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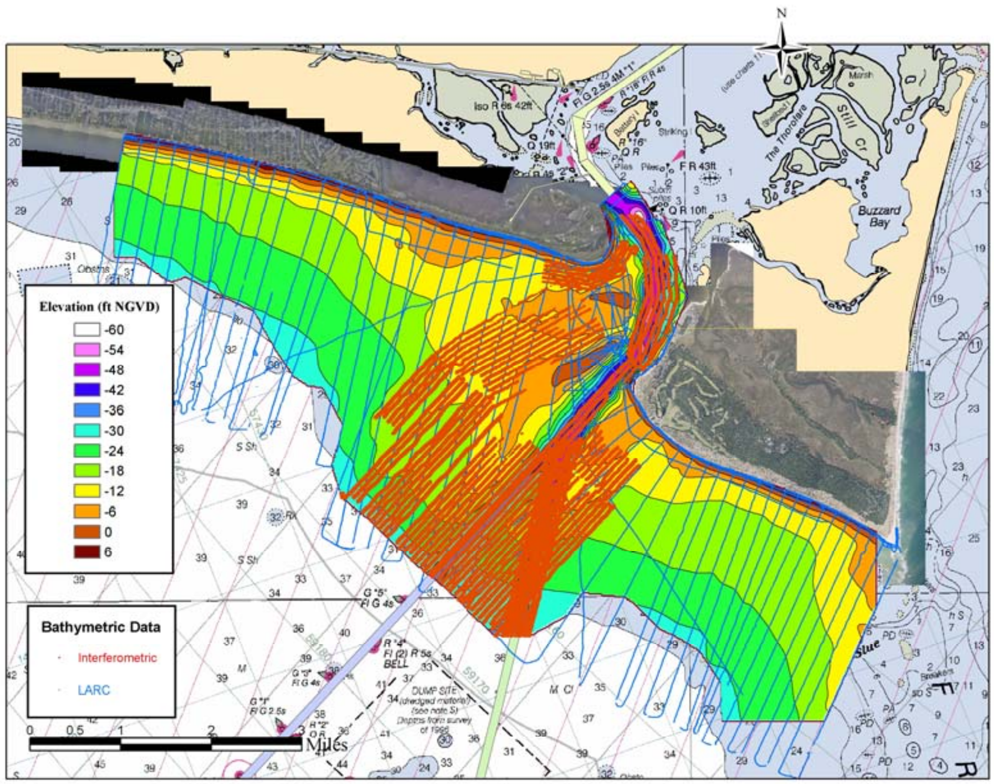
Wilmington District

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 5:
October 2006 – September 2007



APRIL 2008

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EXECUTIVE SUMMARY

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

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

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

This report is the fifth in a series and serves to update the monitoring program with data collected October 2006 through September 2007. The initial report published in July 2004 covered the period of August 2000 (pre-construction survey) through June 2003. The second, third and fourth reports covered the periods of; June 2003 to June 2004, June 2004 to August 2005, and September 2005 to October 2006, respectively. The remaining reports are scheduled to be prepared on an annual basis.

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

(LARC) survey system. The LARC vehicle transits through the water, across shoals, through the surf zone up to the base of the beach dunes.

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

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

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

Vertical color aerial photographs are taken yearly generally near the time of the spring profile survey. The nominal scale of the photography is 1 inch equals 1000 feet over the entire project area and 1 inch equals 500 feet for the Wilmington Harbor monitoring area. The larger scale print coverage extends from the westward beach disposal limit on Oak Island to the eastern end of South Beach on Bald Head Island.

Data collected over the present monitoring period of October 2006 through September 2007 have included: two complete beach profile surveys (January 2007 and July 2007), one ebb shoal survey (January 2007), one entrance channel current measurement (February/March 2007), and near continuous wave measurements.

Results to Date

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

- Oak Island/Caswell Beach did erode over the last year but still remains stable overall. Shoreline retreated an average of 12 feet over the last year but is on the average 97 feet more seaward than it was at the start of the project seven years ago
- Most of the initial beach disposal material remains along Oak Island/Caswell Beach with more than 1.4 million cubic yards still present above the pre-project condition
- Comparing long-term shoreline change rates with those of the 7-year monitoring period show Oak Island presently experiencing high rates of accretion versus historic minor erosion

- Bald Head Island experienced overall shoreline gains over the last year in response to the beach fill placed along South Beach. When comparisons are made over the 7-year monitoring period accretion is evident along most of Bald Head Island, however, a small area of chronic shoreline recession remains present along the south-western corner of the island.
- Comparing long-term shoreline change rates with those of the 7-year monitoring period show Bald Head Island is presently experiencing less erosion overall. However, the post-construction rates are higher along the western end of South Beach
- Village of Bald Head reconstructed a geo-textile groin field following the placement of the January 2005 beach fill along about 6,500 feet of shoreline within the problem area at the western end of South Beach. The groin field appears to have had a positive effect in retaining the beach, particularly within the upper portions of the beach profile.
- 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 the width fell below the 500 foot threshold limit in November 2006. This was corrected with the 2007 maintenance dredging and the present minimum width is 657 feet at station 19+00 of Reach 1.
- Rate of spit growth into Baldhead Shoal Channel has decreased following the 2005 dredging versus the 2001-02 dredging and has remaining relatively low thus far following the 2007 dredging
- Overall change in ebb and nearshore bathymetry included moderate changes within Jay Bird Shoals, growth of the western portions of Bald Head Shoal, and infilling of the old channel bed (aided by dredged material disposal)
- Current measurements taken before and after project channel dredging show similar overall flow regimes, except for consistently higher peak velocities measured with the after project condition

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 4 (October 2006) 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 2006 to July 2007) and for the entire period (from August/September 2000 to July 2007).

For Oak Island/Caswell Beach, the shoreline change measured over the last year has been somewhat variable over the 6-mile monitoring area with an overall trend being one of erosion. When considering all profile lines, an average shoreline retreat of 12 feet is evident for the present period of October 2006 to July 2007. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –100 to +75 feet), the alongshore trend is also erosional with an average 13 foot loss for the same period with the greatest losses occurring within the western half of the region. When considering changes with respect to the August 2000 pre-construction position, the same high degree of variability is evident near the tip of the island, but a much stronger trend towards accretion is present extending westward along the remaining portions of the island. In fact, except for a couple exceptions, the surveys show that all shoreline changes measured west of Profile 40 are positive. To a large degree, this reflects the shoreline response and subsequent stable behavior of the fill placed along this entire reach associated with the channel deepening in 2001. In considering all the profile data, the alongshore average shoreline position was 97 feet more seaward in January 2007 than it was in 2000. Likewise, the shoreline position was 82 feet more seaward in July 2007 than it was seven years ago at the start of the project. Only one area may be of some concern along Oak Island. This 3,000-foot-long area, just to the west of the CP&L canal (between Profiles 90 and 120), did not receive material during the 2001 dredging. This reach has remained stable over the years, but has relatively smaller shoreline advances (about 0 to 30 feet) compared to the adjacent reaches. Further, although the remaining portions of Oak Island remain healthy with respect to the base condition, these fill areas have eroded over the last year particularly evident within the western half of the monitoring area.

In terms of volume change, Oak Island/Caswell Beach has shown mostly accretion except for a zone extending between Profiles 60 & 100 over the current period. The erosional zone extends for about 4000 feet and represents a modest volumetric loss of 53,000 cubic yards. Aside from this area, the remaining data show positive changes throughout. When considering all profile lines, a net gain of 112,400 cubic yards was computed since the last report, between October 2006 and July 2007. This overall stable trend observed over the current period is typical of that measured for the entire 7-year monitoring period. As such, all reported volume changes are positive with the exception of several isolated profiles which show small losses. The alongshore pattern shows relatively lower volume gains in the vicinity of Profiles 40, 100, and 180. All other areas are very healthy with respect to volumetric gains relating back to August 2000 base condition. Specifically, by the end of the period, an excess of 1,423,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity actually reflects a modest net gain above the fill volume placed in 2001 of about 280,000 cubic yards. Most of this remaining balance is within the western portion of the monitoring area and is believed to be the result of the eastward spreading of a separate beach fill (Sea Turtle Habitat Project in 2001) placed just beyond the boundary of the project area. The alongshore distribution of material basically follows the shoreline response where net gains are seen along most of the island.

Since the last reporting, most of the profile locations along Bald Head Island have been accretional. This response is largely driven by the beach fill completed in April 2007, which is bracketed by the two most recent monitoring surveys. The results show large gains at each end of South Beach with more moderate gains in the mid-portions of the beach, reflecting the nature of the fill disposal which was placed in two segments with a gap in the middle. Specifically, the largest accretion measured at the end of the period was more than 250 feet at the western terminus of the fill, located in the vicinity of the spit. Another peak gain of more than 200 feet was measured in an area near the eastern terminus of the fill between Profiles 160 and 170. In between these peak gain areas, the beach remained stable showing shoreline changes from 0 to 50 feet. When considering the overall area bounded by the outer limits of the fill (between Profiles 45 to 170), the shoreline was found to have advanced an average of 118 feet. Extending east of the fill area, the beach remains stable and then turns erosional in the immediate vicinity of the cape.

As indicated in prior reports, the area in the vicinity of the spit (Profiles 32 to 47) is found to be highly variable. Over the last year, a portion of this area has shown gains of about 300 feet with adjacent portions losing 60 feet. The greatest gains are found at Profiles 40 thru 47 under the direct influence of the recent beach fill. In contrast the greatest loss is found at Profile 36 just inside the advancing spit. The remaining area along West Beach (Profiles 0 thru 28) has shown a general loss over the period, with the shoreline retreating about 5 to 10 feet over much of this area. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 7 feet with the January 2007 survey and a gain of 70 feet as of July 2007, since the last reporting.

Shoreline change patterns as measured over the last 7-year period, i.e., since the monitoring was initiated, are strongly positive when measuring relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional, with the July 2007 shorelines being typically 50 feet to as much as 300 feet seaward of their September 2000 positions. In fact only one profile along south beach (Profile 61) is shown to have a net erosion of the last 7-year period with a retreat of 13 feet. The measured shorelines in the vicinity of the cape also remain positive at the end of period being more than 300 feet through the most current survey. The exception to this general stable pattern is a small area of erosion within the vicinity of the spit area at the western limit of South Beach. Specifically, this area contains Profiles 43 and 45 which are located just west of the groin field, where present shoreline retreat is on the order of 20 feet. By comparison with the two prior surveys, this erosion area has been greatly reduced through the placement of the recent fill. Proceeding further to the west, the erosion turns positive over the remaining portions of the spit area, reaching a maximum advance of 235 feet. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline has shown an average loss of about 13 feet when compared to the base condition. When considering all locations along Bald Head Island (Profiles 0 to Profile 218), the shoreline is presently on the average 131 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey (October 2006) of Report 4 to the present, Bald Head Island is dominated by large gains along most of South Beach, except for a few areas which have relatively small losses. As discussed above, the volumetric increases are driven by the most recent beach disposal along South Beach. As such, the greatest increases are located along the western and eastern portions of South Beach, with relatively smaller gains shown between these two peak areas. The few areas which have volumetric losses over the present cycle are located along West Beach, the spit and near the cape. In summing the changes over the entire monitoring area, the losses are overridden by the gains which resulted from beach disposal amounting to a positive net change of about 792,400 cubic yards over the period from October 2006 to July 2007. Additionally, the zones along South Beach which received the dredged material (Profiles 44 to 91 and 110 to 170) were found to have increased by 855,000 cubic yards over the same period. This compares favorably to the in-place quantity computed during the fill operation which amounted to 978,500 cubic yards, implying a relatively modest loss of the fill of 123,500 cubic yards or about -13% loss of material.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, Bald Head Island is again dominated by overall gains over the last seven years. The most substantial increases are found along the western half of South Beach and in the vicinity of the spit. Elsewhere, there are two areas which have recorded net overall losses for the period. One is located at the extreme eastern end of south beach, where some losses have occurred near the cape. The other, which is of greater concern, is along the westernmost portion South Beach extending into the spit area between Profiles 45 to 70. This reach, covering approximately 2,500 feet, has been the site of chronic erosion in the past. Volumetrically this represents net loss of about 249,400 cubic yards. Aside from these areas of erosion, all other profile volume changes are positive throughout. As a result of this overall response in the profiles, the net volume change is a gain with respect to the beginning of the monitoring in 2000. The total volume change is a 456,300 cubic yard gain in January 2007 and 1,316,800 cubic yard gain by July 2007.

Rates of shoreline change were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the North Carolina Division of Coastal Management (NCDCM) shoreline data based on a 62-year period of record (1938-2000). Although the monitoring period spans a relatively shorter time period of about 7 years, it is of interest to compare these trends with established long-term shoreline response for the area.

Shoreline change rates computed over the initial 7-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 beach fill. Although these positive rates have been found to moderate since the fill placement, they remain in sharp contrast to the long-term trend. Overall, the shoreline change rate averaged over the entire monitoring area was about +21 feet per year for the 7-year period. By comparison the long-term NCDCM rate over the entire reach was –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 7-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 although the extent and magnitude of this zone have decreased for rates computed through the present period. A direct comparison of the pre- and post-construction shoreline change rates show that only three profile lines are eroding at a higher rate during the post-construction period. These lines at located at the western end of south beach (Profiles 53, 57 and 61). Adjacent Profile 66 is presently eroding but at a lower rate as compared to the pre-construction condition. All other lines are accreting in direct contrast to the long-term erosion experienced along the remaining areas of South Beach. Most of this response is attributable to the beach fill placement and possibly to the positive effect of the rehabilitated groin field.

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 established with respect to a minimum acceptable channel width is 500 feet at the -42 feet mean low water (MLW) elevation. As of 2007, seventeen condition surveys have been accomplished, four of which occurred over the present reporting period (January 2007, March 2007, June 2007 and September 2007). The channel condition at the end of the prior reporting period in Report 4 revealed that stations 20+00 through 24+00 and stations 33+00 through 34+00 within Bald Head Shoal Channel 1 had all exceeded the threshold. The average navigable width in these areas was 469 feet with the minimum occurring at station 23+00 at a width of 438 feet. Do to the forthcoming 2007 maintenance dredging no action was undertaken at that time. With the subsequent dredging being under taken over the present period (March-April 2007), this breach of the navigable width threshold has now been corrected. As a result all reaches easily satisfy the minimum width criteria of 500’ at -42’ MLW as of the present reporting period. Specifically, the minimum navigable width within Reach 1 was approximately 657 feet at station 19+00 and the maximum navigable width was found to be 1019 feet at station 6+00. Further Reach 1 had an overall average navigable width of 787 feet.

The navigation channel surveys have shown the area of the spit to have enlarged volumetrically to at least twice as large as previously observed following the 1.8 million cubic yard fill placement in 2001-02. The same area of growth was monitored following the dredging and placement of 1.2 million cubic yards in 2004-05 as discussed previously in Report 4. The comparison showed that the rate of growth was slower following the second event. This analysis was continued for the present report leading up to the 2007 dredging event. The results showed that the trend continued showing a lower shoaling rate for the entire period following the second dredging. Specifically, the initial rate was about 16,000 cubic yards per month versus the second rate of about 9,800 cubic yards per month, i.e., a 39 % reduction in shoaling rate. A similar analysis was done following the most recent dredging in 2007. The results showed an even lower monthly shoaling rate of 3,650 cubic yards was evident for the third dredging/shoaling cycle. This result is only based on two surveys of the most recent cycle, so the results should be viewed with caution and additional future data are needed to verify this trend. Among the possible explanations for this slower spit growth rate are: (1) sand tube groin field constructed immediately after the 2004/2005 placement has been effective in retaining the fill, (2) smaller volume of material placed in the 2004/2005 placement dispersed from the island at a slower rate, (3) different location of placement with the second fill being farther away from the channel, and/or (4) possible dissimilar wave and current conditions for each period of record.

The effectiveness of the reconstructed groins was analyzed by comparing the response of the 2001 beach fill (without the groins) to the 2006 beach fill (with the groins). The analysis revealed that the new groin field has 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. In this regard, shoreline changes over similar time frames after the first and second fills show shoreline retreats on the order of twice as large for the first post-fill period. Specifically, the average retreat within the groin field for the 23 month period after the first fill was 160 feet compared to 90 feet for the similar period after the second fill. The onshore volume losses were also found to be significantly greater following the first fill without the benefit of the groins. This is particularly true within the western portions of the groin field with losses being on the order of three times as large.

Detailed bathymetric surveys were made of the ebb and nearshore shoals in the vicinity of the entrance channel to assess any changes associated with the entrance channel deepening and realignment. Aside from the direct changes resulting from dredging the new channel, the major overall changes in morphology of the ebb and nearshore shoals since the start of the monitoring have included changes along Jay Bird Shoals, Bald Head Shoals, and within the vicinity of the old channel bed. The changes within Jay Bird Shoals have been somewhat complex with some portions shoaling and some portions scouring. Generally, the outer portions have shown a generalized lowering but a moderate amount of shoaling has occurred within the northernmost area of Jay Bird Shoals just off the tip of Oak Island. Adjacent to this shoal is a scour feature associated with a flood channel just offshore of Oak Island although the last two surveys have shown this feature to have become more stable. On the other side of the channel, Bald Head Shoal has shown significant gains extending off of the southwestern corner of Bald Head Island. Additionally, the old channel bed has also accreted since the beginning of the monitoring period, as this area is used as a disposal site for other dredging operations in the river.

To date currents have been measured on seven occasions, with the initial occurring before the channel improvements and the remaining six after the deepening. Currents are measured over a complete tidal cycle along transects across the mouth of the entrance channel and along the seaward portion of the ebb tide delta near the intersection of the old and new channel alignments. Comparison of current measurements taken before and after the channel dredging show very similar flow regimes and are consistent with the minimal change seen in the overall bathymetry of the ebb tide delta. Of interest, however, is that with each of the post-dredging measurements, the maximum velocities are found to be greater than those of initial current survey. This was evident with both the inlet and offshore transects.

Sand Management Considerations.

Operation of the project involves the implementation of a Sand Management Plan. Under this plan, disposal of beach compatible sediment is to occur on the beaches adjacent to the Cape Fear River entrance every 2 years. The distribution is such that disposal is 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 (i.e. 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 fill. The groin reconstruction took place over the period of March-May 2006. 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 next maintenance is scheduled for disposal along eastern Oak Island/Caswell Beach in 2009 and will complete the first overall 2 to 1 sand management cycle (i.e. through year 6). Ongoing monitoring efforts will be used to document the performance of this recently placed fill and to plan the third maintenance cycle. The results presented in this report along with the next scheduled monitoring surveys will be used to establish the quantities and limits of the fill. The final disposal plan will be fully coordinated with local interests.

PHYSICAL MONITORING
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REPORT 5

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PHYSICAL MONITORING
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REPORT 5

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 fifth 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 2006 through September 2007. Monitoring Reports 1, 2, 3 and 4 were published in August 2004, February 2005, May 2006 and May 2007, respectively, and covered the first six years of monitoring (USACE 2004, USACE 2005, USACE 2006 and USACE 2007). The monitoring program is designed to meet two main objectives: (1) to document the response of the adjacent beaches to the deepening and alignment changes of the entrance channel and (2) to use the results of the program to effectively implement the project's sand management plan.

Project Description

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

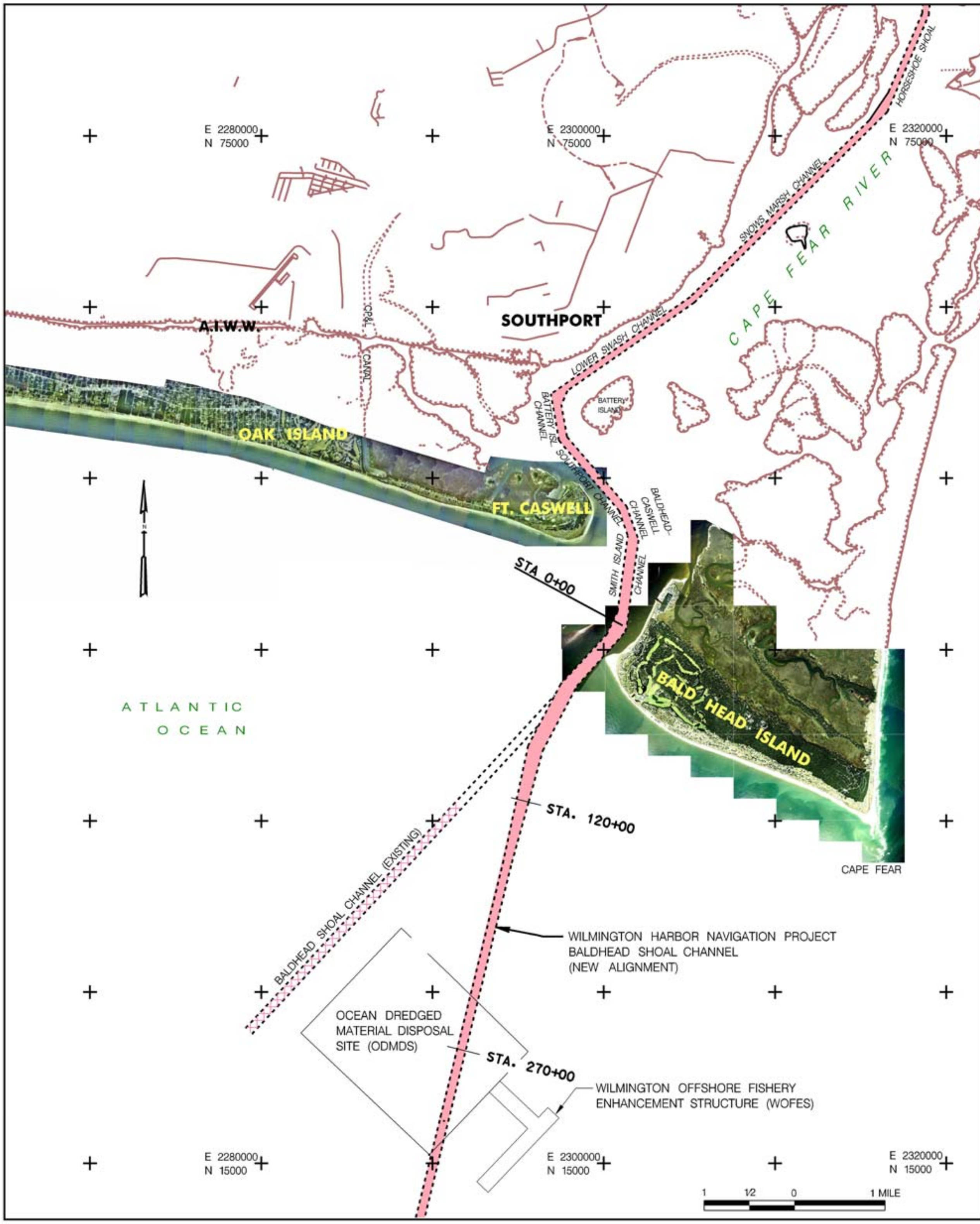


Figure 1.1 Project Location Map

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

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

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

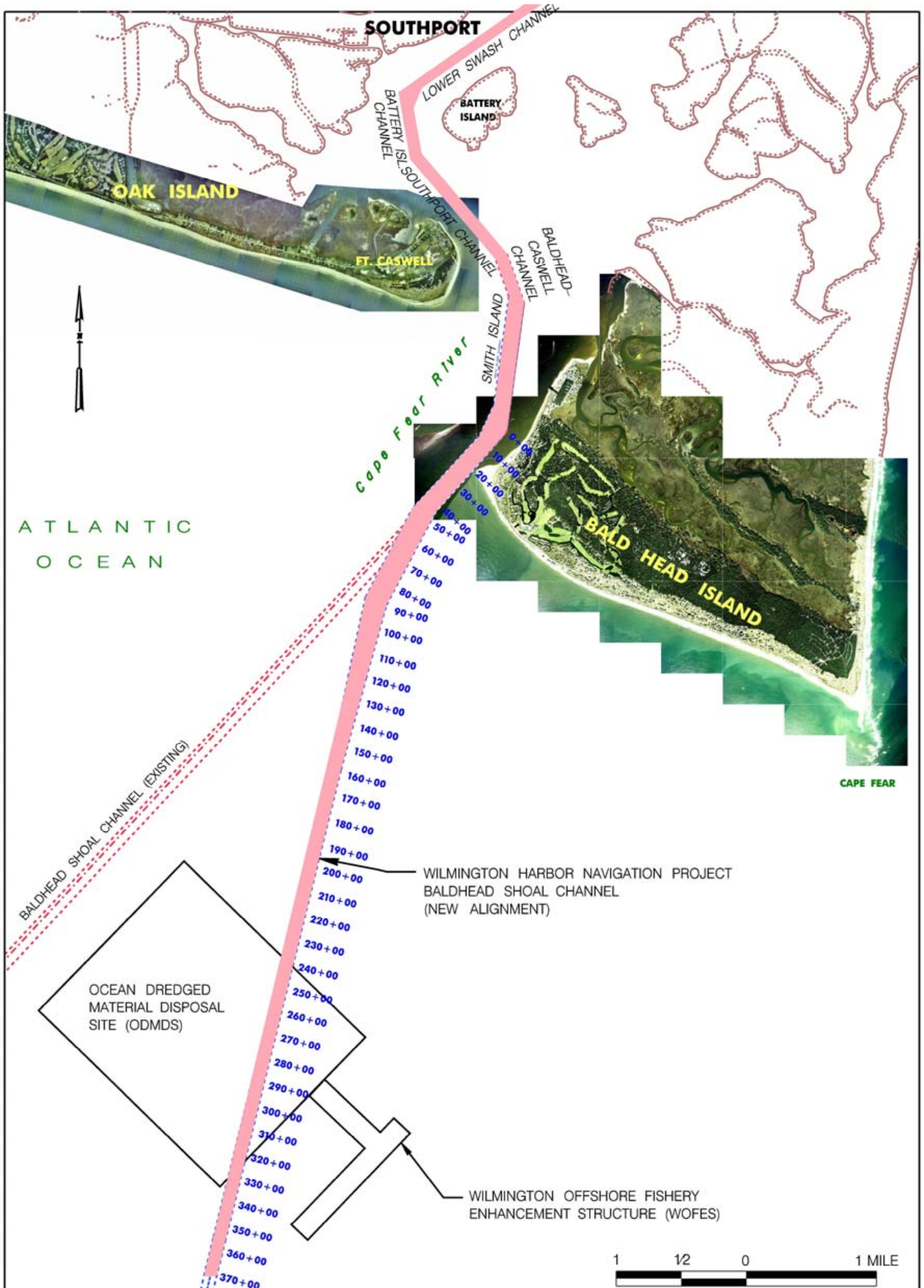


Figure 1.2 Realignment of the Federal Navigation Channel at the Cape Fear River Entrance

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. 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	PLACEMENT LIMITS			PLACEMENT DATES		BEACH VOLUME	DREDGE
	APPROX	NORTHING	EASTING	START	STOP	(INPLACE)	
	BL STA	(ft, NAD83)	(ft, NAD83)	mm/dd/yyyy	mm/dd/yyyy	(cy)	
			(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		

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. As such, approximately 1,217,500 cubic yards of beach fill 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.

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. The future maintenance includes the periodic 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 is 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 will be 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 will be placed back on Bald Head Island and the remaining cubic yards placed on east Oak Island/Caswell Beach. Maintenance of the channel is planned to take place biennially. In order to accomplish this two-to-one distribution, the littoral shoal material removed from the entrance channel for maintenance would be 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 would take 6 years to complete.

Each maintenance operation is expected to involve the removal and disposal of approximately 1,000,000 cubic yards of beach material. The disposal locations on each island are to be based on the measured beach response during the operation of the project as determined by the monitoring program. The overall disposal lengths include 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 includes 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 are planned to fall within the above limits, but may not cover the entire area on any given operation.

Monitoring Program

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

Program Elements. The present monitoring program consists of five basic elements namely; beach profile surveys, channel and ebb tide delta surveys, wave and current measurements, aerial photography, and data analysis/reporting. The data collection effort is a large undertaking and involves numerous entities including the Corps of Engineers, private contractors, and academia. The Wilmington District manages the program and is responsible for project coordination, funding, data analysis and report preparation. The majority of the data collection is accomplished by the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Field Research Facility (FRF) located in Duck, North Carolina. The FRF is responsible for obtaining the beach profile surveys, ebb shoal surveys, wave and current measurements, and associated data reduction, quality control, and analysis. The wave/current gauges are operated by Evans Hamilton, Inc (EHI) through the FRF and the detailed ebb tide delta and shipboard current surveys have been performed by the Virginia Institute of Marine Science, through EHI and more recently by the FRF. Some of the beach profile surveys and aerial photography are also obtained by the Wilmington District through the use of private companies. The beach profiles have been surveyed by McKim & Creed Engineering and Greenhorne & O'Mara (subcontract with Geodynamics); whereas, the aerial photos have been provided under contract with Barton Aerial Technologies, Inc. and Nova Digital Systems, Inc. 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 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. For Bald Head Island, the beach profiles begin at the entrance to the Bald Head Island marina on West Beach, and extend all the way to Cape Point, located at the eastern end of South Beach as shown in Figure 1.3. The location of these profile stations were selected to coincide with existing beach profile stations currently being monitored by the Village of Bald Head Island, which are spaced at an interval of approximately 400 feet. The total shoreline distance covered along Bald Head Island is about 22,000 feet and includes a total of 58 beach profile stations. For the Oak Island/Caswell Beach portion, beach profile stations were established at approximately 500-foot intervals, beginning near the Cape Fear River Entrance and extending west along Caswell Beach/Oak Island, as shown in Figure 1.4. This coverage includes approximately 5,000 feet of shoreline fronting the North Carolina Baptist Assembly grounds at Fort Caswell (2,500 feet along the inlet shoulder and 2,500 feet along the ocean-front) plus 26,000 feet along Oak Island extending west of the Baptist Assembly property. The beach profile stations extend 1000 feet westward of the designated disposal limit on Oak Island and encompass a total shoreline length of 31,000 feet. A total of 62 profile lines comprise this shoreline reach. The profile locations follow along an existing baseline established by the Corps of Engineers that had designated profile stations at 1,000 foot intervals. The monitoring plan added intermediate lines at 500-feet and utilized the pre-existing 1,000 foot stations so that prior surveys could be incorporated into the program as necessary.

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

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

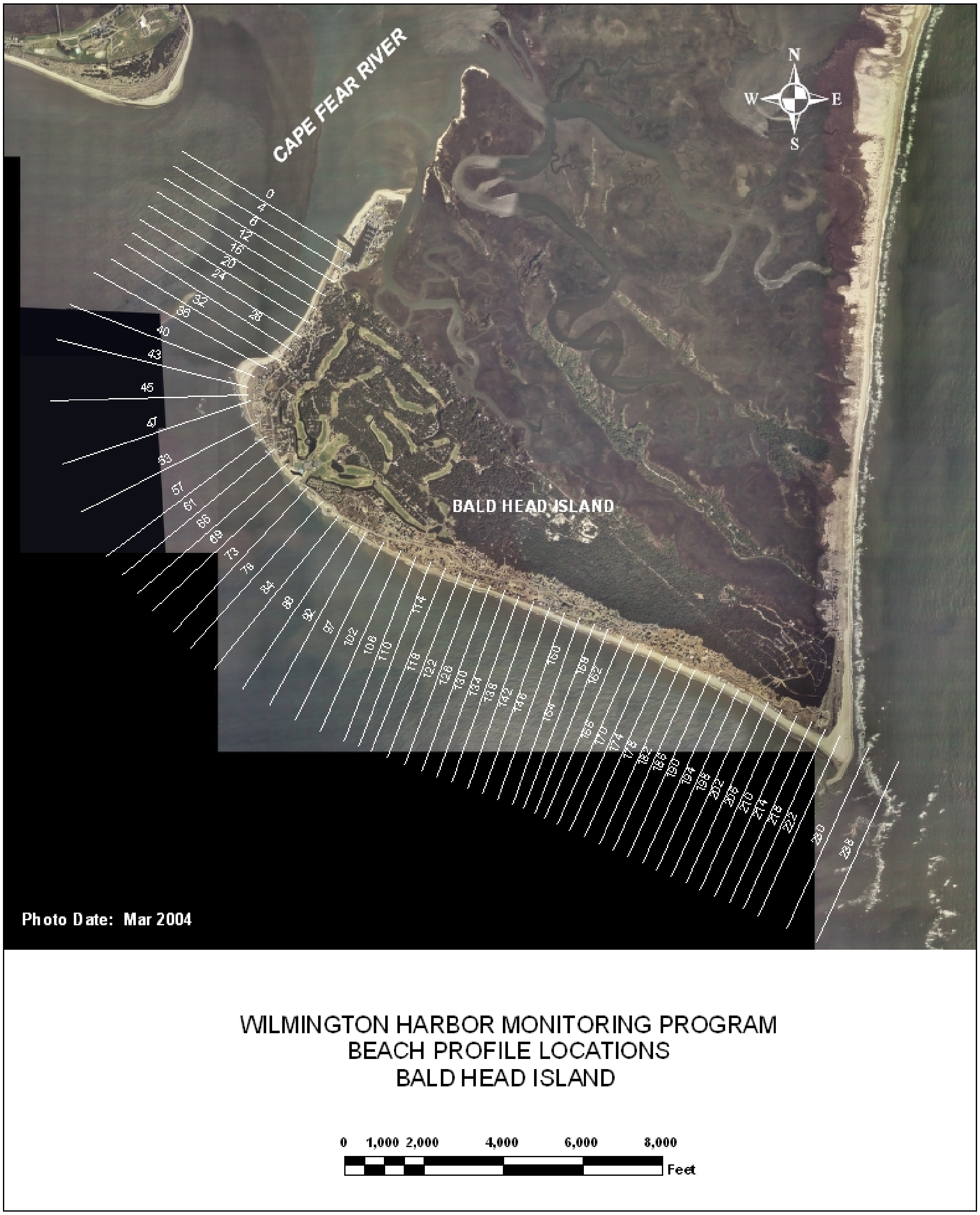
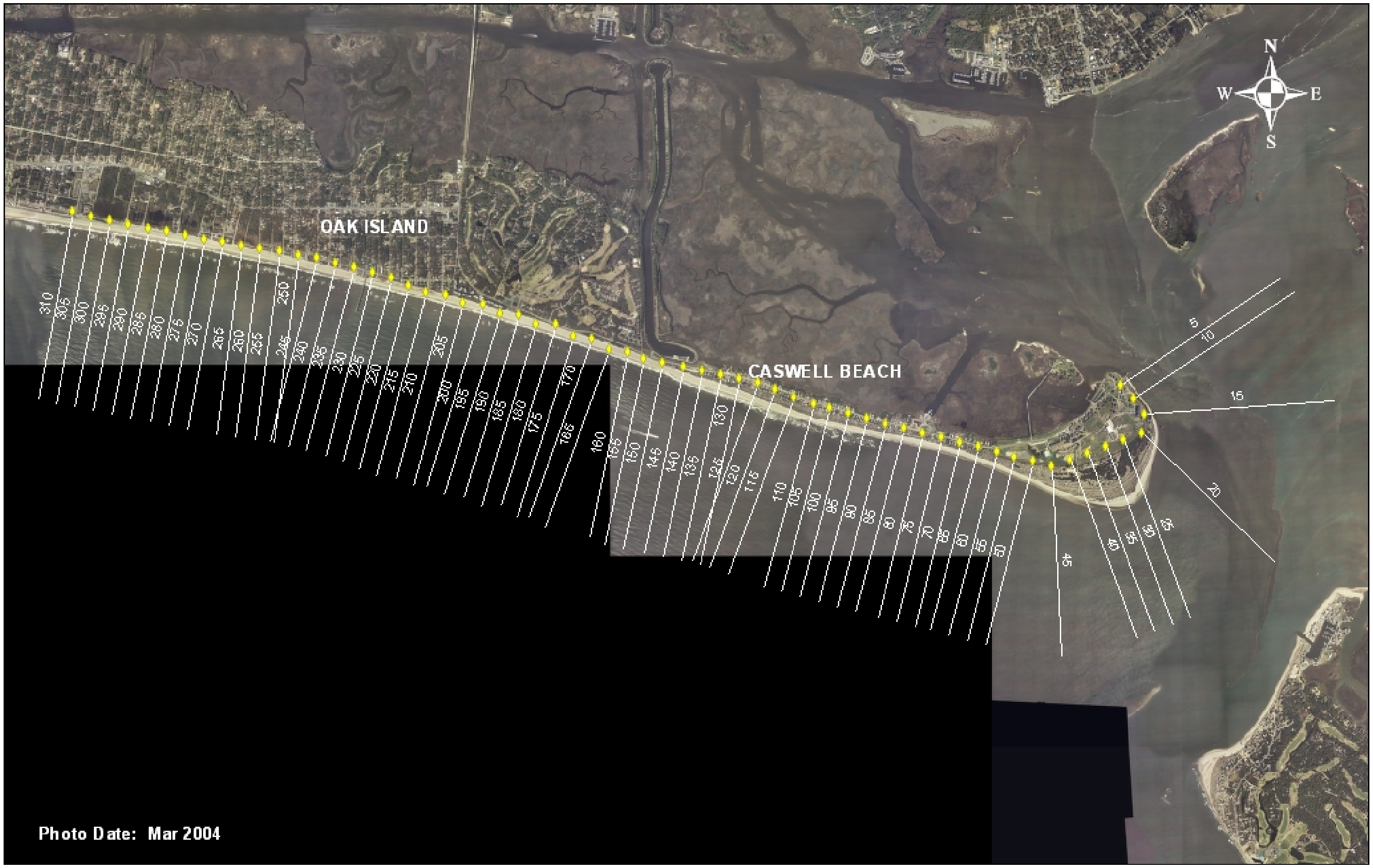


Figure 1.3 Bald Head Island Beach Profile Locations



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

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

Figure 1.4 Oak Island/Caswell Beach Profile Locations

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

Figure 1.5 FRF Hydro-LARC Survey System

<u>Channel and Ebb Tide Delta Surveys.</u> The Corps of Engineers routinely surveys the condition of the ocean entrance channel from the Smith Island Range seaward to the Bald Head Shoal Range about once every 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 associated with numerous dredging contracts that will continue during the future maintenance of the channel.

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

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

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

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

Aerial Photography. Vertical color aerial photographs are taken yearly generally near the time of the spring profile survey. The over-flight for this monitoring effort is part of a larger project that provides aerial coverage from the North Carolina-South

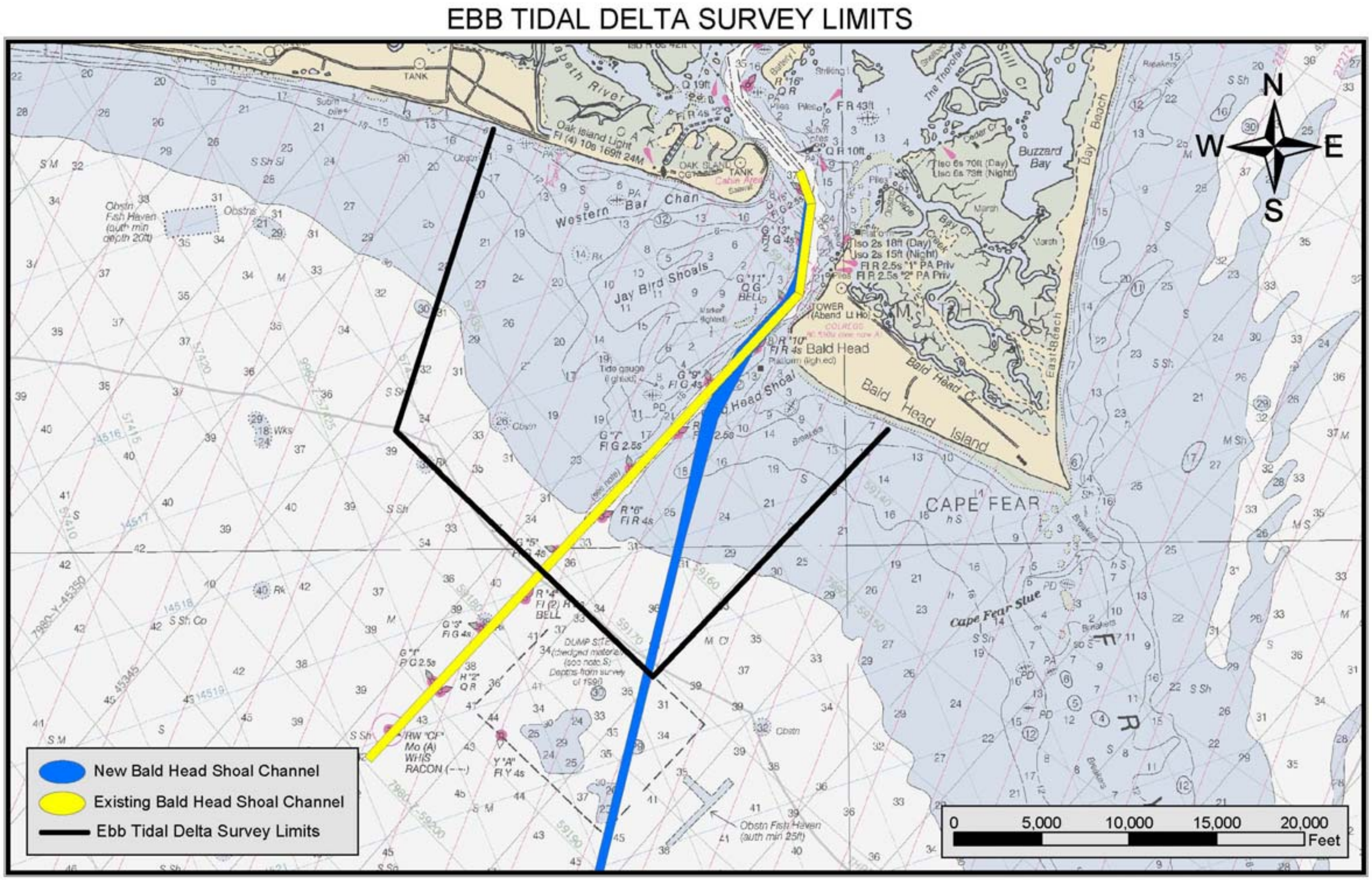


Figure 1.6 Entrance Channel and Ebb Tide Delta Survey Coverage

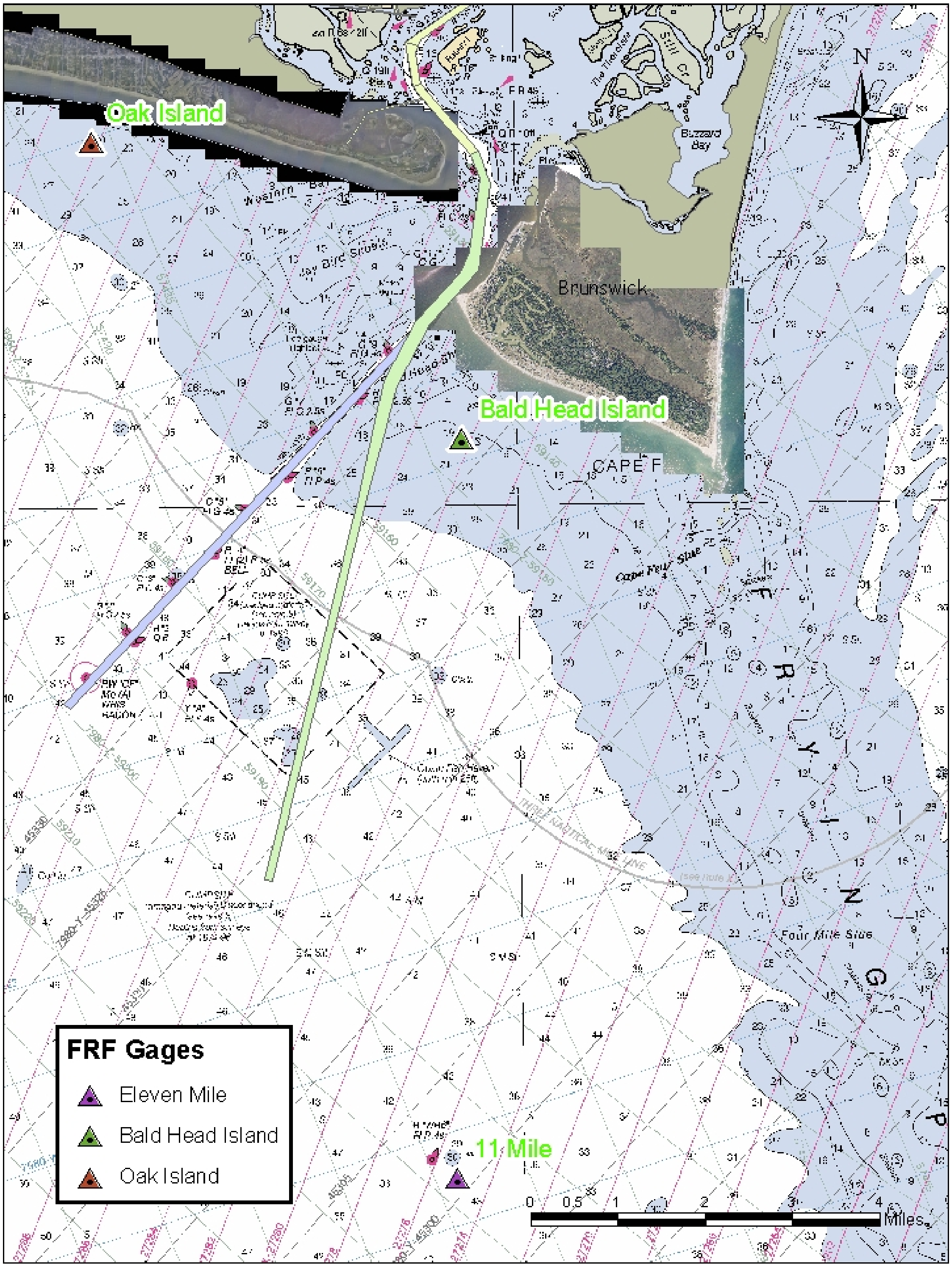


Figure 1.7 Wave and Current Gauge Locations

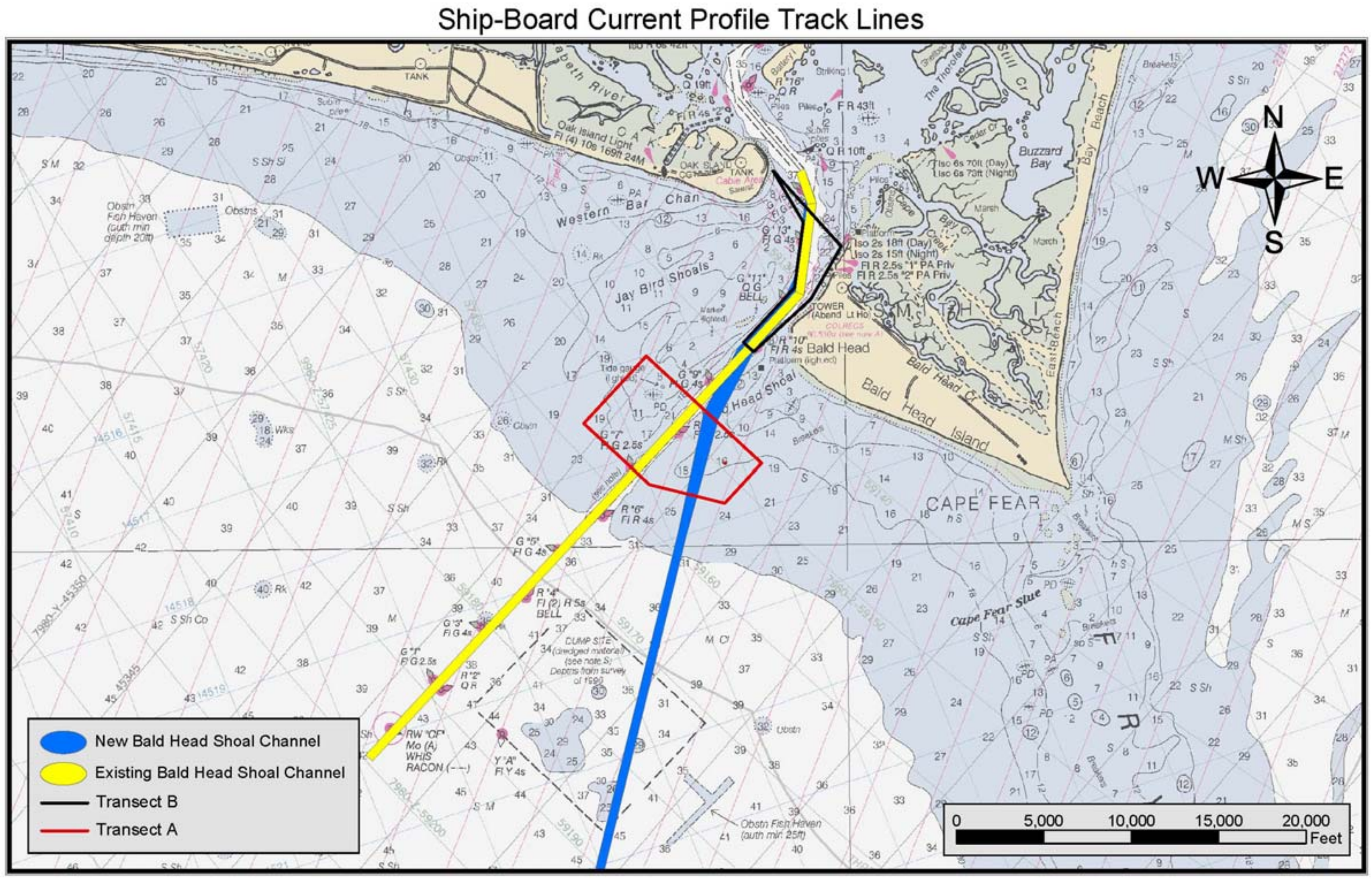


Figure 1.8 Shipboard Current Profile Locations

Carolina state line northward to Cape Lookout. The nominal scale of the photography is 1 inch equals 1000 feet over the entire project area and 1 inch equals 500 feet for the Wilmington Harbor monitoring area. The larger scale print coverage extends from the westward beach disposal limit on Oak Island to the eastern end of South Beach on Bald Head Island.

Data Analysis and Reporting. Reports summarizing the monitoring activity are scheduled for preparation on an annual basis. Each report will 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.

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 coverages for the Village of Bald Head Island monitoring surveys. In 2005 following the recent 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 - September	20 to 166	X	
1997 - March	20 to 166	X	
1997 - June	20 to 162	X	
1997 - September	24 to 162	X	
1998 - March	20 to 162	X	
1998 - June	20 to 162	X	
1998 - September	20 to 158	X	
1998 - December	24 to 166	X	
1999 - March	24 to 166	X	
1999 - November	0 to 218	X	X
2000 - November	0 to 214	X	X
2001 - August	8 to 210	X	X
2002 - July	8 to 210	X	X
2002 - December	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

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 July 2007 beach survey and therefore spans an initial period of seven years. Table 1.3 lists all the monitoring surveys to date. Since the initiation of the program there have been 13 onshore beach profile surveys, 11 offshore beach profile surveys and seven 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	

[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 six occasions. These data were collected in October 2000 with the initial data collection effort and in April 2002, March 2003, January 2004, March 2006 and February/March 2007.

Additionally, aerial photographs were taken on the following seven occasions: October 11, 2000, February 7, 2001, May 16, 2002, March 10, 2003, August 15, 2003, June 1, 2004 and April 24, 2006. There was no new photography was flown during the present monitoring period; however, photography was obtained from the Village of Bald Head taken in October 2006 and May 20, 2007.

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. This operation involved disposal of approximately 978,500 cubic yards of sediment along Bald Head Island.

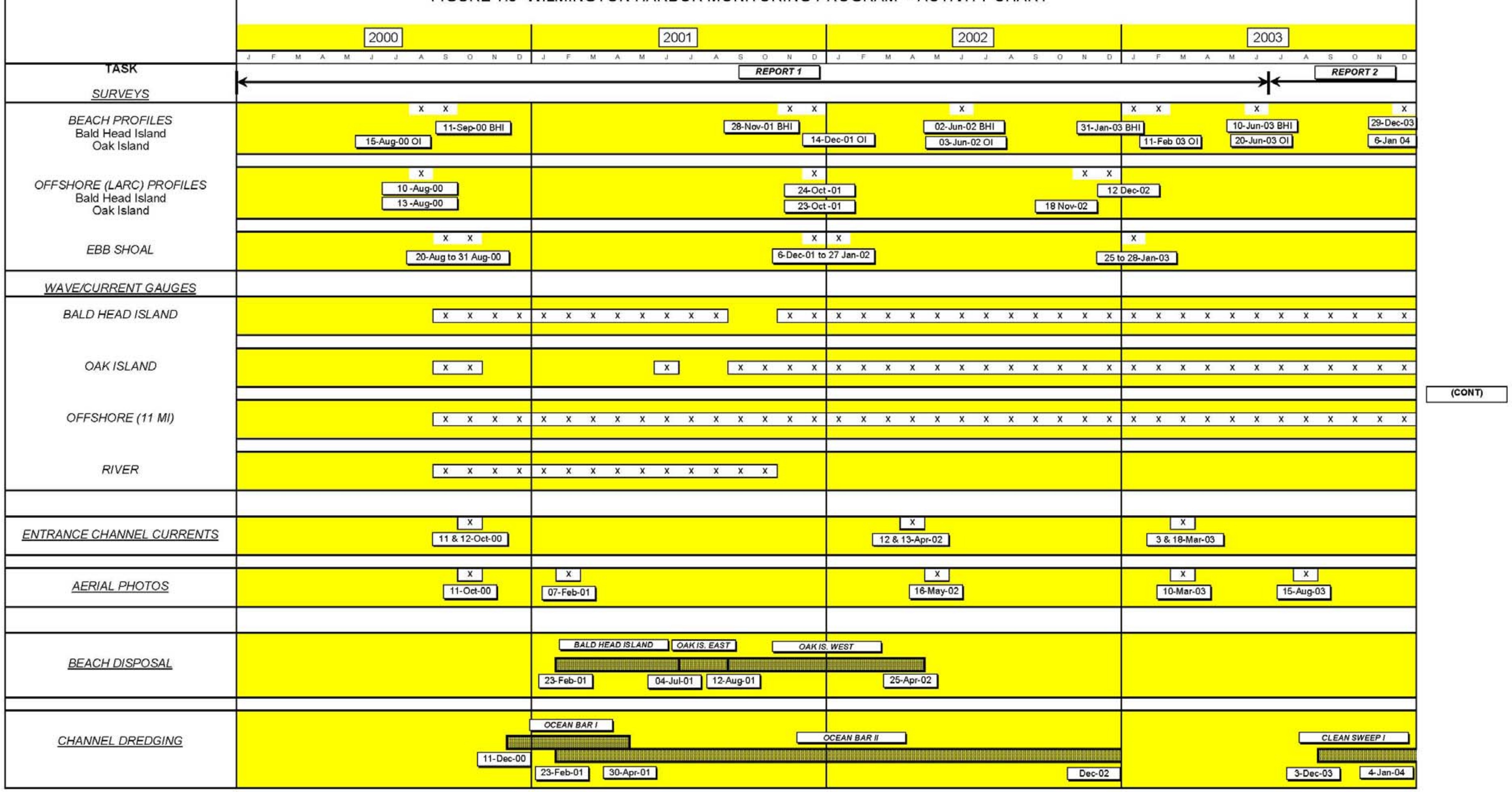
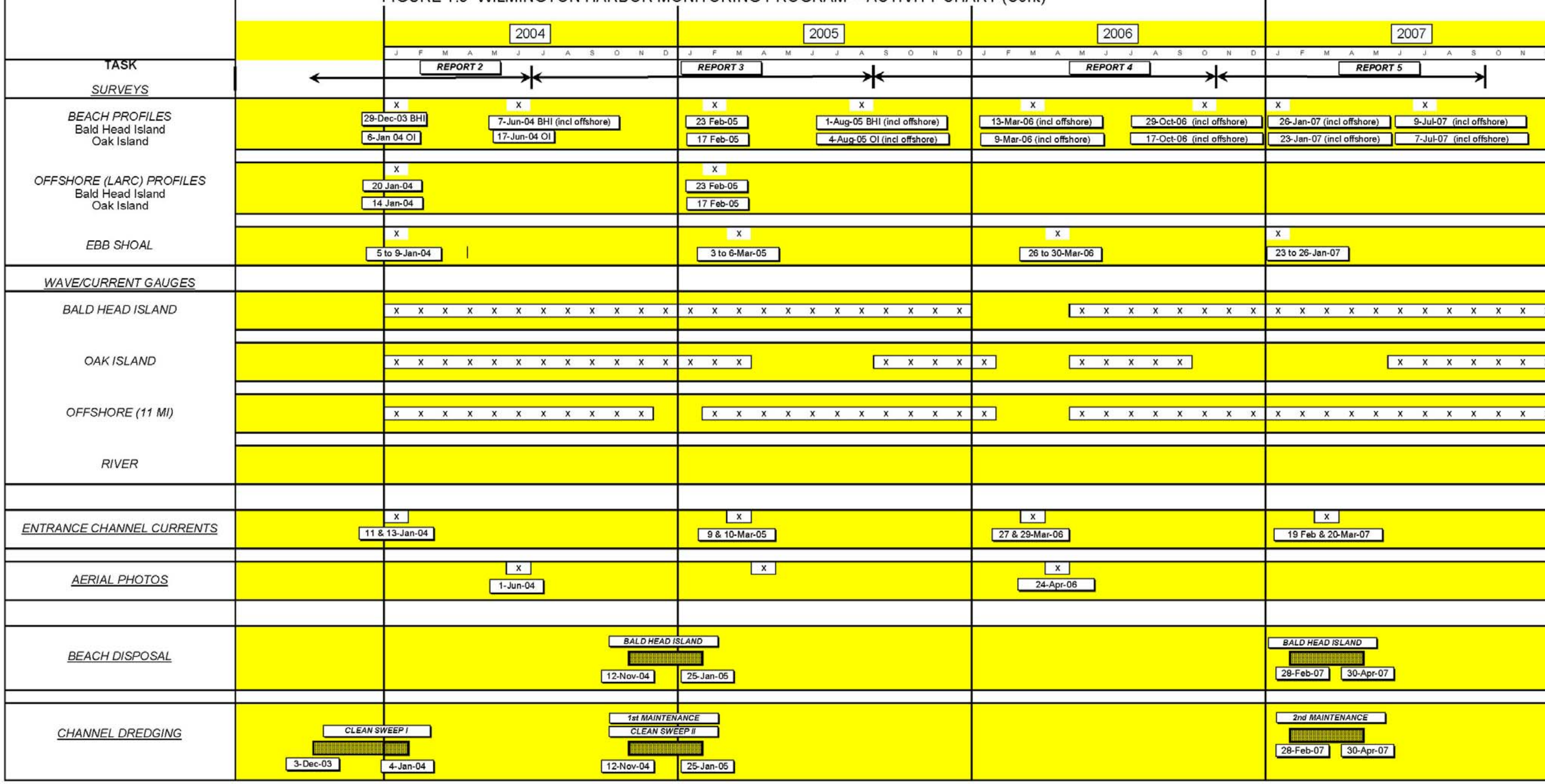


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART

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



Part 2 BACKGROUND INFORMATION

Shoreline Change Rates

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

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

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

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

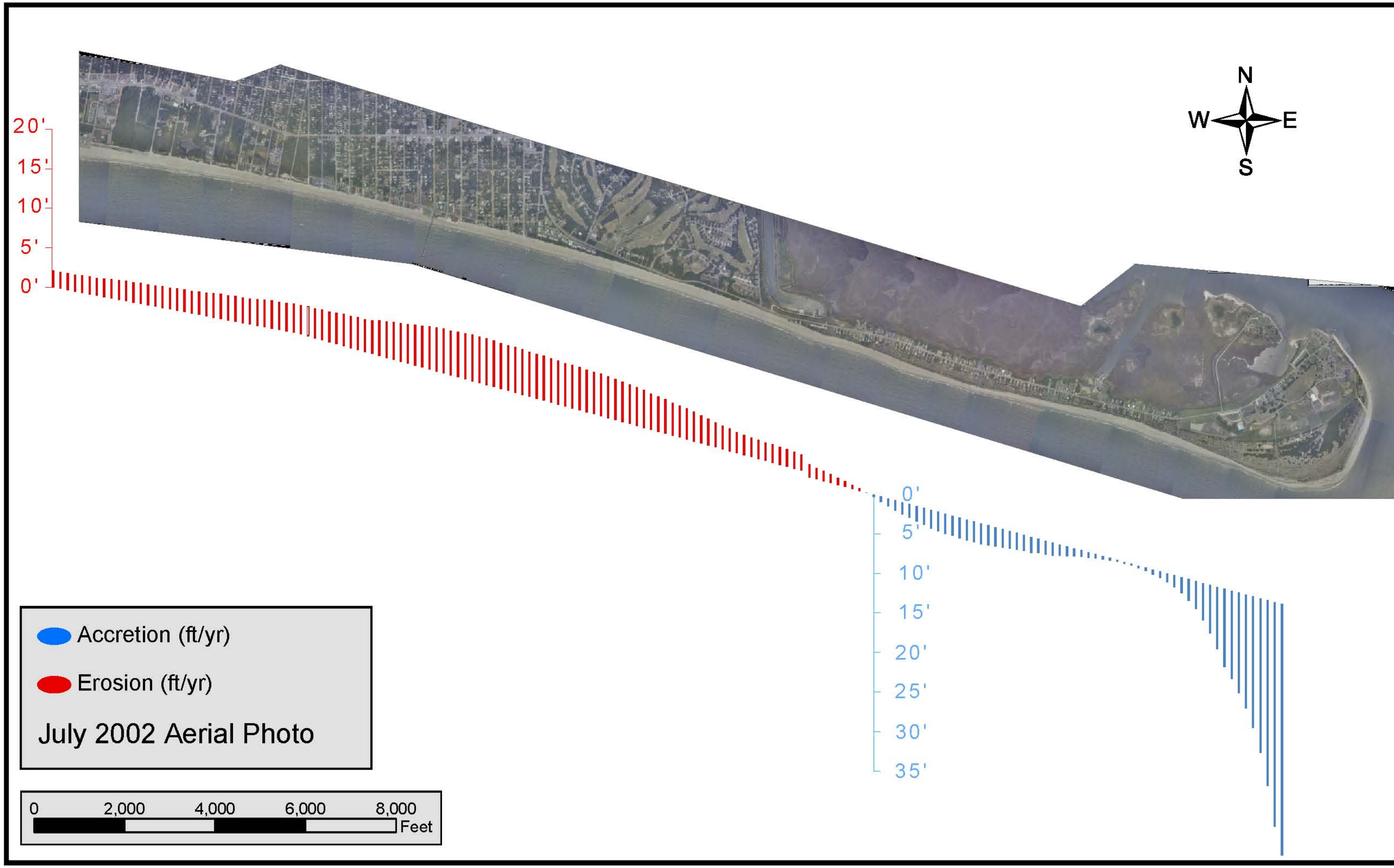


Figure 2.1 Long-Term Average Annual Shoreline Change Rates (1938-2000) Oak Island/Caswell Beach

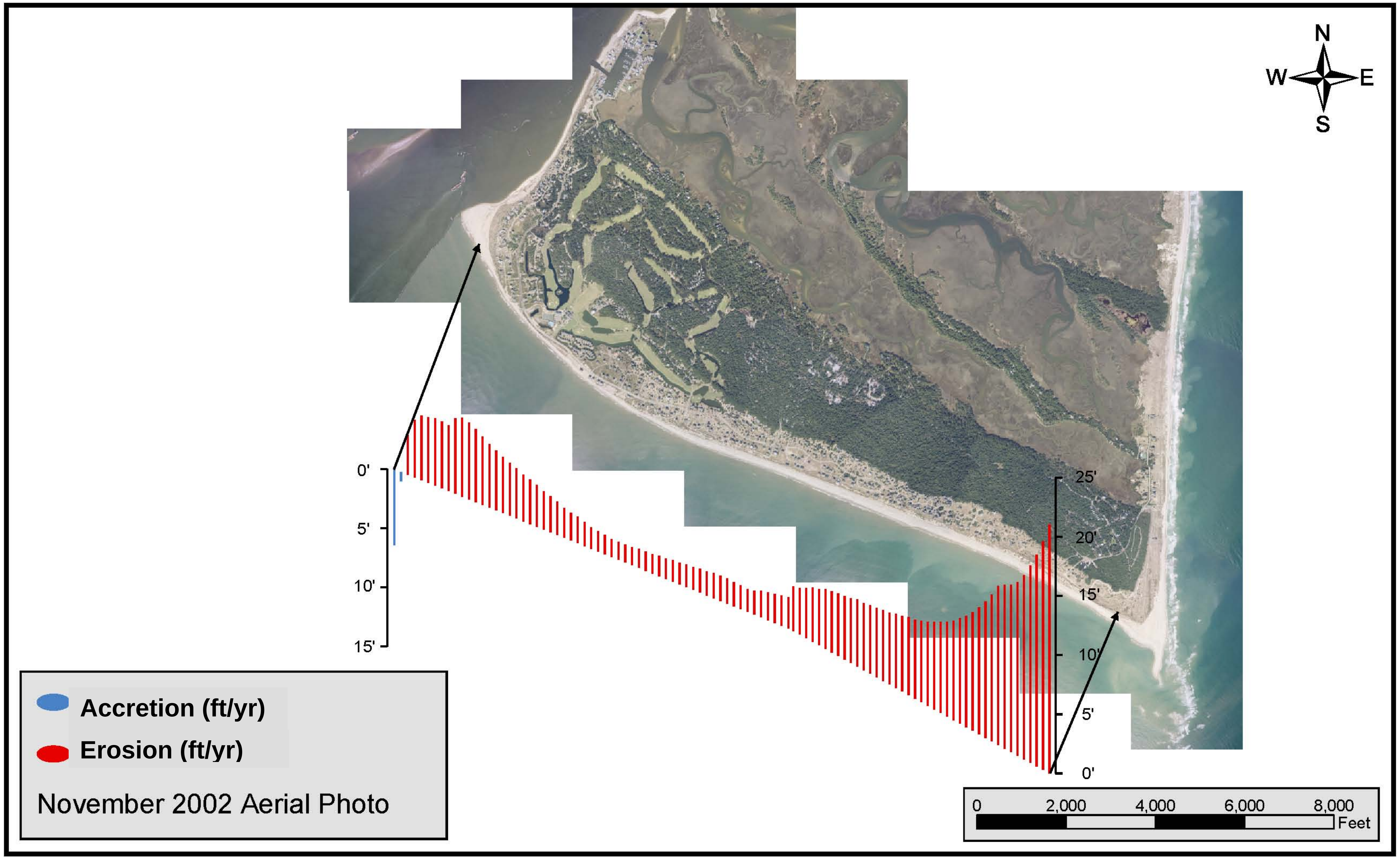


Figure 2.2 Long-Term Average Annual Shoreline Change Rates (1938-2000) Bald Head Island

Erosion Control Activities at Bald Head Island

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

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

In 1994 a 645-foot-long sand bag revetment was placed along the badly eroding portion of western South Beach. In 2003-2004 the sand bag revetment was expanded by increasing the overall length by 200 feet, increasing the base width from 20 to 40 feet and increasing the crest elevation by 6 feet to +12 feet NGVD. A view of the expanded sand bags are shown in Figure 2.3, as it appeared in April 2003. This structure is now, for the most part, covered by the new sediment with the subsequent beach disposal operations.

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 fill placement in 2005. As such a sixteen structure sand tube groinfield was reconstructed along South Beach between stations 47+00 and 105+00. The replacement geo-tubes were constructed between January and March 2006. 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 groinfield, (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 4 months following placement.

Figure 2.4 Reconstructed Groinfield 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.

Bald Head Island has also begun planning for a future beach disposal operation scheduled to occur in the winter of 2008/2009 (Olsen, 2007). This operation is proposed to cover the open maintenance cycle, when according to the sand management plan, material is designated to go to Oak Island. The plan is expected to place up to 2 million cubic yards of sand using the seawardmost portion of Jay Bird Shoals as the proposed borrow area. The material is intended to cover all portions of South Beach and West Beach.

Part 3 DATA ANALYSIS AND RESULTS THRU FIFTH MONITORING CYCLE

General. Data collection for the monitoring program was initiated in August 2000 just prior to construction of the entrance channel improvements. This part of the report describes the data collected to date and results through September 2007, the end of the fifth monitoring cycle. The data analyses generally describe changes that have occurred since those last reported in October 2006 and also relative to the base (pre-project) conditions established with the initial monitoring surveys. The following discussion covers the four main data collection efforts, namely: shoreline and volumetric changes as measured from the beach profile surveys, ebb and nearshore shoal response, wave data, and current measurements in the entrance channel.

Beach Profile Analysis-Shoreline and Profile Change

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

Bald Head Island. Shoreline changes measured along Bald Head Island over the current monitoring cycle are given in Figure 3.1 and 3.2. The present monitoring period includes two surveys undertaken in January 2007 and July 2007. Figure 3.1 shows the shoreline changes relative the October 2006 position, i.e. the last referenced location in Report 4. Figure 3.2 gives the shoreline changes with respect to the start of the monitoring program in September 2000.

As indicted in Figure 3.1, most of the profile locations along Bald Head Island have been accretional over the last year. This response is largely driven by the beach fill completed in April 2007, which is bracketed by the two most recent monitoring surveys. The results show large gains at each end of South Beach with more moderate gains in the mid-portions of the beach, reflecting the nature of the fill disposal which was placed in two segments with a gap in the middle. Specifically, the largest accretion measured at the end of the period was more than 250 feet at the western terminus of the fill, located in the vicinity of the spit. Another peak gain of more than 200 feet was measured area near the eastern terminus of the fill between Profiles 160 and 170. In between these peak gain areas, the beach remained stable showing shoreline changes from 0 to 50 feet. When considering the overall area bounded by the outer limits of the fill (between Profiles 45 to

170), the shoreline was found to have advanced an average of 118 feet. Extending east of the fill area, the beach remains stable and then turns erosional in the immediate vicinity of the cape.

As indicated in prior reports, the area in the vicinity of the spit (Profiles 32 to 47) is found to be highly variable. Over the last year, a portion of this area has shown gains of about 300 feet with adjacent portions losing 60 feet. The greatest gains are found at Profiles 40 thru 47 under the direct influence of the recent beach fill. In contrast the greatest loss is found at Profile 36 just inside the advancing spit. The remaining area along West Beach (Profiles 0 thru 28) has shown a general loss over the period, with the shoreline retreating about 5 to 10 feet over much of this area. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 7 feet with the January 2007 survey and a gain of 70 feet as of July 2007, since the last reporting.

Shoreline change patterns as measured over the last 7-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 October 2006, January 2007 and July 2007. This figure reveals that for the most part, the shoreline changes are strongly positive when measuring relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional, with the July 2007 shorelines being typically 50 to as much as 300 feet seaward of their September 2000 positions. In fact only one profile along south beach (Profile 61) is shown to have a net erosion of the last 7-year period with a retreat of 13 feet. The measured shorelines in the vicinity of the cape also remain positive at the end of period being more than 300 feet through the most current survey. The exception to this general stable pattern is a small area of erosion within the vicinity of the spit area at the western limit of South Beach. Specifically, this area contains Profiles 43 and 45 which are located just west of the groin field, where present shoreline retreat is on the order of 20 feet. By comparison with the two prior surveys, this erosion area has been greatly reduced through the placement of the recent fill. Proceeding further to the west, the erosion turns positive over the remaining portions of the spit area, reaching a maximum advance of 235 feet. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline has shown an average loss of about 13 feet when compared to the base condition. When considering all locations along Bald Head Island (Profiles 0 to Profile 218), the shoreline is presently on the average 131 feet more seaward than it was in 2000.

Typical profile plots shown in Figures 3.3 and 3.4 are taken along Bald Head's South Beach. Figure 3.3 shows Profile 61 within an area which has been prone to erosion; whereas, Figure 3.4 gives Profile 150 in the more stable area to the east. Both of these profiles received beach fill associated with the initial channel dredging during the February-July 2001 time frame and with the third, most recent (April 2007), beach disposal. However, the second fill in January 2005 fill did not extend to Profile 150. Figure 3.3 shows the widened beach berm from the initial fill 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 December 2003. At this time the shoreline 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 7-year monitoring period as measured from the September 2000 position. (For comparison purposes both Profile 61 and 150 are given on the chart). After reaching the maximum recession, Profile 61 remained about the same in June 2004, possibly being restrained by sand bags placed at this location. The second fill was then added, advancing the berm and shoreline to about 25 feet beyond its September 2000 location in February 2005, where it remained stable for about 6-months. Beginning in August 2005, the fill began once again to erode, in a manner similar to the first cycle immediately following the initial fill. By January 2007, the shoreline was about 60 feet landward of its September 2000 position. With the most recent fill, a gain occurred moving the shoreline back to near its original position being about 13 feet shy its location in 2000. Examination of the shoreline loss rates following fill placement show a similar response, with a rapid retreat of shoreline at Profile 61 occurring after each fill. However, the rate of loss is about half as much for the second fill (64 feet/year versus 120 ft/year with the initial fill), as indicated on the figure. One possible explanation of this difference could be the positive influence of the groin field in reducing the loss rate of the fill.

For Profile 150 (Figure 3.4) a much more stable behavior is evident. In this instance much of the initial fill 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 July 2001 fill extent, 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 fill, the shoreline gained slightly even though this profile line was outside of the limits of the fill, indicating some dispersal of sediment by natural means. By the end of the period, following the third disposal, the shoreline advanced significantly and is presently 257 feet seaward of its September 2000 position.

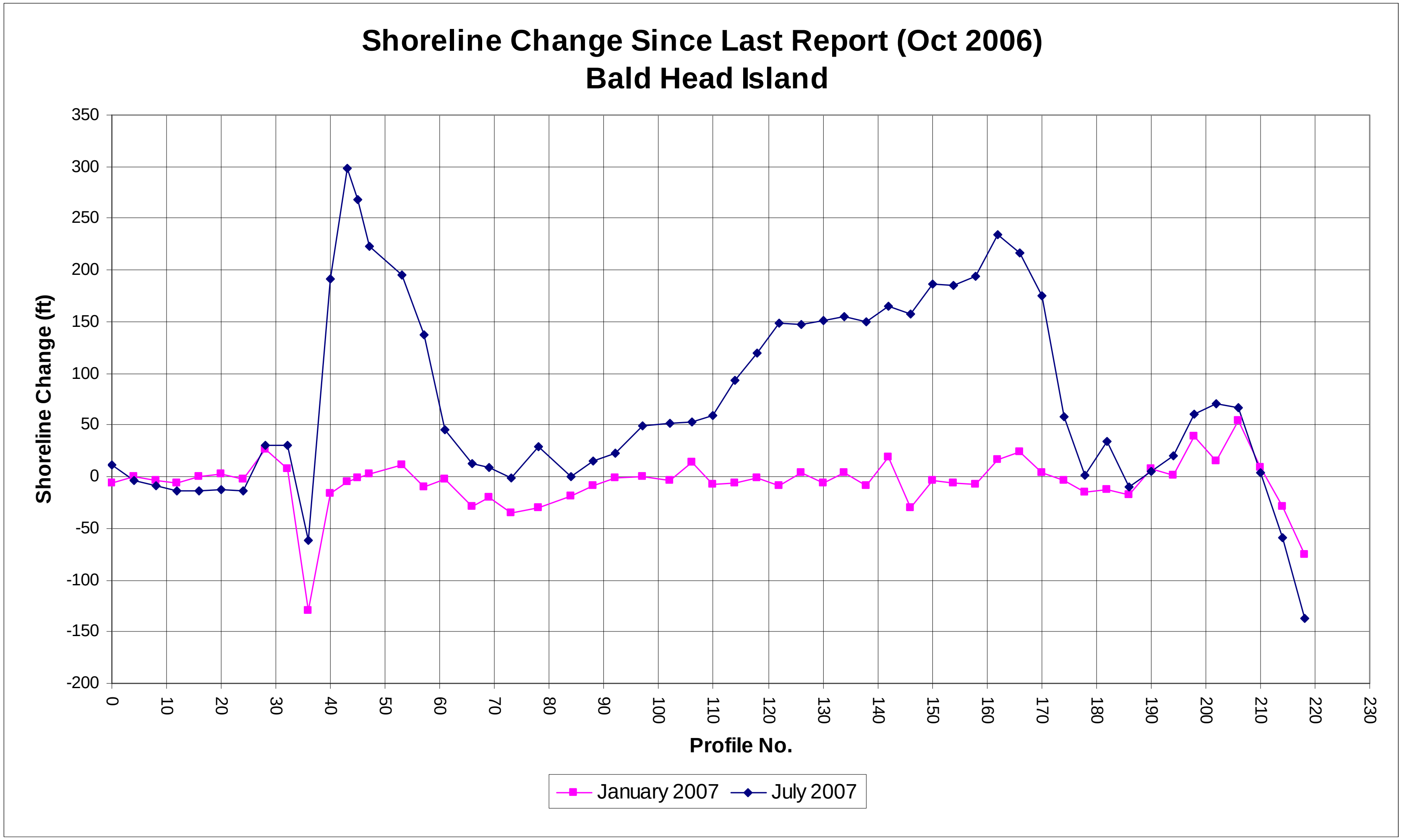


Figure 3.1 Shoreline Change Since Last Report (October 2006) Bald Head Island

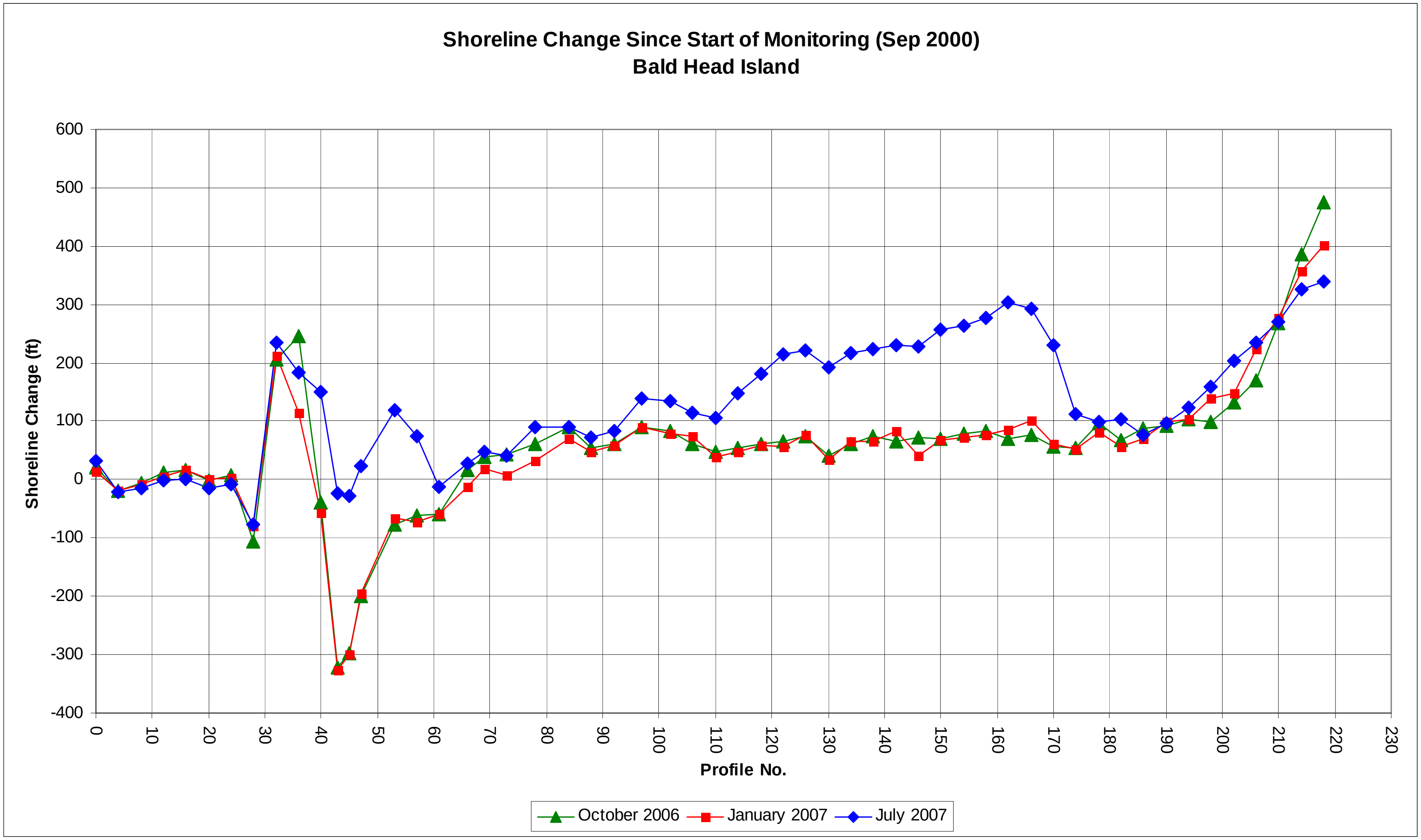


Figure 3.2 Shoreline Change Since Start of Monitoring (Sep 2000) Bald Head Island

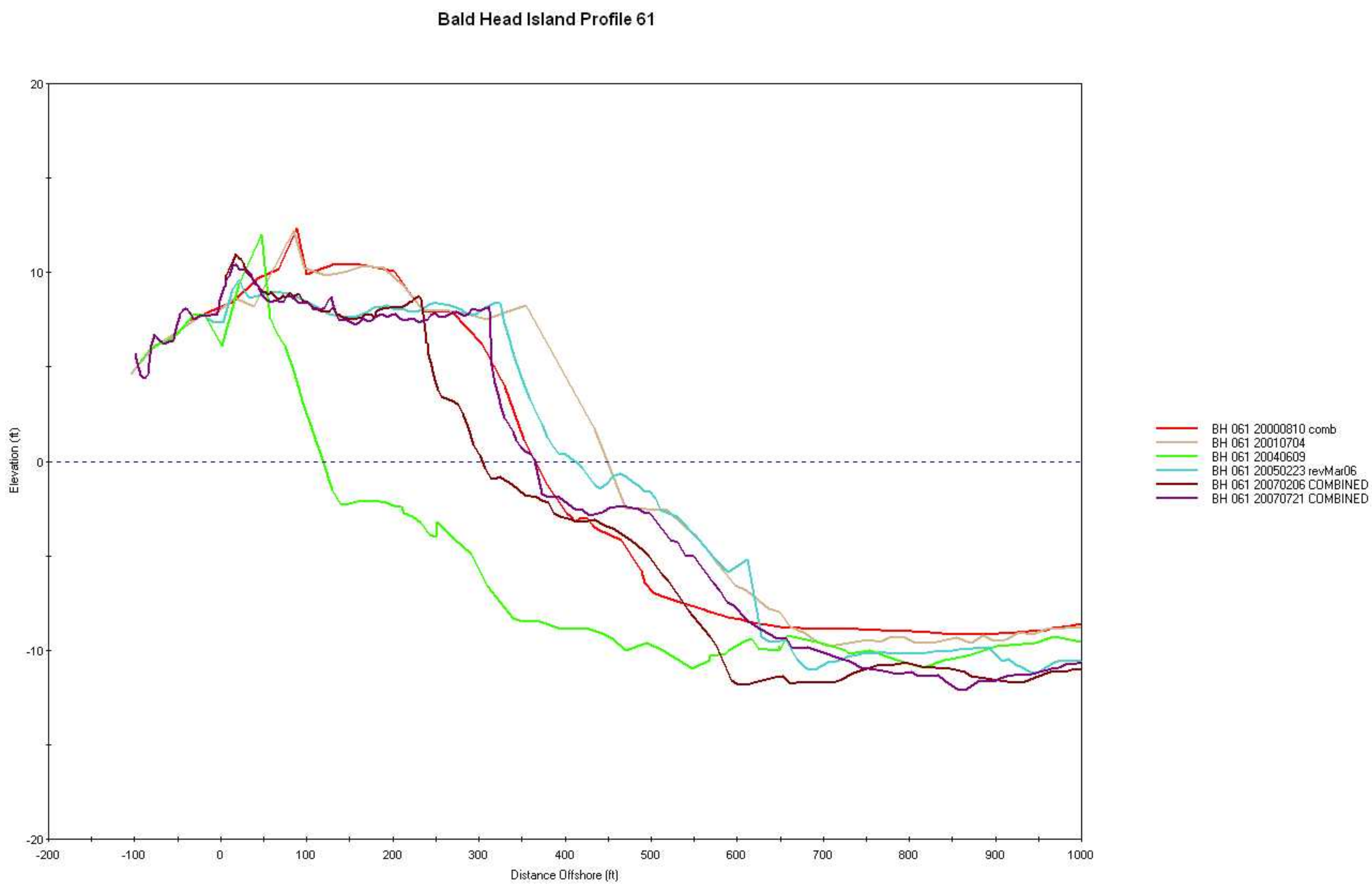


Figure 3.3 Bald Head Island Profile 061

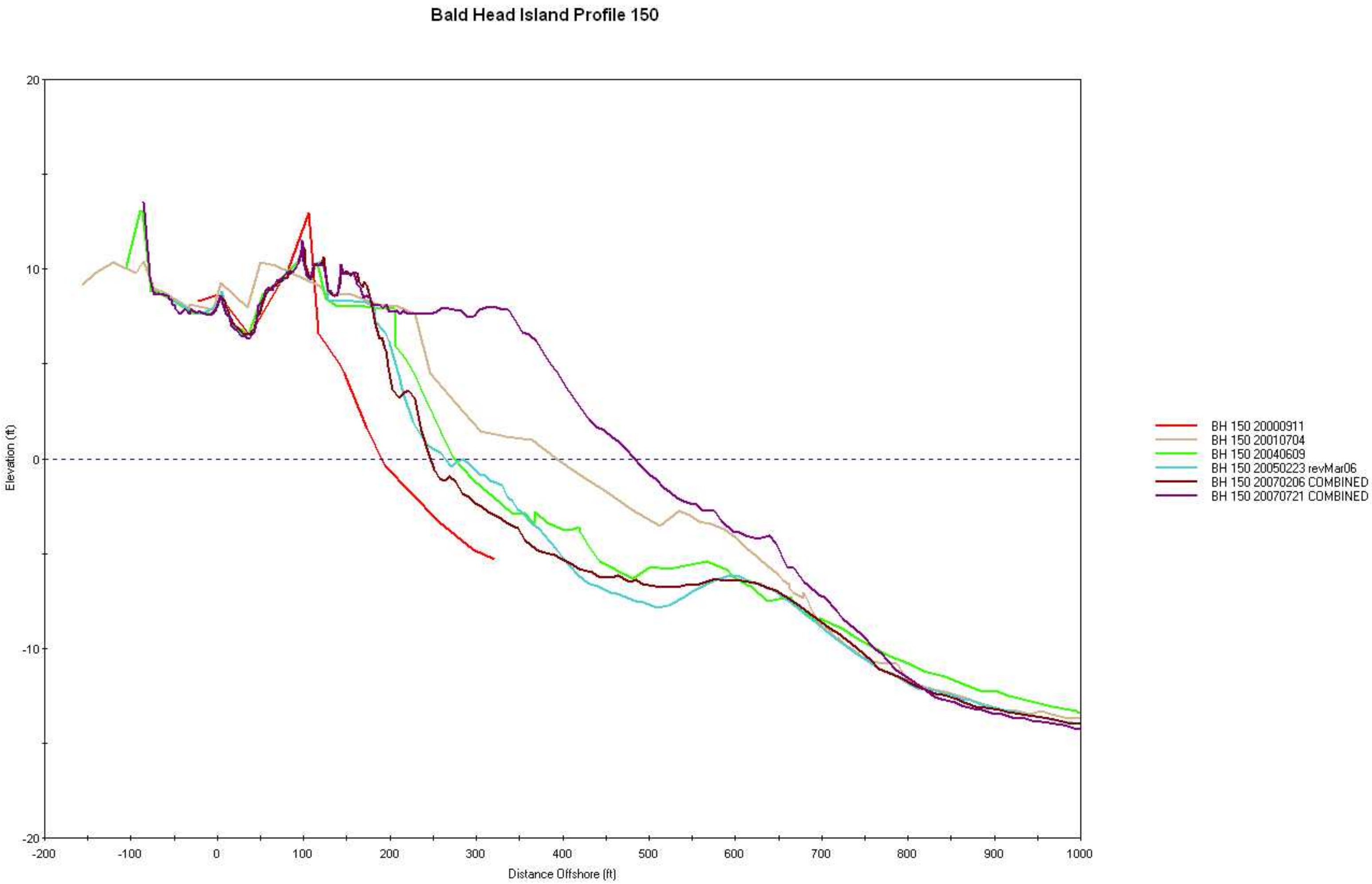


Figure 3.4 Bald Head Island 150

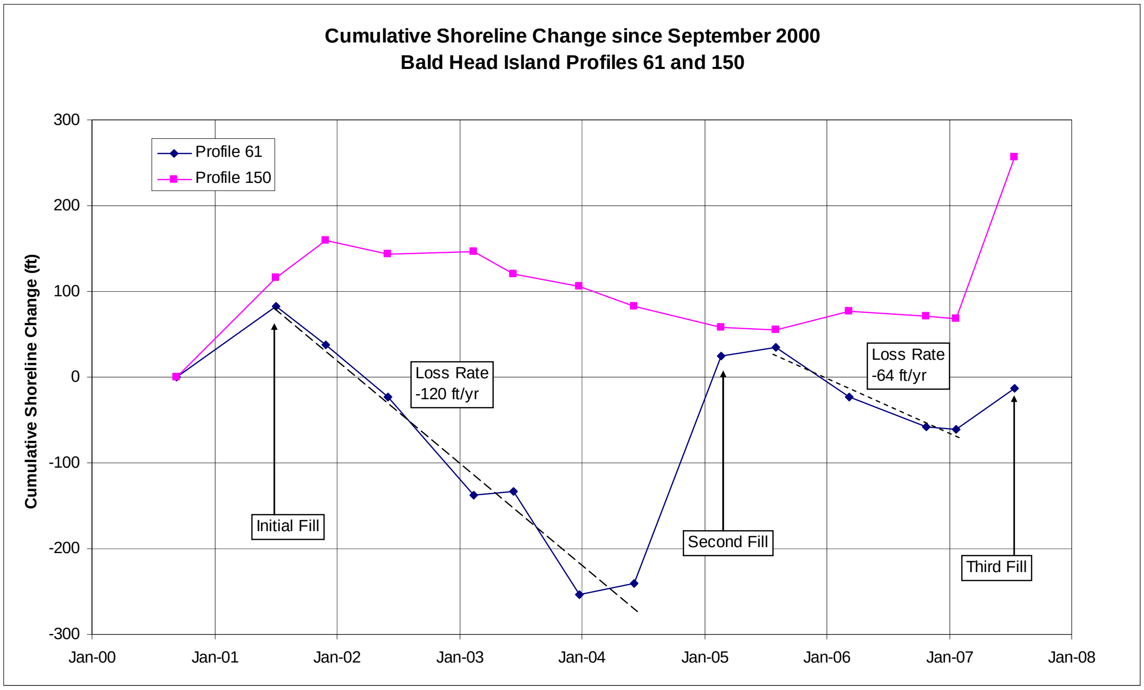


Figure 3.5 Cumulative Shoreline Changes Since September 2000

Bald Head Island Profiles 61 and 150

Oak Island. Shoreline changes measured along Oak Island over the current monitoring cycle are given in Figures 3.6 and Figures 3.7. The present monitoring period includes the January 2007 and July 2007 surveys. Figure 3.6 shows the shoreline changes relative the October 2006 position, i.e. the last referenced location in Report 4. Figure 3.7 gives the shoreline changes with respect to the initial monitoring survey in August 2000.

As indicted in Figure 3.6, the profile locations around the tip of Caswell Beach closest to the Cape Fear River (Profiles 5-50) have shown a large degree of variability over the current cycle. Within this highly dynamic area, the shoreline change has ranged from about –100 feet to +75 feet. Overall however, a negative change has been more prevalent with the alongshore average change being a loss of about 9 feet from October 2006 to July 2007. For the remaining monitoring area extending westward from Profile 50, the shoreline changes have been somewhat variable, with the overall trend being one of stability with the January 2007 survey and of recession occurring by July of that year. The difference between the two surveys is most prevalent throughout the western half of the monitoring profiles, west of about Profile 140. From this point west, the January 2007 shorelines are positive (with a few negative lines), versus the July 2007 data which is mostly negative. Specifically, the July recessions are found to range between about 15 to 40 feet, with the erosion generally increasing proceeding further to the west. The average change in shoreline for the reach between Profile 60 and 310 is computed to be -13 feet. When considering all profiles within the Oak Island monitoring area (Profiles 5 thru 310), the average shoreline change is a retreat of 12 feet for the present period of October 2006 to July 2007.

When comparing the shoreline changes back to August 2000 (i.e. the pre-project survey), Figure 3.7 shows a much more definite pattern. In this regard, the same high degree of variability is evident near the tip of the island, but a much stronger trend towards accretion is present extending westward along the remaining portions of the island. In fact, except for a couple exceptions, both the January and July 2007 surveys show that all shoreline changes measured west of Profile 40 are positive. The exceptions are Profiles 65 (Jan 07) and 105 (Jul 07) both of which are slightly negative. To a large degree, this reflects the positive shoreline response and subsequent stable behavior of the fill placed along this reach associated with the channel deepening in 2001. This beach disposal operation included placement along the entire reach extending westward from Profile 60, except for a gap between Profiles 90 to 120. This unfilled reach is obvious in the figure where the positive shoreline changes (ranging from 0 to 30 feet) are relatively less that the adjacent areas. In addition, a rather large, wide fill was also placed just to the west of the monitoring limits (also completed in 2001) associated with the Sea Turtle Habitat Project. This fill has positively influenced the shoreline along the western monitoring limits which display the largest overall seaward offsets typically being between 75 and 170 feet more now than with the August 2000 base condition.

In considering all the profile data, the alongshore average shoreline position was 97 feet more seaward in January 2007 than it was in 2000. Likewise, the shoreline position was 82 feet more seaward in July 2007, than it was about seven years earlier at the start of the project. Only one area as discussed above may be of some concern along Oak Island. This 3,000-foot-long area, just to the west of the CP&L canal (between Profiles 90 and 120), has remained stable over the years, but has relatively smaller shoreline advances (about 0 to 30 feet) compared to the adjacent reaches. Further, although the remaining portions of Oak Island remain healthy with respect to the base condition, the fill areas are found to have eroded with the most recent survey within the western half of the monitoring area.

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 fill area and Figure 3.9 shows Profile 220 within the western portion of the fill area. The plot of Profile 80 shows the seaward advance of the fill followed by a period of adjustment between the September 2001 and June 2002 surveys. Following this initial adjustment period, over which about half of the berm width was eroded, the profile has remained stable. A similar response is shown in Figure 3.9 for Profile 220; however, the berm was wider and more fill remains (about 60%) at the end of the period by July 2007. Plots of the cumulative shoreline changes for each of these profiles are given on Figure 3.10. For Profile 80, the shoreline has remained generally stable over the last five years following the adjustment to the initial fill. Over this time period (between June 2002 and July 2007), the mean high water shoreline at Profile 80 has varied between about 70 and 95 seaward of its August 2000 position. For Profile 220, the shoreline has also remained relatively stable following the initial fill adjustment; however a slight erosional trend is noticeable over the last five years.

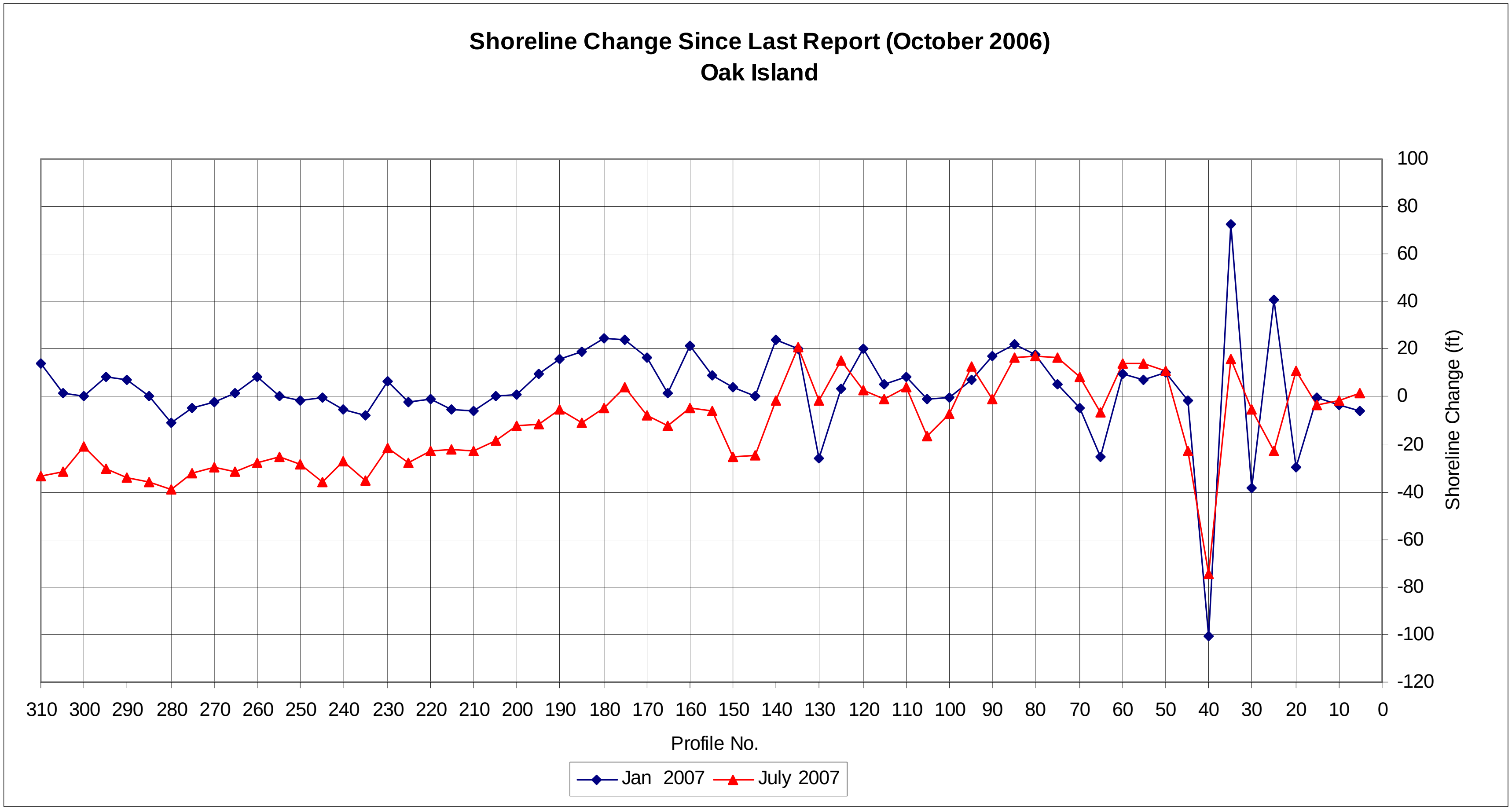


Figure 3.6 Shoreline Change Since Last Report (October 2006) Oak Island

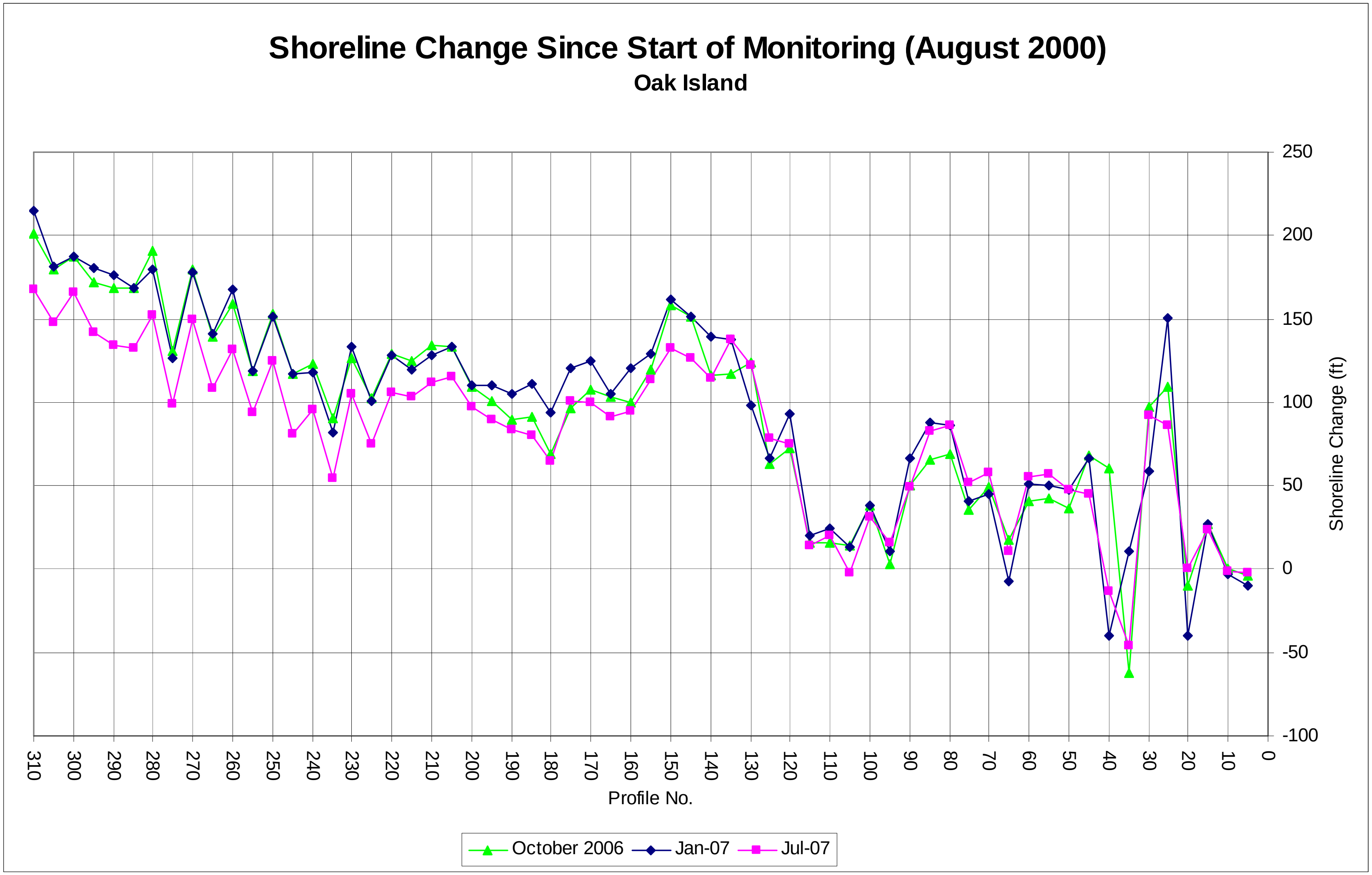


Figure 3.7 Shoreline Change Since Start of Monitoring (August 2000) - Oak Island

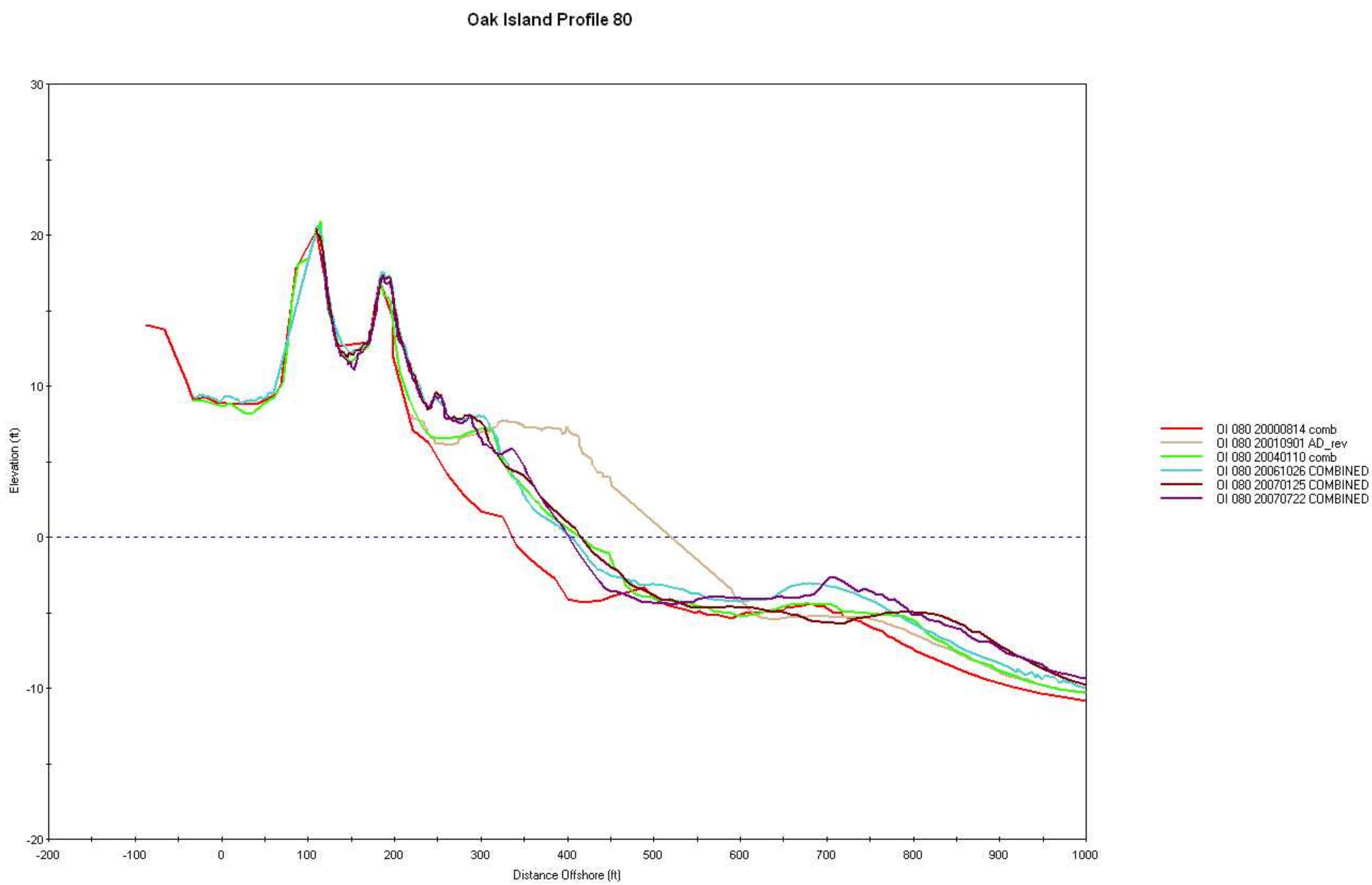


Figure 3.8 Oak Island Profile 80

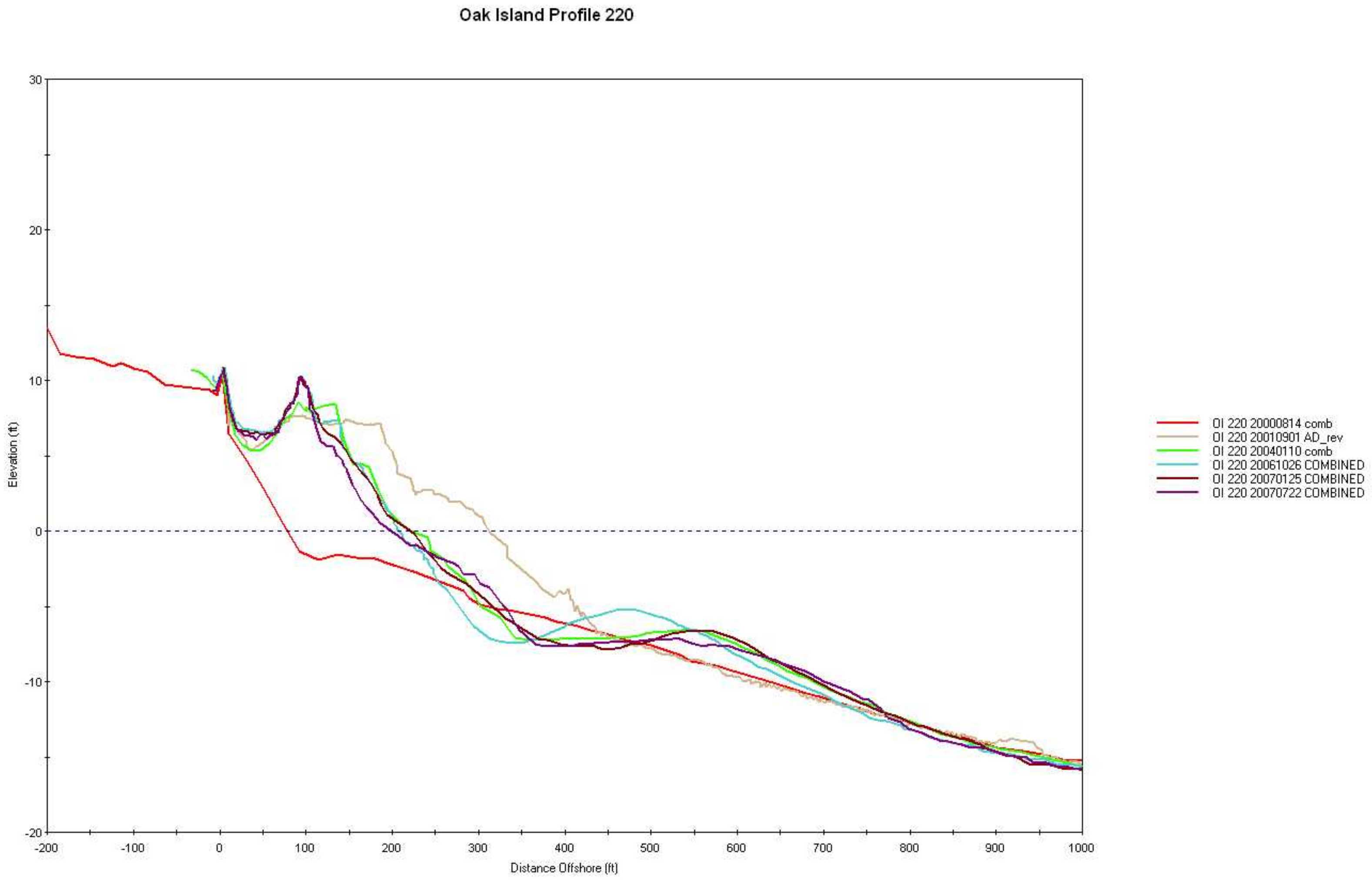


Figure 3.9 Oak Island Profile 220

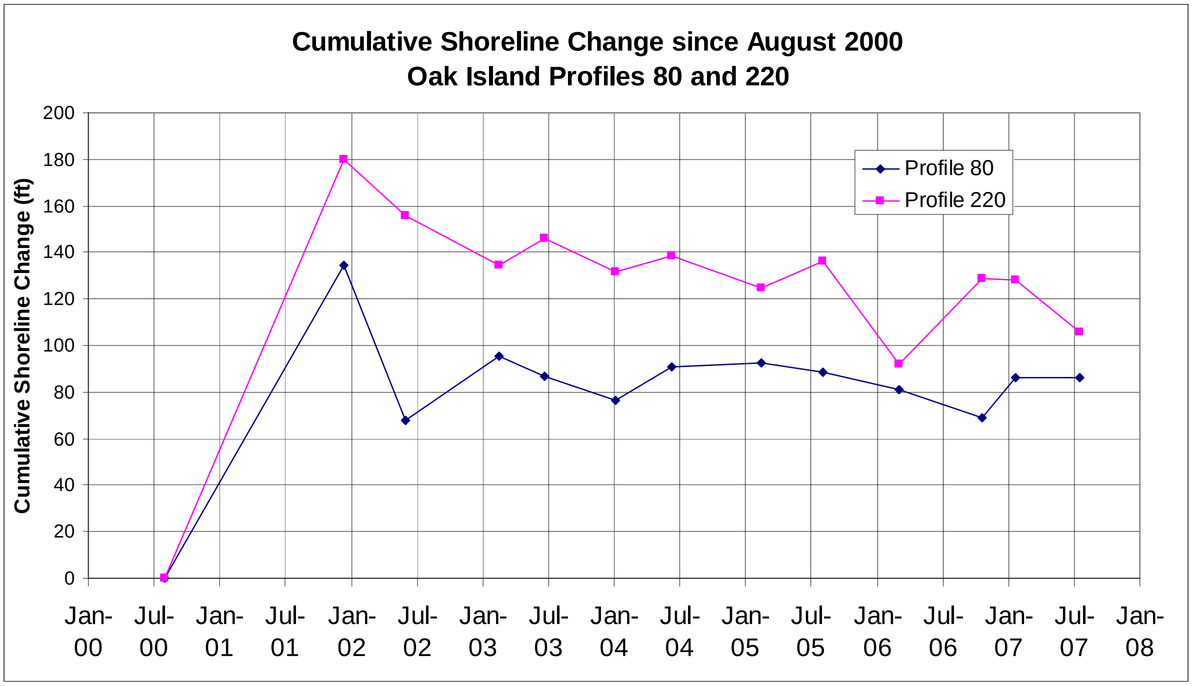


Figure 3.10 Cumulative Shoreline Change Since August 2000

Oak Island Profiles 80 and 220

Beach Profile Analysis-Volumetric Change

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

The current monitoring cycle included the 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 2007 and July 2007 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 the October 2006 onshore survey, i.e. the last referenced onshore survey in Report 4. Figure 3.12 gives the volumetric changes with respect to the start of the monitoring program in September 2000.

