Responsible Agency:

Mobile Bay National Estuary Program
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Mobile – Tensaw Delta Hydrological Modifications Impact Study

Final Report

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EXECUTIVE SUMMARY

Within the Delta proper, a large dike-like causeway built in the late 1920s has severed a number of once open bays from immediate contact with the waters of the Gulf of Mexico. By altering tidal exchange and volume of flow, this hydrological modification may have altered the ecological function and biodiversity of the Mobile-Tensaw Delta as well. To address this question, the Mobile Bay National Estuary Program funded a one year study designed to collect preliminary data assessing causeway impacts on the ecology of the lower Mobile-Tensaw Delta.

Based on the 2003-2004 continuous hydrographic monitoring and sampling events, short and long-term variations in the data were evident for the Mobile-Tensaw Delta sites. Continuous monitoring data documented that variability in water quality parameters can be great, changing on temporal scales ranging from days to months. Typical seasonal changes in temperature, salinity and dissolved oxygen occurred at all sites although the magnitude of these changes varied among sites. During all three major sampling events, significant differences in salinity, dissolved oxygen (mg/l), chlorophyll *a* and turbidity were documented among sites. Salinity was greatest on the western side of the Delta and south of the causeway, especially during August and October. Dissolved oxygen was highest in February but variable by site and month in June and October samplings. North of the causeway, thirteen hypoxic events were recorded in Justin's Bay between April and November 2004 and two hypoxic events were recorded in Chocolatta Bay compared with four hypoxic events at Meaher Park located south of the causeway. Hypoxic events were short lived at all three sites. Generally, chlorophyll *a* levels were low at all sites and for all sampling periods. Nutrient concentrations (ammonia, nitrate-nitrite, total Kjeldahl nitrogen and total phosphorus) also varied significantly suggesting a seasonal influence. Nutrient levels may also be influenced by water quality parameters (e.g. temperature, dissolved oxygen), rainfall, point source loadings and non-point source loadings.

Spatial variability was evident both within and among sites for benthic, fish and sediment collections as well. Significant or marginally significant differences among sites were detected with regard to number of species and total number of organisms in the February, June and October 2004 benthic collections. Based on BIO-ENV analyses, spatial differences in the benthic community composition were best explained by sediment grain size composition rather than water quality parameters and nutrients. Consistently, sites located south of the causeway had higher numbers of species and organisms than sites north of the causeway. Sites south of the causeway also had high percentages of sand while sites north of the causeway were characterized by higher levels of clay and silt. Northern site sediments were also characterized by significantly higher percentages of water and total carbon than sites south of the causeway. Fish species composition, number of species and number of organisms also differed north and south of the causeway during March and July 2004. Fish abundance and numbers of species were greater in collections made in Chocolatta Bay than collections south of the causeway. The composition and density of organisms was not influenced by habitat type (open, closed and riverbank sites).

Although this study was limited to a single year the documented biological and physical variability in the lower Mobile-Tensaw Delta suggests that effects of the dike-like causeway are widespread and ecologically important. Additionally, present and past land use may also affect

the magnitude of causeway impacts on the study area and will require additional evaluation. The western shore of the lower Mobile-Tensaw Delta is characterized by urban industrial development. As such, the impacts of the causeway on biotic and sediment characteristics documented in Polecat Bay, Delvan Bay, Chocolatta Bay and Mouth of Pinto Pass may be compounded by western shore land-use impacts. In contrast, the eastern shore is less developed with low levels of commercial and residential development and thus impacts of land use practices to these areas of the lower Mobile-Tensaw Delta may not be as detrimental as those on the western shore.

In summary, the results of this preliminary study point strongly towards a significant impact of the causeway on ecological function in the lower Mobile-Tensaw Delta. Interpretation of these impacts may be compounded by local land use practices with noticeable differences in benthic community composition and sediment characteristics along a west to east gradient. Given the intense short term episodic hydrographic variations superimposed upon causeway induced differences in sediment grain size, future studies should be multifaceted and include both additional monitoring and ecological experimentation to tease apart the impacts of local regional land use practices from causeway impacts on the ecology of the Mobile-Tensaw Delta.

PROJECT DESCRIPTION

OBJECTIVE AND SCOPE

The Mobile-Tensaw Delta is the terminus of the fourth largest watershed in the continental United States in terms of water volume, receiving 20% of our nation's freshwater supply. The Mobile-Tensaw Delta in turn empties into Mobile Bay. The Environmental Protection Agency designated the Mobile-Tensaw Delta and Mobile Bay as an Estuary of National Significance in 1995 by establishing the Mobile Bay National Estuary Program. Concerns in this watershed include water quality, habitat alteration and invasive species issues.

Since 1923, some 20 large dams and other major water control structures have been built on the Delta's two primary feeder streams – the Alabama/Coosa/ Tallapoosa and the Tombigbee/Black Warrior river systems. Within the Delta proper, a large dike-like causeway built in the late 1920s has sealed off a number of once open bays from immediate contact with the Gulf. In addition, hydrologic impacts may be forecast because of multi-state water compact negotiations. By altering the seasonal variation and volume of flows, these hydrological modifications have potentially altered the ecological function and biodiversity of one of North America's largest, most productive and diverse estuaries, on a local and system-wide basis.

Evidence has been found in studies of similar situations around the country showing that change occurs when the natural system is modified. In the Mobile-Tensaw Delta as well, these upstream and downstream modifications may have altered the productivity of ecological communities within the lower Delta via reduced salt and fresh water exchange and altered circulation patterns, resulting in changes in nutrient cycling and increased incidences of exotic and invasive plant species. A number of commercially and recreationally important species such as white shrimp and speckled trout have declined in response to reductions of available estuarine habitat. Prior to any attempts at restoration or remediation, hydrologic data and comprehensive ecological analyses are needed.

In the lower delta, continuous water quality monitoring at two permanent stations north of the causeway within the embayments recorded variations in temperature, salinity, dissolved oxygen and turbidity. Additionally, three continuous monitoring stations along the rivers recorded temperature and salinity. Data collected from the continuous monitoring stations were compared with data from the Meaher Park weather station. The Meaher Park weather station is located south of the causeway and is maintained by the Dauphin Island Sea Lab for the Mobile Bay National Estuary Program (MBNEP).

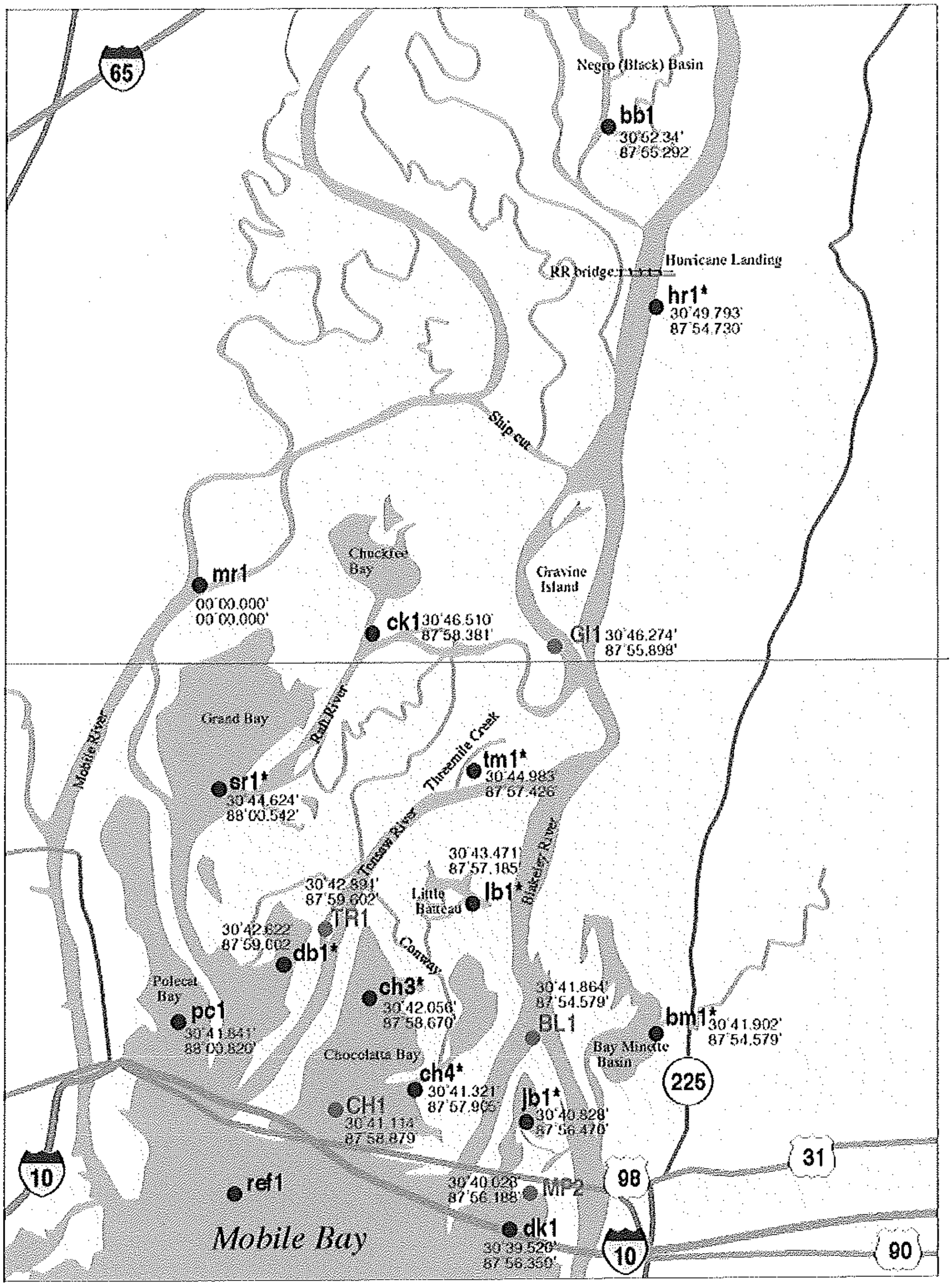
Biological data was collected to develop a better understanding of the ecological consequences of causeway influenced hydrological alterations of water quality and chemistry. We anticipated that these data would show the importance of the Delta in determining the productivity of both riverine and coastal ecosystems in Alabama, and perhaps the degree to which the causeway and upstream hydrological changes have reduced habitat function, ecosystem productivity and species and habitat diversity in the Delta. We compared and contrasted the measurements of hydrographic parameters (salinity, temperature and dissolved oxygen), community structure and composition (benthic invertebrates and fishes), and nutrient concentrations in embayments and riverbanks north and south of the causeway.

SAMPLING STATIONS

Continuous monitoring sites for the 2003 – 2004 study are identified in Figure 1, Figure 2 and Table 1. Continuous monitoring in Chocolatta Bay, Tensaw River, Gravine Island and Blakeley River was initiated in July 2003 and continued through April 22, 2004. From April 22, 2004 to November 17, 2004 the Chocolatta Bay YSI was "continuously" deployed and maintained. In May 2004, a monitoring station was added in Justin's Bay and was "continuously" deployed and maintained through November 17, 2004.

The Meaher Park weather station (Figures 1 and 2) began collecting meteorological data in September 2003. A YSI was placed at the site in January 2004 and continues to be maintained by the Dauphin Island Sea lab. Station information is available online at the Mobile Bay National Estuary Program site (http://www.mobilebaynep.com).

Mobile-Tensaw Delta biological sampling stations for 2003 - 2004 are presented in Figure 2 and Table 2. Study sites north of the causeway are representative of embayment and riverbank habitats which dominate this portion of the lower delta. Embayment and river sites vary with regard to water column turnover and retention time. Stations south of the causeway were located roughly parallel to the stations north of the causeway and provided representative reference sites that provided comparative data to assess the extent to which causeway induced alterations of hydrography have altered ecosystem fauna and production of the Mobile-Tensaw Delta.



Register graphic I

Figure 1. Map of the Mobile-Tensaw Delta continuous (red) monitoring sites for 2003 – 2004 (GI1 = Gravine Island, TR1 = Tensaw River, BL1 = Blakeley River, CH1 = Chocolatta Bay and MP2 = Meaher Park). GPS locations are listed for each site.

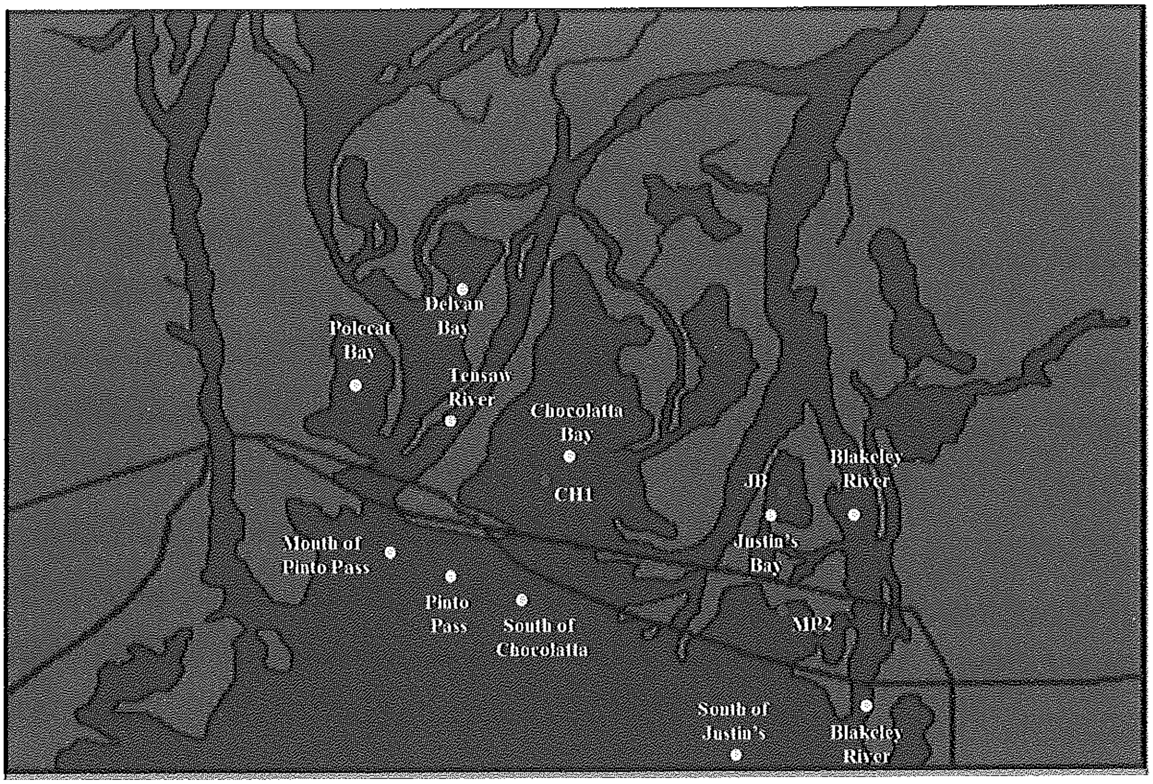


Figure 2. Mobile-Tensaw Delta biological monitoring sites (yellow) and continuous monitoring sites (red) are presented for 2003 – 2004 study. Continuous monitoring sites for 2003 – 2004 include Chocolatta Bay (CH1), Justin's Bay (JB) and Meaher Park (MP2). Location dots are not exact.

Table 1. Mobile-Tensaw Delta continuous monitoring stations for 2003 – 2004 are listed by site abbreviation and site name. The GPS location, instrument type and deployment times are given for each site.

Site Name	Site	Latitude	Longitude	Years	Instrument
Chocolatta Bay	CH1	30° 41.114	087⁰ 58.879	Sept. 2003 – April 2004; May 2004 – Dec. 2004	YSI 6600
Justin's Bay	Northeast of jb1	30° 41.091	87° 56.378	May 2004 – Dec. 2004	YSI 6600
Blakeley River	BL1	30⁰ 41.864'	087⁰ 54.579	Sept. 2003 – April 2004	Hydrolab Data Sonde
Gravine Island	GI1	30⁰ 46.274'	087⁰ 55.898'	Sept. 2003 – April 2004	Hydrolab Data Sonde
Tensaw River	TR1	30⁰ 42.894	087⁰ 59.602	Sept. 2003 – April 2004	Hydrolab Data Sonde
Meaher Park	MP1	30⁰ 40.028'	087⁰ 56.188'	Jan. 2004 – ongoing	YSI 6600

Table 2. Mobile-Tensaw Delta biological sampling stations occupied during 2003 - 2004 are listed by site name, site abbreviation, location with respect to the causeway (N = north, S = south) and treatment (O = open, C = closed, RB = riverbank). The latitude and longitude are given for each site from the initial sampling event.

Site Name	Site	North or South of Causeway	Treatment (OCR)	Latitude	Longitude
Polecat Bay	PB	N	O	N 30° 42.034	W 088° 00.712
Delvan Bay	DB	N	O	N 30° 42.796	W 087° 59.499
Tensaw Riverbank	RB1	N	RB	N 30° 42.095	W 087° 59.329
Chocolatta Bay	CB	N	C	N 30° 41.101	W 087° 58.871
Blakeley Riverbank	RB2	N	RB	N 30° 41.472	W 087° 55.903
Justin's Bay	JB	N	C	N 30° 40.902	W 087° 56.482
Mouth of Pinto Pass	Site 7	S	RB	N 30° 40.783	W 088° 00.529
Pinto Pass	Site 8	S	O	N 30° 40.653	W 088° 00.218
South of Chocolatta Bay	Site 9	S	O	N 30° 39.987	W 087° 59.327
South of Justin's Bay	Site 10	S	O	N 30° 38.637	W 087° 56.684
South Blakeley Riverbank	Site 11	S	RB	N 30° 38.841	W 087° 55.540

PROJECT SCHEDULE

The 2003 – 2004 sampling schedule for the Mobile-Tensaw Delta is found in Table 3.

Table 3. Sampling schedule for the 2003 – 2004 Mobile-Tensaw Delta project.

Tasks	August 2003	September 2003	February 2004	March 2004	April 2004	May 2004	June 2004	July 2004	August 2004	September 2004	October 2004	November 2004
Continuous Monitoring (4 sites)	X	X	X	X	X							
Continuous Monitoring YSIs (2 sites)					X	X	X	X	X	X	X	X
Benthic Sampling			X				X				X	
Sediment Sampling			X									
Fish Sampling				X				X				
Water Grab			X			X	X		X		X	
YSI (with Chl)			X			X	X	X	X		X	

SAMPLING METHODS

A Quality Assurance Project Plan (QAPP) (Mobile Bay Watch, Inc. / Mobile Baykeeper and Dauphin Island Sea Lab 2004) was prepared for the 2003 – 2005 Mobile – Tensaw Delta Hydrological Modifications Impact Study. Additional details of the sampling methods are found in the QAPP.

Continuous Monitoring

The Chocolatta YSI and Tensaw River, Blakeley River and Gravine Island hydrolabs were deployed July 28, 2003 and maintained continuously through April 22, 2004. From April 22, 2004 to November 17, 2004 the Chocolatta Bay YSI was "continuously" deployed and maintained. A YSI was deployed in Justin's Bay on May 4, 2004 and was "continuously" deployed and maintained until November 17, 2004.

A YSI 6600 equipped with an extended deployment system was moored in Chocolatta Bay (CH1) and Justin's Bay (Figure 2). The Chocolatta Bay YSI was moored just above the bottom. Because Justin's Bay is relatively shallow, the YSI was mounted horizontally on a PVC frame and the PVC frame was placed on the bottom with the instrument located just above the bottom. The YSIs were programmed to record water temperature, specific conductance, salinity, dissolved oxygen (mg/L and % saturation) and turbidity at 15-minute intervals. Salinity was calculated from specific conductance and temperature using an algorithm and recorded at the same interval. Deployed instruments were replaced at two to three week intervals. Beginning in April instruments were removed from the site and returned to the laboratory for service. Instruments were deployed to the sites within three to five days after removal from the field. Length of deployment periods varied depending on season, temperature and/or degree of fouling.

Hydrolab Data Sonde III's were deployed at three riverine stations north of the causeway on July 28, 2003 (Figure 1, Table 1). The instruments were mounted above the bottom except in extremely shallow areas where the instrument was mounted on a PVC frame and the PVC frame was placed on the bottom with the instrument located just above the bottom. Instruments were programmed to measure water temperature and specific conductance at 15 minute intervals. Salinity was calculated from specific conductance and temperature using an algorithm and recorded at the same interval. Field deployed instruments were replaced with clean, calibrated instruments at two to three week intervals. Length of deployment periods varied depending on season, temperature and/or degree of fouling.

Biological Monitoring

Macroinvertebrates

During 2003 - 2004, three biological sampling events were conducted at 11 stations in the Mobile-Tensaw Delta including a baseline field sampling event in February 2005 (Table 3). Eleven sites were sampled: six sites north of the causeway and five sites south of the causeway.

The sites north of the causeway included Polecat Bay, Delvan Bay, Chocolatta Bay, Justin's Bay, Tensaw riverbank and Blakeley riverbank. Sites south of the causeway roughly paralleled stations above the causeway (Table 2 and Figure 2). GPS readings were recorded for each sampling location.

The macroinvertebrate community was sampled at the 11 Mobile-Tensaw Delta sites using a petite ponar grab. At each site, three (five in February) petite ponar samples were collected in unvegetated areas for analysis of the invertebrate community. Analysis of the February benthic sampling indicated that three replicates were adequate to characterize biodiversity and density and provided sufficient power to detect differences in community composition on each side of the causeway. Initially, samples were sieved in the field over a standard 500-micron sieve to remove small debris and excess sediment. Large debris was thoroughly washed over the sieve and discarded. Immediately following collection, samples were placed in prelabeled containers. Additional labels were placed inside all biological samples to identify the sample in the event the outer label is accidentally removed or obliterated. Samples were immediately placed on ice and returned to the lab for processing.

Laboratory taxonomic evaluations for macroinvertebrate samples were performed at the Dauphin Island Sea Lab. Taxonomy data sheets, standard forms and standard operating procedures are found in the Hydrological Modifications Impact Study Quality Assurance Project (Mobile Bay Watch, Inc. and Dauphin Island Sea Lab 2004). Organisms were identified to family. Genus and species were documented when possible.

Sediment

During the baseline sampling event (February 2004), a petite ponar was used to collect three sediment samples at each site for grain size, total carbon (TC – loss on ignition) and percent water analyses. Sediment samples were collected from the same locations as the invertebrate samples. The top 3 cm of sediment were removed using a spatula and placed in prelabeled containers. Additional labels were placed inside containers to identify the sample in the event the outer label is accidentally removed or obliterated. Samples were immediately placed on ice and returned to the lab for processing.

Sediment grain size, percent water and total carbon analyses were conducted by scientists at the University of South Alabama. In order to compare results with previously collected data and to achieve a higher resolution, sediment grain size was determined using the pipette and sieve method rather than the hydrometer method. Total carbon content was determined using the loss on ignition method. Percent water was determined based on the difference of the wet sample and the dried sample weights.

Water Column

A YSI 6600 was used to measure water quality at the three sampling locations within each site. YSI readings were collected from the same locations as the invertebrate and sediment samples during each sampling event. Measured water quality parameters included temperature, conductivity, salinity, dissolved oxygen, turbidity and chlorophyll *a*.

During each biological sampling event, a surface water grab sample was collected at each site for nutrient analysis (nitrogen and phosphorus). Water samples were collected in 32-ounce sample containers that had been rinsed three times with site water. Samples were immediately be placed on ice and returned to ADEM's (Alabama Department of Environmental Management) laboratory for sample preservation and analyses. Water samples were collected in February, May, June, August and October 2004 from all eleven stations. Simultaneously, a YSI 6600 was used to measure water quality at each water sampling station and GPS readings for each collection site were recorded (Table 3). Water grab samples were analyzed for ammonia (method EPA 350.1), nitrate/nitrite (method EPA 353.2), total Kjeldahl nitrogen (method EPA 351.2) and total phosphorus (method EPA 365.4).

Fish

During 2003 - 2004, two fish sampling events were conducted using a trawl and gill net within Chocolatta Bay and two sites south of the causeway (Table 3). Fish were identified, counted and the first ten specimens of each species were measured (total length). Unidentified fish were returned to the lab for identification.

DATA MANAGEMENT AND ANALYSES

CONTINUOUS MONITORING

Instrument data was uploaded to a laptop computer using EcoWatch (© 1996-2000 YSI Inc.) software and Microsoft © HyperTerminal version 5.1 (Hydrolab Data Sonde III). Uploaded data was stored as Excel files for viewing. Riverine monitoring data were graphically presented as weekly means. Data from Chocolatta Bay, Justin's Bay and Meaher Park were graphically presented as weekly means with ranges for each deployment duration.

BIOLOGICAL MONITORING

The biotic community assemblages of the embayments (open and closed) and riverbanks, north of the causeway and reference stations south of the causeway (Table 2), were compared using robust statistics initially developed to analyze the impacts of disturbances in marine environments. Differences in assemblages were tested using Analyses of Similarity (ANOSIM) and these differences were graphically presented with Multi-Dimensional Scaling plots (MDS) using the Primer E statistical package (Clarke & Green 1988; Warwick & Clarke 1991; Clarke 1993). ANOSIM is a non-parametric, multivariate analog of Analysis of Variance and is robust to differences in community structure even when differences between treatments are small in magnitude when compared to variability within treatments (Clarke, personal communication). In addition, Tukey HSD tests were used to compare treatment effects on the biotic community assemblages. When parametric statistics were appropriate, analyses were conducted using SPSS. Treatment comparisons included the following:

1. Location (site)
2. Embayments (open and closed) / Riverbanks
3. North of Causeway / South of Causeway.

Biological, sediment, nutrient and water quality data were graphically depicted by site and treatments. Graphical depictions revealed any trends or patterns with regard to site, treatment or season.

RESULTS

CONTINUOUS MONITORING

Figures of the continuous monitoring data are found in Appendix 1 and Appendix 2. Figures 1-1 through 1-7 present weekly means for temperature, level/depth, specific conductivity, salinity, dissolved oxygen (% and mg/L) and turbidity plotted by week for Tensaw River, Blakeley River, Gravine Island, Chocolatta Bay, Meaher Park and Justin's Bay. Figures 2-1 through 2-21 contain weekly means with ranges for temperature, depth, specific conductivity, salinity, dissolved oxygen (% and mg/L) and turbidity plotted by week for Chocolatta Bay, Meaher Park and Justin's Bay.

Short term and seasonal variations of measured parameters were evident for all continuous monitoring sites (Appendices 1 and 2). Temperature followed a typical yearly cycle with highs occurring in the summer and lows in the winter (Figs. 1-1, 2-1, 2-8 and 2-15). Mean level/depth also followed a seasonal pattern which is influenced by tidal cycle and storm events (e.g. watershed rainfall) (Fig. 1-2, 2-2, 2-9 and 2-16). The effects of Hurricane Ivan (September 2004) on Chocolatta Bay, Meaher Park and Justin's Bay water level are evident in Figures 2-2, 2-9 and 2-16.

Peaks in specific conductivity and salinity occurred during fall 2003 and late summer/early fall 2004 with a smaller peak occurring in April 2004. Gravine Island, the northernmost site, had the lowest salinity and specific conductivity during fall 2003 (Figs. 1-3 and 1-4). The Chocolatta Bay and Tensaw River sites had the highest salinity and specific conductivity during the fall 2003 (Figs. 1-3 and 1-4). Salinity was higher during late summer/early fall 2004 than in 2003 reaching weekly means of approximately 6 ppt at Chocolatta Bay and Meaher Park (Figs. 1-3 and 1-4). Salinity and specific conductivity values were highest during Hurricane Ivan (September 2004) in Chocolatta Bay, Meaher Park and Justin's Bay (Figs. 2-3, 2-4, 2-10, 2-11, 2-17 and 2-18).

Dissolved oxygen (Figs. 1-5 and 1-6) and turbidity (Fig. 1-7) data were collected in Chocolatta Bay, Meaher Park and Justin's Bay. Dissolved oxygen levels were greatest during the winter of 2003. Periods of low dissolved oxygen occurred during July and September 2004 at all three sites (Figs. 1-5, 1-6, 2-5, 2-6, 2-12, 2-13, 2-19 and 2-20). Dissolved oxygen in Justin's Bay, Chocolatta Bay and Meaher Park dropped below the hypoxia level (3 mg/L) during the late summer early fall of 2004 (Figs. 2-5, 2-12 and 2-19). Thirteen hypoxic events were recorded in Justin's Bay from April to November 2004 (Fig. 2-12) compared with two hypoxic events in Chocolatta Bay (Fig. 2-5) and four hypoxic events at Meaher Park (Fig. 2-19).

Turbidity fluctuations were greater in Chocolatta Bay and Meaher Park than in Justin's Bay, with the exception of Hurricane Ivan during September 2004 (Figs. 1-7, 2-7, 2-14 and 2-21). Because Justin's Bay is fairly protected, storm and wind driven events probably had a stronger effect on the less protected Chocolatta Bay and Meaher Park sites.

BIOLOGICAL MONITORING - MACROINVERTEBRATES

Results from the February, June and October 2004 sampling events are found in Appendix 3. Comparative analyses (SPSS) of differences in species number and the total number of organisms among sites utilized all the samples taken during each event. Additional results presented in this section are based on the mean of all samples collected at each site. Data were analyzed by site, location north or south of the causeway (N/S), and open closed or riverbank treatment (OCR). Analyses of the proportion of dominant invertebrate groups were also conducted for each sampling event. The Primer E statistical package was also used to analyze the benthic community as a whole by site, N/S and OCR. Tables 3-1 through 3-7 and Figures 3-1 to 3-21 summarize the benthic macroinvertebrate data by sampling event for the Mobile-Tensaw Delta. Mean values presented in the following text are based on mean per petite ponar grab.

Macroinvertebrates - February 2004

Mean number and standard deviation of macroinvertebrate taxa and total number of organisms collected in February 2004 are presented by site in Table 3-1, Figure 3-1 and Figure 3-2. Significant differences in species number ($p=0.000$) and total organisms ($p=0.000$) among sites were noted (Table 3-2). The lowest numbers of species occurred north of the causeway in Polecat Bay (mean$\pm$1std = 2.2 ± 1.6), Chocolatta Bay (mean$\pm$1std = 2.4 ± 1.5), and Delvan Bay (mean$\pm$1std = 3.8 ± 0.8). Polecat Bay (PB) and Chocolatta Bay (CB) were not significantly different from each other, and had significantly fewer species than all sites except Delvan Bay, Mouth of Pinto Pass (Site 7) and Tensaw Riverbank (RB1). Delvan Bay (DB) had significantly fewer species than Site 10 (South of Justin's) and South Blakeley Riverbank (Site 11). The Mouth of Pinto Pass (Site 7) had significantly fewer species than South of Justin's (Site 10).

The Mouth of Pinto Pass (Site 7) and Justin's Bay (JB) had the greatest number of organisms while Polecat Bay (PB), Delvan Bay (DB) and Chocolatta Bay (CB) had the fewest organisms (Tables 3-1 and 3-2, Figs. 3-1 and 3-2). Significantly fewer benthic organisms were found in Polecat Bay than in all other sites except Chocolatta Bay and Delvan Bay. Delvan Bay (DB) and Chocolatta Bay (CB) were not significantly different from each other, and had a significantly lower number of organisms than all sites except Polecat Bay (PB), Tensaw Riverbank (RB1) and South of Chocolatta (Site 9).

Comparisons of benthic community structure using Primer's ANOSIM found significant differences among locations (site) (Global R=0.592, p=0.001). Sites were significantly different from each other, with a few exceptions. The community structure of Polecat Bay was not significantly different from that of Delvan Bay (p=0.421) or Chocolatta Bay (p=0.373). Site 10 (South of Justin's) was not significantly different from sites located at Tensaw Riverbank (p=0.119), South of Chocolatta (p=0.135) or South Blakeley Riverbank (p=0.317). Pinto Pass and South of Chocolatta were not significantly different from each other as well (p=0.333). Differences in assemblages are graphically presented with Multi-Dimensional Scaling plots (MDS) (Figs. 3-3 to 3-5). The MDS plots present the benthic assemblages by site (Fig. 3-3), north and south of the causeway (Fig. 3-4) and open, closed or riverbank (Fig. 3-5). MDS comparisons of the benthic community assemblages at the eleven sampling locations had a stress value of 0.09, which is considered a good data fit. Sites grouped by similar benthic community characteristics reflect the same patterns detected in the ANOSIM analyses (Fig. 3-3).

Comparisons of sites located north and south of the causeway showed marginally significant differences in number of species (p=0.101) and number of organisms (p=0.088) (Table 3-2). Sampling sites identified by location north or south of the causeway formed two distinct groups (Fig. 3-4). Sites located south of the causeway had greater numbers of organisms (mean±1std=58.3±34.1) and species (mean±1std=8.0±3.2) than sites north of the causeway (mean total number±1std =31.9±33.8; Mean number species±1std =5.1±3.0) (Figs. 3-6 and 3-8). ANOSIM results showed significant differences in community structure at sites located north and south of the causeway (Global R=0.254, p=0.001).

Significant differences in species (p=0.770) and organism number (p=0.430) were not evident for the open, closed and riverbank sites (Table 3-2, Figs. 3-7 and 3-9). Riverbanks had greater numbers of organisms (mean±1std=56.2±30.5) and species (mean±1std=7.1±2.6) than the open (mean total number±1std=32.6±34.7; mean number species±1std =6.4±3.9) or closed (mean total number±1std =50.2±43.7; mean number species±1std =5.3±3.5) sites. Community structure varied significantly among open, closed and riverbank treatments (Global R=0.200, p=0.001). Figure 3-5 identifies three groupings of sites classified as open, closed and riverbank.

Table 3-3 summarizes the proportions of major taxa by site, location north and south of the causeway, and by open, closed and riverbank treatments. The greater proportions of chironomids were found in Chocolatta Bay and Justin's Bay, which were classified as closed (Fig. 3-10). Significantly more chironomids were collected from sites north of the causeway than from sites south of the causeway (p=0.001) (Fig. 3-16). The closed sites, Chocolatta Bay and Justin's Bay, had significantly higher proportions of freshwater chironomids than did the riverbank sites (p=0.034) (Fig. 3-15).

South of Justin's, Polecat Bay and South Blakeley Riverbank benthic communities were characterized by estuarine organisms with greater proportions of polychaetes than other sites. Amphipod proportions were highest in Mouth of Pinto Pass, Pinto Pass, Justin's Bay and Blakeley Riverbank. Proportions of polychaetes and amphipods were not significantly different for north/south and open/closed/riverbank analyses (Figs. 3-16, 3-17, 3-20 and 3-21).

Significantly greater proportions of bivalves (p=0.004) and isopods (p=0.006) were collected south of the causeway. Proportion of Ephemeroptera was significantly greater in riverbank sites than open sites (p=0.040) (Table 3-3).

Macroinvertebrates - June 2004

The numbers of macroinvertebrate taxa and organisms collected in June 2004 are presented by site in Table 3-1, Figure 3-22 and Figure 3-23. Significant differences in species number (p=0.000) and total organisms (p=0.000) were detected among sites (Table 3-4). The fewest species were collected at the westernmost sites: Polecat Bay (2.0 $\pm$ 1.0), Mouth of Pinto Pass (5.0$\pm$1.0) and Delvan Bay (5.0$\pm$3.6). Polecat Bay (PB) had significantly fewer species than the Tensaw Riverbank (RB1), Blakeley Riverbank (RB2), South of Chocolatta (Site 9), South of Justin's (Site 10) and South Blakeley Riverbank (Site 11). Delvan Bay (DB) and Mouth of Pinto Pass (Site 7) had significantly fewer of species than either the Blakeley Riverbank (RB2) or South Blakeley Riverbank (Site 11). Chocolatta Bay (CB), Justin's Bay and Pinto Pass (Site 8) were not significantly different from any other site (Fig. 3-23).

South Blakeley Riverbank (Site 11) (139.0$\pm$83.0), Blakeley Riverbank (RB2) (110.0$\pm$26.9) and Tensaw Riverbank (RB1) (108.7$\pm$28.0) had the greatest number of organisms while Polecat Bay (PB) (4.3$\pm$3.2), Delvan Bay (DB) (14.3$\pm$16.7) and Mouth of Pinto Pass (Site 7) (19.0$\pm$10.8), had the least number of organisms (Tables 3-1 and 3-4, Fig. 3-22). Significantly fewer organisms were collected in Polecat Bay than Tensaw Riverbank (RB1), Blakeley Riverbank (RB2), Pinto Pass (Site 8), South of Justin's (Site 10) and South Blakeley Riverbank (Site 11). Delvan Bay (DB) had a significantly lower number of organisms than Tensaw Riverbank (RB1), Blakeley Riverbank (RB2), and South Blakeley Riverbank (Site 11). Chocolatta Bay (CB), Justin's Bay, Mouth of Pinto Pass (Site 7) and Pinto Pass (Site 8) were not significantly different from any other site (Fig. 3-22).

Comparisons of community structure using Primer's ANOSIM found significant differences among locations (site) (Global R = 0.362, p=0.001). Sites with few species, Polecat Bay and Delvan Bay, were found to be similar (p = 0.60) and were found to be different (p=0.10) from all other sites except Chocolatta Bay, Justin's Bay and Mouth of Pinto Pass. Tensaw Riverbank differed significantly (p=0.10) from all sites except Mouth of Pinto Pass (Site 7) (p=0.20) and South of Justin's (Site 10) (p=0.60). The Chocolatta Bay community differed significantly (p=0.10) from Tensaw Riverbank, Pinto Pass, South of Chocolatta and South of Justin's. Justin's Bay had a significantly (p=0.10) different community than Pinto Pass, South of Chocolatta, South of Justin's and South Blakeley Riverbank. The Mouth of Pinto Pass site was only significantly different from Blakeley Riverbank (p=0.10). Pinto Pass located south of the causeway was significantly different from all other sites except Mouth of Pinto Pass, South of

Chocolatta and South of Justin's (p=0.10) which are all located south of the causeway. The site located South of Chocolatta differed from all other sites except Mouth of Pinto Pass and Pinto Pass.

The June 2004 MDS plots in Figures 3-24 to 3-26 present the benthic assemblage by site (Fig. 3-24), north and south of the causeway (Fig. 3-25) and open, closed or riverbank (fig. 3-26). The community assemblages for the eleven sampling locations had a stress value of 0.08 which is a good data fit. Similarity in benthic community structure by site is depicted in Figure 3-24 and reflects the ANOSIM analysis results.

Sites north and south of the causeway were similar in terms of species number (p=0.463) and organism abundance (p=0.538) (Table 3-4). Sites located south of the causeway had more organisms (mean±1std=64.2±56.6) and species (mean±1std=9.5±3.3) than sites north of the causeway (mean total number±1std =54.9±50.7; mean number species±1std =7.8±4.3) (Figs. 3-6 and 3-8). ANOSIM also found significant differences north and south of the causeway (Global R=0.074, p=0.054) indicating that the species composition differed. MDS Figure 3-25 identifies the sampling sites by location north or south of the causeway. With one exception (Tensaw Riverbank – RB1), sites north and south of the causeway were clearly different in terms of benthic community structure (Fig. 3-25).

Significant differences in species (p=0.425) and organism number (p=0.289) were not evident for habitat type (open, closed and riverbank sites) (Table 3-4, Figs. 3-7 and 3-9). Riverbanks had the highest numbers of organisms (mean±1std=94.2±61.3) and species (mean±1std=10.4±4.0) followed by closed (mean total number±1std =46.2±43.1; mean number species±1std =8.2±2.5) and open (mean total number±1std =36.3±32.8; mean number species±1std =7.3±4.9) sites. Community structure was not significantly different for open, closed and riverbank treatments (Global R=0.049, p=0.203). Figure 3-5 identifies the sampling sites by open, closed and riverbank that form three overlapping groups.

Table 3-5 summarizes the proportions of major taxa by site, location north and south of the causeway, and by open, closed and riverbank treatments. The greatest proportions of chironomids were found in Polecat Bay, Pinto Pass, Tensaw Riverbank, Chocolatta Bay and South of Justin's (Fig. 3-10). Proportions of chironomids were not significantly different between north and south sites (p=0.547) or open, closed and riverbank sites (p=0.582) (Figs. 3-14 and 3-15).

With the exception of Mouth of Pinto Pass and Delvan Bay, sites with the highest salinities, Pinto Pass, Tensaw Riverbank, South of Chocolatta and Polecat Bay, had the greatest proportions of polychaetes over all sites (Fig. 3-11). Open sites had marginally greater proportions of polychaetes than the closed sites (p=0.096) (Fig. 3-17) but proportions were not significantly different among sites north and south of the causeway (p=0.276) (Fig. 3-16). Greater proportions of oligochaetes were collected in Blakeley Riverbank, Justin's Bay and Chocolatta Bay (Fig. 3-12). Closed sites had significantly greater numbers of oligochaetes than riverbank sites (p=0.021) (Fig. 3-19). North and south sites were similar in the occurrence of oligochaetes (p=0.766) (Fig. 3-18). Amphipod proportions were highest at the Blakeley Riverbank, Mouth of Pinto Pass and Pinto Pass (Fig. 3-13). Proportions of amphipods were not significantly different for north/south (p=0.264) and open/closed/riverbank (p=0.318) analyses (Figs. 3-20 and 3-21). A significant difference occurred for proportion of Decapoda (crabs) (p=0.037) with all of the crabs occurring south of the causeway (Table 3-3).

Macroinvertebrates – October 2004

The originally planned sampling event in September 2004 was delayed until October 2004 due to Hurricane Ivan which made landfall on September 16, 2004. In order to allow time for the benthic communities to recover, sampling was delayed until October 6-7, 2004.

By site, Table 3-1, Figures 3-27 and 3-28 contain mean number and standard deviation of macroinvertebrate taxa and total number of organisms collected in October 2004. The number of species (p=0.040) varied significantly among sites while total number of organisms (p=0.127) was only marginally significantly different among sites (Table 3-6). Sites located along the South Blakeley Riverbank (Site 11) (mean±1std: 10.7±1.5) and South of Justin's (Site 10) (mean±1std: 10.3±3.8) had the highest number of species. The lowest numbers of species were again collected from Polecat Bay (PB) (mean±1std: 4.0 ± 1.0) and Delvan Bay (DB) (mean±1std: 4.3±2.1). Blakeley Riverbank (RB2) (mean±1std: 5.3±2.3), Delvan Bay (DB) and Polecat Bay (PB) had significantly fewer species than Pinto Pass (Site 8) (mean±1std: 9.7±3.2), South of Justin's (Site 10) and South Blakeley Riverbank (Site 11). Justin's Bay had significantly fewer species than South Blakeley Riverbank. Chocolatta Bay (CB) (mean±1std: 7.7±4.2), Tensaw Riverbank (RB1) (mean±1std: 7.3±0.6), Mouth of Pinto Pass (Site 7) (mean±1std: 7.0±1.0) and South of Chocolatta (Site 9) (mean±1std: 8.0±3.5) were not significantly different from any of the other sites (Fig. 3-28).

Although there were apparent differences in organism density among sites, the variability was high which resulted in no significant differences among sites (p=0.127) (Table 3-6). Chocolatta Bay (CB) (mean±1std: 73.3±43.8), Justin's Bay (mean±1std: 66.3±29.4), Pinto Pass (mean±1std: 63.0±25.2) and South Blakeley Riverbank (Site 11) (mean±1std: 59.0±41.9) had higher numbers of organisms during October 2004. Blakeley Riverbank (RB2) (mean±1std: 19.0±13.7), Polecat Bay (mean±1std: 26.7±5.5) and Mouth of Pinto Pass (Site 7) (mean±1std: 28.0±9.6) had the fewest organisms (Tables 3-1 and 3-6, Fig. 3-27).

Comparisons of community structure using Primer's ANOSIM detected significant differences among locations (site) as well (Global R=0.582, p=0.001). Polecat Bay differed (p=0.10) from all sites except Delvan Bay (p=0.20). Delvan Bay was different (p=0.10) from all sites except Polecat Bay and Chocolatta Bay (p = 0.20). The Chocolatta Bay benthic community differed significantly (p=0.10) from Polecat Bay, Mouth of Pinto Pass, Pinto Pass and South of Chocolatta. Blakeley Riverbank had a significantly different benthic community than all sites except Tensaw Riverbank, Chocolatta Bay, South of Justin's and South Blakeley Riverbank. Justin's Bay had a significantly (p=0.10) different community structure than all sites except Chocolatta Bay, Tensaw Riverbank and South Blakeley Riverbank. The Mouth of Pinto Pass site had a significantly (p=0.10) different benthic community than all sites except Tensaw Riverbank. The Pinto Pass benthic community was similar only to Tensaw Riverbank, South of Chocolatta and South of Justin's. The site located South of Chocolatta differed in community structure from all sites except Pinto Pass and Tensaw Riverbank. The community composition of South of Justin's was significantly (p=0.10) different from Justin's Bay, Delvan Bay, Polecat Bay, Mouth of Pinto Pass and South of Chocolatta.

The October 2004 MDS plots in Figures 3-29 to 3-31 present the benthic assemblage by site (Fig. 3-29), north and south of the causeway (Fig. 3-30) and open, closed or riverbank (fig. 3-31). The community assemblages for the eleven sampling locations had a stress value of 0.11. Sites groupings by similarity in benthic community reflect the same patterns reported from the Primer ANOSIM analysis (Fig. 3-29).

During October 2004, significantly more species (p=0.006) were collected at sites located south (mean±1std=9.1±2.8) of the causeway than at sites north (mean±1std=5.8±2.4) of the causeway (Table 3-6, Fig. 3-6). In contrast, invertebrate abundances were similar at the south (mean±1std=48.2±27.0) and north (mean±1std=45.4±27.9) sites (p=0.807) (Table 3-6, Fig. 3-8). ANOSIM results showed significant differences in community composition north and south of the causeway (Global R=0.41, p=0.001). Figure 3-30 identifies the sampling sites by location north or south of the causeway. A clear separation of sites north and south of the causeway is seen in Figure 3-30 illustrating different biological community structure.

Habitat type had limited impacts on some aspects of the benthic community. Open, closed and riverbank sites had similar numbers of species (p=0.963) but marginally different organism numbers (p=0.074) (Table 3-6, Figs. 3-7 and 3-9). Closed sites had more organisms (mean±1std =69.8±33.6) followed by open (mean±1std =45.4±21.2) and riverbank (mean±1std =36.7±25.5) sites. Community composition varied significantly among open, closed and riverbank treatments (Global R=0.157, p=0.011). Open and riverbank sites were significantly different from each other (p=0.006). Community structure at the open and closed sites was similar (p=0.195). Figure 3-31 identifies the sampling sites by open, closed and riverbank with three distinct groups. Within the open sites, sites located north of the causeway (Polecat Bay and Delvan Bay) were similar to each other, as were South of Justin's, South of Chocolatta and Pinto Pass located south of the causeway.

Table 3-7 summarizes the proportions of major taxa by site, location north and south of the causeway, and by open, closed and riverbank treatments. Lower proportions of chironomids occurred in October compared with February and June collections. The greatest proportions of chironomids were found in Justin's Bay and Blakeley Riverbank (Fig. 3-10). Proportions of chironomids were not significantly different between north and south sites (p=0.453) or open, closed and riverbank sites (p=0.407) (Figs. 3-14 and 3-15).

Polychaetes dominated the benthic community in October (Fig. 3-11) when salinities were greatest. Polychaetes comprised greater than fifty percent of all organisms collected in Delvan Bay, Mouth of Pinto Pass, Tensaw Riverbank, Polecat Bay, South of Chocolatta Bay, Pinto Pass and Justin's Bay (Fig. 3-11). Proportions of polychaetes did not differ significantly between north and south sites (p=0.863) or among open, closed and riverbank sites (p=0.607) (Figs. 3-16 and 3-17). Greater proportions of oligochaetes occurred in Blakeley Riverbank, South Blakeley Riverbank, and Chocolatta Bay (Fig. 3-12). Riverbank sites had greater numbers of oligochaetes than the open sites (p=0.063) (Fig. 3-19). Proportions of oligochaetes were similar north and south of the causeway (p=0.266) (Fig. 3-18). Generally, amphipod numbers in October were lower than in February and June (Fig. 3-13). Highest proportions of amphipods were found in Chocolatta Bay, South of Chocolatta and South Blakeley Riverbank (Fig. 3-13). Proportions of amphipods were not significantly different north/south (p=0.661) or in open/closed/riverbank (p=0.429) analyses (Figs. 3-20 and 3-21). Sites located south of the causeway had a marginally greater proportion of isopods (p=0.054) and decapods (crabs) (p=0.059) than north sites (Table 3-7). A significant difference occurred for proportion of bivalves (p=0.033) with all of the bivalves occurring at sites south of the causeway (Table 3-7).

BIOLOGICAL MONITORING - SEDIMENT

Sediment samples were collected in February 2004 from each Mobile-Tensaw Delta site along with benthic invertebrate samples, nutrient samples and YSI readings. Table 4-1 and Figures 4-1 through 4-9 summarize results from the sediment analyses. Samples were analyzed by site, location north or south of the causeway and habitat type (open, closed or riverbank sites).

Sediment grain size analyses included percent clay, silt, sand and gravel. Gravel was only found in Polecat Bay (0.05%) and therefore was excluded from statistical analyses. By site, percentages of silt (p=0.533) and sand (p=0.551) were not significantly different from each other (Table 4-1, Fig. 4-1). Percent clay differed marginally among sites (p=0.075) (Table 4-1, Fig. 4-1). Polecat Bay (mean±1std=28.02%±6.04) and Justin's Bay (mean±1std=25.93%±5.95) had the greatest proportions of clay while South of Chocolatta (mean±1std=10.00%±8.61) and Mouth of Pinto Pass (mean±1std=7.71%±2.90) had the lowest amounts of clay. Sediment percent silt ranged from 39.55% (±1std=±5.95) in Polecat Bay to 60.23% (±1std=±6.30) in Justin's Bay. Justin's Bay sediment contained the least amount of sand (mean±1std=13.83%±10.09) while Mouth of Pinto Pass had the greatest percentage of sand (mean±1std=48.15%±8.84) (Fig. 4-1).

Analyses by location north and south of the causeway were significant for percent clay (p=0.024) and sand (p=0.047) but only marginally significant for percent silt (p=0.132) (Table 4-1, Fig. 4-2). Sites located north of the causeway had greater amounts of clay (mean±1std=19.20%±7.67) and silt (mean±1std=54.44%±10.53) than sites located south of the causeway (clay mean±1std=12.84%±8.16, silt mean±1std=47.52%±15.21). In contrast, southern sites had higher percentages of sand (mean±1std=39.64%±22.75) than northern sites (mean±1std=26.34% ± 13.29) (Fig. 4-2). Sites classified as open, closed and riverbank were similar in terms of grain size composition (Table 4-1, Fig. 4-3).

Sediment percent water (p=0.000) and total carbon (p=0.012) varied significantly among sites, north or south of the causeway (water: p=0.000; carbon: p=0.003), and open, closed and riverbank treatments (water: p=0.007; carbon: p=0.005) (Table 4-1, Fig.4-4). Justin's Bay sediment contained the greatest percentage of total carbon (mean±1std: 8.85%±2.3) and was significantly greater than Mouth of Pinto Pass (mean±1std: 2.25%±1.0), South of Chocolatta (mean±1std: 2.98%±1.66) and South of Justin's (mean±1std: 3.75%±1.60). Sediment percent water was also greatest in Justin's Bay sediment (mean±1std: 72.36%±7.69) which was significantly greater than Blakeley Riverbank (mean±1std: 47.03%±11.32) and all sites south of the causeway. Delvan Bay (mean±1std: 65.78%±9.95) and Polecat Bay (mean±1std:

64.64%±2.41) sediments contained significantly higher percentages of water than Mouth of Pinto Pass (mean±1std: 36.47%±5.95) (Table 4-1, Fig.4-4).

Sediments collected at sites located north of the causeway contained significantly higher percentages of water (mean±1std: 61.66%±10.20) and total carbon (mean±1std: 5.44%±2.10) than sites south of the causeway (water mean±1std: 43.22%±9.29; carbon mean±1std: 3.38%±1.59) (Figs. 4-5 and 4-6). Closed site sediments contained significantly higher percentages of water (mean±1std: 66.94%±7.88) and total carbon (mean±1std: 6.96%±2.55) than open (water mean±1std: 52.78%±12.85; carbon mean±1std: 4.15%±1.54) and riverbank sites (water mean±1std: 47.07%±11.87; carbon mean±1std: 3.73%±1.77) (Figs. 4-5 and 4-6).

Figures 4-7 through 4-9 graphically depict sediment data as MDS plots from Primer analyses. Data are presented by site (Fig. 4-7), location north or south of the causeway (Fig. 4-8), and open, closed and riverbank treatments (fig. 4-9). MDS analyses of sediment parameters and nutrients resulted in a stress value of 0.01 and thus a good data fit. Four major site groupings are apparent in Figure 4-7. Justin's Bay and Polecat Bay were not similar to other sites in terms of sediment characteristics. Blakeley Riverbank (RB2), South Blakeley Riverbank, South of Justin's, Pinto Pass (Site 8), South of Chocolatta (Site 9) and Mouth of Pinto Pass (Site 7) were similar in sediment characteristics. Sediment parameters were similar for Tensaw Riverbank (RB1), Chocolatta Bay and Delvan Bay (Fig. 4-7). Figure 4-8 presents the same data as Figure 4-7 but labeled by location north or south of the causeway. Sediment characteristics of south and north sites were distinctly different (Fig. 4-8) except Blakeley Riverbank (RB2) which was similar to sites south of the causeway. Data plotted as open, closed or riverbank sites suggests overlapping characteristics in the open and riverbank sites. Chocolatta Bay and Justin's Bay, the closed sites, had similar sediment characteristics but also showed similar characteristics as Delvan Bay (open) and Tensaw Riverbank (riverbank) (Fig. 4-9).

BIOLOGICAL MONITORING – WATER COLUMN PARAMETERS

Water Column Parameters – YSI Readings

YSI readings were made during the February, May, June, July, August and October 2004. In addition to the eleven primary sites, readings were also made in upper Chocolatta Bay (Chocolatta Bay 2), Mouth of Chocolatta (CB Mouth) and the Tensaw River Channel (RB1 Channel) during February 2004. Additionally, YSI readings were collected in upper Chocolatta Bay during May, June, August and October 2004. During July 2004, readings were recorded for six sites as part of another investigation. Figures with all collected data and summary tables for the major sampling events (February, June and October) are contained in Appendix 5. Statistical analyses were conducted for February, June and October 2004 data and will be discussed below. The results presented here include salinity, dissolved oxygen, turbidity and chlorophyll *a*.

YSI Readings – February 2004

In February, salinity, dissolved oxygen (mg/l), turbidity and chlorophyll *a* all varied significantly among sites (p=0.000) (Table 5-1, Figs. 5-1 to 5-5). Salinity ranged from 0.05 ppt to 0.12 ppt. Salinity in Delvan Bay (mean=0.12 ppt) was significantly greater than all sites except Chocolatta Bay (mean=0.09 ppt) and Justin's Bay (mean=0.08 ppt). Chocolatta Bay had significantly higher salinity than all sites except Delvan Bay, Polecat Bay (mean=0.06 ppt) and Justin's Bay (Fig. 5-1). Salinity was significantly (p=0.000) greater at sites north of the causeway (mean=0.08 ppt) than sites south of the causeway (mean=0.05 ppt) (Fig. 5-6) but differences were small and probably not biologically significant. Closed sites (mean=0.09 ppt) had significantly (p=0.000) higher salinity than open (mean=0.07 ppt) and riverbank sites (mean=0.05 ppt). Open sites were also significantly different from riverbank sites (Table 5-1 and Fig. 5-7). Although salinity differences were significant, the differences were small and probably not biologically significant.

