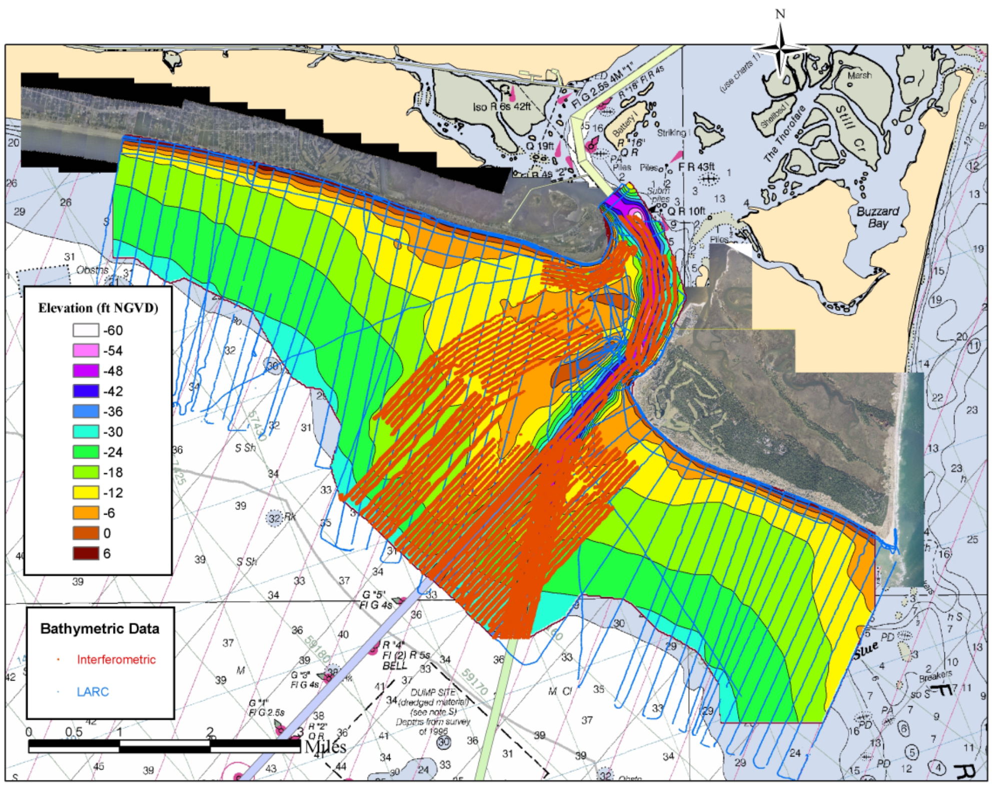
US Army Corps of Engineers®
Wilmington District

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 8:
October 2009 – September 2010

DRAFT



January 2011

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EXECUTIVE SUMMARY

The mouth of the Cape Fear River and Wilmington Harbor entrance channel are located in eastern Brunswick County, near Cape Fear, about 25 miles south of Wilmington, North Carolina. The river mouth, which is approximately one mile in width, is bordered on the east by Bald Head Island and to the west by Oak Island/Caswell Beach. Bald Head Island is a barrier island beach stretching from the river entrance to Cape Fear. The south-facing beach covers about three miles and is commonly referred to as South Beach. Likewise, the approximately 1.5-mile portion of the island that borders along the river is called West Beach. Oak Island/Caswell Beach is part of a barrier island that covers about 13 miles extending from Lockwoods Folly Inlet on the western end to the Cape Fear River on the east. The eastern half of this island, which consists of a portion of Oak Island, Caswell Beach and Fort Caswell, falls within the project monitoring area.

The comprehensive Wilmington Harbor-96 Act Project consists of channel improvements extending from the ocean entrance upstream to just above the Northeast Cape Fear River railroad bridge in Wilmington, some 37 miles. The improvements pertinent to this study consist of deepening the ocean bar channel and entrance channel from the authorized depth of 40 feet to 44 feet, beginning at a point approximately 6.7 miles offshore through the Battery Island Channel located 2.9 miles upstream. Continuing from Battery Island Channel to the Cape Fear Memorial Bridge, 24.3 miles, the authorized channel is deepened from 38 feet to 42 feet.

This physical monitoring program for the Wilmington Harbor navigation channel-deepening project is examining the response of adjacent beaches, entrance channel shoaling patterns, and the ebb tide delta to the channel deepening and realignment for which construction began in December 2000. The present monitoring program involves five elements: beach profile surveys, channel and ebb tide delta surveys, wave and current measurements, aerial photography; and data analysis/reporting.

This report is the eighth in a series and serves to update the monitoring program with data collected October 2009 through September 2010. The initial report published in July 2004 covered the period of August 2000 (pre-construction survey) through June 2003. The second, third, fourth, fifth, sixth, and seventh reports covered the periods of; June 2003 to June 2004, June 2004 to August 2005, September 2005 to September 2006, October 2006 to September 2007, October 2007 to September 2008, and October 2008 to November 2009 respectively.

Beach profile surveys are the primary data source and are collected along both Bald Head Island and Oak Island/Caswell Beach. The beach surveys consist of specified transects, or profiles, taken generally perpendicular to the trend of the shoreline. Bald Head Island profiles include 58 stations along about 22,000 feet of shoreline. Oak Island/Caswell Beach profiles include 62 stations along about 31,000 feet of shoreline. Beach profile surveys are taken semi-annually. Bathymetric portions of these profiles from offshore through the surf zone and over the shoal areas that border each side of the Cape Fear entrance channel, and those near Frying Pan Shoals are typically collected with the US Army

Engineer Research and Development Center's Lighter Amphibious Re-supply Cargo (LARC) survey system. The LARC vehicle transits through the water, across shoals, through the surf zone up to the base of the beach dunes.

Channel and ebb tide delta surveys are collected using a Submetrix Interferometric (SI) System. This system collects swath bathymetry and side scan sonar from a hull-mounted transducer and covers about a 19 square mile area encompassing the channel and outer limits of the extensive ebb tide delta. These surveys are taken at the same time as the LARC survey.

Wave data are collected by three bottom-mounted wave gauges consisting of an Acoustic Doppler Current Profiler (ADCP) meter and a pressure gauge. The gauges are located just offshore of Oak and Bald Head Islands plus in the offshore waters about 11 miles from the coast.

Currents are also measured along specified transects across the mouth of the Cape Fear River and near the new channel realignment using a downward-looking, shipboard-mounted current profiler. Current measurements are collected over a complete tidal cycle and are scheduled at the same time as the ebb tide delta surveys.

Aerial photography of the project area is obtained through the Civil Works Imagery Monitoring Program in conjunction with the National Geospatial-Intelligence Agency (NGA). The NGA has contracted with two satellite imagery providers, DigitalGlobe and GeoEye, to obtain requested imagery from one of five active satellites. Image resolution ranges from 1.4 to 3 foot resolution depending on the satellite tasked. Two images were obtained for use in the current monitoring report including February and August 2010.

Data collected over the present monitoring period of October 2009 through September 2010 have included: two complete beach profile surveys (March 2010 and September 2010), one ebb shoal survey (March 2010), one entrance channel current measurement (Spring 2010), and near continuous wave measurements.

Results to Date

Significant observations through the current monitoring period are summarized below in bulleted format. The paragraphs following the bulleted items provide further explanation of the results to date.

- Shoreline offset along Oak Island/Caswell Beach decreased an average of only 4 feet over the last year and is on the average 135 feet more seaward than it was at the start of the project 10 years ago.

- There have been two disposal operations along Oak Island/Caswell Beach which placed 1,181,800 cubic yards with the initial construction and 1,064,400 with the May 2009 disposal operation and the majority of this material remains in place. A combination of this material with diffused material from the nearby Sea Turtle Habitat project leaves the beach with 2,035,000 cubic yards more than the August 2000 pre-construction condition.

- Comparing long-term shoreline change rates with those of the 10-year monitoring period show Oak Island presently experiencing high rates of accretion (+15.8 ft/yr average for the entire monitoring area) versus historic minor erosion (-1.1 ft/yr average for the entire monitoring area) due largely to the disposal of sediment from the project.
- Bald Head Island experienced overall shoreline gains over the last year with the beach nourishment activity undertaken by the Village of Bald Head Island. This project placed approximately 1,594,500 cubic yards of material along portions of West Beach and the western end of South Beach. Material from the project was dredged from an area within Jay Bird shoal measuring approximately 153 acres.
- When comparisons are made over the 10-year monitoring period accretion is most prevalent along Bald Head Island; however, an area of chronic shoreline recession remains present along a 2,050 foot section in the south-western corner of the island which is slightly smaller than the 3,400 foot section reported in the previous Monitoring Report.
- Overall, Bald Head Island has more material on the beach than the pre-construction condition in August 2000 (+1,231,000 cubic yards); however, the western end of the island has lost 318,000 cubic yards between Profiles 53 and 61. This is an area of chronic erosion that has been noted in previous reports.
- Comparing long-term shoreline change rates with those of the 10-year monitoring period show Bald Head Island is presently experiencing less erosion overall. However, the post-construction rates are higher along the western end of South Beach.
- Village of Bald Head reconstructed a geo-textile groin field following the placement of their beach nourishment between November 2009 and March 2010. The groin field was completed in May 2010 with only minor modifications to the groin field layout. Initial comparisons with the groin field constructed in 2005 indicate this groin field is performing similarly through the first 5-6 month period in retaining the beach width for this area.
- Village of Bald Head and the Wilmington District have entered in a legal settlement agreement which requires bi-monthly channel surveys to monitor the minimum navigable width along the channel reaches of Smith Island, Bald Head Shoal Reach 1 and Bald Head Shoal Reach 2. Results indicate that the channel width did not fall below the 500 foot threshold limit throughout the current monitoring period.
- All widths within the navigation channel were greater than 500 feet as of August 2010, with the minimum width within the channel being 512 feet.
- Rate of spit growth into Baldhead Shoal Channel decreased following the 2005 dredging versus the 2001-02 dredging and reduced even further following the 2007 dredging. For the period following the February-April 2009 dredging event the progression of the groin field failure, which began as early as November 2008,

combined with the recent placement of beach nourishment by the Village of Bald Head Island in proximity to the navigation channel escalated shoaling into the channel. The rate of shoaling was comparable to that recorded following the initial placement of sediment in 2001-02 during which no functioning groins were present.

- Overall change in ebb and nearshore bathymetry included the dredge cut for the beach nourishment project by the Village of Bald Head Island which removed up to 14 feet of material within a 153 acre area of Jay Bird Shoals, growth of the western portions of Bald Head Shoal, and indisposaling of the old channel bed.
- Current measurements were obtained in 2010, however the data for these measurements is not currently available and this section of the report will be updated when the data becomes available.
- The initial 3-event cycle of the sand management plan has been completed, as well as monitoring of disposal performance following the most recent disposal along Oak Island/Caswell Beach in 2009. An assessment report entitled "Reevaluation Report Sand Management Plan Wilmington Harbor Navigation Project" has been written with potential modifications to the sand management plan and should be released in early 2011.

Discussion of Results

Beach profile surveys were compared for the beaches on either side of the entrance channel. In each case comparisons were made from the current surveys to the last survey as reported in Report 7 (May 2009) and with respect to the initial pre-project condition established with the survey of August/September 2000. Comparisons were analyzed to determine the overall condition of the beach with respect to both changes in shoreline and profile volumes. Shoreline and volumetric changes were computed over the current period (from October 2009 to September 2010) and for the entire period (from August/September 2000 to September 2010).

For Oak Island/Caswell Beach, the shoreline change measured over the last year continues to be greatly influenced by the disposal activity between February and April 2009. The two zones along Oak Island where material was placed in 2009 between Profiles 60 and 95 (123,400 cubic yards) and Profiles 120 and 260 (941,000 cubic yards), have shown significant erosion relative to the May 2009 post-placement survey. The losses of shoreline within these disposal areas are accompanied by increases in shoreline position on the western end of the monitoring area and between the two disposal areas. This is most likely a result of the longshore sediment transport processes that occur just after a disposal is placed as the beach section adjusts to the perturbations. Overall the shoreline eroded 4.4 feet over the current monitoring period relative to May 2009. When considering the shoreline changes along Oak Island with respect to the pre-construction position in August 2000, the beach width has increased an average of 135 feet. In fact, with the exception of two zones on the eastern tip of the island (Profiles 5 through 20 and 35 through 50) all other profile lines have shown gains of 50 feet or more.

In terms of volume change, Oak Island/Caswell Beach has eroded over the vast majority of profiles (28 of 33) covering the island with the exception of two areas between Profiles 15 through 30 and Profiles 90 through 100. When considering all profile lines, a net loss of 377,000 cubic yards was computed since the last report, between May 2009 and September 2010. This amount of volumetric loss is within the range of losses observed over prior monitoring periods and closely resembles the trend observed along the island prior to the most recent beach disposal in 2009. The overall volume response has been positive when considering the measurements over the entire 10-year monitoring period. As such, all reported volume changes are positive with the exception of five profiles on the eastern tip of the island which show small losses. All other areas are very healthy with respect to volumetric gains relating back to August 2000 base condition. Specifically, by the end of the period, an excess of 2,035,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity actually reflects a modest net gain above the sum of the disposal volumes placed in 2001 and 2009 of about 172,000 cubic yards. This surplus above the placed quantity is believed to be the result of the eastward spreading of a separate beach disposal (Sea Turtle Habitat Project in 2001) placed just beyond the boundary of the project area. The alongshore distribution of material basically follows the shoreline response where net gains are seen along most of the island.

Since the last reporting, most of the profile locations along Bald Head Island have been accretional. The primary reason for this seaward shift of the shoreline since the last report is the beach disposal placed along the island between November 1, 2009 and March 9, 2010. This disposal placement, which was accomplished by the Village of Bald Head Island, placed 1,594,553 cubic yards of material along two sections of Bald Head Island. These sections included West Beach (Sta. 12+00 to 28+00) and South Beach (Sta. 39+60 to 162+00). The profile locations found to be eroding occurred along a short section of West Beach (Profiles 0 through 8), at a single location in the Spit area (Profile 36) , and along the eastern end of South Beach (Profiles 218 to 222). The largest increases in shore width were measured within the Spit and western portions of South Beach, between Profiles 40 and 97 and along the eastern end of South Beach between Profiles 110 and 182. These areas closely correspond to the locations of the recent beach disposal placement area. Specifically, the peak seaward increase measured at the end of the period was 138 feet (Profile 57) and the average increase for the entire South Beach region since May 2009 was 63 feet. The area covering Profiles 32 through 45 which defines the spit had an average increase of 7 feet over the current period, while the area along West Beach (Profiles 0 thru 28) gained an average of 19 feet. The average seaward movement of the shoreline position for the entire monitoring area since Monitoring Report 7 is a gain of 36 feet.

Shoreline change patterns as measured over the last 10-year period, i.e., since the monitoring was initiated, are generally positive when measuring relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional. For this area, the September 2010 shoreline is an average of nearly 159 feet more seaward of its September 2000 position. In contrast, the western portion of South Beach and a portion of the Spit area continue to be highly erosional as documented in prior reports. As of September 2010, the shoreline was found to be landward of the base position between Profiles 40 and 61, an area nearly 1,200 feet smaller than the erosive area reported in Monitoring Report 7. The average shoreline loss over this 2,100 foot reach was 144 feet, with a peak recession of 315 feet occurring at Profile 43. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline has shown an average loss of about 6 feet when compared to the base condition. When considering all location along Bald Head Island (Profiles 0 to Profile 218), the shoreline is presently on the average 89 feet more seaward than it was in 2000. While measuring against the base survey in September 2000 is useful in gauging changes for comparison between the pre-and post-project conditions, , it is somewhat limited in that it compares of only two specific points in time. The September 2000 shoreline position reflects a static condition along a generally highly variable shoreline that has been influenced by several beach nourishment projects along the island in 1991, 1996, and 1997 as well as groin construction activity. These actions can artificially influence the pre-project shoreline position and may skew the measured observations.

In terms of volumetric change from the last survey (May 2009) of Report 7 to the present, Bald Head Island is dominated by increases throughout the majority of the monitoring area as a result of the beach disposal placed in 2009/2010. Profiles 0 through 186 experienced volumetric increases while Profiles 194 through 210 lost material when compared to the May 2009 condition survey. In summing the changes over the entire monitoring area, the increases total to approximately 1,113,000 cubic yards of material. The zones along the Spit and South Beach which received beach disposal during the recent local project (Sta. 39+60 to 162+00) were found to have gained nearly 963,000 cubic yards of sand. The disposal zone along West Beach (Sta. 12+00 through 28+00) gained nearly 76,000 cubic yards.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, the majority of Bald Head Island has gained material over the last 10 years. The most substantial decreases are noted along the western and eastern ends of South Beach. These areas (Profiles 53 to 57 and Profiles 202 to 210) have lost approximately 318,000 and 392,000 cubic yards of material since August 2000, respectively, with minor losses noted at Profile 106 near the center of South Beach. The area between Profiles 53 and 57 was noted in the previous two monitoring reports as being an area of chronic erosion. As a result of the disposal placed along Bald Head Island since the previous monitoring report, the extent of this chronic erosion area has greatly reduced from the 6,100 feet noted in Monitoring Report 7 to approximately 800 feet. This is the shortest extent for this erosion zone since the measurements taken in October 2001. Summarizing the changes over the entire island show the net volume change is a significant gain of 1,231,000 cubic yards as of September 2010 with respect to the beginning of the monitoring in 2000.

Rates of shoreline change were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the North Carolina Division of Coastal Management (NCDCM) shoreline data based on a 62-year period of record (1938-2000). Although a direct comparison is not possible given the difference in the 10-years of monitoring data versus the 60-plus years of the historic data base, they are useful in observing overall trends in the rate of shoreline response.

Shoreline change rates computed over the initial 10-year period show that for Oak Island/Caswell Beach substantial accretion is present over most of the island largely reflecting the influence of the 2001 and 2009 beach disposals. Although these positive rates have been found to moderate since the placement, they remain in sharp contrast to the long-term trend. Overall, the shoreline change rate averaged over the entire monitoring area is computed to be +15.6 feet per year. By comparison the long-term NCDCM rate over the entire reach is -1.1 feet per year.

For Bald Head Island, the comparison of the long-term rates with the rates computed since 2000 show that most of the island is eroding less over the initial 10-year monitoring period. However, notwithstanding this overall positive response, the post-construction erosion rates continue to be greater along the western corner of South Beach. A direct comparison of the pre- and post-construction shoreline change rates show that only three profile lines are eroding at a higher rate during the post-construction period. These lines are located at the western end of South Beach (Profiles 53, 57 and 61). While these three lines were reported previously as exceeding the pre-construction shoreline change rate, the recent disposal placed by the Village of Bald Head Island has positively influenced the area and reduced the erosion rates in this area. Adjacent Profile 66 is also slightly erosional, but at a lower rate when compared to the pre-construction condition. All other lines are accreting in direct contrast to the long-term erosion experienced along the remaining areas of South Beach. Most of this response is attributable to the multiple disposals of navigation dredging material along the island over the past 10 years and to the beach disposal recently placed by the Village of Bald Head Island.

In March 2005, the Village of Bald Head and the Wilmington District entered into an agreement to conduct bi-monthly navigation channel surveys within the channel locations along the island. These surveys are intended to document the channel shoaling and to record the navigable channel width throughout the area. The threshold deemed to be a minimum acceptable channel width is 500 feet at the -42 feet mean low water (MLW) elevation. As of August 2010, 31 condition surveys have been accomplished. Four of these occurred over the current reporting period (February 2010, April 2010, June 2010, and August 2010). There are now seven post-dredging settlement survey following the Feb-April 2009 channel dredging operation. The 2009 dredging event increased the navigable width measured at -42' MLW so that every station within the navigation channel exceeds the minimum required navigable width of 500 feet. Widths within the channel as of August 2010 ranged from a minimum of 512 feet at station 20+00 to a maximum of 974 feet at station 5+00, with no violations of the minimum width criteria. The width at station 23+00, which has historically been a location of increased shoaling, had a navigable width of 540 feet as of August 2010.

The navigation channel surveys have also been used to analyze the rate of shoaling along Reach 1 in the immediate vicinity of the Bald Head spit. Following the initial placement in 2001-02 (1.8 million cubic yards), the area of the spit was found to have enlarged volumetrically to at least twice as large as observed during the five years prior to the initial placement. The same area of growth was monitored following the two subsequent dredging events (i.e. 2004-05 (1.2 million cubic yards and 2007 (1.0 million cubic yards).

The comparison showed that the rate of growth was slower following both the second event and third events. Specifically, the initial rate was about 16,500 cubic yards per month. An analysis of all surveys for the second dredging event, January 2005 through March 2007, showed that the shoaling had slowed to about 9,900 cubic yards per month, i.e., a 40 % reduction in the shoaling rate. Analysis for the third monitoring period, April 2007 through February 2009, showed a comparable rate to the prior period at 8,950 cubic yards per month. This is a 46% reduction in the shoaling rate versus the initial dredging operation and a 10% reduction when compared to the second dredge cycle. Calculation of the shoaling rate following the most recent dredging event in February-April 2009 revealed that the infilling rate has increased to 17,300 cubic yards per month. This represents a 94% increase over the computed rate from the previous dredge cycle but is about the same as the rate following the initial dredging event being only 5% greater. The increase in shoaling rates within the channel since the most recent dredging activity is most likely associated with the failure of the Bald Head Island groin field and the subsequent loss of material that had been retained within the field. In addition, the disposal material recently placed along Bald Head Island by the Village of Bald Head Island introduced significant quantities of sand into the system in areas in proximity to the navigation channel. Material lost from these areas over the current monitoring period was most likely transported into the adjacent navigation channel, leading to the increased shoaling rates.

In prior reports the effectiveness of the reconstructed groins was analyzed by comparing the response of the 2001 beach disposal (without the groins) to the 2007 beach disposal (with the groins). The analysis revealed that the reconstructed groin field had an apparent positive effect in retaining the beach, particularly within the upper portions of the beach profile. This is reflected in the positive response with respect to shoreline change and changes in the onshore volumes. Changes of this nature would be expected given the cross-shore extent of the groins having a length of about 300 feet, and with the shoreward end of the groins terminating at elevations of about -2 feet or above. For the present report, this analysis was updated to include a similar comparison with the fourth beach disposal (by the Village of Bald Head Island) and subsequent reconstruction of the groin field in early 2010. Given that the data following the construction of this new groin field is limited to two data points, with one of these serving as the base condition, analysis of the data set was limited to only one survey date. These comparisons were made over similar 5 to 6 month periods following each respective event. Due to the time limitations of this comparison it is difficult to determine any significant pattern and draw any useful conclusions at this time.

Detailed bathymetric surveys were made of the ebb and nearshore shoals in the vicinity of the entrance channel to assess any changes associated with the entrance channel deepening and realignment. Aside from the direct changes resulting from dredging the new channel, the major overall changes in morphology of the ebb and nearshore shoals since the start of the monitoring have included changes along Jay Bird Shoals, Bald Head Shoals, and within the vicinity of the old channel bed. The changes within Jay Bird Shoals have been somewhat complex with some portions shoaling and some portions scouring. Generally, the outer portions have shown a generalized lowering but a moderate amount of shoaling has occurred within the northernmost area of Jay Bird Shoals just off the tip of Oak Island. A significant change that is evident within the most recent survey of the ebb shoal complex is noted in the outer portions of Jay Bird Shoals where material was dredged as a sand source for the recent disposal placed by the Village of Bald Head Island. The dredging activity within Jay Bird shoals covered an area of approximately 153 acres and lowered elevations within this area by as much as 14 feet. Adjacent to the northernmost section of Jay Bird Shoal is a scour feature associated with a flood channel just offshore of Oak Island which is relatively stable, with only minor changes in depth occurring over the recent monitoring period. On the other side of the channel, Bald Head Shoal has shown significant gains extending off of the southwestern corner of Bald Head Island since the start of the project. Additionally, the old channel bed has also accreted since the beginning of the monitoring period, as this area is used as a disposal site for other dredging operations in the river. In general, the offshore area, with the exception of the old and new channels, has remained relatively stable over the entire monitoring period.

To date currents have been measured on ten occasions, with the initial occurring before the channel improvements and the remaining nine after the deepening. At the release of this draft document, the most recent current measurement report data is unavailable for update. The current measurement section of this report contains the results from Monitoring Report 7 and will be updated as soon as data become available.

Sand Management Considerations.

Operation of the project involves the implementation of a Sand Management Plan. The plan assumes dredging of the Cape Fear River entrance channel every two years, with disposal to occur in a 2 to 1 ratio with two-thirds of the material going to Bald Head Island and the remaining one-third to Oak Island/Caswell Beach. This sediment ratio is accomplished by having the first two maintenance cycles (e.g. years 2 and 4) place sediment on Bald Head with the last cycle going to Oak Island/Caswell. Thus a complete operation and maintenance cycle will take 6-years to accomplish.

The first maintenance dredging was accomplished between November 2004 and January 2005. In accordance with the sand management plan, the beach compatible material dredged during the first cycle was placed along Bald Head Island. The Corps of Engineers and the Village of Bald Head worked jointly to develop this disposal plan. Approximately 1,217,500 cubic yards of beach quality sediment were placed along the most critically eroding portions of South Beach. This work was coupled with the replacement of geo-textile groins by the Village of Bald Head under a private permit action, with the intent of reducing the erosion of the in-place disposal. The groin reconstruction took place over the period of March-May 2005. The second maintenance cycle occurred February-April 2007 and involved disposal of material along Bald Head Island as scheduled. This operation amounted to an additional 978,500 cubic yards placed along South Beach. The most recent maintenance dredging involved placement of beach compatible sediments along Oak Island/Caswell Beach. During this work, the third maintenance cycle, approximately 1,064,400 cubic yards were placed between February and April 2009. With the completion of this maintenance dredging, the first overall 2 to 1 sand management cycle has been accomplished (e.g. through a 6-year cycle).

In accordance with the sand management plan, an assessment has been made following the completion of the first full cycle regarding the effectiveness of the current sand distribution scheme to determine if changes could be made to improve the disposal plan. This assessment is being published as a separate document entitled “Reevaluation Report Sand Management Plan Wilmington Harbor Navigation Project” and is scheduled for release in early 2011.

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 8

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PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT

REPORT 8

Part 1 INTRODUCTION

Purpose

Wilmington Harbor navigation project covers over 37 miles of channel improvements extending from the mouth of the Cape Fear River to Wilmington, N.C. and the Northeast Cape Fear River. Improvements consist of a general deepening of the river by 4-ft from the mouth to the North Carolina State Port facilities, numerous improvements to turns and bends in the channel, a passing lane and implementation of environmental mitigation features. This document is the eighth in a series of monitoring reports that focuses on the navigation improvements in the immediate vicinity of the Cape Fear ocean entrance channel and covers the period of August 2009 through September 2010. Monitoring Reports 1, 2, 3, 4, 5, 6 and 7 were published in August 2004, February 2005, May 2006, May 2007, April 2008, June 2009, and August 2010 respectively, and covered the first nine years of monitoring (USACE 2004, USACE 2005, USACE 2006, USACE 2007, USACE 2008, USACE 2009, and USACE 2010). The monitoring program is designed to meet two main objectives: (1) to document the response of the adjacent beaches to the deepening and alignment changes of the entrance channel and (2) to use the results of the program to effectively implement the project's sand management plan.

Project Description

Location. The mouth of the Cape Fear River and Wilmington Harbor entrance channel are located in eastern Brunswick County, near Cape Fear, about 25 miles south of Wilmington. Cape Fear is the southernmost of three large capes that predominate the North Carolina coastal plan-form. Frying Pan Shoals extend southeastward from the cape some 20 miles into the Atlantic Ocean. The river mouth, which is approximately one mile in width, is bordered on the east by Bald Head Island and to the west by Oak Island/Caswell Beach as shown in Figure 1.1. Bald Head Island is a barrier beach stretching from the river entrance to Cape Fear. The south-facing beach covers about three miles and is commonly referred to as South Beach. Likewise, the approximately 1.5-mile portion of the island that borders along the river is called West Beach and the reach extending northward from the point at Cape Fear, facing east toward the Atlantic Ocean, is termed East Beach. Oak Island/Caswell Beach is part of a barrier island that covers about 13 miles extending from Lockwoods Folly Inlet on the western end to the Cape Fear River on the east. The eastern half of this island which consists of a portion of Oak Island, Caswell Beach and Fort Caswell, falls within the project monitoring area.

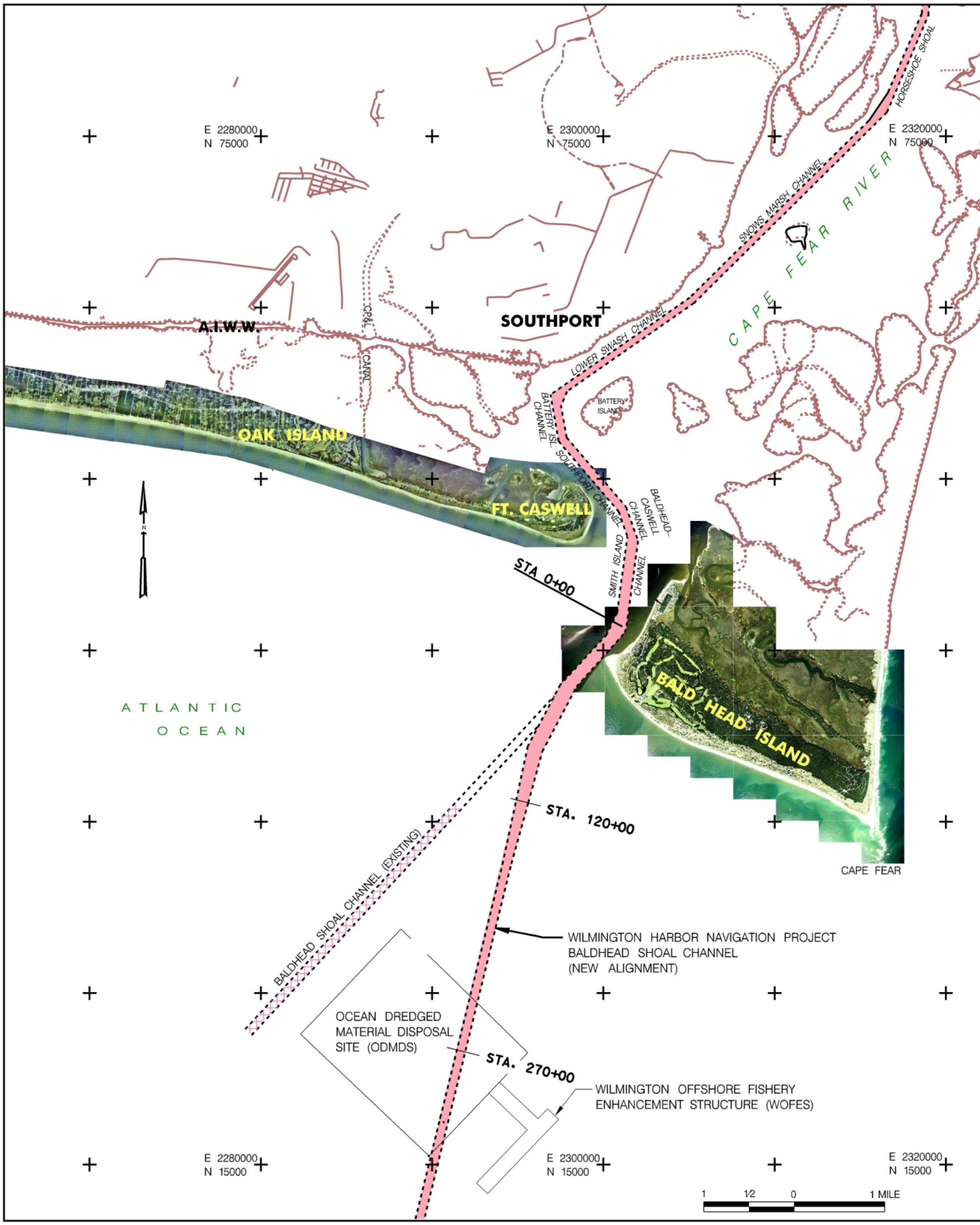


Figure 1.1 Project Location Map

Federal Channel Realignment and Deepening. With the signing of the Energy and Water Appropriations Bill on October 13, 1998 three separate projects (Wilmington Harbor – Northeast Cape Fear River project, Wilmington Harbor – Channel Widening Project, and Cape Fear – Northeast Cape Fear rivers project) were combined into one known as the Wilmington Harbor, NC – 96 Act project. This comprehensive project, with a total estimated cost of $440 million, consists of channel improvements extending from the ocean entrance upstream to just above the Northeast Cape Fear River railroad bridge in Wilmington, some 37 miles. The improvements consist of deepening the ocean bar channel and entrance channel from the authorized depth of 40 feet to 44 feet, beginning at a point approximately 6.7 miles offshore through the Battery Island Channel located 2.9 miles upstream. Continuing from Battery Island Channel to the Cape Fear Memorial Bridge, 24.3 miles, the authorized channel is deepened from 38 feet to 42 feet.

This stretch includes a new passing lane and numerous turn and bend improvements, plus channel widening and enlargement of the anchorage basin at the state port facility. The final 2.2 mile stretch of the river spanning along the Wilmington waterfront and beyond, includes deepening the channel from 32 feet to 38 feet to just above the Hilton Railroad Bridge and from 25 feet to 34 feet to the upstream limits of the project.

The entrance channel improvements, which are most relevant to the monitoring effort, are shown on Figure 1.2. In addition to the 4-foot deepening, the channel was realigned from a southwesterly orientation to a more south-southwest orientation. This 30-degree southern shift in alignment of the Baldhead Shoal Channel was recommended based on achieving significant cost savings (approximately $39 million) by avoiding the removal of rock that existed along the former alignment. The new channel also was widened from 500-feet to as much as 900-feet to accommodate safe ship navigation in the vicinity of the intersection of the old and new alignments.

Construction Activity. The realignment and deepening of the entrance channels were accomplished under two dredging contracts. One contract involved dredging of the seaward most portion of the Baldhead Shoal channel covering the outer 4.5 miles of the new alignment (station 120+00 seaward). Material dredged from this portion of the new channel consisted of fine silts and sands that were deemed unsuitable for beach disposal. This material was placed in the designated offshore disposal site. Work began in December 2000 and was completed in April 2001 by Great Lakes Dredge and Dock at a cost of $13.6 million.

The second contract covered the remaining portions of the entrance channels beginning at the inner section of the Baldhead Shoal Channel through the Snows Marsh reach, a distance of about 9.5 miles. Most of the material dredged from this portion of the river was suitable for beach disposal and was placed on the Brunswick County Beaches. This contract was undertaken by Bean-Stuyvesant for a cost of $64.7 million. Beach disposal began in February 2001 and was completed in April 2002, with the dredging of portions of the channel containing non-compatible beach material continuing until December 2002. Beaches receiving the compatible sand included Bald Head Island, Caswell Beach/eastern Oak Island, western Oak Island and Holden Beach. The Baldhead Island and Caswell

Beach/East Oak Island portions were determined to be least costly beach disposal alternatives and material was placed at 100% Federal expense. The other beach placement activities where accomplished under Section 933 authority of the Water Resources Development Act of 1986 where the local government covered the added cost of pumping material to their respective beaches.

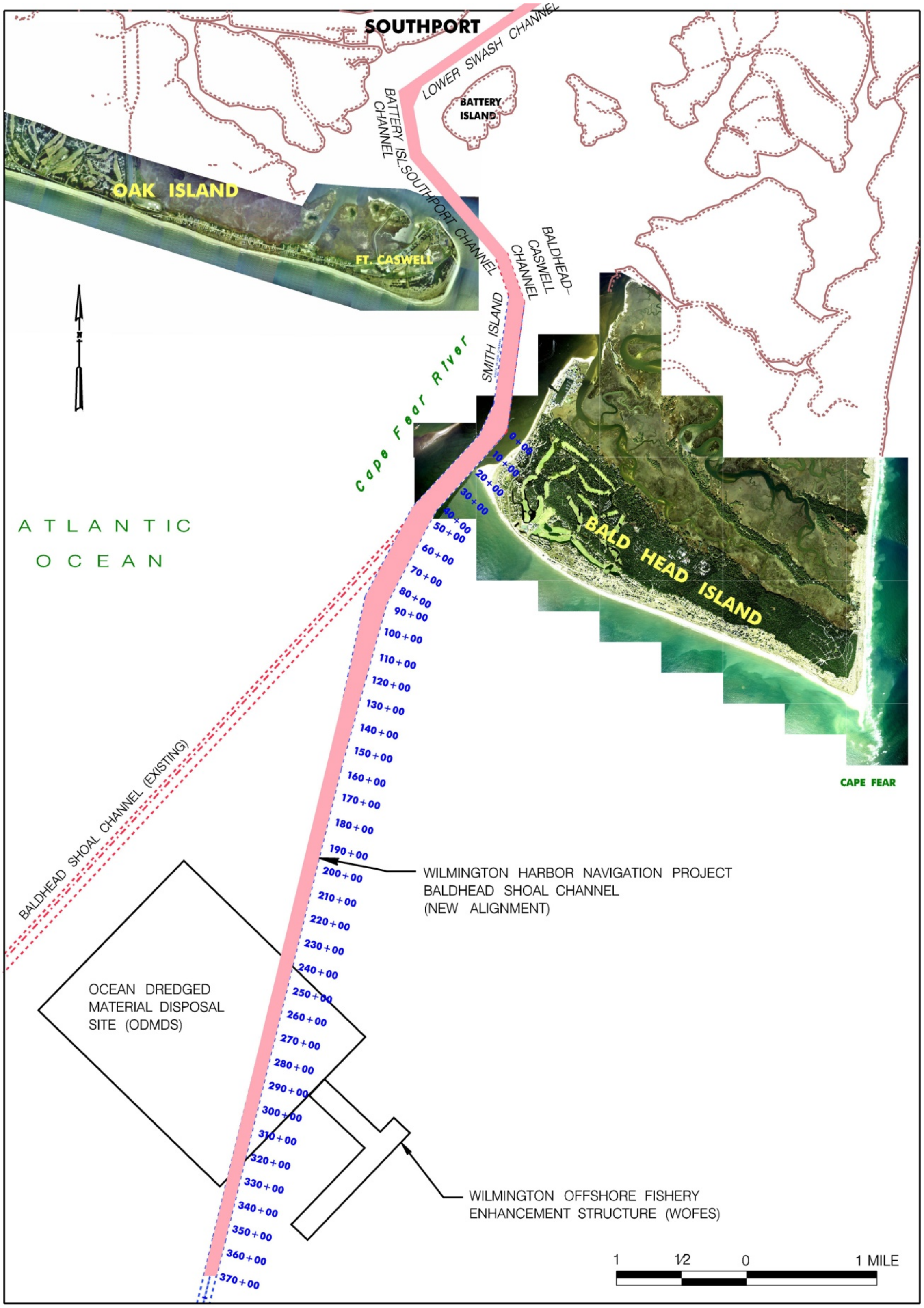


Figure 1.2 Realignment of the Federal Navigation Channel at the Cape Fear River Entrance

Overall, on the order of 5 million cubic yards of sediment (in-place beach volume measurement) were placed on the Brunswick County beaches under this contract for the initial deepening. Table 1.1 summarizes the distribution of volume of material between the beach communities along with placement dates and various other pertinent factors.

TABLE 1.1 WILMINGTON HARBOR BEACH DISPOSAL OPERATIONS

(INITIAL CONSTRUCTION)

LOCATION	APPROX BL STA	PLACEMENT LIMITS NORTHING (ft, NAD83)	EASTING (ft, NAD83)	PLACEMENT DATES START mm/dd/yyyy	STOP mm/dd/yyyy	BEACH VOLUME (INPLACE) (cy)	DREDGE
BALD HEAD ISLAND	41+60	43,692.25	2,300,542.01	2/23/2001		1,849,000	*Stuyvesant & Merridian*
	205+50	35,750.21	2,314,236.42		7/4/2001		
OAK ISLAND EAST (CASWELL)	60+00	52,126.62	2,295,138.57	7/5/2001		133,200	*Merridian*
	80+00	52,847.44	2,292,954.85				
OAK ISLAND EAST	121+00	53,711.05	2,289,255.43			1,048,600	*Merridian*
	294+00	58,418.34	2,272,322.77		8/12/2001		
OAK ISLAND WEST	415+00	60,332.24	2,260,537.66	8/13/2001		1,269,800	*Merridian*
	665+50	59,778.68	2,235,486.44		4/25/2002		*Eagle*
HOLDEN BEACH	84+00	60,092.96	2,222,254.95	12/9/2001		501,400	*Eagle*
	195+00	58,820.26	2,211,433.72		2/20/2002		
(FIRST MAINTENANCE CYCLE)							
BALD HEAD ISLAND	46+00	43,836.00	2,300,813.68	11/12/2004		1,217,500	*Illinois*
	130+00	39,051.42	2,307,196.47		1/25/2005		
(SECOND MAINTENANCE CYCLE)							
BALD HEAD ISLAND	44+00	42,243.24	2,301,716.03	2/28/2007		398,500	*Illinois*
	91+00	40,550.81	2,303,601.67				
	110+00	39,771.16	2,305,333.49			580,000	*Illinois*
	170+00	37,552.01	2,310,903.49		4/30/2007		
(THIRD MAINTENANCE CYCLE)							
CASWELL BEACH/OAK ISLAND	60+00	52,733.39	2,295,144.60	2/8/2009		123,400	*Illinois*
	95+00	53,605.88	2,291,753.90				
	120+00	54,349.03	2,289,368.51			941,000	*Illinois*
	260+00	58,047.07	2,275,885.90		4/24/2009		

Maintenance Dredging. Subsequent to the initial construction, plans were made to implement two dredging operations to remove localized “high-spots” remaining within the authorized channel limits. These two dredging contracts involved removal of unsuitable beach material along the outer channel termed “Clean Sweep I” and the removal of beach compatible material along the inner channel reaches termed “Clean Sweep II”. Clean Sweep I contract was awarded in September 2003 and was completed in January 2004. The beach disposal operation of Clean Sweep II was completed in 2005. With the timing of Clean Sweep II coming approximately two years after completion of the initial construction, this operation is considered as the first maintenance dredging of the new channel. In accordance with the sand management plan described below, the beach compatible sediments dredged during the first two cycles are designated for disposal along Bald Head Island with the third cycle going to Caswell Beach/Oak Island. As such, approximately 1,217,500 cubic yards of beach quality sediment were placed along Bald Head Island between November 2004 and

January 2005 as indicated above in Table 1.1. This was followed two years later by the second maintenance cycle, with an additional 978,500 cubic yards placed along Bald Head Island, over the period of February-April 2007. The most recent maintenance dredging involved placement of beach compatible sediments along Oak Island/Caswell Beach. During this work, the third maintenance cycle, approximately 1,064,400 cubic yards were placed between February and April 2009

Sand Management Plan. A sand management plan developed for the Wilmington Harbor 96 Act project (USACE 2000) addressed the disposal of beach quality sand during both the construction and maintenance phases of the project. Maintenance of the project following initial construction included the disposal of littoral material removed from the ocean entrance channel on the beaches adjacent to the Cape Fear River Entrance. The goal of the sand management plan was to make the best use of littoral sediments during maintenance of the project and return beach compatible material back to the adjacent beaches. This is in keeping with the state of North Carolina policy to insure that beach quality sand is not removed from the active beach system.

The results of wave transformation/sediment transport analysis conducted by the U.S. Army Corps of Engineers Coastal and Hydraulics Lab (Thompson, Lin, & Jones 1999) for the Wilmington District found that the distribution of sediment transport at the Cape Fear entrance was such that two-thirds of the material comes from Bald Head Island and one-third is derived from Oak Island/Caswell Beach. In order to maintain the sediment balance on both islands, littoral material removed from the entrance channel has been placed back on the beach from whence it came in the same distribution. Accordingly, two out of every three cubic yards of littoral shoal material removed from the entrance channel were placed back on Bald Head Island and the remaining cubic yards were placed on east Oak Island/Caswell Beach. Maintenance of the channel takes place biennially. In order to accomplish this two-to-one distribution, the littoral shoal material removed from the entrance channel for maintenance was placed on Bald Head Island in years 2 and 4 following the construction of the new ocean entrance channel and on Caswell Beach-Oak Island during year 6. Accordingly, one full maintenance cycle took 6 years to complete.

Each maintenance operation within the first full maintenance cycle involved the removal and disposal of approximately 1,000,000 cubic yards of beach material. The disposal locations on each island were based on the measured beach response during the operation of the project as determined by the monitoring program. The overall disposal lengths included 16,000 feet on Bald Head Island and 25,000 feet along Oak Island/Caswell Beach. The 16,000-foot reach on Bald Head Island included approximately 14,000 feet of South Beach and 2,000 feet of West Beach. The disposal boundary on Oak Island/Caswell Beach, nearest to the Cape Fear River entrance, falls along the eastern town limits of Caswell Beach (located approximately 2,500 feet west of the river entrance) and extends westward along Oak Island. Actual disposal locations fell within the above limits and are summarized in Table 1.1.

The disposal operation along Oak Island / Caswell Beach during the February-April 2009 dredging event concluded the initial 6-year maintenance cycle following the initial harbor deepening. Evolution of the disposal material along both Oak and Bald Head Island has continued to be monitored throughout 2010. These data have been used to evaluate the efficacy of the current sand management plan and were used in conjunction with the entire monitoring data set to establish a long term sand management plan that maximizes beneficial use of the dredged materials. This plan is scheduled for release in the early spring of 2011 as a separate document titled "Reevaluation Report Sand Management Plan, Wilmington Harbor Navigation Project".

Monitoring Program

Scope. The monitoring program is designed to measure the response of the adjacent beaches, shoaling patterns in the entrance channel, and changes in the ebb tide delta of the entrance channel beginning immediately before initial construction and continuing throughout the operation and maintenance of the project. The results of this monitoring program will be used to make necessary adjustments in the beach disposal location for the littoral material removed from the entrance channel and to document the response of the adjacent beaches to the deepening and alignment changes of the entrance channel.

Program Elements. The present monitoring program consists of five basic elements namely; beach profile surveys, channel and ebb tide delta surveys, wave and current measurements, aerial photography, and data analysis/reporting. The data collection effort is a large undertaking and involves numerous entities including the Corps of Engineers, private contractors, and academia. The Wilmington District manages the program and is responsible for project coordination, funding, data analysis and report preparation. The majority of the data collection is accomplished by the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Field Research Facility (FRF) located in Duck, North Carolina. The FRF is responsible for obtaining the beach profile surveys, ebb shoal surveys, wave and current measurements, and associated data reduction, quality control, and analysis. The wave/current gauges are operated by Evans Hamilton, Inc (EHI) through the FRF and the detailed ebb tide delta and shipboard current surveys have been performed by the Virginia Institute of Marine Science, through EHI and more recently by the FRF. Some of the beach profile surveys and aerial photography are also obtained by the Wilmington District through the use of private companies. The beach profiles have been surveyed by McKim & Creed Engineering and Greenhorne & O'Mara (subcontract with Geodynamics); whereas, the aerial photos have been provided under contract with Barton Aerial Technologies, Inc. and Nova Digital Systems, Inc. Additional aerial photography has recently been acquired through the Civil Works Imagery Monitoring Program. This program contracts with two satellite providers, DigitalGlobe and GeoEye, to obtain satellite imagery of varying resolution and can be obtained at more frequent intervals than traditional aerial photography. The basic program elements are described in the following paragraphs.

Beach Profile Surveys. The beach profile surveys serve as the backbone of the monitoring program and are taken along Bald Head Island and Oak Island/ Caswell Beach. The beach surveys consist of specified transects, or profiles, taken generally perpendicular to the trend of the shoreline. For Bald Head Island, the beach profiles begin at the entrance to the Bald Head Island marina on West Beach, and extend all the way to Cape Point, located at the eastern end of South Beach as shown in Figure 1.3. The location of these profile stations were selected to coincide with existing beach profile stations currently being monitored by the Village of Bald Head Island, which are spaced at an interval of approximately 400 feet. The total shoreline distance covered along Bald Head Island is about 22,000 feet and includes a total of 58 beach profile stations. For the Oak Island/Caswell Beach portion, beach profile stations were established at approximately 500-foot intervals, beginning near the Cape Fear River Entrance and extending west along Caswell Beach/Oak Island, as shown in Figure 1.4. This coverage includes approximately 5,000 feet of shoreline fronting the North Carolina Baptist Assembly grounds at Fort Caswell (2,500 feet along the inlet shoulder and 2,500 feet along the ocean-front) plus 26,000 feet along Oak Island extending west of the Baptist Assembly property. The beach profile stations extend 1000 feet westward of the designated disposal limit on Oak Island and encompass a total shoreline length of 31,000 feet. A total of 62 profile lines comprise this shoreline reach. The profile locations follow along an existing baseline established by the Corps of Engineers that had designated profile stations at 1,000 foot intervals. The monitoring plan added intermediate lines at 500-feet and utilized the pre-existing 1,000 foot stations so that prior surveys could be incorporated into the program as necessary.

The designated assigned profile numbers as shown on the figures are correlated to their respective location along the established baseline for each transect location. For example, Profile 310 on Oak Island (the last line) corresponds with baseline Station 310+08.91, and is approximately 31,000 feet from the inlet entrance.

The beach profile surveys are taken semi-annually. At the start of the program, the surveys were scheduled to coincide with the spring (April-May) and fall (October-November) seasons. During the spring survey all profiles are surveyed with coverage over the onshore portion of the beach. The onshore survey coverage extends from the landward limit of the profile line (a stable point beyond the back toe of the dune) seaward to wading depth. During the fall the onshore coverage is repeated; however, the coverage of every other line is extended offshore to a seaward distance of 15,000 feet or to a depth of 25 feet. Beginning in 2005, both the fall and spring surveys were designated to have the same coverage with both having onshore and offshore profile lines. This revised coverage is expected to continue as long as funds are available. The survey data are reported with respect to the National Geodetic Vertical Datum (NGVD) 1929 and North American Datum (NAD) 1983 horizontal datum.

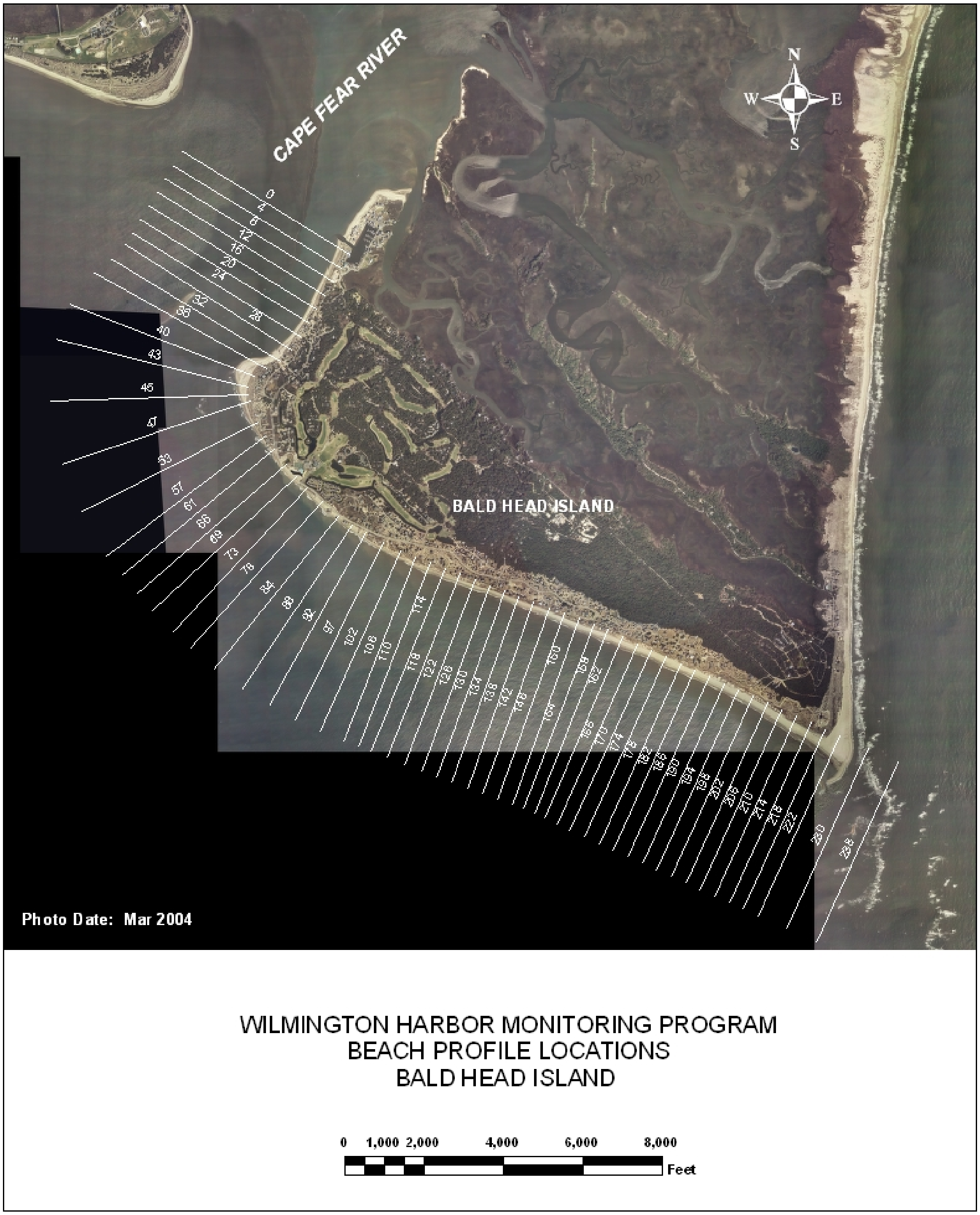
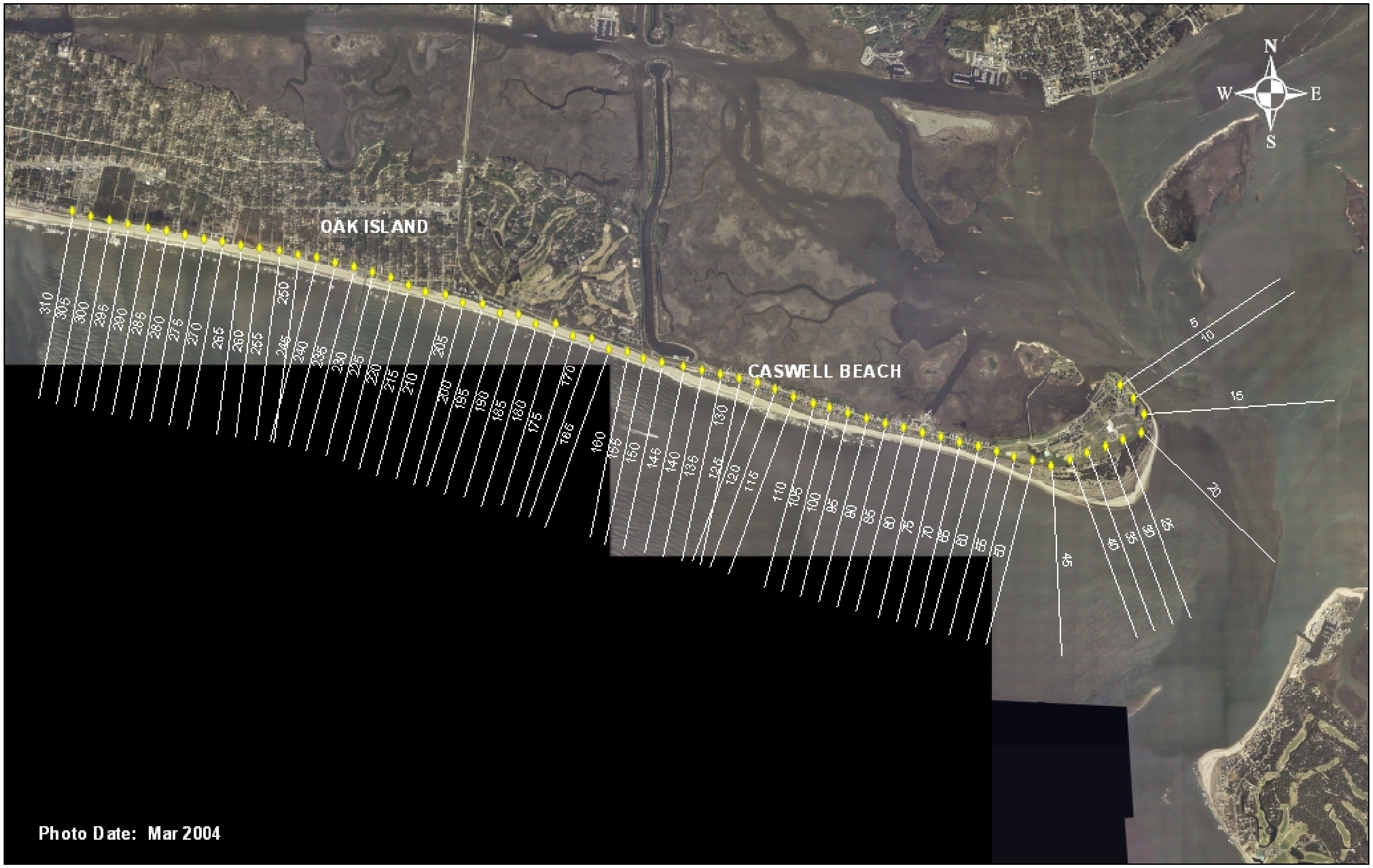


Figure 1.3 Bald Head Island Beach Profile Locations



WILMINGTON HARBOR MONITORING PROGRAM
BEACH PROFILE LOCATIONS
OAK ISLAND/CASWELL BEACH

0 1,000 2,000 4,000 6,000 8,000 Feet

Figure 1.4 Oak Island/Caswell Beach Profile Locations

The most difficult areas to obtain accurate bathymetric surveys are through the surfzone and over the shoal areas that border each side of the Cape Fear entrance channel, and those near Frying Pan Shoals. Access to these locations is very difficult for conventional watercraft due to breaking waves and shallow depths. Under the present monitoring effort these access problems are largely eliminated through the use of the FRF's Lighter Amphibious Re-supply Cargo (LARC) survey system. The LARC vehicle, shown in Figure 1.5, is uniquely designed to transit through the water, across shoals, and through the surf zone up to the base of the beach dunes. The LARC is equipped with a Trimble Real-Time Kinematic Global Positioning Satellite (RTK-GPS) survey system for accurate horizontal and vertical positioning of the vehicle and a Knudsen Echosounder to measure depth while traversing the profile lines.

Figure 1.5 FRF Hydro-LARC Survey System

<u>Channel and Ebb Tide Delta Surveys.</u> The Corps of Engineers routinely surveys the condition of the ocean entrance channel from the Smith Island Range seaward to the Bald Head Shoal Range about once every two to three months. The area covered by these surveys includes the entire width of the authorized channel and some limited areas adjacent to the channel but outside the channel prism lines. Additional surveys are obtained in association with the numerous dredging contracts that will continue during the future maintenance of the channel.

The realignment of the seaward portion of the Bald Head Shoal Range is expected to be accompanied by a reconfiguration in the shape of the ebb tide delta. The major change expected is the reorientation of the western portion of the ebb tide delta with the reoriented delta essentially paralleling the alignment of the new channel. To monitor these changes, detailed surveys of the offshore area encompassing the entire ebb tide delta are accomplished on an annual basis. The surveys are scheduled to coincide with the offshore beach profile surveys so that the coverage can be combined where applicable. The general extent of the ebb delta surveys is indicated on Figure 1.6.

The bathymetric data over the ebb shoal area are collected using a very detailed and accurate Submetrix Interferometric (SI) System. This system collects swath bathymetry and sidescan sonar from a hull-mounted transducer. Horizontal and vertical accuracy, when coupled with RTK-GPS and a motion sensor is 15-20 cm (6-8 inches). Unlike traditional multi-beam systems, the SI maintains a swath width of 8-10 times the water depth and simultaneously collects both depth and seabed reflection properties. This system performs particularly well in shallow waters, ranging from 2-20 meters (6 to 66 feet) and produces swath soundings at 2 meter (6 foot) grid spacing.

Wave and Current Measurements. Wave and current measurements are also included as an integral part of the monitoring program. Three bottom-mounted gauges have been positioned in the project area in the ocean as shown in Figure 1.7. One gauge is located immediately offshore of Bald Head Island in 19 feet of water, the second is located just offshore of Oak Island (23 feet water depth), with the third positioned in 42 feet of water 11 miles offshore. The outer gauge was positioned to measure wave and water level data seaward of the navigation channel and ebb shoal influence. The nearshore gauges provide data in the vicinity of the navigation channel, nearshore shoals and adjacent beaches. A fourth gage was temporarily deployed just inside the entrance channel of the river where it was periodically moved to three locations in 2000-2001. All gauges consist of a combination of an Acoustic Doppler Current Profiler (ADCP) meter and a pressure gauge. This combination is capable of producing measurements of wave height, period and direction, water level (tide and surges) as well as currents over the water column. Water temperature near the bottom is also recorded. The sensors are mounted in a steel framed pod for protection from trawlers and are self-recording. Data are recorded at 3-hour intervals; except for the Oak Island gauge which is presently hard-wired to shore and reports on an hourly basis.

In addition to fixed bottom mounted gauges described above, currents are also measured along specified transects across the mouth of the Cape Fear River and near the new channel realignment. These measurements are recorded using a downward-looking, shipboard-mounted current profiler, which operates along the two closed loops as shown in Figure 1.8. The vessel navigates along the tracks over a complete tidal cycle to capture both ebb and flood flows as well as the entire tidal prism. Current surveys are accomplished annually corresponding with the ebb tide delta survey.

Aerial Photography. Vertical color aerial photographs have been obtained yearly generally near the time of the spring profile survey. The nominal scale of the historic

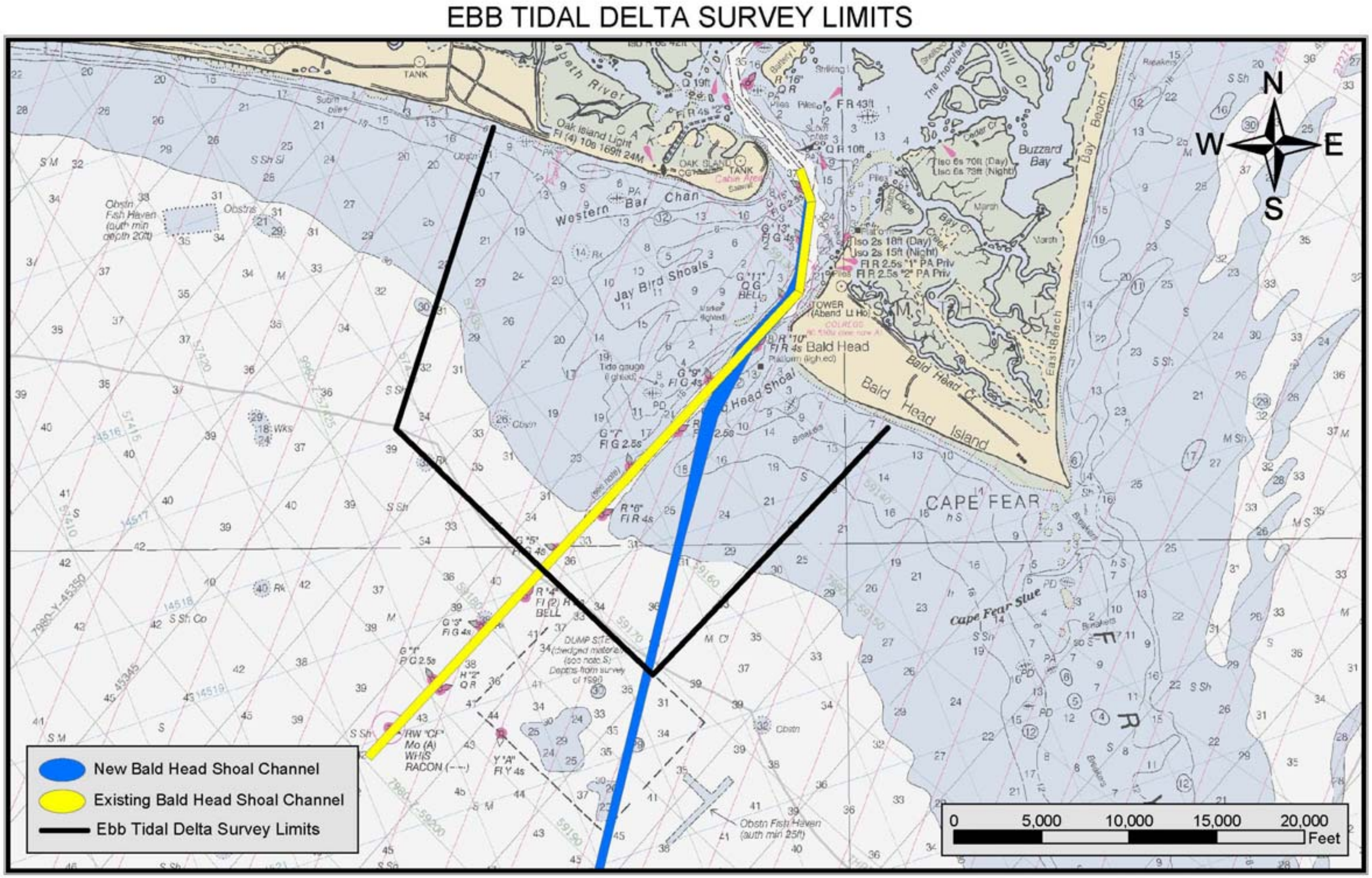


Figure 1.6 Entrance Channel and Ebb Tide Delta Survey Coverage

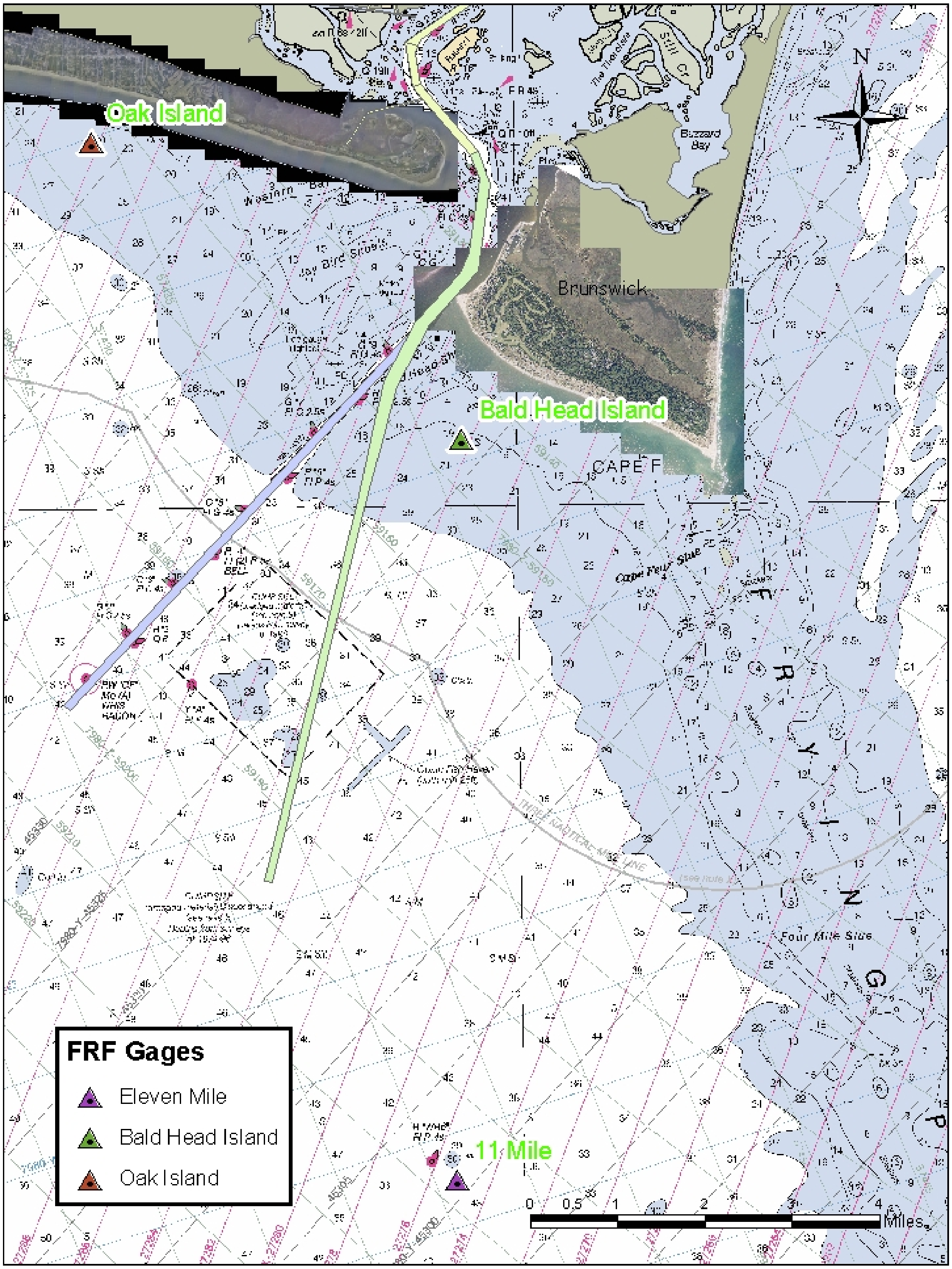


Figure 1.7 Wave and Current Gauge Locations

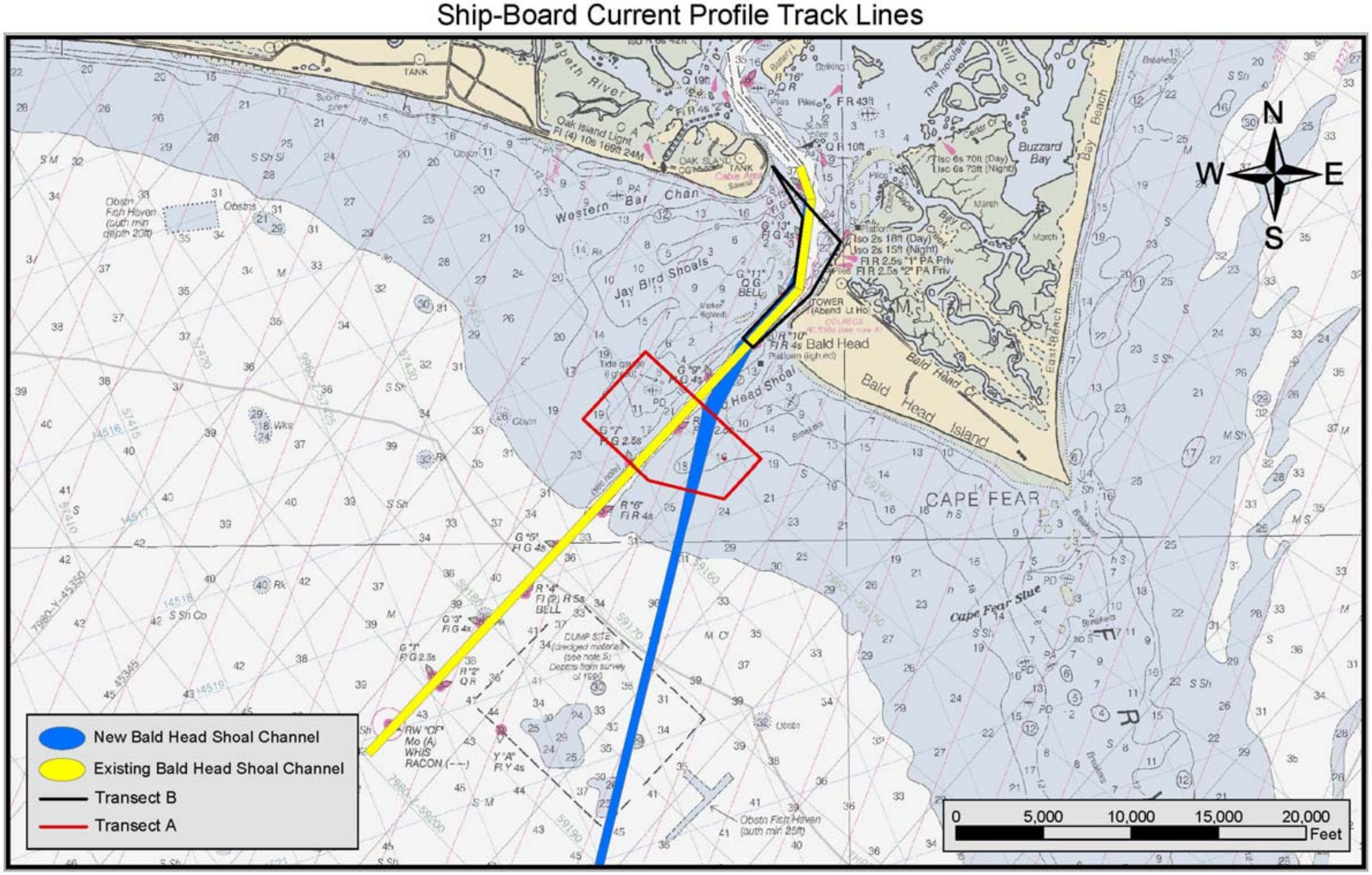


Figure 1.8 Shipboard Current Profile Locations

photography ranges from 1 inch equals 1000 feet over the entire project area to1 inch equals 500 feet for the Wilmington Harbor monitoring area. Recent imagery of the monitoring area has been obtained through the National Geospatial Intelligence Agency (NGA). The NGA is the Department of Defense executive agent for commercial satellite imagery acquisition. Through the existing NGA contracts with DigitalGlobe and GeoEye, the USACE is able to request imagery through one of five satellites with image resolution ranging from 1.4 to 3 foot resolution depending on availability and usage requirements. The ability to acquire satellite imagery has improved our monitoring effort by providing the ability to use imagery that correlates to specific events while lowering the overall cost of the monitoring effort.

Data Analysis and Reporting. Reports summarizing the monitoring activity are scheduled for preparation on an annual basis. Each report includes an analysis of the observed changes and trends along the adjacent beaches and a comparison to expected or historical trends. The reports also include an assessment of the shoaling patterns in the ocean entrance channel, temporal changes in the ebb tide delta and an analysis of the wave and current measurements. All reports are provided to the Village of Bald Head Island, the Town of Caswell Beach, the Town of Oak Island, and interested parties for their review and comment.

Bald Head Island Monitoring Survey Program.

In addition to the federal activity, a monitoring program is also being implemented by the Village of Bald Head Island. The Village has contracted with Olsen Associates to provide coastal engineering services for this program. Table 1.2 is a listing of the dates and coverage for the Village of Bald Head Island monitoring surveys. In 2005 following a beach disposal activity, the locals reconstructed a groin-field project along the western portion of South Beach (see Part 2 for discussion of this project and others undertaken by the Village of Bald Head). As a condition of the CAMA permit, the Village is required to submit an annual survey monitoring report to the NC Division of Coastal Management assessing the performance/impacts of the groin field.

Further, beginning in January 2005, the Corps of Engineers has agreed, as part of a legal settlement agreement, to initiate bi-monthly condition surveys of the channel along Bald Head Island. These surveys cover the Smith Island Range plus Bald Head Shoal Ranges 1 & 2. These surveys are being utilized to monitor the condition of the channel, the navigable channel width, and the relationship with the stability of Bald Head Island. The details of this effort and results to date are given in Part 4 of this report.

Table 1.2 Village of Bald Head Island Beach Profile Surveys

Date of Survey	Range of Stations	On Shore	Off Shore
1996 - Sep	20 to 166	X	
1997 - Mar	20 to 166	X	
1997 - Jun	20 to 162	X	
1997 - Sep	24 to 162	X	
1998 - Mar	20 to 162	X	
1998 - Jun	20 to 162	X	
1998 - Sep	20 to 158	X	
1998 - Dec	24 to 166	X	
1999 - Mar	24 to 166	X	
1999 - Nov	0 to 218	X	X
2000 - Nov	0 to 214	X	X
2001 - Aug	8 to 210	X	X
2002 - Jul	8 to 210	X	X
2002 - Dec	0 to 222	X	X
2003-May	0 to 218	X	X
2003-Oct	0 to 218	X	X
2004-Apr	0 to 218	X	X
2004-Oct	0 to 218	X	X
2005-Apr	0 to 218	X	X
2005-Nov	0 to 218	X	X
2006-Apr	0 to 218	X	X
2006-Nov	0 to 218	X	X
2007-Jun	0 to 218	X	X
2007-Nov	0 to 218	X	X
2008-May	0 to 218	X	X
2008-Nov	0 to 218	X	X
2009-May	0 to 218	X	X
2009-Sep	0 to 218	X	X
2010-May	0 to 218	X	X

<u>Activities to Date.</u> Figure 1.9 gives a time line activity chart that summarizes all tasks undertaken to date associated with the physical monitoring program. Data collection for the Wilmington Harbor monitoring program began in August 2000 prior to the dredging of the entrance channel. This report covers the monitoring activity through the September 2010 beach survey and therefore spans an initial period of 10 years. Table 1.3 lists all the monitoring surveys to date. Since the initiation of the program there have been 19 onshore beach profile surveys, 17 offshore beach profile surveys and 10 surveys of the ebb tide delta. Additional surveys of portions of the beach were also conducted before, during and after placement of the various beach disposals associated with the dredging contracts.

Table 1.3 Wilmington Harbor Monitoring Surveys

Survey Date	Onshore Profiles	Offshore Profiles	Ebb Shoal
Aug-Sep 2000	X	X	X
Oct 2001		X	
Nov-Dec 2001	X		
Dec 01-Jan 02			X
June 2002	X		
Nov-Dec 2002		X	
Jan 2003			X
Jan-Feb 2003	X		
June 2003	X		
Dec 03-Jan 04	X		
Jan 04		X	X
June 2004	X	X[1]	
Feb 2005	X	X	
Mar 2005			X
Aug 2005	X	X	
Mar 2006	X	X	
Apr 2006			X
Oct 2006	X	X	
Jan 2007			X
Jan 2007	X	X	
Jul 2007	X	X	
Jan 2008	X	X	X
Jul 2008	X	X	
Jan 2009	X	X	X
May 2009	X	X	
March 2010	X	X	X
September 2010	X	X	

[1] Bald Head Only

With respect to the wave/current meters, all four instruments were initially deployed in September 2000. All three ocean gauges have been maintained over the entire monitoring period, but have undergone periods of downtime do to servicing and other problems. The river gauge was in operation from September 2000 through September 2001 as it was cycled between three sites near the river entrance. The shipboard current measurements were taken on eight occasions beginning with the initial October 2000 data collection effort as shown in the listing in Table 1.4. Additionally, aerial photographs were taken on fourteen occasions to date as given in Table 1.5 including those provided by the Village of Bald Head. The most recent photography for the current monitoring period was collected under the NGA program on August 5, 2010.

Table 1.4 Wilmington Harbor Shipboard Current Measurements

October 2000
April 2002
March 2003
January 2004
March 2006
February/March 2007
March 2008
April 2009
May 2010

Table 1.5 Wilmington Harbor Aerial Photography

October 11, 2000
February 7, 2001
May 16, 2002
March 10, 2003
August 15, 2003
June 1, 2004
April 24, 2006
October, 2006*
May 20, 2007*
May 13, 2008*
Nov 18, 2008
Jan 14, 2009*
Mar 22, 2009
Aug 8, 2009
Nov 16, 2009
Feb 7,2010
August 5, 2010
*Provided by BHI

Also included on the activity chart (Figure 1.9) are the dredging periods for the entrance channel and associated beach disposal time frames. As discussed earlier in this report, this initial construction was accomplished under two contracts. One contract, commonly known as Ocean Bar I, covered the outer bar channel, (Bald Head Shoal-Outer Reach). The second, Ocean Bar II, covered Bald Head Shoal-Inner channel plus the lower river channel ranges of Smith Island, Bald Head-Caswell, Southport, Battery Island, Lower Swash, and Snows Marsh. Dredging on Ocean Bar I began in December 2000 and was completed April 2001, with all the material being removed and deposited in the designated ocean disposal site. Ocean Bar II work involved removal of beach compatible sediments as well as fine silts and clays designated for offshore disposal. Dredging of Ocean Bar II commenced February 2001 with disposal on Bald Head Island. The Bald Head placement was completed in early July 2001 and the disposal was then initiated on Eastern Oak Island/Caswell Beach. This segment was finished in August 2001 followed by completion of the Oak Island West beach disposal in April 2002. The overall Ocean Bar II contract, including the dredging of non-suitable beach material was completed in December 2002.

Subsequently, the first maintenance cycle along the realigned/deepened channel was undertaken approximately two years following the initial construction. This cycle included the Clean Sweep I dredging over the period of September 2003 through January 2004, plus the Clean Sweep II contract completed during January 2005. The latter contract involved beach disposal activity between November 2004 and January 2005 along Bald Head Island. The second maintenance cycle was completed over the February-April 2007 time period with disposal again going to Bald Head Island. The third maintenance cycle involved placement along Oak Island/Caswell Beach, which was done over the period of February-April 2009.

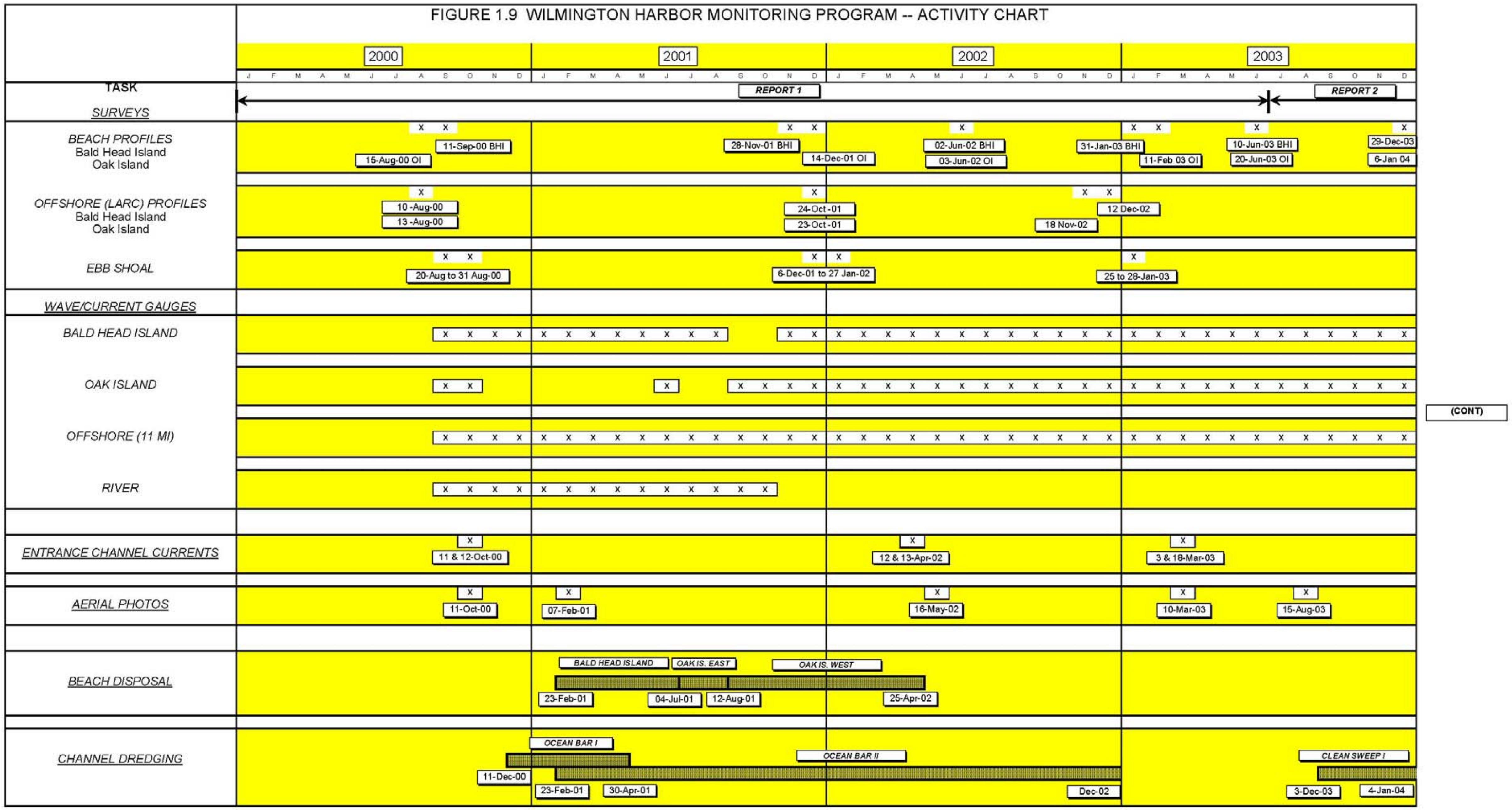


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART

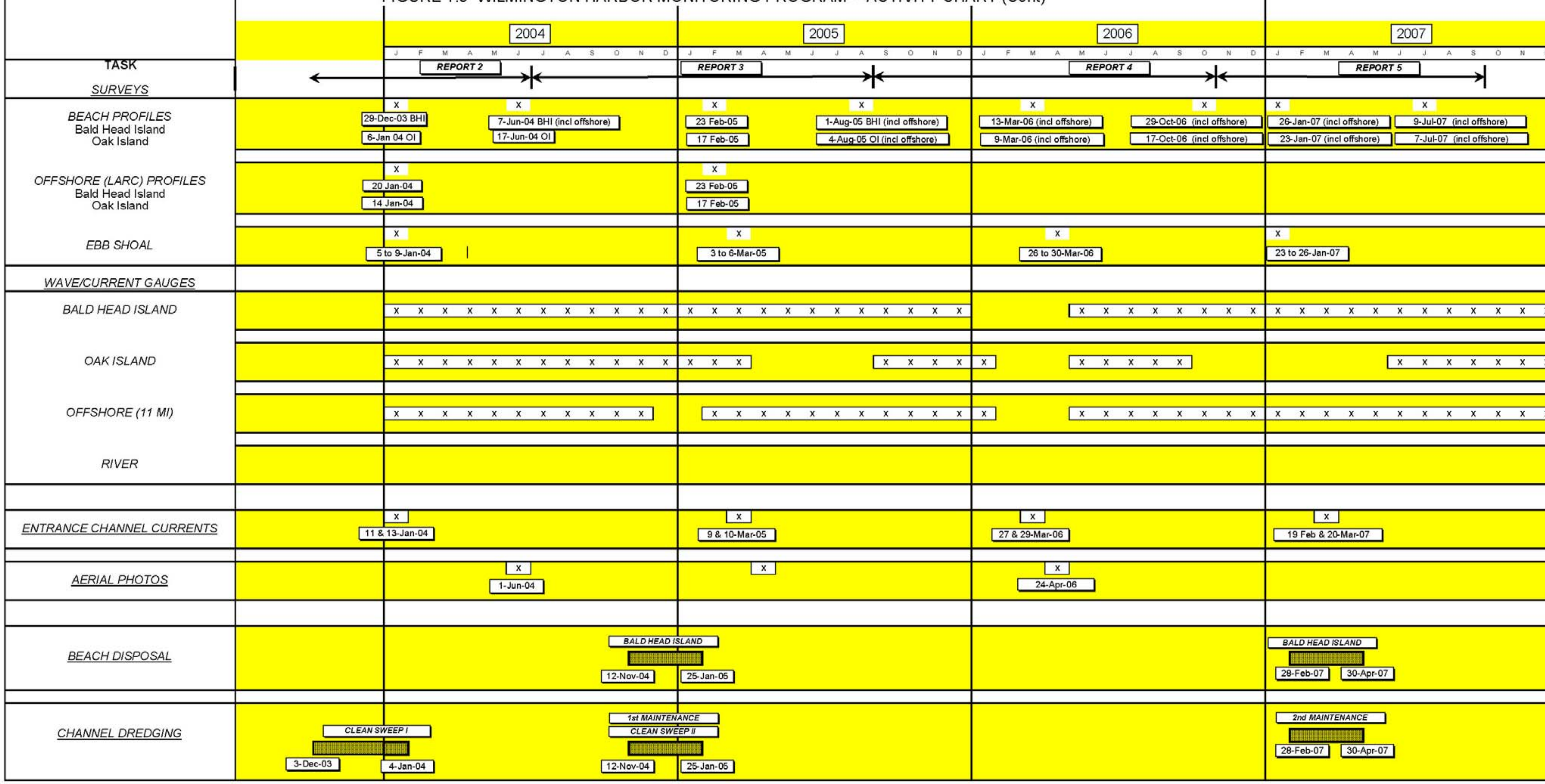


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART (Cont)

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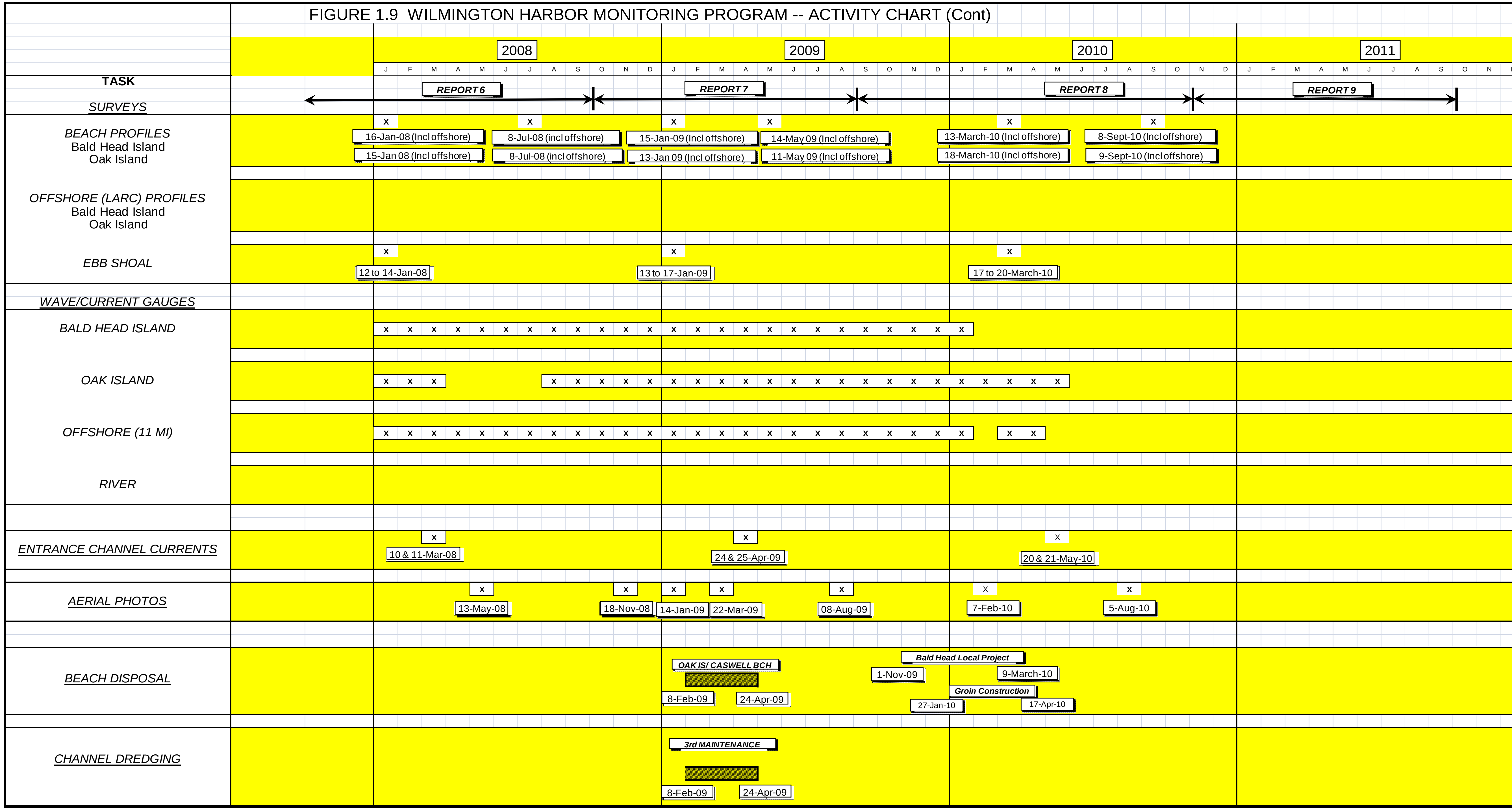


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART (Cont)

Part 2 BACKGROUND INFORMATION

Shoreline Change Rates

State Erosion Rates. Rates of shoreline change have been calculated for the entire coastline of North Carolina by the NC Division of Coastal Management (NCDCM). These data are used for planning and regulatory purposes in establishing construction setback distances along the ocean front shoreline. The shoreline changes are representative of long-term average annual rates based on the comparison of shoreline locations interpreted from historic aerial photos. The shoreline position is recorded from a common shore parallel baseline along fixed transects that run at right angles to the base line. Transects are spaced every 50-meters (164 feet) along the coastline and are grouped in individual base maps consisting of 72 transects each. Each base map covers about 3.6 km (2.2 miles) of coastline. In reporting the shoreline change data, the NCDCM uses the end point method that compares the earliest shoreline position with most recent position and divides the shoreline change by the time interval between the two dates. An alongshore average is then used to smooth out smaller perturbations along the coast. This running average uses 17 adjacent transects consisting of eight transects on either side of the transect of interest.

For this study NCDCM shoreline position data were combined with the initial monitoring survey of Aug/Sep 2000, taken immediately prior to the channel deepening and realignment. The NCDCM data included shoreline positions taken from aerial photos dated 1-Apr 38, 16-Aug 59, 8-Dec 80, 25-Aug 86 and 1-Sep 92. Average annual shoreline change rates were computed by taking a least-squares fit of all the shoreline positions spanning the dates 1938 through 2000. A running alongshore average, as noted above, was then computed from the least squares fit data. The final computations represent long-term shoreline change rates for the monitoring area spanning more than 62 years before the new channel work was initiated. These long-term pre-construction rates are given in Figure 2.1 for Oak Island/Caswell Beach and in Figure 2.2 for Bald Head Island. Later in Part 4 of this report, these computed rates are compared to the rates calculated over the monitoring period to date (i.e. the post-construction period).

Oak Island/Caswell Beach Shoreline Change Rates. Figure 2.1 covers about 6 miles of coastline along Oak Island/Caswell Beach just west of the Cape Fear entrance. The trend in long-term shoreline change rates show a general erosion pattern along the western two-thirds of the area and accretion along the remaining third nearest the river entrance. The erosion rates range from 2 feet per year at the western end of the study area, to a maximum erosion of nearly 6 feet per year, which occurs near the boundary line between Oak Island and Caswell Beach. The erosion then diminishes moving eastward from the peak eventually turning accretionary at a point about 2000 feet to the east of the CP&L canal area. From this point eastward, the beach has historically been stable showing rates of accretion ranging from 1 to 2 feet per year to a maximum of more than 30 feet per year along the tip of Fort Caswell.

Bald Head Island Shoreline Change Rates. As shown on Figure 2.2, the long-term trend in shoreline change for Bald Head Island is one of erosion. The erosional pattern along the 3-mile extent of South Beach shows relatively higher erosion both at the western and eastern ends with more stability along the central reach. The pattern holds true except for a few transects nearest the river entrance that are found to be accretionary at the southwestern tip of Bald Head. Proceeding eastward from this stable area is an erosion zone covering about one mile where the rates range from –2 feet per year to a maximum of –6.6 feet per year. The rates then range from –2 to –3 feet per year average along the central portions of South Beach. Eastward beyond this relatively more stable reach the rates gradually increase towards Cape Fear reaching a maximum erosion rate of about 20 feet per year.

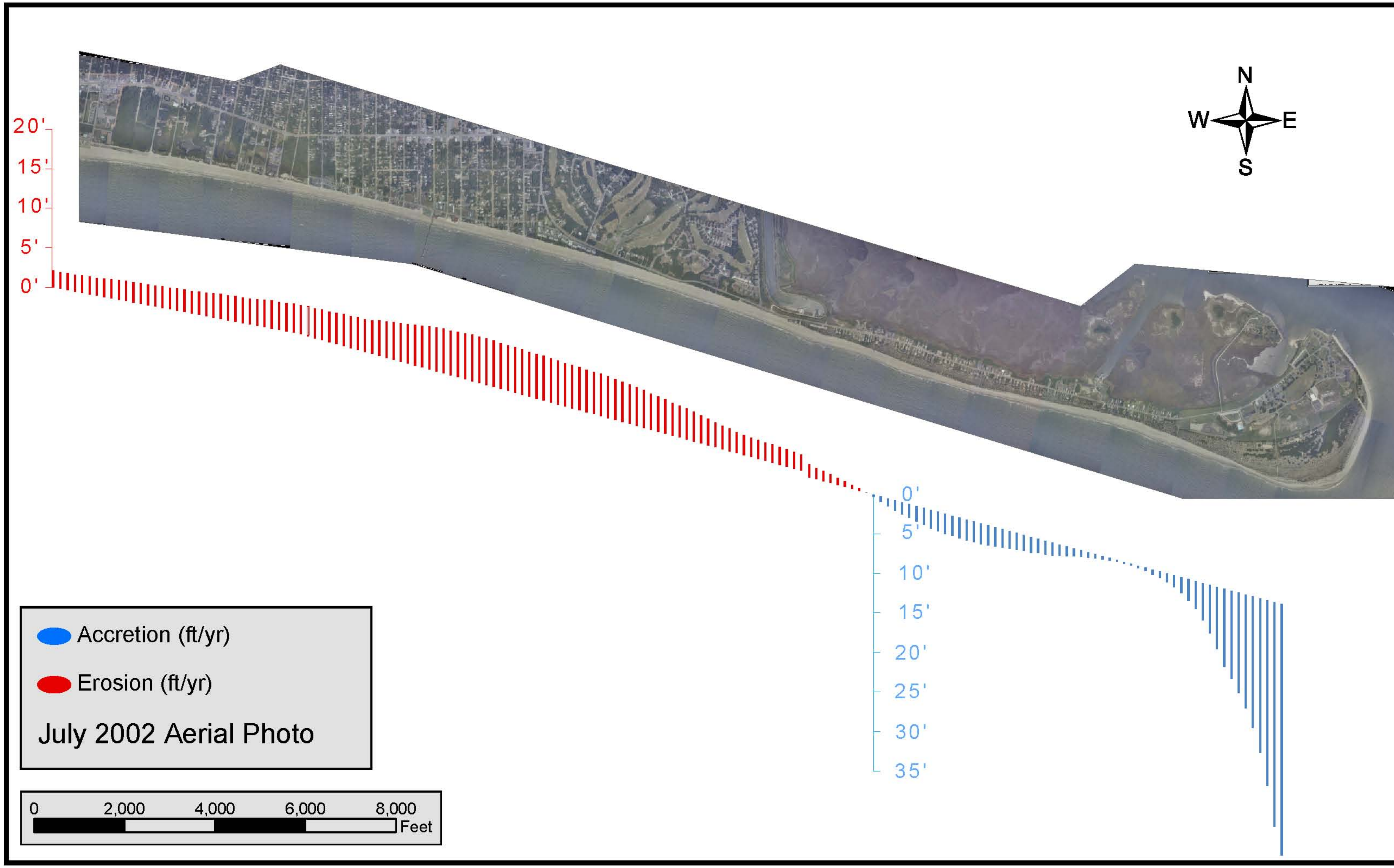


Figure 2.1 Long-Term Average Annual Shoreline Change Rates (1938-2000) Oak Island/Caswell Beach

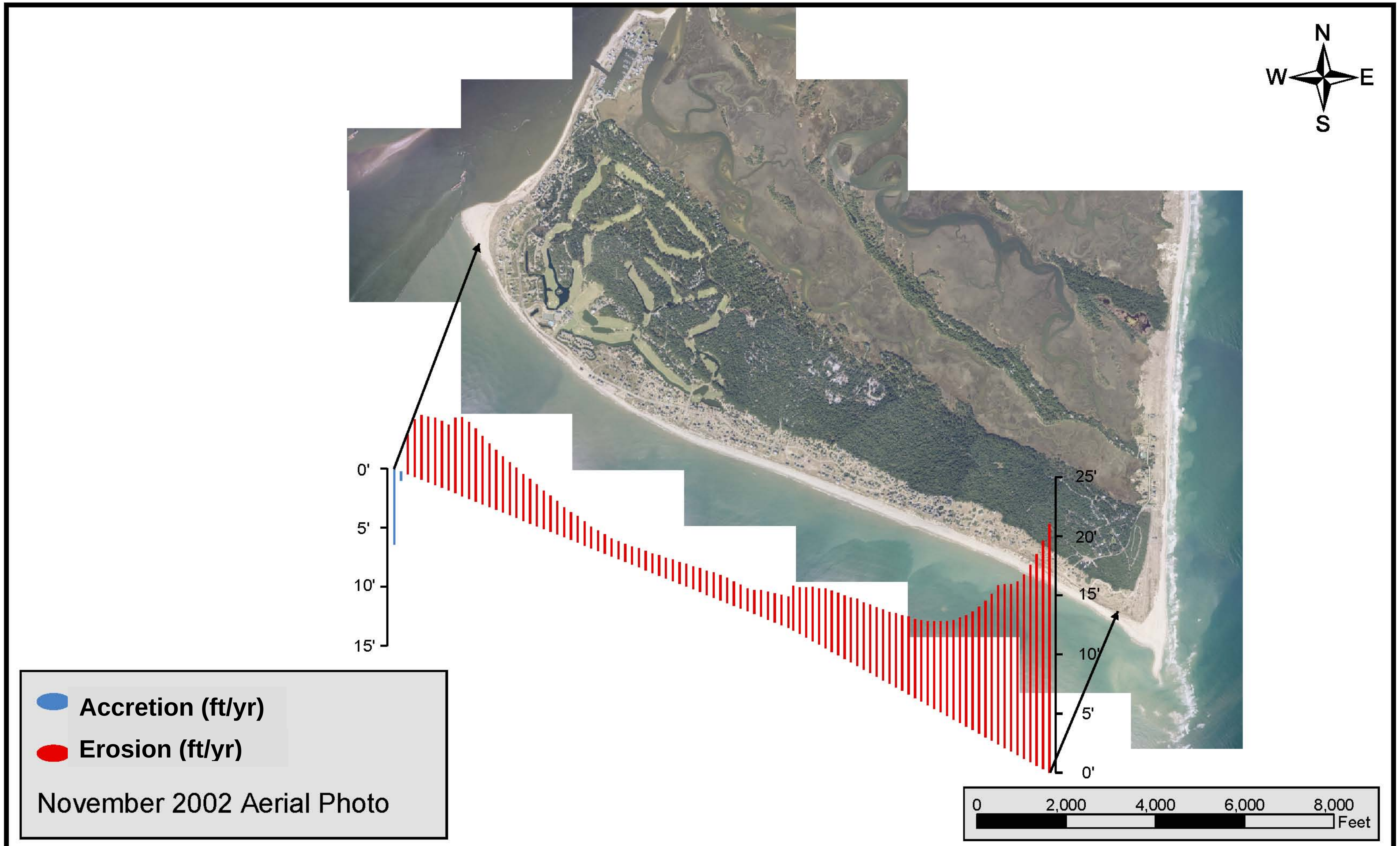


Figure 2.2 Long-Term Average Annual Shoreline Change Rates (1938-2000) Bald Head Island

Erosion Control Activities at Bald Head Island

To combat the erosion that Bald Head Island has been experiencing since the early 1970's, there have been a number of erosion control activities undertaken including beach disposal projects, groin field construction/rehabilitation and sand bag placement. These operations have concentrated on the south-western portion of Bald Head Island where erosion problems have been most acute.

Three beach disposals of approximately 360,000 cubic yards in 1991, 650,000 cubic yards in 1996, and 450,000 cubic yards in 1997 were placed with slight variations of the start and stop locations between stations 36+00 and 134+00. These projects were cost-shared or paid for by the Village of Bald Head Island. In 2001, 1,849,000 cubic yards were placed between stations 41+60 and 205+50 in conjunction with the entrance channel realignment and deepening. This was followed by the 2005 and 2007 placement of 1,217,500 cubic yards and 978,500 cubic yards of sand, respectively, as part of the navigation channel maintenance.

In 1994 a 645-foot-long sand bag revetment was placed along the badly eroding portion of western South Beach. In 2003-2004 the sand bag revetment was expanded by increasing the overall length by 200 feet, increasing the base width from 20 to 40 feet and increasing the crest elevation by 6 feet to +12 feet NGVD. A view of the expanded sand bags are shown in Figure 2.3, as it appeared in April 2003.

Figure 2.3 Sand Bag Revetment along South Bald Head Wynd, April 2003.

In 1996, the Village constructed sixteen geo-textile groins from station 49+00 to Station 114+00. The groins were 9 feet in diameter and 325 feet long. The spacing between the groins was about 450 feet. The groin field slowed the erosion for several years before they began to fail and ceased to function in 2000. Due to apparent effectiveness of the geo-textile groins, the Village of Bald Head Island decided to rebuild the groin field following the beach disposal in 2005. As such a sixteen structure sand tube groin field was reconstructed along South Beach between stations 47+00 and 105+00. The replacement geo-tubes were constructed between January and March 2005. Some modifications were made to the original 1996 plan. These modifications included: (1) the spacing was reduced from 450 feet to 385 feet thereby reducing the overall extent for the groin field, (2) the tube lengths were 300 feet for 14 of the structures and 250 feet for the remaining two, (3) the individual tubes were tapered with a landward maximum diameter of 10 feet to 6 feet at the seaward end, and (4) the entire groin field was shifted westward to be more aligned with the problem area. Figure 2.4 shows an aerial view of the completed groins taken in July 2006, about 16 months following placement.

Figure 2.4 Reconstructed Groin field along Bald Head Island, July 2006 (Courtesy of Village of Bald Head Island)

A further recent beach disposal operation was undertaken by the Village of Bald Head in January 2006. This involved dredging of Bald Head Creek, located just north of the marina, and placing approximately 47,800 of beach quality sediments along an eroding portion of West Beach. Placement occurred along a 1600-foot-reach (between Profile 16 and 34) immediately north of the point.

Most recently, Bald Head Island undertook a large beach re-nourishment project to cover portions of South and West Beach. The work commenced in November 2009 (Figure 2.5) with completion in March 2010. This operation was undertaken to cover the "open" maintenance cycle, when according to the sand management plan, material is designated to go to Oak Island. Approximately 1.6 million cubic yards of sand were dredged from an offshore borrow site comprising the seawardmost portions of Jay Bird Shoals. The contract also involved the replacement of the geotextile groins in conjunction with the disposal placement.

Figure 2.5 Start of 2009-10 local Beach Disposal Project along Bald Head Island, November 2009 (Courtesy of Village of Bald Head Island)

Part 3 DATA ANALYSIS AND RESULTS THRU THE CURRENT MONITORING CYCLE

General. Data collection for the monitoring program was initiated in August 2000 just prior to construction of the entrance channel improvements. This part of the report describes the data collected to date and results through September 2010, the end of the eighth monitoring cycle. The data analyses generally describe changes that have occurred since those last reported in May 2009 and also relative to the base (pre-project) conditions established with the initial monitoring surveys. The following discussion covers the four main data collection efforts, namely: shoreline and volumetric changes as measured from the beach profile surveys, ebb and nearshore shoal response, wave data, and current measurements in the entrance channel.

Beach Profile Analysis-Shoreline and Profile Change

The beach profile surveys were analyzed using BMAP (Beach Morphology Analysis Program) (Sommerfield, 1994) to determine both shoreline and unit volume changes over time for each profile of interest. The beach profile locations were given previously in Figure 1.3 for Bald Head Island and Figure 1.4 for Oak Island. It is noted that the beach profile numbers are reflective of their location on the baseline. For example, the origin of beach profile 43 is located near station 43+00 on the Bald Head Island baseline. The shoreline is represented by the mean high water line which is 2.71 feet above NGVD29 for the monitoring area.

Bald Head Island. Shoreline changes measured along Bald Head Island over the current monitoring cycle are given in Figures 3.1 and 3.2. The present monitoring period includes two surveys undertaken in March 2010 and September 2010. Figure 3.1 shows the shoreline changes relative to the May 2009 position, i.e. the last referenced location in Report 7. Figure 3.2 gives the shoreline changes with respect to the start of the monitoring program in September 2000. While comparisons to the pre-project survey in September 2000 are useful in gauging changes, they are limited in the respect that they are a comparison of two specific points in time. The September 2000 pre-project survey reflects a static condition along a generally highly variable shoreline that has been influenced by several beach nourishment projects that occurred along the island in 1991, 1996, and 1997, as well as, groin construction activity. Further, other factors such as seasonal and episodic fluctuations in wave climate strongly influence shoreline positions along both Oak and Bald Head Island.

As indicted in Figure 3.1, most of the profile locations along Bald Head Island have accreted or moved seaward over the last year. The primary reason for the seaward migration of the shoreline since the last report is the beach disposal placed along Bald Head Island between November 1, 2009 and March 9, 2010. During this placement approximately 1,594,600 cubic yards of sediment were placed along West Beach (Sta. 12+00 to 28+00) and South Beach (Sta. 39+60 to 162+00) concurrent with the construction of a new groin field in this area. Significant accretion occurred along the spit and western portions of South Beach, between Profiles 40 through 97, and along the eastern portions of South Beach between Profiles 110 through 182. The maximum seaward movement of the shoreline position was measured for both the March 2010 and September 2010 surveys relative to the May 2009 position. The maximum for the March 2010 survey was calculated to be 315 feet at Profile 43 near the spit. By September 2010 the maximum change value had reduced to 138 feet and was located at Profile 73 near the center of the newly constructed groin field. In general, the accreting areas are located approximately where disposal material was recently placed; however, the majority of the area adjacent to the disposal shows accretion as well. This is the result of the sediment placed within the construction template diffusing along the shoreline as the profile assumed a more natural equilibrium offshore profile. A small number profiles within the monitoring area have eroded since the last monitoring cycle ended. These include Profiles 0 thru 8 (located within West Beach), Profile 36 in the Spit area, and the area between Profiles 194 and 218 (located near the east end of South Beach). These areas were outside the limits of the most recent disposal.

The greatest variability was again found within the spit area which has been defined in previous reports as a zone between Profiles 32 to 45. This very dynamic area had shoreline changes which ranged from gains of about 315 feet to losses of more than 119 feet. Both of these extreme values occurred during the March 2010 survey which is the first post-disposal placement survey following the local beach project. The September 2010 survey indicated the disposal within the spit area had significantly diffused which resulted in a much less variable shoreline. Maximum accretion within the spit area at the conclusion of the monitoring period was only 29’ at station 45, while the maximum eroded distance was located at profile 36 and measured 31 feet.

The remaining area along West Beach (Profiles 0 thru 28) has had a mixture of losses and gains over the period, with the shoreline accreting on average 19 feet. The overall accretion of this area is directly related to beach disposal activities since the previous monitoring period. The area between Profiles 0 and 8 which did not receive beach placement had significant erosion of up to 66 feet at the northern most profile 0. Overall, the alongshore average shoreline changes measured over the entire monitoring area were gains of 36 feet between May 2009 and September 2010.

Shoreline change patterns as measured over the last 10-year period, i.e., since the monitoring was initiated, are shown in Figure 3.2. Included in the figure are the three most recent surveys of May 2009, March 2010 and September 2010. This figure reveals that for the majority of the profiles, the shoreline changes are positive when measuring relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional, with the September 2010 shoreline being an average of nearly 159 feet seaward of its September 2000 position. Large gains and losses are present within the spit area where the shoreline has advanced on the order of 230 feet at Profile 32 and lost nearly 315 feet at Profile 43 over the monitoring period. On average, the spit area (Profiles 32-45) has lost nearly 35 feet since September 2000. An area of progressive erosion is seen along the western portion of South Beach between Profiles 47 through 61. Average shoreline loss within this region is approximately 100 feet with a peak loss of nearly 262 feet occurring at Profile 47.

For West Beach (Profiles 0 through 28), located immediately along the river channel, the shoreline has shown an average loss of about 6 feet when compared to the base condition. This area was highly variable as well with changes ranging from shoreline loss of 63 feet at Profile 4 to shoreline gains of 64 feet at Profile 28. When considering all locations along Bald Head Island (Profiles 0 through 218), the shoreline is presently on the average 89 feet more seaward that it was in 2000.

Typical profile plots shown in Figures 3.3 and 3.4 are taken along Bald Head's South Beach. Figure 3.3 shows Profile 61 within an area which has been prone to erosion; whereas, Figure 3.4 gives Profile 150 in the more stable area to the east. Both of these profiles received sediment associated with the initial channel dredging during the February-July 2001 time frame. Both of these areas received material during the April 2007 Corps of Engineers beach disposal operation and with the most recent Village of Bald Head Island disposal between November 2009 and March 2010. However, the second disposal in January 2005 did not extend to Profile 150. Figure 3.3 shows the widened beach berm from the initial disposal marked by maximum seaward extent of the July 2001 survey. In July 2001 the shoreline was about 80 feet seaward of the September 2000 position. From this point, the profile is shown to march progressively landward, reaching its maximum landward retreat January 2004. At this time the shoreline had retreated about 250 feet from its initial position. The nearly uniform retreat is displayed graphically in Figure 3.5. This figure shows the cumulative change in shoreline position over the 10-year monitoring period as measured from the September 2000 position. (For comparison purposes both Profile 61 and 150 are given on the chart). After reaching the maximum recession, Profile 61 remained about the same in June 2004, possibly being restrained by sand bags placed at this location. The second disposal was then added, advancing the berm and shoreline to about 25 feet beyond its September 2000 location in February 2005, where it remained stable for about 6-months. Beginning in August 2005, the disposal began once again to erode, in a manner similar to the first cycle immediately following the initial disposal. By January 2007, the shoreline was about 60 feet landward of its September 2000 position. As a result of the beach placement in April 2007, a gain occurred moving the shoreline back to near its original position being about 13 feet shy its location in 2000. The profile continued to erode following the third disposal and by May 2009 was 144 feet landward of the September 2000 base year position. With the most recent disposal placed within this area, the shoreline was extended to within 24 feet of the September 2000 position. The most recent survey of this profile (September 2010) shows that the shoreline moved further seaward and is currently only 14 feet short of the pre-project shoreline position measured in September 2000.

For Profile 150 (Figure 3.4) a much more stable behavior is evident. In this instance much of the initial disposal material has remained intact and the shoreline retreat has occurred at a slower rate. The response is clearly apparent in Figure 3.5 as well, especially when compared to Profile 61. Profile 150 actually widened some beyond the extent of the July 2001 disposal, and remained stable for about the next 2 years, at which time it experienced a much slower but progressive loss of material. After the second disposal, the shoreline gained slightly even though this profile line was outside of the limits of the disposal, indicating some dispersal of sediment by natural means. Following the third disposal, the shoreline advanced significantly to 257 feet seaward of its September 2000 position. The material has eroded much more rapidly following the third disposal with an annual loss rate of 79 feet/year, similar to the loss rate at Profile 61. The shoreline position of Profile 150 in May 2009, just prior to the Bald Head Island local disposal, remained positive being approximately 114 feet seaward of the September 2000 shoreline position. The disposal placed between November 2009 and March 2010 pushed the shoreline seaward to nearly 197 feet beyond the September 2000 initial position. Slight erosion did occur over the current period, however the shoreline at this location remains approximately 183 feet seaward of the initial pre-project condition.

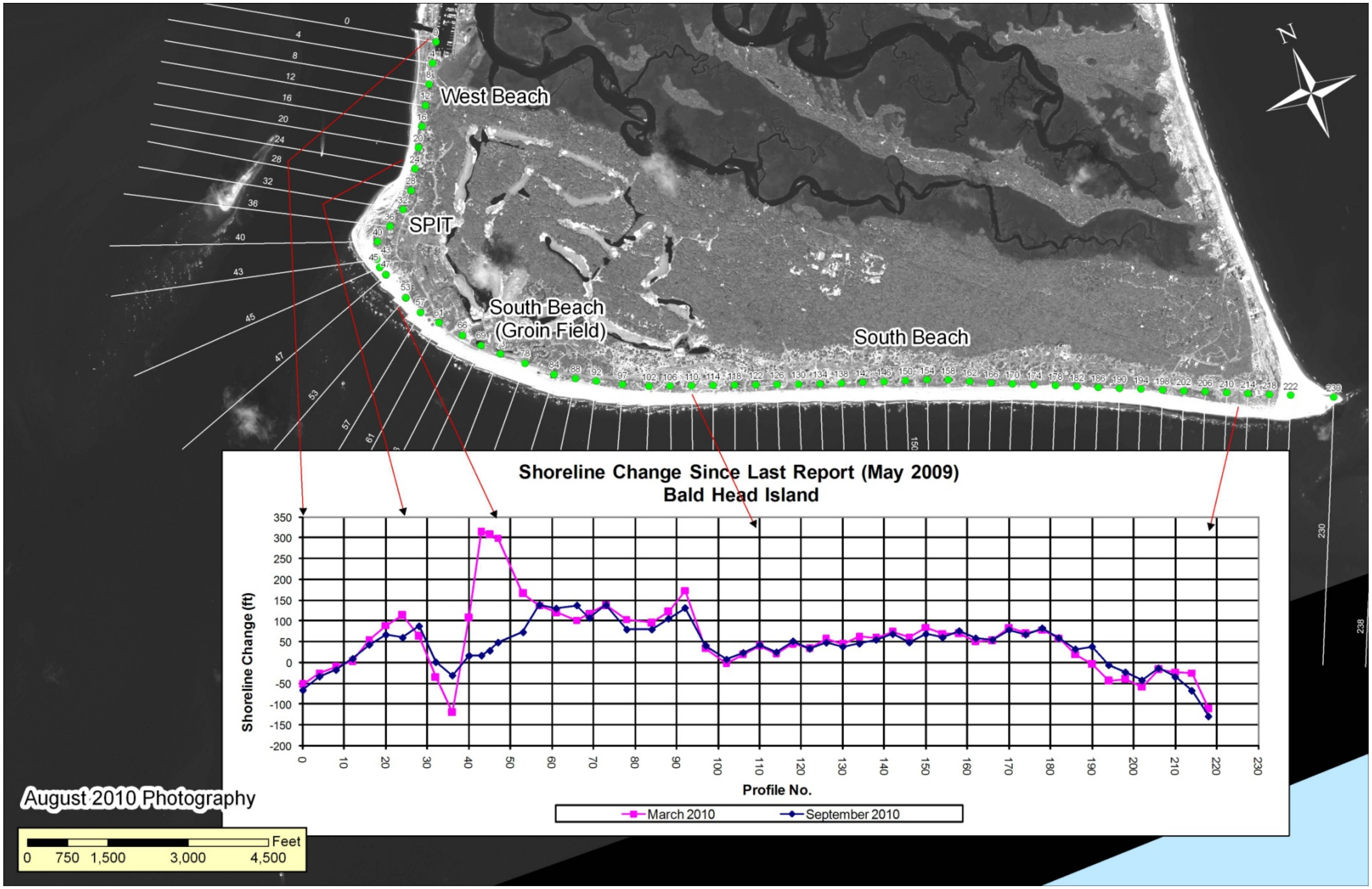


Figure 3.1 Shoreline Change Since Last Report (May 2009) Bald Head Island

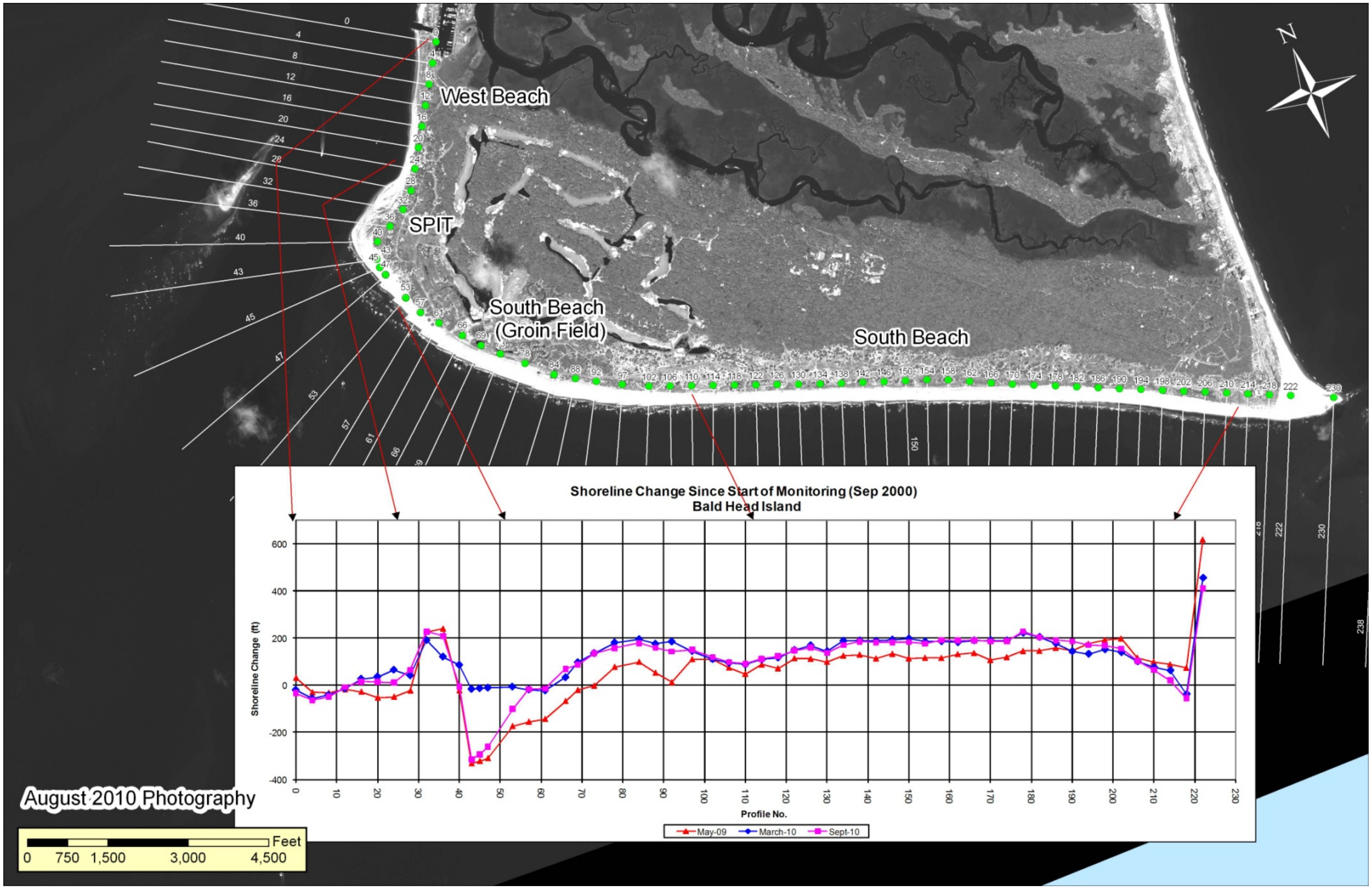


Figure 3.2 Shoreline Change Since Start of Monitoring (Sep 2000) Bald Head Island

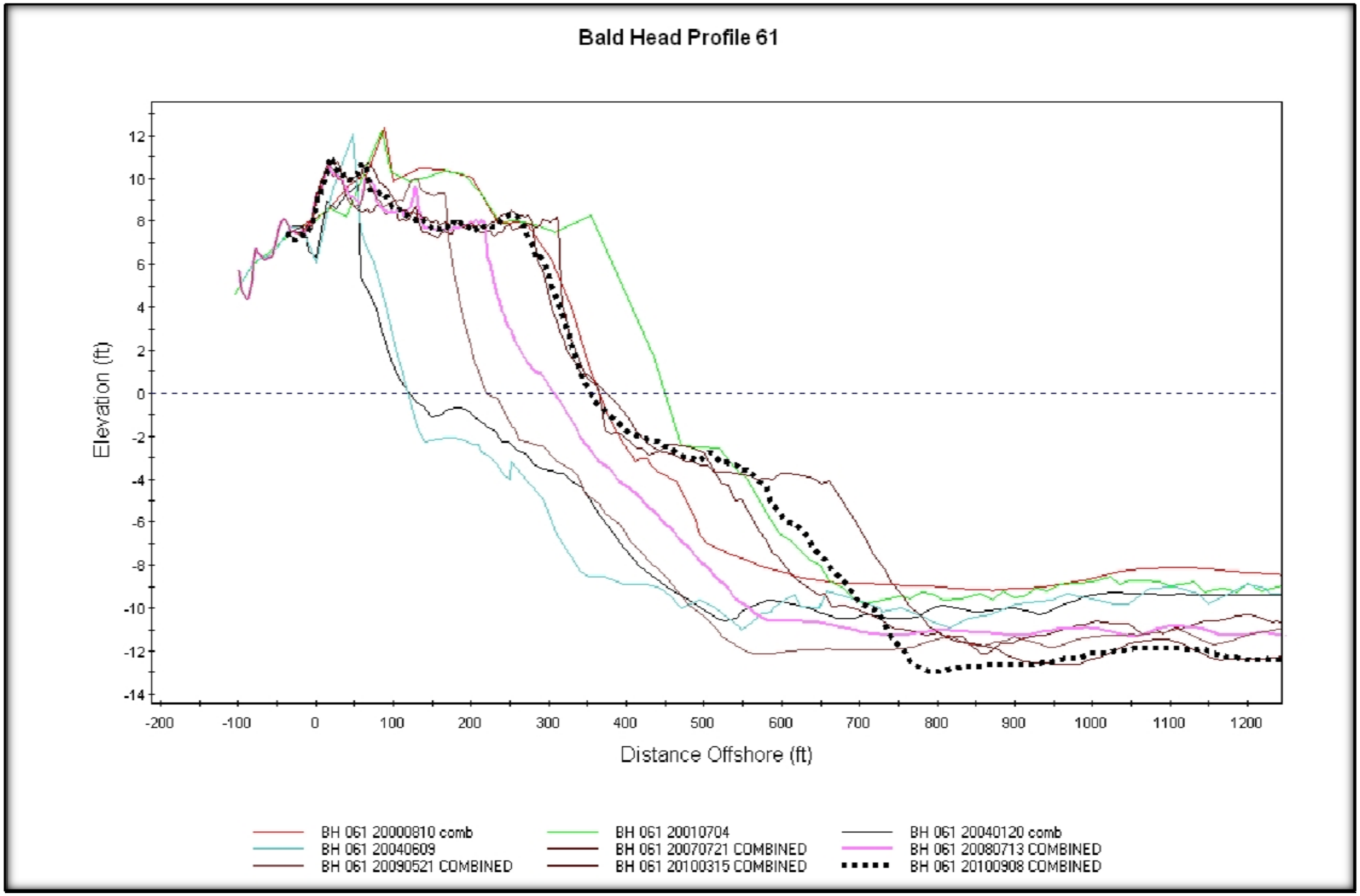


Figure 3.3 Bald Head Island Profile 061

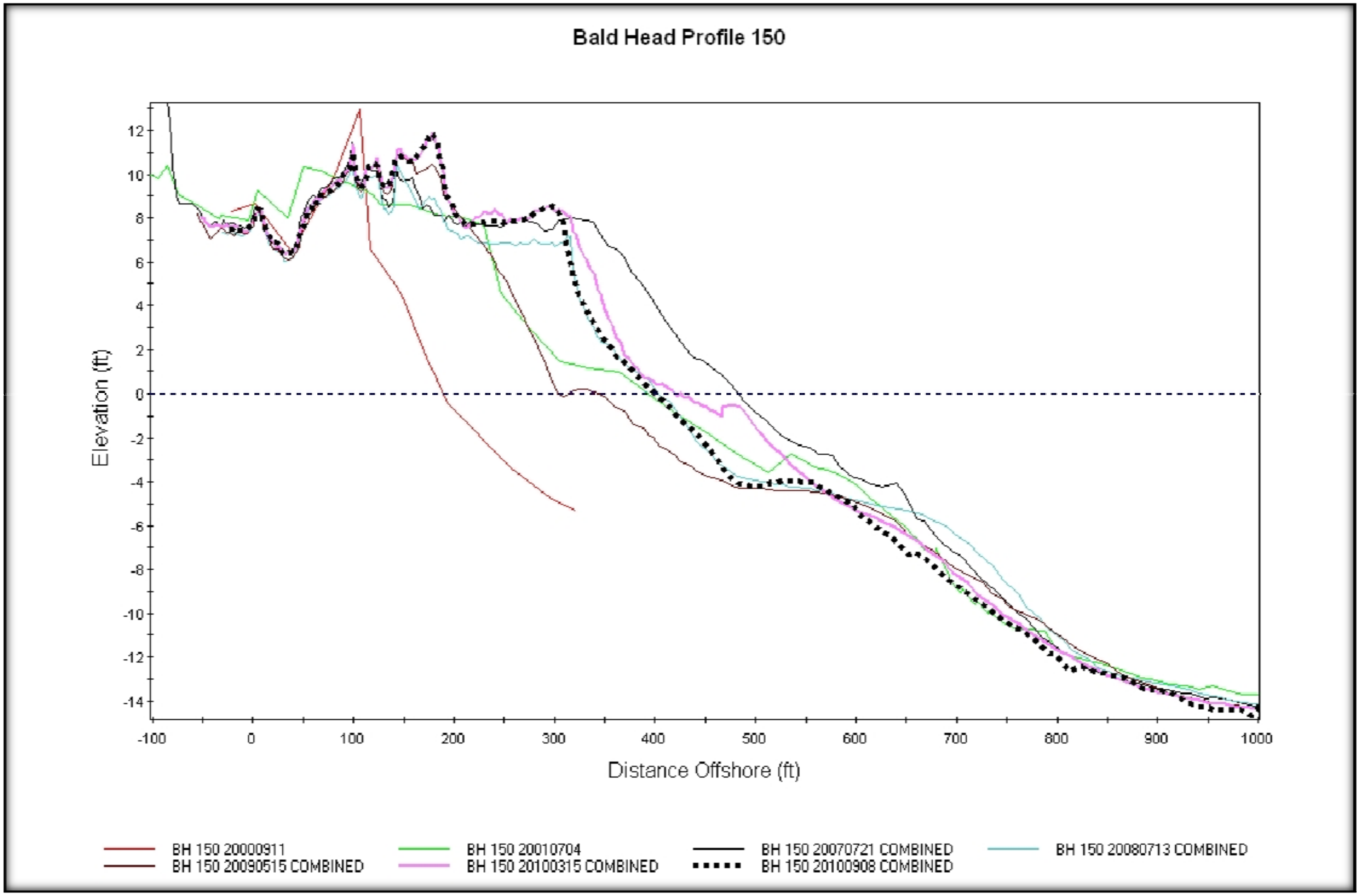


Figure 3.4 Bald Head Island 150

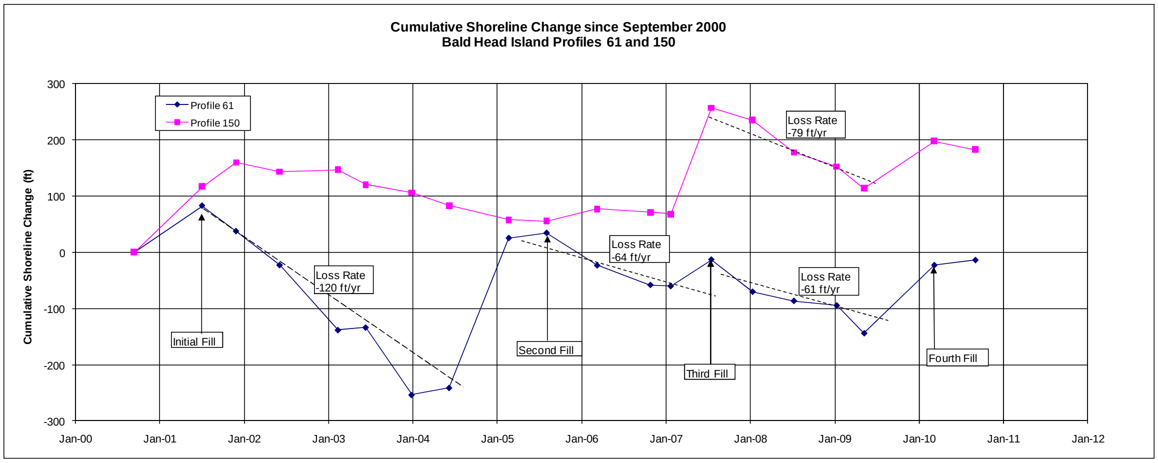


Figure 3.5 Cumulative Shoreline Changes Since September 2000

Bald Head Island Profiles 61 and 150

Oak Island. Shoreline changes measured along Oak Island over the current monitoring cycle are given in Figure 3.6 and Figure 3.7. The present monitoring period includes the March 2010 and September 2010 surveys. Figure 3.6 shows the shoreline changes relative to the May 2009 position, i.e. the last referenced location in Report 7. Figure 3.7 gives the shoreline changes with respect to the initial monitoring survey in August 2000.

