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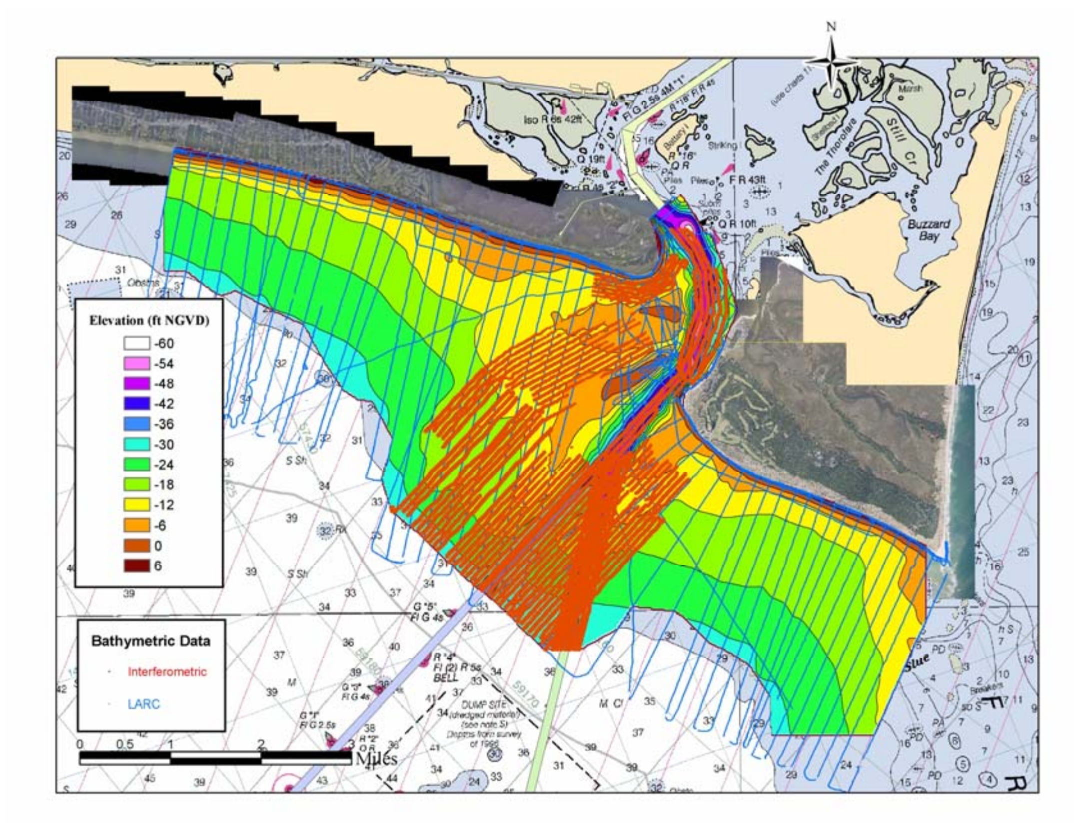
Wilmington District

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 4:
September 2005 – October 2006



MAY 2007

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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 fourth in a series and serves to update the monitoring program with data collected September 2005 through October 2006. The initial report published in July 2004 covered the period of August 2000 (pre-construction survey) through June 2003. The second and third reports covered the periods of June 2003 to June 2004 and June 2004 through August 2005, 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 September 2005 through October 2006 have included: two complete beach profile surveys (March 2006 and October 2006), one ebb shoal survey (April 2006), one entrance channel current measurement (March 2006), 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 eroded over the last year but still remains stable overall. Shoreline retreated an average of 5 feet over the last year but is on the average 94 feet more seaward than it was at the start of the project six years ago
- Most of the initial beach disposal material remains along Oak Island/Caswell Beach with more than 1.2 million cubic yards still present above then pre-project condition

- Comparing long-term shoreline change rates with those of the 6-year monitoring period show Oak Island presently experiencing high rates of accretion versus historic minor erosion
- Bald Head Island experienced overall shoreline erosion over the last year, most of which was within the limits of beach fill placed along South Beach in 2005. In contrast, when comparisons are made over the 6-year monitoring period accretion is evident along most of Bald Head Island. However, an area of chronic shoreline recession remains present along the south-western corner of the island.
- Bald Head's West Beach is generally stable compared to the pre-project condition, being aided by fill placed by the Village from dredging of Bald Head Creek in January 2006
- Comparing long-term shoreline change rates with those of the 6-year monitoring period show Bald Head Island is presently experiencing less erosion overall. However, the post-construction rates are higher along the western 1,000 feet 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 reaching a minimum of 438 feet (Bald Head Shoal Station 23+00) by November 2006, just prior to dredging. This was corrected with the present ongoing maintenance dredging and no further action was taken except continued monitoring
- Rate of spit growth into Baldhead Shoal Channel has decreased following the 2005 dredging versus the 2001-02 dredging
- Overall change in ebb and nearshore bathymetry included moderate changes within Jay Bird Shoals, growth of the western portions of Bald Head Shoal, infilling of the old channel bed (aided by dredged material disposal) and an area of erosion at the juncture of the old and new channel alignments
- 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 3 (August 2005) 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 August 2005 to October 2006) and for the entire period (from August/September 2000 to October 2006).

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 slightly negative. When considering all profile lines, an average shoreline retreat of 5 feet is evident for the present period of August 2005 to October 2006. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –60 to +90 feet), the alongshore trend is also erosional with an average 6 foot loss for the same period. 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 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 73 feet more seaward in March 2006 than it was in 2000. Likewise, the shoreline position was 94 feet more seaward in August 2005, than it was six years ago at the start of the project. Only one area may be of some minor 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. As such, this reach has accreted, but at a relatively smaller magnitude (about 5 to 20 feet) compared to the adjacent reaches.

In terms of volume change, Oak Island/Caswell Beach has experienced losses in the western half and gains over the eastern half for the current period. When considering all profile lines, a net loss of 196,000 cubic yards was computed since the last report, between August 2005 and October 2006. Although a net loss has occurred over the current period, the beach remains in a stable state when considering the entire 6-year monitoring period. As such, positive changes have occurred following the initial fill placement in 2001 associated with the project dredging. Specifically, by the end of the period, 1,203,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity reflects even a net gain above the fill volume placed in 2001 (1,143,000 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 eroding with the exception of the vicinity of the spit (at the southwestern tip of the island), a western portion of South Beach and the easternmost lines near the cape. The erosion is most evident along South Beach, within the area of the January 2005 beach disposal (Profiles 46 to 138). Over this 9,200 foot reach, the beach is up to 100 feet narrower, with an alongshore average loss of 71 feet. Extending east of this erosional area is a localized stretch of stable beach and then another pocket of shoreline erosion. This stable zone is likely the result of the spreading of the 2005 beach material. Proceeding eastward toward the cape, the shoreline change becomes highly accretional, reaching a maximum advance of between 300 and 400 feet. As indicated in prior reports, the area in the vicinity of the spit (Profiles 32 to 47) is found to be highly variable. Over this report period, a portion of this area has shown gains of about 200 feet with adjacent portions losing 200 feet. The greatest losses are found at Profiles 45 and 47. These lines are located immediately west or downdrift of the new groin field. The remaining area along West Beach (Profiles 0 thru 28) has shown an overall gain, reflecting the positive impact associated with the Bald Head Creek disposal project in January 2006. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 9 feet and 8 feet for the March 2006 and October 2006 surveys, respectively.

Shoreline change patterns as measured over the last 6-year period, i.e., since the monitoring was initiated, are for the most part positive when measured relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional, with the October 2006 shorelines being typically 50 to 100 feet seaward of their September 2000 position. The exception to this general stable pattern is a zone of erosion within the vicinity of the spit area extending into the western portion of South Beach. Specifically, this zone extends from Profile 43 thru Profile 61. Between Profiles 53 and 61, which is contained within the western end of the groin field, the shoreline retreat is on the order of 60 feet. By contrast, the eroded profiles just to the west of the groins (Profiles 43 thru 47) have shoreline recessions of 200 feet to more than 300 feet, when compared to the September 2000 position. Proceeding further to the west, the erosion turns positive over the remaining portions of the spit area, reaching a maximum advance of 245 feet. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline is shown to be generally stable, except for Profile 28, located in the lee of the spit. When considering all locations along Bald Head Island (Profile 0 to Profile 218), the shoreline is presently on the average 55 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey (August 2005) of Report 3 to October 2006, Bald Head Island was dominated by losses along most of South Beach, except for the eastern area near the cape. All other areas, specifically the spit and West Beach, showed volumetric gains over the last year. Along South Beach, the losses are found to extend between Profile 53 through 178, with the losses being approximately twice as large along the western half than along the eastern half of this 12,500-foot reach. The total loss within this reach amounts to 684,000 cubic yards. These losses are nearly balanced by the gains recorded near the cape (+ 205,000 cubic yards), the spit (+84,000 cubic yards) and West Beach (+133,000 cubic yards). The net change over the entire monitoring area amounts to a loss of 262,000 cubic yards over the period from August 2005 to October 2006.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, three areas of loss are present along Bald Head Island. One is located at the extreme eastern end of south beach where some small losses have occurred near the cape. The other two, which are of greater concern, are along the western portions of South Beach. The larger of the two extends from Profile 45 to 69, covering approximately 2,400 feet, which has been the site of chronic erosion in the past. Following the January 2005 beach disposal, this area has progressively worsened. The latter erosion area along South Beach is developing further to the east between Profiles 88 and 114, within and just beyond the eastern portion of the groin field. 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 635,000 cubic yard gain in March 2006 and 524,000 cubic yard gain by October 2006.

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 6 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 6-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 +24 feet per year for the 6-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 island is eroding less over the initial 6-year monitoring period. However, notwithstanding this overall positive response, the present erosion rates continue to be greater along the western corner of South Beach. A direct comparison of the long-term and present shoreline change rates show that only two profile lines are eroding at a higher rate during the present 6-year period. These lines are located at the western end of South Beach (Profiles 53 thru 61). Adjacent Profiles 57, 66 and 69 are presently eroding but at a lower rate as compared to the long-term 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 recently 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 2006, thirteen condition surveys have been accomplished, four of which occurred over the present period (May 2006, July 2006, September 2006 and November 2006). The recent surveys reveal that additional shoaling has occurred in the vicinity of the

Bald Head spit. The shoaling has occurred in an elongated pattern along the eastern edge of the channel along Bald Head Shoal. The average shoaling can be broken into two areas for the current monitoring period. The navigable width from Sta. 0+00 to 17+00 had an average reduction of 18 feet, while Sta. 18+00 to 44+99 had an average bottom width reduction of 74 feet. Navigable width was maintained above the threshold limit for the majority of the channel throughout the current monitoring period. The first breach of the threshold limit occurred at Sta. 21+00 to 22+00 in May 2006. Subsequent bi-monthly surveys revealed that the shoaling continued throughout the current monitoring period. The final survey taken in November 2006 showed that stations 20+00 through 24+00 and stations 33+00 through 34+00 have all exceeded the threshold. The average navigable width in these areas is 469 feet, with the minimum occurring at station 23+00 at a width of 438 feet. It was determined at that time that no immediate action was necessary and that the width would continue to be closely monitored. Significant channel width reduction did not occur until the November 2006 survey, at which point the next dredging contract was in place to begin in January 2007. Based on the monitoring surveys to date, it appears that the current dredging cycle of 24 months provides adequate channel width. Shoaling will continue to be monitored on a bi-monthly basis to confirm this pattern, and adjustments made as necessary.

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 3. The comparison showed that the rate of growth was slower following the second event. Specifically, the initial rate was about 16,000 cubic yards per month versus the second rate of about 10,000 cubic yards per month, i.e., a 38 % reduction in shoaling rate. Analysis for the current monitoring period shows that the growth rate has continued to decrease and is now at a rate of 8,700 cubic yards per month. This is a 46% reduction in the shoaling rate versus the initial dredging operation. 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 2005 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. 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 19 month period after the first fill was 160 feet compared to 80 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. Along either side of this particular shoal are scour features with one to the west along a flood channel near Oak Island and the other to the east along the margin of the main channel. The scour present along the main channel is found to extend along most of the eastern edge of Jay Bird Shoals, some of it being attributed to the channel deepening in this area. 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. Finally, the “v” shaped area between the old and new channels just seaward of their intersection has also experienced infilling since 2000.

To date currents have been measured on six occasions, with the initial occurring before the channel improvements and the remaining five 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. Similar to results reported previously, there still does not appear to be a substantial decrease in the current magnitude through the old channel since the opening of the new channel. Of interest, however, is that for each of the post-dredging measurements, the maximum velocities are found to be greater when compared to the 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 is scheduled for 2007, which would involve placing on the order of 1,000,000 cubic yards along Bald Head Island's South Beach. Close coordination of this work will be maintained with the Village in determining the final distribution of this beach disposal operation. Ongoing monitoring efforts will be used to document the performance of this fill and to plan the third maintenance cycle (year 6). As stated above, this cycle is scheduled for placement along Oak Island. 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
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 4

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PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT

REPORT 4

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 fourth 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 September 2005 through October 2006. Monitoring Reports 1, 2 and 3 were published in August 2004, February 2005 and May 2006, respectively, and covered the first five years of monitoring (USACE 2004, USACE 2005 and USACE 2006). 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.

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

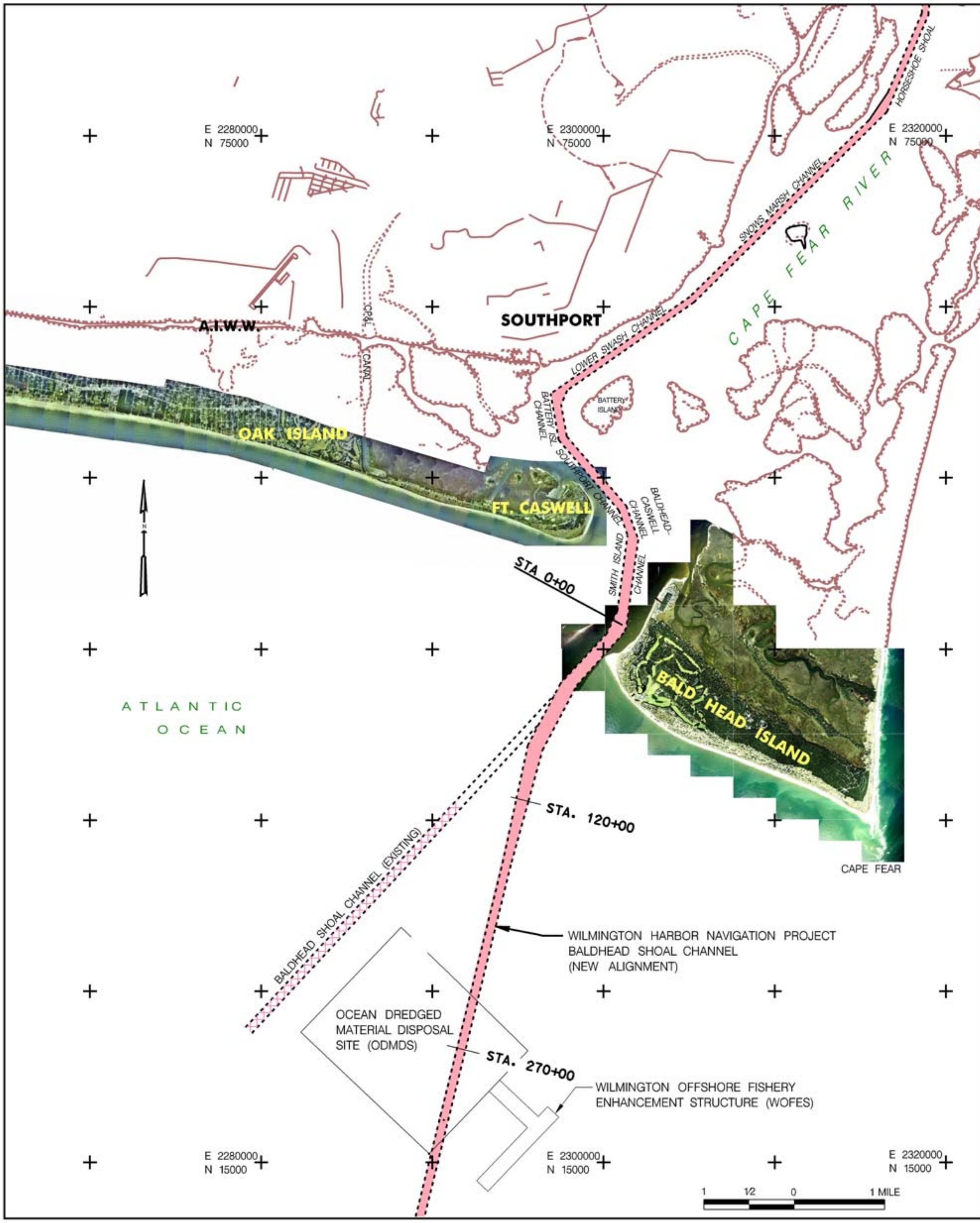


Figure 1.1 Project Location Map

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.

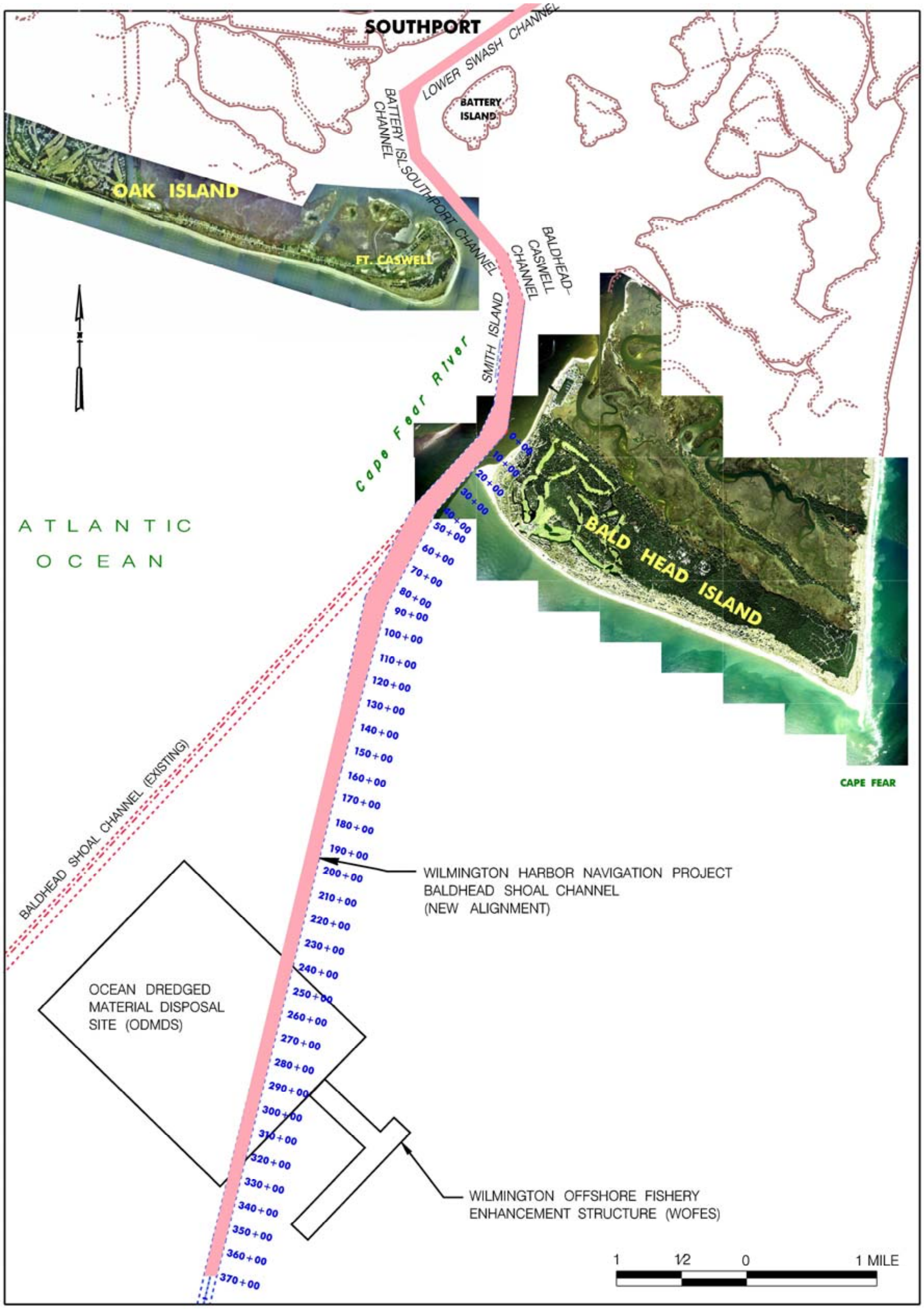


Figure 1.2 Realignment of the Federal Navigation Channel at the Cape Fear River Entrance

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						
			(INITIAL CONSTRUCTION)				
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)	
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		
		(SCHEDULED 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			(Preliminary est)	
	110+00	39,771.16	2,305,333.49			580,000	*Illinois*
	170+00	37,552.01	2,310,903.49	(SCHEDULED)	4/30/2007	(Preliminary est)	

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 material dredged during the first cycle is 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. The next maintenance cycle, also earmarked for Bald Head, is scheduled for 2007 involving on the order of 1,000,000 cubic yards of in-place sand.

<u>Sand Management Plan.</u> 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 are performed by the Virginia Institute of Marine Science, through EHI. 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.

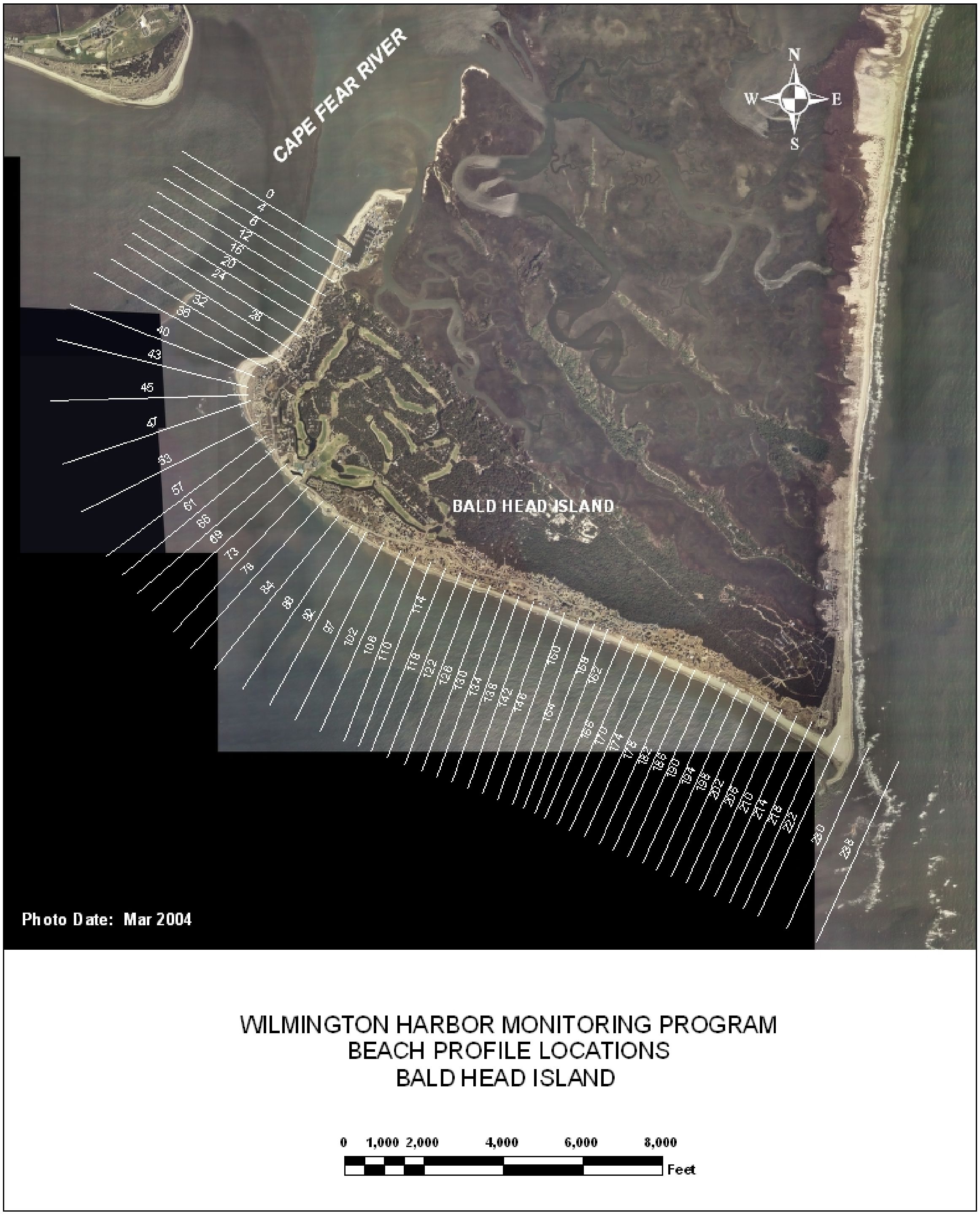
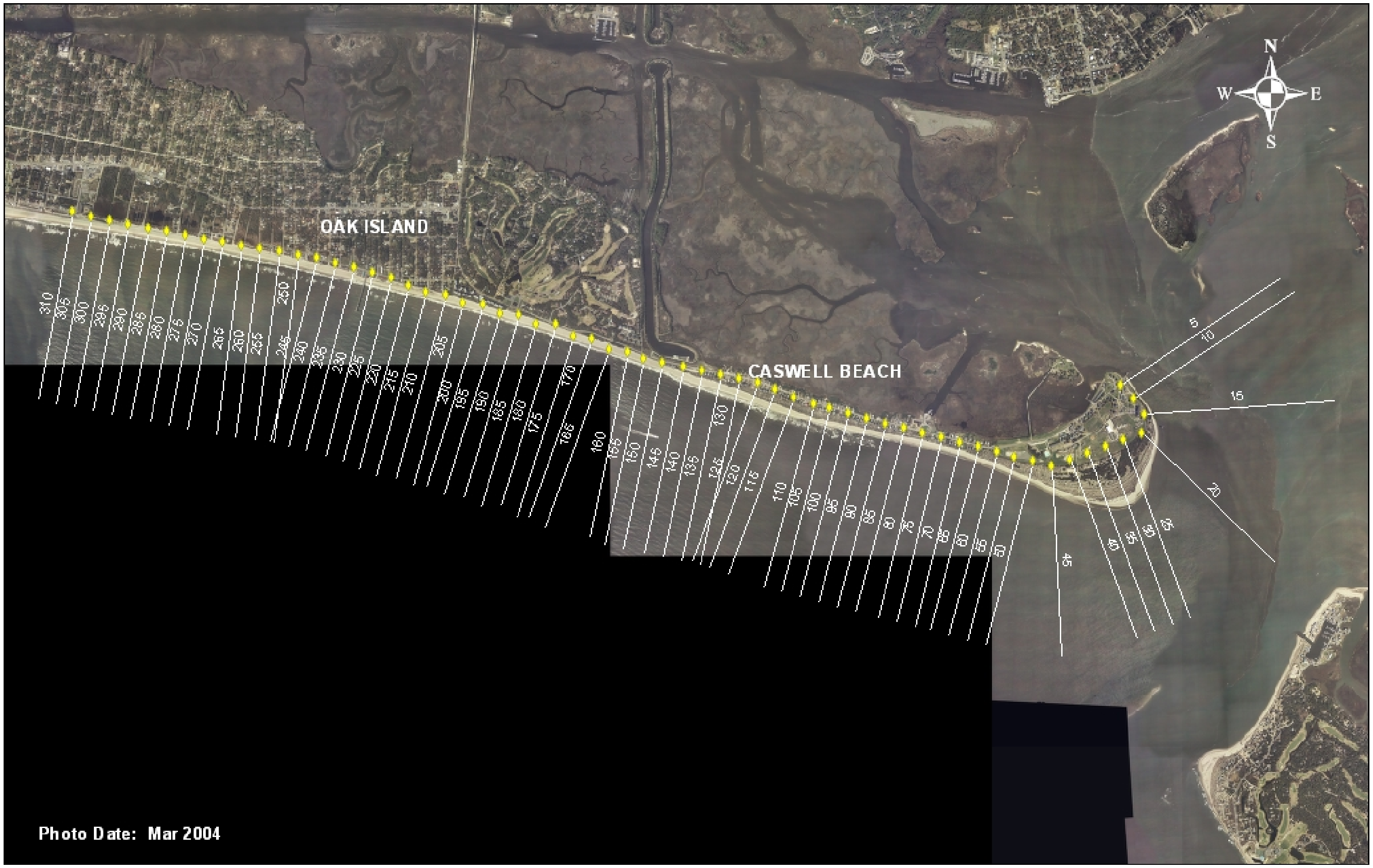


Figure 1.3 Bald Head Island Beach Profile Locations



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

Channel and Ebb Tide Delta Surveys. 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

EBB TIDAL DELTA SURVEY LIMITS

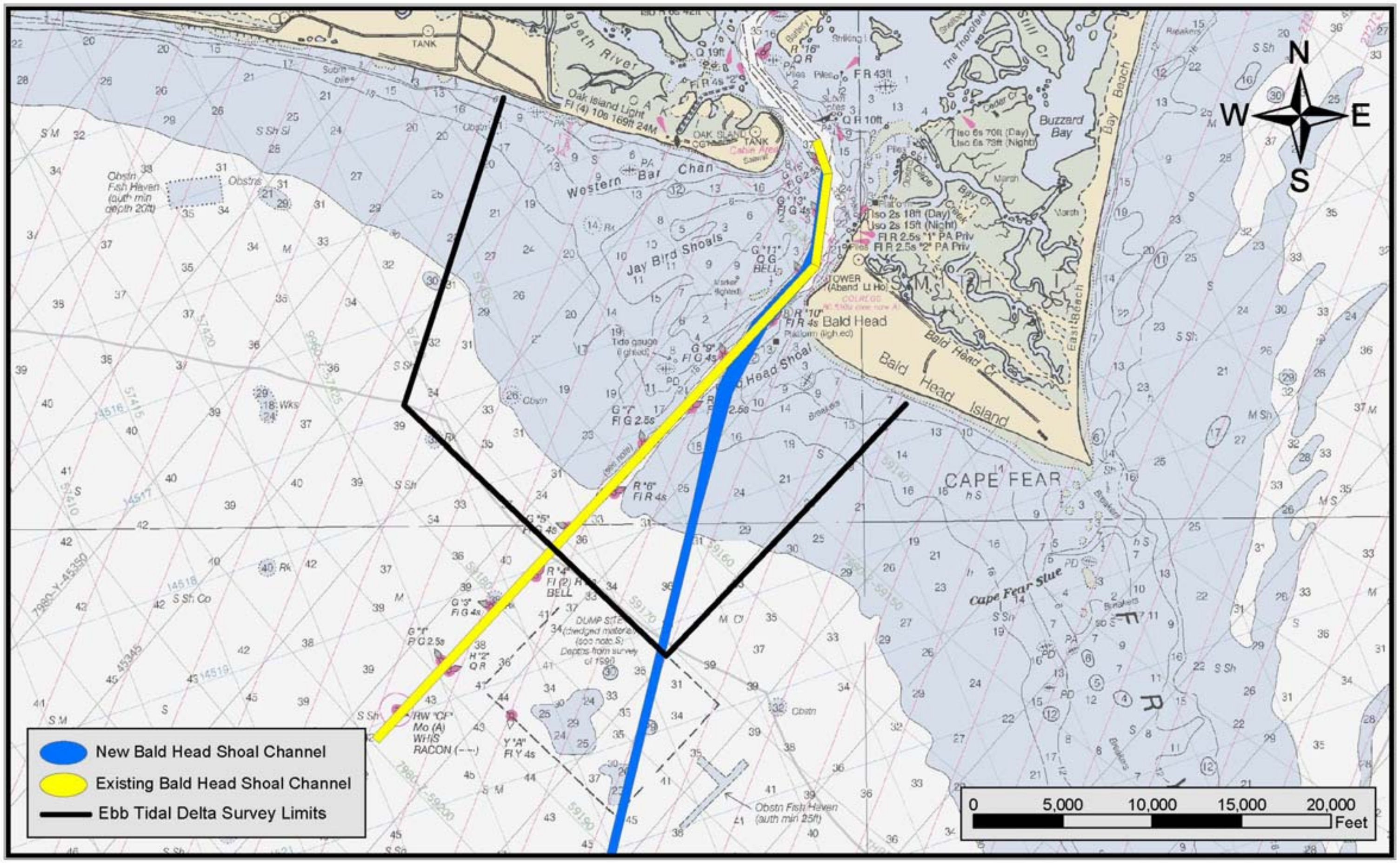


Figure 1.6 Entrance Channel and Ebb Tide Delta Survey Coverage

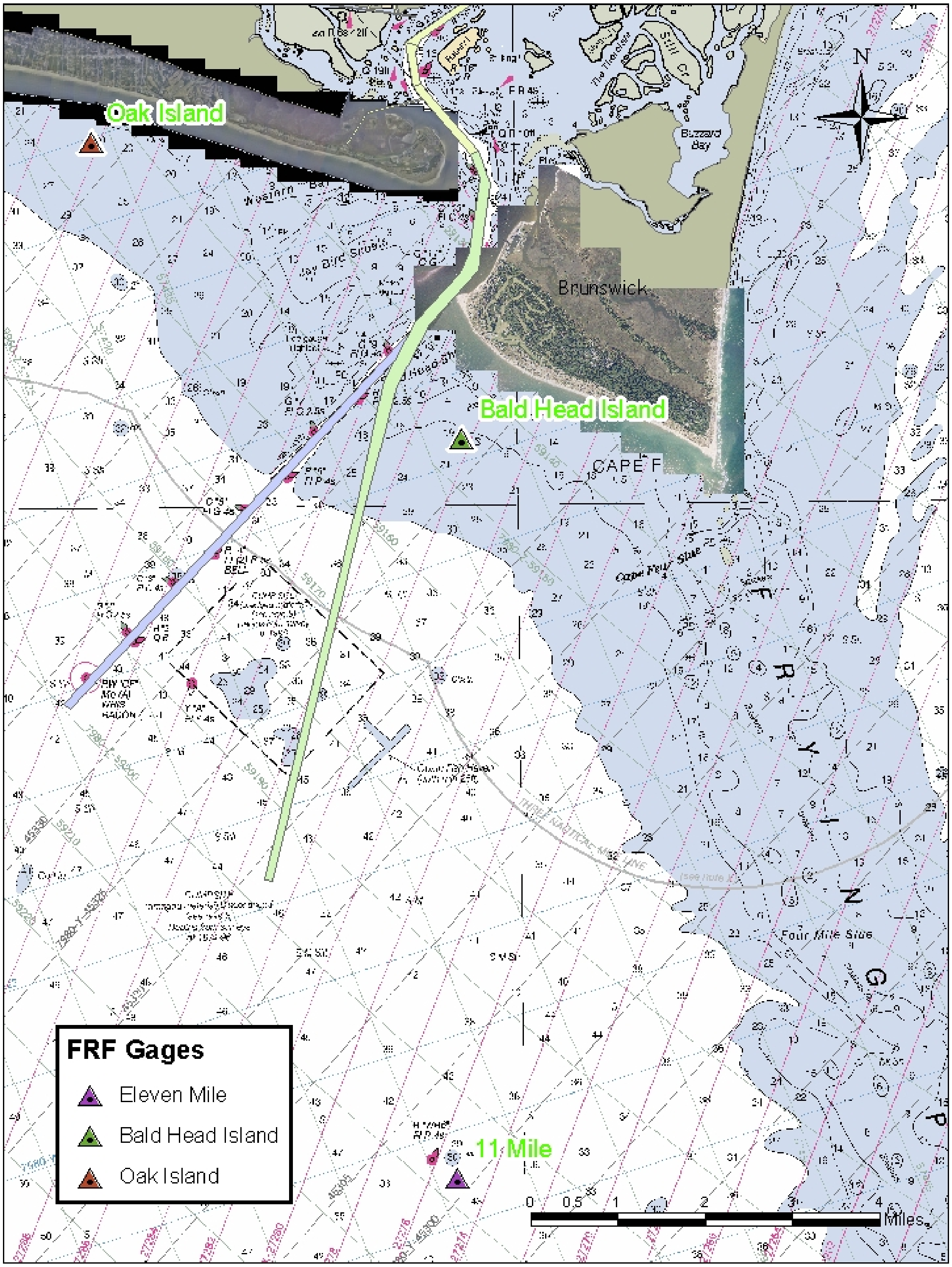


Figure 1.7 Wave and Current Gauge Locations

Ship-Board Current Profile Track Lines

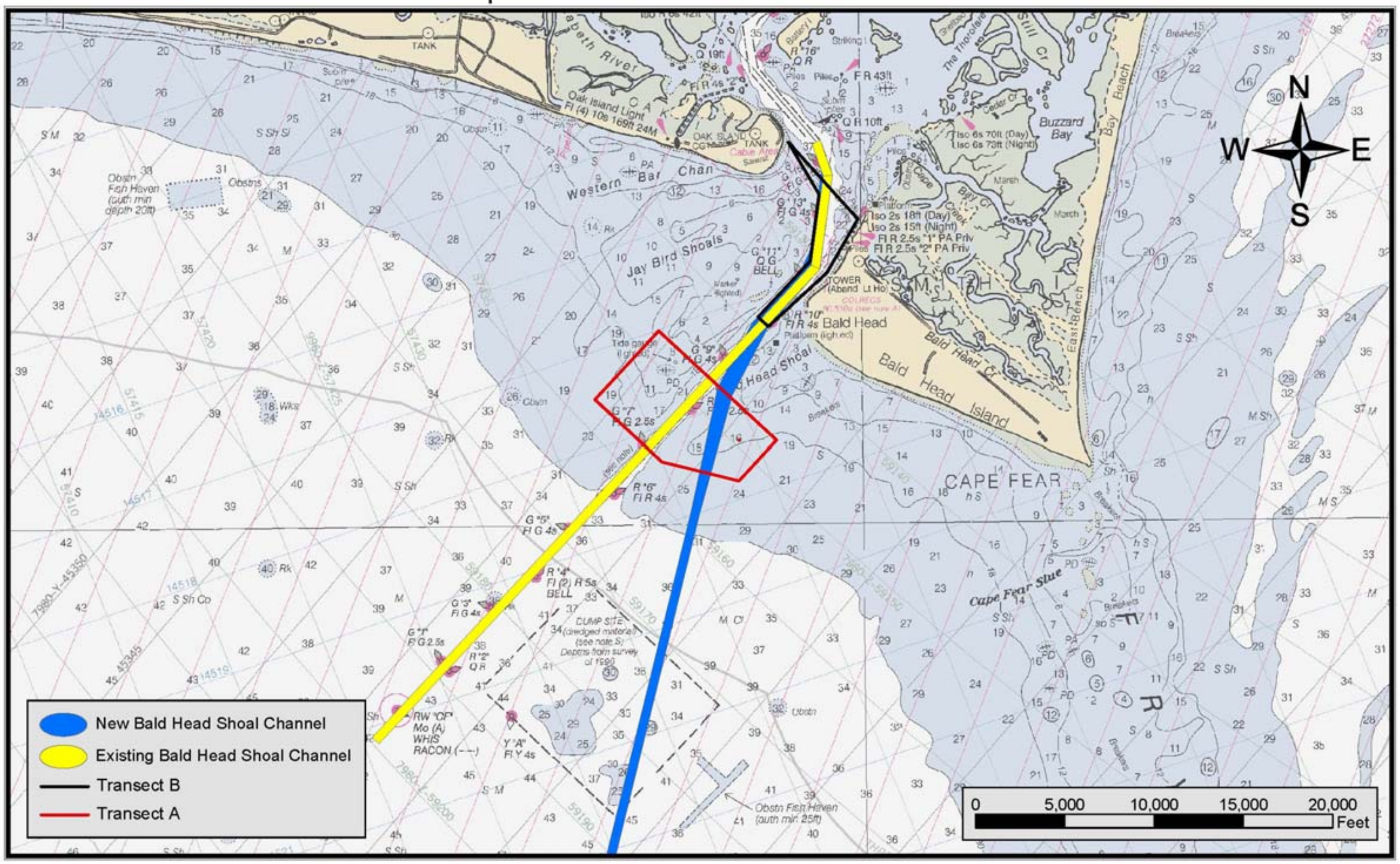


Figure 1.8 Shipboard Current Profile Locations

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

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 October 2006 beach survey and therefore spans an initial period of slightly more than six years. Table 1.3 lists all the monitoring surveys to date. Since the initiation of the program there have been 11 onshore beach profile surveys, nine offshore beach profile surveys and six 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	

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 five occasions. These data were collected in October 2000 with the initial data collection effort and in April 2002, March 2003, January 2004 and March 2006. 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.

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 is currently underway with placement during over the February-April 2007 time period. This operation involves disposal of approximately 978,500 cy of sediment along Bald Head Island.

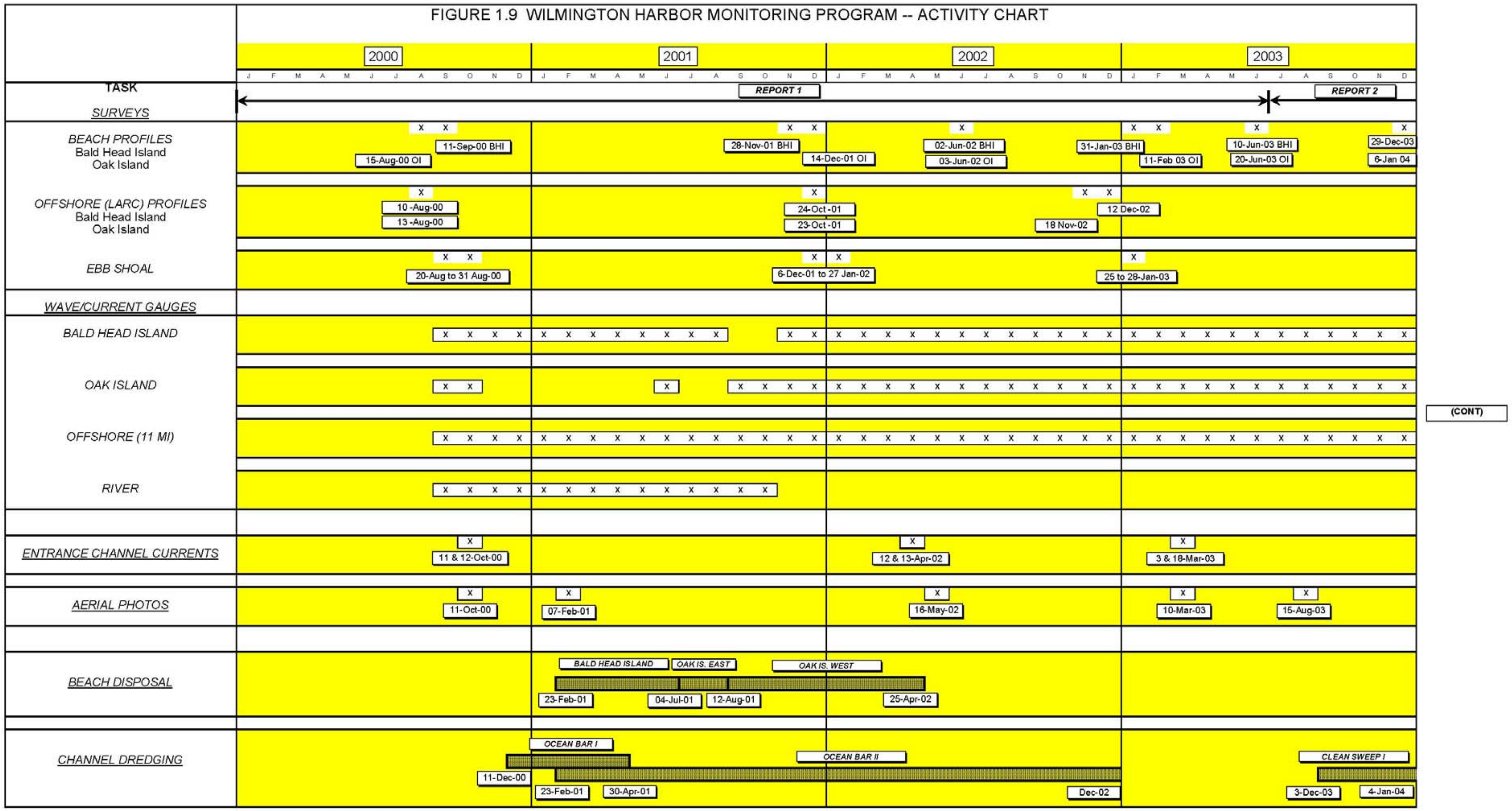


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART
2000
2001
2002
2003
TASK
REPORT 1
REPORT 2
SURVEYS
BEACH PROFILES
Bald Head Island
Oak Island
15-Aug-00 OI
11-Sep-00 BHI
28-Nov-01 BHI
14-Dec-01 OI
02-Jun-02 BHI
03-Jun-02 OI
31-Jan-03 BHI
11-Feb 03 OI
10-Jun-03 BHI
20-Jun-03 OI
29-Dec-03
6-Jan 04
OFFSHORE (LARC) PROFILES
Bald Head Island
Oak Island
10 -Aug-00
13 -Aug-00
24-Oct -01
23-Oct -01
18 Nov-02
12 Dec-02
EBB SHOAL
20-Aug to 31 Aug-00
6-Dec-01 to 27 Jan-02
25 to 28-Jan-03
WAVE/CURRENT GAUGES
BALD HEAD ISLAND
OAK ISLAND
OFFSHORE (11 MI)
RIVER
(CONT)
ENTRANCE CHANNEL CURRENTS
11 & 12-Oct-00
12 & 13-Apr-02
3 & 18-Mar-03
AERIAL PHOTOS
11-Oct-00
07-Feb-01
16-May-02
10-Mar-03
15-Aug-03
BEACH DISPOSAL
BALD HEAD ISLAND
OAK IS. EAST
OAK IS. WEST
23-Feb-01
04-Jul-01
12-Aug-01
25-Apr-02
CHANNEL DREDGING
OCEAN BAR I
OCEAN BAR II
CLEAN SWEEP I
11-Dec-00
23-Feb-01
30-Apr-01
Dec-02
3-Dec-03
4-Jan-04

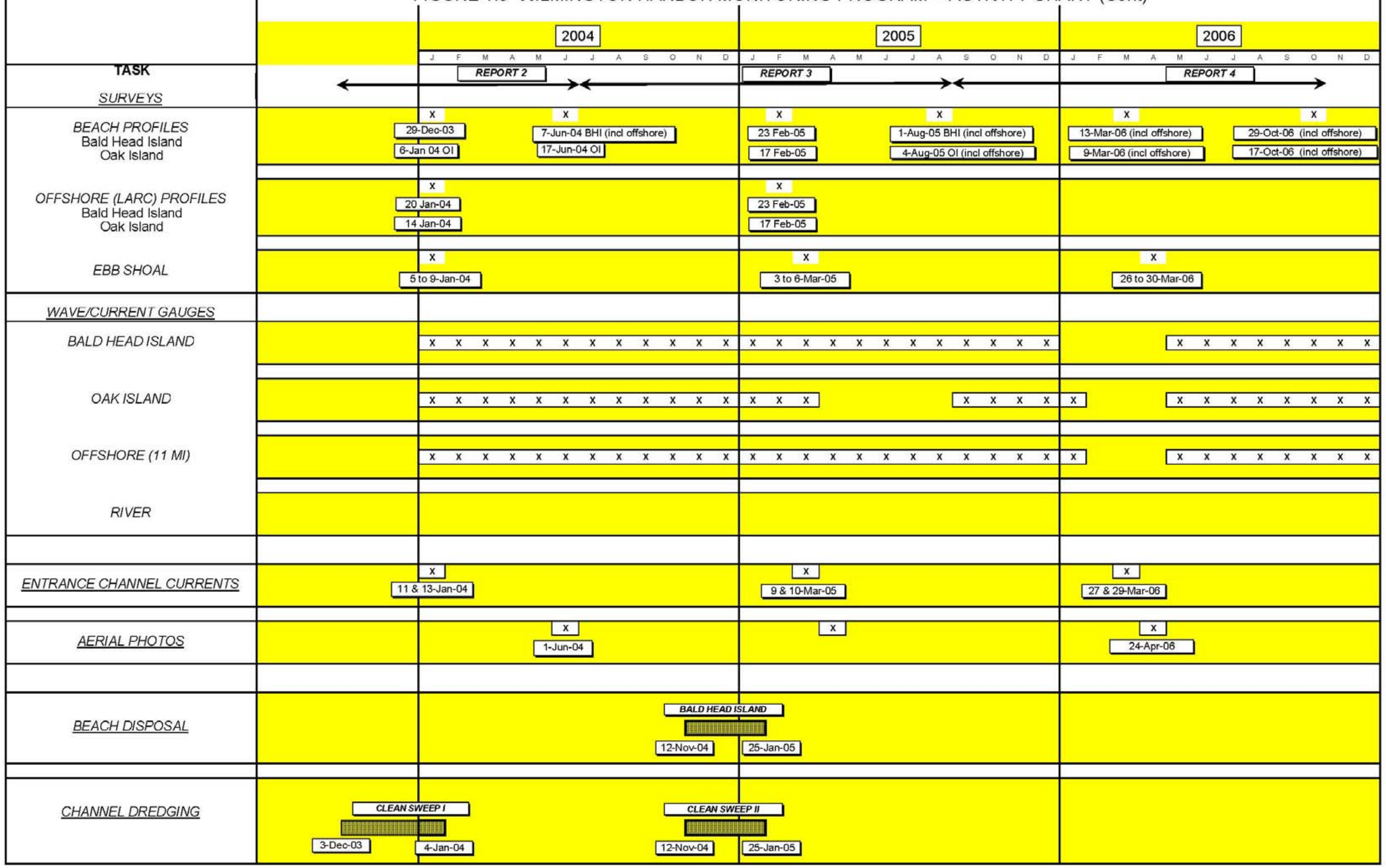


FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART (Cont)

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.

