Mobile – Tensaw Delta Hydrological Modifications Impact Study

Final Report

Responsible Agencies:

Funding for this project provided by the Mobile Bay Watch, Inc./Mobile Baykeeper through a grant received by the Environmental Protection Agency's Gulf of Mexico Program. This is a joint project. Partners include Mobile Bay Watch, Inc./Mobile Baykeeper, Dauphin Island Sea Lab, The Nature Conservancy, Alabama Power, the Mobile Bay National Estuary Program, Coastal Conservation Association, and Alabama Wildlife Federation.

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EXECUTIVE SUMMARY

Based on the 2005-2006 monitoring and sampling events, short and long-term variations in the hydrography were evident on each side of the causeway. Continuous monitoring data showed that variability in water quality parameters can be great, changing on temporal scales ranging from days to months. Seasonal changes in temperature, salinity (and specific conductivity) and dissolved oxygen occurred at all sites although the magnitude of these changes varied among sites. Tensaw River North, the most northern site, had lower salinity than sites closer to the causeway. Continuous monitoring salinity data suggests that salt and fresh water exchange does occur in the lower Delta. During fall 2005, salinities were highest at USS Alabama and Chocolatta Bay and to a lesser extent Tensaw River South and Apalachee River South suggesting that gulf waters are primarily moving up the western side of the Delta.

Salinity was highest following the passages of hurricanes Katrina and Rita in August and September 2005, respectively. High salinities were detected at the most northern sites: Apalachee River North and Tensaw River North. Salinity exceeded 15 psu at all sites during Hurricane Katrina but persisted longer at the most southern stations (esp. USS Alabama and Chocolatta). During the passage of Hurricane Ivan in 2004, Chocolatta Bay salinity peaked at 14 psu. The occurrence of these extremely large intrusions of high salinity waters undoubtedly masked causeway impacts on the local fauna observed in the first year of study.

Periods of low dissolved oxygen were recorded in Chocolatta Bay and at stations at the USS Alabama and Apalachee River North following the passage of each hurricane and were probably the result of low DO water being pushed up into the Delta from Mobile Bay. In addition to the passages of Hurricanes Dennis, Katrina and Rita, outer bands from other hurricanes (Table 4) also affected the Mobile-Tensaw Delta DO. Between July and December 2005, four hypoxic events were recorded north of the causeway at Apalachee River North and nine hypoxic events were recorded in Chocolatta Bay. In contrast, only three hypoxic events at USS Alabama located south of the causeway. Hypoxic events ranged in duration from a few hours to eight days depending on the site. Intermittent hypoxic “spikes” were also observed at the Delta sites. As such, the Chocolatta Bay site appears to have low water column turnover and high retention time. Although Chocolatta water exchange is not clearly understood, it is apparent that the hurricane systems allowed water exchange to occur within Chocolatta Bay but did not necessarily decrease the resulting retention time of the “new water”. The numerous hypoxic events recorded in Chocolatta 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, Chocolatta Bay sediments contained high percentages of clay, silt, total carbon and water supporting this hypothesis.

Spatially heterogeneous patterns of hydrography were recorded during all major sampling events. Significant differences in temperature, salinity, dissolved oxygen (mg/l), chlorophyll *a* and turbidity occurred among sites during all major sampling events. Evidence of causeway impacts on local hydrography were also apparent for some water column parameters for sites located north and south of the causeway. Temperatures were greater at sites located north of the causeway during the April and August 2005 and March 2006 sampling events. Temperatures

had decreased at all sites by late October. Unlike the previous sampling efforts, temperatures north and south of the causeway were not statistically significantly different from one another.

During April and August 2005 and March 2006, salinity was generally low and not found to differ north and south of the causeway. Salinity was dramatically higher in October than in previous months. In general, salinity was greater, although not significantly so, at sites south of the causeway than at sites north of the causeway. Monthly salinity readings from the study sites were also greater on the western side of the Delta and to the south of the causeway than elsewhere, especially during August and October.

Dissolved oxygen readings were highest in March 2006 and variable by site and month during the April, August and October samplings. During April 2005, sites located north of the causeway had higher DO concentrations than did sites south of the causeway. These differences may have been due to unimpeded daily exchanges of higher salinity waters from the lower Mobile Bay. If true, these findings suggest important impacts of the causeway on an ecologically important hydrographic parameter. DO concentrations were similar at sites north or south of the causeway during August and October 2005 and March 2006.

Evidence of causeway impacts was also apparent in the chlorophyll analyses. Generally speaking, chlorophyll *a* levels were lower at stations south of the causeway. In contrast, sites located north of the causeway had higher chlorophyll *a* levels that varied in magnitude by month as well as within and among sites. During April and October 2005, chlorophyll *a* concentrations were significantly and marginally greater, respectively, north of the causeway than south of the causeway. Chlorophyll *a* concentrations were greater, albeit not significantly so, at sites north of the causeway than at sites south of the causeway during August 2005 and March 2006. Northern sites had higher chlorophyll *a* levels than southern sites, which may be in part due to reduced flushing rates.

Turbidity was significantly higher north of the causeway than south of the causeway in April and October 2005. Turbidity was similar north and south of the causeway during August 2005 and March 2006. Delta waters were most turbid during March most likely due to passing frontal systems and wind resuspension of fine-grained sediments, which are abundant north of the causeway.

Spatial variability was evident both within and among sites for water quality parameters as well as benthic and sediment collections. The causeway provides a physical barrier, which spatially separated study sites north of the causeway from the control sites located south of the causeway. The evidence of probable barrier effects became less apparent following the passages of hurricanes especially in relation to sediment characteristics and water column salinity and dissolved oxygen concentrations.

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.

Nutrient concentrations (ammonia, nitrate-nitrite, total Kjeldahl nitrogen, total nitrogen and total phosphorus) also varied significantly with season. Significant differences in nutrient concentrations north and south of the causeway were most numerous during early October.

Spatial and temporal variability was evident for sediment collections in April and October 2005. During April 2005, samples collected north of the causeway had significantly greater amounts of clay, water, total organics and TOC and lower amounts of sand than samples collected south of the causeway. In contrast, by October 2005 significant differences in sediment composition were minimal. Sediment water was significantly greater and clay was marginally higher at sites north of the causeway than sediments at sites south of the causeway.

April and October sediment samples differed in overall composition, most likely due to the homogenizing effects by Hurricane Katrina. October sediment samples collected from sites north and south of the causeway contained far more silt and far less clay and sand than found in samples collected in April. Additionally, sediments from three sites (north and south of causeway) contained gravel in October which was absent from all of the April samples. Additionally, sediment organics were higher both north and south of the causeway in October collections than in April collections. North of the causeway, the proportion of sediment water was greater in April samples but south of the causeway sediment water content was greater in October samples.

Interestingly, noticeable differences in sediment composition from three of the riverbank sites were found between the April and October collections. The riverbank sites located at Mouth of Pinto Pass and along the Blakeley Riverbank and Tensaw Riverbank are all on major water exchange paths through the causeway. The sediment samples collected in October had higher percentages of silt and lower percentages of sand than the April samples. Total organic material was also greater at Mouth of Pinto Pass and Tensaw Riverbank during October. In contrast South Blakeley Riverbank sediments had less silt and more sand and gravel compared with April collections. Sediment changes that occurred at the Delta riverbank sites show the impacts of a major hurricane (i.e. Katrina) on the ecosystem dynamics.

Consistently, sites located south of the causeway had higher species richness and invertebrate density than sites north of the causeway except during April 2005. Sites south of the causeway also had high proportions of sand while sites north of the causeway were characterized by higher proportions of clay and silt. Northern site sediments were also characterized by significantly higher percentages of water and total organics than were sites south of the causeway.

Significant or marginally significant differences occurred among sites with regard to number of species and total number of invertebrates for the August and October 2005 and March 2006 benthic collections but not for April 2005 collections (SPSS results). Comparisons of benthic community structure using Primer's ANOSIM found significant differences to exist among sites during all four sampling events. Based on BIO-ENV analyses, the variance observed in invertebrate distributional patterns (April and October) was influenced by patterns in water

column and sediment parameters. Specific conductivity was the most important variable during April and October and explained 61.9% of the observed variations in benthic community structure. Model combinations of specific conductivity with percent clay, dissolved oxygen or ammonia explained 55.4% to 57.1% of the variance observed in invertebrate distributional patterns.

Proportions of major invertebrates groups changed seasonally. During periods of low salinity, proportions of chironomids were high (April and August) and were found in greatest numbers north of the causeway. Polychaete proportions peaked during October when salinities were highest. Peak oligochaete proportions varied by site and month. Amphipod proportions were highest in April and gradually generally decreased through March 2006, which is most likely explained by fish feeding habits. Gastropods were variable by site and sampling period. Highest proportions of bivalves occurred during April 2005 and March 2006 and were found in higher densities at sites south of the causeway for all four sampling events.

Fish species composition, species richness and invertebrate density also differed north and south of the causeway during June 2005, August 2005, November 2005 and March 2006. Mixtures of estuarine dependent and freshwater fishes were collected in June and August. Estuarine dependent fish (anchovies) and invertebrates (brown shrimp) dominated collections in November 2005. March 2006 collections also contained estuarine dependent fishes. Fish abundance and species diversity were greater in collections made in Chocolatta Bay than in collections south of the causeway except during March when fish abundance was slightly higher south of the causeway which suggests both spatial and seasonal factors influence the fish community.

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. Compared with 2004, however, these effects were not as strong during 2005/2006 due to active hurricane season.

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 confounded by western shore land-use impacts. In contrast, the eastern shore is less developed with lower 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 we suspect along 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 proliferation of invasive species.

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. 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 similar situations around the country that show significant ecological changes can occur when natural hydrography is modified. In the Mobile-Tensaw Delta as well, 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, frequency of occurrence and persistence of hypoxic events and increased incidences of exotic and invasive plant species. Prior to any attempts at restoration or remediation, hydrologic data and comprehensive ecological analyses are needed to determine if predictions of dramatic impacts have in fact occurred.

In the lower delta, continuous water quality monitoring at three permanent stations north of the causeway within the embayments and along rivers recorded variations in temperature, salinity, dissolved oxygen and turbidity. Additionally, three continuous monitoring stations along the rivers recorded temperature and salinity. Due to the damage of the Meaher Park pier by Hurricane Ivan, data collected from the continuous monitoring stations could not be compared with data from the Meaher Park weather station in 2005. 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 anticipated 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 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 measurements of hydrographic parameters (temperature, salinity, dissolved oxygen, chlorophyll

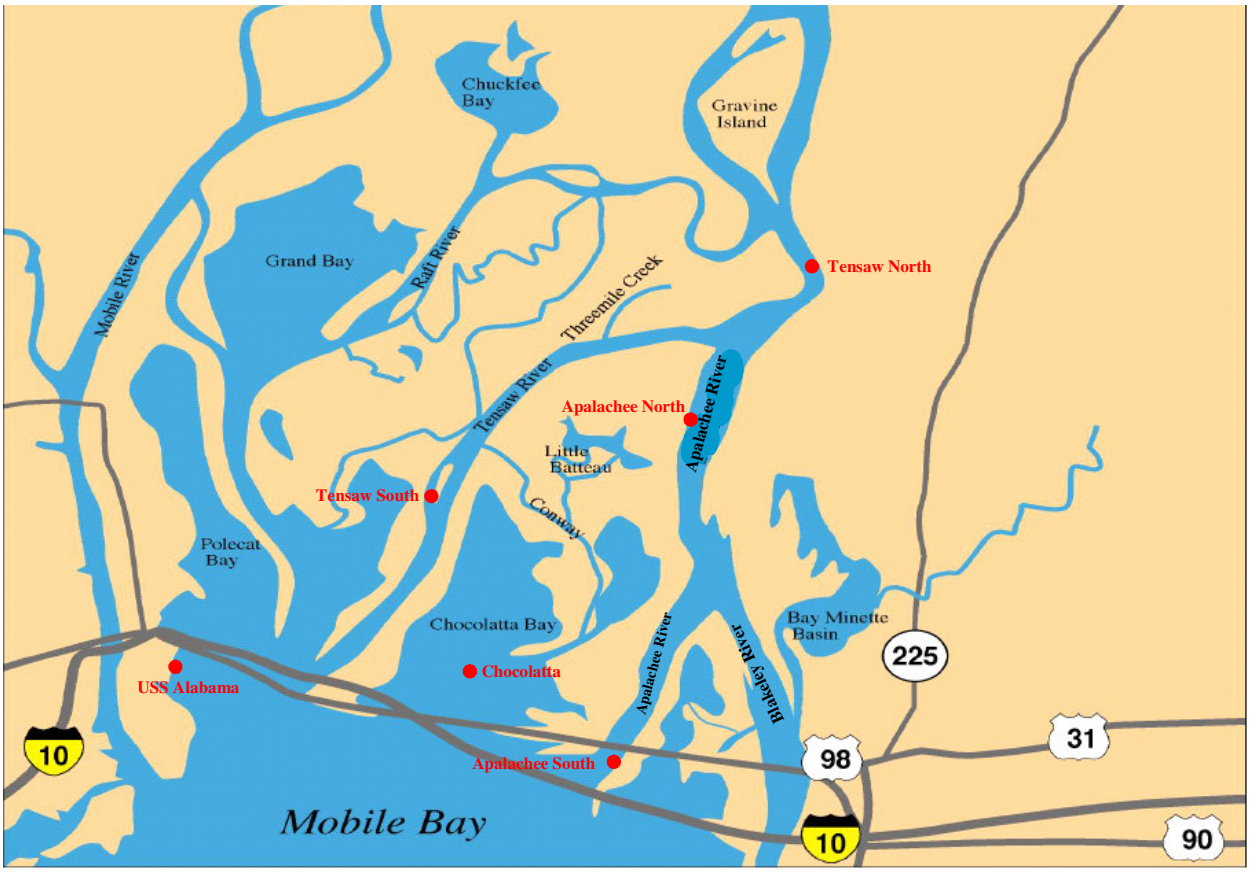
a and turbidity), nutrient concentrations, sediment characteristics, and community structure and composition (benthic invertebrates and to a lesser extent fishes) in embayments and riverbanks north and south of the causeway.

SAMPLING STATIONS

Continuous monitoring sites for the 2005 – 2006 study are identified in Figure 1 and Table 1. Monitoring sites were selected based on The Nature Conservancy recommendations following evaluations of previously collected data. Continuous monitoring in Chocolatta Bay, Tensaw River, Apalachee River and at USS Alabama was initiated on July 8, 2005 and continued through December 8, 2005. From July to December YSIs were continuously deployed and maintained at USS Alabama pier, Chocolatta Bay and Apalachee River north. Hydrolabs were continuously deployed and maintained at Tensaw River south, Apalachee River south and Tensaw River north.

The Meaher Park weather station (Figure 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. At the end of August 2005, the newly completed pier was destroyed by Hurricane Katrina. Therefore, we were unable to compare our continuous data with the Meaher Park weather station data. Station information is available online at the Mobile Bay National Estuary Program site (http://www.mobilebaynep.com).

Mobile-Tensaw Delta biological sampling stations for 2005 - 2006 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

Figure 1. Map of the Mobile-Tensaw Delta continuous monitoring sites for 2005-2006: USS Alabama, Tensaw South, Chocolatta, Apalachee South, Apalachee North and Tensaw North.

Table 1. Mobile-Tensaw Delta continuous monitoring stations occupied in 2005. The GPS location, instrument type, deployment times and notes are given for each site.

Site Name	Site	Latitude	Longitude	Years	Instrument	Notes
Apalachee North	AN	30° 43.626	087^{0} 56.489	July – Dec. 2005	YSI 6600	South of Mudhole Creek
Apalachee South	AS	30° 40.280	87° 57.056	July – Dec. 2005	Hydrolab Data Sonde	Apalachee River mouth just below Causeway and before split
Chocolatta Bay	CH1 CB	30^{0} 41.114	087^{0} 58.879	Sept 2003–Apr 2004; May – Dec. 2004; July – Dec. 2005	YSI 6600	Same as previous years
Tensaw River South	TR1 TS	30^{0} 42.893	087^{0} 58.975'	Sept 2003–Apr 2004; July – Dec. 2005	Hydrolab Data Sonde	Same as previous years except slightly different spot
Tensaw River North	TN	30^{0} 45.149	087^{0} 55.121	July – Dec. 2005	Hydrolab Data Sonde	North of Apalachee split; Steam Mill Landing area
USS Alabama	US	30^{0} 40.990'	088^{0} 00.76'	July – Dec. 2005	YSI 6600	USS Alabama pier

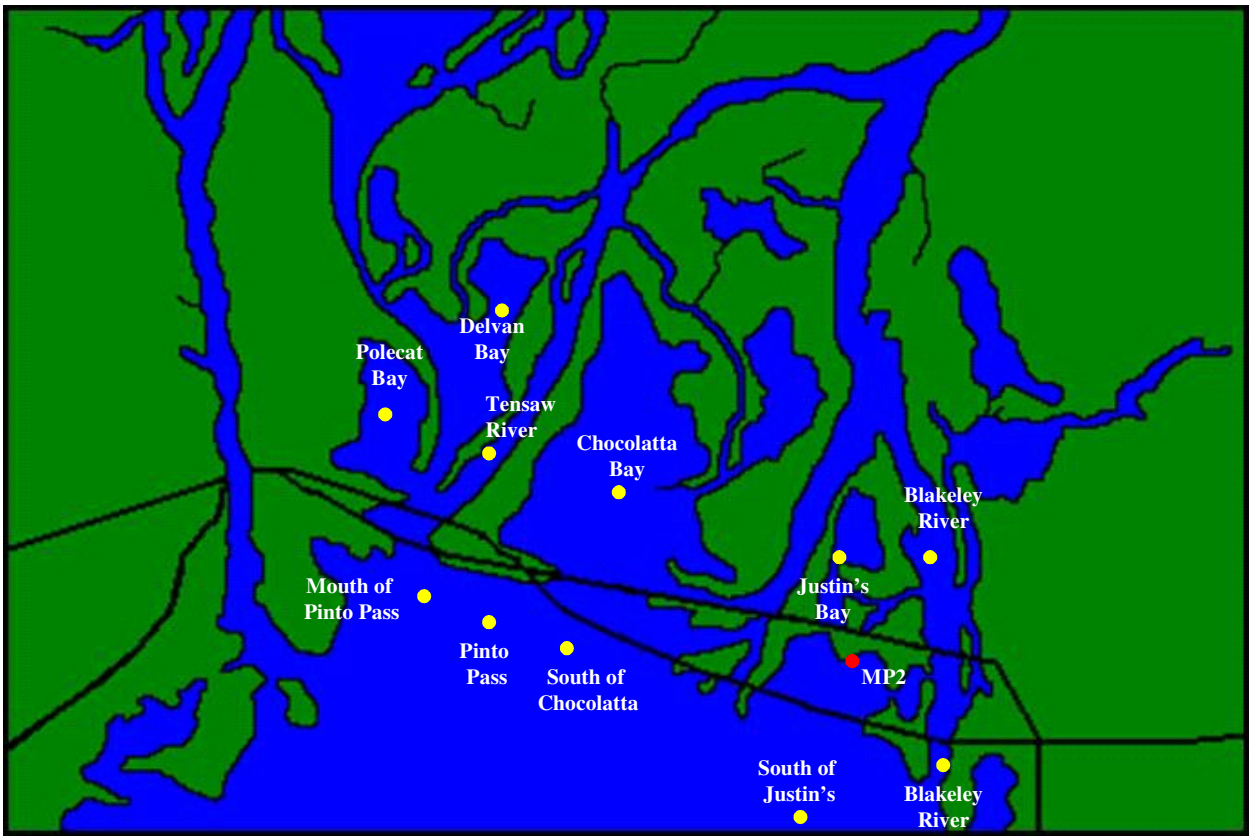


Figure 2. Mobile-Tensaw Delta biological monitoring sites are presented for the 2005 – 2006 study. The Meaher Park weather station is identified as MP2.

Table 2. Mobile-Tensaw Delta biological sampling stations occupied during 2005 - 2006 are listed by site name, site abbreviation and location with respect to the causeway (N = north, S = south). The latitude and longitude are given for each site from the initial sampling event.

Site Name	**Site**	**North or South of Causeway**	**Latitude**	**Longitude**
Polecat Bay	PB	N	N 30° 42.040	W 088° 00.671
Delvan Bay	DB	N	N 30° 42.580	W 087° 59.627
Tensaw Riverbank	RB1	N	N 30° 41.641	W 087° 59.794
Chocolatta Bay	CB	N	N 30° 41.116	W 087° 58.871
Blakeley Riverbank	RB2	N	N 30° 41.495	W 087° 55.669
Justin’s Bay	JB	N	N 30° 40.795	W 087° 56.479
Mouth of Pinto Pass	Site 7	S	N 30° 40.728	W 088° 00.550
Pinto Pass	Site 8	S	N 30° 40.607	W 088° 00.173
South of Chocolatta Bay	Site 9	S	N 30° 39.991	W 087° 59.311
South of Justin's Bay	Site 10	S	N 30° 38.643	W 087° 56.647
South Blakeley Riverbank	Site 11	S	N 30° 39.058	W 087° 55.740

PROJECT SCHEDULE

The revised 2005 – 2006 sampling schedule for the Mobile-Tensaw Delta is found in Table 3.

Table 3. Revised sampling schedule for the 2005 – 2006 Mobile-Tensaw Delta project.

Tasks	April/May 2005	June 2005	July 2005	August 2005	September 2005	October 2005	November 2005	December 2005	January 2006	February 2006	March 2006
Continuous Monitoring YSIs (3 sites)			X	X	X	X	X	X			
Continuous Monitoring Hydrolabs (3 sites)			X	X	X	X	X	X			
Benthic Sampling	X			X		X					X
Sediment Sampling	X					X					
Fish Sampling		X		X			X				X
Water Grab	X	X	X	X	X	X					X
YSI (with Chl *a*)	X	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 Hydrography Monitoring

The USS Alabama, Chocolatta Bay and Apalachee River North YSIs and Tensaw River (North and South) and Apalachee River South hydrolabs were deployed July 8, 2005 and maintained continuously through December 8, 2005. All instruments remained in the field during the passages of hurricanes Dennis, Katrina and Rita (Table 4).

A YSI 6600 equipped with an extended deployment system was moored in Chocolatta Bay, Apalachee River North and at the USS Alabama pier (Fig. 1 and Table 1). Hydrolab Data Sonde III's were deployed at three riverine stations north and south of the causeway on July 8, 2005 (Fig. 1 and Table 1): Apalachee River South, Tensaw River North and Tensaw River South. The YSIs were programmed to record water temperature, specific conductance, salinity, dissolved oxygen (mg/L and % saturation) and turbidity at 15-minute intervals. Hydrolabs were programmed to measure water temperature, specific conductance and salinity at 15 minute intervals. Salinity was calculated from specific conductance and temperature using an algorithm and recorded at the same interval.

All instruments were mounted horizontally on a PVC frame and the PVC frame was placed on the bottom with the instrument located just above the bottom. Deployed instruments were replaced at two to three week intervals. Lengths of deployment varied depending on season, temperature and/or degree of instrument fouling.

Table 4. Summary of hurricanes during 2005 (http://www.ncdc.noaa.gov/oa/climate/research/2005/hurricanes05.html) that directly (XX) or indirectly (X) (e.g. outer storm bands) affected the Mobile-Tensaw Delta (MTD).

MTD	Tropical Cyclone	Maximum Sustained Windspeed (kt)	Landfall and Strike Information (date, location and sustained winds)
XX	Dennis	130	7/8/05 – Cuba (Cat 4); 7/10/05 Pensacola, FL (105 kt)
X	Emily	140	7/14/05 – Grenada (80 kt); 7/18/05 – Cozumel, Mexico (115 kt); 7/18/05 Tulum (Yucatan) Mexico (115 kt); 7/20/05 Fernando, Mexico (110 kt)
XX	Katrina	150	8/25/05 – Hollywood, FL (70 kt); 8/29/05 Buras, LA (110 kt) and Ansley, MS (105 kt)
XX	Rita	150	9/24/05 – Between Sabine Pass TX and Johnson's Bayou, LA (105 kt)
X	Stan	70	10/02/05 – Yucatan Peninsula, Mexico (40 kt); 10/04/05 – SE of Veracruz, Mexico (70 kt)
X	Tammy	45	10/05/05 – Jacksonville, FL (45 kt)
X	Wilma	150	10/21/05 – Cozumel, Mexico (120 kt); 10/22/05 – Playa del Carmen, Mexico (115 kt); 10/24/05 – near Everglades City, FL (105 kt)

Biological Monitoring

Macroinvertebrates

During 2005 - 2006, four sampling events were conducted at 11 stations located in the Mobile-Tensaw Delta (Table 3). Six sites were located north of the causeway and five sites were located south of the causeway. Sample sites located north of the causeway included Polecat Bay, Delvan Bay, Chocolatta Bay, Justin's Bay, Tensaw riverbank and Blakeley riverbank. Sites selected below the causeway were located directly south of stations located above the causeway (Table 2 and Fig. 2). GPS readings were recorded for each sampling location.

Macroinvertebrates were collected at the sites using a petite ponar grab. At each site, three samples were collected in unvegetated areas. Analysis of samples collected in February 2004 indicated that three replicates were adequate to characterize biodiversity and density and provided sufficient power to detect possible differences in invertebrate abundance and community structure among sites located on each side of the causeway.

Initially, samples were rinsed over a 500-micron sieve to remove small debris and fine-grained sediment in the field. Large debris (e.g., wood, empty shells) was thoroughly washed over the sieve and discarded. Next, samples were placed in prelabeled containers. Samples were immediately placed on ice and returned to the lab for processing. Taxonomic evaluations of these samples were performed at the Dauphin Island Sea Lab. Taxonomy data sheets, standard forms and operating procedures can be 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 level. Genus and species level identifications were made when possible.

Sediment

During April 2005 and October 2005, a petite ponar was also used to collect three sediment samples at each of the 11 sites. Sediment samples were collected from the same locations as the invertebrate samples. Grain size, total organics (loss on ignition) and percent water analyses were conducted on these samples. The April 2005 samples were also analyzed for total organic carbon (TOC). To conduct these analyses, the top 3 cm of sediment contained within the ponar were removed using a spatula and placed in prelabeled containers. As with the macroinvertebrate samples, sediment samples were immediately placed on ice and returned to the lab for processing.

Sediment grain size, percent water and total organics analyses were conducted by scientists at the University of South Alabama. In order to compare these results with previous collections, and to achieve a higher level of resolution, grain size analyses were conducted using the pipette and sieve method rather than the hydrometer method. Total organic content was determined using the loss on ignition method. Percent water was determined based on the differences between the wet sample and the dried sample weights. Sediment total organic carbon analyses (April 2005)

were conducted by Severn Trent Laboratories, Inc. in Mobile, Alabama using EPA method SW846 9060.

Water Column

A YSI 6600 was used to measure water quality parameters at the same sites of the invertebrate and sediment samples during each sampling event. Water quality parameters included temperature, conductivity, salinity, dissolved oxygen, turbidity and chlorophyll *a*.

During each sampling event, a surface water sample was also collected at each site for nutrient analysis (nitrogen and phosphorus). Water samples were collected using 32-ounce sample containers that were rinsed three times with site water. Samples were immediately placed on ice and returned to ADEM's (Alabama Department of Environmental Management) laboratory for preservation and analyses. Additional water samples were collected on June 14, 2005, July 27-28, 2005 and October 5, 2005 from the eleven stations. Simultaneously, a YSI 6600 was used to measure water quality at each site and GPS readings for each collection site were recorded (Table 3). Water 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) concentration.

Fish

During 2005, three fish sampling events were conducted, using trawl nets, within Chocolatta Bay and at three sites south of the causeway (Table 3). During the March 2006 sampling event, only trawling was conducted within Chocolatta Bay and south of the causeway. Fish were identified to species, counted and the first ten specimens of each species were measured (total length in inches). Unidentified fish were returned to the lab for identification.

DATA MANAGEMENT AND ANALYSES

CONTINUOUS HYDROGRAPHY 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 in Excel files for viewing. All monitoring data were graphically presented as weekly means with ranges for each deployment duration.

BIOLOGICAL MONITORING

The biotic assemblages in the embayments and riverbank sites north of the causeway and reference stations south of the causeway (Table 2) were compared using robust statistics developed to analyze the impacts of anthropogenic disturbances in marine environments. Differences in numbers and composition of macroinvertebrate and fish assemblages were tested for using the Analyses of Similarity (ANOSIM) technique. ANOSIM is a non-parametric, multivariate analog of Analysis of Variance that can detect differences in community structure even when differences between treatments are small (Clarke, personal communication). These differences were then graphically depicted using Multi-Dimensional Scaling plots (MDS) contained in the Primer E statistical package (Clarke & Green 1988; Warwick & Clarke 1991; Clarke 1993). When parametric statistics were appropriate, analyses were conducted using SPSS. Tukey HSD tests were used to compare treatment effects. Treatment comparisons included the following:

1. North of Causeway / South of Causeway
2. Site.

Biological, sediment, nutrient and water quality data were graphically depicted by site and treatments. Graphical depictions were used to aid in the detection of trends or patterns in benthic composition with regard to site, treatment or season.

RESULTS

CONTINUOUS HYDROGRAPHY MONITORING

The continuous monitoring data can be found in Appendices 1 and 2. Figures 1-1 through 1-7 present weekly means for temperature, depth, specific conductivity, salinity, dissolved oxygen (% and mg/L) and turbidity at the six continuous monitoring locations. Figures 2-1 through 2-33 contain weekly means and ranges for temperature, depth, specific conductivity, salinity, dissolved oxygen (% and mg/L) and turbidity plotted by week and site. The passages of hurricanes are also identified on Appendix 2 figures.

Short term and seasonal variations of measured parameters were evident at all continuous monitoring sites (Appendices 1 and 2). Temperature varied seasonally with highs occurring in summer and lows in winter (Figs. 1-1, 2-1, 2-8, 2-12, 2-19, 2-23 and 2-30). Mean depth, which is influenced by tidal cycle and storm events (e.g. watershed rainfall, hurricanes), also varied seasonally (Figs. 1-2, 2-2, 2-9, 2-13, 2-20, 2-24 and 2-31). The effects of Hurricanes Dennis (landfall: July 10, 2005), Katrina (landfall: August 29, 2005) and Rita (landfall: September 24, 2005) on water level were also evident at all sites. Outer bands of Hurricane Wilma, which ultimately made a final landfall to the south near Everglades City, Florida, also appear to have affected water level and temperature at our monitoring sites during mid-October.

Salinity was highest during late summer/early fall 2005. Geographically, salinity was lowest at Tensaw River North and Apalachee River North, the northernmost of the sites, during fall 2005 (Figs. 1-3 and 1-4). The sites at USS Alabama and in Chocolatta Bay had the highest recorded salinities during fall 2005 (Figs. 1-3 and 1-4). Salinity reached weekly means of approximately 12 psu at USS Alabama and 8 psu in Chocolatta Bay also during late summer/early fall (Figs. 1-3 and 1-4). In contrast, during fall of 2004, salinity in Chocolatta Bay peaked, on average, at approximately 6 psu. This point illustrates how variable salinity can be from year to year.

The occurrences of extremely high salinities were also detected following the passages of Hurricanes Katrina and Rita at the most northern sites: Apalachee River North and Tensaw River North (Figs. 2-25, 2-26, 2-32 and 2-33). Salinity exceeded 15 psu at all sites during the passage of Hurricane Katrina but persisted longer at the most southern stations (esp. USS Alabama and Chocolatta) (Figs. 2-4, 2-11, 2-15, 2-22, 2-26 and 2-33). During the passage of Hurricane Ivan in 2004, Chocolatta Bay salinity reached 14 psu. When taken together, these records indicate that the episodic occurrences of hurricanes within the northern Gulf of Mexico can have drastic impacts on the Delta hydrography, that appear to overwhelm causeway impacts, even when landfall is elsewhere.

Continuous measurements of dissolved oxygen (Figs. 1-5 and 1-6) were also made at sites located at the USS Alabama and in Chocolatta Bay and Apalachee River North. For the most part, Dissolved oxygen (DO) was high during the late fall/early winter of 2005. The exception being periods of low DO that occurred following the passage of each hurricane (Table 4). These episodic events were probably the result of deeper, low DO, water being pushed up from Mobile Bay by hurricane driven winds and tides (Figs. 1-6, 2-5, 2-6, 2-16, 2-17, 2-27 and 2-28). These observations also suggest an important role for large episodic disturbances in determining ecosystem function in the study area.

Dissolved oxygen dropped below hypoxic levels (3 mg/L) during July, August, September and October 2005 at USS Alabama, Chocolatta Bay and Apalachee River North (Figs. 1-6, 2-5, 2-6, 2-16, 2-17, 2-27 and 2-28). Enclosed embayments were more susceptible to hypoxia, as nine hypoxic events were recorded in Chocolatta Bay from July to December 2005 (Fig. 2-16), than at the more open locations with three recorded hypoxic events at USS Alabama (Fig. 2-5) and four recorded hypoxic events at Apalachee River North (Fig. 2-27). In addition to Hurricanes Dennis, Katrina and Rita, outer bands from other hurricanes (Table 4) also seem to have affected the hydrography of Mobile-Tensaw Delta resulting in periods of hypoxia. The duration of hypoxic events ranged from several hours to eight days depending on the site. Intermittent hypoxic "spikes" were also observed at the Delta sites.

Turbidity (Fig. 1-7) data were collected at USS Alabama, Chocolatta Bay and Apalachee River North. Hurricane events produced dramatic, albeit short-term, increases in turbidity at USS Alabama, Chocolatta Bay and Apalachee River North (Figs. 1-7, 2-7, 2-18 and 2-29). During the fall, turbidity also fluctuated during the passages of storms and fronts at the Chocolatta Bay and USS Alabama sites (Figs. 1-7, 2-7 and 2-18).

WATER COLUMN PARAMETERS

Water Column Parameters – YSI Readings

YSI measurements were made during benthic samplings in April, June, July, August and October 2005 and March 2006. Figures depicting these data, as well as summary tables from the major sampling events (April 2005, August 2005, October 2005 and March 2006), are contained in Appendix 3. Statistical analyses were conducted for April 2005, August 2005, October 2005 and March 2006 data and are discussed below. The results presented here include temperature, salinity, dissolved oxygen (mg/l), turbidity and chlorophyll *a*.

YSI Readings – April 2005

Spatially heterogeneous patterns of hydrography were recorded in April. Still, evidence of causeway impacts on local hydrography were apparent in this first sampling event. Water temperature was significantly higher (p=0.015) north of the causeway than it was south of the causeway (Table 3-1 and Fig. 3-1). Temperature (p=0.000) also varied significantly among some sites (Table 3-1 and Fig. 3-2) and ranged from 17.97^{o}C to 22.6^{o}C. Temperature in Chocolatta Bay was significantly greater than at all sites south of the causeway. Of these, temperature at the Mouth of Pinto Pass was significantly lower than at all other sites. Tensaw Riverbank temperature was higher than at sites in Pinto Pass and South of Chocolatta (Table 3-1 and Fig. 3-2). These differences in temperature on each side of the causeway seem to reflect differences in water retention time among sites.

Salinity was low and not found to differ (p=0.707) north and south of the causeway (Table 3-1 and Fig. 3-3). Salinity (p=0.000) varied significantly among some sites (Table 3-1 and Fig. 3-4). These small differences were unlikely, however, to have influenced ecosystem structure. Salinity ranged from just 0.06 psu to 0.75 psu. Salinity at Tensaw Riverbank was significantly greater than at all other sites. Mouth of Pinto Pass salinity was also higher than at all other sites except the Tensaw Riverbank, Pinto Pass and Polecat Bay (Table 3-1 and Fig. 3-4). This pattern indicates that salinity was higher, generally, at the western most sites.

Sites located north of the causeway had higher (p=0.009) DO concentrations than did sites south of the causeway (Fig. 3-5). DO also varied significantly (p=0.000) among some sites on each side of the causeway (Table 3-1 and Fig. 3-6). DO was greatest in Polecat Bay and lowest at the site directly south of Chocolatta Bay. For the most part, sites south of the causeway had the lowest DO. The site located south of Chocolatta had significantly lower DO than did all other sites except Mouth of Pinto Pass, Pinto Pass and South of Justin's. No evidence of hypoxia was detected in April. It is of note that all of the sites are located south of the causeway where salinities were higher.

Evidence of causeway impacts was also apparent in the chlorophyll analyses. Chlorophyll *a* concentrations were greater (p=0.01) north of the causeway than south of the causeway (Table 3-1 and Fig. 3-7). Mean chlorophyll *a* concentrations ranged from just 2.97 ug/l South of Justin's to over 20 ug/l in Blakeley Riverbank and significant differences among some sites were

detected (p=0.001) (Table 3-1 and Fig. 3-8). Chlorophyll *a* concentrations were significantly higher in Blakeley Riverbank than at most sites south of the causeway (Mouth of Pinto Pass, South of Chocolatta and South of Justin's) (Fig. 3-8).

Turbidity was also higher (p=0.004) north of the causeway than south of the causeway (Table 3-1 and Fig. 3-9). Turbidity also varied significantly among some sites (p=0.000) during April 2005 (Table 3-1 and Fig. 3-10). Turbidity was greatest in Justin's Bay, Delvan Bay and Polecat Bay and lowest at sites South of Justin's and South of Chocolatta (Table 3-1 and Fig. 3-10). Turbidity was significantly higher in Justin's Bay than at all sites south of the Causeway. Delvan Bay turbidity measurements were also higher than at all sites south of the causeway except South Blakeley Riverbank. Turbidity in Polecat Bay was significantly higher than sites at Mouth of Pinto Pass, Pinto Pass and South of Chocolatta (Fig. 3-10).

YSI Readings – August 2005

In contrast to April, temperatures at sites north of the causeway were only marginally higher (p=0.070) than at sites south of the causeway in August (Table 3-2 and Fig. 3-1). Similar to April, August 2005 temperatures varied significantly among some sites (Table 3-2 and Fig. 3-2). Water temperatures peaked during August and were highest in Chocolatta Bay. In contrast, temperature was significantly lower at South of Chocolatta than at all other sites (Fig. 3-2).

Overall salinity remained low in August and did not vary significantly (p=0.607) at sites north and south of the causeway (Fig. 3-3). Salinity ranged from 0.07 psu at South Blakeley Riverbank to 4.31 psu at Pinto Pass. Numerous significant differences among some sites were detected during August (p=0.000). As in April, the eastern most sites both north and south of the causeway had the lowest salinities (Table 3-2 and Fig. 3-4).

During August 2005, DO concentrations were similar at sites north or south of the causeway (p=0.769) (Table 3-2 and 3-5). Even so, significant differences in DO (mg/l) concentrations (p=0.011) (Table 3-2 and Fig. 3-6) among some sites were found. DO was greater in Polecat Bay, at the Mouth of Pinto Pass and in Pinto Pass that at South of Chocolatta and in Delvan Bay (Fig. 3-6).

Patterns of chlorophyll *a* concentrations in August differed from those observed in April. Chlorophyll *a* concentrations were greater (p=0.154), albeit not significantly so, at sites north of the causeway than at sites south of the causeway (Fig. 3-7). Mean chlorophyll *a* ranged from just under 3 ug/l south of Chocolatta Bay to almost 14 ug/l in Polecat Bay. Significant differences were detected among some sites (p=0.000) (Table 3-2 and Fig. 3-8). Polecat Bay had significantly more chlorophyll *a* than did Blakeley Riverbank, Tensaw Riverbank, Mouth of Pinto Pass, Justin's Bay and Delvan Bay (Fig. 3-8). South of Chocolatta chlorophyll *a* concentrations were significantly lower than at all other sites except Delvan Bay and Pinto Pass. Chlorophyll *a* in Pinto Pass was significantly lower than along either the Tensaw or Blakeley Riverbanks, and in Polecat and Chocolatta Bays and at the station located south of Justin's Bay (Fig. 3-8).

During August 2005, turbidity was not significantly (p=0.91) different north and south of the causeway (Table 3-2 and Fig. 3-9). Turbidity did vary significantly among sites (p=0.004), however. Turbidity in Chocolatta Bay was significantly greater than turbidity at South of Chocolatta and Tensaw Riverbank (Table 3-2 and Fig. 3-10).

YSI Readings – October 25-27, 2005

Temperatures had decreased at all sites by late October (Fig. 3-2, see October B). Unlike the previous sampling efforts, temperatures north and south of the causeway were not statistically significantly different from one another (p=0.339) (Table 3-3 and Fig. 3-1). Similar to April and August, October 2005 temperature did, however, vary significantly among some sites (Table 3-3 and Fig. 3-2, see October B). North of the causeway, sites at Tensaw Riverbank and Blakeley Riverbank had significantly higher temperatures than at Delvan Bay and Polecat Bay (Fig. 3-2) and Polecat Bay and Delvan Bay differed significantly from all other sites. The Tensaw Riverbank and Blakeley Riverbank sites also had significantly higher temperatures than did the site South of Chocolatta. Temperatures in Justin's Bay were lower than at Blakeley Riverbank located just to the east (Fig. 3-2).

Salinity was dramatically higher in October than in previous months. Salinity was greater (p=0.301), although not significantly so, at sites south of the causeway than at sites north of the causeway (Table 3-3 and Fig. 3-3). Salinity ranged from a low of 2.4 psu in Justin's Bay to 15.43 psu at Pinto Pass (Fig. 3-4). Because of the wide range of variability among sites, significant differences were numerous. Generally, salinity was higher on the west side of the Delta both above and below the causeway (Fig. 3-4) as was seen in April.

During late October, DO was not significantly different at sites located north and south of the causeway (p=0.283) (Table 3-3 and Fig. 3-5). Even so, DO varied significantly among some sites (p=0.000) (Table 3-3 and Fig. 3-6). DO was greatest in Chocolatta Bay, Delvan Bay and Polecat Bay. Dissolved oxygen was lowest at Blakeley Riverbank and South of Chocolatta (Fig. 3-6). These differences were probably not biologically significant as none dipped below hypoxic levels.

Chlorophyll *a* concentrations were marginally greater (p=0.097) at sites north of the causeway than at sites located south of the causeway (Table 3-3 and Fig. 3-7). Again, significant differences occurred among some sites (p=0.029) (Table 3-3 and Fig. 3-8). Mean chlorophyll *a* values ranged from 3.25 ug/l at South of Chocolatta to 16.0 ug/l at Tensaw Riverbank.

Turbidity was again significantly higher (p=0.007) at sites located north of the causeway than at sites south of the causeway (Table 3-3 and Fig. 3-9). During October 2005, sites had significantly (p=0.000) different levels of turbidity (Table 3-3 and Fig. 3-10). Mean turbidity readings ranged from 6.37 NTU at South of Chocolatta to 28.53 NTU in Polecat Bay (Fig. 3-10). Polecat Bay turbidity was significantly greater than all sites except Justin's Bay and Delvan Bay. Turbidity values in Justin's Bay were higher than Blakeley Riverbank and all sites south of the causeway. South of Chocolatta had lower turbidity than Chocolatta Bay, Delvan Bay and Tensaw Riverbank sites (Fig. 3-10).

YSI Readings – March 2006

As in the previous spring, sites north of the causeway had significantly (p=0.003) higher temperatures than sites south of the causeway (Table 3-4 and Fig. 3-1). Similar to previous sampling events, March 2006 temperatures differed significantly among some sites and primarily related to location north or south of the causeway (p=0.000) (Table 3-4 and Fig. 3-2). March temperatures were the lowest observed (Fig. 3-2). Temperature ranged from 12.6^{o}C at Pinto Pass to 18.0^{o}C in Justin's Bay (Fig. 3-2).

Salinity was not significantly different (p=0.269) at sites located north and south of the causeway (Table 3-4 and Fig. 3-3). Salinities were low overall during March 2006 and ranged from 0.1 psu to 1.2 psu. Although differences among some sites were significant statistically (p=0.000), differences were probably not biologically significant (Table 3-4 and Fig. 3-4).

DO concentrations were highest in March 2006 and significant differences were not found between sites located north and south of the causeway (p=0.23) (Table 3-4 and Fig. 3-5). DO concentrations varied significantly among some sites (p=0.000) (Table 3-4 and Fig. 3-6) and was greatest in Polecat Bay and in Delvan Bay. Lowest DO occurred to the east in Justin's Bay and at South of Justin's (Fig. 3-6).

Chlorophyll *a* concentrations were similar (p=0.144) at sites north and south of the causeway (Table 3-4 and Fig. 3-7). Significant differences occurred among some sites (p=0.000) (Table 3-4 and Fig. 3-8). Mean chlorophyll *a* values ranged from 3.7 ug/l at South of Chocolatta to 14.4 ug/l in Delvan Bay. Delvan Bay chlorophyll values were significantly higher than Chocolatta Bay, Tensaw Riverbank, Blakeley Riverbank and all sites south of the causeway. South of Chocolatta had higher chlorophyll *a* concentrations than Justin's Bay and Polecat Bay. Chocolatta Bay differed from Polecat Bay (Table 3-4 and Fig. 3-8).

Turbidity was similar (p=0.114) north and south of the causeway (Table 3-4 and Fig. 3-9). During March 2006, significant differences among some sites (p=0.001) were detected (Table 3-4 and Fig. 3-10). Mean turbidity readings ranged from 15.7 NTU at South of Chocolatta to 52.4 NTU at South Blakeley Riverbank (Fig. 3-10). Turbidity at South Blakeley Riverbank was significantly higher than at South of Chocolatta and Justin's Bay. South of Justin's turbidity levels were greater than South of Chocolatta, Justin's Bay and Polecat Bay (Table 3-4 and Fig. 3-10).

Water Column Parameters – Nutrients

During each sampling event, a surface water sample was also collected at each site for nutrient analysis. Additional water samples were collected on June 14, 2005, July 27-28, 2005 and October 5, 2005 from all eleven stations. Figures depicting these data, as well as summary tables are contained in Appendix 4. Multiple comparisons by site were not conducted because at least one group had fewer than two cases.

Nutrients – April 2005

April nutrient analyses are summarized in Table 4-1, Figures 4-1 through 4-6. Sites located south of the causeway had marginally significantly higher levels of total nitrogen (p=0.077) and total phosphorus (p=0.062) (Table 4-1, Figs. 4-1 and 4-3) than did sites north of the causeway. Ammonia, nitrate-nitrite and TKN were similar in the north/south analyses (Table 4-1, Figs. 4-1 and 4-2). Ammonia levels were low and ranged from 0.01 mg/l in Justin's Bay to 0.08 mg/l at Mouth of Pinto Pass (Fig. 4-5). Nitrate-nitrite ranged from 0.139 mg/l at Chocolatta Bay to 0.258 mg/l at South of Chocolatta. TKN was highest at Tensaw Riverbank and lowest at South of Chocolatta (Fig. 4-4). Total nitrogen was greatest at Mouth of Pinto Pass and lowest in Polecat Bay (Fig. 4-4). South of Chocolatta had the lowest total phosphorus and Mouth of Pinto Pass had the highest levels (Fig. 4-6).

Nutrients – June 2005

Data from the June 2005 sampling are found in Table 4-2. Ammonia levels were below method detection limits for all samples (<0.01 mg/l). In contrast to April, the remaining nutrients had concentrations that were similar north and south of the causeway (Figs. 4-2, 4-3 and 4-7). Nitrate-nitrite ranged from 0.184 mg/l in Delvan Bay to 0.607 mg/l at Blakeley Riverbank. Delvan Bay, Pinto Pass and Tensaw Riverbank had the highest levels of TKN and total nitrogen (Fig. 4-8). Total phosphorus ranged from 0.051 mg/l in Polecat Bay to 0.101 mg/l in Blakeley Riverbank (Fig. 4-6).

Nutrients – July 2005

July 2005 nutrient analyses are summarized in Table 4-3. Similar to June, sites located north and south of the causeway contained similar concentrations of ammonia, TKN and total nitrogen (Figs. 4-2 and 4-9). In contrast to previous months, however, sites south of the causeway had greater concentrations (p=0.018) of nitrate-nitrite and total phosphorus (p=0.042) than did sites north of the causeway (Table 4-3, Figs. 4-3 and 4-9).

By site, ammonia levels were below method detection limits (<0.01 mg/l) at all sites except Mouth of Pinto Pass (0.002 mg/l) (Table 4-3 and Fig. 4-5). Nitrate-nitrite ranged from below method detection limits (0.005 mg/l) in Polecat Bay, Delvan Bay, Chocolatta Bay and Justin's Bay to 0.097 mg/l at South Blakeley Riverbank (Fig. 4-10). Tensaw Riverbank and South of Chocolatta had the lowest TKN and total nitrogen levels while riverbanks south of the causeway had the highest values (Fig. 4-10). Total phosphorus levels were lowest at Tensaw Riverbank, Blakeley Riverbank and Chocolatta Bay and highest in Delvan Bay (Fig. 4-6).

Nutrients – August 2005

Data from the August 2005 sampling are summarized in Table 4-4. Ammonia (p=0.297), TKN (p=0.173), total nitrogen (p=0.220) and total phosphorus (p=0.251) were not significantly different among sites located north and south of the causeway during August. Nitrate-nitrite was marginally higher (p=0.091) at sites south of the causeway than at sites north of the causeway (Table 4-4, Figs. 4-2, 4-3 and 4-11).

Similar to July, August ammonia levels were low and remained below method detection limits (0.01 mg/l) at all sites except Pinto Pass (0.04 mg/l) (Table 4-4 and Fig. 4-5). August nitrate-nitrite ranged from below method detection limits (0.005 mg/l) in embayments north of the causeway (Polecat Bay, Delvan Bay, Chocolatta Bay and Justin's Bay) to 0.066 mg/l at Tensaw Riverbank (Fig. 4-12). South of Chocolatta and South Blakeley Riverbank had the lowest TKN and total nitrogen levels while Polecat Bay and South of Justin's had the highest values (Fig. 4-12). Over all sampling events, the highest total phosphorus level occurred during August at Tensaw Riverbank (Fig. 4-6).

Nutrients – October 5, 2005

Nutrient analyses from October 5, 2005 are summarized in Table 4-5. Analysis of samples collected in early October found significant differences to exist between locations north or south of the causeway. Sites south of the causeway had significantly greater levels of ammonia (p=0.002) and nitrate-nitrite (p=0.017) than did sites located north of the causeway (Figs. 4-2 and 4-13). In contrast, sites located north of the causeway had significantly higher levels of TKN (p=0.012) and total nitrogen (p=0.015) than sites south of the causeway (Fig. 4-13). Phosphorus levels were similar north and south of the causeway (Fig. 4-3).

Overall ammonia levels continued to be low and ranged from below method detection limits (<0.01 mg/l) in Delvan Bay to 0.07 mg/l at South of Chocolatta (Table 4-5 and Fig. 4-5). Nitrate-nitrite ranged from below method detection limits (0.005 mg/l) in Delvan Bay to 0.188 mg/l at Blakeley Riverbank (Fig. 4-14). South Blakeley Riverbank had the lowest TKN and total nitrogen levels while Chocolatta Bay, Polecat Bay and Justin's Bay had the highest levels (Fig. 4-14). Total phosphorus levels were lowest at South of Chocolatta and highest in Chocolatta Bay (Fig. 4-6).

Nutrients – October 25-27, 2005

Nutrient analyses from October 25-27, 2005 are summarized in Table 4-6. Differences by location north and south of the causeway were minimal compared with the early October nutrient results. Sites north and south of the causeway all had similar levels of all nutrients (Table 4-6, Figs. 4-2, 4-3 and 4-15). Overall ammonia levels continued to be low and ranged from below method detection limits (<0.01 mg/l) in Polecat Bay and Delvan Bay to 0.07 mg/l at Mouth of Pinto Pass (Fig. 4-5). Nitrate-nitrite ranged from 0.028 mg/l in Delvan Bay to 0.204 mg/l at Blakeley Riverbank (Fig. 4-16). Pinto Pass, Tensaw Riverbank and Chocolatta Bay had the

lowest TKN and total nitrogen levels while Mouth of Pinto Pass and Polecat Bay had the highest levels (Fig. 4-16). Polecat Bay had the lowest total phosphorus levels and Mouth of Pinto Pass had the highest total phosphorus (Table 4-6 and Fig. 4-6).

Nutrients – March 2006

Nutrient analyses from March 2006 are summarized in Table 4-7. Similar to late October, sites north and south of the causeway had similar levels of all nutrients (Table 4-7, Figs. 4-2, 4-3 and 4-17). Ammonia levels continued to be low and ranged from 0.01 mg/l in Polecat Bay to 0.03 mg/l at Tensaw Riverbank, Blakeley Riverbank and South of Chocolatta (Fig. 4-5). Nitrate-nitrite ranged from 0.139 mg/l in Delvan Bay to 0.279 mg/l at Tensaw Riverbank and Pinto Pass (Fig. 4-18). Blakeley Riverbank and South of Chocolatta had the lowest TKN and total nitrogen levels while South Blakeley Riverbank and Polecat Bay had the highest levels (Fig. 4-18). Total phosphorus concentrations ranged from 0.055 in Polecat Bay to 0.210 mg/l at South of Justin's (Table 4-7 and Fig. 4-6).

Water Column Parameters – YSI and Nutrients MDS Plots

Appendix 5 contains MDS plots from Primer analyses, which graphically depict YSI and nutrient results by location north or south of the causeway and site. Data found in the MDS plots were from the four main sampling events: April 2005, August 2005, October 2005 and March 2006.

April 2005

Figures 5-1 and 5-2 graphically depict April 2005 data from YSI readings and nutrient analyses. MDS analyses of YSI and nutrient data resulted in a stress value of 0.06. Figure 5-1 presents the data labeled by location north or south of the causeway. Sites north of the causeway were distinct from sites south of the causeway with overlap limited to South Blakely Riverbank (Site 11). Comparisons of YSI parameters and nutrient concentrations using Primer's ANOSIM found significant differences to exist among sites north and south of the causeway (Global R=0.541, p=0.006). Grouping of sites with similar characteristics is clear in Figure 5-2. Mouth of Pinto Pass (Site 7), Pinto Pass (Site 8), South of Chocolatta (Site 9) and South of Justin's (Site 10) are grouped together and all are located south of the causeway reflecting similar YSI parameters and nutrient characteristics. Tensaw Riverbank (RB1) was not closely grouped with other sites. Polecat Bay (PB) and Delvan Bay (DB) were similar as were Chocolatta Bay and South Blakeley Riverbank.

August 2005

Figures 5-3 and 5-4 graphically depict data from YSI readings and nutrient analyses from the August 2005 collections. MDS analyses for YSI and nutrient parameters resulted in a stress value of 0.06 that is a good fit for the data. In contrast to April, distinctions among water quality

characteristics for sites north and south of the causeway are not clearly grouped (Fig. 5-3). ANOSIM analysis of YSI parameters and nutrient concentration failed to detect significant differences among north and south sites (Global R=0.011, p=0.370). Plotted by open, closed or riverbank, the data form three indistinct overlapping groups. Figure 5-4 depicts data labeled by site. Tensaw Riverbank and Mouth of Pinto Pass (riverbank) were similar in water quality measurements as were Pinto Pass (Site 8) and south of Chocolatta (Site 9). During August, 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. Delvan Bay (DB) and Chocolatta Bay (CB) were grouped and similar to the Blakeley riverine sites (Fig. 5-4).

October 2005

Figures 5-5 and 5-6 graphically depict data collected the YSI and from the nutrient analyses in October 2005. A stress value of 0.12 resulted from the MDS analyses for YSI and nutrient parameters which is a useful data fit but not as strong as the April or August data. Water quality characteristics for sites north and south of the causeway were similar at sites influenced by the Blakeley River (Blakeley Riverbank, South Blakeley Riverbank and South of Justin's) (Global R=0.211, p=0.115) (Fig. 5-5). Three distinct groupings of sites with similar characteristics are clear in Figure 5-6. Mouth of Pinto Pass (Site 7) water quality parameters were similar to Pinto Pass (Site 8) and South of Chocolatta (Site 9) (Fig. 5-6). As in August, 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. Polecat Bay (PB), Delvan Bay (DB), Chocolatta Bay (CB) and Tensaw Riverbank (RB1) are grouped together and all are located on the western side and north of the causeway.

March 2006

Figures 5-7 and 5-8 graphically depict data from YSI readings and nutrient analyses from the March 2006 collections. A stress value of 0.03 resulted from the MDS analyses for YSI and nutrient parameters that is an excellent fit for the data. Water quality characteristics for sites north and south of the causeway overlapped at the Mouth of Pinto Pass (Site 7), Pinto Pass (Site 8) and Blakeley Riverbank (RB2) sites (Global R=0.112, p=0.143). Tensaw Riverbank and Chocolatta Bay were also similar to sites located south of the causeway (Fig. 5-7). Groupings of sites with similar characteristics are clear in Figure 5-8 and different from April, August and October. Water characteristics in Polecat Bay (PB) and Delvan Bay (DB) were different from all other sites (Figure 5-8). Mouth of Pinto Pass (Site 7) water quality parameters were similar to Pinto Pass (Site 8) and Blakeley Riverbank (RB2) (Fig. 5-8). In contrast to August and October, only South Blakeley Riverbank (Site 11) and South of Justin's (Site 10) were closely grouped. Characteristics of South of Chocolatta were distinct but similar to Blakeley Riverbank, Chocolatta Bay, Mouth of Pinto Pass and Pinto Pass (Fig.5-8).

SEDIMENT PARAMETERS

Sediment samples were collected in April 2005 and October 2005 from each Mobile-Tensaw Delta site. Results from these analyses are found in Appendix 6. Comparative analyses (SPSS) of differences in sediment parameters 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. Samples were analyzed by location north or south of the causeway and site. The Primer E statistical package was also used to analyze sediment characteristics as a whole by north or south of the causeway and site.

Sediment – April 2005

Grain Size

Sediment analyses were conducted for percent clay, silt, sand and gravel composition. Gravel was not found in April samples and therefore was excluded from subsequent analysis. Causeway impacts on sediment grain size distribution in the lower Delta were apparent. Analyses by location north and south of the causeway detected significant differences to exist for percent clay ($p=0.013$) and sand ($p=0.026$) but not for percent silt ($p=0.128$) (Table 6-1, Fig. 6-1). Sites located north of the causeway had greater proportions of clay in samples than did sites located south of the causeway. In contrast, southern sites had higher percentages of sand in samples than did northern sites (Fig. 6-1).

Percentages of clay ($p=0.001$) and sand ($p=0.012$) varied significantly among some sites (Table 6-1, Fig. 6-2). Polecat Bay, Delvan Bay and Justin's Bay, all located north of causeway, had the greatest proportions of clay while some sites south of the causeway, Mouth of Pinto Pass and South Blakeley Riverbank, had the lowest proportions of clay. The proportion of clay at Polecat Bay was significantly different from those at Blakeley Riverbank, Mouth of Pinto Pass, Pinto Pass and South Blakeley Riverbank. Delvan Bay sediments contained significantly less sand than sediments at the Mouth of Pinto Pass and Pinto Pass. Percent silt differed marginally among some sites ($p=0.055$) (Table 6-1, Fig. 6-2). Silt composition ranged from a high of 65.35% in Delvan Bay to a low of 30.31% in Mouth of Pinto Pass (Table 6-1 and Fig. 6-2).

Percent Water, Total Organics and TOC

Percent water ($p=0.000$), total organics ($p=0.000$) and total organic carbon (TOC) ($p=0.004$) varied significantly north and south of the causeway. Sediments collected at sites located north of the causeway contained significantly higher percentages of water, total organics and TOC than did sites south of the causeway (Table 6-1, Figs. 6-3 and 6-5).

Percent water ($p=0.001$), total organics ($p=0.007$) and TOC ($p=0.024$) in sediments varied significantly among some sites (Table 6-1). Delvan Bay and Polecat Bay sediments contained high proportions of clay, silt and water. The lowest percentages of sediment water were found in samples collected south of the causeway where sandy sediments were abundant. Tensaw Riverbank sediments had the highest organic content while lowest organic content was found in sediments collected from sites south of the causeway. TOC was greatest in Delvan Bay and Tensaw Riverbank samples and lowest in sediments taken from Mouth of Pinto Pass, South of

Justin's and South Blakeley Riverbank (Table 6-1, Fig. 6-4 and 6-6). Variations in sediment organic material and TOC may be explained by differences in flushing patterns within the Delta.

Sediment MDS Plots

Figures 6-7 and 6-8 graphically depict sediment data as MDS plots. Data are presented by location north or south of the causeway (Fig. 6-7) and site (Fig. 6-8). MDS analyses of sediment parameters resulted in a stress value of 0.01 and thus an excellent data fit. Sediment characteristics of south and north sites were distinctly different from one another (Fig. 6-7), with the exception of Blakeley Riverbank. ANOSIM results showed significant differences in sediment characteristics at sites located north and south of the causeway (Global R=0.635, p=0.006).

Spatial heterogeneity in sediment composition are apparent in the figures and ANOSIM results which showed significant differences in sediment characteristics to exist among some sites (Global R=0.362, p=0.001) (Fig. 6-8). Polecat Bay was similar only to Justin's Bay in terms of sediment characteristics. Delvan Bay sediments were different from all sites except Tensaw Riverbank and Justin's Bay. Chocolatta Bay sediments differed from Delvan Bay, Polecat Bay and all sites south of the causeway. Tensaw Riverbank sediments differed from Polecat Bay (p=0.057) and Mouth of Pinto Pass (p=0.10). Justin's Bay sediment characteristics were similar to all sites except Pinto Pass and South Blakeley Riverbank. Sediment parameters were similar for Pinto Pass, South of Chocolatta, South of Justin's and South Blakeley Riverbank (Fig. 6-8).

Sediment – October 2005

Grain Size

Sediment grain size samples were collected again in October 2005 and analyses of the samples were conducted as previously described except that total organic carbon (TOC) was not measured. Unlike the April sampling, sediment composition north and south of the causeway was found to be only marginally significantly different for percent clay (p=0.064). No significant differences were detected for the proportions of silt (p=0.521), sand (p=0.241) or gravel (p=0.586) in samples (Table 6-2 and Fig. 6-9). In all likelihood these lack of differences were due to the close passage of Hurricane Katrina. Still, sites located north of the causeway had greater amounts of clay and silt than did sites located south of the causeway. In contrast, southern sites had higher percentages of sand than did the northern sites (Fig. 6-9).

Percentages of clay (p=0.013), silt (p=0.018), sand (p=0.012) and gravel (p=0.049) varied significantly among some sites (Table 6-2 and Fig. 6-10). Polecat Bay and Delvan Bay still had significantly greater proportions of clay than did the South Blakeley Riverbank. Delvan Bay also had a significantly greater percentage of silt and lower percentage of sand in samples than did those collected from South Blakeley Riverbank. Sediments at South Blakeley Riverbank also had a greater percentage of sand than did Tensaw Riverbank sediments. Unlike the previous sampling, gravel was found in sediments from South Blakeley Riverbank, Blakeley Riverbank and Pinto Pass (Table 6-2 and Fig. 6-10).

Percent Water and Total Organics

Sites north or south of the causeway differed in terms of percent water (p=0.041) but not total organics (p=0.144) (Table 6-2, Figs. 6-11 and 6-13). Sediments collected at sites north of the causeway contained significantly higher percentages of water than did sediments collected from sites south of the causeway (Fig. 6-11). While total organic content was greater at sites north of the causeway, it was not so at sites south of the causeway (Fig. 6-13).

Sediment water (p=0.000) and total organics (p=0.001) varied significantly among some sites (Table 6-2, Figs 6-12 and 6-14). Delvan sediments contained significantly higher percentages of water and total organics than did those collected from South Blakeley Riverbank and South of Justin's Bay. Delvan Bay sediment water content was also significantly greater than it was in Blakeley Riverbank, Justin's Bay, Mouth of Pinto Pass and Pinto Pass. South Blakeley Riverbank sediments contained lower percent water than did Polecat Bay, Chocolatta Bay and Tensaw Riverbank. South of Justin's Bay, sediment was lower in water content than it was in Polecat Bay (Fig. 6-12). Total organic content was significantly lower at South Blakeley Riverbank compared to Polecat Bay, Delvan Bay, Tensaw Riverbank and Mouth of Pinto Pass. Additionally, Delvan Bay sediments had higher percentages of organics than Blakeley Riverbank and South of Justin's (Fig.6-14).

Sediment MDS Plots

Figures 6-15 and 6-16 graphically depict sediment data as MDS plots. Data are presented by location north or south of the causeway (Fig. 6-15) and site (Fig. 6-16). MDS analyses of sediment parameters resulted in a stress value of 0.02 which is an excellent data fit. Sediment characteristics of south and north sites were similar (Fig. 6-15). ANOSIM results showed similar sediment characteristics at sites located north and south of the causeway (Global R=0.027, p=0.323).

Three major site groupings are apparent in Figure 6-16 and ANOSIM results showed significant differences in sediment characteristics among some sites (Global R=0.217, p=0.005). South Blakeley Riverbank sediments differed from all sites except Justin's Bay and Blakeley Riverbank. Polecat Bay, Delvan Bay and Tensaw Riverbank were similar in terms of sediment characteristics. Delvan Bay sediments were different from all sites except Tensaw Riverbank and Polecat Bay (Fig. 6-16).

