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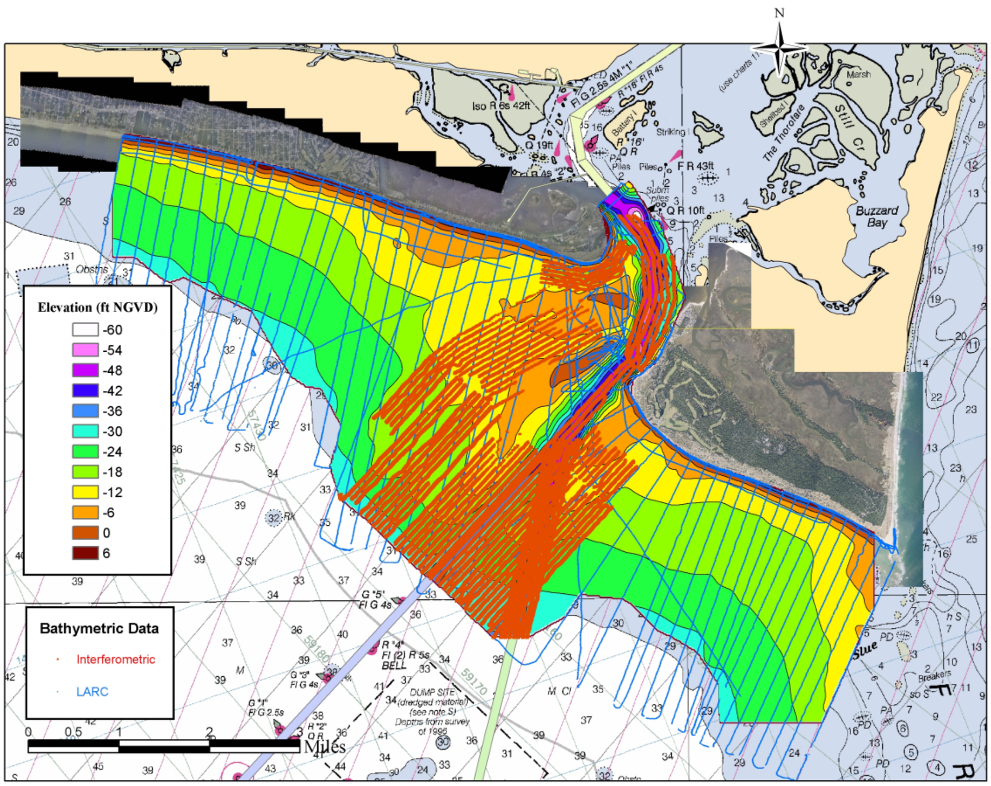
Wilmington District

PHYSICAL MONITORING WILMINGTON HARBOR NAVIGATION PROJECT REPORT 9: October 2010 – August 2012



December 2013

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 9:
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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 changes in the ebb tide delta to the channel deepening and realignment for which construction began in December 2000. The monitoring program through Report 8 involved five elements: beach profile surveys, channel and ebb tide delta surveys, wave and current measurements, aerial photography; and data analysis/reporting. With the completion of a 6 year dredging cycle and the reevaluation of the sand management plan the monitoring program was reduced and has eliminated the wave and current measurement sections for this and future reports.

This report is the ninth in a series and serves to update the monitoring program with data collected October 2010 through August 2012. 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, seventh and eighth 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, October 2008 to November 2009 and October 2009 to September 2010 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 were collected by three bottom-mounted wave gauges consisting of an Acoustic Doppler Current Profiler (ADCP) meter and a pressure gauge. The gauges were located just offshore of Oak and Bald Head Islands plus in the offshore waters about 11 miles from the coast. Due to funding constraints, the three ADCPs were supposed to officially be removed from the water by June of 2009. The gauges were kept in water for extra 18 months but the collected data was not processed and is available in raw binary format.

Currents 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 were not collected during this monitoring period.

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. Three images were obtained for use in the current monitoring report including January 2011, September 2011 and June 2012.

Data collected over the present monitoring period of October 2010 through August 2012 have included: two complete beach profile surveys (January 2012 and August 2012), and raw wave data 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 position along Oak Island/Caswell Beach decreased an average of 20 feet over the last year and is on the average 115 feet more seaward than it was at the start of the project 12 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. Measured volumes for the entire monitoring area with the August 2012 survey totaled nearly 2,039,300 cubic yards greater than what was measured in August 2000. Comparing long-term shoreline change rates with those of the 12-year monitoring period show Oak Island presently experiencing high rates of accretion (+14.4 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.
- The area of local concern around Profiles 35 and 40 along Oak Island shows that there has been a significant change in the shoreline change rate for this area relative to the pre-construction change rates. While the longshore average change rates for these two profiles remain positive, they have reduced significantly. Specifically, the pre-project shoreline change rate at Profile 35 has changed from +29.9 ft/yr to 3.84 ft/yr through August 2012. The rate at Profile 40 has reduced from a pre-project accretion rate of +17.2 ft/yr to only 1.32 ft/yr. The non-longshore averaged post-project rates for these two profiles are -8.0 ft/yr and -6.1 ft/yr for Profiles 35 and 40, respectively.
- Bald Head Island experienced overall shoreline loss over the current monitoring period. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 48 feet between September 2010 and August 2012.
- When comparisons are made over the 12-year monitoring period accretion is most prevalent along Bald Head Island; however, the western portion of South Beach and a portion of the Spit area continue to be highly erosional as documented in prior reports. Overall, Bald Head Island has slightly more material on the beach than the pre-construction condition in August 2000 (+176,500 cubic yards); however, the western end of the island has lost 568,500 cubic yards between Profiles 45 and 61. Previous reports have noted the erosion zone along this area and although erosion within this area has increased since Report 8, it is not near historic levels.
- Comparing long-term shoreline change rates with those of the 12-year monitoring period show that most of 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. The shoreline change measured within the groin field appears to be more stable following the latest re-construction than the previous events. The 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 between stations 22+00 and

44+00 had fallen below the 500 foot threshold limit throughout the current monitoring period.

- 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 has increased over this most recent time period to levels near the initial rate when the groin field was not in place.
- 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 is pending District approval for release.

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 8 (September 2010) 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 2010 to August 2012) and for the entire period (from August/September 2000 to August 2012).

For Oak Island/Caswell Beach, the shoreline change 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 relatively high losses since the last survey reported in Report 8. This is most likely related to the diffusion of the material from the disposal area toward the adjacent beaches. Over the current period, the western most section of the monitoring, which had previously experienced shoreline growth, has become erosive and the area between placement zones continued the accretionary trend previously reported in Report 8. Change throughout the remaining monitoring area was more variable. When considering all profiles within the Oak Island monitoring area, the average shoreline change was a loss of approximately 20 feet for the present period of October 2010 to August 2012.

In considering all the profile data, the alongshore average shoreline position was 115 feet more seaward in August 2012 than it was in September 2000. This is a decrease of nearly 20 feet when compared to the values measured in Report 8. With the exception of only four profiles on the eastern tip of the island (Profiles 20, 35, 40 and 45) all other profile lines have shown some shoreline increase. 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 fluctuated between erosion (16 profiles) and accretion (17 profiles) evenly when comparing the August 2012 survey with the last survey included in Report 8 (September 2010). One area of concern noted since Report 8 is the significant erosion observed at Profiles 30 and 40. The area of the beach represented by these two profiles lost approximately 51,300 cubic yards of material since September 2010 (Report 8). The overall change at the conclusion of the current monitoring period was slight accretion, with a total increase of approximately 4,400 cubic yards since September 2010 over the entire monitoring area. The overall volume response has been positive when considering the measurements over the entire 12-year monitoring period. As such, all reported volume changes are positive with the exception of 4 profiles along the eastern end of the island which include Profiles 5, 30, 40, and 45. The most significant volumetric loss occurred between Profiles 40 and 45, close to the area of erosion noted over the current monitoring period. Measured volumes for the entire monitoring area with the August 2012 survey totaled nearly 2,039,300 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.

Since the last reporting, almost all of the profile locations along Bald Head Island have eroded or moved landward. In general, the eroding areas are relatively uniform throughout South Beach; however, the erosion does decrease with increasing distance from the inlet (moving east). The increases in beach width within West beach and the Spit are likely due to longshore diffusion of the beach fill placed in 2009/2010 migrating toward and around the inlet. The greatest variability was again found between the south end of West Beach through the west end of South Beach between Profiles 28 and 45. This very dynamic area had shoreline changes which ranged from gains of about 312 feet to losses of more than 295 feet. The remaining area along West Beach (Profiles 0 thru 24) has had a mixture of losses and gains over the period, with the shoreline accreting on average 18 feet, similar to previous averages for the area. The area between Profiles 0 and 8 which was reported in Report 8 as having significant erosion of up to 66 feet at the northern most profile 0 was found to have accreted over this current monitoring period by 130 feet at profile 0. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 48 feet between September 2010 and August 2012.

Shoreline change patterns as measured over the last 12-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 69 are largely accretional. For this area, the August 2012 shoreline is an average of nearly 101 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. Large gains and losses are present within the spit area where the shoreline has advanced on the order of 261 feet at Profile 32 and lost nearly 478 feet at Profile 43 over the monitoring period. On average, the spit area (Profiles 32-45) has lost nearly 162 feet since September 2000. An area of progressive erosion is seen along the western portion of South Beach between Profiles 47 through 66. Average shoreline loss within this region is approximately 134 feet with a peak loss of nearly 332 feet occurring at Profile 47. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline has shown an average increase of about 49 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 43 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 which placed approximately 1.46 million cubic yards of material along the beaches. In addition, a groin field was constructed in the mid-1990's to retain the nourishment material and stabilize the western end of South Beach. 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 (September 2010) of Report 8 to the present, most of the profile locations of Bald Head Island show material loss over the current period. In summing the changes over the entire monitoring area, the losses total to approximately 1,054,500 cubic yards of material since September 2010. The most significant volumetric loss occurred within the Spit and the western end of South Beach. This area between Station 32+00 and 69+47 lost nearly 493,800 cubic yards of material or approximately 47% of the total material lost within the monitoring limits.

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 12 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 (Profiles 202 and 206), where some losses have occurred near the cape. Another is an area on South Beach that is just east of the new groin field (Profiles 97 through 114). This area has grown since Report 8 (in both magnitude and length) where it was reported as only a single profile showing minor losses. The third area spans three stations from Profile 45 to 61, 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. This area has increased as well from the values reported in Report 8, however the length and magnitude of the observed erosion is not near historic levels. Volumetrically this erosive region has lost about 568,500 cubic yards to date, compared to the 318,000 loss recorded in Report 8. The net volume change over the entire monitoring area is a slight gain of nearly 176,500 cubic yards as of August 2012 with respect to the beginning of the monitoring in 2000.

Rates of shoreline change were likewise computed over the 12-year 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 the comparison is not between data sets of similar durations, the comparison is useful in observing overall trends in the rate of shoreline response.

Shoreline change rates computed over the initial 12-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. The exception to this overall trend is located at profiles 35, 40, and 45 where while the average rate for these profiles is positive it is significantly lower than the pre-project accretion rates. In fact, when looking at the individual rates for these profiles rather than the longshore average used to compare to the pre-project Division of Coastal Management rates it is found that profiles 35 and 40 have consistently eroded throughout the post-project monitoring term. Specifically, the post-construction rate for Profile 35 is -8.0 ft/yr and the rate for Profile 40 is -6.1 ft/yr. Overall, the shoreline change rate averaged over the entire monitoring area is computed to be +14.4 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 12-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 are 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 and have remained stable relative to the values calculated for Monitoring Report 8. 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.

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 2012, 39 condition surveys have been accomplished. Eight of these occurred over the current reporting period (September 2010, February 2011, May 2011, July 2011, August 2011, March 2012, April 2012 and June 2012). There are now fifteen post-dredging settlement survey following the Feb-April 2009 channel dredging operation. The area between stations 5+00 and 21+00 had modest increases in channel width while the area between stations 23+00 through 44+00 had modest to severe reductions in channel width. In fact, at the end of the current monitoring period the area between stations 22+00 and 44+00 had fallen below the minimum threshold. The change in navigable width measured at -42 ft MLW, ranged from an increase of 116 feet at station 17+00 to a maximum reduction of 234 feet at station 42+00.

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 14,300 cubic yards per month. This represents a 60% 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 13% lower. 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 nourishment 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 (nourishment by the Village of Bald Head Island) and subsequent reconstruction of the groin field in early 2010. Shoreline change comparisons were made over similar 22 to 24 month periods following each respective event. The shoreline change measured within the groin field appears to be more stable following the fourth re-construction than the previous events.

<u>Sand Management Considerations.</u>

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 included in this report 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 has been published as a separate document entitled “Reevaluation Report Sand Management Plan Wilmington Harbor Navigation Project”, dated December 2011.

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REPORT 9

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 ninth 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 October 2010 through August 2012. Monitoring Reports 1, 2, 3, 4, 5, 6,7 and eight were published in August 2004, February 2005, May 2006, May 2007, April 2008, June 2009, August 2010, and December 2011 respectively, and covered the first ten years of monitoring (USACE 2004, USACE 2005, USACE 2006, USACE 2007, USACE 2008, USACE 2009, USACE 2010, and USACE 2011). 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.

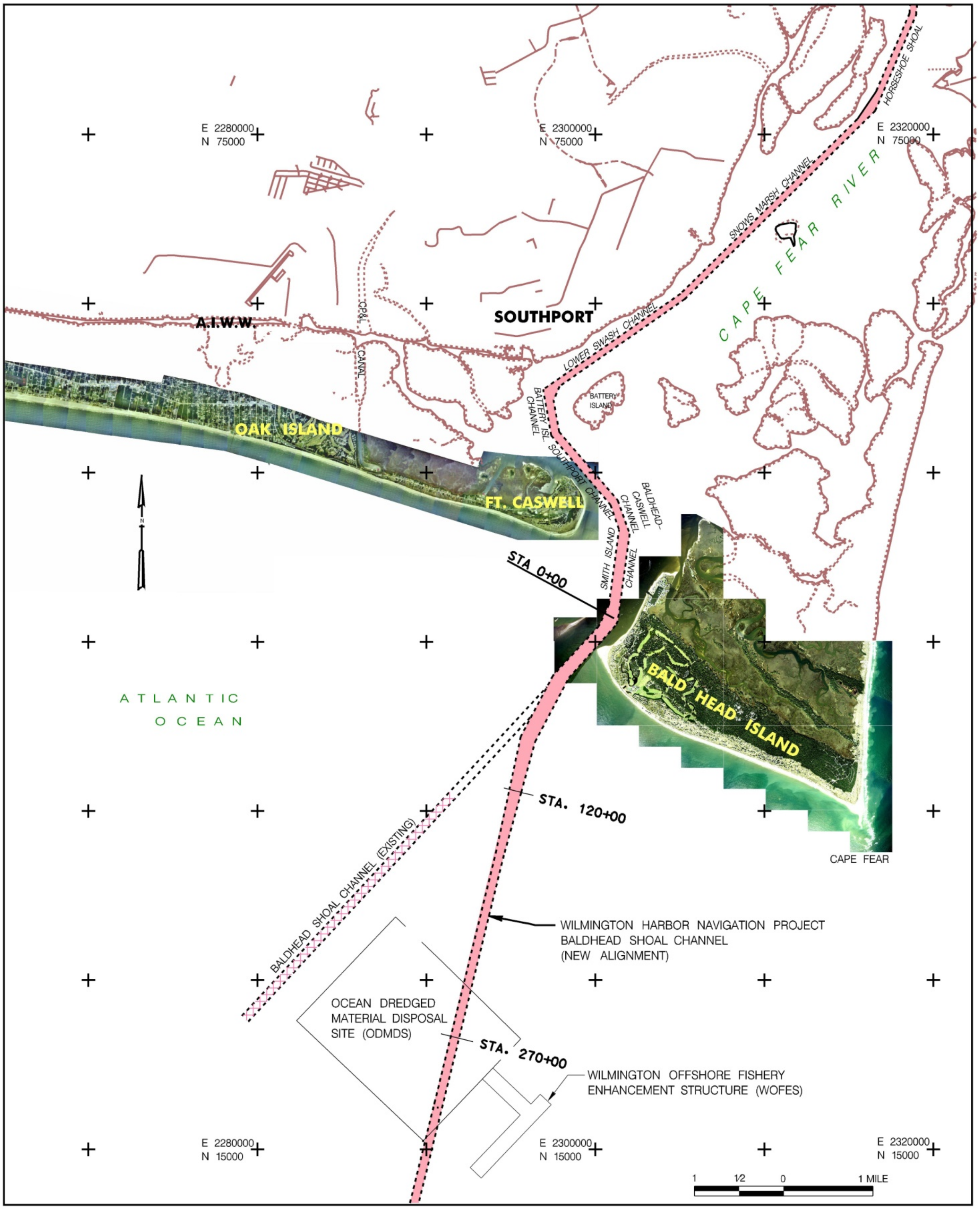


Figure 1.1 Project Location Map

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 (Figure 1.2, Station 370+00) through the Battery Island Channel located 2.9 miles upstream from the Bald Head Island Spit. 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. Detailed information on the deepening and realignment of the navigation channel can be found within the Section 905(b) Analysis located at: http://www.saw.usace.army.mil/Portals/59/docs/navigation/Dredging/Projects/WilmHarbor%20905b%20REV%2022Apr2011.pdf

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.

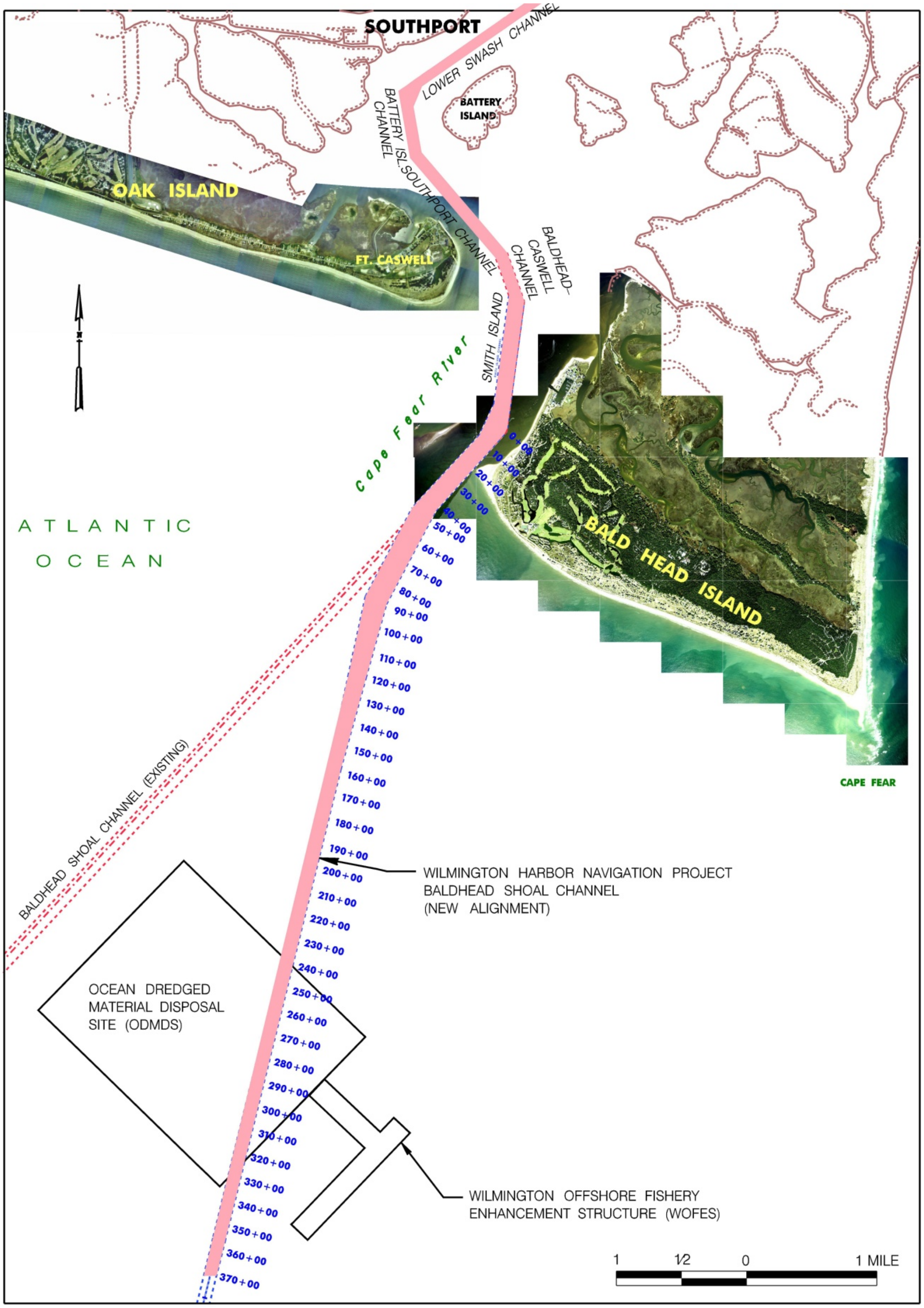


Figure 1.2 Realignment of the Federal Navigation Channel at the Cape Fear River Entrance

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

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
(INITIAL CONSTRUCTION)							
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 third 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 2012. The data collected through September 2010 were 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 contained in a separate document titled "Reevaluation Report Sand Management Plan, Wilmington Harbor Navigation Project" (USACE 2011a).

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 initial monitoring program consisted of five basic elements namely; beach profile surveys, channel and ebb tide delta surveys, wave and current measurements, aerial photography, and data analysis/reporting. Following the completion of the full dredging cycle in September 2010, the wave and current measurement portion of the monitoring program was discontinued. 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 has been 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 Greenhorn & 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.

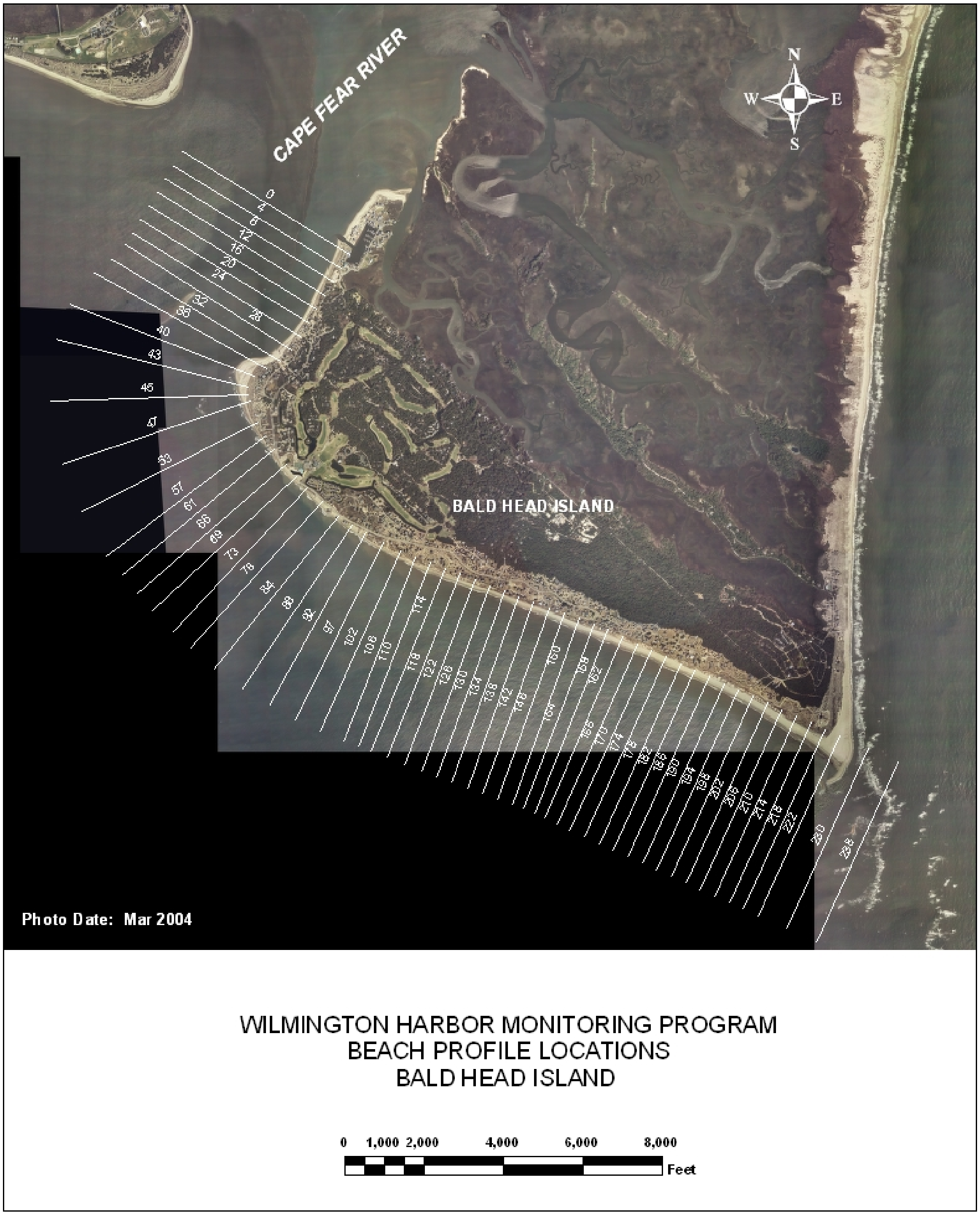


Figure 1.3 Bald Head Island Beach Profile Locations

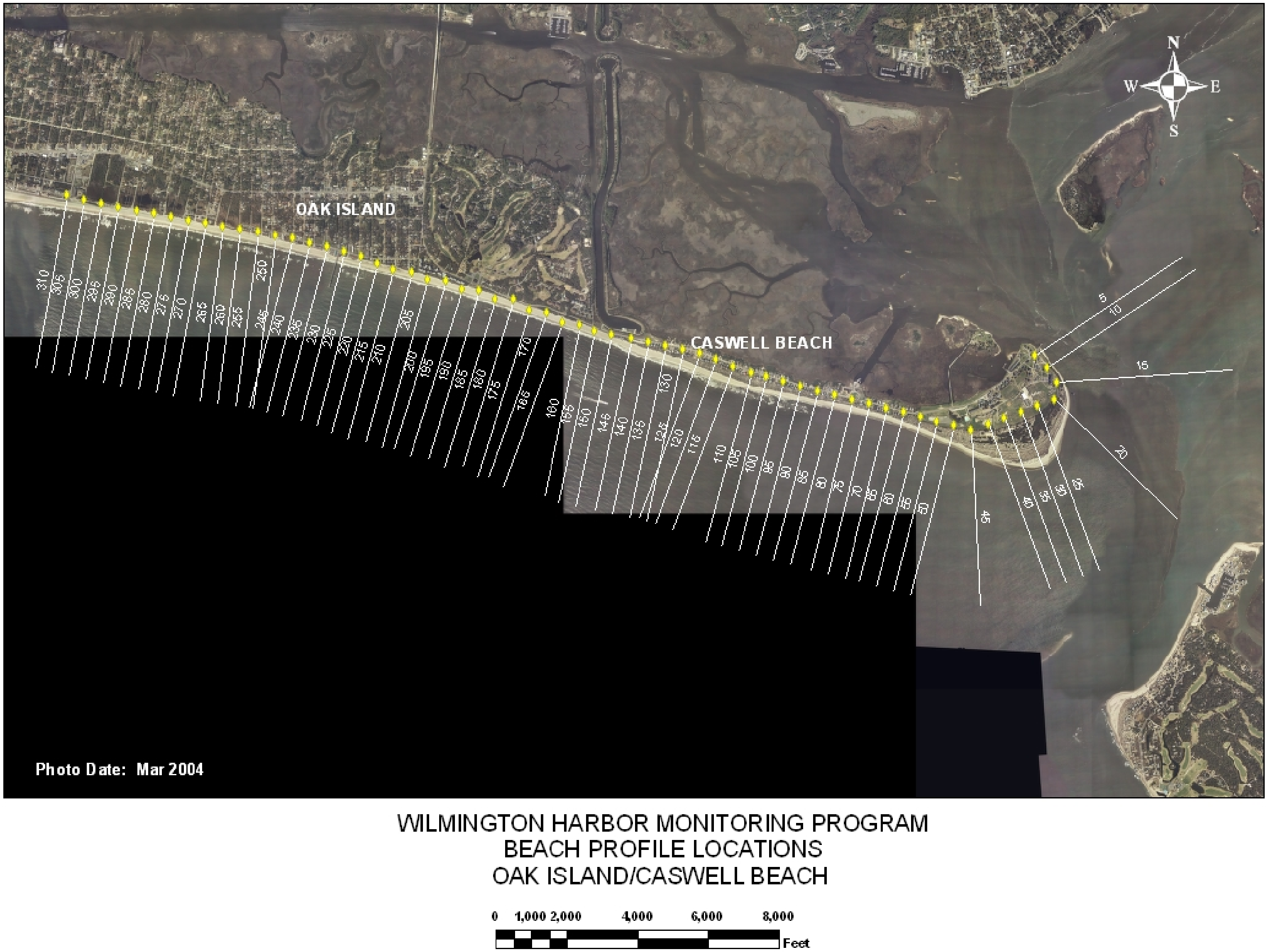


Figure 1.4 Oak Island/Caswell Beach Profile Locations

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.

For the current monitoring cycle, there was no collection of data to measure the ebb and nearshore shoal response.

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. Due to funding constraints, the three ADCPs were supposed to be officially removed from the water by June of 2009. The gauges were kept in water for extra 18 months but the collected data was not processed for this monitoring period and is available in raw binary format.

In addition to fixed bottom mounted gauges described above, currents have historically been measured along specified transects across the mouth of the Cape Fear River and near the new channel realignment. These measurements were recorded using a downward-looking, shipboard-mounted current profiler, which operated along the two closed loops as shown in Figure 1.8. The vessel navigated along the tracks over a complete tidal cycle to capture both ebb and flood flows as well as the entire tidal prism. Current surveys were accomplished annually corresponding with the ebb tide delta survey. Following the completion of the first sand management cycle the collection of current measurements within the entrance channel was suspended and is no longer included in the annual monitoring report.

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 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 include 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.

EBB TIDAL DELTA SURVEY LIMITS

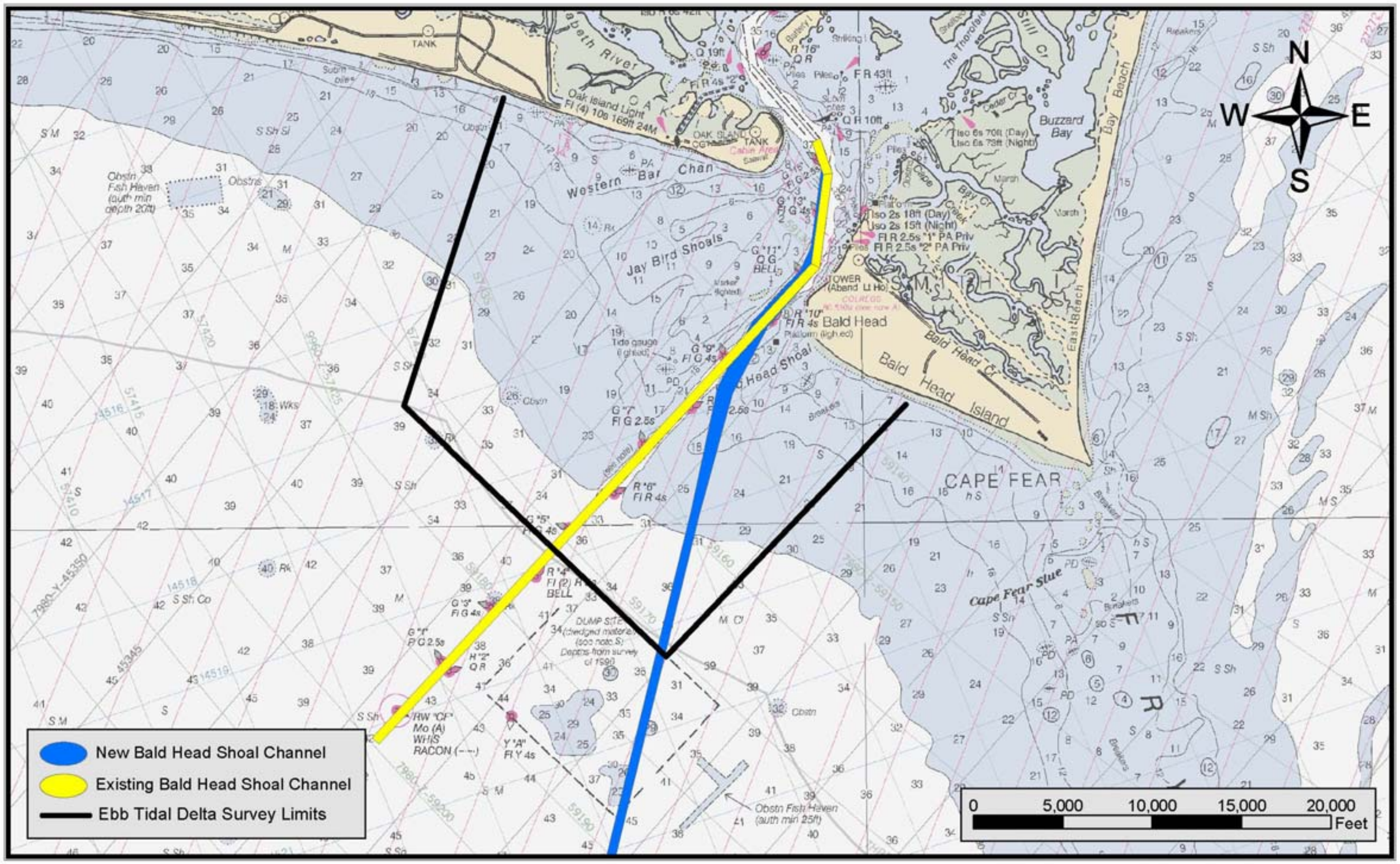


Figure 1.6 Entrance Channel and Ebb Tide Delta Survey Coverage

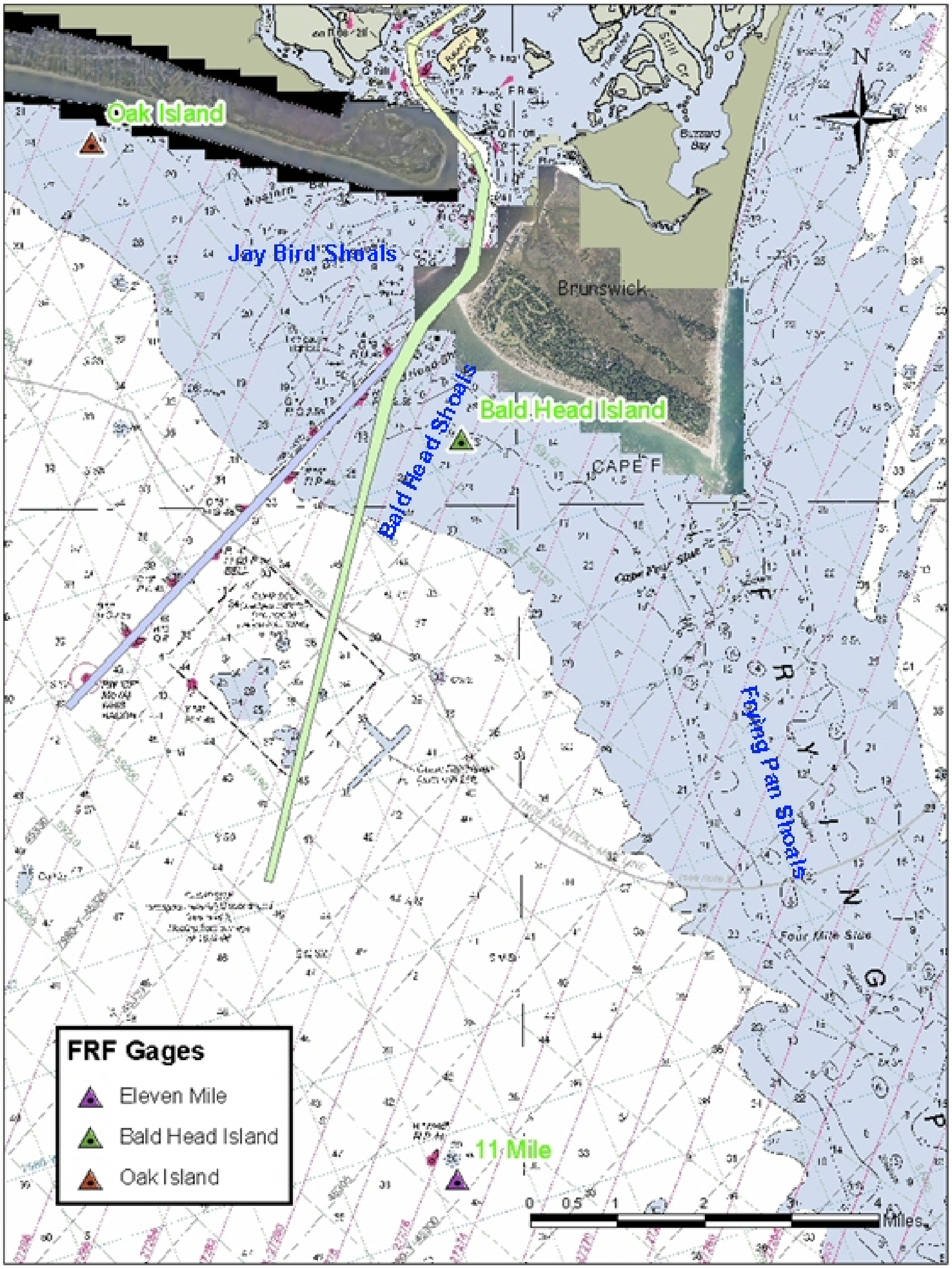


Figure 1.7 Wave and Current Gauge Locations

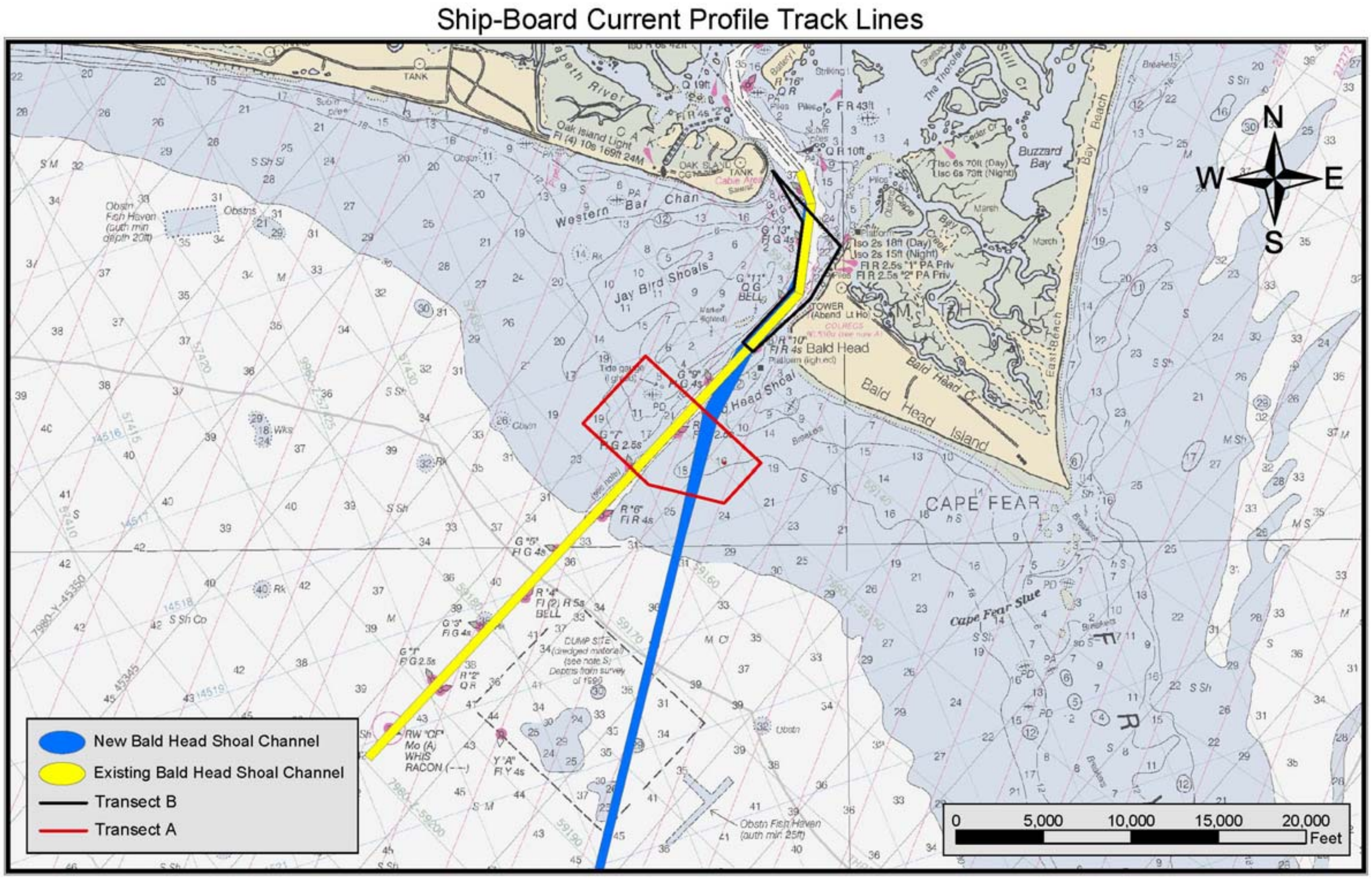


Figure 1.8 Shipboard Current Profile Locations

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
2010-Sep	0 to 218	X	X
2011-May	0 to 218	X	X
2011-Sep	0 to 218	X	X
2012-May	0 to 218	X	X
2012-Nov	0 to 218	X	X

Activities to Date. 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 August 2012 beach survey and therefore spans an initial period of 12 years. Table 1.3 lists all the monitoring surveys to date. Since the initiation of the program there have been 21 onshore beach profile surveys, 19 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	
January 2012	X	X	
August 2012	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 nine 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 twenty occasions to date as given in Table 1.5 including those provided by the Village of Bald Head.

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
January 21, 2011
September 1, 2011
June 28, 2012
*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.

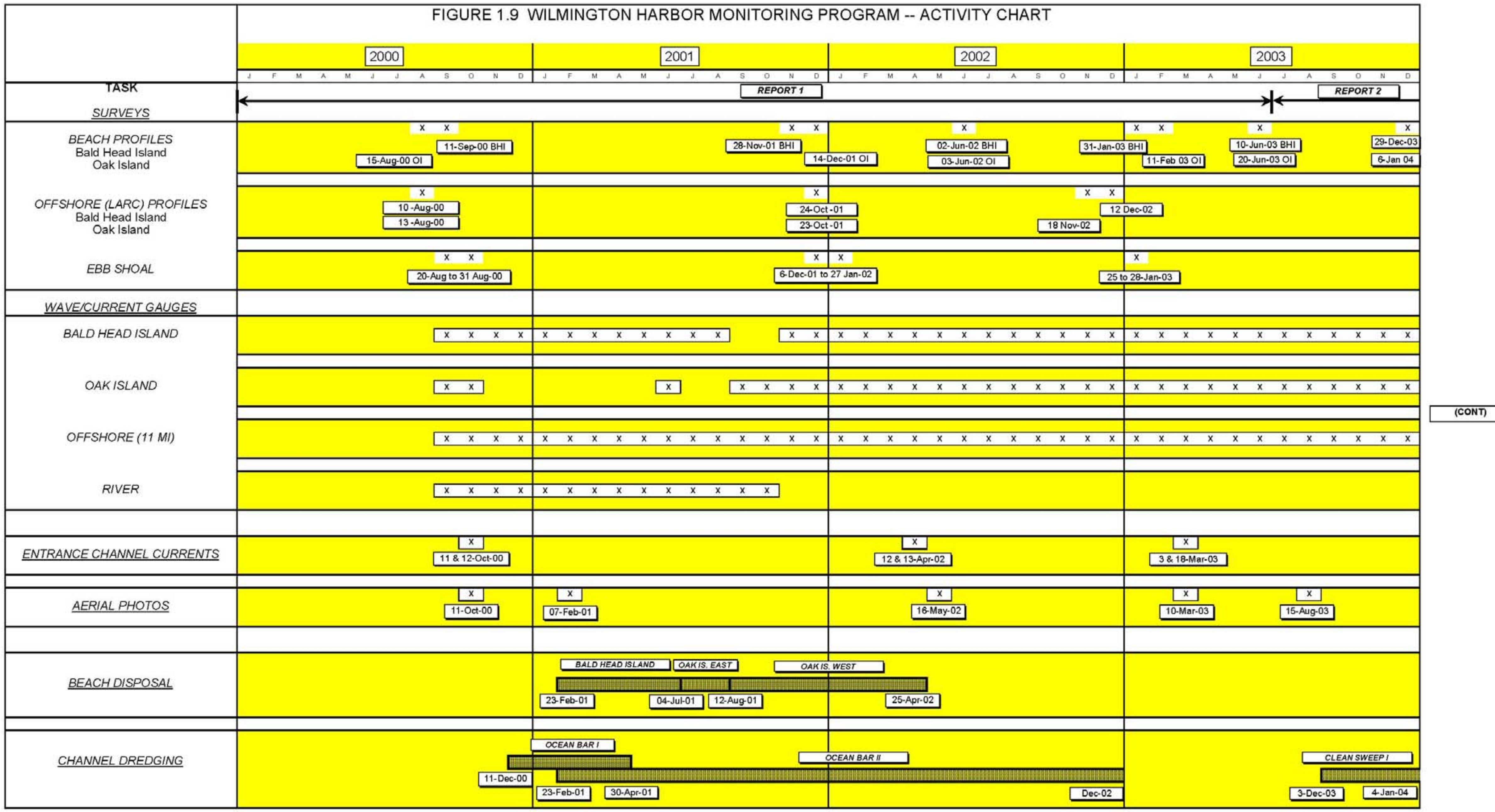


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART

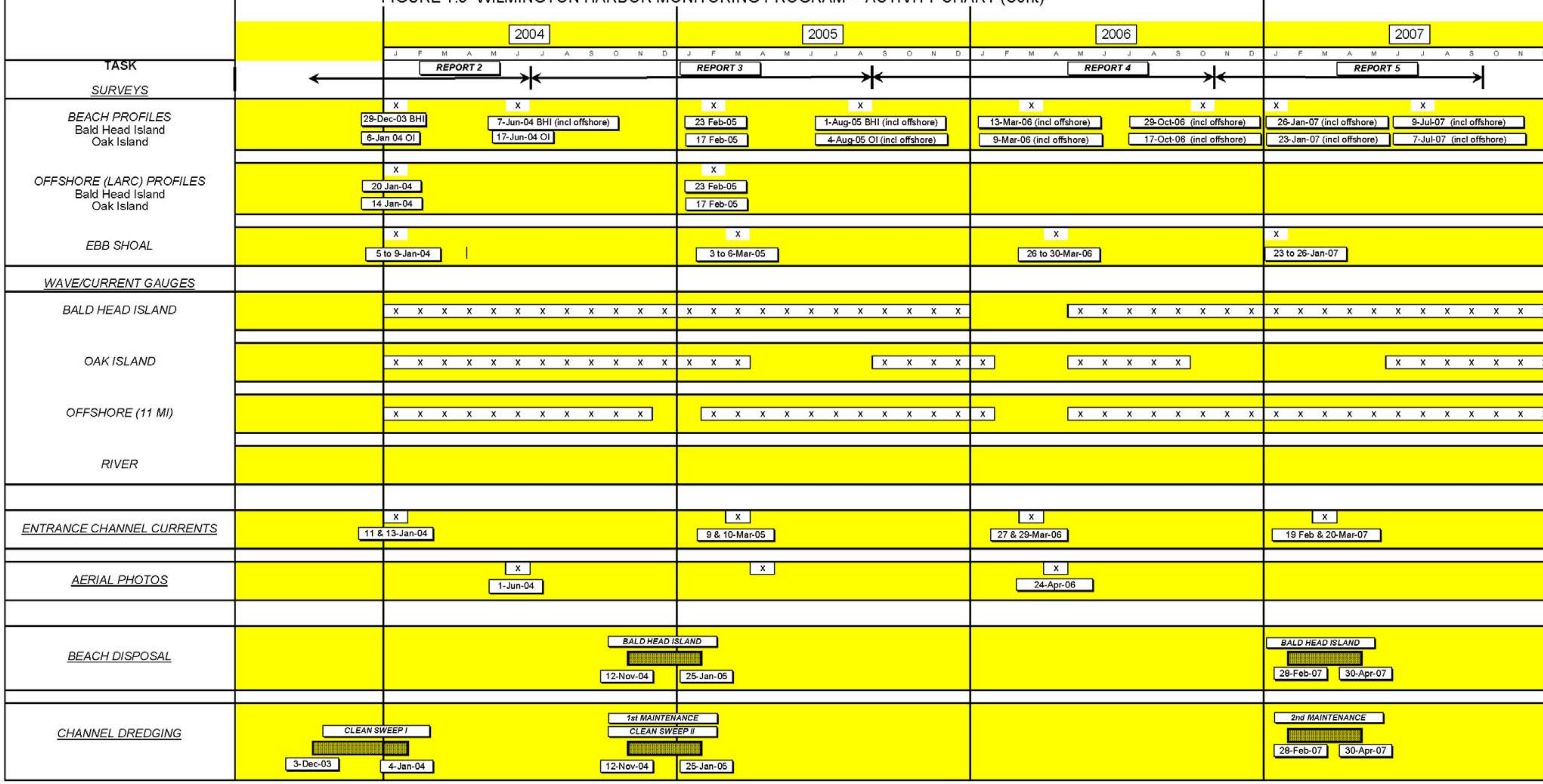
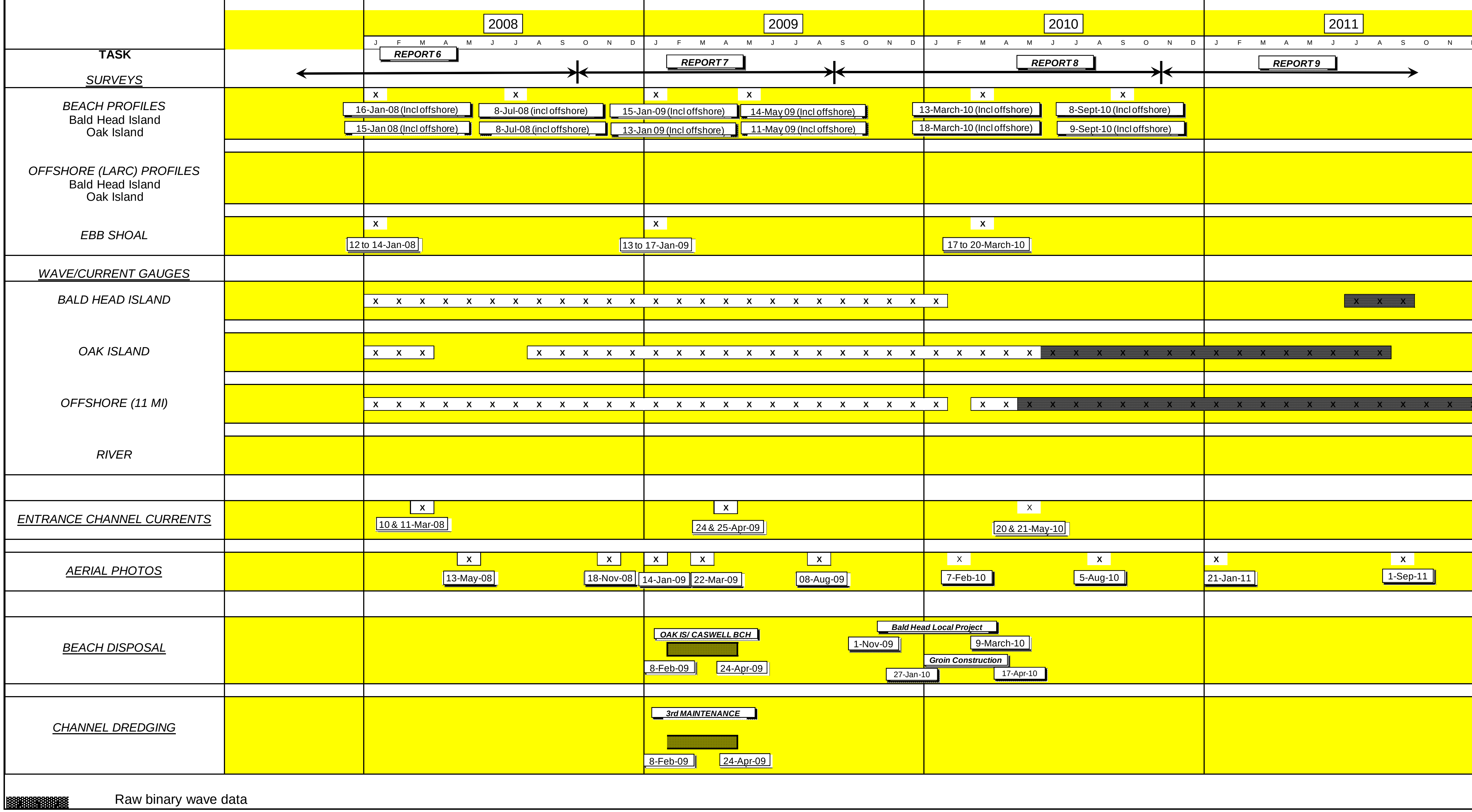


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART (Cont)

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



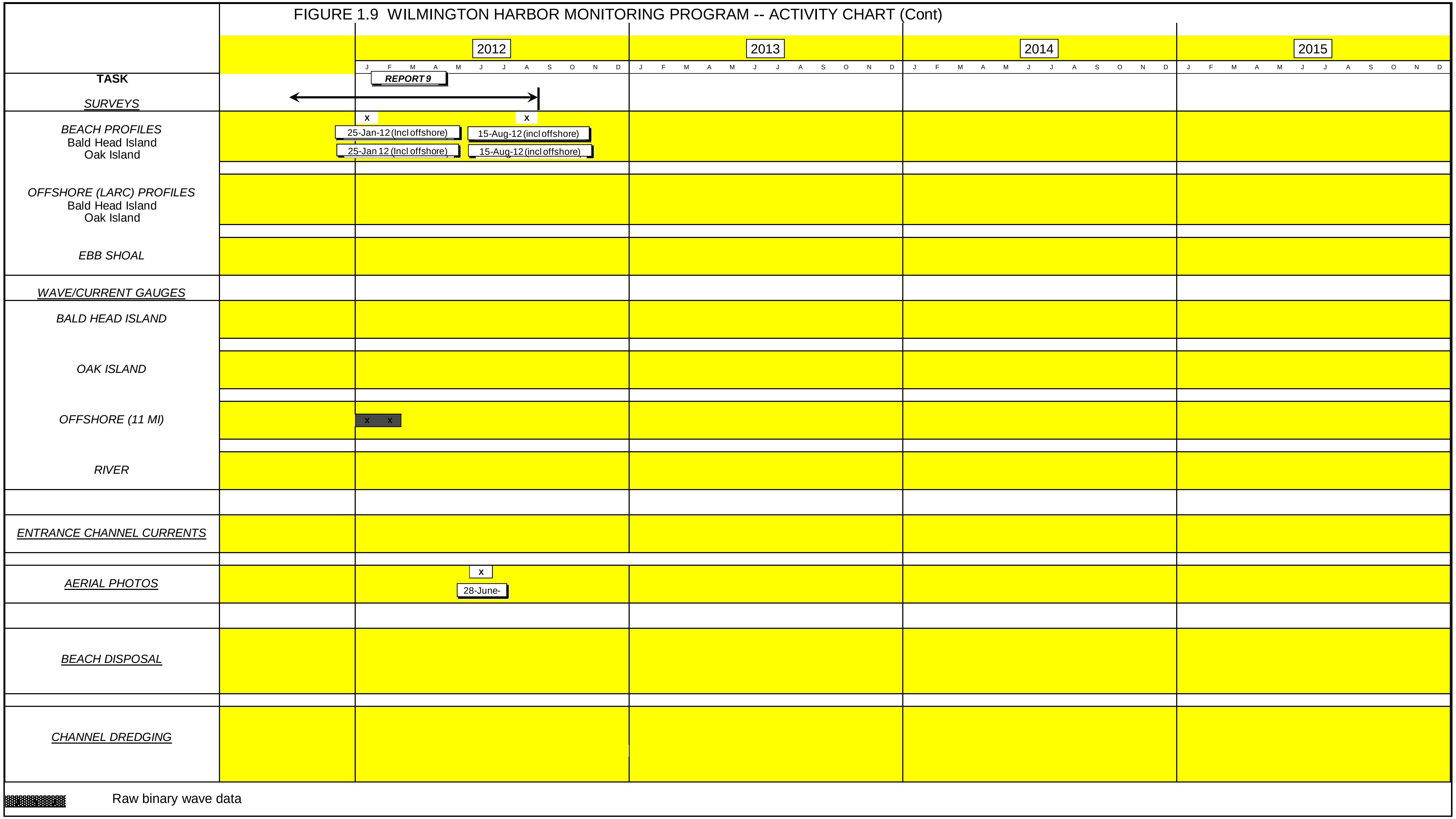


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART (Cont)

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 the 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 Brunswick Nuclear power plant 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.

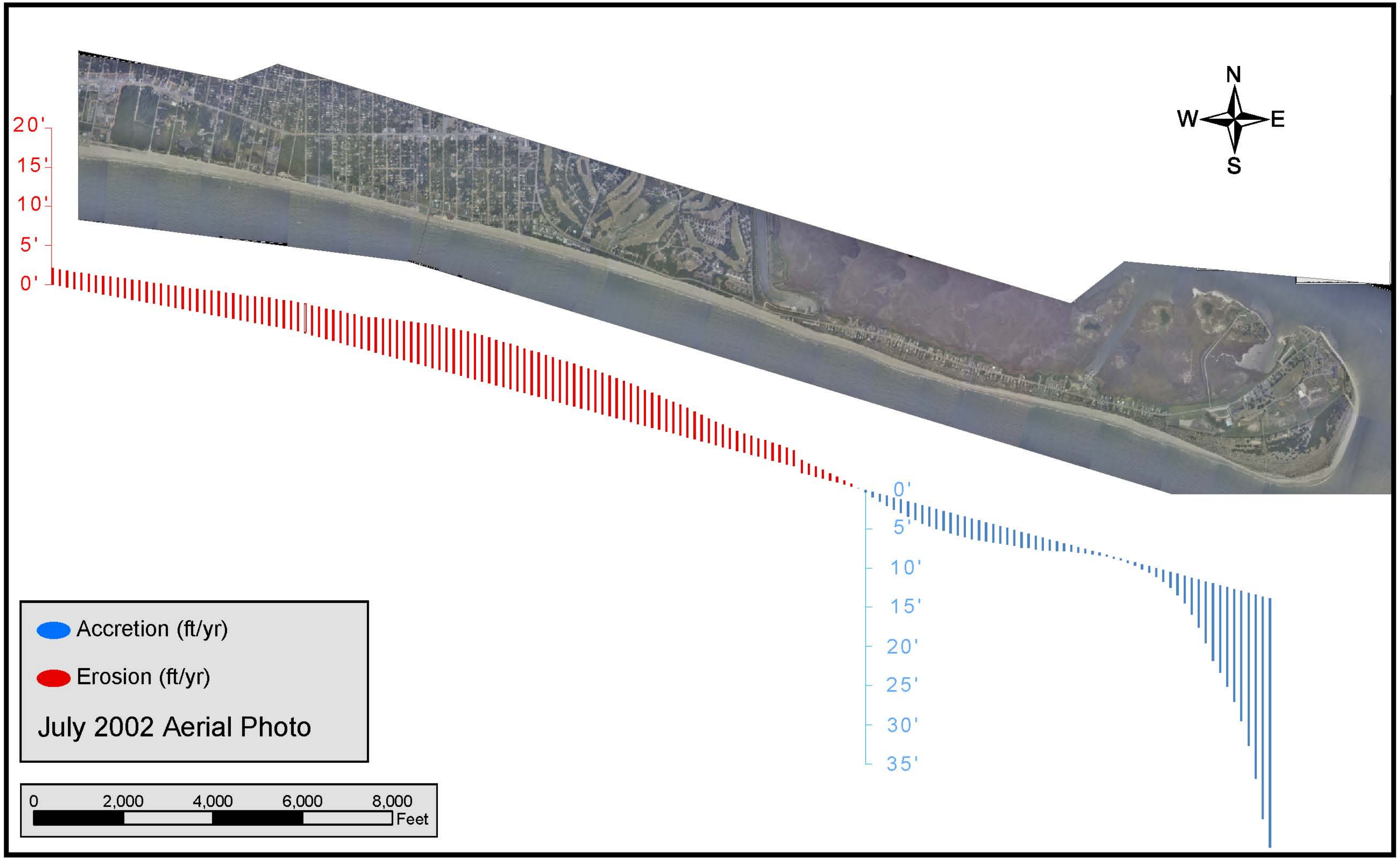


Figure 2.1 Long-Term Average Annual Shoreline Change Rates (1938-2000) Oak Island/Caswell Beach

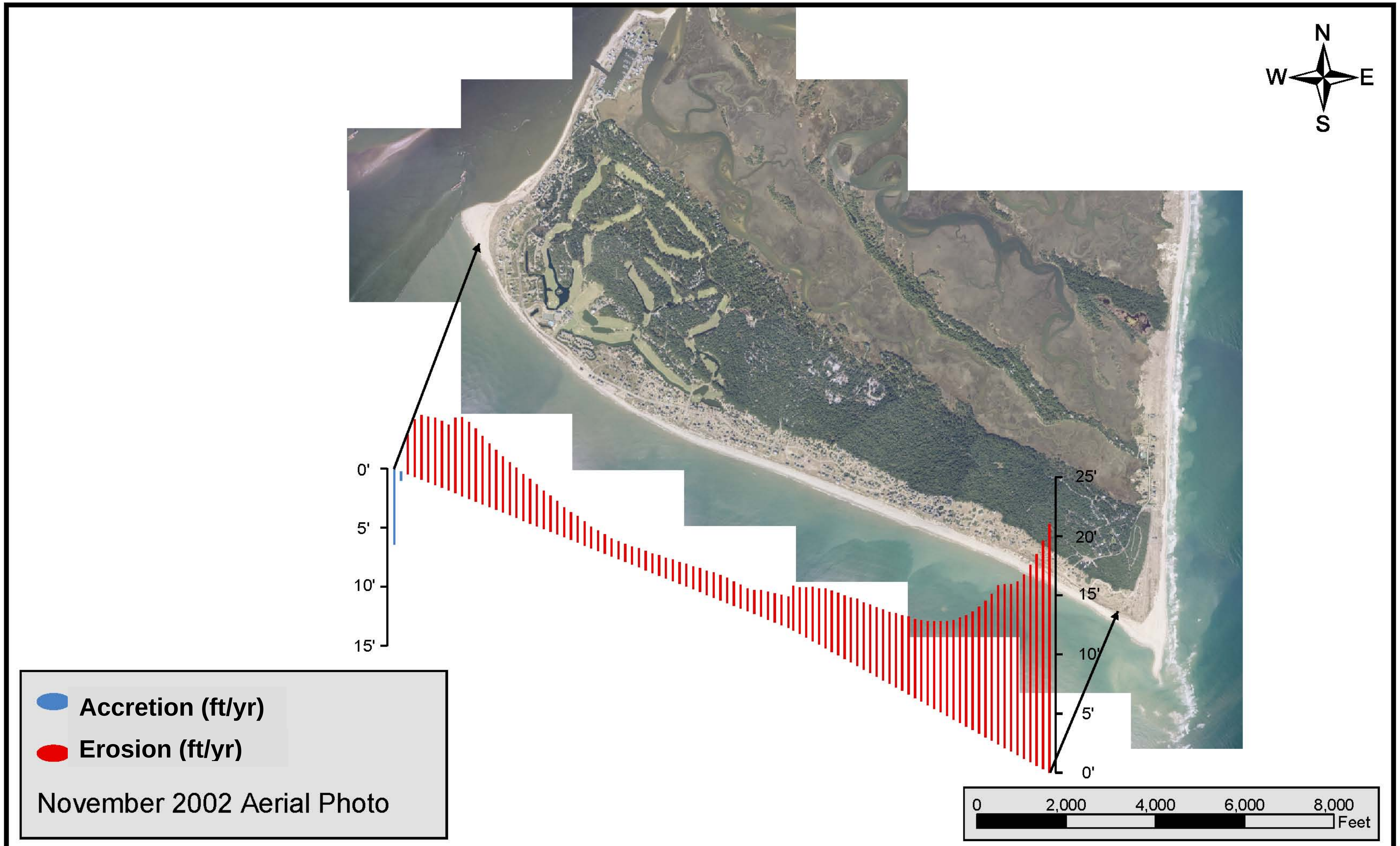


Figure 2.2 Long-Term Average Annual Shoreline Change Rates (1938-2000) Bald Head Island

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 1.85 million cubic yards of sand were dredged from an offshore borrow site comprising the seaward most 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 the 2009-2010 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 August 2012, the end of the ninth monitoring cycle. The data analyses generally describe changes that have occurred since those last reported in September 2010 and also relative to the base (pre-project) conditions established with the initial monitoring surveys. The following discussion covers the two main data collection efforts, namely: shoreline and volumetric changes as measured from the beach profile surveys and wave data. For this monitoring cycle there was no collection of data to measure the ebb and nearshore shoal response. Additionally, collection of current measurements within the entrance channel was suspended and is not part of this monitoring report.

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 January 2012 and August 2012. Figure 3.1 shows the shoreline changes relative to the September 2010 position, i.e. the last referenced location in Report 8. 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 Islands.

As indicted in Figure 3.1, almost all of the profile locations along Bald Head Island have eroded or moved landward over the last twenty three months. The maximum landward movement of the shoreline position was measured for both the January 2012 and August 2012 surveys relative to the September 2010 position. The maximum for the January 2012 survey was calculated to be -295 feet at Profile 36 near the spit. By August 2012 the maximum change value had reduced to -216 feet and was located at Profile 40 near the western end of the groin field. In general, the eroding areas are relatively uniform throughout South Beach; however, the erosion does decrease with increasing distance from the inlet (moving east). A small number of profiles within the monitoring area have accreted since the last monitoring cycle ended. These include Profiles 0, 4, 8, 12, and 28 (located within West Beach), Profile 32 in the Spit area, and Profile 214 (located near the east end of South Beach). The increases in beach width within West beach and the Spit are likely due to longshore diffusion of the beach fill placed in 2009/2010 migrating toward and around the inlet.

The greatest variability was again found between the south end of West Beach through the west end of South Beach between Profiles 28 and 45. This very dynamic area had shoreline changes which ranged from gains of about 312 feet to losses of more than 295 feet. The extreme erosive measurement occurred during the January 2012 survey while the extreme seaward measurement was measured in August 2012, again indicating movement of sediment around the spit toward West Beach.

The remaining area along West Beach (Profiles 0 thru 24) has had a mixture of losses and gains over the period, with the shoreline accreting on average 18 feet, similar to previous averages for the area. The area between Profiles 0 and 8, which was reported in Report 8 as having significant erosion of up to 66 feet at the northern most profile 0, was found to have accreted over this current monitoring period by 130 feet at profile 0. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 48 feet between September 2010 and August 2012.

Shoreline change patterns as measured over the last 12-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 September 2010, January 2012 and August 2012. 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, with only the exception of Profile 218, all lines along South Beach extending eastward from Profile 69 are largely accretional. The average position of the August 2012 is measured to be nearly 101 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 261 feet at Profile 32 and lost nearly 478 feet at Profile 43 over the monitoring period. On average, the spit area (Profiles 32-45) has lost nearly 162 feet since September 2000. An area of progressive erosion is seen along the western portion of South Beach between Profiles 47 through 66. Average shoreline loss within this region is approximately 134 feet with a peak loss of nearly 332 feet occurring at Profile 47.

For West Beach (Profiles 0 through 28), located immediately along the river channel, the shoreline has shown an average increase of about 49 feet when compared to the base condition. This area was highly variable as well with changes ranging from shoreline loss of 46 feet at Profile 20 to shoreline gains of 96 feet at Profile 0. When considering all locations along Bald Head Island (Profiles 0 through 218), the shoreline is presently on the average 43 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 shows 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 nourishment 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 by 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 12-year monitoring period as measured from the September 2000 position. (For comparison purposes both Profile 61 and 150 are shown in Figure 3.5). 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. During 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 September 2010 survey shows that the shoreline moved further seaward to within 14 feet of the pre-project shoreline position measured in September 2000. The most recent survey of this profile (August 2012) shows the profile has eroded and is currently approximately 98 feet seaward of the pre-project shoreline 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. Since the most recent material placement the profile has eroded at a lower rate than over the previous nourishment cycle. For this most recent period, the erosion rate at Profile 150 is calculated to be 43 ft/yr, which is similar to the erosion rate at Profile 61 of 36 ft/yr.