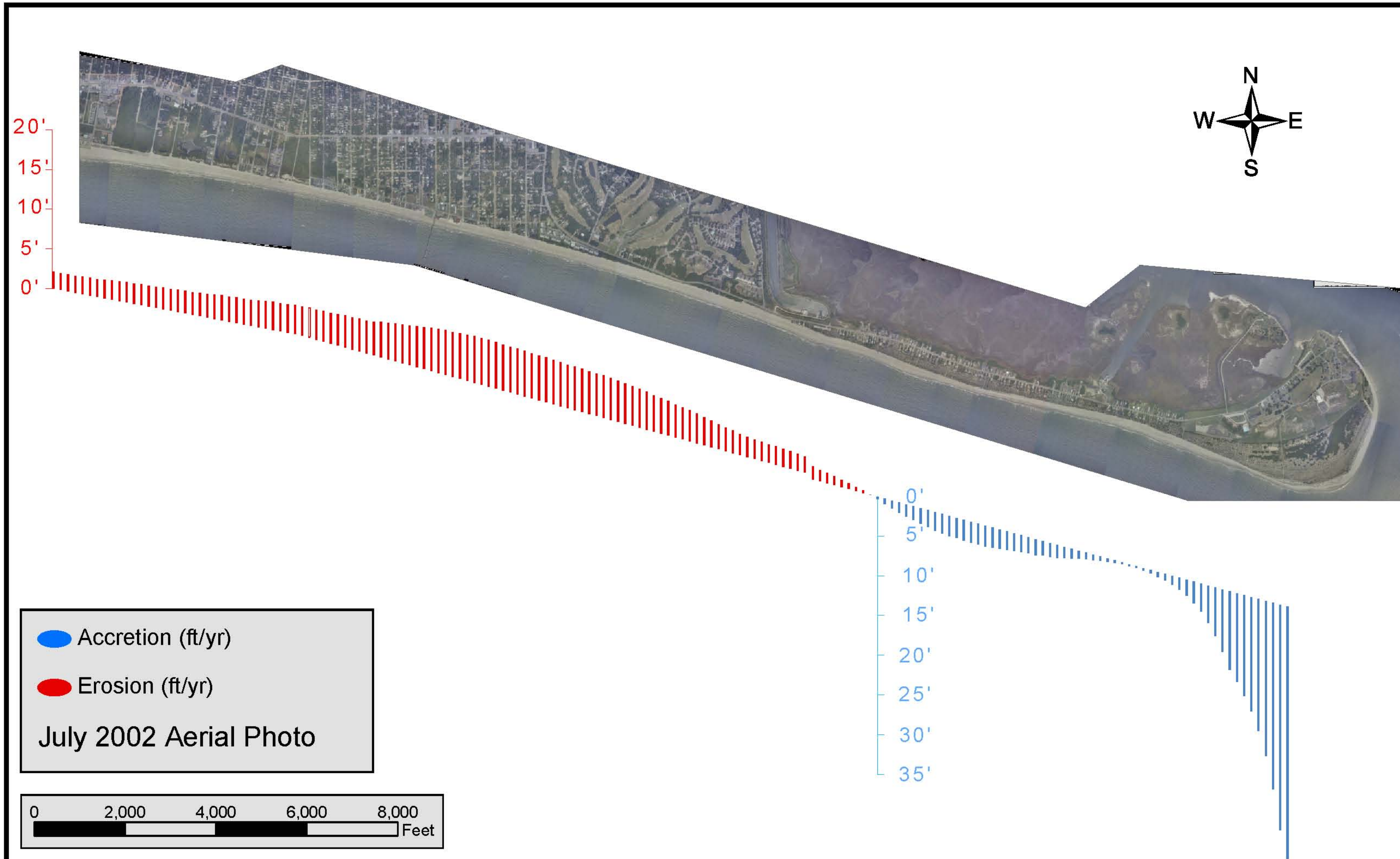


Figure 2.1 Long-Term Average Annual Shoreline Change Rates (1938-2000) Oak Island/Caswell Beach

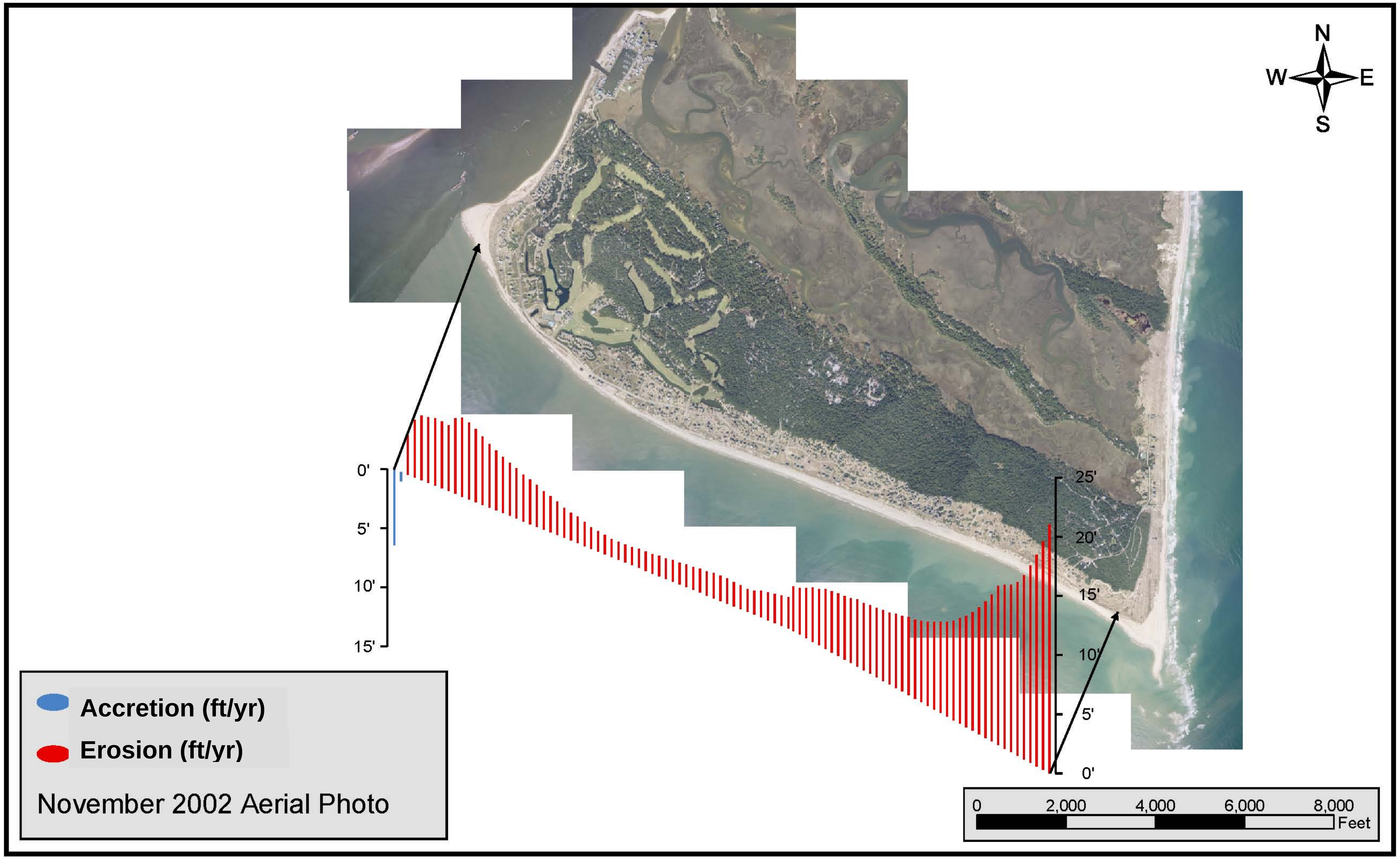


Figure 2.2 Long-Term Average Annual Shoreline Change Rates (1938-2000) Bald Head Island

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 placement of 1,217,500 cubic yards of sand 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. With the latest beach disposal, this structure is for the most part covered by the new sediment.

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 2005. Some modifications were made to the original 1996 plan. These modifications included: (1) the spacing was reduced from 450 feet to 385 feet thereby reducing the overall extent for the 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.

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.

Part 3 DATA ANALYSIS AND RESULTS THRU FOURTH 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 October 2006, the end of the fourth monitoring cycle. The data analyses generally describe changes that have occurred since those last reported in August 2005 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 March 2006 and October 2006. Figure 3.1 shows the shoreline changes relative the August 2005 position, i.e. the last referenced location in Report 3. 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 erosional over the last year. This is particularly evident along South Beach, within the area of the January 2005 beach disposal (Profiles 46 to 138). Over this 9,200 foot reach, the beach is up to 100 feet narrower, with an alongshore average loss of 71 feet. Extending east of this erosional area is a localized stretch of stable beach and then another pocket of shoreline erosion. This stable zone is likely the result of the spreading of the 2005 beach material. Proceeding eastward toward the cape, the shoreline change becomes highly accretional, reaching a maximum advance of between 300 and 400 feet.

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 200 feet with adjacent portions losing 200 feet. The greatest losses are found at Profiles 45 and 47. These lines are located immediately west of the new groin field. Photographic evidence (see Figure 2.4) along with measurements taken by the Village of Bald Head along the groins (Olsen, 2006) confirms that the western sides of the groins are on the downdrift sides of the structures. The remaining area along West Beach (Profiles 0 thru 28) has shown an overall gain, with the shoreline advancing an average of 10 feet since August 2005. This gain reflects the positive impact associated with the Bald Head Creek disposal project in January 2006. However, from Figure 3.1, it is seen that the shoreline in this area has receded between March and October 2006, following this disposal. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 9 feet and 8 feet for the March 2006 and October 2006 surveys, respectively.

Shoreline change patterns as measured over the last 6-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 August 2005, March 2006 and October 2006. This figure reveals that for the most part, the shoreline changes are positive when measuring relative to the September 2000 base survey. For example, all lines along South Beach, extending eastward from Profile 61 are largely accretional, with the October 2006 shorelines being typically 50 to 100 feet seaward of their September 2000 position. The measured shorelines in the vicinity of the cape are even more positive beginning with Profile 198. Shoreline changes in the cape region range from 100 feet to nearly 500 feet closest to the cape. The exception to this general stable pattern is a zone of erosion within the vicinity of the spit area extending into the western portion of South Beach. Specifically, this zone extends from Profile 43 thru Profile 61. Between Profiles 53 and 61, which is contained within the western end of the groin field, the shoreline retreat is on the order of 60 feet. By contrast, the eroded profiles just to the west of the groins (Profiles 43 thru 47) have shoreline recessions of 200 feet to more than 300 feet. Proceeding further to the west, the erosion turns positive over the remaining portions of the spit area, reaching a maximum advance of 245 feet. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline is shown to be generally stable, except for Profile 28, located in the lee of the spit. When considering all locations along Bald Head Island (Profiles 0 to Profile 218), the shoreline is presently on the average 55 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, however the most recent 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 6-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 October 2006, the fill shoreline was about 58 feet landward of its September 2000 position. 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 somewhat less with the second fill eroding at about 75 feet/year versus the initial fill eroding at a rate of about 115 feet/year, 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, the shoreline remained about 71 feet seaward of its September 2000 position.

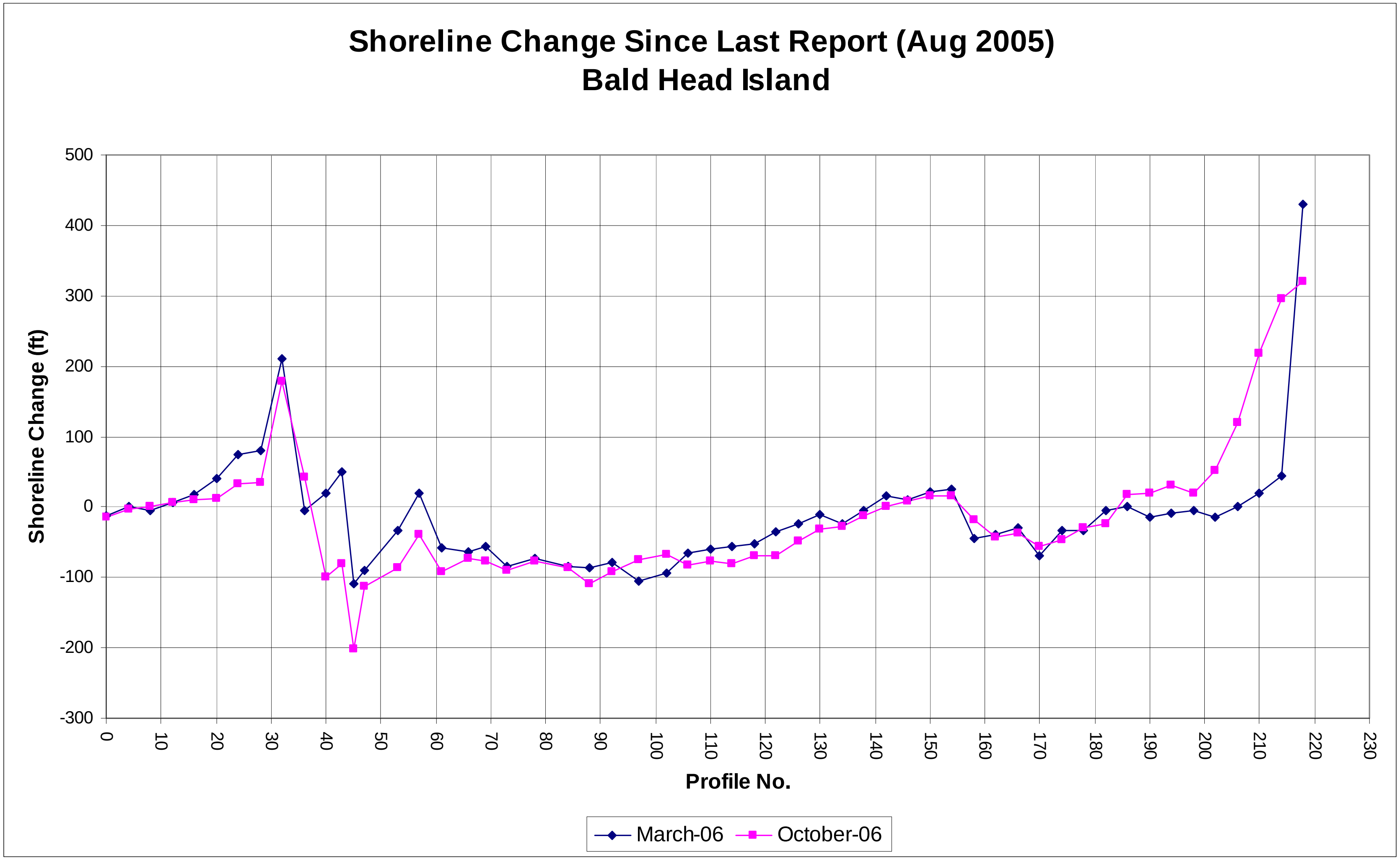


Figure 3.1 Shoreline Change Since Last Report (Aug 2005) Bald Head Island

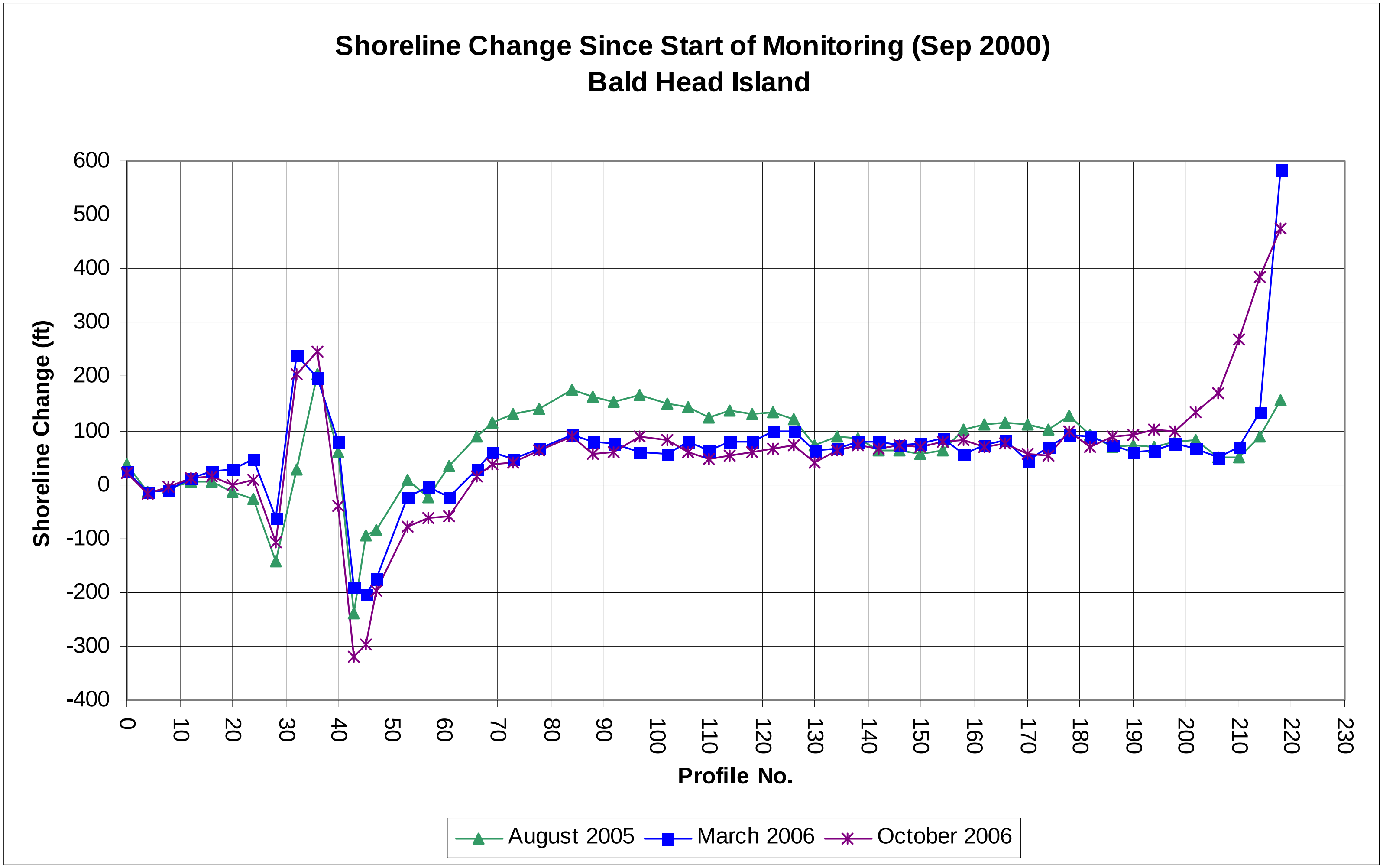


Figure 3.2 Shoreline Change Since Start of Monitoring (Sep 2000) Bald Head Island

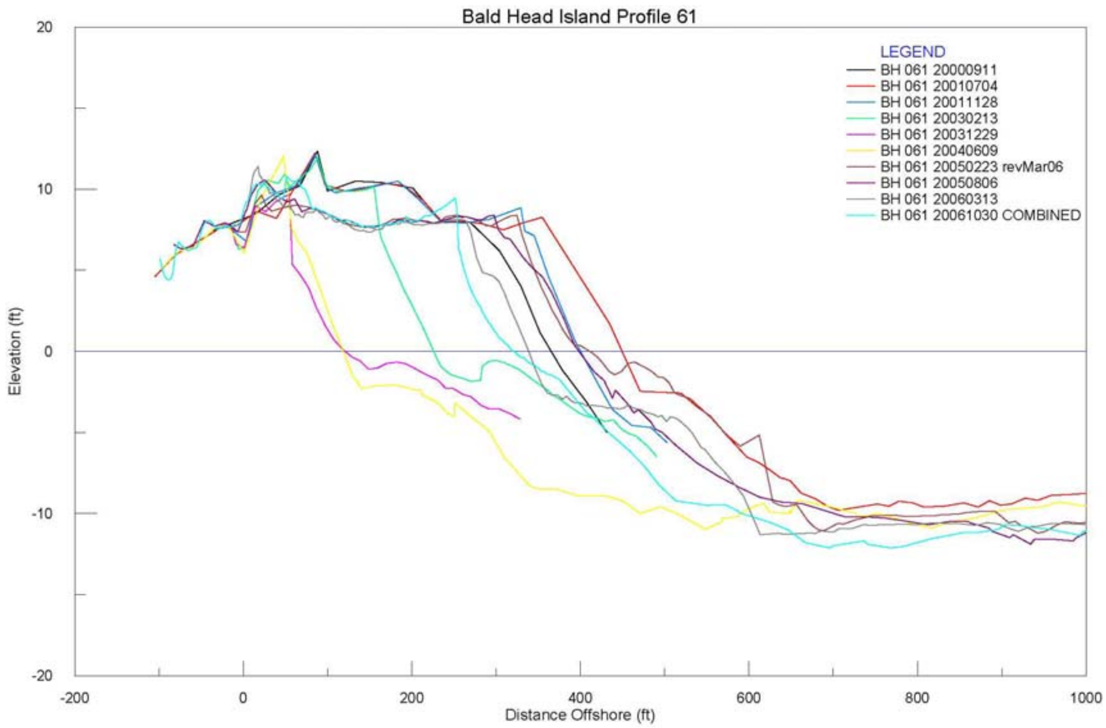


Figure 3.3 Bald Head Island Profile 061

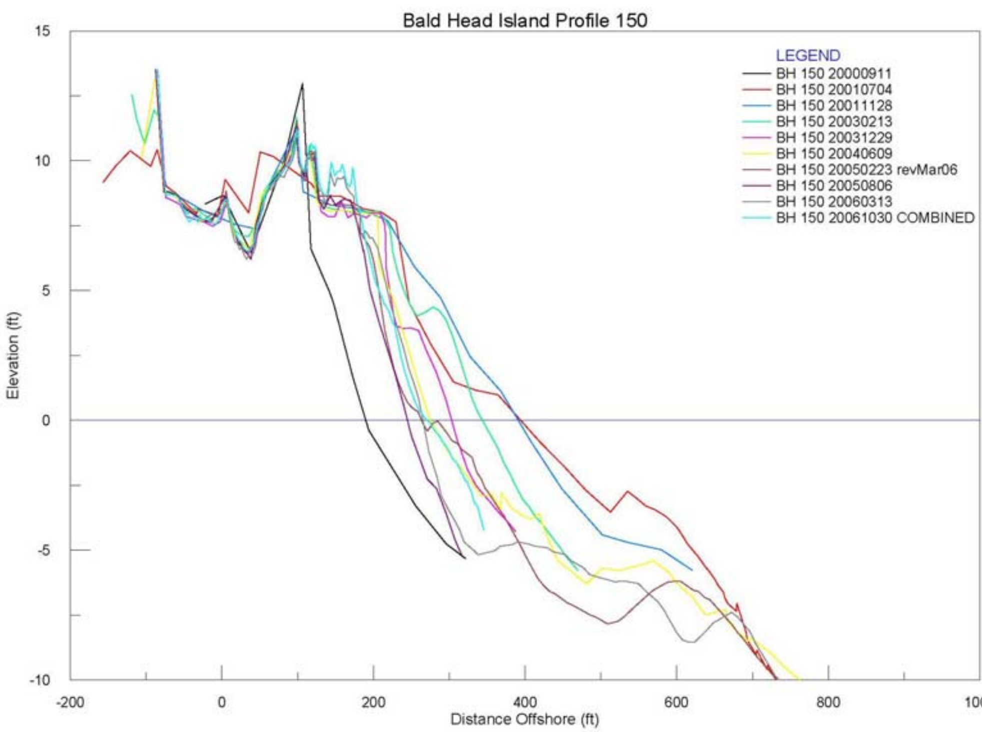


Figure 3.4 Bald Head Island 150

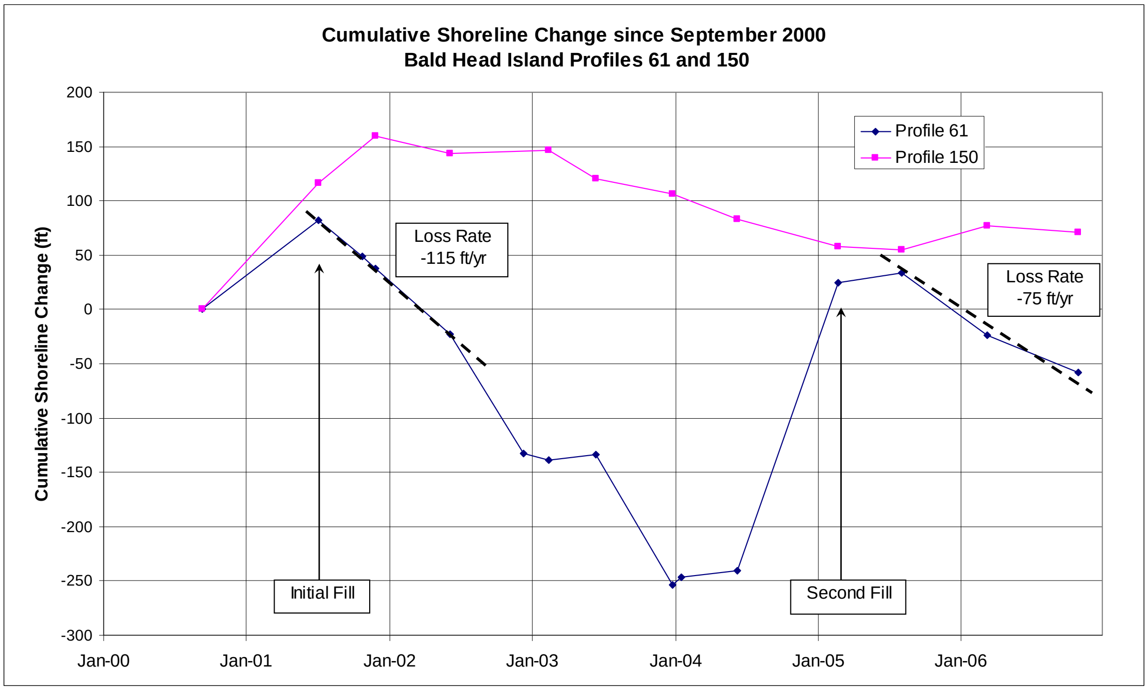


Figure 3.5 Cumulative Shoreline Changes Since September 2000

Bald Head Island Profiles 61 and 150

<u>Oak Island.</u> 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 March 2006 and October 2006 surveys. Figure 3.6 shows the shoreline changes relative the August 2005 position, i.e. the last referenced location in Report 3. 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 –60 feet to +90 feet. Overall however, positive change has been more prevalent with the alongshore average change being a gain of about 5 feet from August 2005 to October 2006. For the remaining monitoring area extending westward from Profile 50, the shoreline changes have been somewhat variable, with the overall trend being one of recession. With the March 2006 survey, most profiles were found to be eroding west of Profile 50, except for a stable zone between Profiles 90 and 120. However, with the October 2006 survey most of the profiles within the western half of the monitoring area showed substantial recovery. With this most recent survey a generalized pattern of shoreline change is present in which the first third is eroding, the middle third accreting or stable and the last third is again eroding. The area of most significant erosion is over about a mile section (between Profiles 90 and 50), where shoreline recessions range between 20 to 40 feet. The other erosion area is along the westernmost profiles, covering a distance of approximately 9,000 feet where the shoreline has receded between 10 and 20 feet over the last year. In contrast, the central third, between Profiles 90 to 215 is largely stable with shoreline changes ranging on the order of +/- 10 feet. The average change in shoreline for the reach between Profile 60 and 310 is computed to be -6 feet. When considering all profiles within the Oak Island monitoring area (Profiles 5 thru 310), the average shoreline change is a retreat of 5 feet for the present period of August 2005 to October 2006.

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 for both the March and October 2006 surveys, 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 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 of between 150 and 200 feet more than the August 2000 base condition. In considering all the profile data, the alongshore average shoreline position was 73 feet more seaward in March 2006 than it was in 2000. Likewise, the shoreline position was 94 feet more seaward in October 2006, than it was about six years earlier at the start of the project. Only one area may be of some minor 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 5 to 20 feet) compared to the adjacent reaches.

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 2/3) at the end of the period by October 2006. Plots of the cumulative shoreline changes for each of these profiles are given on Figure 3.10. In each case following the initial adjustment of the fill, the shoreline has remained generally stable over the last four years. Over this time period (between June 2002 and October 2006), the mean high water shoreline at Profile 80 has varied between about 70 and 95 seaward of its August 2000 position. Likewise, the shoreline at Profile 220 has also remained stable, aside from a dip with the March 2006 survey, ranging from a positive 156 to 125 feet, over the same period.

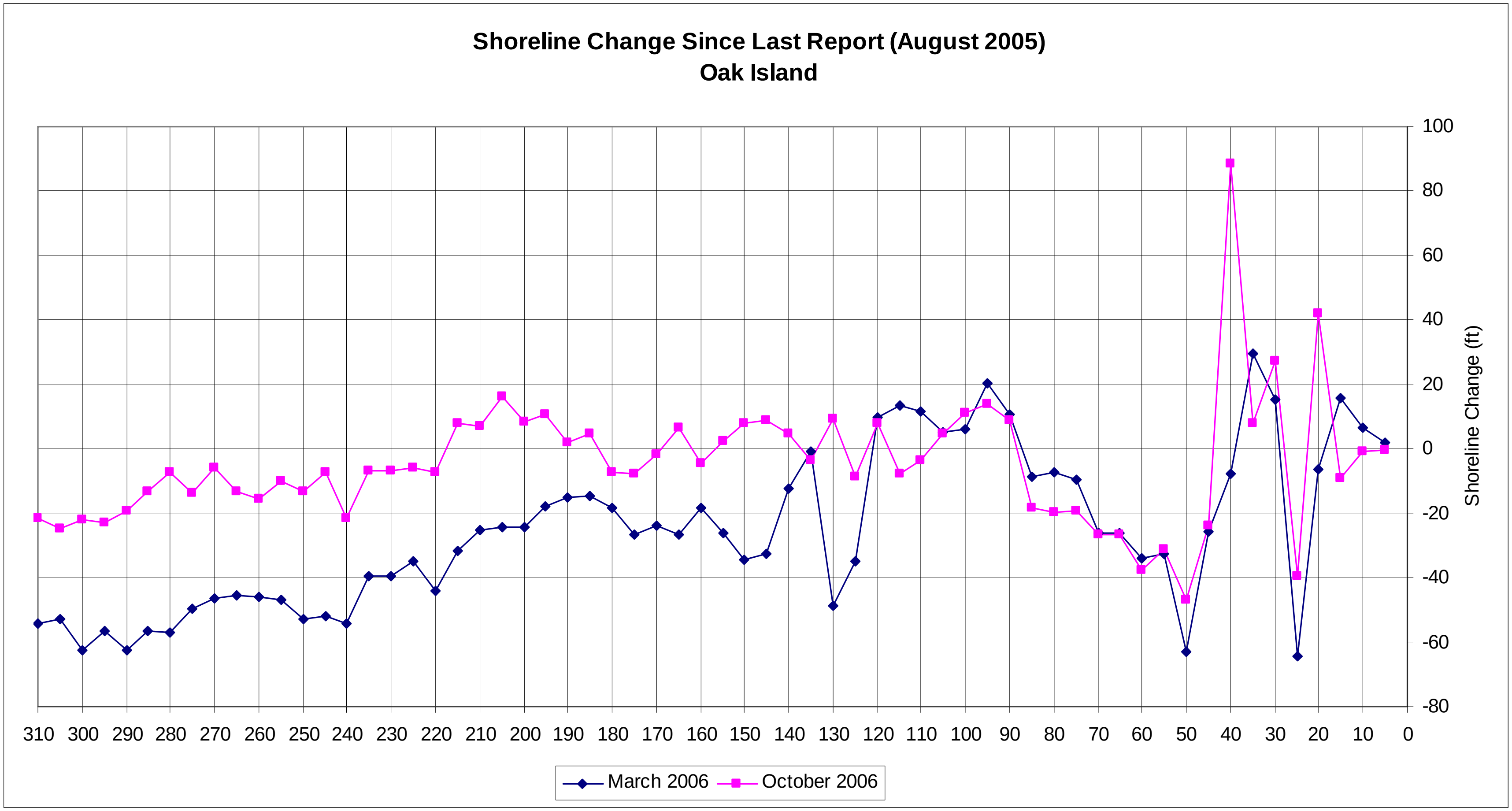


Figure 3.6 Shoreline Change Since Last Report (August 2005) Oak Island

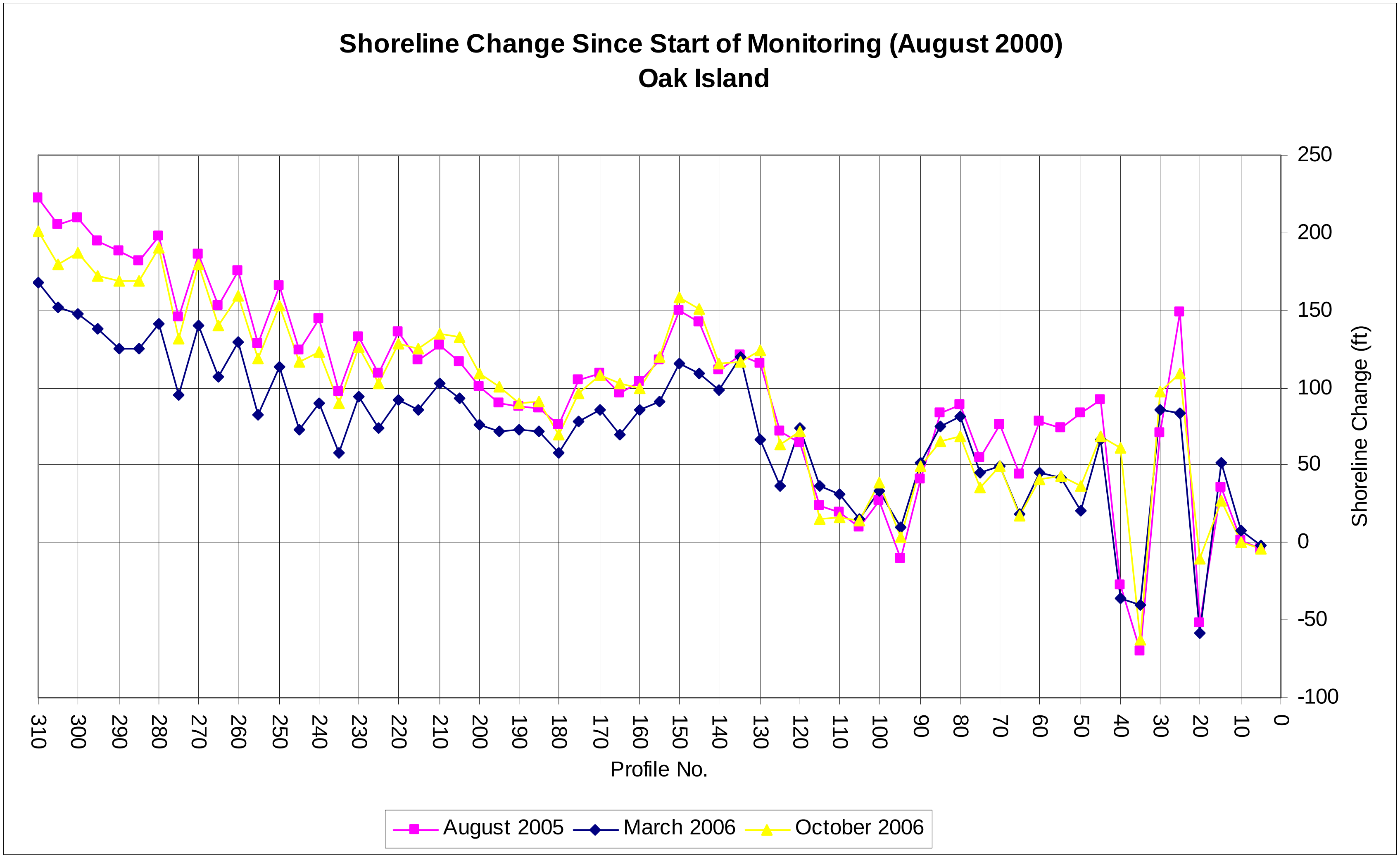


Figure 3.7 Shoreline Change Since Start of Monitoring (August 2000) - Oak Island

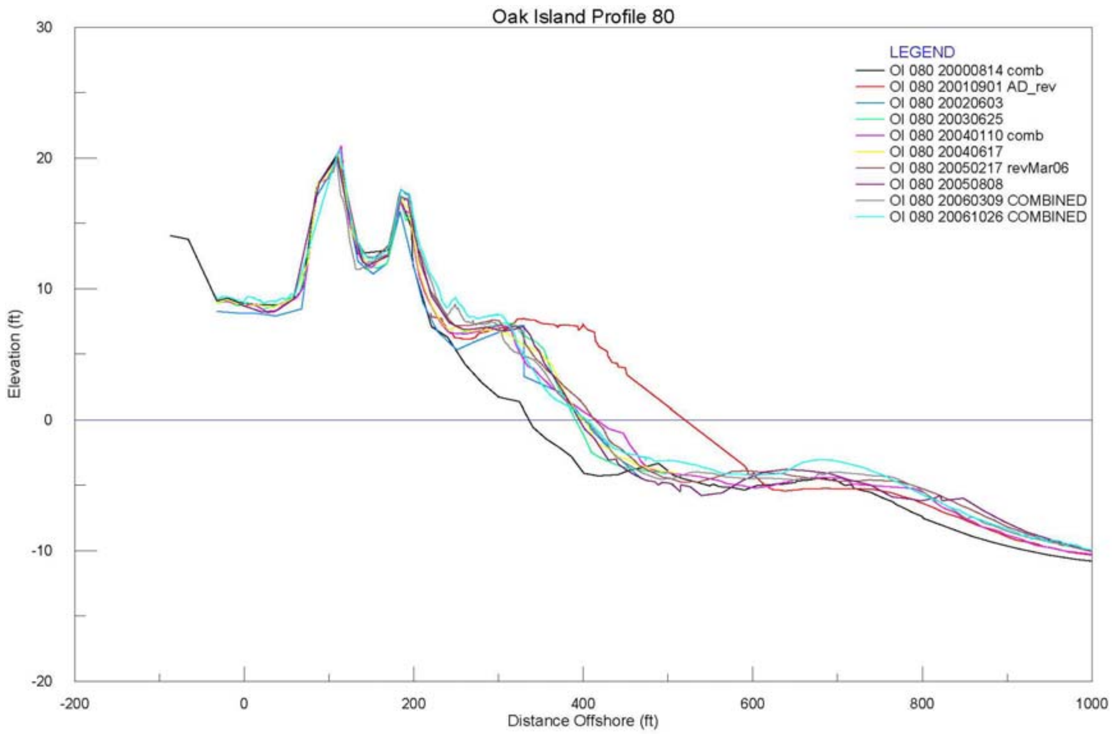


Figure 3.8 Oak Island Profile 80

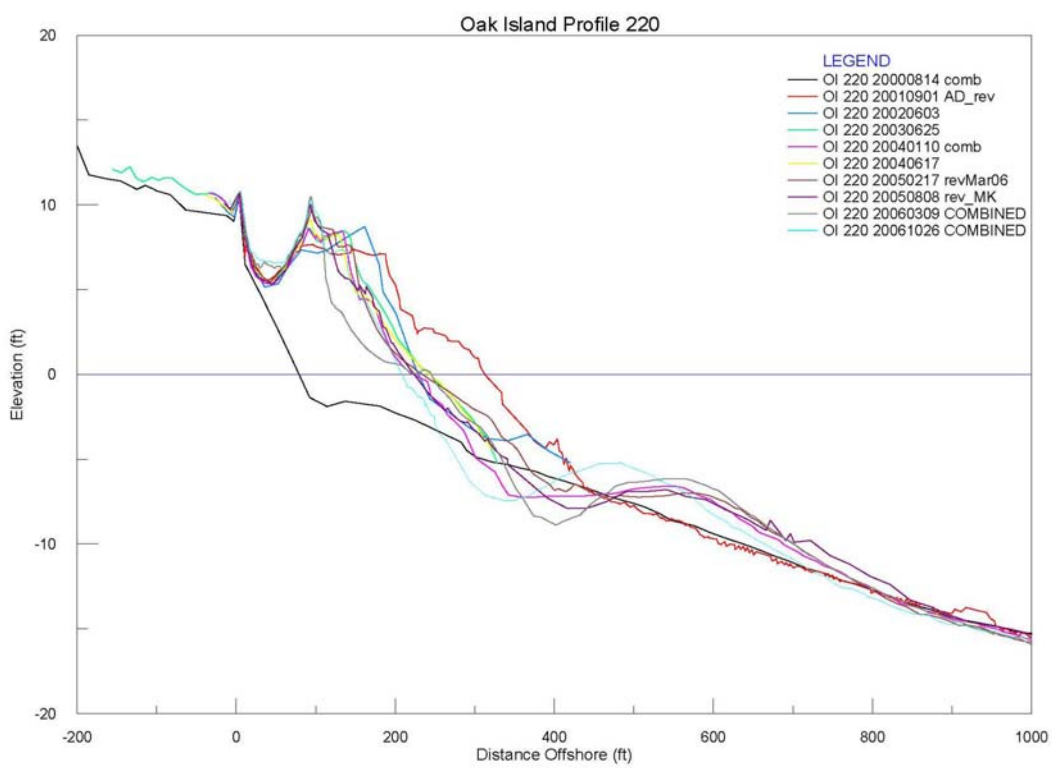


Figure 3.9 Oak Island Profile 220

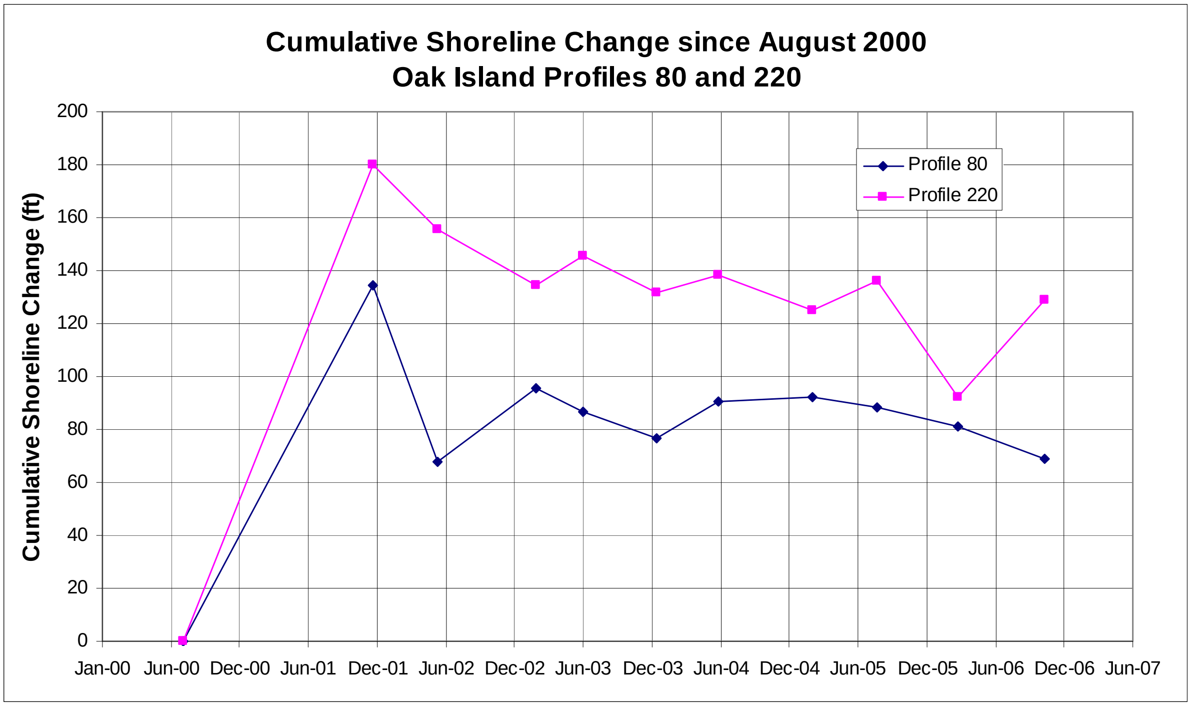


Figure 3.10 Cumulative Shoreline Change Since August 2000 Oak Island Profiles 80 and 220

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 March 2006 and October 2006 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 August 2005 onshore survey, i.e. the last referenced onshore survey in Report 3. 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 most profile locations have been erosional over the present reporting period. Most of this loss is recorded within the prior beach disposal area (Profiles 46 to 130). This erosion area is bounded by gains measured along West Beach and near the Cape on the east. Within the limits of the fill about 226,600 cubic yards of material have been lost over the 14 month period between August 2005 and October 2006. For west beach (Profiles 0-28), there is a trend of increased volume gain proceeding towards the spit, reflecting the positive affect of the January 2006 Bald Head Creek disposal. Collectively, the West Beach onshore volume changes amount to gain of about 38,700 cubic yards by the end of the current period. In considering the total onshore volume changes for all profiles over the current monitoring cycle, approximately 154,000 cubic yards were lost between August 2005 and October 2006.

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 the exception of one area, all profile locations have experienced net gains in the onshore over the last six years. The area that experienced onshore losses since the beginning of the project are along western end of South Beach and adjoining spit area. The greatest losses are found near Profile 47, which is just downdrift of the reconstructed groins. Within this erosion zone, approximately 130,000 cubic yards have been lost since 2000. This area of South Beach has been one of chronic erosion, as documented in the past monitoring reports. Prior to the 2005 fill, the eastern portion of south beach was experiencing volume losses which were increasing in magnitude and progressing eastward from the spit area. The recent fill reversed this trend over much of south beach, but some erosion still remains when compared to the initial monitoring survey.

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 subsequent January 2005 fill, this trend is reversed showing total onshore volumes of around 500,000 cubic yards with the February and August 2005 surveys. With the two most recent surveys, an erosion trend is once again noted; however, there has not been significant overall change between March and October 2006.

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 3 (August 2005); 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 losses along most of South Beach, except for the eastern area near the cape. All other areas, specifically the spit and West Beach, show volumetric gains over the last year. Along South Beach, the losses are found to extend between Profile 53 through 178, with the losses being approximately twice as large along the western half than along the eastern half of this 12,500-foot reach. The total loss within this reach amounts to 684,000 cubic yards. These losses are nearly balanced by the gains recorded near the cape (+ 205,000 cubic yards), the spit (+84,000 cubic yards) and West Beach (+133,000 cubic yards). The net change over the entire monitoring area amounts to a loss of 262,000 cubic yards over the period from August 2005 to October 2006.

When comparing the changes in total profile volume back to the initiation of the project given in Figure 3.15, three areas of loss are present along Bald Head Island. One is located at the extreme eastern end of south beach, where some small losses have occurred near the cape. The other two, which are of greater concern, are along the western portions of South Beach. The larger of the two extends from Profile 45 to 69, covering approximately 2,400 feet, and has been the site of chronic erosion in the past. Following the January 2005 beach disposal, this area has progressively worsened as indicated by the successive survey dates shown on the figure. The latter erosion area along South Beach is developing further to the east between Profile 88 and 114 within and just beyond the eastern portion of the groin field. 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 635,000 cubic yard gain in March 2006 and 524,000 cubic yard gain by October 2006.

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 six years. The western portion of South Beach has gone through cycles of accretion and erosion controlled by the 2001 and 2005 beach disposals, which covered this area. Presently this area is into the second erosion cycle with recovery expected with the next beach fill (Feb-Mar 2007). 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 524,000 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.