BIOLOGICAL MONITORING - MACROINVERTEBRATES

Results from benthic sampling conducted in April, August and October 2005 and March 2006 are found in Appendix 7. Parametric comparisons of species richness and total macroinvertebrate density among sites using SPSS utilized all samples taken during each event. Additional comparisons presented in this section are based on the means of all samples collected at each site. Data were analyzed by location north or south of the causeway (N/S) and site. Analyses of differences in the abundances of the dominant invertebrate groups (conducted on a proportional basis) were also done for each sampling event. Again, the Primer E statistical

package was used to analyze benthic community structure as a whole by N/S and site. Tables 7-1 through 7-9 and Figures 7-1 to 7-30 summarize these data by sampling event. Mean values in the following text are presented on a per grab basis.

Macroinvertebrates – April 2005

Analyses of benthic samples collected north and south of the causeway detected no significant differences to exist for either species richness (p=0.778) or invertebrate density (p=0.366) (Table 7-2). Sites located south of the causeway had more species but fewer invertebrates than did sites north of the causeway (Figs. 7-1 and 7-2). ANOSIM did however detect significant differences in community structure (i.e. species composition and relative abundances) to exist north and south of the causeway (Global R=0.237, p=0.032). These results indicate that while numbers of species and total invertebrate density were comparable, species assemblages north and south of the causeway were different. The April 2005 MDS plot in Figure 7-3 presents the benthic assemblages by location north and south of the causeway. MDS comparisons of the benthic community assemblages at the eleven sampling sites had a stress value of 0.13, which is considered a useful data fit (Fig. 7-3). This indicated that species composition differed greatly on the two sides of the causeway.

The total numbers of invertebrates collected in April 2005 are presented by site in Table 7-1. Species richness (p=0.218) and total invertebrates (p=0.122) were not found to be statistically different among sites either (Table 7-2). Still important differences among sites were apparent but none seemed to be directly related to the causeway. Lower numbers of species were collected north of the causeway in Polecat Bay. More species were collected at stations located at the Blakeley Riverbank and Mouth of Pinto Pass. Blakeley Riverbank and Justin's Bay had the greatest densities of invertebrates than did either Polecat Bay or the site located South of Justin's had the fewest invertebrates (Tables 7-1 and 7-2, Figs. 7-4 and 7-5).

Comparisons of benthic community structure, based on ANOSIM comparisons of Bray-Curtis similarity indices, found significant differences in community structure to exist among sites (Global R=0.516, p=0.001) (Fig. 7-6). Benthic communities at sites north of the causeway and to the west were different from most others. Having said that, subsequent pairwise tests detected numerous differences among some sites and indicate the benthic communities of the Mobile-Tensaw Delta are spatially heterogeneous. Most notably, the community structure of Polecat Bay, where species richness and density were lowest, was found to be different from all other sites. Additionally, benthic composition of Delvan Bay was significantly different from that of sites located South of Chocolatta and South of Justin's. Site groupings by similarity in benthic community reflect the same patterns reported from the Primer ANOSIM analysis (Fig. 7-6).

Table 7-3 summarizes the proportions of major taxa by site and location north and south of the causeway. Chironomids, biting insects, were more abundant in collections made at sites north of the causeway than they were at sites south of the causeway (p=0.248) (Fig. 7-7). The greatest proportions of chironomids were found in samples collected in Polecat Bay and Chocolatta Bay (Fig. 7-8).

Proportions of other macroinvertebrate taxa groups were not found to vary significantly north and south (Table 7-3; Figs. 7-9, 7-11, 7-13, 7-15 and 7-17). In Polecat Bay and Pinto Pass benthic communities were characterized by greater proportions of polychaetes than other sites (Fig. 7-10). South of Justin's Bay and Pinto Pass had the highest proportions of oligochaetes (Fig. 7-12). Amphipod proportions were highest in Delvan Bay, Blakeley Riverbank, Mouth of Pinto Pass and South Blakeley Riverbank (Fig. 7-14). Bivalves were most abundant in collections from Mouth of Pinto Pass and South of Chocolatta (Fig. 7-18). Clearly invertebrate dominance varied greatly throughout the study area.

Macroinvertebrates – August 2005

Sites located north and south of the causeway were again not found to be statistically significantly different from one another in terms of either species richness (p=0.169) or invertebrate density (p=0.198) (Table 7-4). ANOSIM did again however find significant differences in species composition and relative abundance to exist among benthic communities north and south of the causeway (Global R=0.261, p=0.039). The August 2005 MDS plot in Figure 7-19 presents the benthic assemblages by location north and south of the causeway. The community assemblages for the eleven sampling sites had a stress value of 0.1 which is a useful/good data fit. The sites north and south of the causeway were clearly different in terms of benthic community structure (Fig. 7-19).

The numbers of macroinvertebrate taxa and invertebrates collected in August 2005 are presented by site in Table 7-1, Figure 7-20 and Figure 7-21. Significant differences in species richness (p=0.000) and total macroinvertebrate abundance (p=0.004) were detected among some sites (Table 7-4). Fewer species were collected at the westernmost sites north of the causeway: Polecat Bay and Delvan Bay. Collections made in Polecat and Delvan Bays had significantly fewer species than did collections made in Pinto Pass (just to the south), South of Justin's and Blakeley Riverbank. Blakeley Riverbank had more species than did samples taken from either Chocolatta Bay or Justin's Bay (Fig. 7-21). Species richness at Pinto Pass, South of Chocolatta, South Blakeley Riverbank and Tensaw Riverbank did not differ significantly from any other sites.

Samples taken from Blakeley Riverbank and Pinto Pass had the greatest number of invertebrates while Delvan Bay and Polecat Bay had the fewest (Tables 7-1 and 7-4, Fig. 7-20). Significantly fewer invertebrates were collected in Delvan Bay than at the Blakeley Riverbank (RB2), Pinto Pass and South Blakeley Riverbank. Polecat Bay also had significantly lower numbers of invertebrates than did Blakeley Riverbank (Fig. 7-20). Invertebrate densities at Mouth of Pinto Pass, South of Chocolatta, South of Justin's, Tensaw Riverbank and Justin's Bay did not differ significantly from any other sites.

ANOSIM detected significant differences in community structure to exist among sites as well (Global R = 0.502, p=0.001). Sites with few species and low density, Polecat and Delvan Bays, were found to be similar in structure to each other. The benthic structure of Polecat Bay was found to be significantly different from all other sites. Delvan Bay was different from sites south of the causeway and riverbank sites. Tensaw Riverbank differed significantly from all sites

except Chocolatta Bay, Mouth of Pinto Pass and South Blakeley Riverbank. Additionally, the benthic structure at South Blakeley Riverbank was similar to that of Chocolatta Bay, Justin's Bay and South of Justin's. Community structure at South of Chocolatta was different from all sites except Mouth of Pinto Pass, Pinto Pass, South of Justin's and Justin's Bay. Similarity in benthic community structure by site is depicted in Figure 7-22 and reflects the ANOSIM analysis results.

Table 7-5 summarizes proportions of major taxa collected by site and location north and south of the causeway. Proportions of chironomids were not found to be significantly different between north and south sites (p=0.142) (Fig. 7-7). Sites with the greatest proportions of chironomids included Delvan Bay, Blakeley Riverbank and Justin's Bay (Fig. 7-8).

Samples collected at sites south of the causeway had greater proportions of estuarine polychaetes than did samples from sites north of the causeway (p=0.033) (Fig.7-9). Sites with higher salinity, Pinto Pass, Mouth of Pinto Pass, Tensaw Riverbank and South of Chocolatta, were all dominated by polychaetes (Fig. 7-10). Sites located north and south were not significantly different in the occurrence of oligochaetes (p=0.326) (Fig. 7-11). Greater proportions of oligochaetes were collected in Chocolatta Bay, Justin's Bay and Tensaw Riverbank (Fig. 7-12) where salinities were relatively low. Proportions of amphipods were not significantly different north and south of the causeway (p=0.767) (Fig. 7-13). Amphipod proportions were highest at the Blakeley Riverbank, South of Justin's and South of Chocolatta (Fig. 7-14).

Proportions of gastropods collected in samples north and south of the causeway were not significantly different from one another (Table 7-5 and Fig. 7-15). Delvan Bay and South Blakeley Riverbank had the highest proportions of gastropods in samples (Fig. 7-16). Proportion of bivalves collected in samples was marginally higher (p=0.093) at sites south of the causeway than at sites north of the causeway (Figs. 7-17). Bivalve proportions were greatest just south of Justin's and Chocolatta Bays (Fig. 7-18).

Macroinvertebrates – October 2005

The October sampling was conducted from October 25-27, 2005. Because of the anticipated disruption of benthic habitats following Hurricane Katrina, sampling was delayed in order to allow time for the benthic communities to recover from the disturbance.

During October and following the passage of Hurricane Katrina, significantly more species (p=0.05) were collected at sites located south of the causeway than at sites north of the causeway (Table 7-6 and Fig. 7-1). As in August, invertebrate density was similar at the south and north sites (p=0.357) (Table 7-6 and Fig. 7-2). ANOSIM results showed significant differences in community composition to exist north and south of the causeway (Global R=0.52, p=0.004). The October 2004 MDS plot in Figure 7-23 identified 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 7-23 illustrating differences in biological community structure.

By site, Table 7-1 and Figures 7-24 to 7-25 contain mean number and standard deviation of macroinvertebrate taxa and total number of invertebrates collected in October 2005. Species richness (p=0.000) and invertebrate density (p=0.012) varied significantly among some sites (Table 7-6). Sites located along the Tensaw Riverbank and South of Justin's had the highest numbers of species. Lower numbers of species were again collected from Polecat Bay. Pairwise comparisons showed that Polecat Bay had significantly fewer species than all of the other sites except Chocolatta Bay and Blakeley Riverbank (Fig. 7-25). Polecat Bay had significantly lower invertebrate density than did Tensaw Riverbank and South of Justin's. Polecat Bay also had marginally significant lower density than did Justin's Bay (p=0.064) and sites located at South of Chocolatta (p=0.064) and South Blakeley Riverbank (p=0.061) (Tables 7-1 and 7-6, Fig. 7-24). No other significant differences were noted most likely due to the variability within sites.

Comparisons of community structure using Primer's ANOSIM also detected significant differences among sites (Global R=0.569, p=0.001). Site groupings by similarity in benthic community reflect the same patterns reported from the Primer ANOSIM analysis (Fig. 7-26). The patterns of dissimilarity among sites reinforce the differences detected in comparisons of samples collected above and below the causeway. The composition of the benthic community in Polecat Bay differed from all other sites except Delvan Bay and Chocolatta Bay. Delvan Bay was different from all sites except Polecat Bay, Chocolatta Bay and Justin's Bay. The Tensaw Riverbank benthic community differed significantly from Polecat Bay, Delvan Bay, Chocolatta Bay, Mouth of Pinto Pass, Pinto Pass, South of Chocolatta and South of Justin's. Chocolatta Bay was significantly different from all sites except Polecat and Delvan Bays. Blakeley Riverbank had a significantly different benthic community than all sites except Justin's Bay, South Blakeley Riverbank and Tensaw Riverbank. Justin's Bay had a significantly different community structure than all sites except Delvan Bay, Tensaw Riverbank and Blakeley Riverbank. The Mouth of Pinto Pass and Pinto Pass sites were similar and had a significantly different benthic community than all other sites. The sites located South of Chocolatta and South of Justin's differed significantly in community structure compared to all other sites.

Table 7-7 summarizes the relative proportions of major taxa by site and location north and south of the causeway. Proportions of freshwater chironomids, characteristic of freshwater lakes and estuaries, in the benthic communities did not vary significantly at the north and south sites (p=0.124) (Figs. 7-7). Chironomids contributed lower proportions of the overall benthic communities in October than they did in April and August collections perhaps due to the Katrina induced increases in salinity. During late October, salinity levels were at their highest levels during the study. Chironomids contributed a greater proportion of the invertebrates collected in Polecat Bay and Delvan Bay than they did at other sites (Fig. 7-8).

Unlike the previous sampling, proportions of polychaetes did not differ significantly between north and south sites (p=0.33) (Fig. 7-9). Polychaetes dominated the benthic community in October and comprised greater than fifty percent of all invertebrates collected at all sites, except Blakeley Riverbank (Fig. 7-10). It is of note, that polychaetes were not so uniformly distributed in the fall of the previous years study. Proportions of oligochaetes were similar north and south of the causeway (p=0.69) (Fig. 7-11). During October, oligochaete numbers were generally lower than collections in August. Proportions of oligochaetes were greatest in Blakeley Riverbank and South of Justin's (Fig. 7-12).

Generally, amphipod numbers remained low across all sites in October (Fig. 7-14). Proportions of amphipods were not significantly different north or south of the causeway (p=0.627) (Fig. 7-13). The highest proportions of amphipods were found in samples collected at Tensaw Riverbank and Pinto Pass (Fig. 7-13). Proportions of gastropods were similar north and south of the causeway (p=0.595) (Fig. 7-15). Gastropod numbers were highest at Blakeley Riverbank, Delvan Bay and South Blakeley Riverbank (Fig. 7-16). The proportion of bivalves was significantly greater at sites south of the causeway than at sites north of the causeway (p=0.003) with all of the bivalves occurring at sites south of the causeway (Table 7-7 and Figs. 7-17 and 7-18).

Macroinvertebrates – March 2006

Comparisons of sites located north and south of the causeway again showed no significant differences in species richness (p=0.498) or invertebrate density (p=0.490) (Table 7-8, Figs. 7-1 and 7-2). Sampling sites identified by location north or south of the causeway formed two indistinct overlapping groups (Fig. 7-27). ANOSIM results also showed no significant differences in community structure at sites located north and south of the causeway (Global R=0.168, p=0.145). The MDS plot in Figure 7-27 depicts benthic assemblages by north and south of the causeway. MDS comparisons of the benthic community assemblages at the eleven sampling sites had a stress value of 0.09, which is considered a good data fit.

Mean number and standard deviation of macroinvertebrate taxa and total invertebrate abundance collected in March 2006 are presented by site in Table 7-1 and Figures 7-28 and 7-29. Species richness (p=0.095) and invertebrate density (p=0.000) were different among some sites (Table 7-8). Species richness was lower north of the causeway in Polecat Bay and Delvan Bay than other sites. Justin's Bay and South of Justin's Bay had the highest number of species. Justin's Bay and South of Justin's Bay also had the greatest number of invertebrates while Polecat Bay and Chocolatta Bay had the fewest invertebrates (Tables 7-1 and 7-8, Figs. 7-28 and 7-29).

Comparisons made using ANOSIM found significant differences in benthic community structure to exist among sites (Global R=0.684 p=0.001). Graphical depictions of sites mimic patterns detected in the ANOSIM analyses (Fig. 7-30). Pairwise tests showed numerous differences between sites at the p=0.10 level. Clearly, the community structure of Polecat Bay was different from all other sites except Delvan Bay. Delvan Bay and Chocolatta Bay benthic communities were significantly different from all other sites. Tensaw Riverbank was not different from Blakeley Riverbank, South of Justin's and South Blakeley Riverbank. South Blakeley Riverbank in terms of species composition was similar to Blakeley Riverbank, Mouth of Pinto Pass and South of Justin's. The sites at Mouth of Pinto Pass and Pinto Pass were similar as were Pinto Pass and South of Justin's.

Table 7-9 summarizes the relative proportions of major taxa collected at the sites, locations north and south of the causeway, and by habitat type. Relative proportions of chironomids were not significantly different at sites north and south of the causeway (p=0.223) (Fig. 7-7). The greater proportions of chironomids were found in samples collected from Polecat Bay, Delvan Bay and

Tensaw Riverbank (Fig. 7-8). Proportions of chironomids were higher in the March collections than in the October collections.

Proportions of various macroinvertebrate taxa groups were not found to vary significantly with causeway location (Table 7-9), except that bivalves were more abundant south of the causeway ($p=0.002$) (Fig. 7-17) with highest relative proportions occurring at South of Chocolatta, Mouth of Pinto Pass, South Blakeley Riverbank and South of Justin's (Fig. 7-18).

Justin's Bay, Polecat Bay, Pinto Pass and Delvan Bay benthic communities were still characterized by greater proportions of estuarine polychaetes than found at other sites (Fig. 7-10). South of Justin's and all four riverbank sites had the highest proportions of oligochaetes indicating a predominantly freshwater environment (Fig. 7-12). Amphipod proportions were also highest in two riverbank sites: Tensaw Riverbank and Blakeley Riverbank (Fig. 7-14). Chocolatta Bay, Delvan Bay and Tensaw Riverbanks had the highest proportions of gastropods (Fig. 7-16).

Biological Monitoring – Primer BIOENV Analyses

Primer BIO-ENV analyses were conducted using benthic community, YSI parameter, nutrient level and sediment composition data for the April 2005 and October 2005 sampling events. BIO-ENV analysis correlates biological data with physical data using similarity matrices.

The April and October benthic communities were correlated with spatial patterns for water column parameters as well as sediment characteristics (Table 5). The best overall fit for the model was specific conductivity (which was converted to salinity as described previously), which explained 61.9% of the observed benthic community variation (Table 5). Model combinations of specific conductivity with percent clay, dissolved oxygen or ammonia explained 55.4% to 57.1% of the variance observed in invertebrate distributional patterns.

Differences in physical parameters were probably due to seasonal shifts in freshwater inflow and hurricane passages (e.g. Hurricane Katrina). The variance observed in the invertebrate distributional patterns were clearly the result of these influences. For example, DO was significantly different among some sites during April and October. Additionally, differences observed in sediment characteristics from April to October may have been the result of the passage of Hurricane Katrina.

Table 5. The model results from Primer BIO-ENV analyses conducted using benthic community, YSI readings, nutrient data and sediment data for the April 2005 and October 2005 sampling events. The number of model variables, correlation value and variable selections are listed (specific conductivity = SpCond; percent clay = clay; dissolved oxygen = DO; and ammonia = NH_4).

Number of Variables	Correlation	Variable Selections
1	0.619	SpCond
2	0.571	SpCond, DO
2	0.563	SpCond, Clay
2	0.554	SpCond, NH_4

BIOLOGICAL MONITORING – FISH

Appendix 8 contains data tables for the June 2005, August 2005, November 2005 and March 2006 fish sampling. All the fish data is summarized in Table 8-1. Tables 8-2 through 8-24 contain data from individual samplings and Figures 8-1 and 8-2 summarize the number of species and fish collected during each sampling event. Three trawls were conducted in Chocolatta Bay and south of the causeway in all months except November when only two trawls could be conducted south of the causeway. During August the third trawl south of the causeway caught an alligator and therefore no data were collected.

June 2005

Mixtures of estuarine-dependent and freshwater fishes were collected in June. Chocolatta Bay trawl collections during June were dominated by anchovy (Trawl 1: n=129; Trawl 2: n=0; and Trawl 3: n=266). Small sized largemouth bass (n=30), gulf pipefish (n=32) and rainwater killifish (n=32) were also collected in Chocolatta Bay trawl 1. Nine fish were caught in trawl 2 and included black crappie (n=2), channel catfish (n=2), blue catfish, gulf pipefish, redear sunfish, sheepshead and red spot sunfish. In addition to anchovies, trawl 3 included channel sand seatrout (n=8), catfish (n=6), gulf menhaden (n=5), bay whiff (n=4) and spot (n=3). Total numbers of species collected in Chocolatta Bay were 14, 7 and 6 for total fish counts of 272, 9 and 92 respectively (Tables 8-2 to 8-4). South of the causeway, trawl one was dominated by blue catfish (n=58), spot (n=9) and Atlantic croaker (n=8). Trawl two had similar numbers of gulf pipefish (n=3), blue crab (n=2) and brown shrimp (n=2). Spot (n=7) was the dominant species in trawl three followed by silverside (n=3). Total numbers of species collected south of the causeway were 9, 3 and 5 for total fish counts of 95, 7 and 13 respectively (Tables 8-5 to 8-7). Overall, the total number of species and numbers of fish collected were greater in Chocolatta Bay compared to south of the causeway (Figs. 8-1 and 8-2).

August 2005

As in June, estuarine-dependent and freshwater fishes were collected in August. During August 2005, anchovy and sand seatrout dominated the Chocolatta Bay trawls while anchovy and spot dominated the south of the causeway trawls (Tables 8-8 to 8-13). Chocolatta Bay trawls contained 10, 11 and 10 species and 525, 256 and 367 fish (Tables 8-8 to 8-10). South of the causeway, total fish abundance and number of species were lower than the Chocolatta Bay collections (Figs. 8-1 and 8-2). The first trawl contained 9 species and 194 fish and the second trawl had 7 species comprising 75 fish. The third trawl south of the causeway captured an alligator which destroyed the net and therefore no data was collected (Tables 8-11 to 8-13).

November 2005

During November 2005, only estuarine-dependent (bay anchovy and brown shrimp) organisms were collected in Chocolatta Bay and south of the causeway (Tables 8-14 to 8-18). Due to weather constraints, only two trawls were conducted south of the causeway. Total numbers of

species collected in Chocolatta Bay were 5, 8 and 6 for total fish counts of 329, 3119 and 2216 respectively. Trawls south of the causeway contained 6 and 7 species for fish counts of 854 and 1059 respectively. Anchovy comprised approximately 97% of Chocolatta Bay fish and 90% of fish south of the causeway (Tables 8-14 to 8-18). Similar to June and August, species diversity and density were greater in Chocolatta Bay compared to south of the causeway (Figs. 8-1 and 8-2).

March 2006

During March 2006, Chocolatta Bay trawl collections were dominated by estuarine dependent Atlantic croaker, gulf menhaden and bay anchovy (Tables 8-19 to 8-21). While bay anchovy continued to dominate collections south of the causeway, their abundance was lower than in the November collections (Tables 8-22 to 8-24). As in previous months, the total number of fish species was greater in Chocolatta Bay (n=10) than south of the causeway (n=6). In contrast to previous sampling events, collections made south of the causeway had more fish (n=189) than did Chocolatta Bay collections (n=162) (Figs. 8-1 and 8-2).

Biological Monitoring – Fish MDS Plots

Appendix 8 contains MDS plots from Primer analyses, which graphically depict fish results by location north or south of the causeway. Data found in the MDS plots were from the four main sampling events: June 2005, August 2005, November 2005 and March 2006.

Figures 8-3 through 8-6 graphically depict fish data all four collections. During all four sampling events, MDS analyses of collections resulted stress values ranging from 0 to 0.09 which are excellent data fits. Groupings of collections with similar characteristics are clear for each month (Figs. 8-3 to 8-6). Collections from Chocolatta Bay (north) during November are not grouped as closely compared to other months. Anchovies dominated the fish community but the number collected in Trawl 1 (n=315) were lower than trawls 2 and 3 (n=3013, n=2216). Comparisons of fish collections using Primer's ANOSIM found differences between collections from north or south of the causeway during June (Global R=0.444, p=0.10), August (Global R=1.0, p=0.10) and March (Global R=1.0, p=0.10) but not November (Global R=0.0, p=0.50).

SUMMARY

Based on the 2005-2006 monitoring and sampling events, short and long-term variations in the hydrography were evident on each side of the causeway. Continuous monitoring data showed that variability in water quality parameters can be great, changing on temporal scales ranging from days to months. Seasonal changes in temperature, salinity (and specific conductivity) and dissolved oxygen occurred at all sites although the magnitude of these changes varied among sites. Tensaw River North, the most northern site, had lower salinity than sites closer to the causeway. Continuous monitoring salinity data suggests that salt and fresh water exchange does occur in the lower Delta. During fall 2005, salinities were highest at USS Alabama and Chocolatta Bay and to a lesser extent Tensaw River South and Apalachee River South suggesting that gulf waters are primarily moving up the western side of the Delta.

Salinity was highest following the passages of hurricanes Katrina and Rita in August and September 2005, respectively. High salinities were detected at the most northern sites: Apalachee River North and Tensaw River North. Salinity exceeded 15 psu at all sites during Hurricane Katrina but persisted longer at the most southern stations (esp. USS Alabama and Chocolatta). During the passage of Hurricane Ivan in 2004, Chocolatta Bay salinity peaked at 14 psu. The occurrence of these extremely large intrusions of high salinity waters undoubtedly masked causeway impacts on the local fauna observed in the first year of study.

Periods of low dissolved oxygen were recorded in Chocolatta Bay and at stations at the USS Alabama and Apalachee River North following the passage of each hurricane and were probably the result of low DO water being pushed up into the Delta from Mobile Bay. In addition to the passages of Hurricanes Dennis, Katrina and Rita, outer bands from other hurricanes (Table 4) also affected the Mobile-Tensaw Delta DO. Between July and December 2005, four hypoxic events were recorded north of the causeway at Apalachee River North and nine hypoxic events were recorded in Chocolatta Bay. In contrast, only three hypoxic events at USS Alabama located south of the causeway. Hypoxic events ranged in duration from a few hours to eight days depending on the site. Intermittent hypoxic "spikes" were also observed at the Delta sites. As such, the Chocolatta Bay site appears to have low water column turnover and high retention time. Although Chocolatta water exchange is not clearly understood, it is apparent that the hurricane systems allowed water exchange to occur within Chocolatta Bay but did not necessarily decrease the resulting retention time of the "new water". The numerous hypoxic events recorded in Chocolatta 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, Chocolatta Bay sediments contained high percentages of clay, silt, total carbon and water supporting this hypothesis.

Spatially heterogeneous patterns of hydrography were recorded during all major sampling events. Significant differences in temperature, salinity, dissolved oxygen (mg/l), chlorophyll *a* and turbidity occurred among sites during all major sampling events. Evidence of causeway impacts on local hydrography were also apparent for some water column parameters for sites located north and south of the causeway. Temperatures were greater at sites located north of the causeway during the April and August 2005 and March 2006 sampling events. Temperatures

had decreased at all sites by late October. Unlike the previous sampling efforts, temperatures north and south of the causeway were not statistically significantly different from one another.

During April and August 2005 and March 2006, salinity was generally low and not found to differ north and south of the causeway. Salinity was dramatically higher in October than in previous months. In general, salinity was greater, although not significantly so, at sites south of the causeway than at sites north of the causeway. Monthly salinity readings from the study sites were also greater on the western side of the Delta and to the south of the causeway than elsewhere, especially during August and October.

Dissolved oxygen readings were highest in March 2006 and variable by site and month during the April, August and October samplings. During April 2005, sites located north of the causeway had higher DO concentrations than did sites south of the causeway. These differences may have been due to unimpeded daily exchanges of higher salinity waters from the lower Mobile Bay. If true, these findings suggest important impacts of the causeway on an ecologically important hydrographic parameter. DO concentrations were similar at sites north or south of the causeway during August and October 2005 and March 2006.

Evidence of causeway impacts was also apparent in the chlorophyll analyses. Generally speaking, chlorophyll *a* levels were lower at stations south of the causeway. In contrast, sites located north of the causeway had higher chlorophyll *a* levels that varied in magnitude by month as well as within and among sites. During April and October 2005, chlorophyll *a* concentrations were significantly and marginally greater, respectively, north of the causeway than south of the causeway. Chlorophyll *a* concentrations were greater, albeit not significantly so, at sites north of the causeway than at sites south of the causeway during August 2005 and March 2006. Northern sites had higher chlorophyll *a* levels than southern sites, which may be in part due to reduced flushing rates.

Turbidity was significantly higher north of the causeway than south of the causeway in April and October 2005. Turbidity was similar north and south of the causeway during August 2005 and March 2006. Delta waters were most turbid during March most likely due to passing frontal systems and wind resuspension of fine-grained sediments, which are abundant north of the causeway.

Spatial variability was evident both within and among sites for water quality parameters as well as benthic and sediment collections. The causeway provides a physical barrier, which spatially separated study sites north of the causeway from the control sites located south of the causeway. The evidence of probable barrier effects became less apparent following the passages of hurricanes especially in relation to sediment characteristics and water column salinity and dissolved oxygen concentrations.

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.

Nutrient concentrations (ammonia, nitrate-nitrite, total Kjeldahl nitrogen, total nitrogen and total phosphorus) also varied significantly with season. Significant differences in nutrient concentrations north and south of the causeway were most numerous during early October.

Spatial and temporal variability was evident for sediment collections in April and October 2005. During April 2005, samples collected north of the causeway had significantly greater amounts of clay, water, total organics and TOC and lower amounts of sand than samples collected south of the causeway. In contrast, by October 2005 significant differences in sediment composition were minimal. Sediment water was significantly greater and clay was marginally higher at sites north of the causeway than sediments at sites south of the causeway.

April and October sediment samples differed in overall composition, most likely due to the homogenizing effects by Hurricane Katrina (Figs. 3 and 4). October sediment samples collected from sites north and south of the causeway contained far more silt and far less clay and sand than found in samples collected in April. Additionally, sediments from three sites (north and south of causeway) contained gravel in October which was absent from all of the April samples (Fig. 4). Additionally, sediment organics were higher both north and south of the causeway in October collections than in April collections. North of the causeway, the proportion of sediment water was greater in April samples but south of the causeway sediment water content was greater in October samples (Fig. 3).

Interestingly, noticeable differences in sediment composition from three of the riverbank sites were found between the April and October collections. The riverbank sites located at Mouth of Pinto Pass and along the Blakeley Riverbank and Tensaw Riverbank are all on major water exchange paths through the causeway. The sediment samples collected in October had higher percentages of silt and lower percentages of sand than the April samples. Total organic material was also greater at Mouth of Pinto Pass and Tensaw Riverbank during October. In contrast South Blakeley Riverbank sediments had less silt and more sand and gravel compared with April collections. Sediment changes that occurred at the Delta riverbank sites show the impacts of a major hurricane (i.e. Katrina) on the ecosystem dynamics.

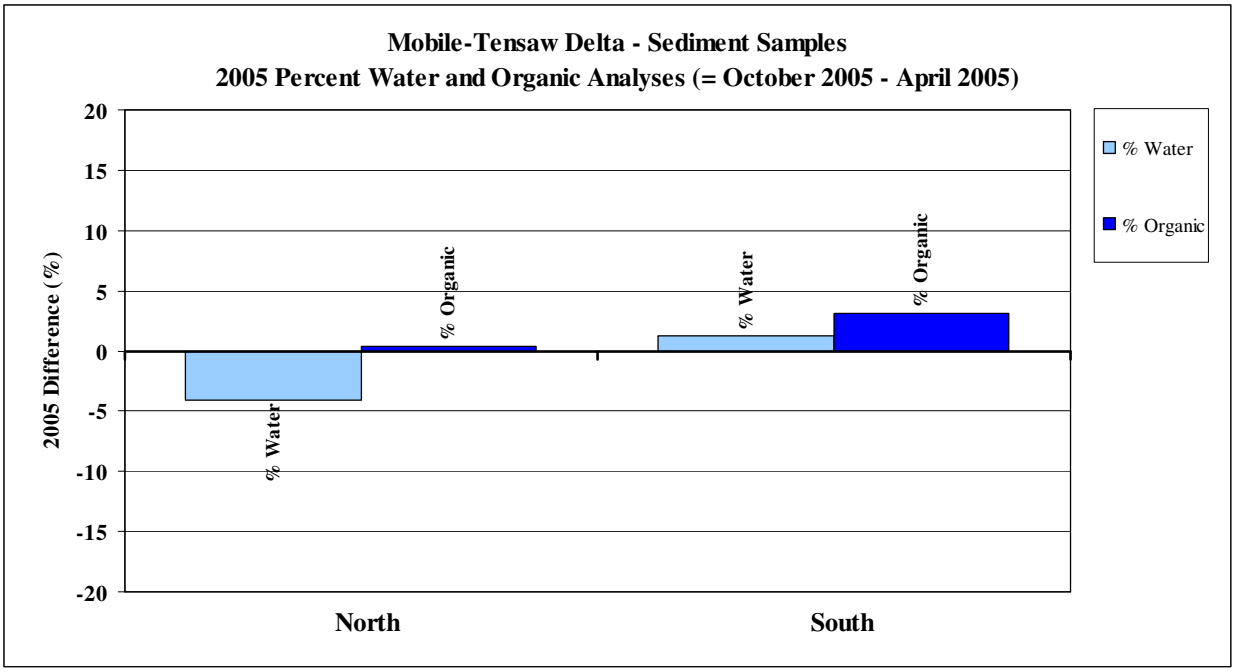


Figure 3. Changes in sediment percent water and total organics (=October 2005 mean weight % - April 2005 mean weight %) are plotted by location north and south of the causeway for the April and October 2005 sampling events.

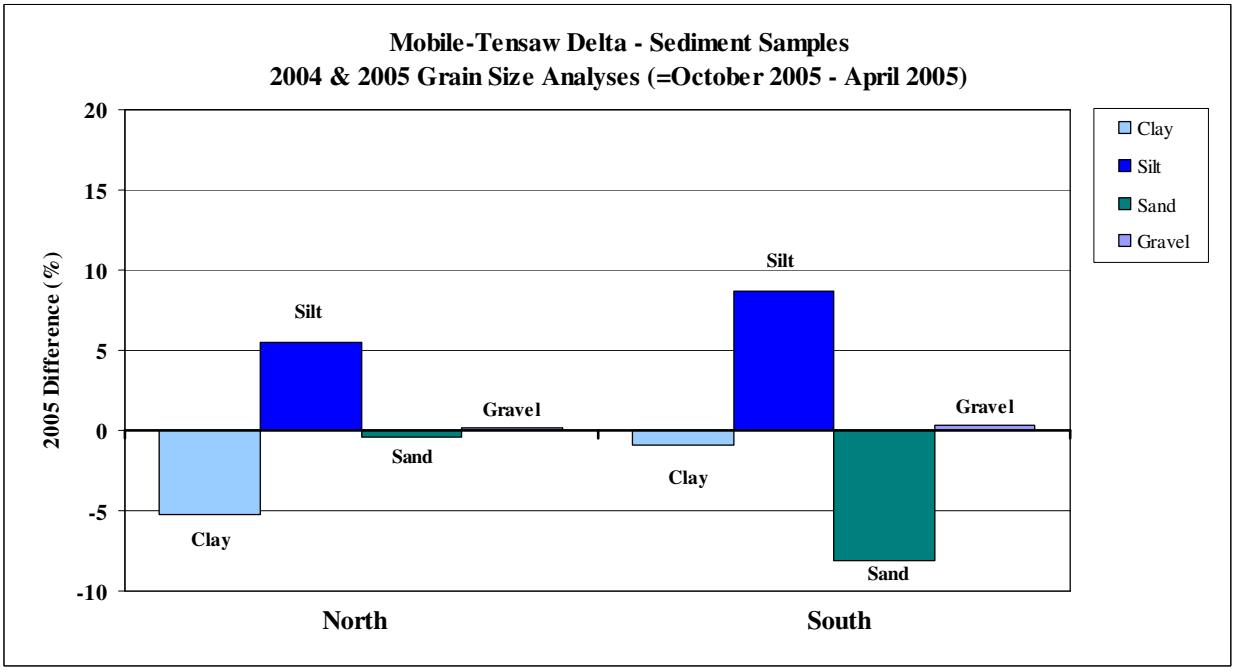


Figure 4. Changes in sediment grain size (=October 2005 mean weight % - April 2005 mean weight %) as gravel, sand, silt and clay are plotted by location north and south of the causeway for the April and October 2005 sampling events.

Consistently, sites located south of the causeway had higher species richness and invertebrate density than sites north of the causeway except during April 2005. Sites south of the causeway also had high proportions of sand while sites north of the causeway were characterized by higher proportions of clay and silt. Northern site sediments were also characterized by significantly higher percentages of water and total organics than were sites south of the causeway.

Significant or marginally significant differences occurred among sites with regard to number of species and total number of invertebrates for the August and October 2005 and March 2006 benthic collections but not for April 2005 collections (SPSS results). Comparisons of benthic community structure using Primer's ANOSIM found significant differences to exist among sites during all four sampling events. Based on BIO-ENV analyses, the variance observed in invertebrate distributional patterns (April and October) was influenced by patterns in water column and sediment parameters. Specific conductivity was the most important variable during April and October and explained 61.9% of the observed variations in benthic community structure. Model combinations of specific conductivity with percent clay, dissolved oxygen or ammonia explained 55.4% to 57.1% of the variance observed in invertebrate distributional patterns.

Proportions of major invertebrates groups changed seasonally. During periods of low salinity, proportions of chironomids were high (April and August) and were found in greatest numbers north of the causeway. Polychaete proportions peaked during October when salinities were highest. Peak oligochaete proportions varied by site and month. Amphipod proportions were highest in April and gradually generally decreased through March 2006, which is most likely explained by fish feeding habits. Gastropods were variable by site and sampling period. Highest proportions of bivalves occurred during April 2005 and March 2006 and were found in higher densities at sites south of the causeway for all four sampling events.

Fish species composition, species richness and invertebrate density also differed north and south of the causeway during June 2005, August 2005, November 2005 and March 2006. Mixtures of estuarine dependent and freshwater fishes were collected in June and August. Estuarine dependent fish (anchovies) and invertebrates (brown shrimp) dominated collections in November 2005. March 2006 collections also contained estuarine dependent fishes. Fish abundance and species diversity were greater in collections made in Chocolatta Bay than in collections south of the causeway except during March when fish abundance was slightly higher south of the causeway which suggests both spatial and seasonal factors influence the fish community.

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. Compared with 2004, however, these effects were not as strong during 2005/2006 due to active hurricane season.

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 confounded by western shore land-use impacts. In contrast, the eastern shore is less developed with lower 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 we suspect along 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.

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Clarke, K. R. and R. H. Green. 1988. Statistical design and analysis for a 'biological effects' study. *Mar. Ecol. Prog. Ser.* 46: 213-226.

Mobile Bay Watch, Inc. / Mobile Baykeeper and Dauphin Island Sea Lab. 2004. Hydrological Modifications Impact Study Quality Assurance Project Plan – Rev. 5 FINAL.

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Appendix 1

Continuous Monitoring 2005:

USS Alabama, Tensaw River South, Chocolatta Bay, Apalachee River South, Apalachee River North and Tensaw River North

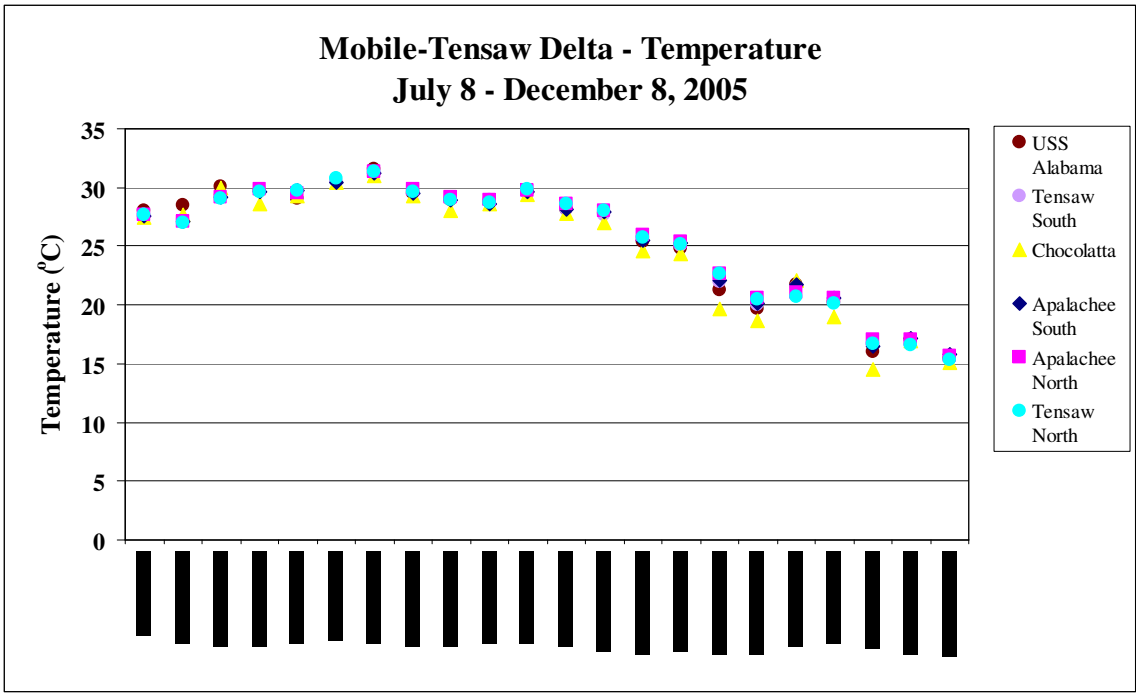

Figure 1-1. Mean temperature (°C) presented by week from July 8 to December 8, 2005 for USS Alabama, Tensaw River South, Chocolatta Bay, Apalachee River South, Apalachee River North and Tensaw River North.

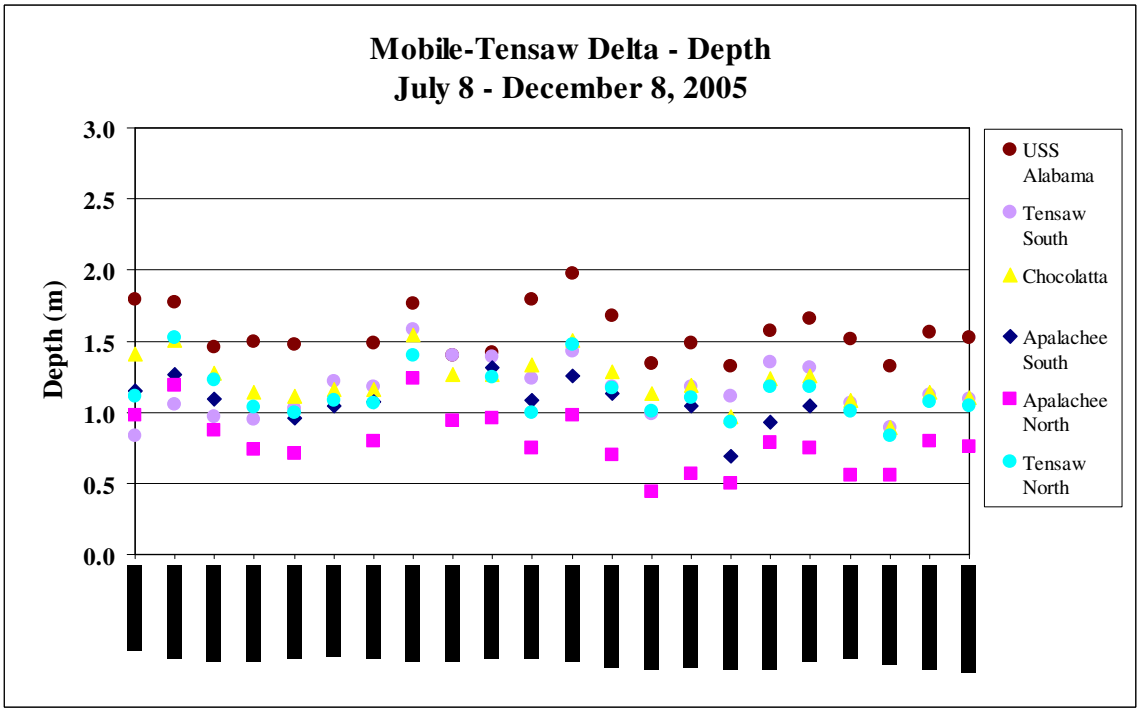

Figure 1-2. Mean depth (m) presented by week from July 8 to December 8, 2005 for USS Alabama, Tensaw River South, Chocolatta Bay, Apalachee River South, Apalachee River North and Tensaw River North.

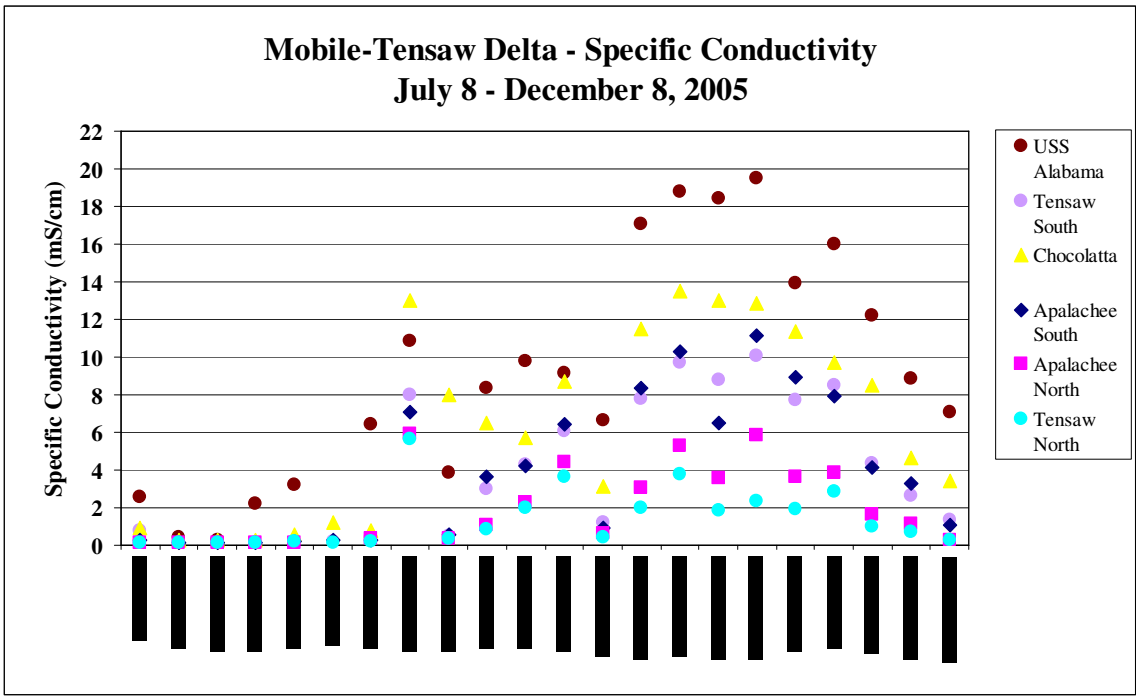

Figure 1-3. Mean specific conductivity (mS/cm) plotted by week from July 8 to December 8, 2005 for USS Alabama, Tensaw River South, Chocolatta Bay, Apalachee River South, Apalachee River North and Tensaw River North.

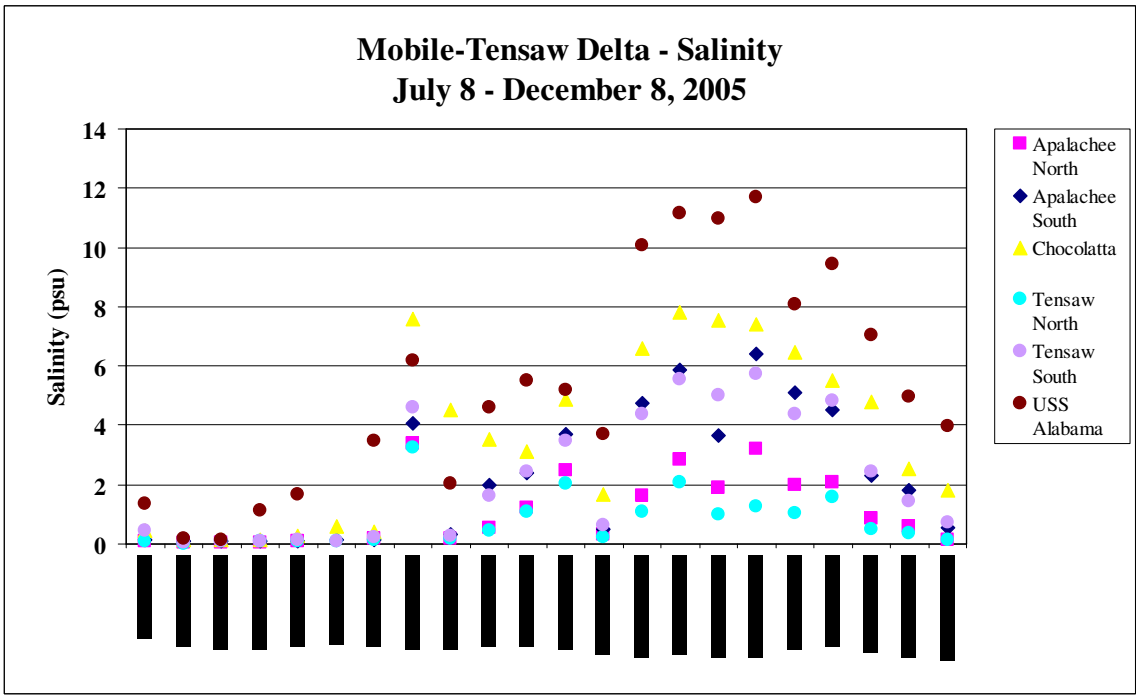

Figure 1-4. Mean salinity (psu) plotted by week from July 8 to December 8, 2005 for USS Alabama, Tensaw River South, Chocolatta Bay, Apalachee River South, Apalachee River North and Tensaw River North.

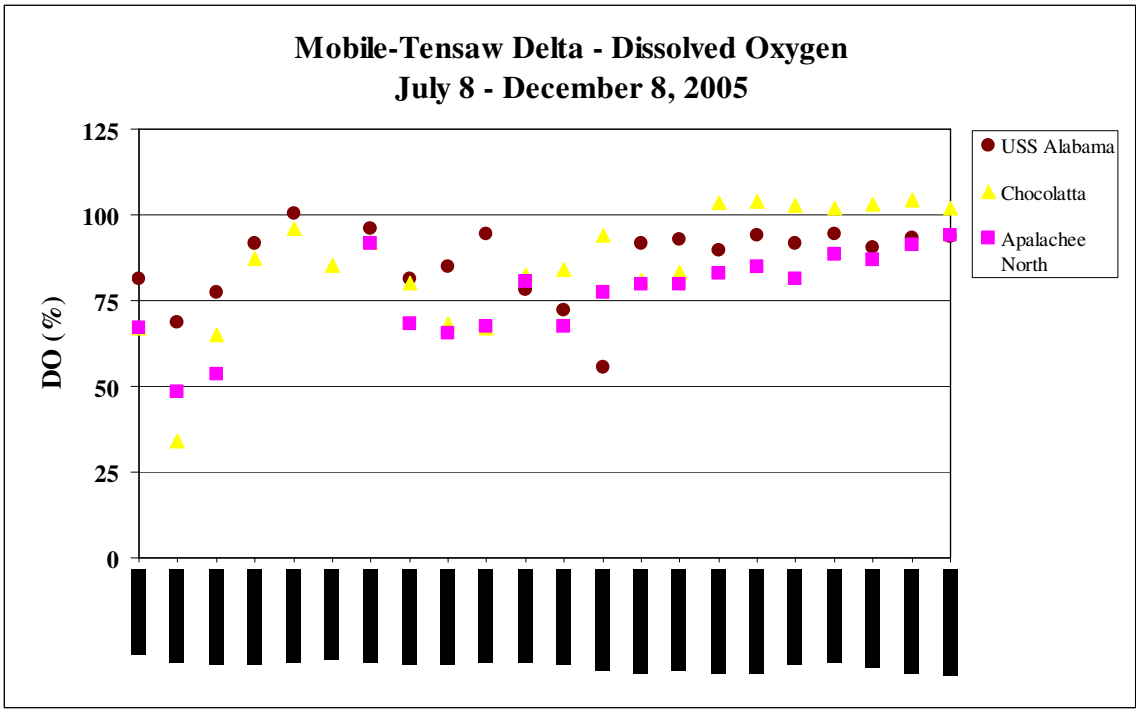

Figure 1-5. Mean dissolved oxygen (%) plotted by week from July 8 to December 8, 2005 for USS Alabama, Chocolatta Bay and Apalachee River North.

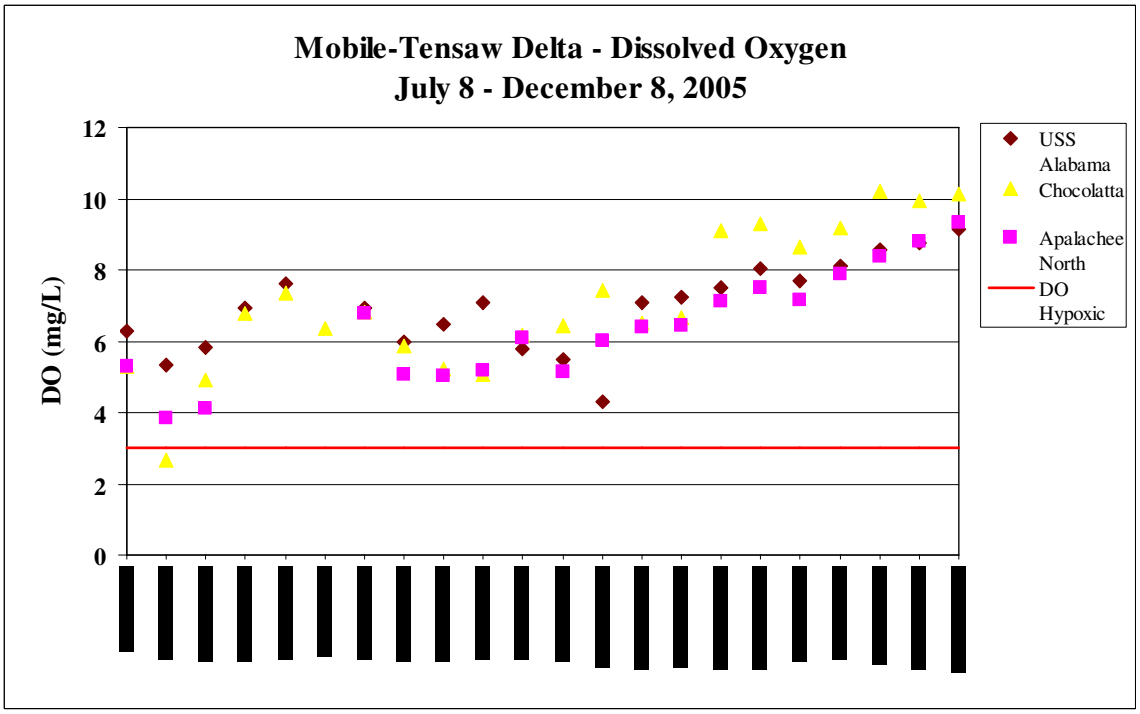

Figure 1-6. Mean dissolved oxygen (mg/l) plotted by week from July 8 to December 8, 2005 for USS Alabama, Chocolatta Bay and Apalachee River North.

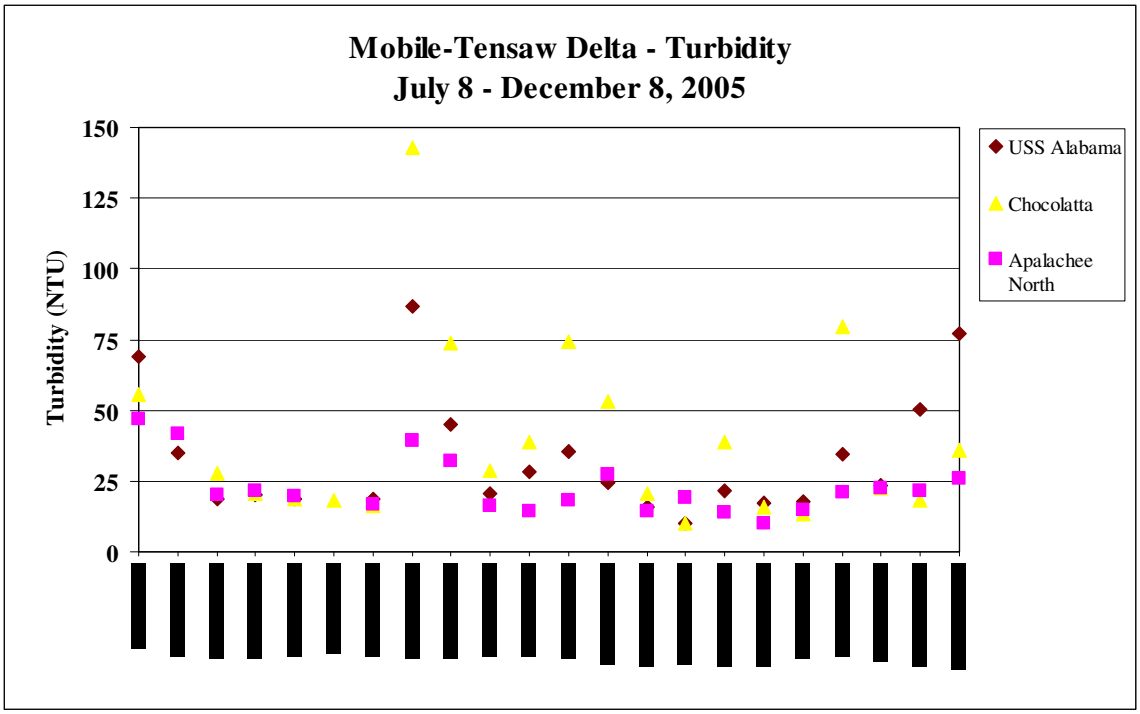

Figure 1-7. Mean turbidity (NTU) plotted by week from July 8 to December 8, 2005 for USS Alabama, Chocolatta Bay and Apalachee River North.

Appendix 2

Continuous Monitoring 2005:

USS Alabama, Tensaw River South, Chocolatta Bay, Apalachee River South, Apalachee River North and Tensaw River North

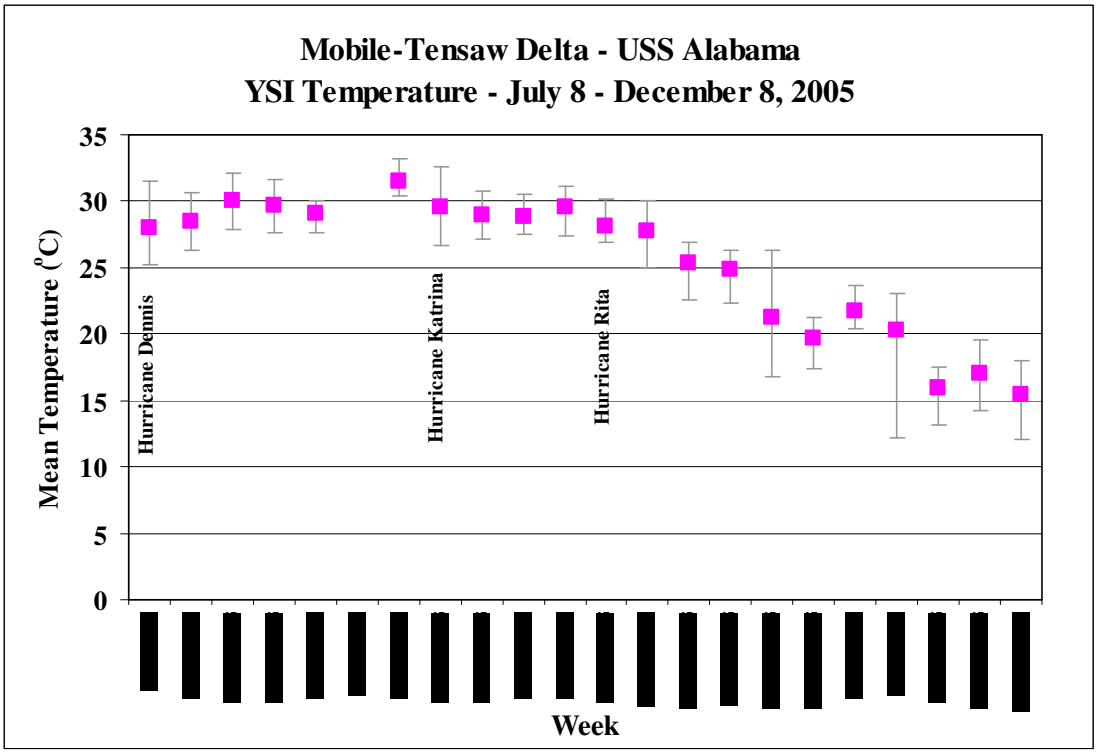

Figure 2-1. Mean temperature (°C) and ranges plotted by week from July 8 to December 8, 2005 for USS Alabama.

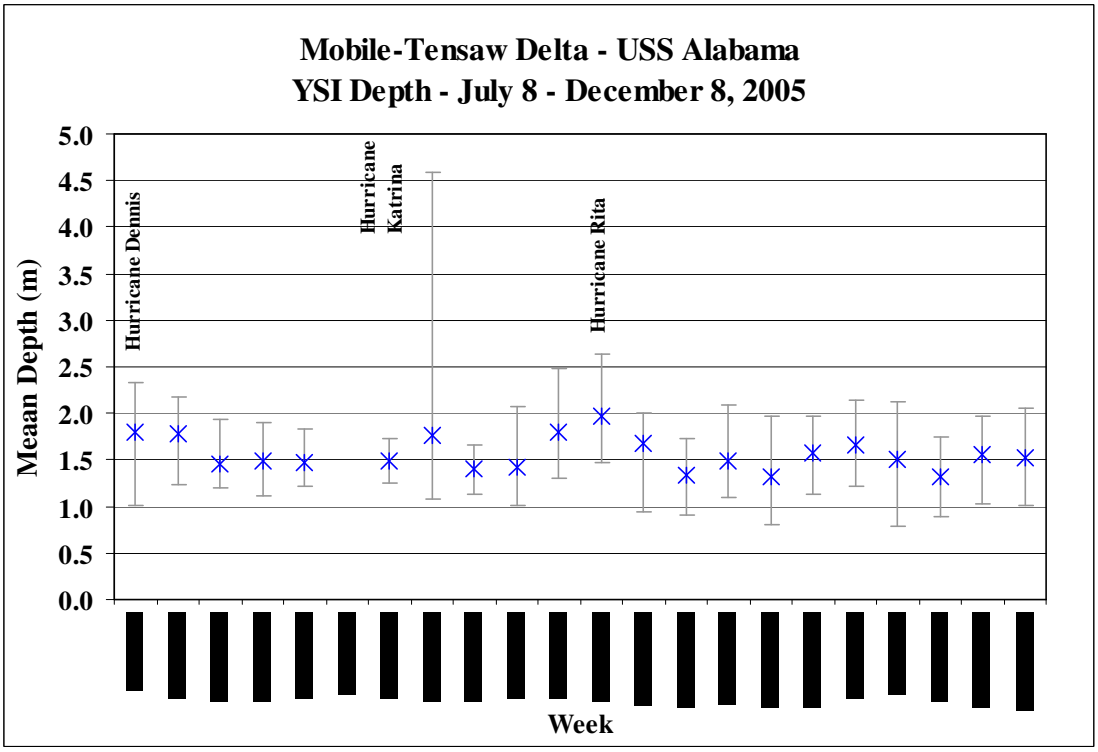

Figure 2-2. Mean depth (m) and ranges plotted by week from July 8 to December 8, 2005 for USS Alabama.

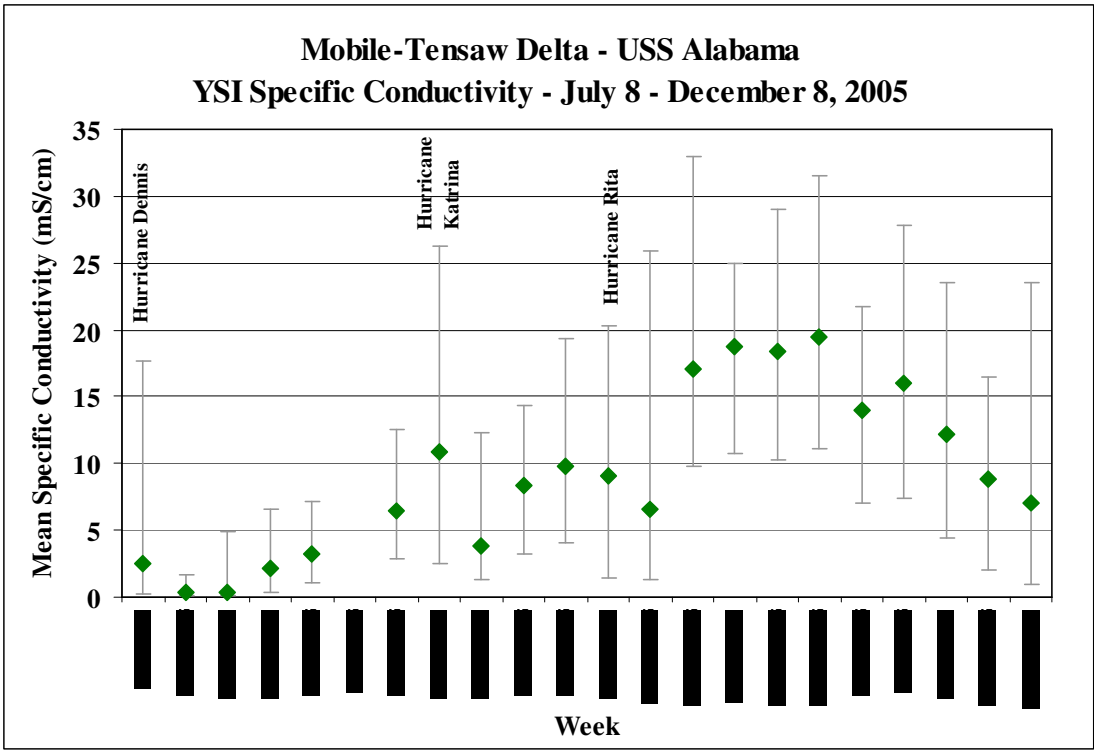

Figure 2-3. Mean specific conductivity (mS/cm) and ranges plotted by week from July 8 to December 8, 2005 for USS Alabama.

