4.28	4.06	3.36	2.67	2.03	xxx	2.73	1.56
696	xxx	xxx	2.33	4.53	4.29	3.51	2.78	2.14	4.13	2.80	1.51
697	xxx	xxx	1.87	3.51	3.30	2.60	2.17	1.43	3.19	2.10	0.99
698	3.87	4.19	2.42	4.15	4.00	3.39	2.82	2.33	3.91	2.96	1.88
699	4.54	4.65	2.60	4.59	4.45	3.80	3.16	2.57	4.31	3.19	1.96
700	4.03	4.36	2.38	4.35	4.20	3.57	2.92	2.32	4.07	3.00	1.86
701	3.32	3.84	2.14	3.90	3.78	3.15	2.55	2.01	3.65	2.67	1.61
702	3.31	xxx	2.19	3.82	3.67	3.04	2.44	1.89	3.58	2.72	1.81
703	4.34	xxx	2.54	4.49	4.32	3.66	3.01	2.39	4.19	3.14	2.09
704	4.04	4.29	2.28	4.27	4.07	3.33	2.58	1.85	3.96	2.87	1.78
705	3.70	4.15	2.22	4.14	3.92	3.19	2.46	1.75	3.82	2.75	1.70
706	4.70	4.90	2.56	4.83	4.60	3.67	2.75	1.92	4.48	3.27	2.09
707	4.49	4.59	2.40	4.59	4.41	3.50	2.63	1.82	4.27	3.11	1.93
708	3.94	4.33	2.48	4.40	4.22	3.37	2.57	1.78	4.13	3.16	2.14
709	3.82	4.19	2.40	4.27	4.09	3.26	2.46	1.72	4.00	3.02	2.02
710	3.64	4.01	2.45	4.01	3.87	3.11	2.34	1.63	3.79	2.93	2.07
711	4.43	4.67	2.71	4.62	4.46	3.65	2.82	2.01	4.35	3.35	2.35
712	4.43	4.64	2.61	4.59	4.37	3.48	2.59	1.74	4.26	3.15	2.07
713	3.76	4.12	2.36	4.13	3.93	3.08	2.26	1.51	xxx	2.83	1.84
714	4.60	4.65	2.80	4.65	4.47	3.53	2.60	1.80	4.37	3.34	2.32
715	5.05	4.90	2.90	4.87	4.68	3.72	2.75	1.89	4.57	3.46	2.39
716	4.55	4.71	2.86	4.70	4.52	3.56	2.66	1.84	4.42	3.38	2.37
717	4.53	4.64	2.82	4.63	4.44	3.49	2.61	1.79	4.35	3.32	2.32
718	4.51	4.61	2.84	4.59	4.40	3.44	2.55	1.72	4.31	3.26	2.29
719	5.39	5.22	3.06	5.14	4.94	3.94	2.99	2.07	xxx	3.63	2.53
720	5.50	5.18	2.92	5.13	4.86	3.75	2.73	1.77	4.73	3.40	2.19
721	5.08	4.98	2.86	4.99	4.73	3.64	2.65	1.73	4.61	3.35	2.17
722	5.41	5.07	2.92	5.02	4.79	3.71	2.63	1.68	4.68	3.40	2.21
723	5.61	5.25	2.98	5.16	4.94	3.85	2.76	1.79	4.81	3.47	2.25
724	5.82	5.33	2.96	5.14	4.86	3.74	2.63	1.34	4.73	3.38	2.14
725	5.76	5.39	2.98	5.23	4.95	3.83	2.72	1.43	4.82	3.45	2.18
726	6.07	5.47	3.03	5.36	5.08	3.89	2.71	1.69	4.95	3.53	2.20
727	5.69	5.08	2.86	4.98	4.70	3.55	2.43	1.51	4.59	3.27	2.03
728	5.76	5.25	3.07	5.12	4.83	3.68	2.58	1.65	4.74	3.52	2.40
729	6.00	5.52	3.15	5.37	5.08	3.90	2.75	1.74	4.96	3.65	2.45