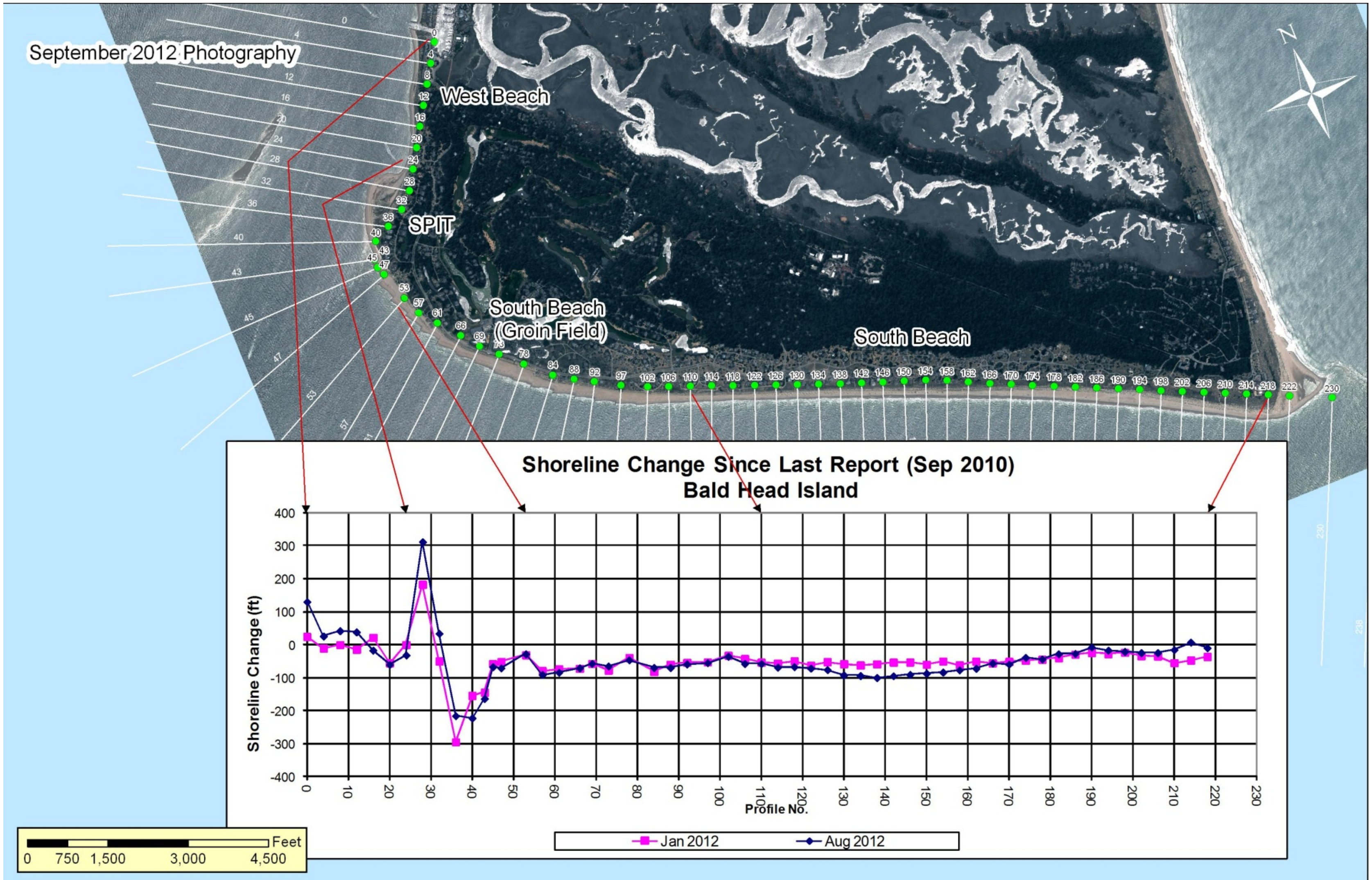


Figure 3.1 Shoreline Change Since Last Report (Sept 2010) Bald Head Island

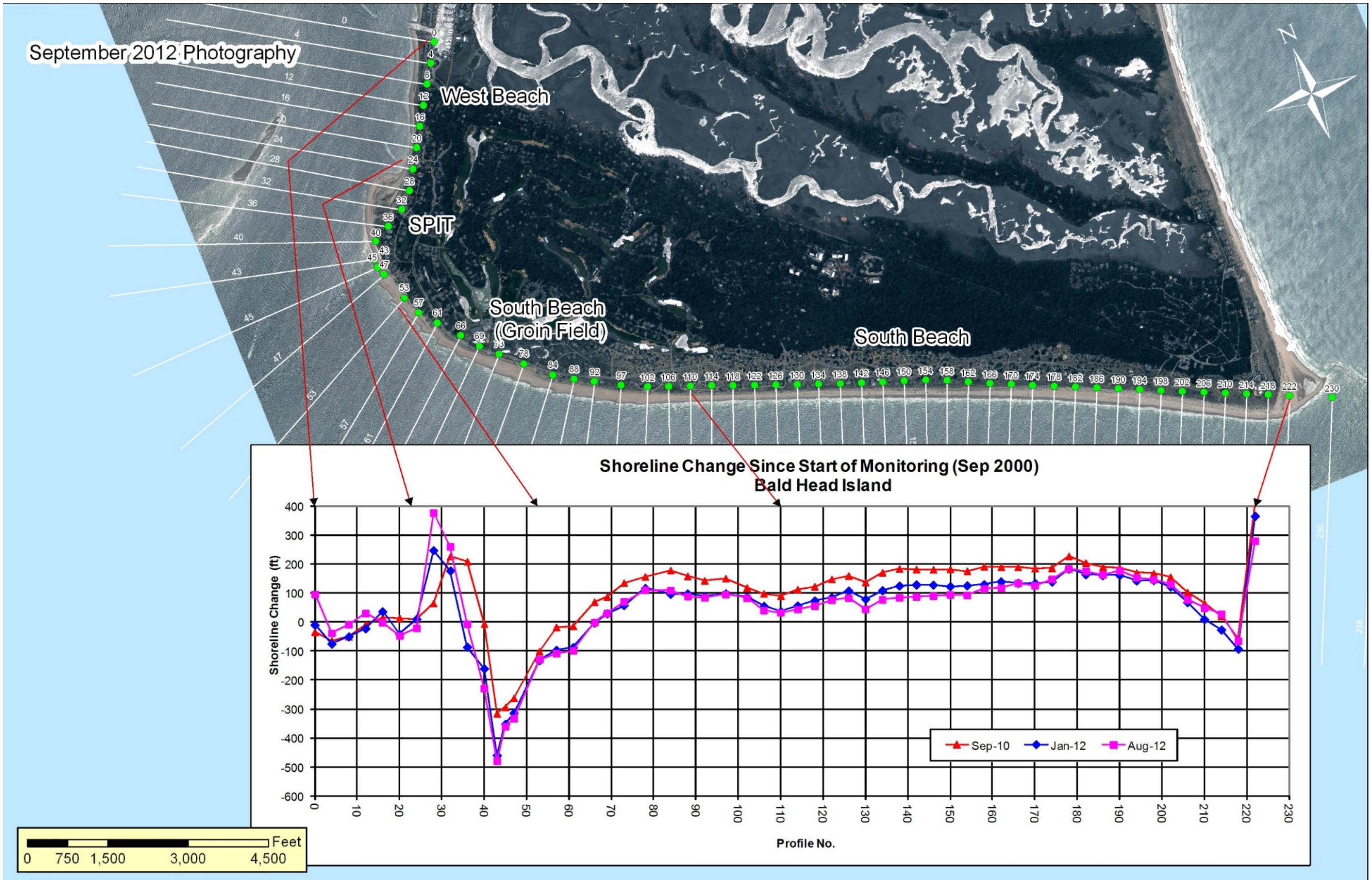


Figure 3.2 Shoreline Change Since Start of Monitoring (Sep 2000) Bald Head Island

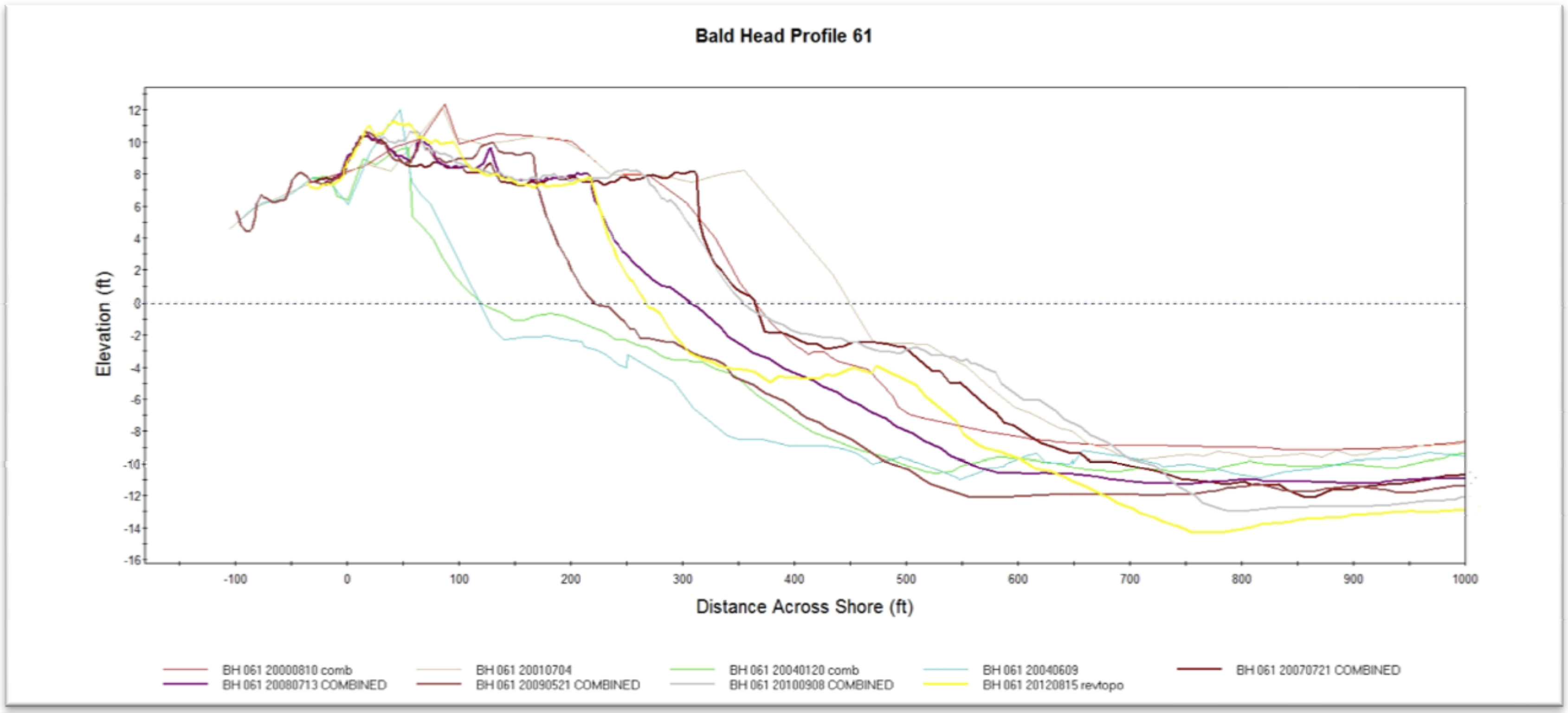


Figure 3.3 Bald Head Island Profile 061

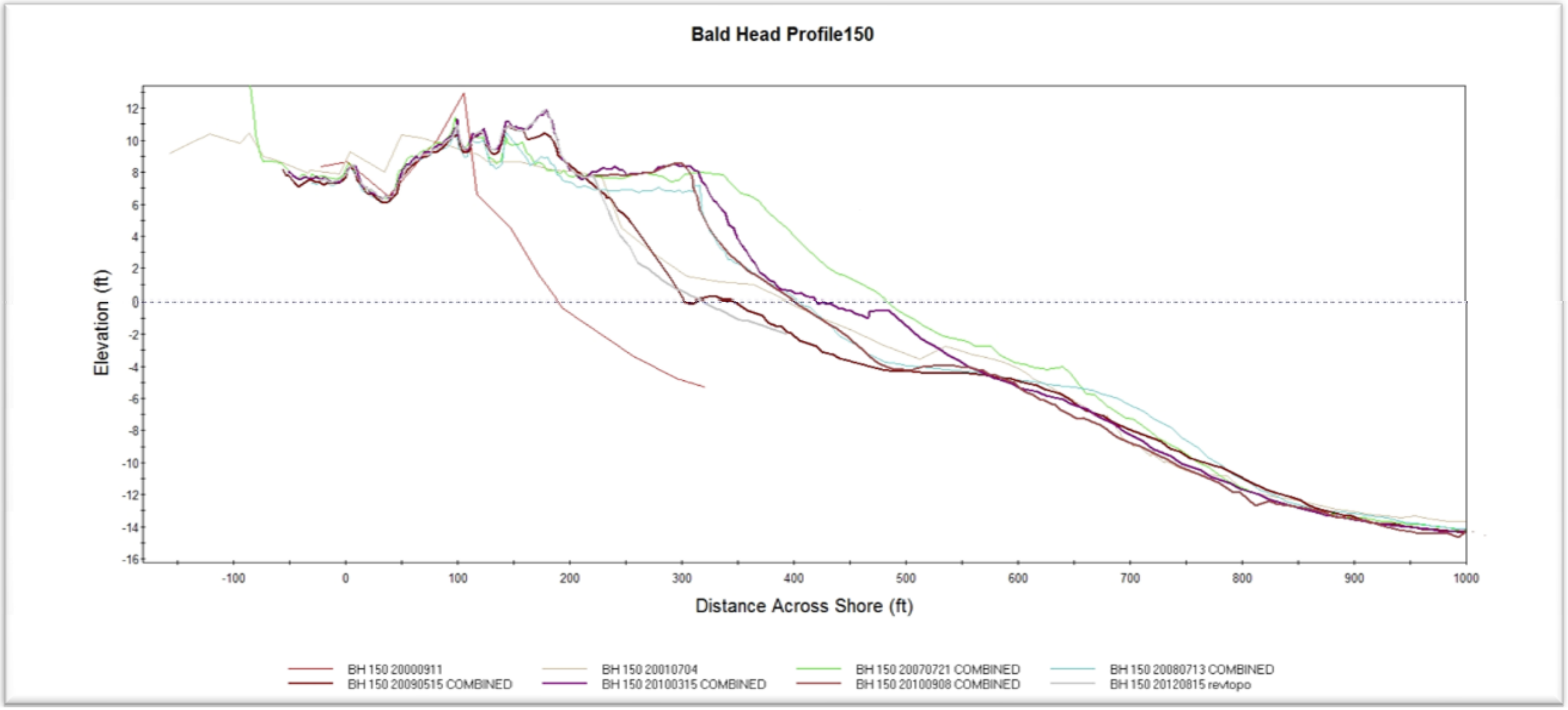


Figure 3.4 Bald Head Island Profile 150

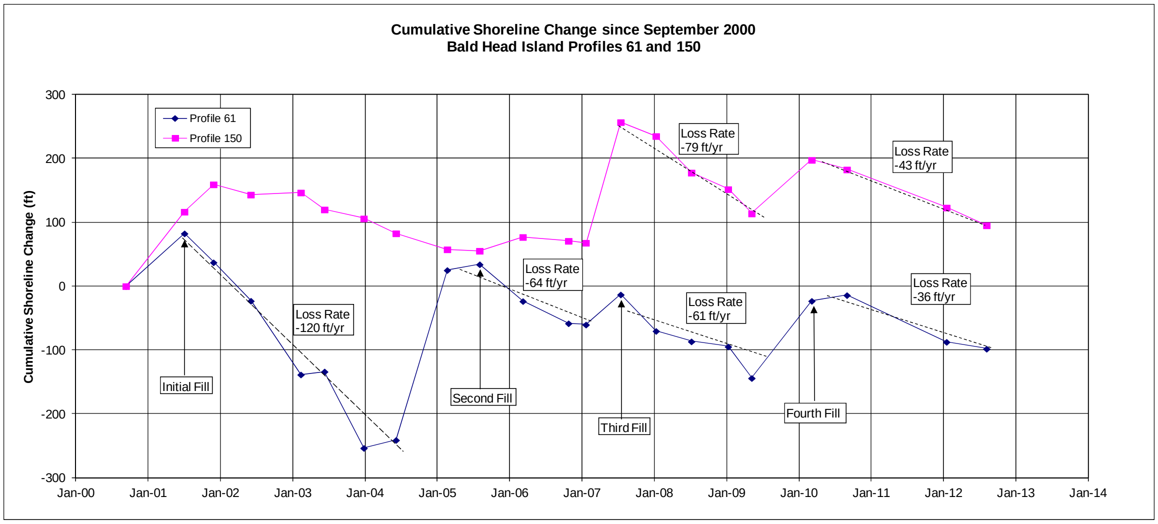


Figure 3.5 Cumulative Shoreline Changes Since September 2000
Bald Head Island Profiles 61 and 150

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 January 2012 and August 2012 surveys. Figure 3.6 shows the shoreline changes relative to the September 2010 position, i.e. the last referenced location in Report 8. 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 five 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, continue to 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 15 feet. The other placement area between Profiles 120 and 260 lost nearly 29 feet of shoreline on average. Over the current period, the western most section of the monitoring area between Profiles 250 and 310, which had previously experienced shoreline growth, has become erosive and on average lost nearly 25 feet of beach width. The area between placement zones (Profiles 100 through 115) continued the accretionary trend previously reported in Report 8, with an average shoreline increase of approximately 20 feet. Change throughout the remaining monitoring area (Profiles 5 through 55) was more variable. This area experienced shoreline loss as large as 109 feet at Profile 40 and increases as high as 44 feet at Profile 30. When considering all profiles within the Oak Island monitoring area

(Profiles 5 thru 310), the average shoreline change was a loss of approximately 20 feet for the present period of October 2010 to August 2012.

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 August 2012 shoreline change plot, the beach has widened by as much as 212 feet (Profile 150). In fact, except for four profiles on the eastern tip of the island (Profiles 20, 35, 40 and 45) all other profile lines have shown some shoreline increase. The most extreme loss along the island was located at Profile 40 which has a measured shoreline loss of 174 feet when compared to the pre-project condition. This profile is in close proximity to Ft. Caswell and has drawn interest from the local residents of Ft Caswell. Some concerns as to whether this erosion is related to the 2009/2010 dredging of Jay Bird Shoals for the locally funded Bald Head Island nourishment project have been expressed, however, the USACE has not evaluated this claim to date. The 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. Given the length of time since its initial construction, it is unlikely the project is continuing to provide significant sediment to the profiles within the monitoring area. In considering all the profile data, the alongshore average shoreline position was 115 feet more seaward in August 2012 than it was in September 2000. This is a decrease of nearly 20 feet when compared to the values measured in Report 8.

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 followed 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. Although the profile has experienced some shoreline loss due to erosion, 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 September 2010 survey with the August 2012 survey show that some erosion, approximately 32 feet, 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 remained generally stable over the 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 131 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 32 feet over the current monitoring period and is currently 148 feet seaward of its initial pre-project position.

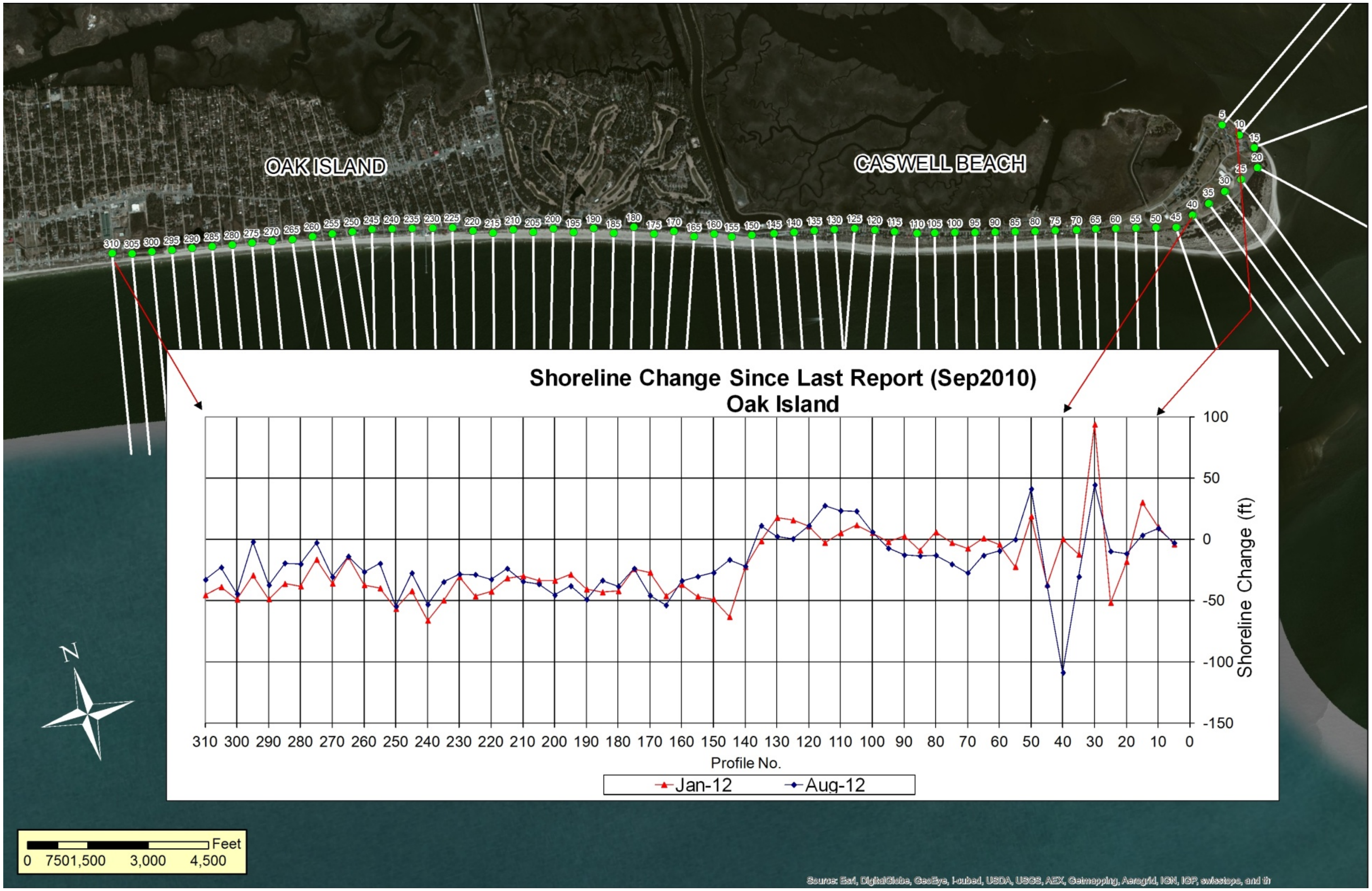


Figure 3.6 Shoreline Change Since Last Report (September 2010) - Oak Island

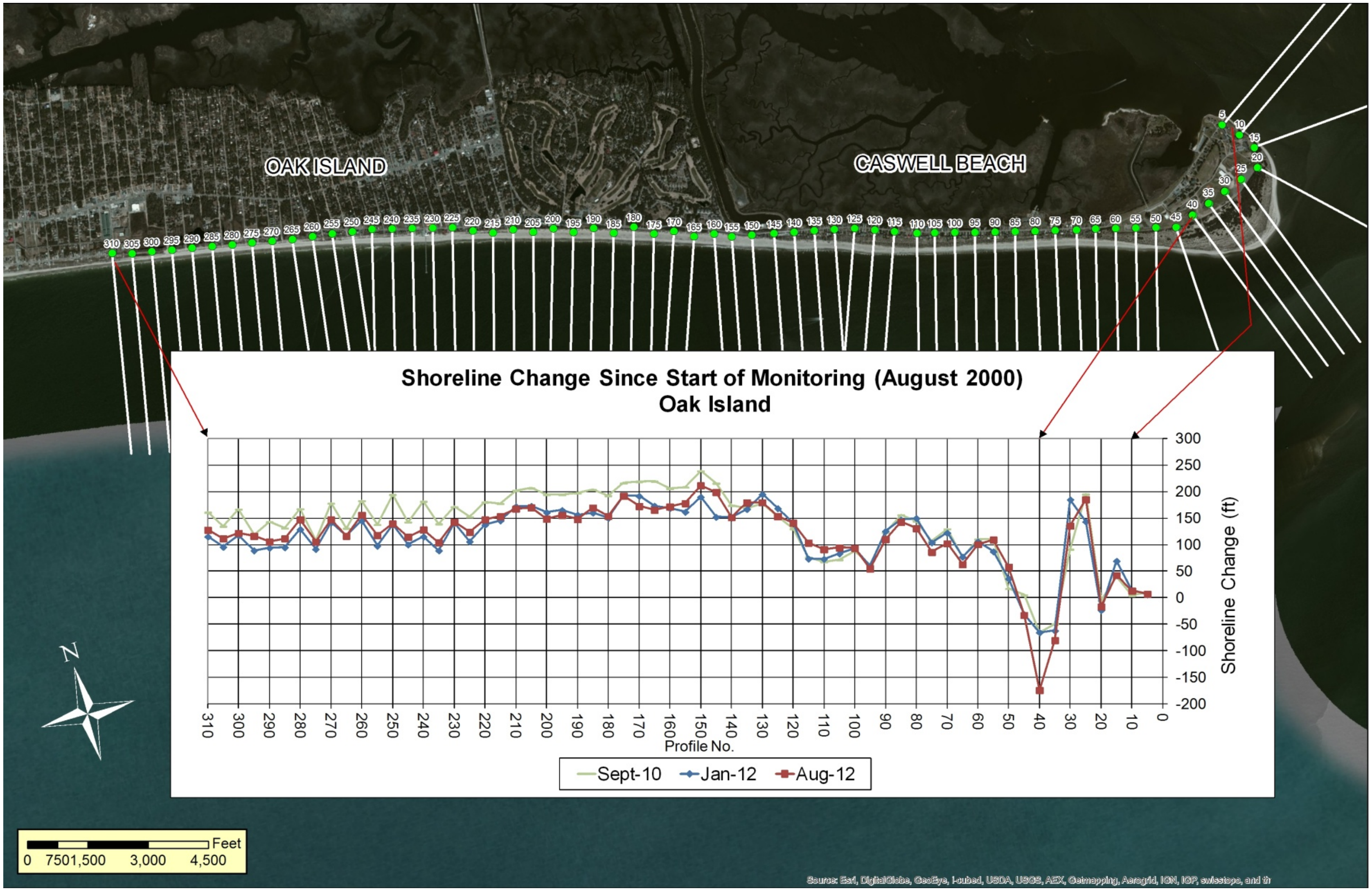


Figure 3.7 Shoreline Change Since Start of Monitoring (August 2000) - Oak Island

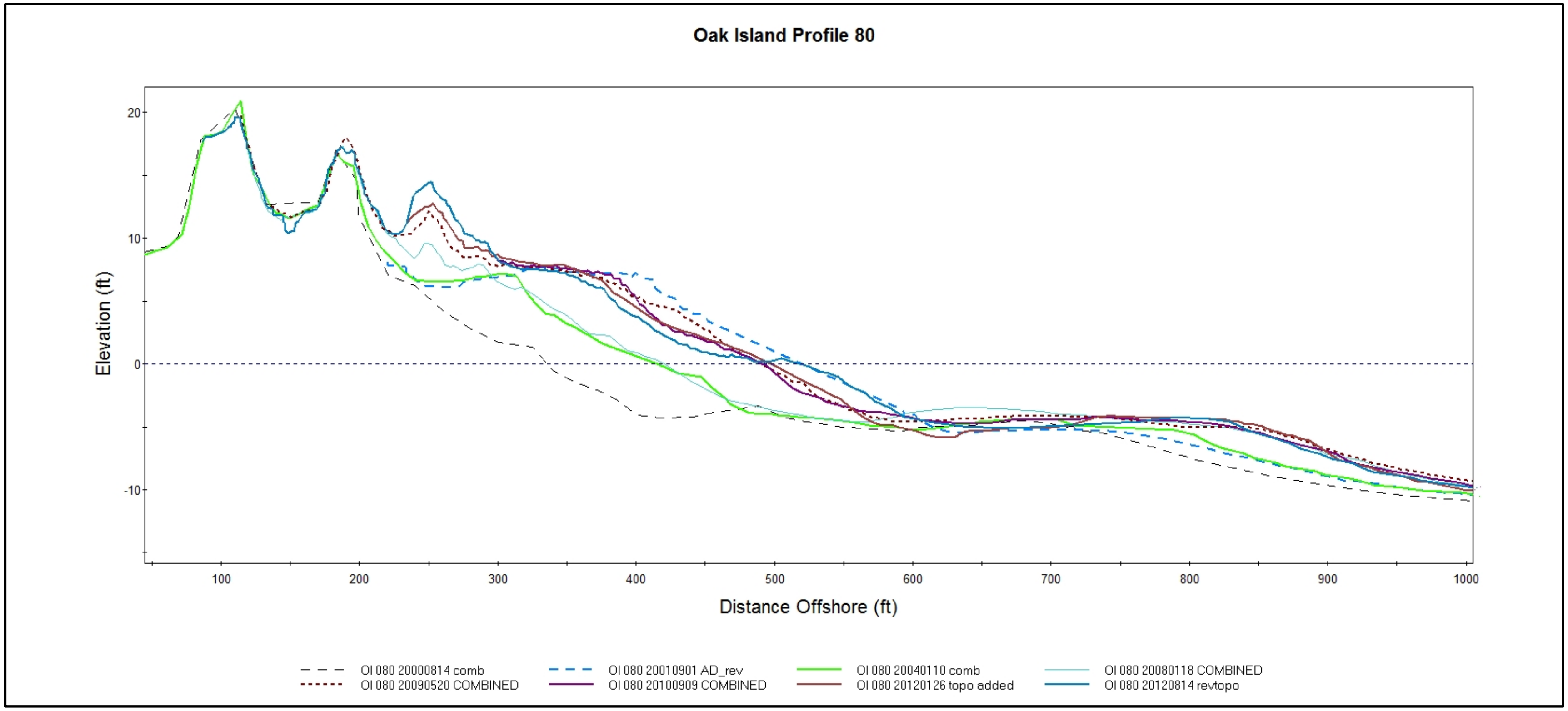


Figure 3.8 Oak Island Profile 80

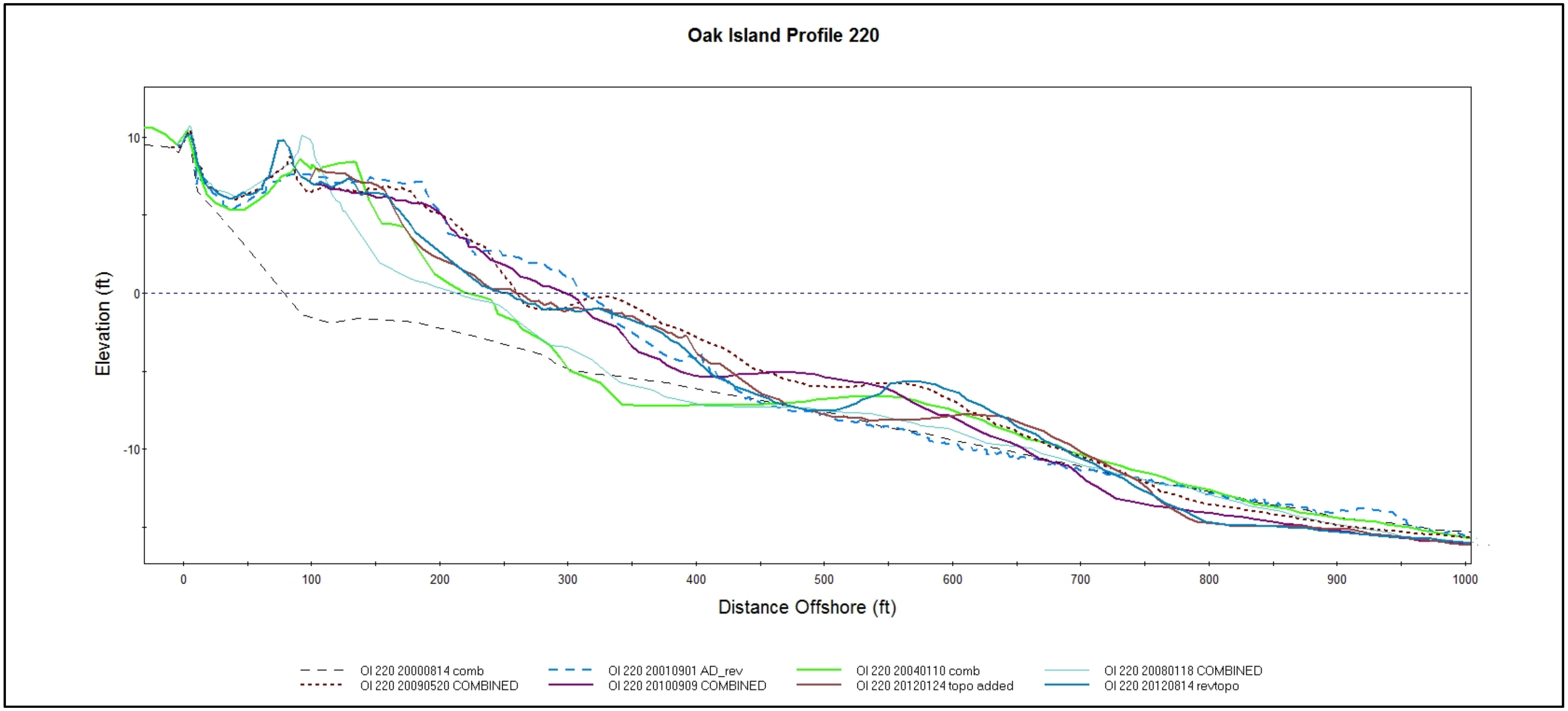


Figure 3.9 Oak Island Profile 220

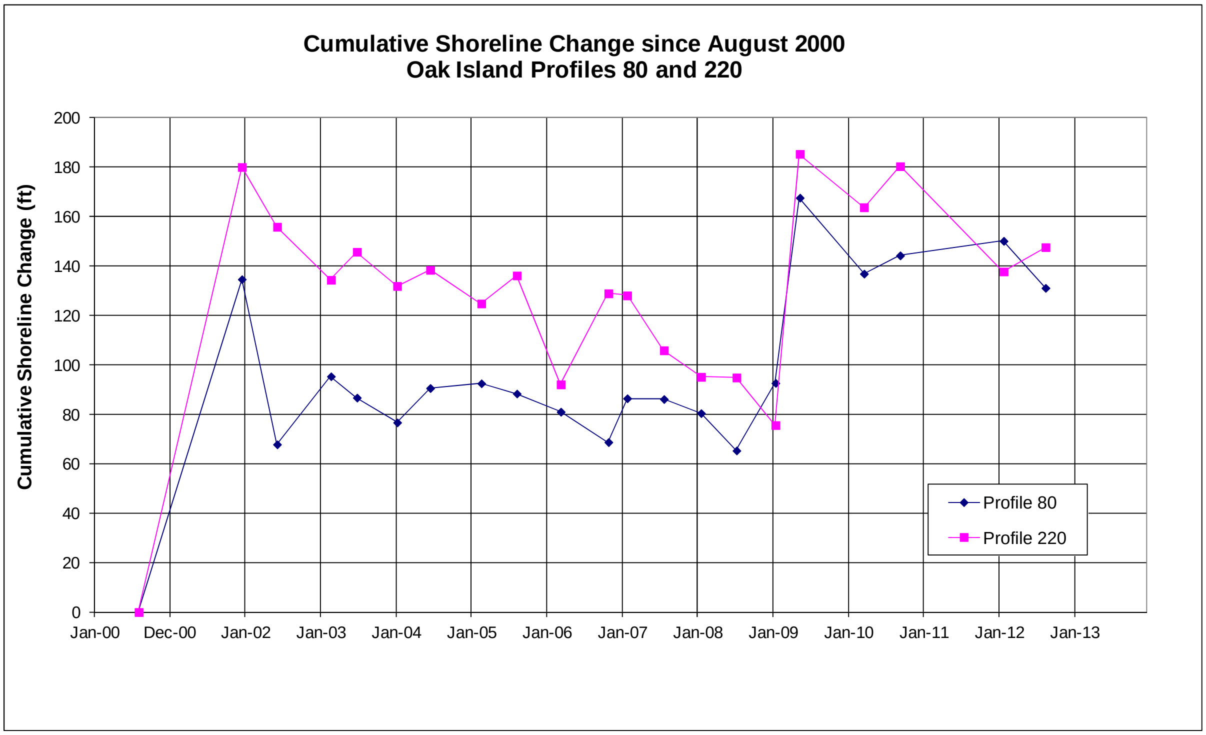


Figure 3.10 Cumulative Shoreline Change Since August 2000

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 based on the existing pre-project surveys. 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 January 2012 and August 2012 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 September 2010 onshore survey, i.e. the last referenced onshore survey in Report 8. 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 material loss over the current period. The most dynamic areas were within the regions of West Beach and the Spit. Specifically, between Profiles 12 and 45 the calculated volumetric change ranged from an increase of nearly 15,500 cubic yards (Profile 28) to a measured loss of approximately 35,500 cubic yards at Profile 40. The area of South Beach eroded relatively uniformly, with the exception of the area near the cape which was only slightly erosive to neutral. At the end of the current monitoring period there were only three areas along the entire island that experienced volumetric increases. The first area was the northern end of West Beach, Profiles 0 through 8, which gained nearly3,800 cubic yards. The second area was located between Profile 24 and 28, which had an increase of 26,000 cubic yards. The final area was at the extreme eastern end of the island at Profile 214. This area was the smallest of the three remaining relatively neutral. In considering the total onshore volume changes for all profiles over the current monitoring cycle, approximately 431,500 cubic yards of material were lost between September 2010 and August 2012.

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 12 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 0-20) which lost approximately 17,000 cubic yards, and along an area that covers part of the spit and the west end of South Beach (Profiles 36-65). This area lost nearly 246,000 cubic yards of sand since the start of the monitoring program. Both of these areas have increased in length and magnitude since the values reported in the previous monitoring report (#8).

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 –2ft NGVD) compared to the 2000 survey. With the second disposal (January 2005), this trend is reversed showing total onshore volume increases of around 500,000 cubic yards when the August 2005 survey is compared with the August 2000 pre-project condition. 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 greater than August 2000 using the July 2007 survey, which was the first monitoring survey following the third disposal. By May 2009, just prior to the beach nourishment initiated by the Village of Bald Head Island, the overall gains in onshore volumes measures 435,000 cubic yards when compared to pre-project conditions. The four 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 August 2012 shows that the cumulative change for the onshore portion of the profiles throughout the island is approximately 455,500 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 8 (September 2010); 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 losses throughout the island with two exceptions in West Beach (Profiles 0 and 24) showing minor increases. In summing the changes over the entire monitoring area, the losses total to approximately 1,054,500 cubic yards of material since September 2010. The most significant volumetric loss occurred within the Spit and the western end of South Beach. This area between stations 32+00 and 69+47 lost nearly 493,800 cubic yards of material or approximately 47% of the total material lost within the monitoring limits.

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 12 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 (Profiles 202 and 206), where some losses have occurred near the cape. Another is an area on South Beach that is just east of the new groin field (Profiles 97 through 114). This area has grown since Report 8 (in both magnitude and length) where it was reported as only a single profile showing minor losses. The third area spans three stations from Profile 45 to 61, 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. This area has increased as well from the values reported in Report 8, however the length and magnitude of the observed erosion is not near historic levels. Volumetrically this erosive region has lost about 568,500cubic yards to date, compared to the 318,000 loss recorded in Report 8. The net volume change over the entire monitoring area is a slight gain of nearly 176,500 cubic yards as of August 2012 with respect to the beginning of the monitoring in August 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). A 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 12 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 nourishment 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 176,500 cubic yards more at this time than in 2000 at the start of the project. This is also indicated in the previously mentioned Figure 3.13 that shows the cumulative volume changes over time for the island.

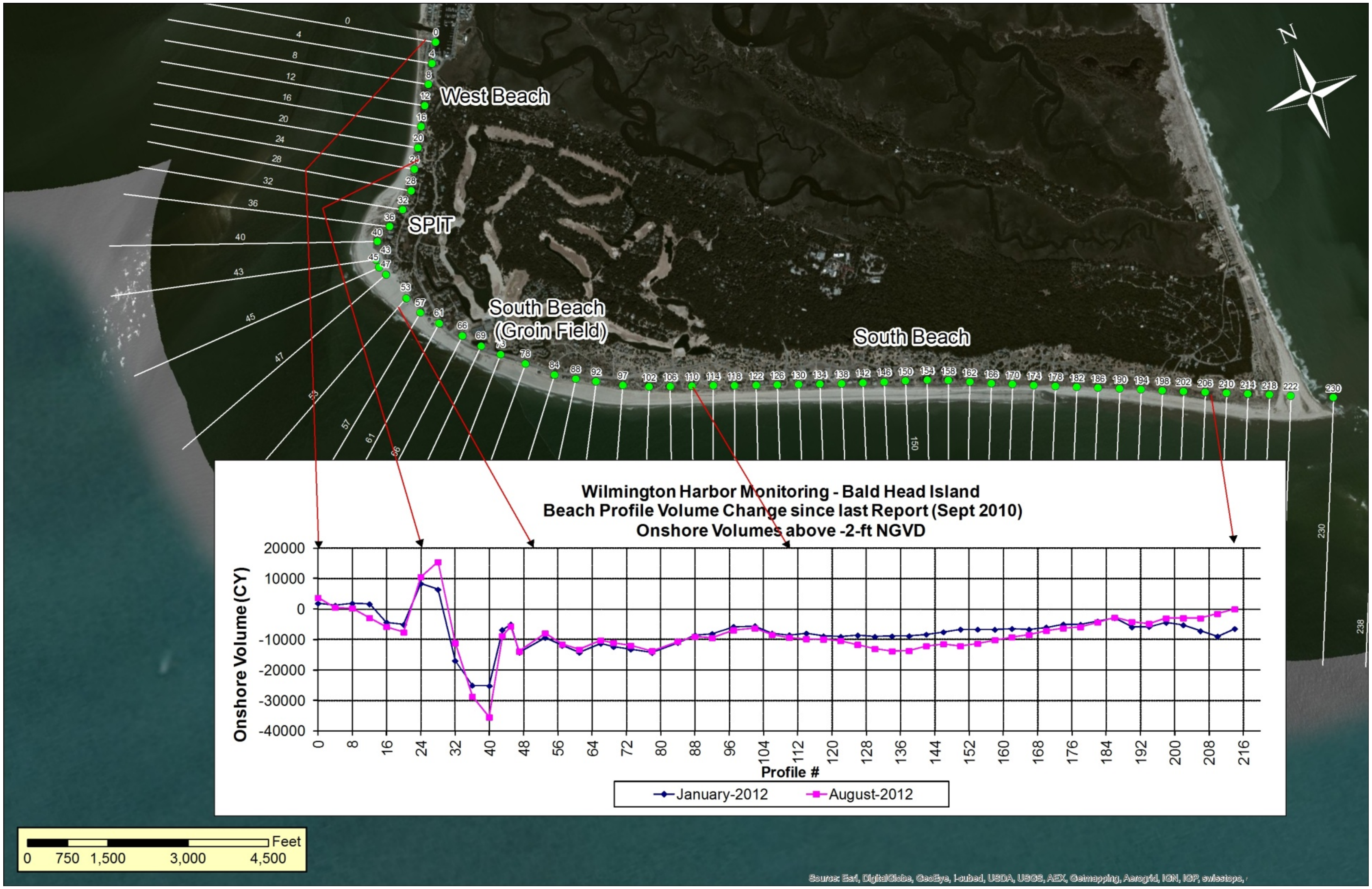


Figure 3.11 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change Since Last Report (September 2010) Onshore Volumes above –2 ft NGVD

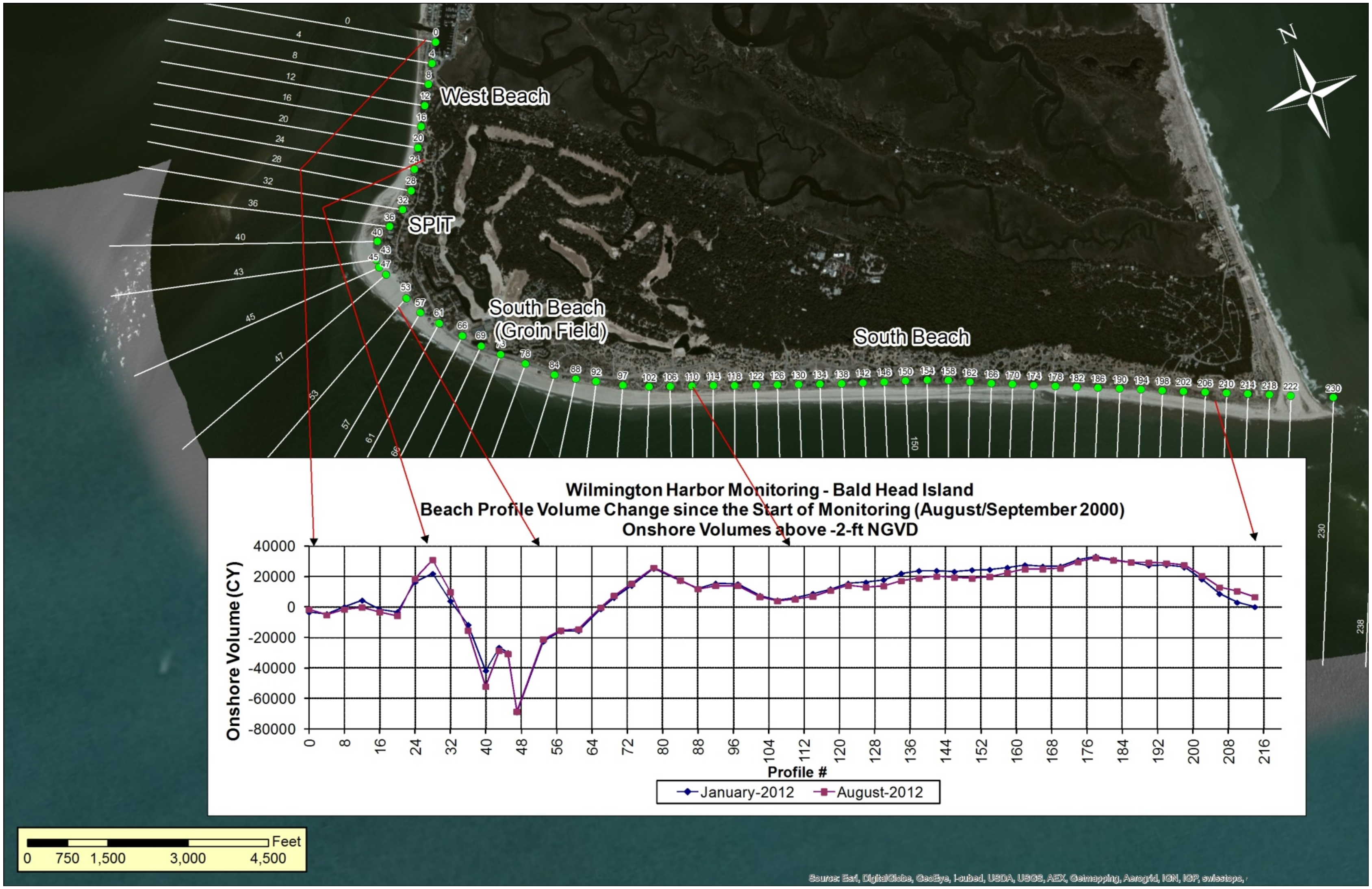


Figure 3.12 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change Since Start of Monitoring (August/September 2000) Onshore Volumes above –2 ft NGVD

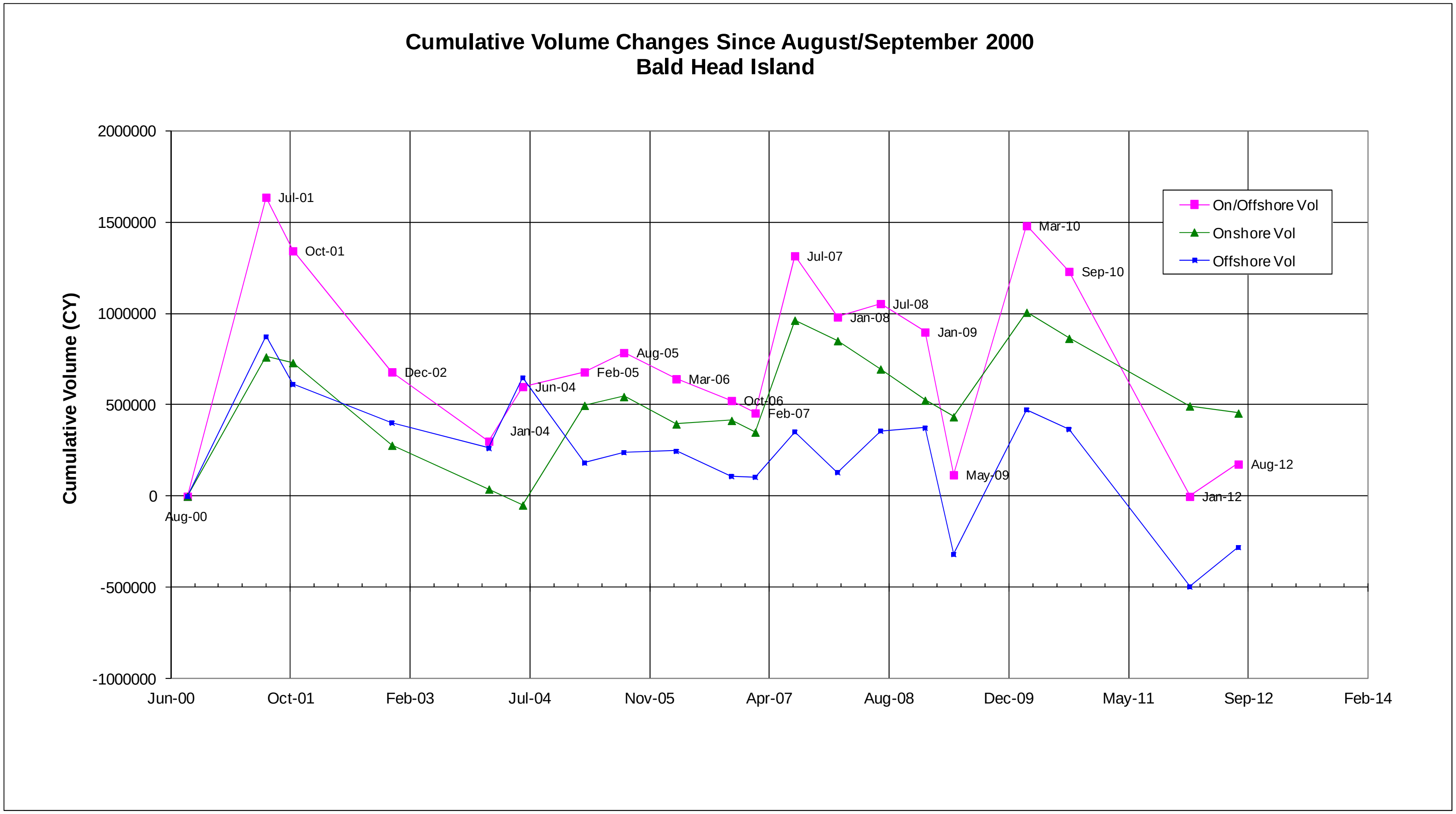


Figure 3.13 Cumulative Volume Changes Since August/September 2000 for Bald Head Island

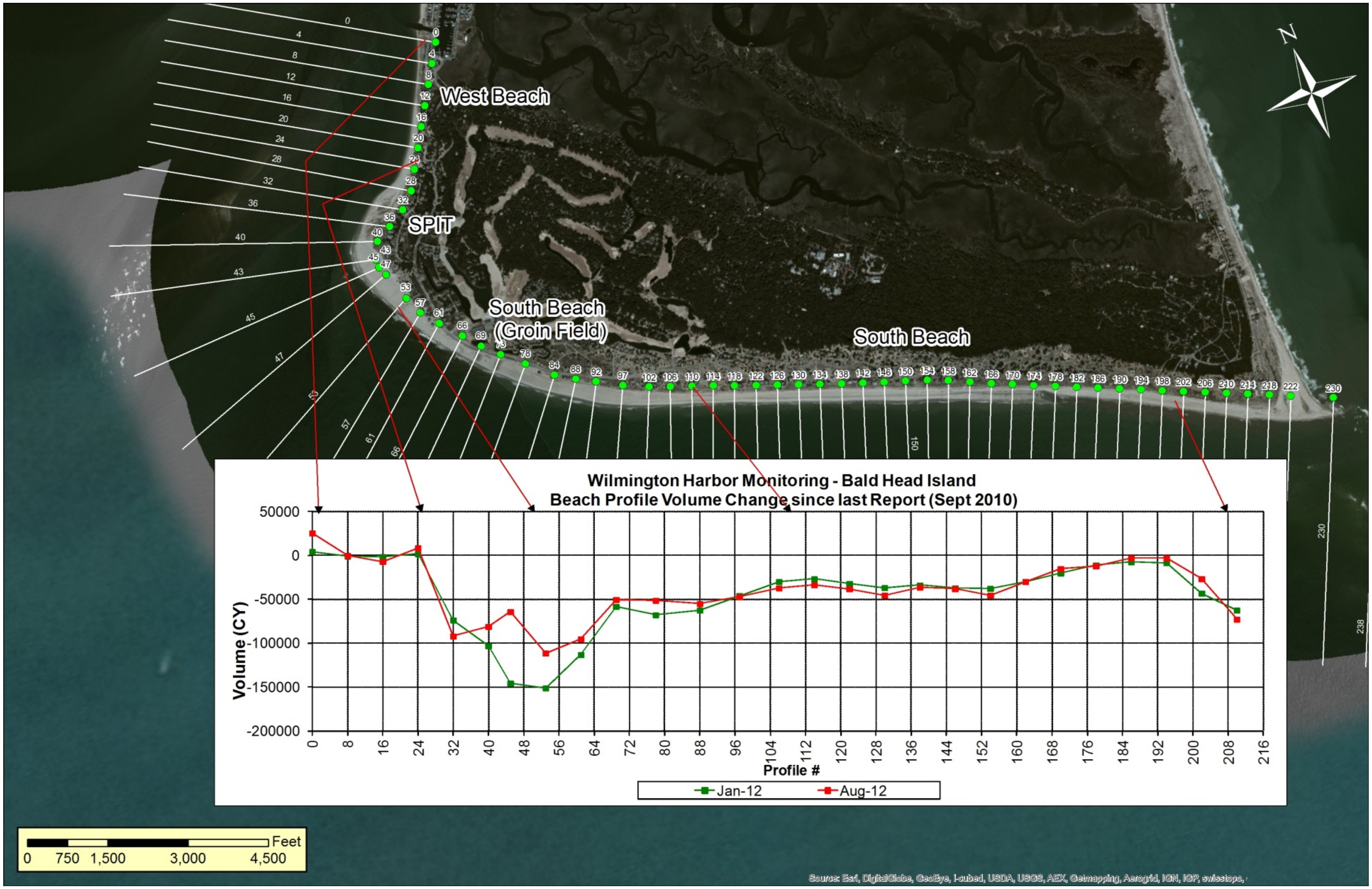


Figure 3.14 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since Last Report (September 2010)

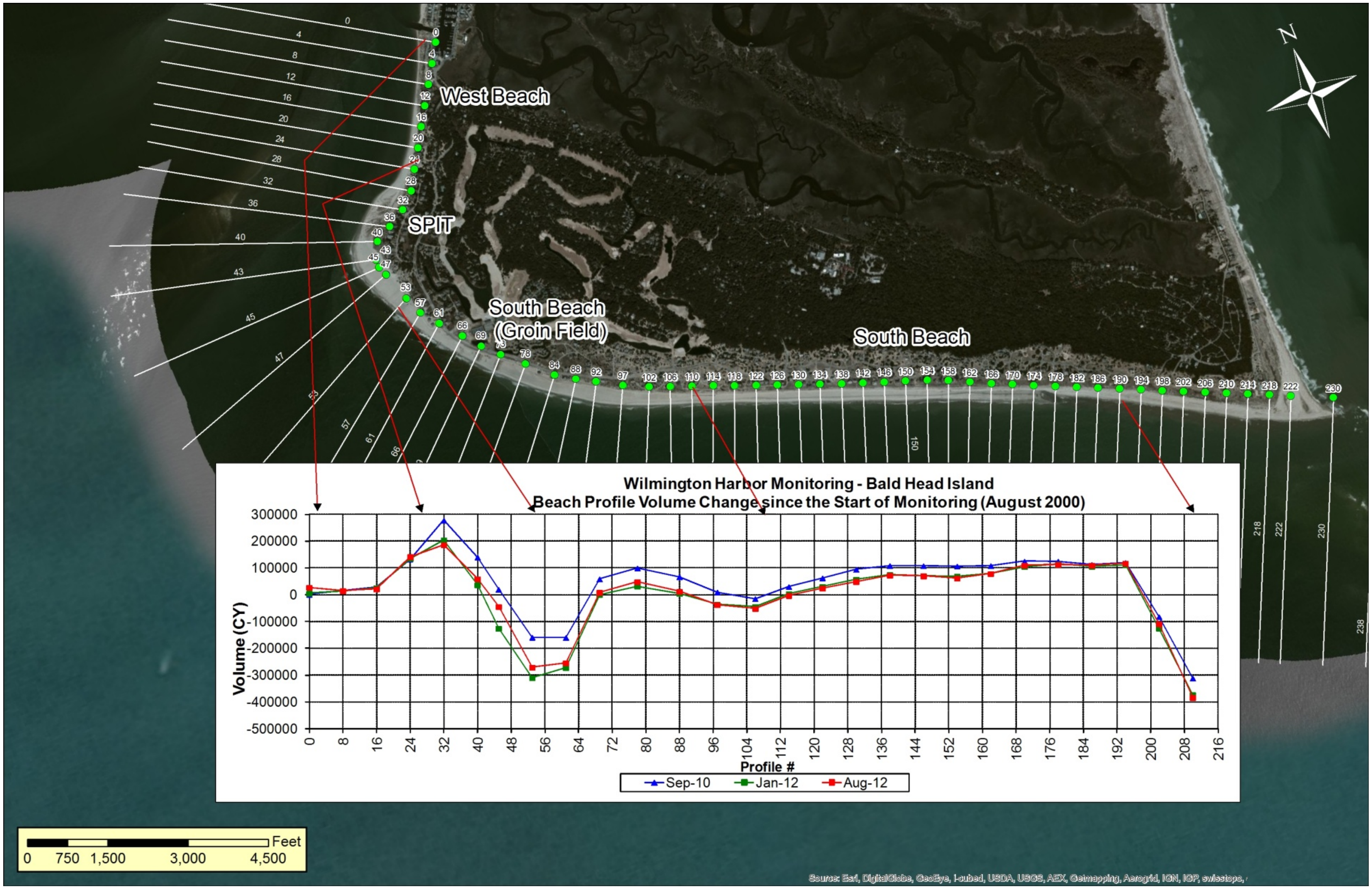


Figure 3.15 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since the Start of Monitoring (August 2000)

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	15-Mar-10	8-Sep-10	25-Jan-12	15-Aug-12
West Beach (Profiles 0 - 24)	0	3,048	29,564	11,618	1,854	14,646	34,221	121,372	166,722	111,871	106,678	97,715	101,369	87,863	77,730	178,739	177,870	181,769	205,208
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	116,953	201,515
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	-624,204	-543,310
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	823,508	805,096
Near Cape (Profiles 198 - 218)	4,675	-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	-498,278	-492,005
Total	1,636,936	1,344,078	681,143	301,859	600,586	680,794	786,557	643,335	524,318	456,283	1,316,745	981,966	1,054,778	899,470	117,865	1,481,398	1,230,985	-252	176,504

Oak Island. The onshore volumetric changes measured along Oak Island over the current monitoring cycle are given in Figure 3.16 and Figure 3.17. Figure 3.16 shows the volumetric changes relative to the September 2010 survey, i.e. the last referenced onshore survey in Report 8. 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 majority of the area was relatively stable fluctuating between slightly erosive to slightly accretionary. The only exceptions would be near the inlet at Profiles 35 and 40 where peak losses of 8,600 cubic yards and 12,900 cubic yards were measured, respectively. Cumulatively, the onshore portion of the profile measured over the entire length of the monitoring area shows a moderate loss of material of approximately 146,200 cubic yards between September 2010 and August 2012.

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 September 2010, January 2012 and August 2012. 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. Profile 40, which has fluctuated over the life of the monitoring report between positive and negative volumetric change has now been erosive for the previous four surveys. Additionally, it is currently at its most eroded condition since the monitoring program was initiated. 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 12 years.

To further illustrate the stable nature of the Oak Island beaches over the last 12 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 greater than the pre-project condition in August 2000. 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 greater than the August 2000 condition, which represents a loss of approximately 4.9% from the 926,100 cubic yards that was placed in December 2001. The placement of 1,064,400 cubic yards of material along Oak Island in 2009 increased the onshore volume over the entire monitoring area to approximately 1,524,000 cubic yards by May 2009, the first post placement monitoring survey. The most recent beach surveys in August 2012 measure the total increase of onshore material to 1,442,000 cubic yards relative to the August 2000 base condition survey. This loss rate calculated for the current placement cycle (May 2009-August 2012) is approximately 25,000 cy/yr for the entire monitoring area.

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 8 (September 2010); 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 volume change relative to the last survey in Report 8 fluctuates between erosion (16 profiles) and accretion (17 profiles) evenly when compared to the August 2012 survey. The trends for the surveys within the current monitoring period vary with the majority of profiles seeing erosion in the January 2012 survey. One area of concern noted since Report 8 is the significant erosion observed at Profiles 30 and 40. The area of the beach represented by these two profiles lost approximately 51,300 cubic yards of material since September 2010 (Report 8). The overall change at the conclusion of the current monitoring period was slight accretion, with a total increase of approximately 4,400 cubic yards since September 2010 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 the 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 4 profiles along the eastern end of the island which include Profiles 5, 30, 40, and 45. The most significant volumetric loss occurred between Profiles 40 and 45, close to the area of erosion noted over the current monitoring period. Measured volumes for the entire monitoring area with the August 2012 survey totaled nearly 2,039,300 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.

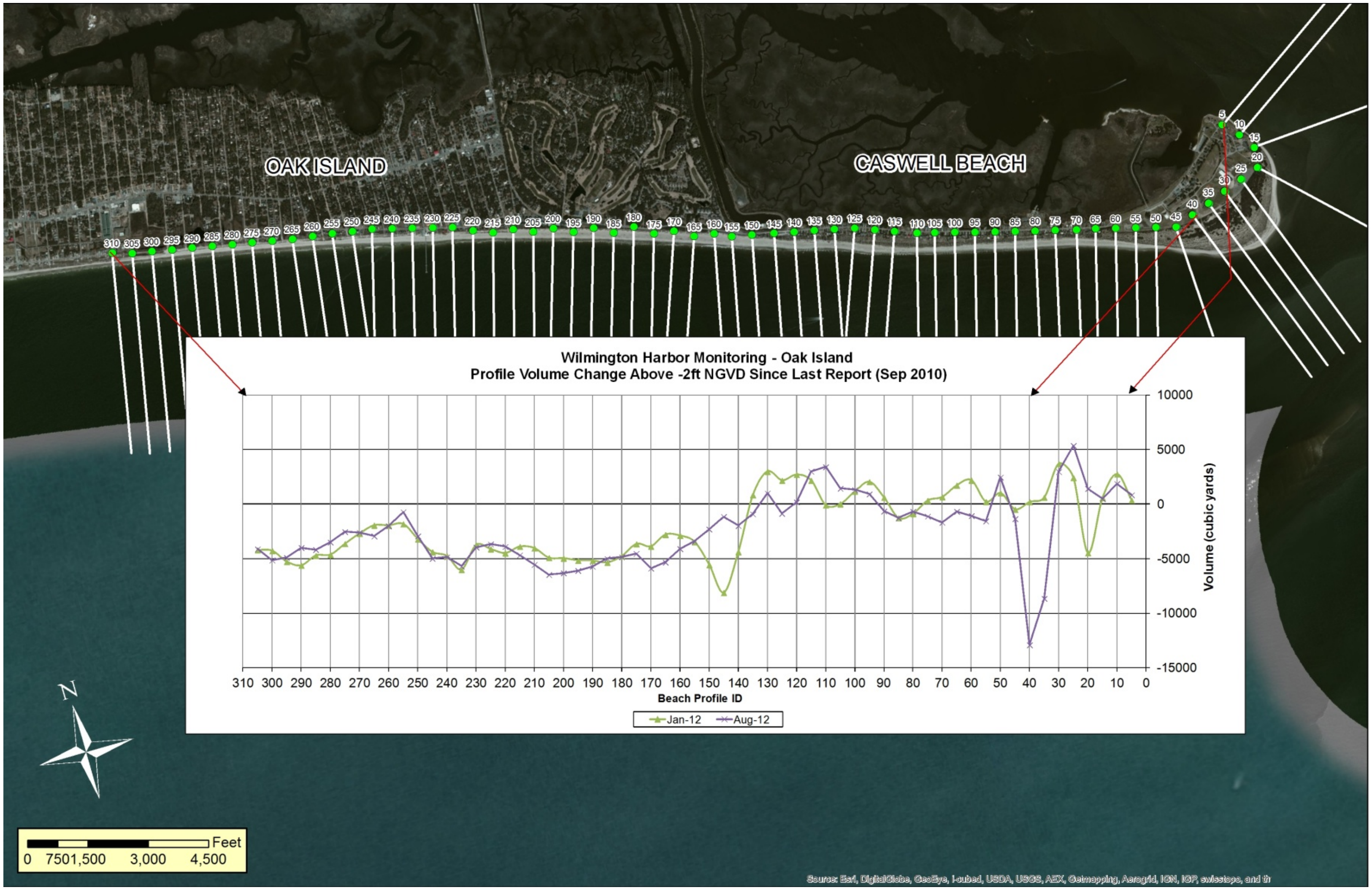


Figure 3.16 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change Since Last Report (September 2010) Onshore Volumes above – 2 ft NGVD

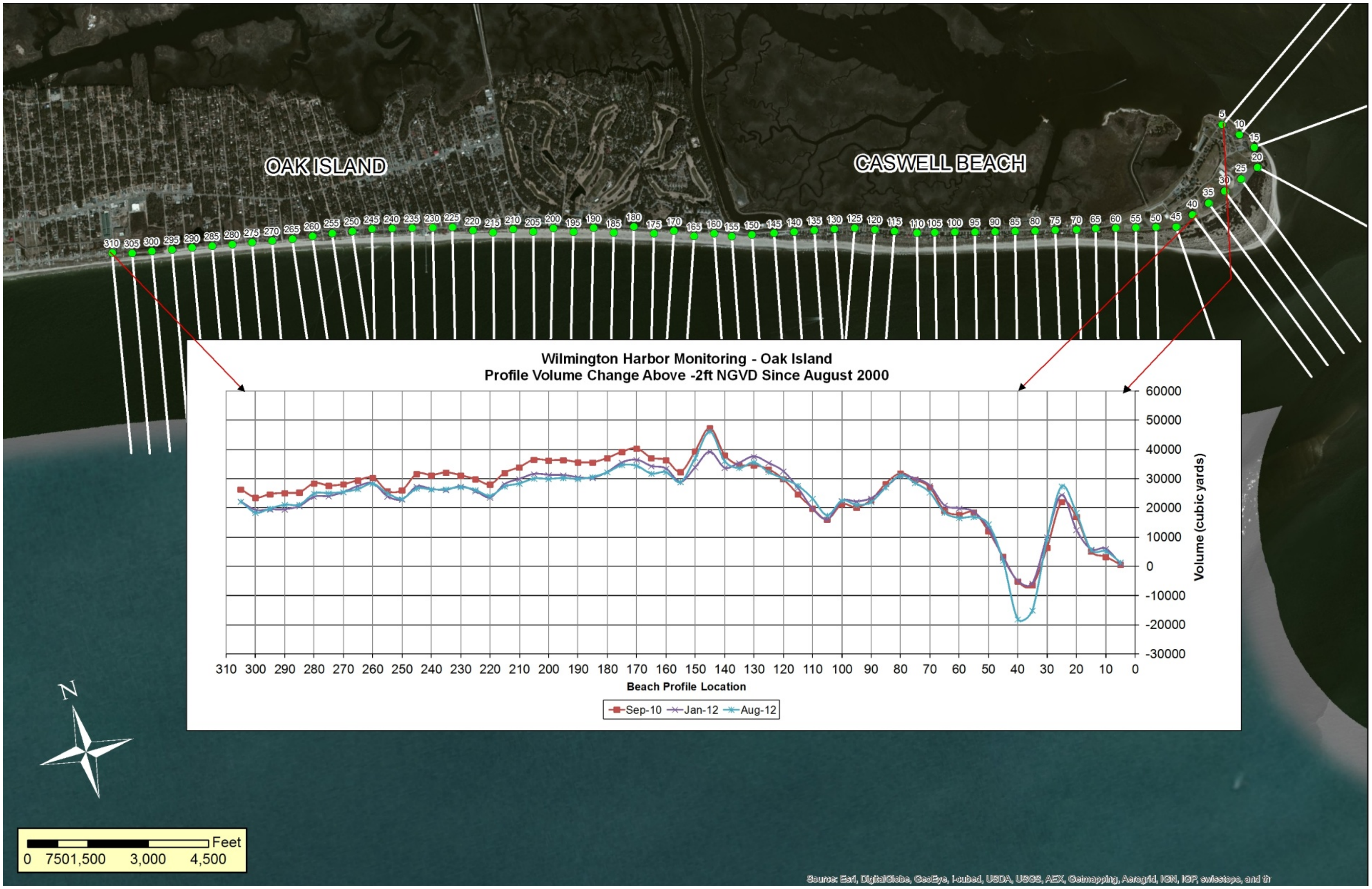


Figure 3.17 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change Since Start of Monitoring (August 2000) Onshore Volumes above –2 ft NGVD

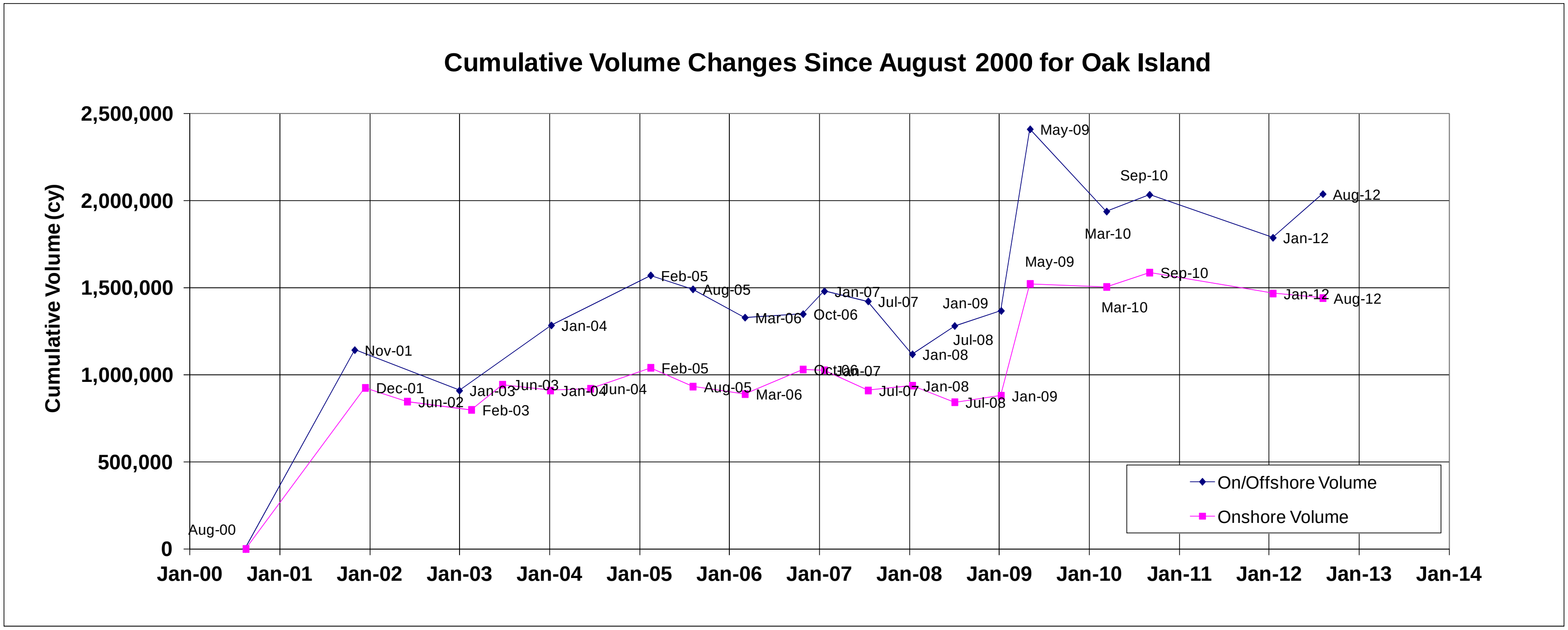


Figure 3.18 Cumulative Volume Changes Since August 2000 for Oak Island

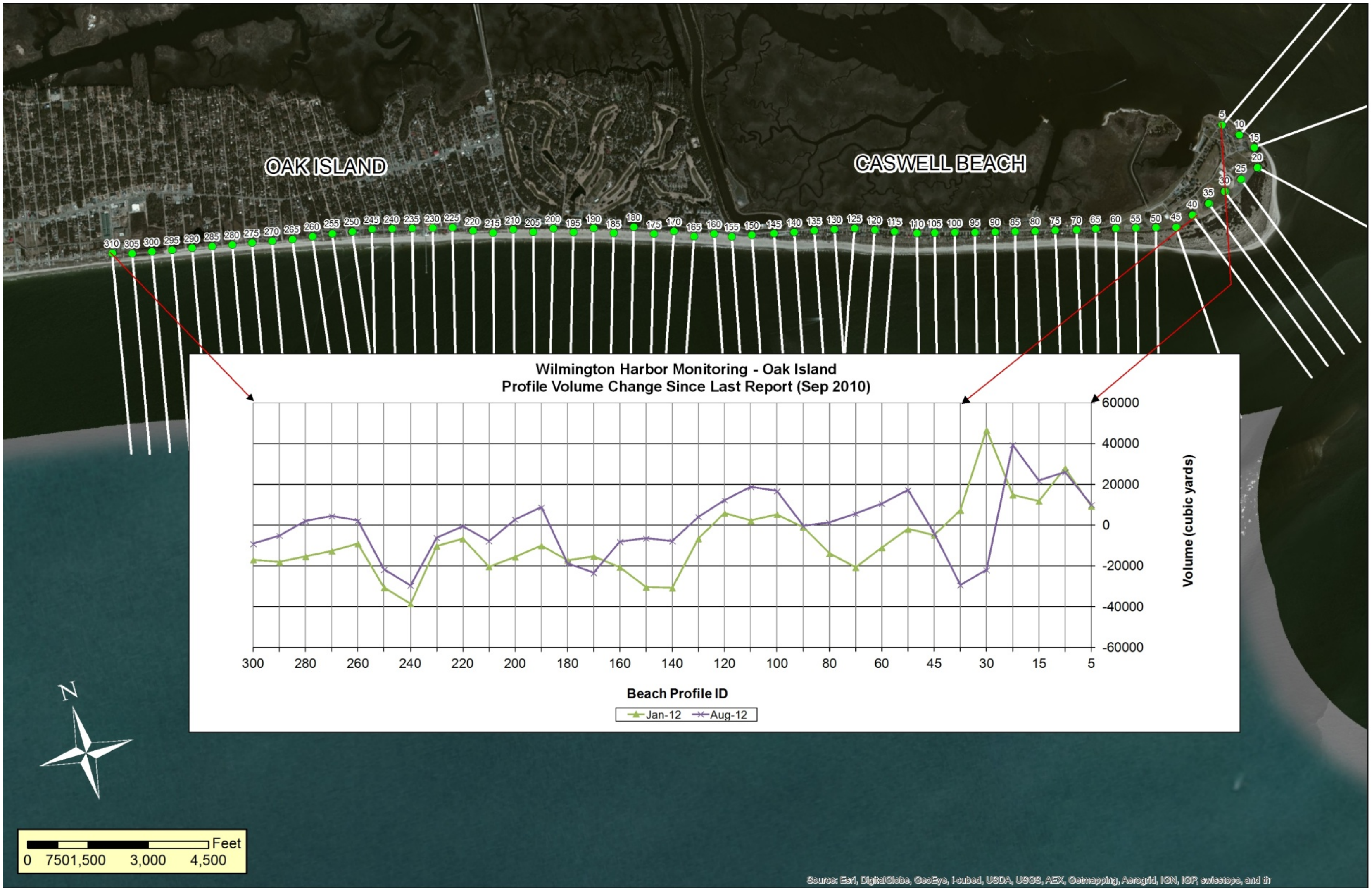


Figure 3.19 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since Last Report (September 2010)

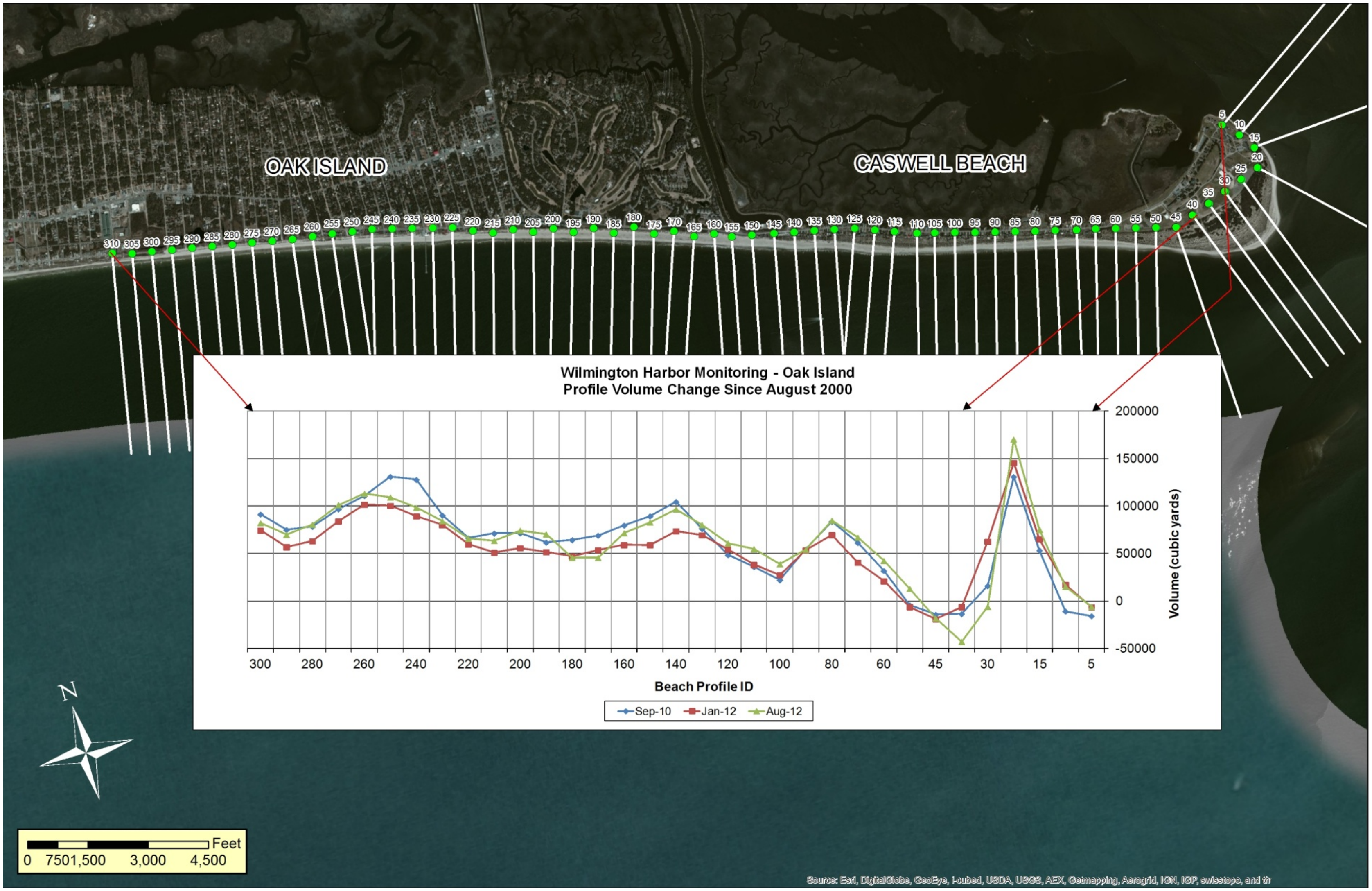


Figure 3.20 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since the Start of Monitoring (August 2000)

Wave Data Analysis

Detailed investigations of wave conditions associated with Wilmington Harbor monitoring were conducted through the use of field data collection using three wave gauges. One gauge was located offshore and the other two were located nearshore so that the local wave climate can be assessed with respect to offshore conditions.

Directional wave, water level, and current data were 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 3.21. 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 were Acoustic Doppler Current Profiler (ADCP) instruments accompanied by a pressure transducer. Directional wave spectra were 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 were determined from the directional spectrum. Peak frequency represents the highest energy density in the frequency spectrum integrated over all directions. Peak direction was determined as the vector mean at the peak frequency. Water level was determined from the pressure transducer record. Time series of current velocity at the surface, mid-depth, and bottom were also provided from the ADCP gauges. The 11-Mile and Bald Head Island gauges collected 20-min time series at 3-hr intervals. The Oak Island gauge collected 20-min time series at 1-hr intervals.

All gauges were initially deployed in September 2000. The 11-Mile gauge 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 caused 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. Due to funding constraints, the three ADCPs were supposed to officially be removed from the water by June of 2009. The gauges were kept in water and were managed by FRF for another approximately 18 months. The collected data during this monitoring period was not processed, however it is available in raw binary format. The 11-Mile gauge operated through Feb 2012. The Bald Head Island gauge was operational between July 2011 and September 2011. The Oak Island gauge was operational through August 2011.

A WaveRider buoy was deployed on 2/6/2013 replacing the network of three gauges within the project area. The new 3-ft diameter surface buoy is anchored at 33 43.26 N and 78 0.88 W, in about a 43-ft of water, approximately 11-miles offshore of Bald Head Island, very near the former 11-mile ADCP. This buoy uses satellite technology to transmit real time wave data plus sea surface temperature (SST) for posting on the Coastal Data Information Program (CDIP) website. The wave data will include wave height, period and direction and is updated about every 30-minutes. The buoy is named “200 Wilmington Harbor NC” and is posted on the Coastal Data Information Program (CDIP) site (http://cdip.ucsd.edu/?nav=historic&stn=200).

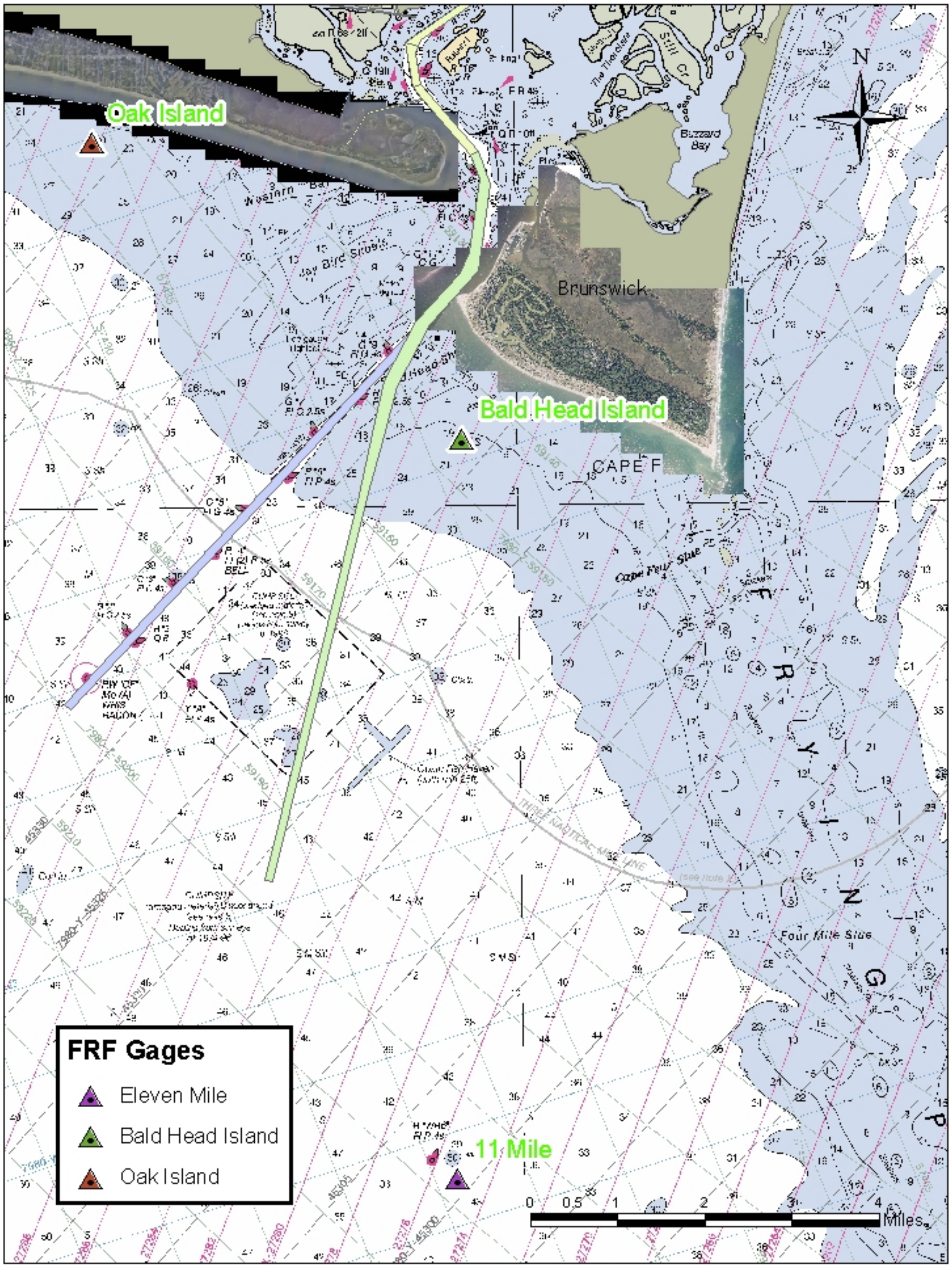


Figure 3.21 FRF Wave and Current Gauges.