During February 2004, dissolved oxygen also varied significantly (p=0.000) among sites (Table 5-1, Figs. 5-2 and 5-3). Dissolved oxygen was greatest in Justin's Bay (mean=11.35 mg/l), Chocolatta Bay (mean=11.22 mg/l) and Delvan Bay (mean=11.18 mg/l) (Fig. 5-3). Tensaw Riverbank (mean=10.10 mg/l) and Mouth of Pinto Pass (mean=10.14 mg/l) had the lowest dissolved oxygen readings. Justin's Bay and Chocolatta Bay had significantly greater dissolved oxygen than Polecat Bay, Tensaw Riverbank, Tensaw River Channel, Mouth of Pinto Pass and Pinto Pass. Delvan Bay had significantly greater dissolved oxygen concentrations than at the Tensaw Riverbank. Sites located north of the causeway (mean=10.79 mg/l) had higher (p=0.012 mg/l) dissolved oxygen concentrations than sites south of the causeway (mean=10.37 mg/l) (Fig. 5-10). Dissolved oxygen in closed sites (mean=11.29 mg/l) was significantly (p=0.000) greater than open sites (mean=10.50 mg/l) (Fig. 5-11).

Mean chlorophyll *a* values ranged from 1.60 ug/l in South of Justin's to 5.57 ug/l in Delvan Bay and significant differences among sites were detected (p=0.000) (Table 5-1 and Fig. 5-4). Chlorophyll *a* concentrations in embayments with reduced flushing rates, Chocolatta Bay (mean=5.04 ug/l), Delvan Bay, and Polecat Bay (mean=4.57 ug/l), were all significantly greater than South of Justin's and South Blakeley Riverbank (mean=1.97 ug/l). Delvan Bay was significantly different from Tensaw Riverbank (mean=3.51 ug/l). South of Justin's had significantly lower chlorophyll *a* values than Pinto Pass (mean=4.05 ug/l) and Tensaw River Channel (Table 5-1 and Fig. 5-4; Note – in Table 5-1 the RB1 mean includes RBI channel). Chlorophyll *a* concentrations were greater (p=0.005) at sites north of the causeway (mean=4.18 ug/l) than at sites located south of the causeway (mean=2.83 ug/l) (Fig. 5-12). Closed sites (mean=4.10 ug/l) had greater (p=0.050) chlorophyll *a* concentrations than riverbank sites (mean=3.04 ug/l) (Fig. 5-13).

Turbidity also varied significantly among sites (p=0.000) during February 2004 (Table 5-1, Fig. 5-5). Turbidity was greatest at the Tensaw Riverbank site (mean=105.79 NTU), Mouth of Pinto Pass (mean=102.38 NTU) and Pinto Pass (mean=97.22 NTU) (Fig. 5-5). Turbidity was lowest in Chocolatta Bay (mean=43.74 NTU) and Justin's Bay (mean=31.44 NTU). Turbidity was significantly higher at Tensaw Riverbank, Tensaw River Channel and Mouth of Pinto Pass than Chocolatta Bay, Mouth of Chocolatta Bay, Delvan Bay (mean=51.33 NTU), Justin's Bay, South of Chocolatta (mean=53.1 NTU) and South Blakeley Riverbank (mean=54.9 NTU). Pinto Pass turbidity was greater than Chocolatta Bay, Delvan Bay, Justin's Bay, South of Chocolatta and South Blakeley Riverbank. Turbidity in Polecat Bay (mean=83.52 NTU) was significantly greater than Chocolatta Bay, Justin's Bay and South Blakeley Riverbank. Justin's Bay turbidity was significantly lower than Blakeley Riverbank (Fig. 5-5). Turbidity was higher (p=0.083) at sites south of the causeway (mean=75.30 NTU) than sites north of the causeway (mean=62.73 NTU) (Fig. 5-14). Turbidity at riverbank sites (mean=80.9 NTU) was significantly (p=0.000) greater than at closed sites (mean=37.59 NTU). Turbidity of open (mean=70.81 NTU) sites was significantly (p=0.000) greater than closed sites (Fig. 5-15) perhaps due to wind influences.

YSI Readings – June 2004

Similar to February, June 2004 salinity, dissolved oxygen (mg/l), turbidity and chlorophyll *a* parameters all varied significantly among sites (Table 5-2, Figs. 5-1 to 5-5). Salinity ranged from 0.10 ppt to 1.92 ppt. Salinity at Mouth of Pinto (mean=1.91 ppt) and in Polecat Bay (mean=1.70 ppt) was significantly greater than Tensaw Riverbank (mean=0.54 ppt), Chocolatta Bay (mean=0.35 ppt), Justin's Bay (mean=0.10 ppt), Blakeley Riverbank (mean=0.10 ppt), South of Justin's (mean=0.11 ppt) and South Blakeley Riverbank (mean=0.11 ppt) (Fig. 5-1). South of Chocolatta was higher in salinity than in Chocolatta Bay, Tensaw Riverbank, South of Justin's, South Blakeley Riverbank, Justin's Bay and Blakeley Riverbank. Salinity in Delvan Bay was greater than in Chocolatta Bay, Tensaw Riverbank, Blakeley Riverbank, Justin's Bay, South of Justin's and South Blakeley Riverbank. South of Justin's and South Blakeley Riverbank also had lower salinities than Chocolatta Bay and Pinto Pass. Salinities in Chocolatta Bay were significantly greater than Justin's Bay and Blakeley Riverbank. Pinto Pass salinities differed from Tensaw Riverbank and Justin's Bay (Fig. 5-1). Salinity was similar (p=0.499) for sites north (mean=0.63 ppt) and south (mean=0.89 ppt) of the causeway (Fig. 5-6). Closed sites (mean=0.23 ppt) had significantly (p=0.002) lower salinity than open (mean=1.02 ppt) sites and open sites had significantly greater salinities than riverbank sites (mean=0.67 ppt) (Table 5-1 and Fig. 5-7). Because salinity was relatively low in June, differences were small and probably not biologically significant.

During June 2004, sites were significantly (p=0.041) different in dissolved oxygen concentrations (Table 5-1, Figs. 5-2 and 5-3). Dissolved oxygen was greatest in Delvan Bay (mean=8.64 mg/l), Blakeley Riverbank (mean=8.49 mg/l) and Tensaw Riverbank (mean=7.92 mg/l). South Blakeley Riverbank (mean=6.15 mg/l) and South of Justin's (mean=6.05 mg/l) had the lowest dissolved oxygen values (Fig. 5-2). Sites located north of the causeway (mean=7.64 mg/l) had higher (p=0.004) dissolved oxygen concentrations than sites south of the causeway (mean=6.52 mg/l) (Fig. 5-10). Dissolved oxygen was not significantly different among open, closed and riverbank sites (p=0.913) (Fig. 5-11).

Mean chlorophyll *a* values ranged from a low of 2.82 ug/l at South of Chocolatta to a high of 10.25 ug/l again in Delvan Bay and significant differences were detected among sites (p=0.000) (Table 5-1 and Fig. 5-4). South of Chocolatta had significantly lower chlorophyll *a* levels than Tensaw Riverbank (mean=8.20 ug/l), Blakeley Riverbank (mean=8.10 ug/l), Polecat Bay (mean=9.20 ug/l), Delvan Bay and Chocolatta Bay (mean=6.33 ug/l). Pinto Pass (mean=2.82

ug/l) had significantly lower chlorophyll *a* than Tensaw Riverbank, Blakeley Riverbank and Delvan Bay. Delvan Bay had greater values than South of Justin's (mean=4.07 ug/l). Chlorophyll *a* values from Justin's Bay, Mouth of Pinto Pass and South Blakeley Riverbank were not significantly different from any other site. Chlorophyll *a* concentrations were greater (p=0.000) at sites north of the causeway (mean=8.01 ug/l) than sites located south of the causeway (mean=3.87 ug/l) (Fig. 5-12). Open, closed and riverbank sites were not different from each other in terms of chlorophyll *a* levels (p=0.259) (Fig. 5-13).

During June 2004, sites were significantly (p=0.024) different in turbidity (Table 5-1 and Fig. 5-5). Turbidity at South of Chocolatta (mean=7.63 NTU) was significantly different from turbidity at South Blakeley Riverbank (mean=34.23 NTU) (Fig. 5-5). Turbidity was not significantly (p=0.690) different among sites located north (mean=20.01 NTU) and south (mean=19.87 NTU) of the causeway. Turbidity of riverbank sites (mean=26.60 NTU) was significantly (p=0.029) greater than open sites (mean=16.06 NTU) (Fig. 5-15).

YSI Readings – October 2004

Similar to February and June, October 2004 salinity, dissolved oxygen (mg/l), turbidity and chlorophyll *a* parameters all differed significantly among sites (Table 5-3, Figs. 5-1 to 5-5). Salinity peaked during August and October, and during October, salinity ranged from 0.88 ppt at Blakeley Riverbank to 8.43 ppt at Pinto Pass (Fig. 5-1). Because of the variability among sites, significant differences among sites were numerous. Salinity was greatest on the west side of the Delta both above and below the causeway (Fig. 5-1). Salinity was also significantly (p=0.001) greater at sites located south (mean=4.98 ppt) than sites north (mean=2.68 ppt) of the causeway (Fig.5-6). Open sites (mean=4.93 ppt) had significantly (p=0.000) higher salinity than closed (mean=1.59 ppt) and riverbank (mean=3.28 ppt) sites (Table 5-1 and Fig. 5-7).

During October 2004, dissolved oxygen varied significantly among sites (p=0.000) (Table 5-3, Figs. 5-2 and 5-3). Dissolved oxygen was greatest in Polecat Bay (mean=8.47 mg/l), Delvan Bay (mean=8.22 mg/l) and Tensaw Riverbank (mean=8.07 mg/l). Dissolved oxygen was lowest at Blakeley Riverbank (mean=4.51 mg/l) and South of Justin's (mean=4.78 mg/l) (Fig. 5-2). As a result, significant dissolved oxygen differences among sites were numerous. Sites located north of the causeway (mean=7.15 mg/l) had higher (p=0.001) dissolved oxygen concentrations than sites south of the causeway (mean=5.52 mg/l) (Fig. 5-10). Dissolved oxygen was not significantly different among open, closed and riverbank sites (p=0.206) (Fig. 5-11).

Mean chlorophyll *a* values ranged from 4.42 ug/l at Pinto Pass to 45.23 ug/l in Chocolatta Bay. Significant differences occurred among sites (p=0.007) (Table 5-3 and Fig. 5-4) with chlorophyll *a* concentrations in Chocolatta Bay being significantly greater than those recorded from Blakeley Riverbank (mean=5.24 ug/l), Pinto Pass and South of Chocolatta (mean=4.90 ug/l). Delvan Bay, Polecat Bay, Justin's Bay, Tensaw Riverbank, Mouth of Pinto Pass, South of Justin's and South Blakeley Riverbank were not significantly different from all other sites in chlorophyll *a* levels. Chlorophyll *a* concentrations were greater (p=0.000) at sites north of the causeway (mean=14.39 ug/l) than at sites located south of the causeway (mean=5.02 ug/l) (Fig. 5-12). Chlorophyll *a* in open, closed and riverbank sites was significantly different (p=0.004) (Fig. 5-13). Chlorophyll *a* in closed (mean=31.99 ug/l) sites was significantly greater than open (mean=20.04 ug/l) and riverbank (mean=16.57 ug/l) sites (Fig. 5-13).

During October 2004, sites were significantly ($p=0.000$) different in turbidity (Table 5-3, Fig. 5-5). Mean turbidity readings ranged from 7.05 NTU at South of Justin's to 50.54 NTU in Chocolatta Bay (Fig. 5-5). Chocolatta Bay turbidity was significantly greater than Blakeley Riverbank (mean=8.70 NTU), South of Justin's and South Blakeley Riverbank (mean=8.95 NTU). South of Justin's also had lower turbidity than Mouth of Pinto Pass (mean=24.35 NTU), Polecat Bay (mean=28.78 NTU) and South of Chocolatta (mean=33.37 NTU). South Blakeley Riverbank (mean=8.95 NTU) turbidity was significantly lower than Polecat Bay and South of Chocolatta. Turbidity levels at Blakeley Riverbank were significantly lower than Polecat Bay and South of Chocolatta (Fig. 5-5). Turbidity was not significantly ($p=0.363$) different among sites located north (mean=23.78 NTU) and south (mean=17.56 NTU) of the causeway. Turbidity was similar between open (mean=20.04 NTU), closed (mean=31.99 NTU) and riverbank (mean=16.57 NTU) sites (Fig. 5-15).

Water Column Parameters – Nutrients

Nutrient data were analyzed by month, site, location (north or south of the causeway), and open, closed and riverbank treatments (Table 6-1). Ammonia ($p=0.011$), nitrate-nitrite ($p=0.001$), total Kjeldahl nitrogen ($p=0.000$) and total phosphorus ($p=0.000$) varied significantly among months. Ammonia levels in August and October were significantly greater than May levels. Nitrate-nitrite concentrations from February, May and October were significantly higher than August nitrate-nitrite concentrations. October total Kjeldahl nitrogen values were greater than February, June and May values. August and June total Kjeldahl nitrogen levels were significantly greater the May levels. Total phosphorus was highest during February 2004 and was significantly greater than May, June, August and October. October phosphorus levels were significantly greater than May and June.

Nutrient data analyzed by site was only significant for nitrate-nitrite ($p=0.001$) (Table 6-1). South of Justin's (mean$\pm$1std: 0.204$\pm$0.148 mg/l) and South Blakeley Riverbank (mean$\pm$1std: 0.214$\pm$0.132 mg/l) had higher nitrate-nitrite than Chocolatta Bay 2 (mean$\pm$1std: 0.035$\pm$0.029 mg/l). Sites located south of the causeway had significantly higher levels of ammonia (mean$\pm$1std: 0.048$\pm$0.036 mg/l) and nitrate-nitrite (mean$\pm$1std: 0.156$\pm$0.091 mg/l) than sites north of the causeway (NH_4 mean$\pm$1std: 0.019$\pm$0.032 mg/l; NO_3-NO_2 mean$\pm$1std: 0.106$\pm$0.077 mg/l). Ammonia ($p=0.171$) and nitrate-nitrite ($p=0.147$) were marginally different for open, closed and riverbank sites (Table 6-1) but no significant differences occurred for total Kjeldahl nitrogen ($p=0.851$) and total phosphorus ($p=0.838$). Ammonia and nitrate-nitrite concentrations were greatest in the riverbank sites (NH_4 mean$\pm$1std: 0.038$\pm$0.042 mg/l; NO_3-NO_2 mean$\pm$1std: 0.151$\pm$0.086 mg/l) followed by open sites (NH_4 mean$\pm$1std: 0.034$\pm$0.039 mg/l; NO_3-NO_2 mean$\pm$1std: 0.119$\pm$0.083 mg/l) and closed sites (NH_4 mean$\pm$1std: 0.017$\pm$0.016 mg/l; NO_3-NO_2 mean$\pm$1std: 0.101$\pm$0.084 mg/l).

Nutrients – February 2004

February nutrient analyses are summarized in Table 5-1, Figures 6-1 through 6-3 and Figures 6-8 through 6-13. Multiple comparisons by site were not conducted because at least one group had fewer than two cases. Nitrate-nitrite (p=0.006) and total phosphorus (p=0.030) were significantly different among sites (Table 5-1). Nitrate-nitrite ranged from 0.005 mg/l at Chocolatta Bay 2 and 0.085 mg/l at Justin's Bay to 0.393 mg/l at South Blakeley Riverbank (Fig. 6-1). Total phosphorus ranged from 0.069 mg/l in Justin's Bay to 0.222 mg/l in Mouth of Pinto Pass (Fig. 6-3). Compared with sites north of the causeway, sites located south of the causeway had higher levels of ammonia (p=0.105) (mean=0.04 mg/l), nitrate-nitrite (p=0.116) (mean=0.22 mg/l) and total phosphorus (p=0.066) (mean=0.14 mg/l) (Figs. 6-8, 6-10 and 6-12). Riverbank sites had greater levels of nitrate-nitrite (p=0.108) (mean=0.23 mg/l) and total phosphorus (p=0.026) (mean=0.14 mg/l) than open (NO3-NO2 mean=0.18 mg/l; TP mean=0.13 mg/l) and closed sites (NO3-NO2 mean=0.09 mg/l; TP mean=0.08 mg/l) (Table 5-1, Figs. 6-9 and 6-13).

Nutrients – May 2004

Data from the May 2004 sampling are found in Figures 6-2 through 6-4 and Figures 6-10 through 6-15. Ammonia (<0.01 mg/l to 0.03 mg/l) and total phosphorus (0.030 mg/l to 0.073 mg/l) levels did not differ significantly among sites (Figs. 6-2 and 6-3). Nitrate-nitrite ranged from 0.052 mg/l in Chocolatta Bay 2 and 0.066 mg/l in Pinto Pass to 0.230 mg/l at Blakeley Riverbank (Fig. 6-4). Pinto Pass had the lowest total Kjeldahl nitrogen (0.16 mg/l) while Chocolatta Bay 2 (0.49 mg/l) and Delvan Bay (0.41 mg/l) had the highest total Kjeldahl nitrogen (Fig. 6-4). Total phosphorus ranged from 0.030 mg/l in Mouth of Pinto Pass to 0.073 mg/l in Justin's Bay (Fig. 6-3).

Sites south of the causeway had greater (p=0.058) levels of ammonia (mean=0.02 mg/l) than sites located north of the causeway (mean=0.01 mg/l) (Fig. 6-10). In contrast, sites north of the causeway had greater levels (p=0.024) of total Kjeldahl nitrogen (mean=0.37 mg/l) than sites south of the causeway (mean=0.26 mg/l) (Fig. 6-14). Phosphorus levels were also higher (p=0.067) in the north (mean=0.05 mg/l) than in the south (mean=0.04 mg/l) (Fig. 6-12). Similar concentrations of all nutrients were observed at open, closed and riverbank sites except total phosphorus (p=0.083) with closed sites having higher levels (mean=0.06 mg/l) than open (mean=0.04 mg/l) and riverbank sites (mean=0.04 mg/l) (Figs. 6-11, 6-13 and 6-15).

Nutrients – June 2004

June nutrient analyses are summarized in Table 5-2. By site, ammonia ranged from below detection limit (<0.01 mg/l) to 0.07 mg/l at Blakeley Riverbank (Fig. 6-2). Nitrate-nitrite ranged from 0.005 mg/l in Polecat Bay and Chocolatta Bay to 0.341 mg/l at South of Justin's (Fig. 6-5). Chocolatta Bay had the lowest total Kjeldahl nitrogen (0.10 mg/l) while Chocolatta Bay 2 (0.71 mg/l) and Delvan Bay (0.68 mg/l) had the highest total Kjeldahl nitrogen (Fig. 6-5). Total phosphorus levels were lowest in Chocolatta Bay (0.005 mg/l) and highest in Justin's Bay (0.086 mg/l) (Fig. 6-3).

Sites south of the causeway had higher concentrations of ammonia ($p=0.060$) (mean=0.03 mg/l) than sites located north of the causeway (mean=0.04 mg/l) (Fig. 6-10). In contrast, sites north of the causeway had greater levels ($p=0.091$) of nitrate-nitrite (mean=0.09 mg/l) than sites south of the causeway (mean=0.19 mg/l) (Fig. 6-16). Similar concentrations of all nutrients were observed at open, closed and riverbank sites (Table 5-2, Figs. 6-11, 6-13 and 6-17).

Nutrients – August 2004

Data from the August 2004 sampling are found in Figures 6-2 through 6-3, Figure 6-6, Figures 6-10 through 6-13 and Figures 6-18 through 6-19. Ammonia levels ranged from 0.01 mg/l in Polecat Bay, Delvan Bay and Chocolatta Bay to 0.10 mg/l at South of Justin's and 0.18 mg/l at Tensaw Riverbank (Fig. 6-2). Nitrate-nitrite ranged from 0.013 mg/l in Delvan Bay and 0.014 mg/l in Polecat Bay to 0.104 mg/l at Blakeley Riverbank (Fig. 6-6). Tensaw riverbank had the lowest total Kjeldahl nitrogen (0.290 mg/l) while Chocolatta Bay 2 (1.700 mg/l) and Polecat Bay (0.900 mg/l) had the highest total Kjeldahl nitrogen (Fig. 6-6). Total phosphorus ranged from 0.041 mg/l in Chocolatta Bay to 0.082 mg/l in Justin's Bay (Fig. 6-3).

Ammonia ($p=0.468$), nitrate-nitrite ($p=0.695$), total Kjeldahl nitrogen ($p=0.533$) and total phosphorus ($p=0.640$) were not significantly different among sites north and south of the causeway during August (Figs. 6-10, 6-12 and 6-18). Similar concentrations of all nutrients were observed at open, closed and riverbank sites except total Kjeldahl nitrogen ($p=0.118$) with closed sites having higher levels (mean=0.98 mg/l) than open (mean=0.72 mg/l) and riverbank sites (mean=0.51 mg/l) (Figs. 6-13, 6-15 and 6-19).

Nutrients – October 2004

Nutrient analyses from October 2004 are summarized in Table 5-3. By site, ammonia ranged from below detection limit (<0.01 mg/l) in Polecat Bay, Delvan Bay and Tensaw Riverbank to 0.16 mg/l at South of Chocolatta (Fig. 6-2). Nitrate-nitrite ranged from 0.078 mg/l in Chocolatta Bay 2 and 0.098 mg/l in Delvan Bay to 0.257 mg/l in South of Justin's (Fig. 6-7). Blakeley Riverbank had the lowest total Kjeldahl nitrogen (0.470 mg/l) while South of Chocolatta (0.930 mg/l) had the highest total Kjeldahl nitrogen (Fig. 6-7). Total phosphorus levels were lowest in Delvan Bay (0.063 mg/l) and highest in South of Chocolatta (0.097 mg/l) (Fig. 6-3).

Sites south of the causeway had significantly greater levels of ammonia ($p=0.001$) (mean=0.09 mg/l) and nitrate-nitrite ($p=0.026$) (mean=0.17 mg/l) than sites located north of the causeway (NH_4 mean=0.09 mg/l; NO_3-NO_2 mean=0.11 mg/l) (Figs. 6-10 and 6-14). Similar concentrations of all nutrients were observed at open, closed and riverbank sites (Table 5-2, Figs. 6-11, 6-13 and 6-21).

Water Column Parameters – YSI and Nutrients MDS Plots

Appendix 7 contains MDS plots from Primer analyses, which graphically depict YSI and nutrient results by site, location north or south of the causeway and open, closed and riverbank treatments. Data found in the MDS plots were from the three main sampling events: February 2004, June 2004 and October 2004.

February 2004

Figures 7-1 through 7-3 graphically depict February 2004 data from YSI readings and nutrient analyses. MDS analyses of YSI parameters and nutrients resulted in a stress value of 0.07. Grouping of sites with similar characteristics is clear in Figure 7-1. Blakeley Riverbank (RB2), South Blakeley Riverbank and South of Justin's are grouped together and all are located on the eastern side of the Delta with riverine influences. Justin's Bay was not closely grouped with other sites. Pinto Pass (Site 8) and Tensaw Riverbank (RB1) were similar in YSI parameters and nutrient characteristics. Polecat Bay (PB) and Mouth of Pinto Pass (Site 7) were similar as were Delvan Bay (DB) and Chocolatta Bay (CB) and South of Chocolatta (Site 9). Figure 7-2 presents the same data as Figure 7-1 but labeled by location north or south of the causeway. Sites north of the causeway broadly separate out from sites south of the causeway with overlap occurring for Pinto Pass (Site 8), South of Chocolatta (Site 9) and Blakeley Riverbank (RB2) sites. Plotted by open, closed or riverbank, the data form three groups except for South of Justin's (Site 10, open) which is most similar to the riverbank sites (Fig. 7-3).

June 2004

Figures 7-4 through 7-6 graphically depict data from YSI readings and nutrient analyses from the June 2004 collections. MDS analyses for YSI and nutrient parameters resulted in a stress value of 0.10 that is a good fit for the data but not as strong as the February data. Although Chocolatta Bay (CB) and Mouth of Pinto Pass (Site 7) are different from other sites for water quality parameters (Fig. 7-4), Chocolatta Bay is most similar to the Delvan Bay, Polecat Bay and Tensaw Riverbank group and Mouth of Pinto Pass is most similar to Pinto Pass and South of Chocolatta (Fig. 7-4). Pinto Pass (Site 8) and south of Chocolatta (Site 9) located south of the causeway are similar in water quality measurements. During June, Justin's Bay (JB), Blakeley Riverbank (RB2), South Blakeley Riverbank (Site 11) and South of Justin's (Site 10) were similar and most likely due to the influence of the Blakeley riverine system. North of the causeway, the closely related sites of Delvan Bay, Polecat Bay and Tensaw Riverbank are all located in the western portion of the Delta (Fig. 7-4). Distinctions between water quality characteristics for sites north and south of the causeway are evident in Figure 7-5. Plotted by open, closed or riverbank, the data forms three groups except for South of Justin's (Site 10, open) which is most similar to the riverbank sites (Fig. 7-6).

October 2004

Figures 7-7 through 7-9 graphically depict data from YSI readings and nutrient analyses from the October 2004 collections. A stress value of 0.11 resulted from the MDS analyses for YSI and nutrient parameters that is a good fit for the data but not as strong as the February data. Site characteristics for October were similar to June results in groupings. Chocolatta Bay (CB) is distinctly different from other sites (Fig. 7-7) and probably most similar to the Delvan Bay, Polecat Bay and Tensaw Riverbank group. Mouth of Pinto Pass (Site 7) water quality parameters were similar to Pinto Pass and South of Chocolatta (Fig. 7-4). During October, Justin's Bay (JB), Blakeley Riverbank (RB2), South Blakeley Riverbank (Site 11) and South of Justin's (Site 10) were similar, as in June 2004. Clear distinctions between water quality characteristics for sites north and south of the causeway occurred in October (Fig. 7-8). Open, closed and riverbank data classifications form three groups with riverbank sites more similar to open sites than to closed sites (Fig. 7-9).

BIOLOGICAL MONITORING – PRIMER BIOENV ANALYSES

Primer BIO-ENV analyses were conducted using benthic community, YSI readings, nutrient data and sediment data for the three main sampling events: February 2004, June 2004 and October 2004. BIO-ENV analysis is used to correlate biological data with physical data using similarity matrices.

The February, June and October benthic communities were highly correlated with sediment parameters. Percent water, clay, silt and sand explained 97.2% of the variance observed for benthic invertebrate distribution patterns. Limiting the number of sediment variables to two, percent clay with percent sand (p_w=0.949) and percent clay with percent silt (p_w=0.938) explained the majority of variation in site benthic communities. The most important determinant of patterns in benthic community structure was the distribution patterns of percent clay (p_w=0.782).

Compared with sediment correlations, spatial patterns for YSI and nutrient concentrations were not strongly correlated with differences in the structure of the benthic communities in February 2004 or June 2004. During February 2004, salinity, chlorophyll *a* and total phosphorus explained 51.3% of the benthic community variation. Salinity and chlorophyll *a* (p_w=0.562) best explained the variability in June benthic community. Hydrography played an increasingly important role during October 2004. Specific conductivity, depth, chlorophyll *a* and turbidity explained 93.3% of the biotic patterns. Limiting the number of YSI/nutrient variables to two, specific conductivity and turbidity (p_w=0.830) explained the majority of variation in site benthic communities. The single best variable for benthic community structure variation in October was turbidity (p_w=0.668).

BIOLOGICAL MONITORING – FISH

Appendix 8 contains data tables for the March 2004 and July 2004 fish sampling. All the fish data is summarized in Table 8-1. Tables 8-2 through 8-11 contain data from individual samplings. During March and July, two trawls were conducted in Chocolatta Bay and south of the causeway. In March, a gill net was set in Chocolatta Bay and south of the causeway.

Chocolatta Bay trawl collections during March were dominated by anchovy (n=643 and 76). Numerous male blue crabs were also collected in Chocolatta Bay (n=13 and 16). Total numbers of species collected in Chocolatta Bay were 9 and 7 for total fish counts of 676 and 106 respectively (Tables 8-1 to 8-3). South of the causeway, trawl one was dominated by minnows (n=61) and trawl two was dominated by blue crab (n=12) and pipefish (n=11). Total numbers of species collected south of the causeway were 6 and 8 for total fish counts of 77 and 44 respectively (Tables 8-1, 8-5 and 8-6). Two blue crabs and a mullet were caught in the Chocolatta gill net (Table 8-1 and 8-4). South of the causeway a mullet and a catfish were caught in the gill net (Table 8-1 and 8-7).

During July 2004, anchovy (n=96), sand seatrout (n=25) and spot (n=236) dominated the first Chocolatta Bay trawl which contained 13 species and 423 fish (Tables 8-1 and 8-8). The second Chocolatta Bay trawl contained 14 species and 204 fish. Pipefish (n=39), rainwater killifish (n=67) and immature sunfish were the dominant species in the second Chocolatta Bay trawl (Tables 8-1 and 8-9). South of the causeway, total fish abundance and number of species were lower than the Chocolatta Bay collections. Spot dominated the first trawl that contained 8 species and 116 fish (Tables 8-1 and 8-10). The second trawl south of the causeway which had a total of 10 species and 41 fish was dominated by rainwater killifish (n=19) (Tables 8-1 and 8-11).

SUMMARY

Within the Delta proper, a large dike-like causeway built in the late 1920s has severed a number of once open bays from immediate contact with the waters of the Gulf of Mexico. By altering tidal exchange and volume of freshwater inflow, this hydrological modification may have altered the ecological function and biodiversity of the Mobile-Tensaw Delta as well.

Based on the 2003-2004 monitoring and sampling events, short and long-term variations in the hydrography were evident in the Mobile-Tensaw Delta. Continuous monitoring data documented the short-term variability in water quality parameters that ranged from days to months. Typical seasonal changes in temperature, salinity and dissolved oxygen occurred at all sites although the degree of changes varied among sites. Gravine Island, the most northern site, had lower salinity than sites closer to the causeway: Chocolatta Bay, Tensaw River and Blakeley Island. Continuous monitoring salinity data suggests that salt and fresh water exchange does occur in the lower Delta. During fall 2003, salinities were highest in Chocolatta Bay and Tensaw River suggesting that gulf waters are moving up the western side of the Delta. Monthly salinity readings from the study sites were greatest on the western side of the delta and gradually decreased in an easterly direction (Fig. 5-1). The highest salinity event occurred during Hurricane Ivan in September 2004, which rapidly forced water into and back out of the Delta.

Periods of low dissolved oxygen were observed in Chocolatta Bay, Justin's Bay and Meaher Park. Thirteen hypoxic events were recorded in Justin's Bay between April and November 2004 compared with two hypoxic events in Chocolatta Bay and four hypoxic events at Meaher Park. Hypoxic events were short lived at all three sites. Chocolatta Bay and Justin's Bay were classified as closed sites with low water column turnover and high retention time. Chocolatta water exchange is not clearly understood but Justin's Bay water exchange occurs solely with the Blakeley River to the east. The numerous hypoxic events in Justin's Bay may be the result of minimal water exchange, rainfall totals, water quality, sediment characteristics and/or decomposing plant material. Compared with all other sites, Justin's Bay sediments contained highest percentages of clay and silt, total carbon and water and lowest percentage of sand supporting this hypothesis.

Primary water exchange in the lower Mobile-Tensaw Delta occurs within the rivers but because rivers are the main passageways through the causeway, flow rate can be extremely high during certain periods (e.g. rain events, frontal passages). During periods of low water flow, water exchange and thus mixing may not occur in embayments resulting low water column turnover and a high retention time. The degree of salt and fresh water exchange will ultimately affect water quality, nutrient concentrations as well as benthic and fish communities.

Spatial variability was evident both within and among sites for water quality parameters as well as benthic and sediment collections. The causeway provided a physical barrier, which spatially separated study sites north of the causeway from the control sites located south of the causeway. Significant or marginally significant differences occurred among sites with regard to number of species and total number of organisms for the February, June and October 2004 benthic collections. Based on BIO-ENV analyses, spatial differences in the benthic community composition were best explained by sediment characteristics not water quality parameters and nutrients. Polecat Bay had the lowest number of species and organisms for all three sampling periods, which may in part be due to the high sediment clay content. Delvan Bay also had the fewest species and organisms in February and June, and low species numbers in October. Mouth of Pinto Pass, Chocolatta Bay and Blakeley Riverbank collections also contained low numbers of species and/or total organisms during one or more sampling periods. Benthic communities from the sites listed above (except Mouth of Pinto Pass – south) probably reflect the sediment characteristics of sites north of the causeway which were characterized by higher levels of clay, silt, water and total carbon than sites south of the causeway.

Consistently, sites located south of the causeway had higher numbers of species and organisms than sites north of the causeway. Sites south of the causeway also had high percentages of sand while sites north of the causeway were characterized by more clay and silt. Northern site sediments also had significantly higher percentages of water and total carbon than sites south of the causeway. Open, closed and riverbank sites were similar in species number and total number of organisms for all three sampling periods. Open, closed and riverbank sites had similar percentages of clay, silt and sand but differed significantly in percentages of water and total carbon with closed sites characterized by the highest values and riverbank sites having the lowest values.

Generally, riverbank sites were similar in characteristics. During June 2004, the riverbank sites, except Mouth of Pinto Pass, had the highest numbers of benthic organisms. Sediment from Mouth of Pinto pass is characterized by low percentages of clay and total carbon as well as a high percentage of sand. This site, located on the western side of the study area, was on the edge of the main water exchange pathway. Mouth of Pinto Pass characteristics may be strongly influenced by high water volume, high flows, scouring, boat traffic and/or commercial fishing activities.

Proportions of major invertebrates groups changed seasonally. During periods of low salinity, proportions of chironomids were high (February and June) and were found in greatest numbers north of the causeway. Polychaete proportions peaked during October when salinities were highest. Amphipod proportions were highest in February and gradually decreased through October, which is most likely explained by fish feeding habits. Highest proportions of gastropods and bivalves also occurred during February.

North and south of causeway differed in fish species composition, number of species and number of organisms during March and July 2004. Fish abundance and species composition was greater in Chocolatta Bay than the collections south of the causeway suggesting both spatial and seasonal factors influence the fish community.

Significant differences in salinity, dissolved oxygen (mg/l), chlorophyll *a* and turbidity occurred among sites during all three major sampling events. Salinities were greatest on the western side of the Delta and south of the causeway especially during August and October. Dissolved oxygen readings were highest in February but variable by site and month for June and October samplings. Generally, chlorophyll *a* levels were low for all sites and sampling periods. Three chlorophyll *a* peaks (>10ug/l) occurred, one in Polecat Bay, Chocolatta Bay and South of Chocolatta. Northern sites had higher chlorophyll *a* levels than southern sites which may be in part due to reduced flushing rates. Delta waters were most turbid during February most likely due to passing frontal systems and wind driven mixing.

Nutrient concentrations of ammonia, nitrate-nitrite, total Kjeldahl nitrogen and total phosphorus were significantly different by month suggesting a seasonal influence. Nutrient levels may also be influenced by water quality parameters (e.g. temperature, dissolved oxygen), rainfall and point source and non-point source loadings.

Biological and physical variability in the lower Mobile-Tensaw Delta may be in part due to effects of the dike-like causeway creating a physical barrier between gulf and delta waters. Additionally, present and past land use may also affect the study area. The western shore of the lower Mobile-Tensaw Delta is characterized by industrial development and impacted by on-going dredging activities. In contrast, the eastern shore is less developed with low levels of commercial and residential development. Clearly, additional research is needed to determine possible effects of the causeway on the lower Mobile-Tensaw Delta.

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Appendix 1

Continuous Monitoring 2003 - 2004:

Tensaw River, Blakeley River, Gravine Island, Chocolatta Bay and Meaher Park

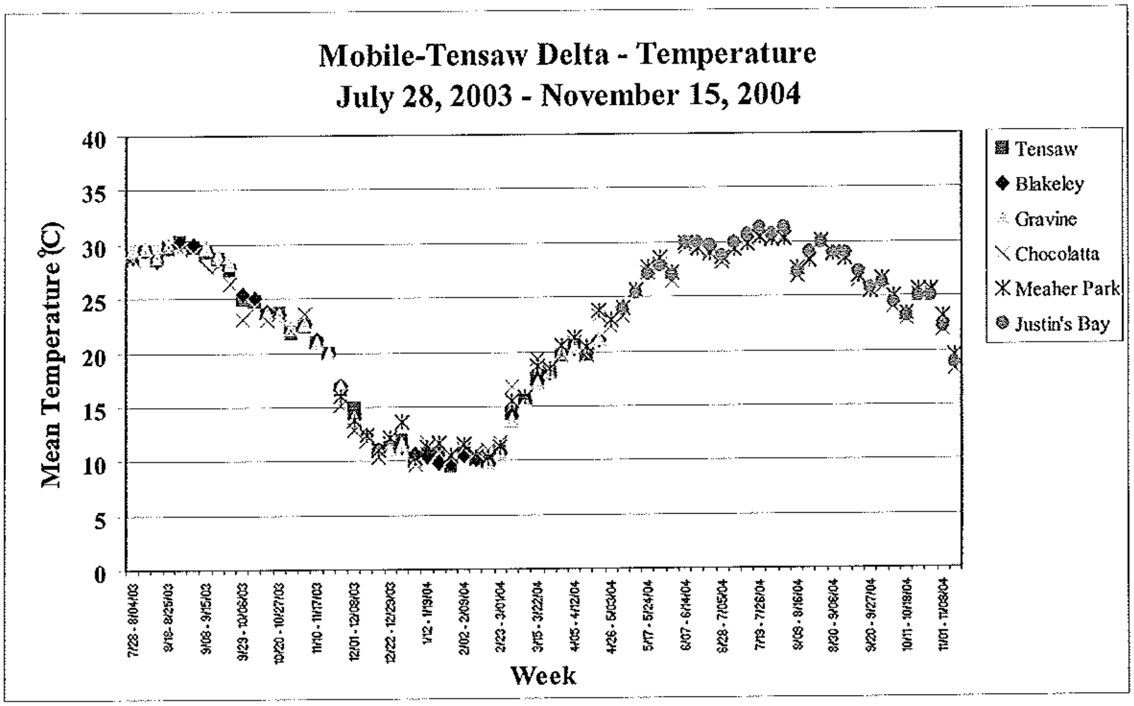

Figure 1-1. Mean temperature (°C) presented by week from July 28, 2003 to November 15, 2004 for Tensaw River, Blakeley River, Gravine Island, Chocolatta Bay, Meaher Park and Justin's Bay.

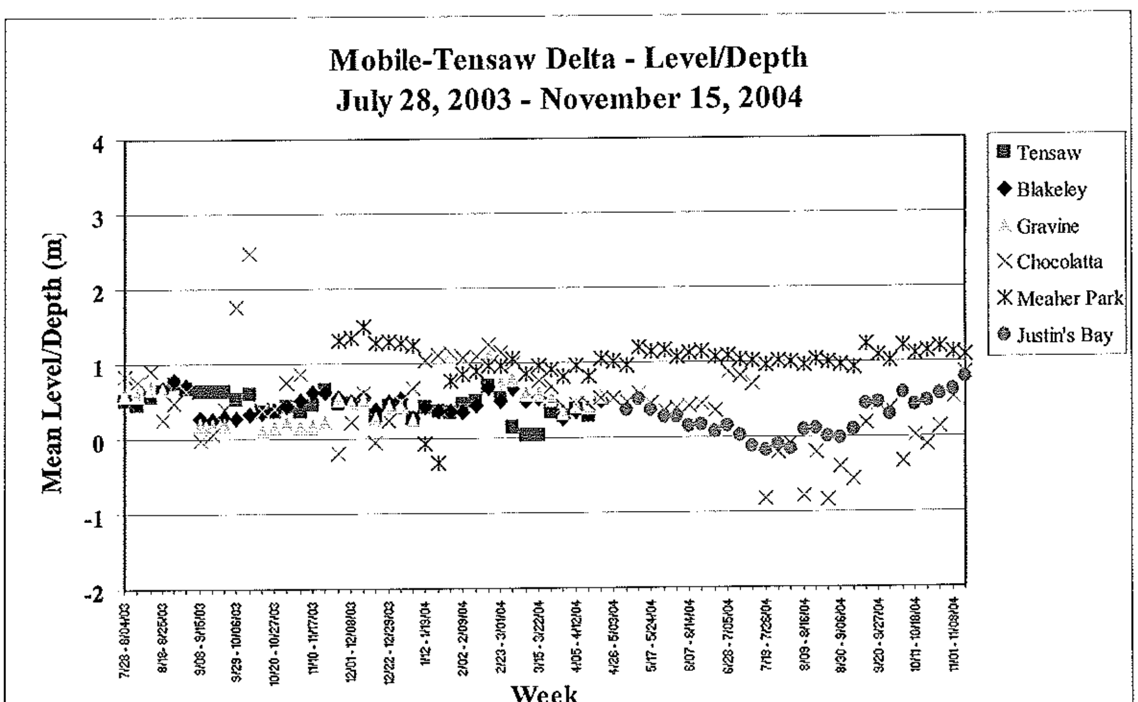

Figure 1-2. Mean level/depth (m) presented by week from July 28, 2003 to November 15, 2004 for Tensaw River, Blakeley River, Gravine Island, Chocolatta Bay, Meaher Park and Justin's Bay.

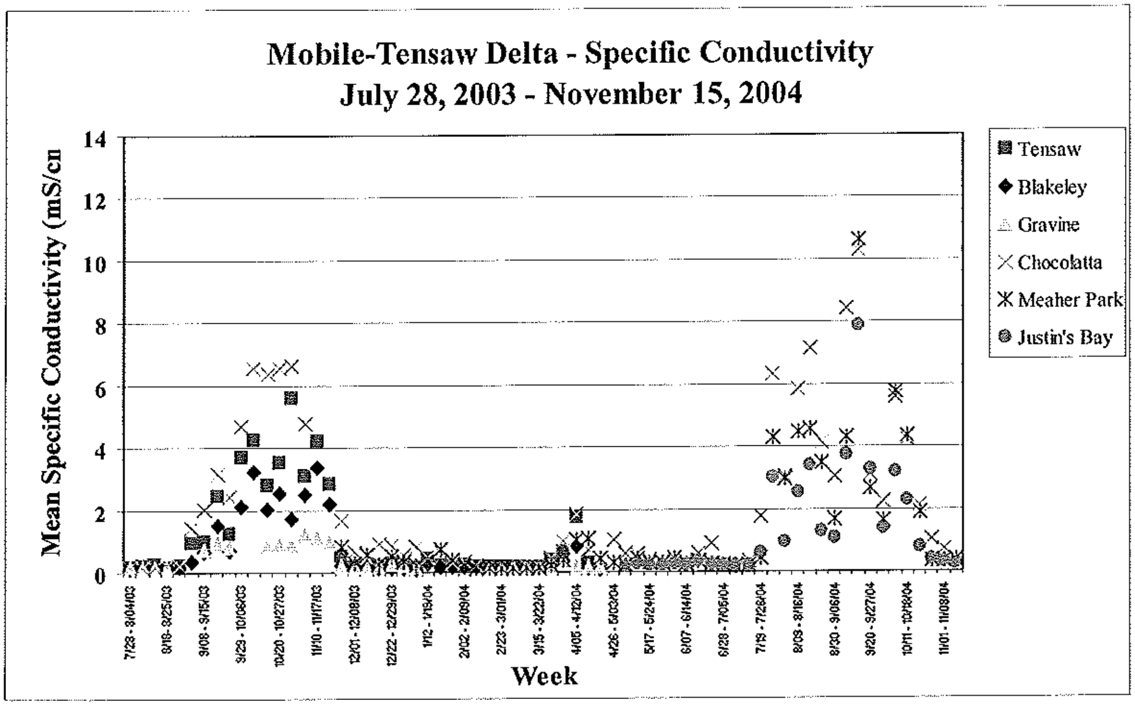

Figure 1-3. Mean specific conductivity (mS/cm) plotted by week from July 28, 2003 to November 15, 2004 for Tensaw River, Blakeley River, Gravine Island, Chocolatta Bay, Meaher Park and Justin's Bay.

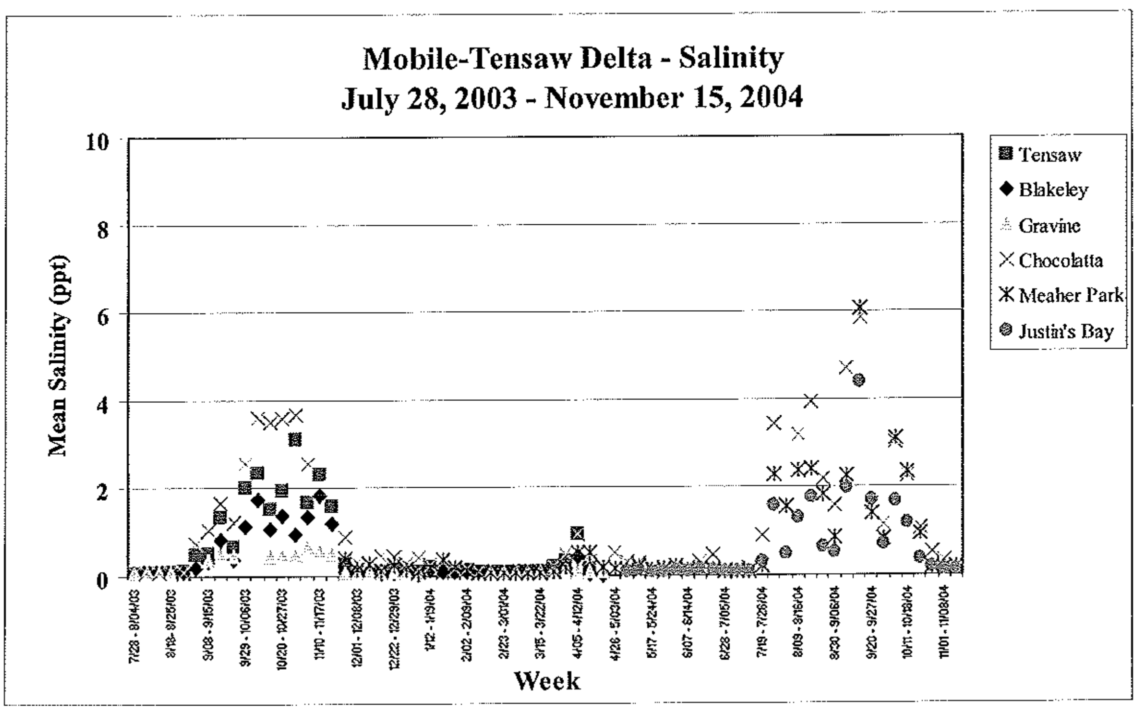

Figure 1-4. Mean salinity (ppt) plotted by week from July 28, 2003 to November 15, 2004 for Tensaw River, Blakeley River, Gravine Island, Chocolatta Bay, Meaher Park and Justin's Bay.

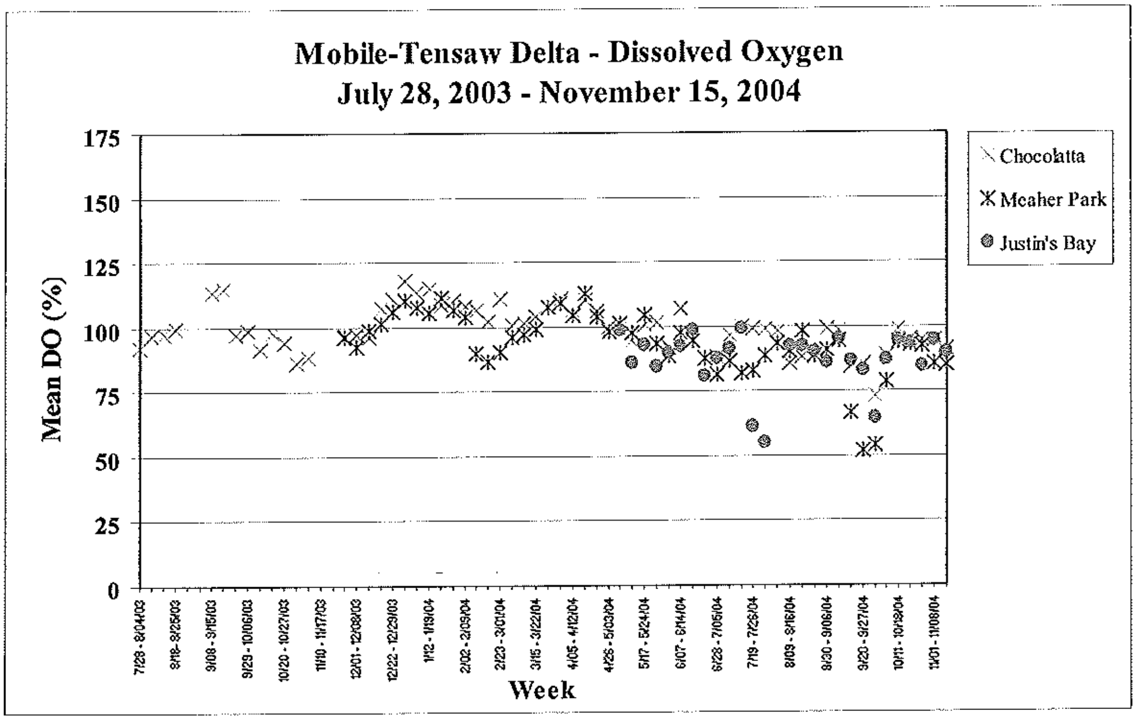

Figure 1-5. Mean dissolved oxygen (%) plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay, Meaher Park and Justin's Bay.

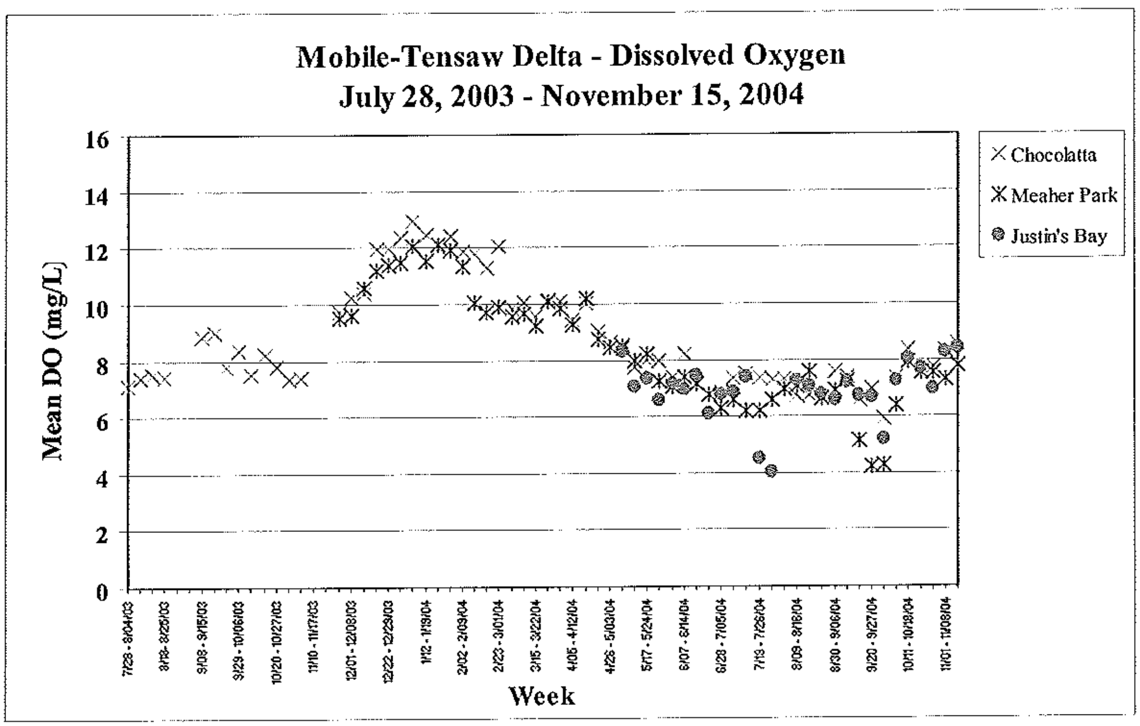

Figure 1-6. Mean dissolved oxygen (mg/l) plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay, Meaher Park and Justin's Bay.

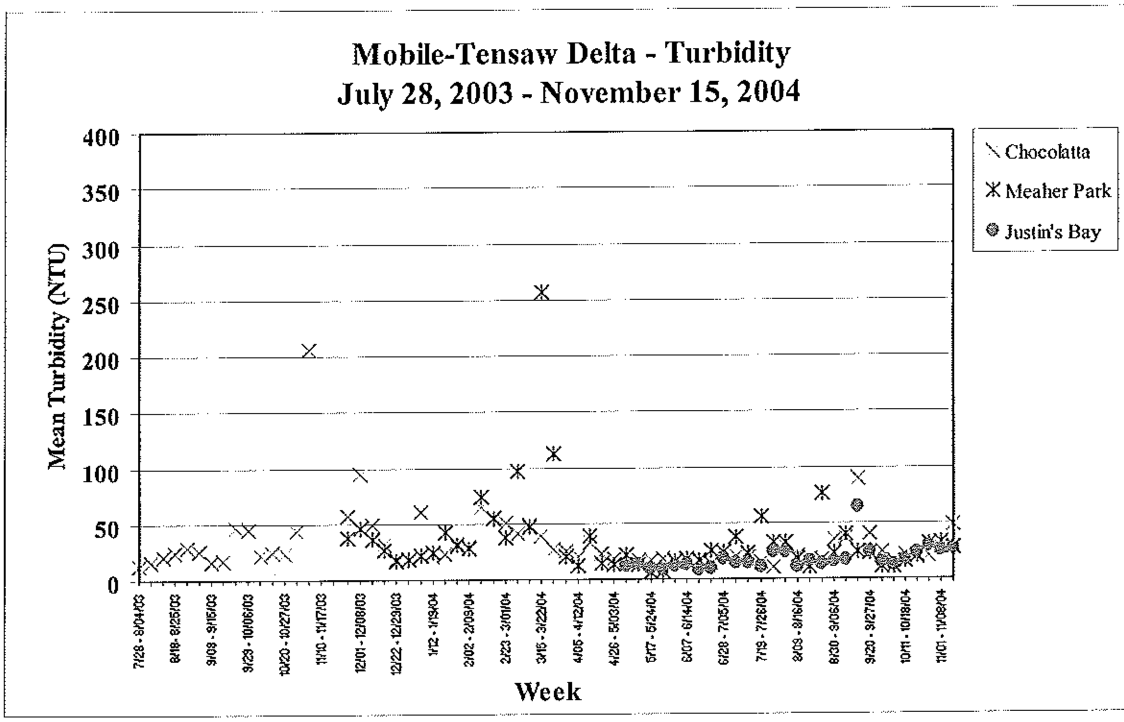

Figure 1-7. Mean turbidity (NTU) plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay, Meaher Park and Justin's Bay.

Appendix 2

Continuous Monitoring 2003 - 2004:

Chocolatta Bay, Justin's Bay and Meaher Park

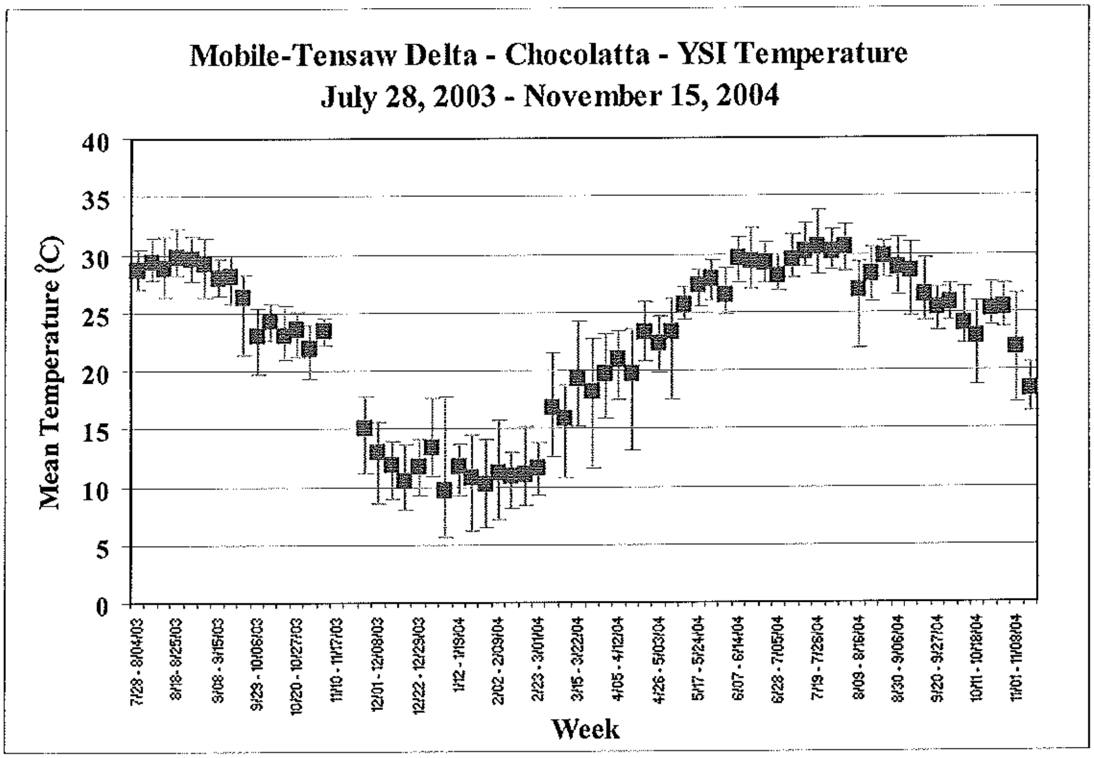

Figure 2-1. Mean temperature (°C) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay.