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

Location	Reach	Jul-01	Oct-01	Dec-02	Jan-04	Jun-04	Feb-05	Aug-05	Mar-06	Oct-06
Profile 0 - 24	**West Beach**	0	3,048	29,564	11,618	1,854	14,646	34,221	113,468	166,722
Profile 32 - 45	**Spit**	145,509	54,159	-31,546	250,297	303,507	88,229	152,494	270,403	236,708
Profile 53 - 106	**South Beach-West Portion**	285,449	251,137	-91,457	-462,106	-406,485	192,205	187,910	-206,714	-274,592
Profile 114 - 194	**South Beach-East Portion**	1,166,870	1,065,270	887,997	671,808	787,235	624,679	632,903	504,521	457,576
Profile 198 - 218	**Near Cape**	-538,703	-29,536	-113,416	-169,758	-85,524	-238,965	-220,972	-46,246	-62,096
Total		**1,059,125**	**1,344,078**	**681,143**	**301,859**	**600,586**	**680,794**	**786,557**	**635,431**	**524,318**

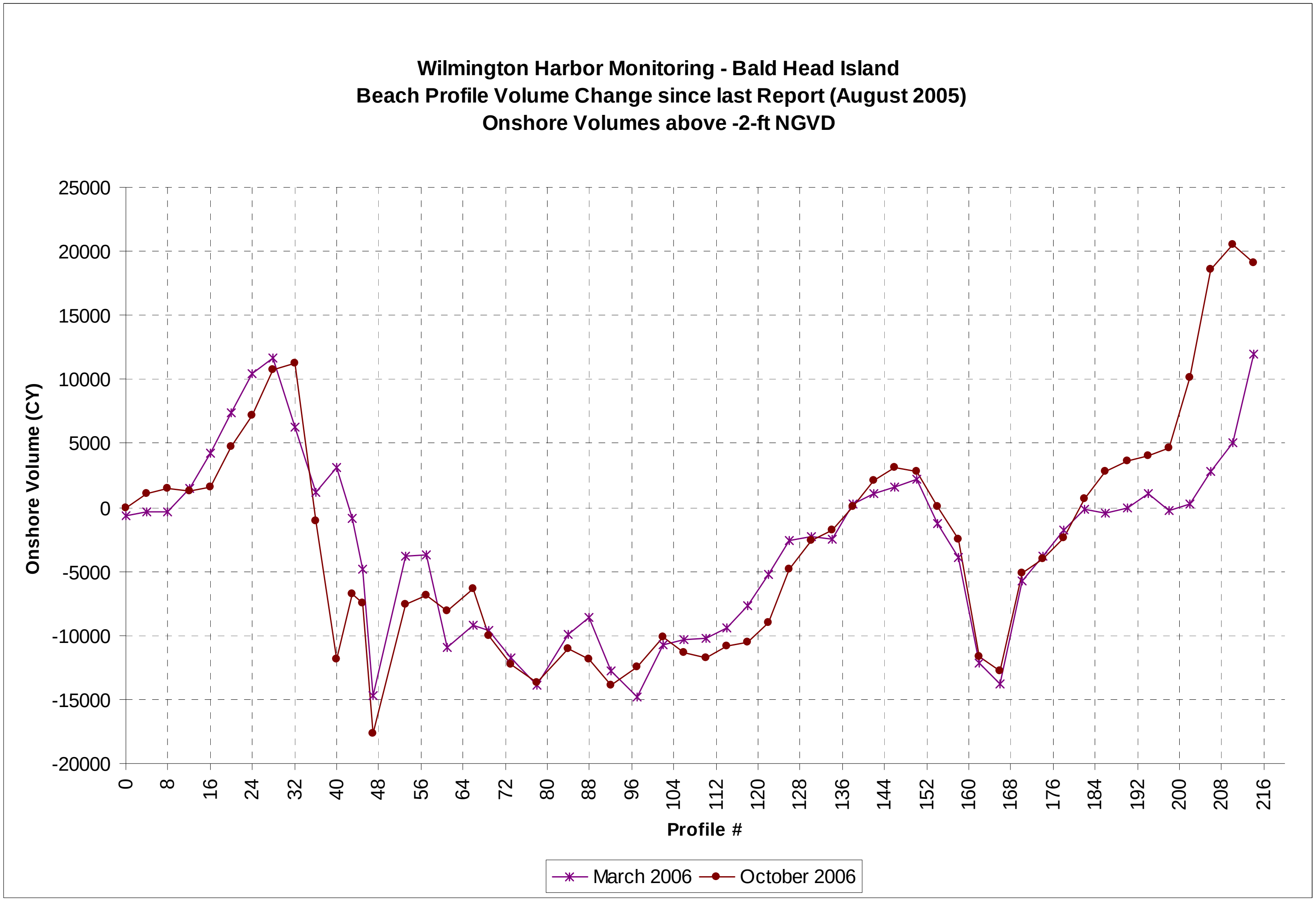


Figure 3.11 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change Since last Report (August 2005) Onshore Volumes above –2 ft NGVD

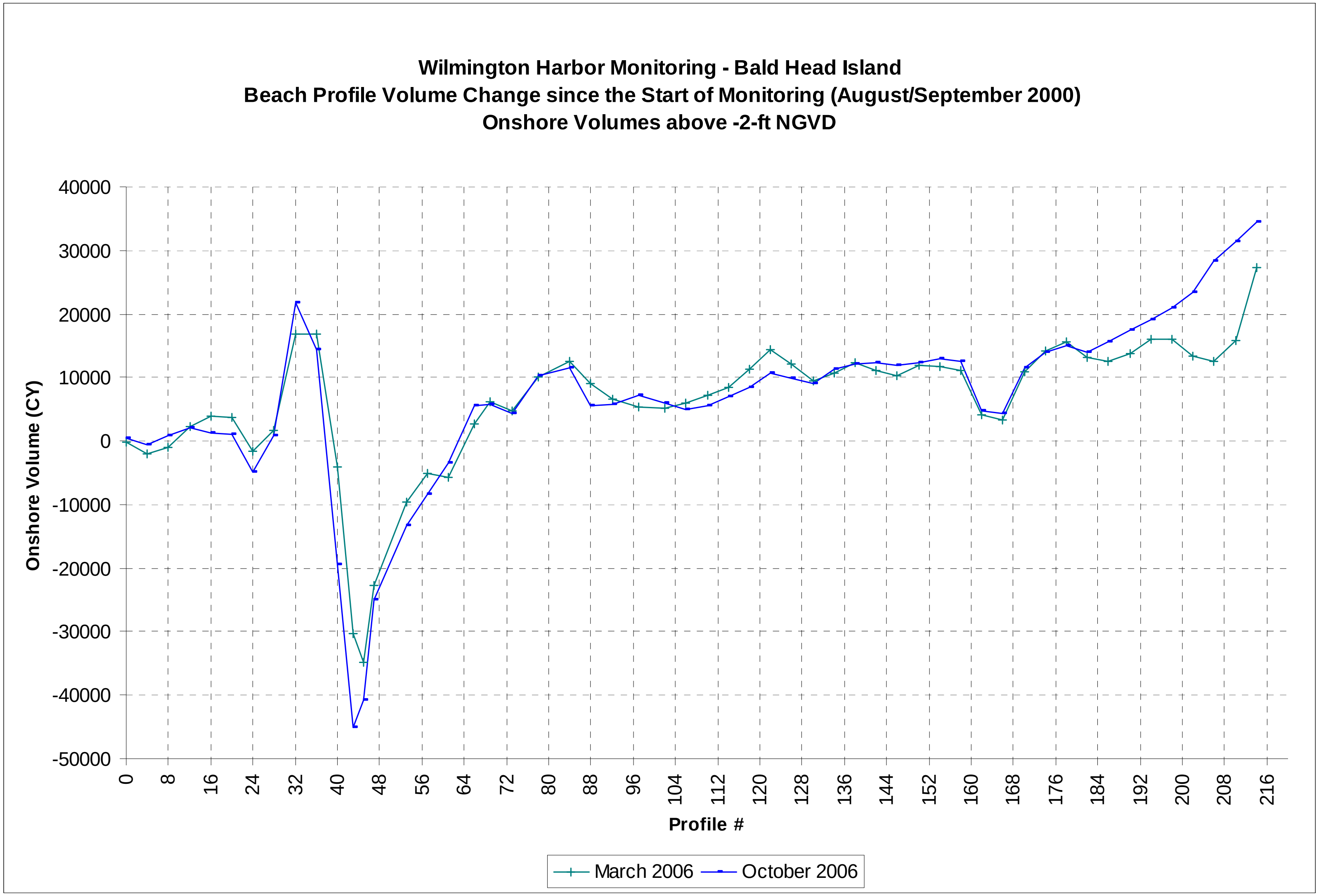


Figure 3.12 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change since Start of Monitoring (August/September 2000) Onshore Volumes above –2 ft NGVD

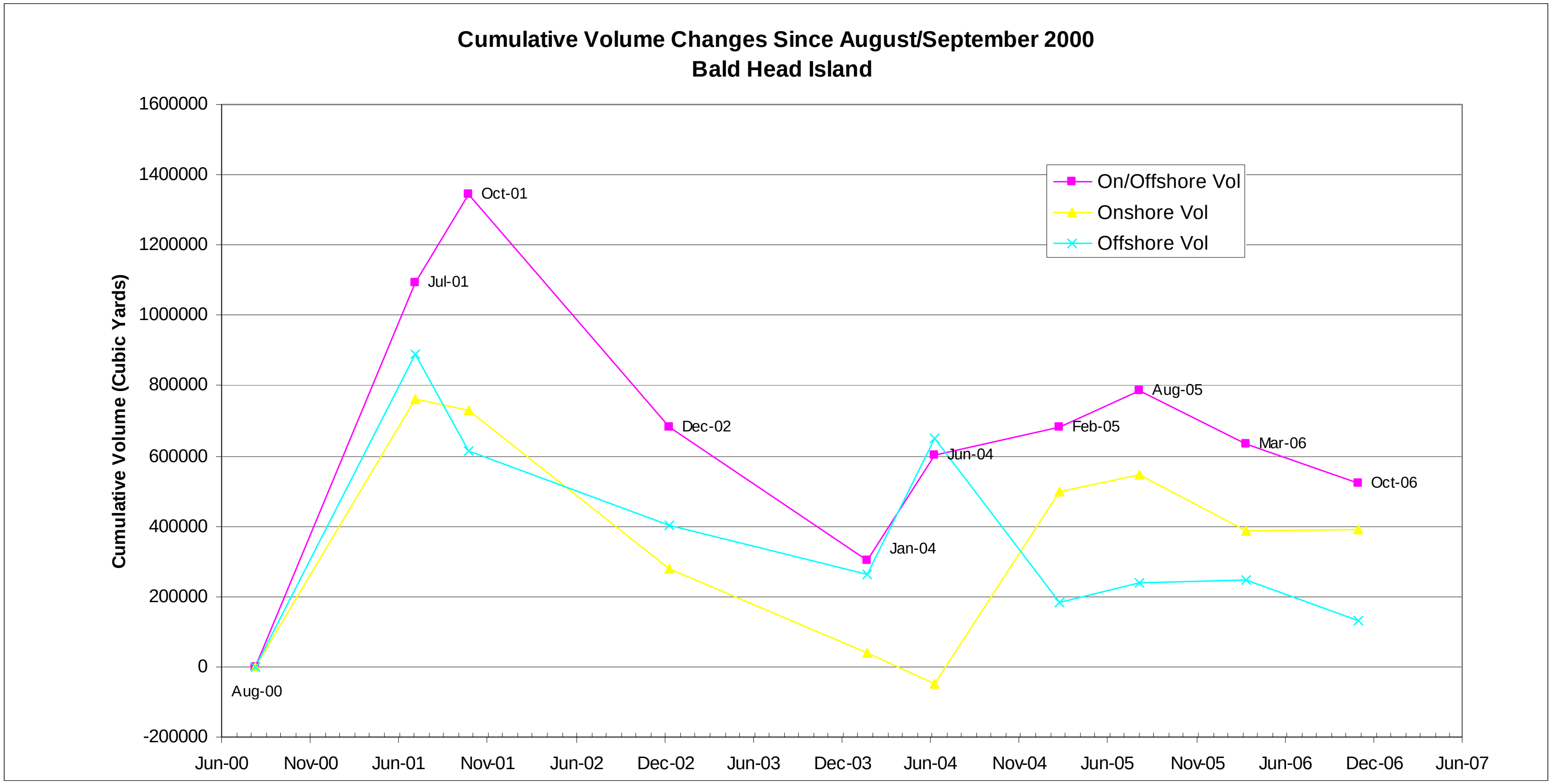


Figure 3.13 Cumulative Volume Changes Since August/September 2000 for Bald Head Island

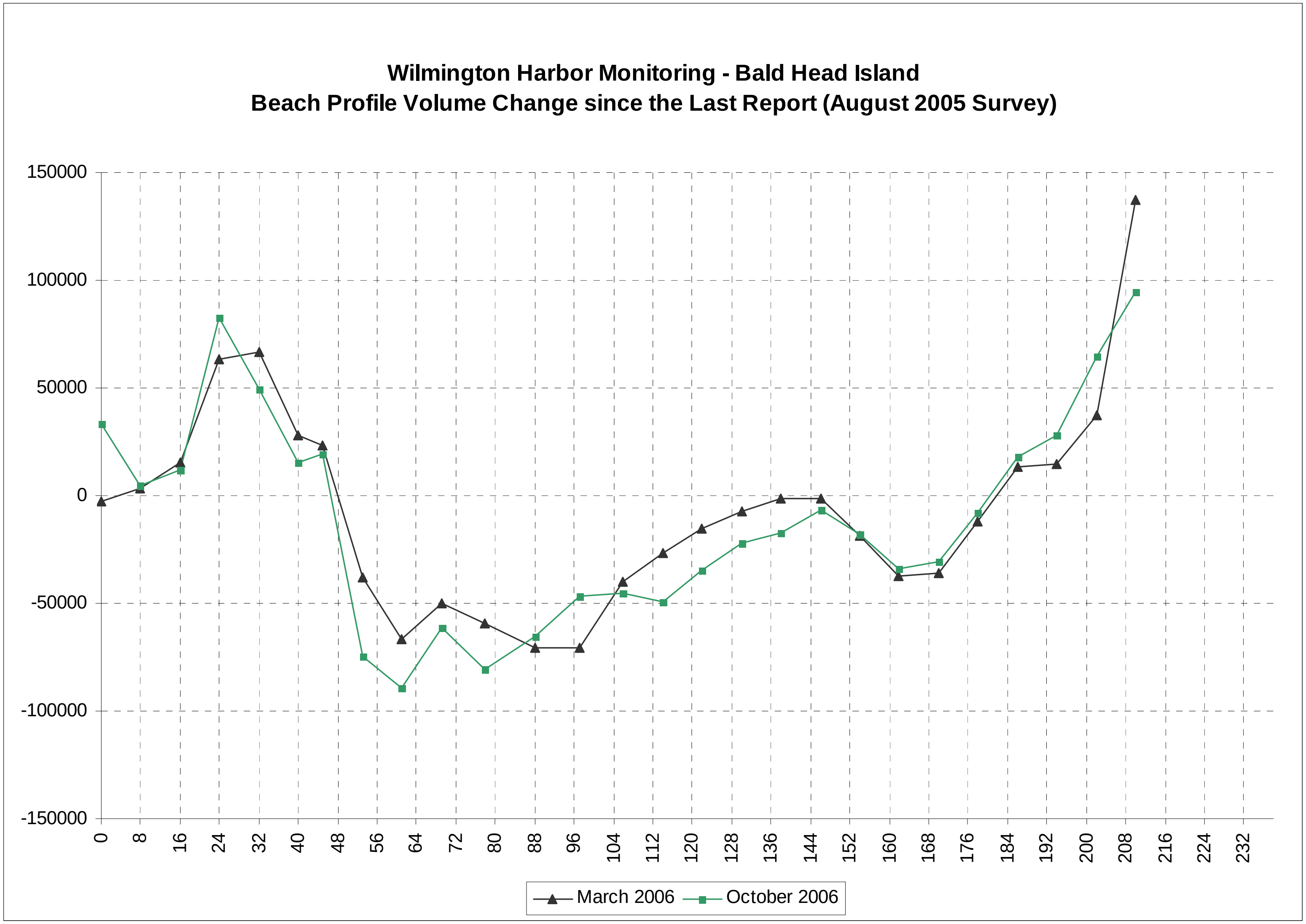


Figure 3.14 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since Last Report (August 2005 Survey)

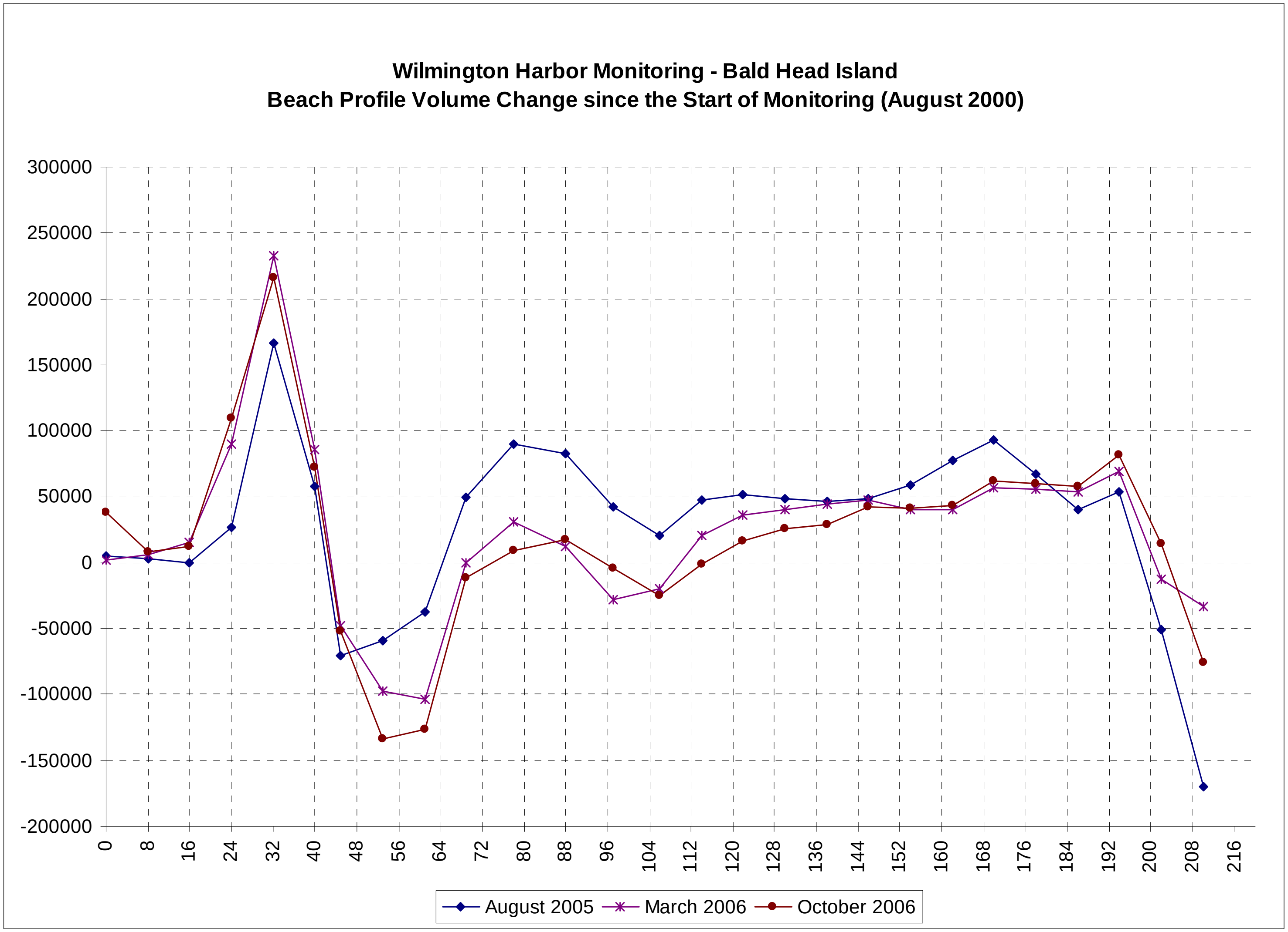


Figure 3.15 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since the Start of Monitoring (August 2000)

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 August 2005 survey, i.e. the last referenced onshore survey in Report 3. 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 minor changes, which are an order of magnitude smaller than those measured along Bald Head Island, reflect the overall stability of the beaches of Oak Island. Specially, profile volume changes range from +8,000 cubic yards to –6,000 cubic yards for each of the recent surveys. The March 2006 survey shows in general a sediment loss, particularly within the western half of the survey area. With the October 2006 survey, an overall recovery is noted, with most of the lines showing gains by the end of the period. In this respect, the onshore volumetric quantities summed over the 6-mile monitoring region show losses of 42,600 cubic yards in March 2006 and a gain of 101,200 cubic yards measured with the October 2006 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 also includes the two prior survey dates, namely February 2005 and August 2005 to further demonstrate the relatively small change that has occurred over the last year. The figure shows that all areas have gained sediment within the onshore except for a small zone at the tip of the island. These data reflect the positive impact of the beach fill placed in 2001 and the continued stability of the fill over the past five years. Further, as of October 2006, only a single line (profiles 35) near the tip of Fort Caswell has experienced 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 six 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. Between June 2003 and October 2006 the onshore beach volume has essentially fluctuated around the one million cubic yard mark. As of the October 2006 survey, the remaining total onshore volume is 1,039,000 cubic yards, which is about a 12% increase over the onshore volume measured in December 2001 following the beach disposal.

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 3 (August 2005); 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 general response of the total profile volume changes along Oak Island have been losses in the western half and gains overall the eastern half of the monitoring area. Note that the data for the first four lines (profiles 5 thru 20) for the October 2006 survey are excluded from the analysis since these lines were found to have been surveyed off of the proper offshore alignment. The positive changes along the eastern portion of the island are generally in the 10,000 to 20,000 cubic yard range, extending westward to about Profile 120. Proceeding westward from this point, losses are most prevalent throughout the remaining survey area. These losses typically range from 20,000 to 30,000 cubic yards. When summing the volume changes over all the profiles (excluding profiles 5 thru 20), a net loss results for the island in the amount of 196,300 cubic yards, since the last report.

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. With the current survey, all reported volume changes are positive with the exception of several isolated profiles which show small losses. These isolated loss areas are found around the eastern tip of the island (east of Profile 50) and at Profile 180.

In summing the volume changes over the entire monitoring area, a total of 1,203,000 cubic yards are found to remain in place when comparing the October 2006 survey to the August 2000 base condition. Referring back to the graph in Figure 3.18, it is seen that this current volume is actually greater than the quantity of material measured in November 2001 following the fill placement (1,143,000 cubic yards), reflecting the overall stability of the beach. Closer inspection of the graph reveals that a substantial gain was measured after the fill reaching a peak of 1,572,000 cubic yards in February 2005. Since that time there has been a fairly uniform volumetric loss to the present condition with 1,203,000 cubic yards remaining in place. Even though the recent trend shows a loss, the volume remaining is still substantial with respect to the pre-project condition and the beach remains in a healthy state. Ongoing monitoring will confirm whether the volumetric loss trend continues and if this action will become an issue of concern with respect to the overall stability of the beach.

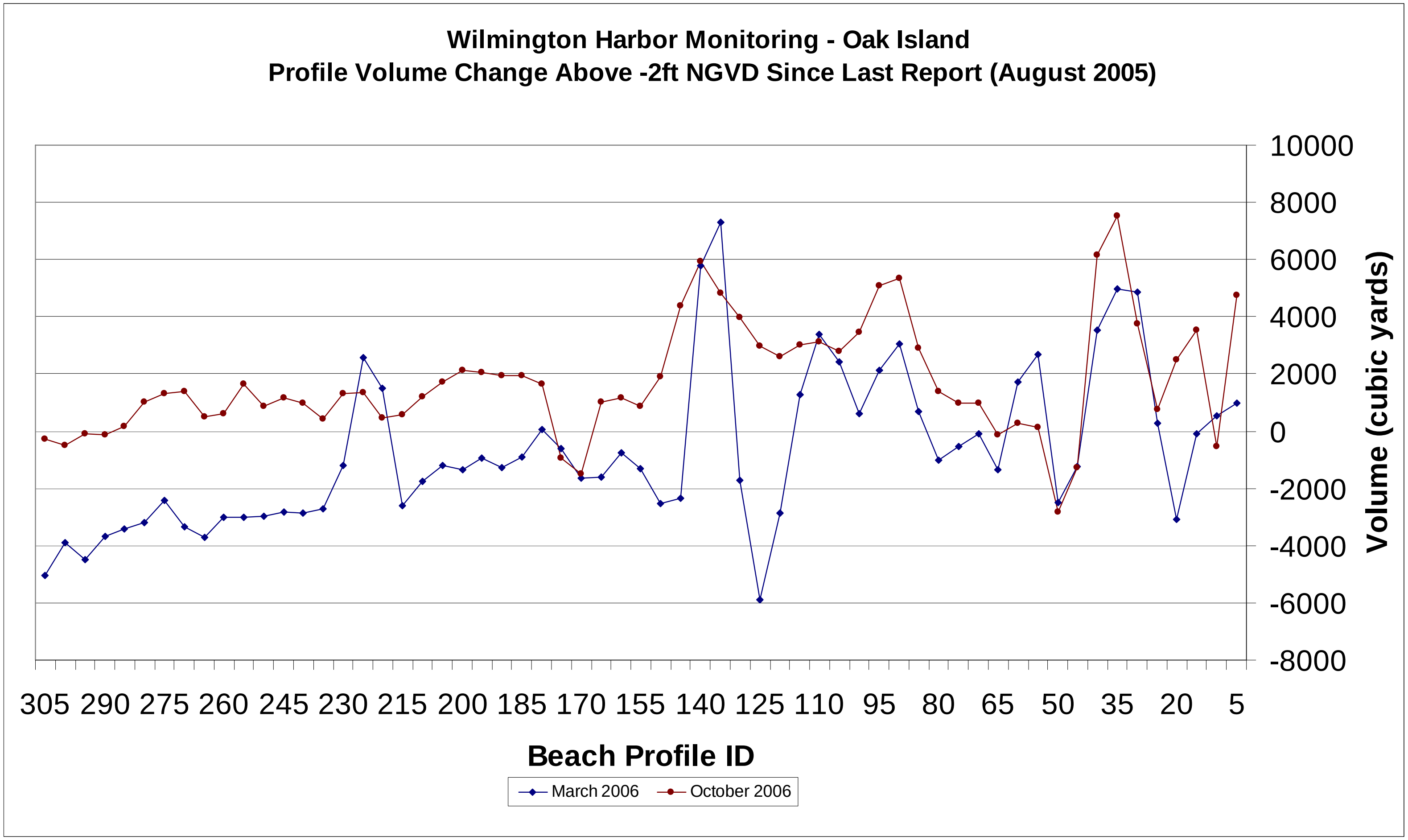


Figure 3.16 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change Since Last Report (August 2005) Onshore Volumes above – 2 ft NGVD

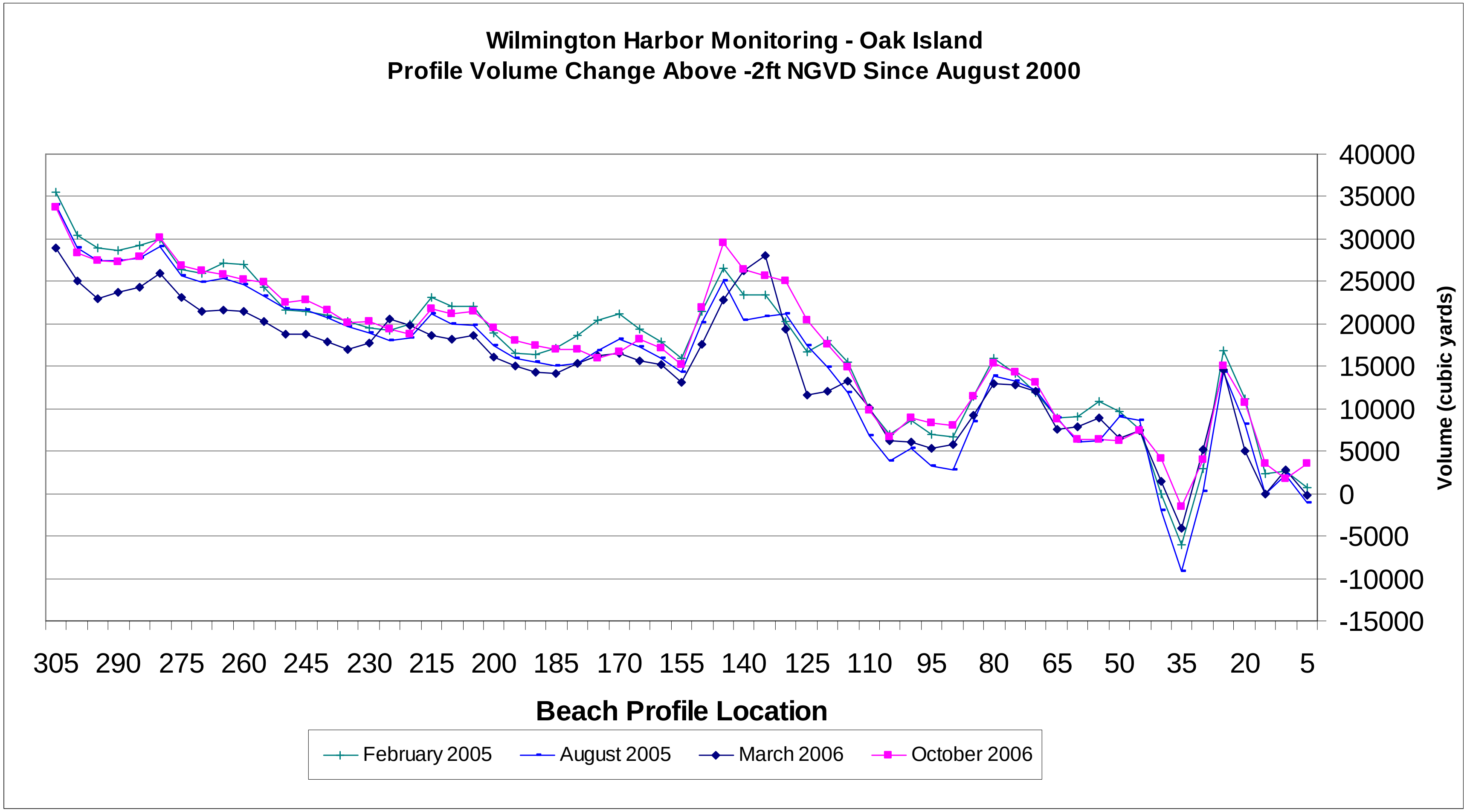


Figure 3.17 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change since Start of Monitoring (August 2000) Onshore Volumes above –2 ft NGVD

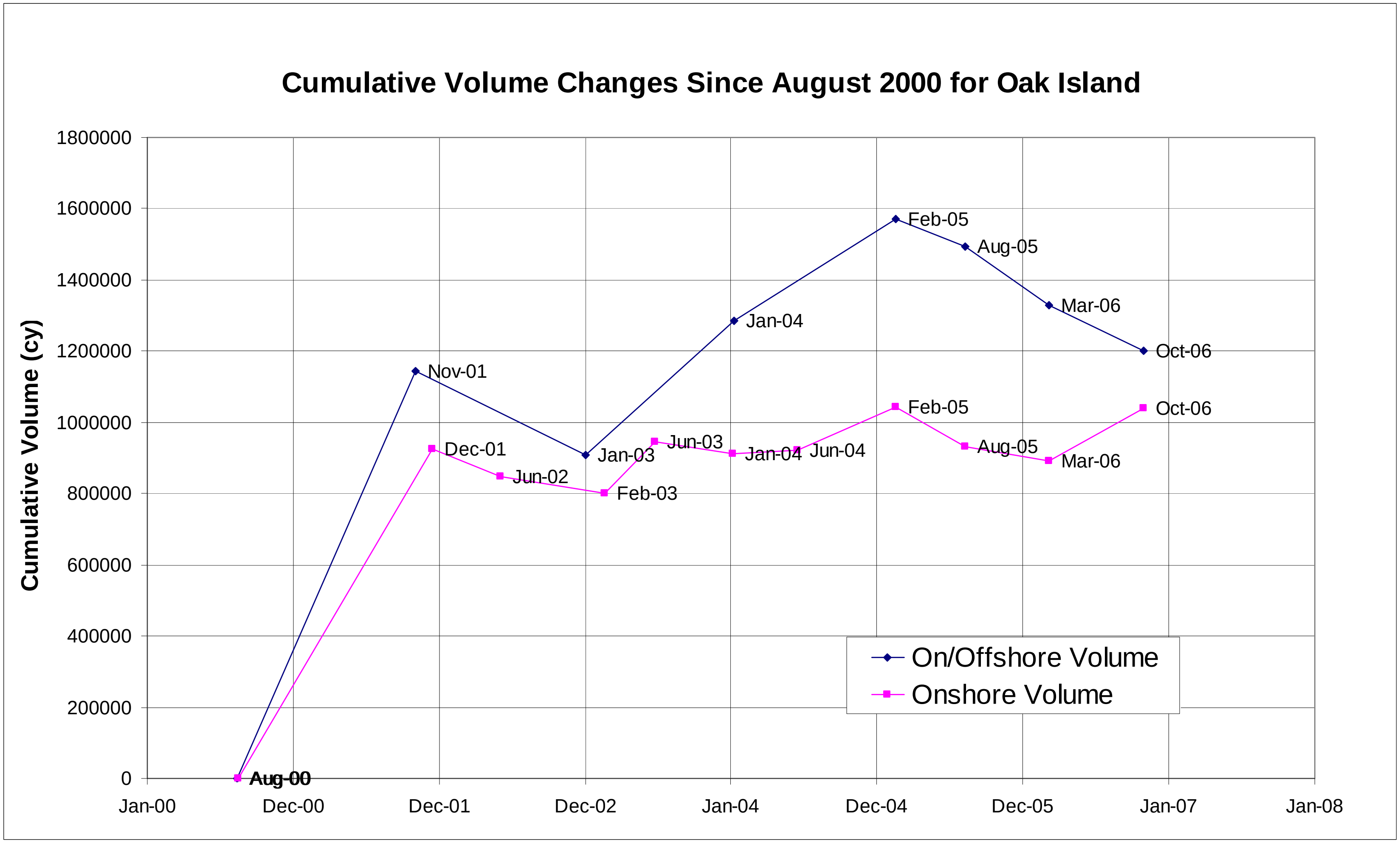


Figure 3.18 Cumulative Volume Changes Since August 2000 for Oak Island

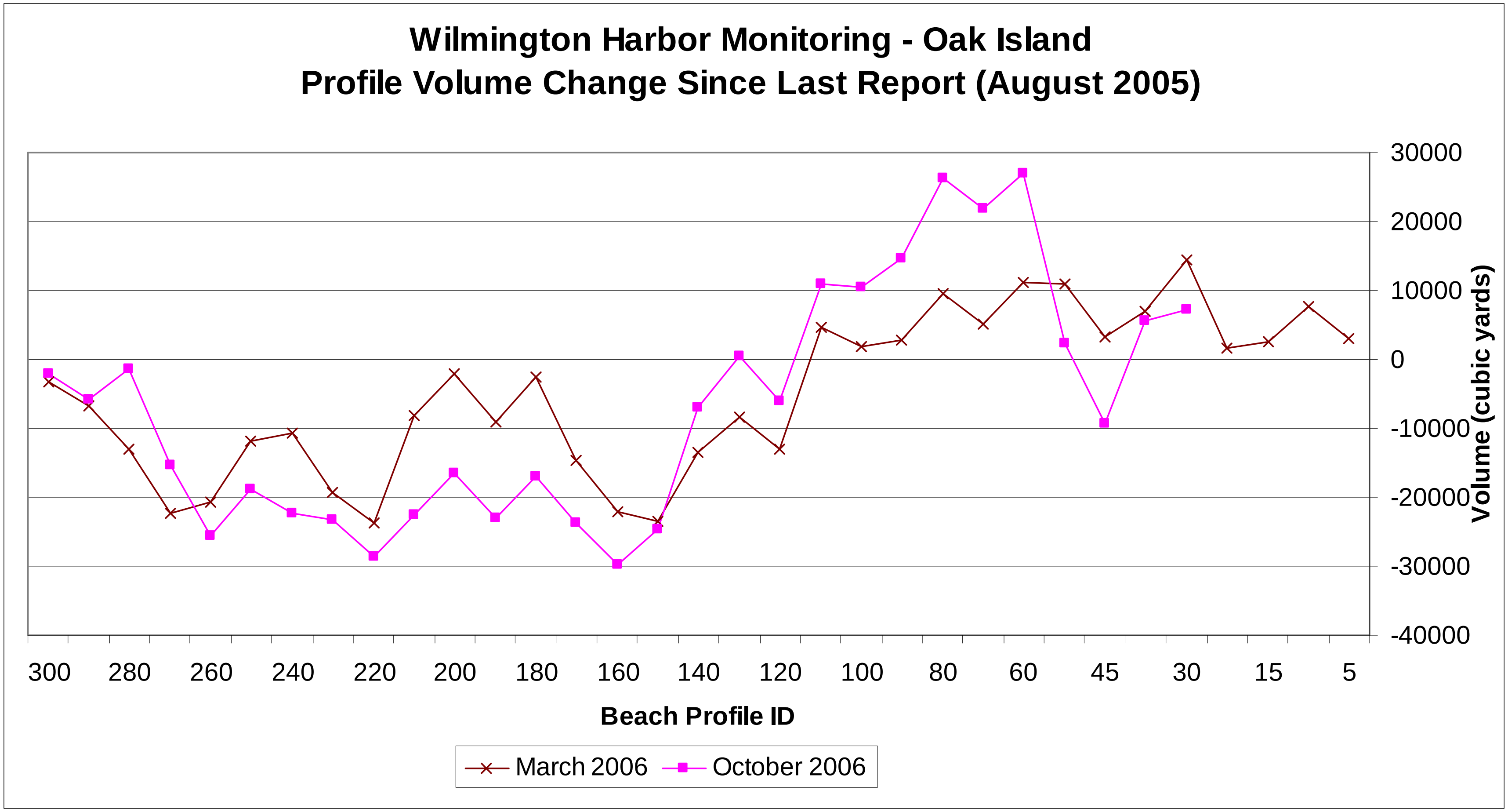


Figure 3.19 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since Last Report (August 2005)

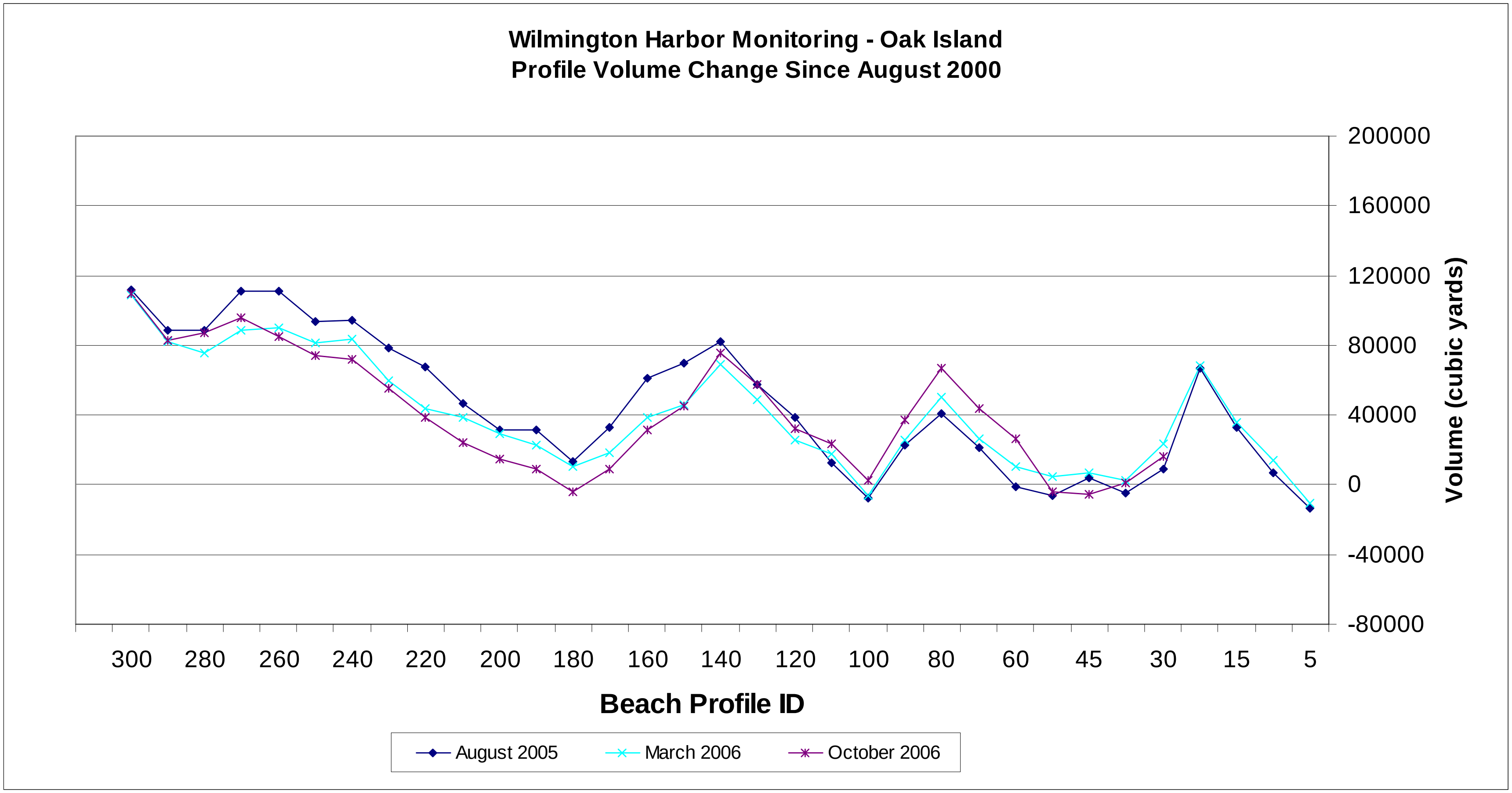


Figure 3.20 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since the Start of Monitoring (August 2000)

Ebb and Nearshore Shoal Analysis

Bathymetric Data Collection. Detailed bathymetry of the Cape Fear River ebb tidal delta and channels were collected on six occasions specifically; August-September 2000, December 2001-January 2002, January 2003, January 2004, March 2005, and April 2006. 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 and McNinch 2004, (Part 2 of USACE 2005a), and McNinch 2006 (Part 2 of USACE 2006a).

Bathymetric data from the USACE LARC cross-shore surveys along the offshore profile lines were combined with those of the interferometric 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 April 2006. From the latest bathymetric survey the gross patterns of in the seafloor morphology are clearly evident in the figure. This survey shows the newly realigned channel as well as the remnants of the existing channel. 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 six bathymetric surveys taken in 2000, 2002, 2003, 2004, 2005, and 2006. These comparisons show a persistence of the three linear shoals, a deepening of the flood margin channel on the Oak Island side and the obvious deepening of the main shipping channel, the latter deepening being attributed to the dredging of the new channel.

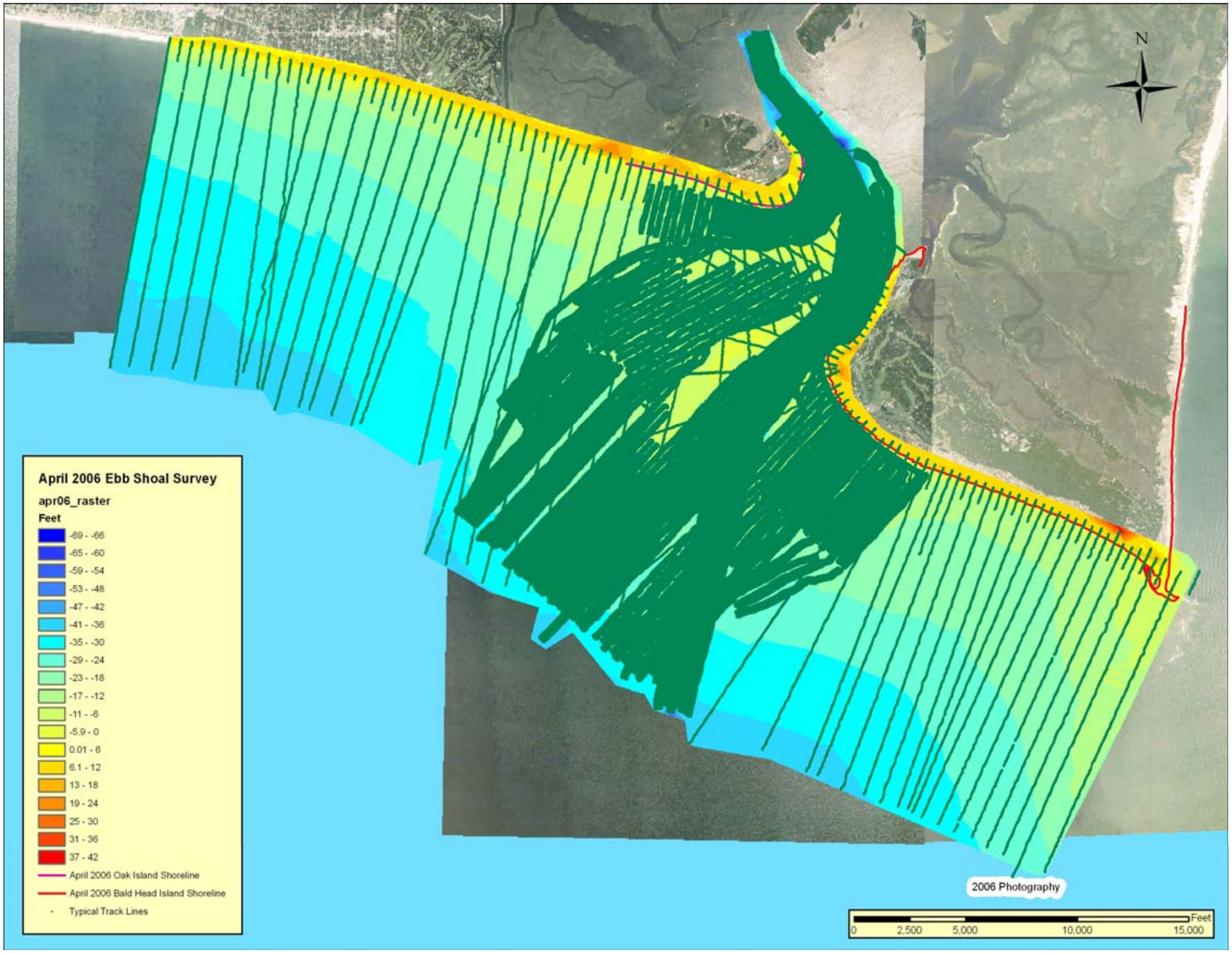


Figure 3.21 Survey Track Lines Collected by the LARC5 and the Interferometric System during the 2006 Survey

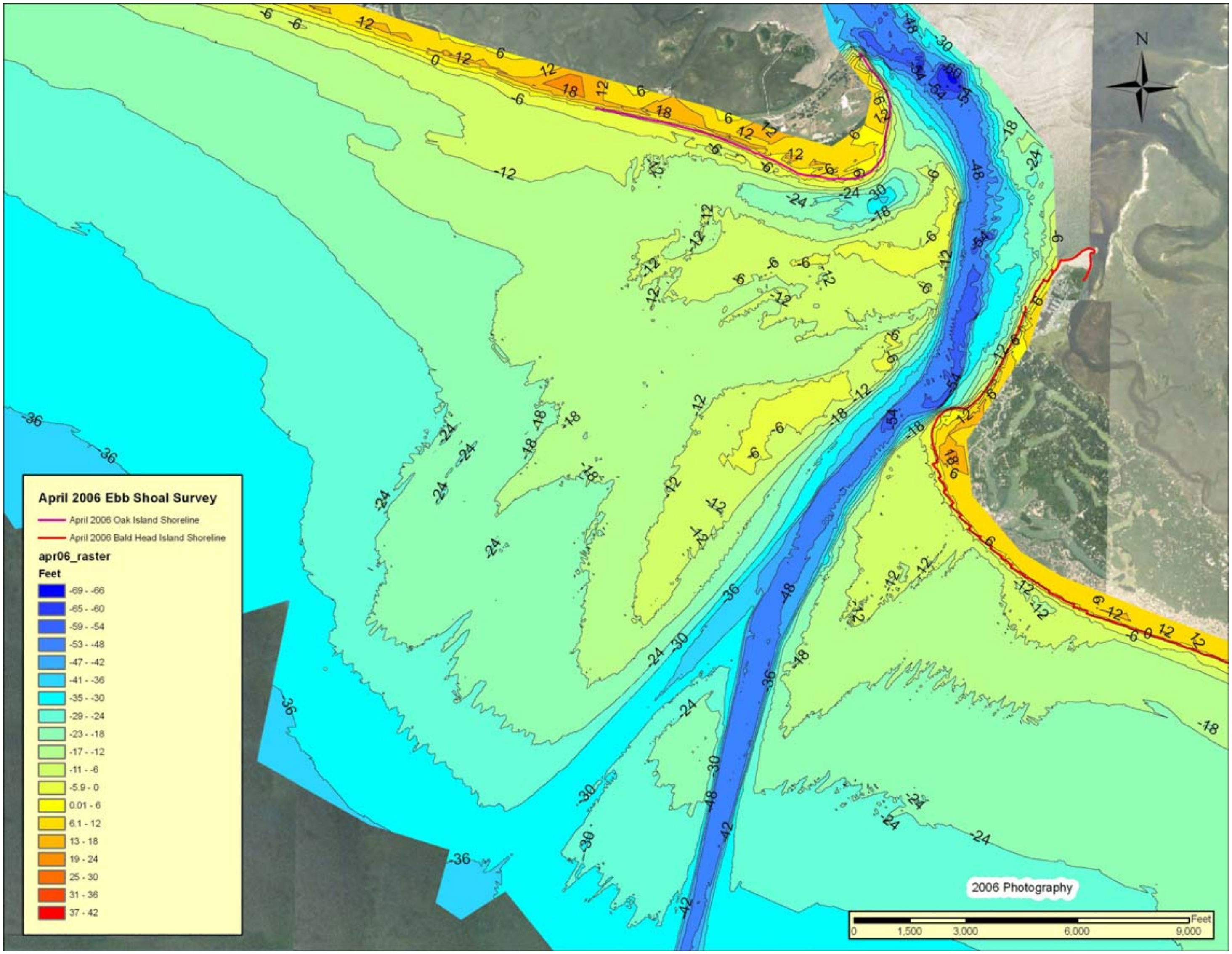


Figure 3.22 April 2006 Ebb Tide Delta Survey

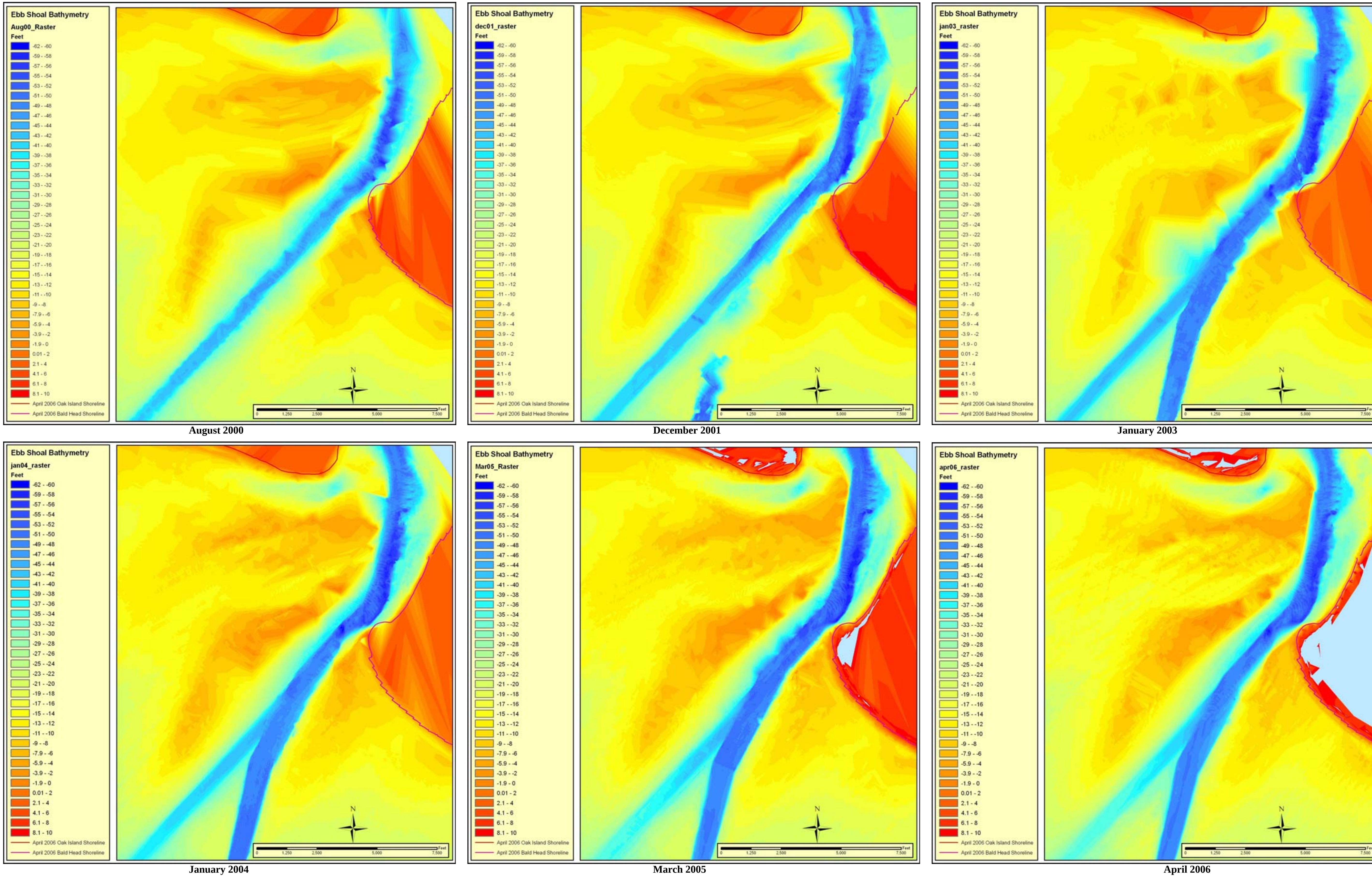


Figure 3.23 Inlet Bathymetry Surveys

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 April 2006 with the prior survey of March 2005 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 March 2005 and April 2006. 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 March 2005. Jay Bird shoals, Reach 2 of the new navigation channel, and the nearshore of west Bald Head Island experienced moderate erosion on the order of three to four feet. The "v" shaped area between the new and old channel alignment as well as the old channel experienced infilling on the order of four to six 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 an area just west of the Smith Island channel. While these shoaling changes were as much as 31 feet, they were relatively small in area and did not restrict navigation as discussed in Part 4 of this report. The only areas where significant deepening occurred were just off the tip of the spit on Bald Head Island and an area just south of this. Surveys show these areas experienced a depth increase of up to seven feet off the tip of the spit and up to twelve feet south of the spit.

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, April 2006, 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 five areas over these two time periods: (1) the Bald Head Island spit growth to the north, (2) the "v" shaped area between the old and new channel alignments continues to accrete, and (3) the old navigation channel shows accretion in both time periods. While 997,400 cubic yards of material has been placed within the old channel to date, no material was placed during the current monitoring period. (4) Jay Bird shoals shows a trend of erosion over both time periods, possibly contributing to the infilling of the old navigation channel. (5) The inner portion of Jay Bird shoal, east of the Oak Island spit, has accreted over the long and short term. The most recent comparison shows the inner shoal growing east toward the navigation channel.

In addition to the trends mentioned above, there are three other areas of change noticed when examining Figure 3.26, as follows: (1) The major excavation of the realigned new channel is very prominent in the figure. This cut was through the relatively shallow portion of the ebb tidal delta to project depths of 44 feet. (2) The channel deepening is evident as well from the outer bar channel through the inlet between the two islands. (3)

The flood margin channel just off the tip of Oak Island where parts of the channel have scoured out as much as 8 feet while the northernmost part of the flood channel has shoaled.