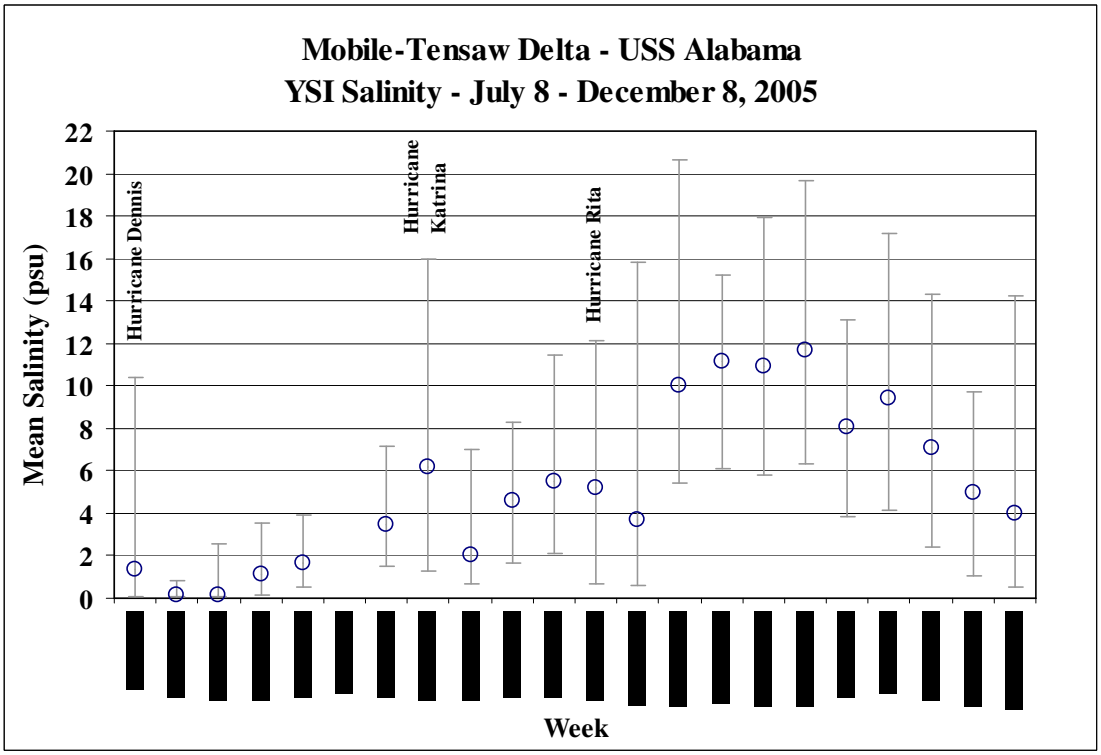

Figure 2-4. Mean salinity (psu) and ranges plotted by week from July 8 to December 8, 2005 for USS Alabama.

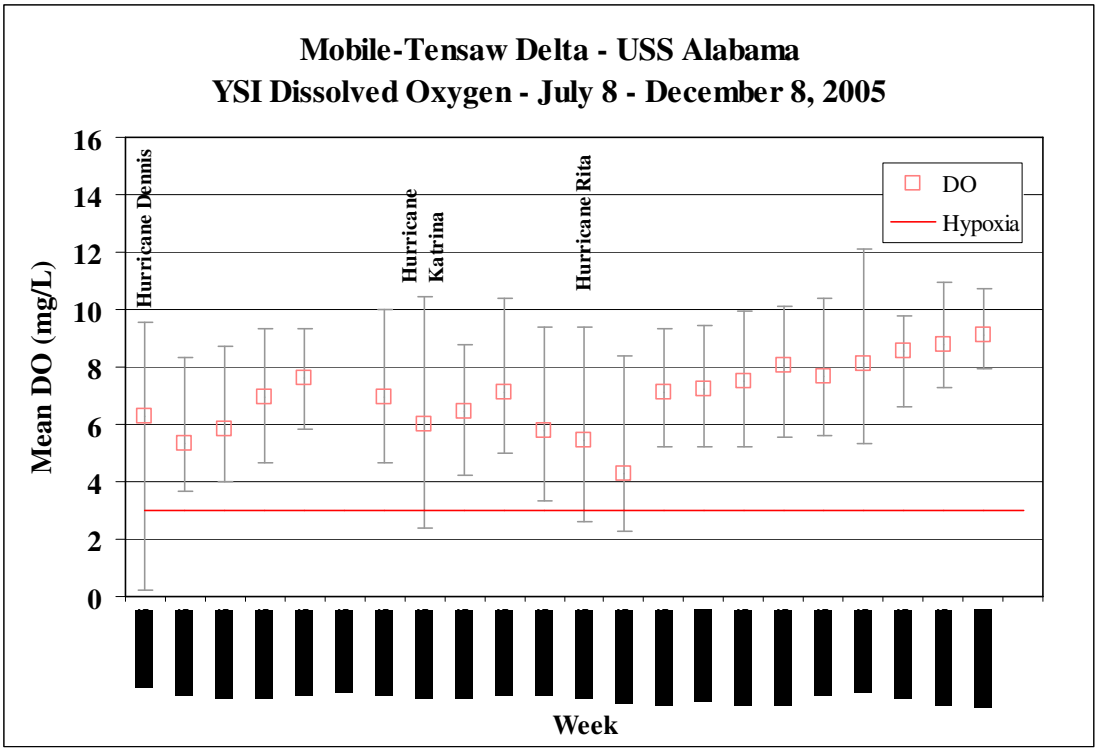

Figure 2-5. Mean dissolved oxygen (mg/L) and ranges plotted by week from July 8 to December 8, 2005 for USS Alabama.

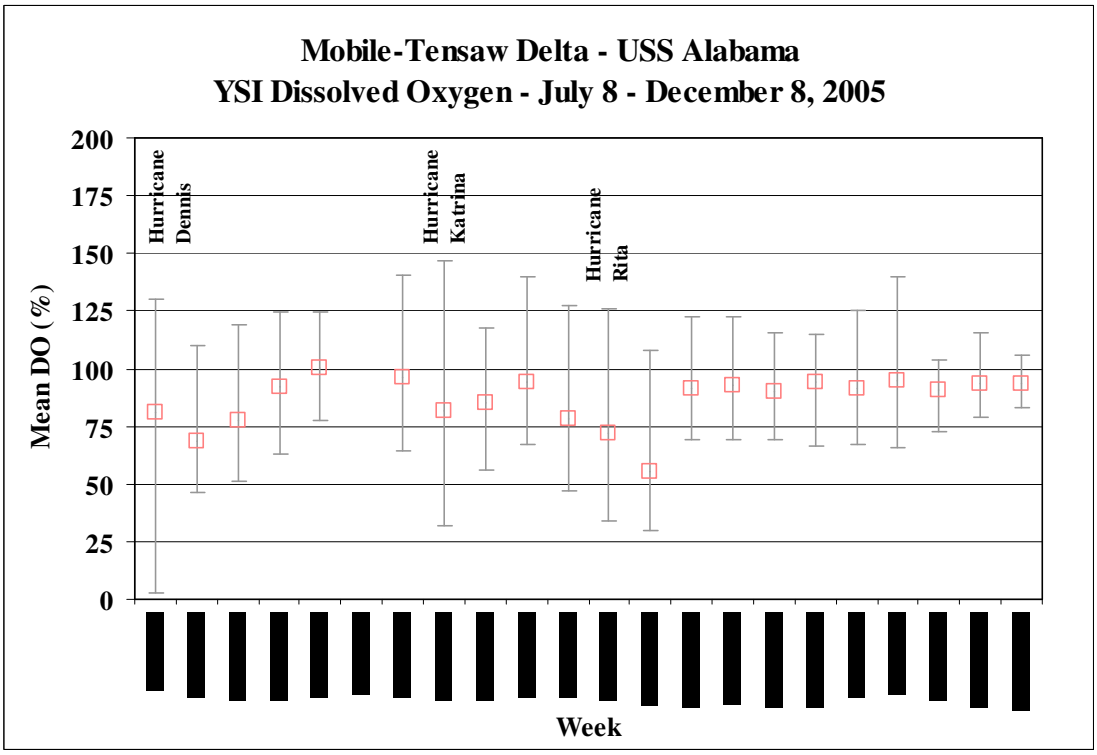

Figure 2-6. Mean dissolved oxygen (%) and ranges plotted by week from July 8 to December 8, 2005 for USS Alabama.

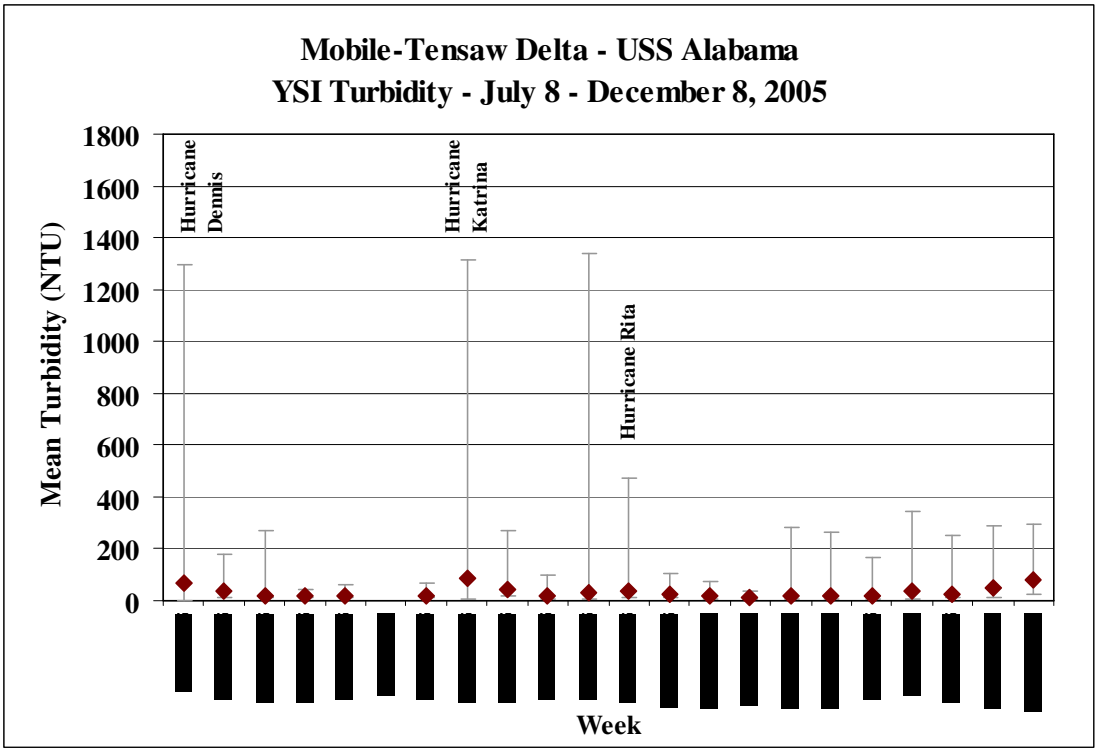

Figure 2-7. Mean turbidity (NTU) and ranges plotted by week from July 8 to December 8, 2005 for USS Alabama.

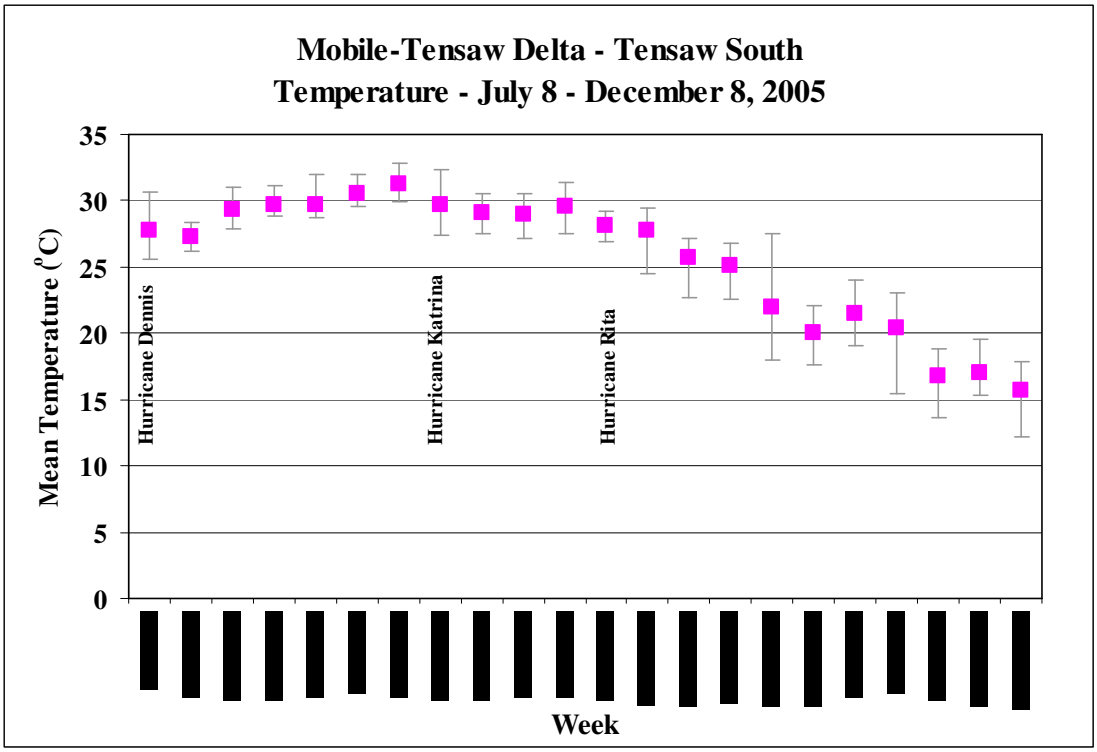

Figure 2-8. Mean temperature (°C) and ranges plotted by week from July 8 to December 8, 2005 for Tensaw River South.

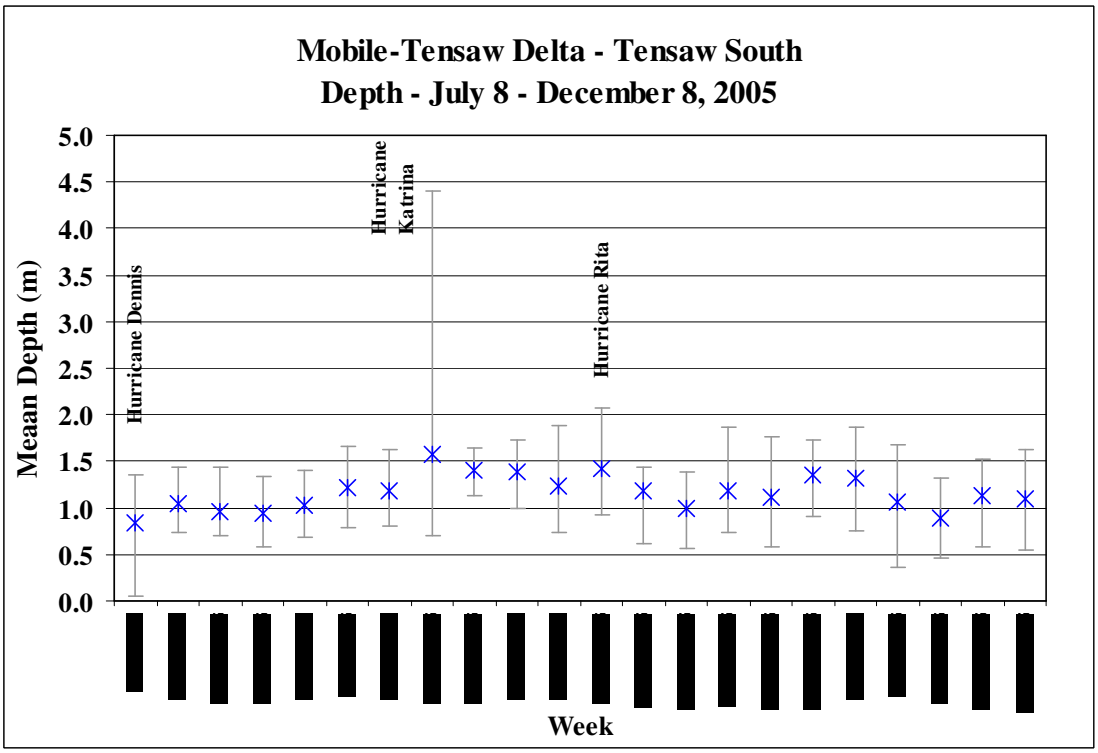

Figure 2-9. Mean depth (m) and ranges plotted by week from July 8 to December 8, 2005 for Tensaw River South.

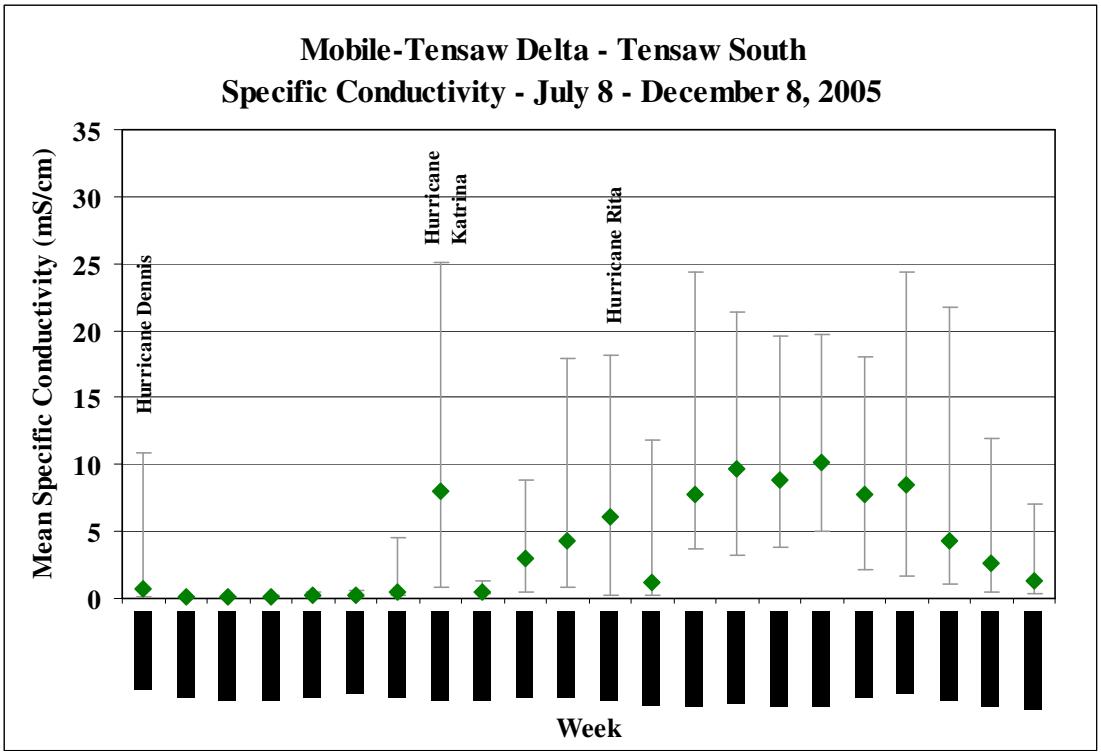

Figure 2-10. Mean specific conductivity (mS/cm) and ranges plotted by week from July 8 to December 8, 2005 for Tensaw River South.

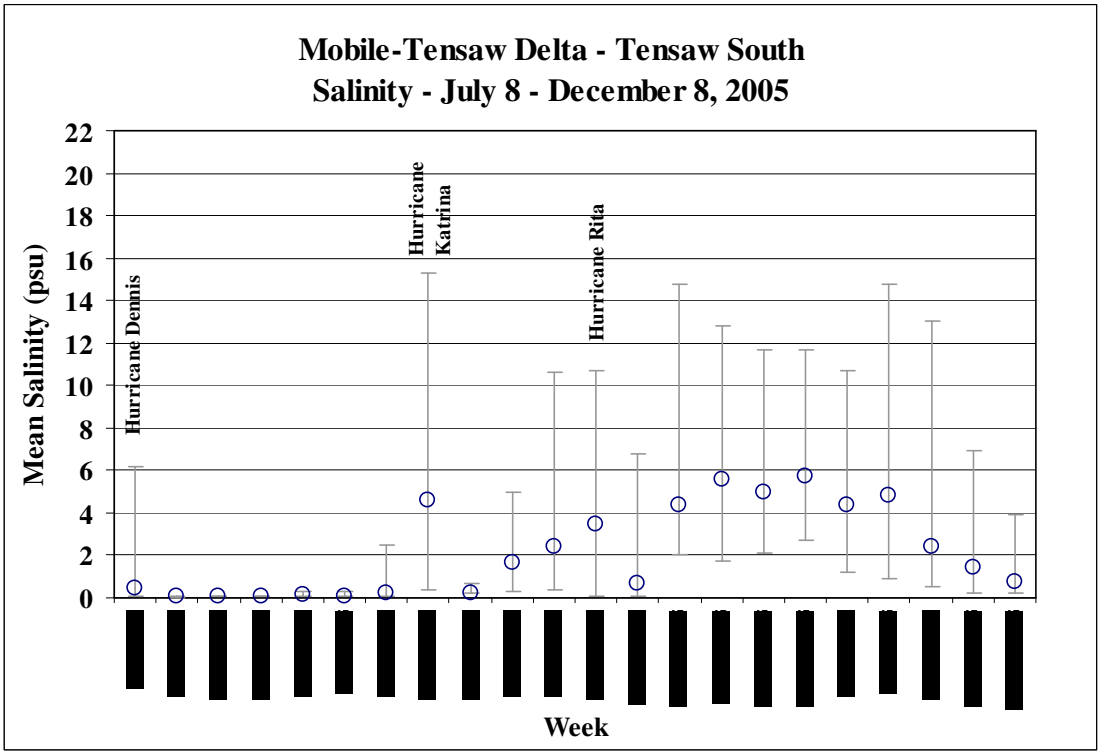

Figure 2-11. Mean salinity (psu) and ranges plotted by week from July 8 to December 8, 2005 for Tensaw River South.

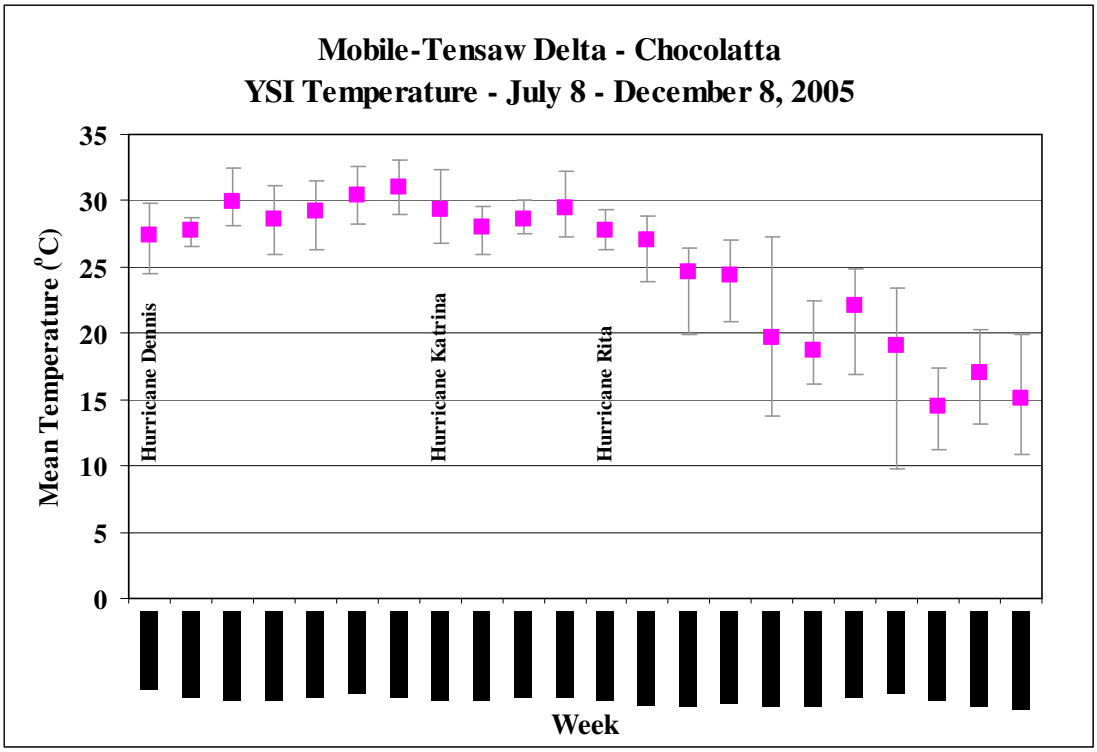

Figure 2-12. Mean temperature (°C) and ranges plotted by week from July 8 to December 8, 2005 for Chocolatta Bay.

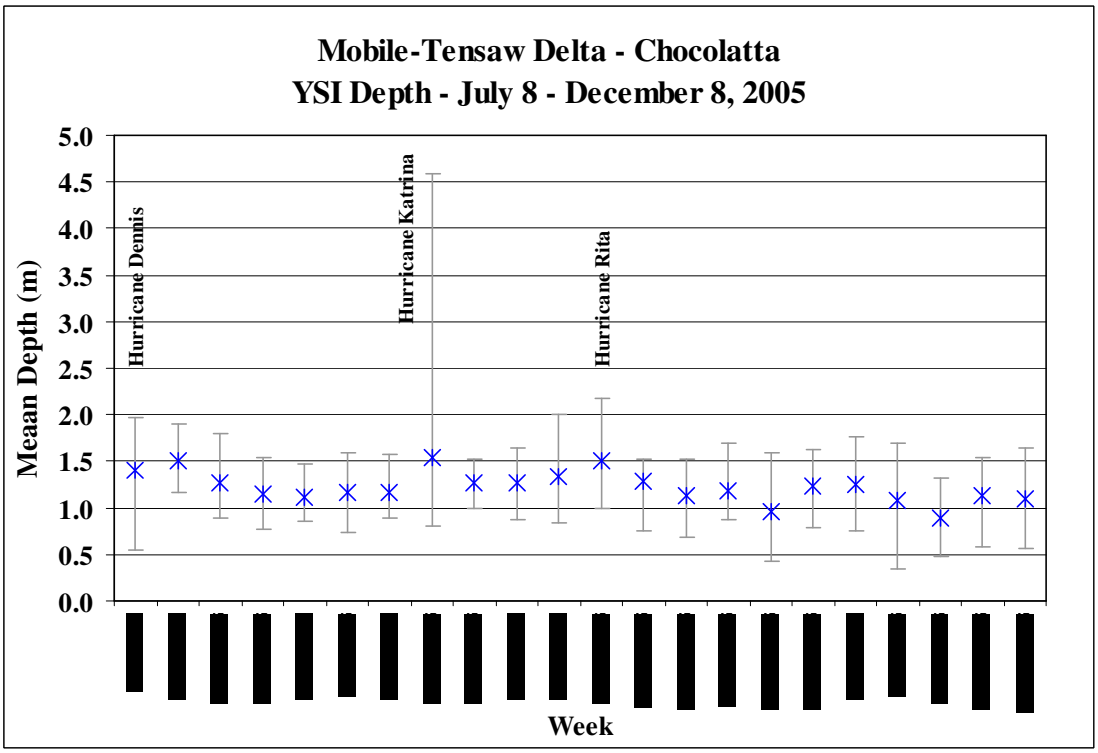

Figure 2-13. Mean depth (m) and ranges plotted by week from July 8 to December 8, 2005 for Chocolatta Bay.

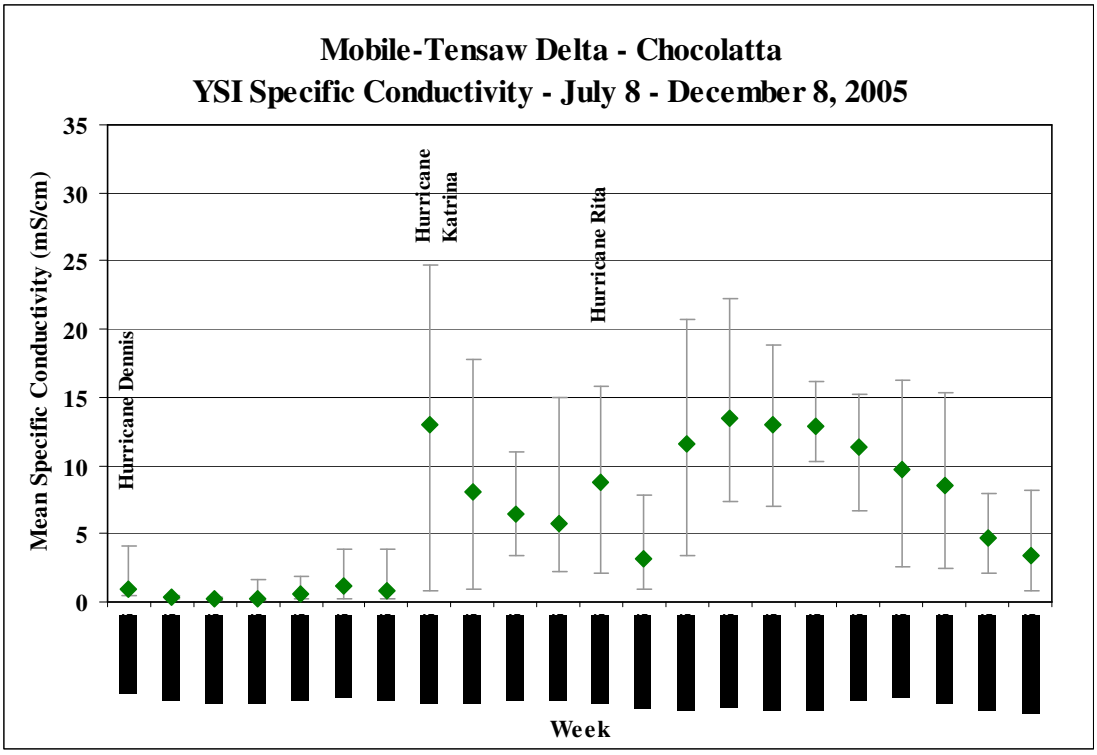

Figure 2-14. Mean specific conductivity (mS/cm) and ranges plotted by week from July 8 to December 8, 2005 for Chocolatta Bay.

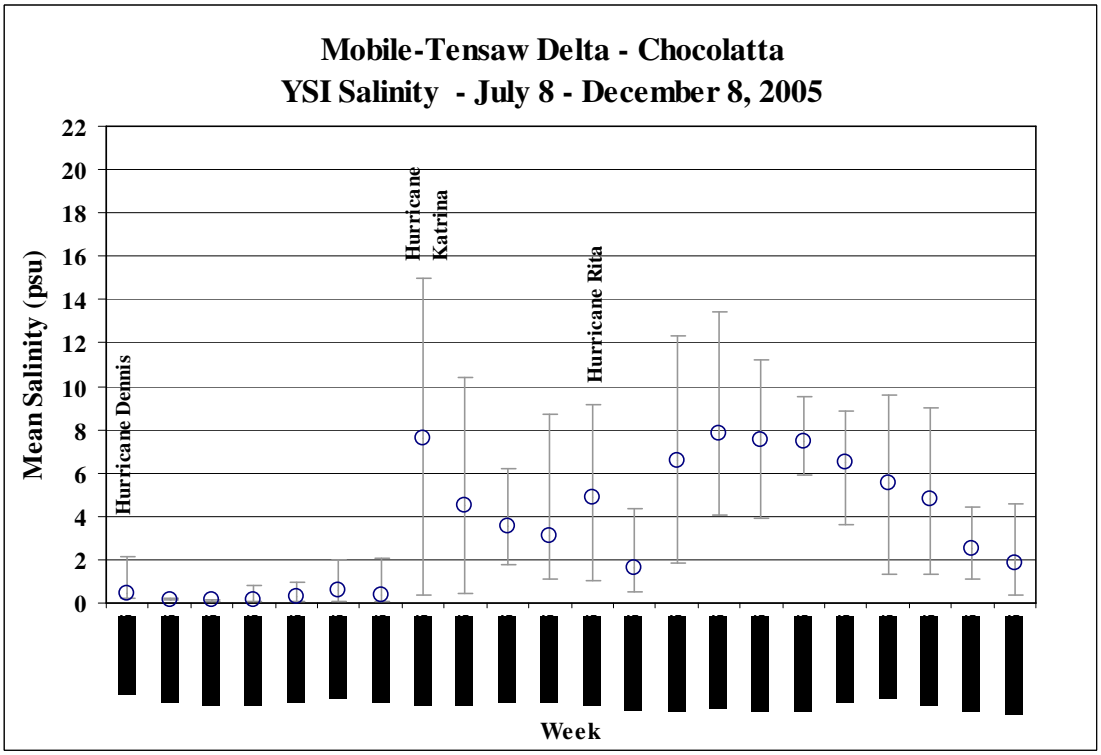

Figure 2-15. Mean salinity (psu) and ranges plotted by week from July 8 to December 8, 2005 for Chocolatta Bay.

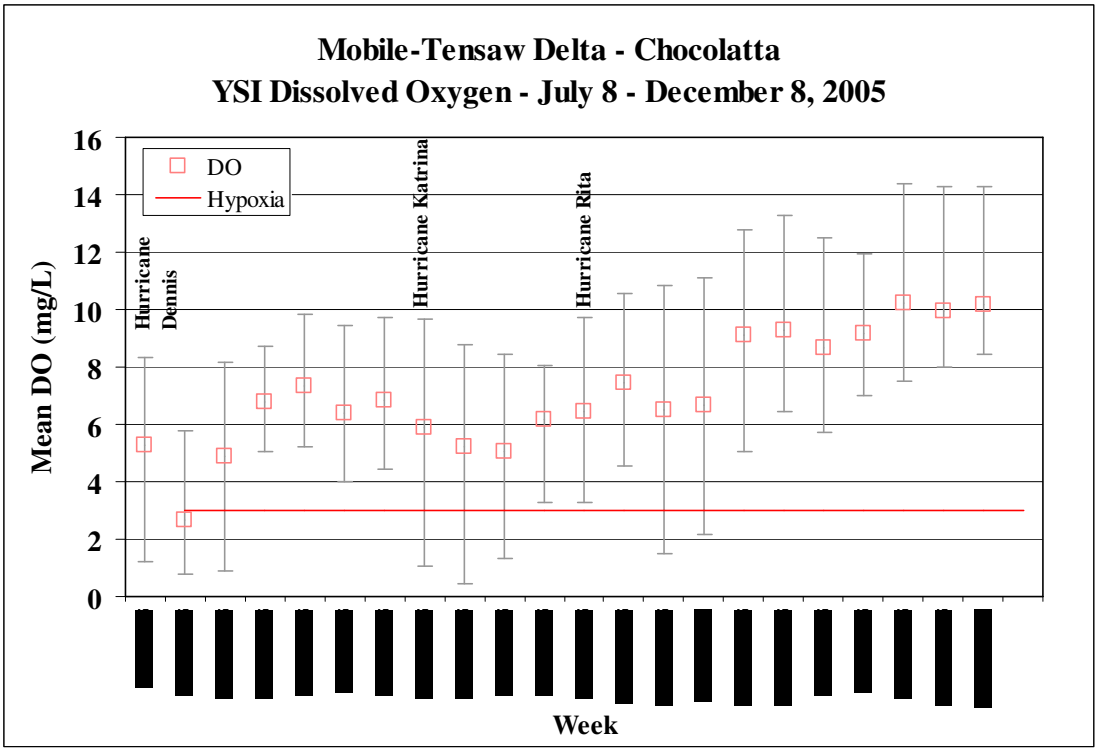

Figure 2-16. Mean dissolved oxygen (mg/L) and ranges plotted by week from July 8 to December 8, 2005 for Chocolatta Bay.

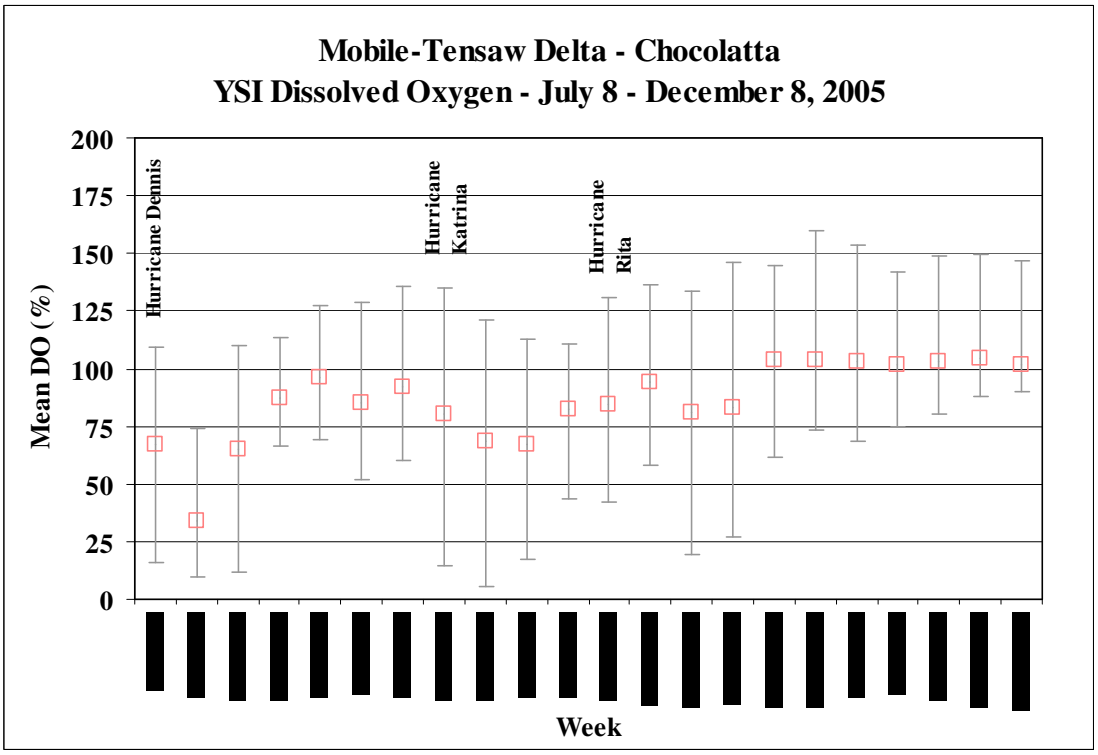

Figure 2-17. Mean dissolved oxygen (%) and ranges plotted by week from July 8 to December 8, 2005 for Chocolatta Bay.

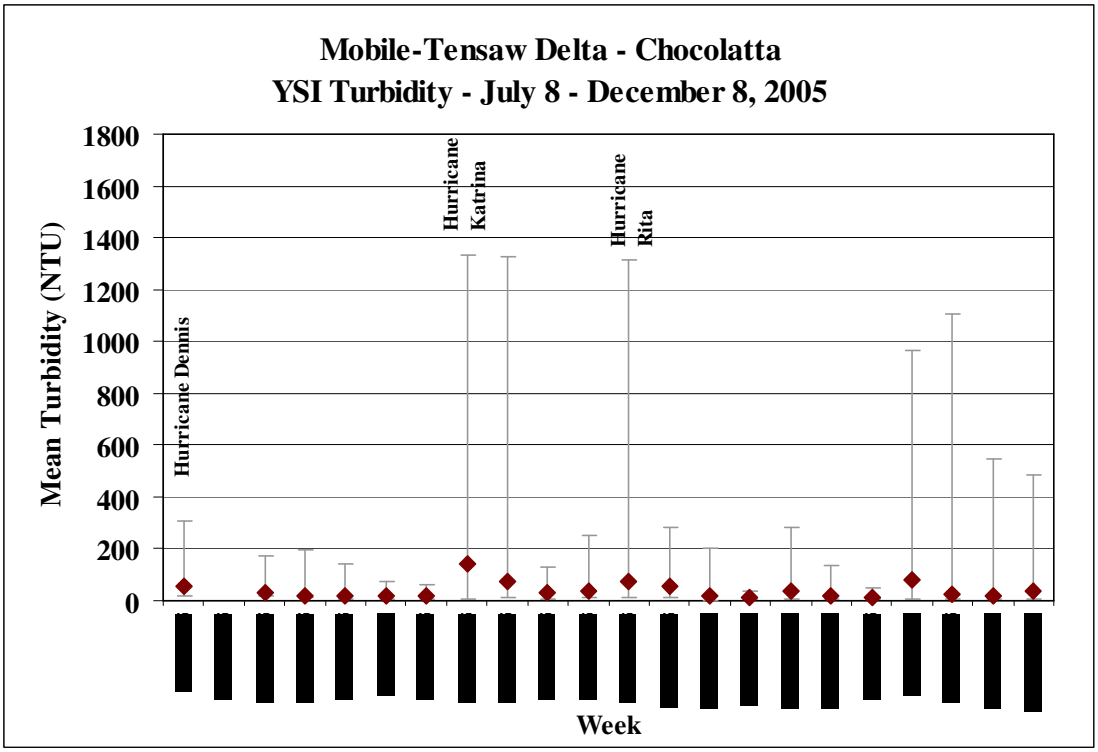

Figure 2-18. Mean turbidity (NTU) and ranges plotted by week from July 8 to December 8, 2005 for Chocolatta Bay.

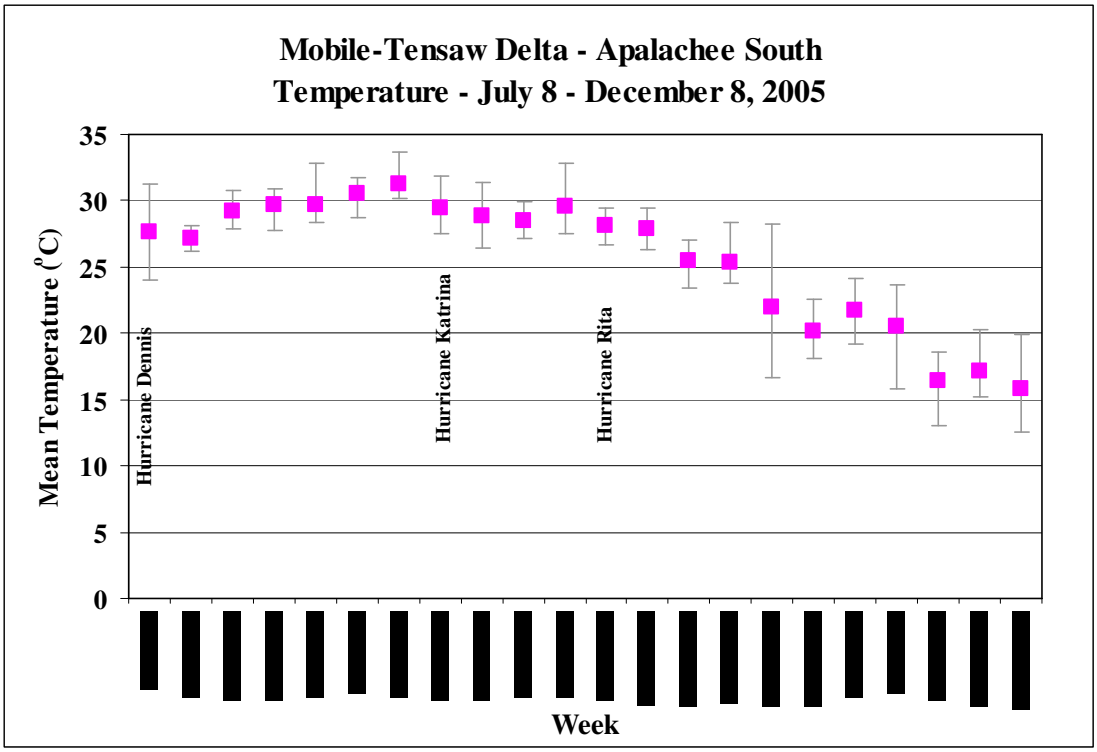

Figure 2-19. Mean temperature (°C) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River South.

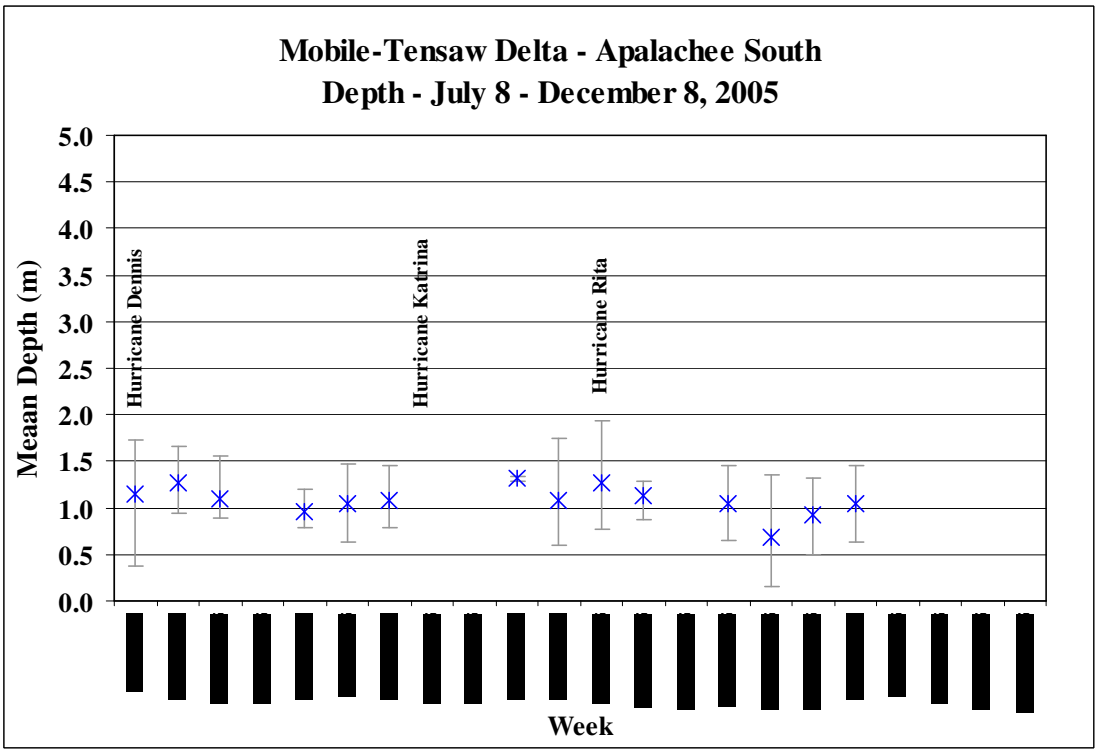

Figure 2-20. Mean depth (m) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River South.

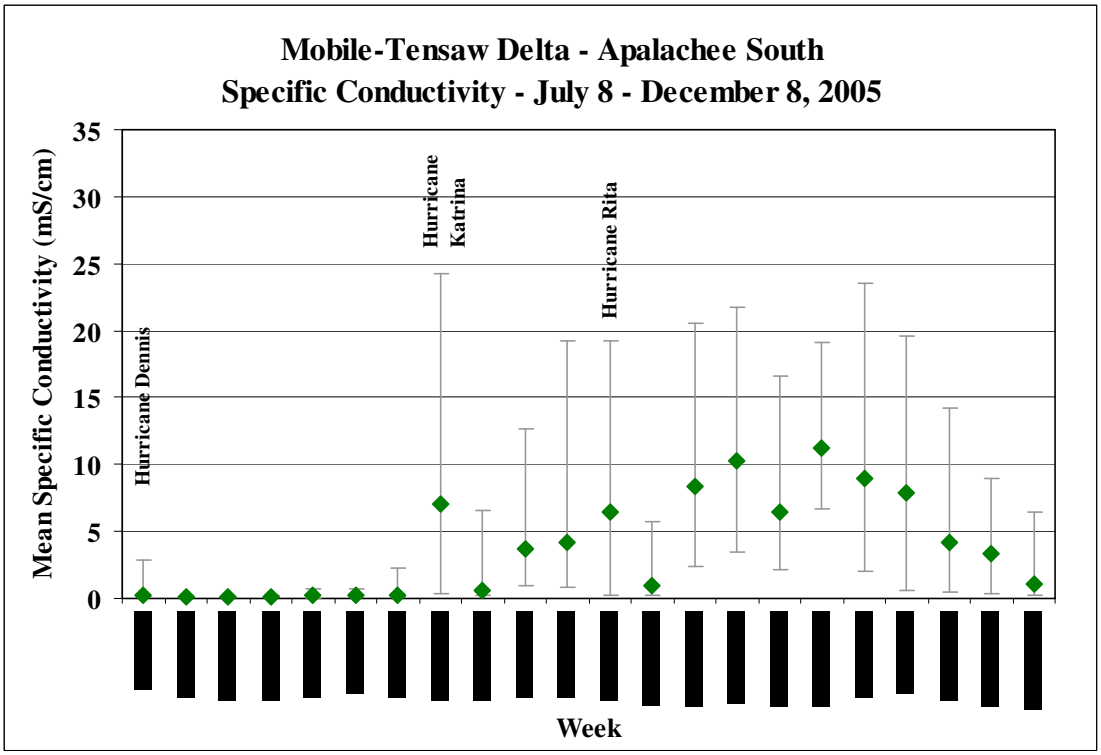

Figure 2-21. Mean conductivity (mS/cm) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River South.

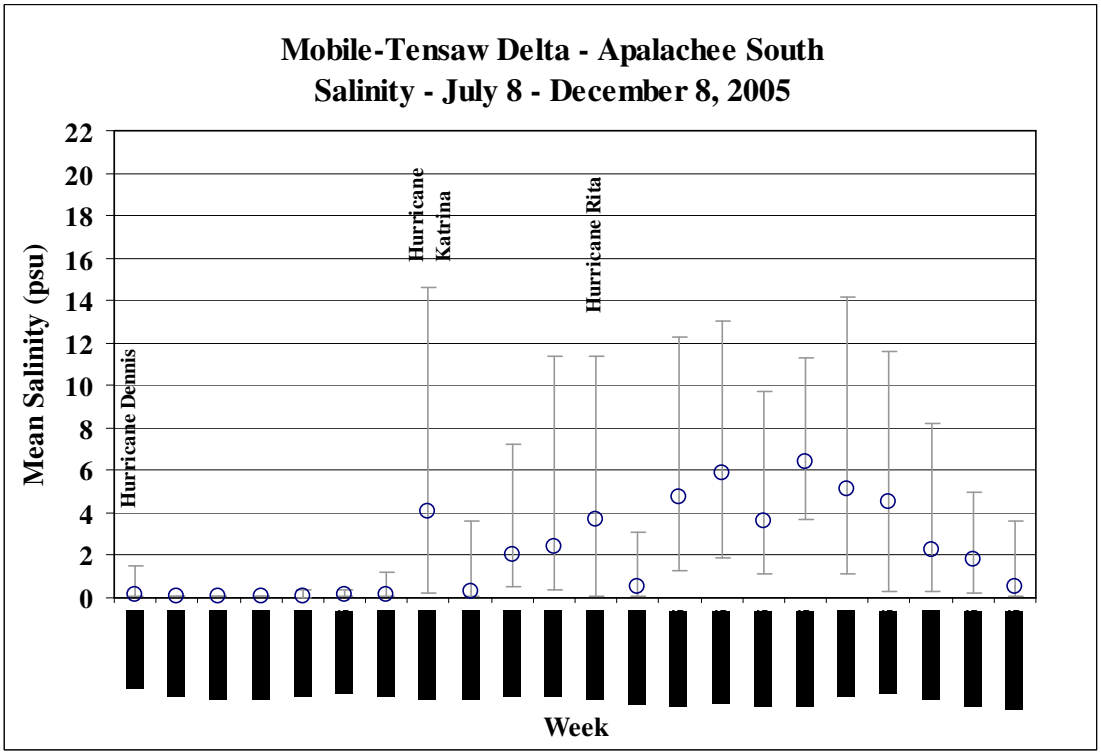

Figure 2-22. Mean salinity (psu) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River South.

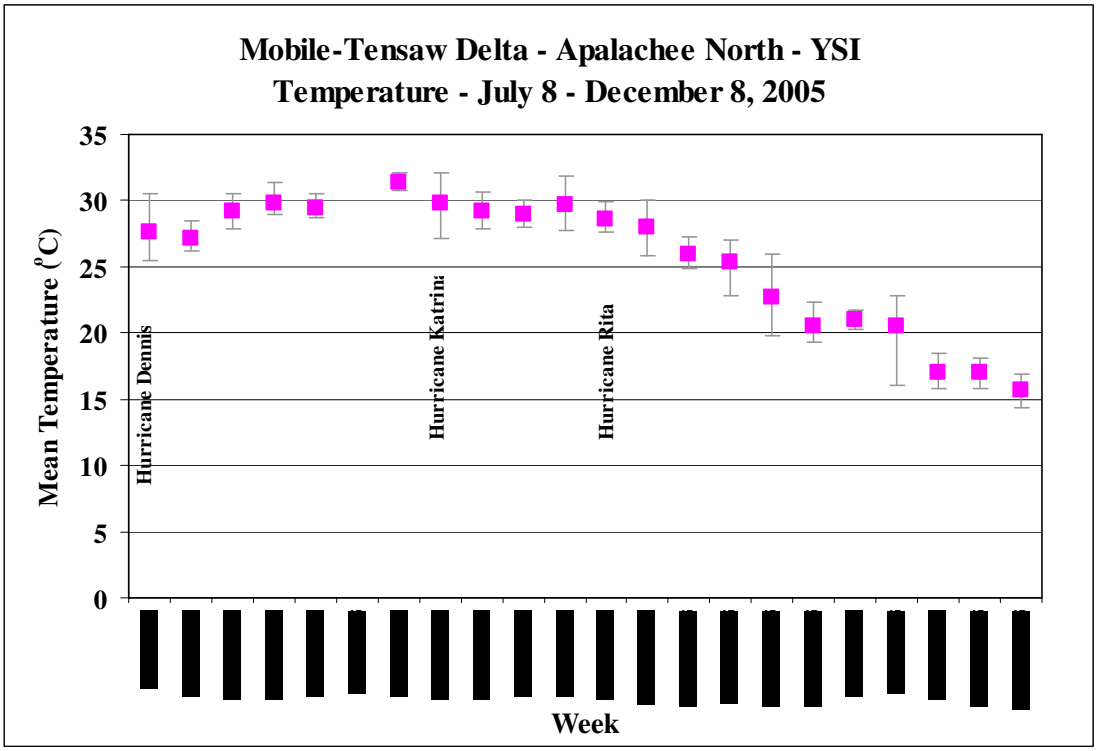

Figure 2-23. Mean temperature (°C) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River North.

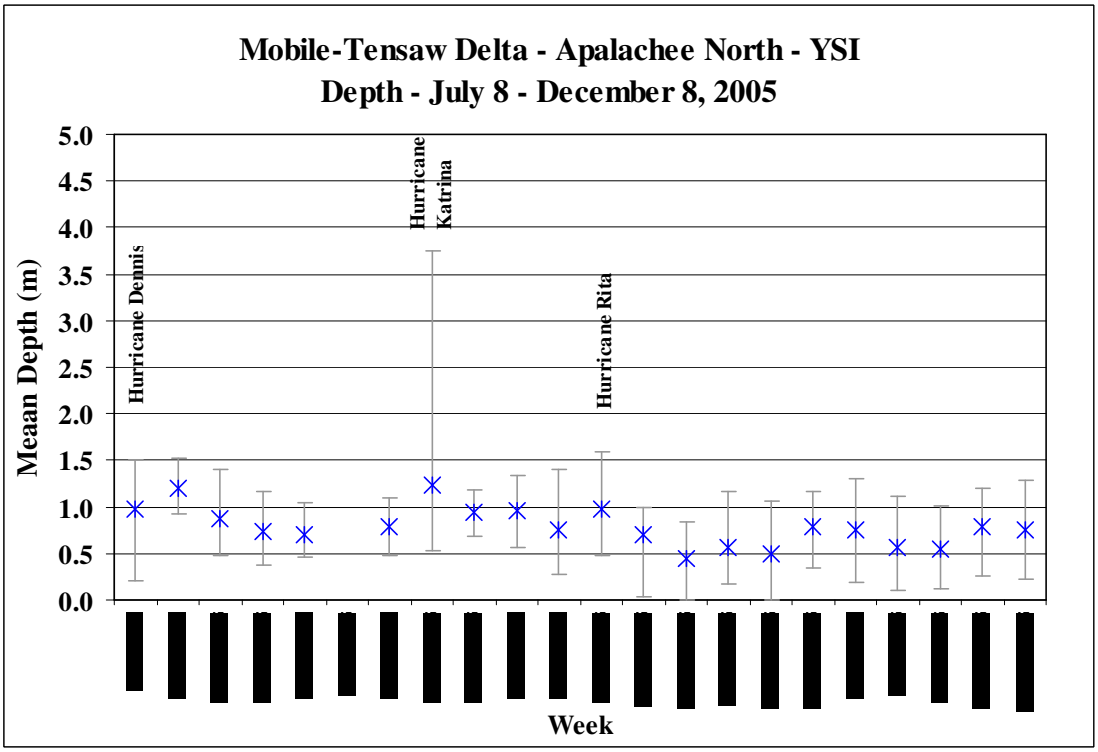

Figure 2-24. Mean depth (m) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River North.

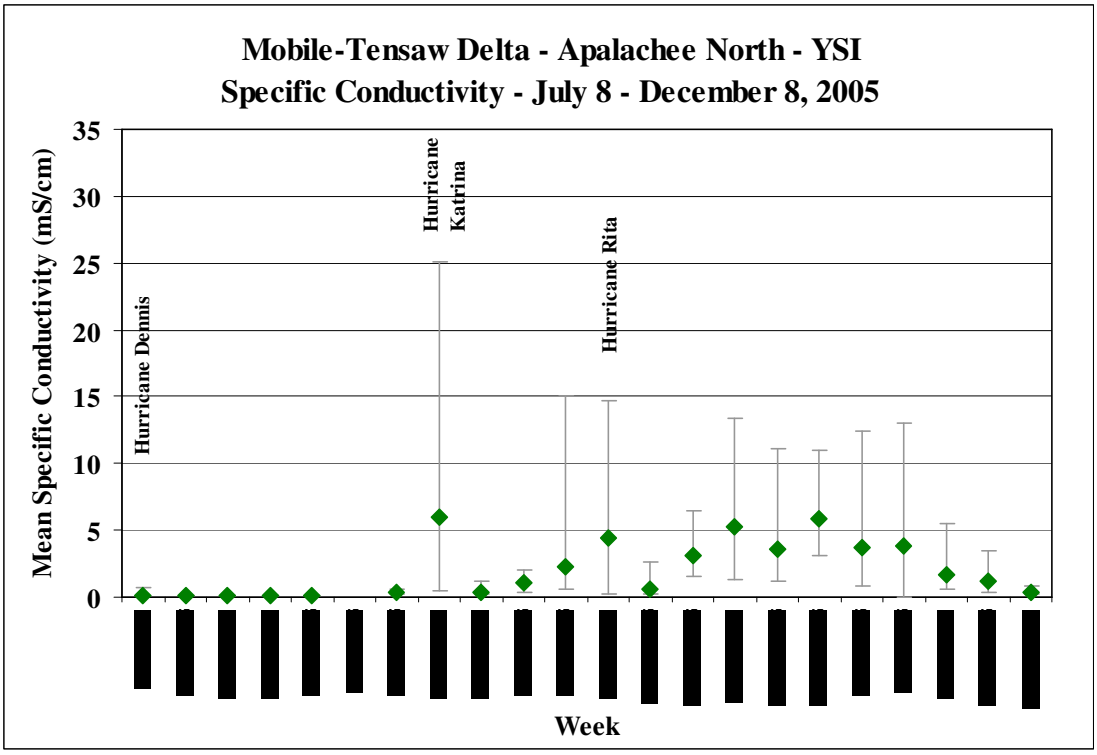

Figure 2-25. Mean conductivity (mS/cm) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River North.

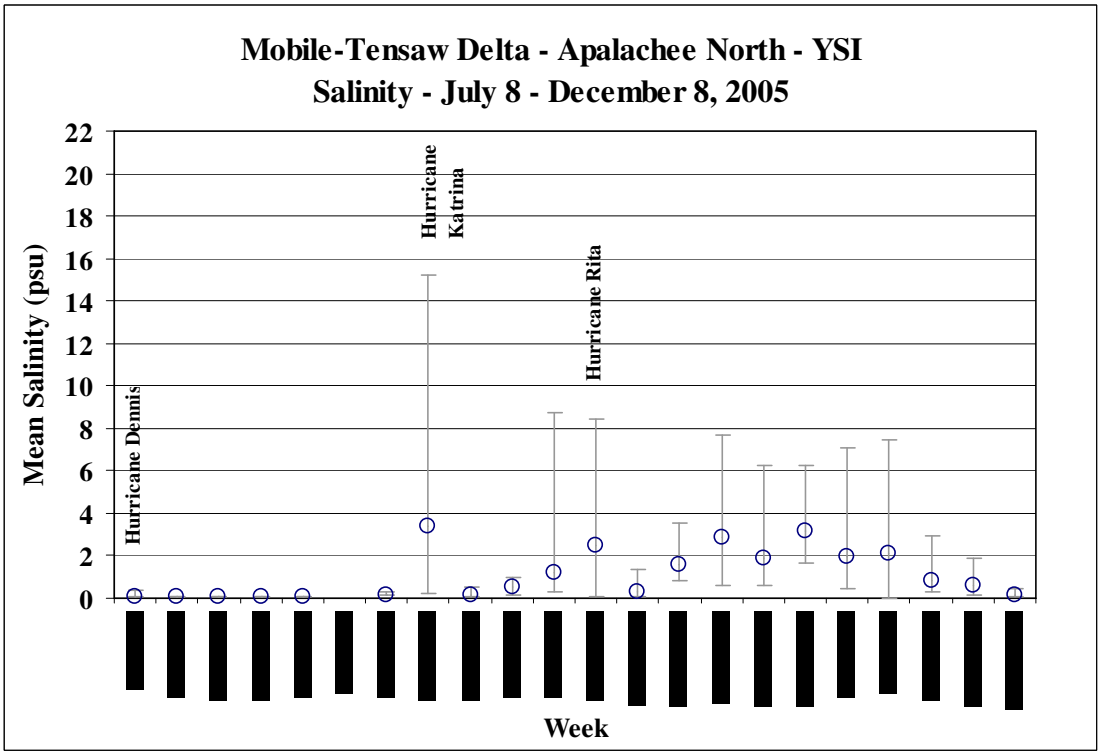

Figure 2-26. Mean salinity (psu) and ranges plotted by week from July 8 to December 8, 2005 for Apalachee River North.

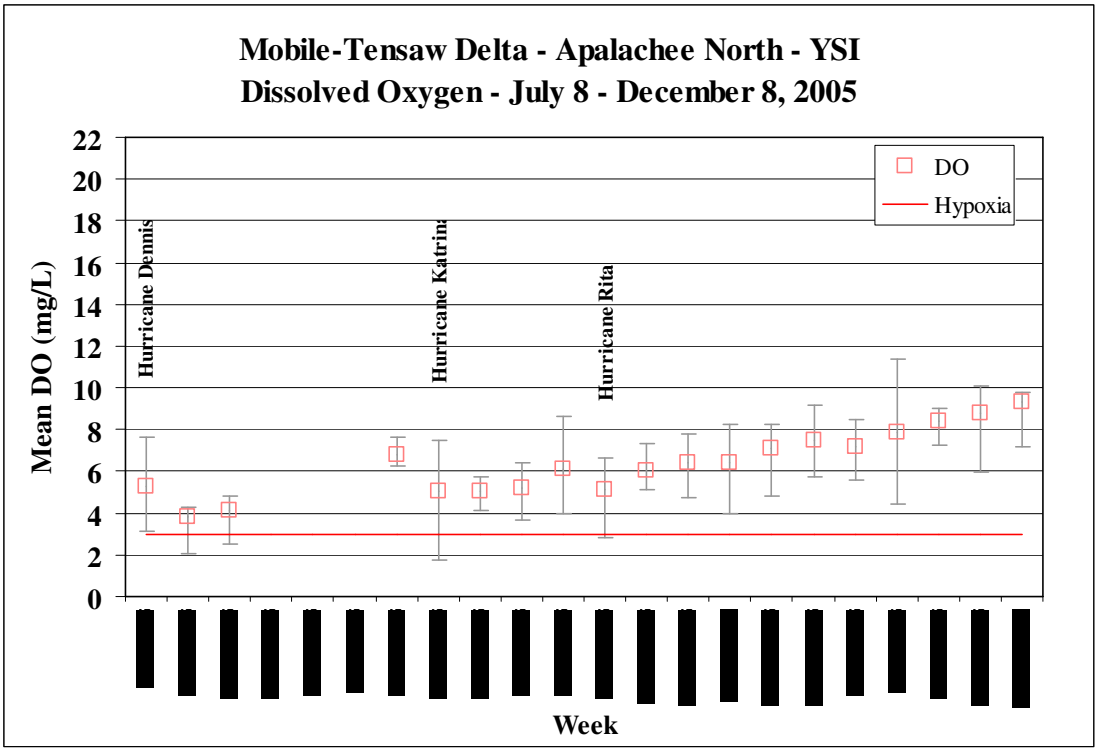

Figure 2-27. Mean dissolved oxygen (mg/l) and ranges plotted by week from July 8, to December 8, 2005 for Apalachee River North.