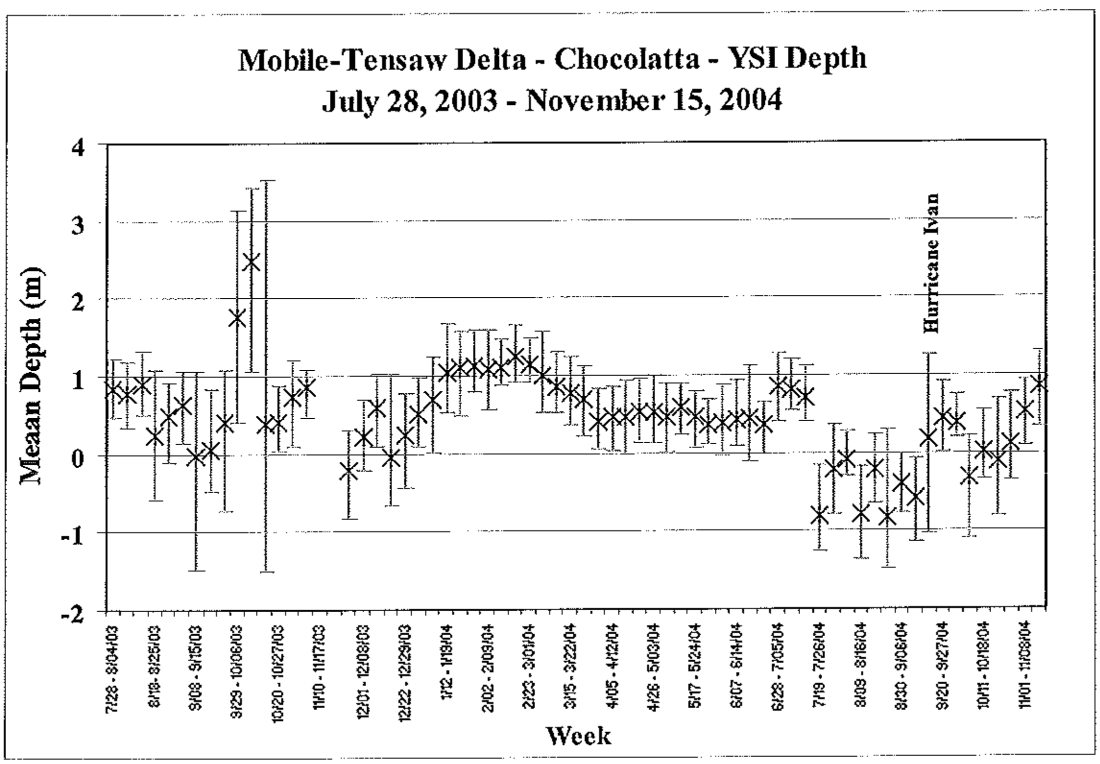

Figure 2-2. Mean depth (m) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay.

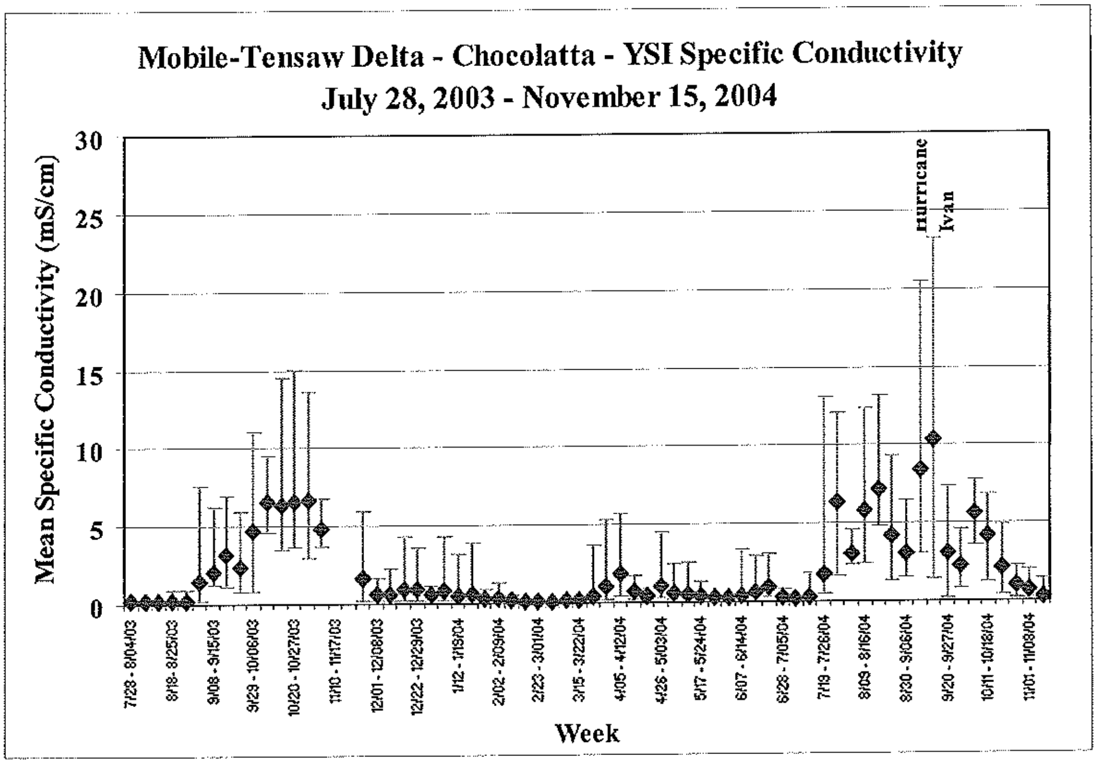

Figure 2-3. Mean specific conductivity (mS/cm) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay.

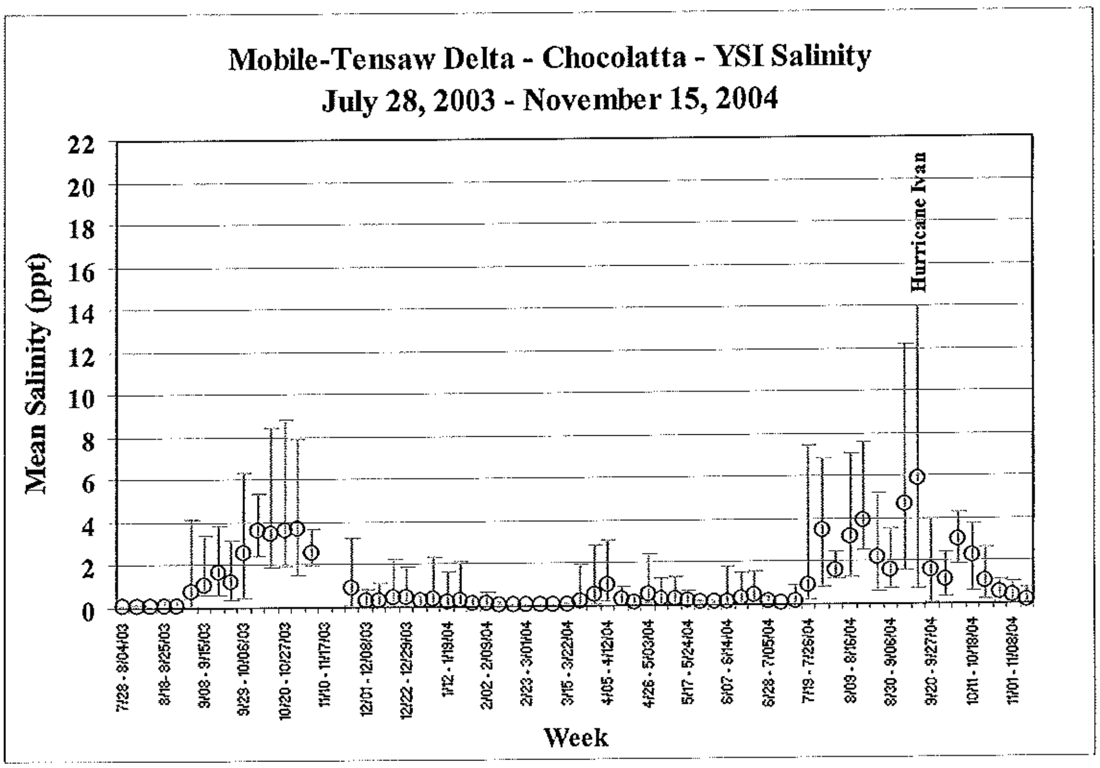

Figure 2-4. Mean salinity (ppt) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay.

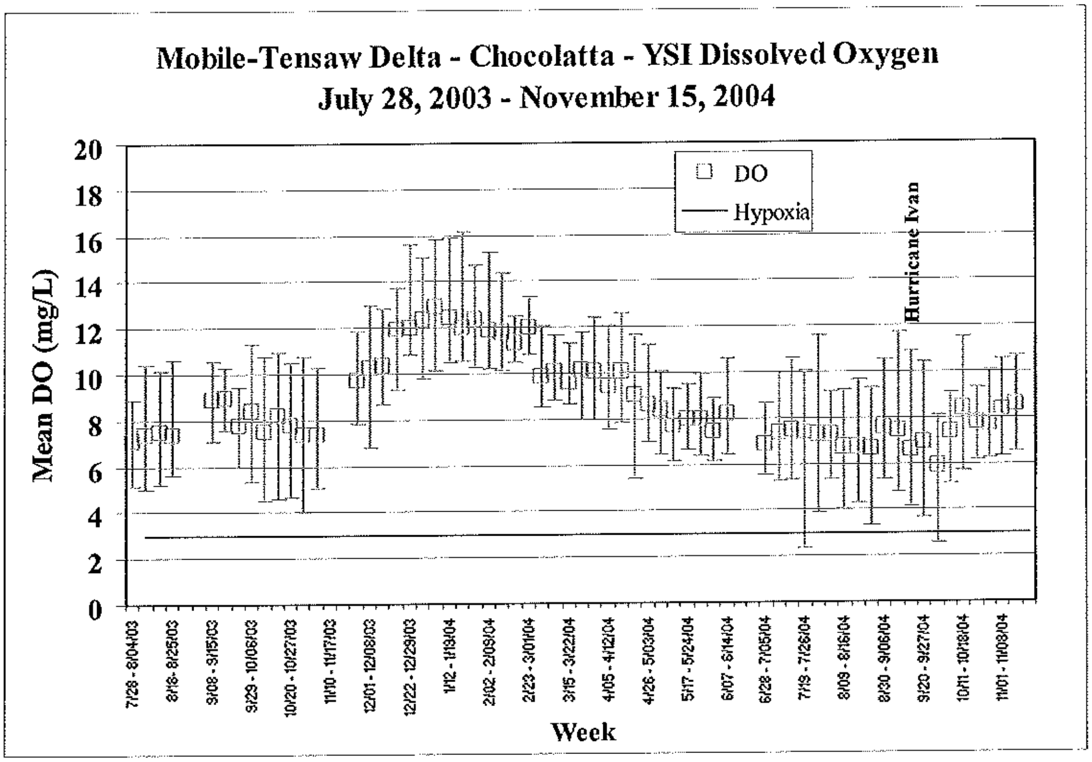

Figure 2-5. Mean dissolved oxygen (mg/L) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay.

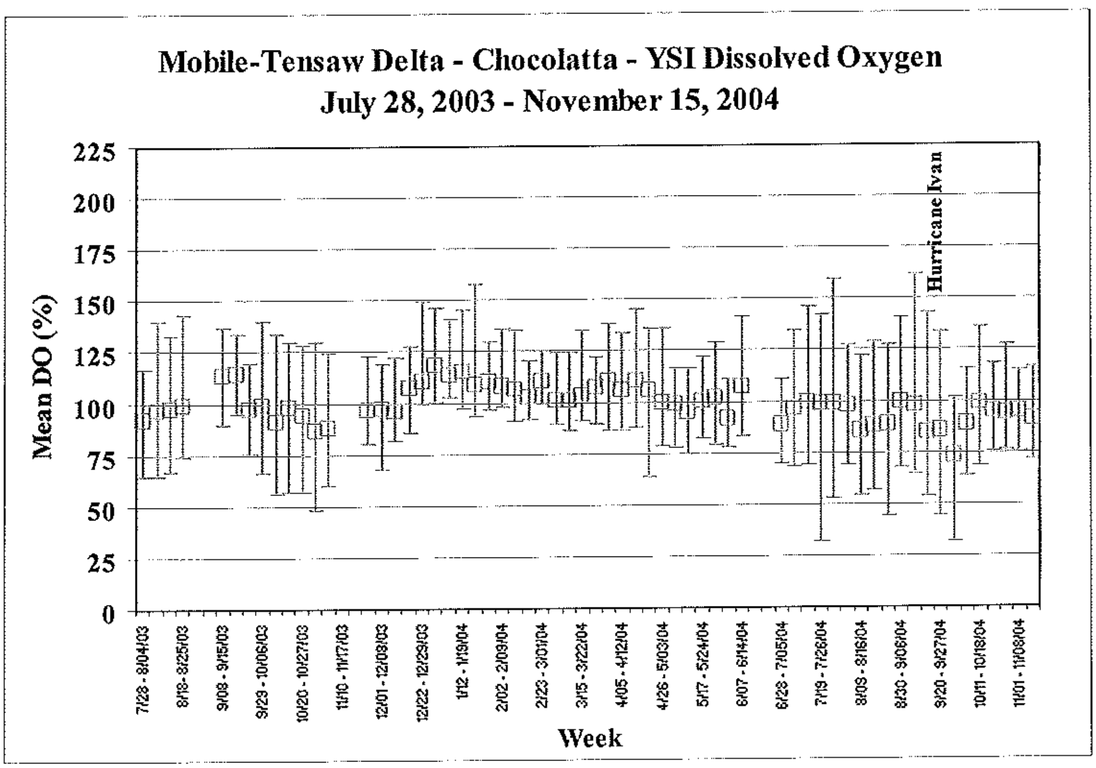

Figure 2-6. Mean dissolved oxygen (%) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay.

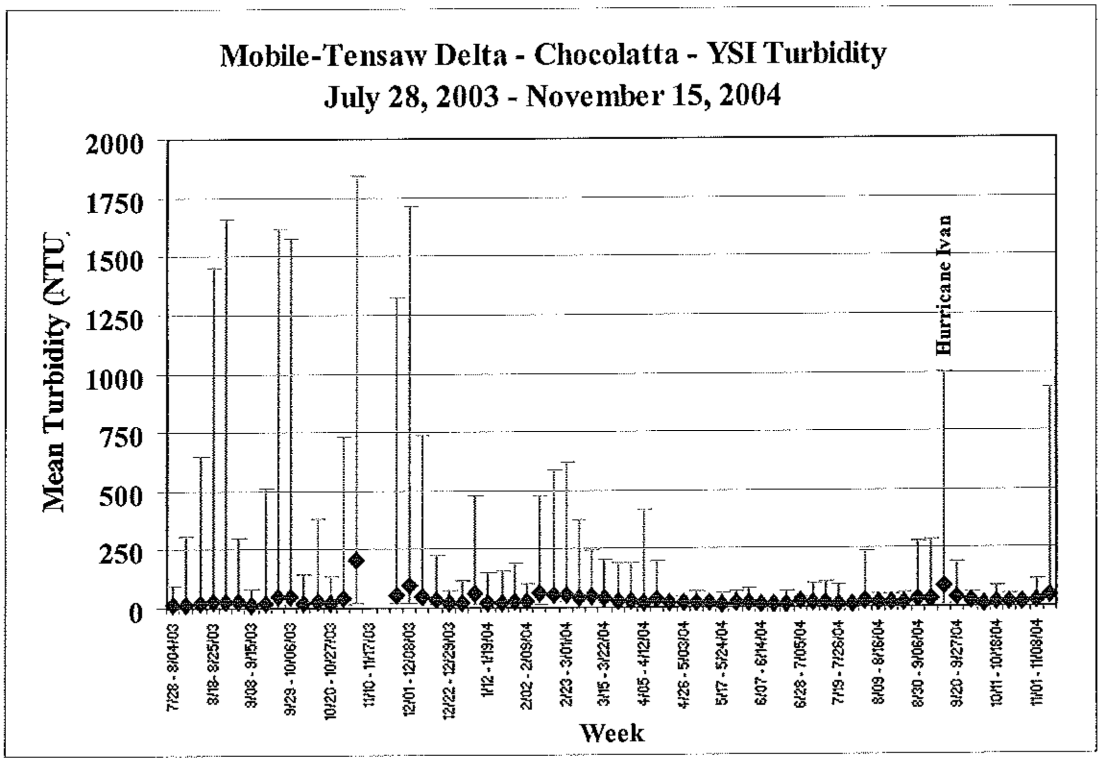

Figure 2-7. Mean turbidity (NTU) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Chocolatta Bay.

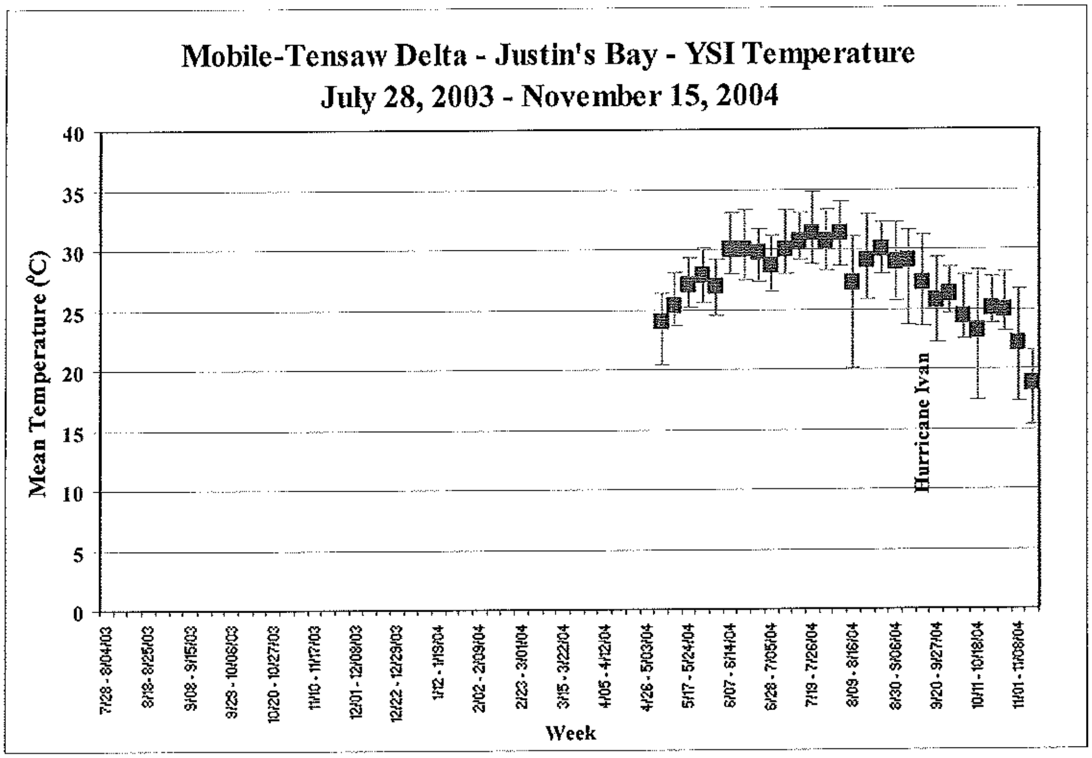

Figure 2-8. Mean temperature (°C) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Justin's Bay.

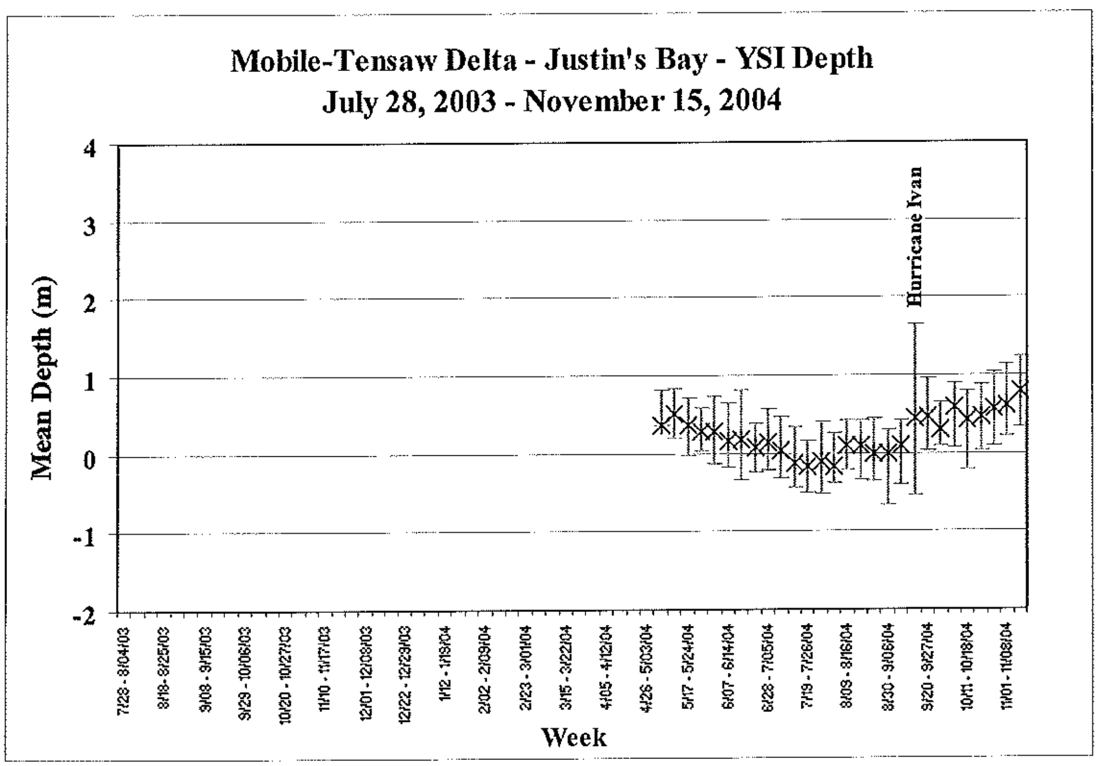

Figure 2-9. Mean depth (m) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Justin's Bay.

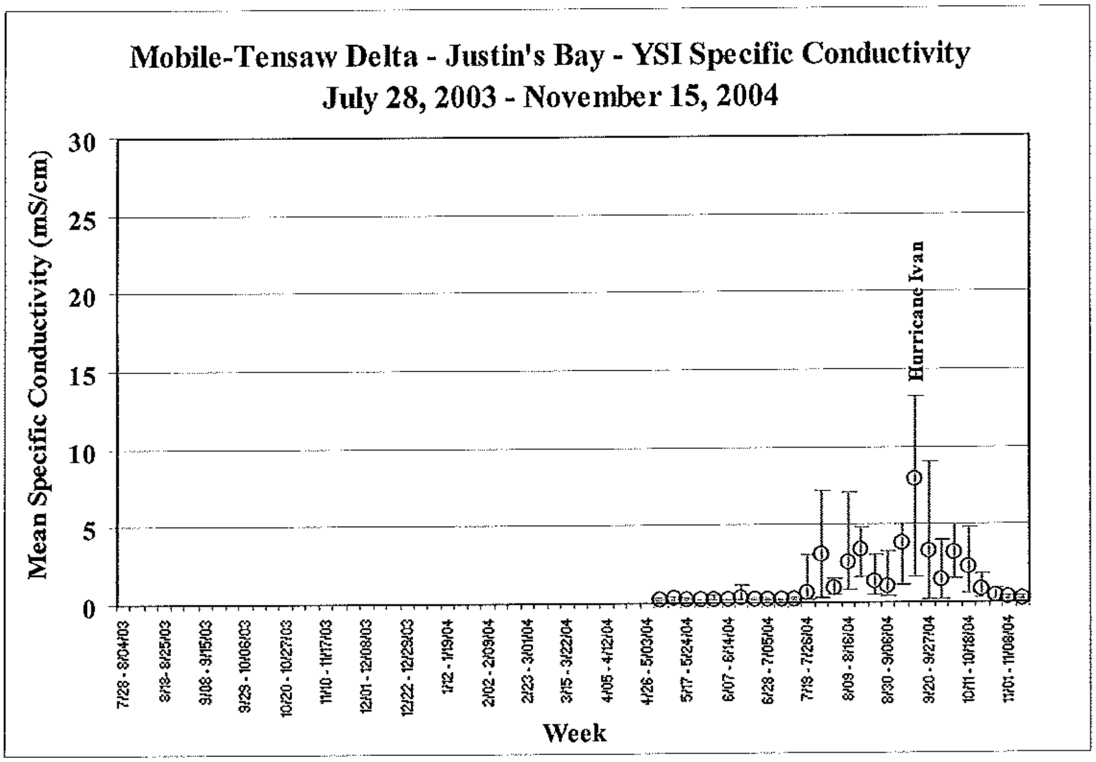

Figure 2-10. Mean specific conductivity (mS/cm) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Justin's Bay.

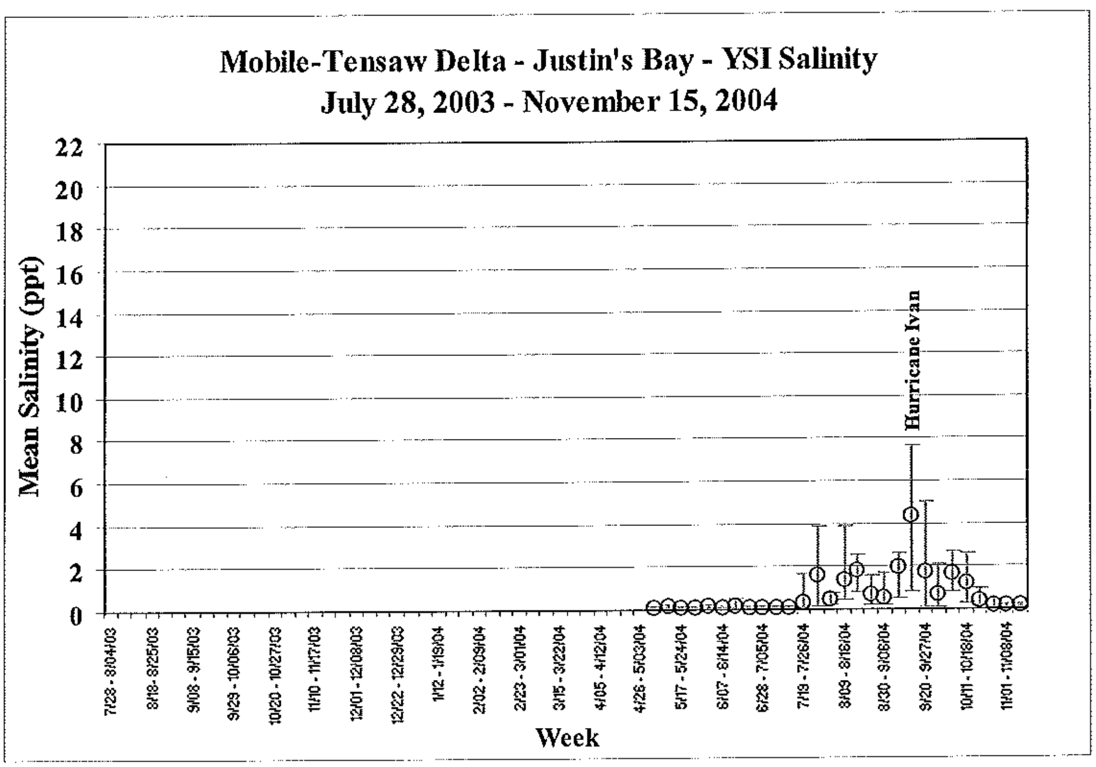

Figure 2-11. Mean salinity (ppt) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Justin's Bay.

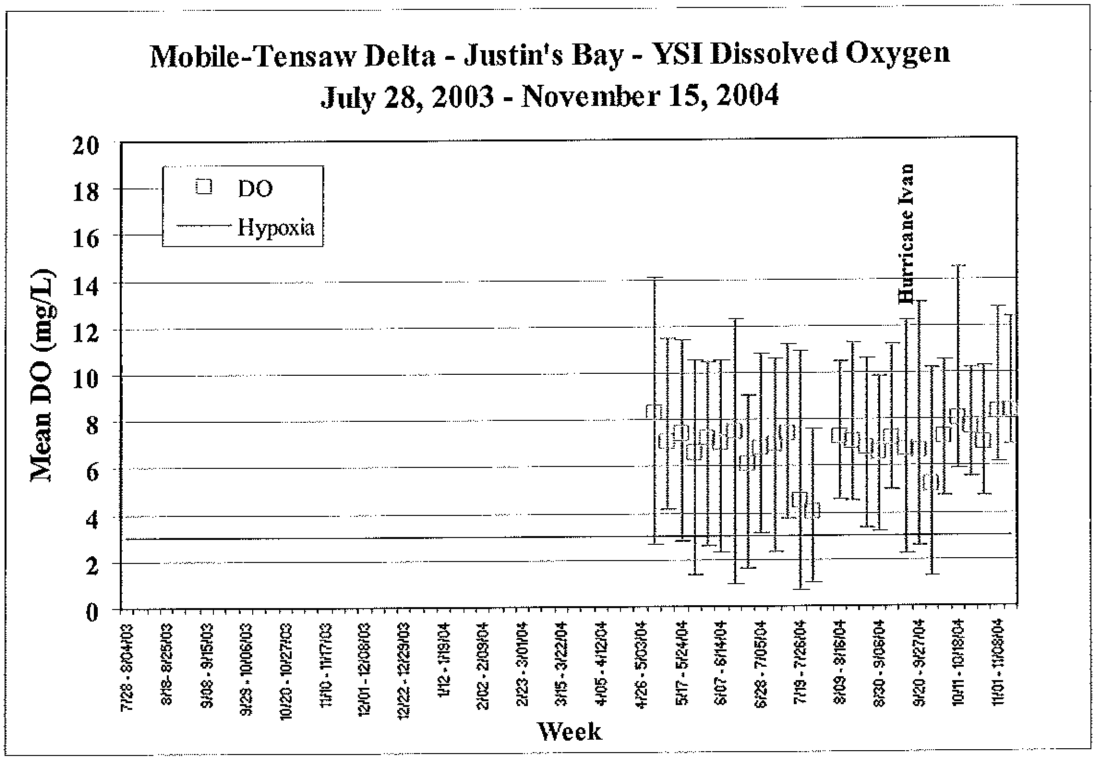

Figure 2-12. Mean dissolved oxygen (mg/L) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Justin's Bay.

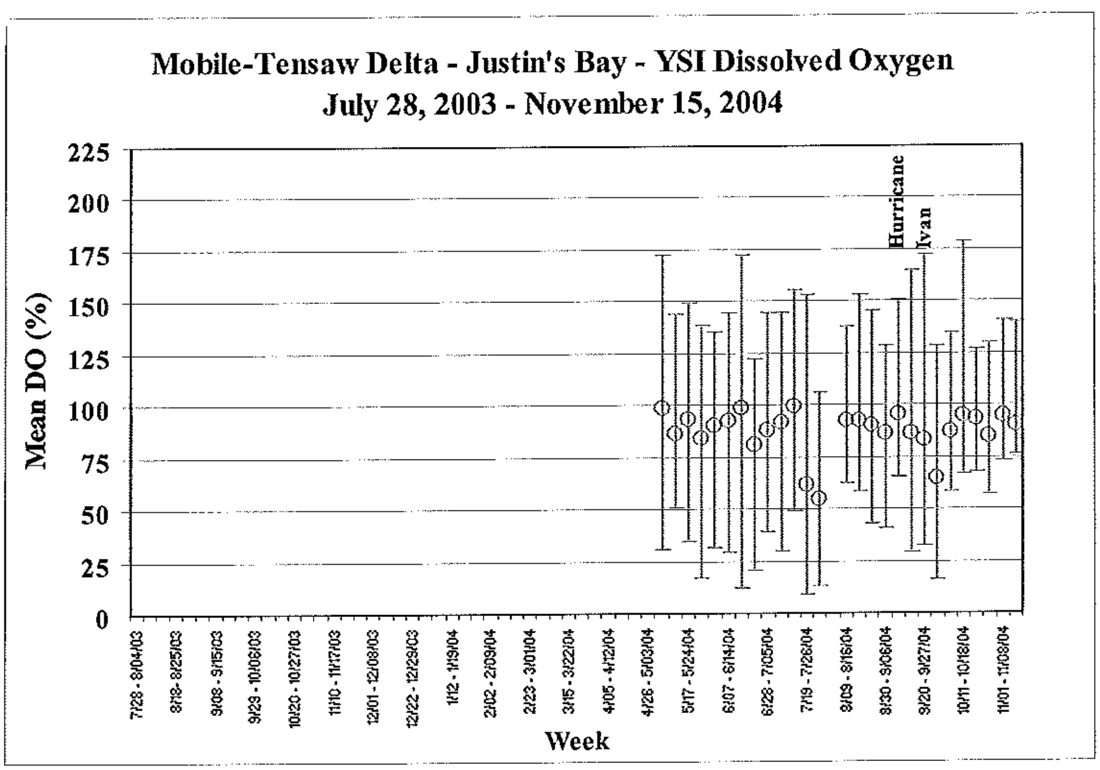

Figure 2-13. Mean dissolved oxygen (%) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Justin's Bay.

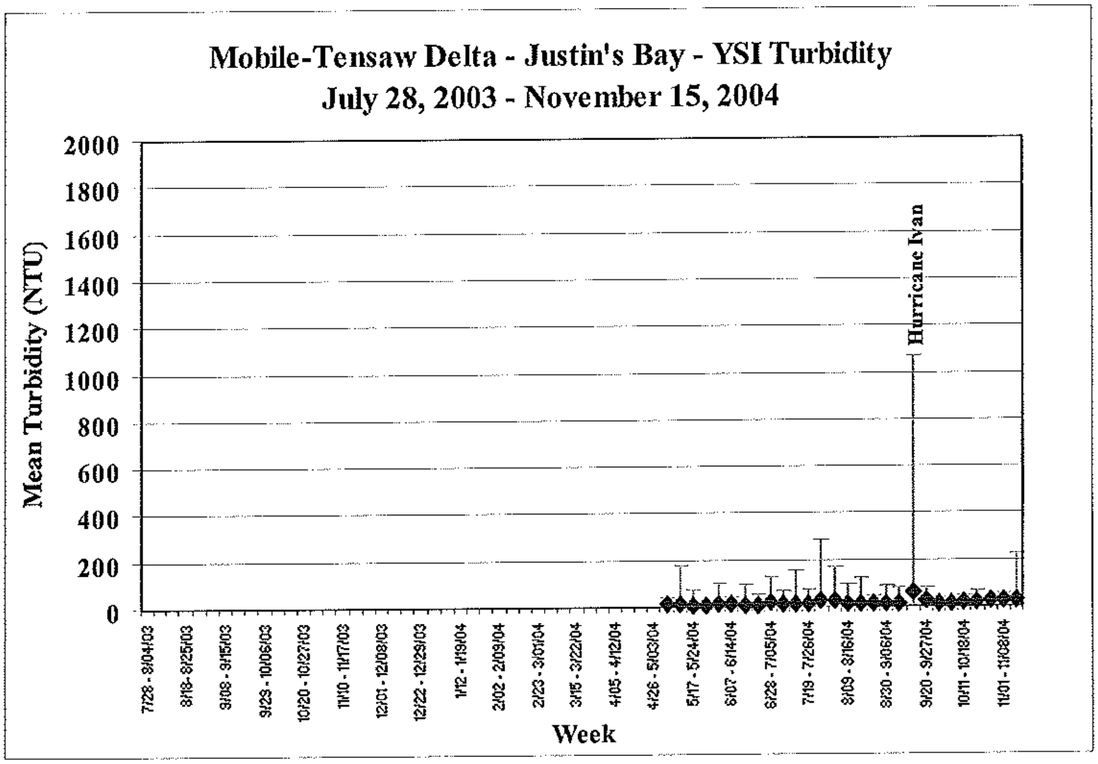

Figure 2-14. Mean turbidity (NTU) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Justin's Bay.

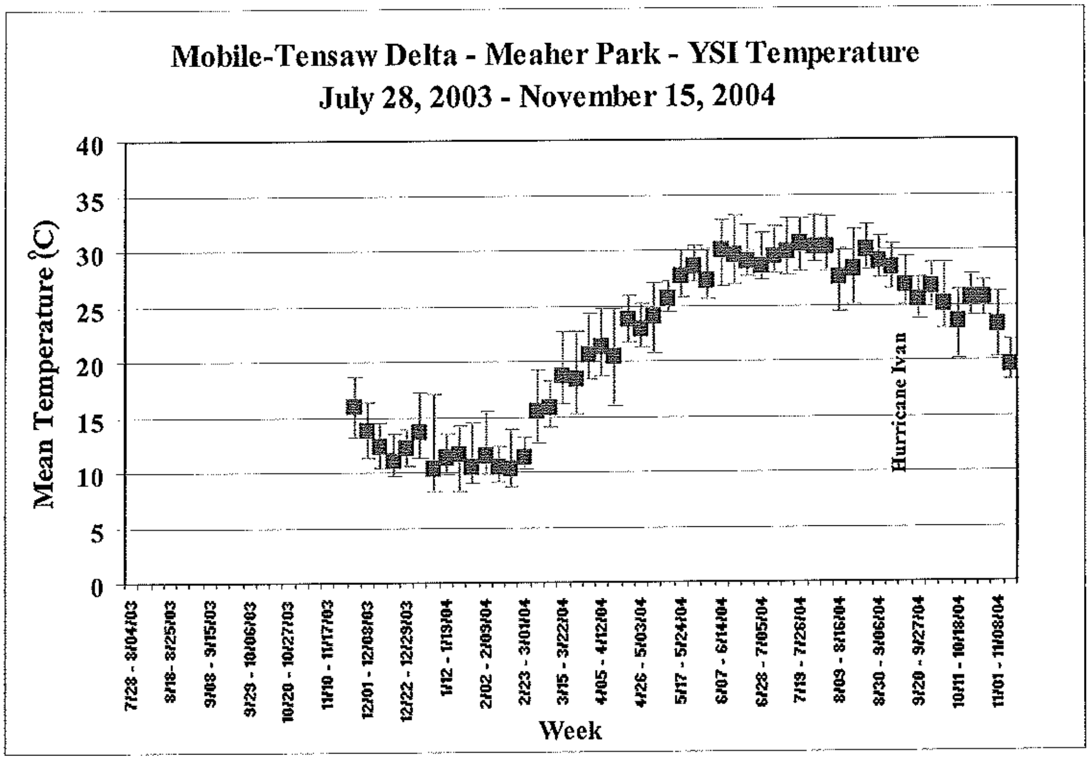

Figure 2-15. Mean temperature (°C) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Meaher Park.

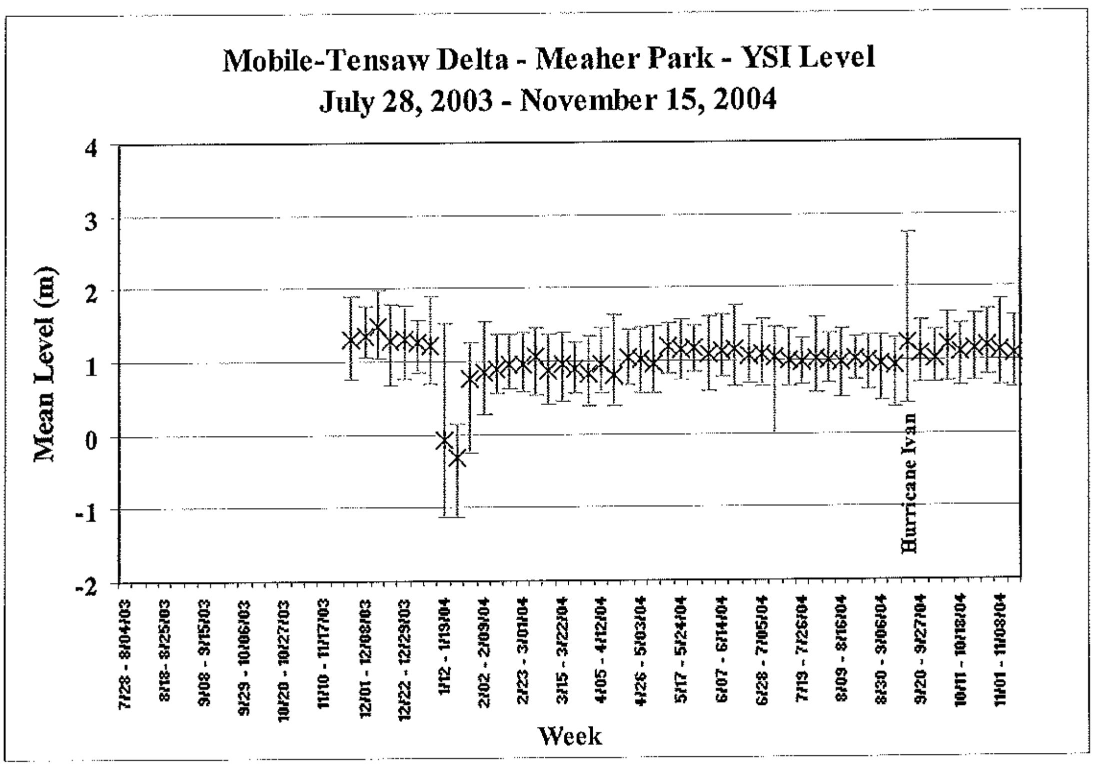

Figure 2-16. Mean depth (m) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Meaher Park.

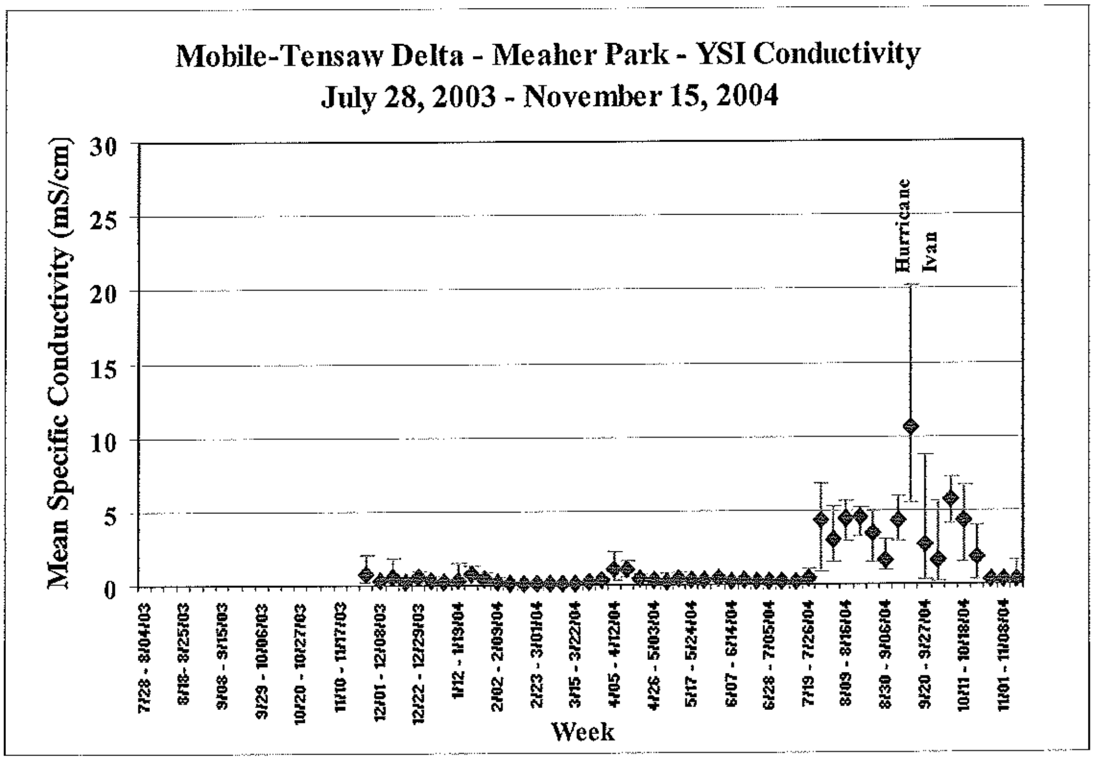

Figure 2-17. Mean conductivity (mS/cm) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Meaher Park.

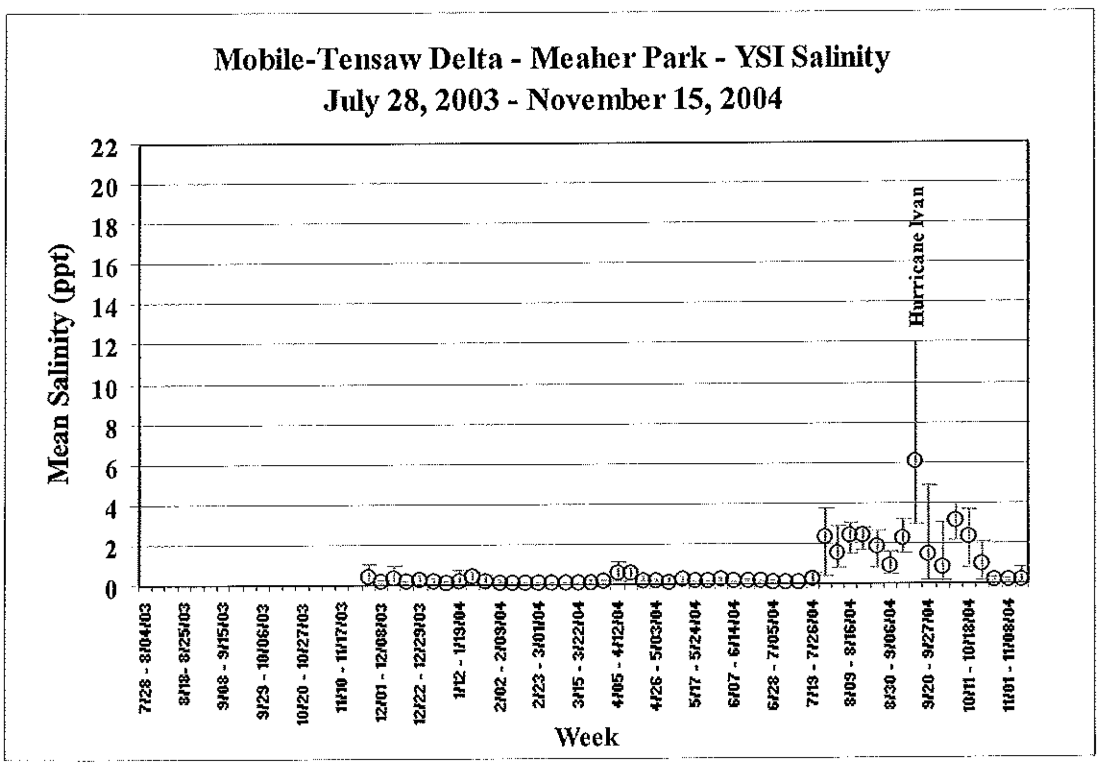

Figure 2-18. Mean salinity (ppt) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Meaher Park.

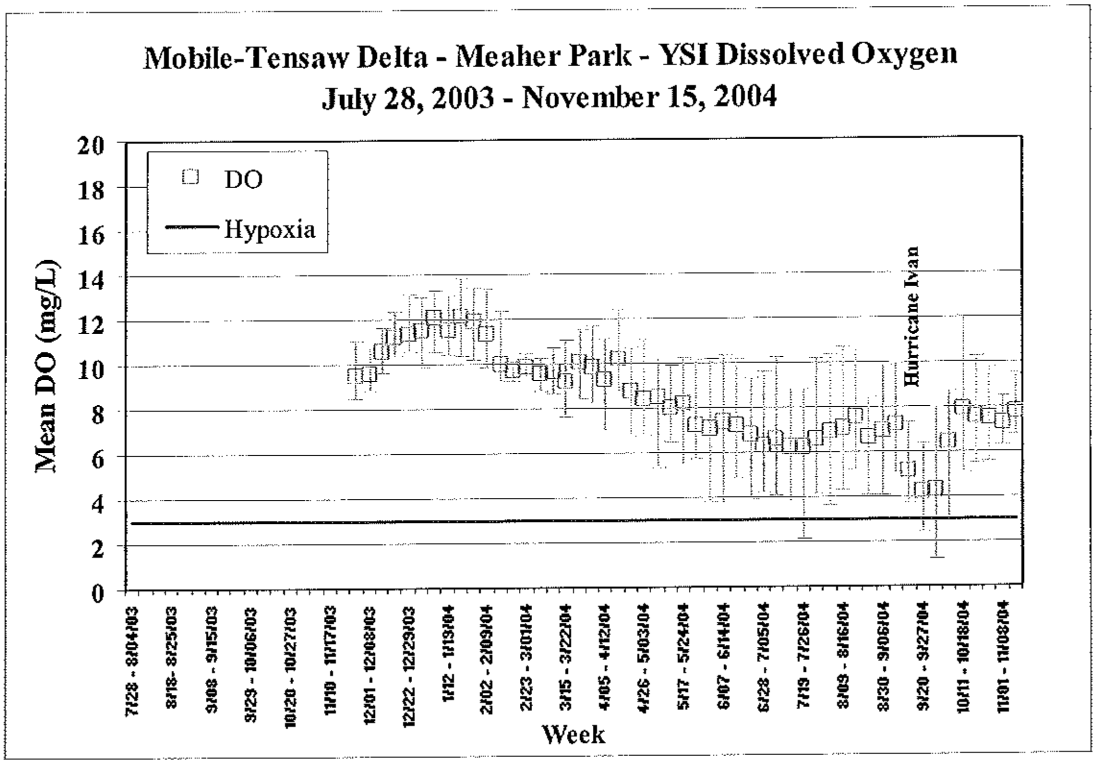

Figure 2-19. Mean dissolved oxygen (mg/l) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Meaher Park.

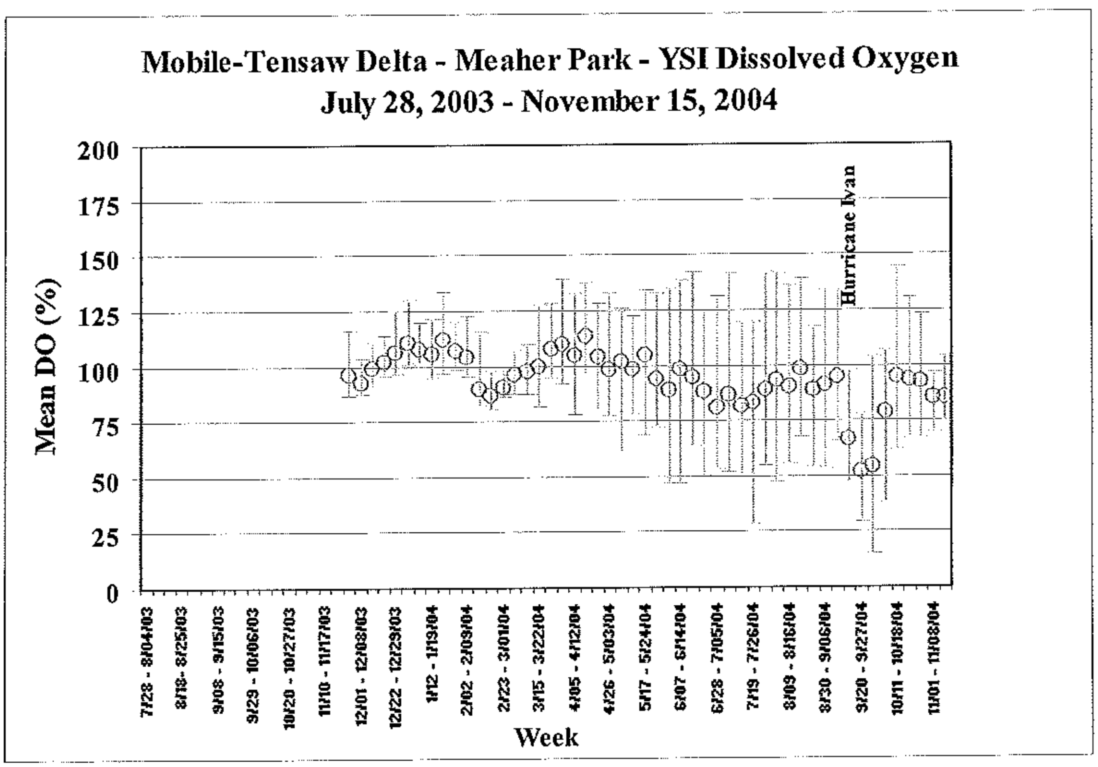

Figure 2-20. Mean dissolved oxygen (%) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Meaher Park.

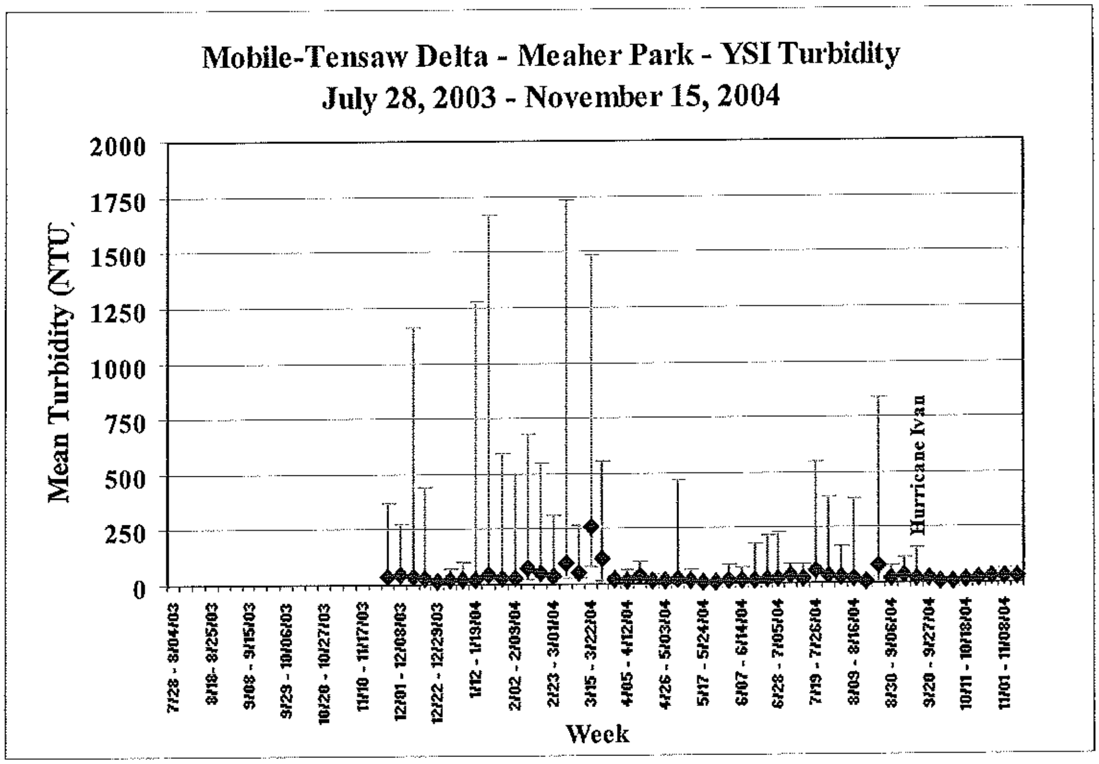

Figure 2-21. Mean turbidity (NTU) and ranges plotted by week from July 28, 2003 to November 15, 2004 for Meaher Park.