The pattern of onshore volume changes shown in Figure 3.11 for Bald Head Island (since the last report) generally mimic those of the reported changes in the mean high water shoreline. In this regard, the volume changes show that with the January 2007 survey most profile locations showed relatively small changes with slightly erosional lines present along the western portions of South Beach. With the July 2007 survey, the impact of the recent beach disposal is clearly evident with most of the beach profile locations showing large onshore volumetric gains. The alongshore distribution of the most recent gains is such that each end of South Beach has relatively large changes in volume bracketing the west-central portion of South Beach which showed relatively smaller gains. One exception, within western South Beach (Profile 66) showed an increase with the fill (between January and July 2007), but remained slightly negative at the end of the period. Within the limits of the fill a gain of about 478,000 cubic yards is computed between October 2006 and July 2007 for the onshore portions of the profile. In contrast, West Beach (Profiles 0-28), has shown a slight decrease in onshore volume, losing about 10,000 cubic yards between October 2006 and July 2007. In considering the total onshore volume changes for all profiles over the current monitoring cycle, approximately 543,000 cubic yards were gained between October 2006 and July 2007 largely a result of the beach disposal operation.

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 with a few exceptions, all profile locations have experienced net gains in the onshore over the last seven years. The areas that experienced onshore losses since the beginning of the project are along West Beach, the spit (Profiles 43 & 45) and one profile within the western end of South Beach (Profile 61). These results reflect the positive impact of the recent disposal operation which eliminated an erosional zone within the western end of South Beach as shown by the January 2007 pre-fill survey. This area of South Beach has been one of chronic erosion, as documented in the past monitoring reports.

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 fill placement survey. By the June 2004 survey, the total onshore volume becomes slightly negative indicating an overall loss of about 48,300 cubic yards (above –2-feet NGVD) compared to the 2000 survey. With the second fill (January 2005), this trend is reversed showing total onshore volumes of around 500,000 cubic yards with the August 2005 surveys. After this fill an overall moderate loss was recorded up to the January 2007 date, followed by the substantial increase with the most recent beach disposal effort. At the end of the period, a net gain of 931,000 cubic yards has been measured overall when considering all onshore volume changes since 2000.

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 4 (October 2006); 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 large gains along most of South Beach, except for a few areas which have relatively small losses. As discussed above, the volumetric increases are driven by the most recent beach disposal along South Beach. As such, the greatest increases are located along the western and eastern portions of South Beach, with relatively smaller gains shown between these two peak areas. The few areas which have volumetric losses over the present cycle are located along West Beach, the spit and near the cape. In summing the changes over the entire monitoring area, the losses are overridden by the gains which resulted from beach disposal amounting to a positive net change of about 792,400 cubic yards over the period from October 2006 to July 2007. Additionally, the zones along South Beach which received the dredged material (Profiles 44 to 91 and 110 to 170) were found to have increased by 855,000 cubic yards over the same period. This compares favorably to the in-place quantity computed during the fill operation which amounted to 978,500 cubic yards. Further, this implies a relatively modest loss of the fill (123,500 cubic yards) or about -13% loss of material.

When comparing the changes in total profile volume back to the initiation of the project given in Figure 3.15, Bald Head Island is again dominated by overall gains over the last seven years. The most substantial increases are found along the western half of South Beach and in the vicinity of the spit. Elsewhere, there are two areas which have recorded net overall losses for the period. One is located at the extreme eastern end of south beach, where some losses have occurred near the cape. The other, which is of greater concern, is along the westernmost portion South Beach extending into the spit area between Profiles 45 to 70. This reach, covering approximately 2,500 feet, has been the site of chronic erosion in the past. Volumetrically this represents net loss of about 249,400 cubic yards. Aside from these areas of erosion, all other profile volume changes are positive throughout. As a result of this overall response in the profiles, the net volume change is a gain with respect to the beginning of the monitoring in 2000. The total volume change is a 456,300 cubic yard gain in January 2007 and 1,316,800 cubic yard gain by July 2007.

Listed in Table 3.1 are the computed volume changes for Bald Head Island for each survey separated into the specific reaches. These reaches were determined in prior reports based on similar physiographic characteristics, namely West Beach (Profiles 0-24), the spit area (Profiles 32-45), South Beach-West Portion (Profiles 53-106), South Beach-East Portion (Profiles 114-194) and the Cape area (Profiles 198-218). The South Beach West portion consists of the profiles which contain the reconstructed groin field. Of the five reaches, two are showing net losses and the remaining three have accreted 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 seven years. The western portion of South Beach has gone through cycles of accretion and erosion controlled by the 2001, 2005 and 2007 beach disposals, which covered this area. The large variability for the Cape area reflects the highly dynamic nature of this physiographic feature. Coupled with the gains measured within the three other reaches of West Beach, the spit, and the eastern portion of South Beach, the beaches of Bald Head have 1,317,000 cubic yards more at this time that in 2000 at the start of the project. This is also indicated in previously mentioned Figure 3.13, that shows the cumulative volume changes over time for the island.

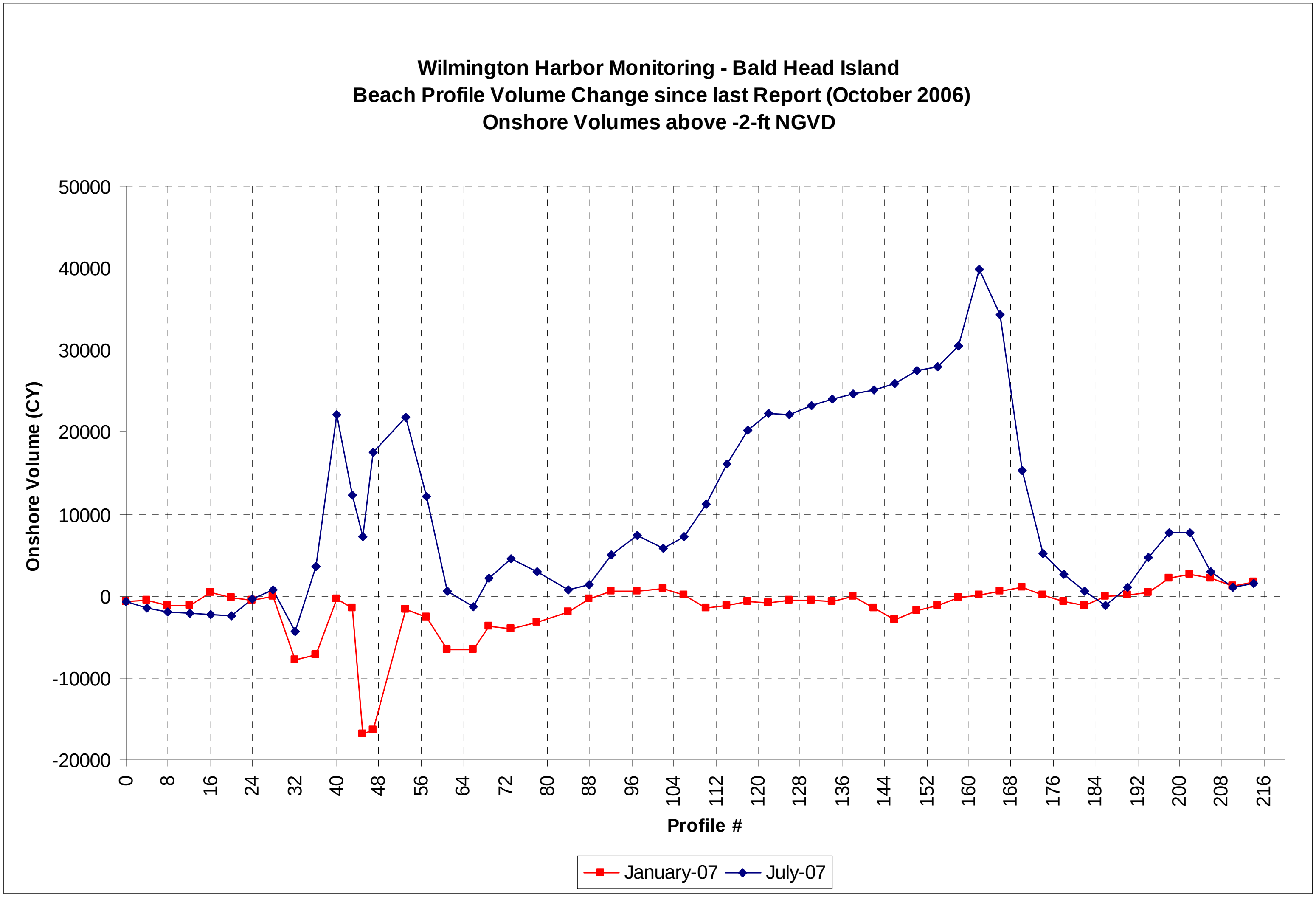


Figure 3.11 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change Since last Report (October 2006) Onshore Volumes above –2 ft NGVD

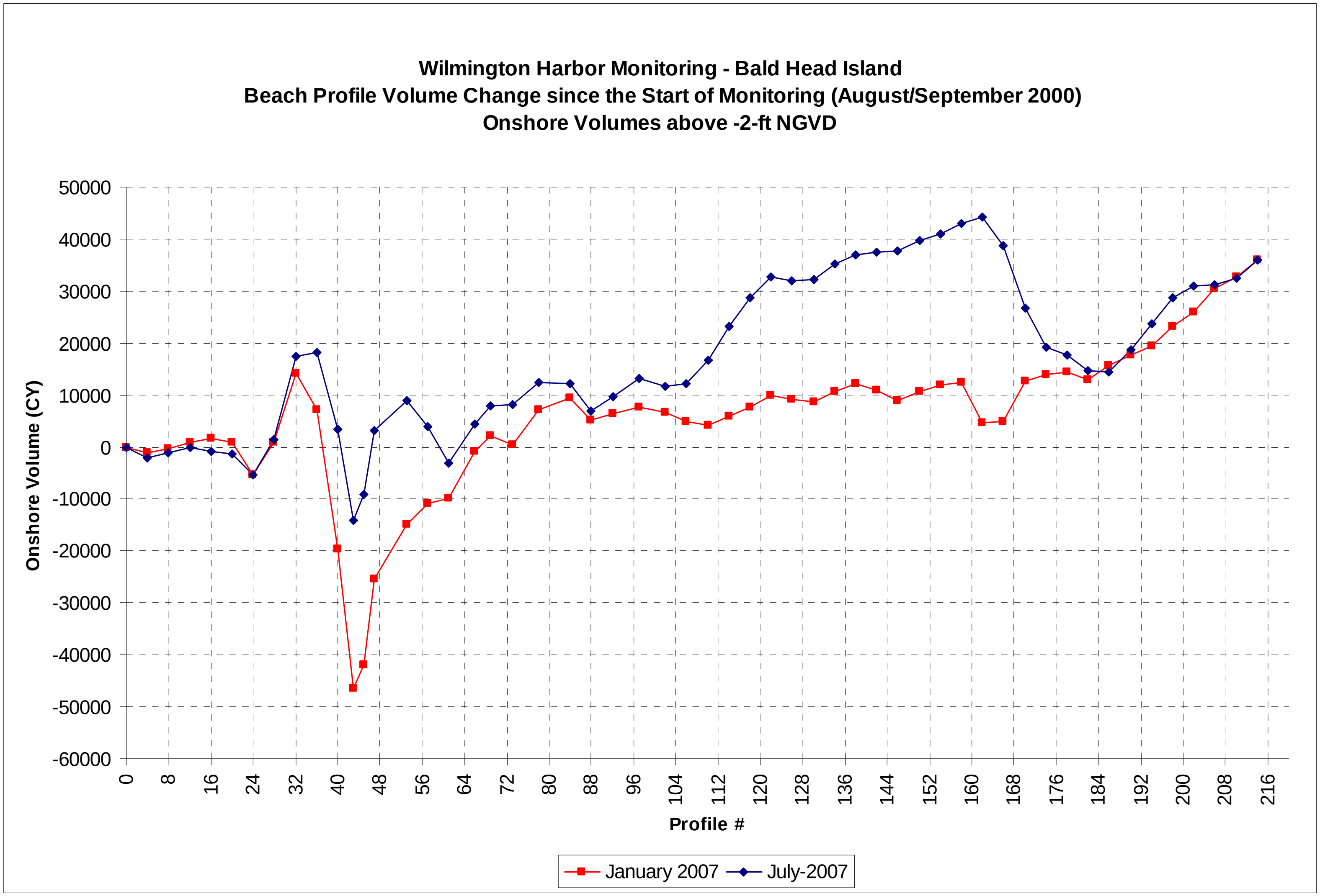


Figure 3.12 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change since Start of Monitoring (August/September 2000) Onshore Volumes above –2 ft NGVD

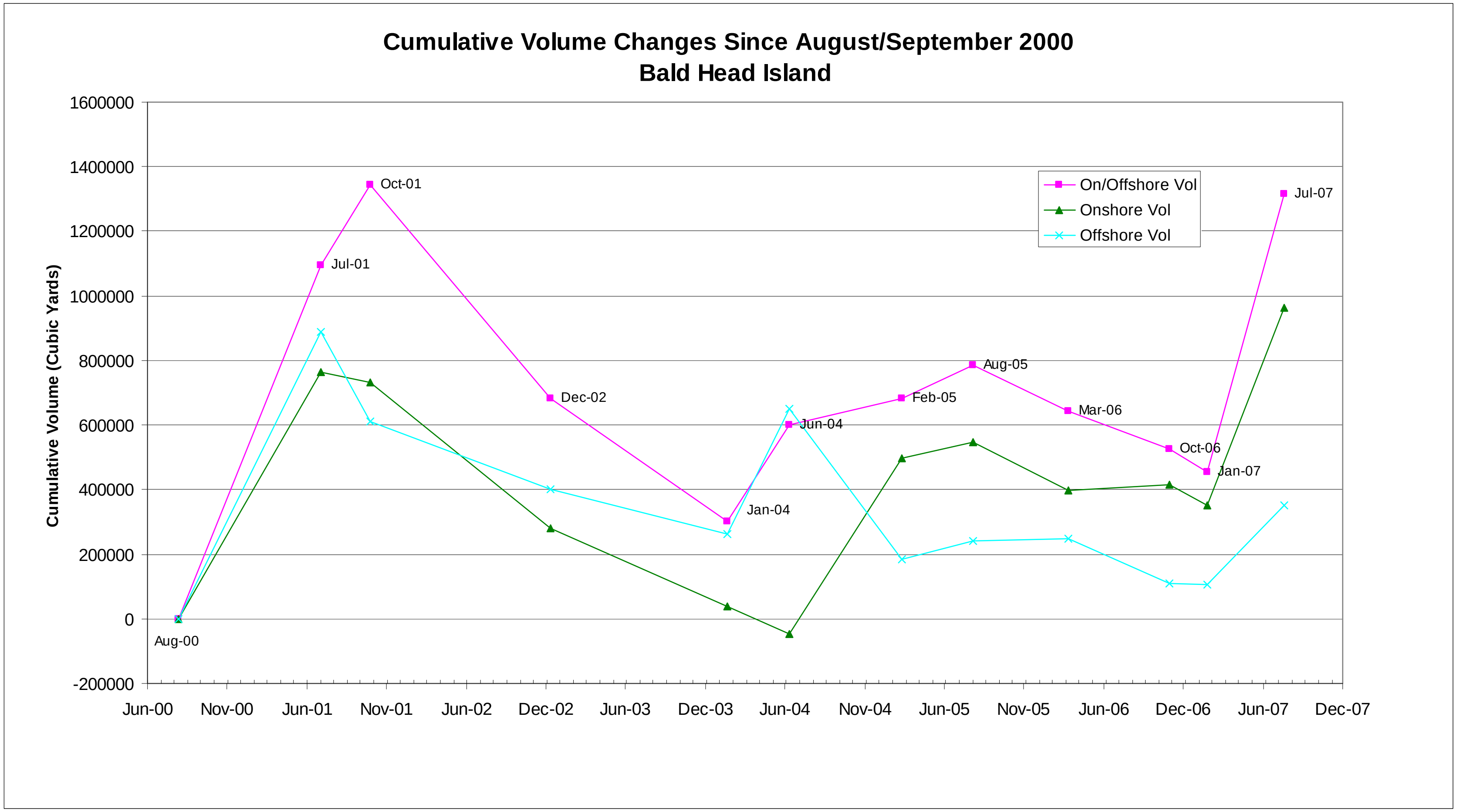


Figure 3.13 Cumulative Volume Changes Since August/September 2000 for Bald Head Island

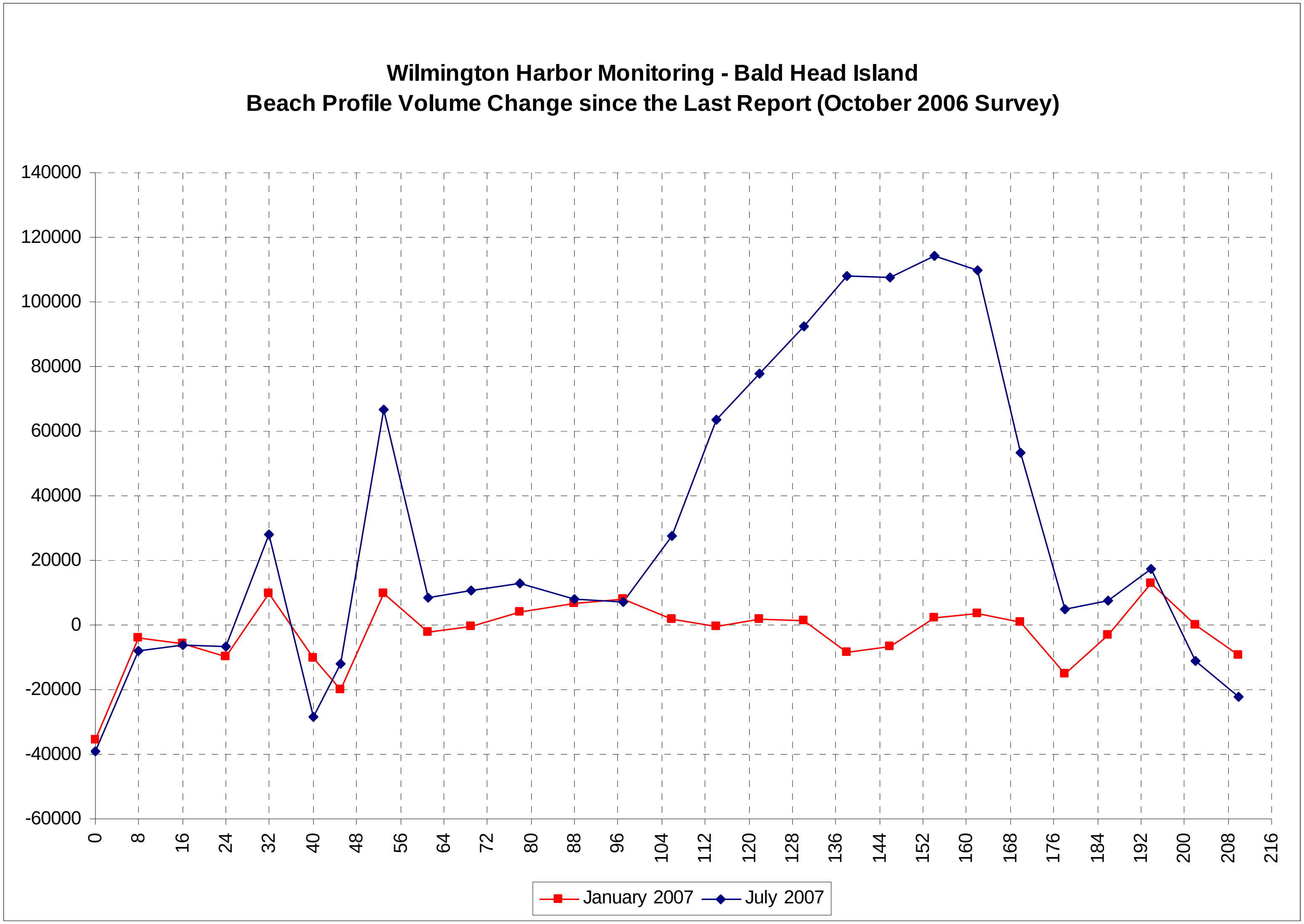


Figure 3.14 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since Last Report (October 2006 Survey)

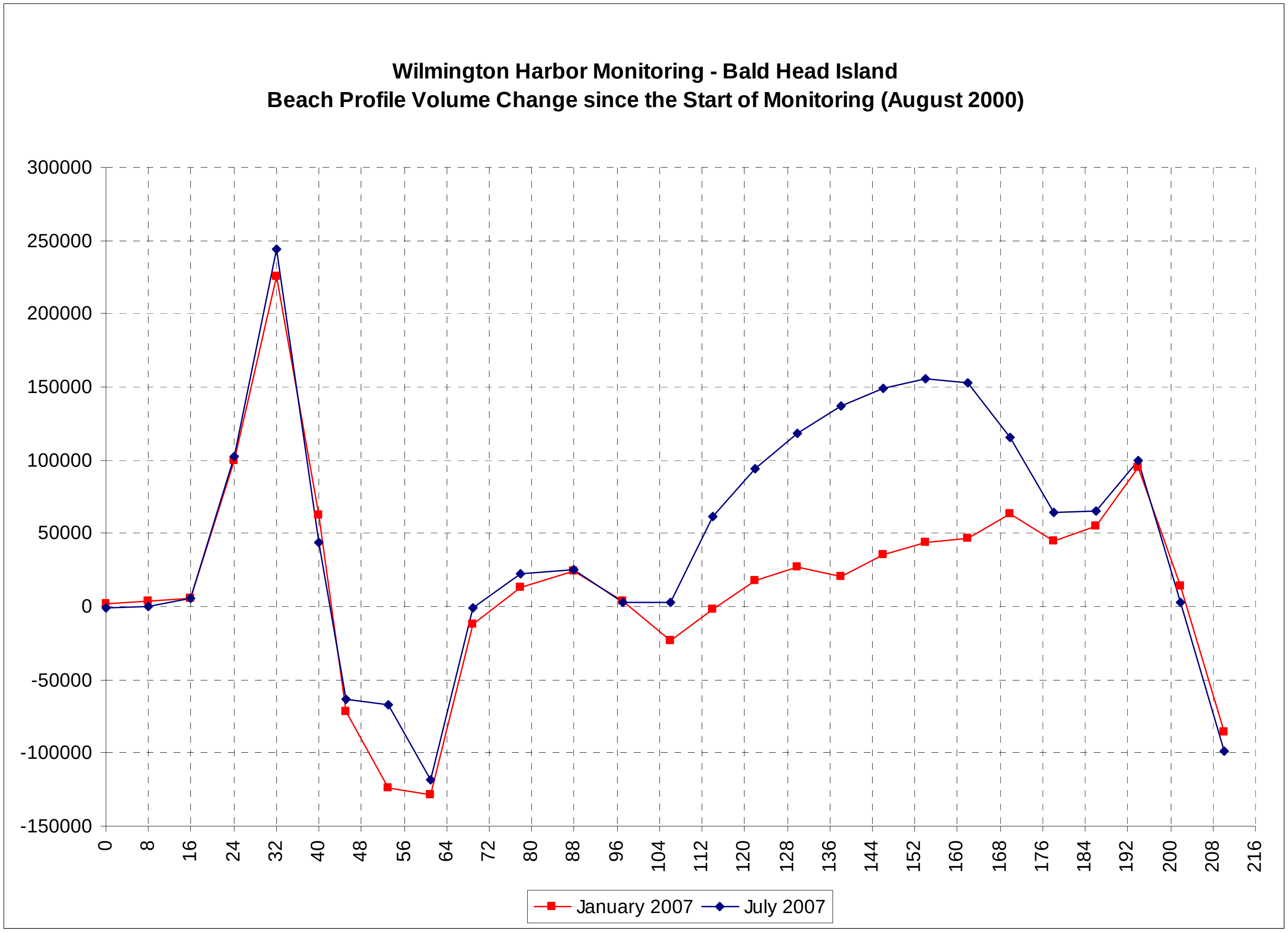


Figure 3.15 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since the Start of Monitoring (August 2000)

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

Location	Jul-01	Oct-01	Dec-02	Jan-04	Jun-04	Feb-05	Aug-05	Mar-06	Oct-06	Jan-07	Jul-07
West Beach (Profiles 0 - 24)	0	3,048	29,564	11,618	1,854	14,646	34,221	113,468	166,722	111,871	106,678
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
South Beach-West Portion (Profiles 53 - 106)	285,449	251,137	-91,457	-462,106	-406,485	192,205	187,910	-206,714	-274,592	-246,745	-133,383
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
Near Cape (Profiles 198 - 218)	-538,703	-29,536	-113,416	-169,758	-85,524	-238,965	-220,972	-46,246	-62,096	-71,646	-95,284
Total	**1,059,125**	**1,344,078**	**681,143**	**301,859**	**600,586**	**680,794**	**786,557**	**635,431**	**524,318**	**456,283**	**1,316,745**

Oak Island. The onshore volumetric changes measured along Oak Island over the current monitoring cycle are given in Figures 3.16 and Figures 3.17. Figure 3.16 shows the volumetric changes relative the October 2006 survey, i.e. the last referenced onshore survey in Report 4. Figure 3.17 gives the volumetric changes with respect to the start of the monitoring program in August 2000.

The pattern of onshore volume changes shown in Figure 3.16 for Oak Island (since the last report) are generally quite variable but the magnitude of the changes are relatively small. These small changes continue to reflect the overall stability of the beaches of Oak Island. Specially, profile volume changes range from +3,000 cubic yards to –6,000 cubic yards for each of the recent surveys. No general trend is apparent with the January 2007 survey as small gains and losses are seen throughout the study area. By July 2007 however, a more general loss is evident with almost all lines showing erosion between the two surveys. This erosion is most prevalent within the western portions of the monitoring area where differences between the last two surveys are greatest. In terms of quantities, the onshore volumetric changes summed over the 6-mile monitoring region show the very minor loss of 6,400 cubic yards in January 2007. This compares to -120,600 cubic yards measured with the July 2007 survey.

The results from the onshore beach profile surveys taken to date since the start of the monitoring in August 2000 are given in Figure 3.17. This graph includes the last three surveys, namely October 2006, January 2007 and July 2007. The figure shows that all areas have gained sediment within the onshore except for some isolated areas at the tip of the island. These data reflect the positive impact of the beach fill placed in 2001 and the general stability of the fill over the past six years. As noted in the above paragraph, some erosion of the onshore is evident with the July 2007 measurements for most of the profile locations. Even with this recent response, only two lines (Profiles 5 & 35) near the tip of Fort Caswell have experienced an overall onshore volume loss, with all other profiles showing significant gains to date.

To further illustrate the stable nature of the Oak Island beaches over the last seven 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 over the entire island. With respect to the onshore volumes, the graph indicates the large increase resulting from the beach fill placement as marked by the December 2001 survey, with a total onshore volume of 926,000 cubic yards. Over the next two years, a mild loss is seen to occur through February 2003, followed by a period of recovery and stability. Since June 2003 the onshore beach volume has essentially fluctuated around the one million cubic yard mark. With July 2007 survey, the onshore volume is on a slight downward trend; however, the remaining total onshore volume is still substantial being approximately 911,200 cubic yards. This value is essentially the same as it was in December 2001 following the beach disposal at 926,100 cubic yards.

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 4 (October 2006); 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 overall response of the total profile volume changes along Oak Island is one of accretion except for a zone extending between Profiles 60 & 100. (Note that no data points are listed for the first four Profiles (5 thru 20) since they were found to have been surveyed along wrong azimuth during the October 2006 survey and comparisons would therefore give erroneous results.) The erosional zone extends for about 4000 feet and represents a modest volumetric loss of 53,000 cubic yards. Aside from this area, the remaining data show positive changes in profile volumes ranging from near zero to about 20,000 cubic yards. When summing the volume changes over all the profiles a net gain results. This value is 112,400 cubic yards over Oak Island since October 2006.

As with the onshore volumes discussed previously, the total (onshore+offshore) profile volume changes have been generally positive and have shown relatively little change over time since the beginning of the monitoring program. Figure 3.20 shows the volume changes for last three onshore/offshore surveys relative to the August 2000 pre-project survey. In this regard, all reported volume changes are positive with the exception of several isolated profiles which show small losses. The alongshore pattern shows relatively lower volume gains in the vicinity of Profiles 40, 100, and 180. All other areas are very healthy with respect to volumetric gains relating back to August 2000 base condition.

In addition, not only has the beach remained stable over time, but the overall volume has actually increased since the fill placement in 2001(see Figure 3.18). As shown on the graph, approximately 1,143,000 cubic yards of material were measured in-place with the November 2001 survey when compared to the August 2000 base year. Since that time, there has been a general trend toward sediment gain over time to February 2005 reaching nearly 1.6 million cubic yards. Following this peak, the volume has fluctuated around 1.4 million cubic yards over the last two years where it remains as of the most recent survey. Specifically, as of July 2007 the overall net increase amounts to 1,423,000 cubic yards. This still reflects a modest gain since the 2001 beach disposal operation.

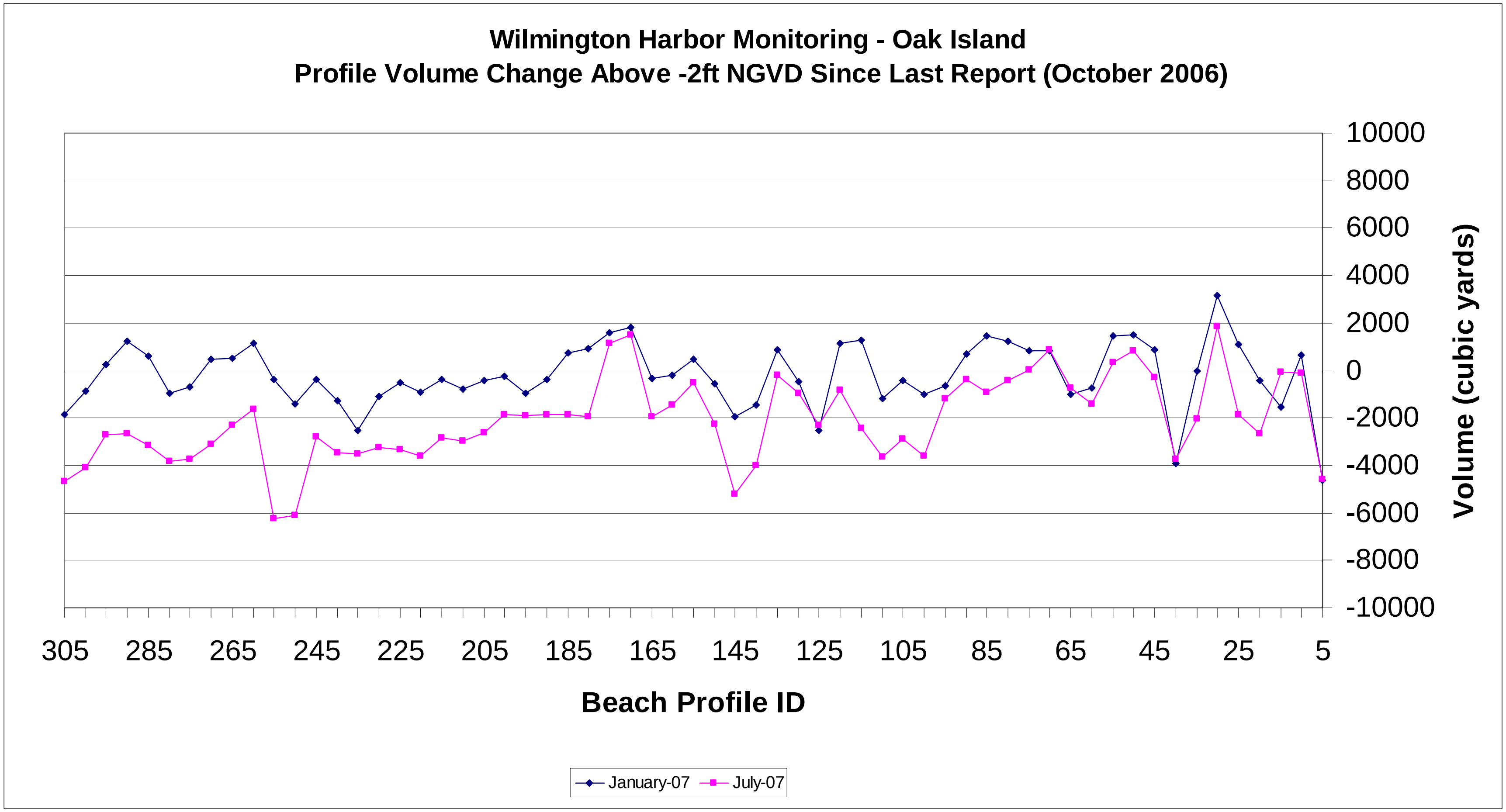


Figure 3.16 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change Since Last Report (October 2006) Onshore Volumes above – 2 ft NGVD

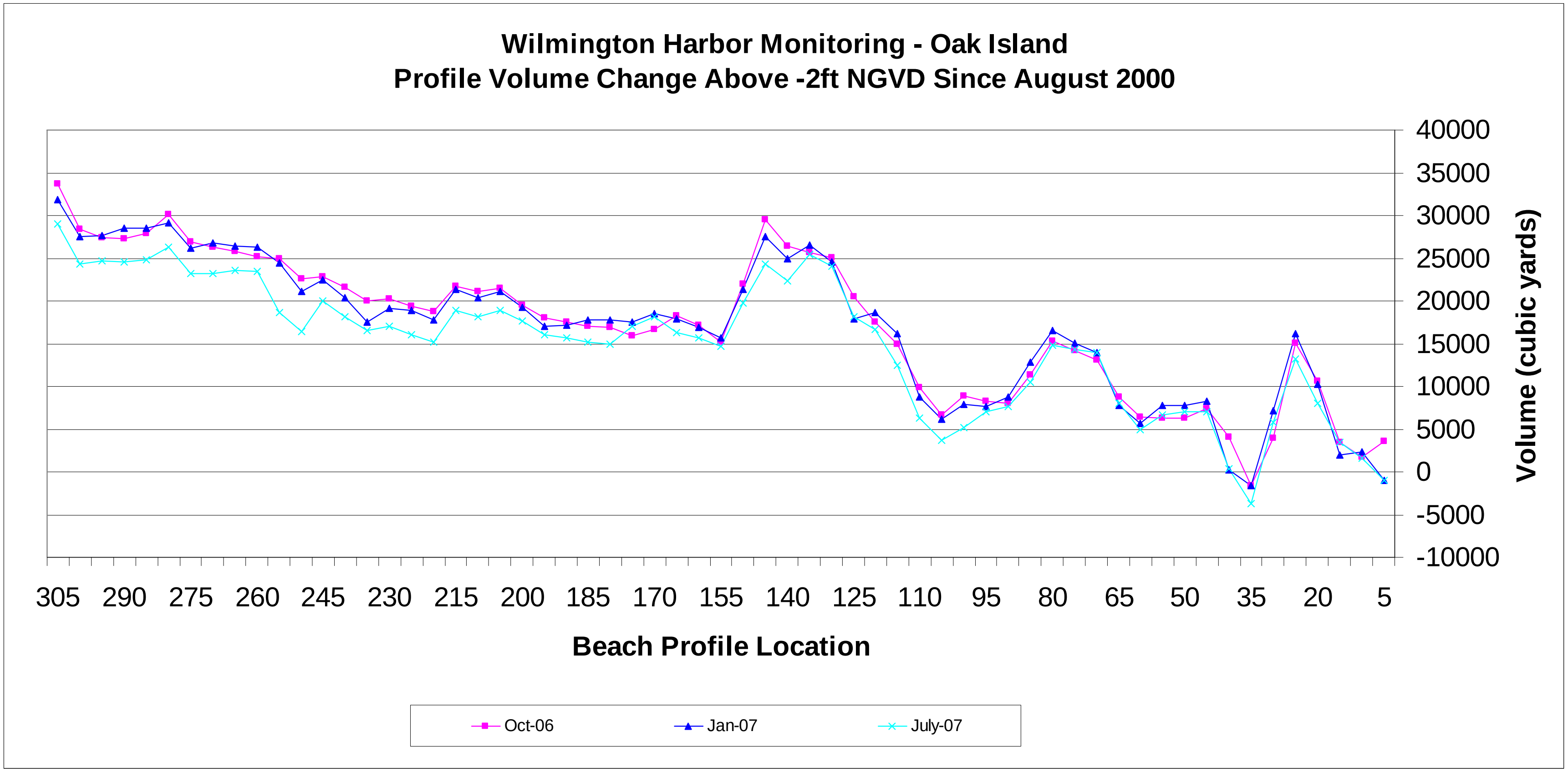


Figure 3.17 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change since Start of Monitoring (August 2000) Onshore Volumes above –2 ft NGVD

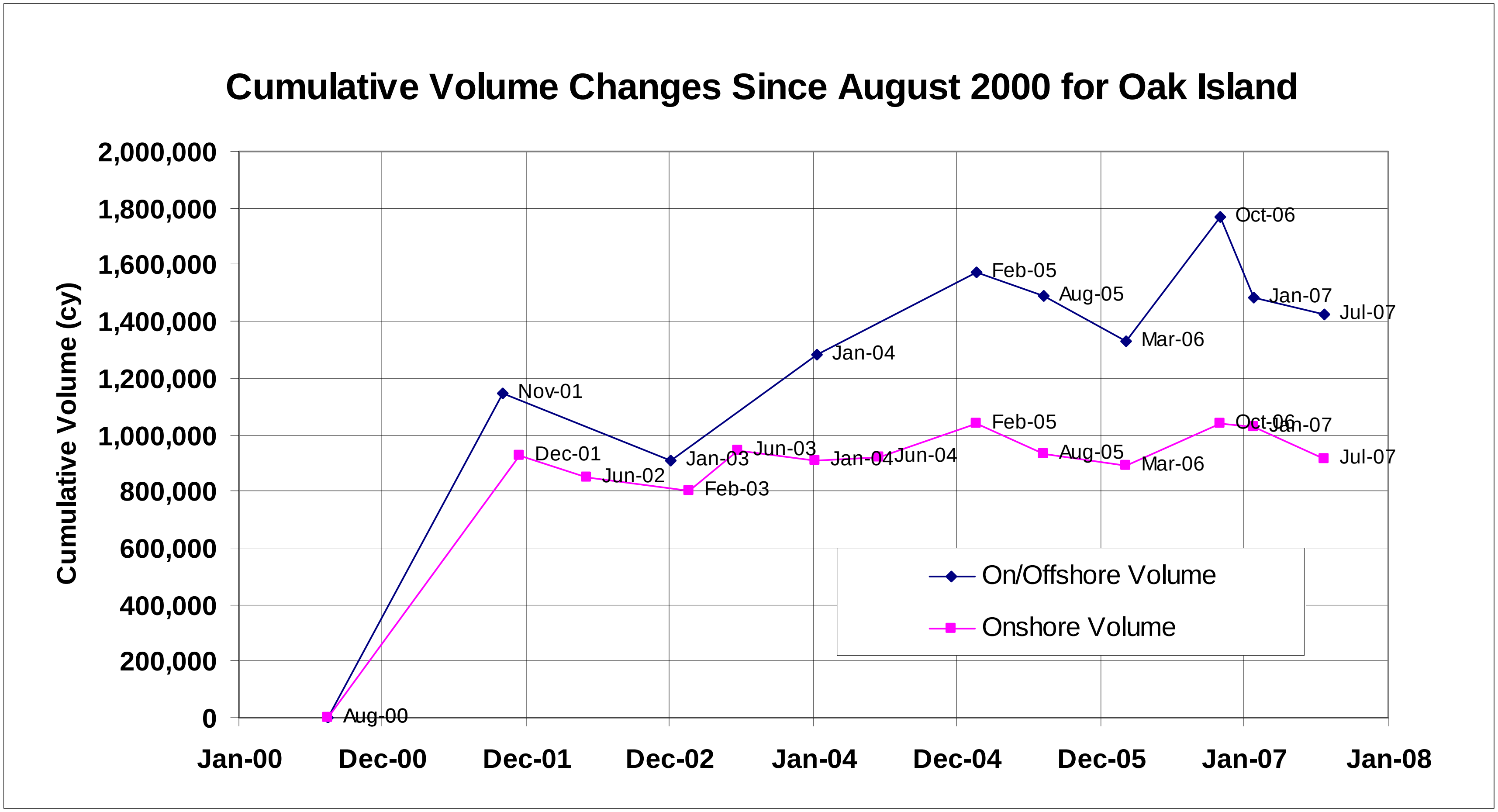


Figure 3.18 Cumulative Volume Changes Since August 2000 for Oak Island

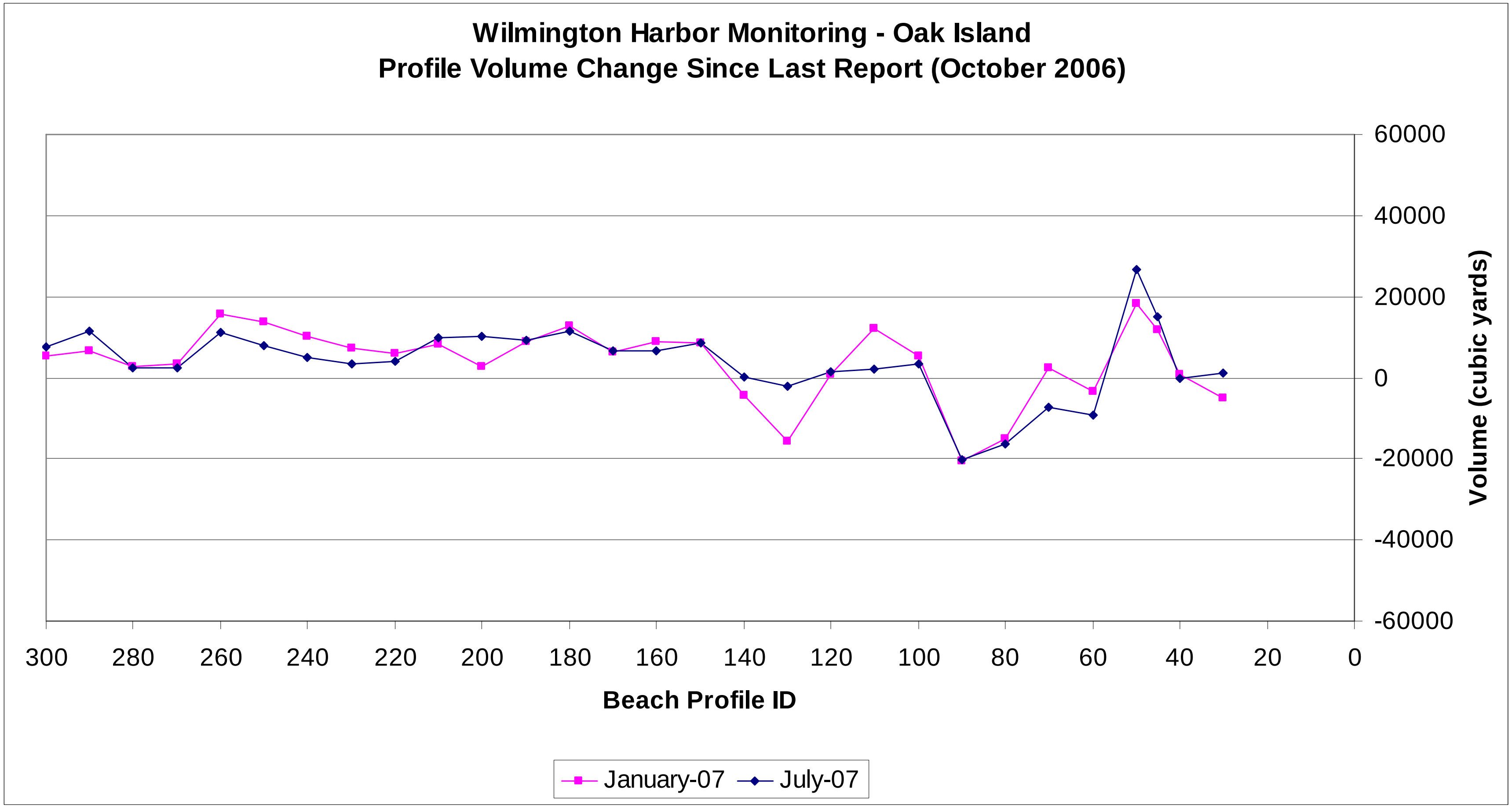


Figure 3.19 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since Last Report (October 2006)

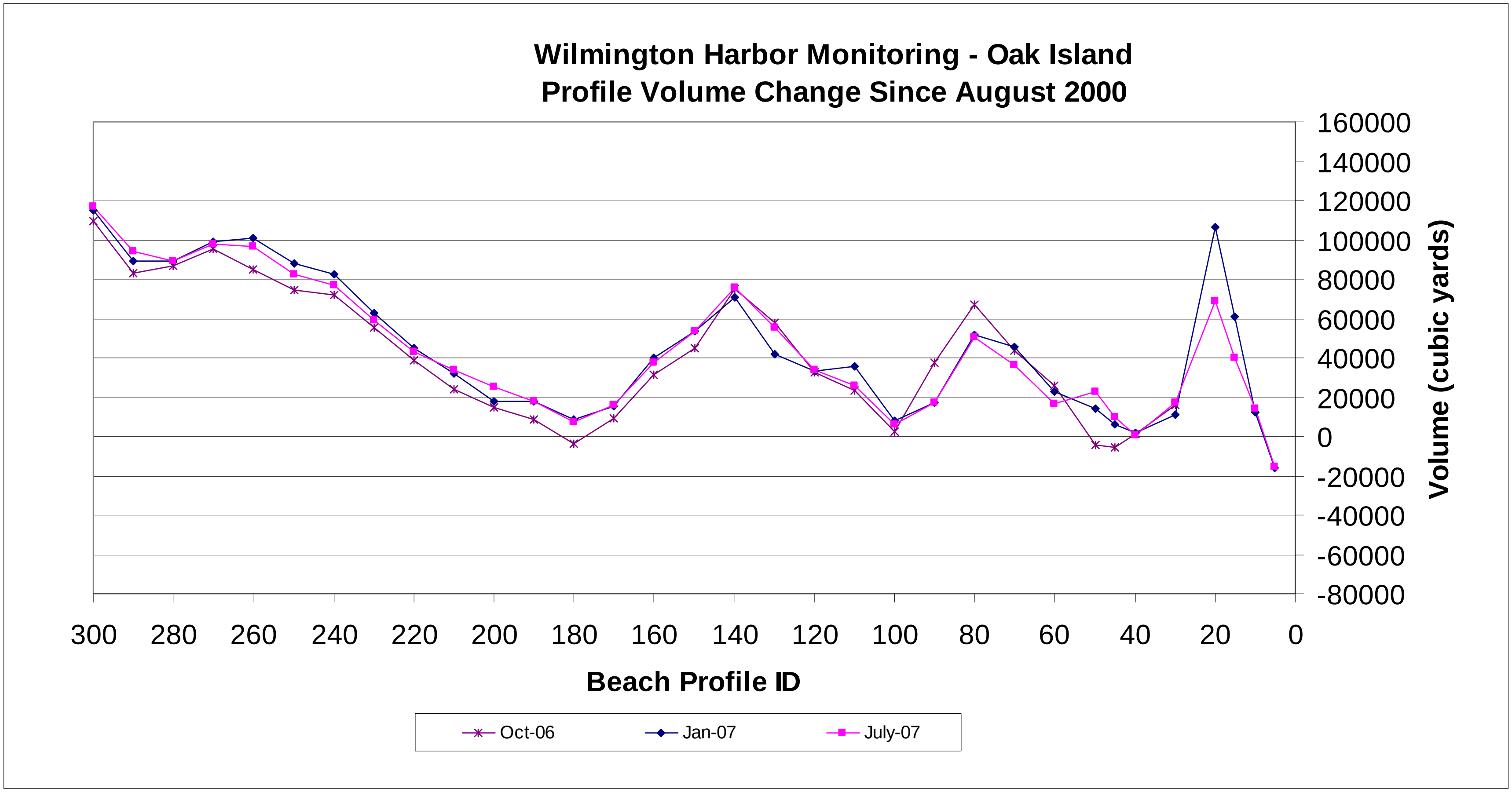


Figure 3.20 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since the Start of Monitoring (August 2000)

Ebb and Nearshore Shoal Analysis

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

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

Results. The ebb tidal delta surrounding the mouth of the Cape Fear River is shown in Figure 3.22 from the most recent survey of January 2007. From the latest bathymetric survey the gross patterns of the seafloor morphology are clearly evident in the figure and have changed very little since the last report. This survey shows the newly realigned channel as well as the remnants of the pre-project channel alignment. Also apparent are three linear shoals that compose much of the ebb tidal delta. Two shoals are present on the west side of the shipping channel which comprise Jay Bird Shoals. The third or Bald Head Shoal protrudes off the southwestern corner of Bald Head Island east of the main channel. The main channel is seen to hug very near Bald Head Island as it exits into the ocean. A well-developed flood margin channel can also be seen flanking Oak Island. However, a similar companion flood channel is not apparent through Bald Head Shoal on the opposite side of the entrance channel.

A side-by-side comparison of the inlet area is shown in Figure 3.23 for each of the seven bathymetric surveys taken in 2000, 2001 and 2003 through 2007. These comparisons show a persistence of the three linear shoals and their relative positions, in addition, they show how the deltas have expanded and contracted over the monitoring period. Also shown is the deepening of the flood margin channel on the Oak Island side which has stabilized over the last 2 surveys with a maximum depth of approximately 38 feet. The most obvious change is the deepening of the main shipping channel which is attributed to the dredging of the new channel in 2001.

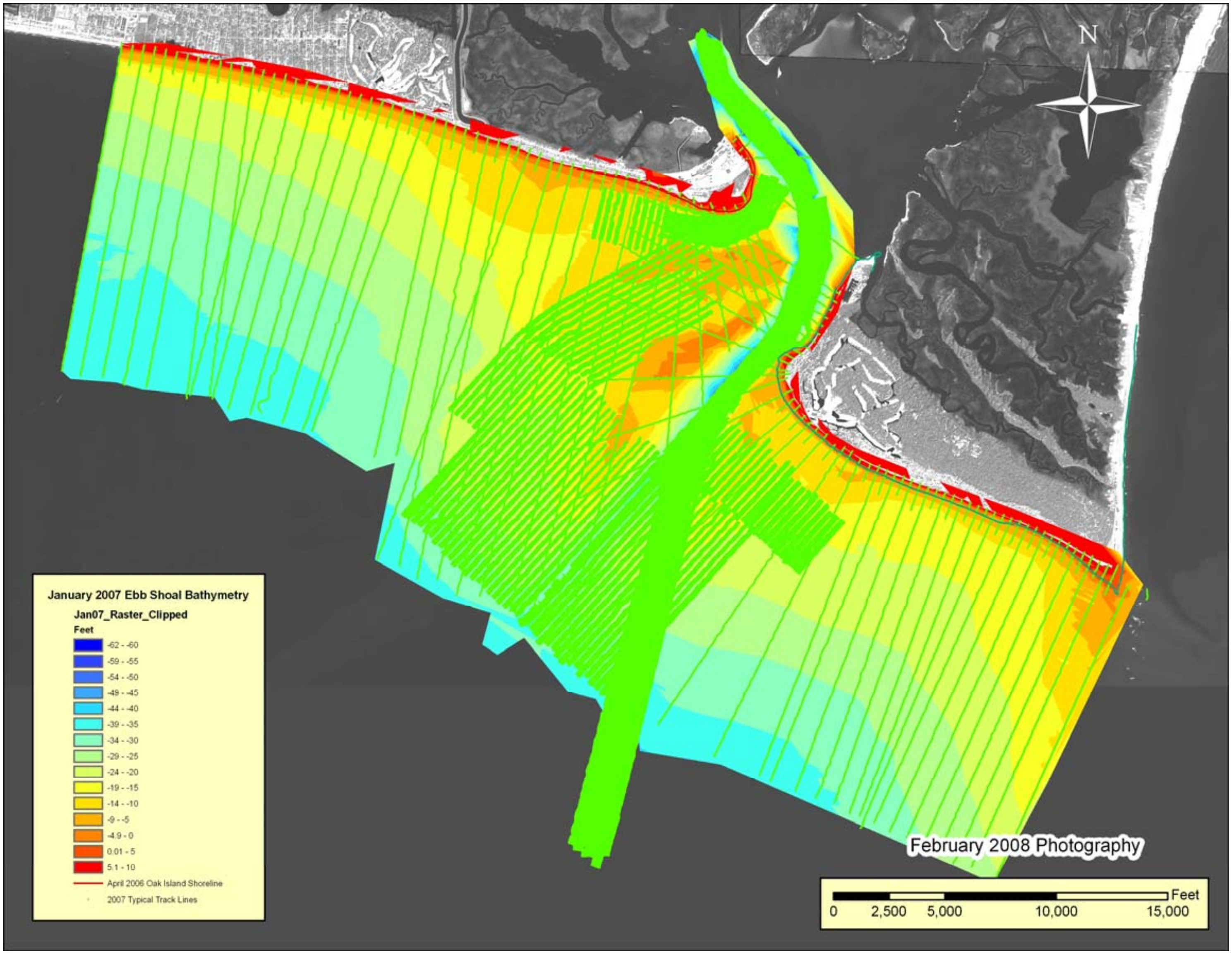


Figure 3.21 Survey Track Lines Collected by the LARC5 and the Interferometric System during the 2007 Survey

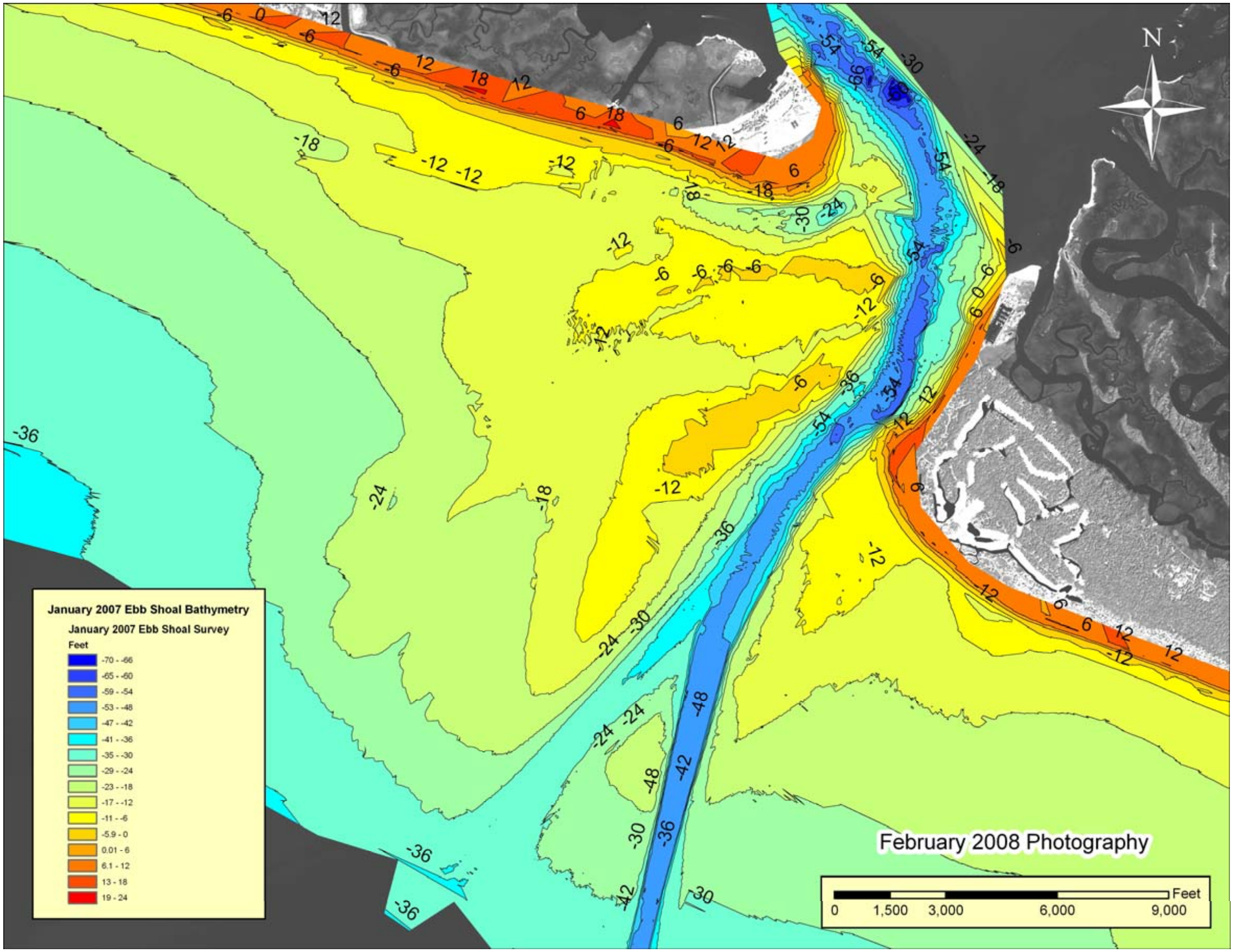
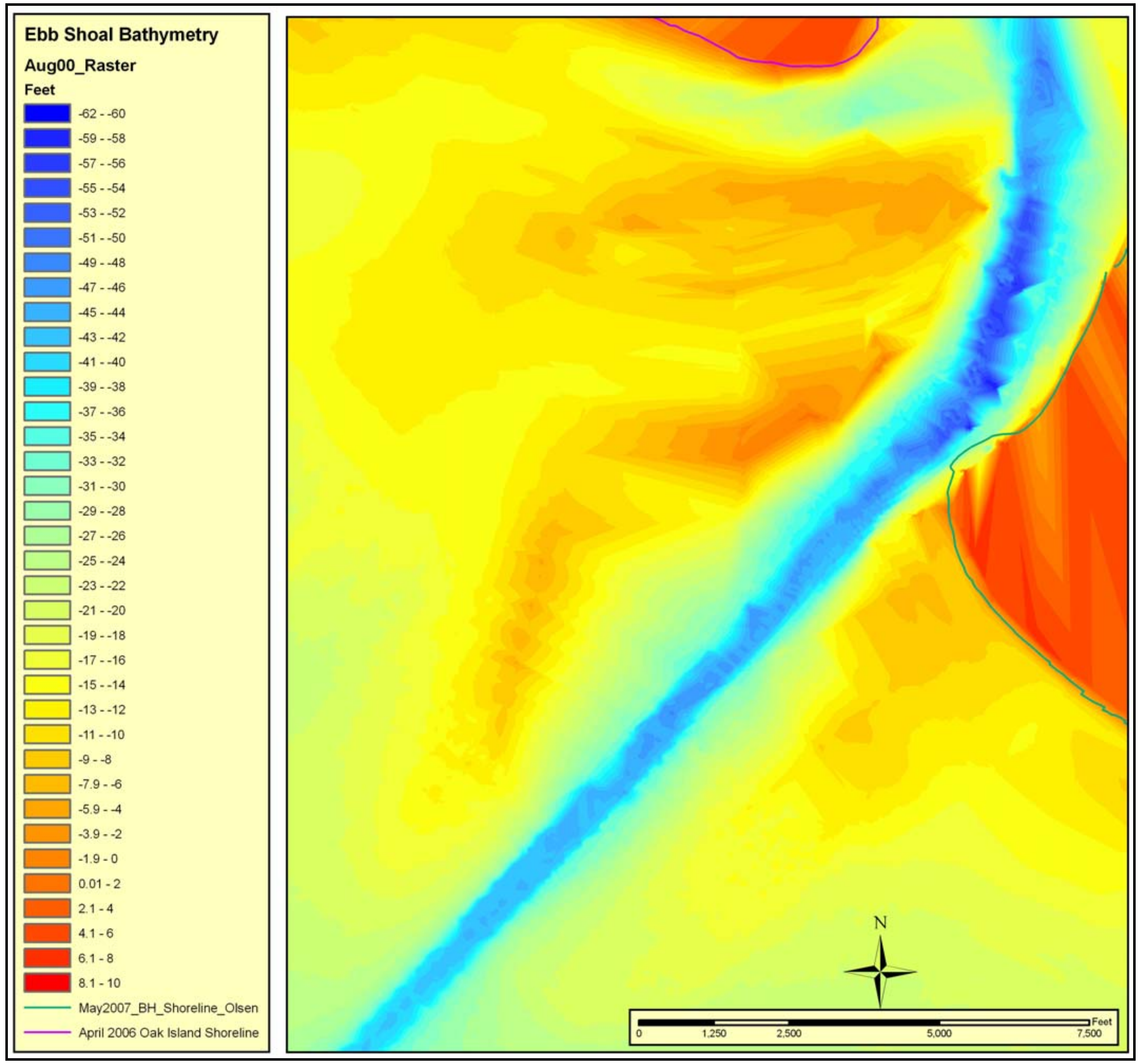
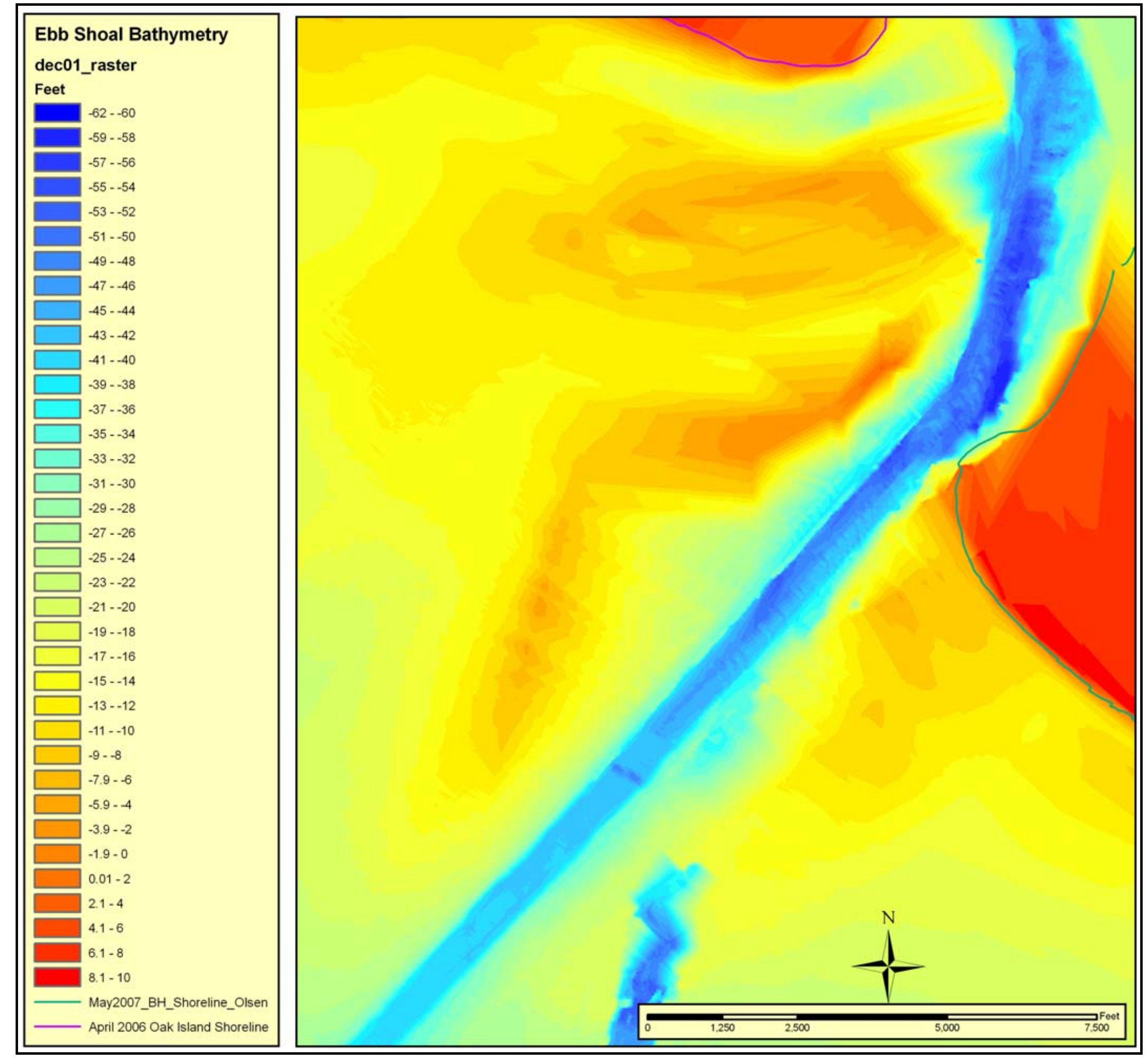


Figure 3.22 January 2007 Ebb Tide Delta Survey

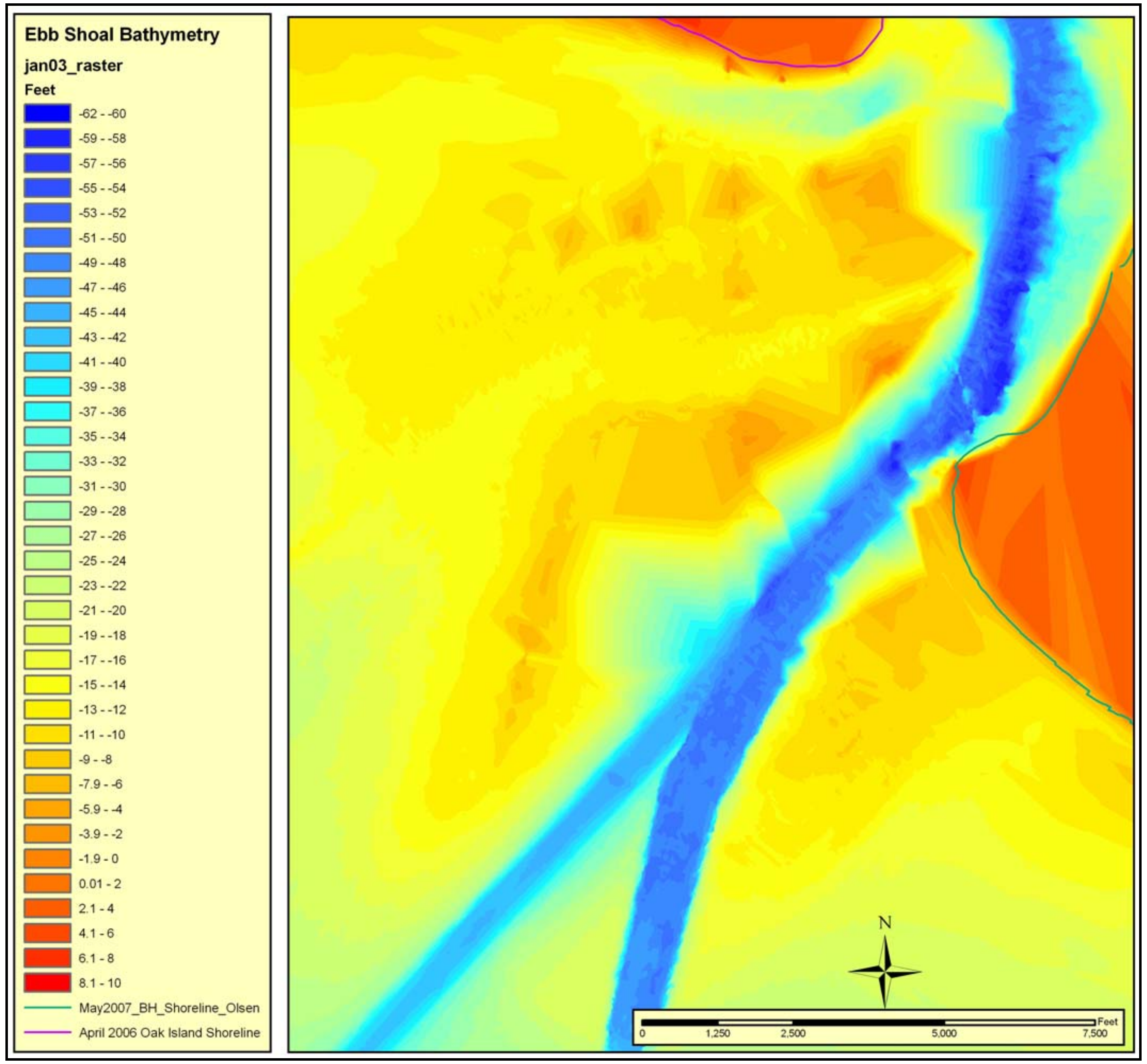


August 2000

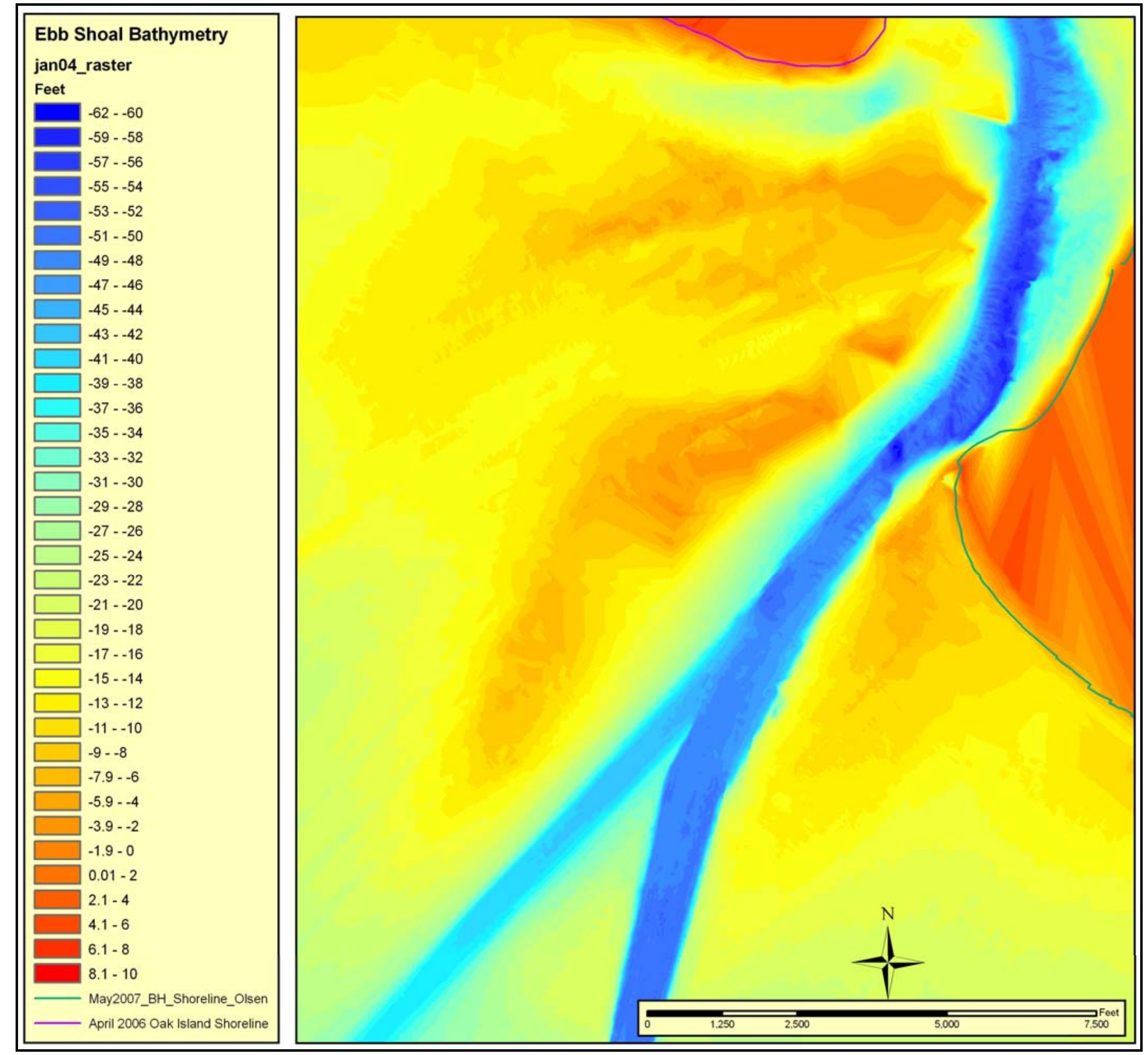


December 2001

Figure 3.23 Inlet Bathymetry Surveys

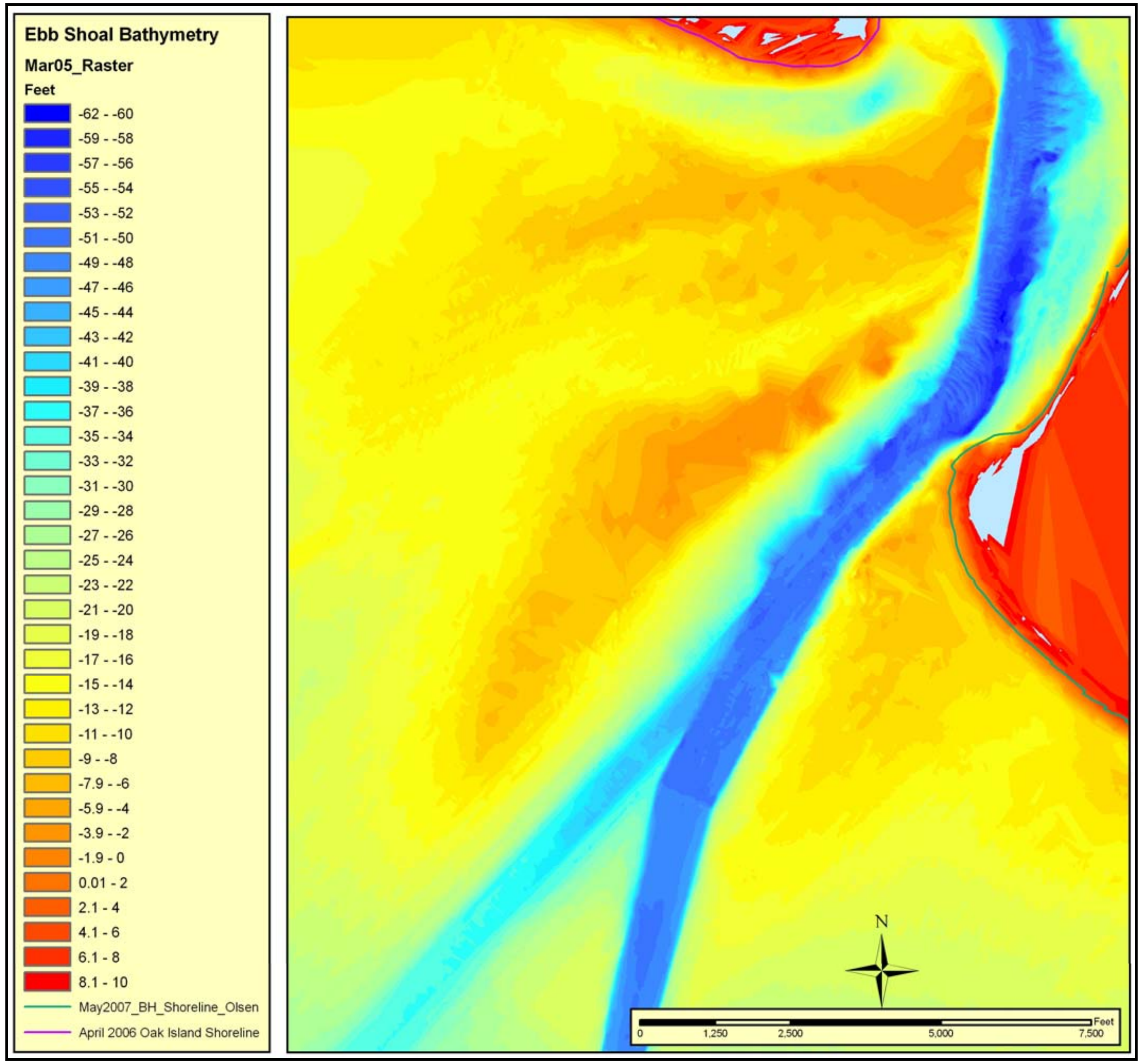


January 2003

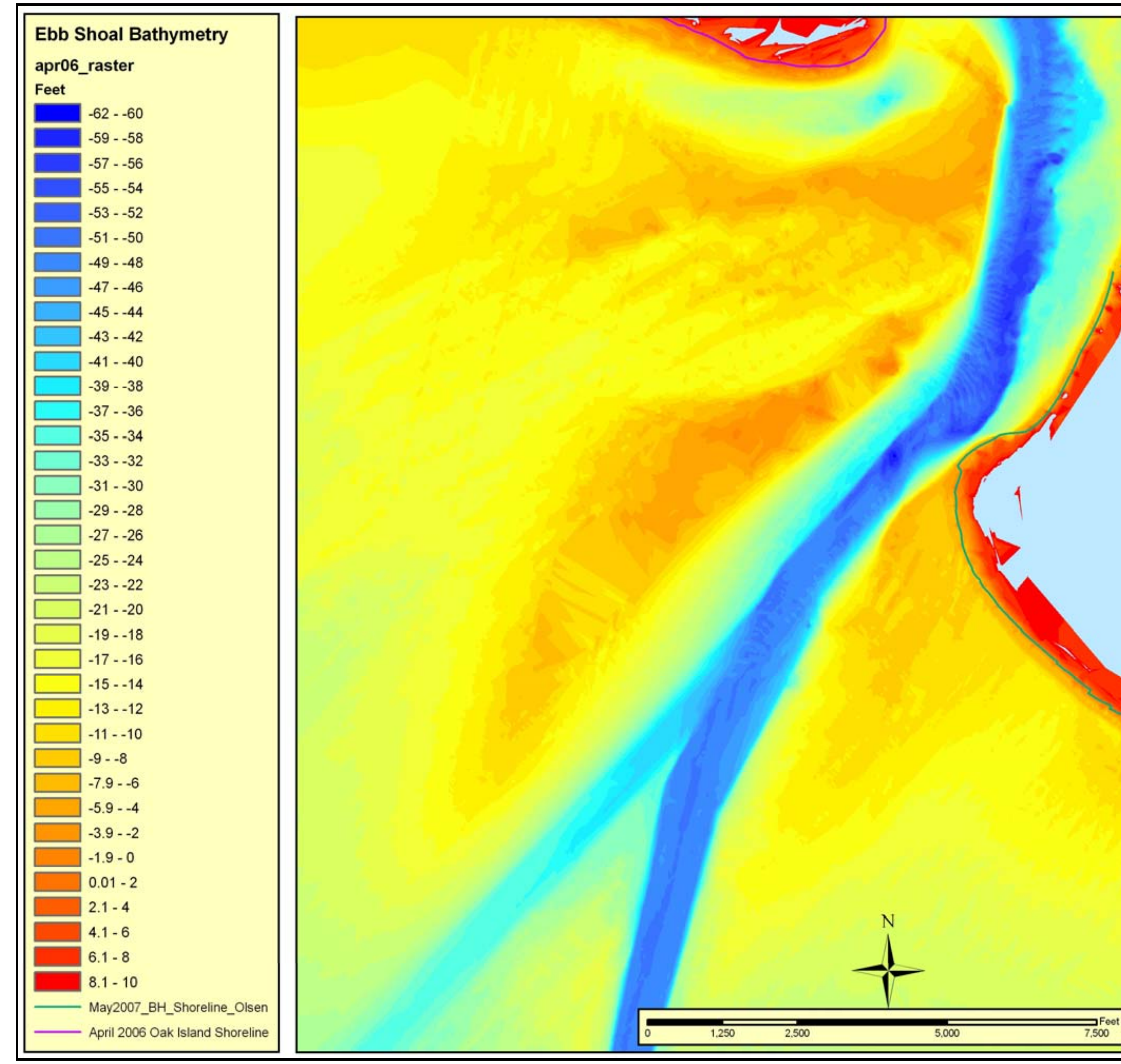


January 2004

Figure 3.23 Inlet Bathymetry Surveys (Continued)

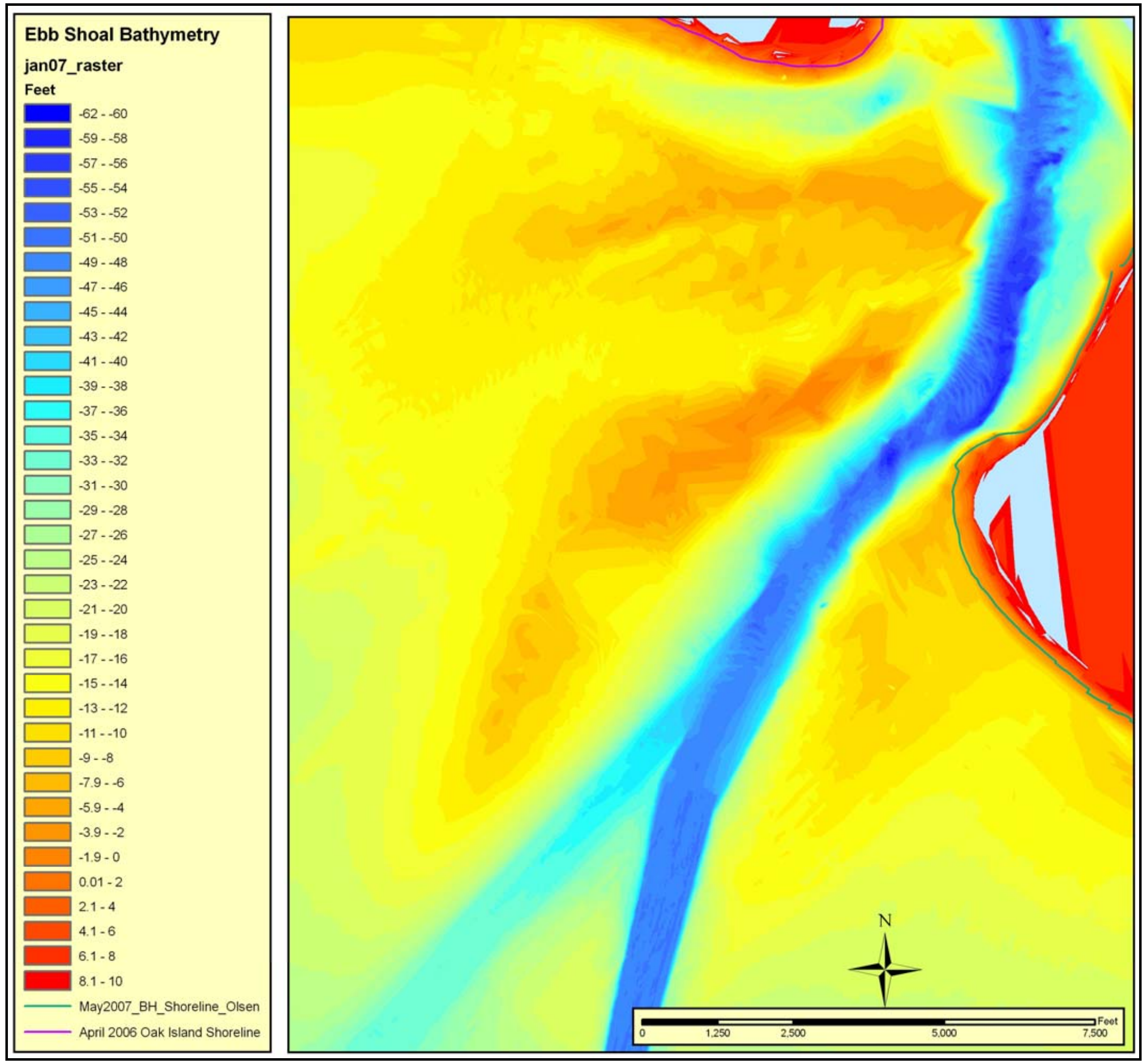


March 2005



April 2006

Figure 3.23 Inlet Bathymetry Surveys (Continued)



January 2007

Figure 3.23 Inlet Bathymetry Surveys (Continued)

Further comparisons between surveys are made by generating maps showing changes in the bathymetry over time. Difference plots were made comparing the most recent survey of January 2007 with the prior survey of April 2006 as well as with the initial pre-project survey of August 2000. Figure 3.24 shows the bathymetric changes for the most recent period between April 2006 and January 2007. Detailed insets of these changes are also shown for two areas namely the vicinity of the inlet and along the realigned channel. These detailed insets are given in Figure 3.25(a) which shows the inlet region and Figure 3.25(b) which shows the new channel area. As noted on the legend, areas of erosion are indicated in shades of blue and infilling areas are in shades of green to red.

As shown in Figures 3.24 and 3.25 the majority of the system experienced only moderate changes since the last survey in April 2006. Jay Bird shoals accreted nearly 3 feet, over this most recent monitoring period. This same area eroded nearly 4 feet between March 2005 and April 2006 which shown the dynamic nature of this area. A similar reversal is seen in the "v" shaped area between the old and new navigation channel, where losses are noted on the order of 2 feet. This same area accreted during the last monitoring period on the order of 4 to 6 feet.

Major elevation changes were noticed in Reach 1 of the new navigation channel just south the Bald Head Island spit, the north side of the Bald Head Island spit, and in areas just west and east of the Smith Island channel, approximately across from the Bald Head Island marina. While these shoaling changes were as much as 16 feet, they were relatively small in area and did not restrict navigation as discussed in Part 4 of this report. No significant areas of scour are noted in the current monitoring cycle.

In addition to the most recent changes in the ebb tidal bathymetry, Figure 3.26 shows the changes which have occurred since the initiation of the monitoring program. This figure compares the August 2000 pre-project survey with the most recent, January 2007, survey. Detailed insets for the inlet region and the new channel area are given in Figures 3.27(a) and 3.27(b). Some of the same patterns described above for the more recent time period are also present over the total monitoring period. Similar trends were observed in the following three areas over these two time periods: (1) The Bald Head Island spit growth to the north. (2) Accretion in Jay Bird Shoals near the old entrance channel. (3) The old navigation channel shows accretion in both time periods. While maintenance dredge material has been disposed of within this area in the past and contributes to the overall infilling, no material has been placed within this area during the current monitoring period.

In addition to the trends mentioned above, there are five other areas of change revealed on Figure 3.26, as follows; (1) the major excavation of the realigned new channel is very prominent in the figure which was cut through the relatively shallow portion of the ebb tidal delta to project depths of 42 feet, (2) the channel deepening is evident as well from the outer bar channel through the inlet between the two islands, (3) portions of south beach have accreted when compared to the pre-existing conditions in the vicinity of the newly rebuilt groin field, (4) significant accretion along the west side of Bald Head Shoal is evident, and (5) the final area of change occurred in the flood margin channel just off the tip of Oak Island. While parts of this channel have scoured out as much as 8 to 10 feet, the northernmost part of the flood channel has accreted.

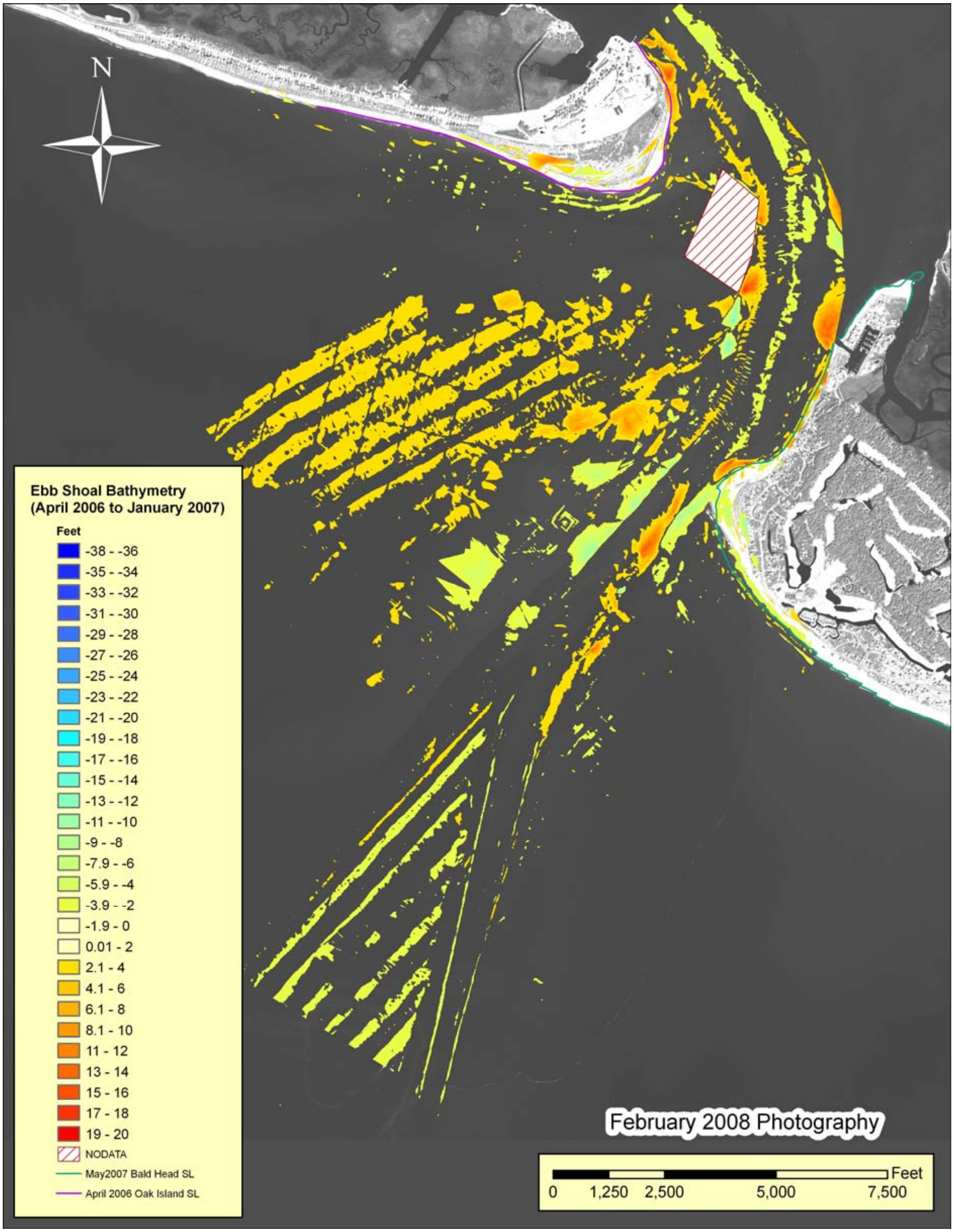


Figure 3.24 Bathymetric Changes of the Ebb Tidal Delta (April 2006 to January 2007)

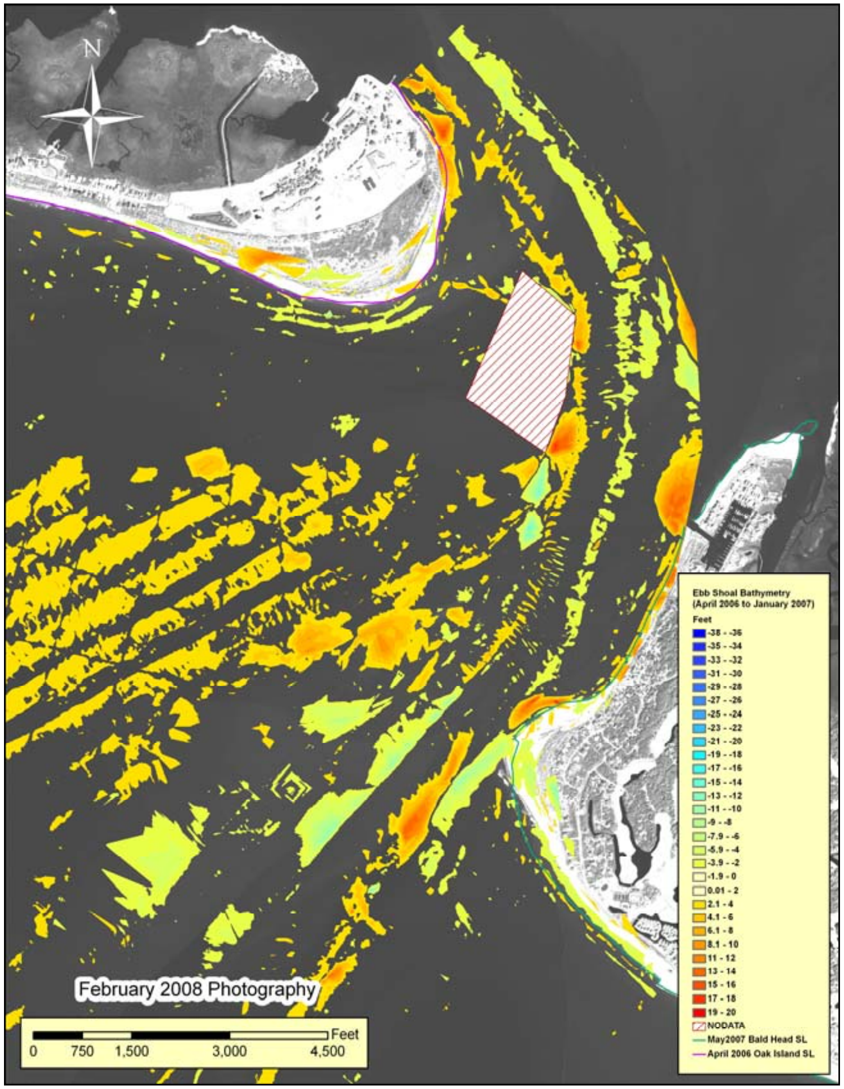


Fig 3.25 (a) Bathymetric Changes of Inlet (April 2006 to Jan 2007)

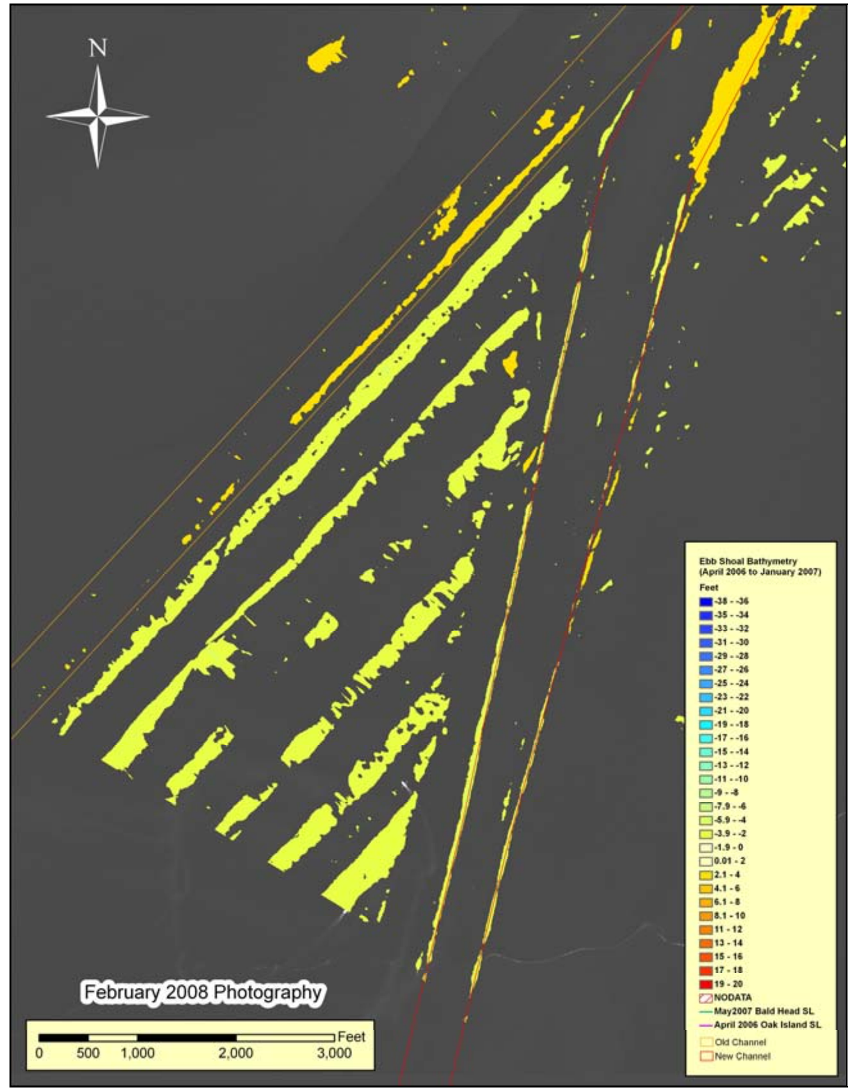


Fig 3.25 (b) Bathymetric Changes of New Channel (April 2006 to Jan 2007)

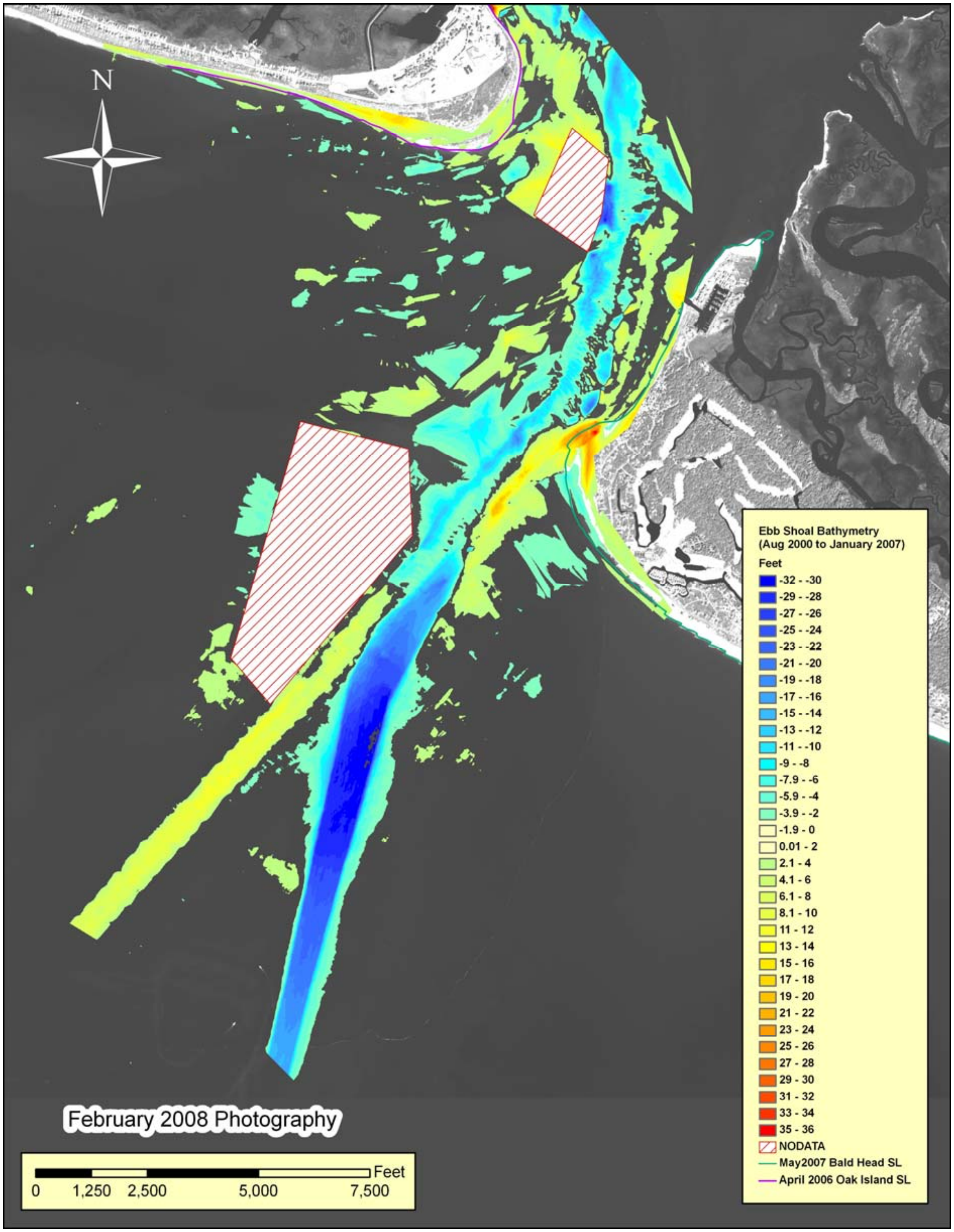


Figure 3.26 Bathymetric Changes of the Ebb Tidal Delta (August 2000 to January 2007)

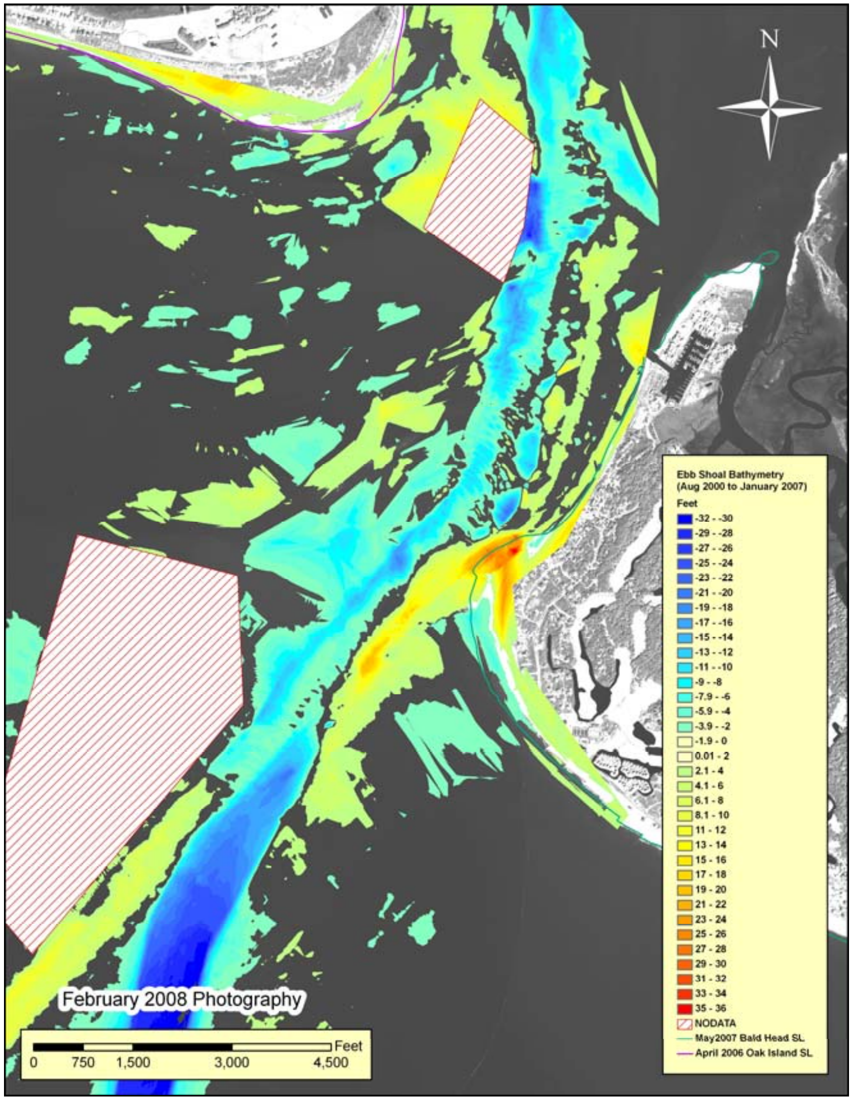


Figure 3.27 (a) Bathymetric Changes of Inlet (August 2000 to January 2007)

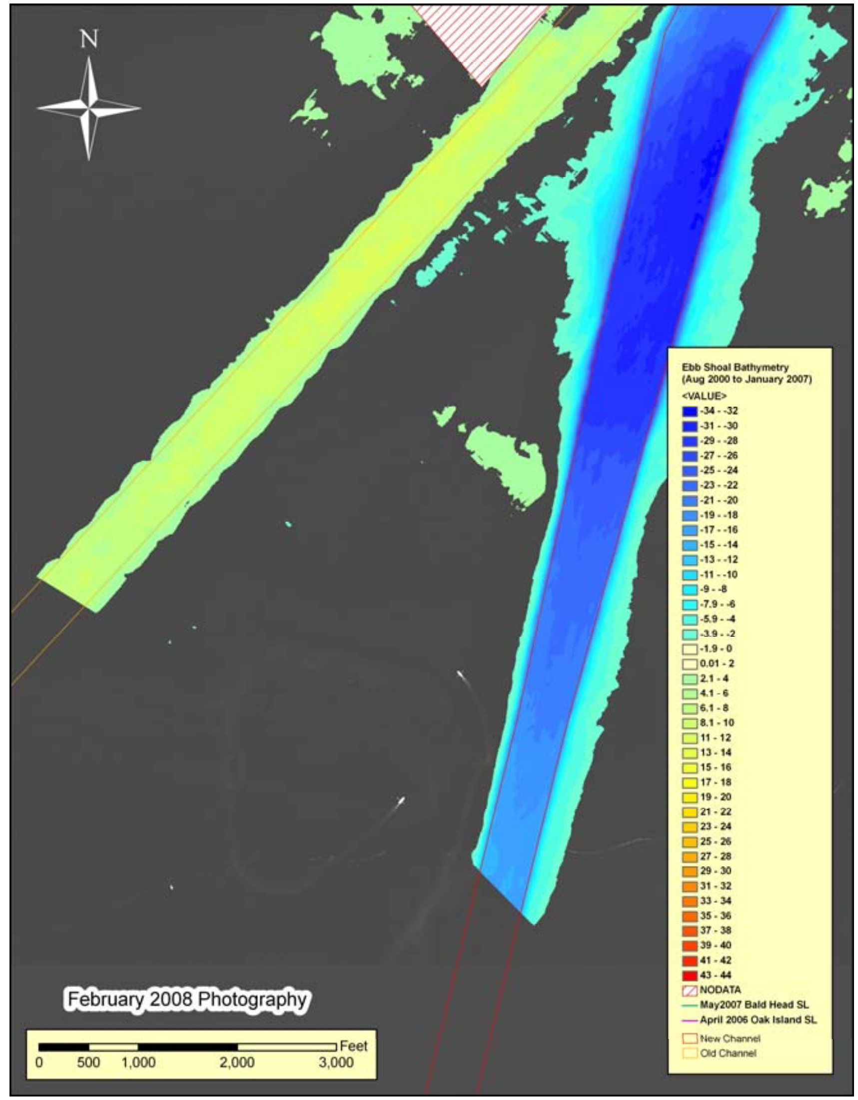


Figure 3.27 (b) Bathymetric Changes of New Channel (August 2000 to January 2007)

Current Measurements

Methodology. Mean currents were measured across the mouth of the Cape Fear River tidal inlet and the seaward portion of the ebb tidal delta around the new and original shipping channel using a ship-mounted Acoustic Doppler Current Profiler (ADCP). The location of the inlet and offshore transects are shown in Figure 3.28. Typically two +13-hour transects were performed during each survey episode. To date seven current surveys have been accomplished on both the inlet and new channel loops as listed in Table 3.2. The current measurements are scheduled to take place on or near spring tide for consistency and all but one of the surveys were accomplished in this manner. The initial October 11-12, 2000 transects were taken prior to the new entrance channel deepening and realignment, with the most recent being collected on February 19, 2007 (inlet region) and 20 March, 2007 (new channel region).