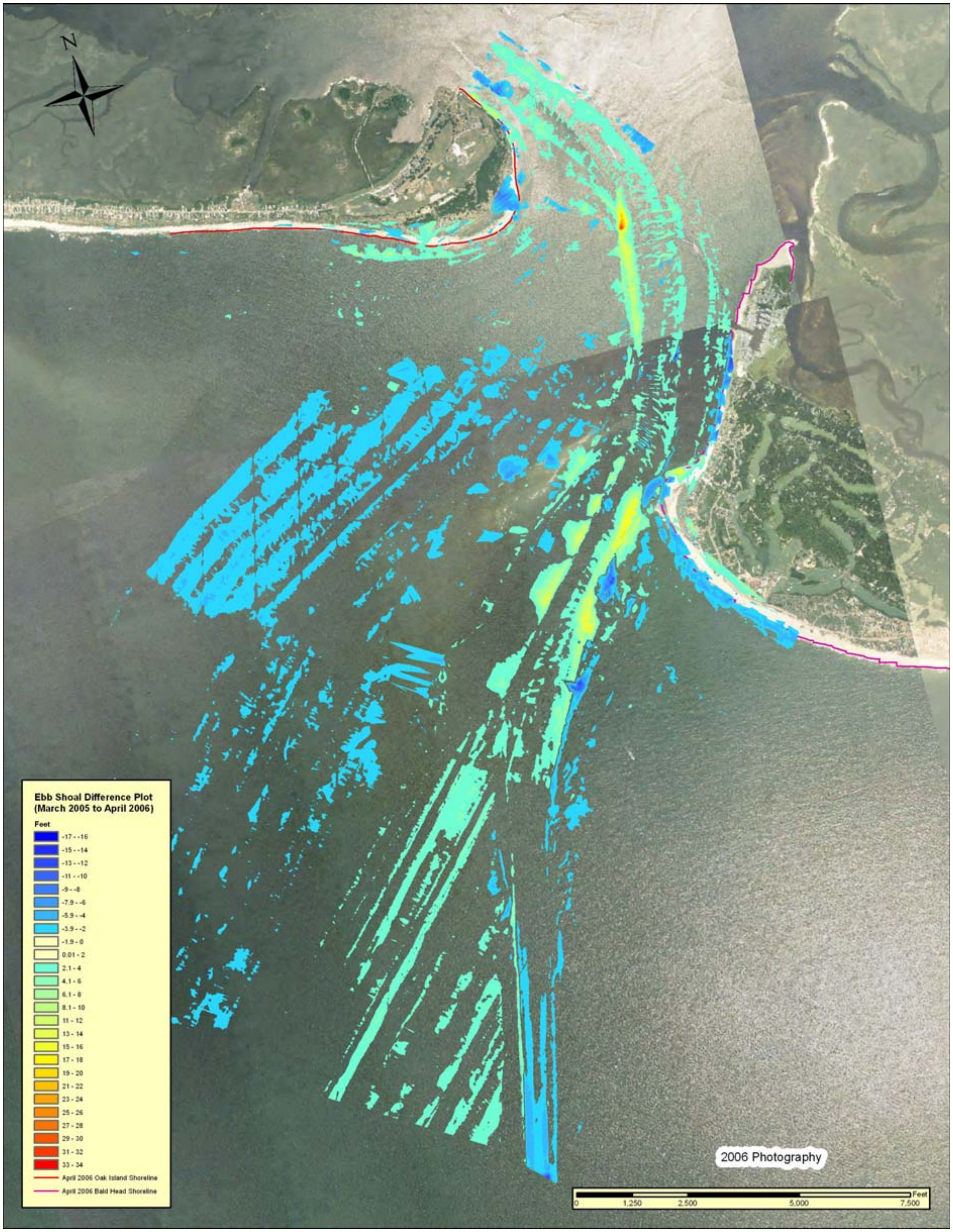


Figure 3.24 Bathymetric Changes of the Ebb Tidal Delta (March 2005 to April 2006)

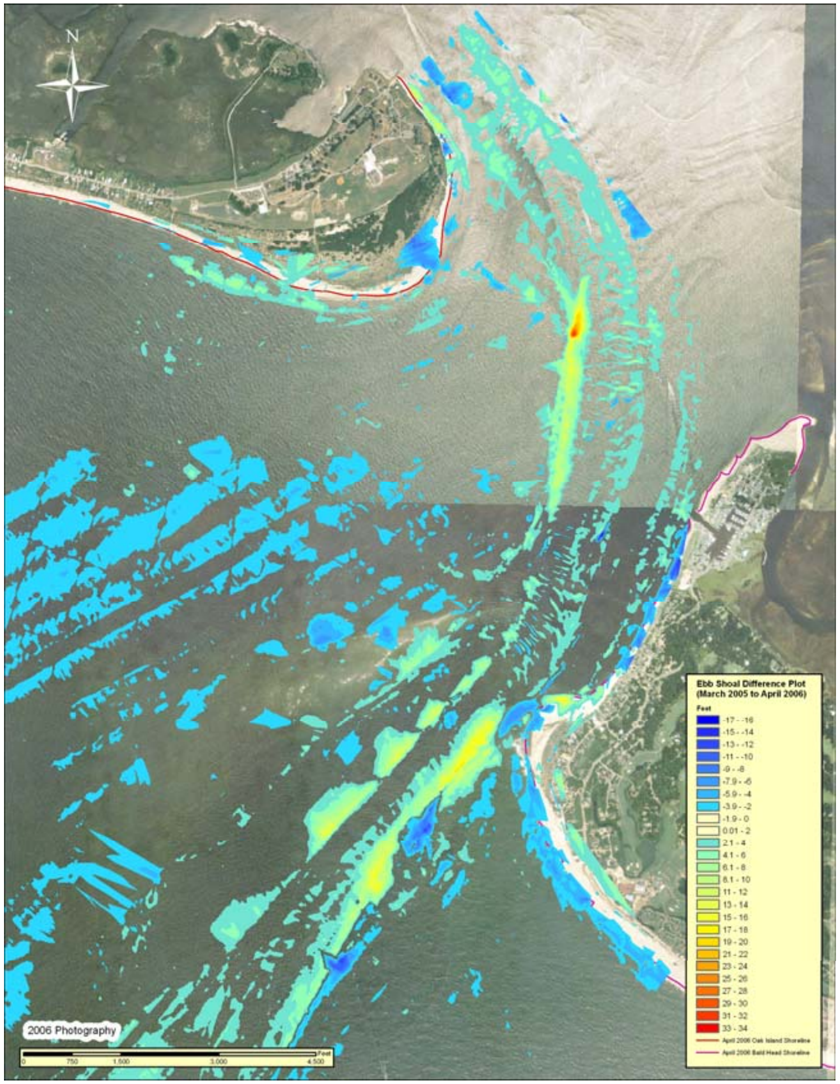


Figure 3.25 (a) Bathymetric Changes of Inlet (March 2005 to April 2006)

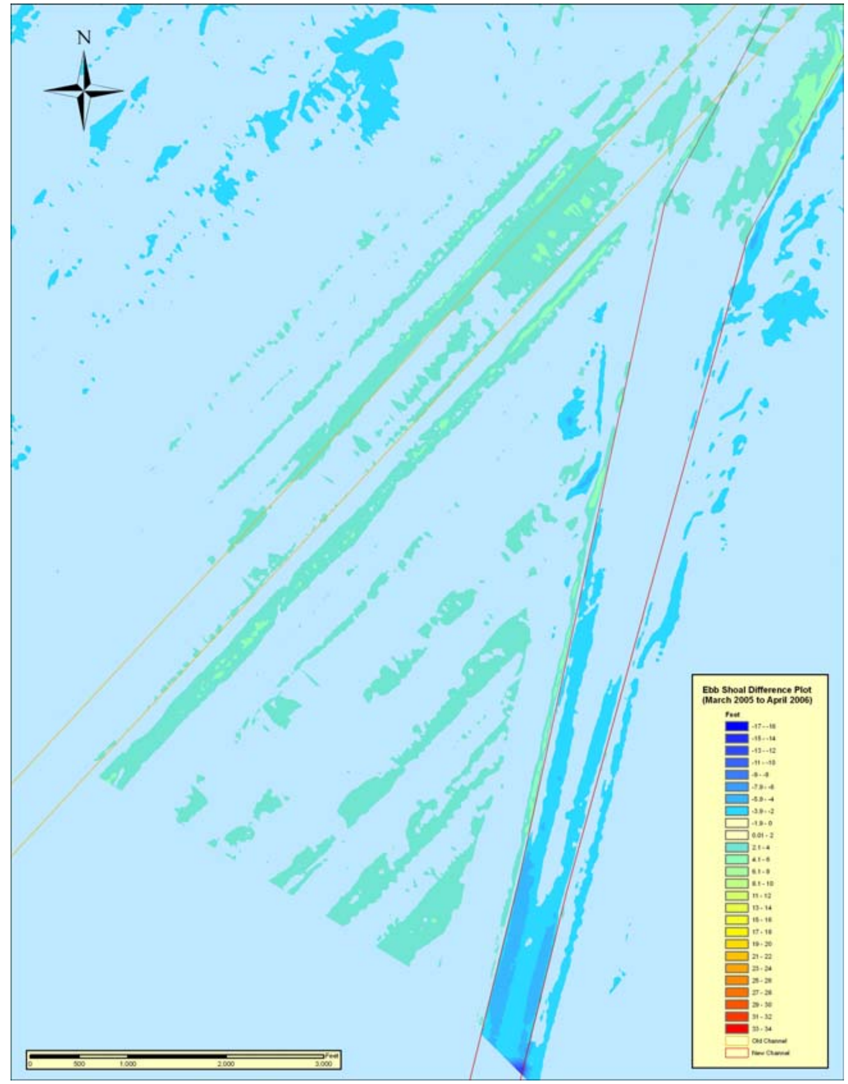


Figure 3.25 (b) Bathymetric Changes of New Channel (March 2005 to April 2006)

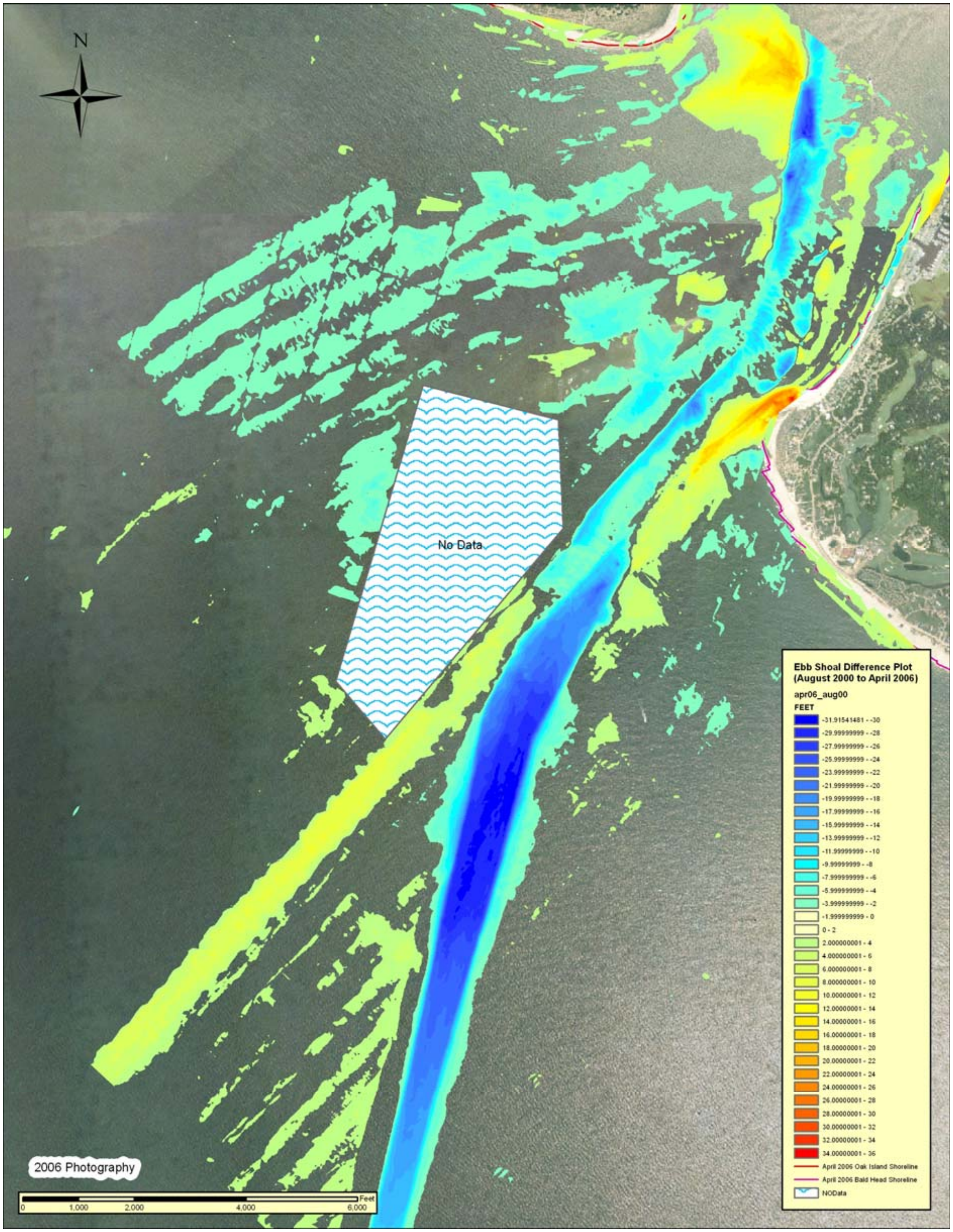


Figure 3.26 Bathymetric Changes of the Ebb Tidal Delta (August 2000 to April 2006)

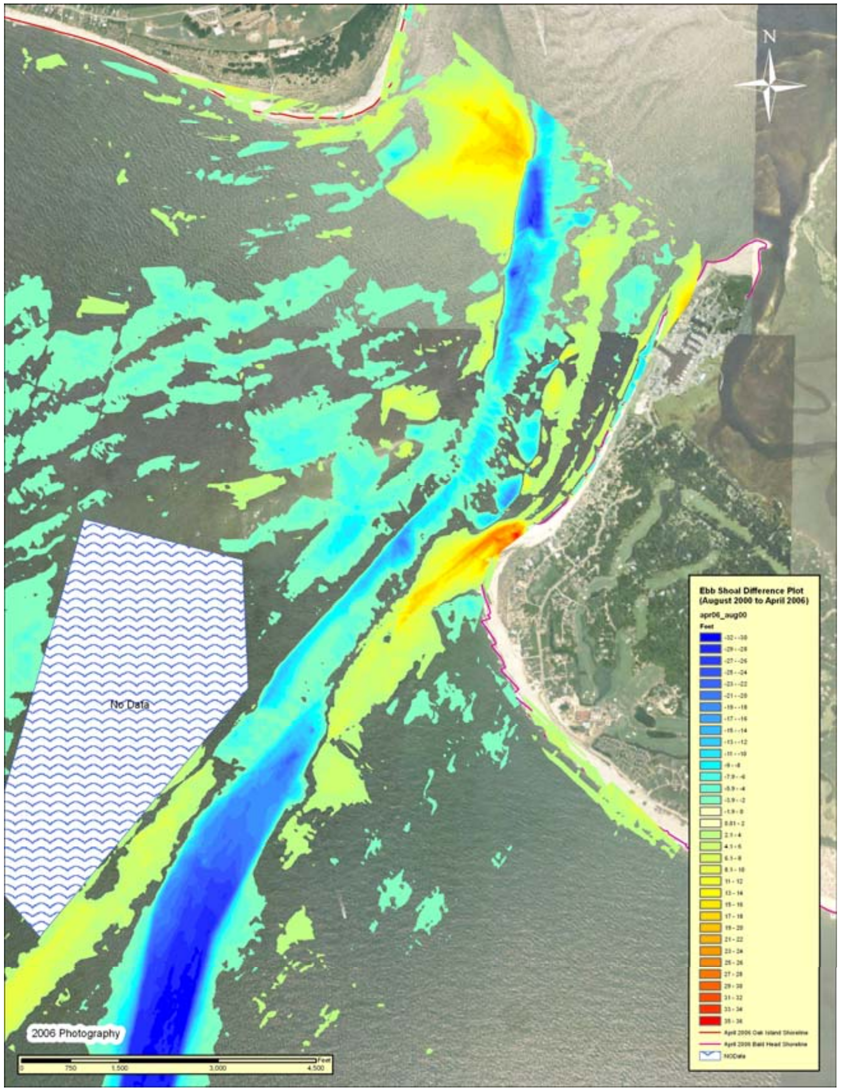


Figure 3.27 (a) Bathymetric Changes of Inlet (August 2000 to April 2006)

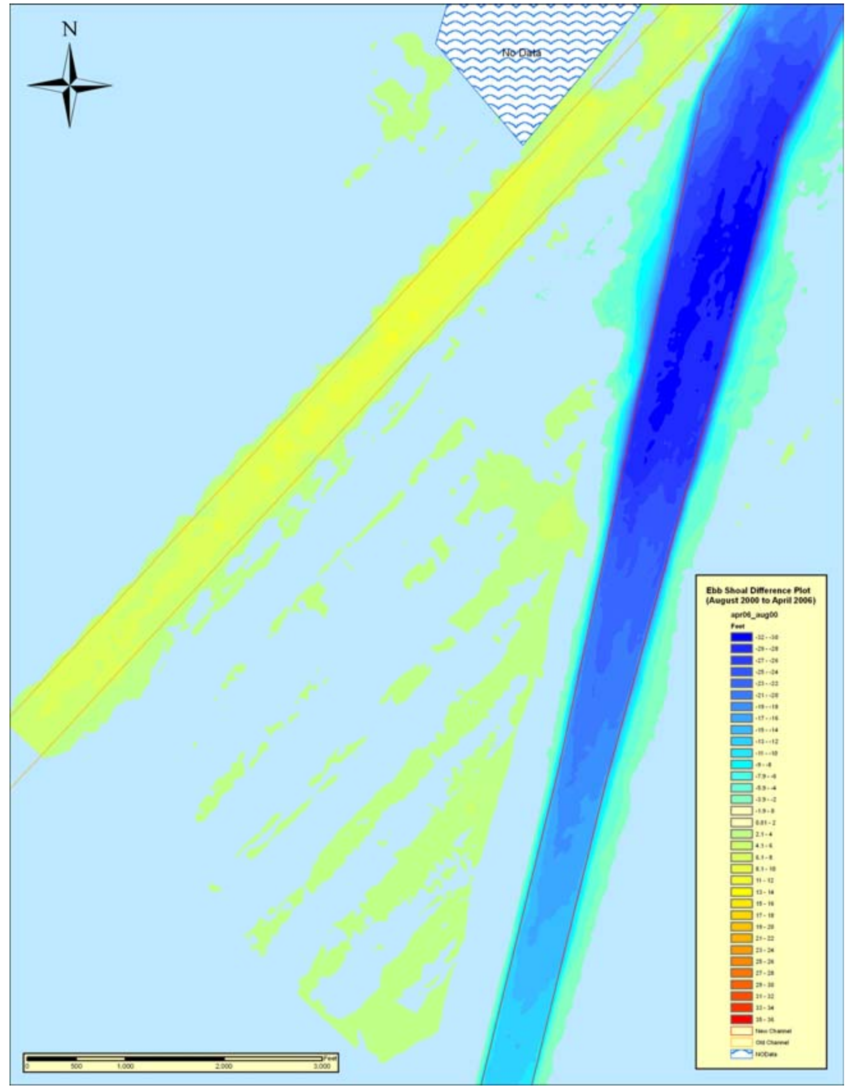


Figure 3.27 (b) Bathymetric Changes of New Channel (August 2000 to April 2006)

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 six 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 March 27-29, 2006. The specific ADCP transects for the 2006 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, McNinch 2002a, McNinch 2003a, McNinch 2004a and Part 3 of USACE 2005a. Details of the most recent current measurements are given in Waller and Pratt 2006.

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

Tidal Inlet Region Results. The results of each transect were processed and analyzed in a time series for each hourly loop. The data summary for the transects that cross the main channel (lines 4 & 6 of Figure 3.30) are listed in Table 3.3. Line 6 is located to capture the entire flow through the inlet. Figures 3.31 and 3.32 show the discharge computed along lines 4 & 6 for 27 March and 29 March, respectively, as well as the predicted tide at Southport. These data are plotted with flood flow as positive values and ebb flows as negative values.

Figures 3.33 and 3.34 show the details of the flow patterns during times of peak flood and peak ebb, respectively, for the March 2006 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 Oct 2000, April 2002, March 2003, Jan 2004 and March 2005 are shown in Figures 3.35 through 3.39, respectively.

Table 3.3 ACDP Data Summary of Transects that Cross the Main Channel of the Inlet Region

Line	File Name	Date	Start Time	End Time	Total Q	Top Q	Meas. Q	Bottom Q	Total Area	Width	Q/Area	Flow Speed	Flow Dir.
Number			EST	EST	[m^3/s]	[m^3/s]	[m^3/s]	[m^3/s]	[m^2]	[m]	[m/s]	[m/s]	[°]
4	CPFR004r.000	3/27/2006	11:18:34	11:22:09	-5049.7	-344.8	-4431.9	-273.0	5284.7	361.2	0.96	1.06	231.4
4	CPFR010r.000	3/27/2006	12:11:54	12:14:49	-3579.0	-264.9	-3130.2	-183.8	4970.3	336.6	0.72	0.72	224.7
4	CPFR016r.000	3/27/2006	13:16:53	13:20:28	-569.3	-59.3	-481.5	-28.5	5258.1	353.8	0.11	0.14	262.0
4	CPFR022r.000	3/27/2006	14:18:58	14:21:32	2604.7	80.5	2383.5	140.8	5208.9	340.7	0.50	0.54	50.7
4	CPFR028r.000	3/27/2006	15:23:04	15:26:08	4830.1	314.5	4267.6	248.0	6146.9	405.6	0.79	0.83	41.8
4	CPFR035r.000	3/27/2006	16:20:24	16:23:38	4388.3	225.1	3941.4	221.8	5496.8	340.2	0.80	0.88	43.6
4	CPFR041r.000	3/27/2006	17:17:19	17:20:05	3981.3	261.0	3519.0	201.4	5436.3	327.3	0.73	0.83	43.6
4	CPFR048r.000	3/27/2006	18:13:30	18:16:41	2787.9	188.6	2460.8	138.5	5470.8	342.1	0.51	0.59	39.3
4	CPFR098r.000	3/29/2006	9:56:02	9:59:43	-6182.4	-466.0	-5392.2	-324.2	6689.2	493.2	0.92	0.96	228.0
4	CPFR104r.000	3/29/2006	10:49:11	10:52:52	-7258.0	-558.4	-6313.0	-386.6	6300.0	479.8	1.15	1.18	228.0
4	CPFR110r.000	3/29/2006	11:41:47	11:44:59	-7253.9	-563.1	-6299.7	-391.1	6245.6	491.4	1.16	1.19	224.8
4	CPFR116r.000	3/29/2006	12:33:51	12:37:46	-6411.9	-516.4	-5556.6	-338.9	6088.3	480.4	1.05	1.07	226.1
6	CPFR006r.000	3/27/2006	11:35:17	11:53:12	-7314.2	-820.2	-6070.5	-423.5	17342.0	1942.5	0.42	0.98	176.3
6	CPFR012r.000	3/27/2006	12:25:04	12:40:11	-4466.7	-487.8	-3710.1	-268.7	17559.0	1939.8	0.25	0.67	172.1
6	CPFR018r.000	3/27/2006	13:29:15	13:41:39	447.6	-74.7	493.1	29.2	18714.4	1918.5	0.02	0.06	115.9
6	CPFR024r.000	3/27/2006	14:28:31	14:38:58	6965.3	578.4	5973.2	413.6	18816.4	1928.0	0.37	0.59	7.5
6	CPFR031r.000	3/27/2006	15:39:10	15:55:07	11003.4	1135.6	9233.4	634.4	19282.1	1943.5	0.57	0.75	16.3
6	CPFR037r.000	3/27/2006	16:32:24	16:50:10	11943.9	1205.7	10008.7	729.5	19018.7	1866.4	0.63	0.80	19.0
6	CPFR044r.000	3/27/2006	17:33:03	17:47:21	10442.3	1004.2	8825.4	612.7	19719.4	1891.3	0.53	0.65	20.3
6	CPFR050r.000	3/27/2006	18:25:25	18:38:59	5500.8	532.0	4838.1	130.7	20079.4	1931.0	0.27	0.37	30.4
6	CPFR100r.000	3/29/2006	10:11:41	10:31:16	-9250.5	-940.5	-7772.2	-537.8	18605.2	1967.6	0.50	1.05	178.7
6	CPFR106r.000	3/29/2006	11:03:36	11:25:16	-9182.7	-946.7	-7706.6	-529.3	18397.6	2025.6	0.50	1.18	175.1
6	CPFR112r.000	3/29/2006	11:56:02	12:16:26	-8521.4	-924.9	-7106.7	-489.8	17873.4	2016.5	0.48	1.16	173.8
6	CPFR118r.000	3/29/2006	12:51:33	13:13:58	-7432.0	-837.2	-6176.8	-417.9	17132.9	1945.8	0.43	1.04	175.3

As with the peak flood conditions, the peak ebb flow patterns (Figure 3.34) 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 Oct 2000, April 2002, March 2003, Jan 2004 and March 2005 are shown in Figures 3.40 through 3.44, respectively.

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.4 for the inlet region. The magnitudes of the currents ranged from a peak surface ebb value of nearly 6.5 ft/s to a near-bottom flood value of just over 3 ft/s. In all cases, with the exception of the March 2003 and 2006 near-bottom measurements, the ebb peak 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 five 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 –4.18 ft/s (ebb) and 3.88 ft/s (flood) versus -3.48 ft/s and 3.28 ft/s, respectively. For the near-surface case, the average values are likewise –5.17 ft/s (ebb) and 4.19 ft/s (flood), versus -4.43 ft/s (ebb) and 3.61 ft/s (flood) for the October 2000 measurements.

Table 3.4 Maximum Magnitude of Mean Flows at Inlet Transect

		October 2000	**April 2002**	**March 2003**	**January 2004**	**March 2005**	**March 2006**
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)
	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)
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)
	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)
*Near-bottom defined by lower half of water column; near-surface defined by upper half of water column							

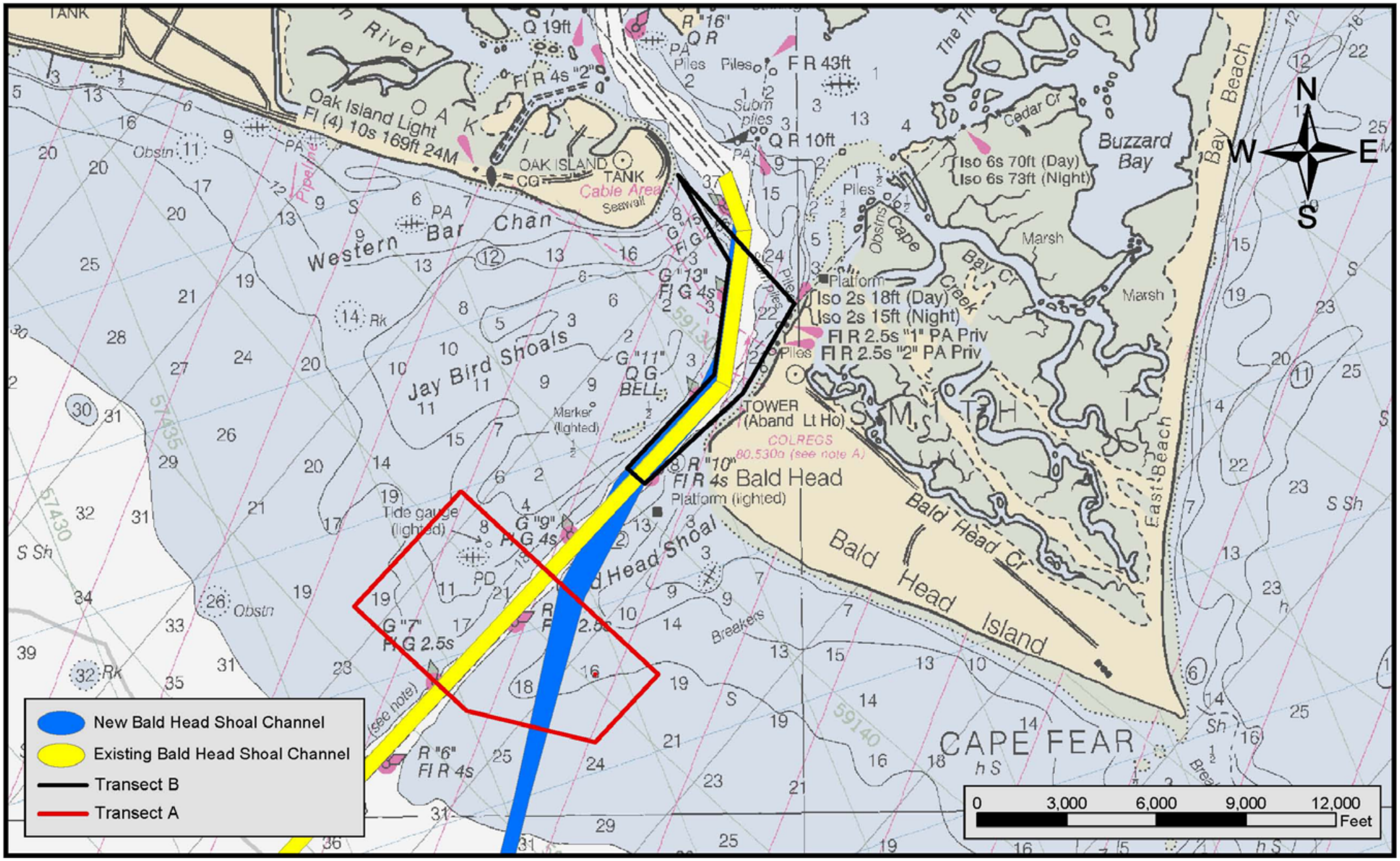


Figure 3.28 Ship-Board current profile track lines

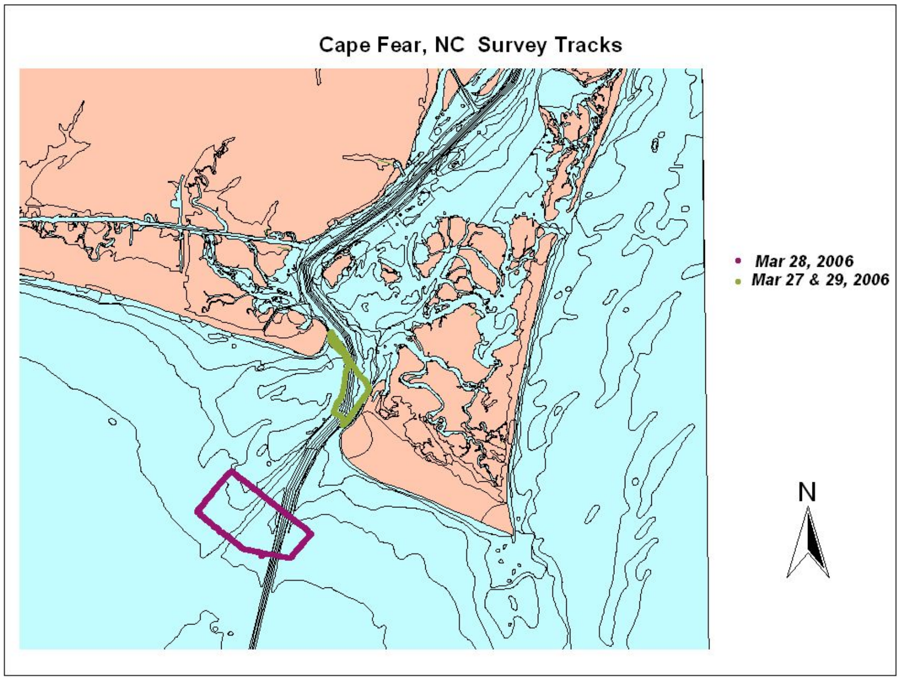


Figure 3.29 Plan View Showing the ADCP Transects Collected 27-29 March 2006

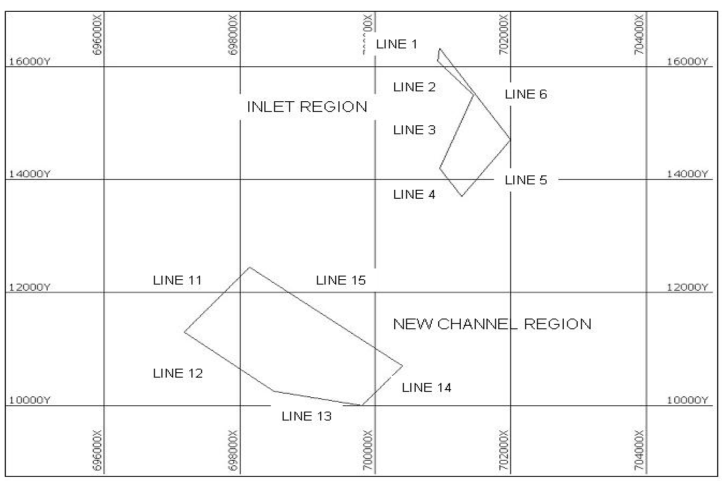


Figure 3.30 ADCP March 2006 Survey Lines on NAD-83 North Carolina State Plane Grid (3200), meters

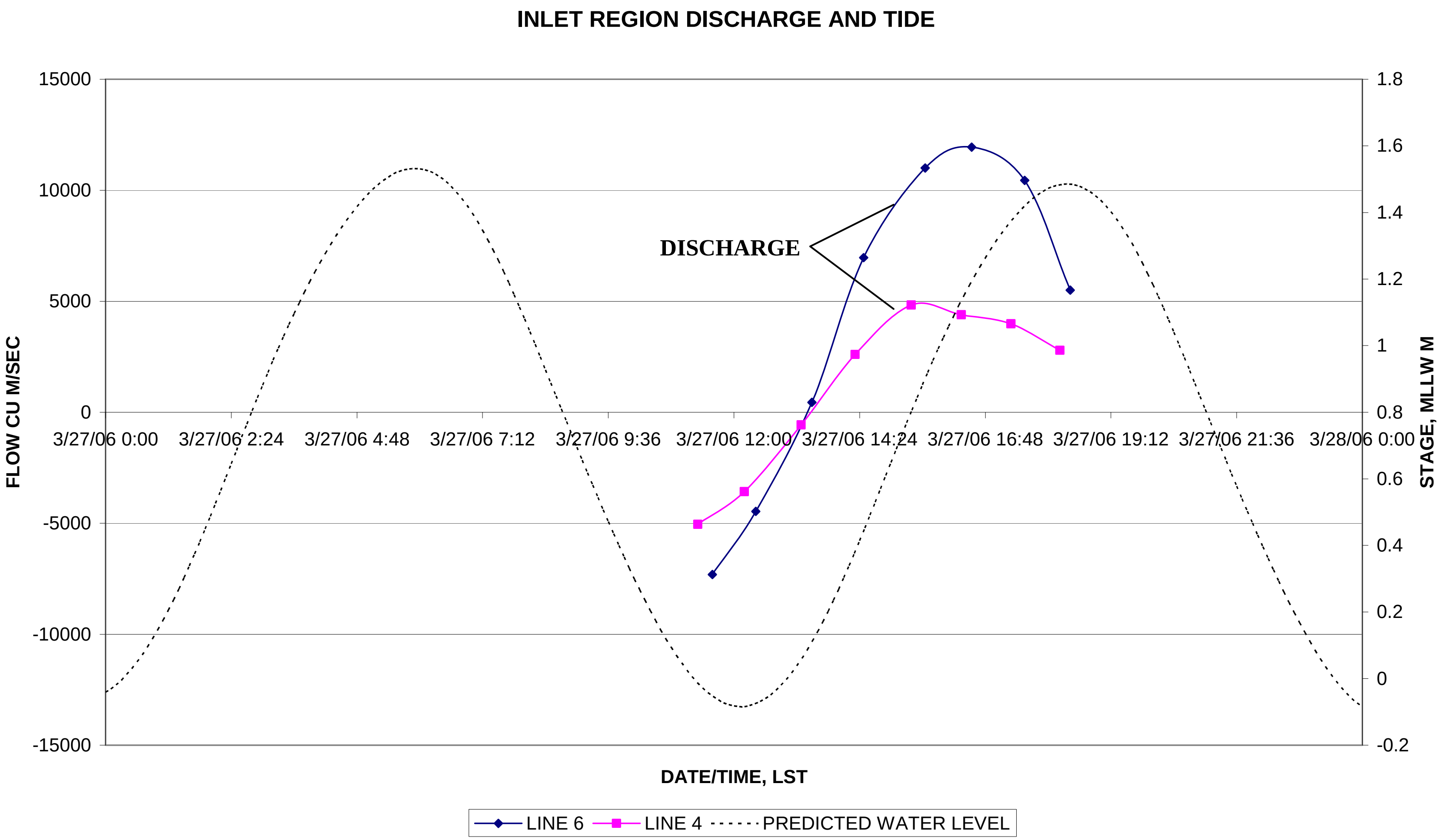


Figure 3.31 Discharge and Water Level for 27 March 2006 ADCP data Collected at the Inlet Region

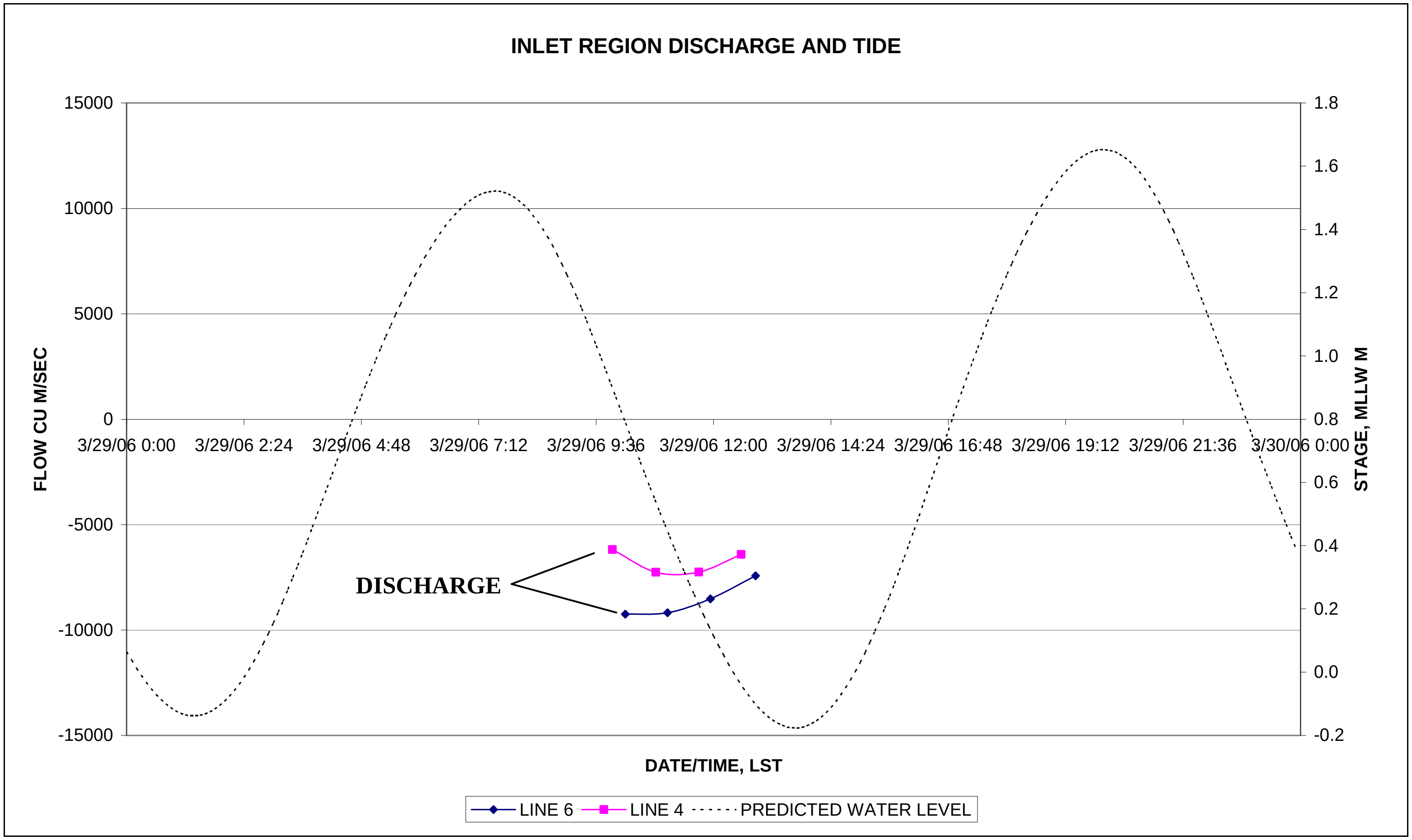


Figure 3.32 Discharge and Water Level for 29 March 2006 ADCP data Collected at the Inlet Region

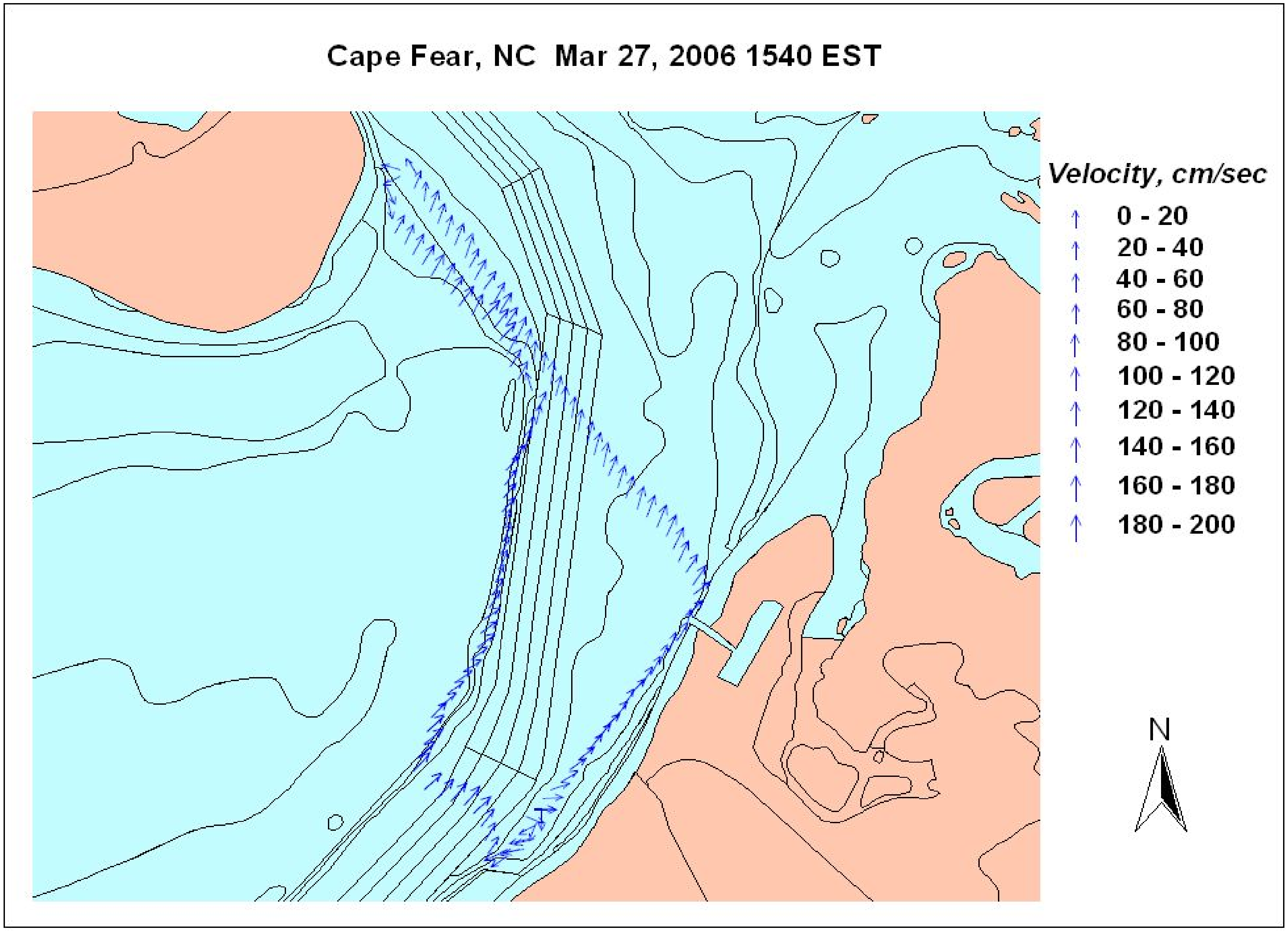


Figure 3.33 March 2006 ADCP survey at the inlet transect during peak flood flow

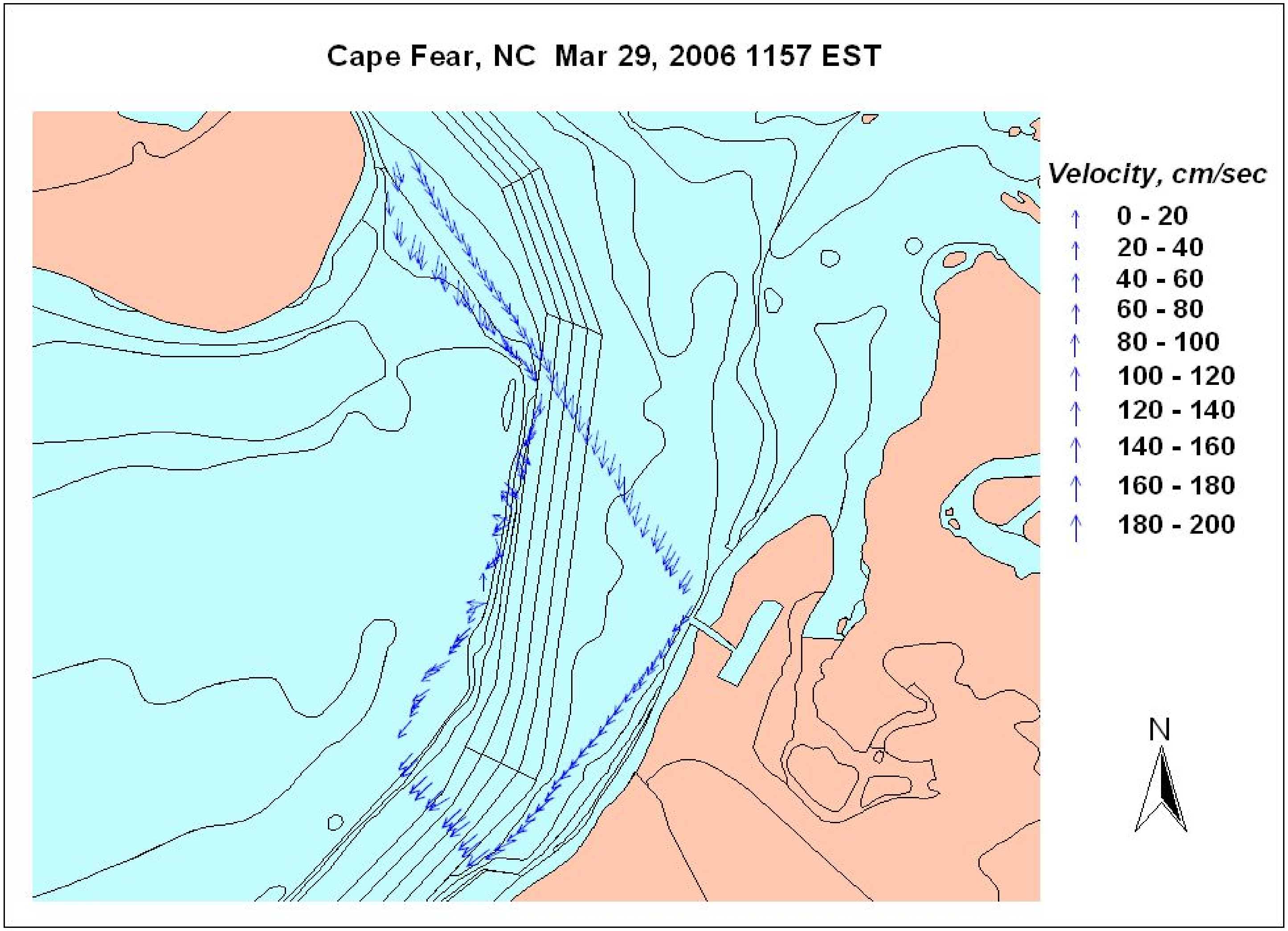


Figure 3.34 March 2006 ADCP survey at the inlet transect during peak ebb flow

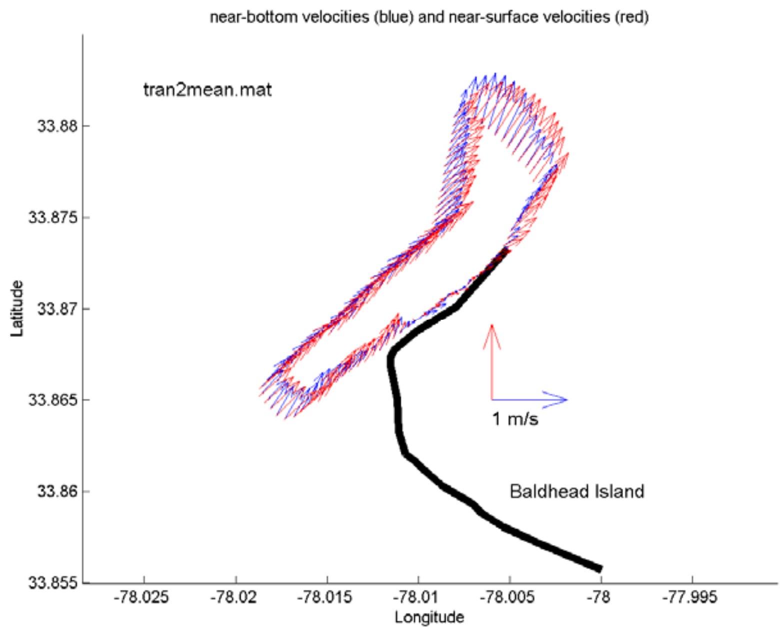


Figure 3.35 October 2000 ADCP survey at inlet transect during peak flood flow. Note that survey transect does not cover same area as the April 2002, March 2003 and January 2004 surveys.