730	5.90	5.40	3.09	5.30	5.02	3.82	2.66	1.64	4.90	3.56	2.32
731	5.57	5.15	2.99	5.06	4.78	3.62	2.50	1.54	4.68	3.41	2.22
732	5.46	5.15	3.07	5.02	4.74	3.62	2.53	1.59	4.65	3.47	2.39
733	6.24	5.70	3.27	5.51	5.22	4.05	2.90	1.85	5.09	3.75	2.55
734	6.03	5.40	2.99	5.25	4.97	3.78	2.64	1.59	4.84	3.44	2.19
735	5.26	4.86	2.80	4.78	4.52	3.38	2.31	1.39	4.45	3.18	2.04
736	5.14	4.85	2.88	4.73	4.48	3.40	2.37	1.32	4.40	3.22	2.18
737	5.93	5.54	3.15	5.34	5.06	3.93	2.82	1.62	4.92	3.59	2.42
738	5.75	5.36	2.89	5.20	4.92	3.75	2.62	1.57	4.79	3.37	2.09
739	4.92	xxx	2.62	4.56	4.29	3.18	2.14	1.27	4.20	3.00	1.85
740	xxx	4.55	2.69	4.51	4.27	3.26	2.31	1.50	4.16	3.07	2.09
741	5.59	5.18	2.97	5.05	4.81	3.73	2.69	1.72	4.67	3.40	2.30
742	5.12	4.91	2.65	4.81	4.59	3.58	2.58	1.66	4.45	3.13	1.92
743	4.13	4.23	2.40	4.24	4.03	3.07	2.13	1.33	3.95	2.83	1.73
744	4.16	4.27	2.58	4.27	4.10	3.27	2.47	1.79	4.00	2.97	1.99
745	4.75	4.76	2.77	4.66	4.46	3.56	2.69	1.89	4.34	3.16	2.12
746	4.68	4.78	2.68	4.71	4.52	3.68	2.90	2.19	4.39	3.14	2.05
747	3.50	3.96	2.35	4.02	3.85	3.05	2.30	1.66	xxx	2.71	1.75
748	3.42	3.91	2.54	3.98	3.87	3.32	2.76	2.30	3.76	2.88	2.07
749	4.18	4.38	2.69	4.32	4.17	3.59	3.01	2.51	4.06	3.07	2.19
750	4.07	4.36	2.64	4.32	4.16	3.64	3.13	2.70	4.04	3.04	2.15
751	2.88	3.47	2.24	3.54	3.41	2.91	2.42	2.00	3.33	2.47	1.73
752	3.08	3.76	2.62	3.87	3.79	3.42	3.05	2.75	3.70	2.95	2.34

753	3.91	xxx	2.77	4.18	4.09	3.71	3.33	3.03	3.96	3.15	2.46
754	3.50	3.94	2.64	4.00	3.94	3.59	3.27	3.03	3.79	2.99	2.32
755	3.22	3.67	2.51	3.76	3.69	3.34	3.02	2.81	3.59	2.80	2.16
756	2.48	3.00	2.11	3.06	3.01	2.81	2.61	2.49	2.95	2.34	1.84
757	3.32	3.69	2.44	3.74	3.64	3.38	3.13	2.97	3.57	2.85	2.23
758	3.52	3.82	2.40	3.88	3.75	3.40	3.10	2.88	3.66	2.76	2.00
759	2.69	3.22	2.14	3.34	3.26	2.95	2.69	2.50	3.18	2.42	1.78
760	2.65	3.14	2.12	3.23	3.18	2.94	2.72	2.58	3.09	2.40	1.83
761	2.97	3.27	2.20	3.32	3.27	3.02	2.79	2.64	3.19	2.48	1.89
762	3.46	3.95	2.68	4.10	4.03	3.72	3.46	3.29	3.91	3.12	2.40
763	2.99	3.49	2.38	3.65	3.58	3.26	2.99	2.82	3.48	2.68	2.00