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

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

The specific ADCP transects for the 2007 data collection are given in Figures 3.29 and 3.30. For details of this system and methodology on data collection and reduction refer to the following referenced letter reports: McNinch 2000, 2002a, 2003a, 2004a, USACE 2005a, and Waller and Pratt 2006. Details of the most recent current measurements are given in McNinch 2007.

Tidal Inlet Region Results. The results of each transect were processed and analyzed in a time series for each hourly loop. Figures 3.31 and 3.32 show the details of the flow patterns during times of peak flood and peak ebb, respectively, for the February 2007 measurements. These flow patterns are generally similar with those measured on previous occasions and are influenced by the local bathymetry. During flood flow, the currents are concentrated within the main channel between Bald Head Island and Jay Bird Shoals. Flow is also concentrated through the flood margin channel near Oak Island. Two other interesting features are also evident with the flood flow pattern. One is over the region of Jay Bird Shoals where water flows from the shoals into the main channel at a fairly high angle relative to the main flow likely causing substantial horizontal sheer. The others are eddies off the main flow that are evident in the lee of the point at the juncture between South Beach and West Beach and also near Oak Island. For comparison purposes, the similar peak flood flow patterns from the prior measurements collected in October 2000, April 2002, March 2003, Jan 2004, March 2005 and March 2006 are given in Appendix D.

As with the peak flood conditions, the peak ebb flow patterns (Figure 3.32) also have two velocity peaks along the inlet transect, one near the marginal channel along Oak Island and the other within the main channel. These flows are funneled into the main channel during ebb impinging on the bank along Bald Head's West Beach. The similar peak ebb flow patterns from the prior measurements collected in October 2000, April 2002, March 2003, Jan 2004, March 2005 and March 2006 are given in Appendix D.

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.3 for the inlet region. The February 2007 data shows in general the highest peak flows recorded to date over the seven sampling events. The peak value listed for the near-bottom ebb of 7.8 ft/s is much higher than previous readings and is even higher than the corresponding near surface ebb velocity. As such, the recording is questionable although the data was checked for accuracy. One possible explanation is that the recording reflects a very localized flow associated with an eddy near the bottom of the inlet. Aside from this high reading, the overall magnitudes of the currents ranged from a peak surface ebb value of 6.5 ft/s to near-bottom flood values of just over 3 ft/s. In all cases, with the exception of the March 2003 and 2006 near-bottom measurements, the peak ebb velocities exceed the peak flood velocities as would be expected for an ebb-dominated system with fresh water inflows of the Cape Fear River. Another trend is evident from the table when comparing the October 2000 pre-project measurements with the six post-construction measurements. In this regard, all of the maximum velocities are greater than the initial pre-project magnitudes. The only exceptions to this are the January 2004 near bottom flood and near-surface ebb measurements. One reason for this exception may be that in this instance the survey was not taken near spring tide as all the others were. Since only one pre-project survey was taken as part of the monitoring effort, it is difficult to draw a firm conclusion regarding the increase in peak flows through the inlet. However, this issue warrants further investigation during the proposed future modeling efforts to determine the significance of this trend in the post-project measurements. In comparing the average of the post-project values with the October 2000 values, all are greater. Specifically for the near-bottom case, the average values are –4.2 ft/s (ebb (excluding Feb07) and 4.0 ft/s (flood) versus -3.5 ft/s and 3.3 ft/s, respectively. For the near-surface case, the average values are likewise –5.4 ft/s (ebb) and 4.4 ft/s (flood), versus -4.4 ft/s (ebb) and 3.6 ft/s (flood) for the October 2000 measurements.

Table 3.3 Maximum Magnitude of Mean Flows at Inlet Transect

		October 2000	**April 2002**	**March 2003**	**January 2004**	**March 2005**	**March 2006**	**February 2007**
Near-bottom*	***ebb***	3.48 ft/s (1.06 m/s)	3.83 ft/s (1.17 m/s)	3.87 ft/s (1.18 m/s)	5.14 ft/s (1.57 m/s)	4.43 ft/s (1.35 m/s)	3.61 ft/s (1.10 m/s)	7.84 ft/s (2.39 m/s)
	flood	3.28 ft/s (1.00 m/s)	3.67 ft/s (1.12 m/s)	4.82 ft/s (1.47 m/s)	3.23 ft/s (0.98 m/s)	3.87 ft/s (1.18 m/s)	3.81 ft/s (1.16 m/s)	4.75 ft/s (1.45 m/s)
Near-surface*	***ebb***	4.43 ft/s (1.35 m/s)	6.46 ft/s (1.97 m/s)	5.41 ft/s (1.65 m/s)	3.88 ft/s (1.18 m/s)	5.58 ft/s (1.70 m/s)	4.53 ft/s (1.38 m/s)	6.50 ft/s (1.98 m/s)
	flood	3.61 ft/s (1.10 m/s)	4.13 ft/s (1.26 m/s)	4.17 ft/s (1.27 m/s)	3.75 ft/s (1.14 m/s)	4.40 ft/s (1.34 m/s)	4.50 ft/s (1.37 m/s)	5.35 ft/s (1.63 m/s)

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

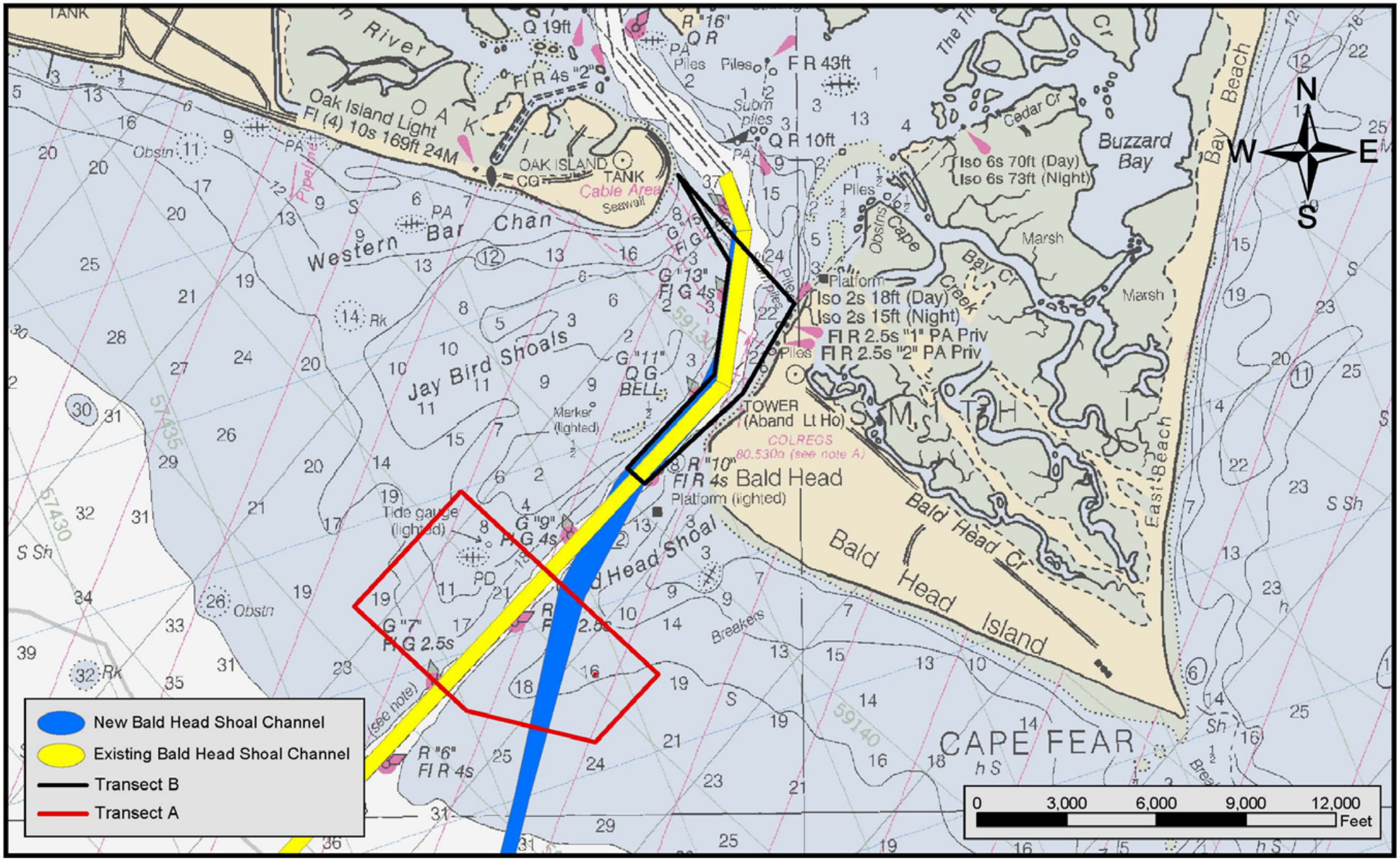


Figure 3.28 Ship-Board current profile track lines

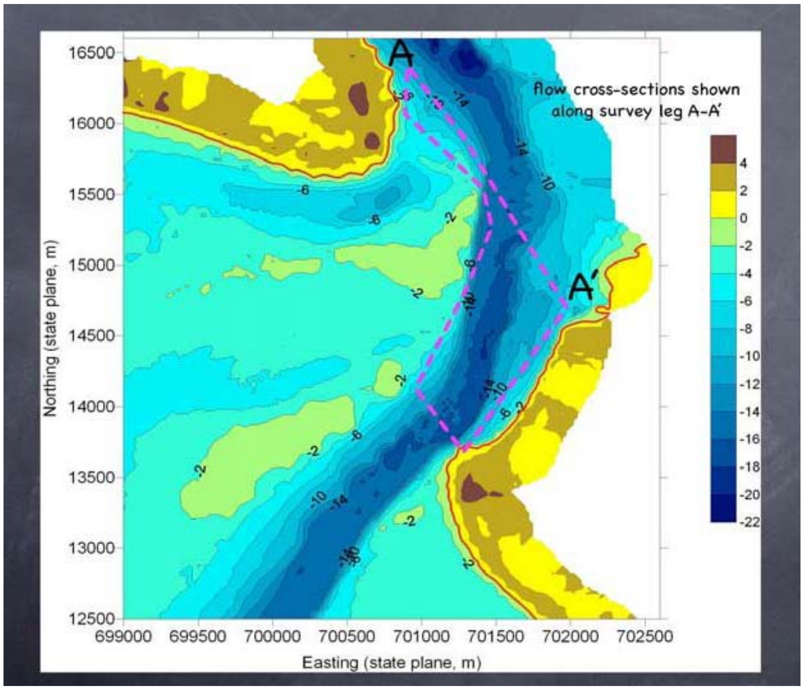


Figure 3.29 Plan View Showing the ADCP Transect Collected 19 February 2007 in the Tidal Inlet Region

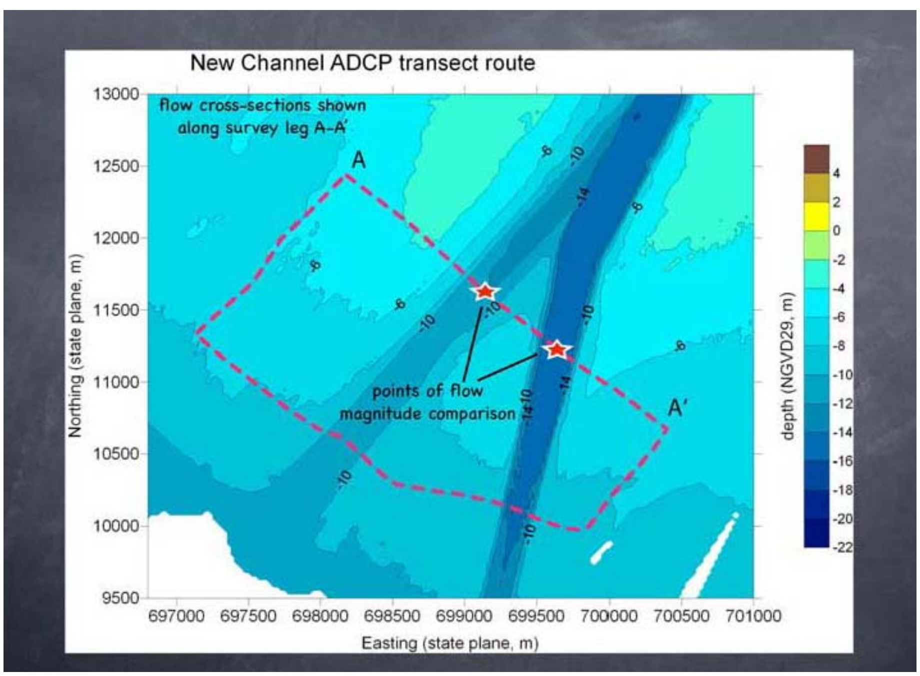


Figure 3.30 Plan View Showing the ADCP transect Collected 20 March 2007 in the New Channel Region

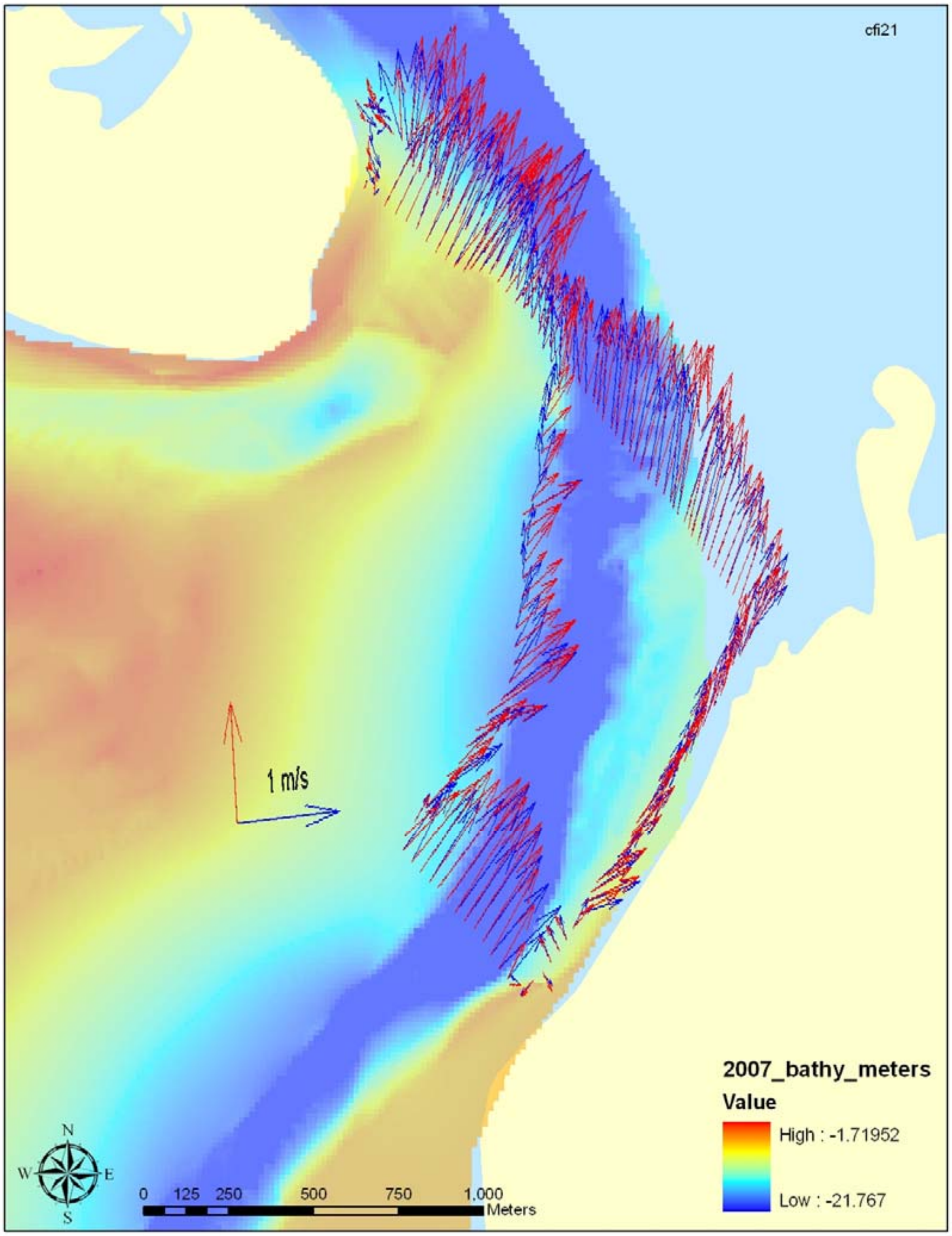


Figure 3.31 February 2007 ADCP Survey at the Inlet Transect during Peak Flood Flow

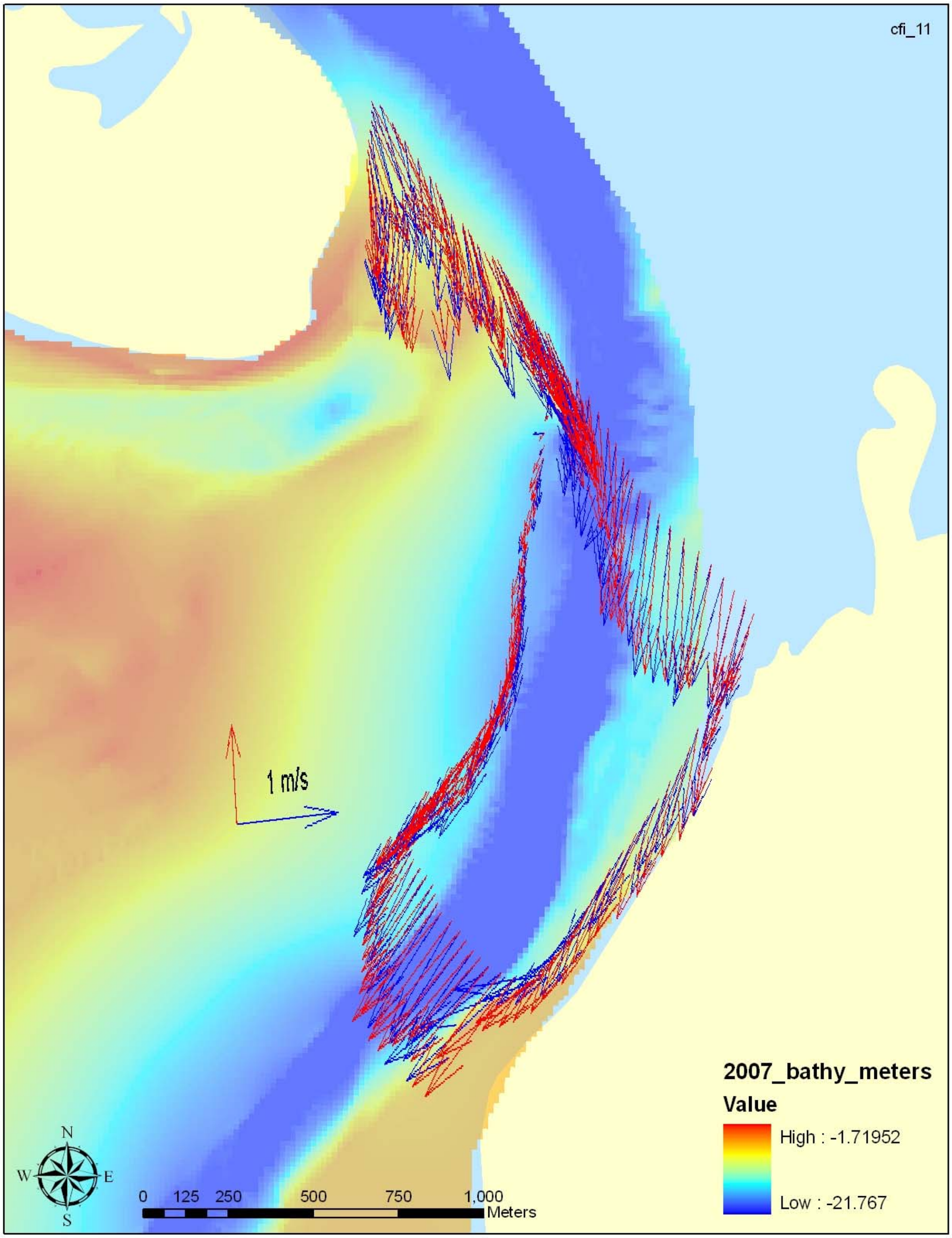


Figure 3.32 February 2007 ADCP Survey at the Inlet Transect During Peak Ebb Flow

Tidal Prism. Tidal prism represents the total volume of water passing though the inlet over the tidal period. Tidal prisms were computed using the inlet throat transect (see Figure 3.29 for example transect) for each of the past current measurements—pre-construction (October 2000) and post-construction (April 2002, March 2003, January 2004, March 2005 and February 2007) ADCP surveys. Unfortunately, calculation of the tidal prism was not possible for the March 2006 ADCP survey due to the shortened data collection resulting from the hazardous weather and sea state conditions. The results are displayed graphically for each of the survey dates in Figure 3.33. These computations represent snapshots of the tidal period for each respective date and include the results of other non-tidal forcing agents as well as natural variations in tide conditions. Other forces which influence flow are wind-forcing, river discharge as well as differences in astronomical tides at different times of the year and across a tidal epoch (i.e. spring tides are not necessarily equal through time). To make more meaningful comparisons of the six surveys, the tidal prism computations were normalized across the inlet cross-section area as defined by the January 2003 bathymetry and associated transect. Table 3.4 summarizes the tidal prism computations and the results are shown graphically in Figure 3.34.

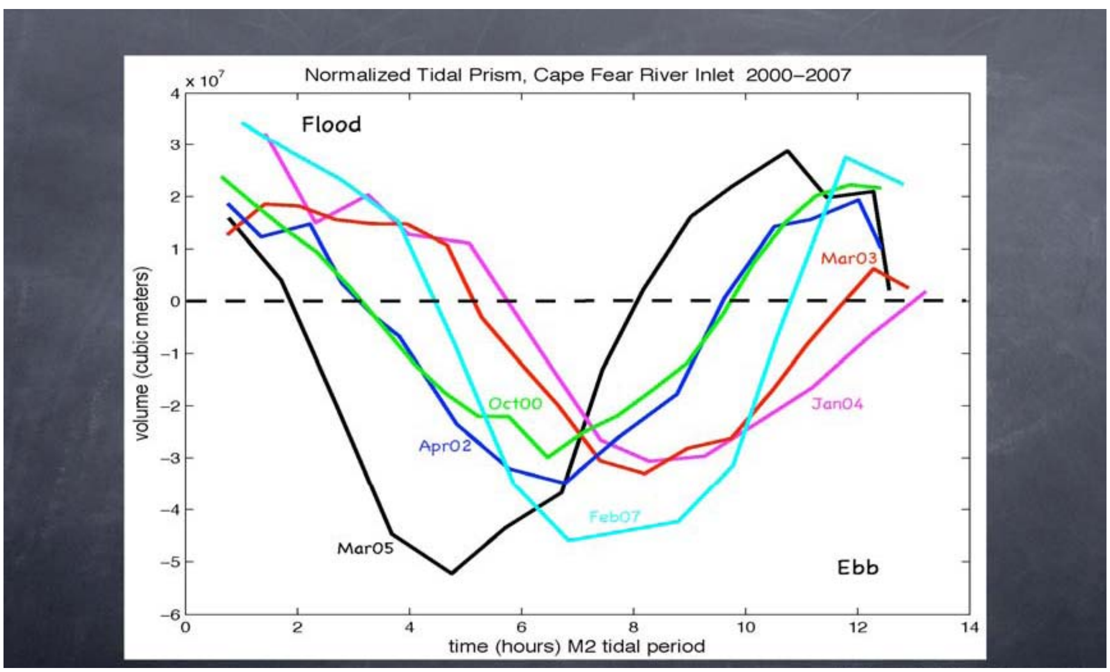


Figure 3.33 Volume of Water Passing through the inlet over the tidal period for all ADCP surveys (2000-2007)

Table 3.4 Normalized Tidal Prism Values for each of the ADCP Surveys (2000-2007)

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

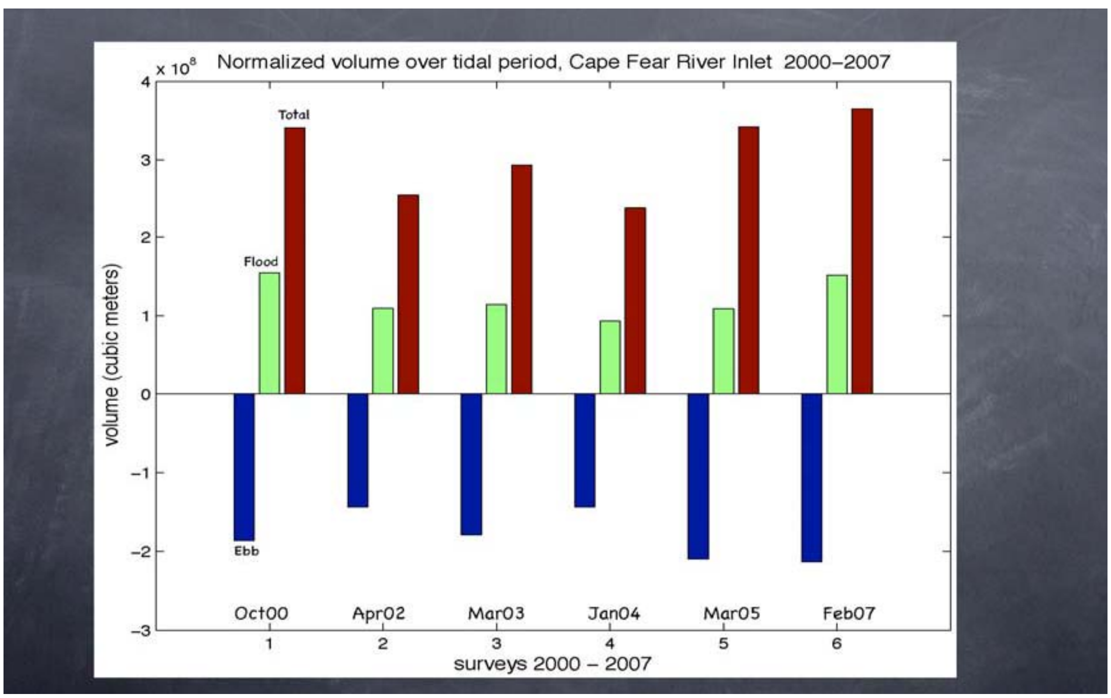


Figure 3.34 Normalized tidal prism for six surveys—(1) October 2000, (2) April 2002, (3) March 2003, (4) January 2004 (5) March 2005 and (6) February 2007(6). Blue—ebb, Green—flood, Red—total

The normalizing process applies the average velocity from the ADCP survey across the inlet cross-section area multiplied by the tidal period. The October 2000 inlet transect survey only covered the inlet throat because at that time it was believed that insignificant flow existed over the shoals adjacent to Oak Island. Subsequent hydrographic surveys and current measurements indicated otherwise, so beginning with the April 2002 survey the inlet transects were enlarged. Thus the average velocity for the October 2000 survey, since it only incorporated a portion of the inlet cross-section, possibly differed from what would have been measured if the whole cross-section had been surveyed. In addition, differences from survey periods relative to spring tides, winds, river discharge, and astronomical period should be considered when explaining the differences observed in Figure 3.34.

The tidal prism results show that the Cape Fear is an ebb-dominated inlet with the average ebb flow volume being 36% greater than the flood volume. The February 2007 current survey is the second of the post-construction data set to have a total tidal prism exceeding that of the computed total volume for the pre-construction October 2000 survey. Plus, it was the largest measured prism to date exceeding the 2000 value by about 14%. The most recent survey had a flood volume that was comparable with the pre-construction measurements but had the largest ebb flow recorded to date which accounted for the relatively large total volume passing through the inlet over the tidal cycle.

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

The peak ebb in the offshore transect is found to start in the new channel and shift to the old ebb channel location. At peak flow the strongest ebb is located generally between the old and new channel regions. This may represent a slight shift from previous measurements in which the peak flows still seem to favor the old channel bed. Outside of this region the ebb flows are greatly reduced particularly around Jay Bird Shoals. The comparative peak ebb flow patterns from the prior measurements are given in Appendix D.

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.5 for the outer transect. Overall, as with the inlet transect, the peak ebb velocities exceed the peak flood velocities. The velocities range from a high measured at near-surface ebb of 4.4 ft/s with a low peak found at near-bottom ebb of just over 1 ft/s. As indicated in the table, the most recent measurements of March 2007 are found to be largest recorded peak ebb flows to date for both the near bottom and near surface conditions. The maximum flood flows however are comparable to other prior measurements.

When comparing the October 2000 pre-project measurements with the post-construction measurements, all of the maximum velocities are found to be greater than the measured pre-project magnitudes. As noted previously since only one pre-project survey was taken as part of the monitoring effort it is difficult to draw a firm conclusion regarding the increase in peak flows in the area of the new channel. However, this issue warrants further investigation during the proposed future modeling efforts to determine the significance of this trend in the post-project measurements. Nevertheless, it is of interest to compare the average of all the post-project values with the October 2000 values. Specifically for the near-bottom case, the average values are –3.1 ft/s (ebb) and 2.1 ft/s (flood) versus -2.0 ft/s and 1.3 ft/s, respectively. For the near-surface case, the average values are likewise –3.8 ft/s (ebb) and 2.0 ft/s (flood), versus –3.1 ft/s (ebb) and 1.4 ft/s (flood) for the October 2000 readings.

Table 3.5 Maximum Magnitude of Mean Flows at New Channel Transect

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

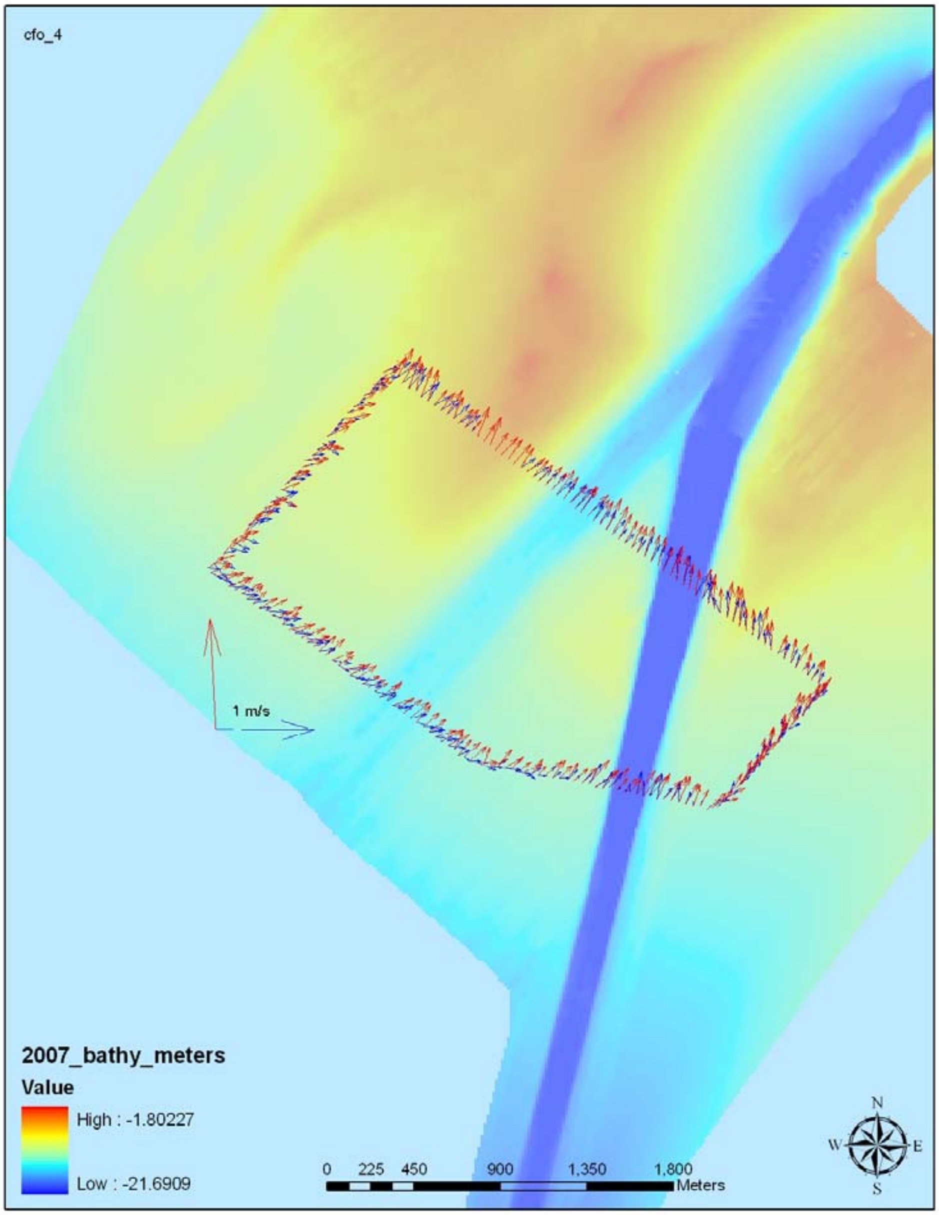


Figure 3.35 March 2007 ADCP survey at the Offshore-New Channel Transect near peak flood flow

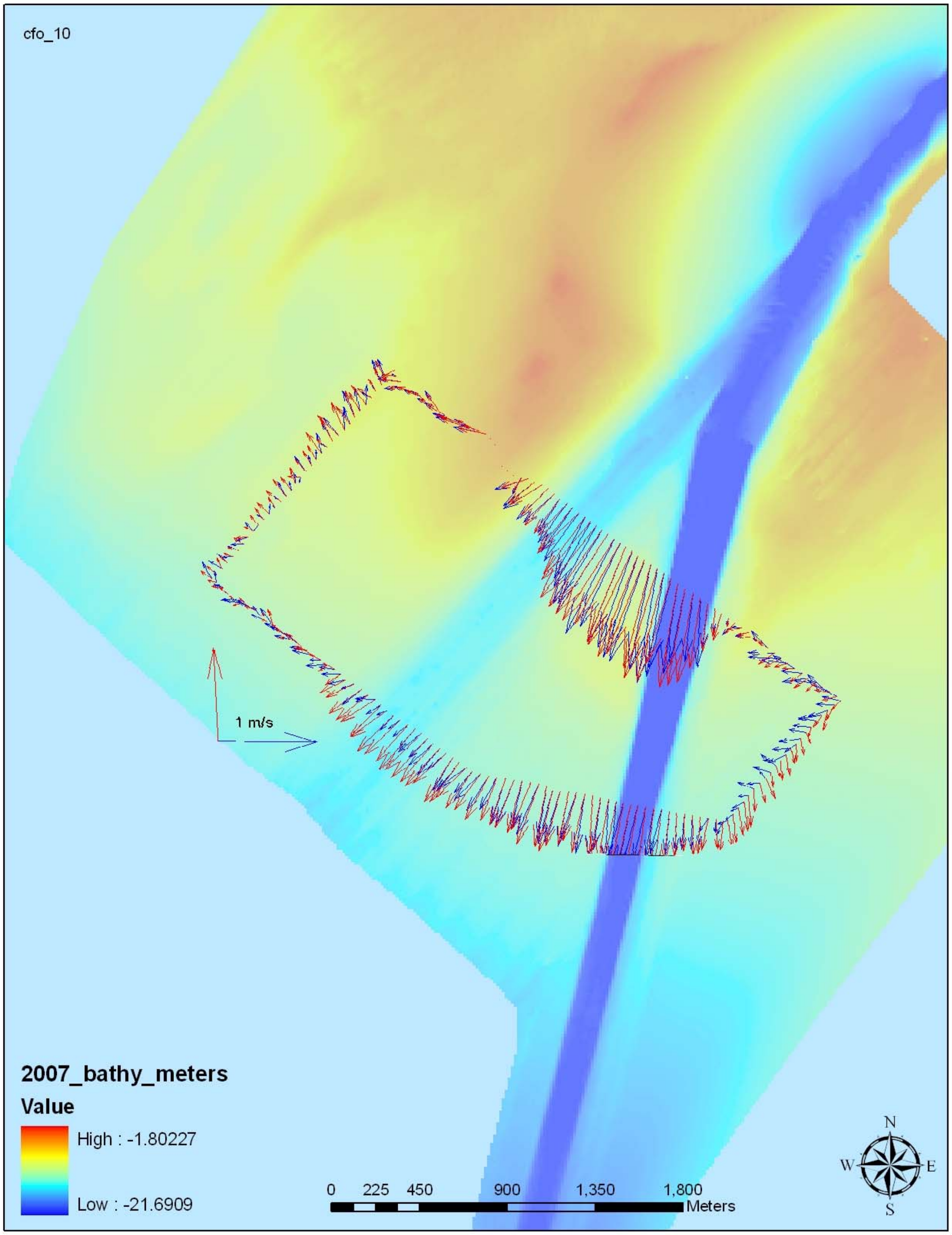


Figure 3.36 March 2007 ADCP survey at the Offshore-New Channel Transect near peak ebb flow

Wave Data Analysis

Detailed investigations of wave conditions associated with Wilmington Harbor monitoring are being conducted through the use of field data collection using three wave gauges. One gauge is located offshore and the other two are located nearshore so that the local wave climate can be assessed with respect to offshore conditions. In this section the wave data collected to date are presented through relative comparisons over time and with each other. Significant wave events are also identified for the initial 7-year monitoring period.

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

All gauges were initially deployed in September 2000. The 11-Mile gauge has operated consistently from initial deployment on 22 Sep 2000, except for a two month data gap between Dec-04 and Feb 05 and another three month gap between Feb-06 and May-06. 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, 1Sep to 25 Sep 2005, and 7 Jan to 26 Apr 2006, 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 led to sporadic data collection between 24 Dec 2005 and 10 Feb 2006. Additional data losses since the last report are noted between 10 Feb and 27 April 2006, as well as between 28 Sep 2006 and 29 March 2007.

Wave Climate. The wave data were analyzed using the Coastal Engineering Design and Analysis System (**CEDAS**), Nearshore Evolution Modeling System (NEMOS) software (NEMOS 2000). The data were updated from the last reporting through the September 2007 deployment. Tables 3.6 through 3.8 summarize the mean monthly conditions for all gauges. These tables include the mean monthly wave height, period and direction (Hsmean, Tpmean & Dpmean). The average annual wave height (Hsmean) observed for the 11-mile gauge increased for the second consecutive monitoring period from 3.1 to 3.3 feet. As seen in Table 3.6, the monthly mean wave heights recorded during the late fall and winter months (Nov-Apr) increased nearly 84%, greatly influencing the overall average, while the remainder of the year compared favorably with previous measurements of similar time periods. The influence of these increased wave heights is also evident in the number of recorded significant events during the current monitoring period discussed later in this section. Average annual wave heights for the Bald Head gauge remained at 1.9, while the Oak Island gauge recorded a reduction in average annual wave height from 1.7 to 1.6 feet. The comparison of average annual wave heights between the offshore 11 mile gauge and the nearshore Bald Head and Oak Island gauges demonstrate the significant wave transformation induced as waves travel over the shoals. In addition to determining average wave conditions, the monthly time series for all gauges were analyzed to determine the maximum wave height (Hsmax). The associated peak period (Tpmax) and wave direction (Dpmax) with each event were also computed. The 11-Mile gauge had monthly maximum wave heights on the order of 8.4 feet, with waves typically arriving from the southeast to southwest directions. Bald Head and Oak Island had monthly maximum wave heights of 6.1 and 5.2 feet, respectively. Both nearshore gauges display the filtering effect of the nearshore shoals, with the predominant number of events having wave directions confined to the south-southwest directions.

The seasonality of the wave climate is illustrated in Figure 3.38. This graph shows the mean monthly wave heights for the all the data collected to date (2000-2007) for each of the three gauges. For the 11-mile gauge the largest waves are found to occur during the late Fall through the winter months and during September reflecting the effect of the northeasters and tropical storms, respectively. For the nearshore gauges, which are sheltered from the east to northeast, the opposite pattern is evident. Both the Bald Head and Oak Island locations generally have the largest mean monthly wave heights during the summer months when the local winds turn predominately onshore. Of further interest, the wave heights measured at Oak Island are slightly lower than Bald Head for all months of the year. The seasonal shift is also seen in Figure 3.39 which is a plot of mean monthly wave direction for each gauge. The directions are given in a meteorological reference with degrees measured from north from indicating the direction from which the waves are traveling. For the nearshore gauges, the mean wave directions are from the south-southwest throughout the majority of the year shifting to the south-southeast during September and October. While the 11 mile gauge wave orientations fluctuate between winter and summer time frames, the mean monthly wave directions consistently originate from the south-southeast.

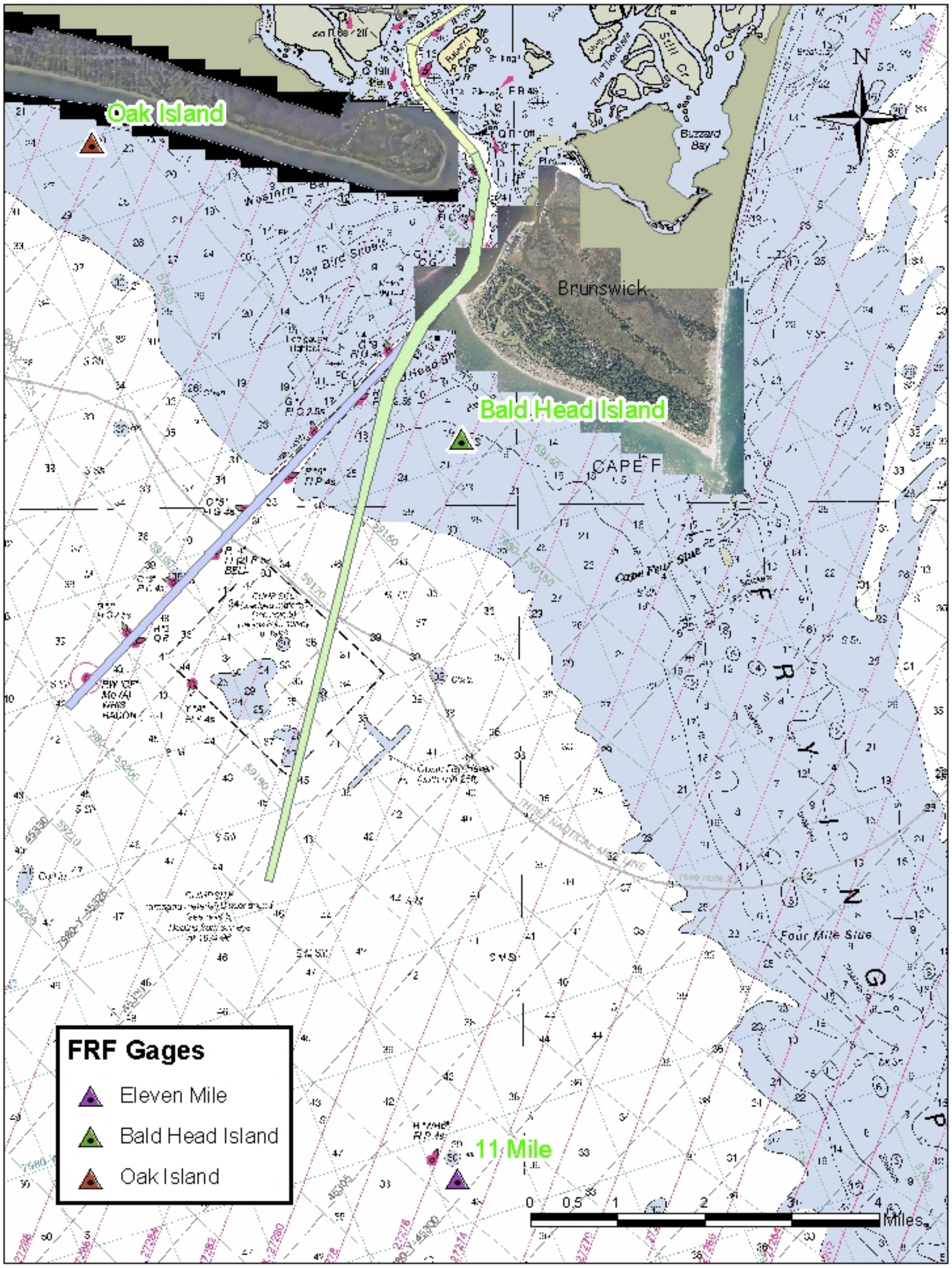


Figure 3.37 FRF Wave and Current Gauges.

Table 3.6 Eleven Mile Gauge Monthly Summaries

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	HsMax	2000	--	--	--	--	--	--	--	--	6.6	5.3	9.0	11.3	**8.1**
Eleven Mile	HsMax	2001	7.1	7.3	10.8	5.1	5.7	8.1	8.6	5.5	7.3	5.9	6.6	8.3	**7.2**
Eleven Mile	HsMax	2002	11.2	8.5	11.5	8.4	7.2	5.9	6.4	4.6	5.6	6.8	9.7	8.8	**7.9**
Eleven Mile	HsMax	2003	7.4	9.7	8.5	7.3	9.3	6.3	6.0	5.9	9.1	6.3	9.7	9.1	**7.9**
Eleven Mile	HsMax	2004	7.3	6.9	6.5	8.5	6.1	5.2	5.2	11.1	9.9	6.8	8.6	--	**7.5**
Eleven Mile	HsMax	2005	--	9.9	11.7	9.5	8.1	5.6	6.0	5.0	11.5	8.0	10.1	11.7	**8.8**
Eleven Mile	HsMax	2006	10.5	--	--	--	8.1	10.9	5.5	10.1	9.5	6.4	13.3	14.1	**9.8**
Eleven Mile	HsMax	2007	12.8	16.4	15.5	11.7	8.1	9.7	5.5	5.4	5.6				**10.1**
	AVERAGE		**9.4**	**9.8**	**10.8**	**8.4**	**7.5**	**7.4**	**6.2**	**6.8**	**8.1**	**6.5**	**9.6**	**10.6**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	DpMax	2000	--	--	--	--	--	--	--	--	213.0	89.0	166.0	253.0	**180.3**
Eleven Mile	DpMax	2001	221.0	159.0	146.0	205.0	33.0	190.0	165.0	227.0	21.0	203.0	154.0	186.0	**159.2**
Eleven Mile	DpMax	2002	182.0	188.0	164.0	212.0	203.0	154.0	217.0	72.0	182.0	153.0	187.0	190.0	**175.3**
Eleven Mile	DpMax	2003	208.0	187.0	160.0	172.0	236.0	191.0	209.0	177.0	319.0	157.0	180.0	187.0	**198.6**
Eleven Mile	DpMax	2004	236.0	144.0	168.0	174.0	231.0	199.0	214.0	198.0	197.0	205.0	184.0	--	**195.5**
Eleven Mile	DpMax	2005	--	161.0	185.0	225.0	17.0	64.0	265.0	194.0	286.0	137.0	191.0	146.0	**170.1**
Eleven Mile	DpMax	2006	172.0	--	--	--	231.0	183.0	231.0	177.0	191.0	146.0	139.0	221.0	**187.9**
Eleven Mile	DpMax	2007	198.0	206.0	194.0	205.0	157.0	160.0	192.0	205.0	213.0				**192.2**
	AVERAGE		**202.8**	**174.2**	**169.5**	**198.8**	**158.3**	**163.0**	**213.3**	**178.6**	**202.8**	**155.7**	**171.6**	**197.2**	

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

(Continued)

Table 3.6 Eleven Mile Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	TpMax	2000	--	--	--	--	--	--	--	--	12.8	**	14.2	**	**13.5**
Eleven Mile	TpMax	2001	**	10.6	16.0	25.6	14.2	**	10.6	11.6	**	18.2	14.2	**	**15.1**
Eleven Mile	TpMax	2002	16.0	16.0	**	10.6	**	11.6	9.8	18.2	12.8	21.3	18.2	18.2	**15.3**
Eleven Mile	TpMax	2003	12.8	14.2	16.0	14.2	14.2	9.1	9.1	16.0	16.0	14.2	14.2	16.0	**13.8**
Eleven Mile	TpMax	2004	11.6	14.2	14.2	12.8	11.6	25.6	9.8	25.6	16.0	25.6	25.6	--	**17.5**
Eleven Mile	TpMax	2005	--	10.6	16.0	16.0	14.2	12.8	10.6	25.6	12.8	14.2	16.0	12.8	**14.7**
Eleven Mile	TpMax	2006	14.2	--	--	--	14.2	12.8	9.8	12.8	25.6	12.8	10.6	10.6	**13.7**
Eleven Mile	TpMax	2007	9.8	10.6	11.6	12.8	25.6	25.6	14.2	16.0	12.8				**15.4**
	AVERAGE		**12.9**	**12.7**	**14.8**	**15.3**	**15.7**	**16.3**	**10.6**	**18.0**	**15.5**	**17.7**	**16.1**	**14.4**	

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

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	Dpmean	2000	--	--	--	--	--	--	--	--	143.3	137.8	169.7	147.7	**149.6**
Eleven Mile	Dpmean	2001	173	149.7	160.9	171.4	168.9	172.5	155.9	166.8	126.8	150.3	142.7	154	**157.7**
Eleven Mile	Dpmean	2002	167.2	160.2	145.4	145.8	158.4	147.1	182	117.7	127.5	120.5	157.2	157.3	**148.9**
Eleven Mile	Dpmean	2003	183.8	156	148.2	165.2	160.5	168.4	178.3	164.5	143.5	140.1	160.6	166.6	**161.3**
Eleven Mile	Dpmean	2004	168	142.5	157.7	171.1	175.2	177.2	173.9	152.7	151.6	143.4	140		**159.4**
Eleven Mile	Dpmean	2005	--	123.6	171.2	170.5	158.2	147.5	173.3	147.3	141.7	141.4	148.2	158.7	**152.9**
Eleven Mile	Dpmean	2006	179.6	--	--	--	178.4	170.5	181.2	160.3	149	145.8	145.1	148.7	**162.1**
Eleven Mile	Dpmean	2007	165.0	152.8	148.1	171.2	145.7	162.3	157.0	157.8	135.4				**155.0**
	AVERAGE		**172.8**	**147.5**	**155.3**	**165.9**	**163.6**	**163.6**	**171.7**	**152.4**	**139.9**	**139.9**	**151.9**	**155.5**	

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

Table 3.7 Bald Head Gauge Monthly Summaries

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

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	DpMax	2000	--	--	--	--	--	--	--	--	192.0	203.0	173.0	198.0	**191.5**
Bald Head	DpMax	2001	206.0	195.0	192.0	222.0	159.0	201.0	195.0	195.0	149.0	201.0	209.0	205.0	**194.1**
Bald Head	DpMax	2002	202.0	179.0	183.0	183.0	189.0	211.0	208.0	204.0	212.0	188.0	194.0	202.0	**196.3**
Bald Head	DpMax	2003	203.0	203.0	169.0	201.0	217.0	200.0	189.0	165.0	250.0	186.0	194.0	200.0	**198.1**
Bald Head	DpMax	2004	195.0	175.0	195.0	203.0	205.0	205.0	202.0	189.0	176.0	197.0	198.0	189.0	**194.1**
Bald Head	DpMax	2005	193.0	203.0	212.0	192.0	235.0	190.0	235.0	214.0	--	149.0	200.0	172.0	**199.5**
Bald Head	DpMax	2006	--	--	--	--	209.0	209.0	191.0	192.0	224.0	177.0	199.0	198.0	**199.9**
Bald Head	DpMax	2007	190.0	202.0	194.0	--	--	--	--	--	--	--	--	--	**195.3**
	AVERAGE		**198.2**	**192.8**	**190.8**	**200.2**	**202.3**	**202.7**	**203.3**	**193.2**	**200.5**	**185.9**	**195.3**	**194.9**	

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

(Continued)

Table 3.7 Bald Head Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	**	14.2	**14.2**
Bald Head	TpMax	2001	**	25.6	18.2	16.0	16.0	25.6	**	10.6	**	**	**		**18.7**
Bald Head	TpMax	2002	**	**	25.6	**	**	**	**	21.3	14.2	18.2	18.2	16.0	**18.9**
Bald Head	TpMax	2003	16.0	16.0	16.0	14.5	16.0	16.0	9.1	16.0	16.0	14.2	12.8	16.0	**14.9**
Bald Head	TpMax	2004	11.6	14.2	14.2	12.8	10.6	10.6	9.8	14.2	18.2	--	--	--	**12.9**
Bald Head	TpMax	2005	12.8	16.0	16.0	16.0	16.0	16.0	14.2	14.2	--	16	12.8	12.8	**14.8**
Bald Head	TpMax	2006	--	--	--	--	16.0	10.6	9.8	14.2	14.2	21.2	14.2	10.6	**13.9**
Bald Head	TpMax	2007	14.2	25.6	10.6	--	--	--	--	--	--	--	--	--	**16.8**
	AVERAGE		**13.7**	**19.5**	**16.8**	**14.8**	**14.9**	**15.8**	**10.7**	**15.1**	**15.7**	**17.4**	**14.5**	**13.9**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	TpMean	2000	--	--	--	--	--	--	--	--	7.6	9.0	7.5	7.4	**7.9**
Bald Head	TpMean	2001	7.2	6.8	7.5	6.1	6.7	6.0	6.2	6.0	11.4	7.5	7.9	7.5	**7.2**
Bald Head	TpMean	2002	7.6	7.5	7.6	6.3	6.3	6.1	5.6	6.2	7.4	8.2	7.7	7.2	**7.0**
Bald Head	TpMean	2003	7.1	7.9	7.3	7.5	6.4	6.8	5.3	5.9	9.1	8.1	7.5	7.9	**7.2**
Bald Head	TpMean	2004	6.9	7.8	7.7	6.4	6.2	5.3	5.7	6.6	9.3	8.5	7.8	7.7	**7.2**
Bald Head	TpMean	2005	7.7	8.5	6.9	7.1	6.7	6.2	5.1	6.3	--	7.7	7.4	7.1	**7.0**
Bald Head	TpMean	2006	--	--	--	--	6.6	6.3	6.0	6.3	8.4	7.2	7.6	7.8	**7.0**
Bald Head	TpMean	2007	7.0	7.0	7.3	--	--	--	--	--	--	--	--	--	**7.1**
	AVERAGE		**7.3**	**7.6**	**7.4**	**6.7**	**6.5**	**6.1**	**5.7**	**6.2**	**8.9**	**8.0**	**7.6**	**7.5**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
Bald Head	Dpmean	2000	--	--	--	--	--	--	--	--	171	165.5	184.9	185	**176.6**
Bald Head	Dpmean	2001	191.4	185	189.4	185.8	186.1	186.1	188.3	199.1	152	179.5	177.6	187.1	**184.0**
Bald Head	Dpmean	2002	189.5	187.3	181.4	183.9	185.9	180.6	193.6	180.4	177.7	172.2	184.0	184.2	**183.4**
Bald Head	Dpmean	2003	198.3	183.7	179.3	186.3	186.5	189.1	193.4	189.1	174.9	175.5	184.2	187.0	**185.6**
Bald Head	Dpmean	2004	187.7	177.3	182.5	188.6	194.6	193.1	193.3	182.7	185.6	179.6	179.2	188.4	**186.1**
Bald Head	Dpmean	2005	185.1	182.0	190.0	191.6	187.6	179.9	196.0	183.5	--	--	--	186.1	**186.9**
Bald Head	Dpmean	2006	--	--	--	--	186.6	188.5	194.6	185	177.7	183.6	178.7	184.0	**184.8**
Bald Head	Dpmean	2007	191.3	188.5	184.3	--	--	--	--	--	--	--	--	--	**186.4**
	AVERAGE		**190.4**	**184.0**	**184.5**	**187.2**	**187.9**	**186.2**	**193.2**	**186.6**	**173.2**	**176.0**	**181.4**	**186.0**	

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

Table 3.8 Oak Island Gauge Monthly Summaries

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

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	DpMax	2000	--	--	--	--	--	--	--	--	206.0	239.0	--	--	**222.5**
Oak Island	DpMax	2001	--	--	--	--	--	192.0	236.0	--	172.0	190.0	181.0	197.0	**194.7**
Oak Island	DpMax	2002	185.0	191.0	182.0	201.0	202.0	193.0	234.0	202.0	177.0	185.0	183.0	193.0	**194.0**
Oak Island	DpMax	2003	214.0	191.0	185.0	185.0	209.0	203.0	209.0	196.0	238.0	210.0	201.0	203.0	**203.7**
Oak Island	DpMax	2004	210.0	224.0	184.0	197.0	175.0	180.0	200.0	172.0	186.0	219.0	189.0	198.0	**194.5**
Oak Island	DpMax	2005	179.0	192.0	190.0	--	--	--	--	--	184.0	171.0	209.0	184.0	**187.0**
Oak Island	DpMax	2006	195.0	--	--	--	206.0	195.0	175.0	183.0	247.0	--	--	--	**200.2**
Oak Island	DpMax	2007	--	--	--	200.0	183.0	188.0	202.0	226.0	208.0	--	--	--	**201.2**
	AVERAGE		**196.6**	**199.5**	**185.3**	**195.8**	**195.0**	**191.8**	**209.3**	**195.8**	**202.3**	**202.3**	**192.6**	**195.0**	

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

(Continued)

Table 3.8 Oak Island Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	--	--	**16.0**
Oak Island	TpMax	2001	--	--	--	--	--	**	5.1	--	**	**	**	**	**5.1**
Oak Island	TpMax	2002	**	**	**	**	**	**	9.1	21.3	21.3	21.3	21.3	16.0	**18.4**
Oak Island	TpMax	2003	16.0	16.0	16.0	16.0	16.0	9.8	9.1	16.0	16.0	14.2	14.2	16.0	**14.6**
Oak Island	TpMax	2004	11.6	14.2	16.0	12.8	25.6	9.1	9.1	25.6	16.0	16.0	25.6	25.6	**17.3**
Oak Island	TpMax	2005	25.6	11.6	16.0	--	--	--	--	--	25.6	16.0	25.6	21.3	**20.2**
Oak Island	TpMax	2006	11.6	--	--	--	25.6	25.6	9.8	21.3	25.6	--	--	--	**19.9**
Oak Island	TpMax	2007	--	--	--	25.6	16.0	25.6	14.2	25.6	25.6	--	--	--	**22.1**
	AVERAGE		**16.2**	**13.9**	**16.0**	**18.1**	**20.8**	**17.5**	**9.4**	**22.0**	**20.9**	**16.9**	**21.7**	**19.7**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	TpMean	2000	--	--	--	--	--	--	--	--	6.1	9.9	--	--	**8.0**
Oak Island	TpMean	2001	--	--	--	--	--	6.4	4.3	--	13.2	8.2	8.6	7.9	**8.1**
Oak Island	TpMean	2002	7.3	8.1	9.2	8.4	11.4	10.1	5.6	5.9	7.6	8.0	8.1	7.2	**8.1**
Oak Island	TpMean	2003	7.2	7.3	7.2	7.3	6.6	5.5	5.1	5.6	8.7	7.6	7.3	7.8	**6.9**
Oak Island	TpMean	2004	6.7	7.8	7.5	6.2	6.0	5.1	5.4	6.5	9.2	8.6	7.4	7.6	**7.0**
Oak Island	TpMean	2005	7.5	7.9	6.8	--	--	--	--	--	7.7	7.7	7.4	7.4	**7.5**
Oak Island	TpMean	2006	6.4	--	--	--	6.0	6.4	5.8	6.1	8.4	--	--	--	**6.5**
Oak Island	TpMean	2007	--	--	--	6.7	7.2	6.1	6.1	6.5	7.0	--	--	--	**6.6**
	AVERAGE		**7.0**	**7.8**	**7.7**	**7.2**	**7.4**	**6.6**	**5.4**	**6.1**	**8.5**	**8.3**	**7.8**	**7.6**	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
Oak Island	DpMean	2000	--	--	--	--	--	--	--	--	202.2	181.1	--	--	**191.7**
Oak Island	DpMean	2001	--	--	--	--	--	188.2	217.5	--	163.9	183.9	178.8	183.8	**186.0**
Oak Island	DpMean	2002	189.5	187.4	183	187.8	188.2	186.2	201.2	157.6	150.5	144.9	176	192.6	**178.7**
Oak Island	DpMean	2003	198.6	191.7	187.6	190.3	193.2	197.4	197.9	194.6	182.2	179.5	186.4	188.1	**190.6**
Oak Island	DpMean	2004	193.8	184.1	190.6	196.6	199.4	196.9	195.3	189.7	185.9	182.5	184.4	189.9	**190.8**
Oak Island	DpMean	2005	189.2	179.8	195.2	--	--	--	--	--	187.2	182.2	185.8	186.2	**186.5**
Oak Island	DpMean	2006	203.8	--	--	--	194.6	192.9	197.2	192	185.5	--	--	--	**194.3**
Oak Island	DpMean	2007	--	--	--	194.1	187.5	193.8	190.5	196.2	184.3	--	--	--	**191.1**
	AVERAGE		**195.0**	**185.8**	**189.1**	**192.2**	**192.6**	**192.6**	**199.9**	**186.0**	**180.2**	**175.7**	**182.3**	**188.1**	

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

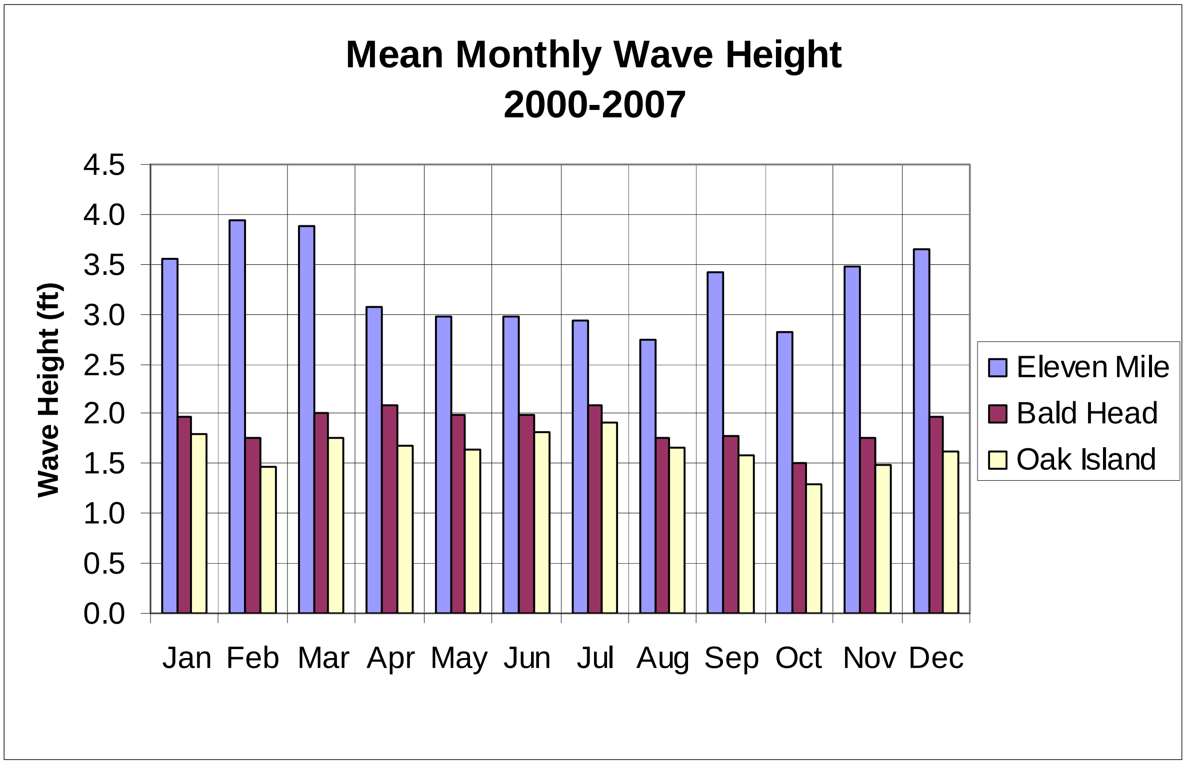


Figure 3.38 Mean Monthly Wave Height 2000-2007 for the Eleven Mile, Bald Head and Oak Island Gauges

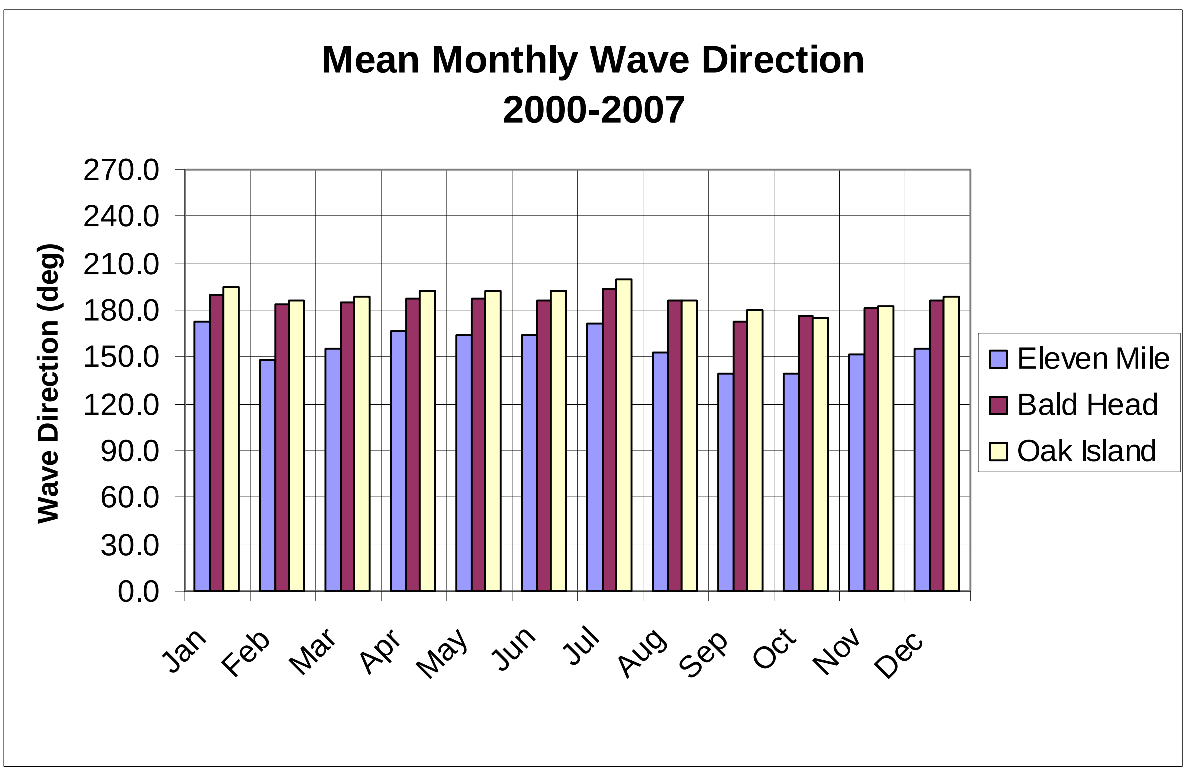


Figure 3.39 Mean Monthly Wave Direction 2000-2007 for the Eleven Mile, Bald Head and Oak Island Gauges

Further insights on the wave climate variability and the impacts of Frying Pan Shoals are shown on Figures 3.40 and 3.41. Figure 3.40 shows wave histograms that were created using all available data from each gauge for the September 2000 to September 2007 time period. Figure 3.41 shows wave roses that were generated for available data revealing the characteristic differences in wave climate for the three locations. Dominant wave directions at 11-Mile Gauge are from southeast and south southeast. At Bald Head Island gauge, dominant directions are shifted to south-southeast through the south-southwest. Oak Island directions are further confined to primarily south and south-southwest. These direction shifts between offshore and nearshore locations are consistent with expected effects of wave refraction.

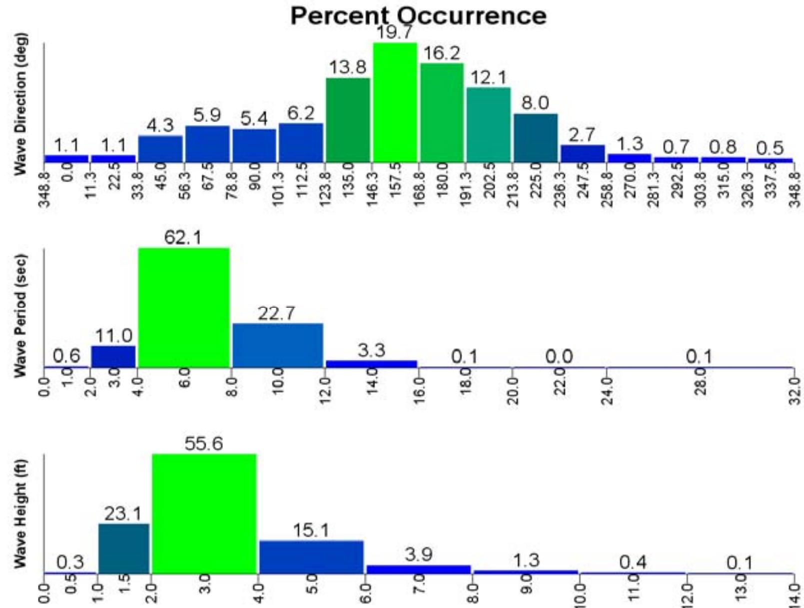
The 11-Mile Gauge wave rose shows a small, but significant component of the wave climate coming from easterly directions. These waves have passed across Frying Pan Shoals to reach the gauge. Frying Pan Shoals filters, but does not eliminate, wave energy reaching the 11-Mile Gauge site from these directions.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

Time series for each gauge were separated into yearly components and analyzed to assess the statistical variation in wave climate. Annual wave height roses for all three gauges for the years 2000 through 2007 were generated and are given in Appendix A. The year to year comparison of the roses shows very similar patterns in the distribution of wave height and direction. One interesting observation is that years that appear to have the offshore gauge dominated by the southeast waves have a nearshore wave distribution with waves dominated from the southwest.

Figures 3.42 and 3.43 give the yearly mean wave height and direction for each of the three gauges. In terms of mean wave height, only minor variation is evident over the initial six years (2000-2005) of the monitoring program, while the last two years have seen a significant increase at the offshore gauge. For the 11-mile gauge, the yearly mean wave height for the first six years of the monitoring program averaged 3.1 feet while the average for the last two years (2006 and 2007) has increased to 3.9 feet, nearly a 27% increase. The nearshore gauges however, have not seen similar increases over the previous two years. The wave transformation occurring between the offshore and nearshore gauges maintain a relatively stable yearly mean wave height averaging 1.9 feet at the Bald Head gauge and 1.6 feet at the Oak Island gauge. With regard to the yearly variation in terms of mean wave direction, Figure 3.43 shows that while there is some fluctuation from year to year the general wave direction is relatively consistent for each gauge with no pattern of directional change observed. The Eleven Mile and Oak Island gauges have the highest yearly fluctuation with standard deviations of 5.1 degrees and 4.9 degrees, respectively.

Significant Events. Several large storm events occurred during the monitoring period that may have significantly altered adjacent beach shorelines and beach profiles. An analysis was conducted to identify storm event parameters that exceeded a 6-ft significant wave height threshold with a minimum duration of 12-hrs. Events were selected through screening of the 11-Mile Gauge time series and were considered to be continuous events until significant wave height fell below 6 feet for more than one three hour recording. Parameters for the Bald Head and Oak Island gauges that correlate to the 11-Mile gauge peaks are reported as well. Thirty-two additional events were added since report four, with Table 3.9 summarizing the 84 events that exceeded the set criteria over the entire monitoring period. The majority of the events, 64%, occurred in the winter (December through March). For the current monitoring period, waves typically originated from the south-southeast, with offshore wave heights of 7.3 to 16.4-ft and wave periods of 2.9 to 16 seconds. These parameters differ from those reported previously in report four, where waves typically originated from the south-southwest. This most recent collection of significant events, as well as the overall average of significant events, correlates well to the overall wave gauge summary where the major angle of wave approach is from the south-southeast. Corresponding conditions at the nearshore gauges indicate significant reduction in wave height, with Bald Head and Oak Island being reduced by 47.8 and 46.7 percent, respectively. The largest significant wave recorded to date at the 11-mile gauge was 16.4 feet in February 2007. At this peak time the wave height recorded at the Bald Head gauge was 5.6 feet. Unfortunately, the Oak Island gauge was out of service at this time and no corresponding wave height is available. The largest wave measured at the Bald Head site was 9.0 feet during January 2002. On 14-August 2004, during Hurricane Charlie, a wave height of 9.9 feet was measured at Oak Island, the largest recorded so far at this gauge.

Eleven-Mile Gauge (Sep 2000 – Sep 2007)



Bald Head Gauge (Sep 2000 – March 2007)

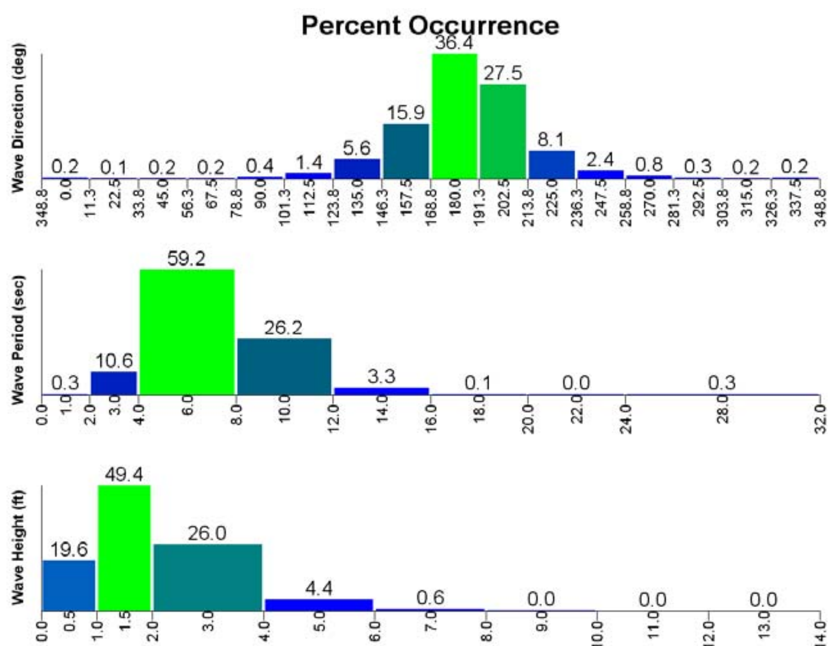


Figure 3.40 Wave Histograms for FRF Gauges throughout deployment.

(Continued)

Oak Island Gauge (Sep 2000 –Sep 2007)

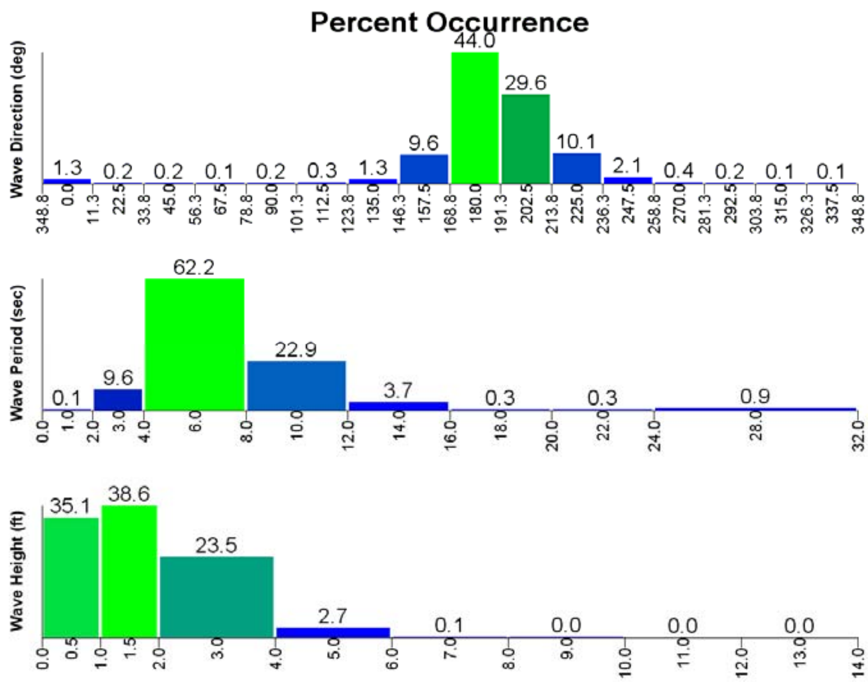
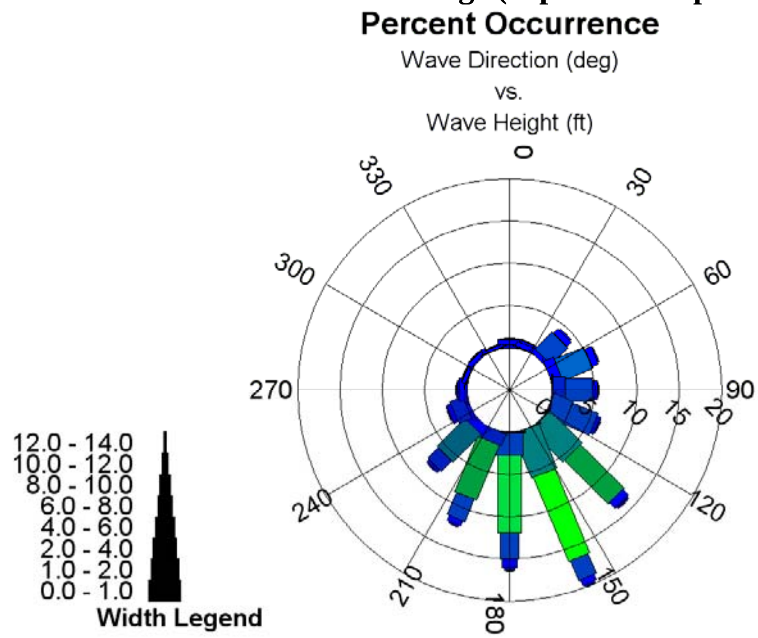


Figure 3.40 Wave Histograms for FRF Gauges throughout deployment. (Continued)

Eleven-Mile Gauge (Sep 2000 – Sep 2007)



Bald Head Gauge (Sep 2000 – March 2007)

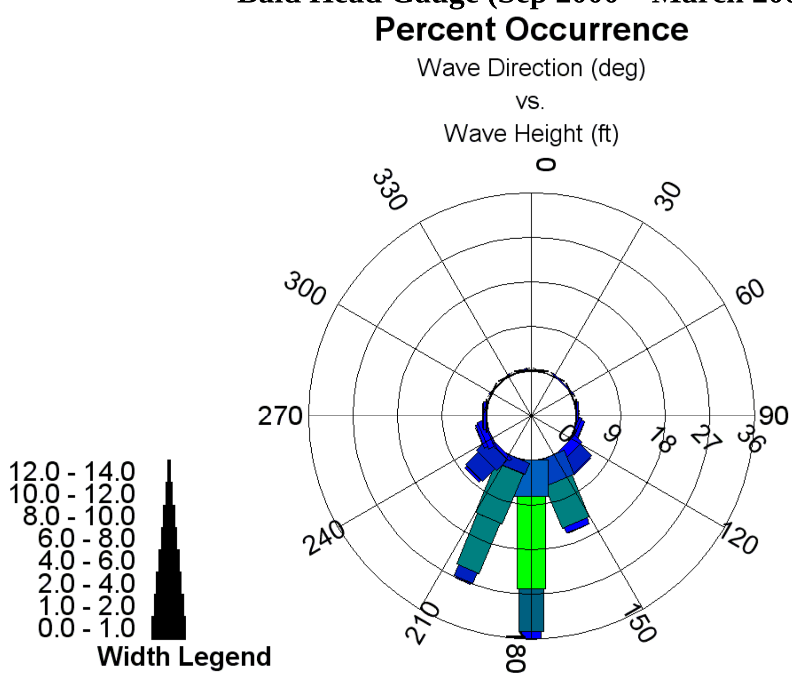


Figure 3.41 Wave Height Roses for FRF Gauges throughout deployment.
(Continued)

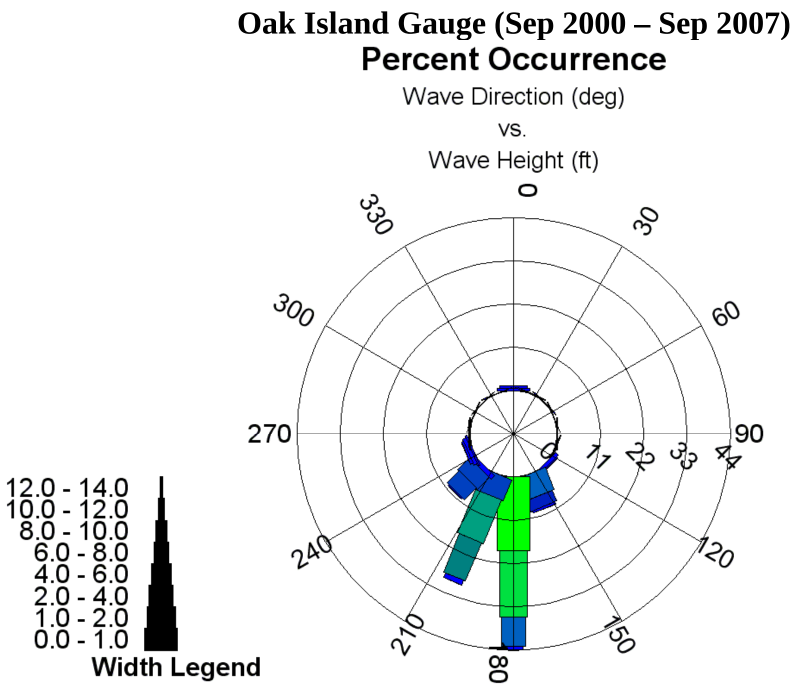


Figure 3.41 Wave Height Roses for FRF Gauges throughout deployment. (Continued)

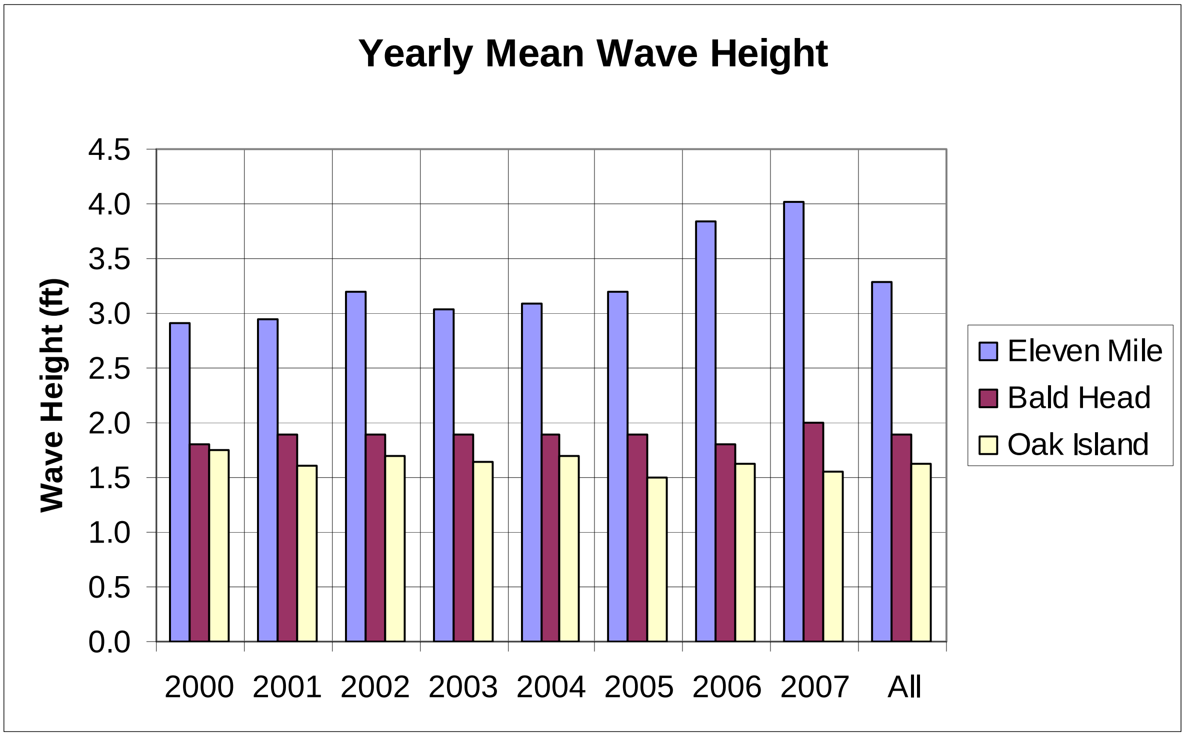


Figure 3.42 Yearly Mean Wave Height for Years 2000 through 2007

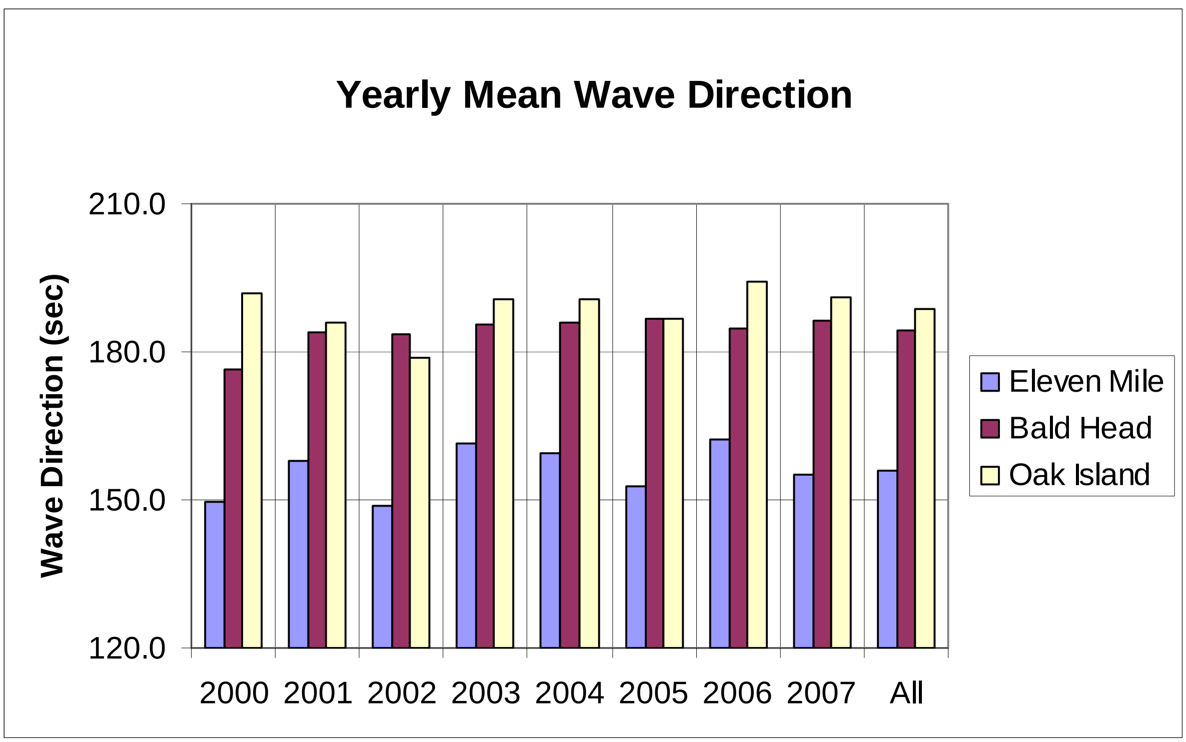


Figure 3.43 Yearly Mean Wave Direction for Years 2000 through 2007

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

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

29	29-Aug-04	1:00	30-Aug-04	4:00	25.00	8.6	7.1	169	29-Aug-04	19:00	6.3	6.7	222	6.1	6.7	210
30	8-Sep-04	1:00	9-Sep-04	4:00	25.00	7.3	6.7	189	9-Sep-04	4:00	5.2	7.5	202	4.8	7.1	191
31	17-Sep-04	13:00	18-Sep-04	7:00	18.00	9.9	7.1	197	17-Sep-04	19:00	7	7.5	194	6.5	6.7	201
32	25-Sep-04	7:00	28-Sep-04	19:00	84.00	9.2	7.5	189	28-Sep-04	16:00	7.7	7.5	176	5.9	7.5	187
33	15-Oct-04	13:00	16-Oct-04	22:00	33.00	6.8	7.5	205	15-Oct-04	19:00	5.7	8	197	4.8	7.5	203
34	24-Nov-04	22:00	25-Nov-04	19:00	21.00	8.6	9.1	184	25-Nov-04	13:00	6	9.8	193	4.7	5.3	227
35	27-Feb-05	19:00	1-Mar-05	22:00	46.00	9.9	10.6	161	28-Feb-05	4:00	3.9	10.6	195	3	11.6	175
36	8-Mar-05	4:00	8-Mar-05	19:00	15.00	11.7	8.5	185	8-Mar-05	7:00	8.5	9.1	212	7.1	8.5	196
37	11-Mar-05	16:00	14-Mar-05	1:00	57.00	9.4	7.5	217	12-Mar-05	16:00	6.2	7.5	207	5.1	7.5	207
38	22-Mar-05	22:00	23-Mar-05	19:00	21.00	7.5	8	150	23-Mar-05	13:00	5.7	8	187	4	7.5	191
39	27-Mar-05	16:00	29-Mar-05	4:00	36.00	8.8	7.1	193	28-Mar-05	22:00	6.9	8	200	5.3	8	195
40	2-Apr-05	4:00	3-Apr-05	10:00	30.00	9.5	7.1	225	2-Apr-05	19:00	7.5	8	192	5.1	8.5	204
41	8-Apr-05	1:00	8-Apr-05	13:00	12.00	6.5	7.5	189	8-Apr-05	1:00	3.7	7.5	191	2.4	8.5	195
42	5-May-05	16:00	6-May-05	7:00	15.00	8.1	4.9	17	6-May-05	1:00	2.6	9.1	187	--	--	--
43	11-Sep-05	10:00	14-Sep-05	19:00	81.00	11.5	7.5	286	14-Sep-05	13:00	--	--	--	3.9	5.5	248
44	6-Oct-05	4:00	8-Oct-05	10:00	54.00	7.8	8.5	162	8-Oct-05	1:00	5.1	8.5	198	3.4	8.5	185
45	21-Nov-05	7:00	22-Nov-05	10:00	27.00	10.1	8	191	22-Nov-05	4:00	7.3	7.1	213	5.6	7.5	206
46	23-Nov-05	22:00	24-Nov-05	19:00	21.00	10	6.7	250	24-Nov-05	1:00	8.5	7.1	200	5.8	7.1	209
47	29-Nov-05	4:00	29-Nov-05	19:00	15.00	6.9	7.1	159	29-Nov-05	19:00	5	8	168	3.2	8	163
48	15-Dec-05	13:00	16-Dec-05	4:00	15.00	7.4	7.5	118	15-Dec-05	19:00	5.1	7.1	192	3.4	7.1	190
49	25-Dec-05	16:00	26-Dec-05	10:00	18.00	7.2	8	186	25-Dec-05	19:00	5.8	9.1	187	--	--	--
50	14-Jan-06	4:00	14-Jan-06	22:00	15.00	6.9	6.7	183	14-Jan-06	4:00	--	--	--	3.3	6	197
51	17-Jan-06	19:00	18-Jan-06	16:00	12.00	10.5	8.5	172	18-Jan-06	4:00	--	--	--	--	--	--
52	31-Aug-06	16:00	1-Sep-06	4:00	12.00	10.1	10.6	177	31-Aug-06	19:00	6.2	8	192	4.1	10.6	197
53*	6-Nov-06	13:00	9-Nov-06	4:00	63.00	10.6	8	175	7-Nov-06	13:00	4.5	8	182	--	--	--
54	20-Nov-06	13:00	24-Nov-06	7:00	90.00	13.3	4.5	139	21-Nov-06	10:00	2.1	10.6	188	--	--	--
55	24-Nov-06	22:00	27-Nov-06	10:00	60.00	9.5	4.9	82	25-Nov-06	7:00	1.4	5.8	150	--	--	--
56*	28-Nov-06	16:00	2-Dec-06	4:00	108.00	12.8	8.5	225	1-Dec-06	19:00	6	8.5	198	--	--	--

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

57	2-Dec-06	22:00	4-Dec-06	22:00	48.00	9.7	3.2	65	3-Dec-06	16:00	1.9	7.1	134	--	--	--
58	6-Dec-06	19:00	7-Dec-06	7:00	12.00	7.3	4	143	6-Dec-06	22:00	2.2	4.7	149	--	--	--
59	12-Dec-06	16:00	14-Dec-06	10:00	42.00	8.1	5.3	42	13-Dec-06	13:00	2.3	9.1	190	--	--	--
60	20-Dec-06	4:00	21-Dec-06	1:00	21.00	9.2	3.4	146	20-Dec-06	4:00	1.5	6.4	170	--	--	--
61*	22-Dec-06	4:00	24-Dec-06	4:00	48.00	13.3	7.5	215	23-Dec-06	4:00	5.3	8	190	--	--	--
62	25-Dec-06	1:00	27-Dec-06	10:00	57.00	14.1	7.5	221	25-Dec-06	13:00	5.8	7.1	191	--	--	--
63*	31-Dec-06	10:00	2-Jan-07	4:00	42.00	9.1	5.8	146	31-Dec-06	19:00	2.6	6	194	--	--	--
64	4-Jan-07	13:00	5-Jan-07	4:00	15.00	8.4	4.2	46	4-Jan-07	13:00	1.9	4.9	178	--	--	--
65*	5-Jan-07	13:00	7-Jan-07	7:00	42.00	9.2	7.5	161	6-Jan-07	1:00	3.5	6.7	190	--	--	--
66	8-Jan-07	1:00	8-Jan-07	13:00	12.00	11.5	7.1	214	8-Jan-07	10:00	5.7	7.1	194	--	--	--
67*	9-Jan-07	16:00	10-Jan-07	16:00	24.00	11.2	5.5	198	9-Jan-07	22:00	3.9	6.4	218	--	--	--
68	16-Jan-07	1:00	16-Jan-07	16:00	15.00	8.6	3.5	18	16-Jan-07	10:00	2.5	4.9	178	--	--	--
69*	17-Jan-07	7:00	19-Jan-07	13:00	54.00	10.3	2.9	261	17-Jan-07	16:00	1.5	8	137	--	--	--
70	20-Jan-07	7:00	20-Jan-07	19:00	12.00	8.1	3	282	20-Jan-07	13:00	0.9	9.8	169	--	--	--
71*	21-Jan-07	13:00	23-Jan-07	10:00	45.00	12.8	6.7	198	22-Jan-07	1:00	5.2	6.7	194	--	--	--
72	27-Jan-07	10:00	28-Jan-07	4:00	18.00	11.5	5.3	157	27-Jan-07	22:00	4	5.3	202	--	--	--
73*	1-Feb-07	16:00	8-Feb-07	13:00	167.00	15.1	6	181	7-Feb-07	13:00	4.2	6.4	203	--	--	--
74*	12-Feb-07	19:00	15-Feb-07	16:00	69.00	7.8	4.9	234	13-Feb-07	7:00	1.7	5.1	178	--	--	--
75	20-Feb-07	22:00	22-Feb-07	22:00	48.00	14.4	2.9	294	20-Feb-07	22:00	4.2	5.5	194	--	--	--
76*	26-Feb-07	1:00	27-Feb-07	13:00	36.00	16.4	8.5	206	26-Feb-07	1:00	5.6	8.5	202	--	--	--
77*	28-Feb-07	16:00	11-Mar-07	4:00	252.00	15.5	7.1	194	1-Mar-07	19:00	4.8	6.4	174	--	--	--
78	11-Mar-07	22:00	12-Mar-07	13:00	15.00	7.9	2.9	31	12-Mar-07	10:00	1.3	7.5	146	--	--	--
79*	15-Mar-07	13:00	18-Mar-07	16:00	75.00	10.9	8.5	222	16-Mar-07	19:00	4.2	8.5	195	--	--	--
80	21-Mar-07	16:00	23-Mar-07	16:00	48.00	9.6	6	50	22-Mar-07	7:00	2.3	6	178	--	--	--
81	24-Mar-07	22:00	26-Mar-07	22:00	48.00	8.7	3.8	142	25-Mar-07	22:00	1.7	6.4	162	--	--	--
82	15-Apr-07	1:00	16-Apr-07	16:00	39.00	11.7	9.1	205	15-Apr-07	22:00	--	--	--	5.3	9.8	212
83	7-May-07	13:00	8-May-07	10:00	21.00	8.1	16	157	7-May-07	22:00	--	--	--	2.2	14.2	172
84	2-Jun-07	16:00	3-Jun-07	22:00	24.00	9.7	9.1	160	3-Jun-07	4:00	--	--	--	3.5	9.1	182

* Denotes significant events where data gaps exist within the event. Significant wave height is assumed to maintain a minimum of 6' within these gaps.

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

28	13-Aug-04	4:00	14-Aug-04	16:00	36.00	11.1	11.6	198	14-Aug-06	1:00	2.5	7.1	198.0	2.6	6.7	228
29	29-Aug-04	1:00	30-Aug-04	4:00	25.00	8.6	7.1	169	29-Aug-04	19:00	6.3	6.7	222	6.1	6.7	210
30	8-Sep-04	1:00	9-Sep-04	4:00	25.00	7.3	6.7	189	9-Sep-04	4:00	5.2	7.5	202	4.8	7.1	191
31	17-Sep-04	13:00	18-Sep-04	7:00	18.00	9.9	7.1	197	17-Sep-04	19:00	1.7	8.5	238	6.5	6.7	201
32	25-Sep-04	7:00	28-Sep-04	19:00	84.00	9.2	7.5	189	28-Sep-04	16:00	7.7	7.5	176	5.9	7.5	187
33	15-Oct-04	13:00	16-Oct-04	22:00	33.00	6.8	7.5	205	15-Oct-04	19:00	5.7	8	197	4.8	7.5	203
34	24-Nov-04	22:00	25-Nov-04	19:00	21.00	8.6	9.1	184	25-Nov-04	13:00	6	9.8	193	4.7	5.3	227
35	27-Feb-05	19:00	1-Mar-05	22:00	46.00	9.9	10.6	161	28-Feb-05	4:00	3.9	10.6	195	3	11.6	175
36	8-Mar-05	4:00	8-Mar-05	19:00	15.00	11.7	8.5	185	8-Mar-05	7:00	8.5	9.1	212	7.1	8.5	196
37	11-Mar-05	16:00	14-Mar-05	1:00	57.00	9.4	7.5	217	12-Mar-05	16:00	6.2	7.5	207	5.1	7.5	207
38	22-Mar-05	22:00	23-Mar-05	19:00	21.00	7.5	8	150	23-Mar-05	13:00	5.7	8	187	4	7.5	191
39	27-Mar-05	16:00	29-Mar-05	4:00	36.00	8.8	7.1	193	28-Mar-05	22:00	6.9	8	200	5.3	8	195
40	2-Apr-05	4:00	3-Apr-05	10:00	30.00	9.5	7.1	225	2-Apr-05	19:00	7.5	8	192	5.1	8.5	204
41	8-Apr-05	1:00	8-Apr-05	13:00	12.00	6.5	7.5	189	8-Apr-05	1:00	3.7	7.5	191	2.4	8.5	195
42	5-May-05	16:00	6-May-05	7:00	15.00	8.1	4.9	17	6-May-05	1:00	2.6	9.1	187	--	--	--
43	11-Sep-05	10:00	14-Sep-05	19:00	81.00	11.5	7.5	286	14-Sep-05	13:00	--	--	--	3.9	5.5	248
44	6-Oct-05	4:00	8-Oct-05	10:00	54.00	7.8	8.5	162	8-Oct-05	1:00	5.1	8.5	198	3.4	8.5	185
45	21-Nov-05	7:00	22-Nov-05	10:00	27.00	10.1	8	191	22-Nov-05	4:00	7.3	7.1	213	5.6	7.5	206
46	23-Nov-05	22:00	24-Nov-05	19:00	21.00	10	6.7	250	24-Nov-05	1:00	8.5	7.1	200	5.8	7.1	209
47	29-Nov-05	4:00	29-Nov-05	19:00	15.00	6.9	7.1	159	29-Nov-05	19:00	5	8	168	3.2	8	163
48	15-Dec-05	13:00	16-Dec-05	4:00	15.00	7.4	7.5	118	15-Dec-05	19:00	5.1	7.1	192	3.4	7.1	190
49	25-Dec-05	16:00	26-Dec-05	10:00	18.00	7.2	8	186	25-Dec-05	19:00	5.8	9.1	187	--	--	--
50	14-Jan-06	4:00	14-Jan-06	22:00	15.00	6.9	6.7	183	14-Jan-06	4:00	--	--	--	3.3	6	197
51	17-Jan-06	19:00	18-Jan-06	16:00	12.00	10.5	8.5	172	18-Jan-06	4:00	--	--	--	--	--	--
52	31-Aug-06	16:00	1-Sep-06	4:00	12.00	10.1	10.6	177	31-Aug-06	19:00	6.2	8	192	4.1	10.6	197

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

Part 4 PROJECT EFFECTS/PERFORMANCE TO DATE

Beach Response – Shoreline Change Rates

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

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

In general, it is apparent that the post-construction shoreline change rates are more variable (longshore and magnitude), when compared to the pre-construction rates. This is due in part to the relatively short time frame of the post rate data (2000 through 2007), when compared to the pre-construction rate data (1938 through 2000), and is also a result of shoreline equilibration that is expected following each beach disposal activity.

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

For the entire Oak Island monitoring area, the pre-construction shoreline change rates along the beach vary from positive (accretion) of more than 30 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 computed for the initial time frame (i.e. through June 2003) were erosional. However, this response is seen to moderate with time and have now turned accretional, although the rates are still less than the historic large accretion of this area.

When compared to pre-construction shoreline change rates, the post construction rates on Oak Island reflect the influence of the beach fill which was placed along Oak Island during the channel dredging in 2001. Specifically, the fill was placed west of Profile 60 to Profile 294, except for a gap between Profile 80 through Profile 121 that did not require fill. Further, material associated with the Sea Turtle Habitat Project extending into the far west end of the monitoring area, specifically Profiles 300 through 310. Positive shoreline change rates were recorded over this entire fill area with a localized minimum occurring near the middle of the non-fill area. With this measured response, all profiles (except for three nearest to the river entrance) 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 constructed fill is redistributed and the rates begin to trend more toward the long-term pattern.

In most cases within the fill 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 to +15 feet per year. This compares to zero to +1.6 feet per year for the pre-construction period. Within the remaining disposal area from station 121+00 through the end to station 294+00, the current rates generally range from about +15 to +40 feet per year, while the pre-construction shoreline change rates for this area are erosional ranging from –0.3 to –5.8 feet per year.