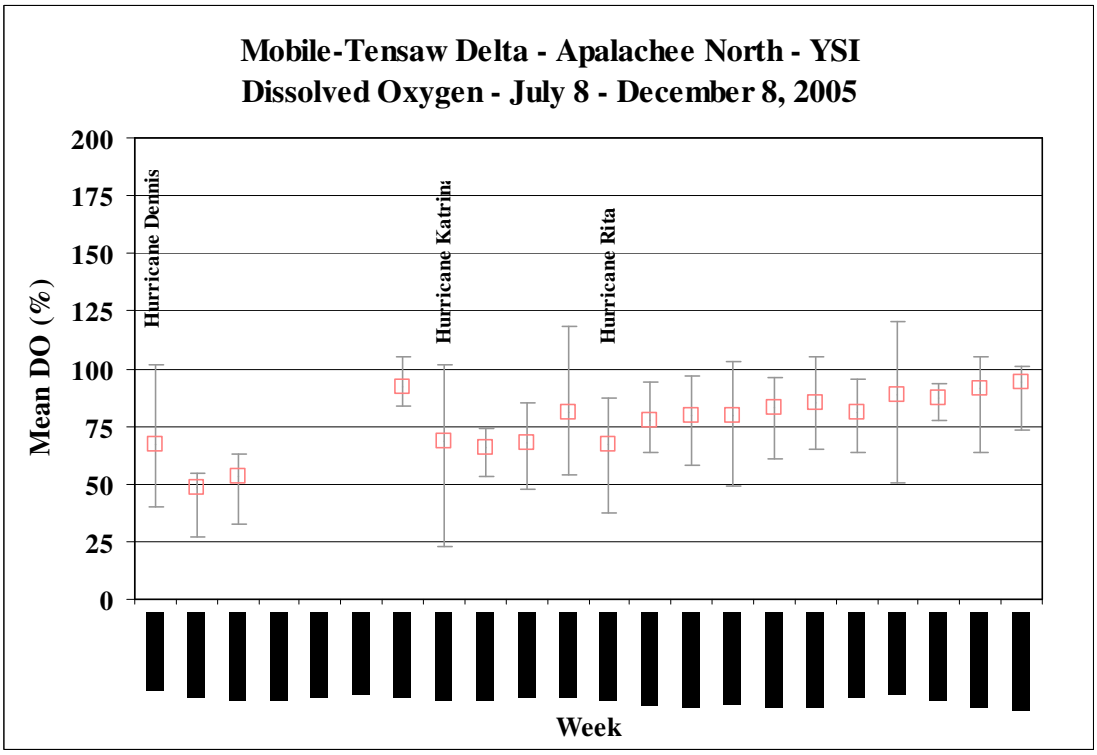

Figure 2-28. Mean dissolved oxygen (%) and ranges plotted by week from July 8, to December 8, 2005 for Apalachee River North.

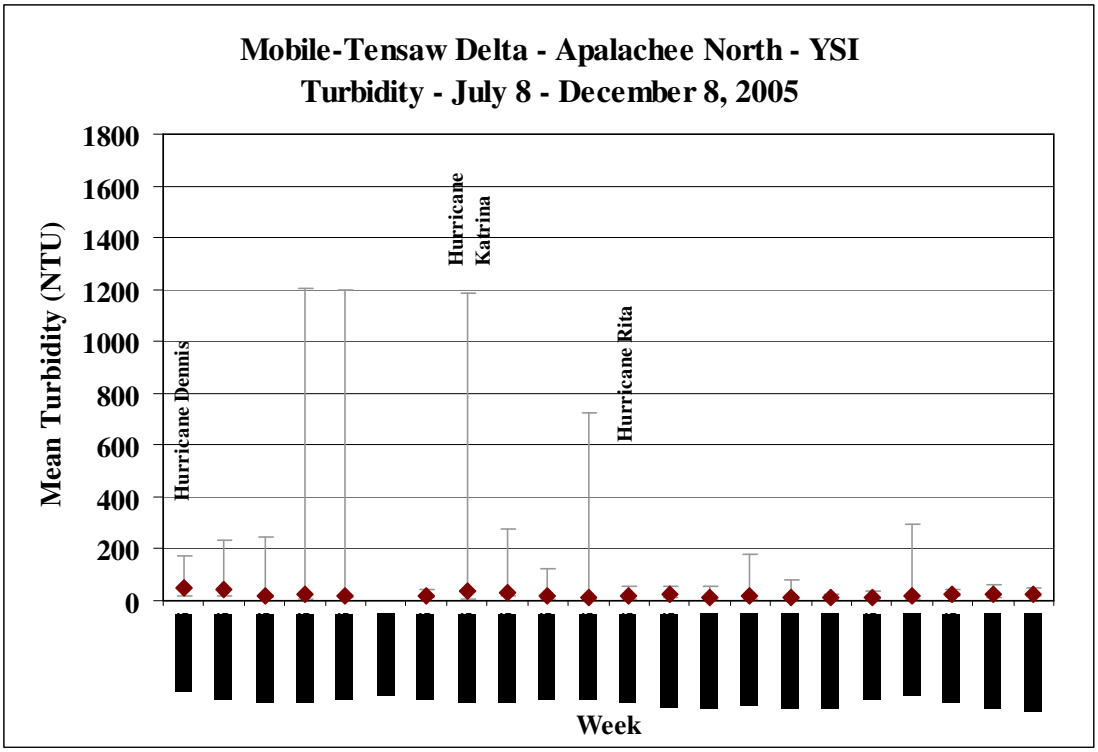

Figure 2-29. Mean turbidity (NTU) and ranges plotted by week from July 8, to December 8, 2005 for Apalachee River North.

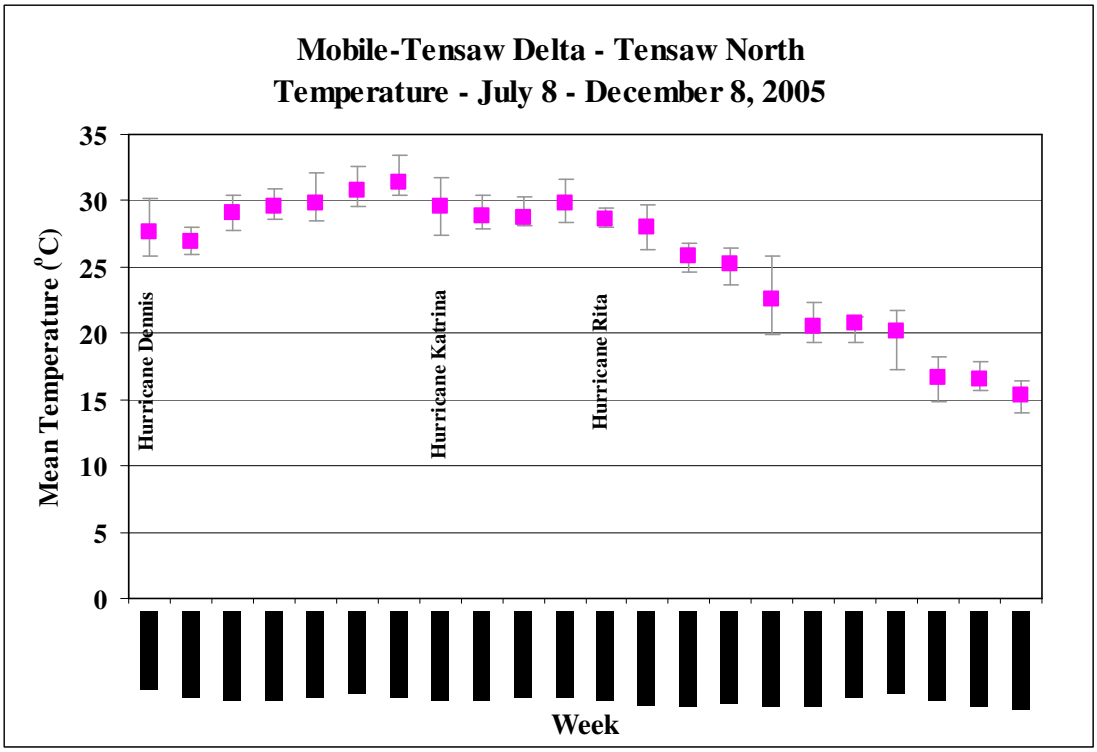

Figure 2-30. Mean temperature (°C) and ranges plotted by week from July 8 to December 8, 2005 for Tensaw River North.

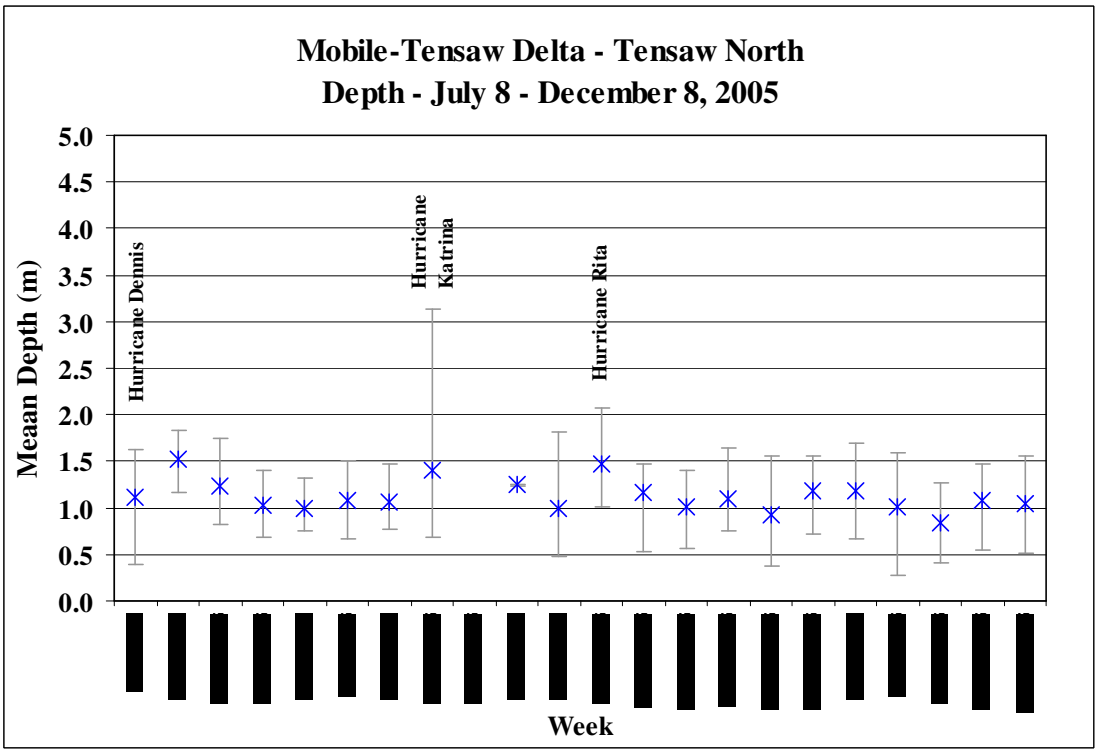

Figure 2-31. Mean depth (m) and ranges plotted by week from July 8 to December 8, 2005 for Tensaw River North.

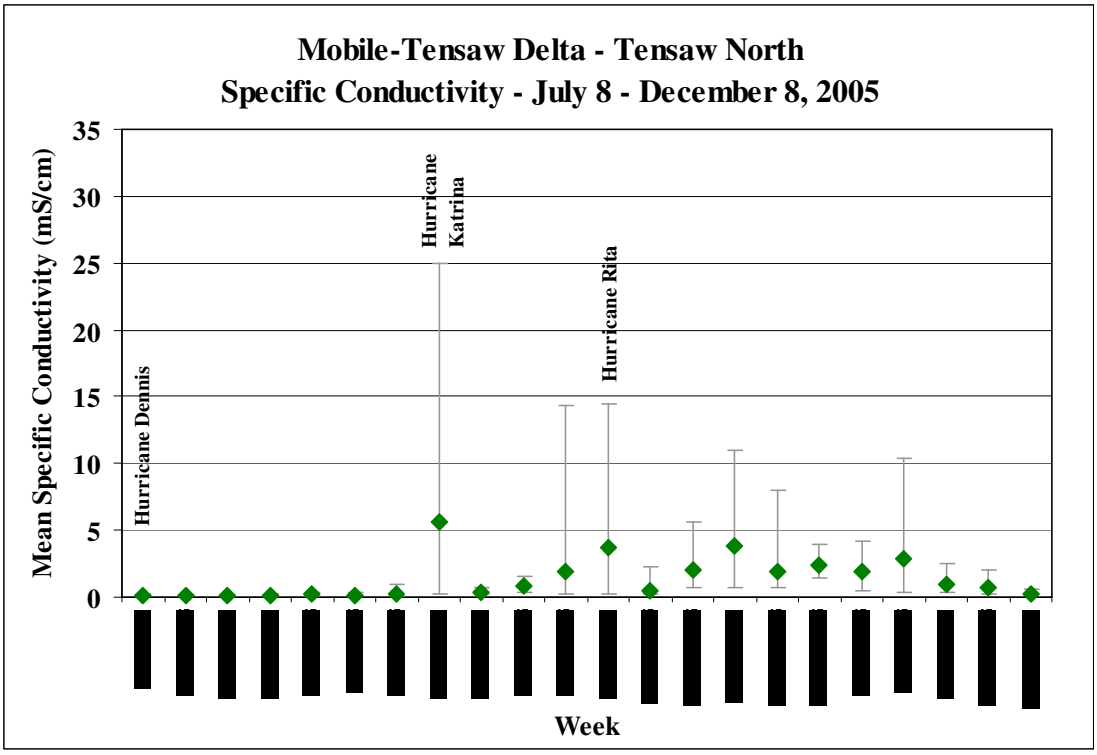

Figure 2-32. Mean specific conductivity (mS/cm) and ranges plotted by week from July 8, to December 8, 2005 for Tensaw River North.

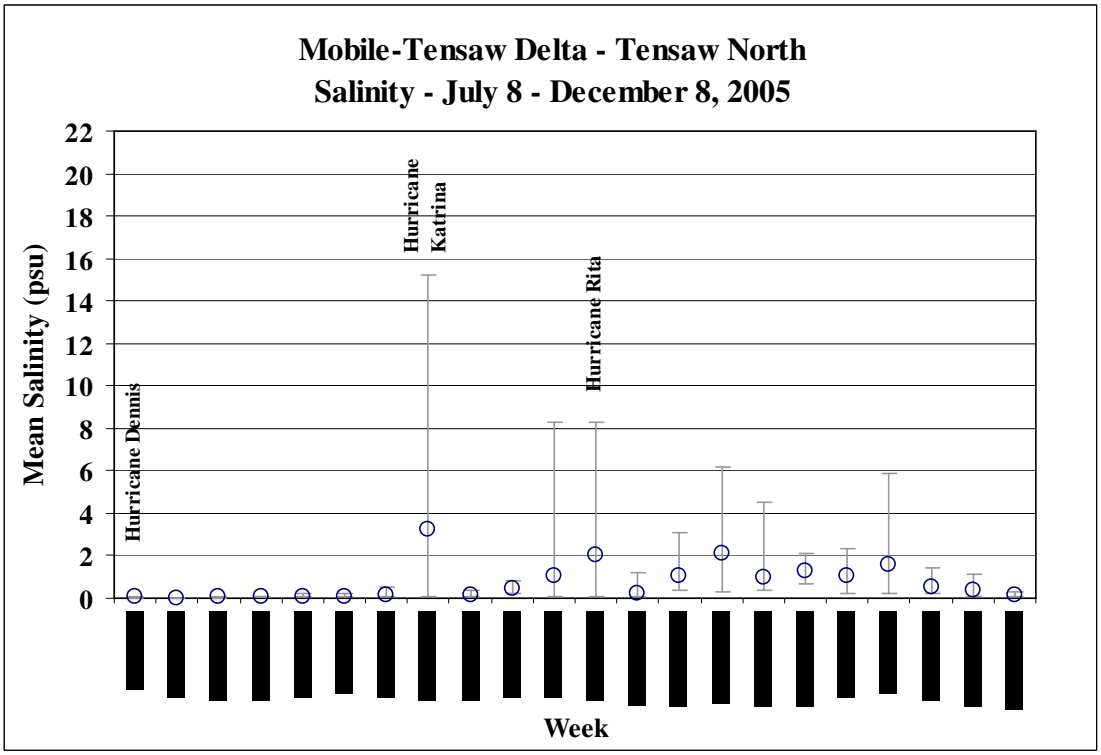

Figure 2-33. Mean salinity (psu) and ranges plotted by week from July 8, to December 8, 2005 for Tensaw River North.

Appendix 3

YSI Readings – April, June, July, August and October 2005 and March 2006

Table 3-1. April 2005 summary table for YSI readings statistical analyses (temperature, conductivity, salinity, dissolved oxygen, depth, turbidity and chlorophyll *a*) by site (not averages) and location north and south of causeway (averages) (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) is listed for each site.

		YSI Readings							
	North or South of Causeway	**Temperature (ºC)**	**Conductivity**	**Salinity**	**Dissolved Oxygen (%)**	**Dissolved Oxygen (mg/l)**	**Depth**	**Turbidity**	**Chlorophyll**
Site Name		**p=0.000**	**p=0.000**	**p=0.000**	**p=0.000**	**p=0.000**	p=0.662	**p=0.000**	**p=0.001**
Polecat Bay	**N**	3	5	3	1	1	3	3	3
Delvan Bay	**N**	6	6	5	6	2	1	2	4
Tensaw Riverbank	**N**	2	1	1	3	6	7	6	8
Chocolatta Bay	**N**	1	7	7	2	3	2	4	6
Blakeley Riverbank	**N**	4	10	8	4	5	6	5	1
Justin's Bay	**N**	5	11	9	7	7	8	1	2
Mouth of Pinto Pass	**S**	11	3	2	10	9	11	9	9
Pinto Pass	**S**	10	2	4	8	8	10	10	5
South of Chocolatta	**S**	9	4	6	11	11	4	11	10
South of Justin's	**S**	8	9	10	9	10	9	8	11
South Blakeley Riverbank	**S**	7	8	11	5	4	5	7	7
North	**N**	A	-	-	A	A	A	A	A
South	**S**	B	-	-	B	B	B	B	B
		N > S	S>N	S>N	N>S	N>S	N>S	N>S	N>S
		p=0.015	p=0.612	p=0.707	**p=0.005**	**p=0.009**	**p=0.144**	**p=0.004**	**p=0.010**

Table 3-2. August 2005 summary table for YSI readings statistical analyses (temperature, conductivity, salinity, dissolved oxygen, depth, turbidity and chlorophyll *a*) by site (not averages) and location north and south of causeway (averages) (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) is listed for each site.

		YSI Readings							
	North or South of Causeway	**Temperature (°C)**	**Conductivity**	**Salinity**	**Dissolved Oxygen (%)**	**Dissolved Oxygen (mg/l)**	**Depth**	**Turbidity**	**Chlorophyll**
Site Name		**p=0.000**	**p=0.000**	**p=0.000**	**p=0.002**	**p=0.011**	p=0.385	**p=0.004**	**p=0.000**
Polecat Bay	**N**	7	4	4	1	1	9	8	1
Delvan Bay	**N**	6	6	6	10	10	9	7	9
Tensaw Riverbank	**N**	2	2	2	8	8	1	10	6
Chocolatta Bay	**N**	1	7	7	6	6	8	1	2
Blakeley Riverbank	**N**	4	10	9	7	7	2	4	5
Justin's Bay	**N**	5	8	8	9	9	7	9	8
Mouth of Pinto Pass	**S**	3	3	3	2	2	10	2	7
Pinto Pass	**S**	8	1	1	3	3	3	3	10
South of Chocolatta	**S**	11	5	5	11	11	5	11	11
South of Justin's	**S**	10	9	9	4	4	6	6	3
South Blakeley Riverbank	**S**	9	10	10	5	5	4	5	4
North	**N**	-	-	-	-	-	-	-	-
South	**S**	-	-	-	-	-	-	-	-
		N > S	S>N	S>N	S>N	S>N	N>S	N>S	N>S
		p=0.070	p=0.574	p=0.607	p=0.851	p=0.769	p=0.713	p=0.910	**p=0.154**

Table 3-3. October 2005 summary table for YSI readings statistical analyses (temperature, conductivity, salinity, dissolved oxygen, depth, turbidity and chlorophyll *a*) by site (not averages) and location north and south of causeway (averages) (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) is listed for each site.

		YSI Readings							
	North or South of Causeway	**Temperature (°C)**	**Conductivity**	**Salinity**	**Dissolved Oxygen (%)**	**Dissolved Oxygen (mg/l)**	**Depth**	**Turbidity**	**Chlorophyll**
Site Name		**p=0.000**	**p=0.000**	**p=0.000**	**p=0.000**	**p=0.000**	p=0.330	**p=0.000**	**p=0.029**
Polecat Bay	**N**	11	5	5	4	3	7	1	4
Delvan Bay	**N**	10	7	7	2	2	10	3	5
Tensaw Riverbank	**N**	2	4	4	9	9	2	4	1
Chocolatta Bay	**N**	6	6	6	1	1	4	5	2
Blakeley Riverbank	**N**	1	9	9	11	11	1	7	10
Justin's Bay	**N**	8	11	11	6	5	6	2	6
Mouth of Pinto Pass	**S**	4	3	3	3	4	8	9	8
Pinto Pass	**S**	5	1	1	5	6	5	6	9
South of Chocolatta	**S**	9	2	2	10	10	3	11	11
South of Justin's	**S**	7	8	8	8	7	9	10	3
South Blakeley Riverbank	**S**	3	10	10	7	8	11	8	7
North	**N**	-	-	-	-	-	-	A	-
South	**S**	-	-	-	-	-	-	B	-
		S > N	S>N	S>N	N>S	N>S	N>S	N>S	N>S
		p=0.339	p=0.305	p=0.301	p=0.572	p=0.283	p=0.231	**p=0.007**	p=0.097

Table 3-4. March 2006 summary table for YSI readings statistical analyses (temperature, conductivity, salinity, dissolved oxygen, depth, turbidity and chlorophyll *a*) by site (not averages) and location north and south of causeway (averages) (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) is listed for each site.

		YSI Readings							
	North or South of Causeway	**Temperature (ºC)**	**Conductivity**	**Salinity**	**Dissolved Oxygen (%)**	**Dissolved Oxygen (mg/l)**	**Depth**	**Turbidity**	**Chlorophyll**
Site Name		**p=0.000**	**p=0.000**	**p=0.000**	**p=0.000**	**p=0.000**	**p=0.002**	**p=0.001**	**p=0.000**
Polecat Bay	**N**	3	1	1	1	1	7	10	3
Delvan Bay	**N**	2	2	2	2	2	6	7	1
Tensaw Riverbank	**N**	6	6	5	5	4	9	6	8
Chocolatta Bay	**N**	4	4	4	3	3	5	8	10
Blakeley Riverbank	**N**	5	7	5	10	9	3	5	9
Justin's Bay	**N**	1	3	3	4	10	8	9	2
Mouth of Pinto Pass	**S**	9	7	5	6	5	2	3	4
Pinto Pass	**S**	11	6	4	7	6	4	4	6
South of Chocolatta	**S**	10	5	3	8	7	1	11	11
South of Justin's	**S**	8	7	5	11	11	10	2	7
South Blakeley Riverbank	**S**	7	7	5	9	8	11	1	5
North	**N**	A	-	-	A	-	-	-	-
South	**S**	B	-	-	B	-	-	-	-
		N > S	N > S	N > S	N > S	N > S	N > S	S > N	N > S
		p=0.003	p=0.153	p=0.269	**p=0.033**	p=0.230	p=0.893	p=0.114	**p=0.144**

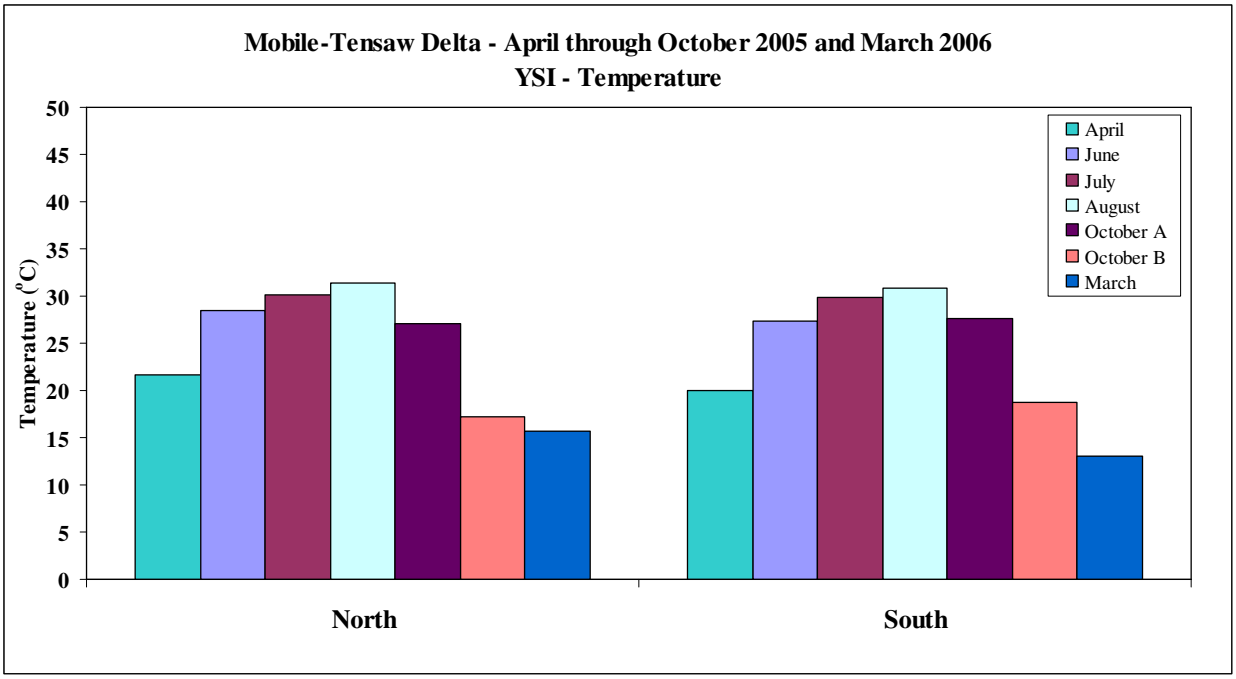

Figure 3-1. Mean temperature (°C) from YSI readings plotted by location north and south of the causeway from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006.

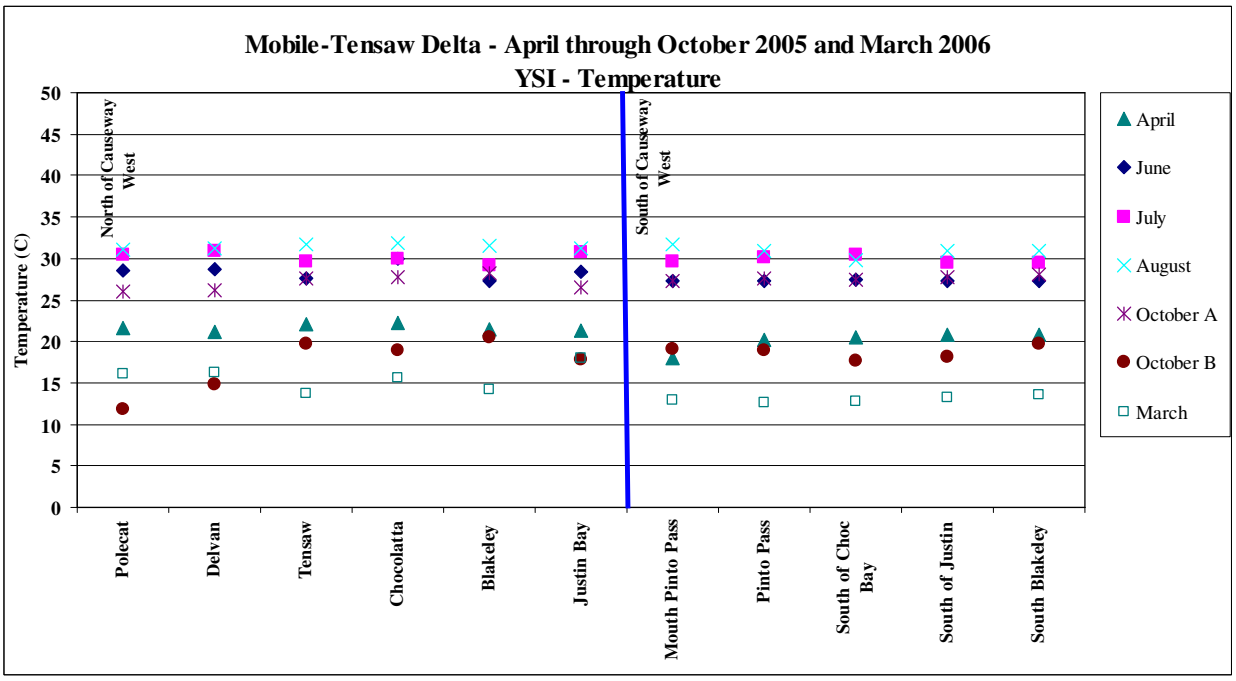

Figure 3-2. Mean temperature (°C) from YSI readings plotted by site from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

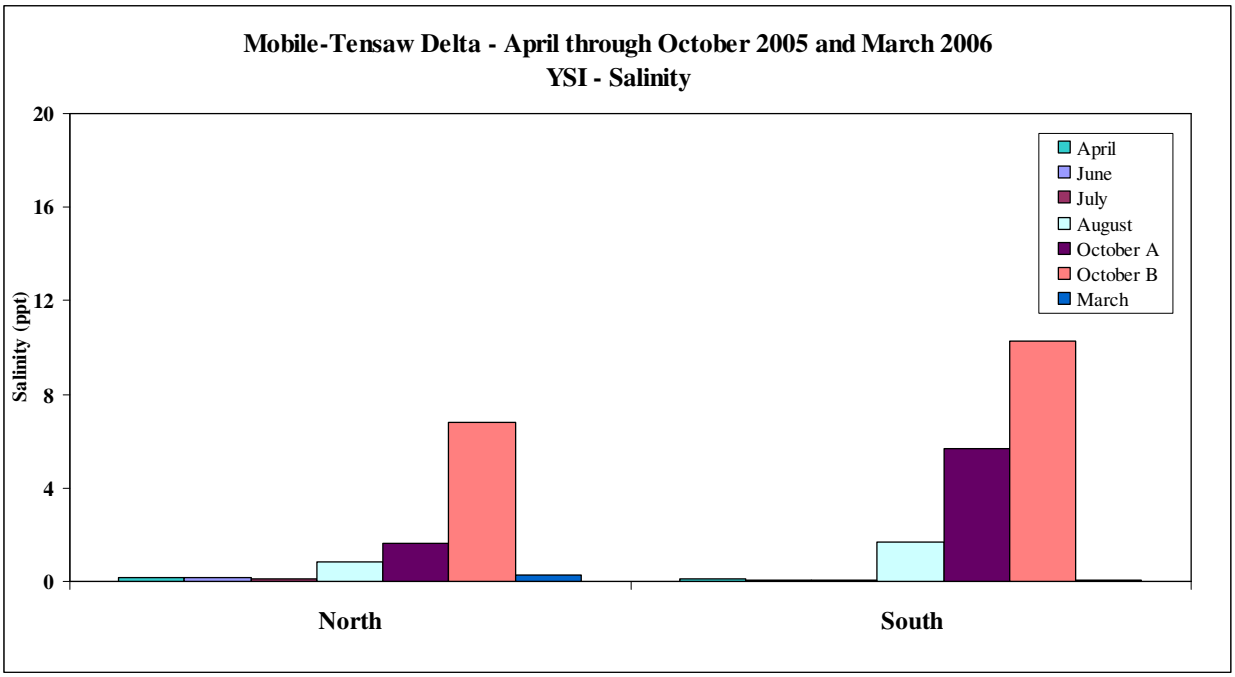

Figure 3-3. Mean salinity (ppt) from YSI readings plotted by location north and south of the causeway from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006.

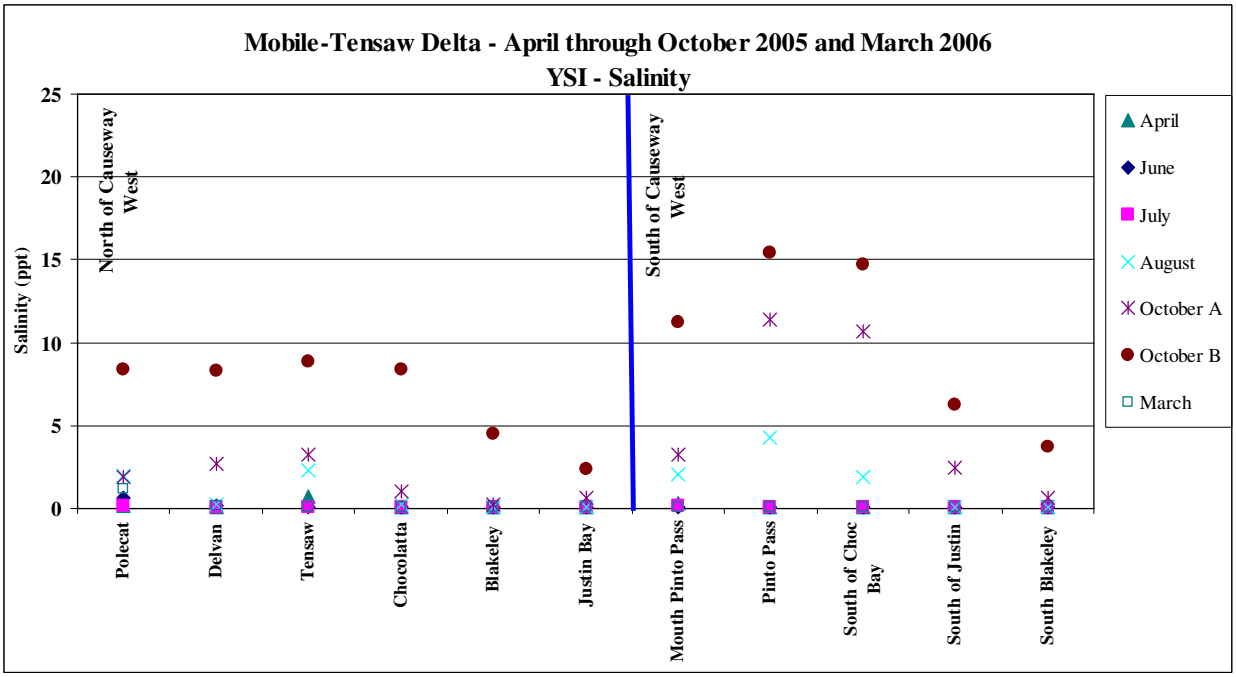

Figure 3-4. Mean salinity (ppt) from YSI readings plotted by site from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

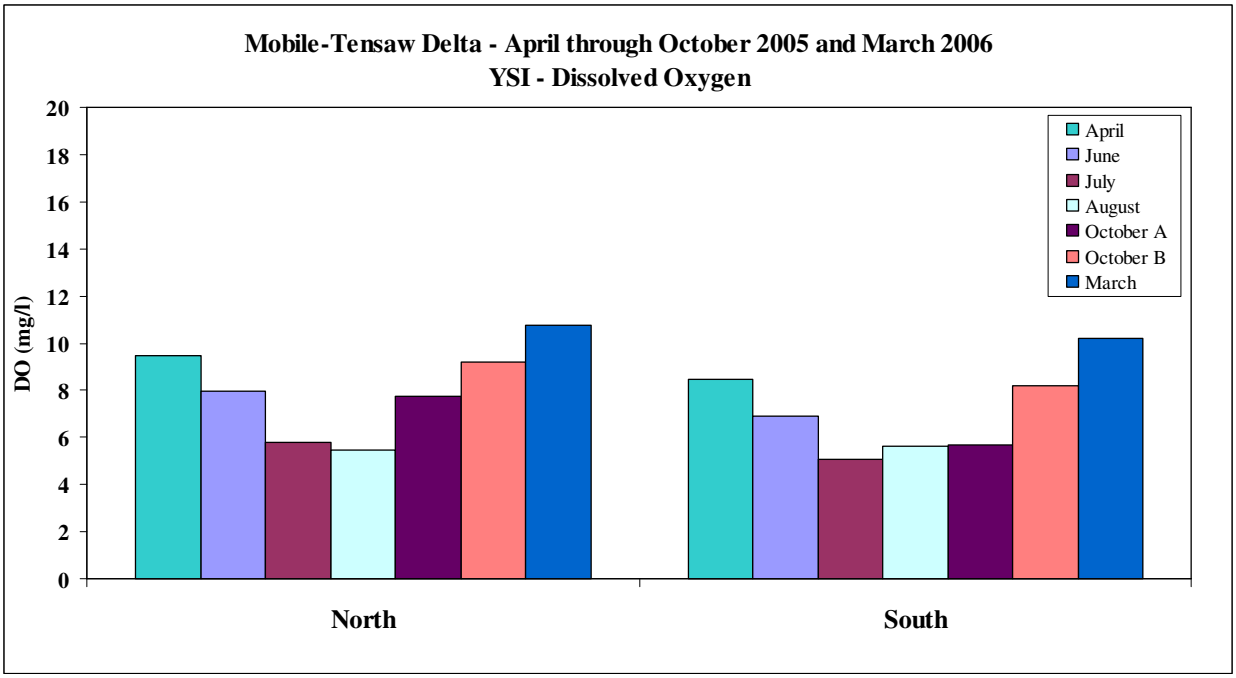

Figure 3-5. Mean dissolved oxygen (mg/l) from YSI readings plotted by location north and south of the causeway from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006.

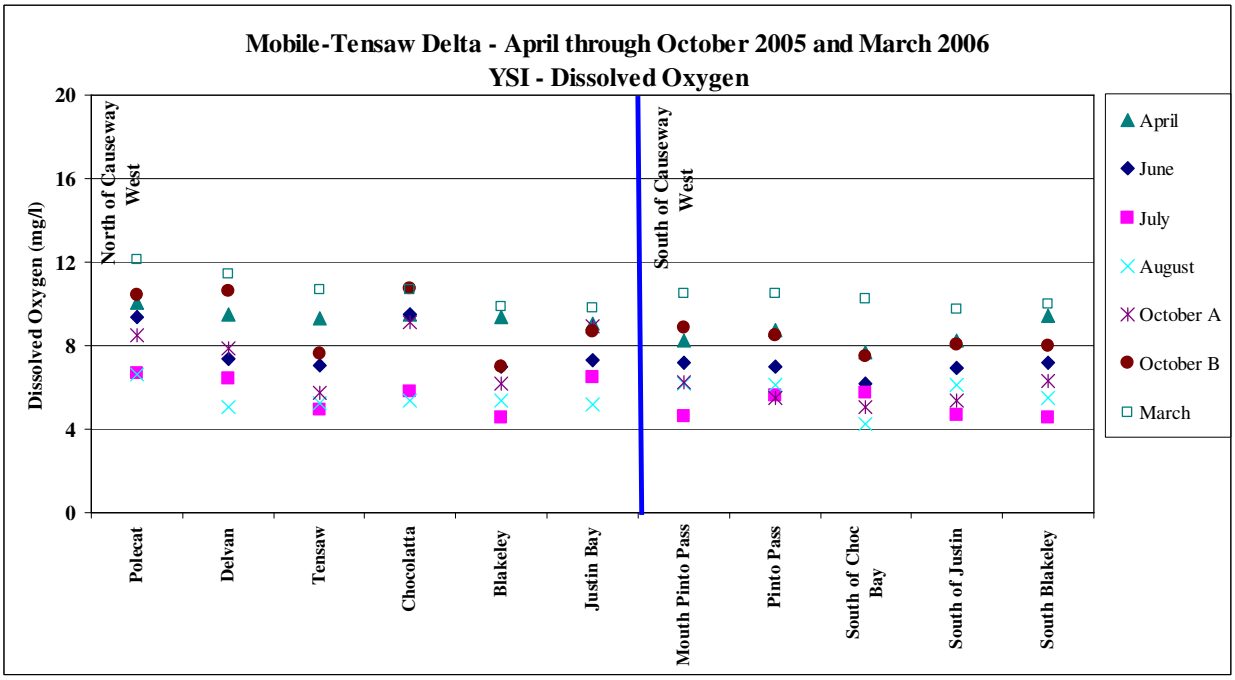

Figure 3-6. Mean dissolved oxygen (mg/l) from YSI readings plotted by site from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

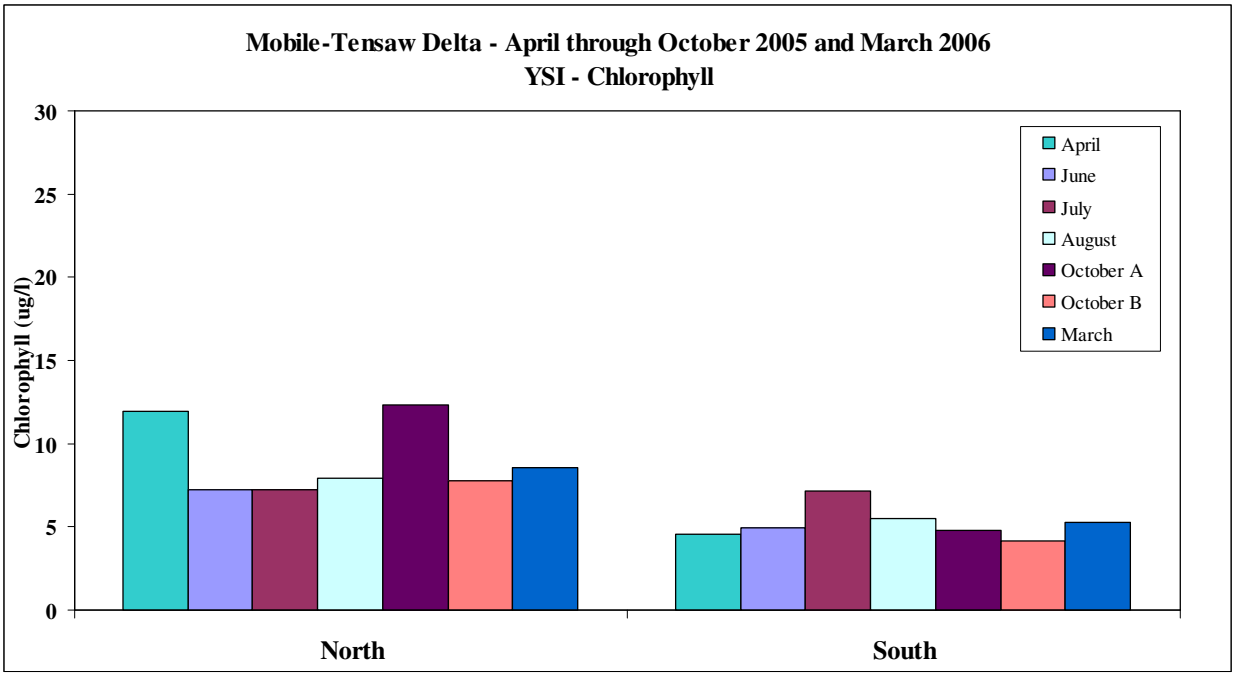

Figure 3-7. Mean chlorophyll *a* (ug/l) from YSI readings plotted by location north and south of the causeway from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006.

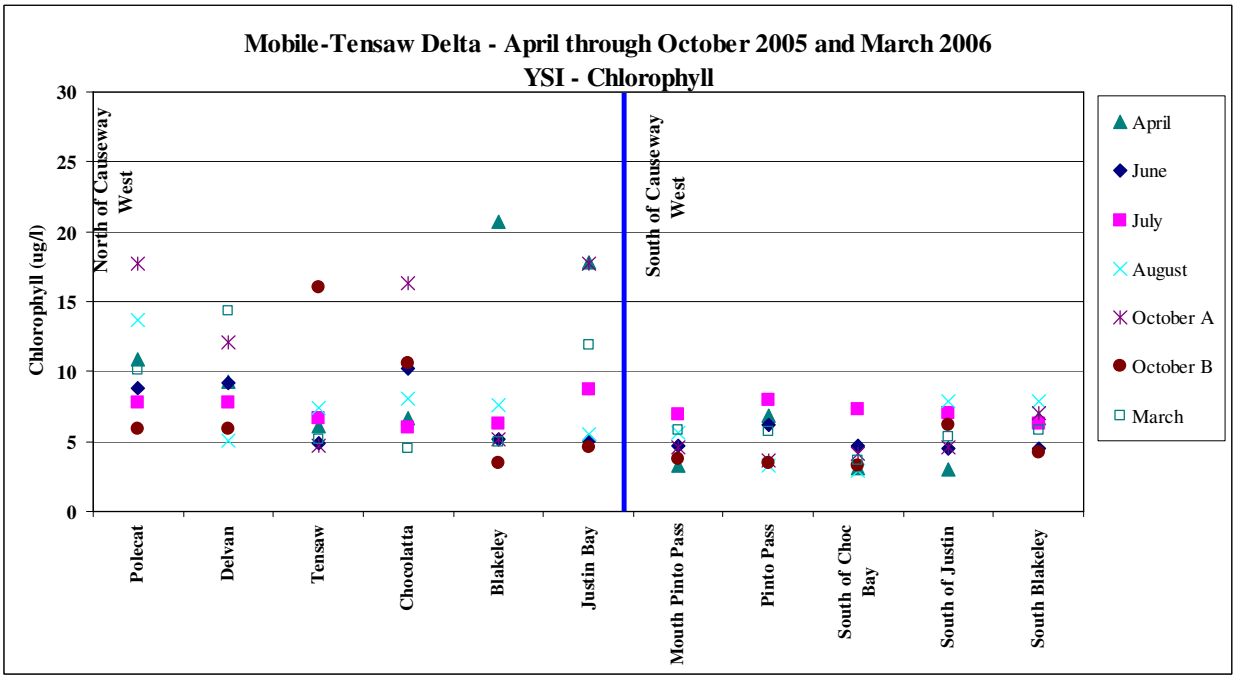

Figure 3-8. Mean chlorophyll *a* (ug/l) from YSI readings plotted by site from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

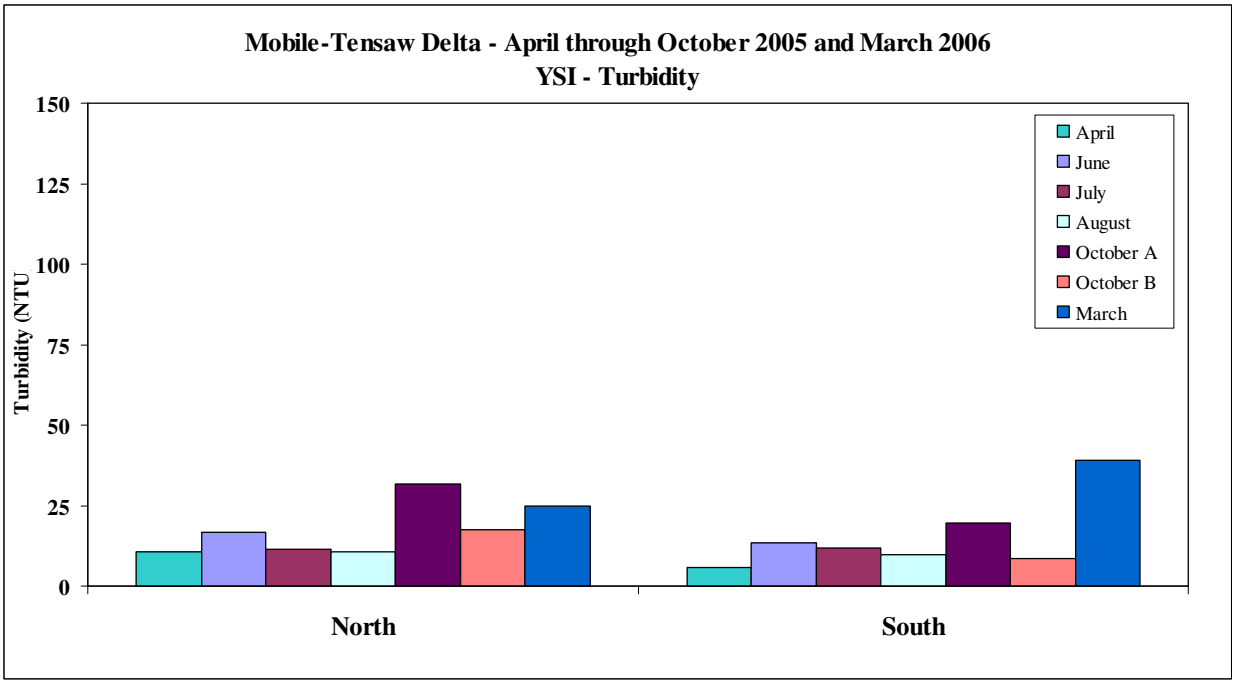

Figure 3-9. Mean turbidity (NTU) from YSI readings plotted by location north and south of the causeway from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006.

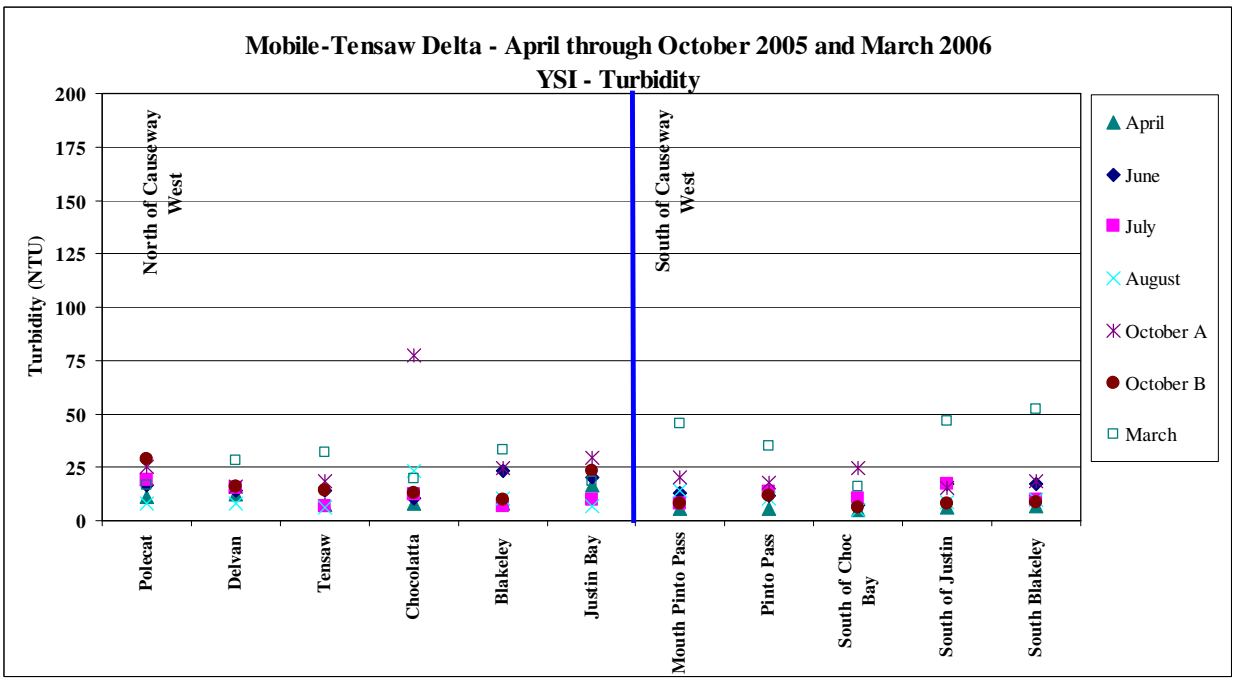

Figure 3-10. Mean turbidity (NTU) from YSI readings plotted by site from April, June, July, August and October (A = Oct. 5; B = Oct. 25-27) 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

Appendix 4

Nutrients – April, June, July, August and October 2005 and March 2006

Table 4-1. Summary table for April 2005 nutrient statistical analyses (NH4, NO3-NO2, TKN, TN and TP) by site and location north or south of causeway (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) is listed for each site.

		Water Column Nutrients				
	North or South of Causeway	**NH4**	**NO3-NO2**	**TKN**	**TN**	**TP**
Site Name		na	na	na	na	na
Polecat Bay	N	5	10	8	11	3
Delvan Bay	N	6	7	6	7	5
Tensaw Riverbank	N	7	9	1	2	7
Chocolatta Bay	N	8	11	4	5	4
Blakeley Riverbank	N	9	5	3	3	8
Justin's Bay	N	11	6	9	10	6
Mouth of Pinto Pass	S	1	3	2	1	1
Pinto Pass	S	2	2	10	9	10
South of Chocolatta	S	4	1	11	8	11
South of Justin's	S	3	4	7	6	2
South Blakeley Riverbank	S	10	8	5	4	9
North	N	-	-	-	-	-
South	S	-	-	-	-	-
		S > N	S > N	N > S	S > N	S > N
		p=0.716	p=0.905	p=0.118	p=0.077	p=0.062

Table 4-2. Summary table for June 2005 nutrient statistical analyses (NH4, NO3-NO2, TKN, TN and TP) by site and location north or south of causeway (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) is listed for each site.

		Water Column Nutrients				
	North or South of Causeway	**NH4**	**NO3-NO2**	**TKN**	**TN**	**TP**
Site Name		na	na	na	na	na
Polecat Bay	N	1	9	3	8	10
Delvan Bay	N	1	11	1	1	7
Tensaw Riverbank	N	1	2	2	2	6
Chocolatta Bay	N	1	10	7	11	7
Blakeley Riverbank	N	1	1	9	7	1
Justin's Bay	N	1	6	5	5	2
Mouth of Pinto Pass	S	1	5	8	10	8
Pinto Pass	S	1	7	2	3	4
South of Chocolatta	S	1	8	6	9	9
South of Justin's	S	1	3	4	4	5
South Blakeley Riverbank	S	1	4	6	6	3
North	N	-	-	-	-	-
South	S	-	-	-	-	-
		S = N	S > N	N > S	N > S	N > S
		na	p=0.827	p=0.802	p=0.771	p=0.708

Table 4-3. Summary table for July 2005 nutrient statistical analyses (NH4, NO3-NO2, TKN, TN and TP) by site and location north or south of causeway (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) is listed for each site.

		Water Column Nutrients				
	North or South of Causeway	**NH4**	**NO3-NO2**	**TKN**	**TN**	**TP**
Site Name		na	na	na	na	na
Polecat Bay	N	2	8	4	4	2
Delvan Bay	N	2	8	4	4	1
Tensaw Riverbank	N	2	5	8	9	10
Chocolatta Bay	N	2	8	7	8	9
Blakeley Riverbank	N	2	3	5	5	10
Justin's Bay	N	2	8	3	3	6
Mouth of Pinto Pass	S	1	4	1	1	4
Pinto Pass	S	2	7	7	7	7
South of Chocolatta	S	2	6	8	10	5
South of Justin's	S	2	2	6	6	3
South Blakeley Riverbank	S	2	1	2	2	8
North	N	-	B	-	-	B
South	S	-	A	-	-	A
		S > N	S > N	S > N	S > N	S > N
		p=0.255	**p=0.018**	p=0.385	p=0.313	**p=0.042**

Table 4-4. Summary table for August 2005 nutrient statistical analyses (NH4, NO3-NO2, TKN, TN and TP) by site and location north or south of causeway (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) is listed for each site.

		Water Column Nutrients				
	North or South of Causeway	**NH4**	**NO3-NO2**	**TKN**	**TN**	**TP**
Site Name		na	na	na	na	na
Polecat Bay	N	2	8	1	1	2
Delvan Bay	N	2	8	3	4	6
Tensaw Riverbank	N	2	1	6	5	1
Chocolatta Bay	N	2	8	7	9	9
Blakeley Riverbank	N	2	3	8	8	3
Justin's Bay	N	2	8	5	6	7
Mouth of Pinto Pass	S	2	4	4	3	4
Pinto Pass	S	1	2	9	7	10
South of Chocolatta	S	2	6	10	10	11
South of Justin's	S	2	5	2	2	5
South Blakeley Riverbank	S	2	7	11	11	8
North	N	-	-	-	-	-
South	S	-	-	-	-	-
		S>N	S>N	N>S	N>S	N>S
		p=0.297	p=0.091	p=0.173	p=0.220	p=0.251

Table 4-5. Summary table for October 5, 2005 nutrient statistical analyses (NH4, NO3-NO2, TKN, TN and TP) by site and location north or south of causeway (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) is listed for each site.

		Water Column Nutrients				
	North or South of Causeway	**NH4**	**NO3-NO2**	**TKN**	**TN**	**TP**
Site Name		na	na	na	na	na
Polecat Bay	N	7	8	2	2	5
Delvan Bay	N	7	10	4	4	9
Tensaw Riverbank	N	6	2	5	5	4
Chocolatta Bay	N	5	9	1	1	1
Blakeley Riverbank	N	6	1	8	8	3
Justin's Bay	N	7	10	3	3	2
Mouth of Pinto Pass	S	4	3	8	9	4
Pinto Pass	S	2	7	6	7	8
South of Chocolatta	S	1	6	7	8	10
South of Justin's	S	3	5	6	6	7
South Blakeley Riverbank	S	6	4	9	10	6
North	N	B	B	A	A	-
South	S	A	A	B	B	-
		S > N	S > N	N > S	N > S	N > S
		p=0.002	**p=0.017**	**p=0.012**	**p=0.015**	p=0.207

Table 4-6. Summary table for October 25-27, 2005 nutrient statistical analyses (NH4, NO3-NO2, TKN, TN and TP) by site and location north or south of causeway (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) is listed for each site.

		Water Column Nutrients				
	North or South of Causeway	**NH4**	**NO3-NO2**	**TKN**	**TN**	**TP**
Site Name		na	na	na	na	na
Polecat Bay	N	7	9	2	2	1
Delvan Bay	N	7	11	3	6	4
Tensaw Riverbank	N	3	2	10	9	3
Chocolatta Bay	N	7	10	9	8	8
Blakeley Riverbank	N	5	1	7	5	5
Justin's Bay	N	4	4	4	3	4
Mouth of Pinto Pass	S	1	7	1	1	9
Pinto Pass	S	4	8	11	10	7
South of Chocolatta	S	6	5	5	4	6
South of Justin's	S	2	6	6	7	2
South Blakeley Riverbank	S	5	3	8	7	6
North	N	-	-	-	-	-
South	S	-	-	-	-	-
		S>N	S>N	S>N	S>N	N>S
		p=0.115	p=0.481	p=0.911	p=0.860	p=0.182

Table 4-7. Summary table for March 2006 nutrient statistical analyses (NH4, NO3-NO2, TKN, TN and TP) by site and location north or south of causeway (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) is listed for each site.

		Water Column Nutrients				
	North or South of Causeway	**NH4**	**NO3-NO2**	**TKN**	**TN**	**TP**
Site Name		na	na	na	na	na
Polecat Bay	N	1	9	2	2	9
Delvan Bay	N	3	10	3	4	5
Tensaw Riverbank	N	2	1	4	3	3
Chocolatta Bay	N	3	3	6	5	7
Blakeley Riverbank	N	2	5	10	10	4
Justin's Bay	N	3	7	7	8	6
Mouth of Pinto Pass	S	3	2	9	8	5
Pinto Pass	S	3	1	8	7	4
South of Chocolatta	S	2	4	10	9	8
South of Justin's	S	3	8	5	6	1
South Blakeley Riverbank	S	3	6	1	1	2
North	N	-	-	-	-	-
South	S	-	-	-	-	-
		N>S	S>N	N>S	N>S	S>N
		p=0.296	p=0.207	p=0.646	p=0.937	p=0.332

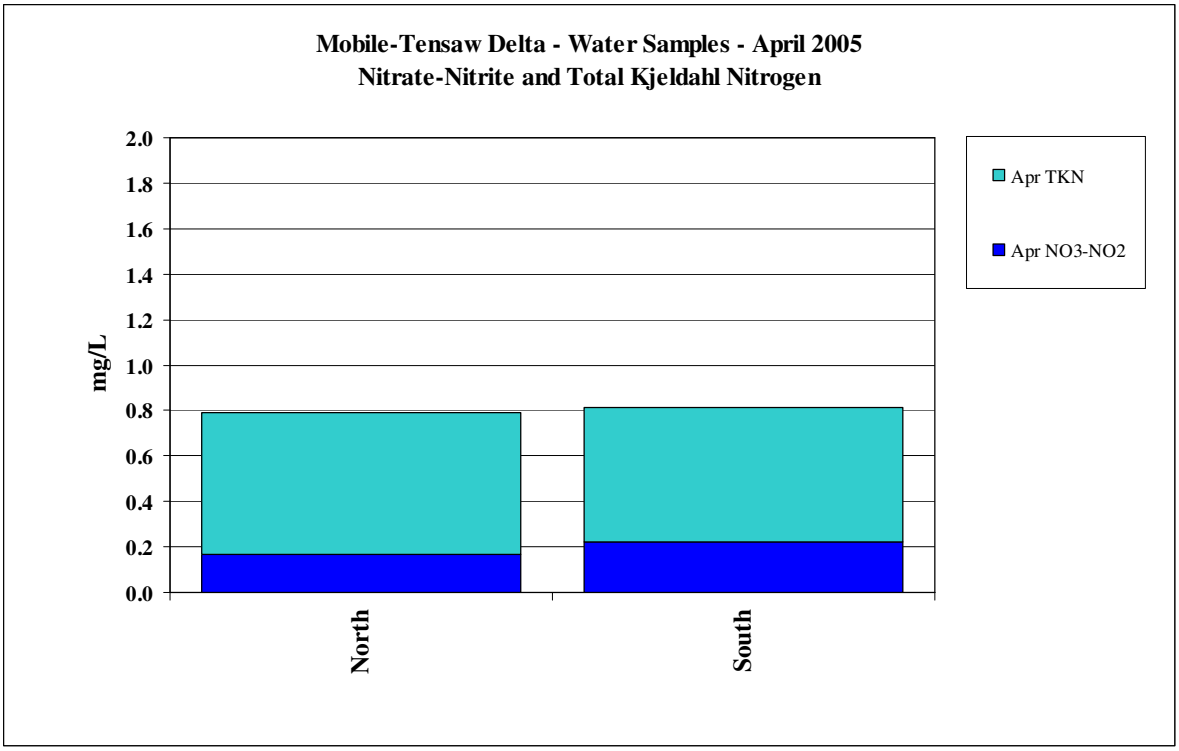

Figure 4-1. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from April 2005.

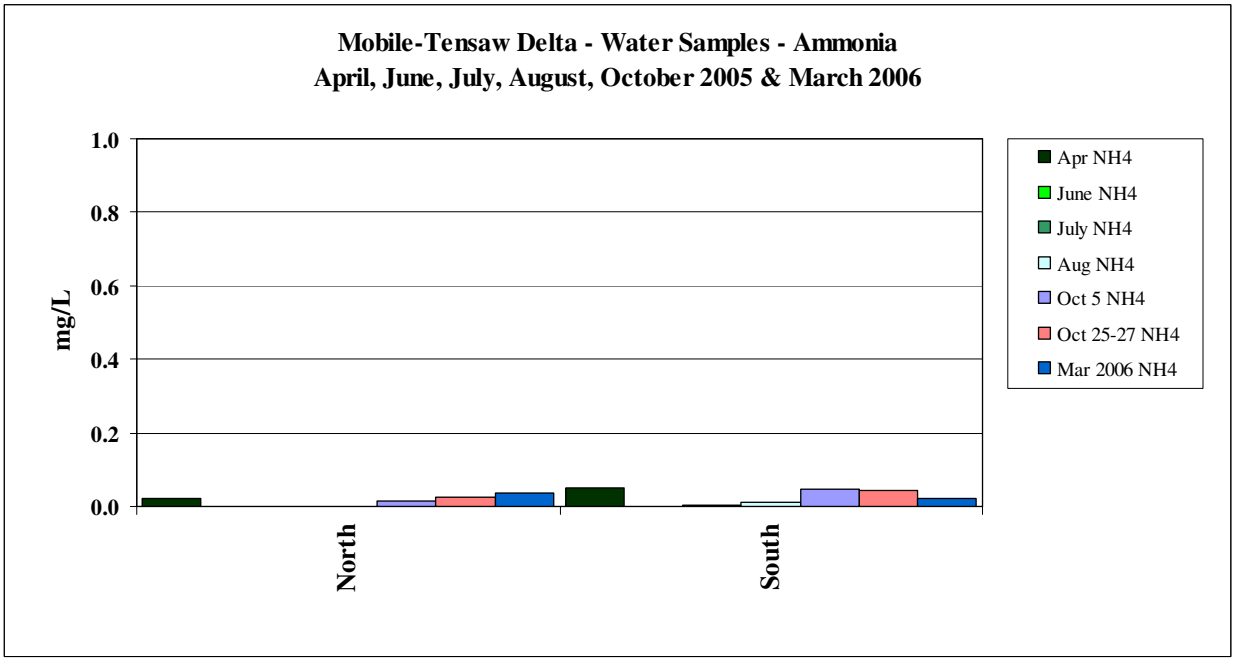

Figure 4-2. Water column ammonia (mg/l) and plotted by location north and south of the causeway from April, June, July, August and October 2005 and March 2006.