Appendix 3

Biological Monitoring:

Macroinvertebrates - February, June and October 2004

Table 3-1. Mean number and standard deviation of macroinvertebrate taxa and total number of species listed by location for benthic samples collected in February, June and October 2004 from the Mobile-Tensaw Delta. Site abbreviation, location north or south of the causeway (N or S), and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

				February 2004				June 2004				October 2004			
Location	Site	NS	OCR	Mean No. Species	Std No. Species	Mean Total No.	Std Total No.	Mean No. Species	Std No. Species	Mean Total No.	Std Total No.	Mean No. Species	Std No. Species	Mean Total No.	Std Total No.
Polecat Bay	PB	N	O	2.2	1.6	4.6	5.9	2.0	1.0	4.3	3.2	4.0	1.0	26.7	5.5
Delvan Bay	DB	N	O	3.8	0.8	7.8	4.5	5.0	3.6	14.3	16.7	4.3	2.1	46.3	4.9
Tensaw Riverbank	RB1	N	R	6.2	2.0	29.0	13.3	11.0	3.0	108.7	28.0	7.3	0.6	40.7	13.3
ChocolattaBay	CB	N	C	2.4	1.5	14.2	11.8	9.0	2.6	42.0	21.9	7.7	4.2	73.3	43.8
Blakeley Riverbank	RB2	N	R	8.5	1.3	54.3	24.7	12.7	2.5	110.0	26.9	5.3	2.3	19.0	13.7
Justin's Bay	JB	N	C	8.2	1.9	86.2	30.3	7.3	2.5	50.3	64.0	6.3	1.2	66.3	29.4
Mouth Pinto Pass	7	S	R	4.8	0.8	87.6	23.7	5.0	1.0	19.0	10.8	7.0	1.0	28.0	9.6
Pinto Pass	8	S	O	8.6	3.2	57.8	41.3	9.3	2.1	77.7	42.1	9.7	3.2	63.0	25.2
S. of Chocolatta	9	S	O	7.4	2.1	33.8	19.0	10.3	1.2	35.0	2.6	8.0	3.5	49.3	24.2
S. of Justin's	10	S	O	9.8	4.4	59.0	40.9	9.7	3.5	50.3	18.8	10.3	3.8	41.7	29.0
South Blakeley Riverbank	11	S	R	9.2	2.9	53.4	28.4	13.0	3.0	139.0	83.0	10.7	1.5	59.0	41.9

Table 3-2. February 2004 summary table for statistical analyses of macroinvertebrate taxa and total number of species analyzed by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven based on numbers of species and organisms (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

Location	North or South of Causeway	Treatment (OCR)	Total no. Organisms (avg)	Total no. species (avg)	Total no. Organisms	Total no. species
Site Name			na	na	**p= 0.000**	**p= 0.000**
Polecat Bay	N	O	11	11		
Delvan Bay	N	O	10	9		
Tensaw Riverbank	N	RB	8	7		
Chocolatta Bay	N	C	9	10		
Blakeley Riverbank	N	RB	5	4		
Justin's Bay	N	C	2	5		
Mouth of Pinto Pass	S	RB	1	8		
Pinto Pass	S	O	4	3		
South of Chocolatta	S	O	7	6		
South of Justin's	S	O	3	1		
South Blakeley Riverbank	S	RB	6	2		
North	N		-	-	B	B
South	S		-	-	A	A
			S > N	S > N	S > N	S > N
			p= 0.088	**p= 0.101**	**p= 0.001**	**p= 0.001**
Open		O	-	-	B	-
Closed		C	-	-	AB	-
Riverbank		RB	-	-	A	-
			R>C >O	R>O >C	R>C >O	R>O >C
			p= 0.430	p= 0.770	**p= 0.013**	p= 0.398

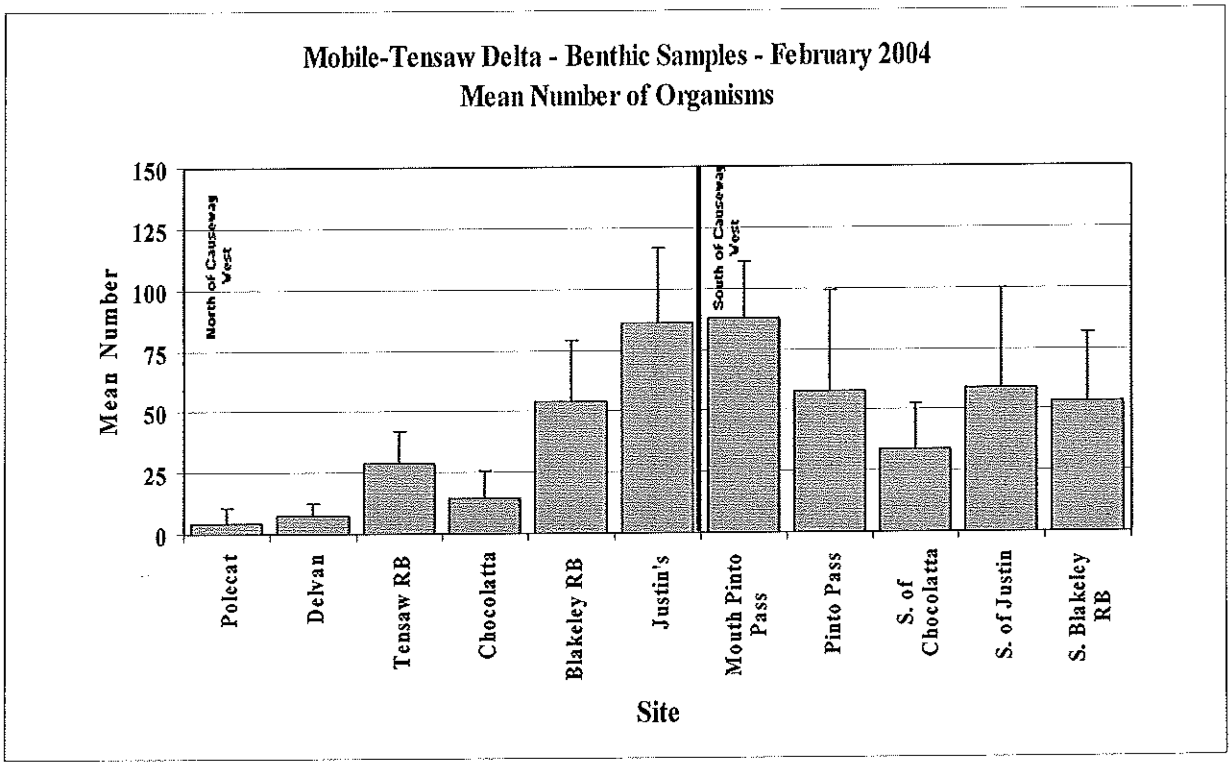

Figure 3-1. Mean number of benthic organisms (±1std) plotted by site from February 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

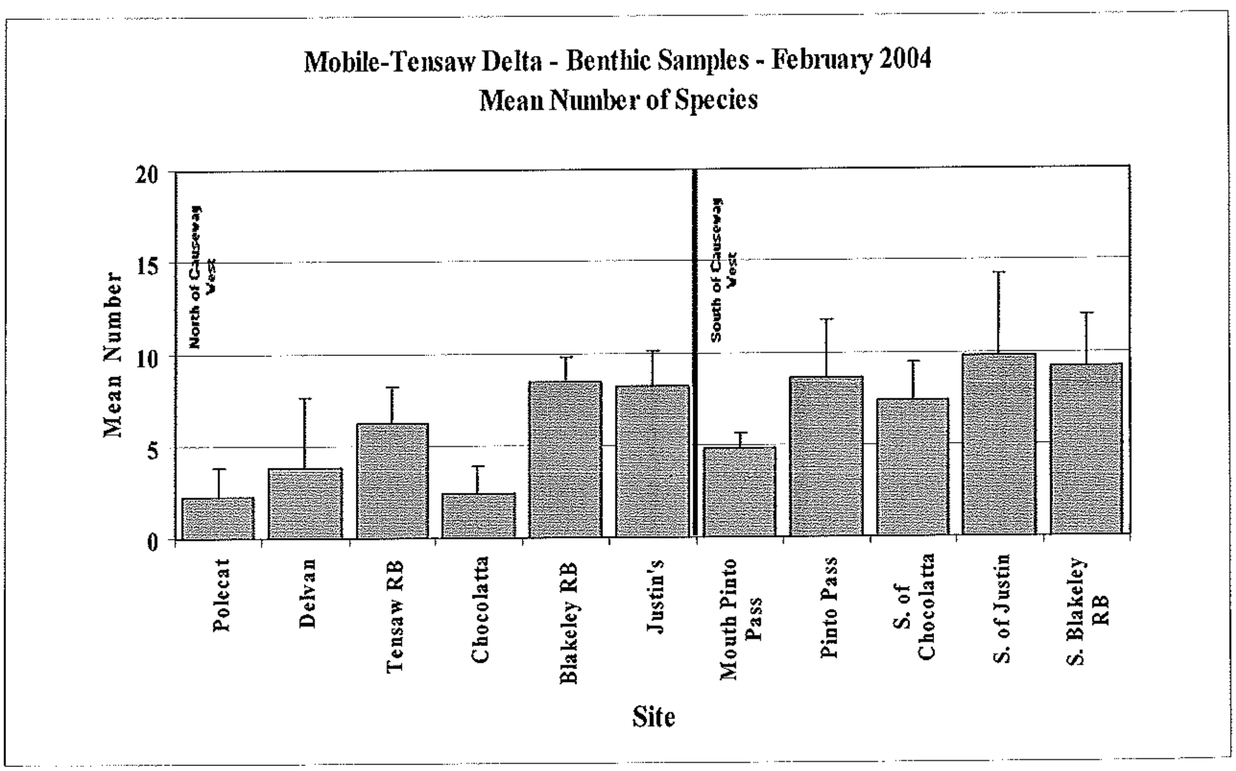

Figure 3-2. Mean number of benthic species (±1std) plotted by site from February 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

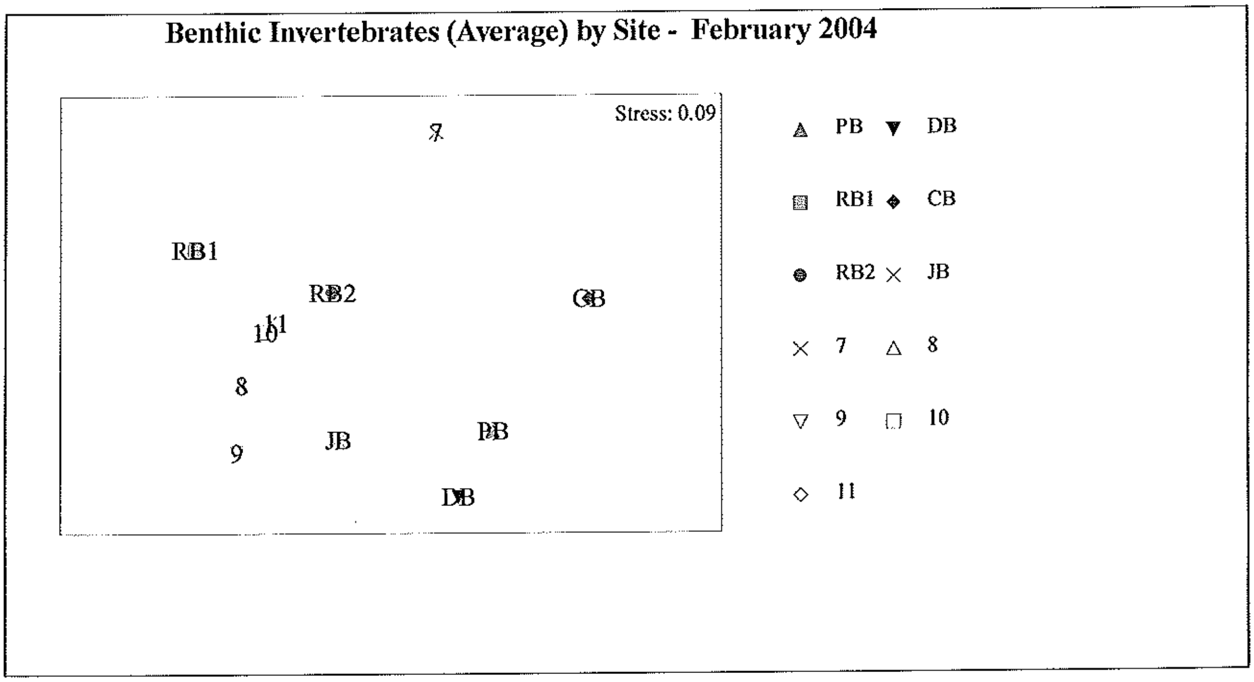

Figure 3-3. MDS plot for February 2004 benthic invertebrates by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

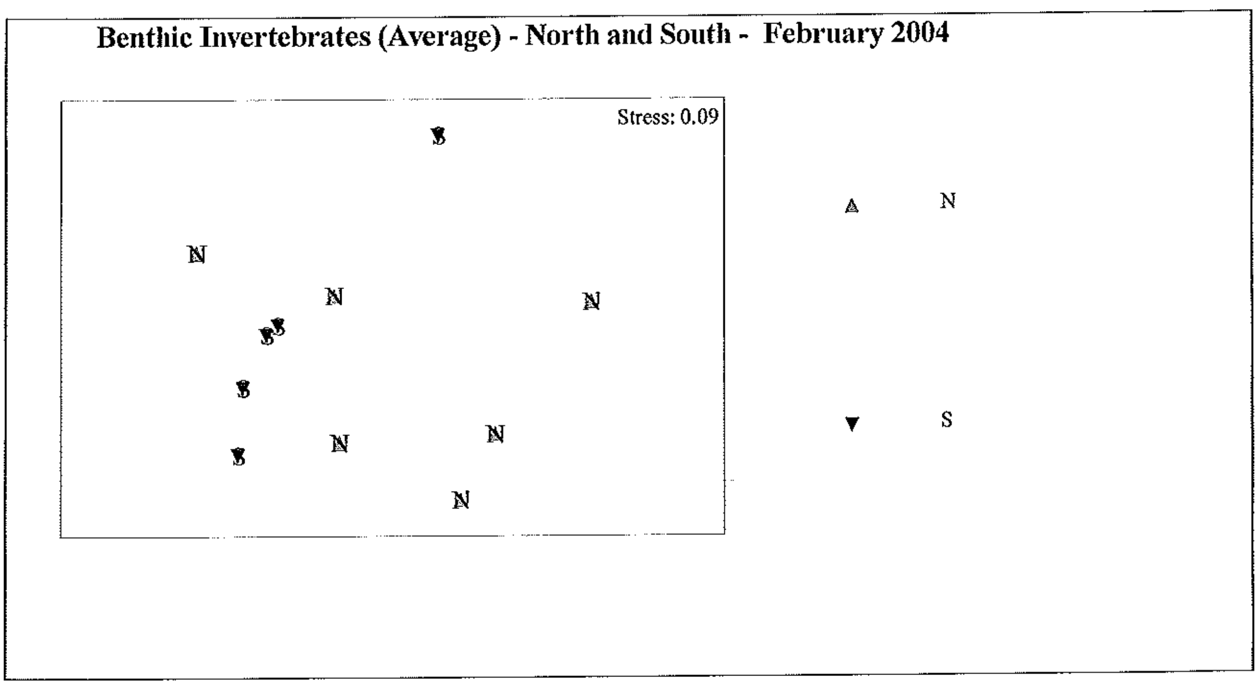

Figure 3-4. MDS plot for February 2004 benthic invertebrates by location north and south of the causeway.

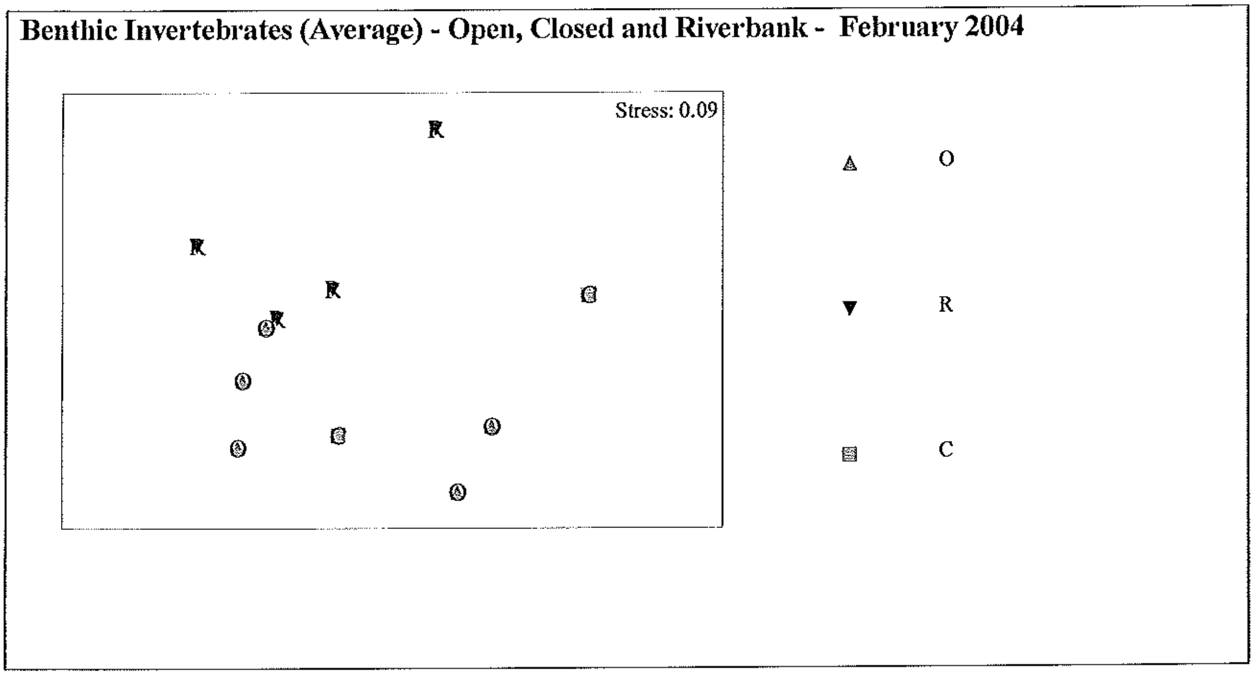

Figure 3-5. MDS plot for February 2004 benthic invertebrates by open (O), closed (C) and riverbank (R) treatments.

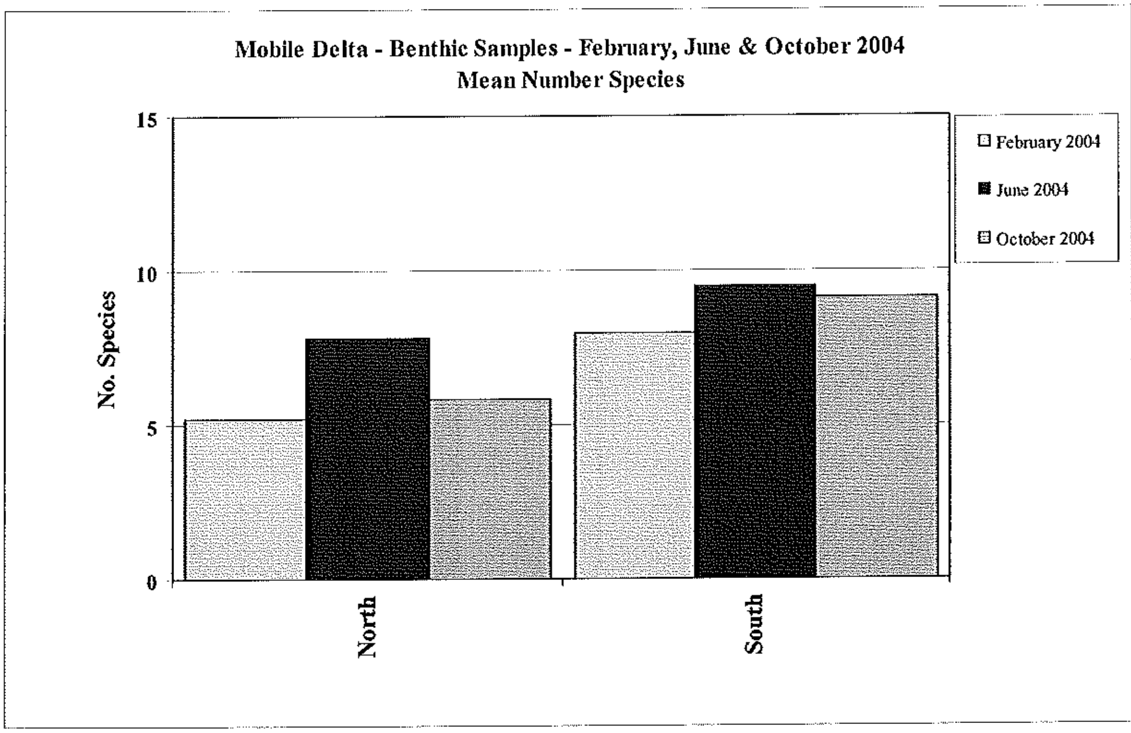

Figure 3-6. Mean number of benthic species plotted by location north and south of the causeway for February, June and October 2004 sampling events.

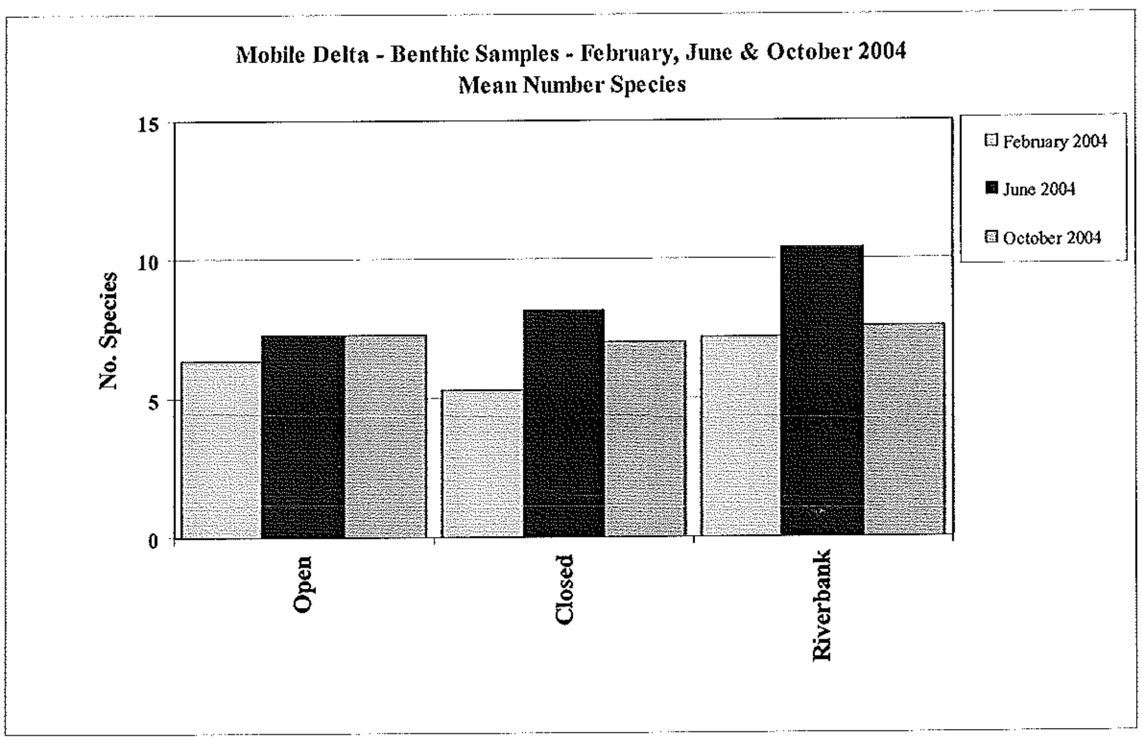

Figure 3-7. Mean number of benthic species plotted by open, closed and riverbank categories for February, June and October 2004 sampling events.

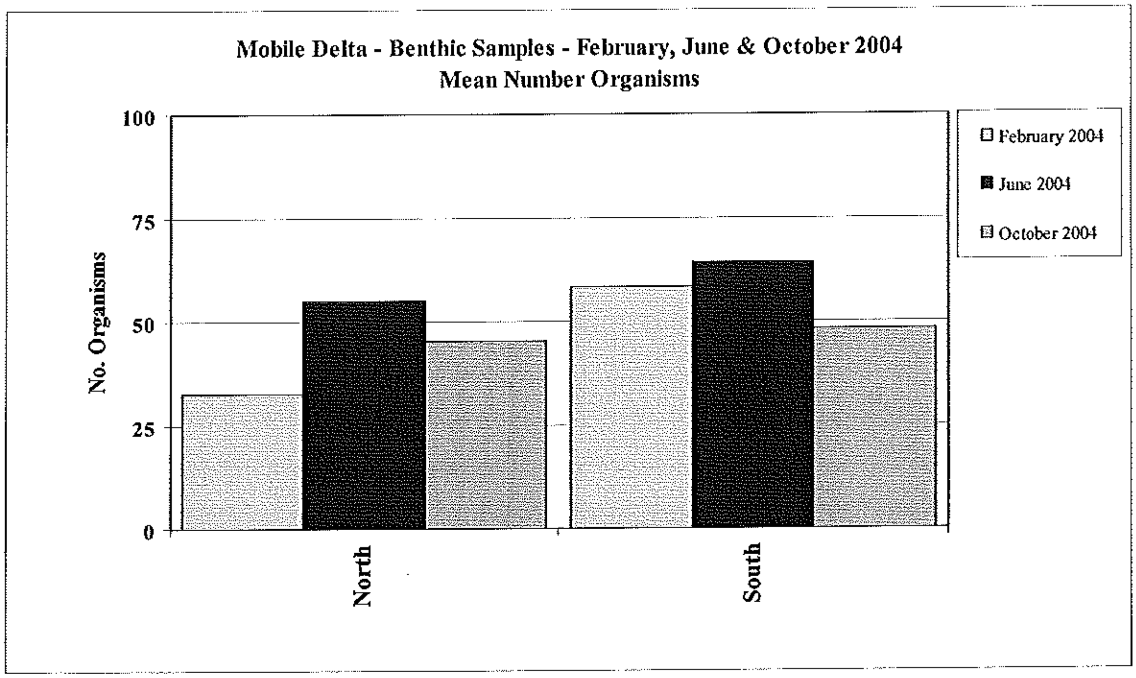

Figure 3-8. Mean number of benthic organisms plotted by location north and south of the causeway for February, June and October 2004 sampling events.

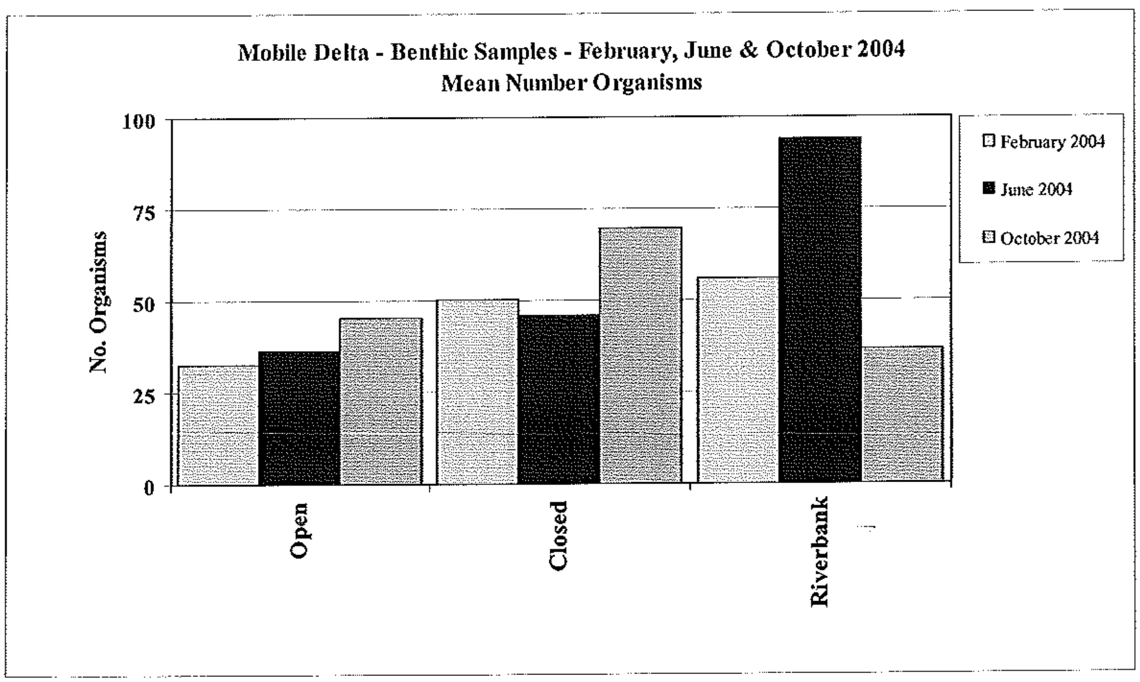

Figure 3-9. Mean number of benthic organisms plotted by open, closed and riverbank categories for February, June and October 2004 sampling events.

Table 3-3. February 2004 summary table for statistical analyses of proportion macroinvertebrate taxa by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference; na = not applicable). Sites are ranked from 1 to 11 based on percentages of organisms (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

Location	North or South of Causeway	Treatment (OCR)	Chironomidae (%) (avg)	Polychaeta (%) (avg)	Amphipoda (%) (avg)	Bivalvia (%) (avg)	Gastropoda (%) (avg)	Isopoda (%) (avg)	Ephemeroptera (%) (avg)	Decapoda - Crabs (%) (avg)
Site Name			na	na	na	na	na	na	na	na
Polecat Bay	N	O	5	2	6	9	9	5	7	6
Delvan Bay	N	O	3	6	7	6	5	5	7	6
Tensaw Riverbank	N	RB	4	8	8	11	3	5	1	1
Chocolatta Bay	N	C	1	7	11	7	9	5	7	6
Blakeley Riverbank	N	RB	6	9	4	10	1	5	3	4
Justin's Bay	N	C	2	10	3	8	8	5	2	6
Mouth of Pinto Pass	S	RB	11	11	1	1	9	5	6	6
Pinto Pass	S	O	8	5	2	3	7	3	7	3
South of Chocolatta	S	O	9	4	10	2	6	1	7	2
South of Justin's	S	O	7	1	5	5	4	4	5	5
South Blakeley Riverbank	S	RB	10	3	9	4	2	2	4	6
North	N		A	-	-	B	-	B	-	-
South	S		B	-	-	A	-	A	-	-
			N > S	S > N	S > N	S > N	S > N	S > N	N > S	S > N
			p= 0.001	p= 0.451	p= 0.427	p= 0.004	p= 0.887	p= 0.006	p= 0.452	p= 0.706
Open		O	AB	-	-	-	-	-	B	-
Closed		C	A	-	-	-	-	-	AB	-
Riverbank		RB	B	-	-	-	-	-	A	-
			C > O > RB	O > RB > C	RB > O > C	O > RB > C	RB > O > C	O > RB > C	RB > C > O	RB > O > C
			p= 0.034	p= 0.197	p= 0.574	p= 0.678	p= 0.124	p= 0.412	p= 0.040	p= 0.501

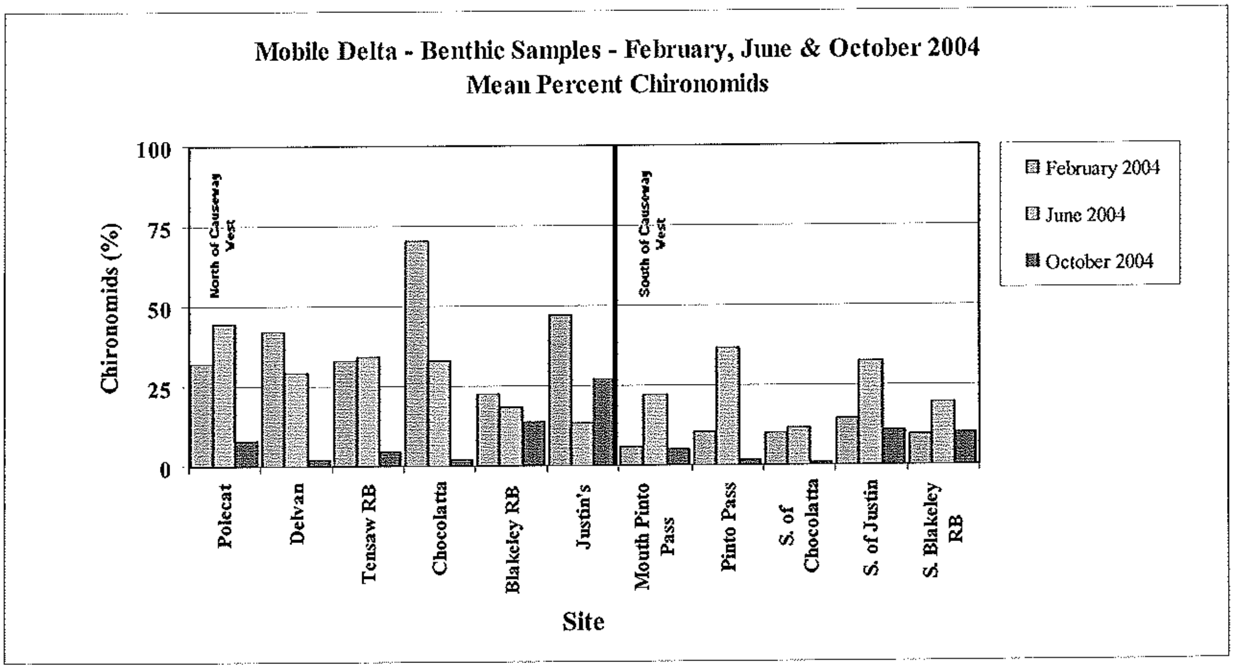

Figure 3-10. Percent chironomids (mean) plotted by site from February, June and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

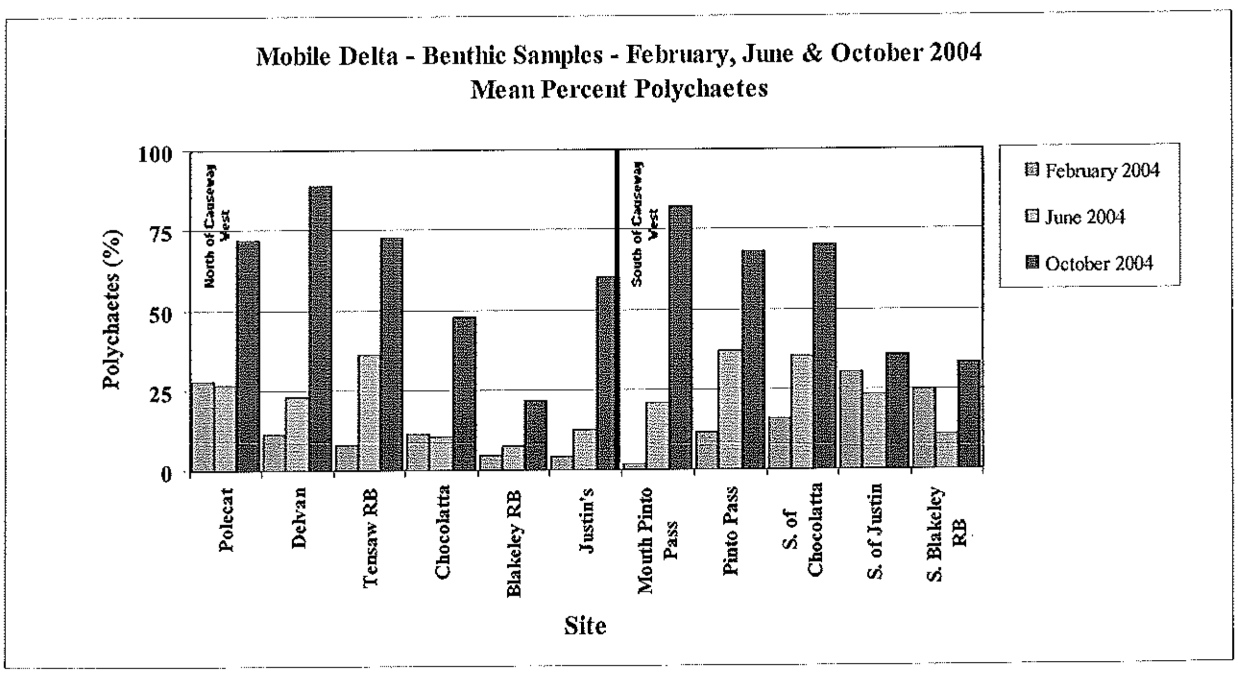

Figure 3-11. Percent polychaetes (mean) plotted by site from February, June and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

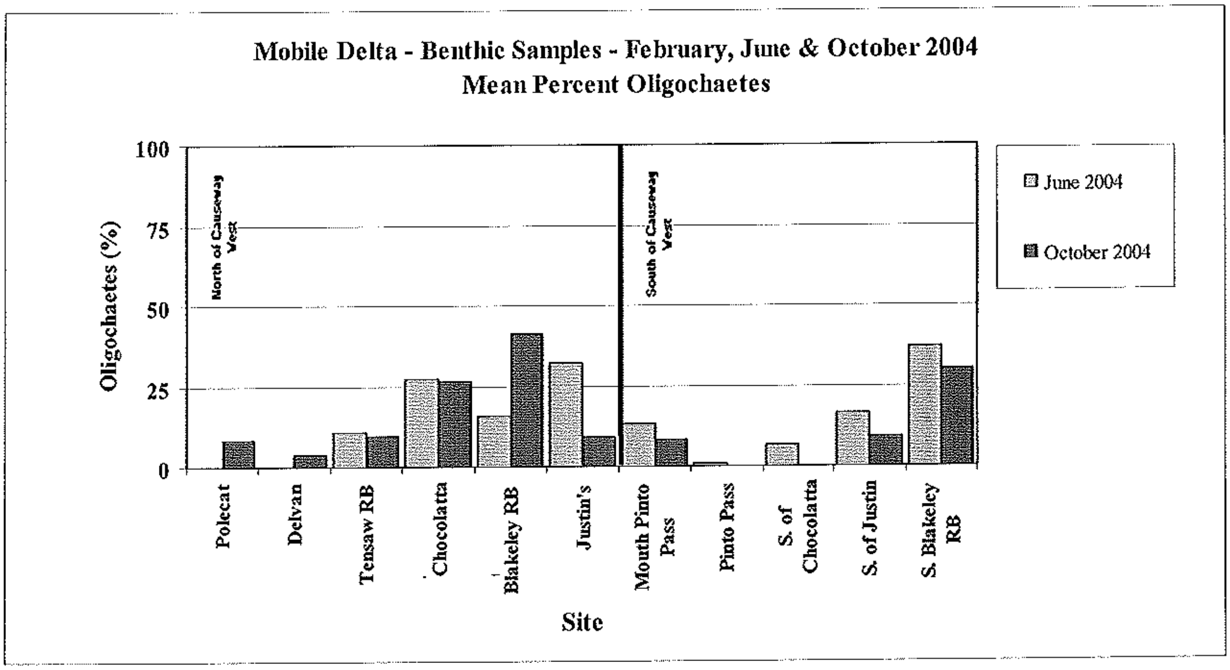

Figure 3-12. Percent oligochaetes (mean) plotted by site from February, June and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

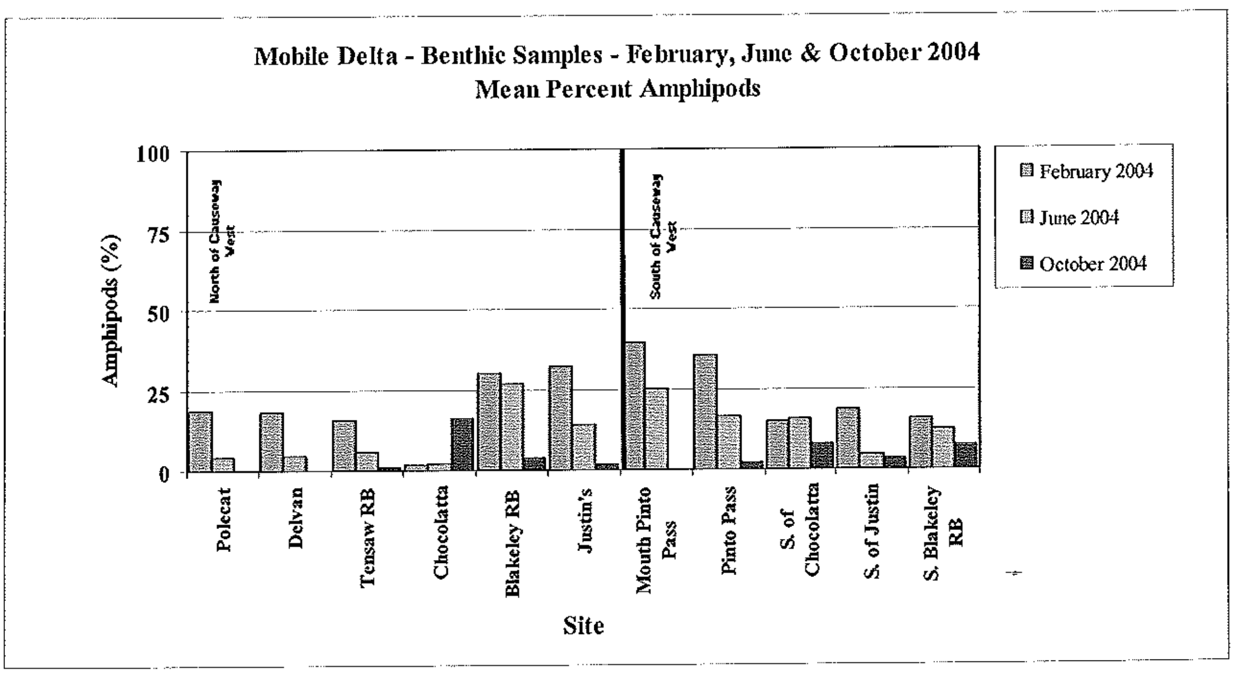

Figure 3-13. Percent amphipods (mean) plotted by site from February, June and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

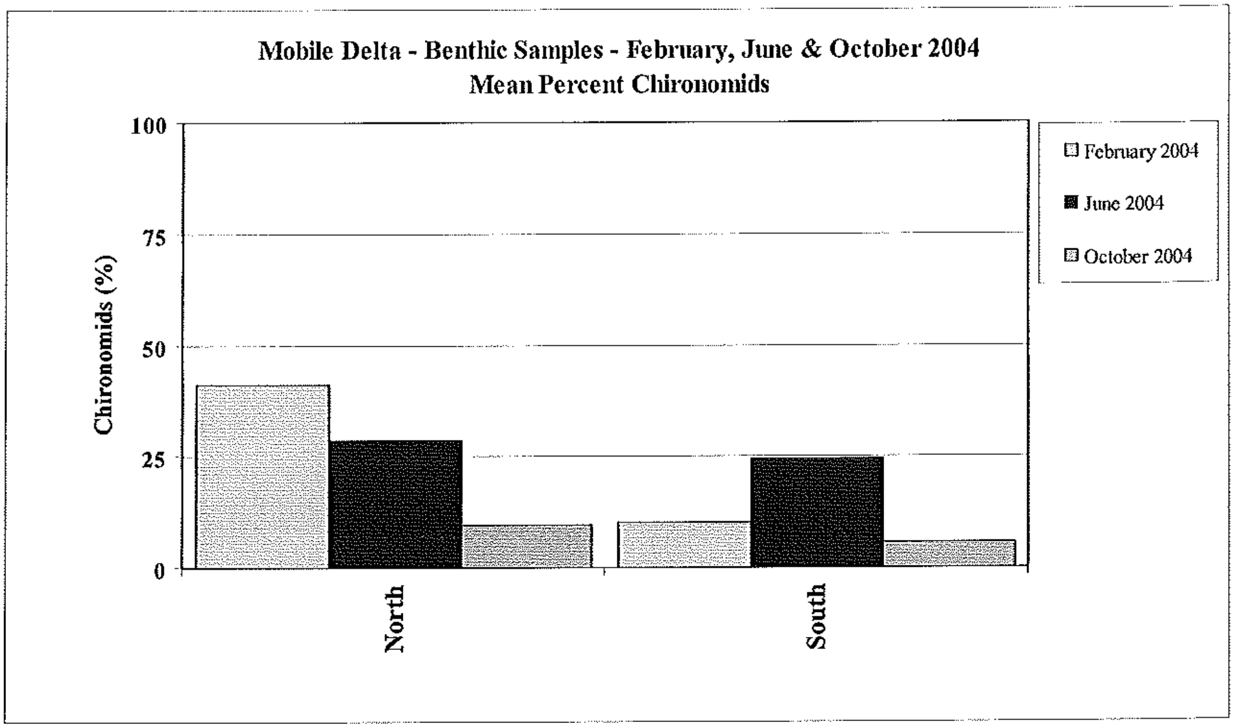

Figure 3-14. Percent chironomids (mean) plotted by location north and south of the causeway for February, June and October 2004 sampling events.

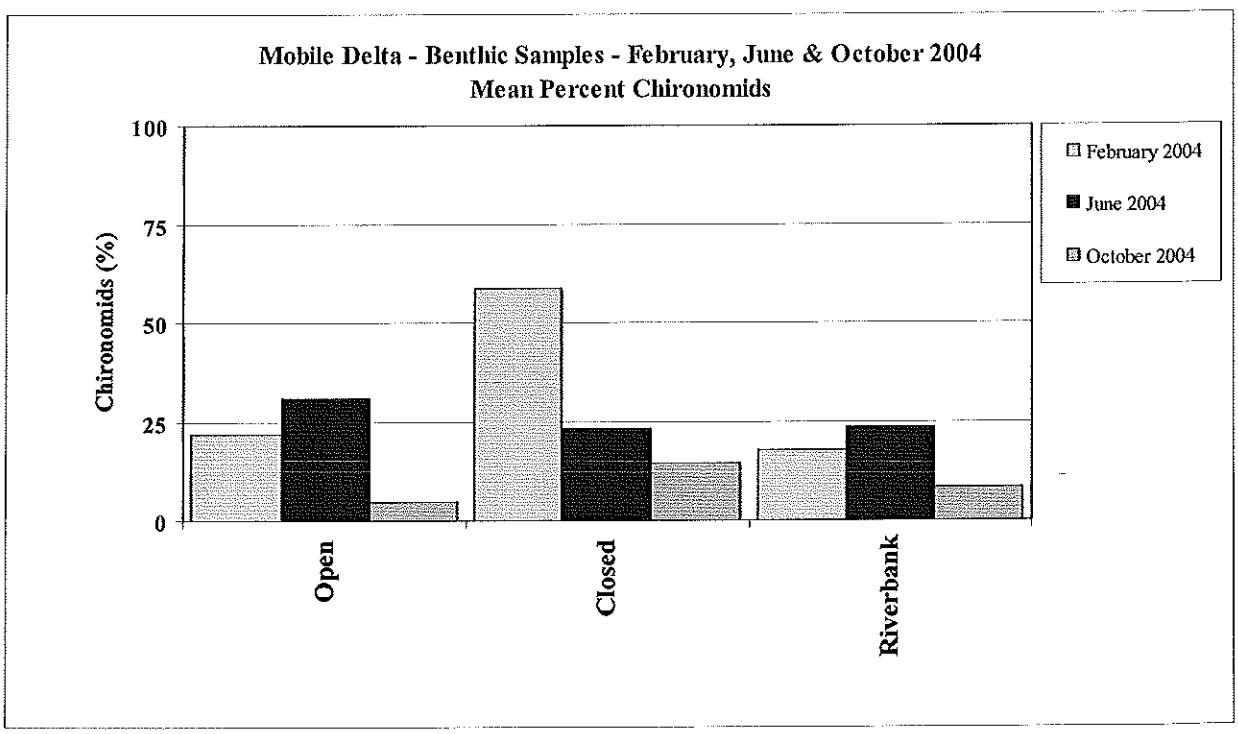

Figure 3-15. Percent chironomids (mean) plotted by open, closed and riverbank categories for February, June and October 2004 sampling events.

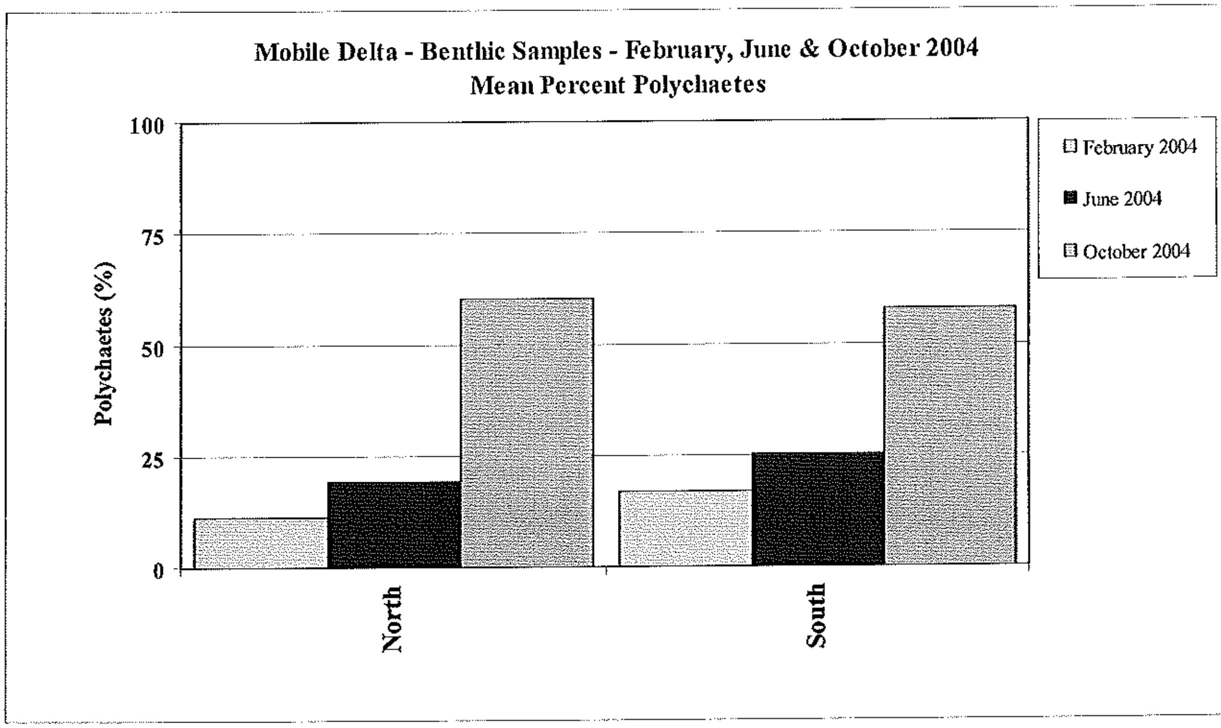

Figure 3-16. Percent polychaetes (mean) plotted by location north and south of the causeway for February, June and October 2004 sampling events.

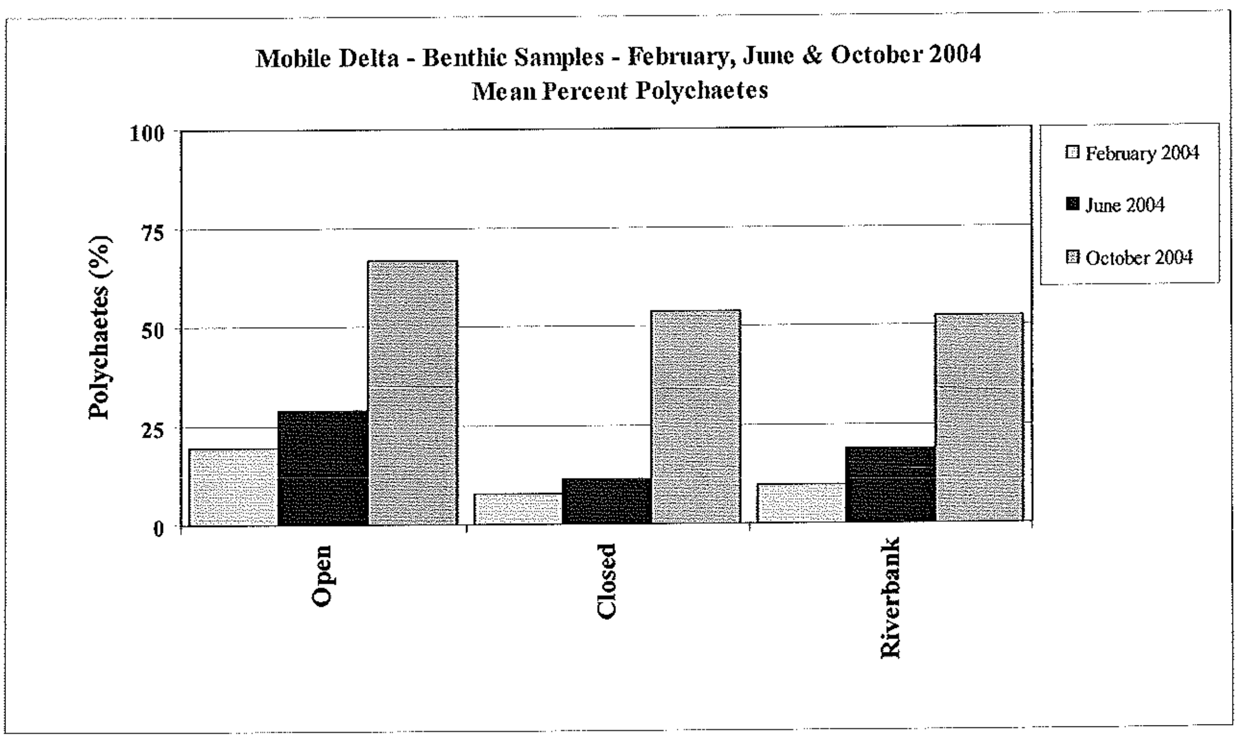

Figure 3-17. Percent polychaetes (mean) plotted by open, closed and riverbank categories for February, June and October 2004 sampling events.

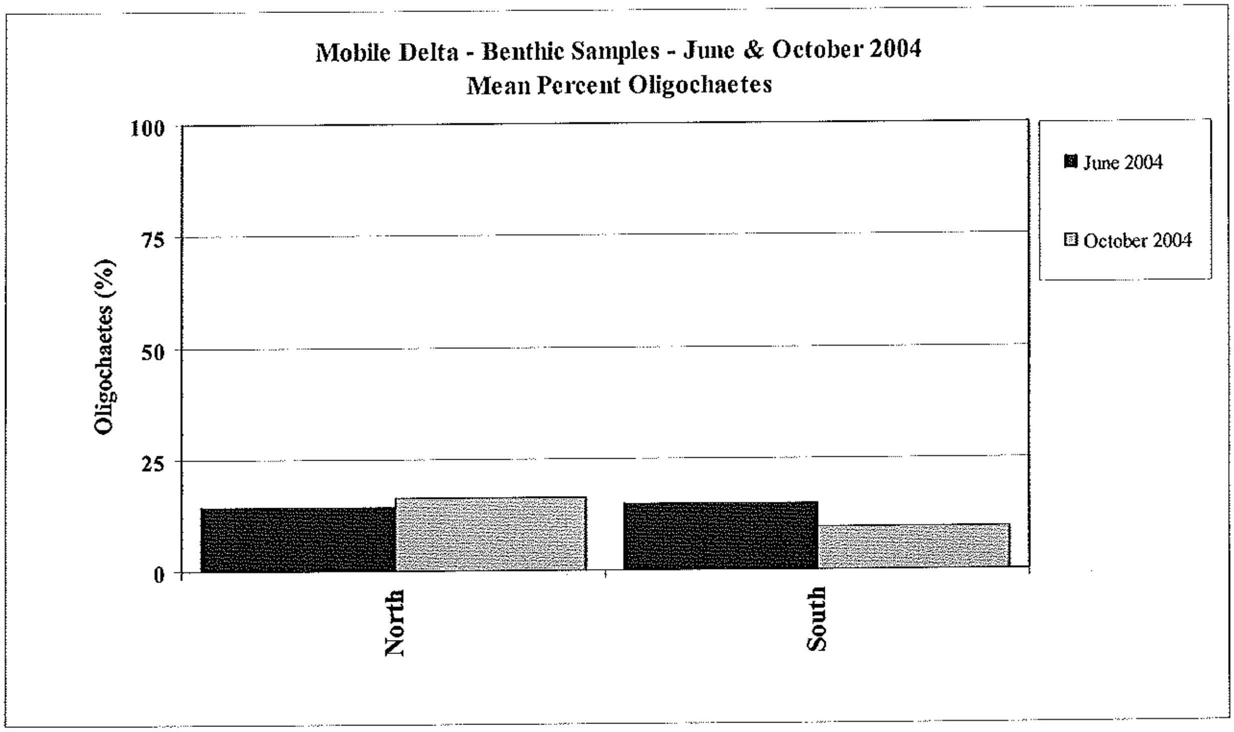

Figure 3-18. Percent oligochaetes (mean) plotted by location north and south of the causeway for February, June and October 2004 sampling events.