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

Overall, the shoreline change rate averaged over the entire 5.2 mile section of Oak Island/Caswell Beach (from Profiles 35-310) is +21 feet per year for the 7-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 Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Aug-00 thru Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	
5	-5.4	-3.2	-2.0	-1.4	-1.3	1.0	1.3	1.9	2.0	1.6	
10	1.3	0.8	0.9	0.8	0.4	-1.5	-1.2	-0.8	-0.4	-0.3	
15	7.0	6.4	7.0	6.8	5.8	-4.1	1.0	3.1	3.3	3.3	
20	-8.7	-8.7	-9.1	-7.7	-6.1	0.2	7.2	8.0	7.5	6.9	
25	-14.8	9.8	19.0	17.9	17.8	-6.8	2.2	3.8	4.2	4.7	
30	16.1	27.7	22.1	19.5	16.8	-12.5	-3.1	-0.7	1.2	2.2	
35	-33.4	-24.3	-20.2	-15.3	-10.8	-12.9	-0.7	3.0	4.8	5.3	29.9
40	-21.9	-20.1	-15.3	-8.3	-6.9	-6.1	0.3	2.0	3.3	3.6	17.2
45	-10.6	3.5	9.2	10.1	9.5	-3.2	-0.5	1.5	2.2	2.6	7.9
50	19.2	14.8	14.2	10.6	9.4	11.7	10.3	10.3	8.8	7.7	2.5
55	30.8	23.5	19.6	14.2	12.0	20.8	17.4	15.8	12.1	10.1	0.8
60	41.3	29.6	24.0	17.5	14.3	30.7	21.9	18.2	13.4	10.9	0.3
65	23.3	15.6	11.9	8.1	5.3	32.9	23.0	18.6	13.6	11.0	0.2
70	38.8	25.9	21.5	16.4	13.5	35.9	24.9	20.1	15.1	12.4	0.4
75	30.4	20.6	15.7	11.8	10.1	35.0	24.2	19.7	15.1	12.7	0.9
80	45.8	33.0	27.2	21.5	18.6	35.5	24.7	20.3	16.0	13.9	1.6
85	36.4	26.0	22.2	17.8	16.0	27.3	19.6	16.0	12.8	11.4	1.9
90	25.9	18.0	14.8	12.4	11.1	22.9	17.0	14.5	11.9	10.7	2.2
95	-1.9	0.2	0.1	0.5	1.0	13.4	10.7	9.5	8.1	7.3	2.5
100	8.2	7.9	8.0	7.3	6.6	8.0	7.0	6.5	5.7	5.1	2.6
105	-1.6	1.3	2.7	2.6	1.9	4.4	5.2	5.2	4.6	3.9	2.5
110	9.6	7.4	7.2	5.9	5.0	12.0	10.9	10.1	8.4	7.2	2.1
115	7.6	9.2	8.1	6.5	5.1	17.8	15.4	13.2	10.4	8.8	1.5
120	36.2	28.9	24.3	19.7	17.3	32.9	25.7	20.8	16.1	13.7	0.7
125	37.1	30.2	23.6	17.1	14.9	44.9	34.7	27.1	21.1	18.1	-0.3
130	73.8	52.7	40.6	31.2	26.3	55.4	42.4	33.2	25.9	22.4	-0.9
135	69.7	52.3	39.0	30.8	27.1	62.1	47.6	36.8	28.7	24.8	-1.4
140	60.2	47.8	38.5	30.6	26.7	68.7	51.7	40.6	32.3	28.0	-2.1
145	69.7	54.8	42.2	33.6	28.9	64.5	49.4	39.1	31.4	27.4	-2.3
150	70.2	50.8	42.9	35.3	30.8	62.9	47.3	38.0	30.5	26.6	-2.5
155	52.9	41.4	33.1	26.6	23.5	61.9	45.8	36.4	29.1	25.3	-2.8
160	61.4	41.5	33.5	26.6	23.1	61.6	44.5	35.6	28.4	24.6	-3.3
165	55.0	40.4	30.3	23.6	20.4	60.1	43.9	34.1	26.6	23.1	-3.9
170	68.7	48.5	38.2	29.8	25.4	60.7	43.4	33.4	25.8	22.1	-4.3
175	62.2	47.9	35.3	26.5	22.9	60.3	43.5	32.9	25.2	21.5	-4.7
180	56.0	38.6	29.9	22.5	18.9	61.4	44.2	33.4	25.5	21.8	-5.0
185	59.6	42.4	30.6	23.4	20.1	59.6	43.2	32.0	24.4	20.9	-5.3
190	60.6	43.5	33.0	25.6	21.7	59.8	42.7	31.9	24.6	21.0	-5.4
195	59.4	43.8	31.1	24.0	20.7	61.1	44.5	33.2	25.9	22.2	-5.5
200	63.5	45.4	35.1	27.6	23.6	63.5	46.3	35.3	27.8	23.8	-5.6
205	62.3	47.6	36.1	28.8	25.1	63.9	46.8	35.8	28.3	24.2	-5.7
210	71.9	51.2	41.2	33.0	27.9	66.3	48.2	37.8	30.0	25.6	-5.8
215	62.3	46.1	35.4	27.9	23.8	64.0	47.1	36.9	29.2	24.9	-5.7
220	71.6	50.9	41.2	32.5	27.5	64.2	46.7	37.2	29.5	25.1	-5.5
225	52.3	39.9	30.8	24.0	20.1	57.5	42.3	33.7	26.7	22.6	-5.2
230	63.1	45.2	37.3	30.1	26.0	56.1	41.3	33.8	26.9	22.8	-4.8
235	38.1	29.3	24.0	19.1	15.9	50.3	37.9	31.3	25.0	21.3	-4.4
240	55.5	41.2	35.6	28.8	24.5	52.1	39.3	33.3	27.0	23.2	-4.1
245	42.6	33.6	28.6	23.2	20.2	48.1	37.3	31.9	25.9	22.3	-3.9
250	61.4	47.4	41.1	34.0	29.5	53.7	41.5	35.8	29.3	25.4	-3.7
255	42.8	35.2	30.1	24.5	21.4	53.9	41.7	36.0	29.5	25.7	-3.6
260	66.0	50.1	43.7	36.2	31.6	60.5	46.3	40.2	33.1	28.7	-3.5
265	56.5	42.1	36.4	29.8	25.7	58.9	45.2	38.9	31.9	27.6	-3.3
270	75.7	56.9	49.6	40.9	35.4	66.1	50.1	43.4	35.6	30.7	-3.2
275	53.5	41.8	35.0	28.2	24.1	67.4	51.2	43.8	35.8	30.8	-3.0
280	78.9	59.6	52.2	42.9	36.8	72.0	54.5	46.6	37.9	32.6	-2.8
285	72.3	55.4	45.8	36.9	31.7	73.5	55.8	46.9	37.8	32.4	-2.7
290	79.7	58.8	50.5	40.6	34.8	82.7	61.8	52.0	41.8	35.7	-2.6
295	83.0	63.3	50.9	40.3	34.5	86.9	64.5	53.1	42.2	35.9	-2.5
300	99.5	72.1	60.7	48.2	40.9	95.8	69.7	57.4	45.5	38.5	-2.3
305	99.9	73.1	57.4	44.8	37.5	99.8	72.4	59.1	46.7	39.5	-2.2
310	116.9	81.2	67.2	53.3	45.0	105.5	75.5	61.8	48.8	41.1	-2.1

Table 4.2 Bald Head Island Shoreline Change Rates

Profile ID	Post-Construction Rate (ft/yr)					Longshore Average Rate (ft/yr)					Longshore Average Pre-Construction Rate
	Aug-00 thru					Aug-00 thru					1938-2000
	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	Jun-03	Jun-04	Aug-05	Oct-06	Jul-07	(ft/yr)
0	-3.1	1.0	2.3	3.0	3.2	-3.0	-2.1	-1.6	-1.0	-0.8	
4	-6.2	-5.6	-5.0	-4.1	-3.7	-1.6	-1.1	-1.0	-0.4	-0.4	
8	0.3	-1.7	-2.3	-1.9	-1.8	0.0	0.4	-0.1	0.4	0.3	
12	2.6	1.9	0.7	1.2	0.9	1.7	1.2	-0.3	0.1	-0.3	
16	6.3	6.2	3.9	3.7	2.9	5.9	4.3	1.2	1.6	0.9	
20	5.7	5.0	1.0	1.4	0.5	4.6	1.3	-3.1	-2.0	-2.1	
24	14.7	10.0	2.7	3.5	2.1	1.3	-3.9	-6.7	-1.2	0.6	
28	-6.5	-16.7	-23.8	-19.8	-16.9	-3.3	-1.7	-1.9	4.5	5.8	
32	-13.7	-23.9	-17.0	5.0	14.5	15.1	10.5	7.0	9.9	10.0	
36	-16.6	16.9	27.8	32.4	28.9	18.1	6.6	1.2	2.4	3.4	
40	97.6	66.1	45.1	28.4	21.4	22.2	6.1	1.3	0.0	1.0	
43	29.9	-9.6	-26.1	-34.2	-31.0	21.6	4.0	-0.6	4.8	-6.5	
45	13.6	-18.8	-23.1	-31.6	-28.9	19.8	-7.5	-10.6	-5.0	-14.2	
47	-16.3	-34.3	-26.5	29.0	-23.0	-5.1	-30.0	-24.1	-13.8	-20.4	
53	-25.5	-40.9	-22.2	-16.8	-9.5	-18.1	-39.3	-24.9	-11.2	-17.3	-2.4
57	-27.0	-46.1	-22.5	-15.2	-9.5	-24.4	-40.5	-20.9	-4.9	-11.5	-5.5
61	-35.2	-56.4	-30.2	-21.1	-15.8	-23.6	-37.4	-15.6	-10.0	-6.1	-5.6
66	-18.1	-24.9	-3.2	-0.2	0.3	-19.7	-32.5	-10.3	-5.5	-3.2	-5.9
69	-12.0	-19.0	0.1	3.5	4.0	-14.8	-24.7	-3.8	-0.4	0.7	-6.4
73	-6.1	-16.1	4.3	5.7	5.0	-6.5	-14.5	5.6	7.1	6.8	-5.5
78	-2.4	-7.3	10.0	10.4	10.0	-2.0	-10.6	9.1	9.8	9.1	-4.6
84	6.2	-5.3	17.0	16.3	14.8	2.7	-7.3	12.3	11.9	10.8	-3.7
88	4.3	-5.4	14.3	13.0	11.6	5.6	-4.6	14.3	13.5	12.8	-3.1
92	11.3	-2.3	15.8	13.9	12.8	8.8	-3.1	15.4	14.2	13.8	-2.6
97	8.8	-2.8	14.2	13.7	14.9	13.7	0.4	16.1	14.3	14.1	-2.0
102	13.5	0.2	15.5	14.0	14.9	19.0	3.8	17.3	14.8	14.5	-1.6
106	30.8	12.5	20.8	17.1	16.1	26.0	8.9	19.5	16.2	15.7	-1.5
110	30.5	11.6	20.0	15.4	13.9	34.2	14.8	22.5	17.8	16.8	-1.6
114	46.2	23.2	27.0	20.9	18.9	43.0	21.4	26.1	20.1	18.7	-1.6
118	50.1	26.5	28.9	21.4	20.3	47.9	25.3	28.1	21.5	20.1	-1.8
122	57.6	33.0	33.7	25.9	24.2	50.2	27.2	28.1	21.5	20.6	-1.9
126	54.9	32.3	31.1	23.8	23.5	51.5	28.9	27.3	20.8	20.6	-2.0
130	42.4	21.2	19.7	15.4	16.1	53.4	31.1	26.8	20.9	20.9	-2.1
134	52.4	31.6	22.9	17.6	19.1	53.2	31.5	24.7	19.3	20.1	-2.0
138	59.9	37.3	26.8	21.5	21.7	54.4	33.0	24.1	19.0	19.8	-2.0
142	56.3	35.1	22.9	18.2	20.3	59.0	37.4	25.7	20.1	21.0	-2.3
146	60.9	39.8	28.2	22.0	21.6	61.8	39.9	27.4	21.5	22.2	-2.6
150	65.8	43.3	27.6	21.0	22.5	65.0	42.9	29.2	22.3	23.1	-2.9
154	66.0	44.1	31.5	24.7	25.0	69.5	46.2	32.5	24.4	24.9	-3.9
158	75.9	52.3	35.9	25.5	26.1	72.6	48.7	34.2	25.3	26.1	-4.7
162	78.9	51.8	39.4	28.7	29.1	72.8	49.3	35.8	26.1	26.4	-5.2
166	76.3	52.3	36.9	26.7	28.0	71.6	49.5	36.0	25.7	25.2	-5.4
170	67.1	45.9	35.5	25.0	24.1	71.6	49.3	36.8	26.8	25.0	-5.6
174	59.7	45.0	32.2	22.7	19.0	67.5	47.1	34.8	25.5	22.9	-5.9
178	76.1	51.4	40.1	30.7	25.0	62.0	43.2	32.4	24.3	20.8	-6.2
182	58.2	40.9	29.2	22.2	18.5	57.1	39.9	29.7	22.9	19.4	-6.5
186	48.7	33.0	25.1	20.7	17.4	51.6	35.5	27.1	21.8	19.0	-7.0
190	42.9	29.3	22.0	18.1	16.9	42.0	30.0	22.9	19.1	17.8	-7.8
194	31.8	22.9	18.9	17.1	17.1	34.5	26.3	20.8	18.3	18.4	-8.6
198	28.3	23.7	19.1	17.4	19.2	25.4	21.9	17.6	16.9	19.1	-10.0
202	20.8	22.7	18.7	18.2	21.2	15.1	16.7	14.3	16.3	20.5	-11.9
206	3.2	10.7	9.0	13.5	21.2	6.8	12.4	12.1	17.7	23.9	-13.7
210	-8.8	3.4	5.8	15.3	24.0	0.2	8.9	11.2	14.5	29.7	-15.0
214	-9.6	1.2	7.6	24.2	34.1	-3.6	4.3	9.3	13.6	31.9	-17.8
218	-4.8	6.2	14.7	1.3	48.3	0.1	3.4	9.4	13.6	35.5	-20.8
222											

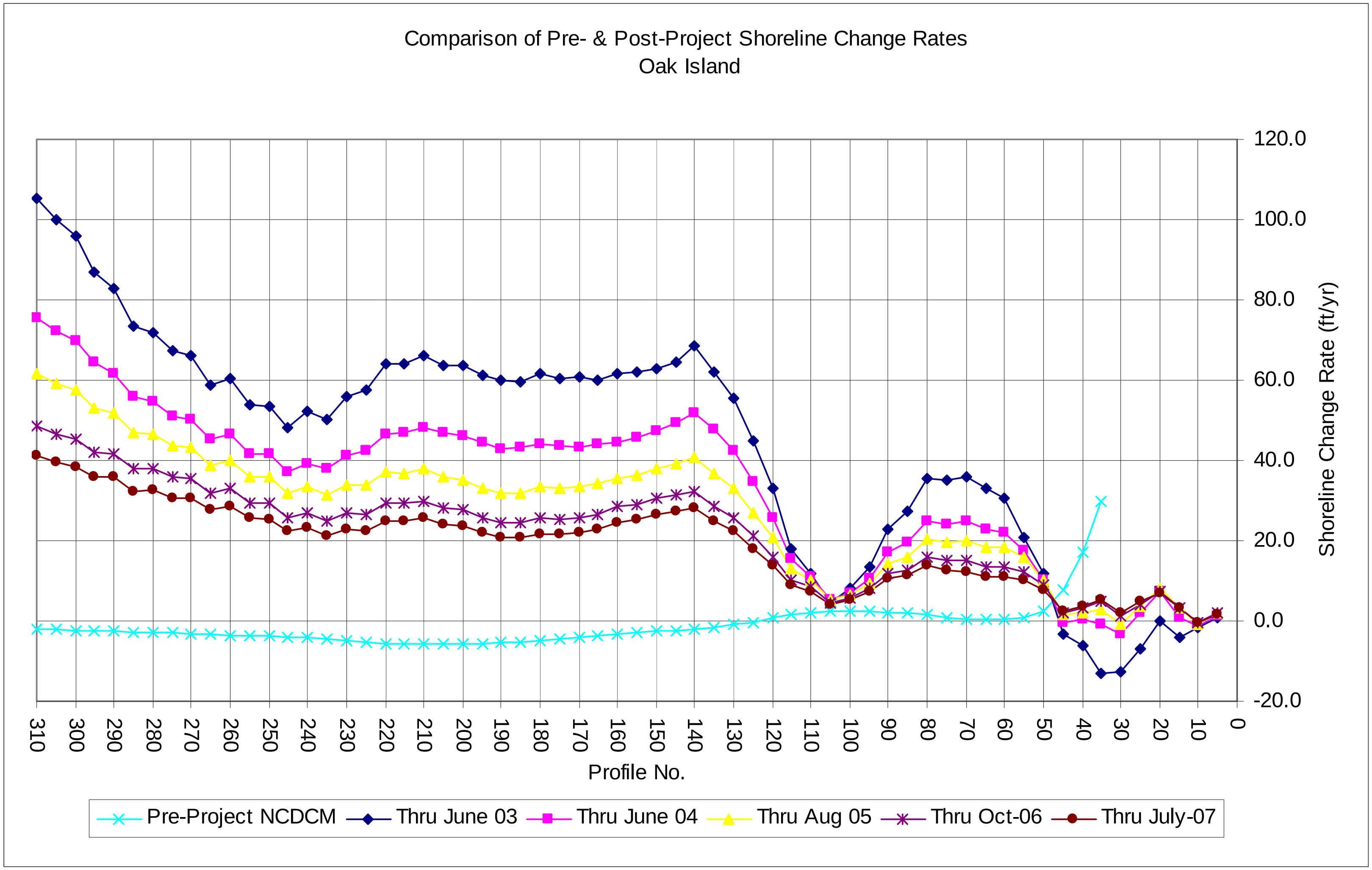


Figure 4.1 Wilmington Harbor Monitoring - Oak Island Comparison of Pre- and Post-Construction Shoreline Change Rates

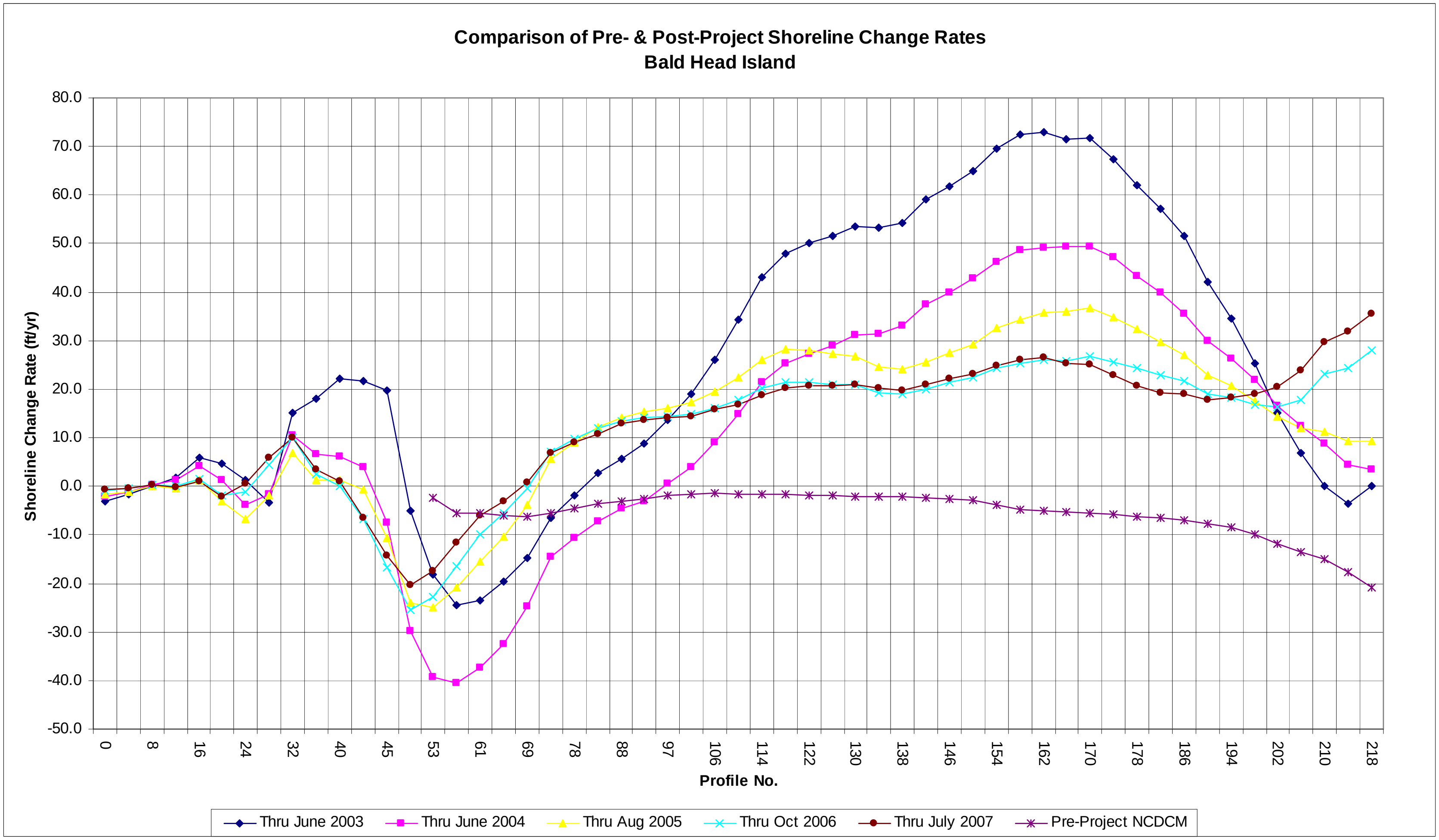


Figure 4.2 Wilmington Harbor Monitoring - Bald Head Island Comparison of Pre- and Post-Construction Shoreline Change Rates

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

As indicated on Figure 4.2, the computed post-construction shoreline change rates are found to be generally positive over the monitoring area for all of the time frames. This in part reflects the positive influence of the beach fills placed throughout this area. In spite of the positive affects of the fill, the western end of South Beach, continues to experience relatively high rates of erosion. The measured rates within the erosion zone increased both in magnitude and extent between the June 2003 and June 2004 survey periods, but have subsequently diminished over the most recent time periods. Specifically for June 2004, the average rate over the zone of erosion was about –20 feet per year with a maximum of –40 feet per year. This compares to an average pre-construction rate of –5 feet per year over this reach. Further, the extent of the erosion rate zone expanded eastward in 2004 extending from Profile 47 thru 97 representing an alongshore distance of about 5,000 feet.

With the subsequent placement of dredged material in January 2005 and April 2007 plus the reconstruction of the groins, the erosion rate zone has now diminished. With the August 2005 survey period, the erosion rate zone covered about 2,400 feet (from Profile 45 thru 69). Over this zone the average rate was –13.8 feet per year with a peak of –25 feet per year. By October 2006, the same area continued to improve as was eroding at an average rate -13.0 feet per year. With the most recent period (thru July 2007), the extent of the erosion zone has shifted slightly westward and the erosion rate magnitudes have continued to diminish to an average of -11.3 feet per year.

Eastward of this erosion zone, the post-construction rates turn positive reflecting the positive impact of the fills placed along this reach. The computed peak shoreline change rates for this area remain highly positive, but are found to be diminishing, as the effect of the fill on the rates moderates with time. Specifically, the peak computed rates were a plus 72 feet per year (thru June 2003), a plus 49 feet per year (thru June 2004), a plus 37 feet per year (thru Aug 2005) a plus 27 feet per year (thru October 2006) and a plus 26 feet per year for the entire period. In terms of average rates for this zone, the positive values are 38, 29, 23, 19 and 19 feet per year for the respective time periods. These rates are in sharp contrast to the erosion indicated along this entire area by the pre-construction rates.

In summary, the comparison of the pre- and post-construction shoreline change rates show that most of Bald Head Island is eroding less over the initial 7-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 although the extent and magnitude of this zone have decreased for rates computed through the present period. A direct comparison of the pre- and post-construction shoreline change rates show that only three profile lines are eroding at a higher rate during the post-construction period. These lines at located at the western end of south beach (Profiles 53, 57 and 61). Adjacent Profile 66 is presently eroding but at a lower rate as compared to the pre-construction condition. All other lines are accreting in direct contrast to the long-term erosion experienced along the remaining areas of South Beach. Most of this response is attributable to the beach fill placement and possibly to the positive effect of the rehabilitated groin field.

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 the initial dredging and Bald Head Island disposal that ended in January 2005 as well as subsequent dredging and disposal events. Ultimately, these surveys will serve as a catalyst for discussion of possible measures to be taken if navigation becomes restricted during the scheduled two-year period between dredging events. The threshold criterion outlined in the settlement agreement at which discussions would initiate is a navigable width less than 500 ft at –42 ft MLW.

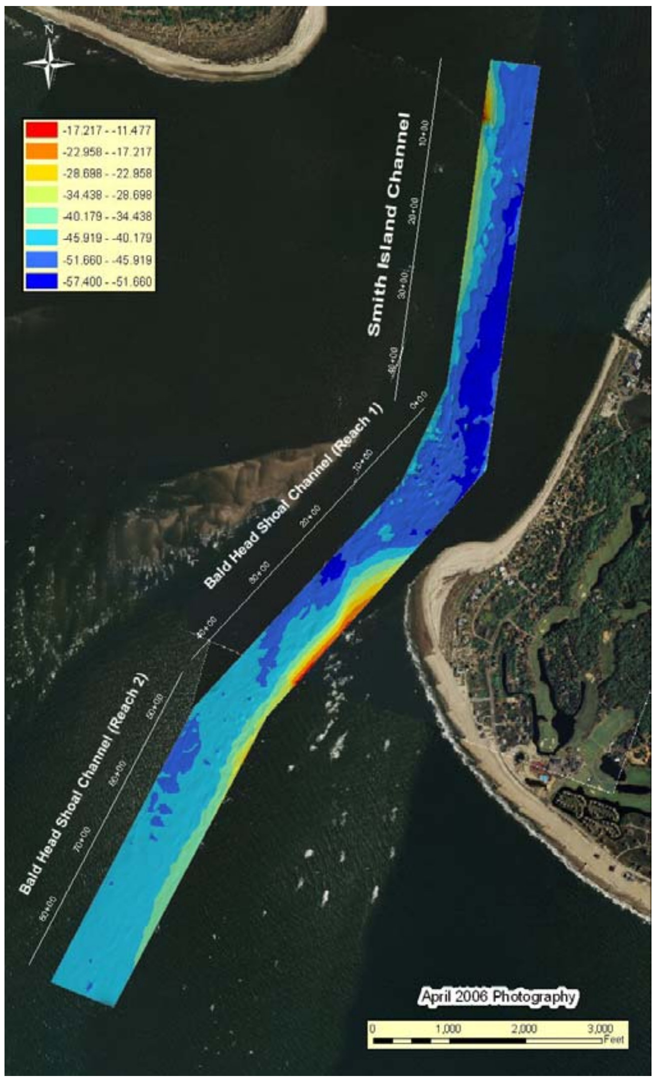


Figure 4.3 Locations for Baldhead Shoal (Reach 1 & 2) and Smith Island Channels

The first settlement agreement survey was conducted in March 2005. It and all subsequent surveys are being compared to the post-dredging survey conducted in January 2005 to track changes. Subsequent 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 it's proximity to Bald Head Island and the tendency of this channel to most likely violate 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 2004 – 25 Jan 2005		
March 2005	23 Mar 2005	18 Mar 2005	18 Mar 2005
May 2005	17 May 2005	12 May 2005	13, 17 May 2005
July 2005	20 Jul 2005	22-28 Jul 2005	25-28 Jul 2005
September 2005	22 Sep 2005	21-23 Sep 2005	22-23 Sep 2005
October 2005[2]	18 Oct 2005	18-19 Oct 2005	19 Oct 2005
November 2005	29 Nov 2005	30 Nov 2005	30 Nov 2005
January 2006	28 Jan 2006	27 Jan 2006	27 Jan 2006
March 2006	17, 21 Mar 2006	16 Mar 2006	17 Mar 2006
May 2006[3]	23 May 2006	19 May 2006	18 May 2006
July 2006[3]	25 July 2006	21 July 2006	20 July 2006
September 2006[3]	26,27 Sep 2006	28 Sep 2006	26 Sep 2006
November 2006[3]	17 Nov 2006	28 Nov 2006	20 Nov 2006
January 2007[4]	25 Jan 2007	29 Jan 2007	31 Jan 2007
March 2007[4]	19 Mar 2007	8 Mar 2007	9 Mar 2007
June 2007[4]	26 June 2007	27 June 2007	26 June 2007
September 2007[4]	27 Sept 2007	26 Sept 2007	26 Sept 2007

[1]Post dredging surveys are a mosaic 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

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 January 2005 and November 2006, respectively. The January 2005 survey serves as the baseline for comparisons with all subsequent surveys. The November 2006 survey is the last settlement survey included in Monitoring Report 4. The channel widths by reach for Baldhead Shoal Channel 1 in January 2005 and November 2006 are shown in Figure 4.6.

A difference plot of the total amount of change (January 2005 – November 2006) in all three channels is shown in Figure 4.7. A significant amount of channel shoaling occurred over the time period covered in Monitoring Report 4 between Sta. 17+00 and Sta. 44+99, which continues the shoaling trend established in Monitoring Report 3. The shoaling, i.e. reduction of navigable width measured at -42' mllw, ranged from 106 feet to 318 feet, with the maximum occurring at station 23+00. The minimum navigable width did fall below the threshold minimum width of 500' at seven locations within reach 1 during the time period covered by Monitoring Report 4. Because the regular scheduled dredging was so close to the November 2006 survey when these breaches of minimum navigable width were discovered, no emergency dredging was necessary.

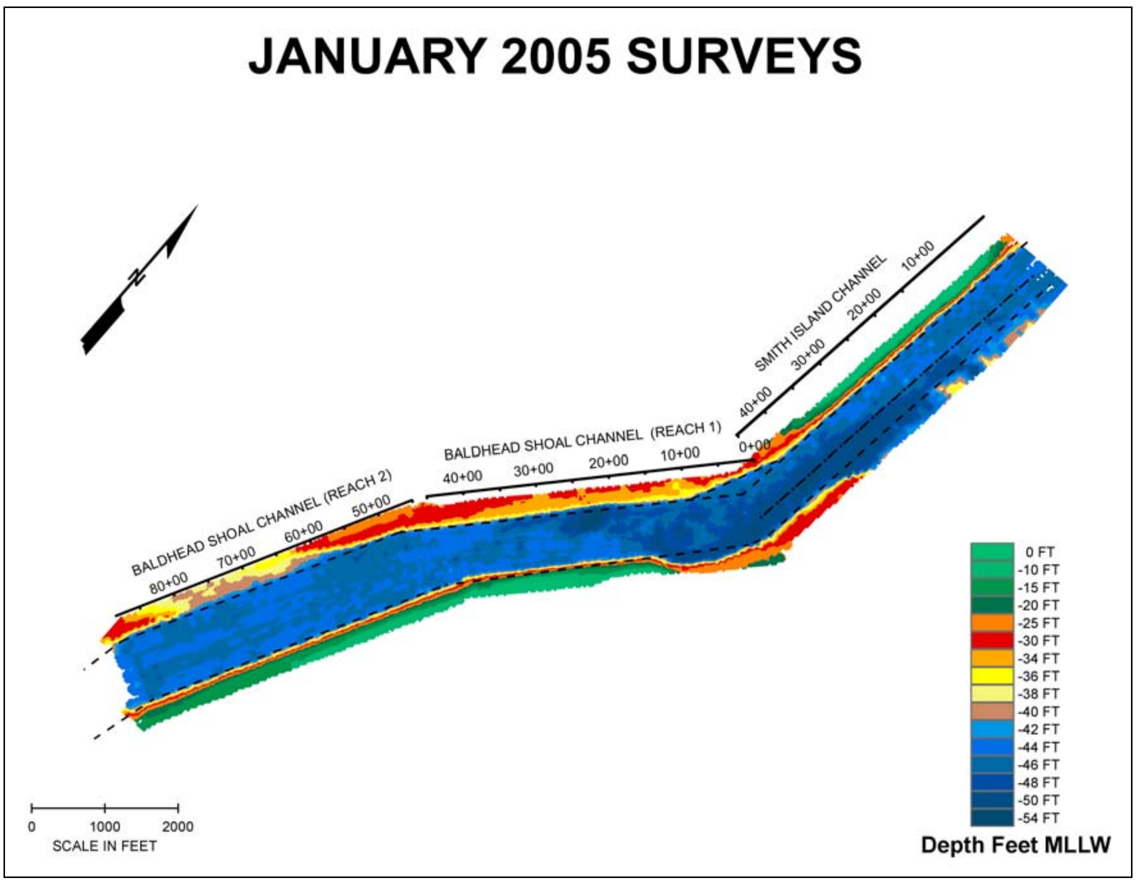


Figure 4.4. January 2005 channel Conditions

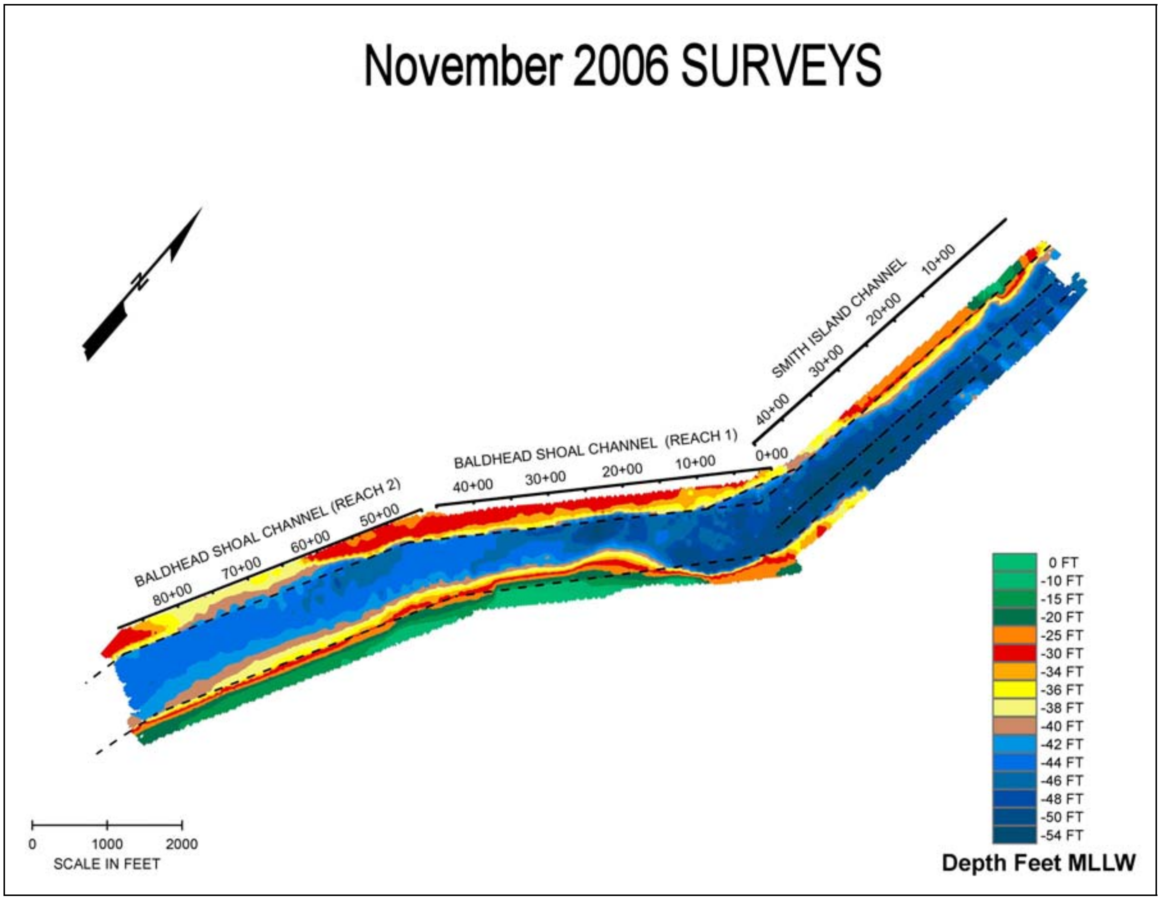


Figure 4.5. November 2006 channel conditions

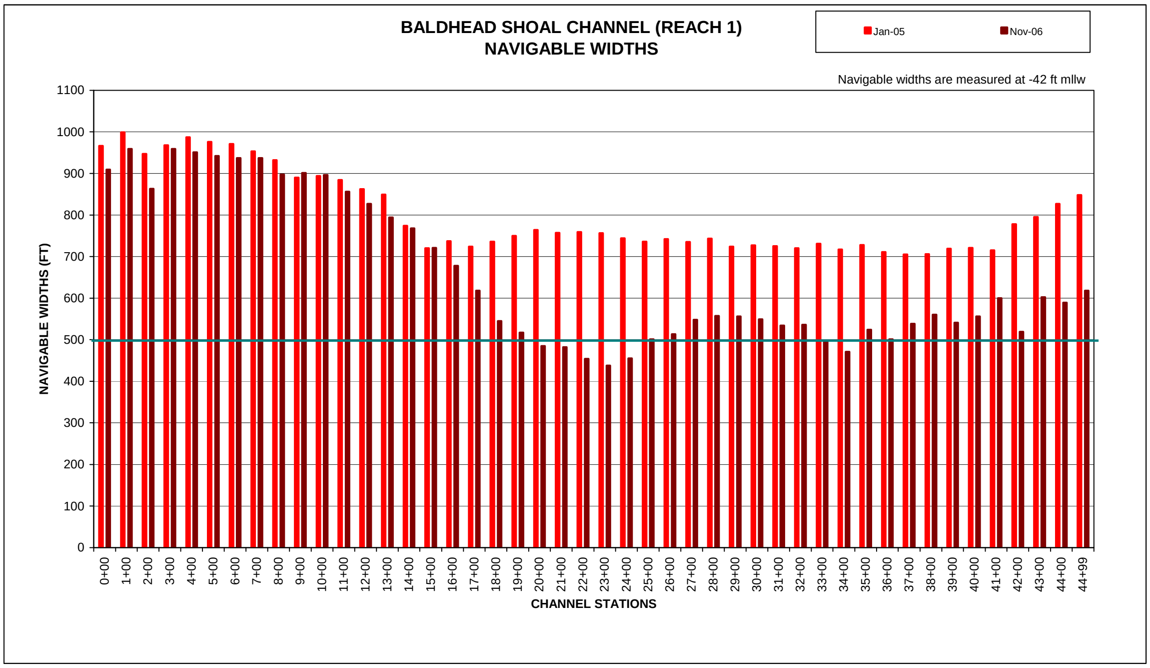


Figure 4.6. Baldhead Shoal Channel 1 Navigable Widths

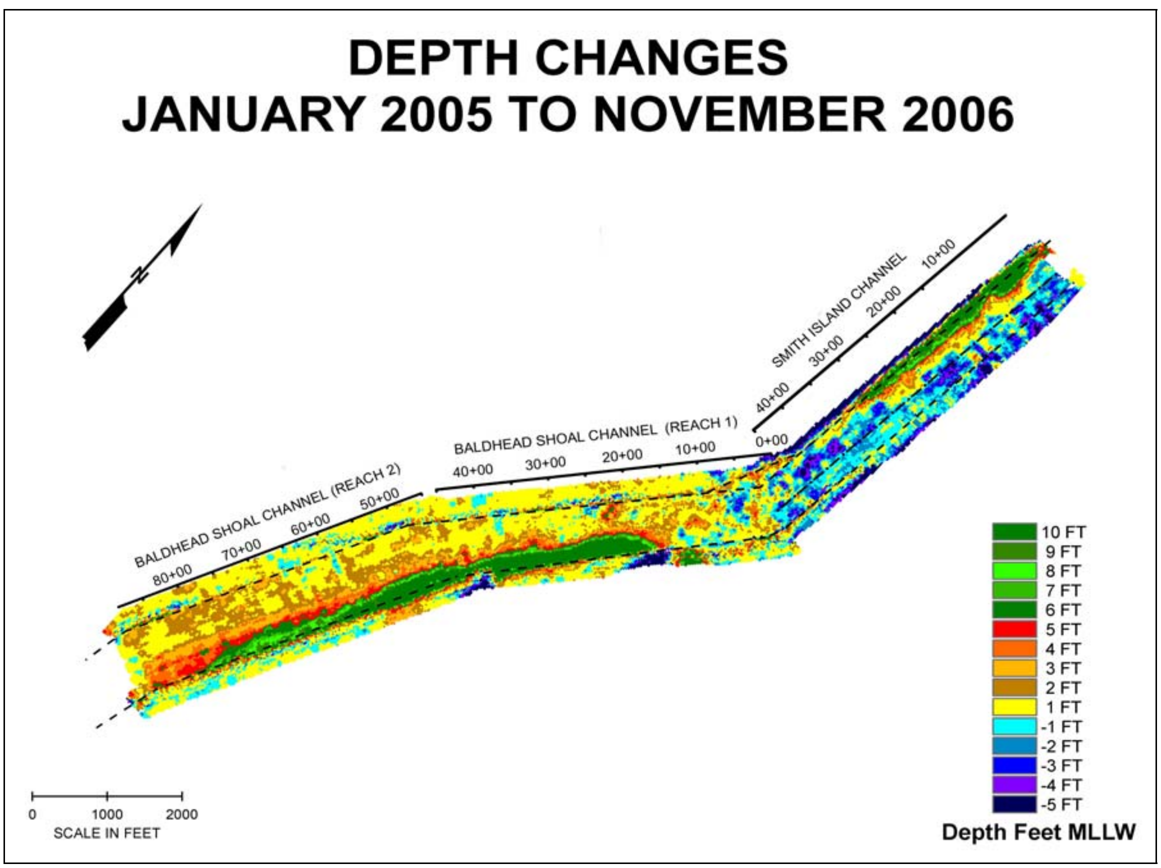


Figure 4.7 Depth changes from January 2005 to November 2006

Monitoring Report 5 includes four additional settlement surveys taken from January 2007 through September 2007, as summarized in Table 4.3. Figures 4.8 and 4.9 show the January 2007 and September 2007 surveys, respectively. A plot showing depth changes over the current monitoring period is shown in Figure 4.10. As seen in this plot, the major elevation changes occurred within the navigation channel as a result of the March-April 2007 dredging. The dredging removed the shoaling due east of Bald Head Island in Bald Head Shoal Channel Reach 1 from approximate station 15+00 through 44+99, as well as shoaling on the east half of Bald Head Shoal Channel Reach 2. In addition to this shoaling, significant dredging occurred on the west side of Smith Island Channel to remove material building from Jay Bird Shoals into the navigation channel. In total, the dredging contract removed approximately 1,176,399 cubic yards of material from Bald Head Shoal Channel 1, Bald Head Shoal Channel 2, and Smith Island Channel.

Figure 4.11 (Stations 0+00 to 23+00) and 4.12 (Stations 24+00 to 45+00) show navigable widths for various time periods along Reach 1 over the entire monitoring period. For the current monitoring period, these graphs show that the channel width has naturally widened between the November 2006 and January 2007 surveys in the most critical areas where the breach of minimum width requirements occurred during Monitoring Report 4. This natural widening could be the result of many natural processes; however, further investigation would be needed to attempt to determine possible causes. Also shown in the graph is the dramatic increase in channel width associated with the dredging of the channel which occurred in the March to April 2007 time frame. These post-dredging channel surveys show that stations 18+00 through 24+00 and stations 43+00 through 44+99 immediately began to shoal and narrow the navigable width while the remainder of the channel appeared relatively stable.

With the dredging event happening during this monitoring period all reaches easily satisfy the minimum width criteria of 500’ at -42’ MLW. Average navigable width within Reach 1 was approximately 787 feet. Maximum navigable width was found to be 1019 feet at station 6+00, with the minimum navigable width of 657 feet found at station 19+00.

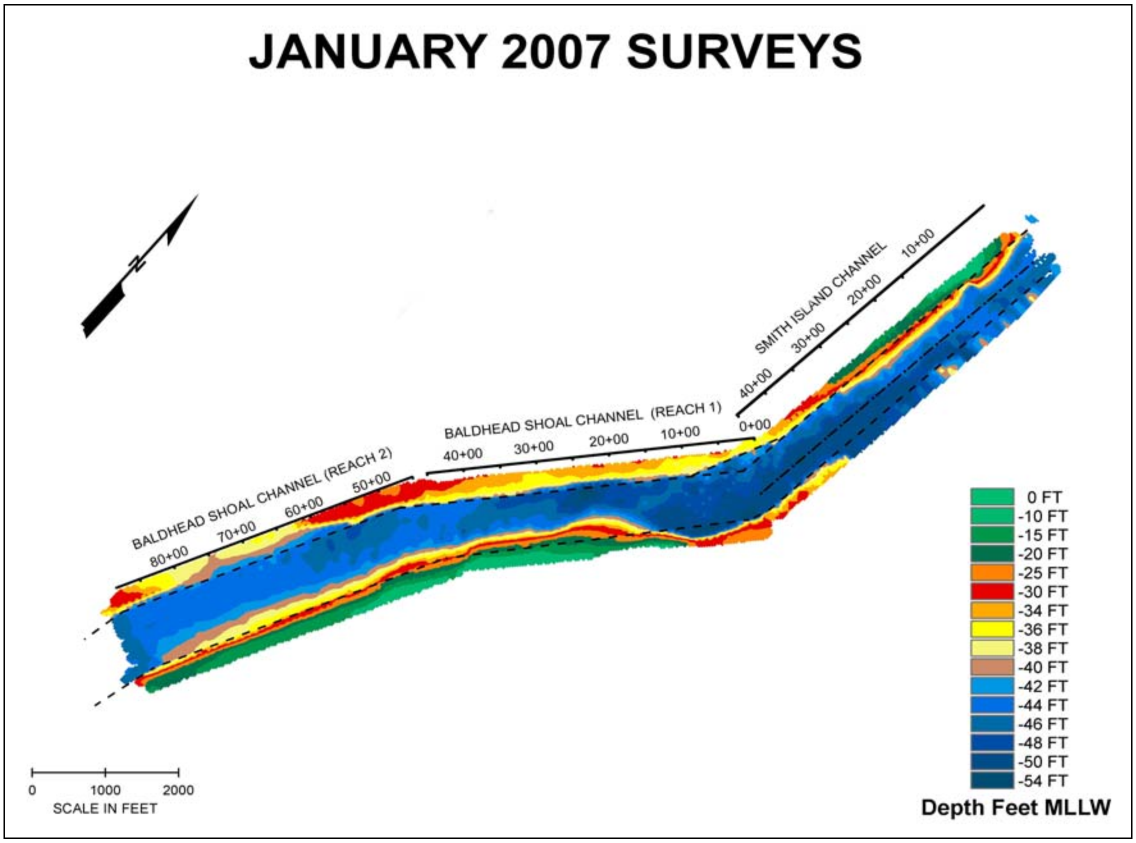


Figure 4.8 January 2007 Survey

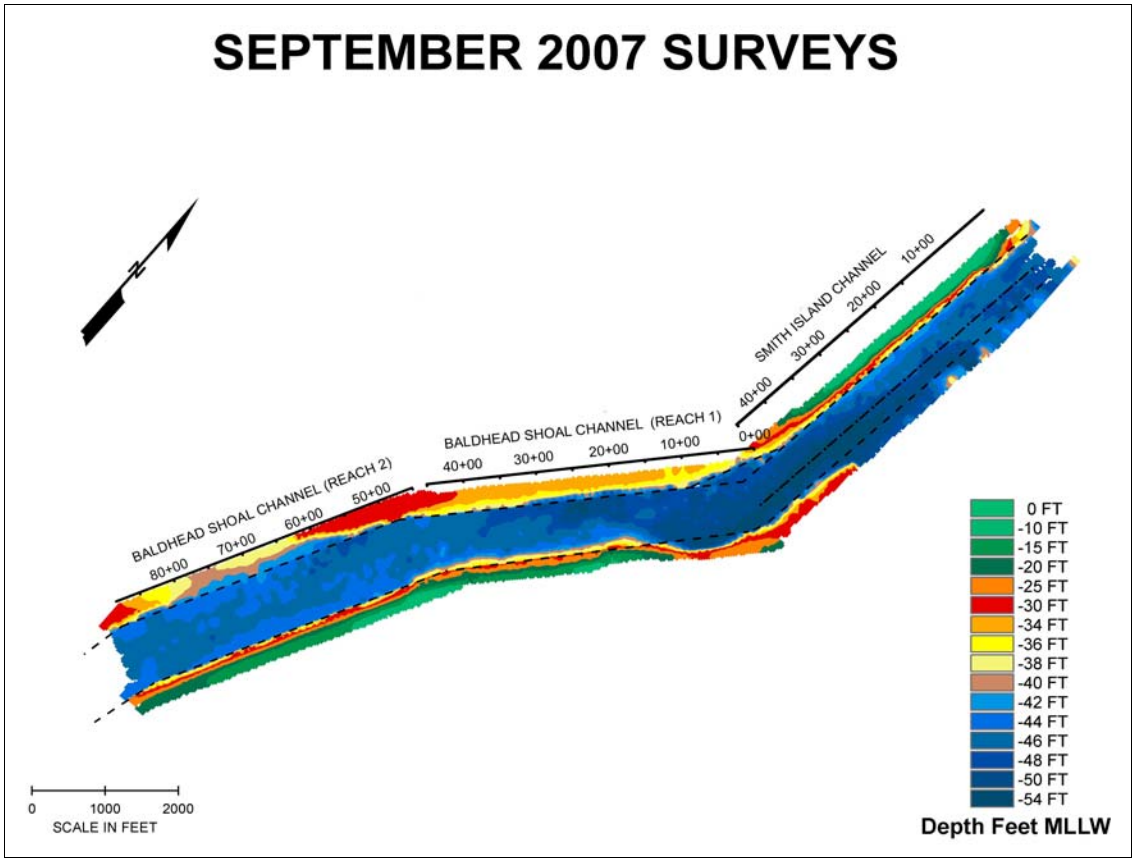


Figure 4.9 September 2007 Survey

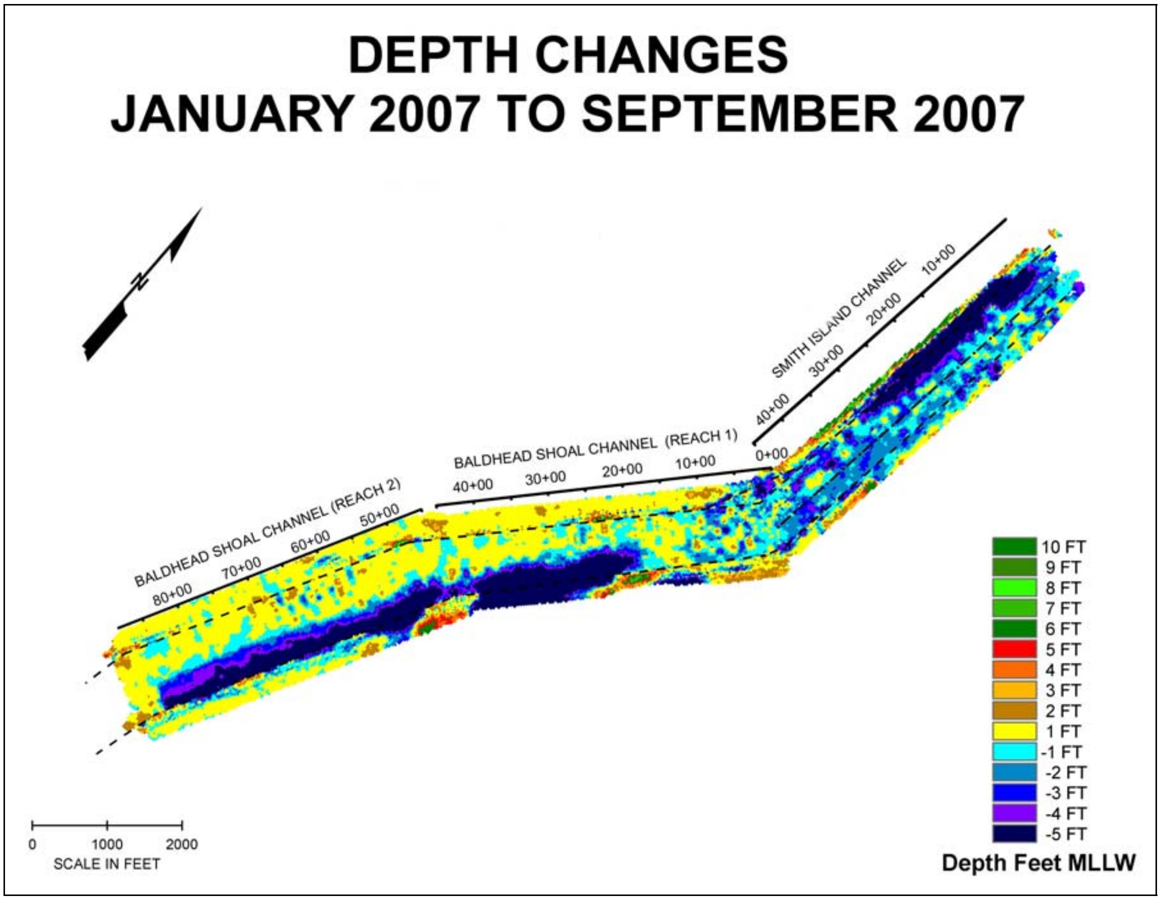


Figure 4.10 Depth Changes for the Current Monitoring Period (Jan 2007 to Sept 2007)

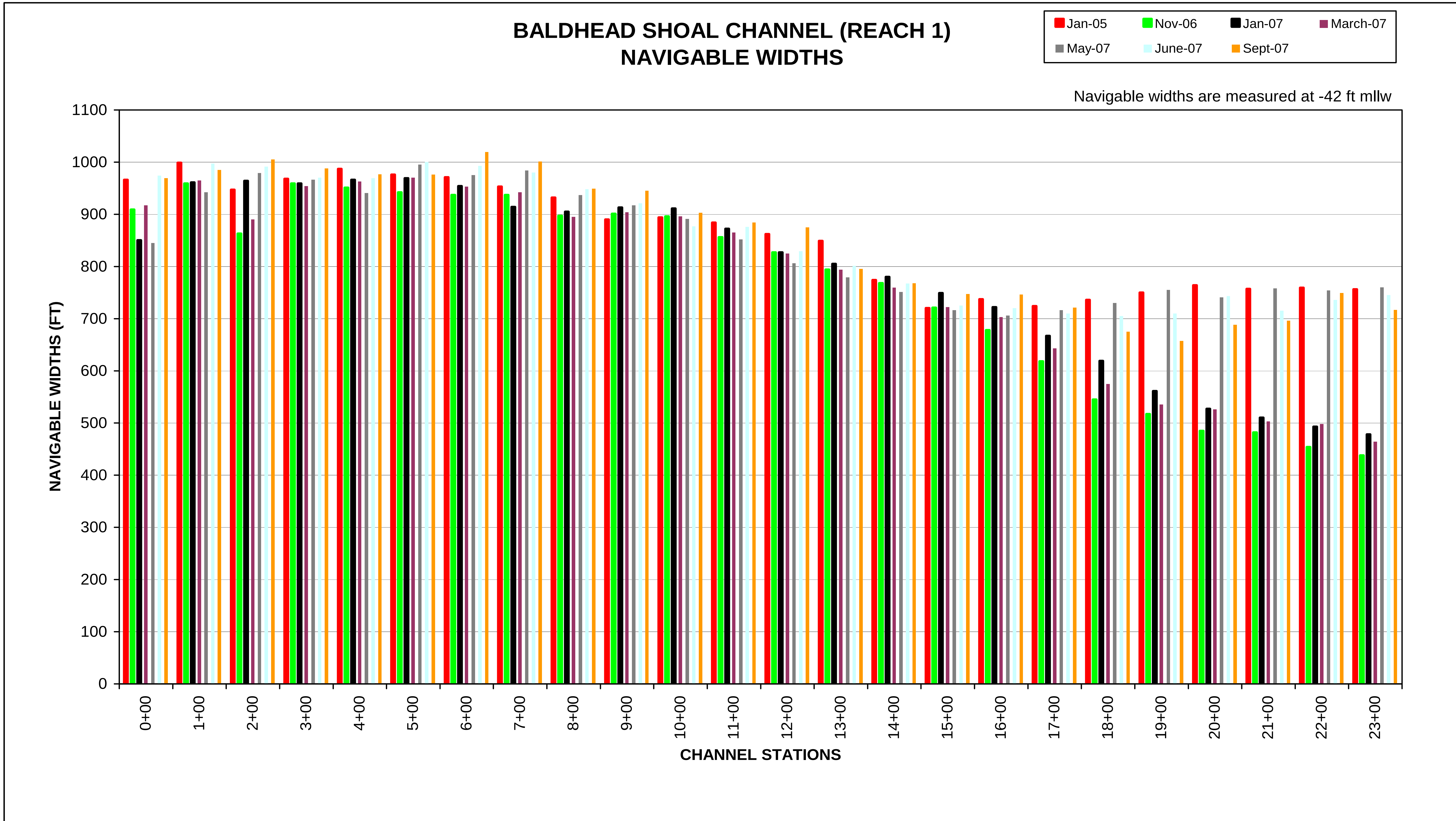


Figure 4.11. Baldhead Shoal Channel 1 width by station: Station 0+00 to 23+00

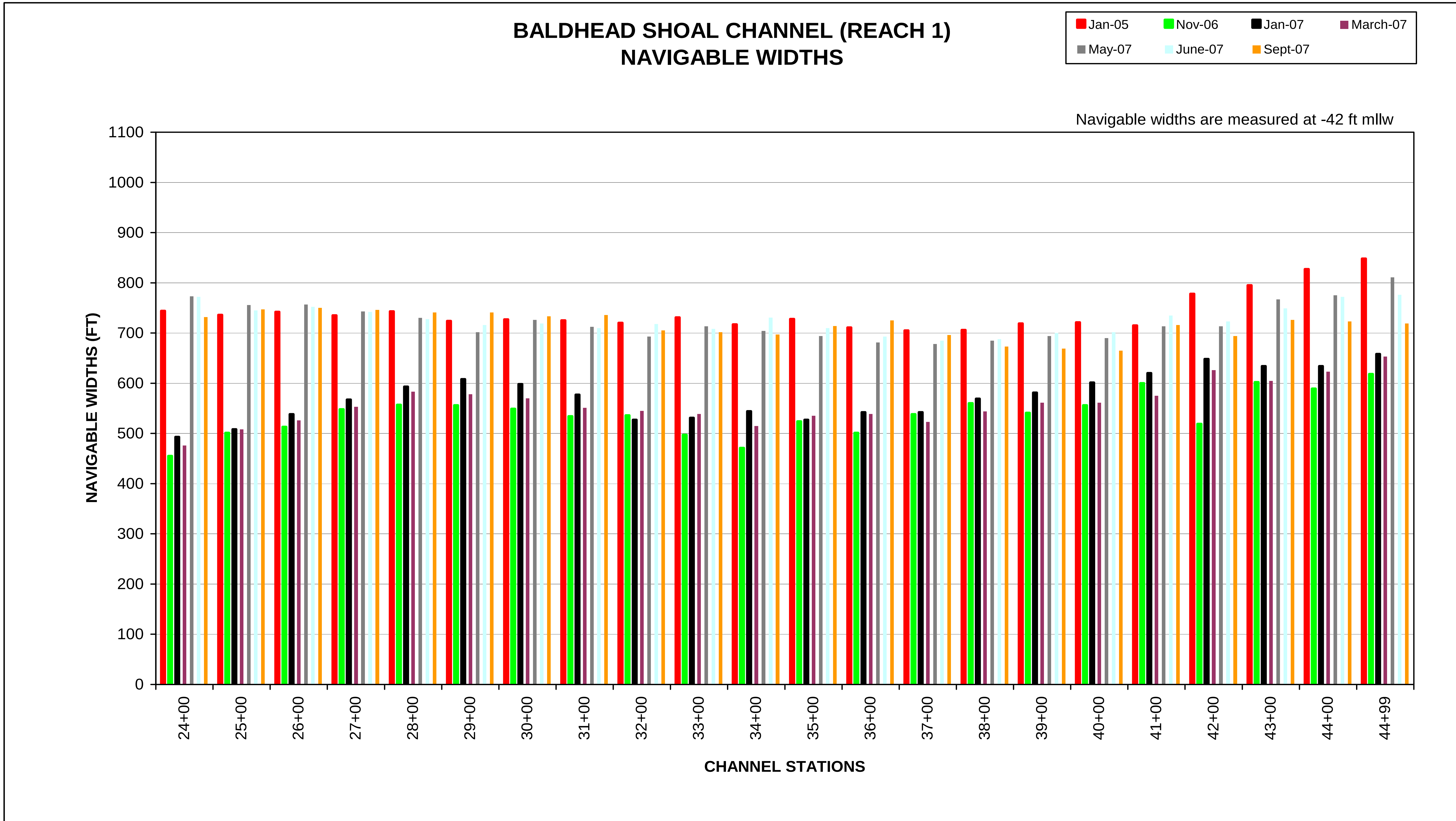


Figure 4.12. Baldhead Shoal Channel 1 width by station: Station 24+00 to 45+00

Spit Growth. In 2001-02 approximately 1.8 million cubic yards of sand were dredged and subsequently placed on Bald Head Island from station 41+60 to 205+50. After placement, the spit on the east side of Baldhead Channel 1 doubled in volume (400,000 cubic yards in October 2004 versus 200,000 cubic yards pre-2001). From November 2004 through January 2005, approximately 1.2 million cubic yards of material were dredged and placed from station 47+00 to 130+00. 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/fill operation grew to nearly 340,000 cubic yards and are discussed further in the channel shoaling section of this report. The most recent fill occurred 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.

The influence of the reconstructed groin field is shown in Figure 4.13. From this figure it is evident that the sediment transport along the groin field is from the East to West, creating a saw-tooth shoreline. Also seen in this figure is the May 2007 wet/dry shoreline which shows accretion in most areas when compared to the April 2006 wet/dry line from Monitoring Report 4. This is predominantly due to the recent nourishment of the beach during the second maintenance cycle. The section along South Beach where the second maintenance cycle of dredge material was placed, station 44+00 to 91+00, has almost completely covered the groin field. The area along South Beach where no material was placed during the second maintenance cycle still shows signs of the saw toothed shoreline created by east to west filling of the groin field; however, this area has accreted as well. The south beach portion of the fill is evident in the figure with shoreline changes up to 230’ as compared to the previously reported wet/dry line (April 2006). The northeast migration of the spit reported in Monitoring Report 4 appears to have almost stopped with only minor accretion noted between station 28+00 and 32+00.

Spit volumes were calculated within the bounding polygons shown in Figure 4.14. The change in spit volumes above -44 ft MLLW for Baldhead Shoal Reach 1 are shown in Figure 4.15 with the three dredging/placement events noted. Figure 4.16 shows a comparison of the three post-placement responses from Figure 4.15. Note the difference in slope between the three post-placements. 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 16,000 cubic yards per month. An analysis of all settlement surveys for the second dredging event, January 2005 through March 2007, showed that the spit growth had slowed to about 9,800 cubic yards per month, i.e., a 39 % reduction in the shoaling rate. Analysis for the current monitoring period shows that the growth rate has continued to decrease and is now at a rate of 3,650 cubic yards per month. This is a 77% reduction in the shoaling rate versus the initial dredging operation. This reduction percentage is slightly skewed because there are only two surveys included in the calculation of the third dredge event shoaling rate. Volumetric analysis within the reach 1a polygon showed that there was no infilling of the channel associated with the northern growth of the spit.

Among the possible explanations for this slower spit growth rate are: (1) sand tube groin field constructed immediately after the 2004/2005 placement has been effective in retaining the fill as shown in Figure 4.13, (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 fill being farther away from the channel, and/or (5) possible dissimilar wave and current conditions for each period of record.

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

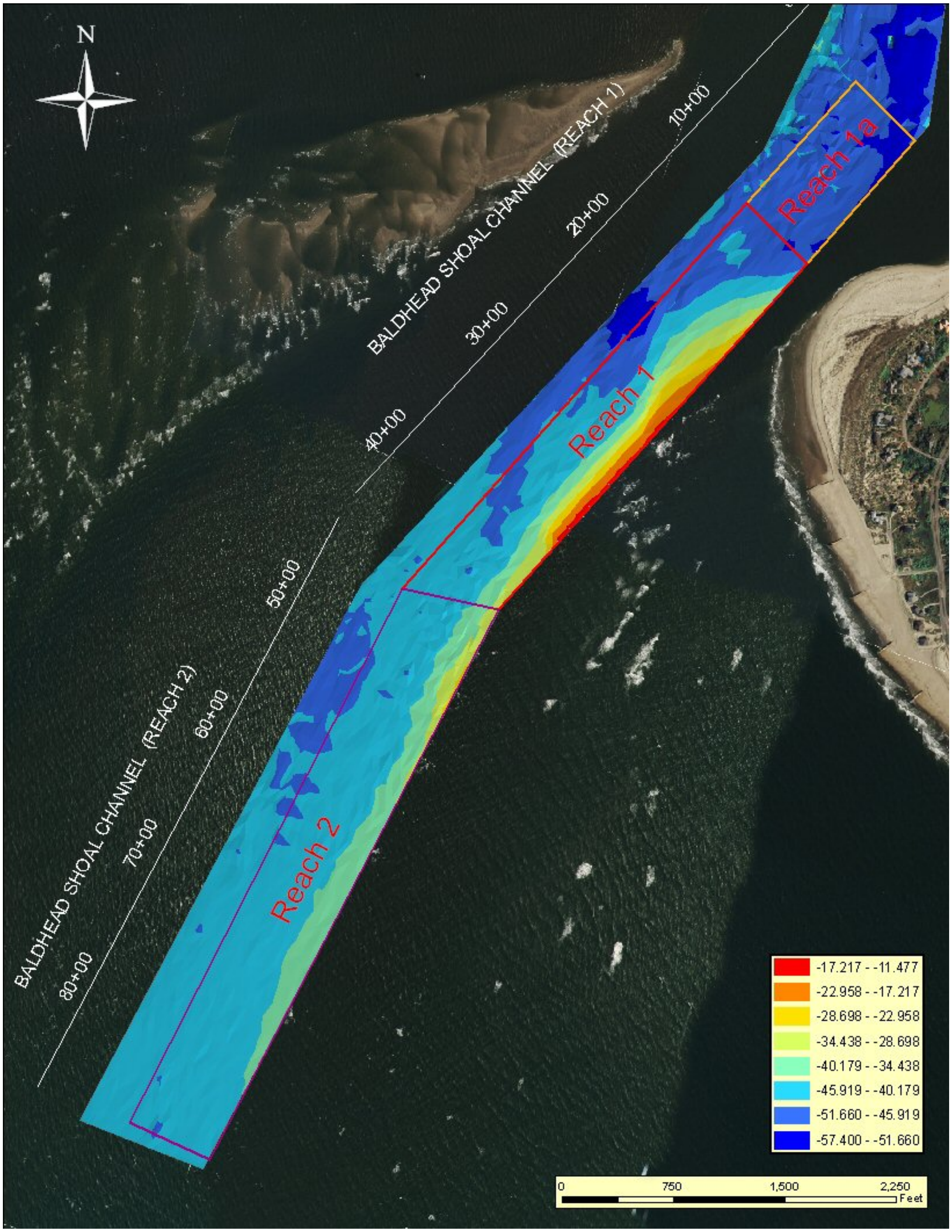


Figure 4.14. Spit volume bounding polygons

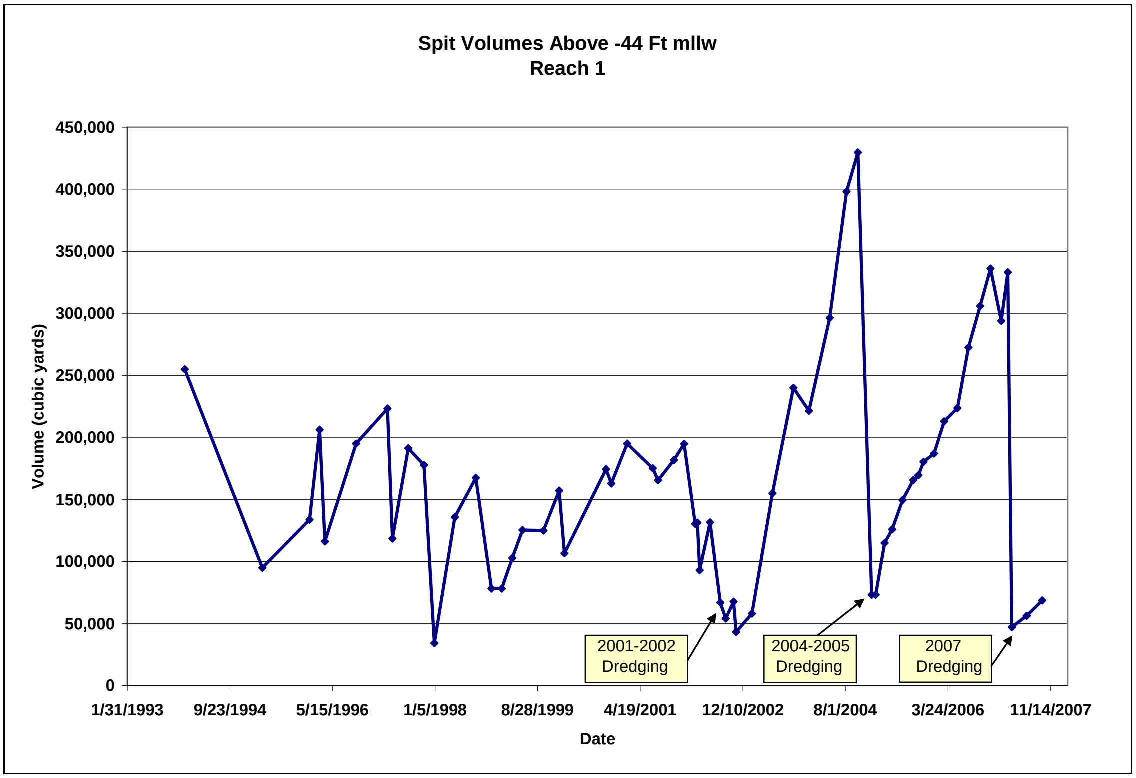


Figure 4.15 Baldhead Shoal Channel 1 Spit Volumes

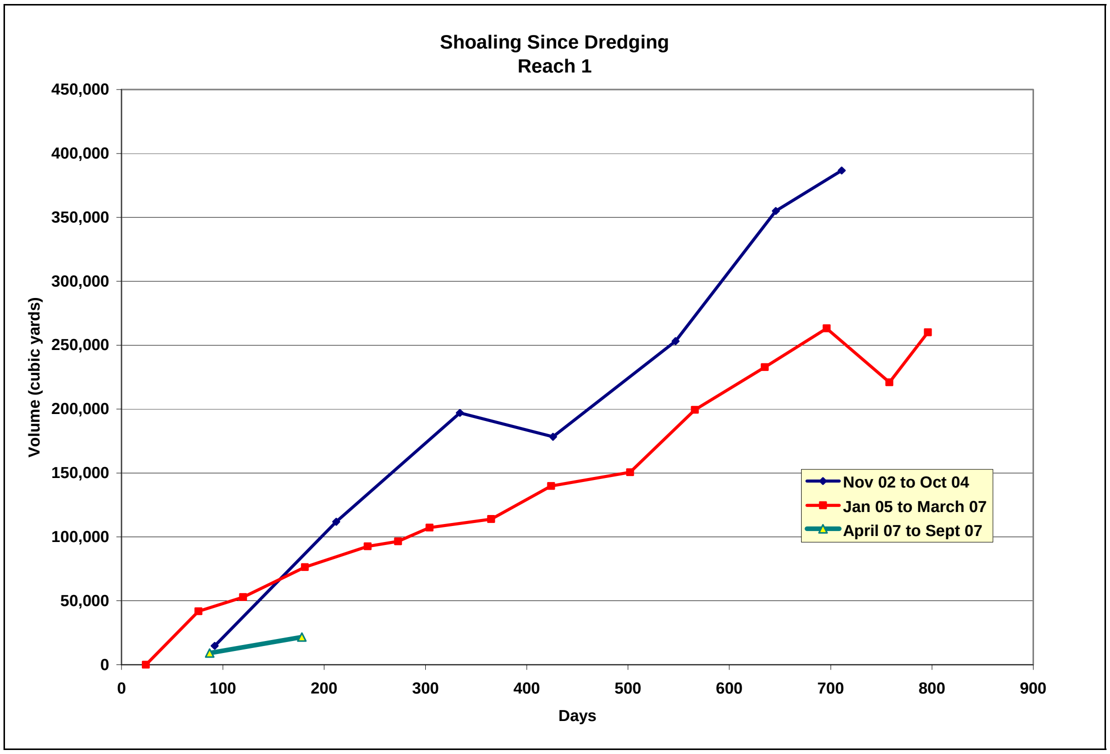


Figure 4.16 Comparison of post-placement spit growth from Figure 4.15 (Above)

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 fill placement in 2005. As such, a sixteen structure sand tube groin field was reconstructed along South Beach between stations 47+00 and 105+00. The replacement geo-tubes were constructed between January and March 2005 using the in situ sand to fill the 300-foot long tubes.

The section of beach contained within the reconstructed groins has now received beach fill on three occasions. These occasions include the 2001 fill before the reconstruction, the 2005 fill with the reconstruction and the most recent 2007 fill. In this regard, it is possible to assess the performance of the groins by comparing the beach response with and without groins in place. Since only one survey is presently available following the 2007 beach disposal, the comparison is made for only the first two fills at this time.

Shoreline Response. Changes in the position of the mean high water shoreline were calculated for selected monitoring surveys following each of the first two fills. In each case, the shoreline measured form the profiles contained within the influence of the groin field were compared to the first post-fill survey (for 2001 and 2005). The results are given in Figure 4.17, showing the shoreline changes for six surveys following the first fill and four surveys following the second fill. The surveys following the first fill are displayed as solid brown lines compared to the post-second fill surveys which are displayed as dashed blue lines. The results indicate that the shoreline losses are progressive following each fill; however, those following the first fill are greater than those of the second fill, particularly within the western half of the groin field. Further, the post-fill retreat is found to be more uniform within the groin field. The total time spans reported in the figure are different for each of the fills, spanning 35 months for the first fill cycle versus 23 months for the second fill. In this regard, shoreline changes over similar time frames can be compared by using the February 2003 versus the January 2007 survey dates both of which are 23 months after the first and second fills, respectively. This comparison, shown as a heavy weighted line in each case, shows shoreline retreats are significantly less for the second fill with the groins in place. This is particularly true for the western half of the groin field where the shoreline retreats are on the order of twice as large for the first post-fill period. Specifically, the average retreat within the groin field 23 month period after the first fill was 160 feet compared to 90 feet for the similar period after the second fill.

As an additional comparison in shoreline response, the rate of shoreline change was computed for both of the periods following the first and second fills. This comparison is shown in Figure 4.18. Like the previous shoreline change comparison, Figure 4.18 shows much larger rates of recession for the first fill period, particularly within the western portion of the groin field. However, for the eastern portion the computed rates over each period are found to be similar. Rates computed along the western half of the groins range from -5 to -10 feet/mo versus about -3 to -5 feet/month for the respective first and second fill periods.

Profile Volume Response. Volumetric changes were also computed and compared for each of the two post-fill periods within the zone covered by the reconstructed groins. Similar to the prior section of the report for the shoreline, the volumetric changes were computed for selected post fill surveys documenting changes for each profile within the groin field area following each fill 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 fill are given in solid brown lines on the graph, whereas the second fill volume change data are shown with dashed blue lines. As with the shoreline changes, the trends in the volumes show the general progressive loss of the fills over time, with the losses being generally uniform in the alongshore sense for the second fill cycle. Further, the losses associated with the first fill are largest within the western portions of the groin field. Unlike the shorelines, one section (around profile 88) is found to have eroded less during the first fill than with the second fill. Further inspection of this profile shows that some material appears to have been deposited within the offshore portion of the profile line during the initial period.

In comparing the post-fill response over similar spans of time, two surveys associated with the initial fill, namely December 2002 (17 months) and the January 2004 (30 months) are used to bracket the comparable date of the second fill. These dates bracket the comparable 23 month time span of the January 2007 survey of the second fill. These plots are shown with a heavy weighted line for each case, where with all other factors being the same, the January 2007 (23 month) blue-dash line should fall about midway between the two bold solid-brown lines from the initial fill period. This comparison reveals that for the overall volume change, the losses are found to be about the same along the eastern half of the groin field but are significantly greater for the first fill cycle along the western half. One reason for this may be that the first fill extended further eastward than the second and also included more material. Some of the sediment placed beyond the groin field limits may have moved westward in this area following the first fill placement. If the volume losses are summed over the extent of the groin field for the common period of interest, the total losses are greater for the first fill period. Specifically, the average loss between Dec02-Jan04 is estimated to be 600,000 cubic yards associated with the first fill versus 440,000 cubic yards, for the second fill.

A similar response is observed for the computed rates of volumetric change when comparing the first and second fill periods. The volumetric rates of change along the Bald Head groin field are shown plotted in Figure 4.20 for each of the fills. Following the trend noted in the above paragraphs, the volumetric rate losses are found to be greater in the western portion of the groin field following the first fill, but are less than the second fill in the remaining eastern portion.

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 fill surveys for the first and second fills. Figure 4.22 likewise shows the rates of onshore volume change computed over each of the fill periods.

From Figure 4.21 it is evident that onshore volume losses were significantly greater following the first fill without the benefit of the groins, versus the second fill period. Along the western portions of the groin field is where the greatest difference is found, with losses being on the order of three times as large. When summing the onshore changes within the groin field the total loss of the second fill amounts to 187,000 cubic yards. In contrast, 405,000 cubic yards were lost in the onshore portions of the profiles during the comparable period of the initial fill.

When the volumetric change rates are compared (as shown in Figure 4.22), a similar 3x's loss rate is also evident in the westernmost areas of the groins, i.e. -1000 cubic yards /month versus -3000 cubic yards/month. Along the eastern portions of the groin field, the loss rates are still less for the second fill, but the difference is not as pronounced between the two fills.

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 bold solid brown lines of the first fill (without groins) can be compared to the second fill (with groins) and the associated bold dashed blue line. It is evident from Figure 4.23 that the response in the offshore is similar except for the middle portions of the area around Profile 88. As noted above, further inspection of this profile shows that some material had been deposited within the offshore portion of the profile line during the initial period. The material could have been sediment that was eroded from the upper portions of the profile and collected into the offshore in this area. As demonstrated above, the onshore losses experienced in the case without the groins were greater. In turn, this eroded material could have deposited just offshore to a greater degree with the first fill. A closer inspection of Figure 4.23, shows that this trend in offshore transport actually continued leading up until the time the of the second fill, with gains in offshore volume occurring between the January 2004 and June 2004 surveys along this area. In terms of overall volume change in the offshore, the total losses of the first fill amounted to 191,000 cubic yards. The compares to a 251,000 cubic yards loss measured over the comparable period of the second fill, an increase loss of 32%.

The computed volumetric change rates for the offshore portions of the profiles are shown in Figure 4.24. This plot shows similar loss rates for the western portion of the groin field area for the two beach fill periods, but a much different pattern for the middle portions. In this regard, the rates associated with the first fill become accretionary for the middle portions of the groin field area, reflecting the offshore profile gains recorded for this area. In contrast, the second fill rates remain negative over this area, although they are found to diminish proceeding to the east.

In summary, the reconstructed groins have had an overall positive effect in retaining the beach to date. This is evident by comparing the beach fill response for two periods, one with and one without the groins. This is particularly evident 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 feet, and with the shoreward end of the groins terminating at elevations of about -2 feet or above. The offshore portions of the profiles (below -2 feet) were found to have greater volumetric losses (32%) with the second fill and the groins in place. One possible explanation for this is that during the first fill, the onshore portions of the beach were more easily eroded without the groins in place. The material deposited just offshore, resulting in larger offshore gains when compared to the second fill with the benefit of the groins.

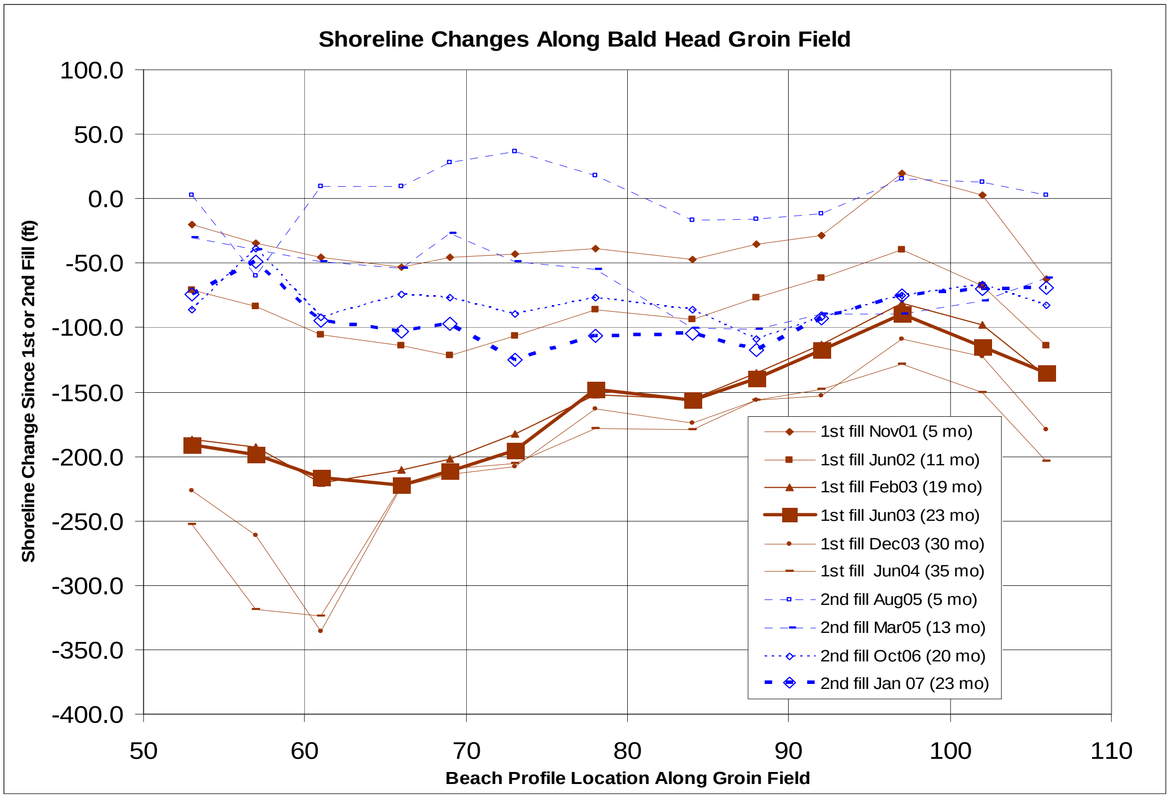


Figure 4.17 Shoreline Changes Along Bald Head Groin Field

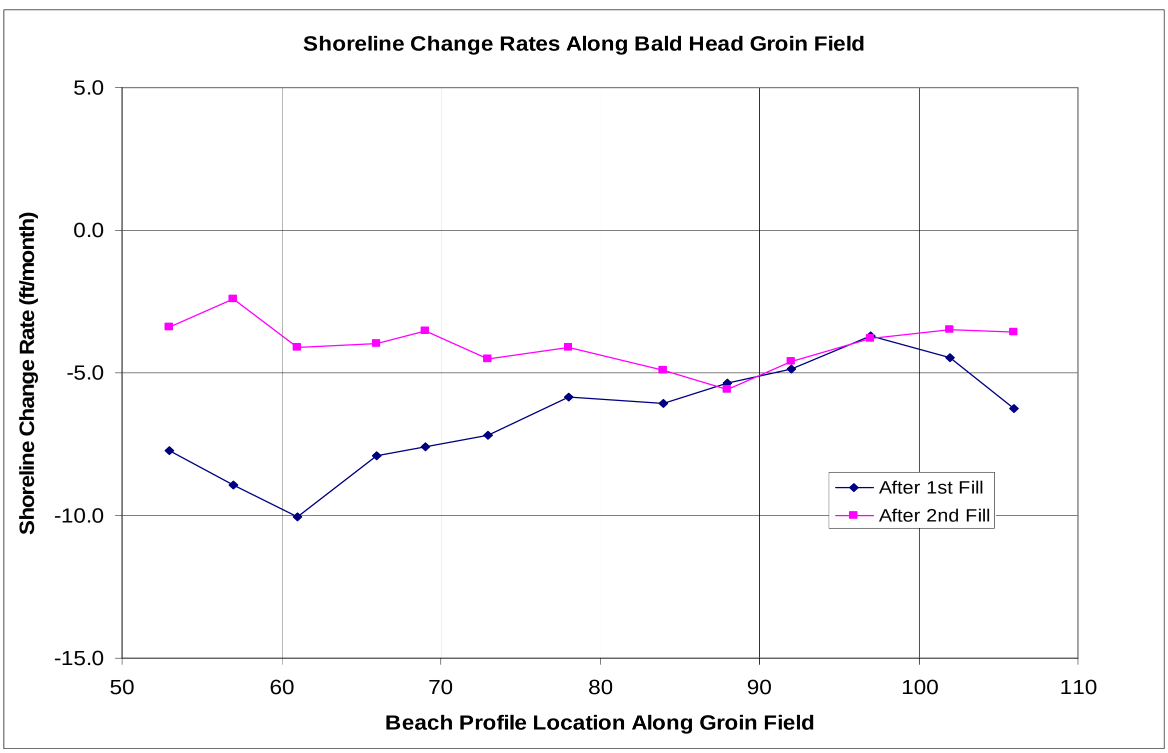


Figure 4.18 Shoreline Change Rates Along Bald Head Groin Field

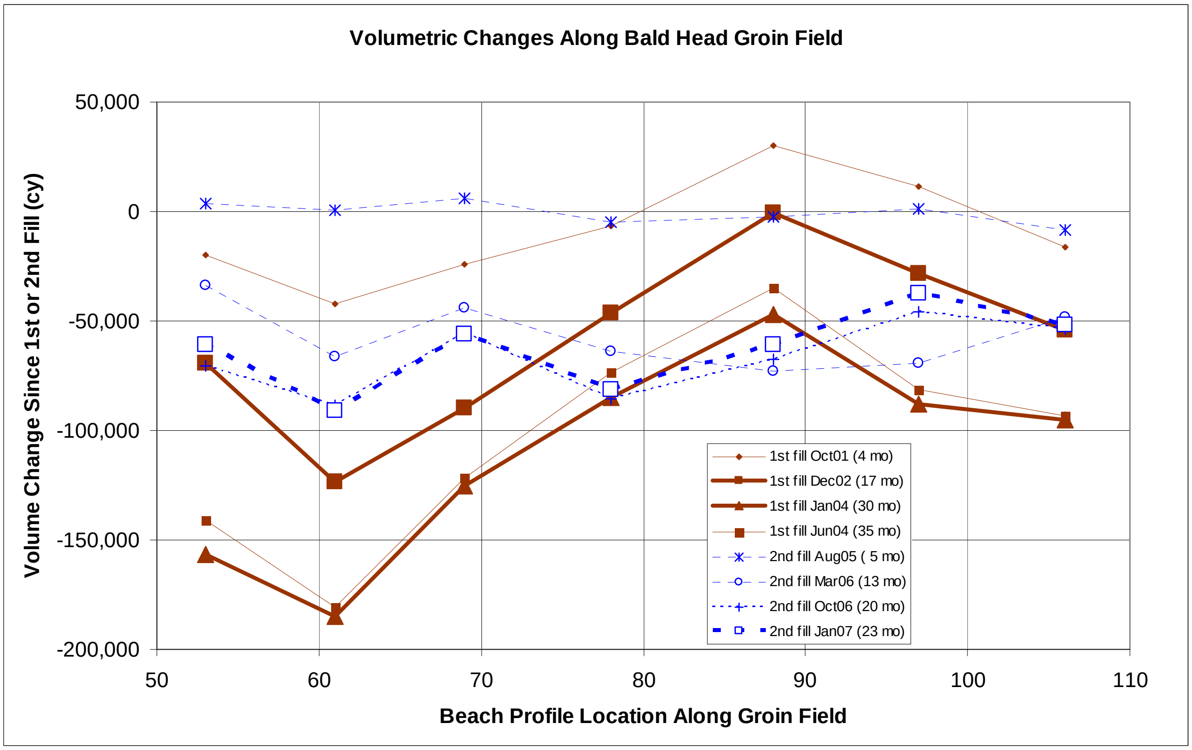


Figure 4.19 Volumetric Changes Along Bald Head Groin Field

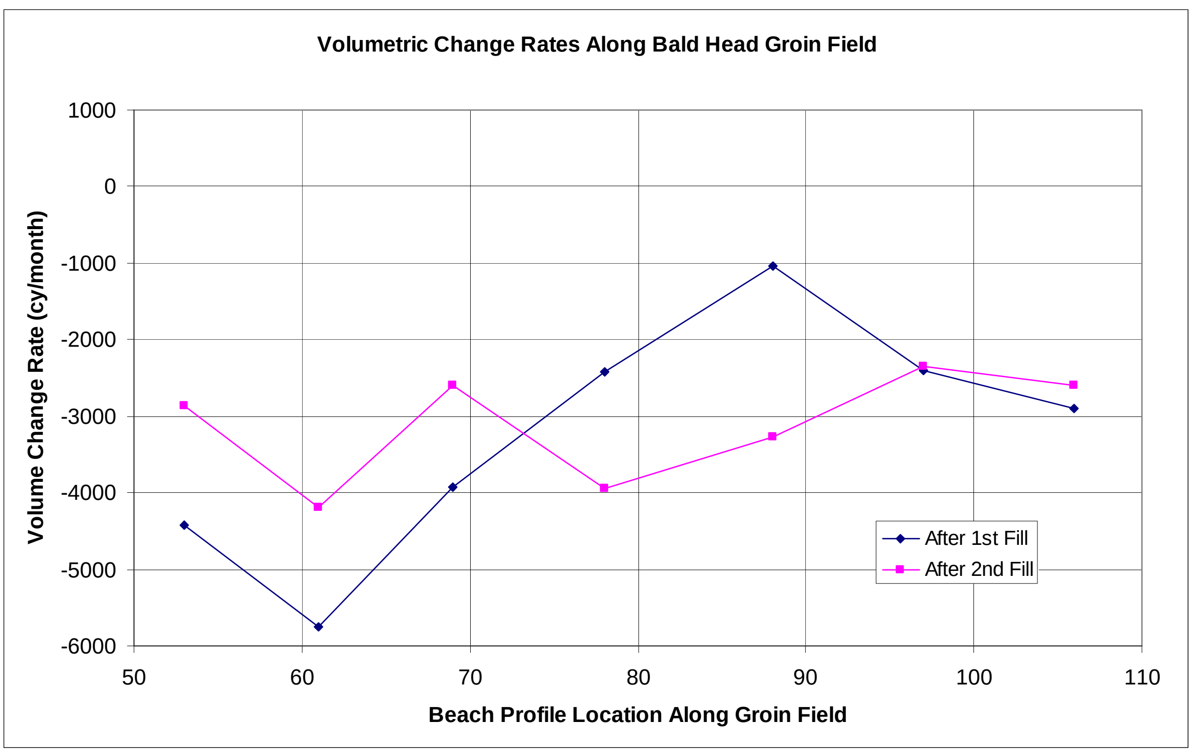


Figure 4.20 Volumetric Change Rates Along Bald Head Groin Field

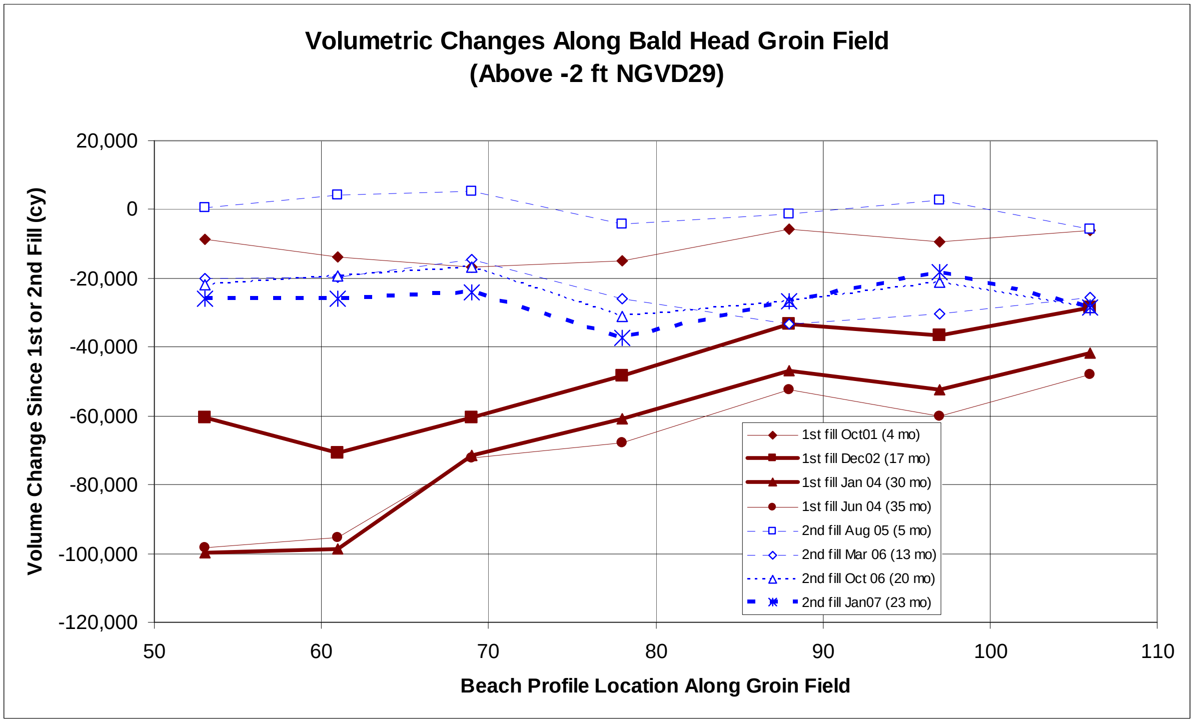


Figure 4.21 Onshore Volumetric Changes Along Bald Head Groin Field (Above -2 ft NGVD29)

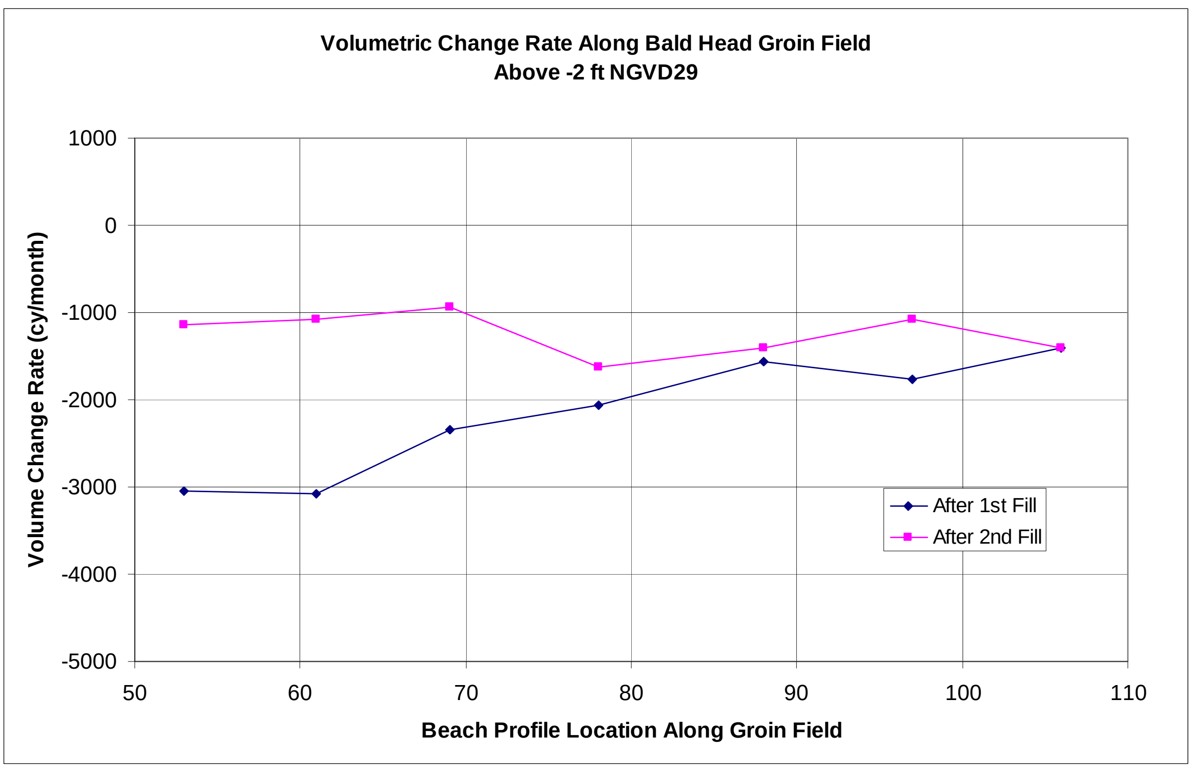


Figure 4.22 Onshore Volumetric Change Rates Along Bald Head Groin Field (Above -2 ft NGVD29)

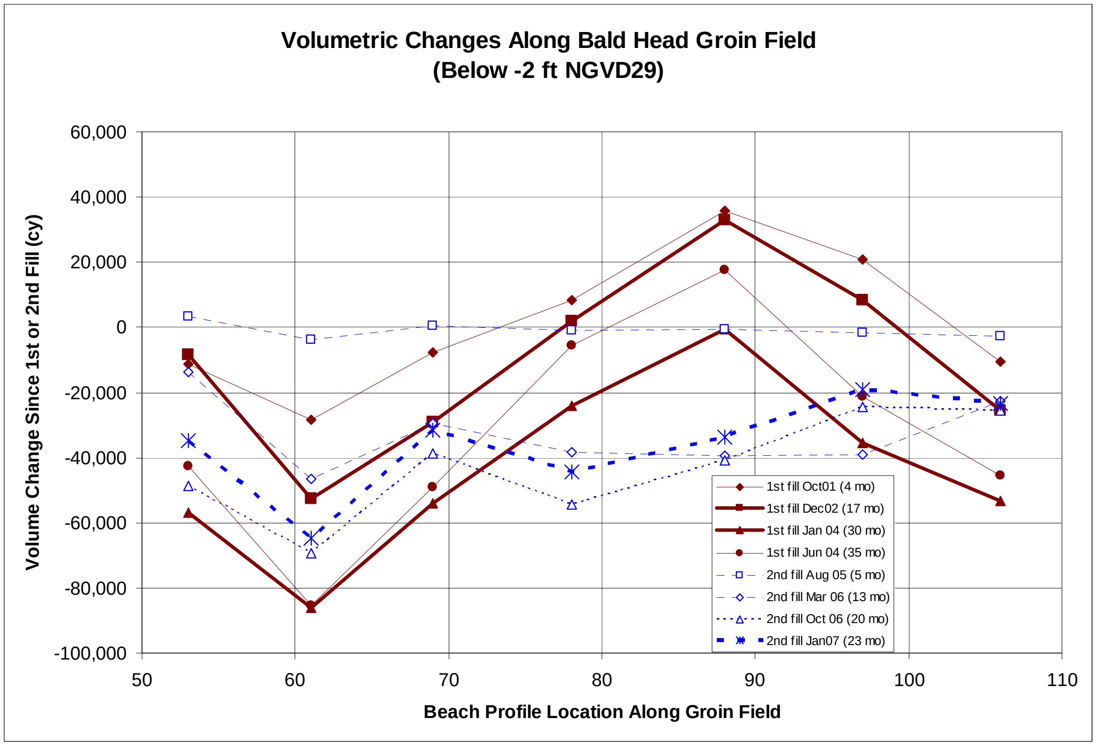


Figure 4.23 Offshore Volumetric Changes Along Bald Head Groin Field (Below -2 ft NGVD29)

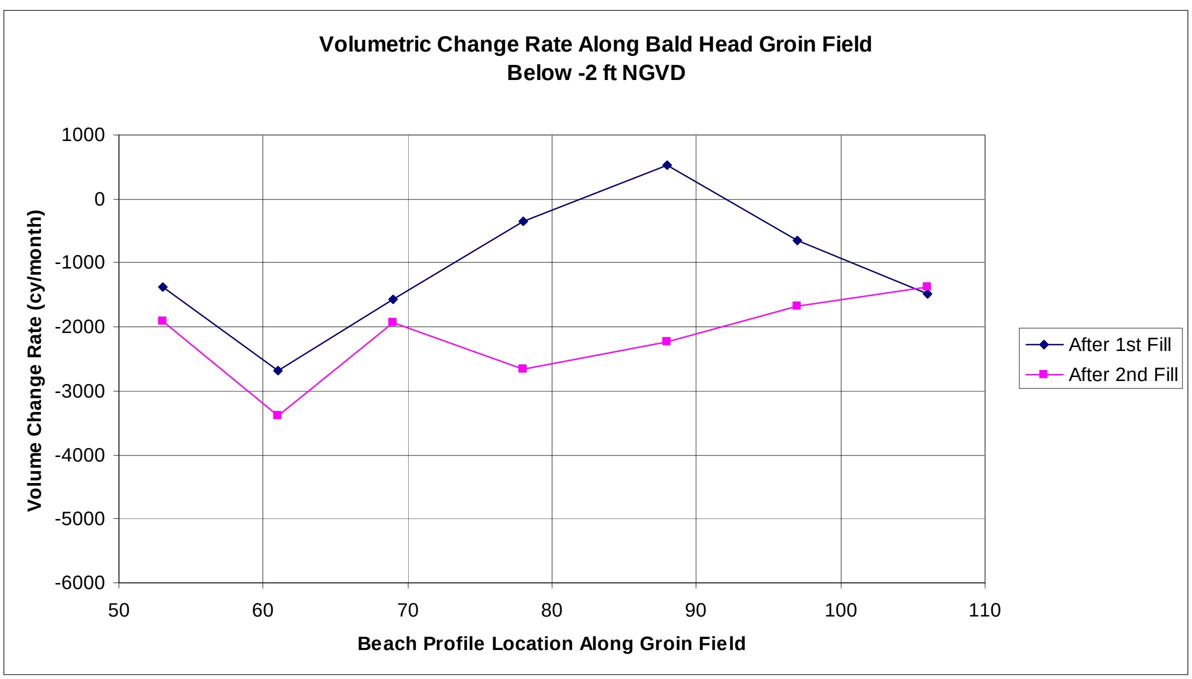


Figure 4.24 Offshore Volumetric Change Rates Along Bald Head Groin Field (Below -2 ft NGVD29)

Part 5 SUMMARY

This report is the fifth of a series updating the data collection and results of the physical monitoring program for the Wilmington Harbor Project. The program consists of periodic beach profile and bathymetric surveys, wave and current measurements designed to document changes associated with the project. The monitoring focuses on the entrance channel improvements and impacts to the adjacent beaches of Oak Island/Caswell Beach to the west and Bald Head Island to the east. It also serves as a tool for overall sand management considerations for the Cape Fear entrance and adjacent beaches. The report covers through the seventh year of data collection and focuses on the most recent period of October 2006 through September 2007. 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 fill were placed along the western half of Bald Head’s South Beach. Following the fill placement, the Village of Bald Head proceeded with the reconstruction of a groinfield along South Beach. The work consisted of replacement of 16 sand filled 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 next maintenance cycle, is scheduled for disposal along eastern Oak Island/Caswell Beach in 2009 in accordance with the sand management plan.

Results to Date.

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 4 (October 2006) 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 2006 to July 2007) and for the entire period (from August/September 2000 to July 2007).

For Oak Island/Caswell Beach, the shoreline change measured over the last year has been somewhat variable over the 6-mile monitoring area with an overall trend being one of erosion. When considering all profile lines, an average shoreline retreat of 12 feet is evident for the present period of October 2006 to July 2007. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –100 to +75 feet), the alongshore trend is also erosional with an average 13 foot loss for the same period with the greatest losses occurring within the western half of the region. When considering changes with respect to the August 2000 pre-construction position, the same high degree of variability is evident near the tip of the island, but a much stronger trend towards accretion is present extending westward along the remaining portions of the island. In fact, except for a couple exceptions, the surveys show that all shoreline changes measured west of Profile 40 are positive. To a large degree, this reflects the shoreline response and subsequent stable behavior of the fill placed along this entire reach associated with the channel deepening in 2001. In considering all the profile data, the alongshore average shoreline position was 97 feet more seaward in January 2007 than it was in 2000. Likewise, the shoreline position was 82 feet more seaward in July 2007, than it was seven years ago at the start of the project. Only one area may be of some concern along Oak Island. This 3,000-foot-long area, just to the west of the CP&L canal (between Profiles 90 and 120), did not receive material during the 2001 dredging. This reach has remained stable over the years, but has relatively smaller shoreline advances (about 0 to 30 feet) compared to the adjacent reaches. Further, although the remaining portions of Oak Island remain healthy with respect to the base condition, these fill areas have eroded over the last year particularly evident within the western half of the monitoring area.

In terms of volume change, Oak Island/Caswell Beach has shown mostly accretion except for a zone extending between Profiles 60 & 100 over the current period. The erosional zone extends for about 4000 feet and represents a modest volumetric loss of 53,000 cubic yards. Aside from this area, the remaining data show positive changes throughout. When considering all profile lines, a net gain of 112,400 cubic yards was computed since the last report, between October 2006 and July 2007. This overall stable trend observed over the current period is typical of that measured for the entire 7-year monitoring period. As such, all reported volume changes are positive with the exception of several isolated profiles which show small losses. The alongshore pattern shows relatively lower volume gains in the vicinity of Profiles 40, 100, and 180. All other areas are very healthy with respect to volumetric gains relating back to August 2000 base condition. Specifically, by the end of the period, an excess of 1,423,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity actually reflects a modest net gain above the fill volume placed in 2001 of about 280,000 cubic yards. Most of this remaining balance is within the western portion of the monitoring area and is believed to be the result of the eastward spreading of a separate beach fill (Sea Turtle Habitat Project in 2001) placed just beyond the boundary of the project area. The alongshore distribution of material basically follows the shoreline response where net gains are seen along most of the island.

Since the last reporting, most of the profile locations along Bald Head Island have been accretional. This response is largely driven by the beach fill completed in April 2007, which is bracketed by the two most recent monitoring surveys. The results show large gains at each end of South Beach with more moderate gains in the mid-portions of the beach, reflecting the nature of the fill disposal which was placed in two segments with a gap in the middle. Specifically, the largest accretion measured at the end of the period was more than 250 feet at the western terminus of the fill, located in the vicinity of the spit. Another peak gain of more than 200 feet was measured in an area near the eastern terminus of the fill between Profiles 160 and 170. In between these peak gain areas, the beach remained stable showing shoreline changes from 0 to 50 feet. When considering the overall area bounded by the outer limits of the fill (between Profiles 45 to 170), the shoreline was found to have advanced an average of 118 feet. Extending east of the fill area, the beach remains stable and then turns erosional in the immediate vicinity of the cape.

As indicated in prior reports, the area in the vicinity of the spit (Profiles 32 to 47) is found to be highly variable. Over the last year, a portion of this area has shown gains of about 300 feet with adjacent portions losing 60 feet. The greatest gains are found at Profiles 40 thru 47 under the direct influence of the recent beach fill. In contrast the greatest loss is found at Profile 36 just inside the advancing spit. The remaining area along West Beach (Profiles 0 thru 28) has shown a general loss over the period, with the shoreline retreating about 5 to 10 feet over much of this area. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 7 feet with the January 2007 survey and a gain of 70 feet as of July 2007, since the last reporting.