764	2.36	2.76	2.04	2.82	2.80	2.64	2.48	2.41	2.75	2.25	1.87
765	3.17	3.55	2.45	3.57	3.51	3.34	3.17	3.08	3.46	2.88	2.36
766	3.34	3.80	2.43	3.85	3.72	3.41	3.10	2.90	3.67	2.77	2.01
767	xxx	3.10	2.05	2.98	2.87	2.57	2.29	2.11	2.82	2.08	1.50
768	xxx	xxx	2.66	3.41	3.38	3.23	3.10	3.03	3.30	2.88	2.51
769	xxx	xxx	2.61	3.60	3.57	3.42	3.27	3.18	3.51	3.02	2.56
770	xxx	3.88	2.78	4.06	3.98	3.69	3.97	3.27	3.92	3.16	2.45
771	3.02	3.29	2.40	3.44	3.38	3.10	xxx	2.75	3.32	2.67	2.09
772	3.08	3.41	2.58	3.46	3.48	3.29	3.14	3.07	3.42	2.88	2.44
773	3.78	4.16	3.01	4.22	4.20	3.99	3.76	3.67	4.13	3.42	2.79
774	3.75	4.10	2.90	4.13	4.02	3.76	3.49	3.37	3.98	3.22	2.59
775	3.50	4.10	2.86	4.09	4.01	3.75	3.51	3.39	xxx	3.25	2.63
776	3.69	4.22	2.96	4.27	4.23	3.95	3.71	3.59	xxx	3.41	2.72
777	3.77	4.05	2.93	4.16	4.12	3.84	3.57	3.44	4.05	3.29	2.61
778	4.19	4.29	3.08	4.34	4.27	3.99	3.70	3.55	4.18	3.40	2.70
779	4.11	4.37	3.13	4.47	4.38	4.09	3.82	3.66	4.29	3.51	2.81
780	4.12	4.38	3.15	4.53	4.45	4.17	3.91	3.78	4.37	3.57	2.86
781	4.08	4.14	2.97	4.29	4.21	3.92	3.63	3.49	4.12	3.32	2.62
782	4.46	4.47	3.24	4.56	4.47	4.15	3.89	3.74	4.35	3.60	2.88
783	4.37	4.43	3.20	4.53	4.43	4.11	3.86	3.71	4.32	3.58	2.86
784	4.49	xxx	3.32	4.76	4.70	xxx	4.10	3.94	4.58	3.80	3.05
785	4.28	xxx	3.10	4.52	4.46	xxx	3.85	3.71	4.35	3.55	2.80
786	4.46	xxx	3.23	4.56	4.47	xxx	3.90	3.76	4.35	3.62	2.92
787	4.94	xxx	3.52	4.95	4.86	xxx	4.26	4.09	4.72	3.95	3.18
788	4.73	xxx	3.45	4.93	4.86	xxx	4.19	4.03	4.72	3.88	3.09
789	4.35	xxx	3.21	4.57	4.54	xxx	3.88	3.74	4.40	3.60	2.87
790	4.54	xxx	3.26	4.57	4.51	xxx	3.87	3.74	4.38	3.60	2.88
791	5.08	xxx	3.62	5.11	5.00	xxx	4.35	4.20	4.86	4.03	3.25
792	5.00	xxx	3.54	5.15	5.04	xxx	4.33	4.15	4.89	4.00	3.17
793	4.31	xxx	3.14	4.65	4.55	xxx	3.86	3.69	4.43	3.59	2.82
794	4.55	xxx	3.25	4.61	4.52	xxx	3.88	3.73	4.39	3.61	2.89
795	5.48	xxx	3.73	5.27	5.16	xxx	4.45	4.28	4.99	4.12	3.31
796	5.25	xxx	3.52	5.27	5.15	xxx	4.42	4.22	4.97	4.08	3.20
797	xxx	xxx	2.71	4.00	3.92	xxx	3.29	3.13	3.78	3.08	2.39
798	xxx	xxx	3.01	4.17	4.13	xxx	3.70	3.61	3.97	3.49	2.93
799	xxx	xxx	3.84	5.34	5.25	xxx	4.76	4.63	5.07	4.41	3.67