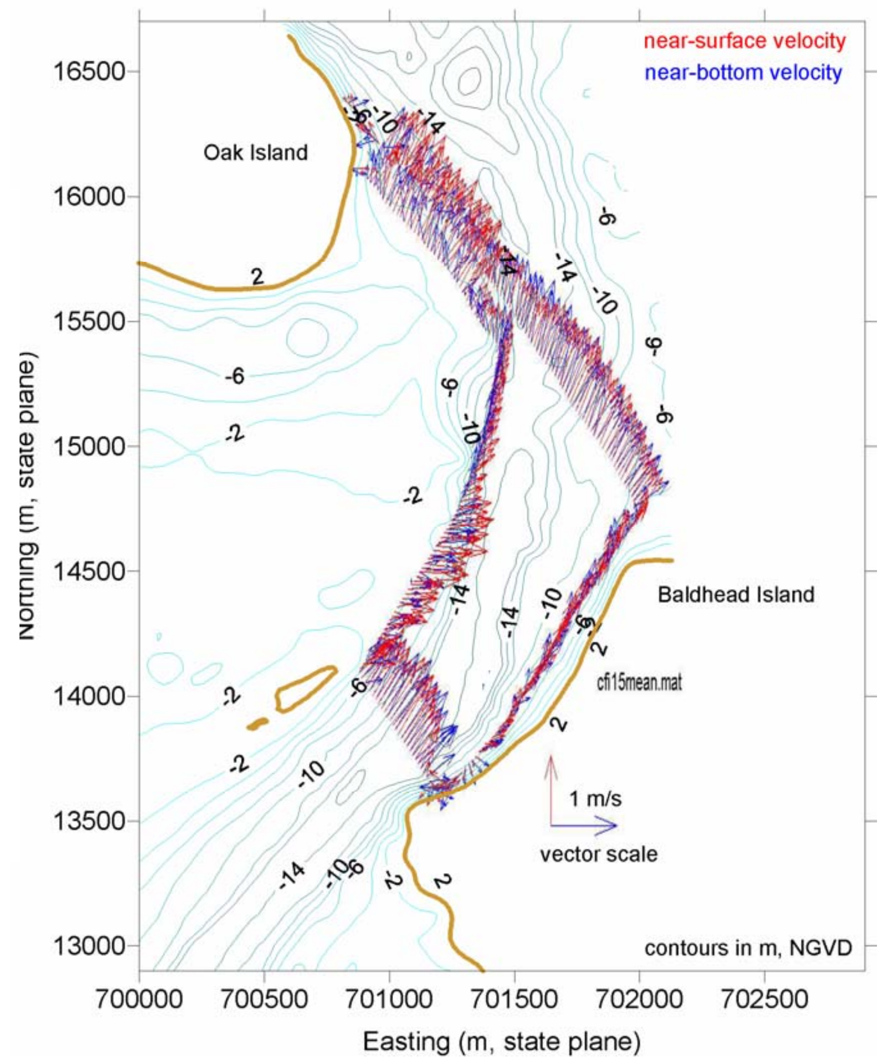


Figure 3.36 April 2002 ADCP survey at inlet transect during peak flood flow.

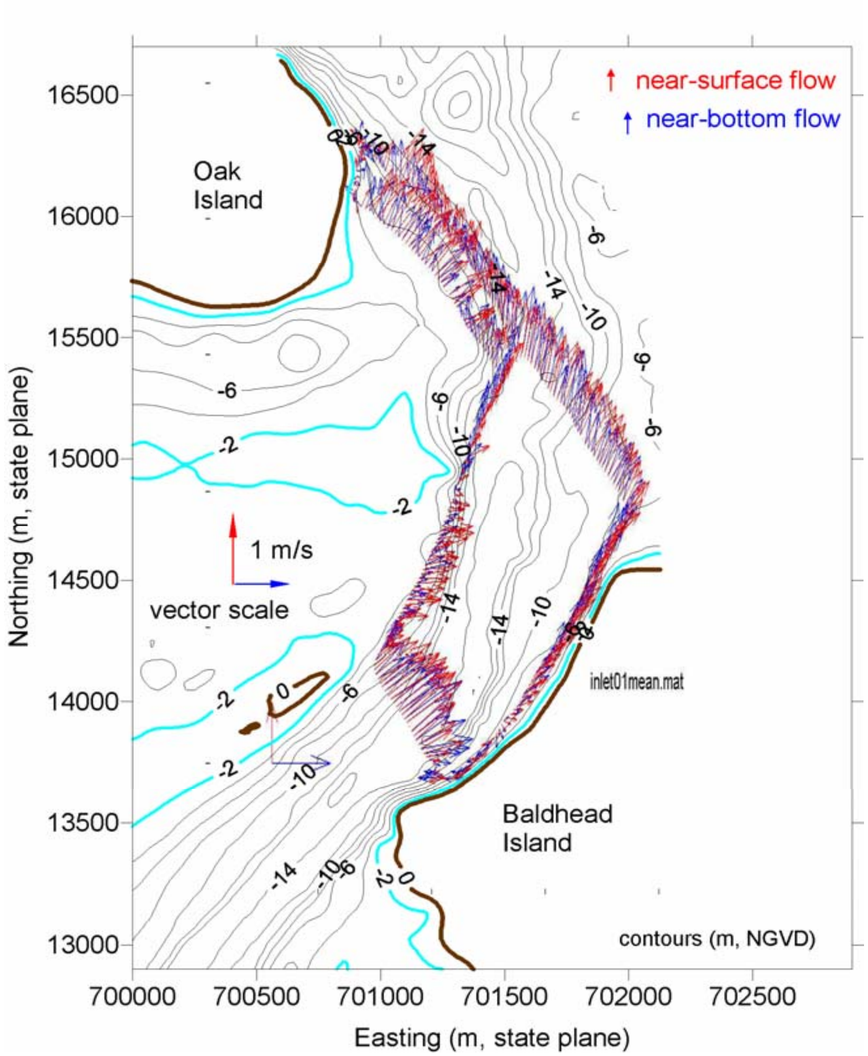


Figure 3.37 March 2003 ADCP survey at inlet transect during flood flow.

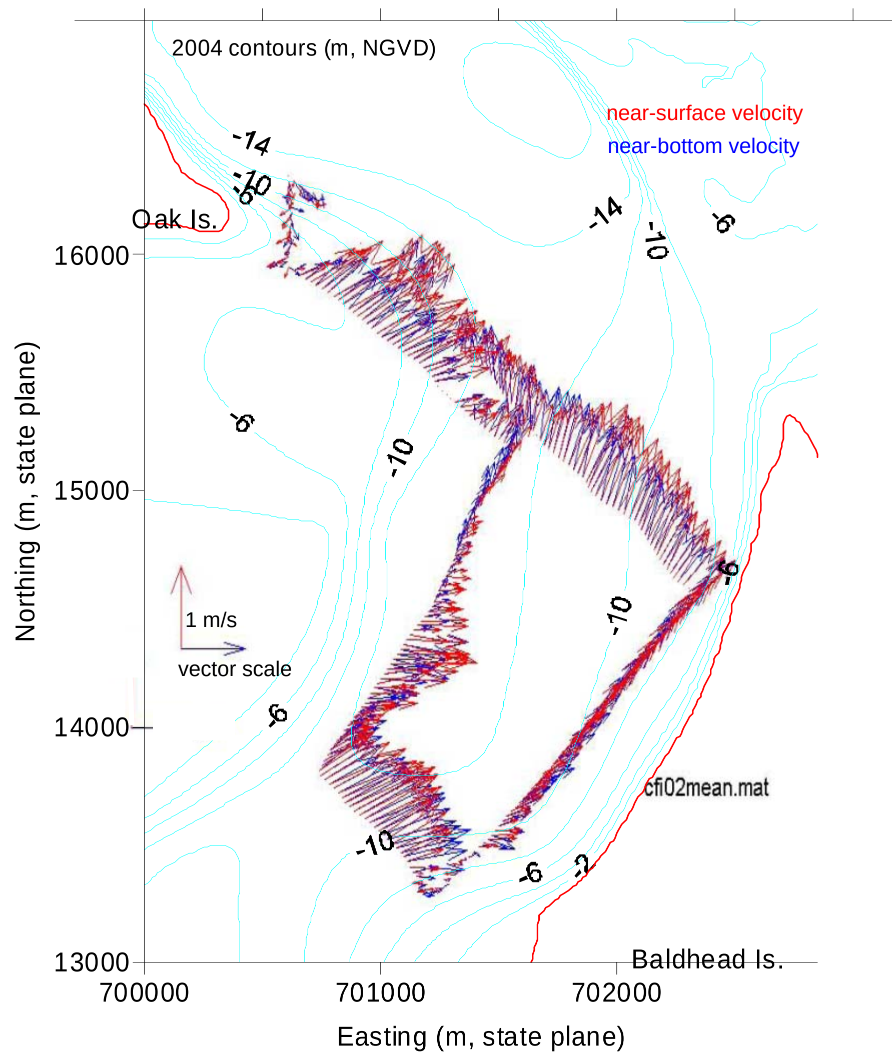


Figure 3.38 January 2004 ADCP survey at inlet transect during flood flow.

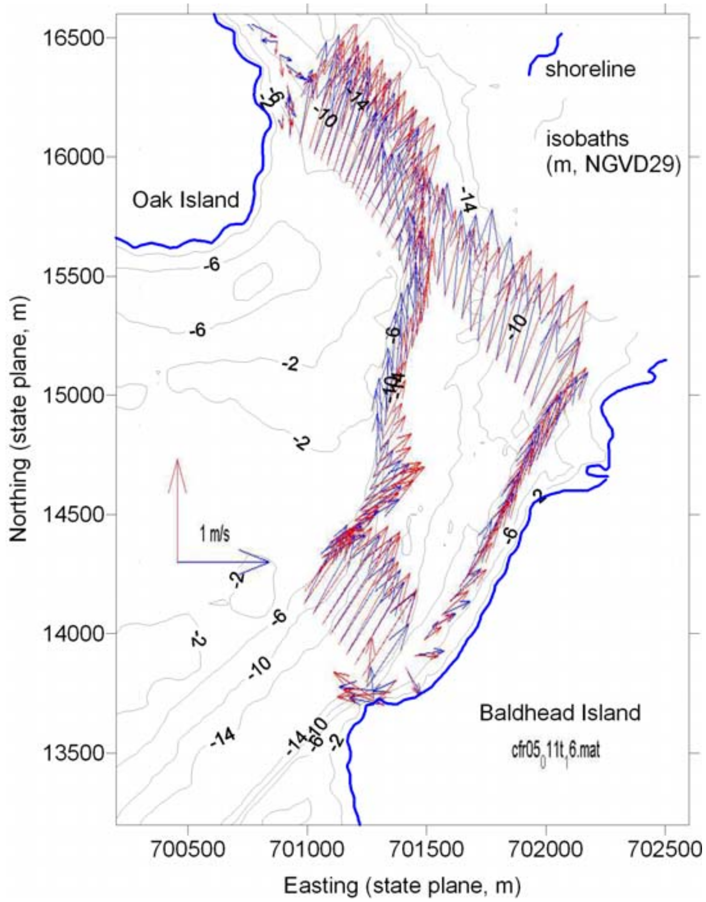


Figure 3.39 March 2005 ADCP survey at inlet transect during flood flow.

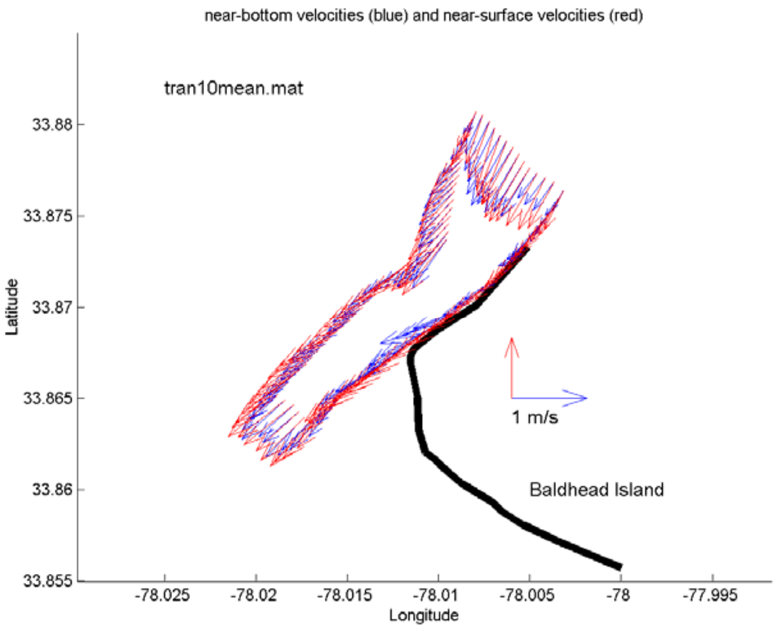


Figure 3.40 October 2000 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the April 2002 survey.

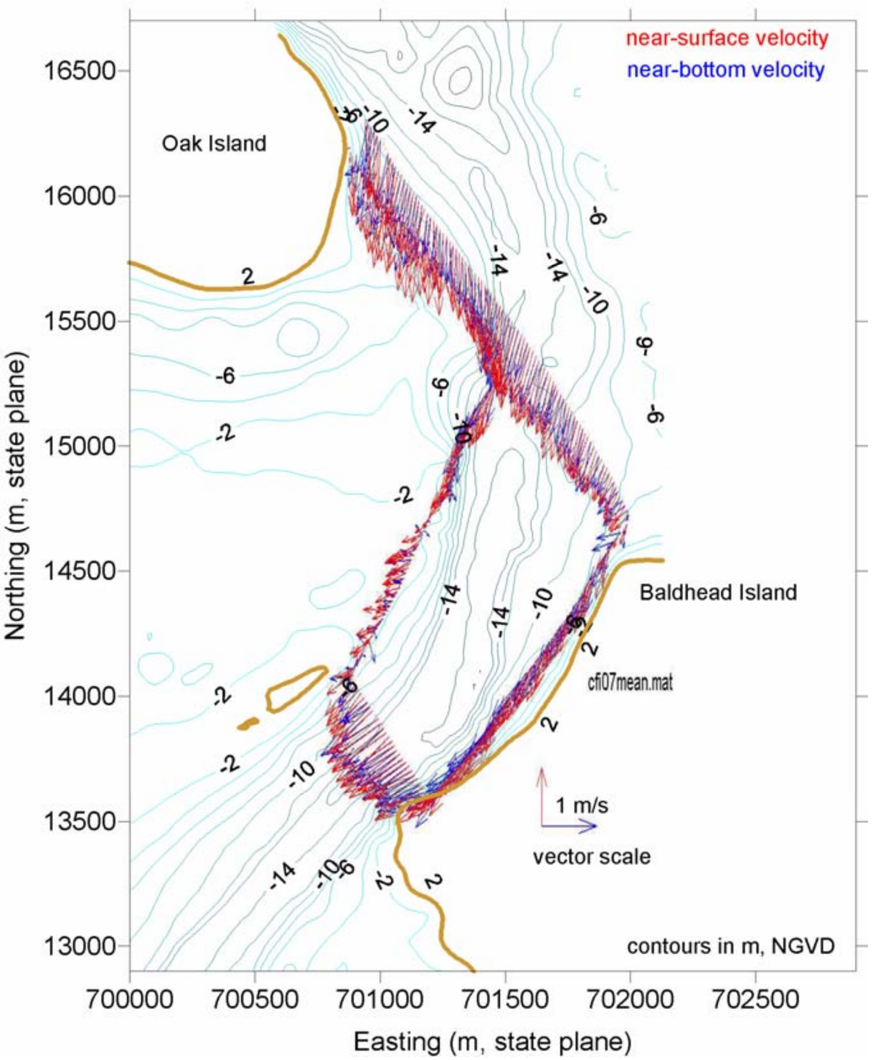


Figure 3.41 April 2002 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the October 2000 survey.

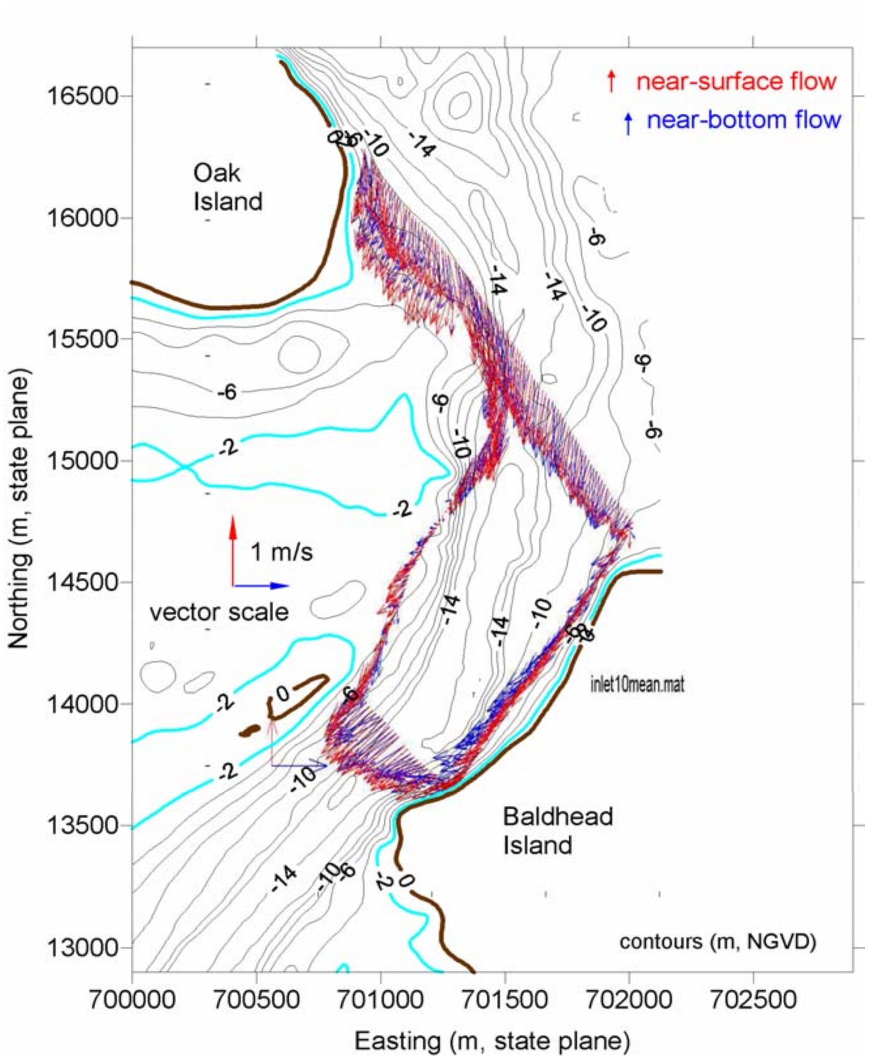


Figure 3.42 March 2003 ADCP survey at inlet transect during ebb flow.

to predict

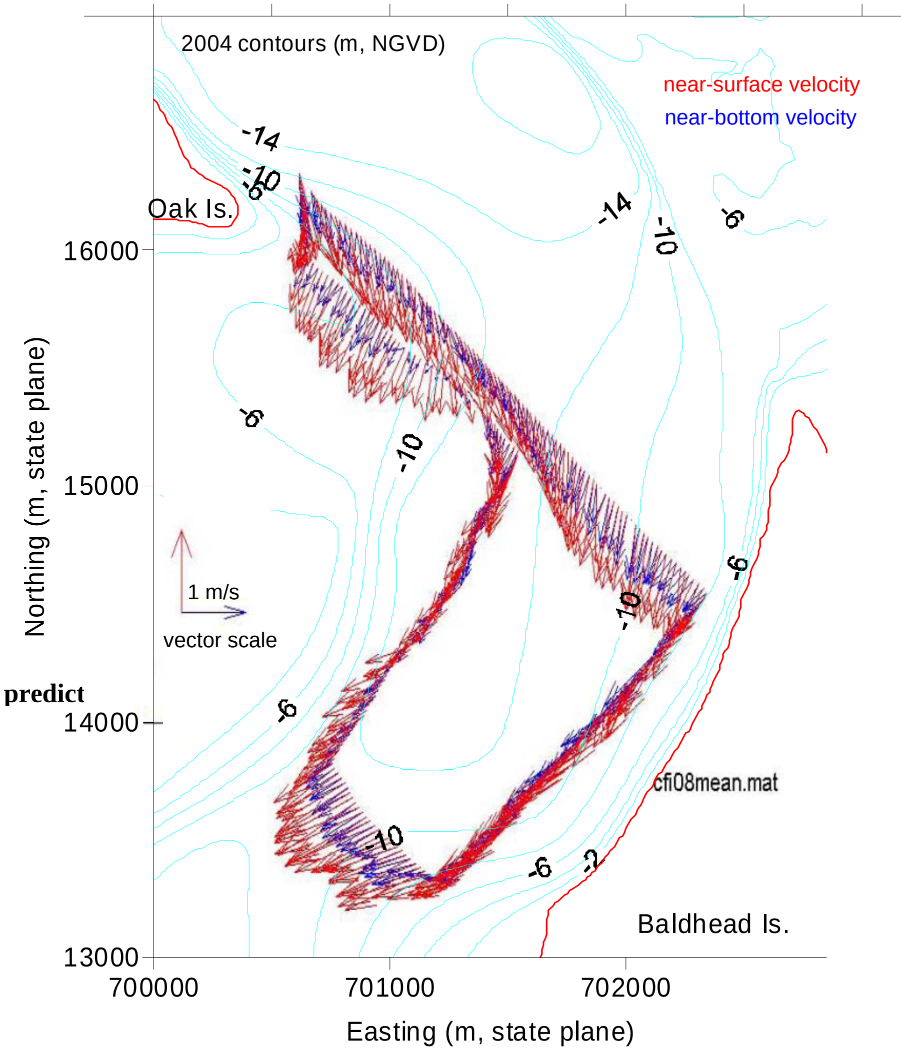


Figure 3.43 January 2004 ADCP survey at inlet transect during ebb flow.

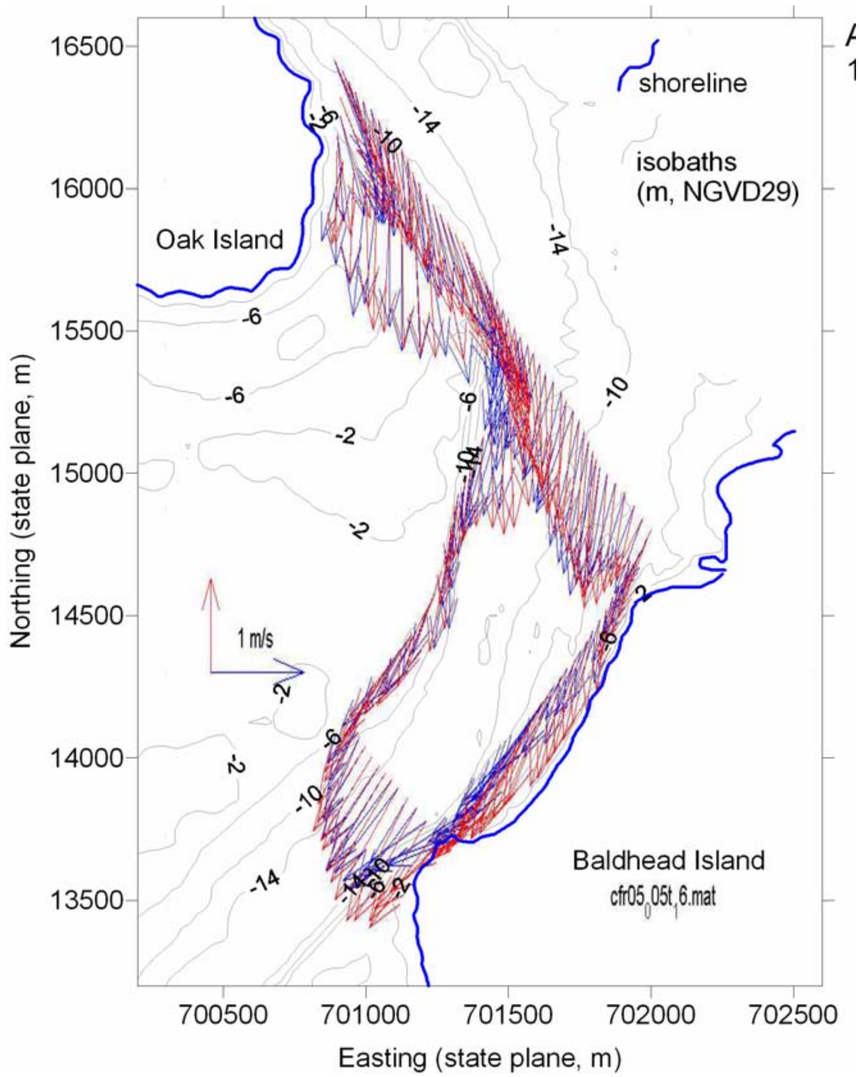


Figure 3.44 March 2005 ADCP survey at inlet transect during ebb flow.

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 for each of the past current measurements—pre-construction (October 2000) and post-construction (April 2002, March 2003, January 2004, and March 2005) 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. Nevertheless, the past computations are displayed graphically for each of the survey dates in Figure 3.45. 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 five surveys, the tidal prism computations were normalized across the inlet cross-section area as defined by the January 2003 bathymetry and associated transect. Table 3.5 summarizes the tidal prism computations and the results are shown graphically in Figure 3.46.

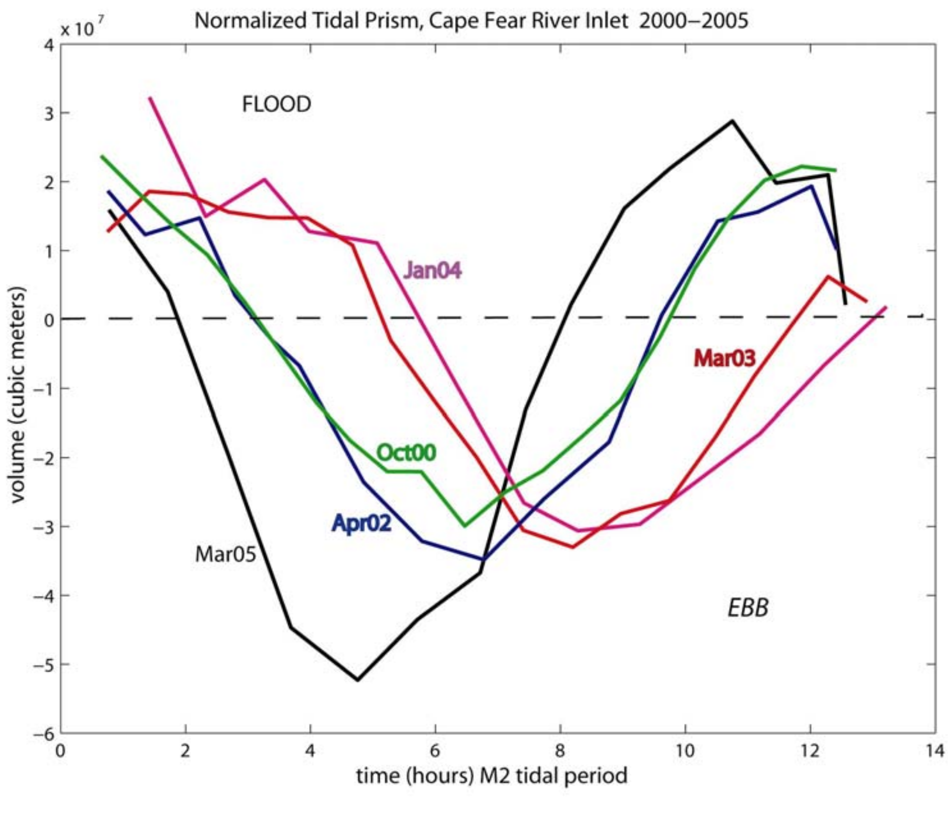


Figure 3.45 Volume of Water Passing through the inlet over the tidal period for all ADCP surveys (2000-2005)

Table 3.5 Normalized Tidal Prism Values for each of the ADCP Surveys (2000-2005)

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*

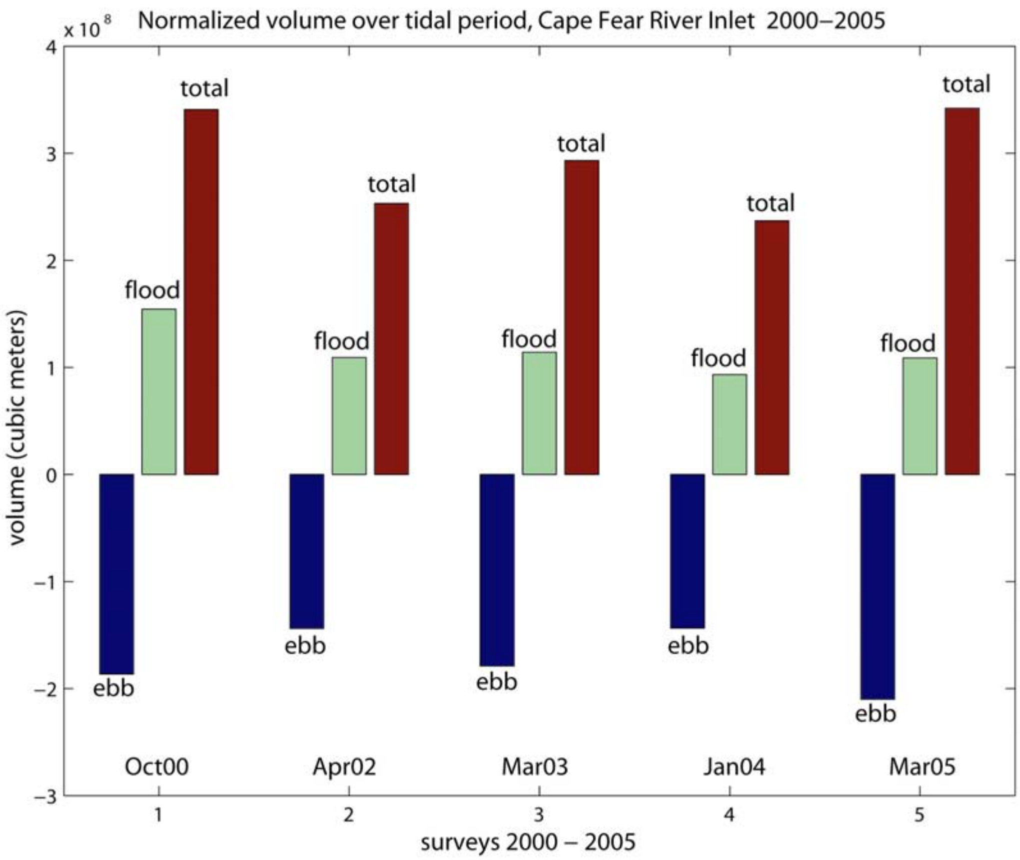


Figure 3.46 Normalized tidal prism for five surveys—(1) October 2000, (2) April 2002, (3) March 2003, (4) January 2004 and (5) March 2005. Blue—ebb, Green—flood, Red—total

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 3.46.

The tidal prism results show that the Cape Fear is an ebb-dominated inlet with the average ebb flow volume being 30% greater than the flood volume. The March 2005 current survey was the first 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. All other total tidal prism values were less than the October 2000 value. The most recent survey had a flood volume that was comparable with the other surveys 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 in a time series for each hourly loop. The data summary for the transects that cross the old and new main channel (line 12 (old), line 13 (new) and 15 (both) of Figure 3.30) are listed in Table 3.6. Figure 3.47 shows the discharge computed along lines 12, 13 and 15 for 28 March, along with the predicted tide at Southport. These data are plotted with flood flow as positive values and ebb flows as negative values.

Figures 3.48 and 3.49 show the details of the flow patterns during the March 2006 measurements. Figure 3.48 shows the time approaching peak flood flow as the time around the peak was not measured due to weather. Figure 3.49 gives the peak ebb for the March 2006 measurements. 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 channel bed 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 and March 2005 are shown in Figures 3.50 through 3.54, respectively.

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 between and within the old and new channel regions. Outside of this region the ebb flows are greatly reduced particularly around Jay Bird Shoals. The similar peak ebb flow patterns from the prior measurements collected in Oct 2000, April 2002, March 2003, Jan 2004 and March 2006 are shown in Figures 3.55 through 3.59, respectively.

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.7 for the outer transect. As noted above, the peak flood values were not collected during the March 2006 ADCP survey. 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 approaching 4 ft/s with a low peak found at near-bottom ebb of just over 1 ft/s. 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 –2.98 ft/s (ebb) and 2.03 ft/s (flood) versus -2.03 ft/s and 1.31 ft/s, respectively. For the near-surface case, the average values are likewise –3.65 ft/s (ebb) and 2.03 ft/s (flood), versus –3.08 ft/s (ebb) and 1.41 ft/s (flood) for the October 2000 readings.

Table 3.6 ACDP Data Summary of Transects that Cross the Main Channel of the New Channel Region

Line Number	File Name	Date	Start Time EST	End Time EST	Total Q [m³/s]	Top Q [m³/s]	Meas. Q [m³/s]	Bottom Q [m³/s]	Total Area [m²]	Width [m]	Q/Area [m/s]	Flow Speed [m/s]	Flow Dir. [°]
12	CPFR053r.000	3/28/2006	10:08:37	10:20:33	-2659.9	-413.8	-2091.8	-154.2	13918.3	1704.2	0.19	0.23	183.0
12	CPFR058r.000	3/28/2006	11:08:36	11:20:24	-2440.0	-299.8	-1985.9	-154.3	13487.4	1695.1	0.18	0.18	219.2
12	CPFR063r.000	3/28/2006	12:08:59	12:22:16	-3052.9	-474.2	-2400.9	-177.8	13055.3	1675.8	0.23	0.25	244.4
12	CPFR068r.000	3/28/2006	13:27:13	13:39:47	-3926.8	-657.2	-3041.8	-227.7	13396.8	1676.0	0.29	0.33	249.8
12	CPFR073r.000	3/28/2006	14:22:30	14:34:57	-2163.7	-432.9	-1612.3	-118.5	14254.2	1702.2	0.15	0.30	281.3
12	CPFR078r.000	3/28/2006	15:18:16	15:34:57	693.6	1.3	648.3	44.1	15125.1	1693.1	0.05	0.26	319.0
12	CPFR084r.000	3/28/2006	16:37:58	16:51:30	2785.6	358.8	2271.9	154.9	15886.8	1666.1	0.18	0.19	65.7
13	CPFR054r.000	3/28/2006	10:20:40	10:29:24	-5290.9	-589.4	-4390.0	-311.5	12036.6	1323.4	0.44	0.45	180.3
13	CPFR059r.000	3/28/2006	11:20:37	11:29:49	-5451.4	-636.6	-4490.8	-323.9	11435.9	1300.8	0.48	0.49	186.3
13	CPFR064r.000	3/28/2006	12:22:30	12:35:17	-3934.5	-436.6	-3256.9	-241.0	11470.2	1326.7	0.34	0.46	215.2
13	CPFR069r.000	3/28/2006	13:40:01	13:49:29	-159.2	-20.9	-130.8	-7.5	11732.0	1308.6	0.01	0.31	279.3
13	CPFR074r.000	3/28/2006	14:35:10	14:44:08	2386.6	300.7	1948.9	137.0	12054.0	1284.9	0.20	0.33	318.2
13	CPFR079r.000	3/28/2006	15:35:11	15:45:58	3430.7	421.8	2811.5	197.5	12936.6	1301.9	0.27	0.27	357.0
13	CPFR085r.000	3/28/2006	16:51:44	17:00:07	3077.0	388.0	2523.0	165.9	13517.2	1287.1	0.23	0.24	35.9
15	CPFR051r.000	3/28/2006	9:35:03	9:55:22	-7720.0	-1183.7	-6037.0	-499.2	21451.8	2914.0	0.36	0.44	185.3
15	CPFR056r.000	3/28/2006	10:36:33	10:58:08	-9074.4	-1279.9	-7250.2	-544.3	19866.6	2849.5	0.46	0.55	192.2
15	CPFR061r.000	3/28/2006	11:37:20	11:57:40	-9064.2	-1258.0	-7271.5	-534.7	19009.1	2840.5	0.48	0.53	215.0
15	CPFR066r.000	3/28/2006	12:58:20	13:17:07	-6148.4	-1097.1	-4687.3	-363.9	18797.9	2789.3	0.33	0.36	250.8
15	CPFR071r.000	3/28/2006	13:55:14	14:12:07	-3099.1	-876.3	-2047.0	-175.8	20349.4	2861.7	0.15	0.24	274.8
15	CPFR076r.000	3/28/2006	14:49:43	15:06:17	974.0	-157.6	1058.3	73.3	21550.3	2868.9	0.05	0.27	321.1
15	CPFR082r.000	3/28/2006	16:03:27	16:23:42	4962.5	566.4	4088.4	307.7	23422.1	2848.9	0.21	0.26	6.0
15	CPFR087r.000	3/28/2006	17:06:04	17:27:09	5977.8	804.0	4829.8	344.1	24714.3	2879.1	0.24	0.24	26.4

Table 3.7 Maximum Magnitude of Mean Flows at New Channel Transect

		October 2000	**April 2002**	**March 2003**	**January 2004**	**March 2005**	**March 2006**
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)	3.00 ft/s (0.85 m/s)	2.89 ft/s (0.88 m/s)
	flood	1.31 ft/s (0.40 m/s)	1.93 ft/s (0.59 m/s)	2.69 ft/s (0.82 m/s)	1.32 ft/s (0.40 m/s)	1.32 ft/s (0.66 m/s)	NA
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)	3.64 ft/s (1.13 m/s)	3.64 ft/s (1.11 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)	1.59 ft/s (0.48 m/s)	1.59 ft/s (0.66 m/s)	NA

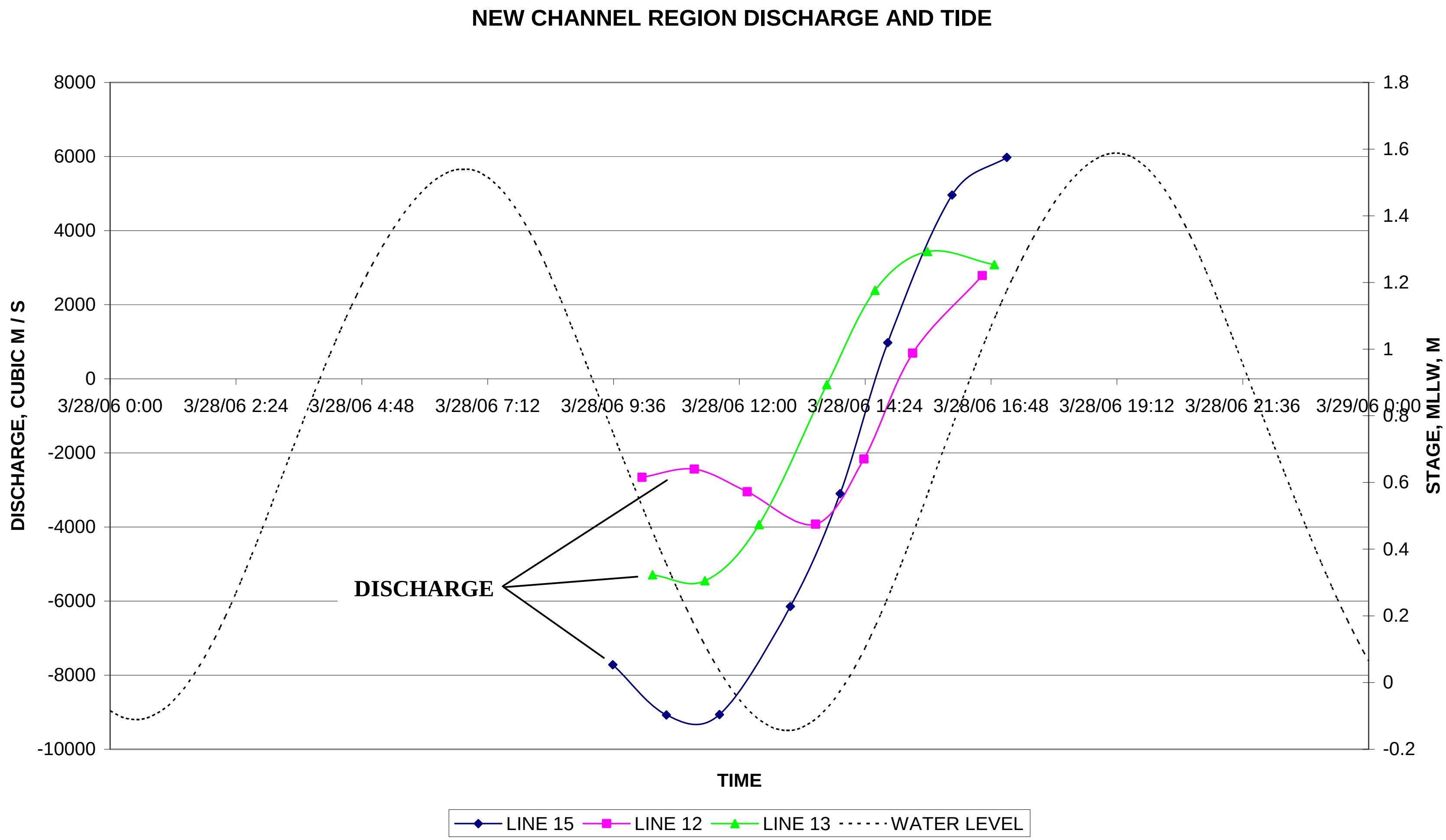


Figure 3.47 Discharge and Water Level for 28 March 2006 Data Collection at the New Channel Region

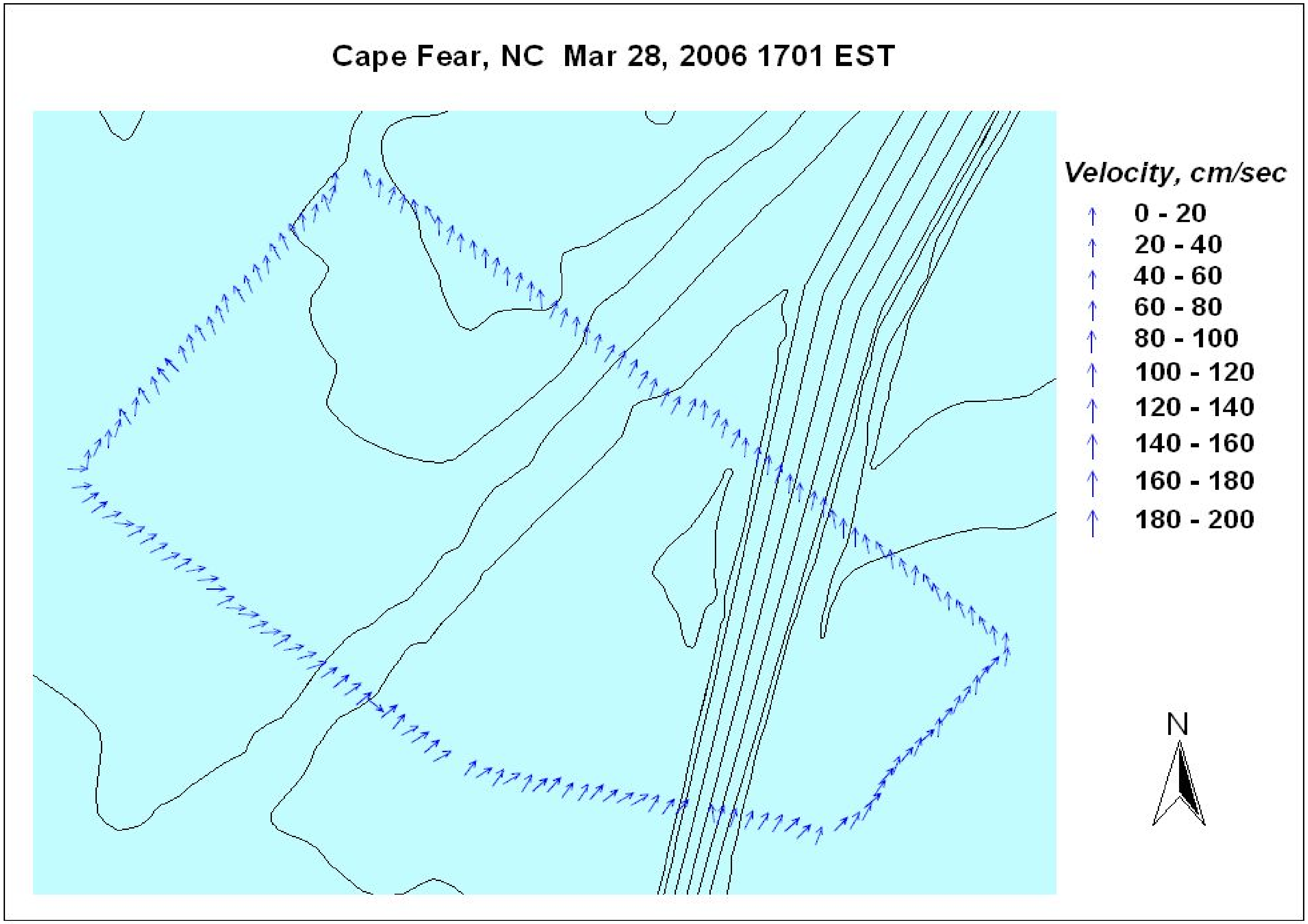


Figure 3.48 March 2006 ADCP survey at the offshore-new channel transect approaching peak flood flow

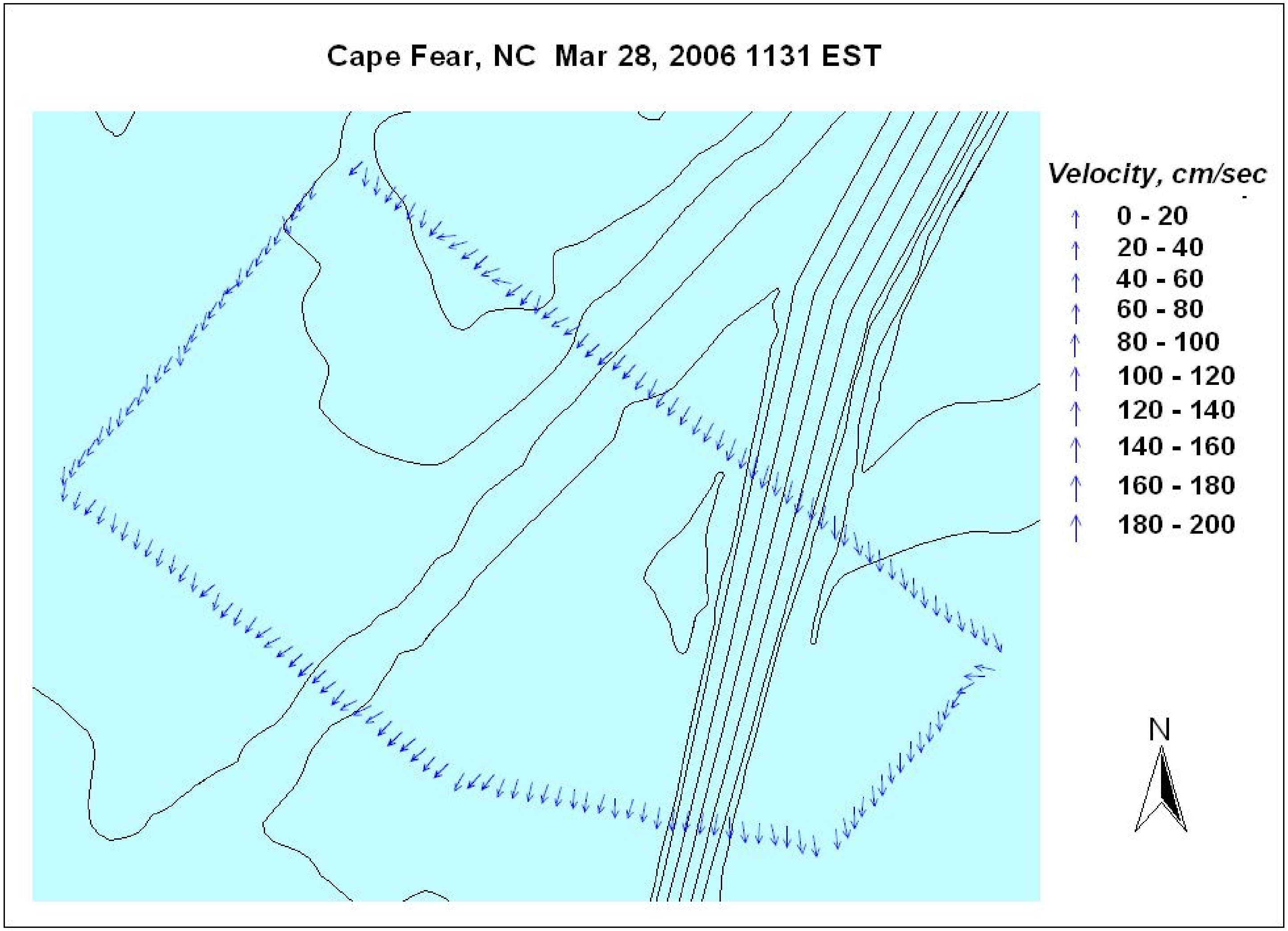


Figure 3.49 March 2006 ADCP survey at the offshore-new channel transect during peak ebb flow

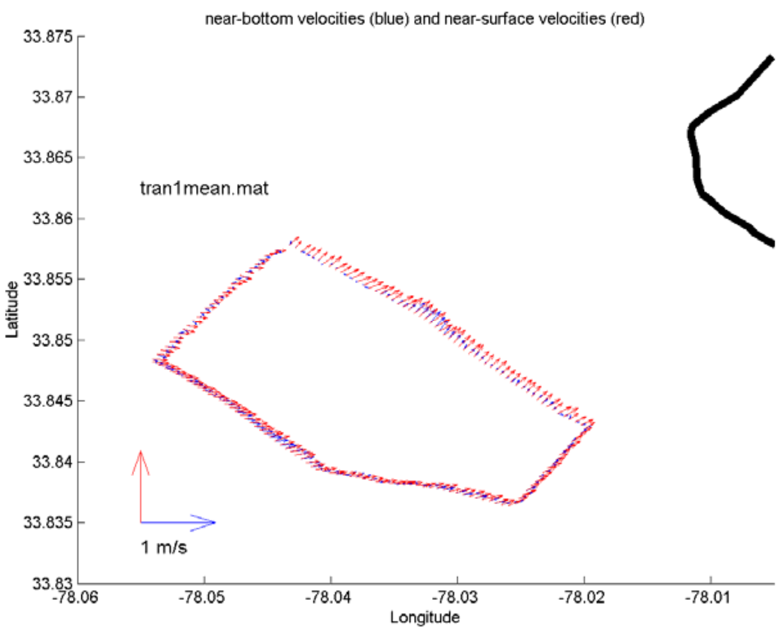


Figure 3.50 October 2000 ADCP survey at offshore transect during peak flood flow.

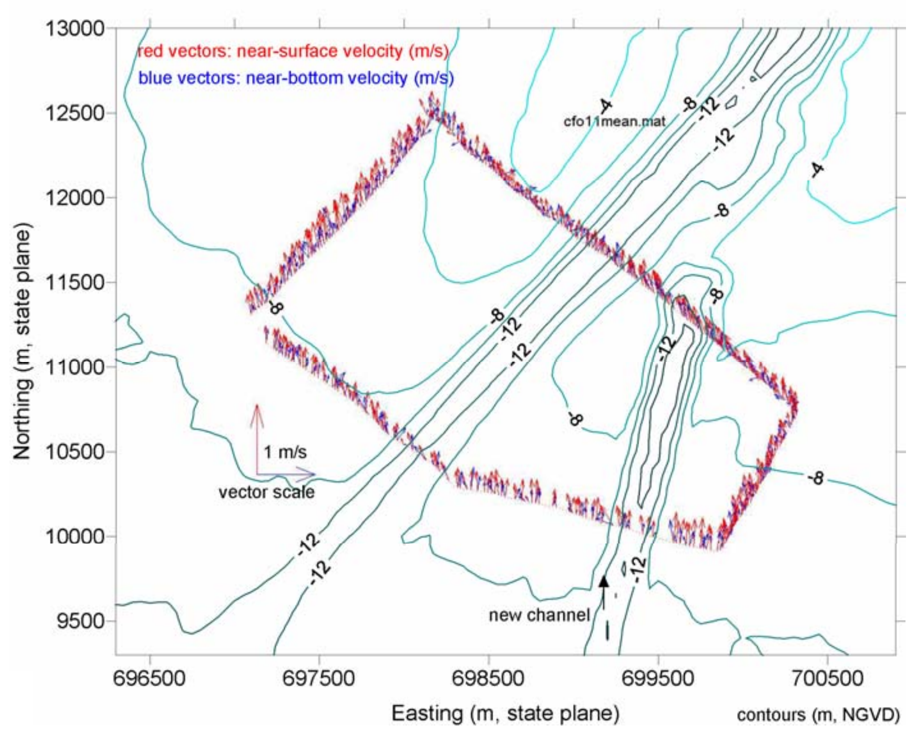


Figure 3.51 April 2002 ADCP survey at offshore transect during peak flood flow.