Shoreline change patterns as measured over the last 7-year period, i.e., since the monitoring was initiated, are strongly positive when measuring relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional, with the July 2007 shorelines being typically 50 feet to as much as 300 feet seaward of their September 2000 positions. In fact only one profile along south beach (Profile 61) is shown to have a net erosion of the last 7-year period with a retreat of 13 feet. The measured shorelines in the vicinity of the cape also remain positive at the end of period being more than 300 feet through the most current survey. The exception to this general stable pattern is a small area of erosion within the vicinity of the spit area at the western limit of South Beach. Specifically, this area contains Profiles 43 and 45 which are located just west of the groin field, where present shoreline retreat is on the order of 20 feet. By comparison with the two prior surveys, this erosion area has been greatly reduced through the placement of the recent fill. Proceeding further to the west, the erosion turns positive over the remaining portions of the spit area, reaching a maximum advance of 235 feet. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline has shown an average loss of about 13 feet when compared to the base condition. When considering all locations along Bald Head Island (Profiles 0 to Profile 218), the shoreline is presently on the average 131 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey (October 2006) of Report 4 to the present, Bald Head Island is dominated by large gains along most of South Beach, except for a few areas which have relatively small losses. As discussed above, the volumetric increases are driven by the most recent beach disposal along South Beach. As such, the greatest increases are located along the western and eastern portions of South Beach, with relatively smaller gains shown between these two peak areas. The few areas which have volumetric losses over the present cycle are located along West Beach, the spit and near the cape. In summing the changes over the entire monitoring area, the losses are overridden by the gains which resulted from beach disposal amounting to a positive net change of about 792,400 cubic yards over the period from October 2006 to July 2007. Additionally, the zones along South Beach which received the dredged material (Profiles 44 to 91 and 110 to 170) were found to have increased by 855,000 cubic yards over the same period. This compares favorably to the in-place quantity computed during the fill operation which amounted to 978,500 cubic yards, implying a relatively modest loss of the fill of 123,500 cubic yards or about -13% loss of material.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, Bald Head Island is again dominated by overall gains over the last seven years. The most substantial increases are found along the western half of South Beach and in the vicinity of the spit. Elsewhere, there are two areas which have recorded net overall losses for the period. One is located at the extreme eastern end of south beach, where some losses have occurred near the cape. The other, which is of greater concern, is along the westernmost portion South Beach extending into the spit area between Profiles 45 to 70. This reach, covering approximately 2,500 feet, has been the site of chronic erosion in the past. Volumetrically this represents net loss of about 249,400 cubic yards. Aside from these areas of erosion, all other profile volume changes are positive throughout. As a result of this overall response in the profiles, the net volume change is a gain with respect to the beginning of the monitoring in 2000. The total volume change is a 456,300 cubic yard gain in January 2007 and 1,316,800 cubic yard gain by July 2007.

Rates of shoreline change were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the North Carolina Division of Coastal Management (NCDCM) shoreline data based on a 62-year period of record (1938-2000). Although the monitoring period spans a relatively shorter time period of about 7 years, it is of interest to compare these trends with established long-term shoreline response for the area.

Shoreline change rates computed over the initial 7-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 beach fill. Although these positive rates have been found to moderate since the fill placement, they remain in sharp contrast to the long-term trend. Overall, the shoreline change rate averaged over the entire monitoring area was about +21 feet per year for the 7-year period. By comparison the long-term NCDCM rate over the entire reach was –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 7-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 although the extent and magnitude of this zone have decreased for rates computed through the present period. A direct comparison of the pre- and post-construction shoreline change rates show that only three profile lines are eroding at a higher rate during the post-construction period. These lines at located at the western end of south beach (Profiles 53, 57 and 61). Adjacent Profile 66 is presently eroding but at a lower rate as compared to the pre-construction condition. All other lines are accreting in direct contrast to the long-term erosion experienced along the remaining areas of South Beach. Most of this response is attributable to the beach fill placement and possibly to the positive effect of the rehabilitated groin field.

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 established with respect to a minimum acceptable channel width is 500 feet at the -42 feet mean low water (MLW) elevation. As of 2007, seventeen condition surveys have been accomplished, four of which occurred over the present reporting period (January 2007, March 2007, June 2007 and September 2007). The channel condition at the end of the prior reporting period in Report 4 revealed that stations 20+00 through 24+00 and stations 33+00 through 34+00 within Bald Head Shoal Channel 1 had all exceeded the threshold. The average navigable width in these areas was 469 feet with the minimum occurring at station 23+00 at a width of 438 feet. Do to the forthcoming 2007 maintenance dredging no action was undertaken at that time. With the subsequent dredging being under taken over the present period (March-April 2007), this breach of the navigable width threshold has now been corrected. As a result all reaches easily satisfy the minimum width criteria of 500’ at -42’ MLW as of the present reporting period. Specifically, the minimum navigable width within Reach 1 was approximately 657 feet at station 19+00 and the maximum navigable width was found to be 1019 feet at station 6+00. Further Reach 1 had an overall average navigable width of 787 feet.

The navigation channel surveys have shown the area of the spit to have enlarged volumetrically to at least twice as large as previously observed following the 1.8 million cubic yard fill placement in 2001-02. The same area of growth was monitored following the dredging and placement of 1.2 million cubic yards in 2004-05 as discussed previously in Report 4. The comparison showed that the rate of growth was slower following the second event. This analysis was continued for the present report leading up to the 2007 dredging event. The results showed that the trend continued showing a lower shoaling rate for the entire period following the second dredging. Specifically, the initial rate was about 16,000 cubic yards per month versus the second rate of about 9,800 cubic yards per month, i.e., a 39 % reduction in shoaling rate. A similar analysis was done following the most recent dredging in 2007. The results showed an even lower monthly shoaling rate of 3,650 cubic yards was evident for the third dredging/shoaling cycle. This result is only based on two surveys of the most recent cycle, so the results should be viewed with caution and additional future data are needed to verify this trend. Among the possible explanations for this slower spit growth rate are: (1) sand tube groin field constructed immediately after the 2004/2005 placement has been effective in retaining the fill, (2) smaller volume of material placed in the 2004/2005 placement dispersed from the island at a slower rate, (3) different location of placement with the second fill being farther away from the channel, and/or (4) possible dissimilar wave and current conditions for each period of record.

The effectiveness of the reconstructed groins was analyzed by comparing the response of the 2001 beach fill (without the groins) to the 2006 beach fill (with the groins). The analysis revealed that the new groin field has 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. In this regard, shoreline changes over similar time frames after the first and second fills show shoreline retreats on the order of twice as large for the first post-fill period. Specifically, the average retreat within the groin field for the 23 month period after the first fill was 160 feet compared to 90 feet for the similar period after the second fill. The onshore volume losses were also found to be significantly greater following the first fill without the benefit of the groins. This is particularly true within the western portions of the groin field with losses being on the order of three times as large.

Detailed bathymetric surveys were made of the ebb and nearshore shoals in the vicinity of the entrance channel to assess any changes associated with the entrance channel deepening and realignment. Aside from the direct changes resulting from dredging the new channel, the major overall changes in morphology of the ebb and nearshore shoals since the start of the monitoring have included changes along Jay Bird Shoals, Bald Head Shoals, and within the vicinity of the old channel bed. The changes within Jay Bird Shoals have been somewhat complex with some portions shoaling and some portions scouring. Generally, the outer portions have shown a generalized lowering but a moderate amount of shoaling has occurred within the northernmost area of Jay Bird Shoals just off the tip of Oak Island. Adjacent to this shoal is a scour feature associated with a flood channel just offshore of Oak Island although the last two surveys have shown this feature to have become more stable. On the other side of the channel, Bald Head Shoal has shown significant gains extending off of the southwestern corner of Bald Head Island. Additionally, the old channel bed has also accreted since the beginning of the monitoring period, as this area is used as a disposal site for other dredging operations in the river.

To date currents have been measured on seven occasions, with the initial occurring before the channel improvements and the remaining six after the deepening. Currents are measured over a complete tidal cycle along transects across the mouth of the entrance channel and along the seaward portion of the ebb tide delta near the intersection of the old and new channel alignments. Comparison of current measurements taken before and after the channel dredging show very similar flow regimes and are consistent with the minimal change seen in the overall bathymetry of the ebb tide delta. Of interest, however, is that with each of the post-dredging measurements, the maximum velocities are found to be greater than those of initial current survey. This was evident with both the inlet and offshore transects.

Sand Management Considerations.

Operation of the project involves the implementation of a Sand Management Plan. Under this plan, disposal of beach compatible sediment is to occur on the beaches adjacent to the Cape Fear River entrance every 2 years. The distribution is such that disposal is 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 (i.e. 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 fill. The groin reconstruction took place over the period of March-May 2006. 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 next maintenance is scheduled for disposal along eastern Oak Island/Caswell Beach in 2009 and will complete the first overall 2 to 1 sand management cycle (i.e. through year 6). Ongoing monitoring efforts will be used to document the performance of this recently placed fill and to plan the third maintenance cycle. The results presented in this report along with the next scheduled monitoring surveys will be used to establish the quantities and limits of the fill. The final disposal plan will be fully coordinated with local interests.

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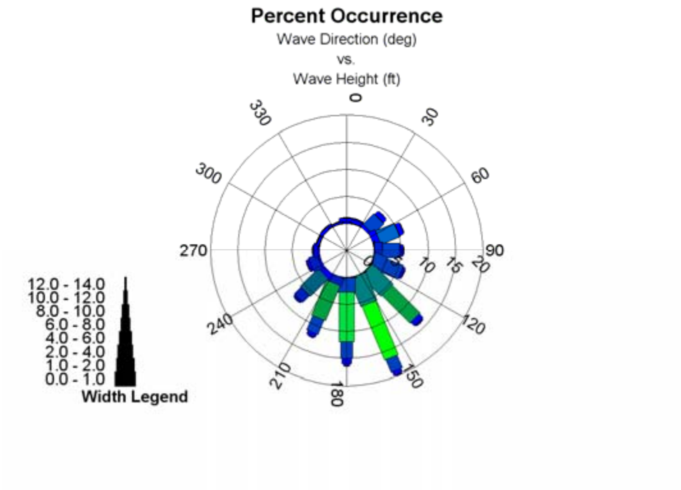
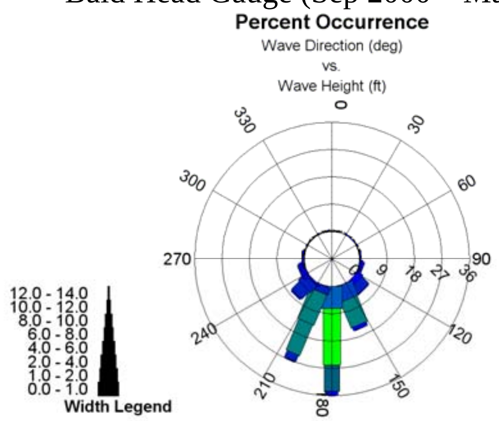
Appendix A

WAVE GAUGE DATA
Wave Roses (2000 thru 2007)

Eleven-Mile Gauge (Sep 2000 – Sep 2007)



Bald Head Gauge (Sep 2000 – Mar 2007)



Oak Island Gauge (Sep 2000 –Sep 2007)

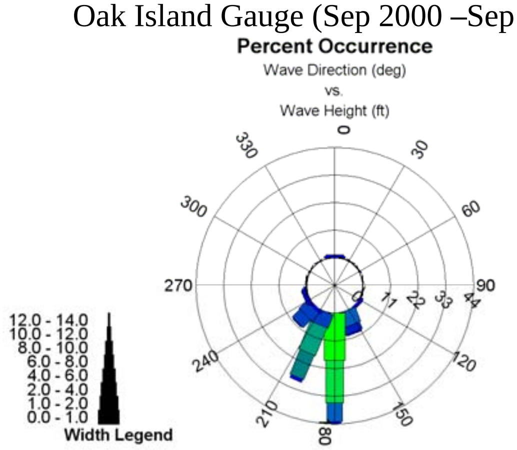
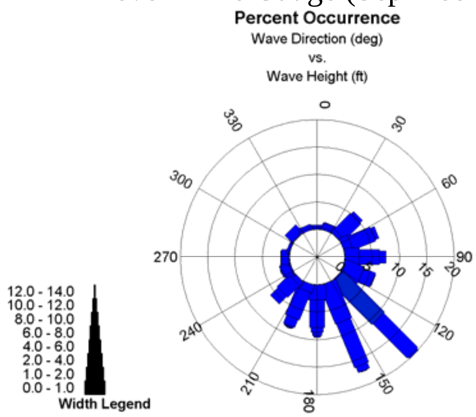
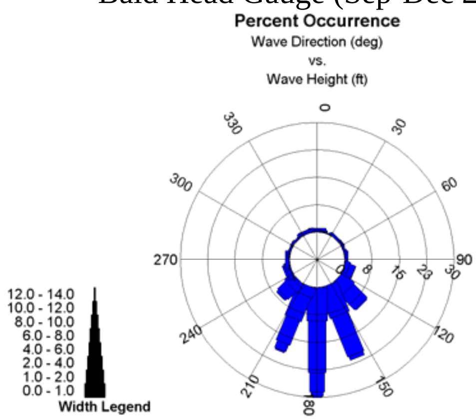


Figure A-1 Wave Height Roses for FRF Gauges throughout deployment.

Eleven-Mile Gauge (Sep-Dec 2000)



Bald Head Gauge (Sep-Dec 2000)



Oak Island Gauge (Sep-Oct 2000)

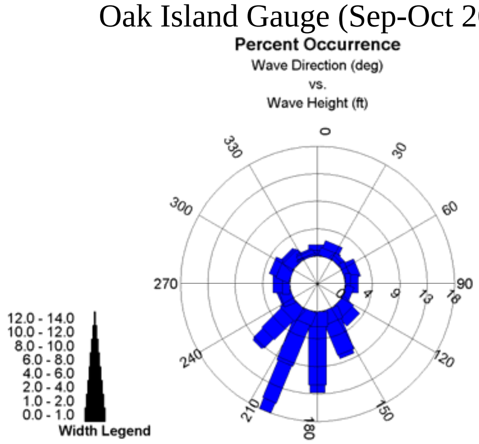
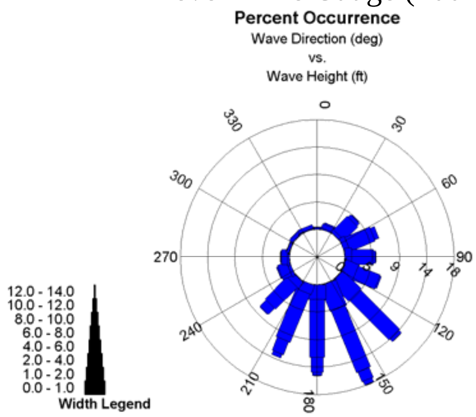
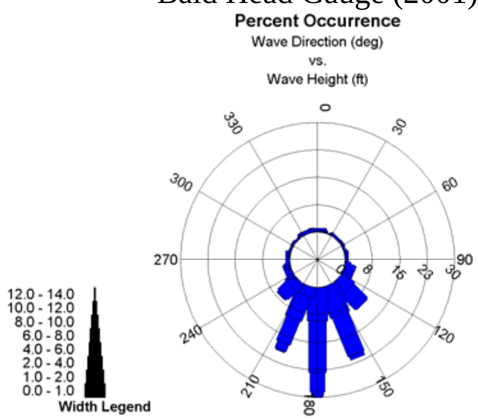


Figure A-2 Wave Height Roses for FRF Gauges (2000).

Eleven-Mile Gauge (2001)



Bald Head Gauge (2001)



Oak Island Gauge (2001)

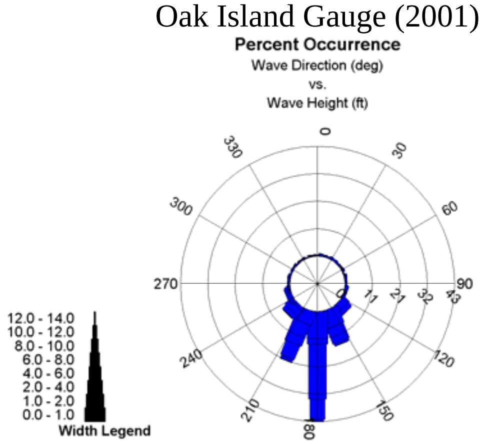
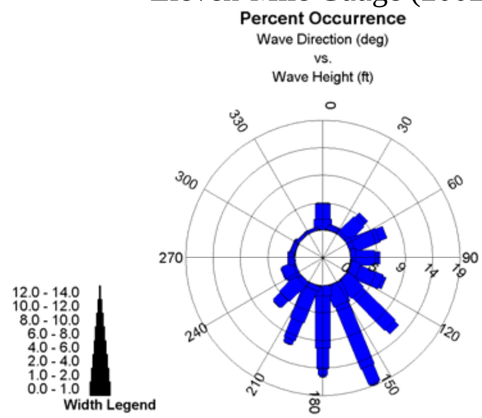
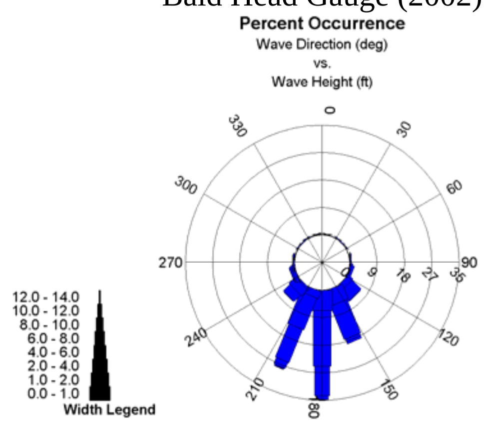


Figure A-3 Wave Height Roses for FRF Gauges (2001).

Eleven-Mile Gauge (2002)



Bald Head Gauge (2002)



Oak Island Gauge (2002)

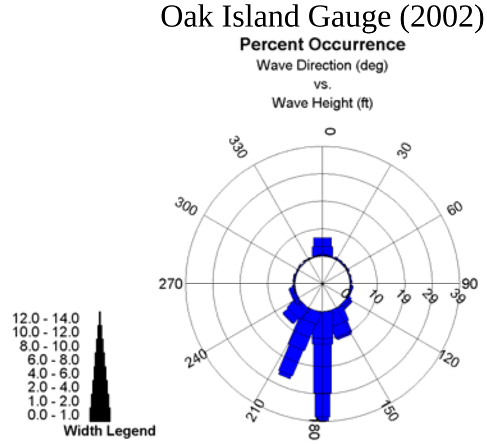
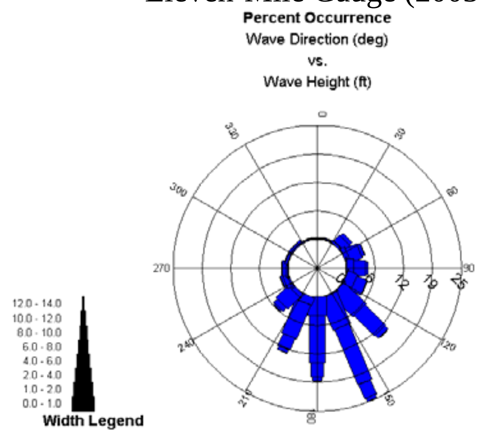
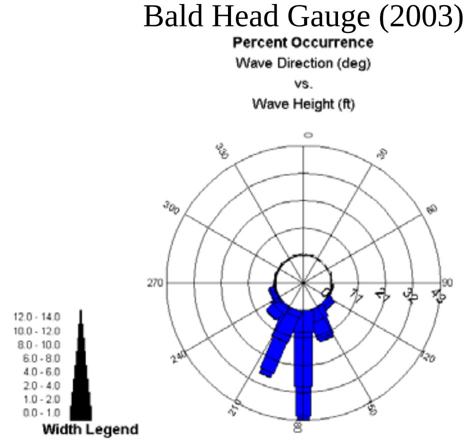


Figure A-4 Wave Height Roses for FRF Gauges (2002).

Eleven-Mile Gauge (2003)



Bald Head Gauge (2003)



Oak Island Gauge (2003)

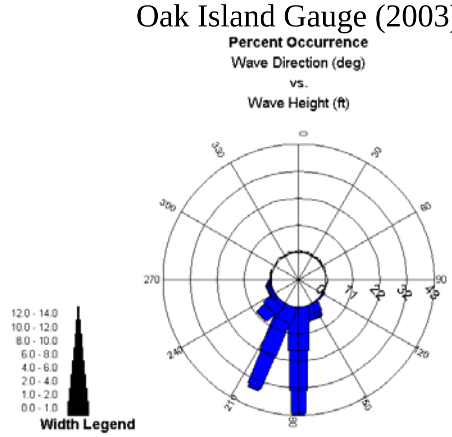
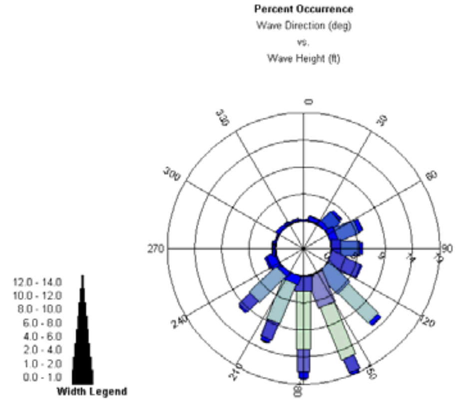
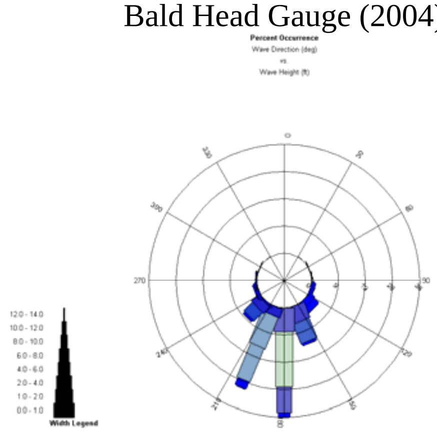


Figure A-5 Wave Height Roses for FRF Gauges (2003).

Eleven-Mile Gauge (2004)



Bald Head Gauge (2004)



Oak Island Gauge (2004)

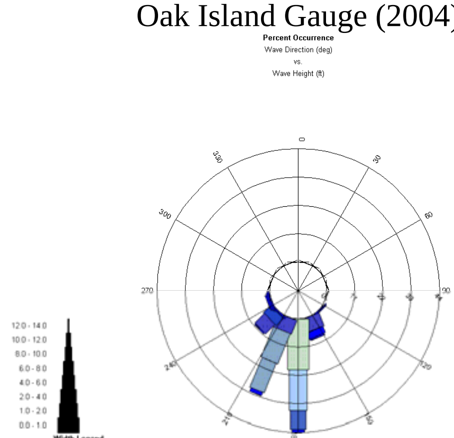
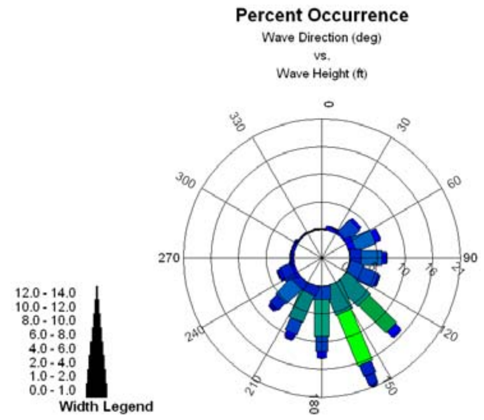
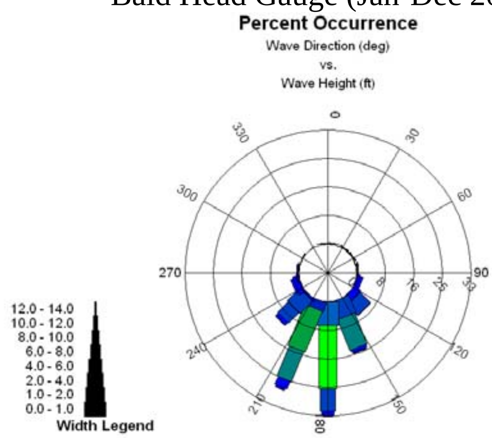


Figure A-6 Wave Height Roses for FRF Gauges (2004).

Eleven-Mile Gauge (Jan-Dec 2005)



Bald Head Gauge (Jan-Dec 2005)



Oak Island Gauge (Jan-Dec 2005)

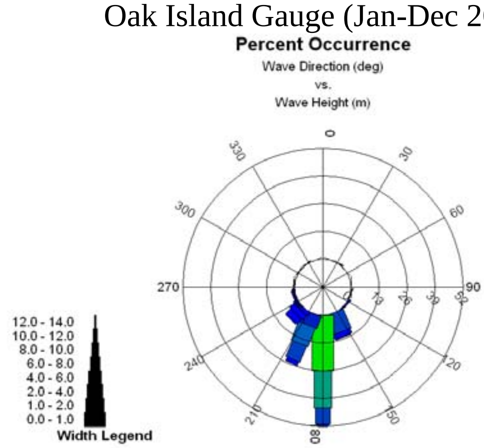
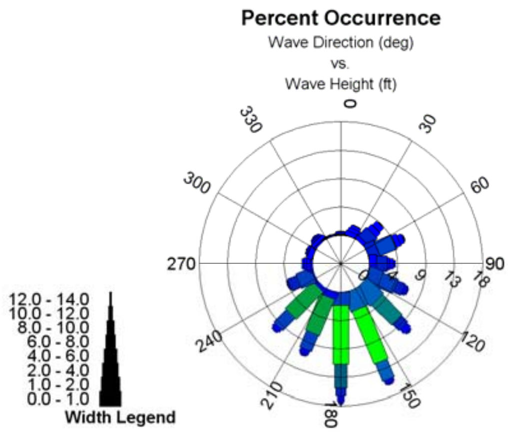
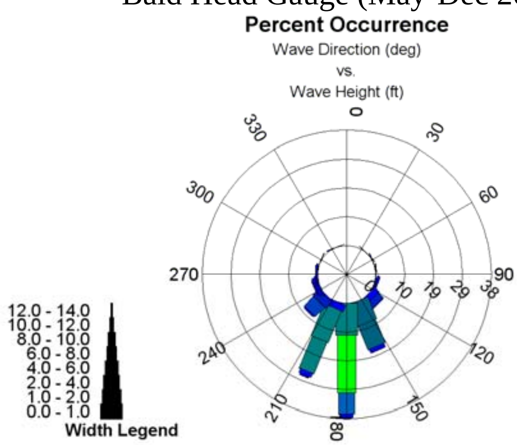


Figure A-7 Wave Height Roses for FRF Gauges (2005).

Eleven-Mile Gauge (Jan-Dec 2006)



Bald Head Gauge (May-Dec 2006)



Oak Island Gauge (Jun-Sep 2006)

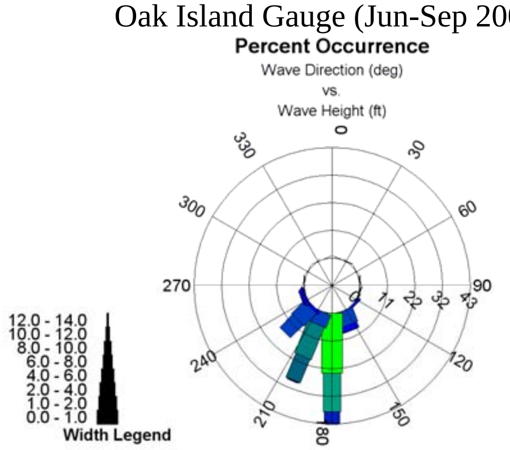
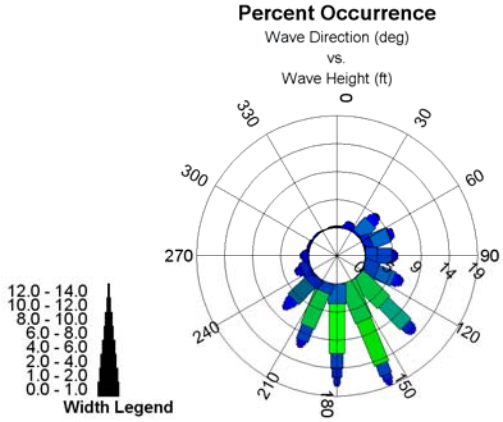
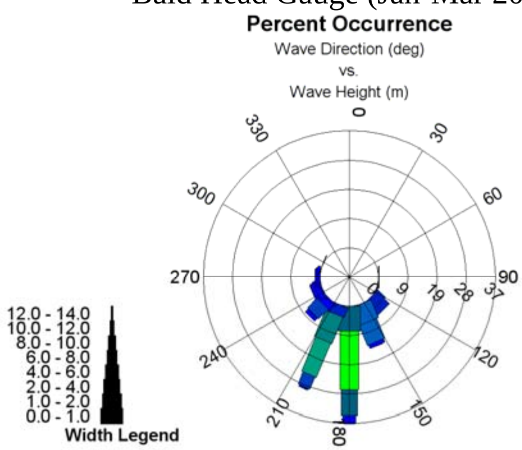


Figure A-7 Wave Height Roses for FRF Gauges (2006).

Eleven-Mile Gauge (Jan-Sep 2007)



Bald Head Gauge (Jan-Mar 2007)



Oak Island Gauge (Apr-Sep 2007)

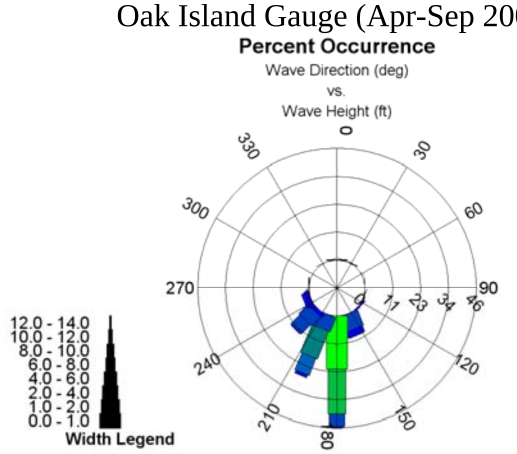
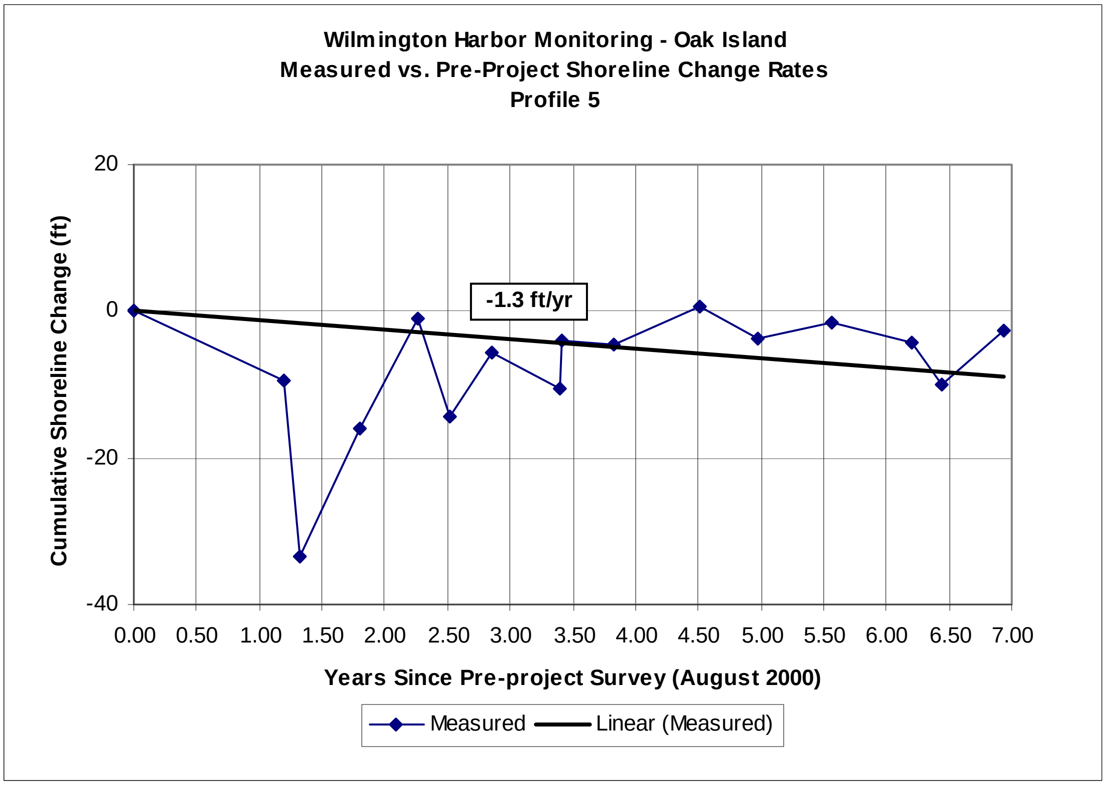
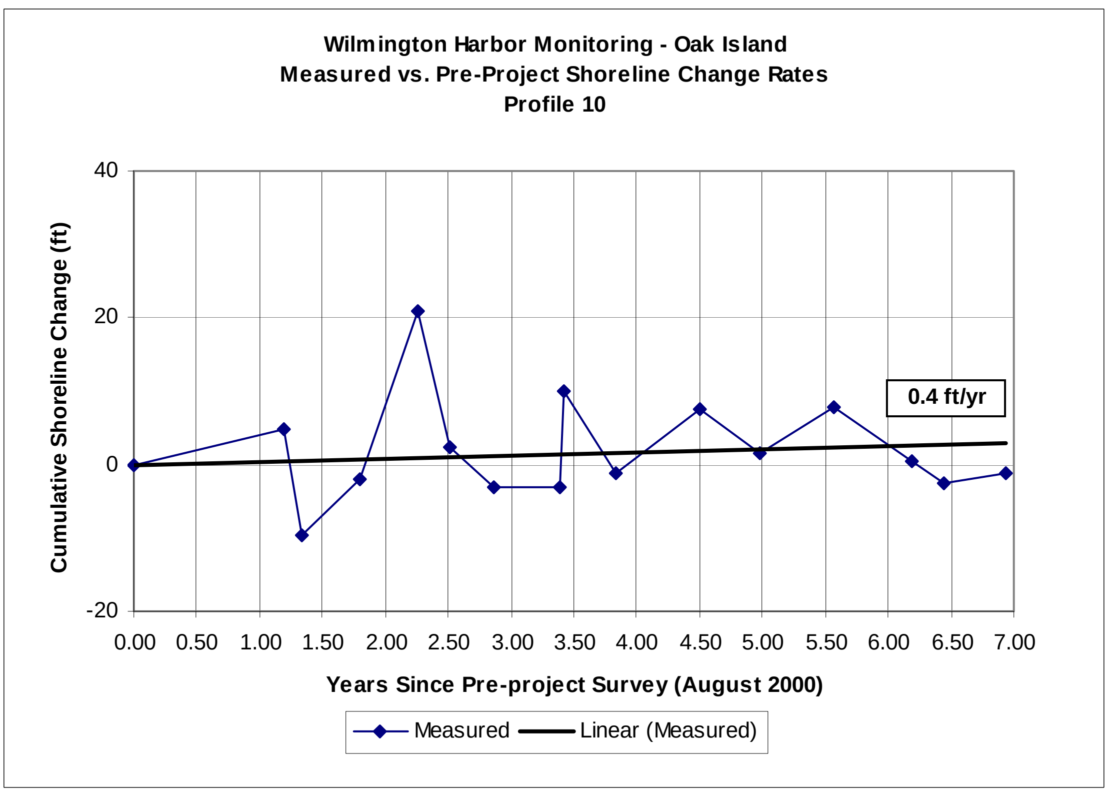


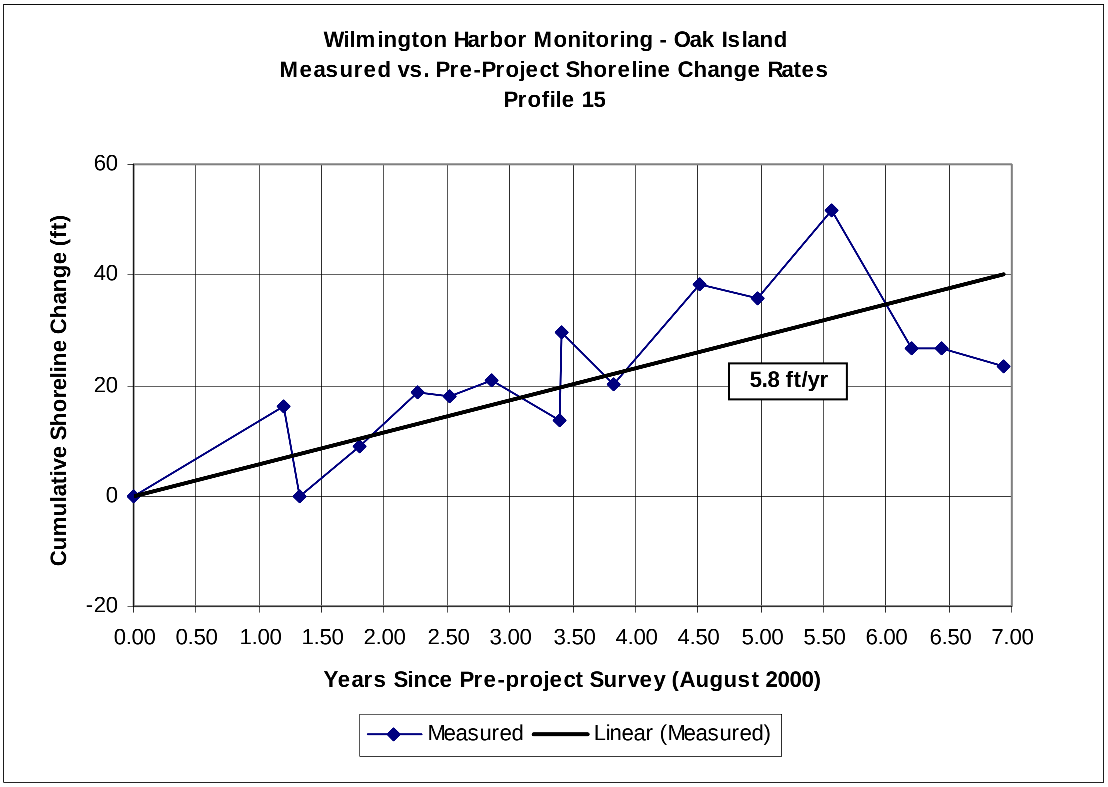
Figure A-7 Wave Height Roses for FRF Gauges (2007).

Appendix B

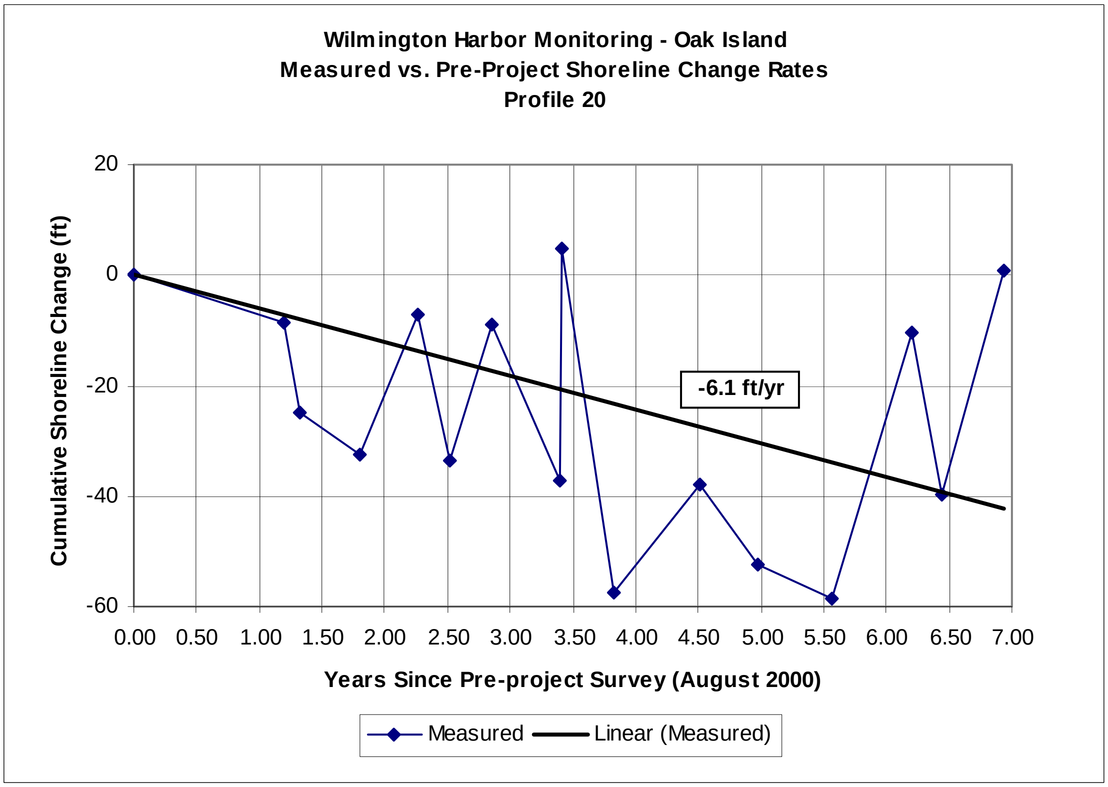
SHORELINE CHANGE RATES
(Oak Island)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 5
-1.3 ft/yr
Cumulative Shoreline Change (ft)
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

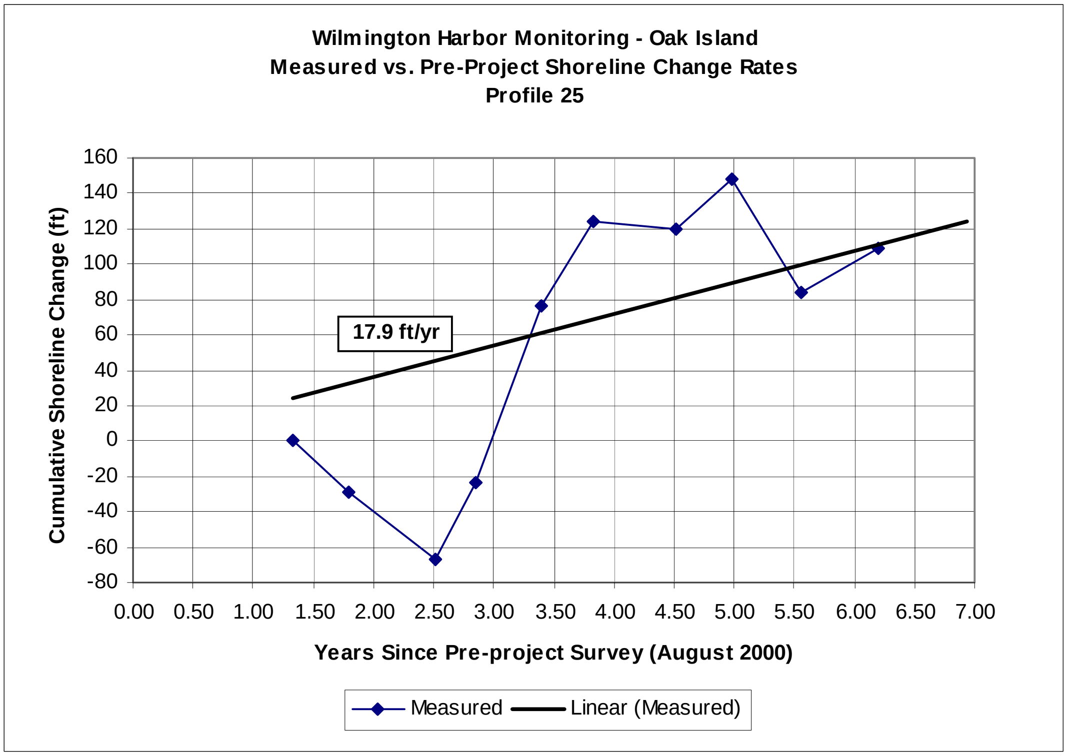

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 10
0.4 ft/yr
Cumulative Shoreline Change (ft)
40
20
0
-20
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

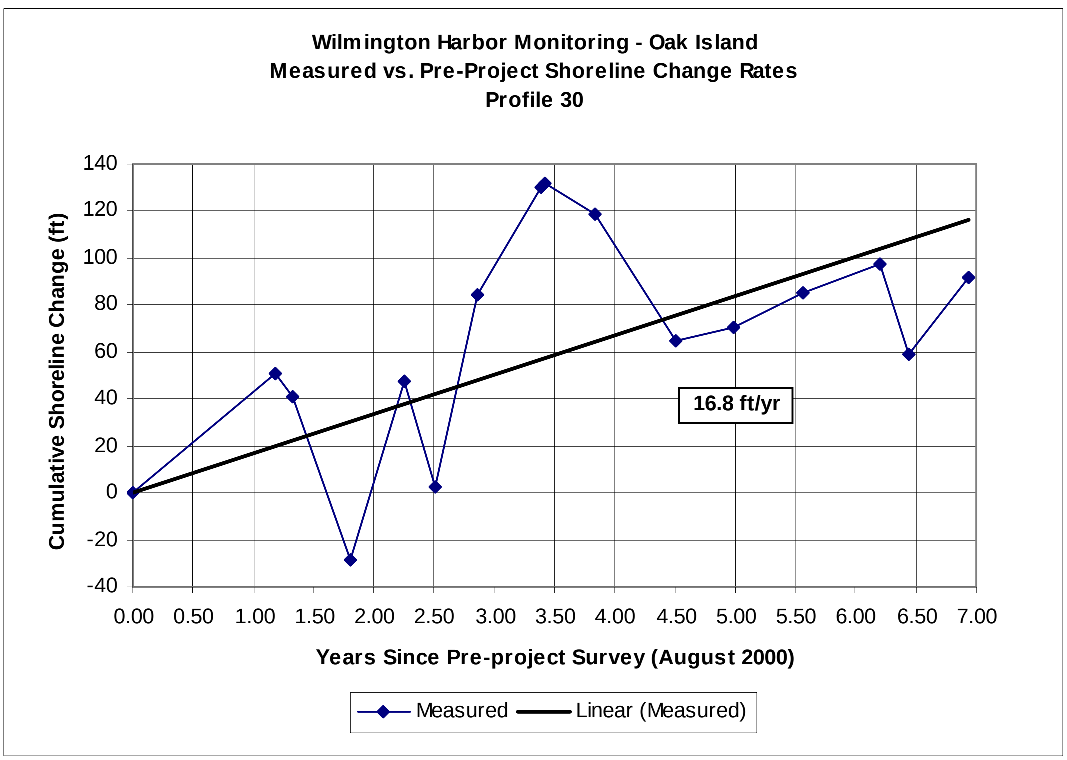


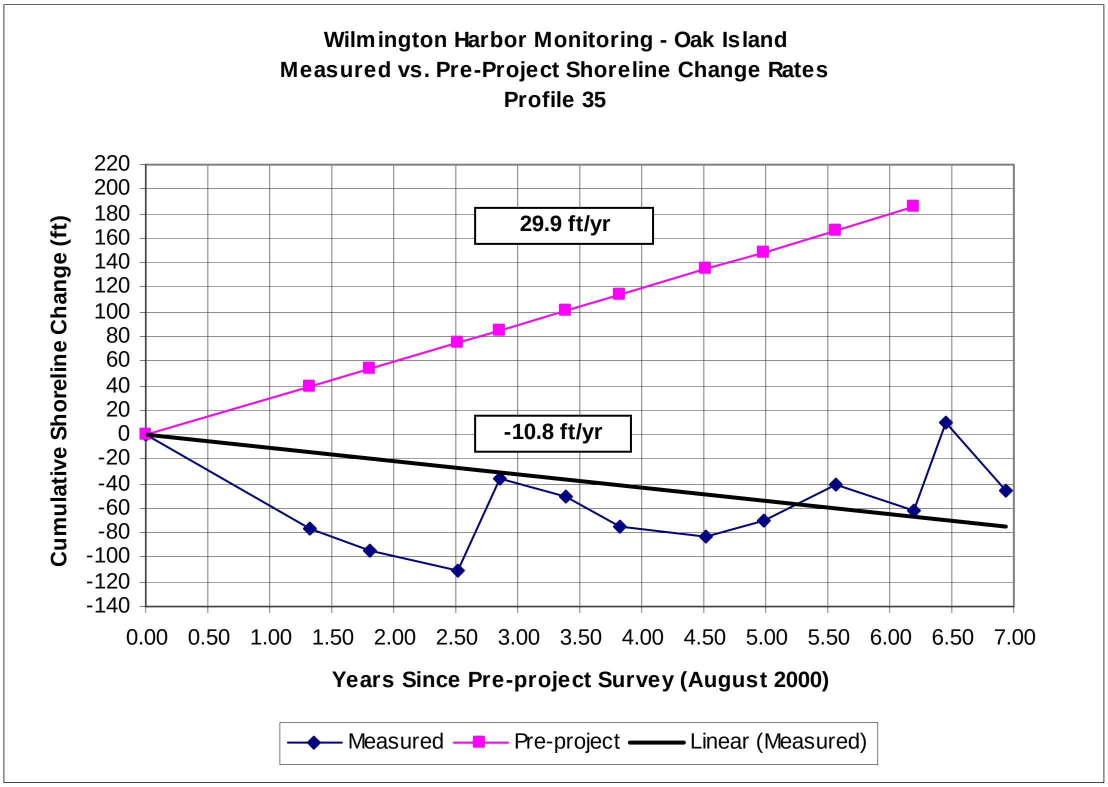
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 15
Cumulative Shoreline Change (ft)
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
5.8 ft/yr
Measured
Linear (Measured)

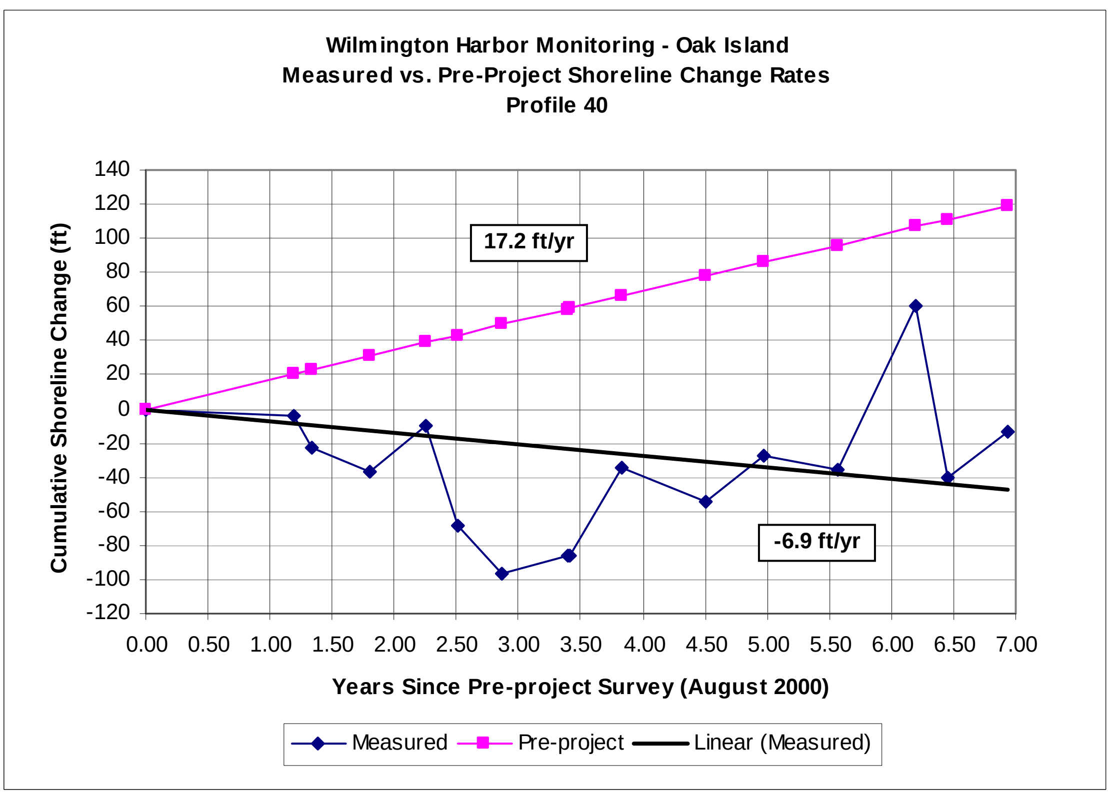


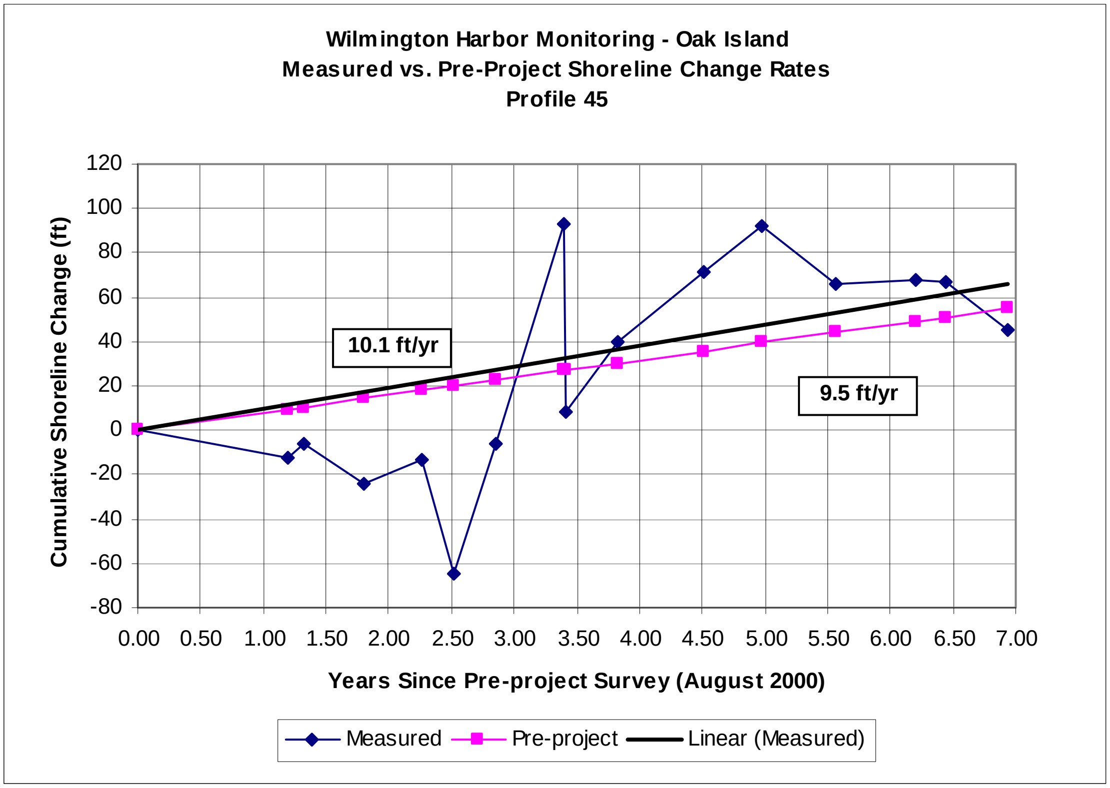
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
-6.1 ft/yr
Measured
Linear (Measured)

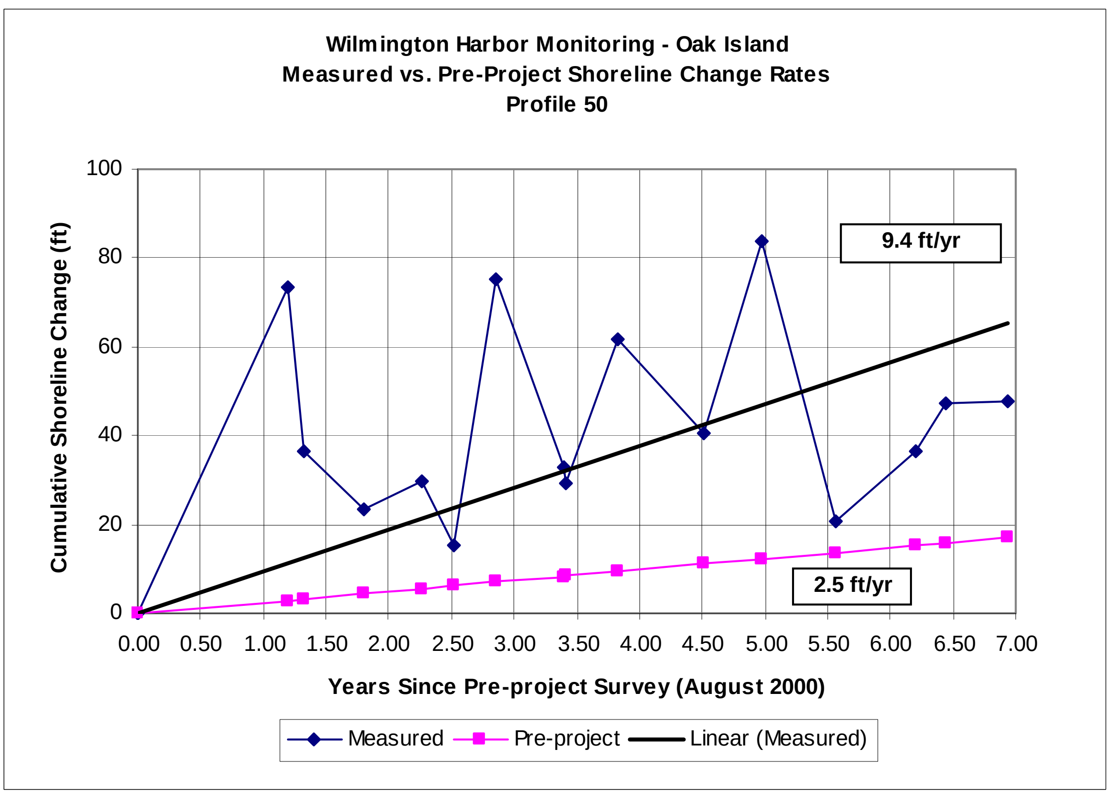

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 25
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
17.9 ft/yr
Measured
Linear (Measured)

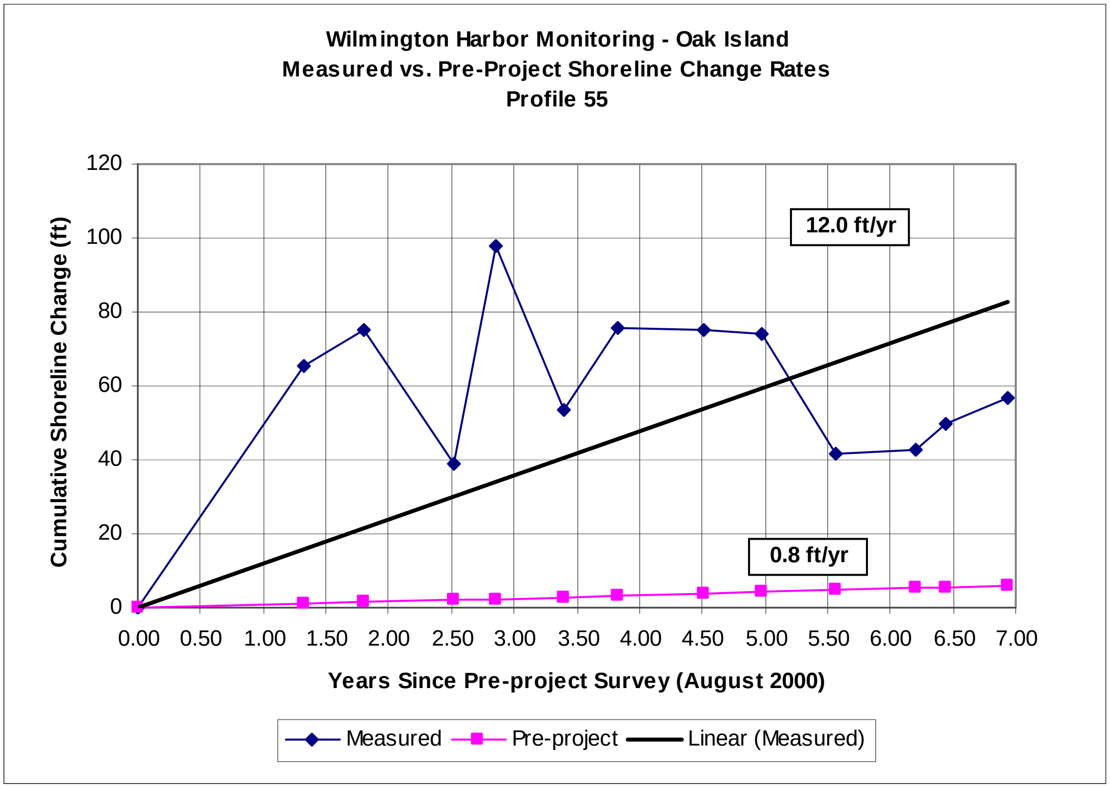

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 30
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
16.8 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 35
29.9 ft/yr
-10.8 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

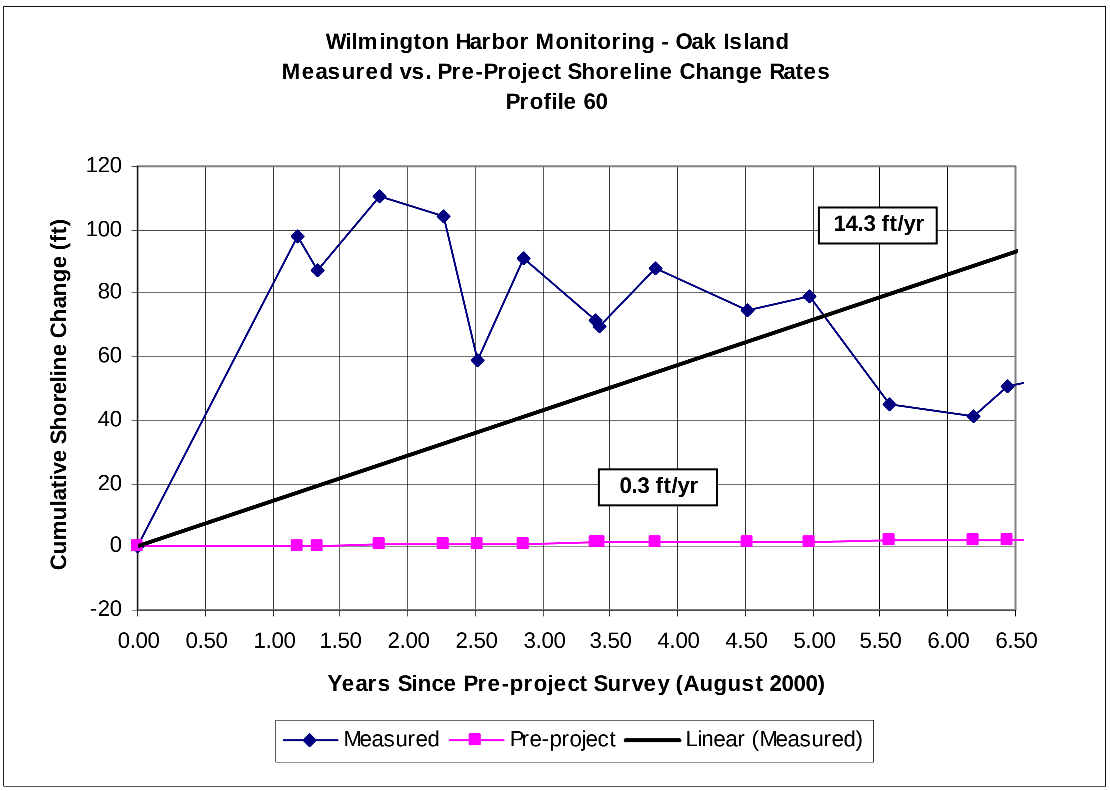

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
17.2 ft/yr
-6.9 ft/yr
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
10.1 ft/yr
9.5 ft/yr
Measured
Pre-project
Linear (Measured)

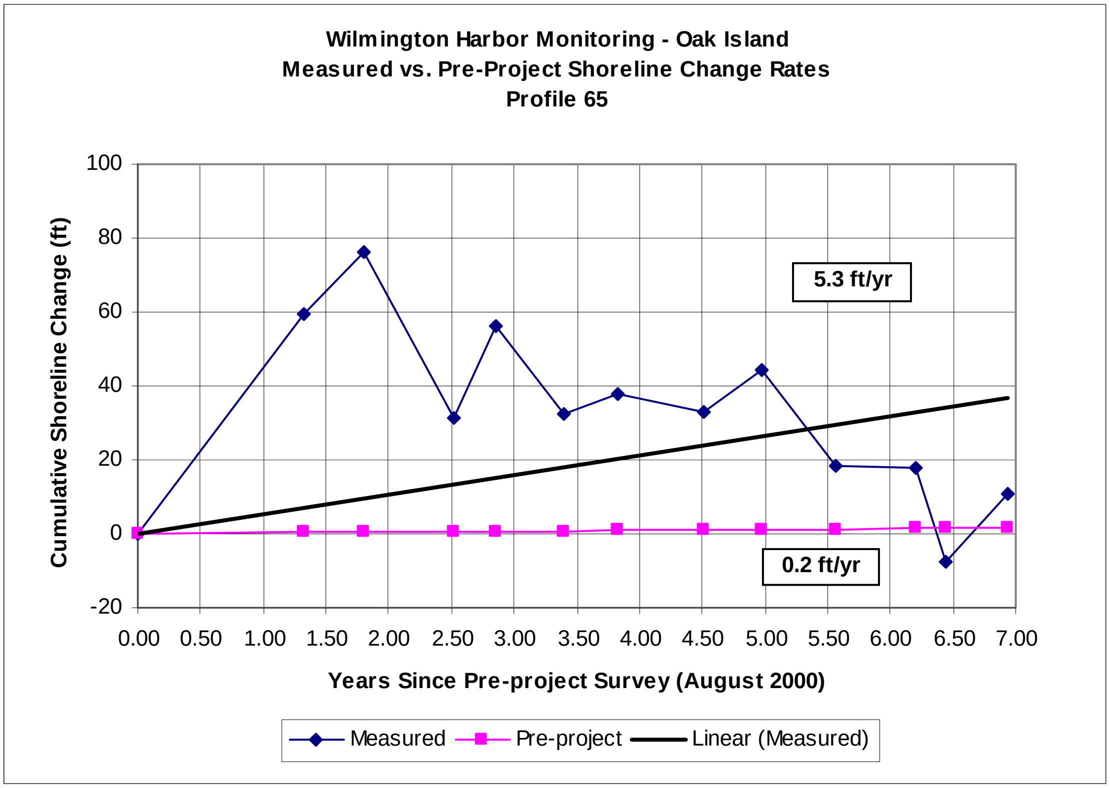

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 50
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
9.4 ft/yr
2.5 ft/yr
Measured
Pre-project
Linear (Measured)

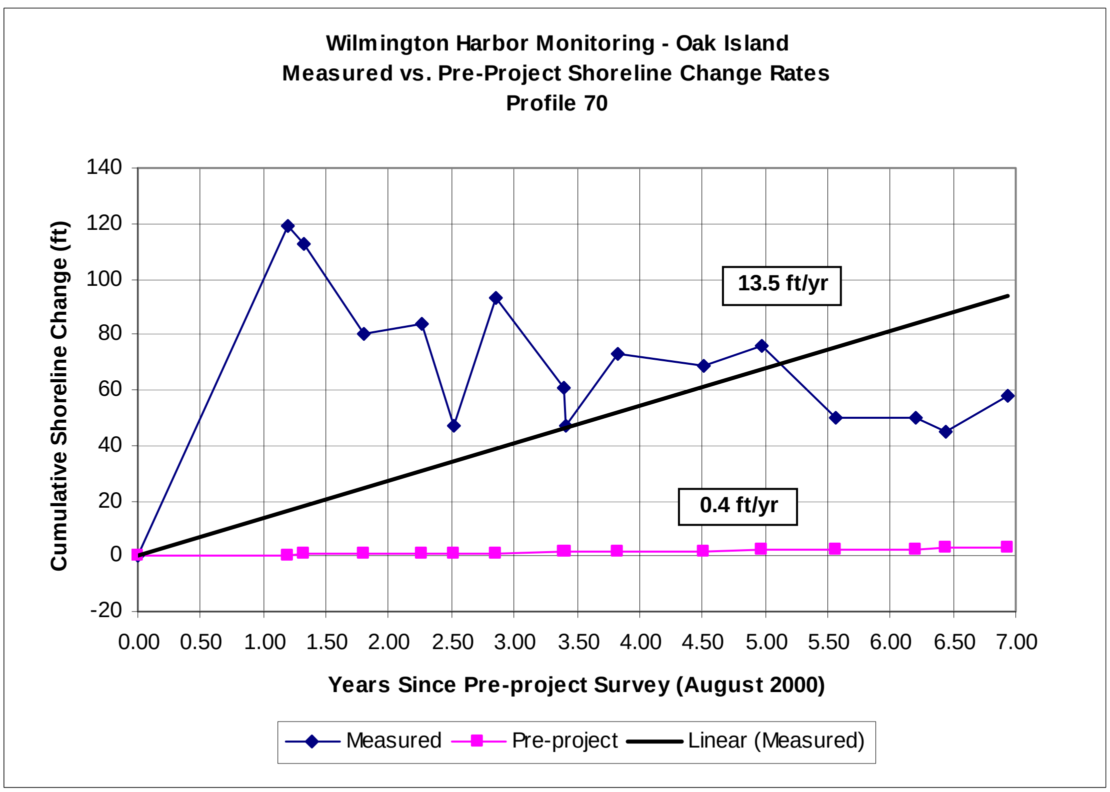


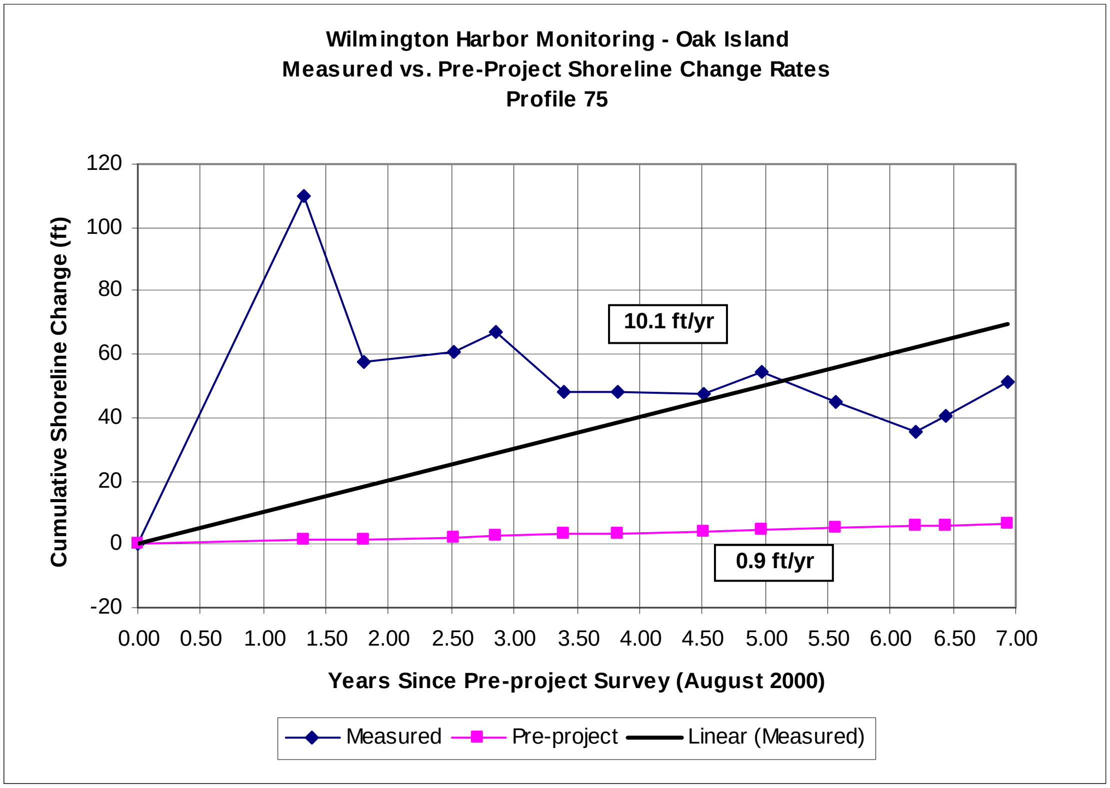
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 55
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
12.0 ft/yr
0.8 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

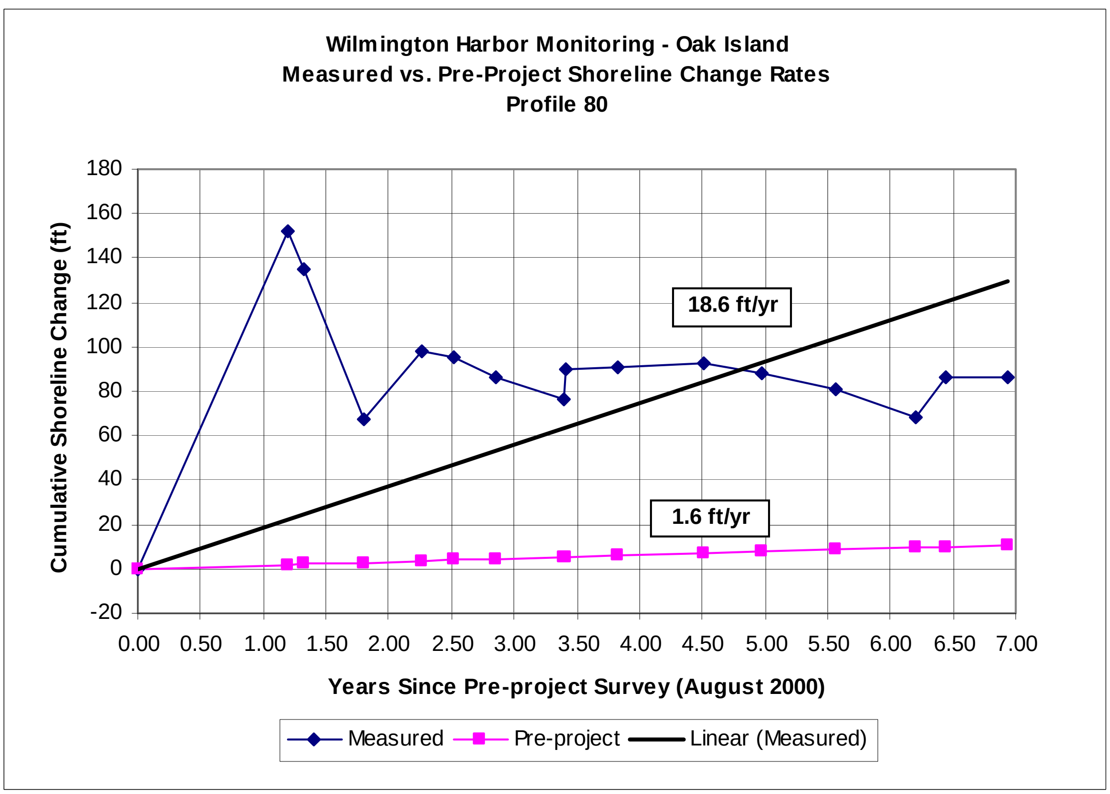


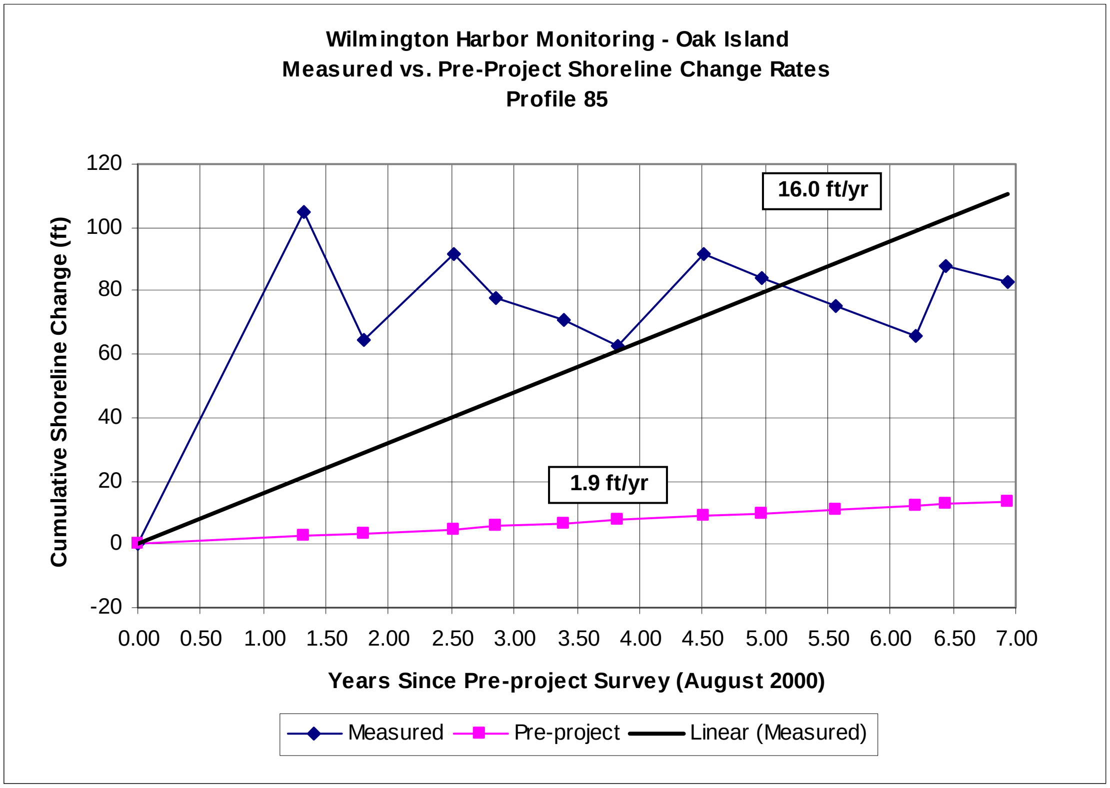
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 60
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
14.3 ft/yr
0.3 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

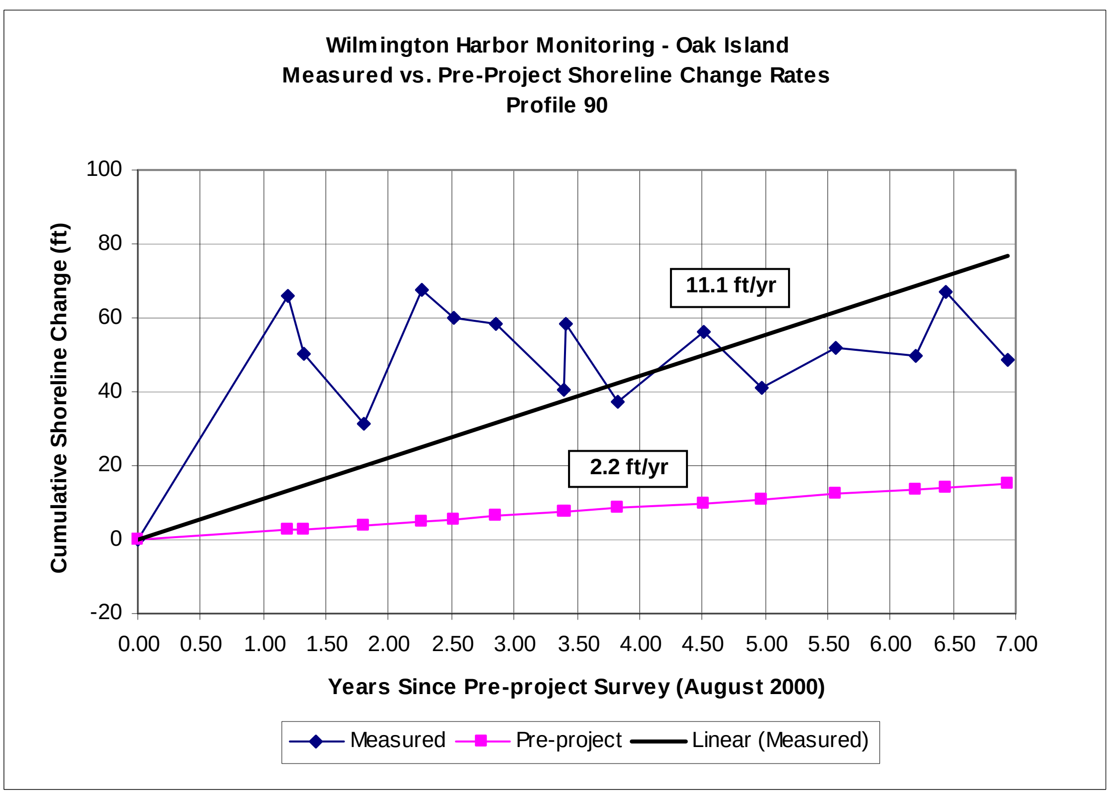

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 65
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
5.3 ft/yr
0.2 ft/yr
Measured
Pre-project
Linear (Measured)

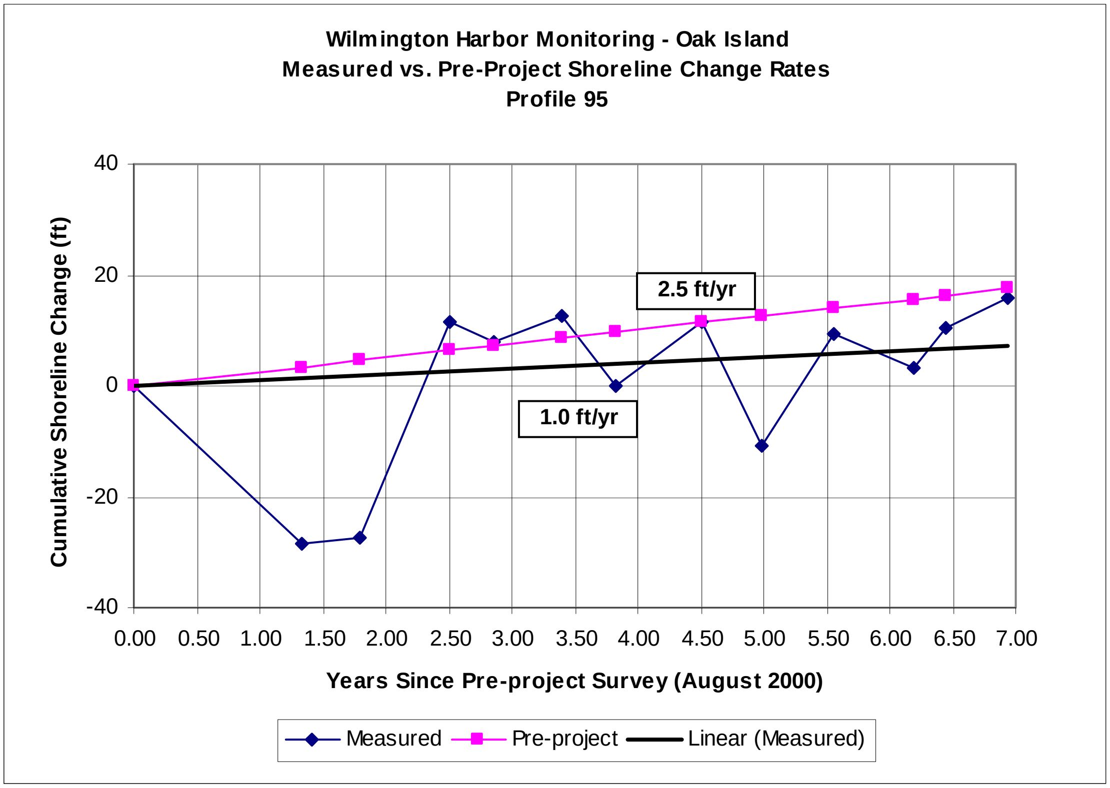

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 70
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
13.5 ft/yr
0.4 ft/yr
Measured
Pre-project
Linear (Measured)

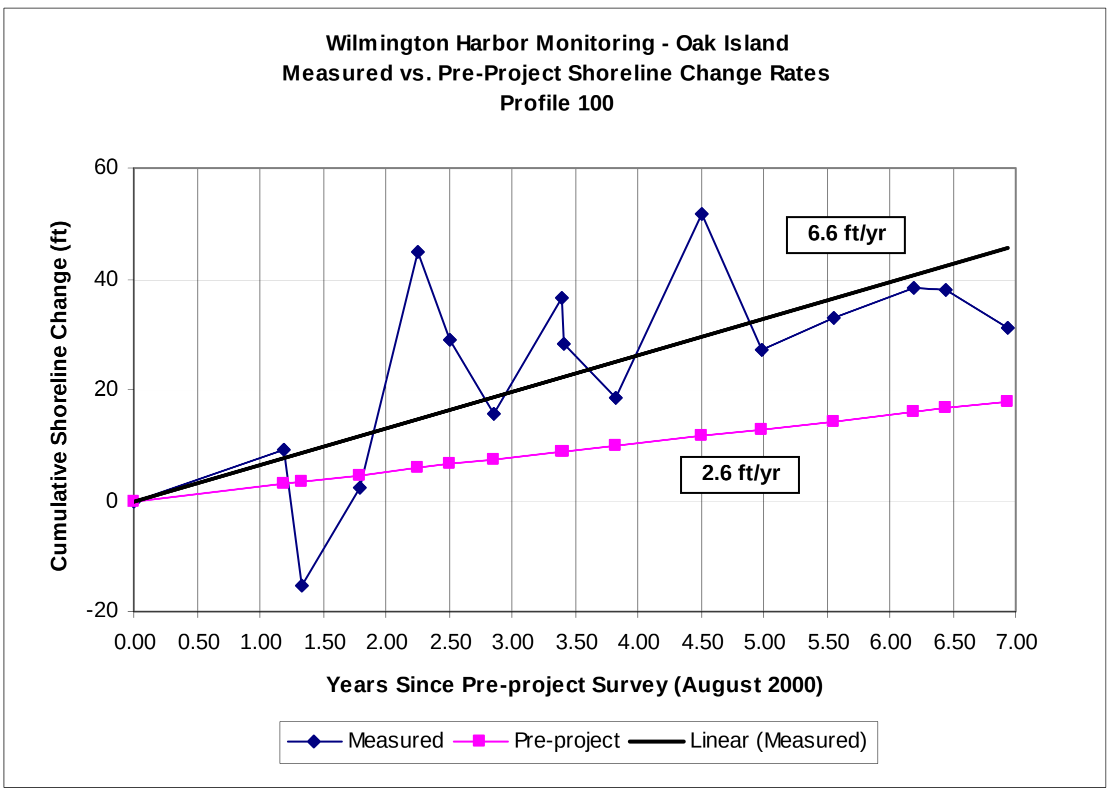

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 75
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
10.1 ft/yr
0.9 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

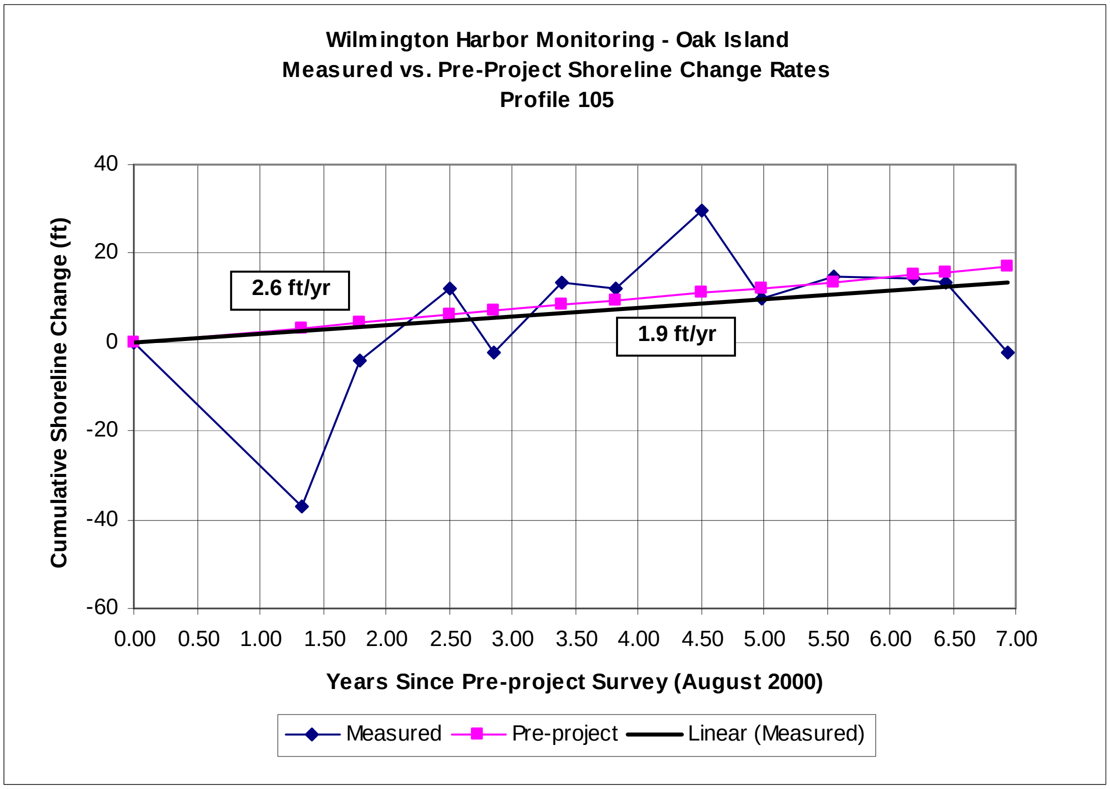

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 80
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
18.6 ft/yr
1.6 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

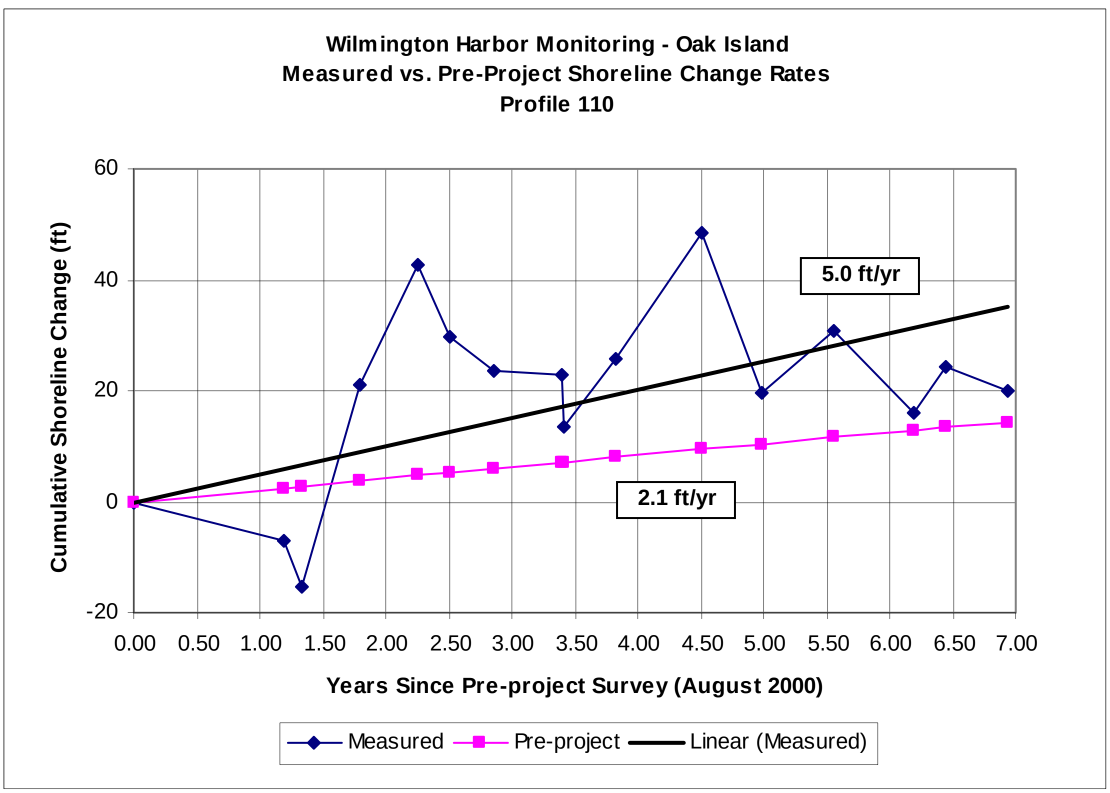

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 85
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
16.0 ft/yr
1.9 ft/yr
Measured
Pre-project
Linear (Measured)

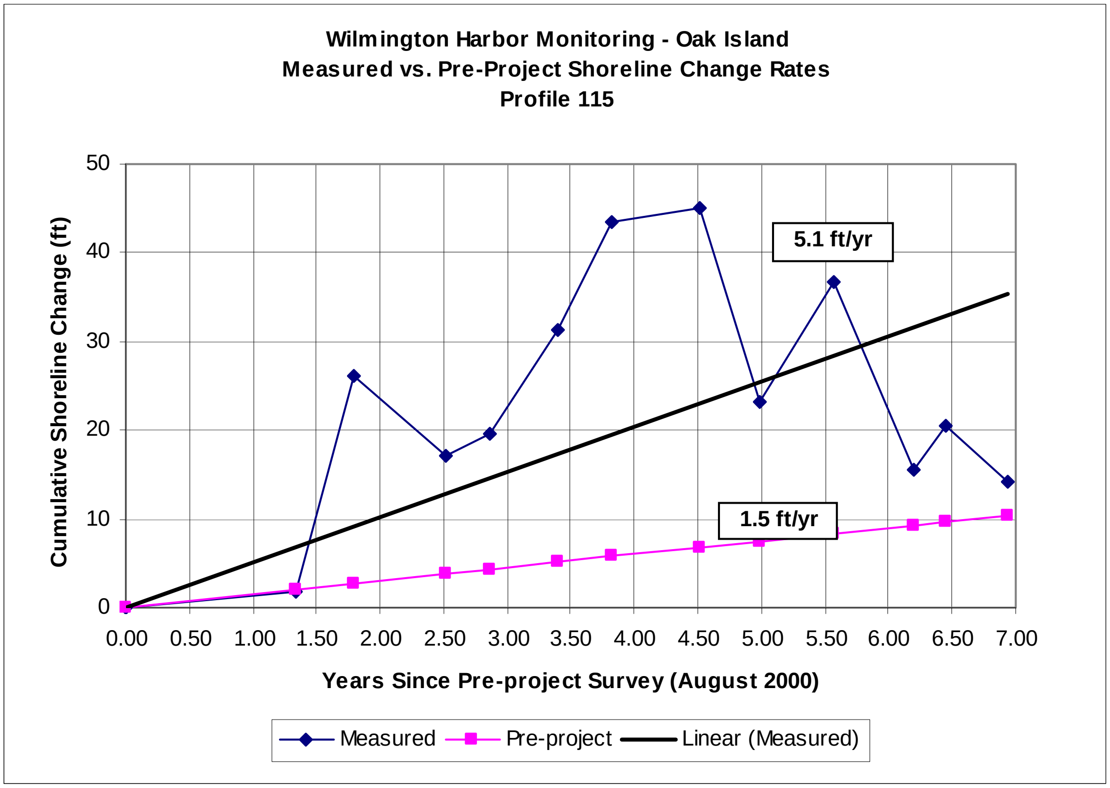

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 90
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
11.1 ft/yr
2.2 ft/yr
Measured
Pre-project
Linear (Measured)

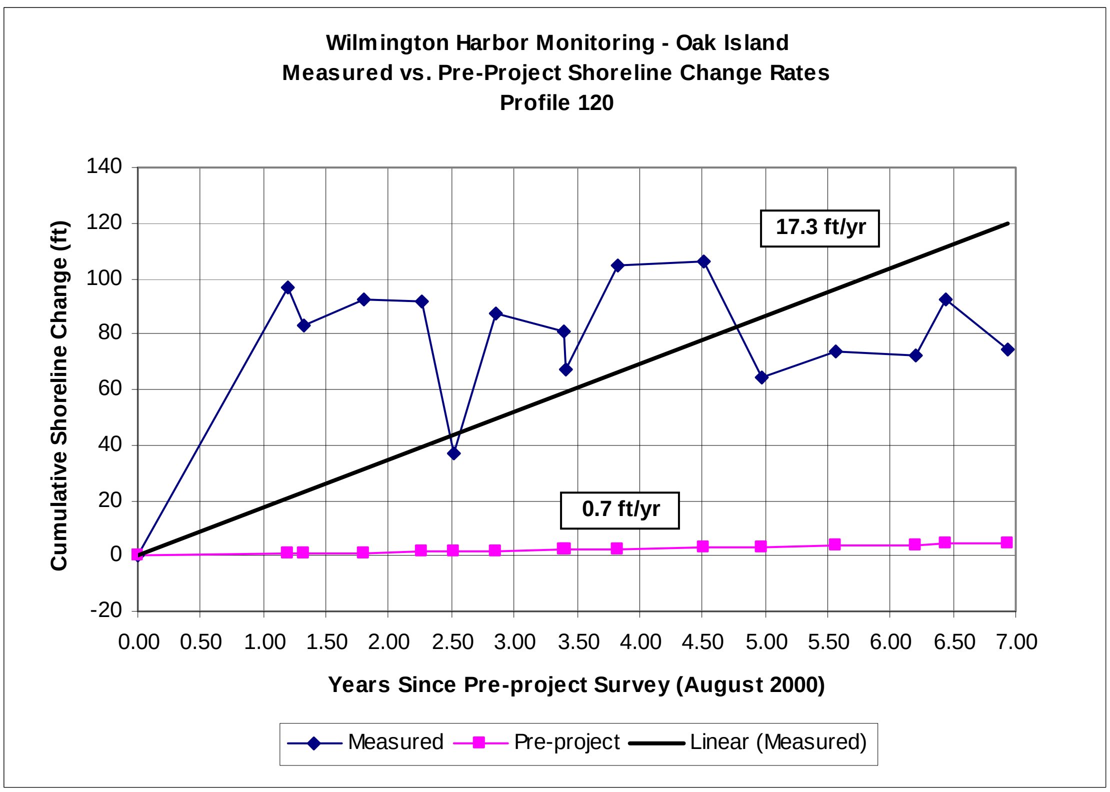

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 95
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
2.5 ft/yr
1.0 ft/yr
Measured
Pre-project
Linear (Measured)

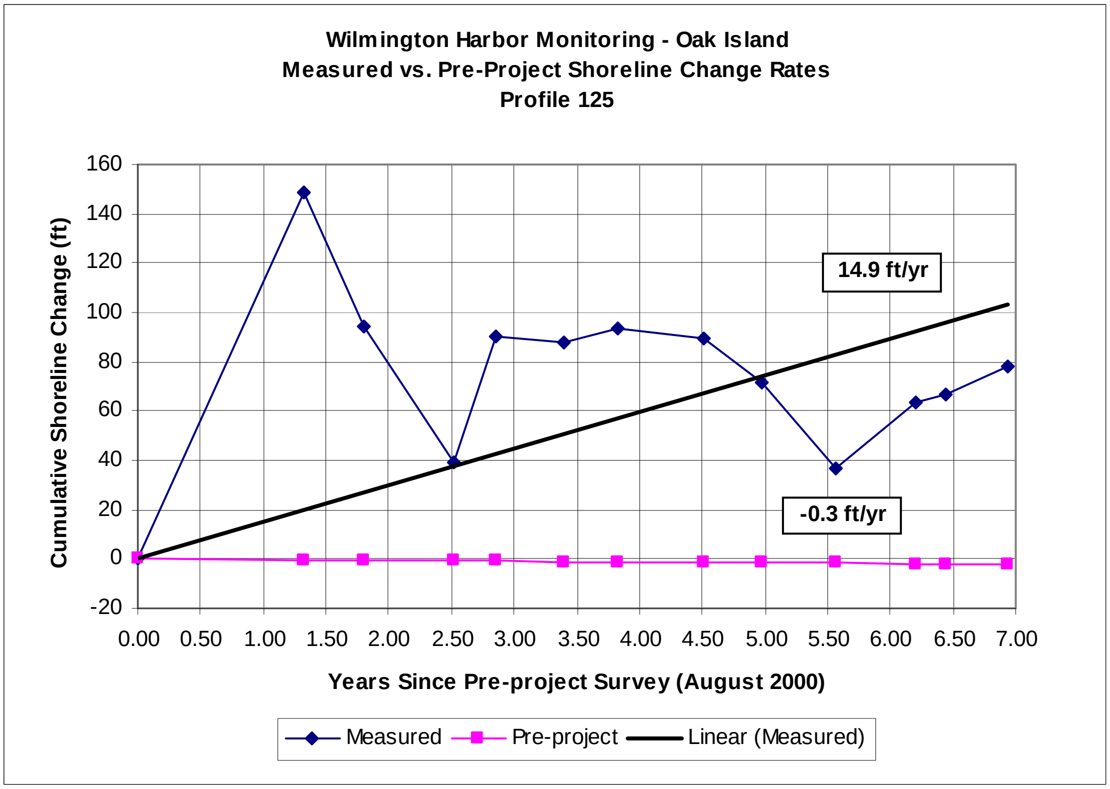

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 100
Cumulative Shoreline Change (ft)
60
40
20
0
-20
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
6.6 ft/yr
2.6 ft/yr
Measured
Pre-project
Linear (Measured)

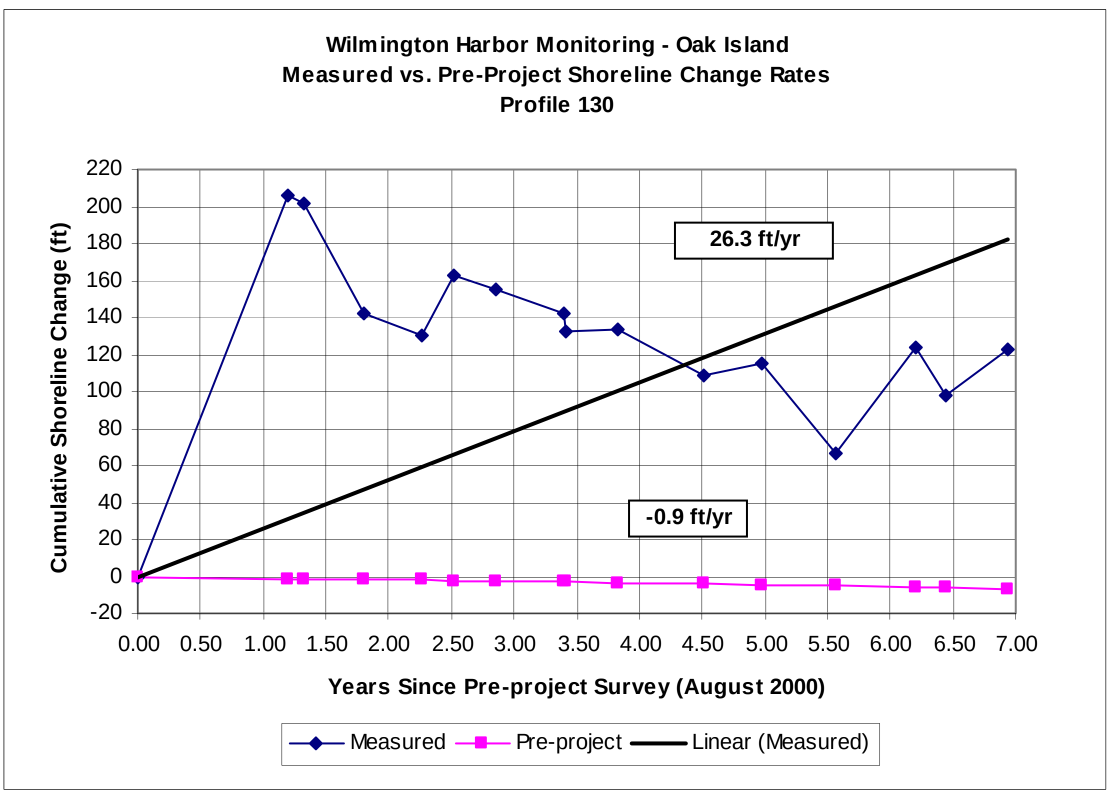

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 105
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
2.6 ft/yr
1.9 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

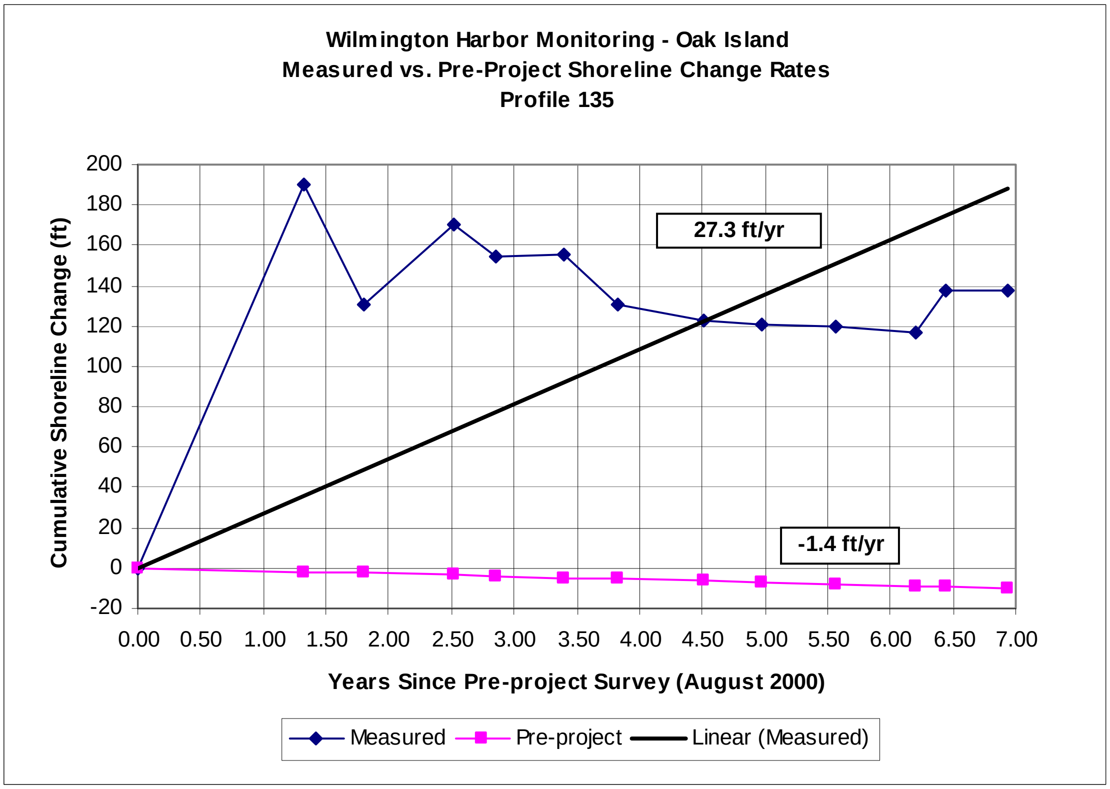

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
60
40
20
0
-20
5.0 ft/yr
2.1 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

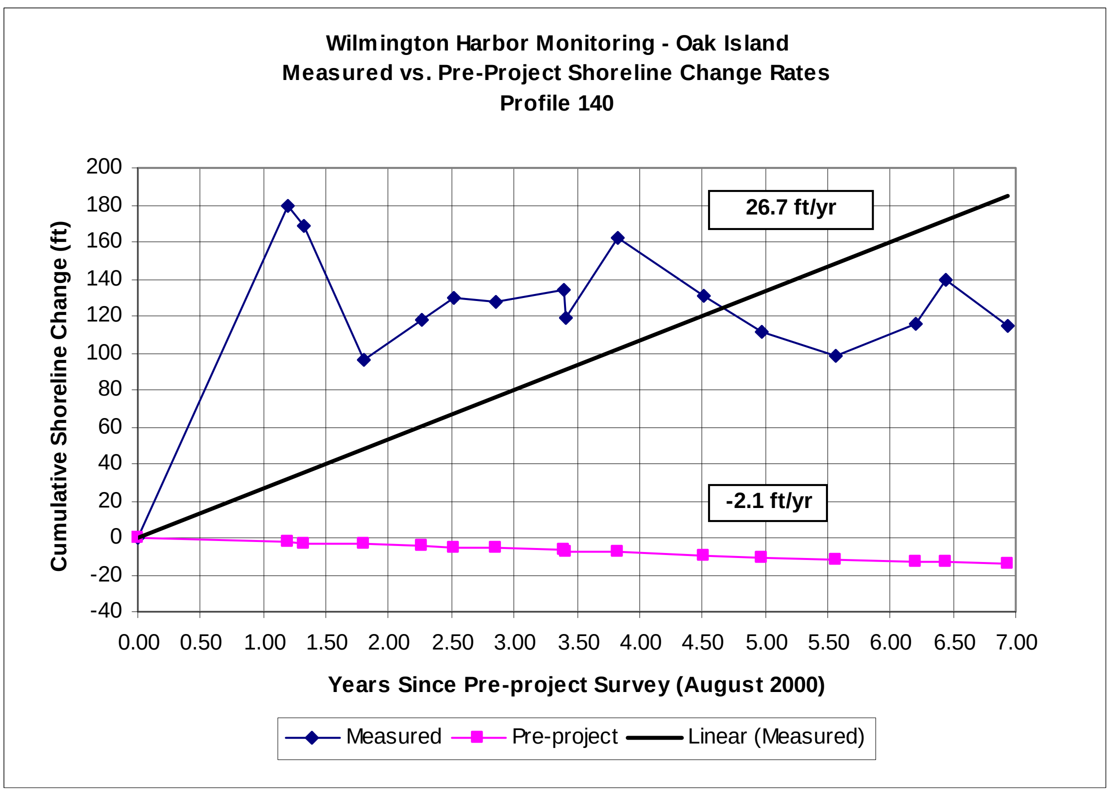

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 115
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
5.1 ft/yr
1.5 ft/yr
Measured
Pre-project
Linear (Measured)