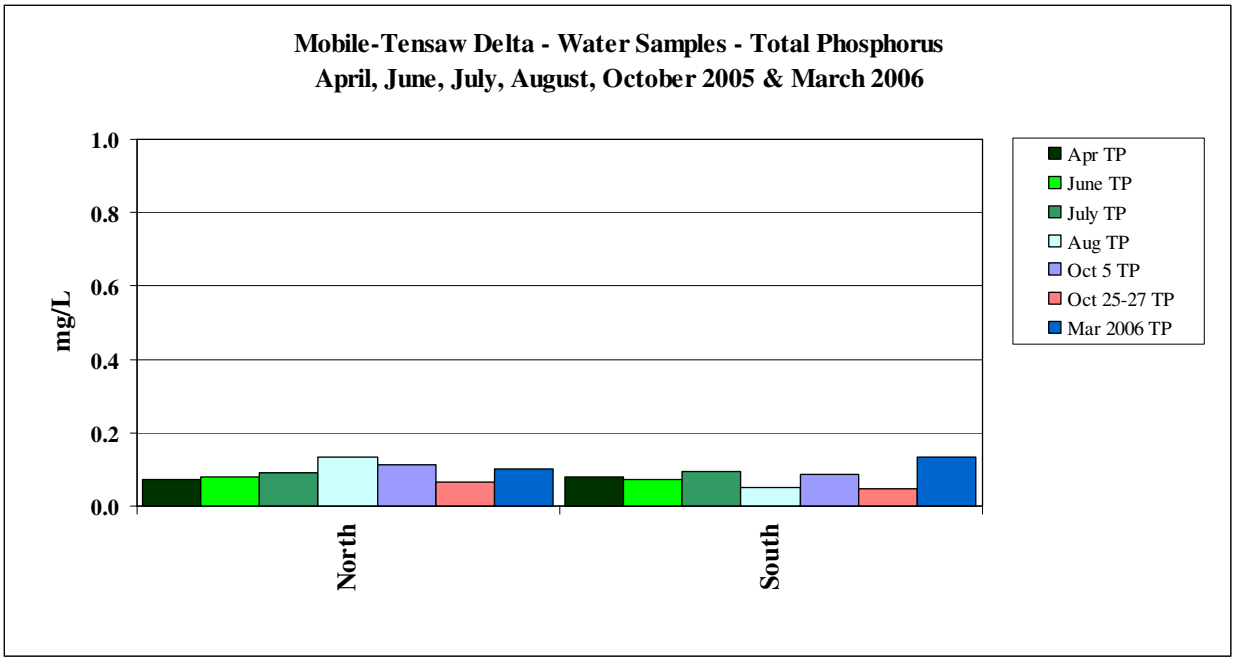

Figure 4-3. Water column total phosphorus (mg/l) plotted by location north and south of the causeway from April, June, July, August and October 2005 and March 2006.

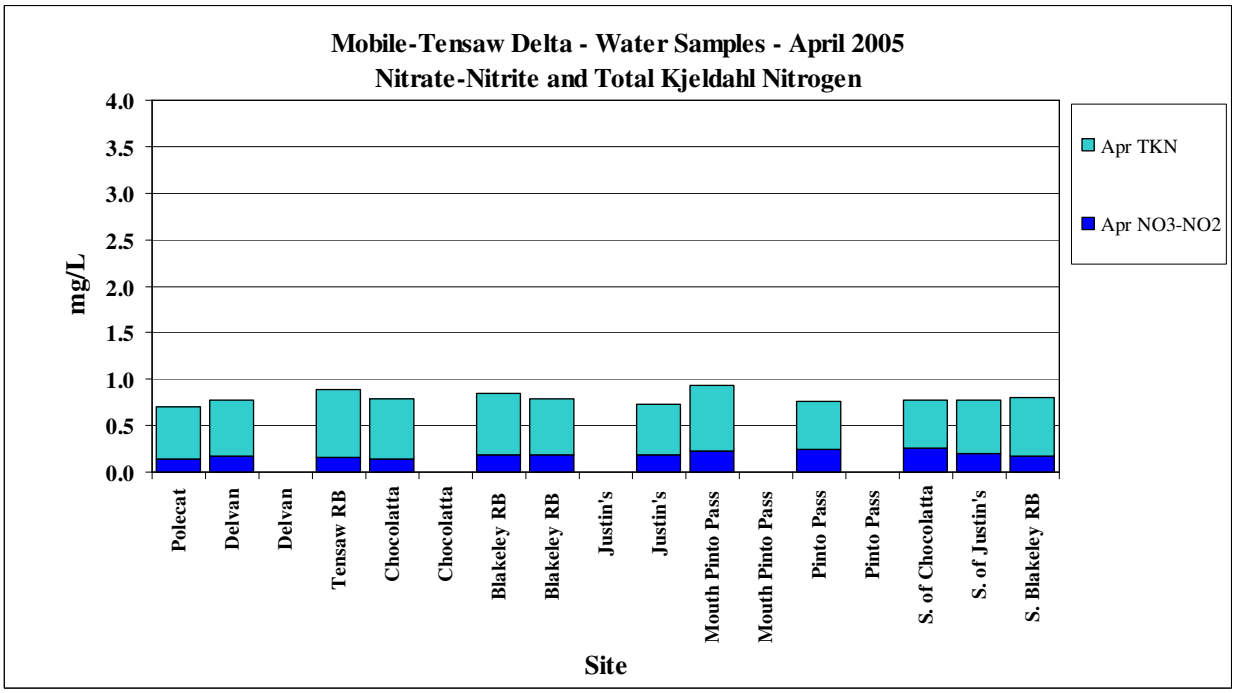

Figure 4-4. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from April 2005. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

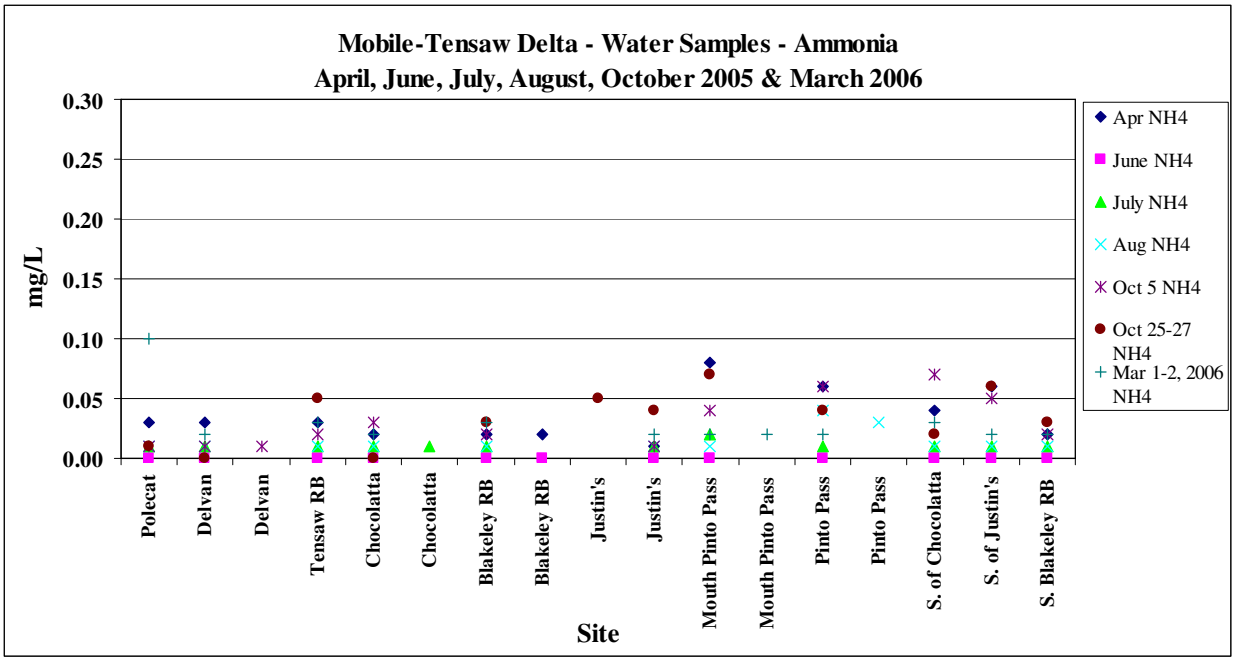

Figure 4-5. Water column ammonia (mg/l) plotted by site from April, June, July, August and October 2005 and March 2006. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

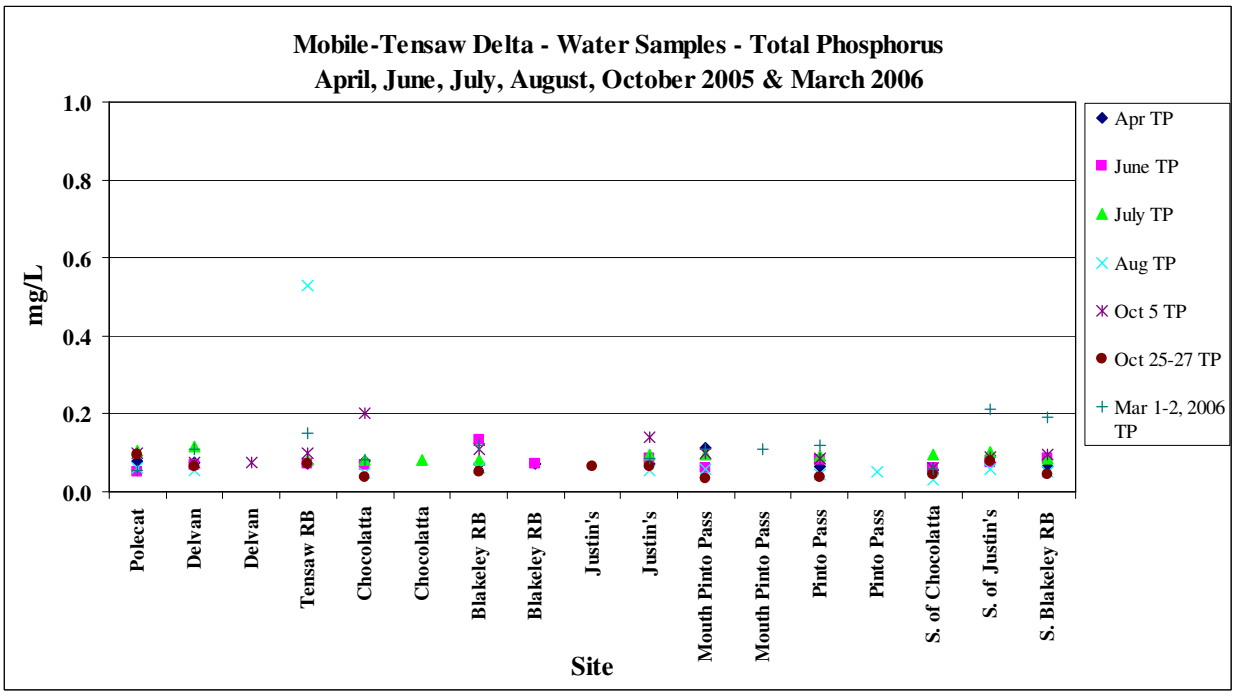

Figure 4-6. Water column total phosphorus (mg/l) plotted by site from April, June, July, August and October 2005 and March 2006. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

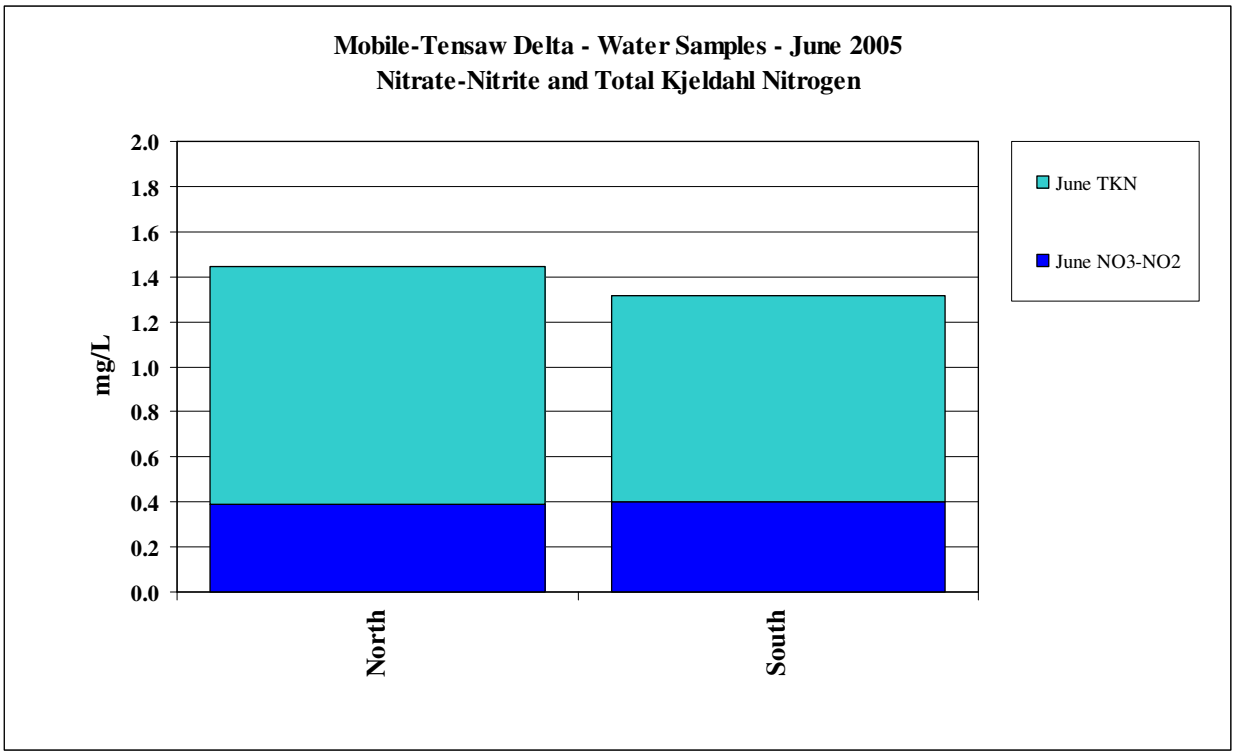

Figure 4-7. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from June 2005.

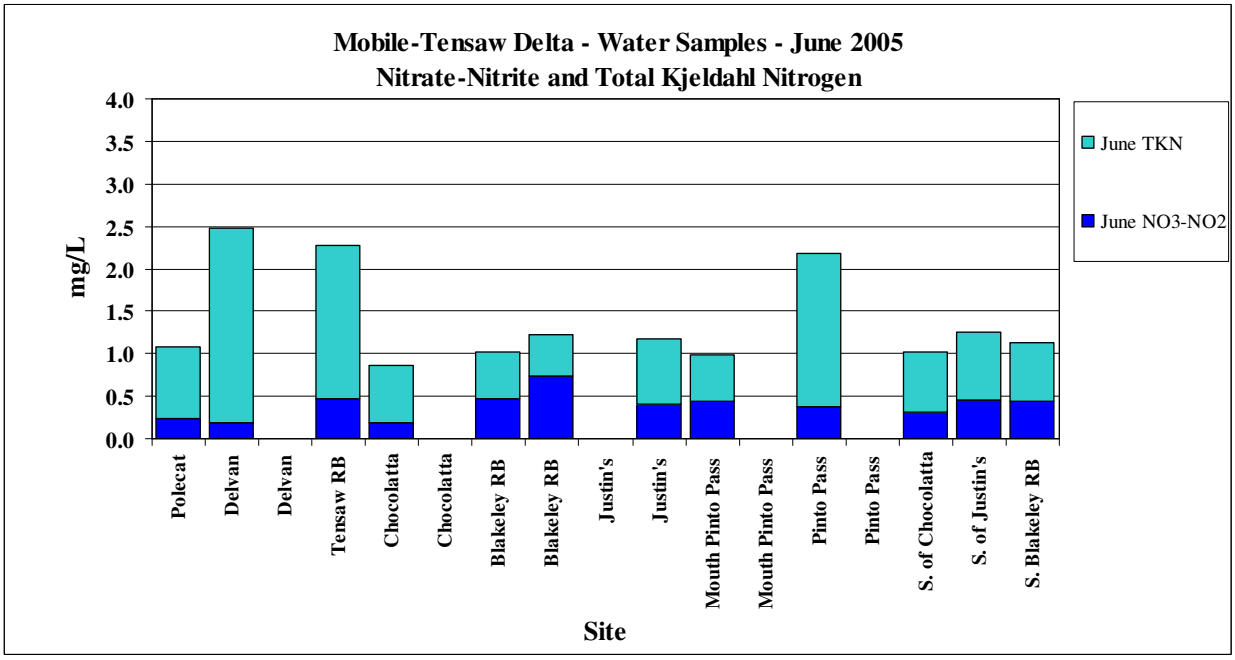

Figure 4-8. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from June 2005. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

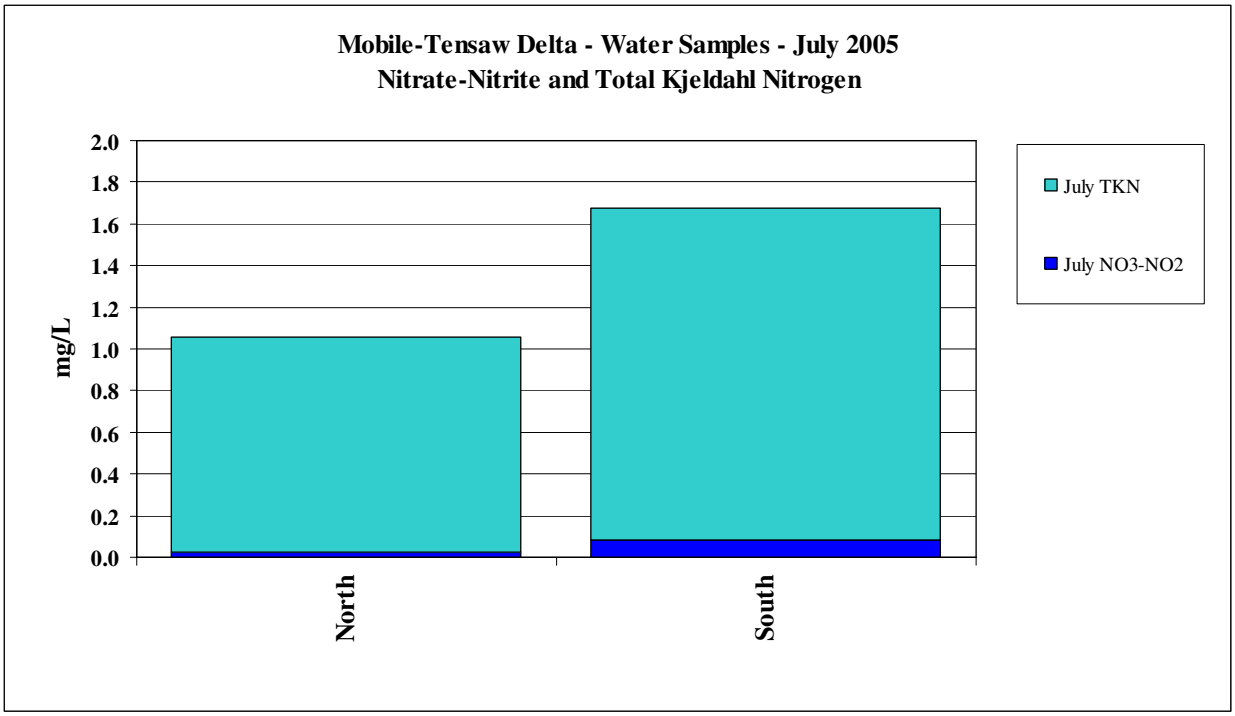

Figure 4-9. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from July 2005.

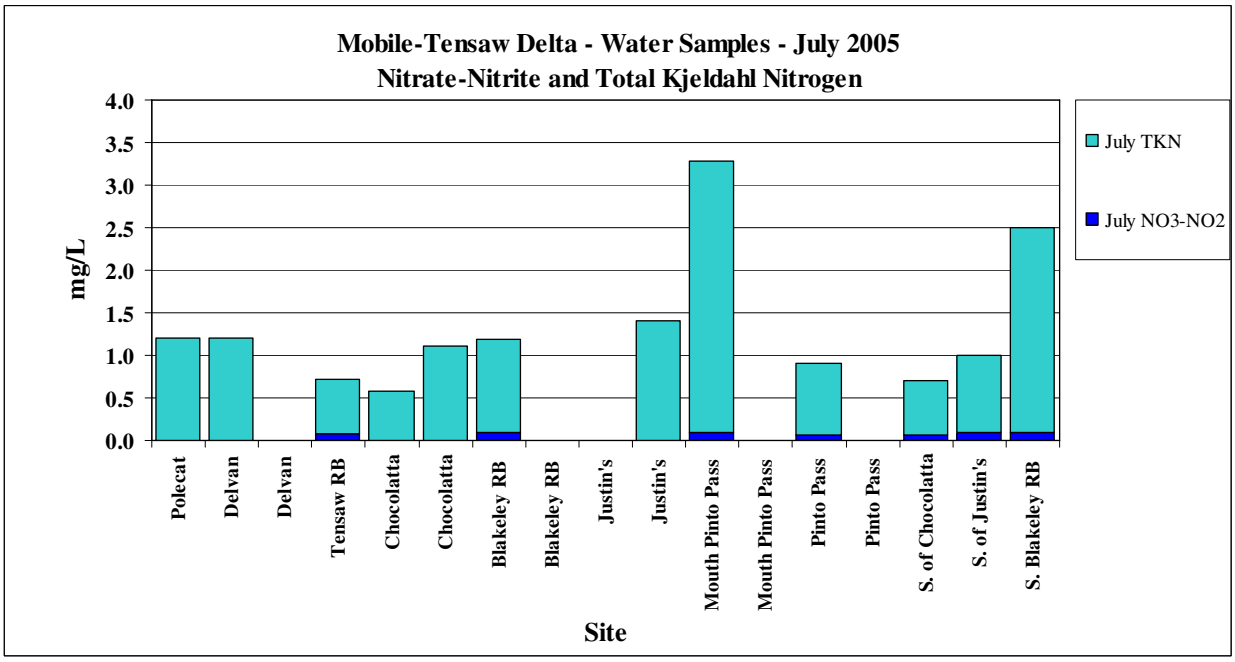

Figure 4-10. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from July 2005. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

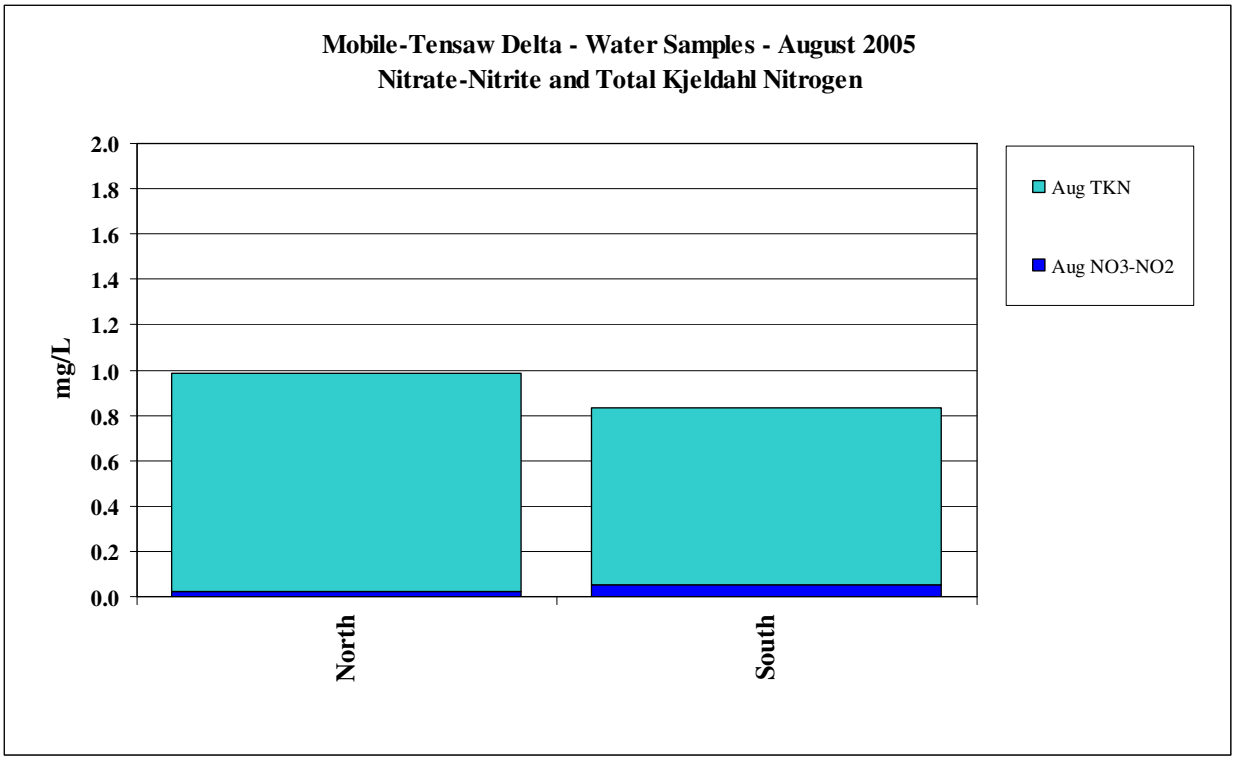

Figure 4-11. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from August 2005.

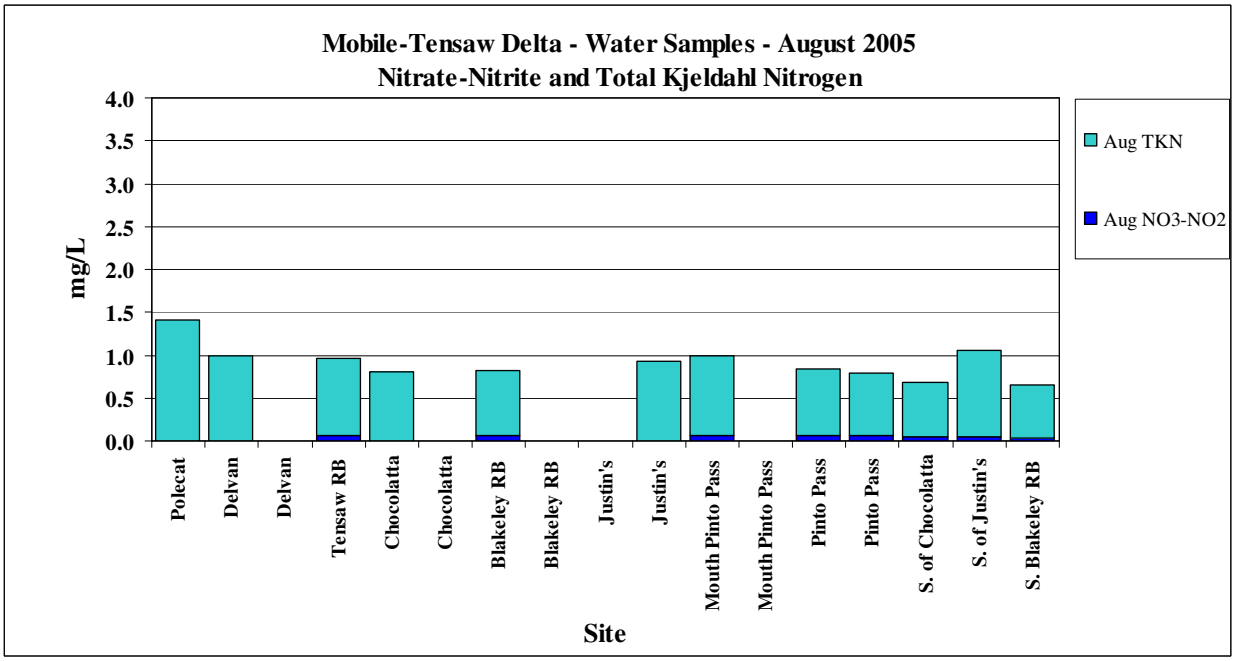

Figure 4-12. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from August 2005. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

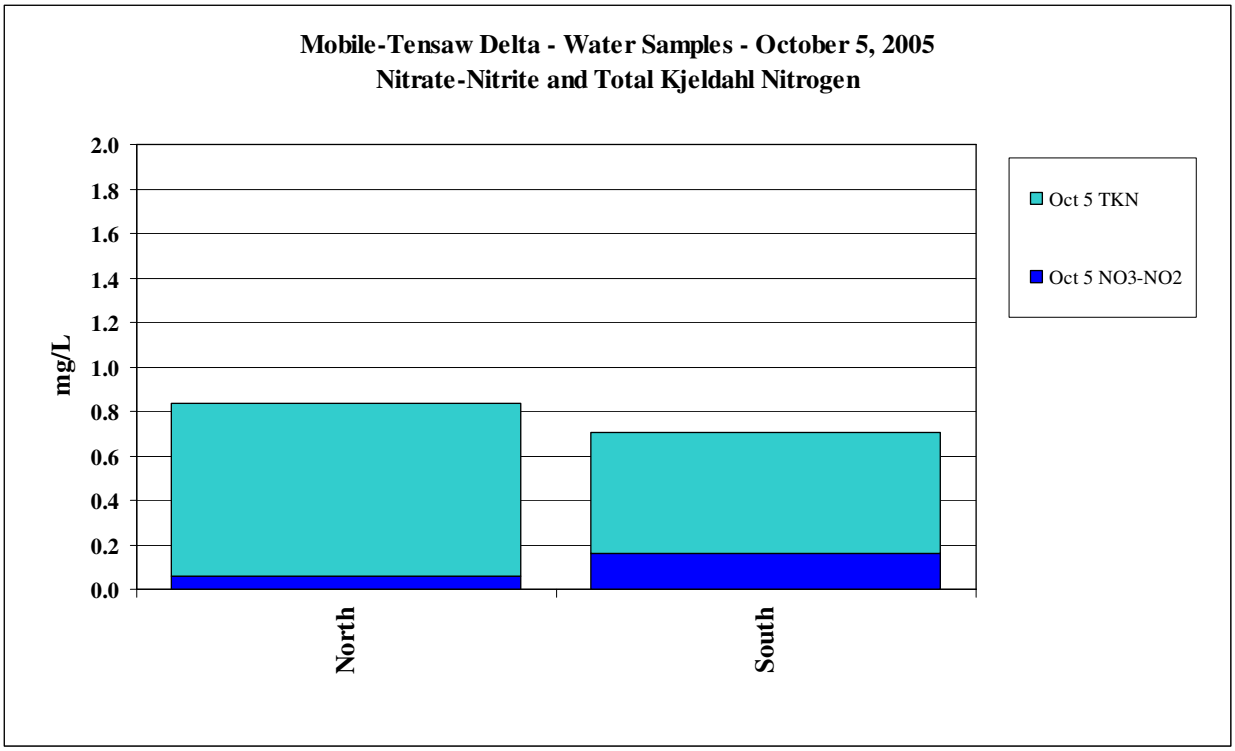

Figure 4-13. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from October 5, 2005.

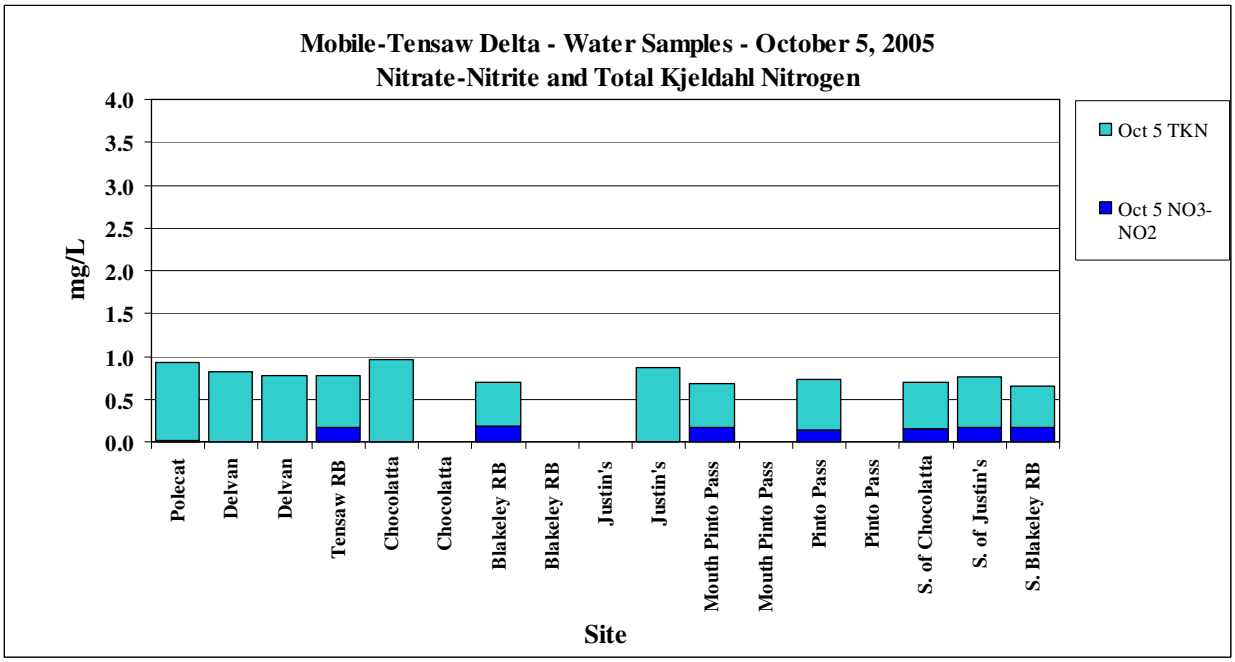

Figure 4-14. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from October 5, 2005. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

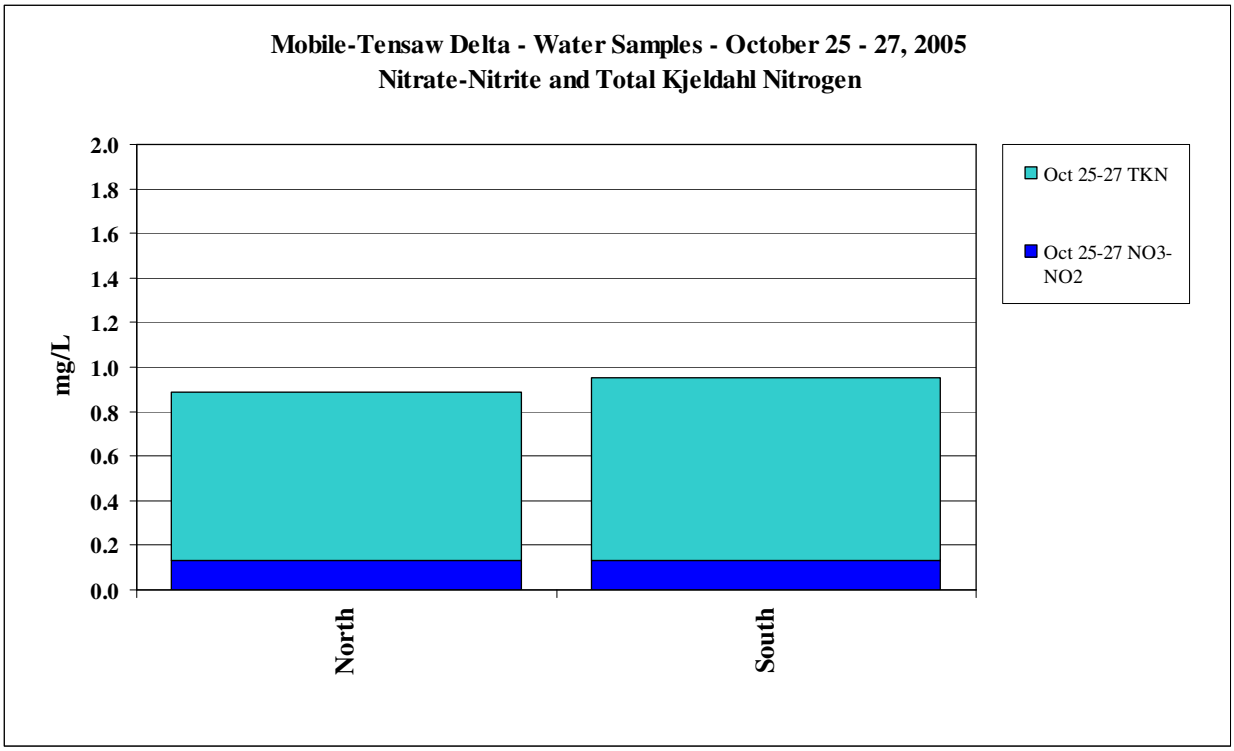

Figure 4-15. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from October 25 - 27, 2005.

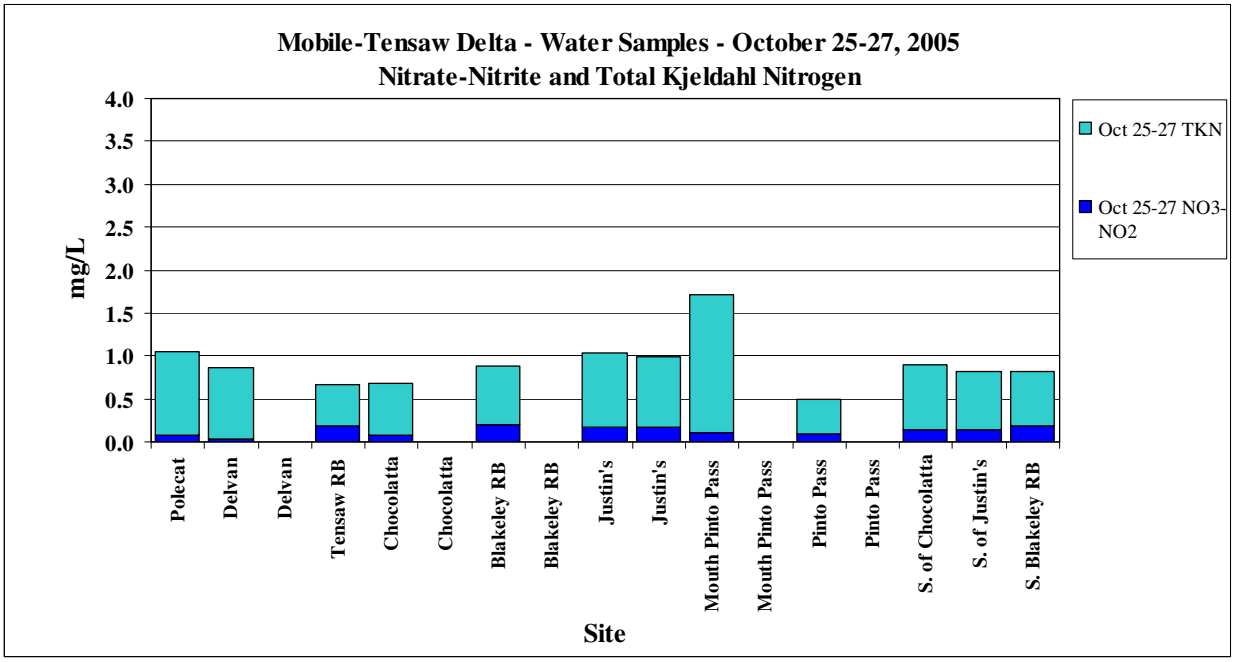

Figure 4-16. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from October 25 – 27, 2005. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

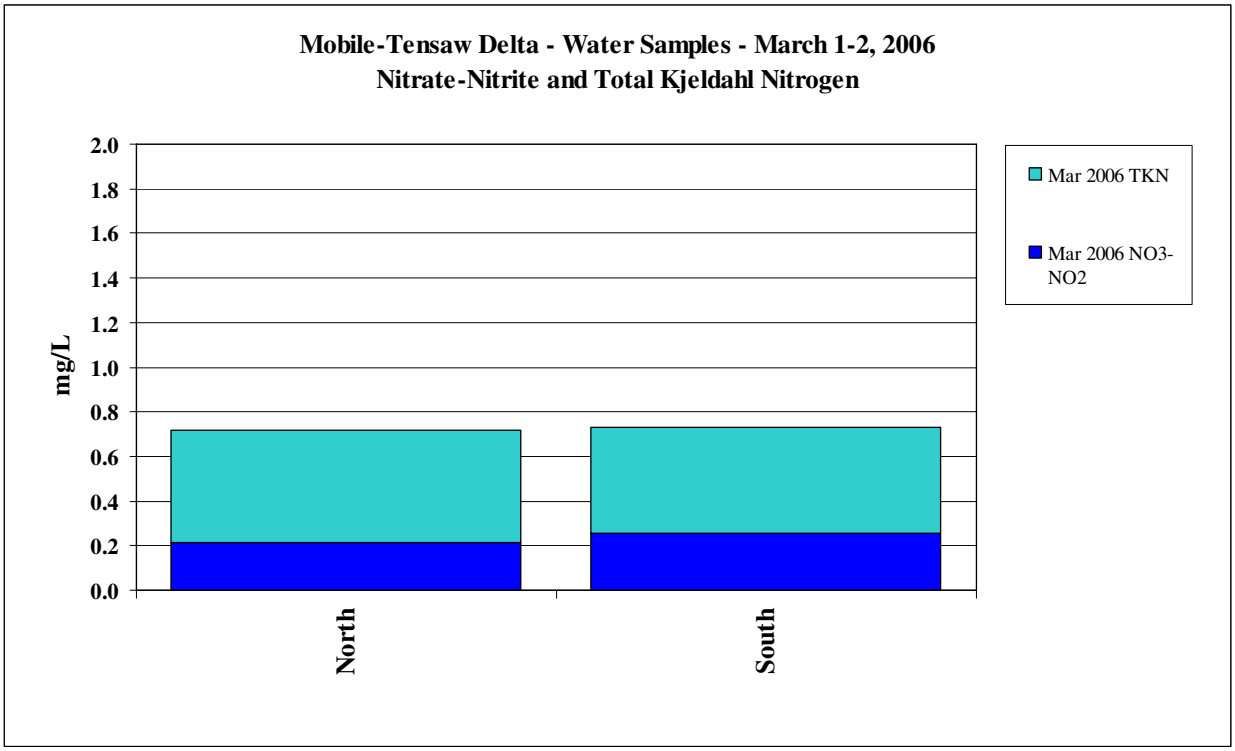

Figure 4-17. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by location north and south of the causeway from March 2006.

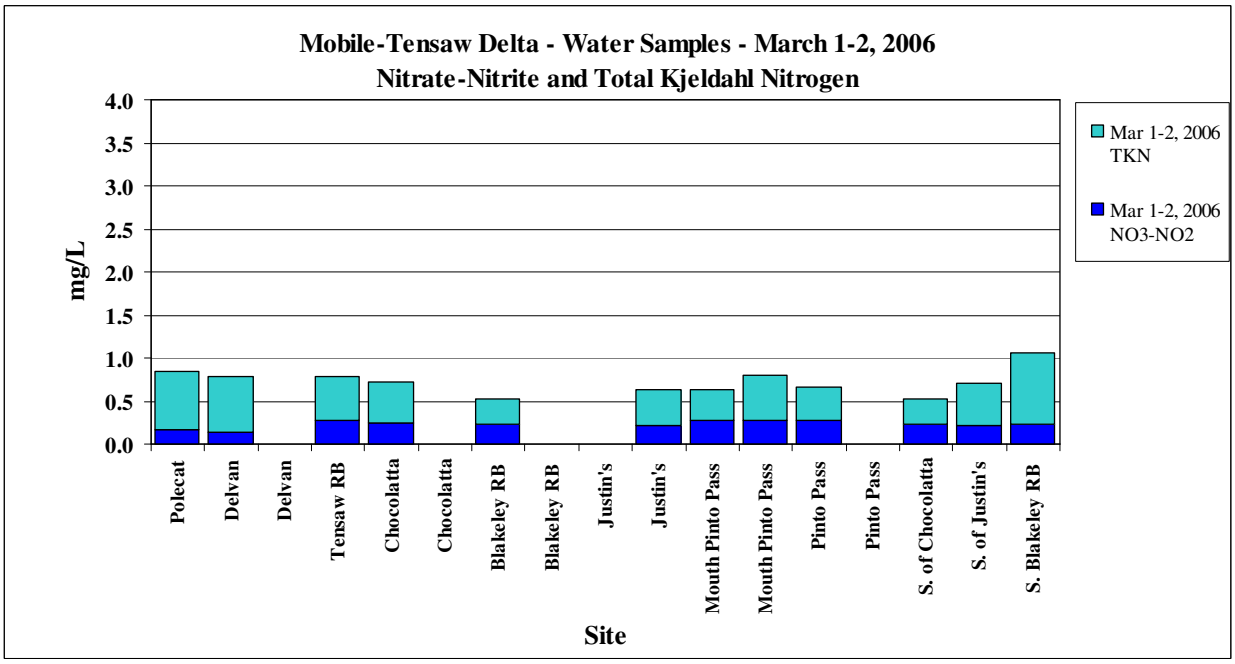

Figure 4-18. Water column nitrate-nitrite (mg/l) and total Kjeldahl nitrogen (mg/l) plotted by site from March 2006. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

Appendix 5

Primer: YSI and Nutrients

April, August and October 2005 and March 2006

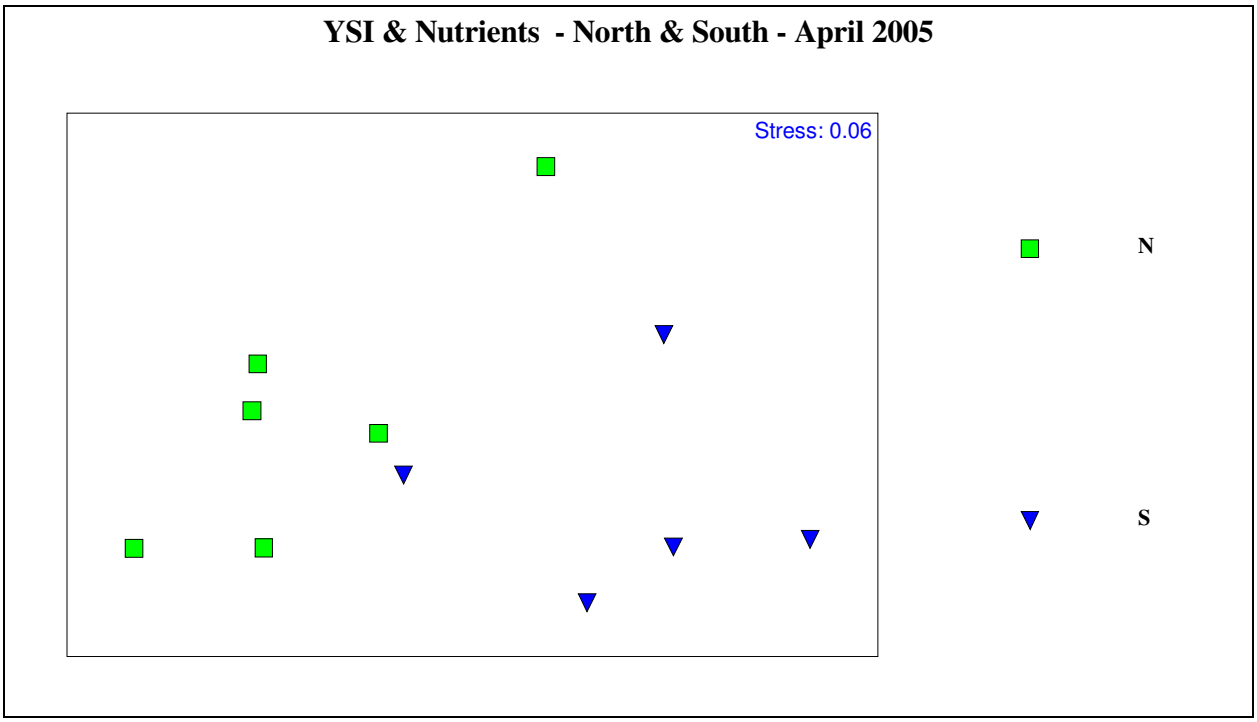

Figure 5-1. MDS plot for April 2005 YSI readings and nutrients by location north (N) and south (S) of the causeway.

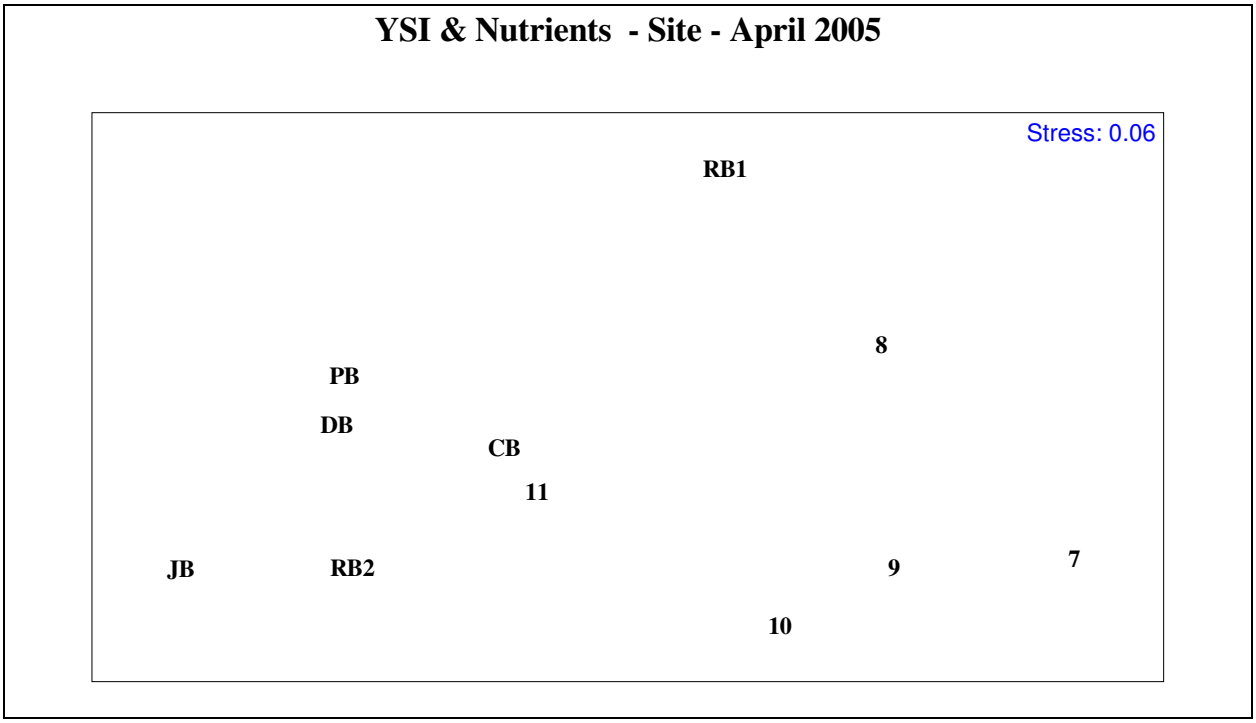

Figure 5-2. MDS plot for April 2005 YSI readings and nutrients by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

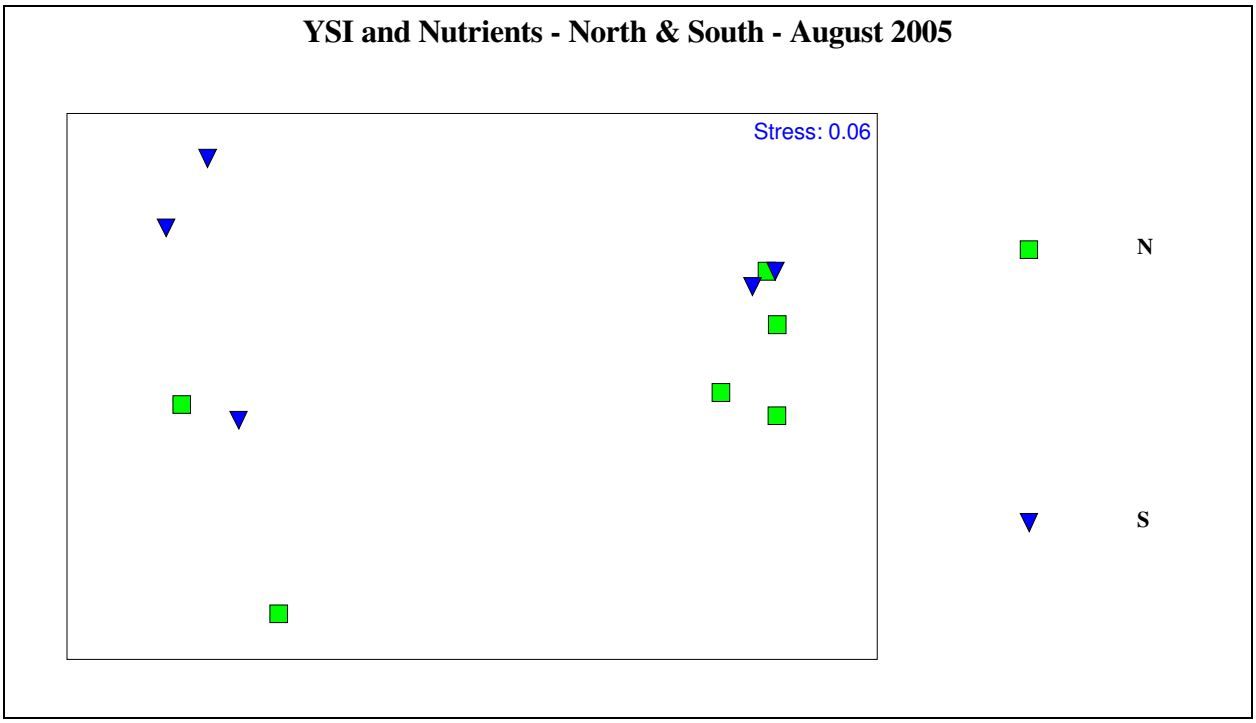

Figure 5-3. MDS plot for August 2005 YSI readings and nutrients by location north (N) and south (S) of the causeway.

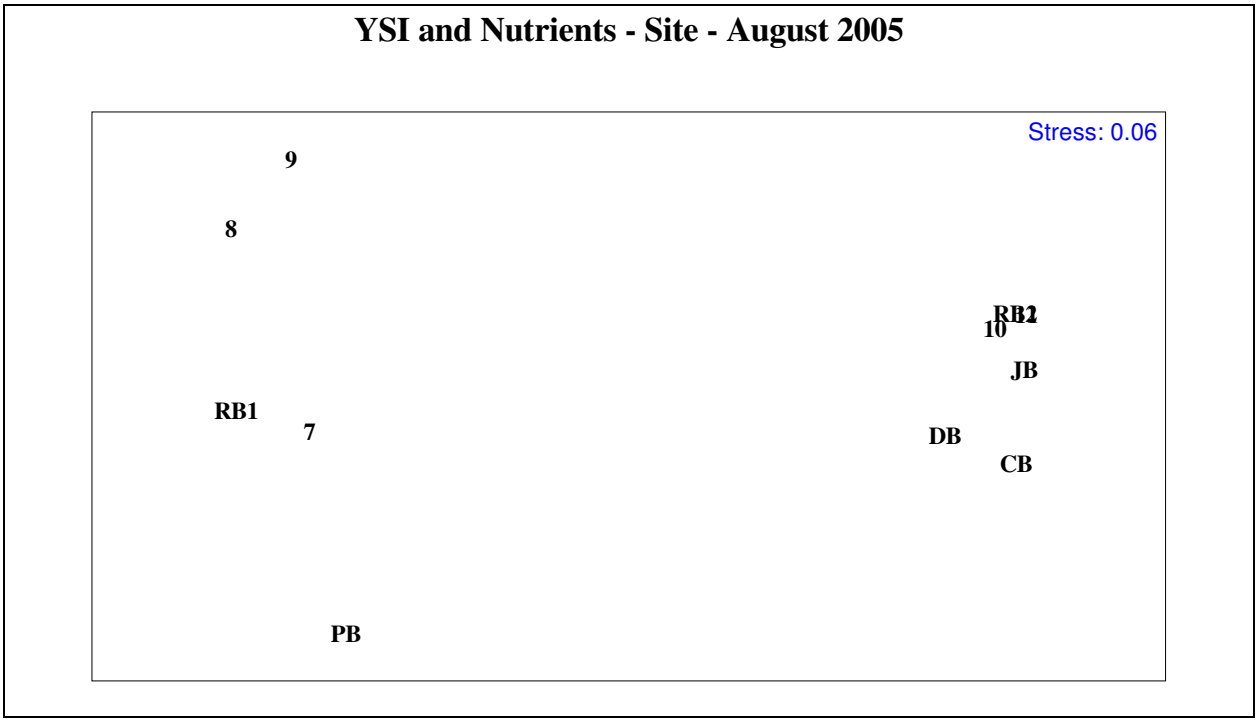

Figure 5-4. MDS plot for August 2005 YSI readings and nutrients by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

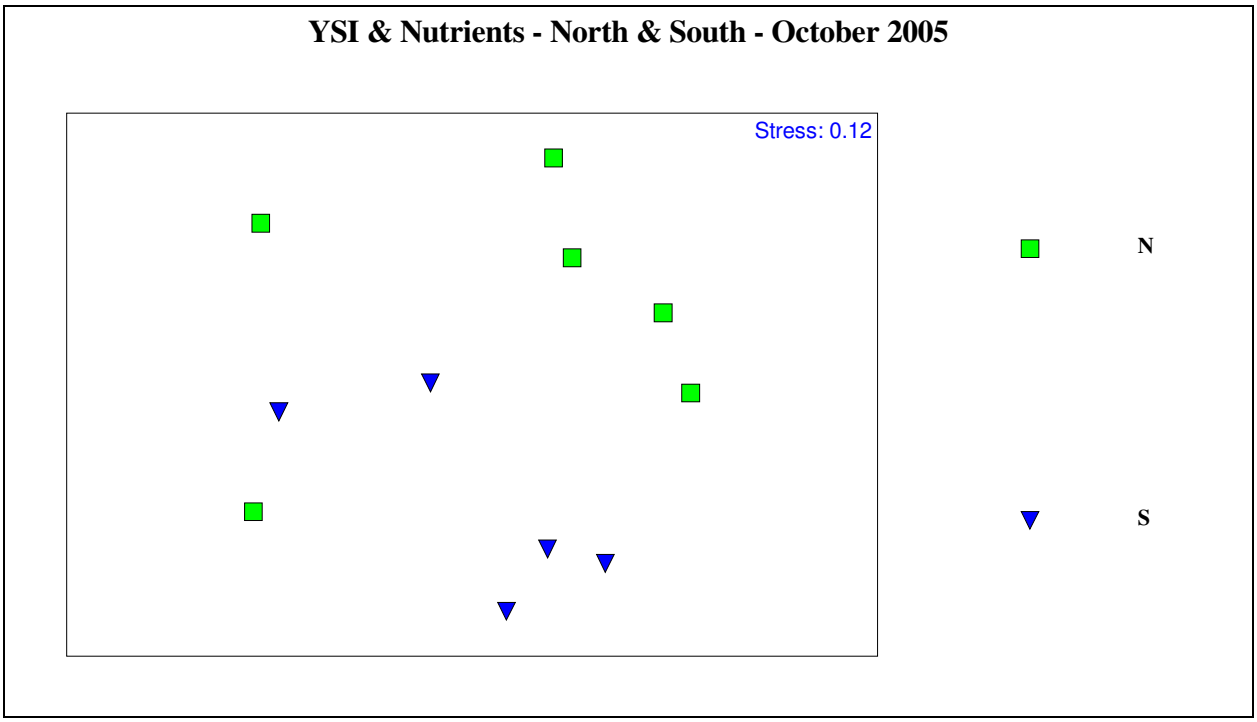

Figure 5-5. MDS plot for October 2005 YSI readings and nutrients by location north (N) and south (S) of the causeway.

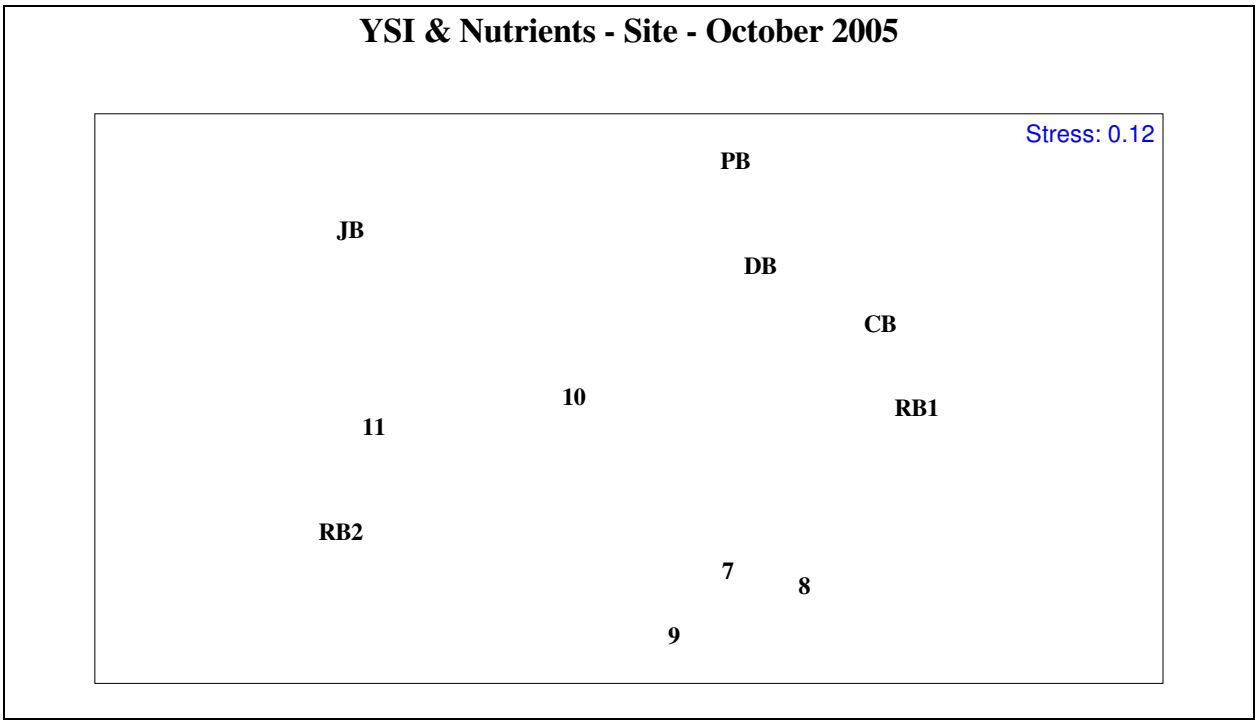

Figure 5-6. MDS plot for October 2005 YSI readings and nutrients by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

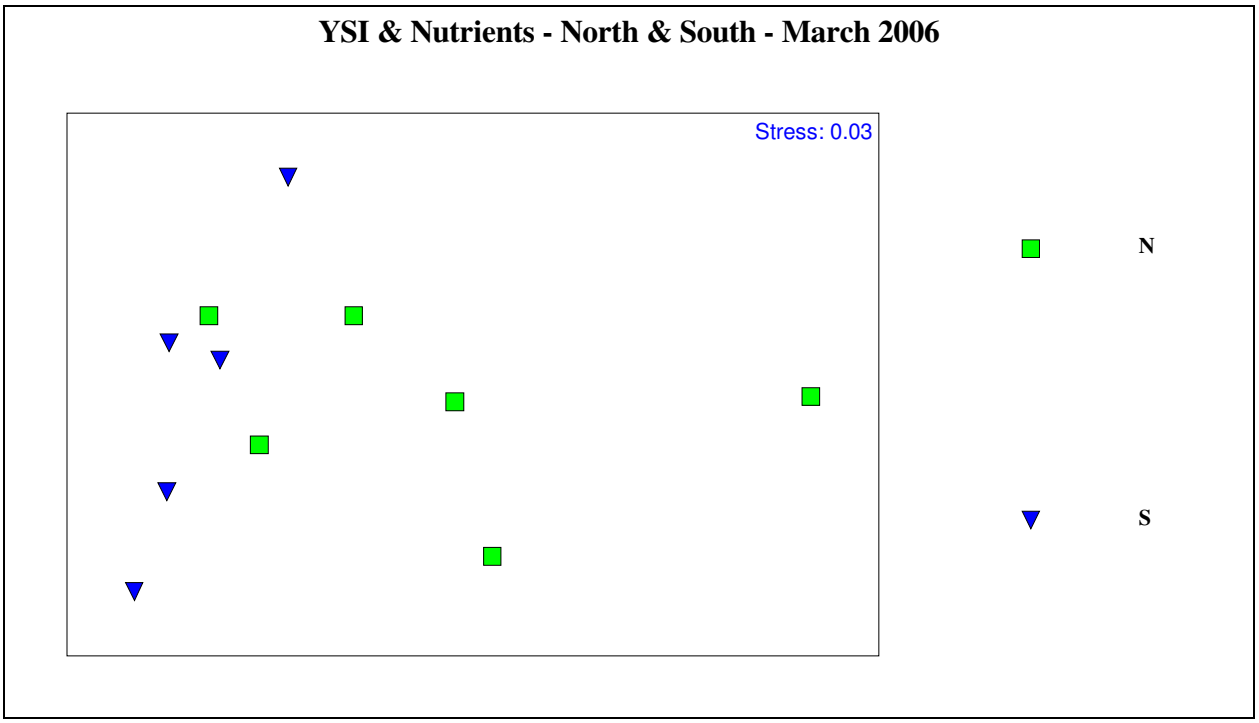

Figure 5-7. MDS plot for March 2006 YSI readings and nutrients by location north (N) and south (S) of the causeway.