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 were 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 nine 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), (8) the survey of September 2010 (as presented in Report 8), and (9) through the most recent survey of August 2012. 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 A (Oak Island) and B (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-construction rate data (2000 through 2012), 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 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) continue to 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 +11 to +21 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 longshore average post-construction rates calculated through June 2003 previously indicated an area of erosion with the only exception being Profile 5 which was 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.

A closer look at the area of local concern around Profiles 35 and 40 shows that there has been a significant change in the shoreline change rate for this area relative to the pre-construction change rates. While the longshore average change rates for these two profiles remain positive, they have reduced significantly. Specifically, the pre-project shoreline change rate at Profile 35 has changed from +29.9 ft/yr to 3.84 ft/yr through August 2012. The rate at Profile 40 has reduced from a pre-project accretion rate of +17.2 ft/yr to only 1.32 ft/yr. The non-longshore averaged post-project rates for these two profiles are -8.0 ft/yr and -6.1 ft/yr for Profiles 35 and 40, respectively.

Overall, the shoreline change rate averaged over the entire 5.2 mile section of Oak Island/Caswell Beach (from Profiles 35-310) is +14.4 feet per year for the 12-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	Aug-12	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jul-08	May-09	Sep-10	Aug-12	
5	-5.4	-3.2	-2.0	-1.4	-1.3	-1.0	-0.9	-0.6	-0.3	1.0	1.3	1.9	2.0	1.6	1.7	1.5	1.4	1.6	
10	1.3	0.8	0.9	0.8	0.4	0.5	0.3	0.3	0.5	-1.5	-1.2	-0.8	-0.4	-0.3	0.1	0.2	0.4	0.6	
15	7.0	6.4	7.0	6.8	5.8	5.6	5.0	4.5	4.6	-7.1	3.2	5.6	4.8	4.5	3.3	4.0	4.1	3.9	
20	-8.7	-8.7	-9.1	-7.7	-6.1	-4.6	-3.4	-2.5	-2.3	-2.8	9.4	10.4	9.0	8.2	6.4	6.7	6.7	6.6	
25	-29.7	20.9	31.1	25.8	23.9	15.9	18.8	18.7	17.2	-9.7	4.4	6.2	5.8	5.9	4.4	4.7	4.9	4.9	
30	16.1	27.7	22.1	19.5	16.8	14.8	12.7	12.5	12.8	-15.5	-0.9	1.7	2.8	3.4	2.2	2.8	3.1	2.7	
35	-33.4	-24.3	-20.2	-15.3	-10.8	-9.7	-9.5	-8.8	-8.0	-15.9	1.5	5.4	6.4	6.5	4.7	5.0	4.7	3.8	29.9
40	-21.9	-20.1	-15.3	-8.3	-6.9	-5.5	-4.5	-4.5	-6.1	-6.1	0.3	2.0	3.3	3.6	2.9	2.4	1.9	1.3	17.2
45	-10.6	3.5	9.2	10.1	9.5	7.9	7.2	5.6	3.3	-3.2	-0.5	1.5	2.2	2.6	1.8	1.7	1.3	0.6	7.9
50	19.2	14.8	14.2	10.6	9.4	6.8	6.0	4.8	4.6	11.7	10.3	10.3	8.8	7.7	6.0	5.6	5.1	4.2	2.5
55	30.8	23.5	19.6	14.2	12.0	9.6	9.2	9.3	9.0	20.8	17.4	15.8	12.1	10.1	7.7	7.3	7.0	6.4	0.8
60	41.3	29.6	24.0	17.5	14.3	11.3	10.2	10.4	9.9	30.7	21.9	18.2	13.4	10.9	8.3	8.0	8.1	7.9	0.3
65	23.3	15.6	11.9	8.1	5.3	3.1	3.8	4.8	5.2	32.9	23.0	18.6	13.6	11.0	8.4	8.5	8.9	8.7	0.2
70	38.8	25.9	21.5	16.4	13.5	10.5	11.0	11.3	10.8	35.9	24.9	20.1	15.1	12.4	9.7	9.8	10.1	9.8	0.4
75	30.4	20.6	15.7	11.8	10.1	7.7	8.3	8.8	8.6	35.0	24.2	19.7	15.1	12.7	10.3	10.7	11.0	10.6	0.9
80	45.8	33.0	27.2	21.5	18.6	15.8	15.7	15.3	14.4	35.5	24.7	20.3	16.0	13.9	11.8	12.0	12.2	11.7	1.6
85	36.4	26.0	22.2	17.8	16.0	14.5	14.7	14.7	14.1	27.3	19.6	16.0	12.8	11.4	9.9	10.2	10.5	10.2	1.9
90	25.9	18.0	14.8	12.4	11.1	10.3	10.4	10.6	10.5	22.9	17.0	14.5	11.9	10.7	9.6	9.9	10.2	10.0	2.2
95	-1.9	0.2	0.1	0.5	1.0	1.3	2.1	3.1	3.6	13.4	10.7	9.5	8.1	7.3	6.9	7.3	7.9	8.1	2.5
100	8.2	7.9	8.0	7.3	6.6	6.2	6.4	7.0	7.3	8.0	7.0	6.5	5.7	5.1	4.8	5.1	5.9	6.3	2.6
105	-1.6	1.3	2.7	2.6	1.9	2.2	2.7	3.8	4.9	4.4	5.2	5.2	4.6	3.9	3.7	3.9	4.8	5.4	2.5
110	9.6	7.4	7.2	5.9	5.0	4.0	4.0	4.7	5.4	12.0	10.9	10.1	8.4	7.2	6.3	6.2	6.9	7.4	2.1
115	7.6	9.2	8.1	6.5	5.1	4.6	4.4	5.4	6.0	17.8	15.4	13.2	10.4	8.8	7.6	7.4	8.1	8.5	1.5
120	36.2	28.9	24.3	19.7	17.3	14.6	13.7	13.7	13.3	32.9	25.7	20.8	16.1	13.7	11.6	11.2	11.4	11.4	0.7
125	37.1	30.2	23.6	17.1	14.9	12.5	12.5	13.0	13.2	44.9	34.7	27.1	21.1	18.1	15.4	14.9	14.7	14.2	-0.3
130	73.8	52.7	40.6	31.2	26.3	22.4	21.5	20.4	19.2	55.4	42.4	33.2	25.9	22.4	18.9	18.2	17.6	16.6	-0.9
135	69.7	52.3	39.0	30.8	27.1	22.7	22.2	20.9	19.2	62.1	47.6	36.8	28.7	24.8	21.0	20.0	19.2	17.9	-1.4
140	60.2	47.8	38.5	30.6	26.7	22.2	21.0	19.9	18.0	68.7	51.7	40.6	32.3	28.0	23.9	22.6	21.6	19.8	-2.1
145	69.7	54.8	42.2	33.6	28.9	24.9	22.7	21.9	20.0	64.5	49.4	39.1	31.4	27.4	23.5	22.4	21.7	19.8	-2.3
150	70.2	50.8	42.9	35.3	30.8	27.0	25.4	25.0	22.9	62.9	47.3	38.0	30.5	26.6	22.8	21.9	21.5	19.7	-2.5
155	52.9	41.4	33.1	26.6	23.5	20.6	20.7	20.9	19.1	61.9	45.8	36.4	29.1	25.3	21.8	21.2	21.3	19.6	-2.8
160	61.4	41.5	33.5	26.6	23.1	19.5	19.7	20.0	18.5	61.6	44.5	35.6	28.4	24.6	21.1	20.9	21.2	19.5	-3.3
165	55.0	40.4	30.3	23.6	20.4	17.1	17.6	18.6	17.4	60.1	43.9	34.1	26.6	23.1	19.6	19.7	20.1	18.7	-3.9
170	68.7	48.5	38.2	29.8	25.4	21.3	21.1	21.3	19.7	60.7	43.4	33.4	25.8	22.1	18.6	18.6	19.2	18.0	-4.3
175	62.2	47.9	35.3	26.5	22.9	19.3	19.2	19.8	18.9	60.3	43.5	32.9	25.2	21.5	18.2	18.1	18.8	17.7	-4.7
180	56.0	38.6	29.9	22.5	18.9	15.8	15.4	16.4	15.5	61.4	44.2	33.4	25.5	21.8	18.4	18.1	18.7	17.5	-5.0
185	59.6	42.4	30.6	23.4	20.1	17.3	17.0	17.9	16.8	59.6	43.2	32.0	24.4	20.9	17.6	17.3	18.0	16.9	-5.3
190	60.6	43.5	33.0	25.6	21.7	18.3	17.8	18.2	16.8	59.8	42.7	31.9	24.6	21.0	17.7	17.2	17.8	16.6	-5.4
195	59.4	43.8	31.1	24.0	20.7	17.2	17.0	17.6	16.5	61.1	44.5	33.2	25.9	22.2	18.9	18.3	18.7	17.3	-5.5
200	63.5	45.4	35.1	27.6	23.6	20.2	19.1	19.1	17.5	63.5	46.3	35.3	27.8	23.8	20.2	19.3	19.4	17.8	-5.6
205	62.3	47.6	36.1	28.8	25.1	21.6	20.6	20.5	18.9	63.9	46.8	35.8	28.3	24.2	20.6	19.5	19.4	17.8	-5.7
210	71.9	51.2	41.2	33.0	27.9	23.9	22.2	21.6	19.6	66.3	48.2	37.8	30.0	25.6	21.8	20.3	19.9	18.1	-5.8
215	62.3	46.1	35.4	27.9	23.8	20.2	18.7	18.3	16.8	64.0	47.1	36.9	29.3	24.9	21.0	19.5	19.1	17.3	-5.7
220	71.6	50.9	41.2	32.5	27.5	22.9	20.8	19.9	17.8	64.2	46.7	37.2	29.5	25.1	21.1	19.5	18.9	17.1	-5.5
225	52.3	39.9	30.8	24.0	20.1	16.5	15.3	15.1	13.6	57.5	42.3	33.7	26.7	22.6	19.0	17.7	17.2	15.5	-5.2
230	63.1	45.2	37.3	30.1	26.0	22.1	20.5	19.6	17.5	56.1	41.3	33.8	26.9	22.8	19.2	17.8	17.2	15.4	-4.8
235	38.1	29.3	24.0	19.1	15.9	13.4	13.0	12.9	11.6	50.3	37.9	31.3	25.1	21.3	18.0	16.9	16.3	14.6	-4.4
240	55.5	41.2	35.6	28.8	24.5	21.0	19.6	18.7	16.4	52.1	39.3	33.3	27.0	23.2	19.8	18.5	17.6	15.6	-4.1
245	42.6	33.6	28.6	23.2	20.2	17.1	16.2	15.4	13.6	48.1	37.3	31.9	25.9	22.3	19.0	17.7	16.8	14.8	-3.9
250	61.4	47.4	41.1	34.0	29.5	25.4	23.1	21.5	18.8	53.7	41.5	35.8	29.3	25.4	21.9	19.9	18.6	16.4	-3.7
255	42.8	35.2	30.1	24.5	21.4	18.3	16.3	15.4	13.7	53.9	41.7	36.0	29.5	25.7	22.1	19.8	18.3	16.1	-3.6
260	66.0	50.1	43.7	36.2	31.6	27.5	24.1	21.8	19.3	60.5	46.3	40.2	33.1	28.7	24.8	21.9	20.0	17.6	-3.5
265	56.5	42.1	36.4	29.8	25.7	22.3	19.2	17.3	15.2	58.9	45.2	38.9	31.9	27.6	23.9	20.9	18.9	16.6	-3.3
270	75.7	56.9	49.6	40.9	35.4	30.7	26.7	23.9	20.7	66.1	50.1	43.4	35.6	30.7	26.7	23.2	20.7	18.1	-3.2
275	53.5	41.8	35.0	28.2	24.1	20.9	18.2	16.1	14.0	67.4	51.2	43.8	35.7	30.8	26.6	23.0	20.4	17.6	-3.0
280	78.9	59.6	52.2	42.9	36.8	32.0	27.9	24.5	21.0	72.0	54.5	46.6	37.9	32.6	28.1	24.3	21.4	18.2	-2.8
285	72.3	55.4	45.8	36.9	31.7	27.3	23.1	20.2	17.0	73.5	55.8	46.9	37.8	32.4	27.9	24.0	20.9	17.7	-2.7
290	79.7	58.8	50.5	40.6	34.8	29.8	25.5	22.4	18.6	82.7	61.8	52.0	41.8	35.7	30.6	26.2	22.9	19.2	-2.6
295	83.0	63.3	50.9	40.3	34.5	29.3	25.0	21.6	18.0	86.9	64.5	53.1	42.2	35.9	30.6	26.1	22.6	18.9	-2.5
300	99.5	72.1	60.7	48.2	40.9	34.7	29.6	25.7	21.5	95.8	69.7	57.4	45.5	38.5	32.7	27.9	24.1	20.0	-2.3
305	99.9	73.1	57.4	44.8	37.5	31.8	27.1	23.3	19.3	99.8	72.4	59.1	46.7	39.5	33.4	28.4	24.6	20.4	-2.2
310	116.9	81.2	67.2	53.3	45.0	37.8	32.1	27.6	22.9	105.5	75.5	61.8	48.8	41.1	34.8	29.6	25.5	21.2	-2.1

Table 4.2 Bald Head Island Shoreline Change Rates

Profile ID	Post-Construction Rate (ft/yr) Aug-00 thru									Longshore Average Rate (ft/yr) Aug-00 thru								
	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jul-08	May-09	Sep-10	Aug-12	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jul-08	May-09	Sep-10	Aug-12
0	-3.1	1.0	2.3	3.0	3.2	2.6	2.8	1.3	2.0	-3.0	-2.1	-1.6	-1.0	-0.8	-0.9	-1.0	-2.0	-1.7
4	-6.2	-5.6	-5.0	-4.1	-3.7	-3.6	-3.7	-4.4	-4.5	-1.6	-1.1	-1.0	-0.4	-0.4	-0.5	-0.8	-1.6	-1.3
8	0.3	-1.7	-2.3	-1.9	-1.8	-1.7	-2.2	-2.9	-2.7	0.0	0.4	-0.1	0.4	0.3	0.0	-0.5	-1.1	-0.9
12	2.6	1.9	0.7	1.2	0.9	0.7	0.0	-0.3	-0.1	1.7	1.2	-0.3	0.1	-0.3	-0.8	-1.5	-1.5	-1.6
16	6.3	6.2	3.9	3.7	2.9	1.7	0.5	0.9	1.1	5.9	4.3	1.2	1.6	0.9	0.0	-1.1	-0.6	-0.7
20	5.7	5.0	1.0	1.4	0.5	-0.9	-2.3	-1.0	-1.8	4.6	1.3	-3.1	-2.0	-2.1	-2.6	-3.0	-1.5	0.3
24	14.7	10.0	2.7	3.5	2.1	0.4	-1.3	0.1	-0.1	1.3	-3.9	-6.7	-1.2	0.6	0.9	1.2	2.8	4.5
28	-6.5	-16.7	-23.8	-19.8	-16.9	-15.1	-12.0	-7.2	2.4	-3.3	-1.7	-1.9	4.5	5.8	6.2	6.9	7.7	7.7
32	-13.7	-23.9	-17.0	5.0	14.5	18.4	21.2	21.3	20.6	15.1	10.5	7.0	9.9	10.0	10.9	10.7	10.6	9.1
36	-16.6	16.9	27.8	32.4	28.9	28.1	28.8	25.6	17.3	18.1	6.6	1.2	2.4	3.4	6.6	5.5	5.7	3.3
40	97.6	66.1	45.1	28.4	21.4	22.9	16.8	13.4	5.0	22.2	6.1	1.3	0.0	1.0	5.4	2.6	2.4	-2.3
43	29.9	-9.6	-26.1	-34.2	-31.0	-21.2	-27.2	-24.5	-28.9	21.6	4.0	-0.6	-6.9	-6.5	-2.0	-6.2	-5.9	-10.9
45	13.6	-18.8	-23.1	-31.6	-28.9	-21.2	-26.6	-23.7	-25.6	19.8	-7.5	-10.6	-16.7	-14.2	-9.5	-14.3	-13.1	-16.5
47	-16.3	-34.3	-26.5	-29.3	-23.0	-18.6	-22.8	-20.5	-22.5	-5.1	-30.0	-24.1	-25.4	-20.4	-16.0	-20.0	-17.5	-19.3
53	-25.5	-40.9	-22.2	-16.8	-9.5	-9.5	-11.7	-10.1	-10.4	-18.1	-39.3	-24.9	-22.8	-17.3	-14.6	-17.4	-14.8	-15.5
57	-27.0	-46.1	-22.5	-15.2	-9.5	-9.6	-11.6	-8.9	-8.9	-24.4	-40.5	-20.9	-16.5	-11.5	-10.5	-12.5	-10.1	-10.4
61	-35.2	-56.4	-30.2	-21.1	-15.8	-14.1	-14.1	-10.9	-10.1	-23.6	-37.4	-15.6	-10.0	-6.1	-6.1	-7.5	-5.2	-5.2
66	-18.1	-24.9	-3.2	-0.2	0.3	-0.7	-2.2	-0.2	-0.2	-19.7	-32.5	-10.3	-5.5	-3.2	-3.3	-4.5	-1.9	-1.9
69	-12.0	-19.0	0.1	3.5	4.0	3.5	2.1	4.1	3.7	-14.8	-24.7	-3.8	-0.4	0.7	0.7	-0.3	2.2	2.1
73	-6.1	-16.1	4.3	5.7	5.0	4.6	3.3	6.2	6.0	-6.5	-14.5	5.6	7.1	6.8	6.5	5.3	7.4	6.8
78	-2.4	-7.3	10.0	10.4	10.0	10.1	9.4	11.5	11.0	-2.0	-10.6	9.1	9.8	9.1	9.0	8.0	10.0	9.2
84	6.2	-5.3	17.0	16.3	14.8	14.7	14.2	15.5	13.7	2.7	-7.3	12.3	11.9	10.8	10.8	9.7	11.6	10.6
88	4.3	-5.4	14.3	13.0	11.6	11.8	11.2	12.8	11.4	5.6	-4.6	14.3	13.5	12.8	12.9	11.8	13.3	11.9
92	11.3	-2.3	15.8	13.9	12.8	12.6	10.3	12.1	10.8	8.8	-3.1	15.4	14.2	13.8	13.8	12.8	13.7	12.1
97	8.8	-2.8	14.2	13.7	14.9	15.1	14.1	14.4	12.7	13.7	0.4	16.1	14.3	14.1	13.9	12.6	13.1	11.4
102	13.5	0.2	15.5	14.0	14.9	15.0	14.2	13.5	11.8	19.0	3.8	17.3	14.8	14.5	14.2	12.6	12.6	10.8
106	30.8	12.5	20.8	17.1	16.1	15.2	13.5	12.5	10.2	26.0	8.9	19.5	16.2	15.7	15.2	13.7	13.1	10.9
110	30.5	11.6	20.0	15.4	13.9	13.1	10.9	10.4	8.4	34.2	14.8	22.5	17.8	16.8	16.1	14.2	13.3	10.9
114	46.2	23.2	27.0	20.9	18.9	17.7	15.7	14.5	11.7	43.0	21.4	26.1	20.1	18.7	17.7	15.5	14.4	11.8
118	50.1	26.5	28.9	21.4	20.3	19.4	16.6	15.4	12.6	47.9	25.3	28.1	21.5	20.1	19.4	17.0	15.9	13.0
122	57.6	33.0	33.7	25.9	24.2	23.2	20.8	19.3	15.9	50.2	27.2	28.1	21.5	20.6	20.2	18.0	16.9	13.9
126	54.9	32.3	31.1	23.8	23.5	23.4	20.8	19.7	16.5	51.5	28.9	27.3	20.8	20.6	20.9	18.8	17.9	14.8
130	42.4	21.2	19.7	15.4	16.1	17.5	16.1	15.6	12.8	53.4	31.1	26.8	20.9	20.9	21.8	19.7	19.0	15.8
134	52.4	31.6	22.9	17.6	19.1	21.2	19.6	19.3	16.1	53.2	31.5	24.7	19.3	20.1	21.6	19.6	19.1	16.0
138	59.9	37.3	26.8	21.5	21.7	23.4	21.5	20.8	17.6	54.4	33.0	24.1	19.0	19.8	21.6	19.8	19.3	16.2
142	56.3	35.1	22.9	18.2	20.3	22.4	20.3	19.9	16.9	59.0	37.4	25.7	20.1	21.0	22.9	20.9	20.4	17.2
146	60.9	39.8	28.2	22.0	21.6	23.5	21.7	21.0	17.8	61.8	39.9	27.4	21.5	22.2	23.8	21.6	20.9	17.7
150	65.8	43.3	27.6	21.0	22.5	23.9	21.5	21.0	17.7	65.0	42.9	29.2	22.3	23.1	24.4	21.9	21.2	17.9
154	66.0	44.1	31.5	24.7	25.0	25.7	23.0	21.8	18.3	69.5	46.2	32.5	24.4	24.9	25.6	22.9	21.9	18.5
158	75.9	52.3	35.9	25.5	26.1	26.4	23.2	22.1	18.8	72.6	48.7	34.2	25.3	26.1	26.3	23.3	22.2	18.9
162	78.9	51.8	39.4	28.7	29.1	28.4	25.1	23.5	20.1	72.8	49.3	35.8	26.1	26.4	26.1	23.1	22.0	18.9
166	76.3	52.3	36.9	26.7	28.0	26.9	23.8	22.6	19.5	71.6	49.5	36.0	25.7	25.2	24.7	21.9	21.2	18.4
170	67.1	45.9	35.5	25.0	24.1	23.2	20.5	20.2	17.7	71.6	49.3	36.8	26.8	25.0	24.0	21.6	21.2	18.7
174	59.7	45.0	32.2	22.7	19.0	18.4	17.0	17.6	16.1	67.5	47.1	34.8	25.5	22.9	21.9	20.1	20.2	18.2
178	76.1	51.4	40.1	30.7	25.0	23.3	21.6	22.0	20.3	62.0	43.2	32.4	24.3	20.8	19.9	18.8	19.2	17.6
182	58.2	40.9	29.2	22.2	18.5	17.8	17.5	18.4	17.4	57.1	39.9	29.7	22.9	19.4	18.8	18.2	18.6	17.4
186	48.7	33.0	25.1	20.7	17.4	17.0	17.1	17.6	16.6	51.6	35.5	27.1	21.8	19.0	18.8	18.5	18.7	17.5
190	42.9	29.3	22.0	18.1	16.9	17.4	17.6	17.4	16.6	42.0	30.0	22.9	19.1	17.8	18.4	18.5	18.3	17.0
194	31.8	22.9	18.9	17.1	17.1	18.3	18.7	17.9	16.5	34.5	26.3	20.8	18.3	18.4	19.7	19.7	18.9	17.2
198	28.3	23.7	19.1	17.4	19.2	21.6	21.7	20.3	18.1	25.4	21.9	17.6	16.9	19.1	21.0	20.5	19.0	16.9
202	20.8	22.7	18.7	18.2	21.2	24.0	23.5	21.3	18.4	15.1	16.7	14.3	16.3	20.5	22.4	21.2	19.0	16.2
206	3.2	10.7	9.0	13.5	21.2	23.5	21.1	18.1	14.8	6.8	12.4	12.1	17.7	23.9	24.9	22.5	19.3	15.7
210	-8.8	3.4	5.8	15.3	24.0	24.4	21.0	17.3	13.3	0.2	8.9	11.2	23.2	29.7	28.5	24.5	19.6	14.9
214	-9.6	1.2	7.6	24.2	34.1	31.0	25.3	19.5	14.1	-3.6	4.3	9.3	24.4	31.9	29.6	24.7	19.2	14.0
218	-4.8	6.2	14.7	44.5	48.3	39.4	31.3	21.6	13.8	0.1	3.4	9.4	28.0	35.5	31.6	25.9	19.5	13.7
222																		

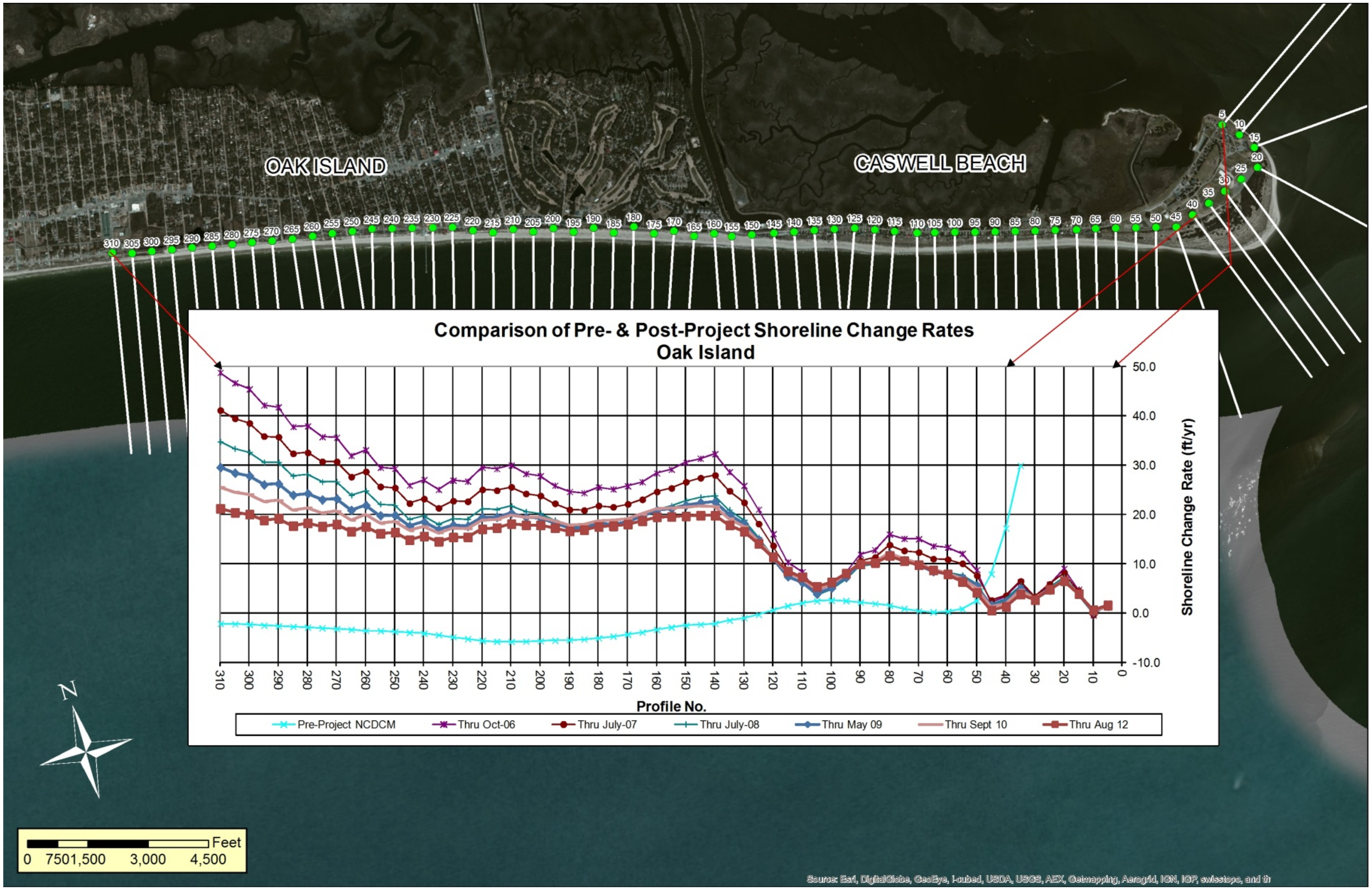


Figure 4.1 Wilmington Harbor Monitoring - Oak Island Comparison of Pre- and Post-Construction Shoreline Change Rates

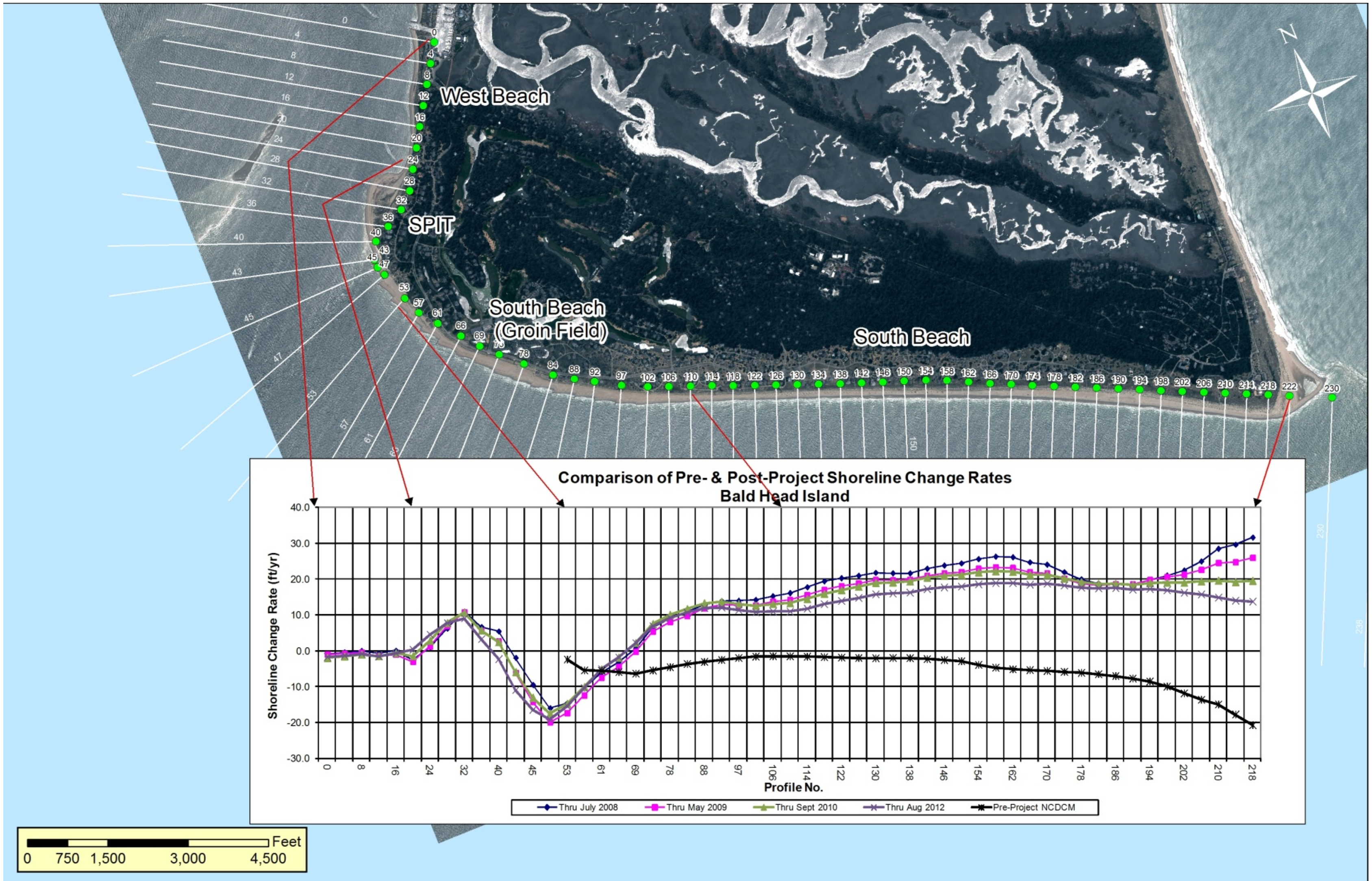


Figure 4.2 Wilmington Harbor Monitoring - Bald Head Island Comparison of Pre- and Post-Construction Shoreline Change Rates

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 show that the reduction in longshore coverage and magnitude observed following the locally funded beach nourishment project is no longer occurring and the area has once again expanded toward the west. This erosion rate zone currently extends from Profile 40 thru 66 representing an alongshore distance of about 2,550 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 August 2012 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 14.6 feet per year. This is in sharp contrast to the erosion indicated along this entire area by the pre-construction rates where this same area eroded on average 5.7 feet per year.

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 12-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 12-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 and have remained stable relative to the values calculated for Monitoring Report 8. 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.

Bald Head Shoal Channel Shoaling and Spit Growth

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 and to verify that the Corps can maintain minimum dimensions for safe navigation with a two-year dredging cycle. 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. These potential measures include, but are not limited to, an alignment alteration in the vicinity of Jay Bird Shoal, the potential use of structures near the inlet to reduce shoaling, and/or the need for interim dredging between the bi-annual scheduled dredging of the channel. 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.

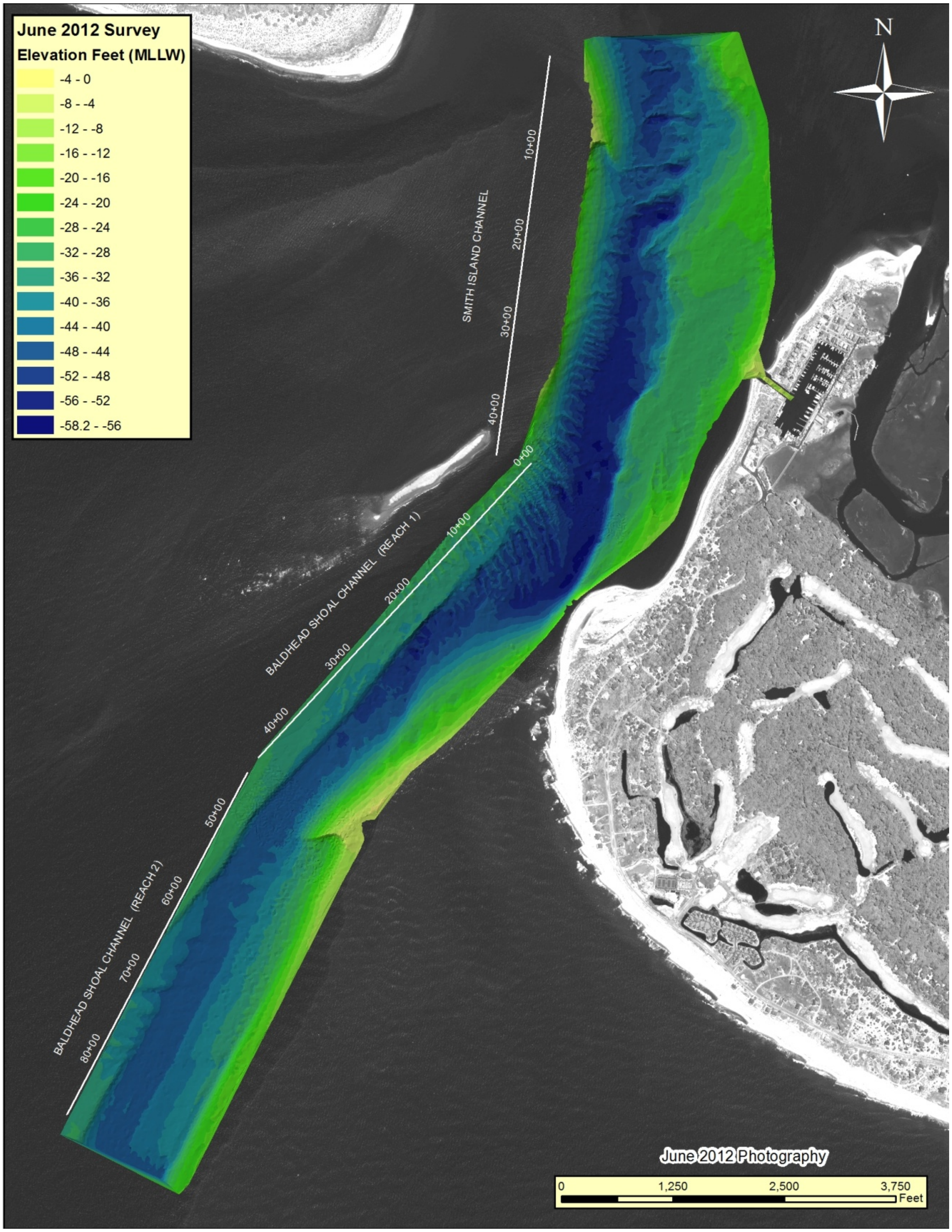


Figure 4.3 Locations for Baldhead Shoal (Reach 1 & 2) and Smith Island Channels

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
September 2010[8]	1-Sep-10	1-Sep-10	1-Sep-10
February 2011[8]	3-Feb-11	3-Feb-11	3-Feb-11
May 2011[8]	4-May-11	4-May-11	4-May-11
July 2011[8]	19-Jul-11	19-Jul-11	19-Jul-11
August 2011[8]	31-Aug-11	31-Aug-11	31-Aug-11
March 2012[8]	7-Mar-12	7-Mar-12	7-Mar-12
April 2012[8]	9-Apr-12	9-Apr-12	9-Apr-12
June 2012[8]	20-Jun-12	20-Jun-12	20-Jun-12

[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

[8]Surveys included in Monitoring Report 9

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 August 2010 and June 2012, respectively. The August 2010 survey is the last survey included in Monitoring Report 8. The June 2012 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 August 2010 and June 2012 are shown in Figure 4.6. A difference plot of the total amount of change (August 2010 – June 2012) in all three channels is shown in Figure 4.7. Changes in channel width vary throughout Baldhead Shoal Reach 1. The area between stations 5+00 and 21+00 had modest increases in channel width while the area between stations 22+00 through 44+00 had modest to severe reductions in channel width. In fact, at the end of the current monitoring period the area between stations 22+00 and 44+00 had fallen below the minimum threshold width of 500 feet established in the settlement agreement. The change in navigable width measured at -42' mllw, ranged from an increase of 116 feet at station 17+00 to a maximum reduction of 234 feet at station 42+00.

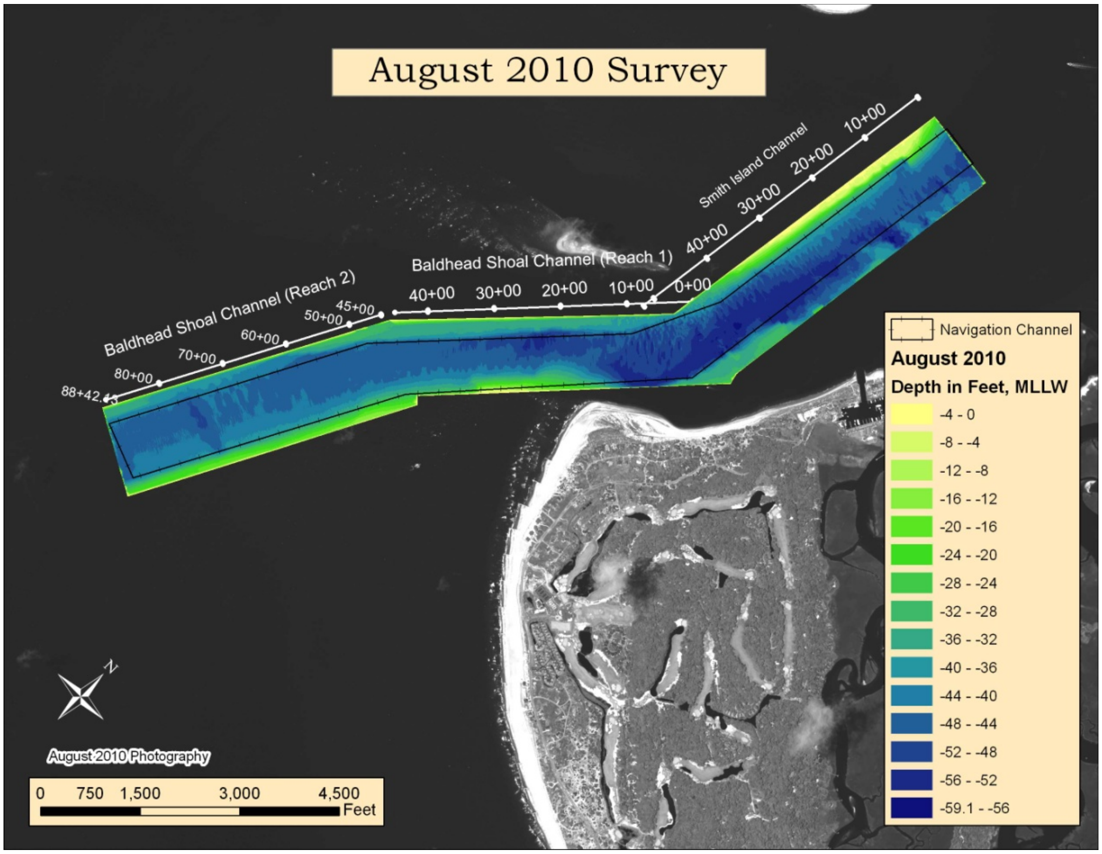


Figure 4.4. August 2010 Channel Conditions

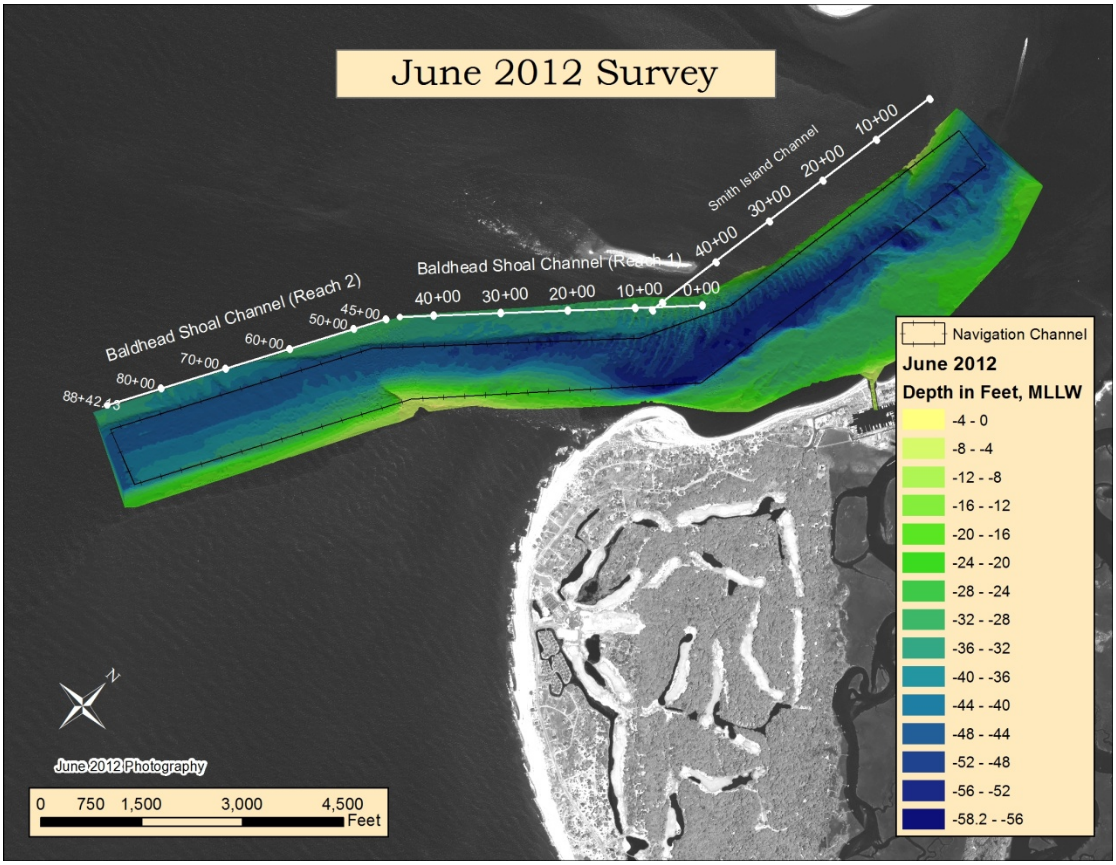


Figure 4.5. June 2012 Channel Conditions

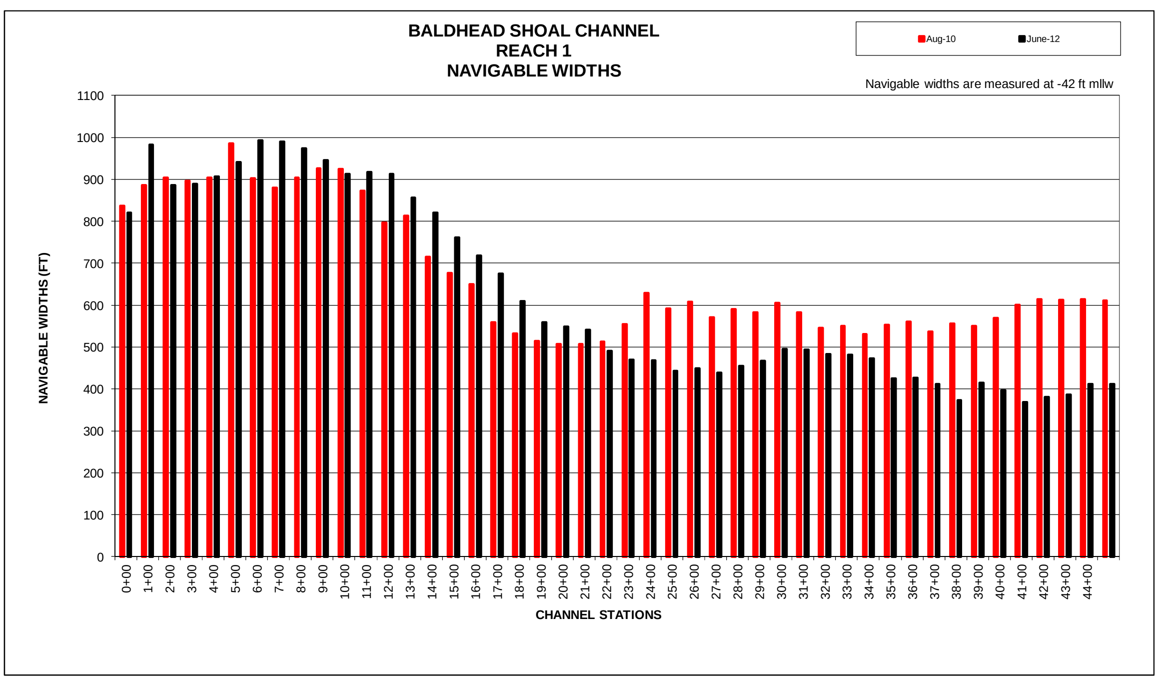


Figure 4.6. Baldhead Shoal Channel 1 Navigable Widths

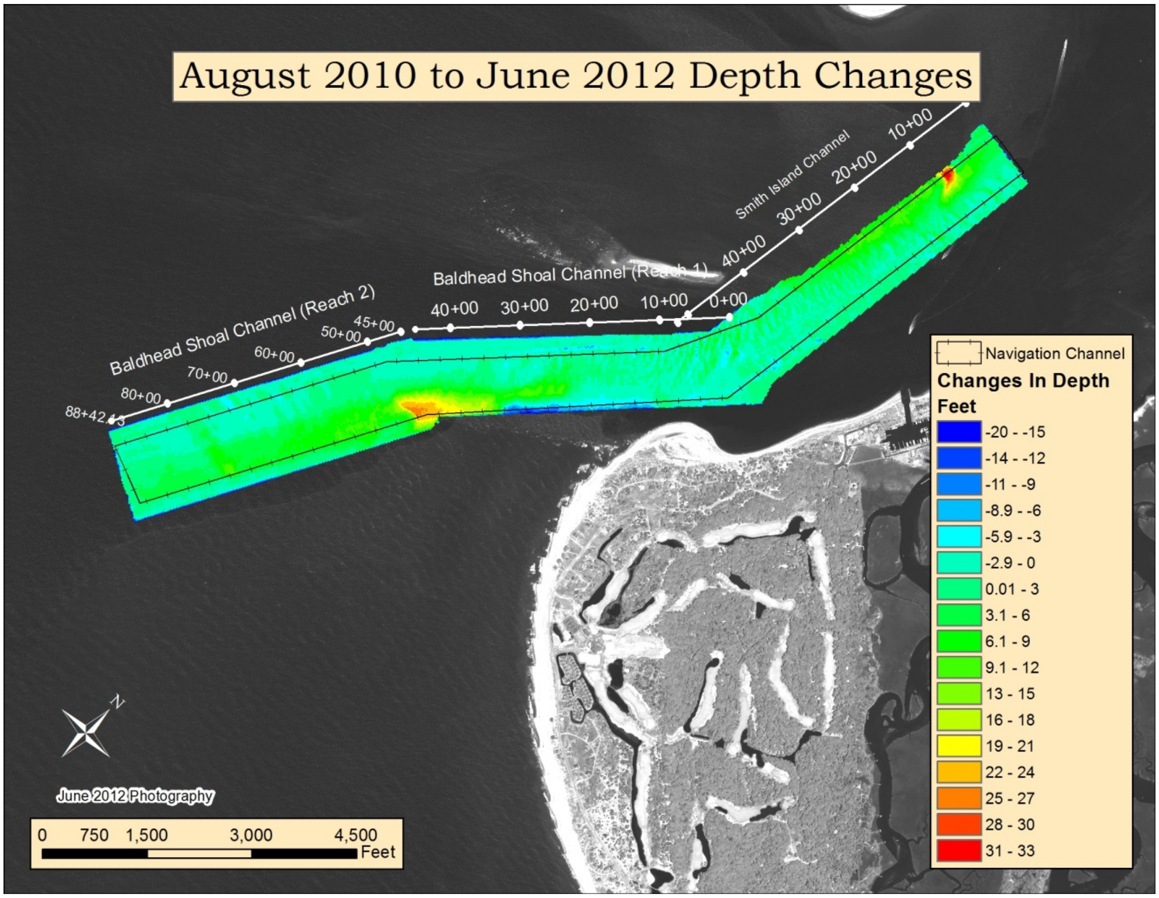


Figure 4.7 Depth changes from August 2010 to June 2012

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 feet at station 35+00. Cumulative changes from the most recent survey of June 2012, 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 adjoining 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 third dredge monitoring cycle through June 2012. 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. 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 below 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. With the significant shoaling and changes in shoaling patterns within the channel over the current monitoring period, several stations have fallen below the 500' minimum width requirement. In fact the entire section of the channel between stations 22+00 and 47+00 is less than 500'. The minimum width measured for the entire channel as of June 2012 was located at station 41+00, which measured 368'

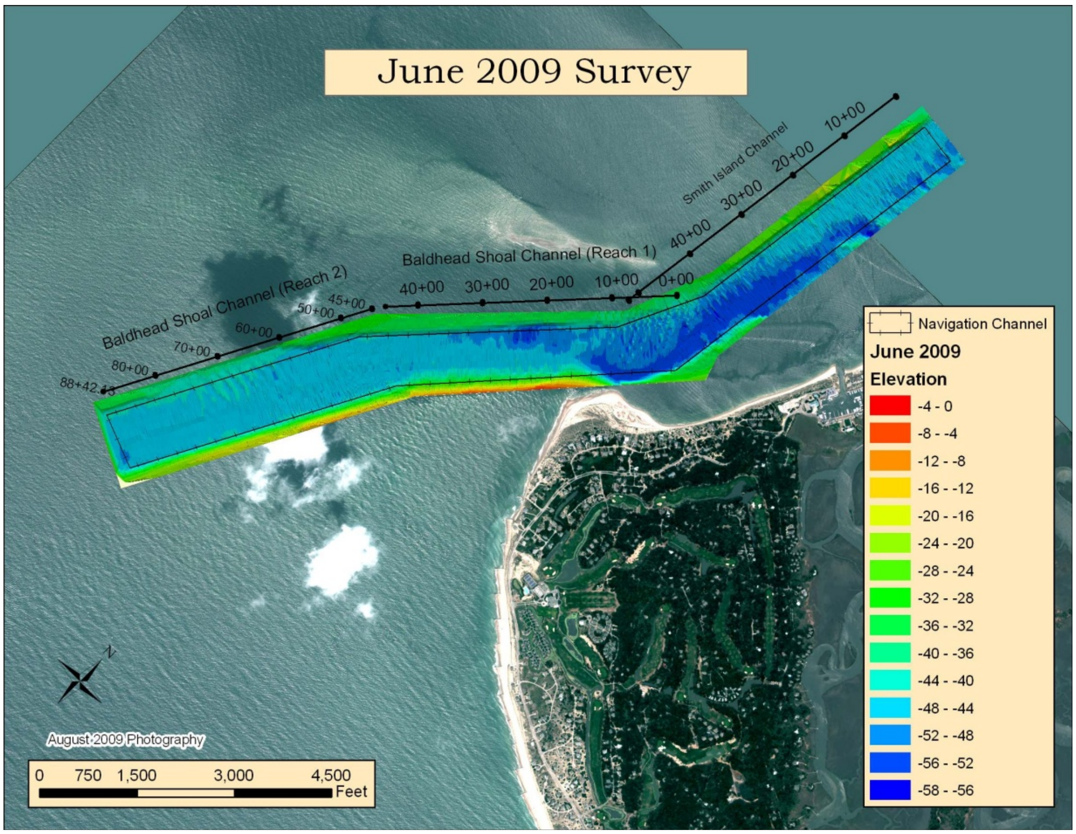


Figure 4.8 June 2009 Survey

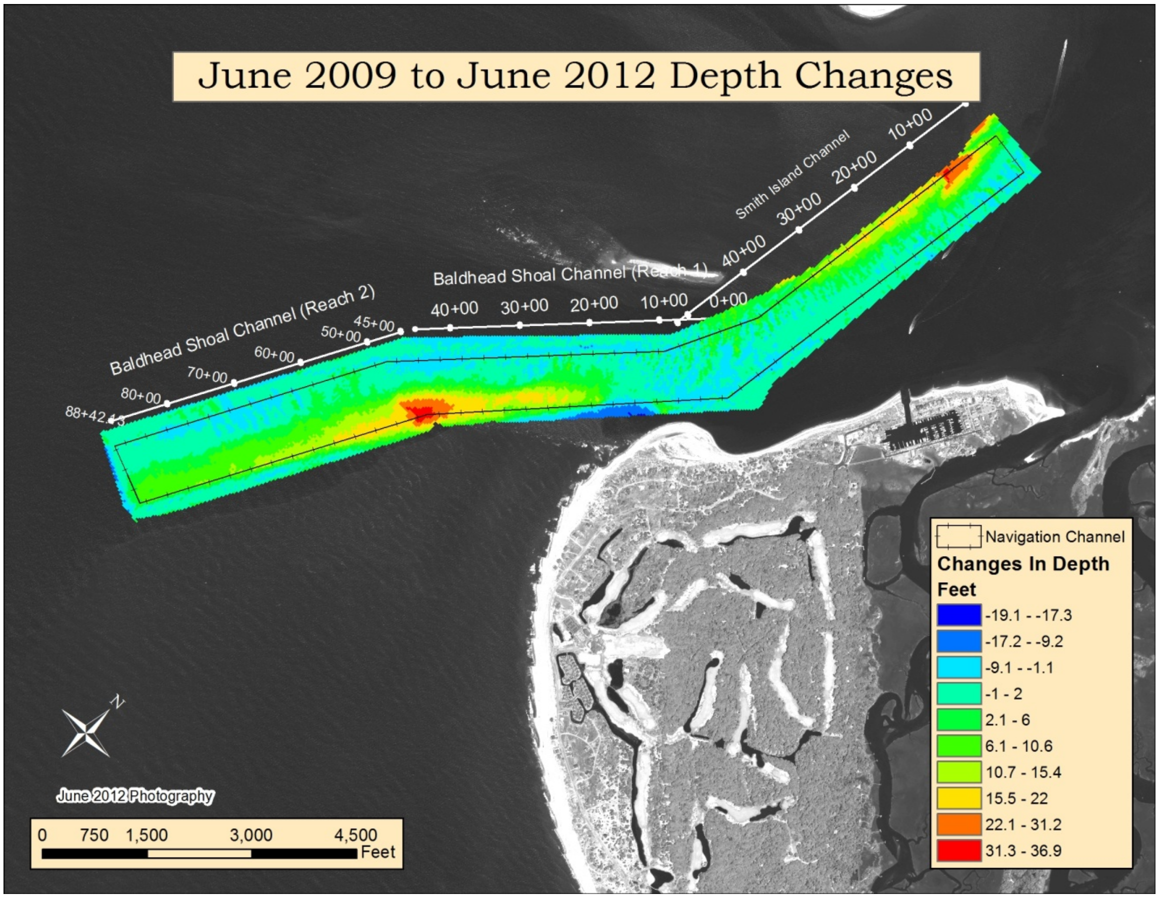


Figure 4.9 Depth changes from June 2009 to June 2012

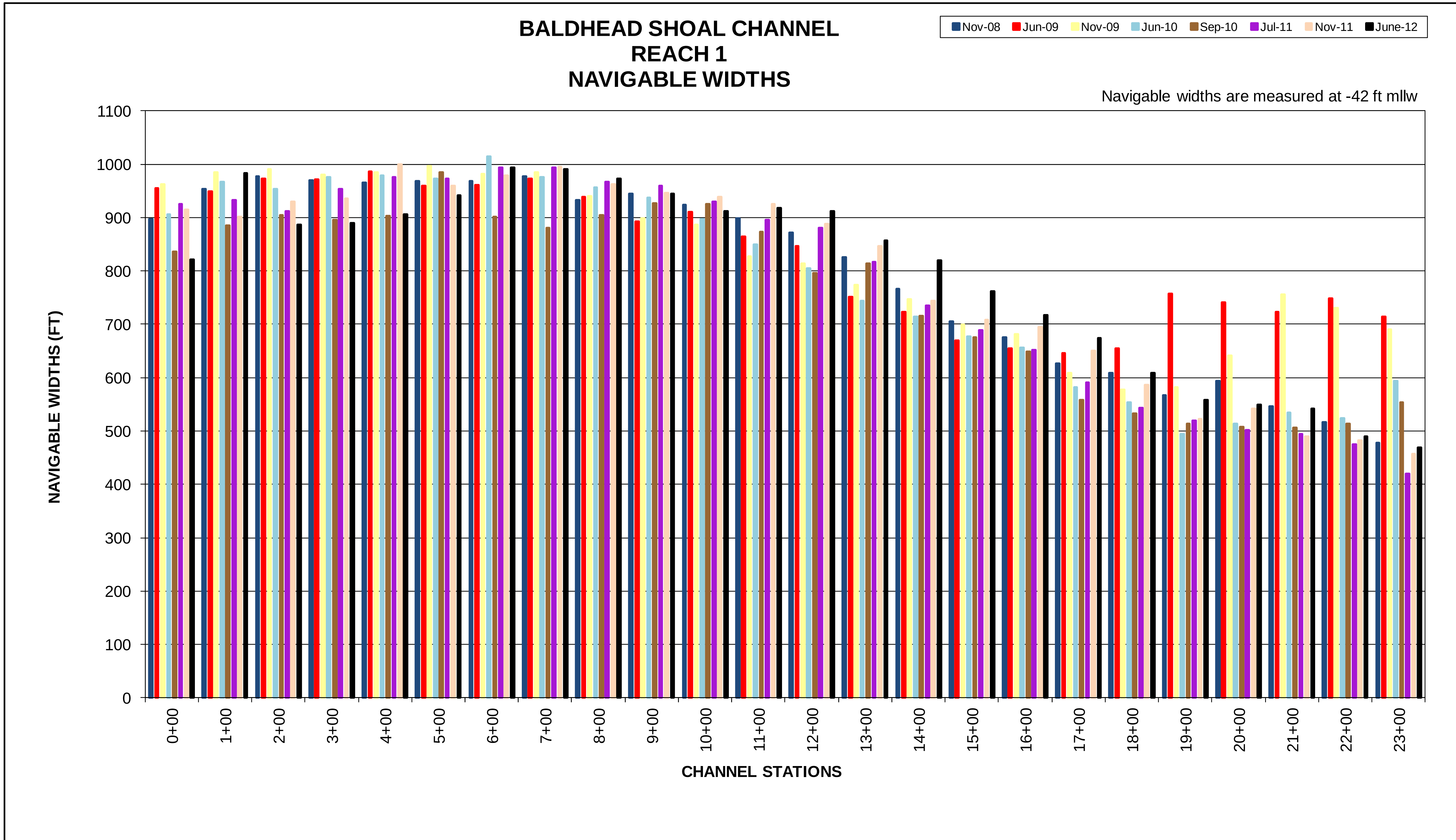


Figure 4.10. Baldhead Shoal Channel 1 width by station: Station 0+00 to 23+00

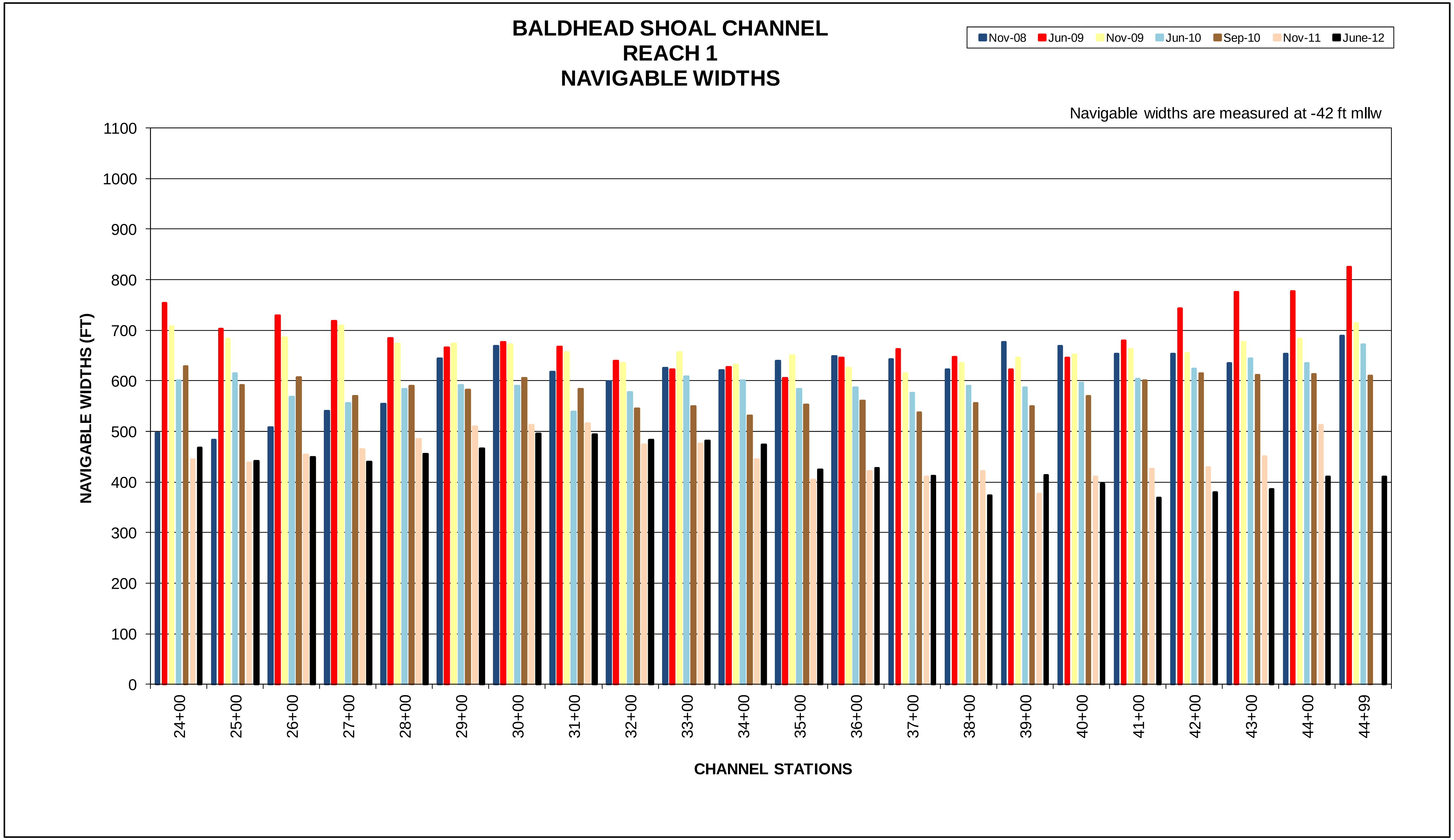


Figure 4.11. Baldhead Shoal Channel 1 width by station: Station 24+00 to 45+00

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 volume, which was calculated within the bounding polygons shown in Figure 4.12, on the east side of Baldhead Channel 1 doubled (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 579,800 cubic yards as of June 2012.

Figure 4.13 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 is visible following both the 2007 and 2009/2010 groin field construction. Comparing the June 2012 shoreline position with the August 2010 shoreline position included in Monitoring Report 8, shows that the shoreline has eroded and reformed the saw tooth pattern within the groin field. The area of the shoreline between Profiles 36 and 47 experienced the most severe erosion while the area between Profile 24 and 36 has accreted. The material within this area appears to be transporting around the point of Bald Head Island toward West Beach resulting in the previously mentioned accretion. Accretion in this area is measured to be as much as 234’ in the vicinity of Profile 32 relative to the August 2010 shoreline position. The majority of the remaining shoreline east of Profile 61 has seen less dramatic erosion when compared to the August 2010 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 4.12 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 over similar time periods. 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 14,300 cubic yards per month, which is approximately a 60% increase over the previous monitoring cycle. However, this is very comparable to the shoaling rate following the initial dredging cycle, being only about 13% lower. This increase since the last dredging cycle 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. 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.

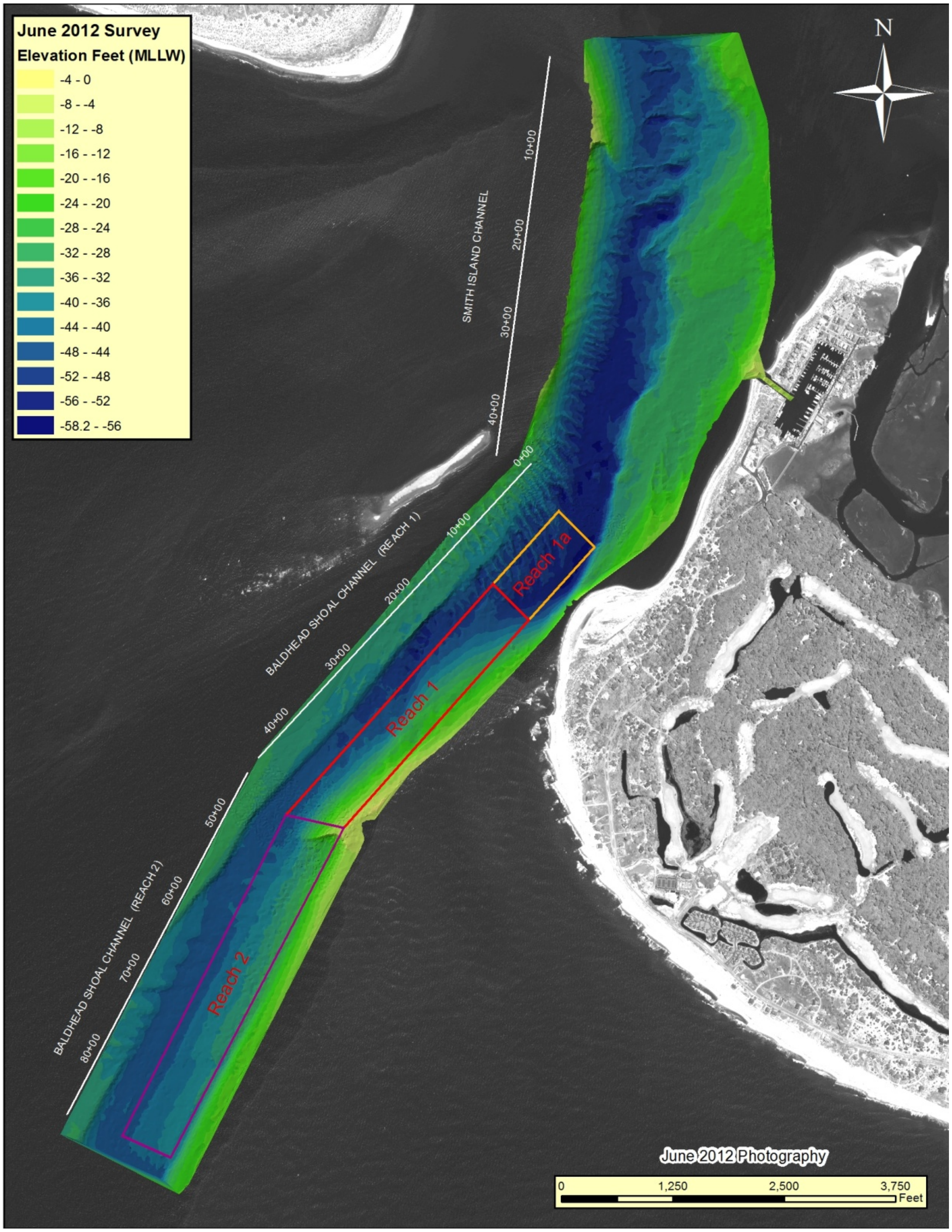


Figure 4.12 Spit Volume Bounding Polygons

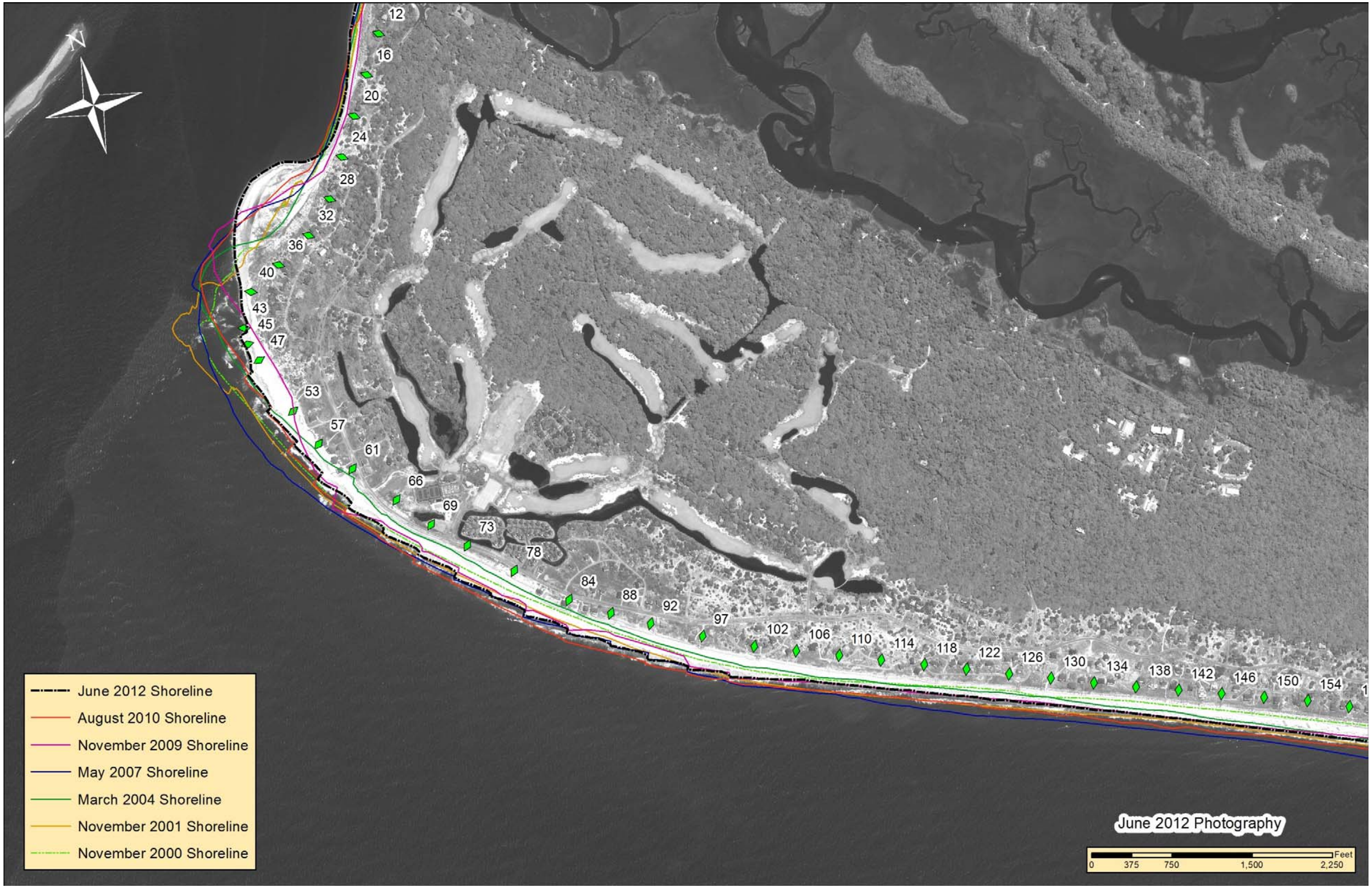


Figure 4.13 Shoreline Comparison: Pre and Post groin field reconstruction and beach disposal

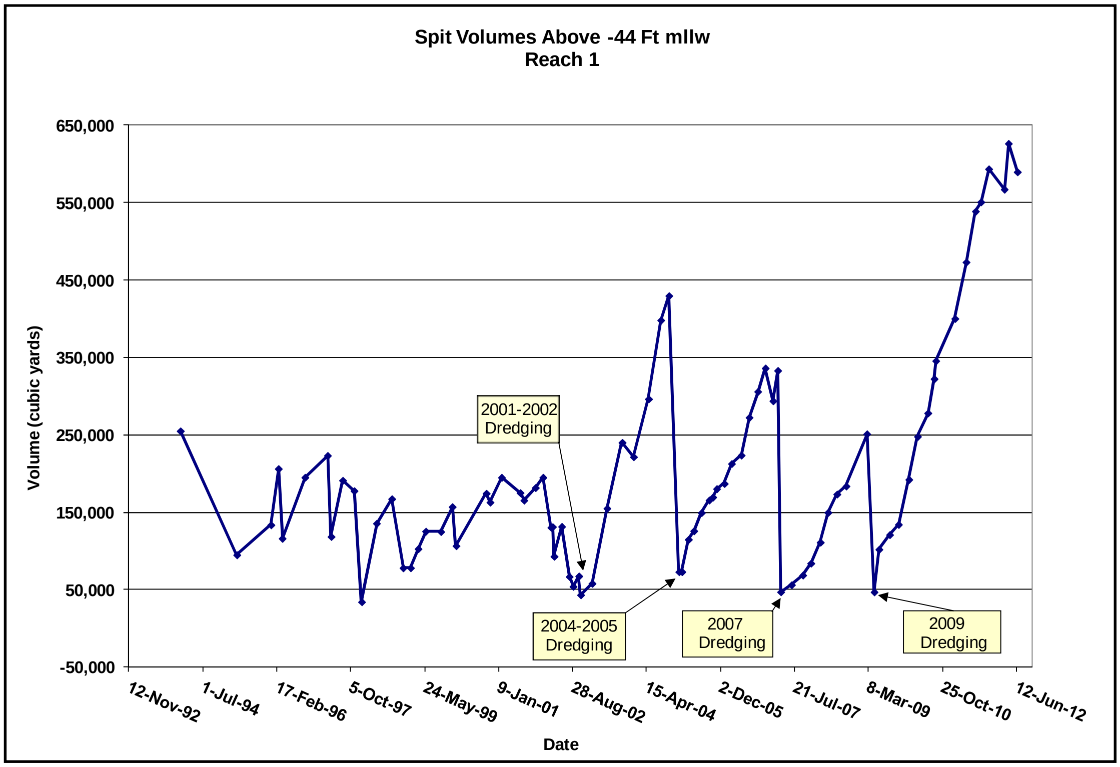


Figure 4.14 Baldhead Shoal Channel 1 Spit Volumes

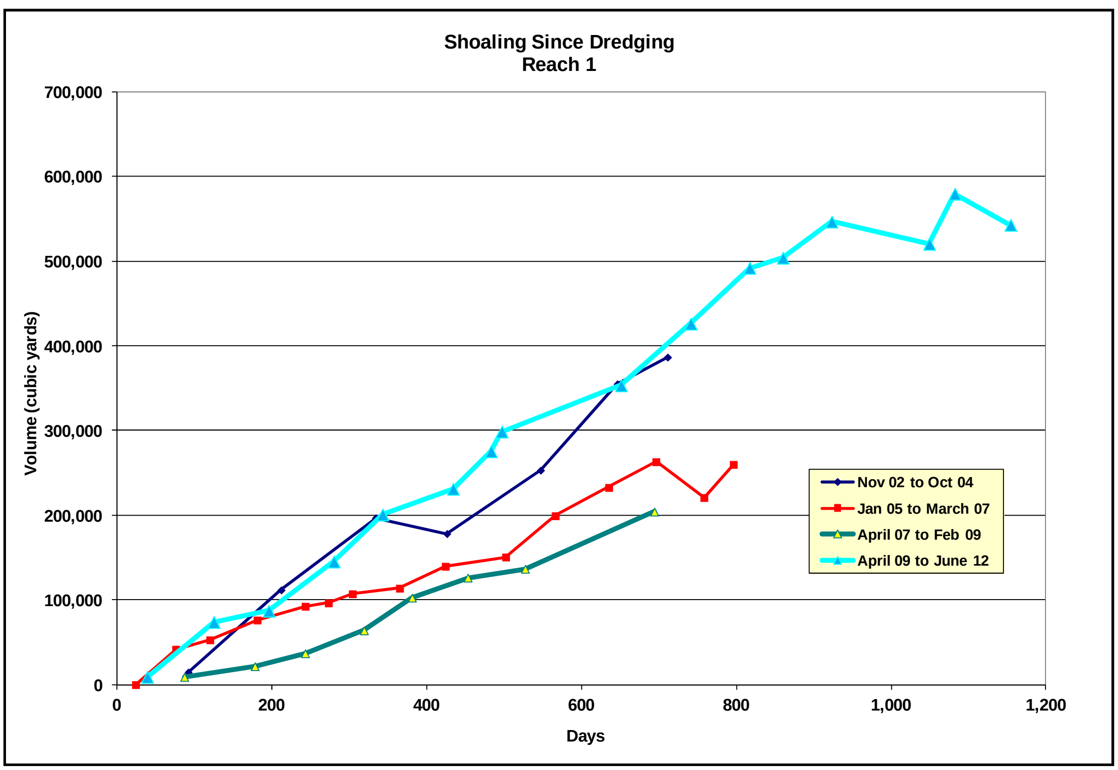


Figure 4.15 Comparison of post-placement spit growth from Figure 4.14 (Above)

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 geo-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 construct the 300-foot long tubes. This groin field was 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 easternmost 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 nourishment 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 shoreline 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.