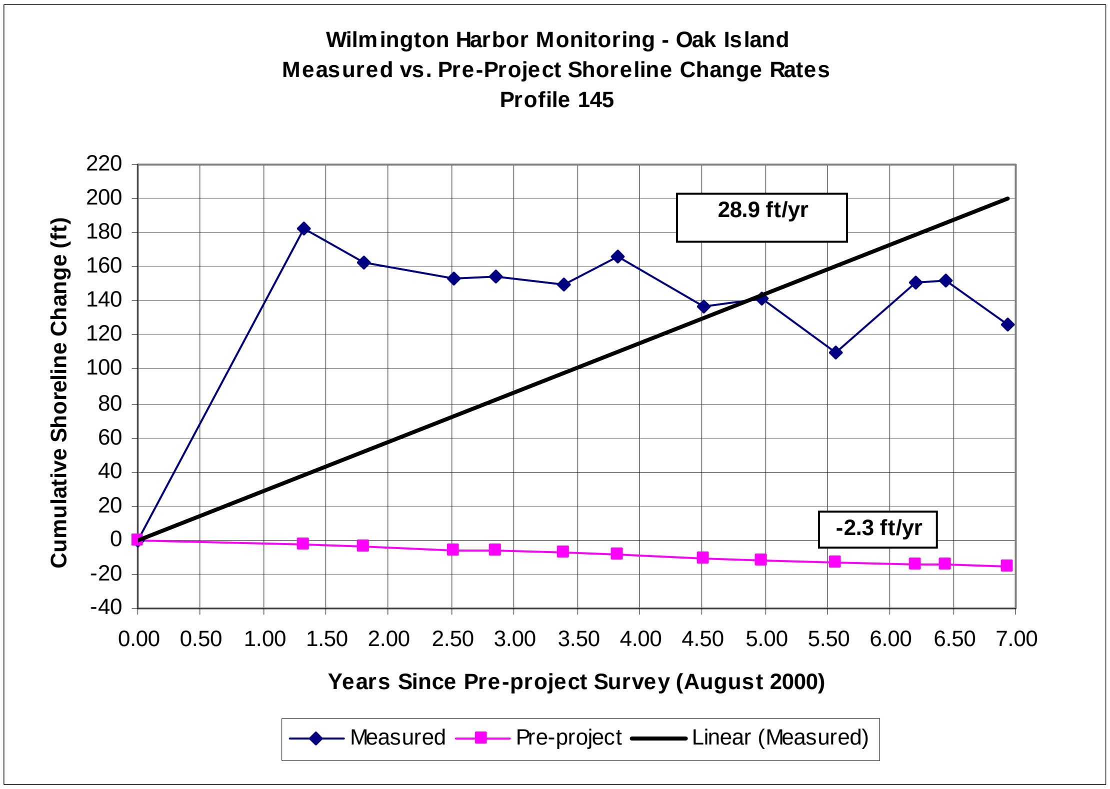

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 120
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
17.3 ft/yr
0.7 ft/yr
Measured
Pre-project
Linear (Measured)

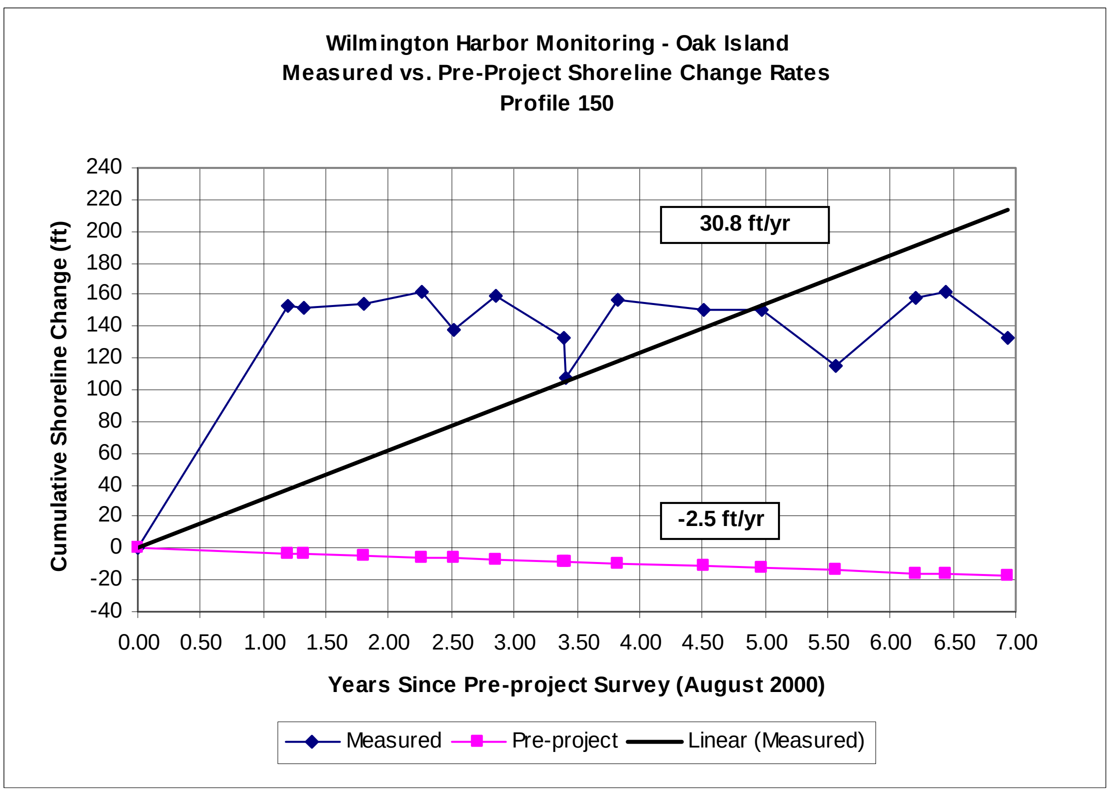

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 125
14.9 ft/yr
-0.3 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

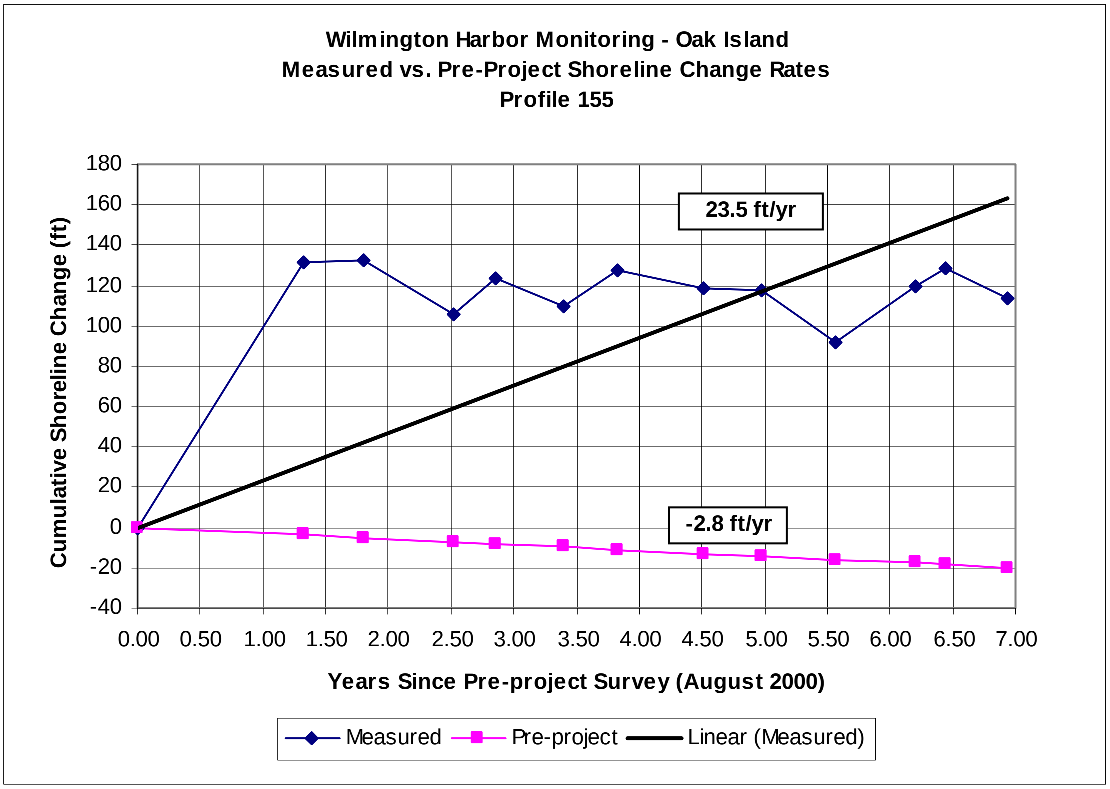

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
26.3 ft/yr
-0.9 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

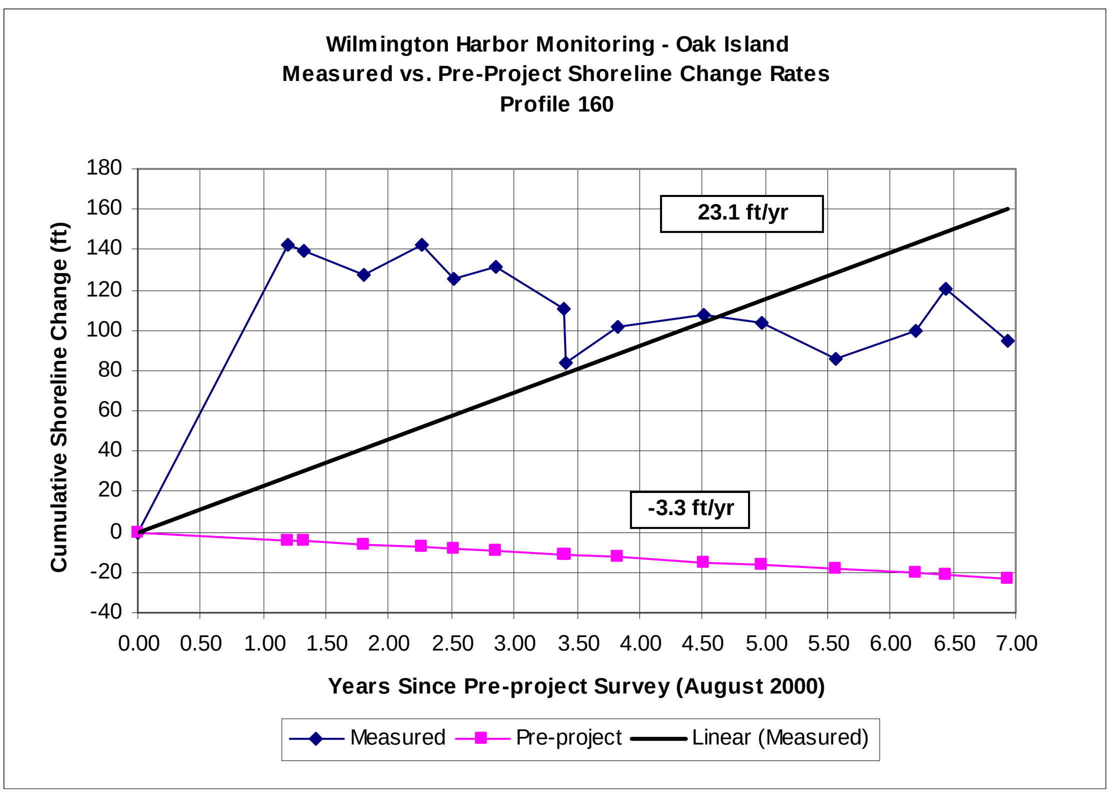

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 135
27.3 ft/yr
-1.4 ft/yr
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

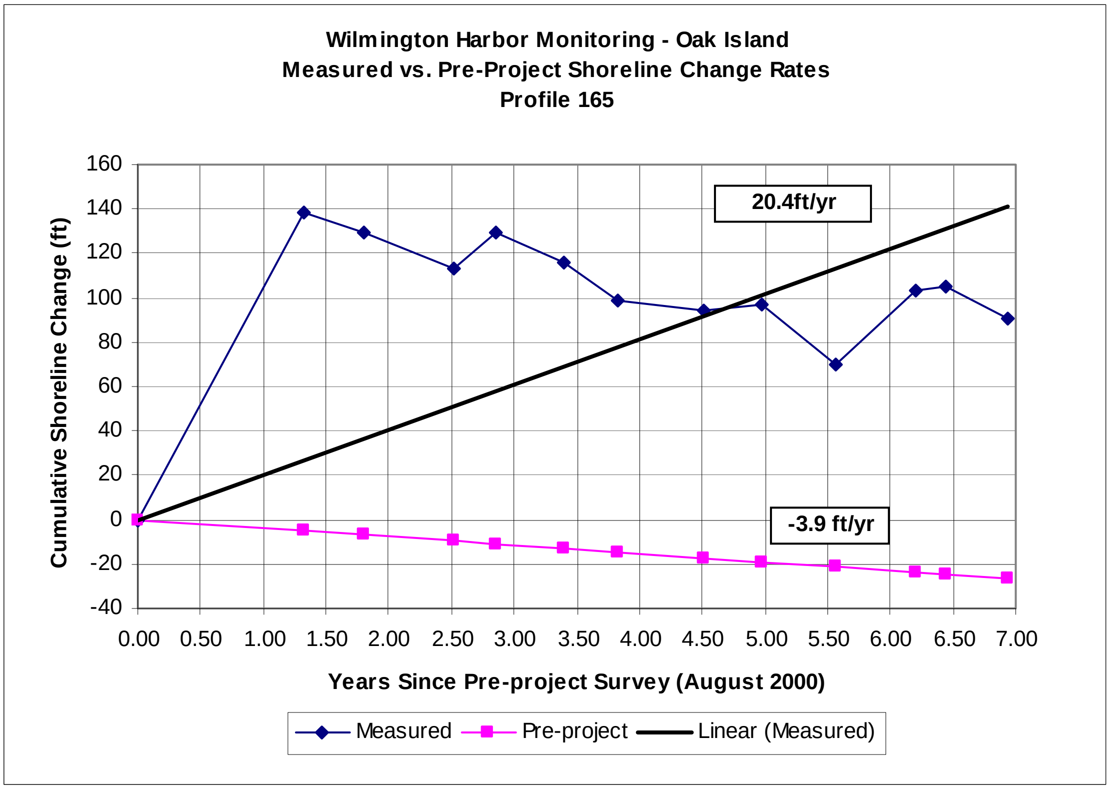

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 140
26.7 ft/yr
-2.1 ft/yr
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 145
28.9 ft/yr
-2.3 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

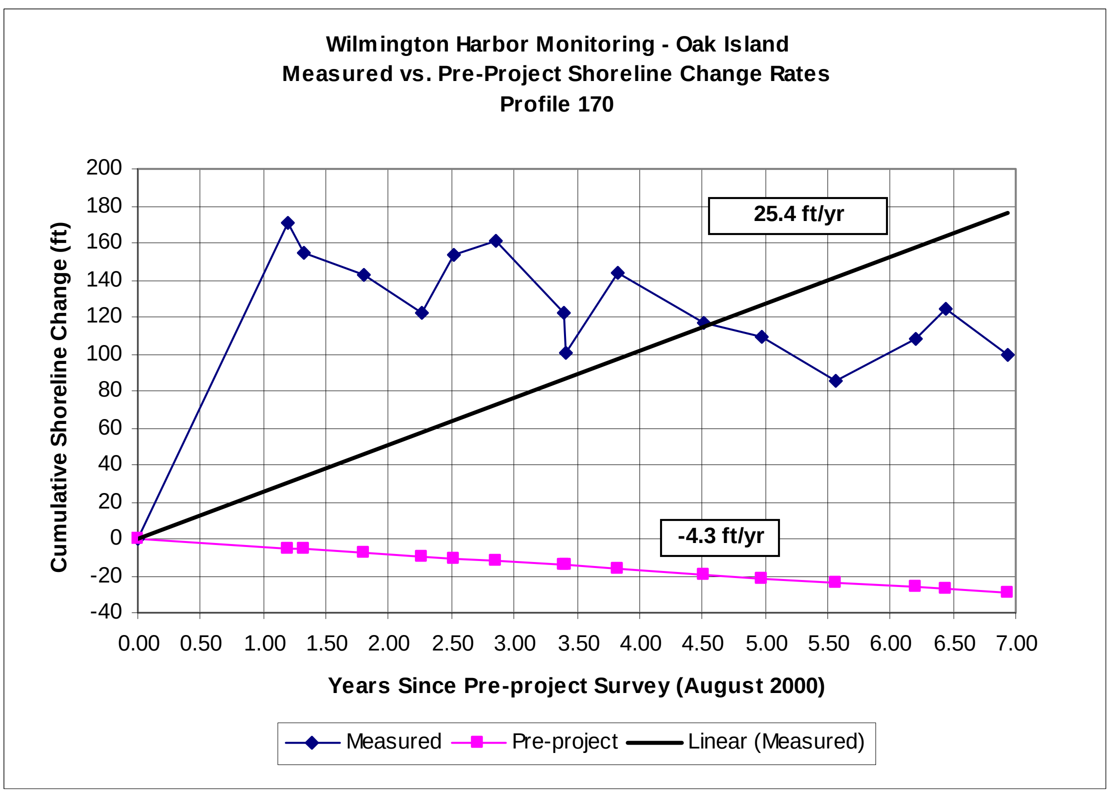

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
30.8 ft/yr
-2.5 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 155
23.5 ft/yr
-2.8 ft/yr
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

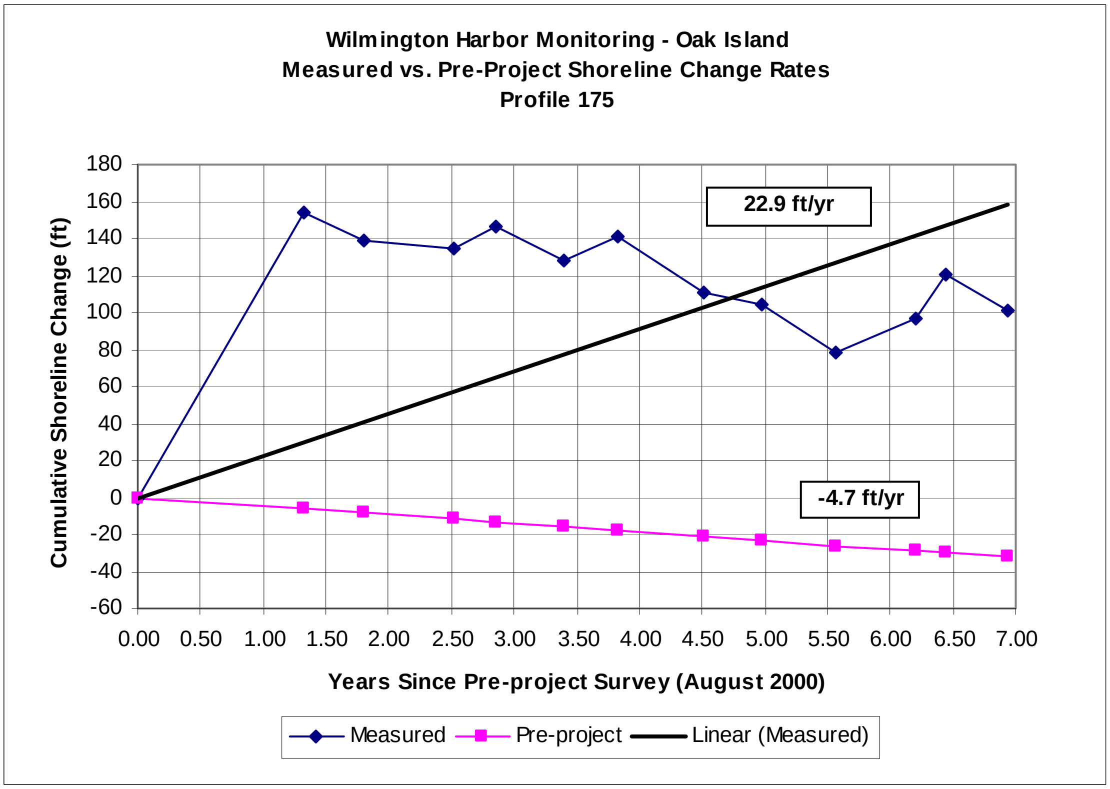

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 160
23.1 ft/yr
-3.3 ft/yr
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

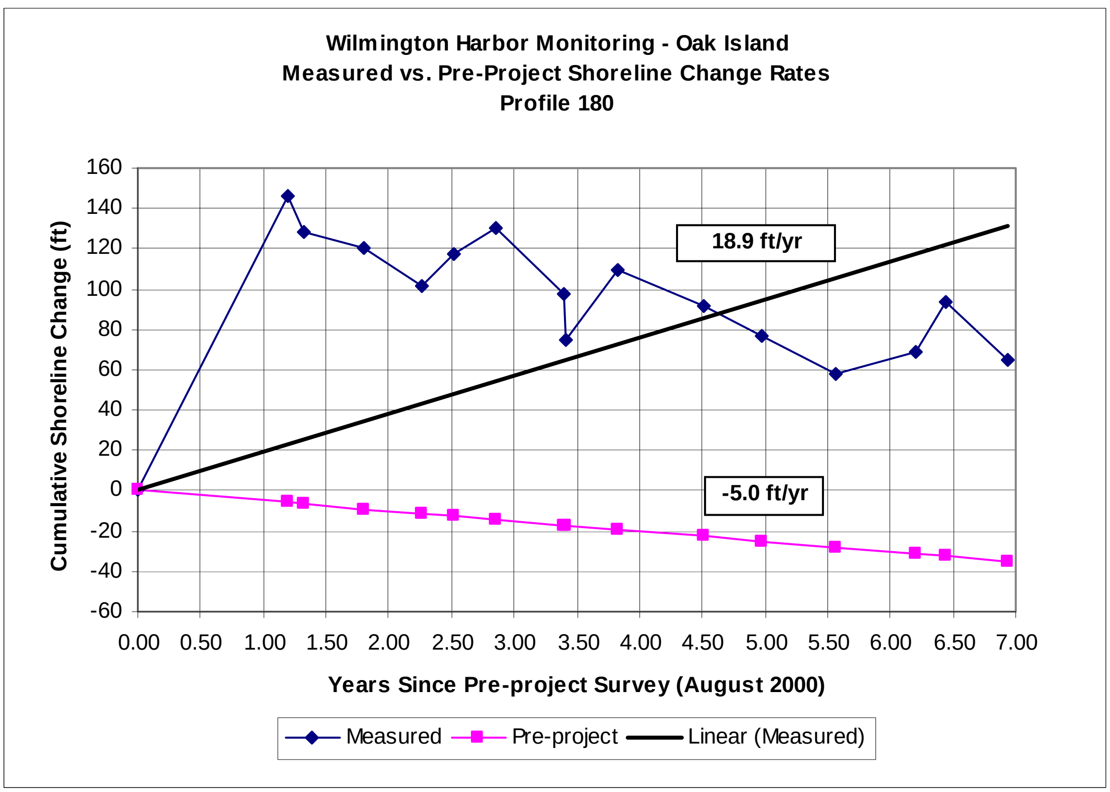


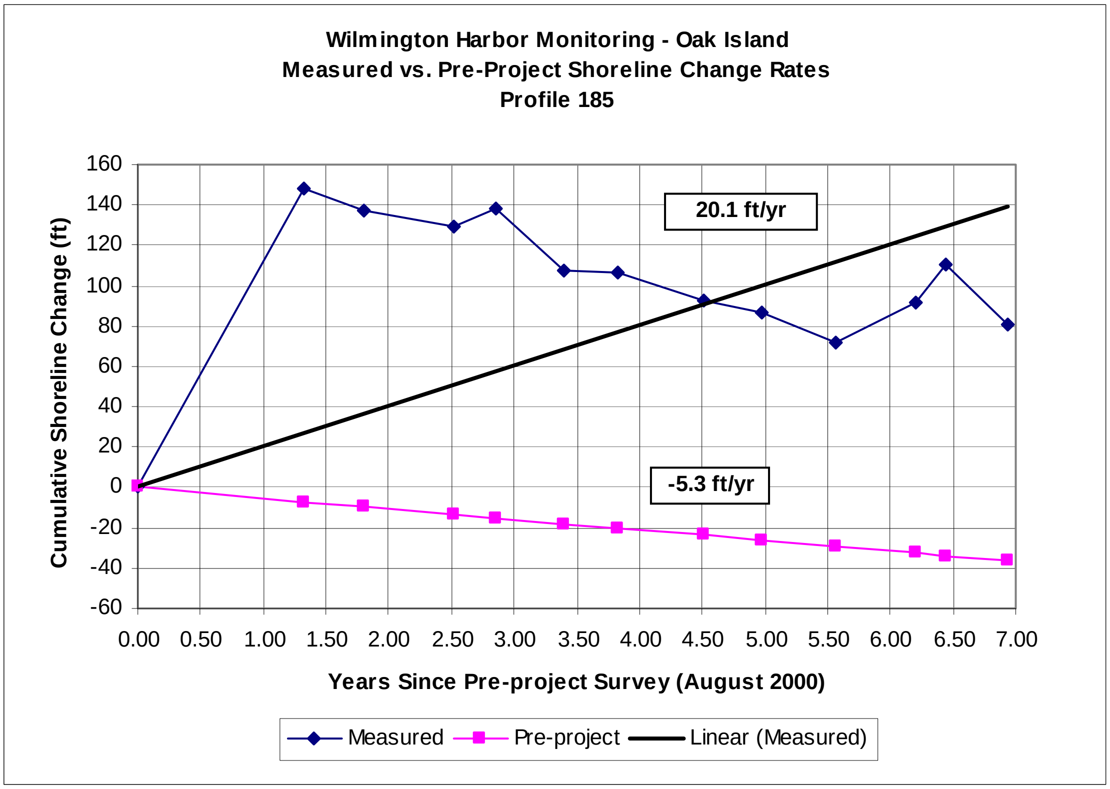
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 165
20.4ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

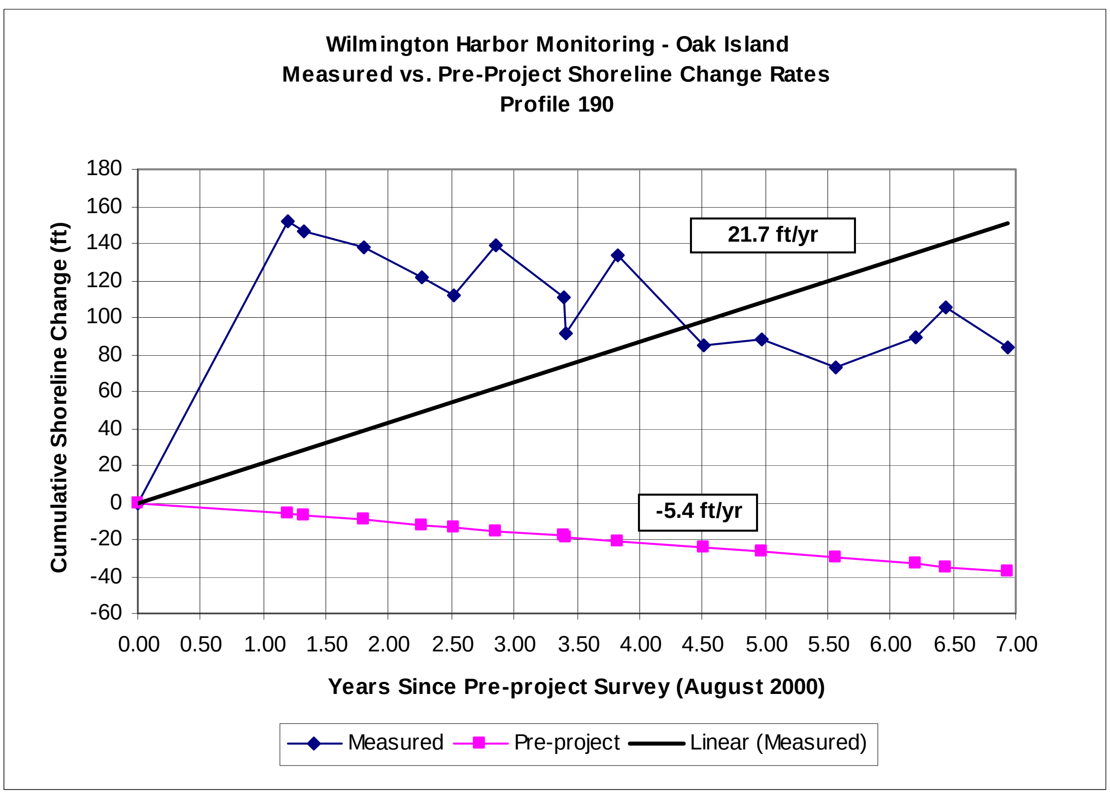


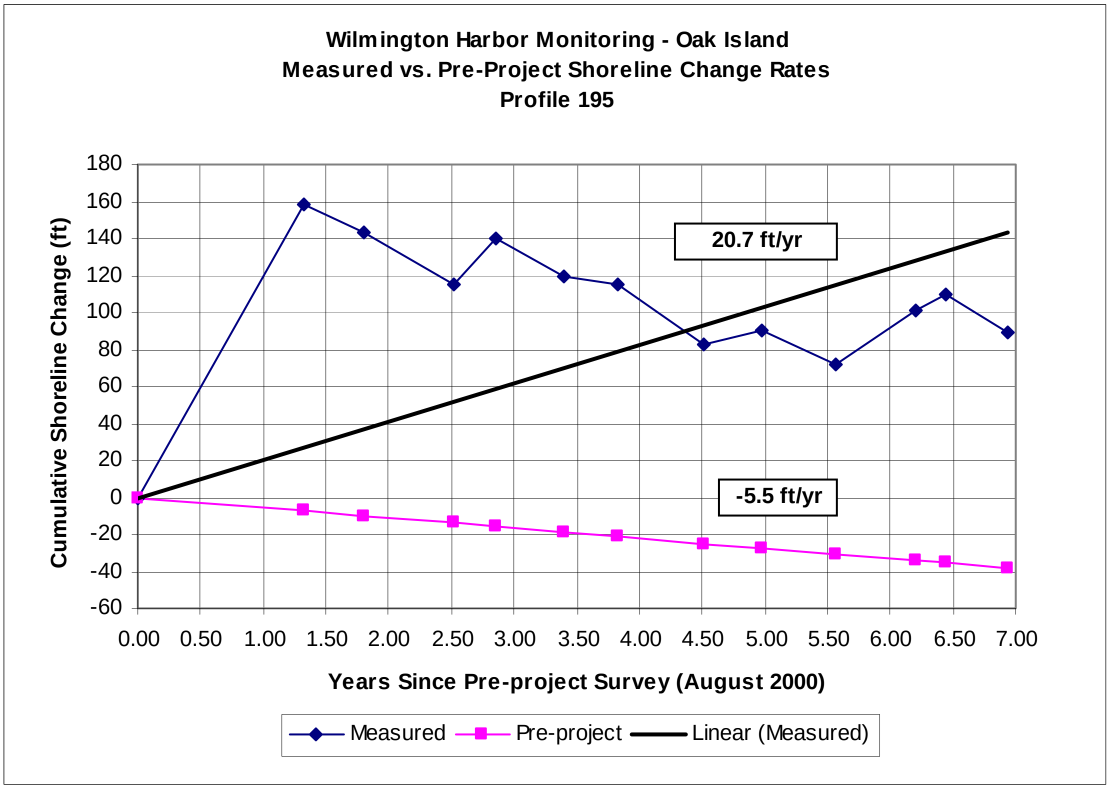
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
25.4 ft/yr
-4.3 ft/yr
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

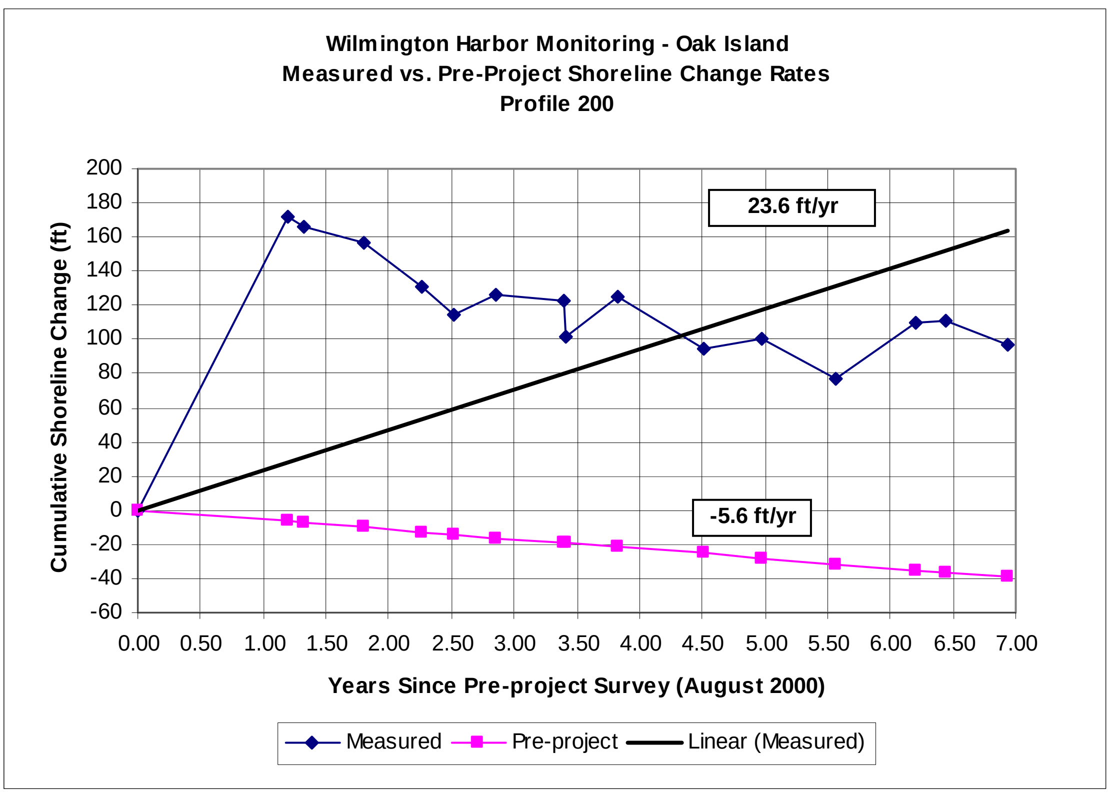

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 175
22.9 ft/yr
-4.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Measured
Pre-project
Linear (Measured)

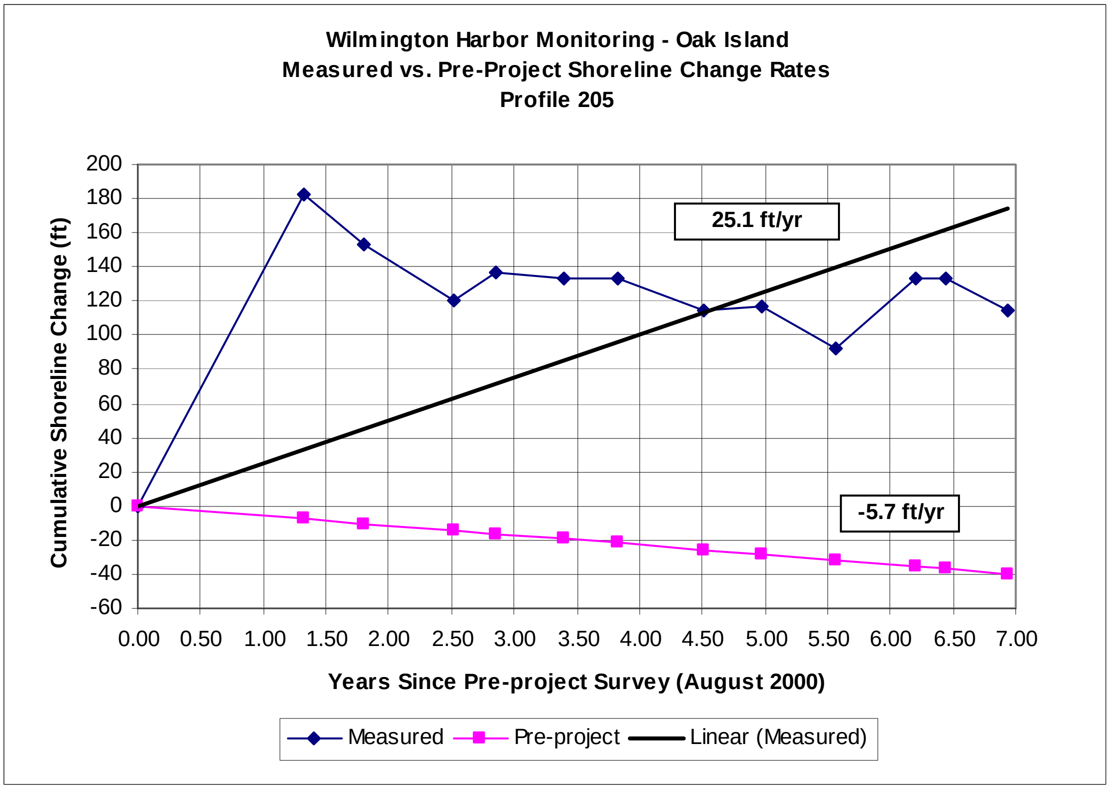

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 180
18.9 ft/yr
-5.0 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Measured
Pre-project
Linear (Measured)

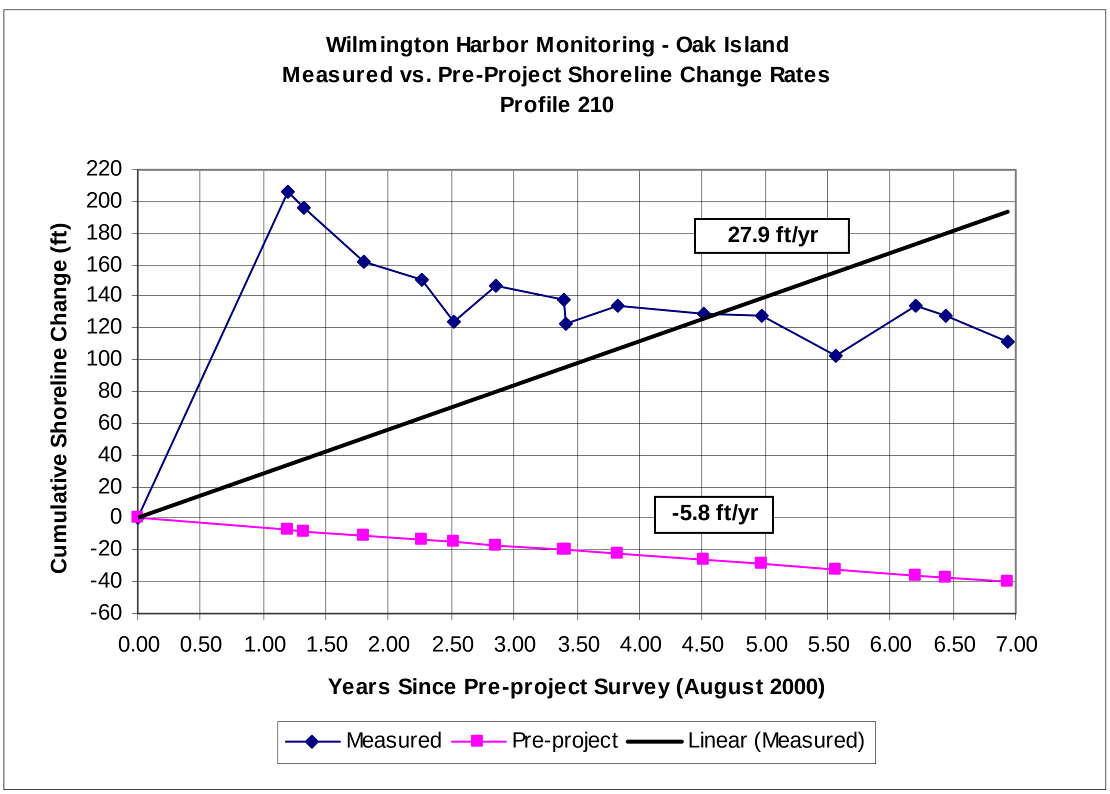

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 185
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
20.1 ft/yr
-5.3 ft/yr
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Measured
Pre-project
Linear (Measured)

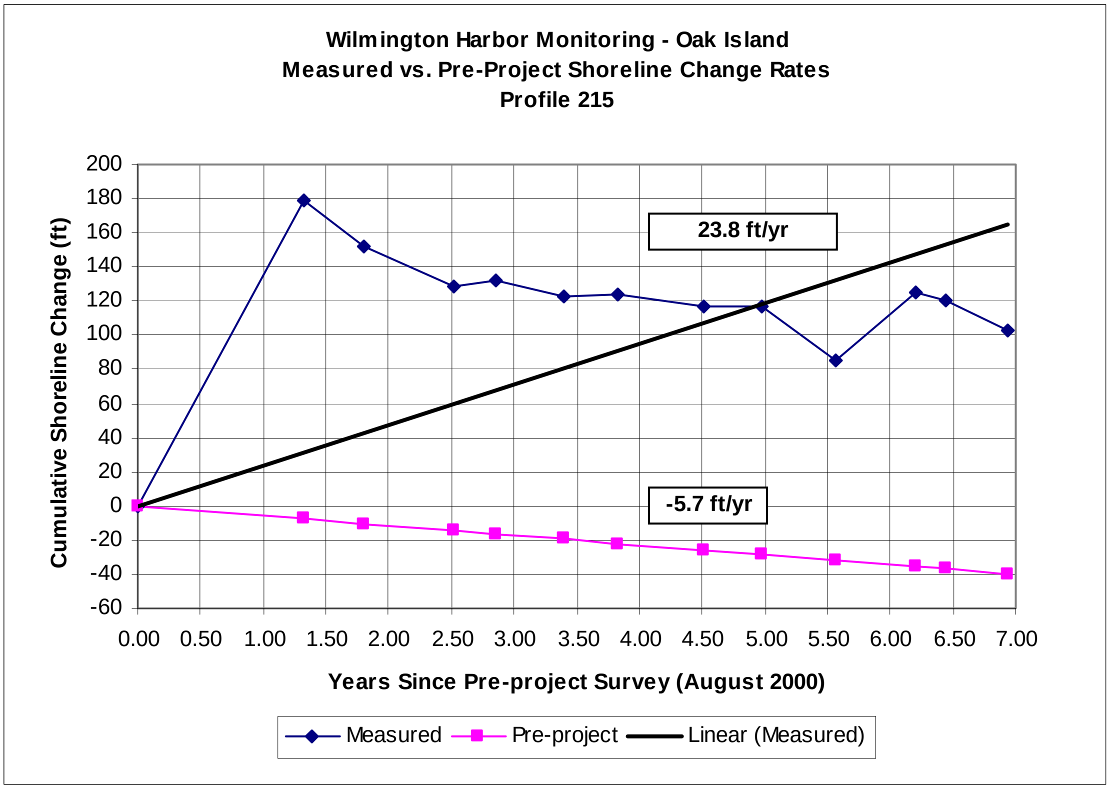

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
21.7 ft/yr
-5.4 ft/yr
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 195
20.7 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

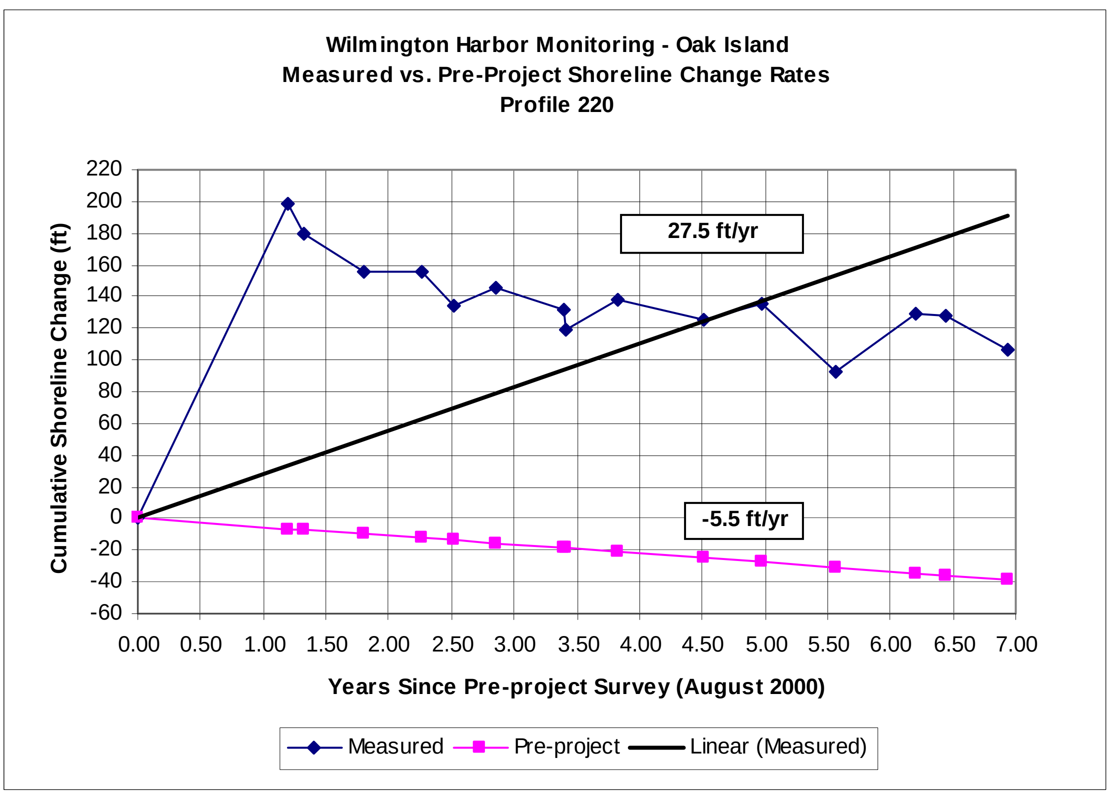

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 200
23.6 ft/yr
-5.6 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 205
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
25.1 ft/yr
-5.7 ft/yr
Measured
Pre-project
Linear (Measured)

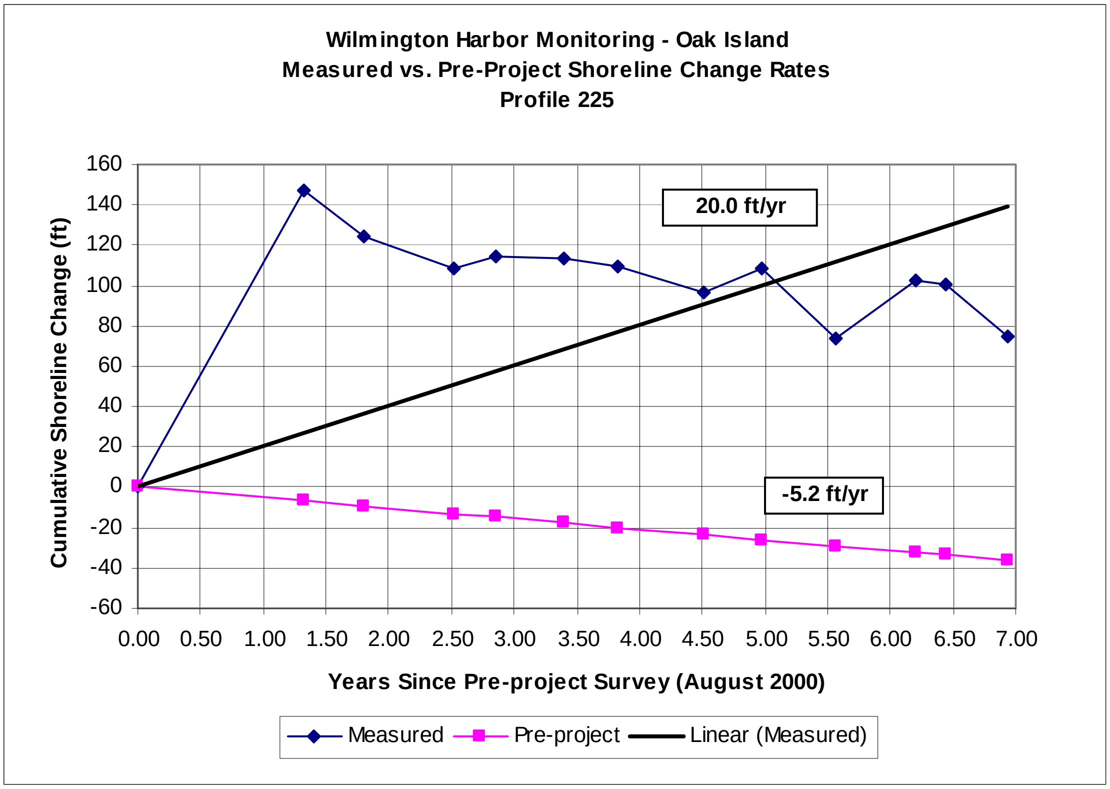

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
27.9 ft/yr
-5.8 ft/yr
Measured
Pre-project
Linear (Measured)



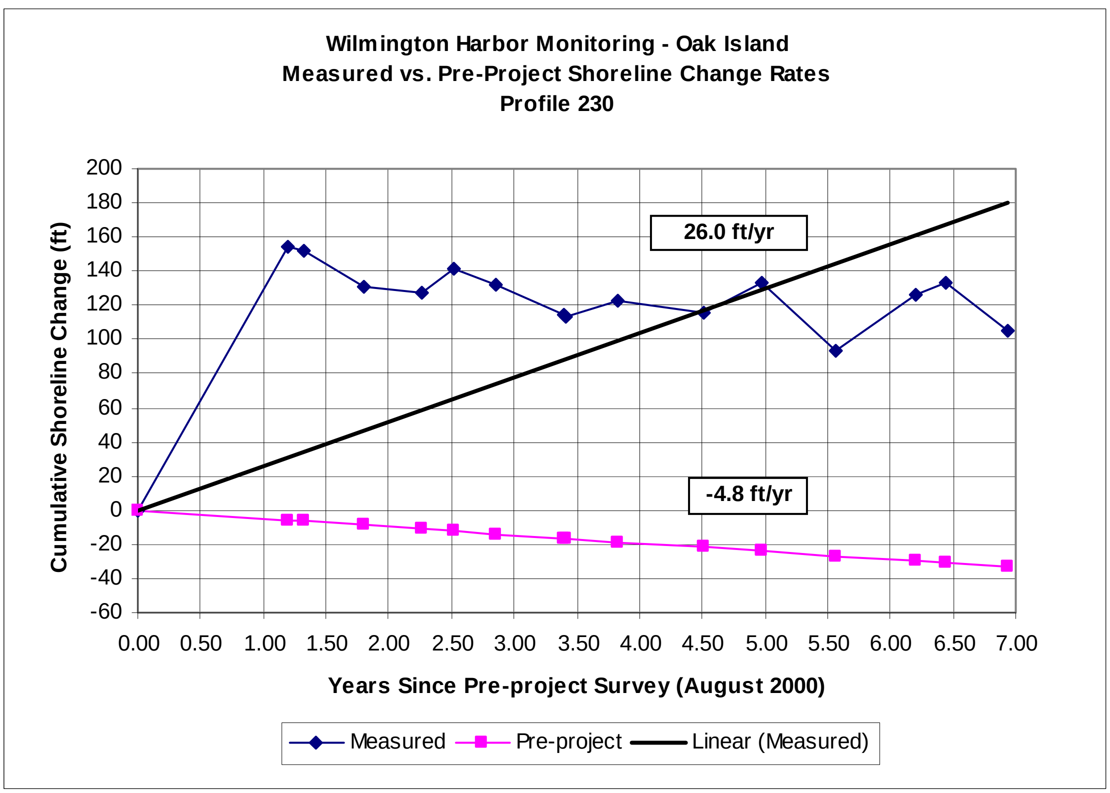
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 215
23.8 ft/yr
-5.7 ft/yr
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)



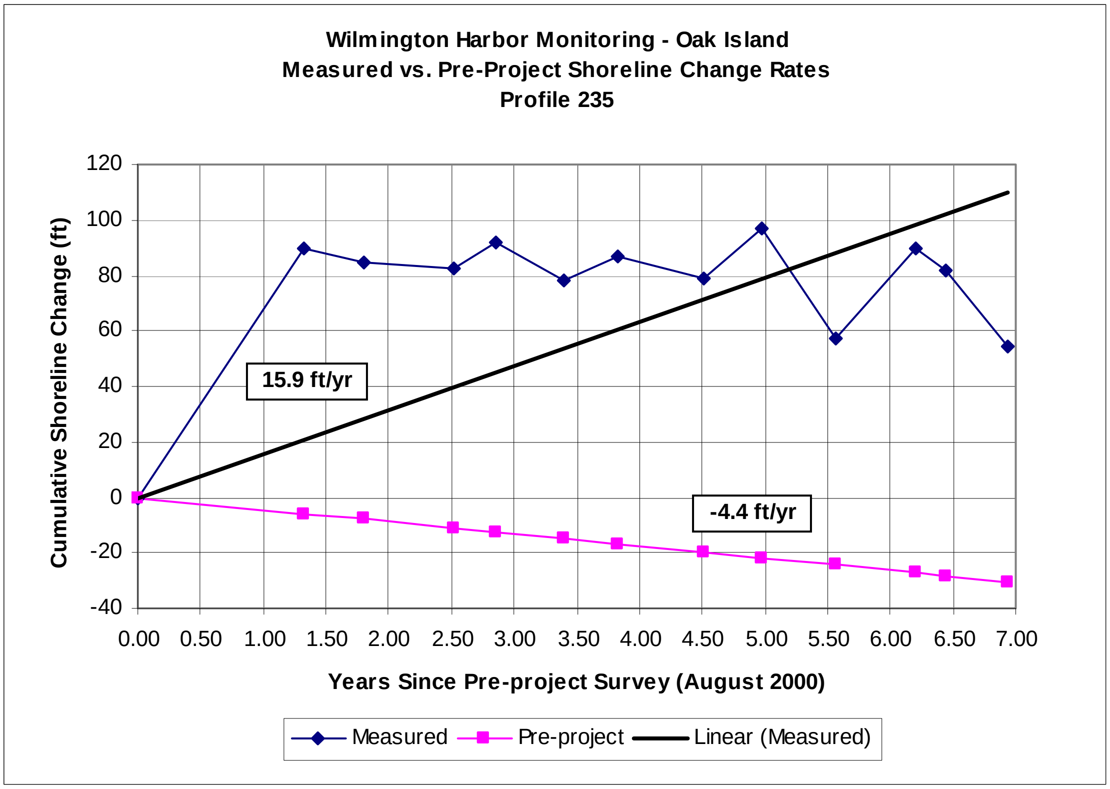
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 220
27.5 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)



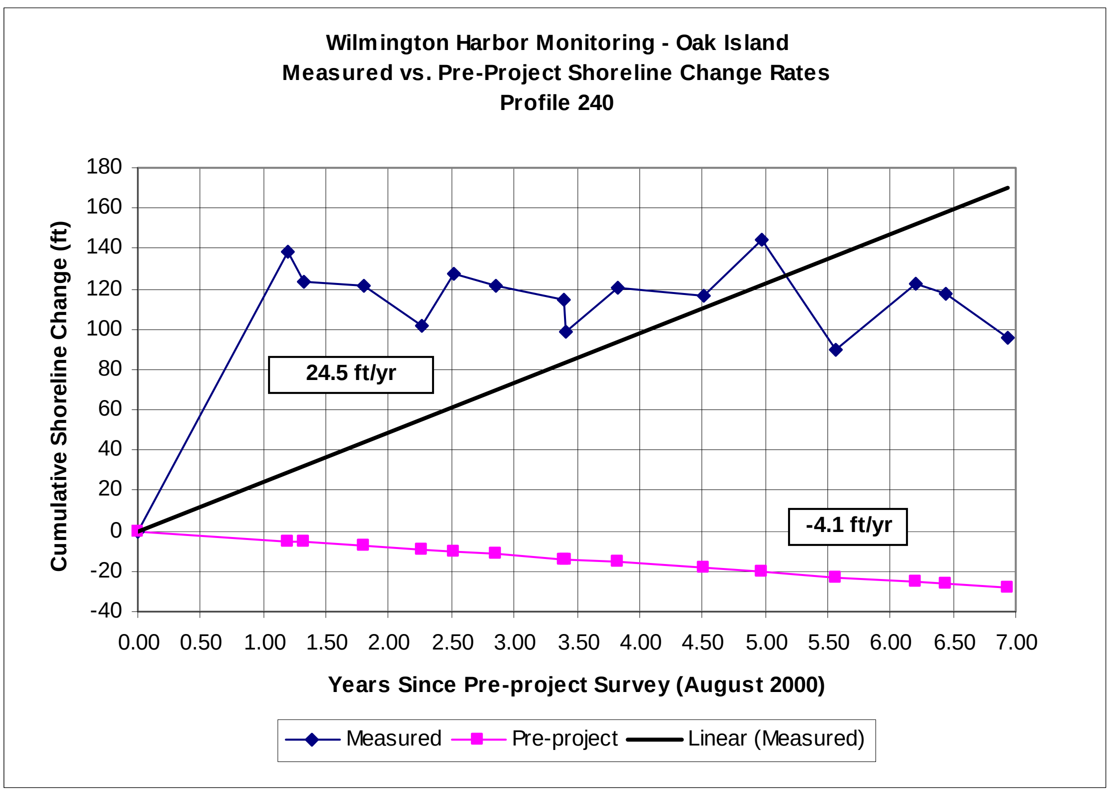
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 225
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
20.0 ft/yr
-5.2 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)



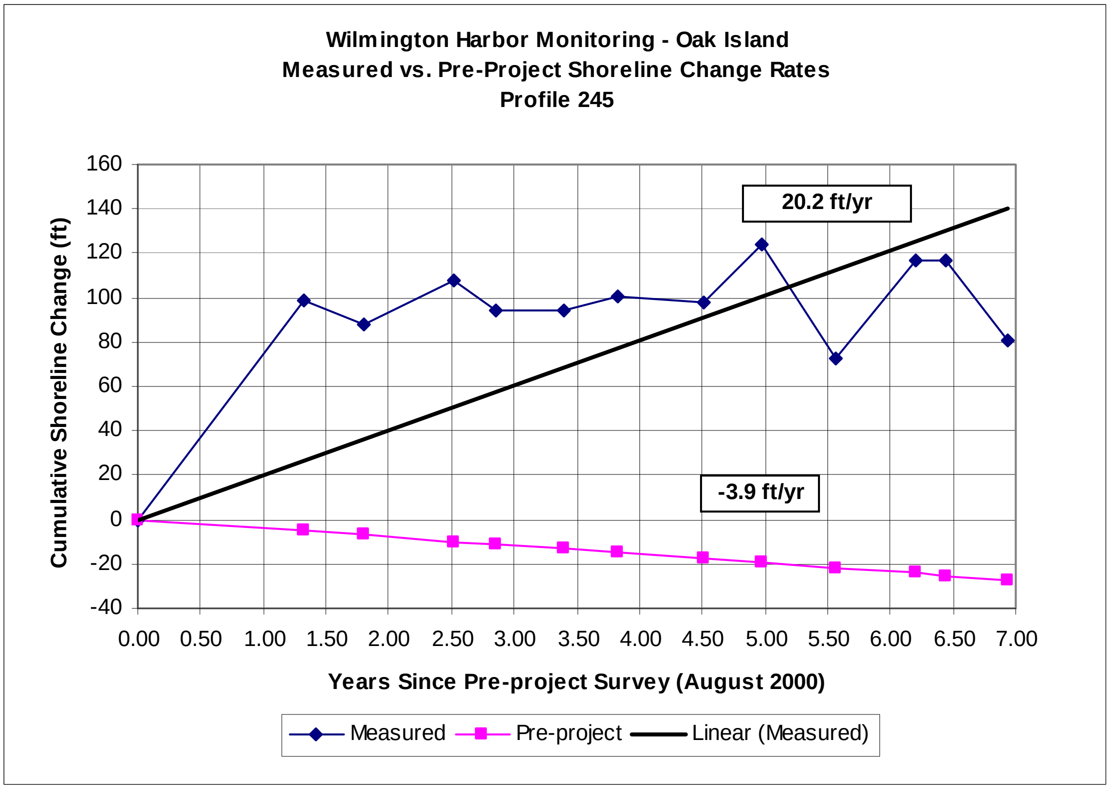
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 230
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
26.0 ft/yr
-4.8 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

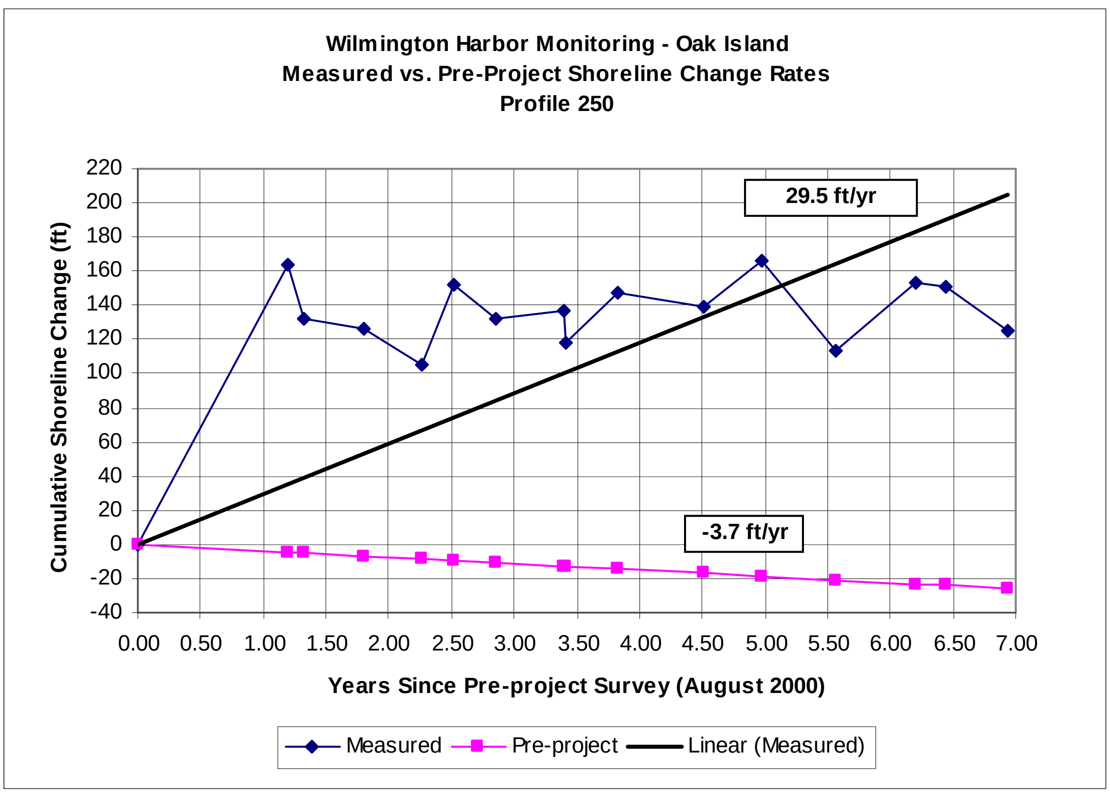


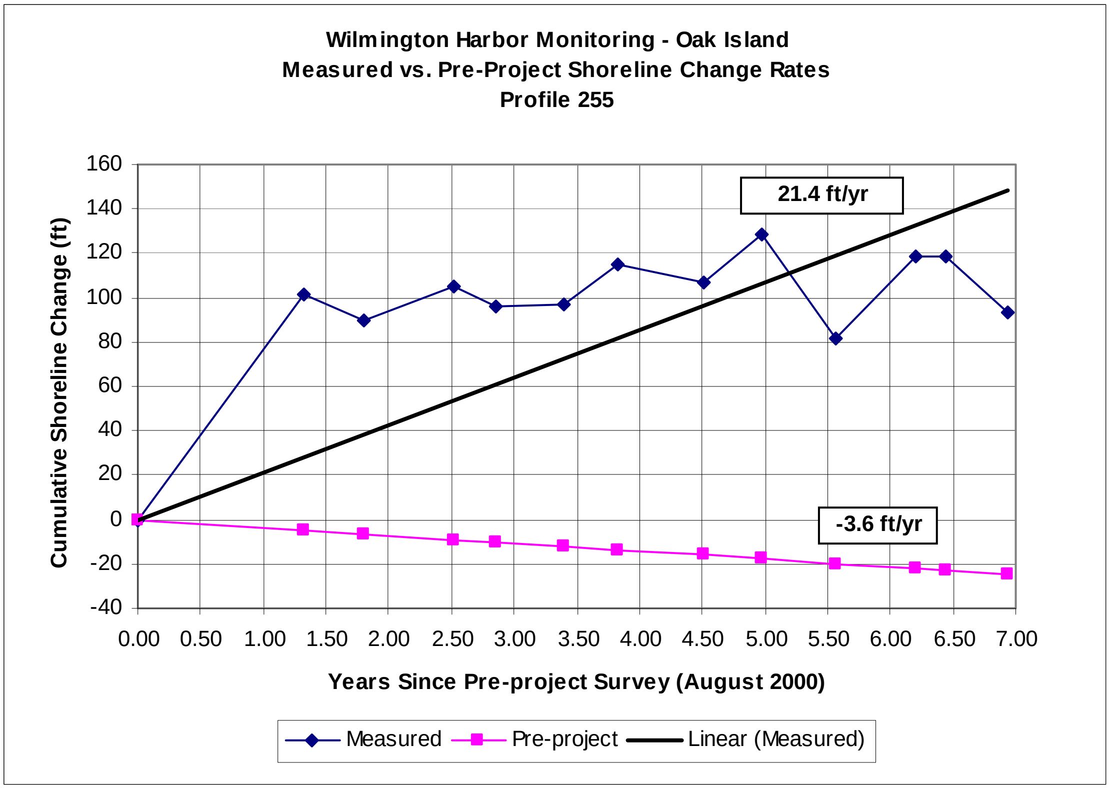
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 235
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
15.9 ft/yr
-4.4 ft/yr
Measured
Pre-project
Linear (Measured)

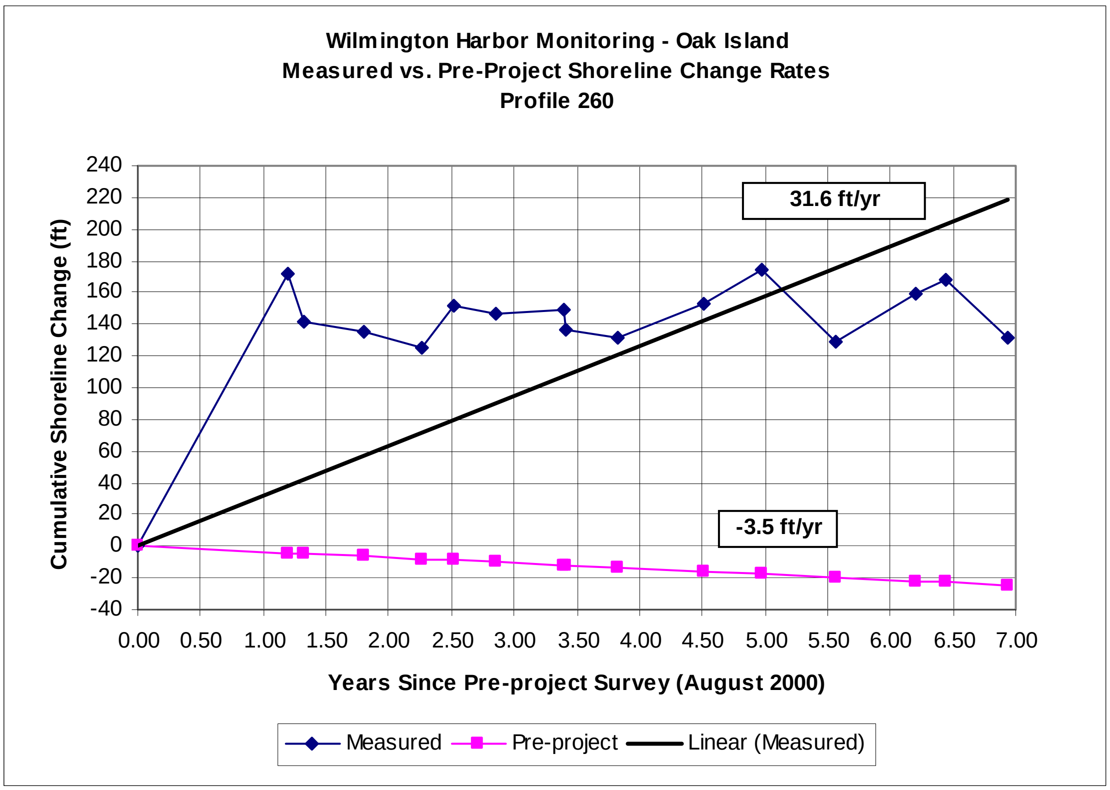


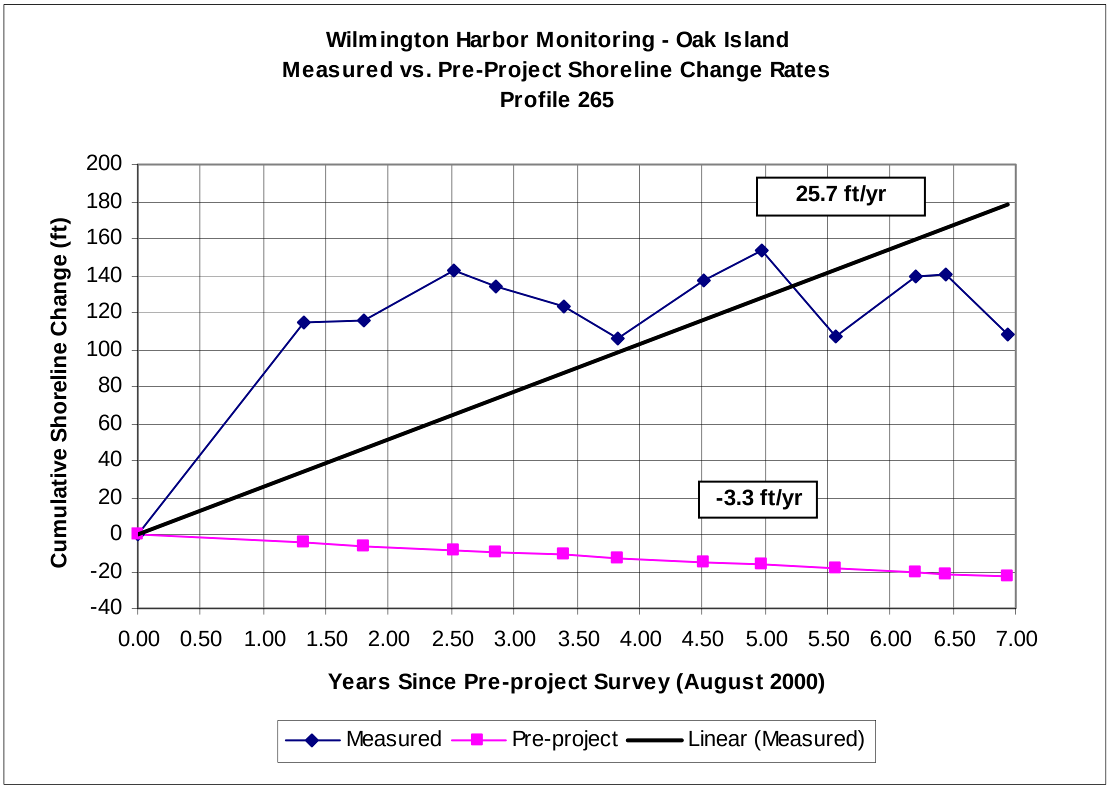
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 240
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
24.5 ft/yr
-4.1 ft/yr
Measured
Pre-project
Linear (Measured)

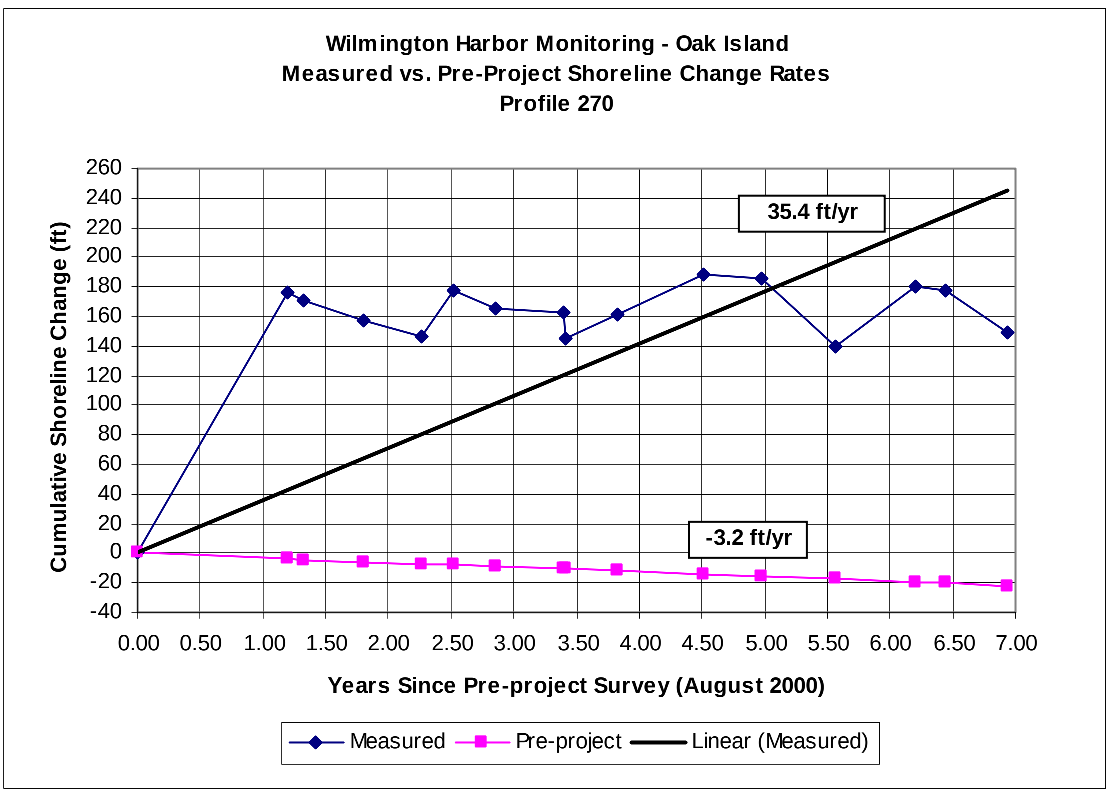

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 245
20.2 ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

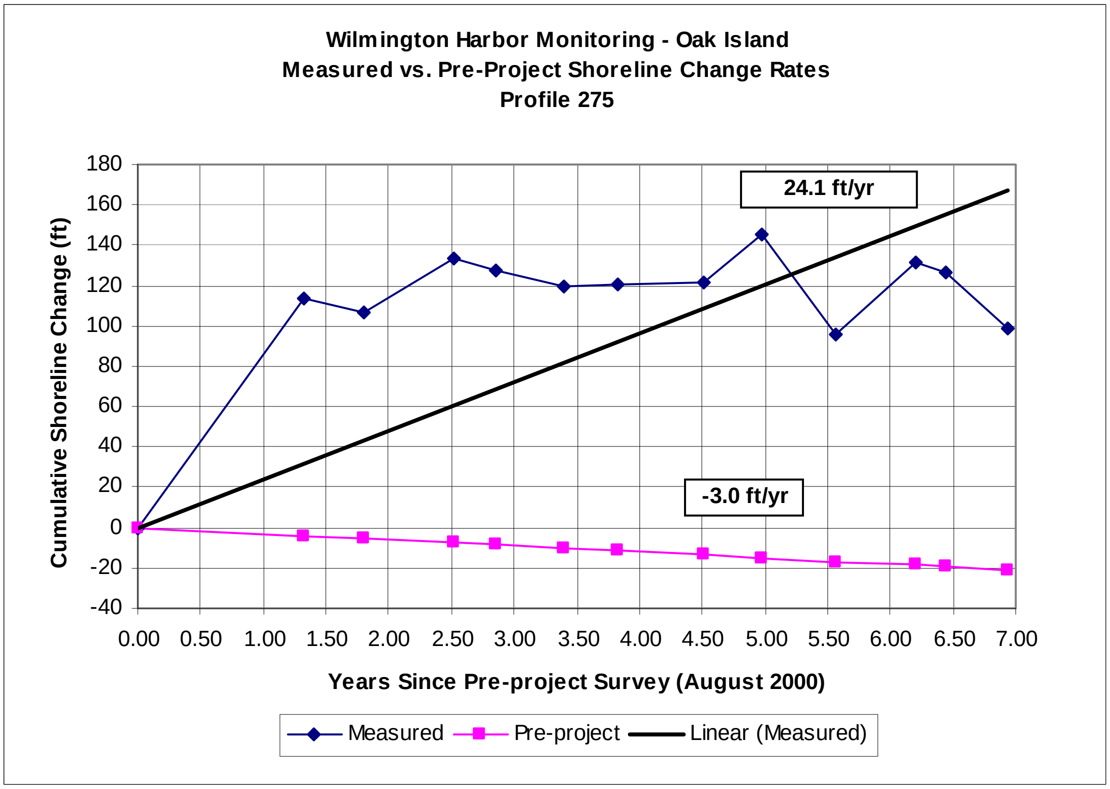

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 250
29.5 ft/yr
-3.7 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

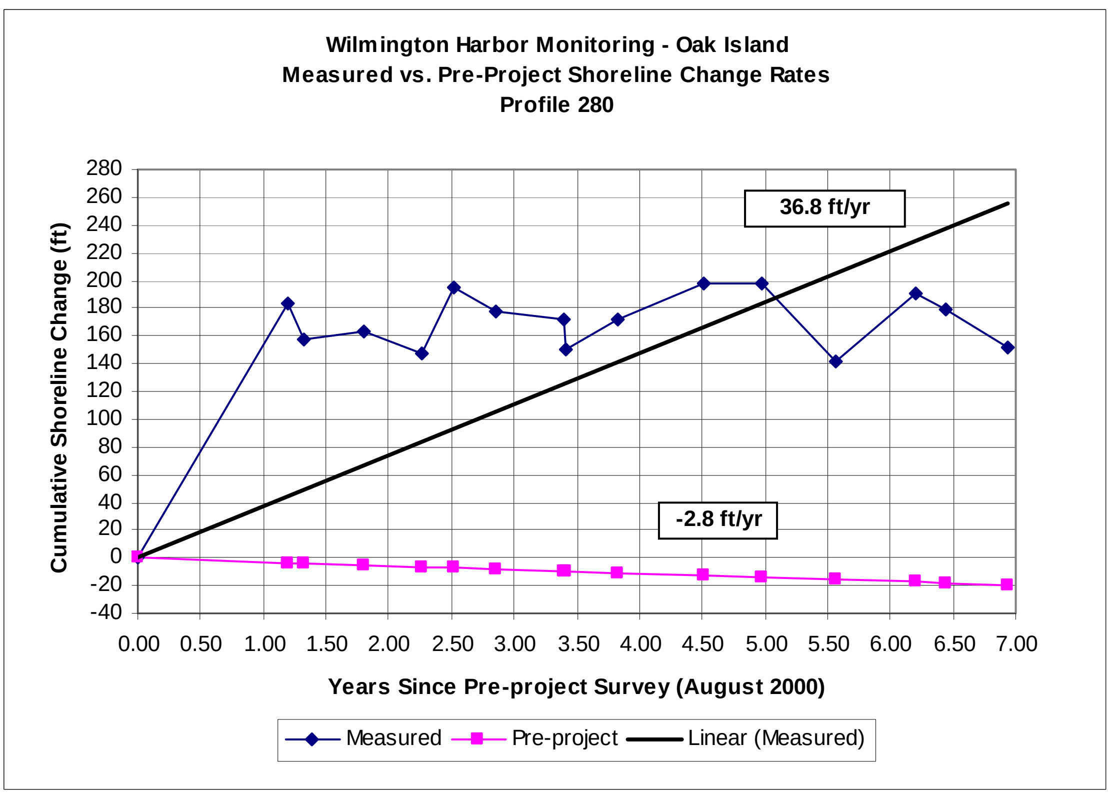

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 255
21.4 ft/yr
-3.6 ft/yr
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

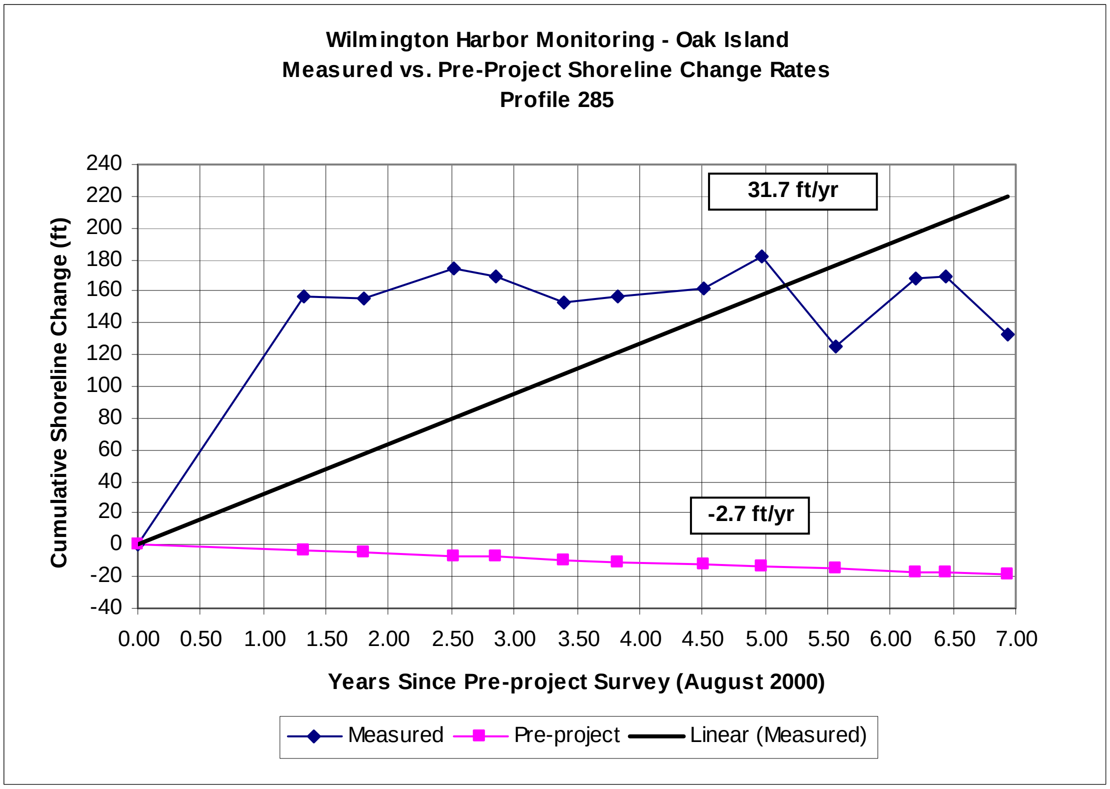

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 260
31.6 ft/yr
-3.5 ft/yr
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

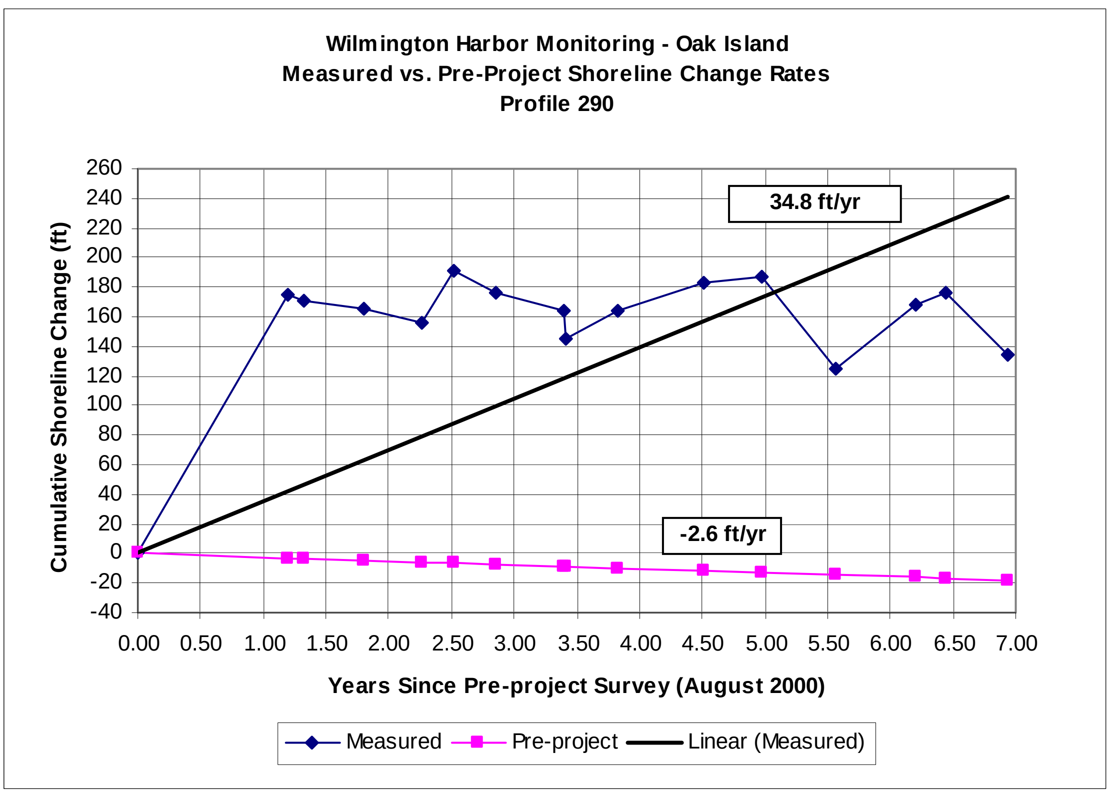

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 265
25.7 ft/yr
-3.3 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

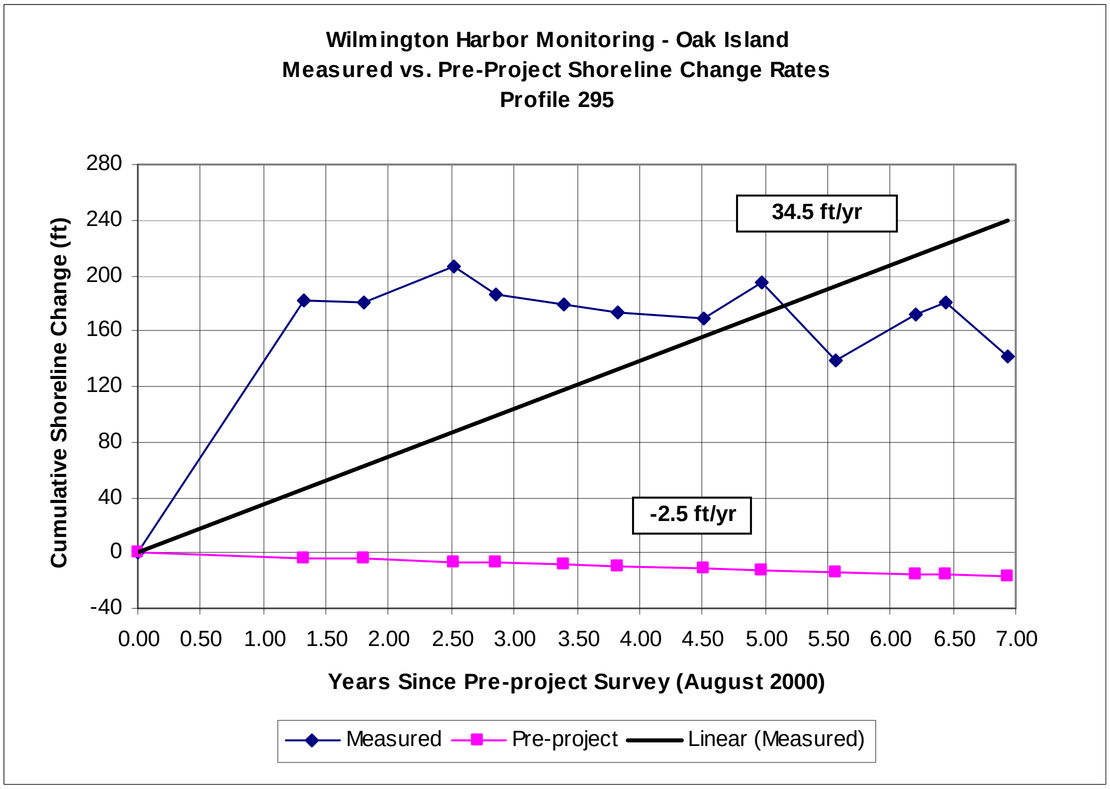

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 270
35.4 ft/yr
-3.2 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 275
24.1 ft/yr
-3.0 ft/yr
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

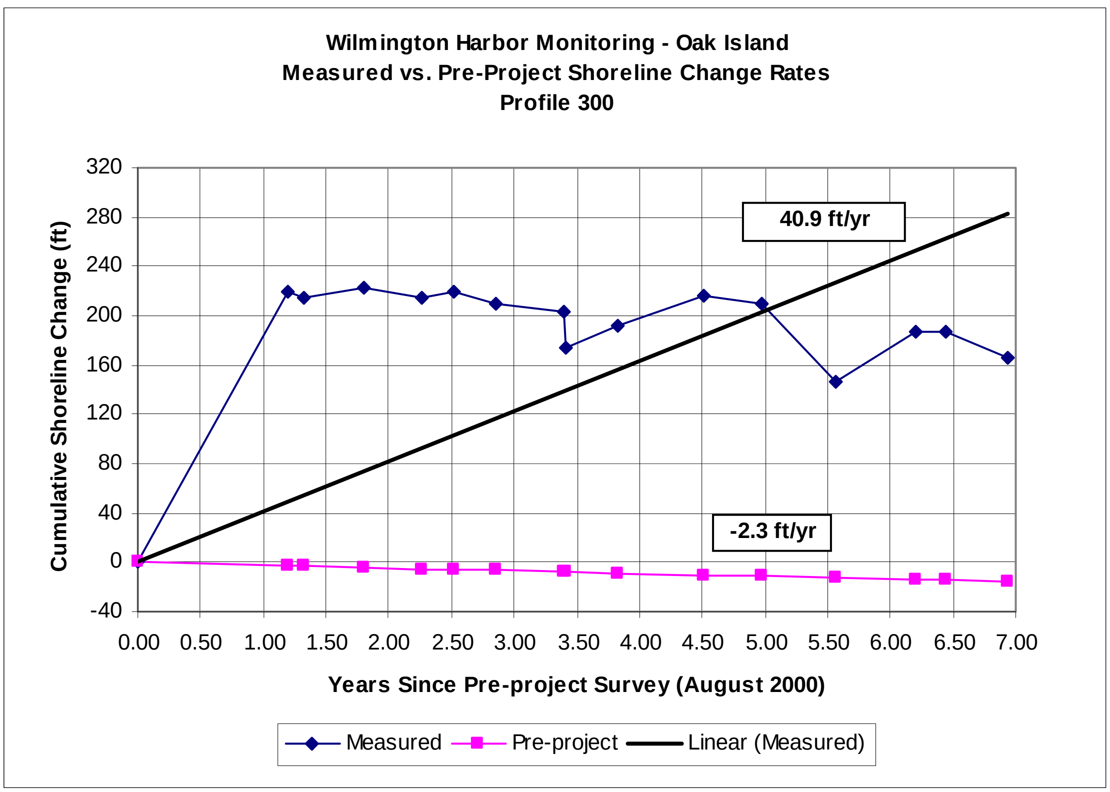

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 280
36.8 ft/yr
-2.8 ft/yr
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


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

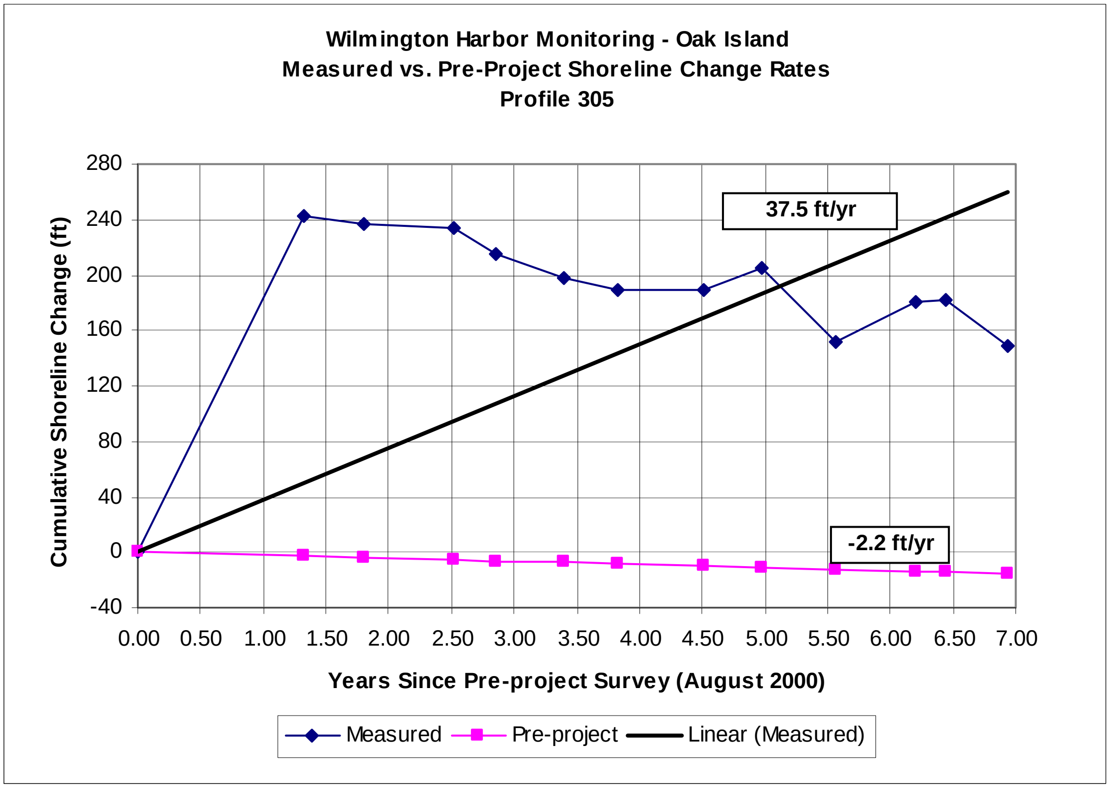

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 290
34.8 ft/yr
-2.6 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

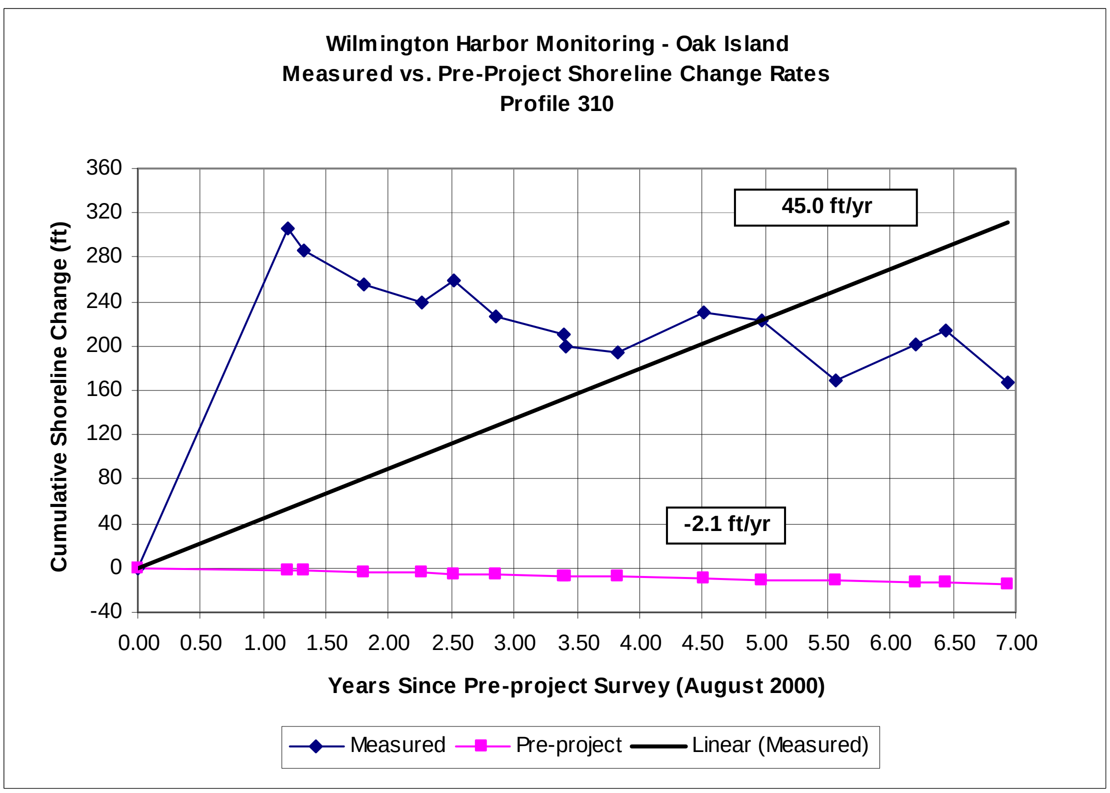


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 295
34.5 ft/yr
-2.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)



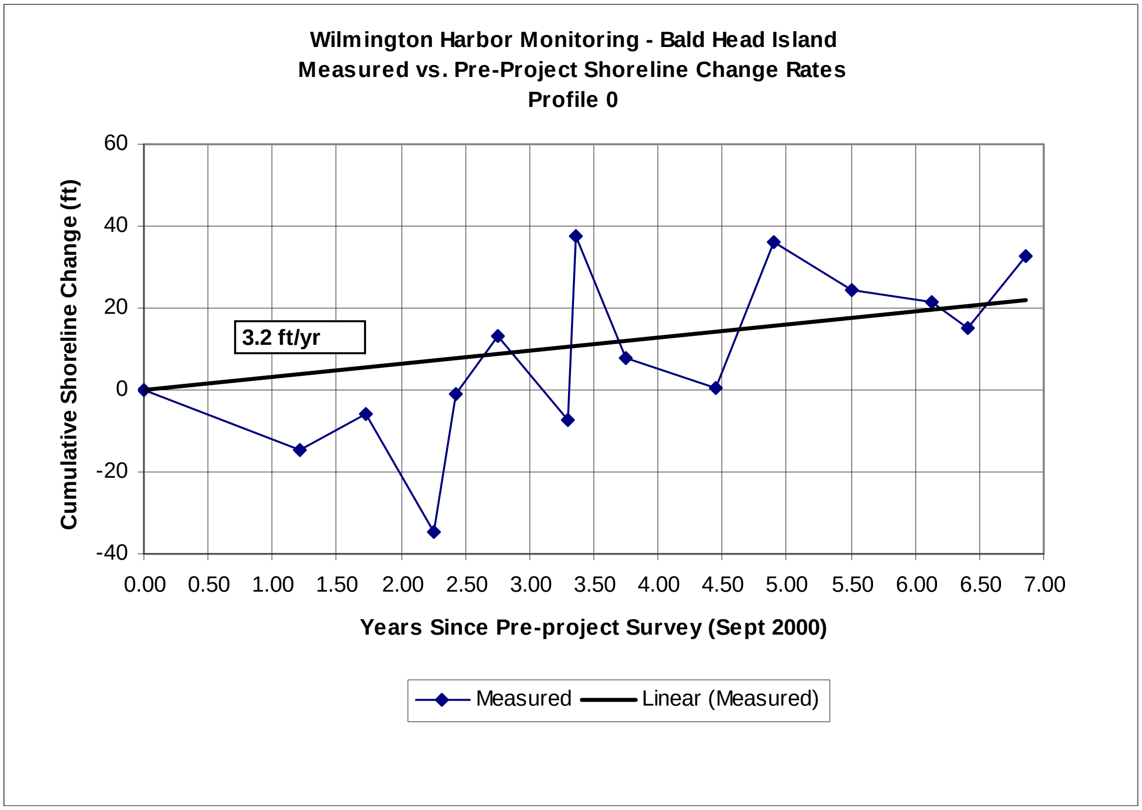
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 300
40.9 ft/yr
-2.3 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

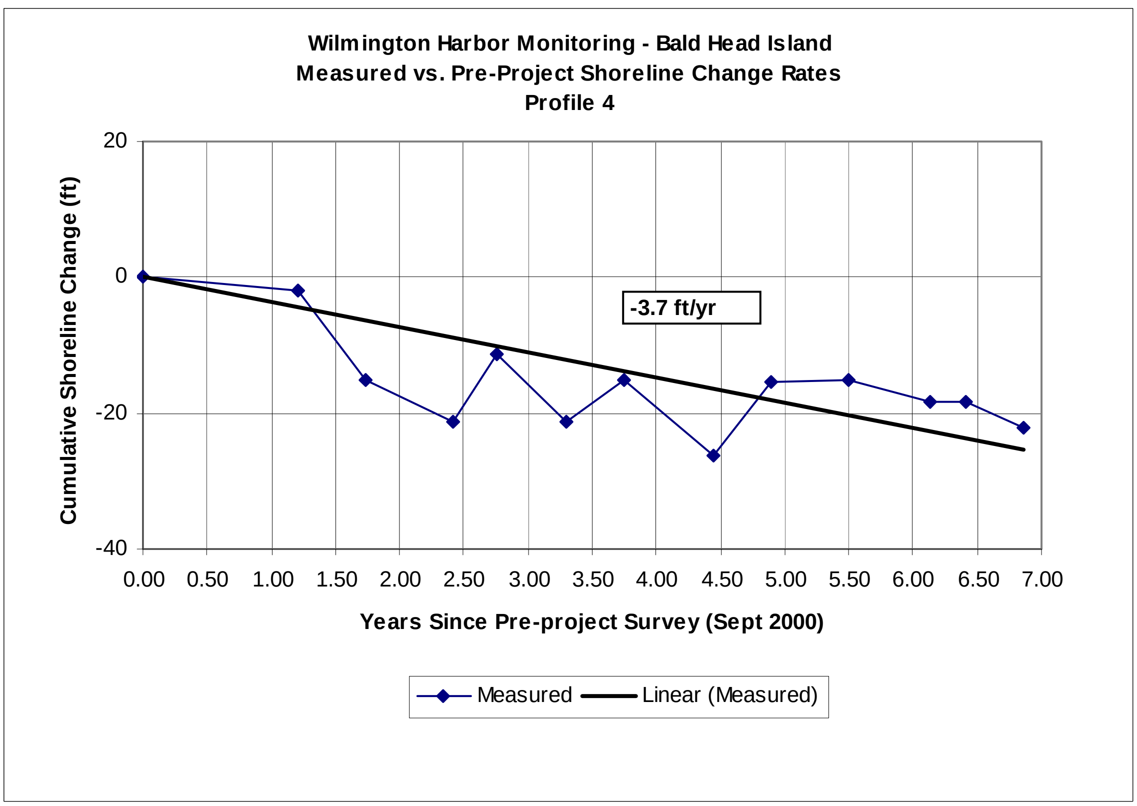

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 305
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
37.5 ft/yr
-2.2 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

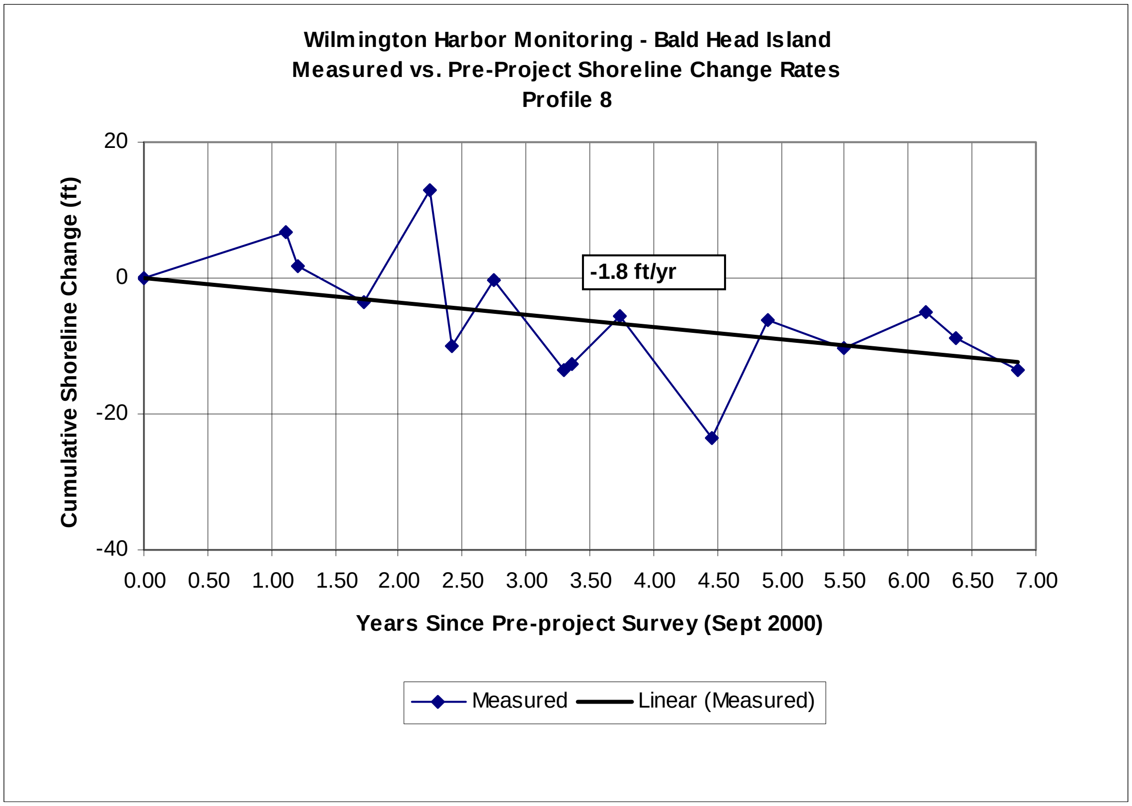

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 310
Cumulative Shoreline Change (ft)
360
320
280
240
200
160
120
80
40
0
-40
45.0 ft/yr
-2.1 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