With the two surveys of the present period there are now three surveys following the most recent beach disposal operation which was completed in April 2009. The disposal occurred in two zones namely between Profiles 60 and 95 and Profiles 120 to 260. These areas, as shown in Figure 3.6, show relatively high losses following the disposal which is most likely related to the diffusion of the material from the disposal area toward the adjacent beaches. Since the last monitoring period, the placement zone between Profiles 60 and 95 has eroded an average of 16 feet. The other placement area between Profiles 120 and 260 lost nearly 10 feet of shoreline. Over this same period, the western most section of the monitoring area between Profiles 250 and 310 experienced shoreline growth on the average of 18 feet. A similar increase of 20 feet in shoreline width was observed in the area between placement zones (Profiles 100 through 115). Change throughout the remaining monitoring area was more variable. When considering all profiles within the Oak Island monitoring area (Profiles 5 thru 310), the average shoreline change was a loss of approximately 4 feet for the present period of May 2009 to September 2010.

When comparing the shoreline changes back to August 2000 (i.e. the pre-project survey), Figure 3.7 shows a definite pattern of accretion at almost all locations. As shown by the September 2010 shoreline change plot, the beach has widened between 130 feet, to more than 230 feet over most locations. In fact, except for two zones on the eastern tip of the island (Profiles 5 through 20 and 35 through 50) all other profile lines have shown gains of 50 feet or more. This overall beach stability has resulted not only from the recent beach disposal, but also from the positive effect of the initial placement of disposal material in 2001, as well as, the nearby Sea Turtle Habitat Project. This latter project (also completed in 2001) was placed just to the west of the monitoring limits, but sediment has dispersed eastward into the study area. In considering all the profile data, the alongshore average shoreline position was 135 feet more seaward in September 2010 than it was in September 2000.

Typical profiles along Oak Island are given in Figures 3.8 and 3.9. Figure 3.8 shows Profile 80 within the eastern portion of the disposal area and Figure 3.9 shows Profile 220 within the western portion of the disposal area. The plot of Profile 80 shows the seaward advance resulting from the initial disposal by a period of adjustment between the September 2001 and January 2004 surveys. Following this initial adjustment period, over which about half of the berm width was eroded, the profile remained stable. The beach was widened again with the 2009 disposal to near the approximate 2001 location. Relatively little change has occurred in the profile since the renourishment in 2009. A similar response is shown in Figure 3.9 for Profile 220; however, the berm remained generally wider through January 2009 leading up to the most recent disposal. Comparisons of the May 2009 survey with the September 2010 survey show that very little erosion has occurred at this location over the current monitoring period. Plots of the cumulative shoreline changes for each of these profiles are given on Figure 3.10. For Profile 80, the shoreline has remained generally stable over the last six years following the adjustment to the initial disposal. Over this time period (between June 2002 and January 2009), the mean high water shoreline at Profile 80 has varied between about 70 and 95 seaward of its August 2000 position. Following the 2009 beach disposal, the shoreline was advanced to 168 feet beyond what it was in 2000 and has since experienced a similar adjustment to the shoreline position as it did following the initial disposal. Currently the shoreline position at Profile 80 is 144 feet seaward of the September 2000 shoreline location. For Profile 220, the shoreline has also remained relatively stable following the initial profile adjustment to the disposal; however, an erosional trend is noticeable over the period following initial placement up through the January 2009 survey. With the latest disposal, the shoreline was pushed seaward to a point which was 185 feet beyond its initial location in 2000. The profile has eroded only 5 feet over the current monitoring period and is currently 180 feet seaward of its initial pre-project position.

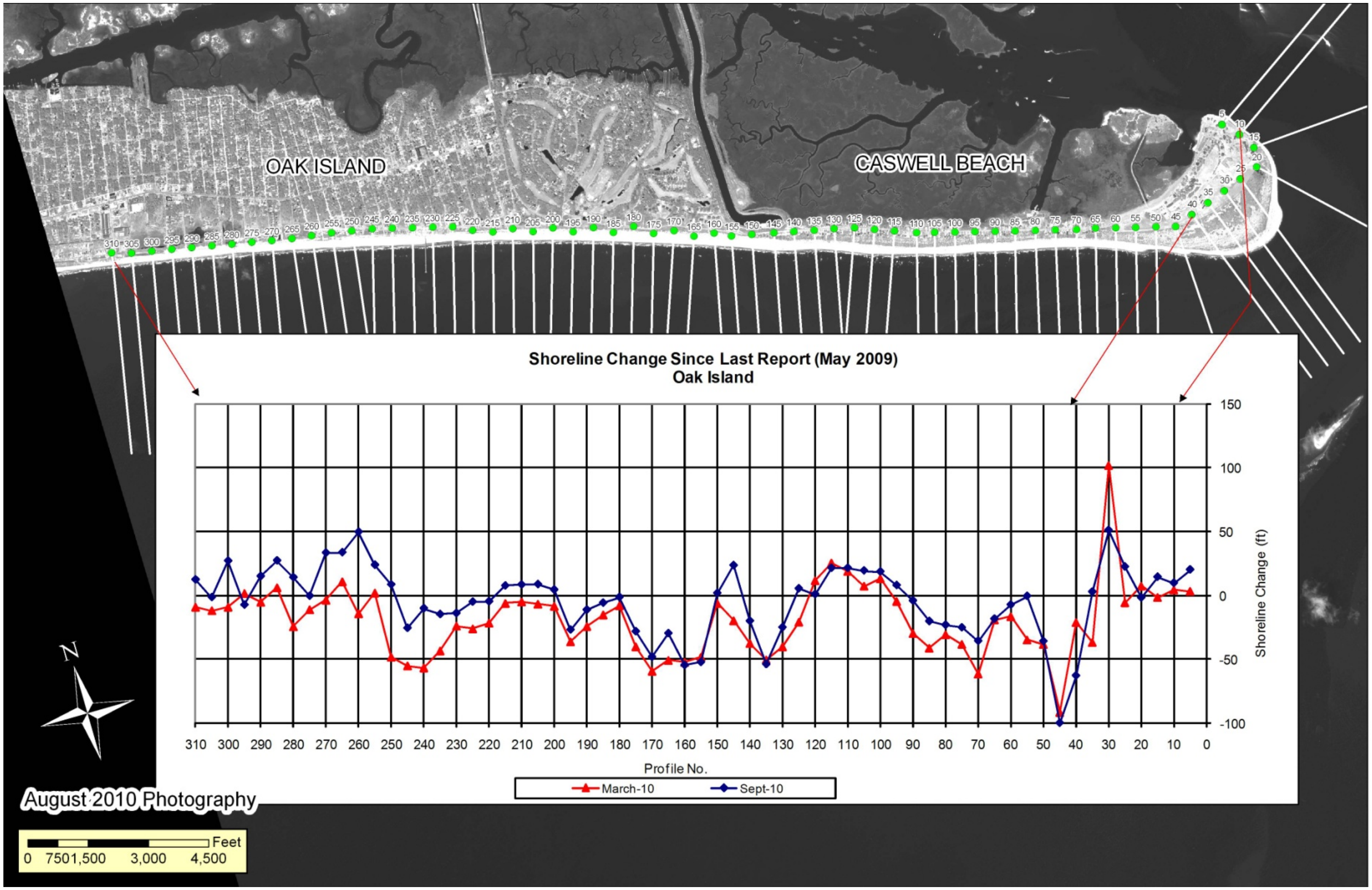


Figure 3.6 Shoreline Change Since Last Report (May 2009) Oak Island

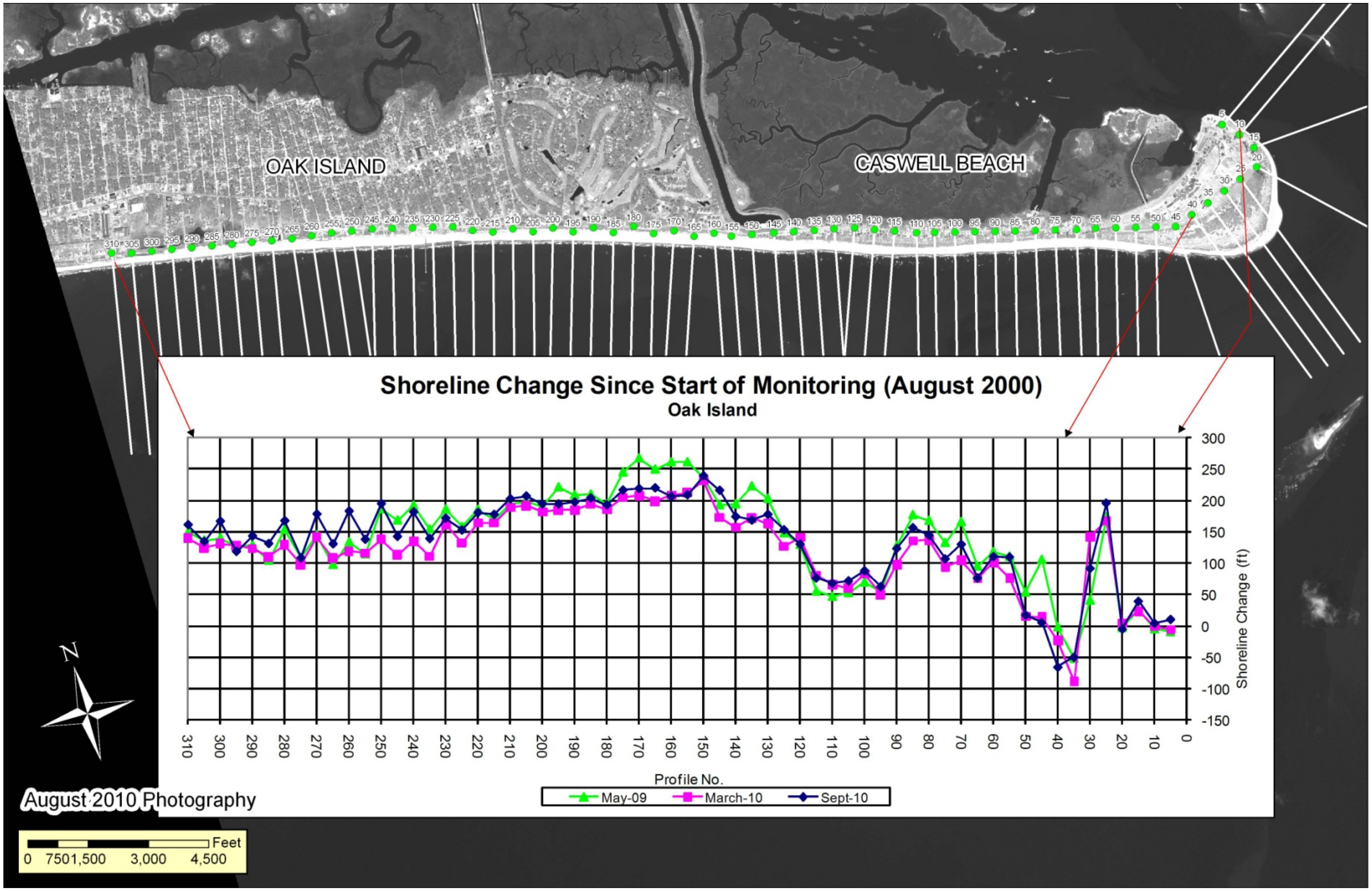


Figure 3.7 Shoreline Change Since Start of Monitoring (August 2000) - Oak Island

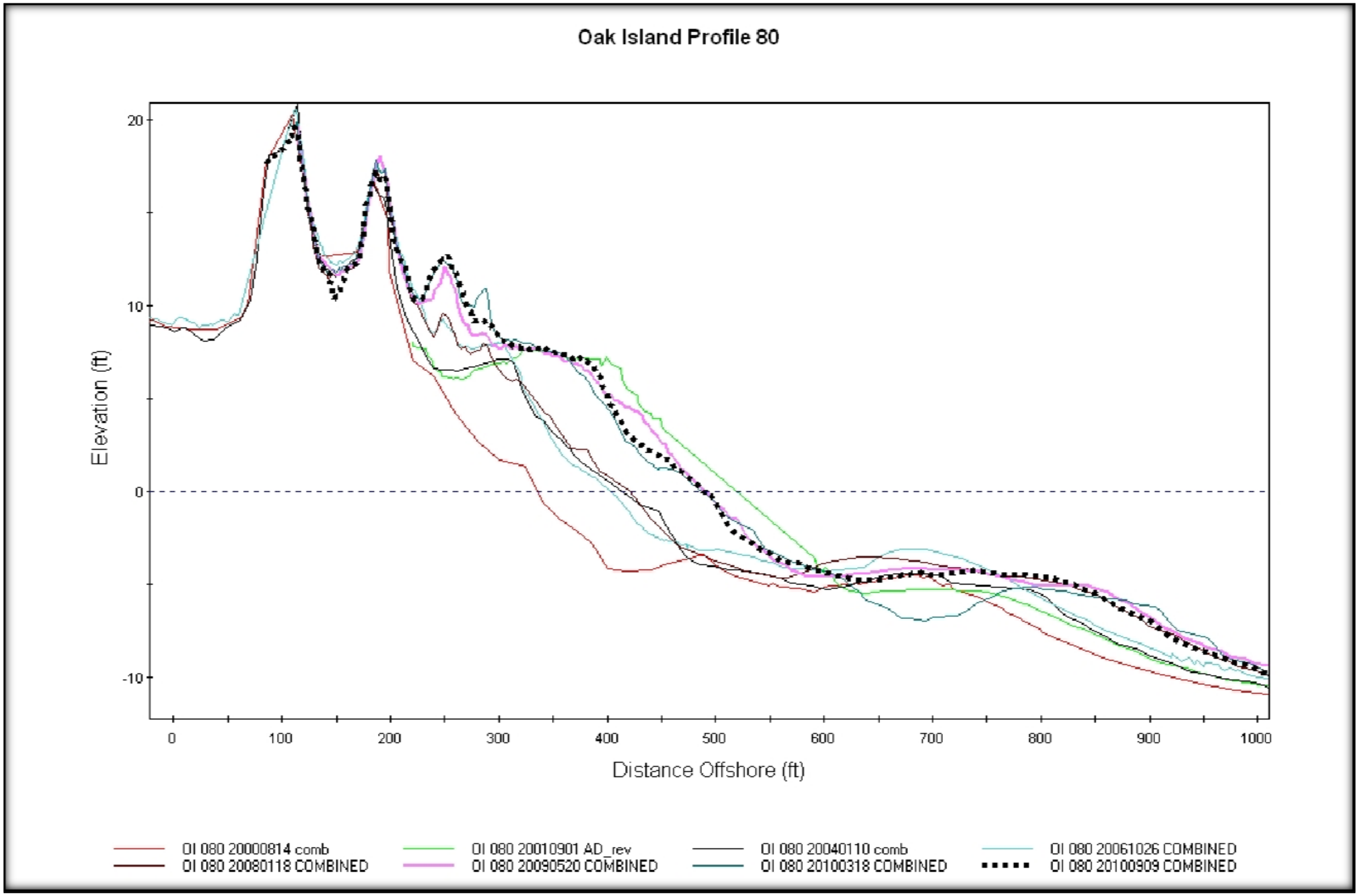


Figure 3.8 Oak Island Profile 80

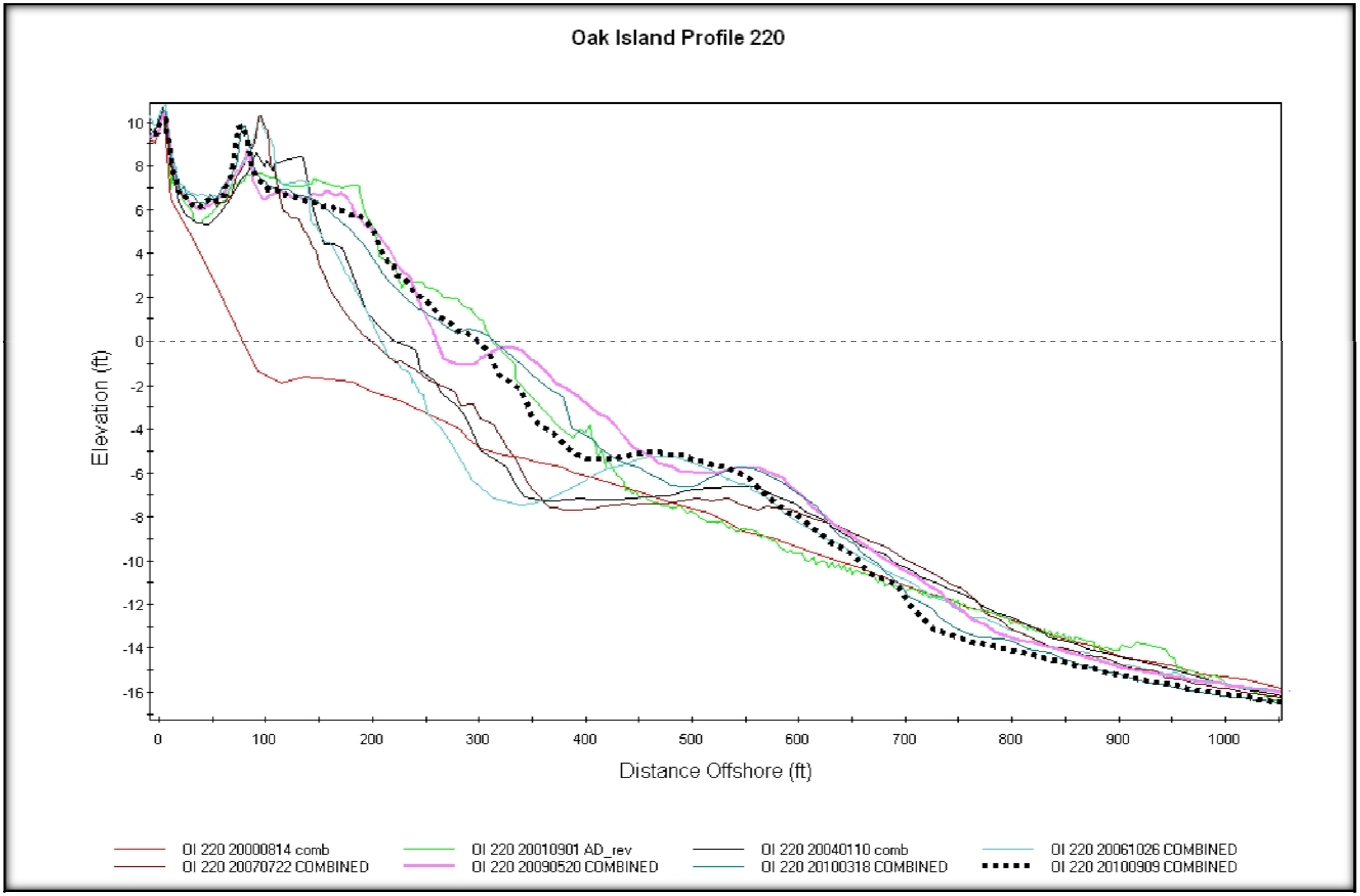


Figure 3.9 Oak Island Profile 220

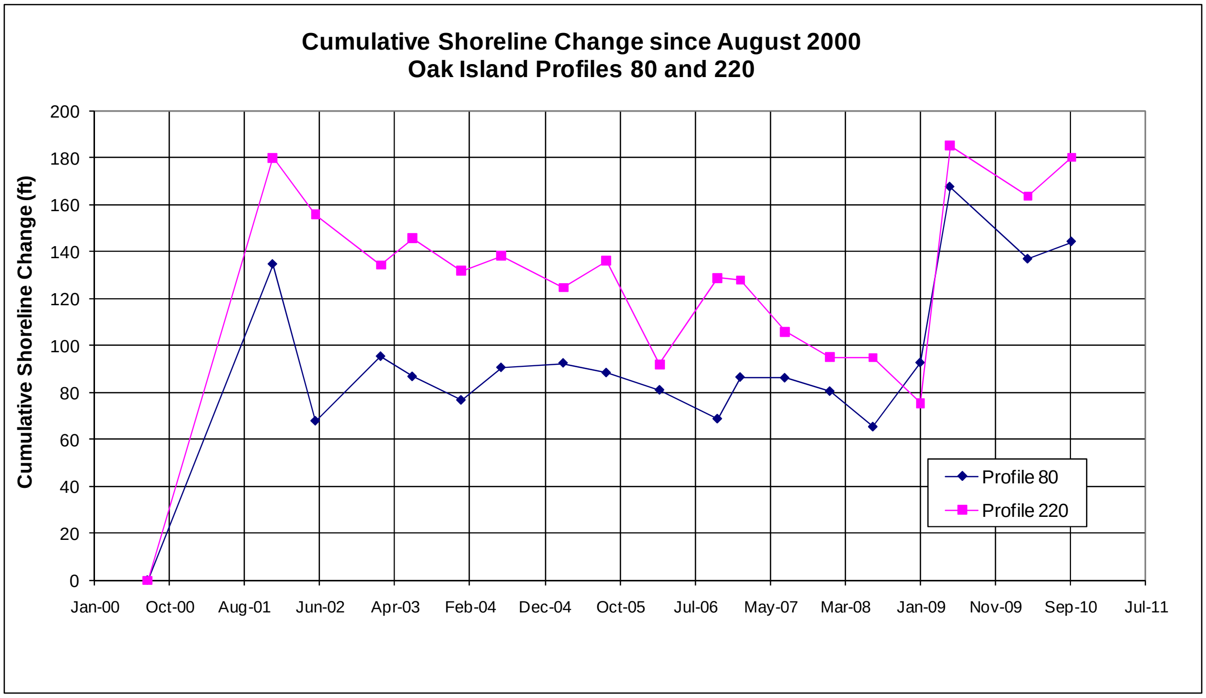


Figure 3.10 Cumulative Shoreline Change Since August 2000

Oak Island Profiles 80 and 220

Beach Profile Analysis-Volumetric Change

General. The analysis of each beach profile also included volumetric changes over time. As with the shoreline change data, the volumetric changes are made relative to the last report and also since the start of the project. Volumes are computed from both the onshore beach profile surveys (i.e. to wading depth) and from total surveys covering both the onshore and offshore areas. The onshore volumes are calculated from a common stable landward point to an elevation down to –2 ft NGVD. The offshore volumes are computed to an observed closure depth for each profile line. The volumes are calculated using the BMAP program where unit volume changes are computed for each profile. The average area end method is then used between profile locations in computing the volume over the length of the respective islands.

The current monitoring cycle includes two complete beach surveys, both of which covered the onshore and offshore portions of the profile. As noted previously, the surveys were accomplished in March 2010 and September 2010 with coverage along both Bald Head and Oak Islands.

Bald Head Island. The onshore volumetric changes measured along Bald Head Island over the current monitoring cycle are given in Figures 3.11 and Figures 3.12. Figure 3.11 shows the volumetric changes relative to the May 2009 onshore survey, i.e. the last referenced onshore survey in Report 7. Figure 3.12 gives the volumetric changes with respect to the start of the monitoring program in September 2000.

The pattern of onshore volumetric changes shown in Figure 3.11 for Bald Head Island (since the last report) generally follow those of the reported changes in the mean high water shoreline. As such, most of the profile locations show gains over the current period related to the recent beach disposal activity on the island between November 2009 and March 2010 with the placement zones showing the most dramatic gains in volume. These areas (Sta. 12+00 through 28+00 and 39+60 through 162+00) combined for a gain of about 404,600 cubic yards. The greatest portion of this onshore volumetric gain was contained within the westernmost portions of South Beach with a peak gain occurring in the vicinity of Profile 73 with respect to the September 2010 survey. However, there was a significant loss of onshore material measured between the March and September 2010 surveys included in Monitoring Report 8. The area between Profile 36 and 57 lost nearly 91,000 cubic yards of material over the 177 days that separated the surveys which is a rate of approximately 516 cubic yards per day. The large erosion rate measured within this hot spot area occurred more than a year following the 2009 dredging event within the adjacent navigation channel. This loss rate is most likely a result of the equilibration of the large quantities of material that were directly placed into this hot spot area adjacent to the navigation channel. At the end of the current monitoring period there were only three areas along the entire island that experienced volumetric loss. The first area was the northern end of West Beach, Profiles 0 and 4, which lost nearly 6,000 cubic yards. The second area was located at Profile 32 which had minor losses of less than 2,000 cubic yards. The final area was at the extreme eastern end of the island from Profile 202 to Profile 214. This area was the largest of the three, however, losses were still relatively minor totaling just under 10,000 cubic yards. In considering the total onshore volume changes for all profiles over the current monitoring cycle, approximately 471,000 cubic yards of material were gained between May 2009 and September 2010.

The results of the onshore beach profile analysis surveys since the start of the monitoring in August/September 2000 are given in Figure 3.12. This graph shows that while the majority of the island has experienced net gains over the last 10 years, some areas are eroding. The two areas that experienced onshore losses since the beginning of the project are along the northern end of West Beach (Profiles 0-8) which lost approximately 12,600 cubic yards, and along an area that covers part of the spit and the west end of South Beach (Profiles 40-61). This area lost nearly 134,200 cubic yards of sand since the start of the monitoring program.

To illustrate the overall trends in volume change, Figure 3.13 shows a plot of cumulative volume changes over time with respect to the August/September 2000 survey. The graph includes not only the onshore volumes (i.e. above –2 ft NGVD) but also the offshore volumes (below –2 ft NGVD) and total onshore/offshore volumes (discussed in the following paragraphs). In each case, the volumes for each survey are total summations over the entire island. With respect to the onshore volumes, the graph indicates the steady volumetric loss following the November 2001 post placement survey. By the June 2004 survey, the total onshore volume becomes slightly negative indicating an overall loss of about 48,300 cubic yards (above –2-feet NGVD) compared to the 2000 survey. With the second disposal (January 2005), this trend is reversed showing total onshore volumes of around 500,000 cubic yards with the August 2005 surveys. After this disposal an overall moderate loss was recorded up to the February 2007 date followed by the substantial increase with the disposal in 2007. The volume measured in the onshore portion of the profile totaled nearly 964,000 cubic yards of sand using the July 2007 survey, which was the first monitoring survey following the third disposal. By May 2009, just prior to the beach disposal initiated by the Village of Bald Head Island, the overall gains in onshore volumes measures 409,000 cubic yards when compared to pre-project conditions. The two surveys taken since the beach disposal initiated in 2009 indicate that a similar pattern of erosion following beach placement is occurring. The most recent survey in September 2010 shows that the cumulative change for the onshore portion of the profiles throughout the island is approximately 879,600 cubic yards greater than the September 2000 pre-project conditions.

Total volumetric changes computed over the entire active profile are given in Figures 3.14 and 3.15 for Bald Head Island. Figure 3.14 shows volume changes relative to the latest survey contained in Report 7 (May 2009); whereas, Figure 3.15 gives changes relative to the August 2000 survey at the beginning of the monitoring. For each profile comparison, volumes were computed from a common stable landward point to an observed closure depth offshore.

Figure 3.14 shows, that as indicated previously with the onshore volumes, the total volume changes are dominated by volumetric increases in the areas where disposal material was placed between November 2009 and March 2010. In addition, the majority of areas beyond the disposal limits were positively influenced by the diffusion of the disposal into these areas and show volumetric increases. The most recent survey in September 2010 indicates that almost all profiles within the monitoring area show gains relative to May 2010 with the only exception being Profile 210. In summing the changes over the entire monitoring area, the gains total to approximately 1,113,000 cubic yards of material since May 2009. The most significant volumetric increases occurred within the disposal limits, as expected. The disposal area between Station 12+00 and 28+00 increased approximately 76,000 cubic yards and the disposal area between Station 39+60 and 162+00 gained nearly 963,000 cubic yards. Comparing these combined volumes (1,039,000 c.y.) to the reported volume placed in the area (1,594,553 c.y.) indicates that approximately 35% of the material placed has moved out of the initial disposal limit areas.

When comparing the changes in total profile volume back to the initiation of the project given in Figure 3.15, the majority of Bald Head Island has gained material over the last 10 years. The most substantial increases continue to be found along the eastern half of South Beach and in the vicinity of the spit, which is consistent with previous monitoring reports. Elsewhere, there are three relatively small areas which have recorded net overall losses for the period. One is located at the extreme eastern end of South Beach, where some losses have occurred near the cape. Another is a single profile on South Beach that is just east of the new groin field, which recorded minor losses. The third area spans two stations from Profile 53 to 51, within the groin field area of South Beach. Previous reports have noted erosion zones along this section of South Beach up to several thousand feet long. However, due to the most recent disposal effort, this volumetric loss zone has been reduced to less than 1,000 feet. Volumetrically this erosive region has lost about 318,000 cubic yards to date. This reduction in the magnitude and extent of volumetric loss throughout this area is related to the recent disposal activity in the area, as well as, the reconstruction of the groin field along this section of South Beach. Groin field performance is discussed in detail in the Groin Field Performance section of this report; however, reconstruction of this groin field should stabilize or reduce volume loss in this chronically eroding area. The net volume change over the entire monitoring area is a gain of nearly 1,231,000 cubic yards as of September 2010 with respect to the beginning of the monitoring in 2000.

Listed in Table 3.1 are the computed volume changes for Bald Head Island for each survey separated into the specific reaches. These reaches were determined in prior reports based on similar physiographic characteristics, namely West Beach (Profiles 0-24), the spit area (Profiles 32-45), South Beach-West Portion (Profiles 53-106), South Beach-East Portion (Profiles 114-194) and the Cape area (Profiles 198-218). The portion of the spit and South Beach West contain the reconstructed groin field. Of the five reaches, two are showing net losses and the remaining three have gained to date. The two areas showing an overall net loss since August 2000 are the South Beach-West Portion and the area near the Cape. Both of these areas have shown a large degree of variability over the last 10 years. The western portion of South Beach has gone through cycles of accretion and erosion controlled by the 2001, 2005, and 2007 beach disposals, as well as the 2009 beach renourishment by the Village of Bald Head Island which covered this area. The large variability for the Cape area reflects the highly dynamic nature of this physiographic feature. Coupled with the gains measured within the three other reaches of West Beach, the spit, and the eastern portion of South Beach, the beaches of Bald Head have 1,231,000 cubic yards more at this time than in

2000 at the start of the project. This is also indicated in previously mentioned Figure 3.13 that shows the cumulative volume changes over time for the island.

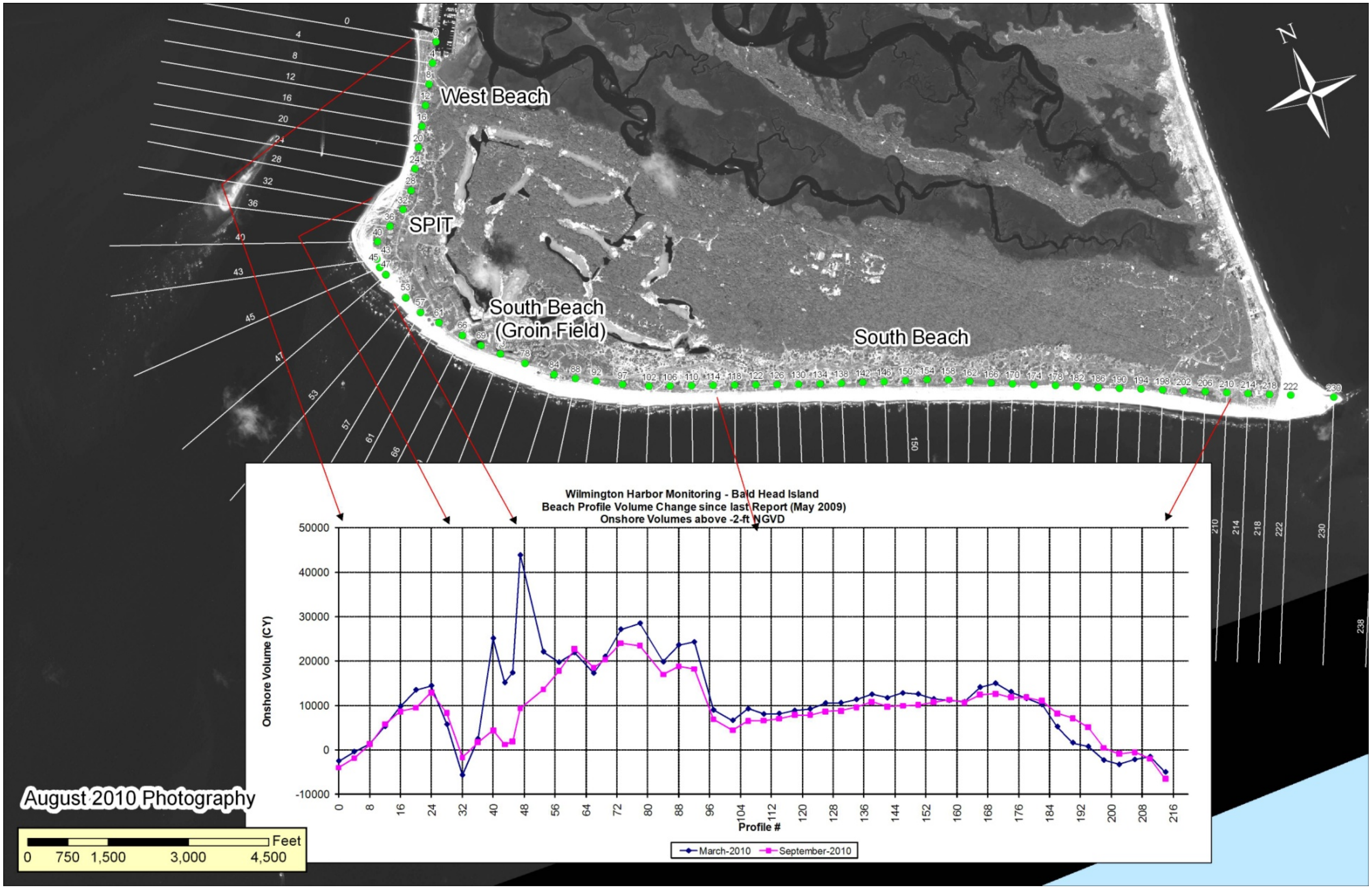


Figure 3.11 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change Since last Report (May 2009) Onshore Volumes above –2 ft NGVD

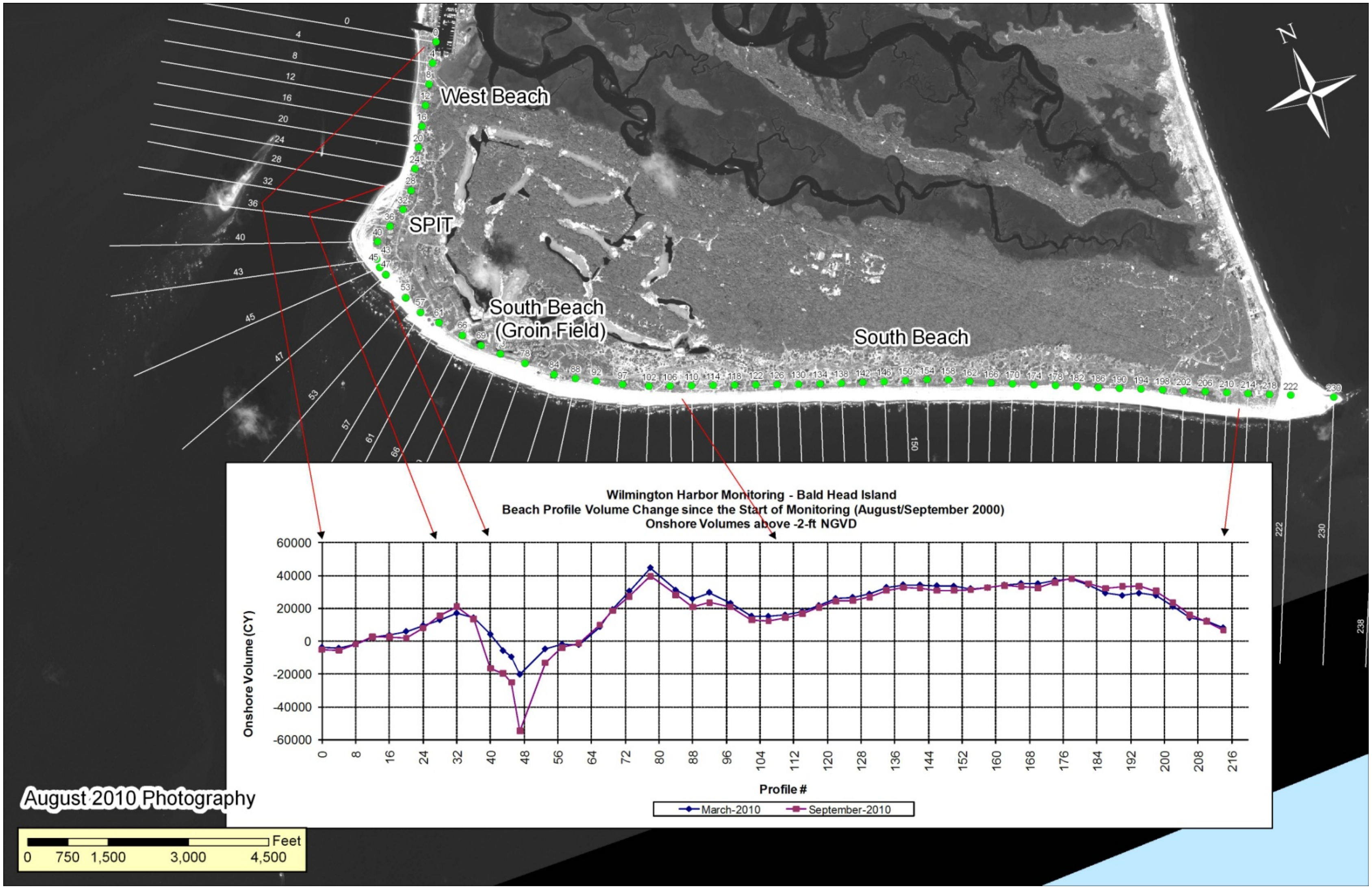


Figure 3.12 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change since Start of Monitoring (August/September 2000) Onshore Volumes above –2 ft NGVD

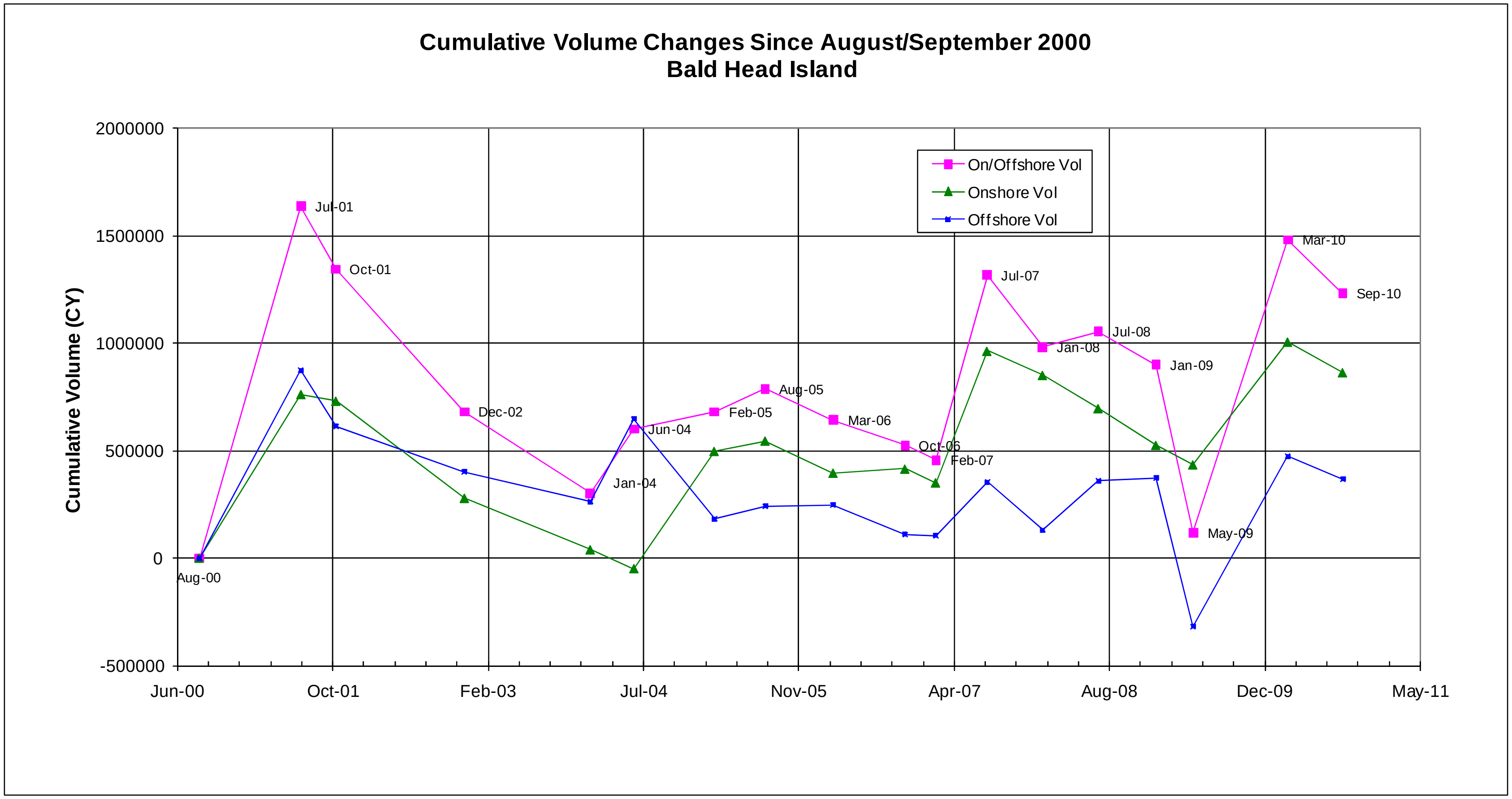


Figure 3.13 Cumulative Volume Changes Since August/September 2000 for Bald Head Island

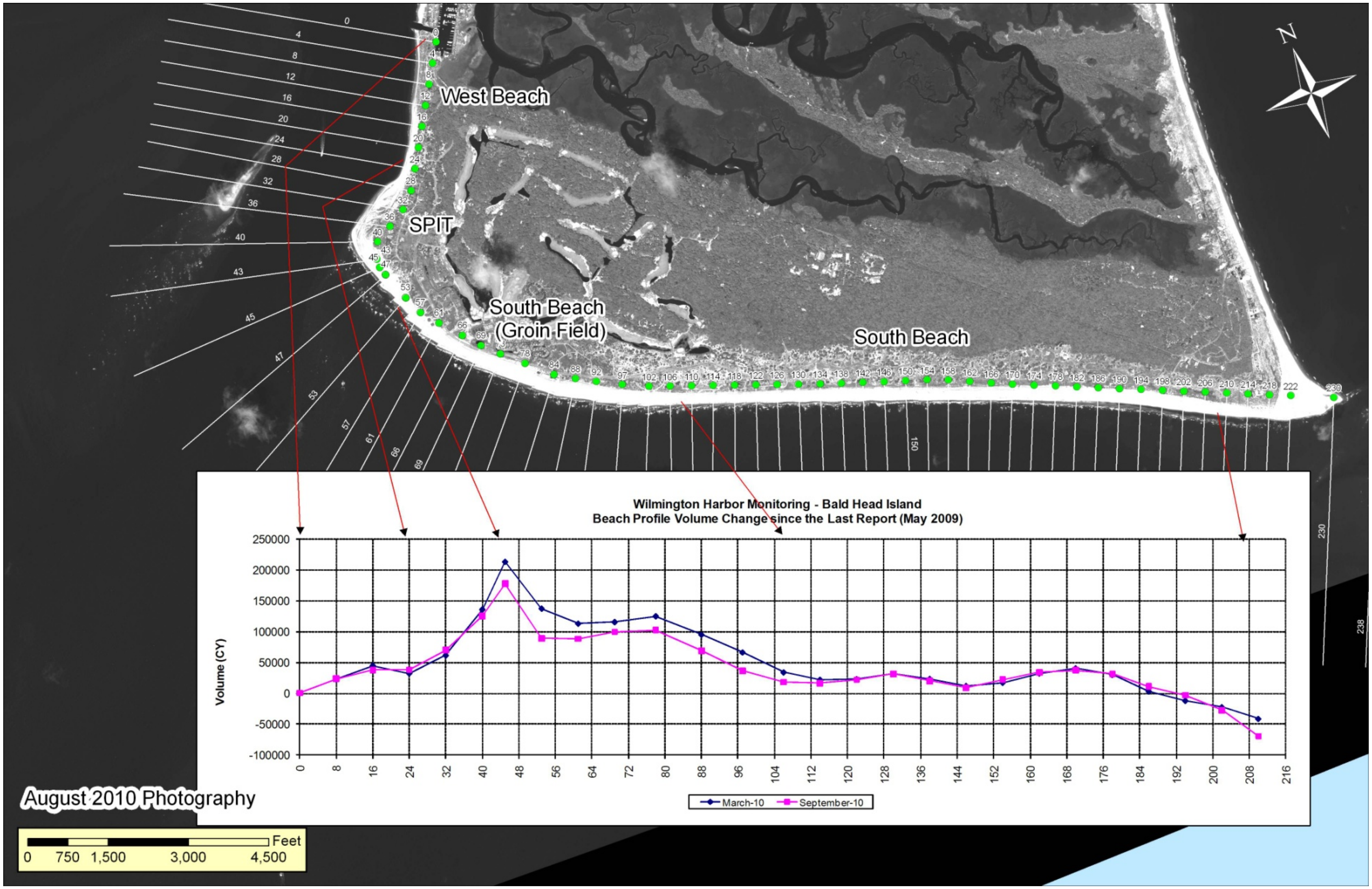


Figure 3.14 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since Last Report (May 2009)

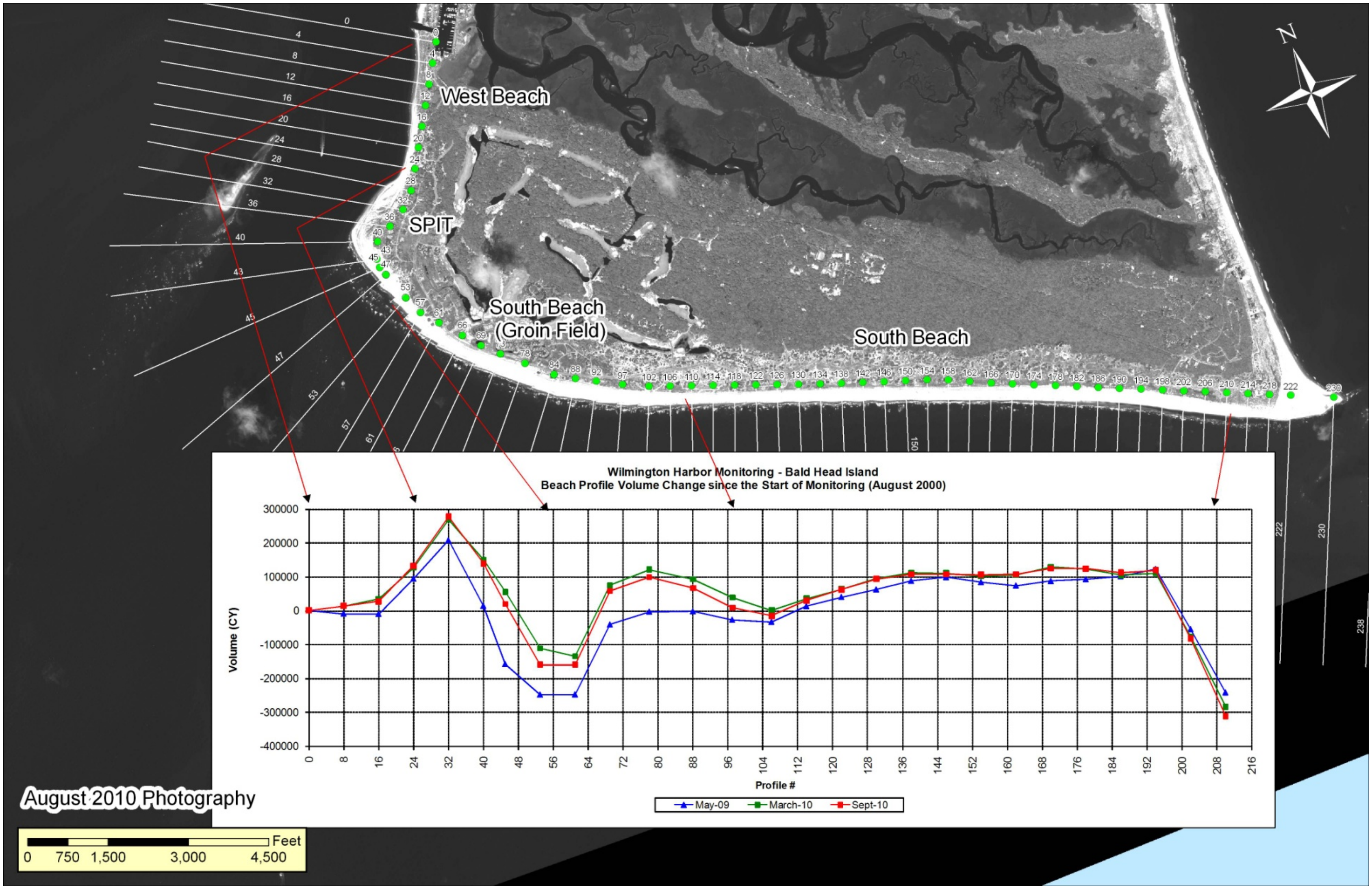


Figure 3.15 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since the Start of Monitoring (August 2000)

TABLE 3.1 Total Volume Changes Along Bald Head Island Since August 2000 (cubic yards)

Location	July-01	October-01	December-02	January-04	June-04	February-05	August-05	March-06	October-06	February-07	July-07	January-08	July-08	January-09	May-09	March-10	September-10
West Beach (Profiles 0 - 24)	0	3,048	29,564	11,618	1,854	14,646	34,221	113,468	166,722	111,871	106,678	97,715	101,369	87,863	77,730	178,739	177,870
Spit (Profiles 32 - 45)	145,509	54,159	-31,546	250,297	303,507	88,229	152,494	270,403	236,708	216,348	224,456	271,896	331,928	253,983	65,297	476,535	438,645
South Beach-West Portion (Profiles 53 - 106)	319,882	251,137	-91,457	-462,106	-406,485	192,205	187,910	-206,714	-274,592	-246,745	-133,383	-297,262	-277,827	-306,639	-600,063	87,853	-96,371
South Beach-East Portion (Profiles 114 - 194)	1,166,870	1,065,270	887,997	671,808	787,235	624,679	632,903	504,521	457,576	446,455	1,214,278	1,077,662	1,113,637	1,068,978	870,990	1,097,676	1,103,685
Near Cape (Profiles 198 - 218)	-538,703	-29,536	-113,416	-169,758	-85,524	-238,965	-220,972	-46,246	-62,096	-71,646	-95,284	-168,045	-214,328	-204,716	-296,089	-359,406	-392,843
Total	1,093,558	1,344,078	681,143	301,859	600,586	680,794	786,557	635,431	524,318	456,283	1,316,745	981,966	1,054,778	899,470	117,865	1,481,398	1,230,985

Oak Island. The onshore volumetric changes measured along Oak Island over the current monitoring cycle are given in Figures 3.16 and Figures 3.17. Figure 3.16 shows the volumetric changes relative to the May 2009 survey, i.e. the last referenced onshore survey in Report 7. Figure 3.17 gives the volumetric changes with respect to the start of the monitoring program in August 2000.

The patterns of onshore volume changes given in Figure 3.16 for Oak Island (since the last report) show that the area was relatively stable with some signs of diffusion of material from areas where disposal material was placed between January and May 2009 to the adjacent beaches. The disposal activity placed approximately 1,064,400 cubic yards of material along Oak Island with 123,000 cubic yards of material placed between profiles 60 and 95 and 941,000 cubic yards between profiles 120 and 260. Examining the onshore volumes within the placement zone between profiles 60 and 95 shows that this area has actually accreted beyond the May 2009 survey of Report 7, with volumetric increases of approximately 18,000 cubic yards. The onshore volumes within the second placement zone, Profiles 120-260, shows relatively minor losses of approximately 9,500 cubic yards. Cumulatively, the onshore portion of the profile measured over the entire length of the monitoring area shows an increase of material of nearly 65,000 cubic yards between May 2009 and September 2010.

The results from the onshore beach profile surveys obtained since the start of the monitoring in August 2000 are given in Figure 3.17. This graph includes the last three surveys, namely May 2009, March 2010 and September 2010. The figure shows that all areas have gained sediment within the onshore except for two profiles (35 and 40) at the east end of the island. Profile 35 was noted in the previous monitoring reports as having lost material. This area has continued to lose material and has now widened to include profile 40, which has fluctuated over the life of the monitoring report between positive and negative volumetric change. Profile 5 which has shown volumetric losses for the majority of the monitoring period has gained material since the last monitoring period and now is slightly positive relative to August 2000. Overall, these data reflect the positive impact of the beach disposals placed in 2001 and 2009, as well as the general stability of these disposals over the past 10 years.

To further illustrate the stable nature of the Oak Island beaches over the last 10 years of monitoring, Figure 3.18 shows a plot of cumulative volume changes over time with respect to the August 2000 survey. Both the onshore and combined onshore/offshore changes (discussed in the following paragraphs) are plotted on the graph. In each case, the volumes for each survey are total summations covering all profiles included in the monitoring plan (approximately 5.9 miles). With respect to the onshore volumes, the graph indicates the large increase resulting from the beach disposal as marked by the December 2001 survey, with a total onshore volume of 926,000 cubic yards. Over the next seven or so years, the onshore volume is seen to undergo mild fluctuations most likely related to seasonal response to changes in wave climate. The remaining total onshore volume just prior to the 2009 placement was roughly 880,700 cubic yards, which represents a loss of approximately 4.9% from the 926,100 cubic yards that was placed in December 2001. With the recent placement of 1,064,400 cubic yards of material along Oak Island as previously described, the onshore volume over the entire monitoring area increased approximately 708,000 cubic yards by September 2010. The most recent beach placement brings the total measured increase of onshore material to 1,588,000 cubic yards relative to the August 2000 base condition survey.

Total volumetric changes computed over the entire active profile are given in Figures 3.19 and 3.20 for Oak Island. Figure 3.19 shows volume changes relative to the latest survey contained in Report 7 (May 2009); whereas, Figure 3.20 gives changes relative to the August 2000 survey at the beginning of the monitoring. For each profile comparison, volumes were computed from a common stable landward point to an observed closure depth.

As displayed in Figure 3.19, the vast majority of profiles (28 of the 33 lines) have eroded since the end of the previous monitoring report. While there is some fluctuation between the volumes measured for the surveys included in the current monitoring period (March 2010 and September 2010), the general trends between the profile responses are very similar. The only exception is within the inlet profile section, Profile 20, where a significant volumetric increase is observed in the September 2010 survey. Upon closer inspection of the profile cross sections, the increase is predominately in the offshore portion of the profile which explains why no significant shoreline change was measured at this profile earlier in this report. The overall change at the conclusion of the current monitoring period was erosive, with a total loss of approximately 377,000 cubic yards since May 2009 over the entire monitoring area.

As with the onshore volumes discussed previously, the total (onshore+offshore) profile volume changes have been generally positive. Figure 3.20 shows the volume changes for last three onshore/offshore surveys relative to the August 2000 pre-project survey. In this regard, all reported volume changes are positive with the exception of 5 profiles along the eastern end of the island which show relatively minor losses. Significant volumetric loss occurred in the areas that received beach disposal material in 2009 between the May 2009 and March 2010 survey. The pattern of volumetric change prior since March 2010 appears to be relatively similar indicating that the initial losses were predominately due to profile equilibration of the newly placed material. Measured volumes for the entire monitoring area with the September 2010 survey totaled nearly 2,035,000 cubic yards greater than what was measured in August 2000. This is only slightly less than the total volume placed along the island in both the 2001 and 2009 beach placement operations which totaled 2,246,200 cubic yards.

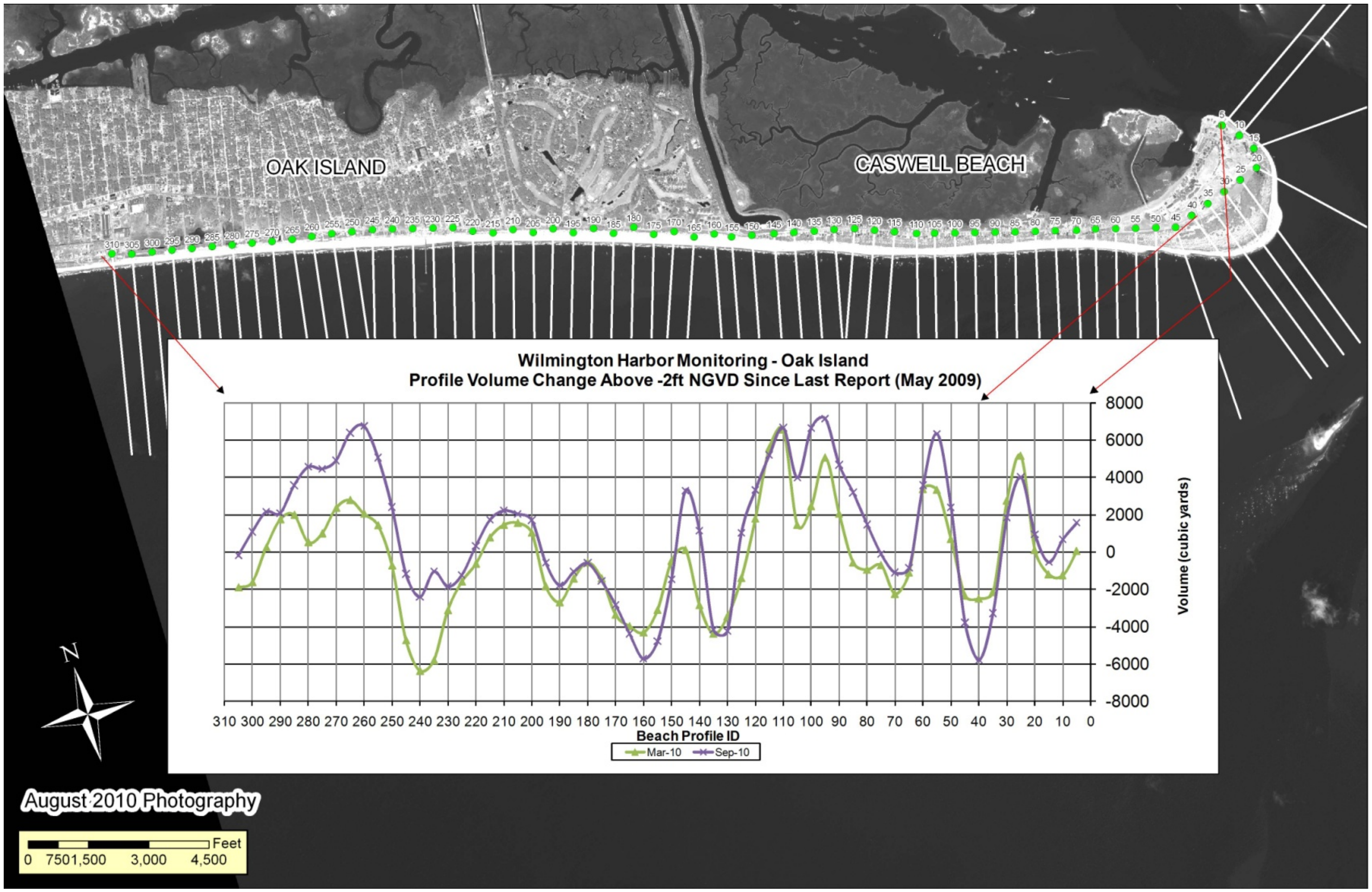


Figure 3.16 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change Since Last Report (May 2009) Onshore Volumes above – 2 ft NGVD

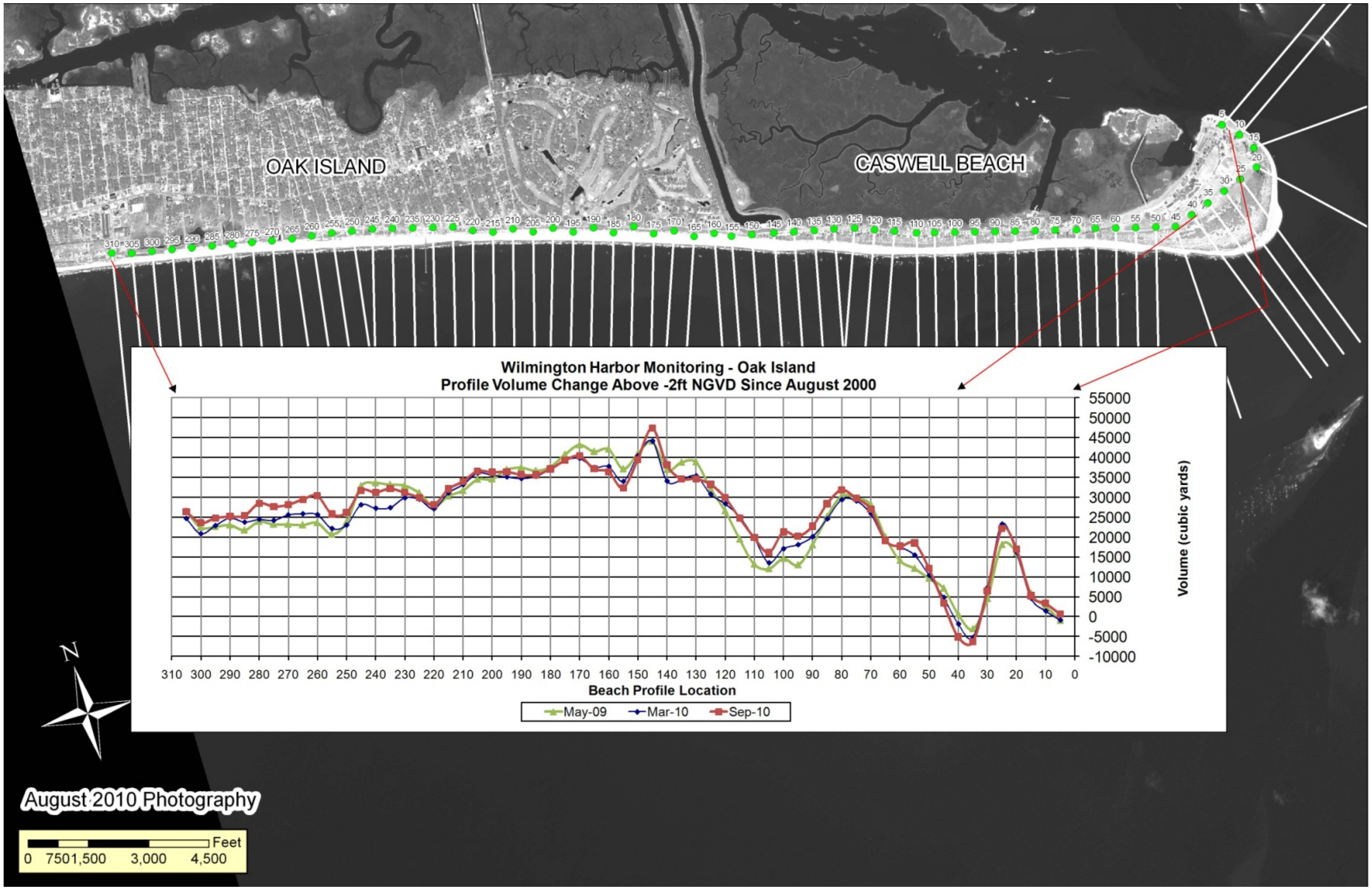


Figure 3.17 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change since Start of Monitoring (August 2000) Onshore Volumes above –2 ft NGVD

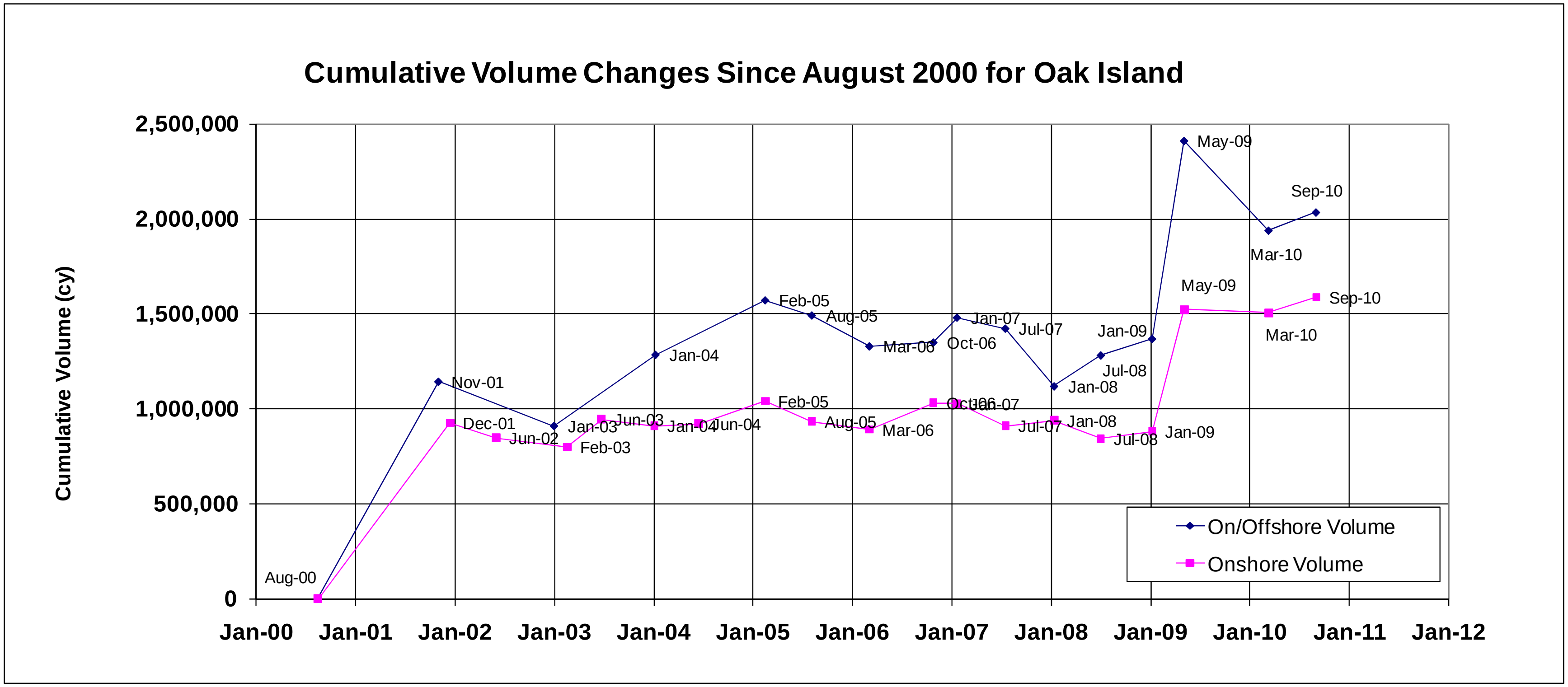


Figure 3.18 Cumulative Volume Changes Since August 2000 for Oak Island

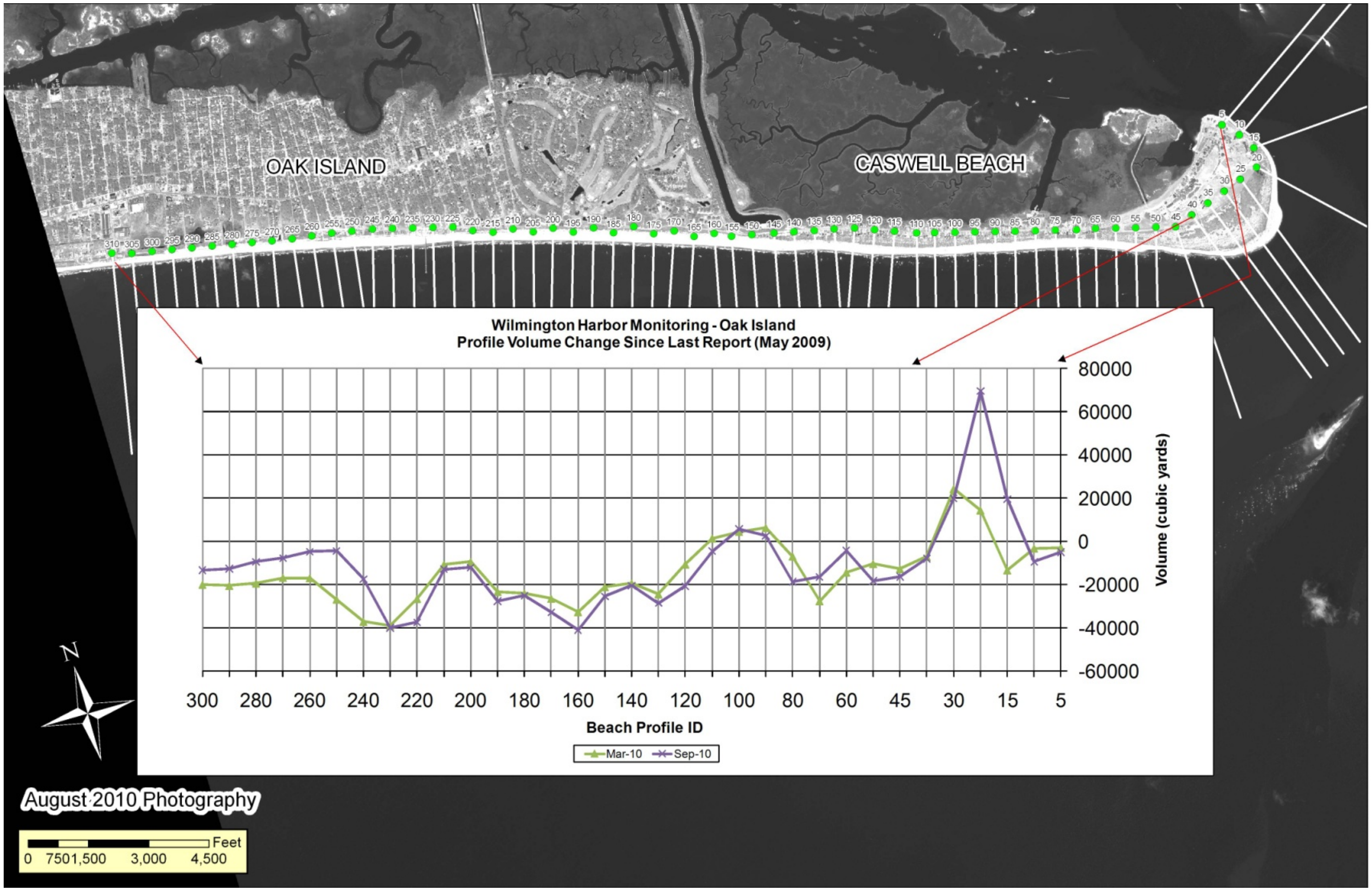


Figure 3.19 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since Last Report (May 2009)

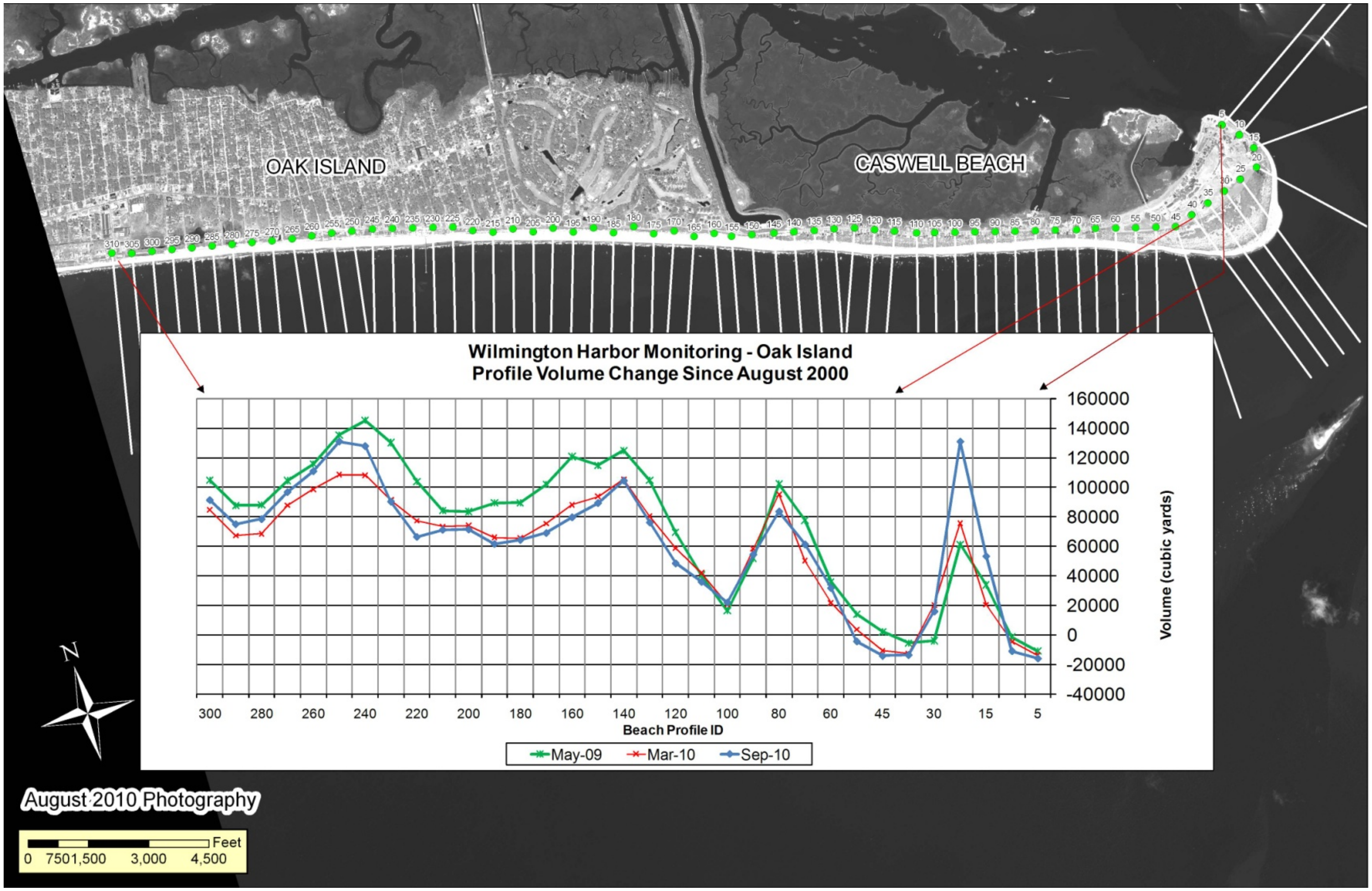


Figure 3.20 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since the Start of Monitoring (August 2000)

Ebb and Nearshore Shoal Analysis

Bathymetric Data Collection. Detailed bathymetry of the Cape Fear River ebb tidal delta and channels were collected on eight occasions specifically; August-September 2000, December 2001-January 2002, January 2003 and 2004, March 2005, April 2006, January 2007-2009, and in March 2010. These data are collected using an interferometric swath sonar system integrated with a motion sensor that removes vessel motion in real-time. Dual-channel RTK GPS provides horizontal and vertical control to correct for water level fluctuations forced by astronomical tides and wind-driven tides using the vertical RTK-GPS measurements. For details of this system and methodology on data collection and reduction refer to the following referenced letter reports; McNinch 2002, McNinch 2003, McNinch 2004, Part 2 of USACE 2005a, McNinch 2006, McNinch 2007, USACE 2008, USACE 2009, and USACE 2010.

Bathymetric data from the USACE LARC cross-shore surveys along the offshore profile lines were combined with those of the interferometic system to produce a comprehensive survey of the monitoring area. A plot of the combined coverage for the most recent March 2010 survey is shown in Figure 3.21 showing the LARC and interferometric system track lines. The results of the surveys are discussed below which are summarized from the previously referenced letter reports.

Results. The ebb tidal delta surrounding the mouth of the Cape Fear River is shown in Figure 3.22 from the most recent survey of March 2010. From the latest bathymetric survey the gross patterns of the seafloor morphology are clearly evident in the figure and have only one significant change since the last ebb shoal survey. The area used as a sediment source for the locally funded beach nourishment project on Bald Head Island is clearly visible just to the west of the intersection of the old and new channel alignments. This survey shows the newly realigned channel as well as the remnants of the pre-project channel alignment. Also apparent are three linear shoals that compose much of the ebb tidal delta. Two shoals are present on the west side of the shipping channel which comprise Jay Bird Shoals. The third or Bald Head Shoal protrudes off the southwestern corner of Bald Head Island east of the main channel. The main channel is seen to hug very near Bald Head Island as it exits into the ocean. A well-developed flood margin channel can also be seen flanking Oak Island. However, a similar companion flood channel is not apparent through Bald Head Shoal on the opposite side of the entrance channel.

A side-by-side comparison of the inlet area is shown in Figure 3.23 for each of the ten bathymetric surveys taken between 2000and 2010. These comparisons show a persistence of the three linear shoals and their relative positions. In addition, they show how the deltas have expanded and contracted over the monitoring period. The deepening of the flood margin channel on the Oak Island side, which has stabilized over the last several surveys, is visible as well. Maximum depths within the flood margin channel continue to be approximately 39 feet, and only slight changes in the area of the flood margin channel are visible. The most obvious change is the deepening of the main shipping channel which is attributed to the dredging of the new channel in 2001 and the excavation from Jay Bird Shoals for the recent nourishment along Bald Head Island, as discussed earlier.

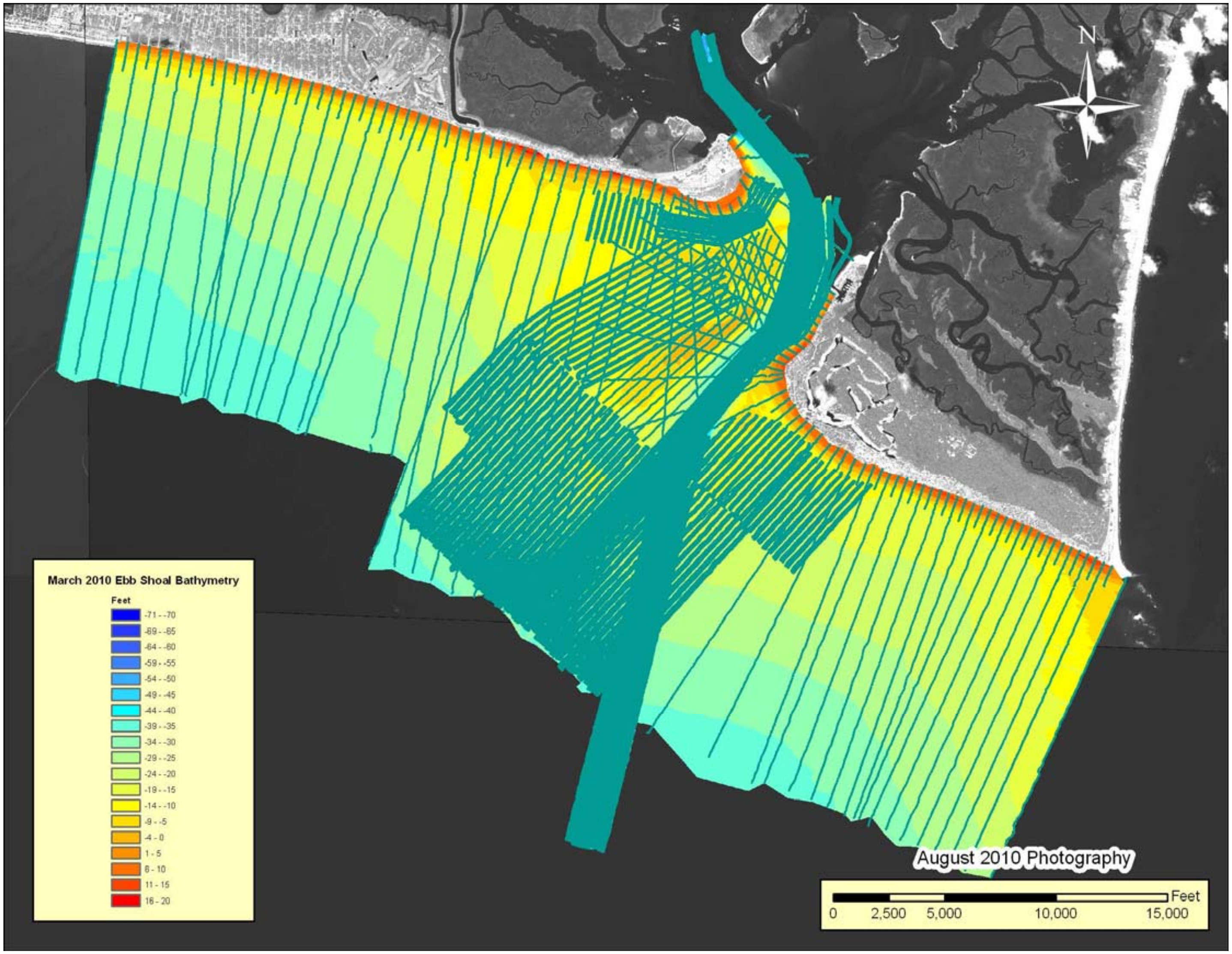


Figure 3.21 Survey Track Lines Collected by the LARC5 and the Interferometric System during the 2010 Survey

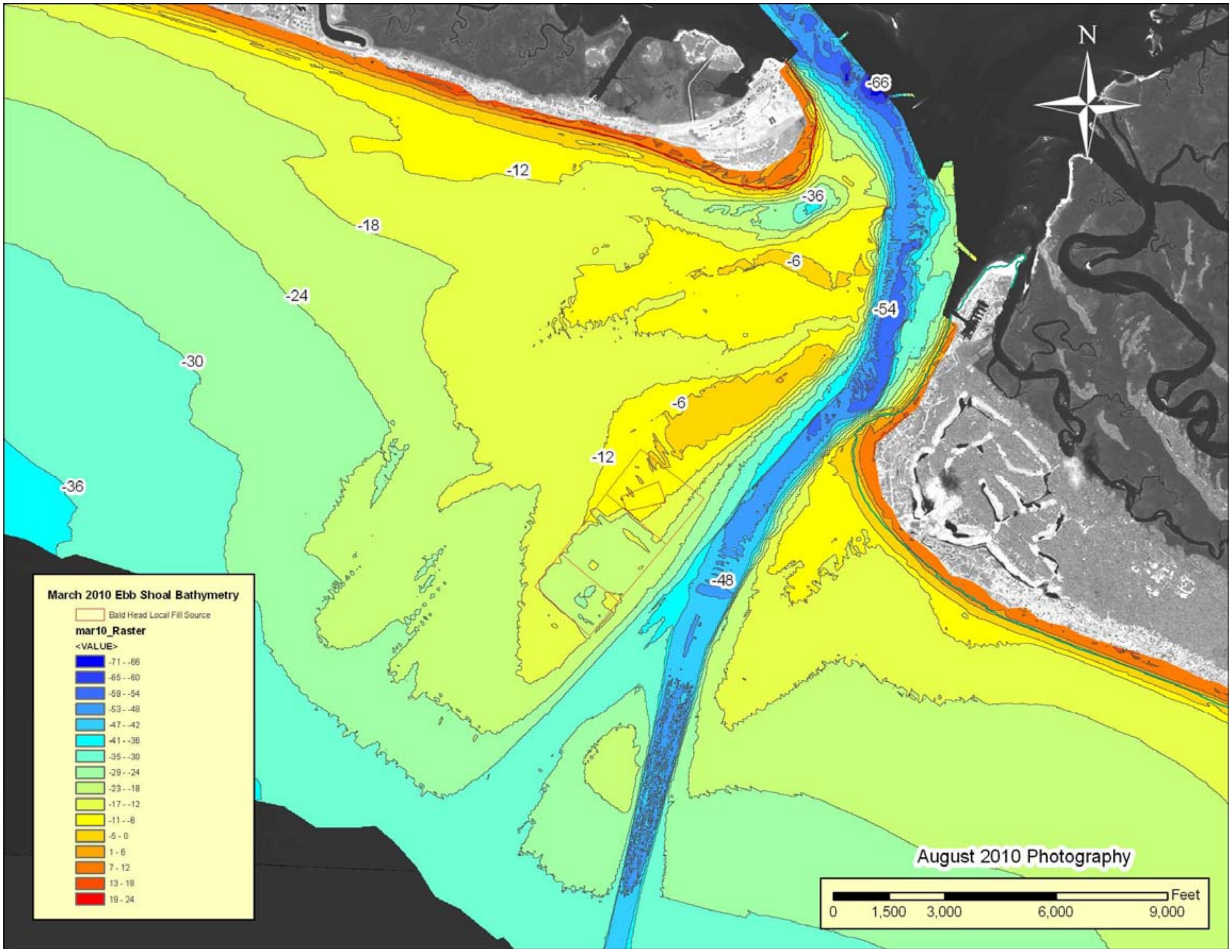


Figure 3.22 March 2010 Ebb Tide Delta Survey

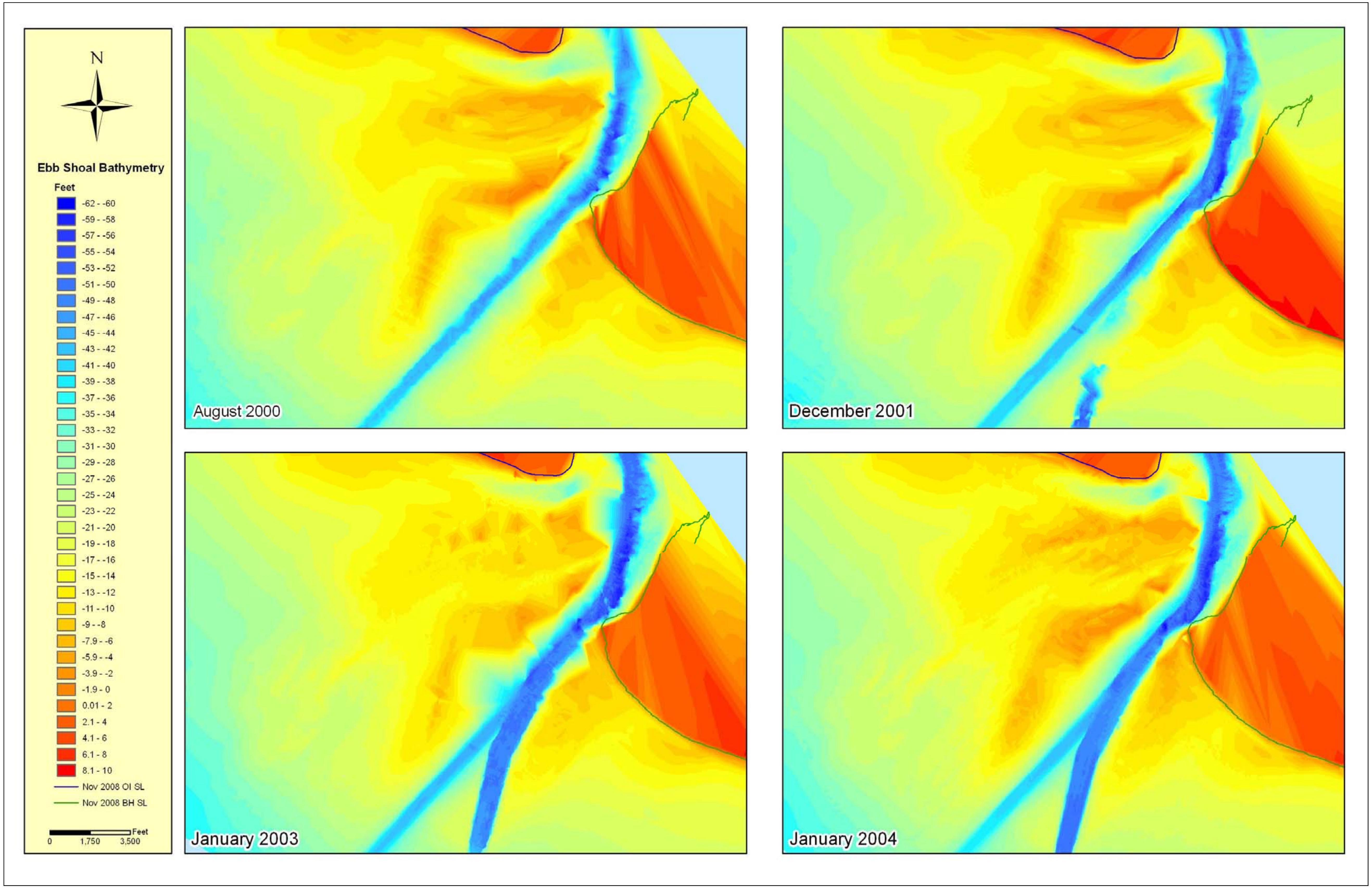


Figure 3.23 Inlet Bathymetry Surveys

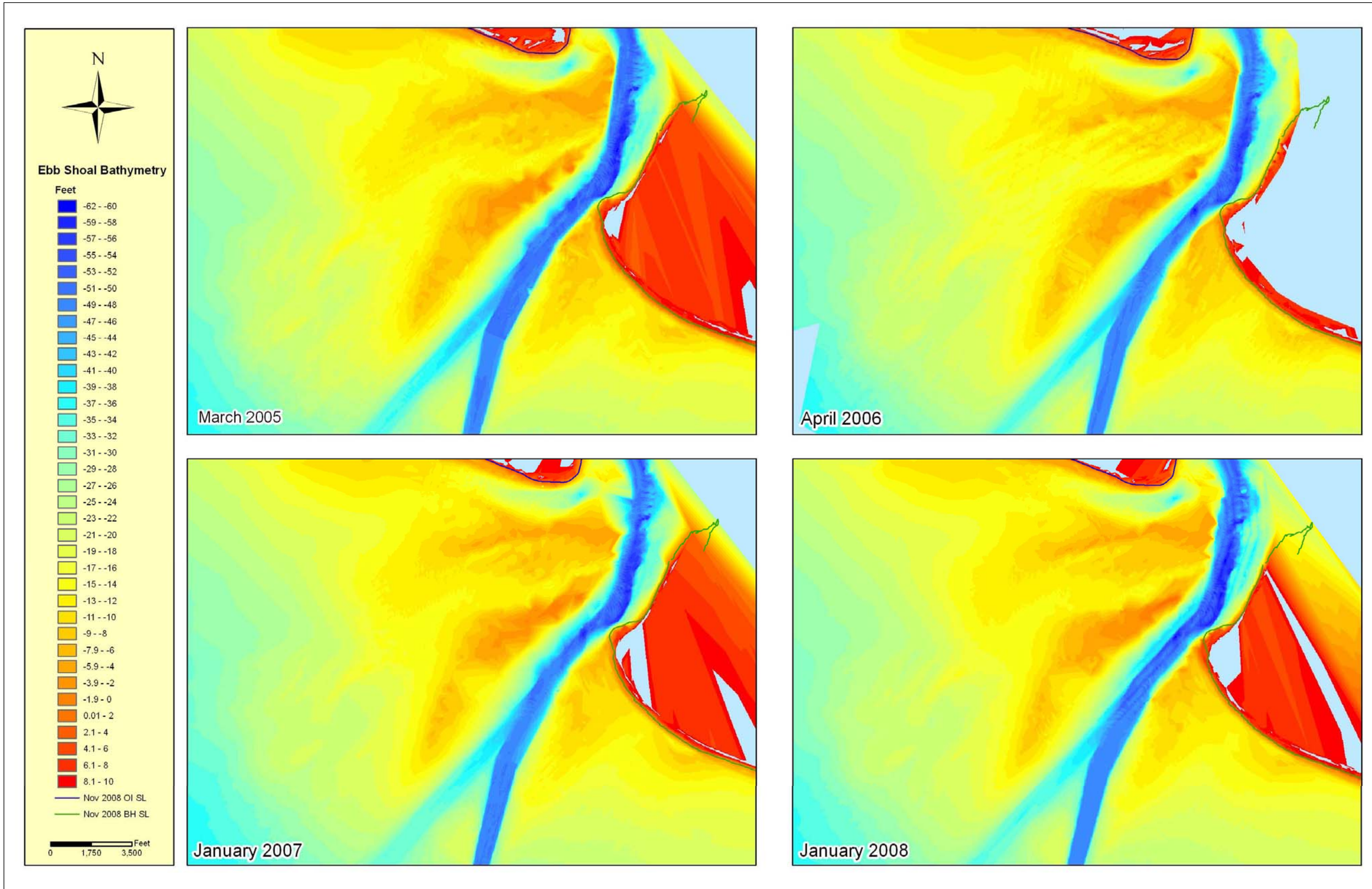


Figure 3.23 Inlet Bathymetry Surveys (Continued)

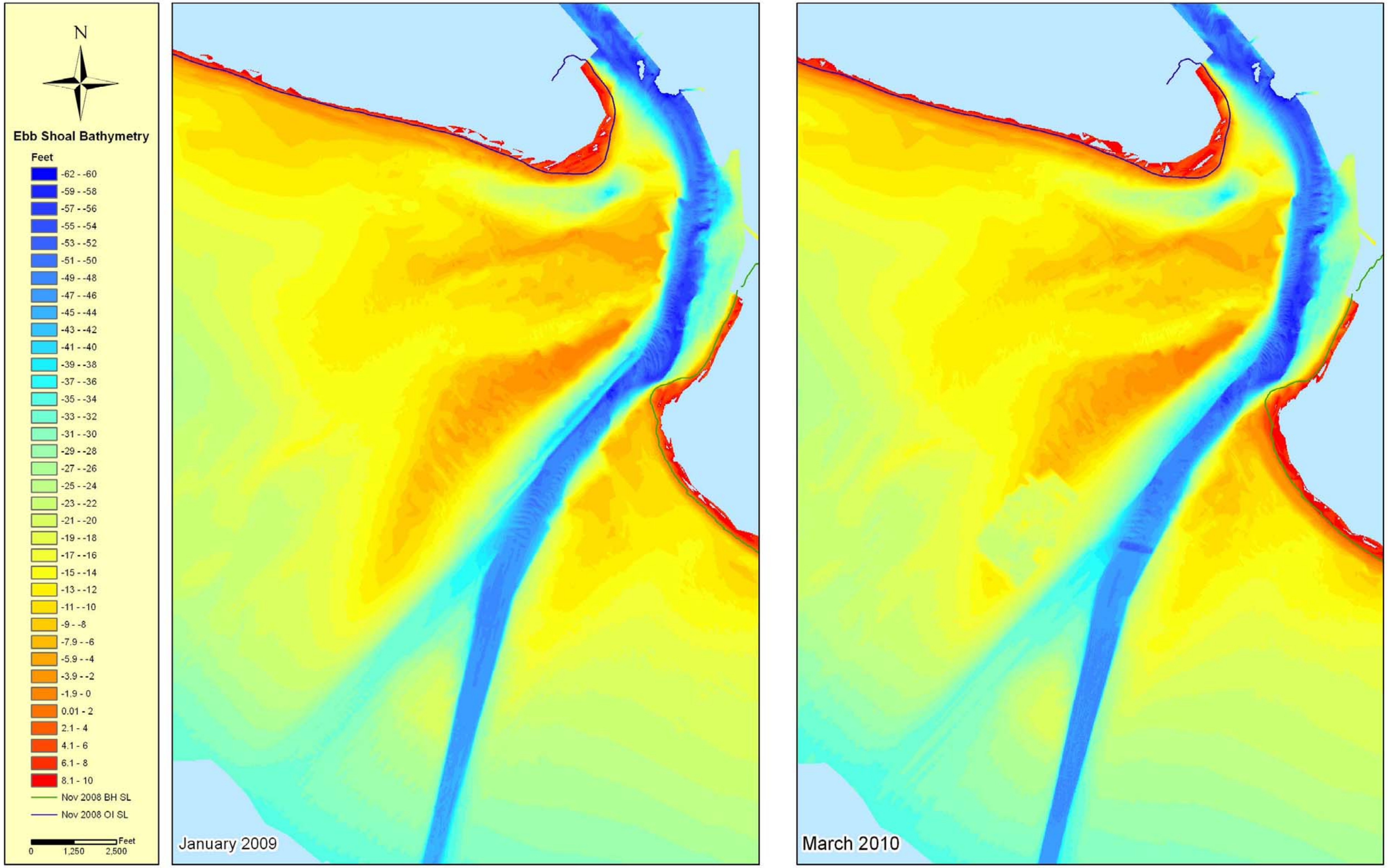


Figure 3.23 Inlet Bathymetry Surveys (Continued)

Further comparisons between surveys are made by generating maps showing changes in the bathymetry over time. Difference plots were made comparing the most recent survey of March 2010 with the prior survey of January 2009, as well as with the initial pre-project survey of August 2000. Figure 3.24 shows the bathymetric changes for the most recent period between January 2009 and March 2010. Detailed insets of these changes are also shown for two areas namely the vicinity of the inlet and along the realigned channel. These detailed insets are given in Figure 3.25(a) which shows the inlet region and Figure 3.25(b) which shows the new channel area. As noted on the legend, areas of erosion are indicated in shades of blue and accreting areas are in shades of green to red.

As shown in Figures 3.24 and 3.25 the majority of the system had little change relative to the last survey in January 2009 with major exceptions being the areas where volume was removed from Jay Bird Shoals and placed along the western half of Bald Head Island. The area used as a borrow source for the Bald Head Island beach nourishment project shows vertical changes of up to -14 feet. Significant increases in elevation, up to 10 feet, are visible on the west end of Bald Head Island which is the direct result of the Bald Head Island beach nourishment project. Smaller increases in elevation, up to 4 feet, are also visible along the east end of Oak Island that most likely resulted from the 2009 disposal of dredged material. General shoaling and erosion is noted within the channel boundaries with the majority occurring in the offshore portion of the navigation channel and old entrance channel.

In addition to the most recent changes in the ebb tidal bathymetry, Figure 3.26 shows the changes which have occurred since the initiation of the monitoring program. This figure compares the August 2000 pre-project survey with the most recent, March 2010, survey. Detailed insets for the inlet region and the new channel area are given in Figures 3.27(a) and 3.27(b).

There are six areas of change noticed when looking Figure 3.26, as follows: (1) The major excavation of the realigned new channel is very prominent in the figure. This cut was through the relatively shallow portion of the ebb tidal delta to project depths of 42 feet. (2) The channel deepening is evident as well from the outer bar channel through the inlet between the two islands. (3) The west end of south beach has accreted when compared to the pre-existing conditions in the vicinity of the newly rebuilt groin field and surrounding beach. This is a reversal of patterns from the previous report which showed the cumulative change within this area to be negative. The southern end of west beach has continued to show overall accretion as previously reported. (4) Significant accretion along the west side of Bald Head Shoal adjacent to the navigation channel is evident. (5) The fifth area of change occurred in the flood margin channel just off the tip of Oak Island. While parts of the channel have scoured out as much as 8 to 10 feet, the northern most part of the flood channel has accreted. (6) The final change area, which is new for this reporting period, is the borrow source area used by the Village of Bald Head Island during their recent private beach nourishment project. This area, located just west of the intersection of the old and new navigation channels, is only partially visible in Figure 3.26 due to the lack of data available in this area within the August 2000 survey. The area is more clearly visible within Figure 3.22 as previously discussed.

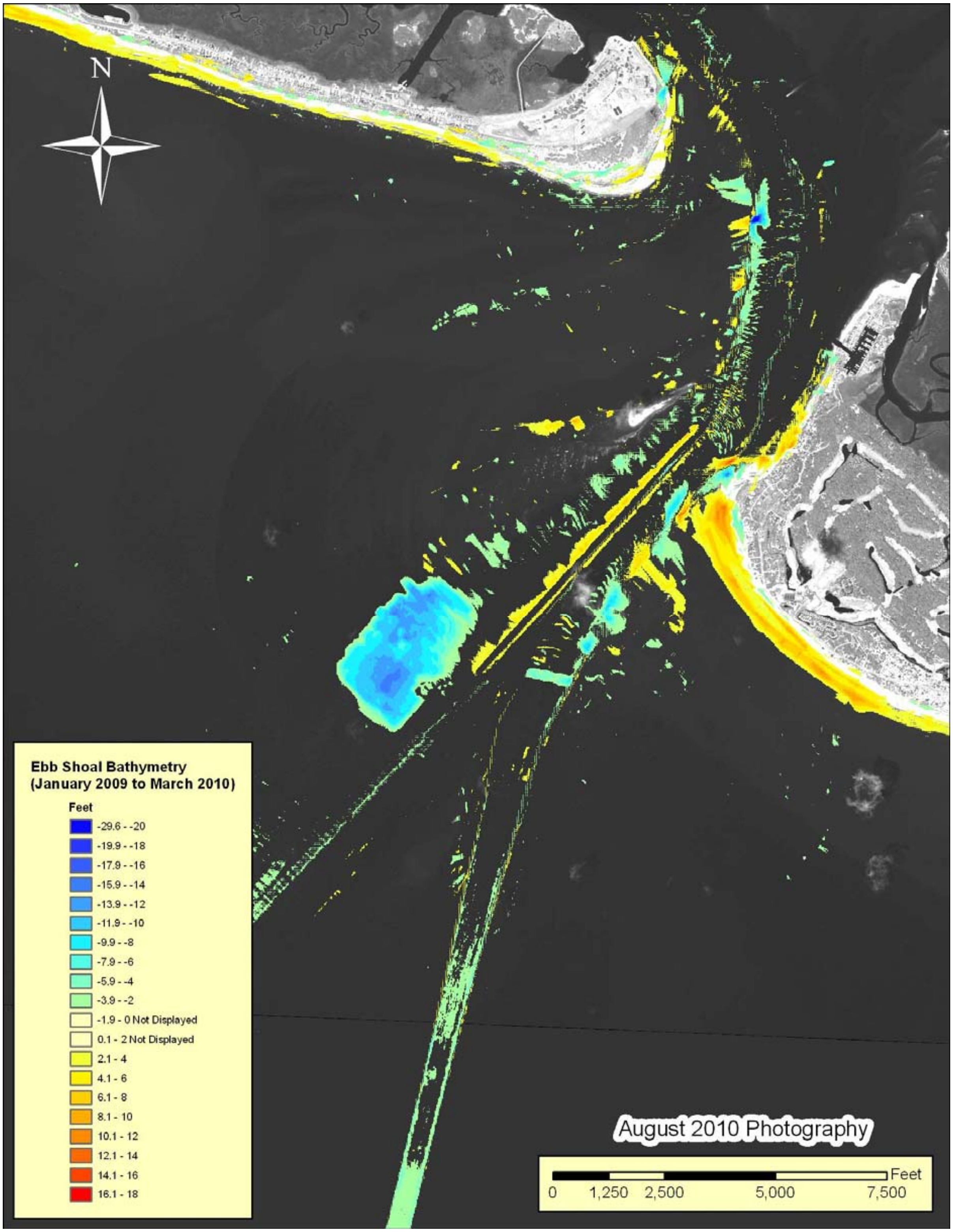


Figure 3.24 Bathymetric Changes of the Ebb Tidal Delta (January 2009 to March 2010)

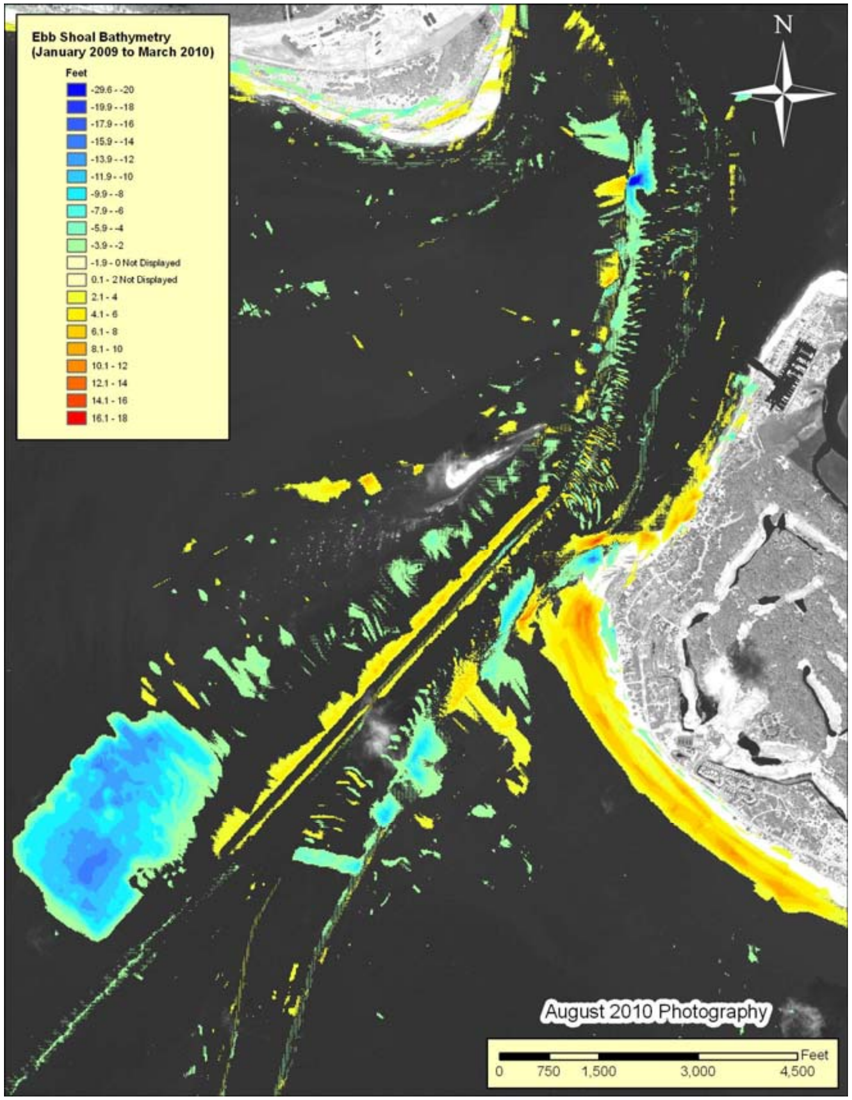


Fig 3.25 (a) Bathymetric Changes of Inlet (January 2009 to March 2010)

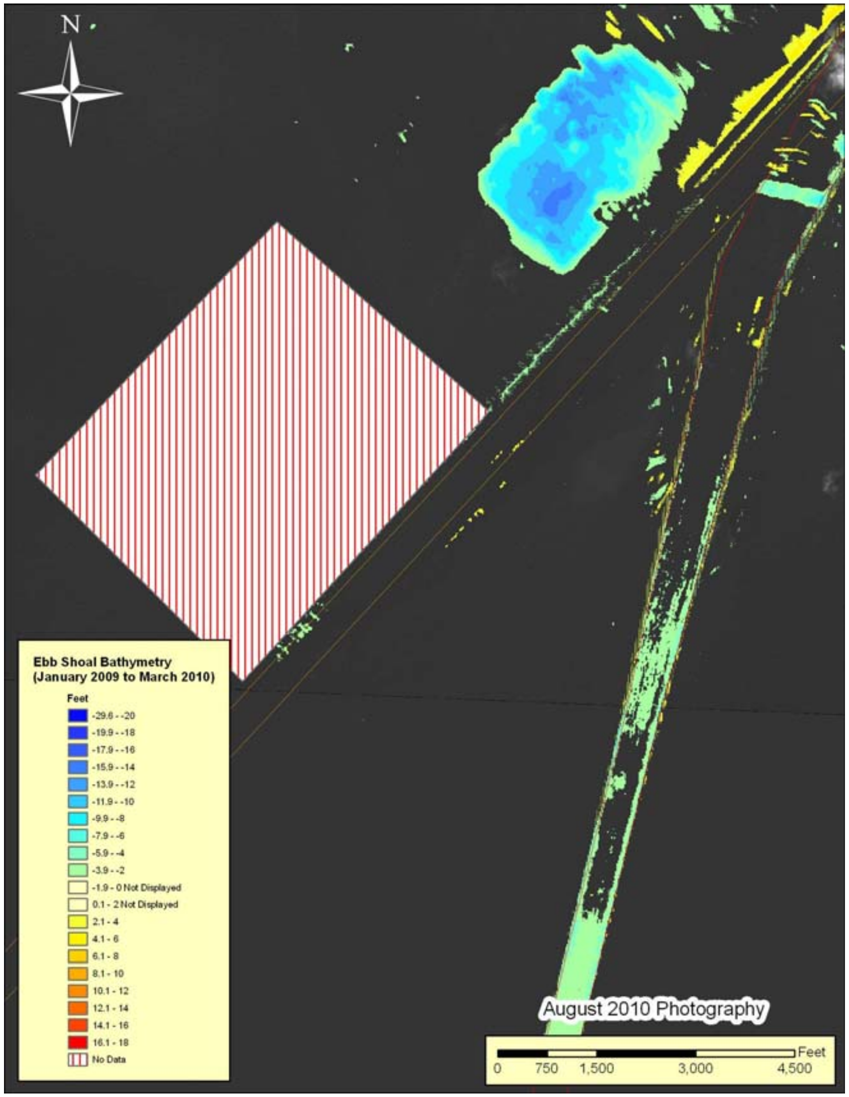


Fig 3.25 (b) Bathymetric Changes of New Channel (January 2009 to March 2010)

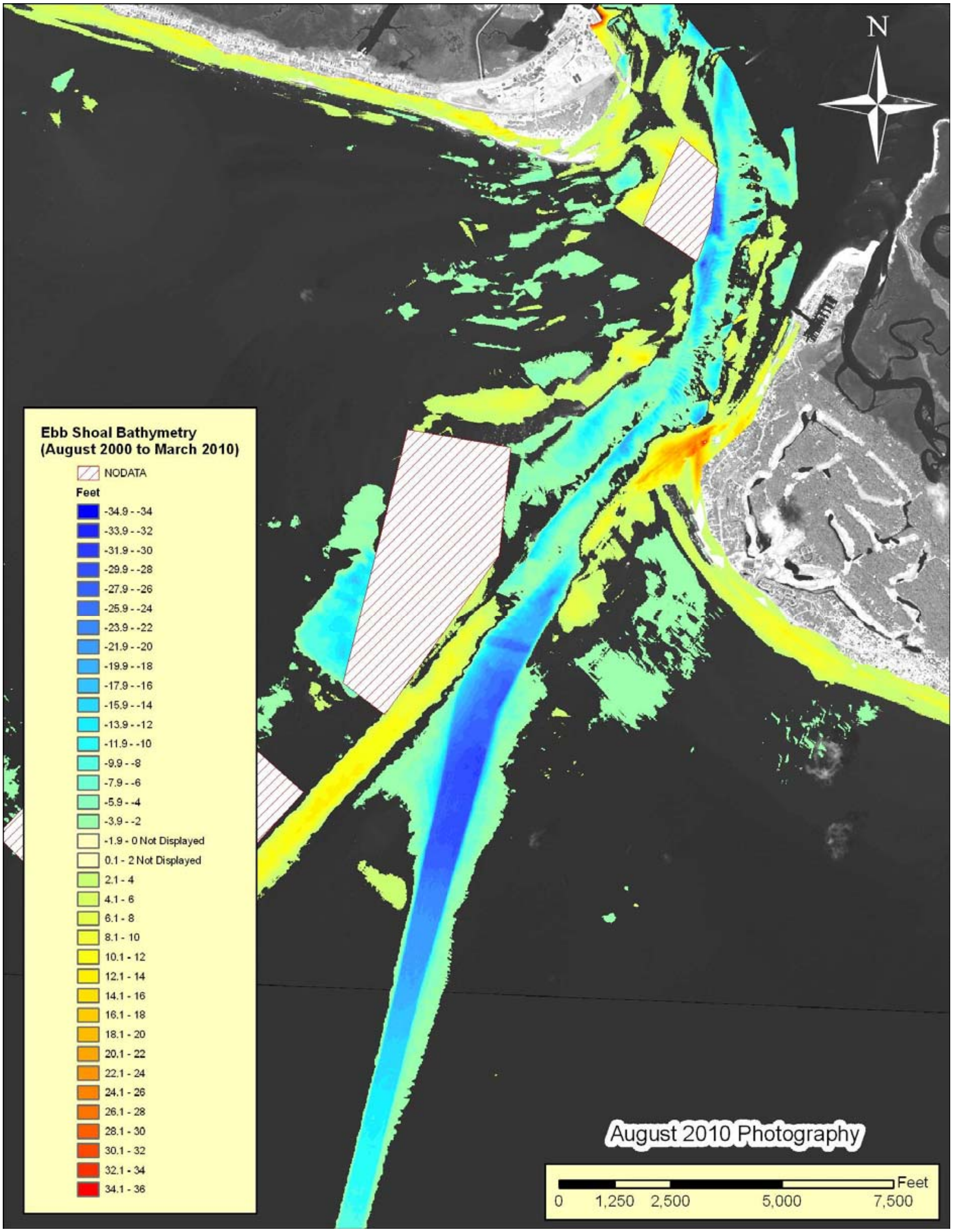


Figure 3.26 Bathymetric Changes of the Ebb Tidal Delta (August 2000 to March 2010)

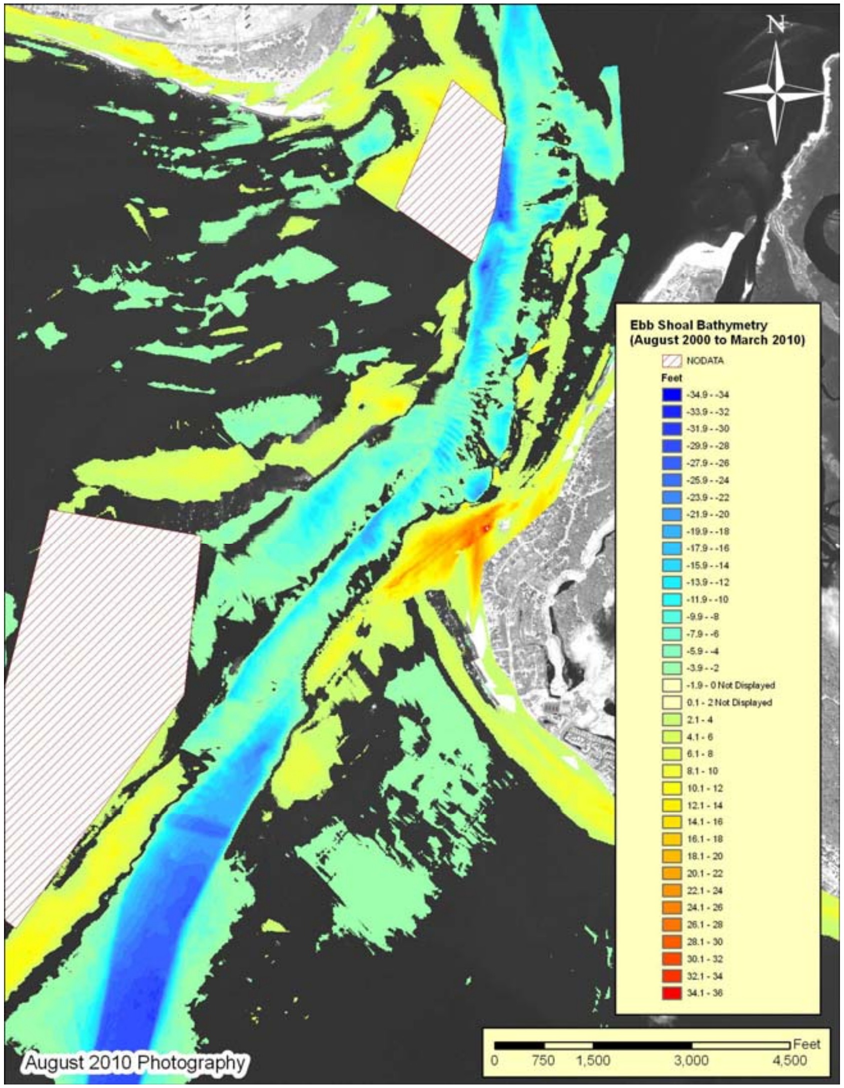


Figure 3.27 (a) Bathymetric Changes of Inlet (August 2000 to March 2010)

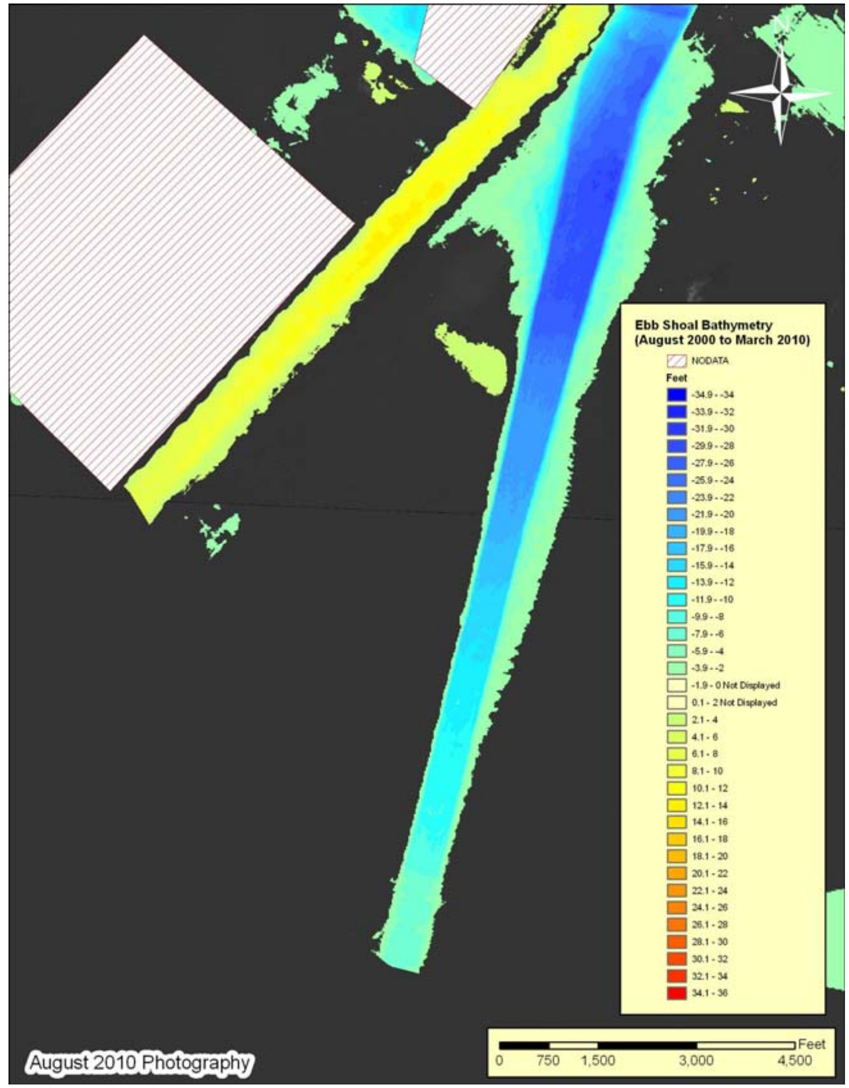


Figure 3.27 (b) Bathymetric Changes of New Channel (August 2000 to March 2010)

Current Measurements

(The current measurements for 2010 were not available at the time of this draft report and this section contains the measurements through Monitoring Report 7. This section will be updated as soon as the 2010 measurements are available.)