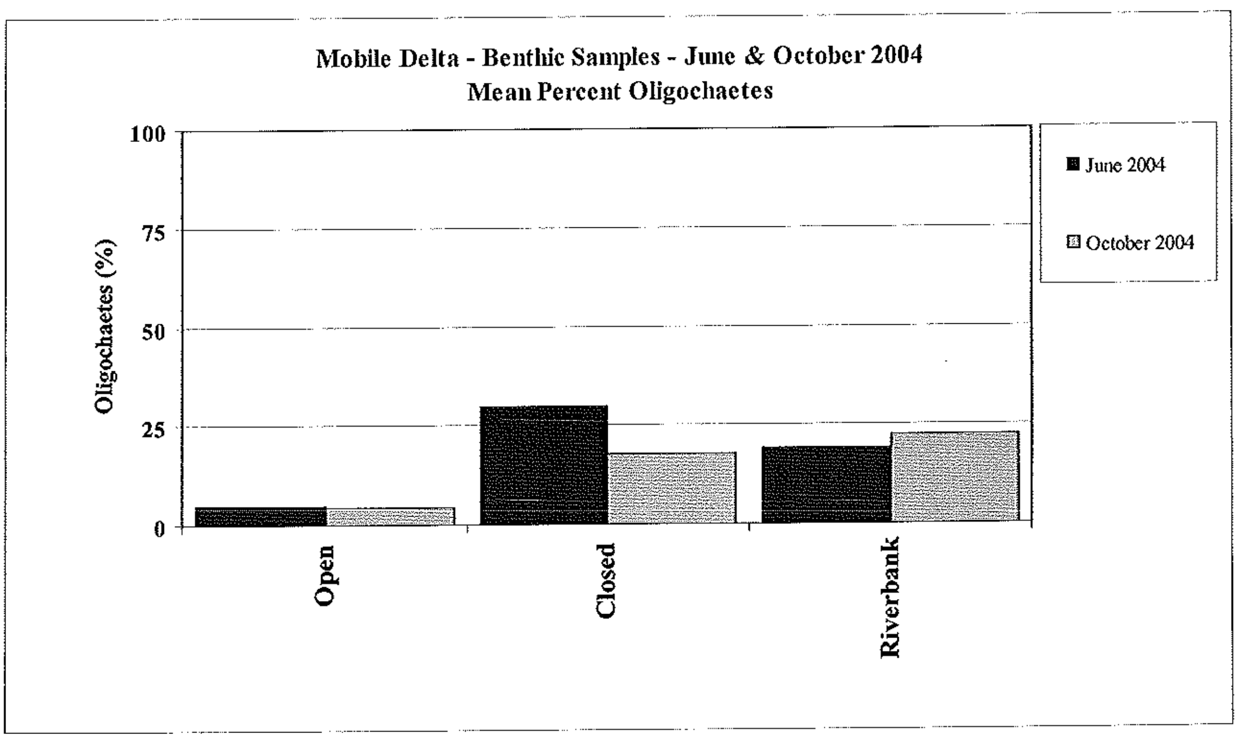

Figure 3-19. Percent oligochaetes (mean) plotted by open, closed and riverbank categories for February, June and October 2004 sampling events.

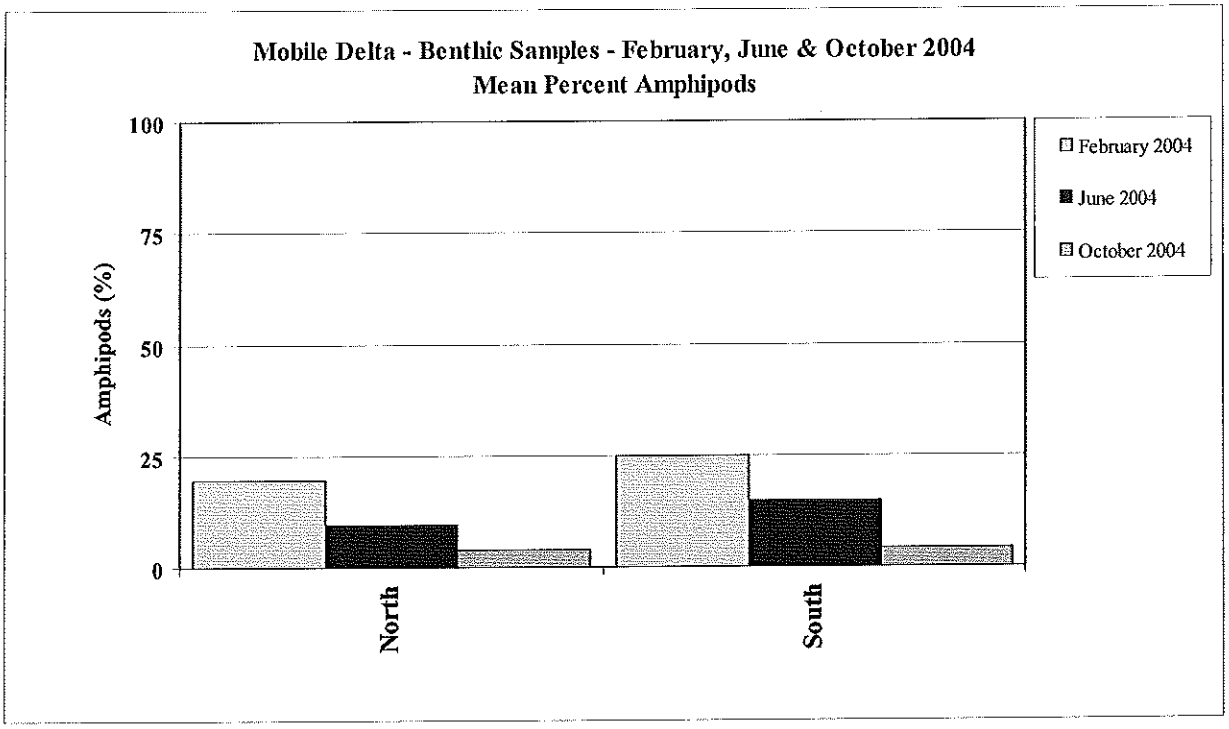

Figure 3-20. Percent amphipods (mean) plotted by location north and south of the causeway for February, June and October 2004 sampling events.

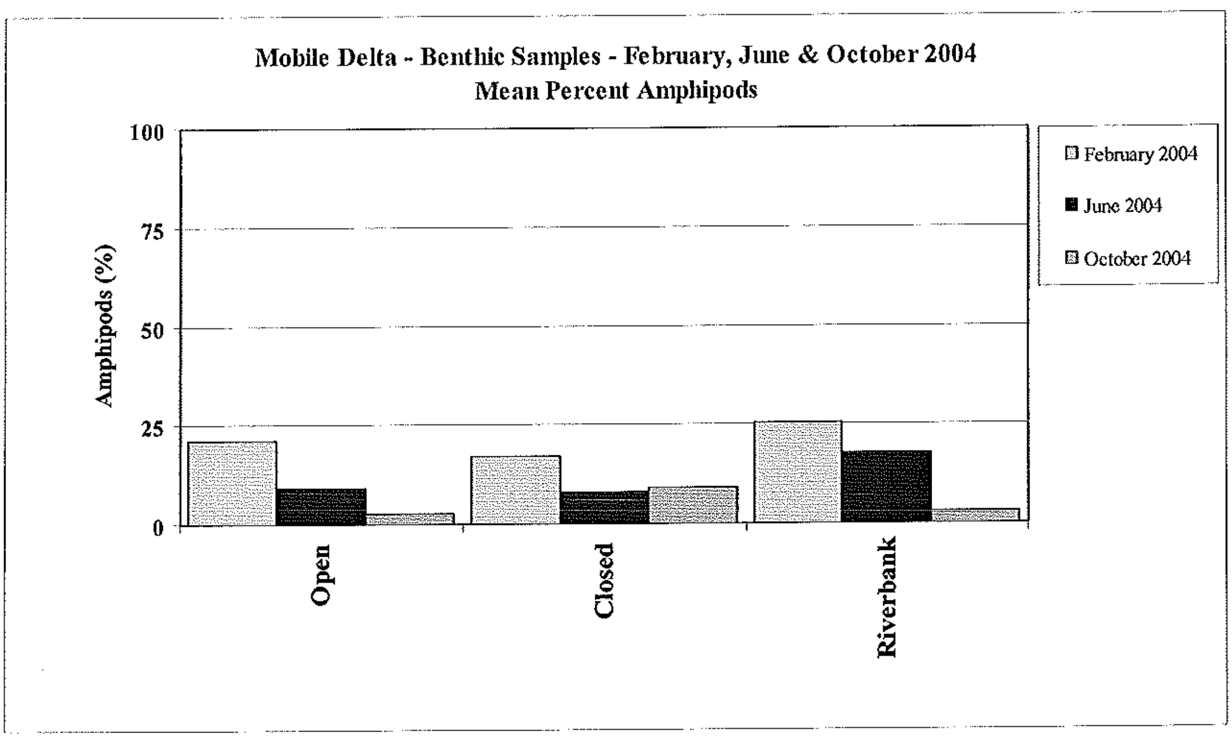

Figure 3-21. Percent amphipods (mean) plotted by open, closed and riverbank categories for February, June and October 2004 sampling events.

Table 3-4. June 2004 summary table for statistical analyses of macroinvertebrate taxa and total number of species analyzed by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven based on numbers of species and organisms (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

Location	North or South of Causeway	Treatment (OCR)	Total no. Organisms (avg)	Total no. species (avg)	Total no. Organisms	Total no. species
Site Name			na	na	p= 0.000	p= 0.000
Polecat Bay	N	O	11	11		
Delvan Bay	N	O	10	9		
Tensaw Riverbank	N	RB	3	3		
Chocolatta Bay	N	C	7	7		
Blakeley Riverbank	N	RB	2	2		
Justin's Bay	N	C	5	8		
Mouth of Pinto Pass	S	RB	9	10		
Pinto Pass	S	O	4	6		
South of Chocolatta	S	O	8	4		
South of Justin's	S	O	6	5		
South Blakeley Riverbank	S	RB	1	1		
North	N		-	-	-	-
South	S		-	-	-	-
			S > N	S > N	S > N	S > N
			p= 0.538	p= 0.463	p= 0.175	p= 0.240
Open		O	-	-	B	-
Closed		C	-	-	AB	-
Riverbank		RB	-	-	A	-
			R>C>O	R>C>O	R>C>O	R>C>O
			p= 0.289	p= 0.425	p= 0.033	p= 0.111

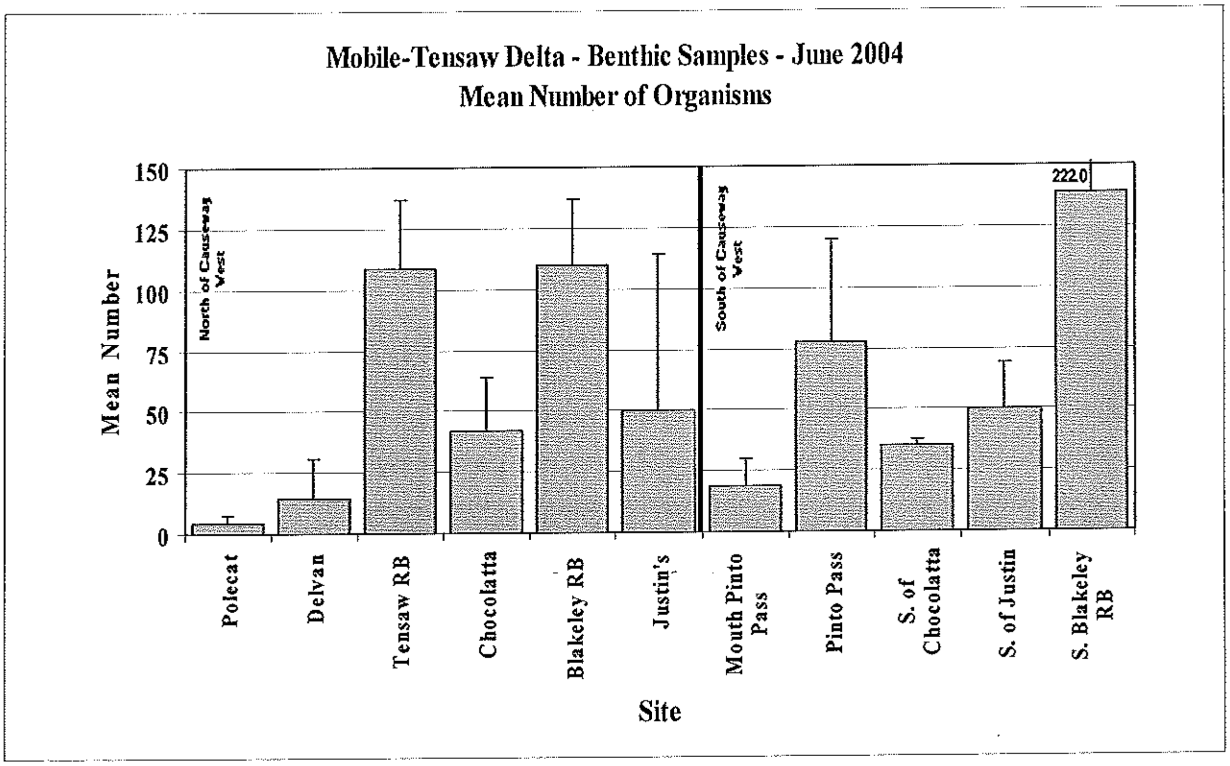

Figure 3-22. Mean number of benthic organisms (±1std) plotted by site from June 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

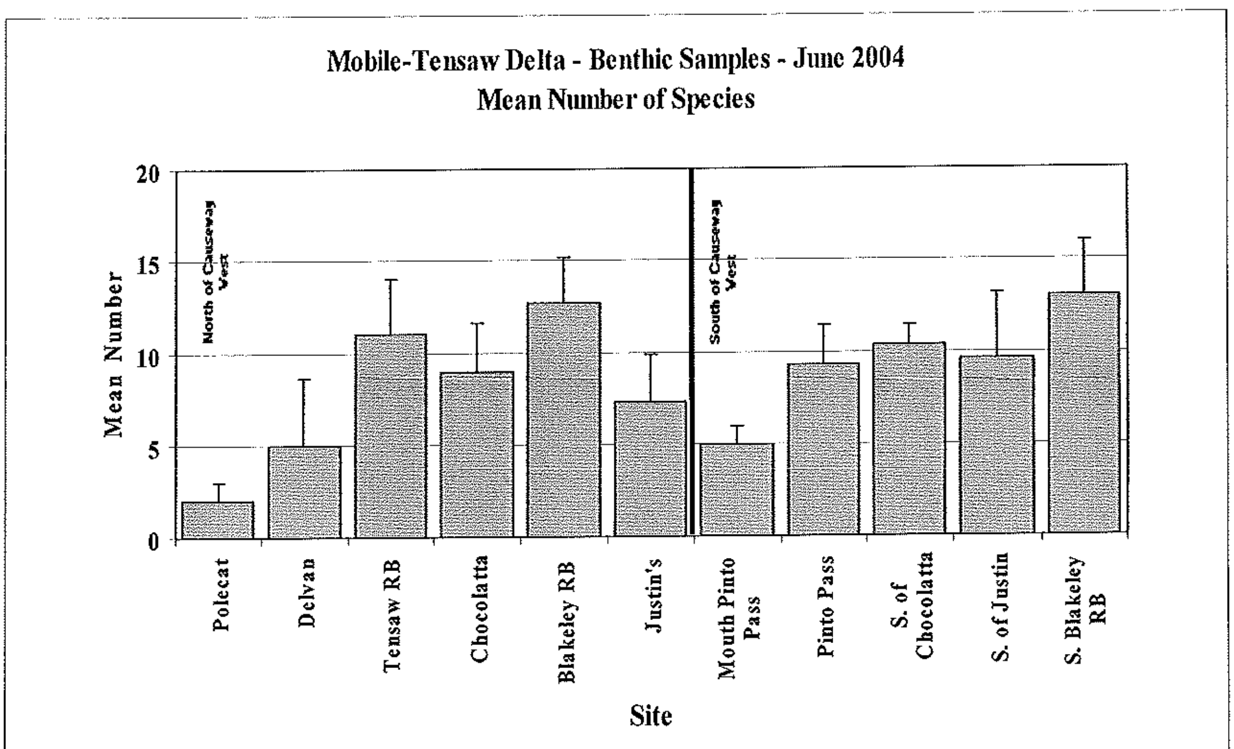

Figure 3-23. Mean number of benthic species (±1std) plotted by site from June 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

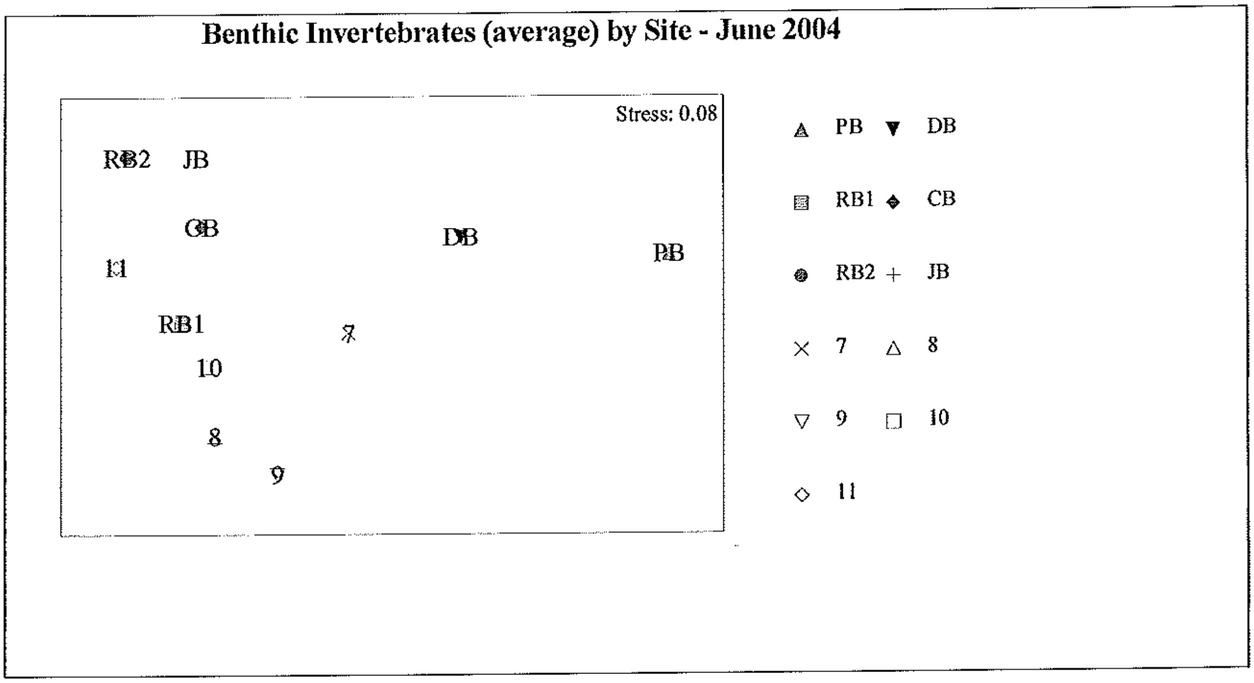

Figure 3-24. MDS plot for June 2004 benthic invertebrates by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

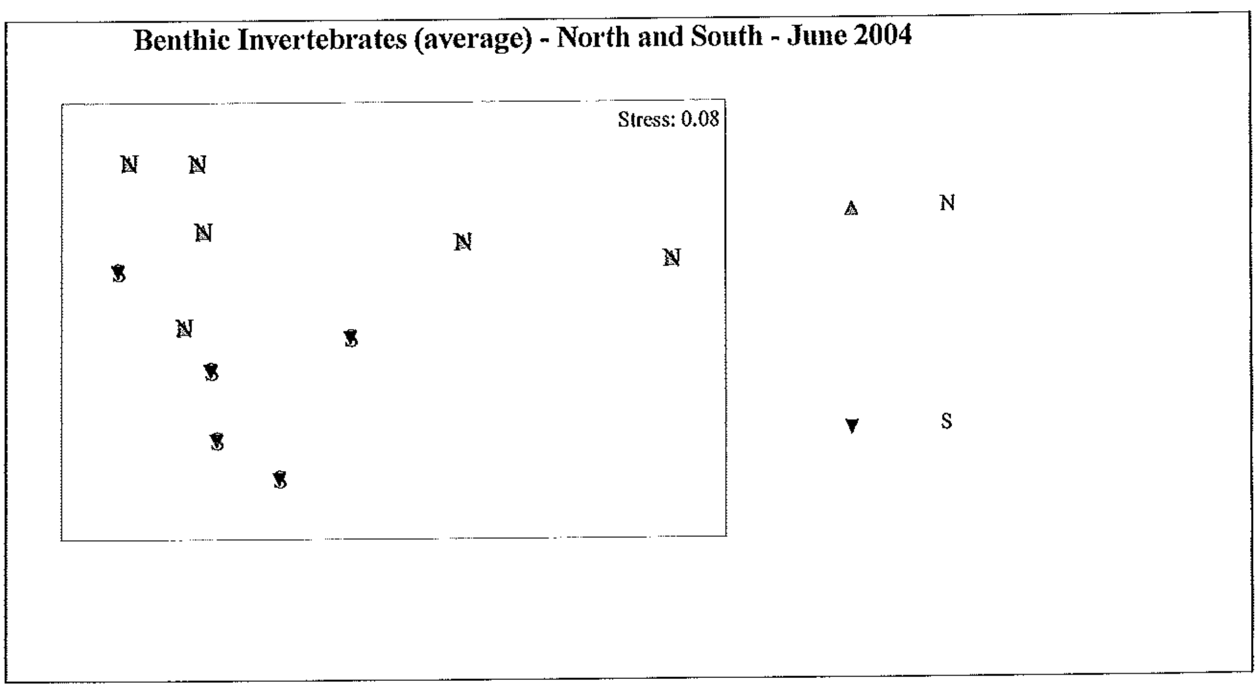

Figure 3-25. MDS plot for June 2004 benthic invertebrates by location north and south of the causeway.

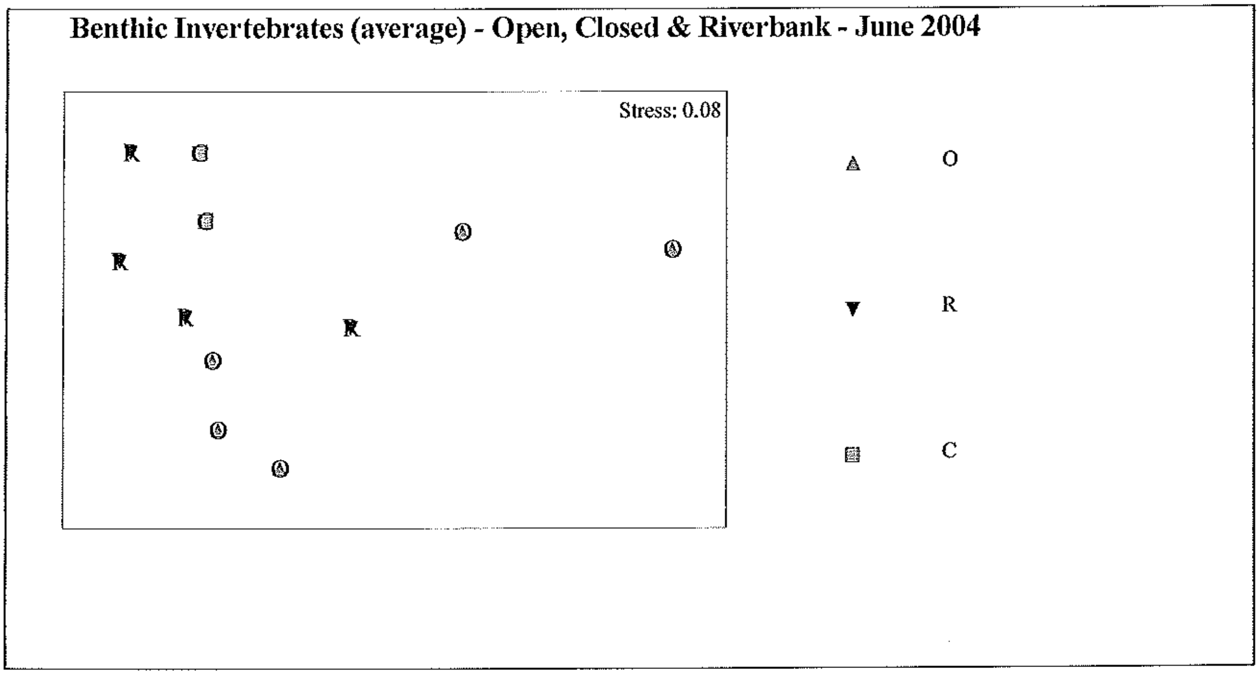

Figure 3-26. MDS plot for June 2004 benthic invertebrates by open (O), closed (C) and riverbank (R) treatments.

Table 3-5. June 2004 summary table for statistical analyses of proportion macroinvertebrate taxa by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference; na = not applicable). Sites are ranked from 1 to 11 based on percentages of organisms (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

Location	North or South of Causeway	Treatment (OCR)	Chironomidae (%) (avg)	Polychaeta (%) (avg)	Oligochaeta (%) (avg)	Amphipoda (%) (avg)	Bivalvia (%) (avg)	Gastropoda (%) (avg)	Isopoda (%) (avg)	Ephemeroptera (%) (avg)	Decapoda - Crabs (%) (avg)
Site Name			na	na	na	na	na	na	na	na	na
Polecat Bay	N	O	1	4	10	10	8	11	7	4	4
Delvan Bay	N	O	6	6	11	8	8	3	7	4	4
Tensaw Riverbank	N	RB	3	2	7	7	5	5	5	4	4
Chocolatta Bay	N	C	4	10	3	11	3	2	4	4	4
Blakeley Riverbank	N	RB	9	11	5	1	8	10	1	1	4
Justin's Bay	N	C	10	8	2	5	2	8	7	3	4
Mouth of Pinto Pass	S	RB	7	7	6	2	8	1	7	4	4
Pinto Pass	S	O	2	1	9	3	7	6	6	4	3
South of Chocolatta	S	O	11	3	8	4	1	4	7	4	4
South of Justin's	S	O	5	5	4	9	4	9	2	4	1
South Blakeley Riverbank	S	RB	8	9	1	6	6	7	3	2	2
North	N		-	-	-	-	-	-	-	-	B
South	S		-	-	-	-	-	-	-	-	A
			N > S	S > N	S > N	S > N	S > N	S > N	S = N	N > S	S > N
			p= 0.547	p= 0.276	p= 0.766	p= 0.264	p= 0.454	p= 0.323	p= 0.999	p= 0.752	p= 0.037
Open		O	-	-	B	-	-	-	-	-	-
Closed		C	-	-	A	-	-	-	-	-	-
Riverbank		RB	-	-	AB	-	-	-	-	-	-
			O > RB > C	O > RB > C	C > RB > O	RB > O > C	C > O > RB	C > RB > O	RB > C > O	RB > C > O	O > RB > C
			p= 0.582	p= 0.096	p= 0.021	p= 0.318	p= 0.265	p= 0.787	p= 0.486	p= 0.194	p= 0.634

Table 3-6. October 2004 summary table for statistical analyses of macroinvertebrate taxa and total number of species analyzed by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven based on numbers of species and organisms (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

Location	North or South of Causeway	Treatment (OCR)	Total no. Organisms (avg)	Total no. species (avg)	Total no. Organisms	Total no. species
Site Name			na	na	p= 0.127	**p= 0.040**
Polecat Bay	N	O	10	11		
Delvan Bay	N	O	6	10		
Tensaw Riverbank	N	RB	8	6		
Chocolatta Bay	N	C	1	5		
Blakeley Riverbank	N	RB	11	9		
Justin's Bay	N	C	2	8		
Mouth of Pinto Pass	S	RB	9	7		
Pinto Pass	S	O	3	3		
South of Chocolatta	S	O	5	4		
South of Justin's	S	O	7	2		
South Blakeley Riverbank	S	RB	4	1		
North	N		-	B	-	B
South	S		-	A	-	A
			S > N	S > N	S > N	S > N
			p= 0.807	**p= 0.006**	p= 0.739	**p= 0.001**
Open		O	-	-	AB	-
Closed		C	-	-	A	-
Riverbank		RB	-	-	B	-
			C>O>R	R>O>C	C>O>R	R>O>C
			p= 0.074	p= 0.963	**p= 0.038**	p= 0.927

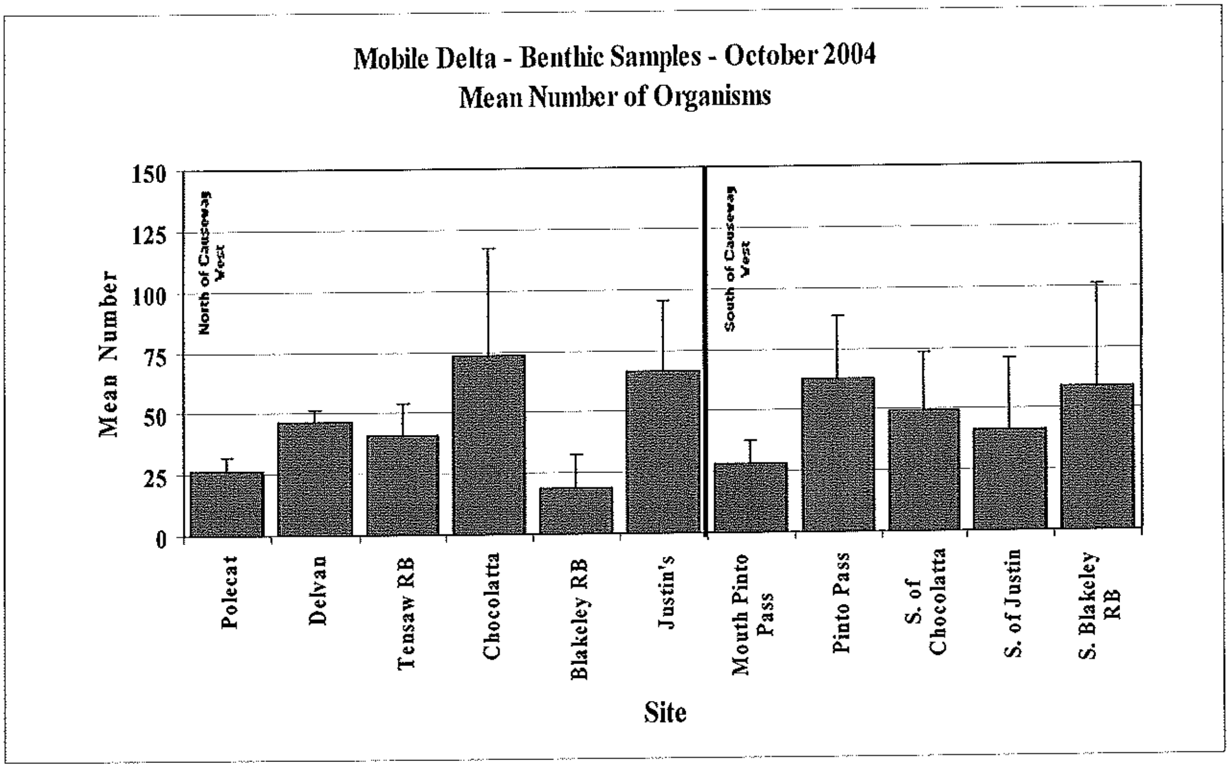

Figure 3-27. Mean number of benthic organisms (±1std) plotted by site from October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

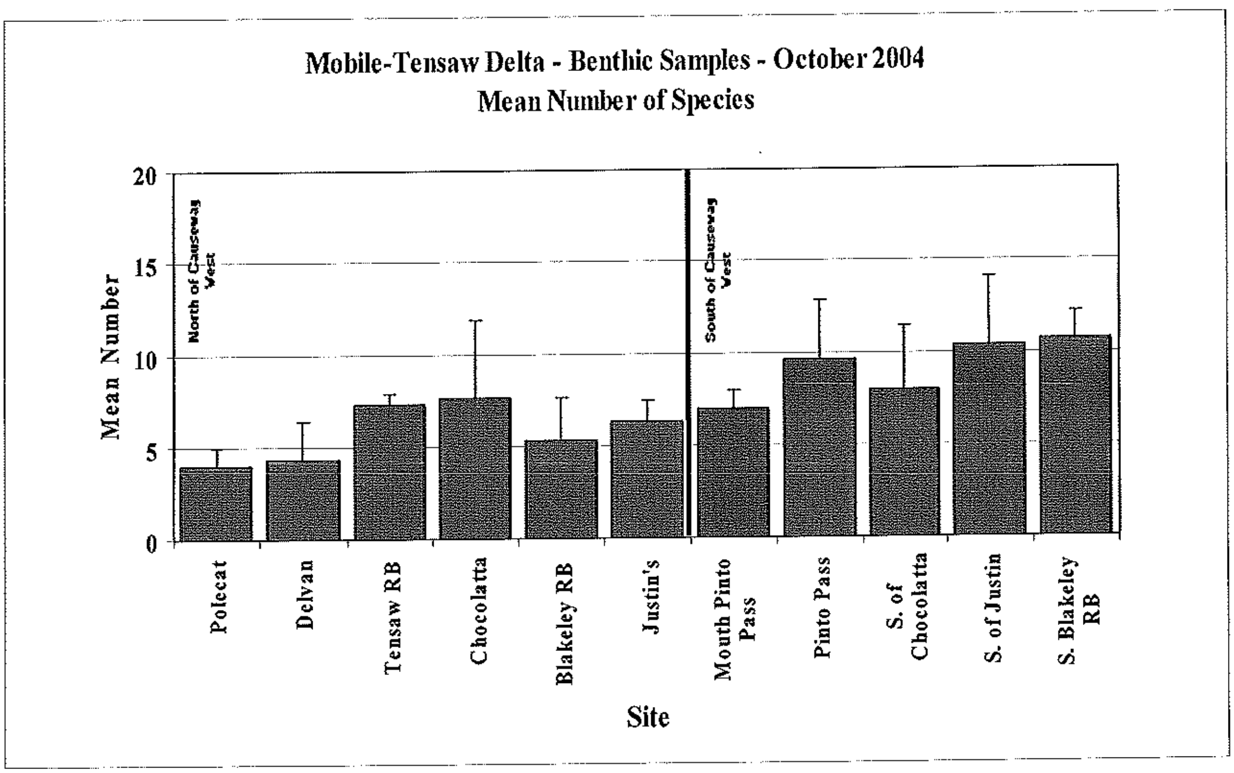

Figure 3-28. Mean number of benthic species (±1std) plotted by site from October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

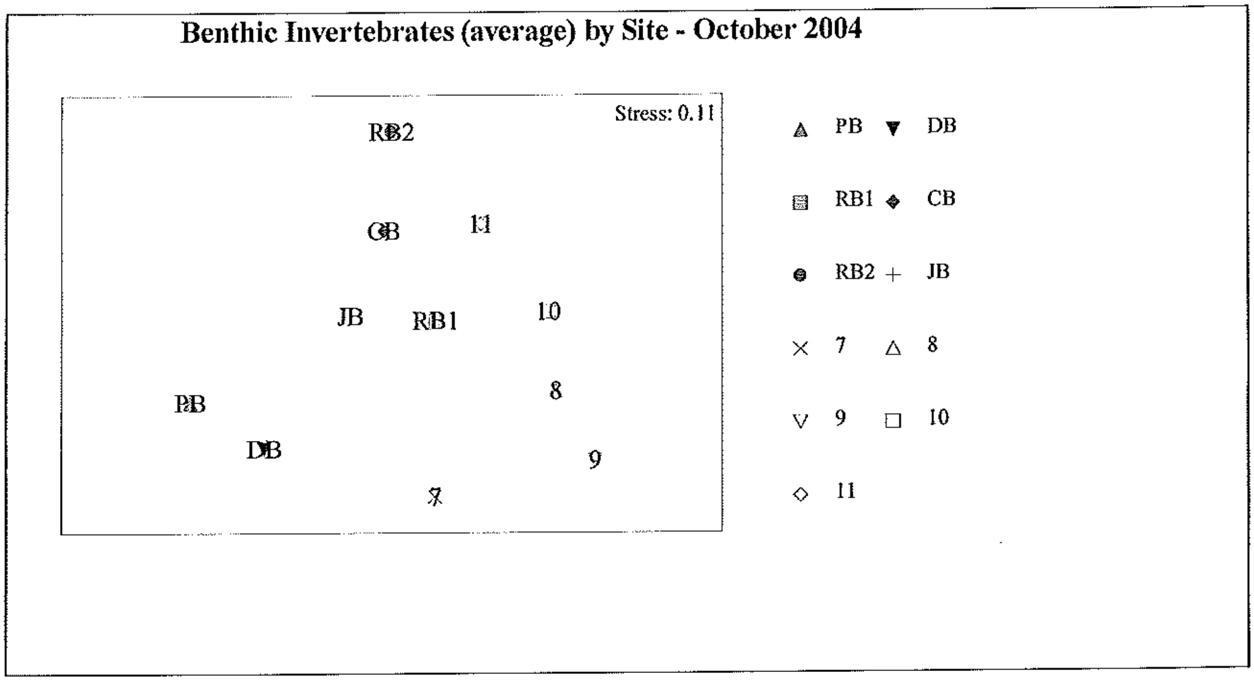

Figure 3-29. MDS plot for October 2004 benthic invertebrates by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

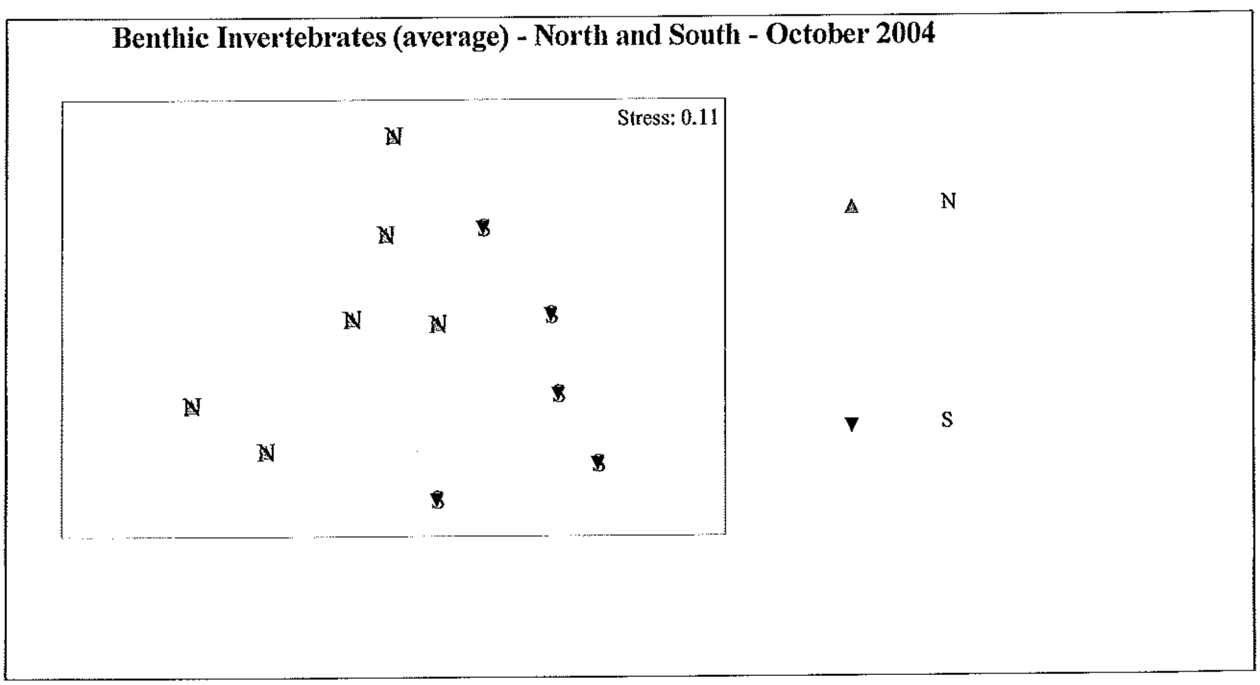

Figure 3-30. MDS plot for October 2004 benthic invertebrates by location north and south of the causeway.

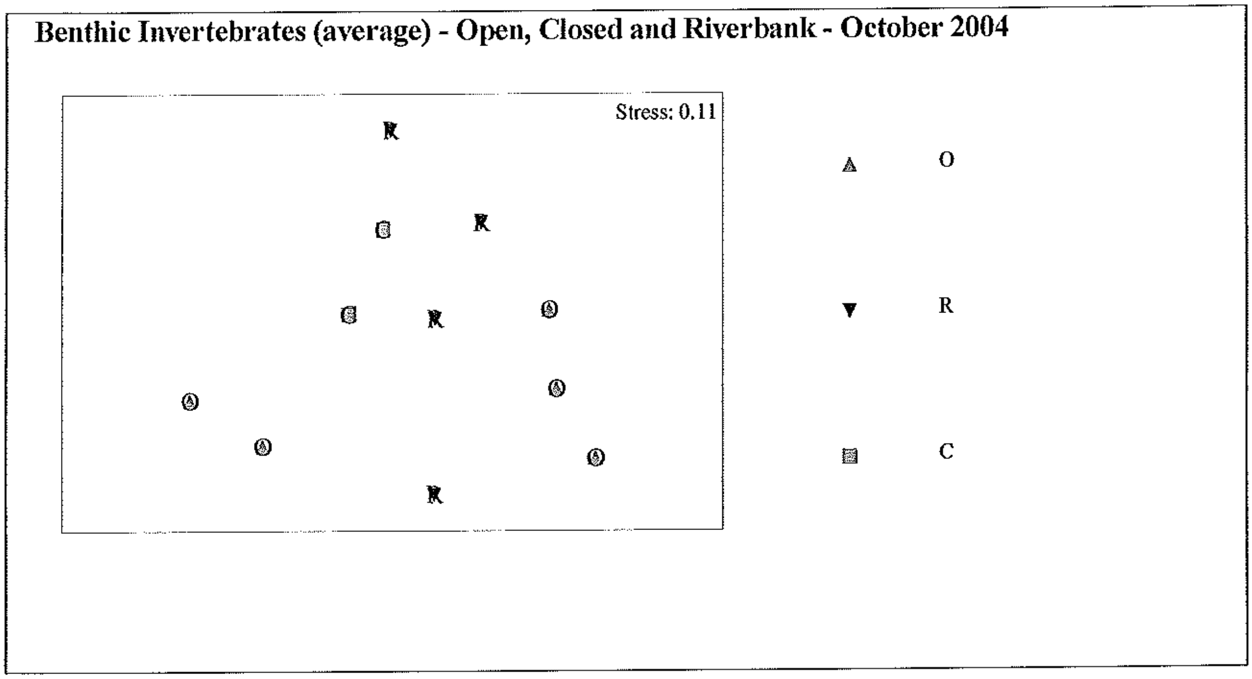

Figure 3-31. MDS plot for October 2004 benthic invertebrates by open (O), closed (C) and riverbank (R) treatments.

Table 3-7. October 2004 summary table for statistical analyses of proportion macroinvertebrate taxa by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference; na = not applicable). Sites are ranked from 1 to 11 based on percentages of organisms (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

Location	North or South of Causeway	Treatment (OCR)	Chironomidae (%) (avg)	Polychaeta (%) (avg)	Oligochaeta (%) (avg)	Amphipoda (%) (avg)	Bivalvia (%) (avg)	Gastropoda (%) (avg)	Isopoda (%) (avg)	Ephemeroptera (%) (avg)	Decapoda - Crabs (%) (avg)
Site Name			na	na	na	na	na	na	na	na	na
Polecat Bay	N	O	5	4	7	9	5	9	8	2	6
Delvan Bay	N	O	8	1	9	9	5	6	7	2	6
Tensaw Riverbank	N	RB	7	3	4	8	5	2	8	2	6
Chocolatta Bay	N	C	9	8	3	1	5	4	5	1	6
Blakeley Riverbank	N	RB	2	11	1	4	5	5	6	2	2
Justin's Bay	N	C	1	7	6	7	5	8	8	2	6
Mouth of Pinto Pass	S	RB	6	2	8	9	5	9	8	2	3
Pinto Pass	S	O	10	6	10	6	3	7	4	2	5
South of Chocolatta	S	O	11	5	10	2	1	9	1	2	6
South of Justin's	S	O	3	9	5	5	2	3	3	2	1
South Blakeley Riverbank	S	RB	4	10	2	3	4	1	2	2	4
North	N		-	-	-	-	B	-	B	-	B
South	S		-	-	-	-	A	-	A	-	A
			N > S	N > S	N > S	S > N	S > N	N > S	S > N	N > S	S > N
			p= 0.453	p= 0.863	p= 0.266	p= 0.661	p= 0.033	p= 0.924	p= 0.054	p= 0.389	p= 0.059
Open		O	-	-	-	-	-	-	-	-	-
Closed		C	-	-	-	-	-	-	-	-	-
Riverbank		RB	-	-	-	-	-	-	-	-	-
			C > RB > O	O > C > RB	RB > C > O	C > RB > O	O > RB > C	RB > C > O	O > RB > C	C > O = RB	RB > O > C
			p= 0.407	p= 0.607	p= 0.063	p= 0.429	p= 0.236	p= 0.519	p= 0.649	p= 0.092	p= 0.506

Appendix 4

Sediment – February 2004

Table 4-1. Summary table for February 2004 sediment statistical analyses (% water, % total carbon, % clay, % silt and % sand) by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven based on numbers of species and organisms (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

Location	North or South of Causeway	Treatment (OCR)	Sediment % Water	Sediment % Total Carbon	% Clay	% Silt	% Sand
Site Name			p= 0.000	p= 0.012	p= 0.075	p= 0.533	p= 0.551
Polecat Bay	N	O	3	5	1	11	6
Delvan Bay	N	O	2	2	7	2	8
Tensaw Riverbank	N	RB	5	4	3	3	10
Chocolatta Bay	N	C	4	3	4	4	9
Blakeley Riverbank	N	RB	7	7	9	6	3
Justin's Bay	N	C	1	1	2	1	11
Mouth of Pinto Pass	S	RB	11	11	11	10	1
Pinto Pass	S	O	6	8	8	8	4
South of Chocolatta	S	O	10	10	10	9	2
South of Justin's	S	O	9	9	6	5	7
South Blakeley Riverbank	S	RB	8	6	5	7	5
North	N		A	A	A	-	B
South	S		B	B	B	-	A
			N>S	N>S	N>S	N>S	S>N
			p= 0.000	p= 0.003	p= 0.024	p= 0.132	p= 0.047
Open		O	B	B	-	-	-
Closed		C	A	A	-	-	-
Riverbank		RB	B	B	-	-	-
			C>O>R	C>O>R	C>O>R	C>R>O	R>O>C
			p= 0.007	p= 0.005	p= 0.178	p= 0.254	p= 0.160

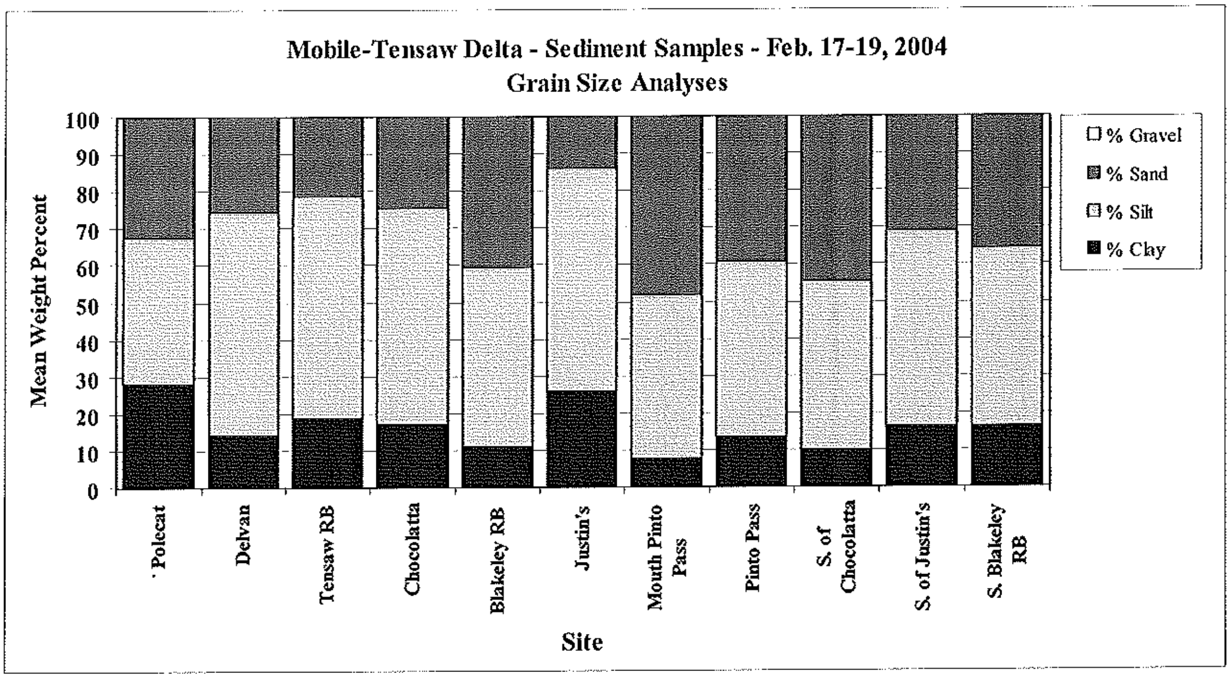

Figure 4-1. Sediment grain size (mean weight %) as gravel, sand, silt and clay are plotted by site from February 2004 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

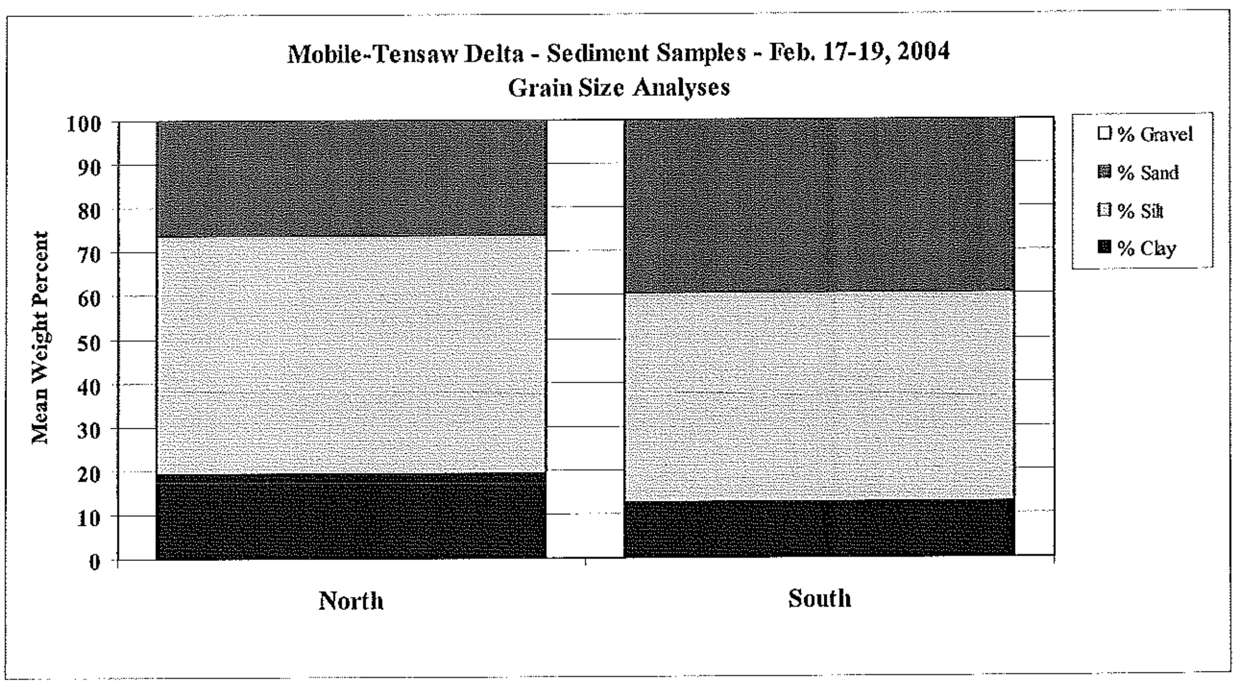

Figure 4-2. Sediment grain size (mean weight %) as gravel, sand, silt and clay are plotted by location north and south of the causeway for February 2004 sampling event.

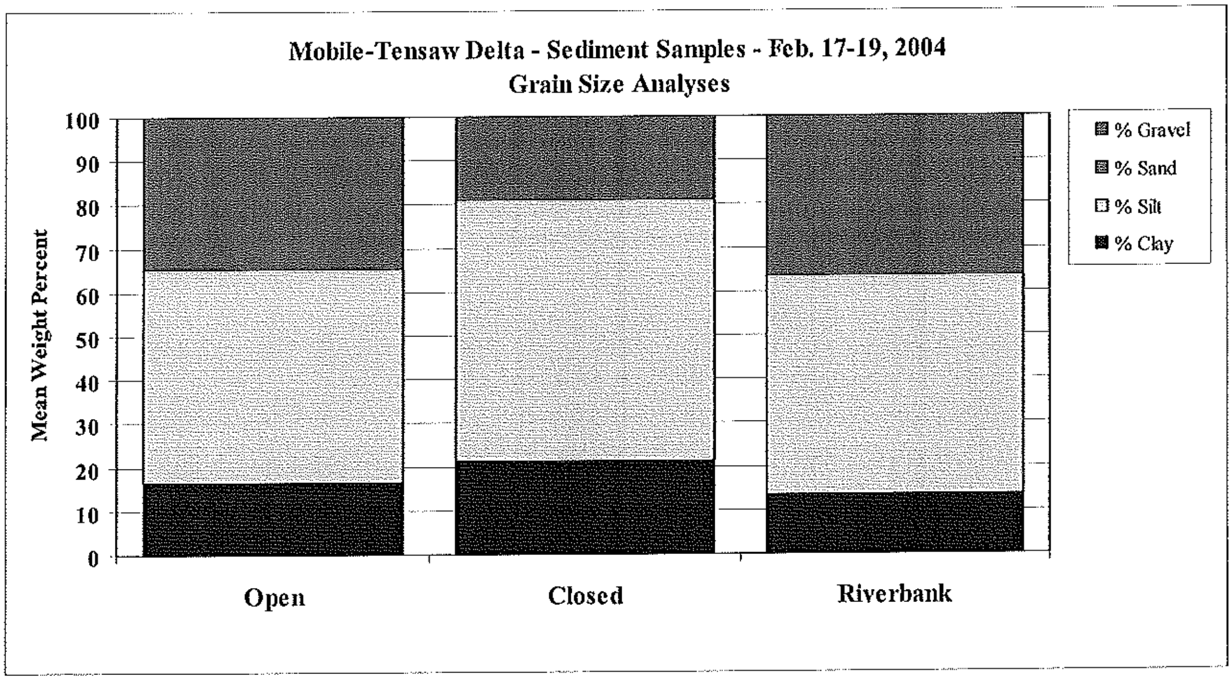

Figure 4-3. Sediment grain size (mean weight %) as gravel, sand, silt and clay are plotted by open, closed and riverbank categories for February 2004 sampling event.