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. Figure 4.16 shows the shoreline changes for six surveys following the first disposal, four surveys following both the second and third disposals, and three surveys 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 surveys following the fourth disposal are displayed as solid orange lines. The results show that following the most recent beach disposal placement and construction of the new groin field in 2010, there has been relatively uniform reduction through the majority of the groin field. The shoreline losses are slightly larger near the inlet area (Profile 53) and slightly lower on the eastern end (Profiles 97 through 106). The most extreme loss, measured at Profile 53, has lost nearly 120 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 29 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 June 2003, February 2007, May 2009, and January 2012 survey dates all of which are approximately 22 to 24 months after their respective disposals. The comparison of these similar time periods shows that the shoreline response following groin reconstruction is highly variable as the measured shoreline in each of these similar time periods is significantly different. The shoreline change measured within the groin field for this time period of analysis (22-24 months) appears to be more stable following the fourth re-construction than the previous three. Specifically, the average shoreline change within the area of the groin field approximately 22 to 24 months after each disposal event was -164 feet for the first disposal with no groin field in place, -91 feet after the second disposal with the newly constructed groin field in place, -80 feet following the third event with the groin field in place, and -68 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 fourth disposal have a lower shoreline change rate within the groin field area. The rates following the fourth disposal on average are lower than those of the other three analysis periods. Specifically, the average change rate within the groin field following the 1st fill was -6.6 ft/yr, -4.0 ft/yr following the 2nd fill, -3.7 ft/yr following the third fill, and -2.6 ft/yr following the 4th and most recent fill.

Aerial photography was obtained for four time periods since the placement of the fourth disposal on Bald Head Island which include February 2010, January 2011, September 2011, and June 2012. Figures 4.18 and 4.18(B) display 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 for 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 8.

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 the current analysis. The second image in Figure 4.18 shows the significant changes that occurred within the eleven months between February 2010 and January 2011. During this period of time the majority of the shoreline retreated with only a small section, Profiles 4 through 7, remaining relatively stable. Measured losses within this time period were as high at 160 feet. The erosion within this groin field combined with the westerly longshore transport within the area produced the saw tooth shoreline visible within the photograph. Figure 4.18(B) displays the shoreline conditions as of September 2011 and June 2012. Shoreline recession measured in September 2011 was observed throughout the groin field area with the majority of the shoreline having retreated back to the pre-project conditions of November 2009. The exception to this was in the area of groins 1 and 2 where the groins remained intact and prevented the extreme erosion measured in November 2009. Even with these groins remaining functional, peak losses were measured near groin 1 of nearly 220 feet. The second image in Figure 4.18(B) shows the June 2012 shoreline. This image shows that the shoreline had recovered some from the extreme conditions observed in September and also shows that the groin field is continuing to function. Peak losses measured during June 2012 were located at groin two and measured to be approximately 150 feet, however the majority of the shoreline continued to be seaward of the pre-project shoreline conditions.

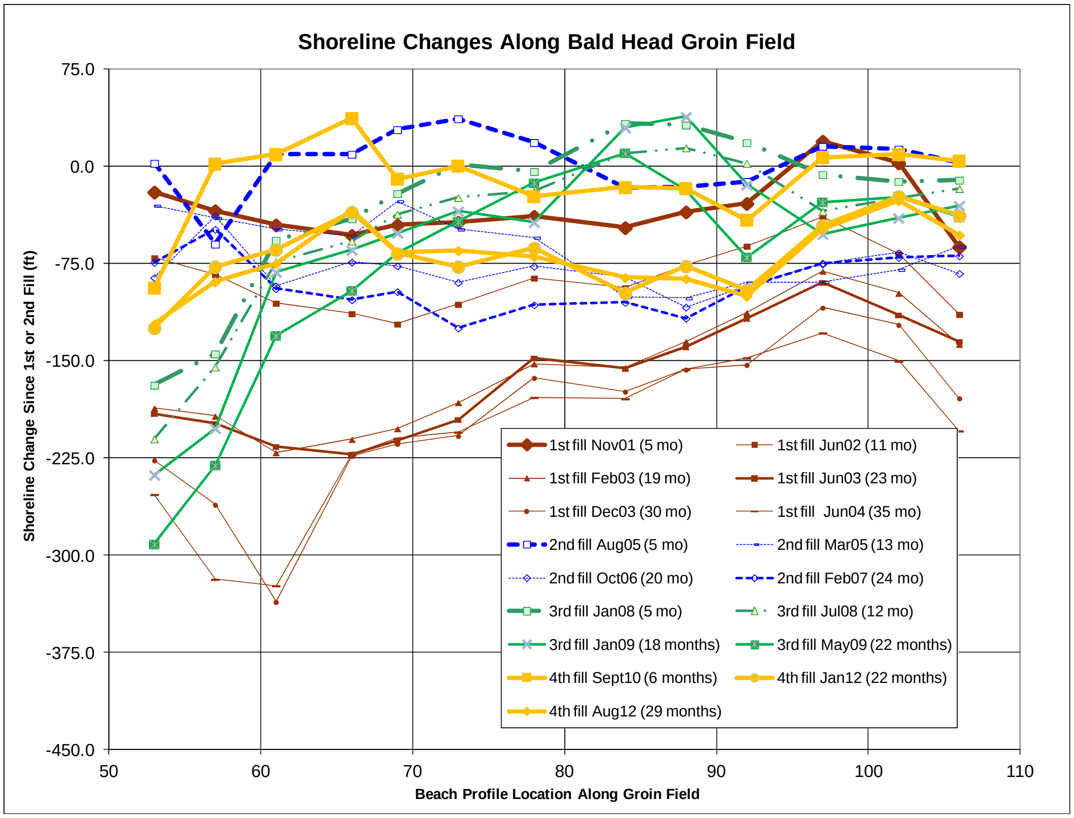


Figure 4.16 Shoreline Changes Along Bald Head Groin Field

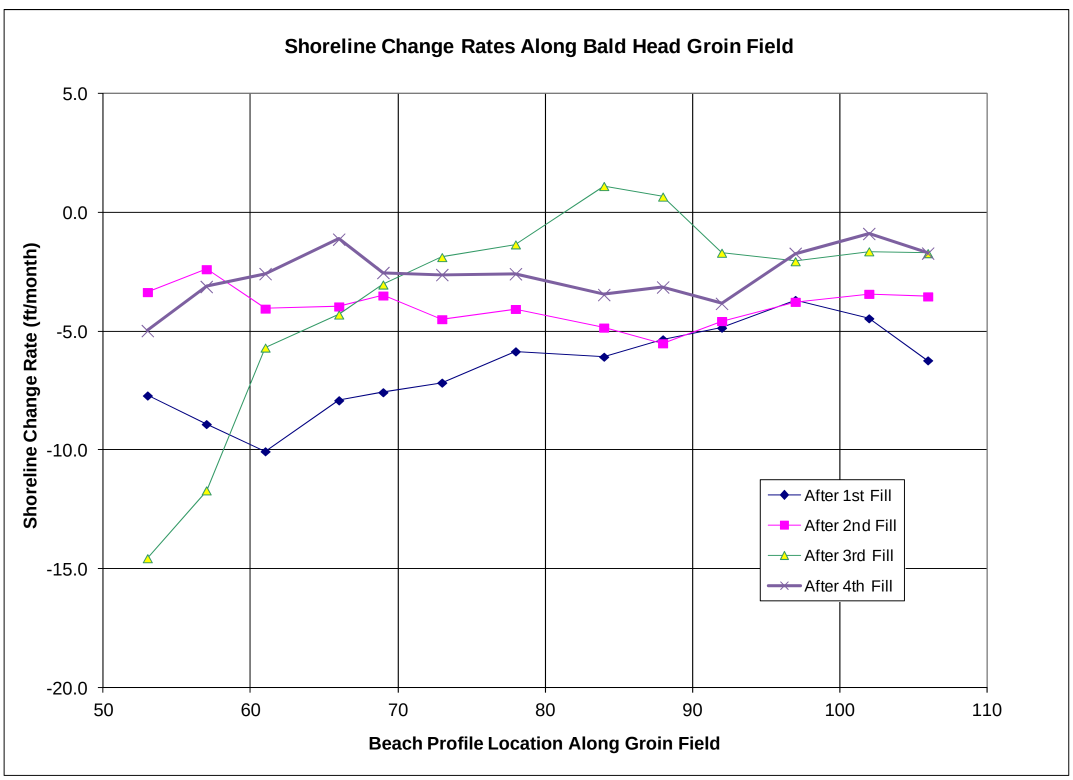


Figure 4.17 Shoreline Change Rates Along Bald Head Groin Field

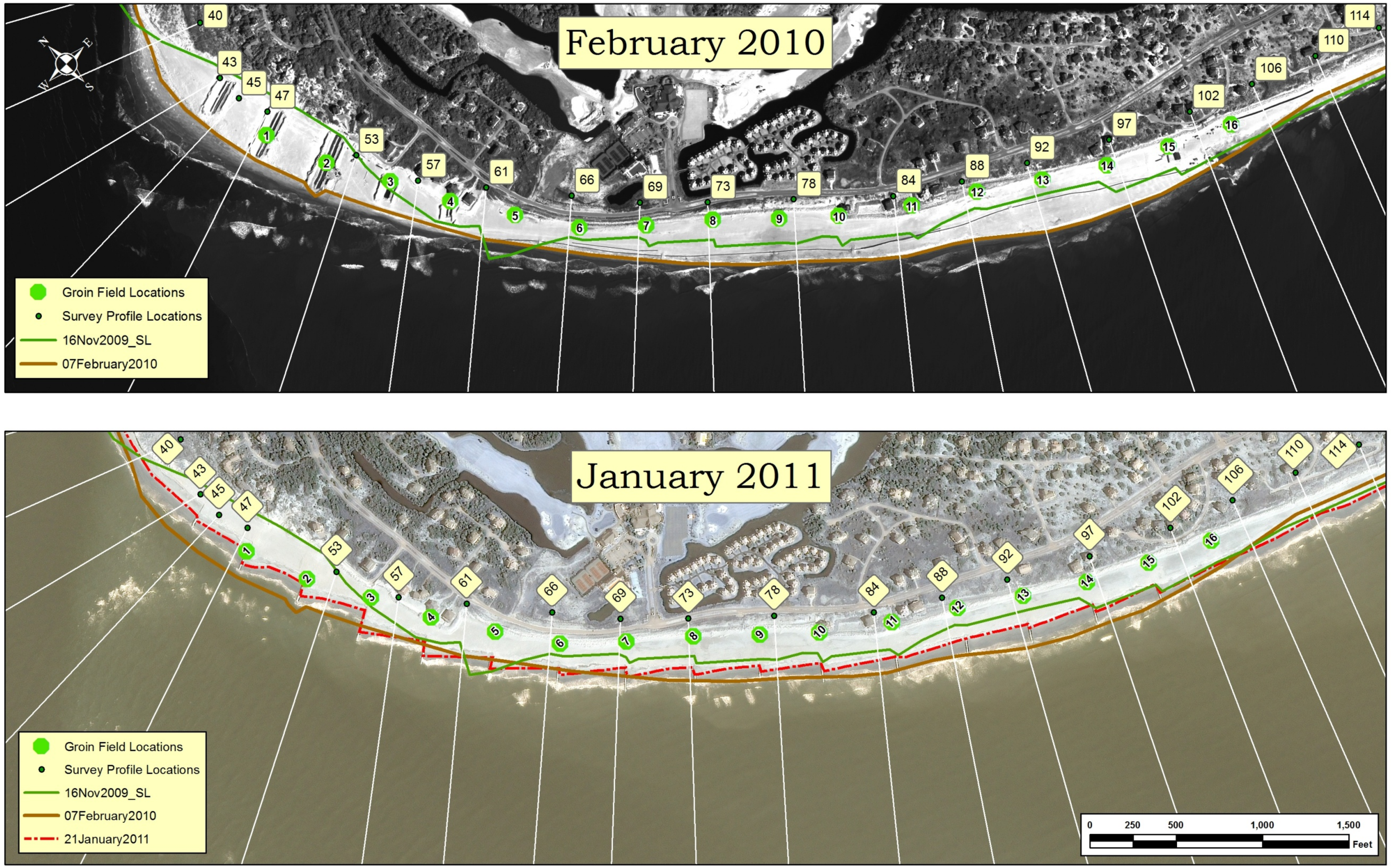


Figure 4.18 Evolution of Groin Field Shoreline (February 2010 and January 2011)

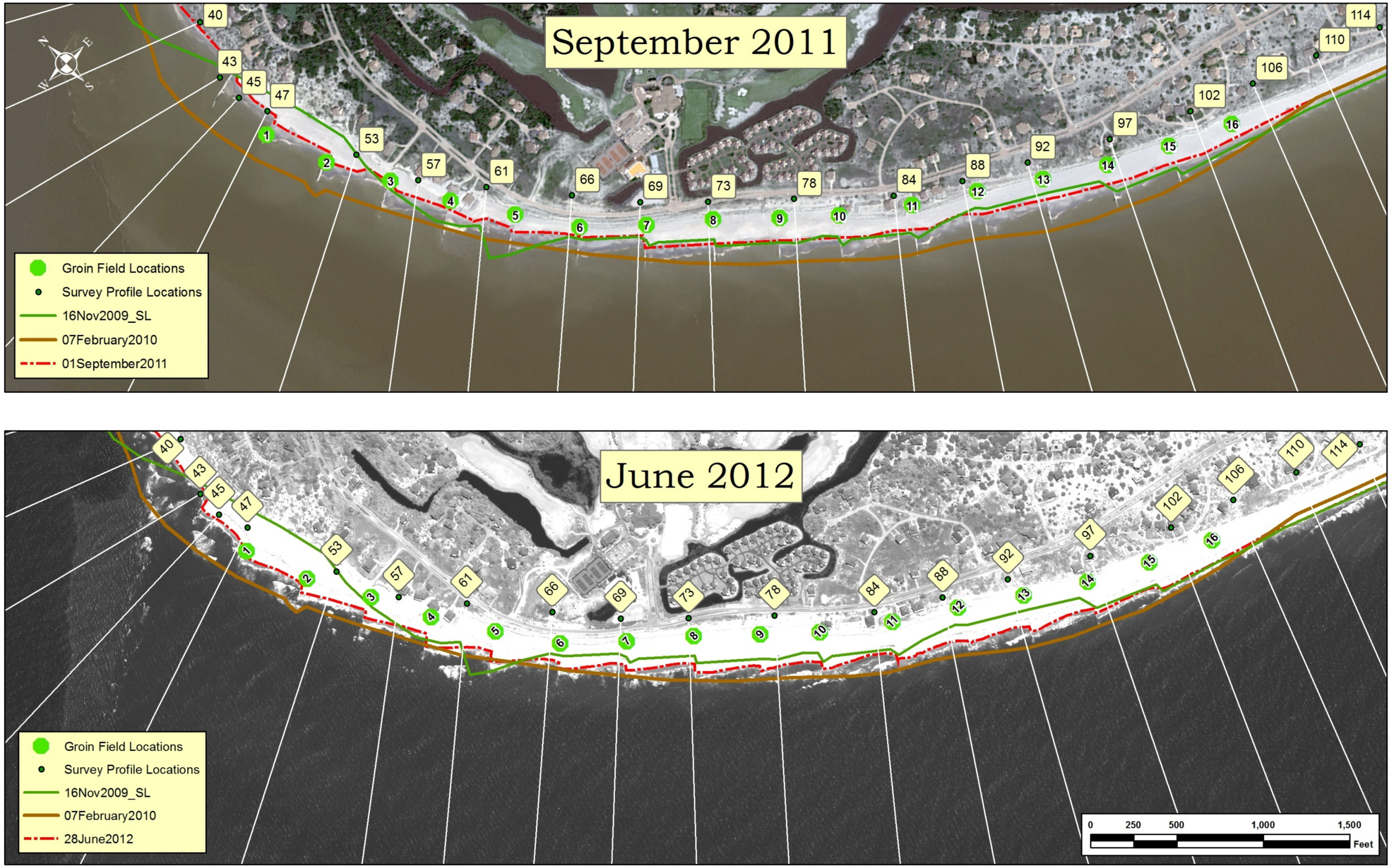


Figure 4.18(B) Evolution of Groin Field Shoreline (September 2011 and June 2012)

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 changes during the fourth period are displayed by solid orange lines. The figure shows that since the reconstruction of the groin field in 2010 the area within the groin field has lost a significant amount of material throughout, with the highest losses measured along the western end of the groin field. In fact, Profile 53 has lost more material as of January 2012, nearly 200,000 cubic yards, than it had during any other post fill period included in the analysis.

Post-disposal volumetric changes over similar time periods of 17-23 months were investigated. The surveys selected following the beach disposals included: December 2002 (17 months) for the first disposal period, January 2007 (23 months) for the second disposal period, May 2009 (22 months) for the third period, and January 2012 (22 months) for the fourth disposal. The average loss across the entire groin field for these similar time periods is estimated to be 411,000 cubic yards associated with the first disposal versus 439,000 cubic yards, for the second disposal, 467,000 cubic yards following the third disposal, and 712,000 cubic yards following the most recent disposal activity. The volumetric loss is higher for the last disposal (January 2012 survey) and is approximately similar for the first three disposals. 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 August 2005 which also followed new groin field construction.

The volumetric rates of change along the Bald Head groin field are shown 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, they do give an indication of the variability of the losses during different time periods. The plot of the change rates shows similarities between the second and fourth disposal events with the exception of the most western profile which is being much more erosive during the fourth disposal. 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 the onshore volume losses are greater following the first disposal without the benefit of the groins, versus the second, third, and fourth disposal periods. When comparing the onshore changes within the groin field along a similar time frame (17 to 23 months), the first disposal period lost the greatest amount of material with a total of 339,000 cubic yards by December 2002 (17 months). This compares to a 187,000 cubic yard loss measured over the second disposal in January 2007 (23 months). A 130,000 cubic yard loss was measured in May 2009 (22 months) following the third disposal and a 176,000 cubic yard loss was measured in January 2012 (22 months) following the most recent disposal. The losses within the groin field following the most recent groin field construction were slightly less than the losses following construction in 2005 and they were significantly less (48%) 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. All three post groin field construction rates are lower than the rates computed after the initial disposal placement. The third disposal shows the lowest rates except at the two most western profiles.

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 dashed blue line and the third disposal (with groins) in the associated solid green line. The most recent volumetric changes are represented in the figure by solid orange lines. It is evident from Figure 4.23 that the general response in the offshore has varied over the four post disposal monitoring periods. The fourth survey of January 2012 shows higher erosive change values than the other disposals except at profiles 69, 97 and 106. 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 loss of 73,000 cubic yards. This compares with a loss of 252,000 cubic yards with the second disposal, 336,000 cubic yards following the third disposal, and 536,000 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 high 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.

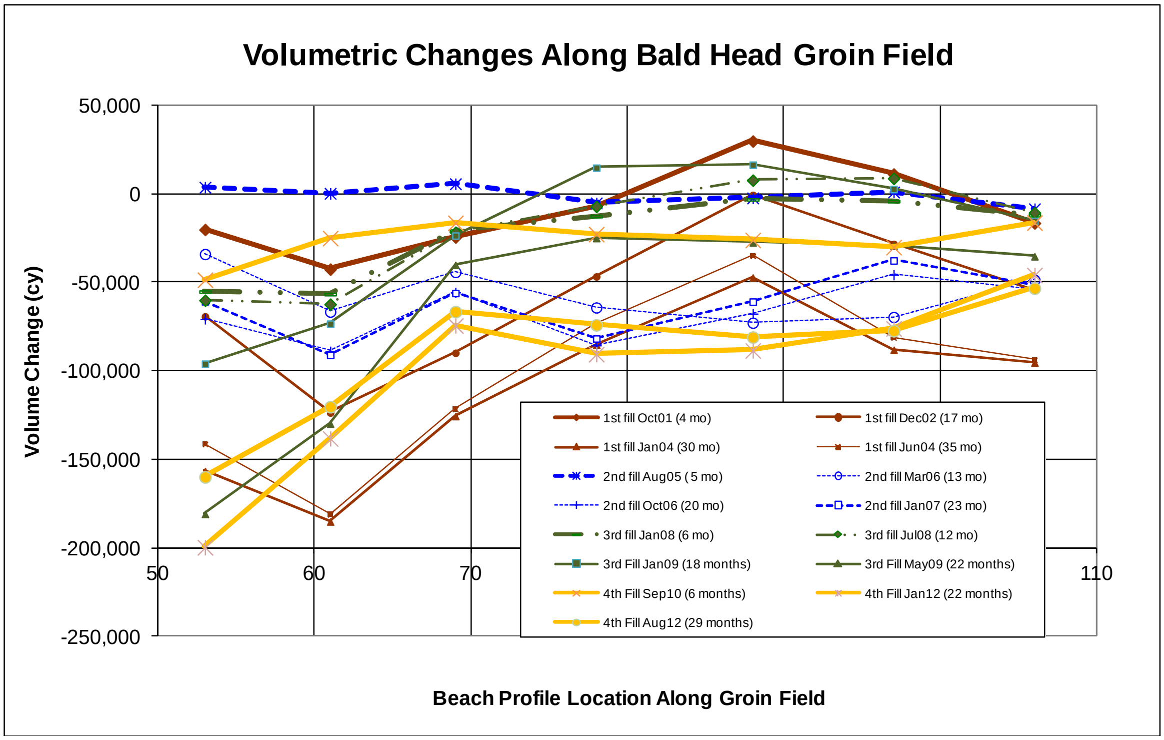


Figure 4.19 Volumetric Changes Along Bald Head Groin Field

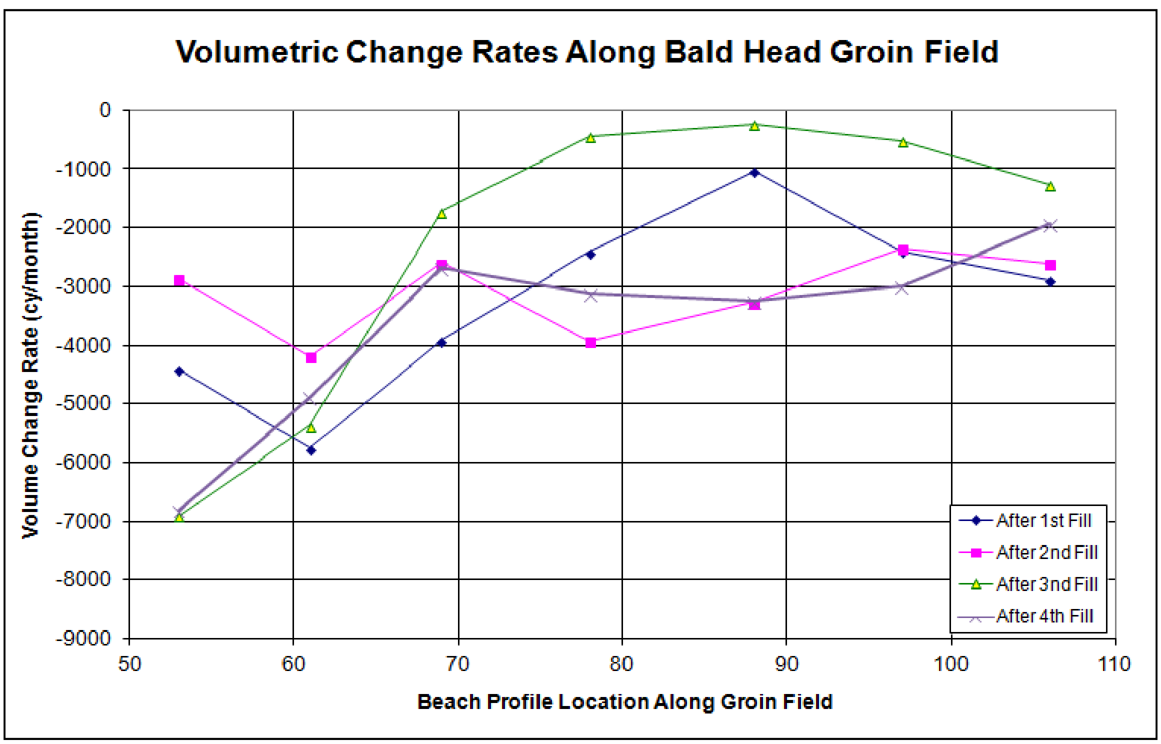


Figure 4.20 Volumetric Change Rates Along Bald Head Groin Field

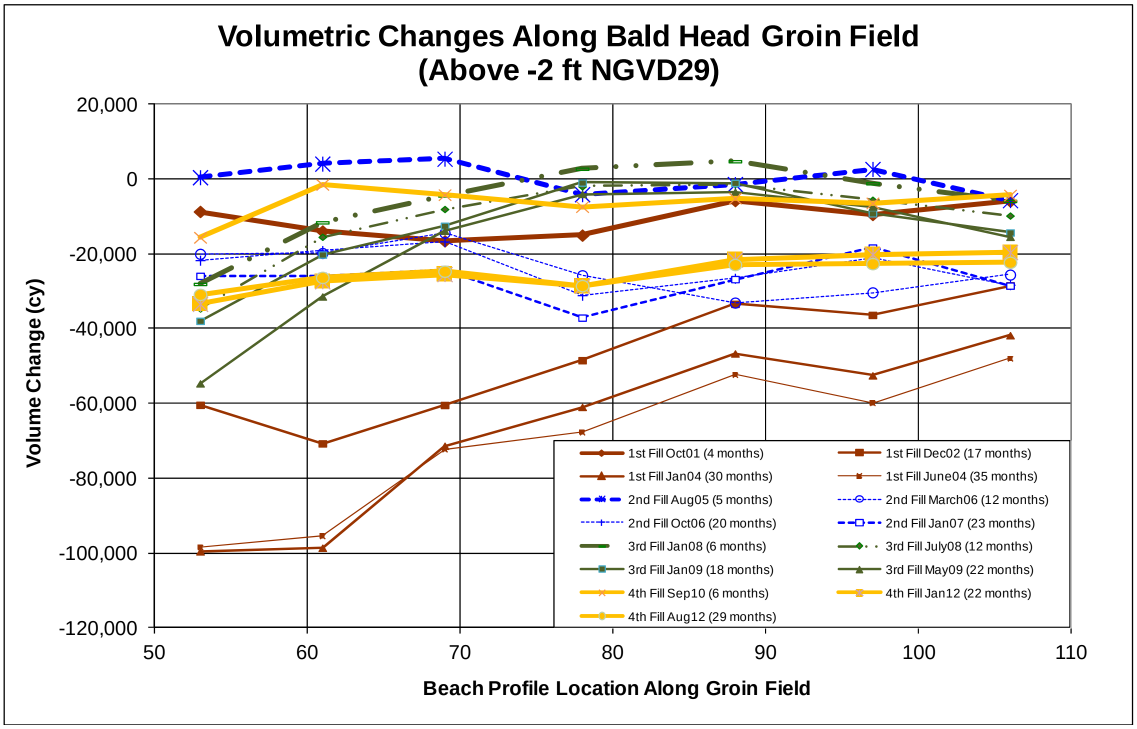


Figure 4.21 Onshore Volumetric Changes Along Bald Head Groin Field (Above -2 ft NGVD29)

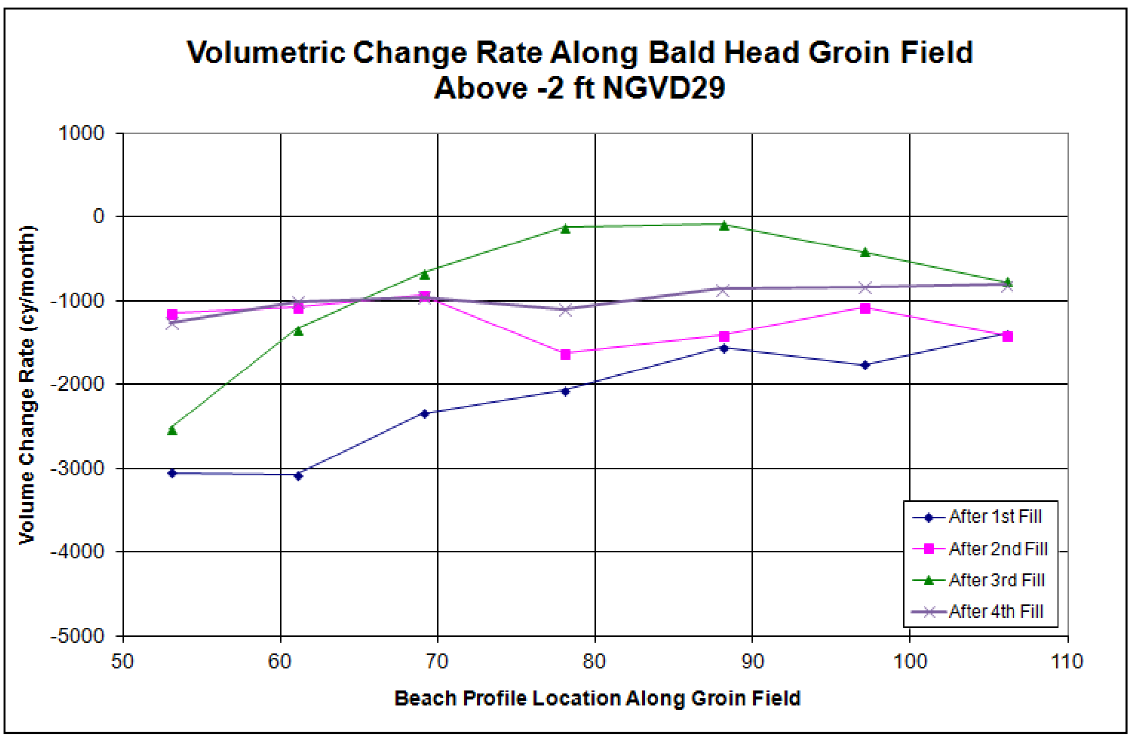


Figure 4.22 Onshore Volumetric Change Rates Along Bald Head Groin Field (Above -2 ft NGVD29)

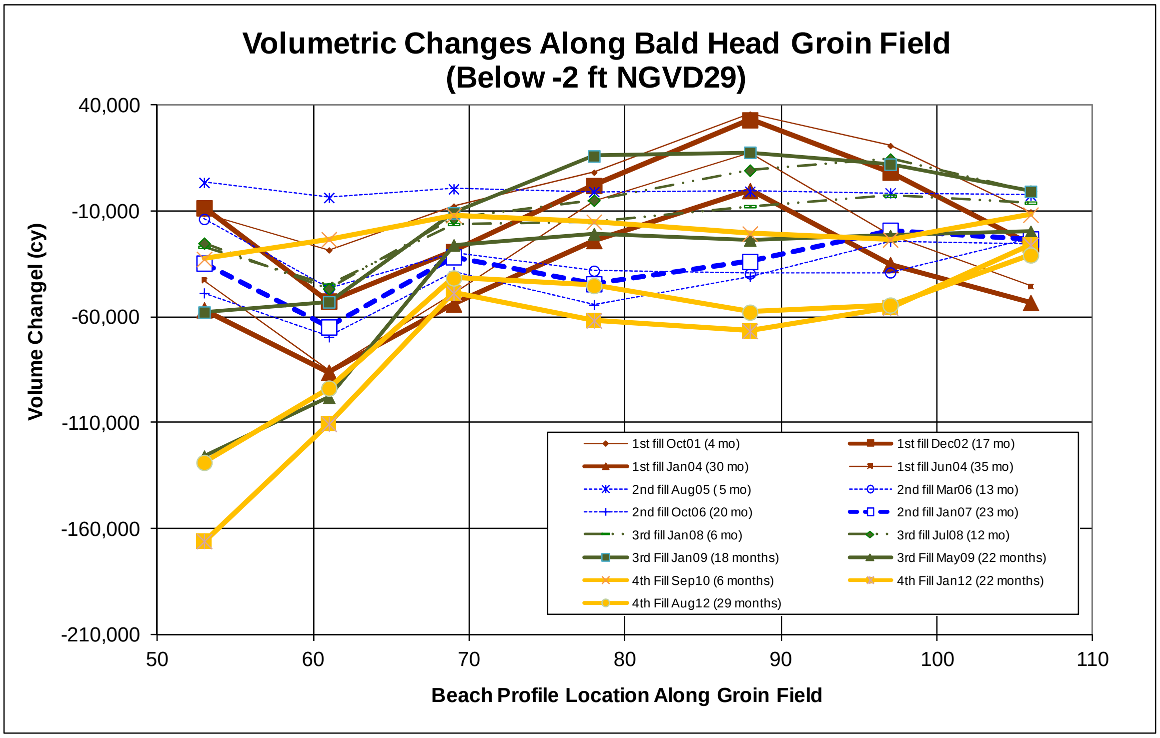


Figure 4.23 Offshore Volumetric Changes Along Bald Head Groin Field (Below -2 ft NGVD29)

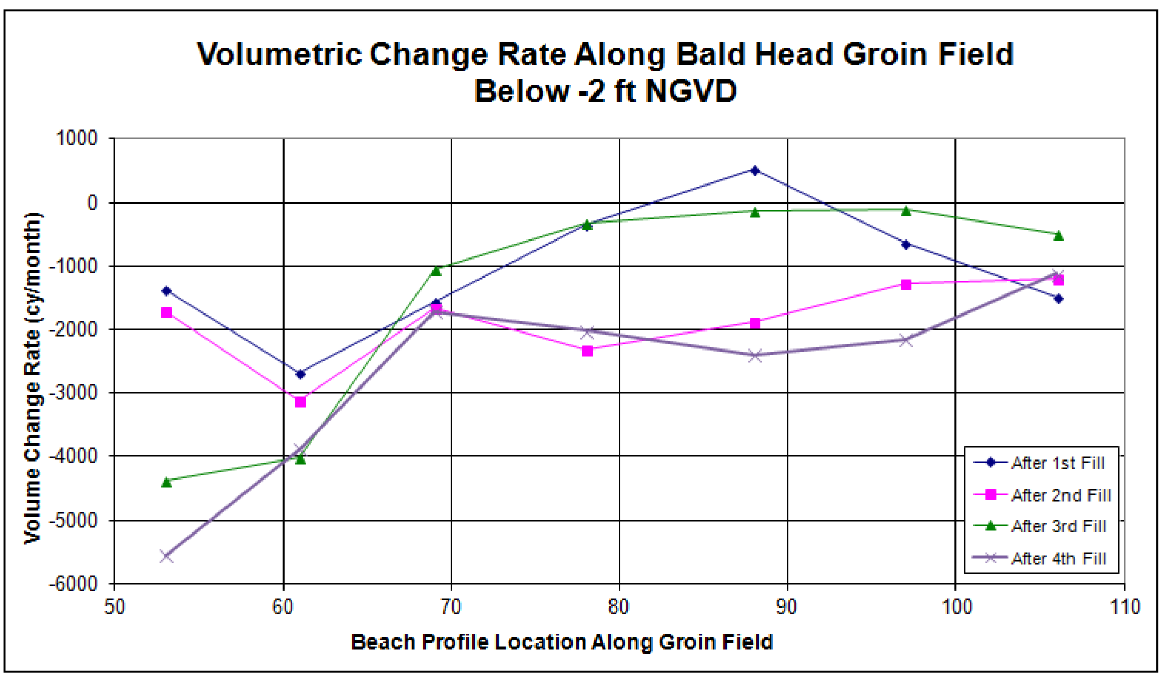


Figure 4.24 Offshore Volumetric Change Rates Along Bald Head Groin Field (Below -2 ft NGVD29)

Part 5 SUMMARY

This report is the ninth of a series updating the data collection and results of the physical monitoring program for the Wilmington Harbor Project. Through Report 8 the program has consisted of periodic beach profile and bathymetric surveys, wave and current measurements designed to document changes associated with the project. With the completion of the first full maintenance cycle and the development of the sand management plan the scope of the monitoring program has been reduced. Wave and current measurements have been removed from the program, however, Report 9 does include a summary of the wave measurements and details of the replacement of the three wave gauges used to date with a single wave rider buoy intended for long term deployment. 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 twelfth year of data collection and focuses on the most recent period of October 2010 through August 2012. 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 was prepared which summarized the performance of the existing sand management practices through Report 8 and made recommendations for modifications to the existing plan. This plan is titled "Reevaluation Report Sand Management Plan Wilmington Harbor Navigation Project", dated December 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 8 (September 2010) 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 2010 to August 2012) and for the entire period (from August/September 2000 to August 2012).

For Oak Island/Caswell Beach, the shoreline change 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 relatively high losses since the last survey reported in Report 8. This is most likely related to the diffusion of the material from the disposal area toward the adjacent beaches. Over the current period, the western most section of the monitoring, which had previously experienced shoreline growth, has become erosive and the area between placement zones continued the accretionary trend previously reported in Report 8. Change throughout the remaining monitoring area was more variable. When considering all profiles within the Oak Island monitoring area, the average shoreline change was a loss of approximately 20 feet for the present period of October 2010 to August 2012.

In considering all the profile data, the alongshore average shoreline position was 115 feet more seaward in August 2012 than it was in September 2000. This is a decrease of nearly 20 feet when compared to the values measured in Report 8. With the exception of only four profiles on the eastern tip of the island (Profiles 20, 35, 40 and 45) all other profile lines have shown some shoreline increase. 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 fluctuated between erosion (16 profiles) and accretion (17 profiles) evenly when comparing the August 2012 survey with the last survey included in Report 8 (September 2010). One area of concern noted since Report 8 is the significant erosion observed at Profiles 30 and 40. The area of the beach represented by these two profiles lost approximately 51,300 cubic yards of material since September 2010 (Report 8). The overall change at the conclusion of the current monitoring period was slight accretion, with a total increase of approximately 4,400 cubic yards since September 2010 over the entire monitoring area. The overall volume response has been positive when considering the measurements over the entire 12-year monitoring period. As such, all reported volume changes are positive with the exception of 4 profiles along the eastern end of the island which include Profiles 5, 30, 40, and 45. The most significant volumetric loss occurred between Profiles 40 and 45, close to the area of erosion noted over the current monitoring period. Measured volumes for the entire monitoring area with the August 2012 survey totaled nearly 2,039,300 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.

Since the last reporting, almost all of the profile locations along Bald Head Island have eroded or moved landward. In general, the eroding areas are relatively uniform throughout South Beach; however, the erosion does decrease with increasing distance from the inlet (moving east). The increases in beach width within West beach and the Spit are likely due to longshore diffusion of the beach fill placed in 2009/2010 migrating toward and around the inlet. The greatest variability was again found between the south end of West Beach through the west end of South Beach between Profiles 28 and 45. This very dynamic area had shoreline changes which ranged from gains of about 312 feet to losses of more than 295 feet. The remaining area along West Beach (Profiles 0 thru 24) has had a mixture of losses and gains over the period, with the shoreline accreting on average 18 feet, similar to previous averages for the area. The area between Profiles 0 and 8 which was reported in Report 8 as having significant erosion of up to 66 feet at the northern most profile 0 was found to have accreted over this current monitoring period by 130 feet at profile 0. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 48 feet between September 2010 and August 2012.

Shoreline change patterns as measured over the last 12-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 69 are largely accretional. For this area, the August 2012 shoreline is an average of nearly 101 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. Large gains and losses are present within the spit area where the shoreline has advanced on the order of 261 feet at Profile 32 and lost nearly 478 feet at Profile 43 over the monitoring period. On average, the spit area (Profiles 32-45) has lost nearly 162 feet since September 2000. An area of progressive erosion is seen along the western portion of South Beach between Profiles 47 through 66. Average shoreline loss within this region is approximately 134 feet with a peak loss of nearly 332 feet occurring at Profile 47. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline has shown an average increase of about 49 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 43 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 which placed approximately 1.46 million cubic yards of material along the beaches. In addition, a groin field was constructed in the mid-1990's to retain the nourishment material and stabilize the western end of South Beach. 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 (September 2010) of Report 8 to the present, most of the profile locations of Bald Head Island show material loss over the current period. In summing the changes over the entire monitoring area, the losses total to approximately 1,054,500 cubic yards of material since September 2010. The most significant volumetric loss occurred within the Spit and the western end of South Beach. This area between Station 32+00 and 69+47 lost nearly 493,800 cubic yards of material or approximately 47% of the total material lost within the monitoring limits.

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 12 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 (Profiles 202 and 206), where some losses have occurred near the cape. Another is an area on South Beach that is just east of the new groin field (Profiles 97 through 114). This area has grown since Report 8 (in both magnitude and length) where it was reported as only a single profile showing minor losses. The third area spans three stations from Profile 45 to 61, 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. This area has increased as well from the values reported in Report 8, however the length and magnitude of the observed erosion is not near historic levels. Volumetrically this erosive region has lost about 568,500 cubic yards to date, compared to the 318,000 loss recorded in Report 8. The net volume change over the entire monitoring area is a slight gain of nearly 176,500 cubic yards as of August 2012 with respect to the beginning of the monitoring in 2000.

Rates of shoreline change were likewise computed over the 12-year 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 the comparison is not between data sets of similar durations, the comparison is useful in observing overall trends in the rate of shoreline response.

Shoreline change rates computed over the initial 12-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. The exception to this overall trend is located at profiles 35, 40, and 45 where while the average rate for these profiles is positive it is significantly lower than the pre-project accretion rates. In fact, when looking at the individual rates for these profiles rather than the longshore average used to compare to the pre-project Division of Coastal Management rates it is found that profiles 35 and 40 have consistently eroded throughout the post-project monitoring term. Specifically, the post-construction rate for Profile 35 is -8.0 ft/yr and the rate for Profile 40 is -6.1 ft/yr. Overall, the shoreline change rate averaged over the entire monitoring area is computed to be +14.4 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 12-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 are 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 and have remained stable relative to the values calculated for Monitoring Report 8. 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.

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 2012, 39 condition surveys have been accomplished. Eight of these occurred over the current reporting period (September 2010, February 2011, May 2011, July 2011, August 2011, March 2012, April 2012 and June 2012). There are now fifteen post-dredging settlement survey following the Feb-April 2009 channel dredging operation. The area between stations 5+00 and 21+00 had modest increases in channel width while the area between stations 23+00 through 44+00 had modest to severe reductions in channel width. In fact, at the end of the current monitoring period the area between stations 22+00 and 44+00 had fallen below the minimum threshold. The change in navigable width measured at -42 ft MLW, ranged from an increase of 116 feet at station 17+00 to a maximum reduction of 234 feet at station 42+00.

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 14,300 cubic yards per month. This represents a 60% 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 13% lower. 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 nourishment 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 (nourishment by the Village of Bald Head Island) and subsequent reconstruction of the groin field in early 2010. Shoreline change comparisons were made over similar 22 to 24 month periods following each respective event. The shoreline change measured within the groin field appears to be more stable following the fourth re-construction than the previous events.

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 included in this report 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 has been published as a separate document entitled "Reevaluation Report Sand Management Plan Wilmington Harbor Navigation Project", dated December 2011.

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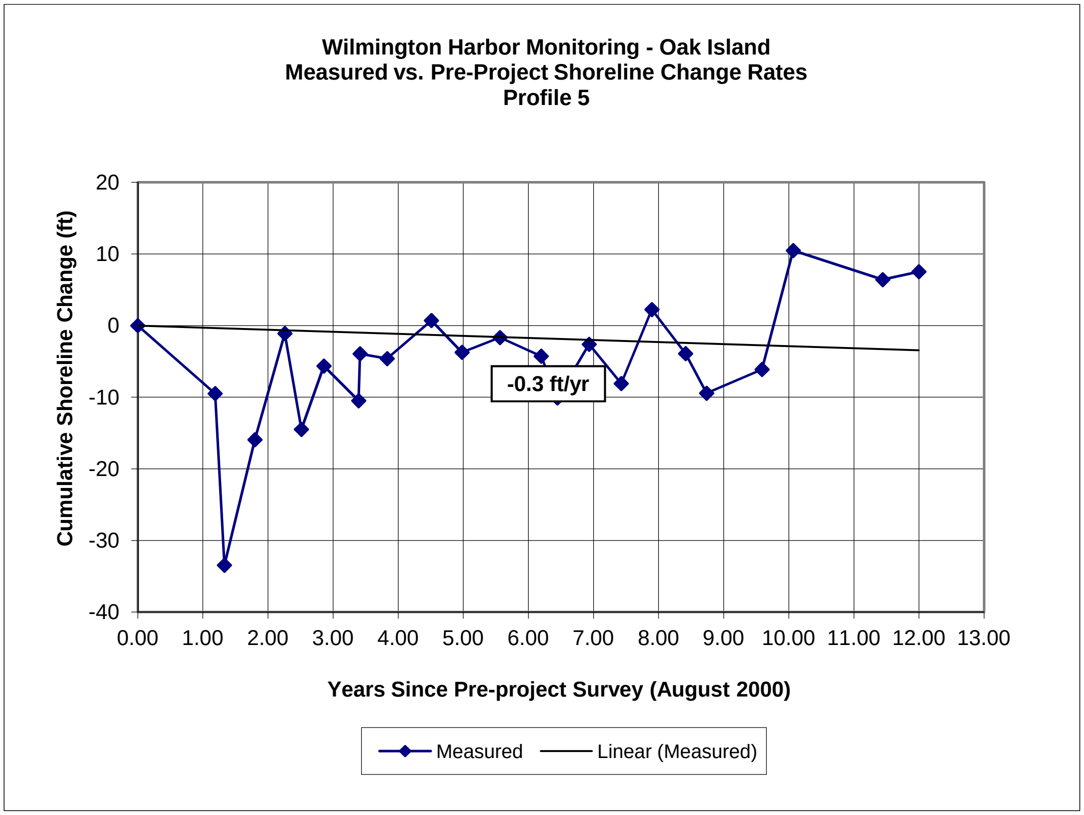
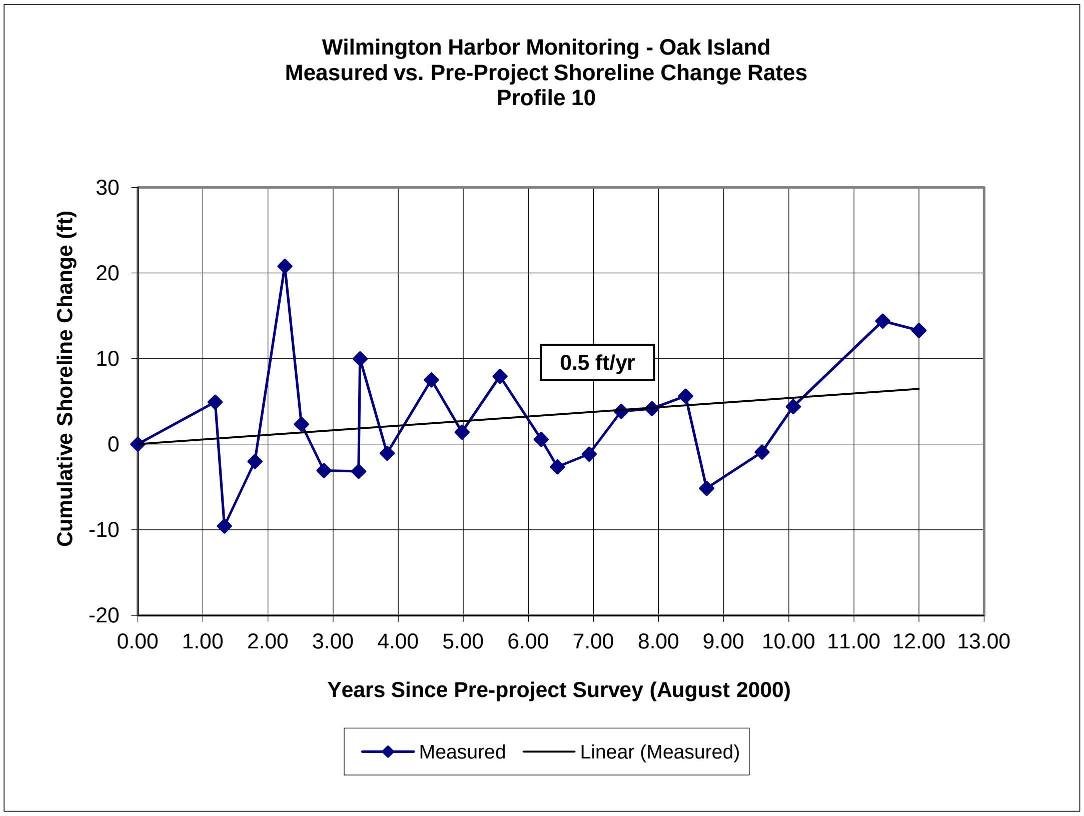
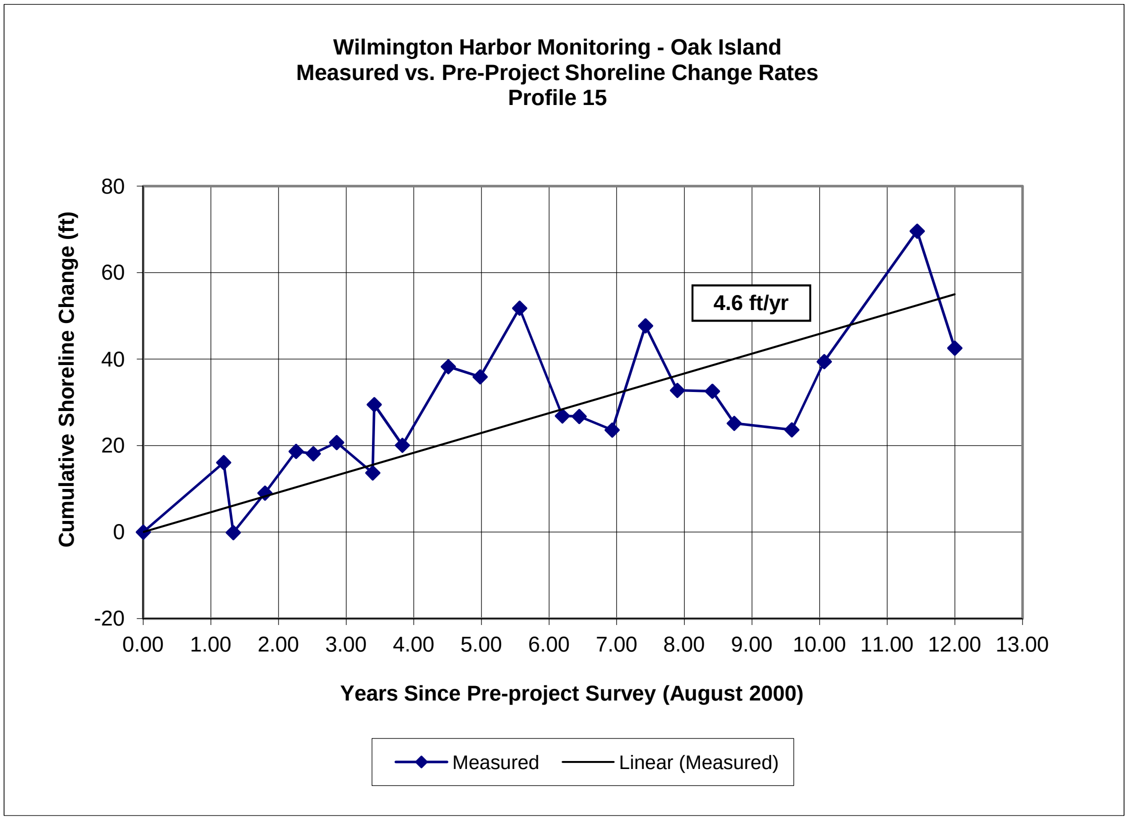
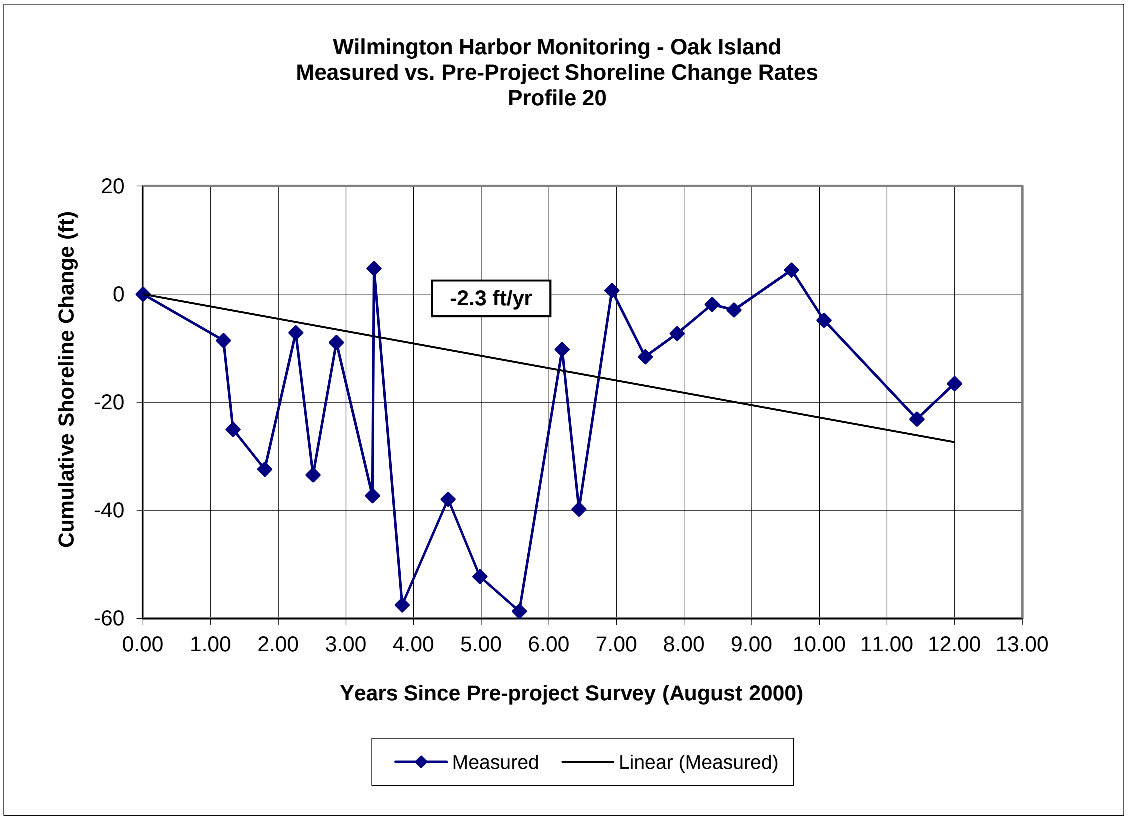
Appendix A

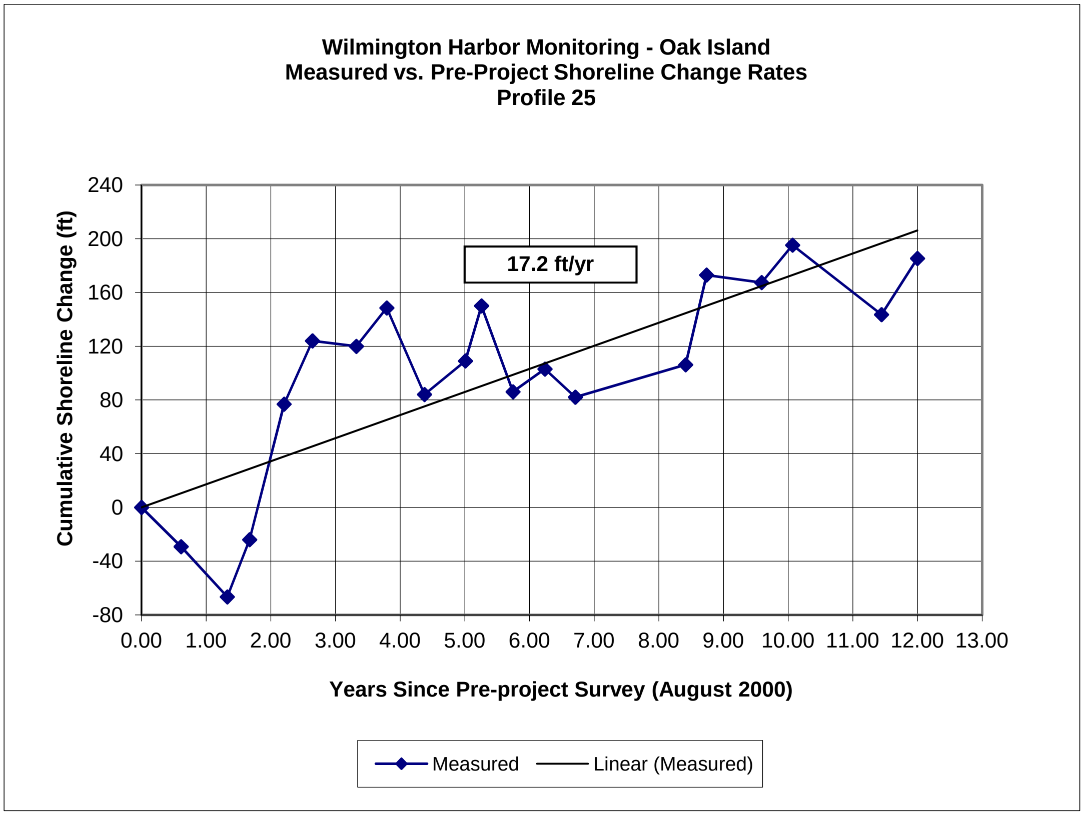
SHORELINE CHANGE RATES
(Oak Island)

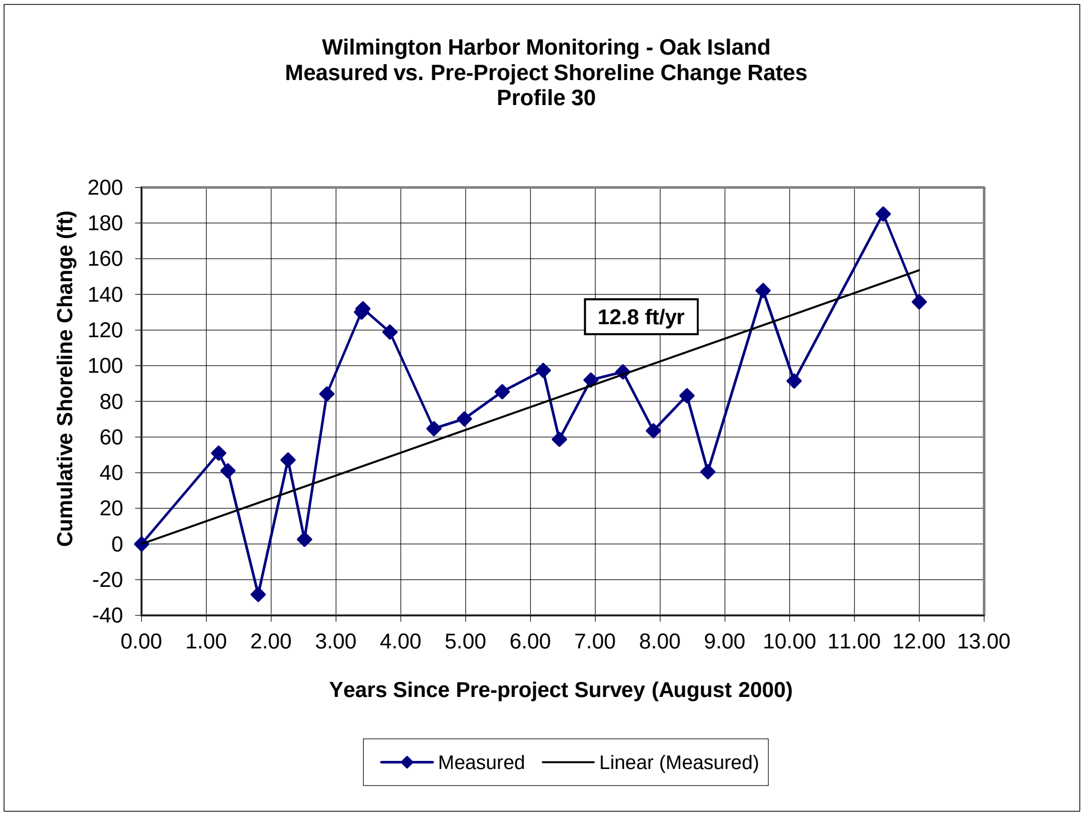

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 5
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
-0.3 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

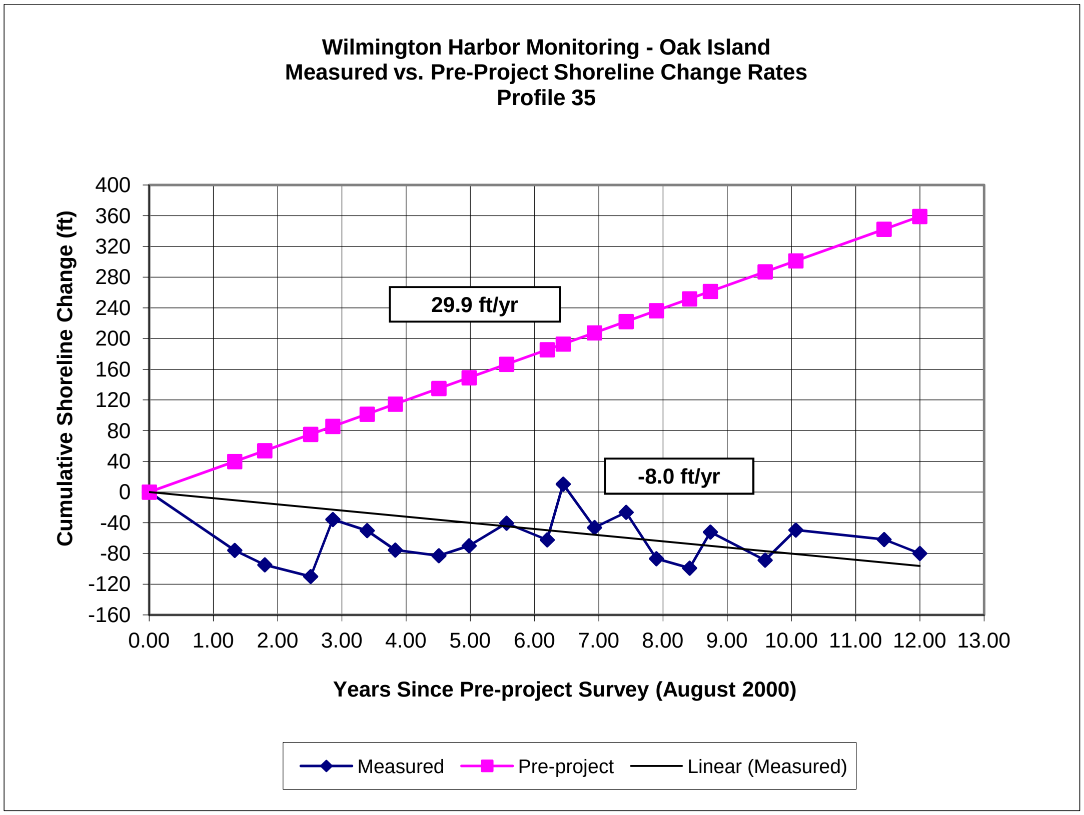

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 10
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
0.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

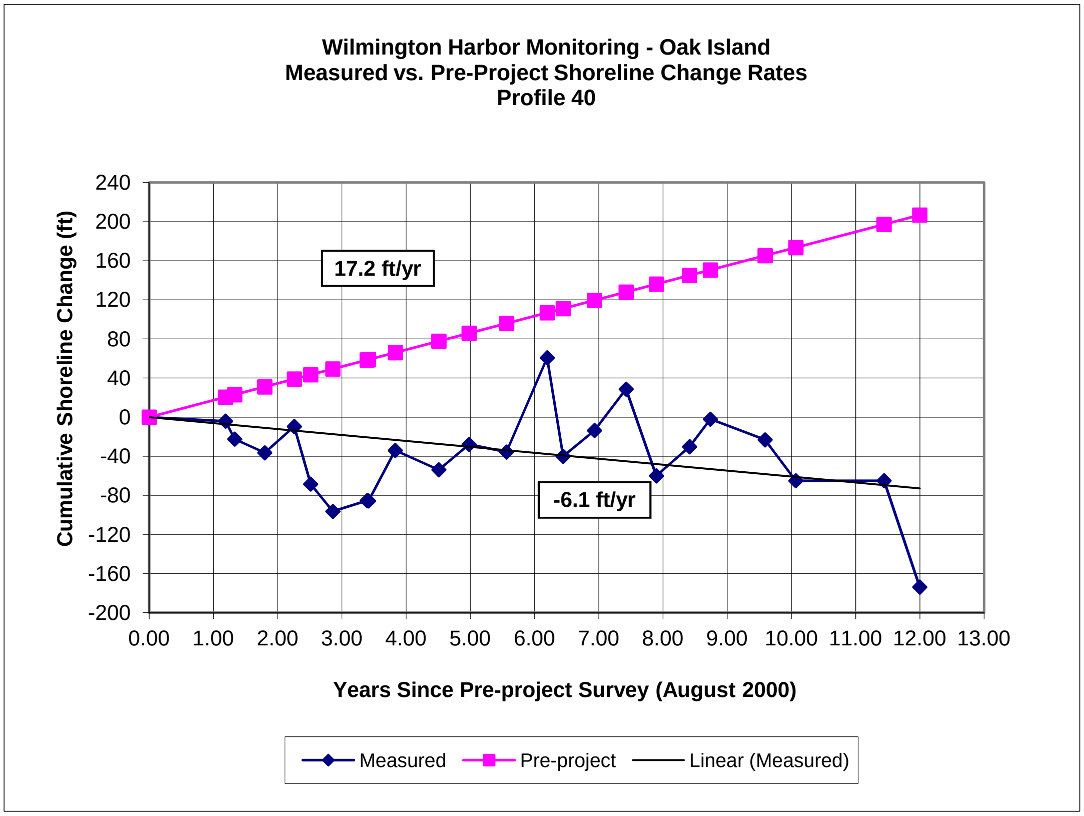

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 15
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
4.6 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

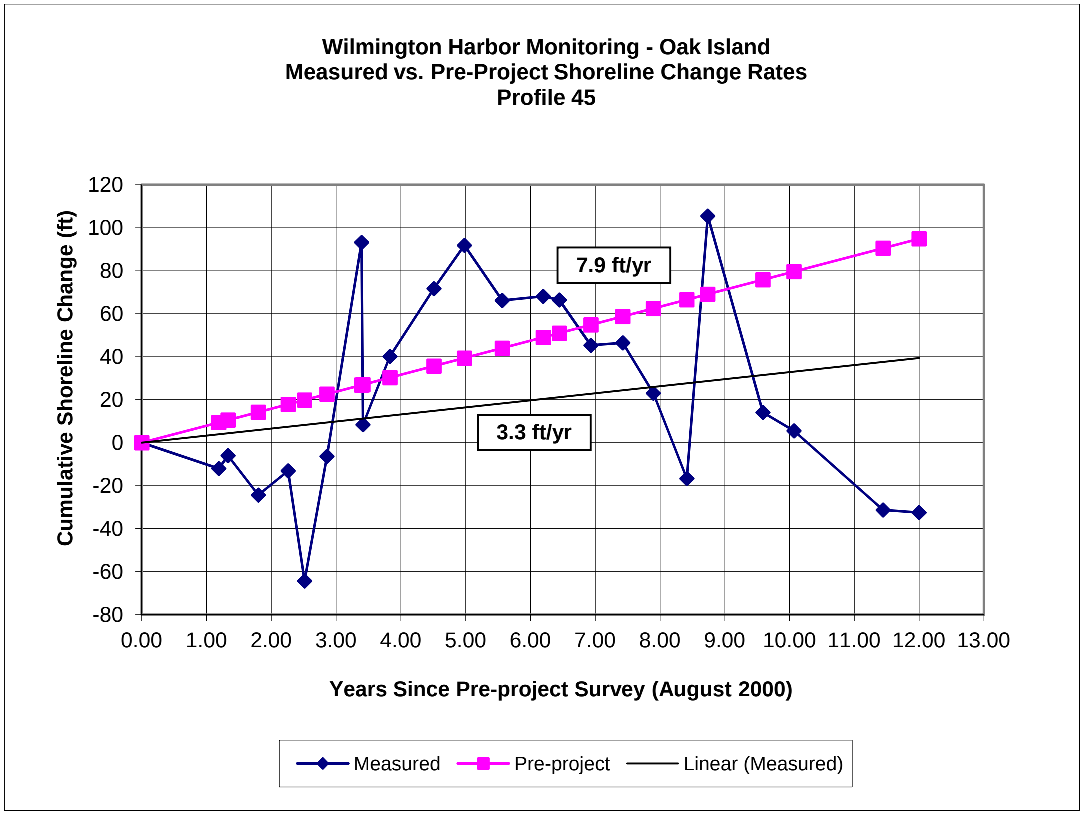

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-2.3 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

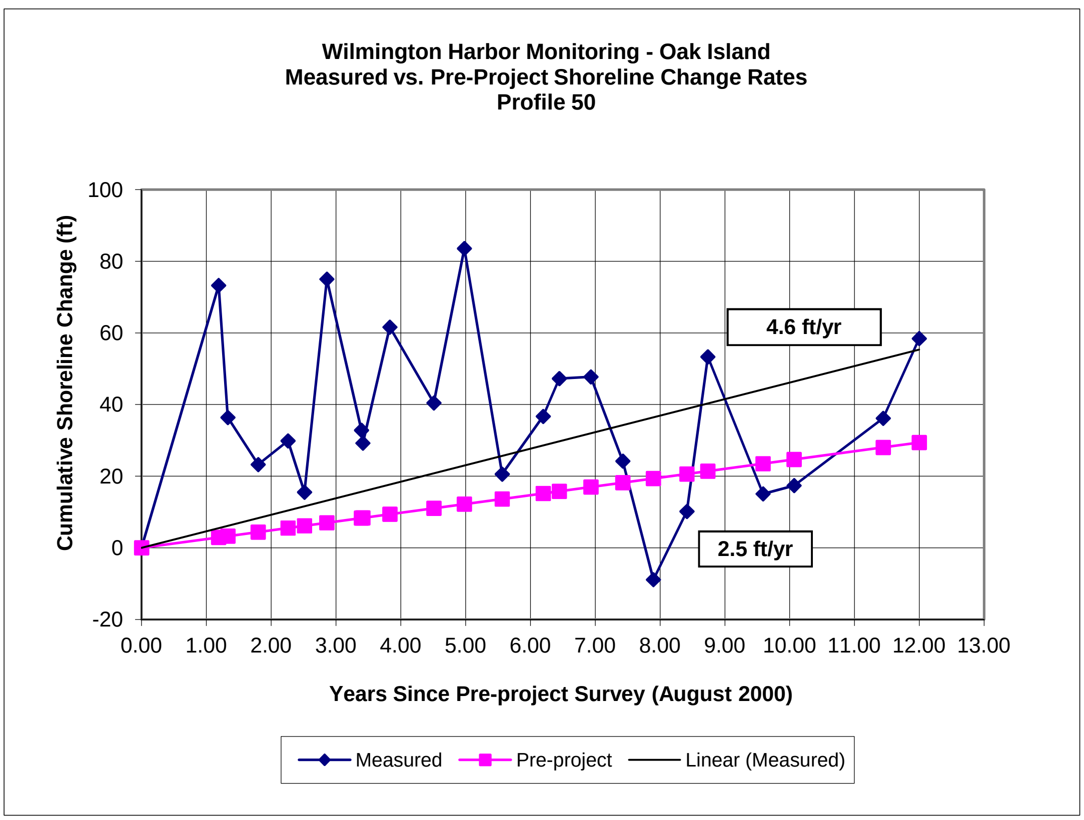

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 25
17.2 ft/yr
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

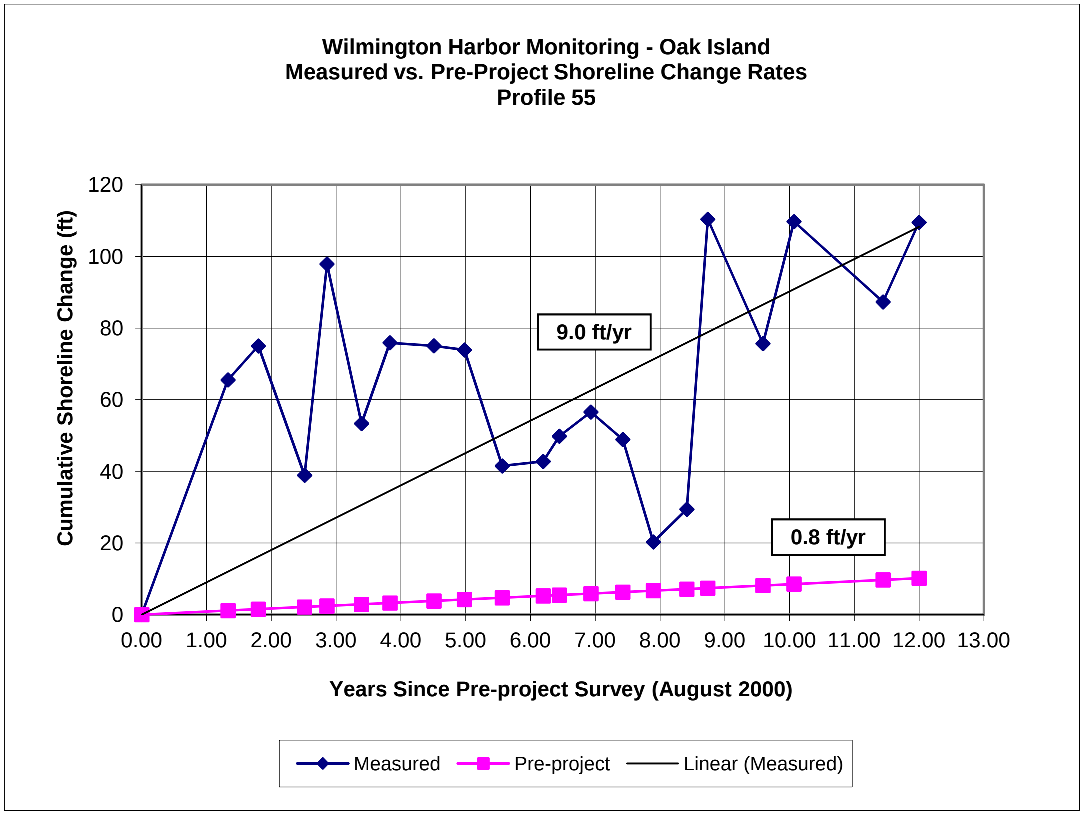

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 30
12.8 ft/yr
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