Methodology. Mean currents were measured across the mouth of the Cape Fear River tidal inlet and the seaward portion of the ebb tidal delta around the new and original shipping channel using a ship-mounted Acoustic Doppler Current Profiler (ADCP). The location of the inlet and offshore transects are shown in Figure 3.28. Typically two +13-hour transects were performed during each survey episode. To date nine current surveys have been accomplished on both the inlet and new channel loops as listed in Table 3.2. The current measurements are scheduled to take place on or near spring tide for consistency and all but one of the surveys were accomplished in this manner. The initial October 11-12, 2000 transects were taken prior to the new entrance channel deepening and realignment, with the most recent being collected on April 25, 2009 (inlet region) and April 24, 2009 (new channel region). The specific ADCP transects for the 2009 data collection are given in Figures 3.29 and 3.30. For details of this system and methodology on data collection and reduction refer to the following referenced letter reports: McNinch 2000, 2002a, 2003a, 2004a, USACE 2005a, Waller and Pratt 2006, McNinch 2007a, and McNinch 2008a. Details of the most recent current measurements are given in McNinch 2009a.

Tidal Inlet Region Results. The results of each transect were processed and analyzed in a time series for each hourly loop. Figures 3.31 and 3.32 show the details of the flow patterns during times of peak flood and peak ebb, respectively, for the April 2009 measurements. The current vectors shown on the figures represent the near surface flow (upper half of the water column) shown in red and the near bottom flow (lower half of the water column) shown in blue. These flow patterns are influenced by the local bathymetry and are generally similar with those measured on previous occasions in overlapping areas. The current track lines for the inlet region were extended further seaward to capture current velocities and directions around the Bald Head spit. No comparison is available within this extended track line region. During flood flow, the currents are concentrated within the main channel between Bald Head Island and Jay Bird Shoals. Flow is also concentrated through the flood margin channel near Oak Island. A similar flow pattern is seen just off the Bald Head spit entering the main channel; however, there is not an associated flood margin channel visible within the bathymetric survey offshore of the Bald Head Island spit. One interesting feature is also evident with the flood flow pattern which reveal eddies off the main flow. These are evident in the lee of the point at the juncture between South Beach and West Beach and also near Oak Island. For comparison purposes, the similar peak flood flow patterns from the prior measurements collected in October 2000, April 2002, March 2003, Jan 2004, March 2005, March 2006, February 2007, and March 2008 are given in Appendix D.

The peak ebb flow patterns (Figure 3.32) have two velocity peaks along the inlet transect, one near the marginal channel along Oak Island and the other within the main channel. These flows are funneled into the main channel during ebb impinging on the bank along Bald Head's West Beach. The similar peak ebb flow patterns from the prior measurements collected in October 2000, April 2002, March 2003, Jan 2004, March 2005, March 2006, February 2007 and March 2008 are given in Appendix D. One significant change from the previous current surveys is the divergence of flow patterns at the seaward end of the survey transect. Previous surveys indicated that flow was constrained within the main channel. The new survey transect shows that while significant velocities are still recorded within the main channel further offshore, they also begin to flow over the eastern ebb tide delta. In addition, an eddy is noticed along the eastern side of the main channel just landward of the seaward extent of the current profile track.

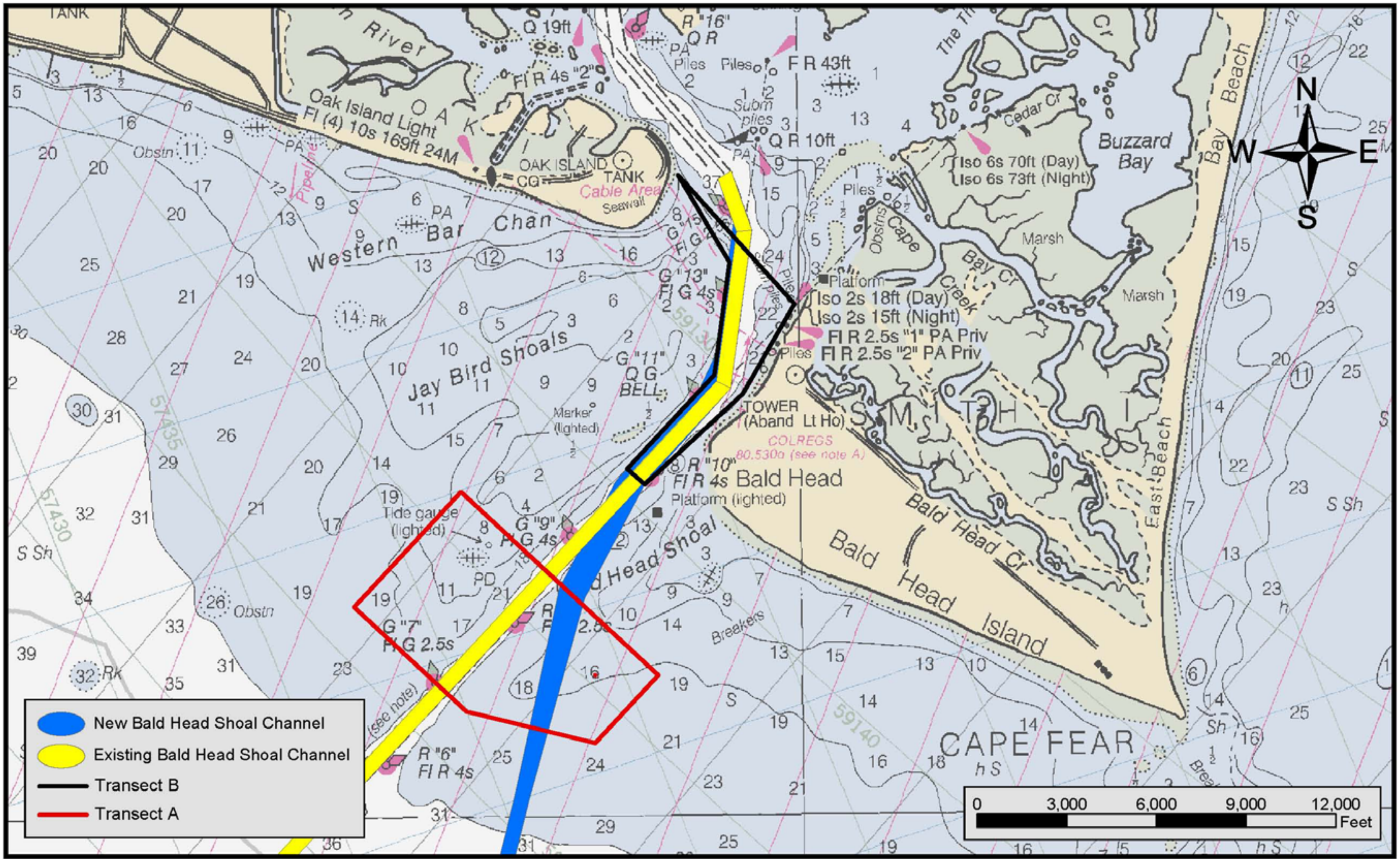


Figure 3.28 Ship-Board current profile track lines

Table 3.2 Listing of ADCP Current Surveys for the Wilmington Harbor Monitoring Program

	Inlet Region	**New Channel Region**
Survey Year	2000	2000
Survey Date	12-Oct	13-Oct
Survey Time	09:00-23:00	10:00-23:00
Tidal Phase	Spring	Spring
Survey Year	2002	2002
Survey Date	13-Apr	12-Apr
Survey Time	06:00-19:00	06:00-19:00
Tidal Phase	Spring	Spring
Survey Year	2003	2003
Survey Date	4-Mar	18-Mar
Survey Time	06:00-19:00	06:00-19:00
Tidal Phase	Spring	Spring
Survey Year	2004	2004
Survey Date	13-Jan	11-Jan –12-Jan
Survey Time	09:00-23:00	15:00-05:00
Tidal Phase	Neap	Neap
Survey Year	2005	2005
Survey Date	10-Mar	9-Mar
Survey Time	07:00-20:00	09:00-21:00
Tidal Phase	Spring	Spring
Survey Year	2006	2006
Survey Date	27-Mar & 29-Mar	28-Mar
Survey Time	11:00-19:00 & 10:00-1300	09:30-17:30
Tidal Phase	Spring	Spring
Survey Year	2007	2007
Survey Date	19-Feb	20-Mar
Survey Time	06:30-20:30	05:45-17:00
Tidal Phase	Spring	Spring
Survey Year	2008	2008
Survey Date	10-Mar	11-Mar
Survey Time	15:00-04:00 (11-Mar)	09:30-22:00
Tidal Phase	Spring	Spring
Survey Year	2009	2009
Survey Date	25-April	24-April
Survey Time	11:30-24:00	12:00-24:50
Tidal Phase	Spring	Spring

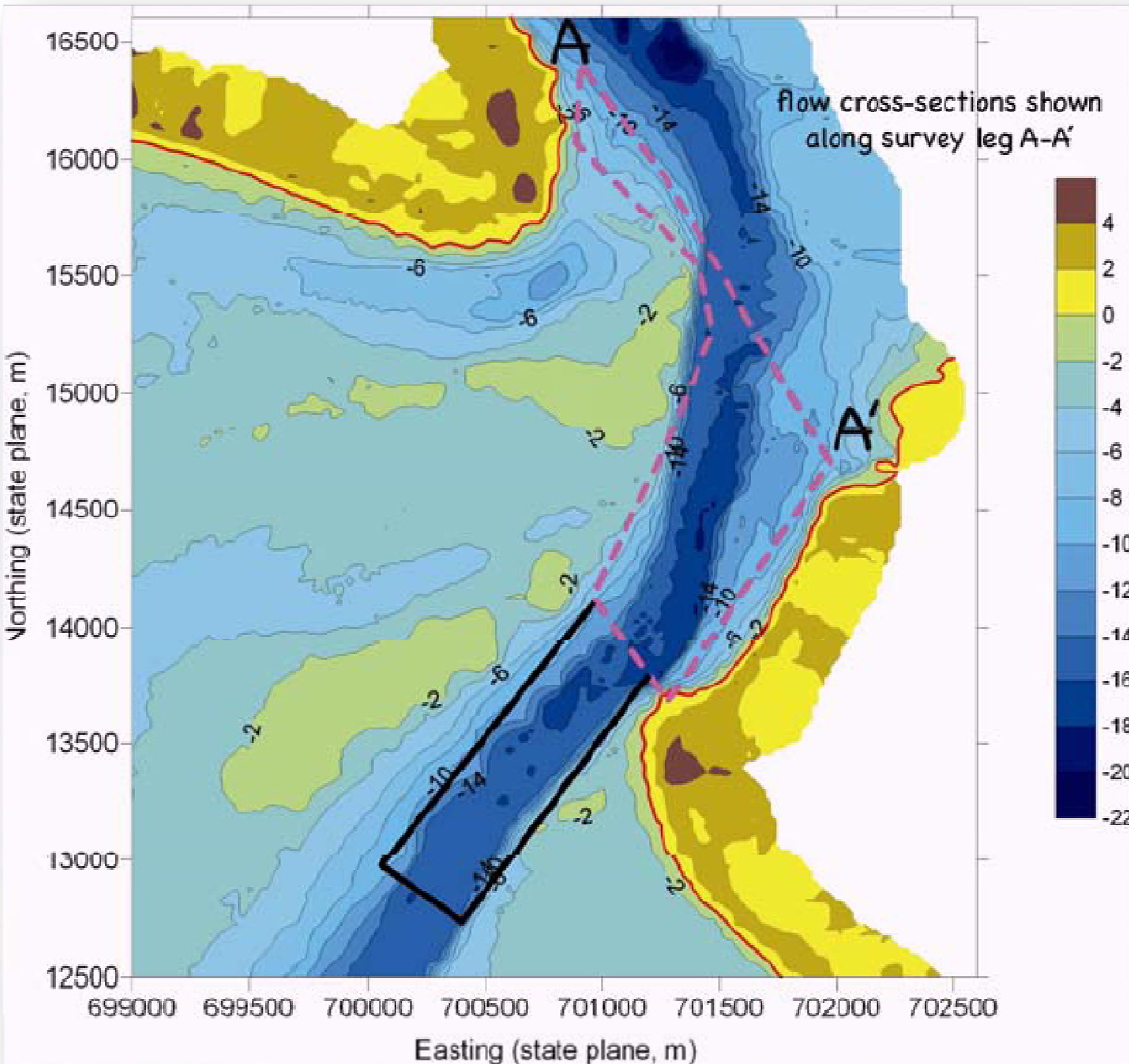


Figure 3.29 Plan View Showing the ADCP Transect Collected 25 April 2009 in the Tidal Inlet Region

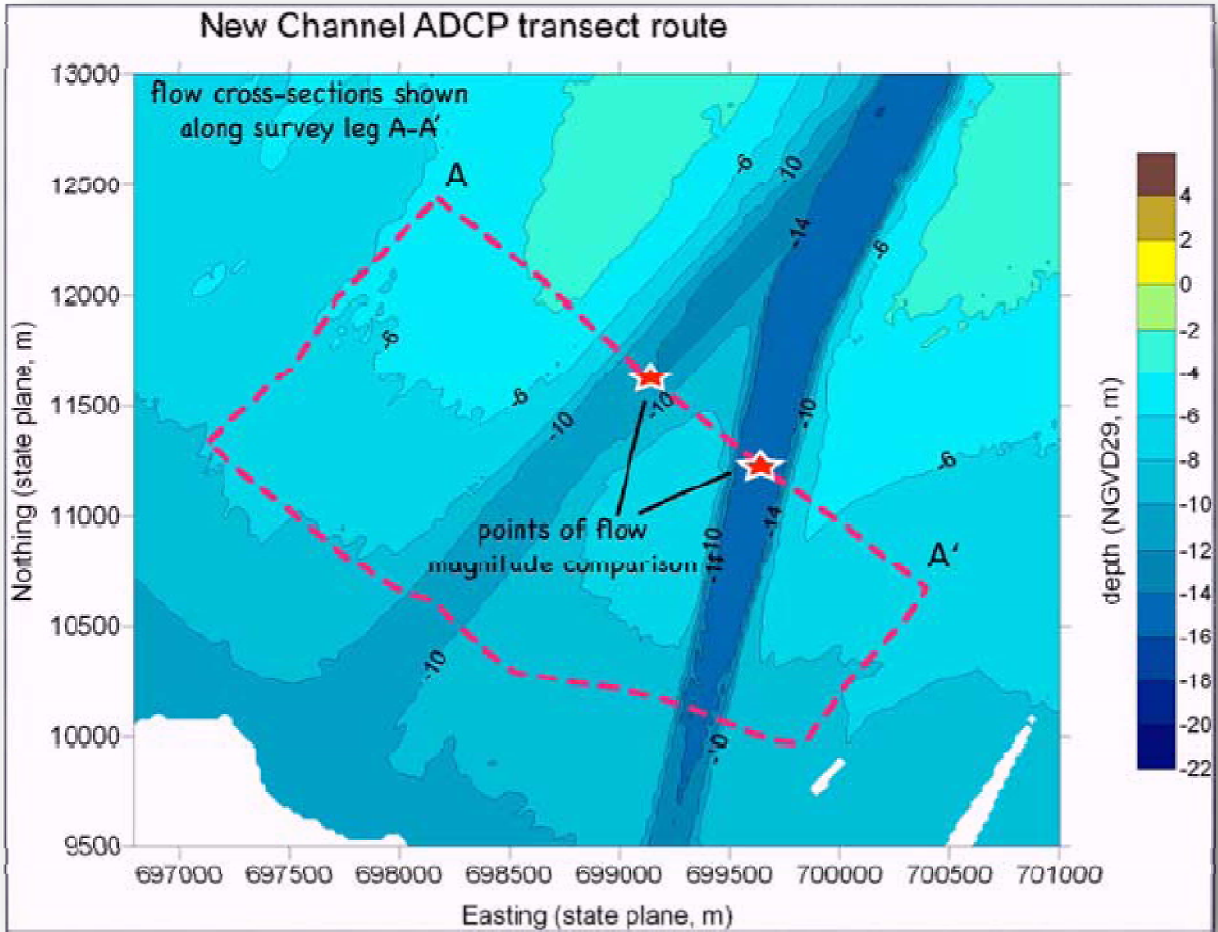


Figure 3.30 Plan View Showing the ADCP transect Collected 24 April 2009 in the New Channel Region

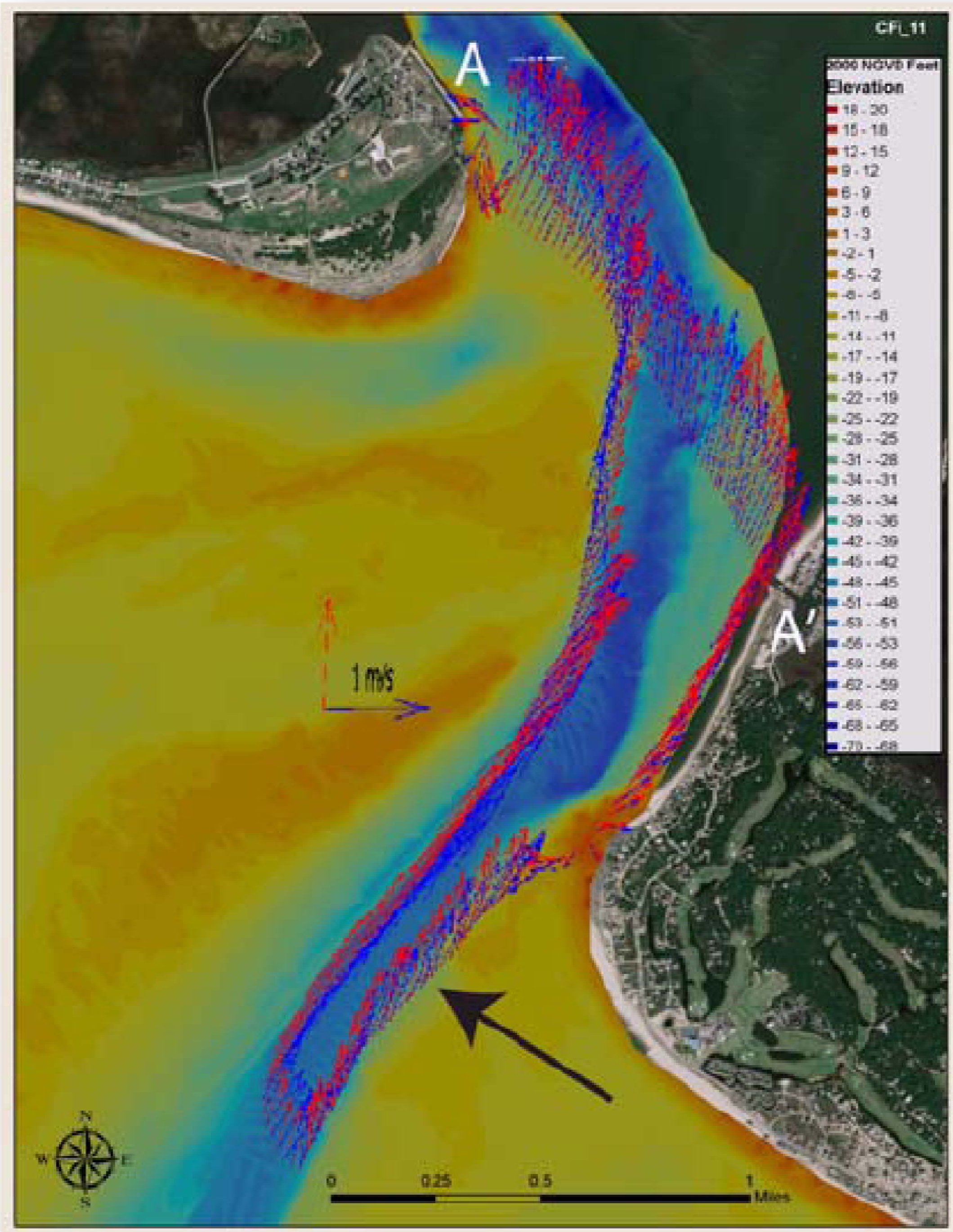


Figure 3.31 April 2009 ADCP Survey at the Inlet Transect during Peak Flood Flow

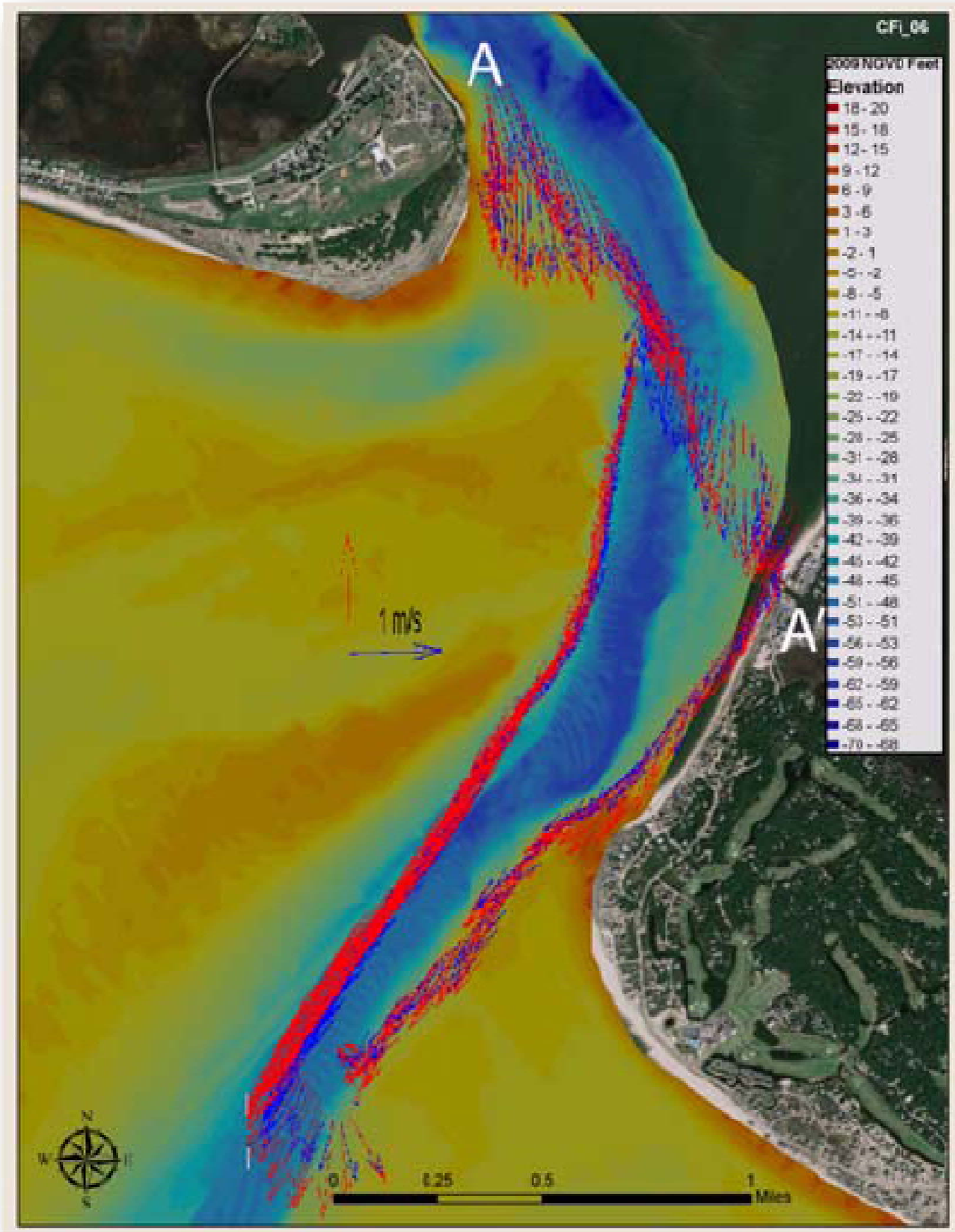


Figure 3.32 April 2009 ADCP Survey at the Inlet Transect During Peak Ebb Flow

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.3 for the inlet region. The April 2009 records are generally comparable to prior years. The overall magnitudes of the currents ranged from a peak surface ebb value of 5.28 ft/s to near-bottom flood values of just under 4 ft/s. Another trend is evident from the table when comparing the October 2000 pre-project measurements with the eight post-construction measurements. In this regard, all of the maximum velocities are greater than the initial pre-project magnitudes. The only exceptions to this remains the January 2004 near bottom flood and near-surface ebb measurements. One reason for this exception may be that in this instance the survey was not taken near spring tide as all the others were. Since only one pre-project survey was taken as part of the monitoring effort, it is difficult to draw a firm conclusion regarding the increase in peak flows through the inlet. In comparing the average of the post-project values with the October 2000 values, all are greater. Specifically for the near-bottom case, the average values are –4.6 ft/s (ebb) and 4.1 ft/s (flood) versus -3.5 ft/s and 3.3 ft/s, respectively. For the near-surface case, the average values are likewise –5.2 ft/s (ebb) and 4.3 ft/s (flood), versus -4.4 ft/s (ebb) and 3.6 ft/s (flood) for the October 2000 measurements.

Table 3.3 Maximum Magnitude of Mean Flows at Inlet Transect

		October 2000	April 2002	March 2003	January 2004	March 2005	March 2006	February 2007	March 2008	April 2009
Near-bottom*	***ebb***	3.48 ft/s (1.06 m/s)	3.83 ft/s (1.17 m/s)	3.87 ft/s (1.18 m/s)	5.14 ft/s (1.57 m/s)	4.43 ft/s (1.35 m/s)	3.61 ft/s (1.10 m/s)	5.74 ft/s (1.75 m/s)	5.31 ft/s (1.62 m/s)	4.86 ft/s (1.48 m/s)
	flood	3.28 ft/s (1.00 m/s)	3.67 ft/s (1.12 m/s)	4.82 ft/s (1.47 m/s)	3.23 ft/s (0.98 m/s)	3.87 ft/s (1.18 m/s)	3.81 ft/s (1.16 m/s)	4.46 ft/s (1.36 m/s)	4.66 ft/s (1.42 m/s)	3.94 ft/s (1.2 m/s)
Near-surface*	***ebb***	4.43 ft/s (1.35 m/s)	6.46 ft/s (1.97 m/s)	5.41 ft/s (1.65 m/s)	3.88 ft/s (1.18 m/s)	5.58 ft/s (1.70 m/s)	4.53 ft/s (1.38 m/s)	5.41 ft/s (1.65 m/s)	5.31 ft/s (1.62 m/s)	5.28 ft/s (1.61 m/s)
	flood	3.61 ft/s (1.10 m/s)	4.13 ft/s (1.26 m/s)	4.17 ft/s (1.27 m/s)	3.75 ft/s (1.14 m/s)	4.40 ft/s (1.34 m/s)	4.50 ft/s (1.37 m/s)	4.59 ft/s (1.40 m/s)	4.66 ft/s (1.42 m/s)	4.56 ft/s (1.39 m/s)

*Near-bottom defined by lower half of water column; near-surface defined by upper half of water column

<u>Tidal Prism.</u> Tidal prism represents the total volume of water passing though the inlet over the tidal period. Tidal prisms were computed using the inlet throat transect (see Figure 3.29 for example transect) for each of the past current measurements—pre-construction (October 2000) and post-construction (April 2002, March 2003, January 2004, March 2005, February 2007, March 2008 and April 2009) ADCP surveys. Unfortunately, calculation of the tidal prism was not possible for the March 2006 ADCP survey due to the shortened data collection resulting from the hazardous weather and sea state conditions. The results are displayed graphically for each of the survey dates in Figure 3.33. These computations represent snapshots of the tidal period for each respective date and include the results of other non-tidal forcing agents as well as natural variations in tide conditions. Other forces which influence flow are wind-forcing, river discharge as well as differences in astronomical tides at different times of the year and across a tidal epoch (i.e. spring tides are not necessarily equal through time). To make more meaningful comparisons of the eight surveys, the tidal prism computations were normalized across the inlet cross-section area as defined by the January 2003 bathymetry and associated transect. Table 3.4 summarizes the tidal prism computations and the results are shown graphically in Figure 3.33.

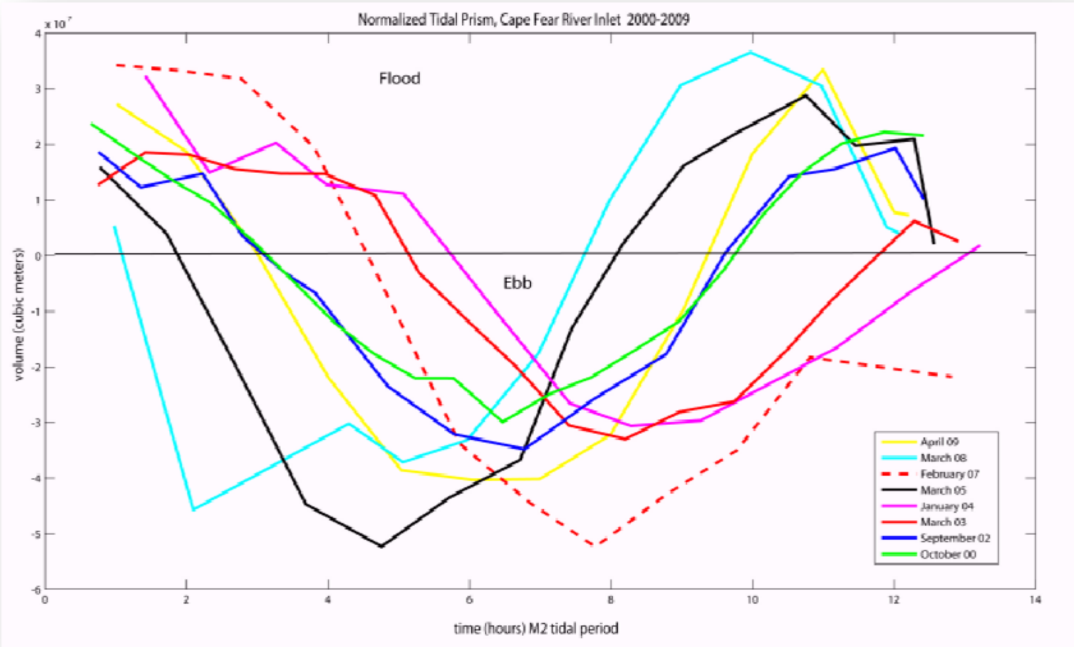


Figure 3.33 Volume of Water Passing through the inlet over the tidal period for all ADCP surveys (2000-2009)

Table 3.4 Normalized Tidal Prism Values for each of the ADCP Surveys (2000-2009)

Survey Date	Ebb	Flood	Total
Oct 2000	$6.7x10^9$ ft^3	$4.7x10^9$ ft^3	$1.1x10^{10}$ ft^3
	$1.9x10^8$ m^3	*$1.3x10^8$ m^3*	*$3.2x10^8$ m^3*
Apr 2002	$5.3x10^9$ ft^3	$3.9x10^9$ ft^3	$9.2x10^9$ ft^3
	$1.5x10^8$ m^3	*$1.1x10^8$ m^3*	*$2.6x10^8 m^3$*
Mar 2003	$6.0x10^9$ ft^3	$4.0x10^9$ ft^3	$1.0x10^{10}$ ft^3
	$1.7x10^8$ m^3	*$1.2x10^8$ m^3*	*$2.8x10^8$ m^3*
Jan 2004	$5.0x10^9$ ft^3	$3.0x10^9$ ft^3	$8.0x10^{10}$ ft^3
	$1.5x10^8$ m^3	*$0.9x10^8$ m^3*	*$2.4x10^8$ m^3*
Mar 2005	$8.3x10^9$ ft^3	$3.9x10^9$ ft^3	$1.2x10^{10}$ ft^3
	$2.3x10^8$ m^3	*$1.1x10^8$ m^3*	*$3.4x10^8$ m^3*
Feb 2007	$7.4x10^9$ ft^3	$5.3x10^9$ ft^3	$1.3x10^{10}$ ft^3
	$2.1x10^8$ m^3	*$1.5x10^8$ m^3*	*$3.6x10^8$ m^3*
Mar 2008	$5.3x10^9$ ft^3	$5.2x10^9$ ft^3	$1.1x10^{10}$ ft^3
	$1.5x10^8$ m^3	*$1.5x10^8$ m^3*	*$3.0x10^8$ m^3*
April 2009	*$6.5x10^9 ft^3$*	*$3.7x10^9 ft^3$*	*$1.0x10^{10} ft^3$*
	$1.8x10^8 m^3$	*$1.1x10^8 m^3$*	*$2.9x10^8 m^3$*

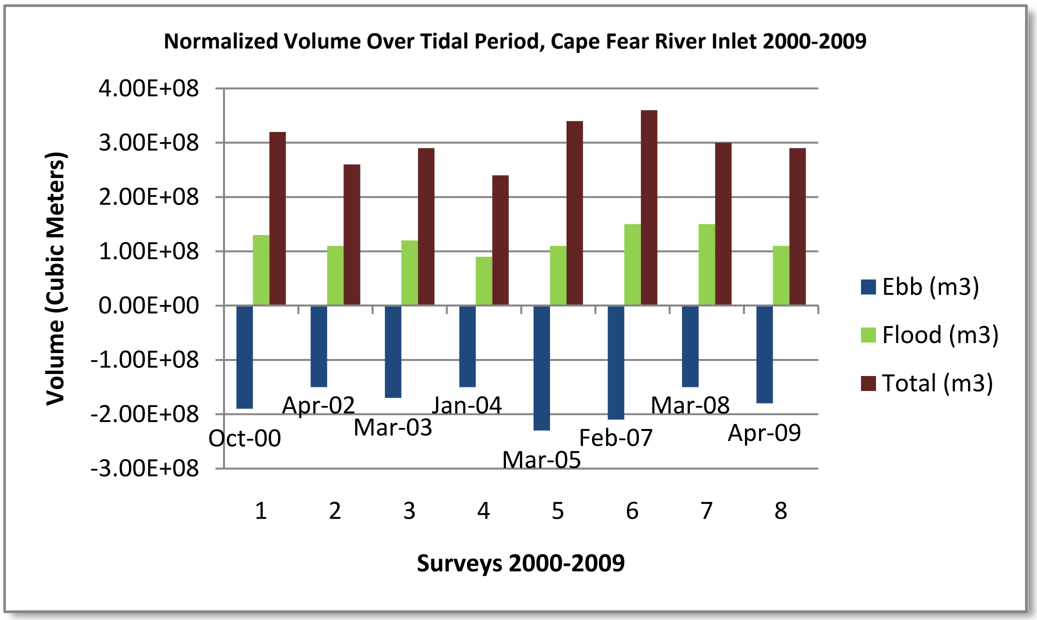


Figure 3.34 Normalized tidal prism for eight surveys—(1) October 2000, (2) April 2002, (3) March 2003, (4) January 2004 (5) March 2005 (6) February 2007 (7) March 2008 and (8) April 2009. Blue—ebb, Green—flood, Red—total

The normalizing process applies the average velocity from the ADCP survey across the inlet cross-section area multiplied by the tidal period. The October 2000 inlet transect survey only covered the inlet throat because at that time it was believed that insignificant flow existed over the shoals adjacent to Oak Island. Subsequent hydrographic surveys and current measurements indicated otherwise, so beginning with the April 2002 survey the inlet transects were enlarged. Thus the average velocity for the October 2000 survey, since it only incorporated a portion of the inlet cross-section, possibly differed from what would have been measured if the whole cross-section had been surveyed. In addition, differences from survey periods relative to spring tides, winds, river discharge, and astronomical period should be considered when explaining the differences observed in Figure 3.33.

The tidal prism results show that the Cape Fear is an ebb-dominated inlet with the average ebb flow volume being 47% greater than the flood volume. The April 2009 current survey resulted in a total tidal prism that was very near the computed total volume for the pre-construction October 2000 survey (being only about 9% less). In addition, the present prism calculations more closely resemble those of the October 2000 survey indicating significant ebb dominance. Ebb volume for the current survey was approximately 64% larger than the flood volume. This exceeds the differential between the ebb and flood volumes for the October 2000 survey in which the ebb volume exceed the flood volume by 46%.

<u>Offshore-New Channel Region Results.</u> As with the inlet transect, the offshore transect in the vicinity of the new channel was also processed and analyzed for each hourly loop. Figures 3.35 and 3.36 show the detailed flow patterns recorded during the April 2009 measurements. Figure 3.35 shows the time of near peak flood flow and Figure 3.36 gives the peak ebb condition. The current vectors shown on the figures represent the near surface flow (upper half of the water column) shown in red and the near bottom flow (lower half of the water column) shown in blue. These flow patterns are generally similar with those measured on previous occasions and reach peak velocities on the order of 1 m/s (3.3 fps). During peak flood flow, the currents are somewhat uniform spatially around the transect, but are slightly more concentrated along the old and new channel beds and in the region between the two channels. For comparison purposes, the similar peak flood flow patterns from the prior measurements collected in Oct 2000, April 2002, March 2003, Jan 2004, March 2005, March 2006 and March 2007 are given in Appendix D.

The peak ebb in the offshore transect is found to start in the new channel and shift to the old ebb channel location. At peak flow the strongest ebb is located generally over the “v” intersection between the old and new channel regions. This velocity concentration spreads out laterally as the ebb flow proceeds seaward between the two channels. Outside of this region the ebb flows are greatly reduced particularly around Jay Bird Shoals. The comparative peak ebb flow patterns from the prior measurements are given in Appendix D.

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.5 for the outer transect. Overall, as with the inlet transect, the peak ebb velocities exceed the peak flood velocities. The velocities range from a high measured at near-surface ebb of 3.4 ft/s with a low peak found at near-bottom flood of just over 1.6 ft/s.

As indicated in the table, the most recent measurements of April 2009 are found to be lower than the flow rates for the previous two years. As discussed in Monitoring Report 6, ebb flow rates for March 2007 and 2008 were above normal when compared to the first 5 years of post construction current surveys. The April 2009 near bottom ebb current measured 2.91 ft/s, which is very close to the 2.98 ft/s average of the near bottom measurements from April 2002 through March 2006. Similarly, the near surface ebb current measured in April 2009 was 3.44 ft/s just slightly lower than the 3.65 ft/s average from April 2002 through March 2006.

When comparing the October 2000 pre-project measurements with the post-construction measurements, all of the maximum velocities are found to be greater than the measured pre-project magnitudes. As noted previously since only one pre-project survey was taken as part of the monitoring effort it is difficult to draw a firm conclusion regarding the increase in peak flows in the area of the new channel. Nevertheless, it is of interest to compare the average of all the post-project values with the October 2000 values. Specifically for the near-bottom case, the average values are –3.2 ft/s (ebb) and 1.9 ft/s (flood) versus -2.0 ft/s and 1.3 ft/s, respectively. For the near-surface case, the average values are likewise –3.9 ft/s (ebb) and 1.9 ft/s (flood), versus –3.1 ft/s (ebb) and 1.4 ft/s (flood) for the October 2000 readings.

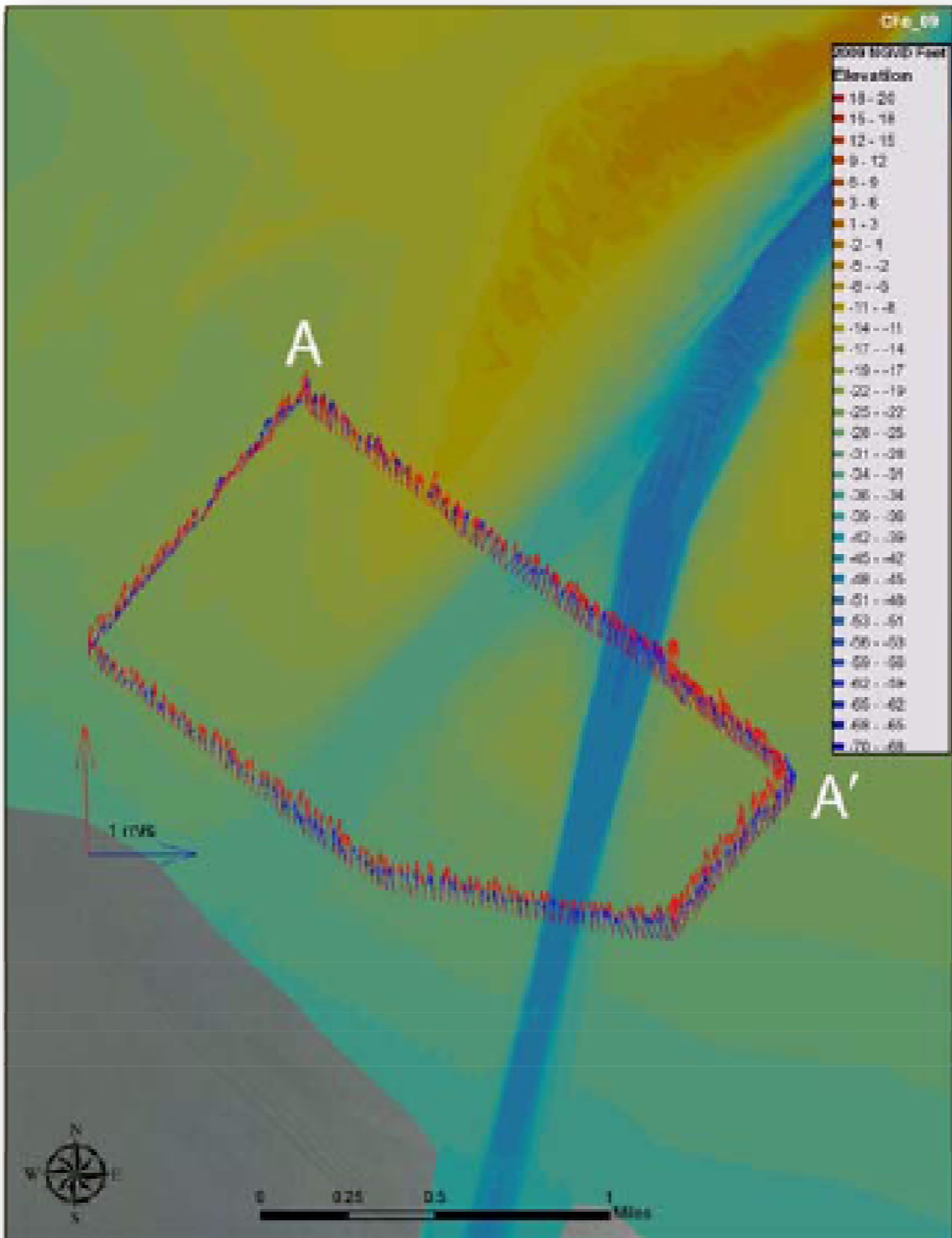


Figure 3.35 April 2009 ADCP survey at the Offshore-New Channel Transect near peak flood flow

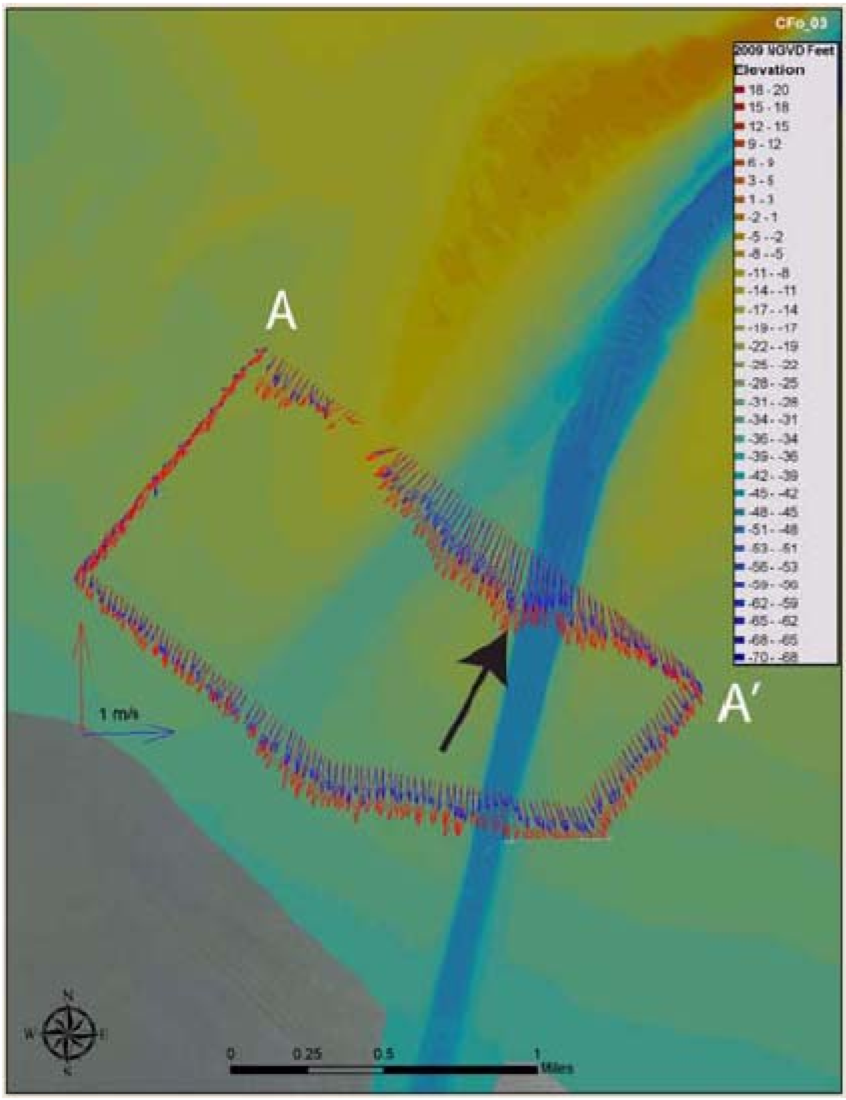


Figure 3.36 April 2009 ADCP survey at the Offshore-New Channel Transect near peak ebb flow

Table 3.5 Maximum Magnitude of Mean Flows at New Channel Transect

		October 2000	April 2002	March 2003	January 2004	March 2005	March 2006	March 2007	March 2008	April 2009
Near-bottom*	***ebb***	2.03 ft/s (0.62 m/s)	3.08 ft/s (0.94 m/s)	3.15 ft/s (0.96 m/s)	3.00 ft/s (0.91 m/s)	2.79 ft/s (0.85 m/s)	2.89 ft/s (0.88 m/s)	3.64 ft/s (1.11 m/s)	3.71 ft/s (1.1 m/s)	2.91 ft/s (0.89 m/s)
	flood	1.31 ft/s (0.40 m/s)	1.94 ft/s (0.59 m/s)	2.69 ft/s (0.82 m/s)	1.32 ft/s (0.40 m/s)	2.20 ft/s (0.67 m/s)	NA	2.17 ft/s (0.66 m/s)	1.34 ft/s (0.41 m/s)	1.61 ft/s (0.49 m/s)
Near-surface*	***ebb***	3.08 ft/s (0.94 m/s)	3.38 ft/s (1.03 m/s)	3.87 ft/s (1.18 m/s)	3.64 ft/s (1.11 m/s)	3.71 ft/s (1.13 m/s)	3.64 ft/s (1.11 m/s)	4.36 ft/s (1.33 m/s)	4.36 ft/s (1.33 m/s)	3.44 ft/s (1.05 m/s)
	flood	1.41 ft/s (0.43 m/s)	2.49 ft/s (0.76 m/s)	1.87 ft/s (0.57 m/s)	1.58 ft/s (0.48 m/s)	2.20 ft/s (0.67 m/s)	NA	2.07 ft/s (0.63 m/s)	1.48 ft/s (0.45 m/s)	1.61 ft/s (0.49 m/s)

Wave Data Analysis

Detailed investigations of wave conditions associated with Wilmington Harbor monitoring are being conducted through the use of field data collection using three wave gauges. One gauge is located offshore and the other two are located nearshore so that the local wave climate can be assessed with respect to offshore conditions. In this section the wave data collected to date are presented through relative comparisons over time and with each other. Significant wave events are also identified for the entire monitoring period to date, which covers from September 2000 to May 2010.

Wave Gauge Analysis. Directional wave, water level, and current data are collected at one offshore location (referred to as the 11-Mile gauge) and two nearshore locations (Oak Island and Bald Head Island), as shown in Figure 3.37 Water depths are about 42 ft at 11-Mile, 23 ft at Oak Island, and 19 ft at Bald Head Island gauges. The 11-Mile gauge was placed just south of a proposed dredged material disposal area, seaward of the navigation channel and ebb shoal influence. The nearshore gauges provide data in the vicinity of the navigation channel, nearshore shoals and adjacent beaches. All three gauges are Acoustic Doppler Current Profiler (ADCP) instruments accompanied by a pressure transducer. Directional wave spectra are calculated from time series of velocity at various depths obtained by the ADCP. Corresponding significant wave height Hm0, peak period Tp, and peak direction Dp parameters are determined from the directional spectrum. Peak frequency represents the highest energy density in the frequency spectrum integrated over all directions. Peak direction is determined as the vector mean at the peak frequency. Water level is determined from the pressure transducer record. Time series of current velocity at the surface, mid-depth, and bottom are also provided from the ADCP gauges. The 11-Mile and Bald Head Island gauges currently collect 20-min time series at 3-hr intervals. The Oak Island gauge collects 20-min time series at 1-hr intervals.

All gauges were initially deployed in September 2000. The 11-Mile gauge has operated consistently from initial deployment on 22 Sep 2000, except for a two month data gap between Dec-04 and Feb 05, a three month gap between Feb-06 and May-06, and a one month gap between 31 January 2010 and 1 March 2010. The Bald Head Island gauge was operational during the same time period, but experienced some data losses for periods of 13 Aug to 27 Sep 2001, 6 Jan to 17 Jan 2001, 1 Sep to 25 Sep 2005, 7 Jan to 26 Apr 2006, 29 March 2007 to 21 September 2007, 21 Jan 2009 to 1 Feb 2009, 23 June 2009 to 1 July 2009, and 27 January 2010 through May 2010, plus some other minor periods of up to several days. The Oak Island gauge has had the most down time of the three gauges. This gauge was damaged by a trawler on 23 Oct 2000 and not successfully reactivated until June 2001. Additional significant periods of data gaps occurred between 1 July and 27 Sep 2001, 6 Mar and 24 Apr 2002, 4 July and 1 August 2002, 8 Apr and 24 Apr 2003, 28 May and 11 June 2003 and 29 Mar and 12 May 2004. Further, the gauge was apparently hit by lightning on 8 Apr 2005 and was not operational again until it was serviced in Sept 2005. A weak battery lead to sporadic data collection between 24 Dec 2005 and 10 Feb 2006. Additional data losses are noted between 10 Feb and 27 April 2006, 28 Sep

2006 and 29 March 2007, 5 April and 29 July 2008, and 9 Jan to 26 Jan 2009. During the current monitoring period the gauge operated continuously with no additional data omissions.

Wave Climate. The wave data were analyzed using the Coastal Engineering Design and Analysis System (**CEDAS**), Nearshore Evolution Modeling System (NEMOS) software (NEMOS 2000). The data were updated from the last report, June 2009, through the May 2010 deployment for the Oak Island and Eleven Mile gauges. Unfortunately, the processor within the Bald Head gauge failed in January 2009 and there have been no updates to its data over the current monitoring period. Tables 3.6 through 3.8 summarize the mean monthly conditions for all gauges for the available data. These tables include the mean monthly wave height, period and direction (Hsmean, Tpmean & Dpmean). The average annual wave height (Hsmean) observed for the 11-mile gauge since its initial deployment did not change from the previous three monitoring reports, remaining at 3.3 feet. The average annual wave height for the Bald Head gauge is 1.9 feet as reported in monitoring report 7. Over this same time period the average annual wave height for the Oak Island gauge slightly decreased from 1.7 feet to 1.6 feet. The comparison of average annual wave heights between the offshore 11 mile gauge and the nearshore Bald Head and Oak Island gauges demonstrate the significant wave transformation induced as waves travel over the shoals. In addition to determining average wave conditions, the monthly time series for all gauges were analyzed to determine the maximum wave height (Hsmax). For the current monitoring period (The associated peak period (Tpmax) and wave direction (Dpmax) with each event were also computed. The 11-Mile gauge had monthly maximum wave heights ranging from 6.3 to 13.8 feet within the current monitoring period, with waves typically arriving from the southeast. The Oak Island gauge had an average monthly maximum wave height of 3.7 feet over the current monitoring period. The gauge clearly shows the filtering effect of the nearshore shoals, with the predominant number of events having wave directions confined to the south-southwest directions, which has been consistent throughout the entire monitoring period.

The seasonality of the wave climate is illustrated in Figure 3.56. This graph shows the mean monthly wave heights for the all the data collected to date (2000-2010) for each of the three gauges. For the 11-mile gauge the largest waves are found to occur during the late Fall through the winter months and during September reflecting the effect of the northeasters and tropical storms, respectively. For the nearshore gauges, which are sheltered from the east to northeast, the opposite pattern is evident. Both the Bald Head and Oak Island locations generally have the largest mean monthly wave heights during the summer months when the local winds turn predominately onshore. Of further interest, the wave heights measured at Oak Island are slightly lower than Bald Head for all months of the year. The seasonal shift is also seen in Figure 3.57 which is a plot of mean monthly wave direction for each gauge. The directions are given in a meteorological reference with degrees measured from north from indicating the direction from which the waves are traveling. For the nearshore gauges, the mean wave directions are from the south-southwest throughout the majority of the year shifting to the south-southeast during September and October. While the 11 mile gauge wave orientations fluctuate between winter and summer time frames, the mean monthly wave directions consistently originate from the south-southeast.

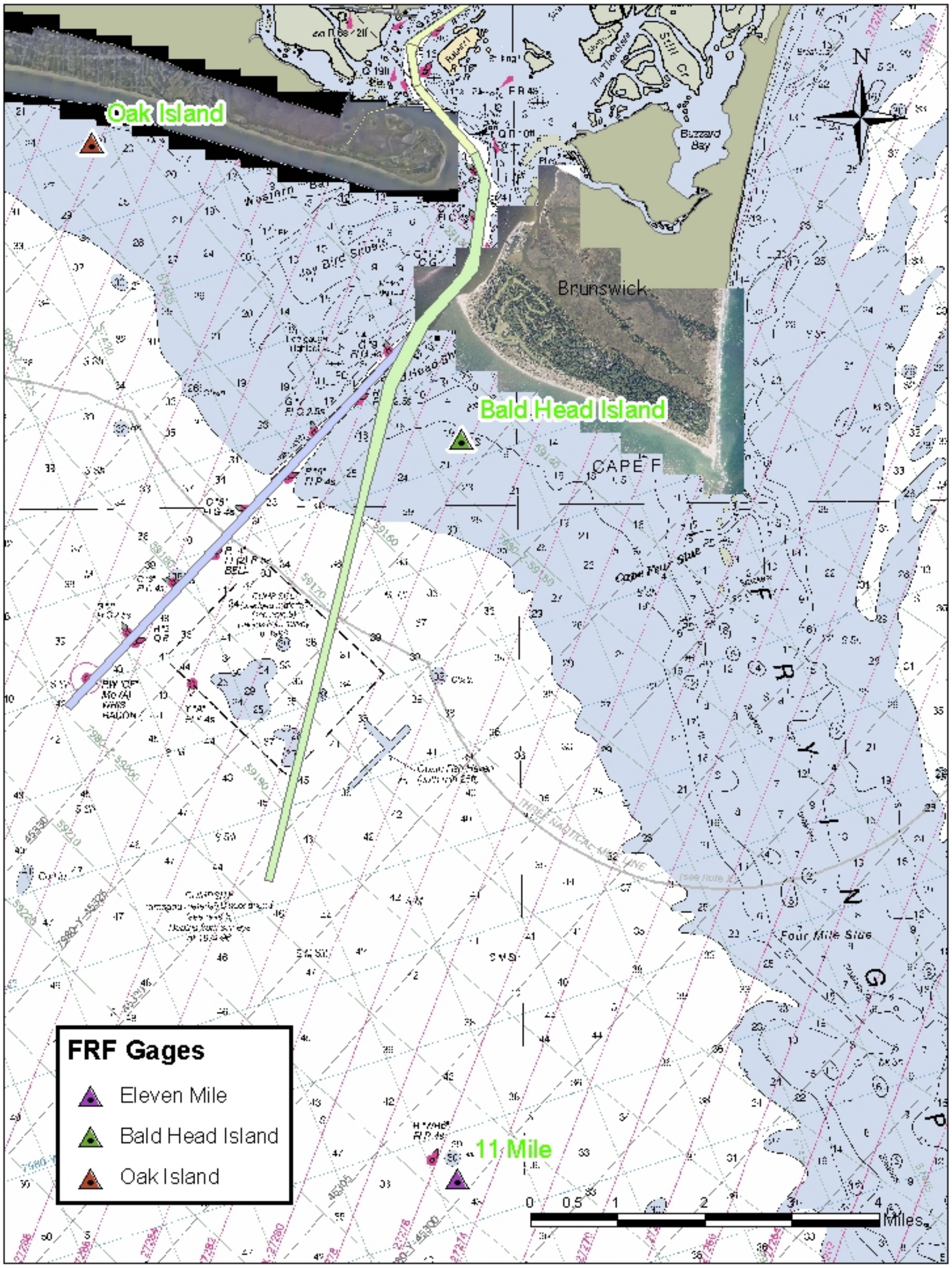


Figure 3.37 FRF Wave and Current Gauges.

Table 3.6 Eleven Mile Gauge Monthly Summaries

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	HsMax	2000	--	--	--	--	--	--	--	--	6.6	5.3	9.0	11.3	**8.1**
Eleven Mile	HsMax	2001	7.1	7.3	10.8	5.1	5.7	8.1	8.6	5.5	7.3	5.9	6.6	8.3	**7.2**
Eleven Mile	HsMax	2002	11.2	8.5	11.5	8.4	7.2	5.9	6.4	4.6	5.6	6.8	9.7	8.8	**7.9**
Eleven Mile	HsMax	2003	7.4	9.7	8.5	7.3	9.3	6.3	6.0	5.9	9.1	6.3	9.7	9.1	**7.9**
Eleven Mile	HsMax	2004	7.3	6.9	6.5	8.5	6.1	5.2	5.2	11.1	9.9	6.8	8.6	--	**7.5**
Eleven Mile	HsMax	2005	--	9.9	11.7	9.5	8.1	5.6	6.0	5.0	11.5	8.0	10.1	11.7	**8.8**
Eleven Mile	HsMax	2006	10.5	--	--	--	8.1	10.9	5.5	10.1	9.5	6.4	13.3	14.1	**9.8**
Eleven Mile	HsMax	2007	12.8	16.4	15.5	11.7	8.1	9.7	5.5	5.4	5.6	6.0	8.7	9.2	**9.6**
Eleven Mile	HsMax	2008	8.8	9.5	10.2	5.3	8.8	6.8	6.4	6.7	15.8	9.5	9.0	10.4	**8.9**
Eleven Mile	HsMax	2009	9.7	8.7	8.2	9.0	6.1	5.6	6.3	7.9	5.8	5.9	7.1	11.0	**7.6**
Eleven Mile	HsMax	2010	13.8	--	8.3	6.9	--	--	--	--	--	--	--	--	**9.7**
	AVERAGE		**9.8**	**9.6**	**10.1**	**8.0**	**7.5**	**7.1**	**6.2**	**6.9**	**8.7**	**6.7**	**9.2**	**10.4**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	DpMax	2000	--	--	--	--	--	--	--	--	213.0	89.0	166.0	253.0	**180.3**
Eleven Mile	DpMax	2001	221.0	159.0	146.0	205.0	33.0	190.0	165.0	227.0	21.0	203.0	154.0	186.0	**159.2**
Eleven Mile	DpMax	2002	182.0	188.0	164.0	212.0	203.0	154.0	217.0	72.0	182.0	153.0	187.0	190.0	**175.3**
Eleven Mile	DpMax	2003	208.0	187.0	160.0	172.0	236.0	191.0	209.0	177.0	319.0	157.0	180.0	187.0	**198.6**
Eleven Mile	DpMax	2004	236.0	144.0	168.0	174.0	231.0	199.0	214.0	198.0	197.0	205.0	184.0	--	**195.5**
Eleven Mile	DpMax	2005	--	161.0	185.0	225.0	17.0	64.0	265.0	194.0	286.0	137.0	191.0	146.0	**170.1**
Eleven Mile	DpMax	2006	172.0	--	--	--	231.0	183.0	231.0	177.0	191.0	146.0	139.0	221.0	**187.9**
Eleven Mile	DpMax	2007	198.0	206.0	194.0	205.0	157.0	160.0	192.0	205.0	213.0	157.0	201.0	193.0	**190.1**
Eleven Mile	DpMax	2008	177.0	173.0	204.0	207.0	219.0	207.0	146.0	117.0	182.0	120.0	217.0	157.0	**177.2**
Eleven Mile	DpMax	2009	197.0	216.0	205.0	185.0	92.0	176.0	213.0	162.0	200.0	136.0	253.0	165.0	**183.3**
Eleven Mile	DpMax	2010	182.0	--	174.0	190.0	--	--	--	--	--	--	--	--	**182.0**
	AVERAGE		**197.0**	**179.3**	**177.8**	**197.2**	**157.7**	**169.3**	**205.8**	**169.9**	**200.4**	**150.3**	**187.2**	**188.7**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	HsMean	2000	--	--	--	--	--	--	--	--	3.6	2.5	2.5	3.1	**2.9**
Eleven Mile	HsMean	2001	2.7	2.7	3.6	2.6	2.7	2.7	3.3	3.0	3.0	2.9	3.2	3.2	**3.0**
Eleven Mile	HsMean	2002	3.3	3.2	3.3	3.5	3.4	3.3	3.4	2.8	3.2	2.8	3.0	3.3	**3.2**
Eleven Mile	HsMean	2003	3.3	2.9	3.1	3.1	3.0	3.2	2.8	2.4	3.6	2.8	3.2	3.1	**3.0**
Eleven Mile	HsMean	2004	2.8	3.2	2.9	2.7	3.1	3.0	2.8	3.3	4.4	2.9	2.8	--	**3.1**
Eleven Mile	HsMean	2005	--	3.9	4.0	3.7	2.8	2.8	2.6	2.5	3.5	3.0	3.2	3.2	**3.2**
Eleven Mile	HsMean	2006	3.2	--	--	--	3.2	3.3	3.3	2.9	3.2	2.9	6.5	6.0	**3.8**
Eleven Mile	HsMean	2007	6.1	7.8	6.4	2.8	2.7	2.6	2.5	2.4	2.9	3.5	3.3	3.2	**3.9**
Eleven Mile	HsMean	2008	3.1	3.8	3.4	3.0	2.8	2.6	2.8	3.1	4.4	3.6	3.6	3.8	**3.3**
Eleven Mile	HsMean	2009	3.4	2.8	3.3	3.6	3.5	2.5	3.6	3.4	3.2	3.0	3.4	4.3	**3.3**
Eleven Mile	HsMean	2010	3.3	--	3.2	2.7	--	--	--	--	--	--	--	--	**3.1**
	AVERAGE		**3.5**	**3.8**	**3.7**	**3.1**	**3.0**	**2.9**	**3.0**	**2.9**	**3.5**	**3.0**	**3.5**	**3.7**	

(Continued)

Table 3.6 Eleven Mile Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	TpMax	2000	--	--	--	--	--	--	--	--	12.8	**	14.2	**	**13.5**
Eleven Mile	TpMax	2001	**	10.6	16.0	25.6	14.2	**	10.6	11.6	**	18.2	14.2	**	**15.1**
Eleven Mile	TpMax	2002	16.0	16.0	**	10.6	**	11.6	9.8	18.2	12.8	21.3	18.2	18.2	**15.3**
Eleven Mile	TpMax	2003	12.8	14.2	16.0	14.2	14.2	9.1	9.1	16.0	16.0	14.2	14.2	16.0	**13.8**
Eleven Mile	TpMax	2004	11.6	14.2	14.2	12.8	11.6	25.6	9.8	25.6	16.0	25.6	25.6	--	**17.5**
Eleven Mile	TpMax	2005	--	10.6	16.0	16.0	14.2	12.8	10.6	25.6	12.8	14.2	16.0	12.8	**14.7**
Eleven Mile	TpMax	2006	14.2	--	--	--	14.2	12.8	9.8	12.8	25.6	12.8	10.6	10.6	**13.7**
Eleven Mile	TpMax	2007	9.8	10.6	11.6	12.8	25.6	25.6	14.2	16.0	12.8	16.0	14.2	14.2	**15.3**
Eleven Mile	TpMax	2008	14.2	14.2	25.6	12.8	14.2	16.0	16.0	11.6	16.0	25.6	25.6	12.8	**17.1**
Eleven Mile	TpMax	2009	25.6	14.2	14.2	12.8	9.1	25.6	10.6	18.2	25.6	25.6	14.2	16.0	**17.6**
Eleven Mile	TpMax	2010	25.6	--	14.2	12.8	--	--	--	--	--	--	--	--	**17.5**
	AVERAGE		**16.2**	**13.1**	**16.0**	**14.5**	**14.7**	**17.4**	**11.2**	**17.3**	**16.7**	**19.3**	**16.7**	**14.4**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	TpMean	2000	--	--	--	--	--	--	--	--	7.2	7.5	6.8	7.0	**7.1**
Eleven Mile	TpMean	2001	6.8	6.7	7.5	6.1	6.9	5.5	5.8	5.9	6.7	6.1	7.4	7.2	**6.5**
Eleven Mile	TpMean	2002	6.3	6.9	7.2	5.9	6.3	6.2	5.6	6.4	7.1	7.2	7.7	6.8	**6.6**
Eleven Mile	TpMean	2003	6.7	7.5	7.0	7.4	6.1	7.1	5.9	6.6	8.9	7.5	7.2	7.7	**7.1**
Eleven Mile	TpMean	2004	6.5	7.1	7.3	6.8	6.8	5.6	6.2	6.8	8.4	8.3	7.2	--	**7.0**
Eleven Mile	TpMean	2005	--	6.3	7.0	6.9	6.5	5.9	5.9	7.7	7.7	7.1	7.1	6.8	**6.8**
Eleven Mile	TpMean	2006	6.9	--	--	--	6.1	6.5	6.3	5.9	8.5	6.5	4.2	5.8	**6.3**
Eleven Mile	TpMean	2007	4.8	4.6	5.3	6.4	7.5	7.1	6.6	7.4	6.2	7.1	6.7	7.5	**6.4**
Eleven Mile	TpMean	2008	7.1	7.1	7.1	7.0	6.3	6.3	7.1	7.1	8.0	6.7	7.0	7.1	**7.0**
Eleven Mile	TpMean	2009	6.7	6.8	7.4	6.9	6.4	6.4	6.0	8.0	7.0	7.2	7.7	7.1	**7.0**
Eleven Mile	TpMean	2010	6.4	--	8.3	6.8	--	--	--	--	--	--	--	--	**7.2**
	AVERAGE		**6.5**	**6.6**	**7.1**	**6.7**	**6.5**	**6.3**	**6.2**	**6.9**	**7.6**	**7.1**	**6.9**	**7.0**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	Dpmean	2000	--	--	--	--	--	--	--	--	143.3	137.8	169.7	147.7	**149.6**
Eleven Mile	Dpmean	2001	173.0	149.7	160.9	171.4	168.9	172.5	155.9	166.8	126.8	150.3	142.7	154.0	**157.7**
Eleven Mile	Dpmean	2002	167.2	160.2	145.4	145.8	158.4	147.1	182.0	117.7	127.5	120.5	157.2	157.3	**148.9**
Eleven Mile	Dpmean	2003	183.8	156.0	148.2	165.2	160.5	168.4	178.3	164.5	143.5	140.1	160.6	166.6	**161.3**
Eleven Mile	Dpmean	2004	168.0	142.5	157.7	171.1	175.2	177.2	173.9	152.7	151.6	143.4	140.0		**159.4**
Eleven Mile	Dpmean	2005	--	123.6	171.2	170.5	158.2	147.5	173.3	147.3	141.7	141.4	148.2	158.7	**152.9**
Eleven Mile	Dpmean	2006	179.6	--	--	--	178.4	170.5	181.2	160.3	149.0	145.8	145.1	148.7	**162.1**
Eleven Mile	Dpmean	2007	165.0	152.8	148.1	171.2	145.7	162.3	157.0	157.8	135.4	158.8	158.2	154.8	**155.6**
Eleven Mile	Dpmean	2008	163.0	167.4	164.5	146.7	165.0	178.9	170.2	167.1	138.6	145.9	176.1	167.6	**162.6**
Eleven Mile	Dpmean	2009	175.3	175.3	145.9	173.7	158.3	166.4	178.4	164.2	146.8	140.2	164.3	149.9	**161.6**
Eleven Mile	Dpmean	2010	184.2	--	162.6	168.3	--	--	--	--	--	--	--	--	**171.7**
	AVERAGE		**173.2**	**153.4**	**156.1**	**164.9**	**163.2**	**165.6**	**172.2**	**155.4**	**140.4**	**142.4**	**156.2**	**156.1**	

NOTE: Wave Height (HsMax, HsMean) Units are feet, Wave Period (TpMax, TpMean) Units are seconds, Wave Direction (DpMax, DpMean) are meteorological (deg North, from).
-- denotes no data or missing data. ** denotes suspect wave period measurements.

Table 3.7 Bald Head Gauge Monthly Summaries

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	HsMax	2000	--	--	--	--	--	--	--	--	6.3	2.5	6.6	7.8	**5.8**
Bald Head	HsMax	2001	6.9	5.4	8.9	4.4	4.3	7.0	6.1	4.8	1.3	4.3	4.3	6.4	**5.3**
Bald Head	HsMax	2002	9.0	6.3	8.1	6.3	6.0	5.0	4.6	4.1	4.3	5.2	7.4	6.5	**6.1**
Bald Head	HsMax	2003	6.3	7.6	5.8	5.9	7.4	5.0	5.4	4.6	6.5	4.9	7.2	8.0	**6.2**
Bald Head	HsMax	2004	6.5	5.0	5.4	6.7	4.6	4.5	4.4	6.5	7.7	5.7	6.8	5.9	**5.8**
Bald Head	HsMax	2005	6.9	4.9	8.5	7.5	5.9	3.4	5.9	4.5	--	5.2	8.5	7.8	**6.3**
Bald Head	HsMax	2006	--	--	--	--	7.9	7.9	4.3	6.8	6.6	8.1	8.2	6.4	**7.0**
Bald Head	HsMax	2007	6.1	6.6	8.2	--	--	--	--	--	2.8	4.2	5.5	7.7	**5.9**
Bald Head	HsMax	2008			6.0	3.7	4.7	4.9	5.6	4.5	9.8	5.7	6.8	7.8	**6.0**
Bald Head	HsMax	2009	7.1	6.3	6.6	5.7	4.3	4.0	5.4	5.1	6.3	4.7	4.9	8.0	**5.7**
Bald Head	HsMax	2010	8.0	--	--	--	--	--	--	--	--	--	--	--	**8.0**
	AVERAGE		**7.1**	**6.0**	**7.2**	**5.7**	**5.6**	**5.2**	**5.2**	**5.1**	**5.7**	**5.1**	**6.6**	**7.2**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	DpMax	2000	--	--	--	--	--	--	--	--	192.0	203.0	173.0	198.0	**191.5**
Bald Head	DpMax	2001	206.0	195.0	192.0	222.0	159.0	201.0	195.0	195.0	149.0	201.0	209.0	205.0	**194.1**
Bald Head	DpMax	2002	202.0	179.0	183.0	183.0	189.0	211.0	208.0	204.0	212.0	188.0	194.0	202.0	**196.3**
Bald Head	DpMax	2003	203.0	203.0	169.0	201.0	217.0	200.0	189.0	165.0	250.0	186.0	194.0	200.0	**198.1**
Bald Head	DpMax	2004	195.0	175.0	195.0	203.0	205.0	205.0	202.0	189.0	176.0	197.0	198.0	189.0	**194.1**
Bald Head	DpMax	2005	193.0	203.0	212.0	192.0	235.0	190.0	235.0	214.0	--	149.0	200.0	172.0	**199.5**
Bald Head	DpMax	2006	--	--	--	--	209.0	209.0	191.0	192.0	224.0	177.0	199.0	198.0	**199.9**
Bald Head	DpMax	2007	190.0	202.0	194.0	--	--	--	--	--	180.0	200.0	180.0	168.0	**187.7**
Bald Head	DpMax	2008	--	--	195.0	199	198.0	216.0	207.0	201.0	186.0	197.0	188.0	196.0	**198.3**
Bald Head	DpMax	2009	202.0	201	203	198	210	210	227	230	189	202	209	218	**208.3**
Bald Head	DpMax	2010	194.0	--	--	--	--	--	--	--	--	--	--	--	**194.0**
	AVERAGE		**198.1**	**194.0**	**192.9**	**199.7**	**202.8**	**205.3**	**206.8**	**198.8**	**195.3**	**190.0**	**194.4**	**194.6**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	HsMean	2000	--	--	--	--	--	--	--	--	2.1	1.2	1.8	1.9	**1.8**
Bald Head	HsMean	2001	1.9	1.8	2.4	2.0	2.1	2.0	2.2	2.0	1.0	1.5	1.7	2.0	**1.9**
Bald Head	HsMean	2002	1.9	1.8	1.8	2.1	2.0	2.1	2.4	1.7	1.7	1.4	1.8	2.0	**1.9**
Bald Head	HsMean	2003	2.2	1.7	1.7	2.0	1.9	2.2	2.2	1.8	1.7	1.4	1.7	2.0	**1.9**
Bald Head	HsMean	2004	1.8	1.7	1.8	1.9	2.3	2.0	1.9	1.9	2.5	1.8	1.5	1.9	**1.9**
Bald Head	HsMean	2005	1.8	1.6	2.5	2.4	1.7	1.6	1.8	1.4		1.7	2.0	2.2	**1.9**
Bald Head	HsMean	2006	--	--	--	--	1.9	2.0	2.0	1.7	1.7	1.6	1.8	1.8	**1.8**
Bald Head	HsMean	2007	2.2	2.0	1.9	--	--	--	--	--	1.2	1.8	1.7	2.6	**1.9**
Bald Head	HsMean	2008			1.8	1.2	1.5	1.6	1.6	1.8	2.1	1.6	2.0	2.2	**1.7**
Bald Head	HsMean	2009	2.0	1.7	1.8	2.1	1.7	1.4	2.4	1.9	1.4	1.5	1.6	2.3	**1.8**
Bald Head	HsMean	2010	2.0	--	--	--	--	--	--	--	--	--	--	--	**2.0**
	AVERAGE		**2.0**	**1.8**	**2.0**	**2.0**	**1.9**	**1.9**	**2.1**	**1.8**	**1.7**	**1.6**	**1.8**	**2.1**	

(Continued)

Table 3.7 Bald Head Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	**	14.2	**14.2**
Bald Head	TpMax	2001	**	25.6	18.2	16.0	16.0	25.6	**	10.6	**	**	**	**	**18.7**
Bald Head	TpMax	2002	**	**	25.6	**	**	**	**	21.3	14.2	18.2	18.2	16.0	**18.9**
Bald Head	TpMax	2003	16.0	16.0	16.0	14.5	16.0	16.0	9.1	16.0	16.0	14.2	12.8	16.0	**14.9**
Bald Head	TpMax	2004	11.6	14.2	14.2	12.8	10.6	10.6	9.8	14.2	18.2	**	**	**	**12.9**
Bald Head	TpMax	2005	12.8	16.0	16.0	16.0	16.0	16.0	14.2	14.2		16	12.8	12.8	**14.8**
Bald Head	TpMax	2006	--	--	--	--	16.0	10.6	9.8	14.2	14.2	21.2	14.2	10.6	**13.9**
Bald Head	TpMax	2007	14.2	25.6	10.6	--	--	--	--	--	14.2	18.2	14.2	11.6	**15.5**
Bald Head	TpMax	2008			16.0	12.8	16.0	16.0	25.6	12.8	16.0	14.2	12.8	25.6	**16.8**
Bald Head	TpMax	2009	21.3	9.5	9.9	9.1	8.3	10.2	12.8	18.2	25.6	18.2	16	16	**14.6**
Bald Head	TpMax	2010	25.6	--	--	--	--	--	--	--	--	--	--	--	**25.6**
	AVERAGE		**15.2**	**17.8**	**15.8**	**13.5**	**14.1**	**15.0**	**13.6**	**15.2**	**16.8**	**17.2**	**14.4**	**15.4**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	TpMean	2000	--	--	--	--	--	--	--	--	7.6	9.0	7.5	7.4	**7.9**
Bald Head	TpMean	2001	7.2	6.8	7.5	6.1	6.7	6.0	6.2	6.0	11.4	7.5	7.9	7.5	**7.2**
Bald Head	TpMean	2002	7.6	7.5	7.6	6.3	6.3	6.1	5.6	6.2	7.4	8.2	7.7	7.2	**7.0**
Bald Head	TpMean	2003	7.1	7.9	7.3	7.5	6.4	6.8	5.3	5.9	9.1	8.1	7.5	7.9	**7.2**
Bald Head	TpMean	2004	6.9	7.8	7.7	6.4	6.2	5.3	5.7	6.6	9.3	8.5	7.8	7.7	**7.2**
Bald Head	TpMean	2005	7.7	8.5	6.9	7.1	6.7	6.2	5.1	6.3	--	7.7	7.4	7.1	**7.0**
Bald Head	TpMean	2006	--	--	--	--	6.6	6.3	6.0	6.3	8.4	7.2	7.6	7.8	**7.0**
Bald Head	TpMean	2007	7.0	7.0	7.3	--	--	--	--	--	7.8	7.4	7.5	7.5	**7.4**
Bald Head	TpMean	2008	--	--	7.8	7.4	6.5	5.7	6.7	6.8	8.5	7.2	7.0	7.6	**7.1**
Bald Head	TpMean	2009	6.6	5.5	6.3	5.5	5.2	4.9	5.8	6.7	7.8	7.3	8.2	7.8	**6.5**
Bald Head	TpMean	2010	7.2	--	--	--	--	--	--	--	--	--	--	--	**7.2**
	AVERAGE		**7.2**	**7.3**	**7.3**	**6.6**	**6.3**	**5.9**	**5.8**	**6.4**	**8.6**	**7.8**	**7.6**	**7.6**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
Bald Head	Dpmean	2000	--	--	--	--	--	--	--	--	171	165.5	184.9	185	**176.6**
Bald Head	Dpmean	2001	191.4	185	189.4	185.8	186.1	186.1	188.3	199.1	152	179.5	177.6	187.1	**184.0**
Bald Head	Dpmean	2002	189.5	187.3	181.4	183.9	185.9	180.6	193.6	180.4	177.7	172.2	184.0	184.2	**183.4**
Bald Head	Dpmean	2003	198.3	183.7	179.3	186.3	186.5	189.1	193.4	189.1	174.9	175.5	184.2	187.0	**185.6**
Bald Head	Dpmean	2004	187.7	177.3	182.5	188.6	194.6	193.1	193.3	182.7	185.6	179.6	179.2	188.4	**186.1**
Bald Head	Dpmean	2005	185.1	182.0	190.0	191.6	187.6	179.9	196.0	183.5	--	--	--	186.1	**186.9**
Bald Head	Dpmean	2006	--	--	--	--	186.6	188.5	194.6	185	177.7	183.6	178.7	184.0	**184.8**
Bald Head	Dpmean	2007	191.3	188.5	184.3	--	--	--	--	--	165.6	178.4	185.4	189.5	**183.3**
Bald Head	Dpmean	2008	--	--	187.5	181.0	187.2	197.3	188.8	191.1	181.0	182.9	194.7	189.5	**188.1**
Bald Head	Dpmean	2009	193.6	187.2	171.1	185.6	180.9	183.5	194.6	189.9	168.1	180.8	180.8	181.9	**183.2**
Bald Head	Dpmean	2010	197.2	--	--	--	--	--	--	--	--	--	--	--	**197.2**
	AVERAGE		**191.0**	**184.4**	**183.2**	**186.1**	**186.9**	**187.3**	**192.8**	**187.6**	**172.6**	**177.6**	**183.3**	**186.3**	

NOTE: Wave Height (HsMax, HsMean) Units are feet, Wave Period (TpMax, TpMean) Units are seconds, Wave Direction (DpMax, DpMean) are meteorological (deg North, from).
-- denotes no data or missing data. ** denotes suspect wave period measurements.

Table 3.8 Oak Island Gauge Monthly Summaries

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	HsMax	2000	--	--	--	--	--	--	--	--	5.3	2.9	--	--	**4.1**
Oak Island	HsMax	2001	--	--	--	--	--	6.0	3.7	--	1.0	4.2	3.9	5.8	**4.1**
Oak Island	HsMax	2002	8.3	5.3	6.6	4.4	4.1	4.7	2.7	3.9	4.2	4.7	6.6	6.0	**5.1**
Oak Island	HsMax	2003	5.4	6.6	5.3	4.2	3.8	4.5	5.3	4.5	6.0	4.2	6.4	6.1	**5.2**
Oak Island	HsMax	2004	6.1	4.9	5.3	5.5	4.5	4.6	4.6	9.9	6.5	5.3	5.6	5.0	**5.7**
Oak Island	HsMax	2005	6.2	4.1	7.3	--	--	--	--	--	3.2	4.2	5.8	5.1	**5.1**
Oak Island	HsMax	2006	6.2	--	--	--	4.8	6.2	3.4	5.9	5.0	--	--	--	**5.3**
Oak Island	HsMax	2007	--	--	--	6.8	2.7	5.1	5.2	4.8	5.2	3.1	4.1	3.4	**4.5**
Oak Island	HsMax	2008	4.3	5.2	5.8	2.3	--	--	--	4.9	9.6	5.6	6.1	7.9	**5.7**
Oak Island	HsMax	2009	6.9	7.0	6.2	6.7	4.6	4.4	3.4	3.1	3.8	2.8	3.1	4.7	**4.7**
Oak Island	HsMax	2010	5.1	4.6	3.6	3.4	3.3	--	--	--	--	--	--	--	**4.0**
	AVERAGE		**6.1**	**5.4**	**5.7**	**4.8**	**4.0**	**5.1**	**4.0**	**5.3**	**5.0**	**4.1**	**5.2**	**5.5**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	DpMax	2000	--	--	--	--	--	--	--	--	206.0	239.0	--	--	**222.5**
Oak Island	DpMax	2001	--	--	--	--	--	192.0	236.0	--	172.0	190.0	181.0	197.0	**194.7**
Oak Island	DpMax	2002	185.0	191.0	182.0	201.0	202.0	193.0	234.0	202.0	177.0	185.0	183.0	193.0	**194.0**
Oak Island	DpMax	2003	214.0	191.0	185.0	185.0	209.0	203.0	209.0	196.0	238.0	210.0	201.0	203.0	**203.7**
Oak Island	DpMax	2004	210.0	224.0	184.0	197.0	175.0	180.0	200.0	172.0	186.0	219.0	189.0	198.0	**194.5**
Oak Island	DpMax	2005	179.0	192.0	190.0	--	--	--	--	--	184.0	171.0	209.0	184.0	**187.0**
Oak Island	DpMax	2006	195.0	--	--	--	206.0	195.0	175.0	183.0	247.0	--	--	--	**200.2**
Oak Island	DpMax	2007	--	--	--	200.0	183.0	188.0	202.0	226.0	208.0	178.0	197.0	194.0	**197.3**
Oak Island	DpMax	2008	210.0	193.0	199.0	186.0	--	--	--	218.0	176.0	181.0	218.0	177.0	**195.3**
Oak Island	DpMax	2009	190.0	220.0	198.0	203.0	186.0	203.0	221.0	217.0	207.0	222.0	202.0	186.0	**204.6**
Oak Island	DpMax	2010	193.0	191.0	177.0	190.0	220.0	--	--	--	--	--	--	--	**194.2**
	AVERAGE		**197.0**	**200.3**	**187.9**	**194.6**	**197.3**	**193.4**	**211.0**	**202.0**	**200.1**	**199.4**	**197.5**	**191.5**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	HsMean	2000	--	--	--	--	--	--	--	--	2.3	1.2	--	--	**1.8**
Oak Island	HsMean	2001	--	--	--	--	--	1.6	2.5	--	0.8	1.4	1.5	1.8	**1.6**
Oak Island	HsMean	2002	1.8	1.5	2.0	2.0	1.6	2.0	1.6	1.6	1.5	1.3	1.6	1.8	**1.7**
Oak Island	HsMean	2003	1.8	1.6	1.4	1.6	1.6	1.8	2.3	1.8	1.5	1.3	1.5	1.5	**1.6**
Oak Island	HsMean	2004	1.6	1.4	1.6	1.7	2.2	2.0	1.8	1.8	2.4	1.4	1.3	1.6	**1.7**
Oak Island	HsMean	2005	1.6	1.4	2.0	--	--	--	--	--	1.4	1.2	1.5	1.4	**1.5**
Oak Island	HsMean	2006	2.2	--	--	--	1.6	1.7	1.6	1.4	1.2	--	--	--	**1.6**
Oak Island	HsMean	2007	--	--	--	1.4	1.2	1.8	1.7	1.7	1.5	1.2	1.1	1.6	**1.5**
Oak Island	HsMean	2008	1.1	1.6	1.5	1.5	--	--	--	1.7	1.8	1.4	1.7	2.0	**1.6**
Oak Island	HsMean	2009	1.8	1.7	1.8	2.3	1.9	1.6	1.5	1.2	0.8	0.8	0.9	1.3	**1.5**
Oak Island	HsMean	2010	1.1	1.2	1.2	1.2	1.0	--	--	--	--	--	--	--	**1.1**
	AVERAGE		**1.6**	**1.5**	**1.6**	**1.7**	**1.6**	**1.8**	**1.9**	**1.6**	**1.5**	**1.2**	**1.4**	**1.6**	

(Continued)

Table 3.8 Oak Island Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	--	--	**16.0**
Oak Island	TpMax	2001	--	--	--	--	--	**	5.1	--	**	**	**	**	**5.1**
Oak Island	TpMax	2002	**	**	**	**	**	**	9.1	21.3	21.3	21.3	21.3	16.0	**18.4**
Oak Island	TpMax	2003	16.0	16.0	16.0	16.0	16.0	9.8	9.1	16.0	16.0	14.2	14.2	16.0	**14.6**
Oak Island	TpMax	2004	11.6	14.2	16.0	12.8	25.6	9.1	9.1	25.6	16.0	16.0	25.6	25.6	**17.3**
Oak Island	TpMax	2005	25.6	11.6	16.0	--	--	--	--	--	25.6	16.0	25.6	21.3	**20.2**
Oak Island	TpMax	2006	11.6	--	--	--	25.6	25.6	9.8	21.3	25.6	--	--	--	**19.9**
Oak Island	TpMax	2007	--	--	--	25.6	16.0	25.6	14.2	25.6	25.6	25.6	18.2	10.6	**20.8**
Oak Island	TpMax	2008	25.6	25.6	21.3	9.1	--	--	--	12.8	25.6	25.6	25.6	25.6	**21.9**
Oak Island	TpMax	2009	25.6	18.2	14.2	14.2	10.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	**21.8**
Oak Island	TpMax	2010	25.6	25.6	21.3	25.6	21.3	--	--	--	--	--	--	--	**23.9**
	AVERAGE		**20.2**	**17.1**	**16.7**	**15.5**	**18.8**	**19.1**	**11.7**	**21.2**	**21.9**	**20.6**	**22.3**	**20.1**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	TpMean	2000	--	--	--	--	--	--	--	--	6.1	9.9	--	--	**8.0**
Oak Island	TpMean	2001	--	--	--	--	--	6.4	4.3	--	13.2	8.2	8.6	7.9	**8.1**
Oak Island	TpMean	2002	7.3	8.1	9.2	8.4	11.4	10.1	5.6	5.9	7.6	8.0	8.1	7.2	**8.1**
Oak Island	TpMean	2003	7.2	7.3	7.2	7.3	6.6	5.5	5.1	5.6	8.7	7.6	7.3	7.8	**6.9**
Oak Island	TpMean	2004	6.7	7.8	7.5	6.2	6.0	5.1	5.4	6.5	9.2	8.6	7.4	7.6	**7.0**
Oak Island	TpMean	2005	7.5	7.9	6.8	--	--	--	--	--	7.7	7.7	7.4	7.4	**7.5**
Oak Island	TpMean	2006	6.4	--	--	--	6.0	6.4	5.8	6.1	8.4	--	--	--	**6.5**
Oak Island	TpMean	2007	--	--	--	6.7	7.2	6.1	6.1	6.5	7.0	7.5	7.0	6.5	**6.7**
Oak Island	TpMean	2008	7.5	7.0	6.7	7.2	--	--	--	6.5	8.3	6.7	6.9	7.0	**7.1**
Oak Island	TpMean	2009	7.4	6.7	7.9	6.5	6.2	5.5	5.8	6.6	8.2	7.8	8.8	8.2	**7.1**
Oak Island	TpMean	2010	7.6	7.7	8.2	6.5	6.9	--	--	--	--	--	--	--	**7.4**
	AVERAGE		**7.2**	**7.5**	**7.6**	**7.0**	**7.2**	**6.4**	**5.4**	**6.2**	**8.4**	**8.0**	**7.7**	**7.5**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
Oak Island	DpMean	2000	--	--	--	--	--	--	--	--	202.2	181.1	--	--	**191.7**
Oak Island	DpMean	2001	--	--	--	--	--	188.2	217.5	--	163.9	183.9	178.8	183.8	**186.0**
Oak Island	DpMean	2002	189.5	187.4	183	187.8	188.2	186.2	201.2	157.6	150.5	144.9	176	192.6	**178.7**
Oak Island	DpMean	2003	198.6	191.7	187.6	190.3	193.2	197.4	197.9	194.6	182.2	179.5	186.4	188.1	**190.6**
Oak Island	DpMean	2004	193.8	184.1	190.6	196.6	199.4	196.9	195.3	189.7	185.9	182.5	184.4	189.9	**190.8**
Oak Island	DpMean	2005	189.2	179.8	195.2	--	--	--	--	--	187.2	182.2	185.8	186.2	**186.5**
Oak Island	DpMean	2006	203.8	--	--	--	194.6	192.9	197.2	192	185.5	--	--	--	**194.3**
Oak Island	DpMean	2007	--	--	--	194.1	187.5	193.8	190.5	196.2	184.3	181.5	190.4	193.4	**190.2**
Oak Island	DpMean	2008	190.2	192.1	193.5	183.1	--	--	--	192.6	188.1	189.0	195.3	195.1	**191.0**
Oak Island	DpMean	2009	194.6	195.5	187.4	194.8	188.1	194.0	196.6	191.3	175.0	178.3	180.1	187.5	**188.6**
Oak Island	DpMean	2010	196.8	192.9	187.2	194.9	186.5	--	--	--	--	--	--	--	**191.7**
	AVERAGE		**194.6**	**189.1**	**189.2**	**191.7**	**191.8**	**192.8**	**199.5**	**187.7**	**180.5**	**178.1**	**184.7**	**189.6**	

NOTE: Wave Height (HsMax, HsMean) Units are feet, Wave Period (TpMax, TpMean) Units are seconds, Wave Direction (DpMax, DpMean) are meteorological (deg North, from).
-- denotes no data or missing data. ** denotes suspect wave period measurements.

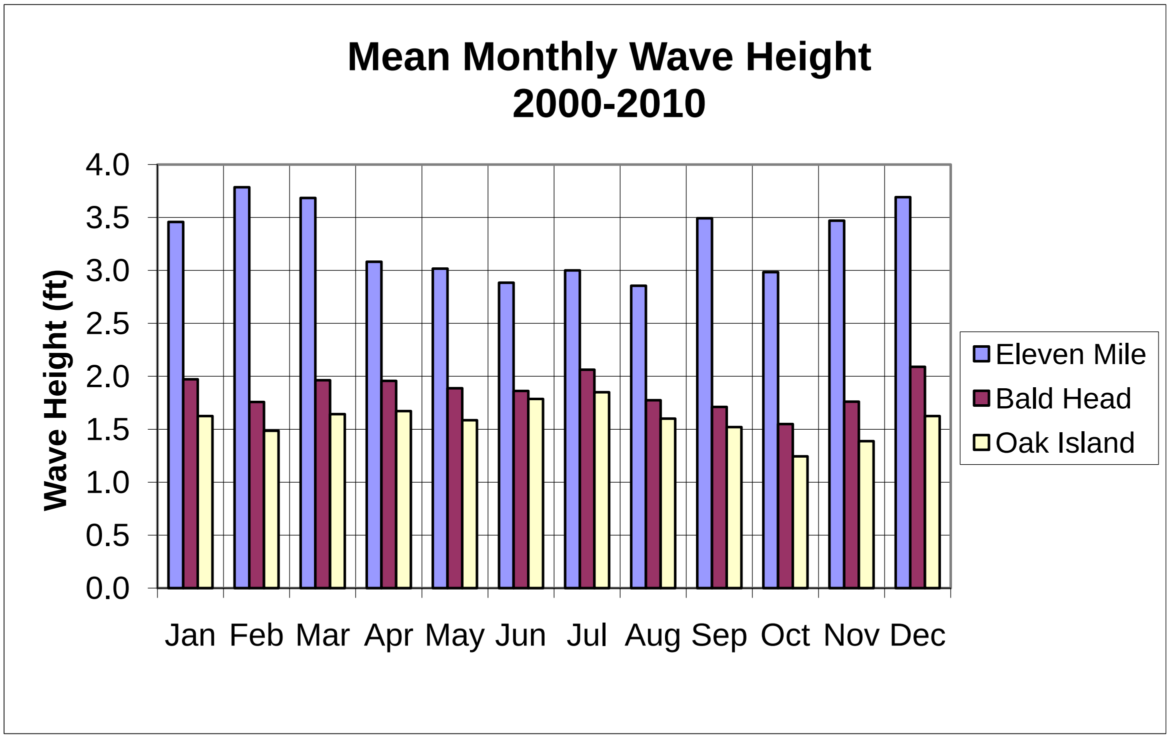


Figure 3.38 Mean Monthly Wave Height from Sep 2000- May 2010 for the Eleven Mile and Oak Island Gauges and Sep 2000- Jan 2010 for the Bald Head Gauge

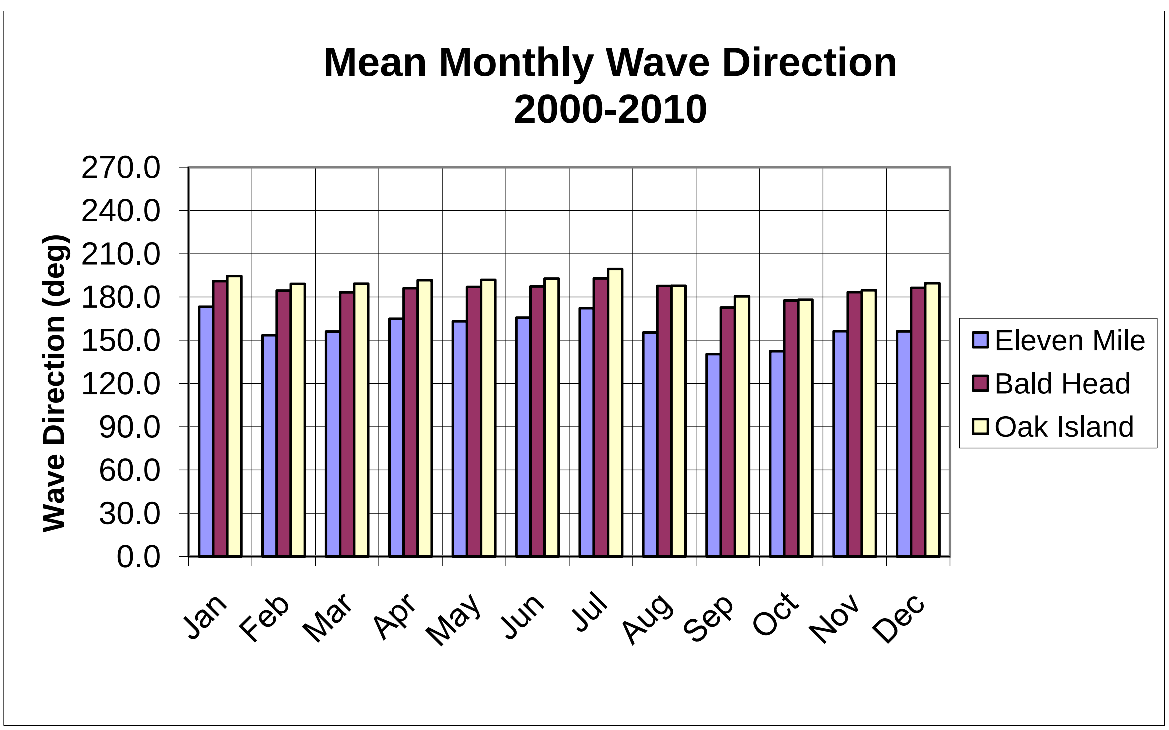


Figure 3.39 Mean Monthly Wave Direction from Sep 2000- May 2010 for the Eleven Mile and Oak Island Gauges and Sep 2000- Jan 2010 for the Bald Head Gauge

Further insights on the wave climate variability and the impacts of Frying Pan Shoals are shown on Figures 3.40 and 3.41. Figure 3.40 shows wave histograms that were created using all available data from each gauge for the entire monitoring period of September 2000 to May 2010. Figure 3.41 shows wave roses that were generated for available data revealing the characteristic differences in wave climate for the three locations. Dominant wave directions at 11-Mile Gauge are from southeast and south southeast. At Bald Head Island gauge, dominant directions are shifted to south-southeast through the south-southwest. Oak Island directions are further confined to primarily south and south-southwest. These direction shifts between offshore and nearshore locations are consistent with expected effects of wave refraction.

The 11-Mile Gauge wave rose shows a small, but significant component of the wave climate coming from easterly directions. These waves have passed across Frying Pan Shoals to reach the gauge. Frying Pan Shoals filters, but does not eliminate, wave energy reaching the 11-Mile Gauge site from these directions. Waves from easterly directions are virtually absent at the Bald Head Island and Oak Island gauges. This site is sheltered to the east by the Bald Head Island land mass and to the east-southeast by an extremely shallow part of Frying Pan Shoals extending from Cape Fear.

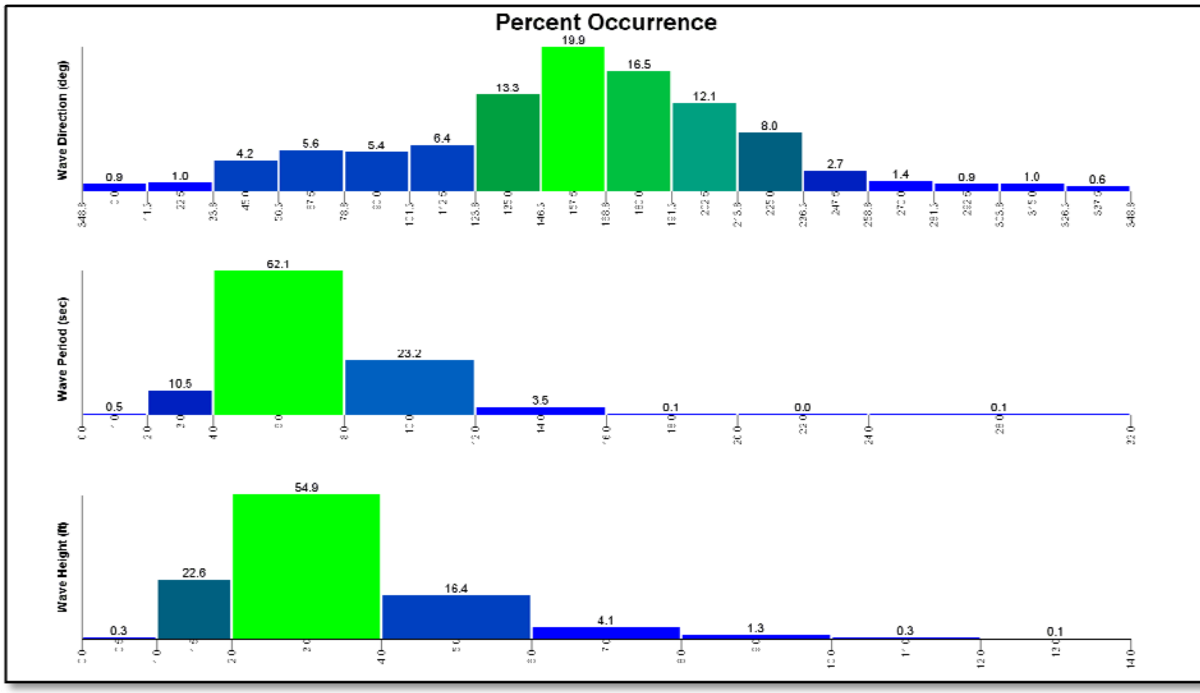
Time series for each gauge were separated into yearly components and analyzed to assess the statistical variation in wave climate. Annual wave height roses for all three gauges for the years 2000 through 2010 were generated and are given in Appendix A. The year to year comparison of the roses shows very similar patterns in the distribution of wave height and direction.

Figures 3.38 and 3.39 give the yearly mean wave height and direction for each of the three gauges. In terms of mean wave height, only minor variation is evident over the initial six years (2000-2005) of the monitoring program, while the next two years (2006-2007) show a significant increase at the offshore gauge. For the current monitoring period, wave heights have continued to decrease from the previous three years and are approximately at the levels observed during the first six years of monitoring. For the 11-mile gauge, the yearly mean wave height for the first six years of the monitoring program averaged 3.1 feet while the average for the next two years (2006 and 2007) increased to 3.9 feet, nearly a 27% increase. For the current monitoring period (January 2009 to April 2010) the average wave height has decreased to 3.1 feet, the same as the initial six year period. The nearshore gauges have been relatively consistent over the entire monitoring period. The wave transformation occurring between the offshore and nearshore gauges show that the gauges have remained relatively consistent over the duration of the monitoring program. The Bald Head gauge average wave height remains at 1.9 feet while the average wave height at the Oak Island gauge decreased slightly by 0.1 feet to an average of 1.6 feet. With regard to the yearly variation in terms of mean wave direction, Figure 3.39 shows that while there is some fluctuation from year to year the general wave direction is relatively consistent for each gauge with no pattern of directional change observed. The Eleven Mile gauge has the highest yearly fluctuation with a standard deviation of 6.6 degrees while the deviation at both the Bald Head and Oak Island gauges is smaller at only 5.0 and 4.2 degrees, respectively.

<u>Significant Events.</u> Several large storm events have occurred since the inception of the monitoring program that may have significantly altered adjacent beach shorelines and

beach profiles. An analysis was conducted to identify storm event parameters that exceeded a 6-ft significant wave height threshold with a minimum duration of 12-hrs. Events were selected through screening of the 11-Mile Gauge time series and were considered to be continuous events until significant wave height fell below 6 feet for more than one three hour recording. Parameters for the Bald Head and Oak Island gauges that correlate to the 11-Mile gauge peaks are reported as well. Eleven additional events were added since report seven, with Table 3.9 summarizing the 117 events that exceeded the set criteria over the entire monitoring period. The majority of the events, 67%, occurred in the winter (December through March) which is a slightly larger percentage than reported in Report 7. For the current monitoring period, waves typically originated from the south-southwest through southeast, with offshore wave heights of 6.9 to 13.8-ft and wave periods of 8 to 9.8 seconds. These parameters were slightly higher at the top end in magnitude and direction as those reported for the previous monitoring period. This most recent collection of significant events has a more south-southeast approach direction than the remainder of the database. Corresponding conditions at the nearshore gauges indicate significant reduction in wave height, with Oak Island being reduced by 49 percent and wave heights at the Bald Head gauge being reduced by 46 percent with respect to the 11-mile readings. The largest significant wave recorded to date at the 11-mile gauge remained 16.4 feet recorded on 26 February 2007. At this peak time the wave height recorded at the Bald Head gauge was 5.6 feet. Unfortunately, the Oak Island gauge was out of service at this time and no corresponding wave height is available. The largest wave measured at the Bald Head site was 9.8 feet which occurred during the month of September 2008. This wave height peak was associated with Tropical Storm Hanna which made landfall on September 6, 2008 near Myrtle Beach, SC. On 14-August 2004, during Hurricane Charlie, a wave height of 9.9 feet was measured at Oak Island, the largest recorded so far at this gauge.

Eleven-Mile Gauge (Sep 2000 – May 2010)



Bald Head Gauge (Sep 2000 – Jan 2010)

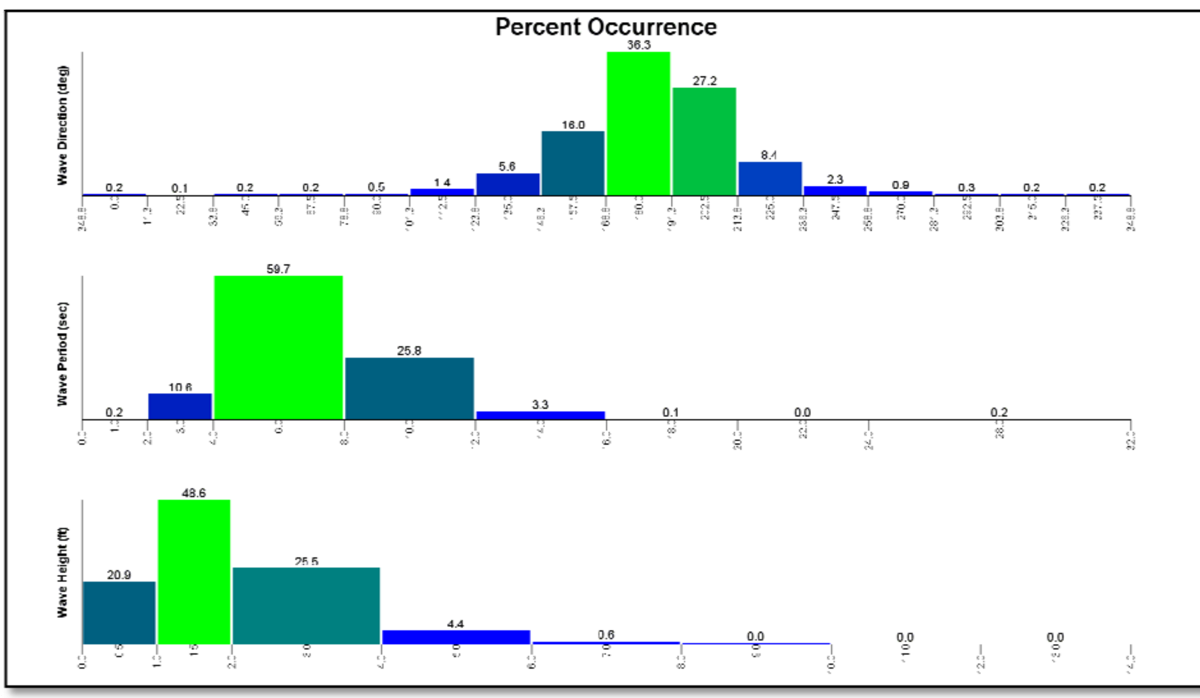


Figure 3.40 Wave Histograms for FRF Gauges throughout deployment.

Oak Island Gauge (Sep 2000 – May 2010)

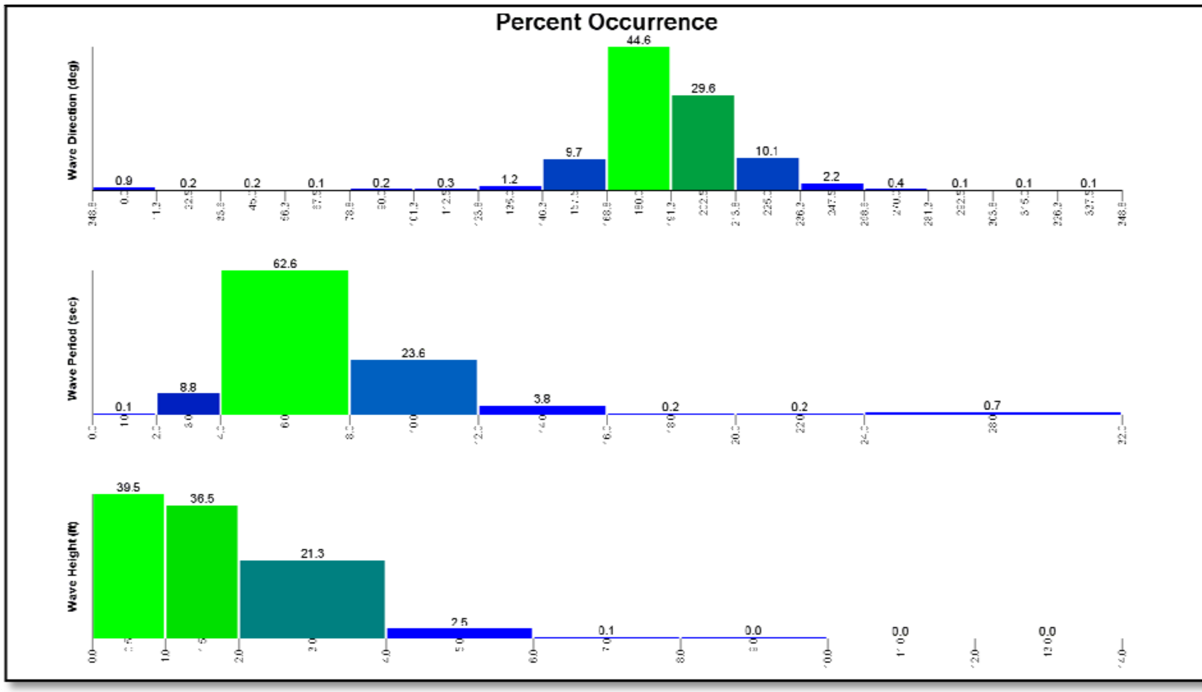
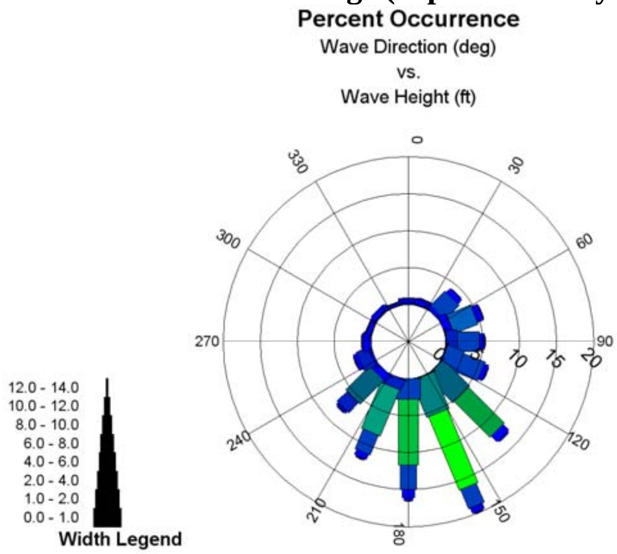


Figure 3.40 Wave Histograms for FRF Gauges throughout deployment. (Continued)

Eleven-Mile Gauge (Sep 2000 – May 2010)



Bald Head Gauge (Sep 2000 – Jan 2010)

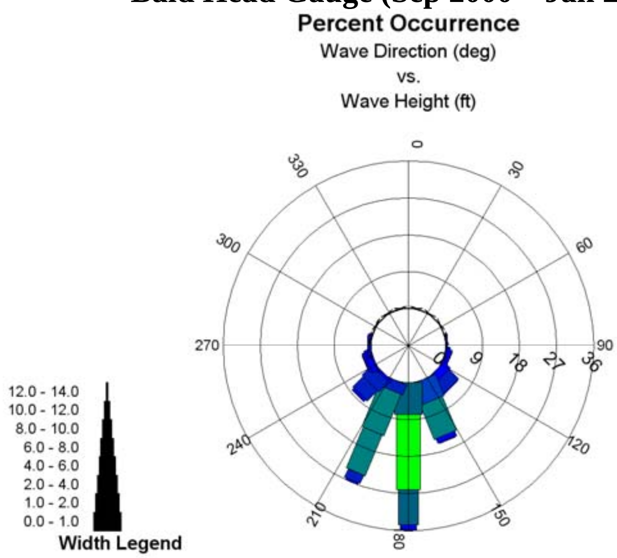


Figure 3.41 Wave Height Roses for FRF Gauges throughout deployment.

Oak Island Gauge (Sep 2000 – May 2010)

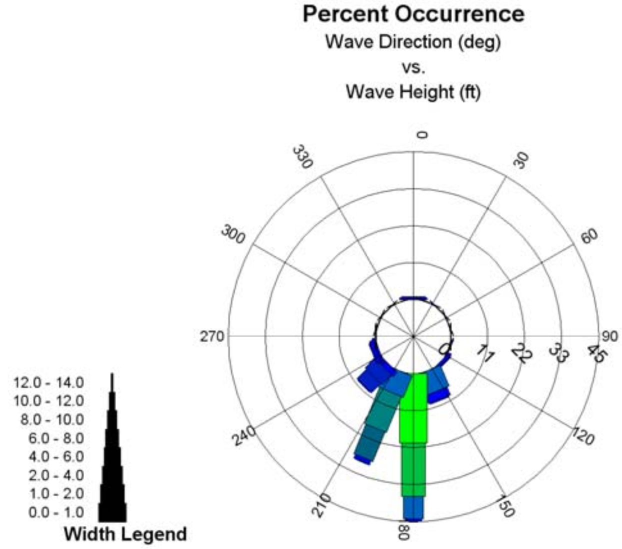


Figure 3.41 Wave Height Roses for FRF Gauges throughout deployment. (Continued)

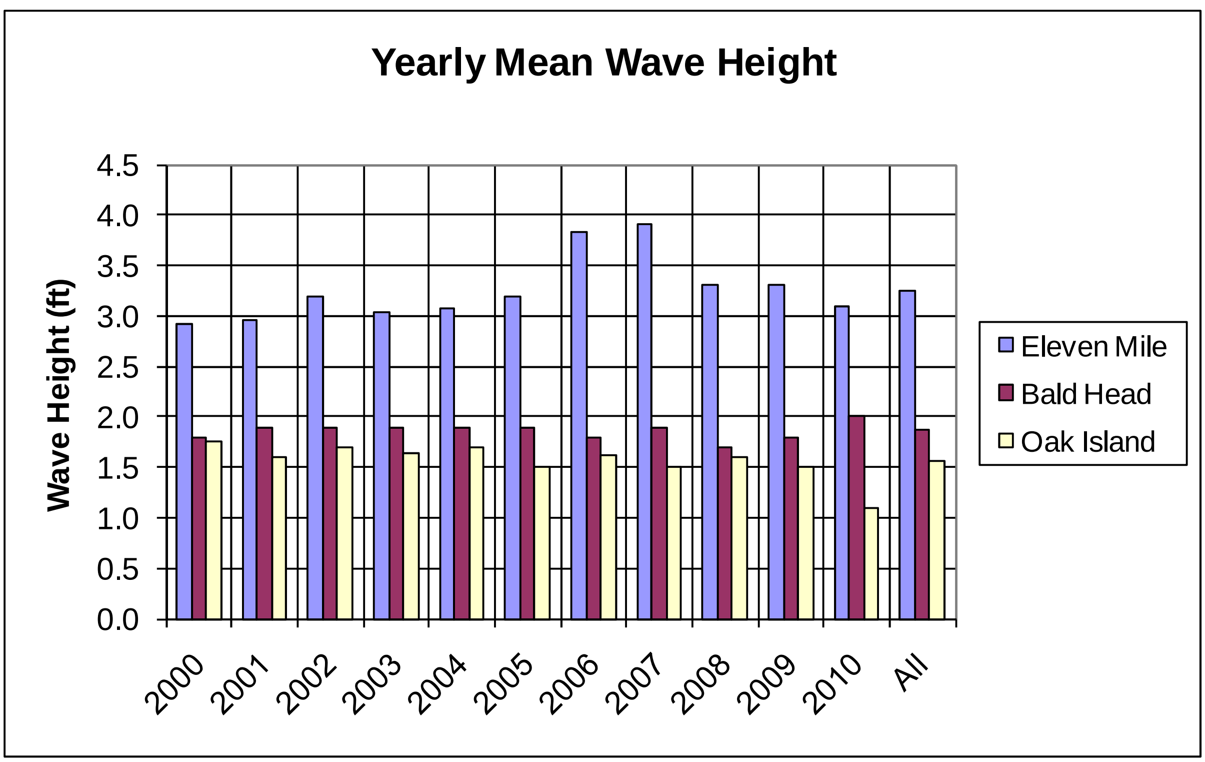


Figure 3.42 Yearly Mean Wave Heights for Years 2000 through 2010

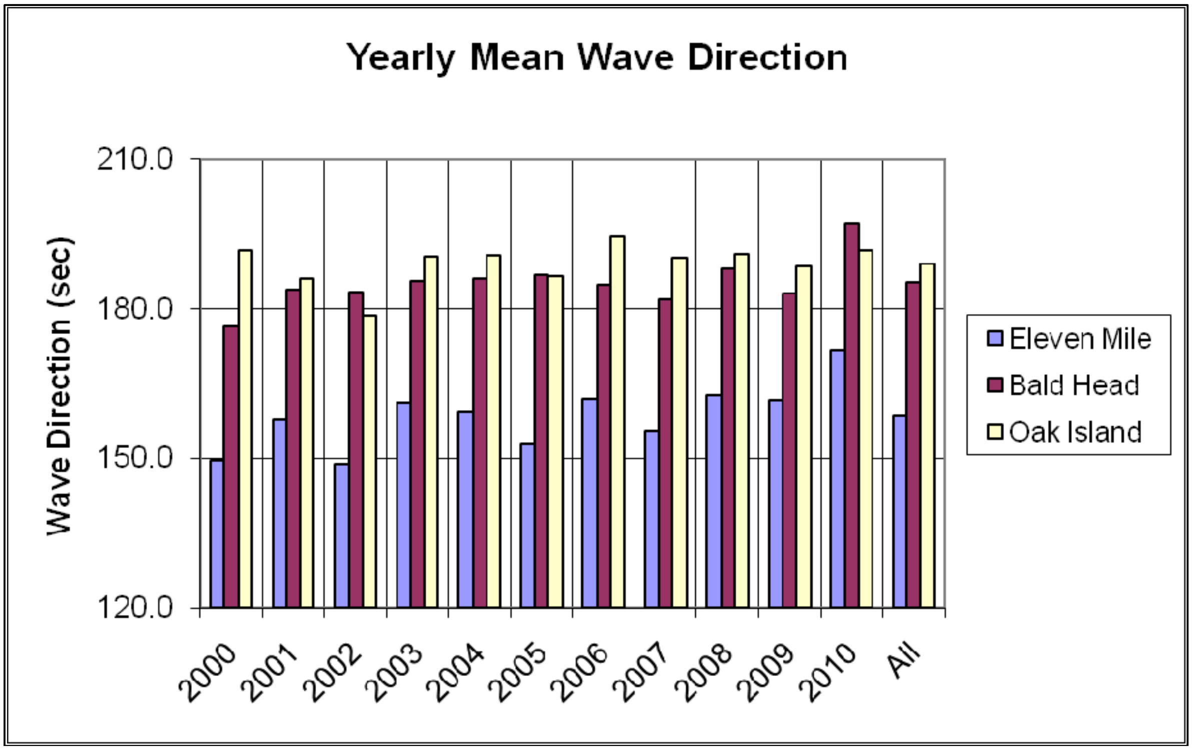


Figure 3.43 Yearly Mean Wave Directions for Years 2000 through 2010

Table 3.9 Significant Events at 11-Mile Gauge Exceeding Significant Wave Height of 6-ft.

						ELEVEN MILE GAGE					BALD HEAD GAGE			OAK ISLAND		
EVENT	START DATE	TIME	STOP DATE	TIME	Duration (hrs)	Hs (ft)	Tp (sec)	Dp (deg)	DATE PEAK	TIME	Hs (ft)	Tp (sec)	Dp (deg)	Hs (ft)	Tp (sec)	Dp (deg)
1	16-Dec-00	3:00	16-Dec-00	18:00	15.00	11.3	9.8	199.5	16-Dec-00	15:00	1.3	6.4	173.0	--	--	--
2	20-Jan-01	6:00	21-Jan-01	0:00	18.00	6.6	8.5	196.3	21-Jan-01	0:00	4.5	6.7	194.0	--	--	--
3	20-Mar-01	12:00	22-Mar-01	0:00	36.00	10.8	11.6	169.0	20-Mar-01	18:00	7.1	10.6	188.0	--	--	--
4	29-Mar-01	9:00	30-Mar-01	3:00	18.00	7.9	9.1	169.3	29-Mar-01	12:00	--	--	--	--	--	--
5	23-Jul-01	21:00	24-Jul-01	12:00	15.00	8.6	8.5	182.8	24-Jul-01	6:00	6.1	9.8	191.4	--	--	--
6	15-Sep-01	3:00	16-Sep-01	6:00	27.00	7.3	11.6	90.3	15-Sep-01	18:00	--	--	--	--	--	--
7	26-Dec-01	23:30	29-Dec-01	2:45	51.25	6.5	7.5	216.5	27-Dec-01	14:45	4.8	6.4	234.0	4.7	6.0	197.0
8	6-Jan-02	11:30	7-Jan-02	8:45	21.25	11.2	10.6	189.6	6-Jan-02	14:45	8.0	9.8	194.0	7.1	9.1	194.0
9	7-Feb-02	4:00	7-Feb-02	22:00	18.00	8.5	9.1	181.3	7-Feb-02	7:00	6.3	8.5	179.0	4.2	8.0	195.0
10	2-Mar-02	13:00	3-Mar-02	22:00	33.00	11.5	10.6	167.8	2-Mar-02	19:00	7.3	9.8	195.0	6.4	9.8	181.0
11	6-Nov-02	4:00	6-Nov-02	19:00	15.00	9.7	10.6	195.8	6-Nov-02	10:00	7.1	9.8	196.0	6.3	9.8	185.0
12	29-Nov-02	22:00	30-Nov-02	22:00	24.00	8.6	8.0	203.4	30-Nov-02	4:00	6.3	7.5	212.0	5.6	6.7	207.0
13	13-Dec-02	13:00	14-Dec-02	16:00	27.00	7.6	9.8	169.2	14-Dec-02	4:00	5.0	9.8	196.0	4.8	9.1	189.0
14	20-Dec-02	1:00	21-Dec-02	1:00	24.00	8.4	9.1	182.6	20-Dec-02	7:00	6.1	8.5	195.0	5.0	9.1	191.0
15	25-Dec-02	10:00	26-Dec-02	1:00	15.00	8.8	9.8	198.0	25-Dec-02	13:00	6.4	9.8	190.0	5.7	9.1	193.0
16	1-Jan-03	1:00	1-Jan-03	16:00	15.00	7.2	9.8	175.8	1-Jan-03	4:00	4.9	9.1	190.0	4.0	8.5	187.0
17	8-Jan-03	4:00	10-Jan-03	4:00	48.00	7.3	8.5	209.8	9-Jan-03	7:00	5.2	7.5	191.0	4.7	6.0	203.0
18	19-Jan-03	7:00	20-Jan-03	19:00	36.00	7.4	8.0	211.9	20-Jan-03	10:00	5.8	6.7	211.0	5.3	6.7	205.0
19	22-Feb-03	19:00	23-Feb-03	16:00	21.00	9.7	9.8	182.4	23-Feb-03	7:00	6.0	9.1	195.0	5.6	8.5	187.0
20	20-Mar-03	7:00	21-Mar-03	7:00	24.00	8.5	9.1	163.1	20-Mar-03	16:00	5.1	8.5	196.0	3.2	8.5	170.0
21	17-Sep-03	1:00	18-Sep-03	19:00	42.00	9.1	6.7	319.0	18-Sep-03	13:00	6.5	6.7	250.0	4.5	5.5	279.0
22	19-Nov-03	1:00	20-Nov-03	1:00	24.00	9.5	7.5	193.0	19-Nov-03	10:00	6.2	8.5	190.0	5.5	7.5	195.0
23	28-Nov-03	19:00	29-Nov-03	7:00	12.00	9.7	6.0	180.0	28-Nov-03	22:00	6.8	8.0	190.0	6.0	6.7	194.0
24	10-Dec-03	10:00	11-Dec-03	10:00	24.00	9.7	9.1	187.0	10-Dec-03	22:00	7.4	9.8	183.0	4.8	9.8	198.0
25	17-Dec-03	7:00	19-Dec-03	10:00	51.00	6.7	7.5	214.0	19-Dec-03	10:00	3.9	6.0	227.0	--	--	--
26	26-Feb-04	10:00	27-Feb-04	1:00	15.00	6.9	6.9	144.0	26-Feb-04	16:00	2.4	2.9	167.0	1.8	9.8	188.0
27	12-Apr-04	16:00	14-Apr-04	10:00	41.00	8.5	8.5	174.0	13-Apr-04	16:00	5.9	8.5	195.0	5.4	8.5	185.0
28	13-Aug-04	4:00	14-Aug-04	16:00	36.00	11.1	11.6	198	14-Aug-06	1:00	2.5	7.1	198	2.6	6.7	228
29	29-Aug-04	1:00	30-Aug-04	4:00	25.00	8.6	7.1	169	29-Aug-04	19:00	6.3	6.7	222	6.1	6.7	210
30	8-Sep-04	1:00	9-Sep-04	4:00	25.00	7.3	6.7	189	9-Sep-04	4:00	5.2	7.5	202	4.8	7.1	191
31	17-Sep-04	13:00	18-Sep-04	7:00	18.00	9.9	7.1	197	17-Sep-04	19:00	7	7.5	194	6.5	6.7	201

32	25-Sep-04	7:00	28-Sep-04	19:00	84.00	9.2	7.5	189	28-Sep-04	16:00	7.7	7.5	176	5.9	7.5	187
33	15-Oct-04	13:00	16-Oct-04	22:00	33.00	6.8	7.5	205	15-Oct-04	19:00	5.7	8	197	4.8	7.5	203
34	24-Nov-04	22:00	25-Nov-04	19:00	21.00	8.6	9.1	184	25-Nov-04	13:00	6	9.8	193	4.7	5.3	227
35	27-Feb-05	19:00	1-Mar-05	22:00	46.00	9.9	10.6	161	28-Feb-05	4:00	3.9	10.6	195	3	11.6	175
36	8-Mar-05	4:00	8-Mar-05	19:00	15.00	11.7	8.5	185	8-Mar-05	7:00	8.5	9.1	212	7.1	8.5	196
37	11-Mar-05	16:00	14-Mar-05	1:00	57.00	9.4	7.5	217	12-Mar-05	16:00	6.2	7.5	207	5.1	7.5	207
38	22-Mar-05	22:00	23-Mar-05	19:00	21.00	7.5	8	150	23-Mar-05	13:00	5.7	8	187	4	7.5	191
39	27-Mar-05	16:00	29-Mar-05	4:00	36.00	8.8	7.1	193	28-Mar-05	22:00	6.9	8	200	5.3	8	195
40	2-Apr-05	4:00	3-Apr-05	10:00	30.00	9.5	7.1	225	2-Apr-05	19:00	7.5	8	192	5.1	8.5	204
41	8-Apr-05	1:00	8-Apr-05	13:00	12.00	6.5	7.5	189	8-Apr-05	1:00	3.7	7.5	191	2.4	8.5	195
42	5-May-05	16:00	6-May-05	7:00	15.00	8.1	4.9	17	6-May-05	1:00	2.6	9.1	187	--	--	--
43	11-Sep-05	10:00	14-Sep-05	19:00	81.00	11.5	7.5	286	14-Sep-05	13:00	--	--	--	3.9	5.5	248
44	6-Oct-05	4:00	8-Oct-05	10:00	54.00	7.8	8.5	162	8-Oct-05	1:00	5.1	8.5	198	3.4	8.5	185
45	21-Nov-05	7:00	22-Nov-05	10:00	27.00	10.1	8	191	22-Nov-05	4:00	7.3	7.1	213	5.6	7.5	206
46	23-Nov-05	22:00	24-Nov-05	19:00	21.00	10	6.7	250	24-Nov-05	1:00	8.5	7.1	200	5.8	7.1	209
47	29-Nov-05	4:00	29-Nov-05	19:00	15.00	6.9	7.1	159	29-Nov-05	19:00	5	8	168	3.2	8	163
48	15-Dec-05	13:00	16-Dec-05	4:00	15.00	7.4	7.5	118	15-Dec-05	19:00	5.1	7.1	192	3.4	7.1	190
49	25-Dec-05	16:00	26-Dec-05	10:00	18.00	7.2	8	186	25-Dec-05	19:00	5.8	9.1	187	--	--	--
50	14-Jan-06	4:00	14-Jan-06	22:00	15.00	6.9	6.7	183	14-Jan-06	4:00	--	--	--	3.3	6	197
51	17-Jan-06	19:00	18-Jan-06	16:00	12.00	10.5	8.5	172	18-Jan-06	4:00	--	--	--	--	--	--
52	31-Aug-06	16:00	1-Sep-06	4:00	12.00	10.1	10.6	177	31-Aug-06	19:00	6.2	8	192	4.1	10.6	197
53*	6-Nov-06	13:00	9-Nov-06	4:00	63.00	10.6	8	175	7-Nov-06	13:00	4.5	8	182	--	--	--
54	20-Nov-06	13:00	24-Nov-06	7:00	90.00	13.3	4.5	139	21-Nov-06	10:00	2.1	10.6	188	--	--	--
55	24-Nov-06	22:00	27-Nov-06	10:00	60.00	9.5	4.9	82	25-Nov-06	7:00	1.4	5.8	150	--	--	--
56*	28-Nov-06	16:00	2-Dec-06	4:00	108.00	12.8	8.5	225	1-Dec-06	19:00	6	8.5	198	--	--	--
57	2-Dec-06	22:00	4-Dec-06	22:00	48.00	9.7	3.2	65	3-Dec-06	16:00	1.9	7.1	134	--	--	--
58	6-Dec-06	19:00	7-Dec-06	7:00	12.00	7.3	4	143	6-Dec-06	22:00	2.2	4.7	149	--	--	--
59	12-Dec-06	16:00	14-Dec-06	10:00	42.00	8.1	5.3	42	13-Dec-06	13:00	2.3	9.1	190	--	--	--
60	20-Dec-06	4:00	21-Dec-06	1:00	21.00	9.2	3.4	146	20-Dec-06	4:00	1.5	6.4	170	--	--	--
61*	22-Dec-06	4:00	24-Dec-06	4:00	48.00	13.3	7.5	215	23-Dec-06	4:00	5.3	8	190	--	--	--
62	25-Dec-06	1:00	27-Dec-06	10:00	57.00	14.1	7.5	221	25-Dec-06	13:00	5.8	7.1	191	--	--	--
63*	31-Dec-06	10:00	2-Jan-07	4:00	42.00	9.1	5.8	146	31-Dec-06	19:00	2.6	6	194	--	--	--

Table 3.9 Significant Events at 11-Mile Gauge Exceeding Significant Wave Height of 6-ft (Continued).