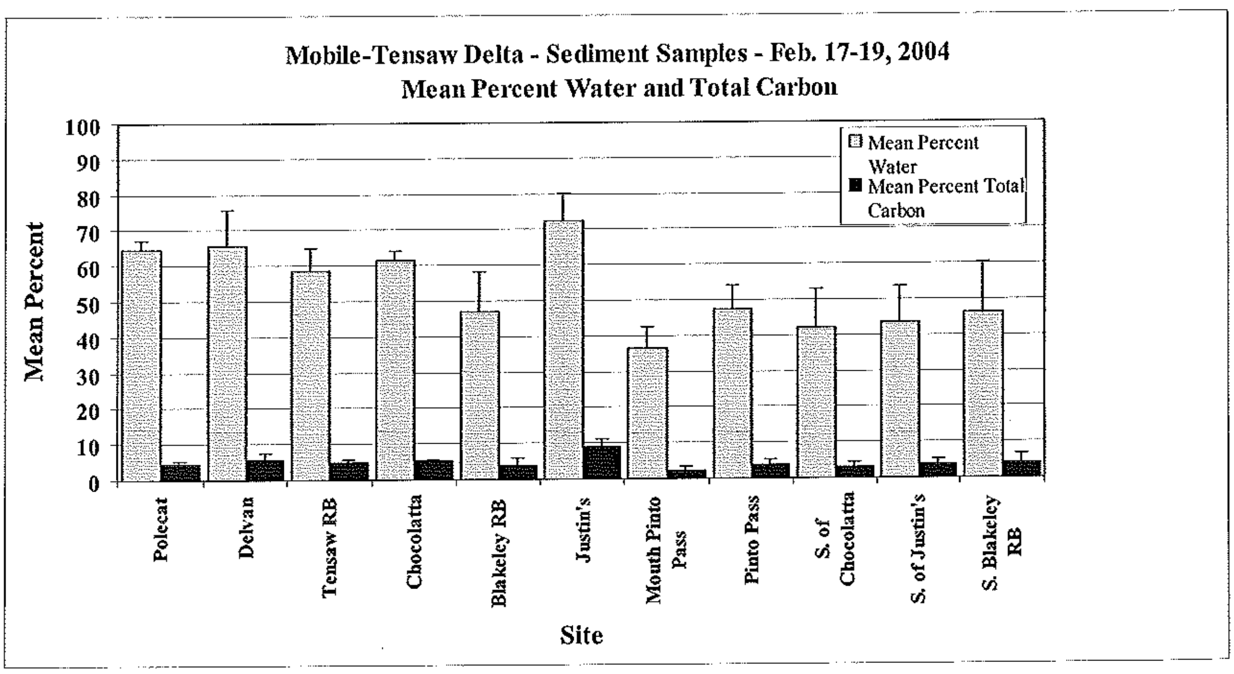

Figure 4-4. Sediment percent water and total carbon (mean %) plotted by site from February 2004 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

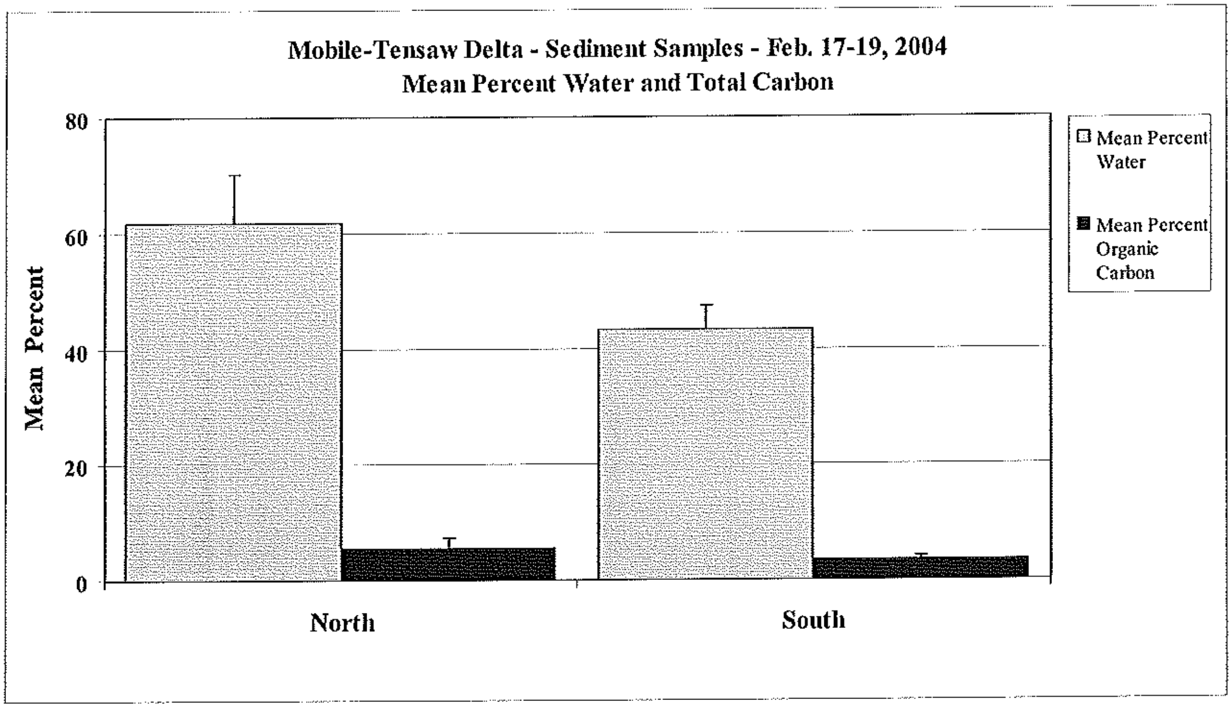

Figure 4-5. Sediment percent water and total carbon (mean %) plotted by location north and south of the causeway for February 2004 sampling event.

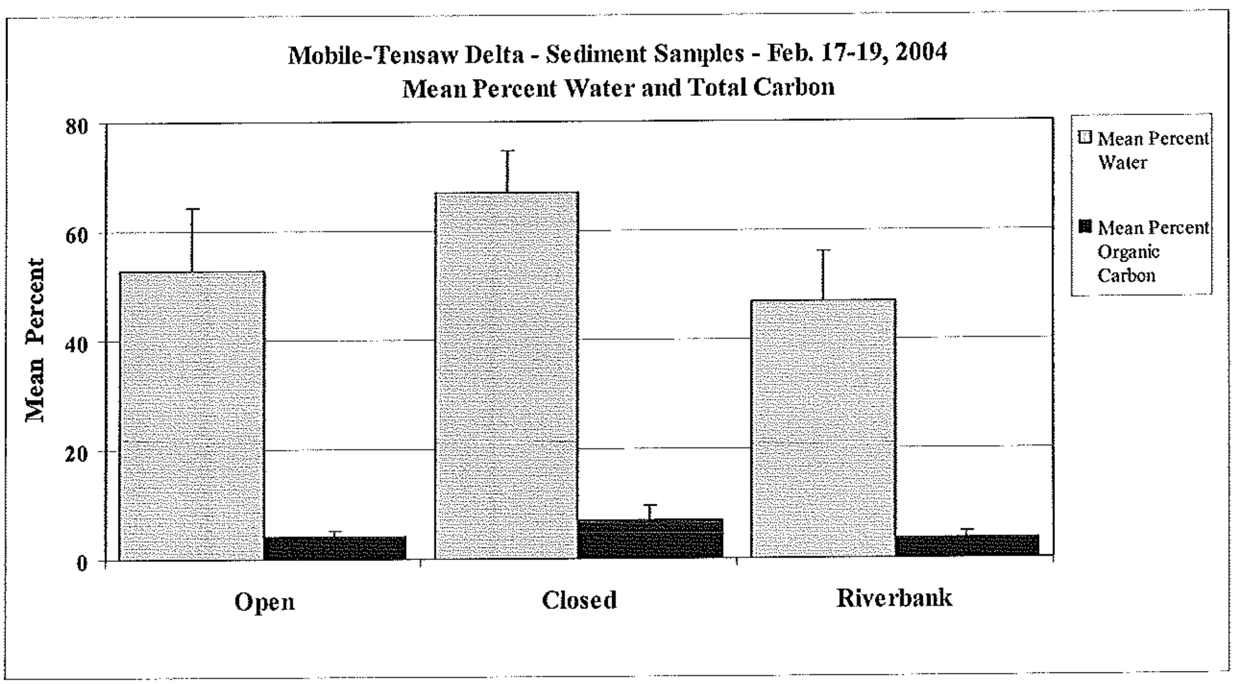

Figure 4-6. Sediment percent water and total carbon (mean %) plotted by open, closed and riverbank categories for February 2004 sampling event.

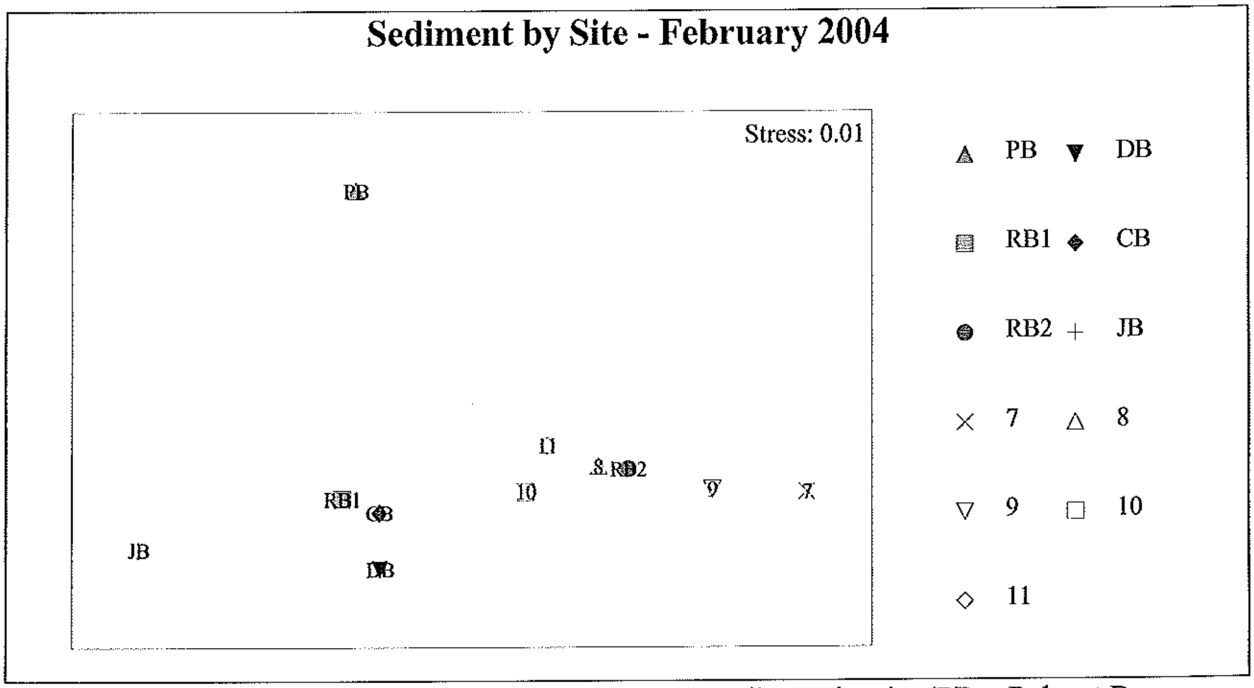

Figure 4-7. Figure 3-29. MDS plot for February 2004 sediment by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

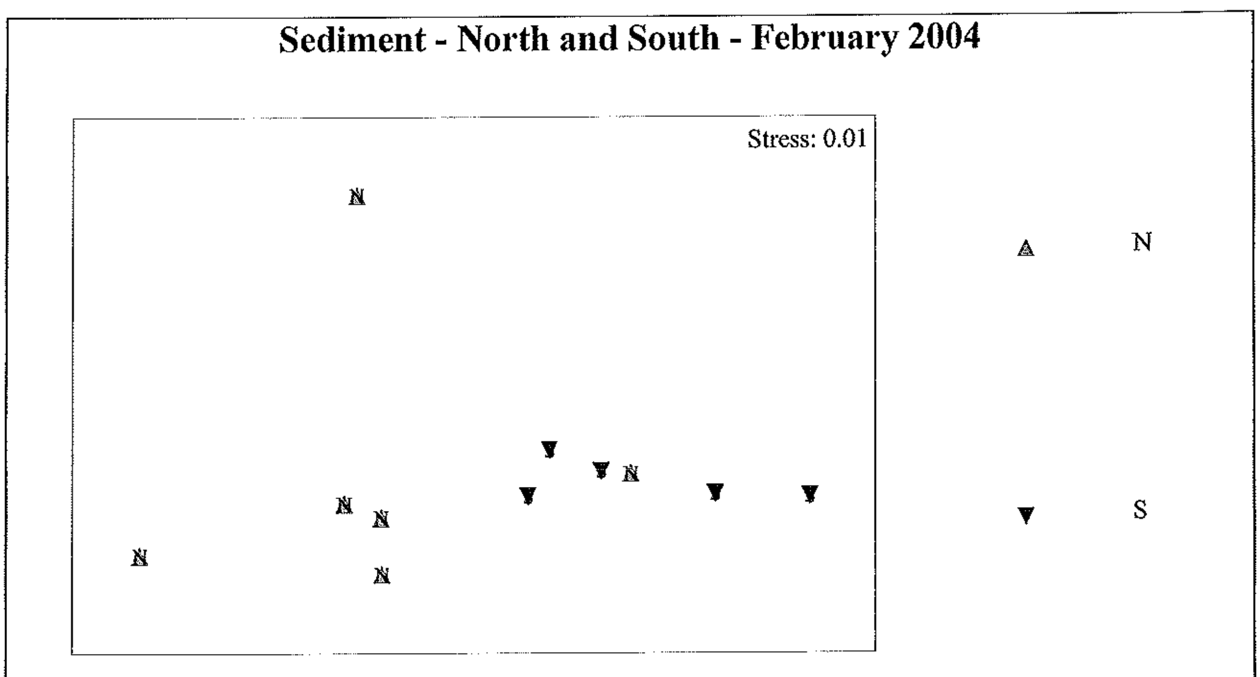

Figure 4-8. MDS plot for February 2004 sediment by location north (N) and south (S) of the causeway.

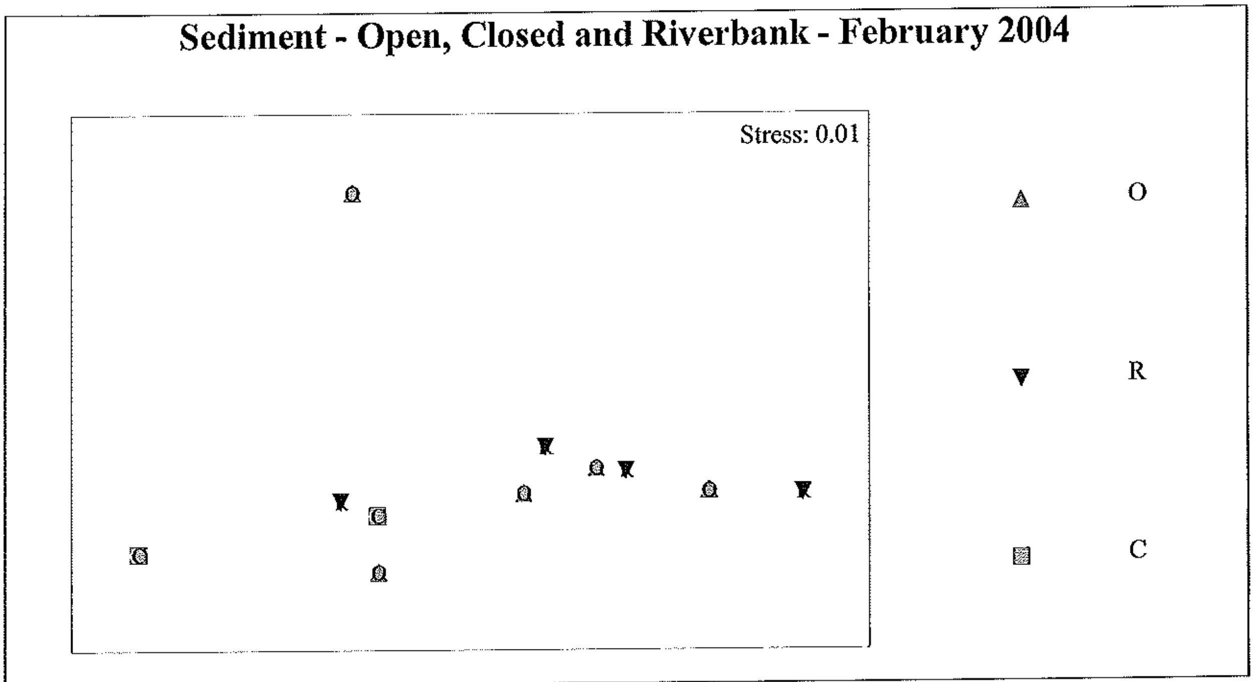

Figure 4-9. MDS plot for February 2004 sediment by open (O), closed (C) and riverbank (R) treatments.

Appendix 5

YSI Readings – February, May, June, July, August and October 2004

Table 5-1. February 2004 summary table for nutrient and YSI readings statistical analyses (NH4, NO3-NO2, TKN, TP, turbidity, chlorophyll *a*, dissolved oxygen and salinity) by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven for each parameter (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

			Water Column Nutrients				YSI Readings				
Location	**North or South of Causeway**	**Treatment (OCR)**	**NH4 (mg/L)**	**NO3-NO2 (mg/L)**	**TKN (mg/L)**	**TP (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (ug/L)**	**Dissolved Oxygen (mg/l)**	**Dissolved Oxygen (%)**	**Salinity (ppt)**
Site Name			p= 0.852	**p= 0.006**	**p= 0.139**	**p= 0.030**	**p= 0.000**	**p= 0.000**	**p= 0.000**	**p= 0.000**	**p= 0.000**
Polecat Bay	N	O	6	9	5	4	4	3	9	11	4
Delvan Bay	N	O	3	7	2	5	9	1	3	2	1
Tensaw Riverbank	N	RB	4	3	7	6	1	5	11	10	7
Chocolatta Bay	N	C	9	10	4	10	10	2	2	3	2
Blakeley Riverbank	N	RB	11	5	6	7	6	7	4	6	9
Justin's Bay	N	C	10	11	10	11	11	8	1	1	3
Mouth of Pinto Pass	S	RB	5	8	1	1	2	6	10	9	8
Pinto Pass	S	O	1	6	3	2	3	4	7	7	5
South of Chocolatta	S	O	2	2	11	9	8	9	6	4	6
South of Justin's	S	O	7	4	8	3	5	11	8	8	9
South Blakeley Riverbank	S	RB	8	1	9	8	7	10	5	5	9
North	**N**		-		-	-	-	A	A	-	A
South	**S**		-		-	-	-	B	B	-	B
			S>N	S>N	N>S	S>N	S>N	N>S	N>S	N>S	N>S
			p= 0.105	**p= 0.116**	p= 0.894	**p= 0.066**	**p= 0.083**	**p= 0.005**	**p= 0.012**	p= 0.250	**p= 0.000**
Open		**O**	-	-	-	AB	B	AB	BC	BC	B
Closed		**C**	-	-	-	B	C	A	A	A	A
Riverbank		**R**	-	-	-	A	AB	B	C	C	C
			O>R>C	R>O>C	R>C>O	R>C>O	R>O>C	C>O>R	C>O>R	C>O>R	C>O>R
			p= 0.280	**p= 0.108**	p= 0.931	**p= 0.026**	**p= 0.000**	**p= 0.050**	**p= 0.000**	**p= 0.000**	**p= 0.000**

Table 5-2. June 2004 summary table for nutrient and YSI readings statistical analyses (NH4, NO3-NO2, TKN, TP, turbidity, chlorophyll *a*, dissolved oxygen and salinity) by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven for each parameter (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

			Water Column Nutrients				YSI Readings				
Location	**North or South of Causeway**	**Treatment (OCR)**	**NH4 (mg/L)**	**NO3-NO2 (mg/L)**	**TKN (mg/L)**	**TP (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (ug/L)**	**Dissolved Oxygen (mg/l)**	**Dissolved Oxygen (%)**	**Salinity (ppt)**
Site Name			na	na	p= 0.234	na	**p= 0.024**	**p= 0.000**	**p= 0.041**	**p= 0.004**	**p= 0.000**
Polecat Bay	N	O	7	11	3	6	5	2	6	6	2
Delvan Bay	N	O	7	10	2	8	8	1	1	1	4
Tensaw Riverbank	N	RB	7	8	1	5	4	3	3	3	6
Chocolatta Bay	N	C	7	9	11	11	9	5	9	9	7
Blakeley Riverbank	N	RB	1	4	7	3	3	4	2	2	10
Justin's Bay	N	C	6	2	4	1	7	6	4	4	11
Mouth of Pinto Pass	S	RB	3	7	5	7	6	8	7	7	1
Pinto Pass	S	O	4	6	9	10	10	10	5	5	5
South of Chocolatta	S	O	5	5	6	9	11	11	8	8	3
South of Justin's	S	O	2	1	10	2	2	9	11	11	9
South Blakeley Riverbank	S	RB	5	3	8	4	1	7	10	10	8
North	**N**		-	-	-	-	-	A	A	A	-
South	**S**		-	-	-	-	-	B	B	B	-
			S > N	N>S	N>S	S>N	N > S	N > S	N > S	N > S	S>N
			p= 0.060	**p= 0.091**	p= 0.395	p= 0.817	p= 0.690	**p= 0.000**	**p= 0.024**	**p= 0.004**	p= 0.499
Open		**O**	-	-	-	-	B	-	-	-	A
Closed		**C**	-	-	-	-	AB	-	-	-	C
Riverbank		**R**	-	-	-	-	A	-	-	-	BC
			R>O>C	R>C>O	O>R>C	R>O>C	R>C>O	C>R>O	R>C>O	R>O>C	O>R>C
			p= 0.305	p= 0.595	p= 0.739	p= 0.824	**p= 0.029**	p= 0.259	p= 0.913	p= 0.953	**p= 0.002**

Table 5-3. October 2004 summary table for nutrient and YSI readings statistical analyses (NH4, NO3-NO2, TKN, TP, turbidity, chlorophyll *a*, dissolved oxygen and salinity) by site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven for each parameter (1 > 2 > 3). Location north or south of the causeway (N or S) and treatment designation of open (O), closed (C) or riverbank (RB) are listed for each location.

			Water Column Nutrients				YSI Readings				
Location	**North or South of Causeway**	**Treatment (OCR)**	**NH4 (mg/L)**	**NO3-NO2 (mg/L)**	**TKN (mg/L)**	**TP (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (ug/L)**	**Dissolved Oxygen (mg/l)**	**Dissolved Oxygen (%)**	**Salinity (ppt)**
Site Name			na	na	na	na	**p= 0.000**	**p= 0.007**	**p= 0.000**	**p= 0.000**	**p= 0.000**
Polecat Bay	N	O	9	9	3	10	3	2	1	1	6
Delvan Bay	N	O	9	11	5	11	6	3	2	2	4
Tensaw Riverbank	N	RB	9	6	7	8	5	4	3	4	5
Chocolatta Bay	N	C	7	10	6	2	1	1	6	6	7
Blakeley Riverbank	N	RB	6	5	11	6	10	8	11	11	11
Justin's Bay	N	C	8	8	9	5	8	5	4	3	10
Mouth of Pinto Pass	S	RB	3	2	2	3	4	9	5	5	2
Pinto Pass	S	O	2	3	4	4	7	11	8	8	1
South of Chocolatta	S	O	1	4	1	1	2	10	7	7	3
South of Justin's	S	O	4	1	10	9	11	6	10	10	8
South Blakeley Riverbank	S	RB	5	7	8	7	9	7	9	9	9
North	N		B	B	-	-	-	A	A	A	B
South	S		A	A	-	-	-	B	B	B	A
			S>N	S>N	S>N	S>N	N>S	N>S	N>S	N>S	S>N
			p= 0.001	**p= 0.026**	p= 0.386	p= 0.325	p= 0.363	**p= 0.000**	**p= 0.001**	**p= 0.016**	**p= 0.001**
Open		O	-	-	-	-	-	B	-	-	A
Closed		C	-	-	-	-	-	A	-	-	C
Riverbank		RB	-	-	-	-	-	BC	-	-	BC
			O>R>C	O>R>C	O>C>R	C>O>R	C>O>R	C>O>R	C>O>R	C>O>R	O>R>C
			p= 0.657	p= 0.418	p= 0.412	p= 0.419	**p= 0.129**	**p= 0.004**	p= 0.206	**p= 0.071**	**p= 0.000**

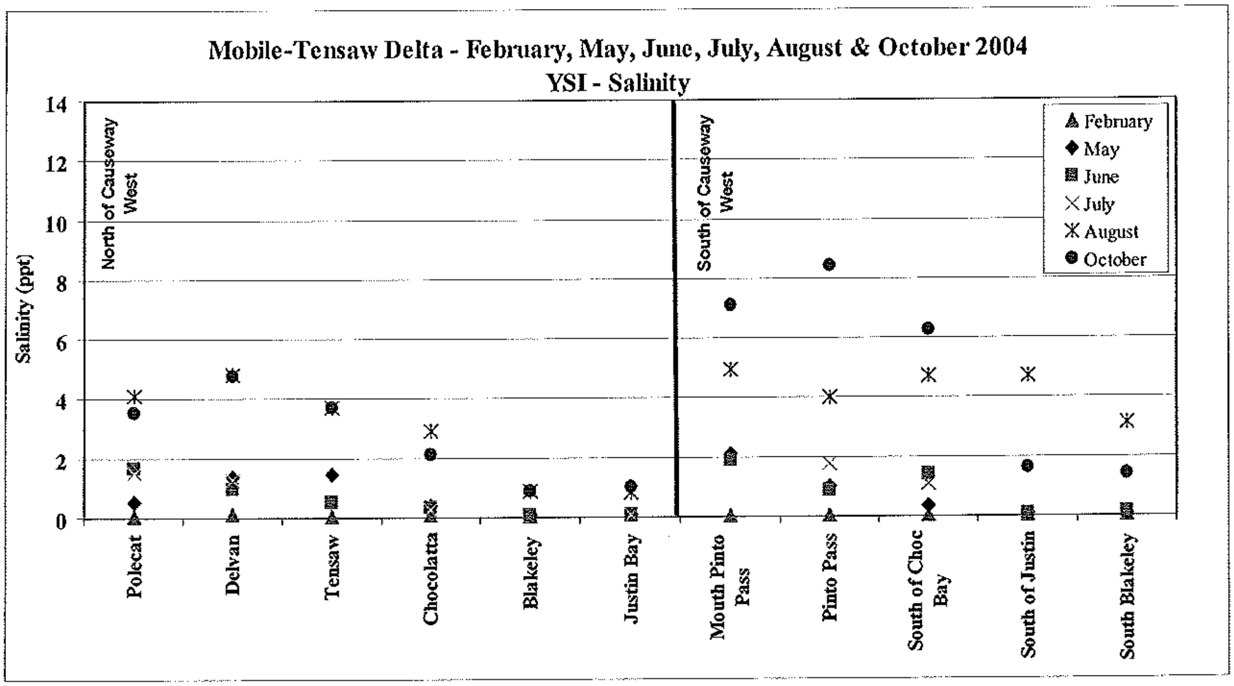

Figure 5-1. Mean salinity (ppt) from YSI readings plotted by site from February, May, June, July, August and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

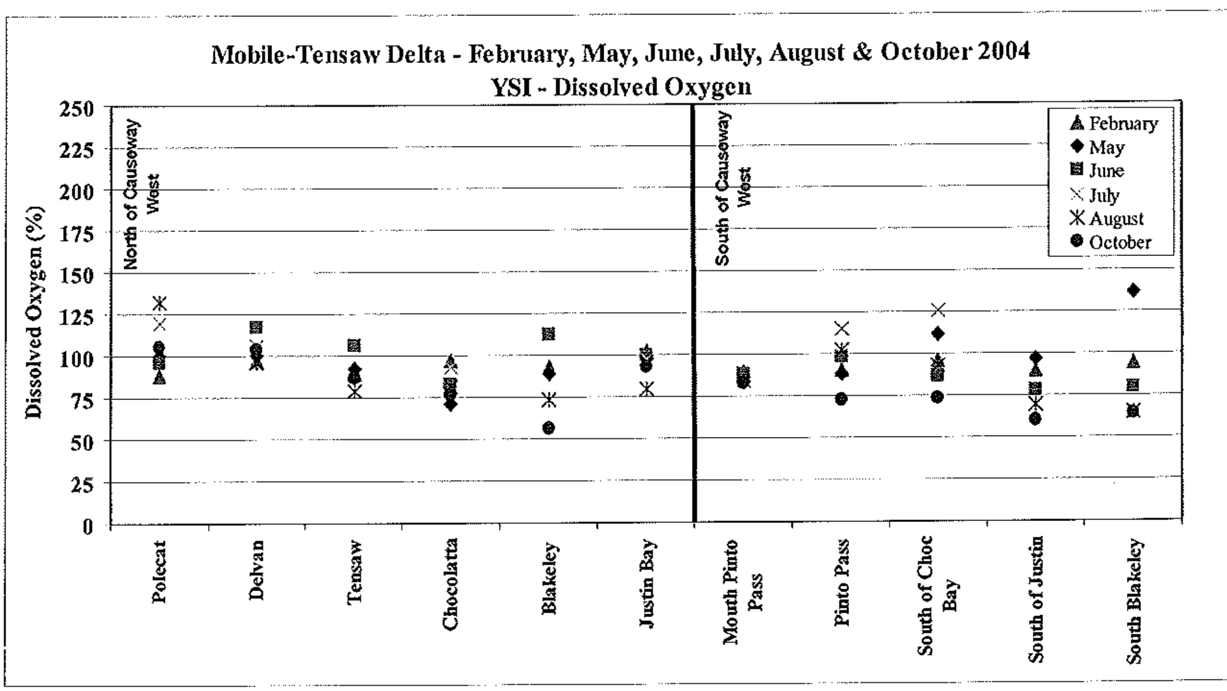

Figure 5-2. Mean dissolved oxygen (%) from YSI readings plotted by site from February, May, June, July, August and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

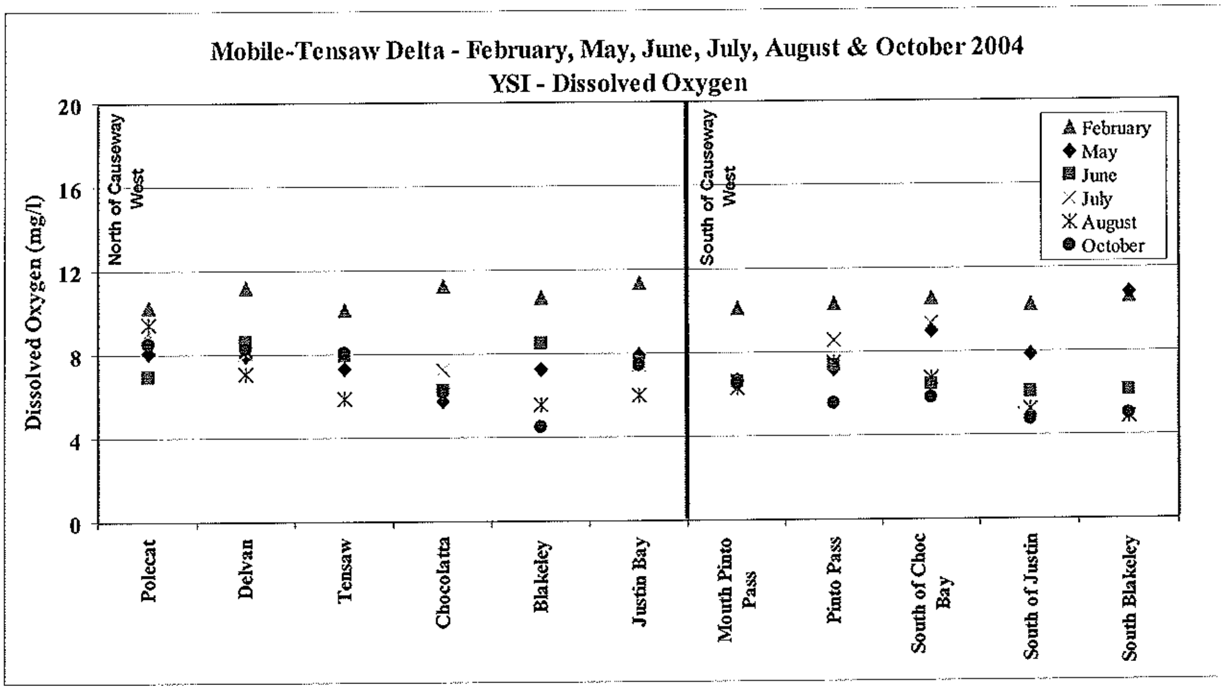

Figure 5-3. Mean dissolved oxygen (mg/l) from YSI readings plotted by site from February, May, June, July, August and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

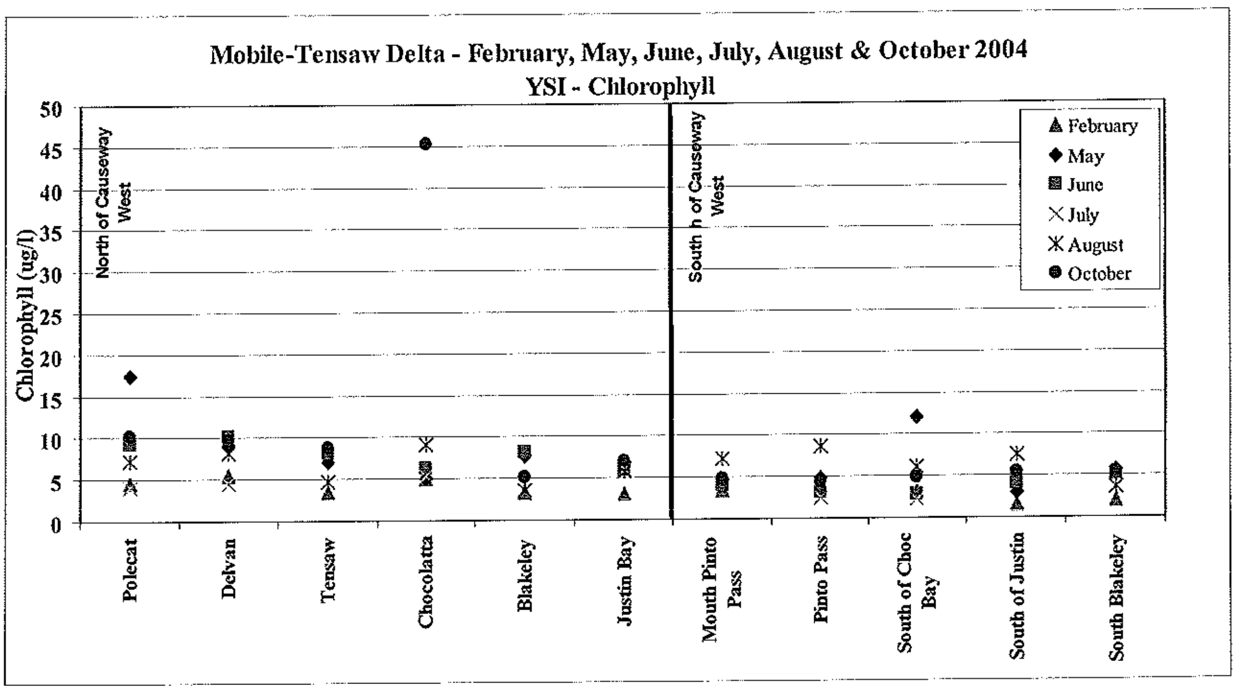

Figure 5-4. Mean chlorophyll *a* (ug/l) from YSI readings plotted by site from February, May, June, July, August and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

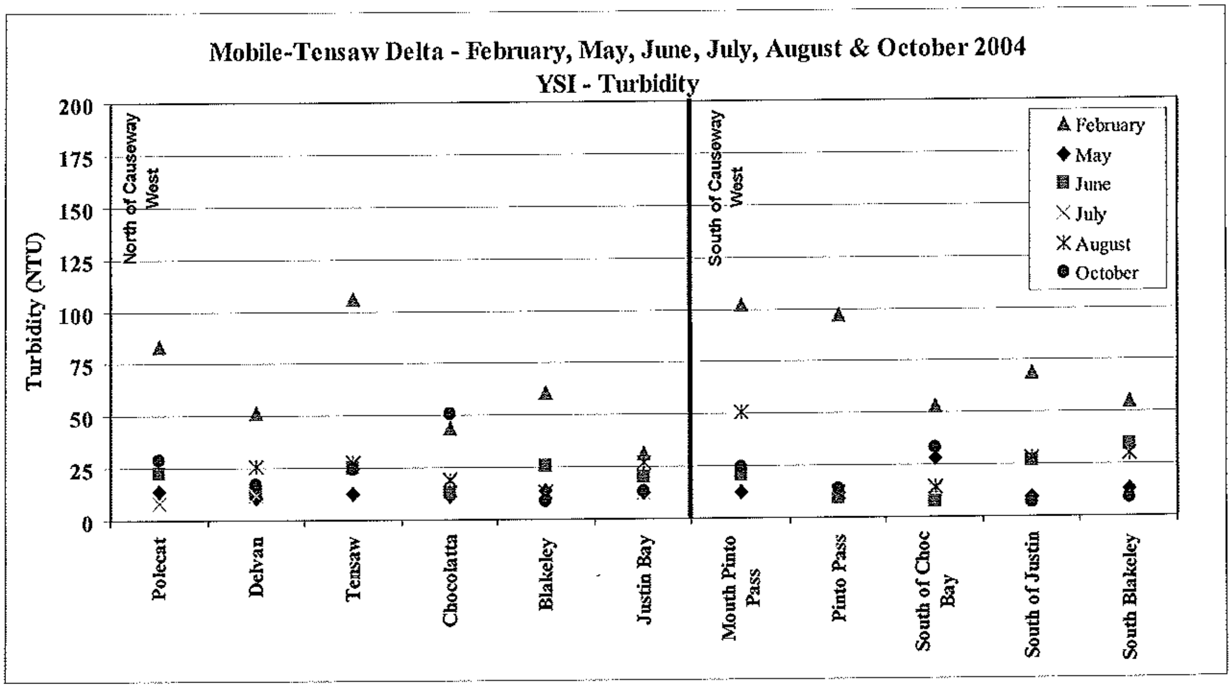

Figure 5-5. Mean turbidity (NTU) from YSI readings plotted by site from February, May, June, July, August and October 2004. The vertical line separates sites located north (left) and south (right) of the causeway.

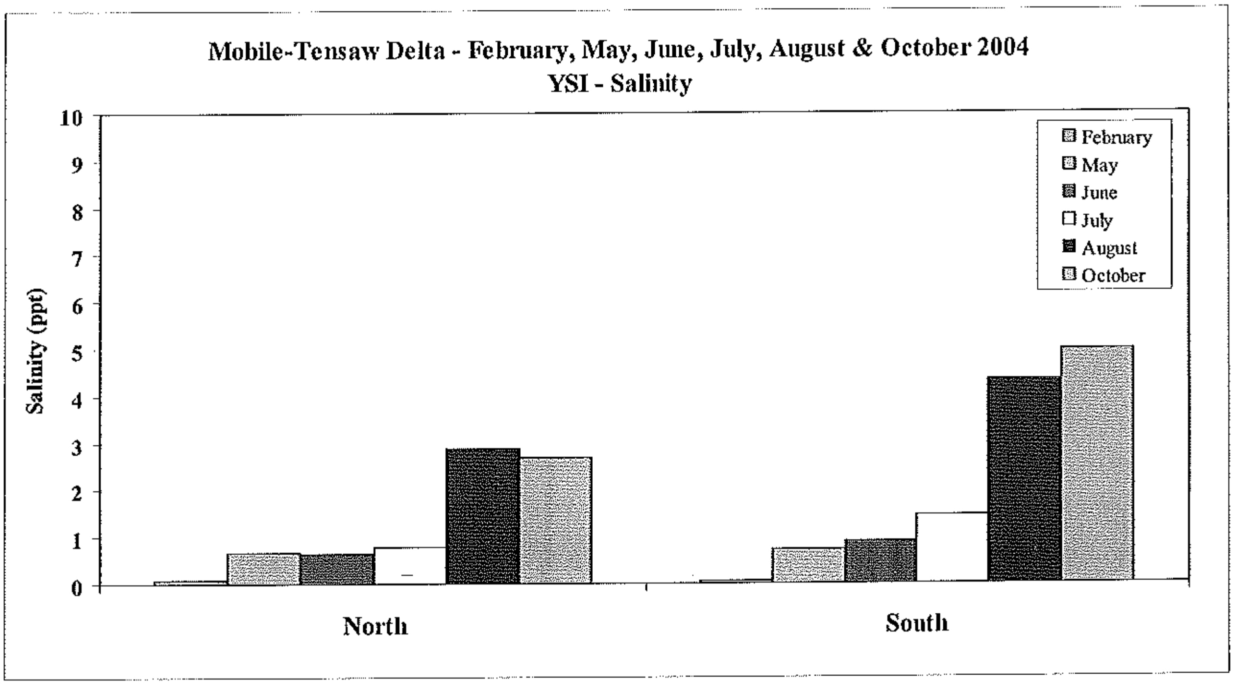

Figure 5-6. Mean salinity (ppt) from YSI readings plotted by location north and south of the causeway from February, May, June, July, August and October 2004.

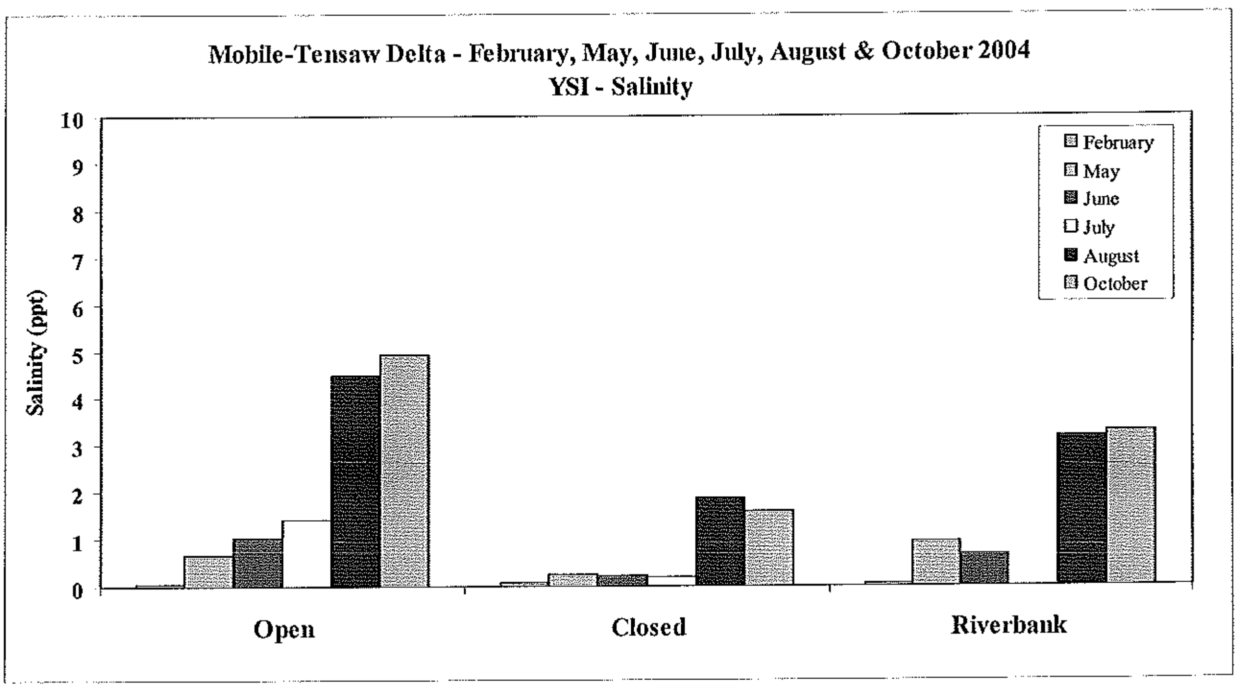

Figure 5-7. Mean salinity (ppt) from YSI readings plotted by open, closed and riverbank categories from February, May, June, July, August and October 2004.

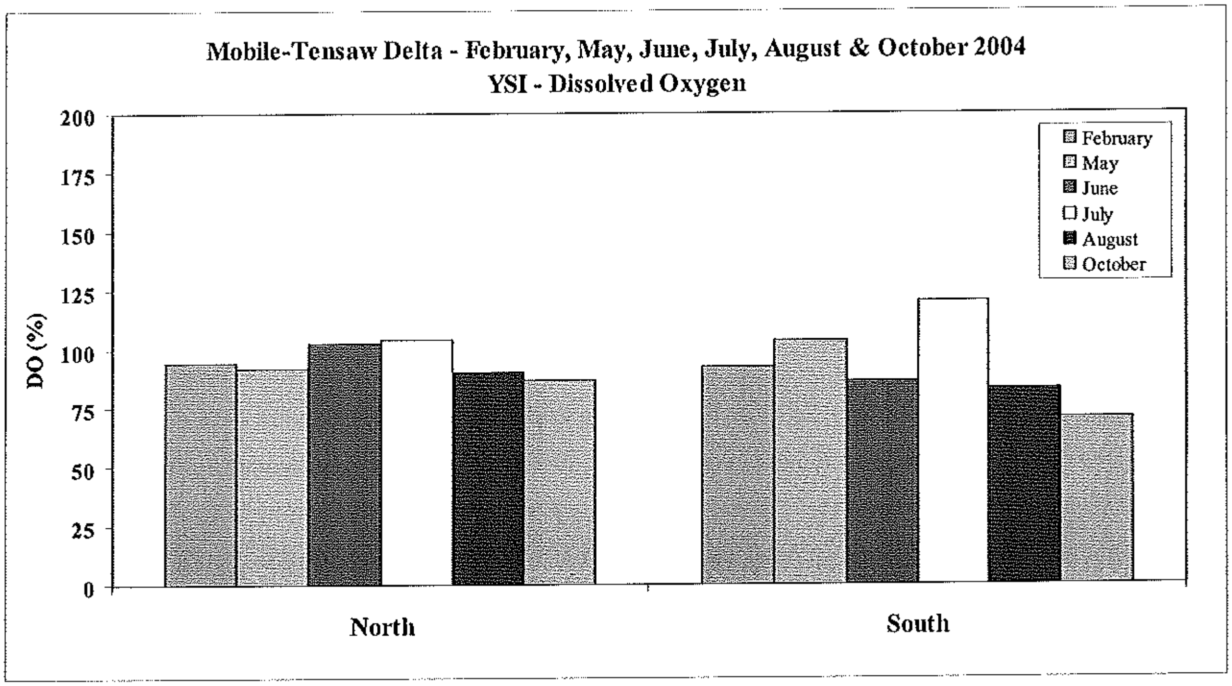

Figure 5-8. Mean dissolved oxygen (%) from YSI readings plotted by location north and south of the causeway from February, May, June, July, August and October 2004.

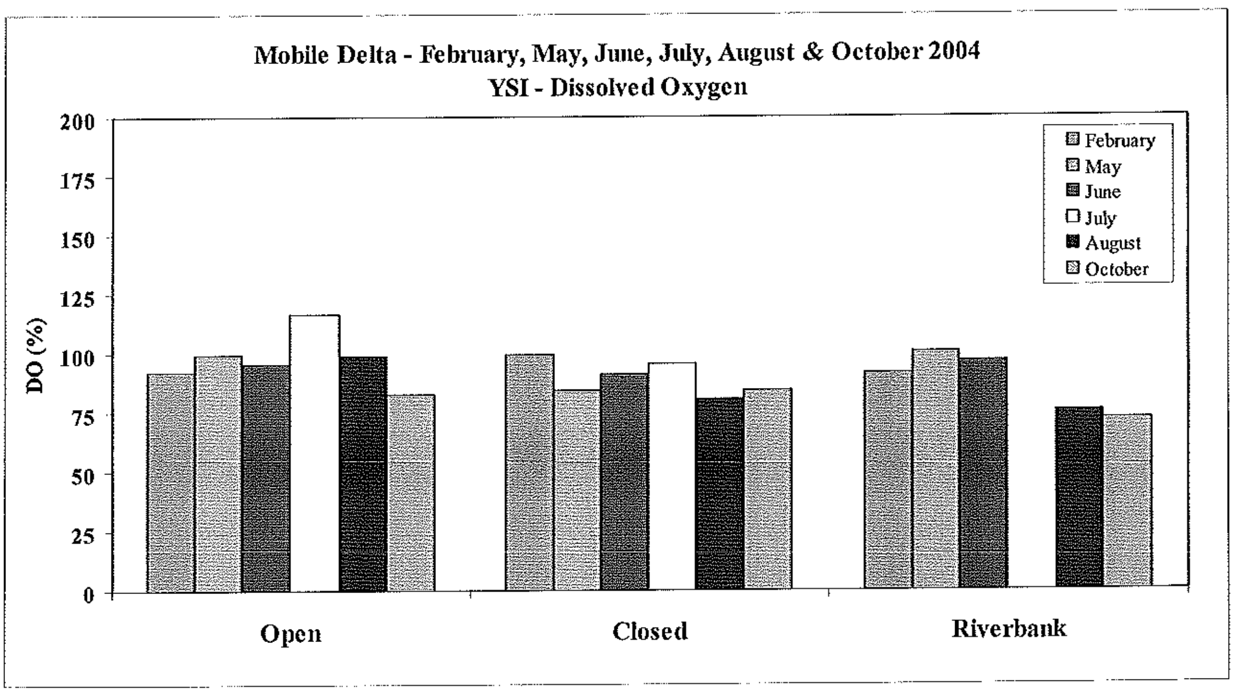

Figure 5-9. Mean dissolved oxygen (%) from YSI readings plotted by open, closed and riverbank categories from February, May, June, July, August and October 2004

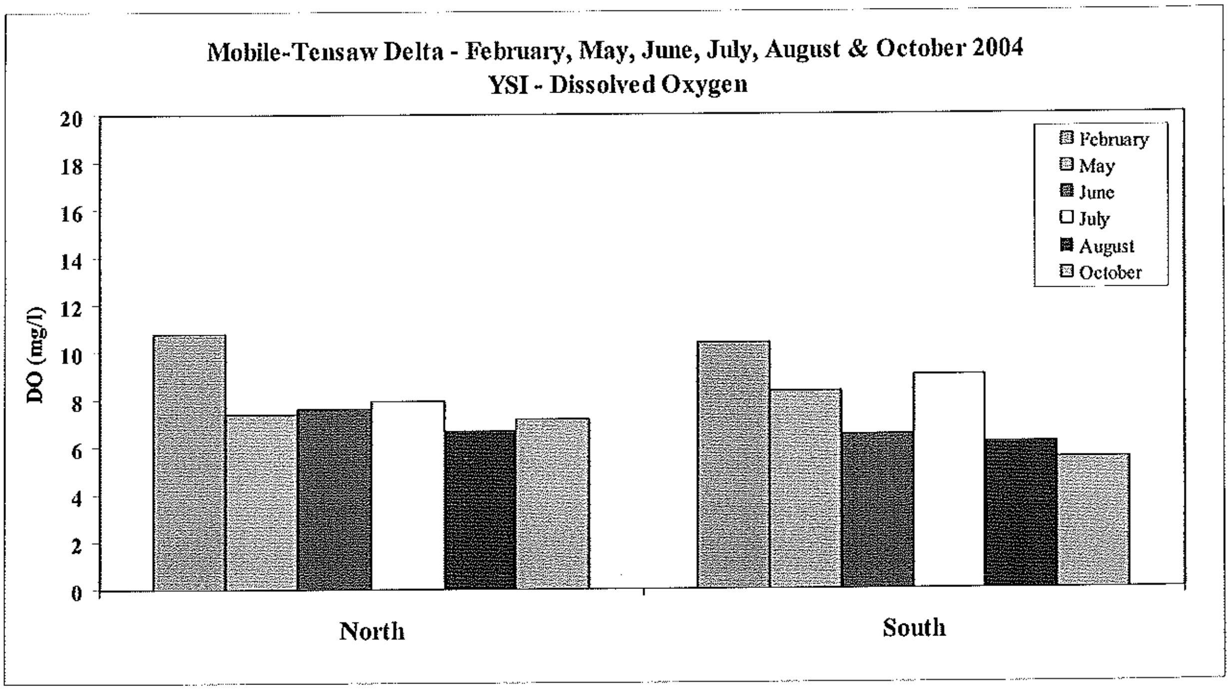

Figure 5-10. Mean dissolved oxygen (mg/l) from YSI readings plotted by location north and south of the causeway from February, May, June, July, August and October 2004.

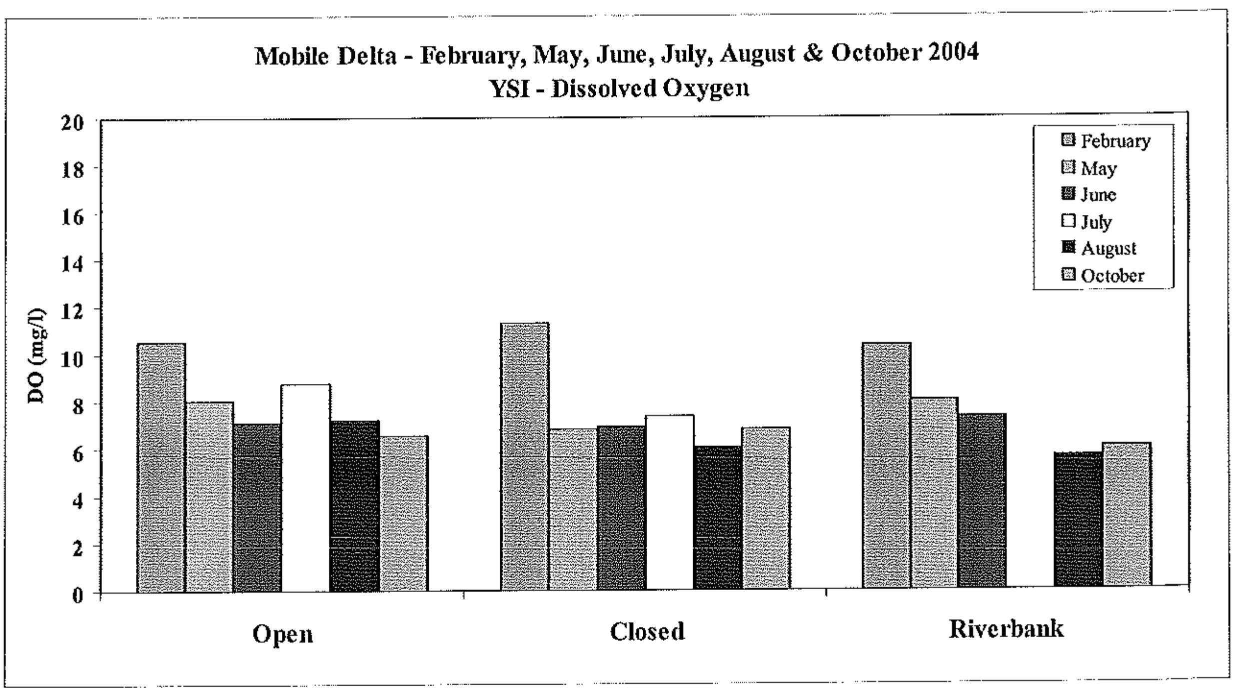

Figure 5-11. Mean dissolved oxygen (mg/l) from YSI readings plotted by open, closed and riverbank categories from February, May, June, July, August and October 2004.