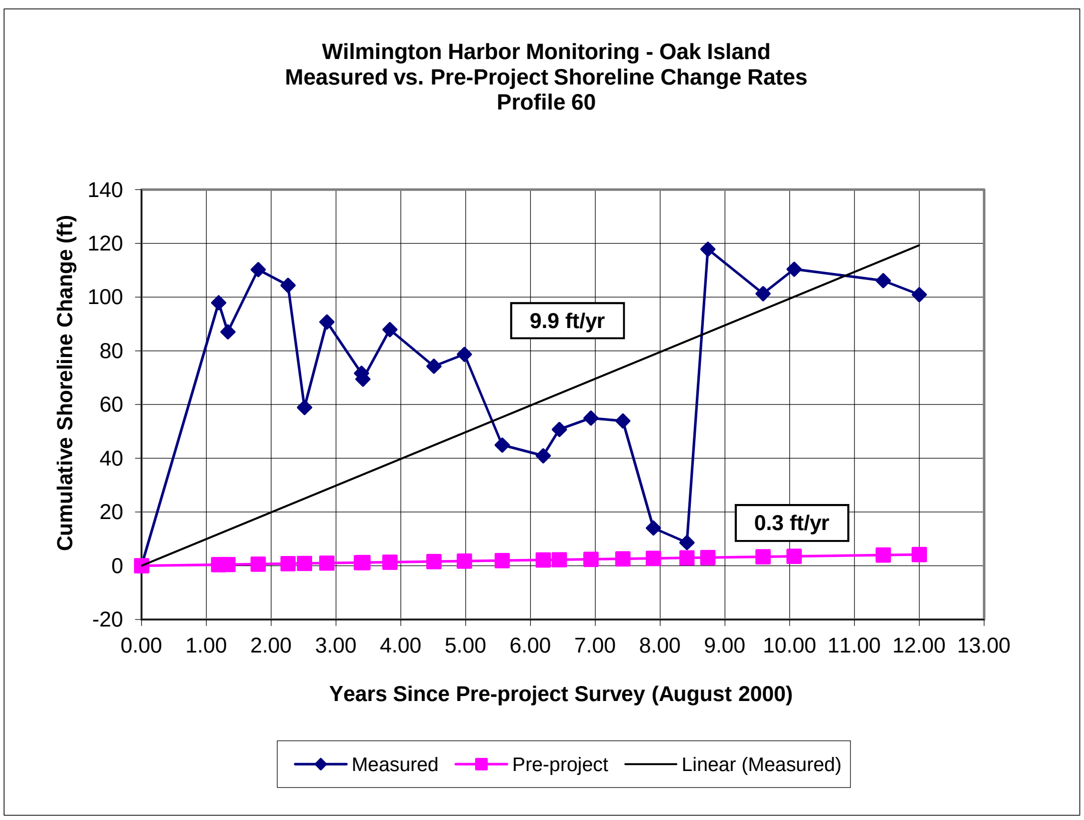

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 35
29.9 ft/yr
-8.0 ft/yr
Cumulative Shoreline Change (ft)
400
360
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

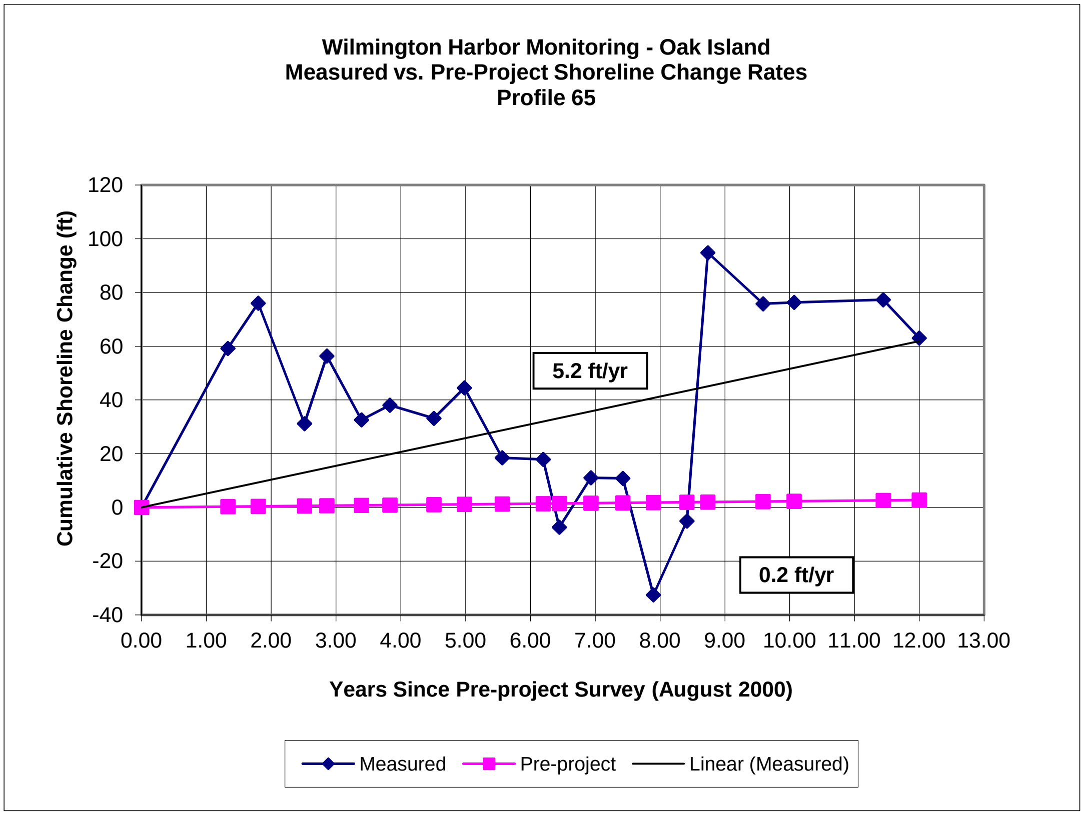

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
17.2 ft/yr
-6.1 ft/yr
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
-120
-160
-200
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

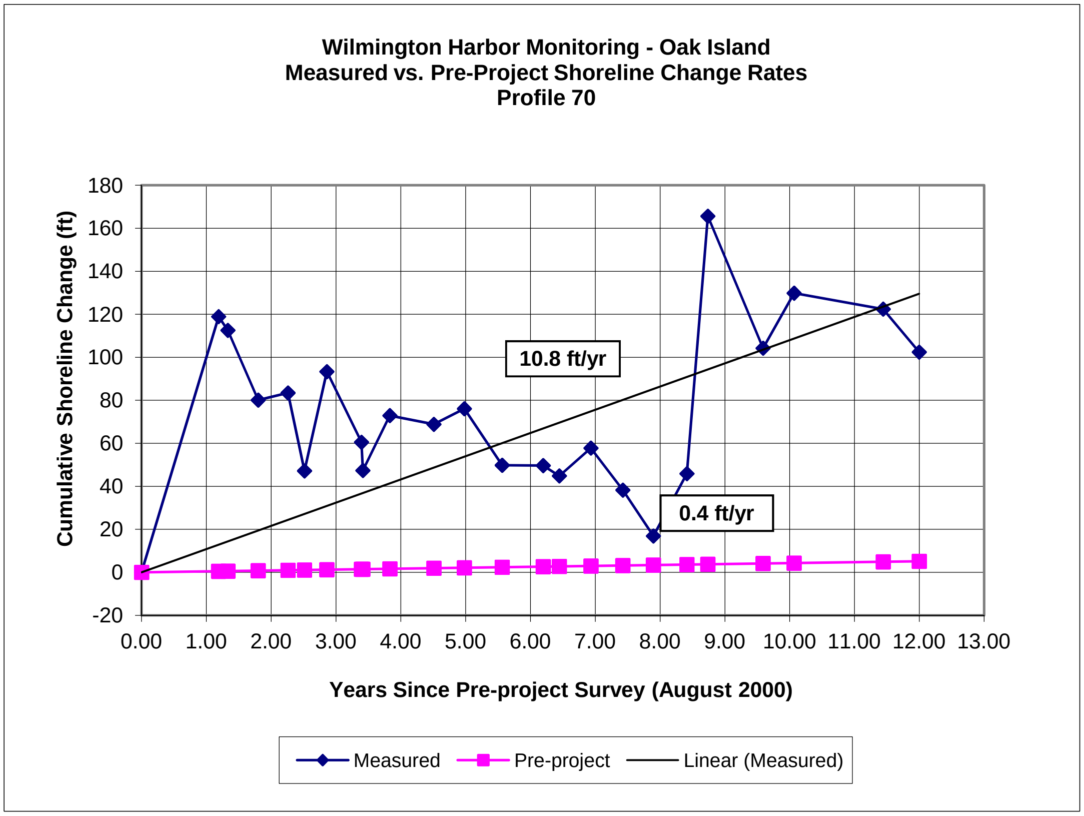

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
7.9 ft/yr
3.3 ft/yr
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

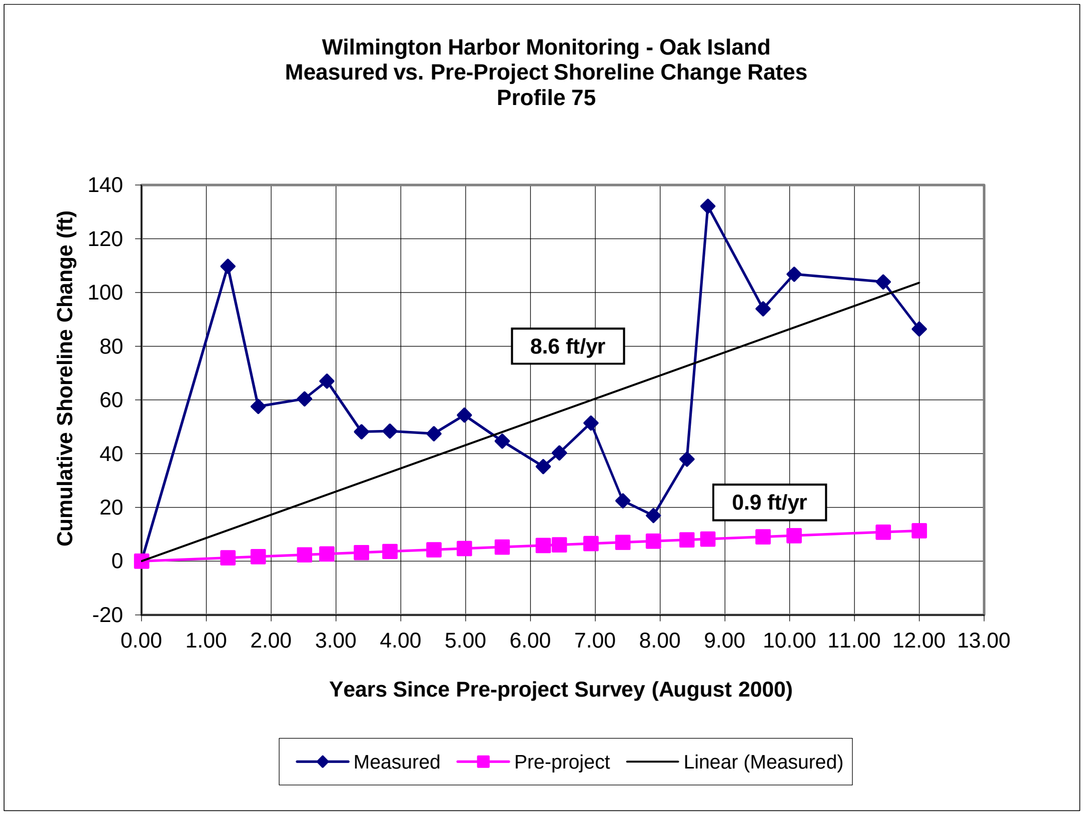

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 50
4.6 ft/yr
2.5 ft/yr
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

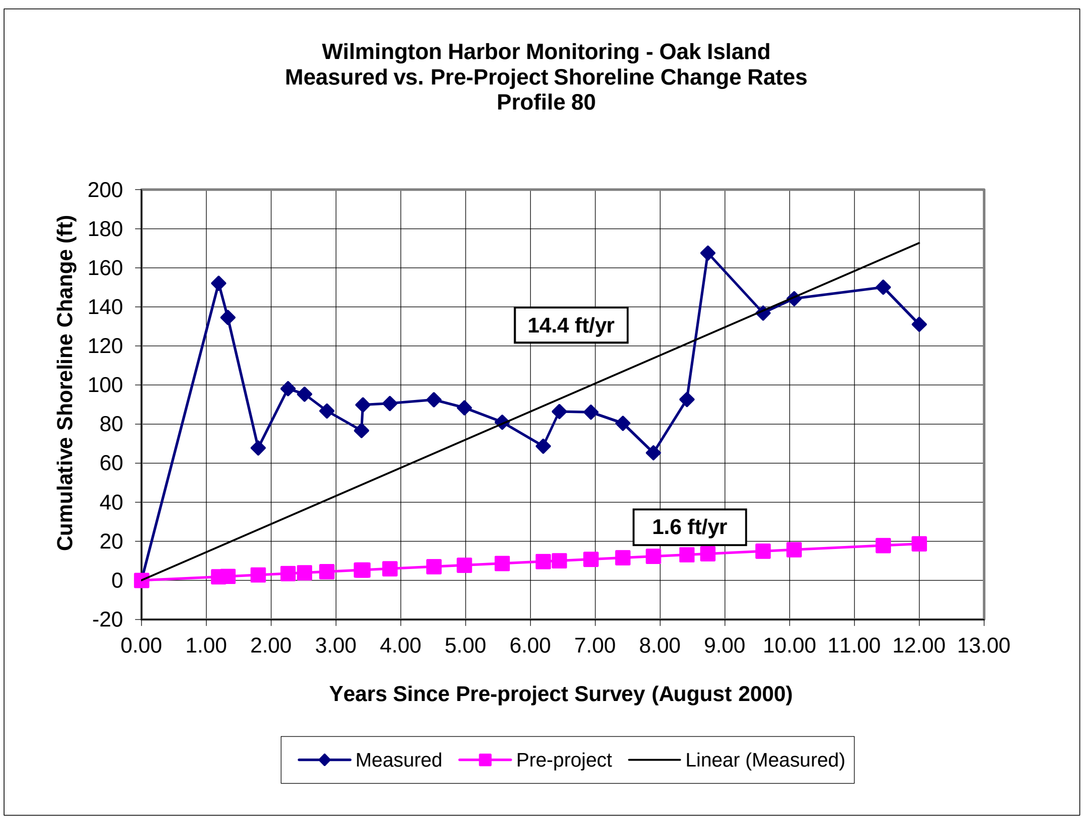

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 55
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
9.0 ft/yr
0.8 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

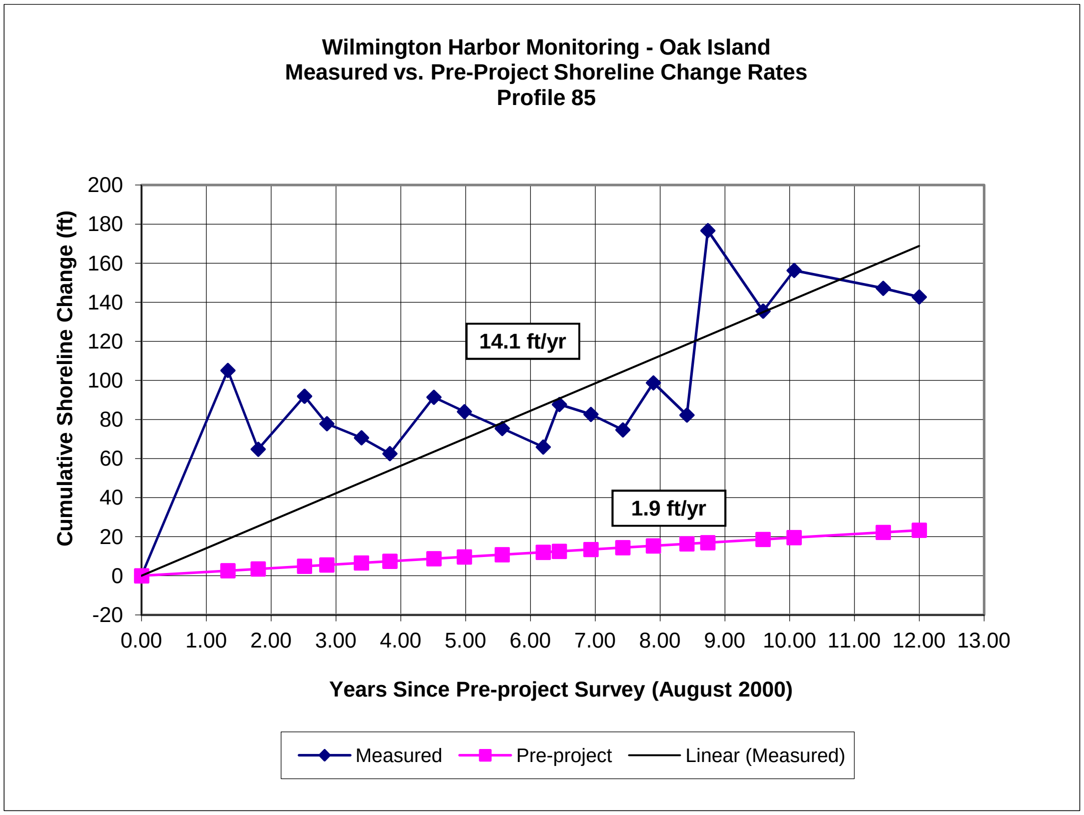

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 60
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
9.9 ft/yr
0.3 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

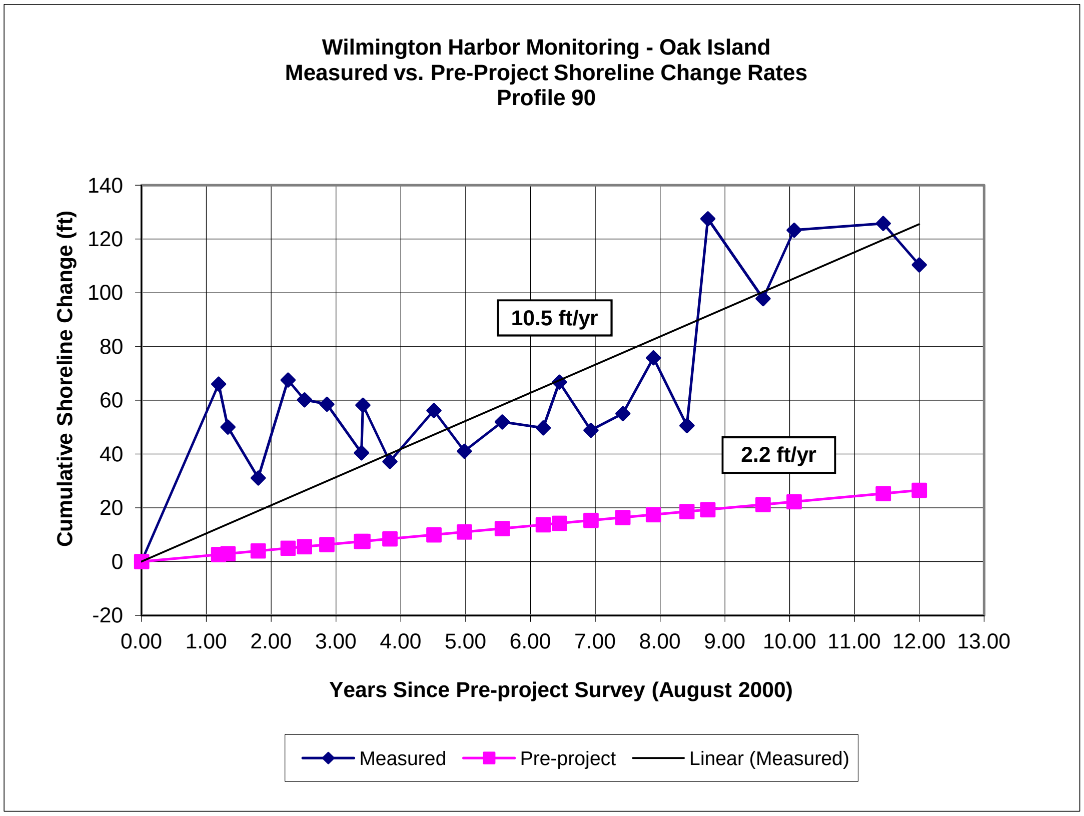

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 65
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
5.2 ft/yr
0.2 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

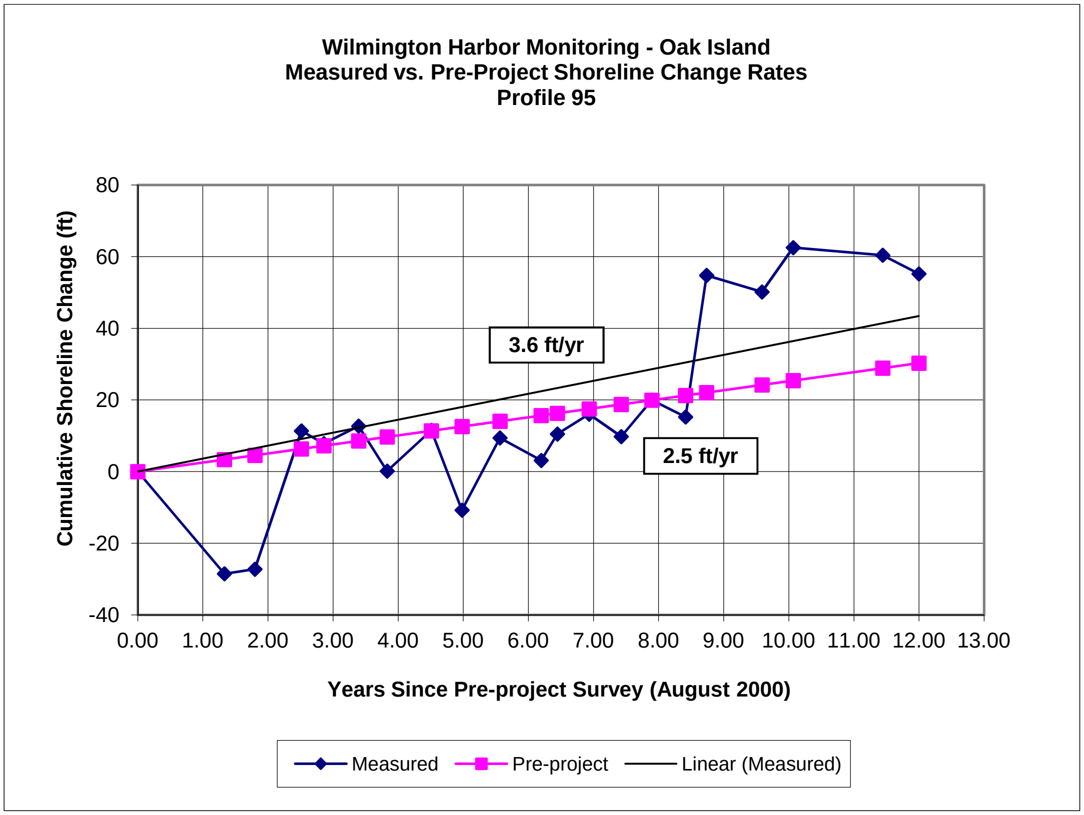

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 70
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
10.8 ft/yr
0.4 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

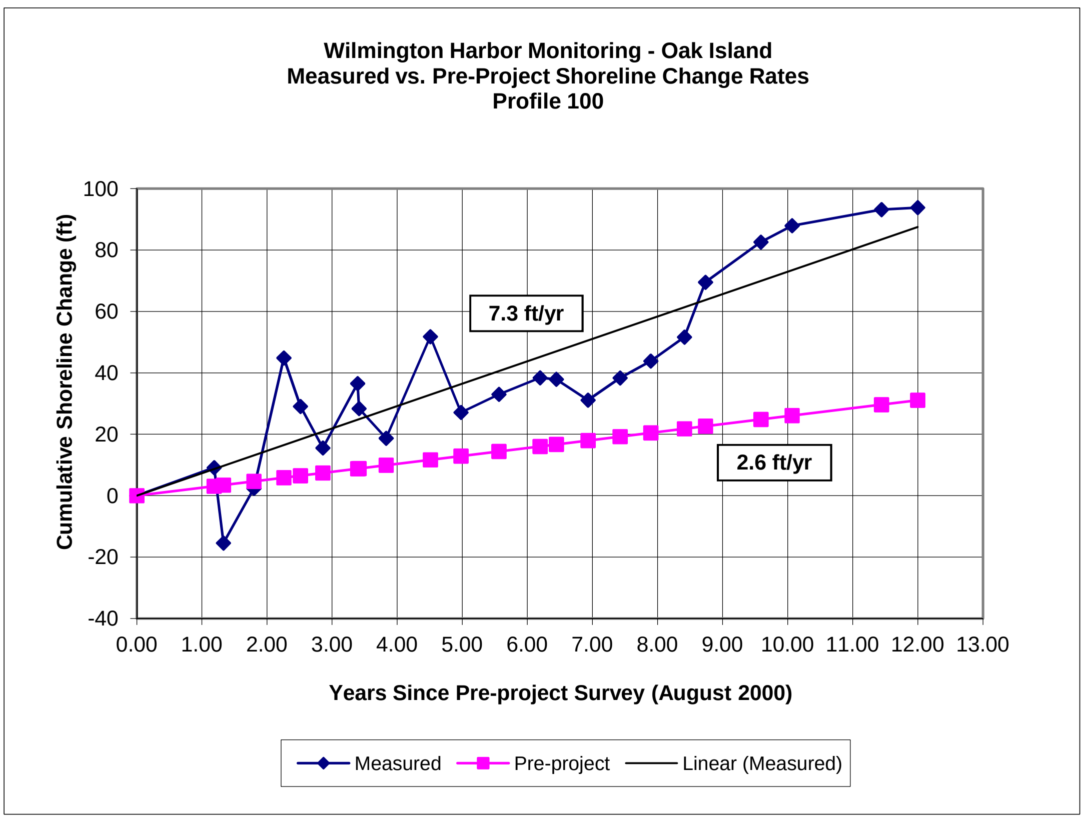

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 75
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
8.6 ft/yr
0.9 ft/yr
Measured
Pre-project
Linear (Measured)

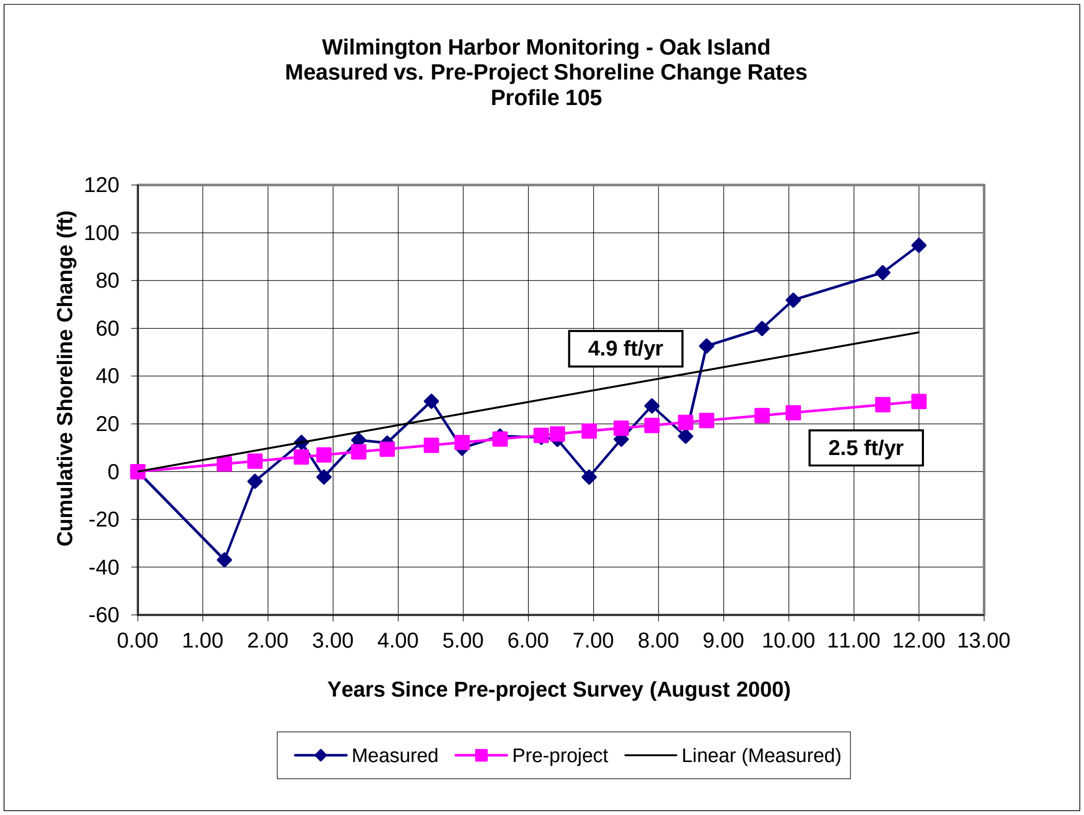

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 80
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
14.4 ft/yr
1.6 ft/yr
Measured
Pre-project
Linear (Measured)

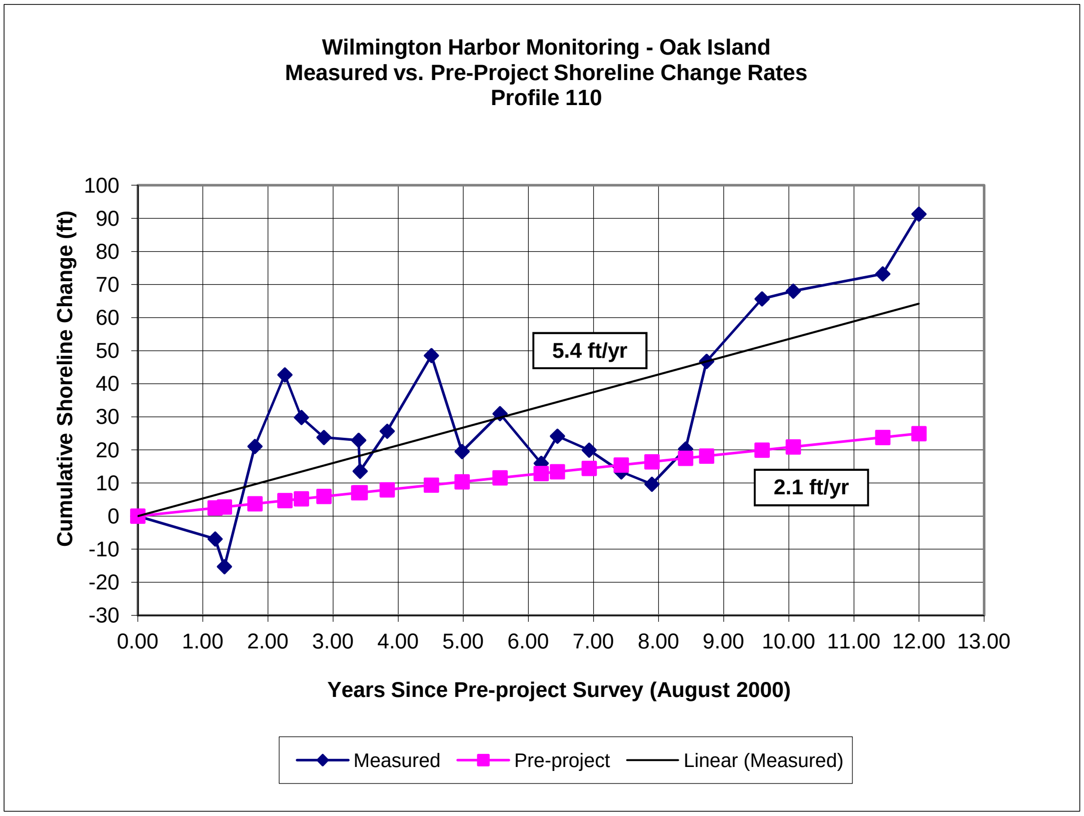

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 85
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.1 ft/yr
1.9 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

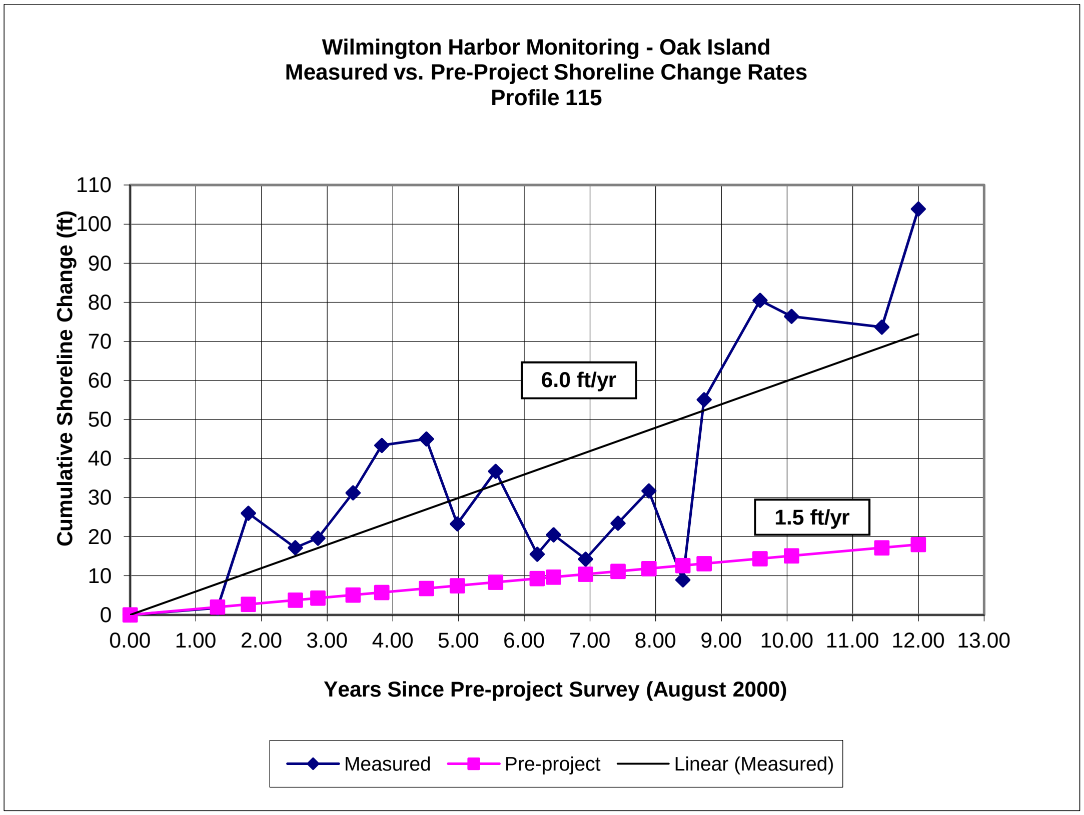

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 90
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
10.5 ft/yr
2.2 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

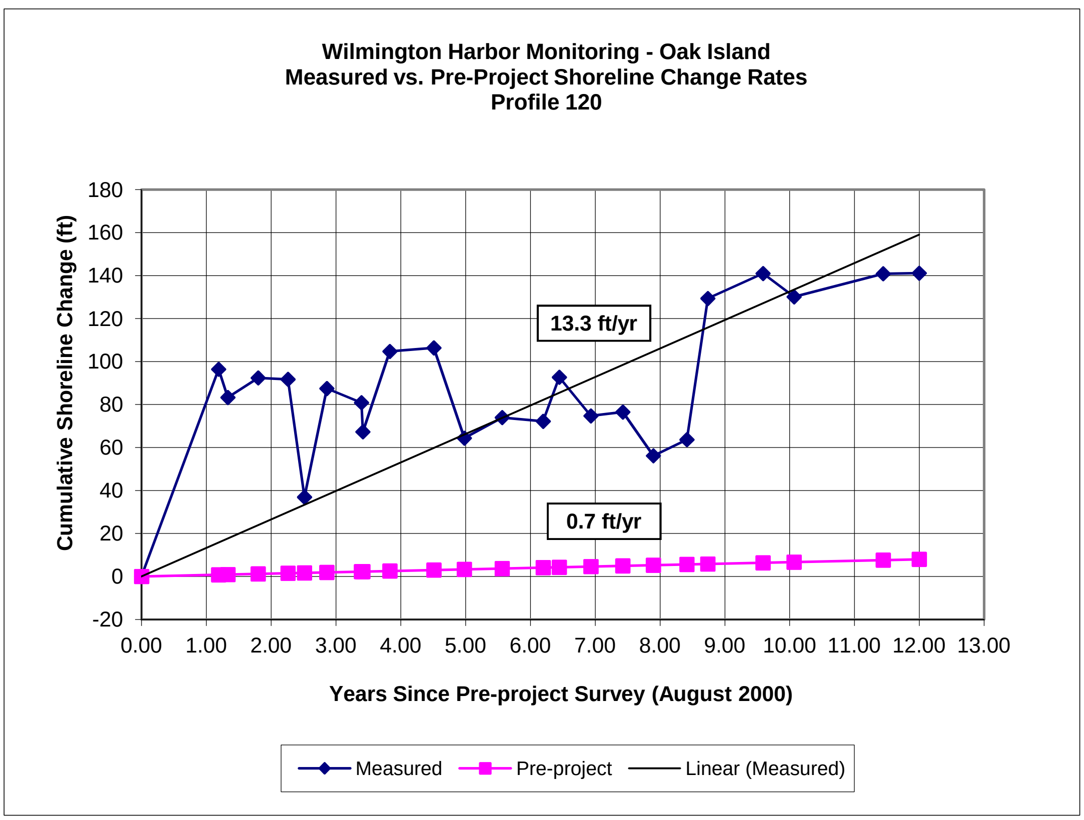

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 95
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
3.6 ft/yr
2.5 ft/yr
Measured
Pre-project
Linear (Measured)

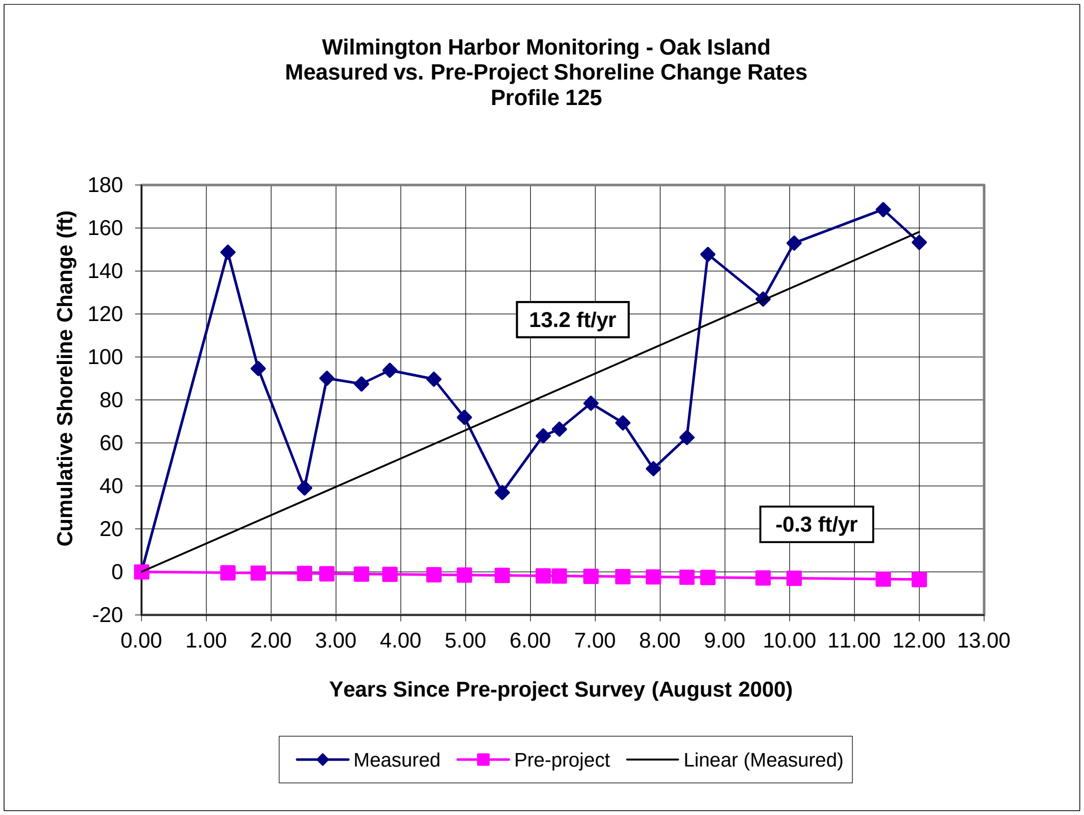

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 100
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
7.3 ft/yr
2.6 ft/yr
Measured
Pre-project
Linear (Measured)

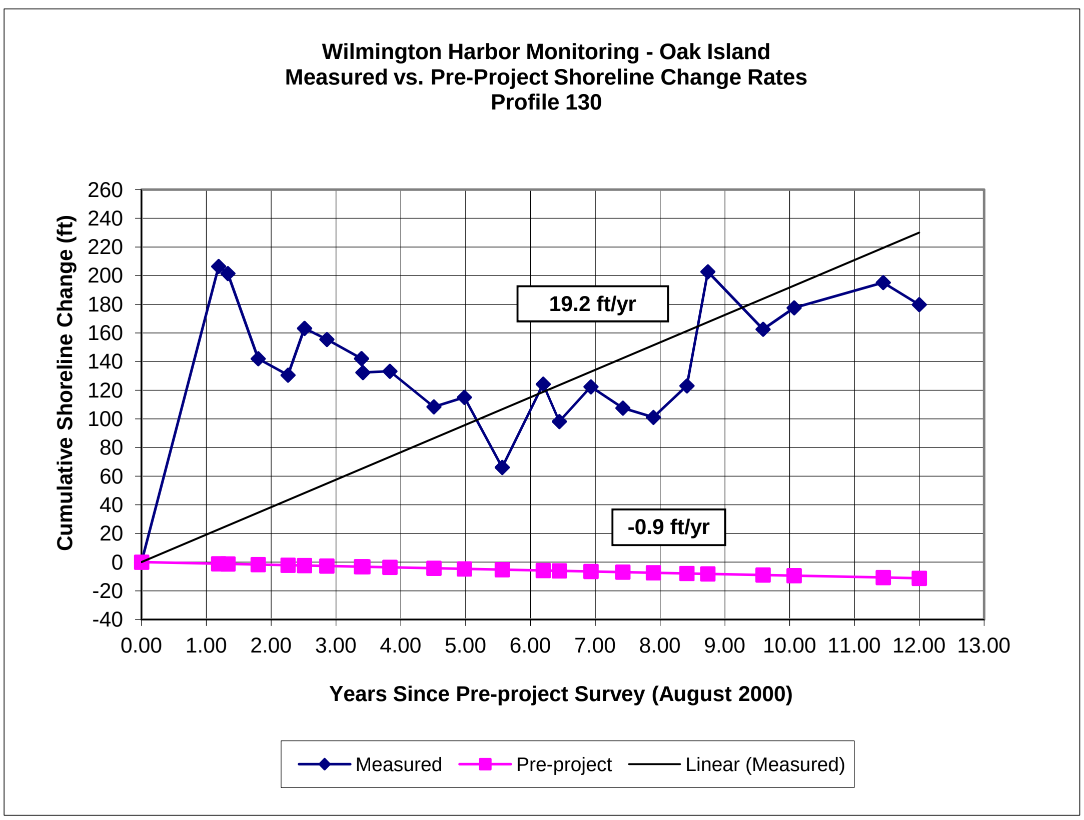

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 105
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
4.9 ft/yr
2.5 ft/yr
Measured
Pre-project
Linear (Measured)

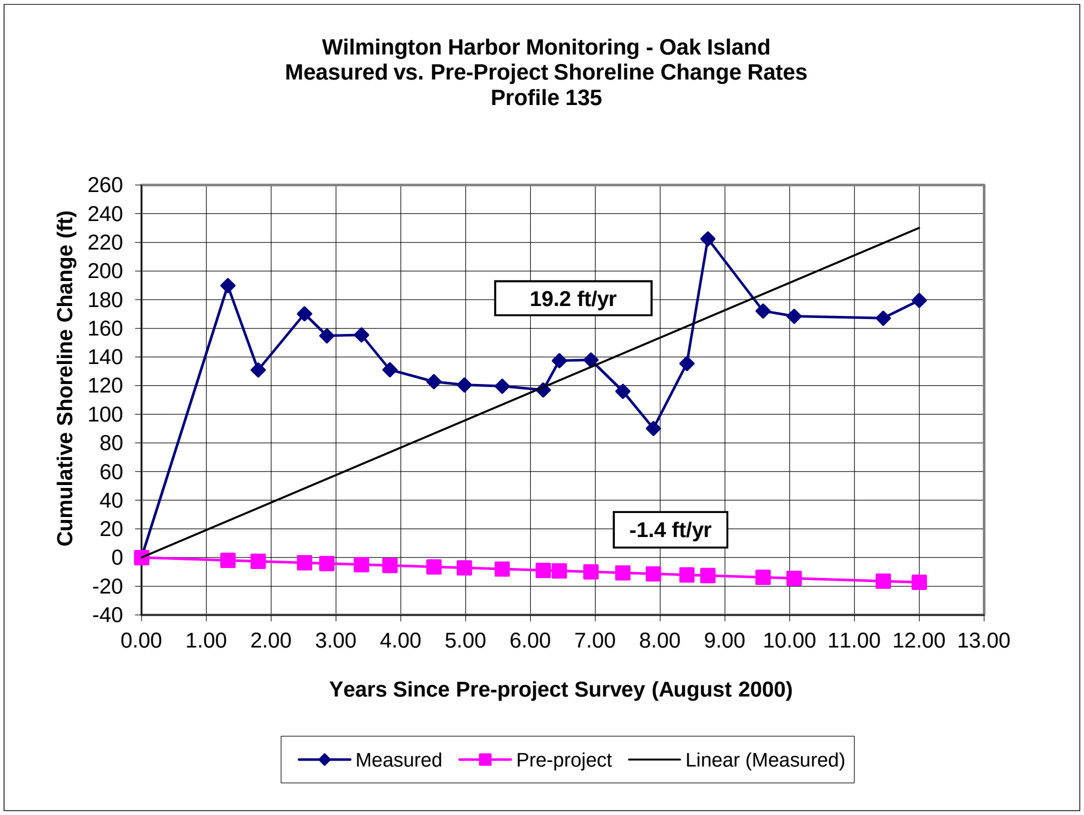

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
5.4 ft/yr
2.1 ft/yr
Measured
Pre-project
Linear (Measured)

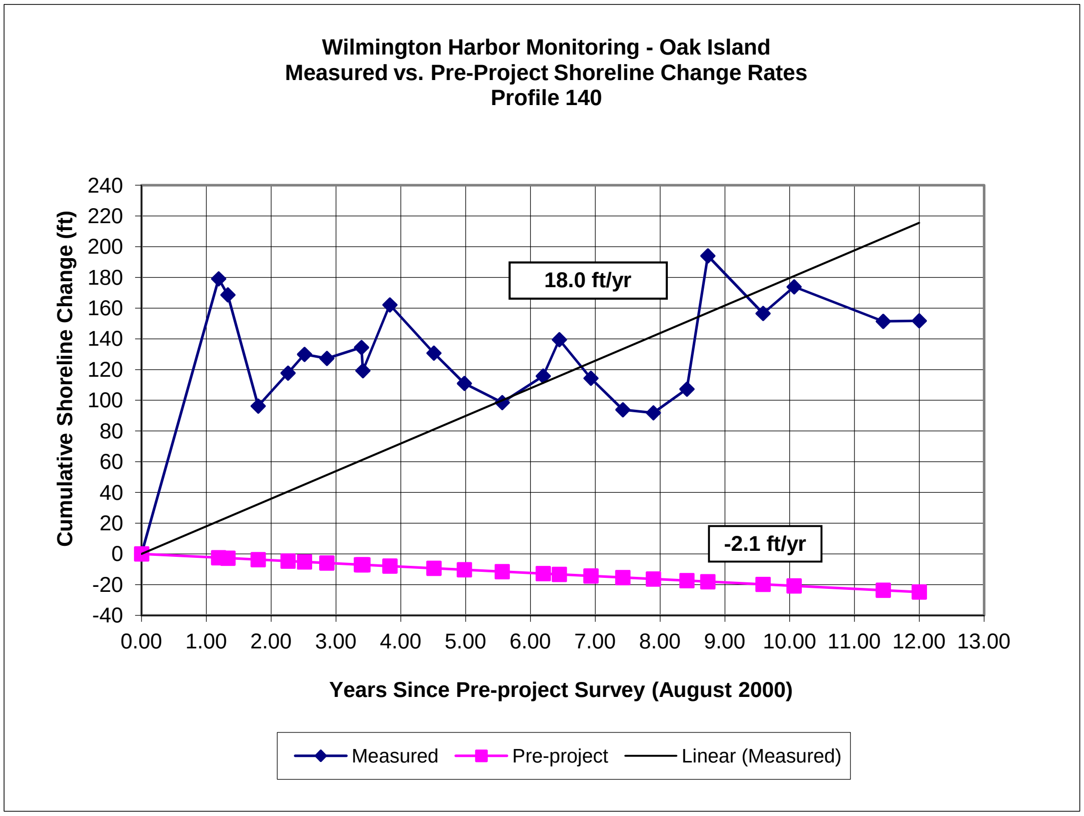

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 115
Cumulative Shoreline Change (ft)
110
100
90
80
70
60
50
40
30
20
10
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
6.0 ft/yr
1.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

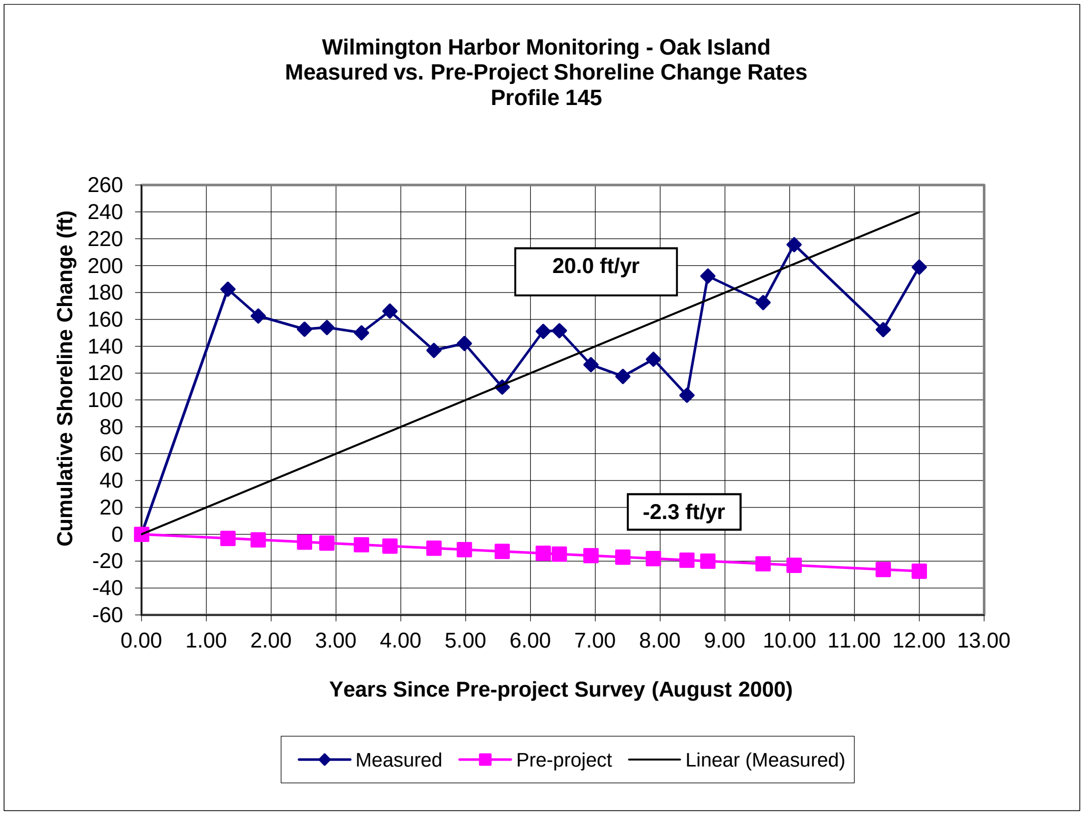

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 120
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
13.3 ft/yr
0.7 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

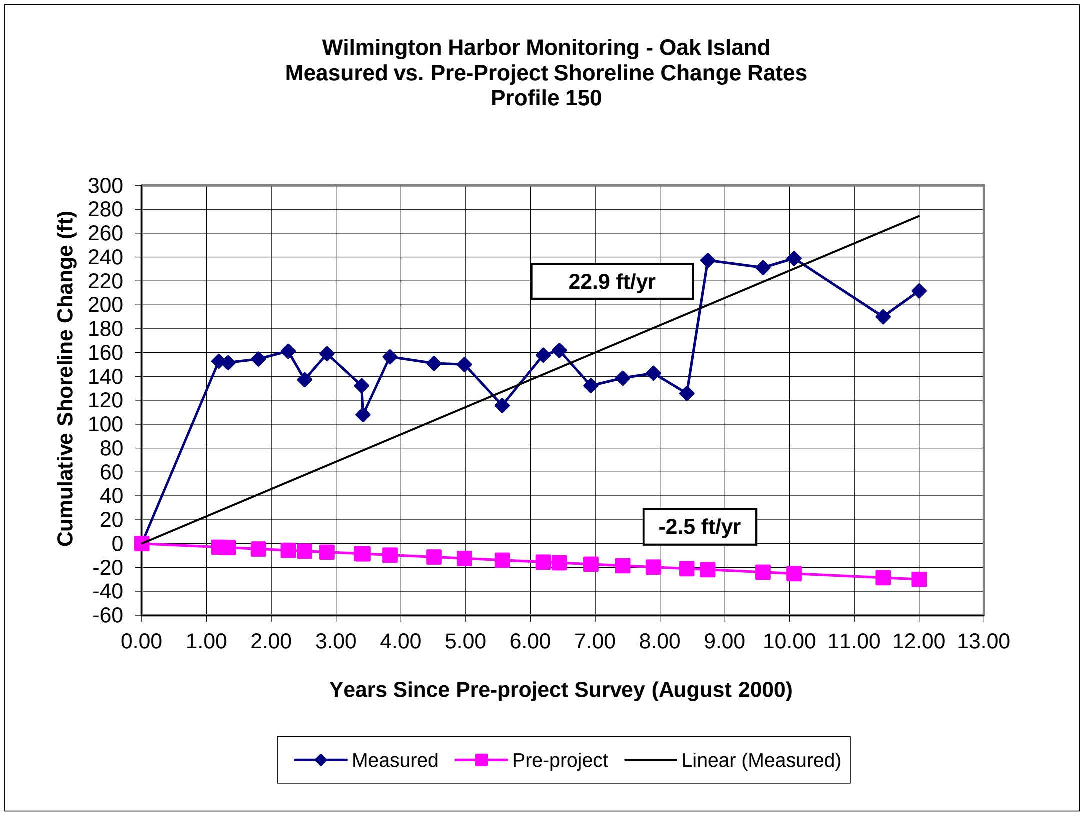

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 125
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
13.2 ft/yr
-0.3 ft/yr
Measured
Pre-project
Linear (Measured)

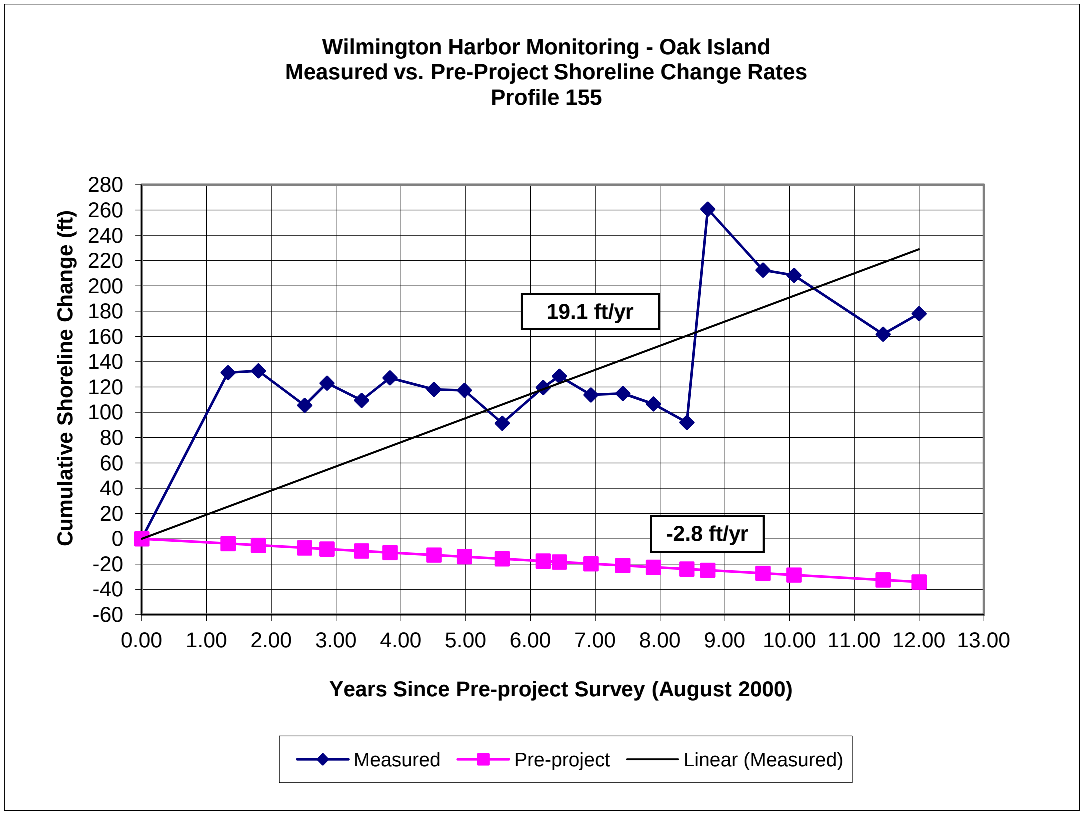

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
19.2 ft/yr
-0.9 ft/yr
Measured
Pre-project
Linear (Measured)

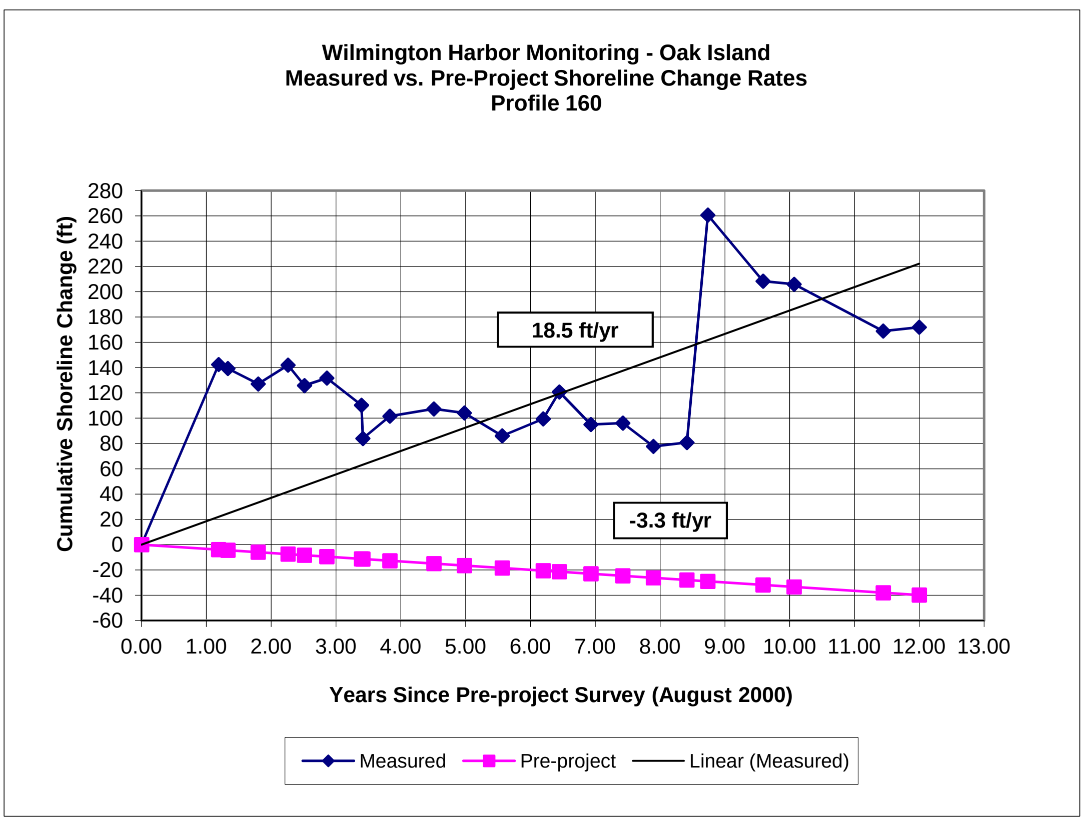

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 135
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
19.2 ft/yr
-1.4 ft/yr
Measured
Pre-project
Linear (Measured)

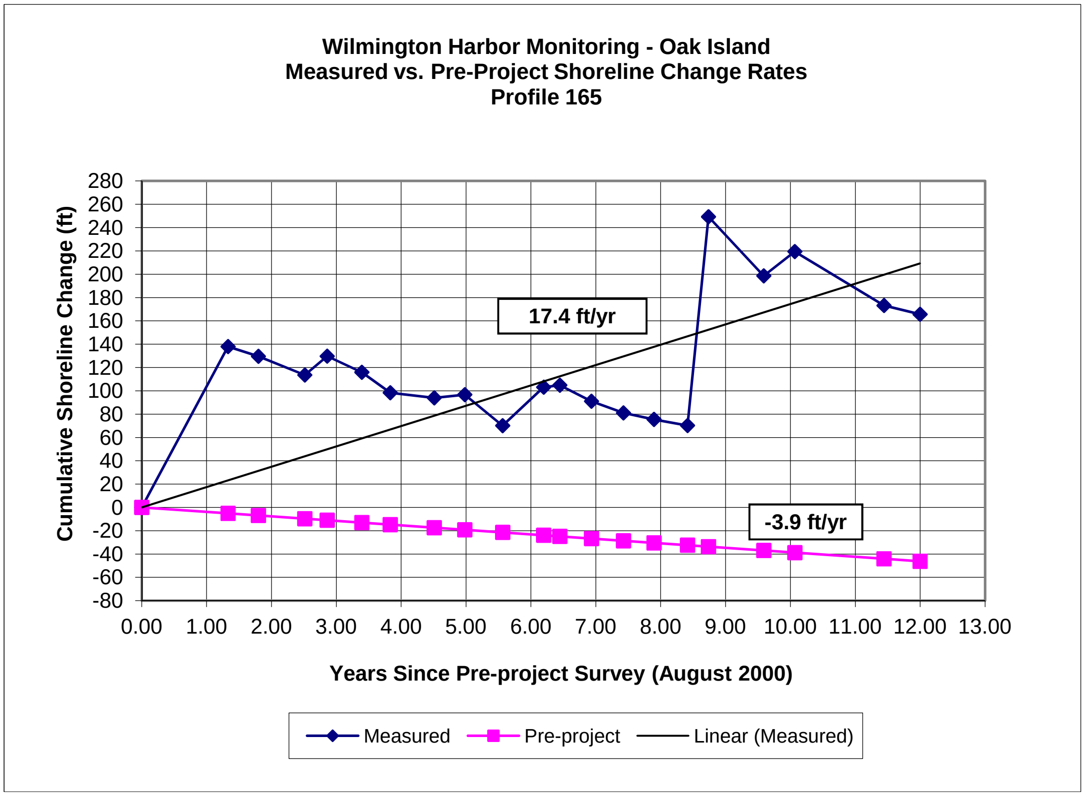

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 140
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
18.0 ft/yr
-2.1 ft/yr
Measured
Pre-project
Linear (Measured)

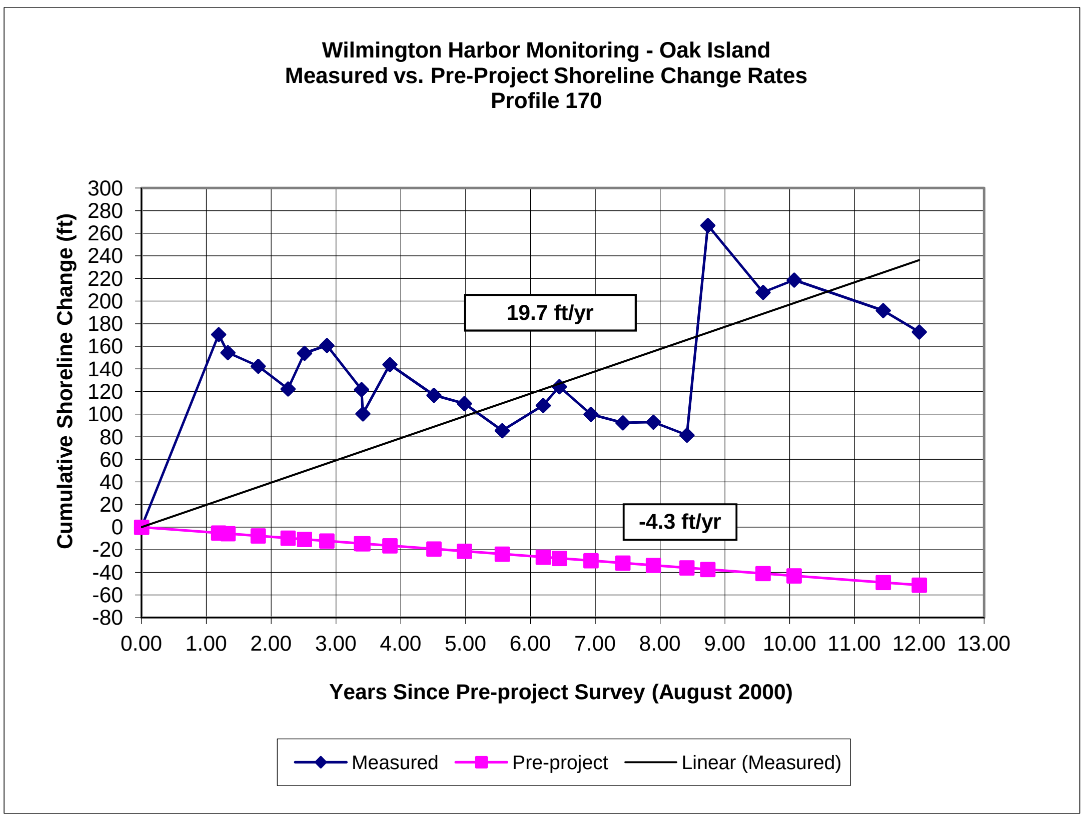

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 145
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
20.0 ft/yr
-2.3 ft/yr
Measured
Pre-project
Linear (Measured)

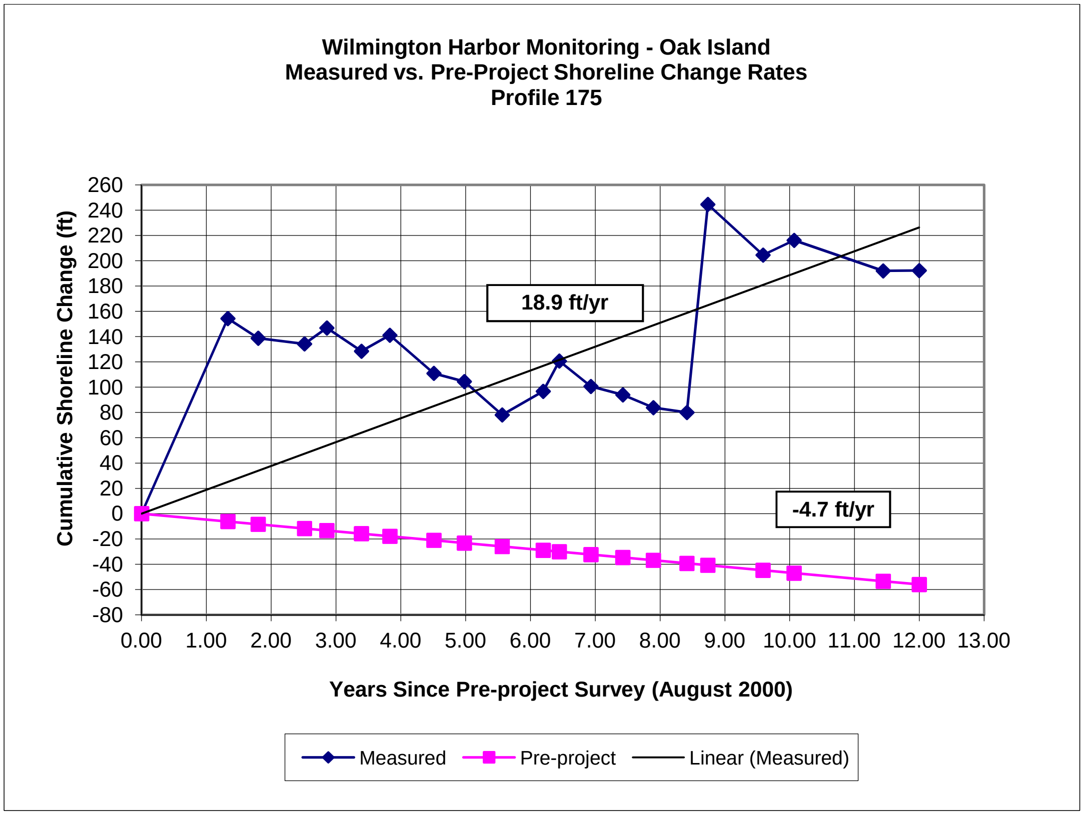

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
22.9 ft/yr
-2.5 ft/yr
Measured
Pre-project
Linear (Measured)

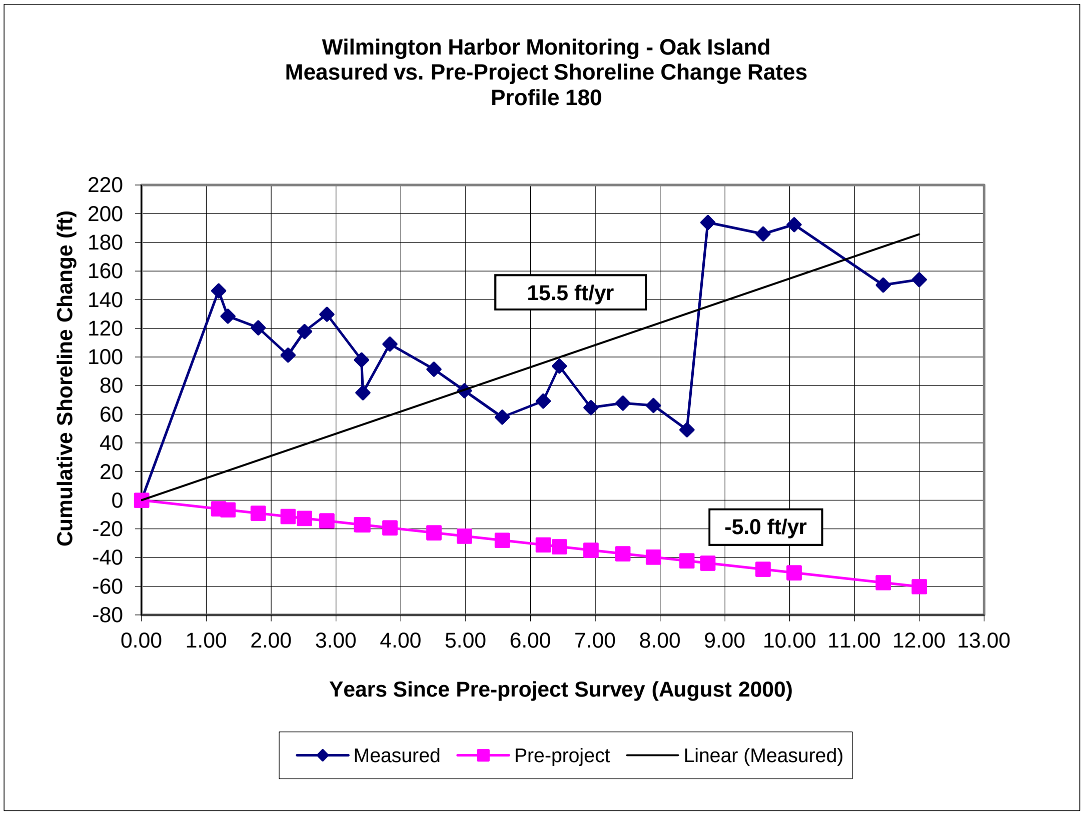

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 155
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
19.1 ft/yr
-2.8 ft/yr
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

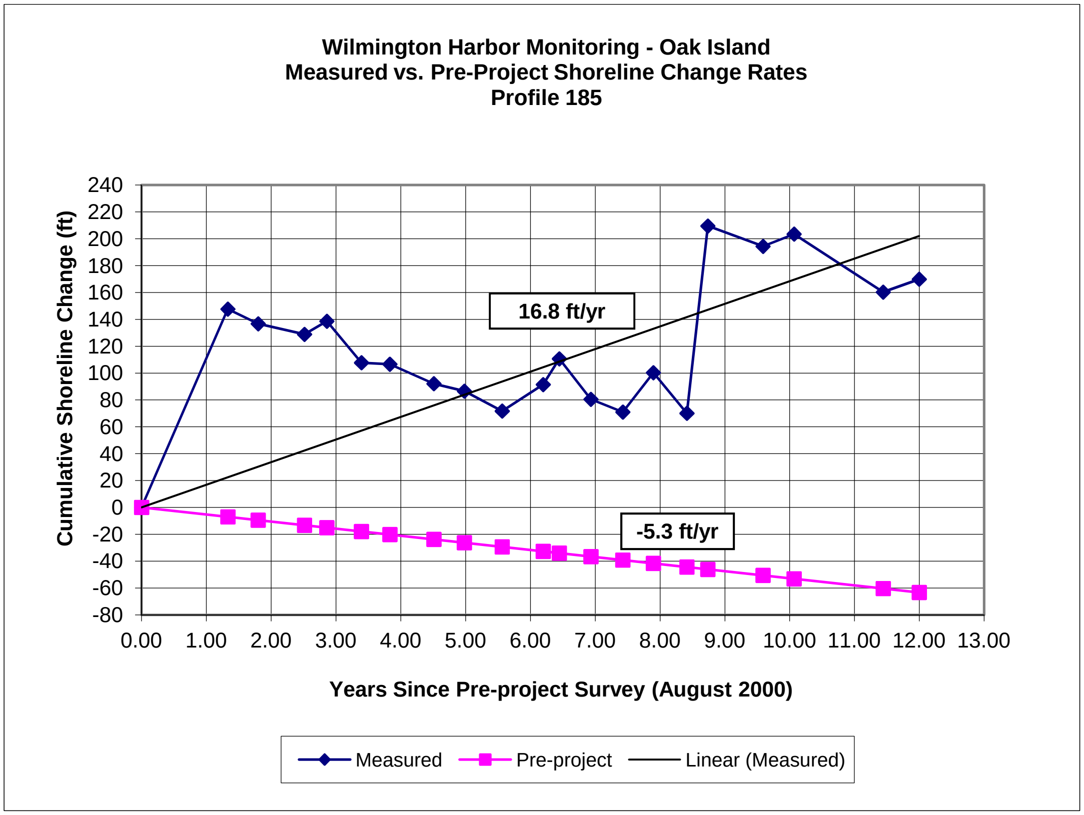

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 160
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
18.5 ft/yr
-3.3 ft/yr
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years 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
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
17.4 ft/yr
-3.9 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