64	4-Jan-07	13:00	5-Jan-07	4:00	15.00	8.4	4.2	46	4-Jan-07	13:00	1.9	4.9	178	--	--	--
65*	5-Jan-07	13:00	7-Jan-07	7:00	42.00	9.2	7.5	161	6-Jan-07	1:00	3.5	6.7	190	--	--	--
66	8-Jan-07	1:00	8-Jan-07	13:00	12.00	11.5	7.1	214	8-Jan-07	10:00	5.7	7.1	194	--	--	--
67*	9-Jan-07	16:00	10-Jan-07	16:00	24.00	11.2	5.5	198	9-Jan-07	22:00	3.9	6.4	218	--	--	--
68	16-Jan-07	1:00	16-Jan-07	16:00	15.00	8.6	3.5	18	16-Jan-07	10:00	2.5	4.9	178	--	--	--
69*	17-Jan-07	7:00	19-Jan-07	13:00	54.00	10.3	2.9	261	17-Jan-07	16:00	1.5	8	137	--	--	--
70	20-Jan-07	7:00	20-Jan-07	19:00	12.00	8.1	3	282	20-Jan-07	13:00	0.9	9.8	169	--	--	--
71*	21-Jan-07	13:00	23-Jan-07	10:00	45.00	12.8	6.7	198	22-Jan-07	1:00	5.2	6.7	194	--	--	--
72	27-Jan-07	10:00	28-Jan-07	4:00	18.00	11.5	5.3	157	27-Jan-07	22:00	4	5.3	202	--	--	--
73*	1-Feb-07	16:00	8-Feb-07	13:00	167.00	15.1	6	181	7-Feb-07	13:00	4.2	6.4	203	--	--	--
74*	12-Feb-07	19:00	15-Feb-07	16:00	69.00	7.8	4.9	234	13-Feb-07	7:00	1.7	5.1	178	--	--	--
75	20-Feb-07	22:00	22-Feb-07	22:00	48.00	14.4	2.9	294	20-Feb-07	22:00	4.2	5.5	194	--	--	--
76*	26-Feb-07	1:00	27-Feb-07	13:00	36.00	16.4	8.5	206	26-Feb-07	1:00	5.6	8.5	202	--	--	--
77*	28-Feb-07	16:00	11-Mar-07	4:00	252.00	15.5	7.1	194	1-Mar-07	19:00	4.8	6.4	174	--	--	--
78	11-Mar-07	22:00	12-Mar-07	13:00	15.00	7.9	2.9	31	12-Mar-07	10:00	1.3	7.5	146	--	--	--
79*	15-Mar-07	13:00	18-Mar-07	16:00	75.00	10.9	8.5	222	16-Mar-07	19:00	4.2	8.5	195	--	--	--
80	21-Mar-07	16:00	23-Mar-07	16:00	48.00	9.6	6	50	22-Mar-07	7:00	2.3	6	178	--	--	--
81	24-Mar-07	22:00	26-Mar-07	22:00	48.00	8.7	3.8	142	25-Mar-07	22:00	1.7	6.4	162	--	--	--
82	15-Apr-07	1:00	16-Apr-07	16:00	39.00	11.7	9.1	205	15-Apr-07	22:00	--	--	--	5.3	9.8	212
83	7-May-07	13:00	8-May-07	10:00	21.00	8.1	16	157	7-May-07	22:00	--	--	--	2.2	14.2	172
84	2-Jun-07	16:00	3-Jun-07	22:00	24.00	9.7	9.1	160	3-Jun-07	4:00	--	--	--	3.5	9.1	182
85	2-Nov-07	4:00	3-Nov-07	1:00	21.00	7.5	4.7	74	2-Nov-07	10:00	2.2	9.1	172.0	1.1	9.1	174
86	16-Dec-07	4:00	17-Dec-07	1:00	21.00	9.2	8.5	193	16-Dec-07	4:00	6.3	9.1	200.0	--	--	--
87	21-Dec-07	16:00	22-Dec-07	10:00	18.00	6.9	9.1	97	22-Dec-07	4:00	3.1	9.8	152.0	--	--	--
88	1-Feb-08	10:00	1-Feb-08	22:00	12.00	8.6	8	185	1-Feb-08	13:00	--	--	--	3.8	7.5	194
89	12-Feb-08	19:00	14-Feb-08	4:00	33.00	9.5	9.8	173	13-Feb-08	7:00	--	--	--	3.6	9.1	194
90	18-Feb-08	4:00	18-Feb-08	22:00	18.00	7.8	7.5	125	18-Feb-08	7:00	--	--	--	3.8	7.5	190
91	4-Mar-08	13:00	5-Mar-08	10:00	21.00	8.7	8.5	180	5-Mar-08	1:00	--	--	--	4.3	7.5	194
92	7-Mar-08	19:00	9-Mar-08	1:00	30.00	10.2	8	204	8-Mar-08	16:00	6.0	8.5	195.0	5.4	9.1	202
93	19-Mar-08	19:00	20-Mar-08	10:00	15.00	7.6	7.5	193	19-Mar-08	22:00	4.6	8.5	187.0	3.7	8.0	197
94	5-Sep-08	10:00	6-Sep-08	22:00	36.00	15.8	12.8	182	6-Sep-08	1:00	9.8	14.2	186.0	9.1	12.8	181
95	24-Sep-08	13:00	26-Sep-08	7:00	42.00	10.7	10.6	160	25-Sep-08	19:00	3.1	5.5	185.0	3.9	8.5	181

Table 3.9 Significant Events at 11-Mile Gauge Exceeding Significant Wave Height of 6-ft (Continued).

96	24-Oct-08	16:00	2-Oct-08	19:00	27.00	9.5	9.1	120	25-Oct-08	4:00	5.8	9.1	197.0	5.6	8.5	181
97	3-Nov-08	16:00	4-Nov-08	10:00	18.00	6.9	9.8	162	3-Nov-08	22:00	3.0	9.1	149.0	2.2	9.1	162
98	15-Nov-08	7:00	15-Nov-08	22:00	15.00	6.7	7.5	176	15-Nov-08	19:00	5.1	7.5	179.0	5.2	7.1	202
99	1-Dec-08	1:00	1-Dec-08	19:00	18.00	9.3	9.8	189	1-Dec-08	1:00	6.5	9.8	198.0	5.2	8.0	197
100	11-Dec-08	13:00	12-Dec-08	13:00	24.00	10.4	8.5	157	12-Dec-08	4:00	7.4	9.1	189.0	7.3	9.1	184
101	7-Jan-09	10:00	8-Jan-09	19:00	33.00	9.7	8.5	197	7-Jan-09	19:00	6.5	8.5	189.0	6.4	6.7	225.0
102	18-Feb-09	19:00	19-Feb-09	13:00	18.00	8.7	7.5	216	19-Feb-09	1:00:03	4.6	7.5	190.0	5.5	5.5	220.0
103	26-Mar-09	10:00	26-Mar-09	22:00	12.00	7.6	6.7	176	26-Mar-09	13:00:03	3.5	7.1	198.0	4.0	6.7	199.0
104	29-Mar-09	4:00	30-Mar-09	1:00	21.00	8.2	6.7	205	29-Mar-09	13:00:03	3.7	9.1	173.0	4.5	4.1	179.0
105	3-Apr-09	7:00	3-Apr-09	19:00	12.00	6.7	9.8	184	3-Apr-09	16:00:03	4.4	9.1	188.0	4.7	9.8	195.0
106	6-Apr-09	10:00	7-Apr-09	4:00	18.00	7.8	5.8	232	7-Apr-09	1:00:03	4.0	8.0	195.0	4.9	6.4	207.0
107	22-Aug-09	4:00	22-Aug-09	19:00	15.00	7.9	14.2	162	22-Aug-09	2:00:03	3.3	14.2	191.0	1.6	4.1	4.7
108	2-Dec-09	11:00	3-Dec-09	14:00	27.00	9.3	8.5	169	3-Dec-09	2:00:03	6.4	8.5	203.0	3.3	8.5	194.0
109	9-Dec-09	2:00	10-Dec-09	8:00	30.00	9.4	8.5	193	9-Dec-09	14:00:03	7.5	8.5	214.0	4.6	8.0	201.0
110	13-Dec-09	8:00	13-Dec-09	20:00	12.00	9.4	8	157	13-Dec-09	11:00:03	4.9	7.5	194.0	2.6	7.5	184.0
111	18-Dec-09	17:00	19-Dec-09	17:00	24.00	9.2	9.8	152	18-Dec-09	23:00:03	4.9	8.0	170.0	2.9	9.1	180.0
112	25-Dec-09	8:00	26-Dec-09	5:00	21.00	10.8	9.1	152	25-Dec-09	17:00:03	8.0	8.5	218.0	4.0	9.8	190.0
113	17-Jan-10	5:00	18-Jan-10	2:00	21.00	9.8	8.5	169	17-Jan-10	8:00:03	7.2	7.5	173.0	4.1	8.0	185.0
114	24-Jan-10	17:00	26-Jan-10	11:00	42.00	13.80	9.8	182	25-Jan-10	5:00:03	8.0	9.8	194.0	5.1	9.1	193.0
115	12-Mar-10	1:00	12-Mar-10	16:00	15.00	8.3	8.5	174	12-Mar-10	7:00:03	--	--	--	3.6	9.8	197.0
116	29-Mar-10	1:00	29-Mar-10	16:00	15.00	7.8	8	133	29-Mar-10	4:00:03	--	--	--	3.1	6.7	186.0
117	25-Apr-10	16:00	26-Apr-10	13:00	21.00	6.9	8.5	190	25-Apr-10	22:00:03	--	--	--	2.9	8.0	196.0
* Denotes significant events w here data gaps exist w ithin the event. Significant w ave height is assumed to maintain a minimum of 6' w ithin these gaps.																	

Table 3.9 Significant Events at 11-Mile Gauge Exceeding Significant Wave Height of 6-ft (Continued).

Part 4 PROJECT EFFECTS/PERFORMANCE TO DATE

Beach Response – Shoreline Change Rates

General Shoreline Change Information. One measure of the potential project impact is to compare the rate of shoreline change that existed before the channel improvements were initiated with those that have been measured after. For this study the shoreline change rates selected for the pre-construction period where those of the updated NCDCM rates presented earlier in Part 2 of this report (See Figure 2.1 for Oak Island and Figure 2.2 for Bald Head Island). These change rates are based on shoreline data spanning a 62-year period from 1938 to 2000 (the survey just prior to dredging of the new channel), and therefore represent long-term trends in shoreline change.

Shoreline change rates were computed for eight post-construction periods beginning with the August/September 2000 survey through; (1) the survey of June 2003 (as presented in Report 1), (2) the survey of June 2004 (as presented in Report 2), (3) the survey of August 2005 (as presented in Report 3), (4) the survey of October 2006 (as presented in Report 4), (5) the survey of July 2007 (as presented in Report 5), (6) the survey of July 2008 (as presented in Report 6), (7) the survey of May 2009 (as presented in Report 7), and (8) through the most recent survey of September 2010. The post-construction rates were developed in the same manner as the pre-construction rates and represent a least squares trend of the data. See Appendices B (Oak Island) and C (Bald Head Island) for shoreline change plots for each monitoring profile for a graphical representation of these calculations. As shown in these appendices, the slope of the trend line for each profile indicates the computed shoreline change rate. A longshore average was then calculated by computing a running average, to be consistent with the NCDCM methodology. Specifically, 5 profiles (2 either side) for Oak Island and 7 profiles (3 either side) for Bald Head Island were averaged together resulting in the longshore average shoreline change rate for that profile of interest. The computed rates for each of the periods are summarized in Table 4.1 for Oak Island and Table 4.2 for Bald Head Island. These rates are plotted in Figure 4.1 and Figure 4.2 for Oak Island/Caswell Beach and Bald Head Island, respectively. These post-construction rates were generated to establish a trend in shoreline response including and encompassing the beach disposal activities.

In general, it is apparent that the post-construction shoreline change rates are more variable (alongshore and magnitude), when compared to the pre-construction rates. This is due in part to the relatively short time frame of the post rate data (2000 through 2010), when compared to the pre-construction rate data (1938 through 2000), and is also a result of shoreline equilibration that is expected following each beach disposal activity.

Oak Island. As indicated on Table 4.1 and Figure 4.1, the pre-construction data for Oak Island covers from Profile 35 through 310. The area east of profile 35 near Fort Caswell along the Cape Fear River entrance was not included in the NCDCM data base so direct comparisons between pre- and post-construction shoreline change rates cannot be made in that area.

For the entire Oak Island monitoring area, the pre-construction shoreline change rates along the beach vary from positive (accretion) of more than 29 feet per year to negative (erosion) of 5.8 feet per year. The overall trend shows accretionary shoreline change rates within the eastern one-third of the study area with the remaining two-thirds showing a general pattern of long-term erosion. By comparison, shoreline change rates for all the post construction periods are largely accretionary over the study area except for those in the immediate vicinity of Ft. Caswell (east of Profile 50). In this area, the rates are generally stable to slightly accretional, but the rates are still less than the historically large accretion of this area.

When compared to pre-construction shoreline change rates, the post construction rates reflect the influence of the beach disposals placed along Oak Island. Beach disposal occurred in 2001 during the initial channel deepening and with the 2009 maintenance cycle. In 2001, the disposal was placed west of Profile 60 to Profile 294, except for a gap between Profile 80 through Profile 121 that did not require material. For 2009, the sediment was deposited between Profiles 60 and 95 and 120 thru 260. Positive shoreline change rates were recorded over this entire disposal area with a localized minimum occurring near the middle of the non-disposal area. With this measured response, all profiles (except for three nearest to the river entrance, Profiles 35, 40, and 45) have significantly more positive post-construction shoreline change when compared to the computed pre-construction rates. As expected the rates have moderated with time, with each subsequent survey period being generally less than the prior period, as the placed disposals are redistributed and the rates begin to trend more toward the long-term pattern.

In most cases within the disposal area the positive changes in the shoreline rate are an order of magnitude greater than the pre-construction change rates. For example, within the easternmost disposal area between Profiles 60 and 80, the post-construction change rates through the current period are about +10 feet per year. This compares to an average of approximately +1 feet per year for the pre-construction period. Within the remaining disposal area from Profile 120 through the western end, the current rates generally range from about +14 to +25 feet per year, while the pre-construction shoreline change rates for this area are erosional ranging from –0.3 to –5.8 feet per year.

In the area of Profiles 5 through 45, encompassing the eastern tip of Oak Island, the measured post-construction rates calculated through June 2003 previously indicated an area of erosion except for the last three profiles along the inlet shoulder, which were stable. Historically, this area, which is in the vicinity of Ft. Caswell, has been accretionary; but has also experienced a rather high degree of shoreline variability being located immediately adjacent to the entrance channel. Beginning with the August 2005 and continuing through the current monitoring period, the rates of the eroding profiles have become positive. This could be an indication that this area is returning to a more accretionary pattern consistent with the long-term shoreline behavior.

Overall, the shoreline change rate averaged over the entire 5.2 mile section of Oak Island/Caswell Beach (from Profiles 35-310) is +15.8 feet per year for the 10-year post-construction period. By comparison the pre-construction rate over the entire reach was an average of –1.1 feet per year.

Table 4.1 Oak Island Shoreline Change Rates

Profile ID	Post-Construction Rate (ft/yr)								Longshore Average Rate (ft/yr)								Longshore Average Pre-Construction Rate 1938-2000 (ft/yr)
	Aug-00 thru								Aug-00 thru								
	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jul-08	May-09	Sep-10	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jul-08	May-09	Sep-10	
5	-5.4	-3.2	-2.0	-1.4	-1.3	-1.0	-0.9	-0.6	1.0	1.3	1.9	2.0	1.6	1.7	1.5	1.4	
10	1.3	0.8	0.9	0.8	0.4	0.5	0.3	0.3	-1.5	-1.2	-0.8	-0.4	-0.3	0.1	0.2	0.4	
15	7.0	6.4	7.0	6.8	5.8	5.6	5.0	4.5	-7.1	3.2	5.6	4.8	4.5	3.3	4.0	4.1	
20	-8.7	-8.7	-9.1	-7.7	-6.1	-4.6	-3.4	-2.5	-2.8	9.4	10.4	9.0	8.2	6.4	6.7	6.7	
25	-29.7	20.9	31.1	25.8	23.9	15.9	18.8	18.7	-9.7	4.4	6.2	5.8	5.9	4.4	4.7	4.9	
30	16.1	27.7	22.1	19.5	16.8	14.8	12.7	12.5	-15.5	-0.9	1.7	2.8	3.4	2.2	2.8	3.1	
35	-33.4	-24.3	-20.2	-15.3	-10.8	-9.7	-9.5	-8.8	-15.9	1.5	5.4	6.4	6.5	4.7	5.0	4.7	29.9
40	-21.9	-20.1	-15.3	-8.3	-6.9	-5.5	-4.5	-4.5	-6.1	0.3	2.0	3.3	3.6	2.9	2.4	1.9	17.2
45	-10.6	3.5	9.2	10.1	9.5	7.9	7.2	5.6	-3.2	-0.5	1.5	2.2	2.6	1.8	1.7	1.3	7.9
50	19.2	14.8	14.2	10.6	9.4	6.8	6.0	4.8	11.7	10.3	10.3	8.8	7.7	6.0	5.6	5.1	2.5
55	30.8	23.5	19.6	14.2	12.0	9.6	9.2	9.3	20.8	17.4	15.8	12.1	10.1	7.7	7.3	7.0	0.8
60	41.3	29.6	24.0	17.5	14.3	11.3	10.2	10.4	30.7	21.9	18.2	13.4	10.9	8.3	8.0	8.1	0.3
65	23.3	15.6	11.9	8.1	5.3	3.1	3.8	4.8	32.9	23.0	18.6	13.6	11.0	8.4	8.5	8.9	0.2
70	38.8	25.9	21.5	16.4	13.5	10.5	11.0	11.3	35.9	24.9	20.1	15.1	12.4	9.7	9.8	10.1	0.4
75	30.4	20.6	15.7	11.8	10.1	7.7	8.3	8.8	35.0	24.2	19.7	15.1	12.7	10.3	10.7	11.0	0.9
80	45.8	33.0	27.2	21.5	18.6	15.8	15.7	15.3	35.5	24.7	20.3	16.0	13.9	11.8	12.0	12.2	1.6
85	36.4	26.0	22.2	17.8	16.0	14.5	14.7	14.7	27.3	19.6	16.0	12.8	11.4	9.9	10.2	10.5	1.9
90	25.9	18.0	14.8	12.4	11.1	10.3	10.4	10.6	22.9	17.0	14.5	11.9	10.7	9.6	9.9	10.2	2.2
95	-1.9	0.2	0.1	0.5	1.0	1.3	2.1	3.1	13.4	10.7	9.5	8.1	7.3	6.9	7.3	7.9	2.5
100	8.2	7.9	8.0	7.3	6.6	6.2	6.4	7.0	8.0	7.0	6.5	5.7	5.1	4.8	5.1	5.9	2.6
105	-1.6	1.3	2.7	2.6	1.9	2.2	2.7	3.8	4.4	5.2	5.2	4.6	3.9	3.7	3.9	4.8	2.5
110	9.6	7.4	7.2	5.9	5.0	4.0	4.0	4.7	12.0	10.9	10.1	8.4	7.2	6.3	6.2	6.9	2.1
115	7.6	9.2	8.1	6.5	5.1	4.6	4.4	5.4	17.8	15.4	13.2	10.4	8.8	7.6	7.4	8.1	1.5
120	36.2	28.9	24.3	19.7	17.3	14.6	13.7	13.7	32.9	25.7	20.8	16.1	13.7	11.6	11.2	11.4	0.7
125	37.1	30.2	23.6	17.1	14.9	12.5	12.5	13.0	44.9	34.7	27.1	21.1	18.1	15.4	14.9	14.7	-0.3
130	73.8	52.7	40.6	31.2	26.3	22.4	21.5	20.4	55.4	42.4	33.2	25.9	22.4	18.9	18.2	17.6	-0.9
135	69.7	52.3	39.0	30.8	27.1	22.7	22.2	20.9	62.1	47.6	36.8	28.7	24.8	21.0	20.0	19.2	-1.4
140	60.2	47.8	38.5	30.6	26.7	22.2	21.0	19.9	68.7	51.7	40.6	32.3	28.0	23.9	22.6	21.6	-2.1
145	69.7	54.8	42.2	33.6	28.9	24.9	22.7	21.9	64.5	49.4	39.1	31.4	27.4	23.5	22.4	21.7	-2.3
150	70.2	50.8	42.9	35.3	30.8	27.0	25.4	25.0	62.9	47.3	38.0	30.5	26.6	22.8	21.9	21.5	-2.5
155	52.9	41.4	33.1	26.6	23.5	20.6	20.7	20.9	61.9	45.8	36.4	29.1	25.3	21.8	21.2	21.3	-2.8
160	61.4	41.5	33.5	26.6	23.1	19.5	19.7	20.0	61.6	44.5	35.6	28.4	24.6	21.1	20.9	21.2	-3.3
165	55.0	40.4	30.3	23.6	20.4	17.1	17.6	18.6	60.1	43.9	34.1	26.6	23.1	19.6	19.7	20.1	-3.9
170	68.7	48.5	38.2	29.8	25.4	21.3	21.1	21.3	60.7	43.4	33.4	25.8	22.1	18.6	18.6	19.2	-4.3
175	62.2	47.9	35.3	26.5	22.9	19.3	19.2	19.8	60.3	43.5	32.9	25.2	21.5	18.2	18.1	18.8	-4.7
180	56.0	38.6	29.9	22.5	18.9	15.8	15.4	16.4	61.4	44.2	33.4	25.5	21.8	18.4	18.1	18.7	-5.0
185	59.6	42.4	30.6	23.4	20.1	17.3	17.0	17.9	59.6	43.2	32.0	24.4	20.9	17.6	17.3	18.0	-5.3
190	60.6	43.5	33.0	25.6	21.7	18.3	17.8	18.2	59.8	42.7	31.9	24.6	21.0	17.7	17.2	17.8	-5.4
195	59.4	43.8	31.1	24.0	20.7	17.2	17.0	17.6	61.1	44.5	33.2	25.9	22.2	18.9	18.3	18.7	-5.5
200	63.5	45.4	35.1	27.6	23.6	20.2	19.1	19.1	63.5	46.3	35.3	27.8	23.8	20.2	19.3	19.4	-5.6
205	62.3	47.6	36.1	28.8	25.1	21.6	20.6	20.5	63.9	46.8	35.8	28.3	24.2	20.6	19.5	19.4	-5.7
210	71.9	51.2	41.2	33.0	27.9	23.9	22.2	21.6	66.3	48.2	37.8	30.0	25.6	21.8	20.3	19.9	-5.8
215	62.3	46.1	35.4	27.9	23.8	20.2	18.7	18.3	64.0	47.1	36.9	29.3	24.9	21.0	19.5	19.1	-5.7
220	71.6	50.9	41.2	32.5	27.5	22.9	20.8	19.9	64.2	46.7	37.2	29.5	25.1	21.1	19.5	18.9	-5.5
225	52.3	39.9	30.8	24.0	20.1	16.5	15.3	15.1	57.5	42.3	33.7	26.7	22.6	19.0	17.7	17.2	-5.2
230	63.1	45.2	37.3	30.1	26.0	22.1	20.5	19.6	56.1	41.3	33.8	26.9	22.8	19.2	17.8	17.2	-4.8
235	38.1	29.3	24.0	19.1	15.9	13.4	13.0	12.9	50.3	37.9	31.3	25.1	21.3	18.0	16.9	16.3	-4.4
240	55.5	41.2	35.6	28.8	24.5	21.0	19.6	18.7	52.1	39.3	33.3	27.0	23.2	19.8	18.5	17.6	-4.1
245	42.6	33.6	28.6	23.2	20.2	17.1	16.2	15.4	48.1	37.3	31.9	25.9	22.3	19.0	17.7	16.8	-3.9
250	61.4	47.4	41.1	34.0	29.5	25.4	23.1	21.5	53.7	41.5	35.8	29.3	25.4	21.9	19.9	18.6	-3.7
255	42.8	35.2	30.1	24.5	21.4	18.3	16.3	15.4	53.9	41.7	36.0	29.5	25.7	22.1	19.8	18.3	-3.6
260	66.0	50.1	43.7	36.2	31.6	27.5	24.1	21.8	60.5	46.3	40.2	33.1	28.7	24.8	21.9	20.0	-3.5
265	56.5	42.1	36.4	29.8	25.7	22.3	19.2	17.3	58.9	45.2	38.9	31.9	27.6	23.9	20.9	18.9	-3.3
270	75.7	56.9	49.6	40.9	35.4	30.7	26.7	23.9	66.1	50.1	43.4	35.6	30.7	26.7	23.2	20.7	-3.2
275	53.5	41.8	35.0	28.2	24.1	20.9	18.2	16.1	67.4	51.2	43.8	35.7	30.8	26.6	23.0	20.4	-3.0
280	78.9	59.6	52.2	42.9	36.8	32.0	27.9	24.5	72.0	54.5	46.6	37.9	32.6	28.1	24.3	21.4	-2.8
285	72.3	55.4	45.8	36.9	31.7	27.3	23.1	20.2	73.5	55.8	46.9	37.8	32.4	27.9	24.0	20.9	-2.7
290	79.7	58.8	50.5	40.6	34.8	29.8	25.5	22.4	82.7	61.8	52.0	41.8	35.7	30.6	26.2	22.9	-2.6
295	83.0	63.3	50.9	40.3	34.5	29.3	25.0	21.6	86.9	64.5	53.1	42.2	35.9	30.6	26.1	22.6	-2.5
300	99.5	72.1	60.7	48.2	40.9	34.7	29.6	25.7	95.8	69.7	57.4	45.5	38.5	32.7	27.9	24.1	-2.3
305	99.9	73.1	57.4	44.8	37.5	31.8	27.1	23.3	99.8	72.4	59.1	46.7	39.5	33.4	28.4	24.6	-2.2
310	116.9	81.2	67.2	53.3	45.0	37.8	32.1	27.6	105.5	75.5	61.8	48.8	41.1	34.8	29.6	25.5	-2.1

Table 4.2 Bald Head Island Shoreline Change Rates

Profile ID	Post-Construction Rate (ft/yr)								Longshore Average Rate (ft/yr)								Longshore Average Pre-Construction
	Aug-00 thru								Aug-00 thru								
	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jul-08	May-09	Sep-10	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jul-08	May-09	Sep-10	
0	-3.1	1.0	2.3	3.0	3.2	2.6	2.8	1.3	-3.0	-2.1	-1.6	-1.0	-0.8	-0.9	-1.0	-2.0	
4	-6.2	-5.6	-5.0	-4.1	-3.7	-3.6	-3.7	-4.4	-1.6	-1.1	-1.0	-0.4	-0.4	-0.5	-0.8	-1.6	
8	0.3	-1.7	-2.3	-1.9	-1.8	-1.7	-2.2	-2.9	0.0	0.4	-0.1	0.4	0.3	0.0	-0.5	-1.1	
12	2.6	1.9	0.7	1.2	0.9	0.7	0.0	-0.3	1.7	1.2	-0.3	0.1	-0.3	-0.8	-1.5	-1.5	
16	6.3	6.2	3.9	3.7	2.9	1.7	0.5	0.9	5.9	4.3	1.2	1.6	0.9	0.0	-1.1	-0.6	
20	5.7	5.0	1.0	1.4	0.5	-0.9	-2.3	-1.0	4.6	1.3	-3.1	-2.0	-2.1	-2.6	-3.0	-1.5	
24	14.7	10.0	2.7	3.5	2.1	0.4	-1.3	0.1	1.3	-3.9	-6.7	-1.2	0.6	0.9	1.2	2.8	
28	-6.5	-16.7	-23.8	-19.8	-16.9	-15.1	-12.0	-7.2	-3.3	-1.7	-1.9	4.5	5.8	6.2	6.9	7.7	
32	-13.7	-23.9	-17.0	5.0	14.5	18.4	21.2	21.3	15.1	10.5	7.0	9.9	10.0	10.9	10.7	10.6	
36	-16.6	16.9	27.8	32.4	28.9	28.1	28.8	25.6	18.1	6.6	1.2	2.4	3.4	6.6	5.5	5.7	
40	97.6	66.1	45.1	28.4	21.4	22.9	16.8	13.4	22.2	6.1	1.3	0.0	1.0	5.4	2.6	2.4	
43	29.9	-9.6	-26.1	-34.2	-31.0	-21.2	-27.2	-24.5	21.6	4.0	-0.6	-6.9	-6.5	-2.0	-6.2	-5.9	
45	13.6	-18.8	-23.1	-31.6	-28.9	-21.2	-26.6	-23.7	19.8	-7.5	-10.6	-16.7	-14.2	-9.5	-14.3	-13.1	
47	-16.3	-34.3	-26.5	-29.3	-23.0	-18.6	-22.8	-20.5	-5.1	-30.0	-24.1	-25.4	-20.4	-16.0	-20.0	-17.5	
53	-25.5	-40.9	-22.2	-16.8	-9.5	-9.5	-11.7	-10.1	-18.1	-39.3	-24.9	-22.8	-17.3	-14.6	-17.4	-14.8	-2.4
57	-27.0	-46.1	-22.5	-15.2	-9.5	-9.6	-11.6	-8.9	-24.4	-40.5	-20.9	-16.5	-11.5	-10.5	-12.5	-10.1	-5.5
61	-35.2	-56.4	-30.2	-21.1	-15.8	-14.1	-14.1	-10.9	-23.6	-37.4	-15.6	-10.0	-6.1	-6.1	-7.5	-5.2	-5.6
66	-18.1	-24.9	-3.2	-0.2	0.3	-0.7	-2.2	-0.2	-19.7	-32.5	-10.3	-5.5	-3.2	-3.3	-4.5	-1.9	-5.9
69	-12.0	-19.0	0.1	3.5	4.0	3.5	2.1	4.1	-14.8	-24.7	-3.8	-0.4	0.7	0.7	-0.3	2.2	-6.4
73	-6.1	-16.1	4.3	5.7	5.0	4.6	3.3	6.2	-6.5	-14.5	5.6	7.1	6.8	6.5	5.3	7.4	-5.5
78	-2.4	-7.3	10.0	10.4	10.0	10.1	9.4	11.5	-2.0	-10.6	9.1	9.8	9.1	9.0	8.0	10.0	-4.6
84	6.2	-5.3	17.0	16.3	14.8	14.7	14.2	15.5	2.7	-7.3	12.3	11.9	10.8	10.8	9.7	11.6	-3.7
88	4.3	-5.4	14.3	13.0	11.6	11.8	11.2	12.8	5.6	-4.6	14.3	13.5	12.8	12.9	11.8	13.3	-3.1
92	11.3	-2.3	15.8	13.9	12.8	12.6	10.3	12.1	8.8	-3.1	15.4	14.2	13.8	13.8	12.8	13.7	-2.6
97	8.8	-2.8	14.2	13.7	14.9	15.1	14.1	14.4	13.7	0.4	16.1	14.3	14.1	13.9	12.6	13.1	-2.0
102	13.5	0.2	15.5	14.0	14.9	15.0	14.2	13.5	19.0	3.8	17.3	14.8	14.5	14.2	12.6	12.6	-1.6
106	30.8	12.5	20.8	17.1	16.1	15.2	13.5	12.5	26.0	8.9	19.5	16.2	15.7	15.2	13.7	13.1	-1.5
110	30.5	11.6	20.0	15.4	13.9	13.1	10.9	10.4	34.2	14.8	22.5	17.8	16.8	16.1	14.2	13.3	-1.6
114	46.2	23.2	27.0	20.9	18.9	17.7	15.7	14.5	43.0	21.4	26.1	20.1	18.7	17.7	15.5	14.4	-1.6
118	50.1	26.5	28.9	21.4	20.3	19.4	16.6	15.4	47.9	25.3	28.1	21.5	20.1	19.4	17.0	15.9	-1.8
122	57.6	33.0	33.7	25.9	24.2	23.2	20.8	19.3	50.2	27.2	28.1	21.5	20.6	20.2	18.0	16.9	-1.9
126	54.9	32.3	31.1	23.8	23.5	23.4	20.8	19.7	51.5	28.9	27.3	20.8	20.6	20.9	18.8	17.9	-2.0
130	42.4	21.2	19.7	15.4	16.1	17.5	16.1	15.6	53.4	31.1	26.8	20.9	20.9	21.8	19.7	19.0	-2.1
134	52.4	31.6	22.9	17.6	19.1	21.2	19.6	19.3	53.2	31.5	24.7	19.3	20.1	21.6	19.6	19.1	-2.0
138	59.9	37.3	26.8	21.5	21.7	23.4	21.5	20.8	54.4	33.0	24.1	19.0	19.8	21.6	19.8	19.3	-2.0
142	56.3	35.1	22.9	18.2	20.3	22.4	20.3	19.9	59.0	37.4	25.7	20.1	21.0	22.9	20.9	20.4	-2.3
146	60.9	39.8	28.2	22.0	21.6	23.5	21.7	21.0	61.8	39.9	27.4	21.5	22.2	23.8	21.6	20.9	-2.6
150	65.8	43.3	27.6	21.0	22.5	23.9	21.5	21.0	65.0	42.9	29.2	22.3	23.1	24.4	21.9	21.2	-2.9
154	66.0	44.1	31.5	24.7	25.0	25.7	23.0	21.8	69.5	46.2	32.5	24.4	24.9	25.6	22.9	21.9	-3.9
158	75.9	52.3	35.9	25.5	26.1	26.4	23.2	22.1	72.6	48.7	34.2	25.3	26.1	26.3	23.3	22.2	-4.7
162	78.9	51.8	39.4	28.7	29.1	28.4	25.1	23.5	72.8	49.3	35.8	26.1	26.4	26.1	23.1	22.0	-5.2
166	76.3	52.3	36.9	26.7	28.0	26.9	23.8	22.6	71.6	49.5	36.0	25.7	25.2	24.7	21.9	21.2	-5.4
170	67.1	45.9	35.5	25.0	24.1	23.2	20.5	20.2	71.6	49.3	36.8	26.8	25.0	24.0	21.6	21.2	-5.6
174	59.7	45.0	32.2	22.7	19.0	18.4	17.0	17.6	67.5	47.1	34.8	25.5	22.9	21.9	20.1	20.2	-5.9
178	76.1	51.4	40.1	30.7	25.0	23.3	21.6	22.0	62.0	43.2	32.4	24.3	20.8	19.9	18.8	19.2	-6.2
182	58.2	40.9	29.2	22.2	18.5	17.8	17.5	18.4	57.1	39.9	29.7	22.9	19.4	18.8	18.2	18.6	-6.5
186	48.7	33.0	25.1	20.7	17.4	17.0	17.1	17.6	51.6	35.5	27.1	21.8	19.0	18.8	18.5	18.7	-7.0
190	42.9	29.3	22.0	18.1	16.9	17.4	17.6	17.4	42.0	30.0	22.9	19.1	17.8	18.4	18.5	18.3	-7.8
194	31.8	22.9	18.9	17.1	17.1	18.3	18.7	17.9	34.5	26.3	20.8	18.3	18.4	19.7	19.7	18.9	-8.6
198	28.3	23.7	19.1	17.4	19.2	21.6	21.7	20.3	25.4	21.9	17.6	16.9	19.1	21.0	20.5	19.0	-10.0
202	20.8	22.7	18.7	18.2	21.2	24.0	23.5	21.3	15.1	16.7	14.3	16.3	20.5	22.4	21.2	19.0	-11.9
206	3.2	10.7	9.0	13.5	21.2	23.5	21.1	18.1	6.8	12.4	12.1	17.7	23.9	24.9	22.5	19.3	-13.7
210	-8.8	3.4	5.8	15.3	24.0	24.4	21.0	17.3	0.2	8.9	11.2	23.2	29.7	28.5	24.5	19.6	-15.0
214	-9.6	1.2	7.6	24.2	34.1	31.0	25.3	19.5	-3.6	4.3	9.3	24.4	31.9	29.6	24.7	19.2	-17.8
218	-4.8	6.2	14.7	44.5	48.3	39.4	31.3	21.6	0.1	3.4	9.4	28.0	35.5	31.6	25.9	19.5	-20.8
222																	

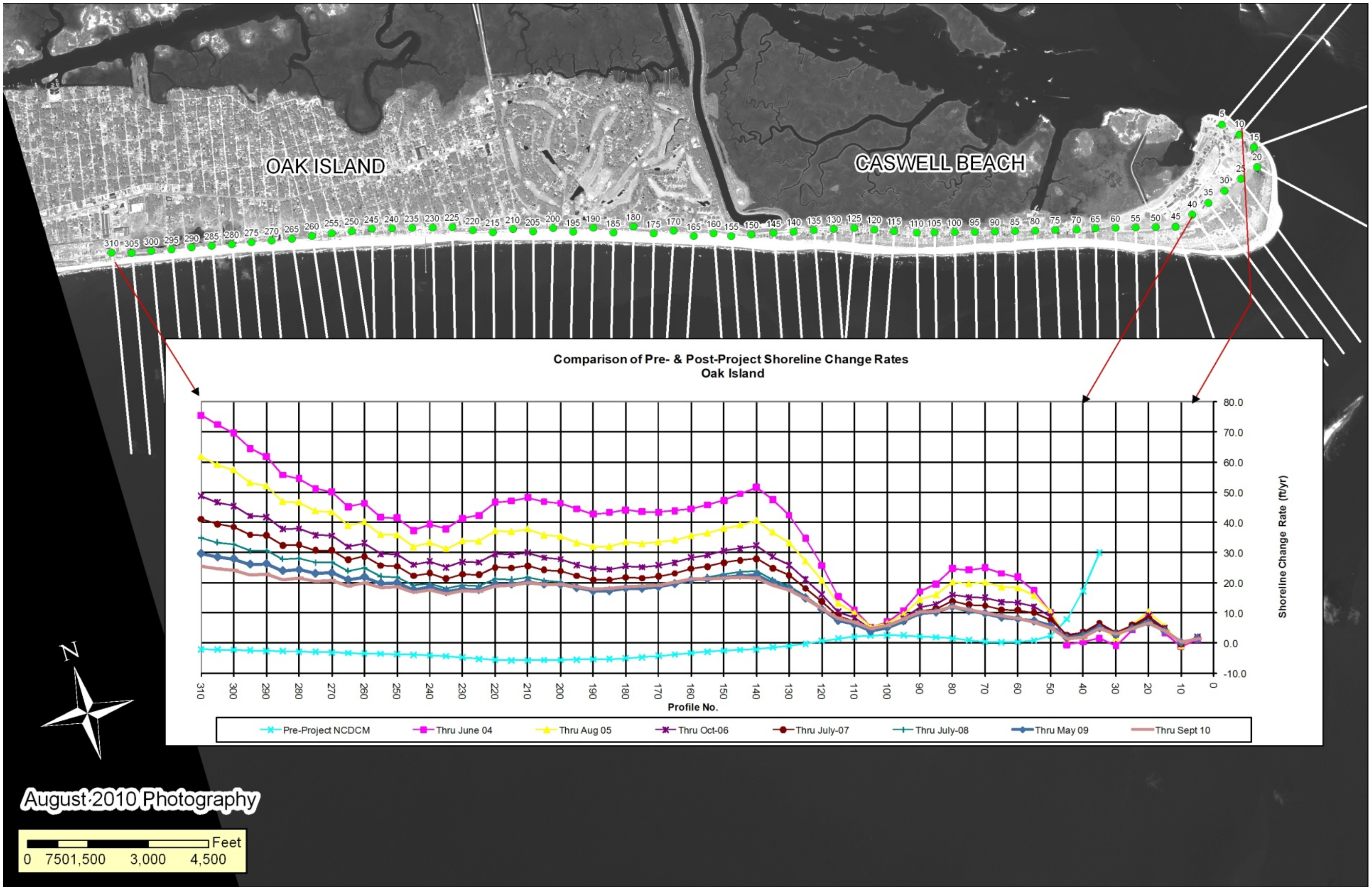


Figure 4.1 Wilmington Harbor Monitoring - Oak Island Comparison of Pre- and Post-Construction Shoreline Change Rates

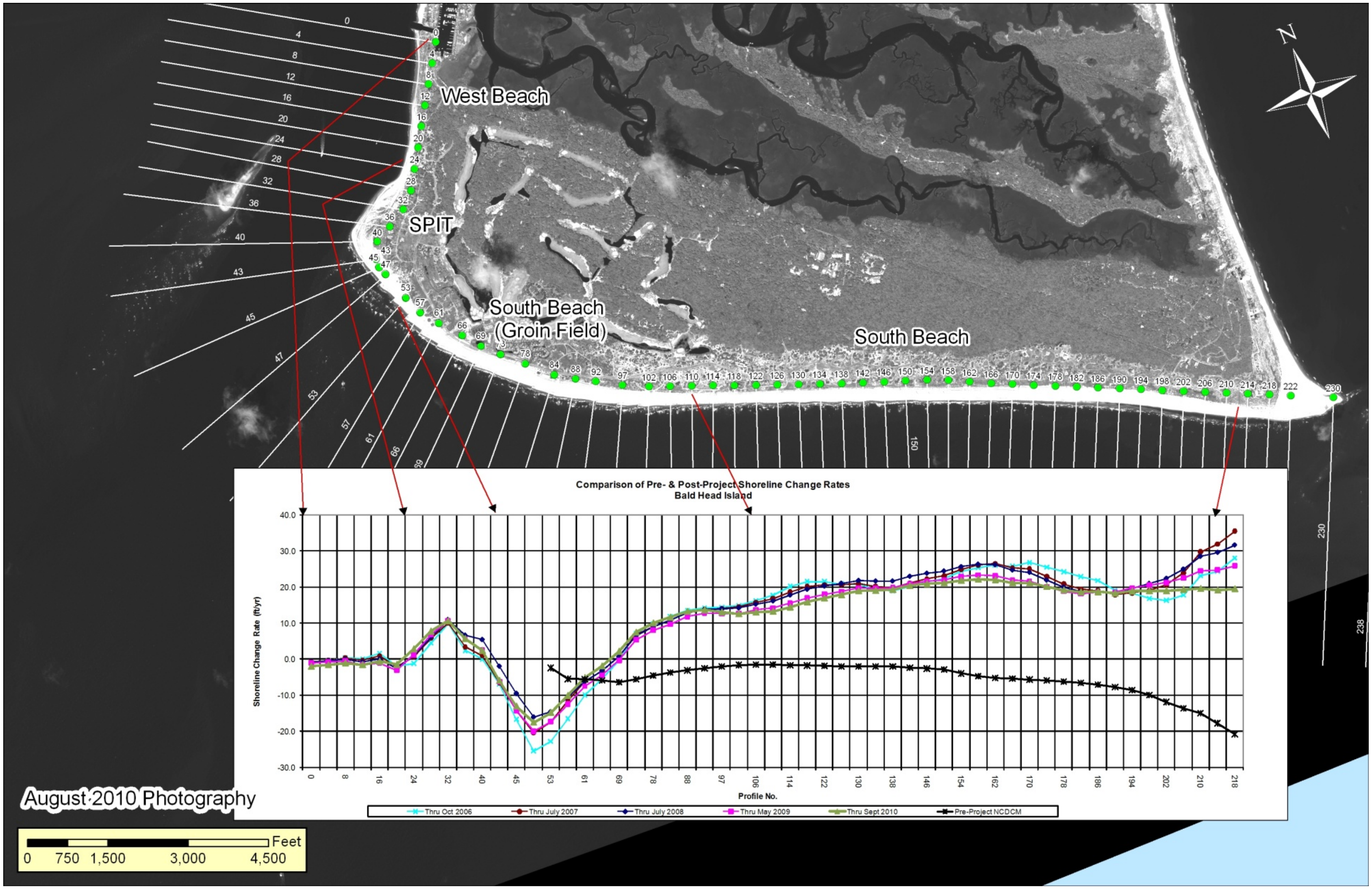


Figure 4.2 Wilmington Harbor Monitoring - Bald Head Island Comparison of Pre- and Post-Construction Shoreline Change Rates

Bald Head Island: Table 4.2 and Figure 4.2 give the comparison of pre- and post-construction shoreline change rates along Bald Head Island. The updated NCDCM pre-construction data are available for Profiles 53 through 218, generally encompassing shoreline along South Beach. Pre-construction shoreline change rates along the beach are all negative and indicate a pattern of higher erosion towards each end of the island with lower erosion rates near the middle. Erosion rates along the western third of South Beach covering about one mile range from –2 feet per year to a maximum of –6.6 feet per year. The rates then range from –2 to –3 feet per year average along the central portions of South Beach. Eastward beyond this relatively more stable central reach, the rates gradually increase towards Cape Fear reaching a maximum erosion rate of about -20 feet per year.

As indicated on Figure 4.2, the computed post-construction shoreline change rates are found to be generally positive over the monitoring area for all of the time frames. This in part reflects the positive influence of the beach disposals placed throughout this area. In spite of the positive effects of the disposal, the western end of South Beach continues to experience relatively high rates of erosion. Prior reports have shown that this area of relatively high erosion expands and contracts with each beach disposal cycle. For example, with the rates measured thru Oct 2006, the zone showing greater erosion rates was relatively large as shown in Figure 4.2. With the subsequent beach disposal in 2007, the zone diminished thru the July 2007 and July 2008 time periods. However, by May 2009 the zone had expanded to nearly the same area as measured in Oct 2006. The current erosion rates calculated within this area following the recent locally funded beach nourishment project show that this zone has once again reduced in both longshore coverage and magnitude. This erosion rate zone currently extends from Profile 43 thru 66 representing an alongshore distance of about 2,300 feet.

Eastward of this erosion zone, the post-construction rates turn positive reflecting the positive impact of the disposals placed along this reach. The computed peak shoreline change rates for this area remain highly positive, but as noted with past reporting are found to be diminishing, as the effect of the disposals on the rate of change moderates with time. As shown in Figure 4.2, the current accretion rates thru September 2010 are slightly less than those of the prior four periods but still remain relatively high. The present rate of change over the eastern accretionary area is an average of 17.1 feet per year. This is in sharp contrast to the erosion indicated along this entire area by the pre-construction rates.

In summary, it is of interest to compare the long-term shoreline change rates with those computed over the monitoring period. Although a direct comparison is not possible given the difference in the 10-years of monitoring data versus the 60-plus years of the historic data base, they are useful in observing overall trends in the rate of shoreline response. The comparison of the pre- and post-construction shoreline change rates show that most of Bald Head Island is eroding less over the initial 10-year monitoring period. However, notwithstanding this overall positive response, the post-construction erosion rates continue to be greater along the western corner of South Beach. A direct comparison of the pre- and post-construction shoreline change rates show that only two profile lines are eroding at a higher rate during the post-construction period. These lines at located at the western end of South Beach (Profiles 53 and 57). Adjacent Profiles 61 and 66 are presently eroding but at a lower rate as compared to the pre-construction condition. All other lines are accreting in direct contrast to the long-term erosion experienced along the remaining areas of South Beach. Most of this response is attributable to the positive impact of the beach disposal placements along Bald Head.

Channel Shoaling (Settlement Surveys). On 24 March 2005, the Village of Bald Head Island and the Wilmington District entered into an agreement to conduct bi-monthly navigation channel surveys for the three channel reaches adjacent to Bald Head Island: Smith Island Channel, Baldhead Shoal Channel 1 and Baldhead Shoal Channel 2 (Figure 4.3). These surveys are intended to document channel shoaling and spit migration after channel dredging events which occurred initially in January 2005. There have been two subsequent dredging events since 2005 with the first occurring in 2007 between the months of March and April and the most recent occurring between February and April of 2009. Ultimately, these surveys will serve as a catalyst for discussion of possible measures to be taken if navigation becomes restricted during the scheduled two-year period between dredging events. The threshold criterion outlined in the settlement agreement at which discussions would initiate is a navigable width less than 500 ft at a depth of –42 ft MLW.

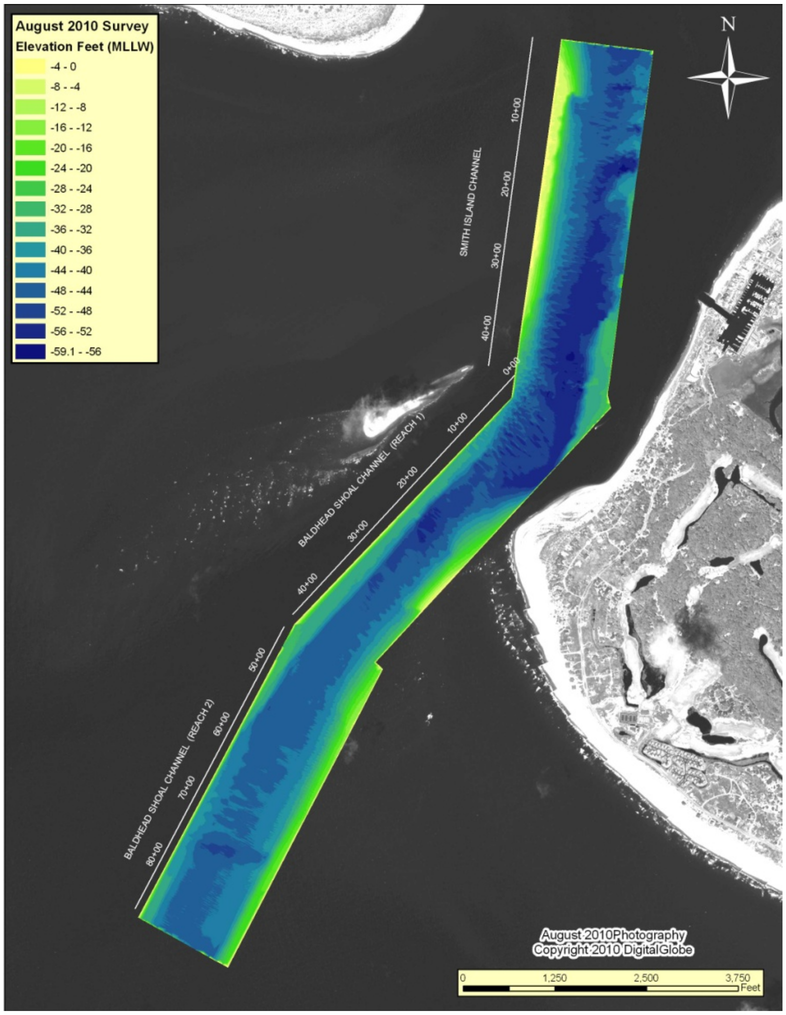


Figure 4.3 Locations for Baldhead Shoal (Reach 1 & 2) and Smith Island Channels

The first settlement agreement survey was conducted in March 2005. It and all subsequent surveys prior to the second dredging event were compared to the post-dredging survey conducted in January 2005 to track changes. The second dredging event occurred between March and April 2007 and the post dredging settlement survey was completed in June 2007. This survey served as the base to which subsequent surveys were compared within the second analysis period. The most recent dredging event occurred between February and April of 2009. Following this third dredging event a settlement survey was obtained in June 2009 which serves as the base condition survey for the third dredging period. Bi-monthly surveys have been made on the dates shown in Table 4.3. The navigable widths discussed in this section of the report focus on Bald Head Channel 1 due to its proximity to Bald Head Island and the tendency of this channel to most likely encroach upon the minimum width requirements. However, all three channels are analyzed and future reports may include more analysis of the other two channels if necessary.

Table 4.3. BHI Settlement Survey Dates

	SI Channel	BH Channel 1	BH Channel 2
January 2005[1]	3-Dec-04 to 25-Jan-05		
March 2005	23-Mar-05	18-Mar-05	18-Mar-05
May 2005	17-May-05	12-May-05	13,17-May-05
July 2005	20-Jul-05	22-28-July-05	25-28-July-05
September 2005	22-Sep-05	21-23-Sep-05	22-23-Sep-05
October 2005[2]	18-Oct-05	18-19-Oct-05	19-Oct-05
November 2005	29-Nov-05	30-Nov-05	30-Nov-05
January 2006	28-Jan-06	27-Jan-06	27-Jan-06
March 2006	17,21-Mar-2006	16-Mar-06	17-Mar-06
May 2006[3]	23-May-06	19-May-06	18-May-06
July 2006[3]	25-Jul-06	21-Jul-06	20-Jul-06
September 2006[3]	26,27-Sep-06	28-Sep-06	26-Sep-06
November 2006[3]	17-Nov-06	28-Nov-06	20-Nov-06
January 2007[4]	25-Jan-07	29-Jan-07	21-Jan-07
March 2007[4]	19-Mar-07	8-Mar-07	9-Mar-07
June 2007[4]	26-Jun-07	27-Jun-07	26-Jun-07
September 2007[4]	27-Sep-07	26-Sep-07	26-Sep-07
November 2007[4]	28-Nov-07	30-Nov-07	11-Dec-07
February 2008[5]	20-Feb-08	14-Feb-08	12-Feb-08
April 2008[5]	17-Apr-08	16-Apr-08	15-Apr-08
June 2008[5]	26-Jun-08	27-Jun-08	1-Jul-08
September 2008[5]	10-Sep-08	9-Sep-08	9-Sep-08
November 2008[6]	19-Nov-08	20-Nov-08	20-Nov-08
February 2008[6]	8-Feb-09	27-Jan-09	28-Jan-09
June 2009[6]	5-Jun-09	11-Jun-09	4-Jun-09
August 2009[6]	26-Aug-09	25-Aug-09	25-Aug-09
November 2009[6]	5-Nov-09	4-Nov-09	3-Nov-09
February 2010[7]	8-Feb-10	27-Jan-10	28-Jan-10
April 2010[7]	8-Apr-10	1-Apr-10	23-Apr-10
June 2010[7]	29-Jun-10	1-Jul-10	30-Jun-10
August 2010[7]	20-Aug-10	19-Aug-10	20-Aug-10

[1]Post dredging surveys are a mosiac of surveys between these dates

[2]October 2005 was an extra survey conducted post-Hurricane Ophelia to determine if any accelerated shoaling had occurred

[3]Surveys included in Monitoring Report 4

[4]Surveys included in Monitoring Report 5

[5]Surveys included in Monitoring Report 6

[6]Surveys included in Monitoring Report 7

[7]Surveys included in Monitoring Report 8

The settlement agreement specifies that a survey report documenting the channel conditions be produced within 20 days of completion of surveying and provided to the Village of Bald Head and the State of North Carolina. These reports are posted on the Wilmington Harbor Project web site at http://www.saw.usace.army.mil/wilmington-harbor/main.htm under the “Sand Management Survey Reports” section.

Figures 4.4 and 4.5 show the condition of the three channel reaches in November 2009 and August 2010, respectively. The November 2009 survey is the last survey included in Monitoring Report 7. The August 2010 survey is the last settlement survey to be included in the analysis for the current monitoring report. The channel widths by reach for Baldhead Shoal Channel 1 in November 2009 and August 2010 are shown in Figure 4.6. A difference plot of the total amount of change (November 2009 – August 2010) in all three channels is shown in Figure 4.7. Significant decreases in channel width are observed during the current period as a result of channel shoaling since channel dredging that occurred between February and April 2009. This is particularly evident between stations 20+00 and 24+00 which has been noted as an area of concern in previous monitoring reports. This area along with two others, station 32+00 through 33+00 and 37+00 through 39+00, is only marginally wider than the minimum navigable width threshold of 500’. Although these areas are close to the minimum navigable width requirements, no area within the channel violated the width requirements as described in the settlement agreement through the August 2010 survey. The change in navigable width measured at -42’ mllw, ranged from an increase of 17 feet at station 11+00 to a maximum reduction of 237 feet at station 21+00, which has historically been a location of increased shoaling,.

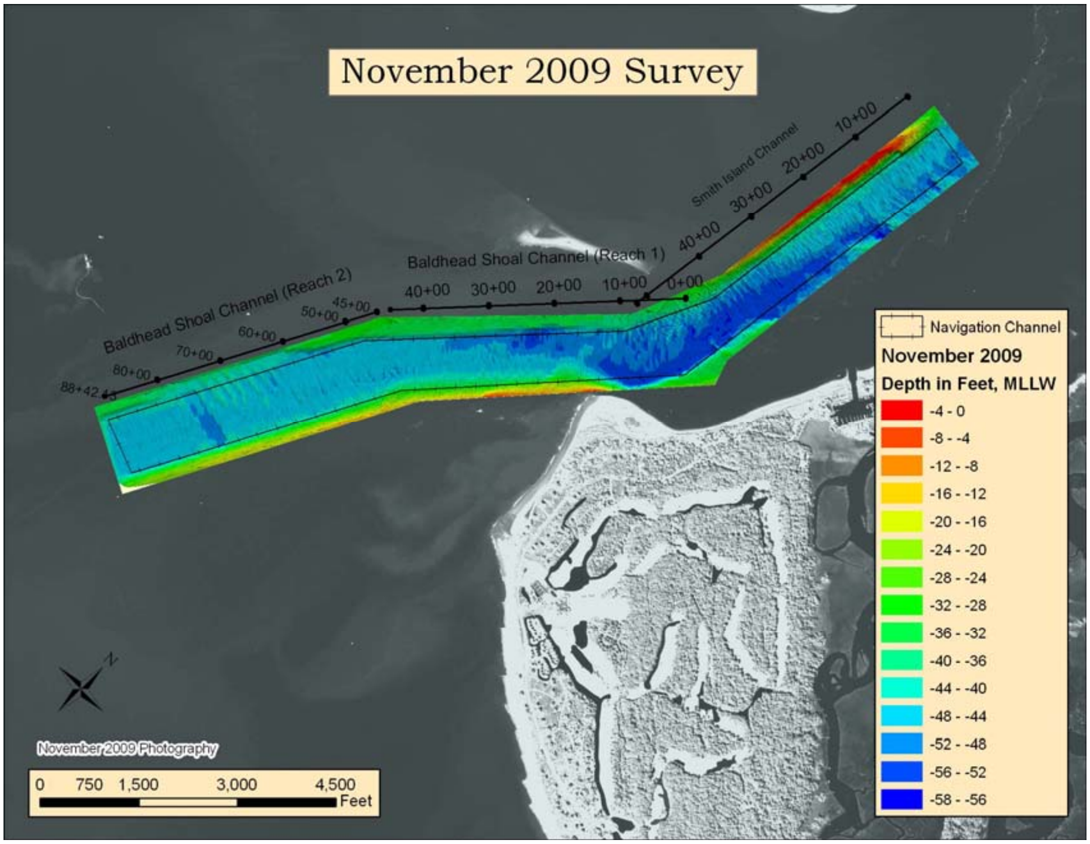


Figure 4.4. November 2009 Channel Conditions

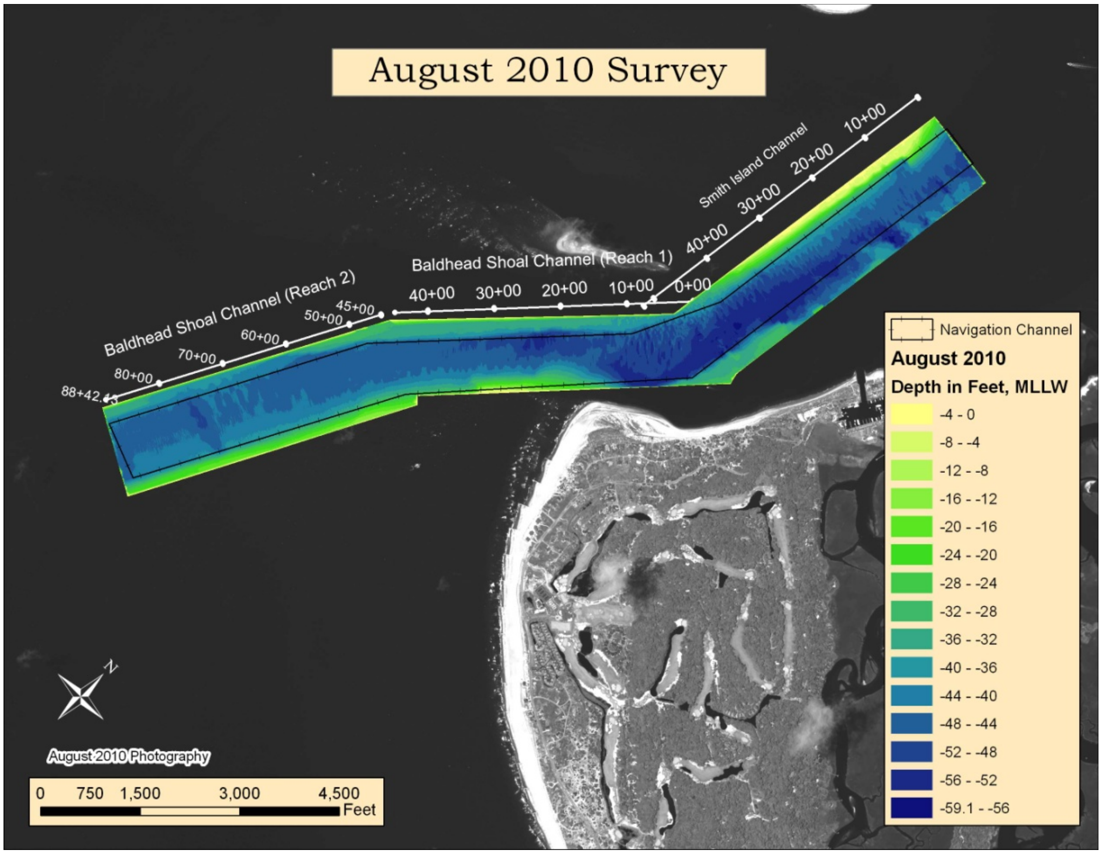


Figure 4.5. August 2010 Channel Conditions

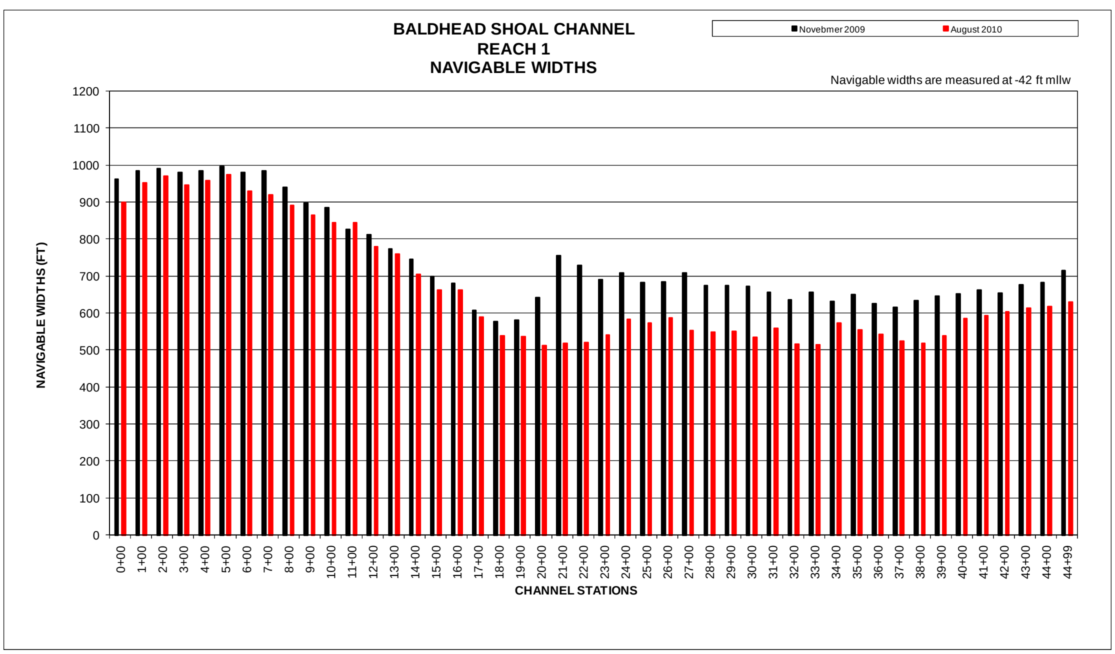


Figure 4.6. Baldhead Shoal Channel 1 Navigable Widths

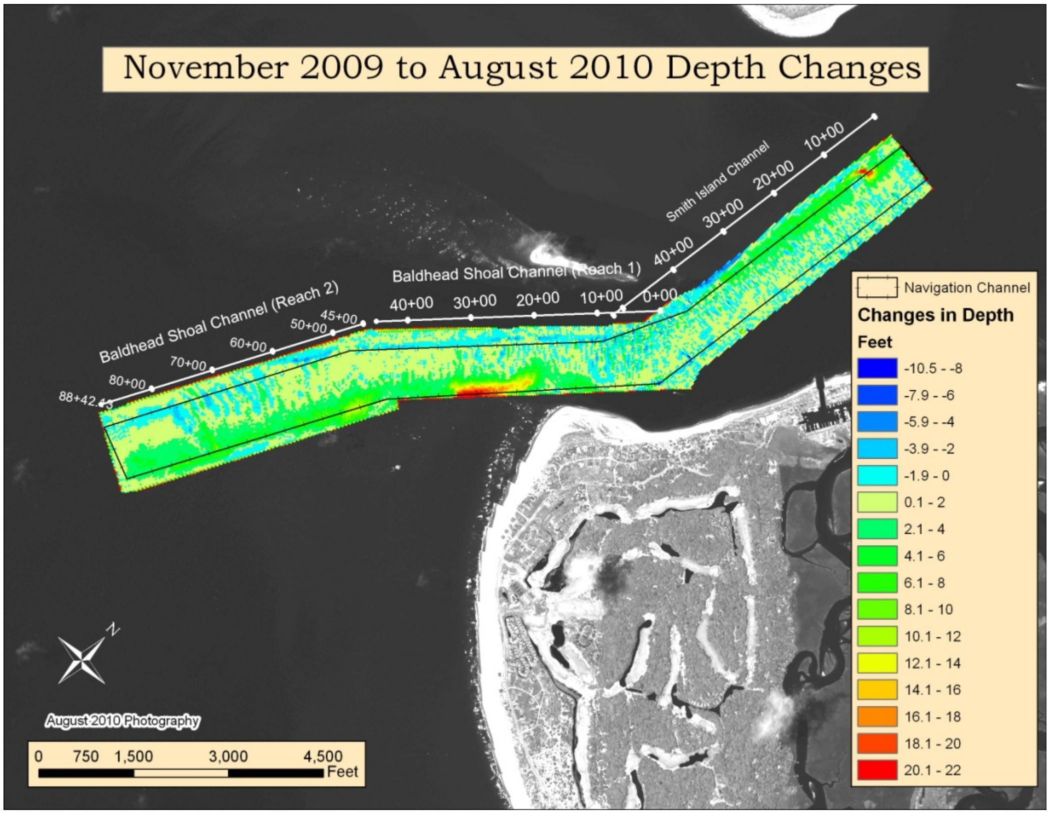


Figure 4.7 Depth changes from November 2009 to August 2010

The survey capturing base conditions following the third dredging event was obtained in June 2009 and is shown in Figure 4.8. This survey serves as the base to which all subsequent surveys are compared when capturing changes during the third dredging cycle. The minimum navigable width measured in the June 2009 survey was 605' at Station 35+00. Cumulative changes from the most recent survey of August 2010, to the June 2009 base condition survey are shown in Figure 4.9. Areas of significant change within this Figure are similar to those observed in Figure 4.7. Typically the areas of extreme change are the western side of the Smith Island channel where material appears to be shoaling in from the Oak Island side of the inlet, and the eastern side of Bald Head Shoal Reach 1 and 2 along the margin of Bald Head Island spit and ajoining Bald Head Shoals. The bottom depth changes outside these areas of significant change are variable between areas of moderate shoaling and erosion throughout all three reaches.

Figure 4.10 (Stations 0+00 to 23+00) and Figure 4.11 (Stations 24+00 to 45+00) show navigable widths for various time periods along Reach 1 over the entire third dredge monitoring cycle. This graph illustrates the impact of the cycle between dredging and shoaling within the channel on the navigable width of the channel. The significant increases in channel width previously observed between stations 19+00 and 28+00, as well as, stations 42+00 through 44+99 resulting from channel dredging are for the most part gone with some areas having less navigable width as of August 2010 than prior to the last dredging event. In addition, the area between stations 29+00 and 41+00, which did not see significant increases in navigable width following the most recent dredging event, has experienced large reductions in width since June 2009 pushing some stations close to the 500' minimum width. The cause of this movement of the channel shoaling area further seaward is unclear, although it may be related to the recent fill placed along the western end of South Beach and the Spit area that contains the re-constructed groin field on Bald Head Island. The large quantity of sand placed adjacent to the navigation channel appears to have resulted in increased shoaling within the adjacent navigation channel in locations further seaward than noted in previous reports. Even with the significant shoaling and changes in shoaling patterns within the channel over the current monitoring period, all stations remain wider than the desired 500 foot navigable width.

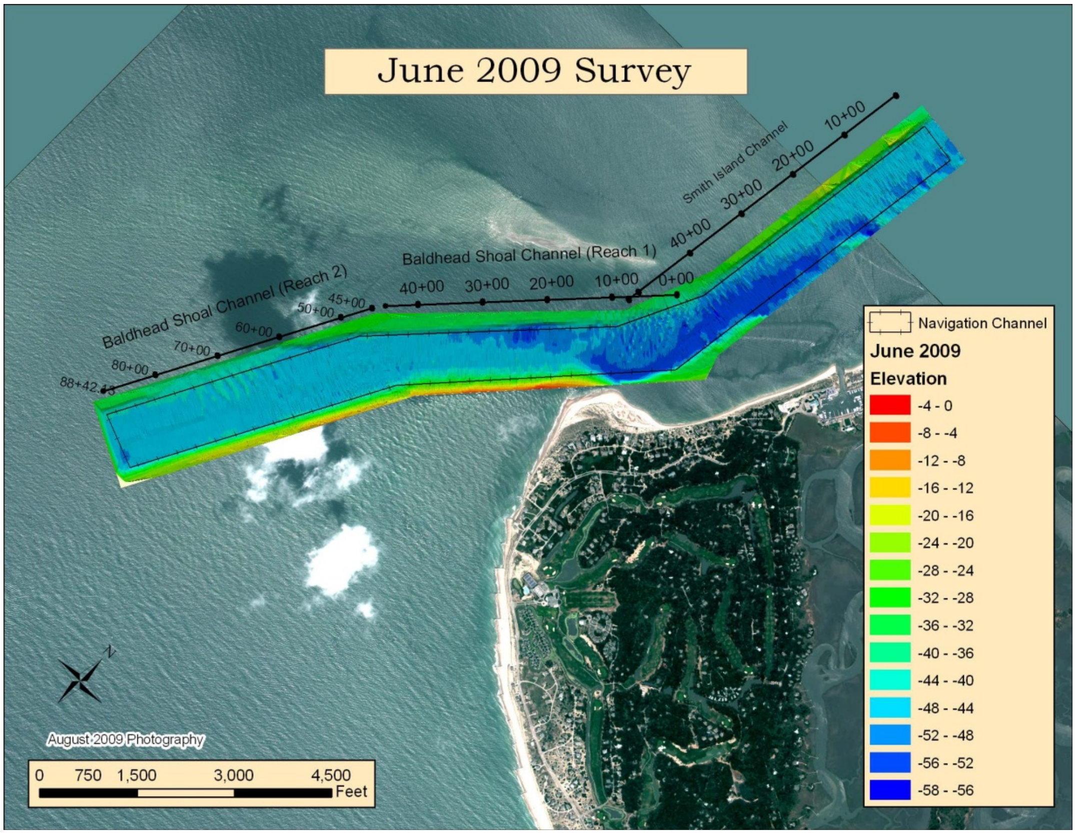


Figure 4.8 June 2009 Survey

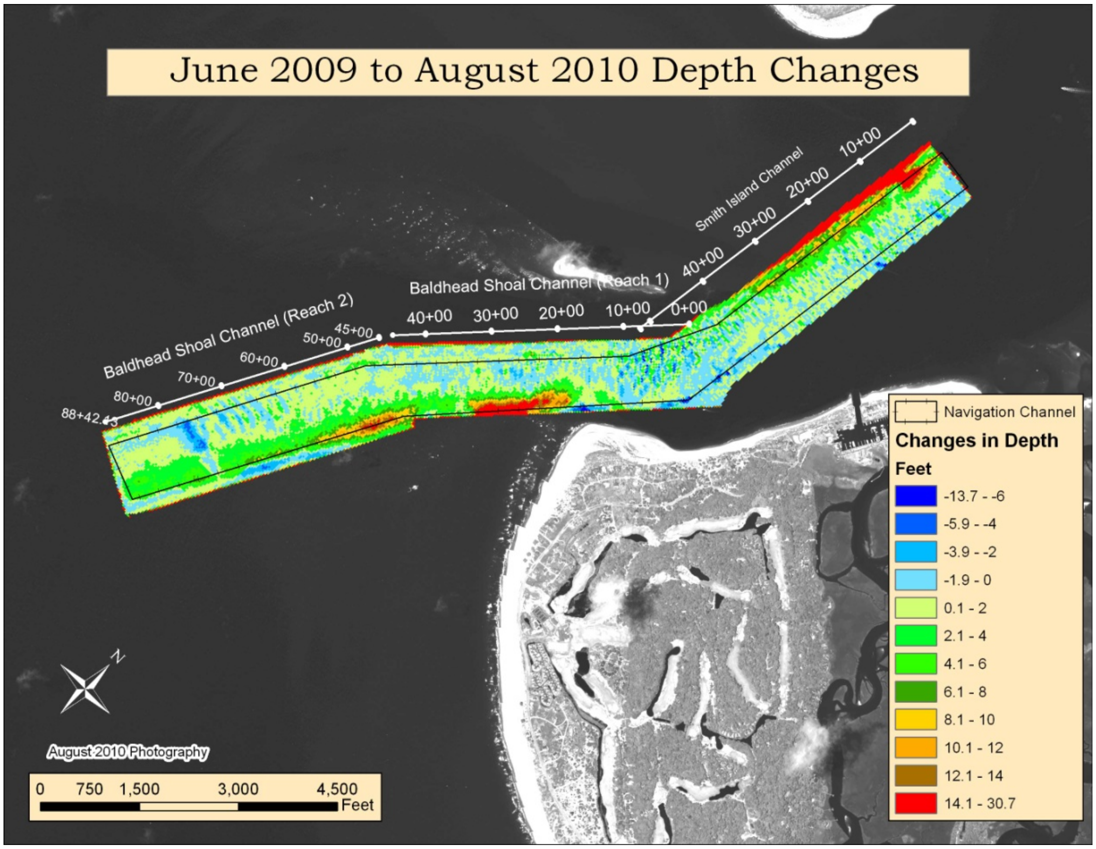


Figure 4.9 Depth changes from June 2009 to August 2010

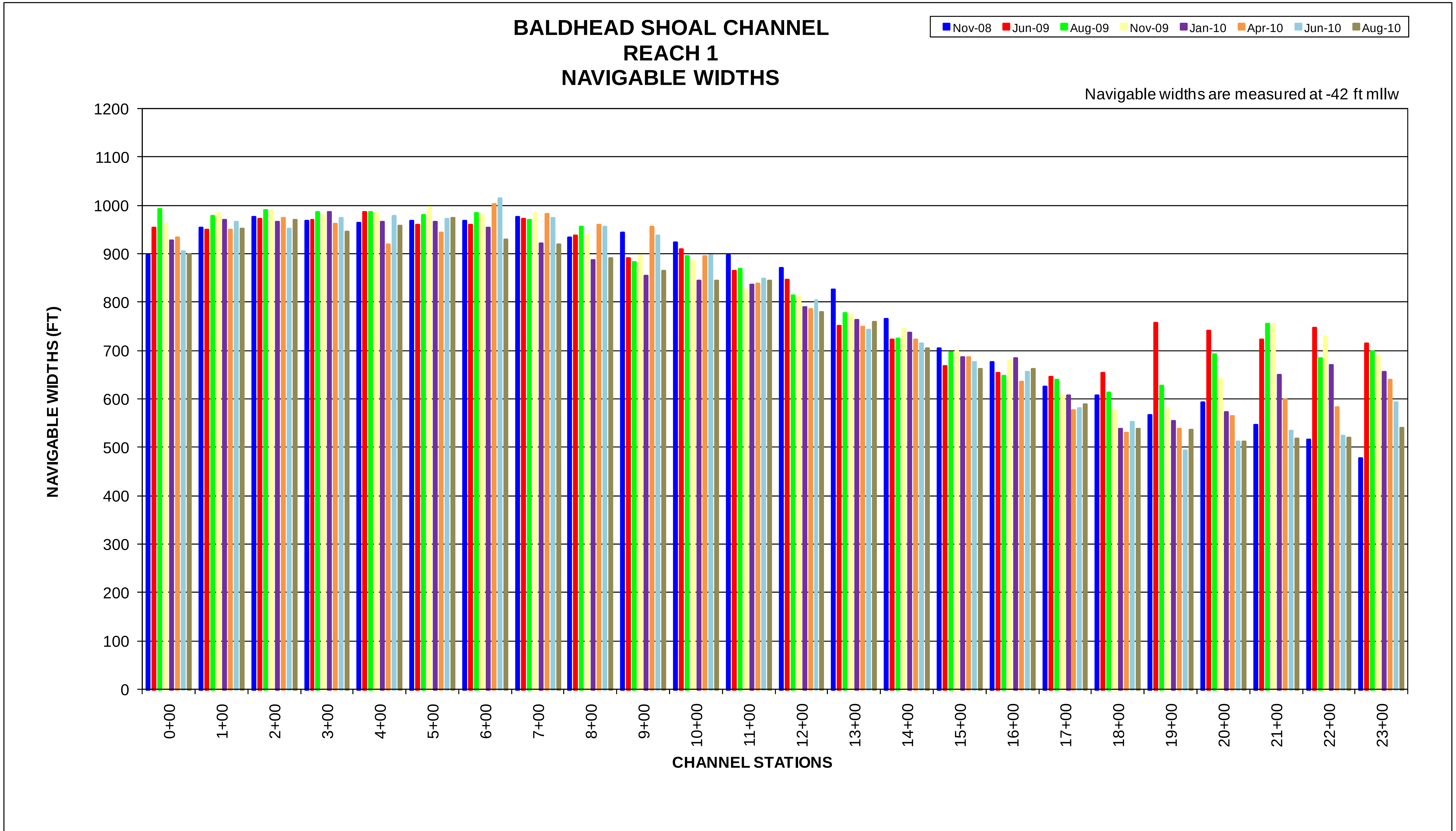


Figure 4.10. Baldhead Shoal Channel 1 width by station: Station 0+00 to 23+00

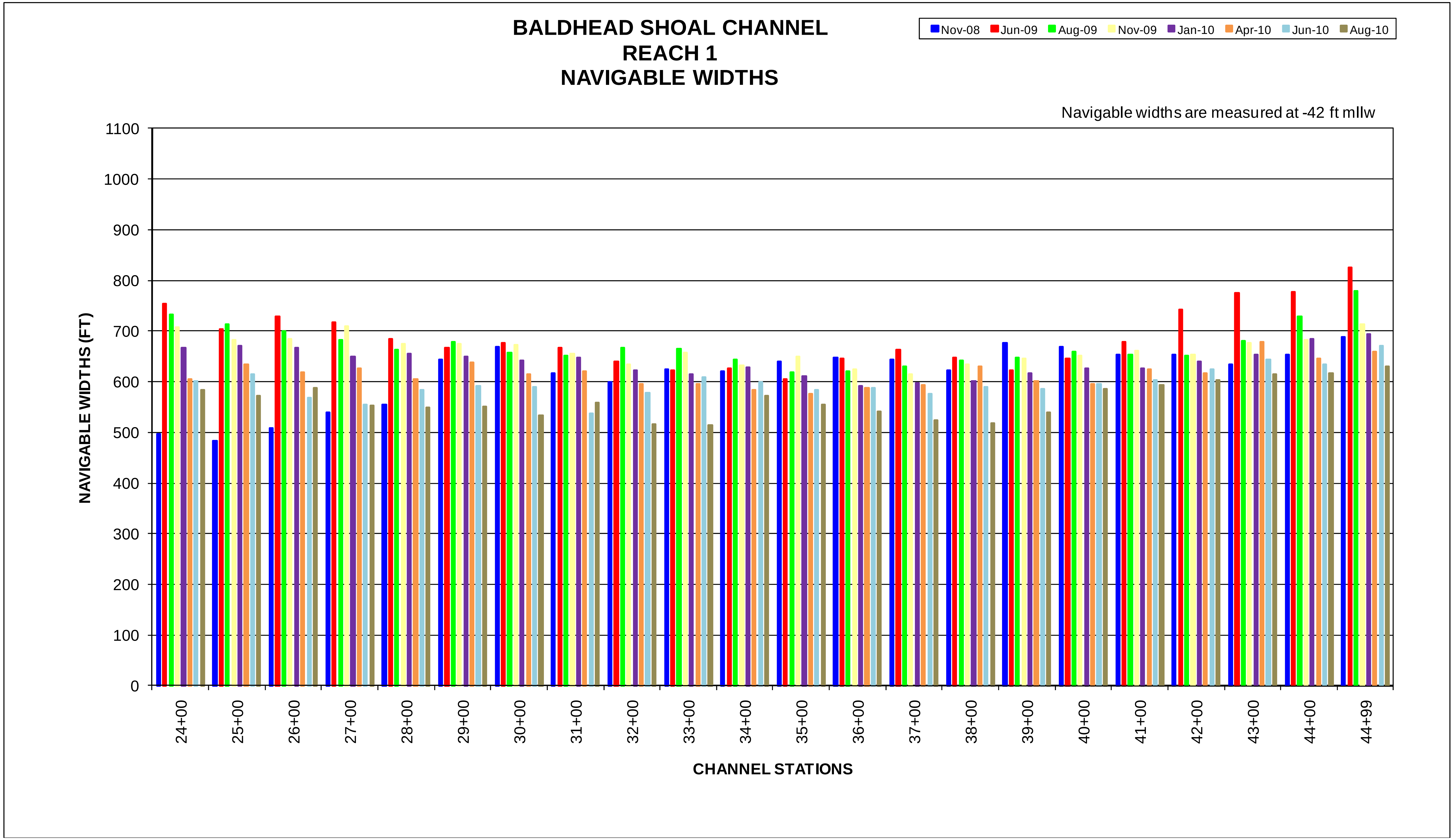


Figure 4.11. Baldhead Shoal Channel 1 width by station: Station 24+00 to 45+00

Spit Growth. In 2001-02 approximately 1.8 million cubic yards of sand were dredged and subsequently placed on Bald Head Island from station 41+60 to 205+50. After placement, the spit on the east side of Baldhead Channel 1 doubled in volume (400,000 cubic yards in October 2004 versus 200,000 cubic yards pre-2001). From November 2004 through January 2005, approximately 1.2 million cubic yards of material were dredged and placed from station 47+00 to 130+00 as part of the first sand management plan maintenance cycle. After this placement cycle, the Village of Bald Head Island reconstructed 16 shore-perpendicular sand tube groins between profile station 47+50 and 104+00. Spit volumes during this second dredge/disposal operation grew to nearly 340,000 cubic yards and are discussed further in the channel shoaling section of this report. The third disposal occurred as part of the second maintenance cycle in the February-April 2007 time frame and was placed in two locations on Bald Head Island. The first location was along the groin field from station 44+00 to 91+00 where approximately 398,500 cubic yards of material were placed. The second location was along south beach from station 110+00 to 170+00 with approximately 580,000 cubic yards placed. Spit volumes during this second maintenance cycle increased to approximately 250,000 cubic yards from the initial measurement of approximately 47,000 cubic yards at the beginning of the second maintenance cycle. Since the last monitoring report placement of sand and reconstruction of the existing groin field was made along Bald Head Island through a project funded by the Village of Bald Head Island. This project placed approximately 1,594,500 cubic yards of material within two zones on the island. The first zone was between stations 12+00 and 28+00 and the second zone was located between stations 39+60 and 162+00. As a result, spit volumes measured since the after dredge survey in April 2009 have increased from approximately 47,000 cubic yards to nearly 322,500 cubic yards as of August 2010.

Figure 4.12 displays the section of Bald Head Island where the reconstructed groin field is located, as well as a collection of digitized shorelines which show the impact of the groin field along the shoreline in this area. From this figure it is evident that the sediment transport along the groin field is from the east to west, which created a saw-tooth shaped shoreline following construction of the field. This pattern of transport flow is visible following both the 2007 and 2009/2010 groin field construction. Comparing the current August 2010 shoreline position with the November 2009 shoreline position included in Monitoring Report 7, shows that significant seaward movement of the shoreline has occurred along the west end of South Beach as a result of the Village's sand placement and groin field reconstruction. The area of the shoreline between Profiles 40 and 61 was noted in the previous monitoring report as being at its most landward position since the beginning of the monitoring program. While the efforts from the Village of Bald Head Island since the last monitoring period have increased the width of the beach in this area, the area remains landward of the initial monitoring position. Also, this is the only area within the newly reconstructed groin field that is not completely covered with sand leaving portions of this most critical area more exposed to wave and current forces. Accretion in this area is measured to be as much as 270' in the vicinity of Profile 43 relative to the November 2009 shoreline position. A small section of the beach between Profiles 32 and 40, at which accretion was observed during the previous monitoring cycle has reversed trends and has eroded as much as 100 feet when compared with the November 2009 shoreline. The remainder of the shoreline east of Profile 61 has seen less dramatic, but consistent accretion when compared to the November 2009 shoreline.

Volumes were calculated within the channel along the margin with Bald Head Spit. These spit volumes were calculated within the bounding polygons shown in Figure 4.13 over a time span from the early 1990's through the current period. The change in spit volumes above -44 ft MLLW for Baldhead Shoal Reach 1 are shown in Figure 4.14 with the four dredging/placement events noted. Figure 4.15 shows a comparison of the four post-placement shoaling trends from Figure 4.14. Slopes following the first three dredging events were progressively shallower while the slope following the most recent dredging event more closely matches the original dredging response. These slope differences indicate a different rate of spit volume growth, with a slower growth rate after the 2004/2005 and after the 2007 placement identified by the flatter slopes. Specifically, the initial rate was about 16,500 cubic yards per month. An analysis of all surveys for the second dredging event, January 2005 through March 2007, showed that the spit growth had slowed to about 9,900 cubic yards per month, i.e., a 40 % reduction in the shoaling rate. Calculation of the shoaling rate from the data collected during the third monitoring period showed that the growth rate had continued to decrease from the previous two dredging cycles to a rate of 8,950 cubic yards per month (but was comparable to the second cycle). This is a 46% reduction in the shoaling rate versus the initial dredging operation and a 10% reduction when compared to the second dredge cycle.

Among the possible explanations for this slower spit growth rate following the initial three dredging events are: (1) sand tube groin field constructed immediately after the 2004/2005 placement was effective in retaining the disposal following the 2004/2005 and 2007 beach placements, (2) smaller volume of material placed in the 2004/2005 placement dispersed from the island at a slower rate, (3) smaller volume of material placed at a lower density over longer reaches during the 2007 dredge disposal, (4) different location of placement with the second disposal being farther away from the channel, and/or (5) possible dissimilar wave and current conditions for each period of record.

The most recent data collected within Reach 1 indicates the shoaling rate has increased to 17,300 cubic yards per month, which is approximately a 94% increase over the previous monitoring cycle. However, this is very comparable to the shoaling rate following the initial dredging cycle, being only about 5% higher,. This increase is most likely due to a combination of the failure of the groin field built in 2007 and the recent beach nourishment efforts, which placed significant quantities of material in proximity to the navigation channel. With the reconstruction of the groin field in 2010 by the Village of Bald Head Island, rates of shoaling within the channel following the next dredging cycle should lower, more in line with cycles two and three. Volumetric analysis within the reach 1a polygon continues to show that there is no narrowing of the channel associated with the northern growth of the spit.

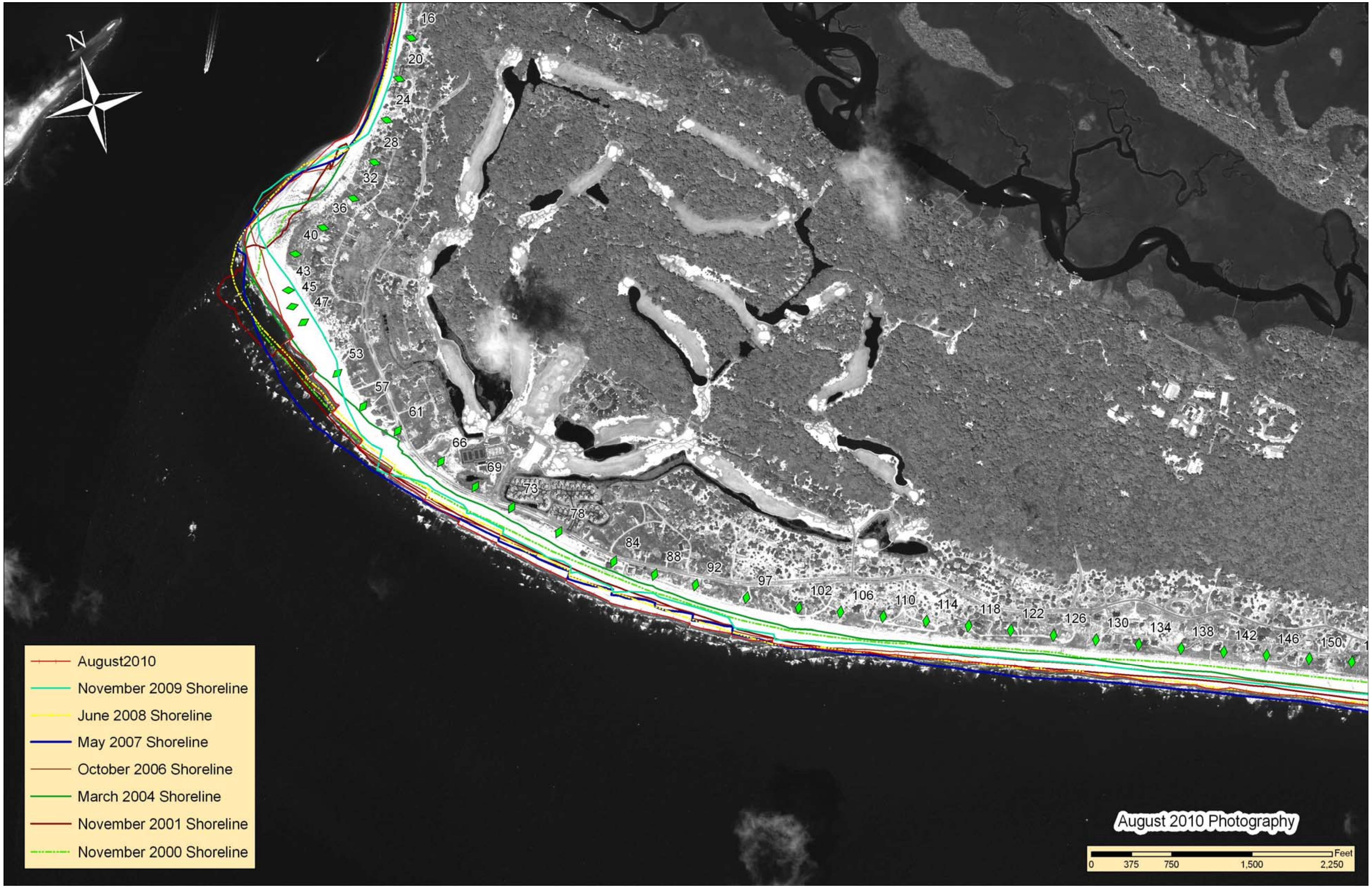


Figure 4.12 Shoreline Comparison: Pre and Post groin field reconstruction and beach disposal

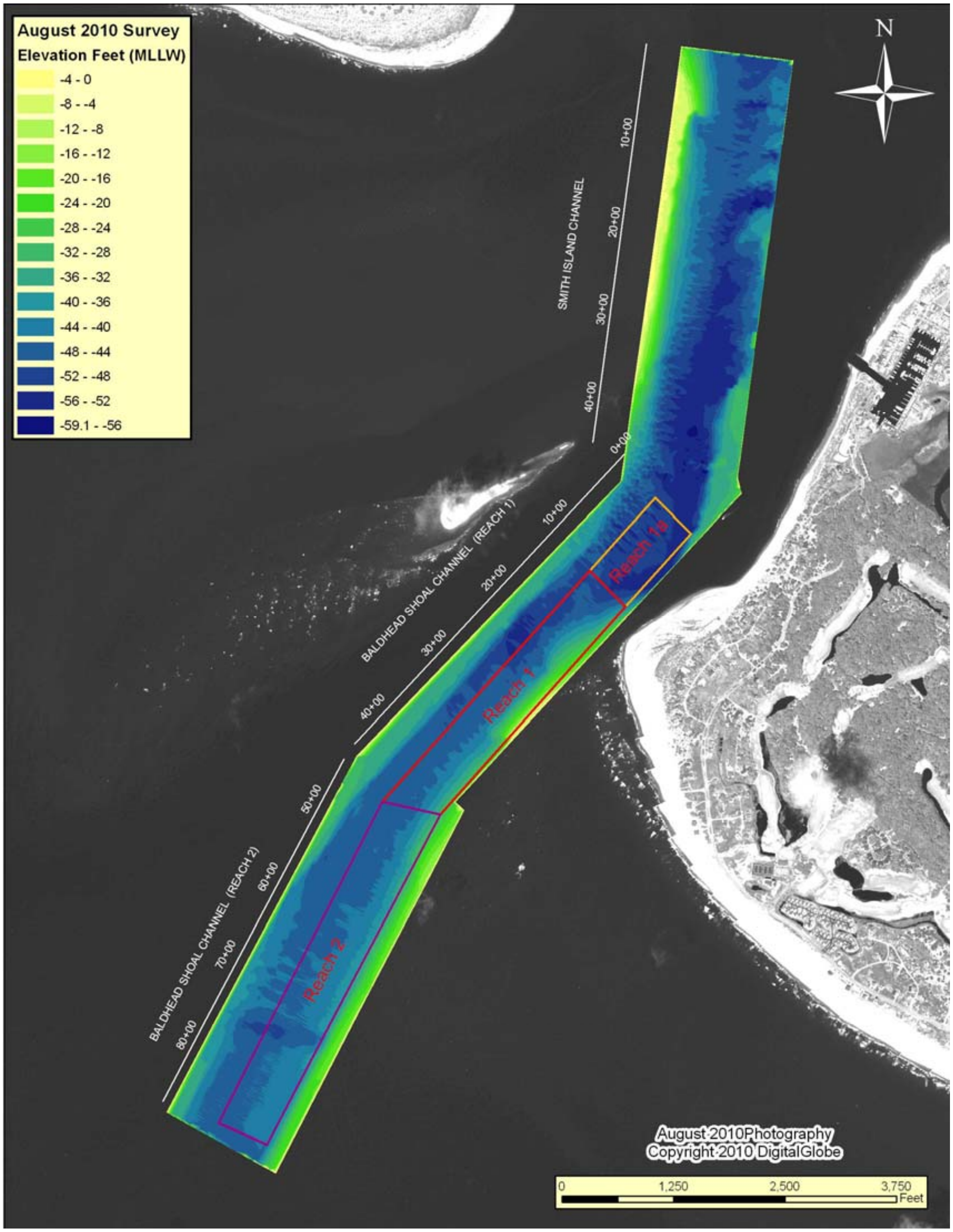


Figure 4.13 Spit Volume Bounding Polygons

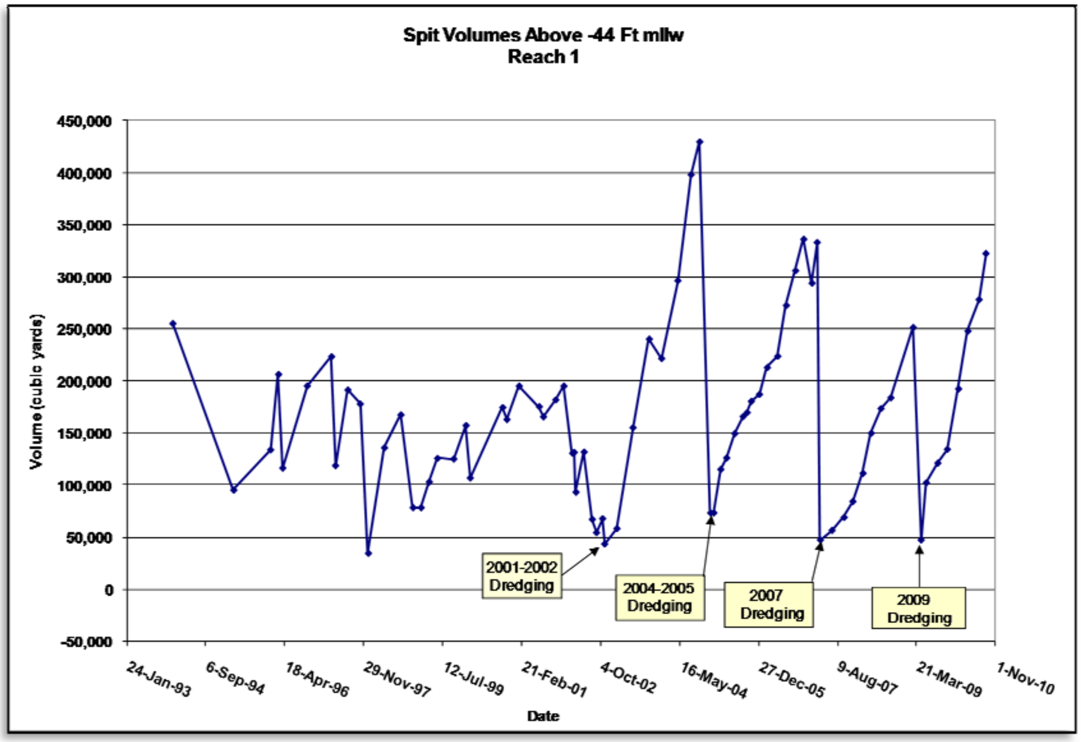


Figure 4.14 Baldhead Shoal Channel 1 Spit Volumes

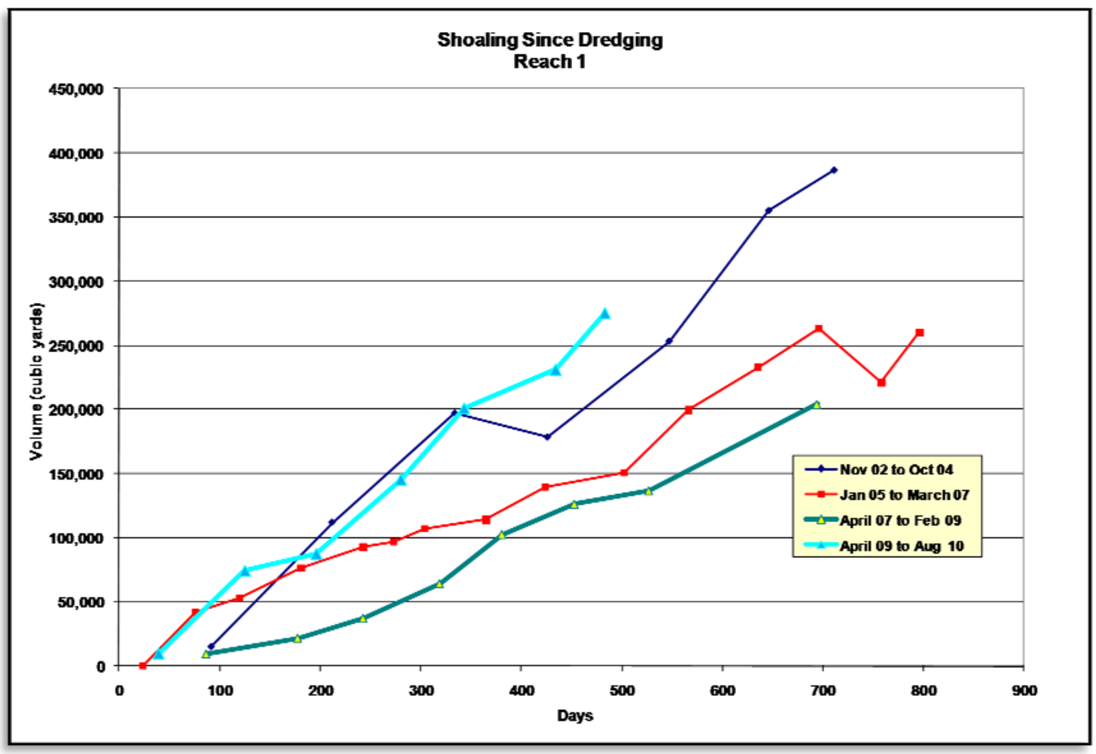


Figure 4.15 Comparison of post-placement spit growth from Figure 4.14 (Above)

Bald Head Groin Field Performance

General. In 1996, the Village of Bald Head Island constructed sixteen geo-textile groins. The groin field slowed the erosion for several years before they began to fail and ceased to function in 2000. Due to apparent effectiveness of the geo-textile groins, the Village decided to rebuild the groin field following the beach disposal in 2005. As such, a sixteen structure sand tube groin field was reconstructed along South Beach between stations 47+00 and 105+00. The replacement geo-tubes were constructed between January and March 2005 using the in situ sand to disposal the 300-foot long tubes. This groin field was recently replaced in May 2010 after the previous field had deteriorated to a point where it no longer functioned as designed. Slight adjustments were made to the configuration of the new field with the eastern most groin being deleted from the reconstruction and an additional groin being added on the western end of South Beach near Profile 43.

The section of beach contained within the reconstructed groins has received beach disposal on four occasions. These occasions include the 2001 disposal before the reconstruction, the 2005 disposal with the reconstruction, the 2007 disposal, and the disposal between November 2009 and March 2010 which was funded by the Village of Bald Head Island. In this regard, it is possible to assess the performance of the groins by comparing the measured changes along this section of the beach with and without groins in place. For consistency with previous reports, the analysis area within this section was not adjusted to include the newly built groin on the west end of South Beach and is limited to Profiles 53 through 106. Given that the data following the construction of this new groin is limited to two data points with one of these serving as the base condition, insufficient data was available for analysis of this added structure.

Shoreline Response. Changes in the position of the mean high water shoreline were calculated for selected monitoring surveys following each of the four beach disposal projects. In each case, the shorelines measured from the profiles contained within the influence of the groin field were compared to the first post-disposal survey for the four beach disposals that occurred in 2001, 2005, 2007, and 2009. The results are given in Figure 4.16, showing the shoreline changes for six surveys following the first disposal, four surveys following both the second and third disposals, and a single survey following the most recent disposal. The surveys following the first disposal are displayed as solid brown lines, the post-second disposal surveys are displayed as dashed blue lines, the surveys following the third disposal are displayed as solid green lines, and the survey following the fourth disposal is a solid orange line. The results show that following the most recent beach disposal placement and construction of the new groin field in 2010, there has been little change of the shoreline position with the exception of the western most profile location. This location, Profile 53, lost nearly 100 feet of shoreline following the most recent disposal. This continues a trend observed during monitoring of the third disposal where the western end experienced increased erosion rates. The total time spans reported in the figure are different for each of the disposals, spanning 35 months for the first disposal cycle, 23 months for the second disposal, 22 months for the third disposal, and only 6 months for the fourth disposal. To account for these differences in monitoring periods, shoreline changes over similar time frames can be compared by using the November 2001, August 2005, January 2008, and September 2010 survey dates all of which are approximately 5 to 6 months after their respective disposals. Due to the time limitations of this comparison it is difficult to determine any significant pattern; however, it is worth noting the similarities between the shoreline positions in August 2005 and September 2010. Both of these time periods follow the construction of the groin fields in 2005 and 2010 and on average show much less shoreline loss than the other time periods in the comparison. Specifically, the average shoreline change within the area of the groin field approximately 6 months after each disposal event was -33 feet for the first disposal with no groin field in place, 2 feet after the second disposal with the newly constructed groin field in place, -29 feet following the third event with the groin field in place, and -10 feet following the forth disposal and most recent groin re-construction.

As an additional comparison in shoreline response, the rate of shoreline change was computed for each of the periods following the four beach disposal placements. This comparison is shown in Figure 4.17. The results show that when compared to the shoreline change rates computed following the first disposal, all of the profiles following the third disposal have a lower change rate with the exception of the two most western profiles within the groin field area. In addition, the change rates following the third disposal are all lower than those calculated following the second disposal with the exception of the four most western profiles. The rates following the fourth disposal on average are lower than those of the other three analysis periods, however insufficient time has elapsed following the most recent disposal activity to develop comparable change rates to the other three disposal periods.

Aerial photography was obtained for two time periods since the placement of the fourth disposal on Bald Head Island which include February 2010 and August 2010. Figure 4.18 displays the available aerial photography with digitized shorelines overlaid to show changes relative to the February 2010 shoreline condition. This shoreline was chosen as a representative shoreline condition following the disposal which concluded in March 2010. In addition to the February 2010 shoreline being shown in both photographs serving as a reference shoreline when viewing subsequent photography, the November 2009 shoreline is also included to serve as a comparison to pre-project condition. This was also the last shoreline included in the analysis of shoreline changes in Monitoring Report 7.

Analysis of the existing groin field through comparison of available aerial photography visually shows the significant impact of the beach disposal and groin field within the area. The first image in Figure 4.18 is the February 2010 photography showing a post-disposal condition along the beach where the shoreline has been moved seaward from the November 2009 position up to 380 feet. Also shown in this photograph is the installation of the five most westerly groins into the beach disposal. The groin in the photograph on the extreme western end is a change from the design of the old groin field as discussed earlier and is not included in our current analysis. The second image in Figure 4.18 shows the significant changes that occurred within the six months between

February and August 2009. During this period of time the central portion of the groin field showed little change in shoreline offset while the western half, groins 1-7, had shoreline retreats of up to 140 feet in some locations. The erosion of this groin field combined with the westerly longshore transport within the area produced the saw tooth shoreline visible within the photograph. This erosion has exposed a significant portion of the groin field when compared to similarly dated photography following the construction of the groin field in 2005.

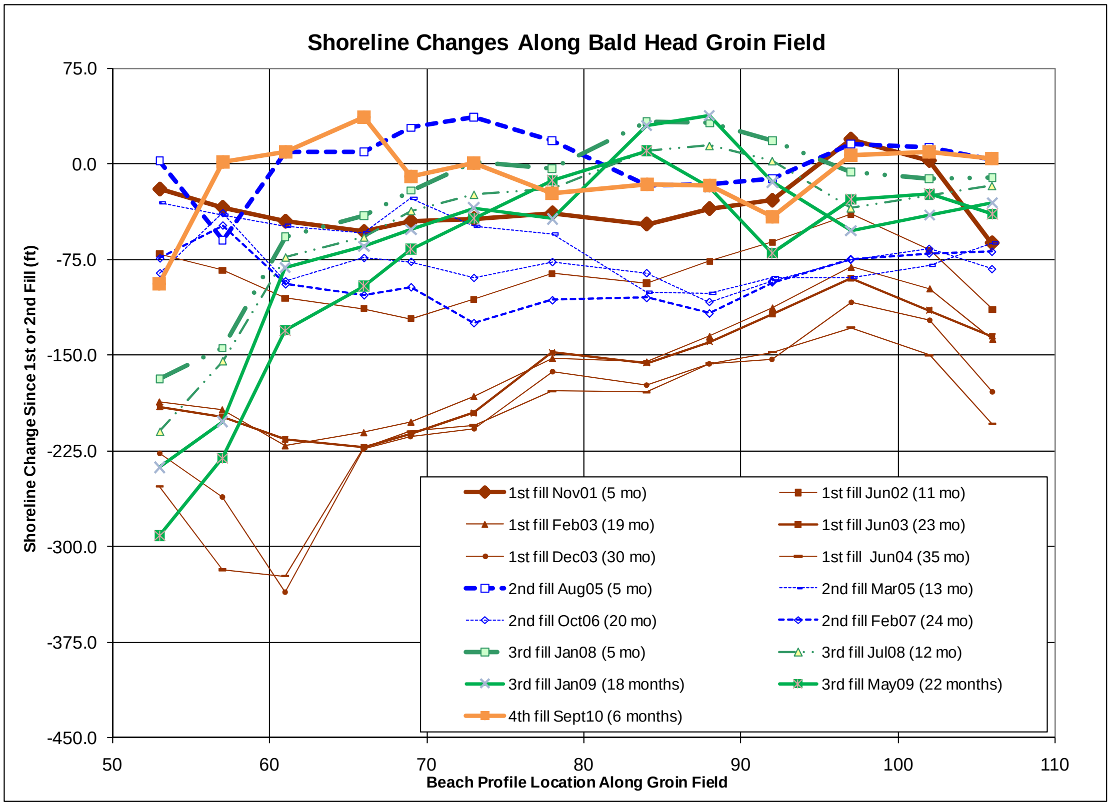


Figure 4.16 Shoreline Changes Along Bald Head Groin Field

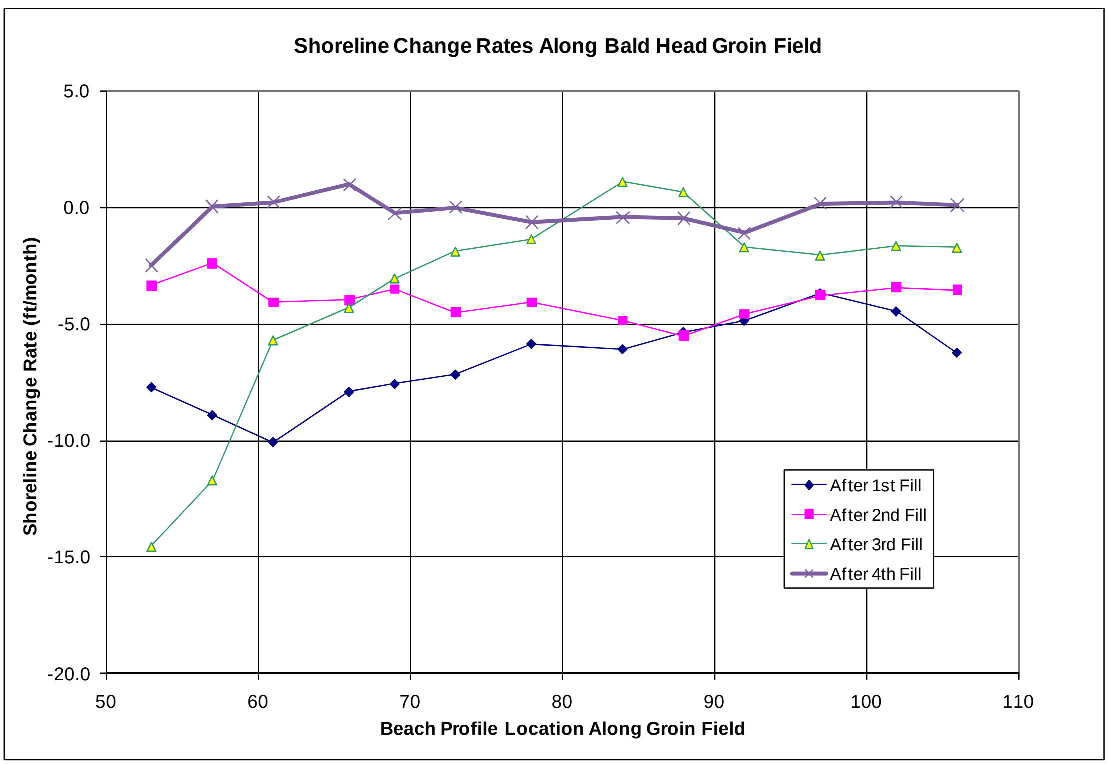


Figure 4.17 Shoreline Change Rates Along Bald Head Groin Field

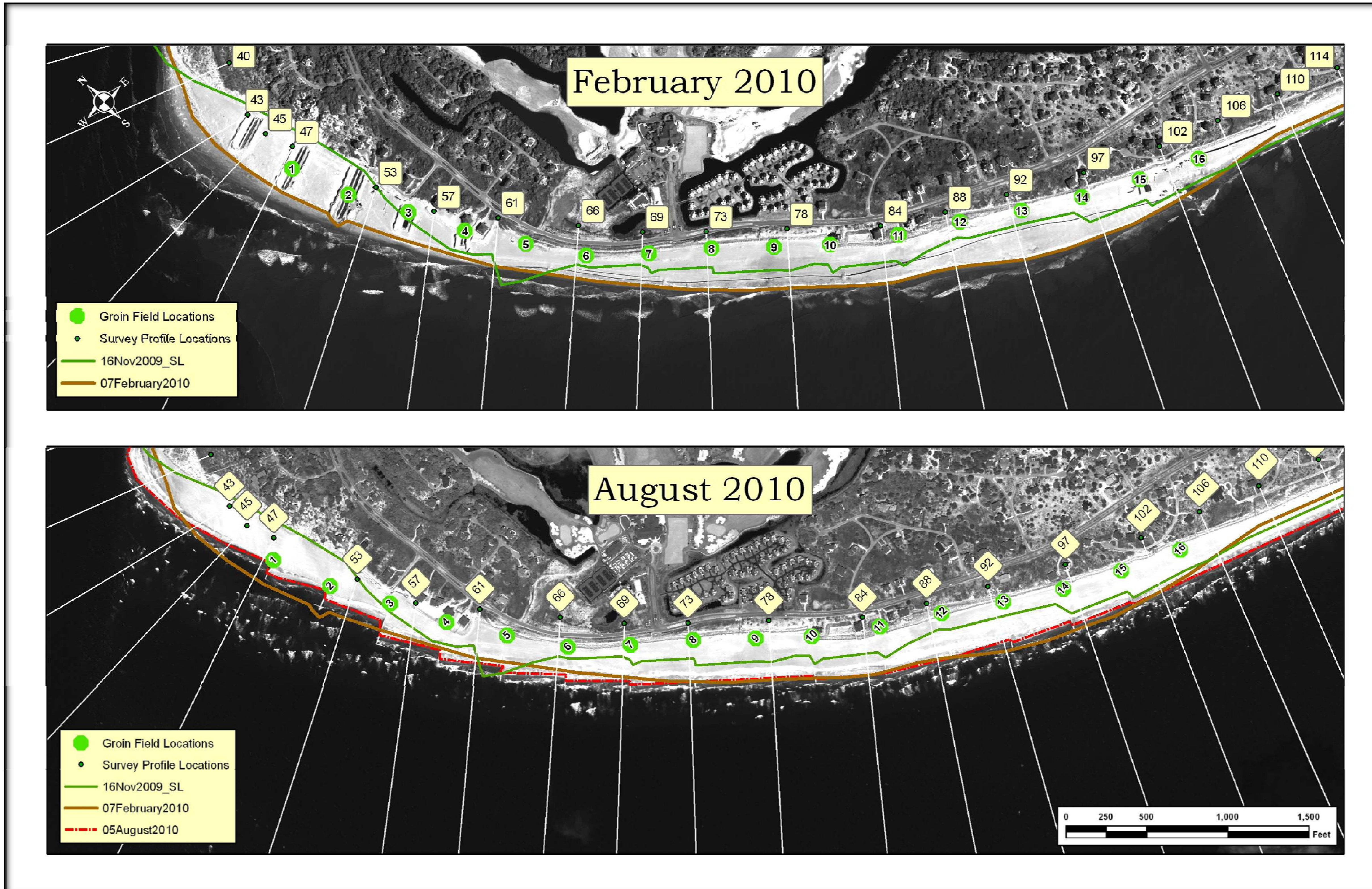


Figure 4.18 Evolution of Groin Field Shoreline (February and August 2010)

Profile Volume Response. Volumetric changes were also computed and compared for each of the four post-disposal periods within the zone covered by the reconstructed groins. Similar to the prior section of the report documenting the shoreline changes, the volumetric changes were computed for selected post disposal surveys documenting changes for each profile within the groin field area following each disposal placement. These volume changes are shown in Figure 4.19 and reflect the total volumes computed over the entire active profile out to the depth of closure. The values associated with the first disposal are given in solid brown lines on the graph, the second disposal volume change data are shown with dashed blue lines, the third disposal volume change data are shown as solid green lines, and the change in during the fourth period is displayed by a solid orange line. With the reconstruction of the groin field in 2010 the figure shows the moderate and relatively uniform volumetric loss across this area of the beach relative to the post placement monitoring survey in March 2010.

In comparing the post-disposal response over similar spans of time, only a relatively short period is possible due to the single survey available following the recent dredging. In this regard, one survey was selected from each post-disposal monitoring period for comparison. The surveys selected following the beach disposals included: October 2001 (4 months-without groin) for the initial disposal period, August 2005 (5 months) for the second disposal period, January 2008 (6 months) for the third period, and September 2010 (6 months) for the most recent disposal. This result is somewhat limited given the short time span but reveals that for the overall volume change within the groin field, the losses are found to be higher for the most recent beach placement activity than any of the other three disposals. The average loss across the entire groin field for these similar time periods is estimated to be 69,000 cubic yards associated with the first disposal versus 4,300 cubic yards, for the second disposal, 164,000 cubic yards following the third disposal, and 184,000 cubic yards following the most recent disposal activity. The increase is most significant when comparing the volumetric change over similar time periods that immediately follow groin field construction activities in March 2005 and May 2010. The volumetric loss in September 2010, which follows groin construction in April 2010, is approximately 180,000 cubic yards more than the losses measured in March 2005 which also followed new groin field construction. As discussed earlier, the losses of material in the current monitoring period have exposed large sections of the groin field to wave and current interaction and could lead to shortened life expectancy of the newly installed groin field.

The volumetric rates of change along the Bald Head groin field are shown plotted in Figure 4.20 for each of the disposals. While it is difficult to compare these change rates given that they cover different periods of time, especially following the fourth disposal, they do give an indication of the variability of the losses during different time periods. The plot of the change rates within the groin field following the fourth disposal period shows how rapidly the material is being lost over the current time period and how the rates have increased along the eastern half of the field. None of the profiles within the groin field indicate accretion during any of the time periods analyzed.

Due to the overall extent of the structures, which can only directly influence the upper portions of the profile, (typically above the -2 foot elevation or greater), the volumetric changes are further divided into onshore and offshore changes, i.e. above and below -2 ft NGVD. The onshore changes are given in Figure 4.21 for selected post disposal surveys for all four disposals. Figure 4.22 likewise shows the rates of onshore volume change computed over each of the disposal periods.

Figure 4.21 shows that while the onshore volume losses are greater following the first disposal without the benefit of the groins, versus the second, third, and fourth disposal periods the differences measured over this short time period are relatively minor. When comparing the onshore changes within the groin field along a similar time frame (4 to 6 months), the first disposal period lost the greatest amount of material with a total of 75,700 cubic yards by October 2001 (4 months). This compares to a 1,100 cubic yard loss measured over the second disposal in August 2005 (5 months), which followed groin field construction in 2005. A 44,000 cubic yard loss was measured in January 2008 following the third disposal and a 45,000 cubic yard loss was measured most recently in September 2010 (6 months) following the most recent disposal and groin field construction in 2010. Based on the short time record comparison of volumetric changes, it appears that while the losses within the groin field following the most recent groin field construction greatly exceeded the losses following construction in 2005, they were significantly less (41%) than the performance of the area in 2001 following to initial construction.

When the volumetric change rates are compared (as shown in Figure 4.22), similarities are found between the second and fourth disposal events. With the exception of the western most Profile, 53, being much more erosive in the fourth period, the remaining profiles follow a similar trend. All three post groin field construction rates are lower than the rates computed after the initial disposal placement. Further monitoring will be needed to confirm the trend established through September 2010 following the fourth disposal due to its limited period of coverage versus the rates computed following the first three disposal events.

The offshore volumetric changes (below -2 ft NGVD) computed along the groin field are shown in Figure 4.23. As in the previous figures, the heavy solid brown lines of the first disposal (without groins) can be compared to the second disposal (with groins) in the associated bold dashed blue line and the third disposal (with groins) in the associated bold solid green line. The most recent volumetric changes for September 2010 are represented in the figure by a solid orange line. It is evident from Figure 4.23 that the general response in the offshore has varied over the four post disposal monitoring periods. The post-disposal responses over this short time period of 4 to 6 months are in general erosive with the exception of the initial disposal response which experienced significant increases in the offshore volumes. In terms of overall volume change in the offshore (compared using the same limited time periods as the onshore), the total changes observed during the first disposal amounted to an increase of 7,000 cubic yards. This compares with a loss of 5,500 cubic yards with the second disposal, 120,000 cubic yards following the third disposal, and 139,000 cubic yards following the most recent disposal.