800	4.90	4.77	3.34	4.89	4.75	4.40	4.06	3.88	4.67	3.77	2.96
801	4.07	4.13	2.99	4.28	4.18	3.83	3.52	3.36	4.12	3.33	2.63
802	4.39	4.30	3.13	4.49	4.39	3.91	3.73	3.56	4.32	3.52	2.81
803	5.44	5.45	3.74	5.61	5.47	4.97	4.75	4.55	5.38	4.38	3.49
804	4.88	4.80	3.14	4.81	4.68	4.28	3.92	3.71	4.62	3.59	2.73
805	3.96	4.09	2.85	4.16	xxx	3.73	3.42	3.25	4.03	3.19	2.47
806	4.09	4.06	2.86	4.12	xxx	3.73	3.44	3.30	3.98	3.19	2.49
807	5.06	4.88	3.25	4.90	4.74	4.43	4.09	3.92	4.69	3.74	2.92
808	4.88	4.85	3.08	4.89	4.70	4.31	3.90	3.68	4.63	3.53	2.57
809	3.57	3.84	2.60	3.97	3.83	3.48	3.13	2.96	3.75	2.89	2.12
810	3.90	4.01	2.89	4.21	4.12	3.84	3.57	3.45	4.05	3.30	2.65

811	4.95	4.66	3.19	4.76	4.65	4.34	4.03	3.88	4.58	3.67	2.90
812	4.50	4.57	3.08	4.70	4.55	4.22	3.92	3.75	4.49	3.57	2.81
813	3.68	3.77	2.61	3.91	3.82	3.50	3.23	3.08	3.75	2.98	2.33
814	3.62	3.83	2.72	3.83	3.79	3.52	3.28	3.19	3.72	3.07	2.52
815	4.48	4.66	3.19	4.66	4.56	4.28	4.01	3.90	4.50	3.68	2.99
816	4.46	4.56	3.11	4.66	4.48	4.18	3.87	3.72	xxx	3.55	2.80
817	3.41	3.76	2.66	3.93	3.83	3.53	3.24	3.11	xxx	3.03	2.37
818	3.92	4.13	3.01	4.25	4.23	3.93	3.65	3.53	xxx	3.43	2.74
819	4.52	4.60	3.29	4.70	4.60	4.31	4.01	3.88	4.55	3.73	2.99
820	4.49	4.58	3.24	4.71	4.55	4.27	xxx	3.84	4.50	3.67	2.91
821	4.02	4.25	3.05	4.41	4.30	4.02	xxx	3.60	4.27	3.49	2.76
822	3.90	4.13	3.01	4.27	4.22	3.94	3.68	3.56	4.17	3.42	2.73
823	4.49	4.60	3.25	4.65	4.55	4.26	3.97	3.83	4.50	3.67	2.93
824	4.70	4.77	3.29	4.78	4.66	4.34	4.04	3.88	4.60	3.71	2.95
825	4.30	4.52	3.12	4.56	4.45	4.12	3.81	3.64	4.42	3.53	2.79
826	4.33	4.52	3.18	4.59	4.51	4.21	3.90	3.75	4.48	3.63	2.87
827	4.60	4.59	3.27	4.67	4.60	4.30	4.00	3.84	4.54	3.70	2.93
828	4.88	4.81	3.41	4.91	4.81	4.48	4.18	4.00	4.72	3.86	3.06
829	4.83	4.80	3.39	4.92	4.81	4.47	4.17	3.97	4.73	3.85	3.04
830	4.80	4.70	3.32	4.80	4.72	4.37	4.00	3.87	4.65	3.74	2.93
831	4.83	4.67	3.31	4.75	4.67	4.32	3.94	3.81	4.59	3.69	2.89
832	4.95	4.86	3.41	4.93	4.80	4.42	4.15	3.97	4.69	3.79	3.03
833	5.39	5.29	3.60	5.38	5.18	4.78	4.49	4.28	5.07	4.08	3.24