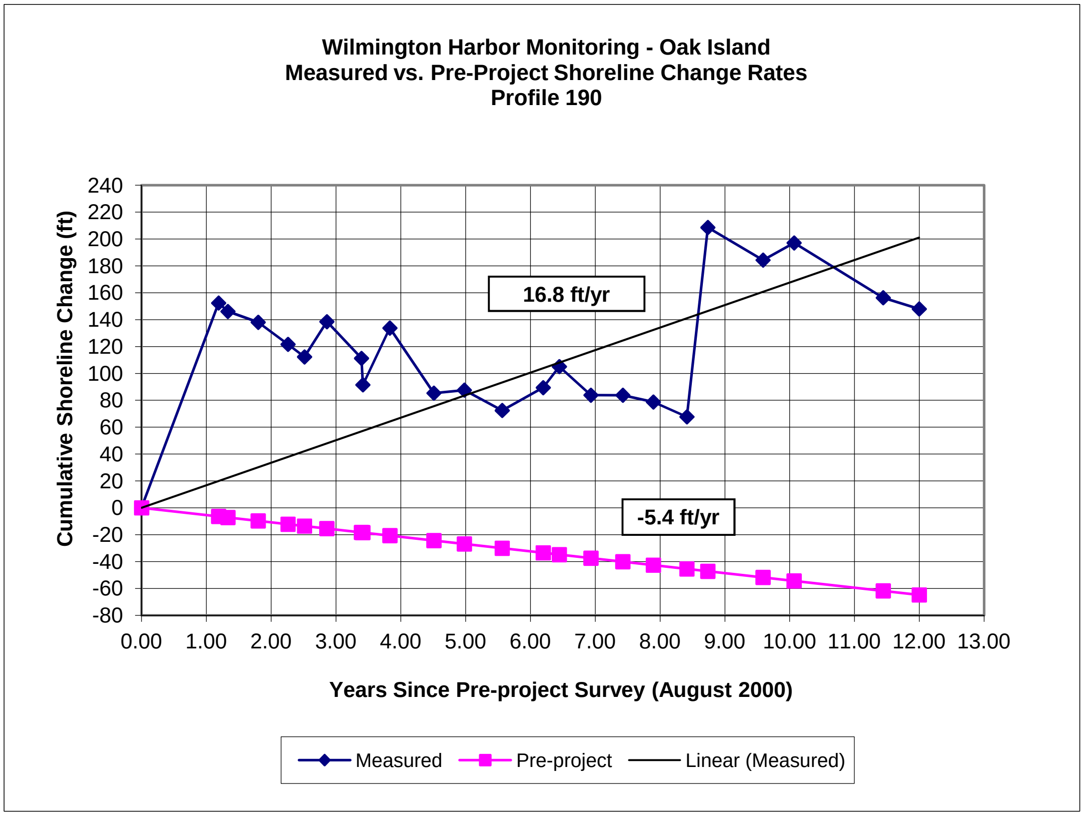

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
Cumulative Shoreline Change (ft)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
19.7 ft/yr
-4.3 ft/yr
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 175
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
18.9 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 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

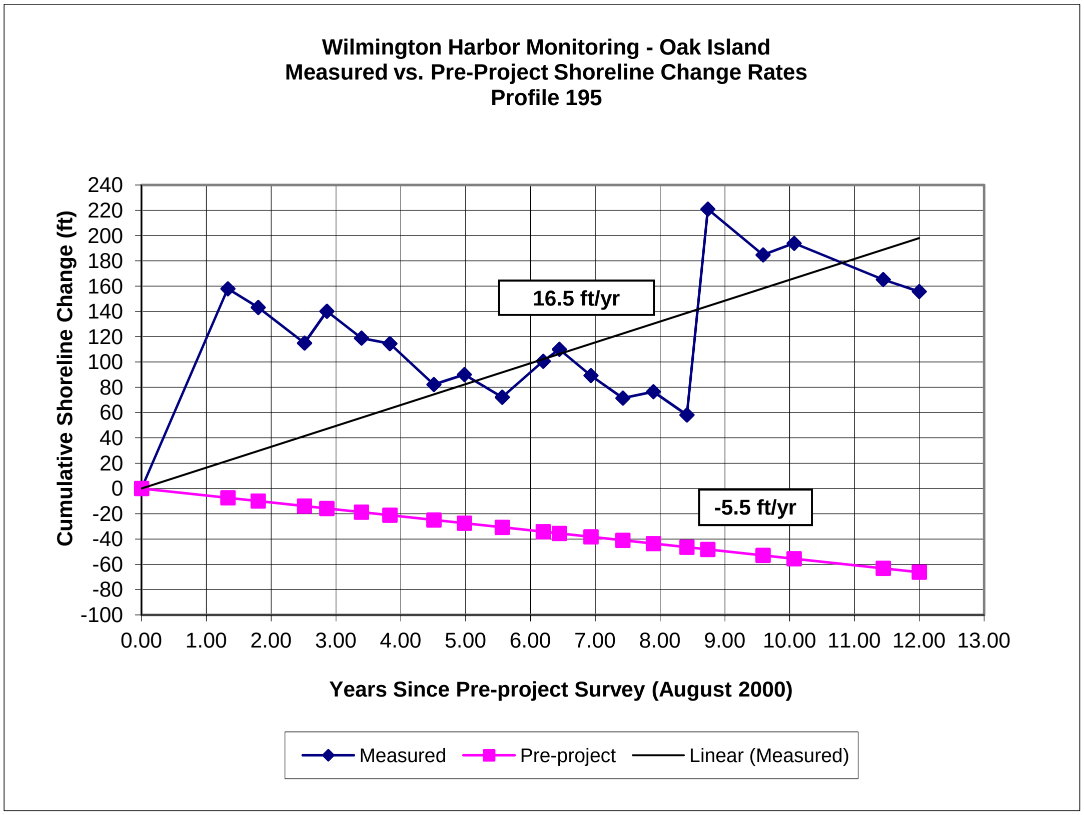

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 180
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
15.5 ft/yr
-5.0 ft/yr
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)



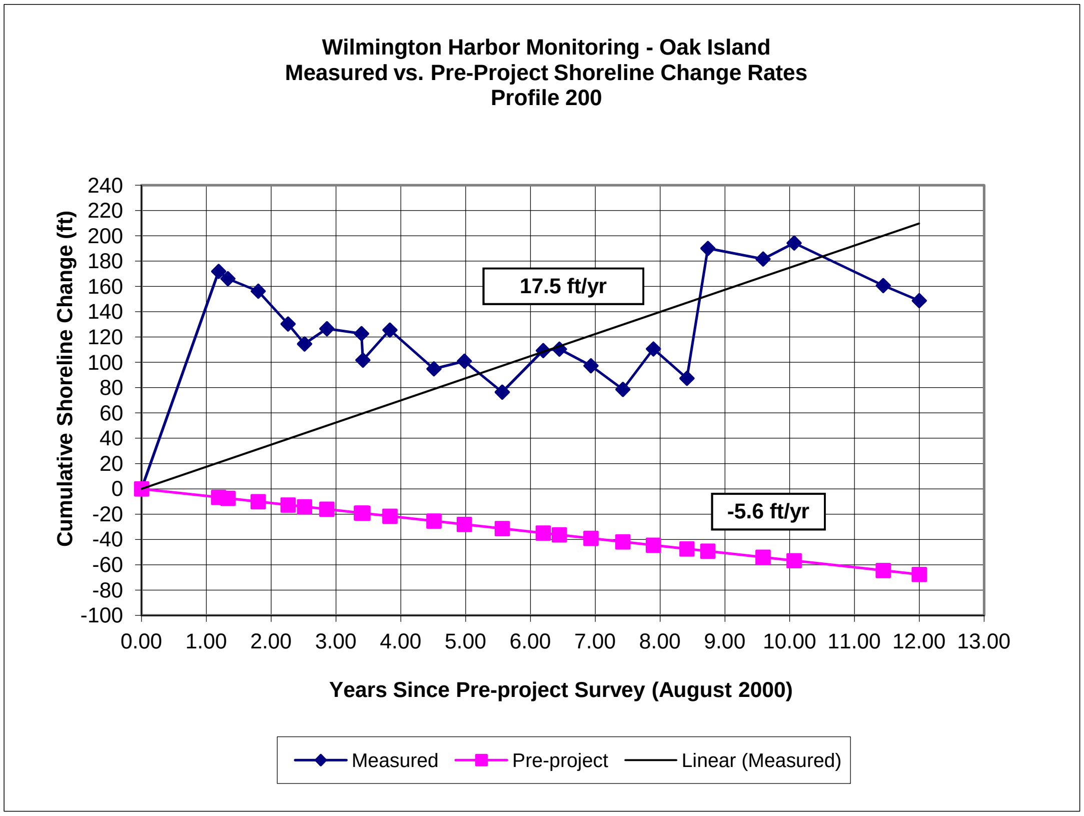
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 185
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
16.8 ft/yr
-5.3 ft/yr
Measured
Pre-project
Linear (Measured)



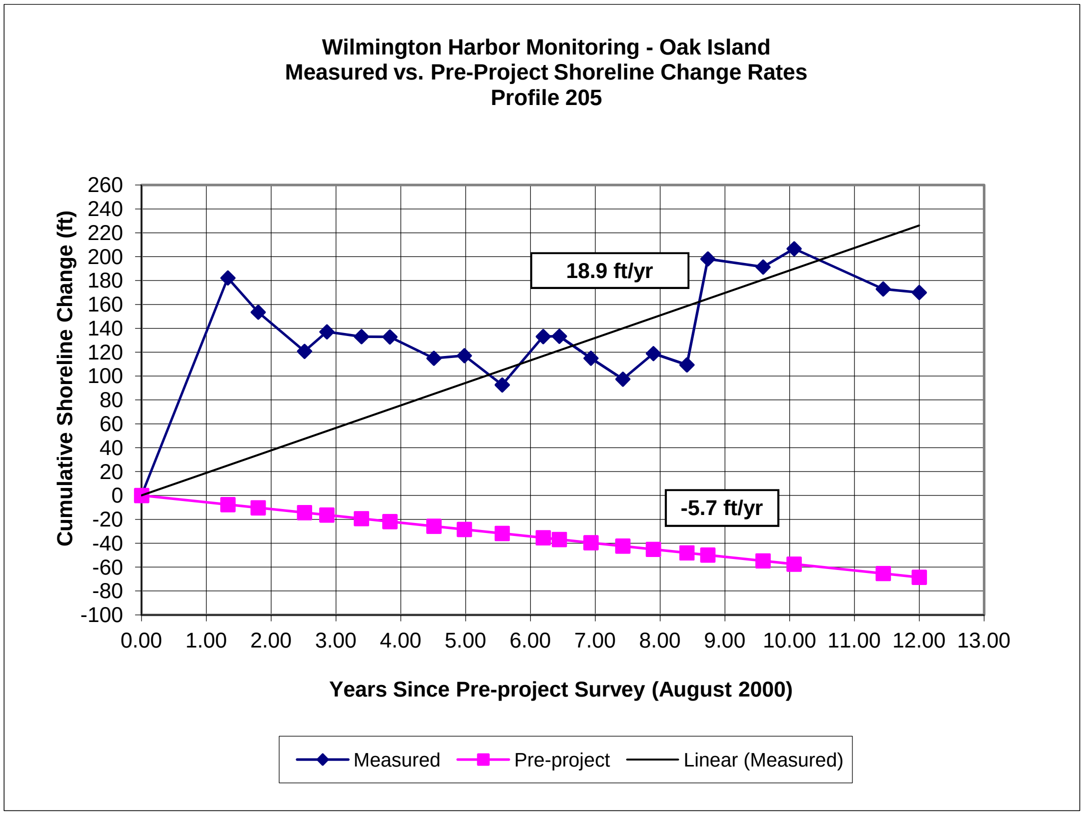
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
16.8 ft/yr
-5.4 ft/yr
Measured
Pre-project
Linear (Measured)

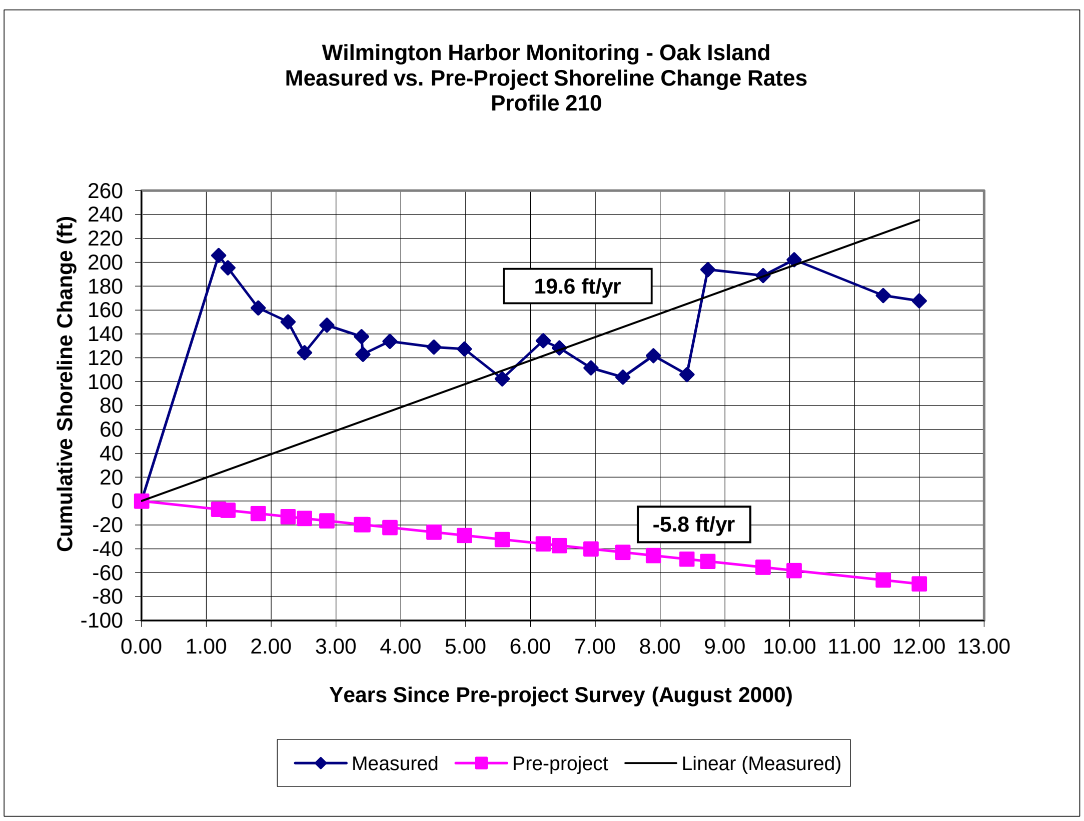


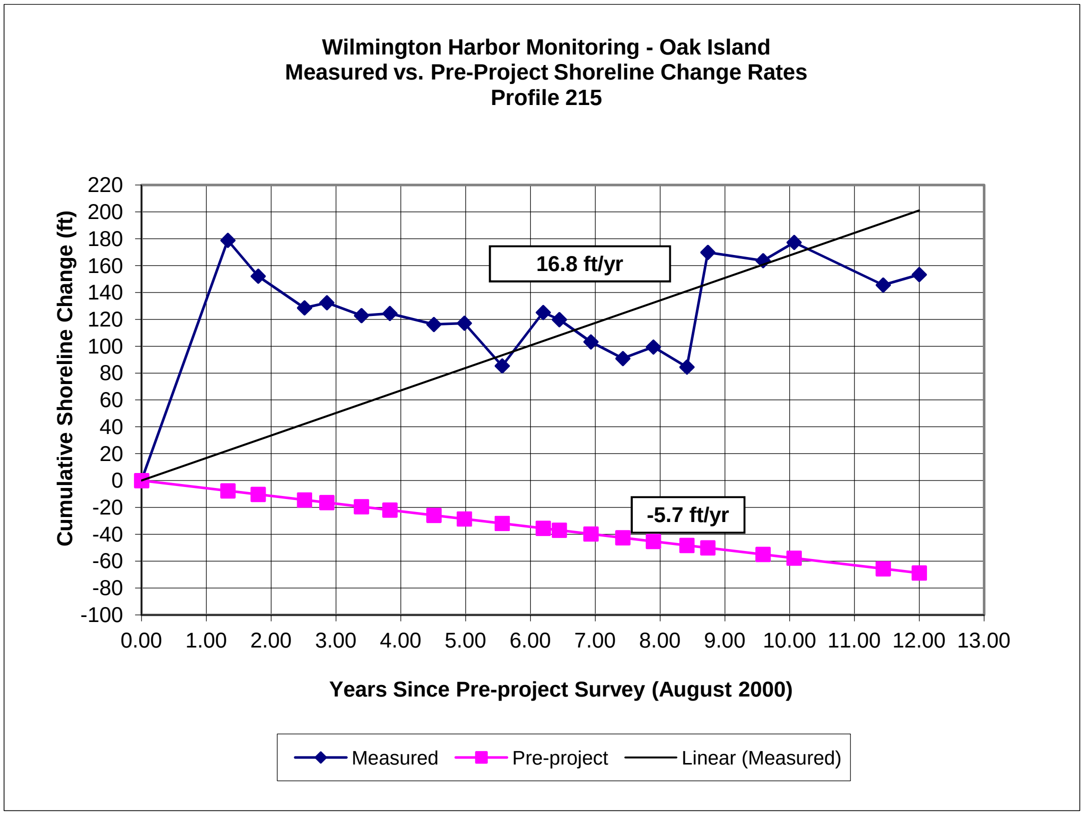
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 195
16.5 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

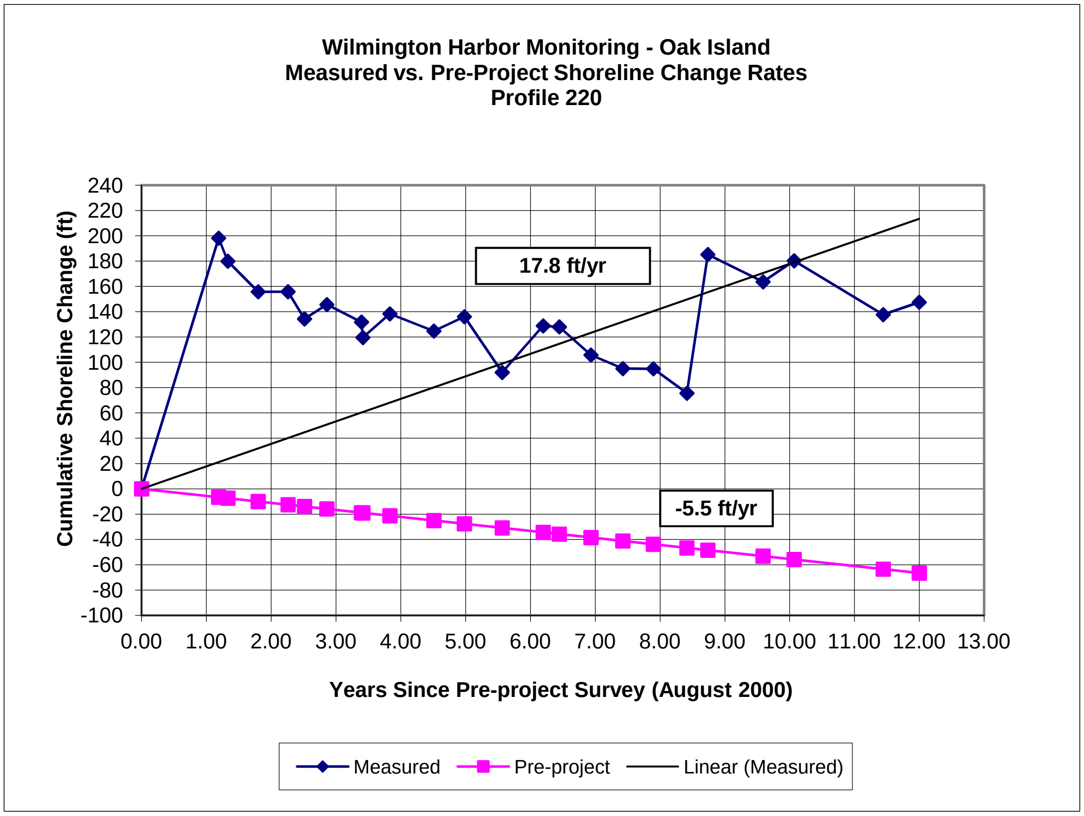


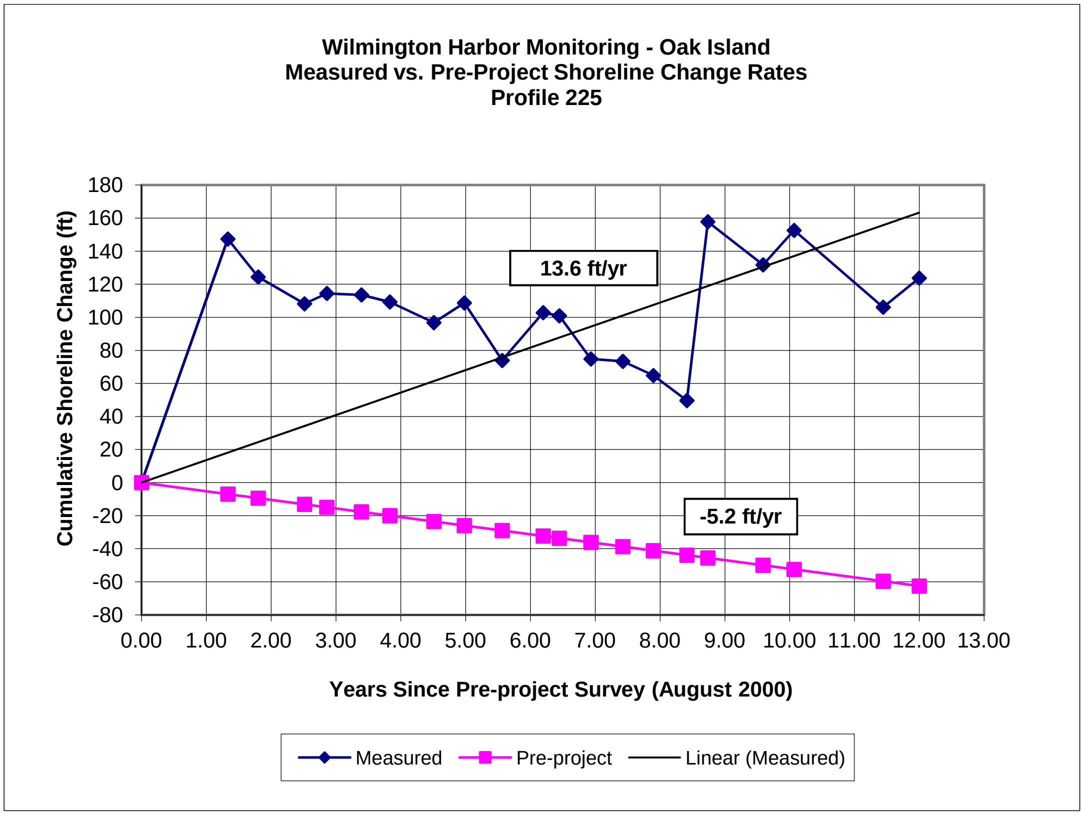
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 200
17.5 ft/yr
-5.6 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

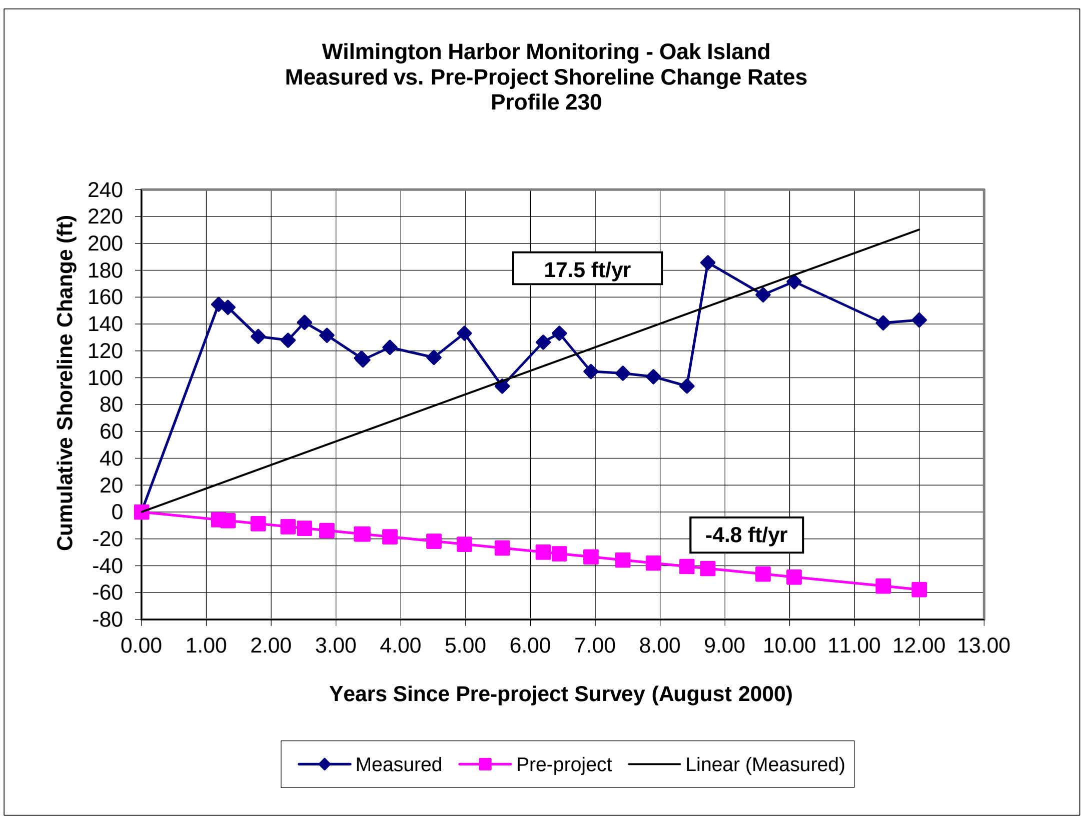

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 205
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
18.9 ft/yr
-5.7 ft/yr
Measured
Pre-project
Linear (Measured)

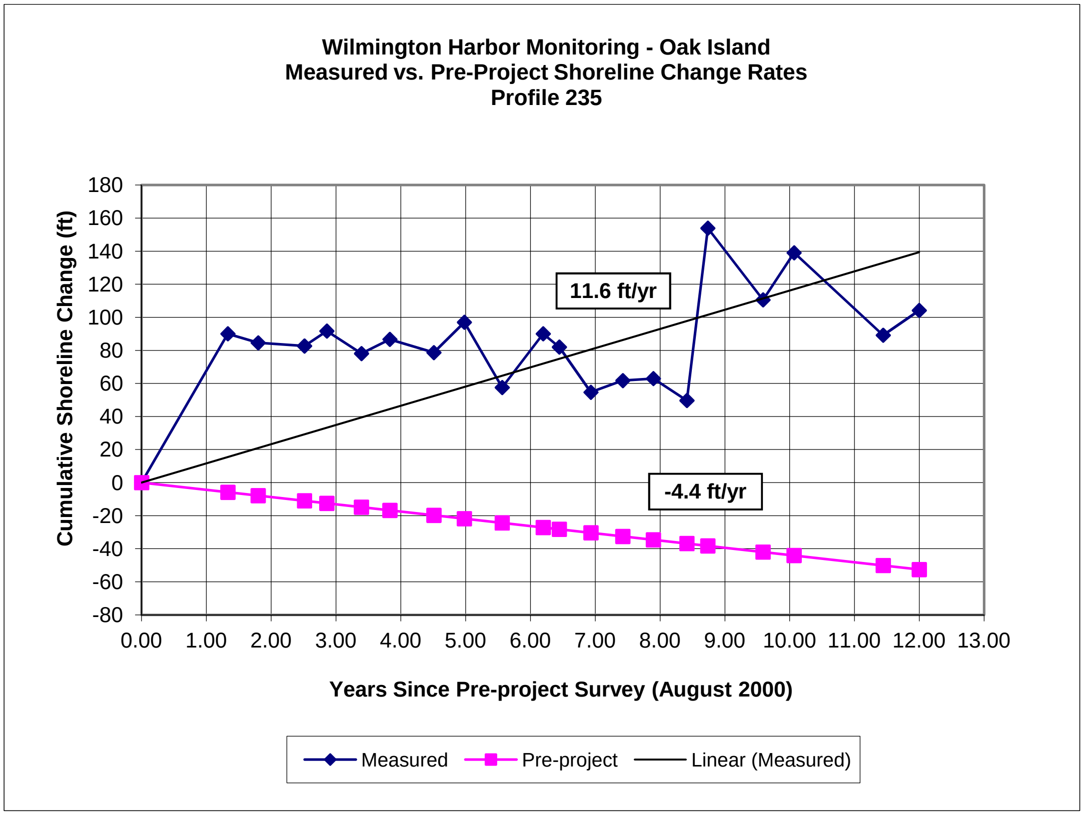

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
19.6 ft/yr
-5.8 ft/yr
Measured
Pre-project
Linear (Measured)

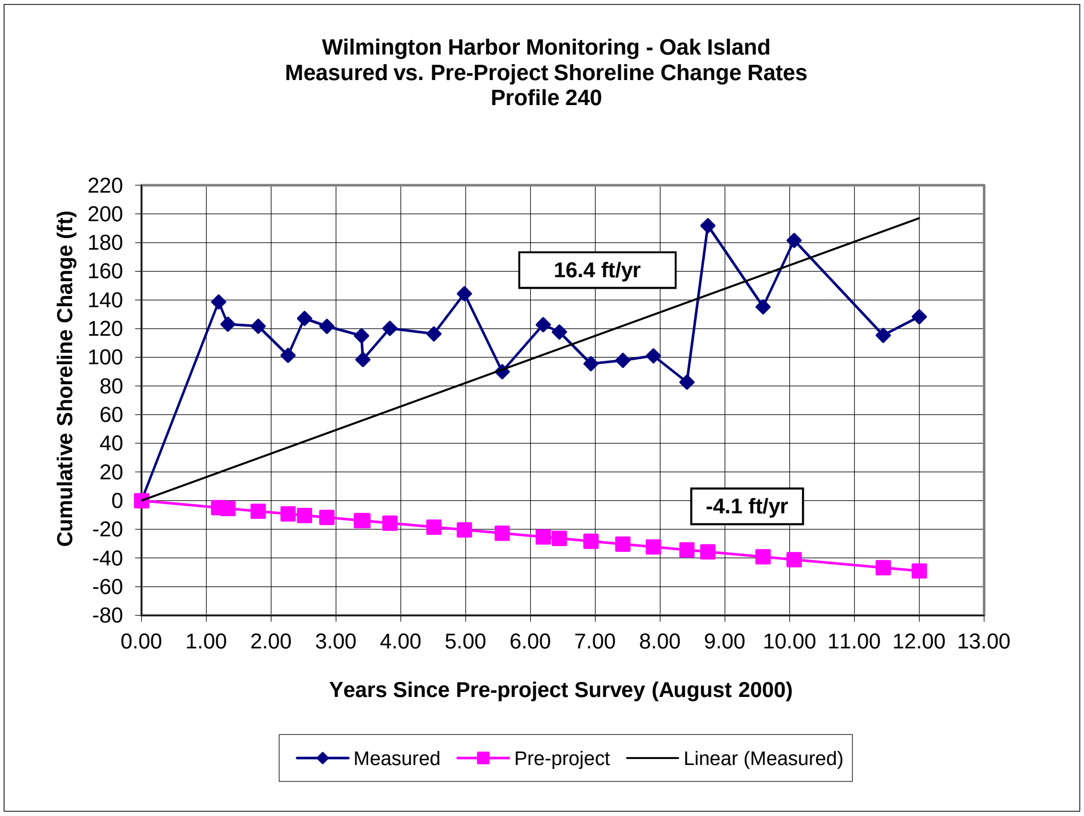

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 215
16.8 ft/yr
-5.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

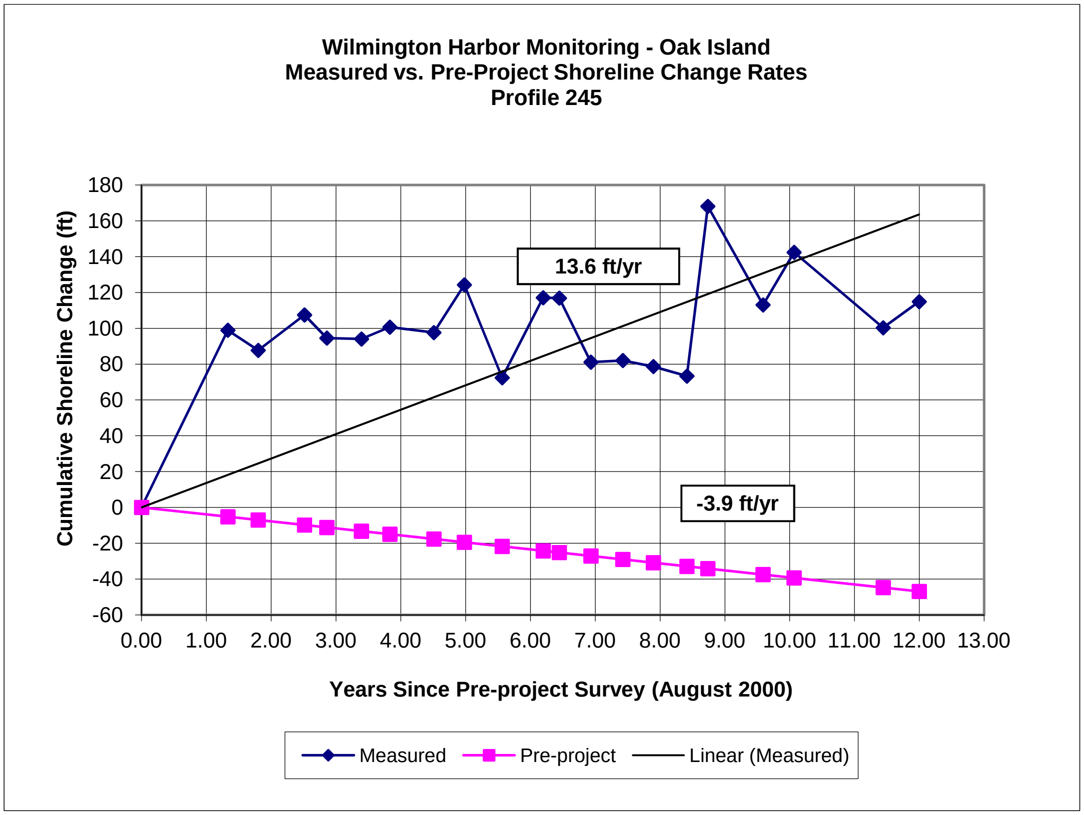

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 220
17.8 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

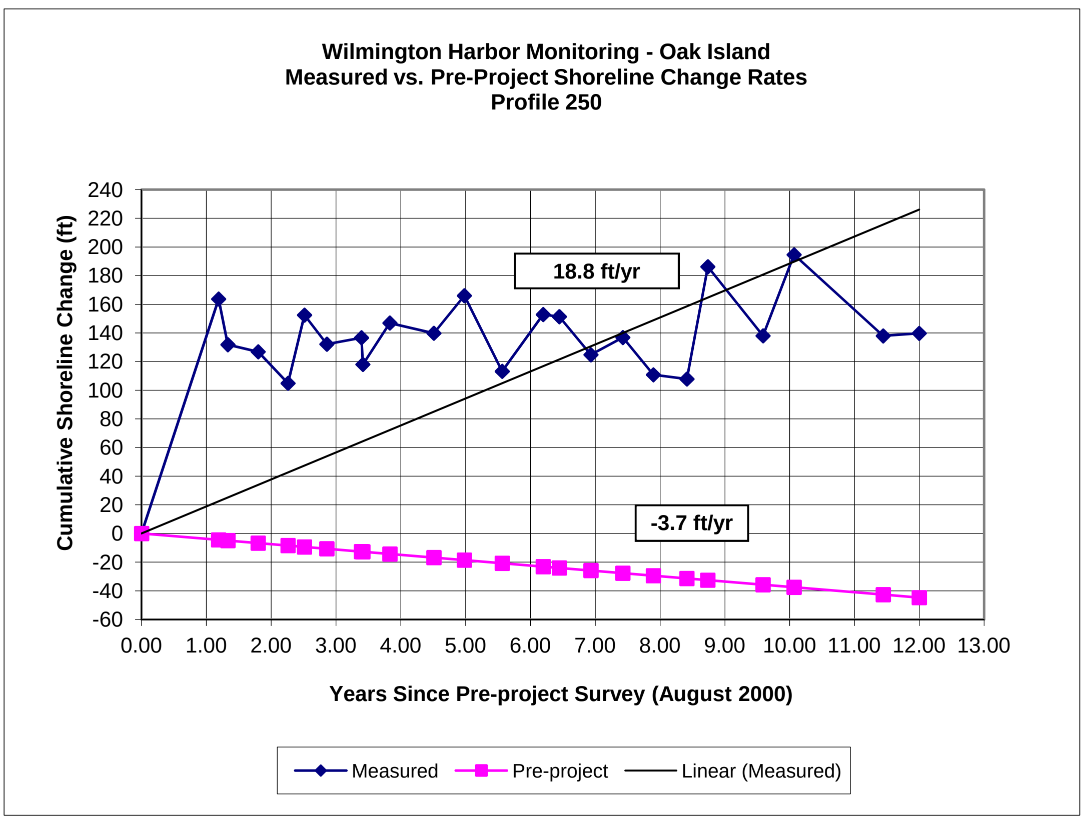

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 225
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
13.6 ft/yr
-5.2 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

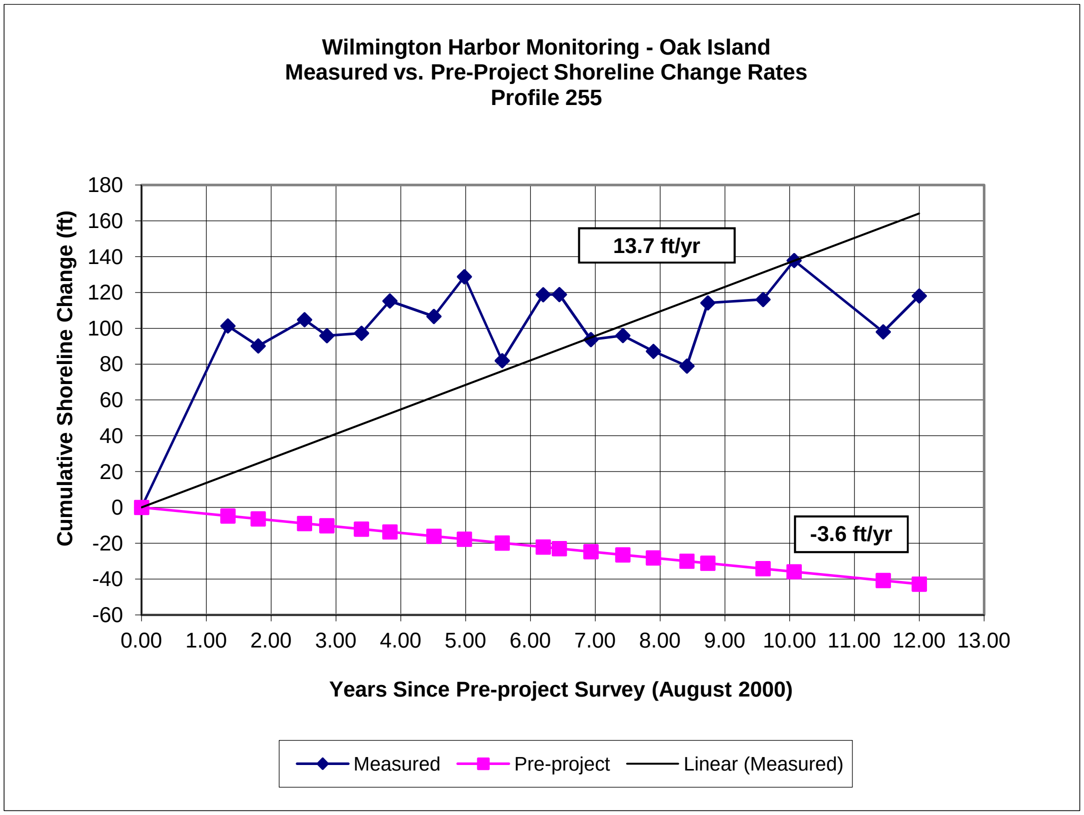

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 230
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
17.5 ft/yr
-4.8 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

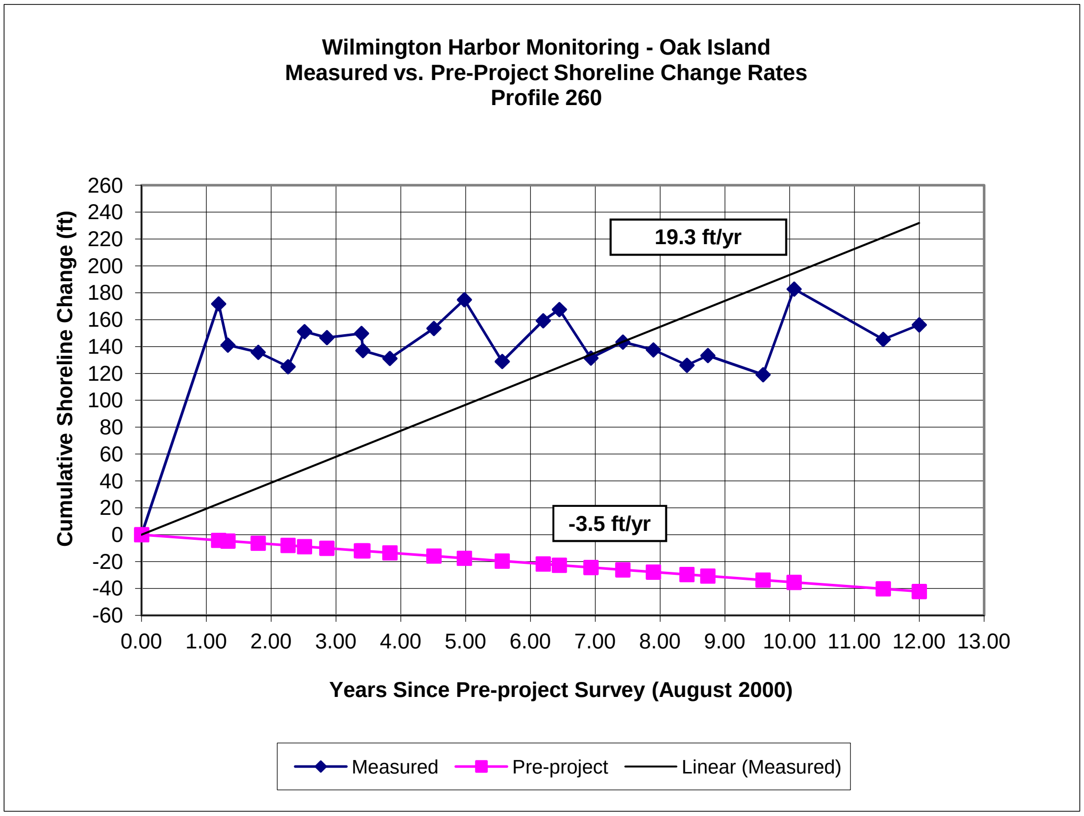

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 235
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
11.6 ft/yr
-4.4 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

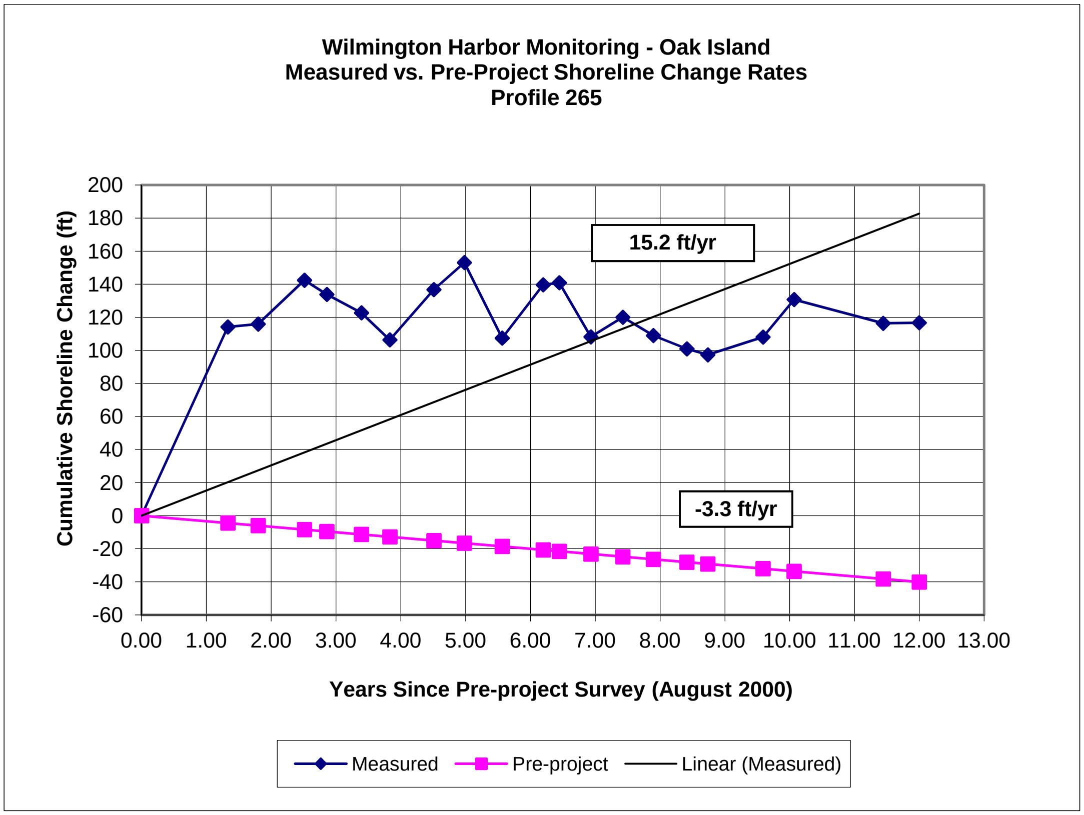

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 240
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
16.4 ft/yr
-4.1 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

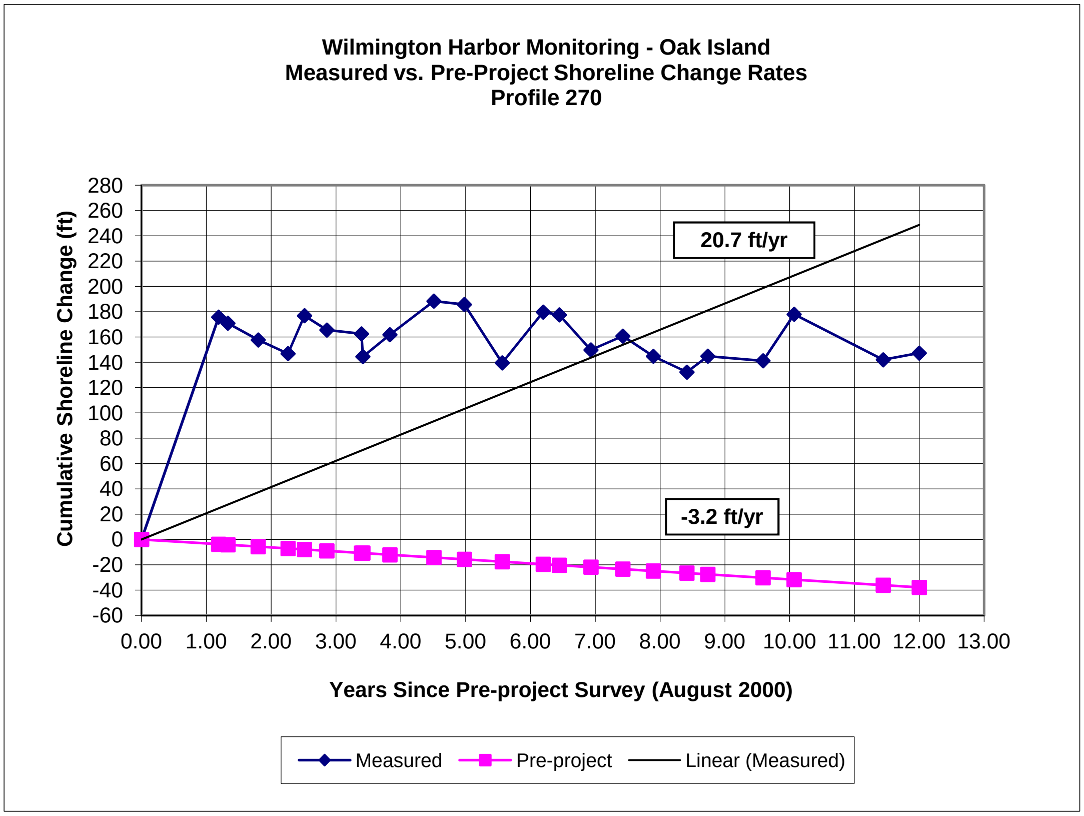

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 245
13.6 ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

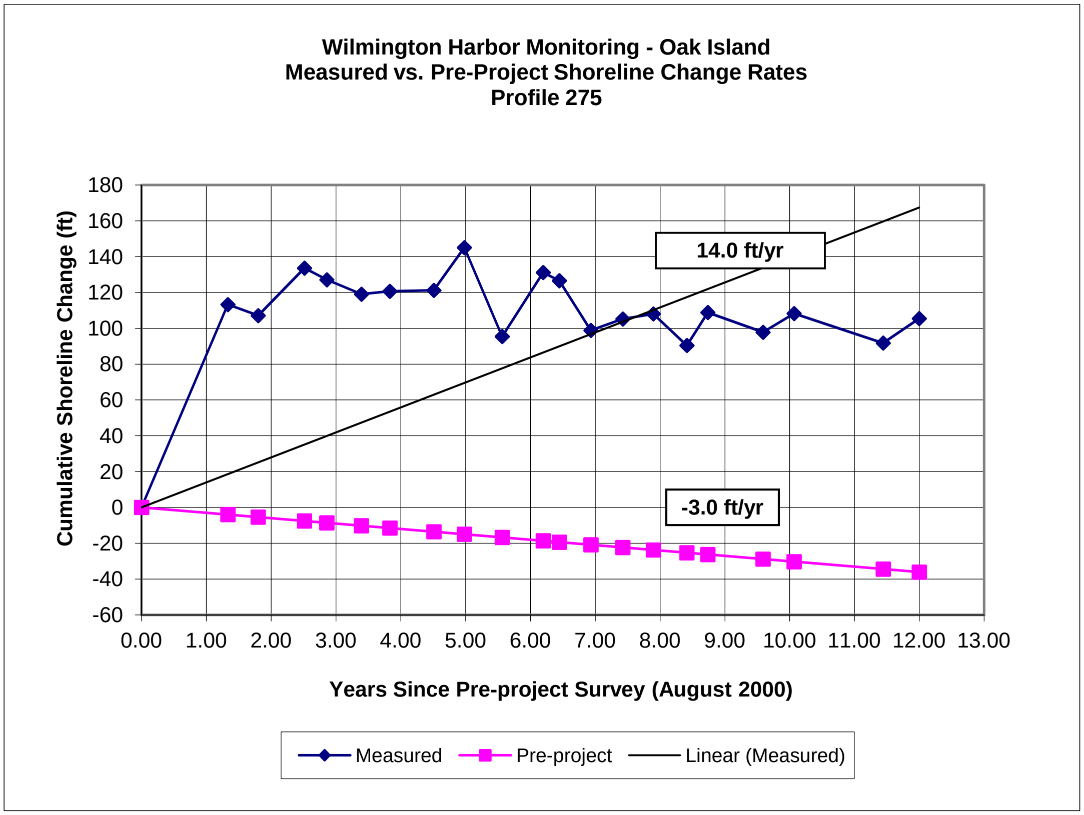

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 250
18.8 ft/yr
-3.7 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

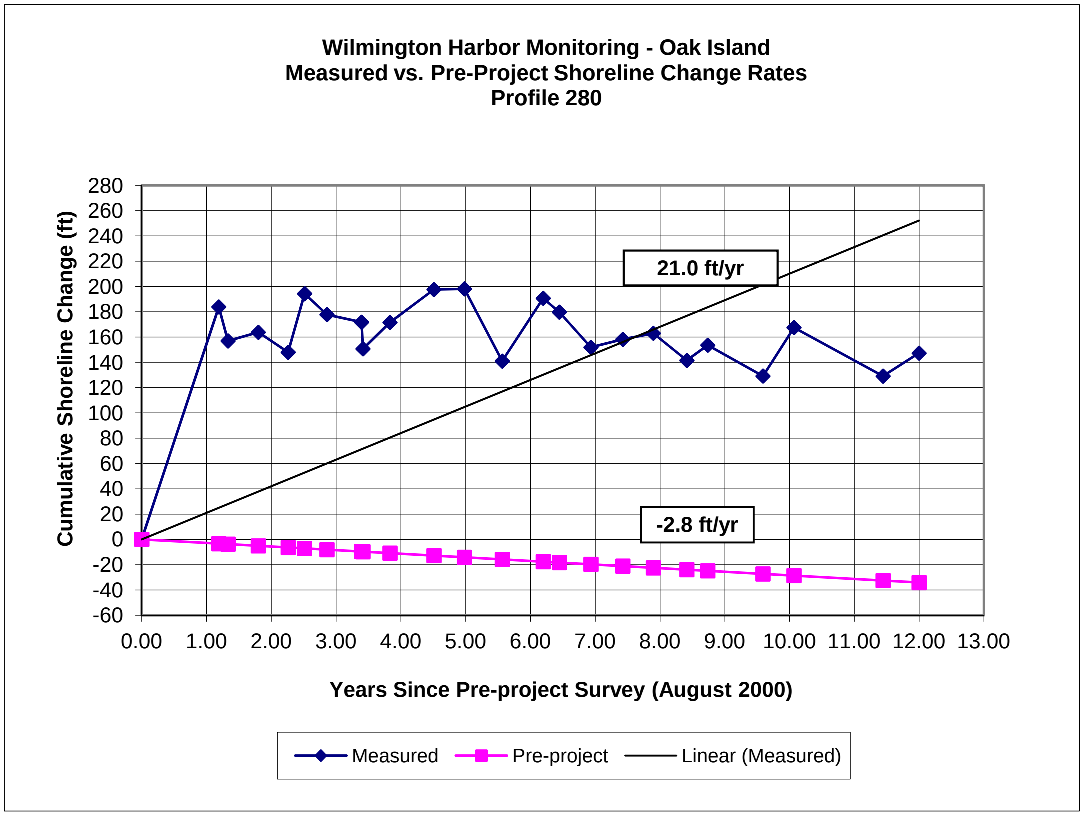

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 255
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
13.7 ft/yr
-3.6 ft/yr
Measured
Pre-project
Linear (Measured)

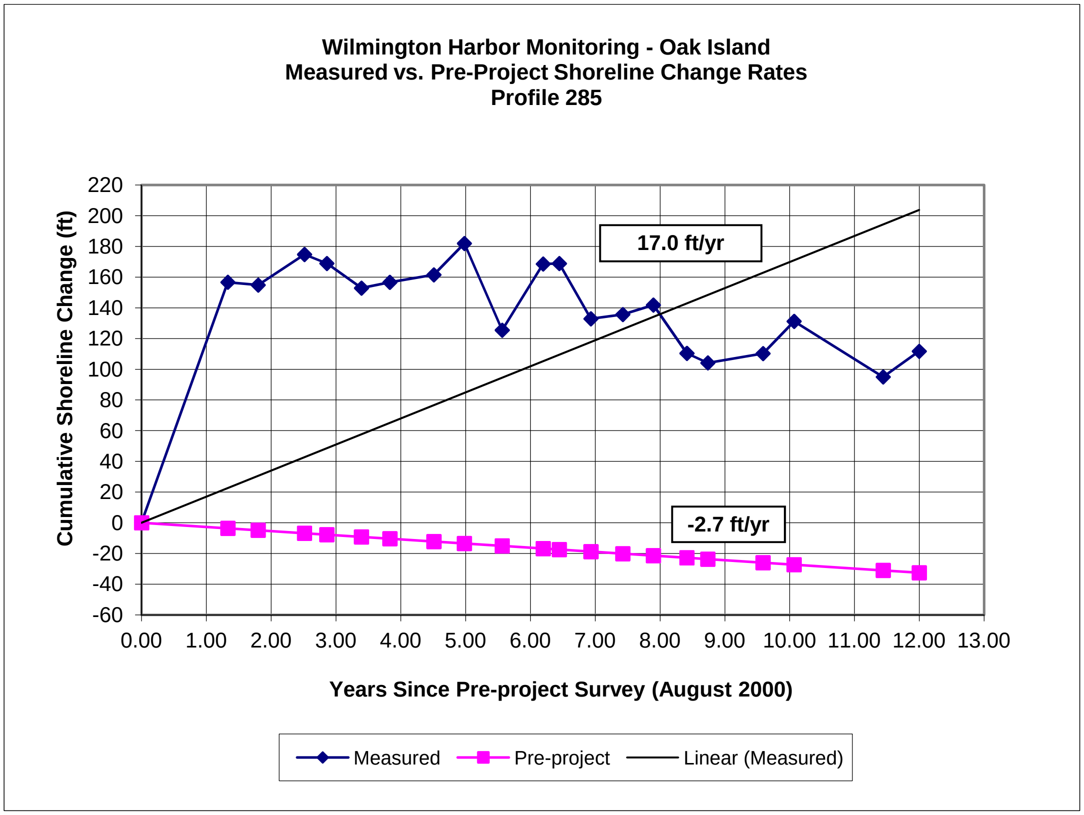

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 260
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
19.3 ft/yr
-3.5 ft/yr
Measured
Pre-project
Linear (Measured)

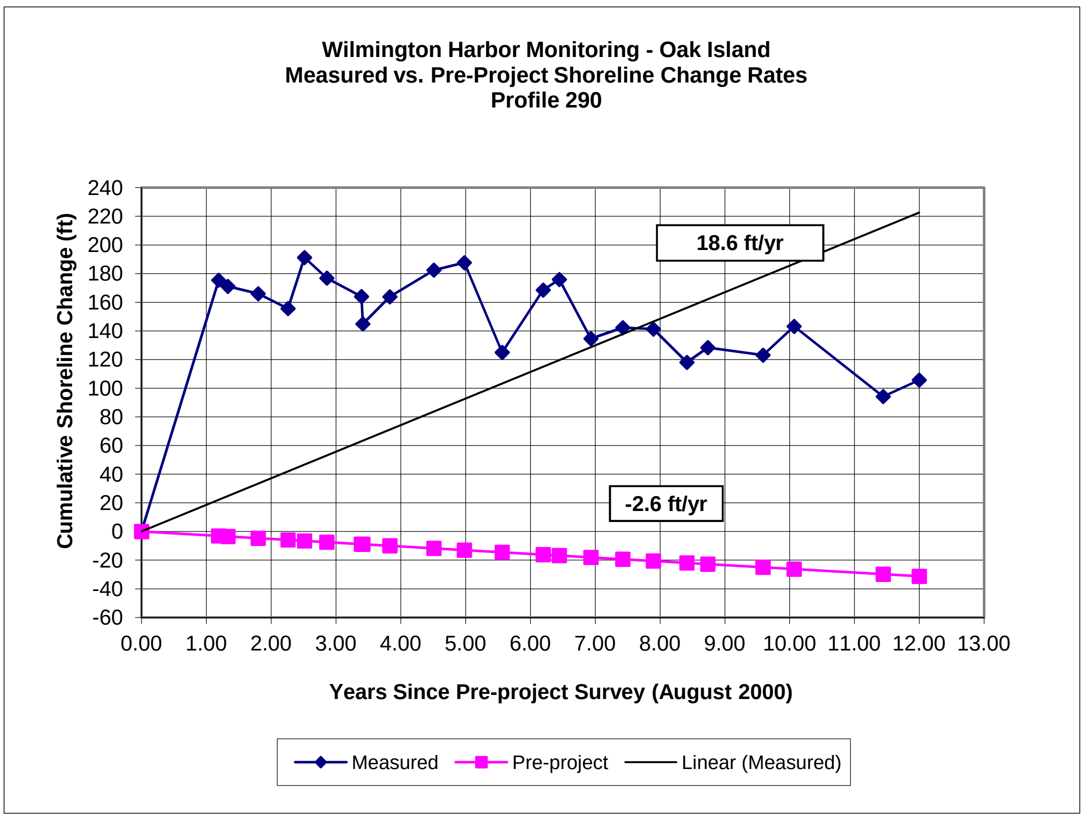

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 265
15.2 ft/yr
-3.3 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

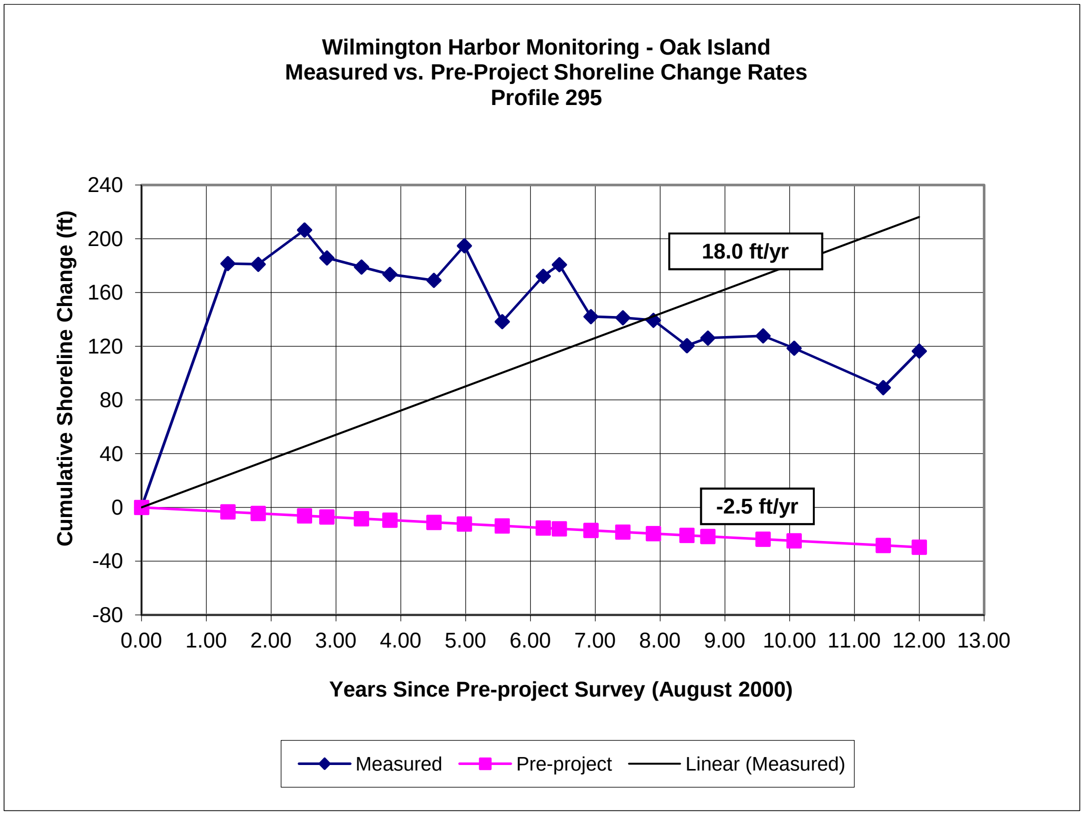

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 270
20.7 ft/yr
-3.2 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

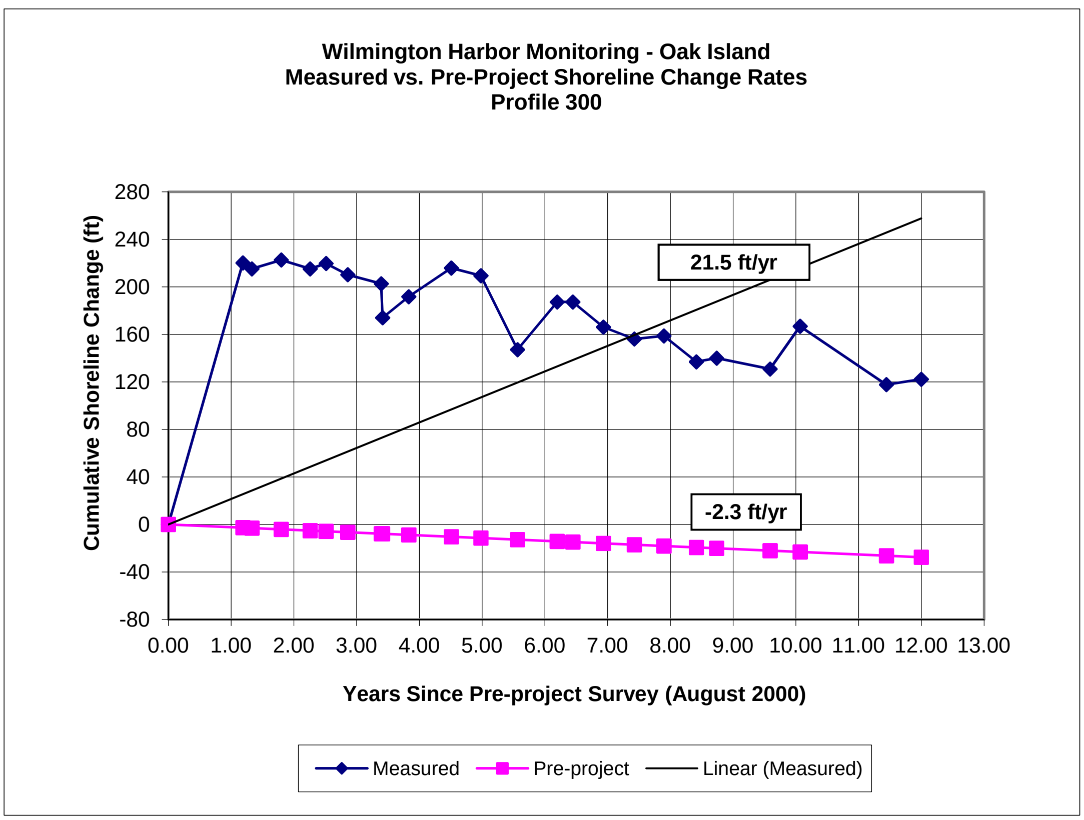

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 275
14.0 ft/yr
-3.0 ft/yr
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

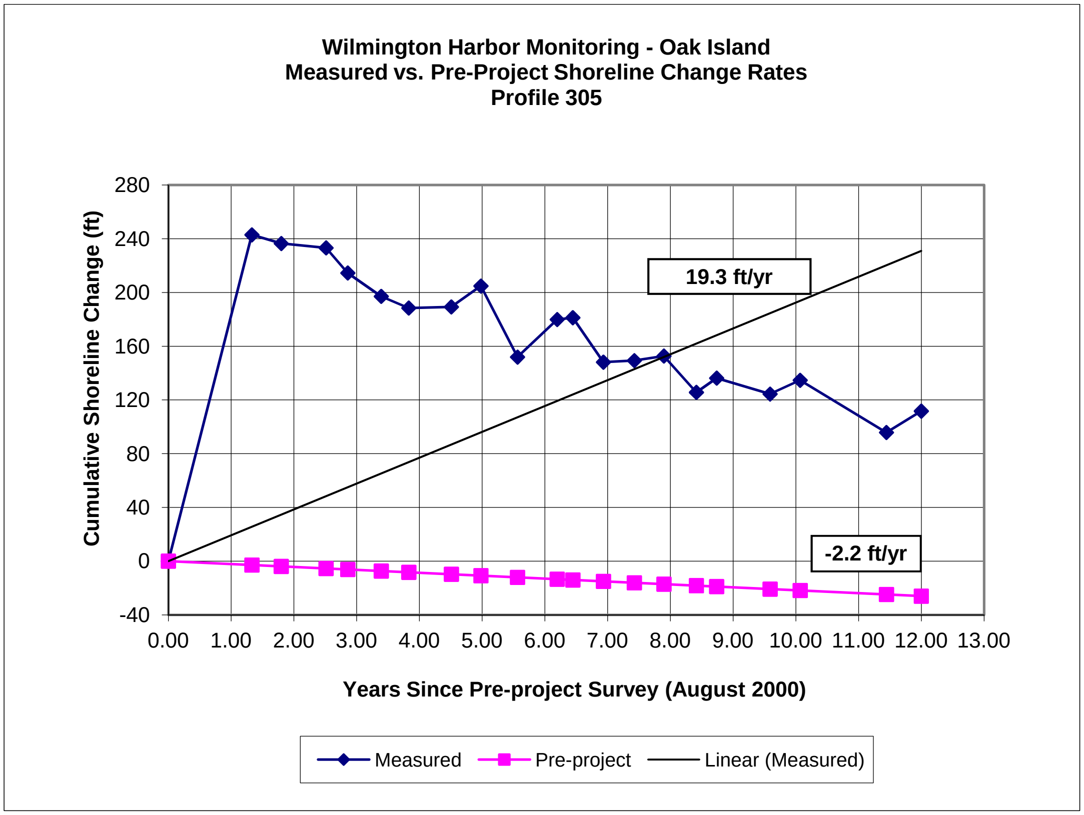

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 280
21.0 ft/yr
-2.8 ft/yr
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 285
17.0 ft/yr
-2.7 ft/yr
Cumulative Shoreline Change (ft)
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 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

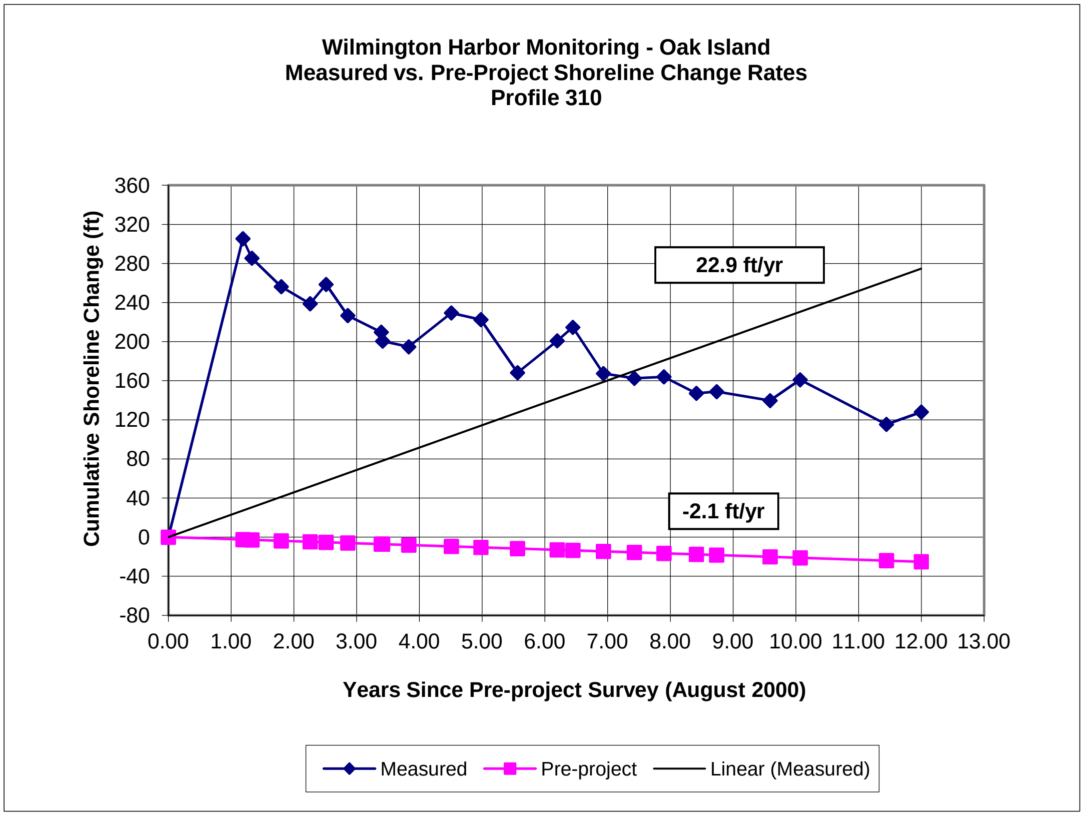

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 290
18.6 ft/yr
-2.6 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since 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
-80
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
18.0 ft/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
-80
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
21.5 ft/yr
-2.3 ft/yr
Measured
Pre-project
Linear (Measured)



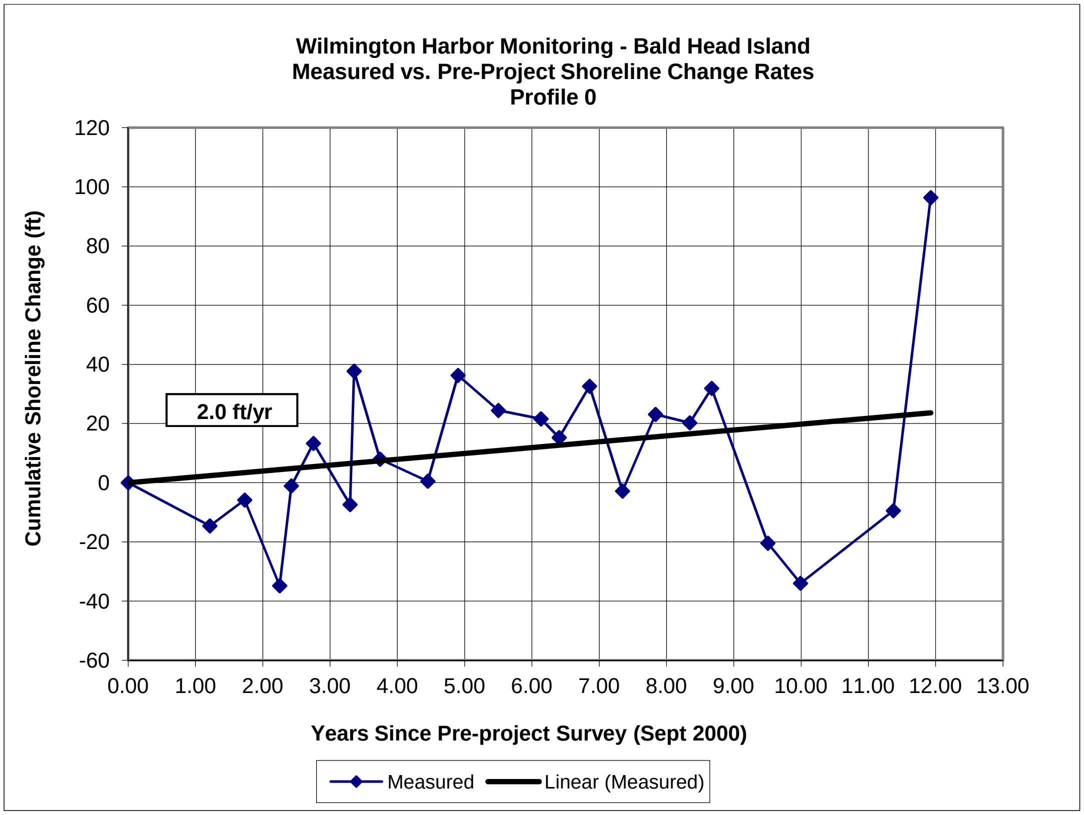
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 305
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
19.3 ft/yr
-2.2 ft/yr
Measured
Pre-project
Linear (Measured)