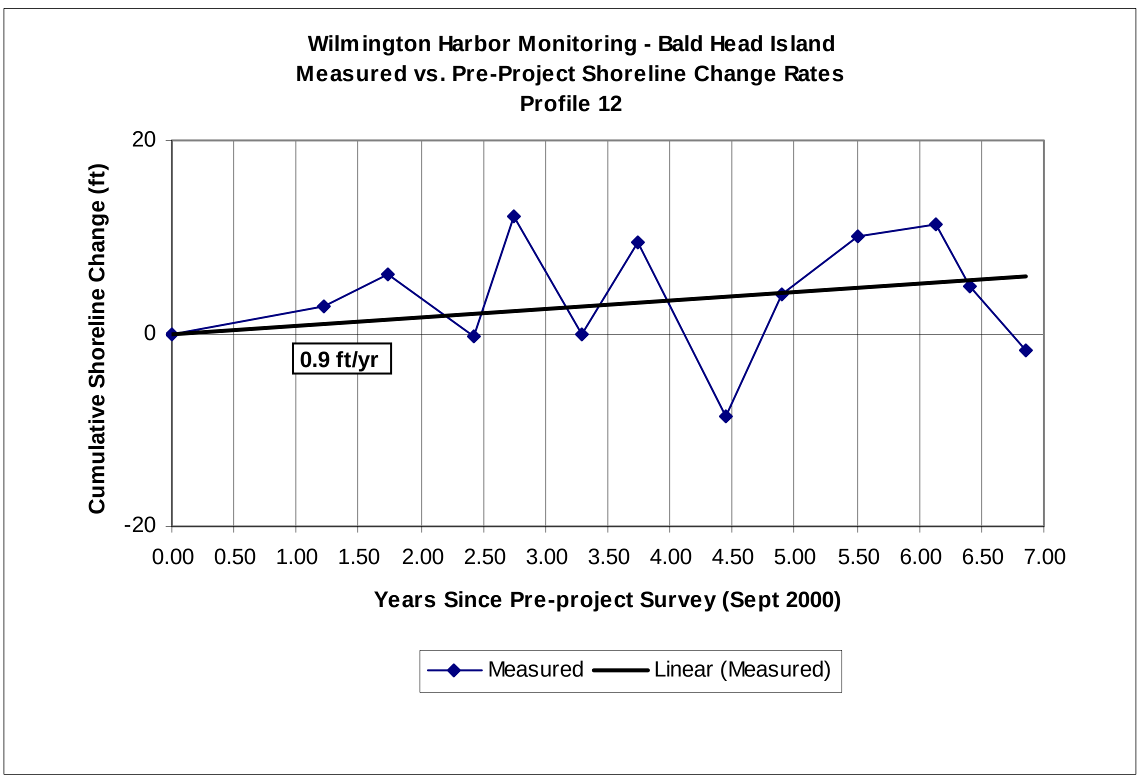
Appendix C

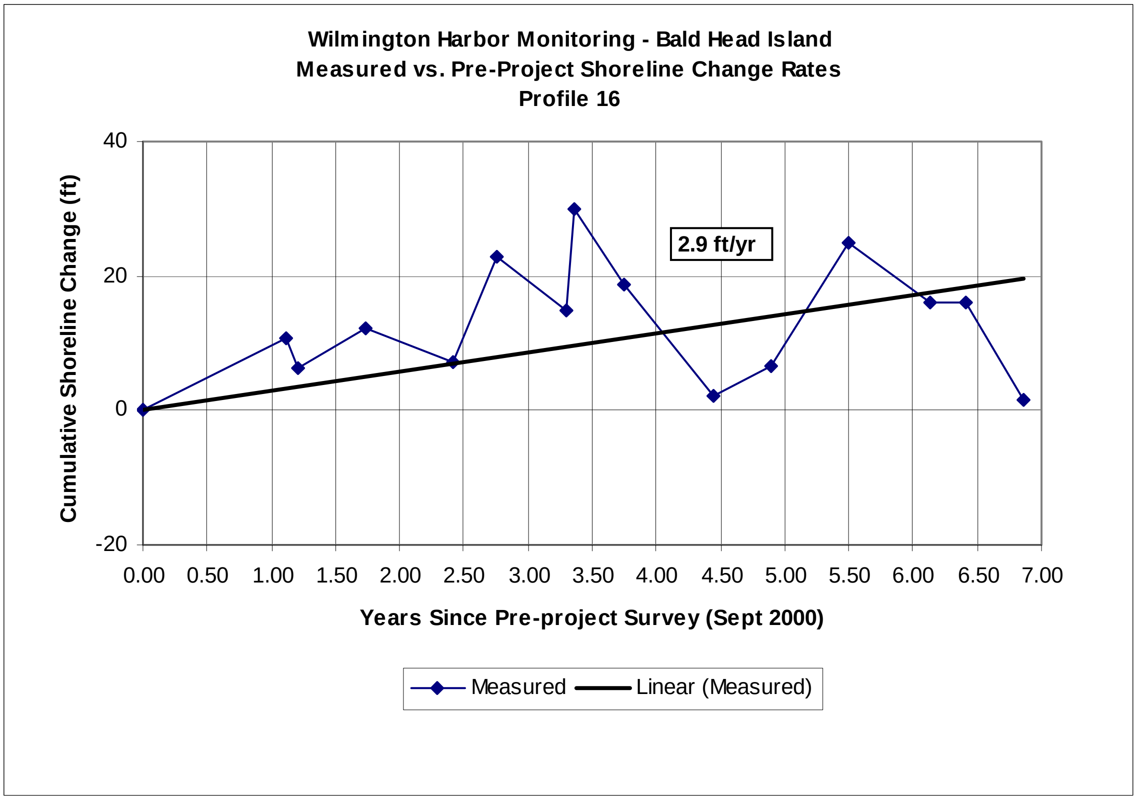
SHORELINE CHANGE RATES
(Bald Head Island)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 0
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
3.2 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

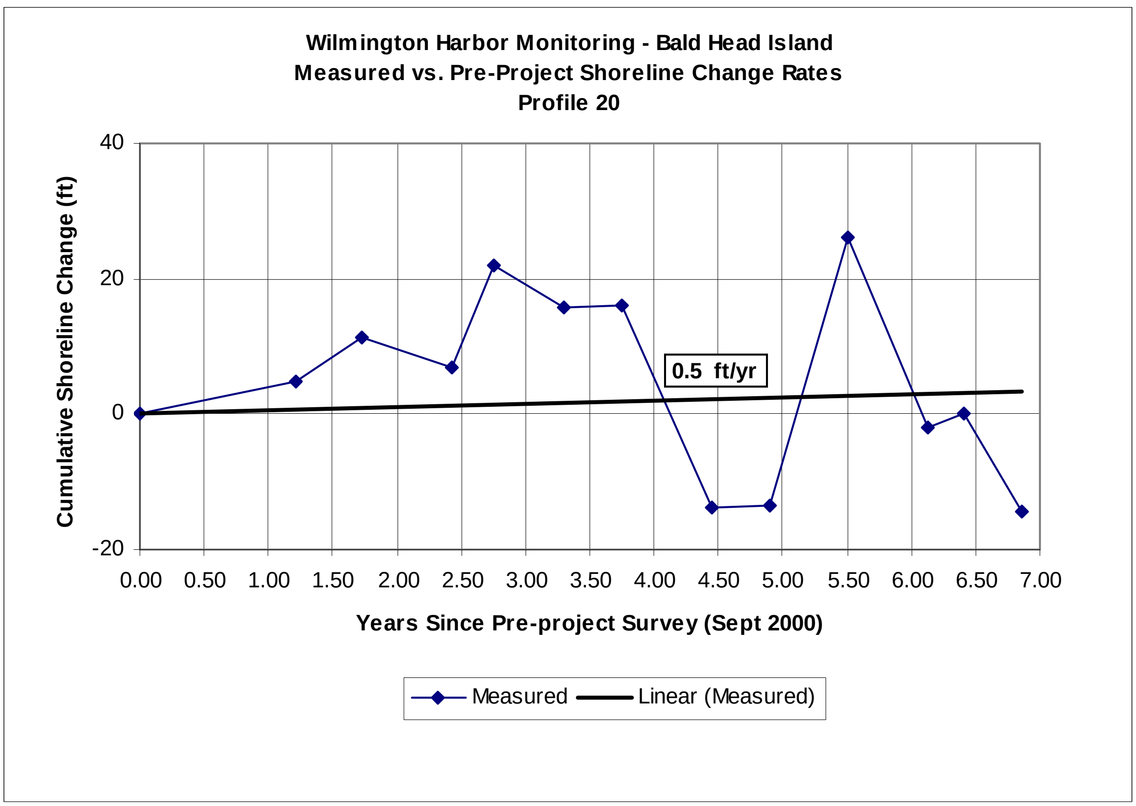

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 4
Cumulative Shoreline Change (ft)
20
0
-20
-40
-3.7 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 8
Cumulative Shoreline Change (ft)
20
0
-20
-40
-1.8 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

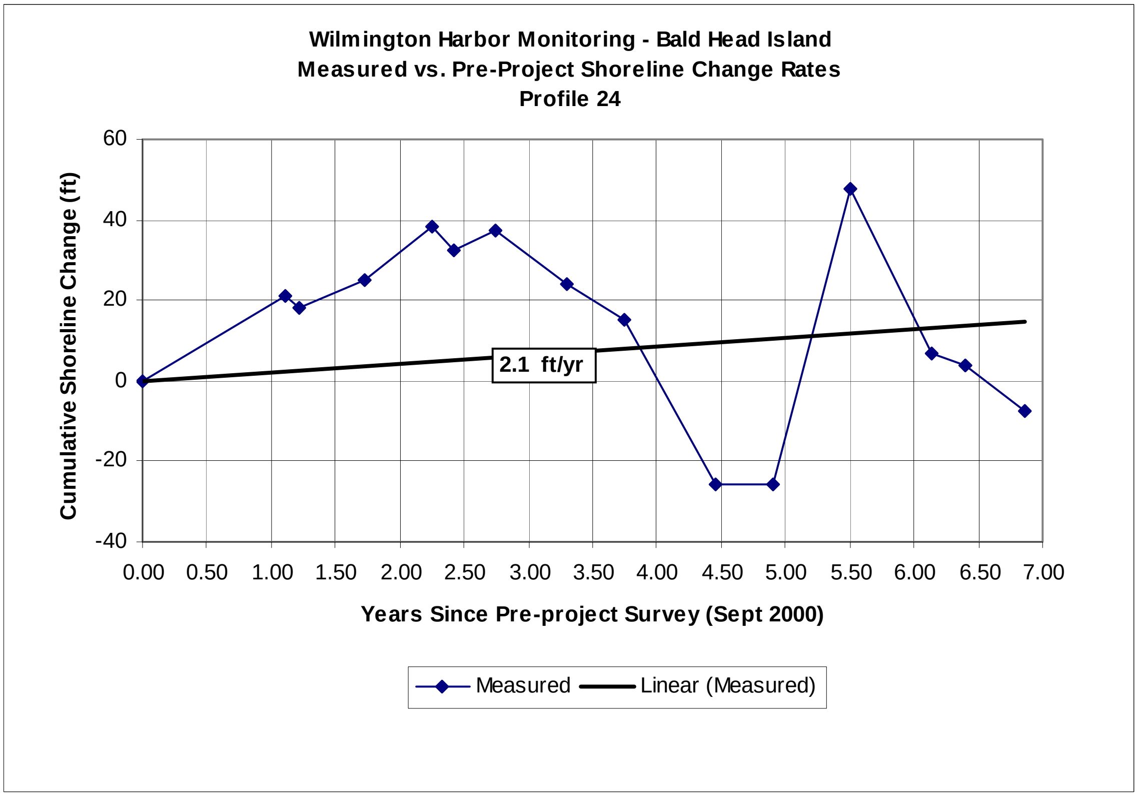

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 12
Cumulative Shoreline Change (ft)
20
0
-20
0.9 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

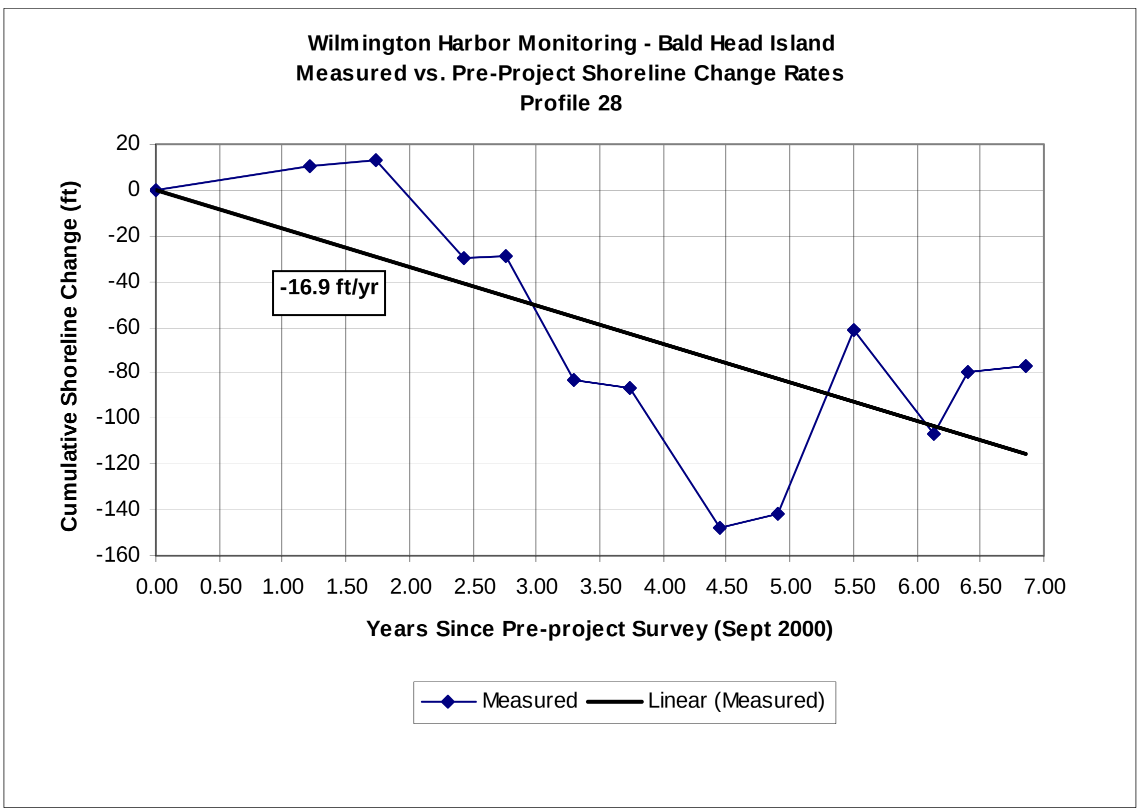


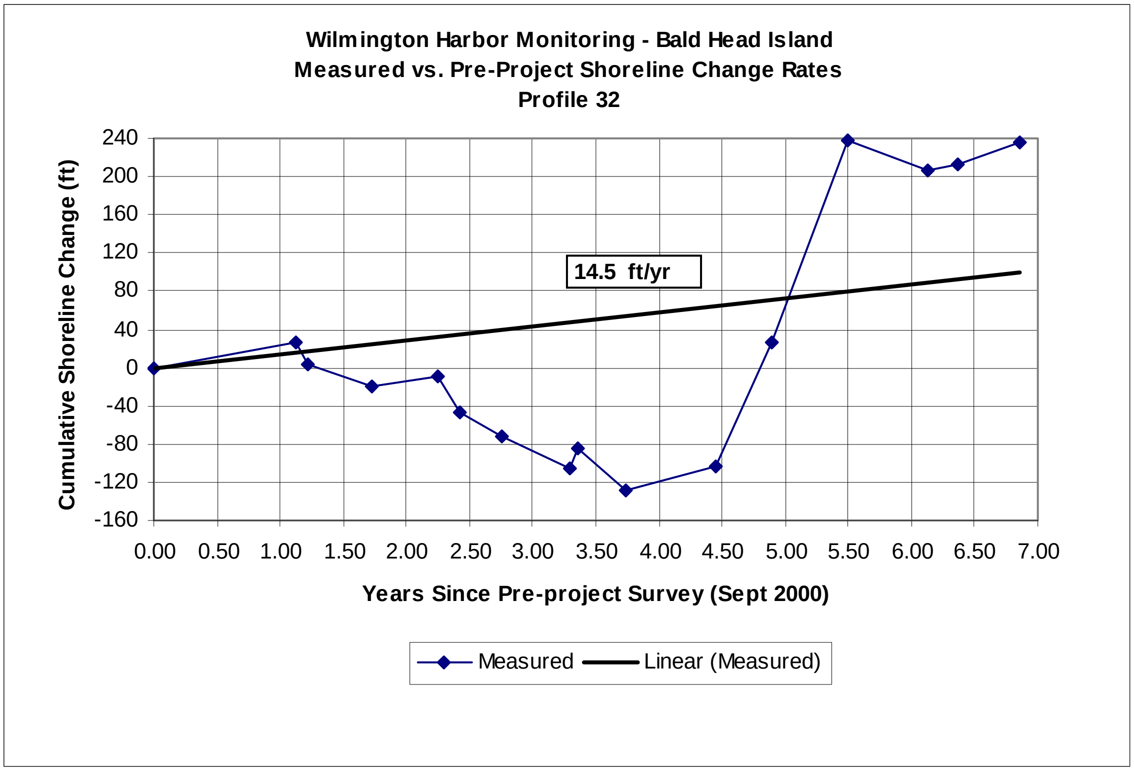
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 16
Cumulative Shoreline Change (ft)
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
2.9 ft/yr
Measured
Linear (Measured)



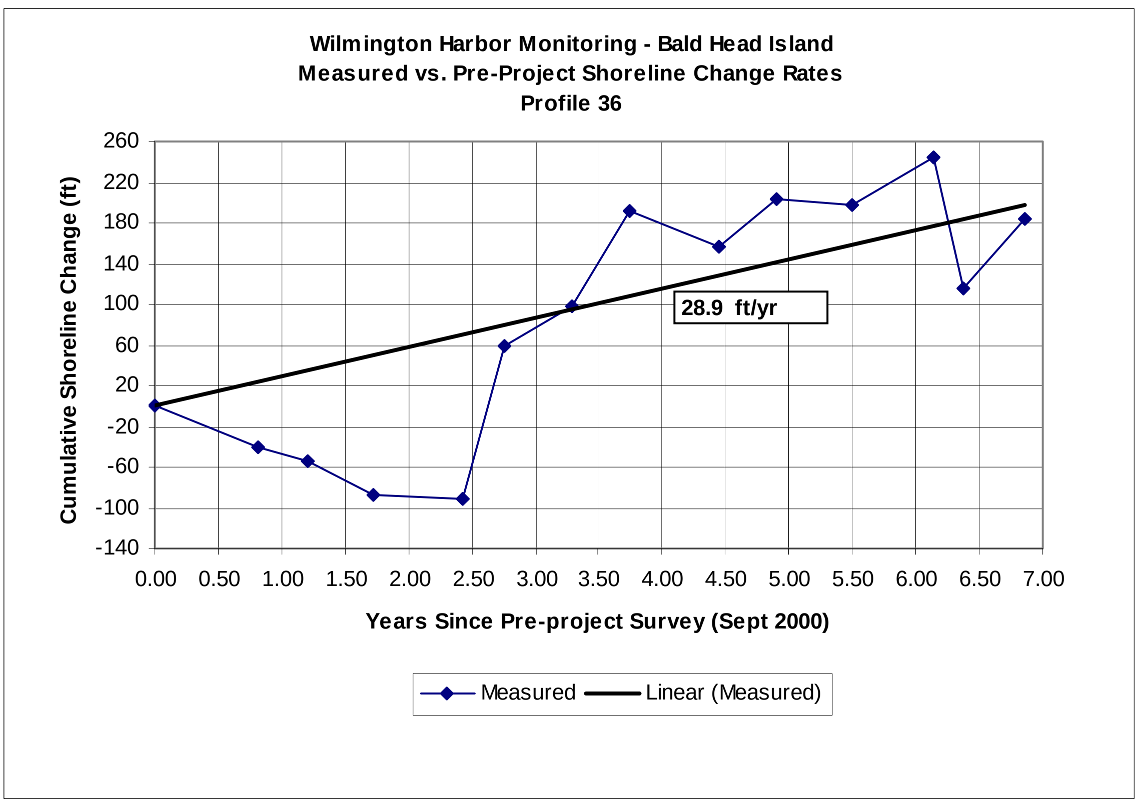
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
0.5 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 24
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
2.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

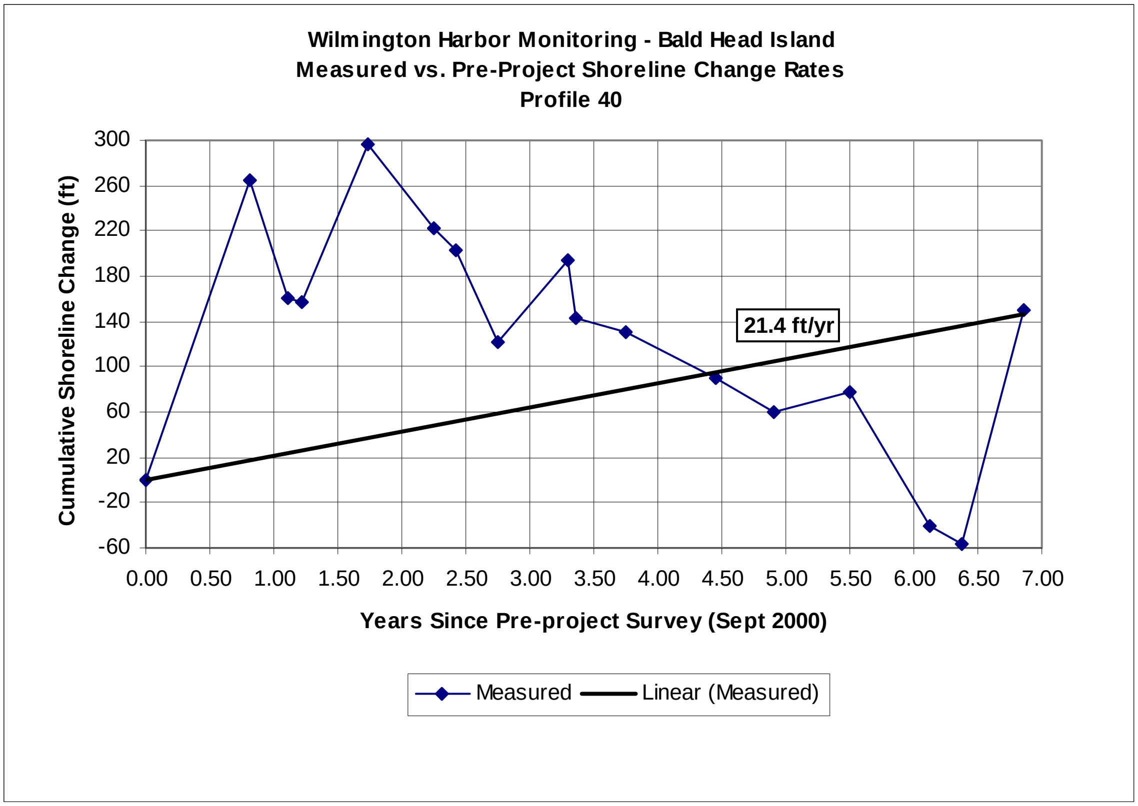

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 28
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
-140
-160
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
-16.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

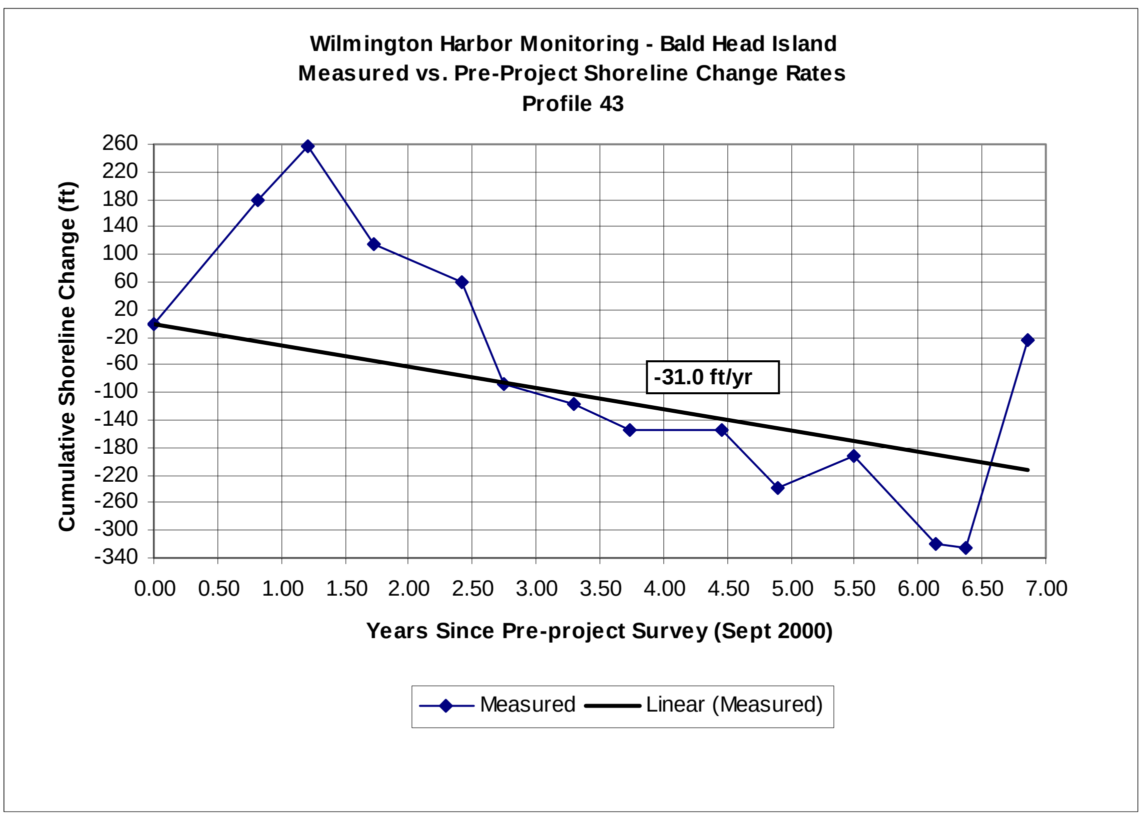


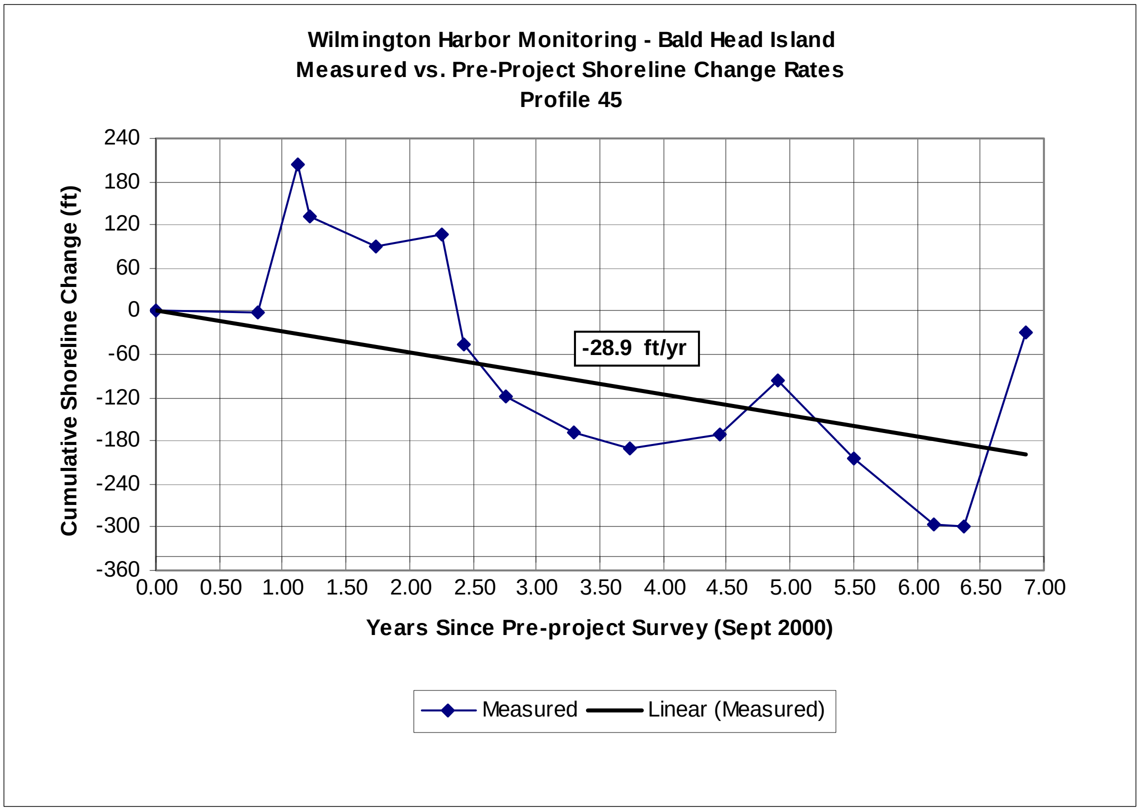
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 32
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
-120
-160
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
14.5 ft/yr
Measured
Linear (Measured)



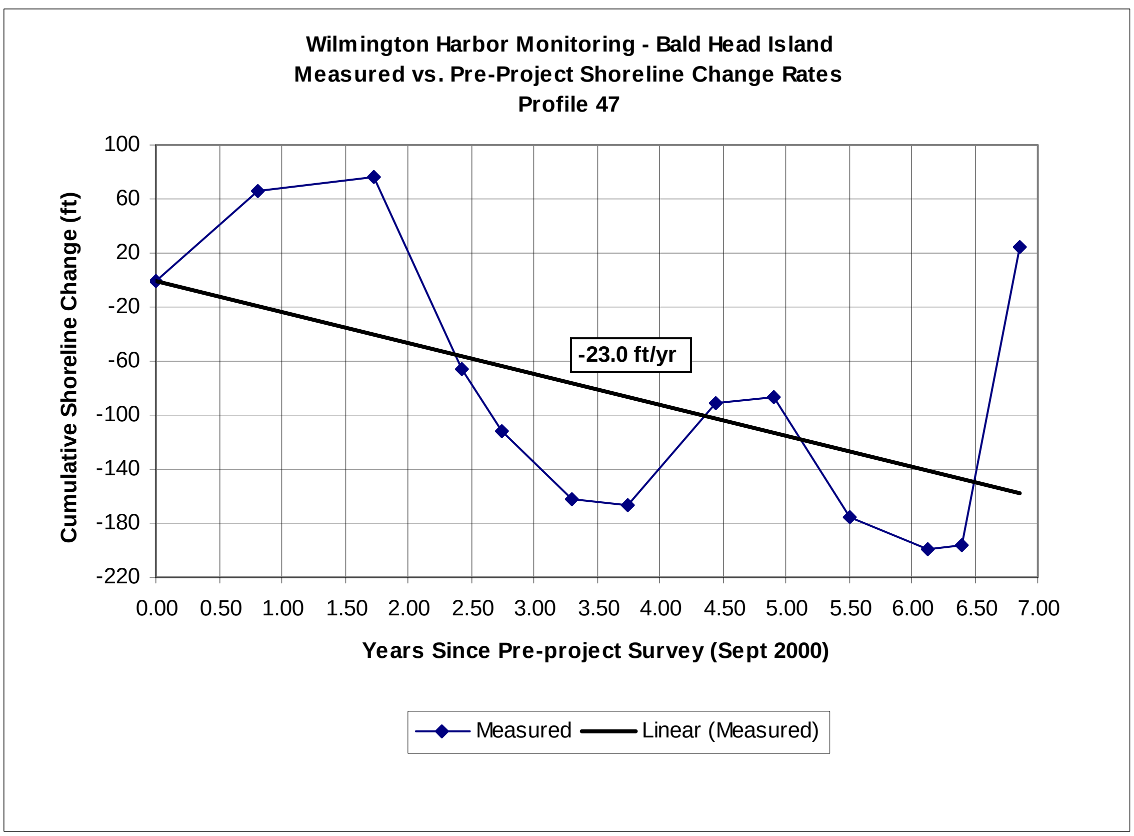
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 36
Cumulative Shoreline Change (ft)
260
220
180
140
100
60
20
-20
-60
-100
-140
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
28.9 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
Cumulative Shoreline Change (ft)
300
260
220
180
140
100
60
20
-20
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
21.4 ft/yr
Measured
Linear (Measured)

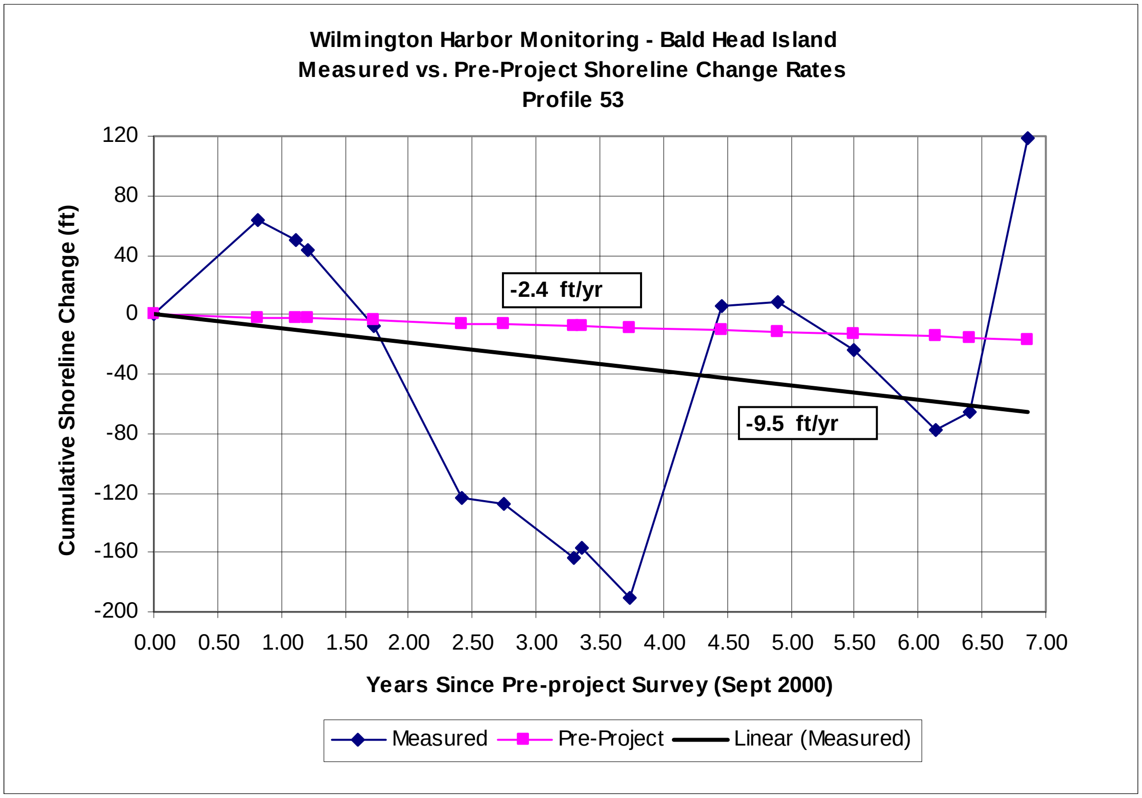

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 43
Cumulative Shoreline Change (ft)
260
220
180
140
100
60
20
-20
-60
-100
-140
-180
-220
-260
-300
-340
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
-31.0 ft/yr
Measured
Linear (Measured)



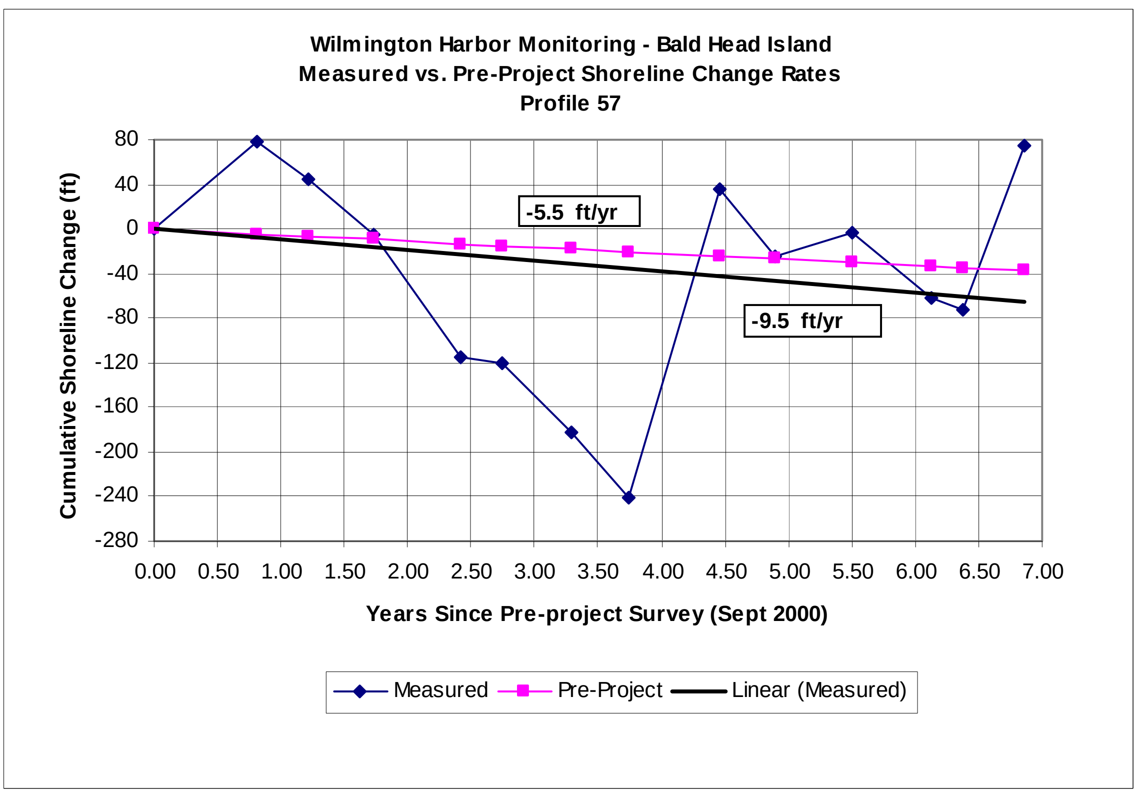
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
240
180
120
60
0
-60
-120
-180
-240
-300
-360
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
-28.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)



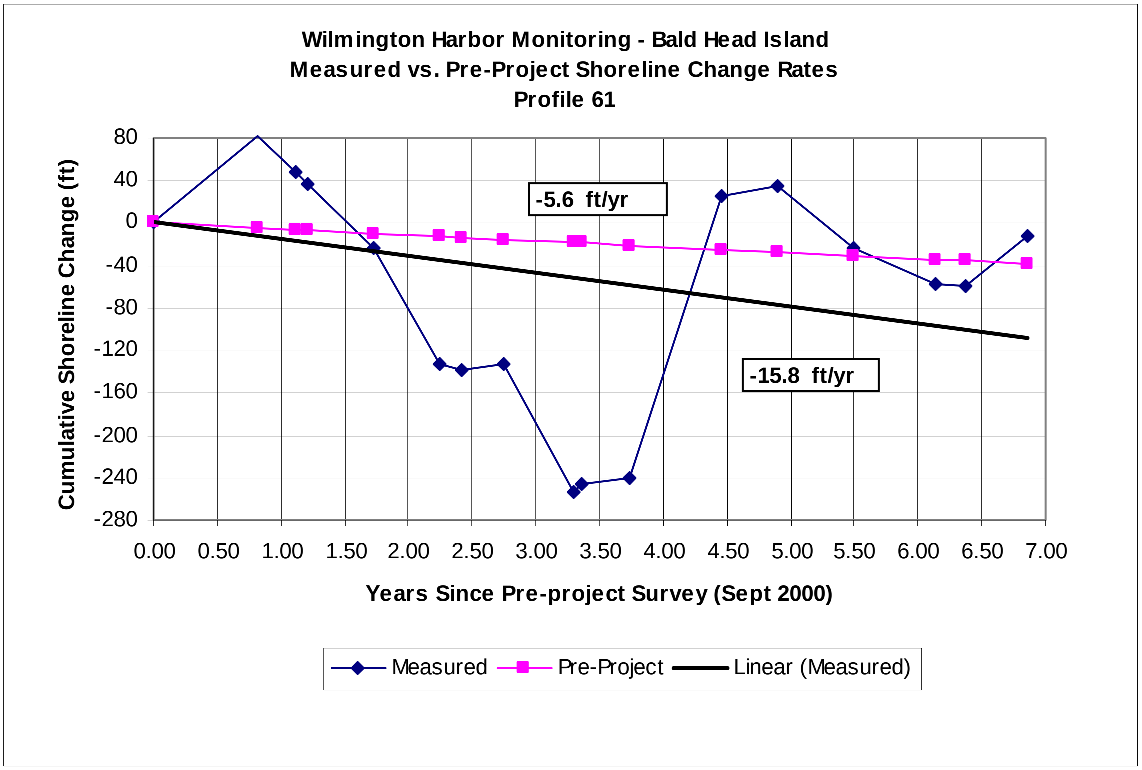
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 47
Cumulative Shoreline Change (ft)
100
60
20
-20
-60
-100
-140
-180
-220
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
-23.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

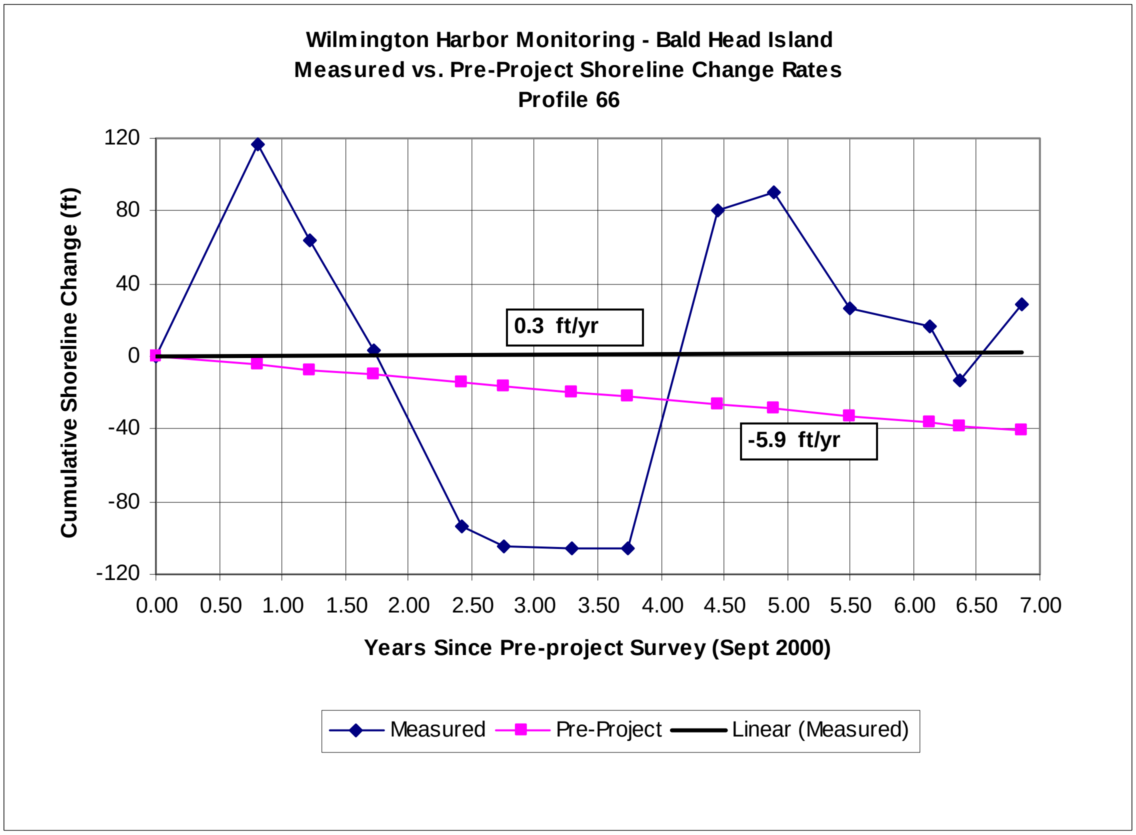


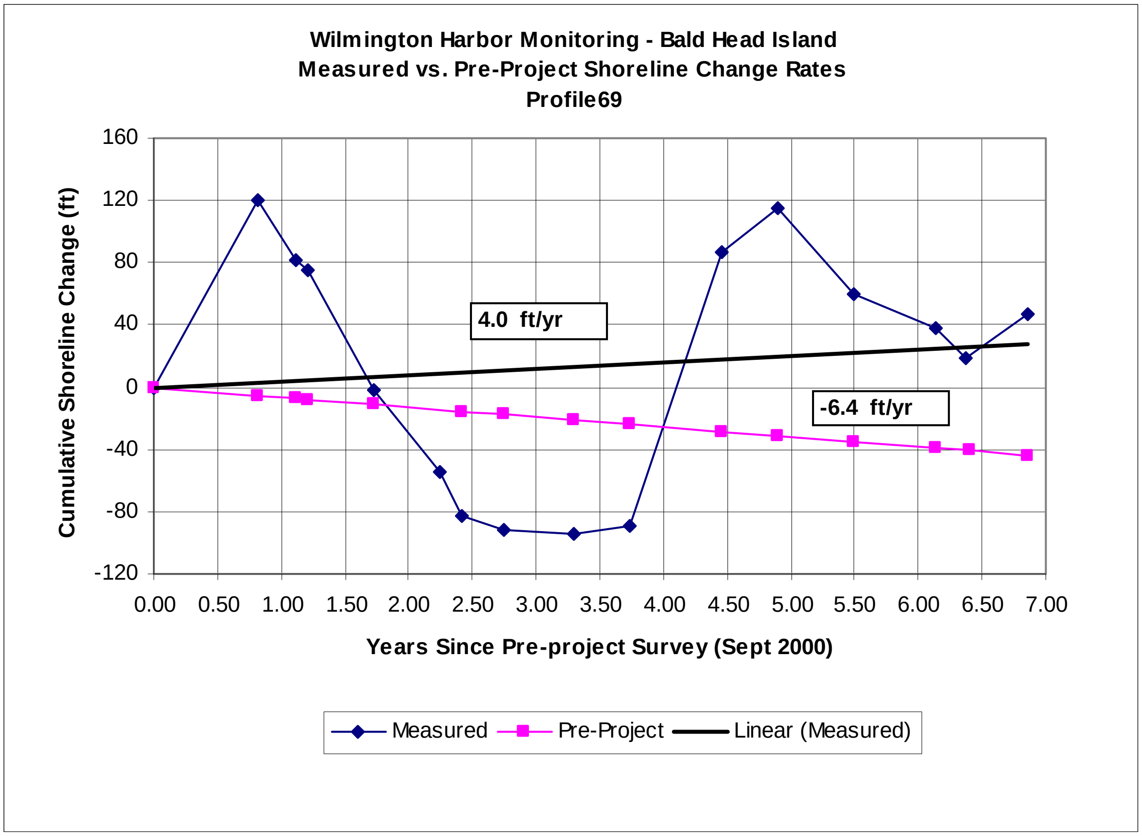
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 53
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
-120
-160
-200
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
-2.4 ft/yr
-9.5 ft/yr
Measured
Pre-Project
Linear (Measured)

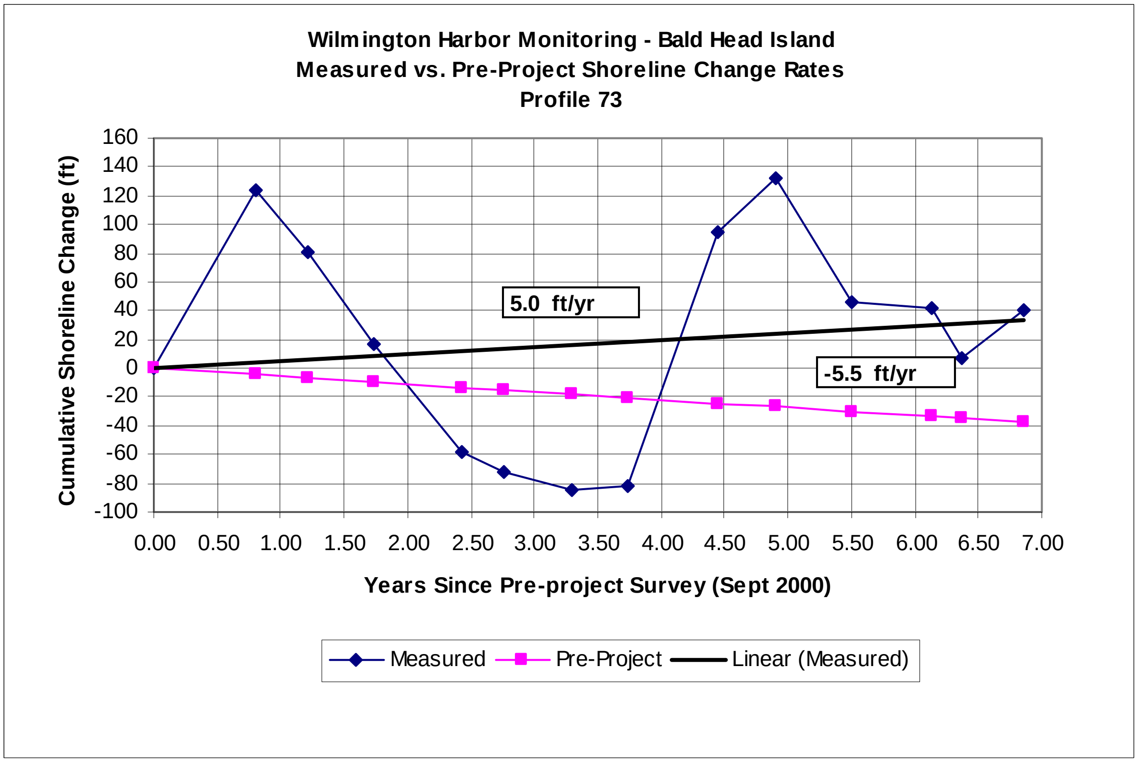


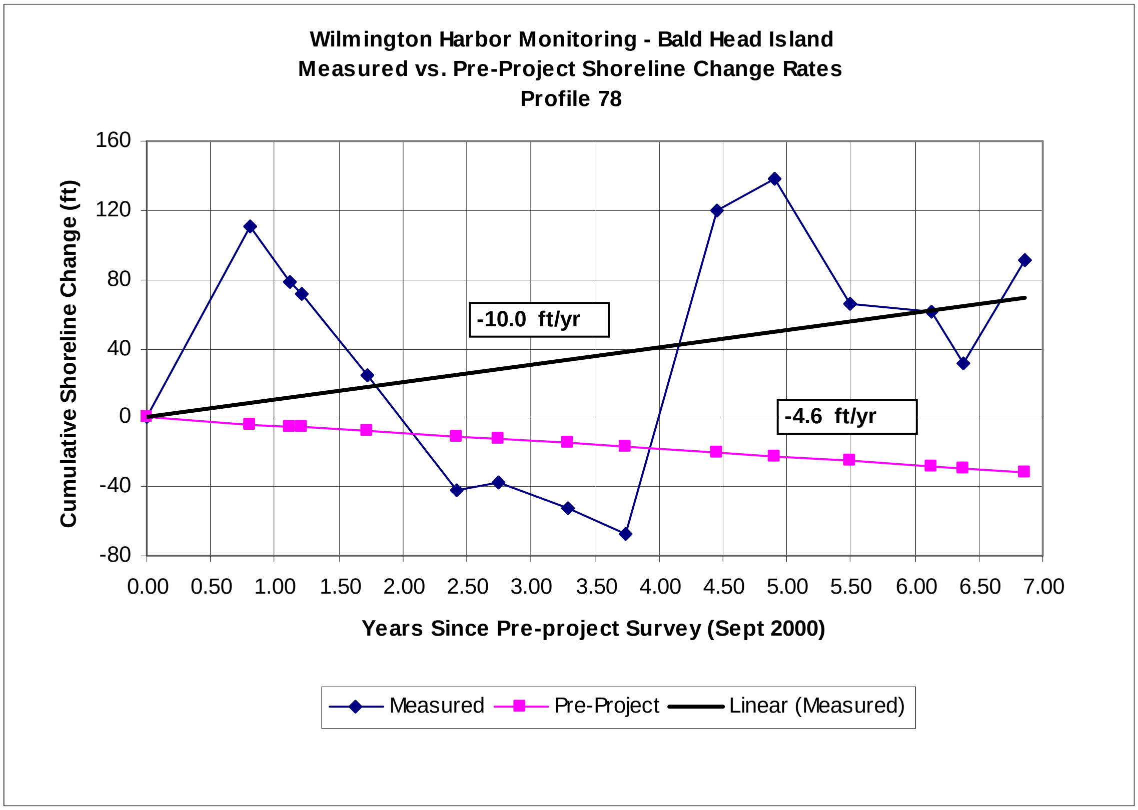
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 57
Cumulative Shoreline Change (ft)
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
-5.5 ft/yr
-9.5 ft/yr
Measured
Pre-Project
Linear (Measured)

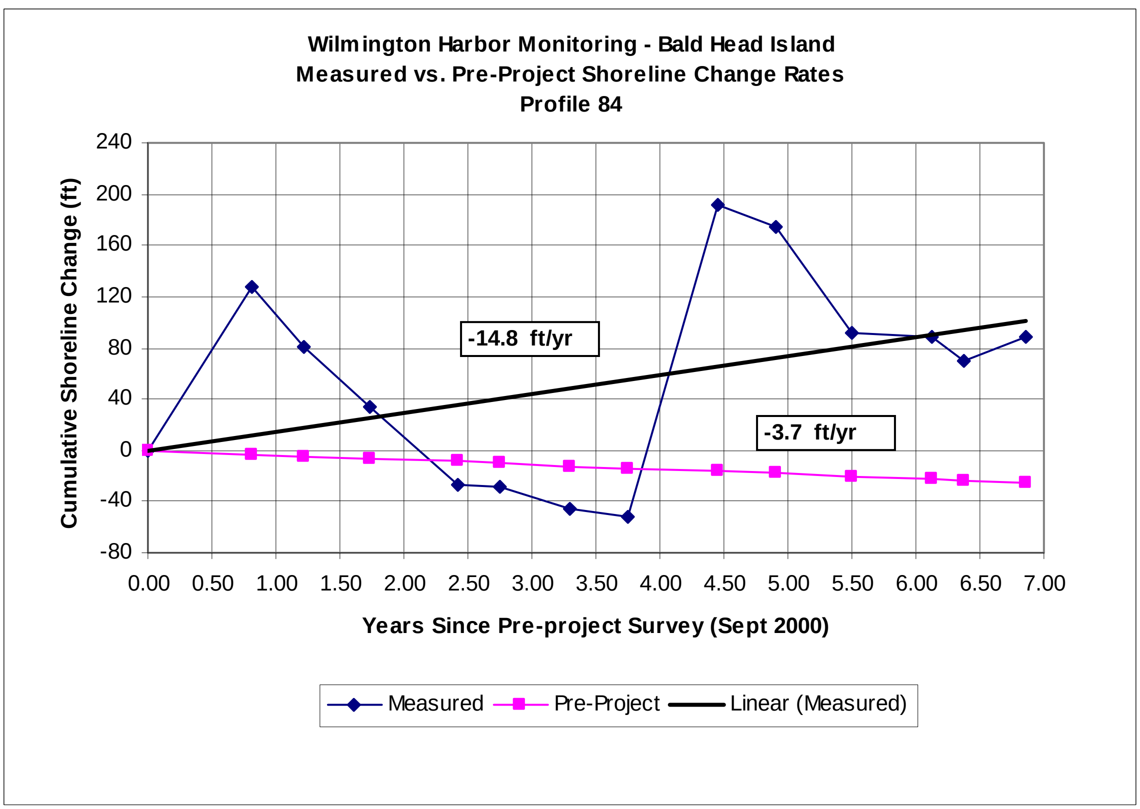

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 61
-5.6 ft/yr
-15.8 ft/yr
Cumulative Shoreline Change (ft)
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

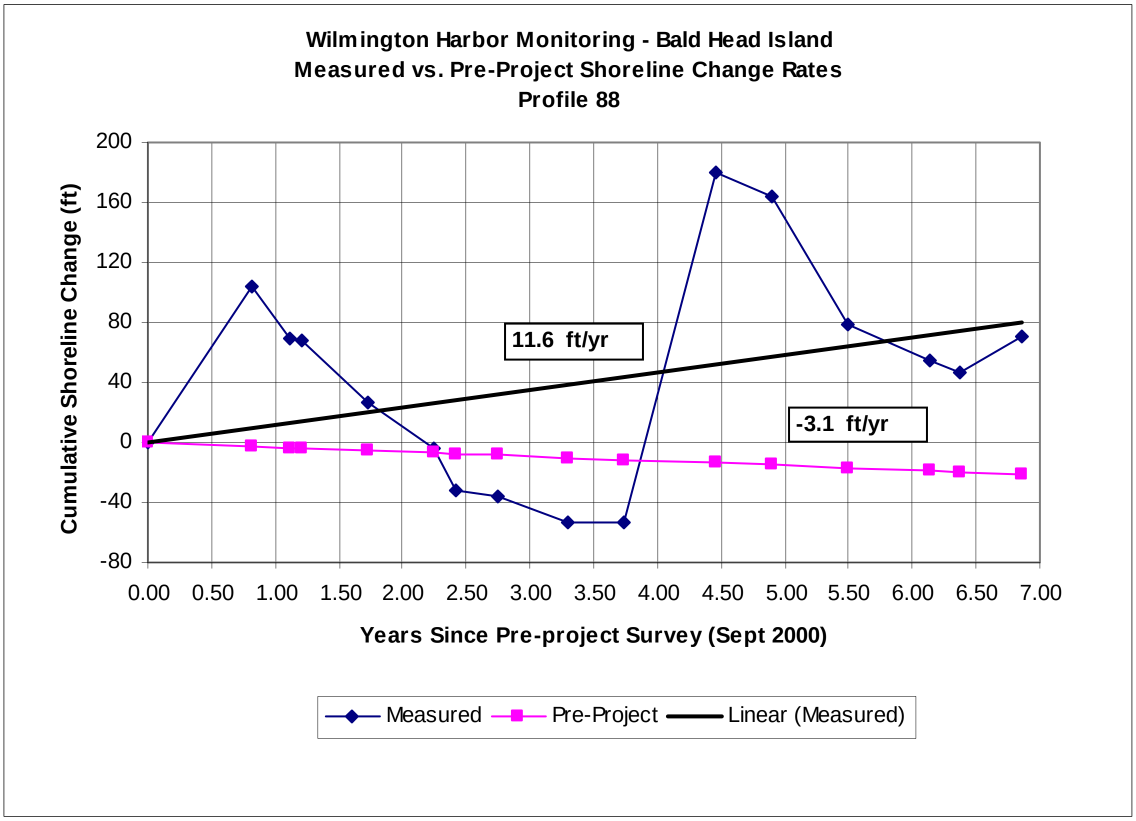

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 66
0.3 ft/yr
-5.9 ft/yr
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

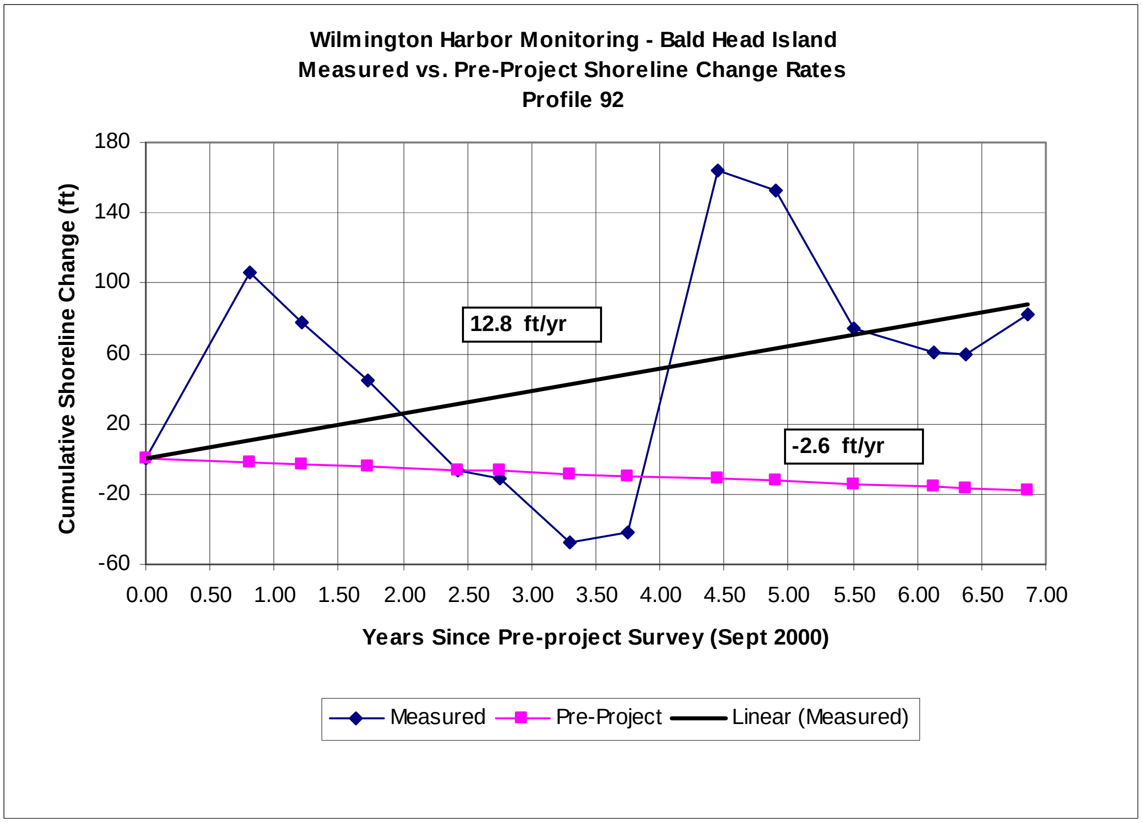

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile69
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
4.0 ft/yr
-6.4 ft/yr
Measured
Pre-Project
Linear (Measured)

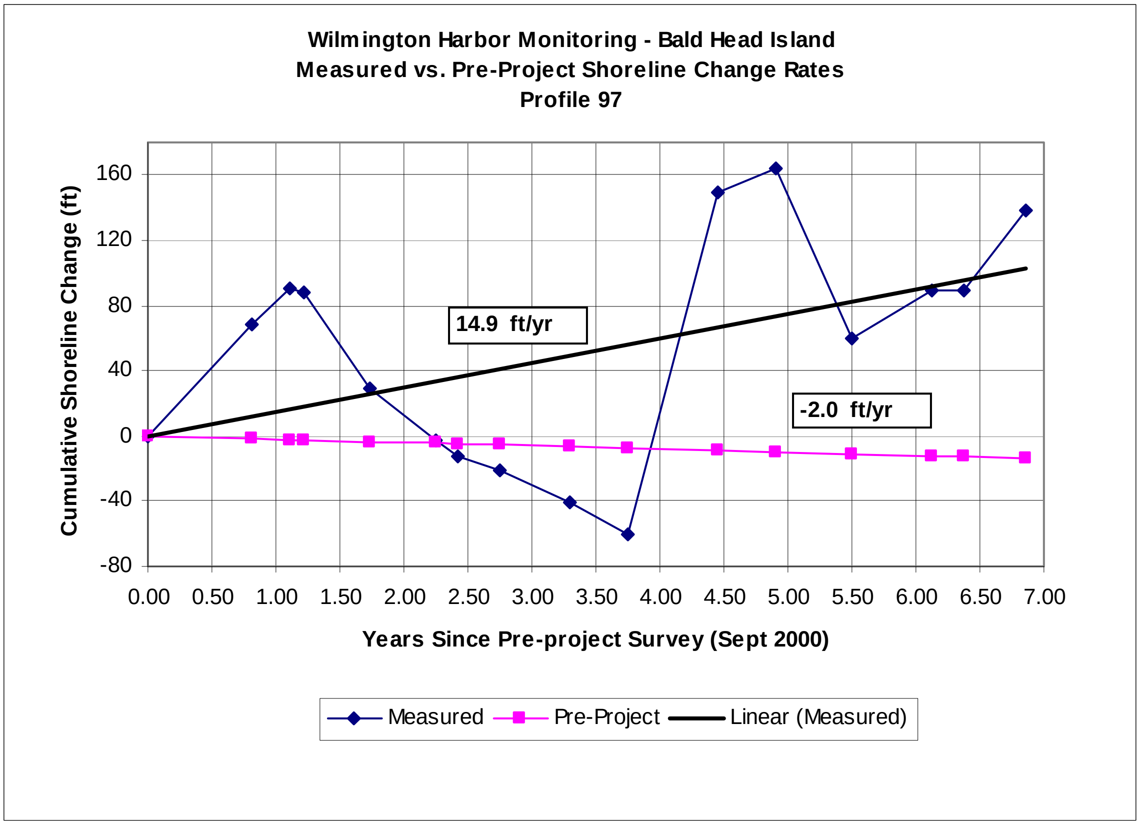

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 73
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
5.0 ft/yr
-5.5 ft/yr
Measured
Pre-Project
Linear (Measured)

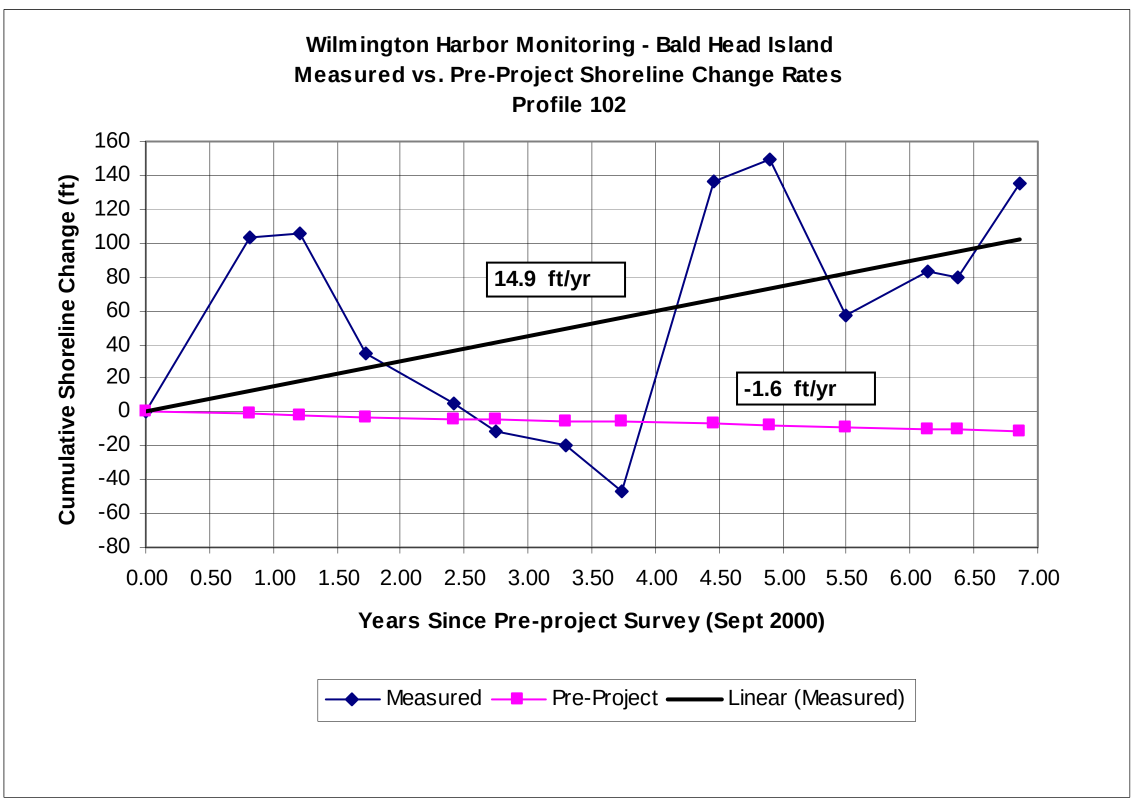

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 78
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
-10.0 ft/yr
-4.6 ft/yr
Measured
Pre-Project
Linear (Measured)

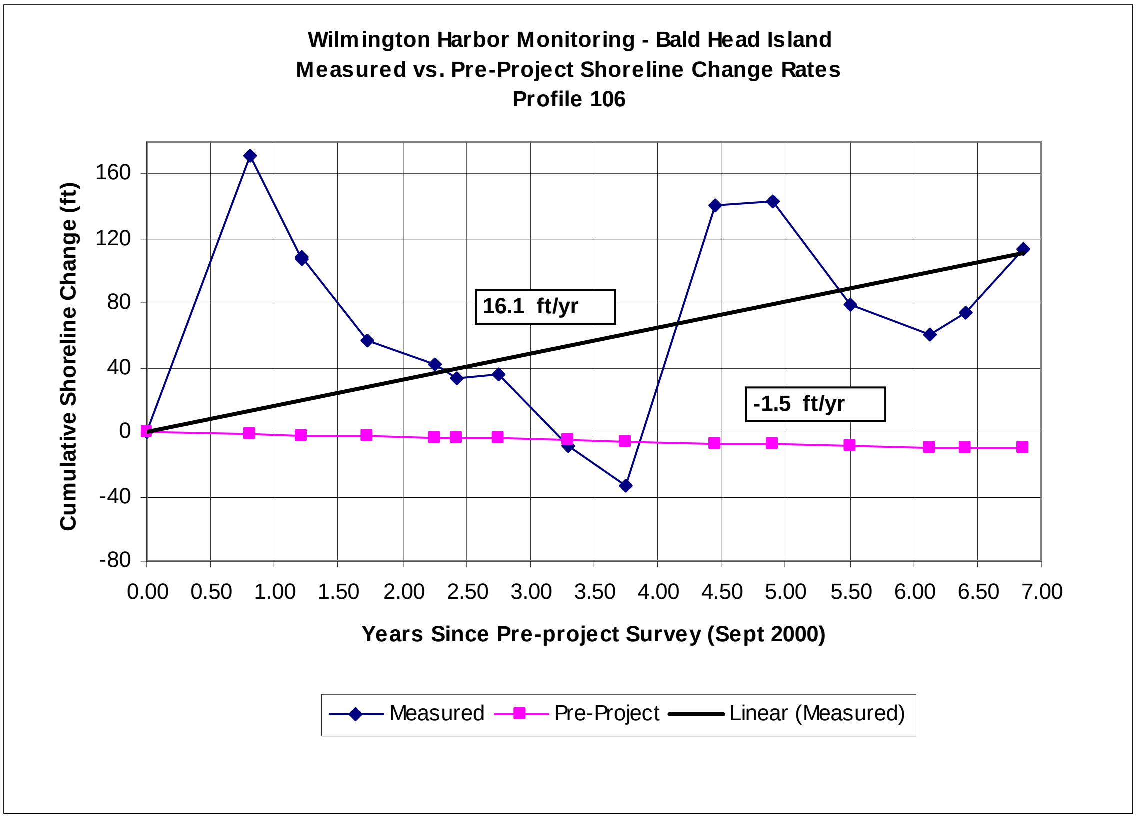

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 84
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
-14.8 ft/yr
-3.7 ft/yr
Measured
Pre-Project
Linear (Measured)

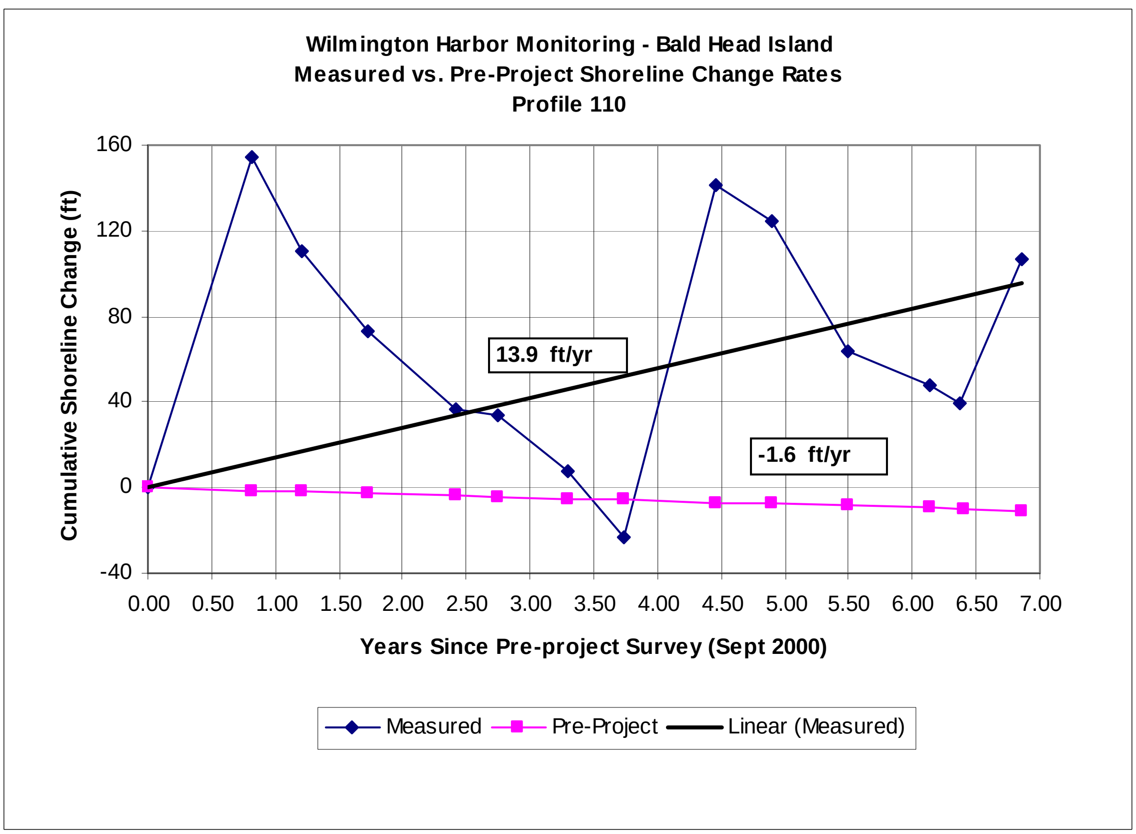

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 88
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
11.6 ft/yr
-3.1 ft/yr
Measured
Pre-Project
Linear (Measured)

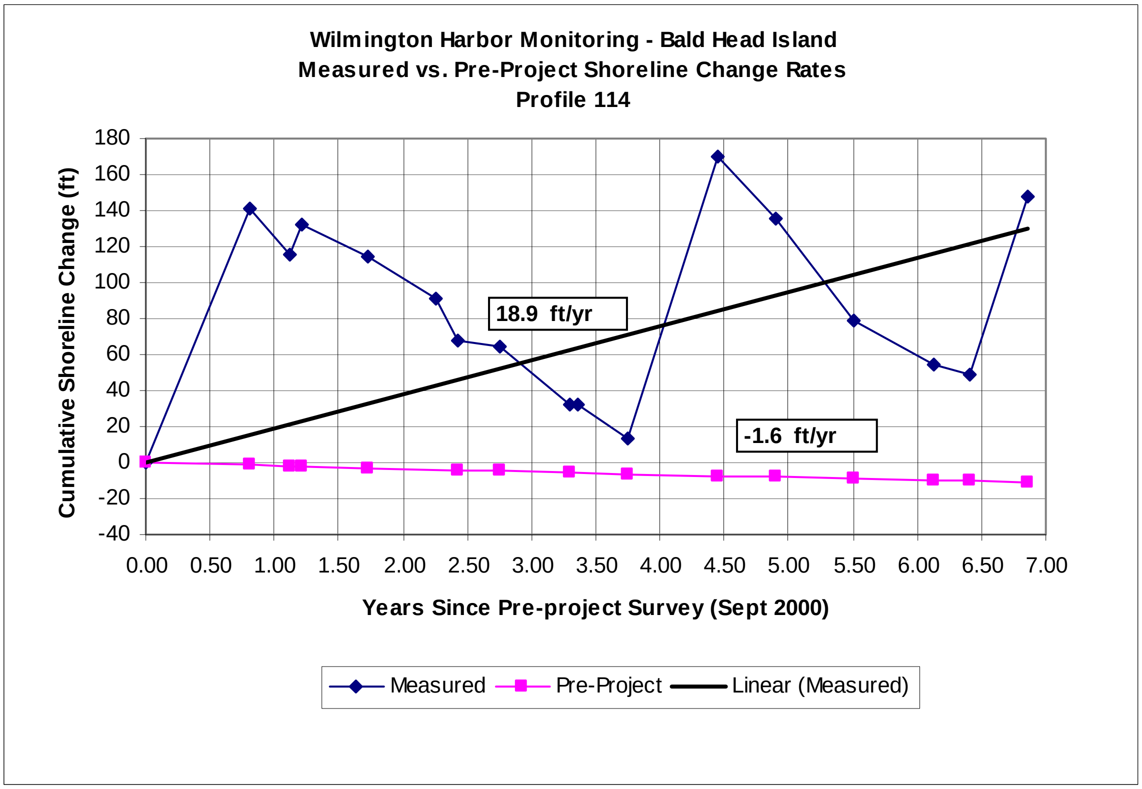

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 92
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
12.8 ft/yr
-2.6 ft/yr
Measured
Pre-Project
Linear (Measured)

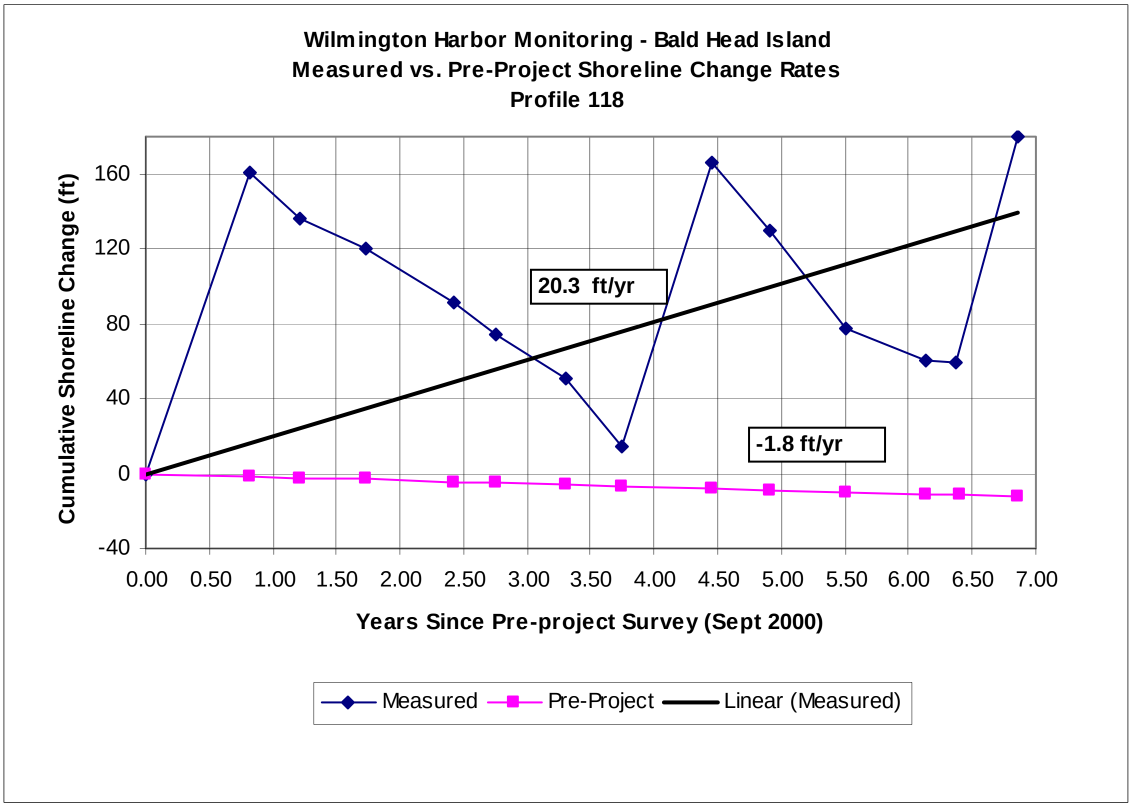

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 97
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
14.9 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

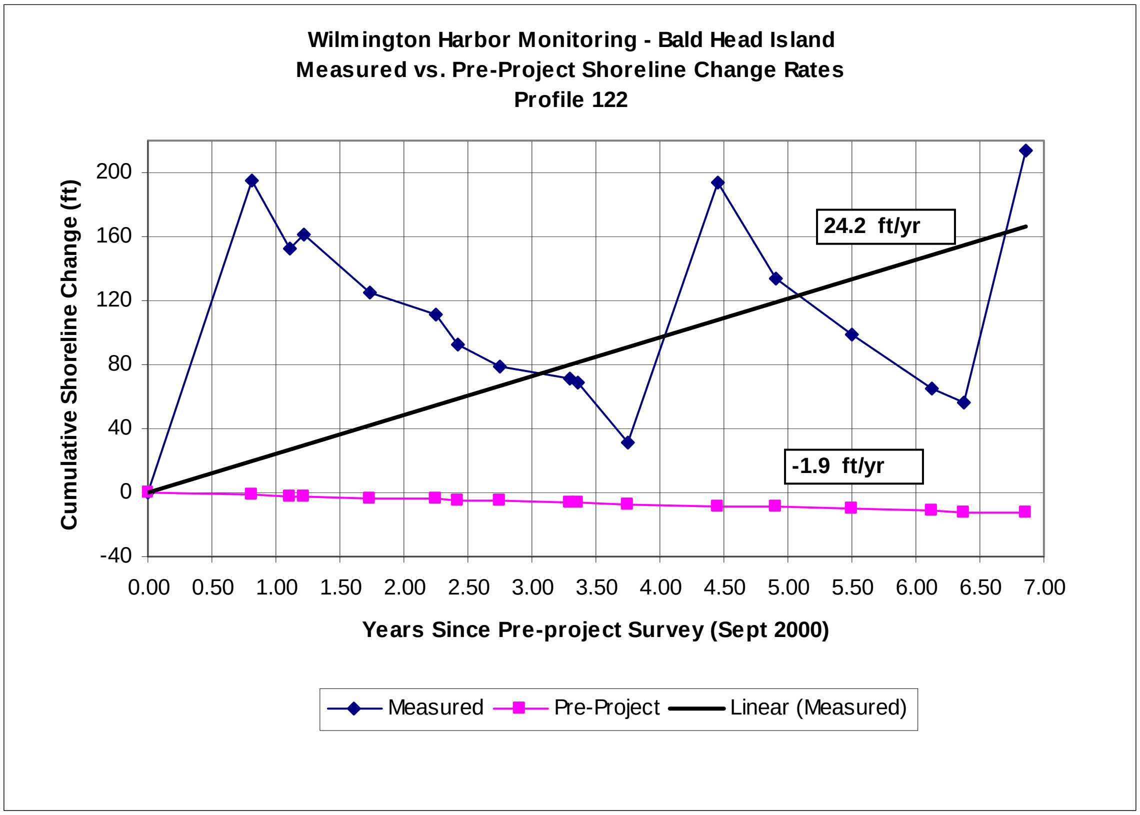

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 102
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
14.9 ft/yr
-1.6 ft/yr
Measured
Pre-Project
Linear (Measured)

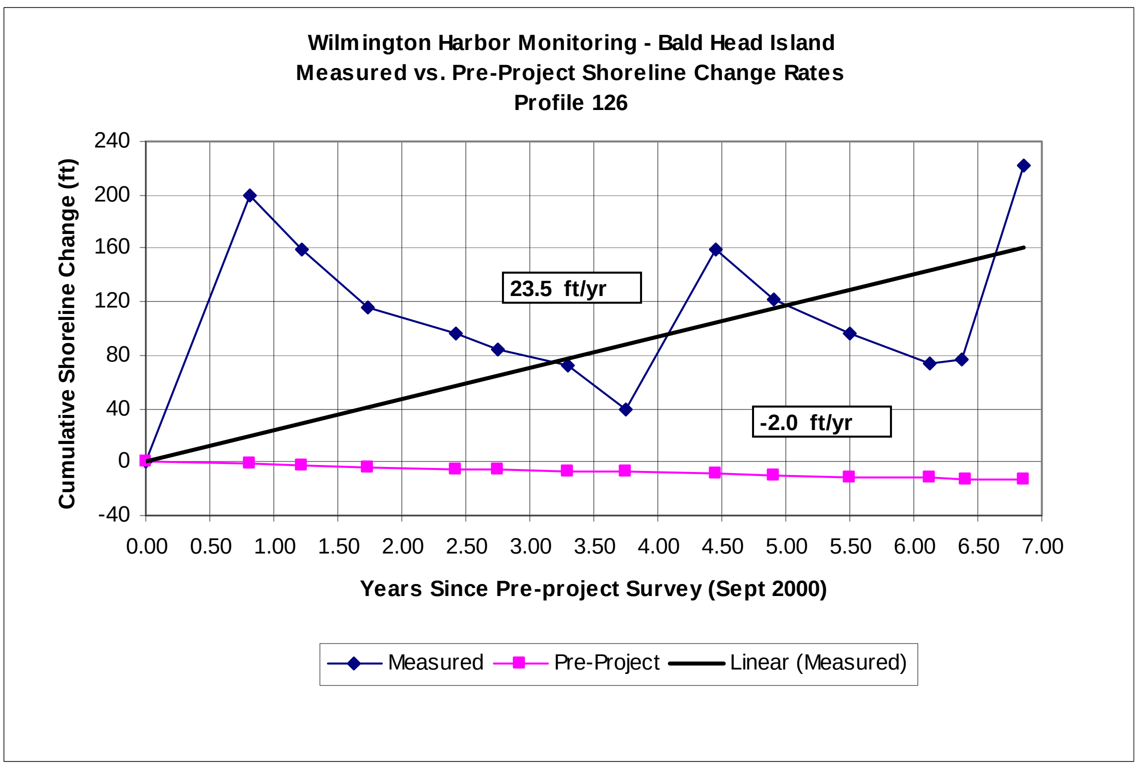

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 106
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
16.1 ft/yr
-1.5 ft/yr
Measured
Pre-Project
Linear (Measured)

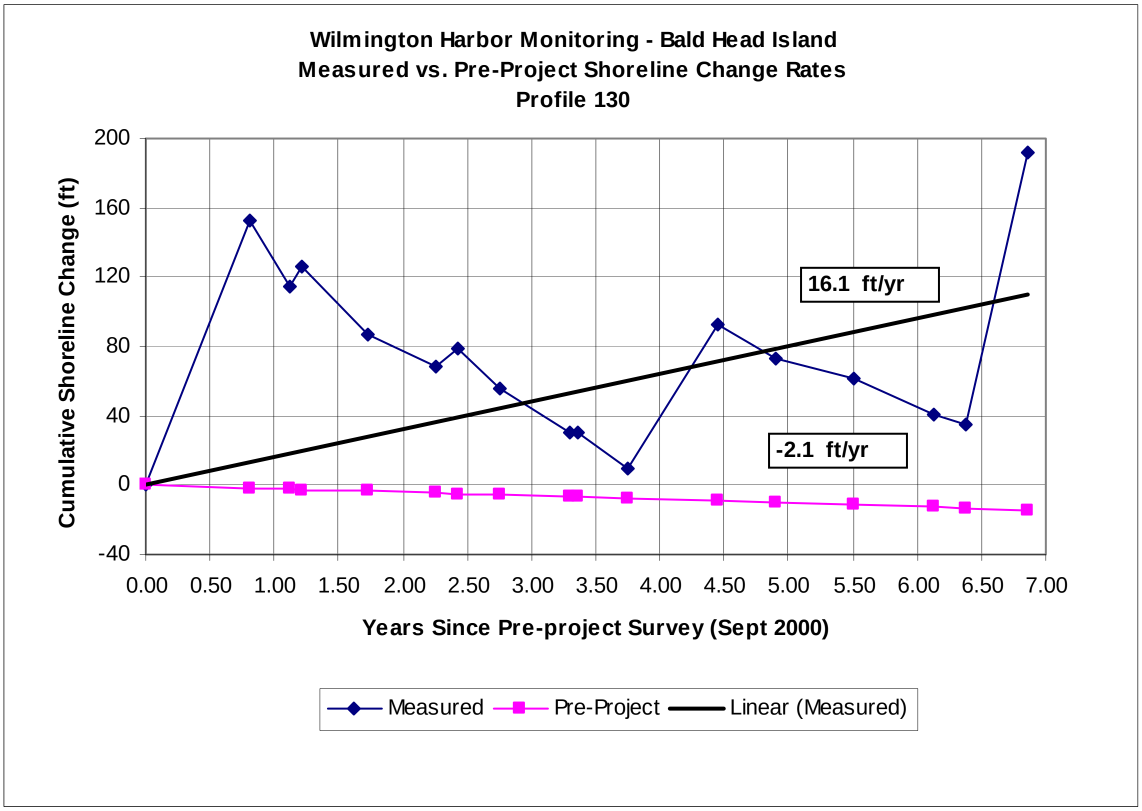

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
13.9 ft/yr
-1.6 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 114
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
18.9 ft/yr
-1.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

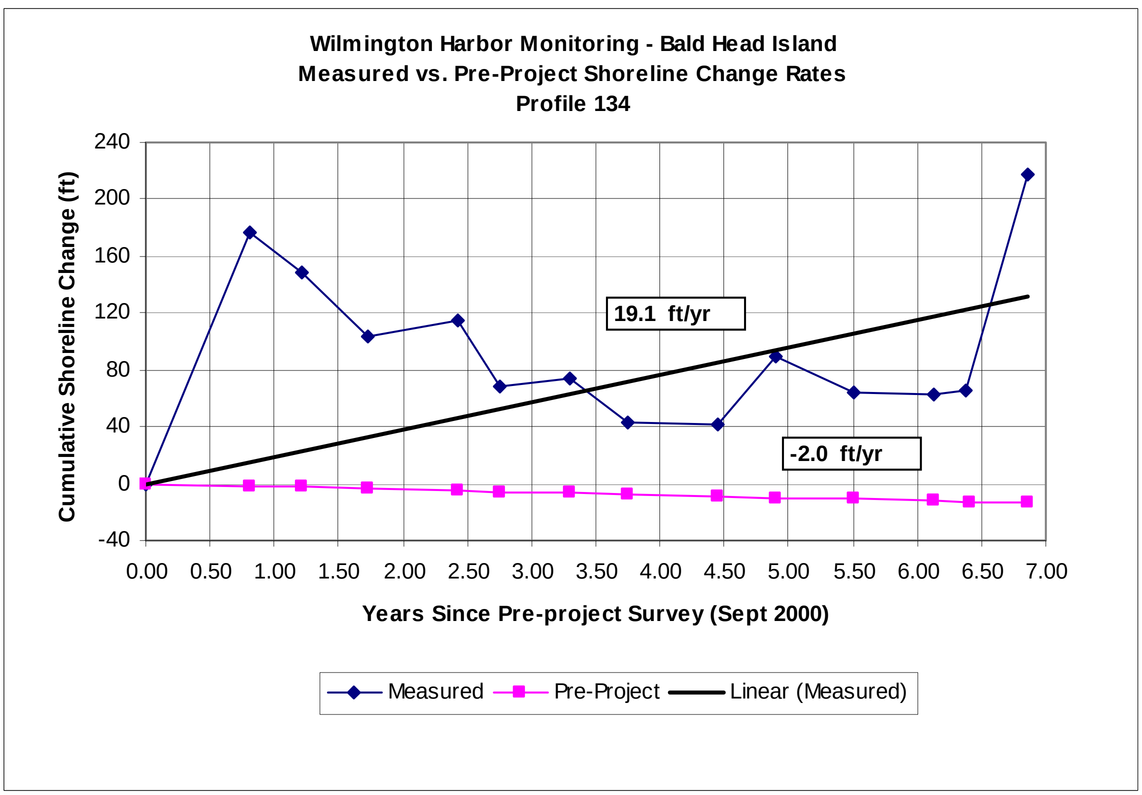

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 118
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
20.3 ft/yr
-1.8 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 122
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
24.2 ft/yr
-1.9 ft/yr
Measured
Pre-Project
Linear (Measured)

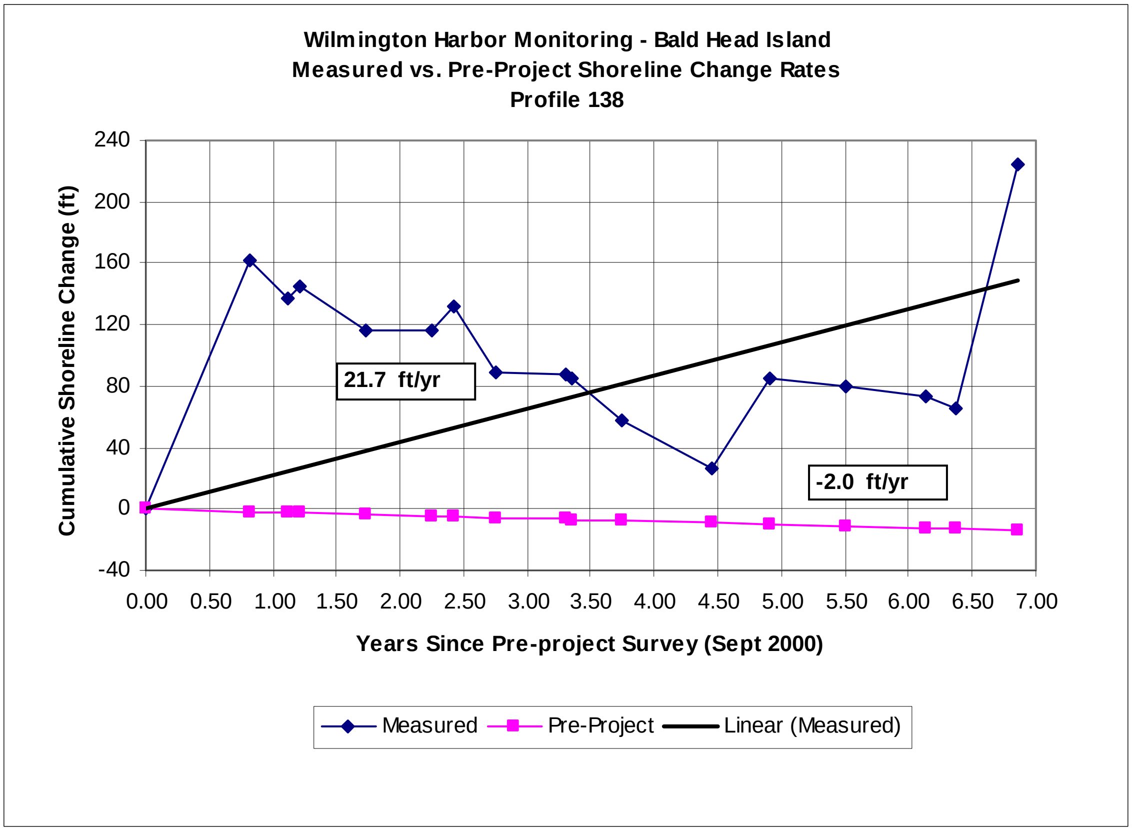

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 126
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
23.5 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

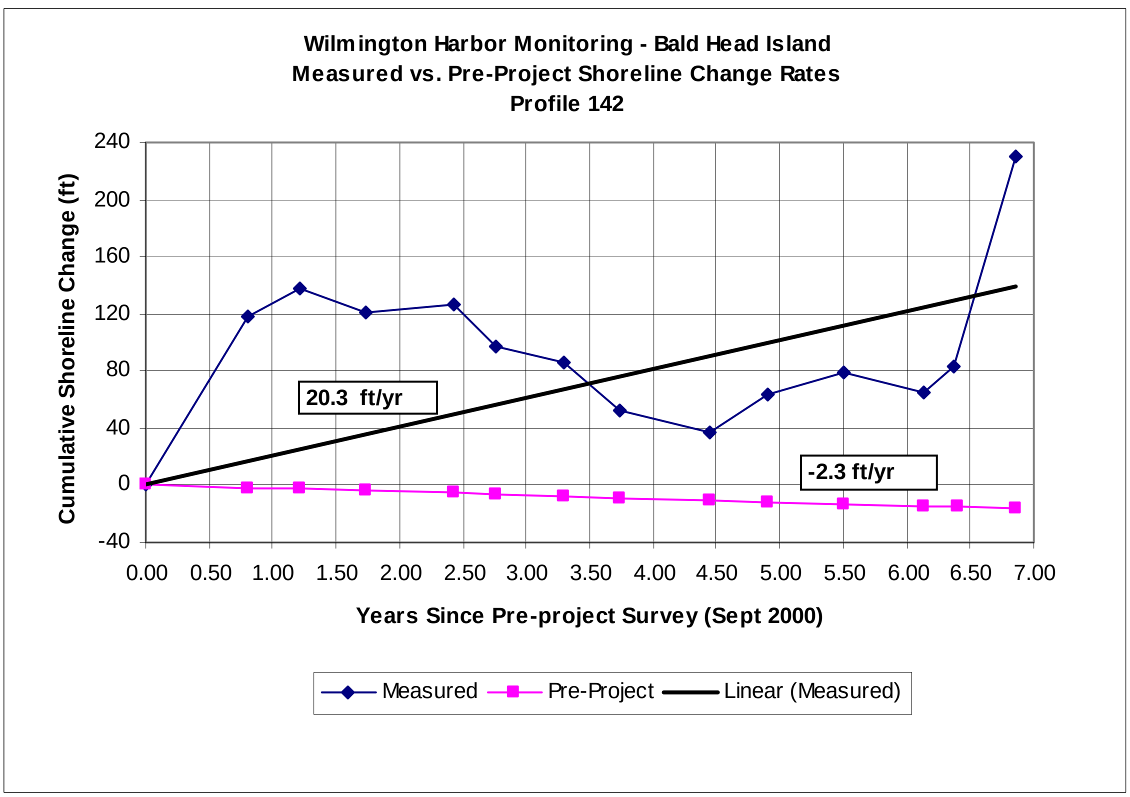


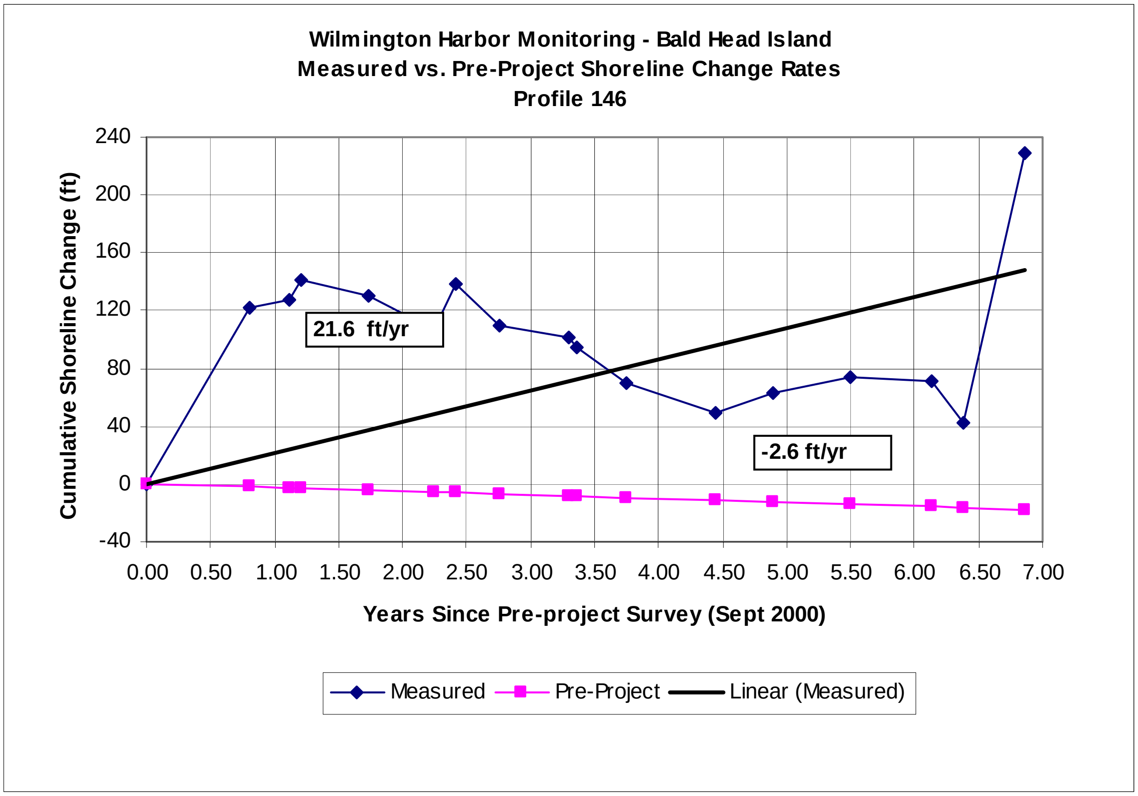
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
16.1 ft/yr
-2.1 ft/yr
Measured
Pre-Project
Linear (Measured)

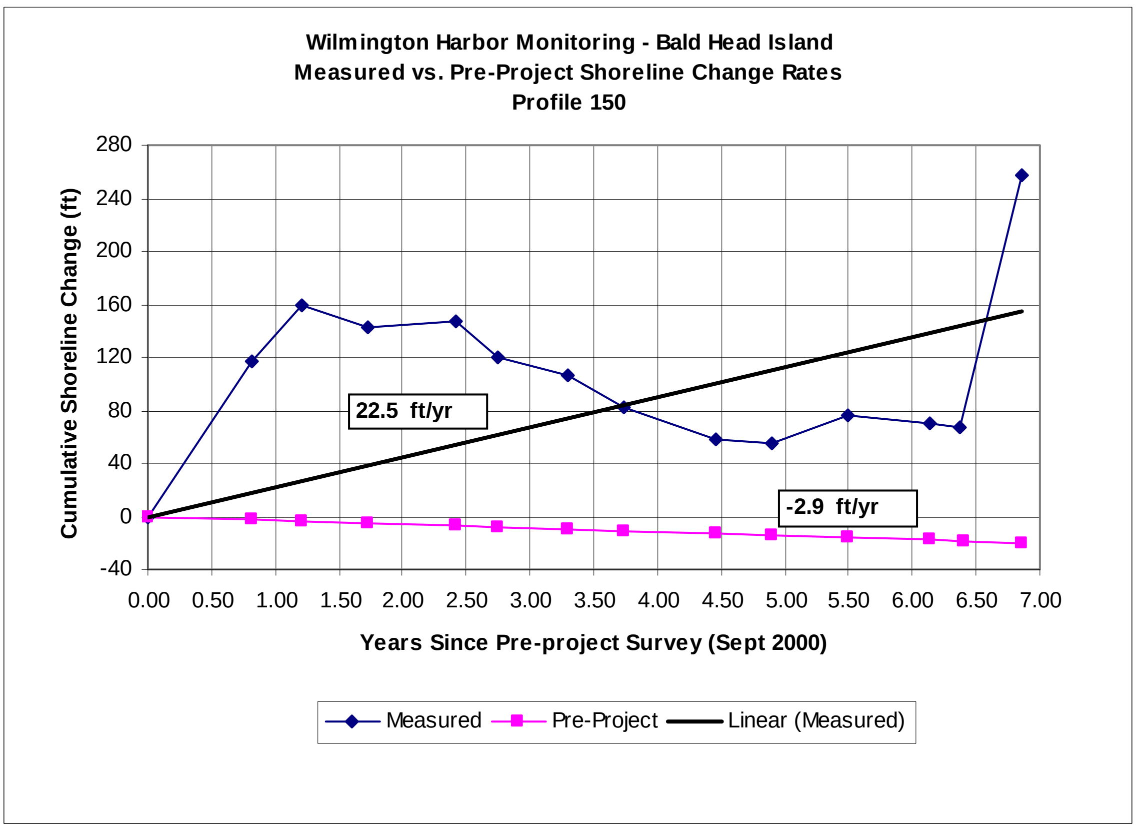


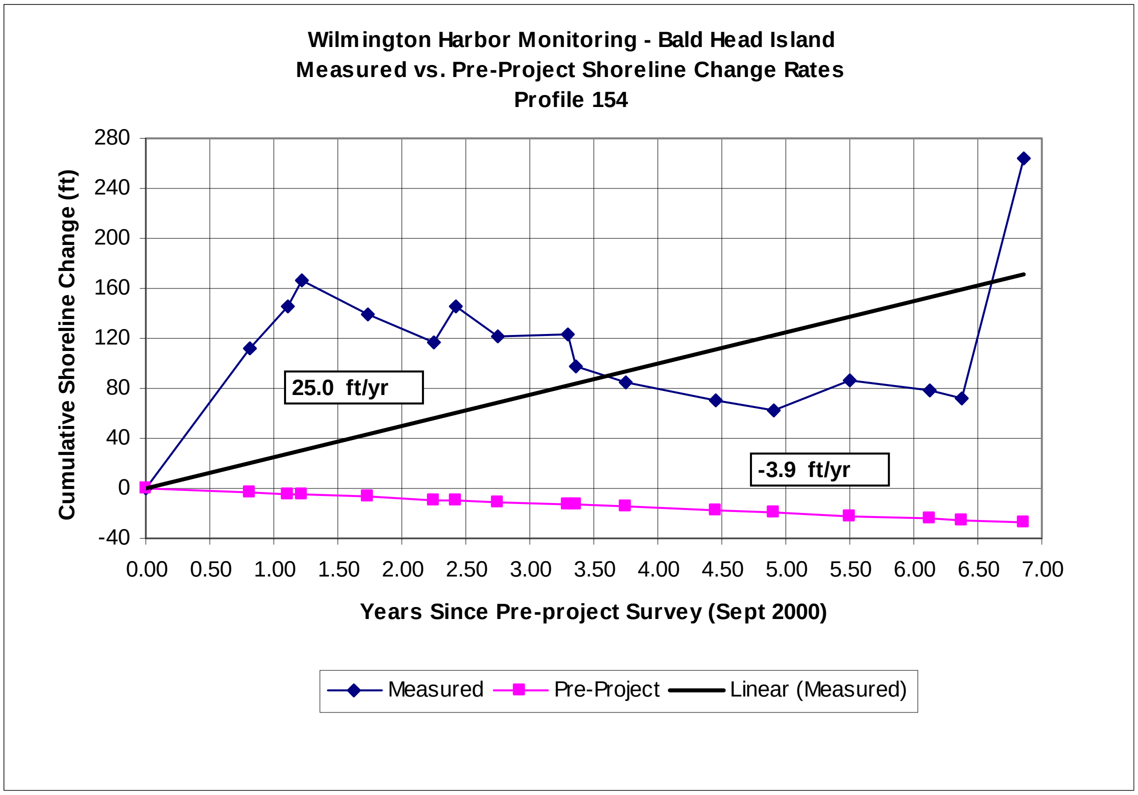
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 134
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
19.1 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

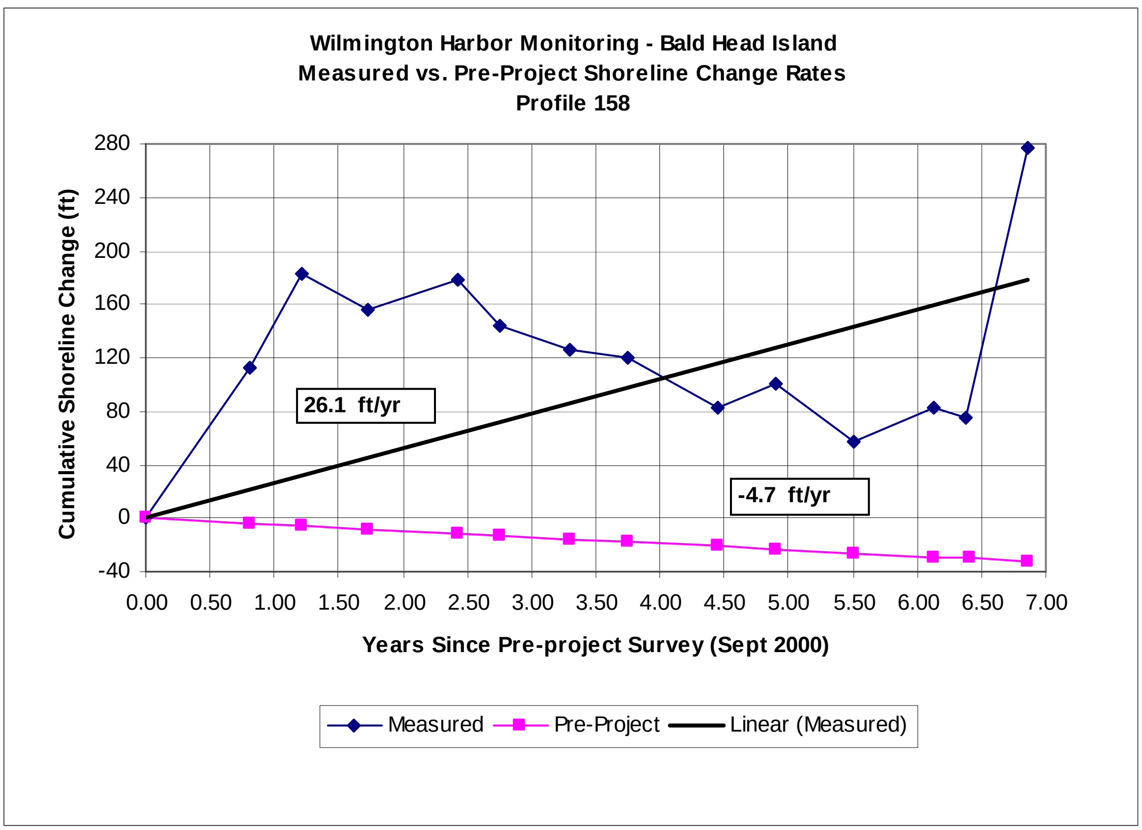

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 138
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
21.7 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