834	5.21	5.08	3.38	5.12	4.93	4.55	4.17	3.99	4.86	3.81	2.88
835	4.89	4.78	3.29	4.80	4.67	4.32	3.96	3.80	4.61	3.65	2.79
836	5.01	4.72	3.28	4.77	4.61	4.30	3.96	3.78	4.55	3.65	2.85
837	5.68	5.32	3.54	5.33	5.13	4.76	4.40	4.19	5.04	4.02	3.13
838	5.61	5.16	3.34	5.25	5.07	4.59	4.19	3.94	4.95	3.78	2.78
839	4.87	4.51	3.07	4.61	4.49	4.06	3.70	3.48	4.39	3.37	2.50
840	4.89	4.74	3.32	4.92	4.82	4.48	4.19	4.00	4.76	3.83	3.06
841	5.98	5.18	3.51	5.30	5.15	4.79	4.46	4.24	5.09	4.08	3.19
842	5.37	4.78	3.17	4.85	4.70	4.33	3.98	3.77	4.63	3.63	2.77
843	4.87	4.62	3.11	4.73	4.60	4.24	3.91	3.72	4.53	3.58	2.75
844	4.97	4.70	3.15	4.82	4.67	4.28	3.92	3.67	4.59	3.59	2.73
845	5.88	5.48	3.48	5.53	5.34	4.87	4.47	4.21	5.25	4.07	3.07
846	5.65	5.07	3.08	5.04	4.87	4.34	3.93	3.65	4.77	3.53	2.47
847	4.37	4.19	2.75	4.25	4.14	3.72	3.37	3.17	4.05	3.07	2.20
848	4.62	4.46	3.01	4.58	4.40	4.07	3.75	3.58	4.34	3.42	2.62
849	5.74	5.38	3.38	5.43	5.20	4.76	4.37	4.12	5.14	3.94	2.95
850	5.51	5.07	3.03	5.04	4.89	4.38	3.93	3.65	4.81	3.50	2.41
851	4.16	3.99	2.61	4.06	3.98	3.58	3.22	3.01	3.90	2.89	2.04
852	4.27	4.19	2.89	4.27	4.15	3.85	3.58	3.42	4.09	3.24	2.52
853	5.32	5.04	3.22	5.07	4.86	4.48	4.16	3.94	4.78	3.73	2.83
854	5.18	4.87	3.00	4.86	4.70	4.24	3.87	3.62	4.60	3.43	2.45
855	3.87	3.87	2.59	3.92	3.85	3.48	3.17	2.98	3.77	2.84	2.06
856	3.77	3.89	2.77	3.98	3.91	3.65	3.40	3.28	3.84	3.10	2.45
857	4.76	4.68	3.11	4.72	4.59	4.29	3.99	3.84	4.52	3.59	2.78
858	4.64	4.52	2.90	4.57	4.43	4.04	3.69	3.48	4.35	3.29	2.39
859	3.48	3.65	2.52	3.80	3.73	3.39	3.10	2.92	3.66	2.79	2.05
860	3.38	3.48	2.51	3.59	3.54	3.32	3.10	2.98	3.48	2.78	2.18
861	4.21	4.13	2.81	4.17	4.08	3.82	3.57	3.43	4.01	3.19	2.48
862	4.16	4.23	2.76	4.26	4.13	3.80	3.53	3.37	4.07	3.13	2.34
863	3.11	3.43	2.37	3.56	3.47	3.19	2.96	2.83	3.43	2.66	2.00
864	xxx	2.96	2.26	3.16	3.14	2.95	2.79	2.74	3.10	2.57	2.16
865	xxx	3.41	2.48	3.51	3.46	3.24	3.05	2.98	3.41	2.78	2.31
866	xxx	3.90	2.76	4.07	3.98	3.74	3.52	3.39	3.94	3.18	2.52
867	3.24	3.45	2.49	3.65	3.58	3.35	3.13	3.00	3.54	2.83	2.22
868	2.45	2.73	2.05	2.83	xxx	2.67	2.49	2.41	2.78	2.30	1.86