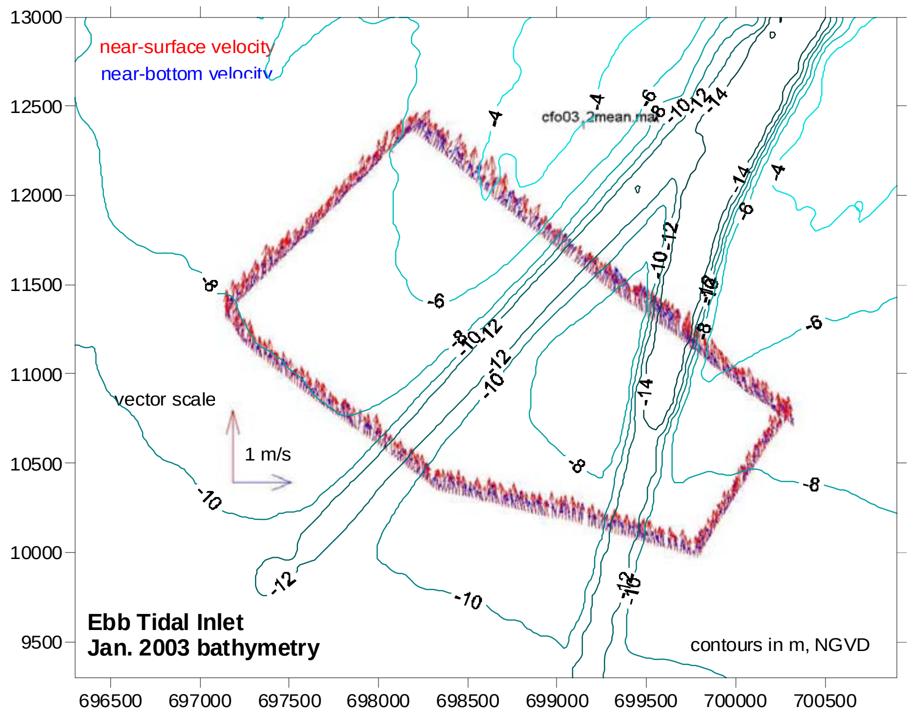


Figure 3.52 March 2003 ADCP survey at offshore transect during flood flow.

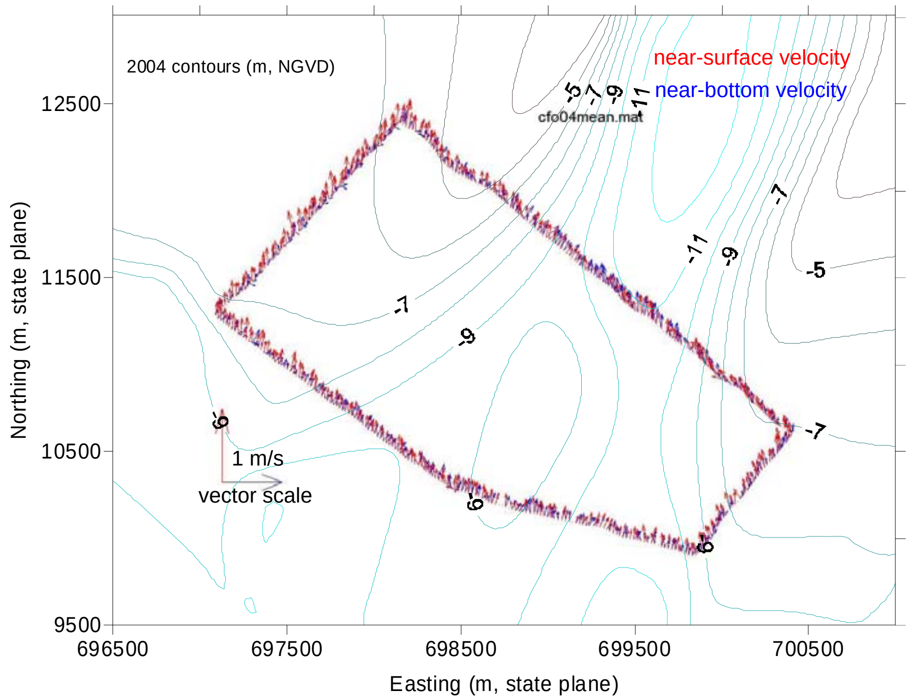


Figure 3.53 January 2004 ADCP survey at offshore transect during flood flow.

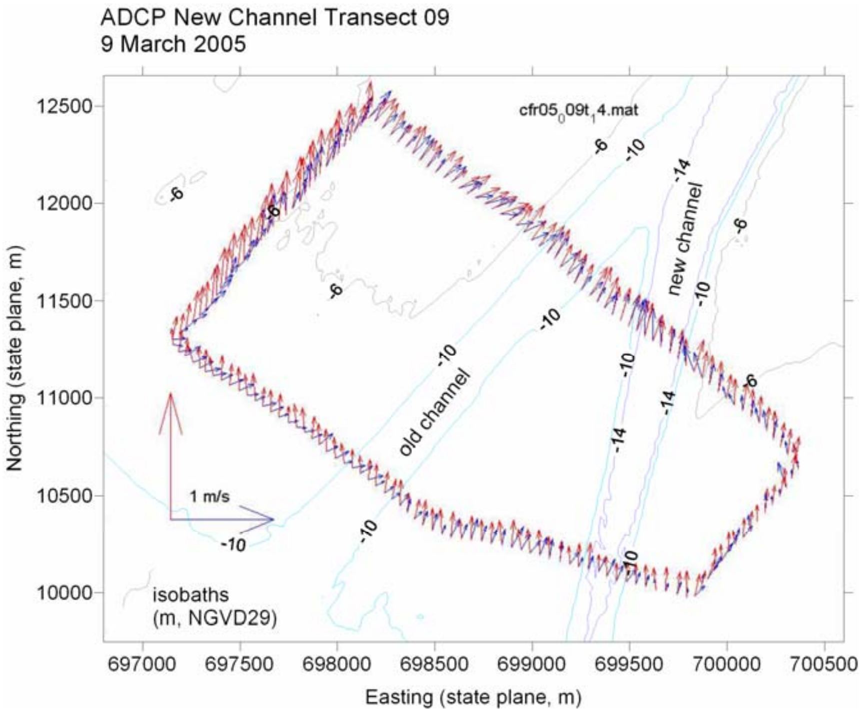


Figure 3.54 March 2005 ADCP survey at offshore transect during flood flow.

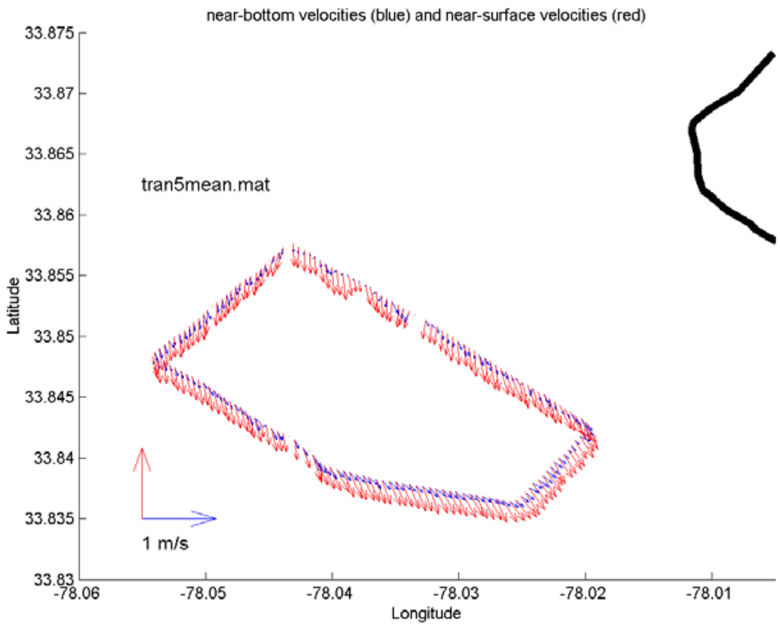


Figure 3.55 October 2000 ADCP survey at offshore transect during peak ebb flow.

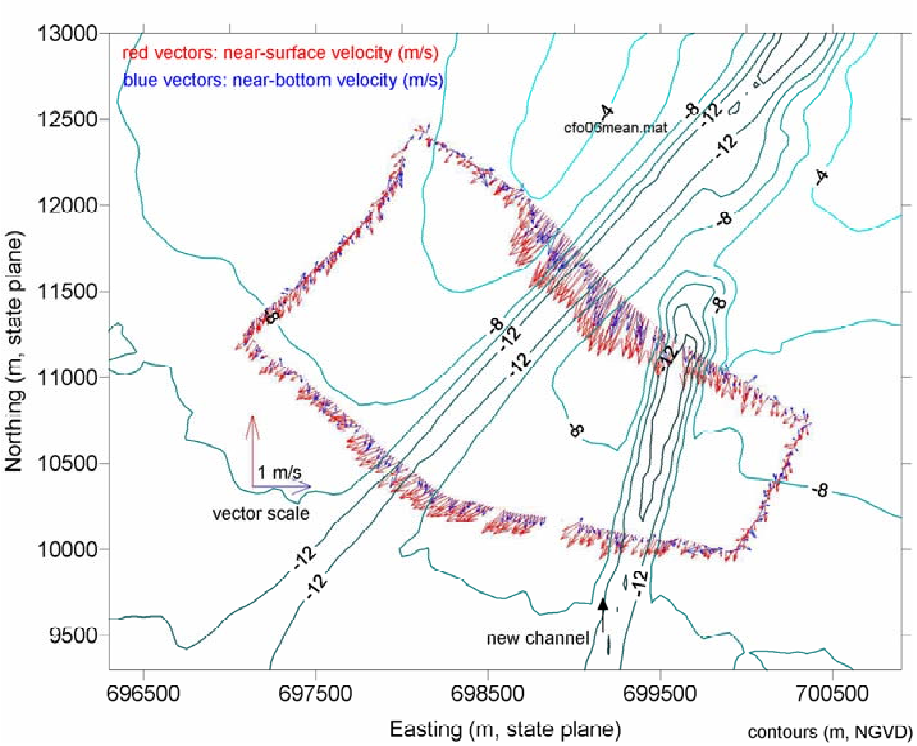


Figure 3.56 April 2002 ADCP survey at offshore transect during peak ebb flow.

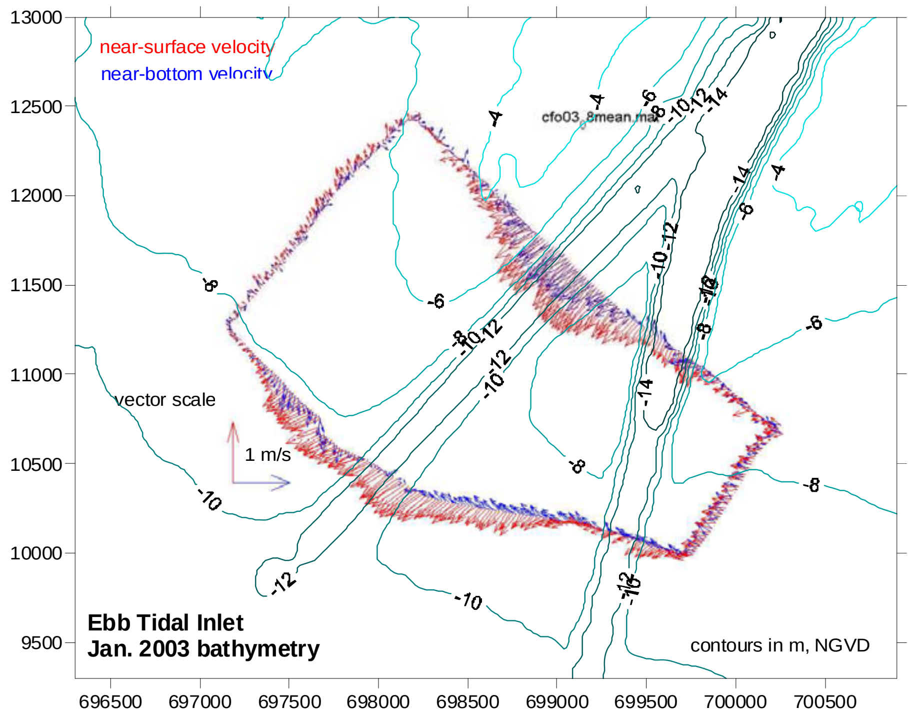


Figure 3.57 March 2003 ADCP survey at offshore transect during ebb flow.

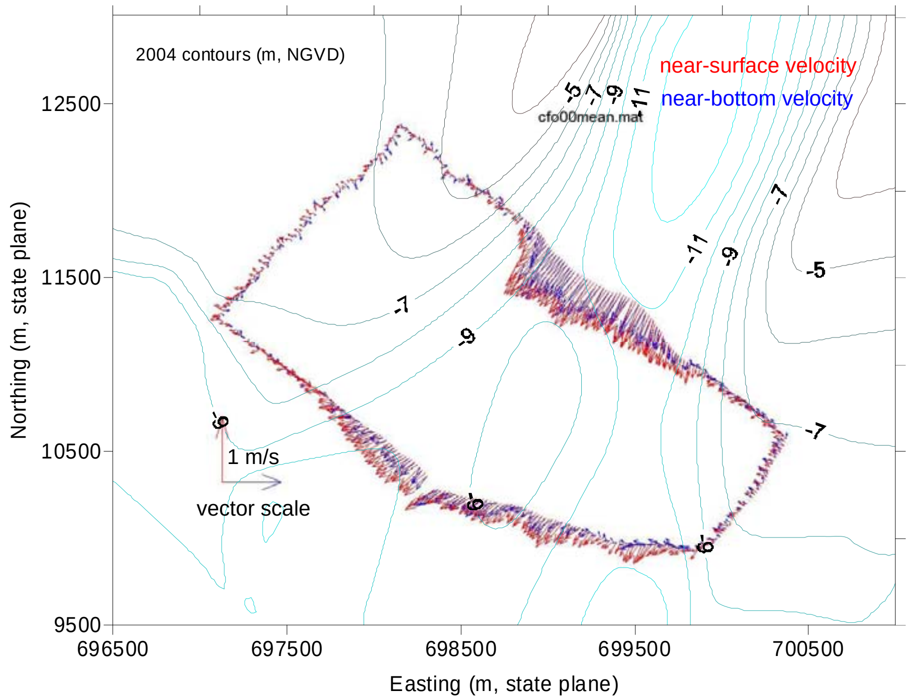


Figure 3.58 January 2004 ADCP survey at offshore transect during ebb flow.

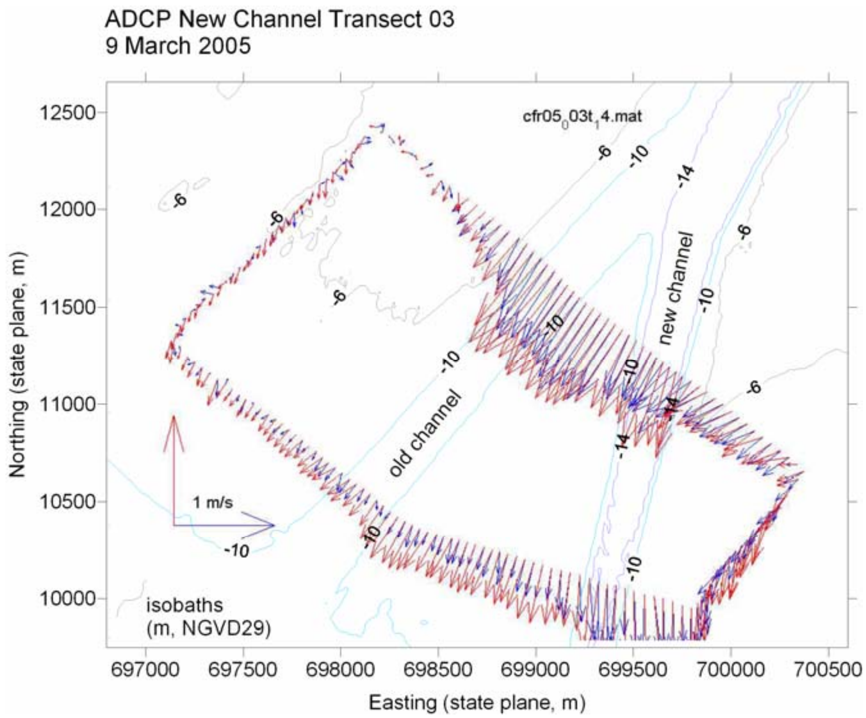


Figure 3.59 March 2005 ADCP survey at offshore transect during ebb flow.

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 6-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 3.60. Water depths are about 42 feet at 11-Mile, 23 feet at Oak Island, and 19 feet 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 an 82 day data gap between Sep-05 and May-06. The Bald Head Island gauge was operational during the same time period, but experienced some data losses for periods of 15 Aug to 26 Sep 2001, 8 Jan to 16 Jan 2002, 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 16 Apr 2002, 4 July and 1 August 2002, 15 Apr and 24 Apr 2003, 28 May and 11 June 2003. The gauge was apparently hit by lightning on 8 Apr 2005 and was not operational again until it was serviced in Sept 2005. The final outage was between 1 Sep 2005 and 27 Apr 2006 when a weak battery caused sporadic data acquisition.

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 2006 deployment. Tables 3.8 through 3.10 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 slightly from 3.0 to 3.1 feet. Average annual wave heights for the Bald Head and Oak Island gauges remained at 1.9 and 1.7 feet, respectively indicating significant wave transformation 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) with a minimum duration of 12-hours. The peak period (Tpmax) and wave direction (Dpmax) with each maximum wave height event were also computed. The 11-Mile gauge had monthly maximum wave heights on the order of 8.0 feet, with waves typically arriving from the southeast to southwest directions. Bald Head and Oak Island had monthly maximum wave heights of 6.0 and 5.1 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 3.61. This graph shows the mean monthly wave heights for all the data collected to date (2000-2006) for each of the three gauges. For the 11-mile gauge the largest waves are found to occur during 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 3.62 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 indicating the direction from which the waves are traveling. For the nearshore gauges, the mean wave directions are from the west-southwest during the summer months shifting to the south-southeast during the fall and winter. A similar shift is evident with the 11-mile wave directions.

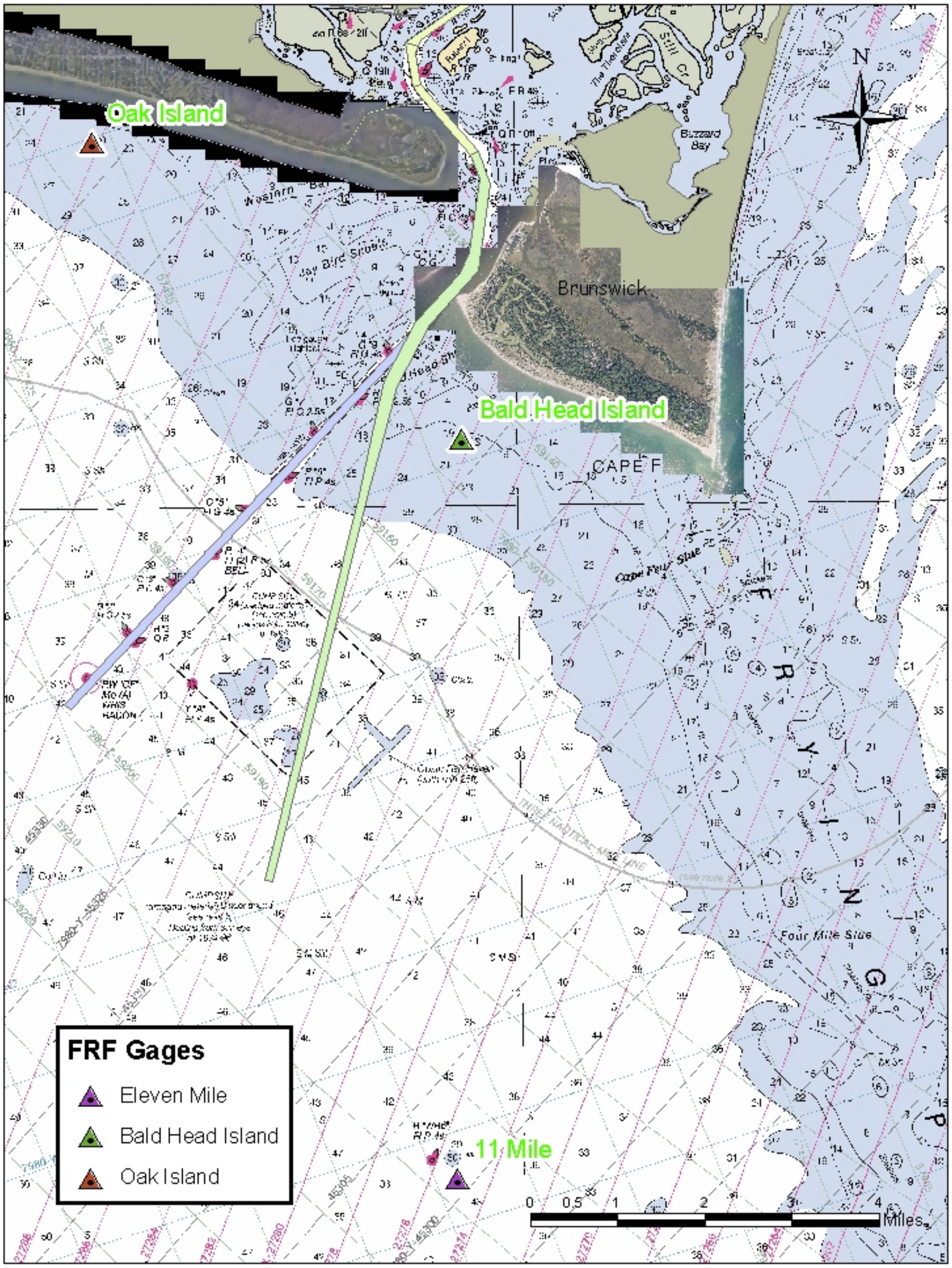


Figure 3.60 FRF Wave and Current Gauges.

Table 3.8 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	--	--	--	**9.1**
	AVERAGE		**8.3**	**8.5**	**9.8**	**7.8**	**7.4**	**7.0**	**6.3**	**7.0**	**8.5**	**6.5**	**9.0**	**9.8**	

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	--	--	--	**197.5**
	AVERAGE		**211.8**	**167.8**	**164.6**	**197.6**	**158.5**	**163.5**	**216.8**	**174.2**	**201.3**	**157.3**	**177.0**	**192.4**	

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	--	--	--	**3.2**
	AVERAGE		**3.0**	**3.2**	**3.4**	**3.1**	**3.0**	**3.0**	**3.0**	**2.8**	**3.5**	**2.8**	**3.0**	**3.2**	

(Continued)

Table 3.8 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	--	--	--	**14.9**
	AVERAGE		**13.7**	**13.1**	**15.6**	**15.8**	**13.7**	**14.4**	**10.0**	**18.3**	**16.0**	**18.7**	**17.1**	**15.7**	

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	--	--	--	**6.7**
	AVERAGE		**6.7**	**6.9**	**7.2**	**6.6**	**6.4**	**6.1**	**6.0**	**6.6**	**7.8**	**7.3**	**7.2**	**7.1**	

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	--	--	--	**169.8**
	AVERAGE		**174.3**	**146.4**	**156.7**	**164.8**	**166.6**	**163.9**	**174.1**	**151.6**	**140.5**	**138.9**	**153.1**	**156.9**	

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 3.9 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	**5.7**
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	--	--	--	**6.7**
	AVERAGE		**7.1**	**5.8**	**7.3**	**6.2**	**6.0**	**5.5**	**5.1**	**5.2**	**5.5**	**4.4**	**6.8**	**7.3**	

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	--	--	--	**205.0**
	AVERAGE		**199.8**	**191.0**	**190.2**	**200.2**	**202.3**	**202.7**	**203.3**	**193.2**	**200.5**	**187.3**	**194.7**	**194.3**	

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	**2.0**
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	--	--	--	**1.9**
	AVERAGE		**1.9**	**1.7**	**2.0**	**2.1**	**2.0**	**2.0**	**2.1**	**1.8**	**1.8**	**1.4**	**1.8**	**2.0**	

(Continued)

Table 3.9 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	--	--	--	**13.0**
	AVERAGE		**13.5**	**18.0**	**18.0**	**14.8**	**14.7**	**15.8**	**10.7**	**15.1**	**15.7**	**16.1**	**14.6**	**14.8**	

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	**6.9**
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	--	--	--	**6.7**
	AVERAGE		**7.3**	**7.7**	**7.4**	**6.7**	**6.5**	**6.1**	**5.7**	**6.2**	**8.9**	**8.1**	**7.6**	**7.4**	

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	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	**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	190	191.6	187.6	179.9	196	183.5	--	--	--	186.1	**186.9**
Bald Head	Dpmean	2006	--	--	--	--	186.6	188.5	194.6	185	177.7	--	--	--	**186.5**
	AVERAGE		**190.4**	**183.1**	**184.5**	**187.2**	**187.9**	**186.2**	**193.2**	**186.6**	**173.2**	**174.5**	**182.0**	**186.3**	

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

Table 3.10 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	**5.8**
Oak Island	HsMax	2005	6.2	4.1	7.3	--	--	--	--	--	3.2	4.2	5.8	5.1	**5.2**
Oak Island	HsMax	2006	6.2	--	--	--	4.8	6.2	3.4	5.9	5.0	--	--	--	**5.3**
	AVERAGE		**6.4**	**5.2**	**6.1**	**4.7**	**4.3**	**5.2**	**3.9**	**6.1**	**4.5**	**4.0**	**5.6**	**6.0**	

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	209	184	**186.3**
Oak Island	DpMax	2006	195.0	--	--	--	206.0	195.0	175.0	183.0	247.0	--	--	--	**200.2**
	AVERAGE		**196.6**	**199.5**	**185.3**	**194.3**	**198.0**	**192.6**	**210.8**	**188.3**	**201.4**	**208.6**	**188.5**	**197.8**	

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	**1.8**
Oak Island	HsMean	2005	1.6	1.4	2.0	--	--	--	--	--	1.4	1.2	1.5	1.4	**1.6**
Oak Island	HsMean	2006	2.2	--	--	--	1.6	1.7	1.6	1.4	1.2	--	--	--	**1.6**
	AVERAGE		**1.8**	**1.5**	**1.8**	**1.8**	**1.8**	**1.8**	**2.0**	**1.7**	**1.6**	**1.3**	**1.5**	**1.7**	

(Continued)

Table 3.10 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	20.2
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	25.6	25.6	15.6
Oak Island	TpMax	2005	25.6	11.6	16.0	--	--	--	--	--	25.6	16	25.6	21.3	19.7
Oak Island	TpMax	2006	11.6	--	--	--	25.6	25.6	9.8	21.3	25.6	--	--	--	19.9
	AVERAGE		**16.2**	**13.9**	**16.0**	**14.4**	**22.4**	**14.8**	**9.3**	**21.1**	**20.1**	**17.8**	**17.8**	**16.0**	

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	6.7
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
	AVERAGE		**7.0**	**7.8**	**7.7**	**7.3**	**7.5**	**6.7**	**5.2**	**6.0**	**8.7**	**8.4**	**8.0**	**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
	AVERAGE		**195.0**	**185.8**	**189.1**	**191.6**	**193.9**	**192.3**	**201.8**	**183.5**	**179.6**	**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.

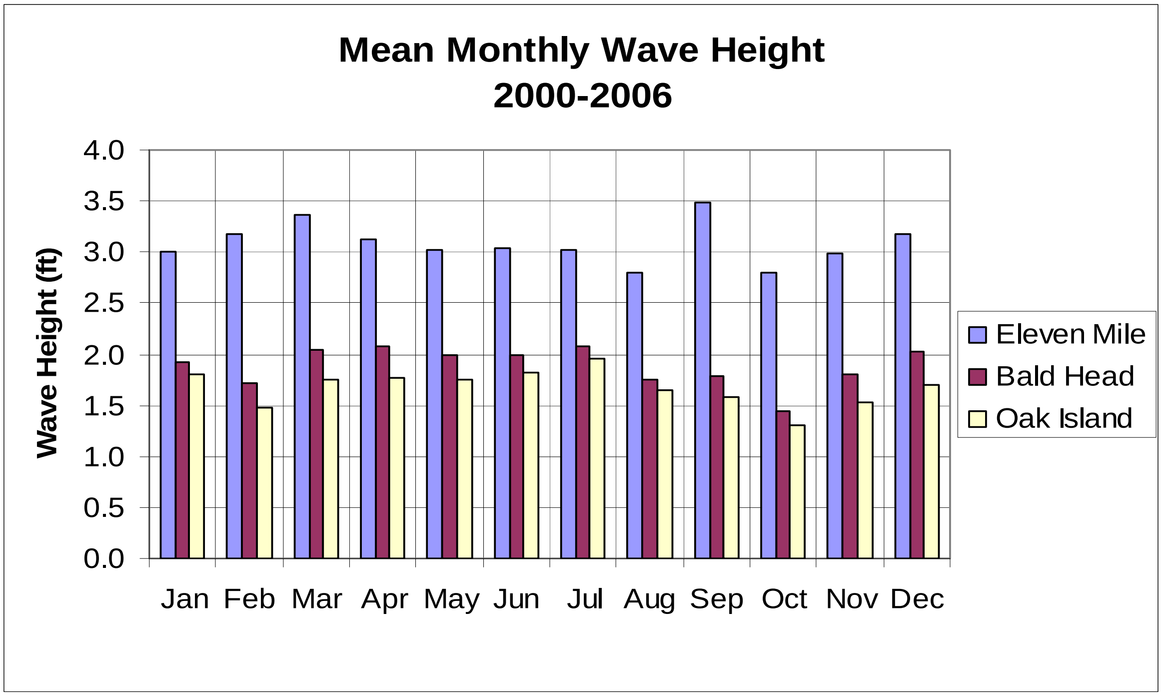


Figure 3.61 Mean Monthly Wave Height 2000-2006 for the Eleven Mile, Bald Head and Oak Island Gauges

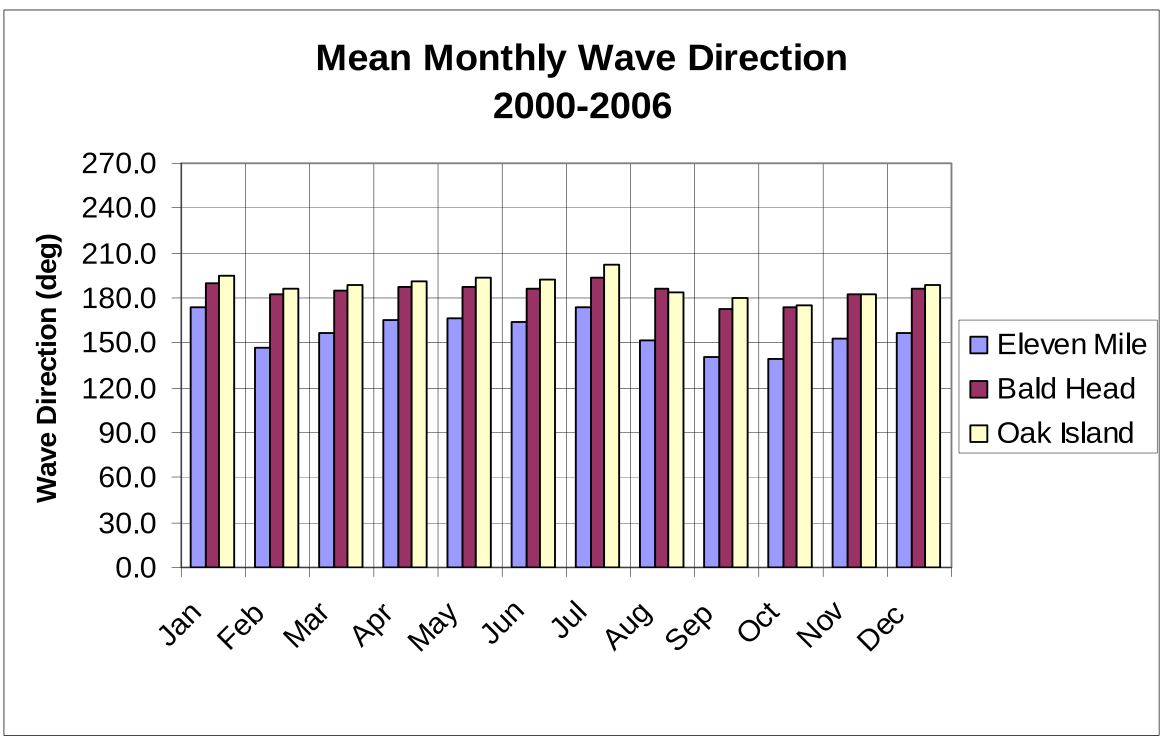


Figure 3.62 Mean Monthly Wave Direction 2000-2006 for the Eleven Mile, Bald Head and Oak Island Gauges

Further insights on the wave climate variability and the impacts of Frying Pan Shoals are shown on Figures 3.63 and 3.64. Figure 3.63 show wave histograms that were created using all available data from each gauge for the September 2000 to September 2006 time period. Figure 3.64 show 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 and 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.

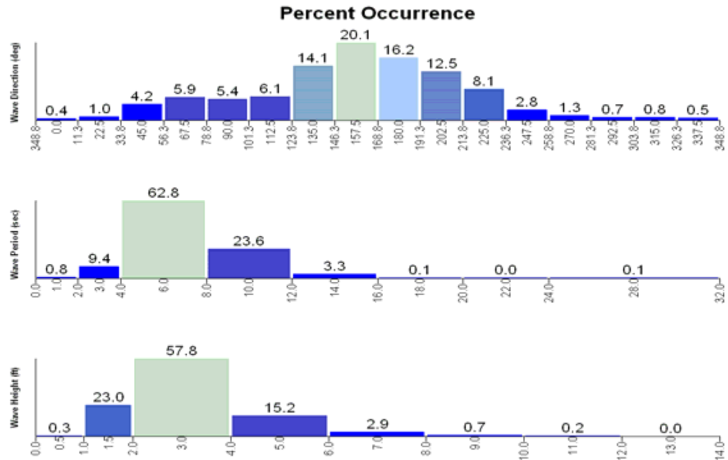
Time series for each gauge were separated into yearly components and analyzed to assess the statistical variation in wave climate. Annual wave height roses for all three gauges for 2000, 2001, 2002, 2003, 2004, 2005, and 2006 were generated and are given in Appendix A. The year to year comparison of 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 3.65 and 3.66 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 six year time span. For the 11-mile gauge, slightly more energetic years are evident in 2002, 2005, and 2006 (to date), than the other years which were essentially the same (except for 2000 which only contains a partial year of data). The nearshore gauges are likewise similar over the years. With regard to the yearly variation in terms of mean wave direction, years 2003 thru 2005 are essentially identical for each of the gauges. For 2001 and 2002, the data show a slightly more easterly component for all the gauges when compared to the other years. Year 2006 showed a slight turn of the mean wave direction to a more south-southeast direction.

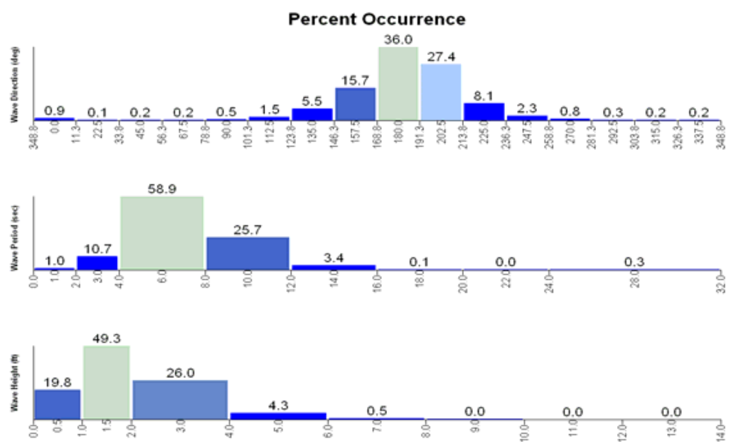
<u>Significant Events.</u> Several large storm events occurred during the monitoring period that may have significantly altered adjacent beach shorelines and beach profiles. An analysis was conducted to identify storm event parameters that exceeded a 6-ft significant wave height threshold with a minimum duration of 12-hrs. Events were selected through screening of the 11-Mile Gauge time series. Associated peak parameters for the Bald Head and Oak Island gauges are reported. Ten additional events were added since report three, with Table 3.11 summarizing the 52 events that exceeded the set criteria over the entire monitoring period. The majority of the events occurred in the winter (December through March). Waves typically originated from the south-southwest, with offshore wave heights of 8 to 11-ft and wave periods of 10 to 11 seconds. Parameters of the significant events since the last

report closely resemble these averages. Corresponding conditions at the nearshore gauges indicate significant reduction in wave height, with Bald Head and Oak Island being reduced by 31 and 43 percent, respectively. The largest significant wave recorded to date at the 11-mile gauge was 11.7 feet in March 2005. At this peak time the waves were 8.5 feet and 7.1 feet at the Bald Head and Oak Island gauges. 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. The largest significant wave record since the last report for the 11-mile gauge was 11.5 feet on September 14, 2005. This corresponded to a wave height of 3.9 feet at the Oak Island gauge, again showing the significant wave transformation between the offshore and nearshore locations. The Bald Head Island gauge was inoperable at the time of this event and no wave data is available.

Eleven-Mile Gauge (Sep 2000 – Sep 2006)



Bald Head Gauge (Sep 2000 – Sep 2006)



Oak Island Gauge (Sep 2000 –Sep 2006)

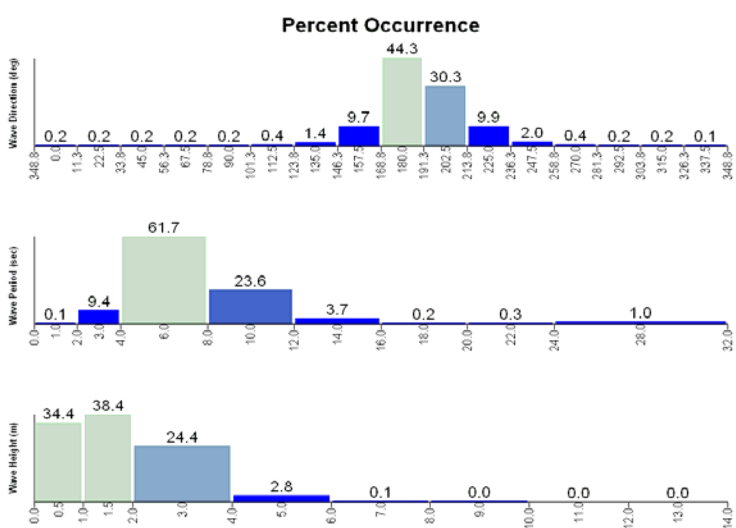
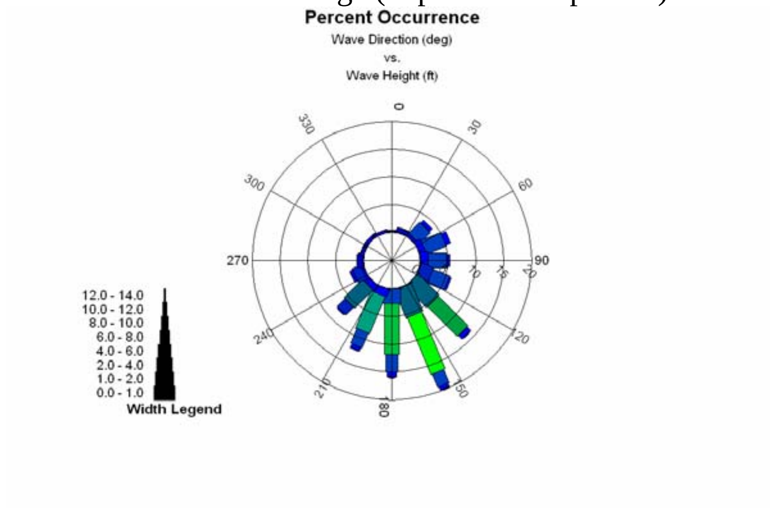
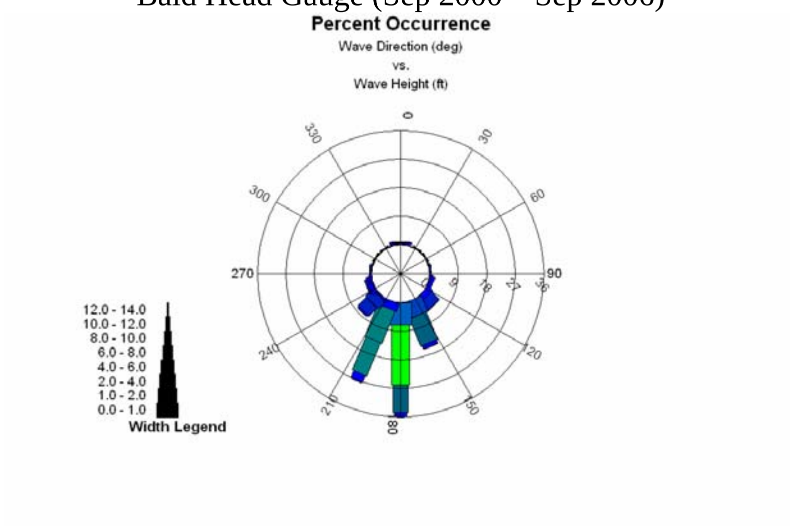


Figure 3.63 Wave Histograms for FRF Gauges throughout deployment.

Eleven-Mile Gauge (Sep 2000 – Sep 2006)



Bald Head Gauge (Sep 2000 – Sep 2006)



Oak Island Gauge (Sep 2000 – Sep 2006)

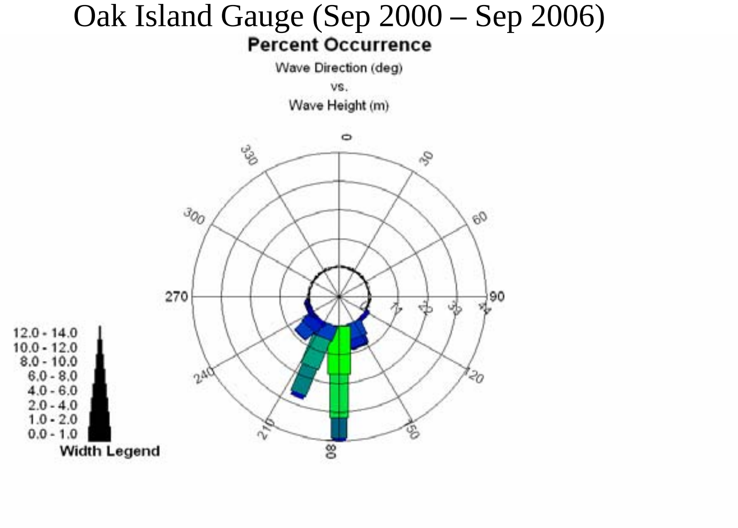


Figure 3.64 Wave Height Roses for FRF Gauges throughout deployment.

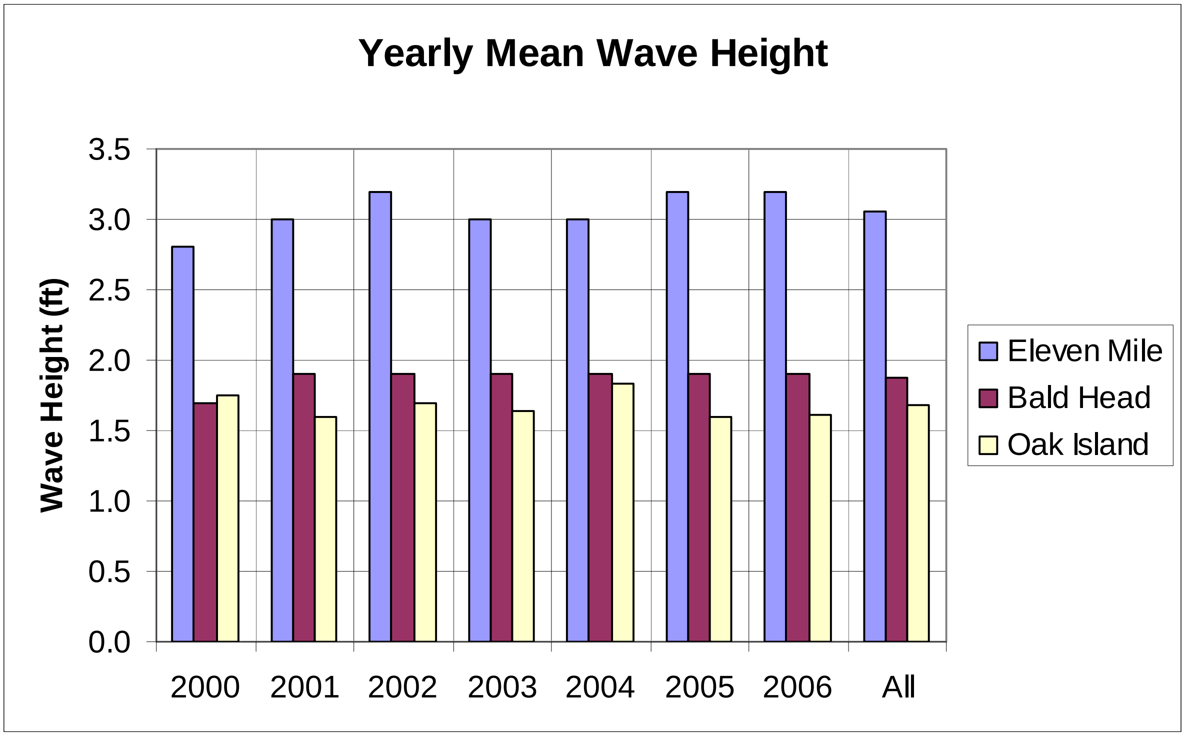


Figure 3.65 Yearly Mean Wave Heights for Years 2000 through 2006

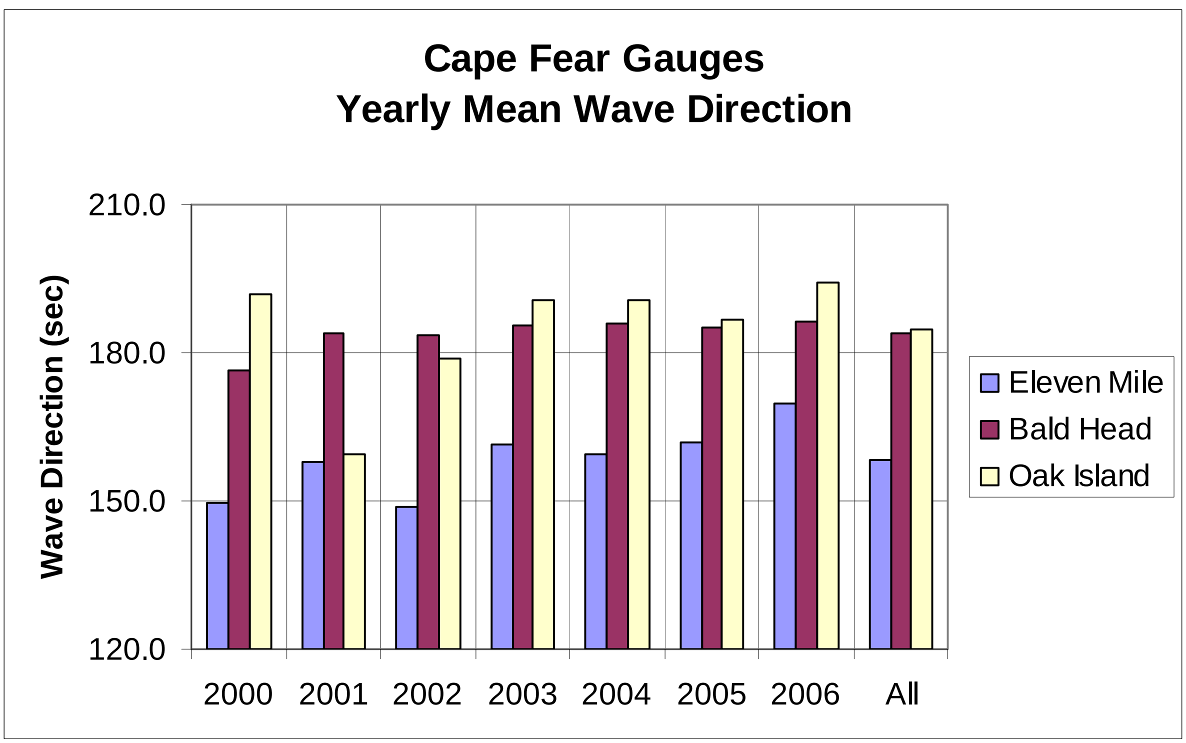


Figure 3.66 Yearly Mean Wave Directions for Years 2000 through 2006

Table 3.11 Significant Events at 11-Mile Gauge Exceeding Significant Wave Height of 6-ft.

						ELEVEN MILE GAGE					BALD HEAD GAGE			OAK ISLAND GAGE		
EVENT	START DATE	TIME	STOP DATE	TIME	Dur (hrs)	Hs (ft)	Tp (sec)	Dp (deg)	DATE PEAK	TIME	Hs (ft)	Tp (sec)	Dp (deg)	Hs (ft)	Tp (sec)	Dp (deg)
1	16-Dec-00	3:00	16-Dec-00	18:00	15.00	11.3	9.8	199.5	16-Dec-00	15:00	7.8	9.8	181.4	--	--	--
2	20-Jan-01	6:00	21-Jan-01	0:00	18.00	6.6	8.5	196.3	21-Jan-01	0:00	5.9	9.1	194.8	--	--	--
3	20-Mar-01	12:00	22-Mar-01	0:00	36.00	10.8	11.6	169.0	20-Mar-01	18:00	8.9	12.8	180.8	--	--	--
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	5.7	14.2	212.6	5.2	14.2	200.7
8	6-Jan-02	11:30	7-Jan-02	8:45	21.25	11.2	10.6	189.6	6-Jan-02	14:45	9.0	11.6	201.3	8.3	11.6	195.3
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	11.6	186.3	5.3	14.2	182.8
10	2-Mar-02	13:00	3-Mar-02	22:00	33.00	11.5	10.6	167.8	2-Mar-02	19:00	8.1	25.6	187.5	6.6	32.0	182.3
11	6-Nov-02	4:00	6-Nov-02	19:00	15.00	9.7	10.6	195.8	6-Nov-02	10:00	7.4	11.6	180.3	6.6	18.2	169.9
12	29-Nov-02	22:00	30-Nov-02	22:00	24.00	8.6	8.0	203.4	30-Nov-02	4:00	6.4	12.8	202.1	5.9	11.6	207.7
13	13-Dec-02	13:00	14-Dec-02	16:00	27.00	7.6	9.8	169.2	14-Dec-02	4:00	6.4	9.8	184.1	5.3	9.8	192.7
14	20-Dec-02	1:00	21-Dec-02	1:00	24.00	8.4	9.1	182.6	20-Dec-02	7:00	6.4	10.6	190.3	5.3	10.6	196.2
15	25-Dec-02	10:00	26-Dec-02	1:00	15.00	8.8	9.8	198.0	25-Dec-02	13:00	6.5	14.2	189.3	6.0	16.0	199.4
16	1-Jan-03	1:00	1-Jan-03	16:00	15.00	7.2	9.8	175.8	1-Jan-03	4:00	5.8	10.6	184.7	4.3	16.0	184.3
17	8-Jan-03	4:00	10-Jan-03	4:00	48.00	7.3	8.5	209.8	9-Jan-03	7:00	5.8	8.5	211.2	4.7	9.8	211.2
18	19-Jan-03	7:00	20-Jan-03	19:00	36.00	7.4	8.0	211.9	20-Jan-03	10:00	6.3	9.1	200.8	5.4	9.8	206.1
19	22-Feb-03	19:00	23-Feb-03	16:00	21.00	9.7	9.8	182.4	23-Feb-03	7:00	7.6	11.6	184.3	6.6	11.6	189.8
20	20-Mar-03	7:00	21-Mar-03	7:00	24.00	8.5	9.1	163.1	20-Mar-03	16:00	5.8	9.8	184.0	5.3	9.8	190.7
21	17-Sep-03	1:00	18-Sep-03	19:00	42.00	9.1	6.7	319.0	18-Sep-03	13:00	5.4	5.8	278.0	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	198.0	2.6	6.7	228

(Continued)

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 3.11 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 four 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), and (4) through the most recent survey of October 2006. 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 2005), 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). The rates computed through June 2003 vary from +115 to –10 feet per year. For the remaining three survey periods, the rates are seen to moderate but still remain largely positive. Specifically, the rates through the June 2004 range from about +80 to –5 feet per year with the August 2005 period ranging from +60 to –1 feet per year. The most recent period, covering over the last six years, the rates are all positive except for Profile 10, which is slightly negative. In this latest time period, the rates range from about +50 to -0.4 feet per year.