The computed volumetric change rates for the offshore portions of the profiles are shown in Figure 4.24. This plot shows that along the western end of the groin field the erosion rates are higher following each disposal period, particularly following the third and fourth disposals. The eastern two thirds of the groin field shows a similar pattern of volumetric change rates following the first and third disposals, while the change rates following the second and fourth disposals are generally more erosive.

In summary, the reconstructed groins have had an overall positive effect in retaining the beach for the first three monitoring periods; however, the groin field has not performed as effectively during this most recent period. By comparing the beach disposal response for the first two periods, one with and one without the groins the positive influence of the groin construction is evident. This is particularly clear within the upper portions of the beach profile which are reflected in the positive response measured with respect to shoreline change and changes in the onshore volumes. Changes of this nature would be expected given the cross-shore extent of the groins having a length of about 300 to 400 feet, and with the shoreward end of the groins terminating at elevations of about -2 feet or above. The reconstruction of the groin field in April 2010 has not yielded the same results observed following the 2005 construction effort thus far. When comparing similar limited time periods, total volumetric losses and offshore losses were observed to have increased during this most recent period. Onshore losses within the groin field are lower than the without groin field condition, however, they do not show similar erosion reduction effects as observed following the 2005 groin field construction and disposal placement.

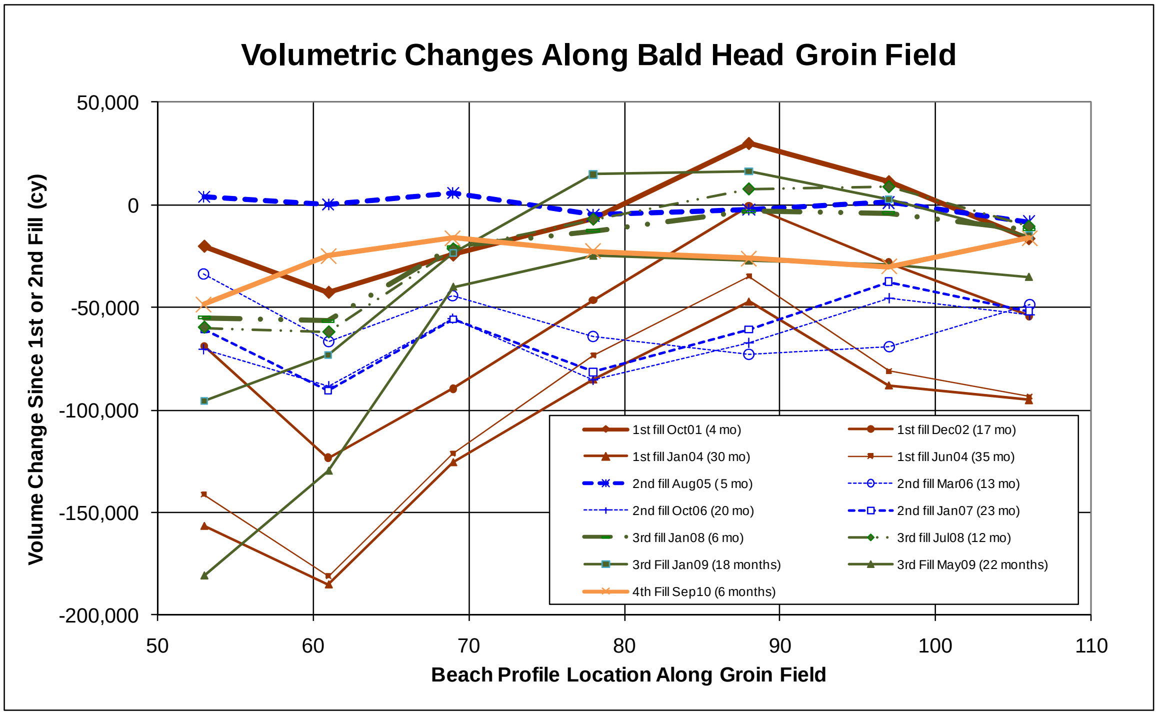


Figure 4.19 Volumetric Changes Along Bald Head Groin Field

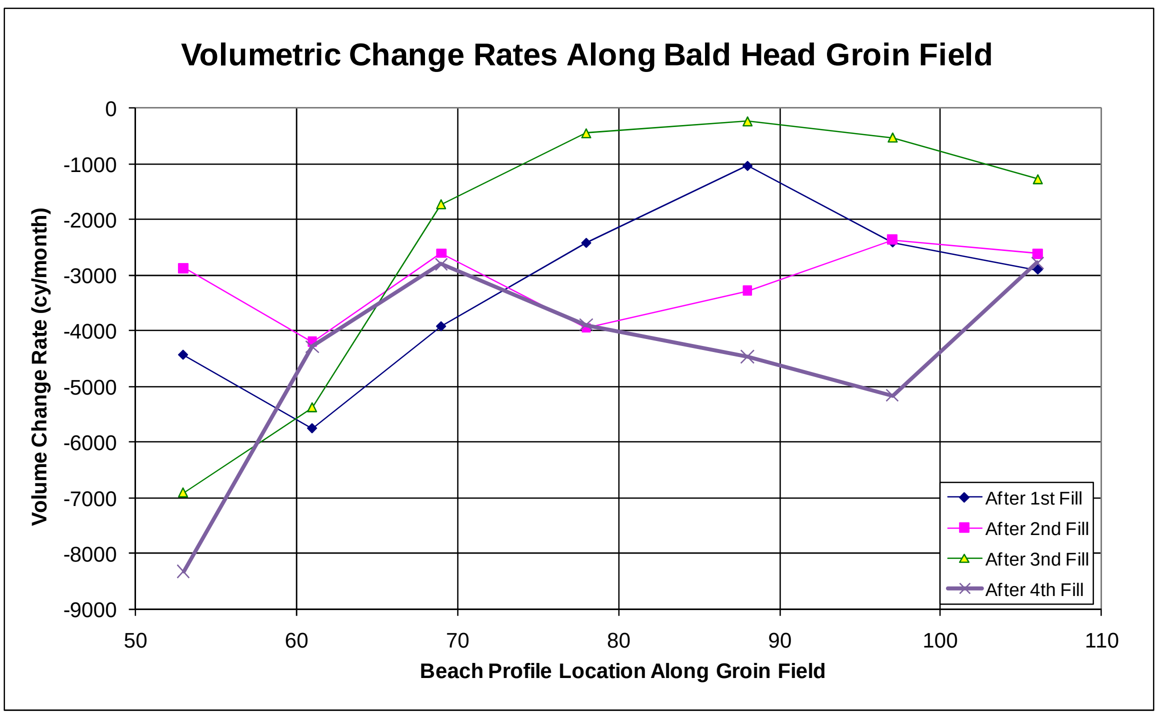


Figure 4.20 Volumetric Change Rates Along Bald Head Groin Field

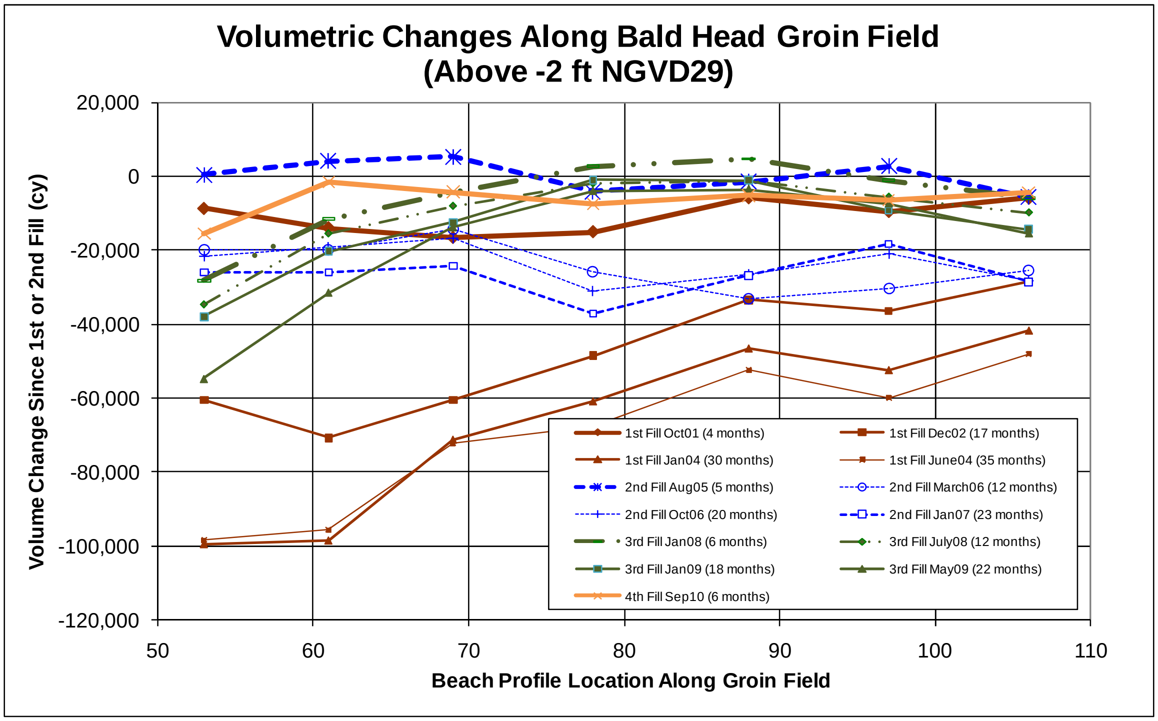


Figure 4.21 Onshore Volumetric Changes Along Bald Head Groin Field (Above -2 ft NGVD29)

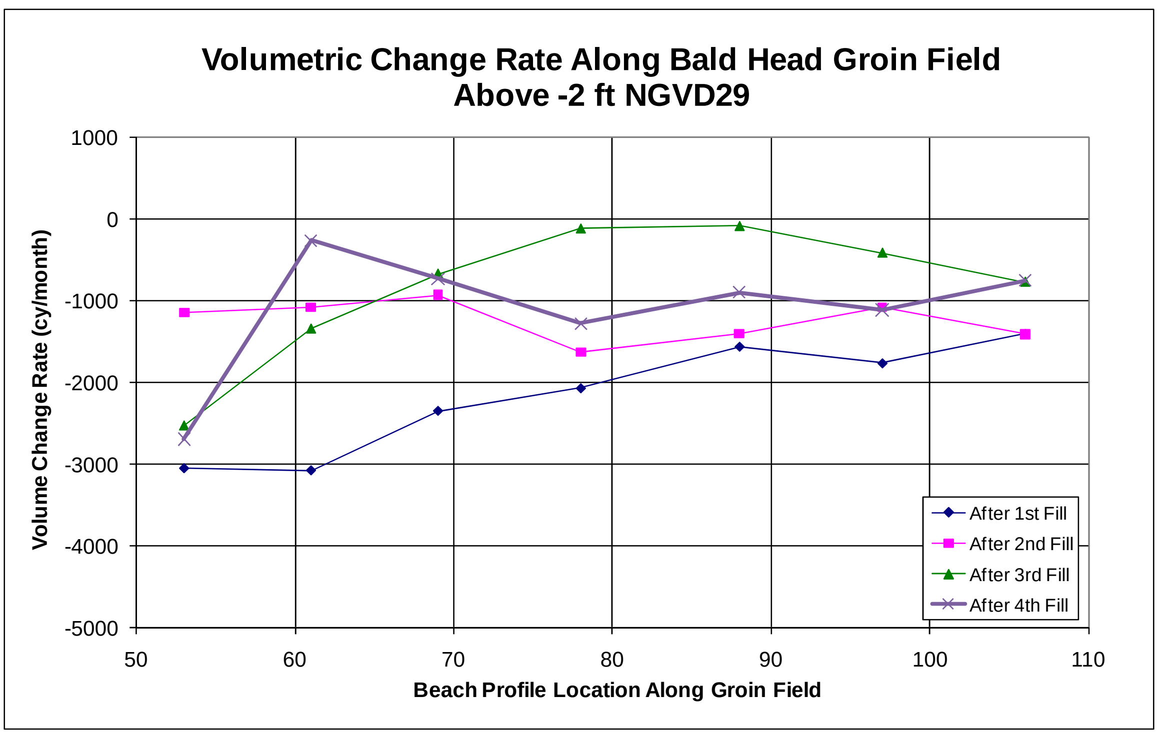


Figure 4.22 Onshore Volumetric Change Rates Along Bald Head Groin Field (Above -2 ft NGVD29)

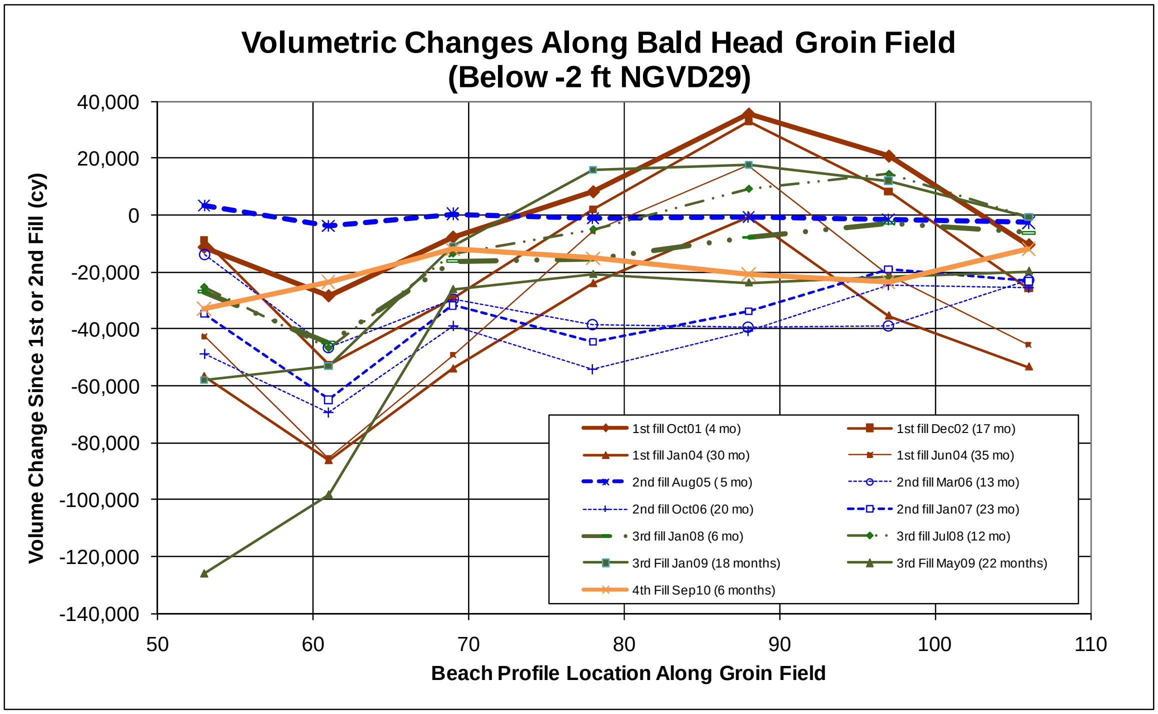


Figure 4.23 Offshore Volumetric Changes Along Bald Head Groin Field (Below -2 ft NGVD29)

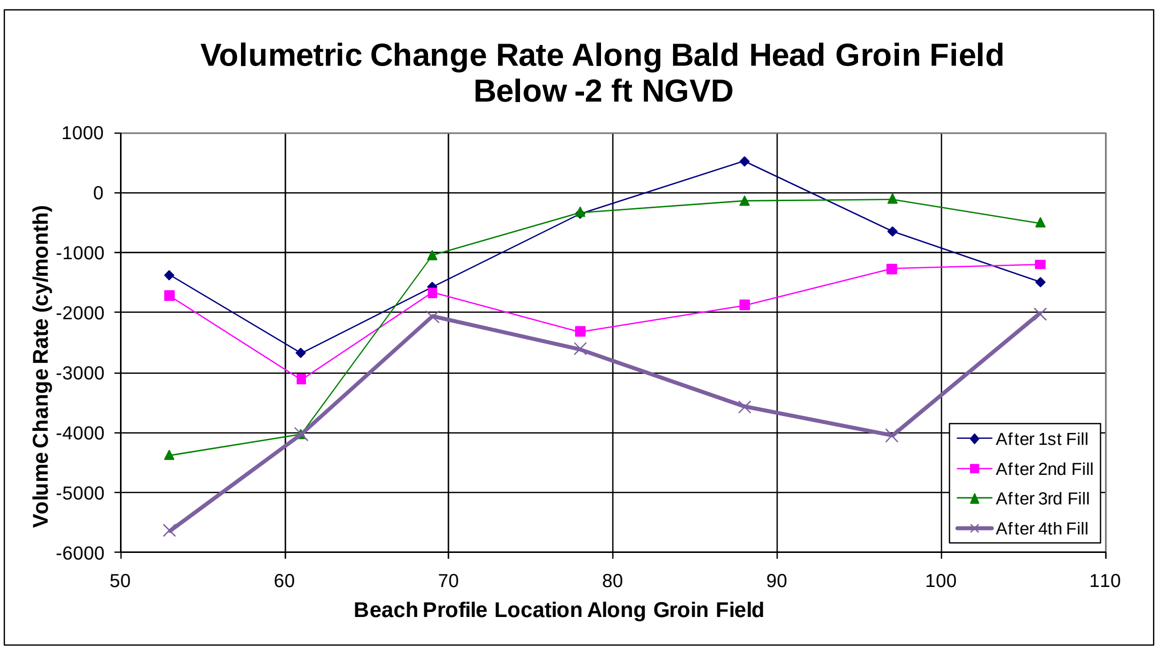


Figure 4.24 Offshore Volumetric Change Rates Along Bald Head Groin Field (Below -2 ft NGVD29)

Part 5 SUMMARY

This report is the eighth of a series updating the data collection and results of the physical monitoring program for the Wilmington Harbor Project. The program consists of periodic beach profile and bathymetric surveys, wave and current measurements designed to document changes associated with the project. The monitoring focuses on the entrance channel improvements and impacts to the adjacent beaches of Oak Island/Caswell Beach to the west and Bald Head Island to the east. It also serves as a tool for overall sand management considerations for the Cape Fear entrance and adjacent beaches. The report covers through the tenth year of data collection and focuses on the most recent period of October 2009 through September 2010. It also serves to update the overall monitoring program which was initiated in August 2000 just prior to the dredging and realignment of the entrance channel.

Over the 2001/2002 time period, the entrance channel was deepened and realigned with all beach compatible sediment being placed on the Brunswick County beaches including the beaches of Oak Island/Caswell and Bald Head Islands, both of which fall within the monitoring limits. Within the monitoring area, approximately 1,181,800 cubic yards of sand were placed on Oak Island/Caswell and 1,849,000 cubic yards were placed along Bald Head Island. In early 2005, the first maintenance dredging of the new channel was completed. In accordance with the sand management plan for the project, the first two maintenance cycles would involve disposal of all beach compatible material along Bald Head Island (with the third cycle to Oak Island). As such, approximately 1,217,500 cubic yards of beach disposal were placed along the western half of Bald Head's South Beach. Following the disposal placement, the Village of Bald Head proceeded with the reconstruction of a groin field along South Beach. The work consisted of replacement of 16 sand groin tubes, 250-300 feet in length, covering about 6,500 feet along the western end of the island. This was followed two years later by the second maintenance cycle, with an additional 978,500 cubic yards placed along Bald Head Island, over the period of February-April 2007. The most recent maintenance dredging undertaken involved placement of beach compatible sediments along Oak Island/Caswell Beach, where approximately 1,064,400 cubic yards were placed between February and April 2009 as part of the third maintenance cycle. With this recent maintenance dredging/disposal along eastern Oak Island/Caswell Beach, the first full cycle has been accomplished in accordance with the sand management plan. The responses of the beaches to the most recent disposal activity have continued to be monitored since the last monitoring report. A separate report is being issued in early 2011 which will summarize the performance to date of the existing sand management practices and determine if any changes in the placement practices are necessary.

Discussion of Results

Beach profile surveys were compared for the beaches on either side of the entrance channel. In each case comparisons were made from the current surveys to the last survey as reported in Report 7 (May 2009) and with respect to the initial pre-project condition established with the survey of August/September 2000. Comparisons were analyzed to determine the overall condition of the beach with respect to both changes in shoreline and profile volumes. Shoreline and volumetric changes were computed over the current period (from October 2009 to September 2010) and for the entire period (from August/September 2000 to September 2010).

For Oak Island/Caswell Beach, the shoreline change measured over the last year continues to be greatly influenced by the disposal activity between February and April 2009. The two zones along Oak Island where material was placed in 2009 between Profiles 60 and 95 (123,400 cubic yards) and Profiles 120 and 260 (941,000 cubic yards), have shown significant erosion relative to the May 2009 post-placement survey. The losses of shoreline within these disposal areas are accompanied by increases in shoreline position on the western end of the monitoring area and between the two disposal areas. This is most likely a result of the longshore sediment transport processes that occur just after a disposal is placed as the beach section adjusts to the perturbations. Overall the shoreline eroded 4.4 feet over the current monitoring period relative to May 2009. When considering the shoreline changes along Oak Island with respect to the pre-construction position in August 2000, the beach width has increased an average of 135 feet. In fact, with the exception of two zones on the eastern tip of the island (Profiles 5 through 20 and 35 through 50) all other profile lines have shown gains of 50 feet or more.

In terms of volume change, Oak Island/Caswell Beach has eroded over the vast majority of profiles (28 of 33) covering the island with the exception of two areas between Profiles 15 through 30 and Profiles 90 through 100. When considering all profile lines, a net loss of 377,000 cubic yards was computed since the last report, between May 2009 and September 2010. This amount of volumetric loss is within the range of losses observed over prior monitoring periods and closely resembles the trend observed along the island prior to the most recent beach disposal in 2009. The overall volume response has been positive when considering the measurements over the entire 10-year monitoring period. As such, all reported volume changes are positive with the exception of five profiles on the eastern tip of the island which show small losses. All other areas are very healthy with respect to volumetric gains relating back to August 2000 base condition. Specifically, by the end of the period, an excess of 2,035,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity actually reflects a modest net gain above the sum of the disposal volumes placed in 2001 and 2009 of about 172,000 cubic yards. This surplus above the placed quantity is believed to be the result of the eastward spreading of a separate beach disposal (Sea Turtle Habitat Project in 2001) placed just beyond the boundary of the project area. The alongshore distribution of material basically follows the shoreline response where net gains are seen along most of the island.

Since the last reporting, most of the profile locations along Bald Head Island have been accretional. The primary reason for this seaward shift of the shoreline since the last report is the beach disposal placed along the island between November 1, 2009 and March 9, 2010. This disposal placement, which was accomplished by the Village of Bald Head Island, placed 1,594,553 cubic yards of material along two sections of Bald Head Island. These sections included West Beach (Sta. 12+00 to 28+00) and South Beach (Sta. 39+60 to 162+00). The profile locations found to be eroding occurred along a short section of West Beach (Profiles 0 through 8), at a single location in the Spit area (Profile 36) , and along the eastern end of South Beach (Profiles 218 to 222). The largest increases in shore width were measured within the Spit and western portions of South Beach, between Profiles 40 and 97 and along the eastern end of South Beach between Profiles 110 and 182. These areas closely correspond to the locations of the recent beach disposal placement area. Specifically, the peak seaward increase measured at the end of the period was 138 feet (Profile 57) and the average increase for the entire South Beach region since May 2009 was 63 feet. The area covering Profiles 32 through 45 which defines the spit had an average increase of 7 feet over the current period, while the area along West Beach (Profiles 0 thru 28) gained an average of 19 feet. The average seaward movement of the shoreline position for the entire monitoring area since Monitoring Report 7 is a gain of 36 feet.

Shoreline change patterns as measured over the last 10-year period, i.e., since the monitoring was initiated, are generally positive when measuring relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional. For this area, the September 2010 shoreline is an average of nearly 159 feet more seaward of its September 2000 position. In contrast, the western portion of South Beach and a portion of the Spit area continue to be highly erosional as documented in prior reports. As of September 2010, the shoreline was found to be landward of the base position between Profiles 40 and 61, an area nearly 1,200 feet smaller than the erosive area reported in Monitoring Report 7. The average shoreline loss over this 2,100 foot reach was 144 feet, with a peak recession of 315 feet occurring at Profile 43. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline has shown an average loss of about 6 feet when compared to the base condition. When considering all location along Bald Head Island (Profiles 0 to Profile 218), the shoreline is presently on the average 89 feet more seaward than it was in 2000. While measuring against the base survey in September 2000 is useful in gauging changes for comparison between the pre-and post-project conditions, , it is somewhat limited in that it compares of only two specific points in time. The September 2000 shoreline position reflects a static condition along a generally highly variable shoreline that has been influenced by several beach nourishment projects along the island in 1991, 1996, and 1997 as well as groin construction activity. These actions can artificially influence the pre-project shoreline position and may skew the measured observations.

In terms of volumetric change from the last survey (May 2009) of Report 7 to the present, Bald Head Island is dominated by increases throughout the majority of the monitoring area as a result of the beach disposal placed in 2009/2010. Profiles 0 through 186 experienced volumetric increases while Profiles 194 through 210 lost material when compared to the May 2009 condition survey. In summing the changes over the entire monitoring area, the increases total to approximately 1,113,000 cubic yards of material. The zones along the Spit and South Beach which received beach disposal during the recent local project (Sta. 39+60 to 162+00) were found to have gained nearly 963,000 cubic yards of sand. The disposal zone along West Beach (Sta. 12+00 through 28+00) gained nearly 76,000 cubic yards.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, the majority of Bald Head Island has gained material over the last 10 years. The most substantial decreases are noted along the western and eastern ends of South Beach. These areas (Profiles 53 to 57 and Profiles 202 to 210) have lost approximately 318,000 and 392,000 cubic yards of material since August 2000, respectively, with minor losses noted at Profile 106 near the center of South Beach. The area between Profiles 53 and 57 was noted in the previous two monitoring reports as being an area of chronic erosion. As a result of the disposal placed along Bald Head Island since the previous monitoring report, the extent of this chronic erosion area has greatly reduced from the 6,100 feet noted in Monitoring Report 7 to approximately 800 feet. This is the shortest extent for this erosion zone since the measurements taken in October 2001. Summarizing the changes over the entire island show the net volume change is a significant gain of 1,231,000 cubic yards as of September 2010 with respect to the beginning of the monitoring in 2000.

Rates of shoreline change were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the North Carolina Division of Coastal Management (NCDCM) shoreline data based on a 62-year period of record (1938-2000). Although a direct comparison is not possible given the difference in the 10-years of monitoring data versus the 60-plus years of the historic data base, they are useful in observing overall trends in the rate of shoreline response.

Shoreline change rates computed over the initial 10-year period show that for Oak Island/Caswell Beach substantial accretion is present over most of the island largely reflecting the influence of the 2001 and 2009 beach disposals. Although these positive rates have been found to moderate since the placement, they remain in sharp contrast to the long-term trend. Overall, the shoreline change rate averaged over the entire monitoring area is computed to be +15.6 feet per year. By comparison the long-term NCDCM rate over the entire reach is -1.1 feet per year.

For Bald Head Island, the comparison of the long-term rates with the rates computed since 2000 show that most of the island is eroding less over the initial 10-year monitoring period. However, notwithstanding this overall positive response, the post-construction erosion rates continue to be greater along the western corner of South Beach. A direct comparison of the pre- and post-construction shoreline change rates show that only three profile lines are eroding at a higher rate during the post-construction period. These lines are located at the western end of South Beach (Profiles 53, 57 and 61). While these three lines were reported previously as exceeding the pre-construction shoreline change rate, the recent disposal placed by the Village of Bald Head Island has positively influenced the area and reduced the erosion rates in this area. Adjacent Profile 66 is also slightly erosional, but at a lower rate when compared to the pre-construction condition. All other lines are accreting in direct contrast to the long-term erosion experienced along the remaining areas of South Beach. Most of this response is attributable to the multiple disposals of navigation dredging material along the island over the past 10 years and to the beach disposal recently placed by the Village of Bald Head Island.

In March 2005, the Village of Bald Head and the Wilmington District entered into an agreement to conduct bi-monthly navigation channel surveys within the channel locations along the island. These surveys are intended to document the channel shoaling and to record the navigable channel width throughout the area. The threshold deemed to be a minimum acceptable channel width is 500 feet at the -42 feet mean low water (MLW) elevation. As of August 2010, 31 condition surveys have been accomplished. Four of these occurred over the current reporting period (February 2010, April 2010, June 2010, and August 2010). There are now seven post-dredging settlement survey following the Feb-April 2009 channel dredging operation. The 2009 dredging event increased the navigable width measured at -42' MLW so that every station within the navigation channel exceeds the minimum required navigable width of 500 feet. Widths within the channel as of August 2010 ranged from a minimum of 512 feet at station 20+00 to a maximum of 974 feet at station 5+00, with no violations of the minimum width criteria. The width at station 23+00, which has historically been a location of increased shoaling, had a navigable width of 540 feet as of August 2010.

The navigation channel surveys have also been used to analyze the rate of shoaling along Reach 1 in the immediate vicinity of the Bald Head spit. Following the initial placement in 2001-02 (1.8 million cubic yards), the area of the spit was found to have enlarged volumetrically to at least twice as large as observed during the five years prior to the initial placement. The same area of growth was monitored following the two subsequent dredging events (i.e. 2004-05 (1.2 million cubic yards and 2007 (1.0 million cubic yards). The comparison showed that the rate of growth was slower following both the second event and third events. Specifically, the initial rate was about 16,500 cubic yards per month. An analysis of all surveys for the second dredging event, January 2005 through March 2007, showed that the shoaling had slowed to about 9,900 cubic yards per month, i.e., a 40 % reduction in the shoaling rate. Analysis for the third monitoring period, April 2007 through February 2009, showed a comparable rate to the prior period at 8,950 cubic yards per month. This is a 46% reduction in the shoaling rate versus the initial dredging operation and a 10% reduction when compared to the second dredge cycle. Calculation of the shoaling rate following the most recent dredging event in February-April 2009 revealed that the infilling rate has increased to 17,300 cubic yards per month. This represents a 94% increase over the computed rate from the previous dredge cycle but is about the same as the rate following the initial dredging event being only 5% greater. The increase in shoaling rates within the channel since the most recent dredging activity is most likely associated with the failure of the Bald Head Island groin field and the subsequent loss of material that had been retained within the field. In addition, the disposal material recently placed along Bald Head Island by the Village of Bald Head Island introduced significant quantities of sand into the system in areas in proximity to the navigation channel. Material lost from these areas over the current monitoring period was most likely transported into the adjacent navigation channel, leading to the increased shoaling rates.

In prior reports the effectiveness of the reconstructed groins was analyzed by comparing the response of the 2001 beach disposal (without the groins) to the 2007 beach disposal (with the groins). The analysis revealed that the reconstructed groin field had an apparent positive effect in retaining the beach, particularly within the upper portions of the beach profile. This is reflected in the positive response with respect to shoreline change and changes in the onshore volumes. Changes of this nature would be expected given the cross-shore extent of the groins having a length of about 300 feet, and with the shoreward end of the groins terminating at elevations of about -2 feet or above. For the present report, this analysis was updated to include a similar comparison with the fourth beach disposal (by the Village of Bald Head Island) and subsequent reconstruction of the groin field in early 2010. Given that the data following the construction of this new groin field is limited to two data points, with one of these serving as the base condition, analysis of the data set was limited to only one survey date. These comparisons were made over similar 5 to 6 month periods following each respective event. Due to the time limitations of this comparison it is difficult to determine any significant pattern and draw any useful conclusions at this time.

Detailed bathymetric surveys were made of the ebb and nearshore shoals in the vicinity of the entrance channel to assess any changes associated with the entrance channel deepening and realignment. Aside from the direct changes resulting from dredging the new channel, the major overall changes in morphology of the ebb and nearshore shoals since the start of the monitoring have included changes along Jay Bird Shoals, Bald Head Shoals, and within the vicinity of the old channel bed. The changes within Jay Bird Shoals have been somewhat complex with some portions shoaling and some portions scouring. Generally, the outer portions have shown a generalized lowering but a moderate amount of shoaling has occurred within the northernmost area of Jay Bird Shoals just off the tip of Oak Island. A significant change that is evident within the most recent survey of the ebb shoal complex is noted in the outer portions of Jay Bird Shoals where material was dredged as a sand source for the recent disposal placed by the Village of Bald Head Island. The dredging activity within Jay Bird shoals covered an area of approximately 153 acres and lowered elevations within this area by as much as 14 feet. Adjacent to the northernmost section of Jay Bird Shoal is a scour feature associated with a flood channel just offshore of Oak Island which is relatively stable, with only minor changes in depth occurring over the recent monitoring period. On the other side of the channel, Bald Head Shoal has shown significant gains extending off of the southwestern corner of Bald Head Island since the start of the project. Additionally, the old channel bed has also accreted since the beginning of the monitoring period, as this area is used as a disposal site for other dredging operations in the river. In general, the offshore area, with the exception of the old and new channels, has remained relatively stable over the entire monitoring period.

To date currents have been measured on ten occasions, with the initial occurring before the channel improvements and the remaining nine after the deepening. At the release of this draft document, the most recent current measurement report data is unavailable for update. The current measurement section of this report contains the results from Monitoring Report 7 and will be updated as soon as data become available.

Sand Management Considerations.

Operation of the project involves the implementation of a Sand Management Plan. The plan assumes dredging of the Cape Fear River entrance channel every two years, with disposal to occur in a 2 to 1 ratio with two-thirds of the material going to Bald Head Island and the remaining one-third to Oak Island/Caswell Beach. This sediment ratio is accomplished by having the first two maintenance cycles (e.g. years 2 and 4) place sediment on Bald Head with the last cycle going to Oak Island/Caswell. Thus a complete operation and maintenance cycle will take 6-years to accomplish.

The first maintenance dredging was accomplished between November 2004 and January 2005. In accordance with the sand management plan, the beach compatible material dredged during the first cycle was placed along Bald Head Island. The Corps of Engineers and the Village of Bald Head worked jointly to develop this disposal plan. Approximately 1,217,500 cubic yards of beach quality sediment were placed along the most critically eroding portions of South Beach. This work was coupled with the replacement of geo-textile groins by the Village of Bald Head under a private permit action, with the intent of reducing the erosion of the in-place disposal. The groin reconstruction took place over the period of March-May 2005. The second maintenance cycle occurred February-April 2007 and involved disposal of material along Bald Head Island as scheduled. This operation amounted to an additional 978,500 cubic yards placed along South Beach. The most recent maintenance dredging involved placement of beach compatible sediments along Oak Island/Caswell Beach. During this work, the third maintenance cycle, approximately 1,064,400 cubic yards were placed between February and April 2009. With the completion of this maintenance dredging, the first overall 2 to 1 sand management cycle has been accomplished (e.g. through a 6-year cycle).

In accordance with the sand management plan, an assessment has been made following the completion of the first full cycle regarding the effectiveness of the current sand distribution scheme to determine if changes could be made to improve the disposal plan. This assessment is being published as a separate document entitled “Reevaluation Report Sand Management Plan Wilmington Harbor Navigation Project” and is scheduled for release in early 2011.

REFERENCES

McNinch, Jesse E. and Christopher W. Freeman, 2000, Letter Report: Shipboard Acoustic Doppler Current Profile Survey, Virginia Institute of Marine Science and UNC-Chapel Hill Institute of Marine Science, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2002, Letter Report: Bathymetry of the Cape Fear River Ebb Tidal Delta, 2001-2002, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2002a, Letter Report: Mean Current Flow Across the Mouth of the Cape Fear River Ebb Tidal Delta and New Channel Region 2002, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2003, Letter Report: Bathymetry of the Cape Fear River Ebb Tidal Delta, 2002-2003, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2003a, Letter Report: Mean Current Flow Across the Mouth of the Cape Fear River Ebb Tidal Delta and New Channel Region 2003, Dr. Jesse E. McNinch, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2004, Letter Report: Bathymetry of the Cape Fear River Ebb Tidal Delta, 2004, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2004a, Letter Report: Mean Current Flow Across the Mouth of the Cape Fear River Ebb Tidal Delta and New Channel Region 2004, Dr. Jesse E. McNinch, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2006, Letter Report: Bathymetry of the Cape Fear River Ebb Tidal Delta, 2004, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2007, Letter Report: Bathymetry of the Cape Fear River Ebb Tidal Delta, 2007, Department of Physical Sciences, Virginia Institute of Marine Science, College of William and Mary, available on the US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2007a, Letter Report: Mean Current Flow Across the Mouth of the Cape Fear River Ebb Tidal Delta and New Channel Region 2007, US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2008, Letter Report: Bathymetry of the Cape Fear River Ebb Tidal Delta, 2008, US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

McNinch, Jesse E. 2008a, Letter Report: Mean Current Flow Across the Mouth of the Cape Fear River Ebb Tidal Delta and New Channel Region 2008, US Army Corps of Engineers, Field Research Facility web page, www.frf.usace.army.mil.

Olsen Associates, 2005, Bald Head Island, N.C., Beach Monitoring Program, Report No. 3 (May 2004-April 2005), prepared for the Village of Bald Head Island by Olsen Associates, Inc, 4438 Herschel Street, Jacksonville, FL 32210, December 2005

Olsen Associates, 2006, Bald Head Island, N.C., Beach Monitoring Program, Report No. 4 (April 2005-May 2006), prepared for the Village of Bald Head Island by Olsen Associates, Inc, 4438 Herschel Street, Jacksonville, FL 32210, July 2006

Olsen Associates, 2007, Bald Head Island, N.C., Beach Monitoring Program, Report No. 5 (April 2006-June 2007), prepared for the Village of Bald Head Island by Olsen Associates, Inc, 4438 Herschel Street, Jacksonville, FL 32210, December 2007

Olsen Associates, 2008, Bald Head Island, N.C., Beach Monitoring Program, Report No. 6 (June 2007-May 2008), prepared for the Village of Bald Head Island by Olsen Associates, Inc, 4438 Herschel Street, Jacksonville, FL 32210, August 2008

Sommerfield, B.G., Mason, J.M., Kraus, N.C. and Larson, M. (1994), BFM;Beach Disposal Module; report 1, Beach Morphology Analysis Package (BMAP)-User's Guide, Instructioinal Report CERC-94-1, U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, Vicksburg, MS.

Thompson, Edward F, Lihwa Lin and Doyle L. Jones, 1999, Wave Climate and Littoral Sediment Transport Potential, Cape Fear River Entrance and Smith Island to Ocean Isle Beach, North Carolina, U.S. Army Corps of Engineers, Engineering Research and Development Center, Technical Report CHL-99-18, September 1999, Prepared for the U.S. Army Engineer District, Wilmington.

USACE 2000, Wilmington Harbor Sand Management Plan, Ocean Entrance Channels and Inner Harbor from Snows Marsh through Horseshoe Shoal Channels, U.S. Army Corps of Engineers, Wilmington District Document, February 2000.

USACE 2004, Physical Monitoring, Wilmington Harbor Navigation Project, Report 1: August 2000-June 2003, U.S. Army Corps of Engineers, Wilmington District, August 2004.

USACE 2005, Physical Monitoring, Wilmington Harbor Navigation Project, Report 2: June 2003-June 2004, U.S. Army Corps of Engineers, Wilmington District, February 2005.

USACE 2005a, Wilmington Harbor Coastal Monitoring 2005, Hydrographic and Topographic Survey, (In preparation) U.S. Army Corps of Engineers, ERDC-CHL, Field Research Facility, 1261 Duck Road, Kitty Hawk, NC Wilmington District, August 2005.

USACE 2006, Physical Monitoring, Wilmington Harbor Navigation Project, Report 3: June 2004-August 2005, U.S. Army Corps of Engineers, Wilmington District, May 2006.

USACE 2006a, Wilmington Harbor Coastal Monitoring 2006, Hydrographic and Topographic Survey, U.S. Army Corps of Engineers, ERDC-CHL, Field Research Facility, 1261 Duck Road, Kitty Hawk, NC Wilmington District, April 2006.

USACE 2007, Physical Monitoring, Wilmington Harbor Navigation Project, Report 4: September 2005-October 2006, U.S. Army Corps of Engineers, Wilmington District, May 2007.

USACE 2007a, Bathymetric Survey Report – Ebb Tidal Delta of Wilmington Harbor Project 2000-2007, Evans Hamilton, Inc for U.S. Army Corps of Engineers, ERDC-CHL, Field Research Facility, 1261 Duck Road, Kitty Hawk, NC August 2007.

USACE 2008, Physical Monitoring, Wilmington Harbor Navigation Project, Report 5: October 2006-September 2007, U.S. Army Corps of Engineers, Wilmington District, April 2008.

USACE 2008a, Bathymetric Survey Report – Ebb Tidal Delta of Wilmington Harbor Project 2000-2008, U.S. Army Corps of Engineers, ERDC-CHL, Field Research Facility, 1261 Duck Road, Kitty Hawk, NC (In preparation).

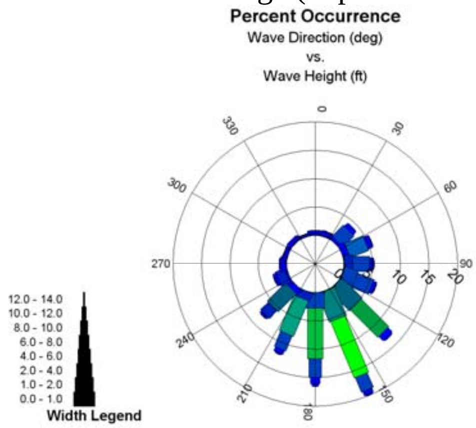
USACE 2009, Physical Monitoring, Wilmington Harbor Navigation Project, Report 6: October 2007-September 2008, U.S. Army Corps of Engineers, Wilmington District, June 2009.

Waller, Terry and Thad Pratt, 2006, Wilmington Harbor Coastal Monitoring Program, Spring 2006 Acoustic Doppler Current Profiler Results, U.S. Army Corps of Engineers, ERDC-CHL, November 2006.

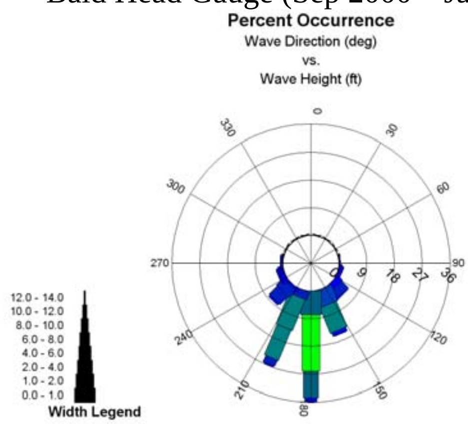
Appendix A

WAVE GAUGE DATA
Wave Roses (2000 thru 2010)

Eleven-Mile Gauge (Sep 2000 – Apr 2010)



Bald Head Gauge (Sep 2000 – Jan 2010)



Oak Island Gauge (Sep 2000 –May 2010)

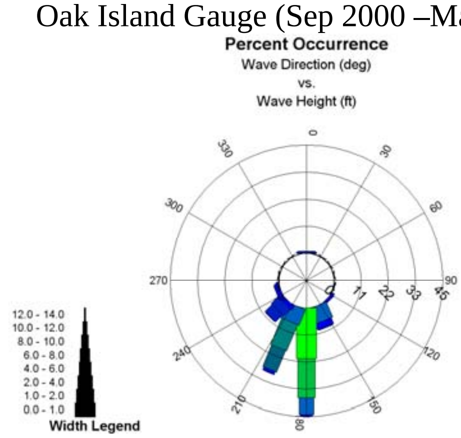
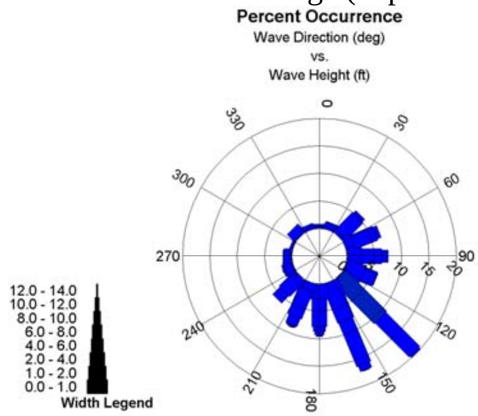
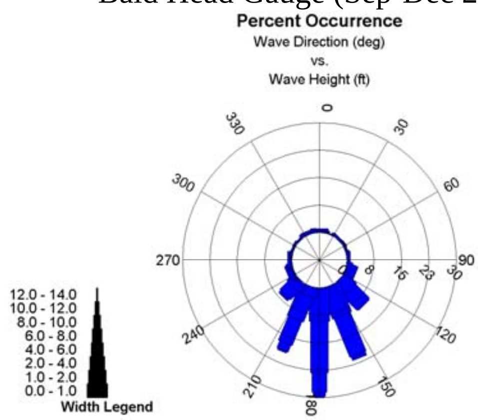


Figure A-1 Wave Height Roses for FRF Gauges throughout deployment.

Eleven-Mile Gauge (Sep-Dec 2000)



Bald Head Gauge (Sep-Dec 2000)



Oak Island Gauge (Sep-Oct 2000)

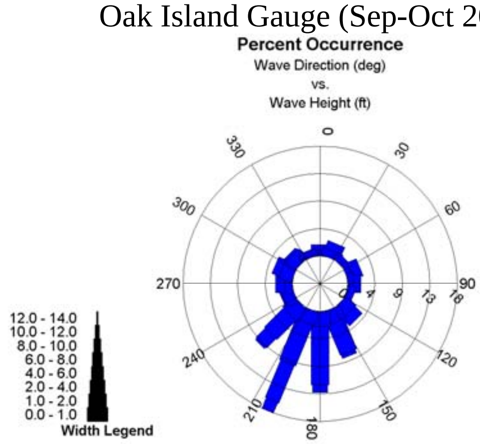
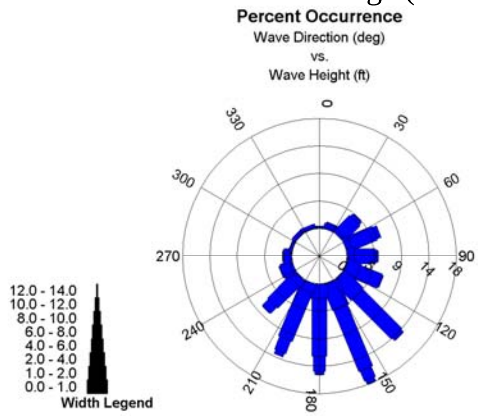
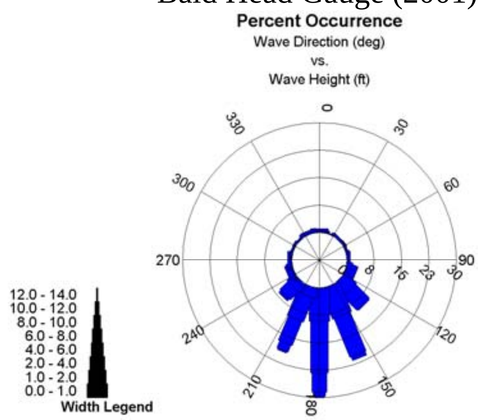


Figure A-2 Wave Height Roses for FRF Gauges (2000).

Eleven-Mile Gauge (2001)



Bald Head Gauge (2001)



Oak Island Gauge (2001)

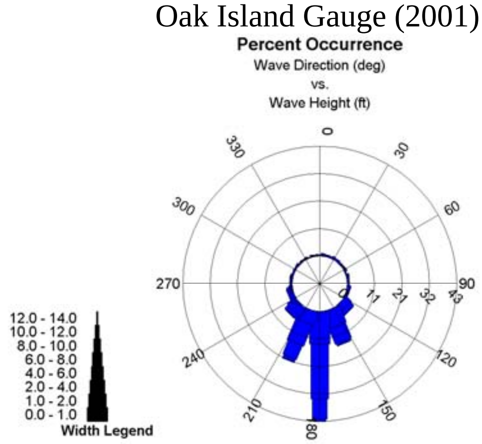
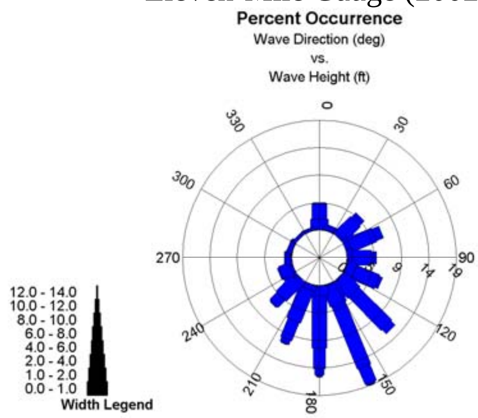
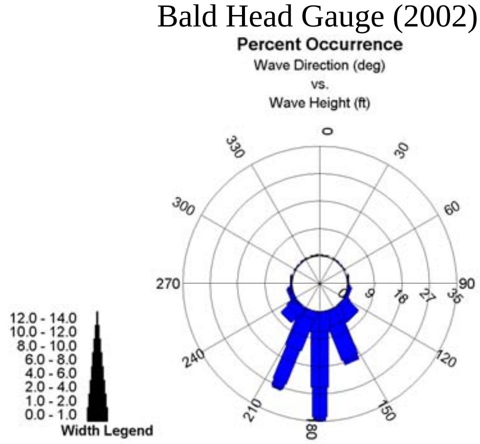


Figure A-3 Wave Height Roses for FRF Gauges (2001).

Eleven-Mile Gauge (2002)



Bald Head Gauge (2002)



Oak Island Gauge (2002)

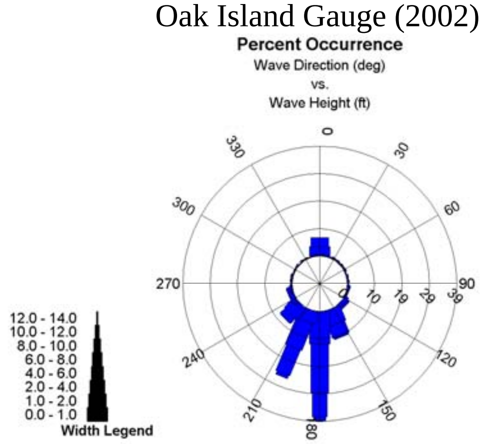
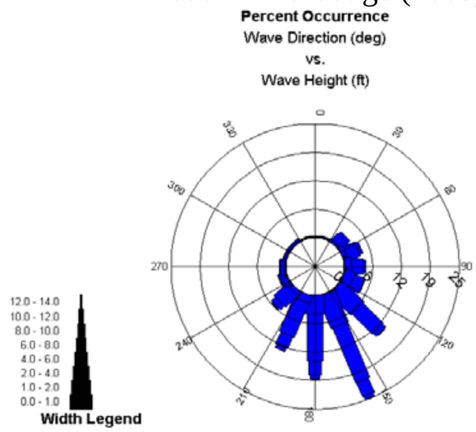
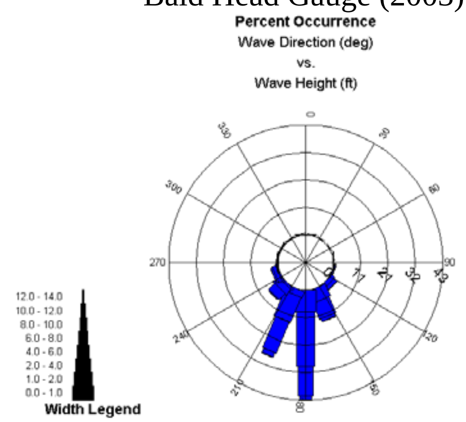


Figure A-4 Wave Height Roses for FRF Gauges (2002).

Eleven-Mile Gauge (2003)



Bald Head Gauge (2003)



Oak Island Gauge (2003)

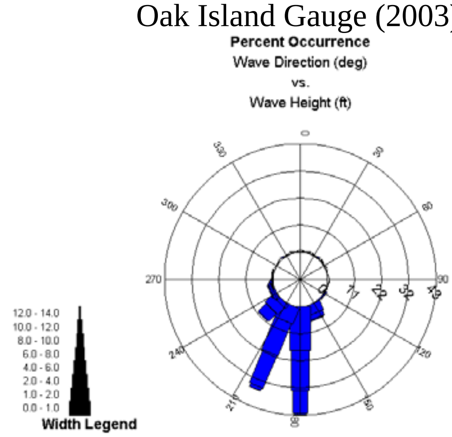
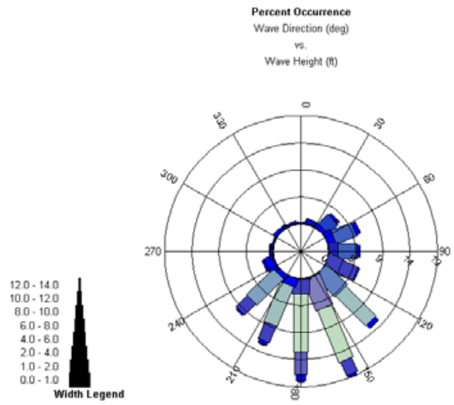
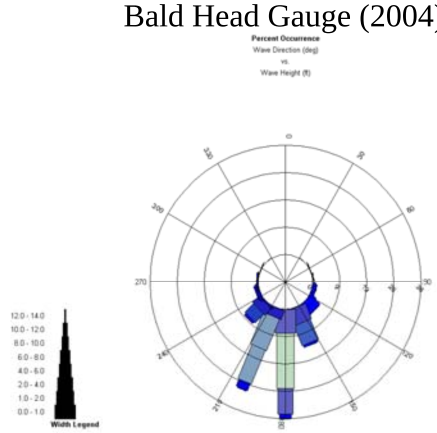


Figure A-5 Wave Height Roses for FRF Gauges (2003).

Eleven-Mile Gauge (2004)



Bald Head Gauge (2004)



Oak Island Gauge (2004)

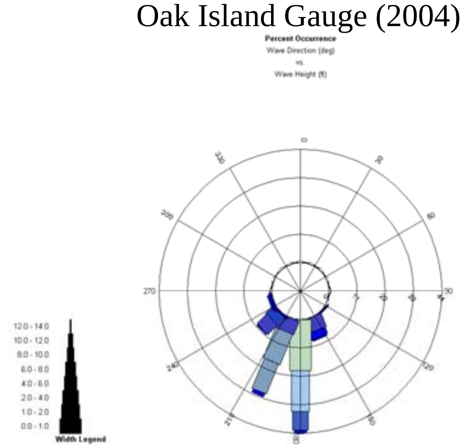
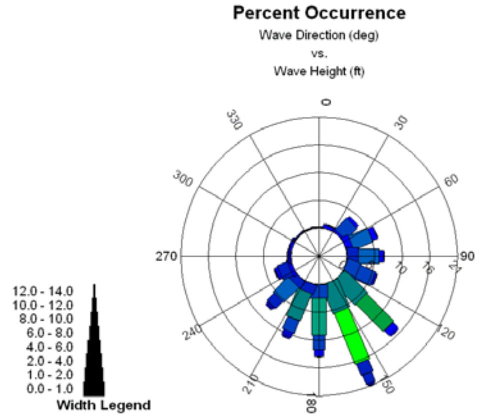
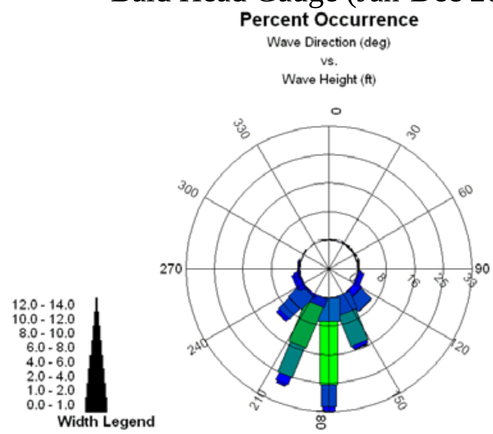


Figure A-6 Wave Height Roses for FRF Gauges (2004).

Eleven-Mile Gauge (Jan-Dec 2005)



Bald Head Gauge (Jan-Dec 2005)



Oak Island Gauge (Jan-Dec 2005)

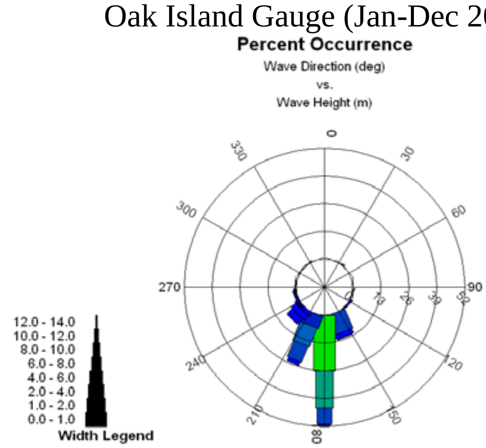
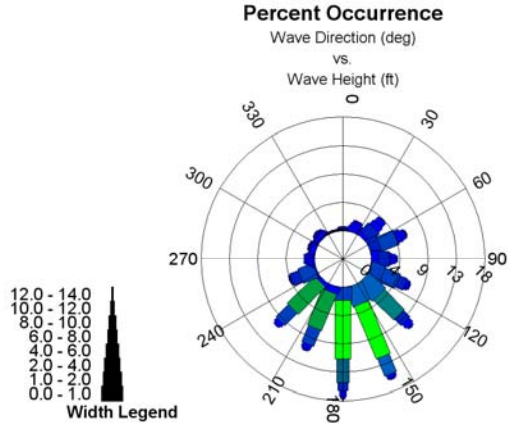
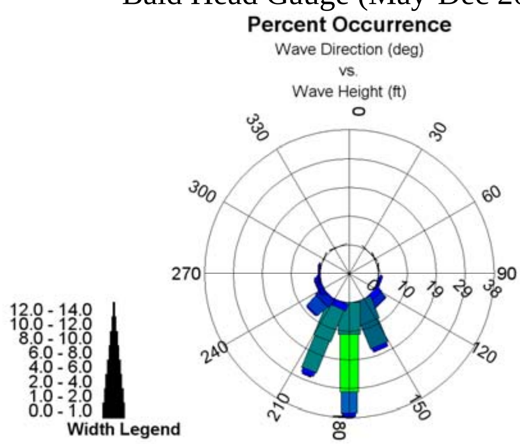


Figure A-7 Wave Height Roses for FRF Gauges (2005).

Eleven-Mile Gauge (Jan-Dec 2006)



Bald Head Gauge (May-Dec 2006)



Oak Island Gauge (Jun-Sep 2006)

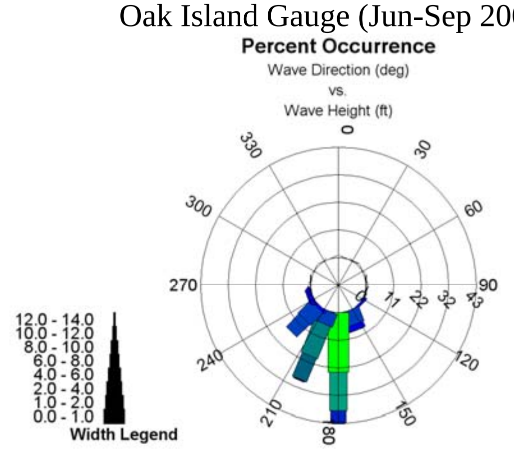
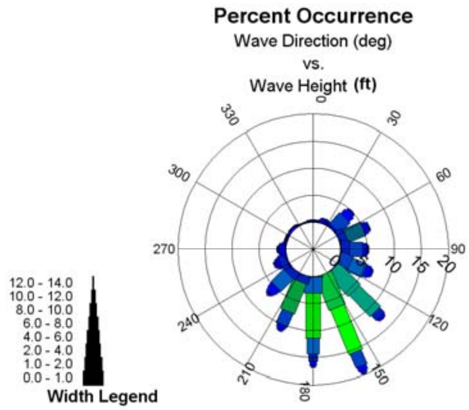
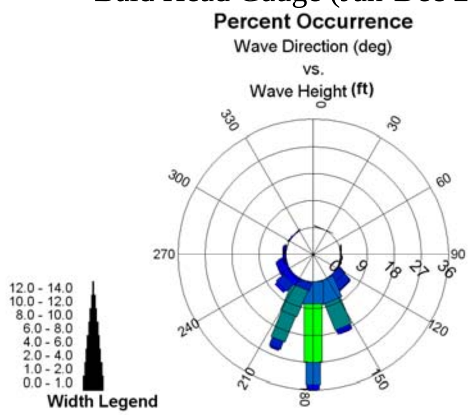


Figure A-8 Wave Height Roses for FRF Gauges (2006).

Eleven-Mile Gauge (Jan-Dec 2007)



Bald Head Gauge (Jan-Dec 2007)



Oak Island Gauge (Apr-Dec 2007)

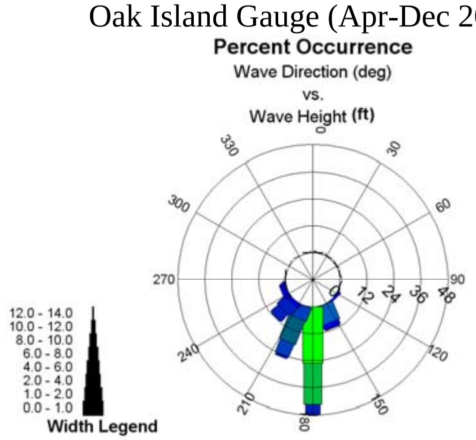
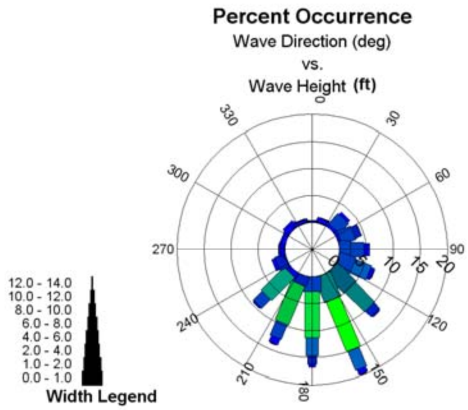
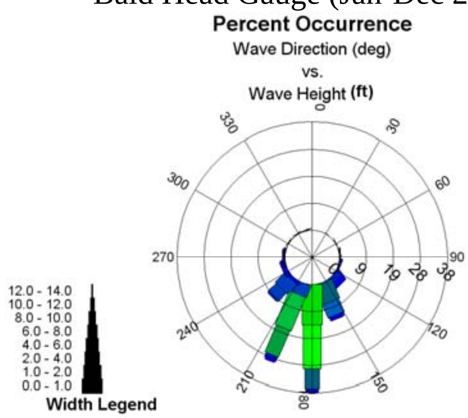


Figure A-9 Wave Height Roses for FRF Gauges (2007).

Eleven-Mile Gauge (Jan-Dec 2008)



Bald Head Gauge (Jan-Dec 2008)



Oak Island Gauge (Jan-Dec 2008)

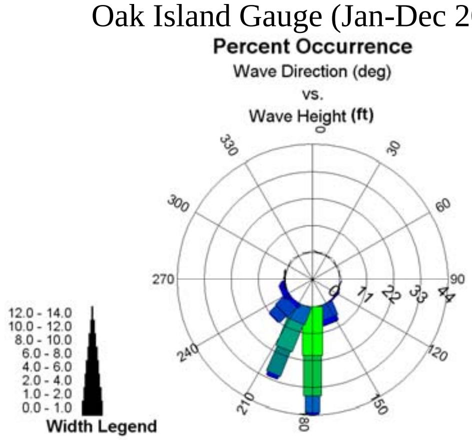
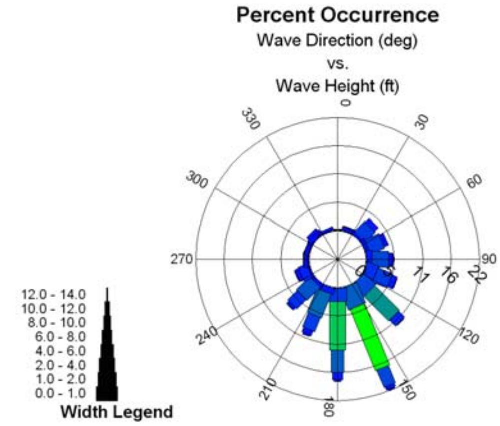
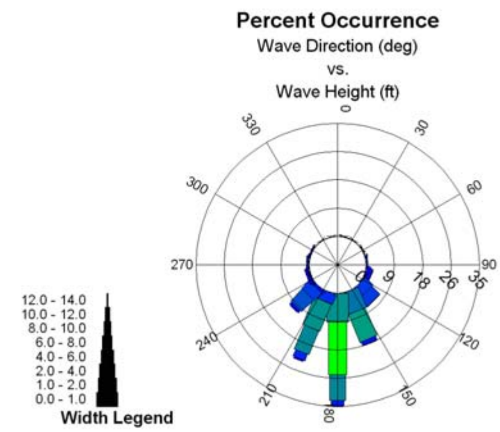


Figure A-10 Wave Height Roses for FRF Gauges (2008).

Eleven-Mile Gauge (Jan-Jun 2009)



Bald Head Gauge (Jan-Dec 2009)



Oak Island Gauge (Jan-Jun 2009)

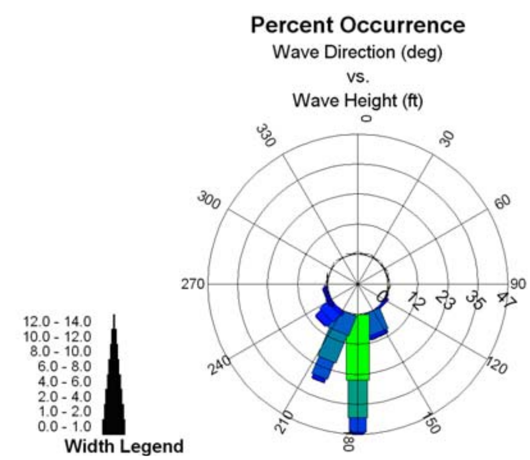
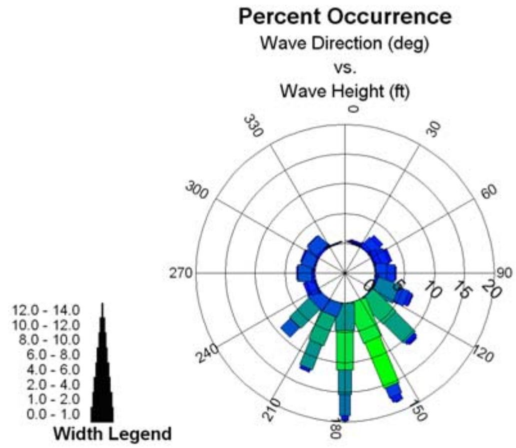
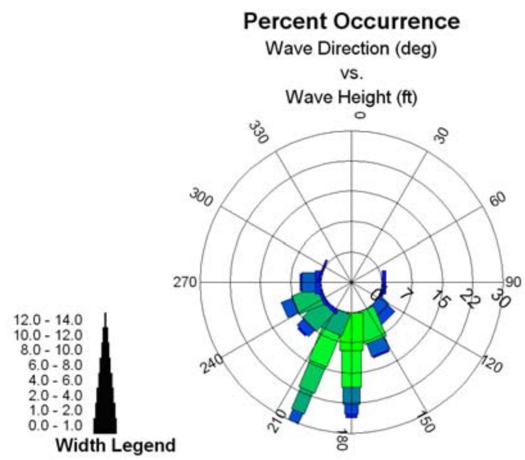


Figure A-10 Wave Height Roses for FRF Gauges (2009).

Eleven-Mile Gauge (Jan-May 2010)



Bald Head Gauge (Jan 2010)



Oak Island Gauge (Jan-May 2010)

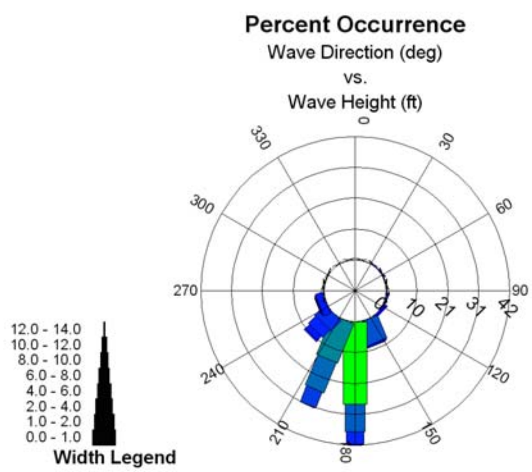
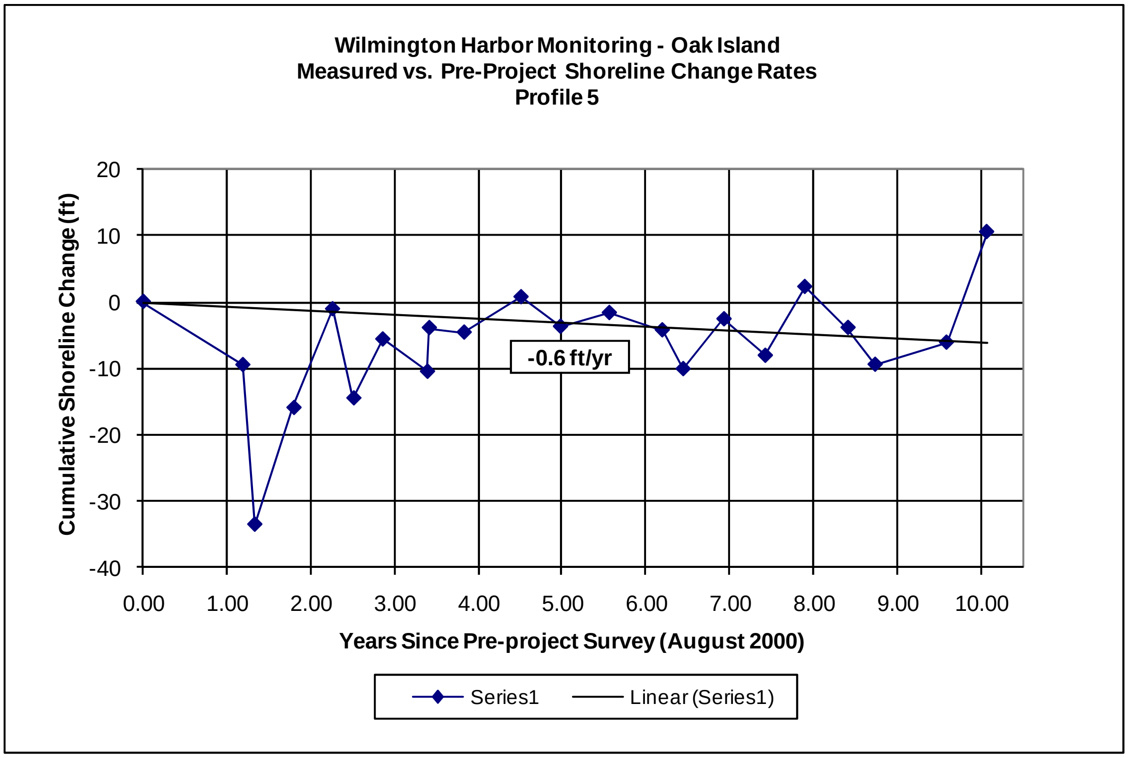
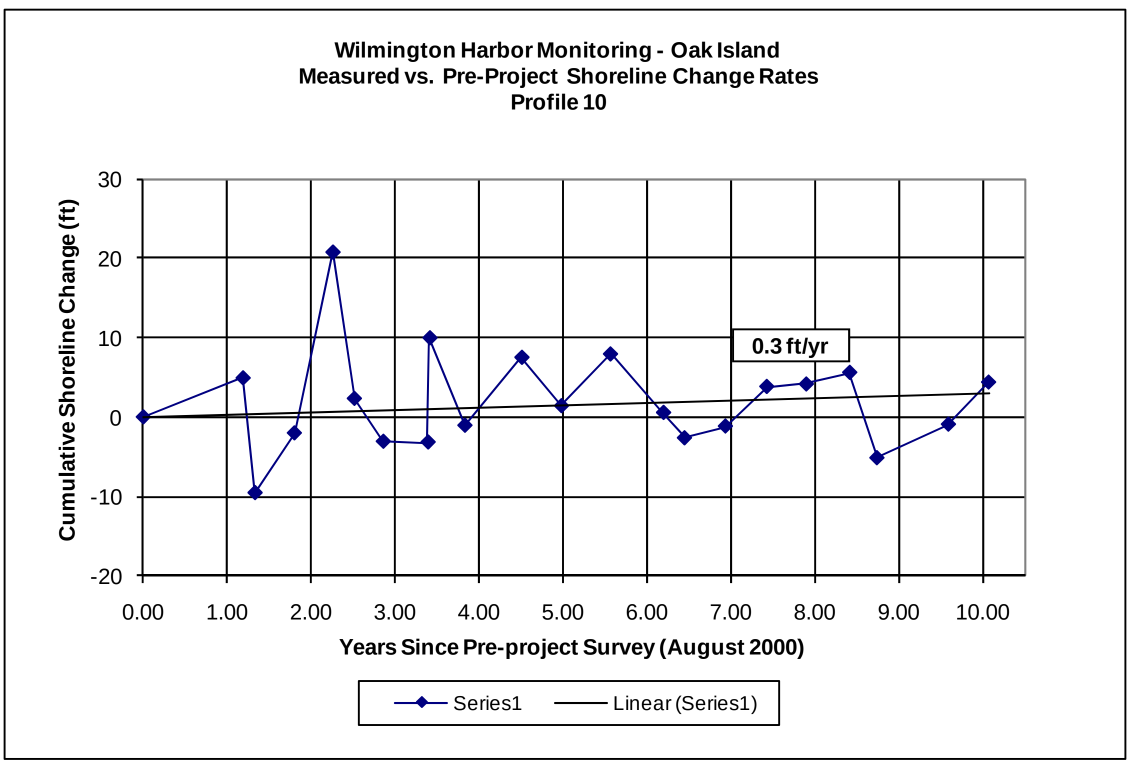


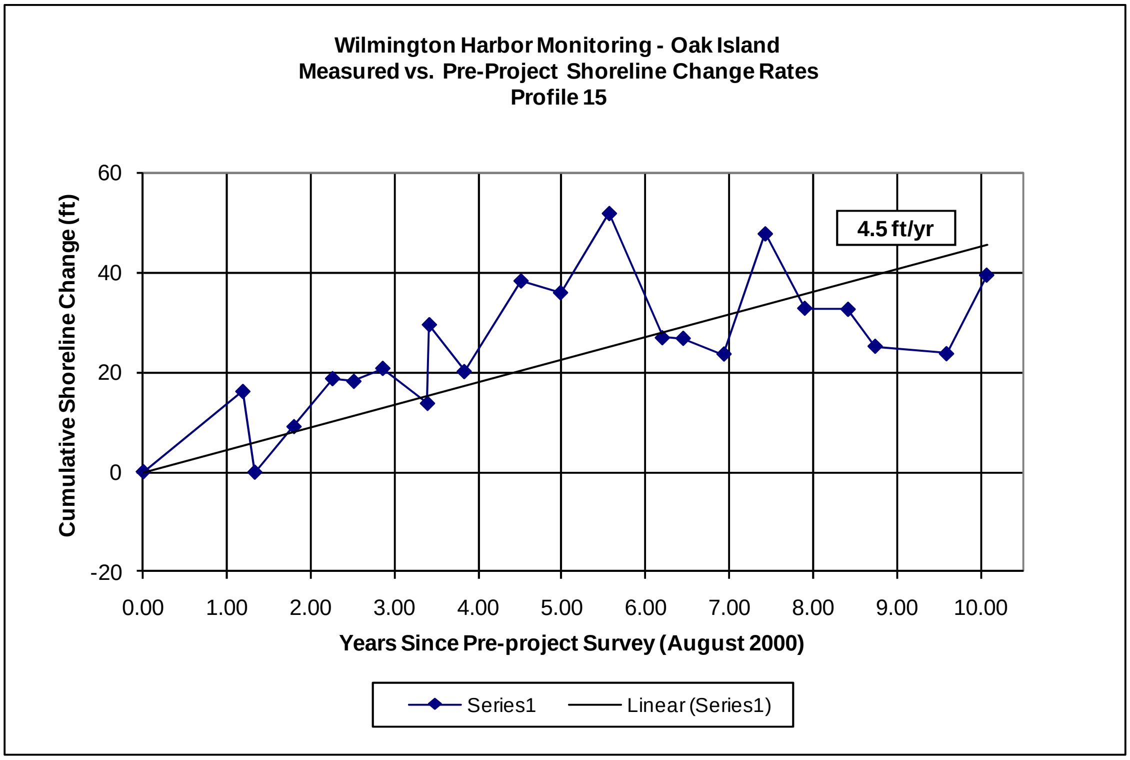
Figure A-10 Wave Height Roses for FRF Gauges (2010).

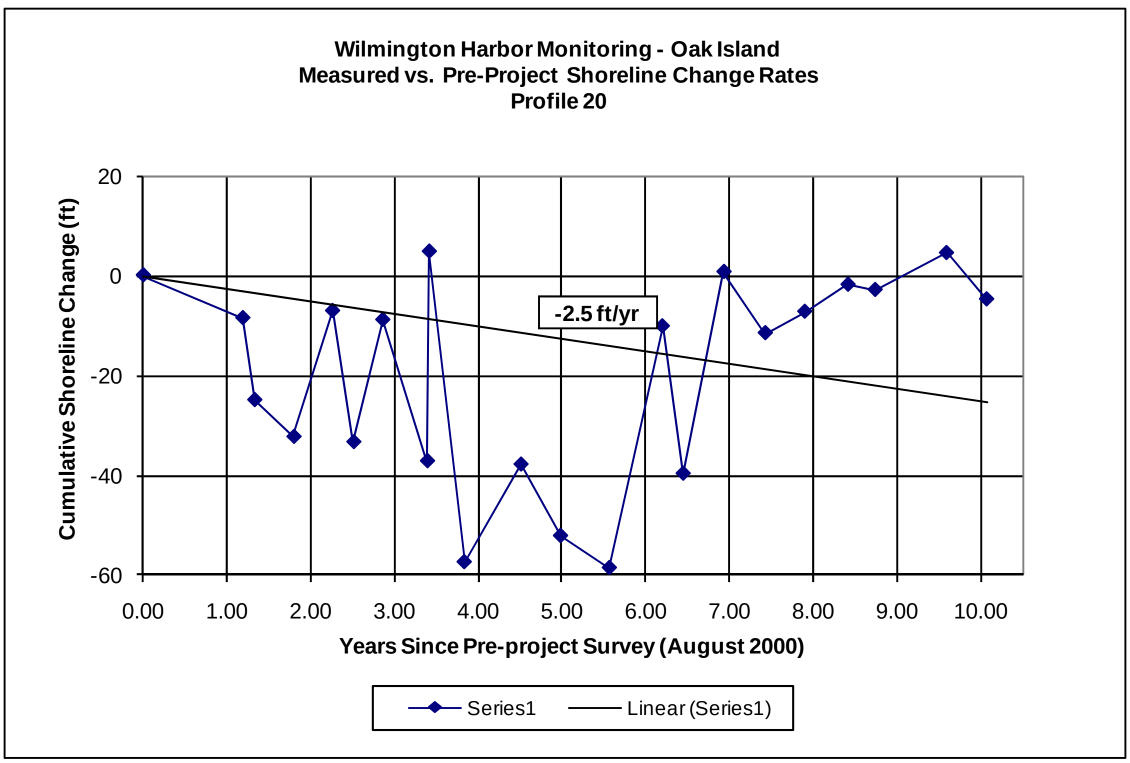
Appendix B

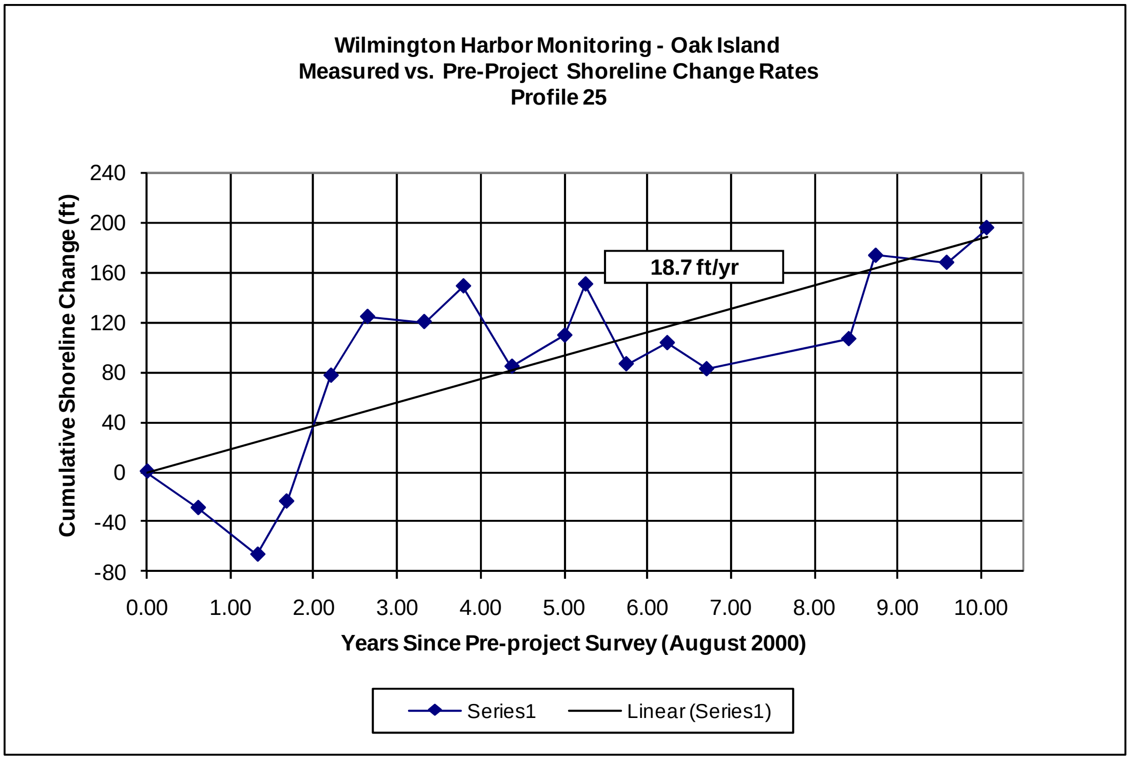
SHORELINE CHANGE RATES
(Oak Island)

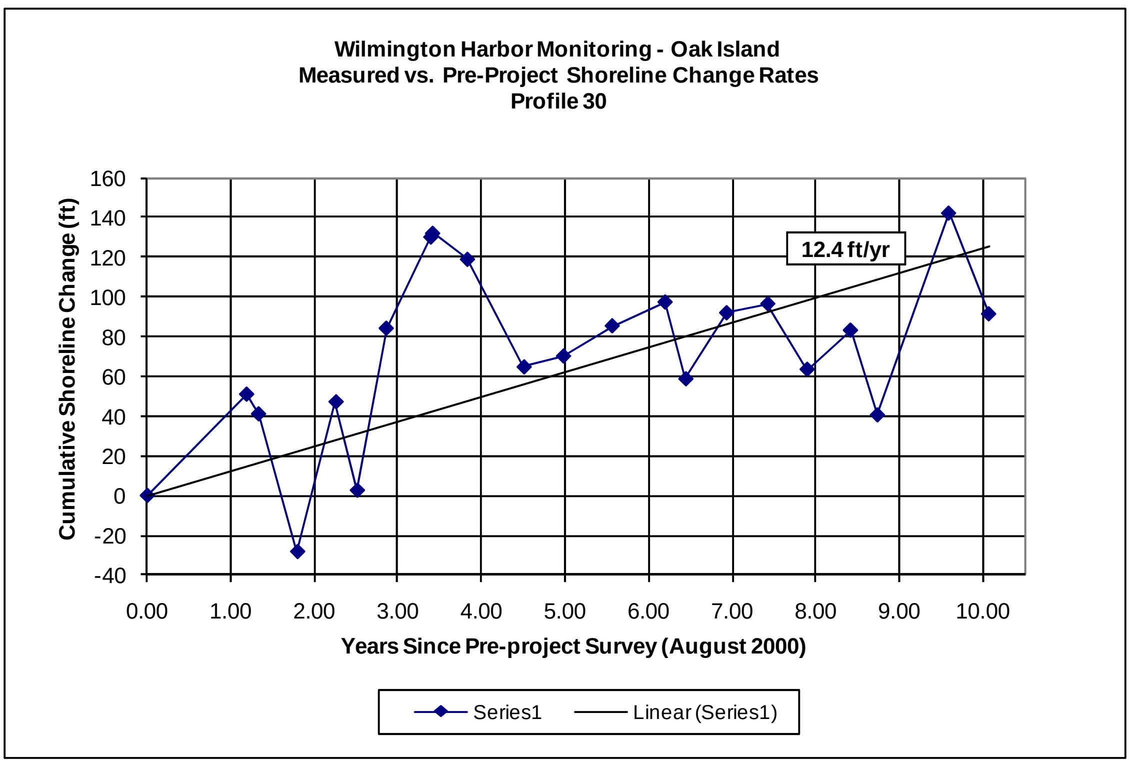

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 5
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
-0.6 ft/yr
Series1
Linear (Series1)

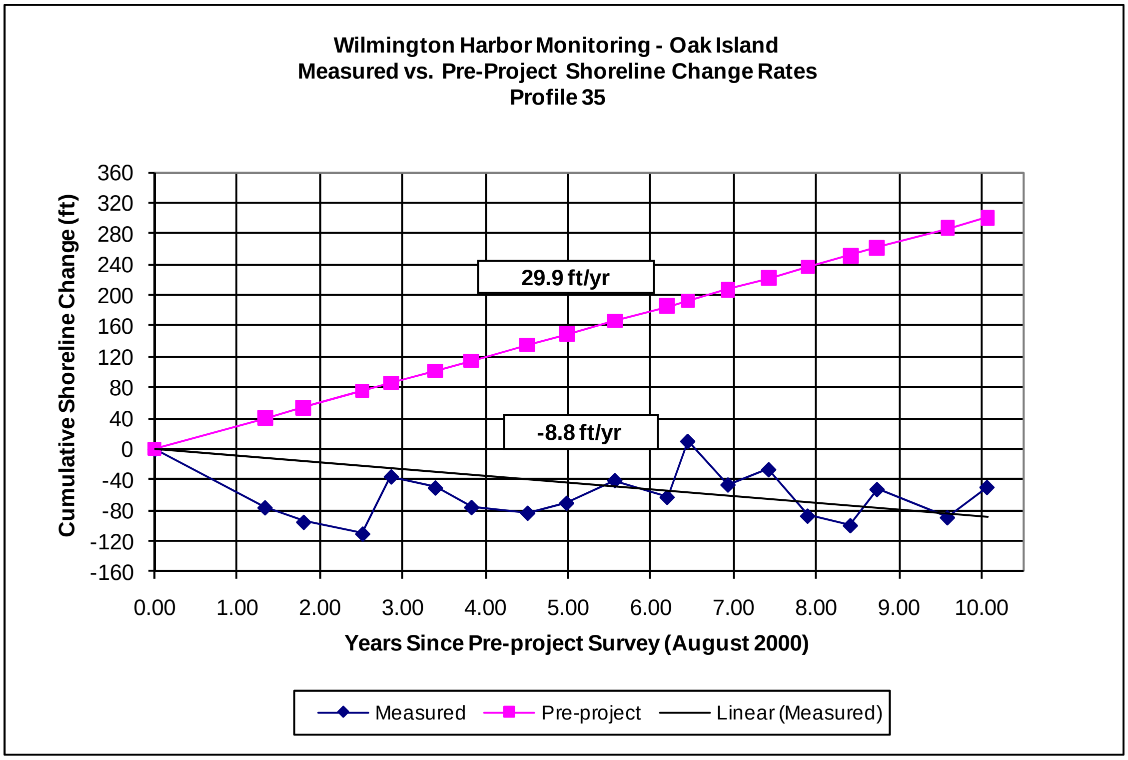

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 10
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
0.3 ft/yr
Series1
Linear (Series1)

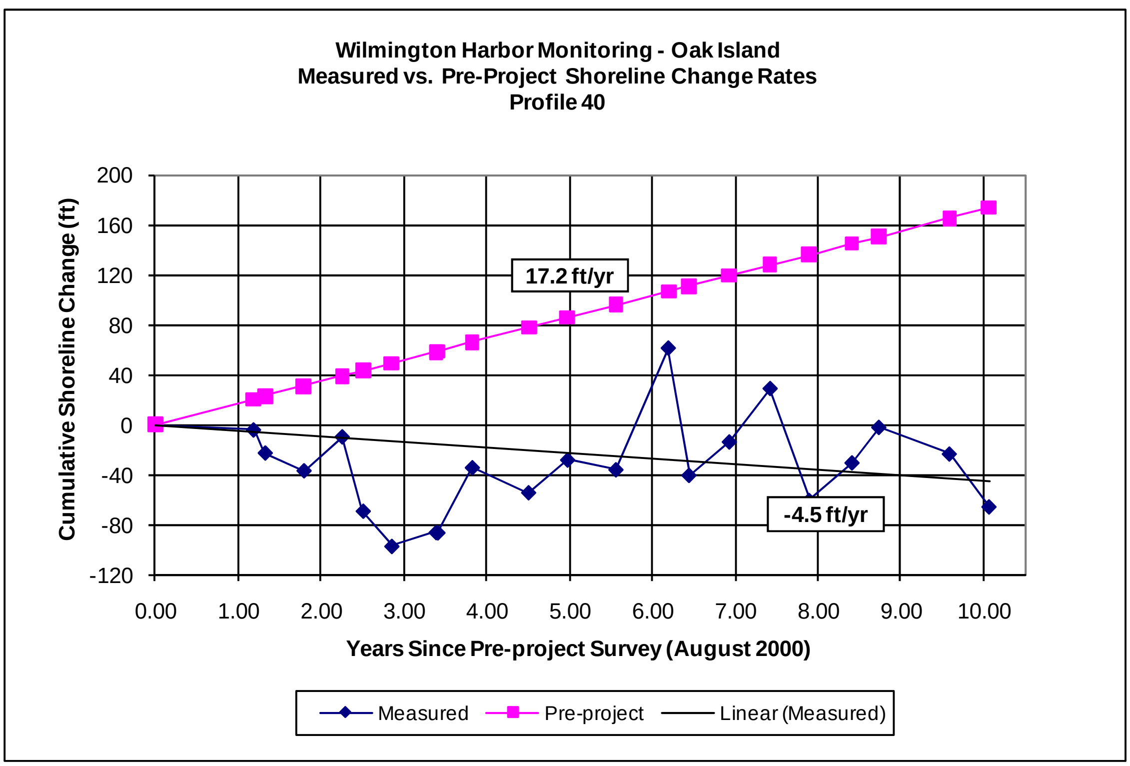

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 15
4.5 ft/yr
Cumulative Shoreline Change (ft)
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Series1
Linear (Series1)

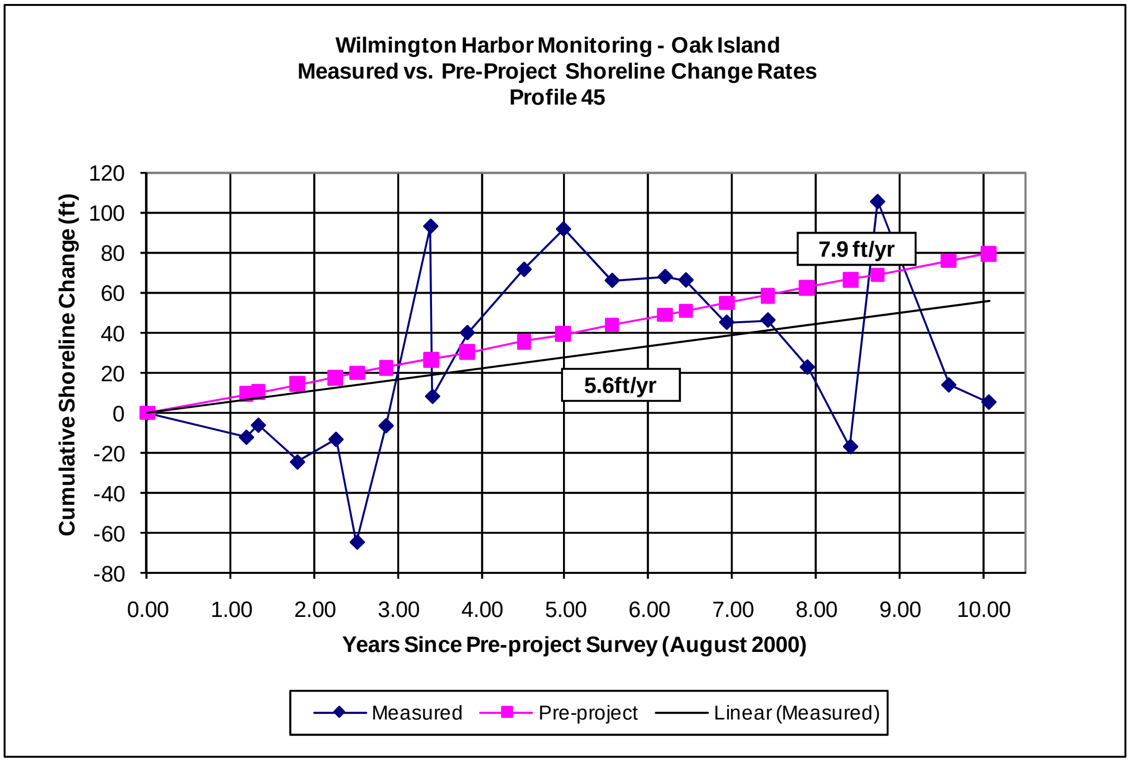

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
-2.5 ft/yr
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Series1
Linear (Series1)

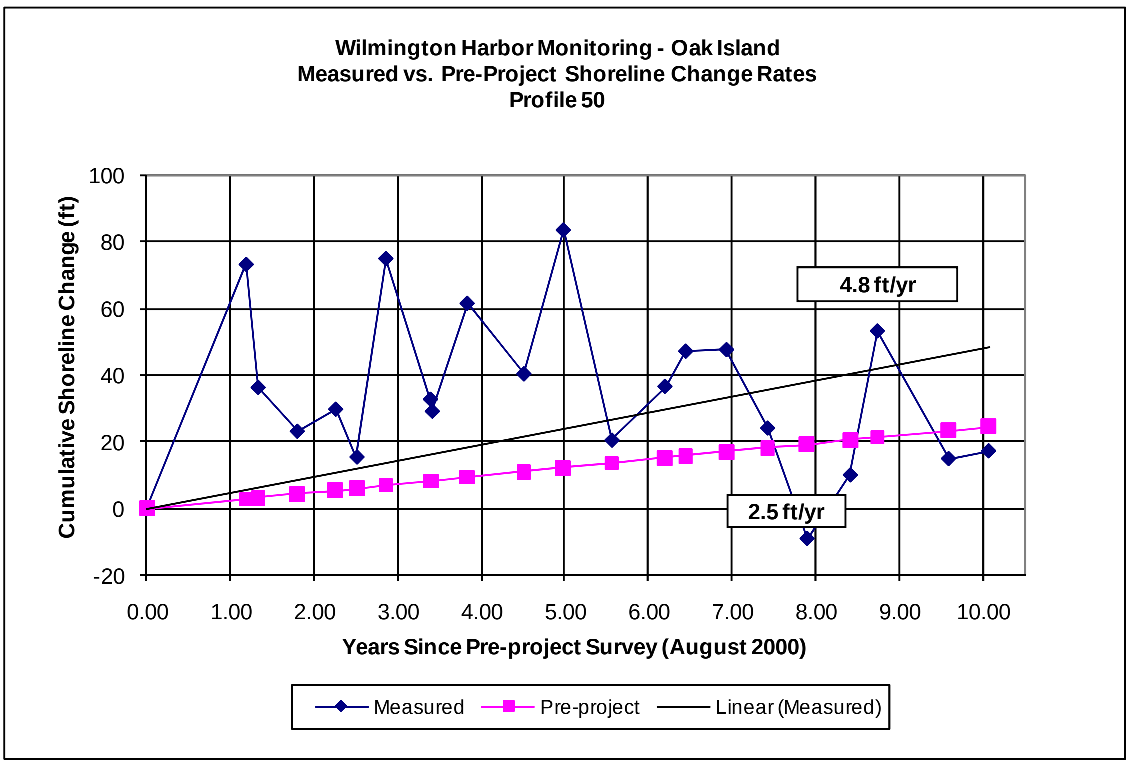

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 25
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
18.7 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Series1
Linear (Series1)

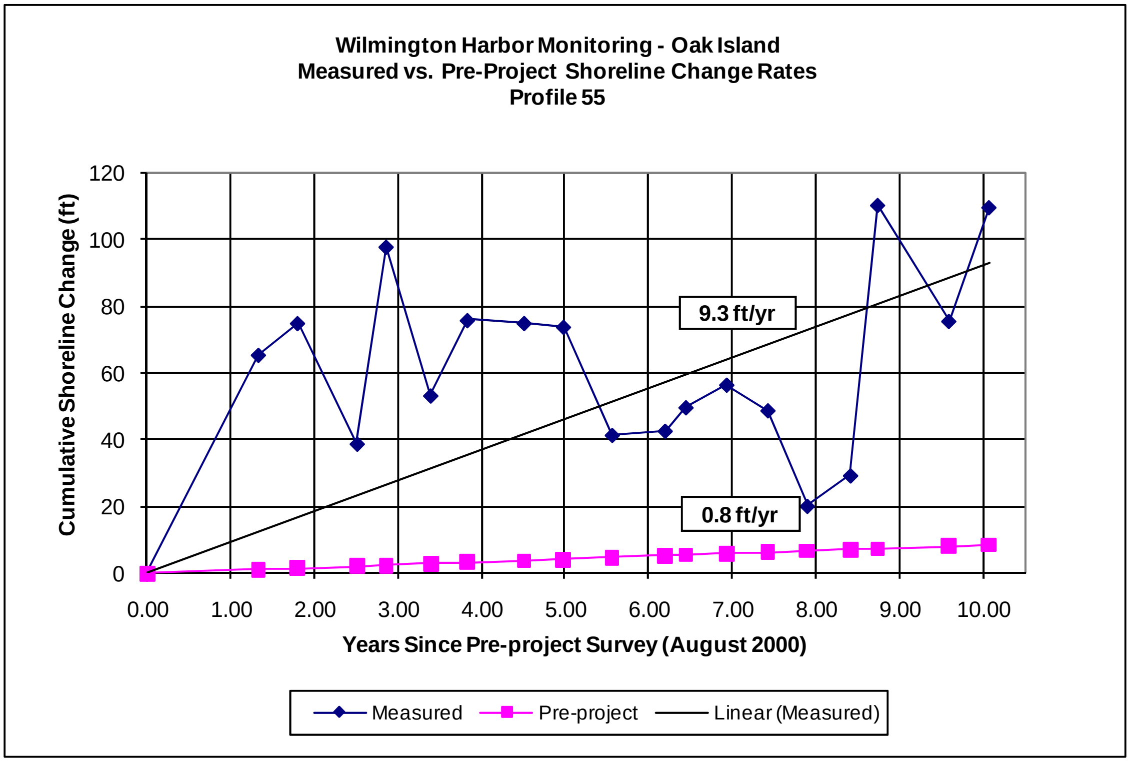

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 30
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
12.4 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Series1
Linear (Series1)

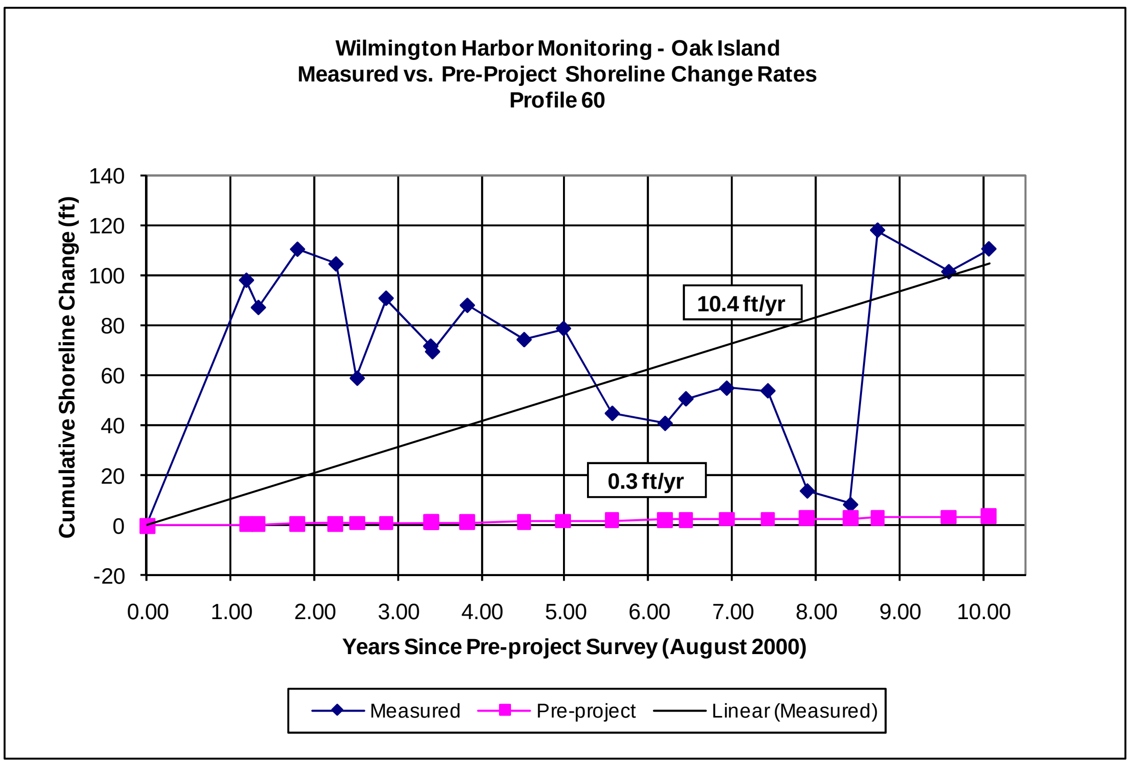

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 35
29.9 ft/yr
-8.8 ft/yr
Cumulative Shoreline Change (ft)
360
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

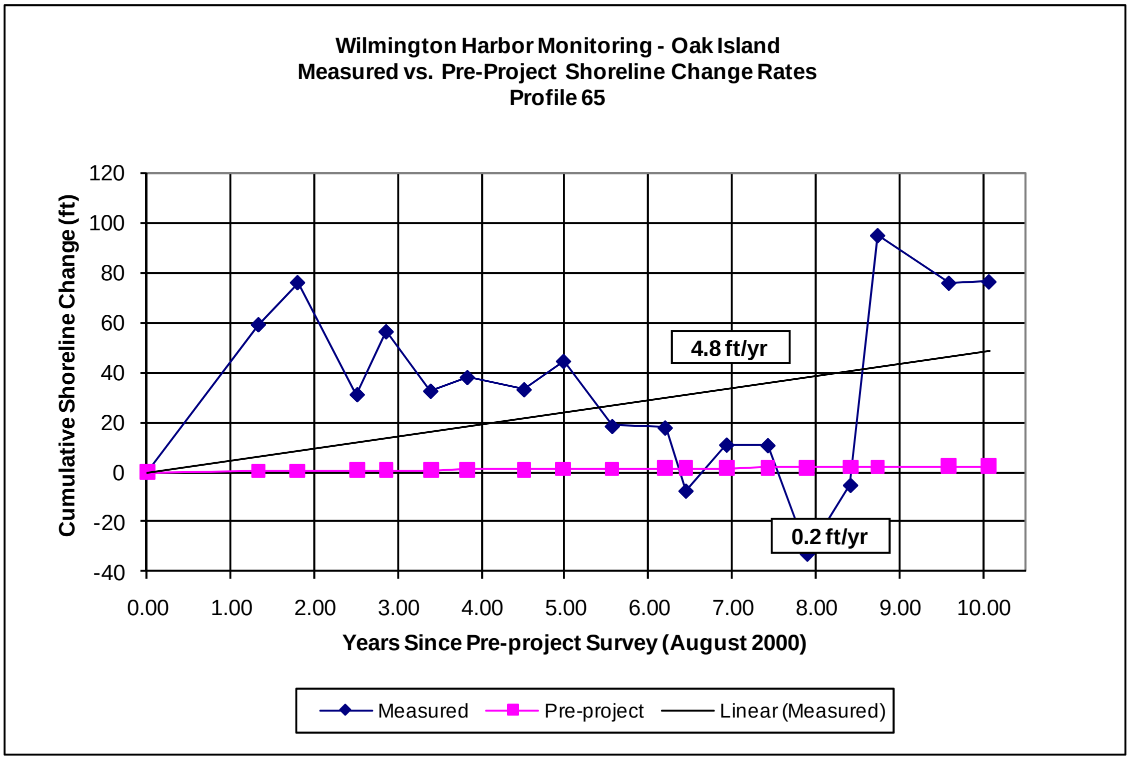

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
17.2 ft/yr
-4.5 ft/yr
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

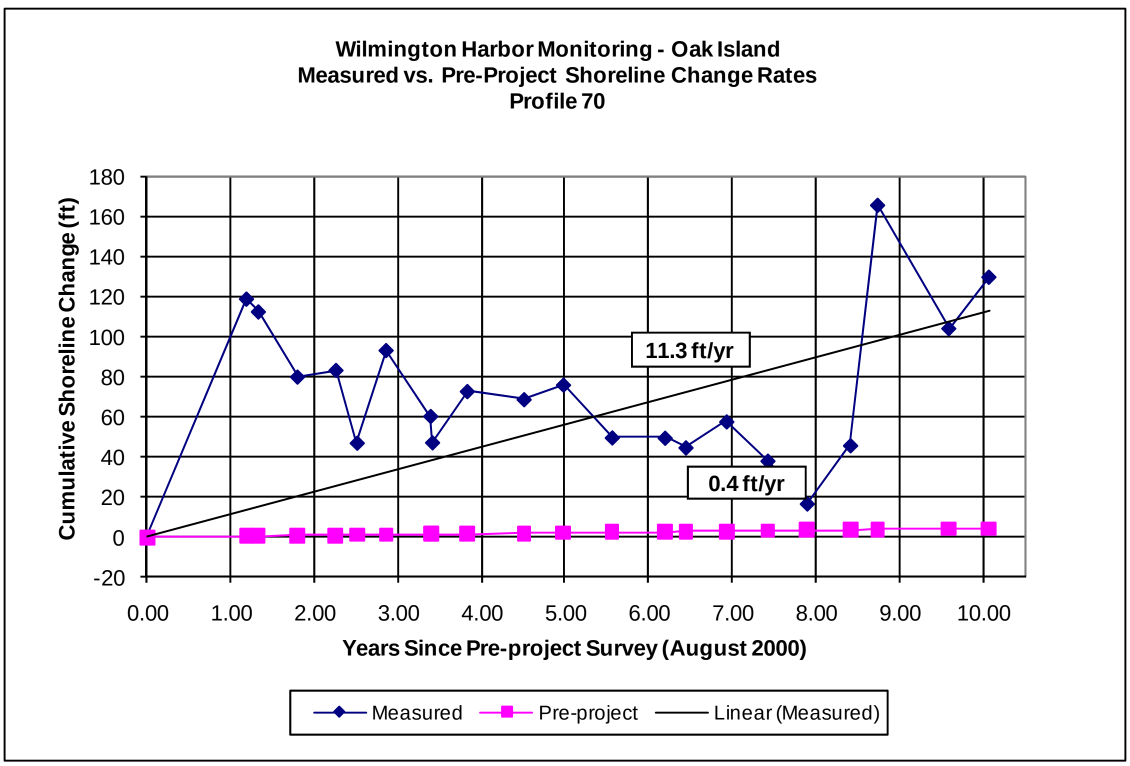

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
7.9 ft/yr
5.6ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

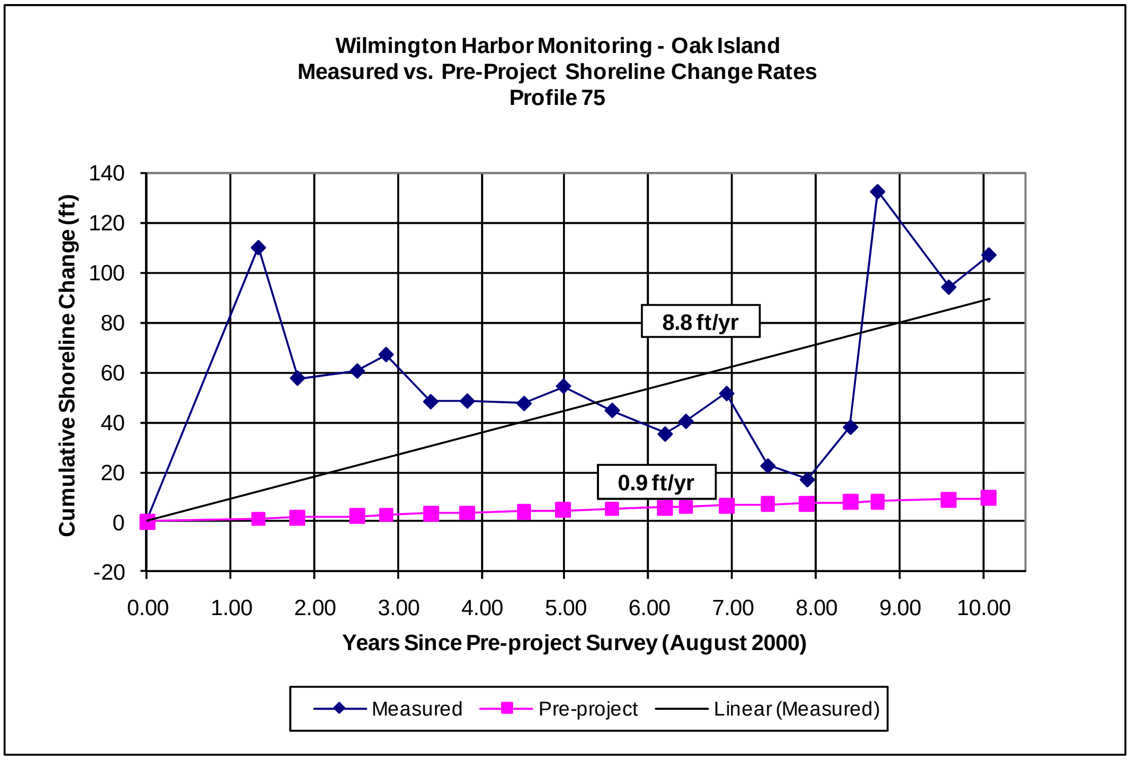

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 50
4.8 ft/yr
2.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

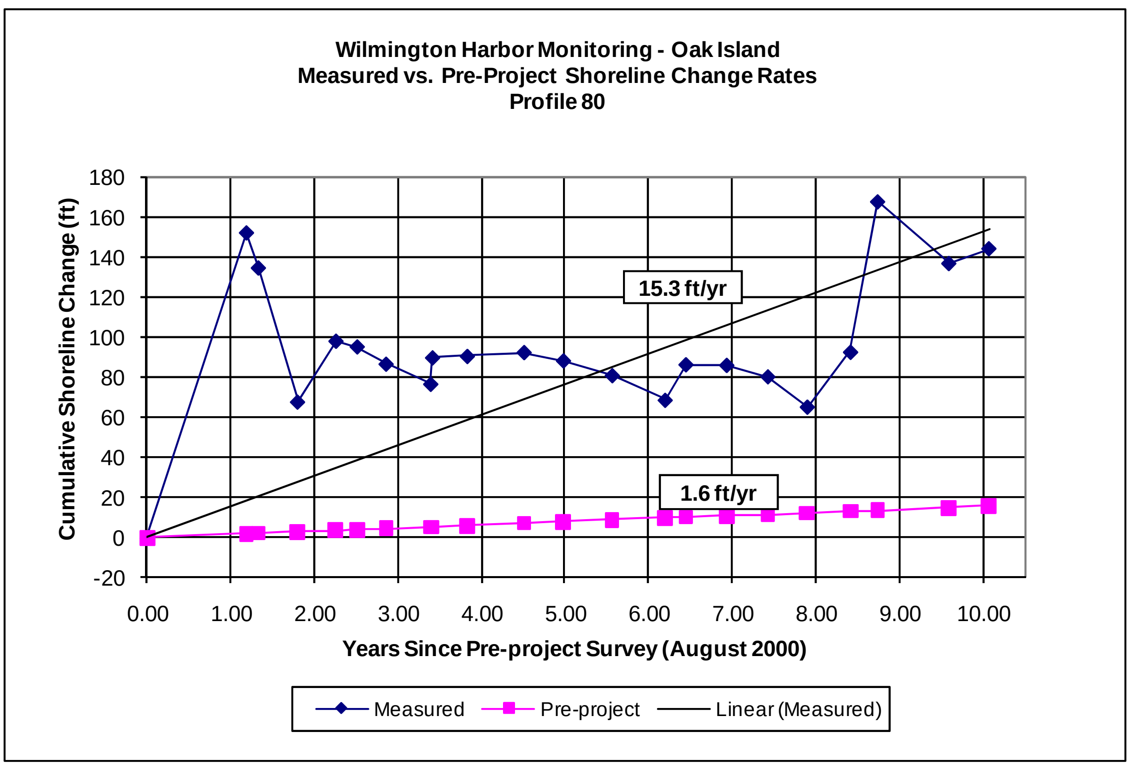

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 55
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
9.3 ft/yr
0.8 ft/yr
Measured
Pre-project
Linear (Measured)

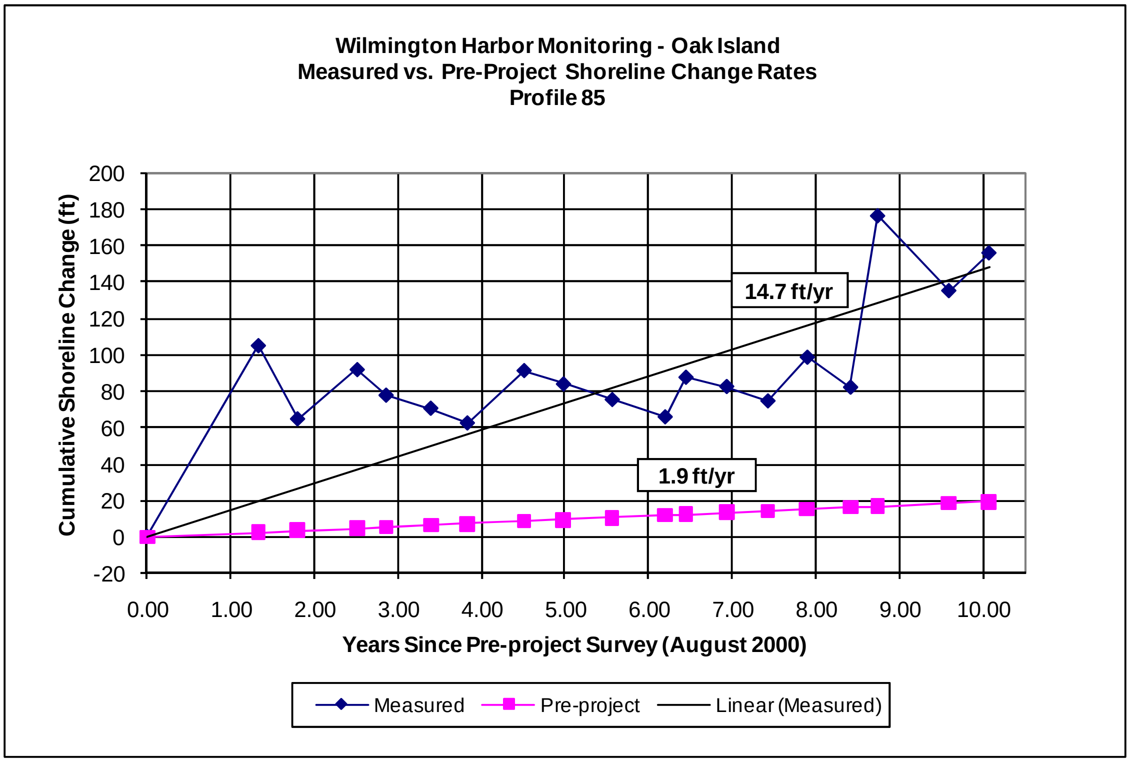

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 60
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
10.4 ft/yr
0.3 ft/yr
Measured
Pre-project
Linear (Measured)

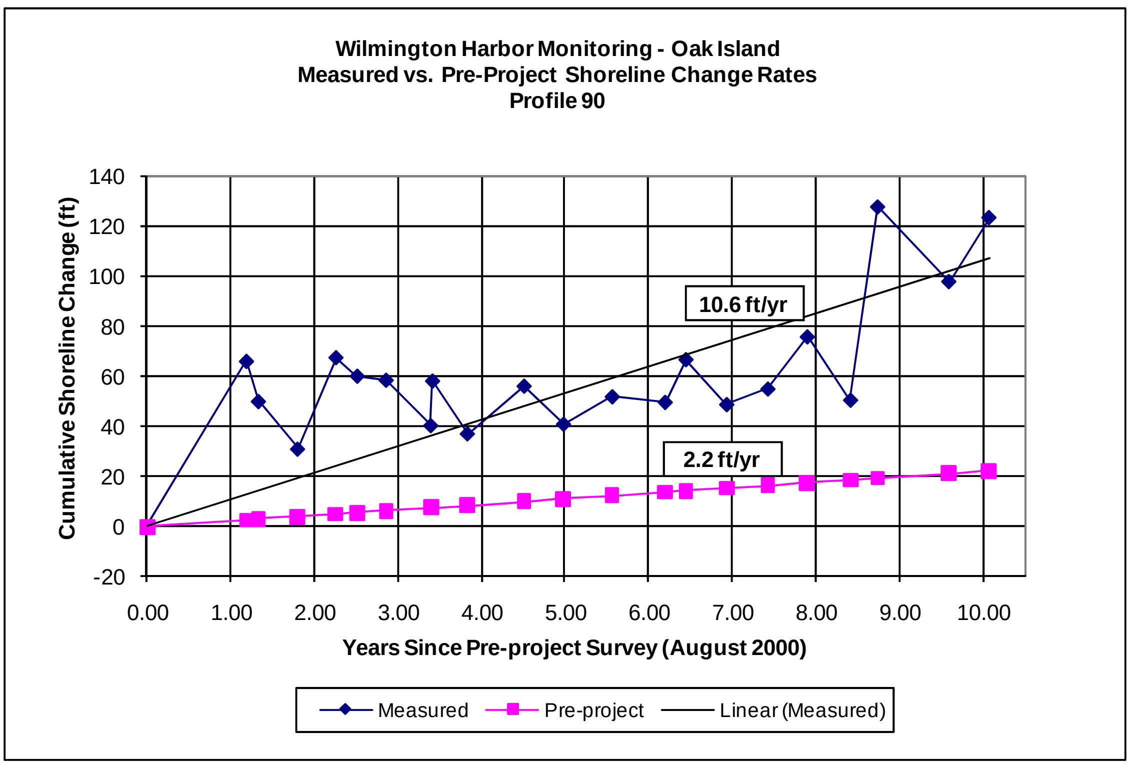

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 65
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
4.8 ft/yr
0.2 ft/yr
Measured
Pre-project
Linear (Measured)

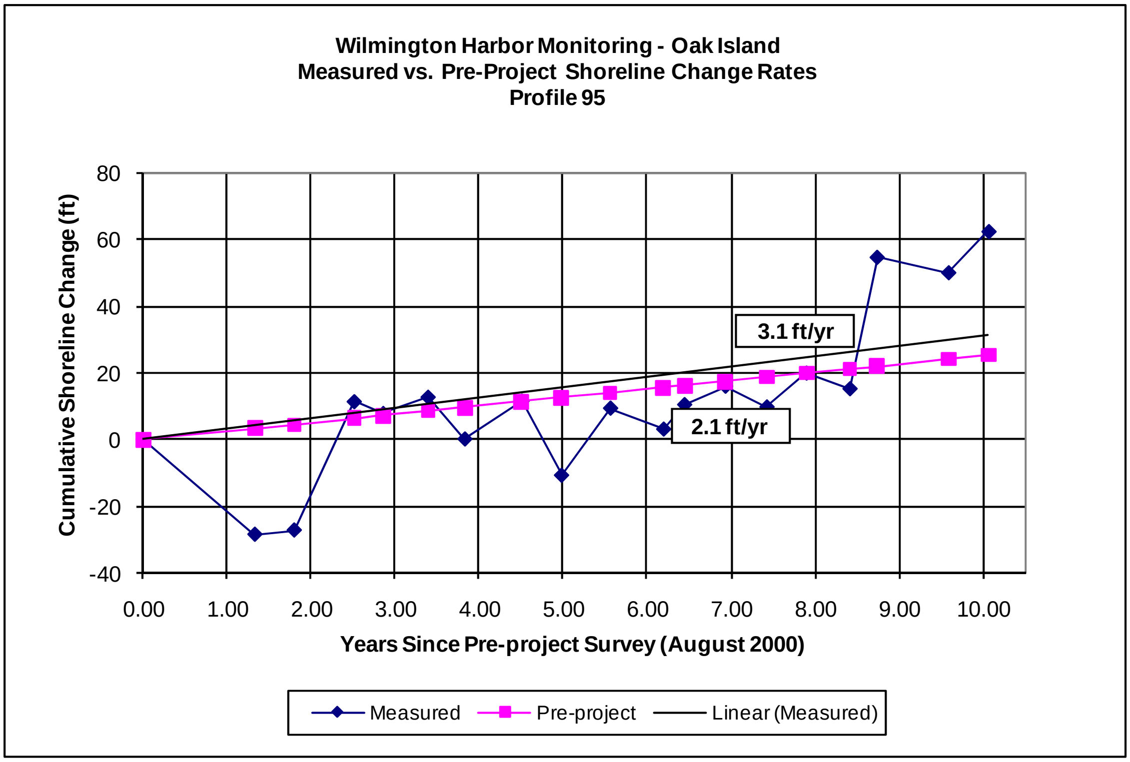

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 70
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
11.3 ft/yr
0.4 ft/yr
Measured
Pre-project
Linear (Measured)

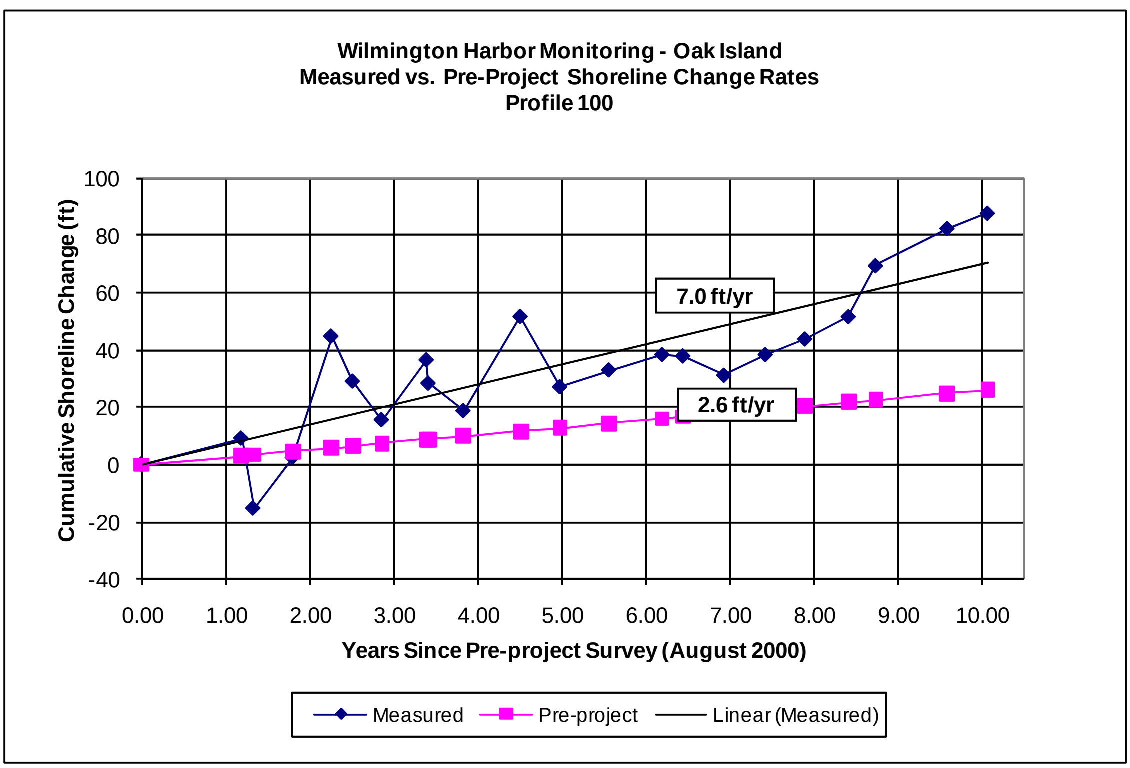

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 75
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
8.8 ft/yr
0.9 ft/yr
Measured
Pre-project
Linear (Measured)