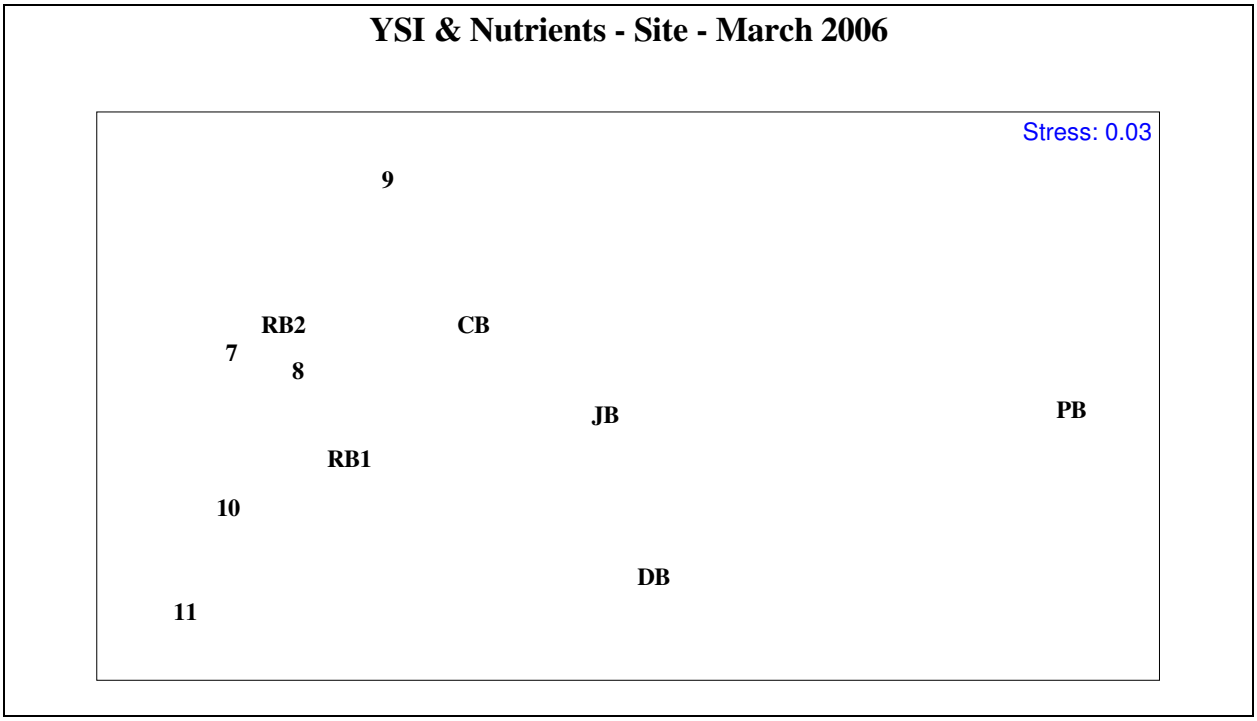

Figure 5-8. MDS plot for March 2006 YSI readings and nutrients by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

Appendix 6

Sediment – April and October 2005

Table 6-1. Summary table for April 2005 sediment statistical analyses (% water, % total organics, % total organic carbon, % clay, % silt and % sand) by site (not average) and location north or south of causeway (average) (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven based on sediment percentages (1 > 2 > 3). Location north or south of the causeway (N or S) is listed for each site.

SEDIMENTS	**North or South of Causeway**	**% Water**	**% Total Organics**	**% Total Organic Carbon**	**% Clay**	**% Silt**	**% Sand**
Site Name		**p=0.001**	**p=0.007**	**p=0.024**	**p=0.001**	p=0.055	**p=0.012**
Polecat Bay	N	2	5	4	1	8	9
Delvan Bay	N	1	4	1	2	1	11
Tensaw Riverbank	N	3	1	2	5	3	8
Chocolatta Bay	N	4	3	3	4	2	10
Blakeley Riverbank	N	6	6	8	8	7	4
Justin's Bay	N	5	2	5	3	6	6
Mouth of Pinto Pass	S	10	10	9	11	11	1
Pinto Pass	S	11	9	7	9	10	2
South of Chocolatta	S	7	8	6	6	4	7
South of Justin's	S	8	7	11	7	9	3
South Blakeley Riverbank	S	9	11	10	10	5	5
North	N	A	A	A	A	-	B
South	S	B	B	B	B	-	A
		N>S	N>S	N>S	N>S	N>S	S>N
		p=0.000	**p=0.000**	**p=0.004**	**p=0.013**	p=0.128	**p=0.026**

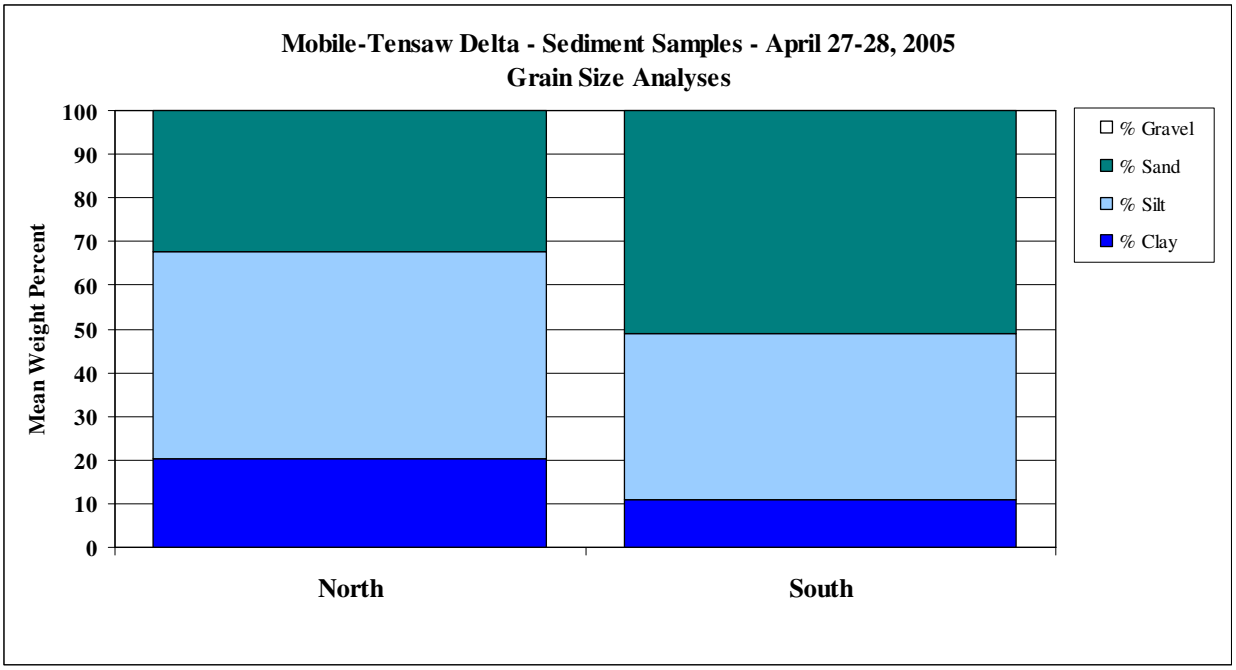

Figure 6-1. Sediment grain size (mean weight %) as gravel, sand, silt and clay are plotted by location north and south of the causeway for April 2005 sampling event.

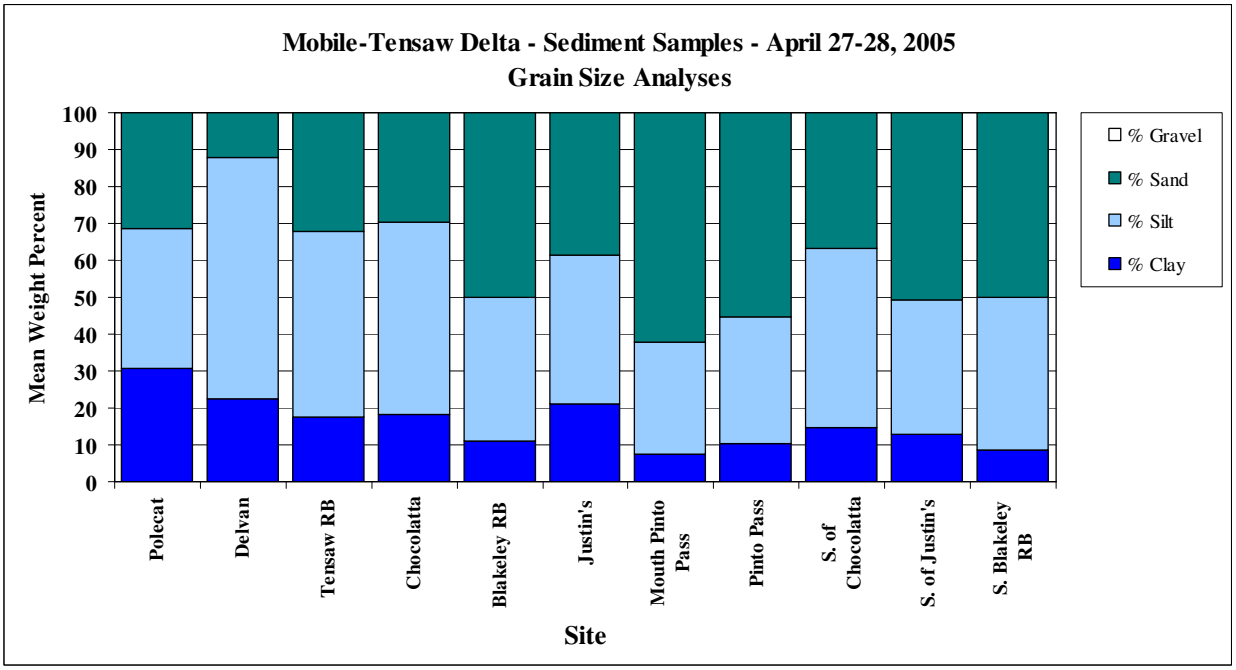

Figure 6-2. Sediment grain size (mean weight %) as gravel, sand, silt and clay are plotted by site from April 2005 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

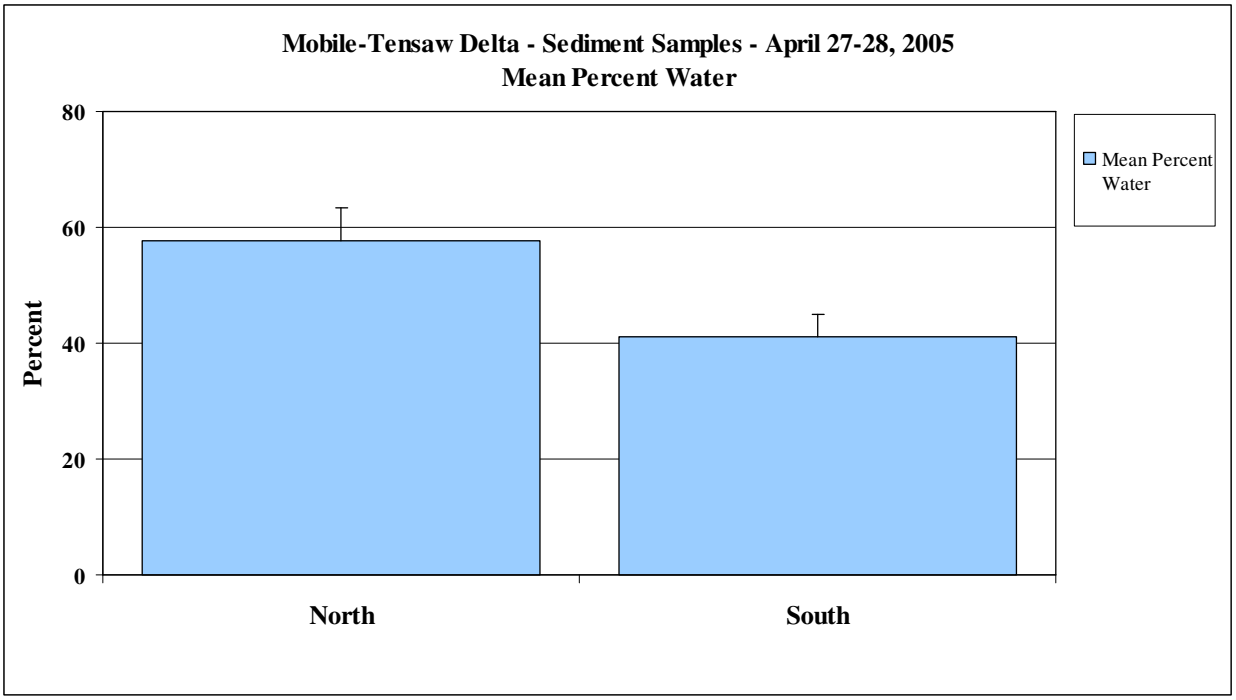

Figure 6-3. Sediment percent water plotted by location north and south of the causeway for April 2005 sampling event.

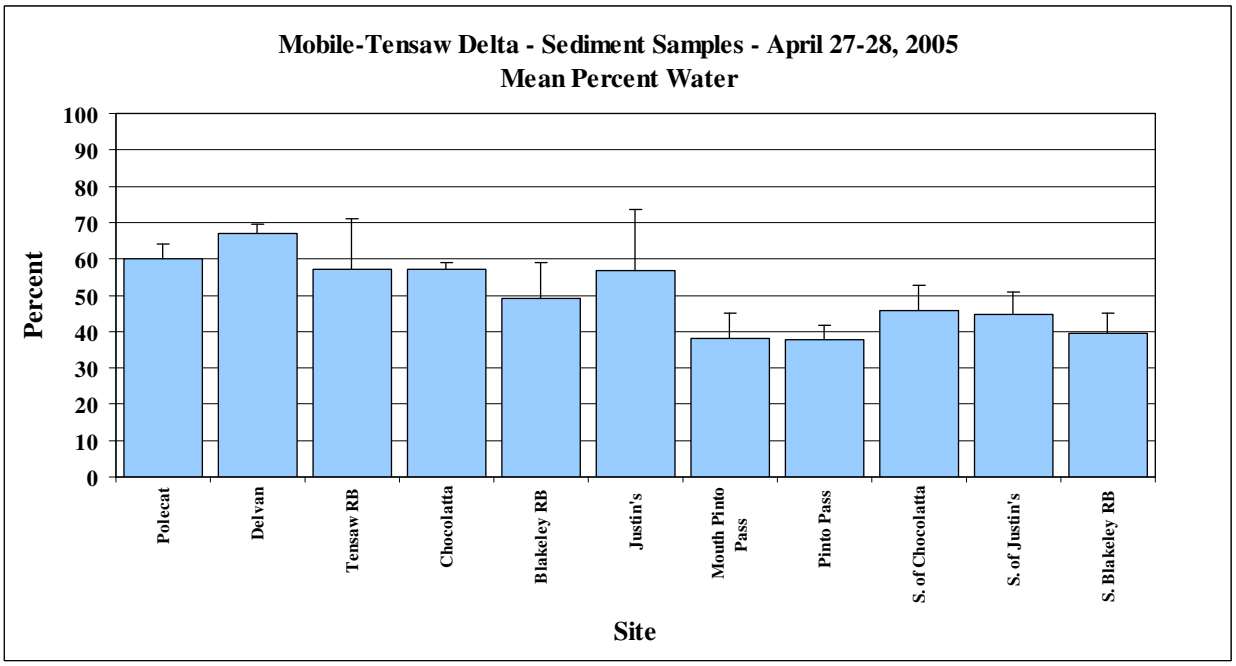

Figure 6-4. Sediment percent water plotted by site from April 2005 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

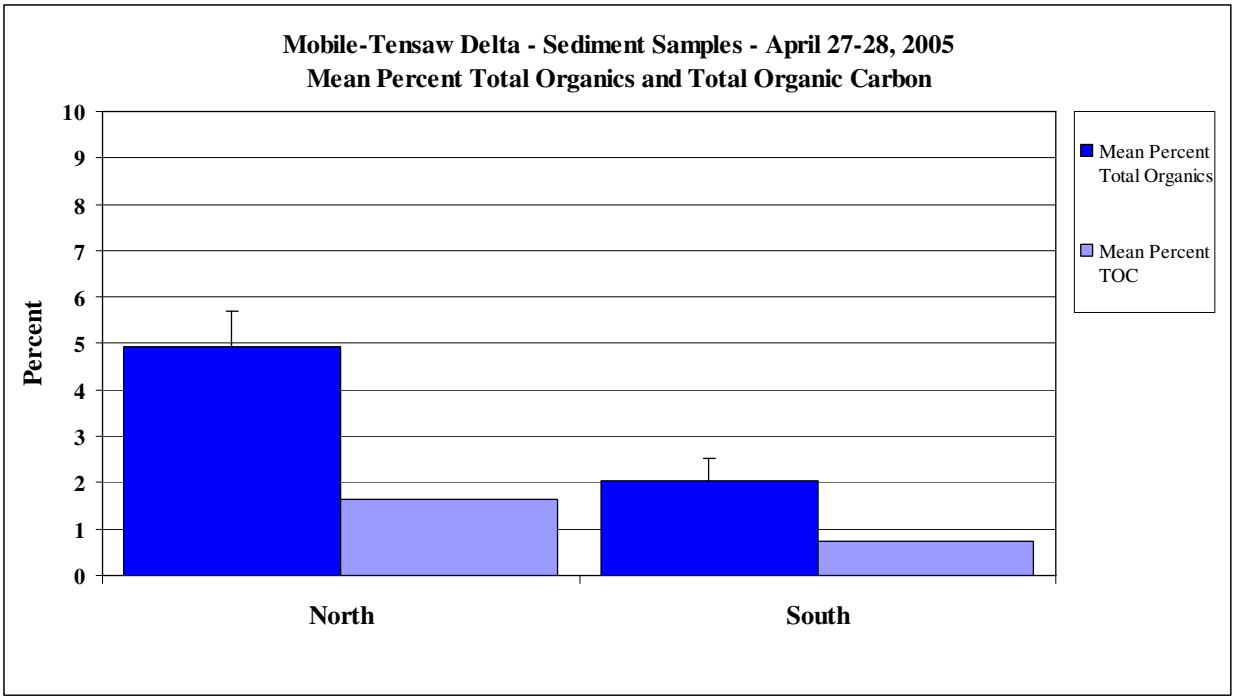

Figure 6-5. Sediment percent total organics and total organic carbon (mean %) plotted by location north and south of the causeway for April 2005 sampling event.

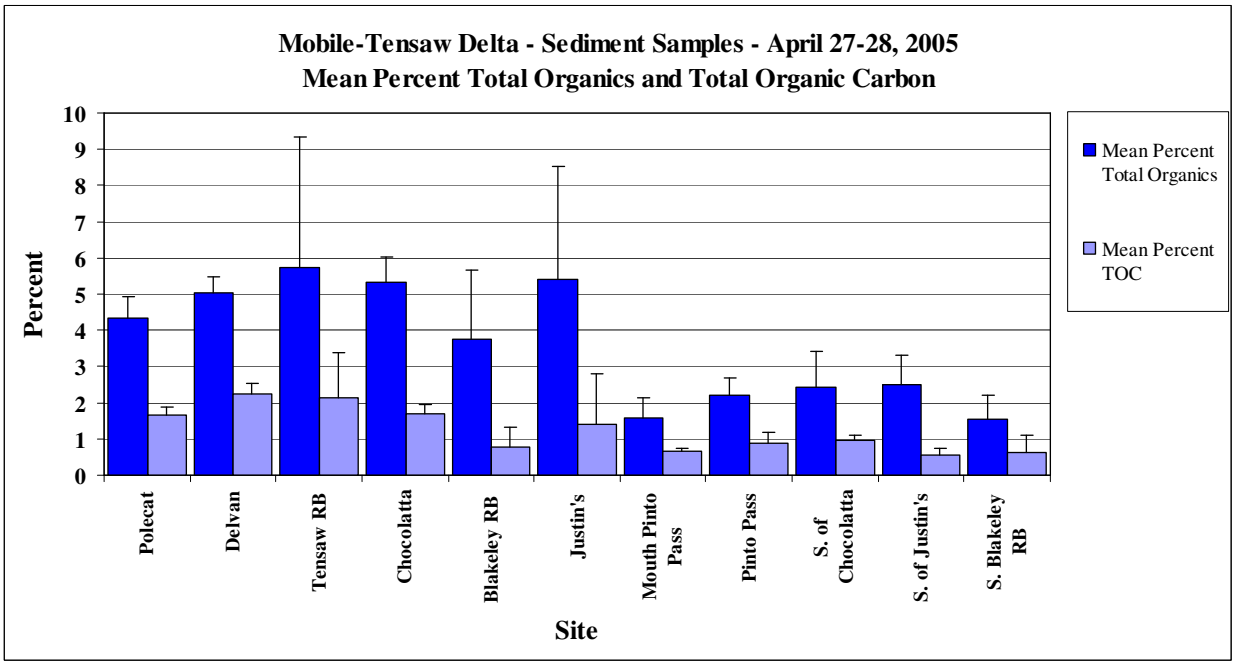

Figure 6-6. Sediment percent total organics and total organic carbon (mean %) plotted by site from April 2005 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

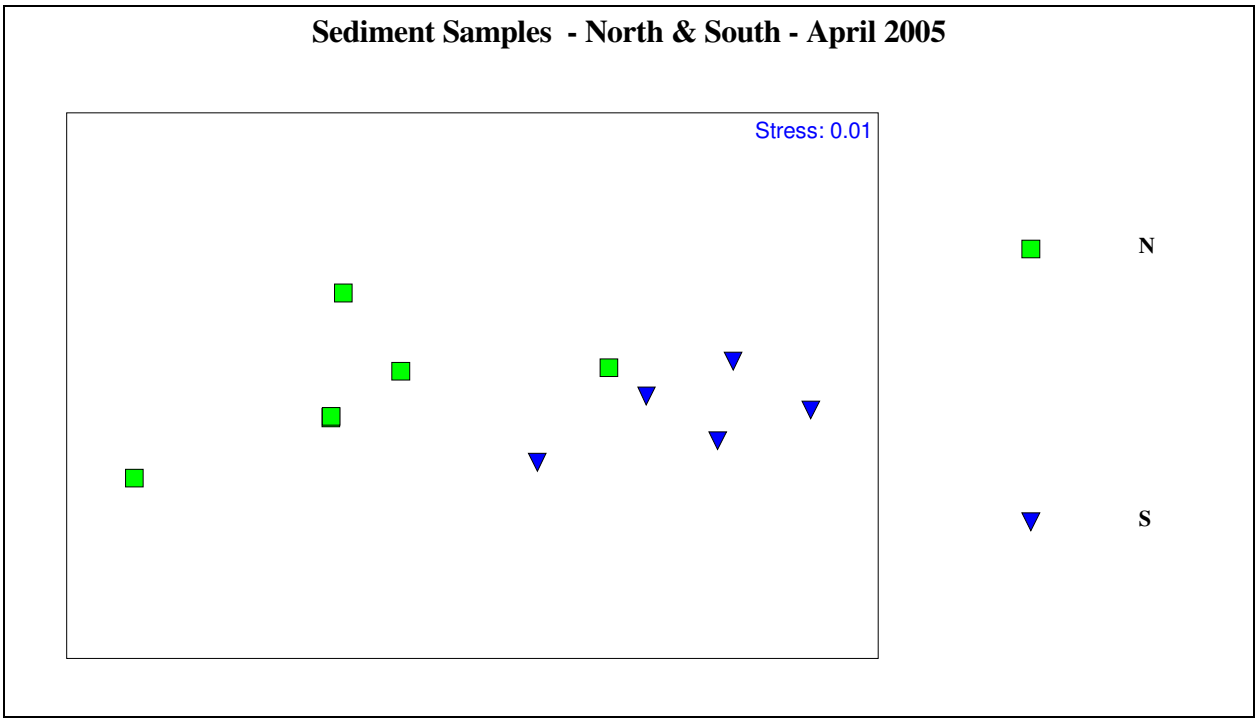

Figure 6-7. MDS plot for April 2005 sediment by location north (N) and south (S) of the causeway.

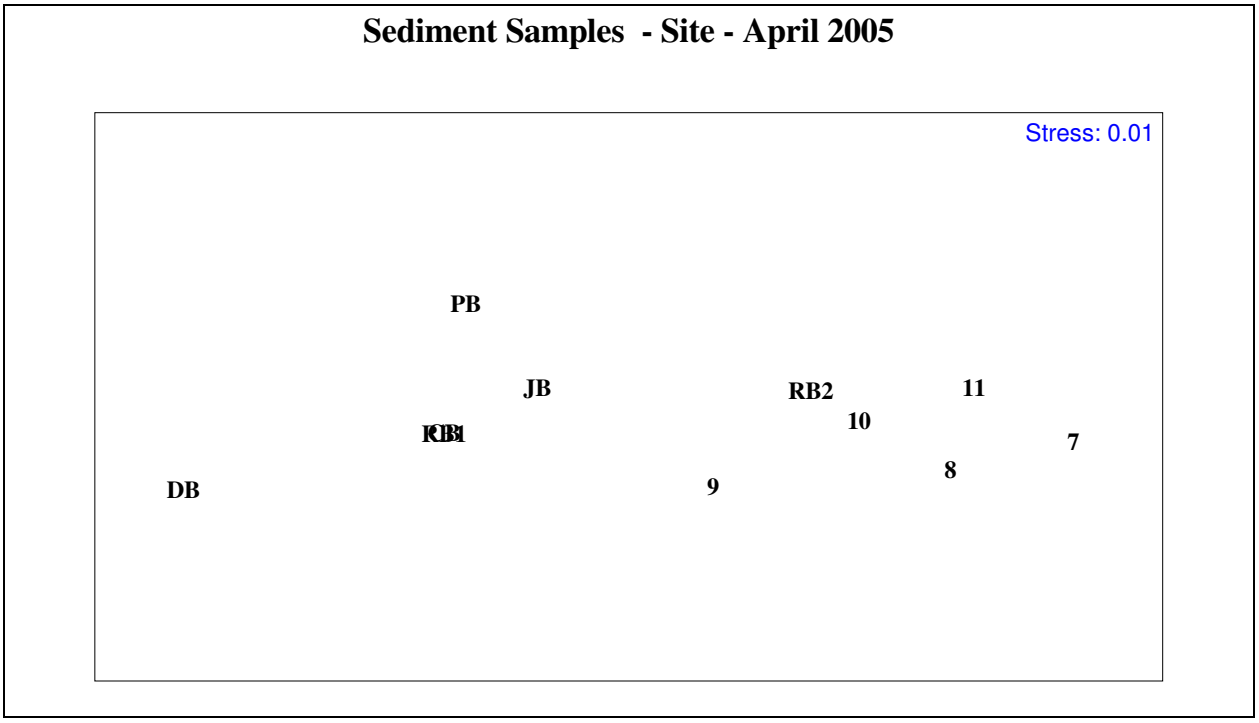

Figure 6-8. MDS plot for April 2005 sediment by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

Table 6-2. Summary table for October 2005 sediment statistical analyses (% water, % total organics, % clay, % silt and % sand) by site (not average) and location north or south of causeway (average) (A > B > C; dashes denote no significant difference). Sites are ranked from one to eleven based on sediment percentages (1 > 2 > 3). Location north or south of the causeway (N or S) is listed for each site.

SEDIMENTS	**North or South of Causeway**	**% Water**	**% Total Organics**	**% Clay**	**% Silt**	**% Sand**	**% Gravel**
Site Name		**p=0.000**	**p=0.001**	**p=0.013**	**p=0.018**	**p=0.012**	**p=0.049**
Polecat Bay	N	2	3	1	7	8	4
Delvan Bay	N	1	1	2	1	11	4
Tensaw Riverbank	N	3	2	3	2	10	4
Chocolatta Bay	N	4	6	6	4	7	4
Blakeley Riverbank	N	9	8	8	9	3	2
Justin's Bay	N	7	9	7	10	2	4
Mouth of Pinto Pass	S	8	4	9	6	4	4
Pinto Pass	S	6	7	4	8	5	3
South of Chocolatta	S	5	5	5	3	9	4
South of Justin's	S	10	10	10	5	6	4
South Blakeley Riverbank	S	11	11	11	11	1	1
North	N	A	-	-	**-**	-	-
South	S	B	-	-	**-**	-	-
		N>S	N>S	N>S	N>S	S>N	S>N
		p=0.041	p=0.144	p=0.064	p=0.521	p=0.241	p=0.586

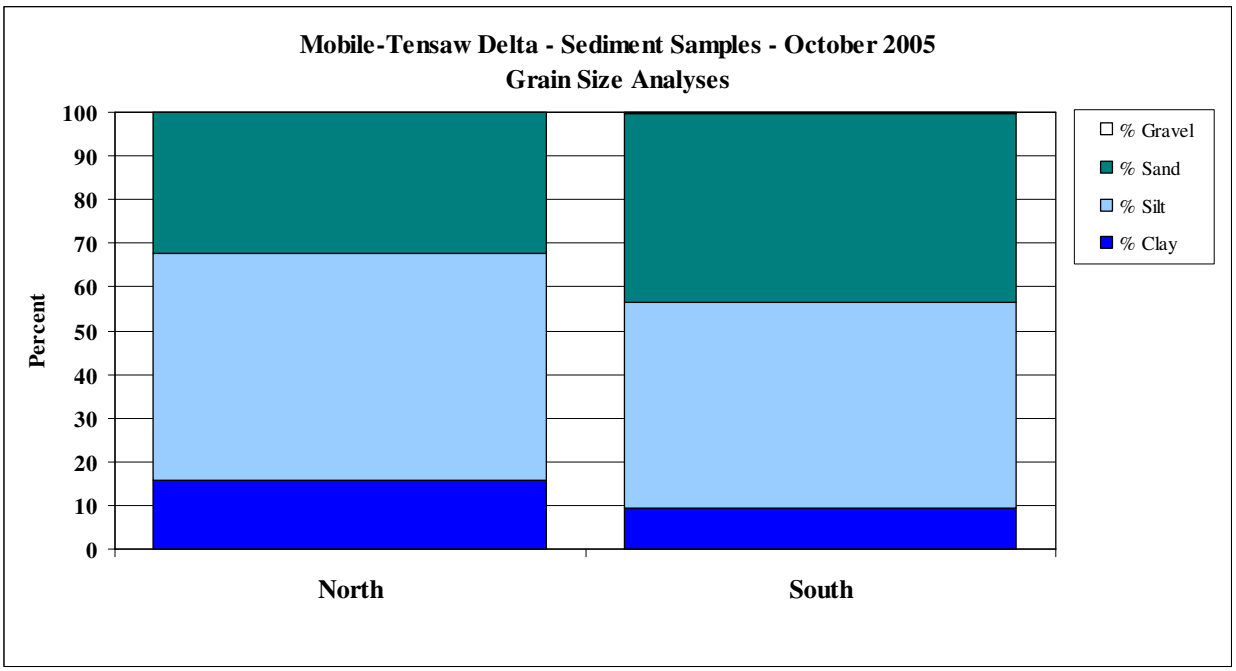

Figure 6-9. Sediment grain size (mean weight %) as gravel, sand, silt and clay are plotted by location north and south of the causeway for October 2005 sampling event.

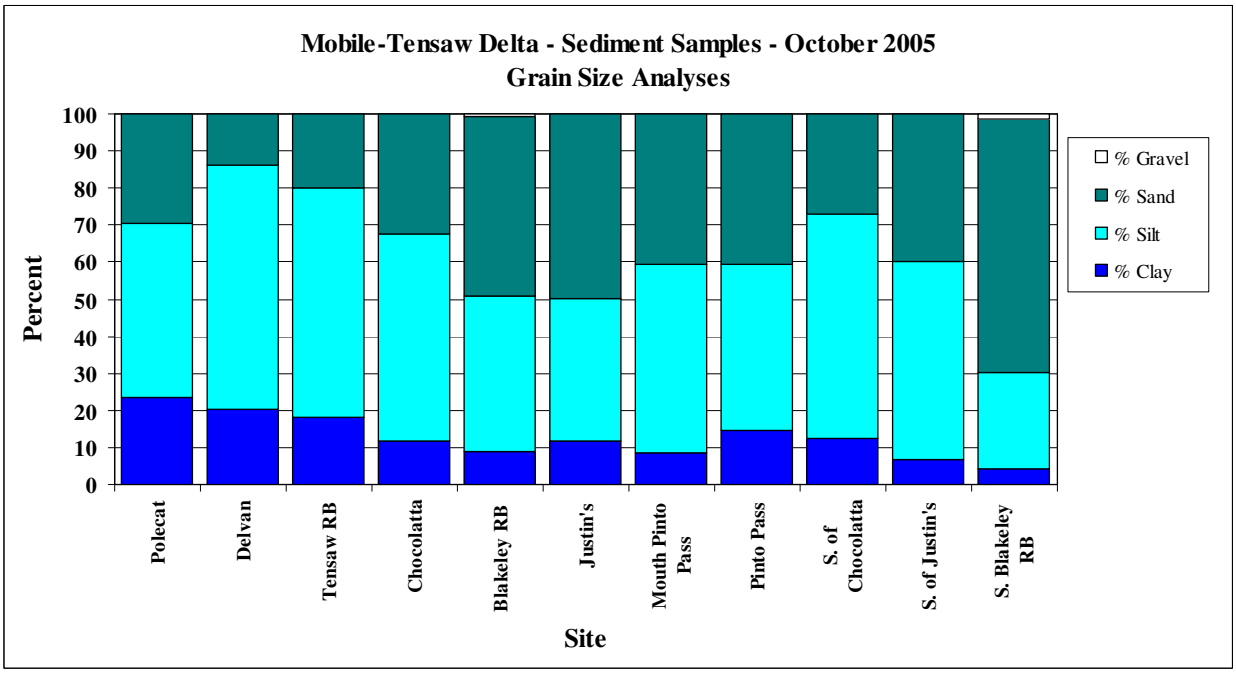

Figure 6-10. Sediment grain size (mean weight %) as gravel, sand, silt and clay are plotted by site from October 2005 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

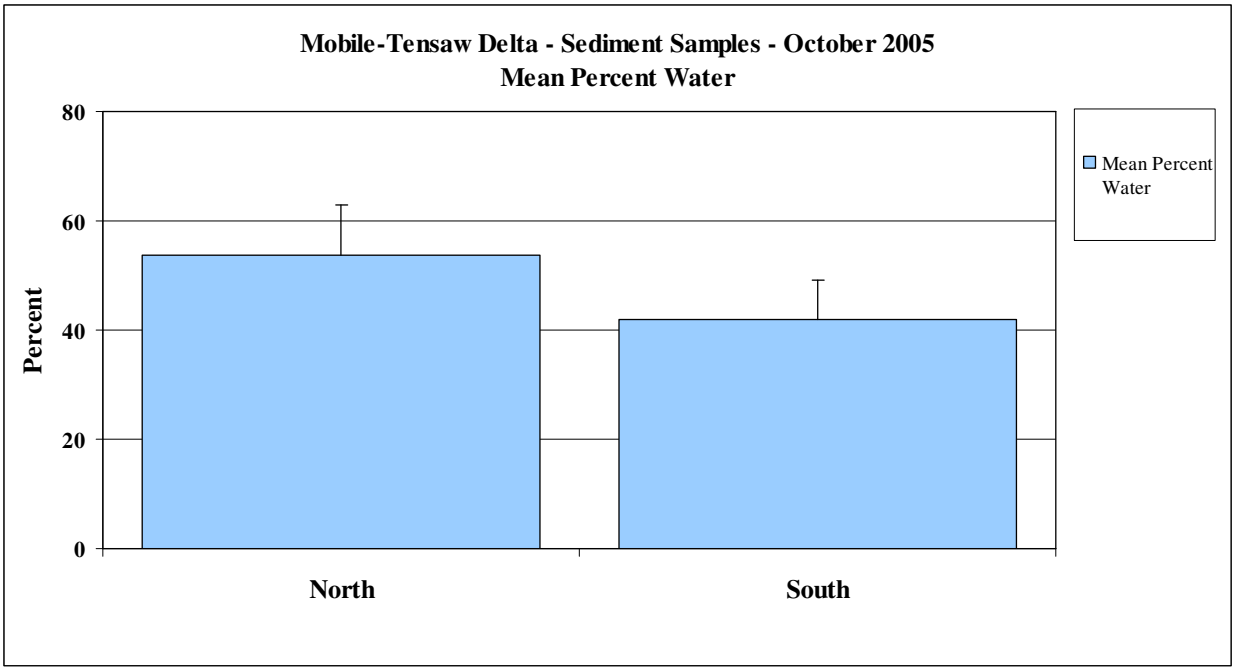

Figure 6-11. Sediment percent water (mean %) plotted by location north and south of the causeway for October 2005 sampling event.

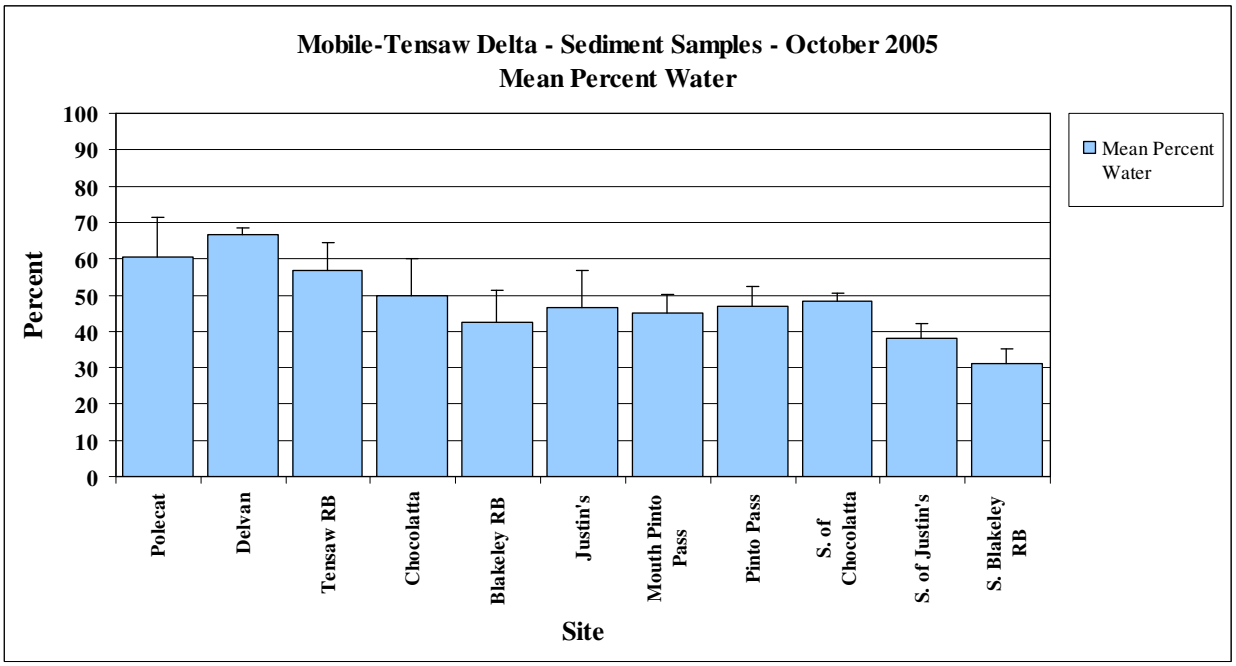

Figure 6-12. Sediment percent water (mean %) plotted by site from October 2005 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

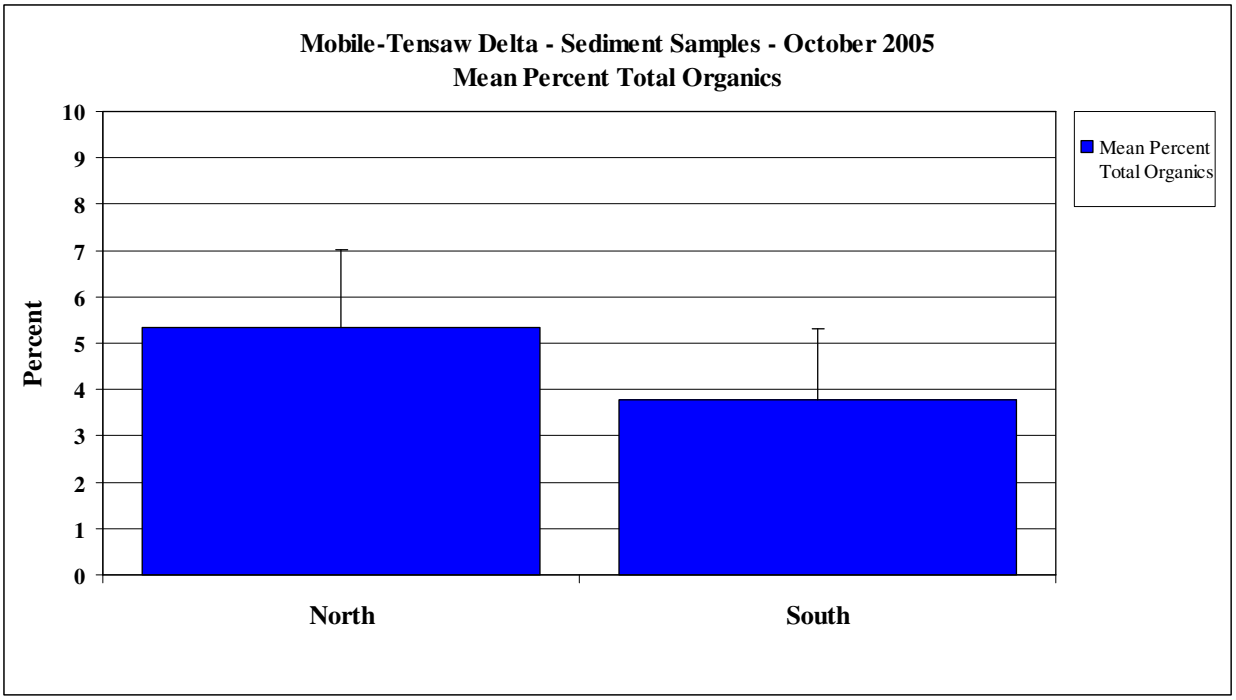

Figure 6-13. Sediment percent total organics (mean %) plotted by location north and south of the causeway for October 2005 sampling event.

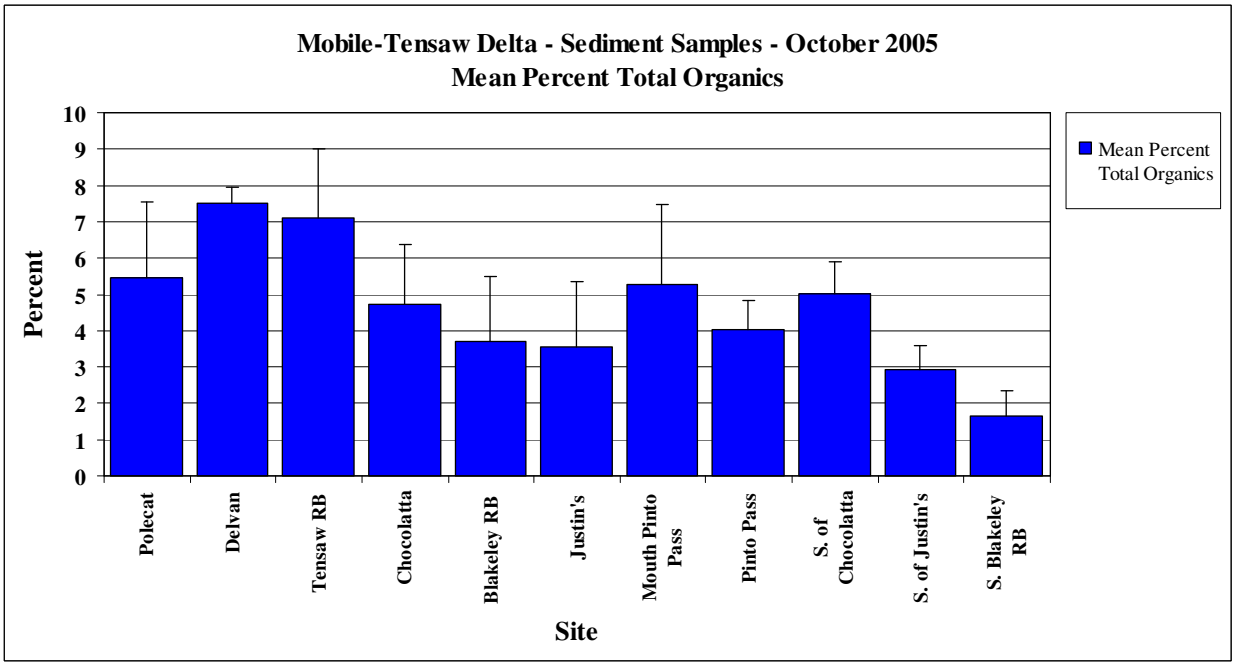

Figure 6-14. Sediment percent total organics (mean %) plotted by site from October 2005 sampling event. Polecat through Justin's Bay sites are located north of the causeway. Mouth of Pinto Pass through South Blakeley Riverbank sites are located south of the causeway.

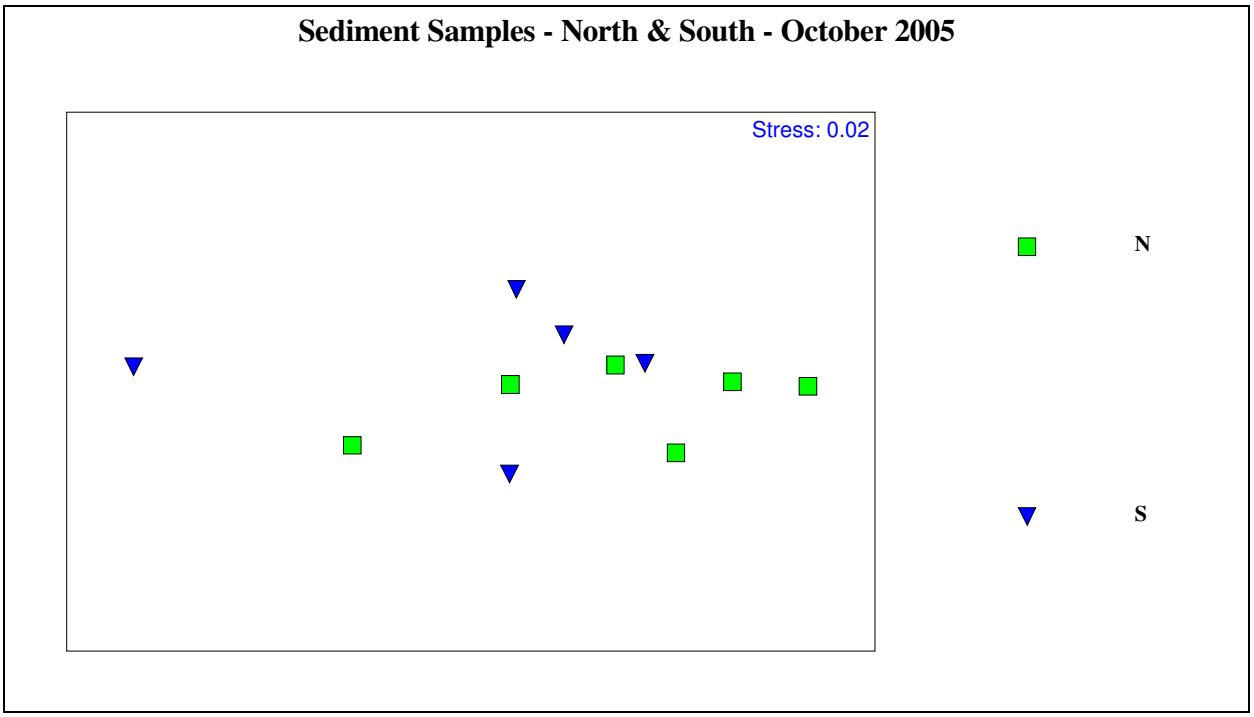

Figure 6-15. MDS plot for October 2005 sediment by location north (N) and south (S) of the causeway.

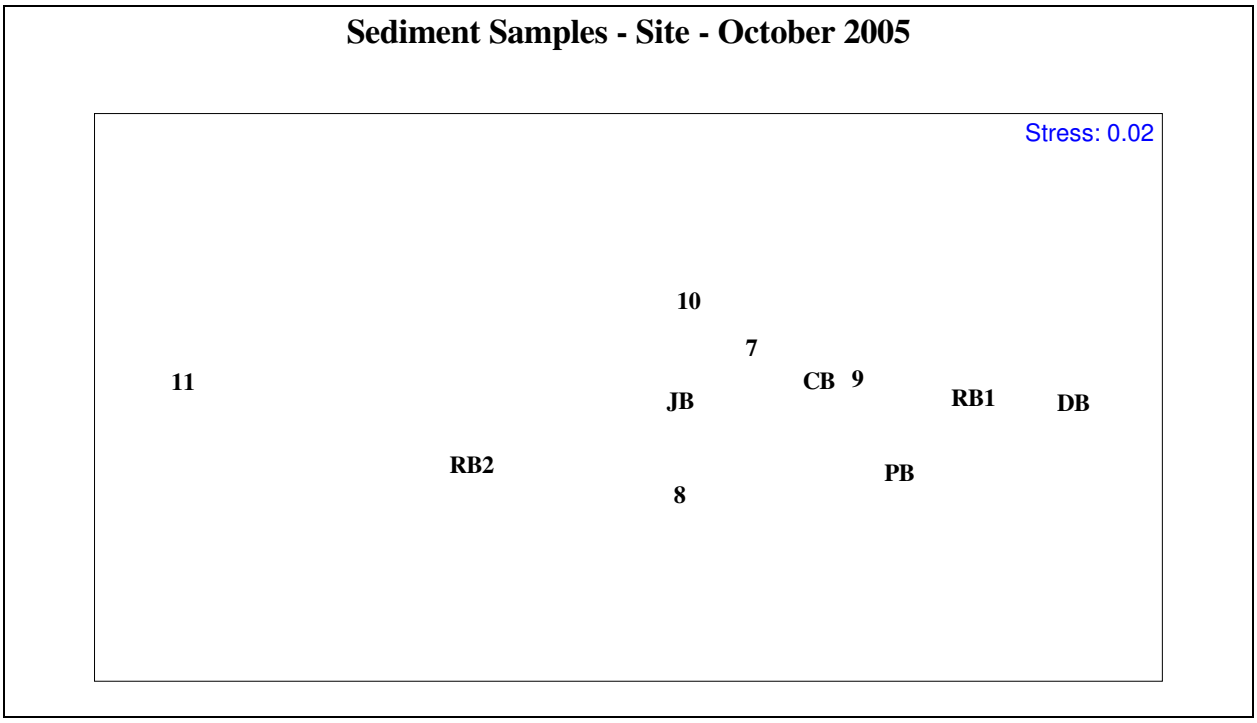

Figure 6-16. MDS plot for October 2005 sediment by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

Appendix 7

Biological Monitoring:

Macroinvertebrates - April, August and October 2005 and March 2006

Table 7-1. Mean number and standard deviation of macroinvertebrate taxa and total number of species listed by site for benthic samples collected in April, August and October 2005 and March 2006 from the Mobile-Tensaw Delta. Site abbreviation and location north or south of the causeway (N or S) are listed for each site.

			April 2005				August 2005				October 2005				March 2006			
	Site	NS	Mean No. Species	Std dev No. Species	Mean Total No.	Std dev Total No.	Mean No. Species	Std dev No. Species	Mean Total No.	Std dev Total No.	Mean No. Species	Std dev No. Species	Mean Total No.	Std dev Total No.	Mean No. Species	Std dev No. Species	Mean Total No.	Std dev Total No.
Polecat Bay	PB	N	3.3	0.6	15.7	9.3	3.3	1.2	9.3	4.0	2.3	1.5	11.0	7.8	7.7	1.2	36.3	11.6
Delvan Bay	DB	N	7.7	3.1	67.7	73.1	3.3	1.2	7.7	3.5	6.7	2.1	43.7	43.6	8.7	0.6	63.7	18.2
Tensaw Riverbank	RB1	N	9.3	2.1	42.3	26.1	8.0	1.0	66.0	35.0	10.3	1.5	106.3	79.6	13.0	1.7	168.3	123.7
Chocolatta Bay	CB	N	7.0	2.6	37.0	25.5	5.0	1.0	41.0	23.0	5.3	2.1	27.7	19.2	10.3	0.6	52.3	6.4
Blakeley Riverbank	RB2	N	10.7	3.8	94.3	70.0	14.7	4.9	138.0	131.4	5.3	4.0	35.7	41.2	9.0	3.6	151.7	81.7
Justin's Bay	JB	N	9.0	5.3	98.3	72.7	4.3	2.3	44.7	35.7	7.0	1.0	80.0	50.7	16.0	1.0	407.3	38.5
Mouth Pinto Pass	7	S	9.7	4.0	46.3	7.8	7.3	0.6	48.0	14.0	8.7	0.6	27.7	6.7	9.3	2.1	100.3	50.8
Pinto Pass	8	S	8.0	1.0	39.0	24.3	10.0	1.0	88.3	40.4	9.3	0.6	60.7	22.7	12.0	5.3	60.0	38.0
S of Chocolatta	9	S	8.3	2.5	34.7	9.3	7.0	3.6	76.0	78.0	9.0	1.7	69.3	14.6	12.3	3.2	224.3	102.5
S of Justin's	10	S	6.3	0.6	17.0	7.2	9.7	3.1	55.7	22.2	10.3	0.6	81.7	24.1	13.7	0.6	252.7	151.7
S Blakeley Riverbank	11	S	8.7	0.6	52.3	25.5	7.7	1.5	75.7	30.7	9.7	3.2	76.0	38.0	10.7	5.7	196.7	89.9

Table 7-2. April 2005 summary table for statistical analyses of macroinvertebrate taxa and total number of species analyzed by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**Total no. Organisms (avg)**	**Total no. species (avg)**	**Total no. Organisms**	**Total no. species**
Site Name		na	na	p=0.122	p=0.218
Polecat Bay	N	11	11		
Delvan Bay	N	3	8		
Tensaw Riverbank	N	6	3		
Chocolatta Bay	N	8	9		
Blakeley Riverbank	N	2	1		
Justin's Bay	N	1	4		
Mouth of Pinto Pass	S	5	2		
Pinto Pass	S	7	7		
South of Chocolatta	S	9	6		
South of Justin's	S	10	10		
South Blakeley Riverbank	S	4	5		
North	N	-	-		
South	S	-	-		
		N > S	S > N		
		p= 0.366	p= 0.778		

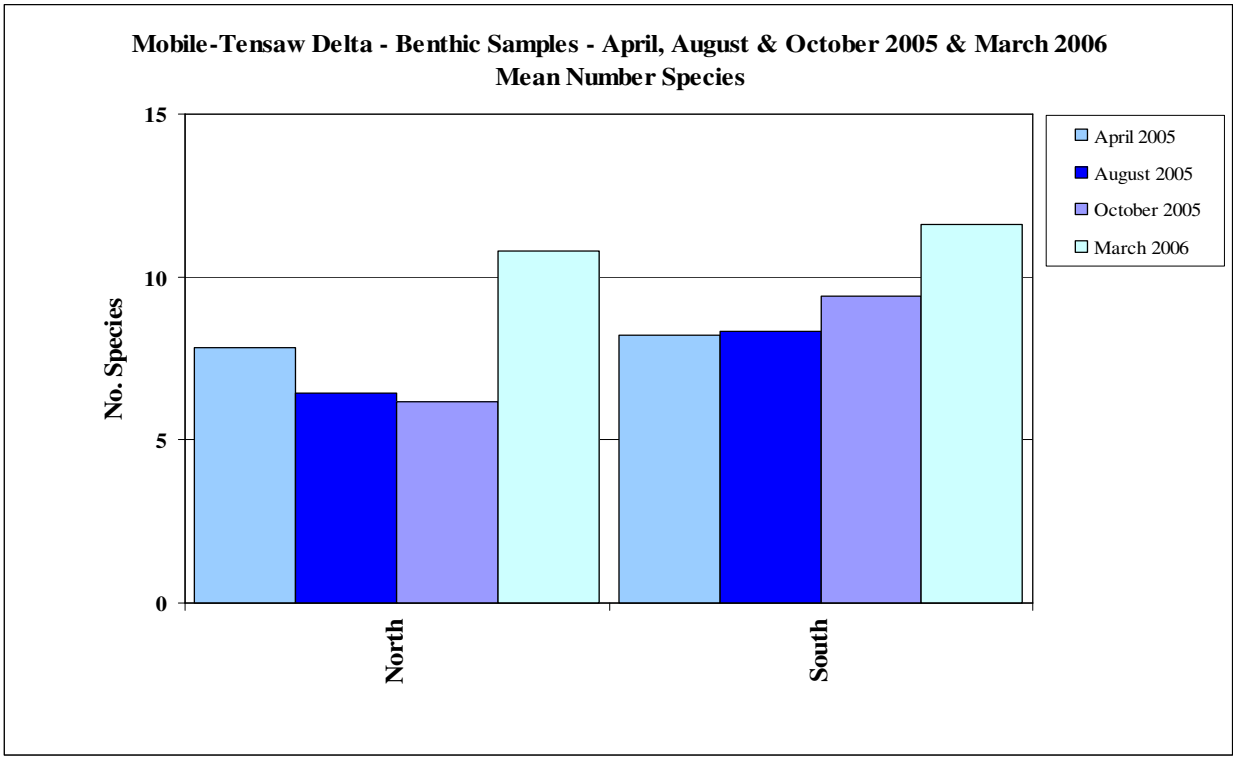

Figure 7-1. Mean number of benthic species plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

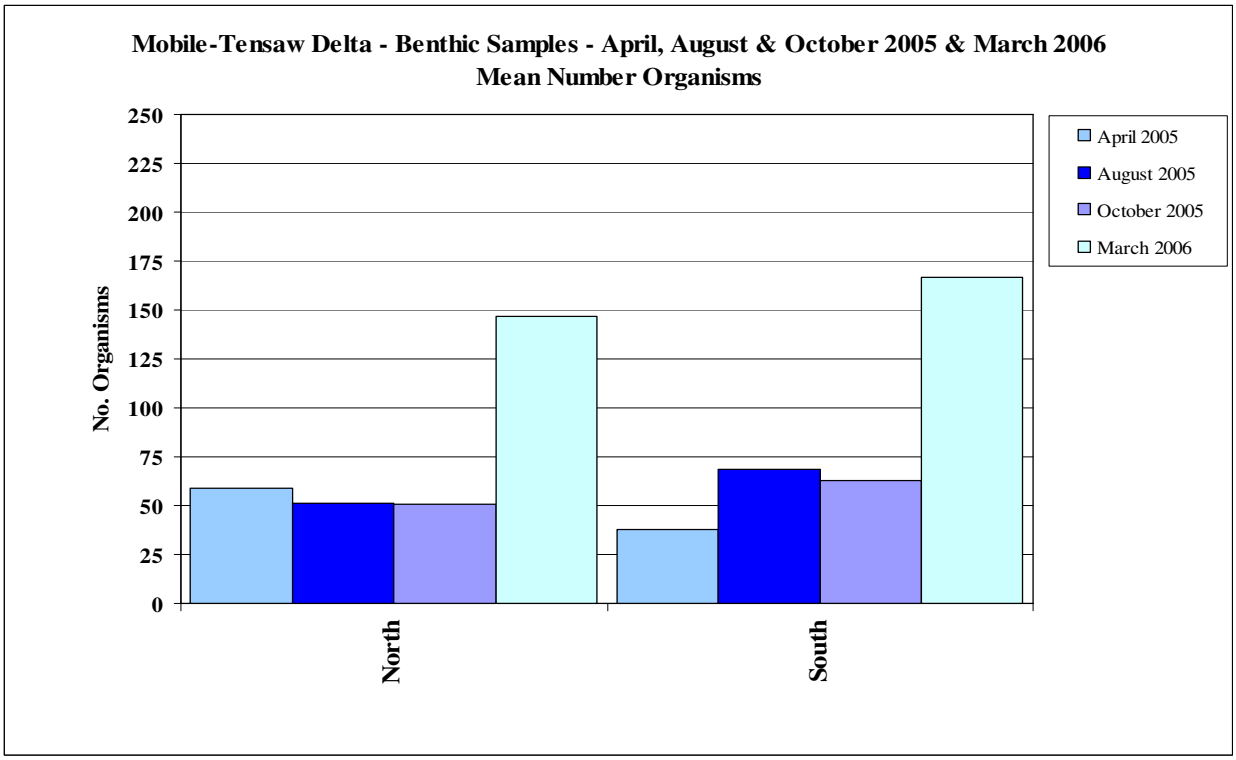

Figure 7-2. Mean number of benthic organisms plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

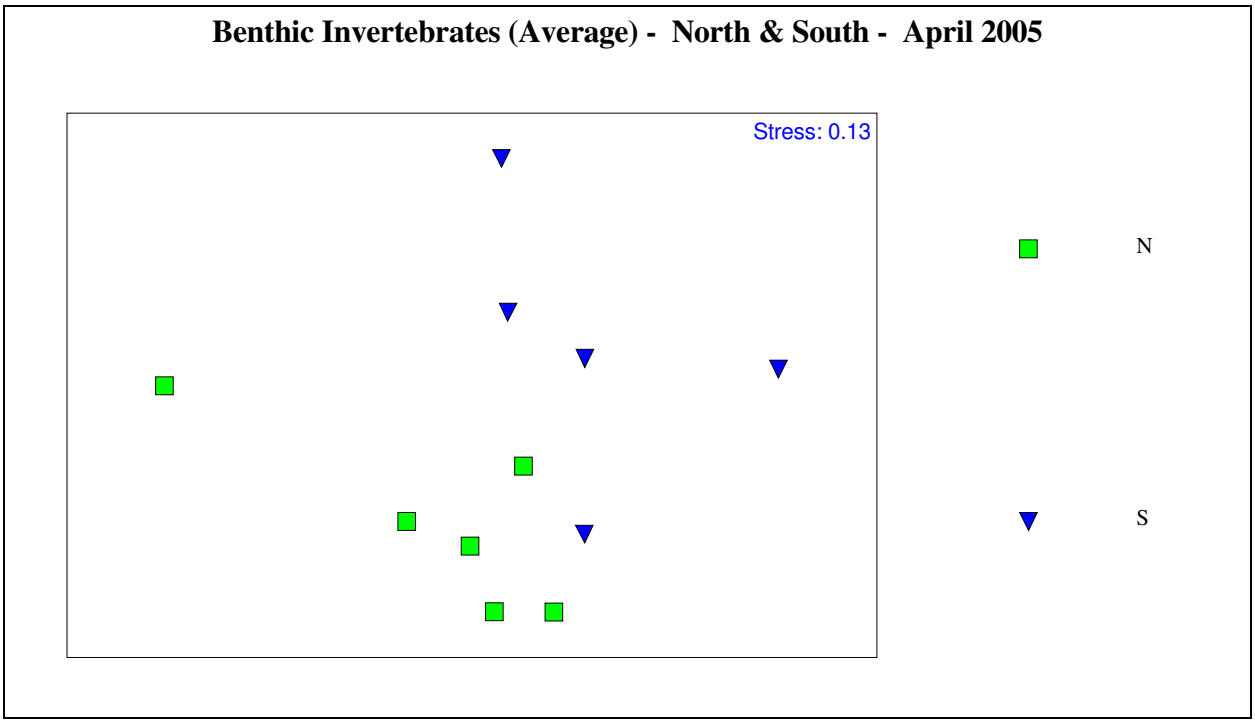

Figure 7-3. MDS plot for April 2005 benthic invertebrates by location north and south of the causeway.

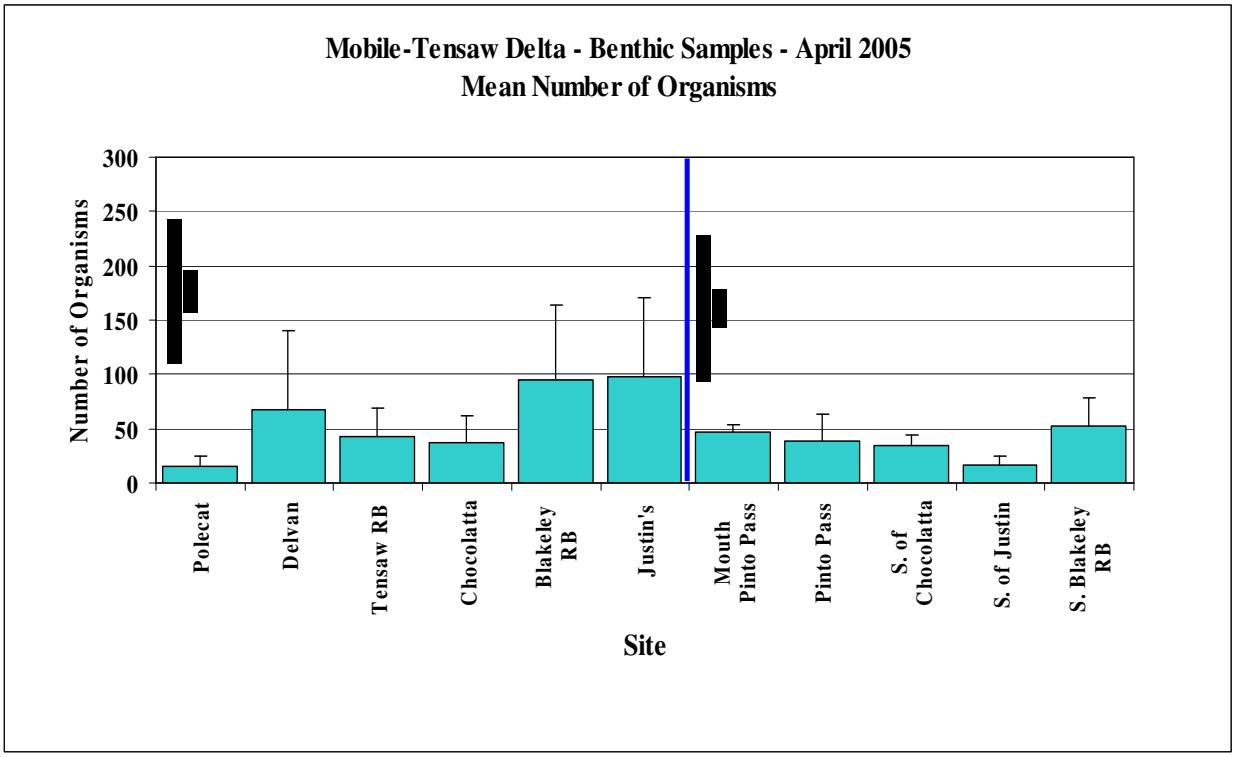

Figure 7-4. Mean number of benthic organisms (±1std dev) plotted by site from April 2005. The vertical line separates sites located north (left) and south (right) of the causeway.