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 +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 +25 to +50 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. With the updated rates through the current period, 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 +24 feet per year for the 6-year post-construction period. By comparison the pre-construction rate over the entire reach was an average of –1.1 feet per year.

Table 4.1 Oak Island Shoreline Change Rates

Profile ID	Post-Construction Rate (ft/yr)				Longshore Average Rate (ft/yr)				Longshore Average Pre-Construction Rate 1938-2000 (ft/yr)
	Aug-00 thru:				Aug-00 thru:				
	Jun-03	Jun-04	Aug-05	Oct-06	Jun-03	Jun-04	Aug-05	Oct-06	
5	-5.4	-3.2	-2.0	-1.4	1.0	1.3	1.9	2.0	
10	1.3	0.8	0.9	0.8	-1.5	-1.2	-0.8	-0.4	
15	7.0	6.4	7.0	6.8	-4.1	1.0	3.1	3.3	
20	-8.7	-8.7	-9.1	-7.7	0.2	7.2	8.0	7.5	
25	-14.8	9.8	19.0	17.9	-6.8	2.2	3.8	4.2	
30	16.1	27.7	22.1	19.5	-12.5	-3.1	-0.7	1.2	
35	-33.4	-24.3	-20.2	-15.3	-12.9	-0.7	3.0	4.8	29.9
40	-21.9	-20.1	-15.3	-8.3	-6.1	0.3	2.0	3.3	17.2
45	-10.6	3.5	9.2	10.1	-3.2	-0.5	1.5	2.2	7.9
50	19.2	14.8	14.2	10.6	11.7	10.3	10.3	8.8	2.5
55	30.8	23.5	19.6	14.2	20.8	17.4	15.8	12.1	0.8
60	41.3	29.6	24.0	17.5	30.7	21.9	18.2	13.4	0.3
65	23.3	15.6	11.9	8.1	32.9	23.0	18.6	13.6	0.2
70	38.8	25.9	21.5	16.4	35.9	24.9	20.1	15.1	0.4
75	30.4	20.6	15.7	11.8	35.0	24.2	19.7	15.1	0.9
80	45.8	33.0	27.2	21.5	35.5	24.7	20.3	16.0	1.6
85	36.4	26.0	22.2	17.8	27.3	19.6	16.0	12.8	1.9
90	25.9	18.0	14.8	12.4	22.9	17.0	14.5	11.9	2.2
95	-1.9	0.2	0.1	0.5	13.4	10.7	9.5	8.1	2.5
100	8.2	7.9	8.0	7.3	8.0	7.0	6.5	5.7	2.6
105	-1.6	1.3	2.7	2.6	4.4	5.2	5.2	4.6	2.5
110	9.6	7.4	7.2	5.9	12.0	10.9	10.1	8.4	2.1
115	7.6	9.2	8.1	6.5	17.8	15.4	13.2	10.4	1.5
120	36.2	28.9	24.3	19.7	32.9	25.7	20.8	16.1	0.7
125	37.1	30.2	23.6	17.1	44.9	34.7	27.1	21.1	-0.3
130	73.8	52.7	40.6	31.2	55.4	42.4	33.2	25.9	-0.9
135	69.7	52.3	39.0	30.8	62.1	47.6	36.8	28.7	-1.4
140	60.2	47.8	38.5	30.6	68.7	51.7	40.6	32.3	-2.1
145	69.7	54.8	42.2	33.6	64.5	49.4	39.1	31.4	-2.3
150	70.2	50.8	42.9	35.3	62.9	47.3	38.0	30.5	-2.5
155	52.9	41.4	33.1	26.6	61.9	45.8	36.4	29.1	-2.8
160	61.4	41.5	33.5	26.6	61.6	44.5	35.6	28.4	-3.3
165	55.0	40.4	30.3	23.6	60.1	43.9	34.1	26.6	-3.9
170	68.7	48.5	38.2	29.8	60.7	43.4	33.4	25.8	-4.3
175	62.2	47.9	35.3	26.5	60.3	43.5	32.9	25.2	-4.7
180	56.0	38.6	29.9	22.5	61.4	44.2	33.4	25.5	-5.0
185	59.6	42.4	30.6	23.4	59.6	43.2	32.0	24.4	-5.3
190	60.6	43.5	33.0	25.6	59.8	42.7	31.9	24.6	-5.4
195	59.4	43.8	31.1	24.0	61.1	44.5	33.2	25.9	-5.5
200	63.5	45.4	35.1	27.6	63.5	46.3	35.3	27.8	-5.6
205	62.3	47.6	36.1	28.8	63.9	46.8	35.8	28.3	-5.7
210	71.9	51.2	41.2	33.0	66.3	48.2	37.8	30.0	-5.8
215	62.3	46.1	35.4	27.9	64.0	47.1	36.9	29.2	-5.7
220	71.6	50.9	41.2	32.5	64.2	46.7	37.2	29.5	-5.5
225	52.3	39.9	30.8	24.0	57.5	42.3	33.7	26.7	-5.2
230	63.1	45.2	37.3	30.1	56.1	41.3	33.8	26.9	-4.8
235	38.1	29.3	24.0	19.1	50.3	37.9	31.3	25.0	-4.4
240	55.5	41.2	35.6	28.8	52.1	39.3	33.3	27.0	-4.1
245	42.6	33.6	28.6	23.2	48.1	37.3	31.9	25.9	-3.9
250	61.4	47.4	41.1	34.0	53.7	41.5	35.8	29.3	-3.7
255	42.8	35.2	30.1	24.5	53.9	41.7	36.0	29.5	-3.6
260	66.0	50.1	43.7	36.2	60.5	46.3	40.2	33.1	-3.5
265	56.5	42.1	36.4	29.8	58.9	45.2	38.9	31.9	-3.3
270	75.7	56.9	49.6	40.9	66.1	50.1	43.4	35.6	-3.2
275	53.5	41.8	35.0	28.2	67.4	51.2	43.8	35.8	-3.0
280	78.9	59.6	52.2	42.9	72.0	54.5	46.6	37.9	-2.8
285	72.3	55.4	45.8	36.9	73.5	55.8	46.9	37.8	-2.7
290	79.7	58.8	50.5	40.6	82.7	61.8	52.0	41.8	-2.6
295	83.0	63.3	50.9	40.3	86.9	64.5	53.1	42.2	-2.5
300	99.5	72.1	60.7	48.2	95.8	69.7	57.4	45.5	-2.3
305	99.9	73.1	57.4	44.8	99.8	72.4	59.1	46.7	-2.2
310	116.9	81.2	67.2	53.3	105.5	75.5	61.8	48.8	-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
	Sep-00 thru:				Sep-00 thru:				1938-2000
	Jun-03	Jun-04	Aug-05	Oct-06	Jun-03	Jun-04	Aug-05	Oct-06	(ft/yr)
0	-3.1	1.0	2.3	3.0	-3.0	-2.1	-1.6	-1.0	
4	-6.2	-5.6	-5.0	-4.1	-1.6	-1.1	-1.0	-0.4	
8	0.3	-1.7	-2.3	-1.9	0.0	0.4	-0.1	0.4	
12	2.6	1.9	0.7	1.2	1.7	1.2	-0.3	0.1	
16	6.3	6.2	3.9	3.7	5.9	4.3	1.2	1.6	
20	5.7	5.0	1.0	1.4	4.6	1.3	-3.1	-2.0	
24	14.7	10.0	2.7	3.5	1.3	-3.9	-6.7	-1.2	
28	-6.5	-16.7	-23.8	-19.8	-3.3	-1.7	-1.9	4.5	
32	-13.7	-23.9	-17.0	5.0	15.1	10.5	7.0	9.9	
36	-16.6	16.9	27.8	32.4	18.1	6.6	1.2	2.4	
40	97.6	66.1	45.1	28.4	22.2	6.1	1.3	0.0	
43	29.9	-9.6	-26.1	-34.2	21.6	4.0	-0.6	4.8	
45	13.6	-18.8	-23.1	-31.6	19.8	-7.5	-10.6	-5.0	
47	-16.3	-34.3	-26.5	29.0	-5.1	-30.0	-24.1	-13.8	
53	-25.5	-40.9	-22.2	-16.8	-18.1	-39.3	-24.9	-11.2	-2.4
57	-27.0	-46.1	-22.5	-15.2	-24.4	-40.5	-20.9	-4.9	-5.5
61	-35.2	-56.4	-30.2	-21.1	-23.6	-37.4	-15.6	-10.0	-5.6
66	-18.1	-24.9	-3.2	-0.2	-19.7	-32.5	-10.3	-5.5	-5.9
69	-12.0	-19.0	0.1	3.5	-14.8	-24.7	-3.8	-0.4	-6.4
73	-6.1	-16.1	4.3	5.7	-6.5	-14.5	5.6	7.1	-5.5
78	-2.4	-7.3	10.0	10.4	-2.0	-10.6	9.1	9.8	-4.6
84	6.2	-5.3	17.0	16.3	2.7	-7.3	12.3	11.9	-3.7
88	4.3	-5.4	14.3	13.0	5.6	-4.6	14.3	13.5	-3.1
92	11.3	-2.3	15.8	13.9	8.8	-3.1	15.4	14.2	-2.6
97	8.8	-2.8	14.2	13.7	13.7	0.4	16.1	14.3	-2.0
102	13.5	0.2	15.5	14.0	19.0	3.8	17.3	14.8	-1.6
106	30.8	12.5	20.8	17.1	26.0	8.9	19.5	16.2	-1.5
110	30.5	11.6	20.0	15.4	34.2	14.8	22.5	17.8	-1.6
114	46.2	23.2	27.0	20.9	43.0	21.4	26.1	20.1	-1.6
118	50.1	26.5	28.9	21.4	47.9	25.3	28.1	21.5	-1.8
122	57.6	33.0	33.7	25.9	50.2	27.2	28.1	21.5	-1.9
126	54.9	32.3	31.1	23.8	51.5	28.9	27.3	20.8	-2.0
130	42.4	21.2	19.7	15.4	53.4	31.1	26.8	20.9	-2.1
134	52.4	31.6	22.9	17.6	53.2	31.5	24.7	19.3	-2.0
138	59.9	37.3	26.8	21.5	54.4	33.0	24.1	19.0	-2.0
142	56.3	35.1	22.9	18.2	59.0	37.4	25.7	20.1	-2.3
146	60.9	39.8	28.2	22.0	61.8	39.9	27.4	21.5	-2.6
150	65.8	43.3	27.6	21.0	65.0	42.9	29.2	22.3	-2.9
154	66.0	44.1	31.5	24.7	69.5	46.2	32.5	24.4	-3.9
158	75.9	52.3	35.9	25.5	72.6	48.7	34.2	25.3	-4.7
162	78.9	51.8	39.4	28.7	72.8	49.3	35.8	26.1	-5.2
166	76.3	52.3	36.9	26.7	71.6	49.5	36.0	25.7	-5.4
170	67.1	45.9	35.5	25.0	71.6	49.3	36.8	26.8	-5.6
174	59.7	45.0	32.2	22.7	67.5	47.1	34.8	25.5	-5.9
178	76.1	51.4	40.1	30.7	62.0	43.2	32.4	24.3	-6.2
182	58.2	40.9	29.2	22.2	57.1	39.9	29.7	22.9	-6.5
186	48.7	33.0	25.1	20.7	51.6	35.5	27.1	21.8	-7.0
190	42.9	29.3	22.0	18.1	42.0	30.0	22.9	19.1	-7.8
194	31.8	22.9	18.9	17.1	34.5	26.3	20.8	18.3	-8.6
198	28.3	23.7	19.1	17.4	25.4	21.9	17.6	16.9	-10.0
202	20.8	22.7	18.7	18.2	15.1	16.7	14.3	16.3	-11.9
206	3.2	10.7	9.0	13.5	6.8	12.4	12.1	17.7	-13.7
210	-8.8	3.4	5.8	15.3	0.2	8.9	11.2	14.5	-15.0
214	-9.6	1.2	7.6	24.2	-3.6	4.3	9.3	13.6	-17.8
218	-4.8	6.2	14.7	1.3	0.1	3.4	9.4	13.6	-20.8
222									

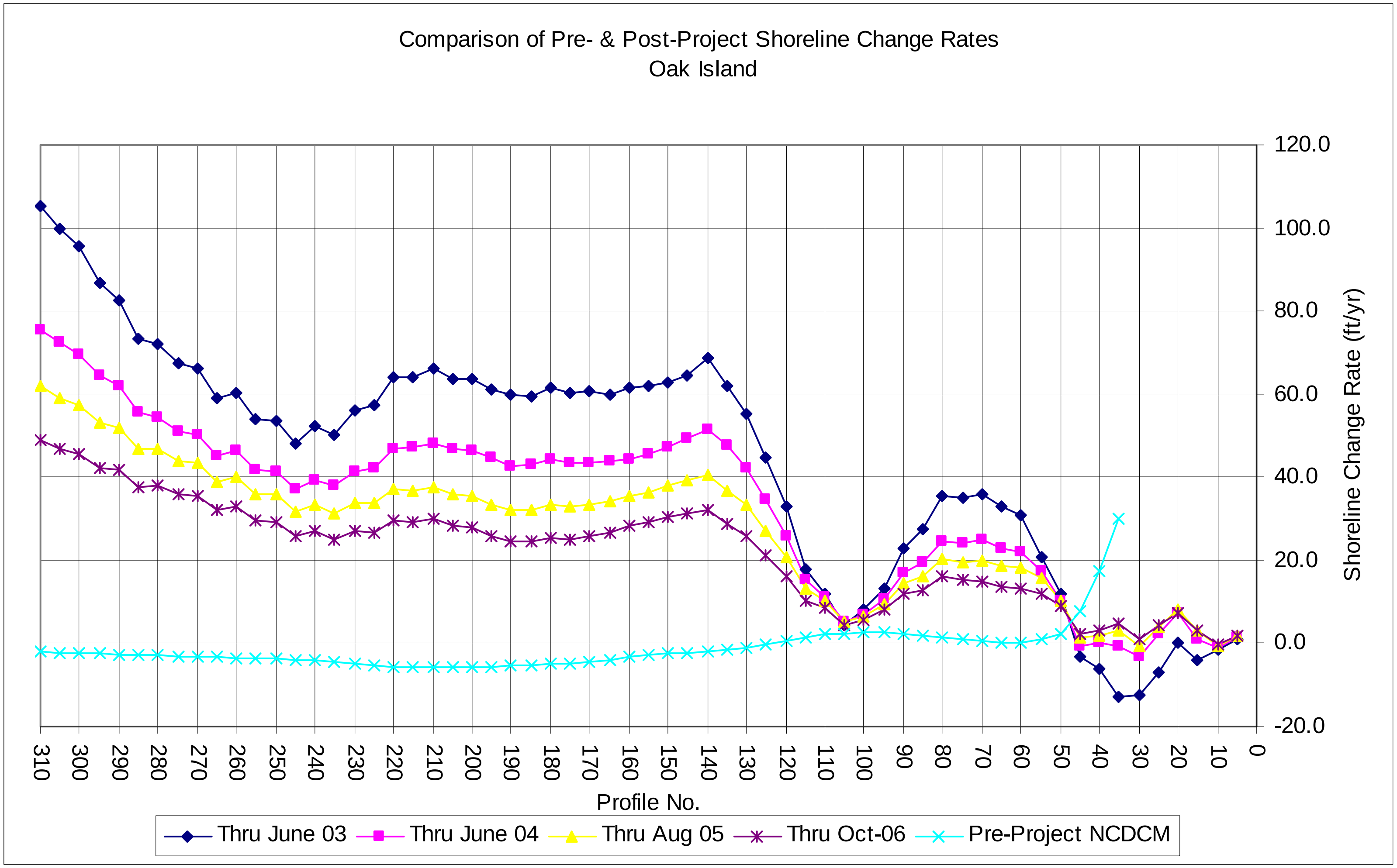


Figure 4.1 Wilmington Harbor Monitoring - Oak Island Comparison of Pre- and Post-Construction Shoreline Change Rates

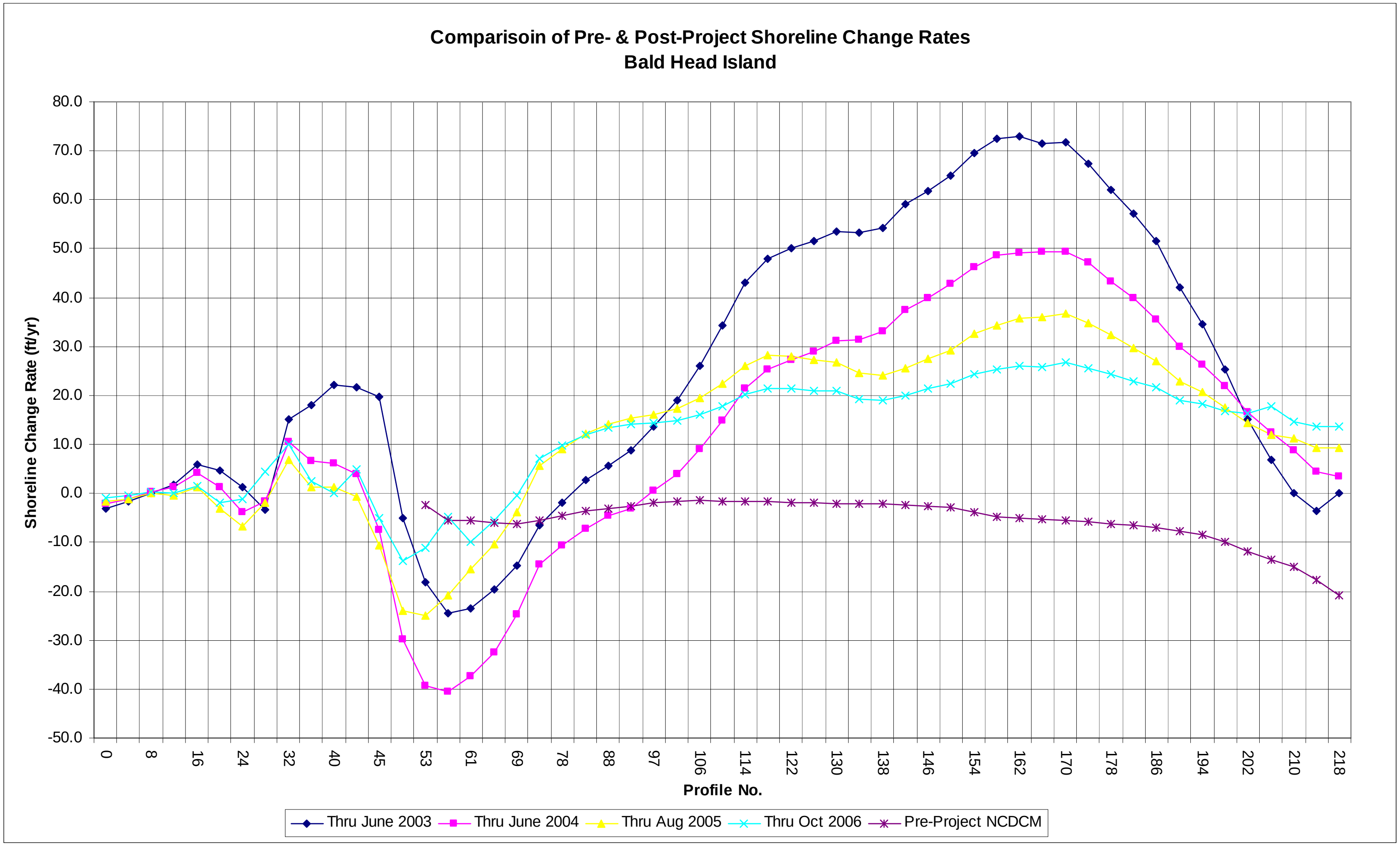


Figure 4.2 Wilmington Harbor Monitoring - Bald Head Island Comparison of Pre- and Post-Construction Shoreline Change Rates

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 (i.e. thru June 2003, June 2004, August 2005 and October 2006). 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, has and 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. Specific average post-construction erosion rates in this area were -15 feet per year with a peak of -25 feet per year as computed through June 2003. Through June 2004, the comparable average 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 from Profile 47 thru 78 in 2003 and Profile 47 thru 97 in 2004. This represented an alongshore increase of about 1,900 feet, from 3,100 feet to 5,000 feet.

With the subsequent placement of dredged material in January 2005 and the reconstruction of the groins, the expanding erosion rate trend has now reversed. 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 is –13.8 feet per year with a peak of –25 feet per year. With the most recent period (thru Oct 2006), which covers about six years, the extent of the erosion zone is about the same; however, the erosion rate magnitudes have continued to diminish. Presently the rates range from -13 to -5 feet per year in this zone of interest.

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 was 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) and plus 27 feet per year for the entire period. In terms of average rates for this zone, the positive values are 38, 29, 23 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 6-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 two profile lines are eroding at a higher rate during the post-construction period. These lines at located at the western end of south beach (Profiles 53 thru 61). Adjacent Profiles 57, 66 and 69 are presently eroding but at a lower rate as compared to the pre-construction condition. All other lines are accreting in direct contrast to the long-term erosion experienced along the remaining areas of South Beach. Most of this response is attributable to the beach fill placement and possibly to the positive effect of the recently 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 dredging and Bald Head Island disposal that ended in January 2005. 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 feet at –42 feet MLW.

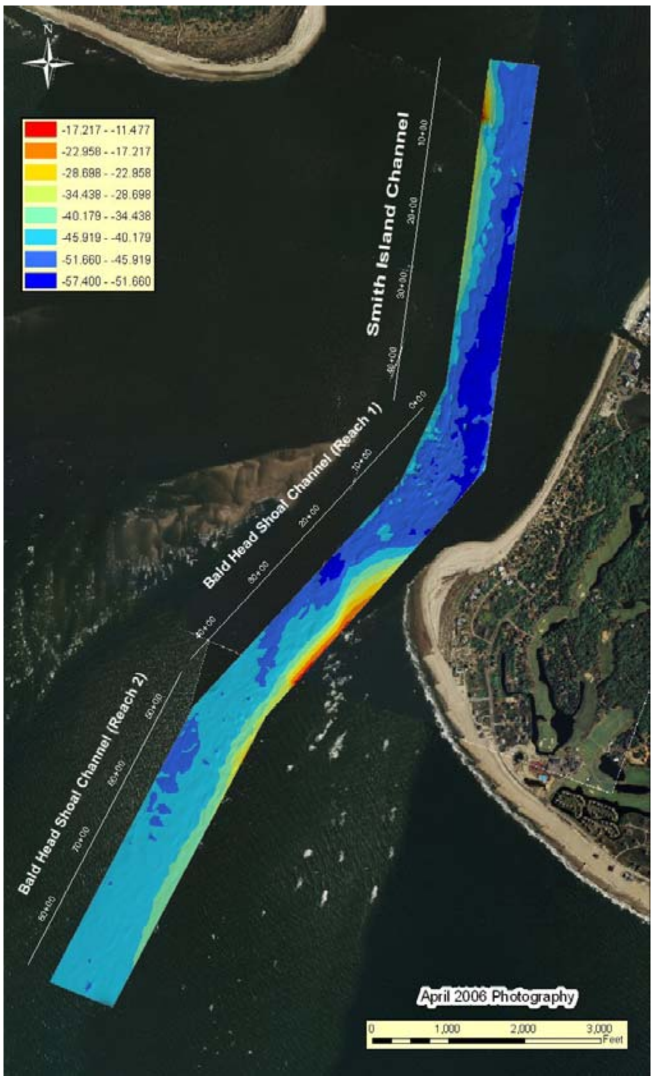


Figure 4.3 Locations for Baldhead Shoal (Reach 1 & 2) and Smith Island Channels

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.

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

[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

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 March 2006, respectively. The January 2005 survey serves as the baseline for comparisons with all subsequent surveys. The March 2006 survey is the last settlement survey included in Monitoring Report 3. The channel widths by reach for Baldhead Shoal Channel 1 in January and March 2006 are shown in Figure 4.6. A difference plot of the total amount of change (January 2005 – March 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 3 between Sta. 17+00 and Sta. 44+99. The shoaling, i.e. reduction of navigable width measured at -42' mlw, ranged from 66 feet to 232 feet, with the maximum occurring at station 20+00. The minimum navigable width did not fall below the threshold minimum width of 500' during the period covered by Monitoring Report 3.

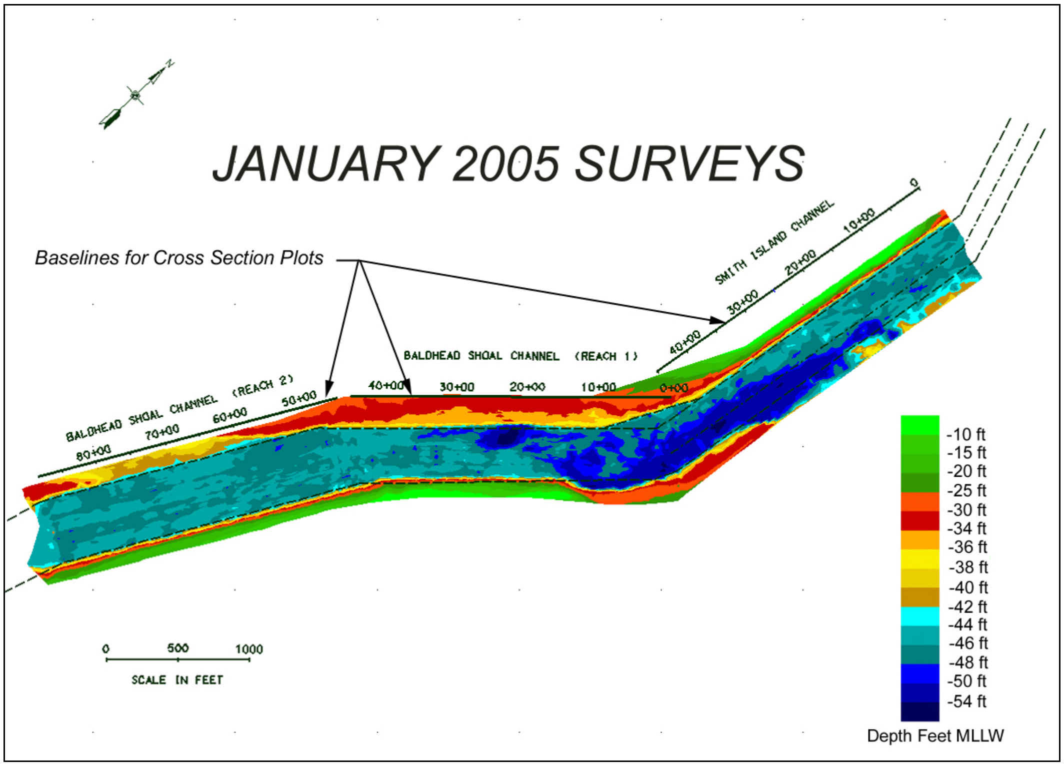


Figure 4.4. January 2005 channel conditions

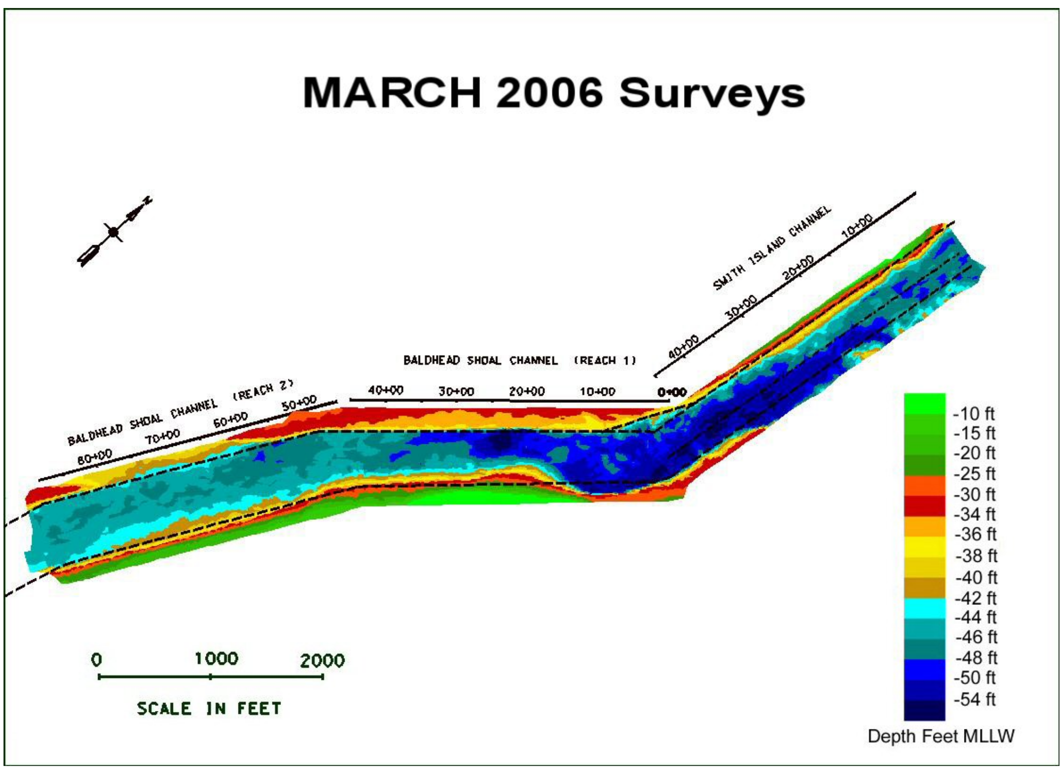


Figure 4.5. March 2006 channel conditions

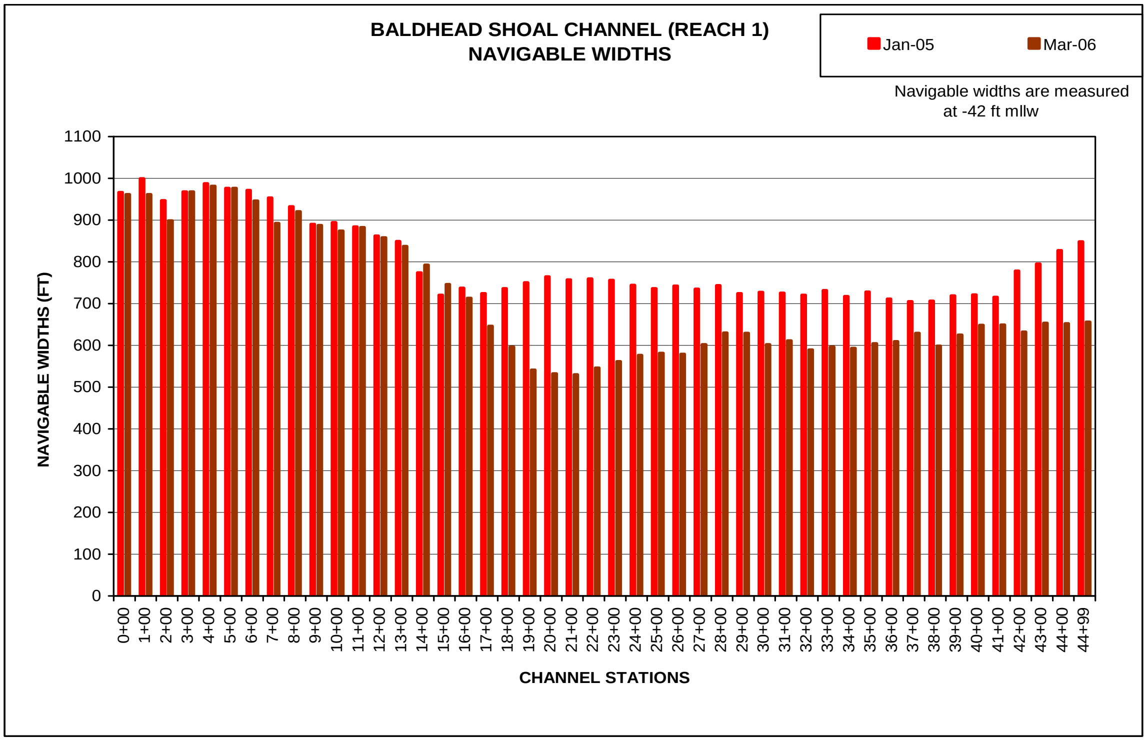


Figure 4.6. Baldhead Shoal Channel 1 Navigable Widths

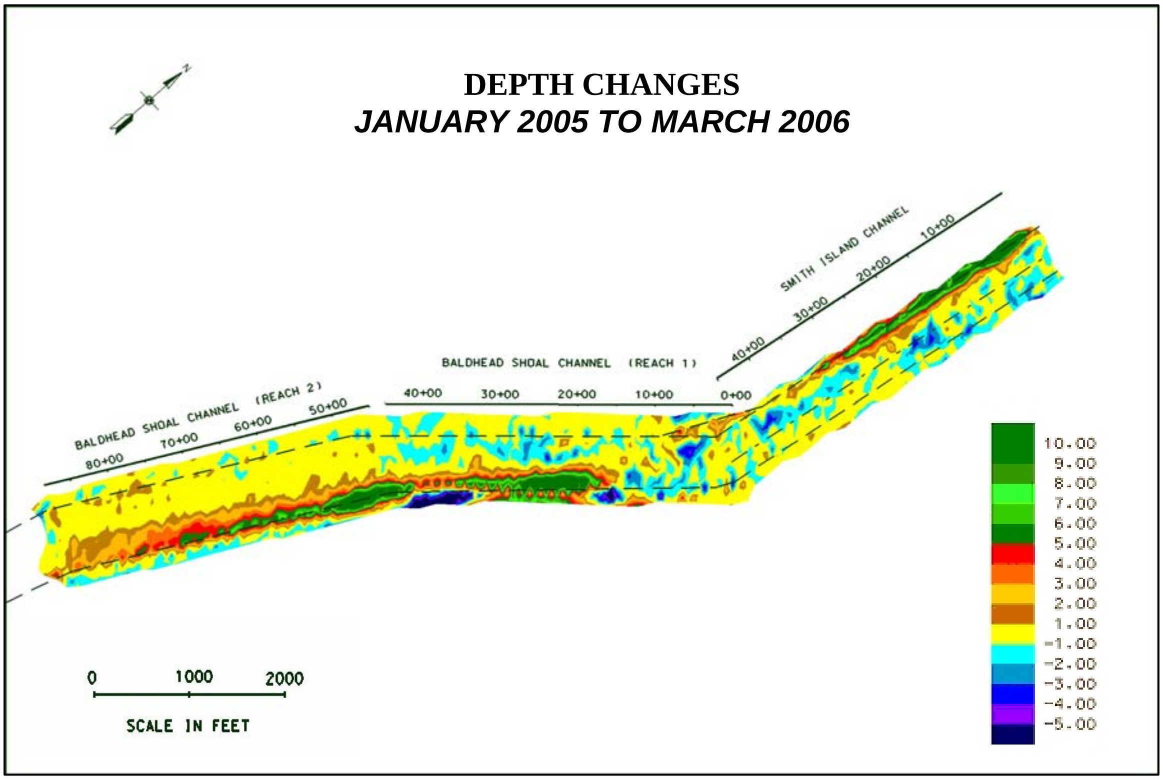


Figure 4.7. Depth changes from January 2005 to March 2006

Monitoring Report 4 includes four additional surveys taken from May 2006 through November 2006. Figures 4.8 and 4.9 show the May 2006 and November 2006 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 shoaling areas are located in Reach 1 from the Bald Head Island spit, approximately Sta. 15+00, south to Sta. 44+99.

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 remained fairly stable between Stations 0+00 and 17+00. Seaward of Station 17+00, a trend of decreasing navigable width can be observed.

The average shoaling can be broken into two areas for the current monitoring period. The navigable width from Sta. 0+00 to 17+00 had an average reduction of 18 feet, while Sta. 18+00 to 44+99 had an average bottom width reduction of 74 feet. Navigable width was maintained above the threshold limit for the majority of the channel throughout the current monitoring period. The first breach of the threshold limit occurred at Sta. 21+00 to 22+00 in May 2006. Subsequent bi-monthly surveys revealed that the shoaling continued throughout the current monitoring period. The final survey taken in November 2006 showed that stations 20+00 through 24+00 and stations 33+00 through 34+00 have all exceeded the threshold. The average navigable width in these areas is 469 feet with the minimum occurring at station 23+00 at a width of 438 feet.

Even though the threshold was exceeded, it was determined at that time that no immediate action was necessary and that the width would continue to be closely monitored. This determination was based on the fact that the significant channel width reduction did not occur until the November 2006 survey, and the next dredging contract was scheduled to commence in January 2007. Based on the surveys to date, it appears that the current dredging cycle of 24 months provides adequate channel width. Shoaling will continue to be monitored on a bi-monthly basis to confirm this pattern, and adjustments made as necessary.

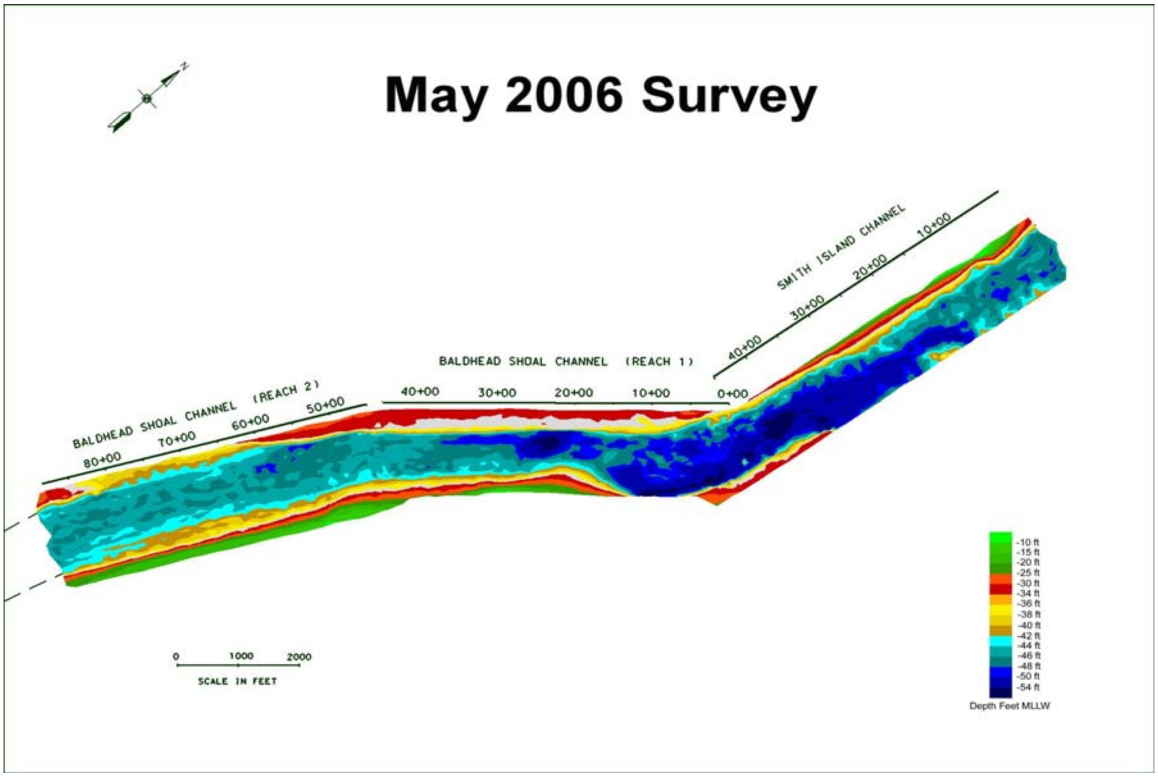


Figure 4.8 May 2006 Survey

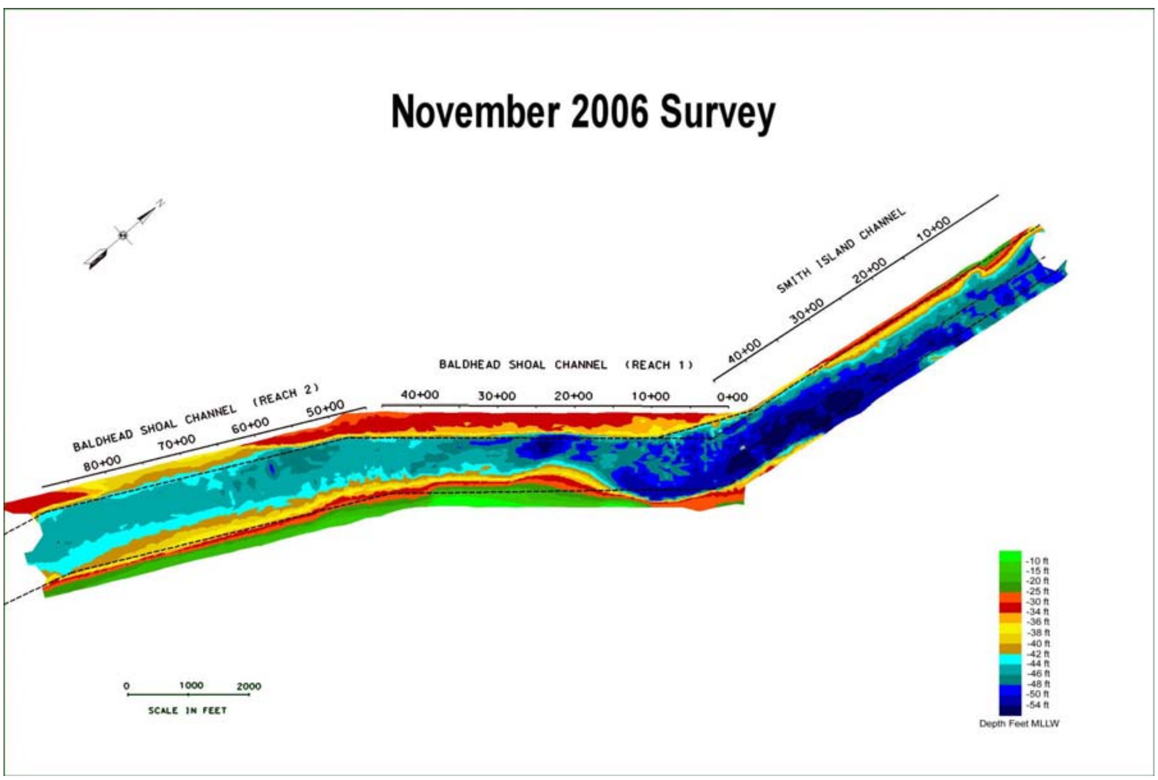


Figure 4.9 November 2006 Survey

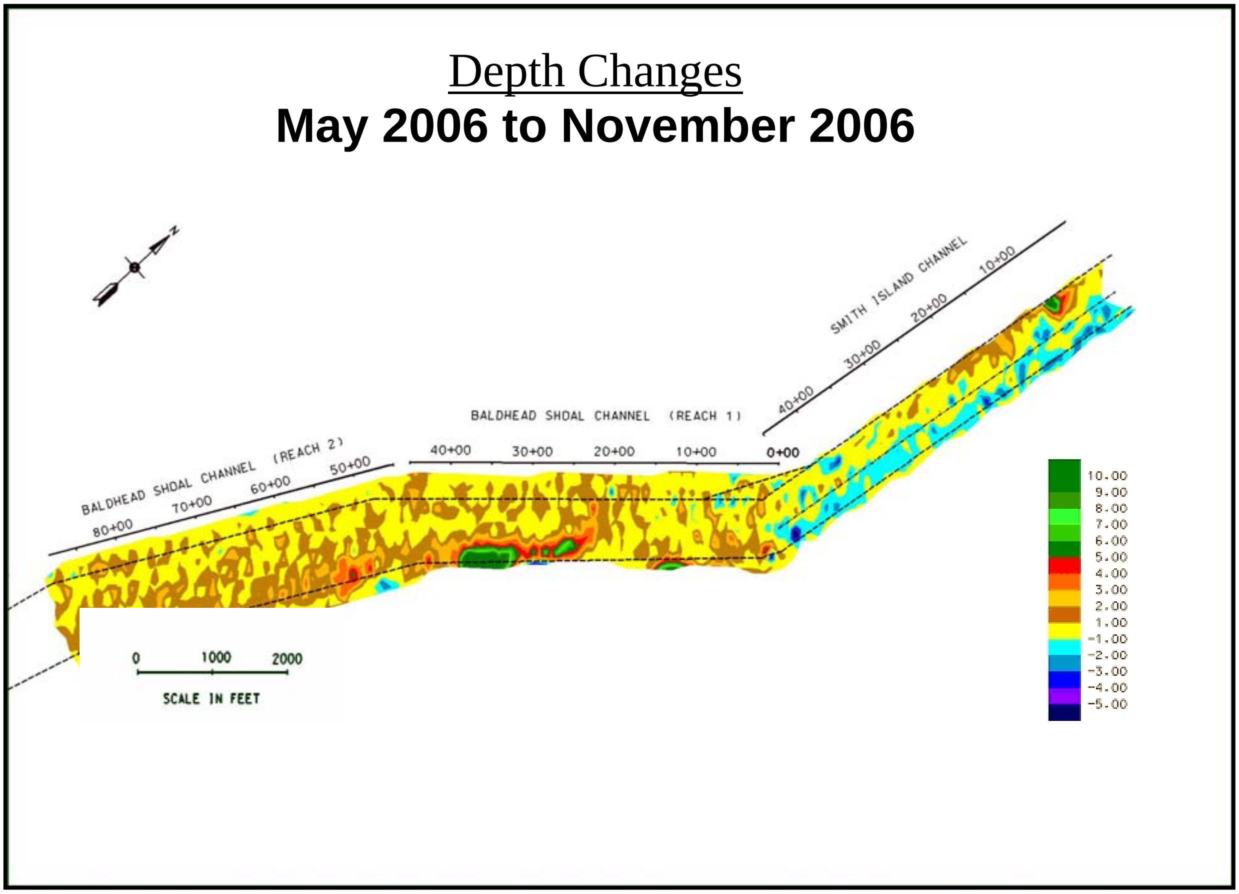


Figure 4.10 Depth Changes May to Nov 2006

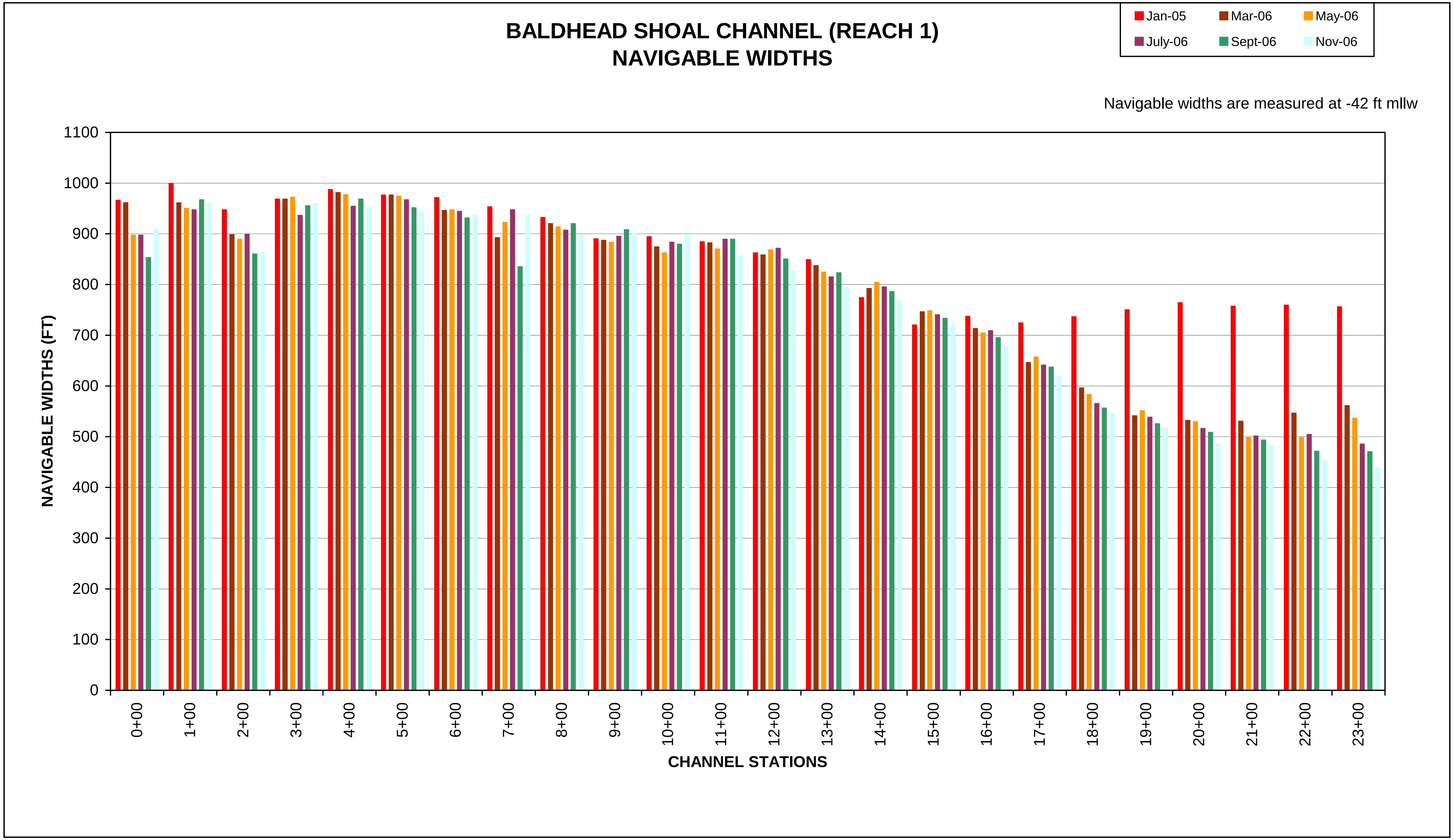


Figure 4.11. Baldhead Shoal Channel 1 width by station: Station 0+00 to 23+00

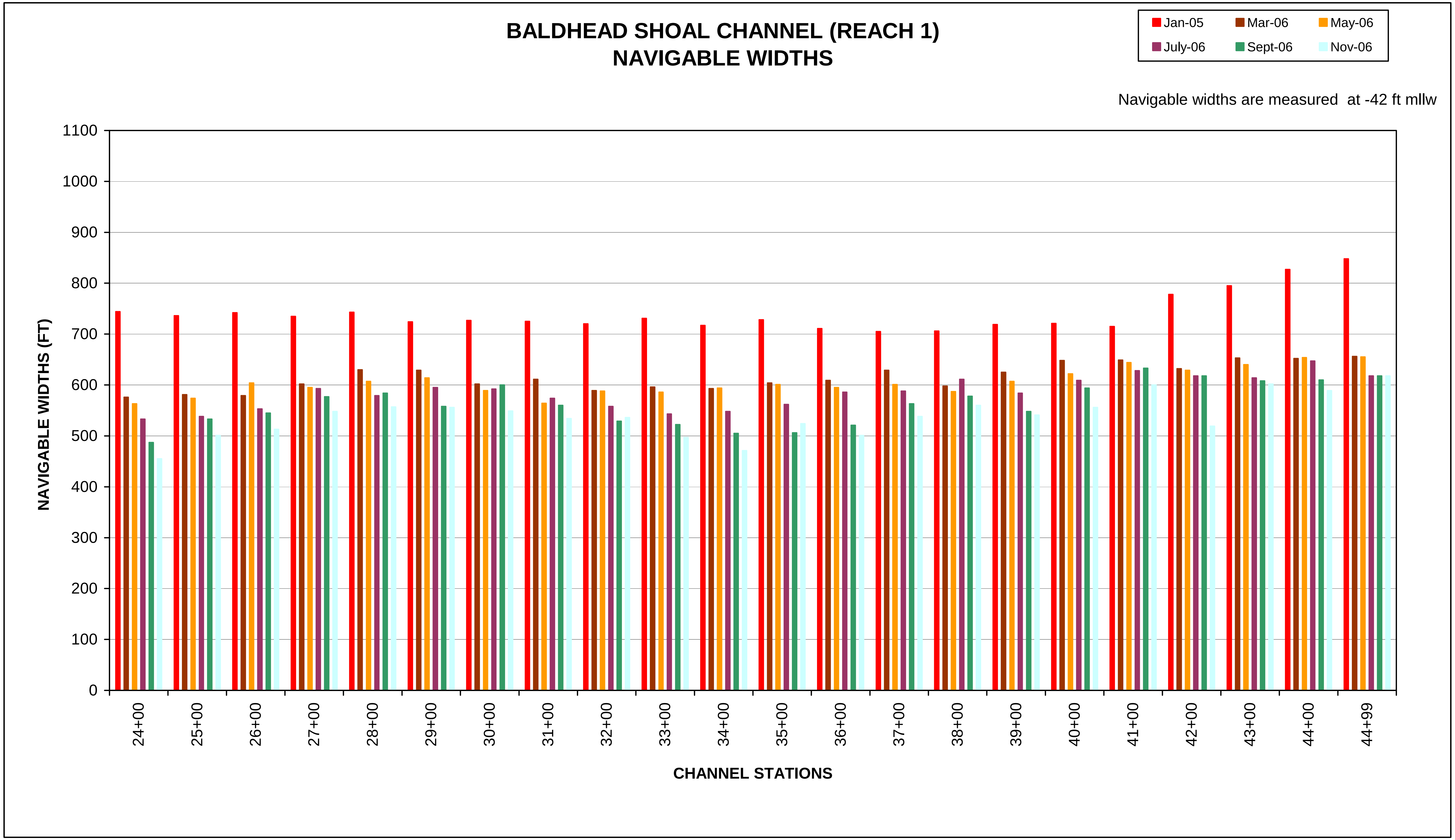


Figure 4.12. Baldhead Shoal Channel 1 width by station: Station 24+00 to 45+00

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.