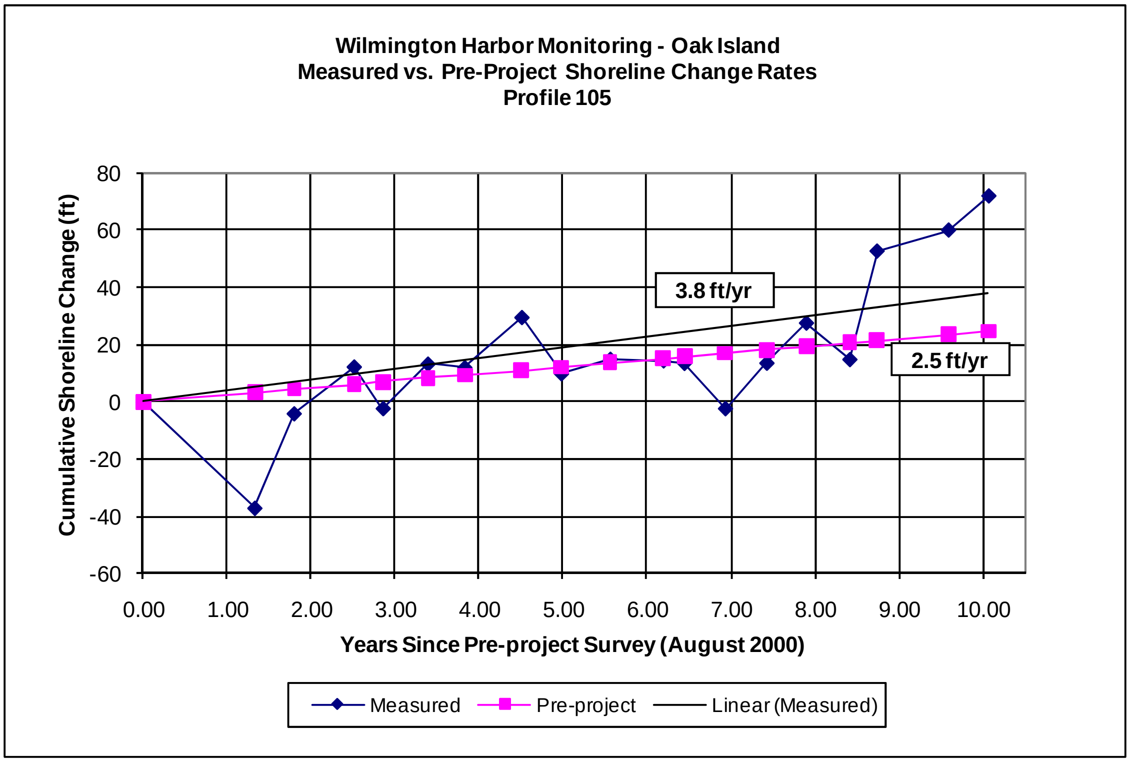

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 80
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
15.3 ft/yr
1.6 ft/yr
Measured
Pre-project
Linear (Measured)

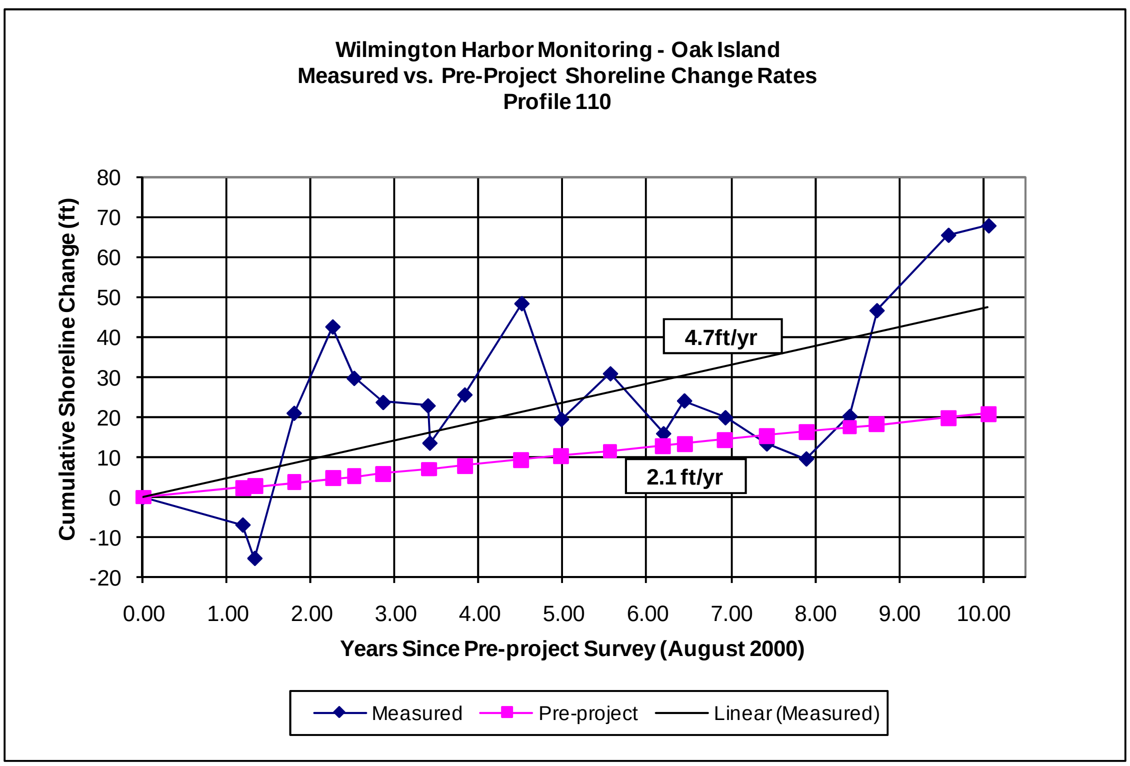

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 85
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
14.7 ft/yr
1.9 ft/yr
Measured
Pre-project
Linear (Measured)

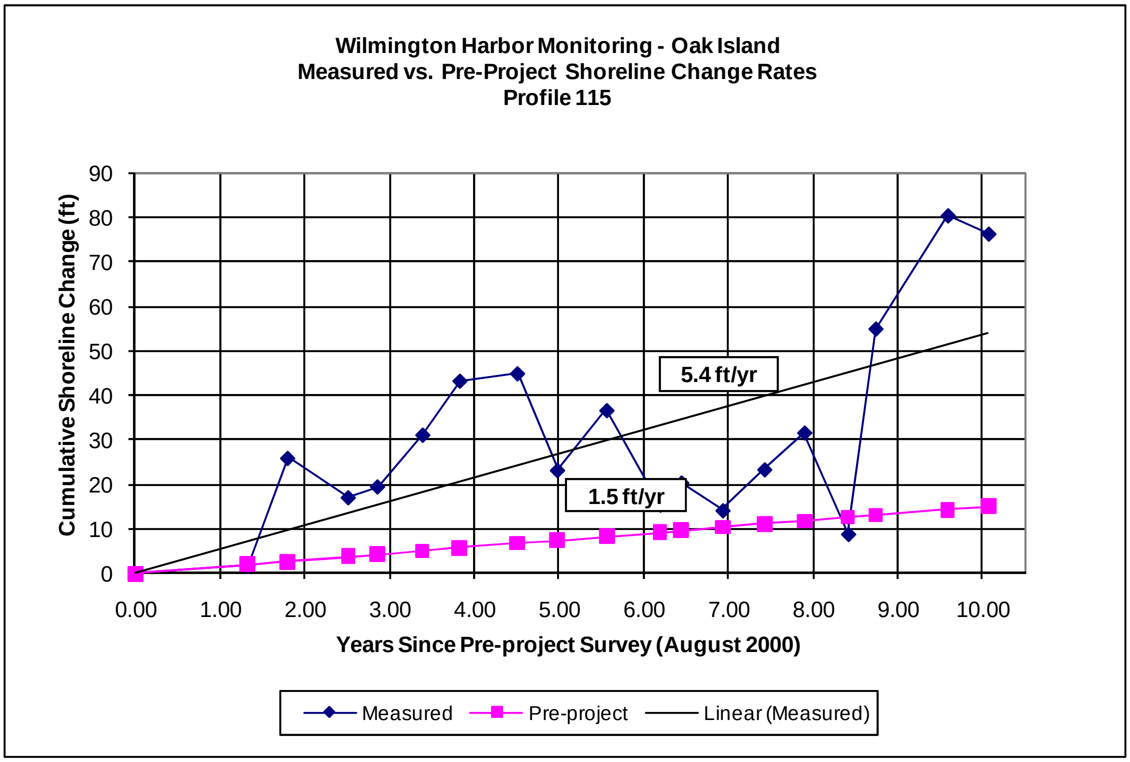

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 90
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
10.6 ft/yr
2.2 ft/yr
Measured
Pre-project
Linear (Measured)

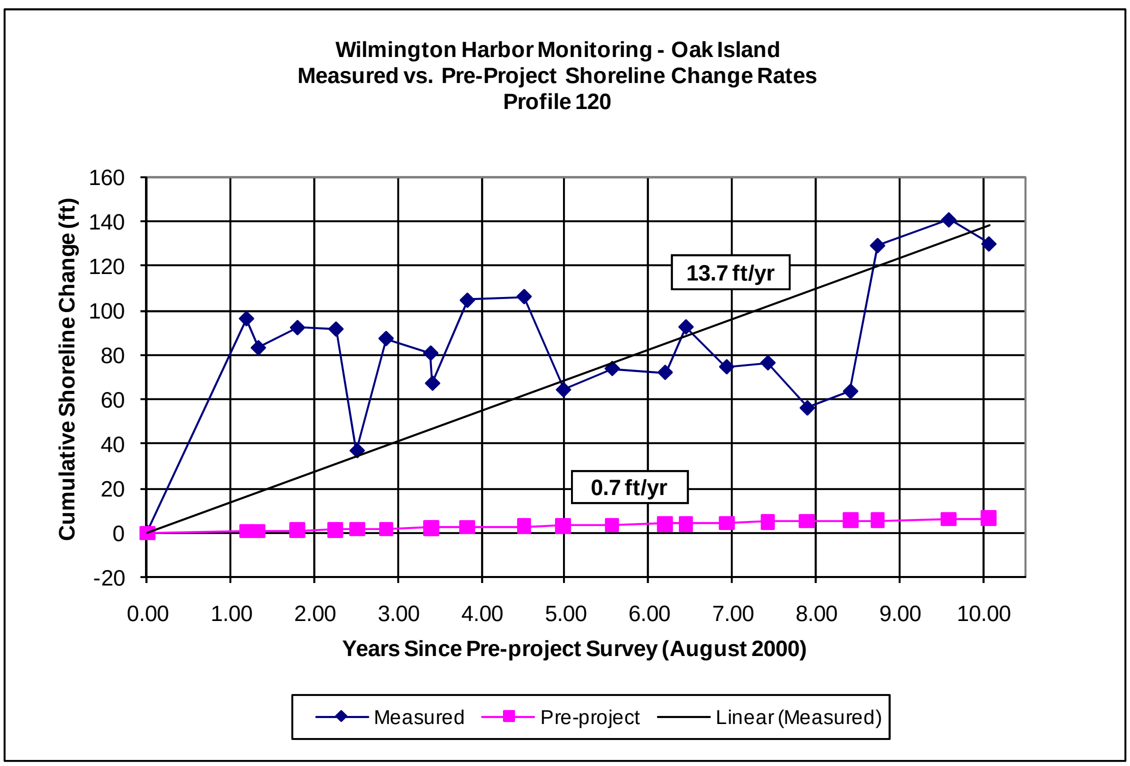

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 95
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
3.1 ft/yr
2.1 ft/yr
Measured
Pre-project
Linear (Measured)

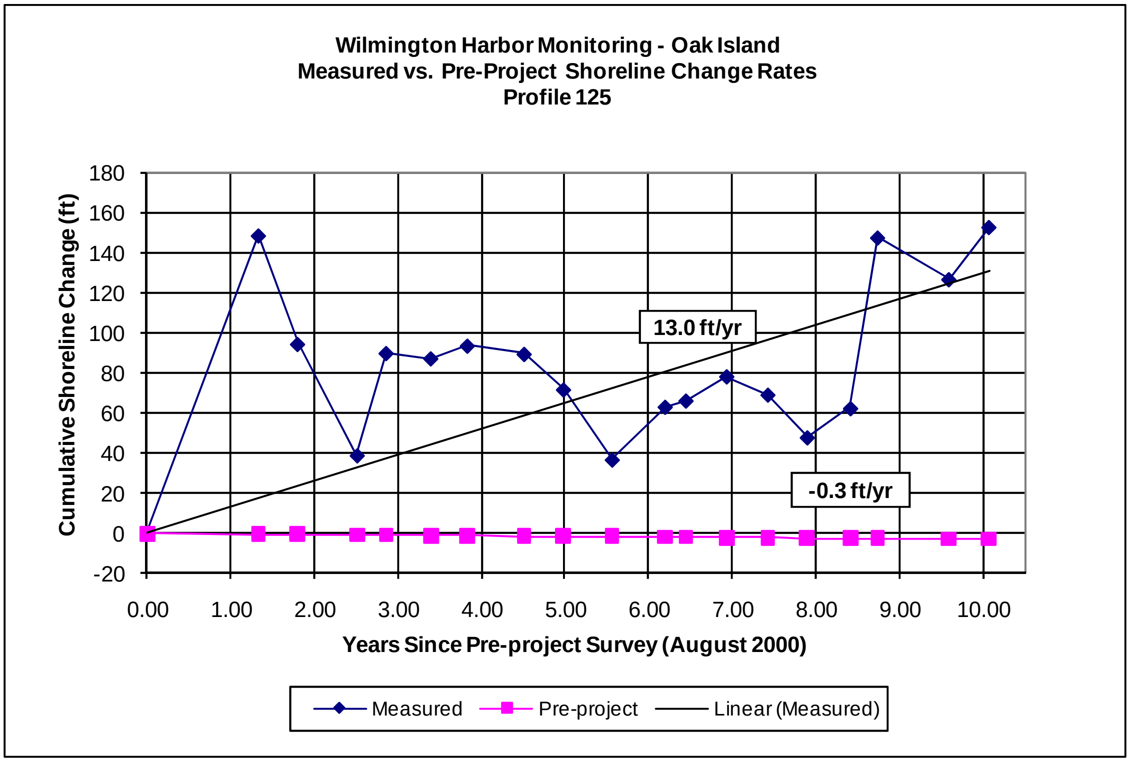

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 100
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
7.0 ft/yr
2.6 ft/yr
Measured
Pre-project
Linear (Measured)

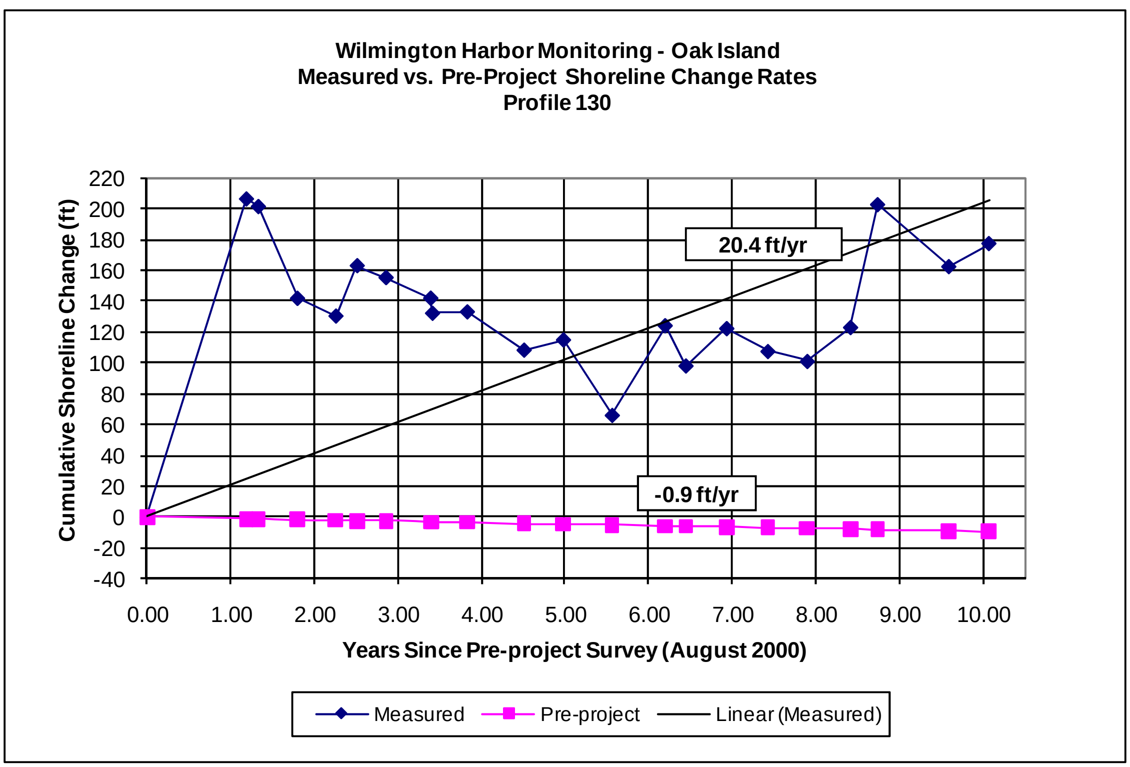

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 105
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
3.8 ft/yr
2.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

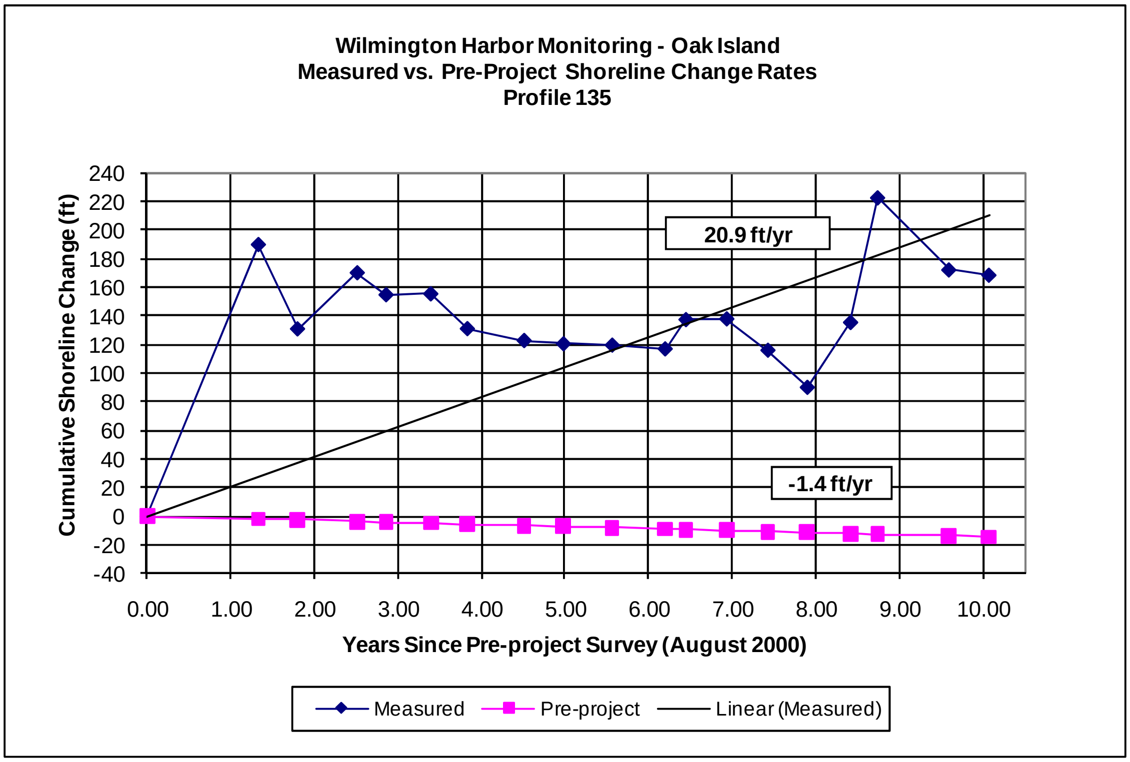

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
80
70
60
50
40
30
20
10
0
-10
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
4.7ft/yr
2.1 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

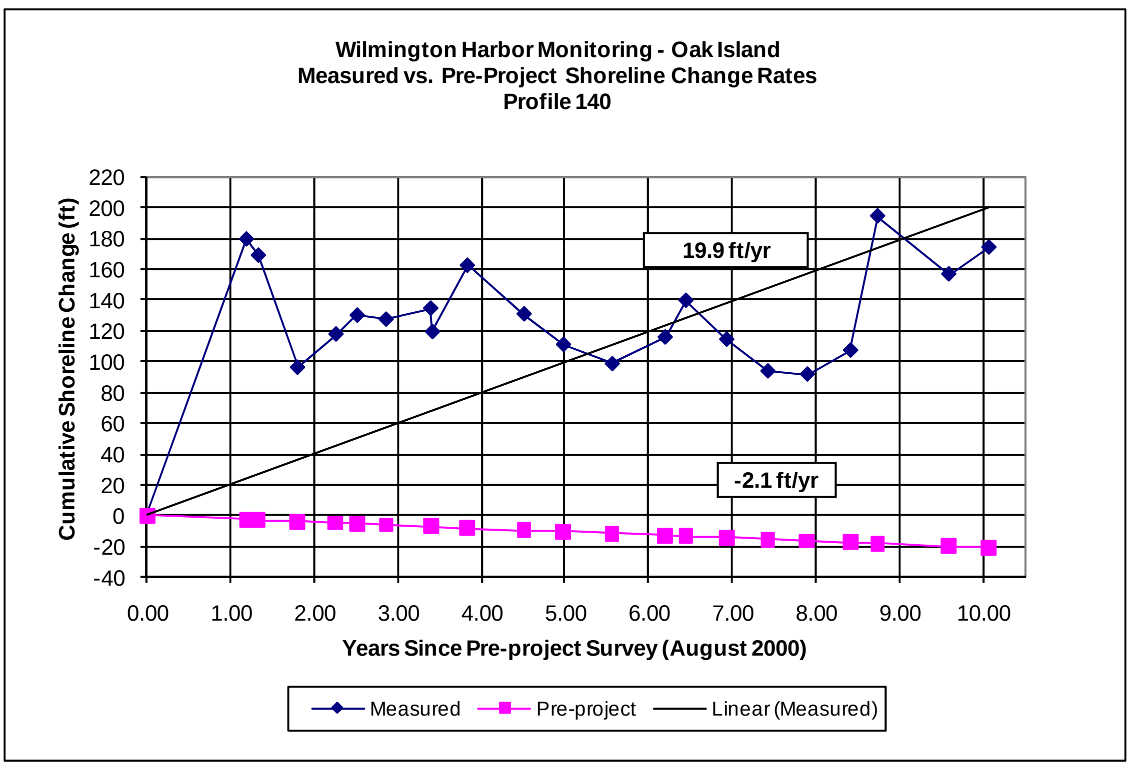

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 115
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
5.4 ft/yr
1.5 ft/yr
Measured
Pre-project
Linear (Measured)

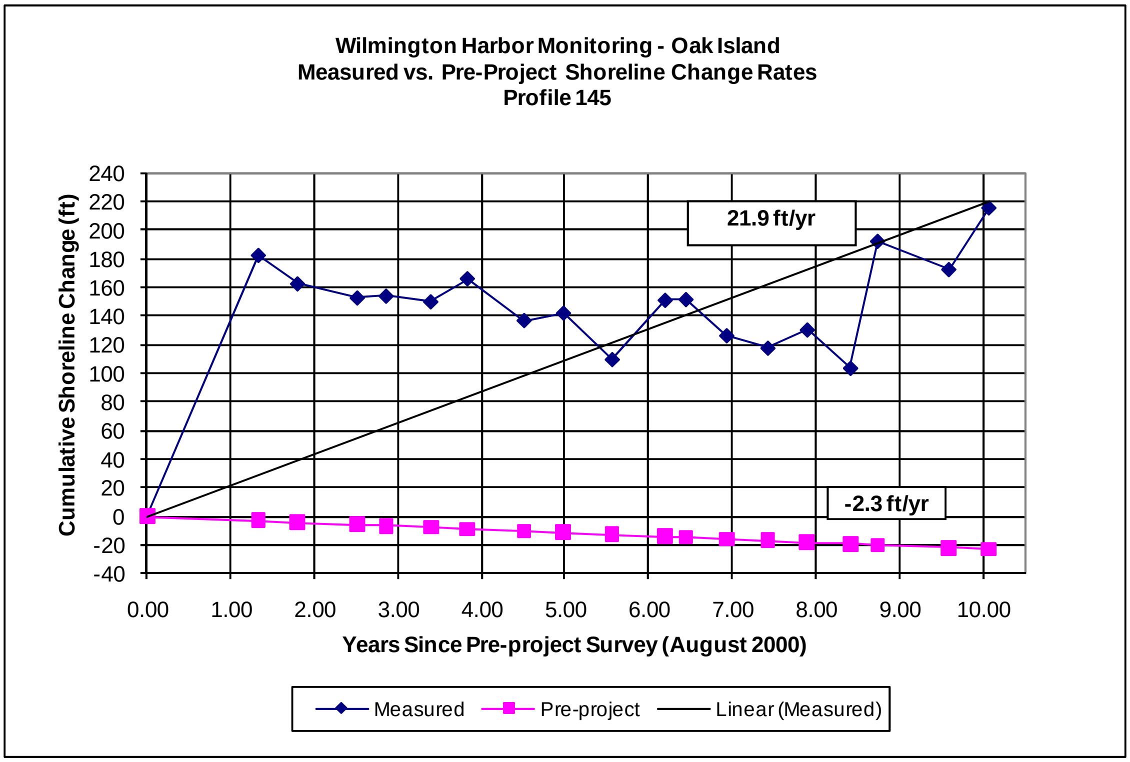

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 120
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
13.7 ft/yr
0.7 ft/yr
Measured
Pre-project
Linear (Measured)

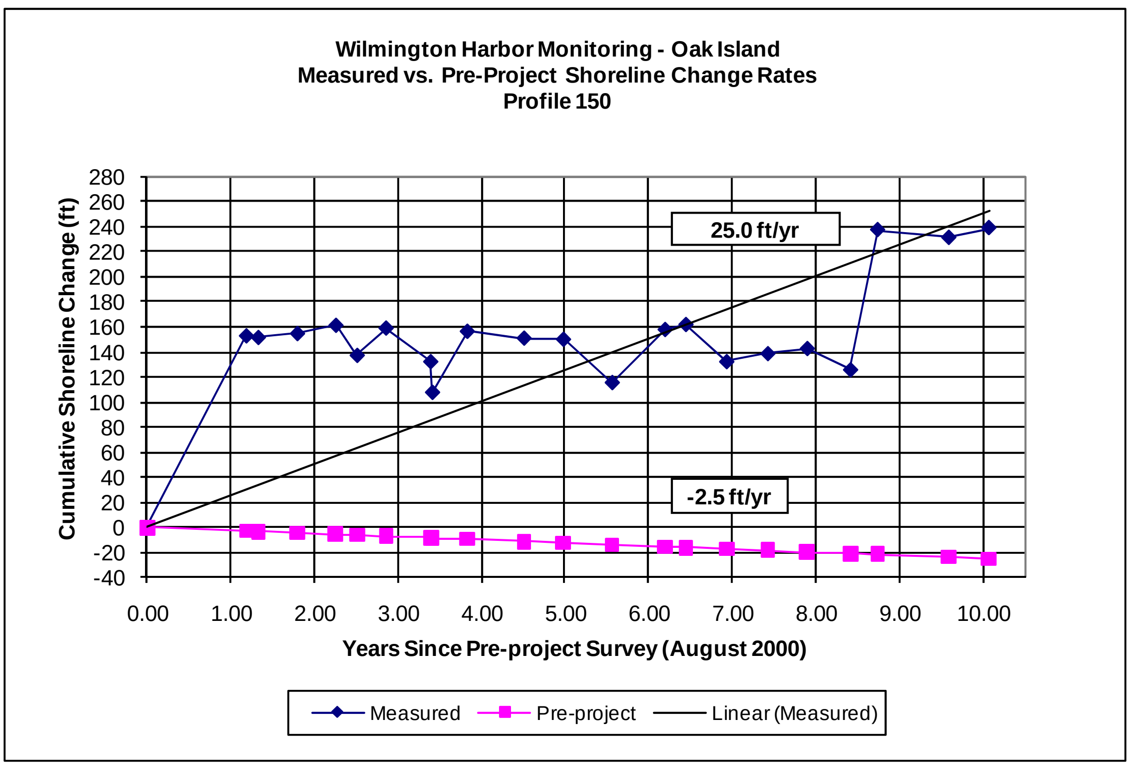

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 125
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
13.0 ft/yr
-0.3 ft/yr
Measured
Pre-project
Linear (Measured)

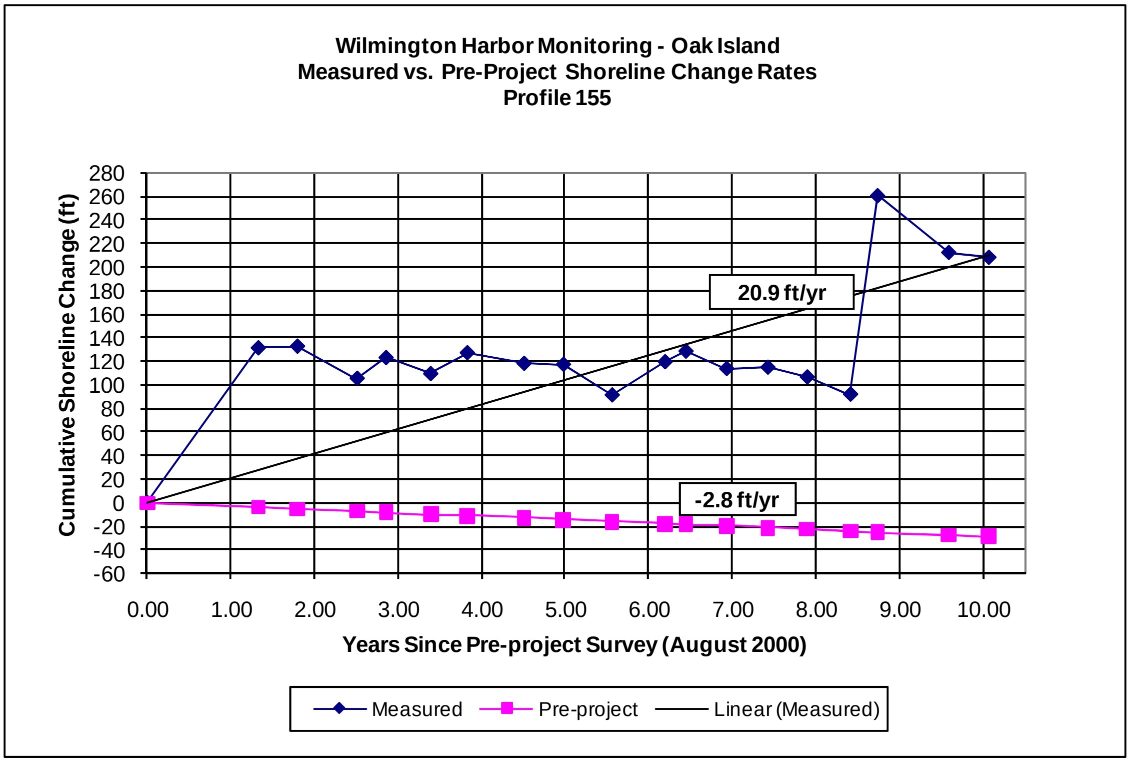

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
20.4 ft/yr
-0.9 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 135
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
20.9 ft/yr
-1.4 ft/yr
Measured
Pre-project
Linear (Measured)

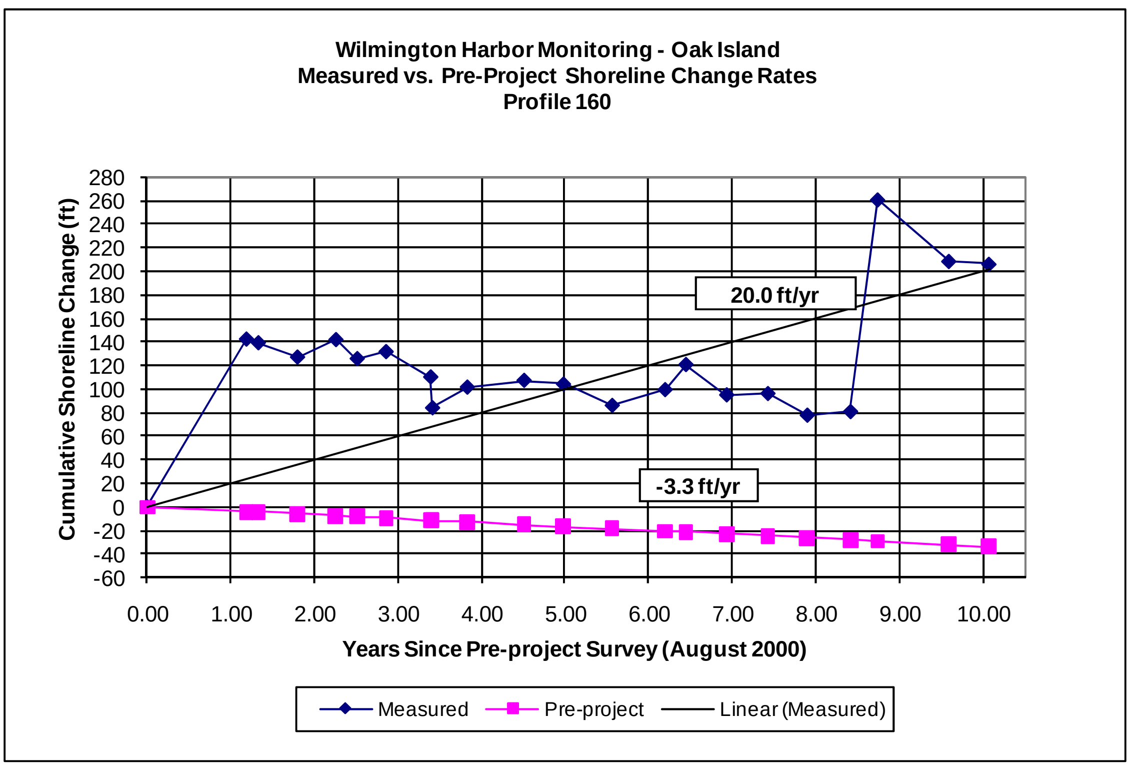

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 140
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
19.9 ft/yr
-2.1 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 145
21.9 ft/yr
-2.3 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

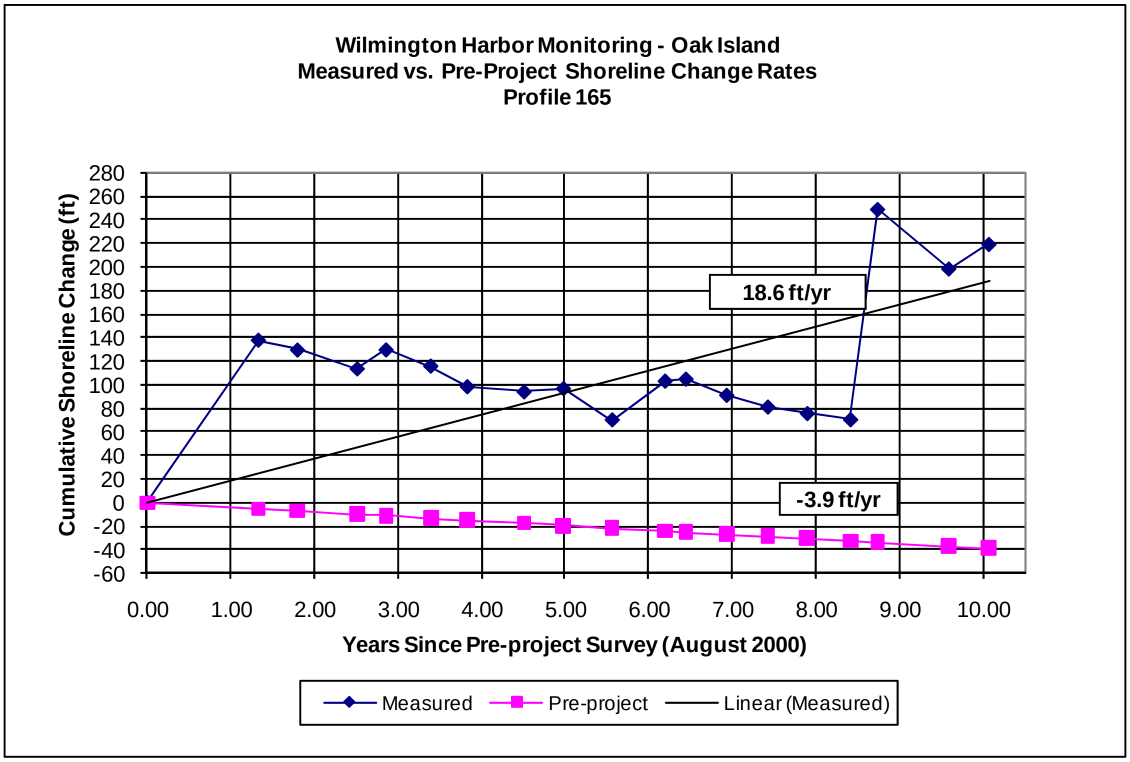

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
25.0 ft/yr
-2.5 ft/yr
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

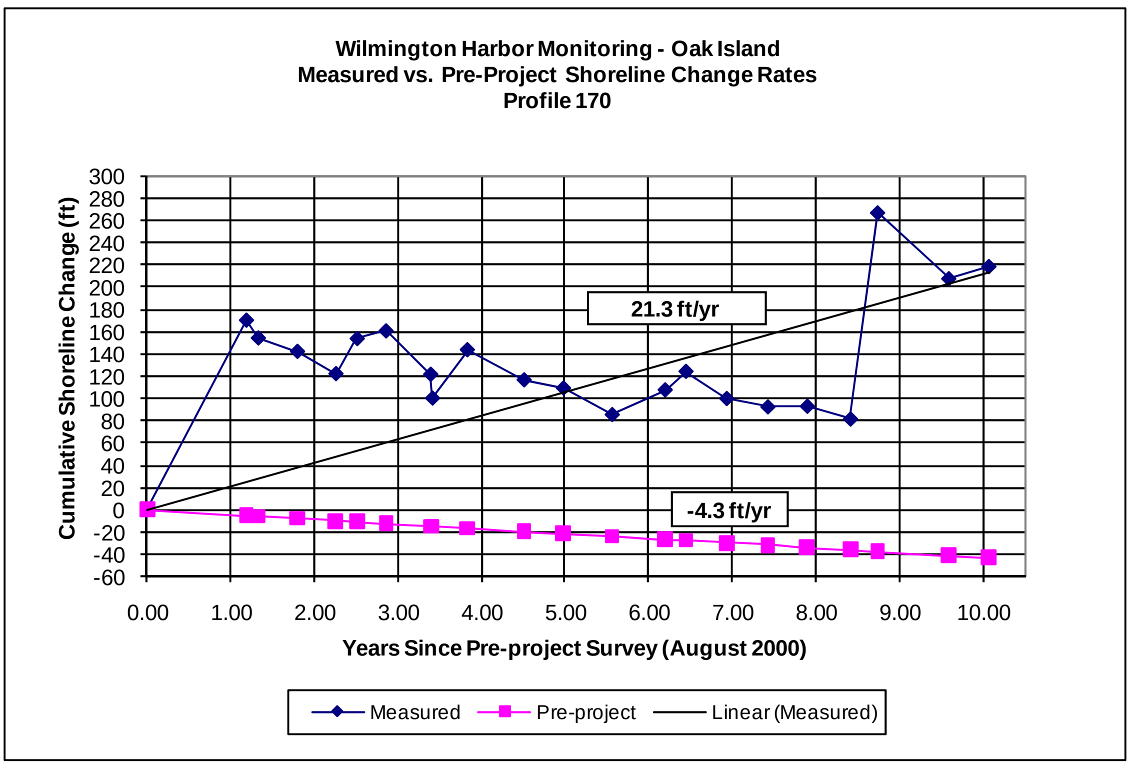


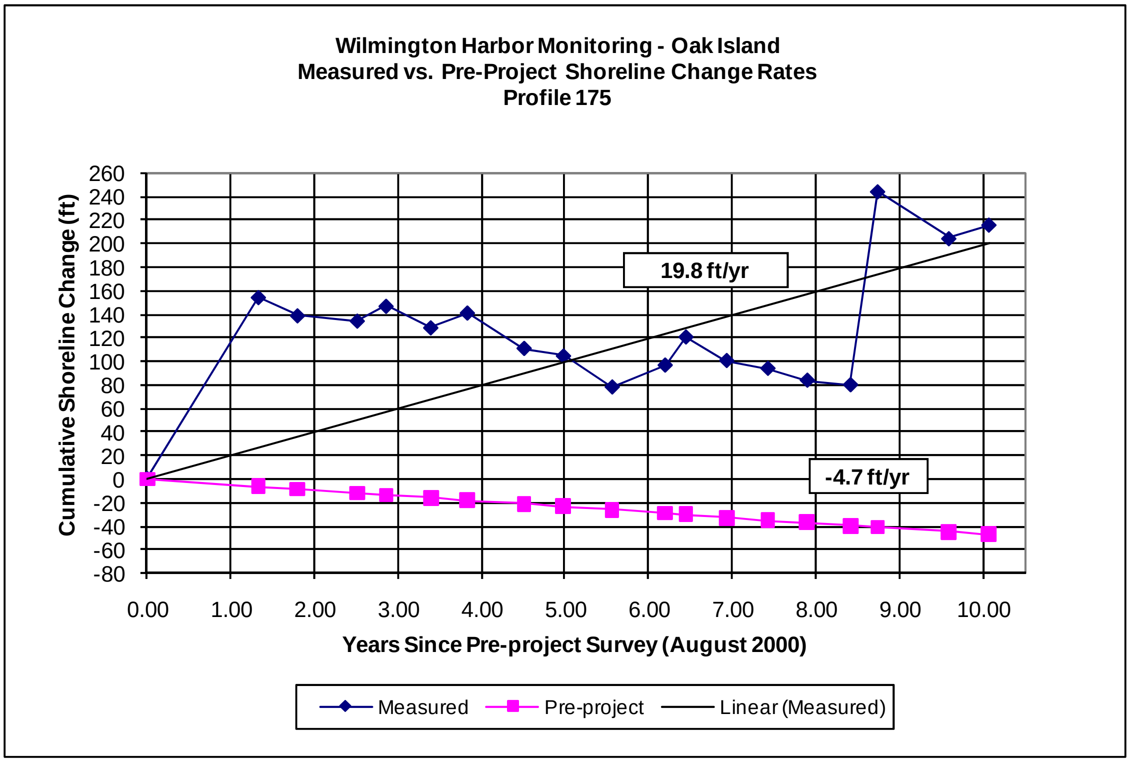
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 155
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
20.9 ft/yr
-2.8 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

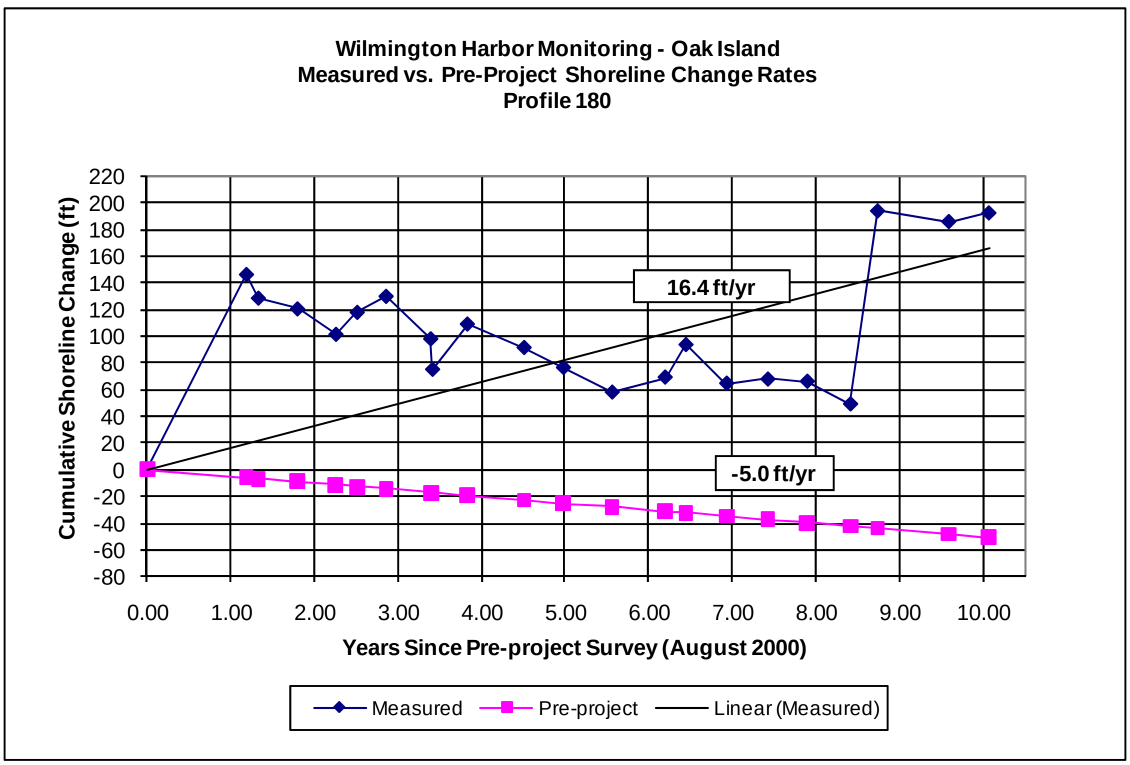


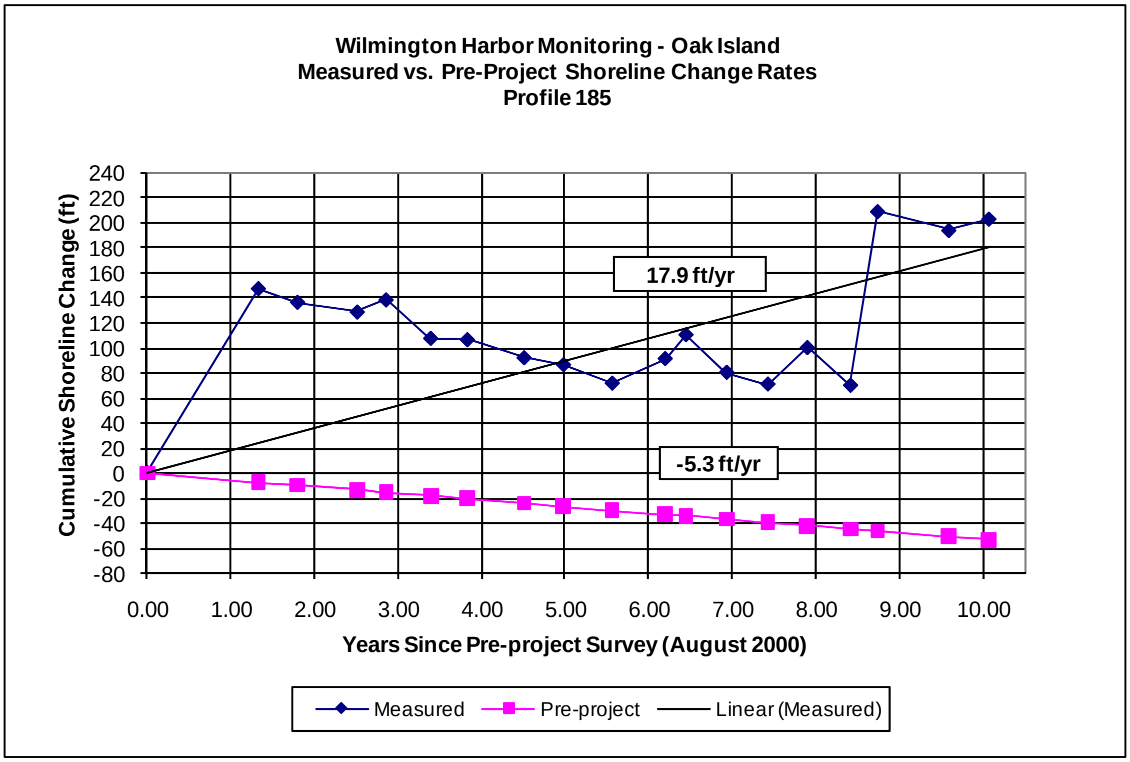
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 160
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
20.0 ft/yr
-3.3 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

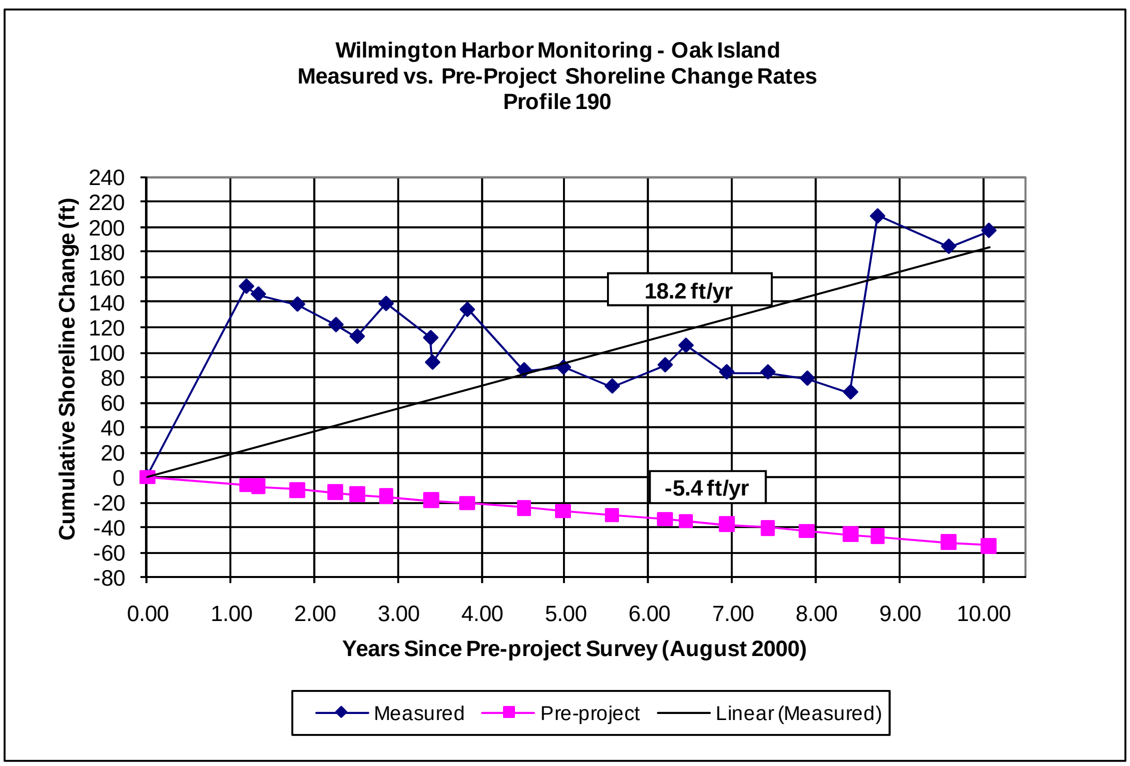

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 165
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
18.6 ft/yr
-3.9 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

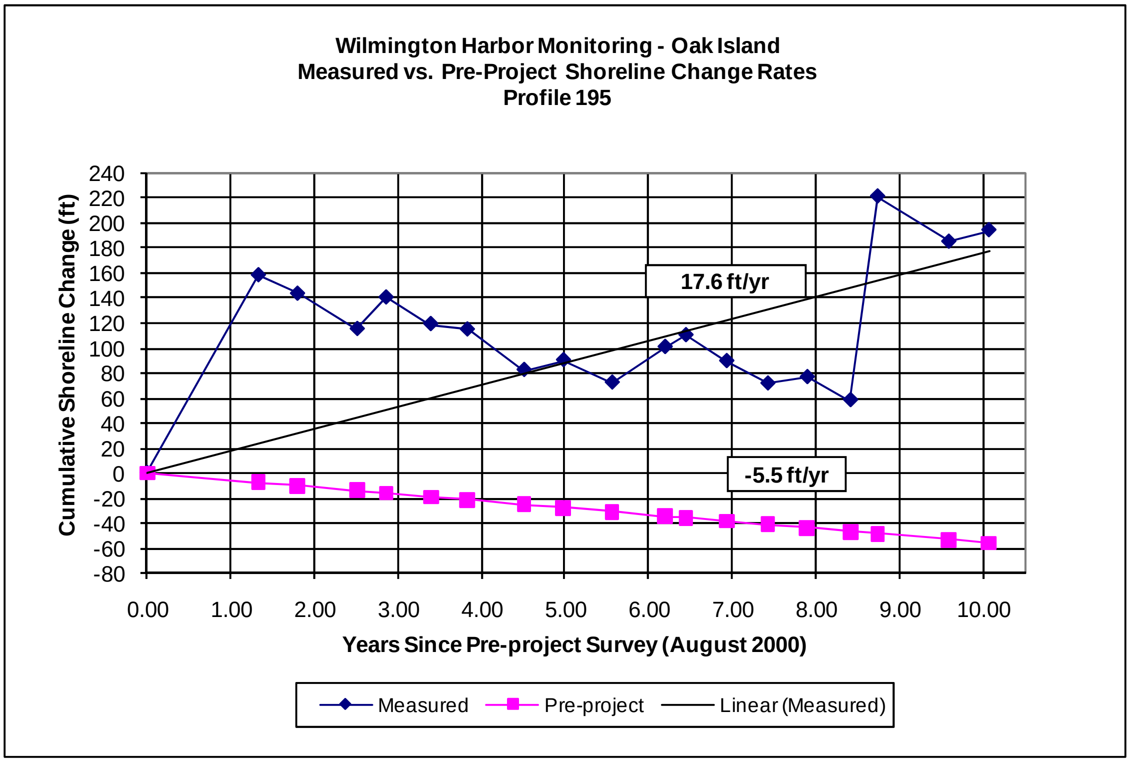

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
Cumulative Shoreline Change (ft)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
21.3 ft/yr
-4.3 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

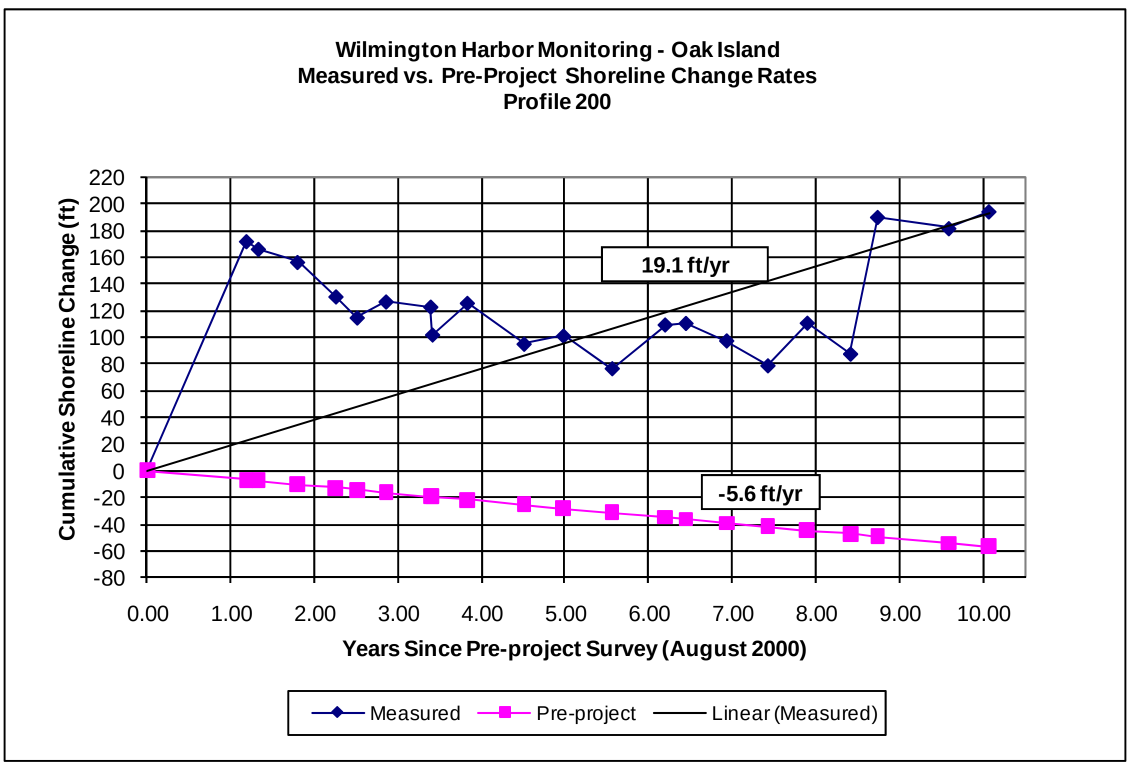

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 175
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
19.8 ft/yr
-4.7 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

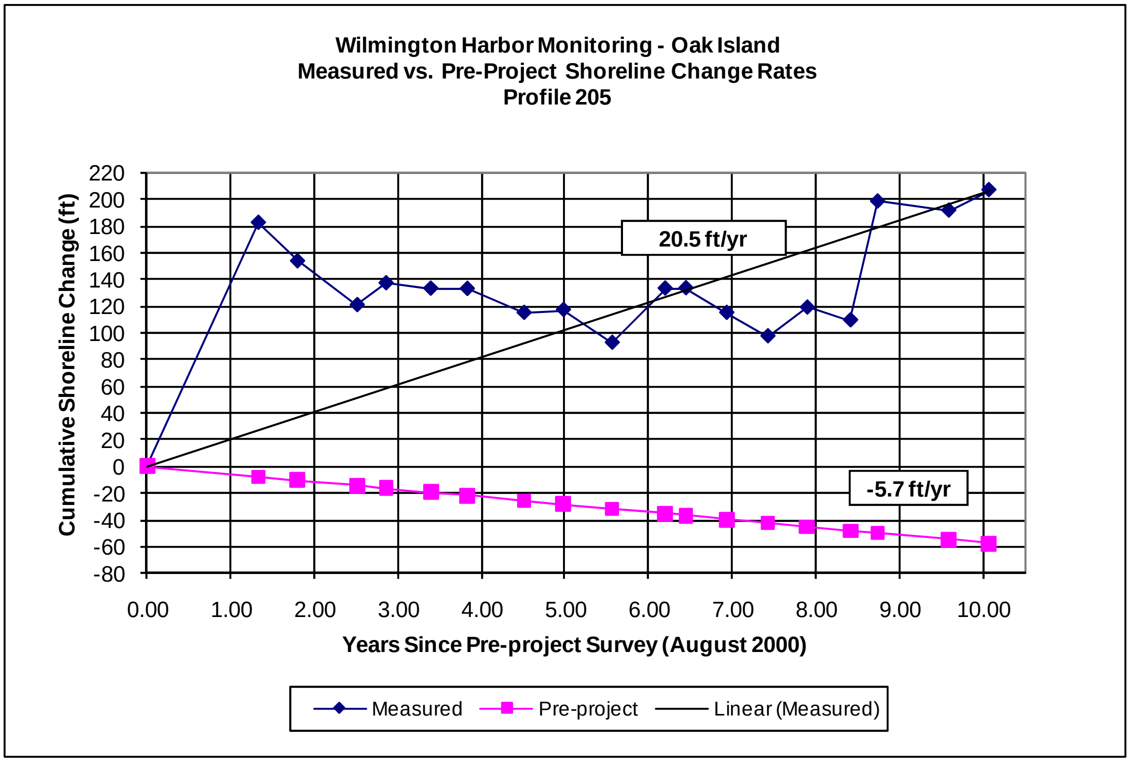

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 180
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
16.4 ft/yr
-5.0 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 185
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
17.9 ft/yr
-5.3 ft/yr
Measured
Pre-project
Linear (Measured)

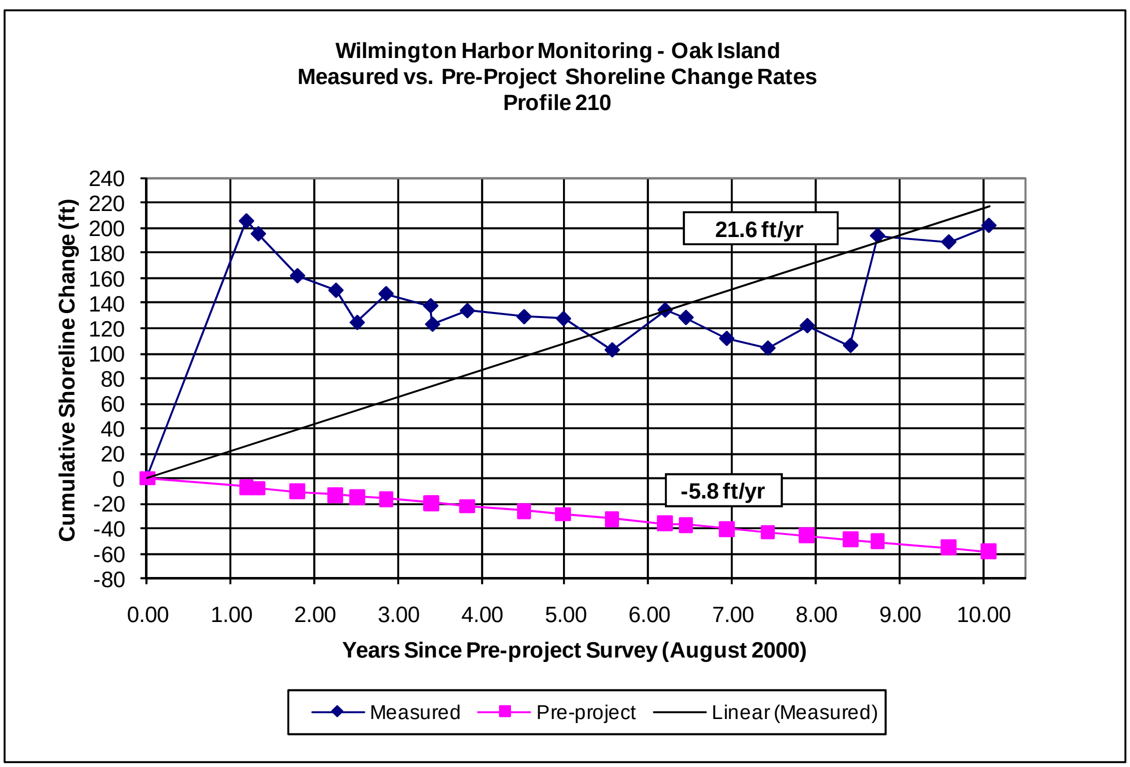

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
18.2 ft/yr
-5.4 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 195
17.6 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

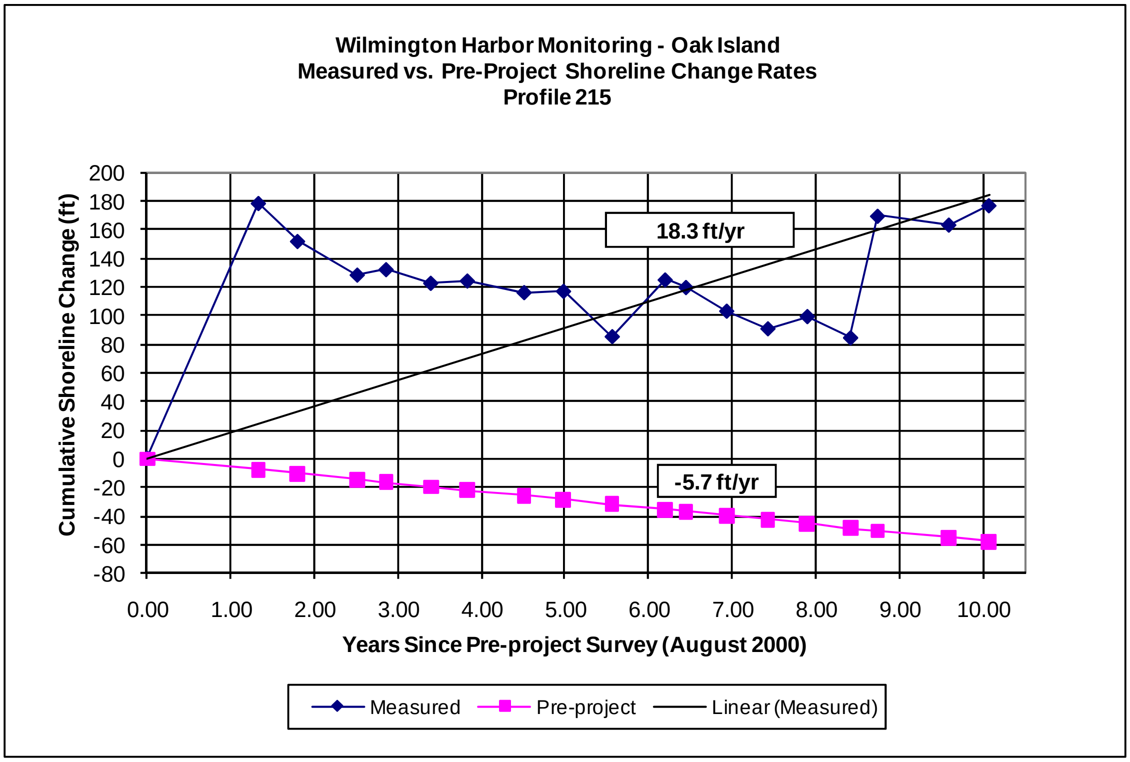

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 200
19.1 ft/yr
-5.6 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

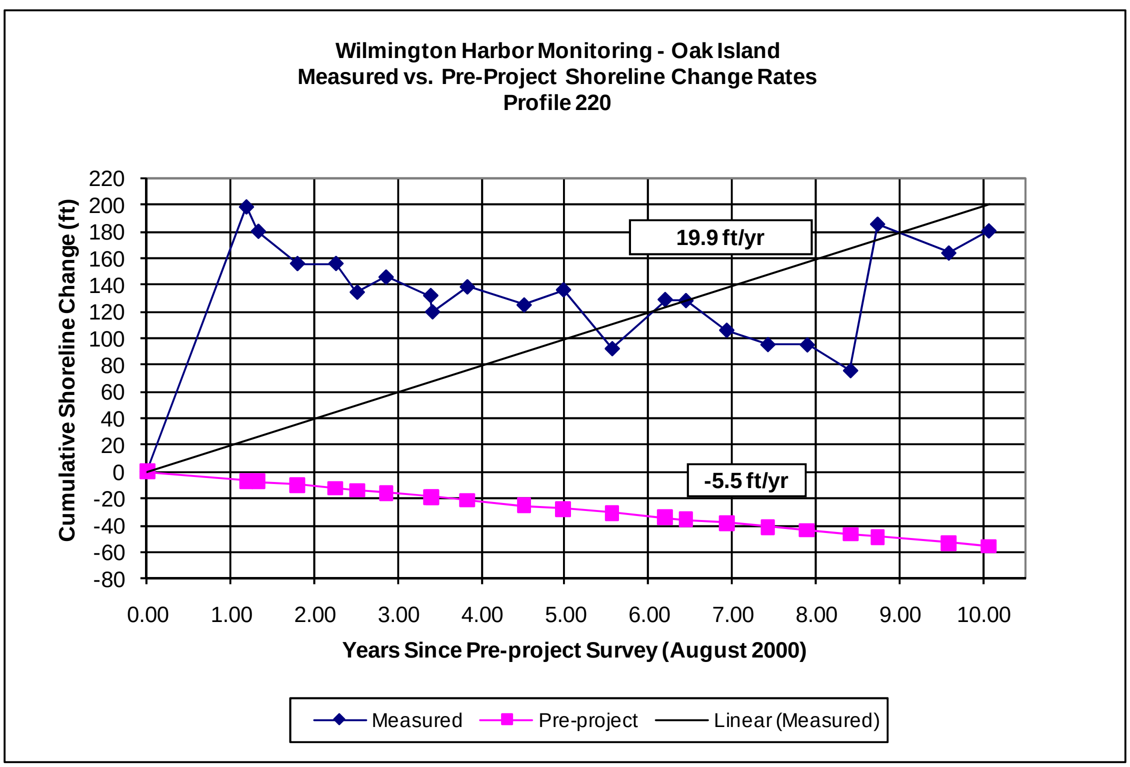


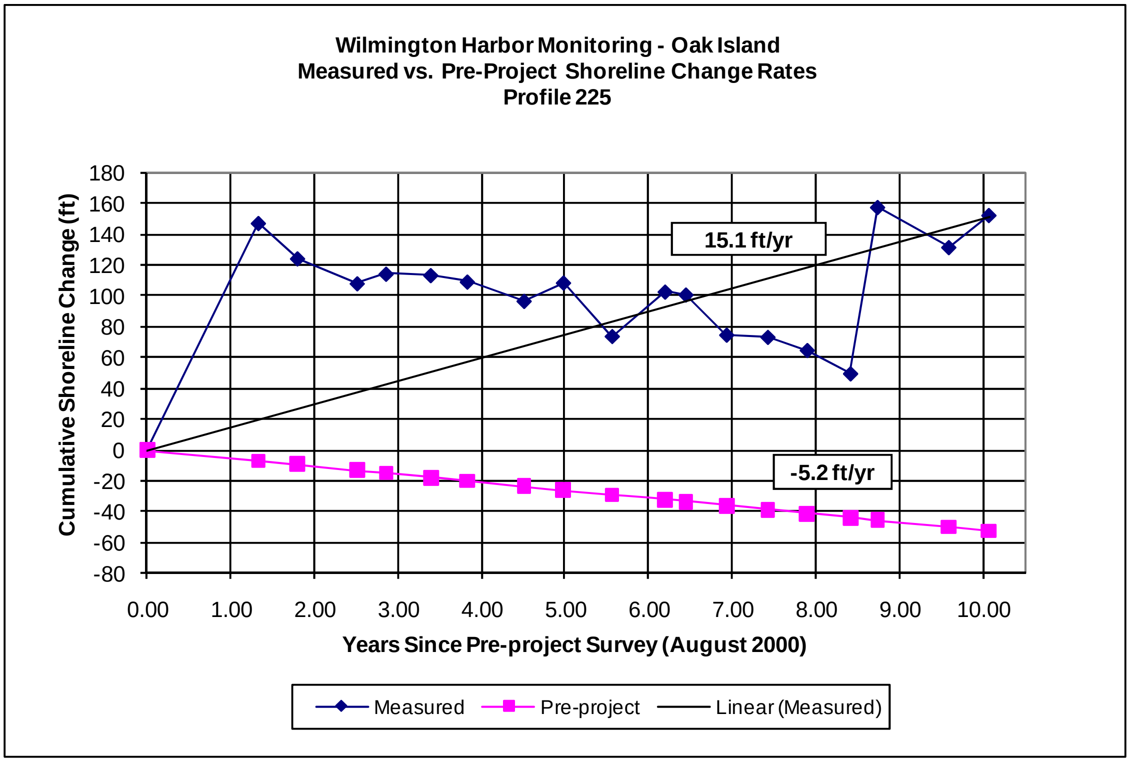
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 205
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
20.5 ft/yr
-5.7 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

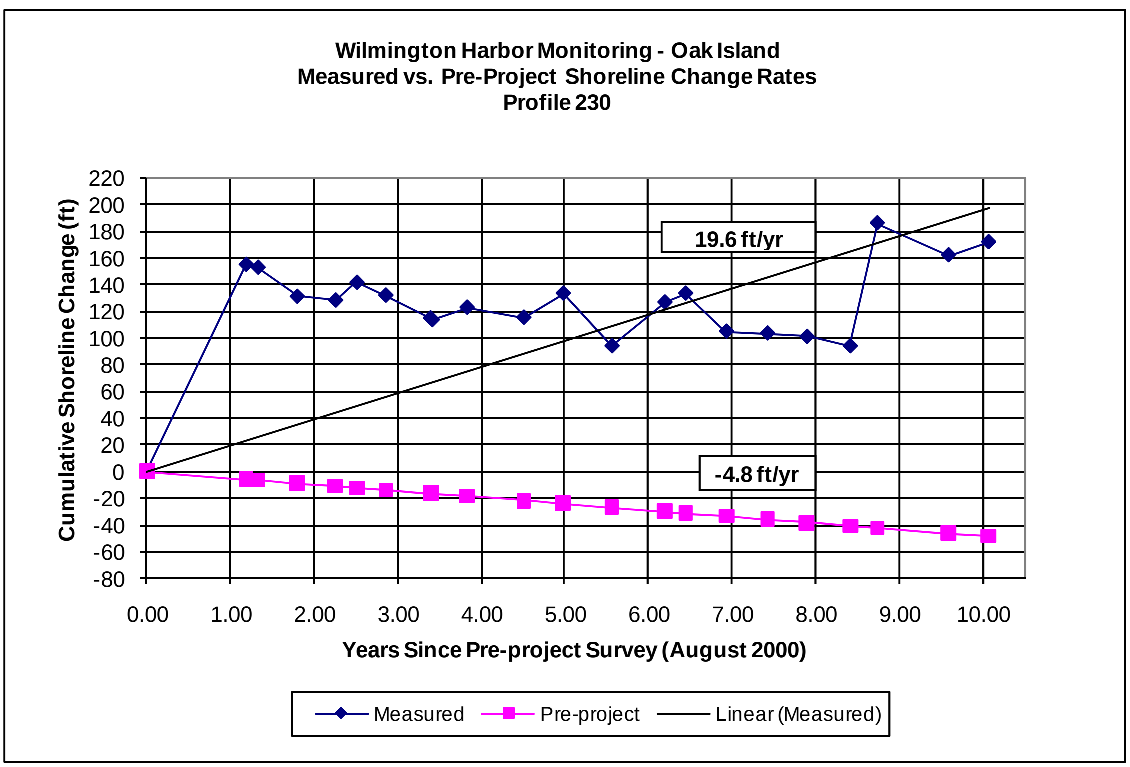


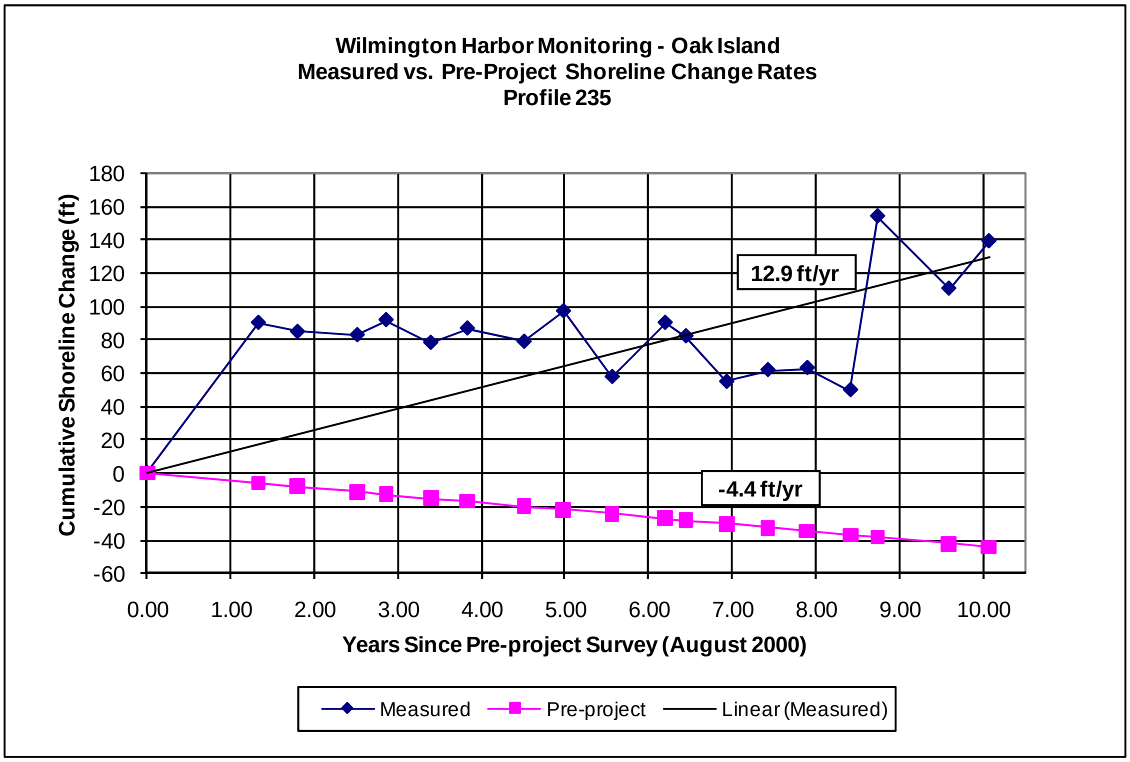
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
21.6 ft/yr
-5.8 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

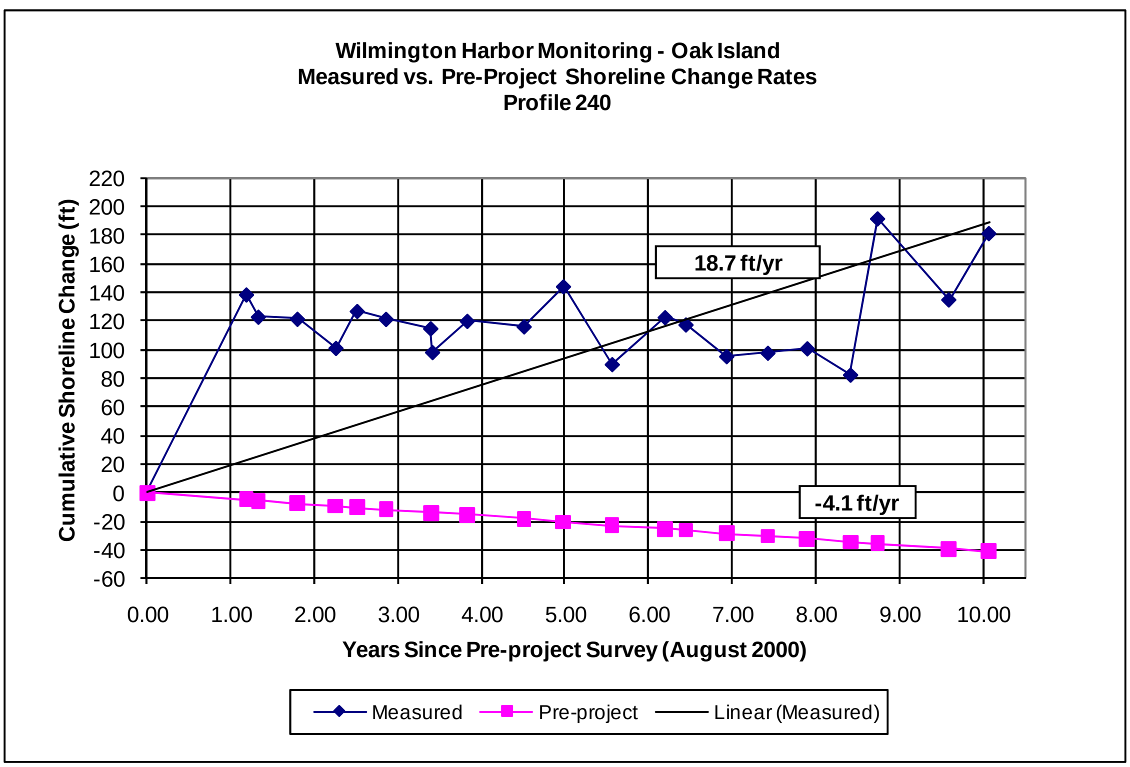

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 215
18.3 ft/yr
-5.7 ft/yr
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

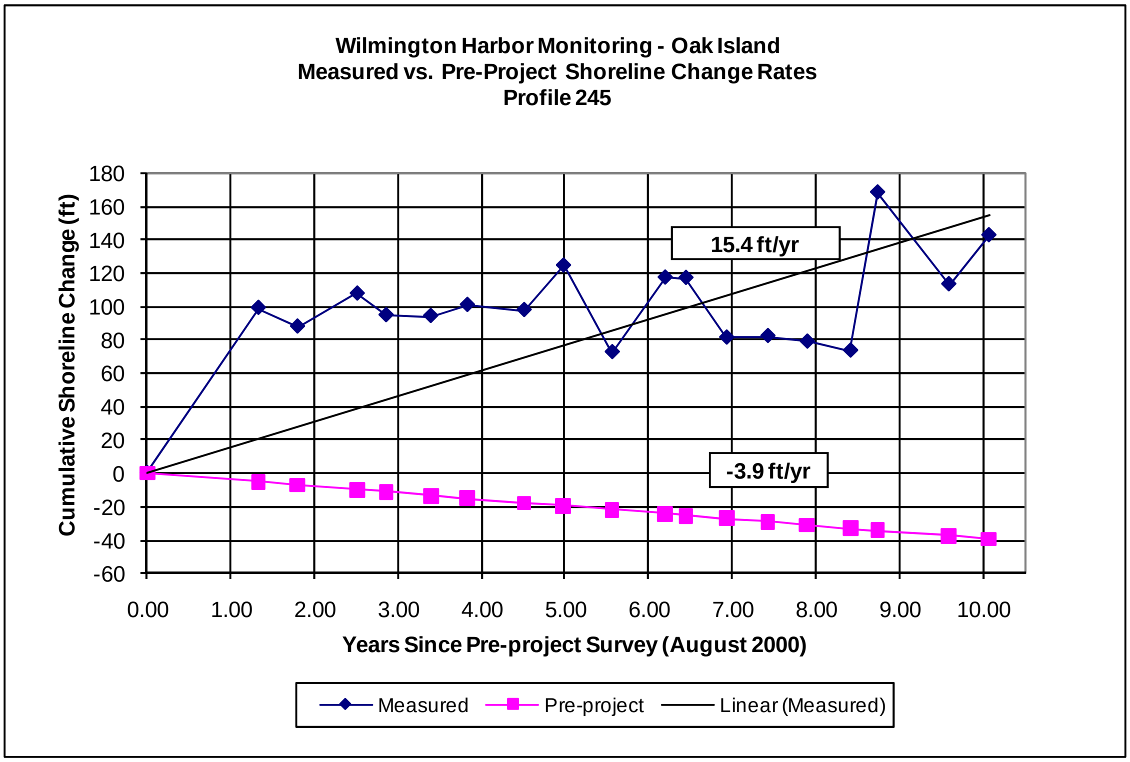

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 220
19.9 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

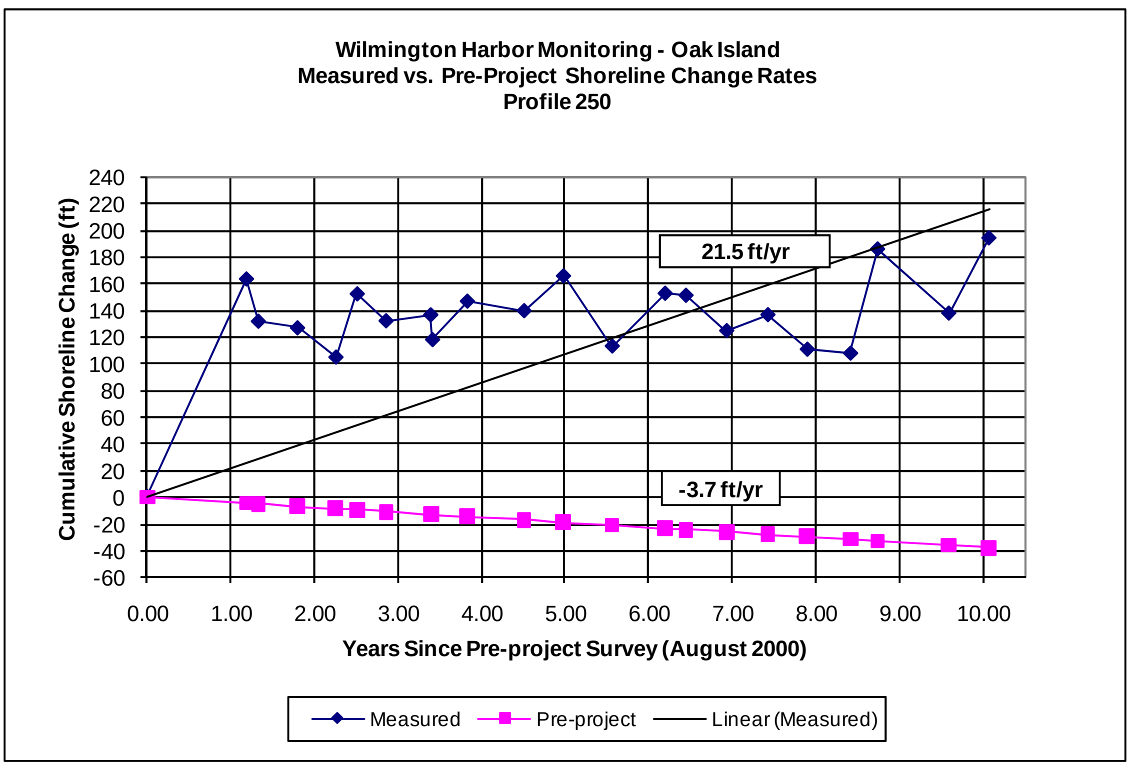

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 225
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
15.1 ft/yr
-5.2 ft/yr
Measured
Pre-project
Linear (Measured)

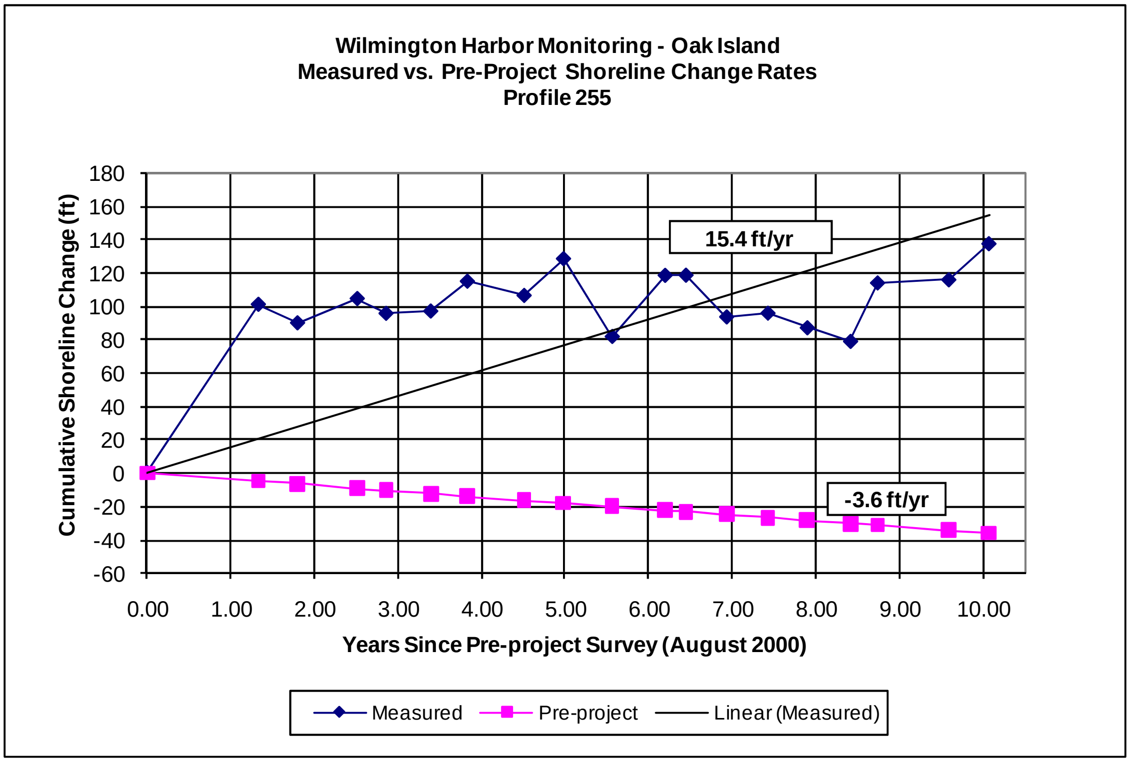

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 230
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
19.6 ft/yr
-4.8 ft/yr
Measured
Pre-project
Linear (Measured)

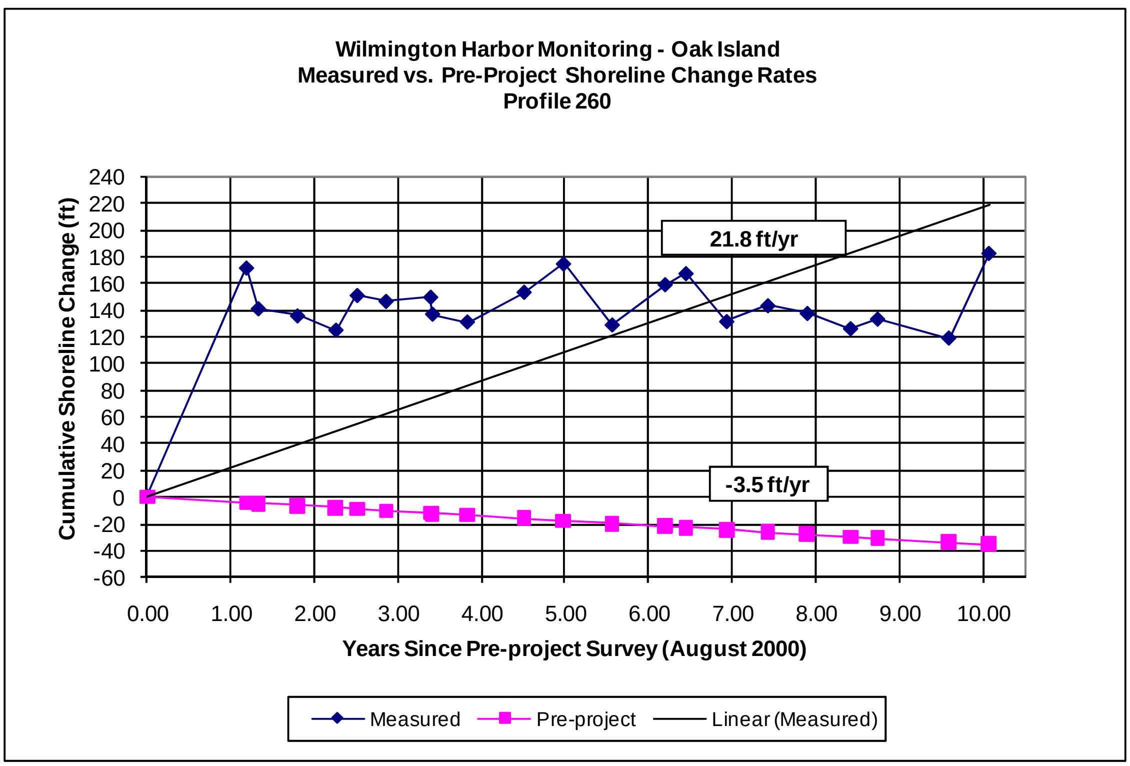

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 235
12.9 ft/yr
-4.4 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

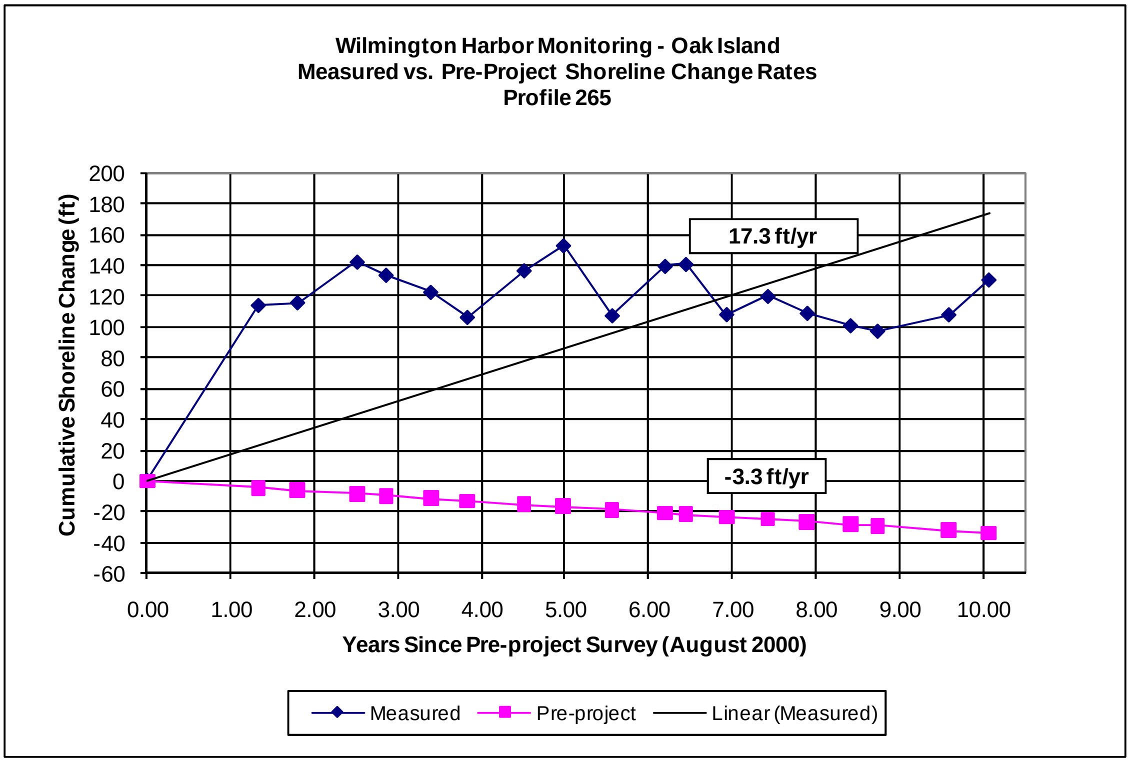

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 240
18.7 ft/yr
-4.1 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

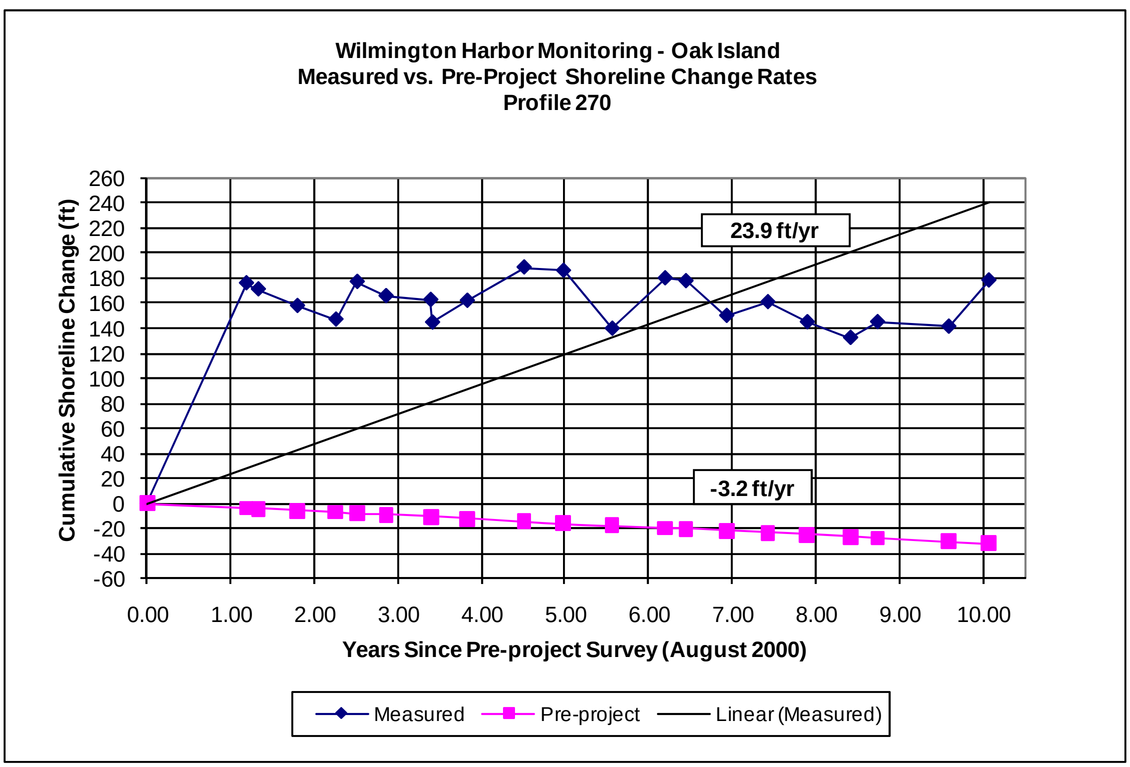

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 245
15.4 ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

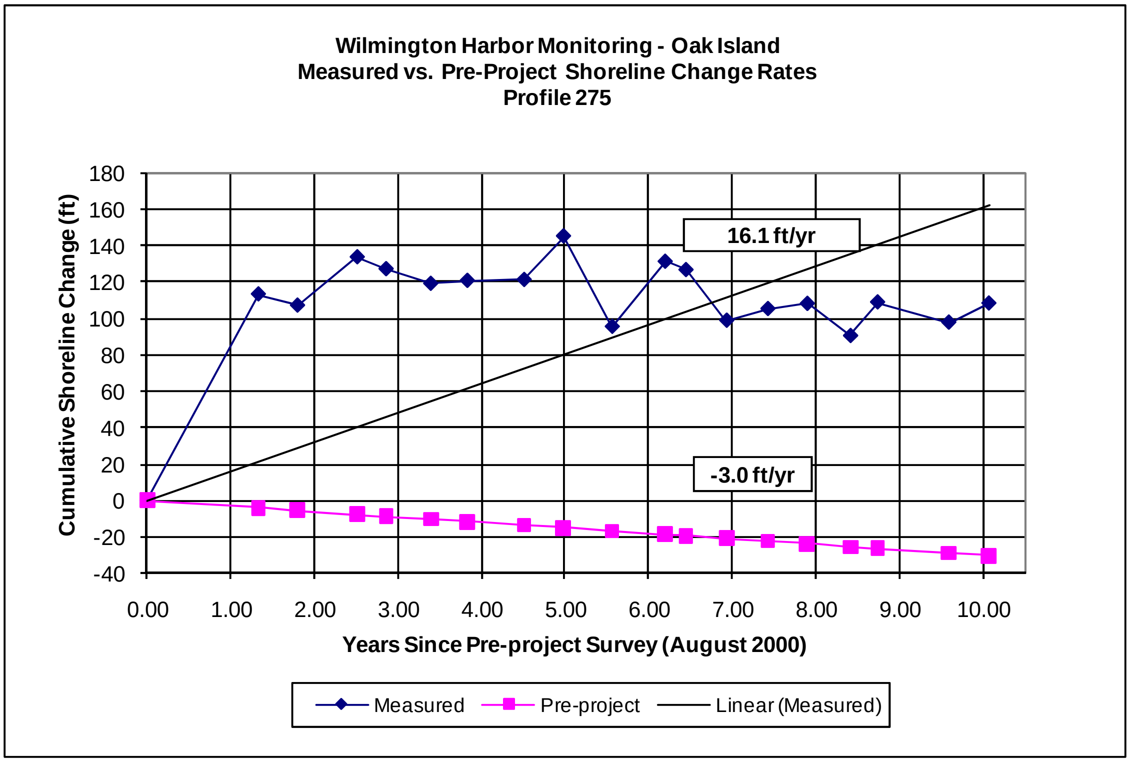

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 250
21.5 ft/yr
-3.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

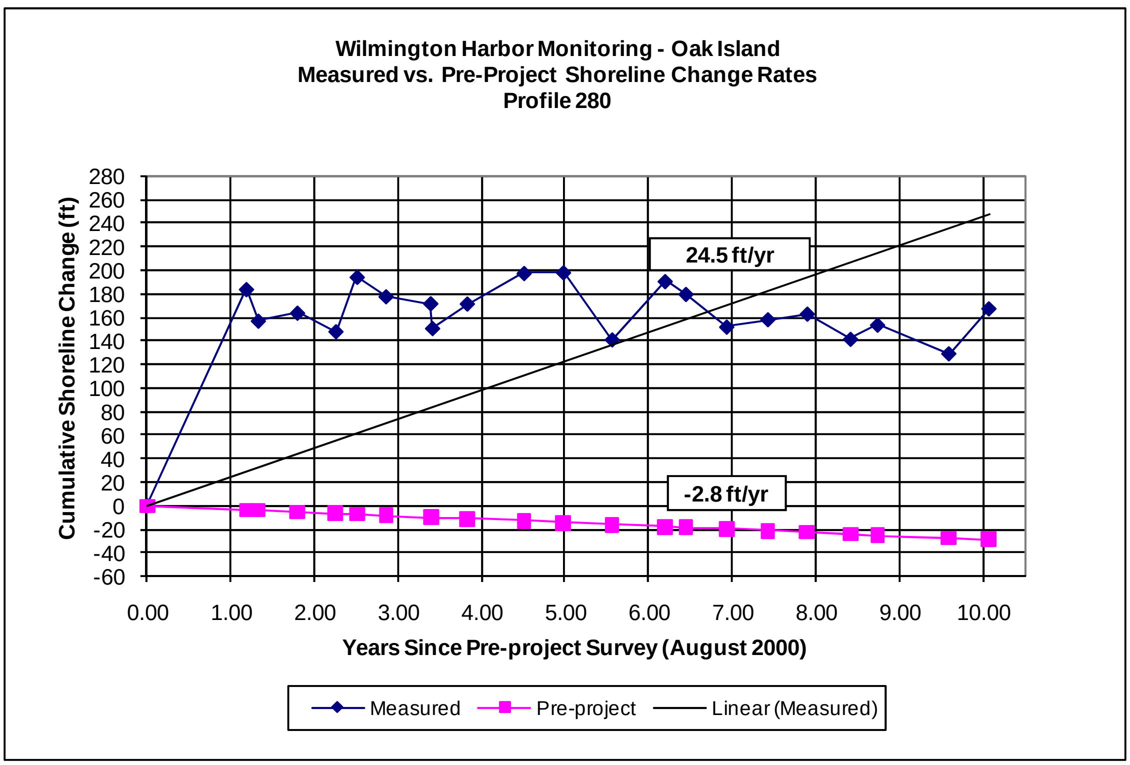

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 255
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
15.4 ft/yr
-3.6 ft/yr
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Measured
Pre-project
Linear (Measured)

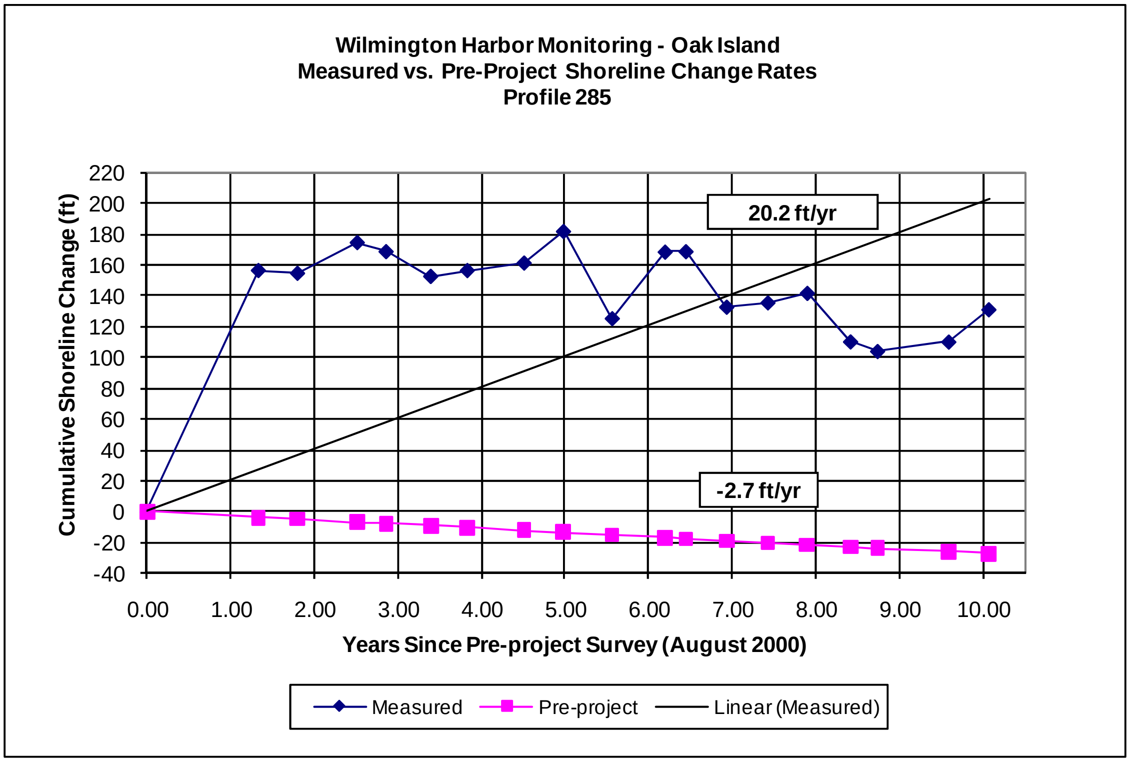

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 260
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
21.8 ft/yr
-3.5 ft/yr
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Measured
Pre-project
Linear (Measured)

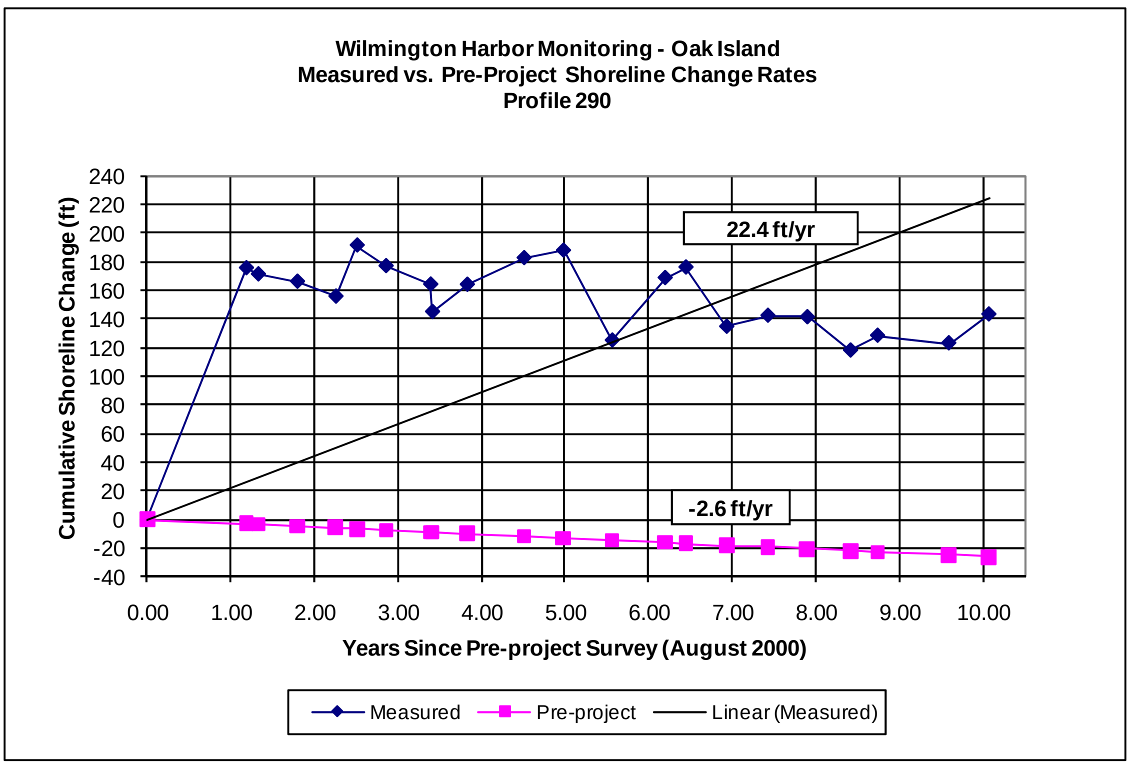

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 265
17.3 ft/yr
-3.3 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

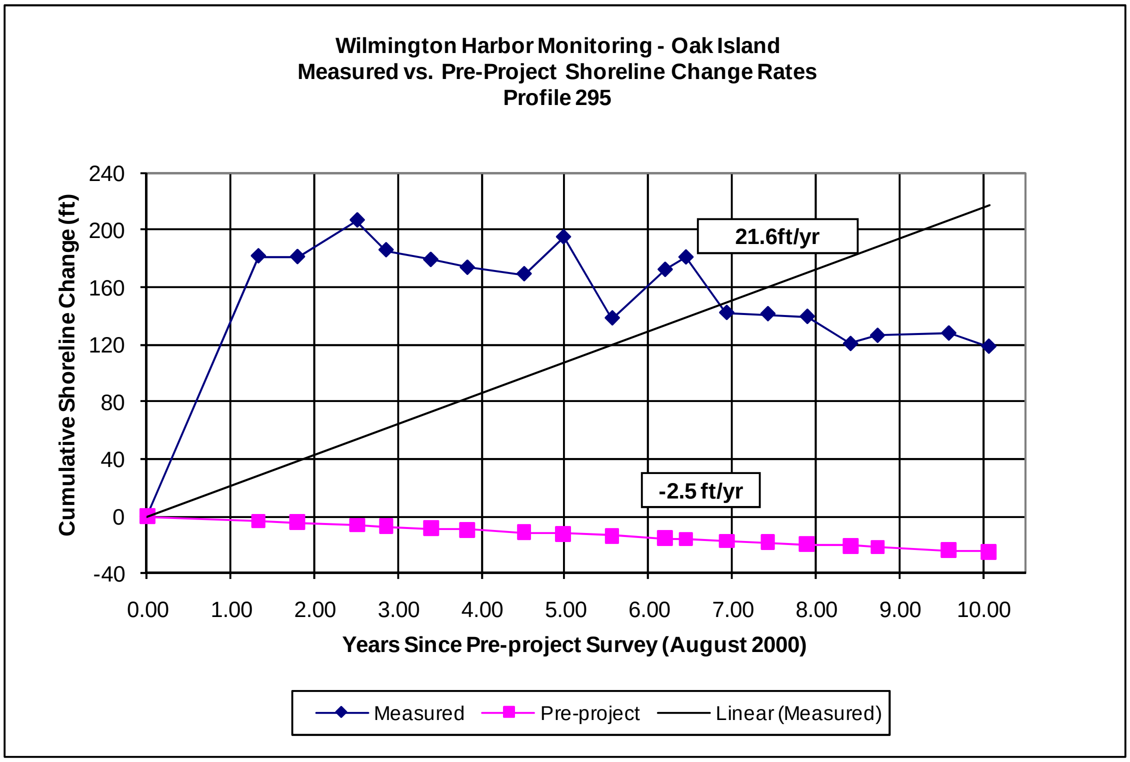

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 270
23.9 ft/yr
-3.2 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

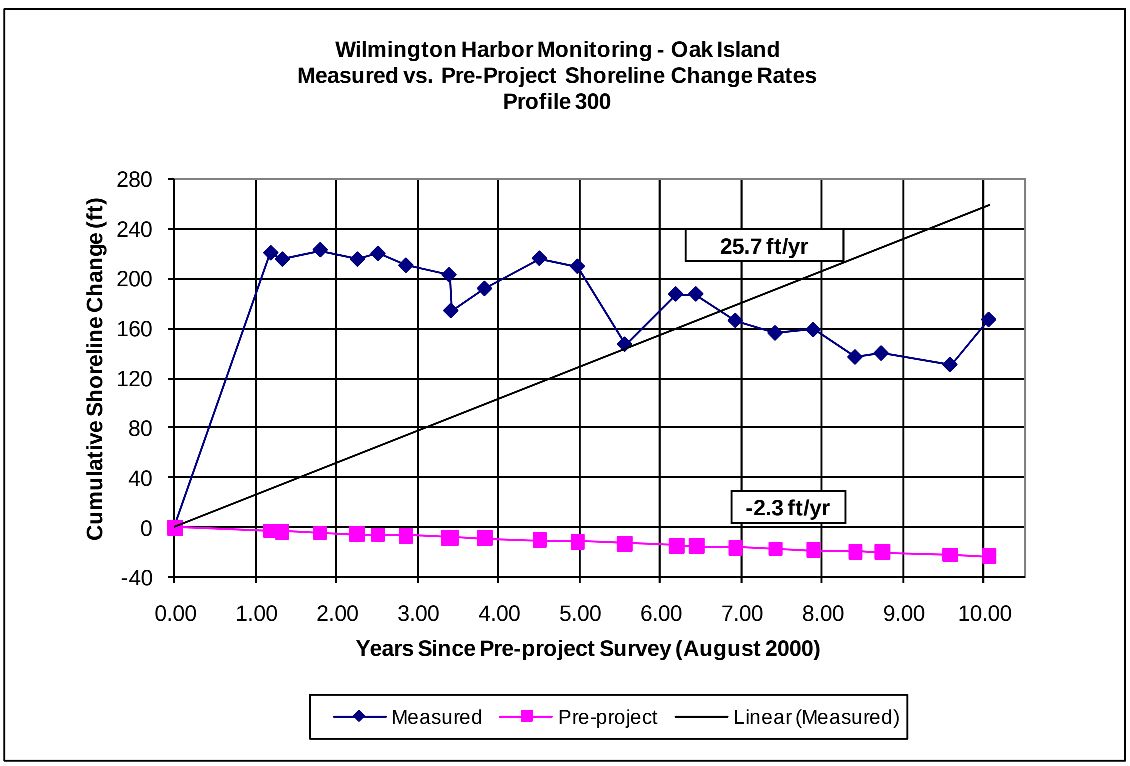

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 275
16.1 ft/yr
-3.0 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

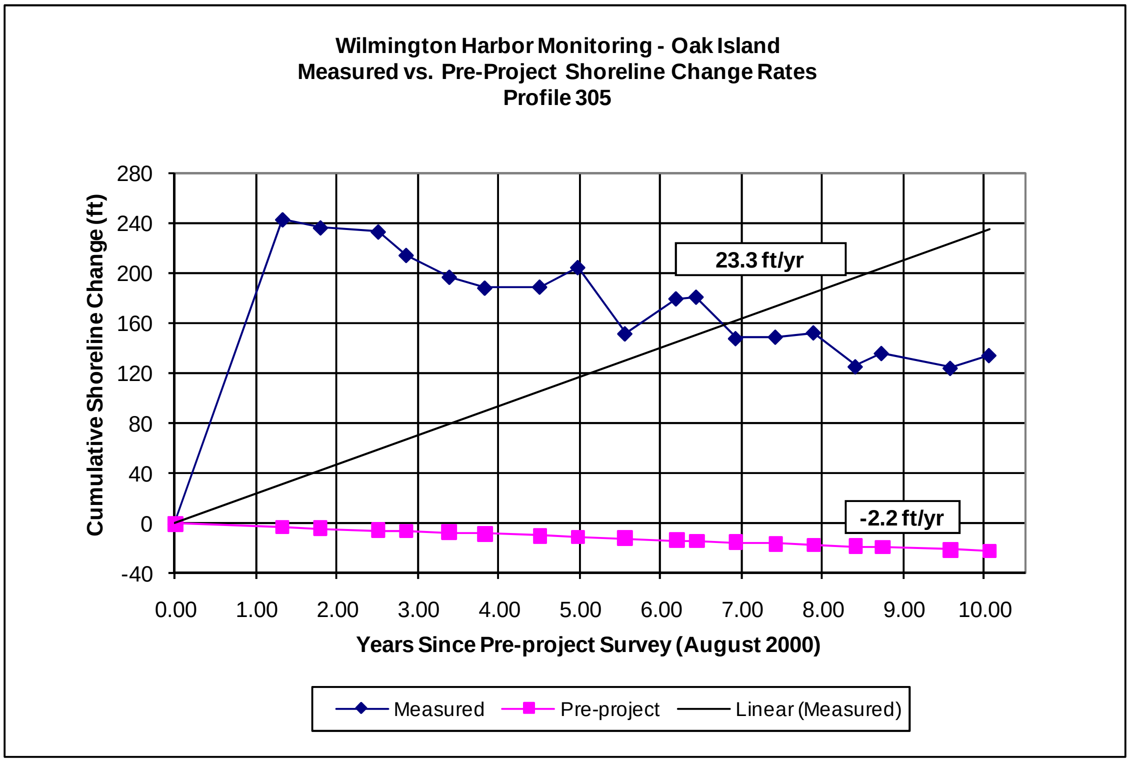

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 280
24.5 ft/yr
-2.8 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

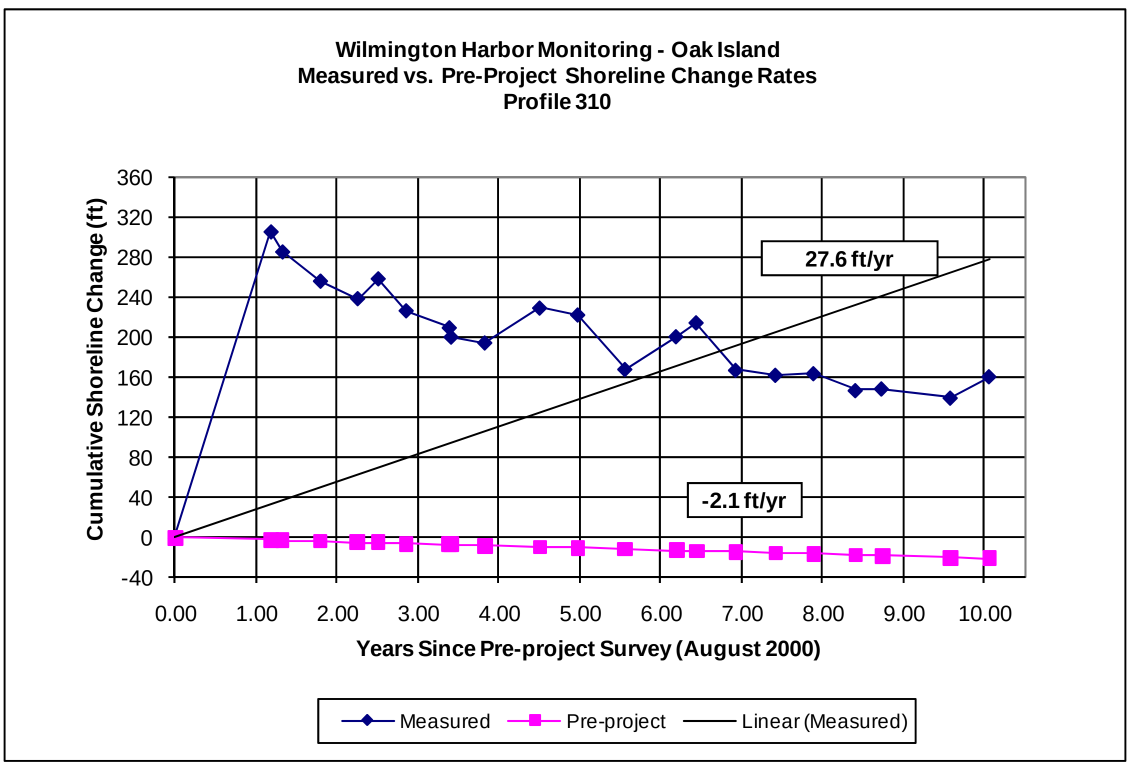

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 285
20.2 ft/yr
-2.7 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 290
22.4 ft/yr
-2.6 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 295
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
21.6ft/yr
-2.5 ft/yr
Measured
Pre-project
Linear (Measured)

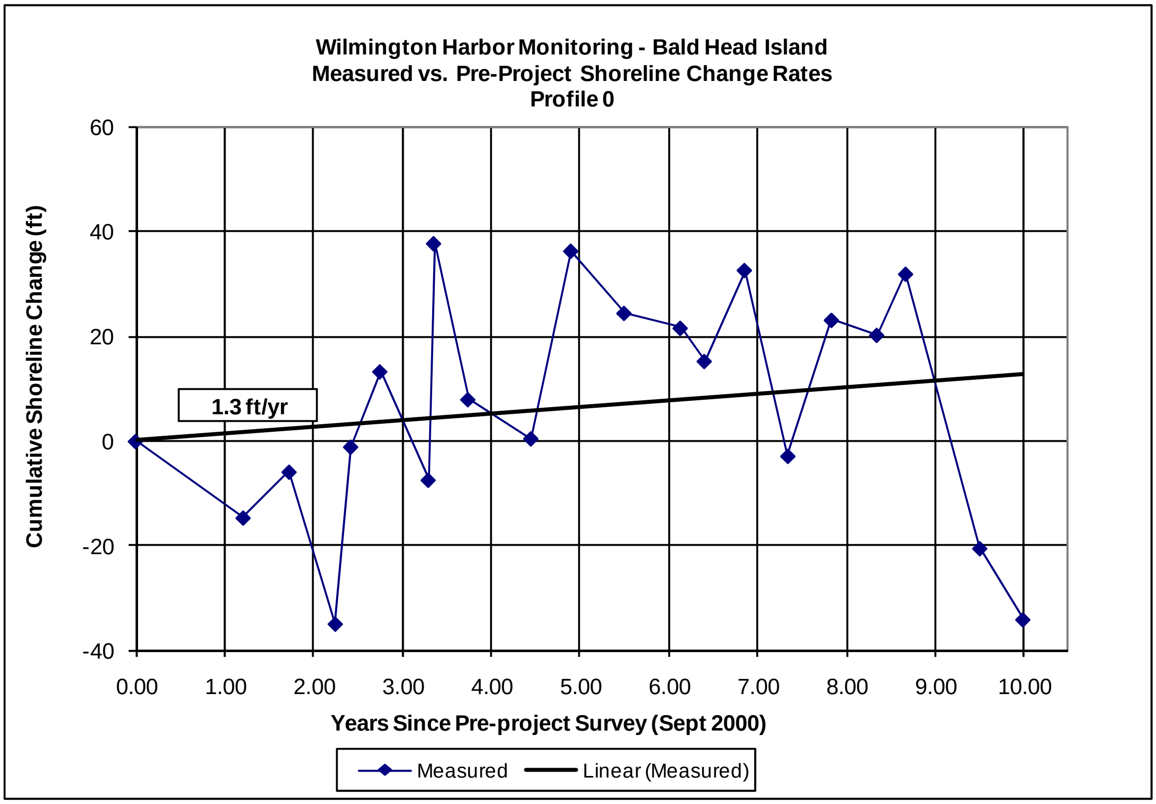

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 300
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (August 2000)
25.7 ft/yr
-2.3 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 305
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
23.3 ft/yr
-2.2 ft/yr
Measured
Pre-project
Linear (Measured)

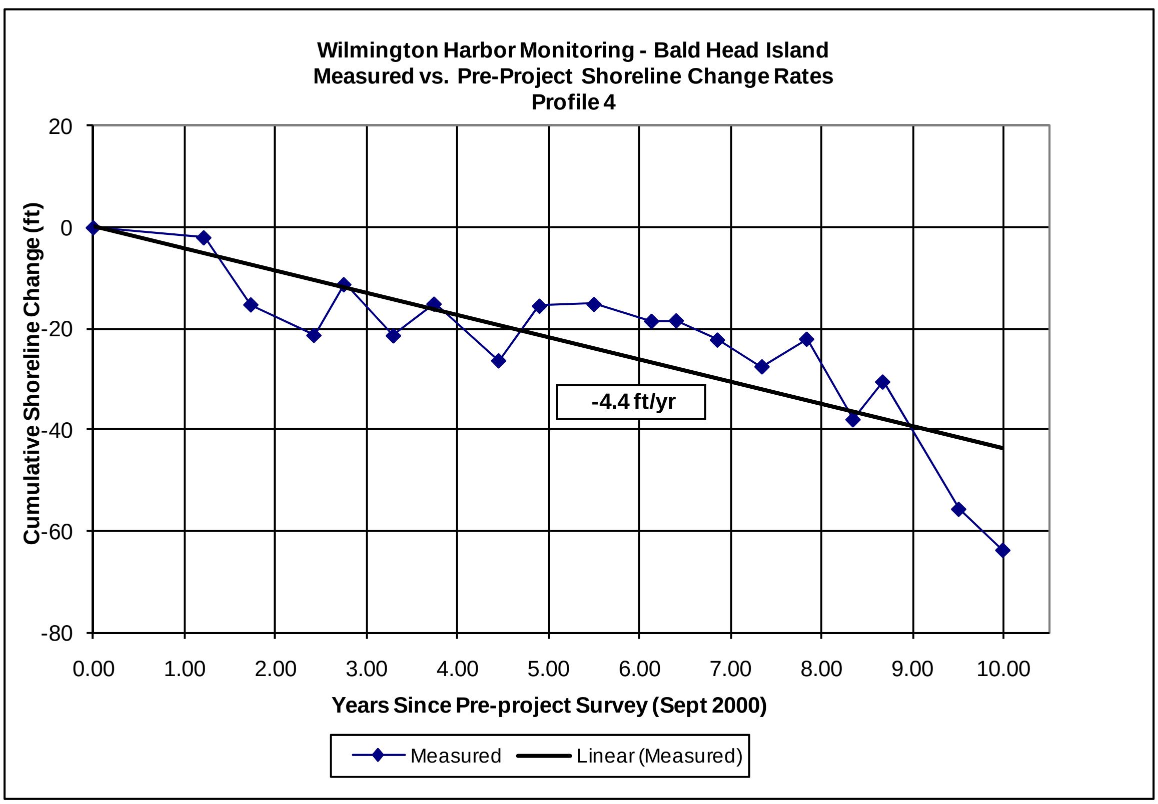

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 310
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
27.6 ft/yr
-2.1 ft/yr
Measured
Pre-project
Linear (Measured)