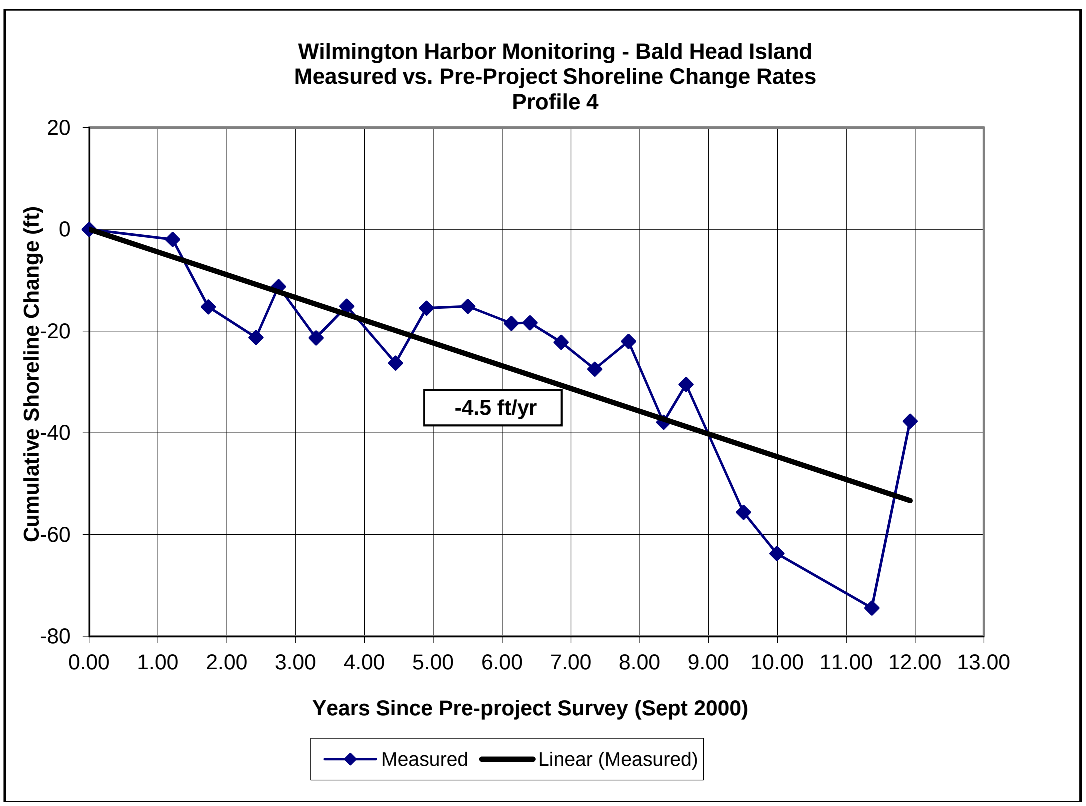


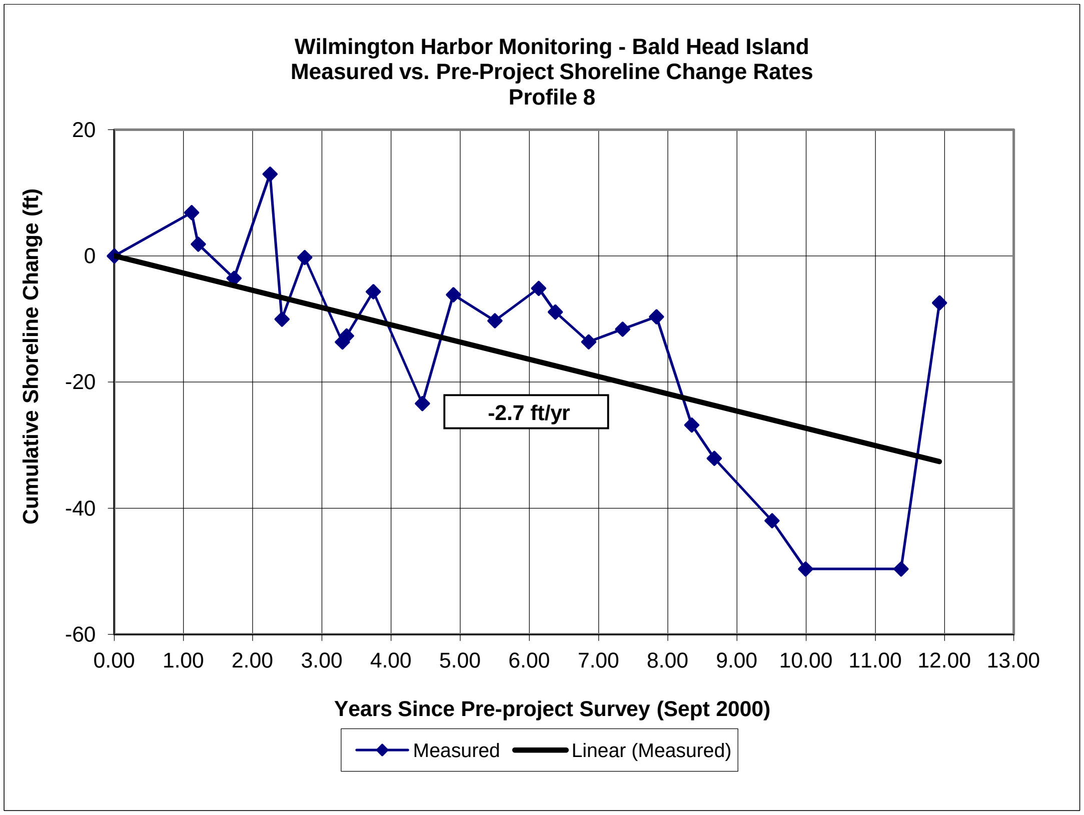
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 310
Cumulative Shoreline Change (ft)
360
320
280
240
200
160
120
80
40
0
-40
-80
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (August 2000)
22.9 ft/yr
-2.1 ft/yr
Measured
Pre-project
Linear (Measured)

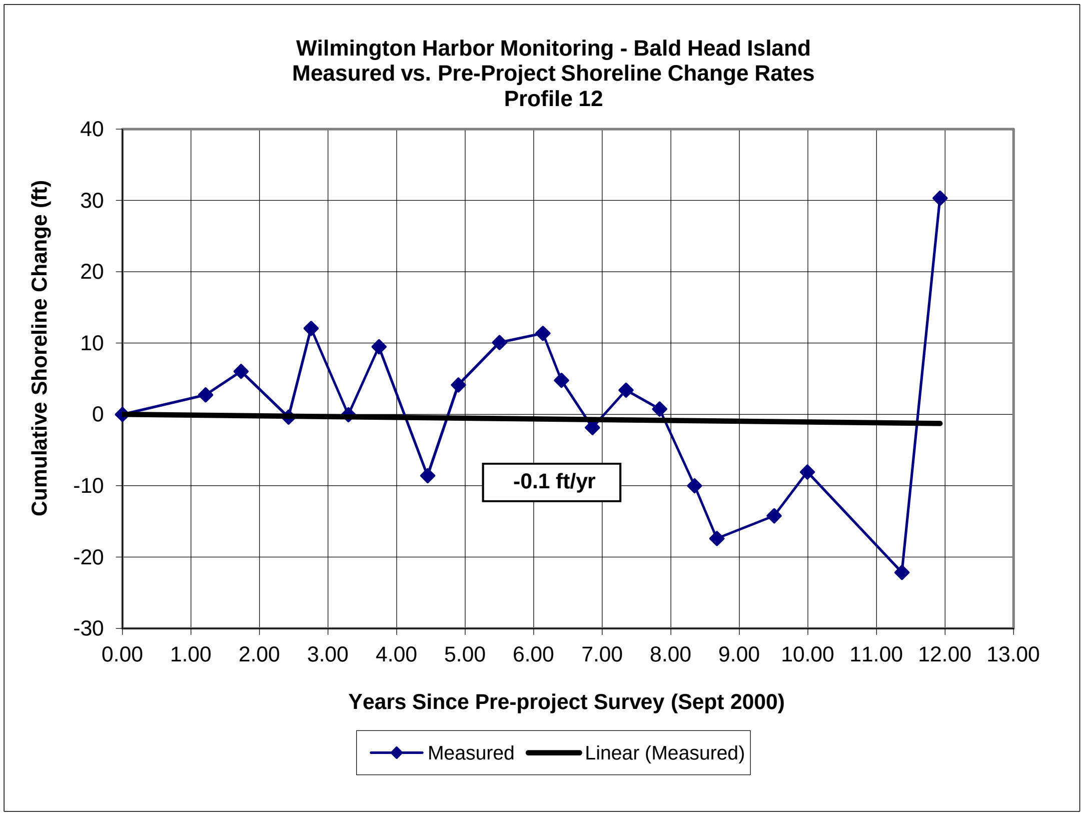
Appendix B

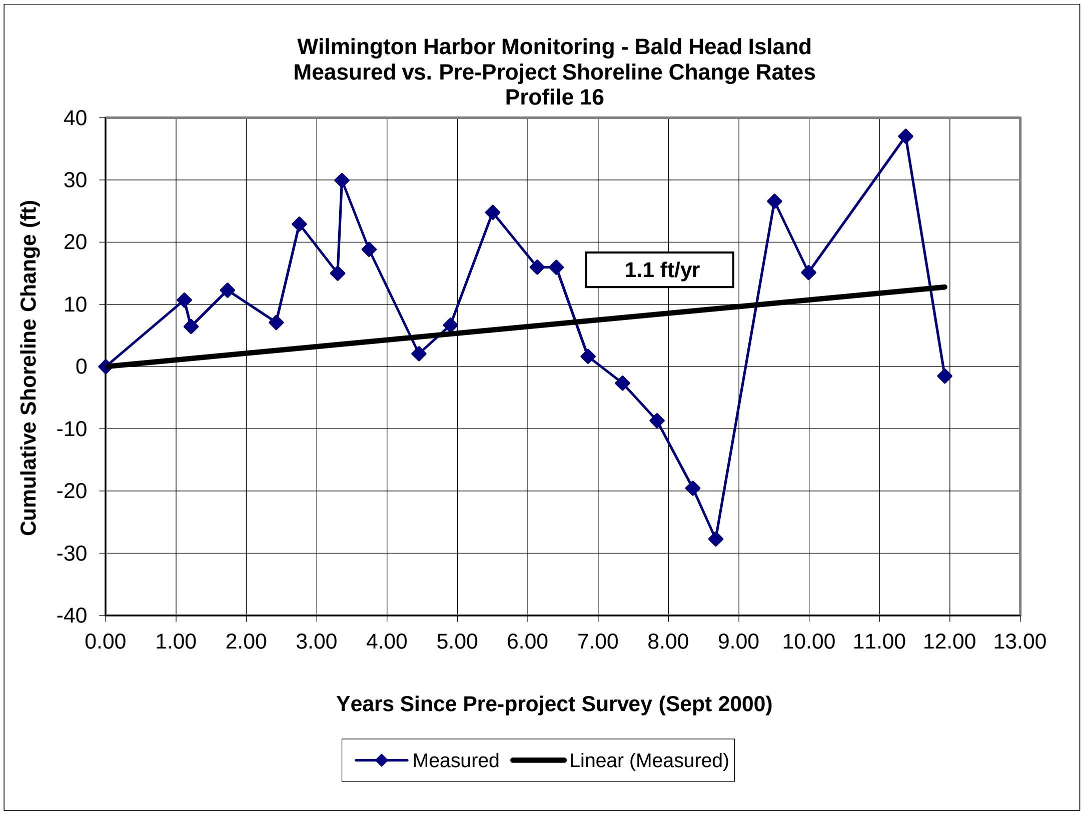
SHORELINE CHANGE RATES
(Bald Head Island)

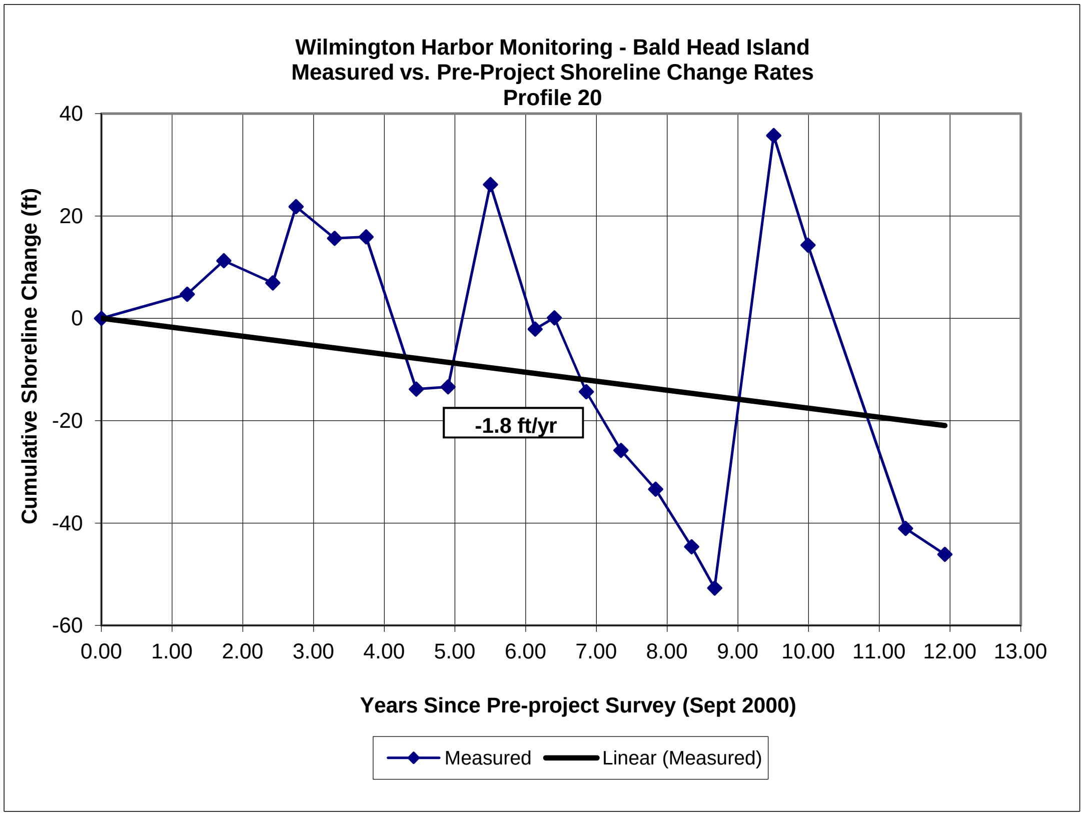

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 0
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
2.0 ft/yr
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

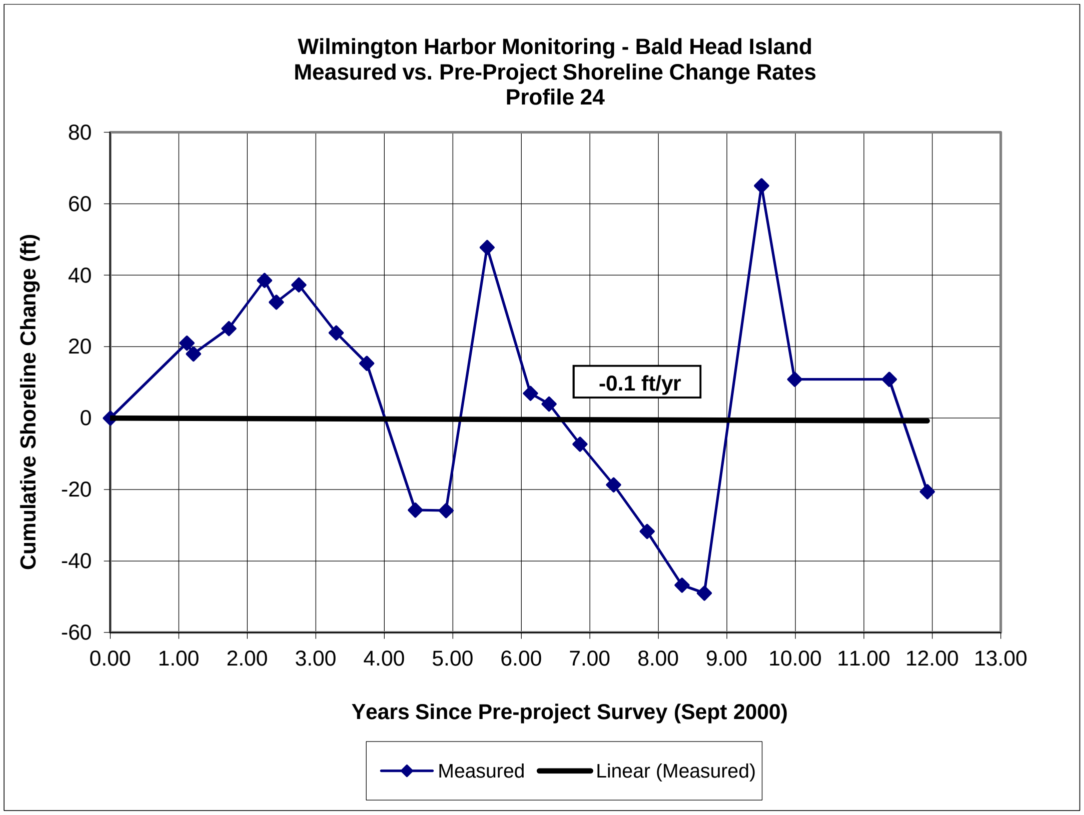

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 4
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-4.5 ft/yr
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

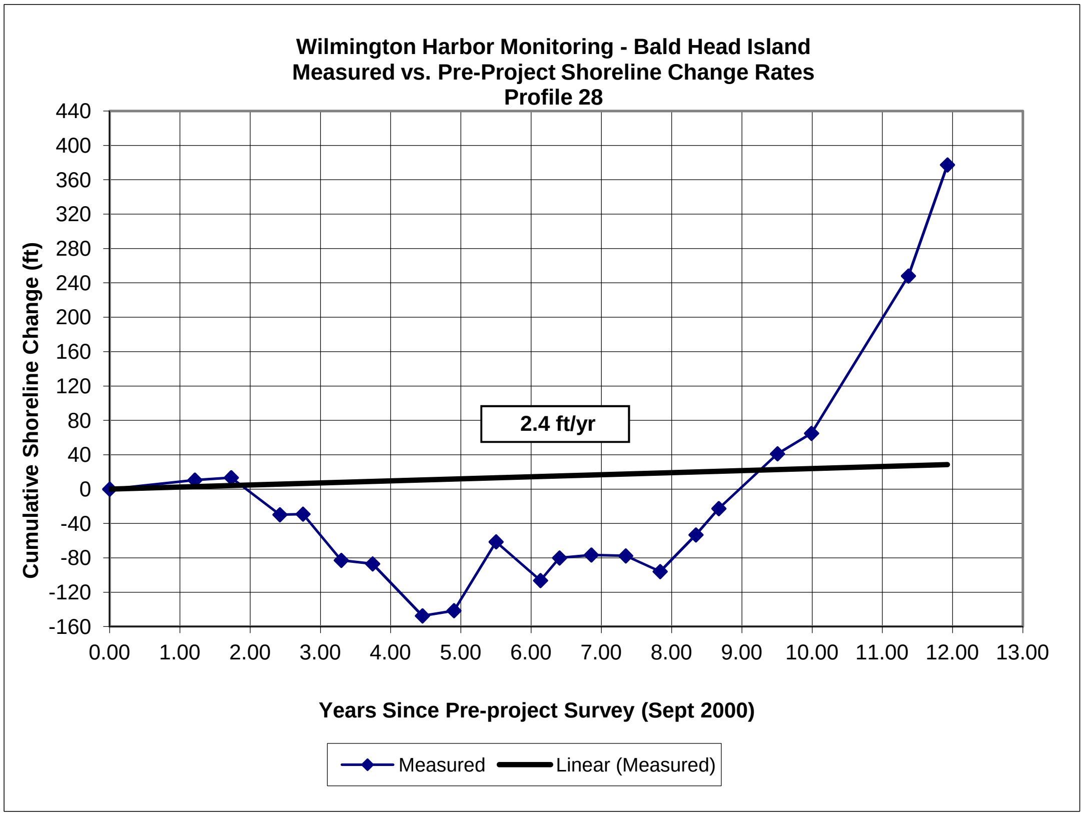

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 8
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-2.7 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

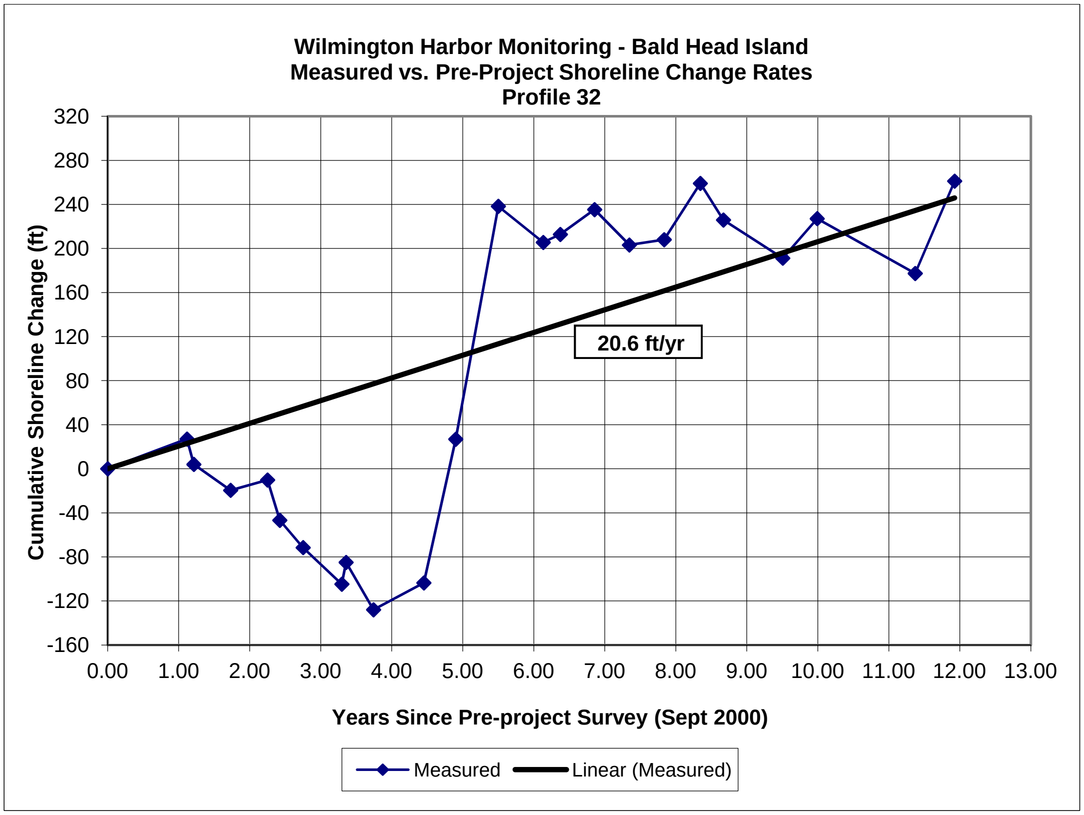

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 12
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-0.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

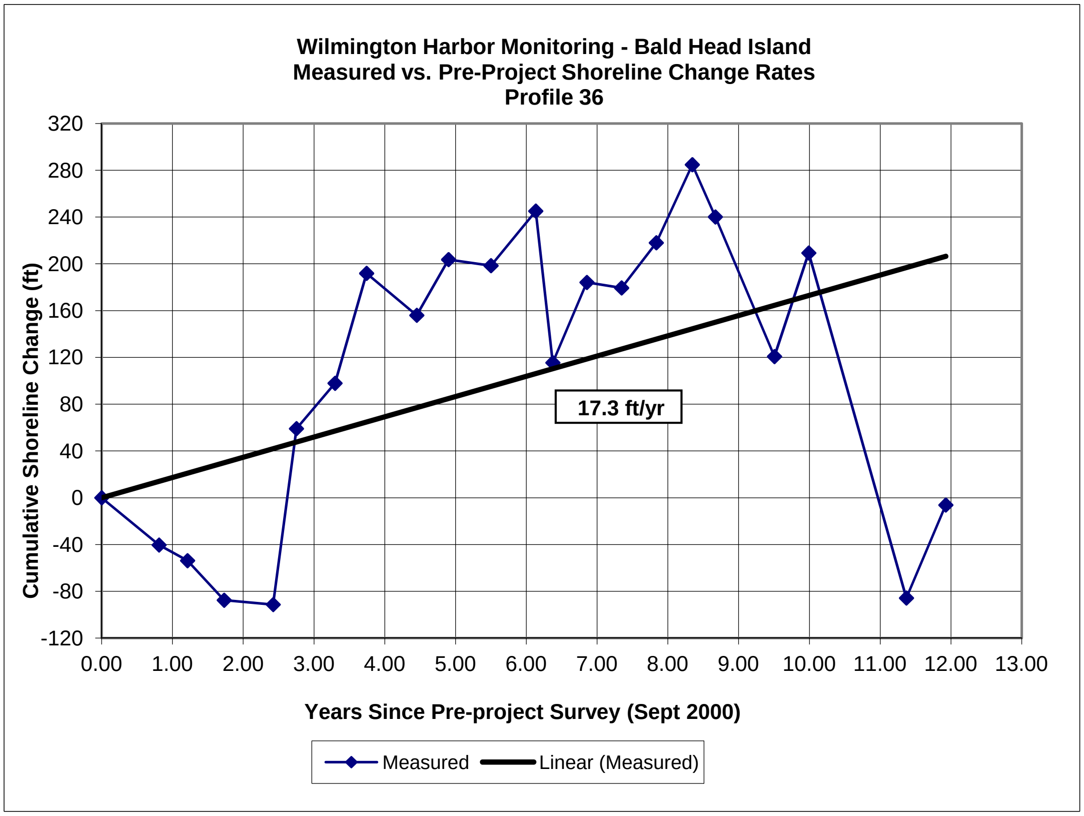

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 16
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
1.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

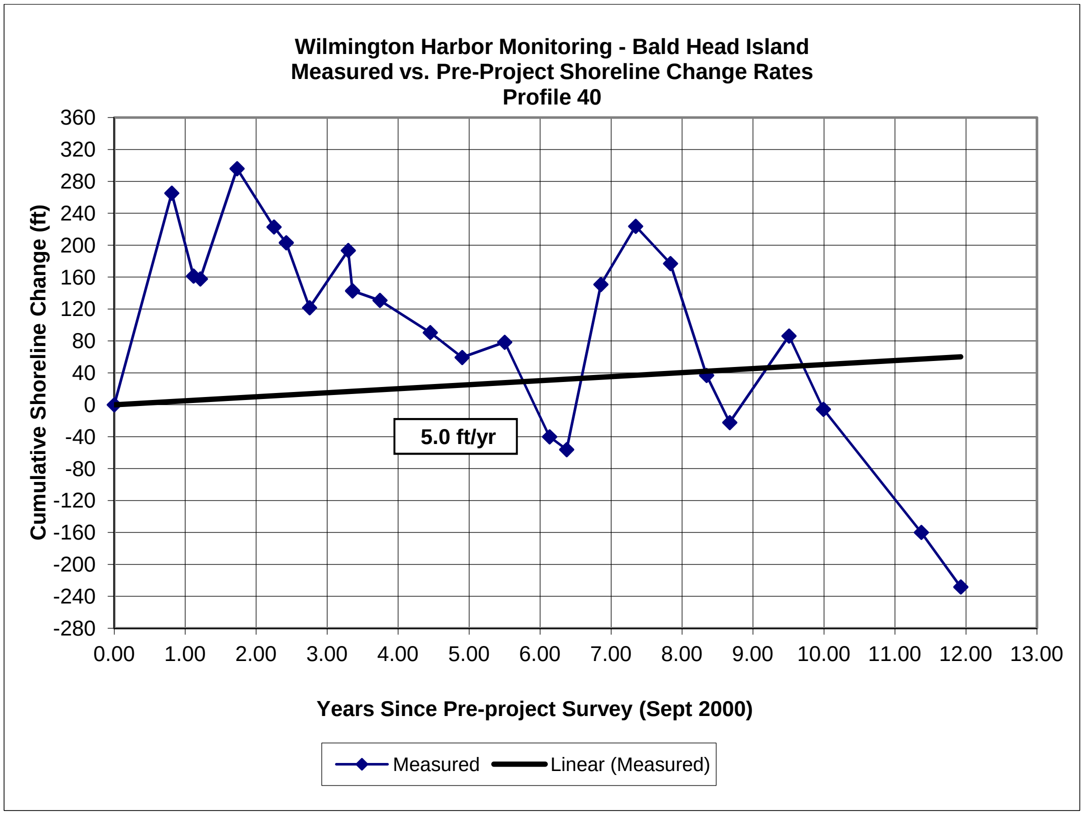

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-1.8 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

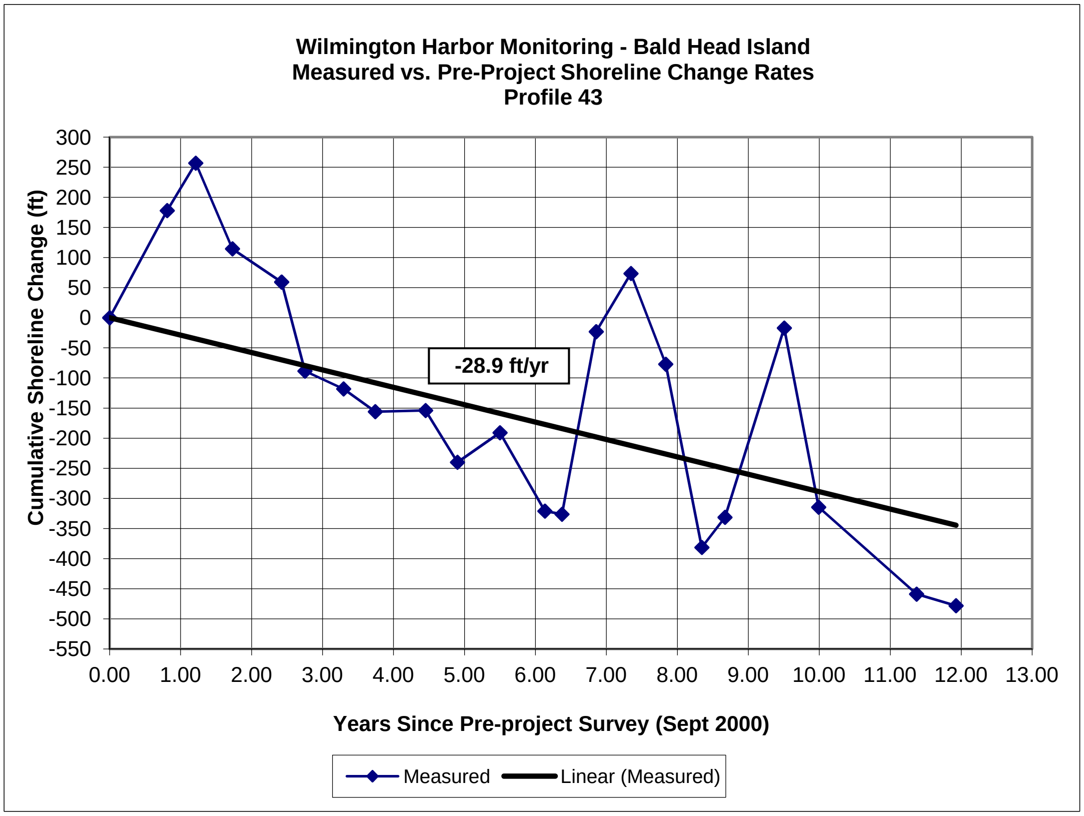

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 24
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
-40
-60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-0.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

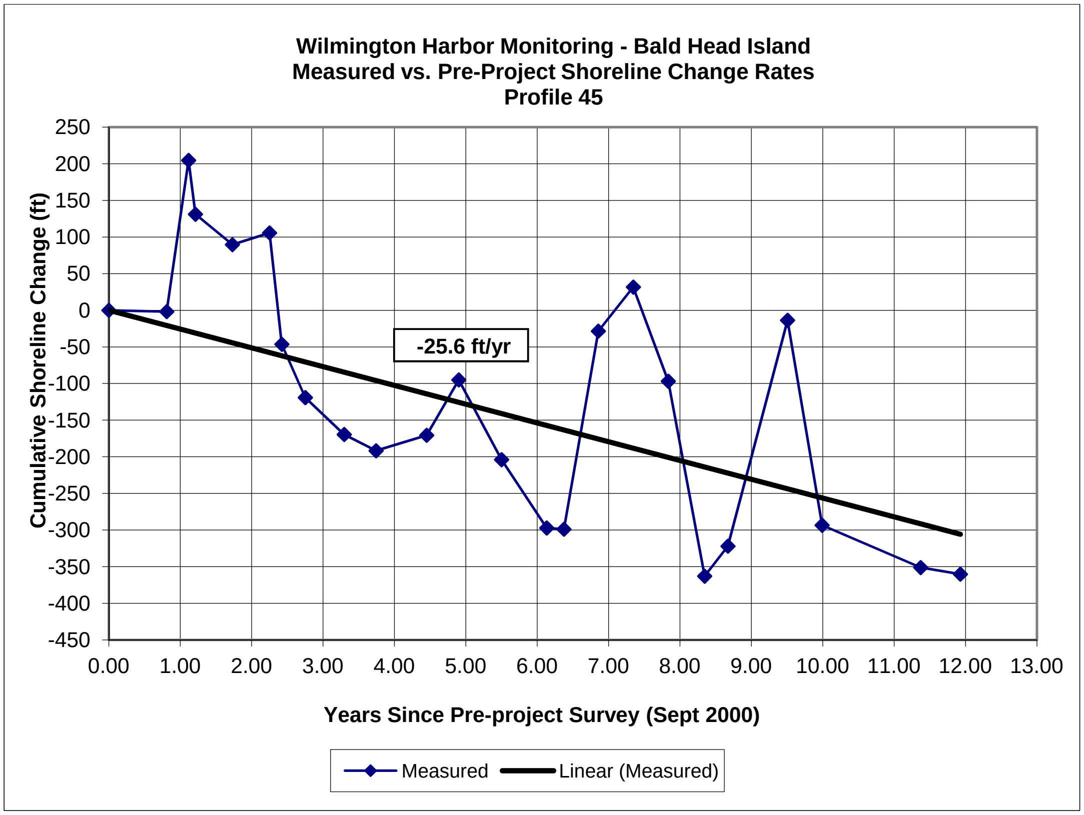

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 28
Cumulative Shoreline Change (ft)
440
400
360
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
2.4 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

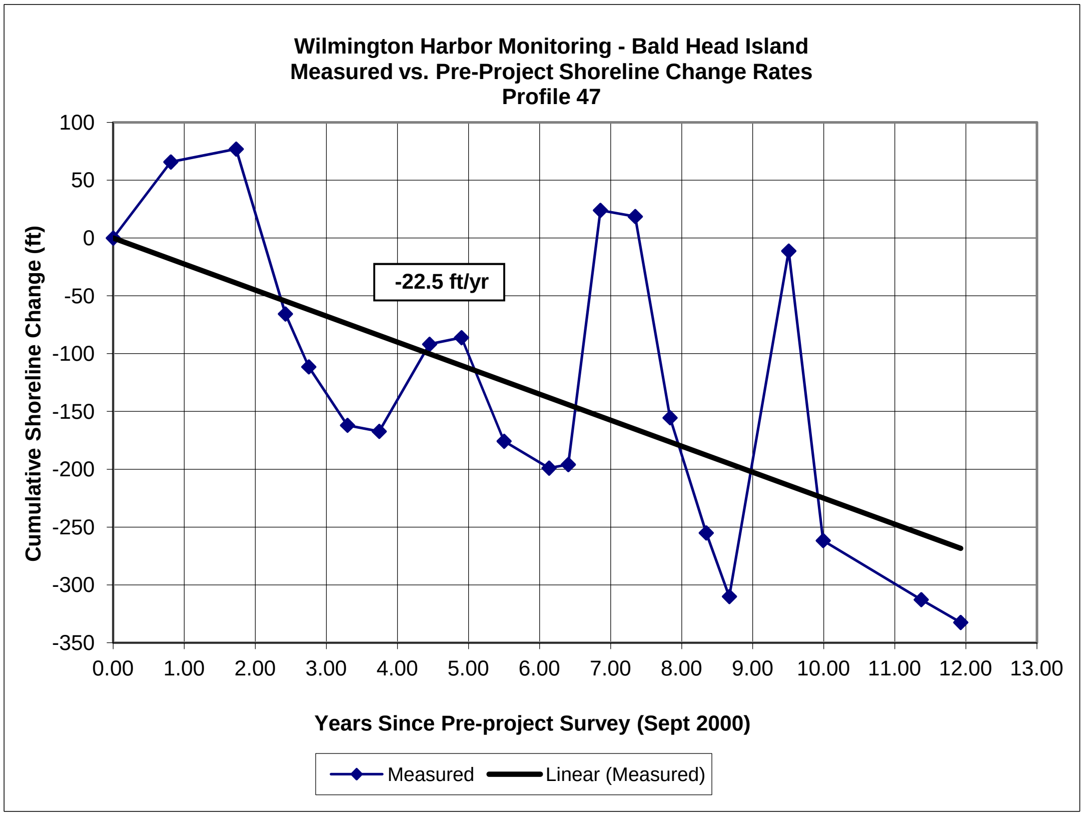

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 32
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
20.6 ft/yr
Measured
Linear (Measured)

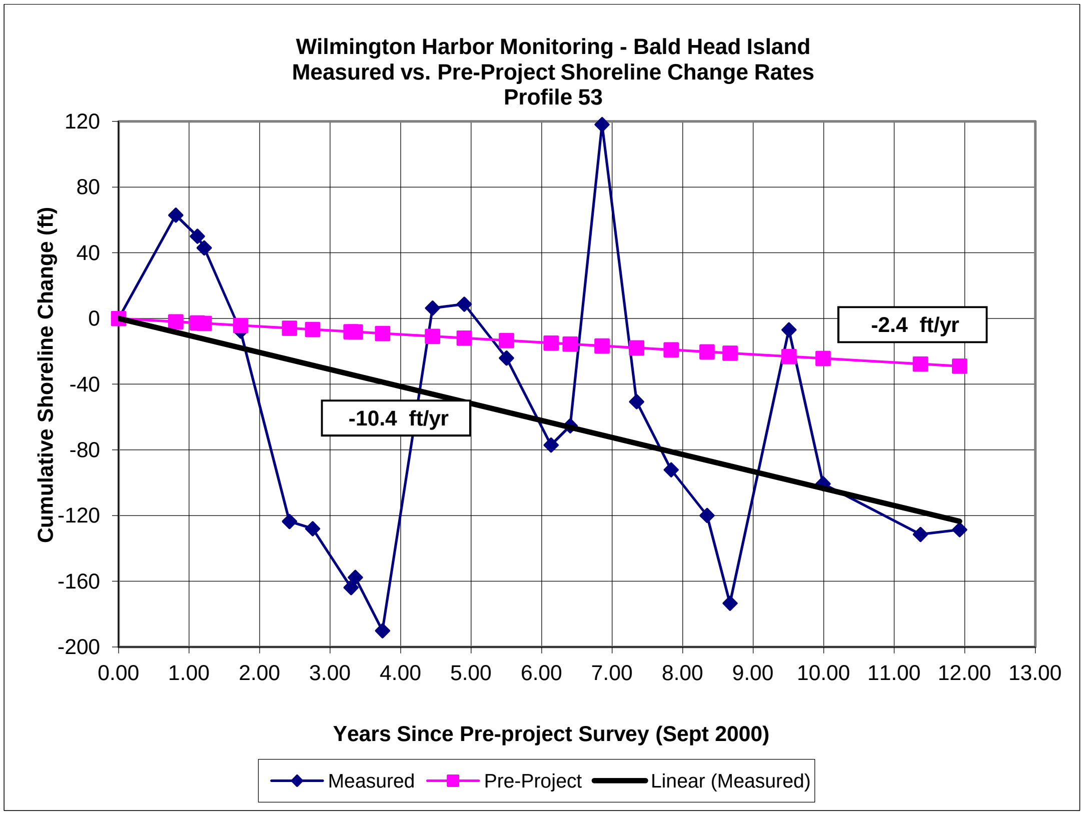

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 36
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
17.3 ft/yr
Measured
Linear (Measured)

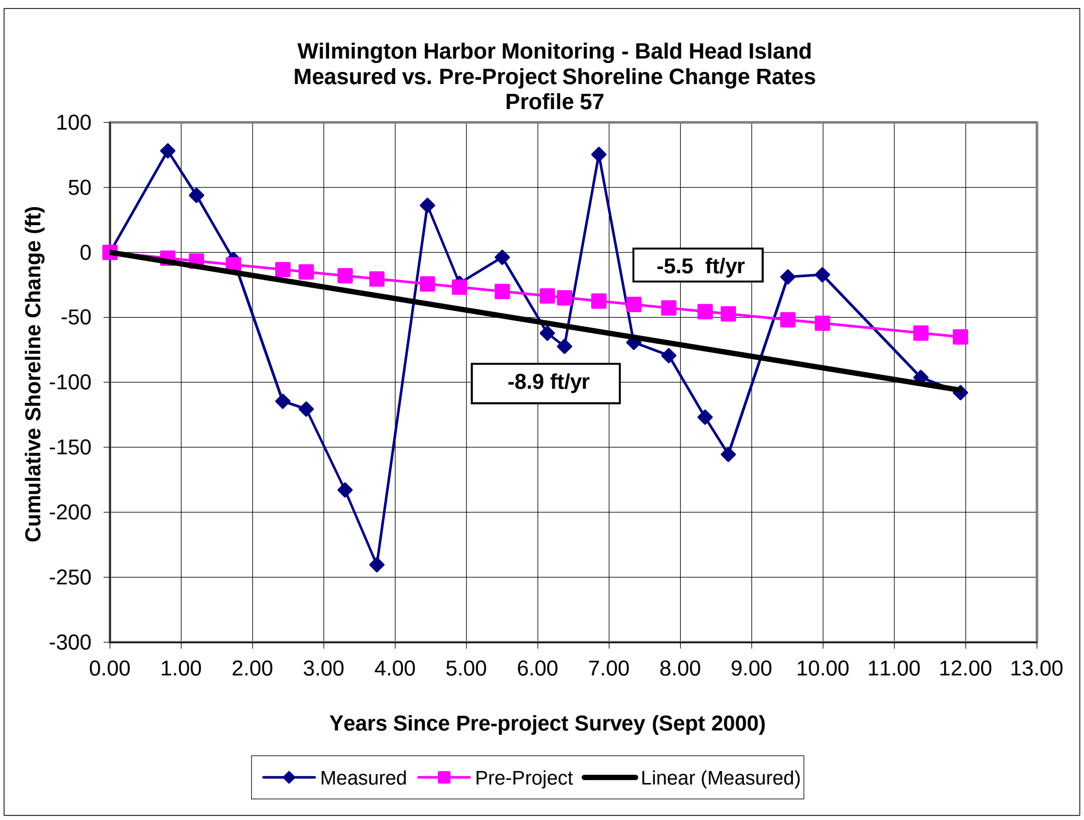

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
Cumulative Shoreline Change (ft)
360
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
5.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

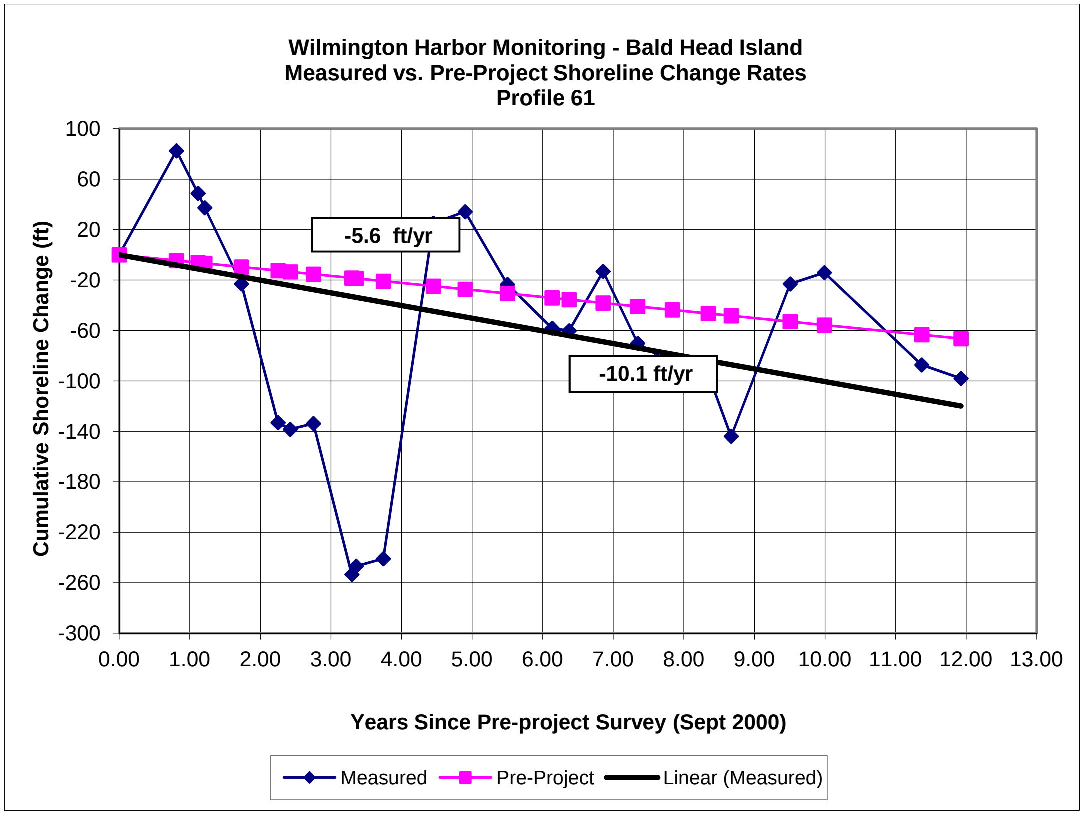

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 43
Cumulative Shoreline Change (ft)
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-550
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-28.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

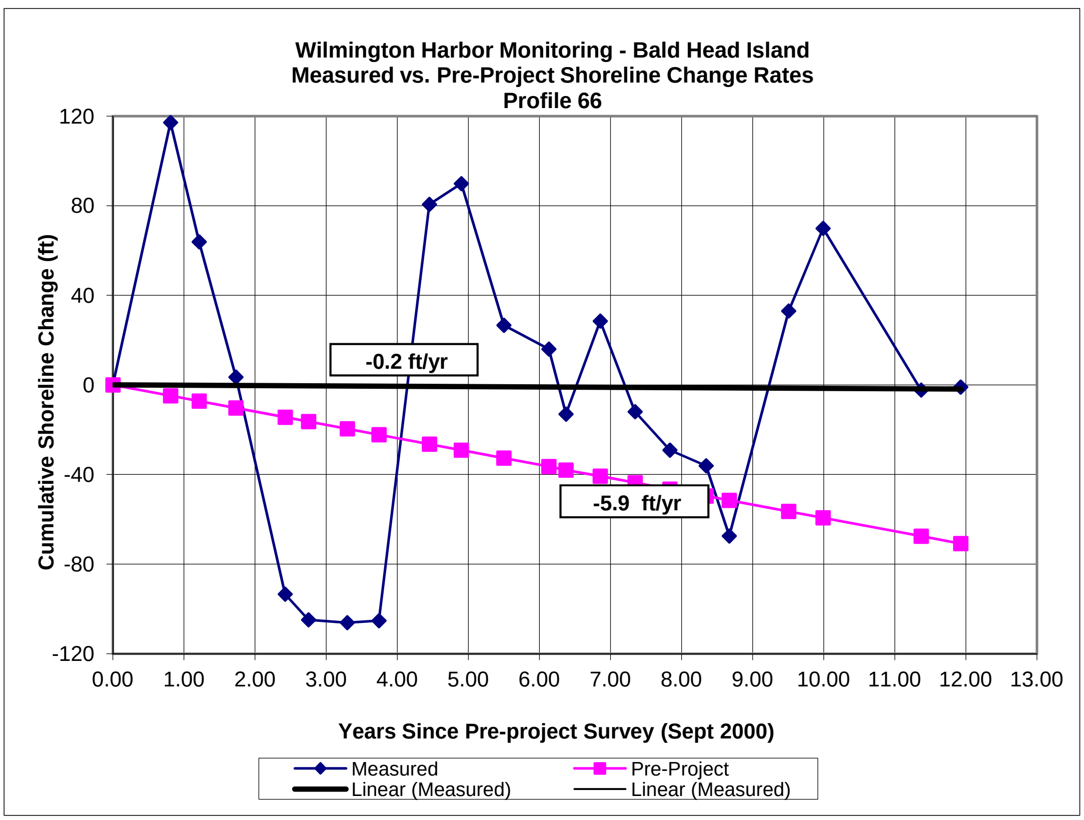

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-25.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

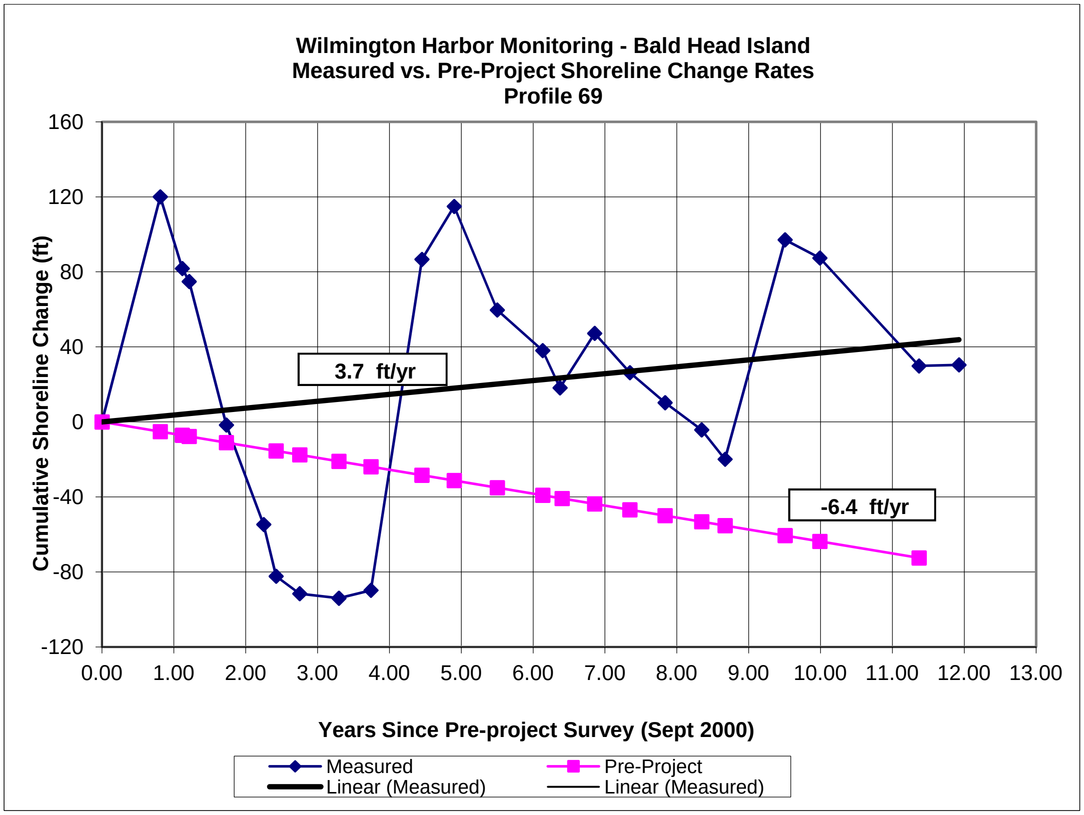

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 47
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
-150
-200
-250
-300
-350
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-22.5 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

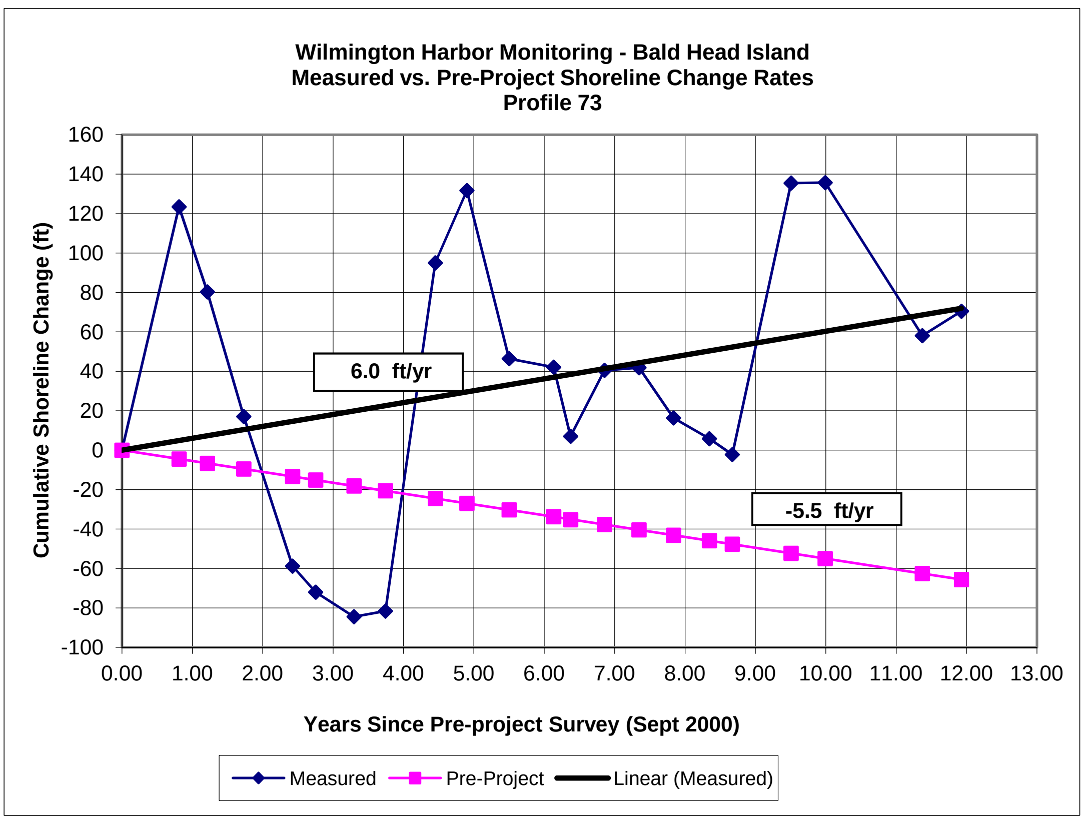

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 53
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
-120
-160
-200
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-2.4 ft/yr
-10.4 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

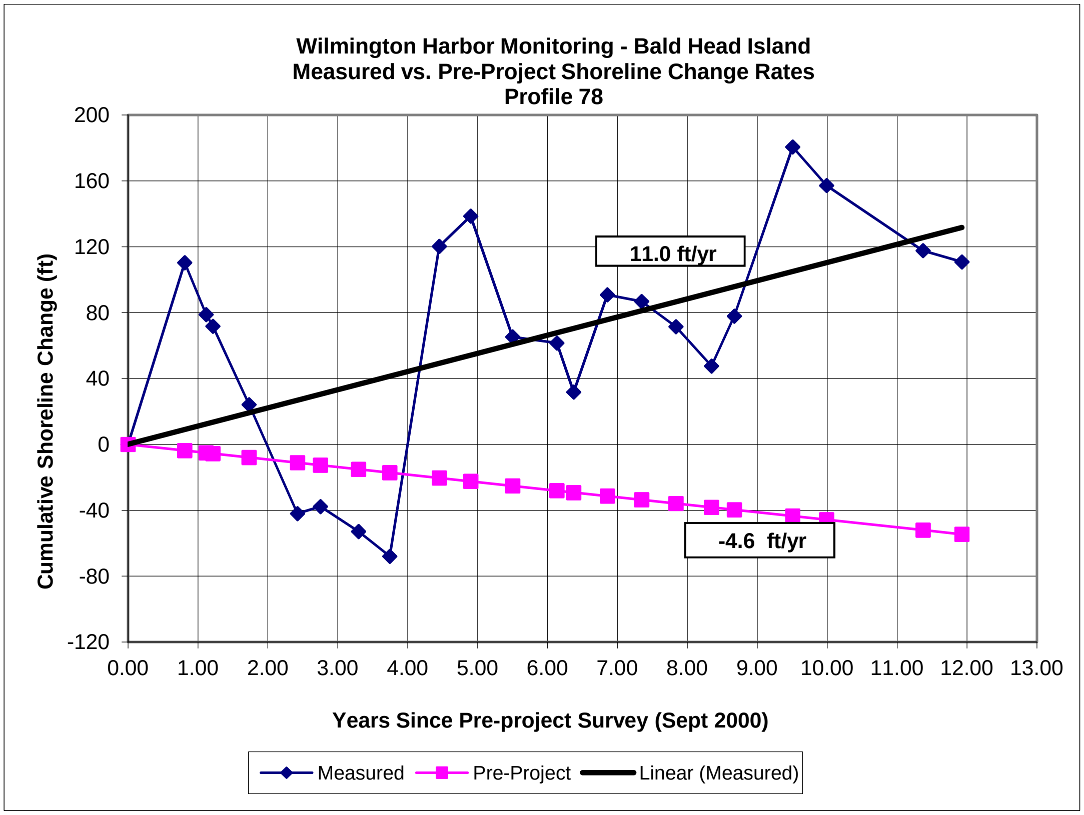

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 57
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
-150
-200
-250
-300
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
-5.5 ft/yr
-8.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

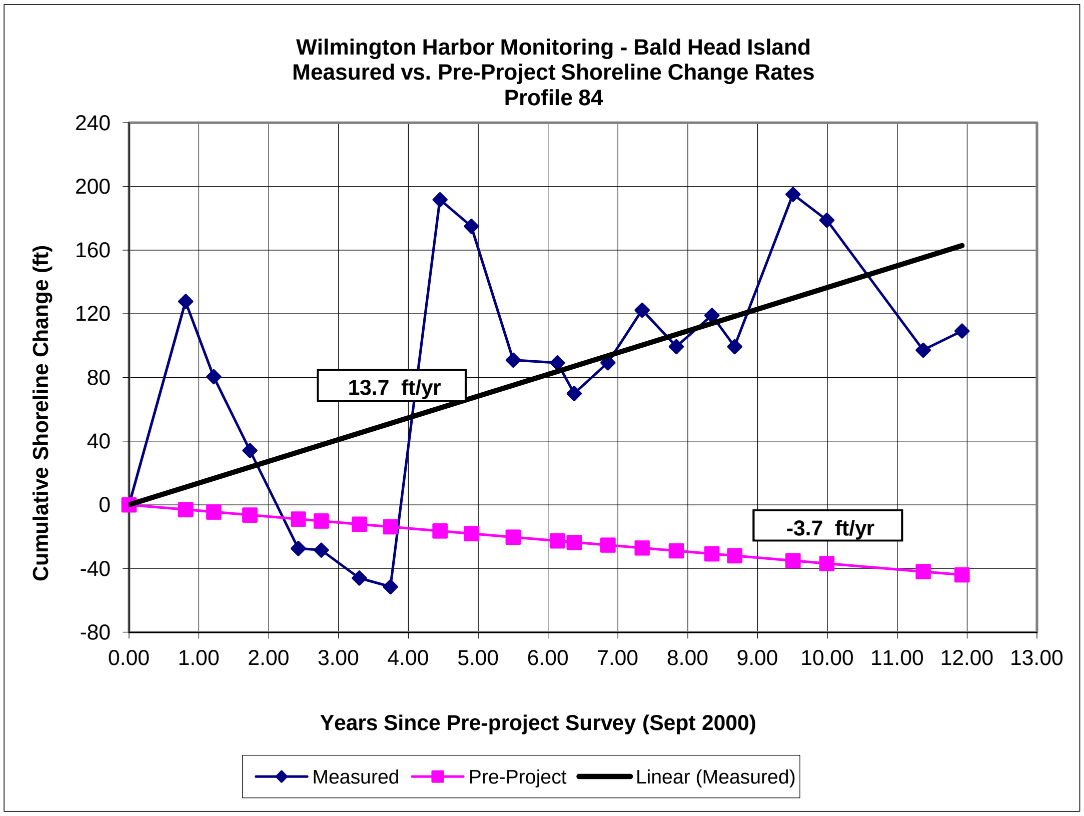

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 61
-5.6 ft/yr
-10.1 ft/yr
Cumulative Shoreline Change (ft)
100
60
20
-20
-60
-100
-140
-180
-220
-260
-300
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

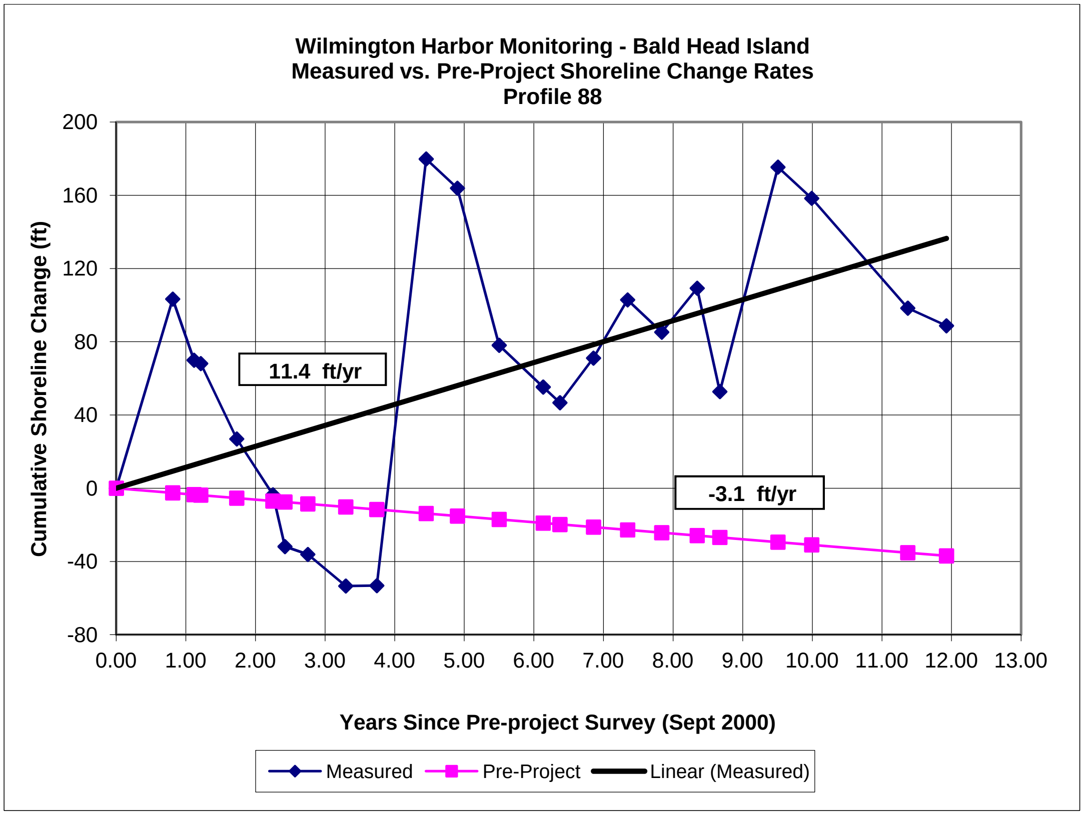

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 66
-0.2 ft/yr
-5.9 ft/yr
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)
Linear (Measured)

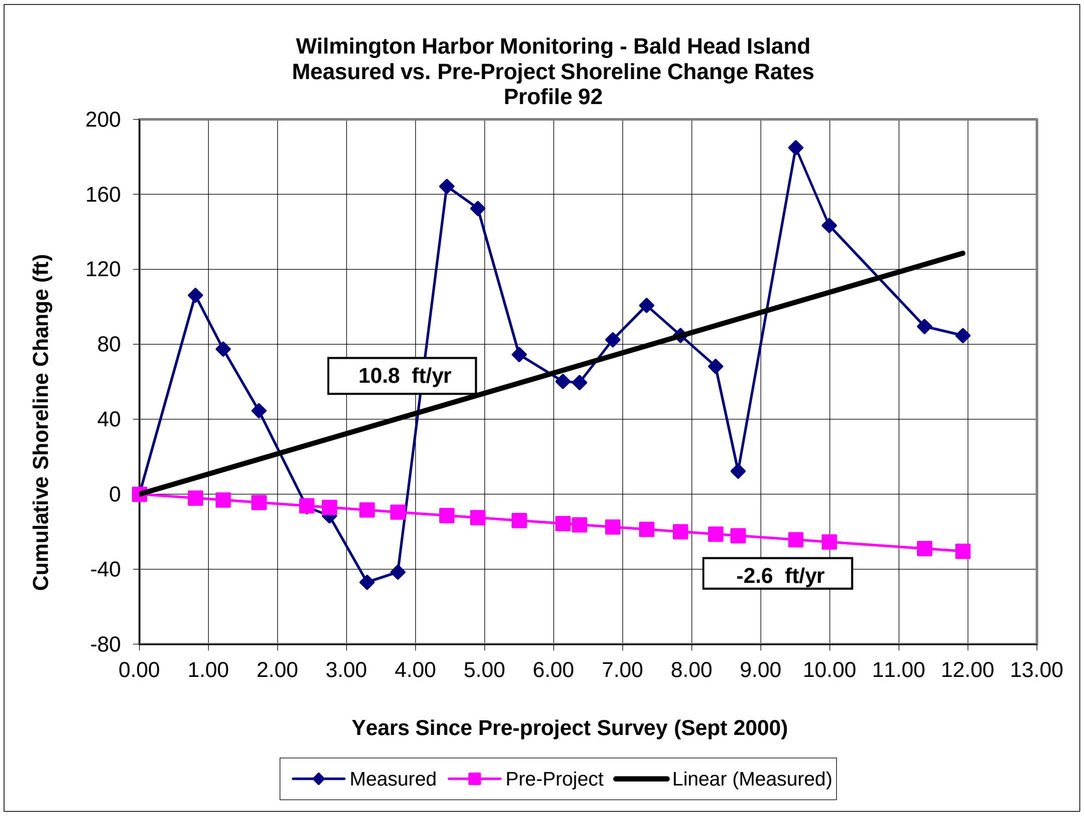

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 69
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
3.7 ft/yr
-6.4 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)
Linear (Measured)

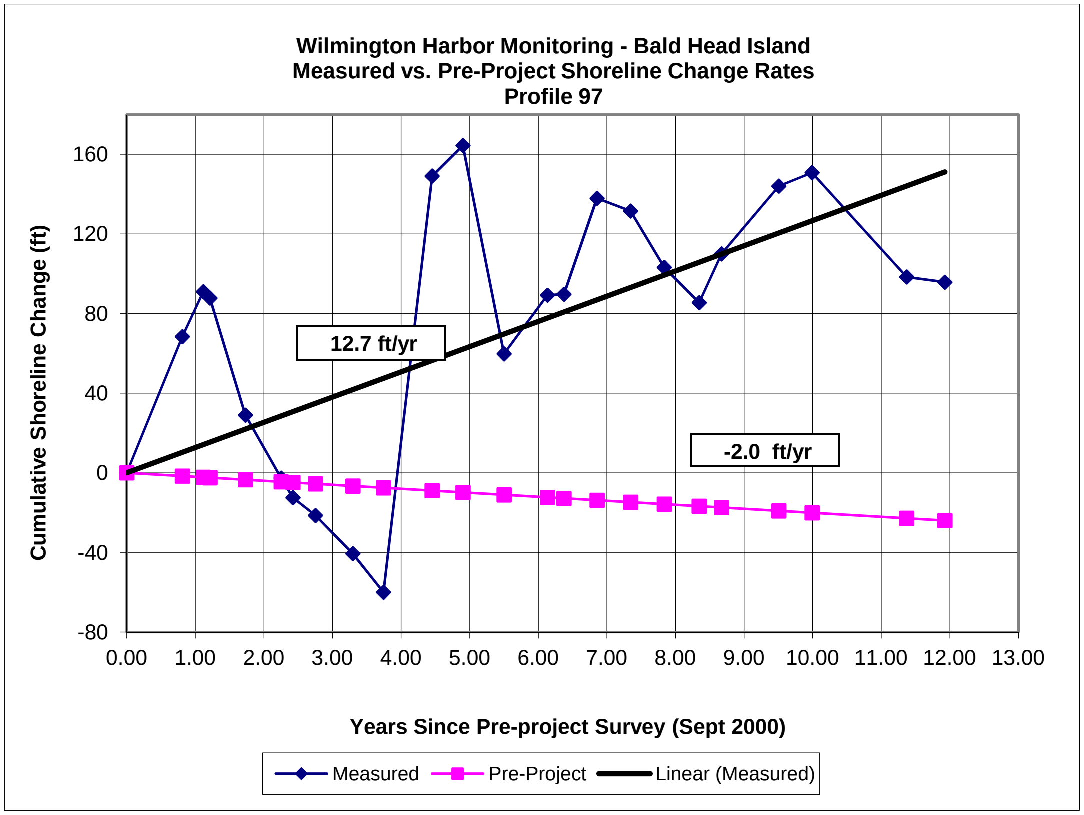

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 73
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
6.0 ft/yr
-5.5 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

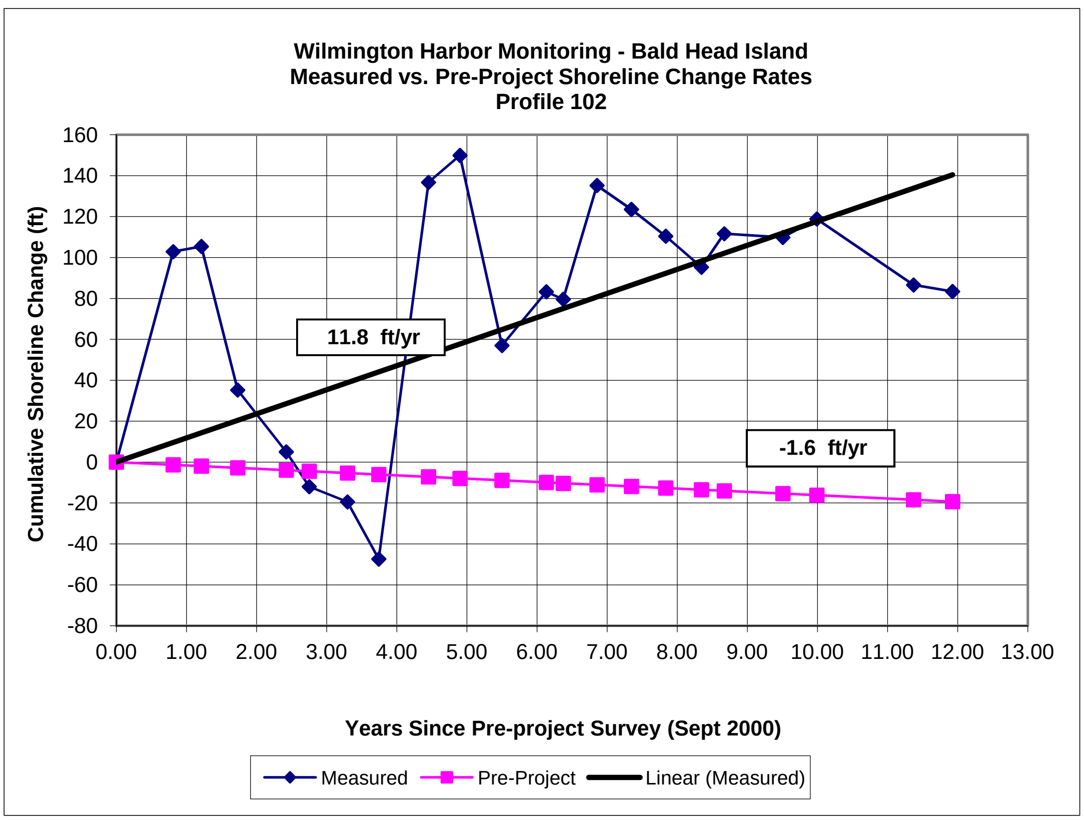

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 78
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
-120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
11.0 ft/yr
-4.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

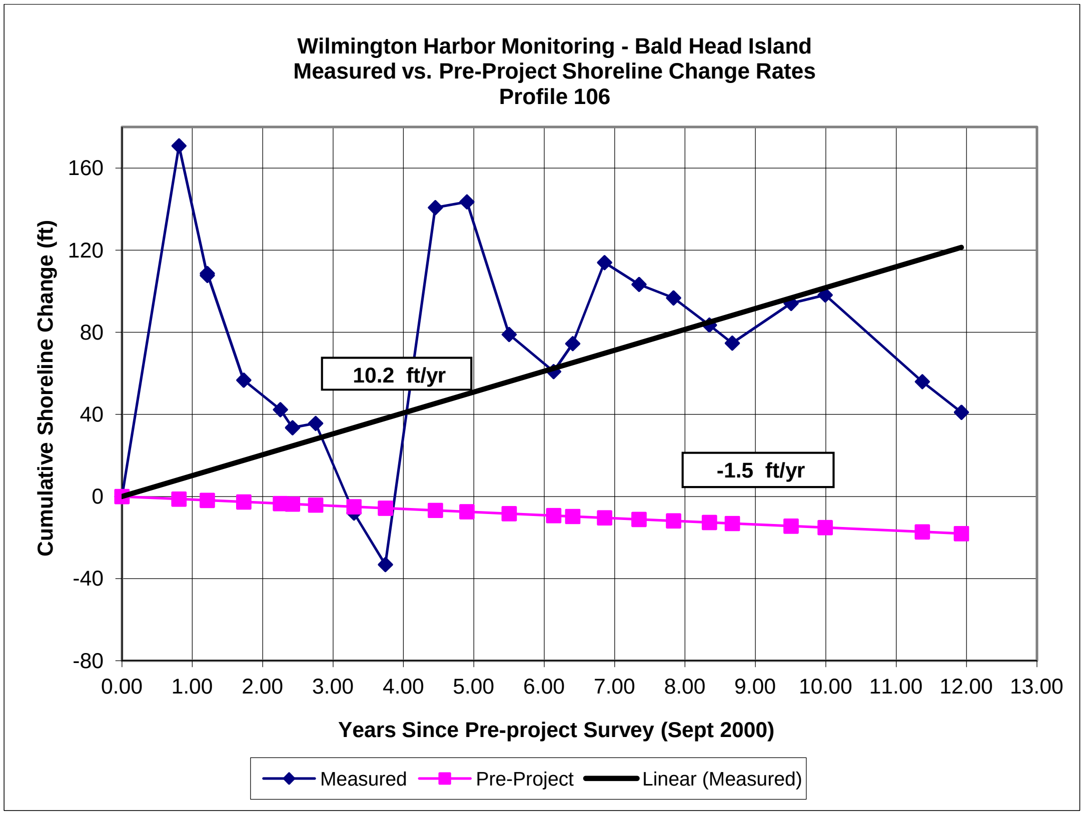

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 84
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
13.7 ft/yr
-3.7 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

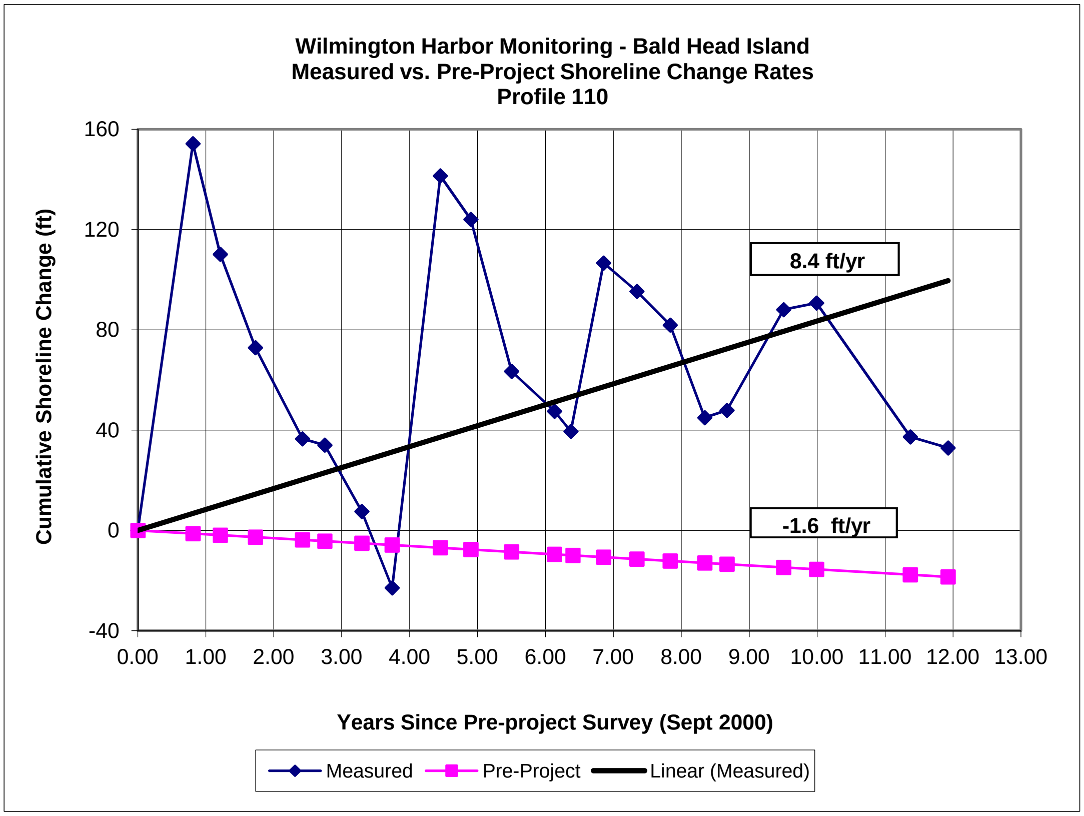

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 88
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
11.4 ft/yr
-3.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

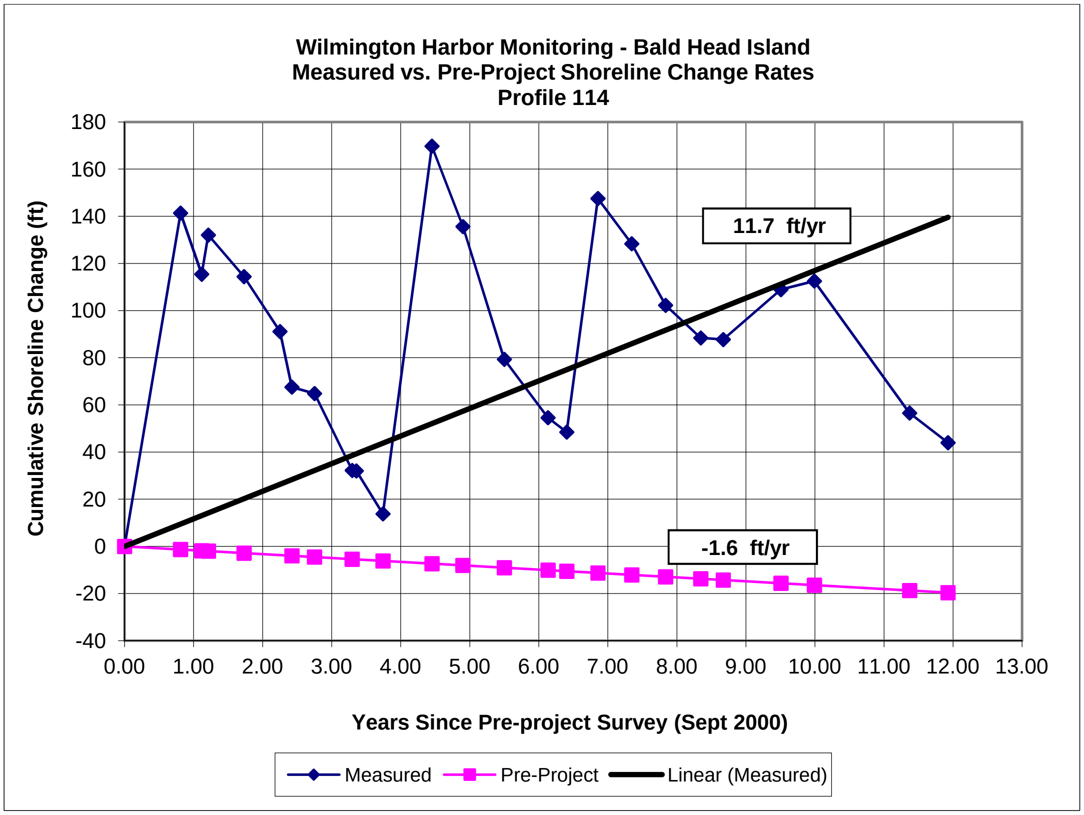

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 92
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
10.8 ft/yr
-2.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