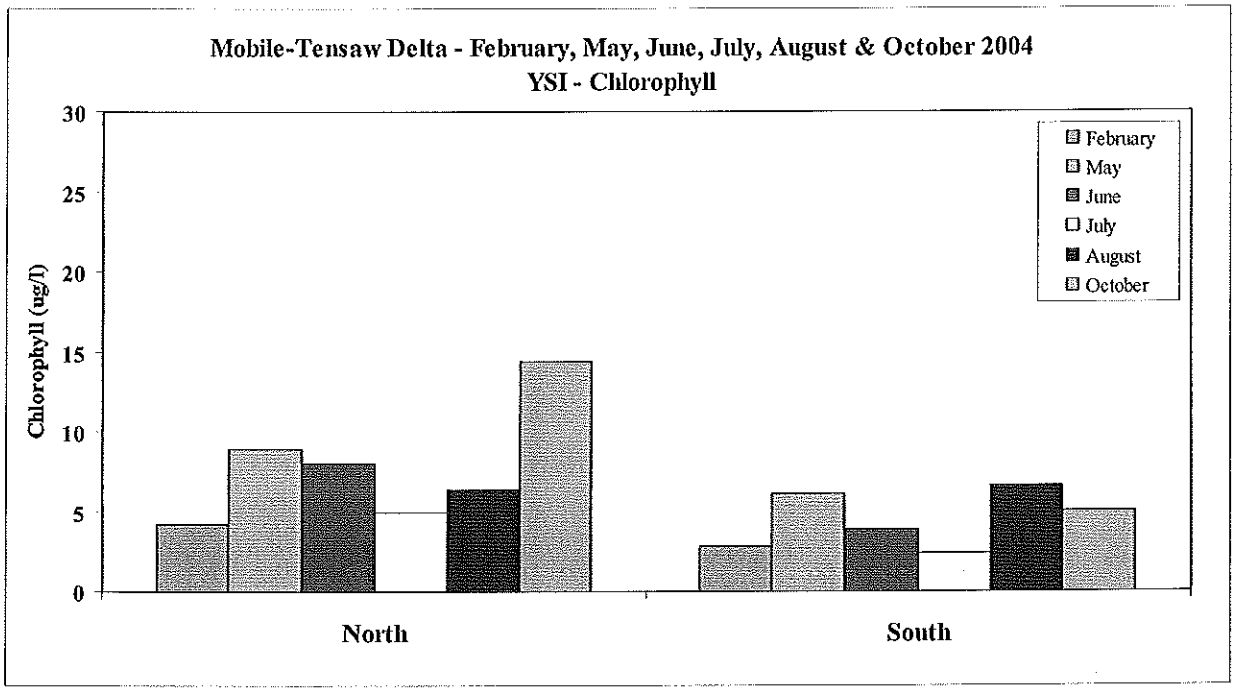

Figure 5-12. Mean chlorophyll *a* (ug/l) from YSI readings plotted by location north and south of the causeway from February, May, June, July, August and October 2004.

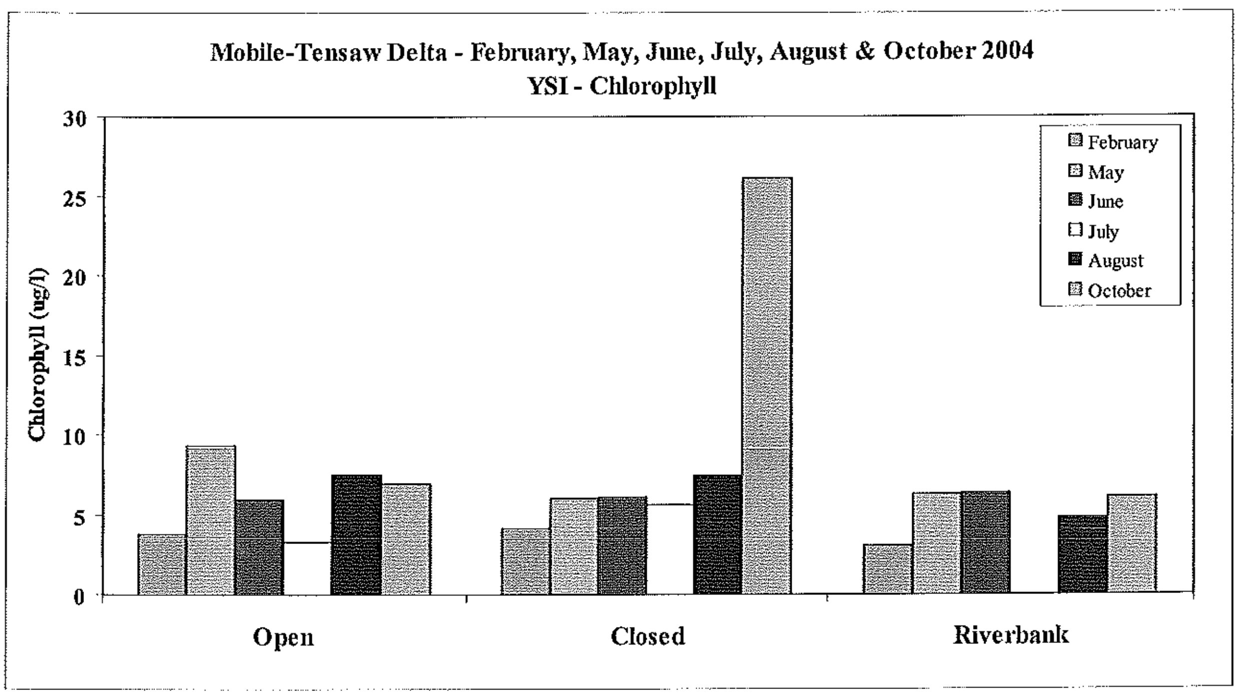

Figure 5-13. Mean chlorophyll *a* (ug/l) from YSI readings plotted by open, closed and riverbank categories from February, May, June, July, August and October 2004.

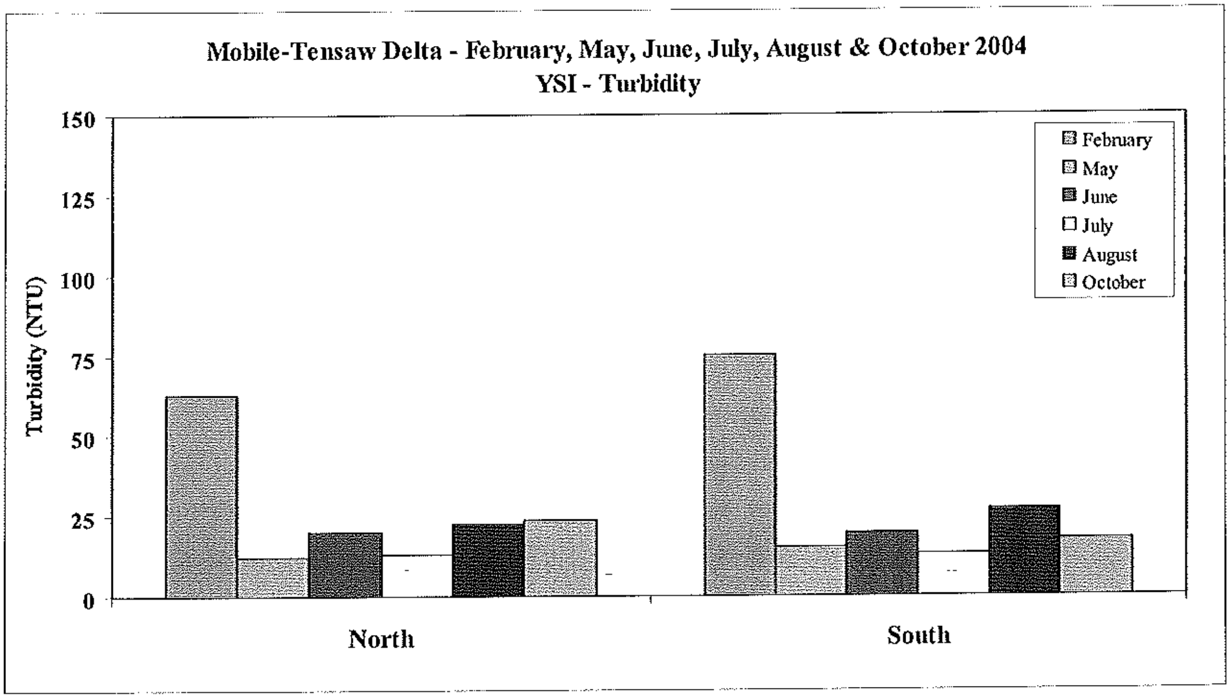

Figure 5-14. Mean turbidity (NTU) from YSI readings plotted by location north and south of the causeway from February, May, June, July, August and October 2004.

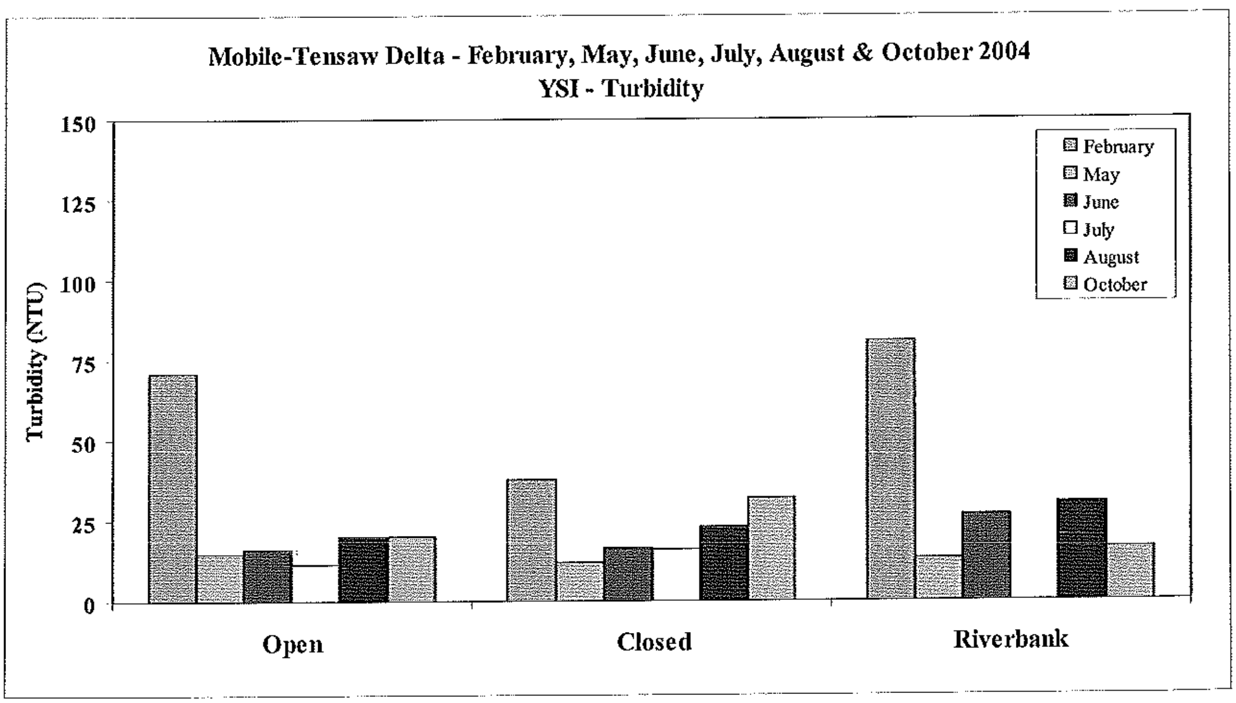

Figure 5-15. Mean turbidity (NTU) from YSI readings plotted by open, closed and riverbank categories from February, May, June, July, August and October 2004.

Appendix 6

Nutrients – February, May, June, August and October 2004

Table 6-1. Summary table for nutrient (February, May, June, August and October 2004) statistical analyses (NH4, NO3-NO2, TKN, TP) by month, site, north and south of causeway, and open, closed and riverbank treatments (A > B > C; dashes denote no significant difference).

	NH4	**NO3-NO2**	**TKN**	**TP**
Month	**p= 0.011**	**p= 0.001**	**p= 0.000**	**p= 0.000**
February	ABC	A	BD	A
May	C	A	DE	CDE
June	ABC	AB	BC	CDE
August	A	B	B	BC
October	AB	A	A	B
	A>O>F>J>M	F>M>O>J>A	O>A>J>F>M	F>O>A>J>M
Location / Site	p= 0.165	**p= 0.013**	p= 0.929	p= 0.994
Polecat Bay	-	AB	-	-
Delvan Bay	-	AB	-	-
Tensaw Riverbank	-	AB	-	-
Chocolatta Bay	-	AB	-	-
Chocolatta Bay 2	-	B	-	-
Blakeley Riverbank	-	AB	-	-
Justin's Bay	-	AB	-	-
Mouth of Pinto Pass	-	AB	-	-
Pinto Pass	-	AB	-	-
South of Chocolatta	-	AB	-	-
South of Justin's	-	A	-	-
South Blakeley Riverbank	-	A	-	-
North	B	B	-	-
South	A	A	-	-
	S > N	S > N	N > S	S > N
	p= 0.001	**p= 0.020**	p= 0.851	p= 0.415
Open	-	-	-	-
Closed	-	-	-	-
Riverbank	-	-	-	-
	RB > O > C	RB > O > C	O > RB > C	RB > O > C
	p= 0.171	p= 0.147	p= 0.544	p= 0.838

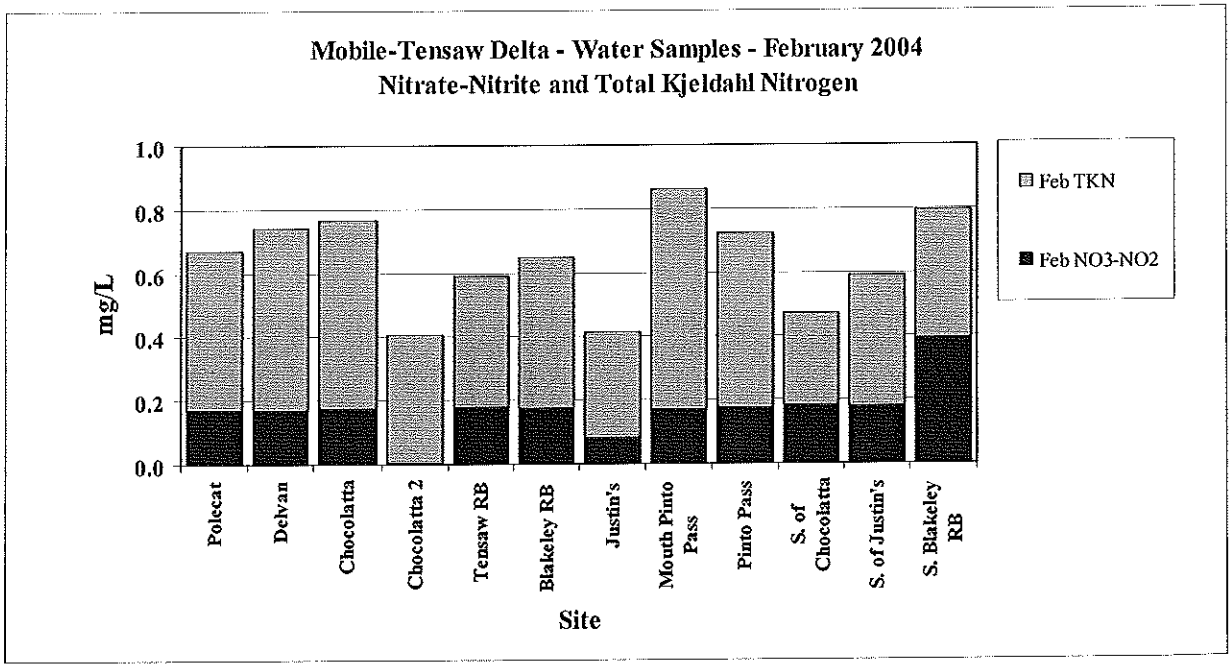

Figure 6-1. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from February 2004. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

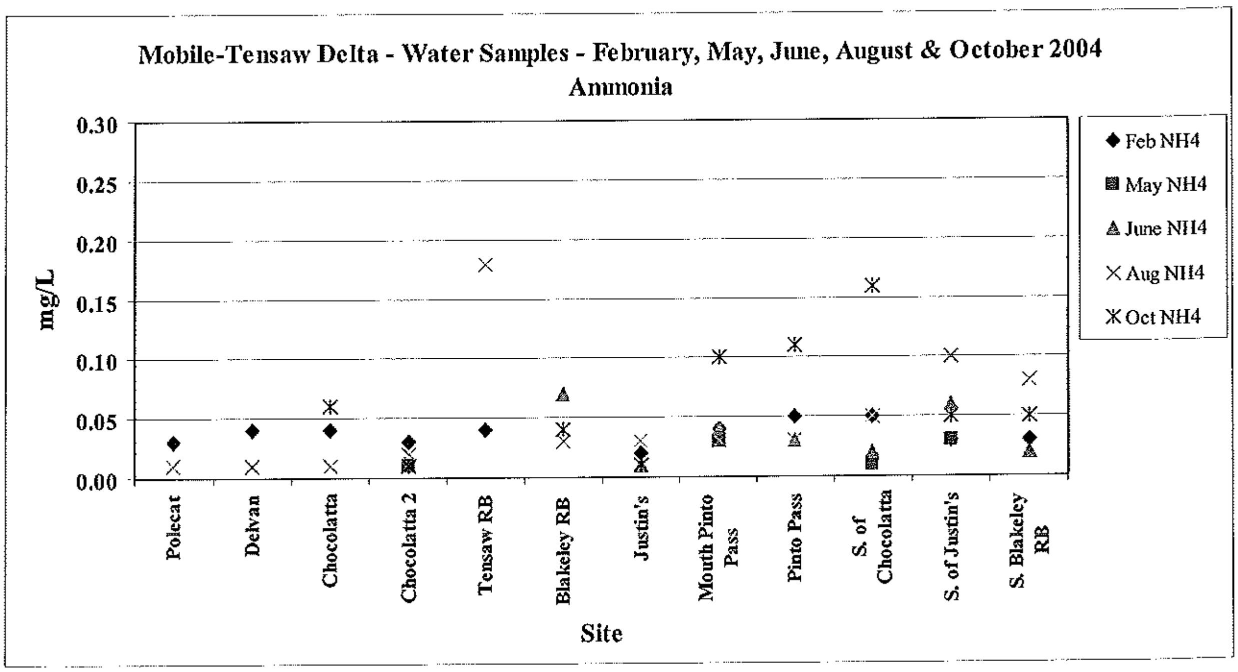

Figure 6-2. Water column ammonia (mg/l) plotted by site from February, May, June, August and October 2004. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

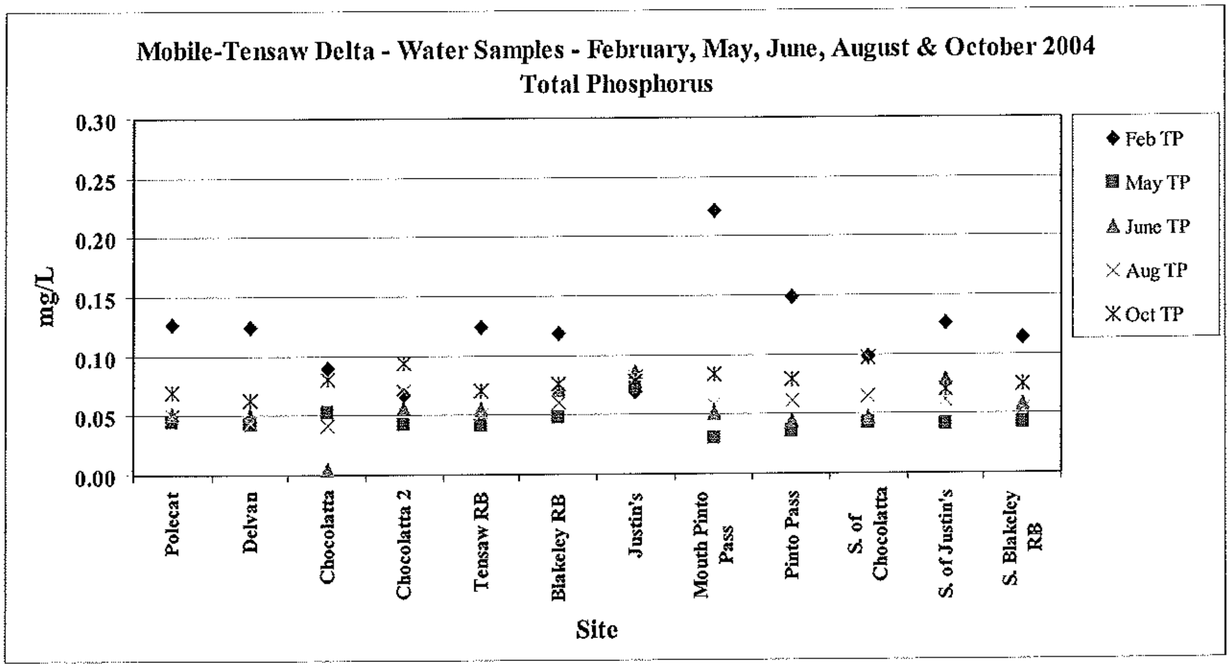

Figure 6-3. Water column total phosphorus (mg/l) plotted by site from February, May, June, August and October 2004. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

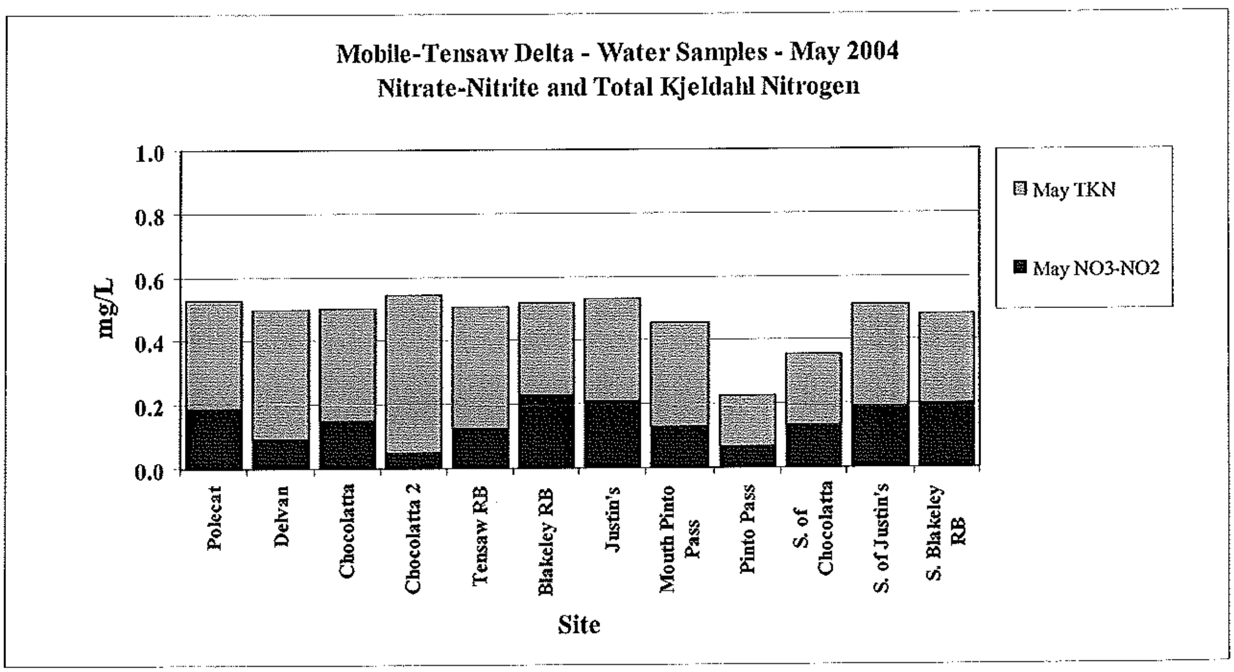

Figure 6-4. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from May 2004. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

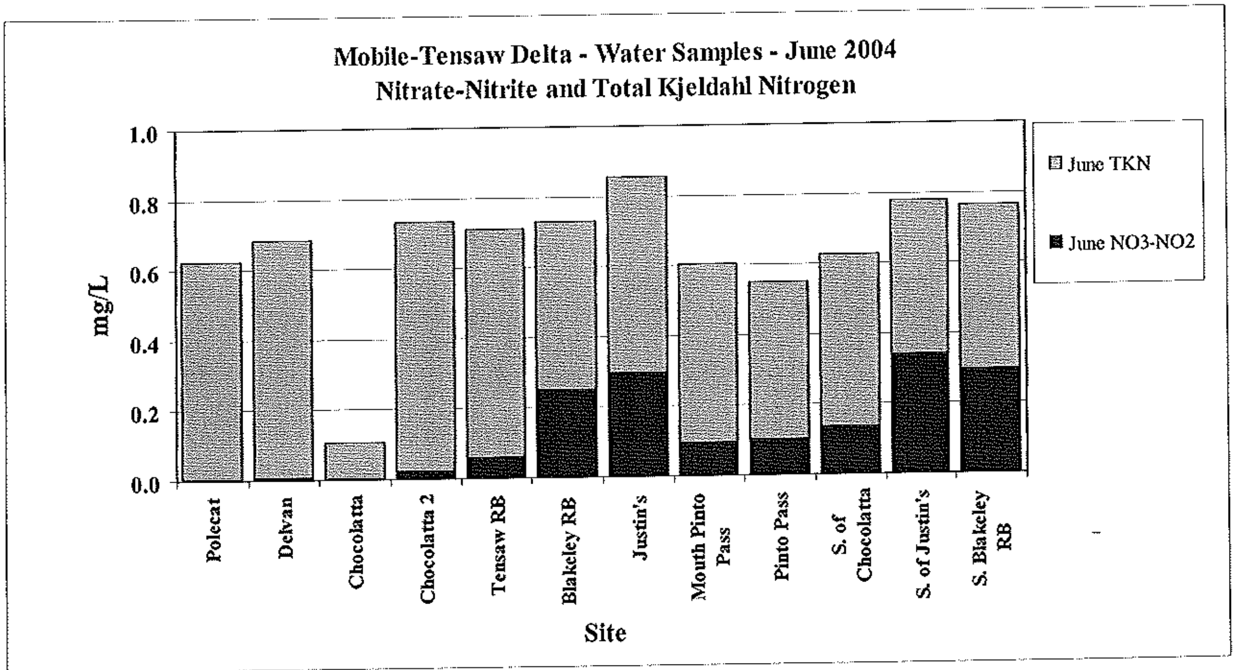

Figure 6-5. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from June 2004. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

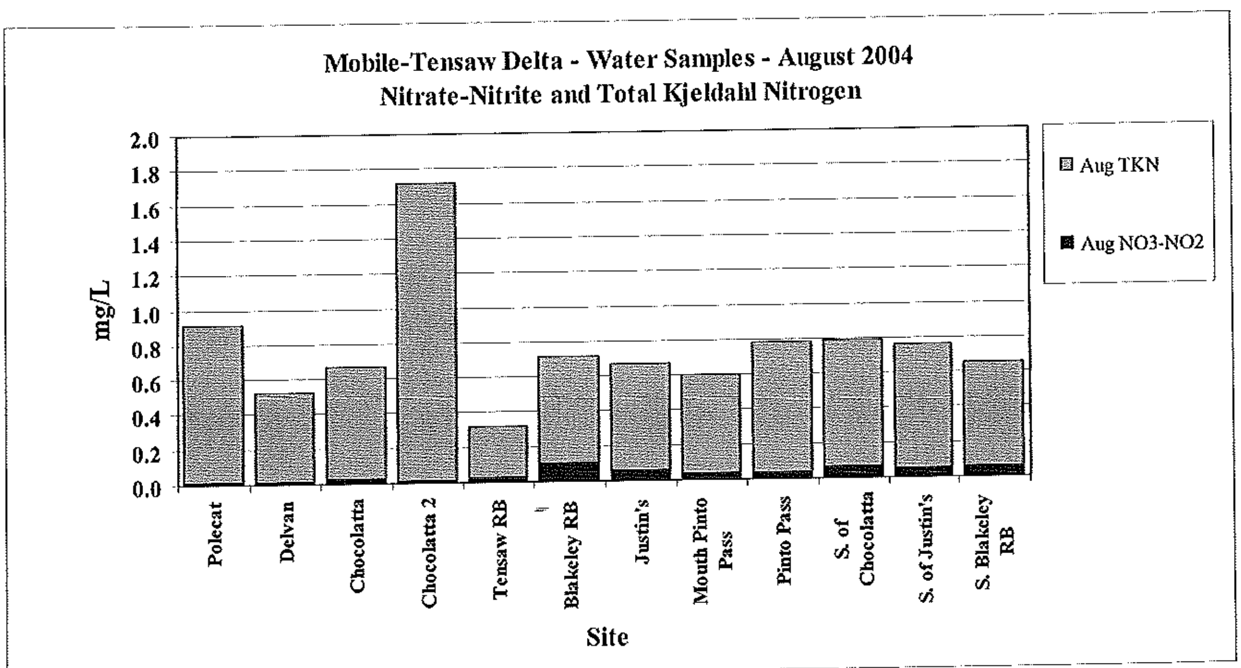

Figure 6-6. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from August 2004. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

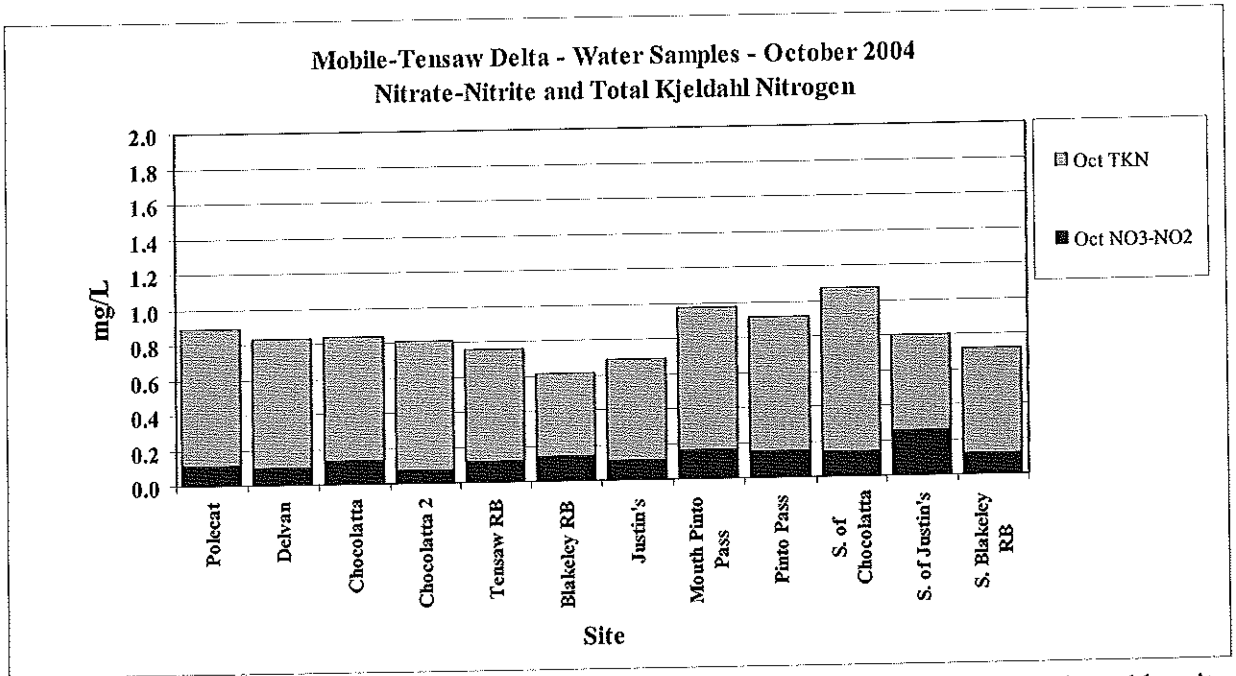

Figure 6-7. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from October 2004. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

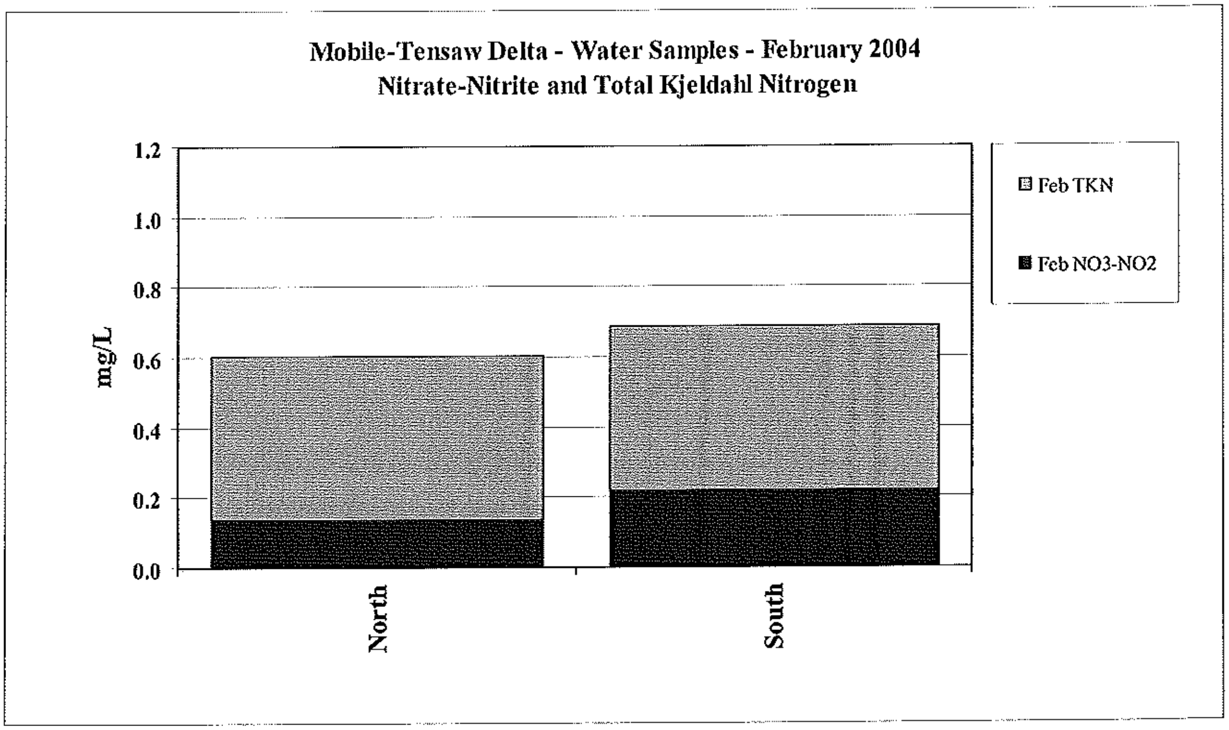

Figure 6-8. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from February 2004.

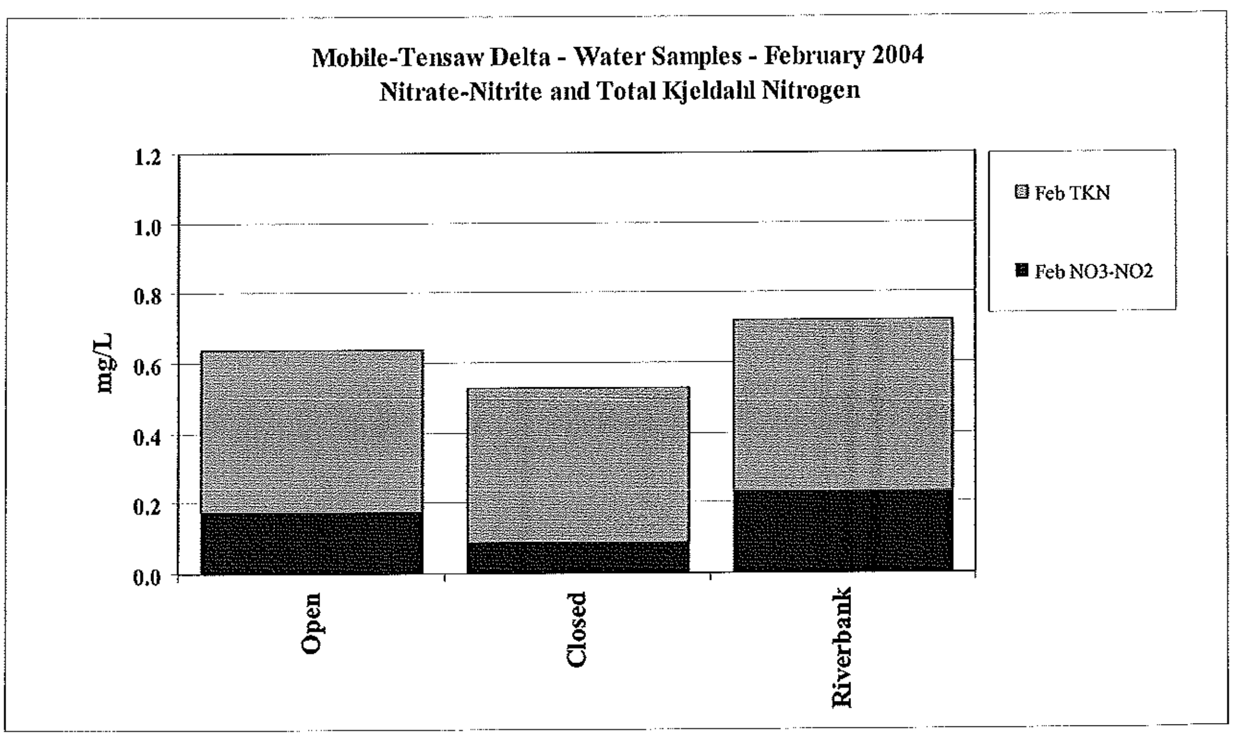

Figure 6-9. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by open, closed and riverbank categories from February 2004.

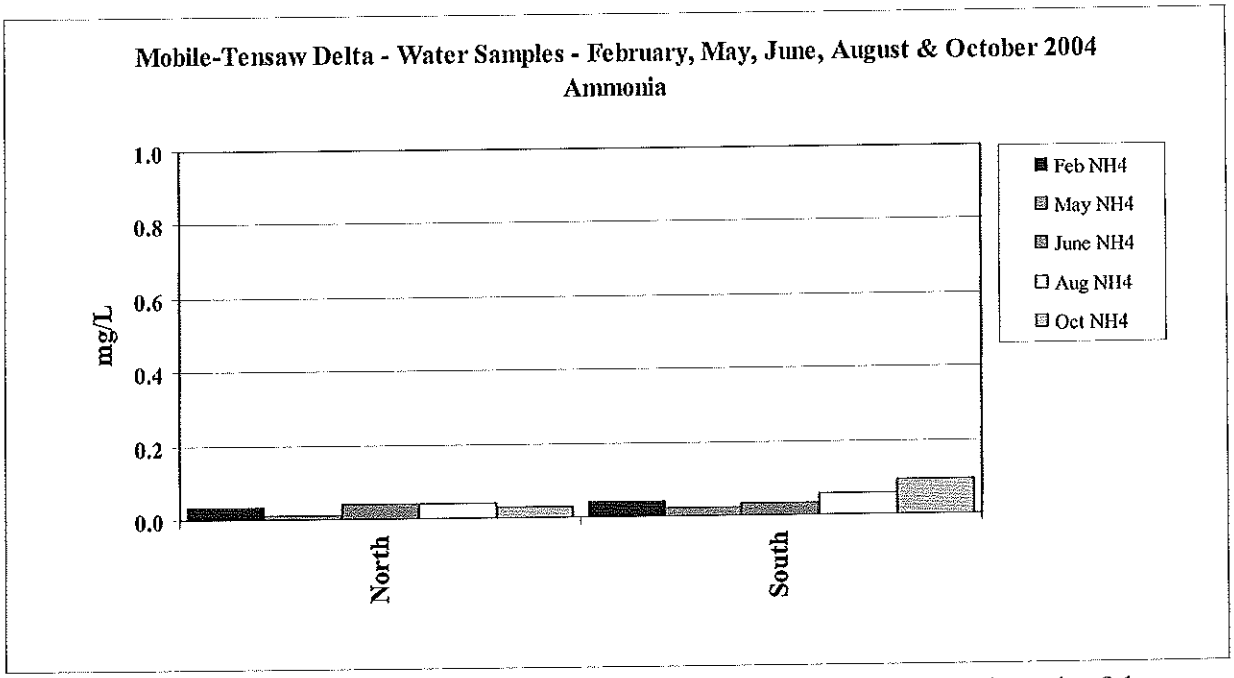

Figure 6-10. Water column ammonia (mg/l) and plotted by location north and south of the causeway from February, May, June, July, August and October 2004.

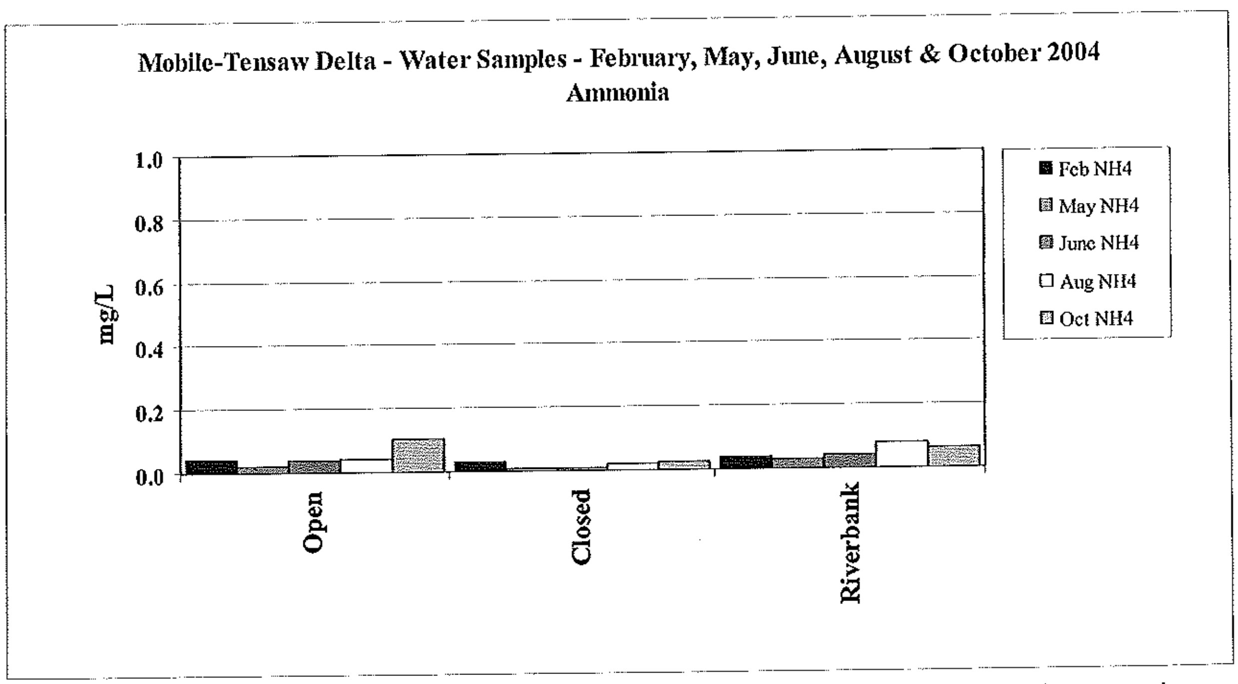

Figure 6-11. Water column ammonia (mg/l) plotted by open, closed and riverbank categories from February, May, June, July, August and October 2004.

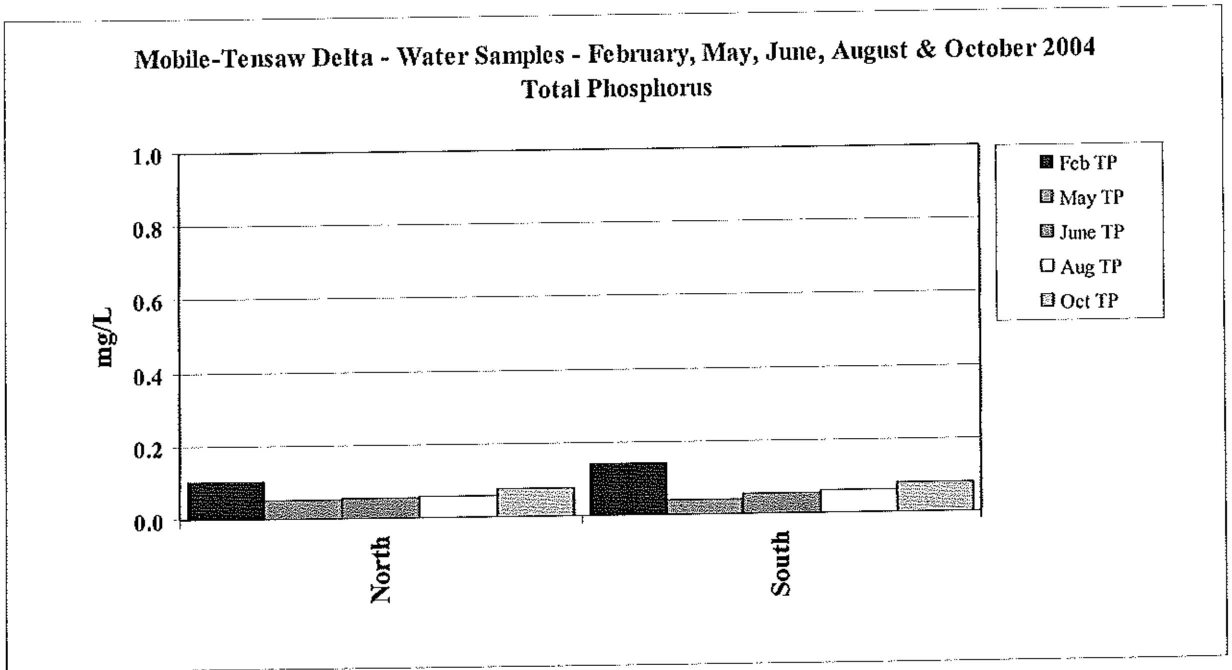

Figure 6-12. . Water column total phosphorus (mg/l) plotted by location north and south of the causeway from February, May, June, July, August and October 2004.

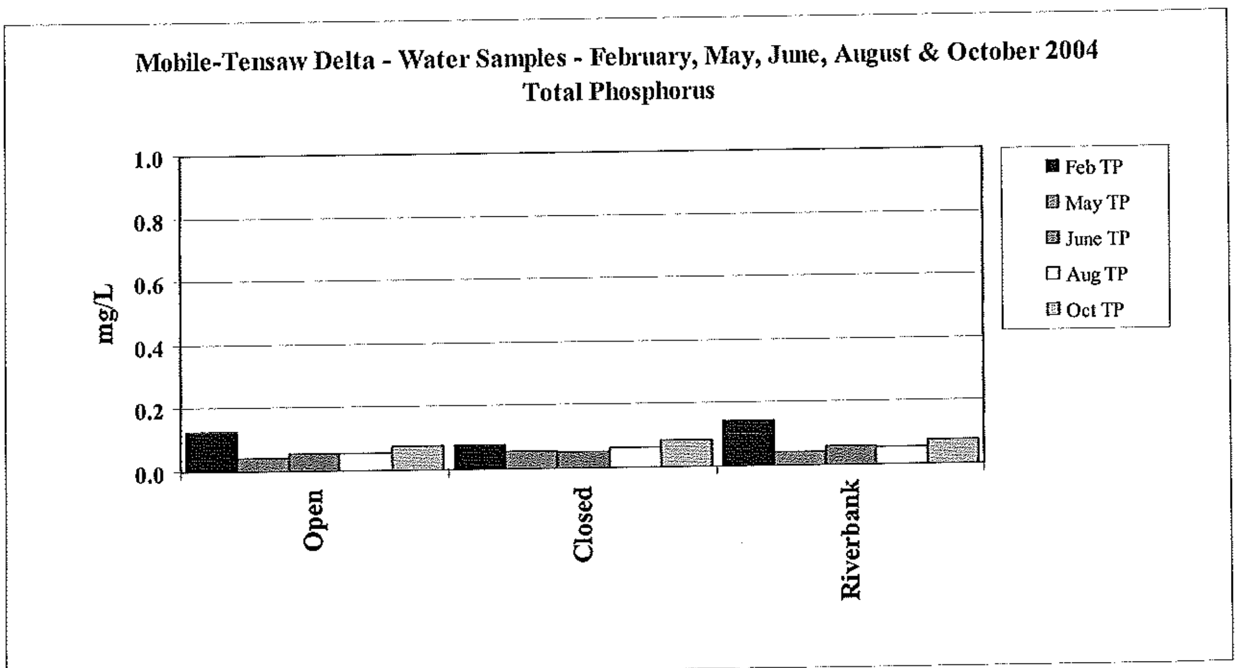

Figure 6-13. Water column total phosphorus (mg/l) plotted by open, closed and riverbank categories from February, May, June, July, August and October 2004.

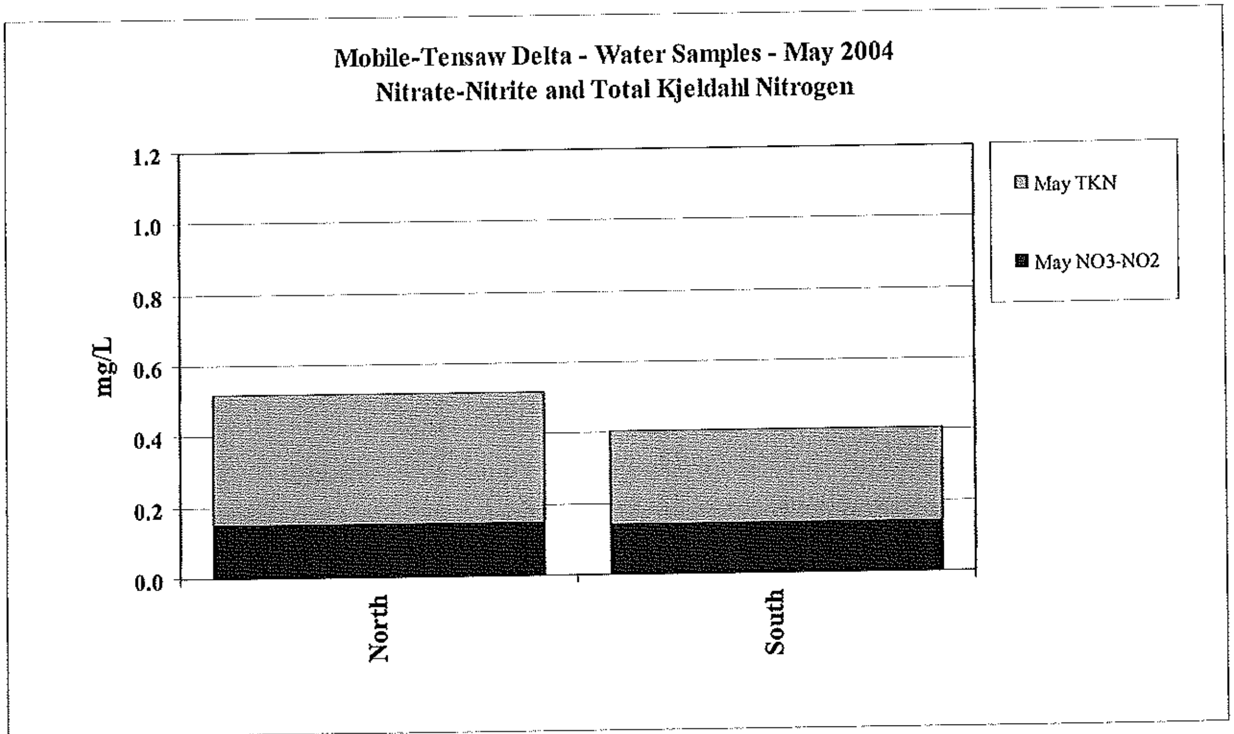

Figure 6-14. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from May 2004.

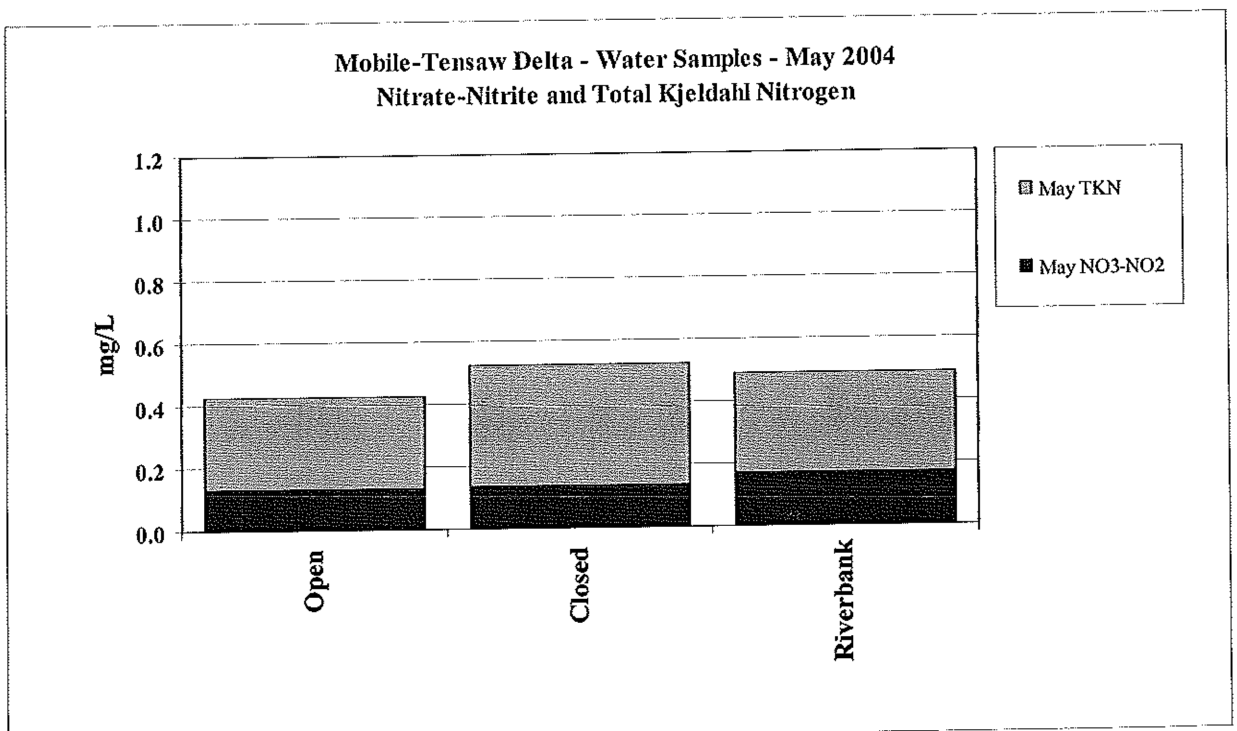

Figure 6-15. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by open, closed and riverbank categories from May 2004.

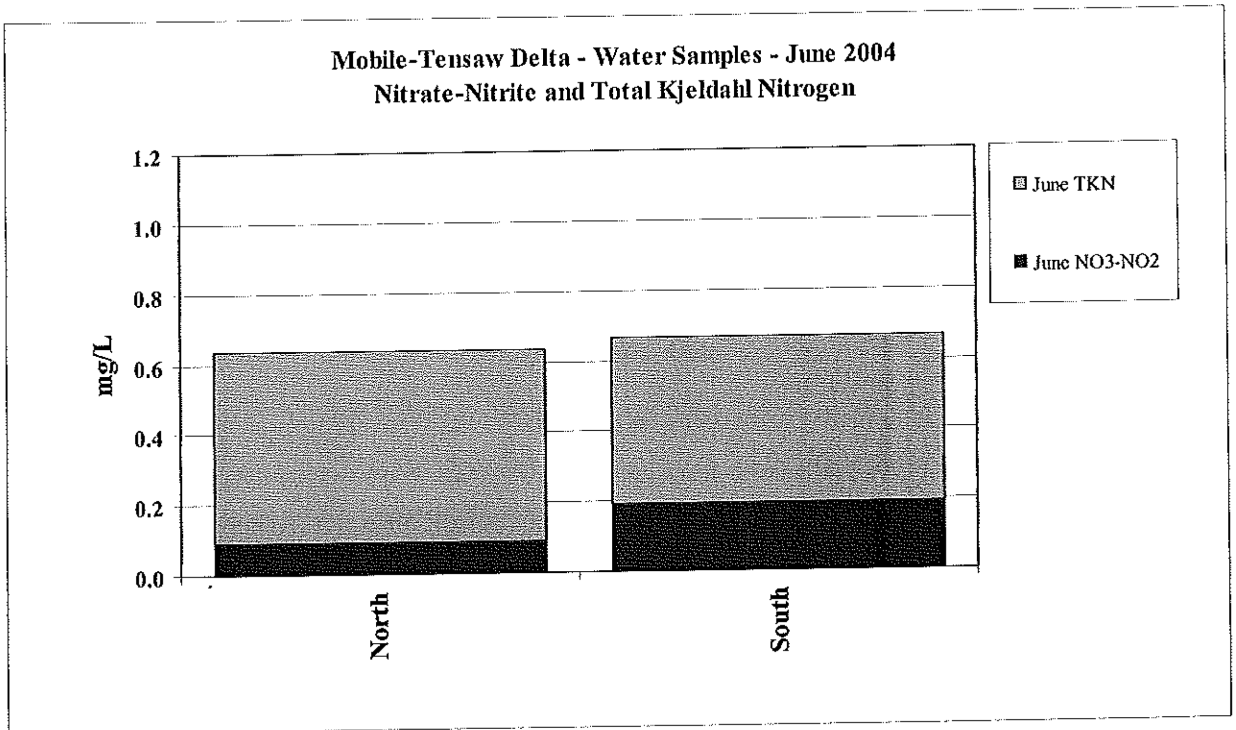

Figure 6-16. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from June 2004.