Appendix C

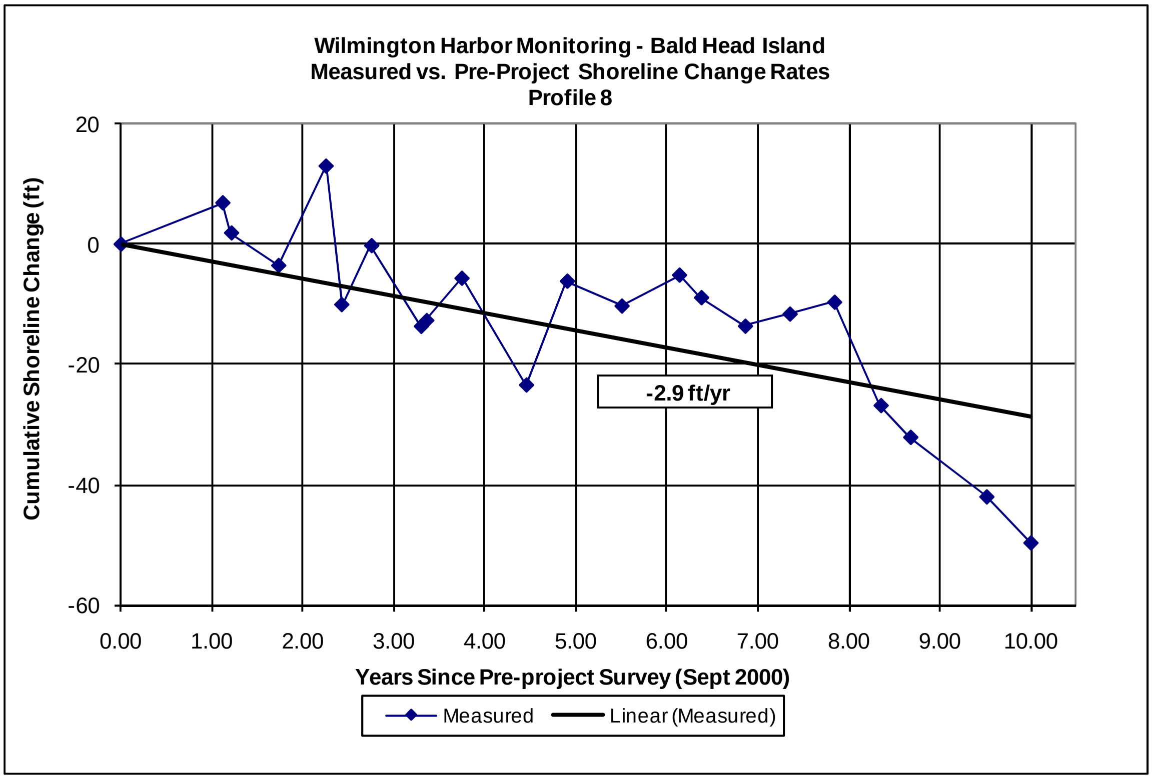
SHORELINE CHANGE RATES
(Bald Head Island)



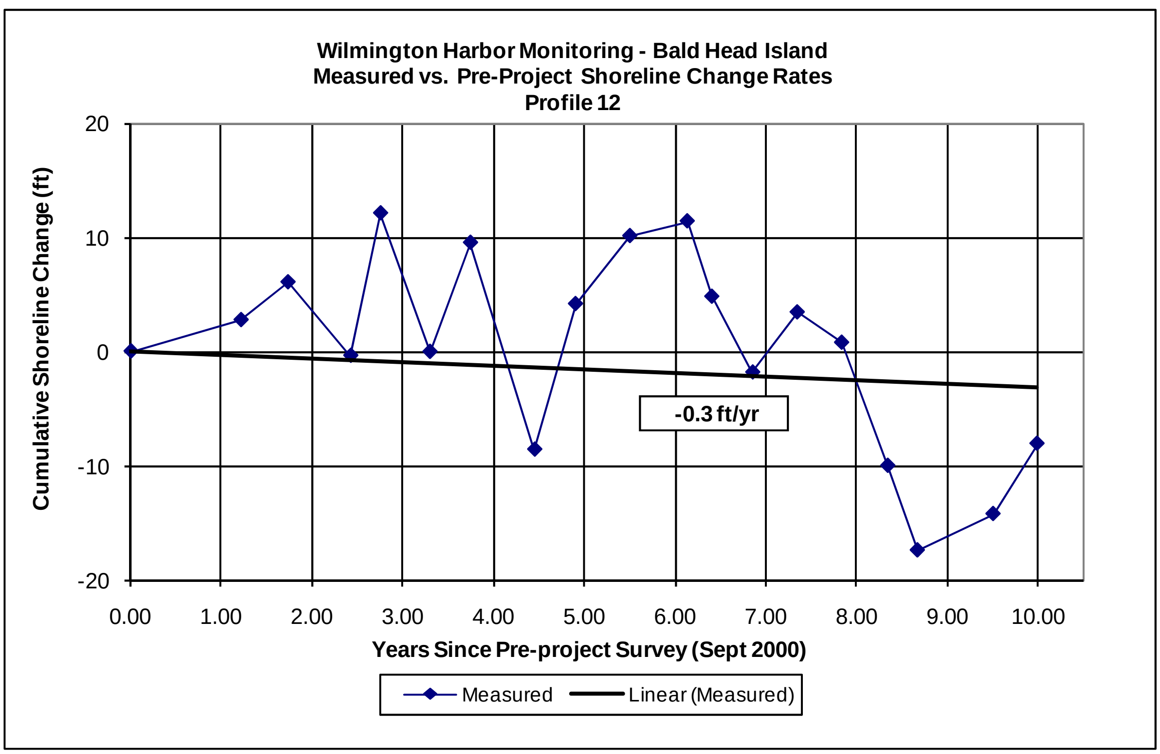
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 0
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
1.3 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)



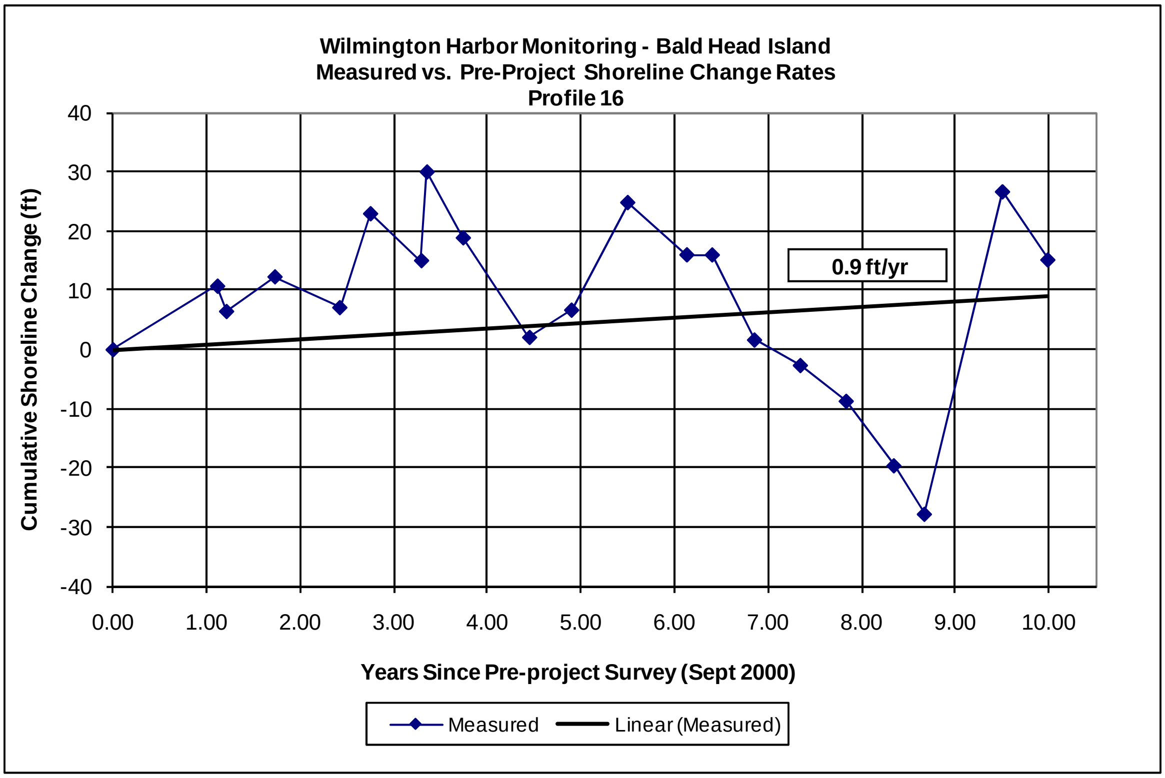
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 4
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-4.4 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

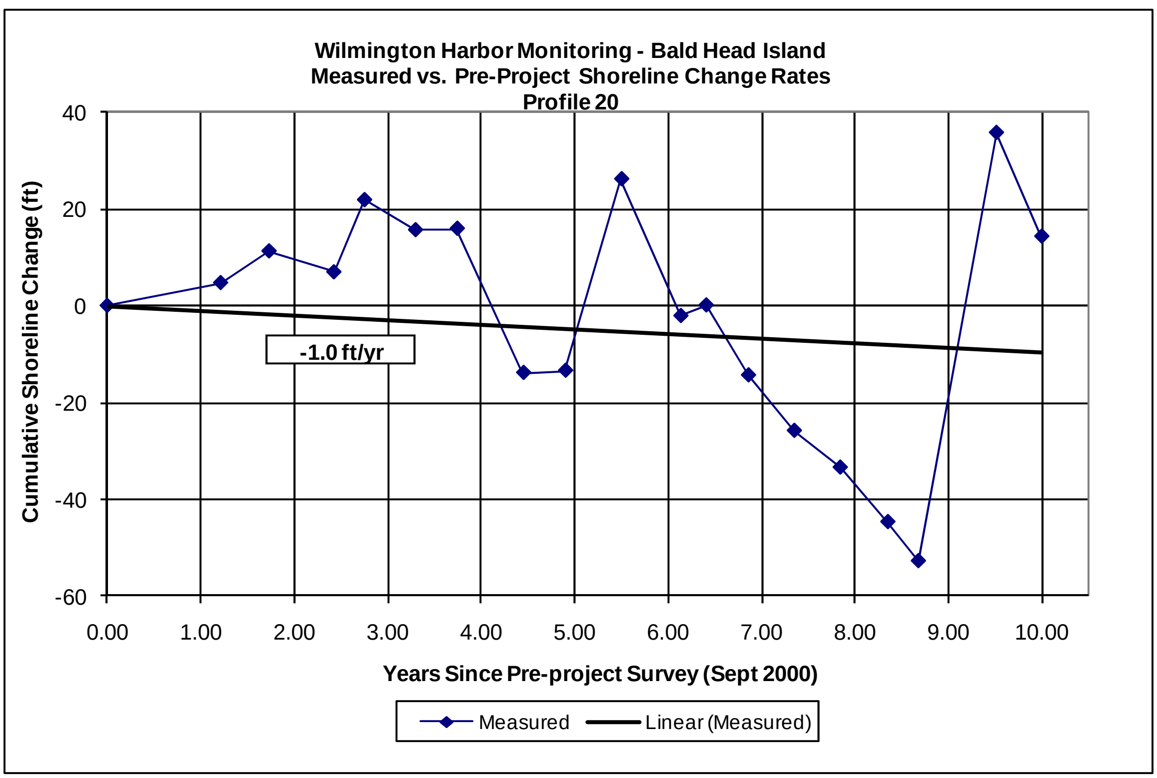


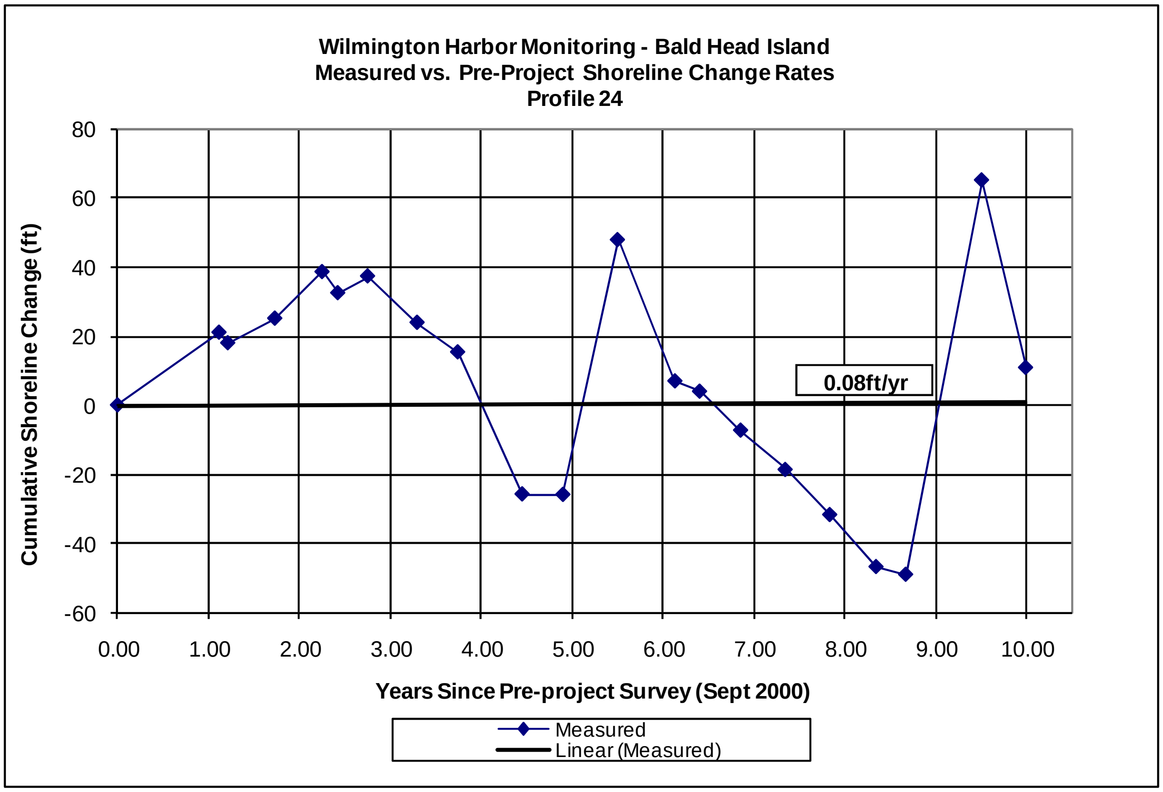
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 8
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
-2.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

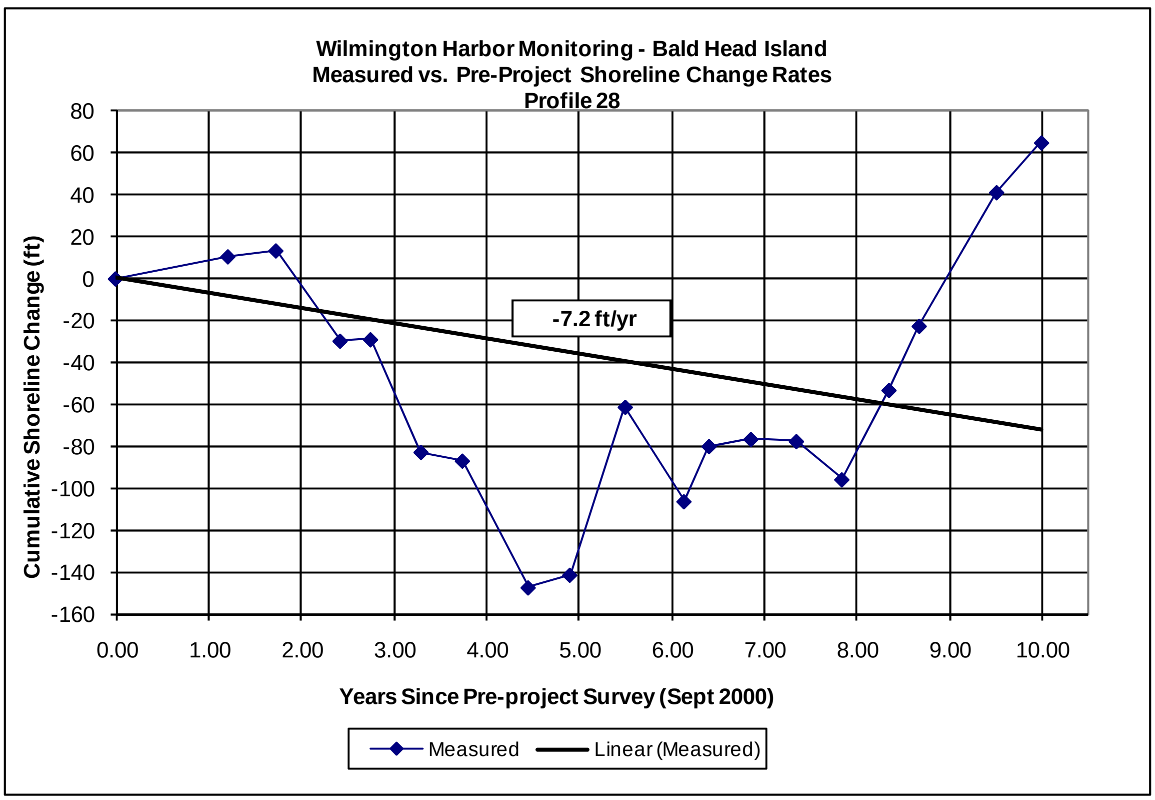


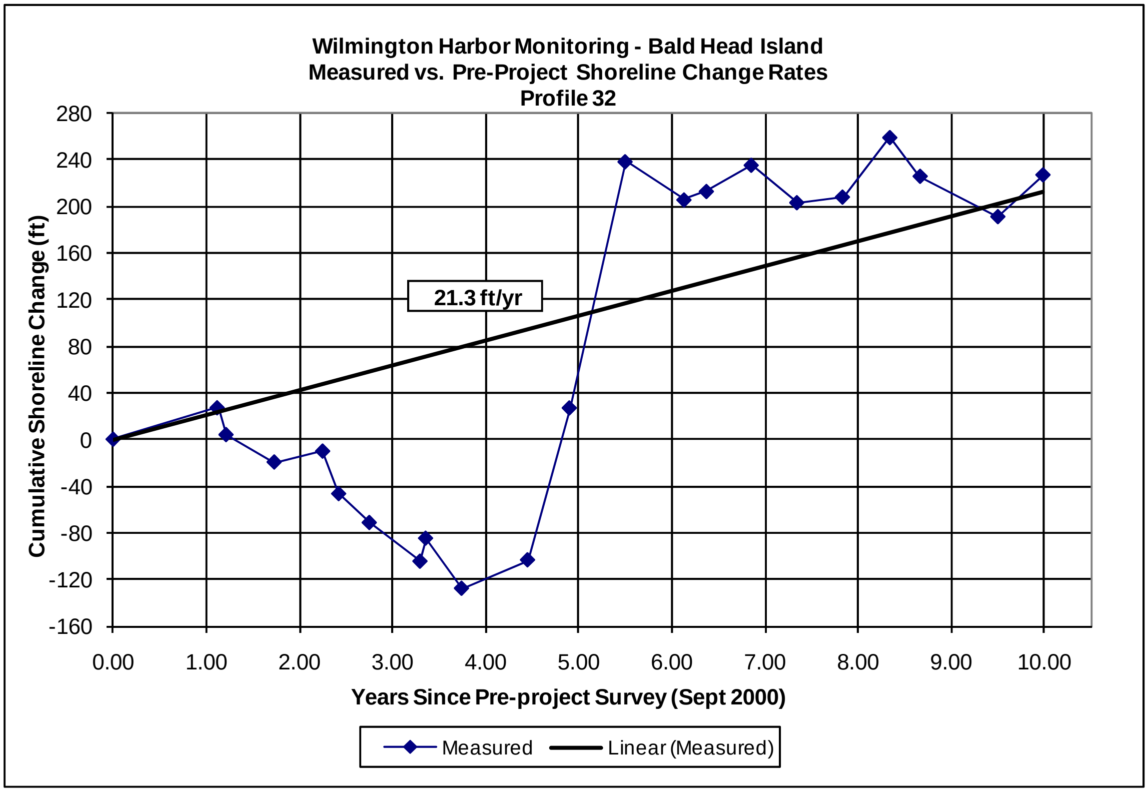
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 12
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
-0.3 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

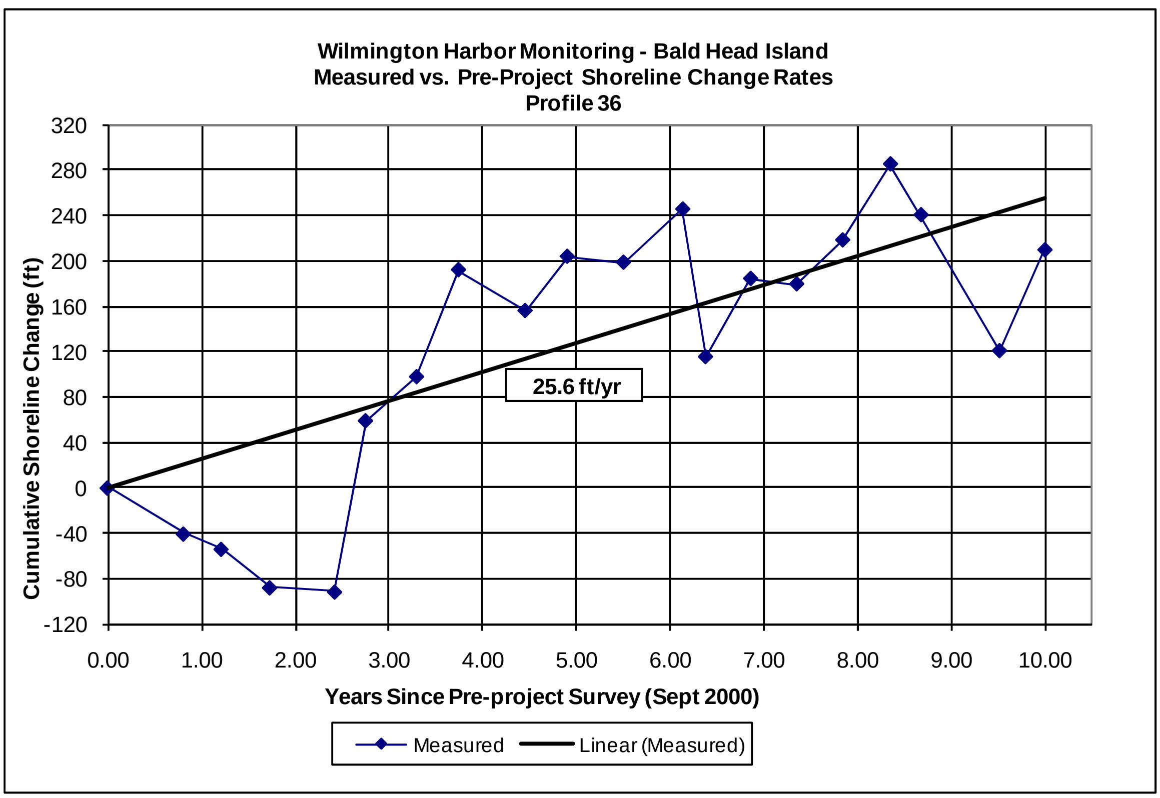

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 16
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
0.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

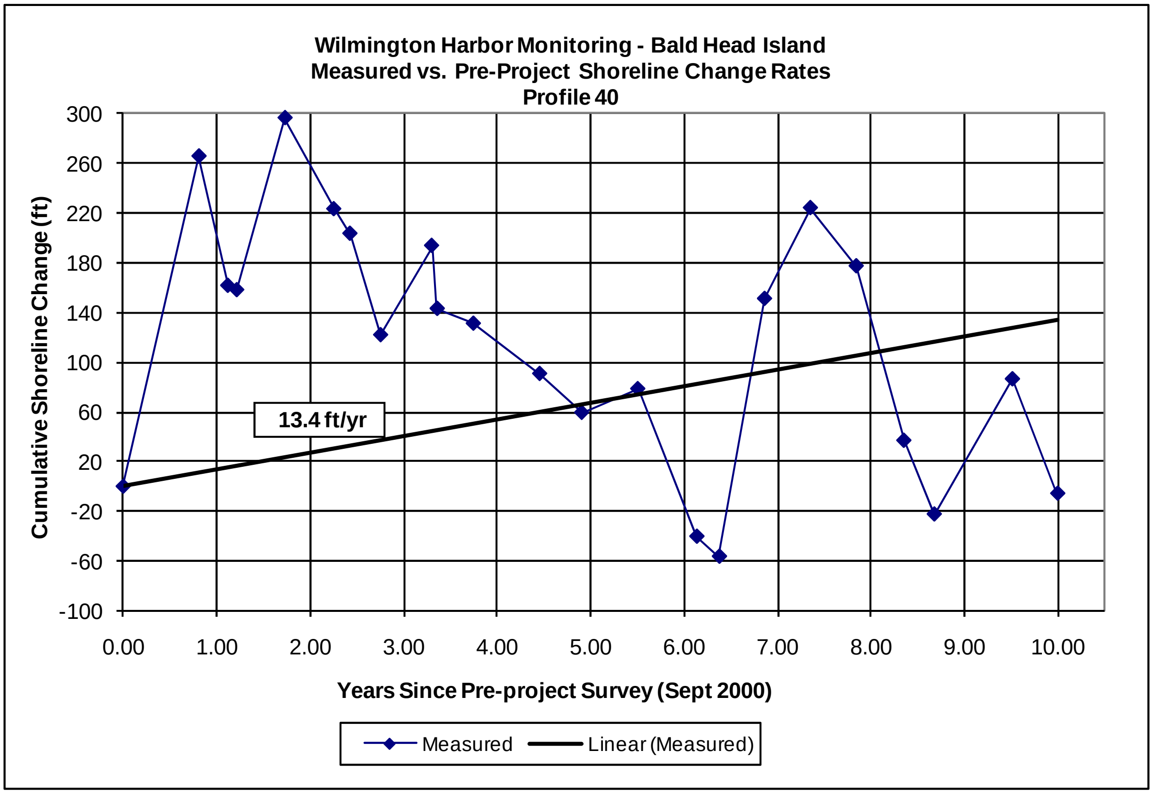

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
-1.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 24
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
0.08ft/yr
Measured
Linear (Measured)

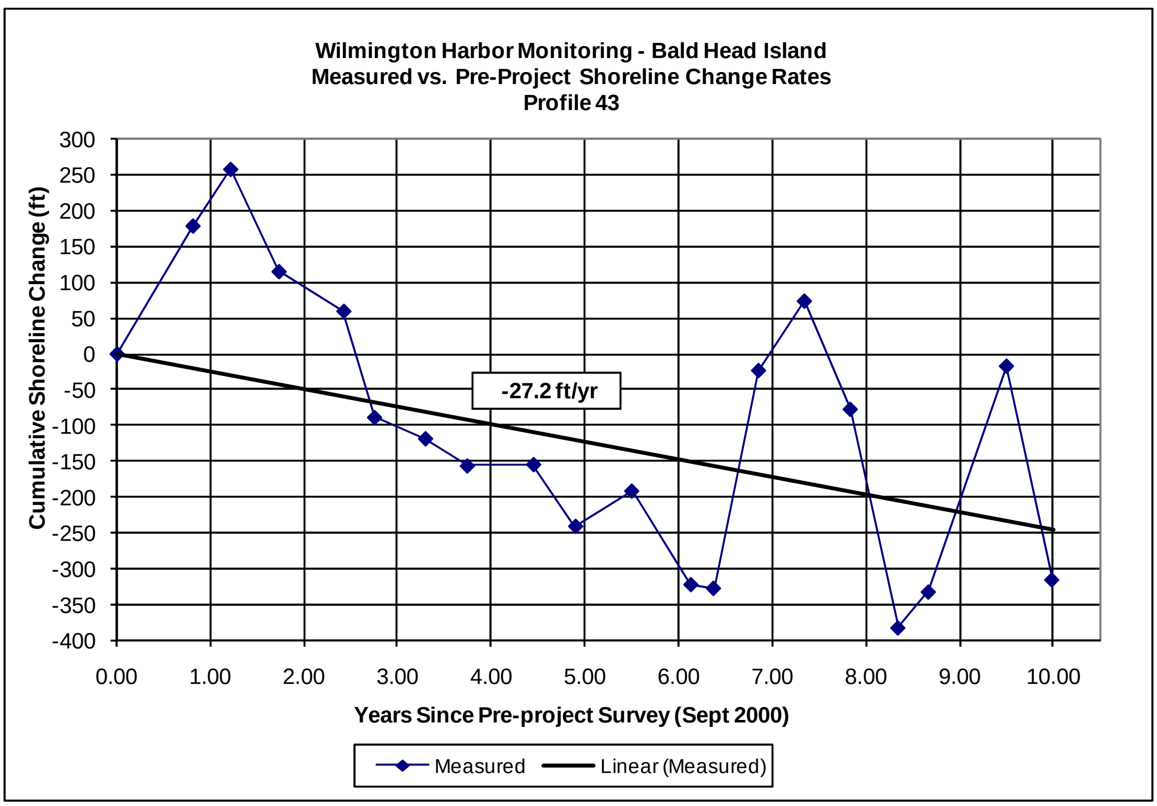

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 28
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
-7.2 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 32
21.3 ft/yr
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
-80
-120
-160
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

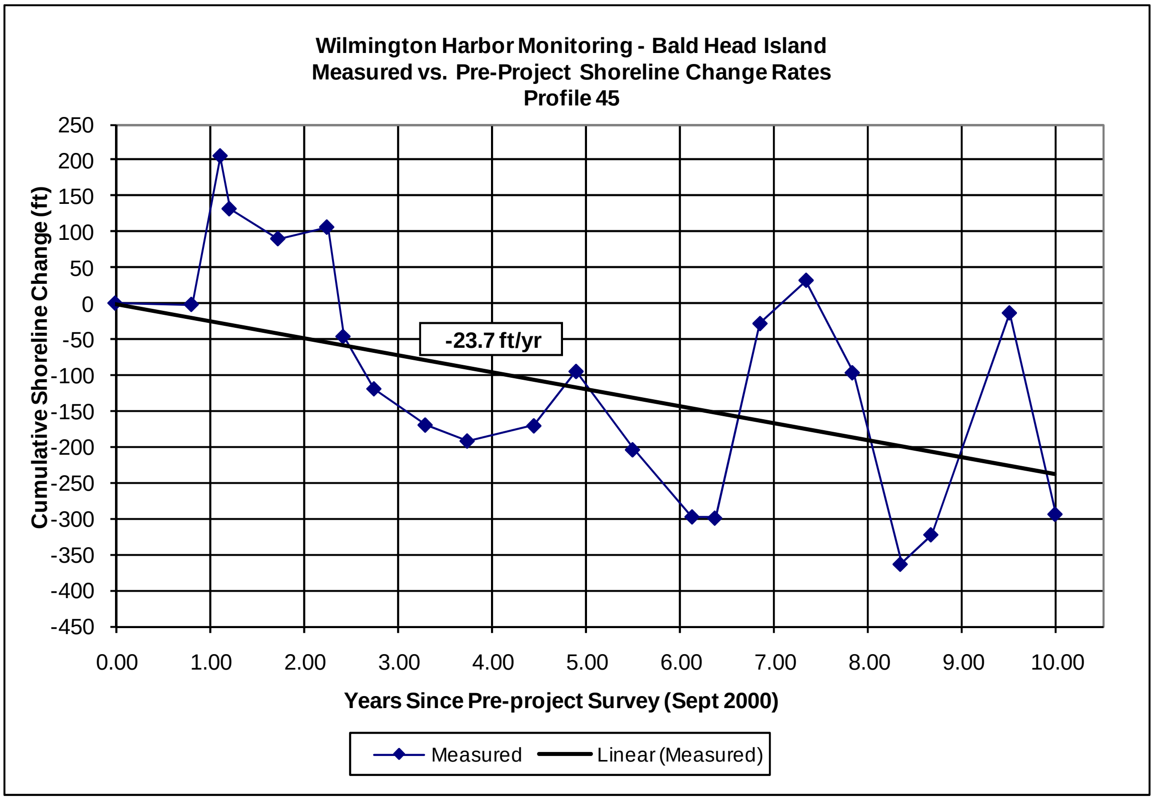

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 36
25.6 ft/yr
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

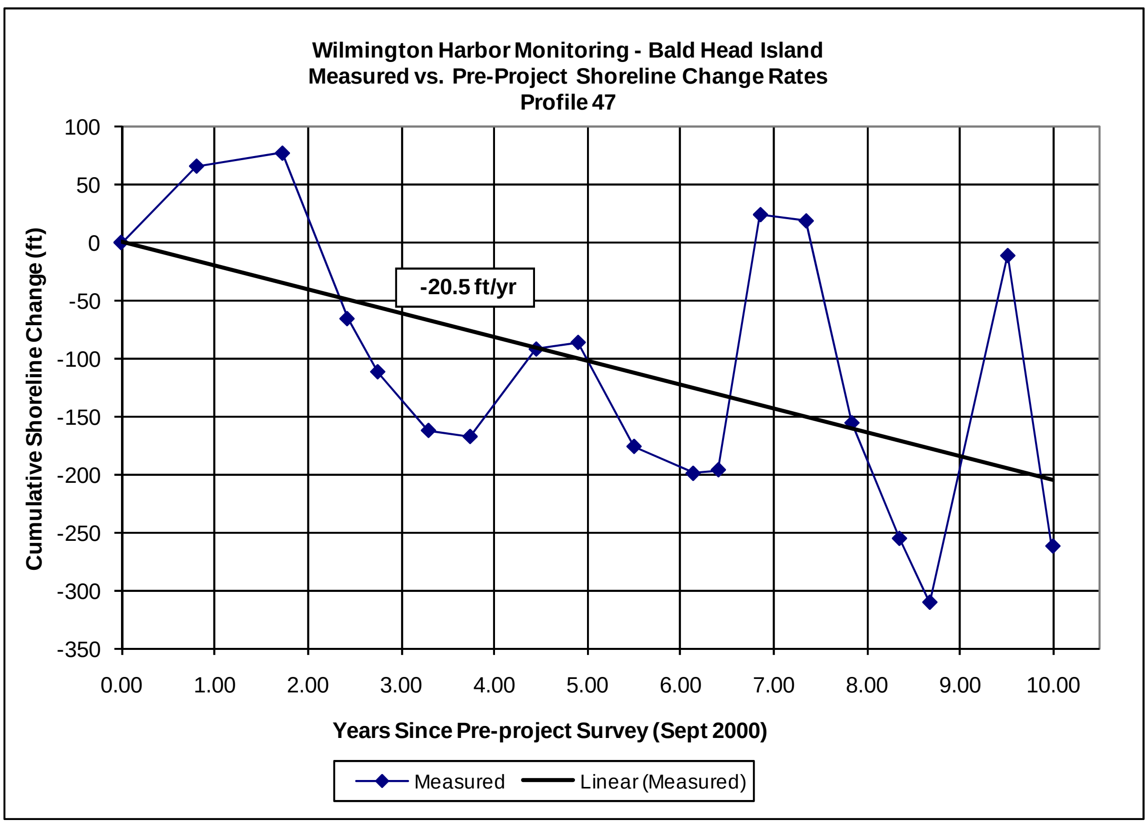


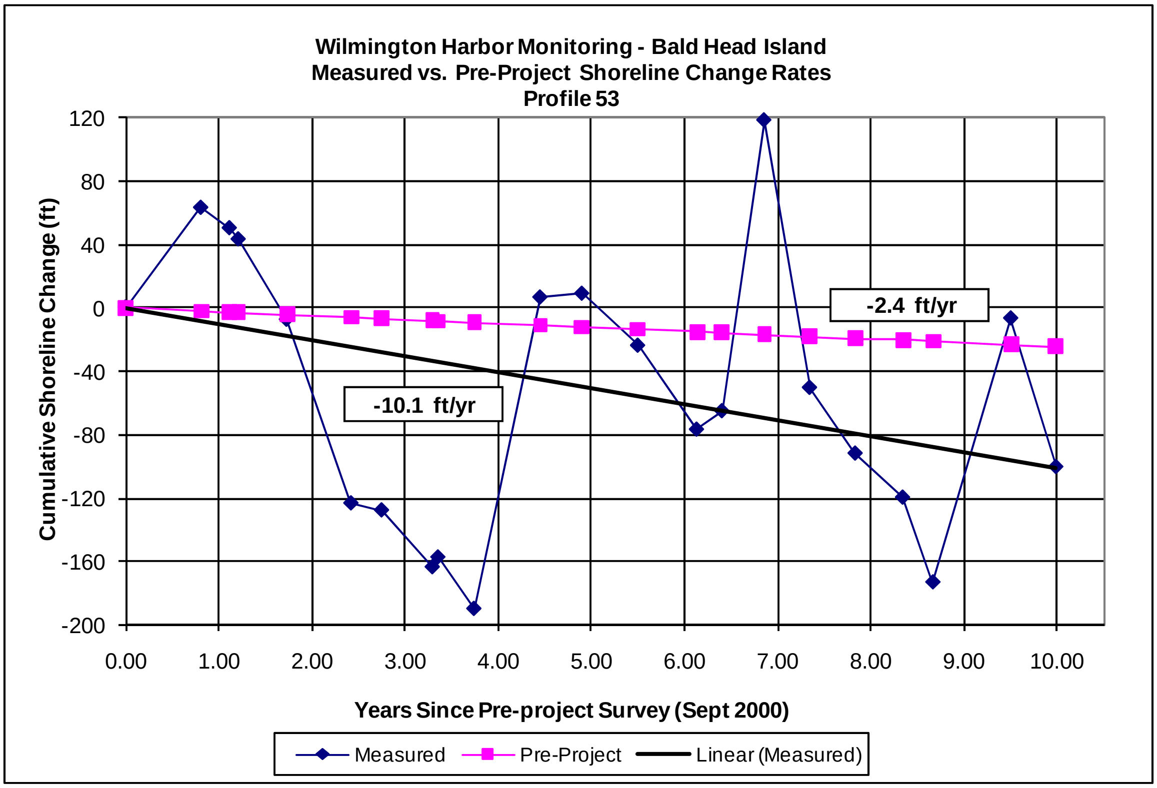
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
Cumulative Shoreline Change (ft)
300
260
220
180
140
100
60
20
-20
-60
-100
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
13.4 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

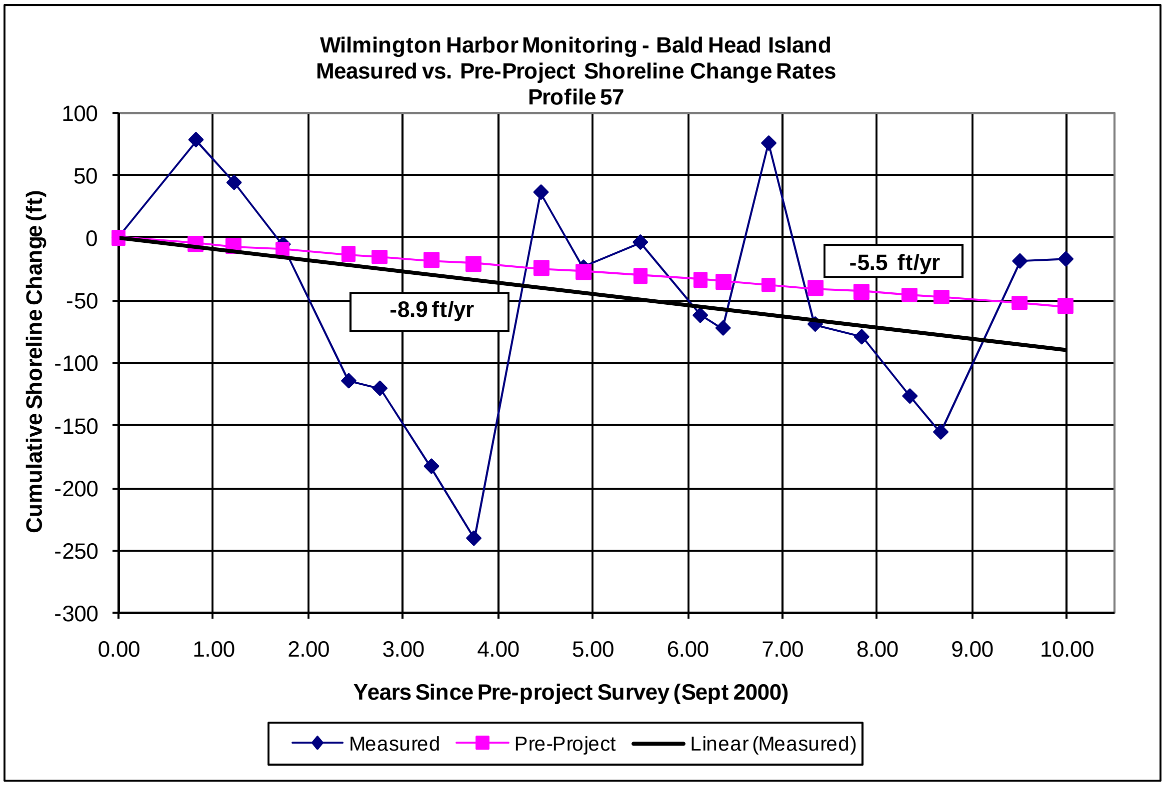


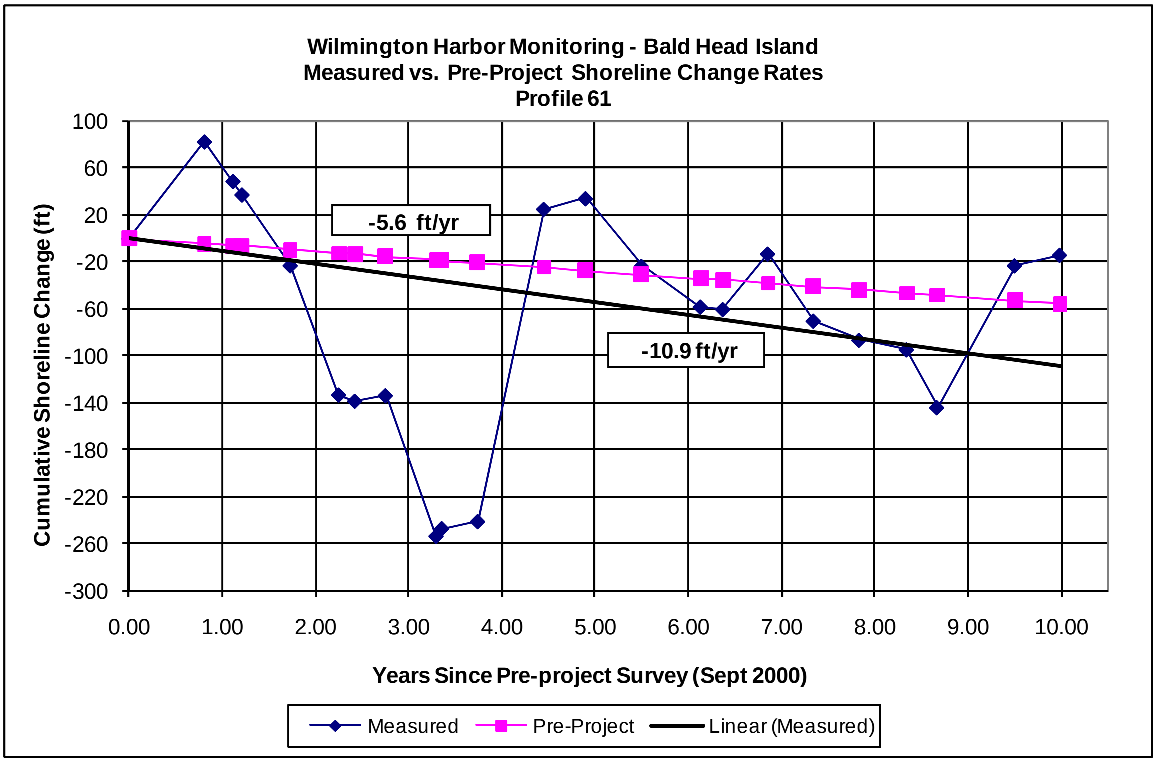
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 43
Cumulative Shoreline Change (ft)
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
-27.2 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
-23.7 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

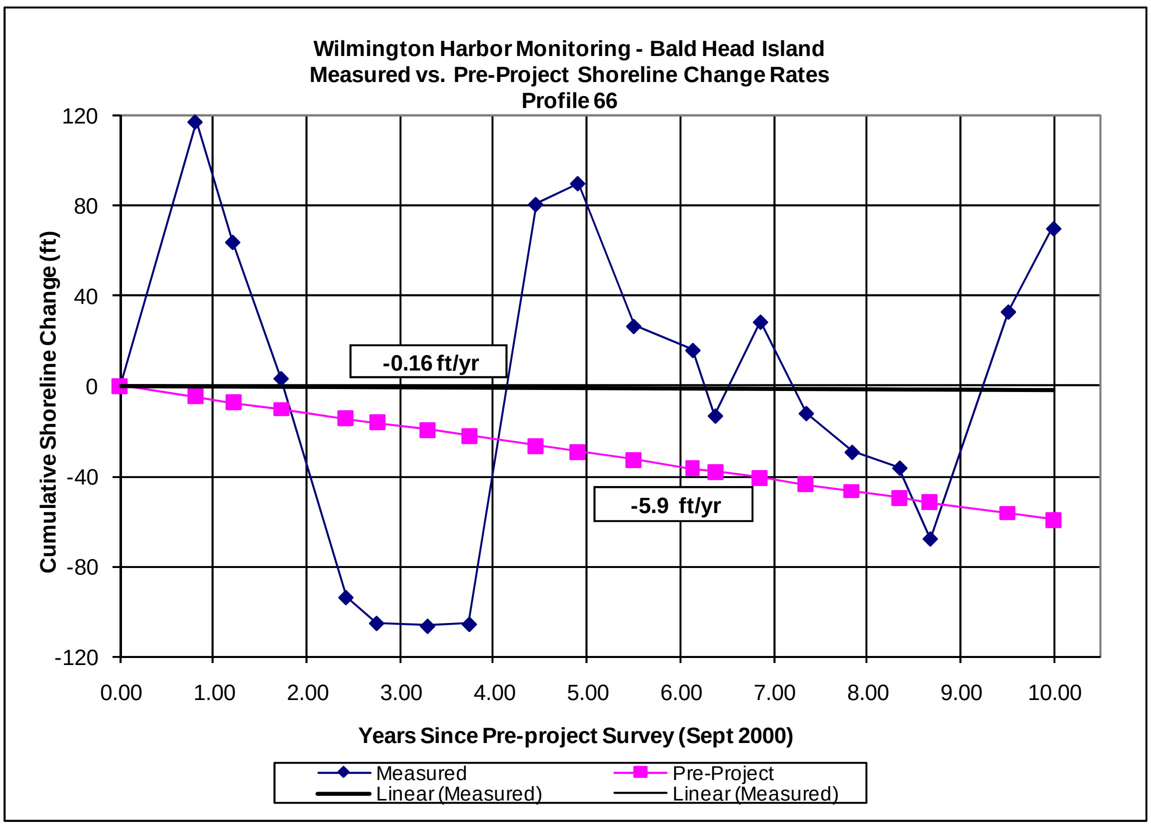

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 47
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
-150
-200
-250
-300
-350
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
-20.5 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 53
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
-120
-160
-200
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
-2.4 ft/yr
-10.1 ft/yr
Measured
Pre-Project
Linear (Measured)

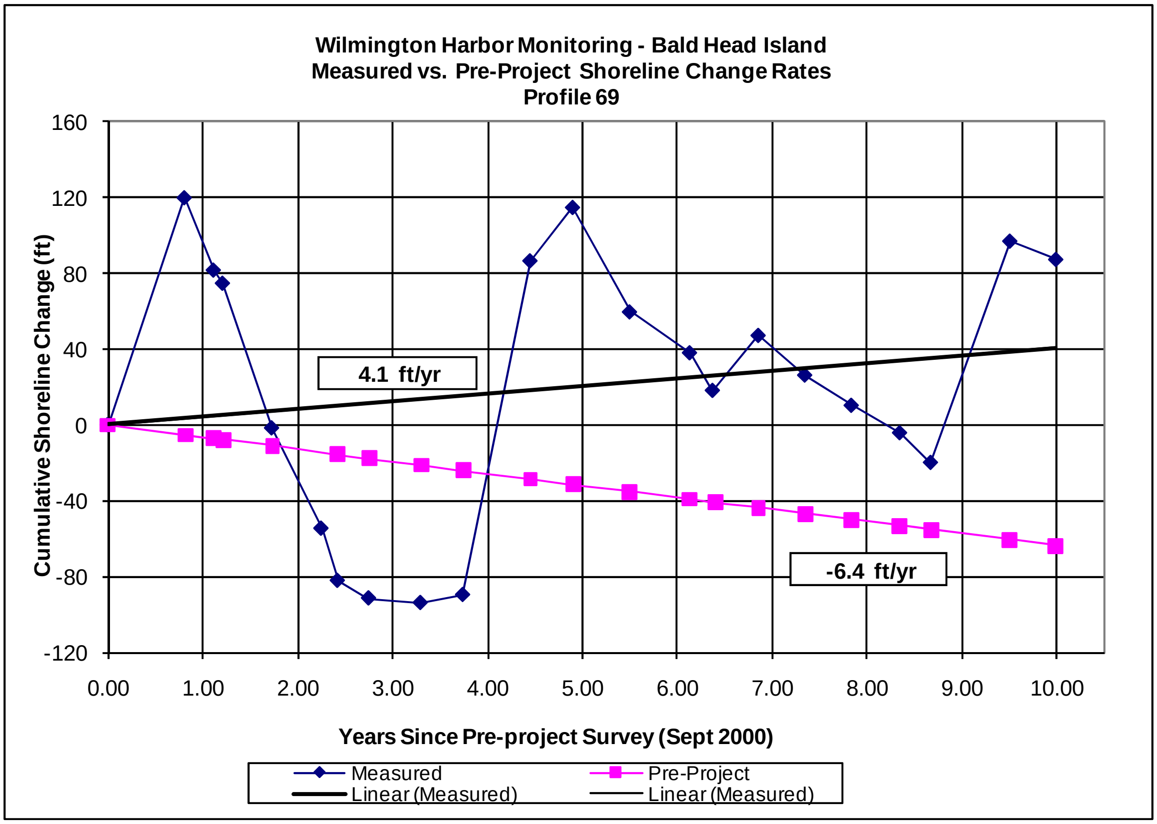

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 57
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
-150
-200
-250
-300
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
-5.5 ft/yr
-8.9 ft/yr
Measured
Pre-Project
Linear (Measured)

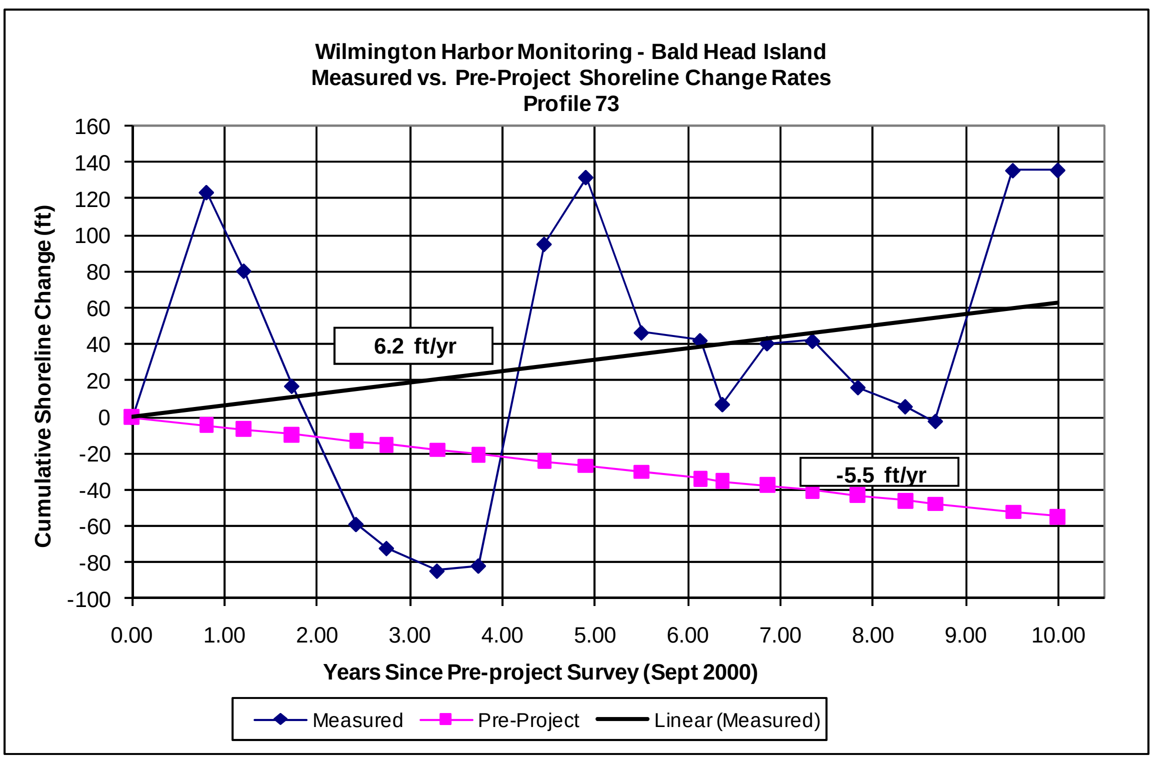


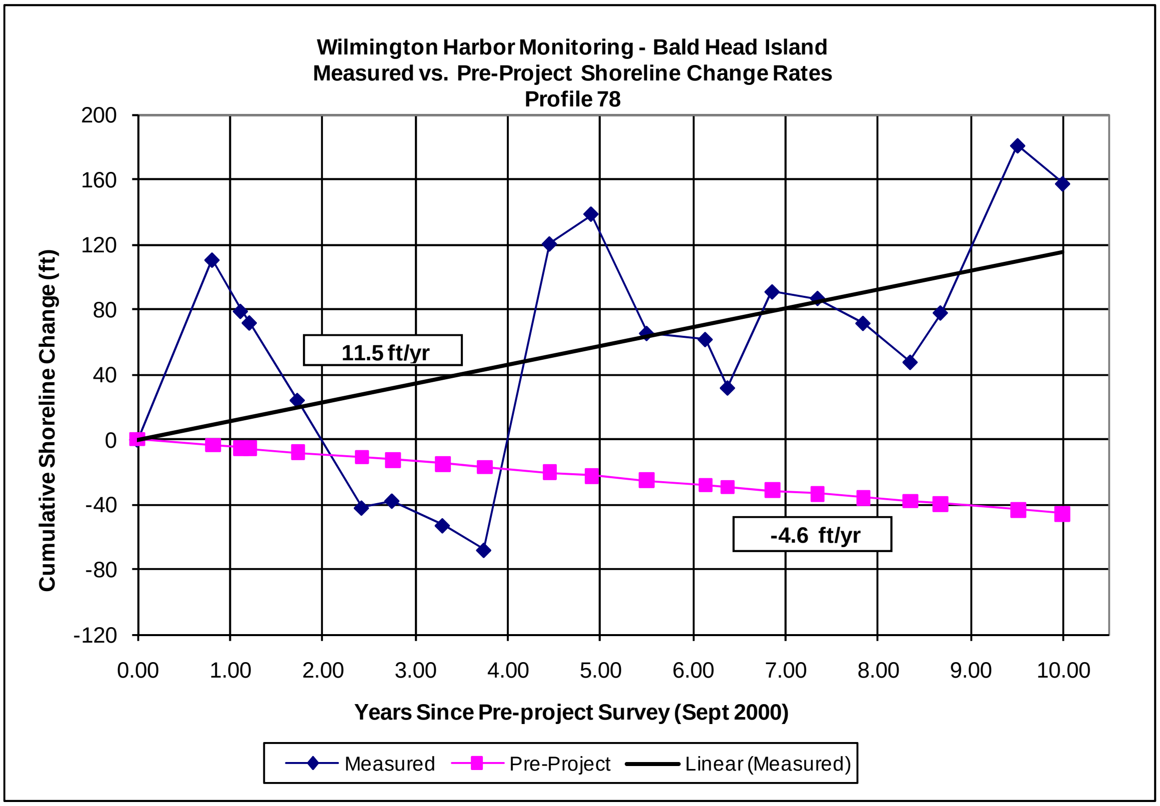
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 61
-5.6 ft/yr
-10.9 ft/yr
Cumulative Shoreline Change (ft)
100
60
20
-20
-60
-100
-140
-180
-220
-260
-300
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

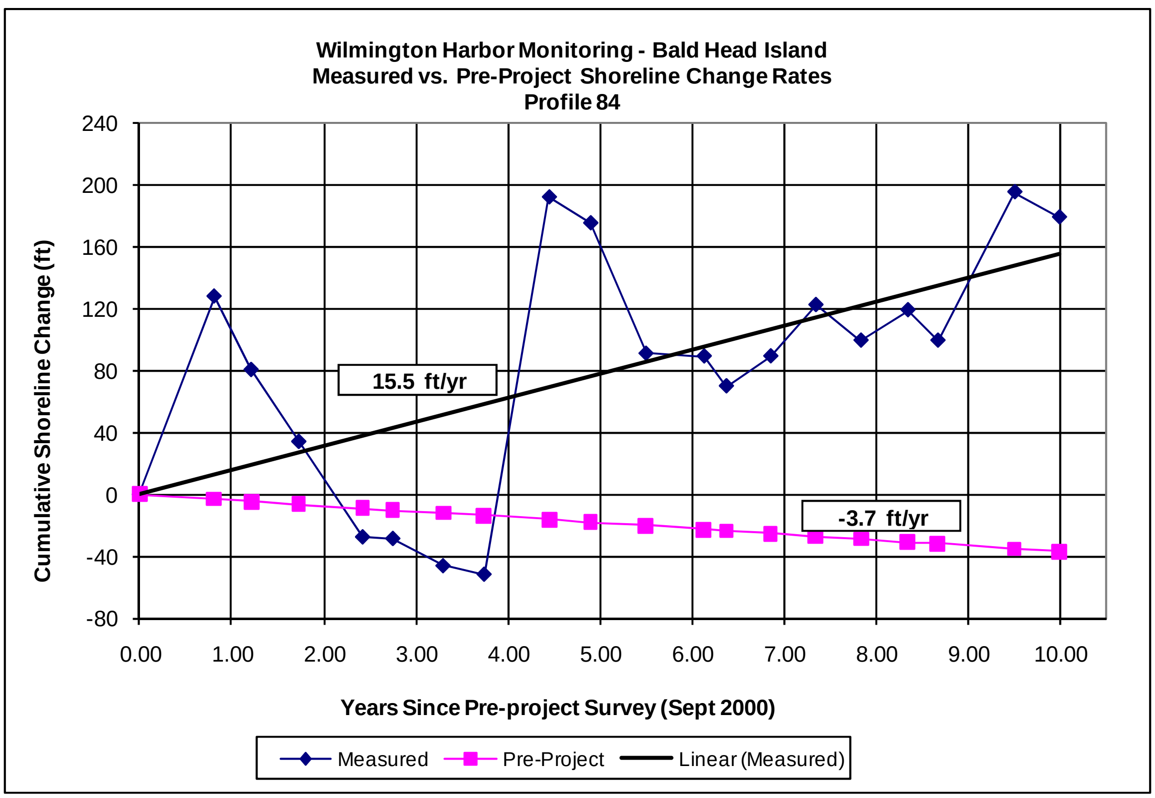


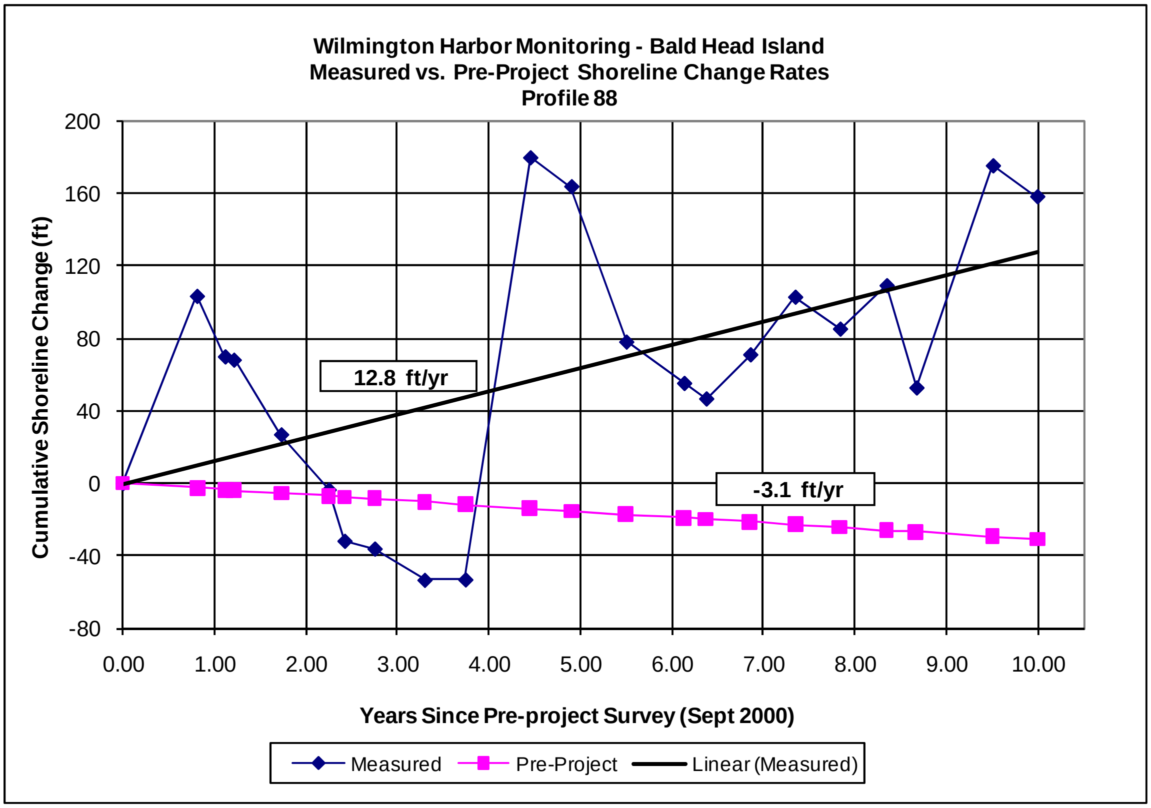
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 66
-0.16 ft/yr
-5.9 ft/yr
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)
Linear (Measured)

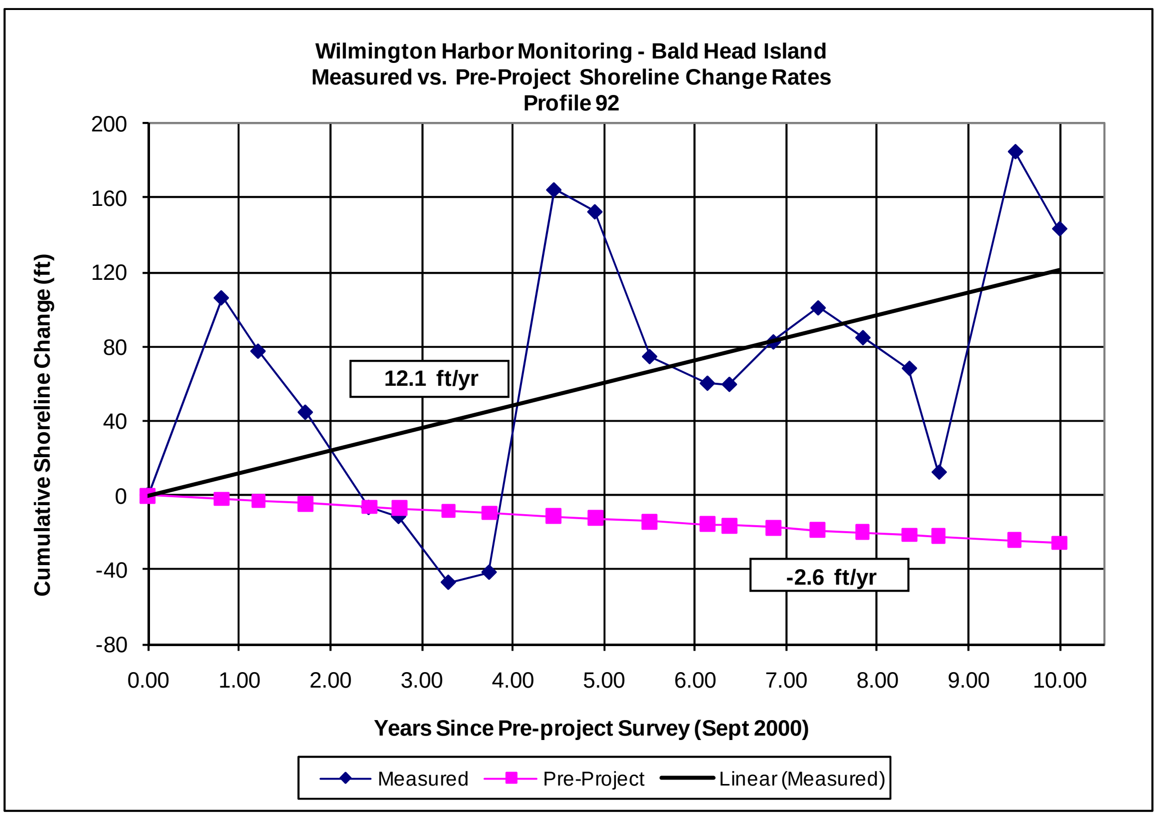

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 69
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
4.1 ft/yr
-6.4 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)
Linear (Measured)

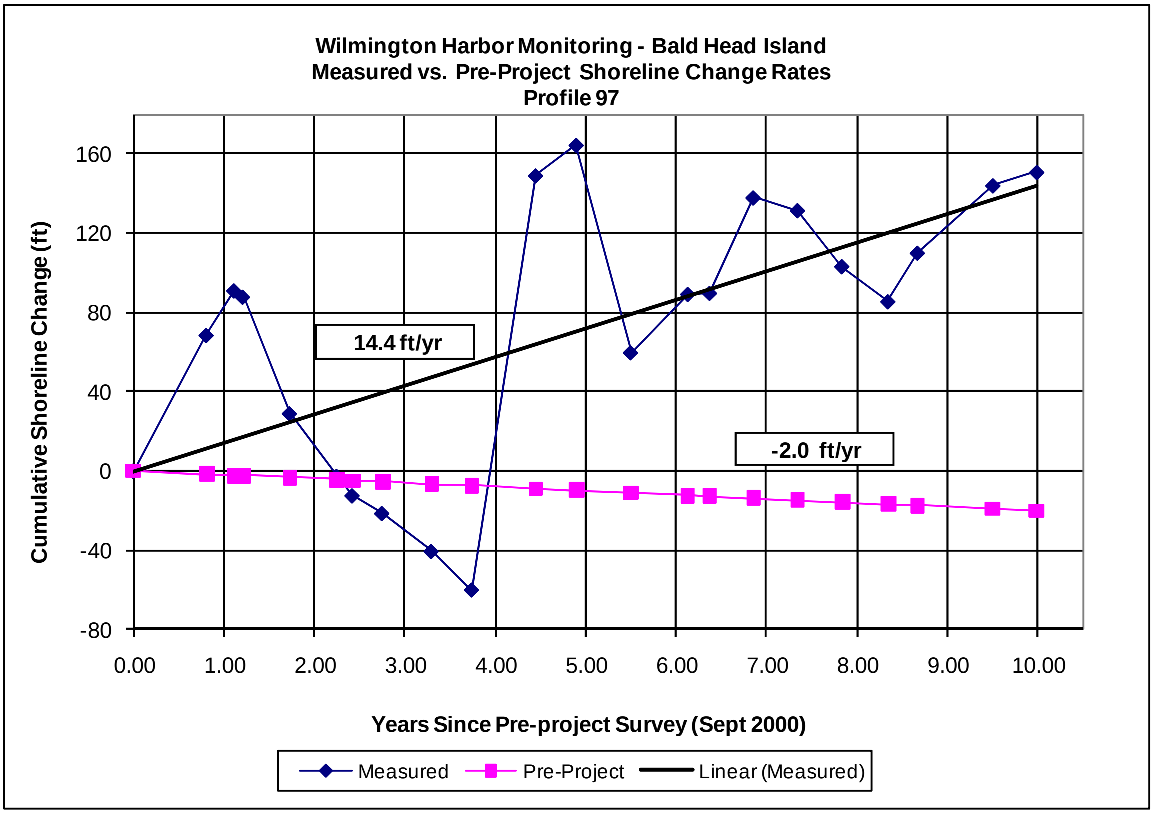

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 73
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
6.2 ft/yr
-5.5 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

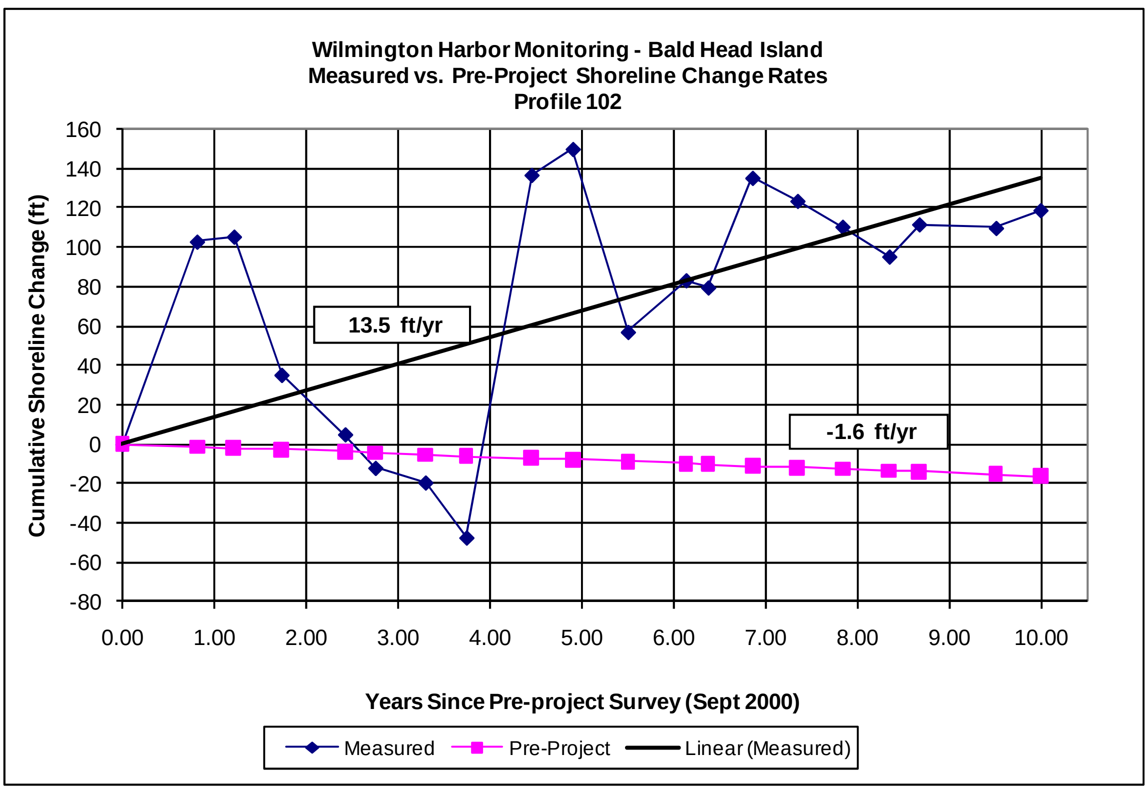

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 78
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.5 ft/yr
-4.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

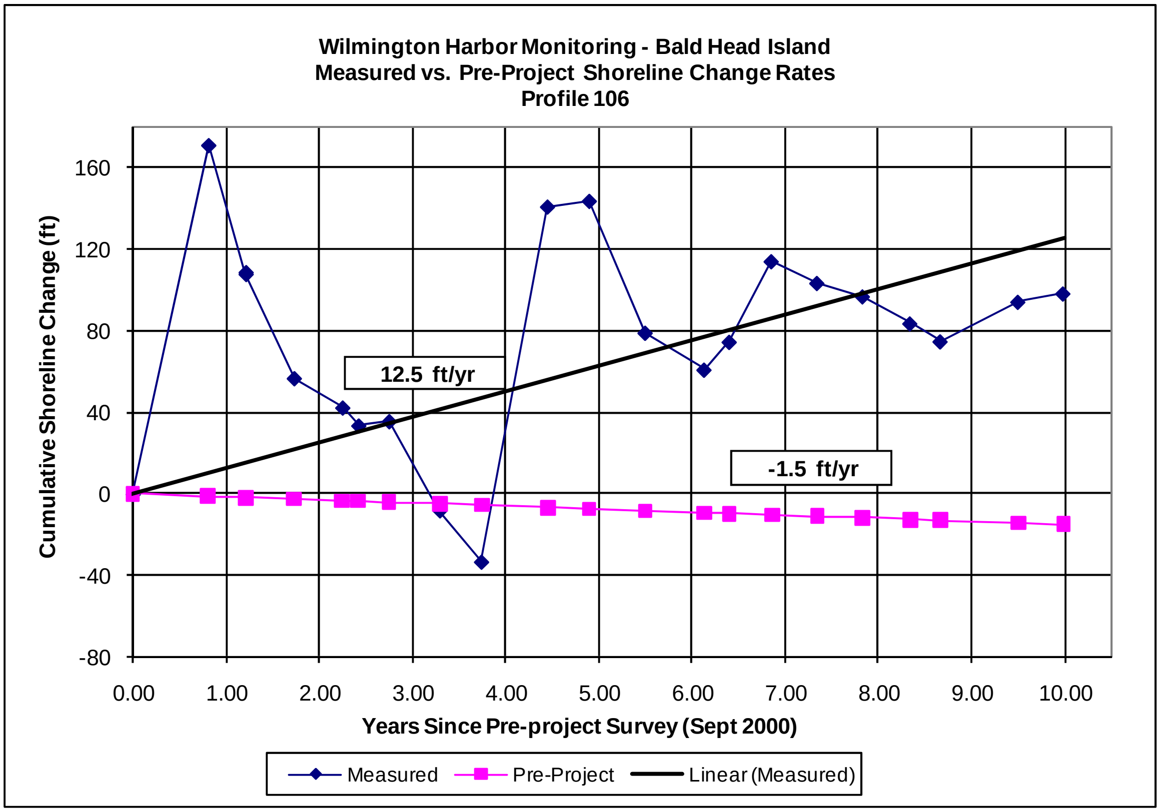

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 84
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
15.5 ft/yr
-3.7 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

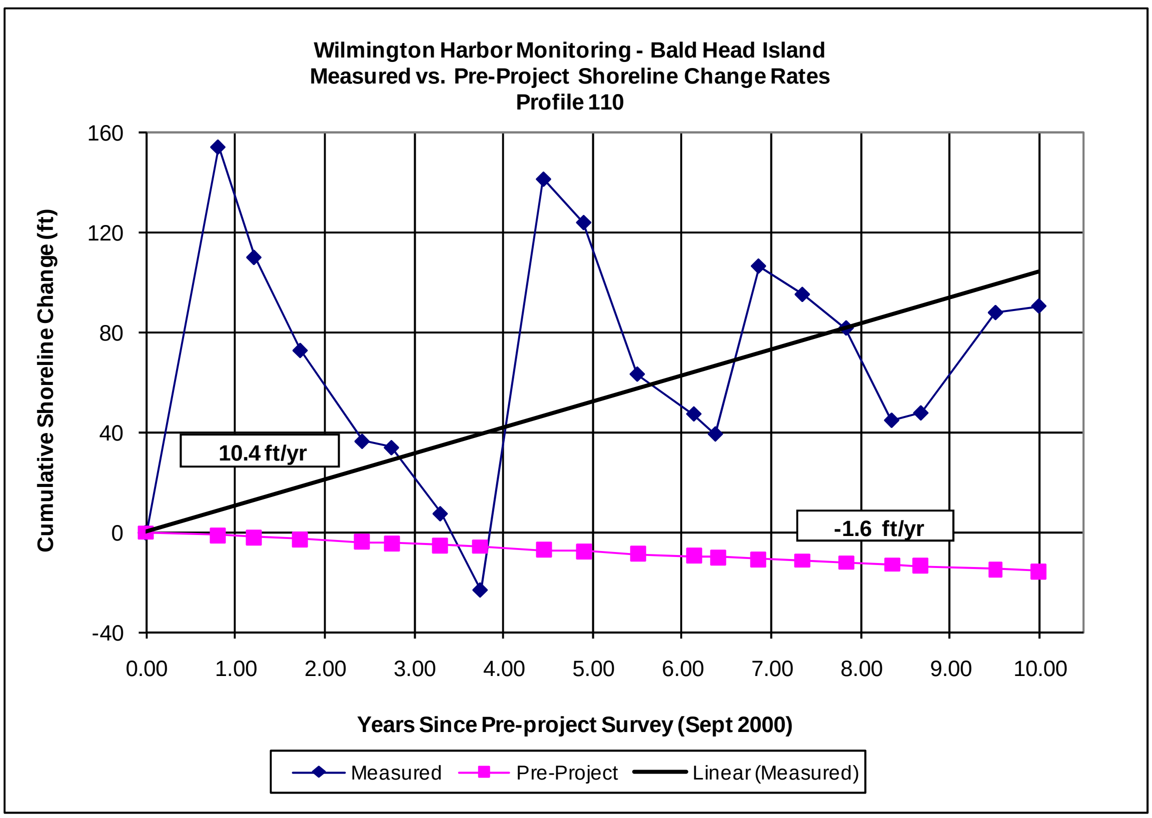

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 88
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
12.8 ft/yr
-3.1 ft/yr
Measured
Pre-Project
Linear (Measured)

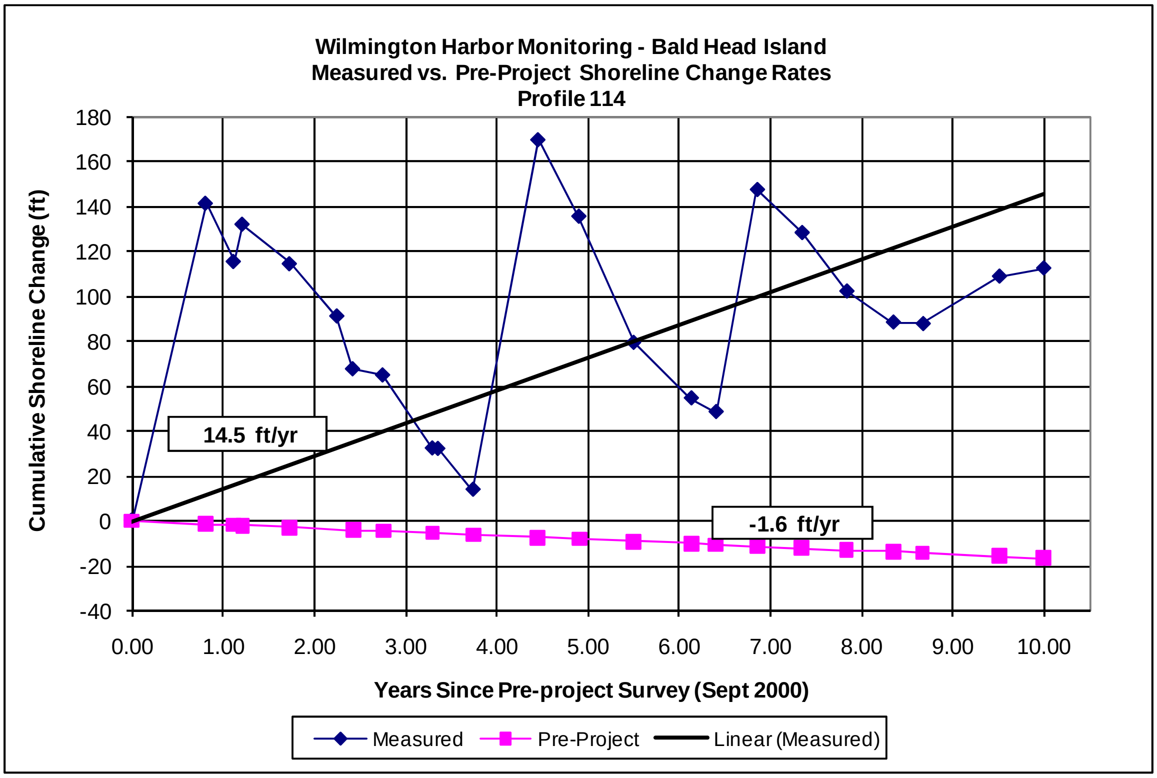

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 92
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
12.1 ft/yr
-2.6 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 97
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
14.4 ft/yr
-2.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

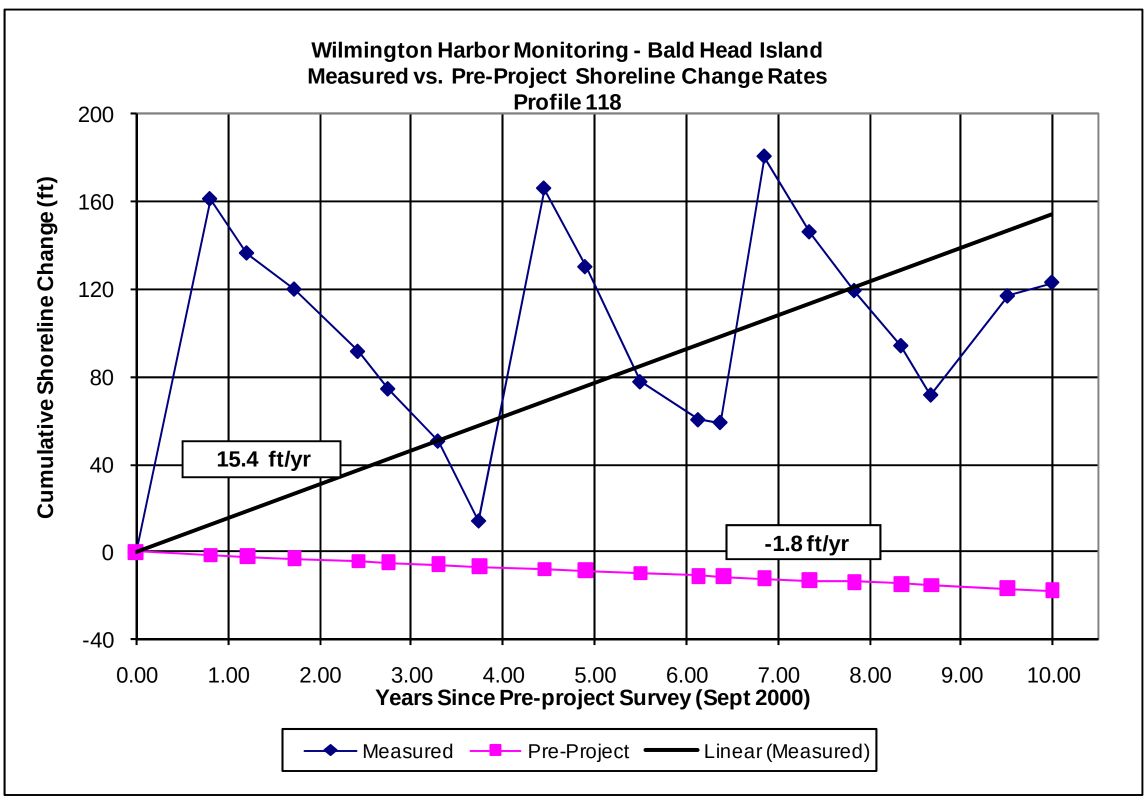

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 102
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
13.5 ft/yr
-1.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 106
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
12.5 ft/yr
-1.5 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

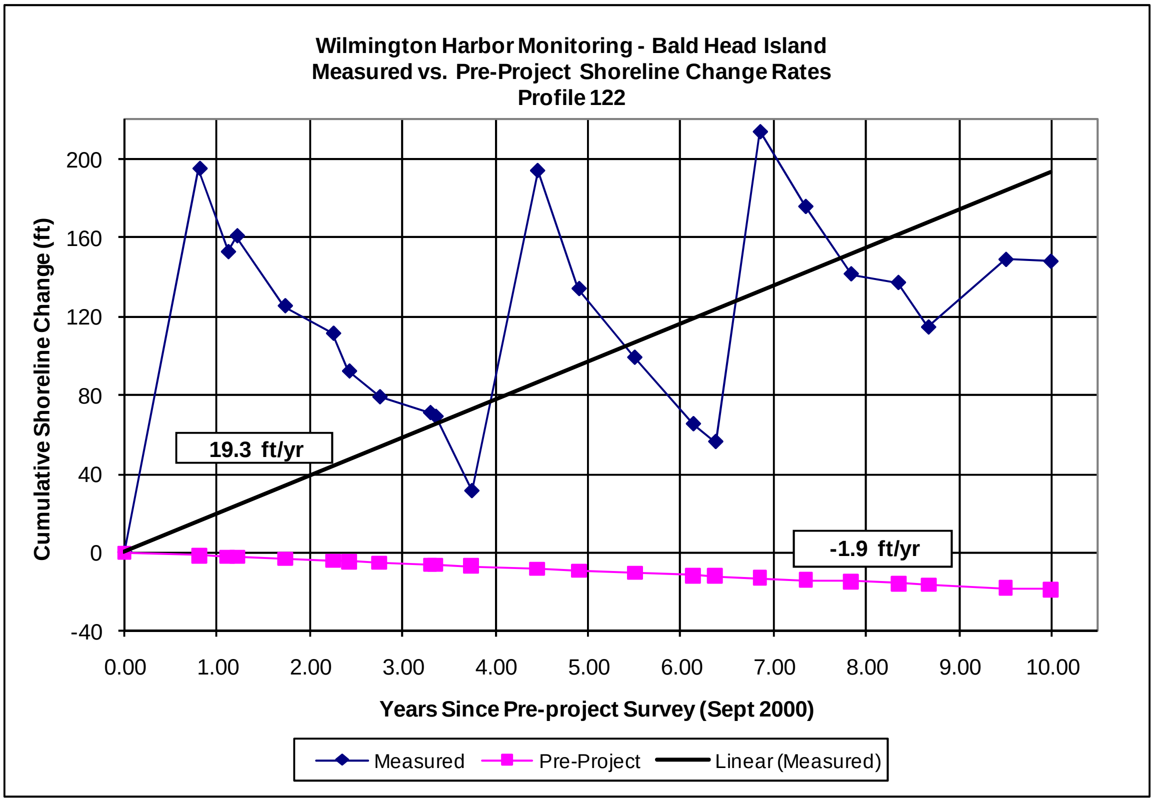

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
10.4 ft/yr
-1.6 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

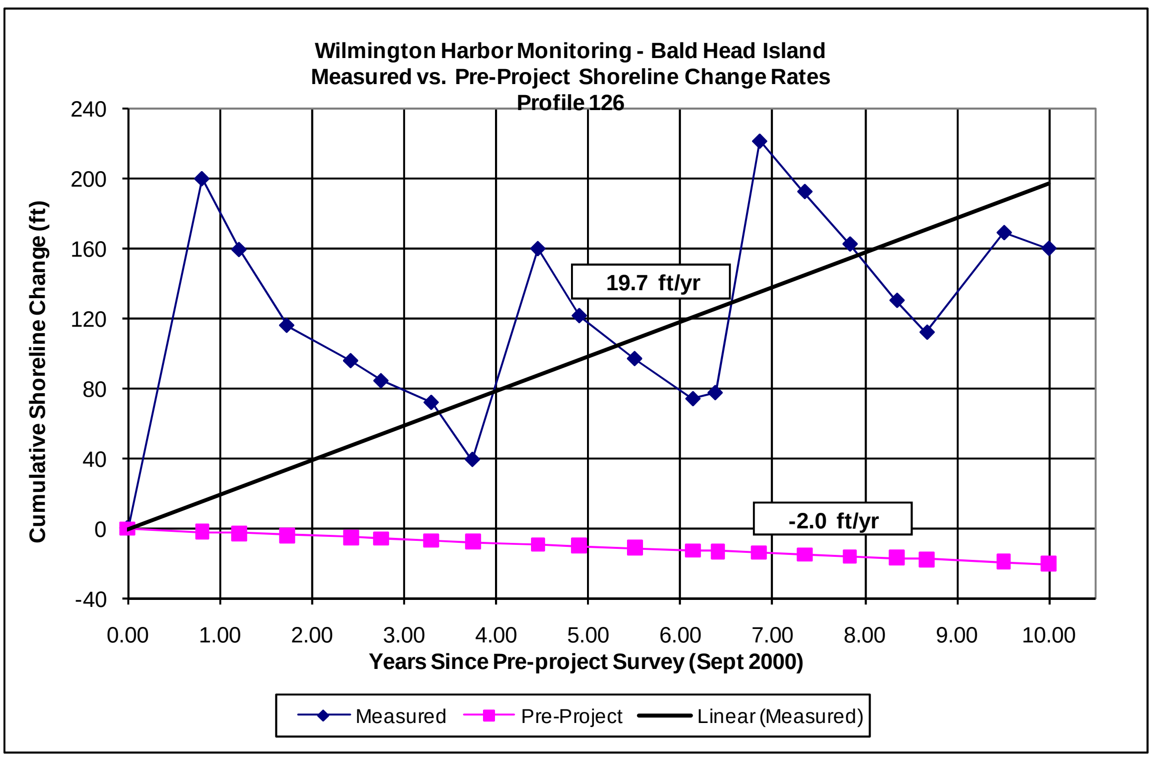


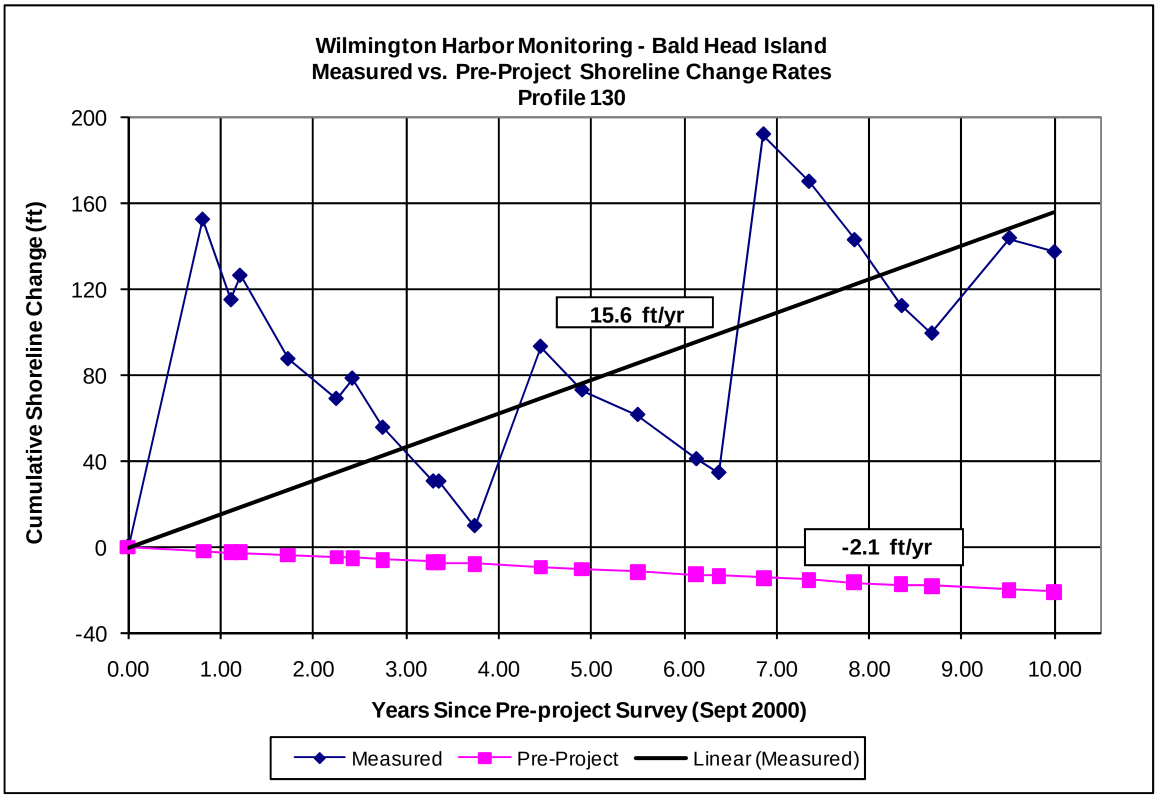
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 114
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
14.5 ft/yr
-1.6 ft/yr
Measured
Pre-Project
Linear (Measured)

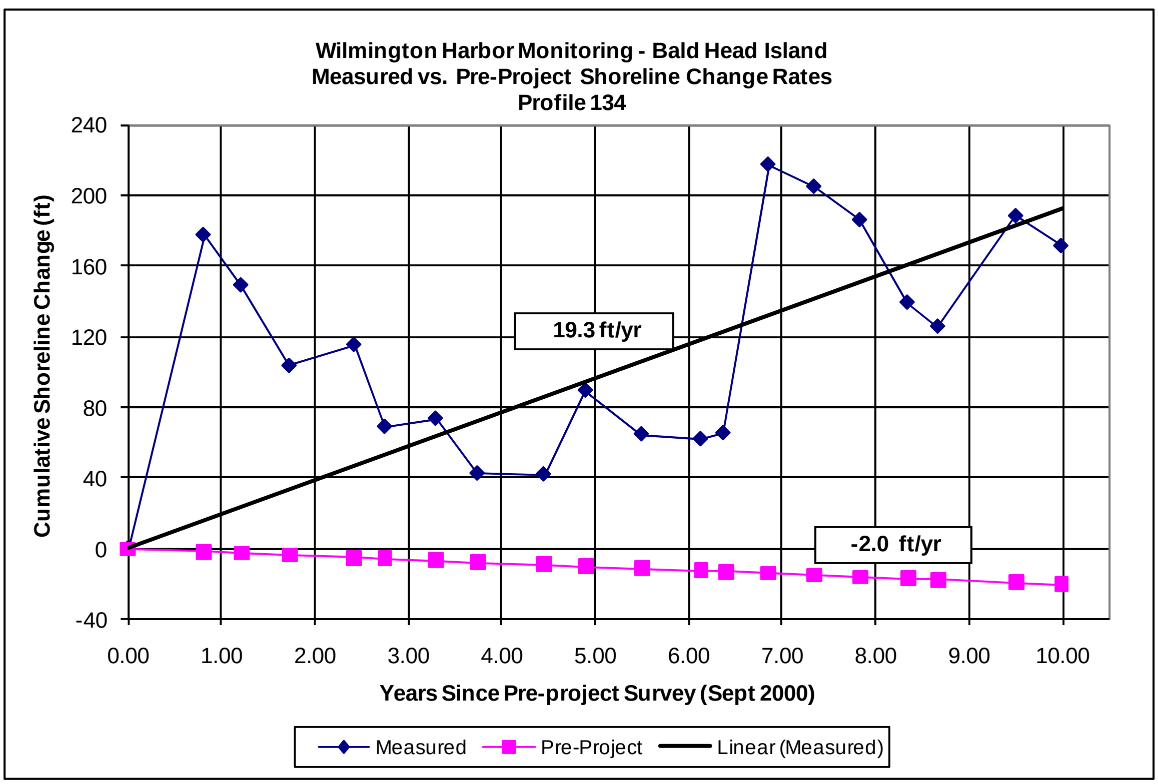


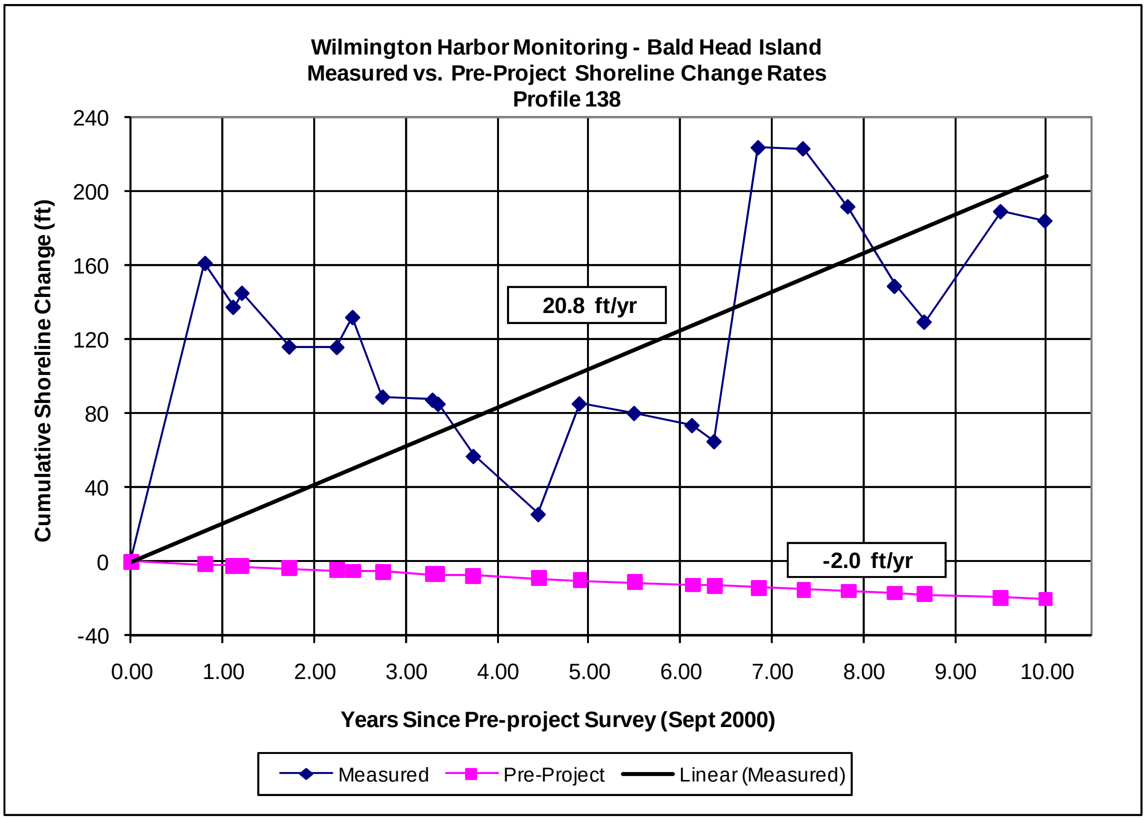
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 118
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
15.4 ft/yr
-1.8 ft/yr
Measured
Pre-Project
Linear (Measured)

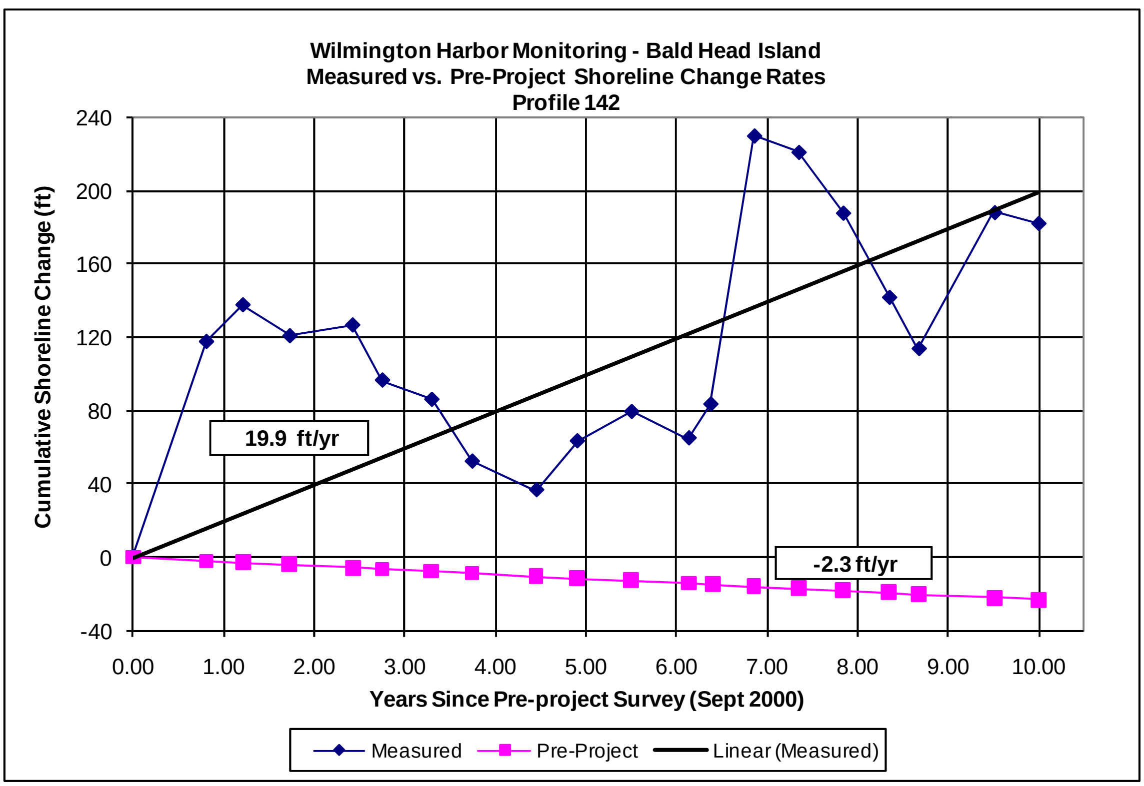

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 122
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
19.3 ft/yr
-1.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

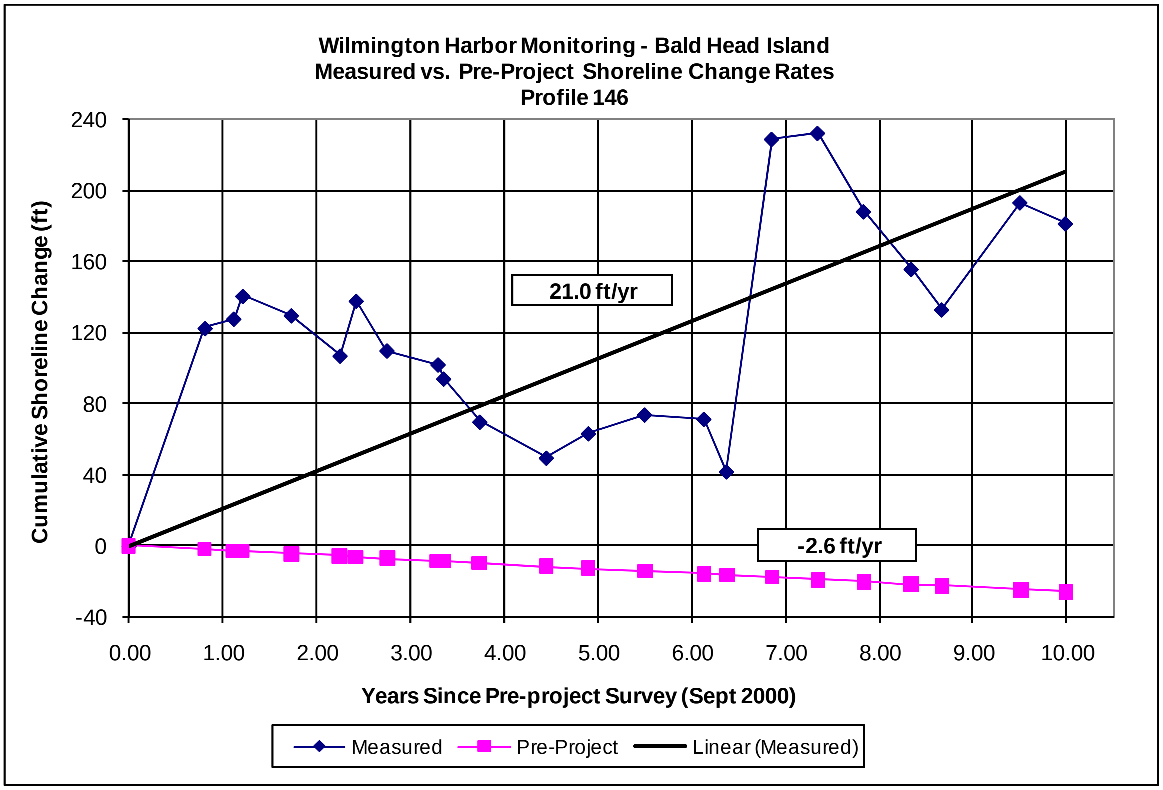

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 126
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
19.7 ft/yr
-2.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

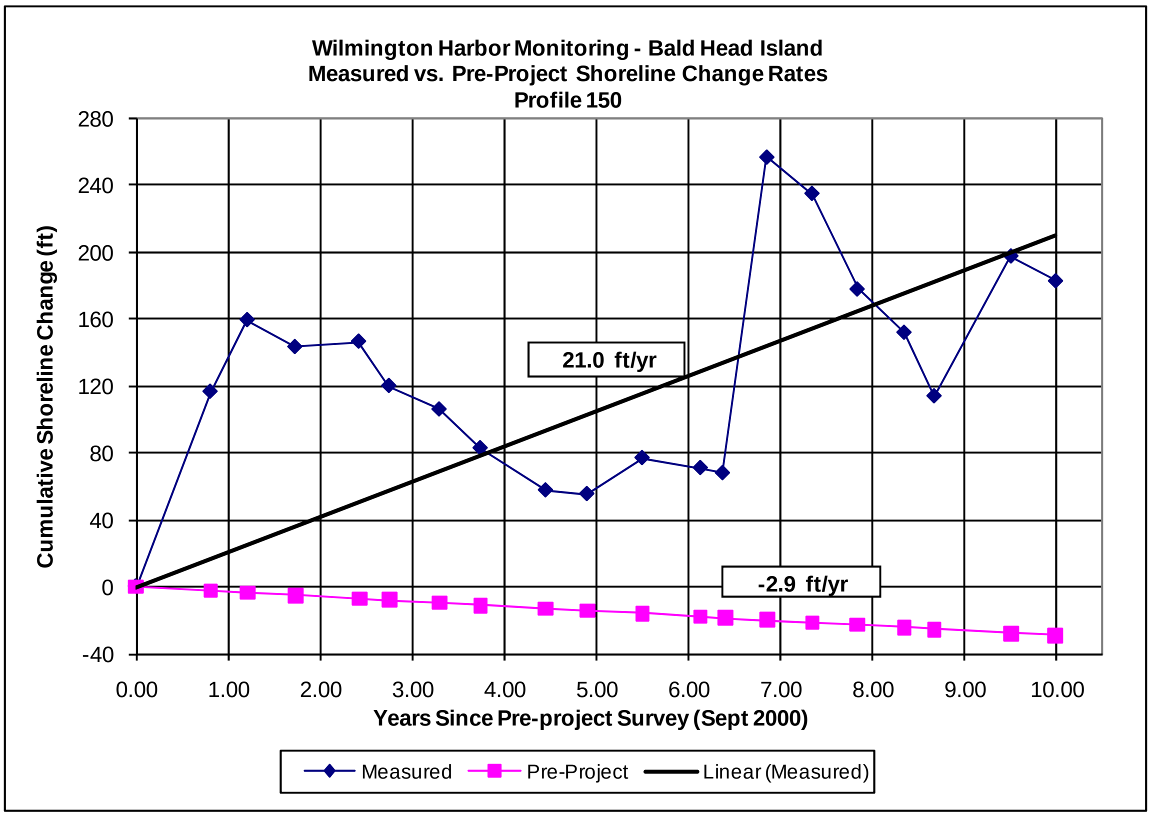

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
15.6 ft/yr
-2.1 ft/yr
Measured
Pre-Project
Linear (Measured)

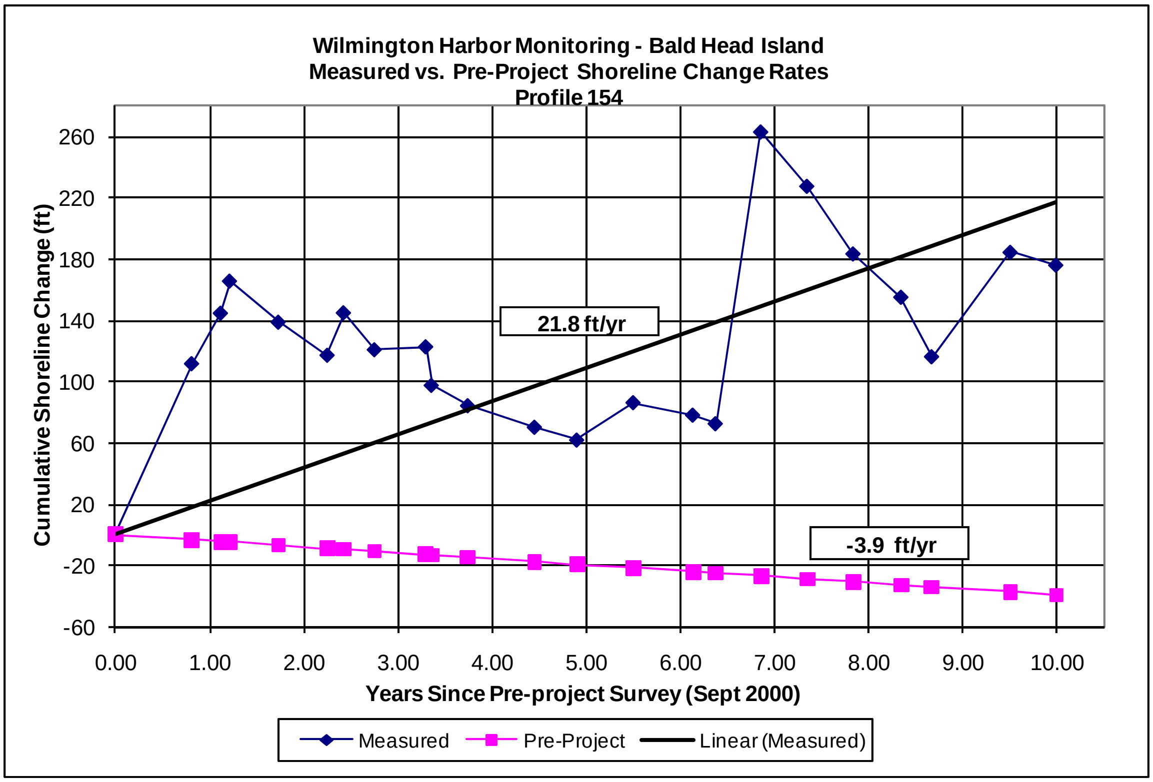

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 134
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
19.3 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

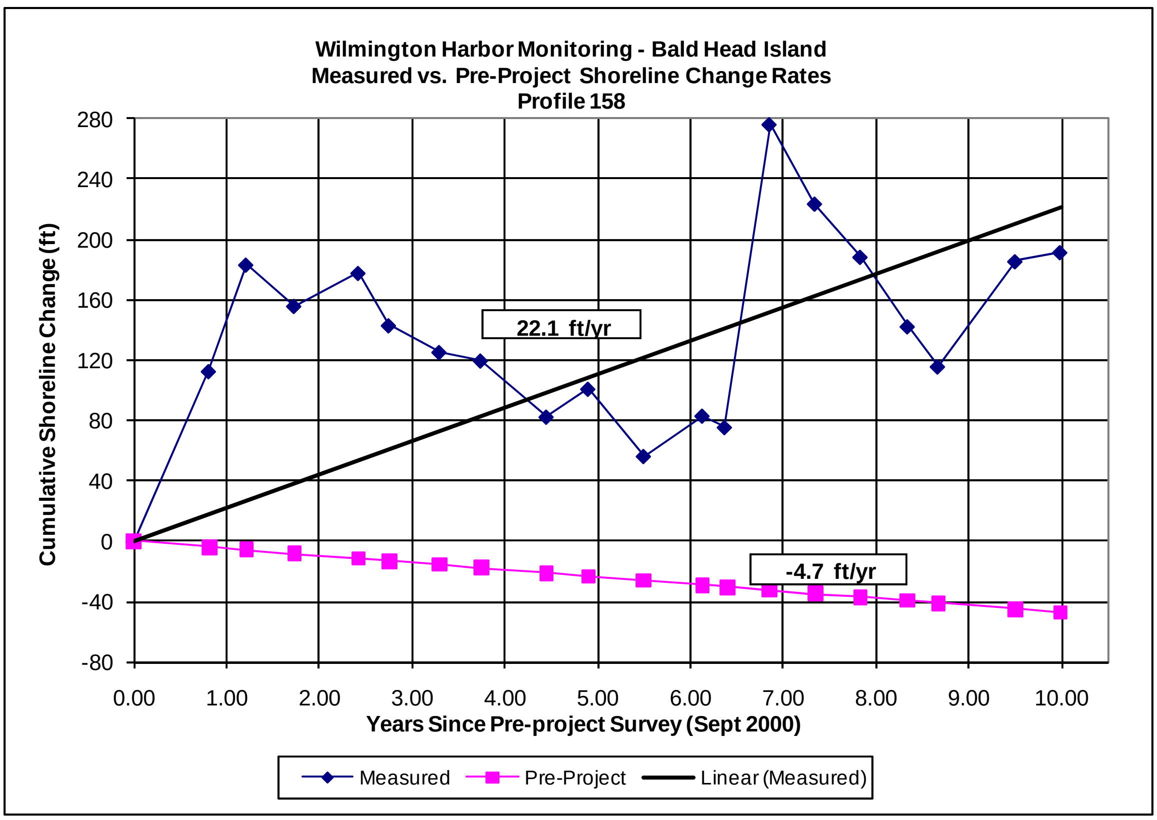

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 138
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
20.8 ft/yr
-2.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

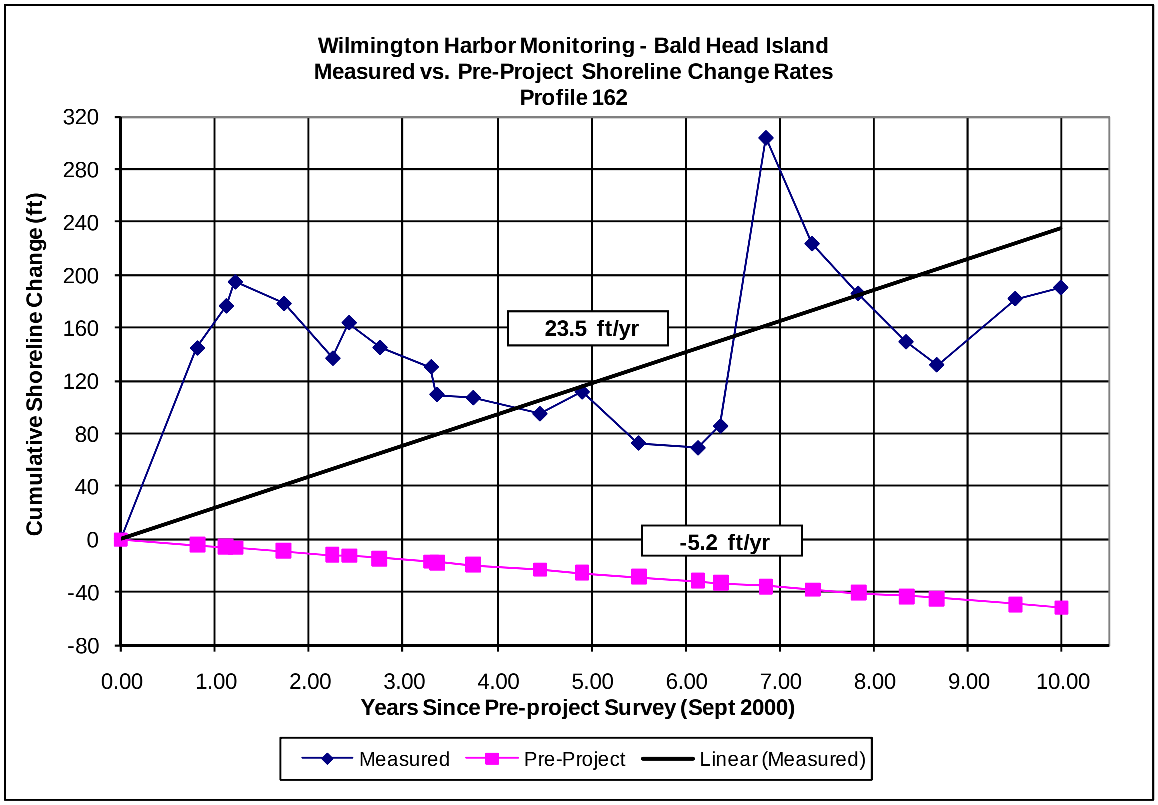

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 142
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
19.9 ft/yr
-2.3 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

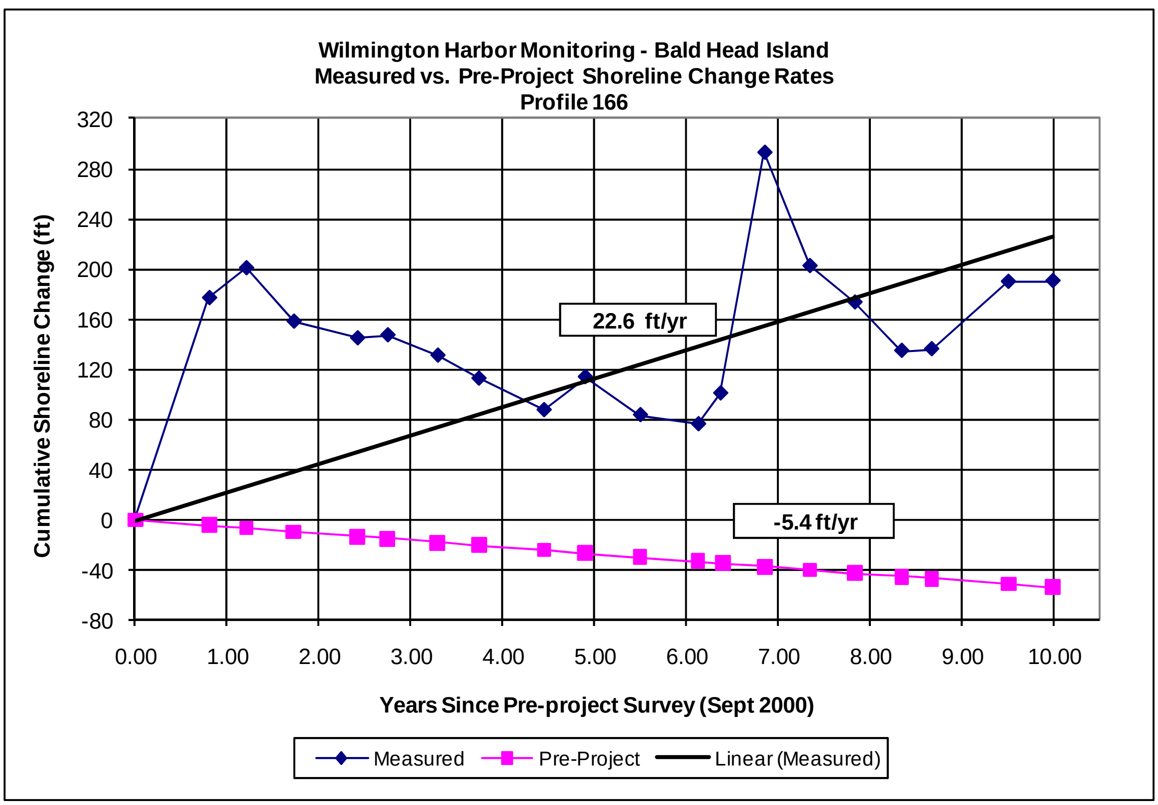

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 146
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
21.0 ft/yr
-2.6 ft/yr
Measured
Pre-Project
Linear (Measured)

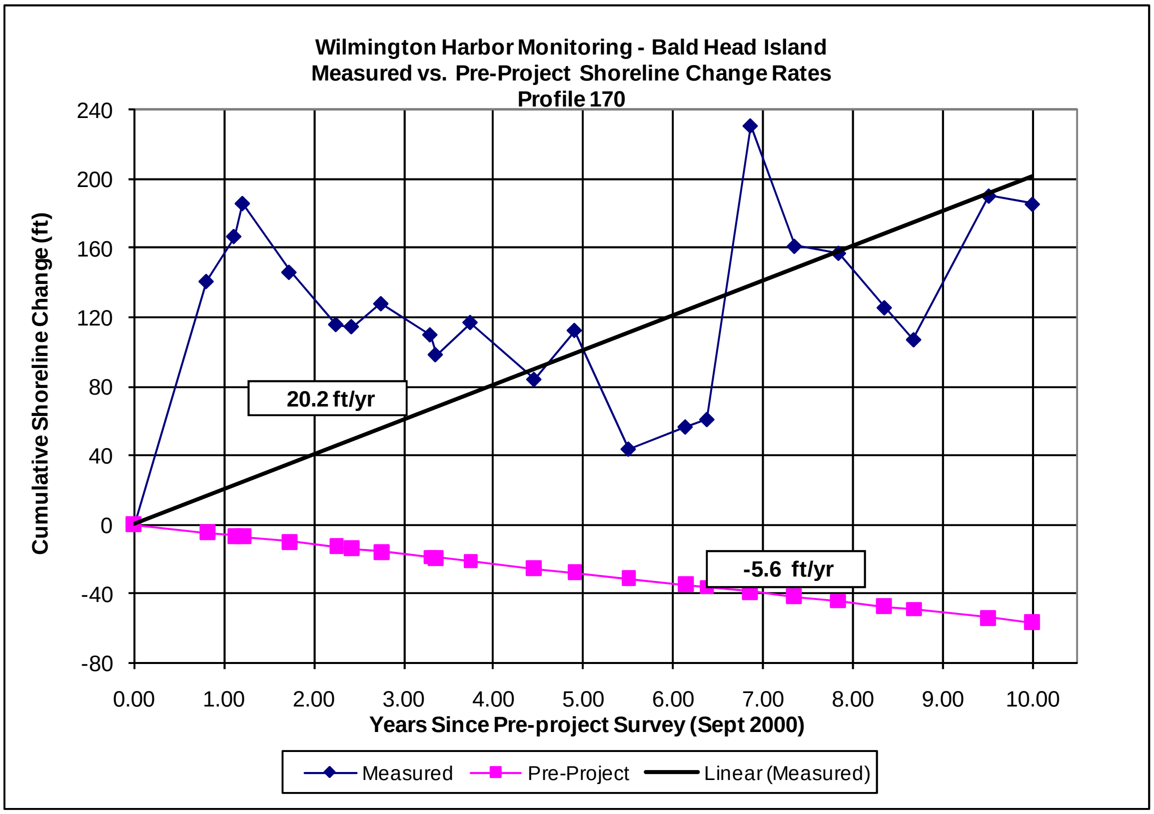

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
21.0 ft/yr
-2.9 ft/yr
Measured
Pre-Project
Linear (Measured)

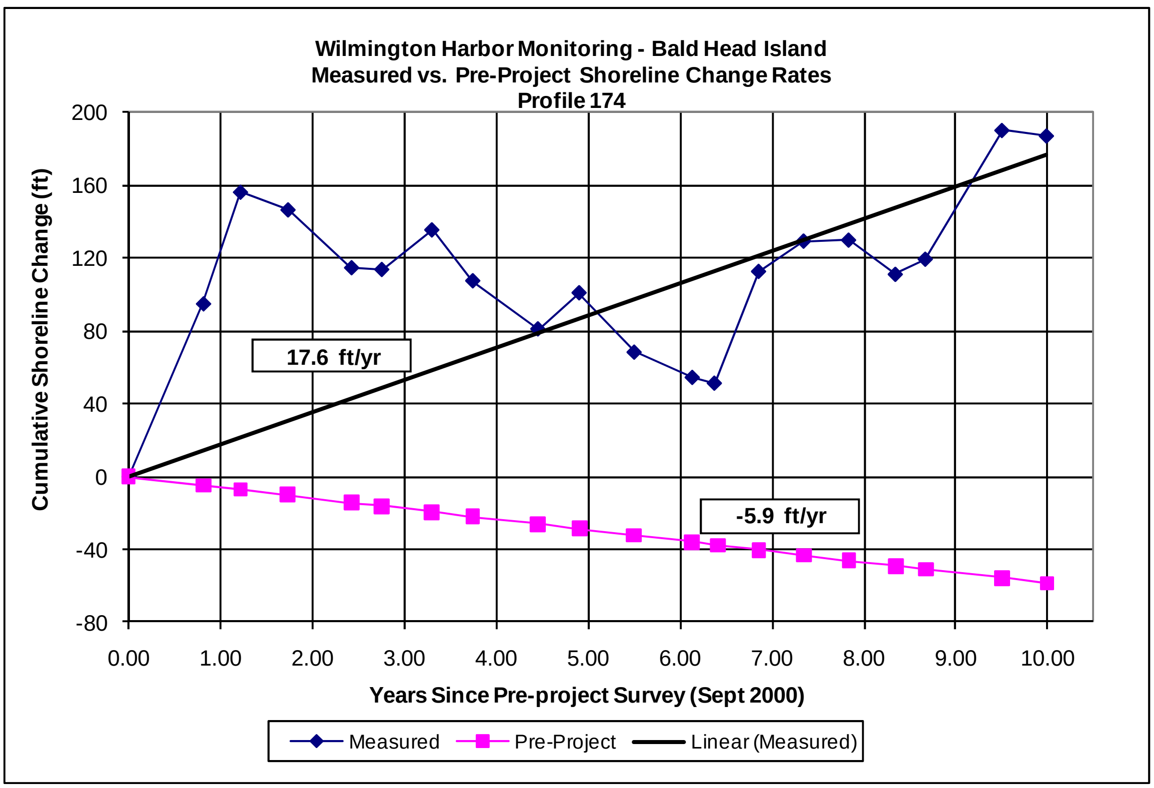

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 154
Cumulative Shoreline Change (ft)
260
220
180
140
100
60
20
-20
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
21.8 ft/yr
-3.9 ft/yr
Measured
Pre-Project
Linear (Measured)