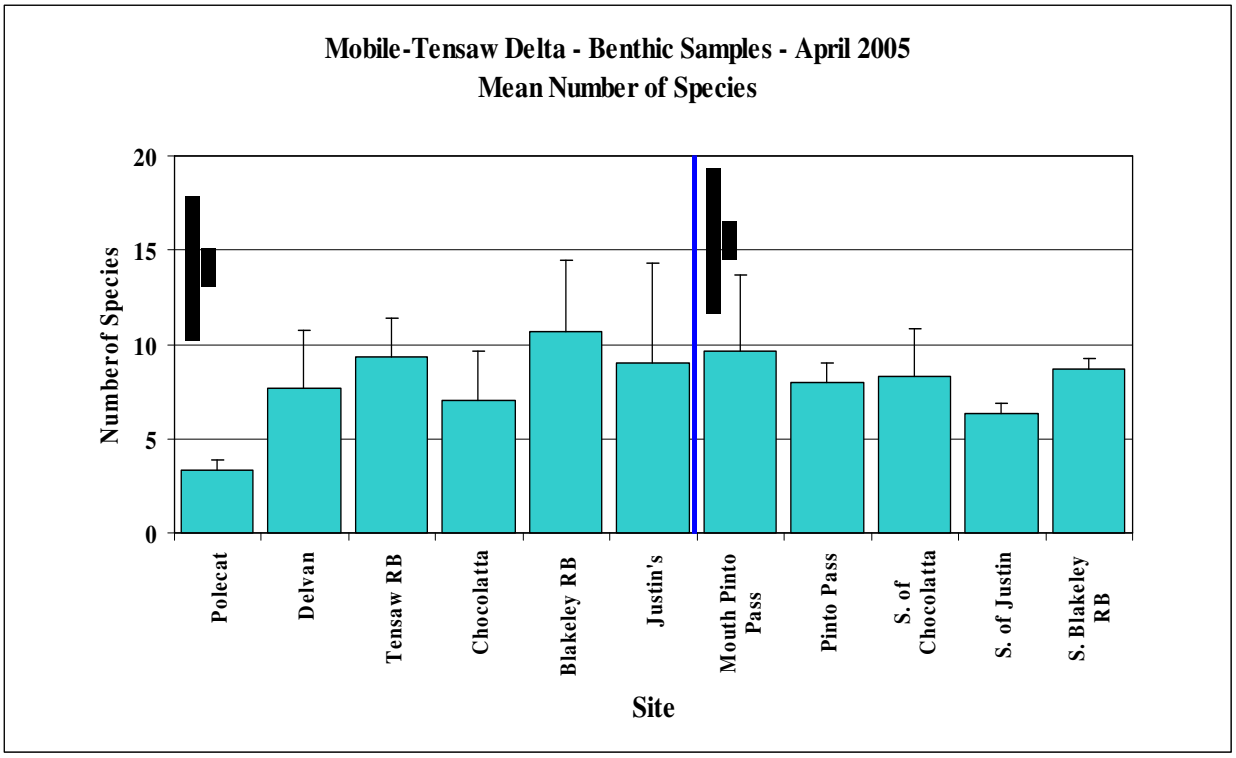

Figure 7-5. Mean number of benthic species (±1std dev) plotted by site from April 2005. The vertical line separates sites located north (left) and south (right) of the causeway.

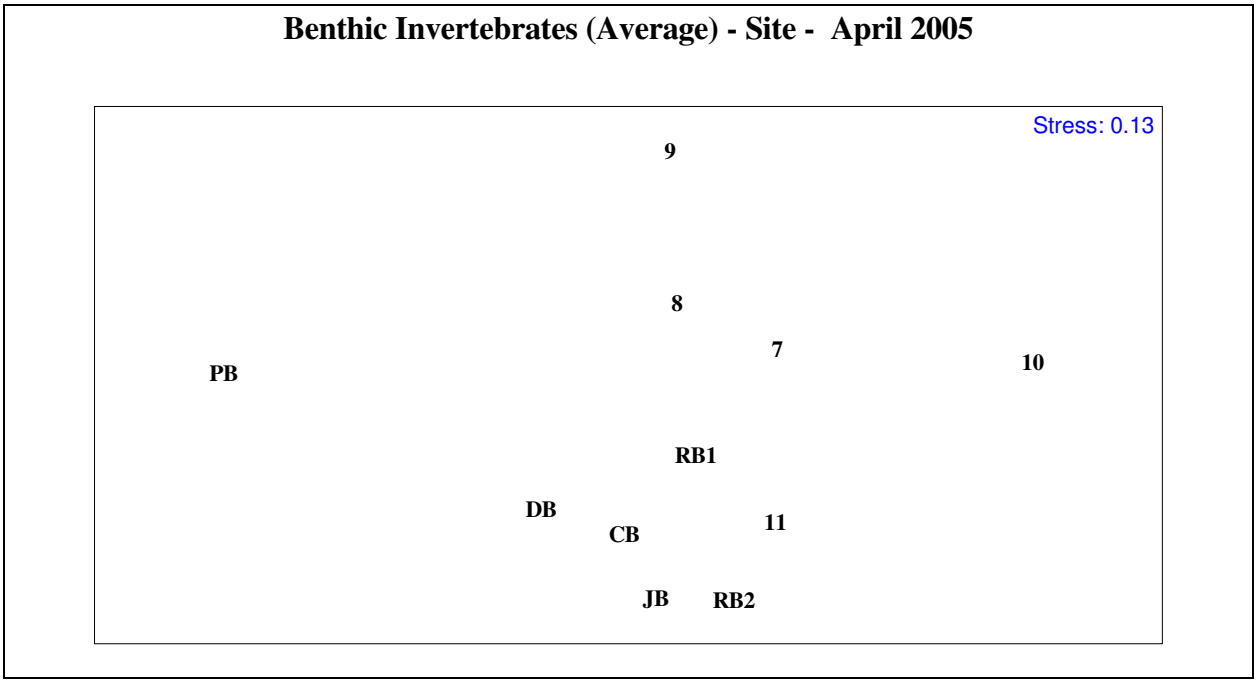

Figure 7-6. MDS plot for April 2005 benthic invertebrates by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

Table 7-3. April 2005 summary table for statistical analyses of proportion macroinvertebrate taxa by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**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	1	1	10	11	6	10	6	3	3
Delvan Bay	N	3	8	7	1	7	9	6	3	3
Tensaw Riverbank	N	5	3	3	6	10	2	3	3	2
Chocolatta Bay	N	2	11	6	10	8	5	6	3	1
Blakeley Riverbank	N	11	7	4	2	11	7	5	2	3
Justin's Bay	N	10	9	9	5	3	1	6	1	3
Mouth of Pinto Pass	S	9	4	5	4	2	4	1	3	3
Pinto Pass	S	8	2	2	7	5	8	2	3	3
South of Chocolatta	S	7	6	11	8	1	3	6	3	3
South of Justin's	S	6	10	1	9	4	11	6	3	3
South Blakeley Riverbank	S	4	5	8	3	9	6	4	3	3
North	N	-	-	-	-	-	-	-	-	-
South	S	-	-	-	-	-	-	-	-	-
		N > S	S > N	S > N	N > S	S > N	N > S	S > N	N > S	N > S
		p= 0.248	p= 0.737	p= 0.475	p= 0.841	p= 0.080	p= 0.809	p= 0.174	p= 0.253	p= 0.186

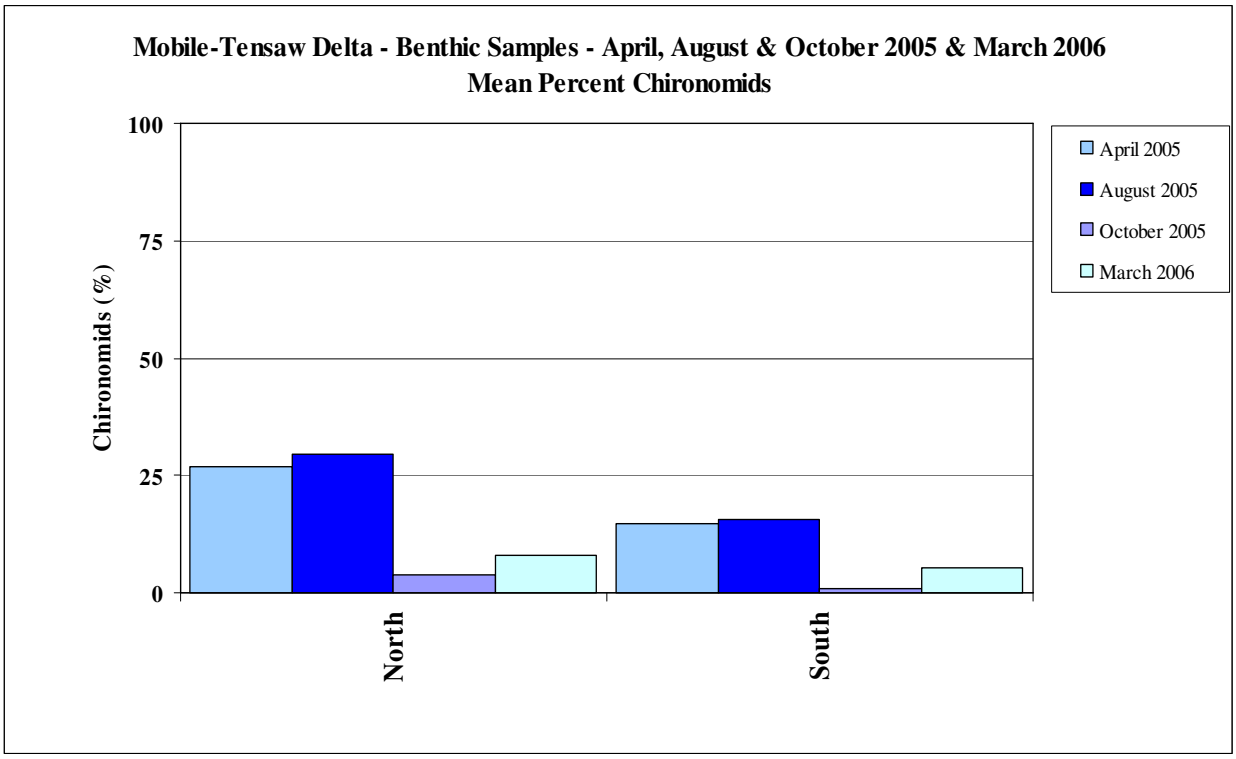

Figure 7-7. Percent chironomids (mean) plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

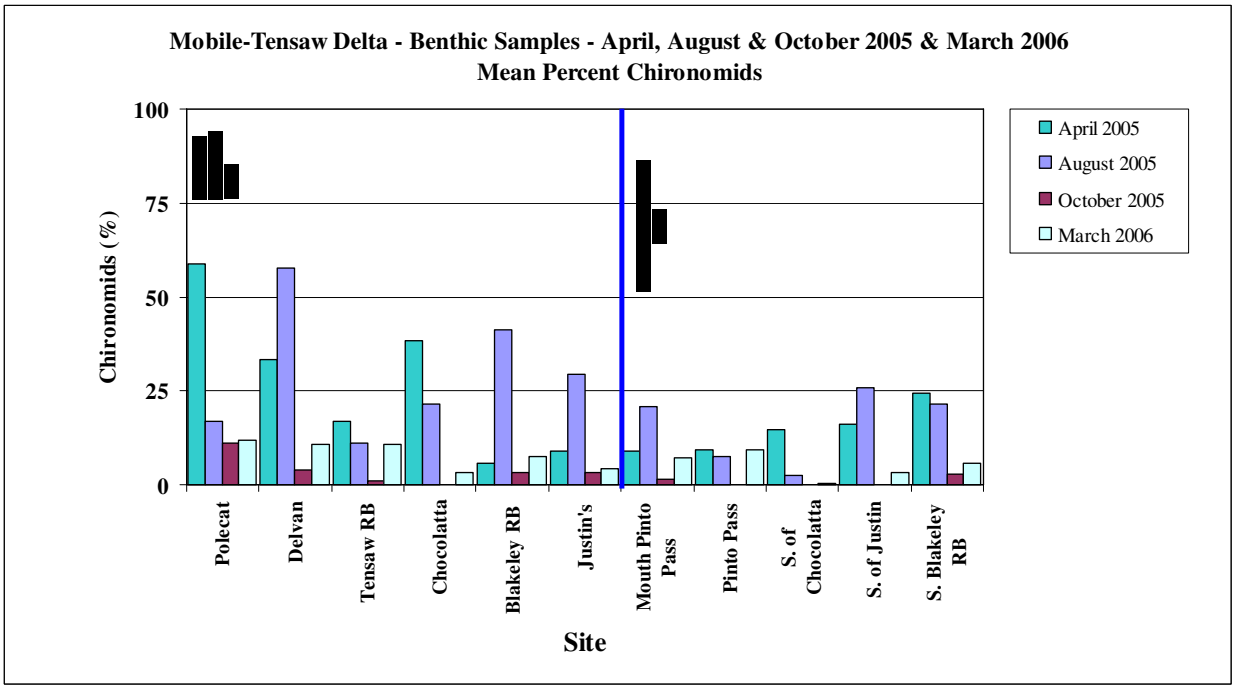

Figure 7-8. Percent chironomids (mean) plotted by site from April, August and October 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

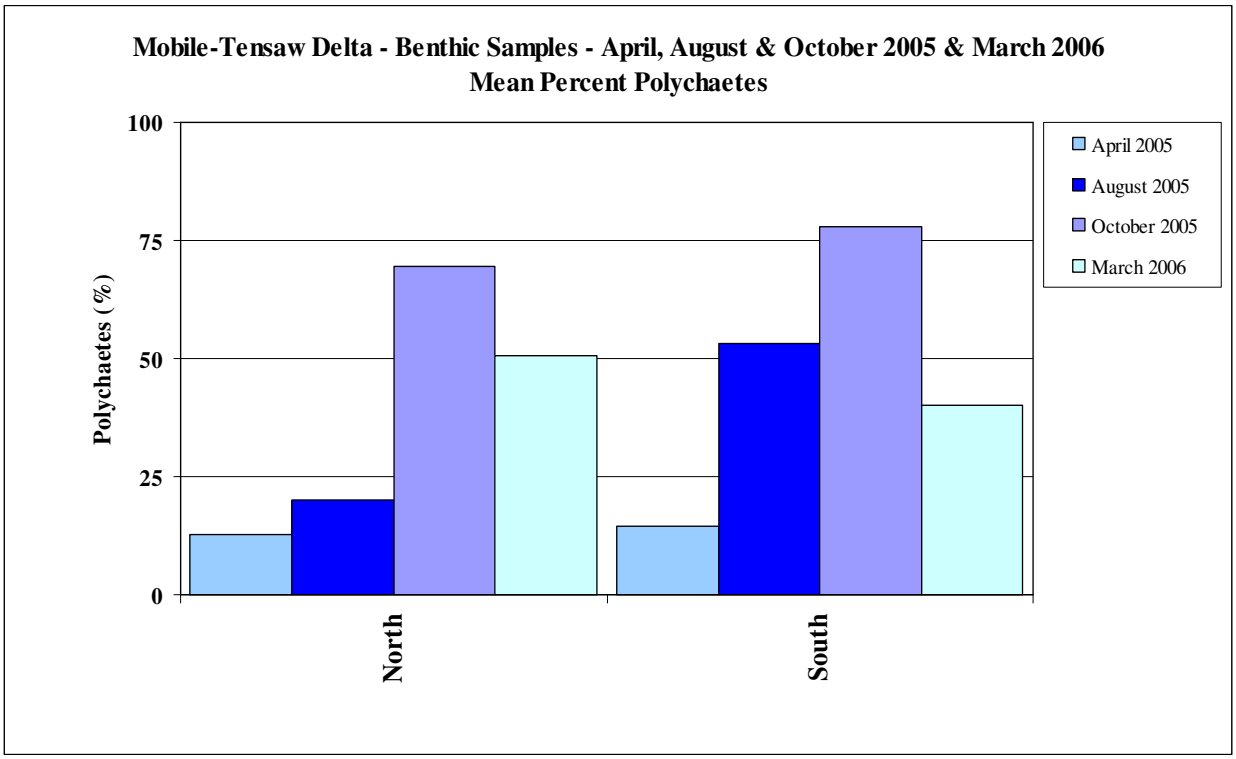

Figure 7-9. Percent polychaetes (mean) plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

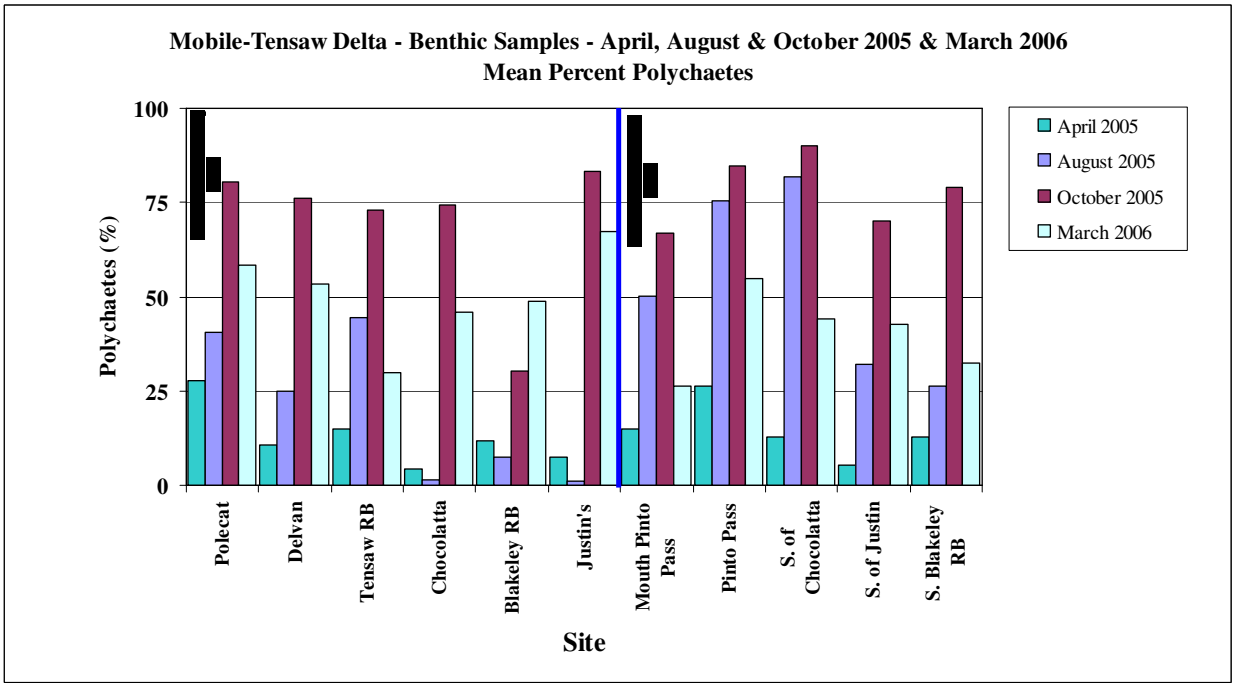

Figure 7-10. Percent polychaetes (mean) plotted by site from April, August and October 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

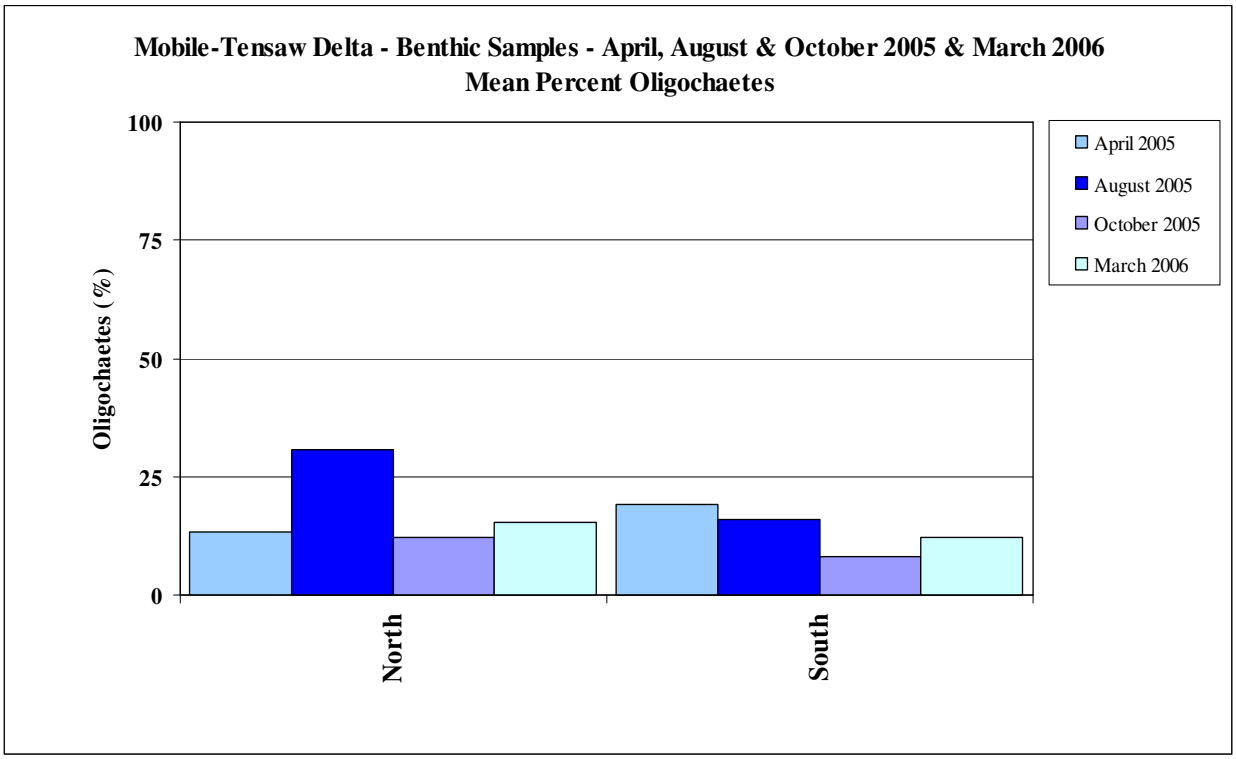

Figure 7-11. Percent oligochaetes (mean) plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

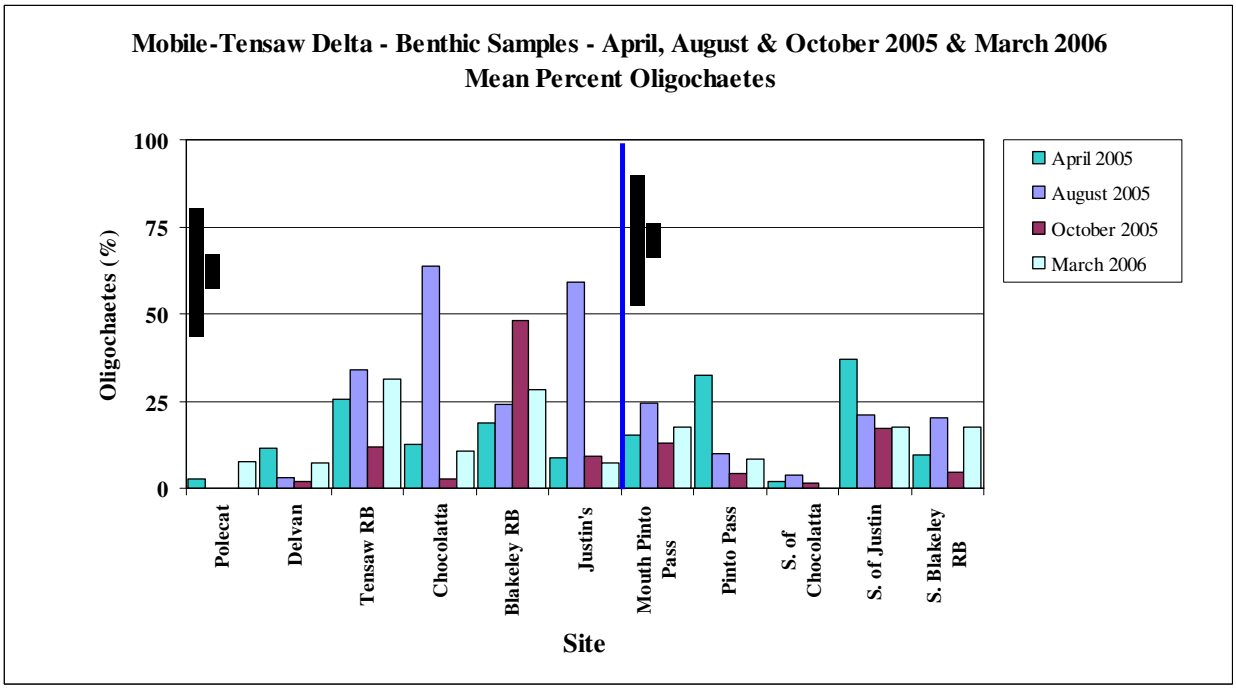

Figure 7-12. Percent oligochaetes (mean) plotted by site from April, August and October 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

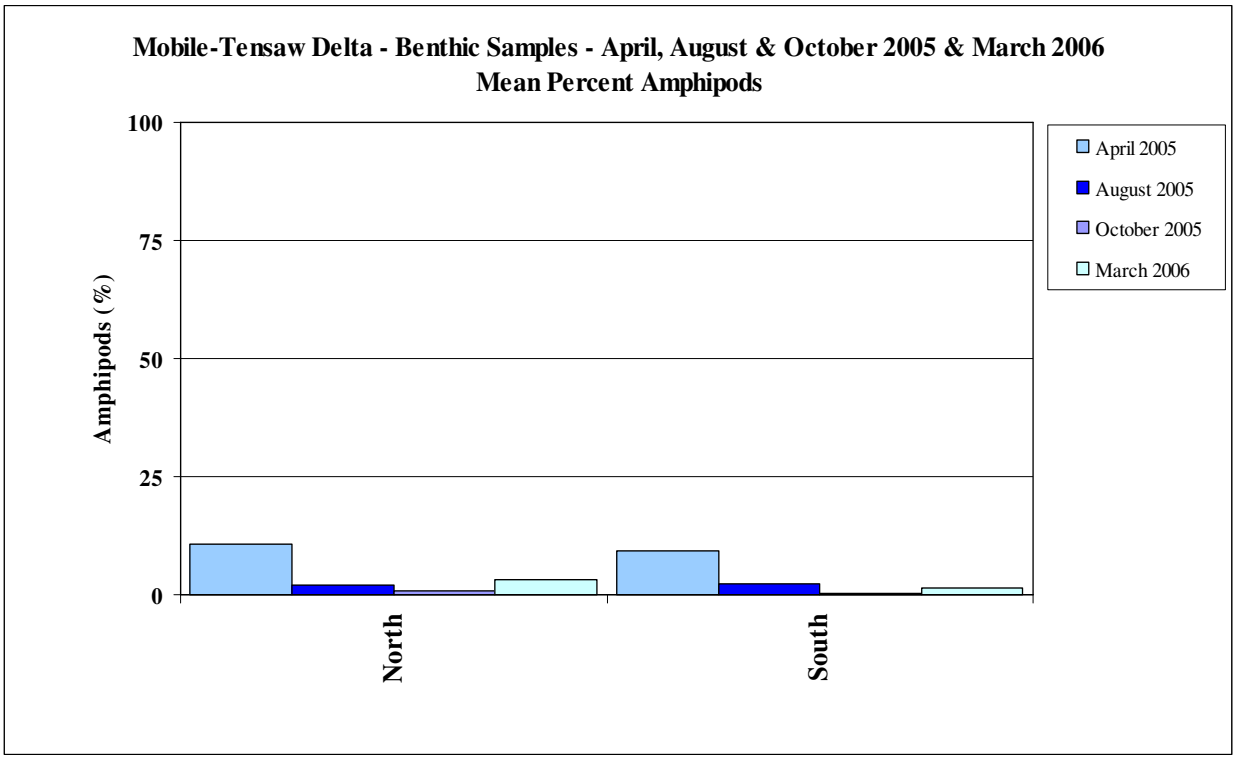

Figure 7-13. Percent amphipods (mean) plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

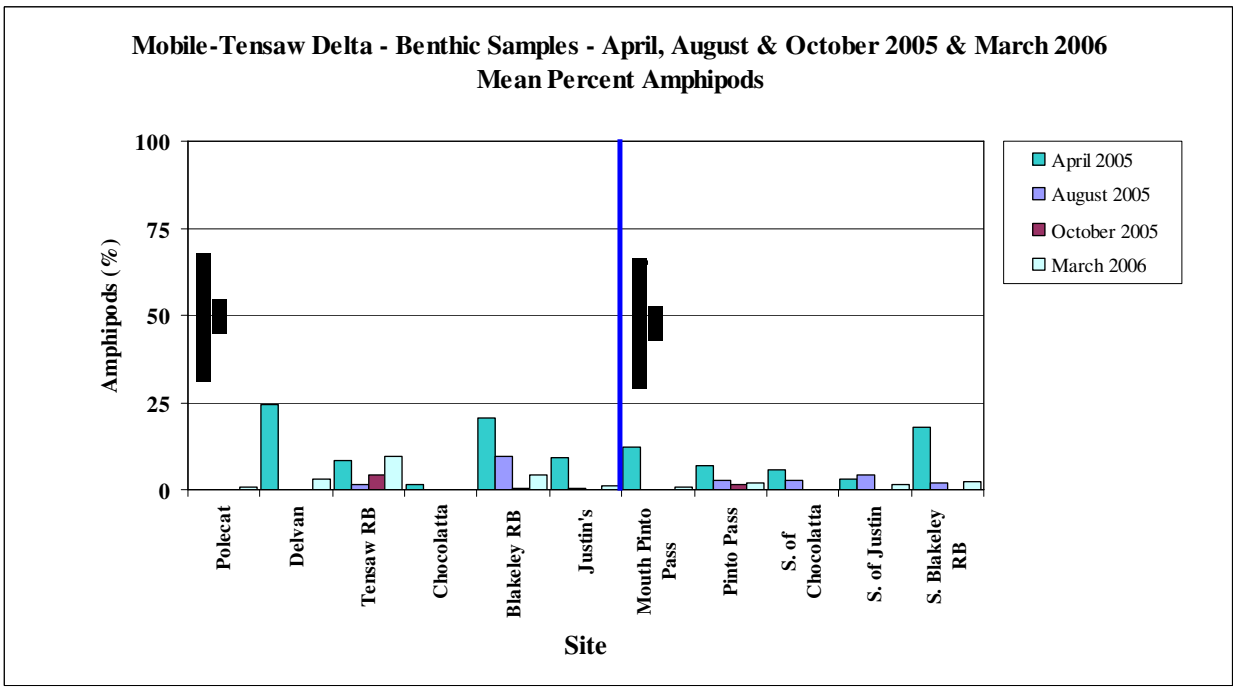

Figure 7-14. Percent amphipods (mean) plotted by site from April, August and October 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

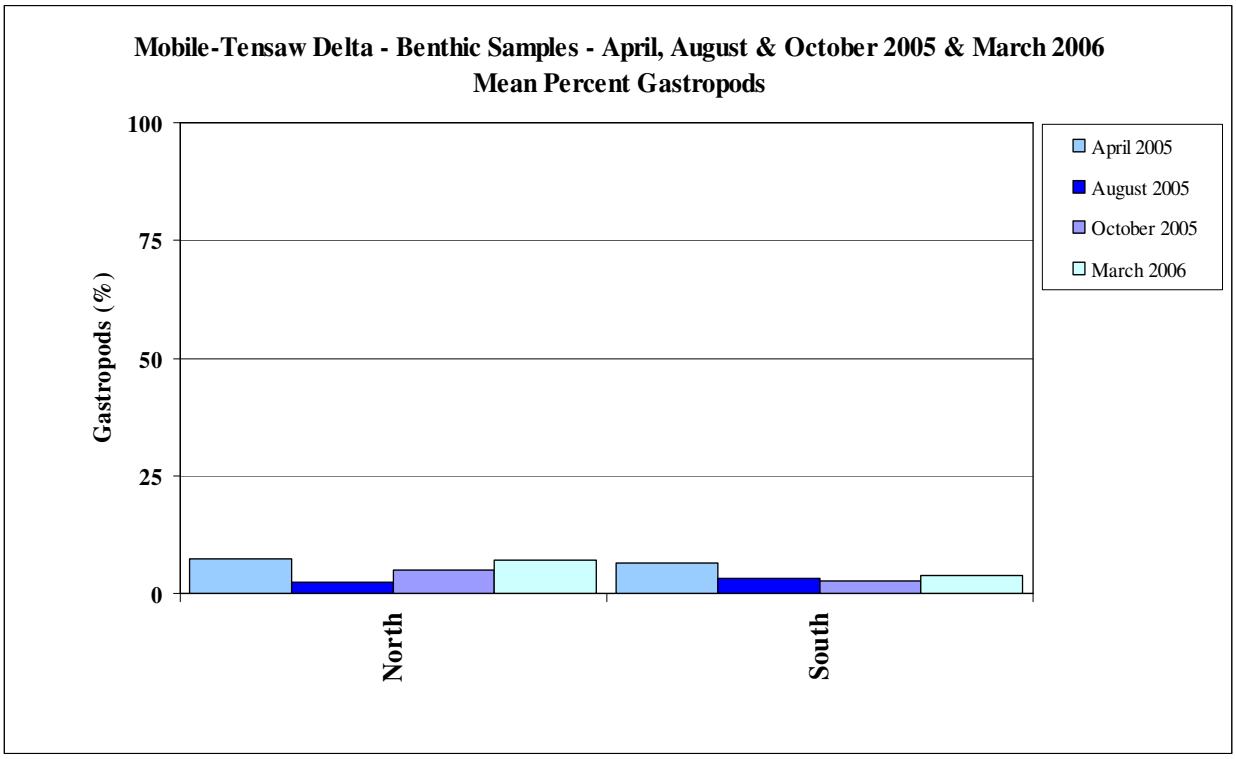

Figure 7-15. Percent gastropods (mean) plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

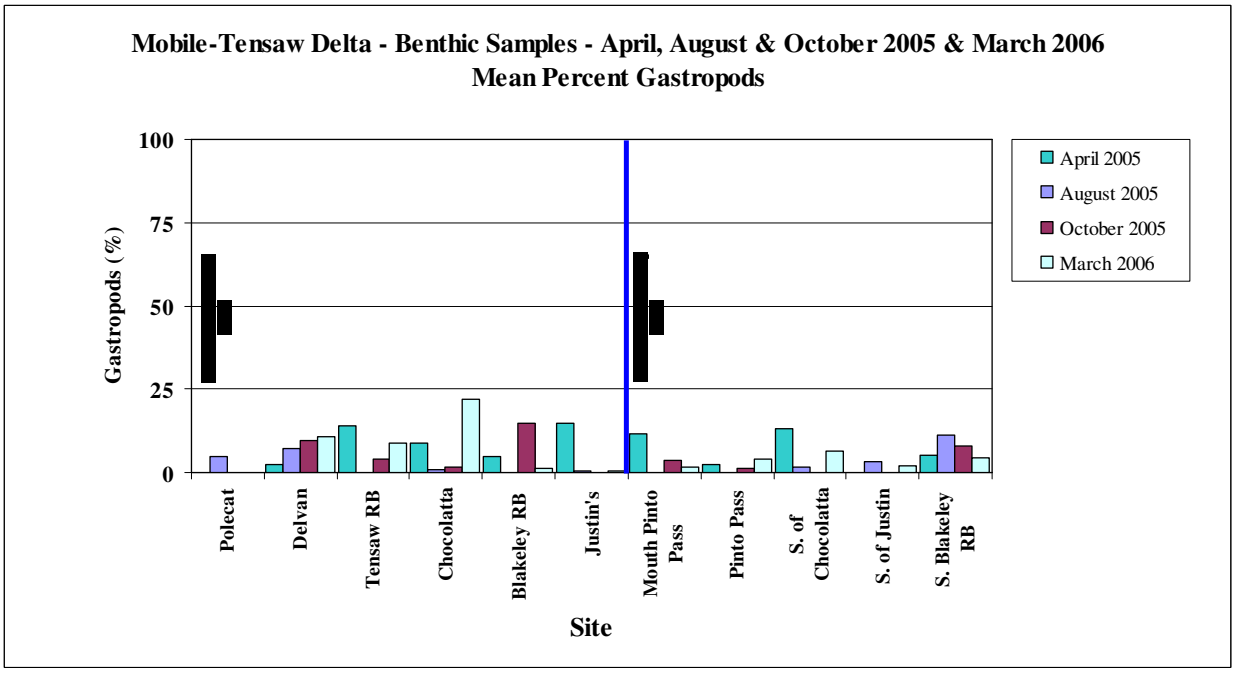

Figure 7-16. Percent gastropods (mean) plotted by site from April, August and October 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

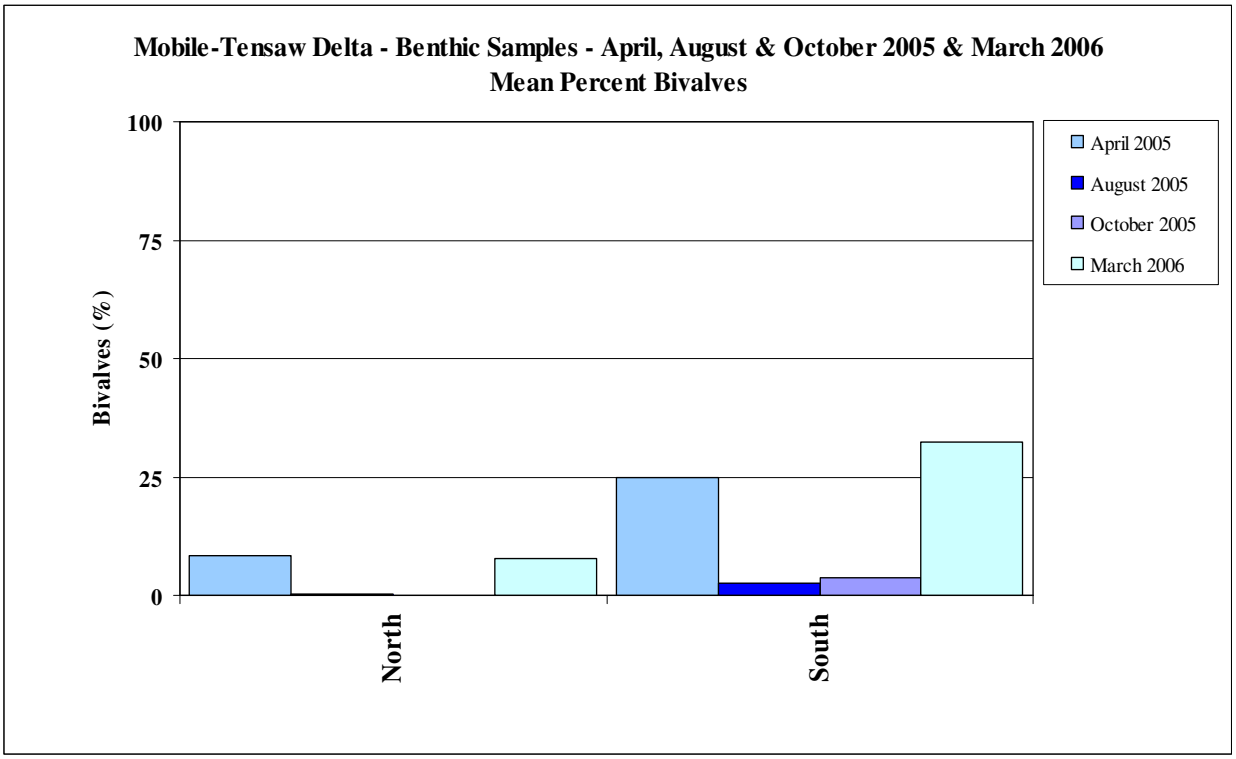

Figure 7-17. Percent bivalves (mean) plotted by location north and south of the causeway for April, August and October 2005 and March 2006 sampling events.

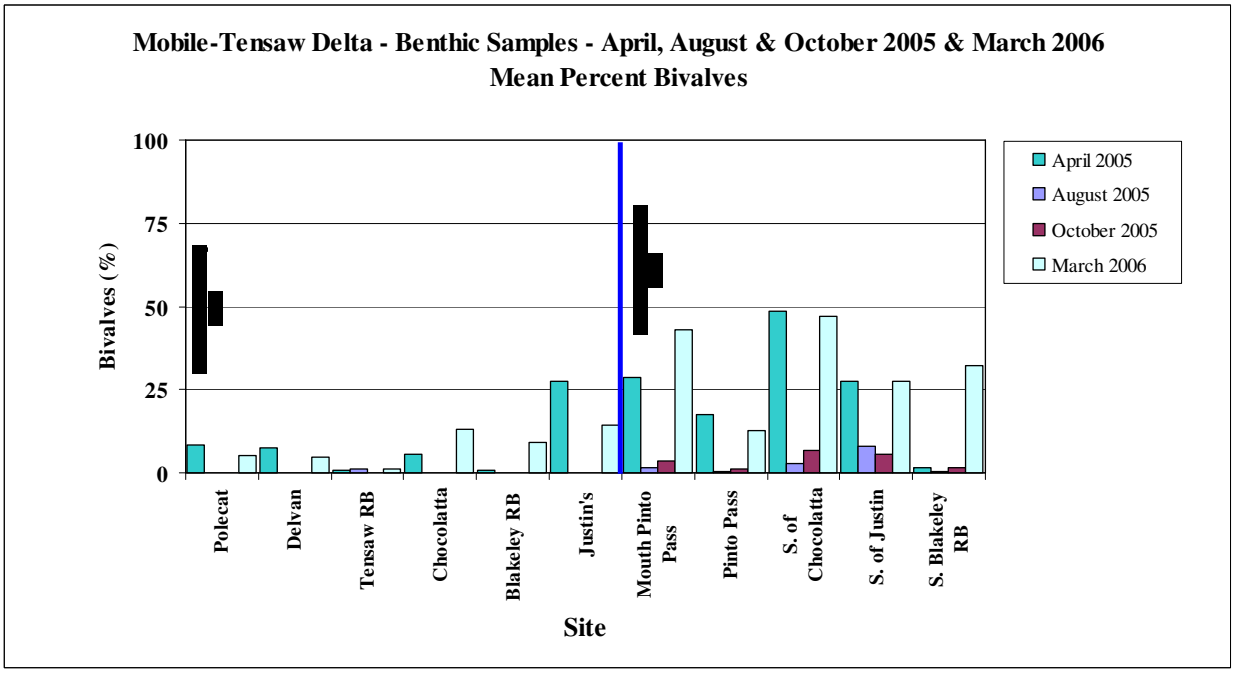

Figure 7-18. Percent bivalves (mean) plotted by site from April, August and October 2005 and March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

Table 7-4. August 2005 summary table for statistical analyses of macroinvertebrate taxa and total number of species analyzed by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**Total no. Organisms (avg)**	**Total no. species (avg)**	**Total no. Organisms**	**Total no. species**
Site		na	na	**p=0.004**	**p=0.000**
Polecat Bay	N	10	10		
Delvan Bay	N	11	11		
Tensaw Riverbank	N	5	4		
Chocolatta Bay	N	9	8		
Blakeley Riverbank	N	1	1		
Justin's Bay	N	8	9		
Mouth of Pinto Pass	S	7	6		
Pinto Pass	S	2	2		
South of Chocolatta	S	3	7		
South of Justin's	S	6	3		
South Blakeley Riverbank	S	4	5		
North	N	-	-		
South	S	-	-		
		S > N	S > N		
		p= 0.198	p= 0.169		

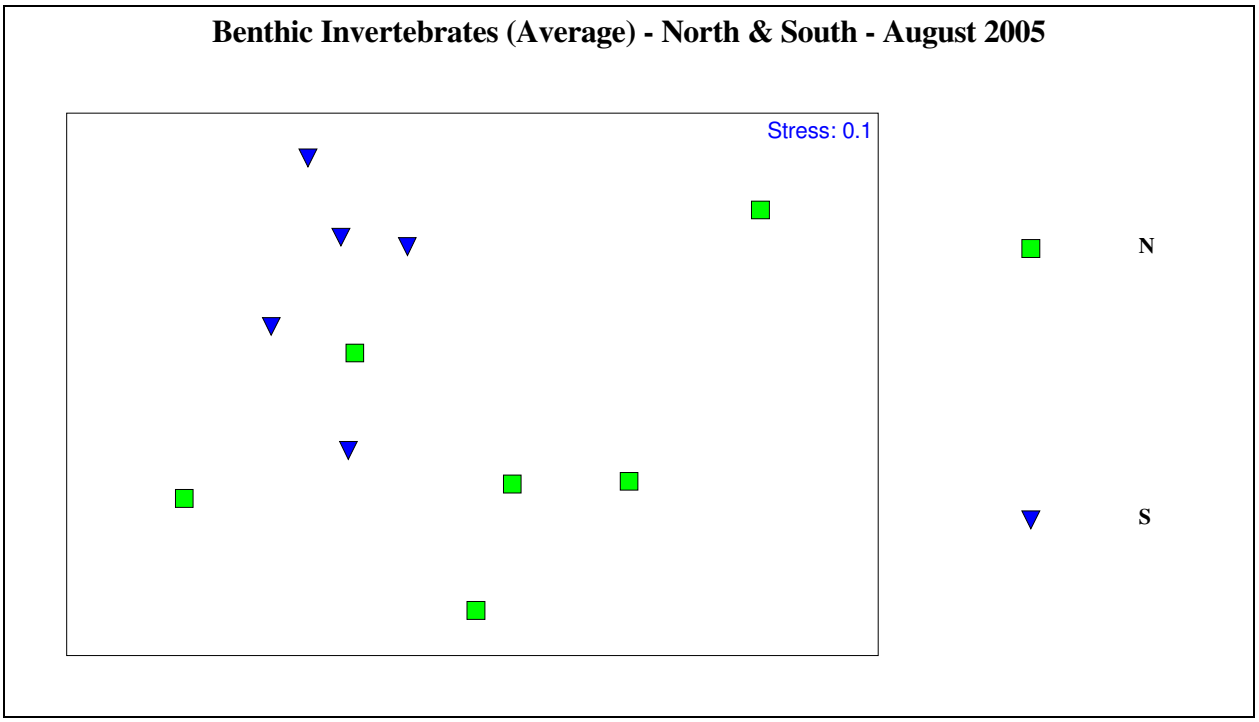

Figure 7-19. MDS plot for August 2005 benthic invertebrates by location north and south of the causeway.

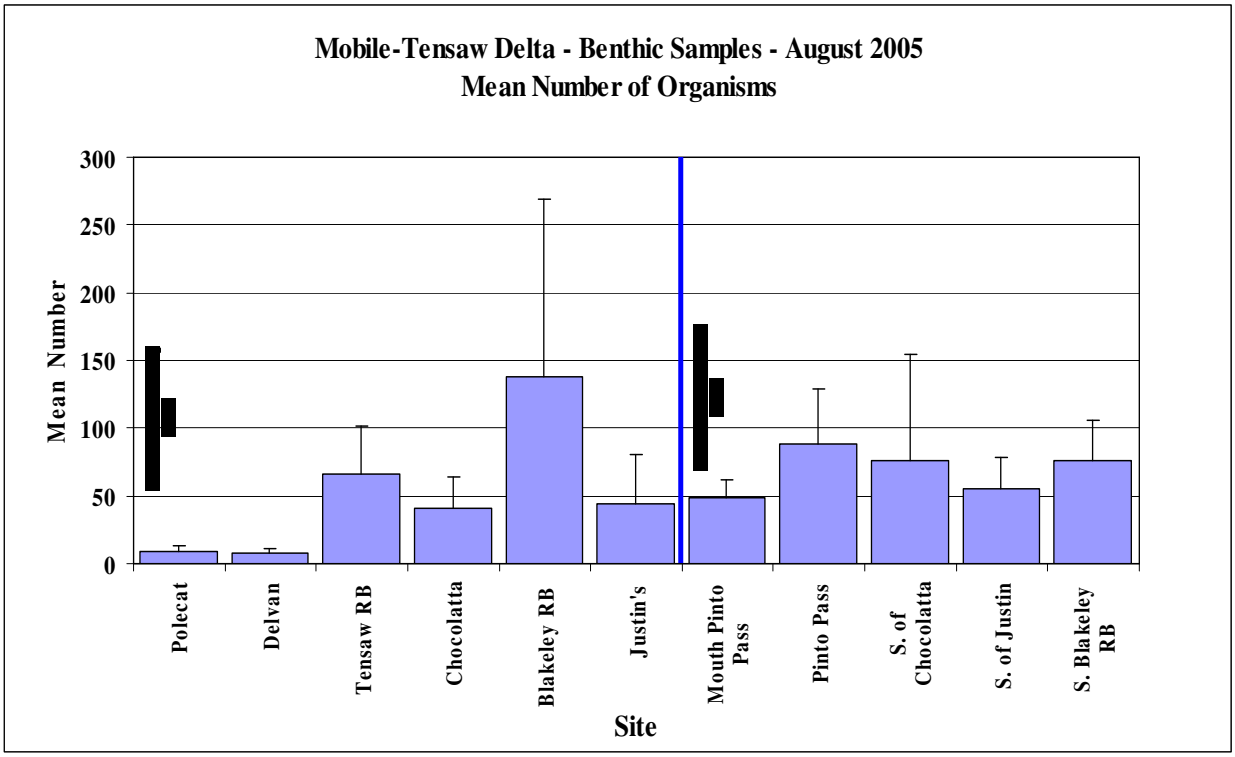

Figure 7-20. Mean number of benthic organisms (±1std dev) plotted by site from August 2005. The vertical line separates sites located north (left) and south (right) of the causeway.

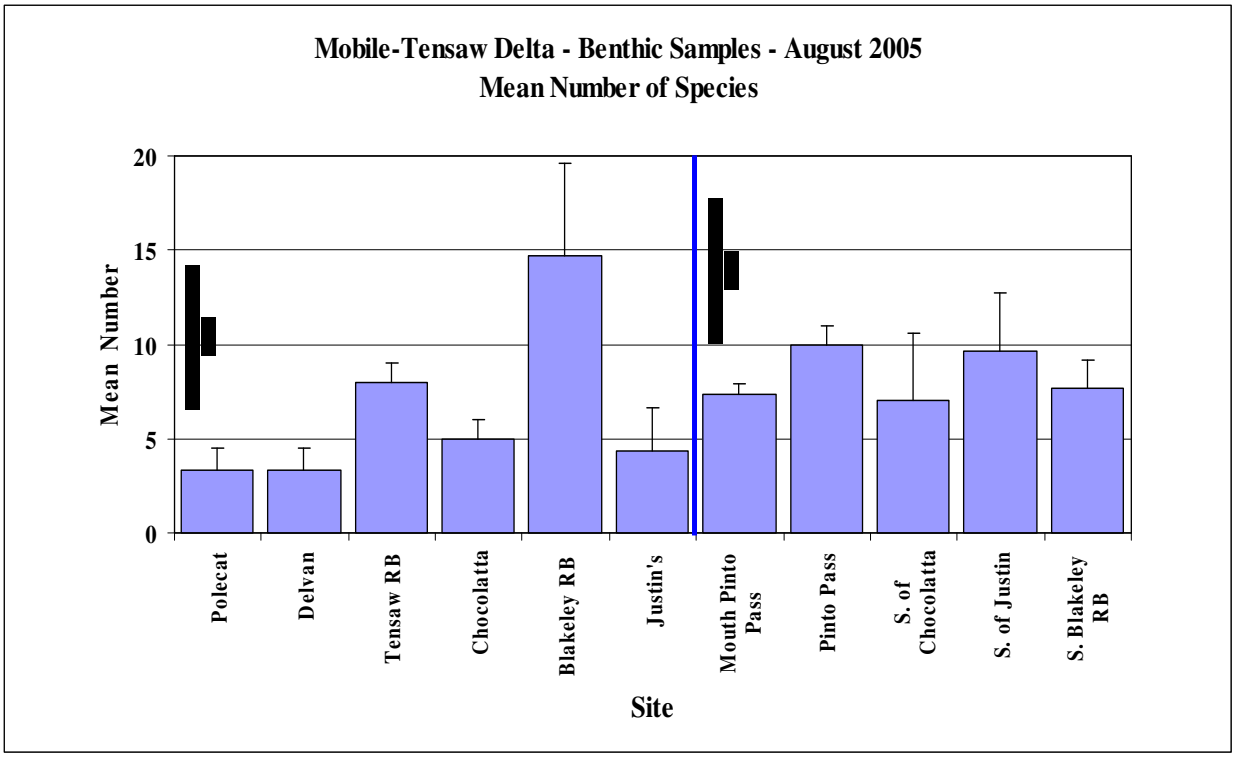

Figure 7-21. Mean number of benthic species (±1std dev) plotted by site from August 2005. The vertical line separates sites located north (left) and south (right) of the causeway.

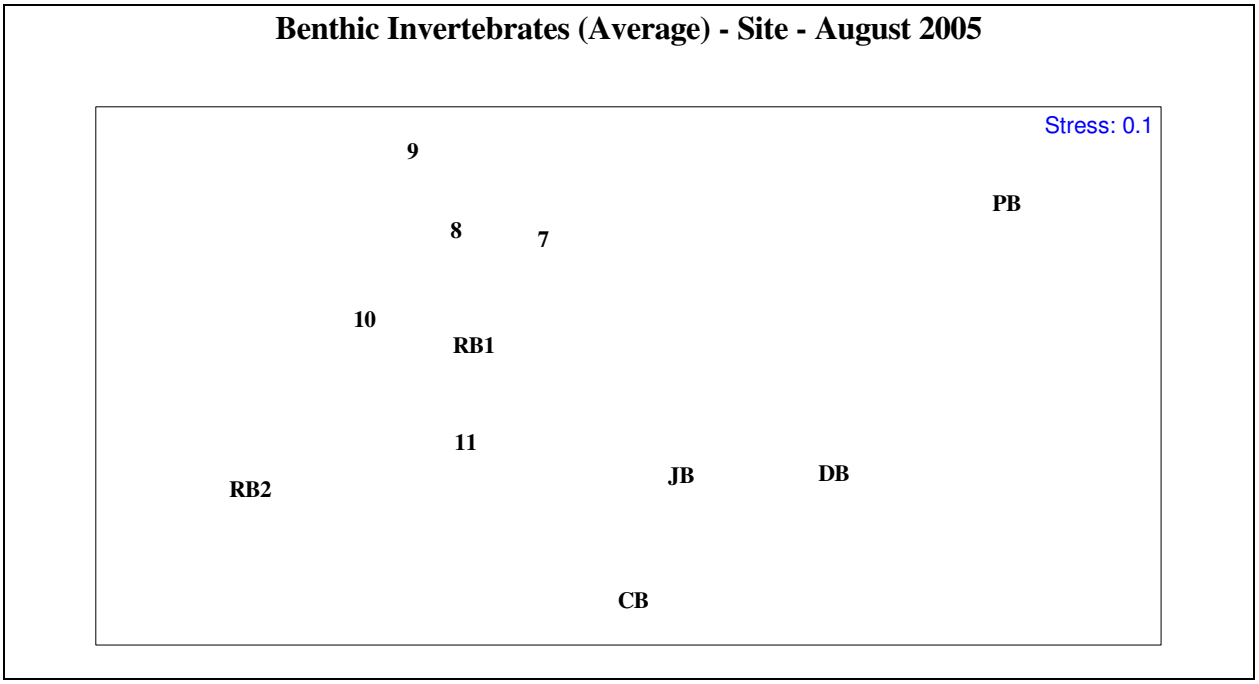

Figure 7-22. MDS plot for August 2005 benthic invertebrates by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

Table 7-5. August 2005 summary table for statistical analyses of proportion macroinvertebrate taxa by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**Chironomidae (%) (avg)**	**Polychaeta (%) (avg)**	**Oligochaeta (%) (avg)**	**Amphipoda (%) (avg)**	**Bivalvia (%) (avg)**	**Gastropoda (%) (avg)**	**Isopoda (%) (avg)**	**Ephemeroptera (%) (avg)**	**Decapoda - Crabs (%) (avg)**
		na	na	na	na	na	na	na	na	na
Polecat Bay	N	8	5	11	7	8	3	6	6	2
Delvan Bay	N	1	8	10	7	8	2	6	6	2
Tensaw Riverbank	N	9	4	3	5	4	8	6	2	2
Chocolatta Bay	N	6	10	1	7	8	6	1	5	2
Blakeley Riverbank	N	2	9	5	1	7	8	2	1	1
Justin's Bay	N	3	11	2	6	8	7	6	6	2
Mouth of Pinto Pass	S	7	3	4	7	3	8	6	6	2
Pinto Pass	S	10	2	8	3	5	8	3	6	2
South of Chocolatta	S	11	1	9	3	2	5	6	6	2
South of Justin's	S	4	6	6	2	1	4	5	3	2
South Blakeley Riverbank	S	5	7	7	4	6	1	4	4	2
North	N	-	B	-	-	-	-	-	-	-
South	S	-	A	-	-	-	-	-	-	-
		N > S	S > N	N > S	S > N	S > N	S > N	N > S	N > S	N > S
		p= 0.142	**p= 0.033**	p= 0.326	p= 0.767	p= 0.093	p= 0.694	p= 0.736	p= 0.568	p= 0.389

Table 7-6. October 2005 summary table for statistical analyses of macroinvertebrate taxa and total number of species analyzed by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**Total no. Organisms (avg)**	**Total no. species (avg)**	**Total no. Organisms**	**Total no. species**
Site Name		na	na	**p=0.012**	**p=0.000**
Polecat Bay	N	11	9		
Delvan Bay	N	7	7		
Tensaw Riverbank	N	1	1		
Chocolatta Bay	N	9	8		
Blakeley Riverbank	N	8	8		
Justin's Bay	N	3	6		
Mouth of Pinto Pass	S	10	5		
Pinto Pass	S	6	3		
South of Chocolatta	S	5	4		
South of Justin's	S	2	1		
South Blakeley Riverbank	S	4	2		
North	N	-	B		
South	S	-	A		
		S > N	S > N		
		p= 0.357	**p= 0.050**		

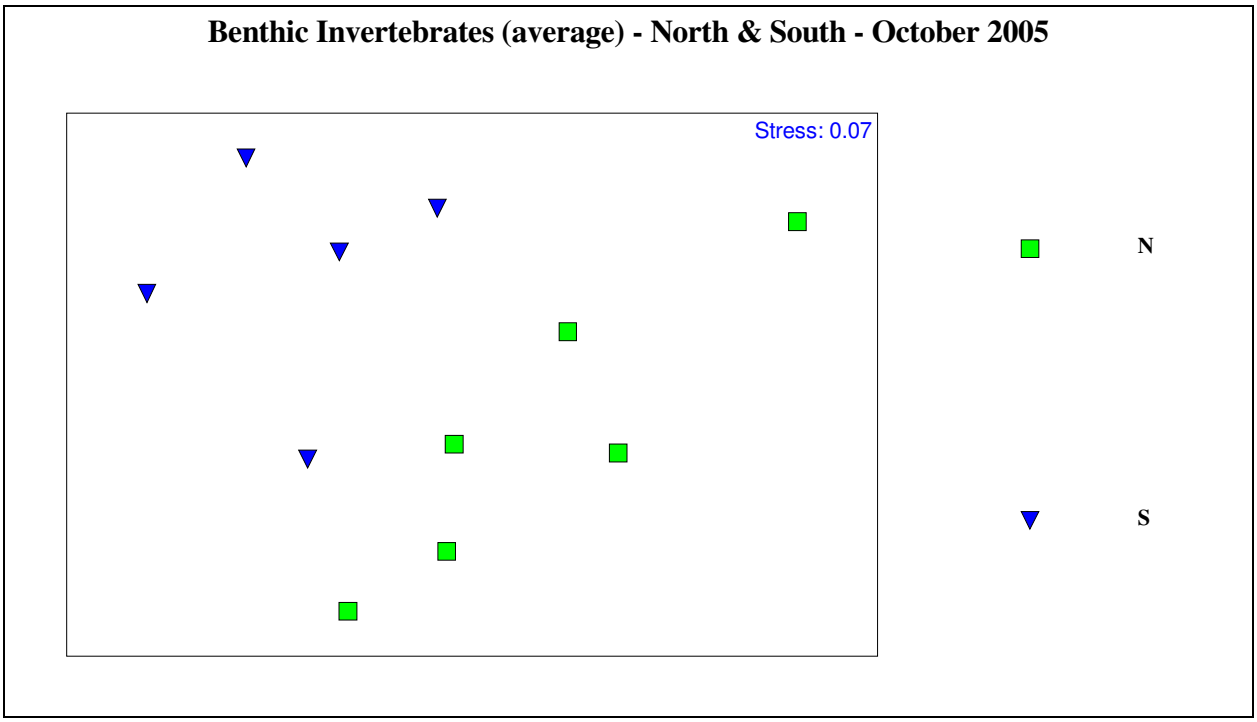

Figure 7-23. MDS plot for October 2005 benthic invertebrates by location north and south of the causeway.

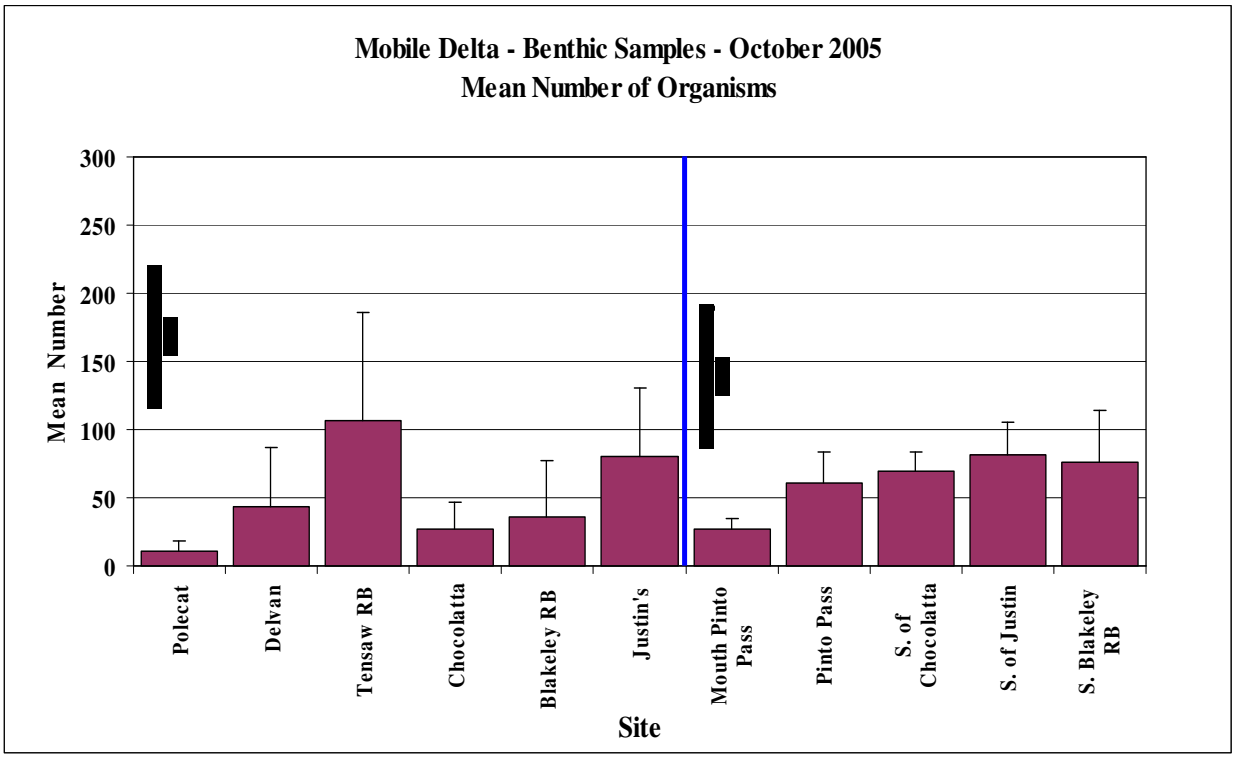

Figure 7-24. Mean number of benthic organisms (±1std dev) plotted by site from October 2005. The vertical line separates sites located north (left) and south (right) of the causeway.