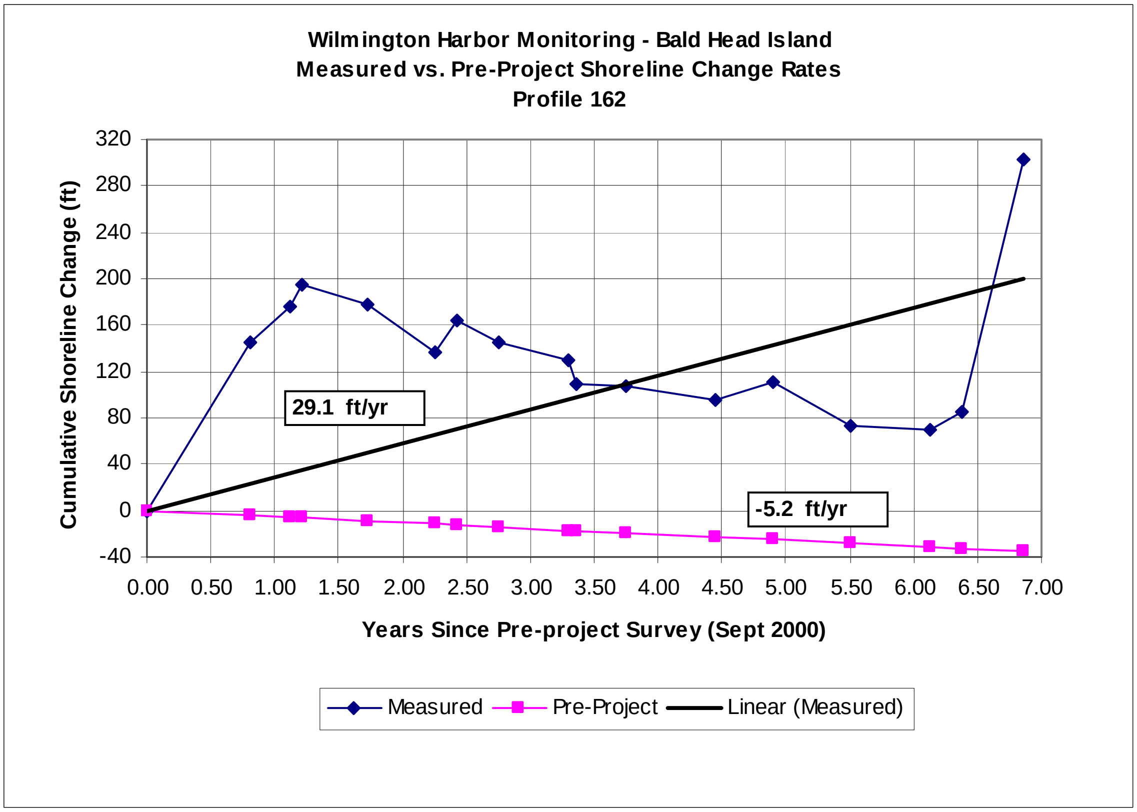

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 142
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
20.3 ft/yr
-2.3 ft/yr
Measured
Pre-Project
Linear (Measured)

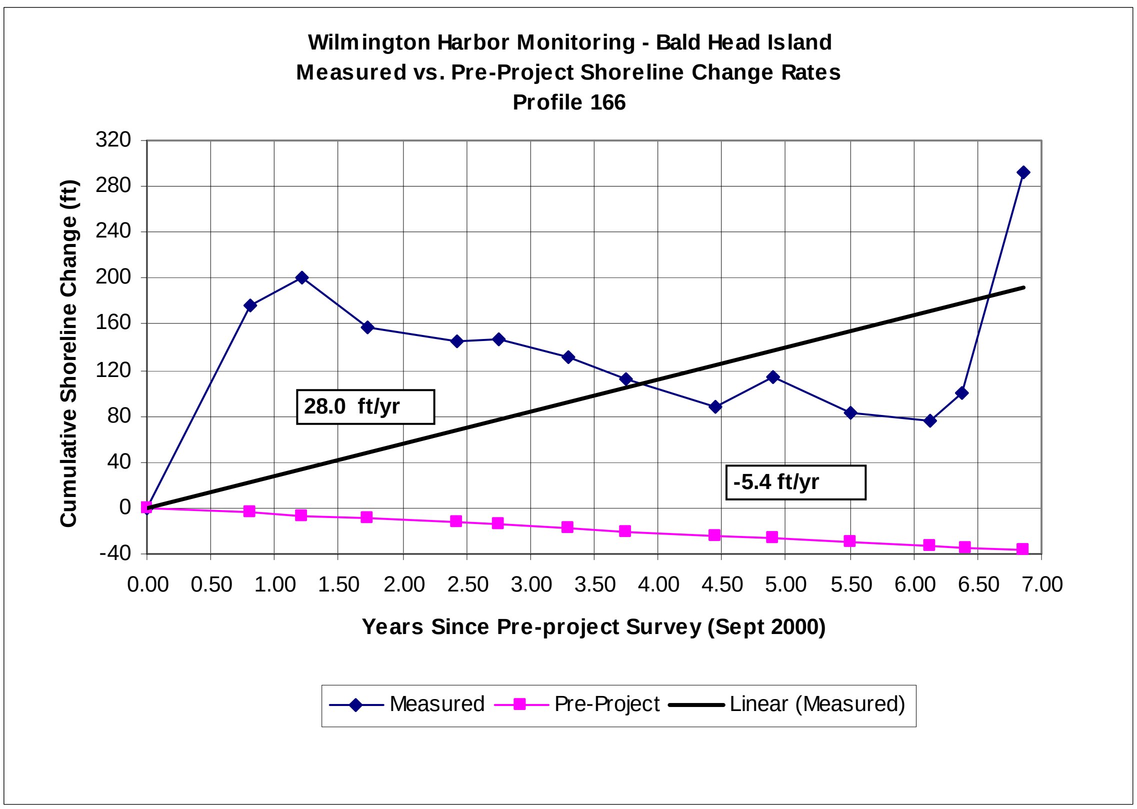

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 146
240
200
160
120
80
40
0
-40
Cumulative Shoreline Change (ft)
21.6 ft/yr
-2.6 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

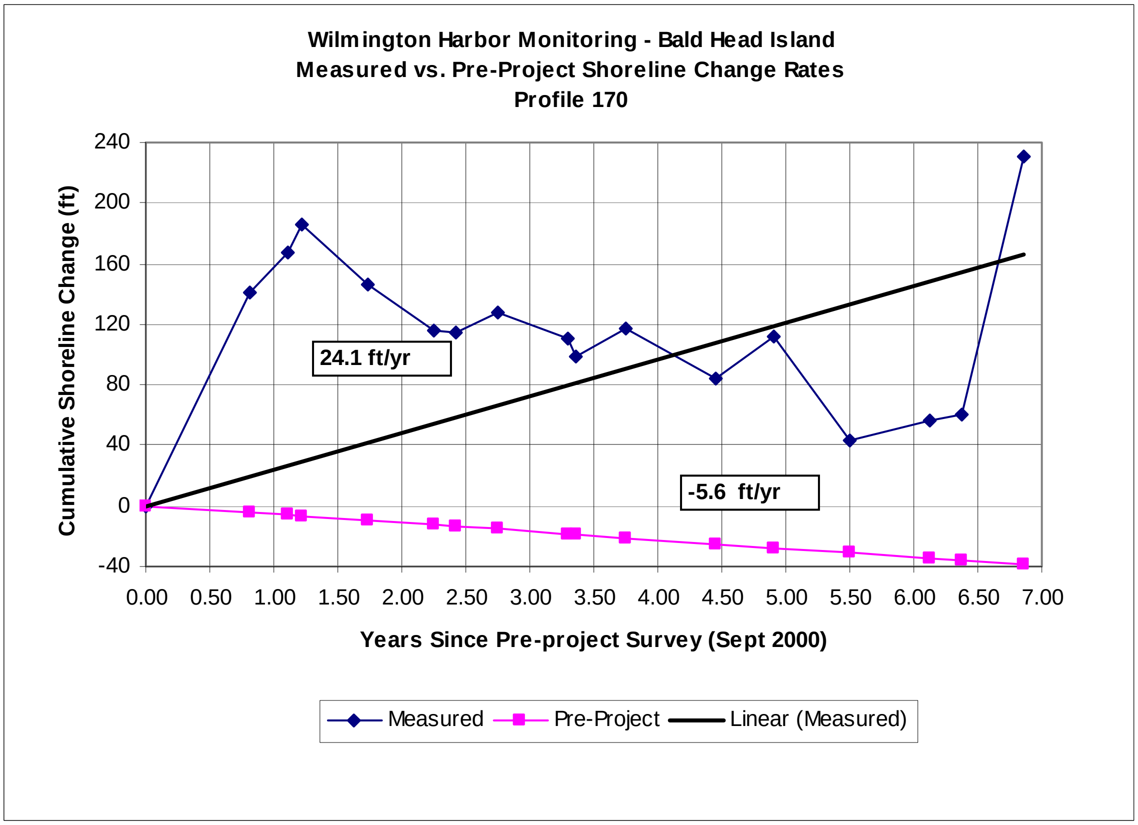

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
280
240
200
160
120
80
40
0
-40
Cumulative Shoreline Change (ft)
22.5 ft/yr
-2.9 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 154
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
25.0 ft/yr
-3.9 ft/yr
Measured
Pre-Project
Linear (Measured)

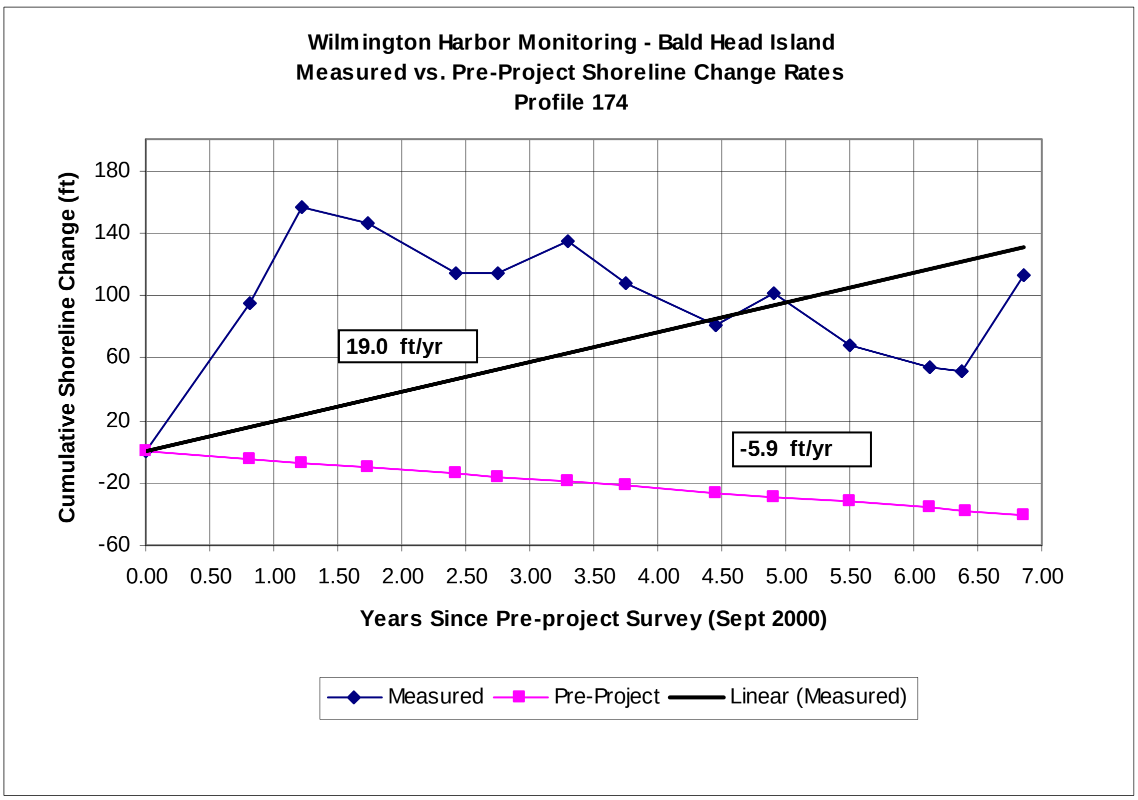

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 158
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
26.1 ft/yr
-4.7 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 162
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
29.1 ft/yr
-5.2 ft/yr
Measured
Pre-Project
Linear (Measured)

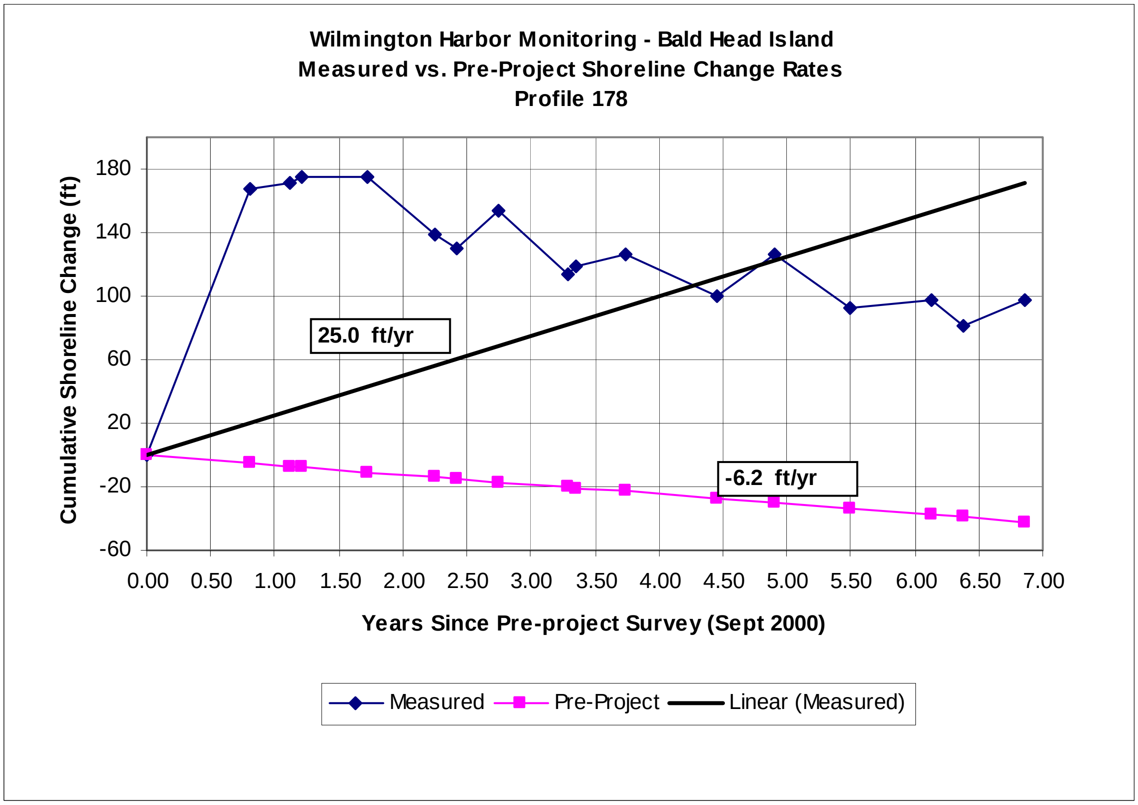

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 166
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
28.0 ft/yr
-5.4 ft/yr
Measured
Pre-Project
Linear (Measured)

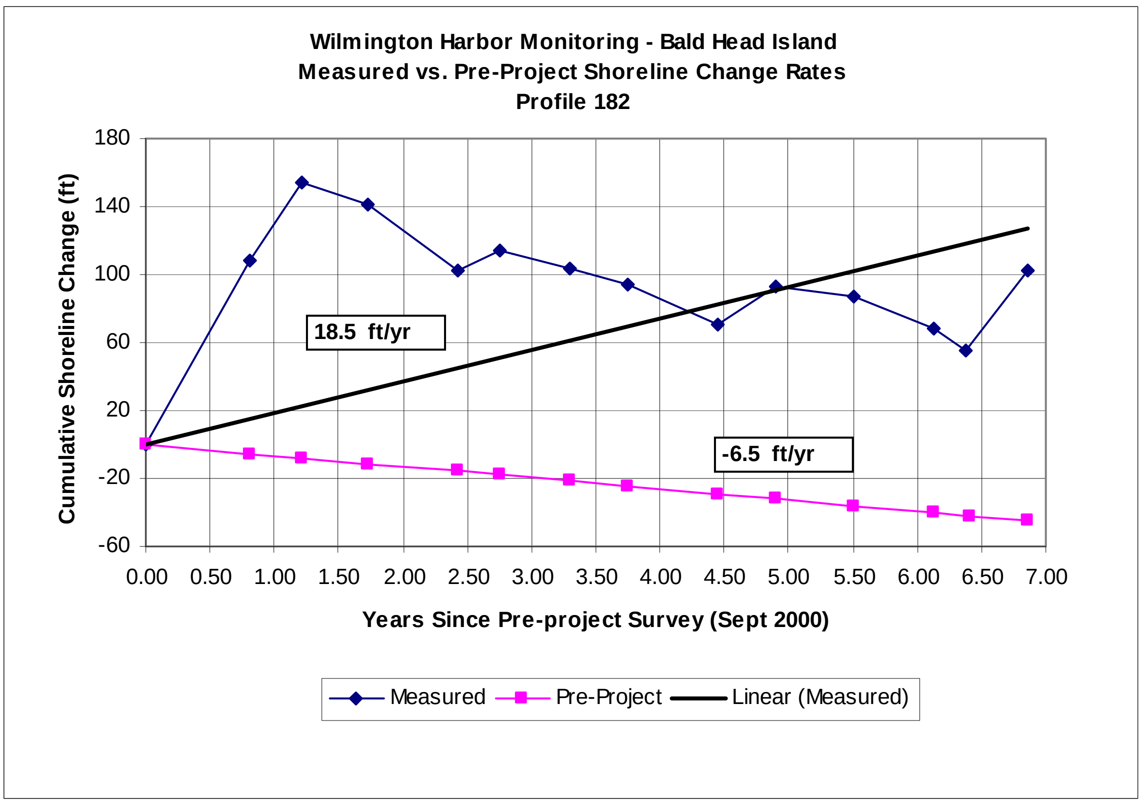


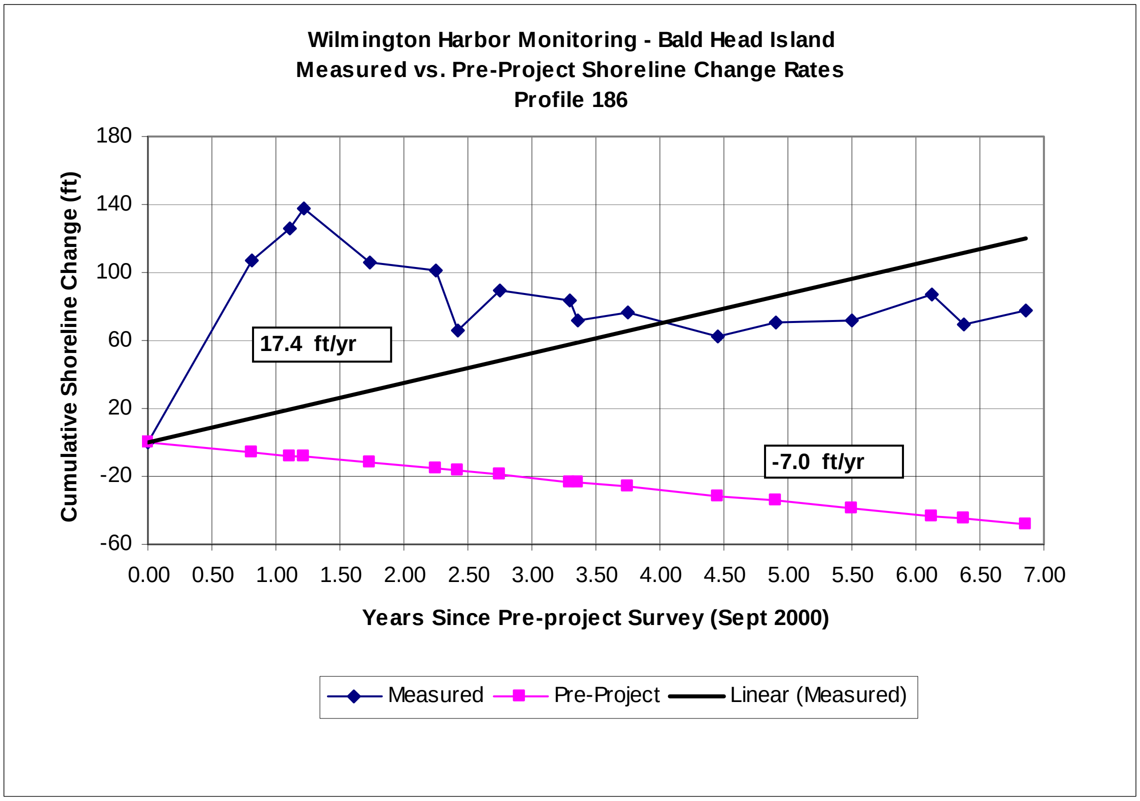
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
24.1 ft/yr
-5.6 ft/yr
Measured
Pre-Project
Linear (Measured)

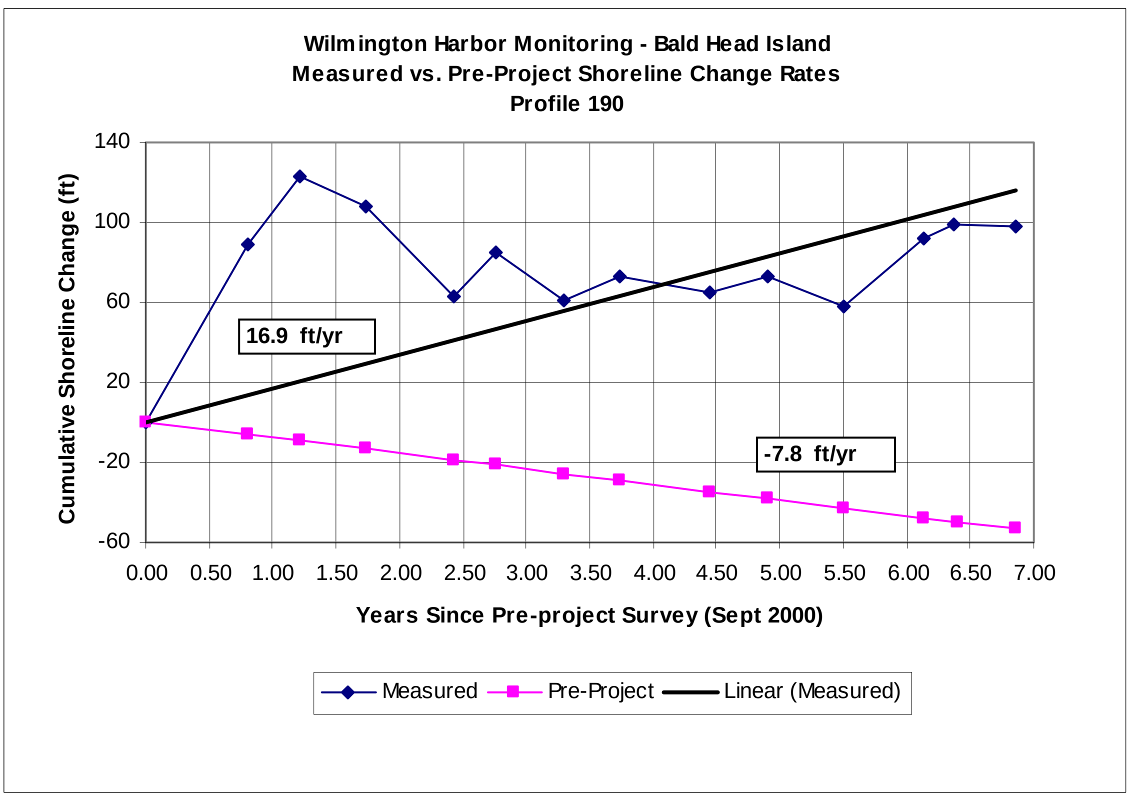


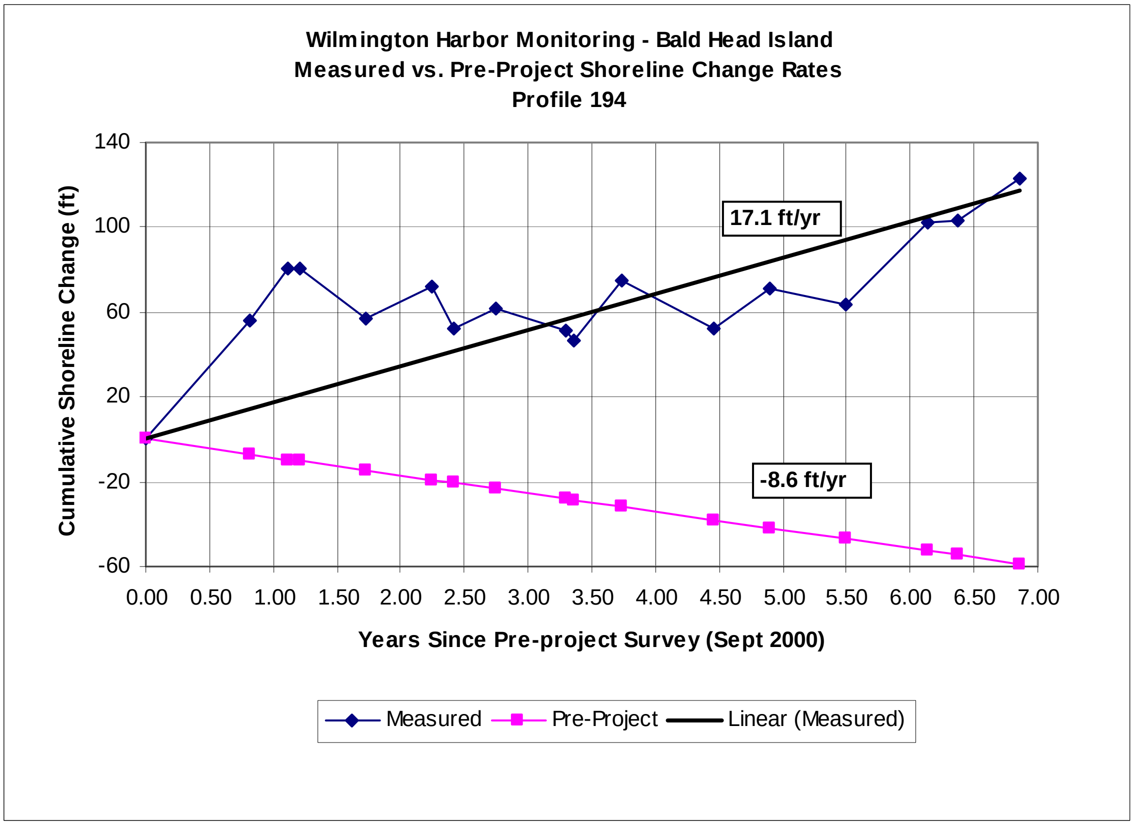
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 174
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
19.0 ft/yr
-5.9 ft/yr
Measured
Pre-Project
Linear (Measured)

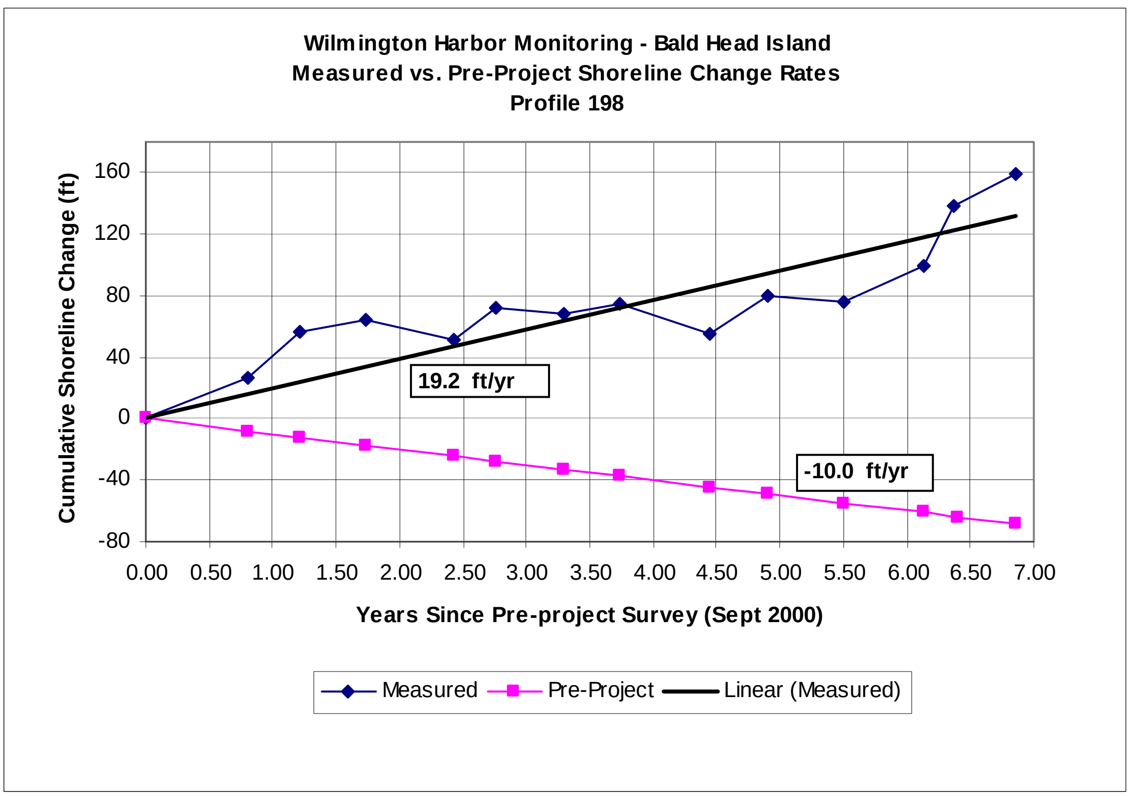

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 178
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
25.0 ft/yr
-6.2 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

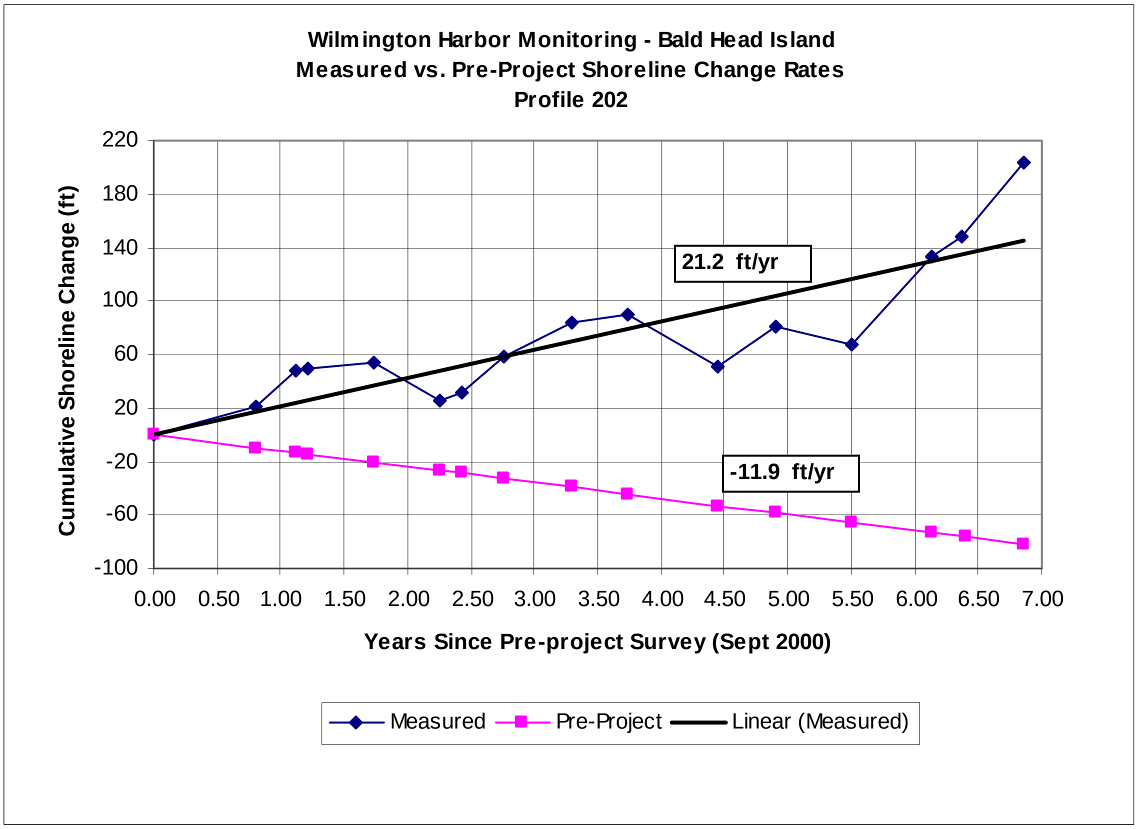

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 182
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
18.5 ft/yr
-6.5 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

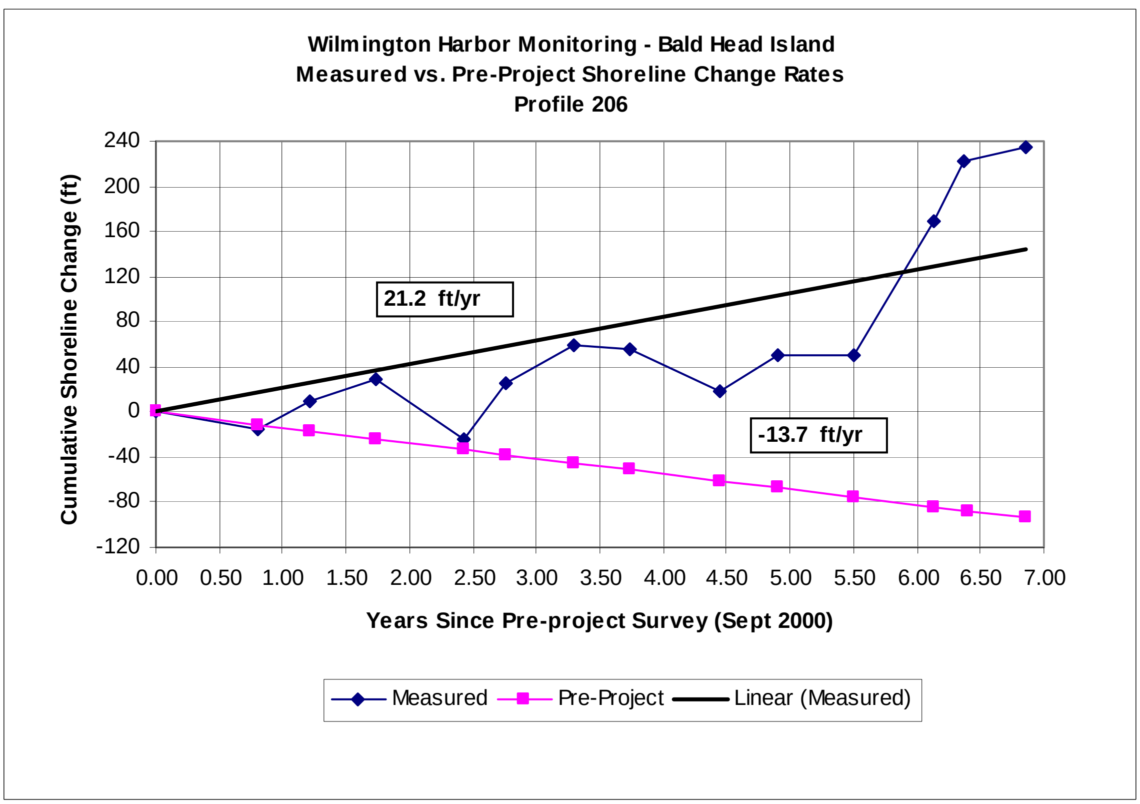

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 186
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
17.4 ft/yr
-7.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

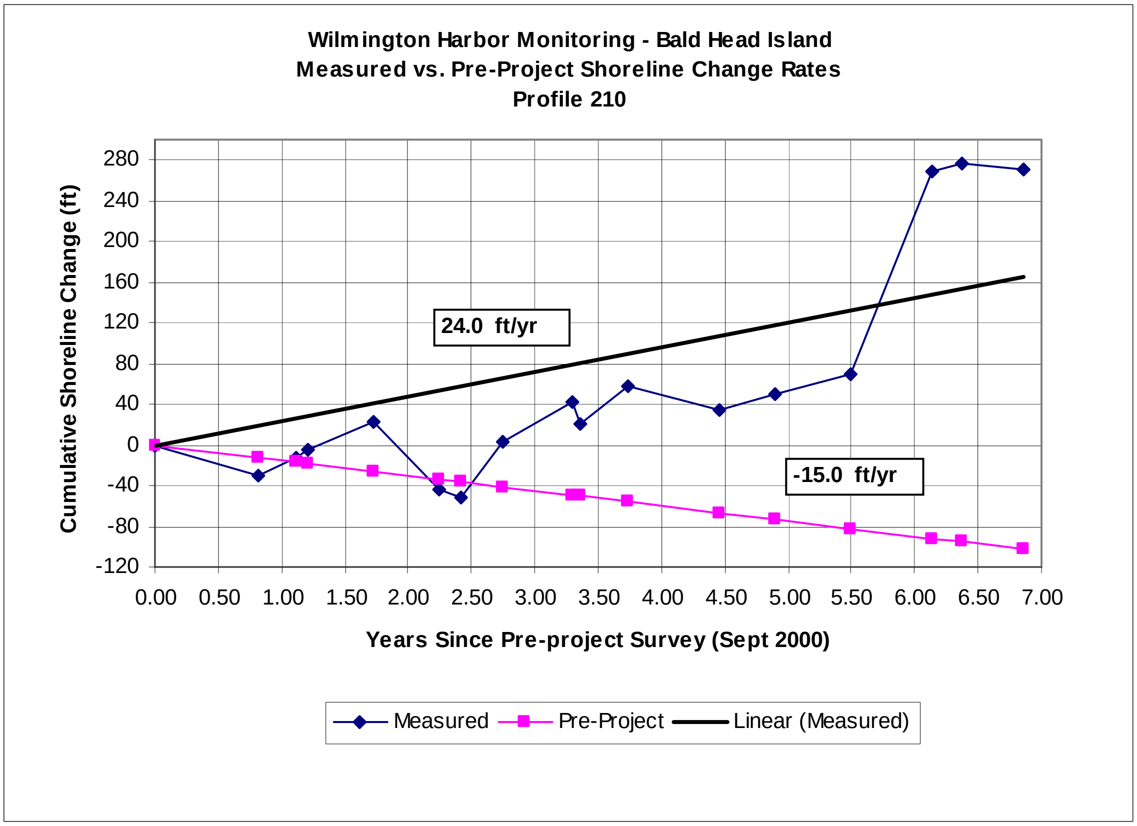

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
140
100
60
20
-20
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
16.9 ft/yr
-7.8 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

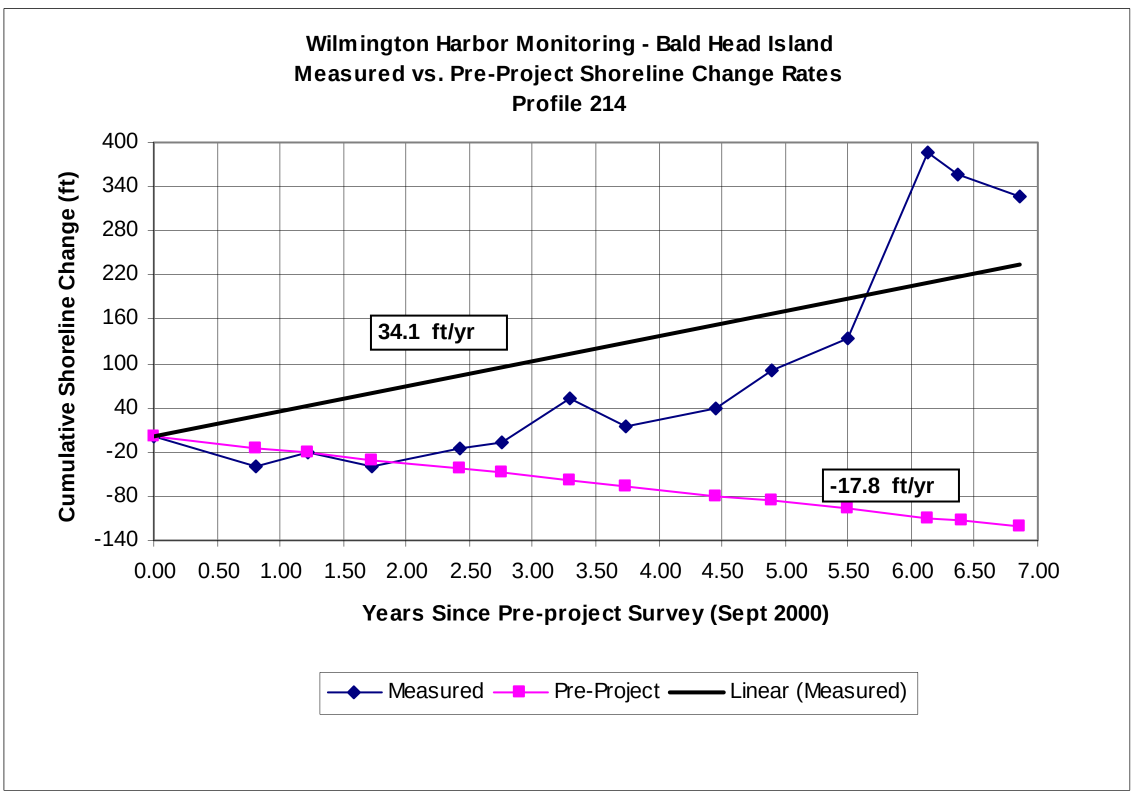

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 194
Cumulative Shoreline Change (ft)
140
100
60
20
-20
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
17.1 ft/yr
-8.6 ft/yr
Measured
Pre-Project
Linear (Measured)

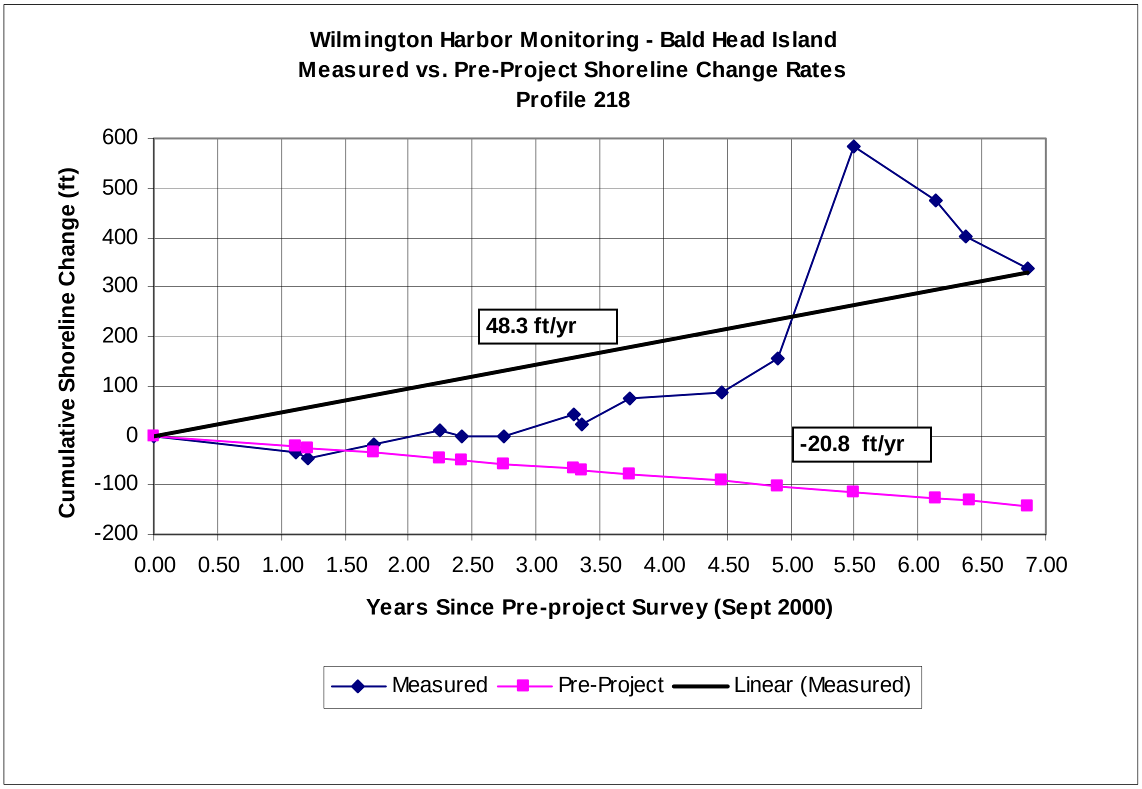

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 198
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
19.2 ft/yr
-10.0 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 202
Cumulative Shoreline Change (ft)
220
180
140
100
60
20
-20
-60
-100
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
21.2 ft/yr
-11.9 ft/yr
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
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00
Years Since Pre-project Survey (Sept 2000)
21.2 ft/yr
-13.7 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
24.0 ft/yr
-15.0 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 214
Cumulative Shoreline Change (ft)
400
340
280
220
160
100
40
-20
-80
-140
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
34.1 ft/yr
-17.8 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 218
Cumulative Shoreline Change (ft)
600
500
400
300
200
100
0
-100
-200
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
Years Since Pre-project Survey (Sept 2000)
48.3 ft/yr
-20.8 ft/yr
Measured
Pre-Project
Linear (Measured)

Appendix D

CURRENT MEASUREMENTS
(Tidal inlet and New Channel Regions)

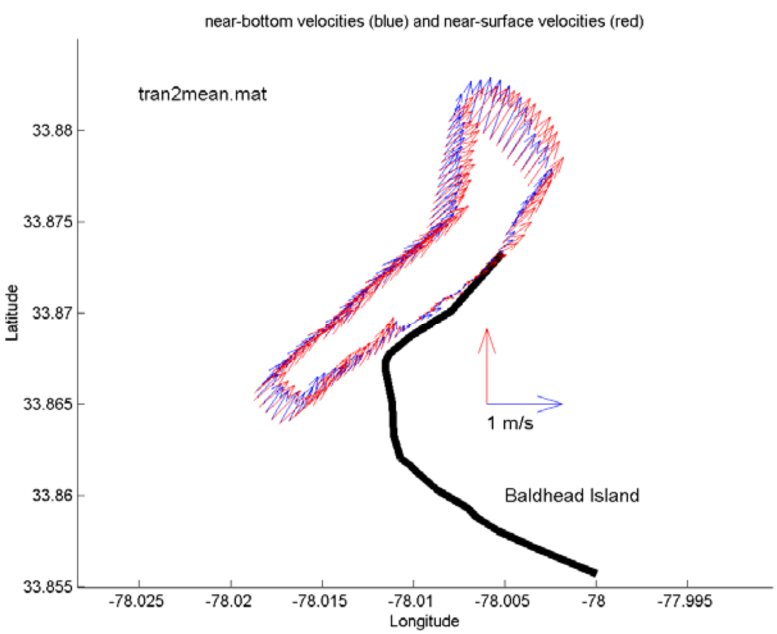


Figure D-1 October 2000 ADCP survey at inlet transect during peak flood flow. Note that survey transect does not cover same area as the April 2002, March 2003 and January 2004 surveys.

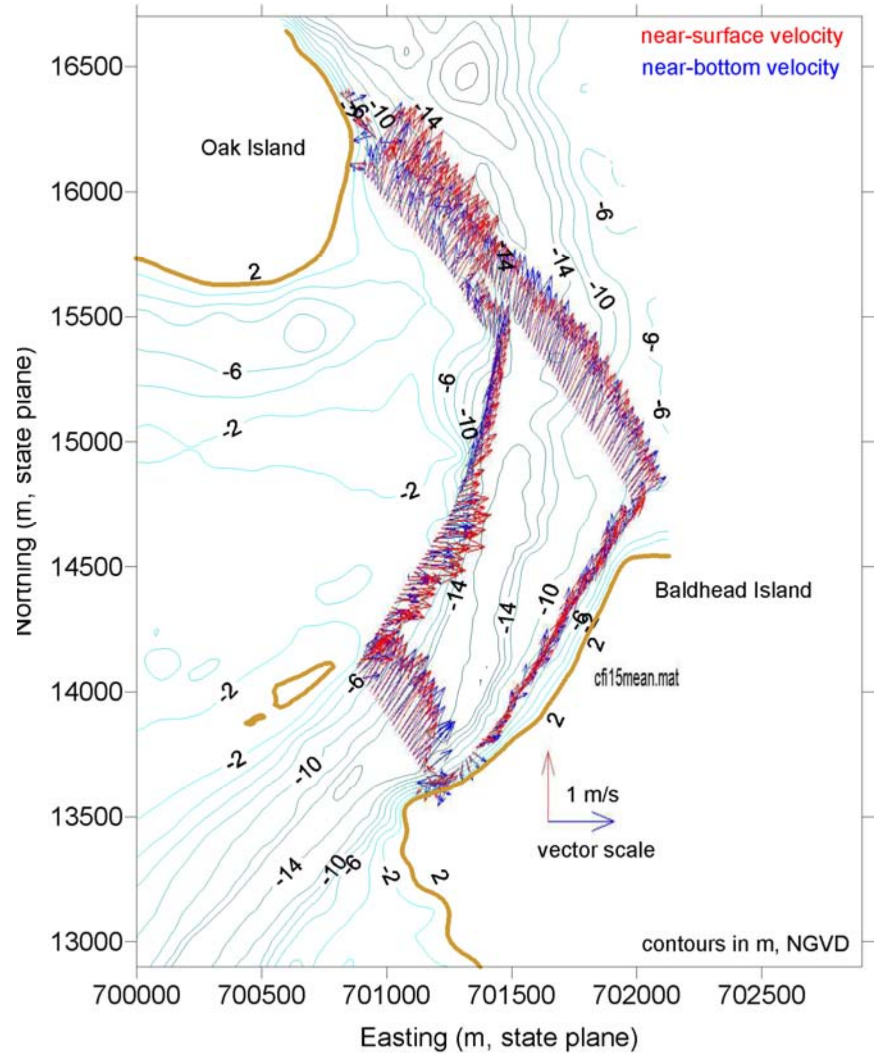


Figure D-2 April 2002 ADCP survey at inlet transect during peak flood flow.

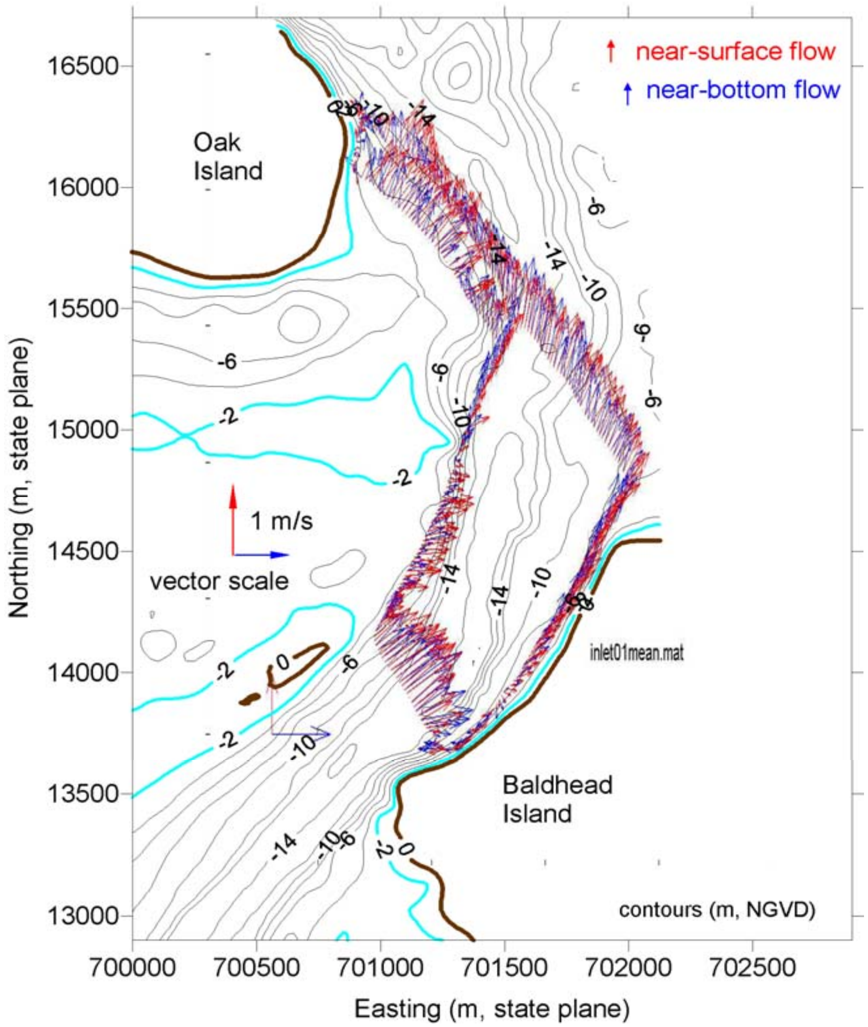


Figure D-3 March 2003 ADCP survey at inlet transect during flood flow.

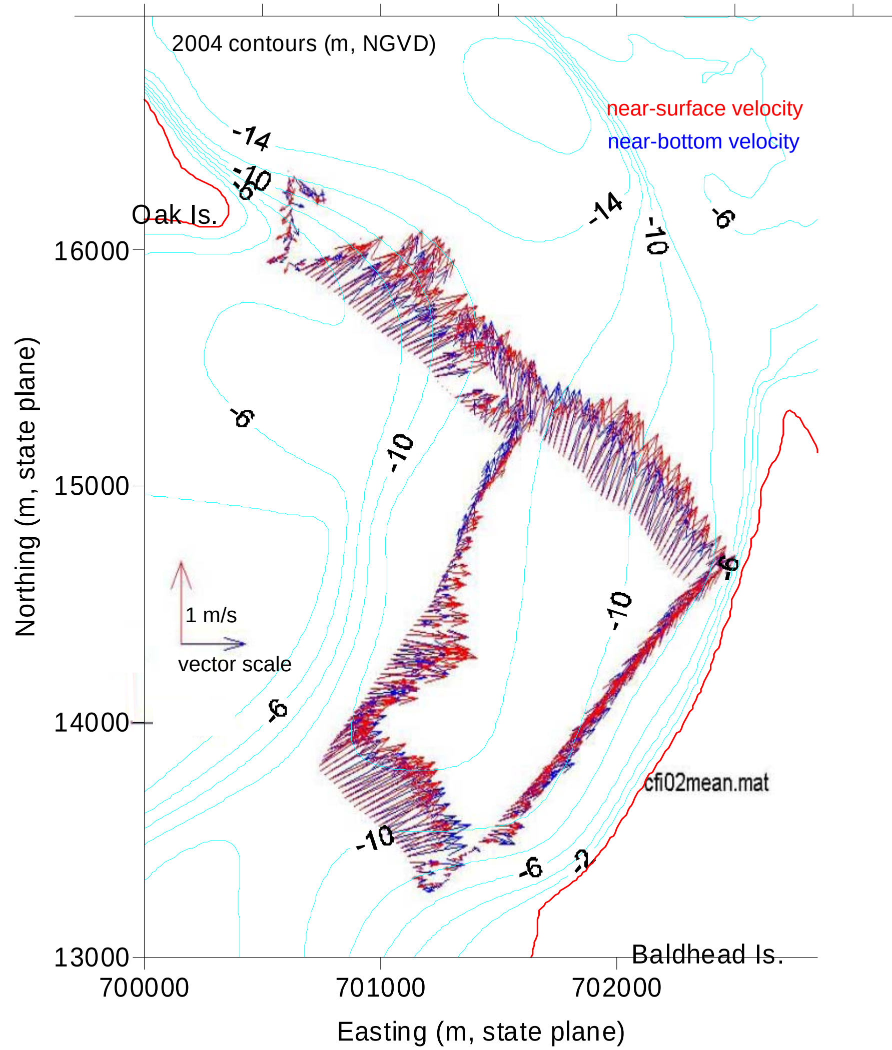


Figure D-4 January 2004 ADCP survey at inlet transect during flood flow.

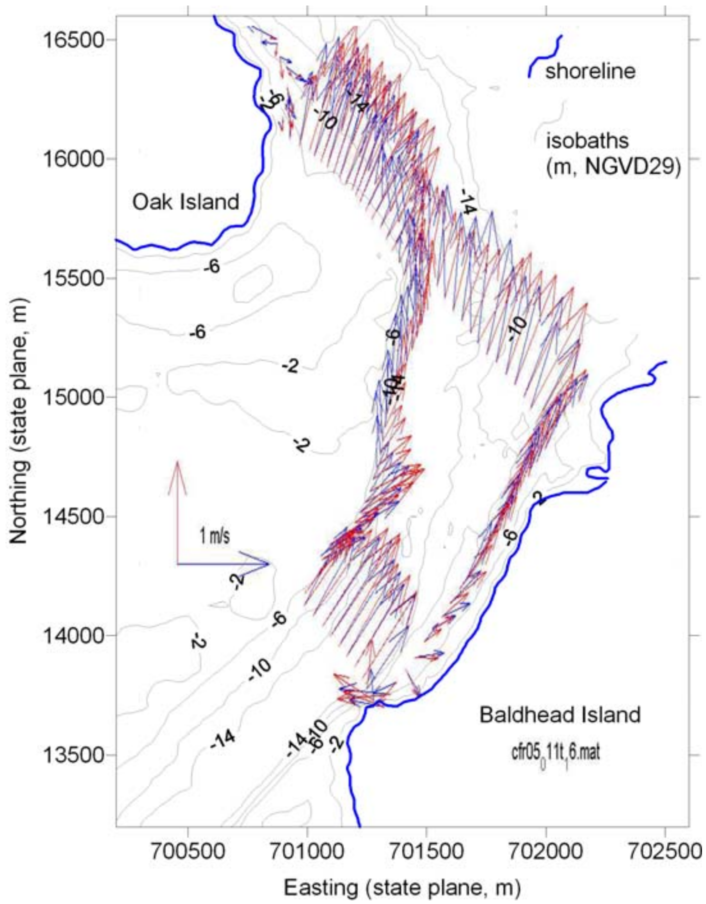


Figure D-5 March 2005 ADCP survey at inlet transect during flood flow.

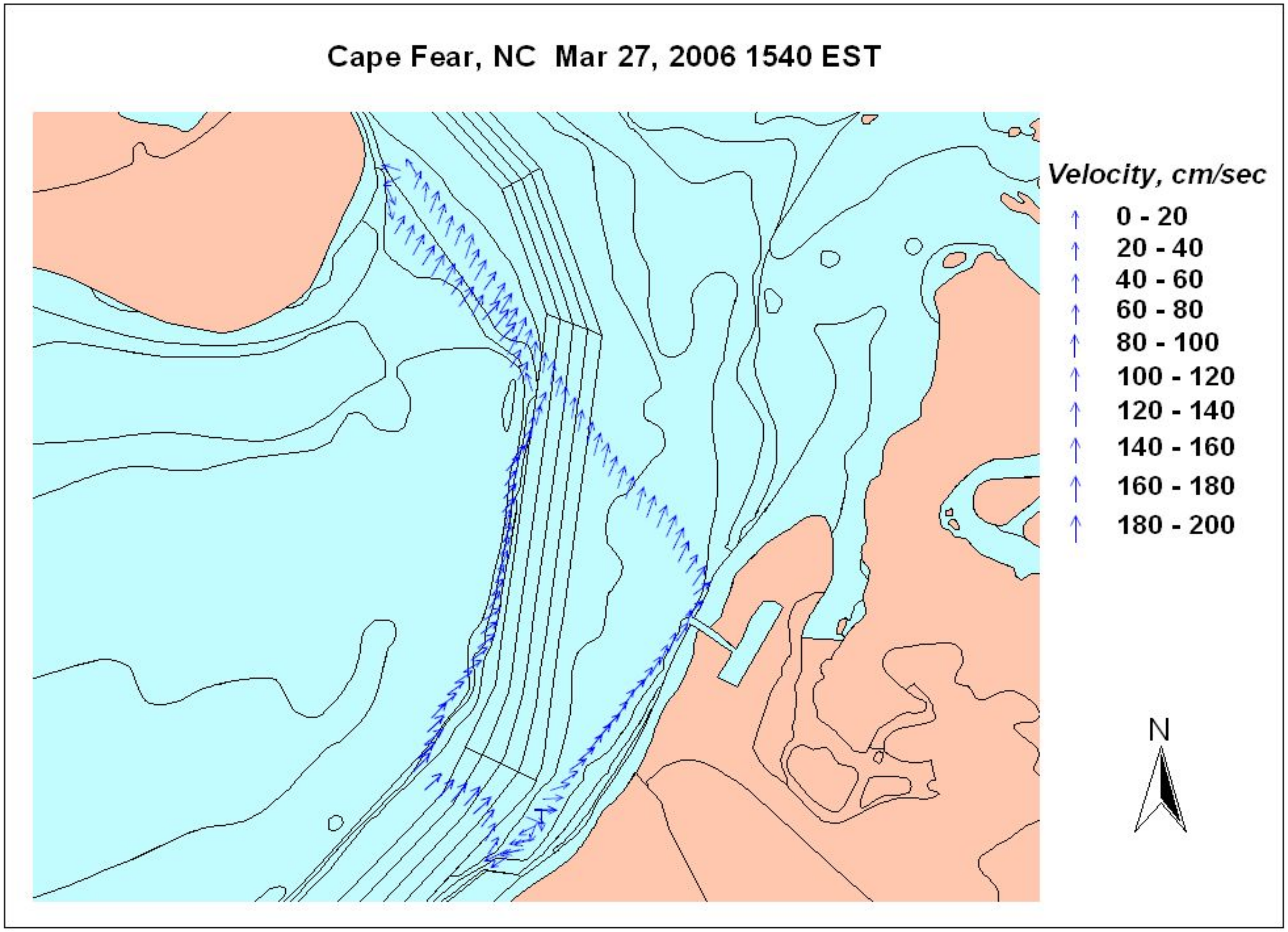


Figure D-6 March 2006 ADCP survey at the inlet transect during peak flood flow

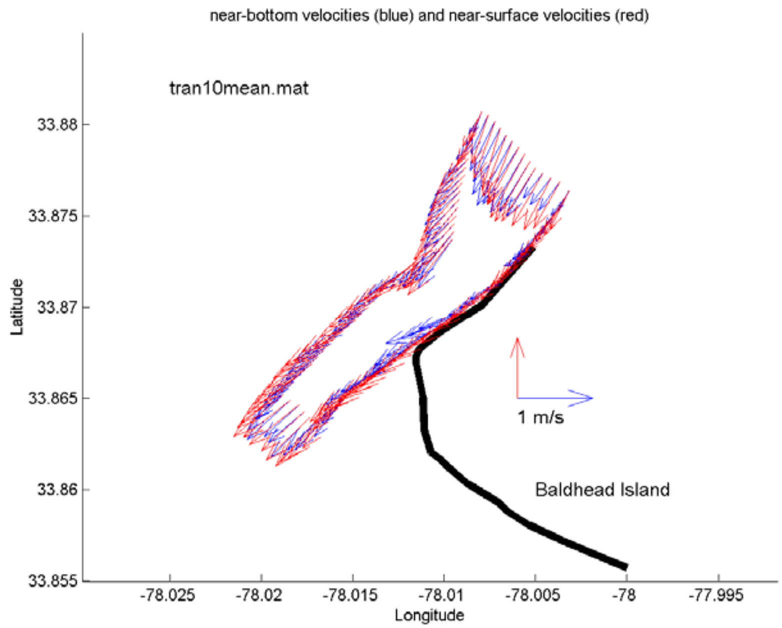


Figure D-7 October 2000 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the April 2002 survey.

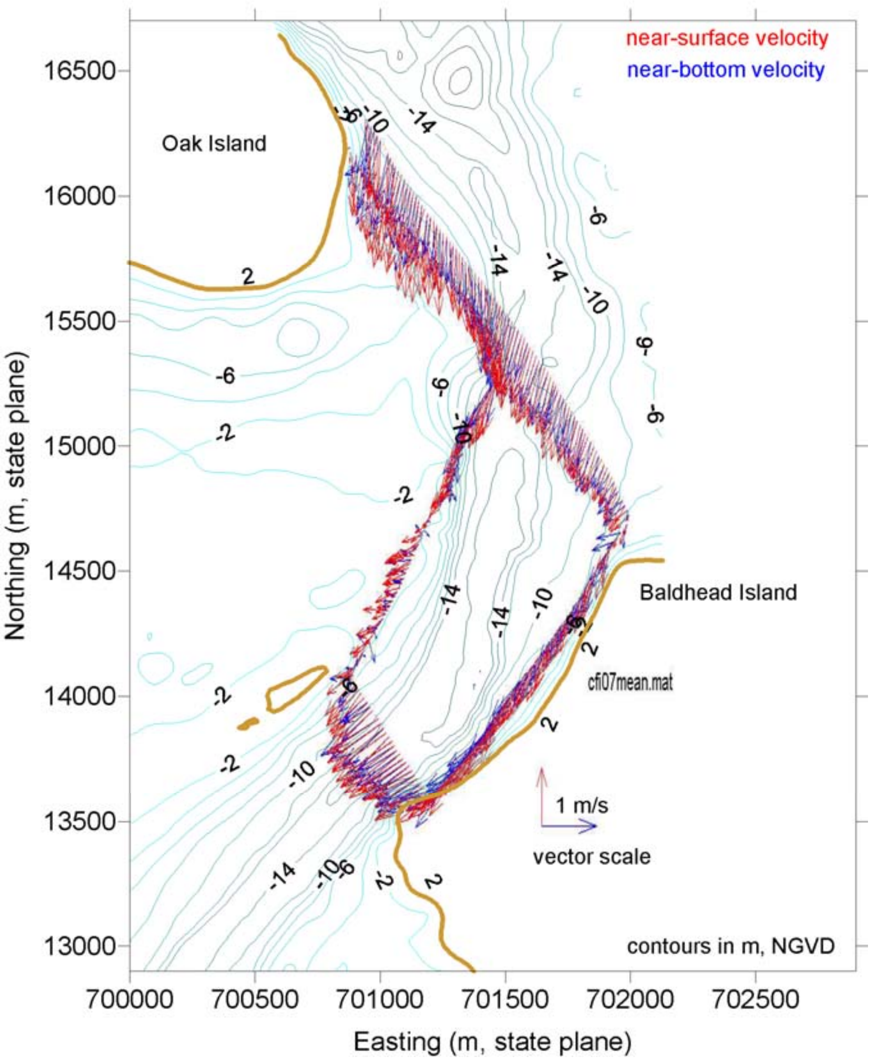


Figure D-8 April 2002 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the October 2000 survey.

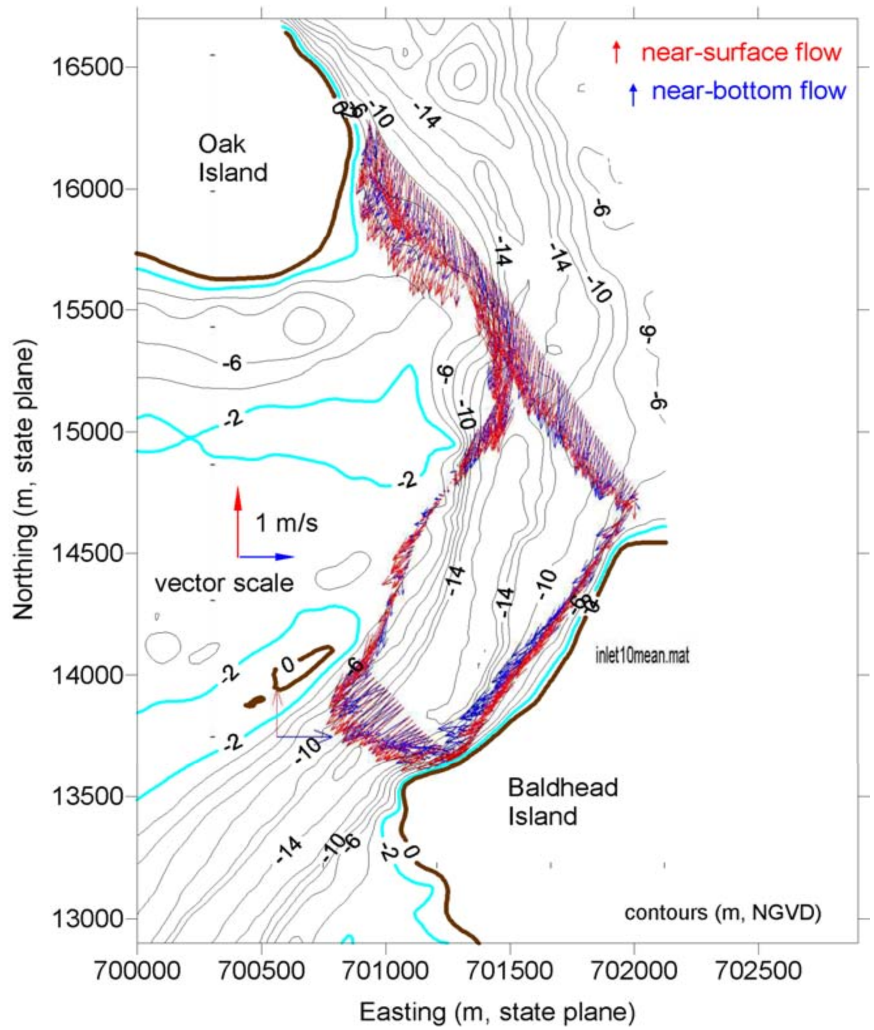


Figure D-9 March 2003 ADCP survey at inlet transect during ebb flow.

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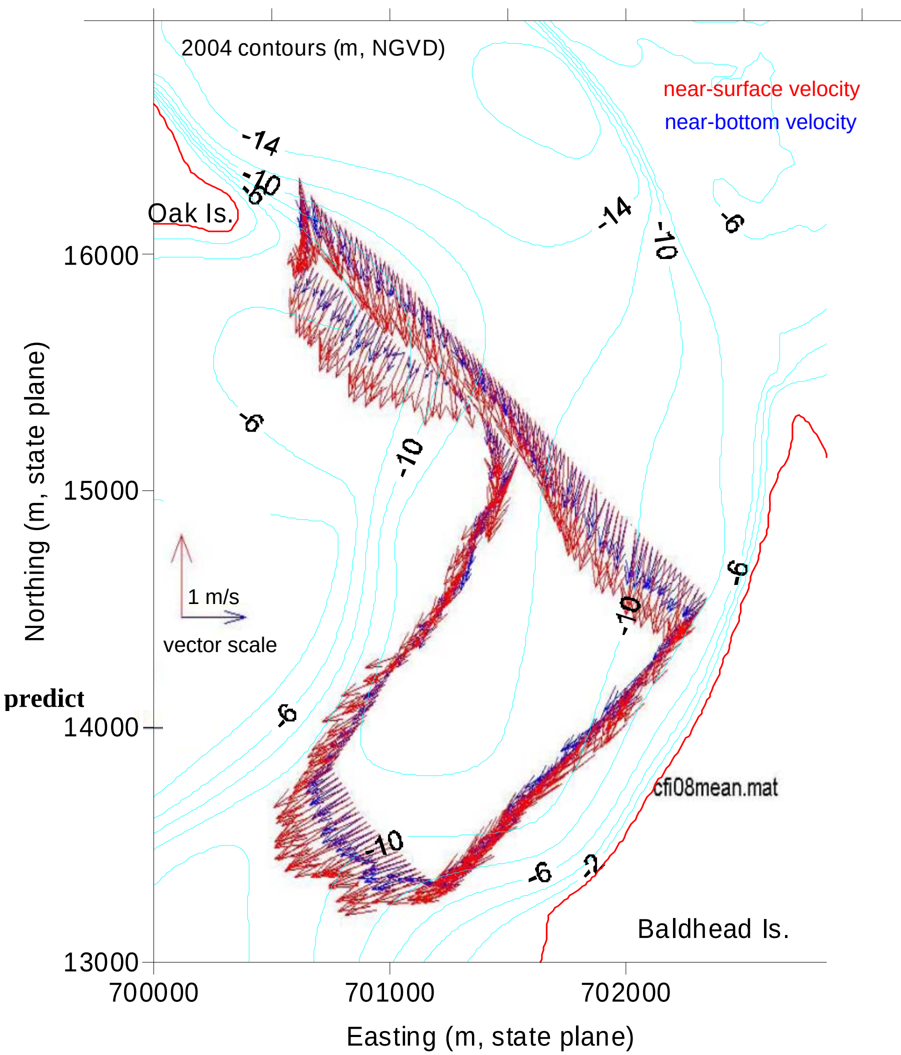

Figure D-10 January 2004 ADCP survey at inlet transect during ebb flow.

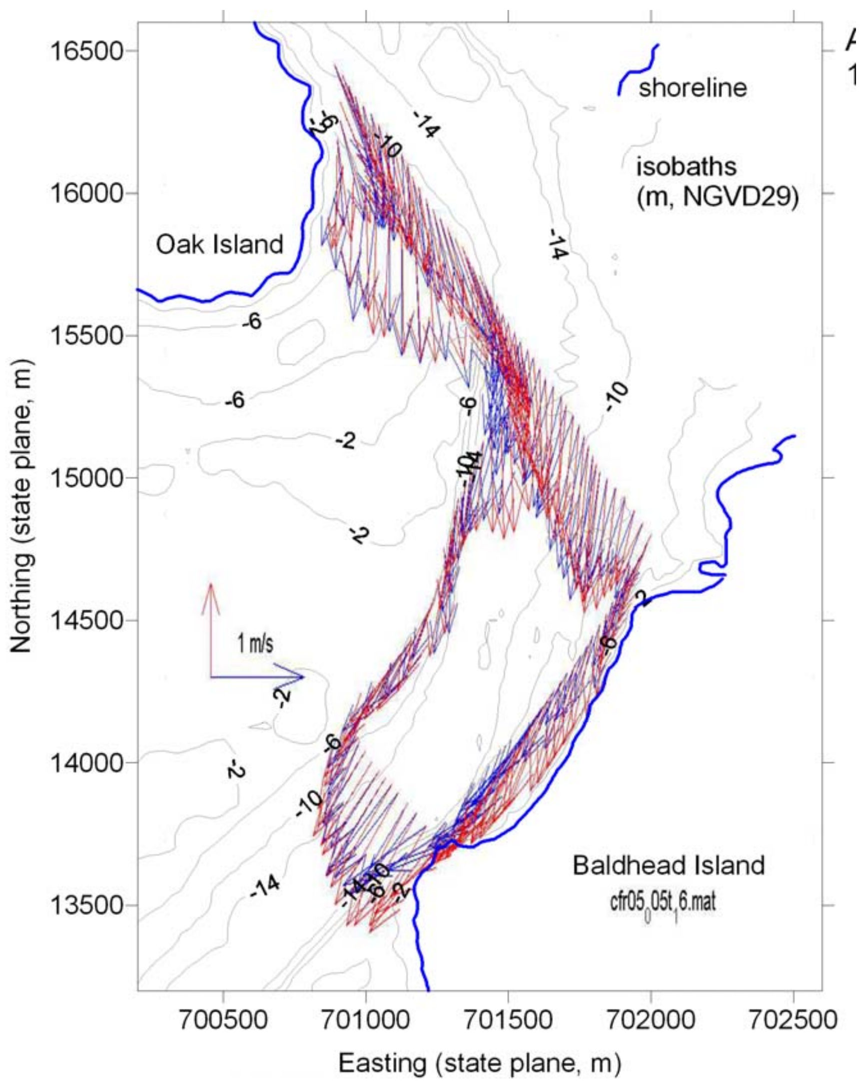

Figure D-11 March 2005 ADCP survey at inlet transect during ebb flow.

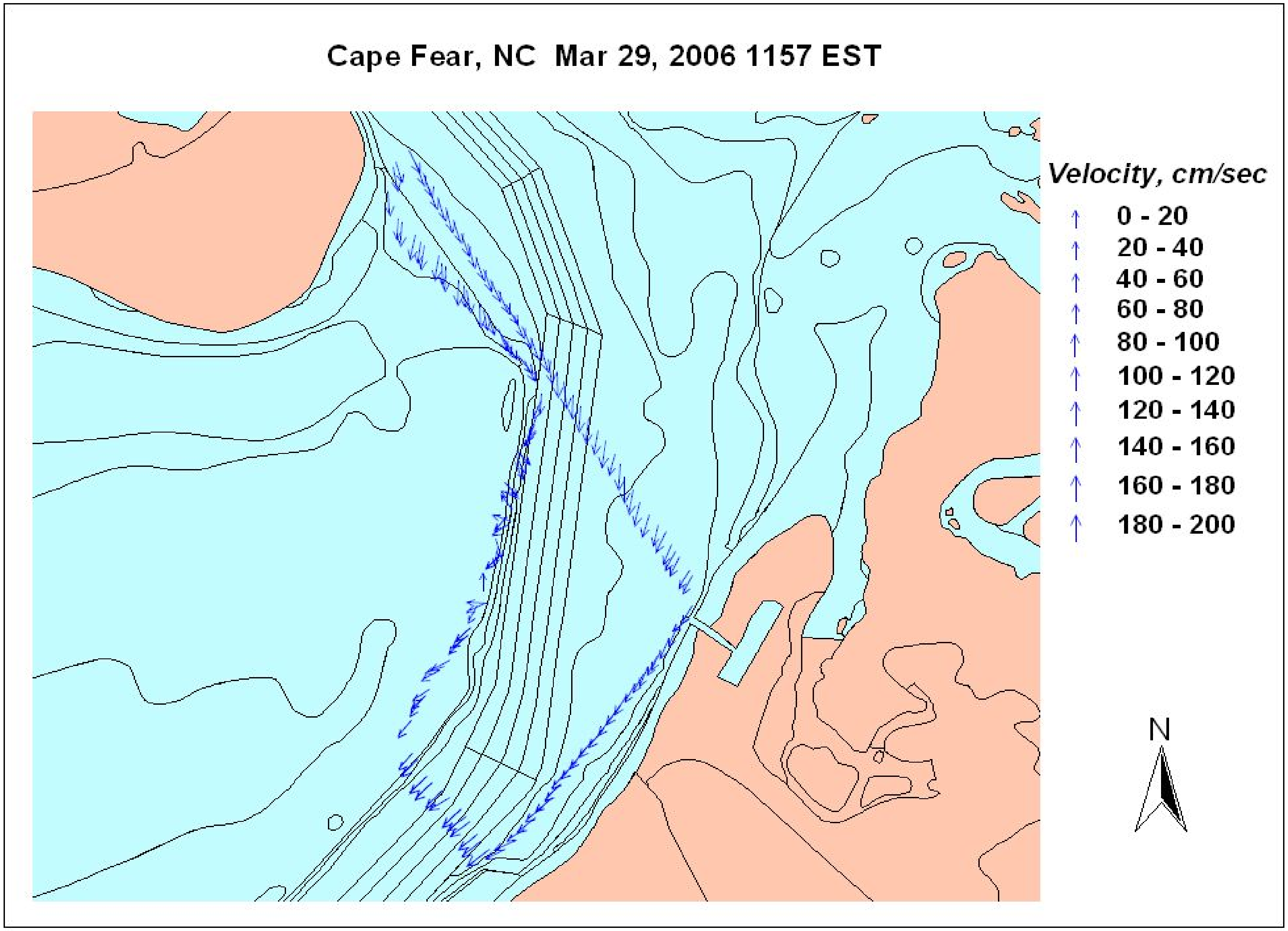

Figure D-12 March 2006 ADCP survey at the inlet transect during peak ebb flow

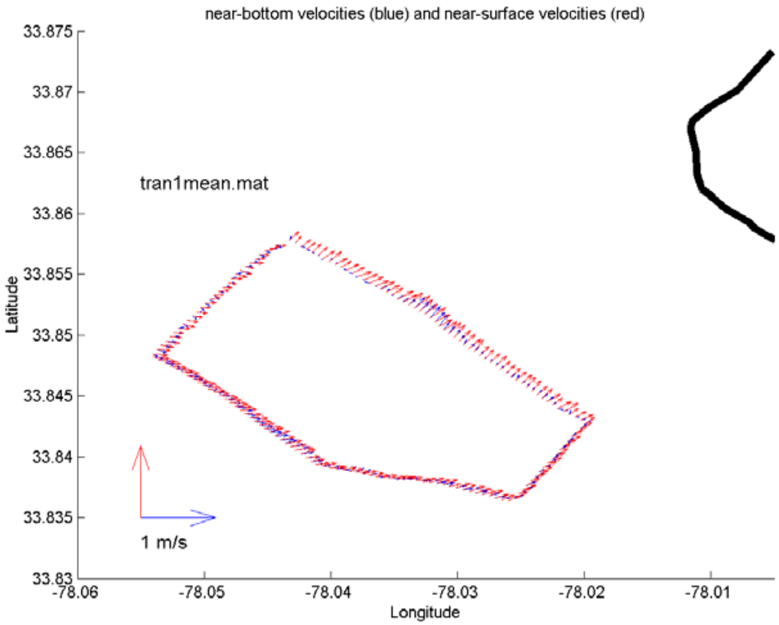

Figure D-13 October 2000 ADCP survey at offshore transect during peak flood flow.

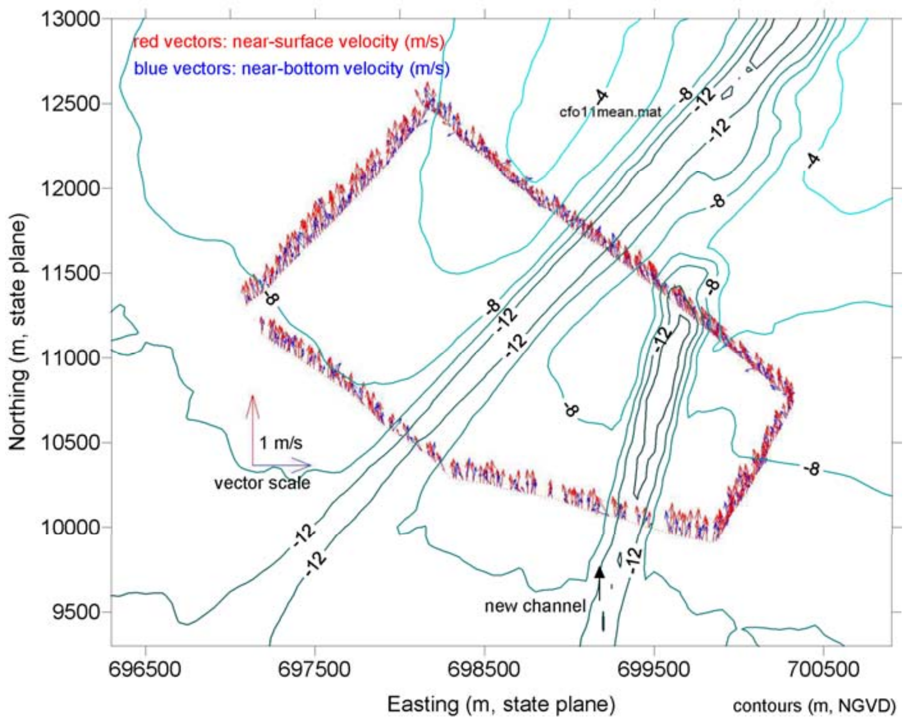

Figure D-14 April 2002 ADCP survey at offshore transect during peak flood flow.

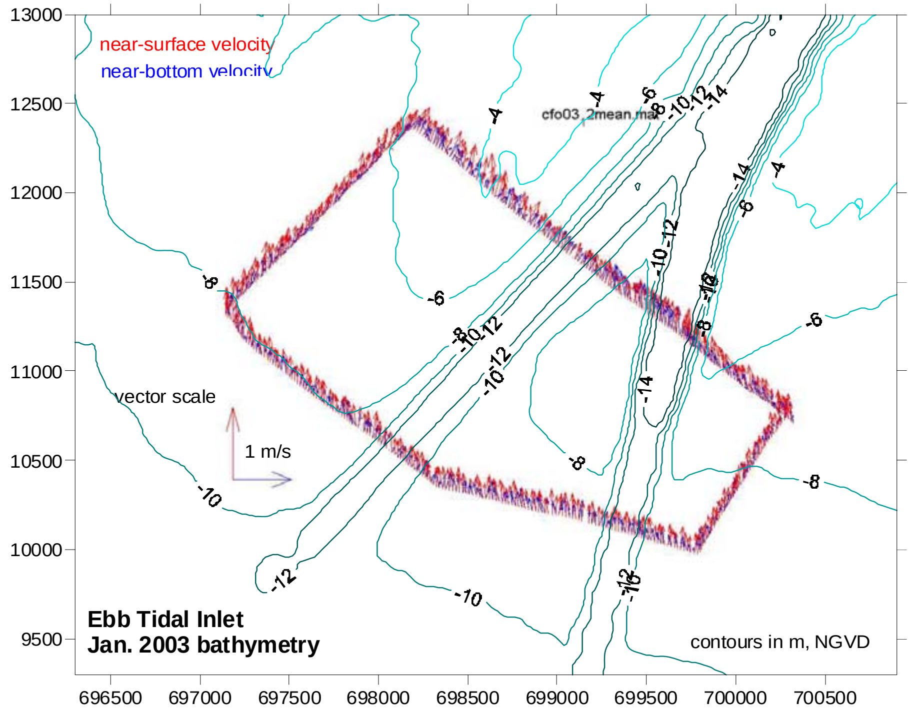

Figure D-15 March 2003 ADCP survey at offshore transect during flood flow.

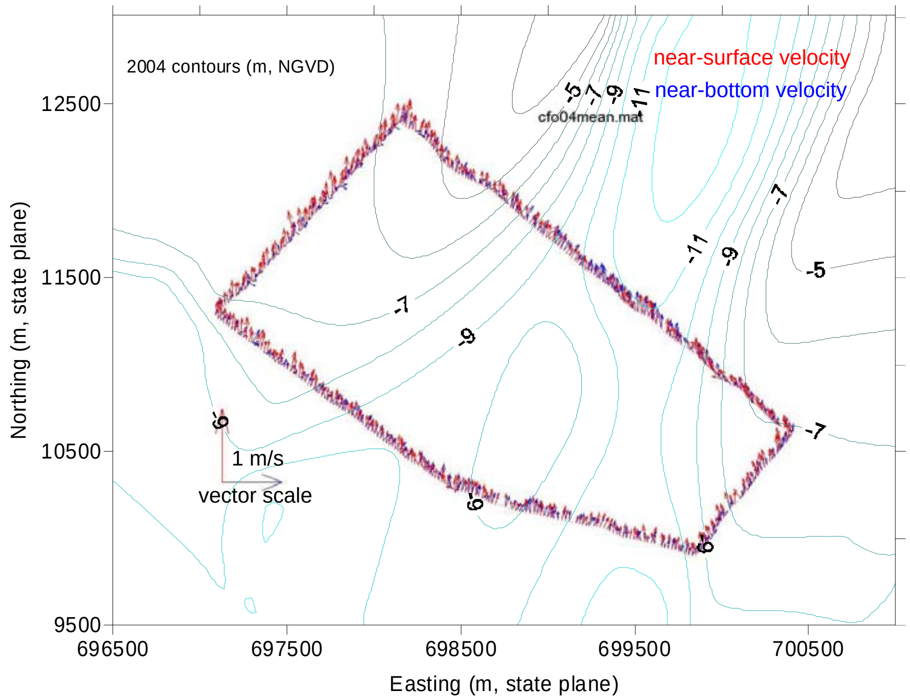

Figure D-16 January 2004 ADCP survey at offshore transect during flood flow.

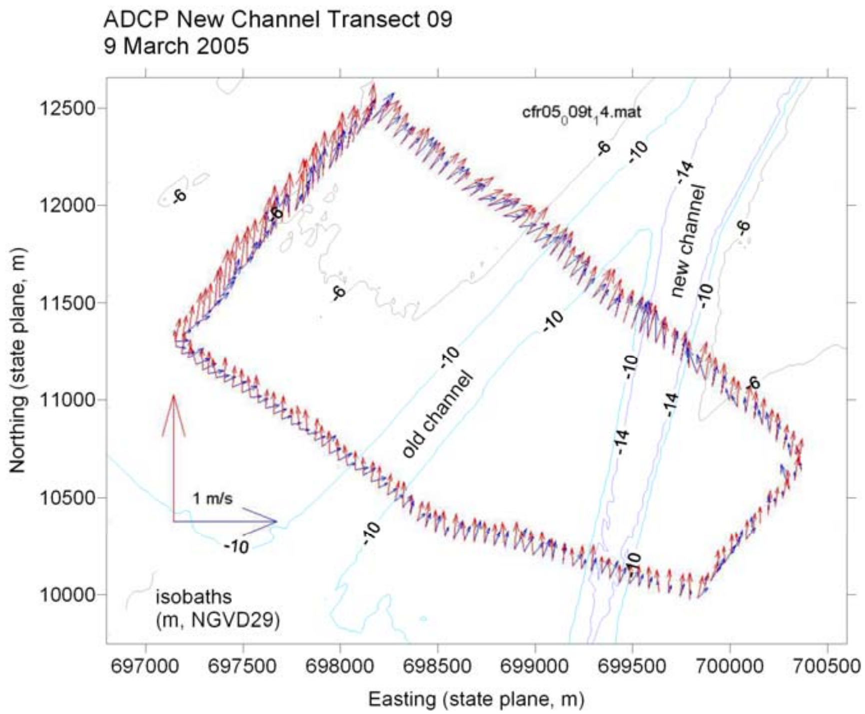

Figure D-17 March 2005 ADCP survey at offshore transect during flood flow.

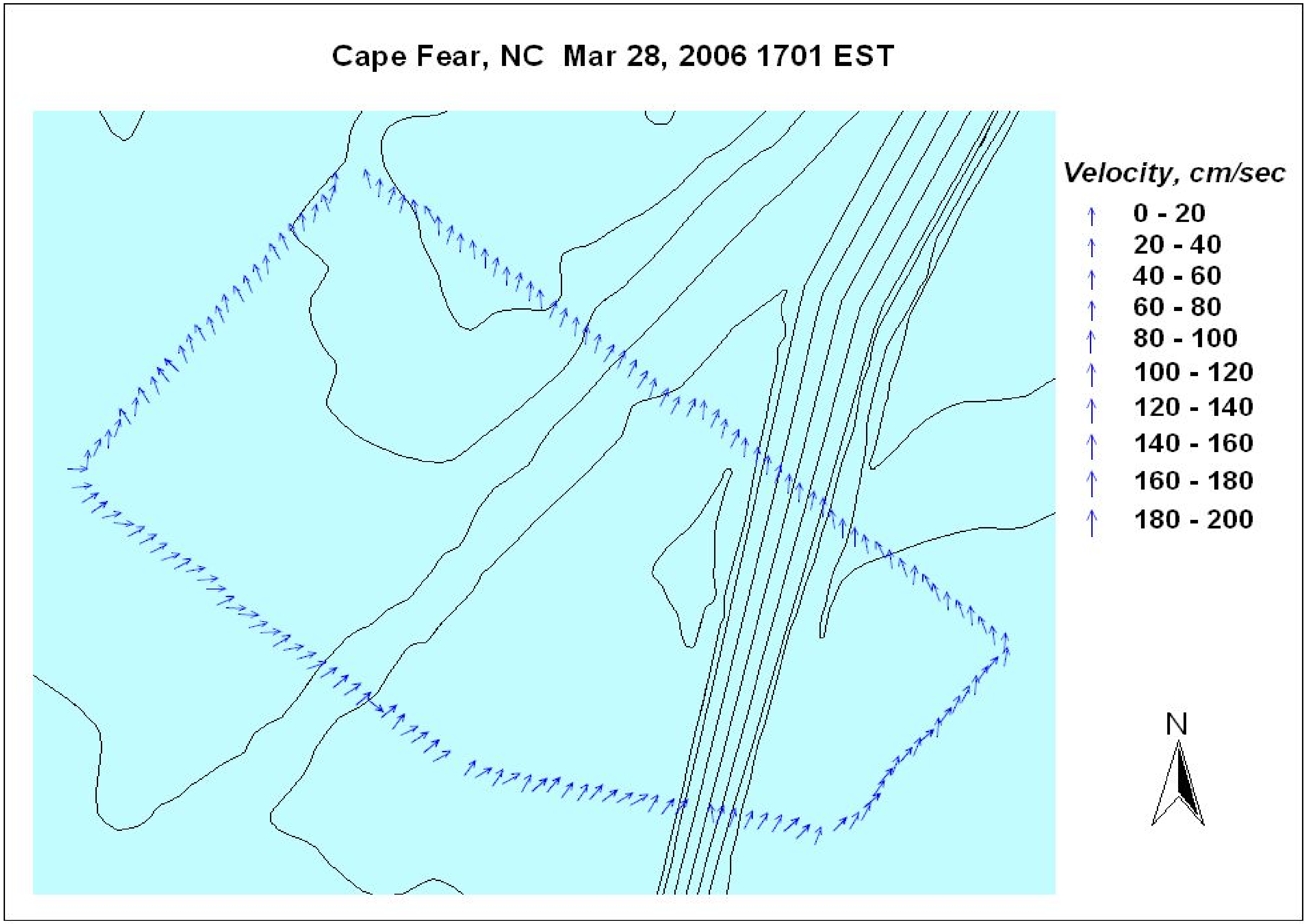

Figure D-18 March 2006 ADCP survey at the offshore-new channel transect approaching peak flood flow

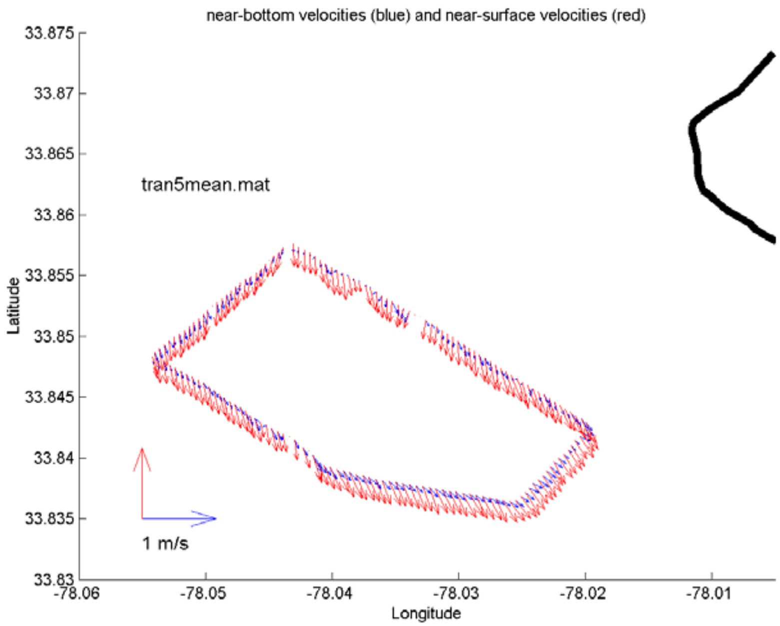

Figure D-19 October 2000 ADCP survey at offshore transect during peak ebb flow.

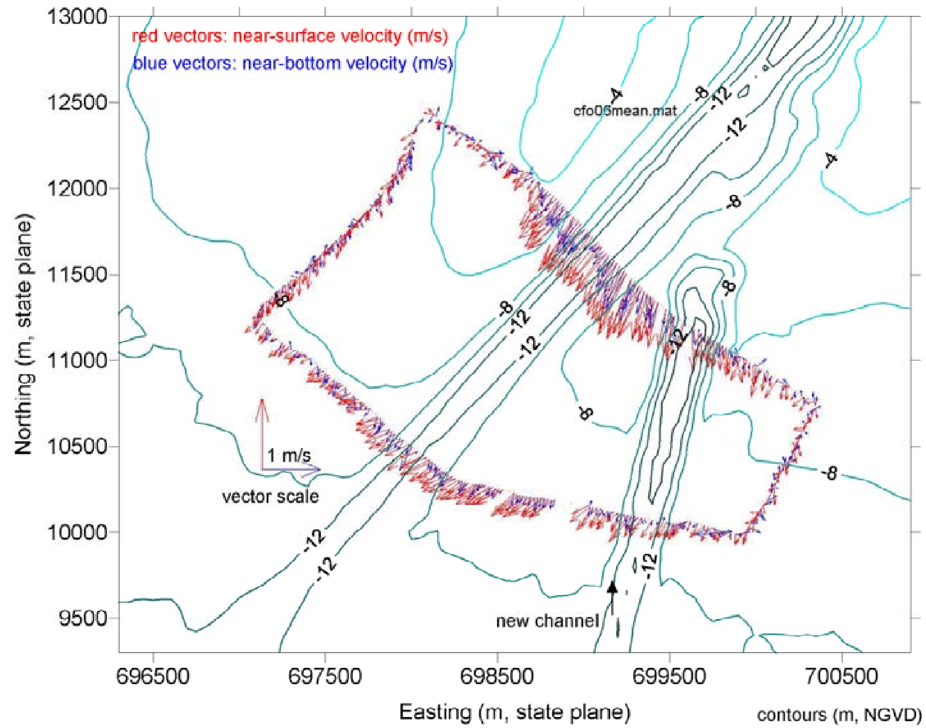

Figure D-20 April 2002 ADCP survey at offshore transect during peak ebb flow.

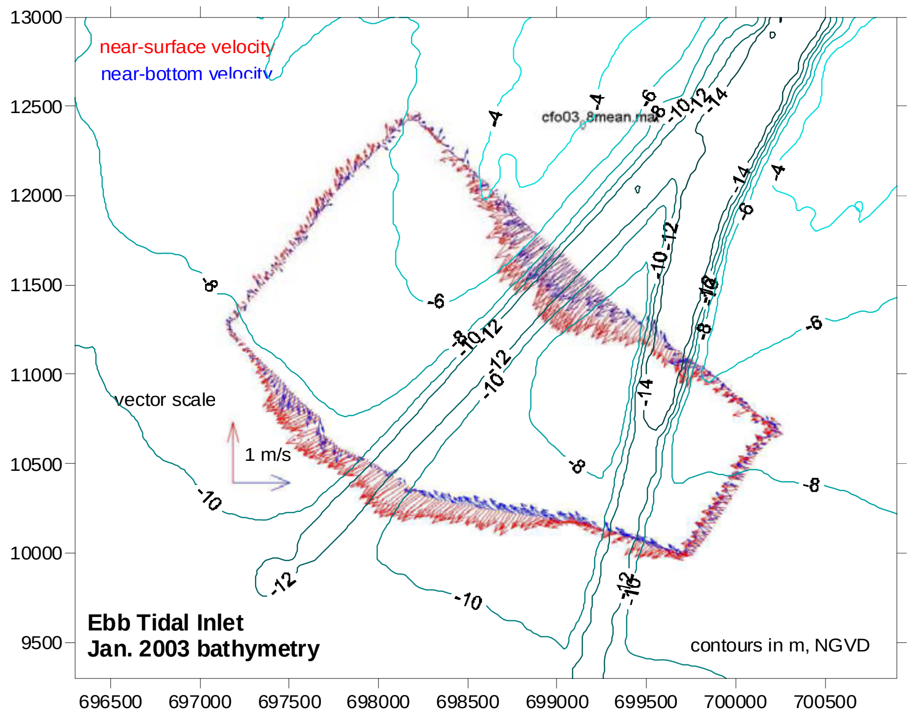

Figure D-21 March 2003 ADCP survey at offshore transect during ebb flow.

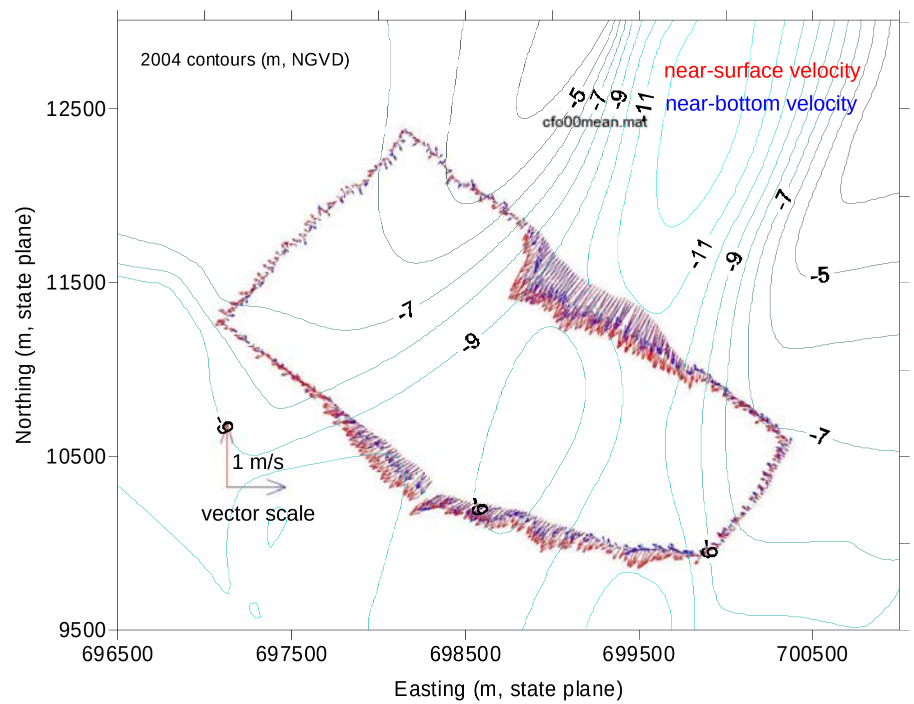

Figure D-22 January 2004 ADCP survey at offshore transect during ebb flow.

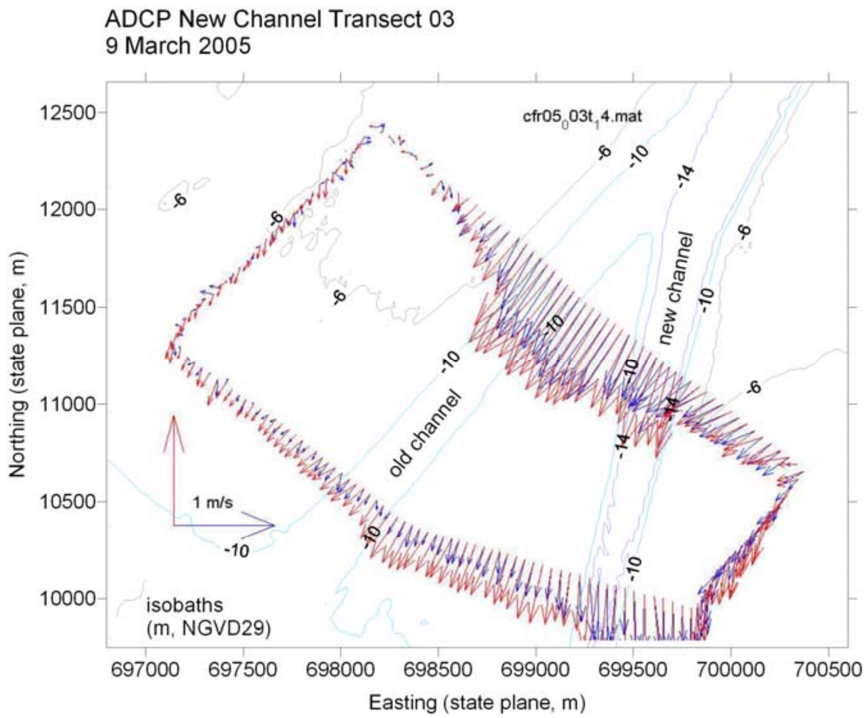

Figure D-23 March 2005 ADCP survey at offshore transect during ebb flow.

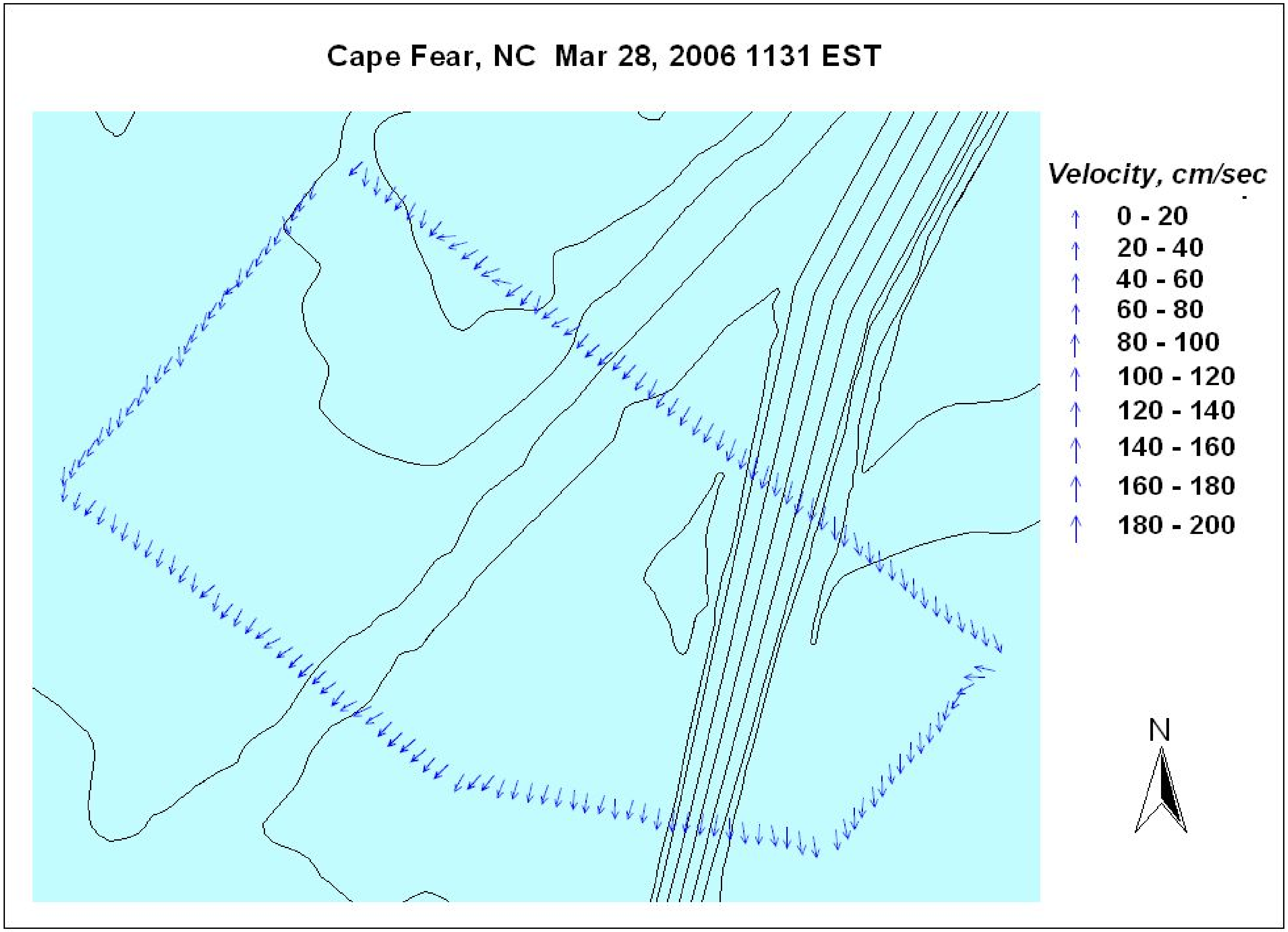

Figure D-24 March 2006 ADCP survey at the offshore-new channel transect during peak ebb flow