869	3.39	3.52	2.49	3.54	3.53	3.36	3.18	3.09	3.47	2.89	2.34
870	3.66	3.77	2.52	3.86	3.76	3.49	3.24	3.08	3.70	2.87	2.14
871	2.94	3.28	2.31	3.47	3.40	3.16	2.92	2.79	3.34	2.61	1.95
872	2.61	xxx	2.13	3.08	3.08	2.89	2.69	2.60	3.03	2.43	1.88
873	3.24	3.43	2.36	3.47	3.45	3.24	3.04	2.93	3.40	2.73	2.12
874	3.57	3.73	2.47	3.81	3.71	3.45	3.18	3.04	3.66	2.83	2.08
875	2.96	3.23	2.25	3.35	xxx	3.04	2.79	2.66	3.22	2.49	1.85
876	2.57	2.87	2.06	2.97	2.96	2.80	2.64	2.55	2.92	2.37	1.83
877	2.87	3.05	2.15	3.13	3.12	2.95	2.78	2.68	3.07	2.50	1.94
878	3.12	3.35	2.34	3.44	3.42	3.23	3.03	2.93	3.34	2.68	2.07
879	xxx	3.44	2.30	3.53	3.50	3.29	3.08	2.97	3.42	2.72	2.06
880	xxx	3.08	2.09	3.16	3.13	2.93	2.75	2.63	3.09	2.46	1.84
881	3.10	3.30	2.22	3.33	3.30	3.09	2.90	2.77	3.30	2.59	1.95
882	3.50	3.73	2.46	3.78	3.73	3.49	3.24	3.09	3.71	2.86	2.13
883	3.47	3.63	2.40	3.70	3.63	3.39	3.15	3.00	3.57	2.78	2.06
884	3.18	xxx	2.24	3.38	3.33	3.12	2.94	2.83	3.27	2.60	1.99
885	3.22	3.51	2.29	3.50	3.45	3.25	3.05	2.94	xxx	xxx	2.04
886	3.74	3.86	2.53	3.92	3.81	3.57	3.31	3.14	3.76	2.91	2.14
887	3.78	4.01	2.58	4.07	3.94	3.68	3.42	3.25	3.90	3.02	2.23
888	3.62	3.77	2.37	3.79	3.70	3.43	3.15	2.98	3.64	2.75	1.95
889	3.38	xxx	2.28	3.57	3.50	3.25	2.98	2.82	3.42	2.60	1.86
890	3.98	4.07	2.72	4.15	4.03	3.78	3.52	3.37	3.97	3.12	2.32
891	4.13	4.25	2.79	4.35	4.20	3.93	3.67	3.50	4.16	3.24	2.39
892	4.00	4.08	2.61	4.10	4.00	3.71	3.42	3.23	3.92	2.98	2.14
893	3.74	3.79	2.48	3.83	3.77	3.50	3.21	3.04	3.68	2.79	2.00
894	4.10	3.95	2.68	4.02	3.93	3.69	3.42	3.26	3.87	2.99	2.19
895	4.74	4.45	2.88	4.46	4.32	4.04	3.75	3.56	4.26	3.28	2.39
896	4.55	4.34	2.71	4.36	4.23	3.88	3.55	3.33	4.15	3.08	2.13
897	3.97	3.91	2.54	3.99	3.91	3.61	3.32	3.14	3.83	2.87	2.00
898	4.48	4.26	2.80	4.17	4.06	3.78	3.48	3.31	3.97	3.06	2.24
899	5.09	4.76	2.99	4.62	4.45	4.12	3.77	3.56	4.37	3.32	2.39
900	4.77	4.54	2.82	4.51	4.35	3.98	3.61	3.38	4.26	3.17	2.21
901	3.99	3.91	2.54	3.97	3.87	3.53	3.19	3.01	3.78	2.81	1.98
902	4.42	4.11	2.78	4.13	4.01	3.72	3.40	3.24	3.93	3.02	2.25