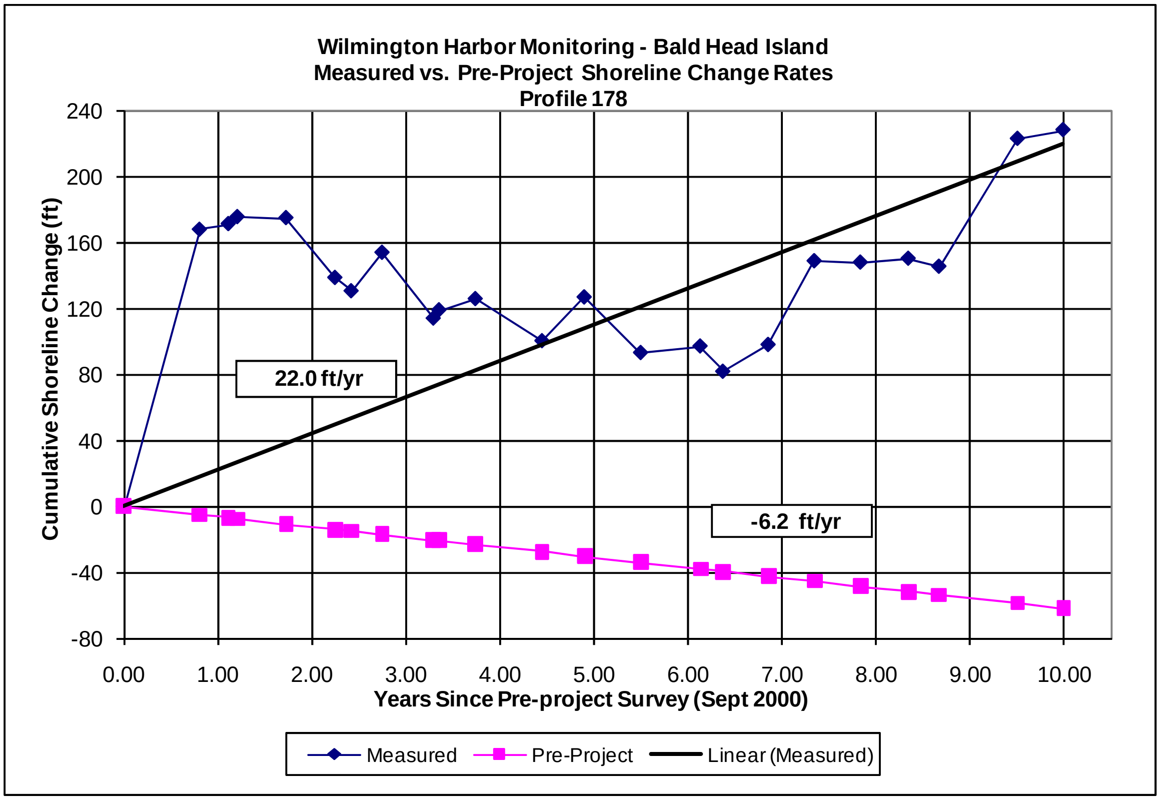

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 158
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
22.1 ft/yr
-4.7 ft/yr
Measured
Pre-Project
Linear (Measured)

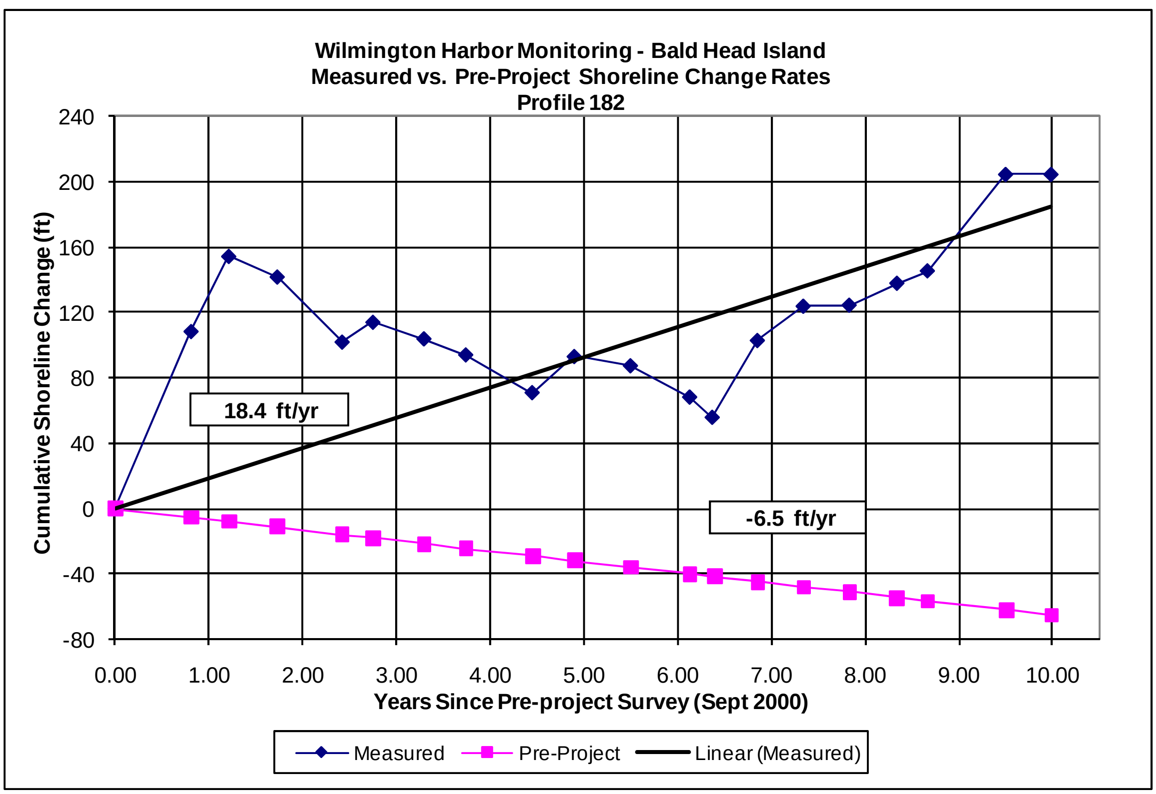

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 162
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
23.5 ft/yr
-5.2 ft/yr
320
280
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Measured
Pre-Project
Linear (Measured)

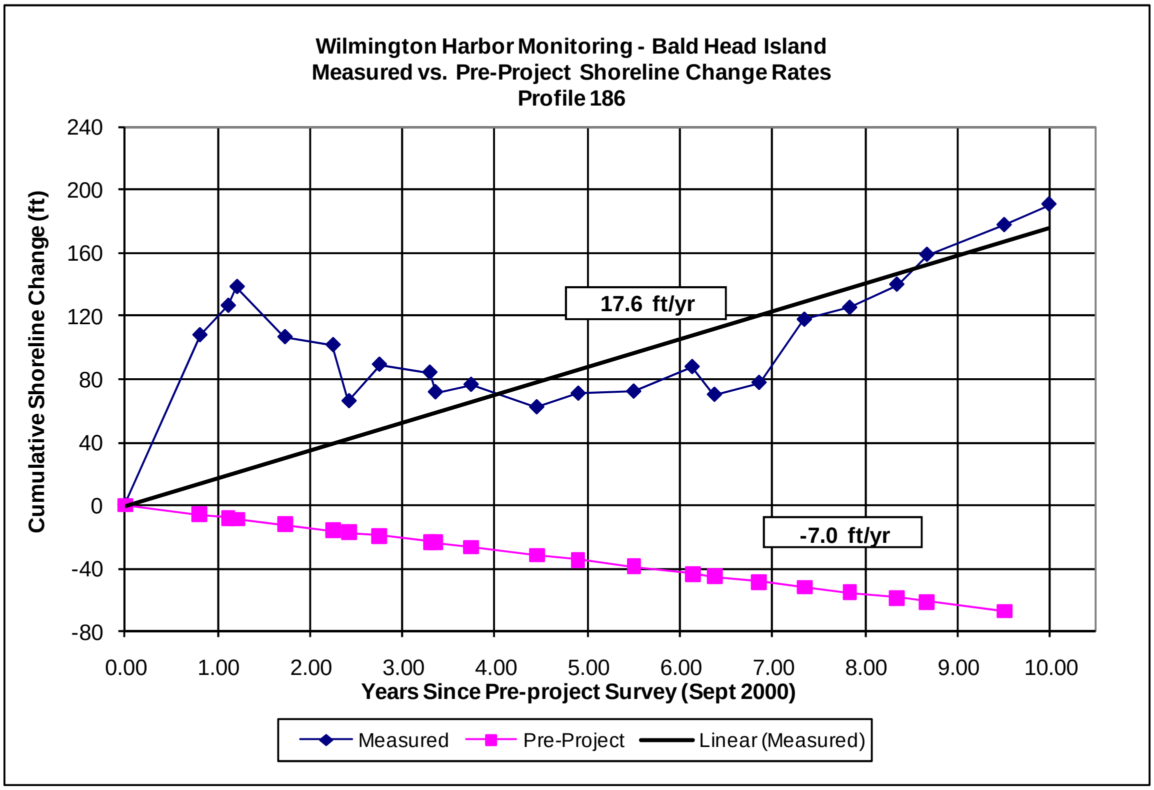

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 166
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
22.6 ft/yr
-5.4 ft/yr
320
280
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Measured
Pre-Project
Linear (Measured)

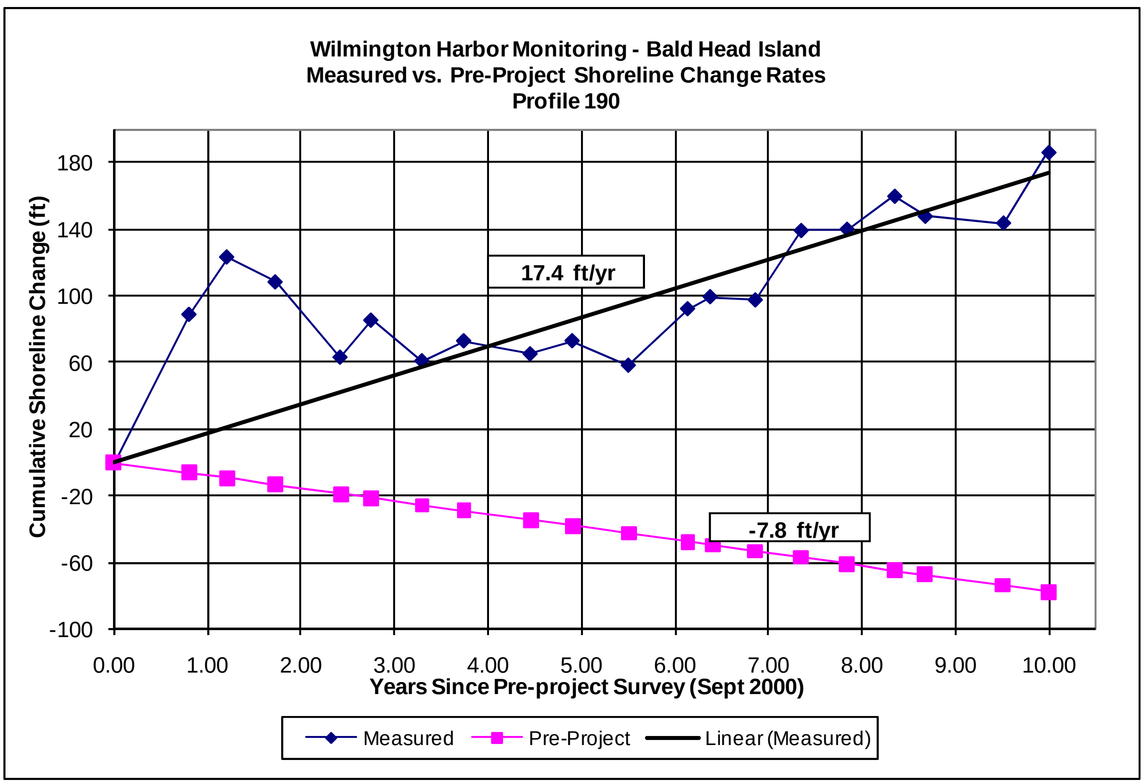

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
20.2 ft/yr
-5.6 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

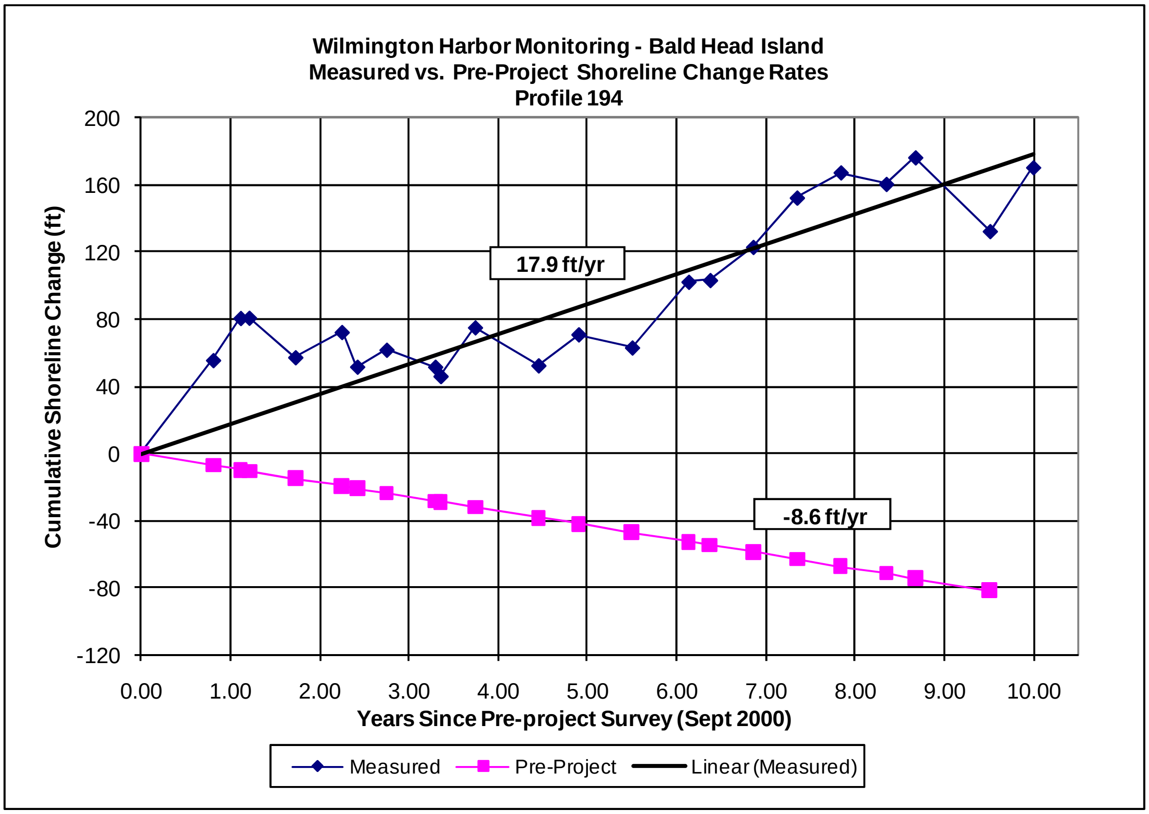

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 174
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
17.6 ft/yr
-5.9 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

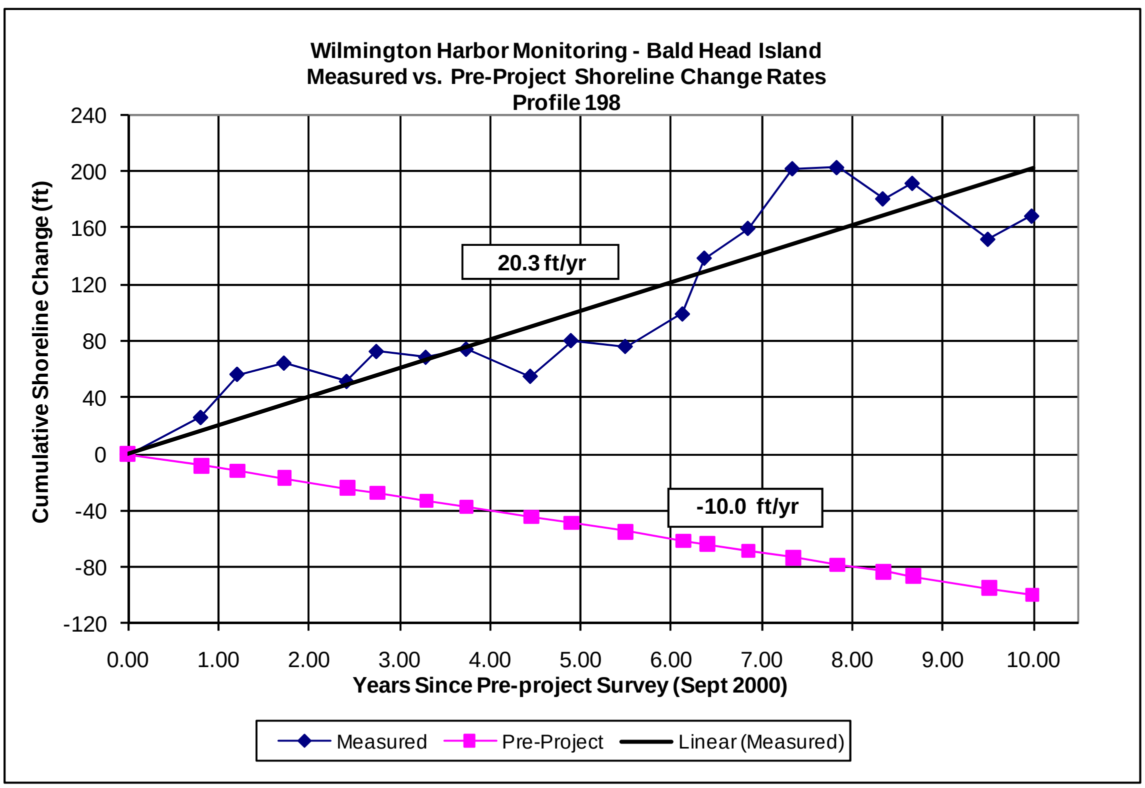

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 178
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
22.0 ft/yr
-6.2 ft/yr
Measured
Pre-Project
Linear (Measured)

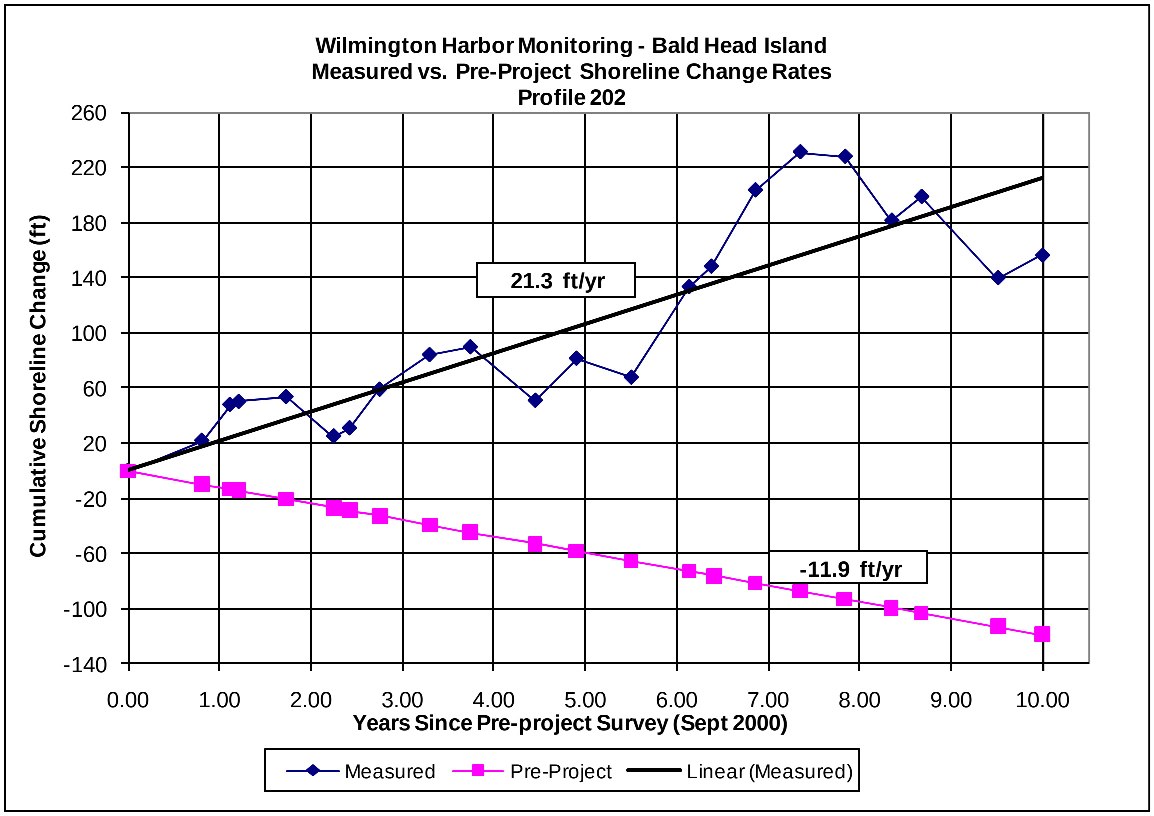

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 182
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
18.4 ft/yr
-6.5 ft/yr
Measured
Pre-Project
Linear (Measured)

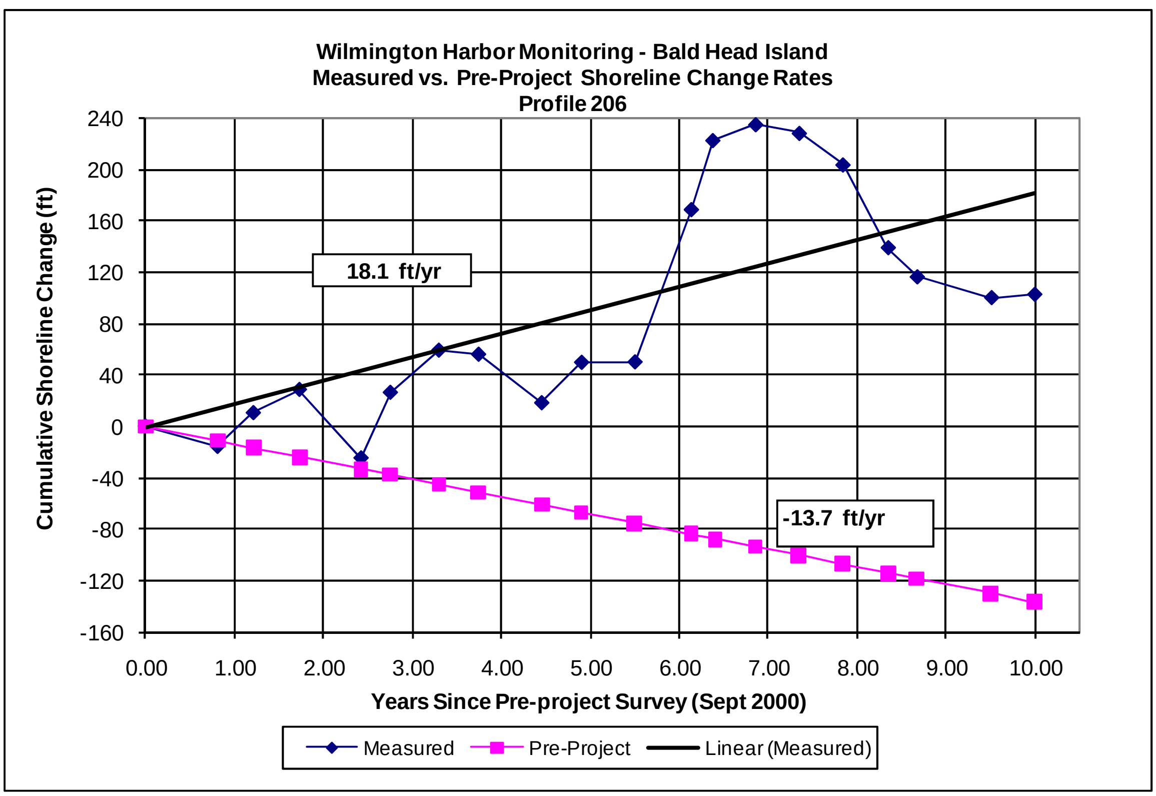

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 186
17.6 ft/yr
-7.0 ft/yr
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

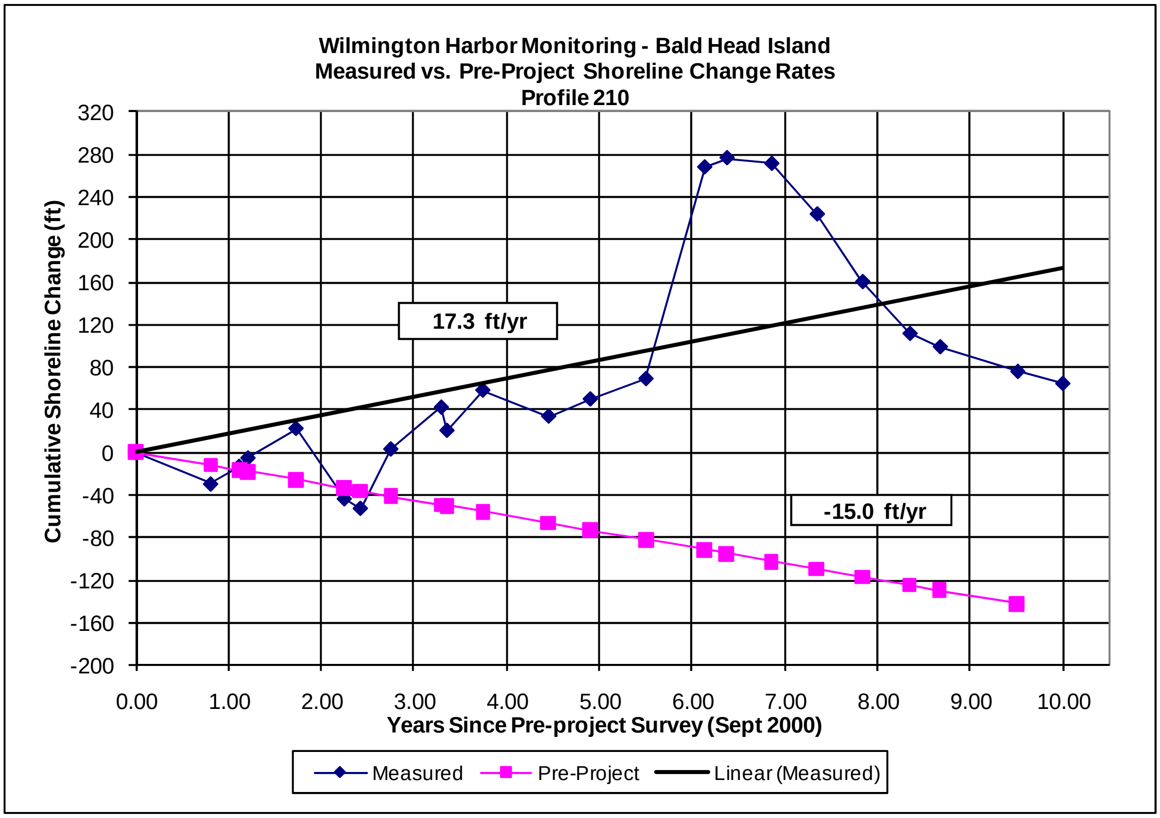

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
17.4 ft/yr
-7.8 ft/yr
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
-100
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 194
17.9 ft/yr
-8.6 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

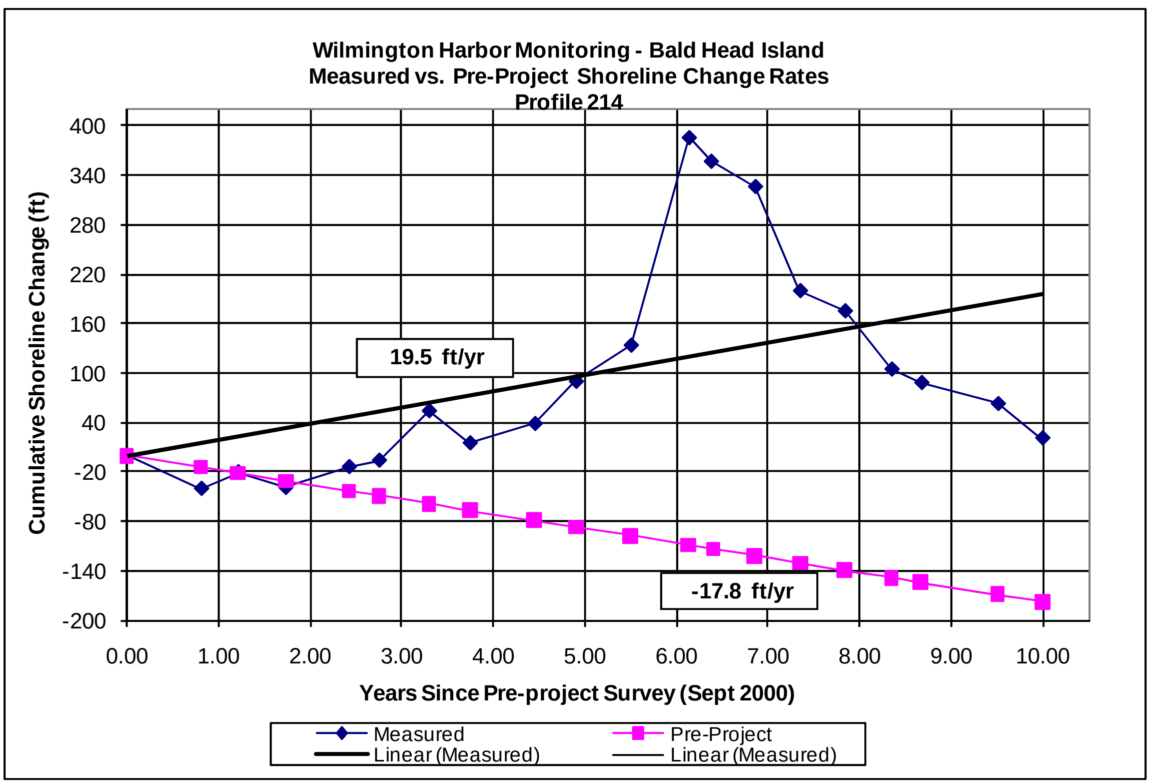

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 198
20.3 ft/yr
-10.0 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 202
21.3 ft/yr
-11.9 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

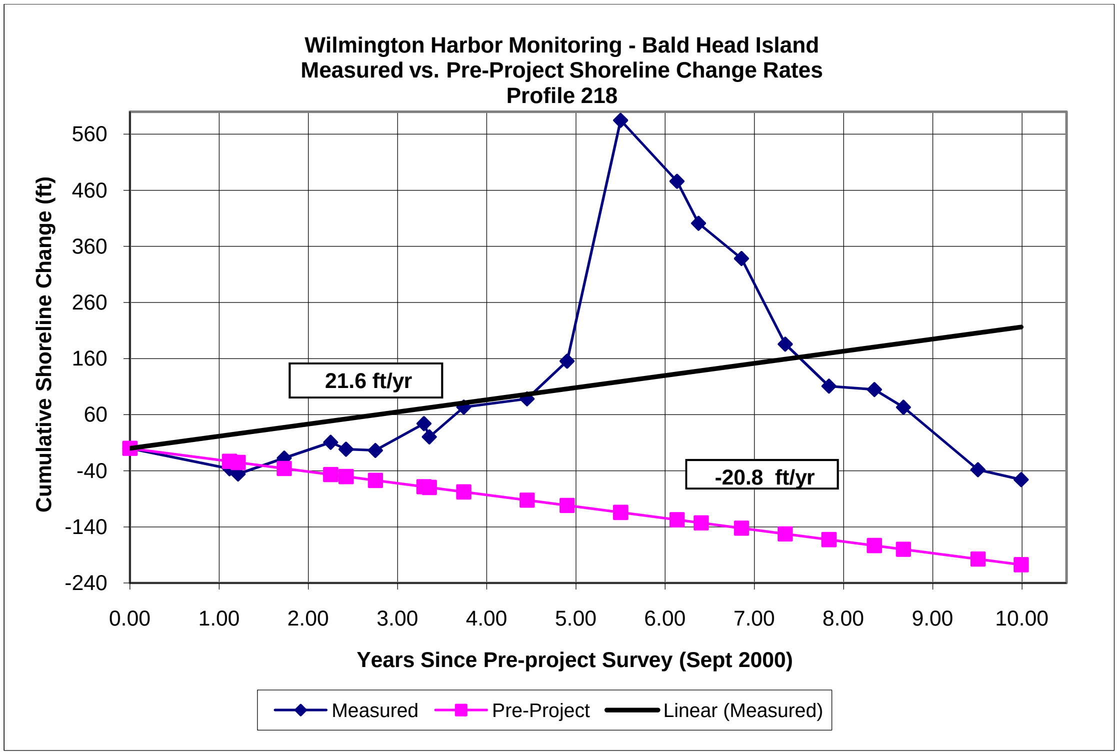

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 206
18.1 ft/yr
-13.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)



Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
-200
17.3 ft/yr
-15.0 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)



Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 214
Cumulative Shoreline Change (ft)
400
340
280
220
160
100
40
-20
-80
-140
-200
19.5 ft/yr
-17.8 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 218
Cumulative Shoreline Change (ft)
560
460
360
260
160
60
-40
-140
-240
21.6 ft/yr
-20.8 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

Appendix D

CURRENT MEASUREMENTS
(Tidal inlet and New Channel Regions)

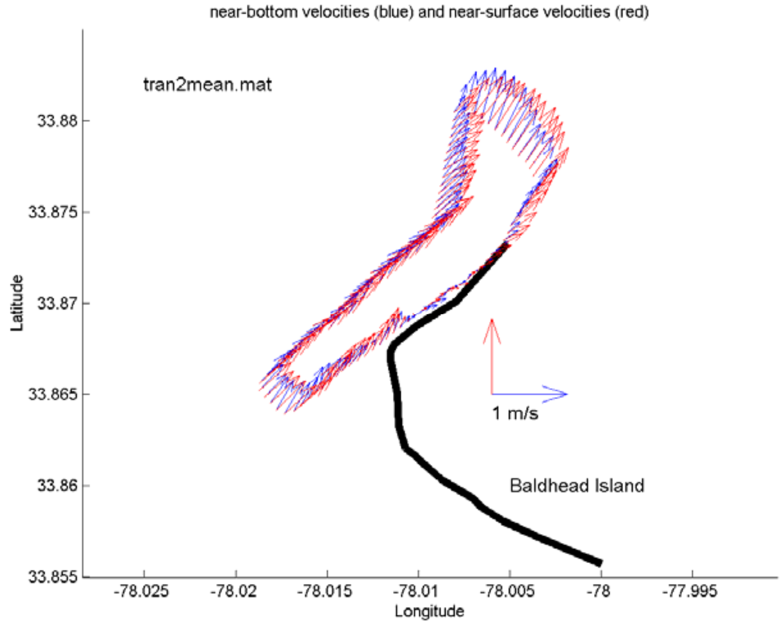


Figure D-1 October 2000 ADCP survey at inlet transect during peak flood flow. Note that survey transect does not cover same area as the April 2002, March 2003 and January 2004 surveys.

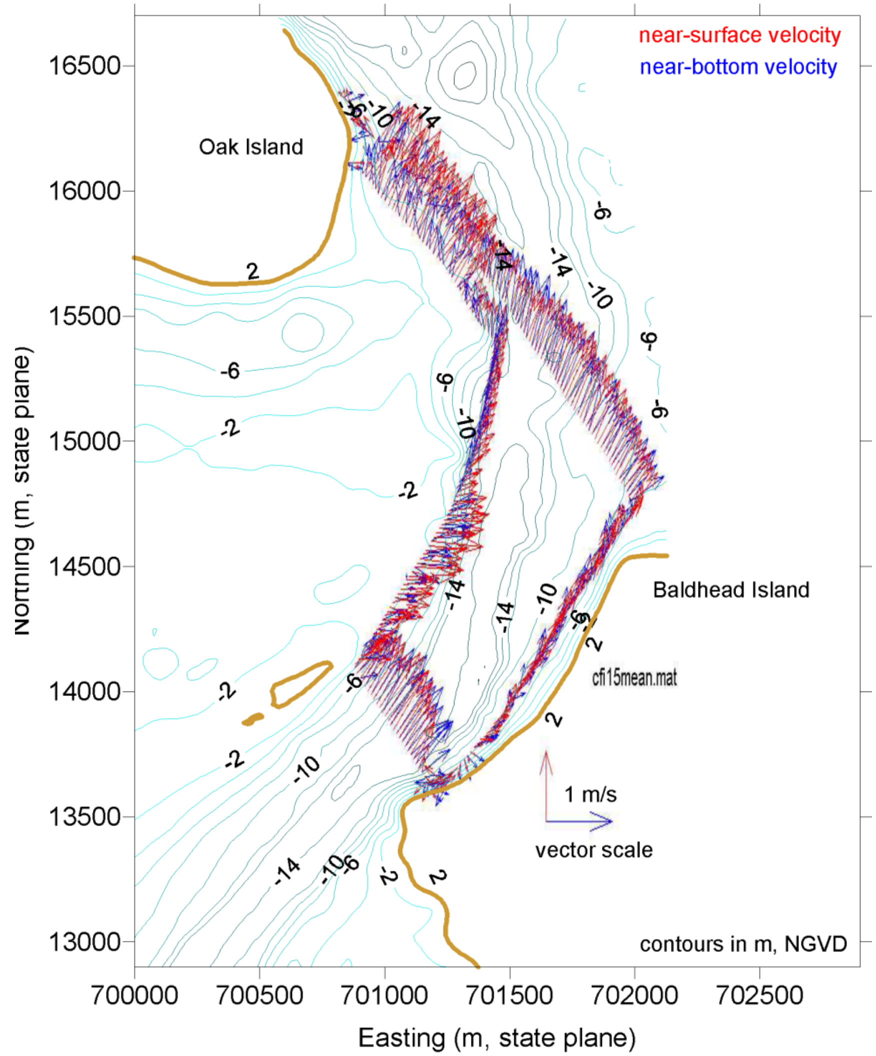


Figure D-2 April 2002 ADCP survey at inlet transect during peak flood flow.

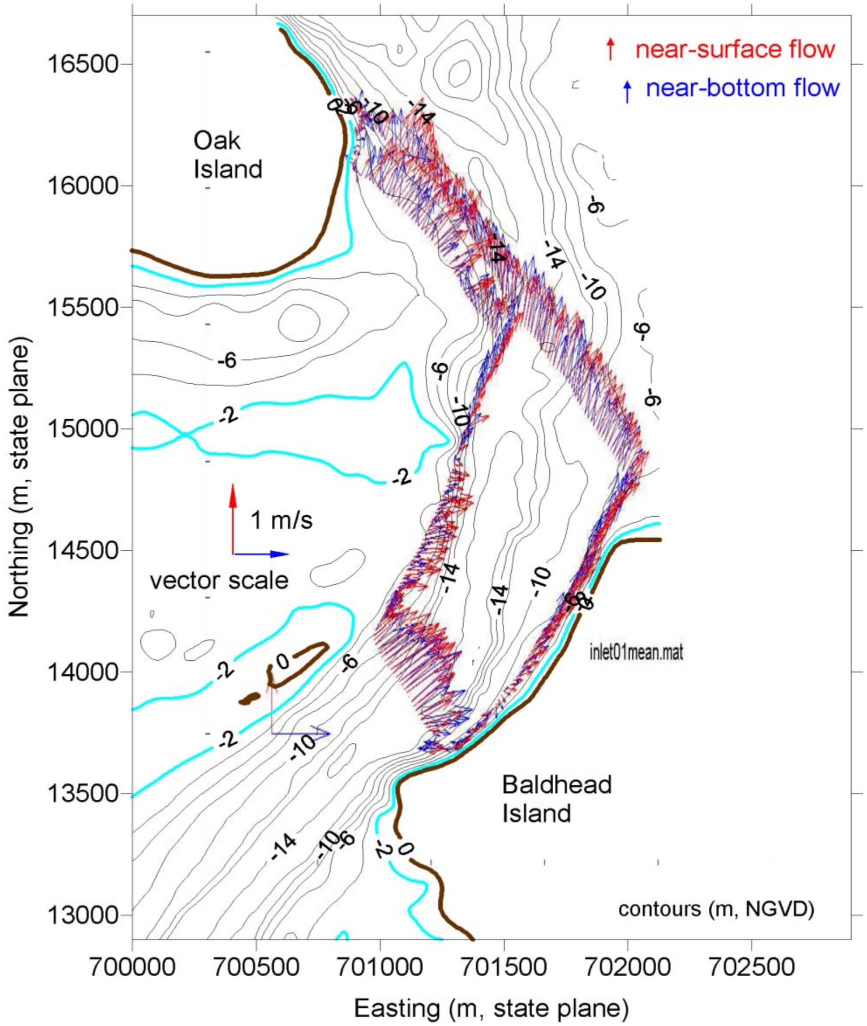


Figure D-3 March 2003 ADCP survey at inlet transect during flood flow.

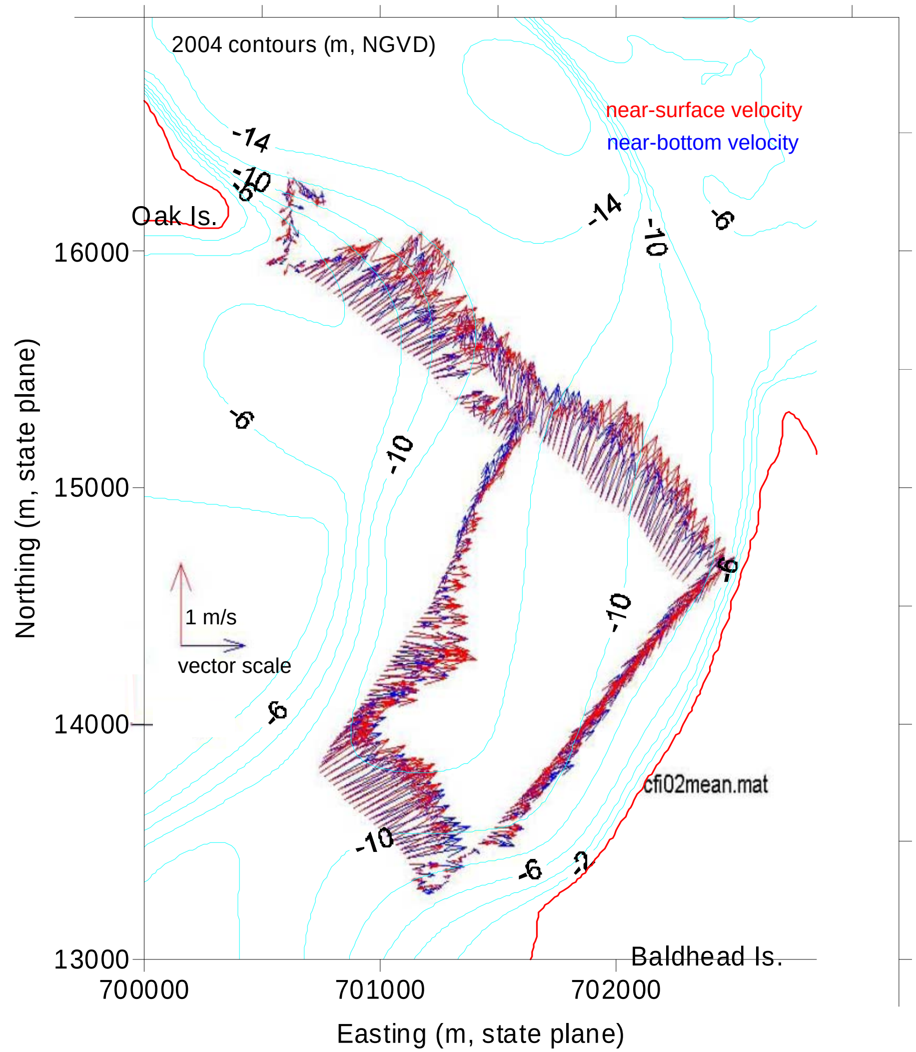


Figure D-4 January 2004 ADCP survey at inlet transect during flood flow.

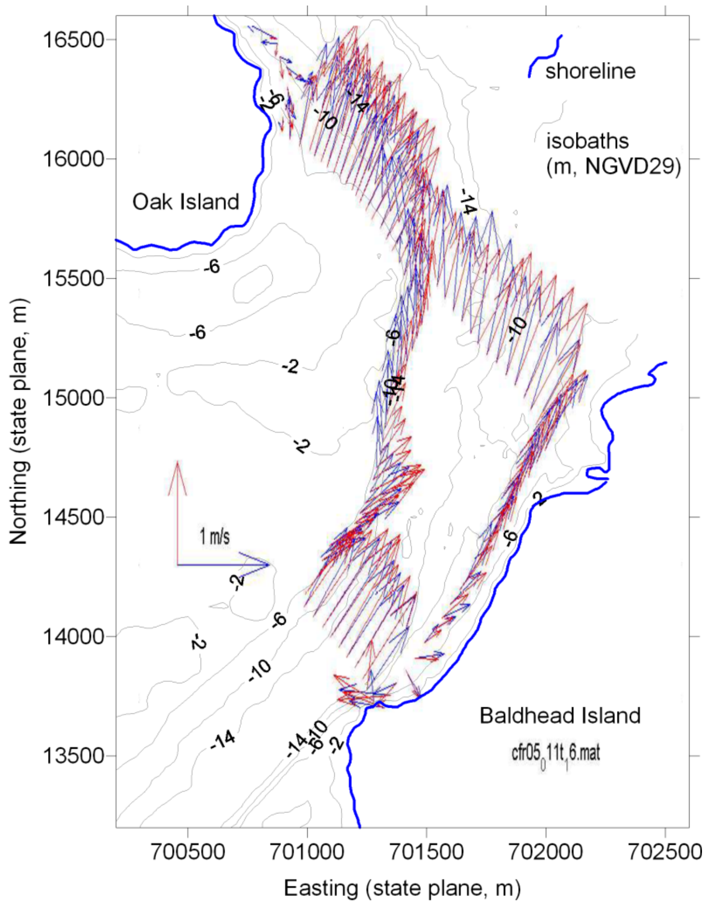


Figure D-5 March 2005 ADCP survey at inlet transect during flood flow.

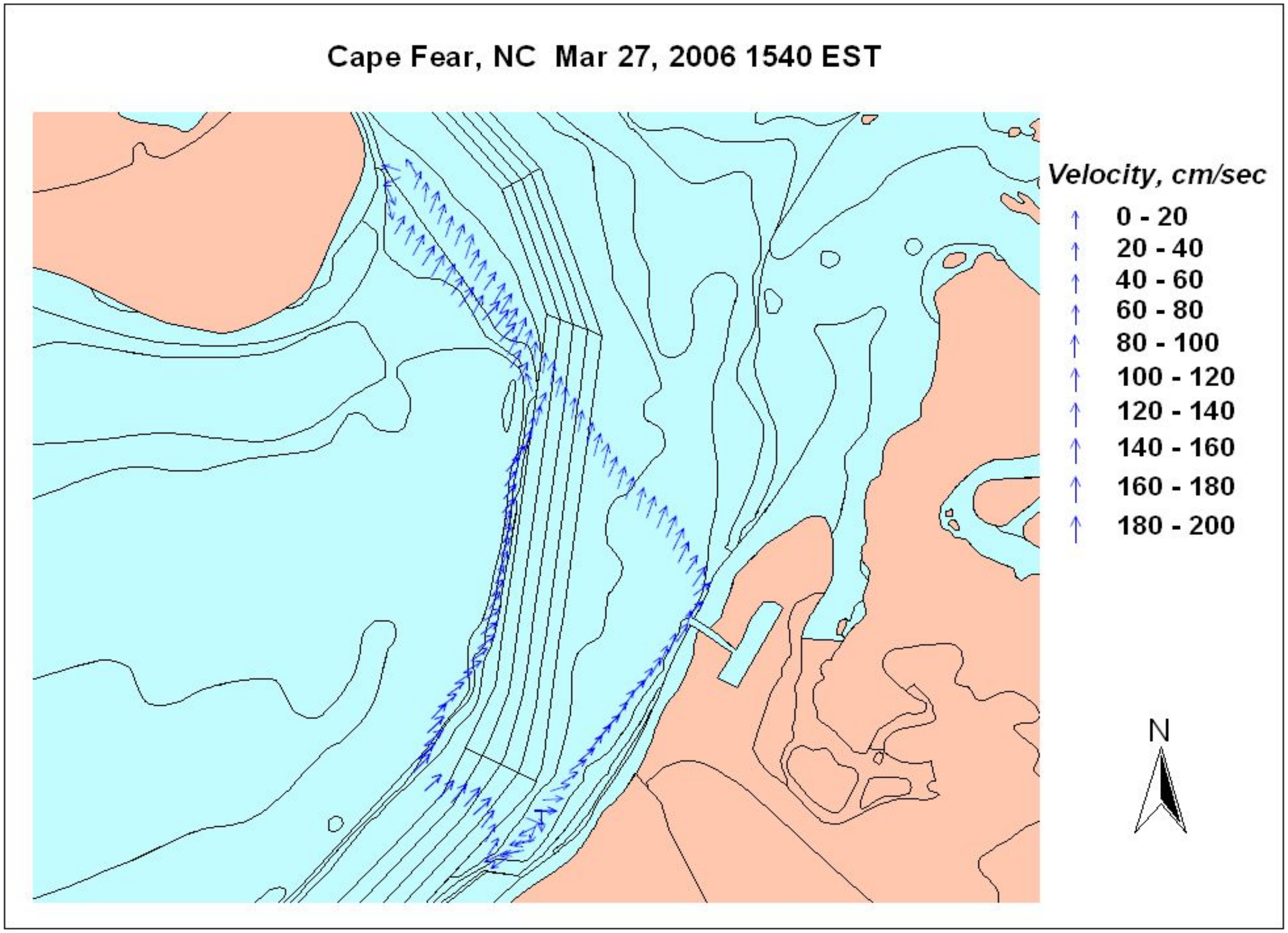


Figure D-6 March 2006 ADCP survey at the inlet transect during peak flood flow

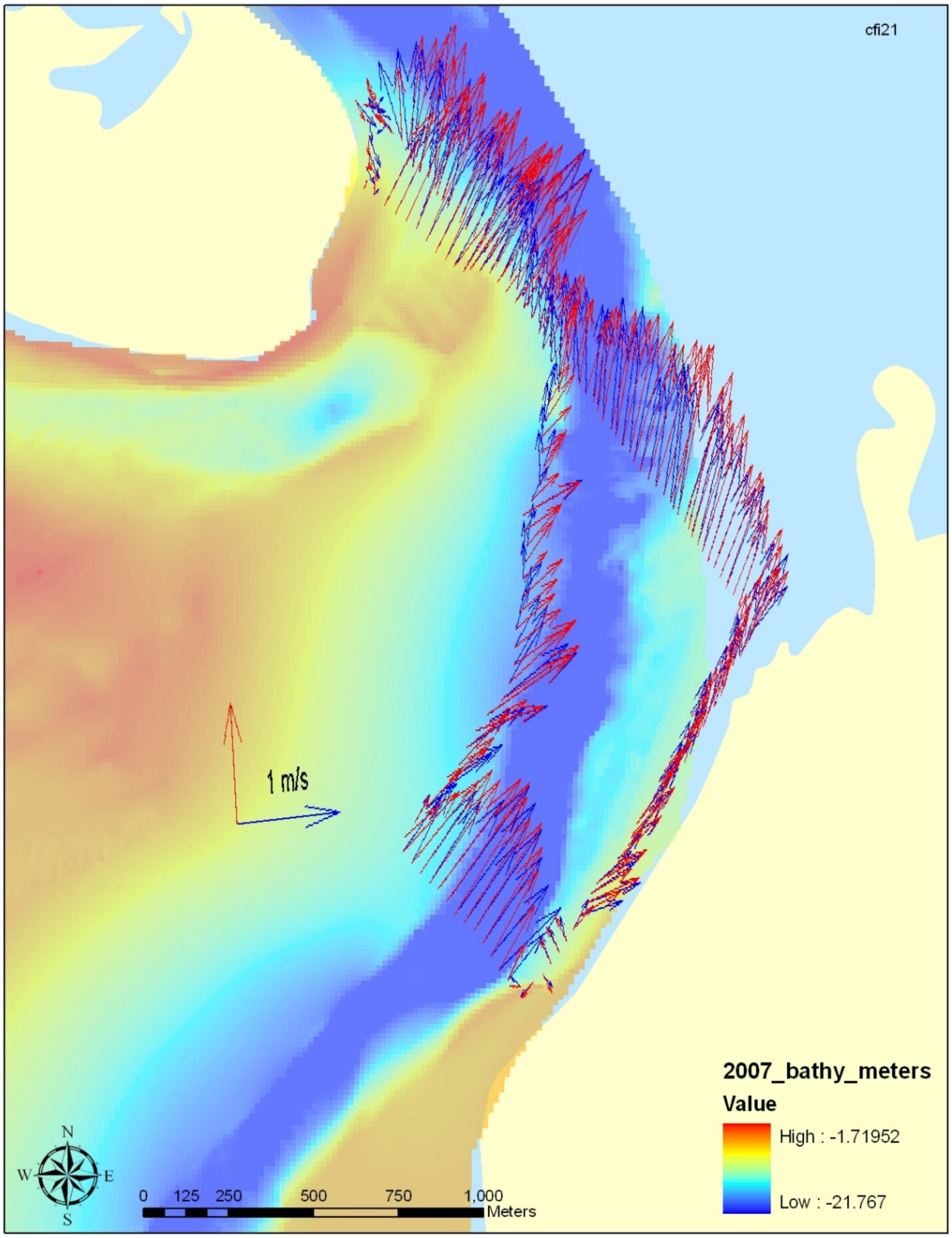


Figure D-7 February 2007 ADCP Survey at the Inlet Transect during Peak Flood Flow

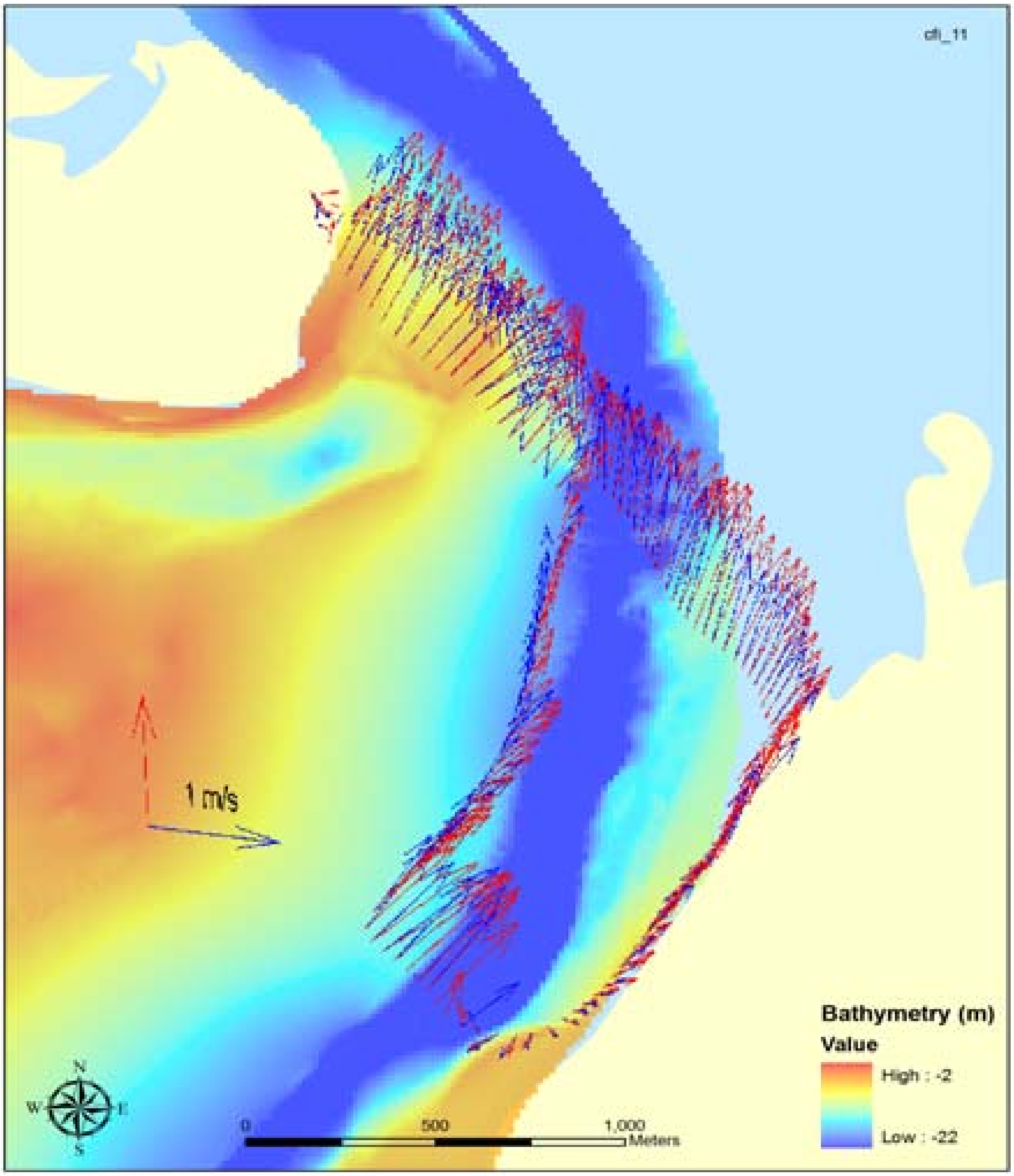


Figure D-8 March 2008 ADCP Survey at the Inlet Transect during Peak Flood Flow

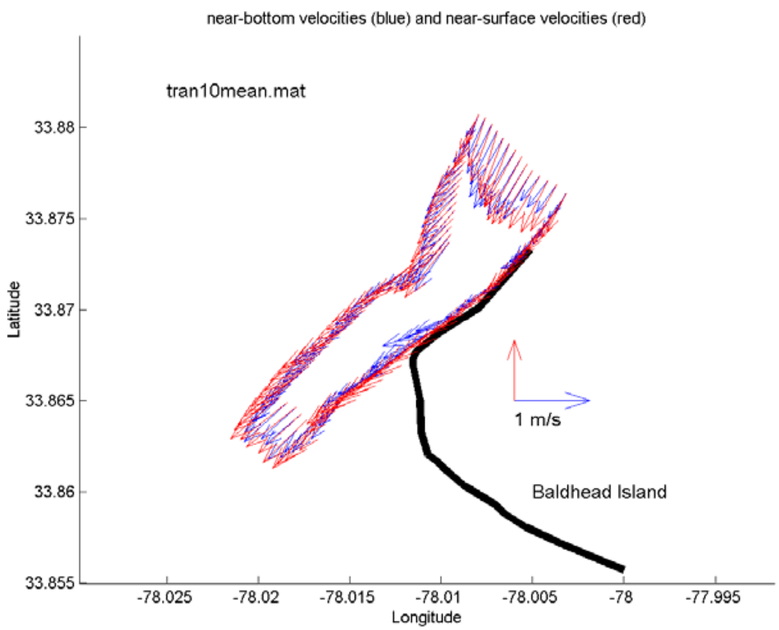


Figure D-9 October 2000 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the April 2002 survey.

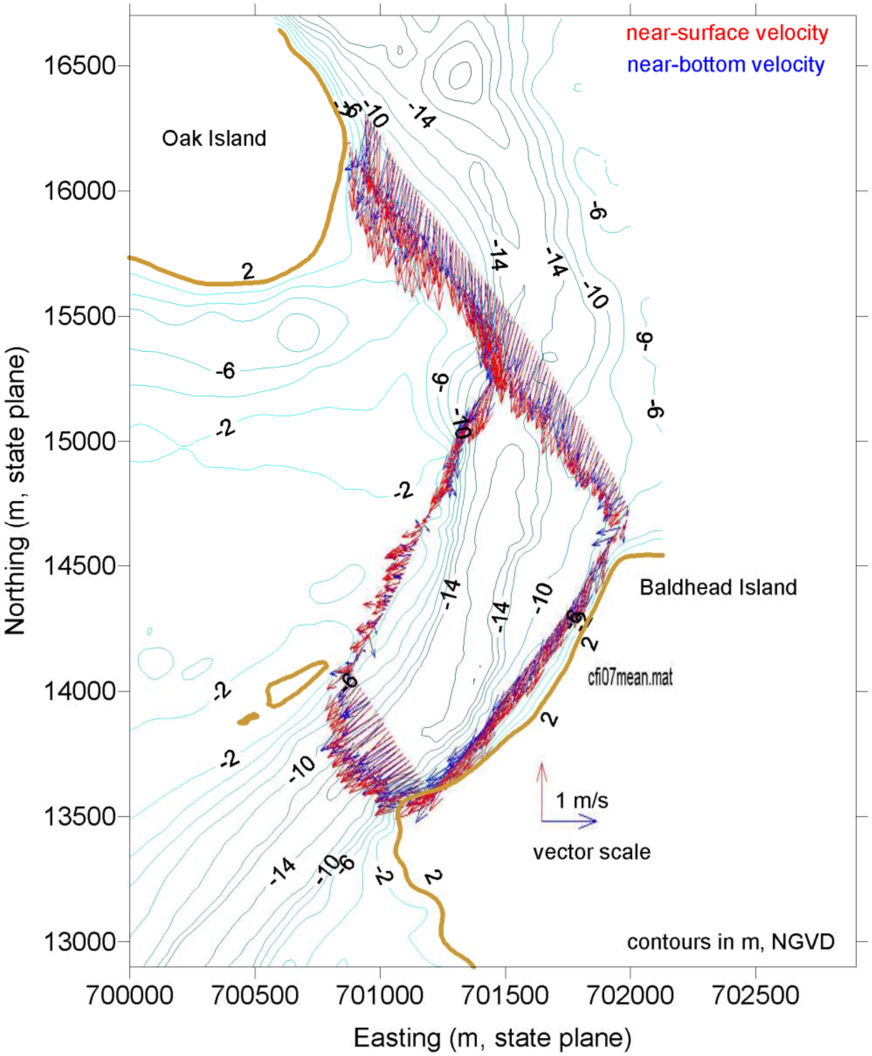


Figure D-10 April 2002 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the October 2000 survey.

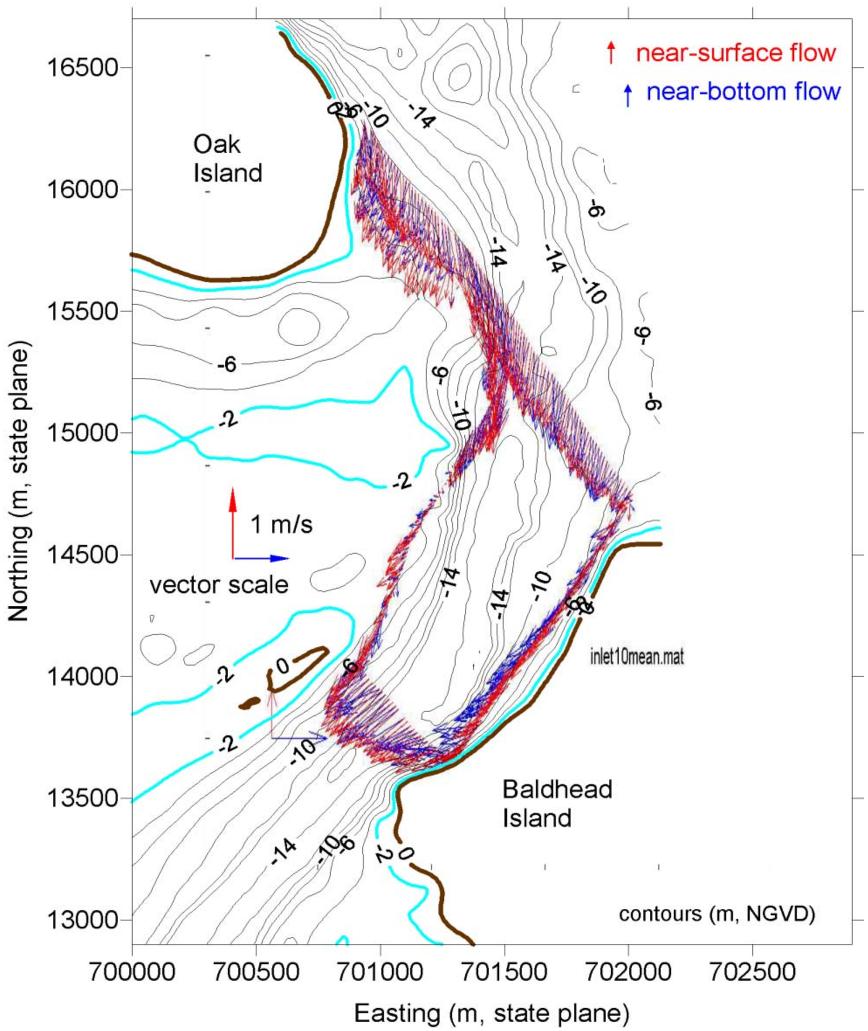


Figure D-11 March 2003 ADCP survey at inlet transect during ebb flow.

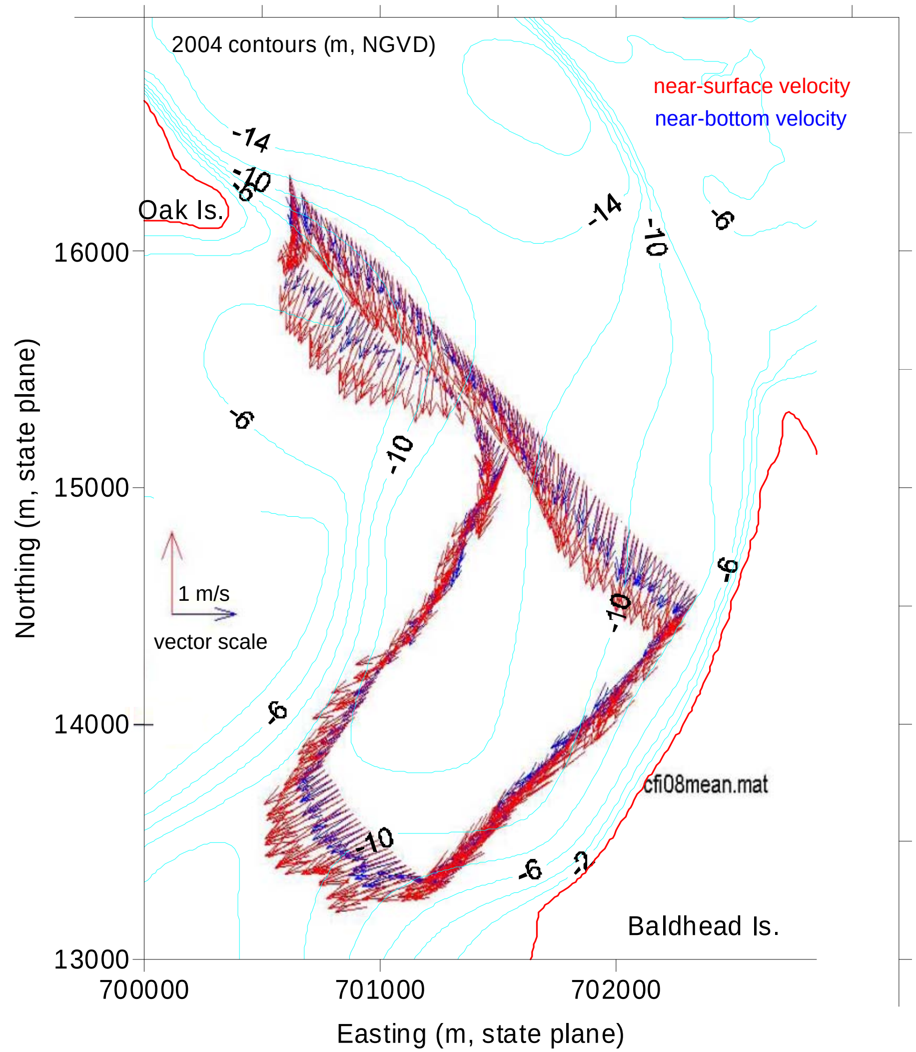


Figure D-12 January 2004 ADCP survey at inlet transect during ebb flow.

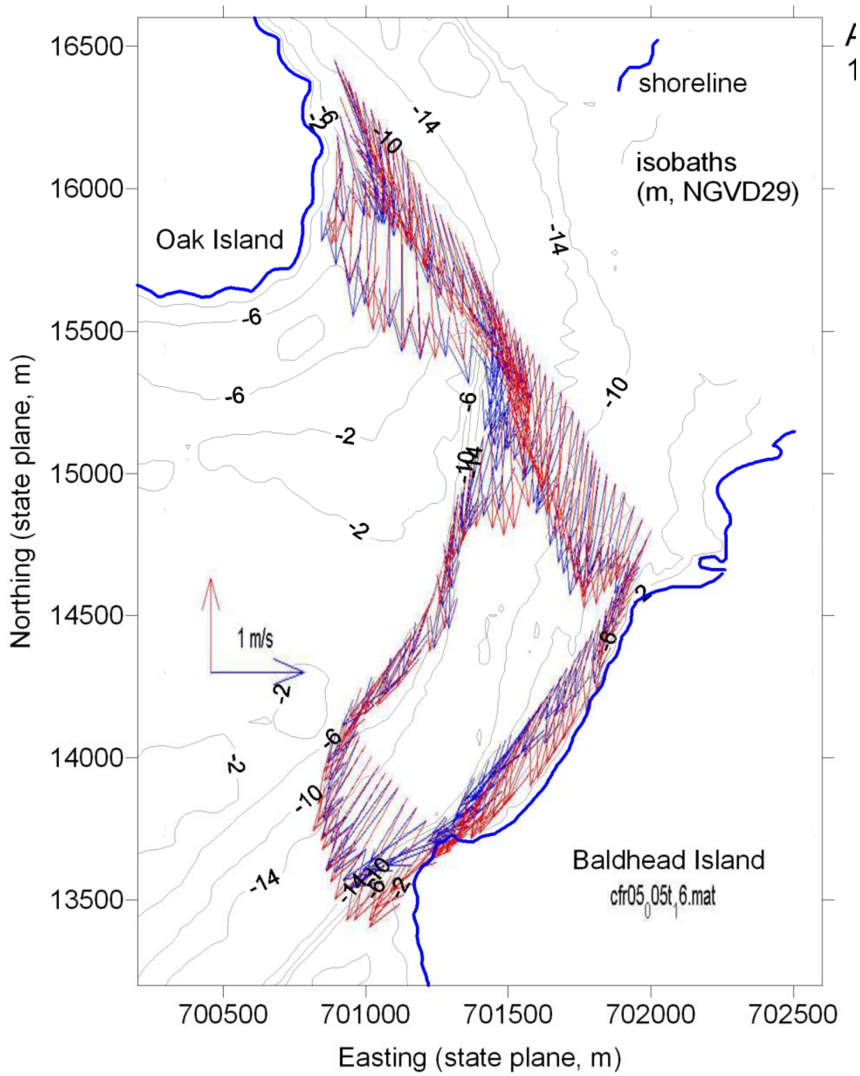


Figure D-13 March 2005 ADCP survey at inlet transect during ebb flow.

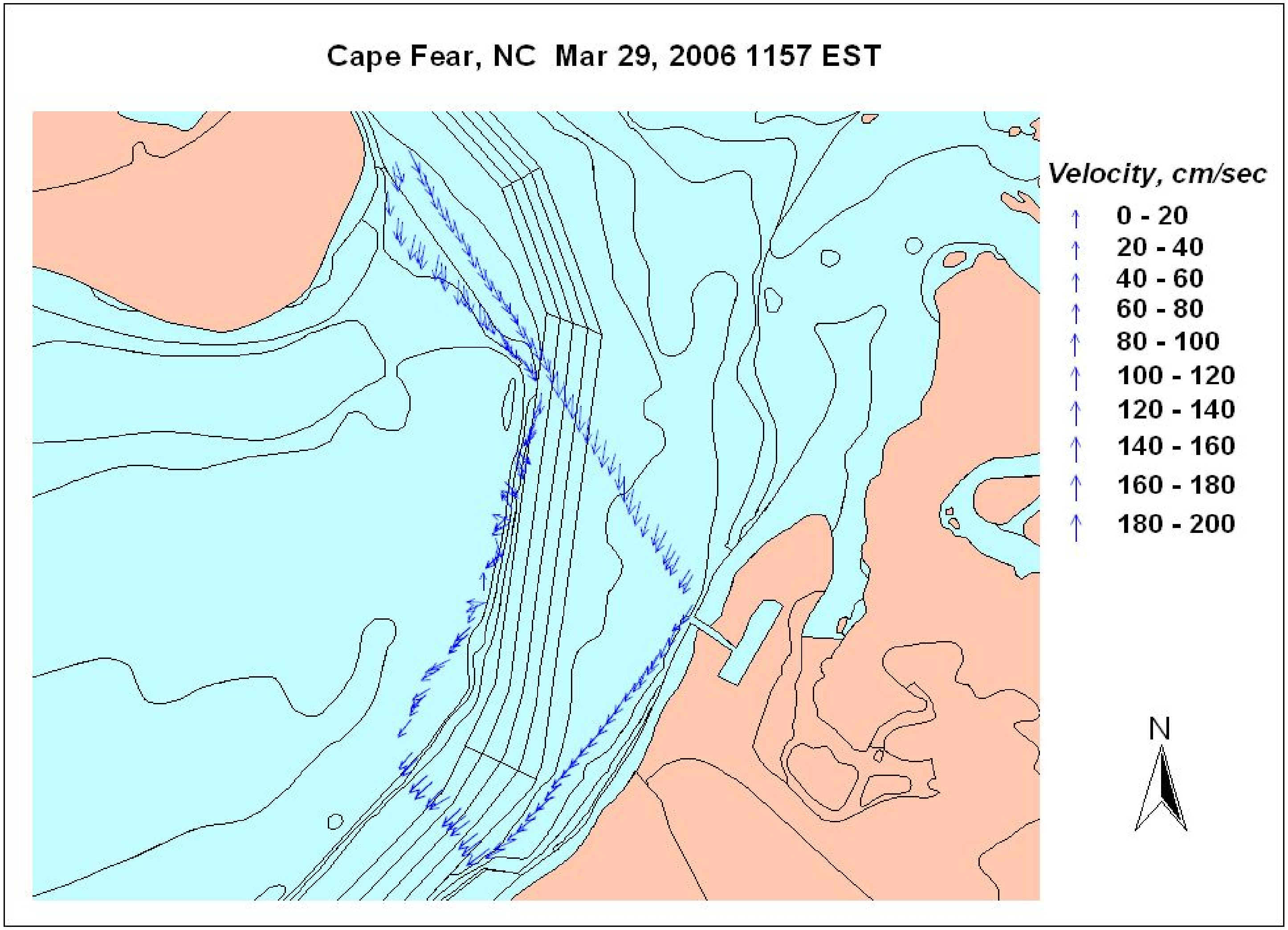


Figure D-14 March 2006 ADCP survey at the inlet transect during peak ebb flow

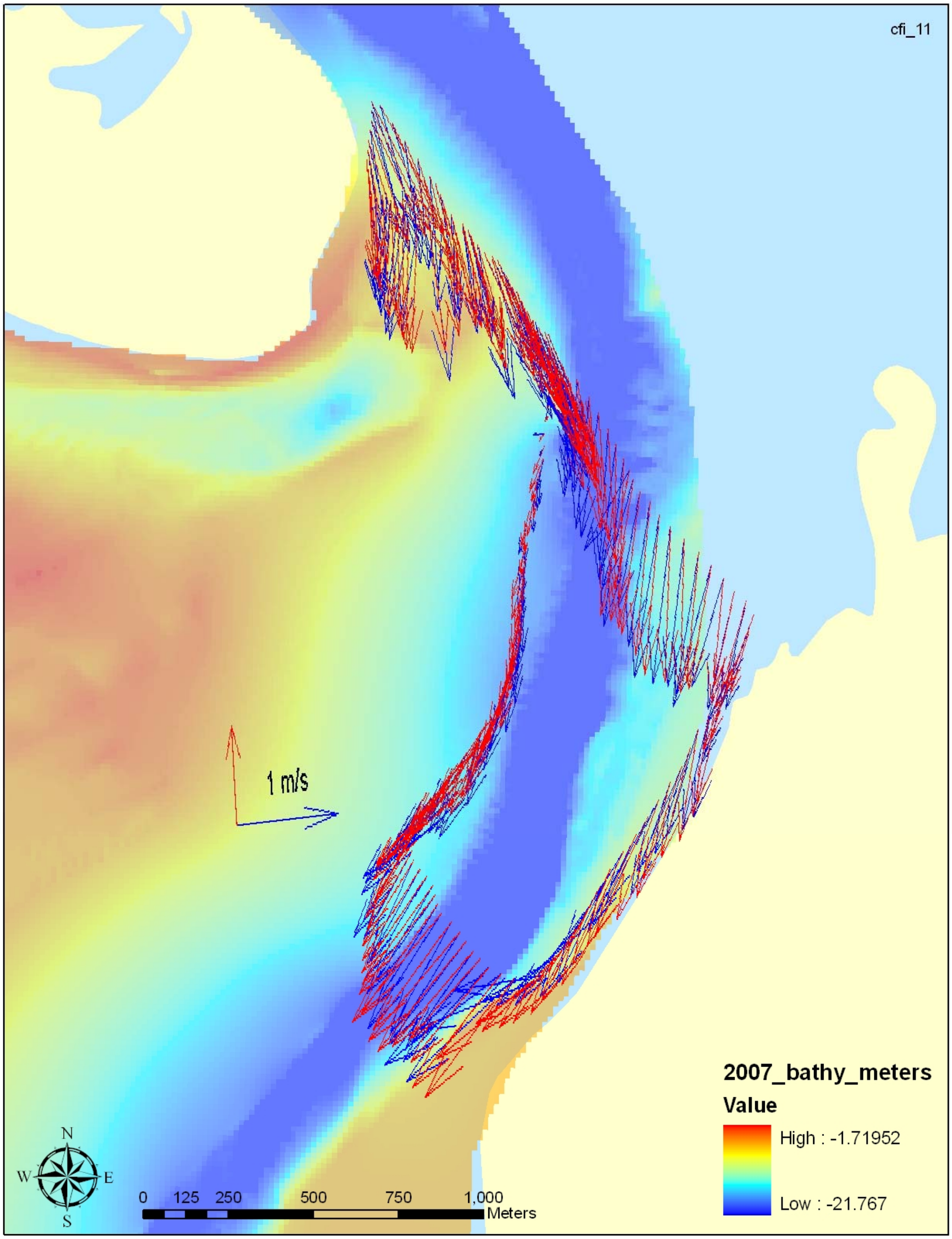


Figure D-15 February 2007 ADCP Survey at the Inlet Transect During Peak Ebb Flow

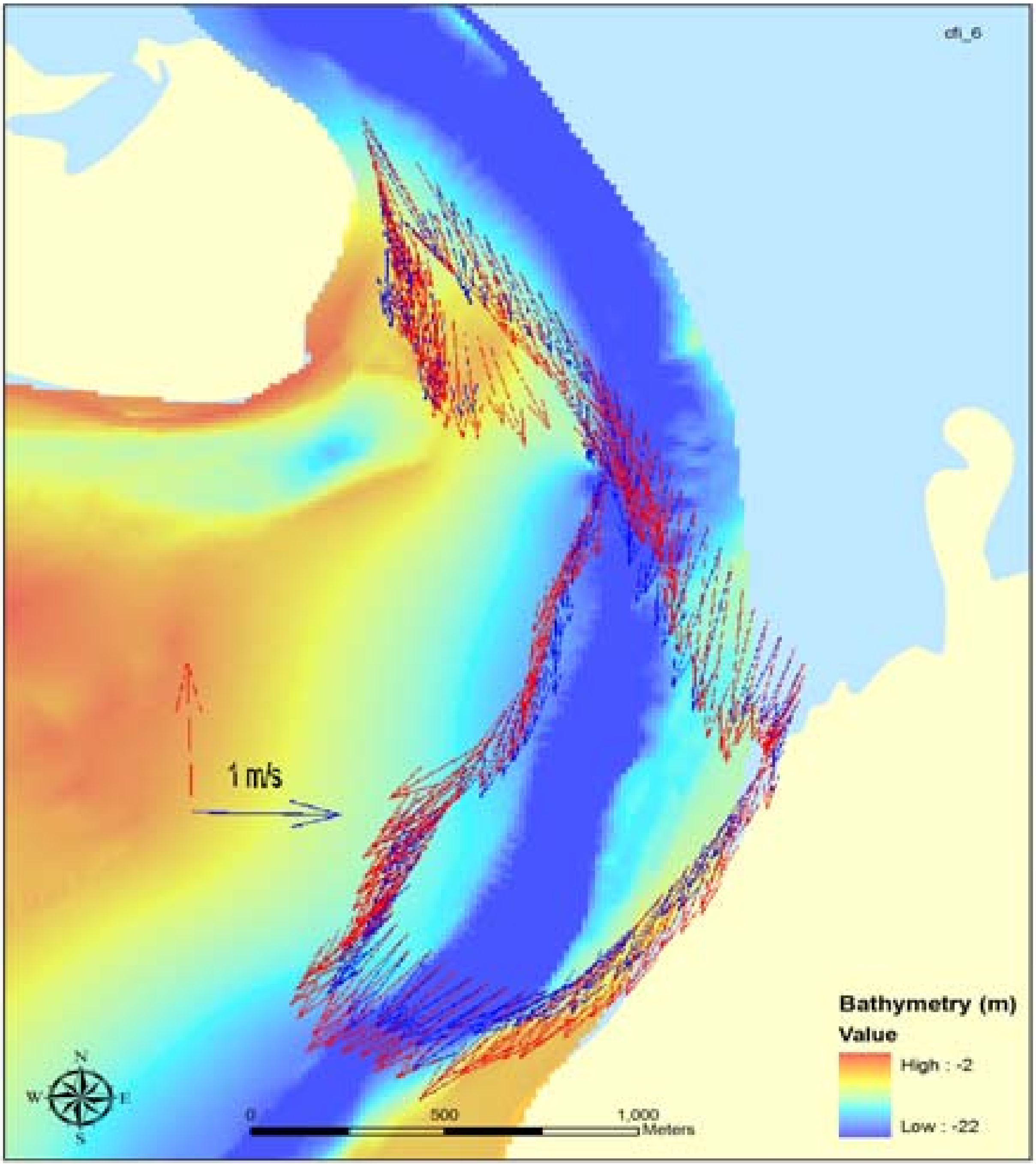


Figure D-16 March 2008 ADCP Survey at the Inlet Transect During Peak Ebb Flow

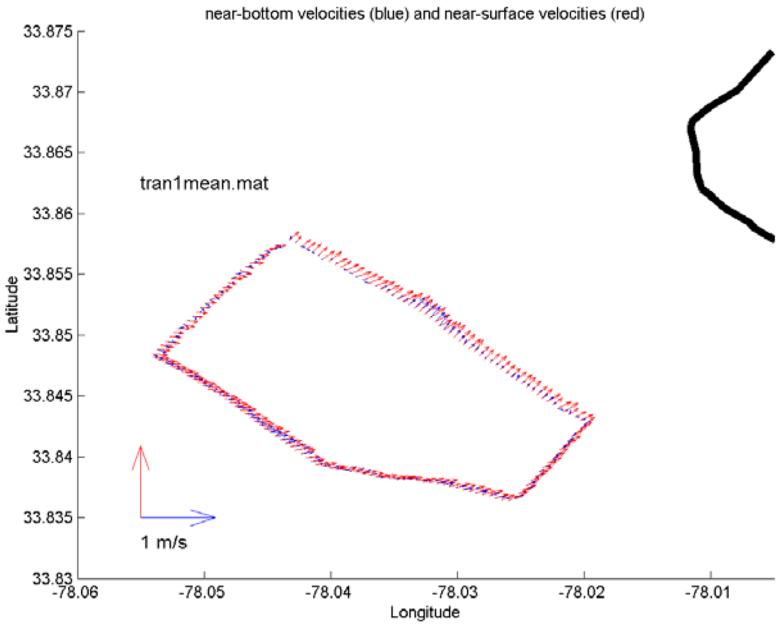


Figure D-17 October 2000 ADCP survey at offshore transect during peak flood flow.

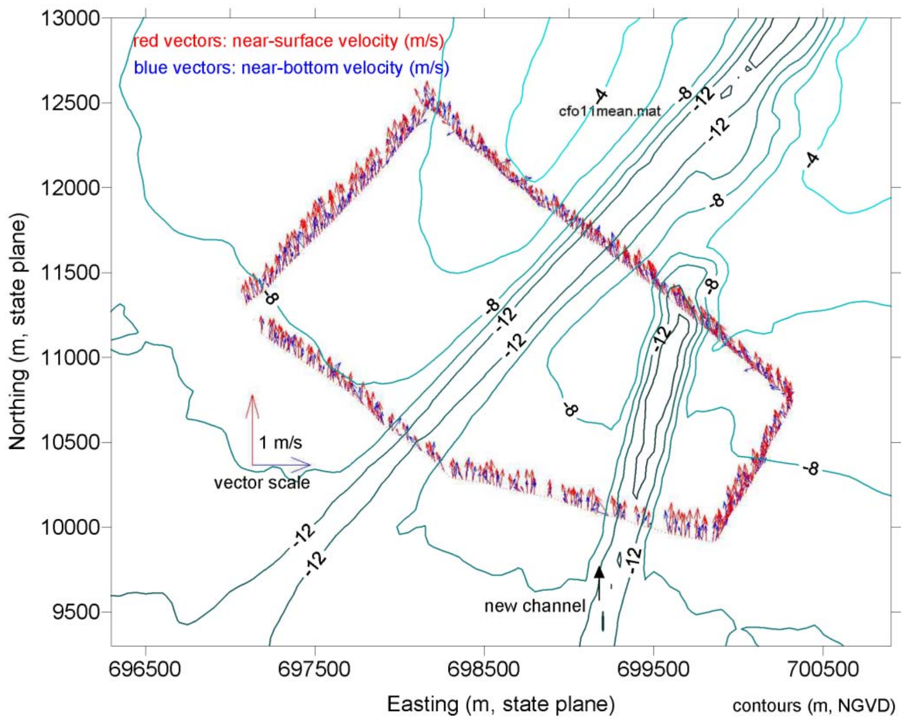


Figure D-18 April 2002 ADCP survey at offshore transect during peak flood flow.

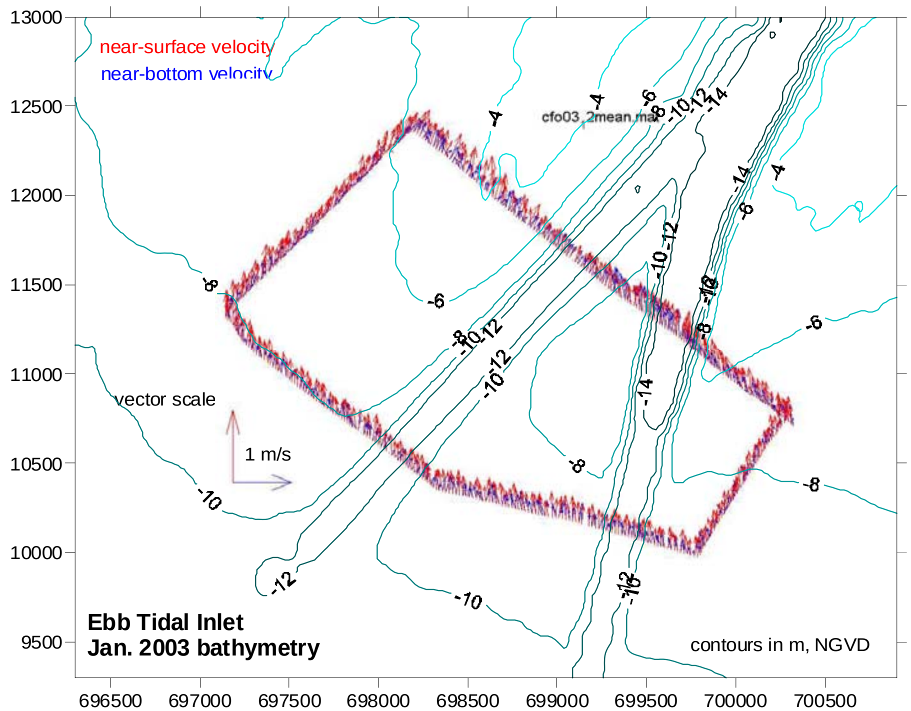


Figure D-19 March 2003 ADCP survey at offshore transect during flood flow.

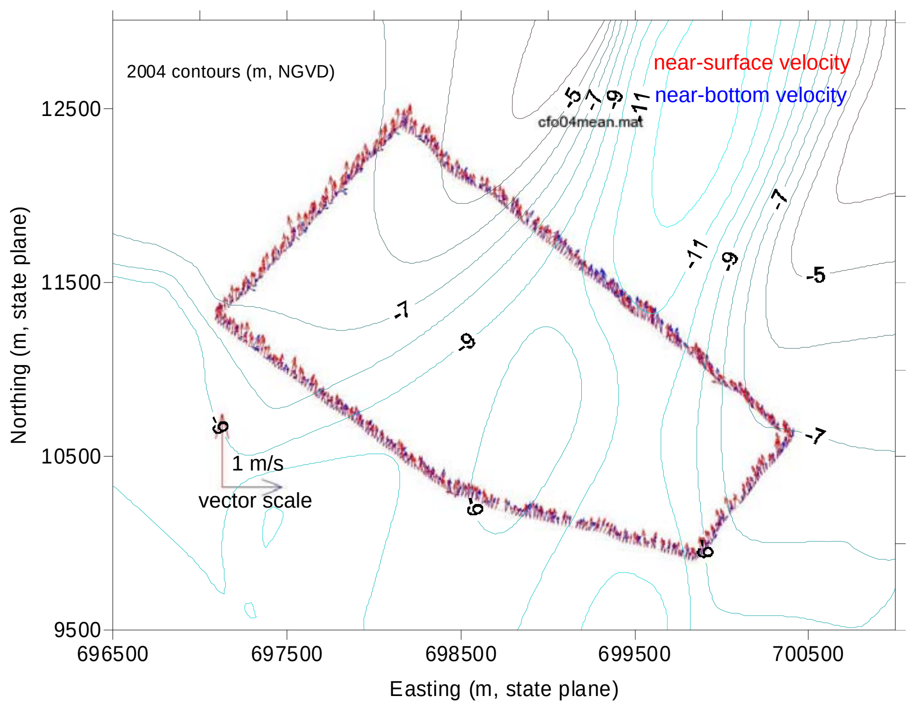


Figure D-20 January 2004 ADCP survey at offshore transect during flood flow.

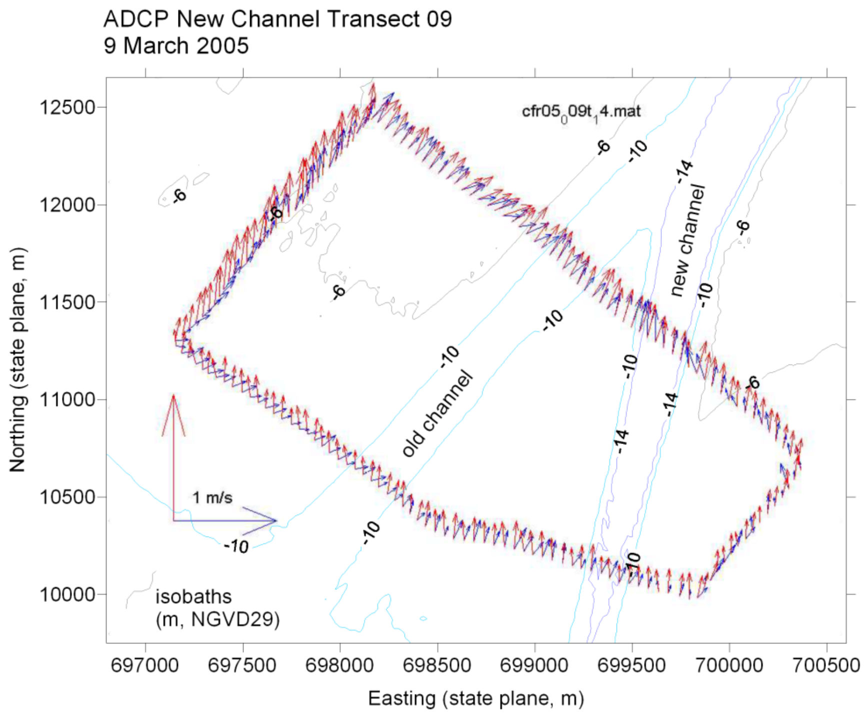


Figure D-21 March 2005 ADCP survey at offshore transect during flood flow.

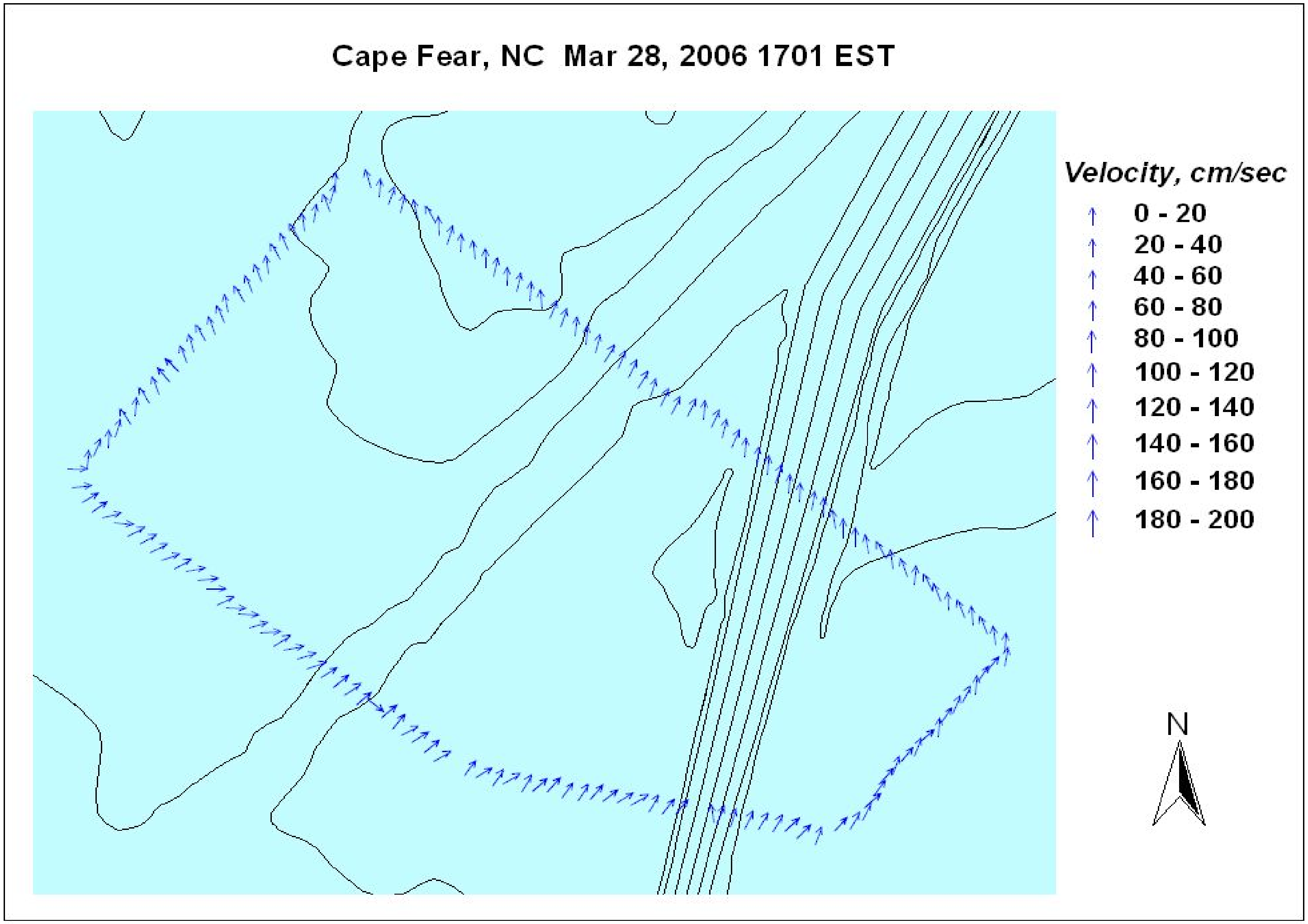


Figure D-22 March 2006 ADCP survey at the offshore-new channel transect approaching peak flood flow

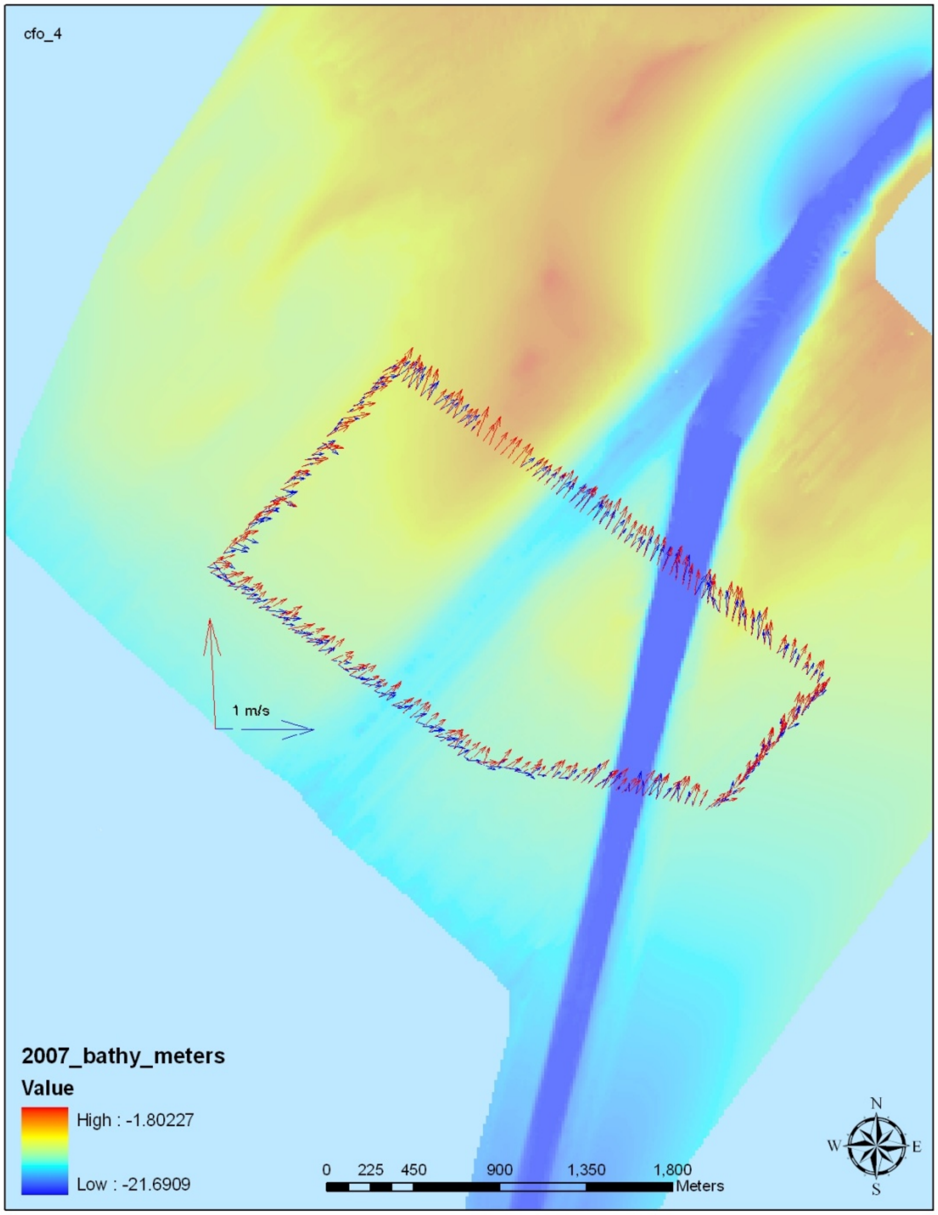


Figure D-23 March 2007 ADCP survey at the Offshore-New Channel Transect near peak flood flow

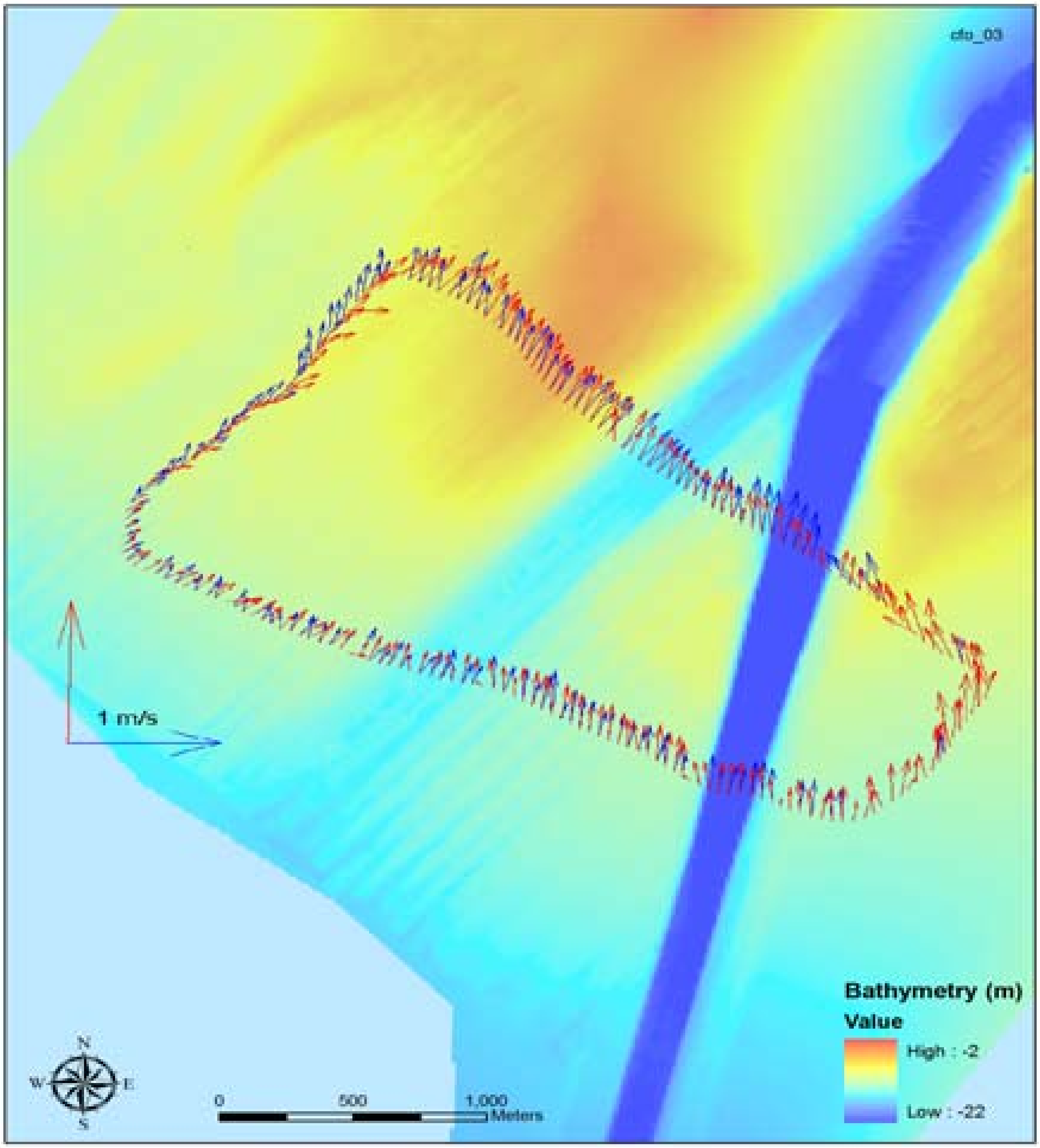


Figure D-24 March 2008 ADCP survey at the Offshore-New Channel Transect near peak flood flow

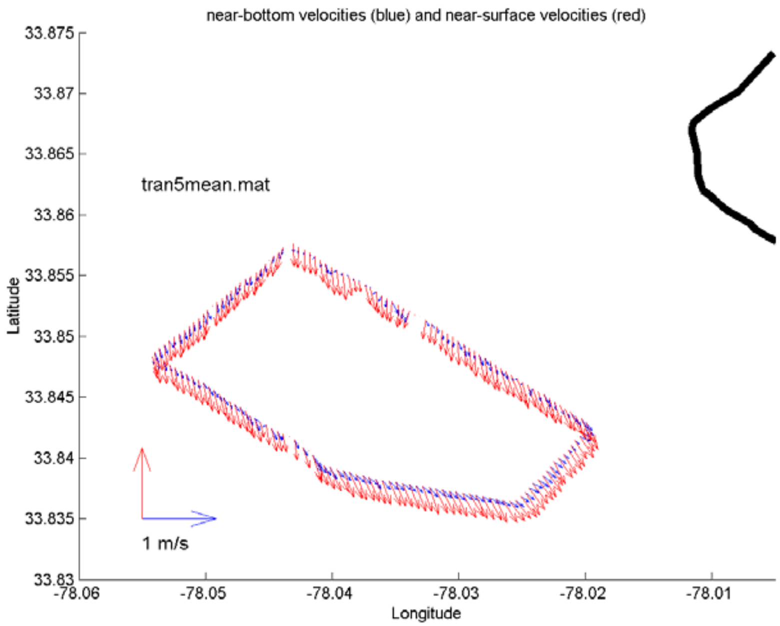


Figure D-25 October 2000 ADCP survey at offshore transect during peak ebb flow.

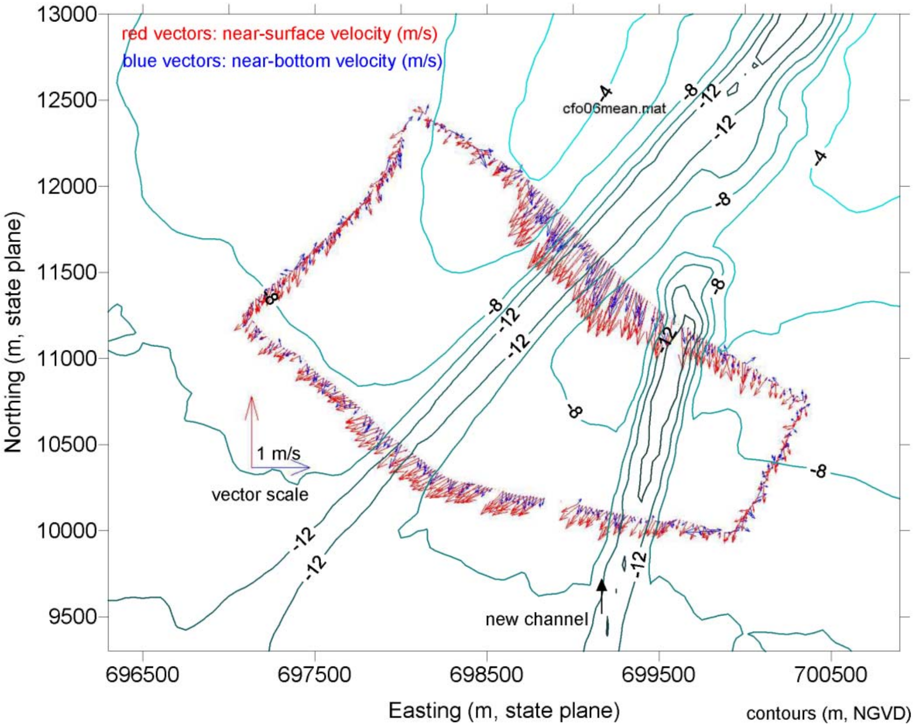


Figure D-26 April 2002 ADCP survey at offshore transect during peak ebb flow.

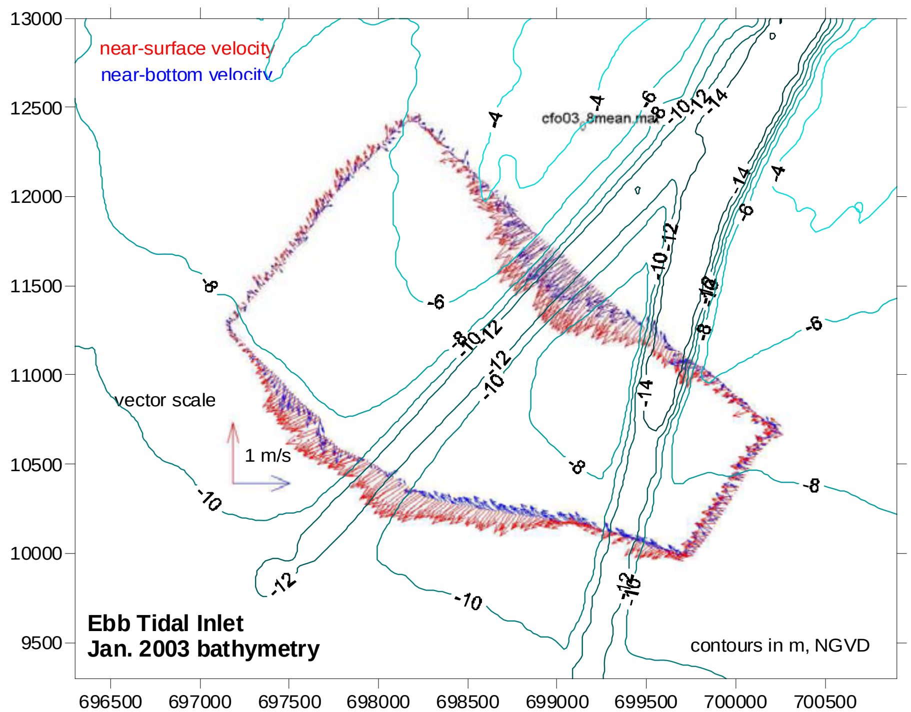


Figure D-27 March 2003 ADCP survey at offshore transect during ebb flow.

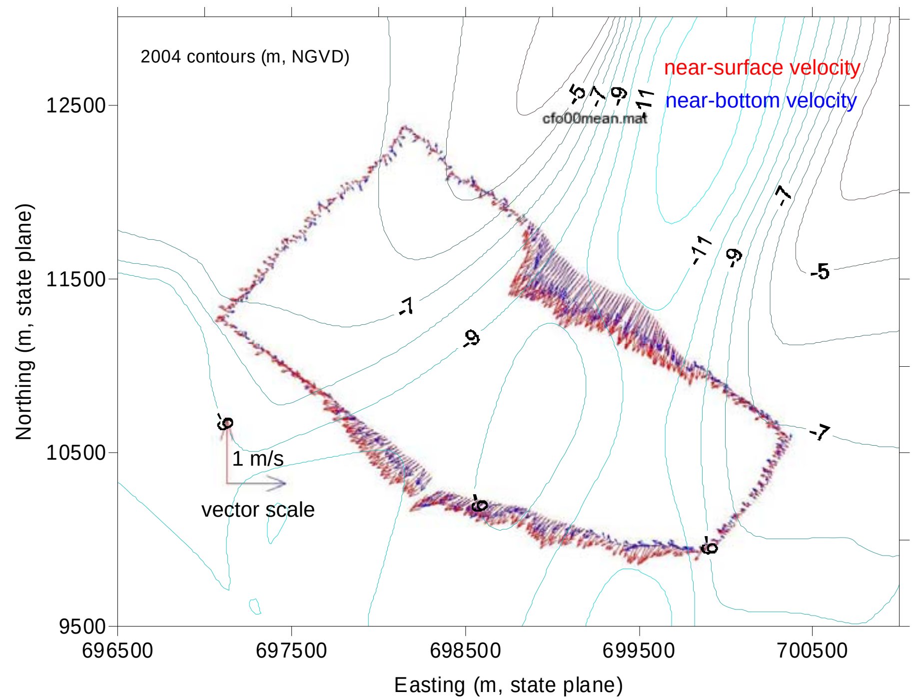


Figure D-28 January 2004 ADCP survey at offshore transect during ebb flow.

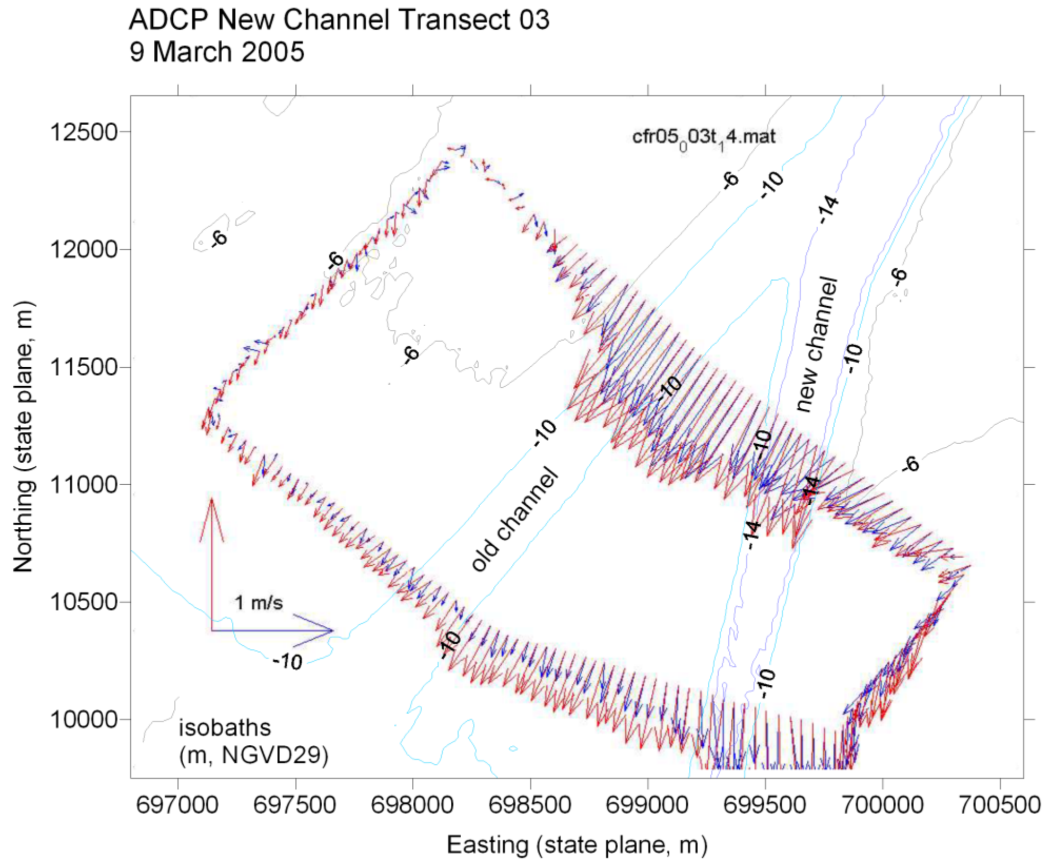


Figure D-29 March 2005 ADCP survey at offshore transect during ebb flow.

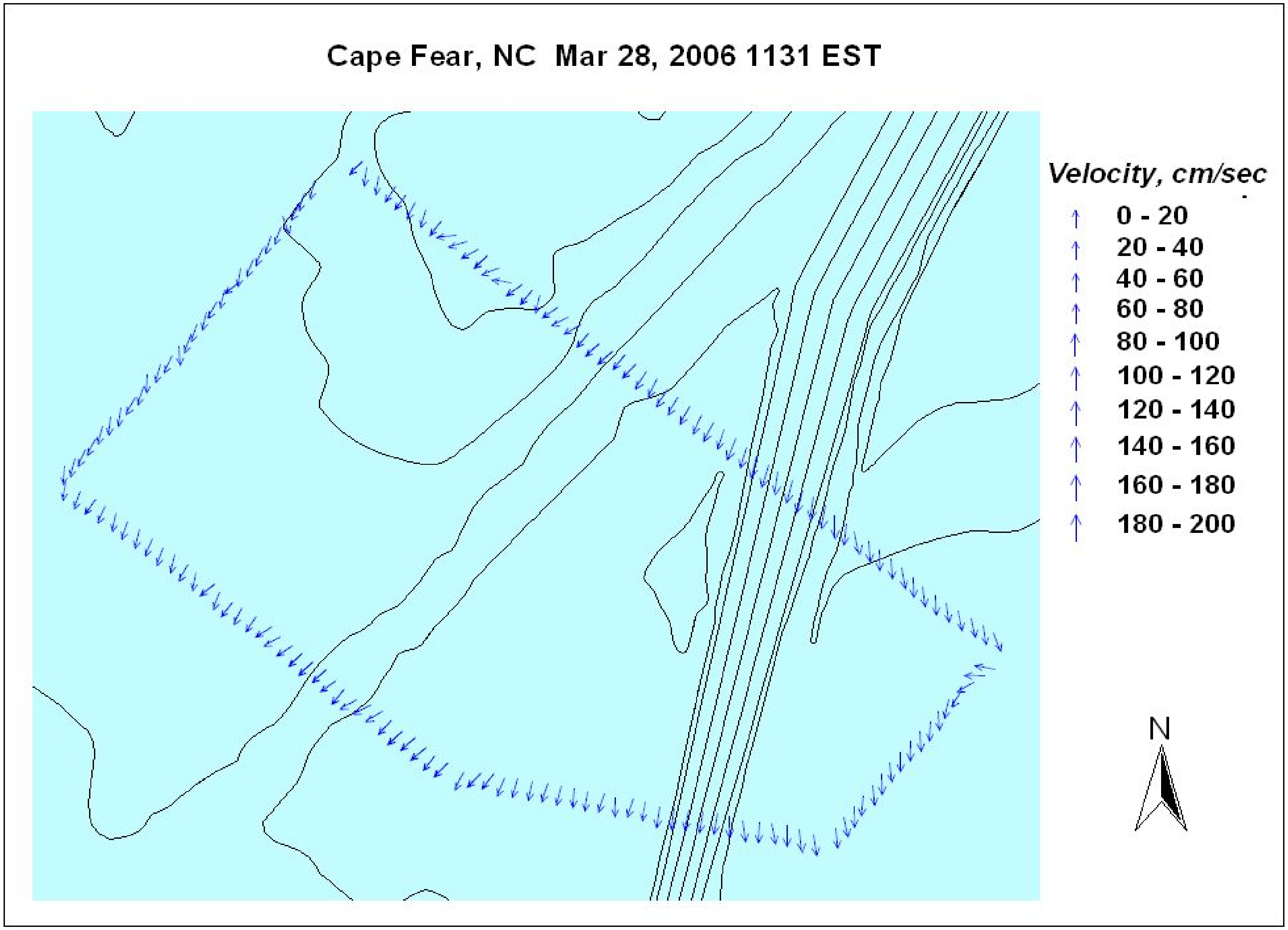


Figure D-30 March 2006 ADCP survey at the offshore-new channel transect during peak ebb flow

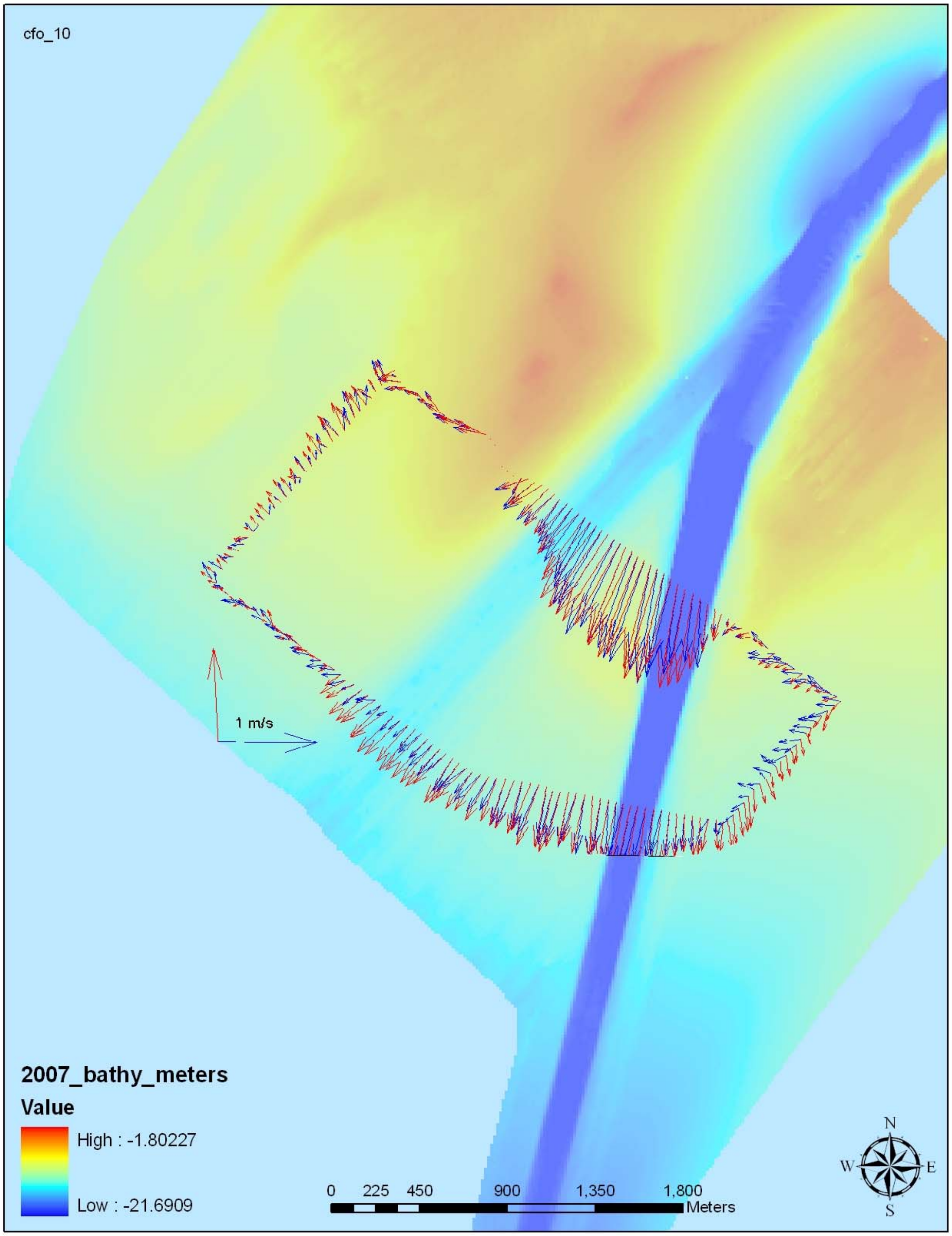


Figure D-31 March 2007 ADCP survey at the Offshore-New Channel Transect near peak ebb flow

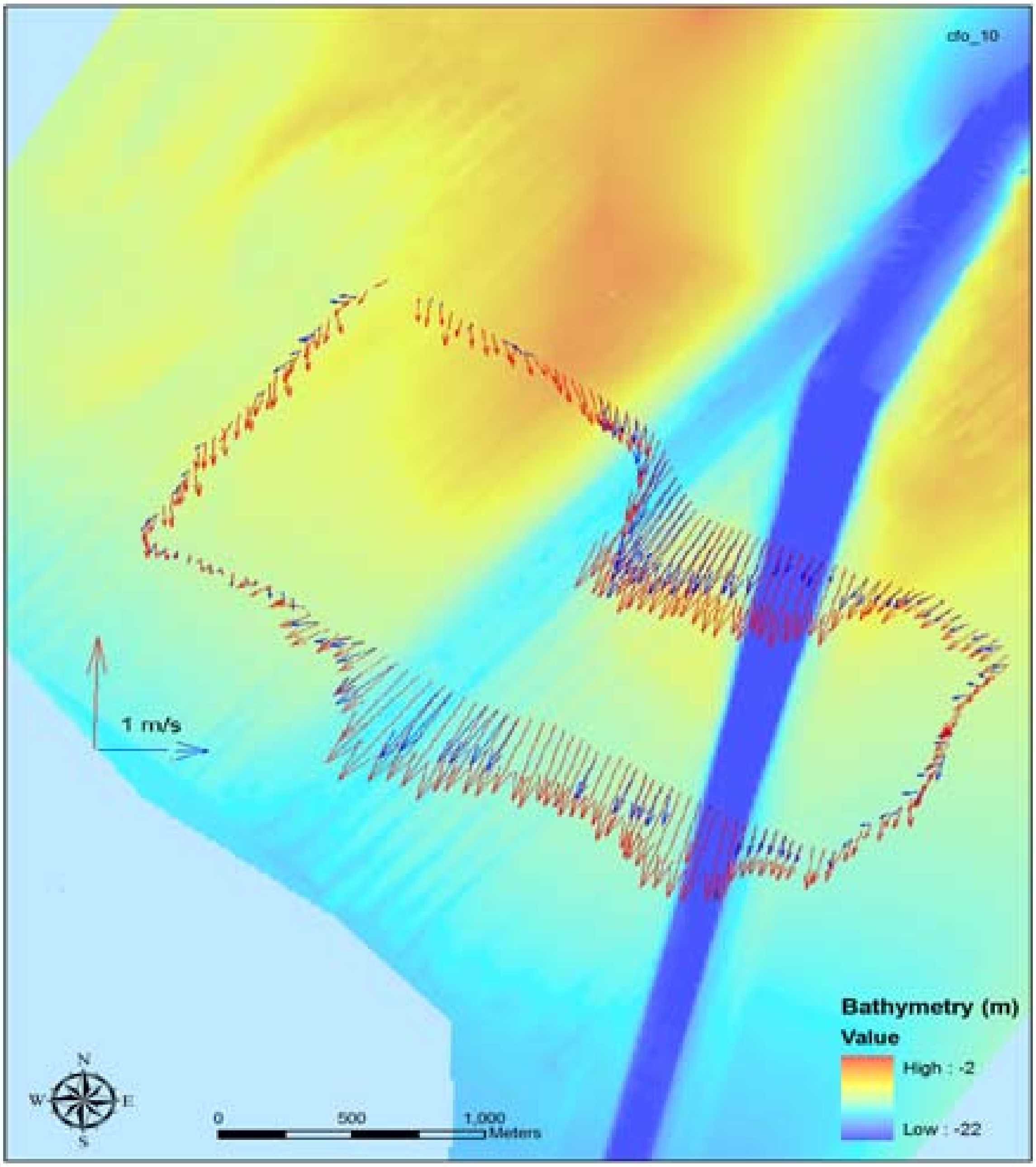


Figure D-32 March 2008 ADCP survey at the Offshore-New Channel Transect near peak ebb flow