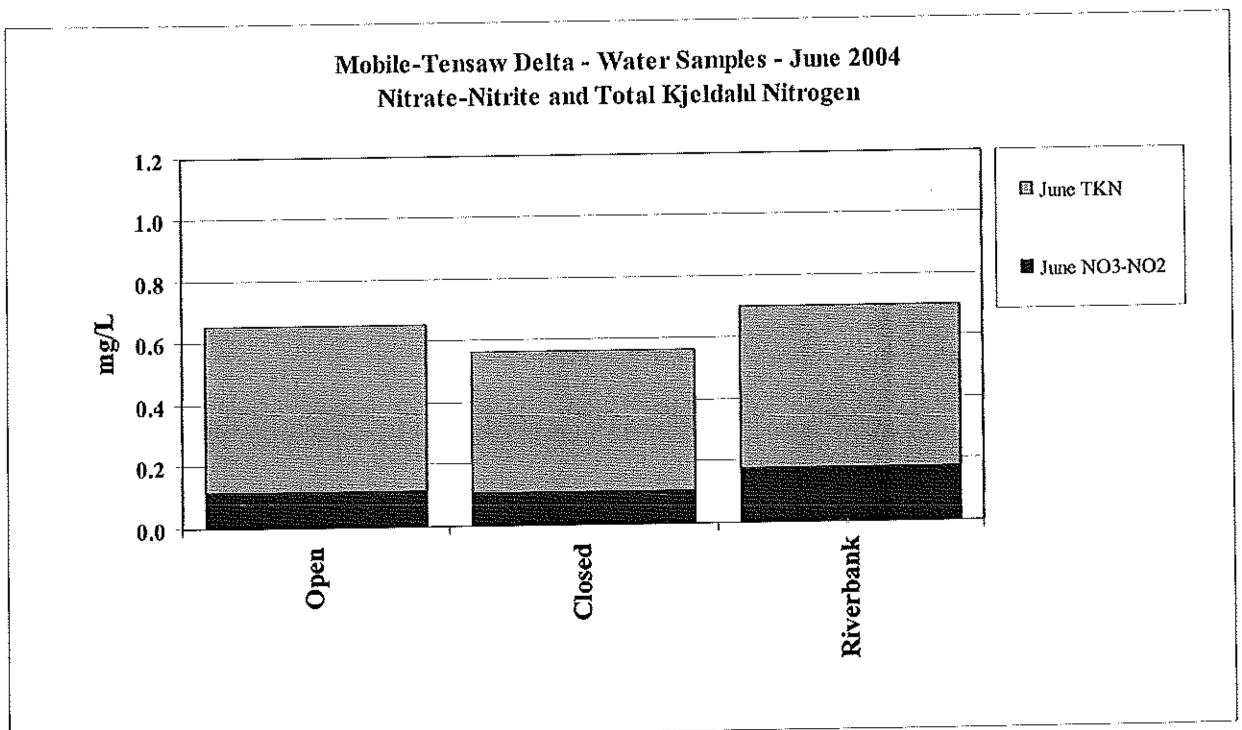

Figure 6-17. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by open, closed and riverbank categories from June 2004.

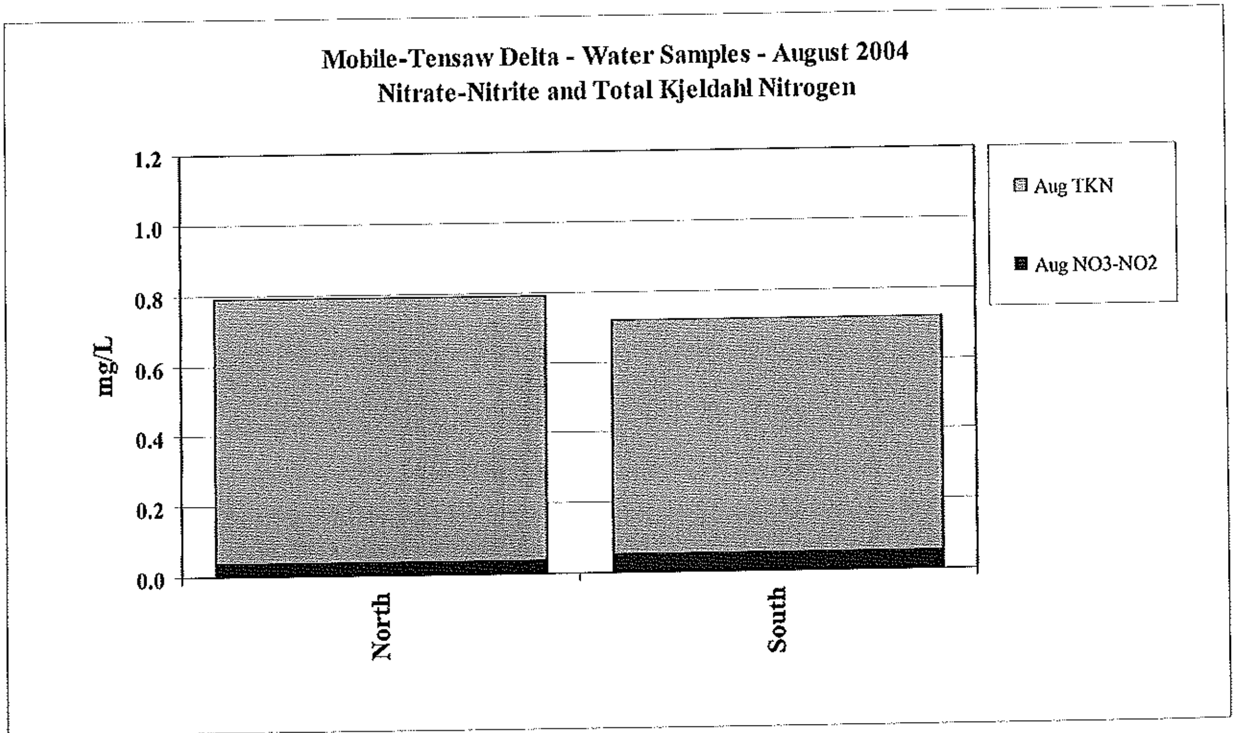

Figure 6-18. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from August 2004.

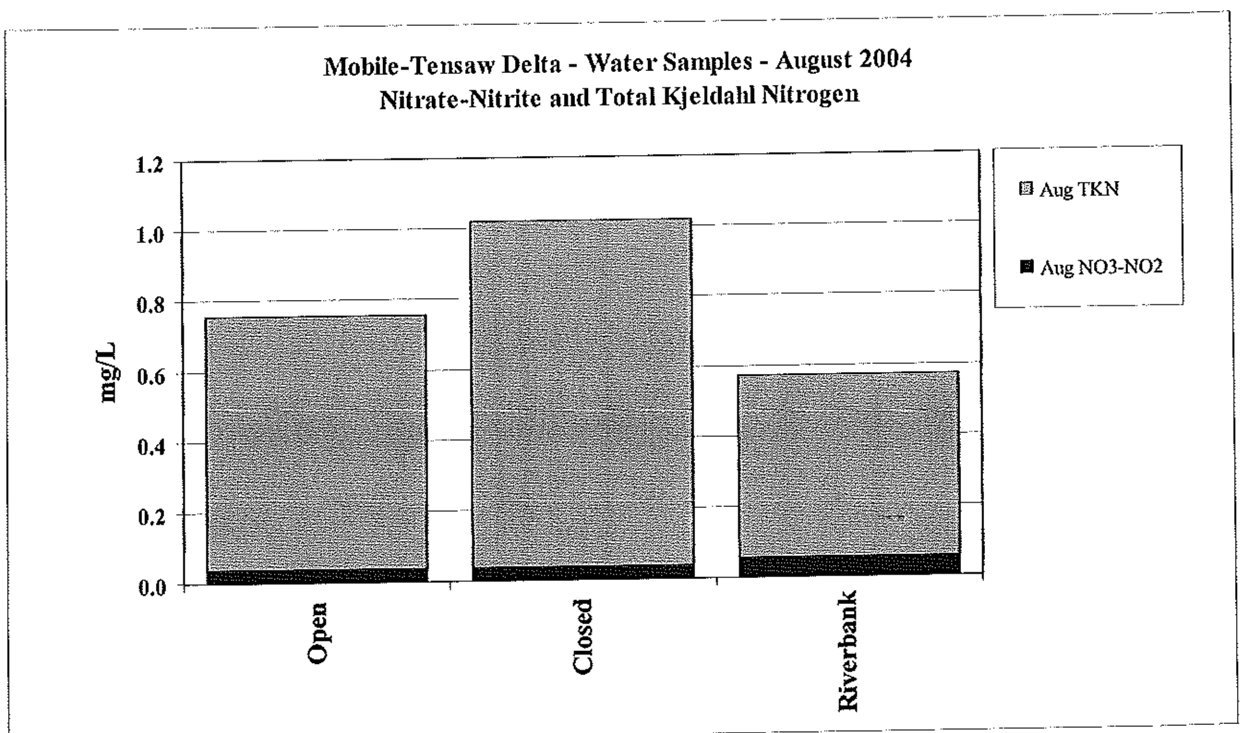

Figure 6-19. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by open, closed and riverbank categories from August 2004.

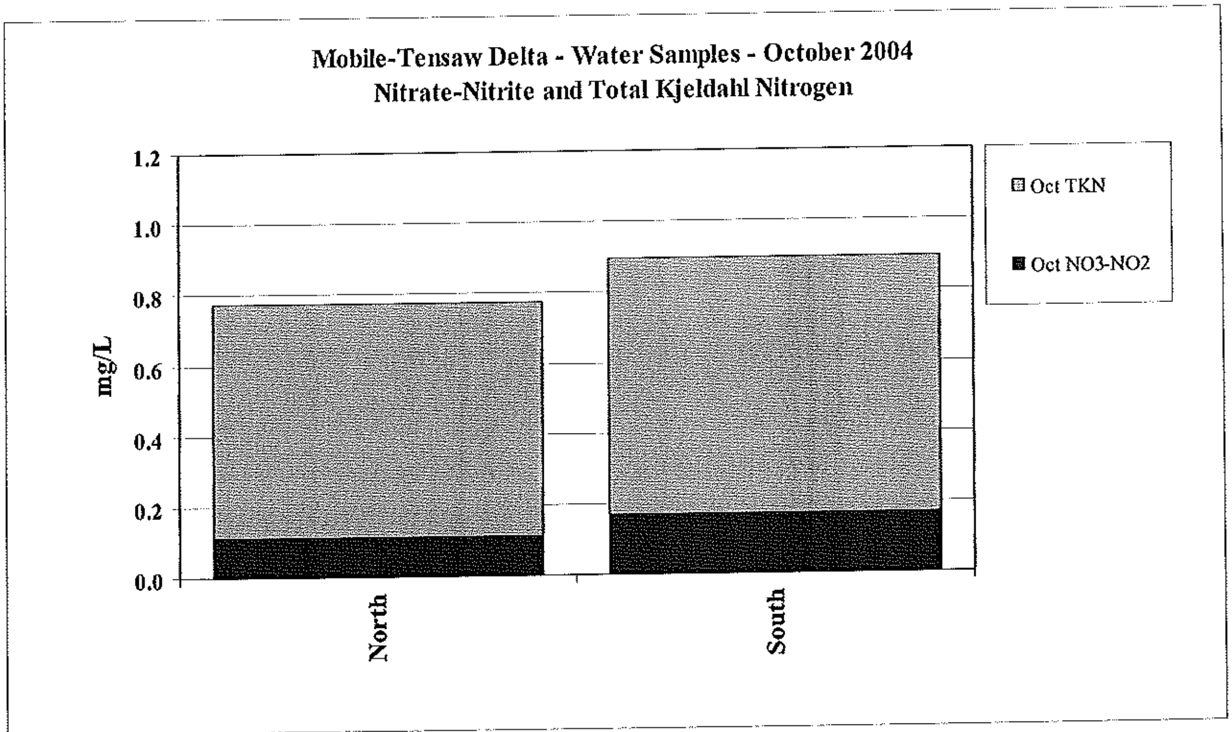

Figure 6-20. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from October 2004.

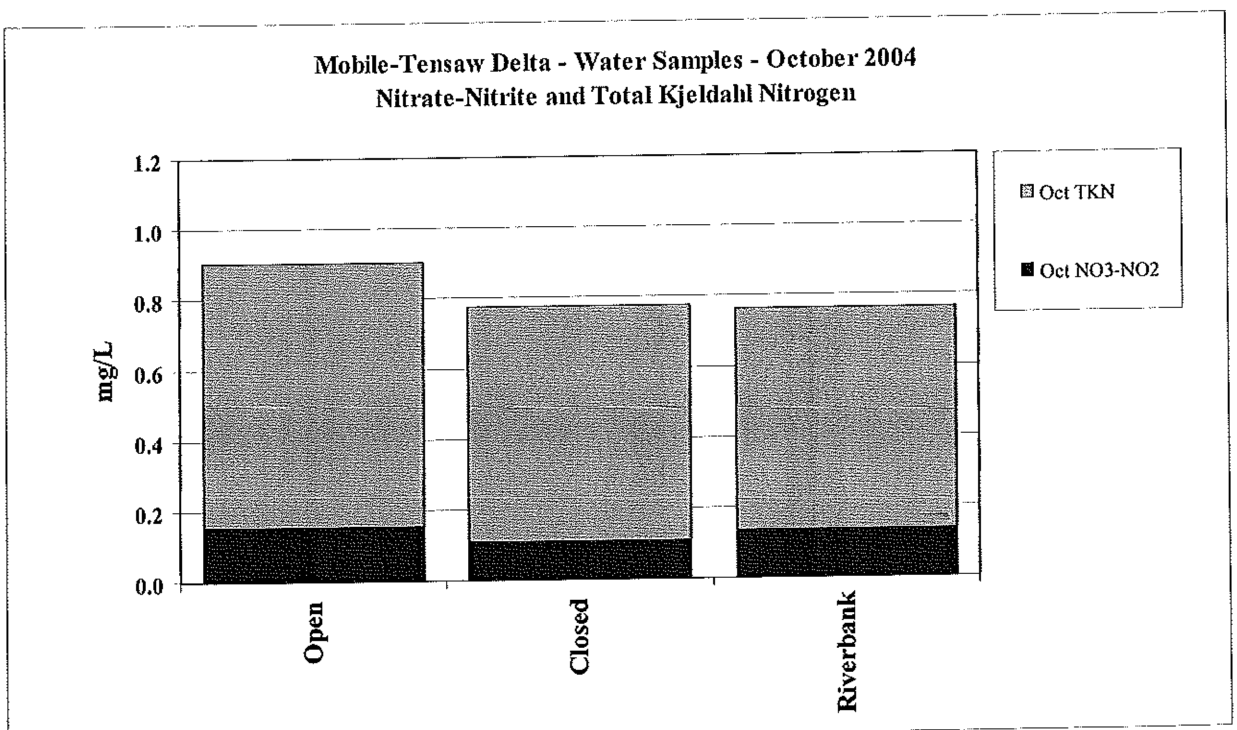

Figure 6-21. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by open, closed and riverbank categories from October 2004.

Appendix 7

Primer: YSI / Nutrients and Sediment

February, June and October 2004

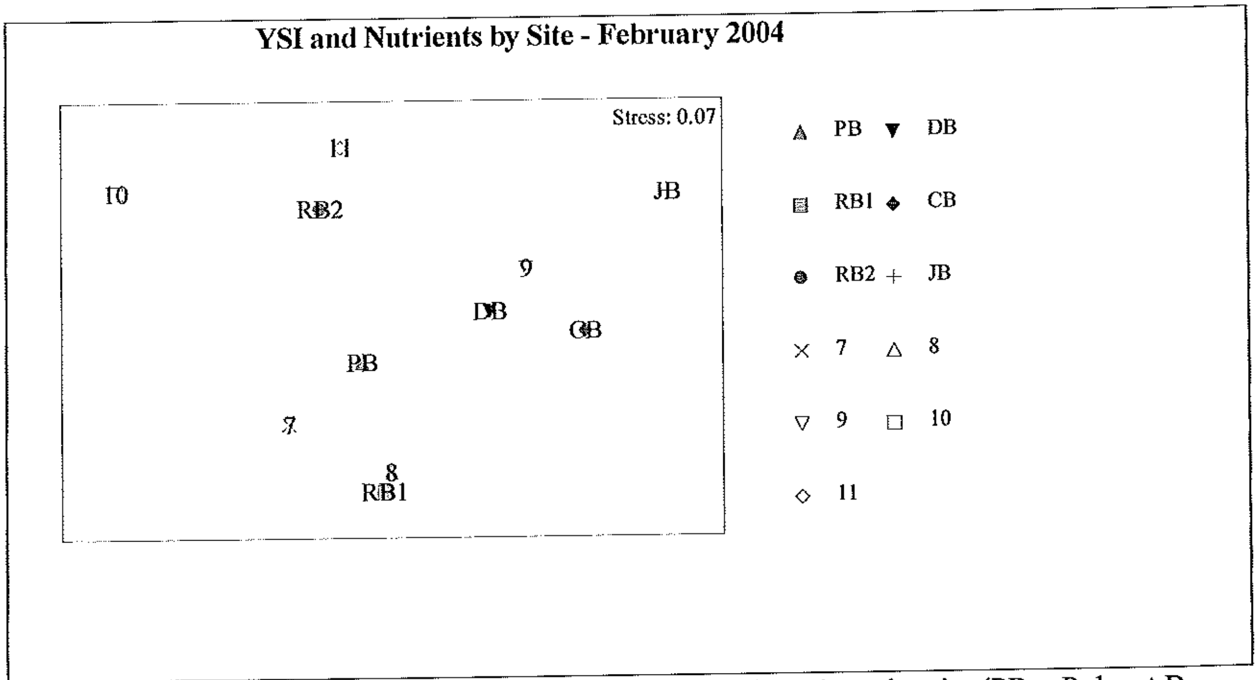

Figure 7-1. MDS plot for February 2004 YSI readings and nutrients by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

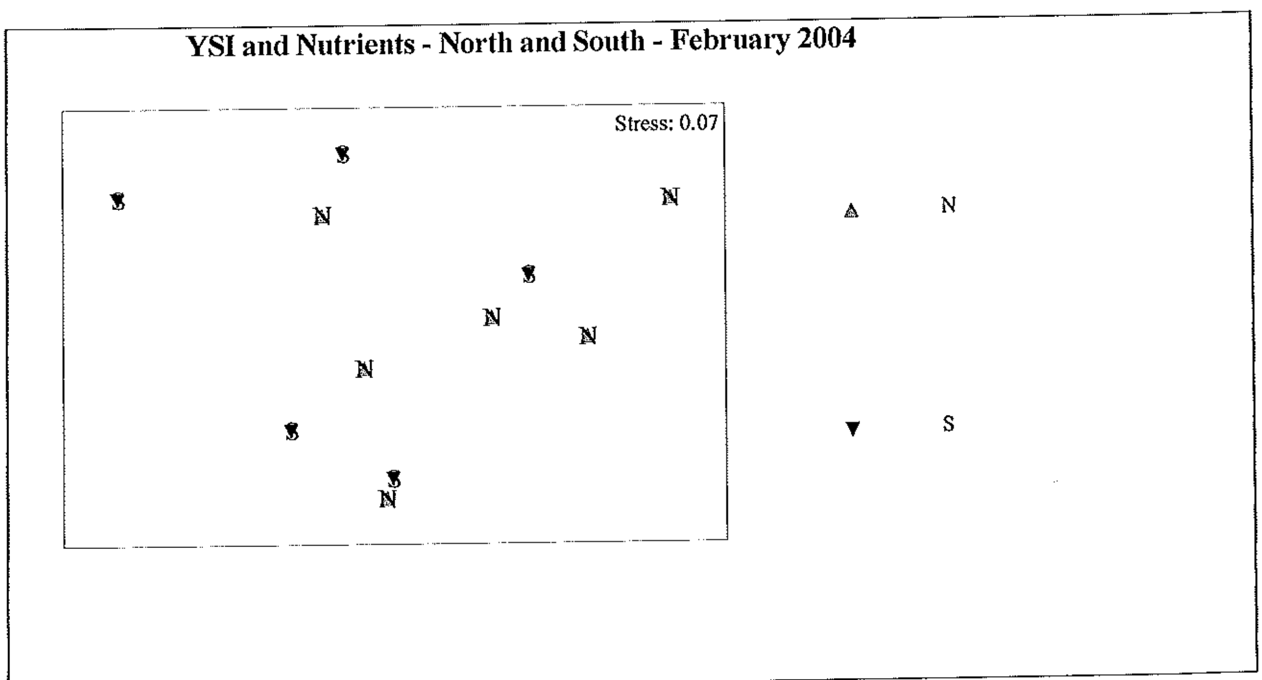

Figure 7-2. MDS plot for February 2004 YSI readings and nutrients by location north (N) and south (S) of the causeway.

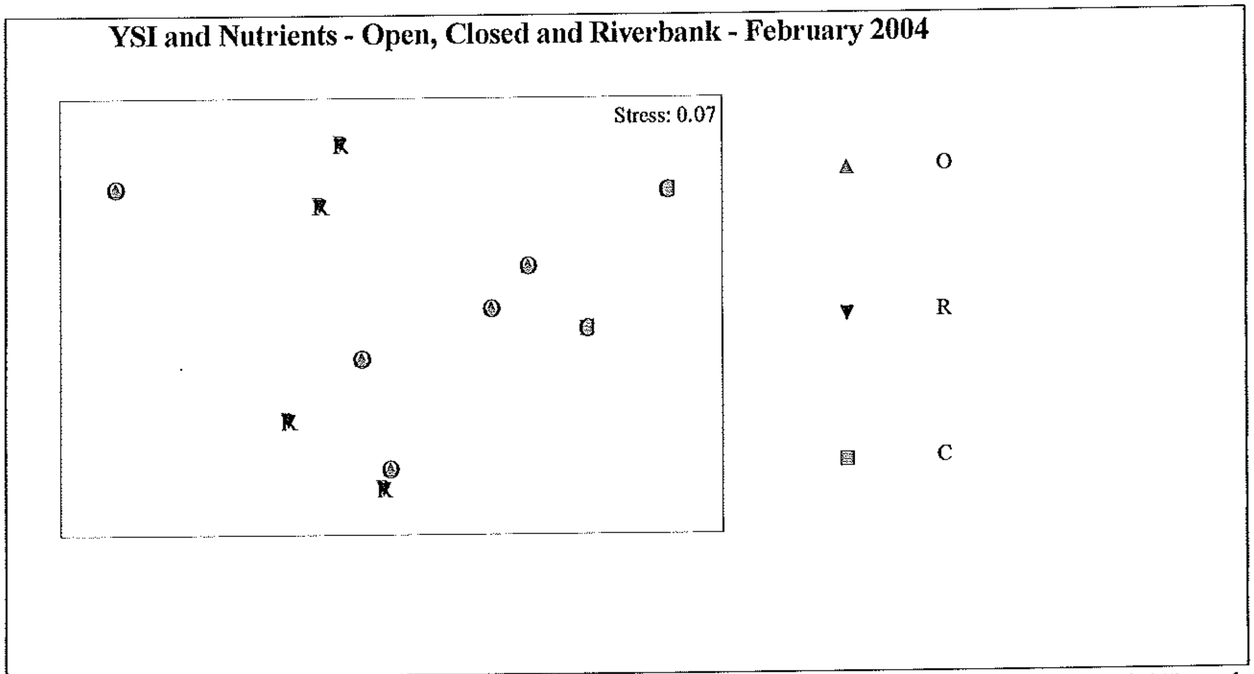

Figure 7-3. MDS plot for February 2004 YSI readings and nutrients by open (O), closed (C) and riverbank (R) treatments.

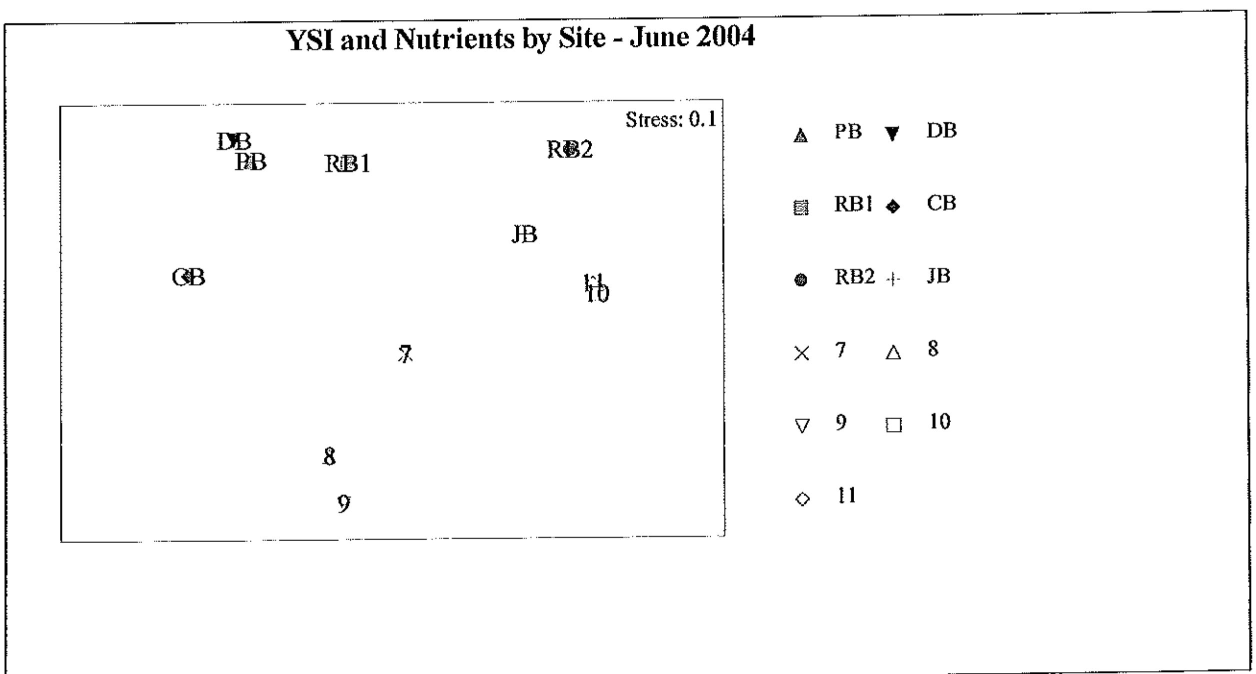

Figure 7-4. MDS plot for June 2004 YSI readings and nutrients by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

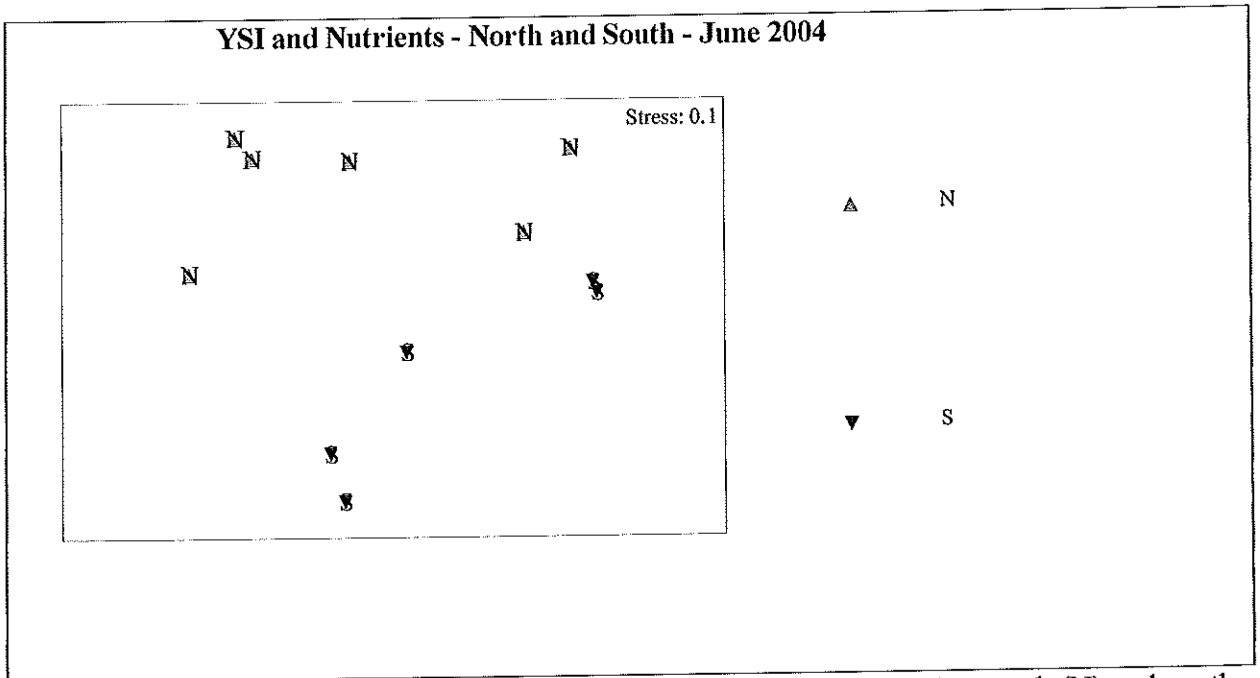

Figure 7-5. MDS plot for June 2004 YSI readings and nutrients by location north (N) and south (S) of the causeway.

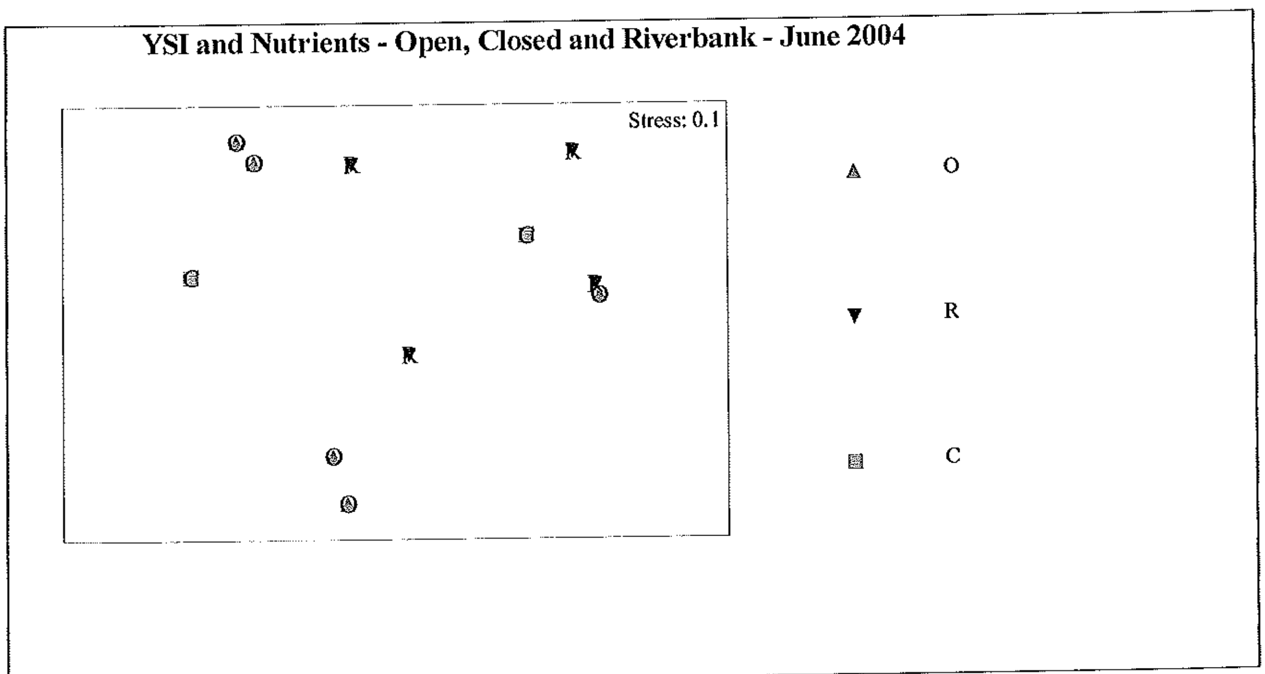

Figure 7-6. MDS plot for June 2004 YSI readings and nutrients by open (O), closed (C) and riverbank (R) treatments.

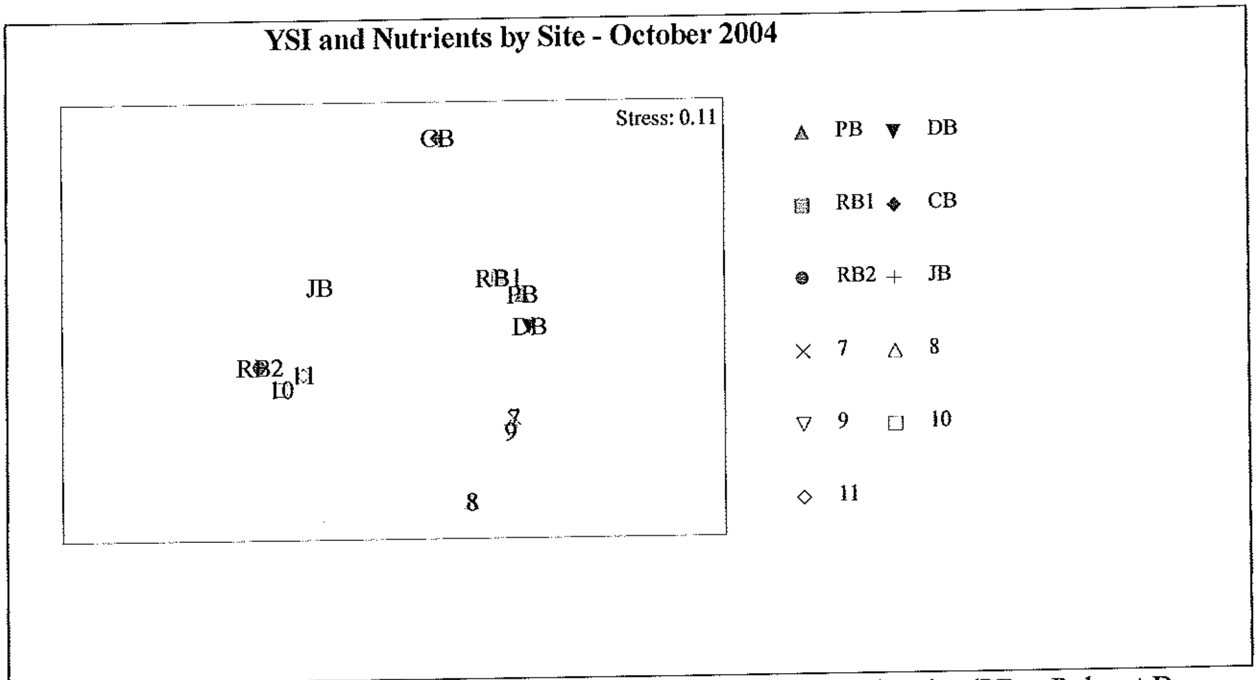

Figure 7-7. MDS plot for October 2004 YSI readings and nutrients by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

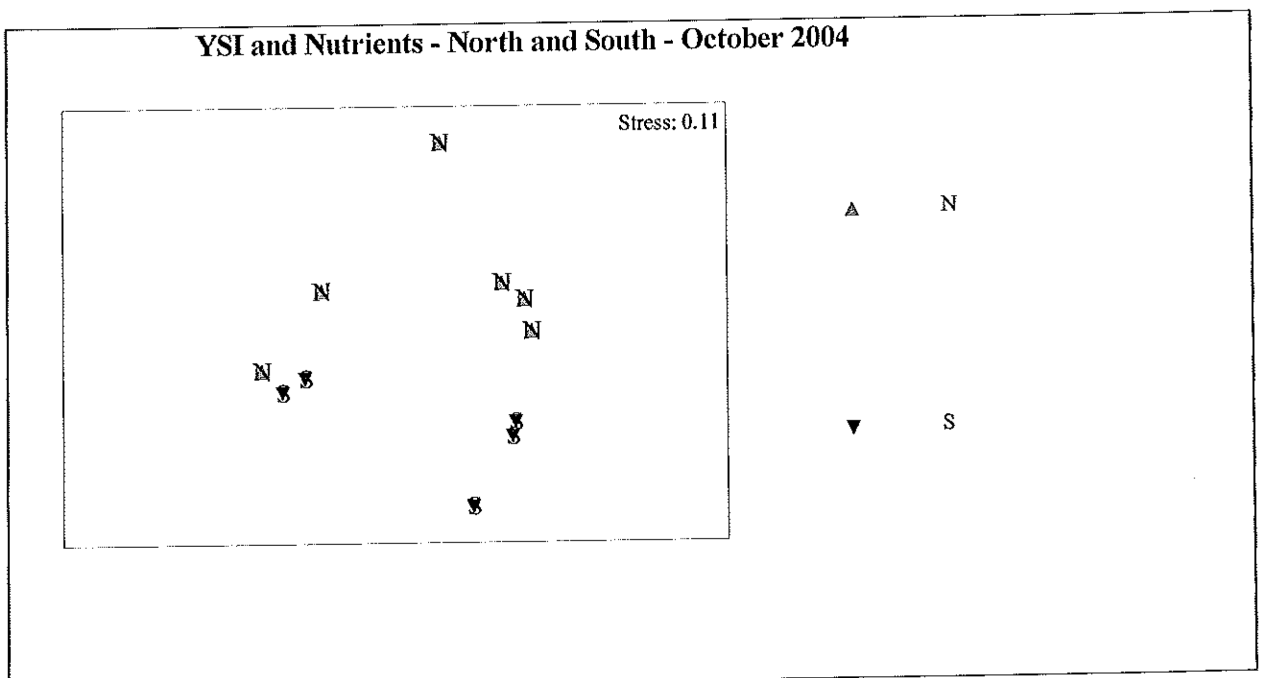

Figure 7-8. MDS plot for October 2004 YSI readings and nutrients by location north (N) and south (S) of the causeway.

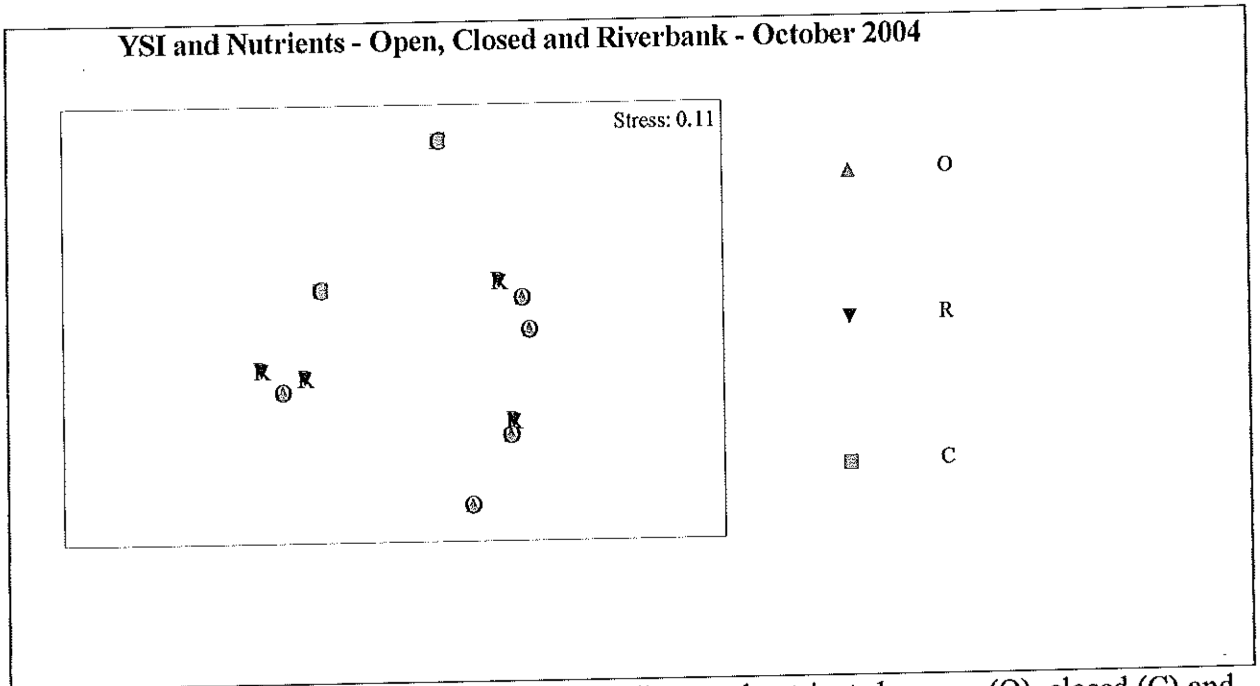

Figure 7-9. MDS plot for October 2004 YSI readings and nutrients by open (O), closed (C) and riverbank (R) treatments.

Appendix 8

Fish Collections- 2004

Table 8-1. Summary table for fish collected on March 4, 2004 and July 2, 2004 from Chocolatta Bay (CB) and south of the causeway (south). Numbers of species are listed by date and location for trawl (T) or gill net (GN) collections.

		CB T1 030404	CB T2 030404	CB GN 030404	South T1 030404	South T2 030404	South GN 030404	CB T1 070204	CB T2 070204	South T1 070204	South T2 070204
Common Name	Species	Num	Num	Num	Num	Num	Num	Num	Num	Num	Num
Anchovy	Anchoa sp.	643	76		3			96	16		1
Atlantic Croaker	Micropogonias undulates							38			
Blue Crab	Callinectes sapidus			2		5			15		
Blue Crab (female)	Callinectes sapidus	1									
Blue Crab (male)	Callinectes sapidus	13	16		8	12		4			3
Bluegill Sunfish	Lepomis macrochirus	1	1			3			1		
Catfish							1				
Catfish (Channel?)	Ictalurus sp.								4		
Channel Catfish	Ictalurus punctatus							7			
Croaker (Atlantic?)	Micropogonias undulatus				2					1	
Flounder						1					
Freshwater Catfish	Ictalurus sp.							5			
Freshwater Drum	Aplodinotus grunniens						1				
Freshwater Gobie	Gobionellus sp.							1		1	
Goby		2	1								
Goby	Gobionellus sp.					7					
Green Sunfish	Lepomis cyanellus					2					
Gulf Menhaden	Brevoortia patronus										1
Hogchoker	Trinectes maculatus				2	1		3			
Largemouth Bass	Micropterus salmoides	5	1								
Minnow?	Notropis sp.				61						
Mud Crab		1								1	
Mullet				1							
Pinfish	Lagodon rhomboides									5	3
Pipefish	Syngnathus sp.	4	3		1	11			39	13	6
Rainwater Killifish	Lucania parva								67		19
Redear Sunfish	Lepomis microlophus	4	8			2			3		1
Sand Seatrout	Cynoscion arenarius							25			
Sheepshead	Archosargus probatocephalus							1			
Shiner	Notropis sp.							1	2		
Shrimp Eel									1		
Silver Perch	Bairdiella chrysoura							4			
Silver Seatrout	Cynoscion Nothus									13	3
Silverside	Atherinidae	2							1	1	
Southern Flounder	Paralichthys lethostigma										1
Spot	Leiostomus xanthurus							236		81	3
Spotted Bass	Micropterus punctulatus								12		
Spotted Sunfish	Lepomis punctatus								9		
Sunfish immature	Lepomis sp.								32		
Threadfin Shad	Dorosoma petenense							2			
Topminnow	Fundulus								2		
	TOTAL	**676**	**106**	**3**	**77**	**44**	**2**	**423**	**204**	**116**	**41**

Table 8-2. Fish collections from Chocolatta Bay collected with a trawl on March 4, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay	Collection Device: Trawl	TL = Total Length (inches)
DATE:	March 4, 2004	Start Time: 9:57	GN = Gill Net
COORDINATES:	N 30' 41.421'	End Time: 10:02	T = Trawl
	W 087' 58.202'	Total Time (hrs): 0.08	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Anchovy	Anchoa sp.	643	T	2.0	2.0	1.5	2.0	1.5	2.0	1.5	1.5	1.5	1.5
Blue Crab (male)	Callinectes sapidus	13	T	4.0	4.0	4.5	5.0	4.0	4.0	4.0	4.5	3.5	3.5
Largemouth Bass	Micropterus salmoides	5	T	11.0	12.0	8.0	7.5	6.5					
Pipefish	Syngnathus sp.	4	T	6.0	3.5	4.0	2.0						
Redear Sunfish	Lepomis microlophus	4	T	3.5	4.0	3.5	3.5						
Silverside	Atherinidae	2	T	3.5	2.5								
Goby		2	T	2.3	2.0								
Blue Crab (female)	Callinectes sapidus	1	T	3.5									
Bluegill Sunfish	Lepomis macrochirus	1	T	1.0									
Mud Crab		1	T										
TOTAL		676											

Table 8-3. Fish collections from Chocolatta Bay collected with a trawl on March 4, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay	Collection Device: Trawl	TL = Total Length (inches)
DATE:	March 4, 2004	Start Time: 10:32	GN = Gill Net
COORDINATES:	Just NE of Trawl 1	End Time: 10:37	T = Trawl
		Total Time (hrs): 0.08	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Anchovy	Anchoa sp.	76	T	1.5	1.5	1.0	1.5	1.5	1.5	1.5	1.0	1.5	1.5
Blue Crab (male)	Callinectes sapidus	16	T	4.5	6.0	4.0	2.0	2.5	2.0	2.5	1.5	3.5	2.5
Redear Sunfish	Lepomis microlophus	8	T	6.5	6.5	3.5	3.5	5.0	5.5	4.5	2.5		
Pipefish	Syngnathus sp.	3	T	3.0	4.0	3.5							
Largemouth Bass	Micropterus salmoides	1	T	8.5									
Bluegill Sunfish	Lepomis macrochirus	1	T	6.0									
Goby		1	T	2.0									
TOTAL		106											

Table 8-4. Fish collections from Chocolatta Bay collected with a gill net on March 4, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay	Collection Device: Gill Net	TL = Total Length (inches)
DATE:	March 4, 2004	Start Time: 9:28	GN = Gill Net
COORDINATES:	N 30' 41.362'	End Time: 10:59	T = Trawl
	W 087' 58.196'	Total Time (hrs): 1.52	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Blue Crab	Callinectes sapidus	2	G	4.0	3.0								
Mullet		1	G	14.5									
TOTAL		3											

Table 8-5. Fish collections from south of the causeway collected with a trawl on March 4, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	South of Causeway	**Collection Device:** Trawl	**TL = Total Length (inches)**
DATE:	March 4, 2004	**Start Time:** 11:37	**GN = Gill Net**
COORDINATES:	N 30' 40.510'	**End Time:** 11:42	**T = Trawl**
	W 087' 59.410'	**Total Time (hrs):** 0.08	
NOTES:	Lots of leaves; east side of gill net		

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Minnow?	Notropis sp.	61	T	1.5	1.8	1.8	1.8	2.0	0.8	1.5	1.5	0.8	0.8
Blue Crab (male)	Callinectes sapidus	8	T	0.8	3.0	3.0	2.0	1.0	1.5	1.8	1.0		
Anchovy	Anchoa sp.	3	T	1.5	1.3	1.8							
Hogchoker	Trinectes maculatus	2	T	1.5	2.0								
Croaker (Atlantic?)	Micropogonias undulatus	2	T	1.5	1.5								
Pipefish	Syngnathus sp.	1	T	4.0									
TOTAL		77											

Table 8-6. Fish collections from south of the causeway collected with a trawl on March 4, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	South of Causeway	**Collection Device:** Trawl	**TL = Total Length (inches)**
DATE:	March 4, 2004	**Start Time:** 11:37	**GN = Gill Net**
COORDINATES:	West side of gill net	**End Time:** 11:42	**T = Trawl**
		Total Time (hrs): 0.08	
NOTES:	Lots of leaves		

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Blue Crab (male)	Callinectes sapidus	12	T	1.5	3.5	2.0	2.0	2.0	2.0	3.0	2.5	2.0	2.0
Pipefish	Syngnathus sp.	11	T	3.5	2.5	3.5	2.0	2.5	2.5	2.5	3.5	4.5	3.5
Goby	Gobionellus sp.	7	T	3.0	2.5	3.0	2.5	1.3	1.0	3.0			
Blue Crab	Callinectes sapidus	5	T	0.8	0.5	0.5	0.3	0.3					
Bluegill Sunfish	Lepomis macrochirus	3	T	2.5	2.5	3.0							
Redear Sunfish	Lepomis microlophus	2	T	5.0	3.5								
Green Sunfish	Lepomis cyanellus	2	T	4.0	3.5								
Hogchoker	Trinectes maculatus	1	T	0.8									
Flounder		1	T	6.5									
TOTAL		44											

Table 8-7. Fish collections from south of the causeway collected with a gill net on March 4, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	South of Causeway	**Collection Device:** Gill Net	**TL = Total Length (inches)**
DATE:	March 4, 2004	**Start Time:** 11:35	**GN = Gill Net**
COORDINATES:	N 30' 40.470'	**End Time:** 13:05	**T = Trawl**
	W 087' 59.431'	**Total Time (hrs):** 1.50	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Catfish		1	G	22.0									
Freshwater Drum	Aplodinotus grunniens	1	G	16.0									
TOTAL		2											

Table 8-8. Fish collections from Chocolatta Bay collected with a trawl on July 2, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay	**Collection Device:** Trawl	**TL = Total Length (cm)**
DATE:	July 2, 2004	**Start Time:** 9:20	**GN = Gill Net**
COORDINATES:	N 30' 40.867'	**End Time:** 9:30	**T = Trawl**
	W 087' 59.302'	**Total Time (hrs):** 0.17	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Spot	Leiostomus xanthurus	236	T	9.5	10.0	10.5	7.5	8.5	9.0	10.0	8.0	12.5	8.0
Anchovy	Anchoa sp.	96	T	9.1	8.2	7.2	6.1	4.3	4.0	4.5	4.2	5.2	6.2
Atlantic Croaker	Micropogonias undulates	38	T	8.0	9.0	9.0	10.2	9.0	10.2	9.5	10.0	8.2	9.2
Sand Seatrout	Cynoscion arenarius	25	T	7.2	9.0	9.2	8.0	9.2	6.0	4.0	4.5	6.0	3.5
Channel Catfish	Ictalurus punctatus	7	T	20.0	10.0	10.0	4.0	10.0	14.0	14.0			
Freshwater Catfish	Ictalurus sp.	5	T	4.5	6.0								
Blue Crab (male)	Callinectes sapidus	4	T	10.0	5.2	5.5	3.0						
Silver Perch	Bairdiella chrysoura	4	T	6.0	6.5	6.0	5.0						
Hogchoaker	Trinectes maculatus	3	T	5.0	4.5	4.7							
Threadfin Shad	Dorosoma petenense	2	T	6.5	6.0								
Sheepshead	Archosargus probatocephalus	1	T	30.0									
Shiner	Notropis sp.	1	T	8.0									
Freshwater Gobie	Gobionellus	1	T	4.0									
TOTAL		423											

Table 8-9. Fish collections from Chocolatta Bay collected with a trawl on July 2, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay	**Collection Device:** Trawl	**TL = Total Length (cm)**
DATE:	July 2, 2004	**Start Time:** 10:10	**GN = Gill Net**
COORDINATES:	N 30' 41.270'	**End Time:** 10:15	**T = Trawl**
	W 087' 58.408'	**Total Time (hrs):** 0.08	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Rainwater Killifish	Lucania parva	67	T	4.0	3.0	2.5	4.0	4.0	4.0	3.0	3.0	4.0	4.0
Pipefish	Syngnathus sp.	39	T	10.0	10.0	8.0	9.0	9.0	9.0	9.0	8.0	9.0	10.0
Sunfish immature	Lepomis sp.	32	T	4.0	4.0	4.0	4.0	4.0	4.0	2.0	3.0	3.0	4.0
Anchovy	Anchoa sp.	16	T	2.0	4.0	4.0	4.5	2.5	2.5	3.5	3.0	3.0	3.0
Blue Crab	Callinectes sapidus	15	T	6.5	5.0	6.0	6.0	5.0	6.0	6.0	6.0	8.0	9.0
Spotted Bass	Micropterus punctulatus	12	T	6.5	7.0	6.0	6.0	8.0	6.5	6.0	6.0	7.0	6.0
Spotted Sunfish	Lepomis punctatus	9	T	10.0	12.0	8.0	9.0	9.0	10.0	11.0	8.0	11.0	
Catfish (Channel?)	Ictalurus sp.	4	T	15.0	9.0	6.0	6.0						
Redear Sunfish	Lepomis microlophus	3	T	16.0	14.0	15.0							
Topminnow	Fundulus	2	T	1.0	1.5								
Shiner	Notropis sp.	2	T	2.5	2.5								
Bluegill Sunfish	Lepomis macrochirus	1	T	9.0									
Shrimp Eel		1	T	8.0									
Silverside		1	T	3.0									
TOTAL		204											

Table 8-10. Fish collections from south of the causeway collected with a trawl on July 2, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	South of Causeway	**Collection Device:** Trawl	**TL = Total Length (cm)**
DATE:	July 2, 2004	**Start Time:** 11:44	**GN = Gill Net**
COORDINATES:	N 30' 40.273'	**End Time:** 11:49	**T = Trawl**
	W 087' 59.461'	**Total Time (hrs):** 0.08	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Spot	Leiostomus xanthurus	81	T	8.0	5.0	6.0	5.5	5.5	5.0	6.5	6.0	5.0	5.5
Pipefish	Syngnathus sp.	13	T	7.0	8.0	10.0	8.0	8.0	7.0	8.0	6.0	8.0	10.0
Silver Seatrout	Cynoscion Nothus	13	T	5.0	5.0	4.0	5.0	6.0	5.0	6.0	5.5	5.0	5.5
Pinfish	Lagodon rhomboides	5	T	10.0	9.0	10.0	9.0	10.0					
Freshwater Gobie	Gobionellus sp.	1	T	7.0									
Croaker (Atlantic?)	Micropogonias undulates	1	T	8.0									
Mud Crab		1	T	2.0									
Silverside	Atherinidae	1	T	6.5									
Anchovy	Anchoa sp.		T										
TOTAL		**116**											

Table 8-11. Fish collections from south of the causeway collected with a trawl on July 2, 2004. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	South of Causeway	**Collection Device:** Trawl	**TL = Total Length (cm)**
DATE:	July 2, 2004	**Start Time:** 12:19	**GN = Gill Net**
COORDINATES:	Duckblind area	**End Time:** 12:24	**T = Trawl**
		Total Time (hrs): 0.08	

Common Name	Species	Number	Method	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10
Rainwater Killifish	Lucania parva	19	T	3.5	2.0	3.5	3.5	2.5	4.5	2.5	1.5	4.5	4.5
Pipefish	Syngnathus sp.	6	T	10.0	8.0	9.0	7.0	8.0	10.0				
Spot	Leiostomus xanthurus	3	T	6.0	6.0	5.5							
Pinfish	Lagodon rhomboides	3	T	8.0	10.0	10.0							
Silver Seatrout	Cynoscion Nothus	3	T	6.0	5.0	5.0							
Blue Crab (male)	Callinectes sapidus	3	T	7.0	7.0	7.0							
Southern Flounder	Paralichthys lethostigma	1	T	10.0									
Redear Sunfish	Lepomis microlophus	1	T	15.0									
Anchovy	Anchoa sp.	1	T	3.0									
Gulf Menhaden	Brevoortia patronus	1	T	3.0									
TOTAL		**41**											