903	5.44	4.90	3.12	4.83	4.65	4.29	3.91	3.69	4.56	3.47	2.54
904	5.28	4.88	2.94	4.89	4.73	4.23	3.79	3.51	4.62	3.35	2.26
905	4.28	3.92	2.54	3.96	3.87	3.44	3.06	2.84	3.77	2.73	1.85
906	4.66	xxx	2.93	4.36	4.22	3.91	3.61	3.45	4.15	3.27	2.50
907	6.04	5.49	3.42	5.50	5.26	4.82	4.45	4.20	5.17	3.98	2.94
908	5.45	5.11	3.02	5.07	4.88	4.35	3.93	3.63	4.78	3.47	2.32
909	4.22	4.11	2.63	4.17	4.07	3.66	3.30	3.07	3.99	2.93	1.99
910	4.51	4.36	2.84	4.35	4.20	3.84	3.53	3.35	4.12	3.17	2.37
911	5.67	5.31	3.23	5.22	4.99	4.52	4.15	3.90	4.89	3.70	2.71
912	5.66	5.14	3.03	5.12	4.93	4.38	3.94	3.63	4.82	3.47	2.33
913	4.18	3.98	2.56	4.12	4.03	3.61	3.25	3.02	3.92	2.87	1.94
914	4.33	4.21	2.91	4.30	4.21	3.90	3.62	3.46	4.11	3.24	2.46
915	5.62	5.20	3.28	5.14	4.95	4.52	4.17	3.94	4.86	3.73	2.76
916	5.22	4.87	2.97	4.87	4.70	4.24	3.86	3.61	4.61	3.40	2.37
917	4.08	3.95	2.61	4.08	4.00	3.67	3.35	3.20	3.92	2.93	2.13
918	4.30	4.07	2.77	4.22	4.13	3.83	3.53	3.42	4.05	3.12	2.38
919	5.50	4.97	3.12	4.97	4.81	4.40	4.04	3.83	4.72	3.58	2.62
920	5.51	5.03	3.04	5.00	4.84	4.35	3.95	3.68	4.73	3.47	2.40
921	4.26	4.17	2.70	4.28	4.18	3.77	3.43	3.21	4.09	3.02	2.11
922	4.17	4.04	2.75	4.12	4.04	3.73	3.45	3.28	3.96	3.06	2.29
923	5.11	4.85	3.02	4.70	4.56	4.19	3.89	3.68	4.47	3.42	2.53
924	5.15	4.98	3.03	4.80	4.63	4.22	3.89	3.65	4.54	3.40	2.44
925	4.11	3.92	2.76	3.95	3.85	3.51	3.19	3.01	3.78	2.85	2.09
926	4.46	4.20	2.95	4.29	4.20	3.90	3.62	3.48	4.13	3.28	2.54

927	5.24	4.93	3.15	4.96	4.81	4.46	4.15	3.96	4.72	3.68	2.75
928	xxx	4.82	3.02	4.86	4.72	4.31	3.95	3.71	4.63	3.51	2.55
929	xxx	4.49	2.97	4.54	4.41	4.03	3.71	3.52	4.34	3.31	2.47
930	xxx	4.36	2.78	4.41	4.29	3.90	3.59	3.39	4.22	3.22	2.38
931	4.61	4.45	2.82	4.51	4.40	4.03	3.72	3.51	4.32	3.32	2.46
932	4.65	4.53	2.90	4.62	4.45	4.13	3.83	3.63	4.39	3.40	2.56
933	4.40	4.41	2.80	4.54	4.38	4.06	3.74	3.55	4.33	3.32	2.46
934	4.19	4.20	2.73	4.30	4.18	3.87	3.54	3.38	4.14	3.19	2.38
935	4.37	4.30	2.76	4.34	4.22	3.91	3.59	3.43	4.16	3.24	2.42
936	4.61	4.52	2.90	4.60	4.43	4.09	3.76	3.57	xxx	3.38	2.51
937	4.92	4.74	2.99	4.81	4.64	4.29	3.95	3.76	xxx	3.52	2.61