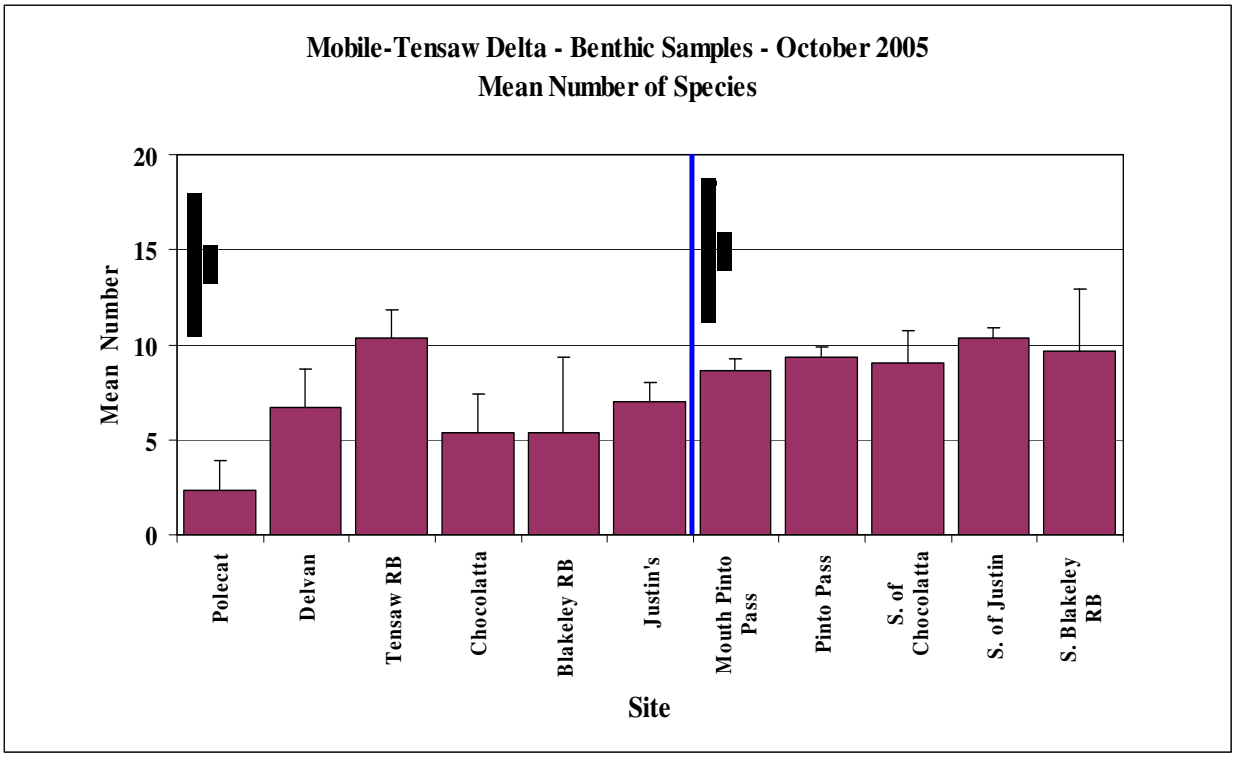

Figure 7-25. Mean number of benthic species (±1std dev) plotted by site from October 2005. The vertical line separates sites located north (left) and south (right) of the causeway.

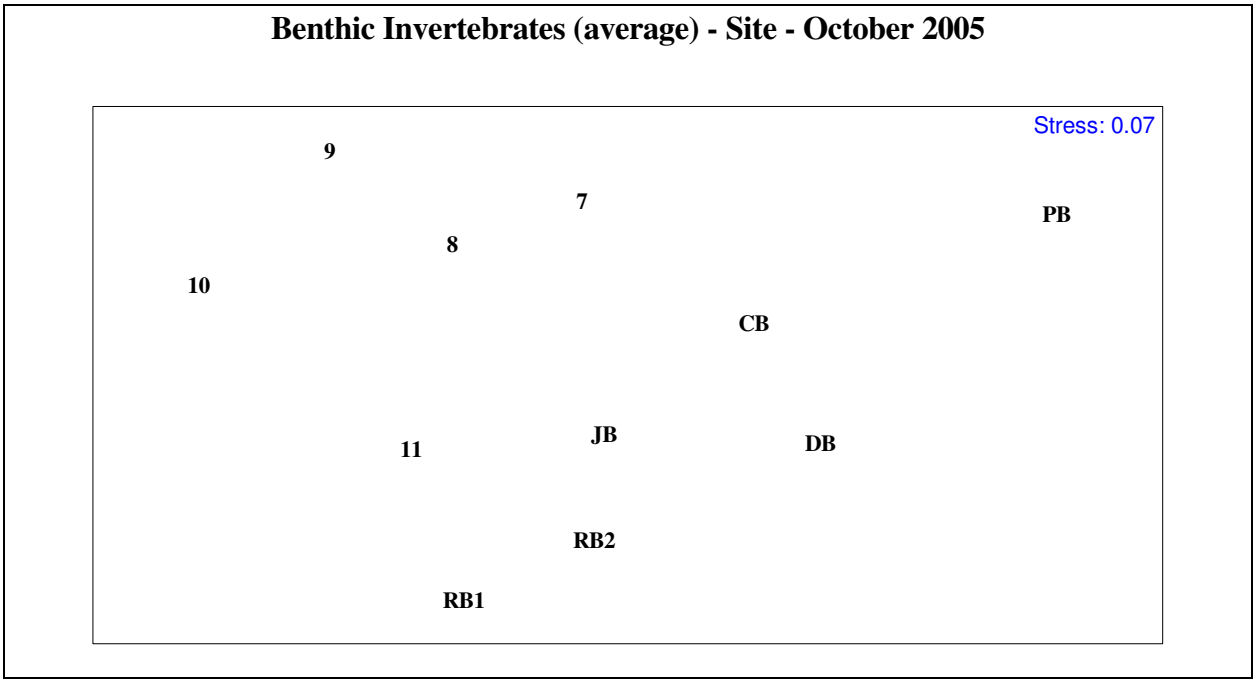

Figure 7-26. MDS plot for October 2005 benthic invertebrates by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

Table 7-7. October 2005 summary table for statistical analyses of proportion macroinvertebrate taxa by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**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	1	4	11	4	6	8	4	na	2
Delvan Bay	N	2	6	9	4	6	2	1	na	2
Tensaw Riverbank	N	7	8	4	1	6	4	3	na	1
Chocolatta Bay	N	8	7	8	4	6	6	4	na	2
Blakeley Riverbank	N	4	11	1	3	6	1	4	na	2
Justin's Bay	N	3	3	5	4	6	8	4	na	2
Mouth of Pinto Pass	S	6	10	3	4	3	5	2	na	2
Pinto Pass	S	8	2	7	2	5	7	4	na	2
South of Chocolatta	S	8	1	10	4	1	8	4	na	2
South of Justin's	S	8	9	2	4	2	8	4	na	2
South Blakeley Riverbank	S	5	5	6	4	4	3	4	na	2
North	N	-	-	-	-	B	-	-		-
South	S	-	-	-	-	A	-	-		-
		N > S	S > N	N > S	N > S	S > N	N > S	N > S		N > S
		p= 0.124	p= 0.330	p= 0.690	p= 0.627	**p= 0.003**	p= 0.595	p= 0.514	na	p= 0.389

Table 7-8. March 2006 summary table for statistical analyses of macroinvertebrate taxa and total number of species analyzed by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**Total no. Organisms (avg)**	**Total no. species (avg)**	**Total no. Organisms**	**Total no. species**
Site Name		na	na	**p=0.000**	p=0.095
Polecat Bay	N	11	11		
Delvan Bay	N	8	10		
Tensaw Riverbank	N	5	3		
Chocolatta Bay	N	10	7		
Blakeley Riverbank	N	6	9		
Justin's Bay	N	1	1		
Mouth of Pinto Pass	S	7	8		
Pinto Pass	S	9	5		
South of Chocolatta	S	3	4		
South of Justin's	S	2	2		
South Blakeley Riverbank	S	4	6		
North	N	-	-		
South	S	-	-		
		S > N	S > N		
		p= 0.490	p= 0.498		

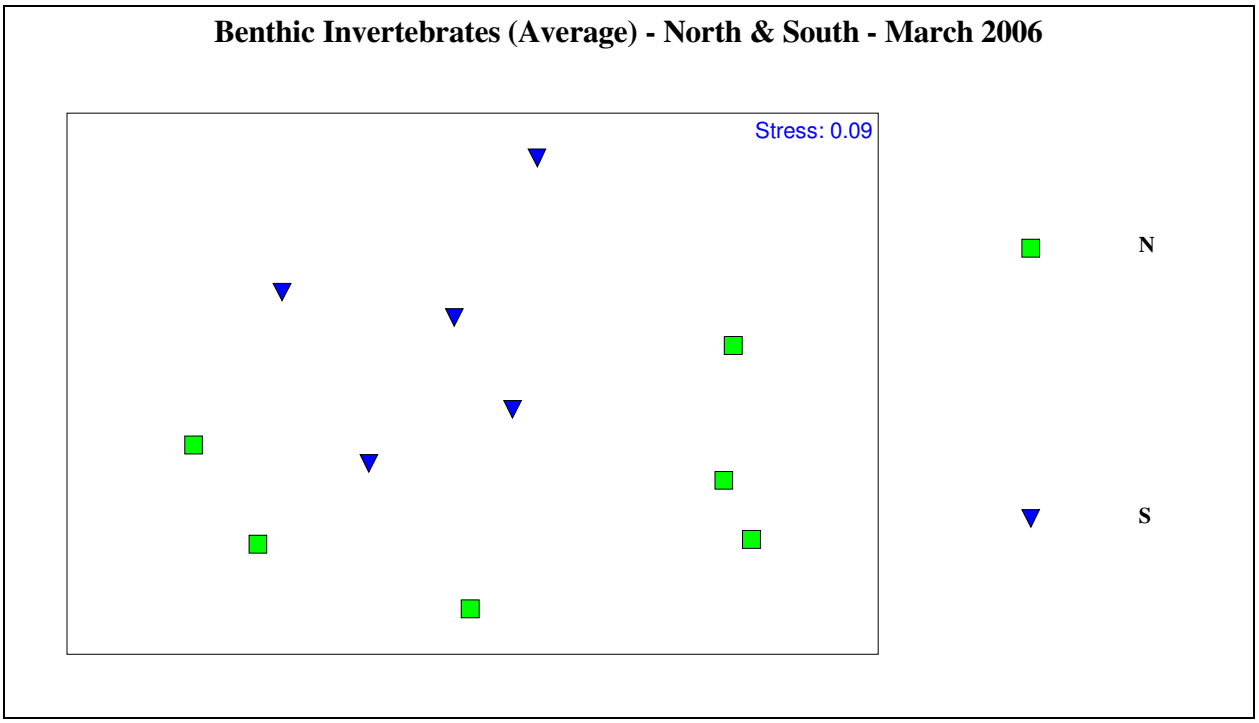

Figure 7-27. MDS plot for March 2006 benthic invertebrates by location north and south of the causeway.

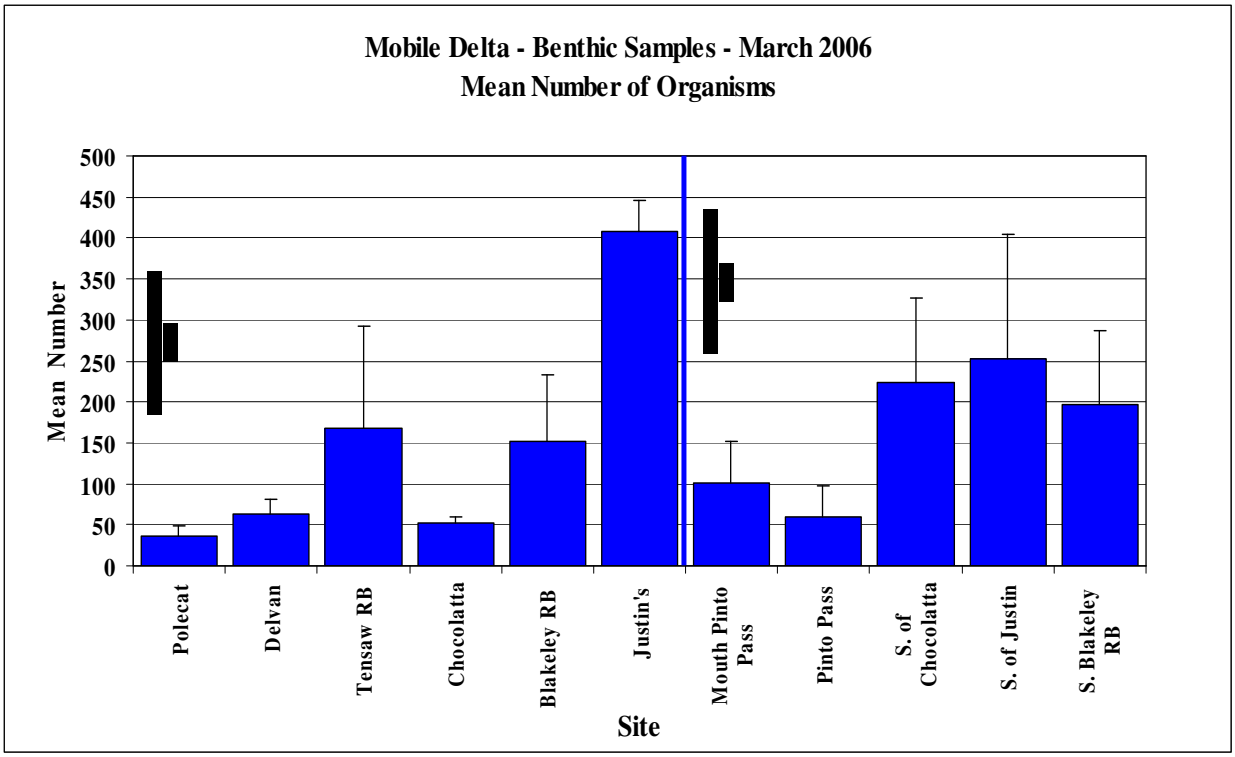

Figure 7-28. Mean number of benthic organisms (±1std dev) plotted by site from March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

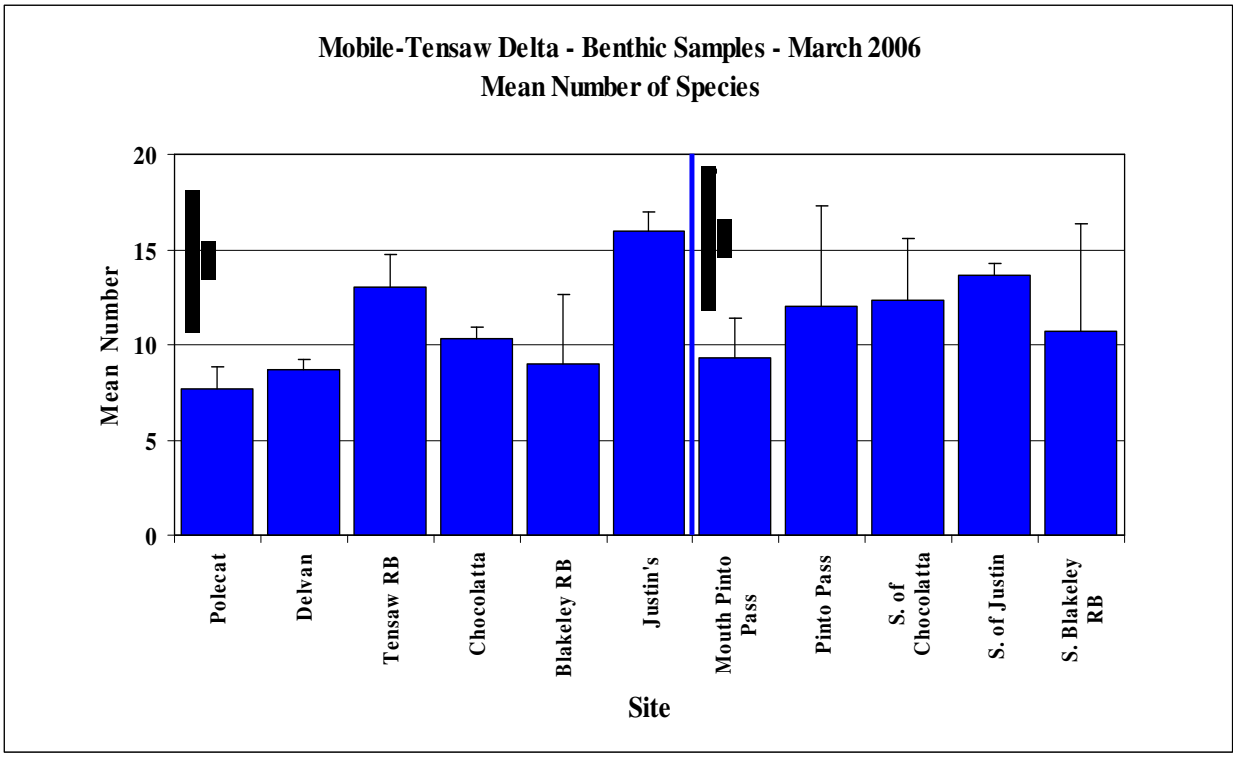

Figure 7-29. Mean number of benthic species (±1std dev) plotted by site from March 2006. The vertical line separates sites located north (left) and south (right) of the causeway.

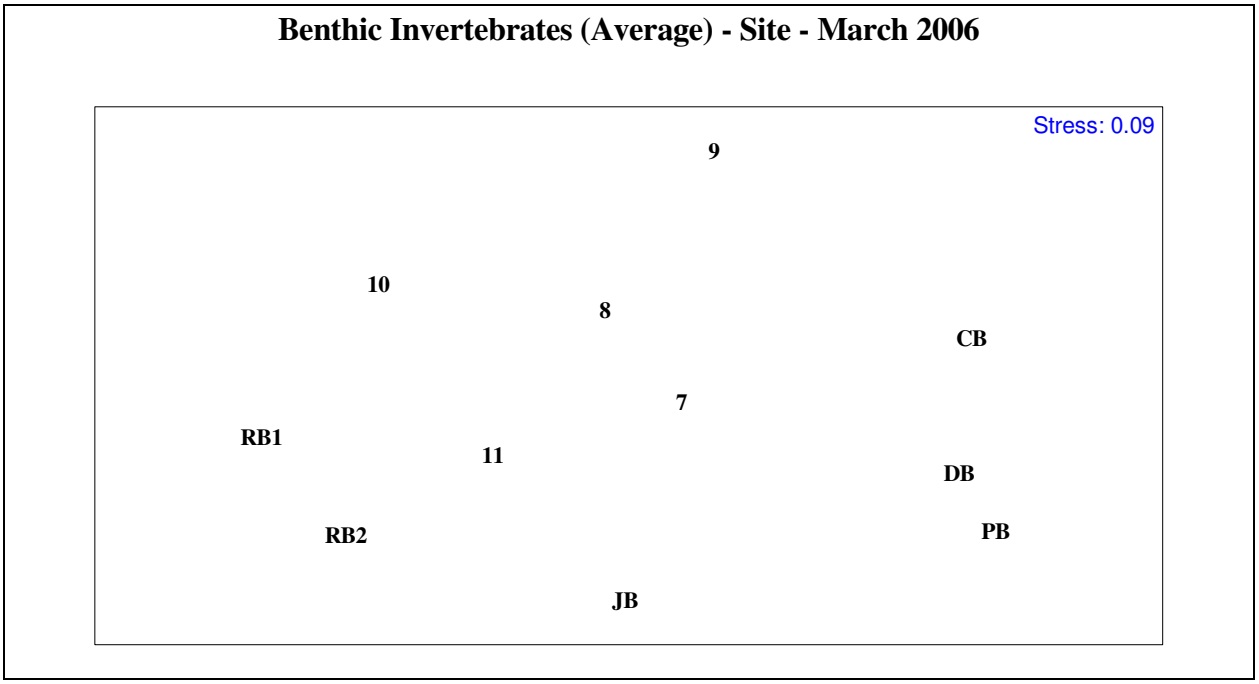

Figure 7-30. MDS plot for March 2006 benthic invertebrates by site (PB = Polecat Bay, DB = Delvan Bay, RB1 = Tensaw Riverbank, CB = Chocolatta Bay, RB2 = Blakeley Riverbank, JB = Justin's Bay, 7 = Mouth of Pinto Pass, 8 = Pinto Pass, 9 = South of Chocolatta, 10 = South of Justin's, 11 = South Blakeley Riverbank).

Table 7-9. March 2006 summary table for statistical analyses of proportion macroinvertebrate taxa by site and location north or south of causeway (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) is listed for each site.

	North or South of Causeway	**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	1	2	7	9	9	11	3	3	3
Delvan Bay	N	3	4	9	3	10	2	3	3	3
Tensaw Riverbank	N	2	10	1	1	11	3	1	3	3
Chocolatta Bay	N	10	6	5	11	6	1	3	3	3
Blakeley Riverbank	N	5	5	2	2	8	9	3	3	3
Justin's Bay	N	8	1	8	7	5	10	2	3	2
Mouth of Pinto Pass	S	6	11	4	8	2	8	3	2	3
Pinto Pass	S	4	3	6	5	7	6	3	3	3
South of Chocolatta	S	11	7	10	10	1	4	3	3	3
South of Justin's	S	9	8	3	6	4	7	3	1	3
South Blakeley Riverbank	S	7	9	4	4	3	5	3	3	1
North	N	-	-	-	-	B	-	-	-	-
South	S	-	-	-	-	A	-	-	-	-
		N > S	N > S	N > S	N > S	S > N	N > S	N > S	S > N	S > N
		p= 0.223	p= 0.181	p= 0.629	p= 0.281	**p= 0.002**	p= 0.448	p= 0.287	p= 0.175	p= 0.900

Appendix 8

Fish Collections – June, August and November 2005 and March 2006

Table 8-1. Summary table for fish collected in June, August and November 2005 and March 2006 from Chocolatta Bay (CB) and south of the causeway (south). Numbers of species are listed by date and location for trawl (T) collections.

		CB T1 062105	CB T2 062105	CB T3 062105	South T1 062105	South T2 062105	South T3 062105	CB T1 082605	CB T2 082605	CB T3 082605	South T1 082605	South T2 082605	South T3 082605	CB T1 110905	CB T2 110905	CB T3 110905	South T1 110905	South T2 110905	CB T1 030306	CB T2 030306	CB T3 030306	South T1 030306	South T2 030306	South T3 030306
Common Name	**Species**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**	**Num**
Atlantic Croaker	Micropogonias undulatus				8		1	2		1	3	1		1					49	14	8		1	1
Bay Anchovy	Anchoa mitchilli	129		66	5			428	224	275	156	59		315	3013	2216	763	949	18	5	5	73	80	26
Bay Whiff	Citharichthys spilopterus			4					1	1														
Bighead Searobin	Prionotus tribulus																2							
Black Crappie	Pomoxis nigromaculatus	6	2																					
Blenny	Blenniidae																		4		1		1	1
Blue Catfish	Ictalurus furcatus		1		58		1	25	9	15									1					
Blue Crab	Callinectes sapidus	2				2			5	1	3	2		1	1		5	15	6	2	2		1	
Bluegill Sunfish	Lepomis macrochirus	15						1																
Brown Penaid	Penaeus aztecus				1	2		1																
Carp	Cyprinus																							
Chain Pipefish	Syngnathus louisianae	20															1							
Channel Catfish	Ictalurus punctatus		2	6				17	2					1										
Common Carp	Cyprinus carpio																							
Freshwater Drum									1															
Freshwater Gobie									2															
Gizzard Shad	Dorosoma cepedianum																							
Gulf Menhaden	Brevoortia patronus	1		5							3				2	11			36	2				
Gulf Pipefish	Syngnathus scovelli	32	1		2	3	1			1								12						
Hardhead Catfish											2													
Hogchoaker	Trinectes maculatus				1			4	2	13		1				1			3	1	2			
Largemouth Bass	Micropterus salmoides	30																			1			
Longnose Gar	Lepisosteus osseus	1																						
Mullet	Mugilidae																			1				
Penaid	Penaeus													11	96	30	82	79						
Puffer*	Tetraodontidae																	1						
Rainwater Killifish	Lucania parva	32																1						
Red Spot Sunfish	Lepomis miniatus	1	1																					
Redear Sunfish	Lepomis microlophus	1	1																1					
Sand Seatrout	Cynoscion arenarius			8	6			34	7	52	5				2	13	1	2						
Searobin	Triglidae															1								
Sheepshead	Archosargus probatocephalus		1																					
Shiner	Notropus sp.	1																						
Silverside	Atherinidae				5		3	1	1	1	9	1										1	2	1
Southern Flounder	Paralichthys lethostigma											1												1
Spot	Leiostomus xanthurus			3	9		7				12	10			1									
Spotted Gar	Lepisosteus oculatus																							
Threadfin Shad	Dorosoma petenense														3									
Toadfish	Batrachoididae														1									
White Penaid	Penaeus							12	2	7	1													
Yellow Bullhead	Ameiurus natalis	1																						

Table 8-2. Fish collections from Chocolatta Bay collected with a trawl on June 21, 2005. 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:	June 21, 2005	**Start Time:**	9:13								**G = Gill Net**		
COORDINATES:	N 30' 41.325'	**End Time:**	9:23								**T = Trawl**		
	W 087' 57.955'	**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**
Bay Anchovy	Anchoa mitchilli	129	T	1.00	1.00	1.50	1.50	0.75	1.50	1.25	1.00	1.25	0.75
Bluegill Sunfish	Lepomis macrochirus	15	T	1.00	3.00	1.50	0.75	1.00	1.00	1.25	1.00	4.00	1.00
Largemouth Bass	Micropterus salmoides	30	T	2.50	1.75	2.50	1.75	2.00	2.50	1.25	2.25	3.00	2.25
Gulf Pipefish	Syngnathus scovelli	32	T	4.50	3.00	4.00	4.00	4.00	4.00	4.00	3.50	3.50	3.25
Chain Pipefish	Syngnathus louisianae	20	T	3.00	2.50	2.75	2.75	2.75	2.75	3.00	3.00	3.50	2.75
Rainwater Killifish	Lucania parva	32	T	1.50	1.25	0.75	1.25	1.00	1.00	0.75	1.50	1.25	1.00
Black Crappie	Pomoxis nigromaculatus	6	T	3.50	2.50	2.50	1.00	3.25					
Blue Crab (male) *	Callinectes sapidus	2	T	3.00	0.75								
Longnose Gar	Lepisosteus osseus	1	T	4.50									
Redear Sunfish	Lepomis microlophus	1	T	5.00									
Shiner	Notropus sp.	1	T	2.00									
Gulf Menhaden	Brevoortia patronus	1	T	1.25									
Yellow Bullhead	Ameiurus natalis	1	T	2.00									
Red Spot Sunfish	Lepomis miniatus	1	T	3.00									
TOTAL	**14**	**272**											

Black Crappie only measured 5
*Blue Crab sizes estimated from memory

Table 8-3. Fish collections from Chocolatta Bay collected with a trawl on June 21, 2005. 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:	June 21, 2005	**Start Time:**	10:17								**G = Gill Net**		
COORDINATES:	N 30' 41.642'	**End Time:**	10:24								**T = Trawl**		
	W 087' 57.295'	**Total Time (hrs):**	0.12										
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**
Black Crappie	Pomoxis nigromaculatus	2	T	3.00	3.00								
Channel Catfish	Ictalurus punctatus	2	T	6.00	9.00								
Blue Catfish	Ictalurus furcatus	1	T	7.00									
Gulf Pipefish	Syngnathus scovelli	1	T	4.00									
Redear Sunfish	Lepomis microlophus	1	T	9.00									
Sheepshead	Archosargus probatocephalus	1	T	16.00									
Red Spot Sunfish	Lepomis miniatus	1	T	3.00									
TOTAL	**7**	**9**											

Trawl stuck on tree - ended at 7 minutes

Table 8-4. Fish collections from Chocolatta Bay collected with a trawl on June 21, 2005. 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:	June 21, 2005	**Start Time:**	11:16							**G = Gill Net**			
COORDINATES:	N 30' 40.862'	**End Time:**	11:23							**T = Trawl**			
	W 087' 59.203'	**Total Time (hrs):**	0.12										
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**
Bay Anchovy	Anchoa mitchilli	66	T	1.50	2.00	1.50	1.50	1.50	2.00	1.75	1.50	1.50	1.75
Sand Seatrout	Cynoscion arenarius	8	T	3.00	3.00	3.25	2.00	2.00	3.00	3.00	3.00		
Channel Catfish	Ictalurus punctatus	6	T	7.50	6.50	6.00	5.50	9.00	5.50				
Gulf Menhaden	Brevoortia patronus	5	T	1.75	2.00	1.50	1.50	1.50					
Bay Whiff	Citharichthys spilopterus	4	T	3.50	4.00	2.75	4.00						
Spot	Leiostomus xanthurus	3	T	3.00	3.00	3.00							
TOTAL	**6**	**92**											

Trawl stuck - ended at 7 minutes

Table 8-5. Fish collections from south of the causeway collected with a trawl on June 21, 2005. 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:	June 21, 2005	**Start Time:**	12:02							**G = Gill Net**			
COORDINATES:	N 30' 40.115'	**End Time:**	12:12							**T = Trawl**			
	W 087' 59.545'	**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**
Blue Catfish	Ictalurus furcatus	58	T	4.50	5.00	7.00	5.00	7.00	5.50	6.00	5.50	6.00	4.00
Spot	Leiostomus xanthurus	9	T	3.00	4.00	3.00	3.50	4.00	3.00	3.00	3.50	3.00	
Atlantic Croaker	Micropogonias undulatus	8	T	4.00	3.00	4.50	3.00	2.50	2.50	2.50	3.00		
Sand Seatrout	Cynoscion arenarius	6	T	3.00	3.00	2.00	3.00	2.50	2.00				
Bay Anchovy	Anchoa mitchilli	5	T	1.50	1.50	1.00	1.50	1.25					
Silverside	Atherinidae	5	T	3.00	2.50	3.00	3.00	3.50					
Gulf Pipefish	Syngnathus scovelli	2	T	2.50	5.00								
Hogchoaker	Trinectes maculatus	1	T	1.50									
Brown Shrimp	Penaeus aztecus	1	T										
TOTAL	**9**	**95**											

Table 8-6. Fish collections from south of the causeway collected with a trawl on June 21, 2005. 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:	June 21, 2005	**Start Time:**	12:33							**G = Gill Net**			
COORDINATES:	N 30' 40.187'	**End Time:**	12:43							**T = Trawl**			
	W 087' 59.564'	**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**
Gulf Pipefish	Syngnathus scovelli	3	T	4.50	4.50	4.00							
Blue Crab (male)	Callinectes sapidus	2	T	1.00	0.75								
Brown Shrimp	Penaeus aztecus	2	T	3.00	2.50								
TOTAL	**3**	**7**											

Table 8-7. Fish collections from south of the causeway collected with a trawl on June 21, 2005. 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:	June 21, 2005	**Start Time:**	13:04								**G = Gill Net**		
COORDINATES:	N 30' 40.391'	**End Time:**	13:14								**T = Trawl**		
	W 087' 59.381'	**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	7	T	3.00	4.00	4.00	3.50	3.00	3.50	3.50			
Silverside	Atherinidae	3	T	2.75	3.00	3.00							
Blue Catfish	Ictalurus furcatus	1	T	6.25									
Atlantic Croaker	Micropogonias undulatus	1	T	4.00									
Gulf Pipefish	Syngnathus scovelli	1	T	4.00									
TOTAL	**5**	**13**											

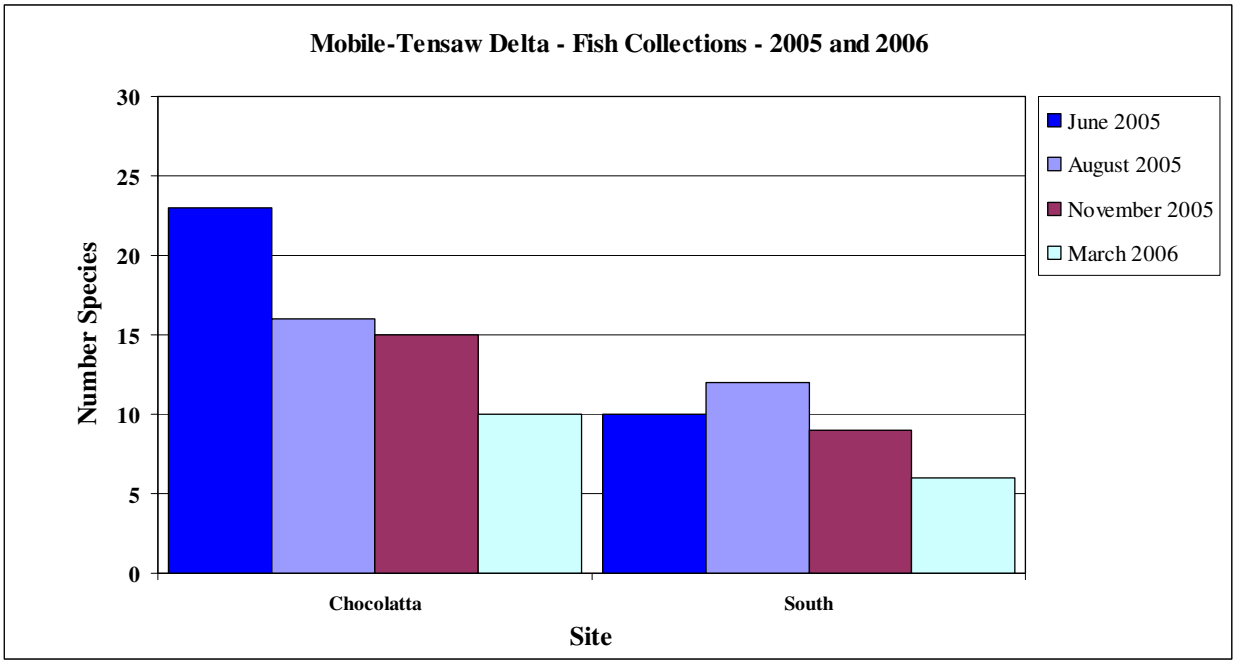

Figure 8-1. Total number of fish species for all trawl and gill net collections (not mean) during June 2005, August 2005, November 2005 and March 2006.

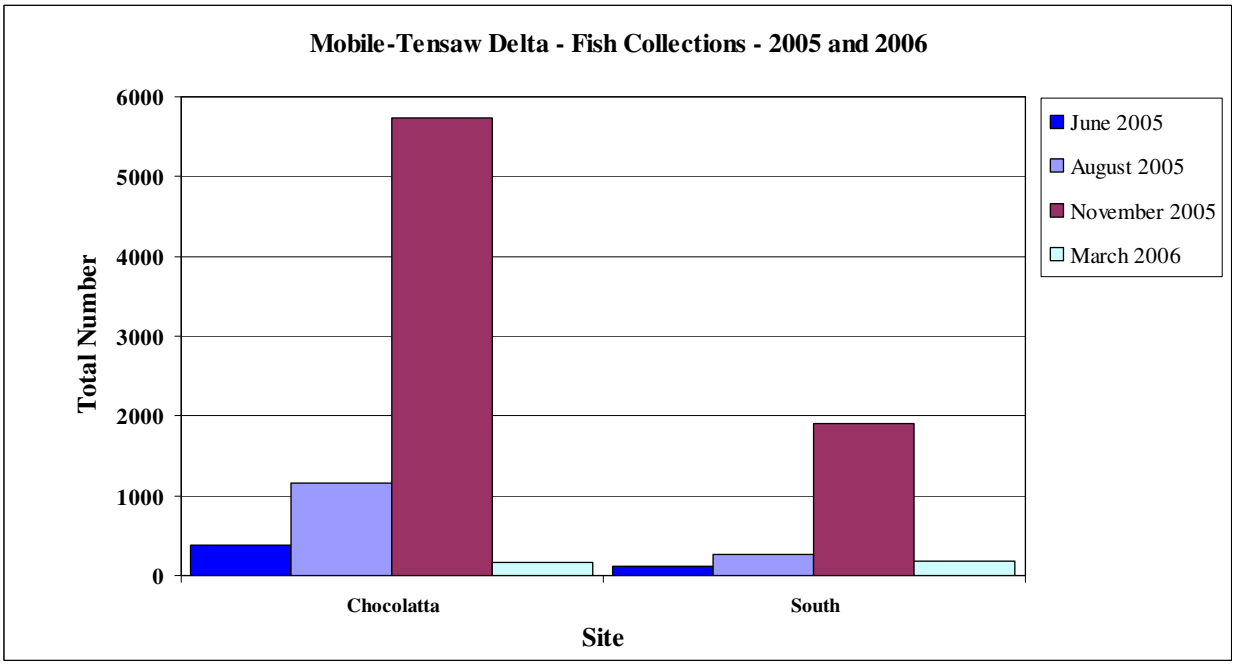

Figure 8-2. Total number of fish for all trawl and gill net collections (not mean) during June 2005, August 2005, November 2005 and March 2006.

Table 8-8. Fish collections from Chocolatta Bay collected with a trawl on August 26, 2005. 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:	August 26, 2005	**Start Time:**	9:12							**G = Gill Net**			
COORDINATES:	N 30' 41.455'	**End Time:**	9:22							**T = Trawl**			
	W 087' 58.272'	**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**
Bay Anchovy	Anchoa mitchilli	428	T	2.54	2.73	1.37	1.37	1.56	1.95	1.56	1.37	1.17	1.95
Sand Seatrout	Cynoscion arenarius	34	T	2.34	3.90	2.73	2.54	3.32	2.34	2.73	2.73	2.73	2.73
Blue Catfish	Ictalurus furcatus	25	T	2.54	3.90	3.78	3.90	4.52	6.24	6.63	3.90	3.90	3.51
Channel Catfish	Ictalurus punctatus	17	T	5.07	6.24	6.24	6.63	5.46	5.46	6.63	6.24	5.46	6.63
White Penaid	Penaeus	12	T	4.68	3.51	4.68	3.12	3.12	2.73	2.34	2.73	2.34	3.12
Hogchoaker	Trinectes maculatus	4	T	1.56	2.93	2.34	2.34						
Atlantic Croaker	Micropogonias undulatus	2	T	4.49	4.88								
Bluegill Sunfish	Lepomis macrochirus	1	T	6.63									
Silverside	Atherinidae	1	T	1.95									
Brown Penaid	Penaeus aztecus	1	T	2.73									
TOTAL	**10**	**525**											

Table 8-9. Fish collections from Chocolatta Bay collected with a trawl on August 26, 2005. 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:	August 26, 2005	**Start Time:**	9:55							**G = Gill Net**			
COORDINATES:	N 30' 41.507'	**End Time:**	10:05							**T = Trawl**			
	W 087' 58.125'	**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**
Bay Anchovy	Anchoa mitchilli	224	T	2.34	1.95	2.54	0.39	1.95	2.34	1.95	1.76	1.76	1.17
Blue Catfish	Ictalurus furcatus	9	T	5.27	4.29	3.51	3.12	6.63	6.05	5.07	2.34	6.05	
Sand Seatrout	Cynoscion arenarius	7	T	2.73	2.73	2.34	3.90	2.73	2.34	1.56			
Blue Crab	Callinectes sapidus	5	T	4.88	4.29	0.78	1.17	1.17					
Freshwater Gobie		2	T	1.56	2.34								
Hogchoaker	Trinectes maculatus	2	T	0.23	0.90								
White Penaid	Penaeus	2	T	2.73	2.73								
Channel Catfish	Ictalurus punctatus	2	T	7.02	5.85								
Freshwater Drum		1	T	3.90									
Silverside	Atherinidae	1	T	2.54									
Bay Whiff	Citharichthys spilopterus	1	T	4.29									
TOTAL	**11**	**256**											

Table 8-10. Fish collections from Chocolatta Bay collected with a trawl on August 26, 2005. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay (channel)	**Collection Device:**	Trawl								**TL = Total Length (inches)**		
DATE:	August 26, 2005	**Start Time:**	11:07								**G = Gill Net**		
COORDINATES:	N 30' 40.864'	**End Time:**	11:17								**T = Trawl**		
	W 087' 59.225'	**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**
Bay Anchovy	Anchoa mitchilli	275	T	2.34	2.34	1.56	2.15	1.76	2.34	2.34	1.17	3.51	1.95
Sand Seatrout	Cynoscion arenarius	52	T	2.73	3.90	3.51	2.34	3.12	1.56	3.12	2.34	3.12	1.76
Blue Catfish	Ictalurus furcatus	15	T	5.46	3.90	5.07	4.29	5.07	5.46	6.63	5.46	3.71	11.31
Hogchoaker	Trinectes maculatus	13	T	2.93	0.59	1.95	0.78	0.59	0.59	0.59	2.34	0.78	0.78
White Penaid	Penaeus	7	T	3.12	3.51	2.34	2.73	2.15	2.73	1.17			
Blue Crab	Callinectes sapidus	1	T	5.07									
Gulf Pipefish	Syngnathus scovelli	1	T	2.73									
Silverside	Atherinidae	1	T	3.51									
Atlantic Croaker	Micropogonias undulatus	1	T	4.68									
Bay Whiff	Citharichthys spilopterus	1	T	3.51									
TOTAL	**10**	**367**											

Table 8-11. Fish collections from south of the causeway collected with a trawl on August 26, 2005. 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:	August 26, 2005	**Start Time:**	12:00								**G = Gill Net**		
COORDINATES:	N 30' 40.131'	**End Time:**	12:10								**T = Trawl**		
	W 087' 59.304'	**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**
Bay Anchovy	Anchoa mitchilli	156	T	2.15	1.76	1.76	1.76	0.98	1.56	1.76	1.95	1.95	1.56
Spot	Leiostomus xanthurus	12	T	4.29	4.68	4.29	4.29	4.68	4.10	3.32	6.83	4.37	4.29
Silverside*	Atherinidae	9	T	2.15	1.56	1.56	1.95	1.56	1.56	1.56	1.95		
Sand Seatrout	Cynoscion arenarius	5	T	2.73	2.93	1.56	1.37	1.95					
Blue Crab	Callinectes sapidus	3	T	4.68	4.68	4.49							
Atlantic Croaker	Micropogonias undulatus	3	T	5.07	4.88	4.37							
Gulf Menhaden	Brevoortia patronus	3	T	1.76	3.90	2.54							
Hardhead Catfish		2	T	6.63	6.24								
White Penaid	Penaeus	1	T	2.73									
TOTAL	**9**	**194**											

*only measured 8

Table 8-12. Fish collections from south of the causeway collected with a trawl on August 26, 2005. 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:	August 26, 2005	**Start Time:**	12:34								**G = Gill Net**		
COORDINATES:	N 30' 40.228'	**End Time:**	12:44								**T = Trawl**		
	W 087' 59.309'	**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**
Bay Anchovy	Anchoa mitchilli	59	T	1.56	1.56	0.78	0.98	1.76	1.56	1.56	1.56	1.95	1.56
Spot	Leiostomus xanthurus	10	T	3.90	4.29	6.24	3.90	3.90	3.90	4.68	5.46	5.07	4.29
Blue Crab	Callinectes sapidus	2	T	5.46	4.68								
Silverside	Atherinidae	1	T	1.95									
Atlantic Croaker	Micropogonias undulatus	1	T	4.99									
Southern Flounder		1	T	5.27									
Hogchoaker	Trinectes maculatus	1	T	2.73									
TOTAL	**7**	**75**											

Table 8-13. Fish collections from south of the causeway collected with a trawl on August 26, 2005. 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:	August 26, 2005	**Start Time:**	13:07								**G = Gill Net**		
COORDINATES:	N 30' 40.138'	**End Time:**	13:17								**T = Trawl**		
	W 087' 59.165'	**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**
Alligator (8 ft) - (worked the alligator out of the net)		1	T										
TOTAL	**1**	**1**											

Table 8-14. Fish collections from Chocolatta Bay collected with a trawl on November 9, 2005. 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:	November 9, 2005	**Start Time:**	11:25								**G = Gill Net**		
COORDINATES:	N 30' 41.480'	**End Time:**	11:35								**T = Trawl**		
	W 087' 58.340'	**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**
Bay Anchovy	Anchoa mitchilli	315	T	1.50	1.75	2.00	1.50	2.00	1.50	1.50	1.50	2.00	1.50
Penaid	Penaeus	11	T	2.00	3.50	4.50	4.00	4.00	5.00	3.50	3.50	4.00	2.50
Channel Catfish	Ictalurus punctatus	1	T	8.00									
Atlantic Croaker	Micropogonias undulatus	1	T	1.50									
Blue Crab	Callinectes sapidus	1	T	1.00									
TOTAL	**5**	**329**											

Table 8-15. Fish collections from Chocolatta Bay collected with a trawl on November 9, 2005. 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:	November 9, 2005	**Start Time:**	12:30								**G = Gill Net**		
COORDINATES:	N 30' 41.520'	**End Time:**	12:40								**T = Trawl**		
	W 087' 58.700'	**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**
Bay Anchovy	Anchoa mitchilli	3013	T	2.00	2.00	1.50	1.50	2.25	2.00	2.00	2.00	1.75	2.00
Penaid	Penaeus	96	T	4.00	4.00	3.00	4.00	2.00	3.50	4.00	3.00	3.00	3.50
Threadfin Shad	Dorosoma petenense	3	T	5.00	3.00	3.00							
Gulf Menhaden	Brevoortia patronus	2	T	4.00	5.00								
Sand Seatrout	Cynoscion arenarius	2	T	4.00	3.00								
Blue Crab	Callinectes sapidus	1	T	8.00									
Spot	Leiostomus xanthurus	1	T	6.00									
Toadfish	Batrachoididae	1	T	1.50									
TOTAL	**8**	**3119**											

Table 8-16. Fish collections from Chocolatta Bay collected with a trawl on November 9, 2005. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay (channel)	**Collection Device:**	Trawl								**TL = Total Length (inches)**		
DATE:	November 9, 2005	**Start Time:**	13:27								**G = Gill Net**		
COORDINATES:	N 30' 40.847'	**End Time:**	13:37								**T = Trawl**		
	W 087' 59.190'	**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**
Bay Anchovy	Anchoa mitchilli	2216	T	1.50	2.00	2.00	1.75	1.75	1.50	2.00	2.00	2.00	2.00
Penaid	Penaeus	30	T	5.00	5.00	5.00	4.00	4.00	4.00	3.00	3.00	5.00	5.00
Sand Seatrout	Cynoscion arenarius	13	T	4.00	3.00	4.00	3.00	3.00	3.25	4.00	3.00	3.50	3.00
Gulf Menhaden	Brevoortia patronus	11	T	7.00	5.00	3.00	4.00	3.00	3.00	3.00	3.50	3.25	3.50
Hogchoaker	Trinectes maculatus	1	T	3.00									
Searobin	Triglidae	1	T	2.00									
TOTAL	**6**	**2272**											

Table 8-17. Fish collections from south of the causeway collected with a trawl on November 9, 2005. 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:	November 9, 2005	**Start Time:**	15:01								**G = Gill Net**		
COORDINATES:	N 30' 40.083'	**End Time:**	15:11								**T = Trawl**		
	W 087' 59.285'	**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**
Bay Anchovy	Anchoa mitchilli	763	T	2.00	2.00	2.50	2.50	1.50	1.75	2.00	2.00	1.75	1.75
Penaid	Penaeus	82	T	4.00	4.00	3.50	3.00	3.50	5.00	5.00	4.00	5.00	3.00
Blue Crab	Callinectes sapidus	5	T	1.00	0.75	0.75	1.00	1.00					
Bighead Searobin	Prionotus tribulus	2	T	2.00	2.00								
Chain Pipefish	Syngnathus louisianae	1	T	4.00									
Sand Seatrout	Cynoscion arenarius	1	T	3.00									
TOTAL	**6**	**854**											

Table 8-18. Fish collections from south of the causeway collected with a trawl on November 9, 2005. 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:	November 9, 2005	**Start Time:**	15:50								**G = Gill Net**		
COORDINATES:	N 30' 40.158'	**End Time:**	16:00								**T = Trawl**		
	W 087' 59.185'	**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**
Bay Anchovy	Anchoa mitchilli	949	T	1.75	1.75	1.75	1.50	2.25	1.50	1.50	2.25	1.50	1.50
Penaid	Penaeus	79	T	5.00	4.00	3.50	4.00	3.50	3.00	2.00	3.00	3.00	6.00
Blue Crab	Callinectes sapidus	15	T	1.00	1.00	0.50	0.75	0.50	0.50	0.75	0.50	0.50	1.00
Gulf Pipefish	Syngnathus scovelli	12	T	4.00	4.00	7.00	4.00	6.00	7.00	6.50	4.00	3.00	5.00
Sand Seatrout	Cynoscion arenarius	2	T	2.00	2.00								
Rainwater Killifish	Lucania parva	1	T	1.00									
Puffer*	Tetraodontidae	1	T										
TOTAL	**7**	**1059**											

* lost - very small

Table 8-19. Fish collections from Chocolatta Bay collected with a trawl on March 3, 2006. 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 3, 2006	**Start Time:**	10:32								**G = Gill Net**		
COORDINATES:	N 30' 41.592'	**End Time:**	10:42								**T = Trawl**		
	W 087' 58.641'	**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**
Atlantic Croaker	Micropogonias undulatus	49	T	3.25	4.00	3.25	1.75	1.75	2.00	1.75	2.50	1.25	1.25
Gulf Menhaden	Brevoortia patronus	36	T	4.00	2.00	1.50	1.50	1.75	3.00	3.25	1.75	1.75	2.00
Bay Anchovy	Anchoa mitchilli	18	T	1.25	1.25	1.50	1.75	1.75	1.50	1.75	1.50	1.50	1.75
Blue Crab (male)	Callinectes sapidus	6	T	4.25	0.75	0.75	0.75	1.50	1.25				
Blenny	Blenniidae	4	T	2.25	2.75	1.50	1.25						
Hogchoaker	Trinectes maculatus	3	T	2.75	1.75	1.75							
Blue Catfish	Ictalurus furcatus	1	T	7.50									
Redear Sunfish	Lepomis microlophus	1	T	8.00									
TOTAL	**8**	**118**											

Table 8-20. Fish collections from Chocolatta Bay collected with a trawl on March 3, 2006. 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 3, 2006	**Start Time:**	11:13								**G = Gill Net**		
COORDINATES:	N 30' 42.132'	**End Time:**	11:23								**T = Trawl**		
	W 087' 58.548'	**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**
Atlantic Croaker	Micropogonias undulatus	14	T	4.00	2.25	1.25	3.00	2.50	1.75	1.00	1.50	2.00	1.25
Bay Anchovy	Anchoa mitchilli	5	T	1.50	1.00	1.25	1.00	1.00					
Gulf Menhaden	Brevoortia patronus	2	T	1.50	1.50								
Blue Crab (female, male)	Callinectes sapidus	2	T	5.50	1.00								
Mullet	Mugilidae	1	T	7.25									
Hogchoaker	Trinectes maculatus	1	T	0.75									
TOTAL	**6**	**25**											

Table 8-21. Fish collections from Chocolatta Bay collected with a trawl on March 3, 2006. Numbers of each species and total lengths for the first ten fish are listed.

SITE:	Chocolatta Bay - Channel	**Collection Device:**	Trawl								**TL = Total Length (inches)**		
DATE:	March 3, 2006	**Start Time:**	11:54								**G = Gill Net**		
COORDINATES:	N 30' 40.855'	**End Time:**	12:04								**T = Trawl**		
	W 087' 59.182'	**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**
Atlantic Croaker	Micropogonias undulatus	8	T	3.50	2.00	2.00	2.50	2.50	1.50	1.50	1.00		
Bay Anchovy	Anchoa mitchilli	5	T	1.75	1.50	1.75	1.50	1.75					
Blue Crab (male)	Callinectes sapidus	2	T	1.75	1.25								
Hogchoaker	Trinectes maculatus	2	T	3.00	1.25								
Largemouth Bass	Micropterus salmoides	1	T	12.00									
Blenny	Blenniidae	1	T	2.50									
TOTAL	**6**	**19**											

Table 8-22. Fish collections from south of the causeway collected with a trawl on March 3, 2006. 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 3, 2006	**Start Time:**	9:00								**G = Gill Net**		
COORDINATES:	N 30' 40.013'	**End Time:**	9:10								**T = Trawl**		
	W 087' 59.238'	**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**
Bay Anchovy	Anchoa mitchilli	73	T	2.50	2.00	2.00	1.50	1.50	1.50	1.50	2.50	2.25	1.25
Silverside	Atherinidae	1	T	4.25									
TOTAL	**2**	**74**											

Table 8-23. Fish collections from south of the causeway collected with a trawl on March 3, 2006. 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 3, 2006	**Start Time:**	9:24								**G = Gill Net**		
COORDINATES:	N 30' 40.021'	**End Time:**	9:34								**T = Trawl**		
	W 087' 59.072'	**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**
Bay Anchovy	Anchoa mitchilli	80	T	2.00	2.00	1.75	1.75	1.75	1.50	2.00	1.75	1.75	1.50
Silverside	Atherinidae	2	T	4.00	3.50								
Atlantic Croaker	Micropogonias undulatus	1	T	2.00									
Blue Crab (male)	Callinectes sapidus	1	T	1.50									
Blenny	Blenniidae	1	T	1.50									
TOTAL	**5**	**85**											

Table 8-24. Fish collections from south of the causeway collected with a trawl on March 3, 2006. 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 3, 2006	**Start Time:**	9:51								**G = Gill Net**		
COORDINATES:	N 30' 39.710'	**End Time:**	10:01								**T = Trawl**		
	W 087' 58.859'	**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**
Bay Anchovy	Anchoa mitchilli	26	T	1.00	1.00	1.75	1.50	1.00	1.00	1.00	1.25	1.00	1.00
Atlantic Croaker	Micropogonias undulatus	1	T	1.00									
Blenny	Blenniidae	1	T	0.75									
Silverside	Atherinidae	1	T	3.75									
Southern (?) Flounder	Paralichthys lethostigma	1	T	1.00									
TOTAL	**5**	**30**											

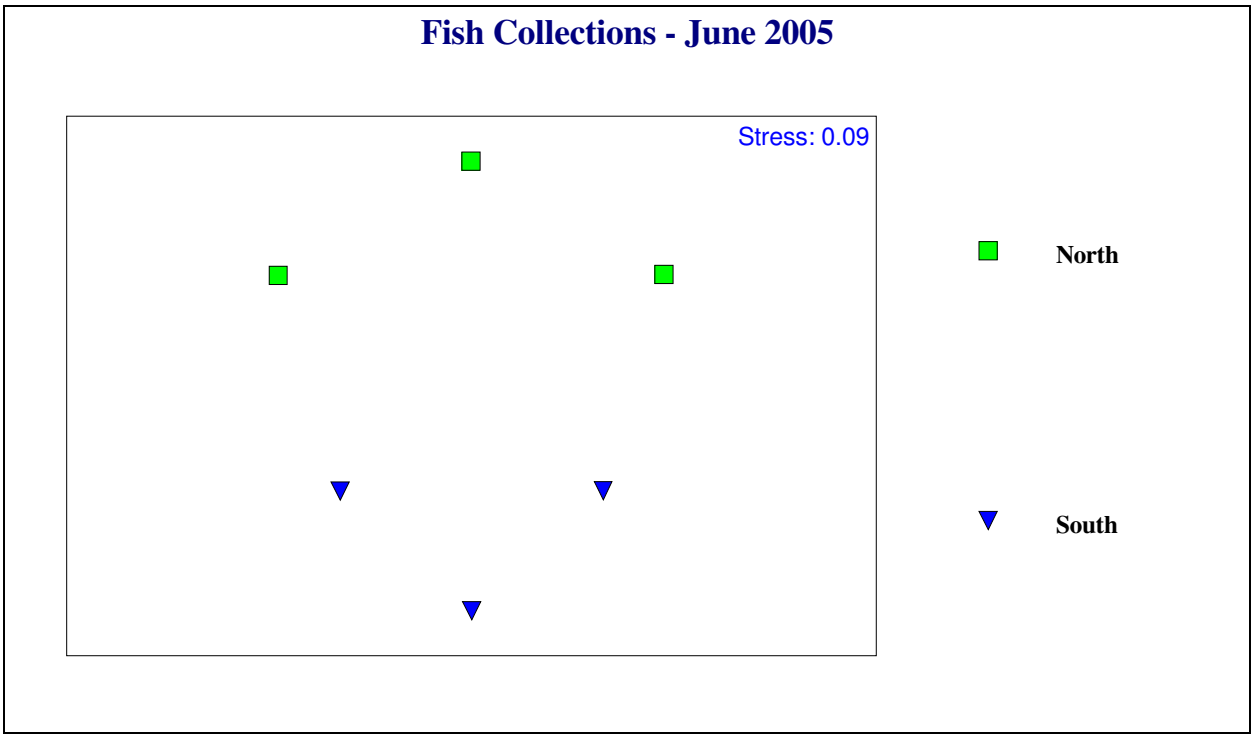

Figure 8-3. MDS plot for June 2005 fish collected with a trawl by location north (Chocolatta Bay) or south of the causeway.

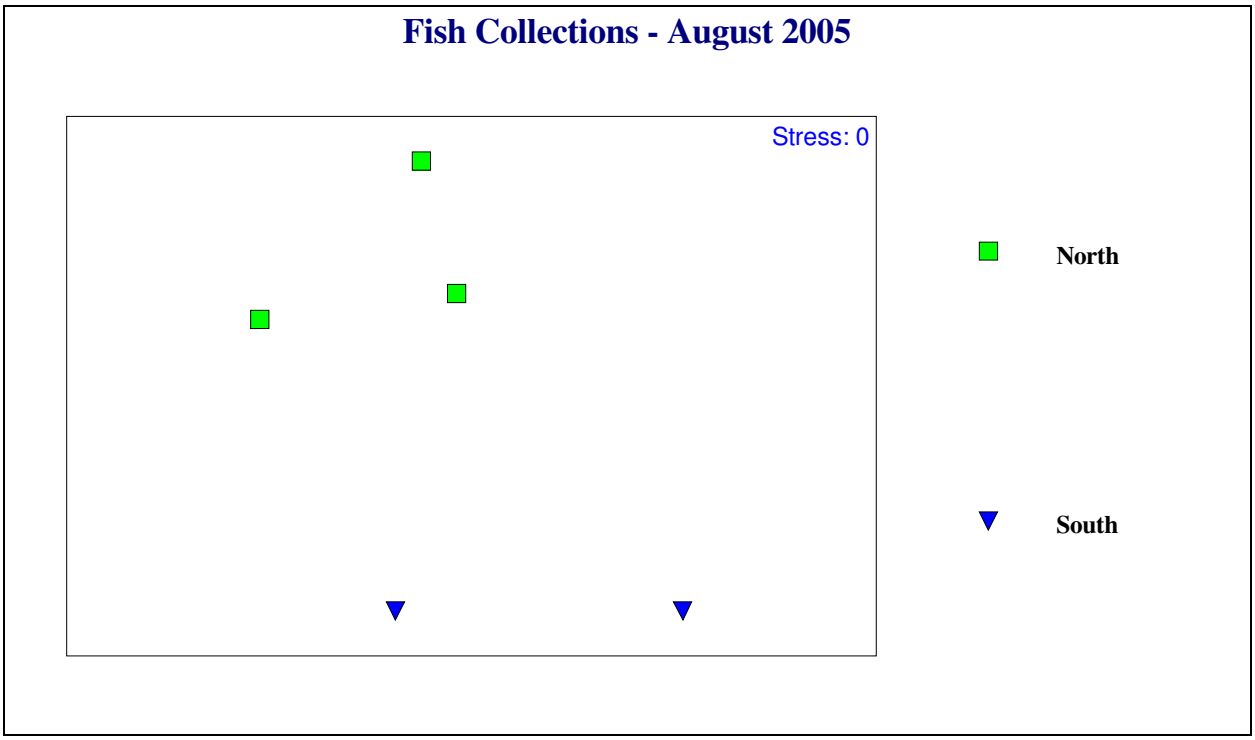

Figure 8-4. MDS plot for August 2005 fish collected with a trawl by location north (Chocolatta Bay) or south of the causeway.

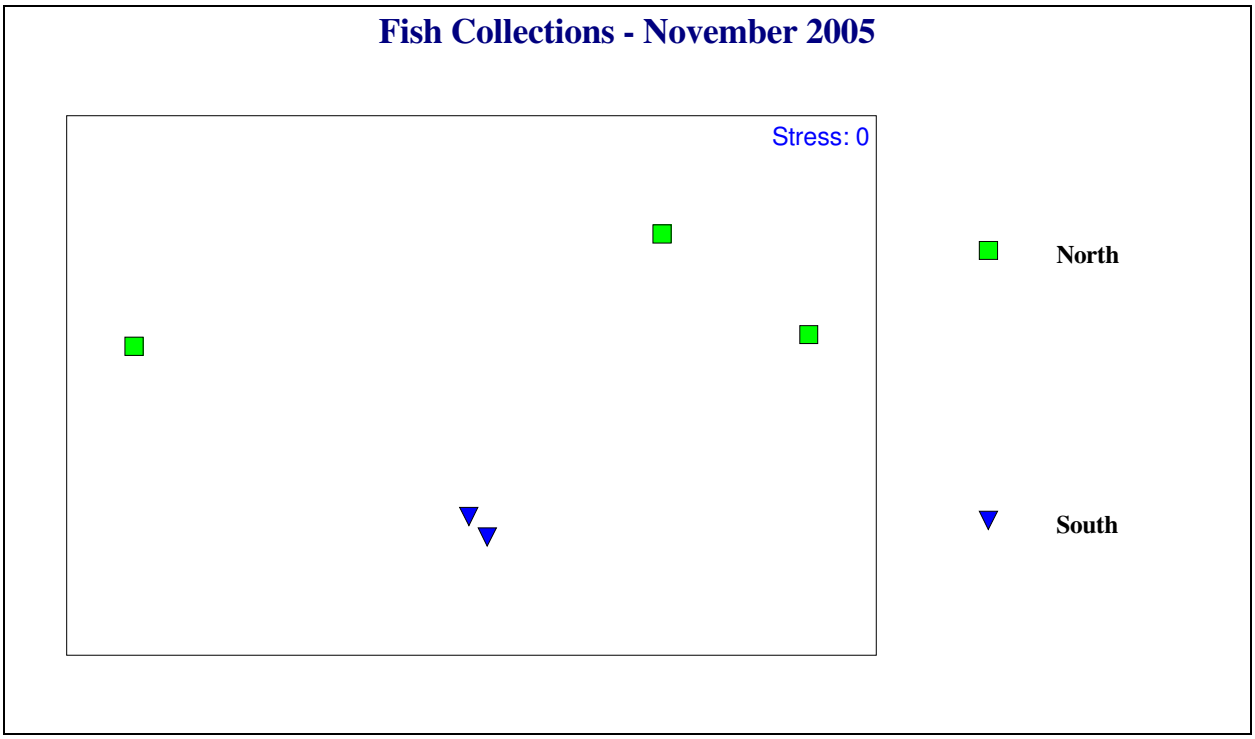

Figure 8-5. MDS plot for November 2005 fish collected with a trawl by location north (Chocolatta Bay) or south of the causeway.

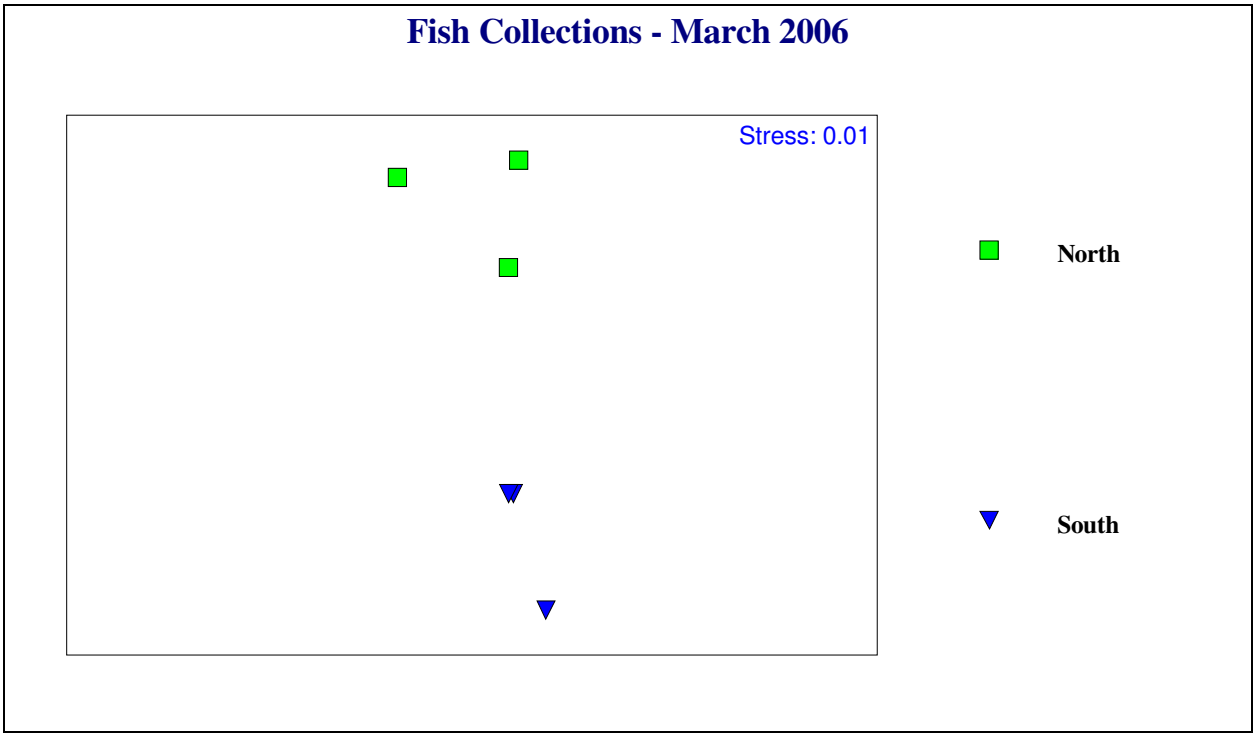

Figure 8-6. MDS plot for March 2006 fish collected with a trawl by location north (Chocolatta Bay) or south of the causeway.