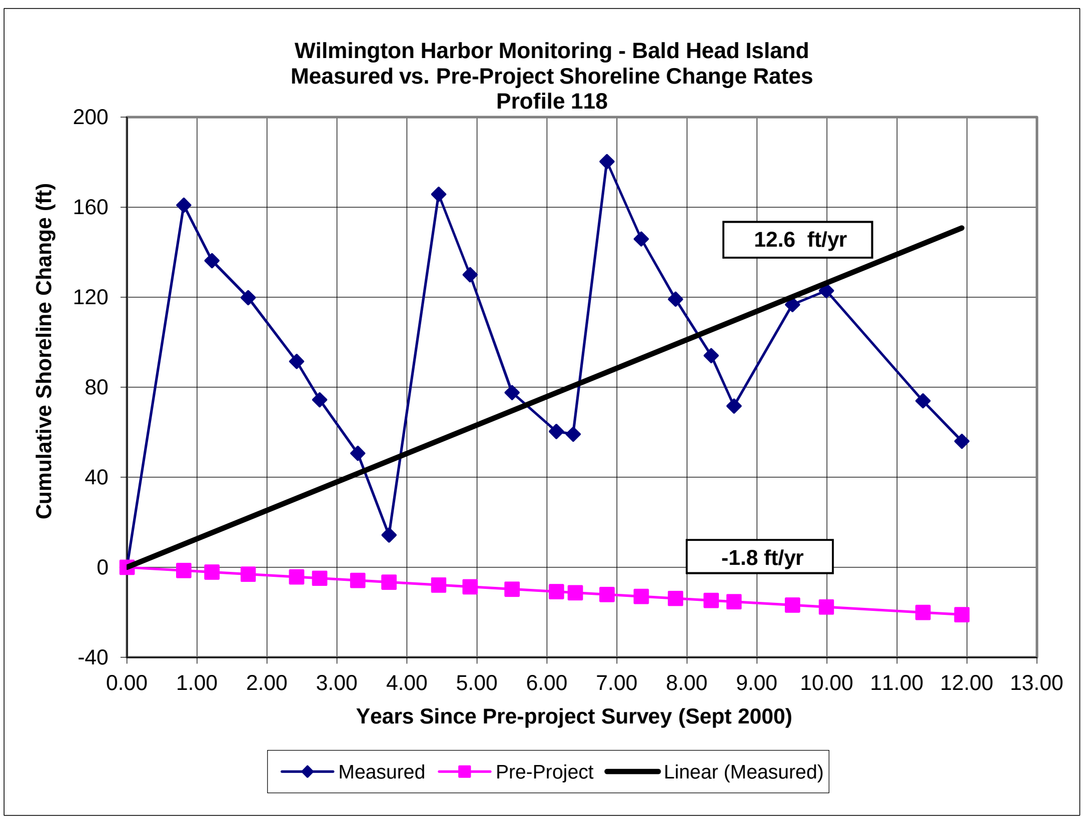

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 97
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
12.7 ft/yr
-2.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

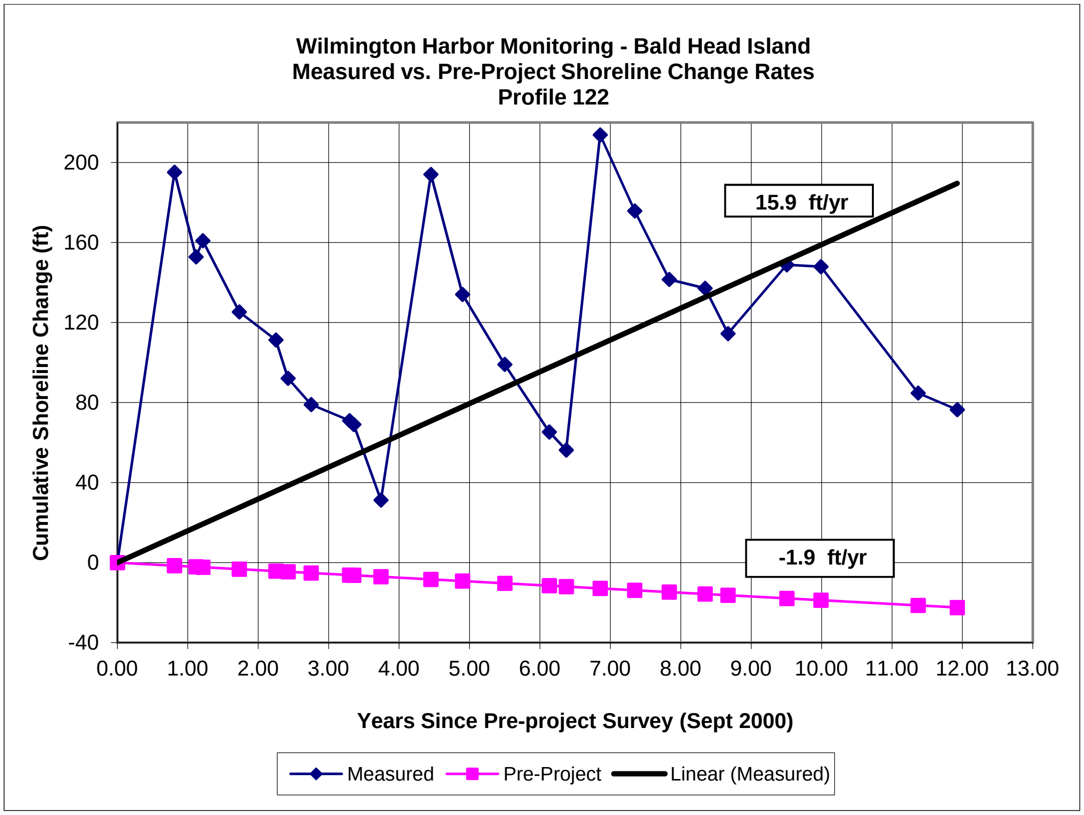

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 102
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
11.8 ft/yr
-1.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

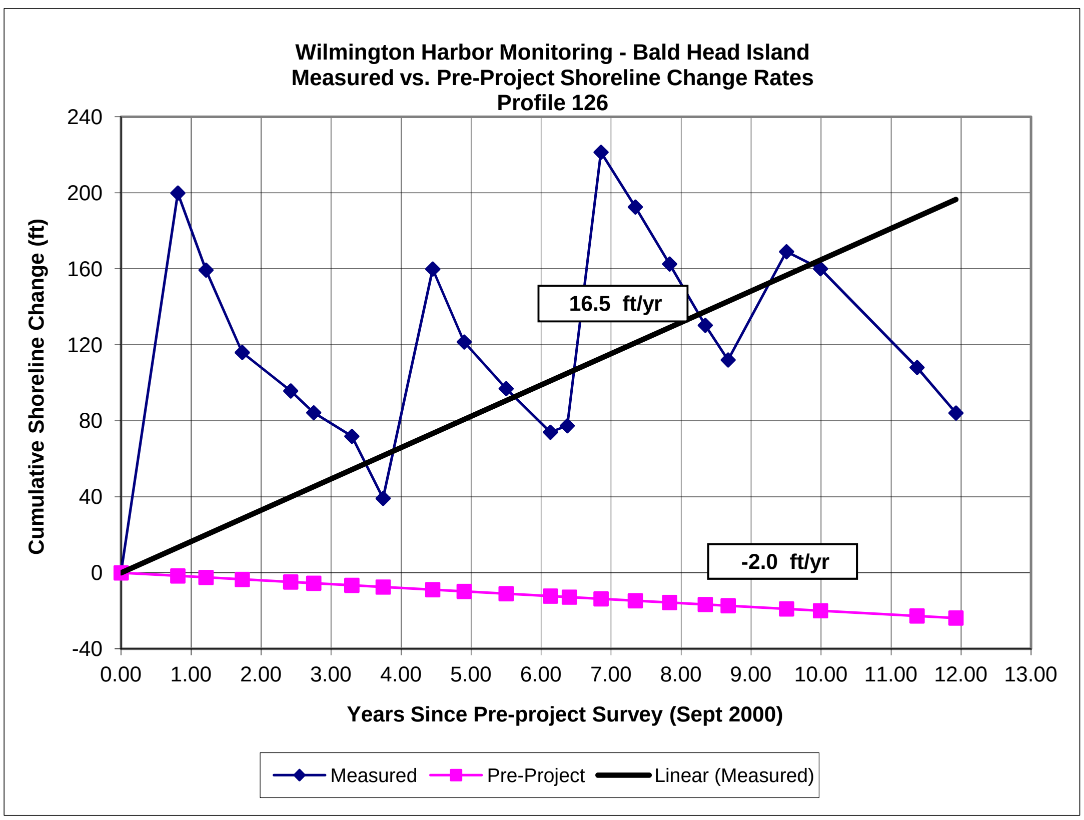

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 106
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (Sept 2000)
10.2 ft/yr
-1.5 ft/yr
Measured
Pre-Project
Linear (Measured)

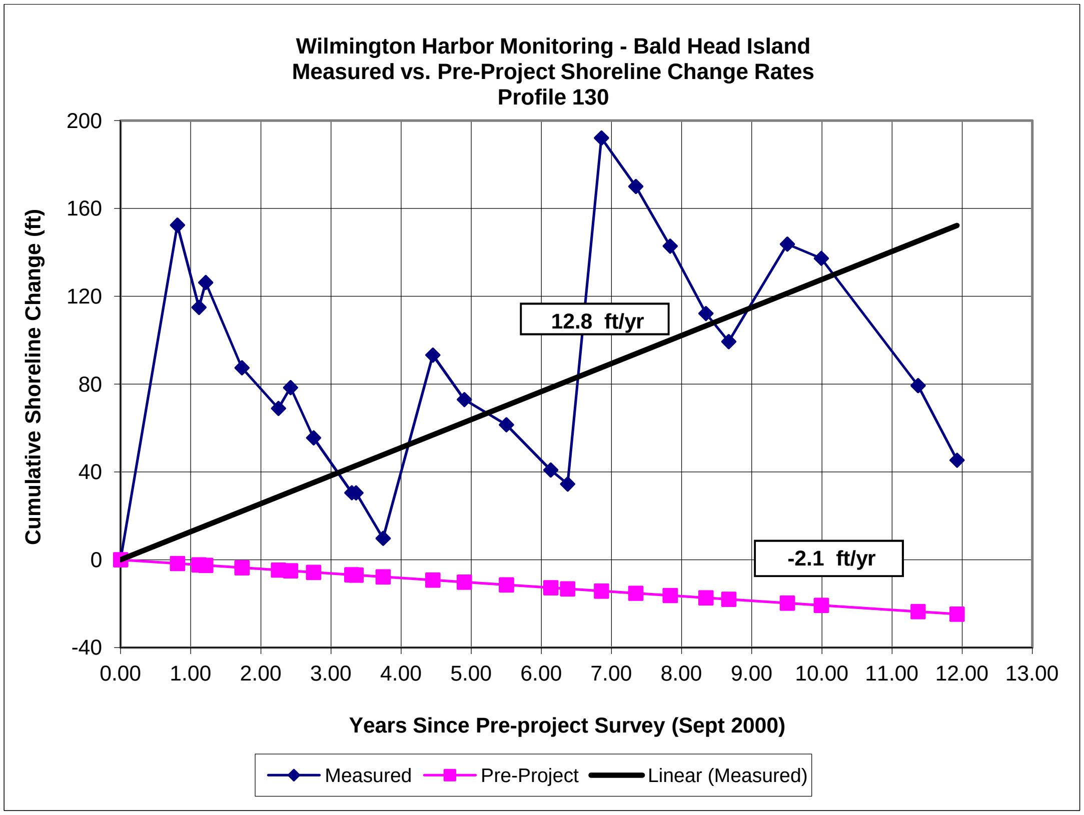

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
Years Since Pre-project Survey (Sept 2000)
8.4 ft/yr
-1.6 ft/yr
Measured
Pre-Project
Linear (Measured)

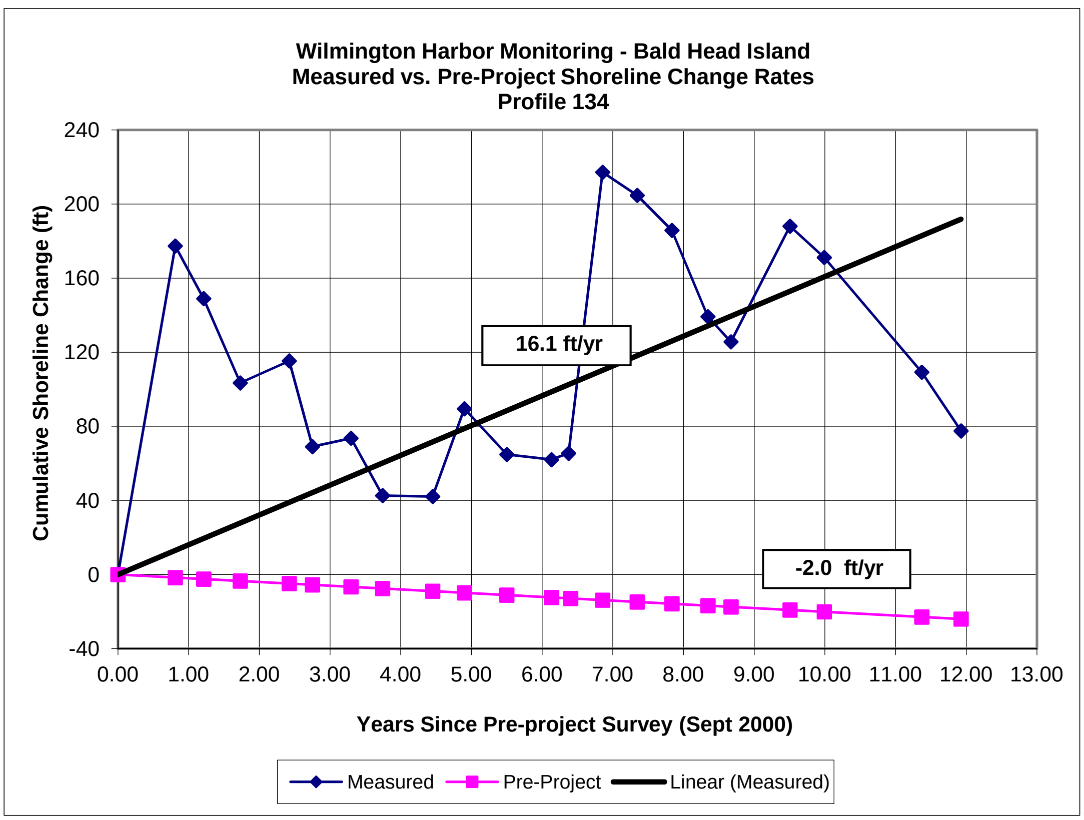

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 114
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
11.7 ft/yr
-1.6 ft/yr
Measured
Pre-Project
Linear (Measured)

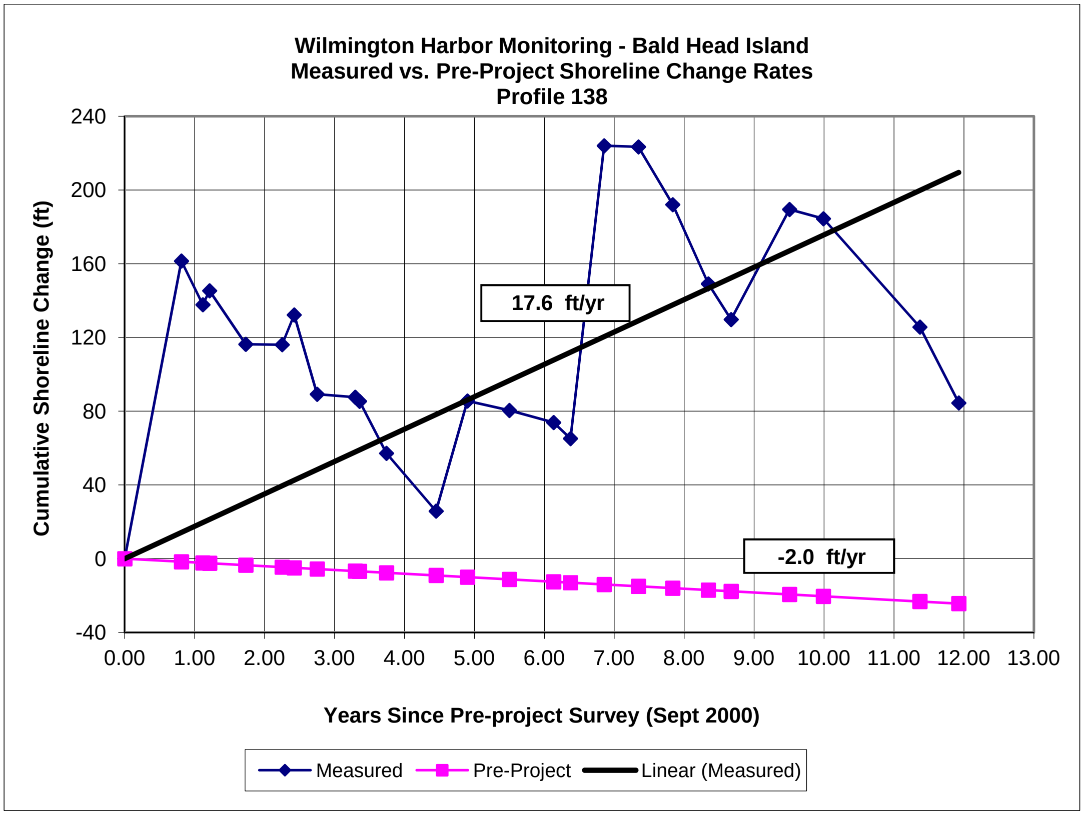

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 118
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
12.6 ft/yr
-1.8 ft/yr
Measured
Pre-Project
Linear (Measured)

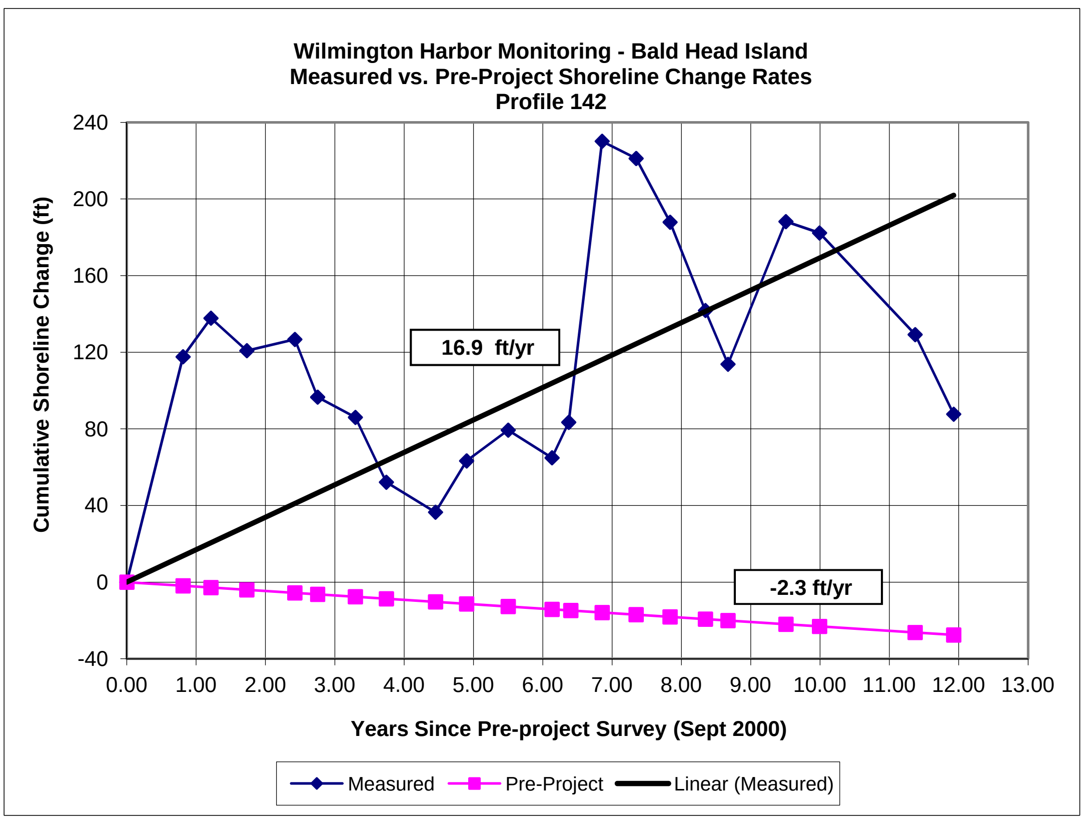

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 122
15.9 ft/yr
-1.9 ft/yr
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

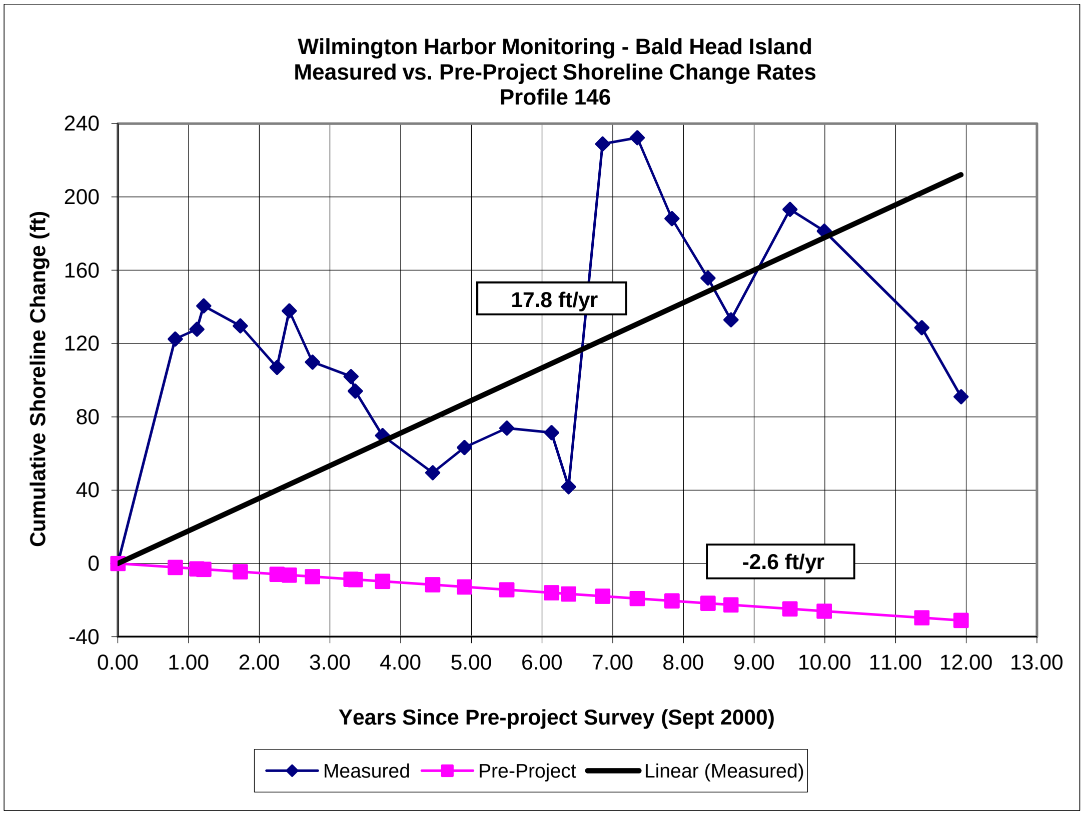

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 126
16.5 ft/yr
-2.0 ft/yr
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

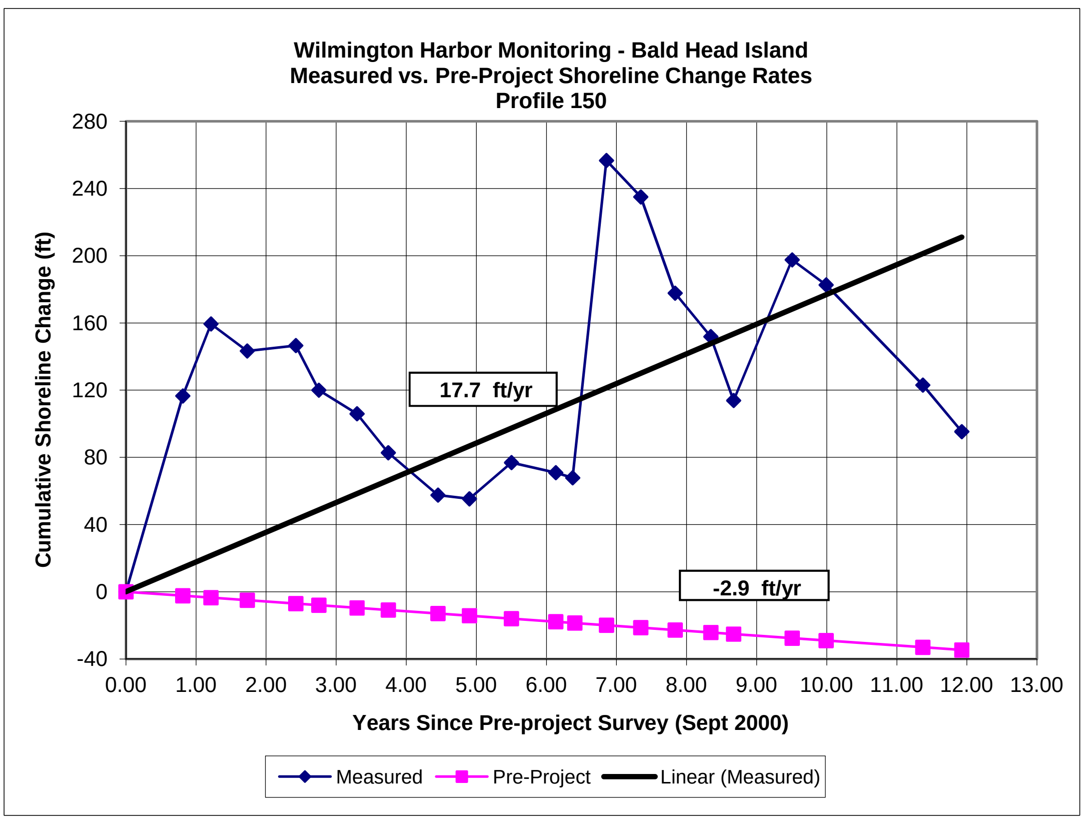

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
12.8 ft/yr
-2.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

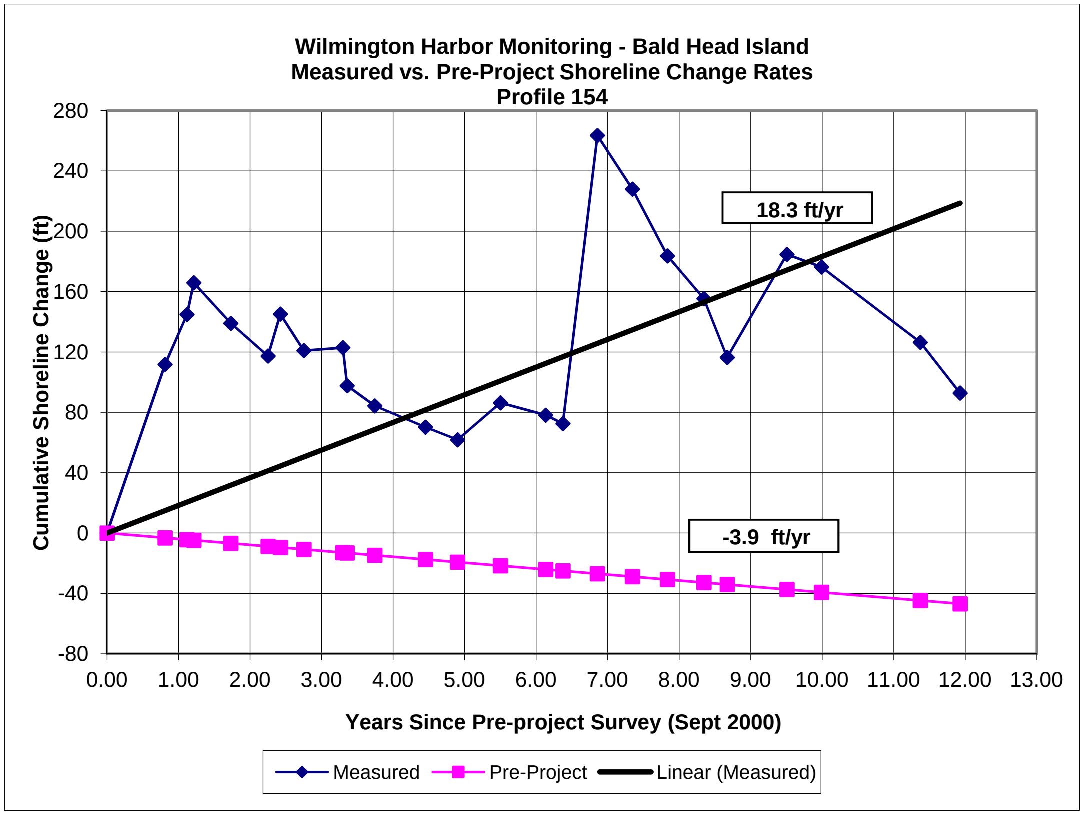

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 134
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
16.1 ft/yr
-2.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

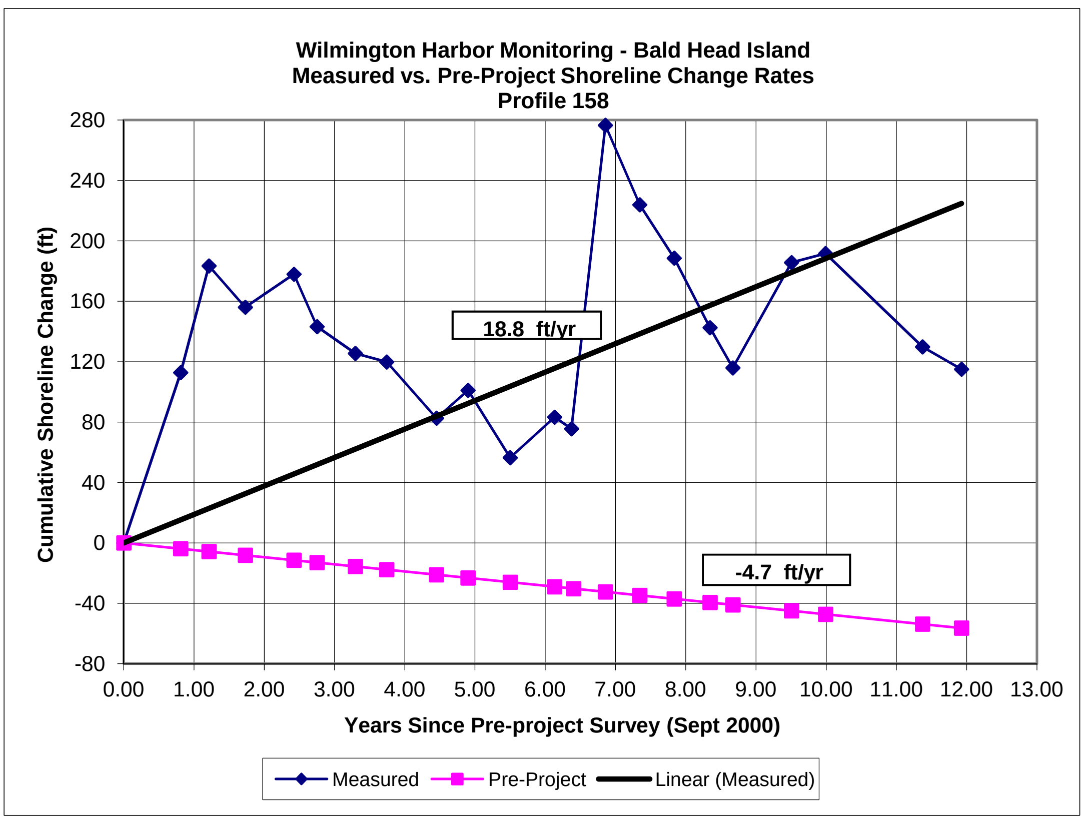

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 138
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
17.6 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

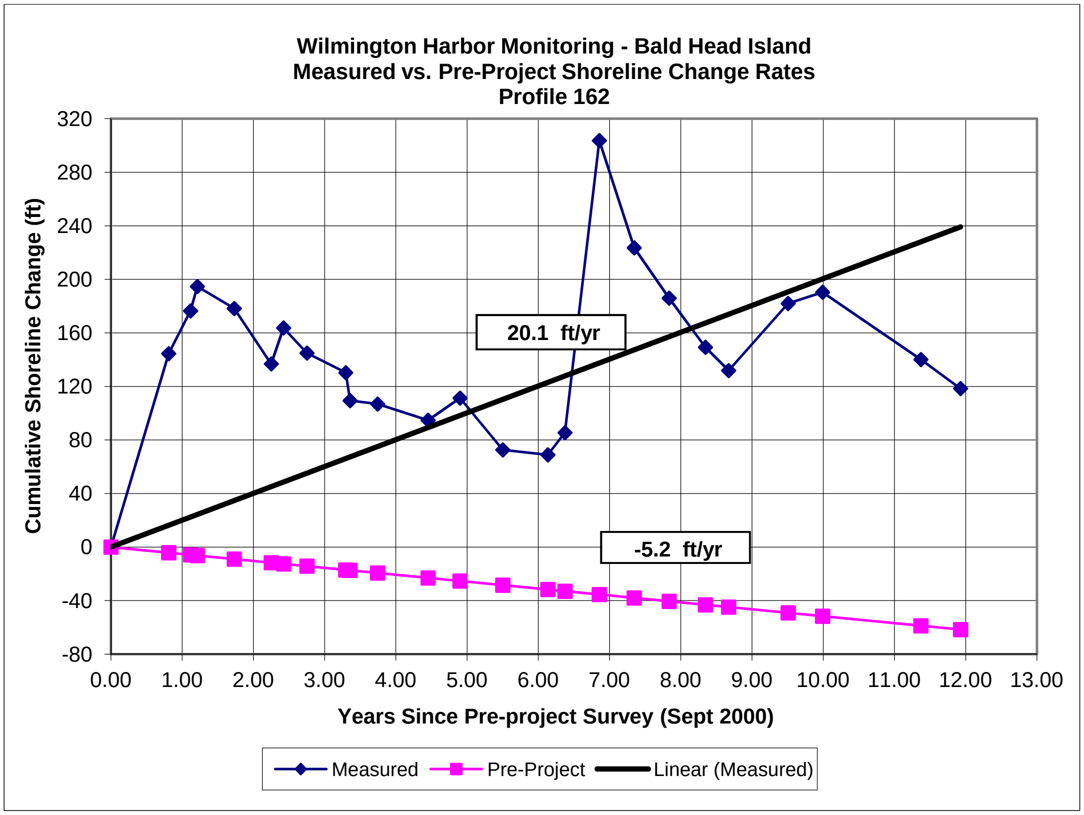

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 142
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
16.9 ft/yr
-2.3 ft/yr
Measured
Pre-Project
Linear (Measured)

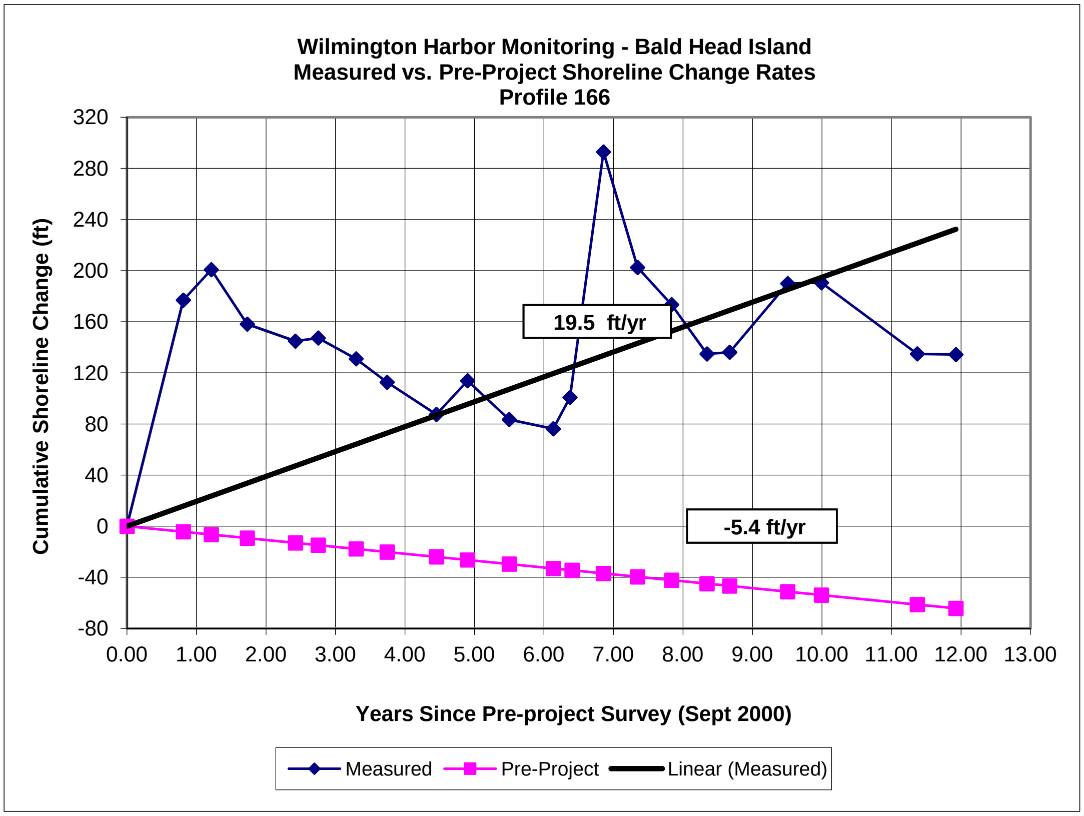

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 146
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
17.8 ft/yr
-2.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

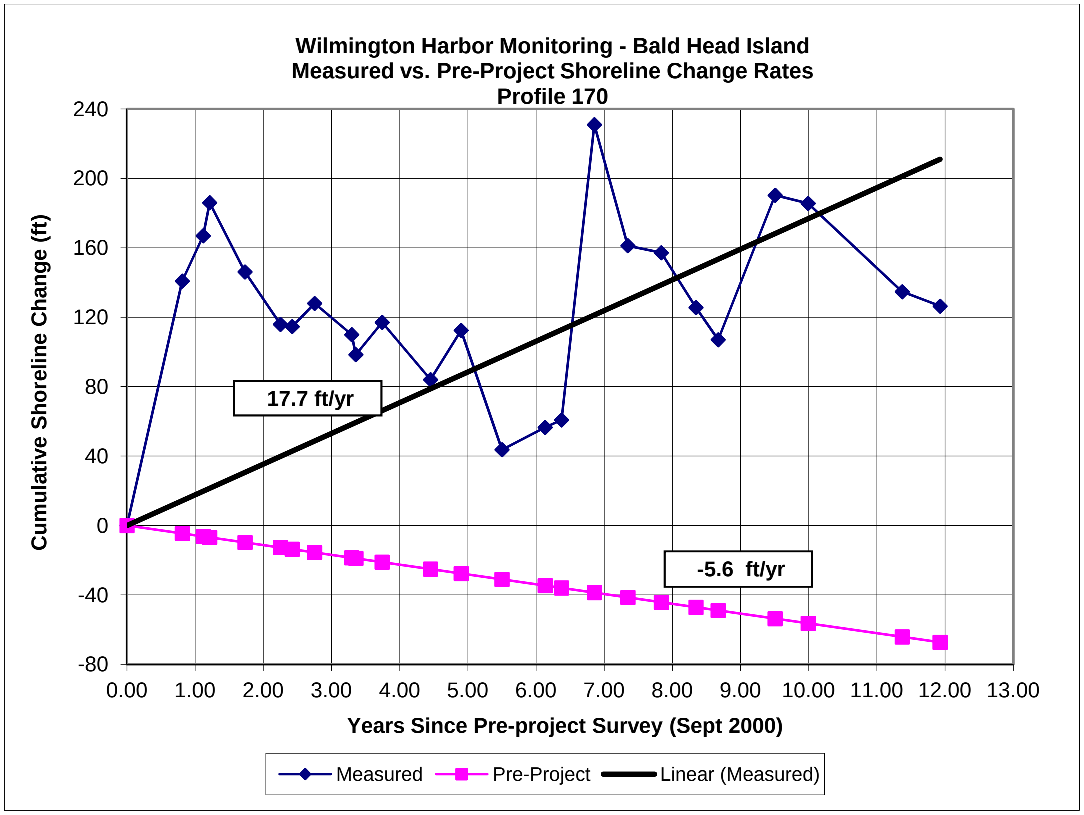

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
17.7 ft/yr
-2.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

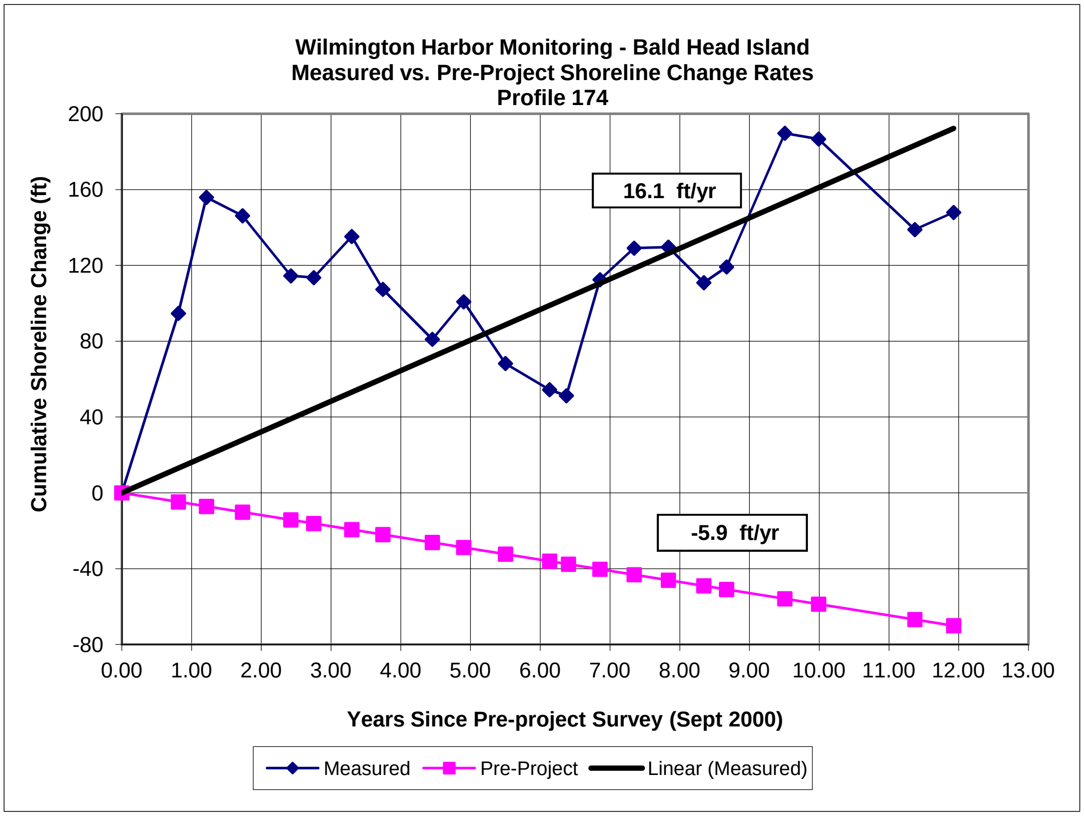

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 154
18.3 ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

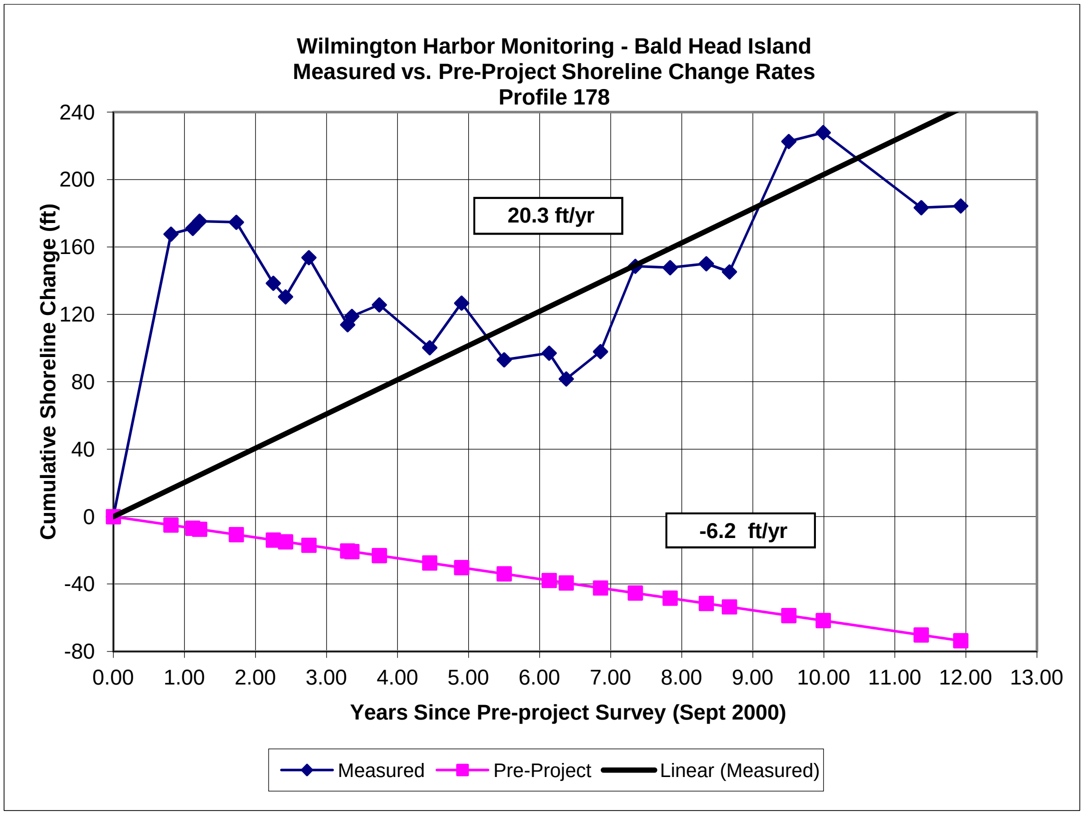

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 158
18.8 ft/yr
-4.7 ft/yr
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

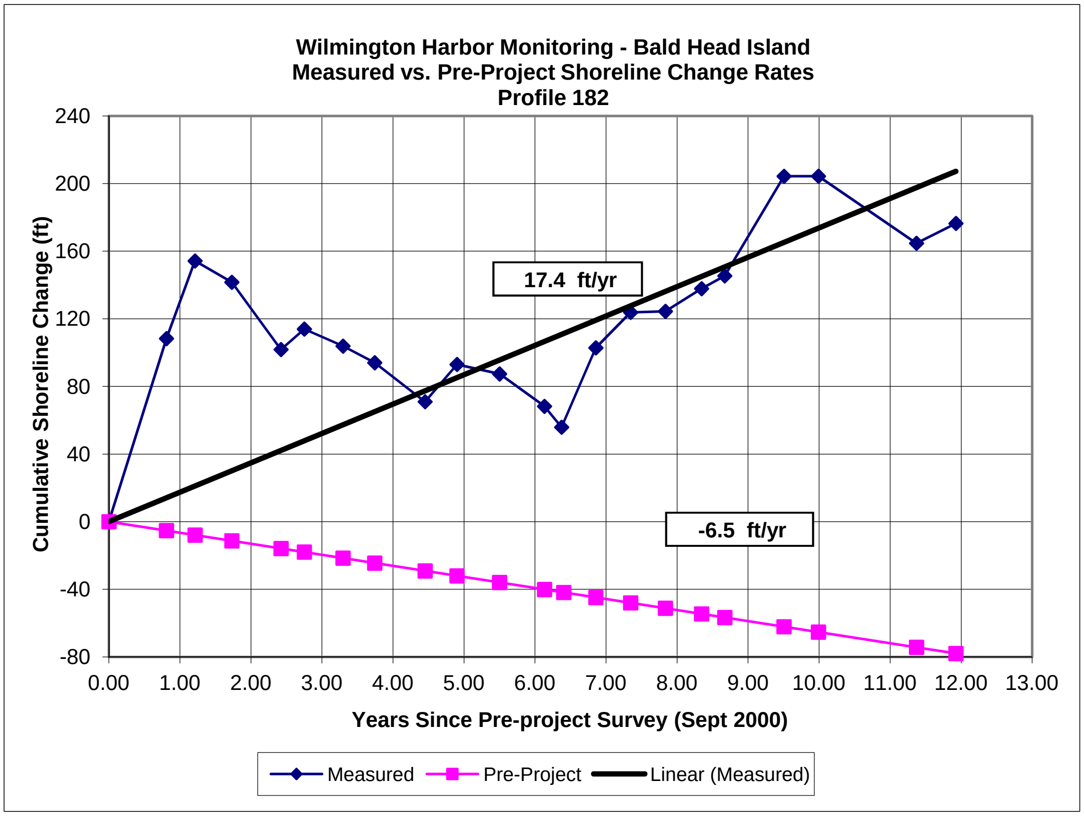

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 162
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
20.1 ft/yr
-5.2 ft/yr
Measured
Pre-Project
Linear (Measured)

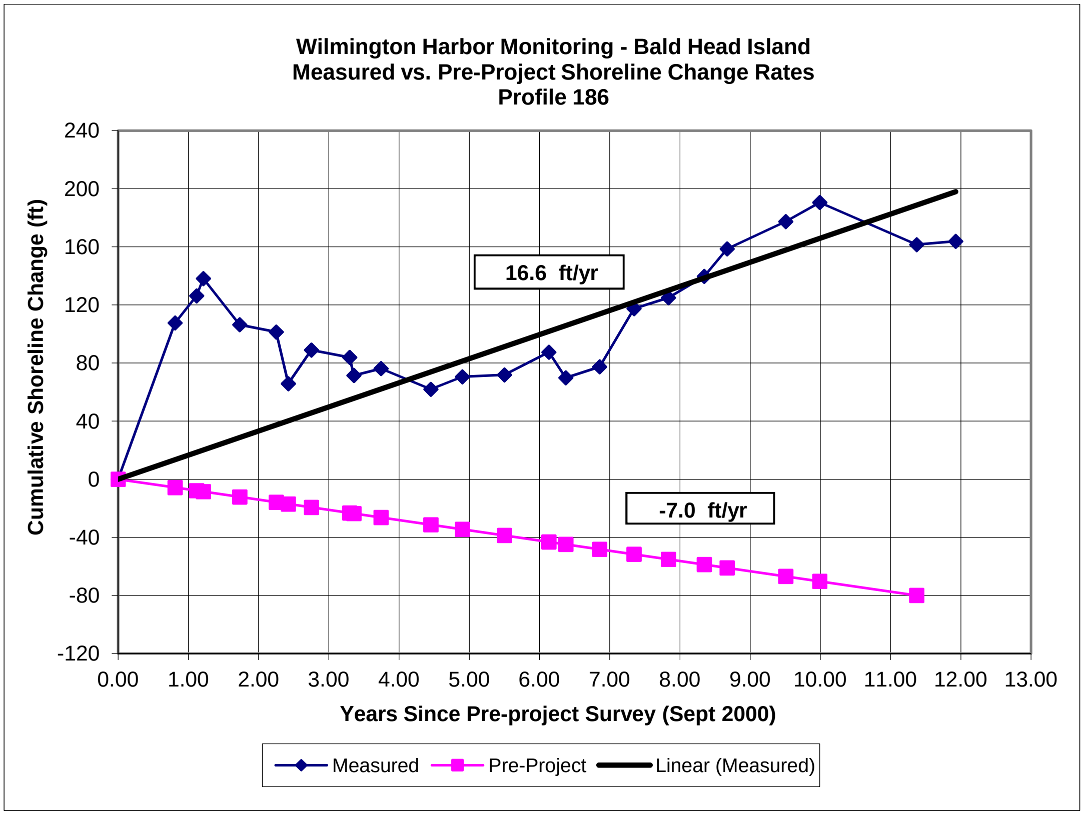

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 166
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
19.5 ft/yr
-5.4 ft/yr
Measured
Pre-Project
Linear (Measured)

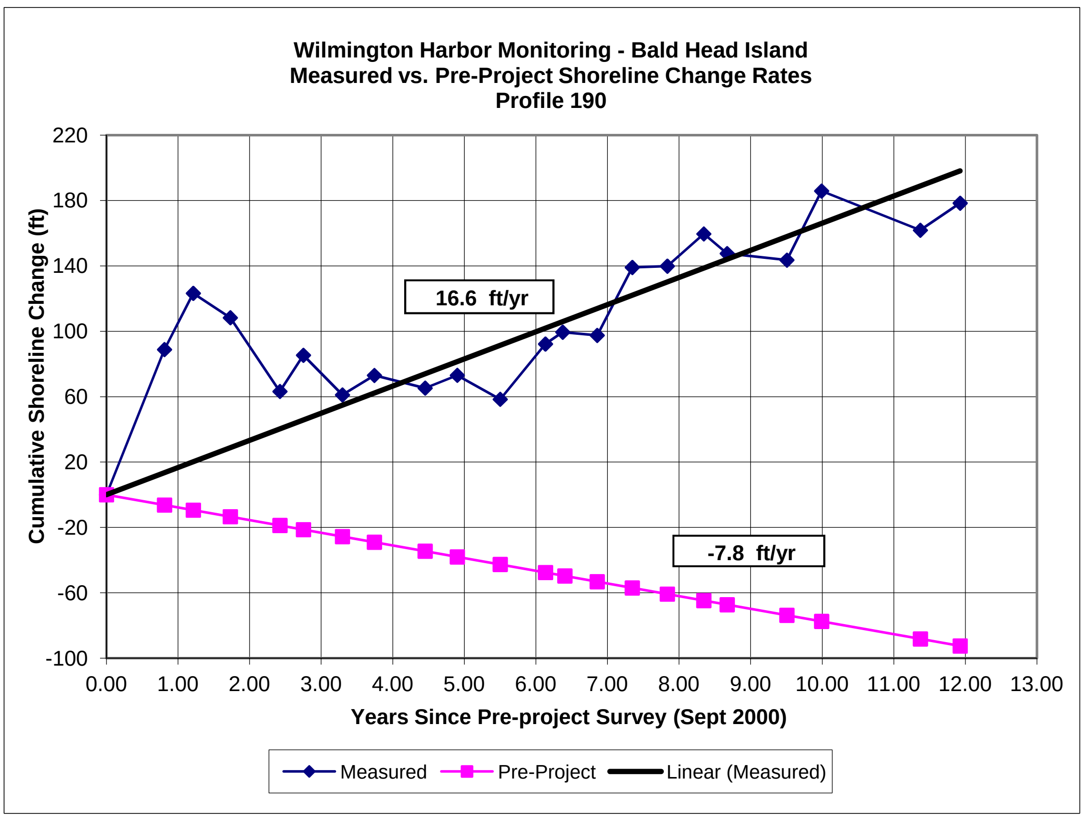

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
17.7 ft/yr
-5.6 ft/yr
Measured
Pre-Project
Linear (Measured)

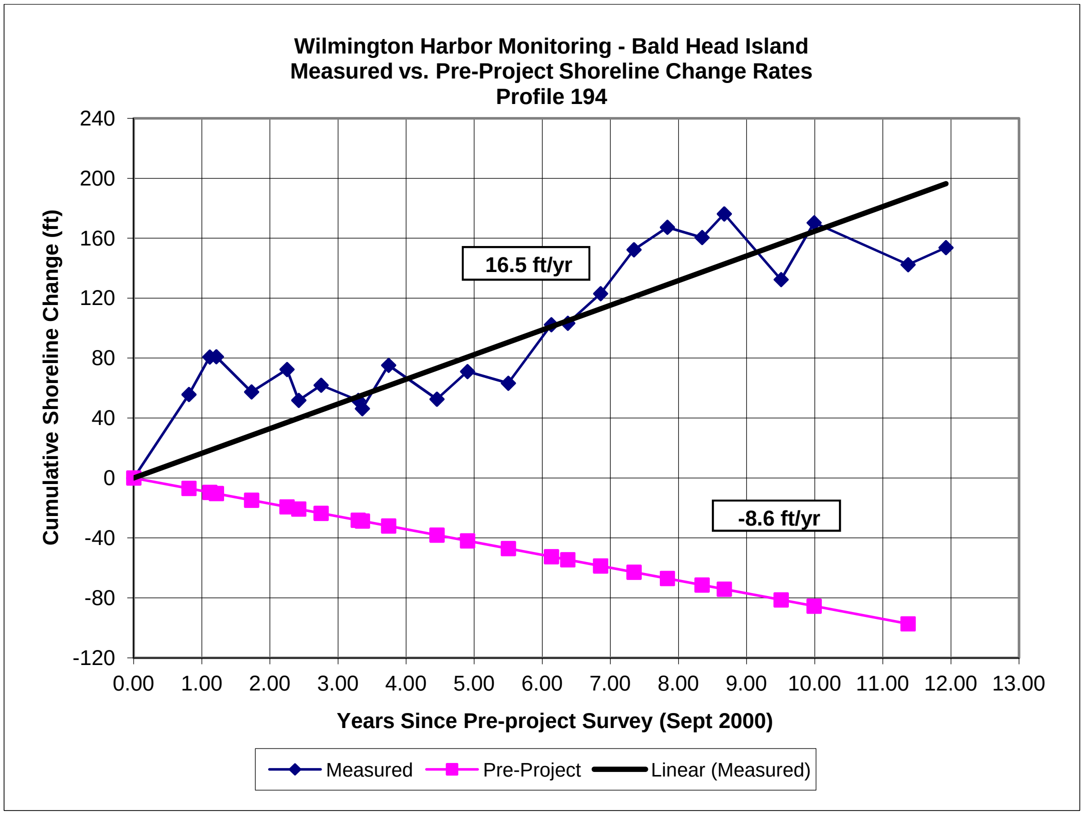

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 174
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
16.1 ft/yr
-5.9 ft/yr
Measured
Pre-Project
Linear (Measured)

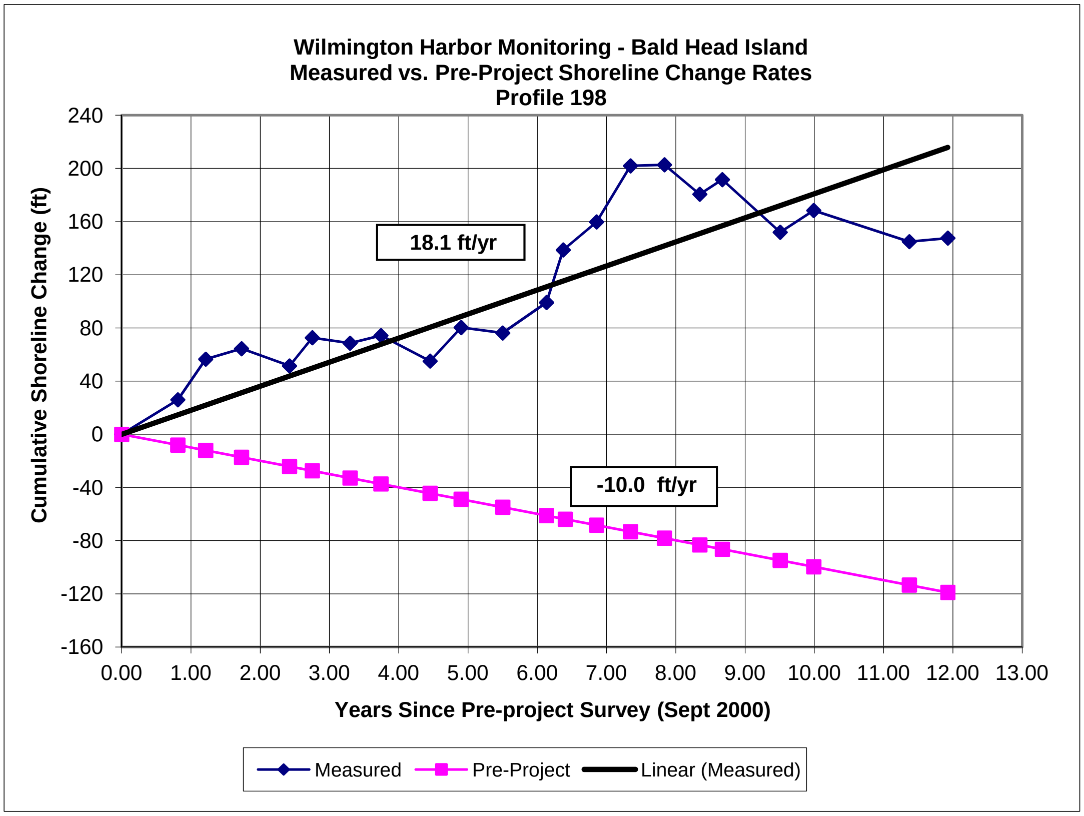

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 178
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
20.3 ft/yr
-6.2 ft/yr
Measured
Pre-Project
Linear (Measured)

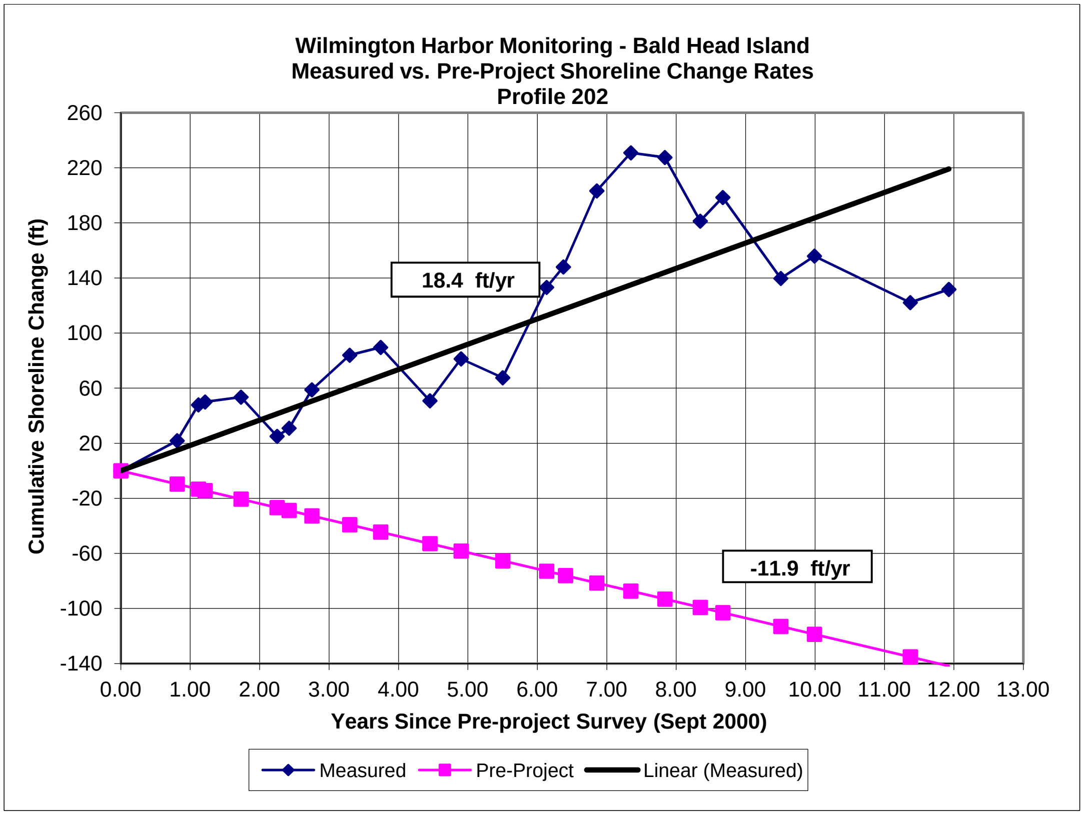

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 182
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
17.4 ft/yr
-6.5 ft/yr
Measured
Pre-Project
Linear (Measured)

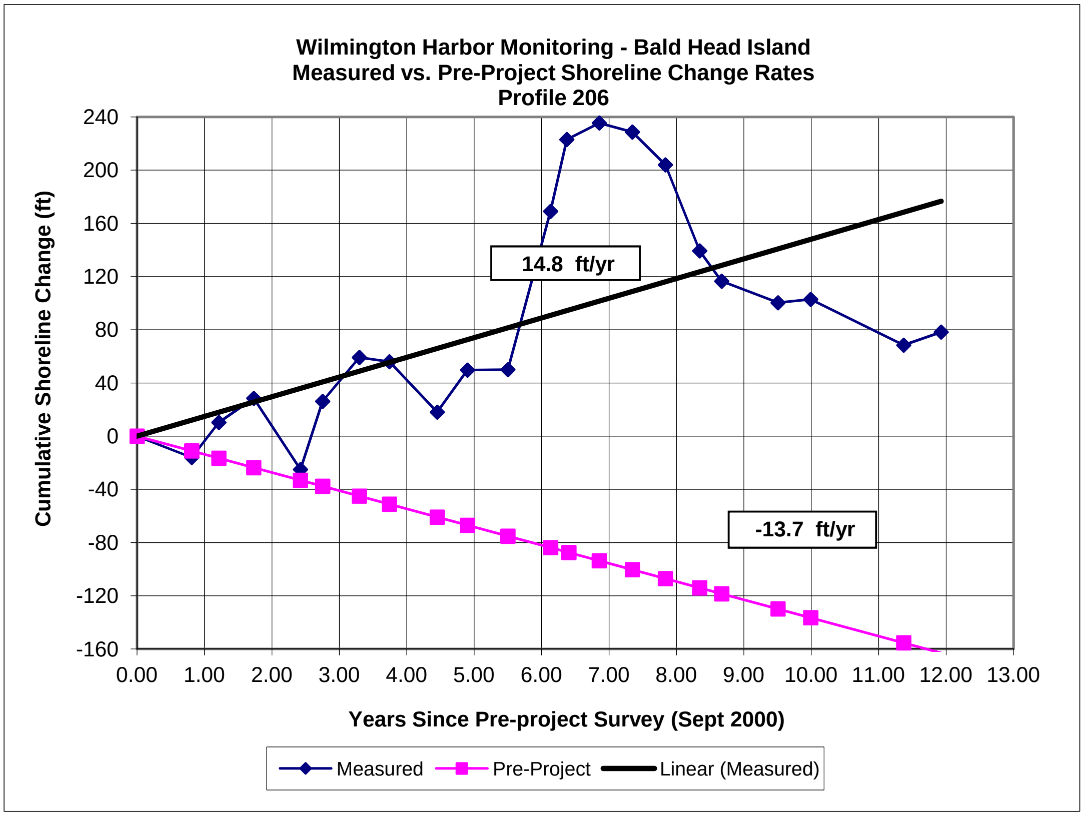

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 186
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
-120
16.6 ft/yr
-7.0 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

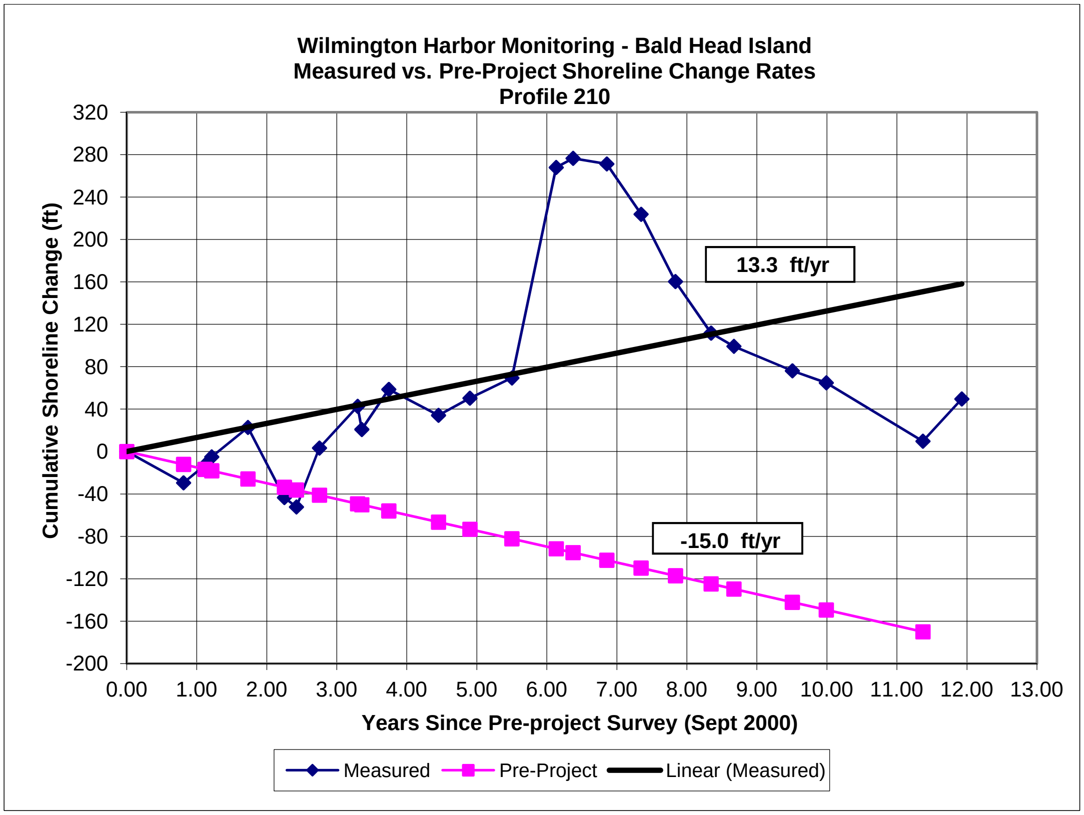

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
220
180
140
100
60
20
-20
-60
-100
16.6 ft/yr
-7.8 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

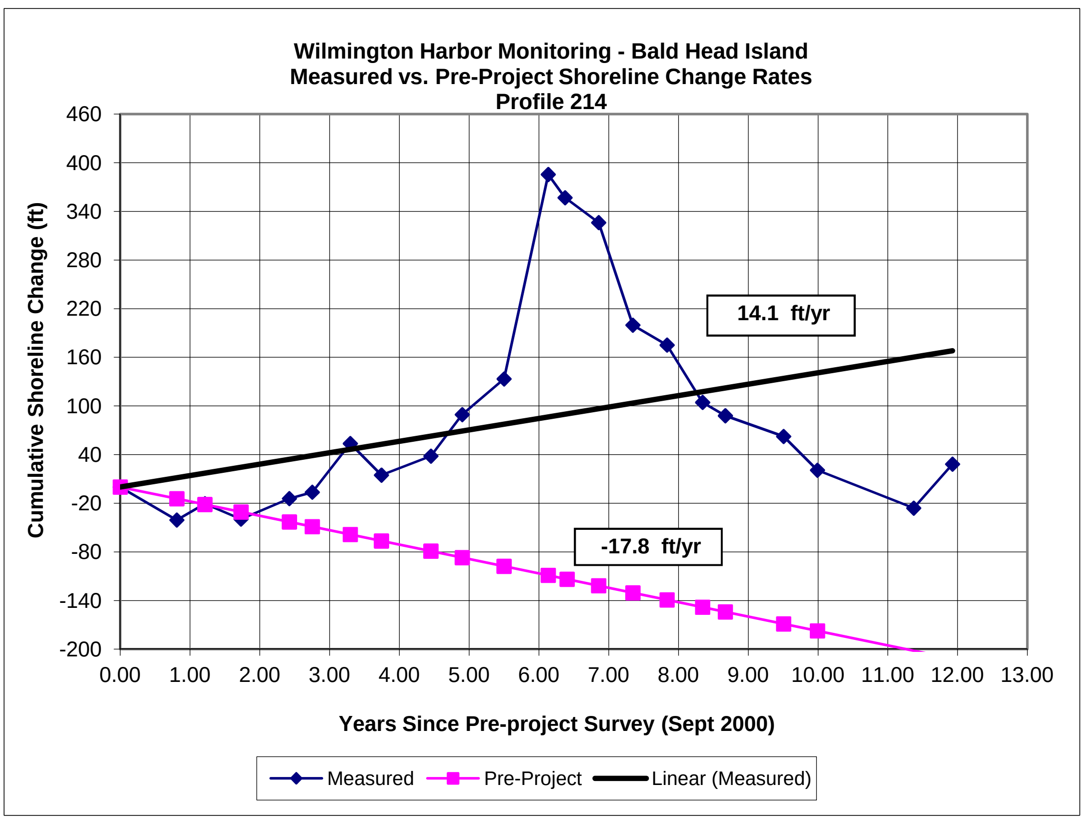

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 194
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
-120
16.5 ft/yr
-8.6 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

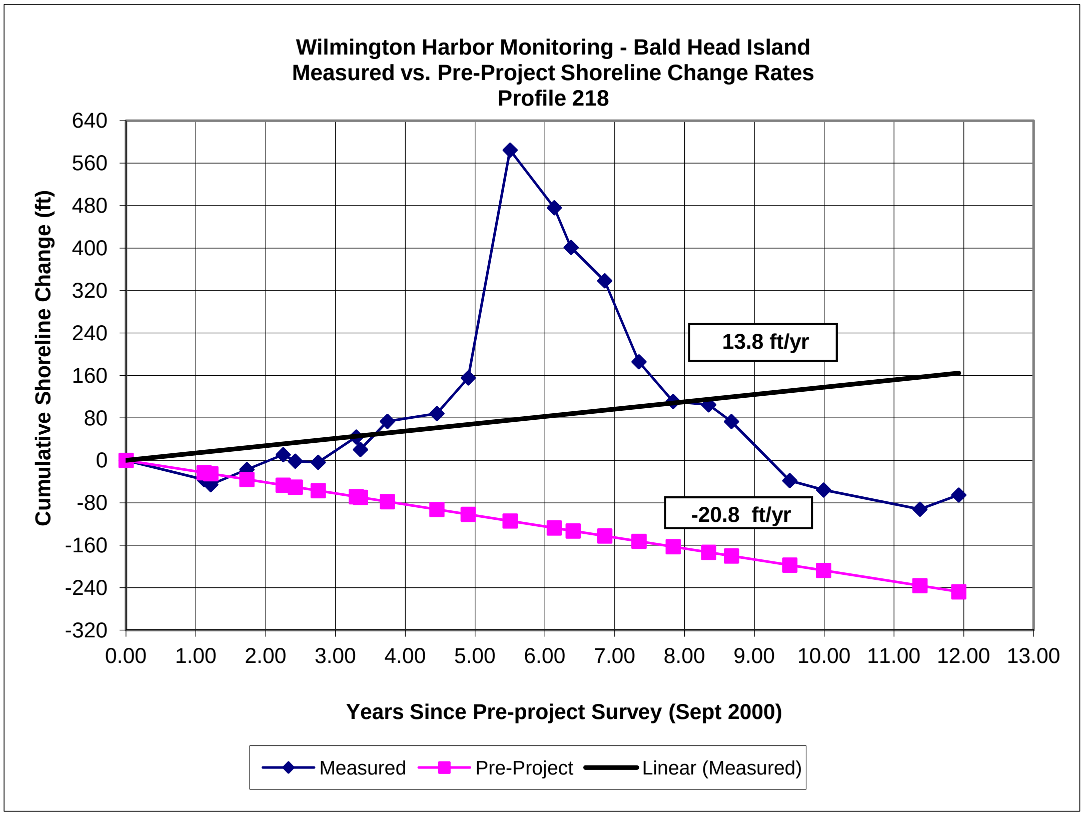

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 198
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
-120
-160
18.1 ft/yr
-10.0 ft/yr
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 202
Cumulative Shoreline Change (ft)
260
220
180
140
100
60
20
-20
-60
-100
-140
18.4 ft/yr
-11.9 ft/yr
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
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 206
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
-120
-160
14.8 ft/yr
-13.7 ft/yr
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
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 210
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
13.3 ft/yr
-15.0 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 214
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
14.1 ft/yr
-17.8 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 218
Cumulative Shoreline Change (ft)
640
560
480
400
320
240
160
80
0
-80
-160
-240
-320
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Years Since Pre-project Survey (Sept 2000)
13.8 ft/yr
-20.8 ft/yr
Measured
Pre-Project
Linear (Measured)