The influence of the newly reconstructed groin field is shown in Figure 4.13. From this figure, it is evident from the saw-tooth pattern of the shoreline that the groin field is capturing sand which is transporting from the East to the West towards the channel. This net transport direction is consistent with previously predicted transport for this area of Bald Head Island. Another feature that is evident in this figure is Northeast migration of the spit. While the seaward shoreline of the spit has remained fairly constant since the last report, the inlet side has grown approximately 400' toward the Bald Head Island marina.

Spit volumes were calculated within the bounding polygons shown in Figure 4.14. In addition to the bounding polygons used in report 3, another polygon was added (reach 1a) in the area of the channel that might be influenced by the observed Northeastward growth of the spit. The change in spit volumes above -44 feet MLLW for Baldhead Shoal Reach 1 is shown in Figure 4.15 with the two dredging/placement events noted. Figure 4.16 shows a comparison of the two post-placement responses from Figure 4.15. Note the difference in slope between the two post-placements. These slope differences indicate a different rate of spit volume growth, with a slower growth rate after the 2004/2005 placement identified by the flatter slope. Specifically, the initial rate was about 16,000 cubic yards per month. Report 3 showed that the spit growth had slowed to about 10,000 cubic yards per month, i.e., a 38 % 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 8,700 cubic yards per month. This is a 46% reduction in the shoaling rate versus the initial dredging operation. Volumetric analysis within the new 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) 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.

Figure 4.13. Shoreline Comparison: Pre and Post groin field reconstruction and 2005 beach disposal

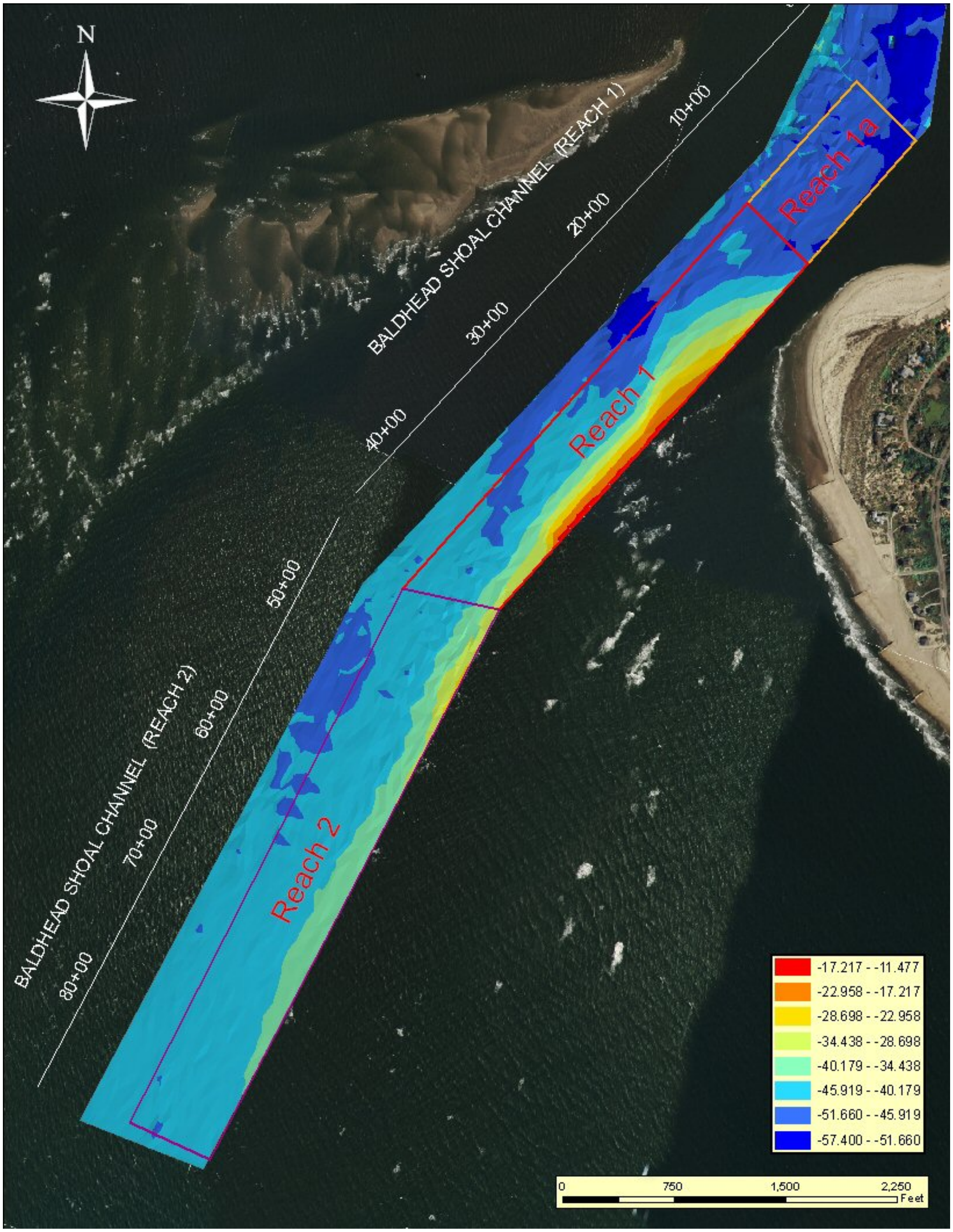


Figure 4.14. Spit volume bounding polygons

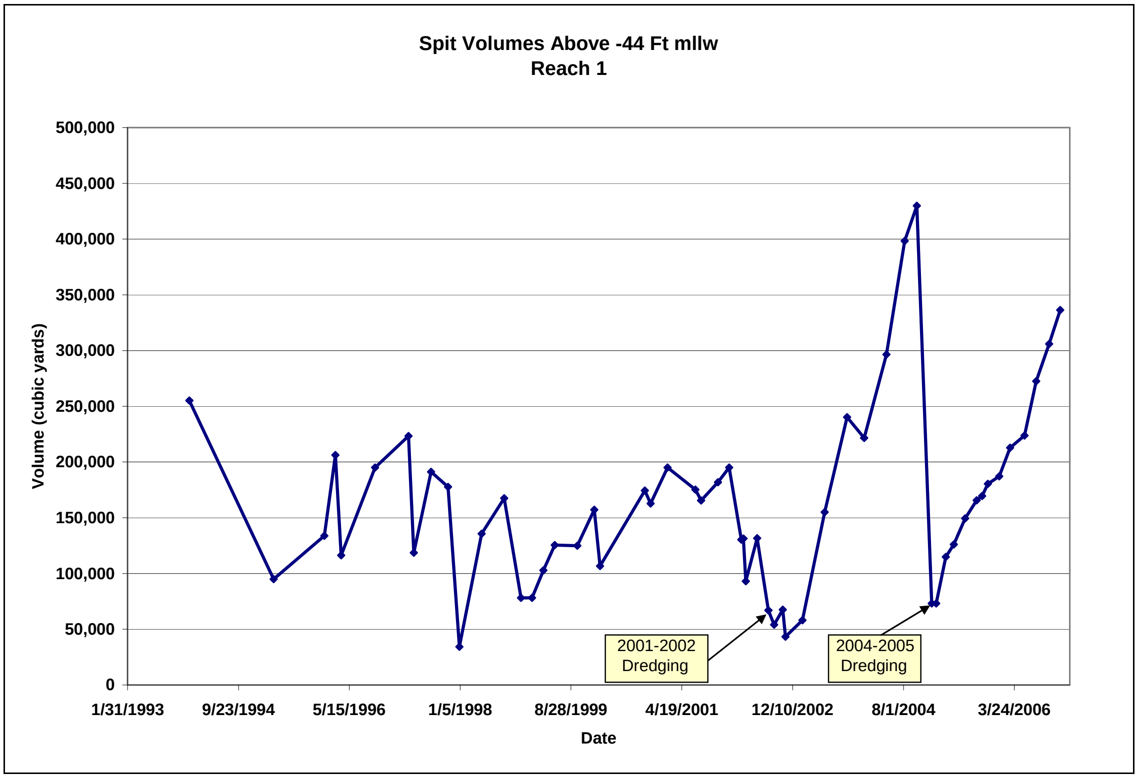


Figure 4.15 Baldhead Shoal Channel 1 Spit Volumes

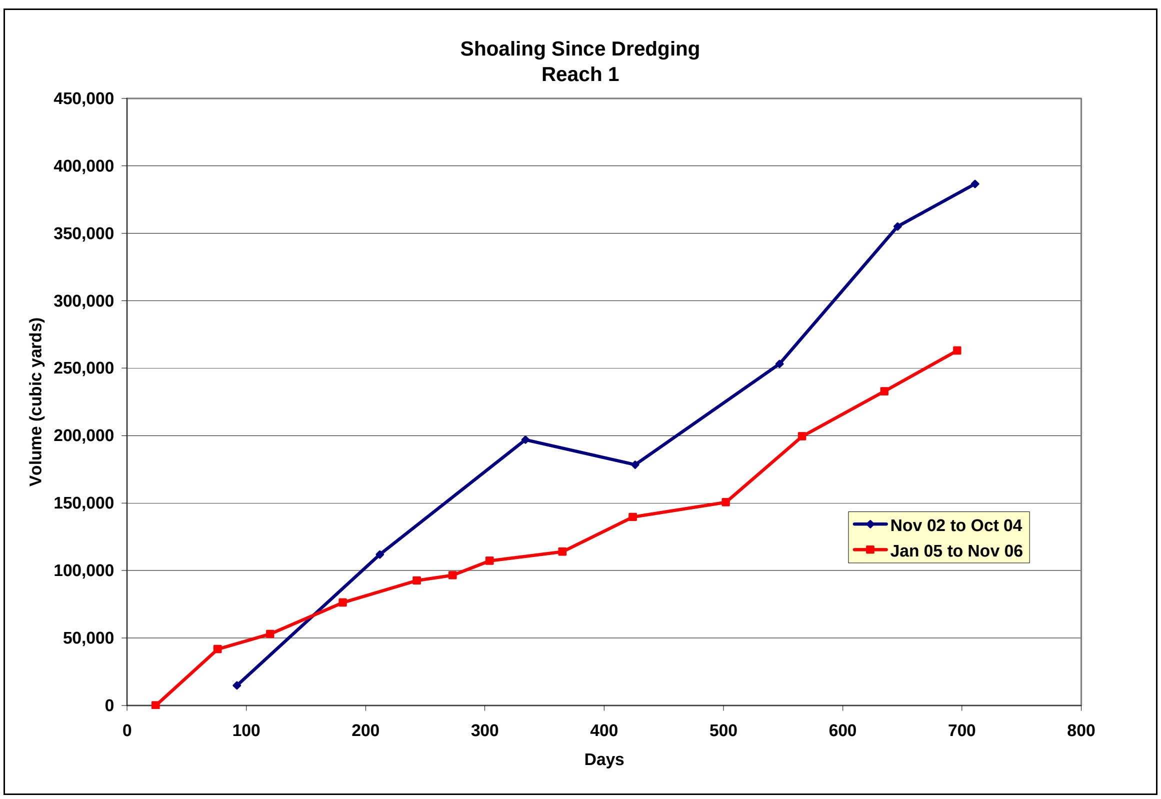


Figure 4.16 Comparison of post-placement spit growth from Figure 4.15 (Above)

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 two occasions, namely in 2001 before the reconstruction and in 2005 with the reconstruction. In this regard it is possible to assess the performance of the groins by comparing the beach fill response following each placement, i.e. the 1st fill without and the 2nd fill with groins.

Shoreline Response. Changes in the position of the mean high water shoreline were calculated for selected monitoring surveys following each fill. In each case, the shoreline measured for 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 five surveys following the first fill and three 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 20 months (to date) for the second fill. In this regard, shoreline changes over similar time frames can be compared by using the Feb 2003 versus the Oct 2006 survey dates which are 19 months and 20 months after the first and second fills, respectively. This comparison, shown as a heavy weighted line in each case, shows 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 19-20 month period after the first fill was 160 feet compared to 80 feet for the similar period after the second fill. Further, the greatest difference is found within the western portion of the groin field where the post-fill recessions are more than twice as large for the initial fill response.

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 active 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 is 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 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. In this regard, some material appears to have moved into the offshore portion of the profile line.

In comparing the post-fill response over similar spans of time, the closest surveys are the Dec 20002 and the Oct 2006, which are 17 months and 20 months after the first and second fills, respectively. These comparable plots are shown with a heavy weighted line for each case. This comparison reveals that for the overall volume change, the losses are found to be greater for the first fill cycle in the western half of the groin field, but less for the second fill cycle in the eastern 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. Interestingly, if the volume losses are summed over the extent of the groin field for the common period of interest, the total losses are about the same with 411,000 cubic yards loss following the first fill versus 467,000 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.

It is not that surprising that the overall volume loss and volume rate loss may be greater along some portions of the beach even following the groin reconstruction. This is due to the overall extent of the structures, which can only influence the upper portions of the profile, typically above the -2 foot elevation or greater. With this in mind, a further analysis was done to reveal volumetric changes along the groin field for the onshore portions of the each profile, i.e., above -2 ft, NGVD29. These 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 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. This is particularly true within the western portions of the groin field. In comparing the losses over similar time periods, the closest surveys of interest are the Dec 02 survey (occurring approximately 17 months into the first fill period) with the survey of Oct 2006 (occurring approximately 20 months into the second fill period). These two survey dates are highlighted with a heavy weighed line type. This comparison reveals that for all profiles, the volume loss from the first fill period is greater that those of the comparable 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 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. For the remaining portions, generally along the eastern half of the groin field, the rates are about the same for both the first and second fills at this time.

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.

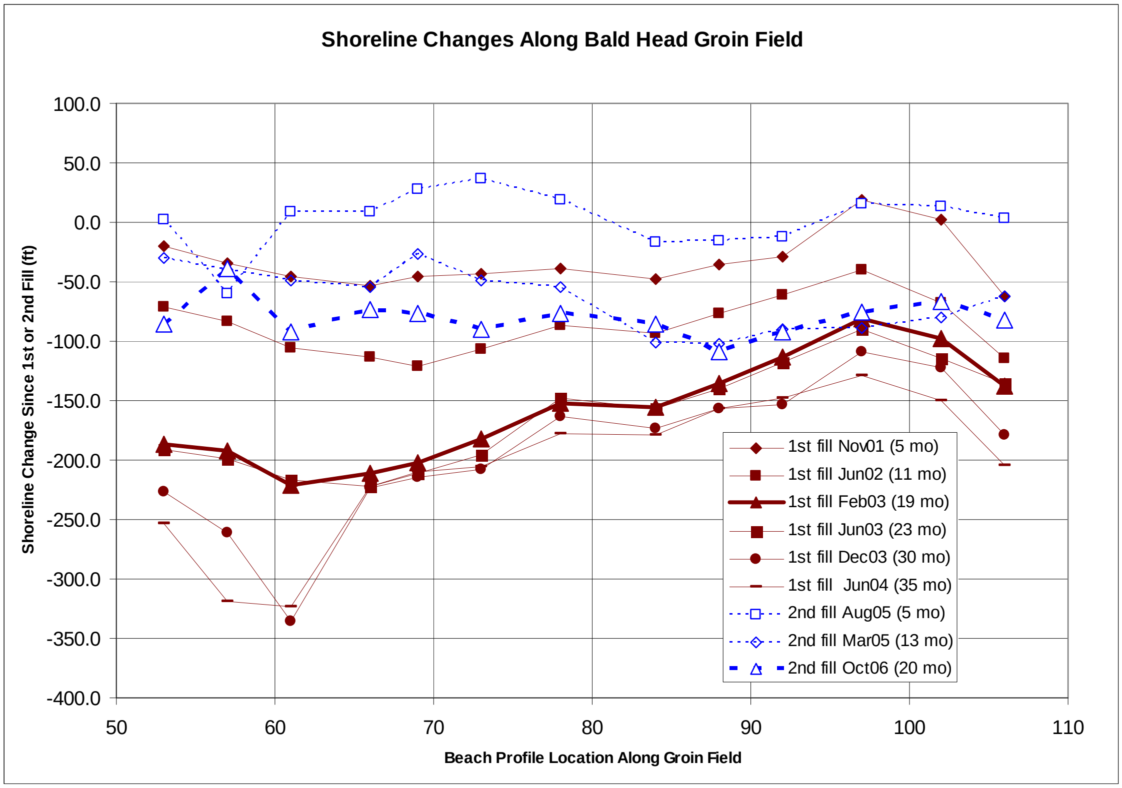


Figure 4.17 Shoreline Changes Along Bald Head Groin Field

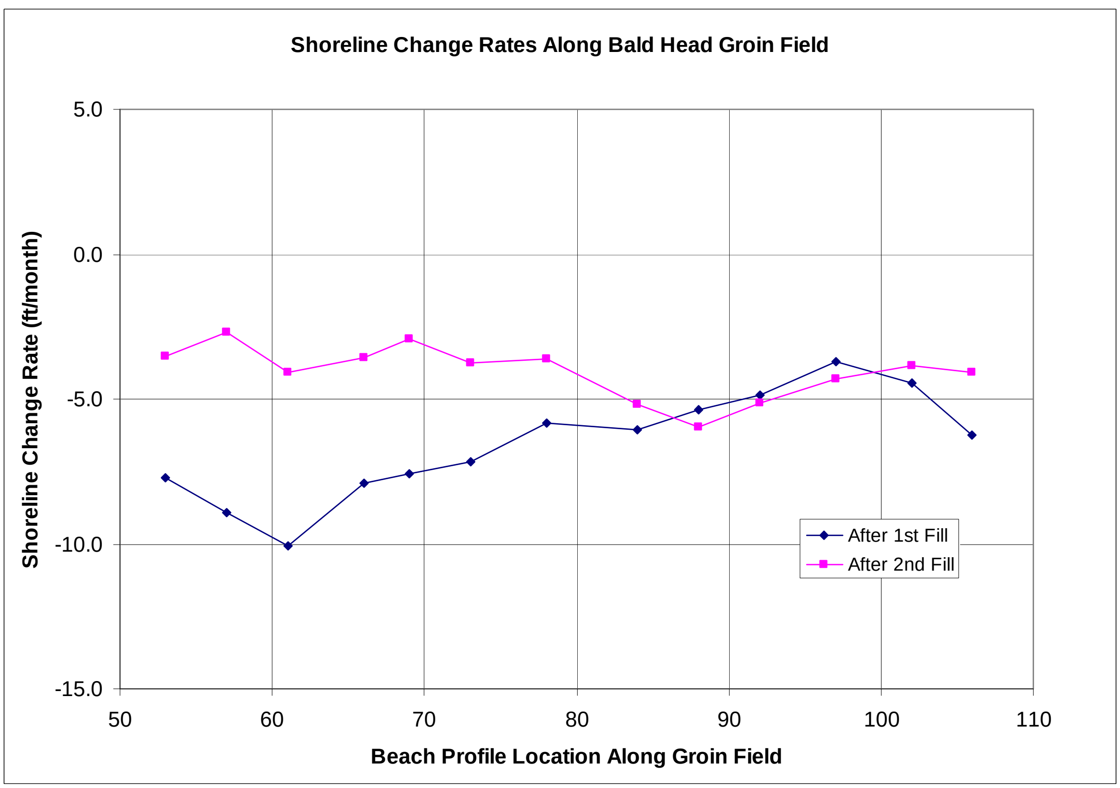


Figure 4.18 Shoreline Change Rates Along Bald Head Groin Field

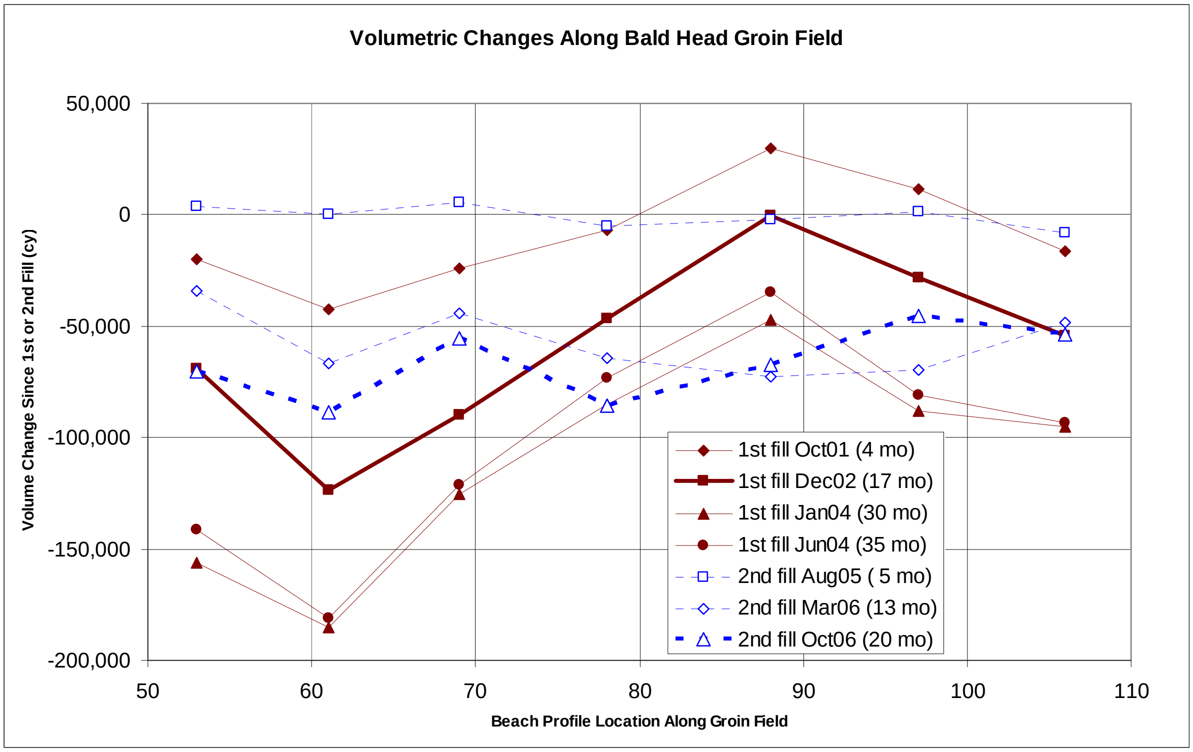


Figure 4.19 Volumetric Changes Along Bald Head Groin Field

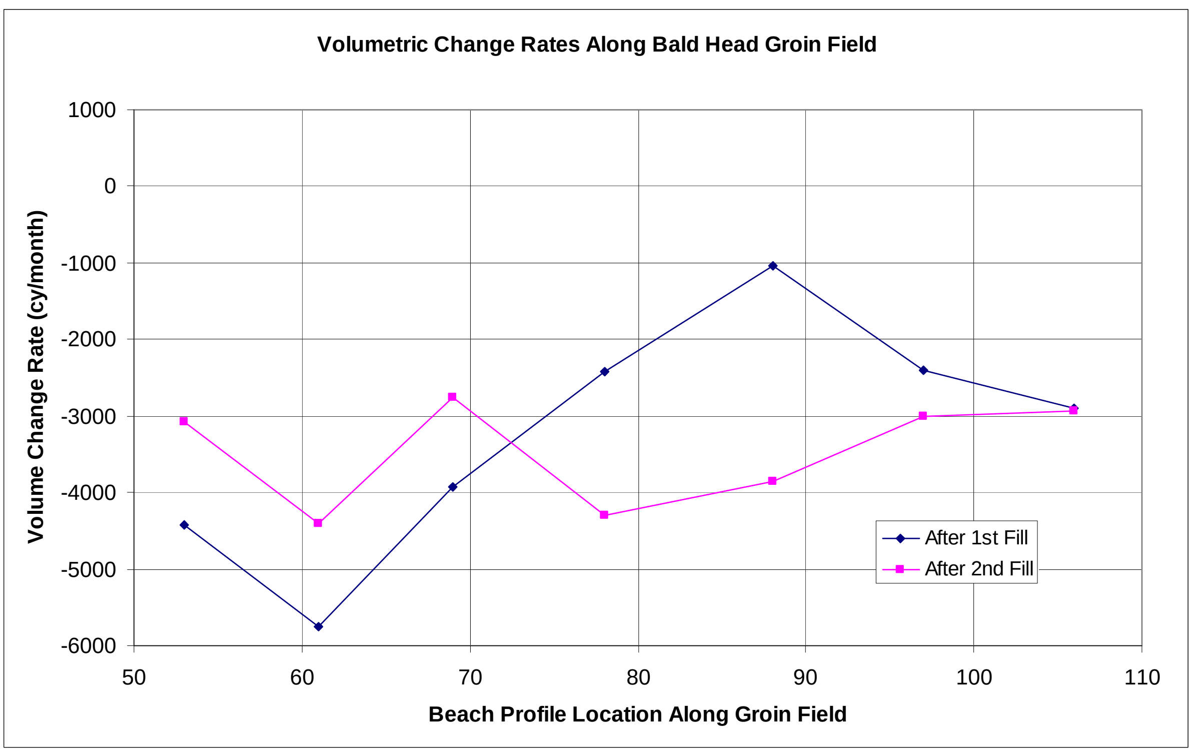


Figure 4.20 Volumetric Change Rates Along Bald Head Groin Field

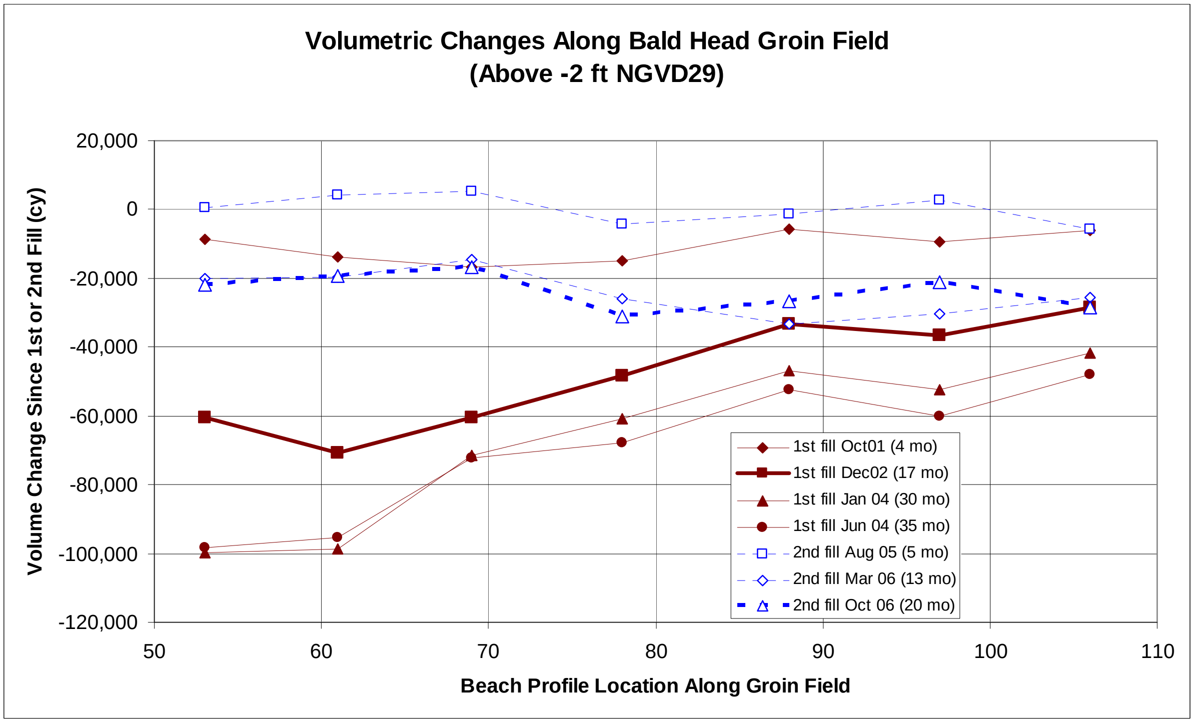


Figure 4.21 Onshore Volumetric Changes Along Bald Head Groin Field (Above -2 ft NGVD29)

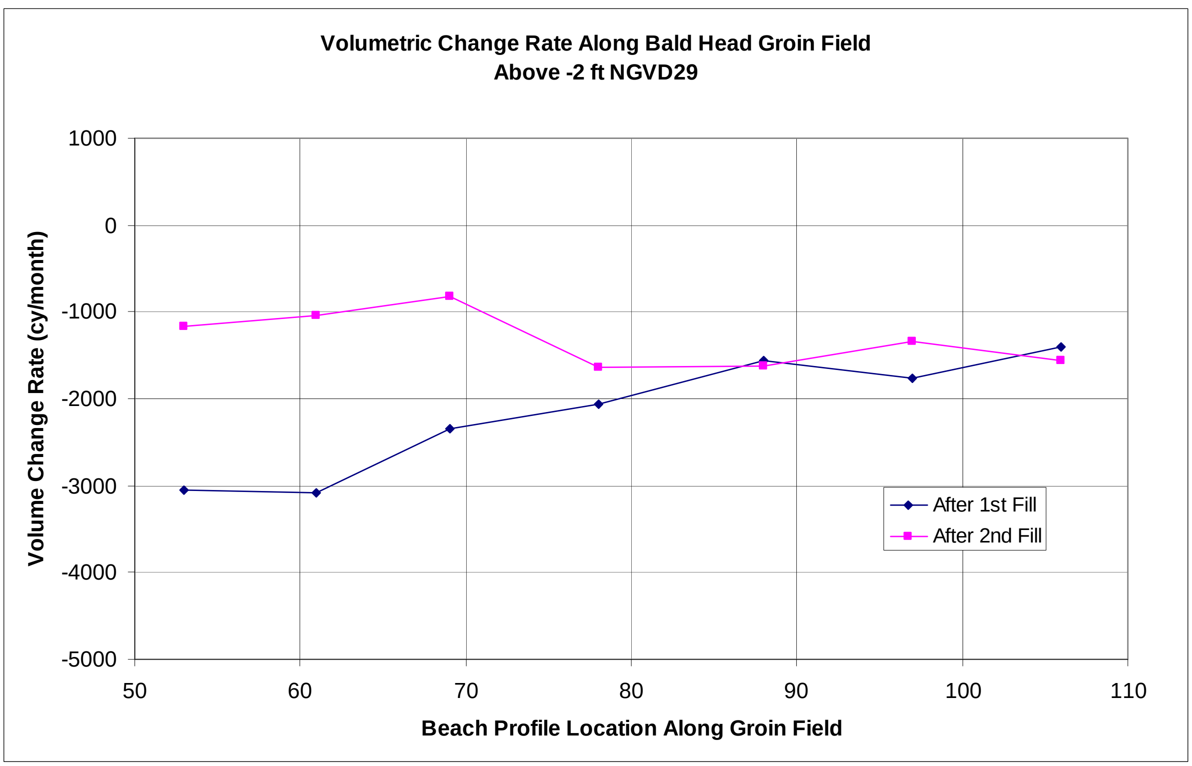


Figure 4.22 Onshore Volumetric Change Rates Along Bald Head Groin Field (Above -2 ft NGVD29)

Part 5 SUMMARY

This report is the fourth 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 sixth year of data collection and focuses on the most recent period of September 2005 through October 2006. 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. The next maintenance cycle, which is scheduled for 2007, involves the placement of 1-million cubic yards, more or less, along South Beach including the area of the groins.

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 3 (August 2005) 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 August 2005 to October 2006) and for the entire period (from August/September 2000 to October 2006).

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 slightly negative. When considering all profile lines, an average shoreline retreat of 5 feet is evident for the present period of August 2005 to October 2006. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –60 to +90 feet), the alongshore trend is also erosional with an average 6 foot loss for the same period. 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 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 73 feet more seaward in March 2006 than it was in 2000. Likewise, the shoreline position was 94 feet more seaward in August 2005, than it was six years ago at the start of the project. Only one area may be of some minor 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. As such, this reach has accreted, but at a relatively smaller magnitude (about 5 to 20 feet) compared to the adjacent reaches.

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In terms of volume change, Oak Island/Caswell Beach has experienced losses in the western half and gains over the eastern half for the current period. When considering all profile lines, a net loss of 196,000 cubic yards was computed since the last report, between August 2005 and October 2006. Although a net loss has occurred over the current period, the beach remains in a stable state when considering the entire 6-year monitoring period. As such, positive changes have occurred following the initial fill placement in 2001 associated with the project dredging. Specifically, by the end of the period, 1,203,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity reflects even a net gain above the fill volume placed in 2001 (1,143,000 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 eroding with the exception of the vicinity of the spit (at the southwestern tip of the island), a western portion of South Beach and the easternmost lines near the cape. The erosion is most evident along South Beach, within the area of the January 2005 beach disposal (Profiles 46 to 138). Over this 9,200 foot reach, the beach is up to 100 feet narrower, with an alongshore average loss of 71 feet. Extending east of this erosional area is a localized stretch of stable beach and then another pocket of shoreline erosion. This stable zone is likely the result of the spreading of the 2005 beach material. Proceeding eastward toward the cape, the shoreline change becomes highly accretional, reaching a maximum advance of between 300 and 400 feet. 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 report period, a portion of this area has shown gains of about 200 feet with adjacent portions losing 200 feet. The greatest losses are found at Profiles 45 and 47. These lines are located immediately west or downdrift of the new groin field. The remaining area along West Beach (Profiles 0 thru 28) has shown an overall gain, reflecting the positive impact associated with the Bald Head

Creek disposal project in January 2006. Overall, the alongshore average shoreline changes measured over the entire monitoring area were losses of 9 feet and 8 feet for the March 2006 and October 2006 surveys, respectively.

Shoreline change patterns as measured over the last 6-year period, i.e., since the monitoring was initiated, are for the most part 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 October 2006 shorelines being typically 50 to 100 feet seaward of their September 2000 position. The exception to this general stable pattern is a zone of erosion within the vicinity of the spit area extending into the western portion of South Beach. Specifically, this zone extends from Profile 43 thru Profile 61. Between Profiles 53 and 61, which is contained within the western end of the groin field, the shoreline retreat is on the order of 60 feet. By contrast, the eroded profiles just to the west of the groins (Profiles 43 thru 47) have shoreline recessions of 200 feet to more than 300 feet, when compared to the September 2000 position. Proceeding further to the west, the erosion turns positive over the remaining portions of the spit area, reaching a maximum advance of 245 feet. For West Beach (Profiles 0 thru 28), located immediately along the river channel, the shoreline is shown to be generally stable, except for Profile 28, located in the lee of the spit. When considering all locations along Bald Head Island (Profile 0 to Profile 218), the shoreline is presently on the average 55 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey (August 2005) of Report 3 to October 2006, Bald Head Island was dominated by losses along most of South Beach, except for the eastern area near the cape. All other areas, specifically the spit and West Beach, showed volumetric gains over the last year. Along South Beach, the losses are found to extend between Profile 53 through 178, with the losses being approximately twice as large along the western half than along the eastern half of this 12,500-foot reach. The total loss within this reach amounts to 684,000 cubic yards. These losses are nearly balanced by the gains recorded near the cape (+ 205,000 cubic yards), the spit (+84,000 cubic yards) and West Beach (+133,000 cubic yards). The net change over the entire monitoring area amounts to a loss of 262,000 cubic yards over the period from August 2005 to October 2006.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, three areas of loss are present along Bald Head Island. One is located at the extreme eastern end of south beach where some small losses have occurred near the cape. The other two, which are of greater concern, are along the western portions of South Beach. The larger of the two extends from Profile 45 to 69, covering approximately 2,400 feet, which has been the site of chronic erosion in the past. Following the January 2005 beach disposal, this area has progressively worsened. The latter erosion area along South Beach is developing further to the east between Profiles 88 and 114, within and just beyond the eastern portion of the groin field. 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 635,000 cubic yard gain in March 2006 and 524,000 cubic yard gain by October 2006.

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 6 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 6-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 +24 feet per year for the 6-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 6-year monitoring period. However, notwithstanding this overall positive response, the post-construction erosion rates continue to be greater along the western corner of South Beach. A direct comparison of the long-term and present shoreline change rates show that only two profile lines are eroding at a higher rate during the post-construction period. These lines are located at the western end of south beach (Profiles 53 thru 61). Adjacent Profiles 57, 66 and 69 are presently eroding but at a lower rate as compared to the long-term 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 recently 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 2006, thirteen condition surveys have been accomplished, four of which occurred over the present reporting period (May 2006, July 2006, September 2006 and November 2006). The recent surveys reveal that additional shoaling has occurred in the vicinity of the Bald Head spit. The shoaling has occurred in an elongated pattern along the eastern edge of the channel along Bald Head Shoal. The average shoaling can be broken into two areas for the current monitoring period. The navigable width from Sta. 0+00 to 17+00 had an average reduction of 18 feet, while Sta. 18+00 to 44+99 had an average bottom width reduction of 74 feet. Navigable width was maintained above the threshold limit for the majority of the channel throughout the current monitoring period. The first breach of the threshold limit occurred at Sta. 21+00 to 22+00 in May 2006. Subsequent bi-monthly surveys revealed that the shoaling continued throughout the current monitoring period. The final survey taken in November 2006 showed that stations 20+00 through 24+00 and stations 33+00 through 34+00 have all exceeded the threshold. The average navigable width in these areas is 469 feet with the minimum occurring at station 23+00 at a width of 438 feet. It was determined at that time that no immediate action was necessary and that the width would continue to be closely monitored. Significant channel width reduction did not occur until the November 2006 survey, at which point the next dredging contract was in place to begin in January 2007. Based on the monitoring surveys to date, it appears that the current dredging cycle of 24 months provides adequate channel width. Shoaling will continue to be monitored on a bi-monthly basis to confirm this pattern, and adjustments made as necessary.

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 3. The comparison showed that the rate of growth was slower following the second event. Specifically, the initial rate was about 16,000 cubic yards per month versus the second rate of about 10,000 cubic yards per month, i.e., a 38 % reduction in shoaling rate. Analysis for the current monitoring period shows that the growth rate has continued to decrease and is now at a rate of 8,700 cubic yards per month. This is a 46% reduction in the shoaling rate versus the initial dredging operation. 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. 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 19 month period after the first fill was 160 feet compared to 80 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. Along either side of this particular shoal are scour features with one to the west along a flood channel near Oak Island and the other to the east along the margin of the main channel. The scour present along the main channel is found to extend along most of the eastern edge of Jay Bird Shoals, some of it being attributed to the channel deepening in this area. 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. Finally, the "v" shaped area between the old and new channels just seaward of their intersection has also experienced infilling since 2000.

To date currents have been measured on six occasions, with the initial occurring before the channel improvements and the remaining five 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. Similar to results reported previously, there still does not appear to be a substantial decrease in the current magnitude through the old channel since the opening of the new channel. 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 is scheduled for 2007, which would involve placing on the order of 1,000,000 cubic yards along Bald Head Island's South Beach. Close coordination of this work will be maintained with the Village in determining the final distribution of this beach disposal operation. Ongoing monitoring efforts will be used to document the performance of this fill and to plan the third maintenance cycle (year 6). As stated above, this cycle is scheduled for placement along Oak Island. 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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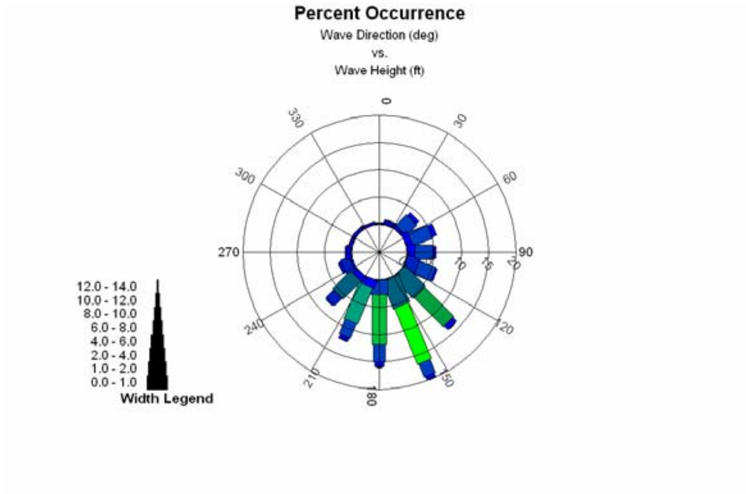
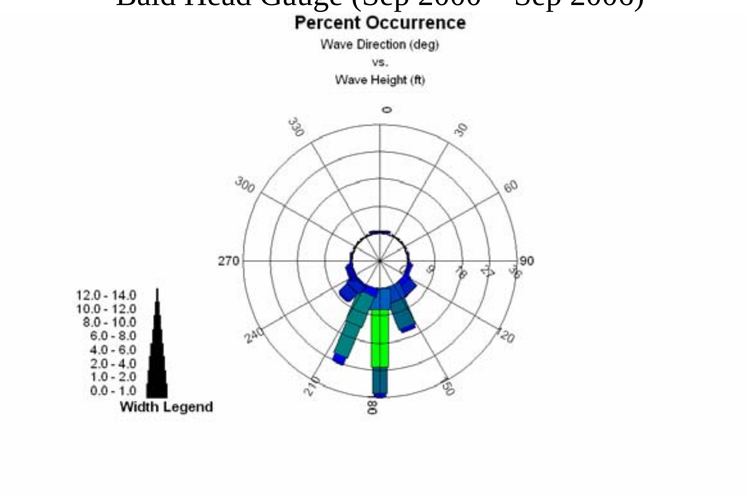
Appendix A

WAVE GAUGE DATA
Wave Roses (2000 thru 2006)

Eleven-Mile Gauge (Sep 2000 – Sep 2006)



Bald Head Gauge (Sep 2000 – Sep 2006)



Oak Island Gauge (Sep 2000 –Apr 2006)

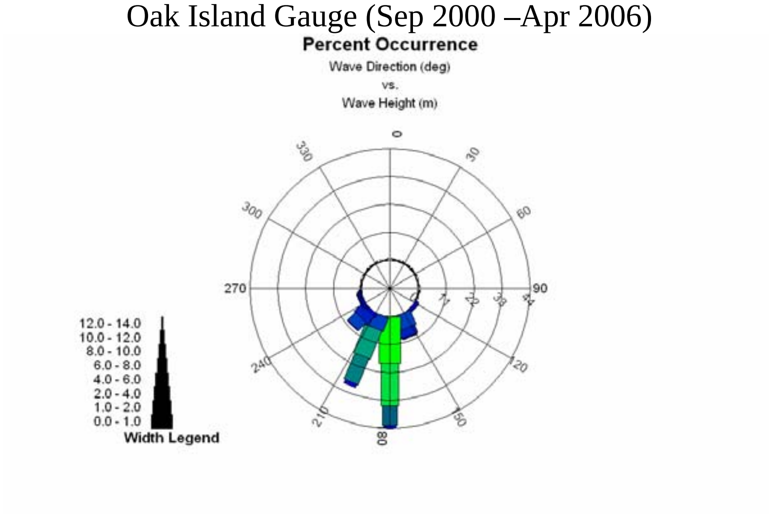


Figure A-1 Wave Height Roses for FRF Gauges throughout deployment.

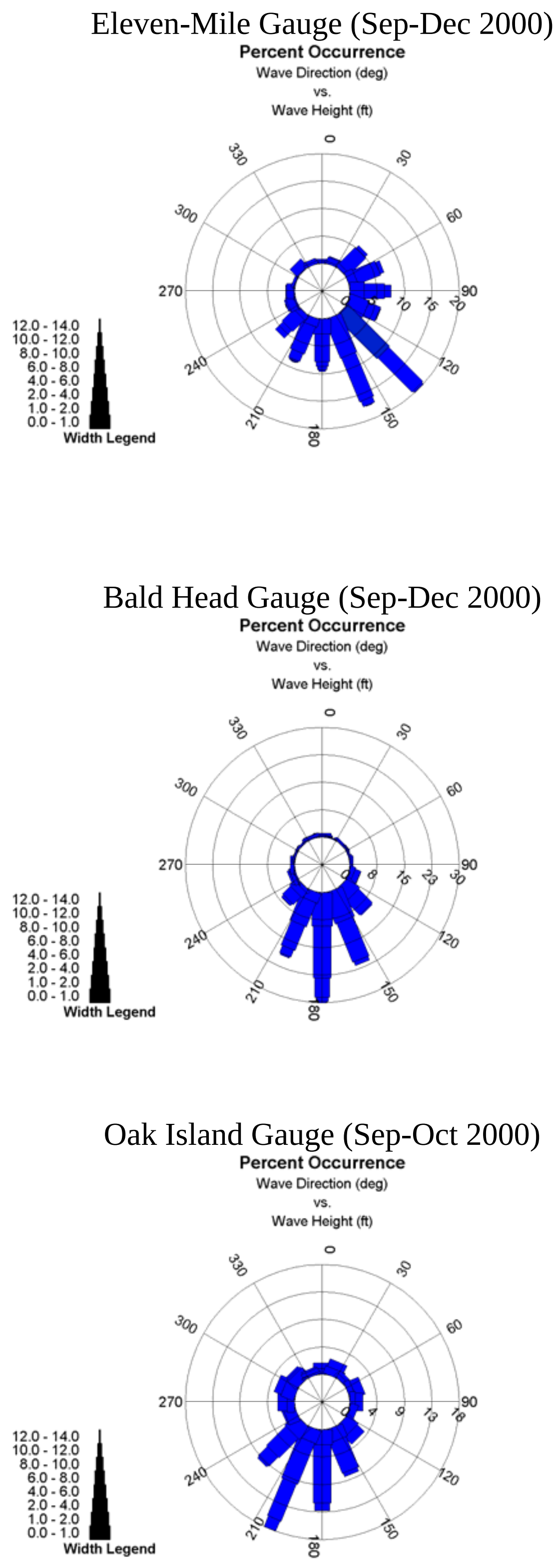
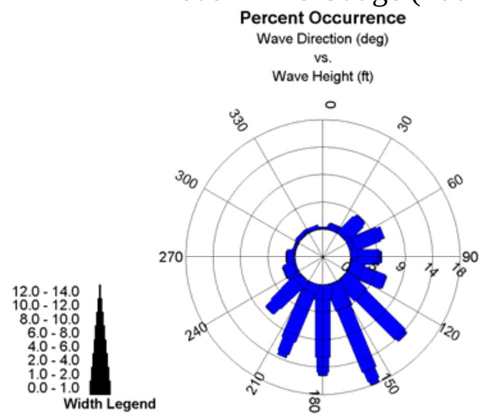
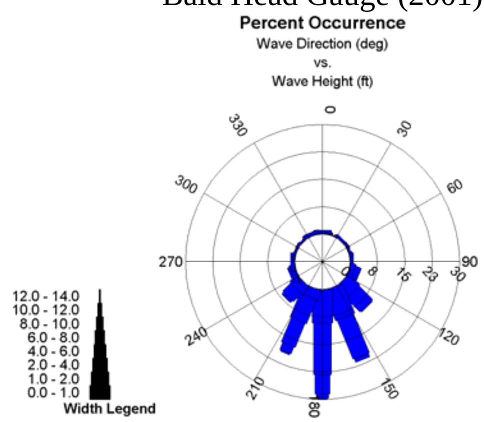


Figure A-2   Wave Height Roses for FRF Gauges (2000).

Eleven-Mile Gauge (2001)



Bald Head Gauge (2001)



Oak Island Gauge (2001)

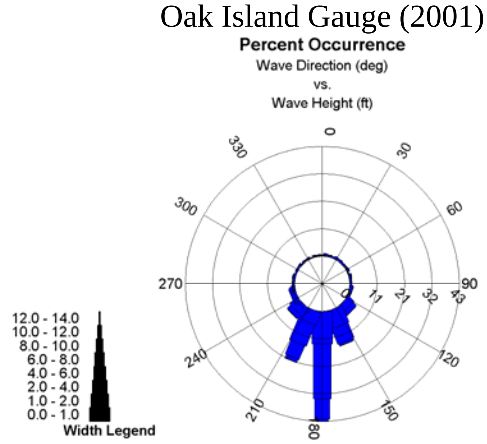
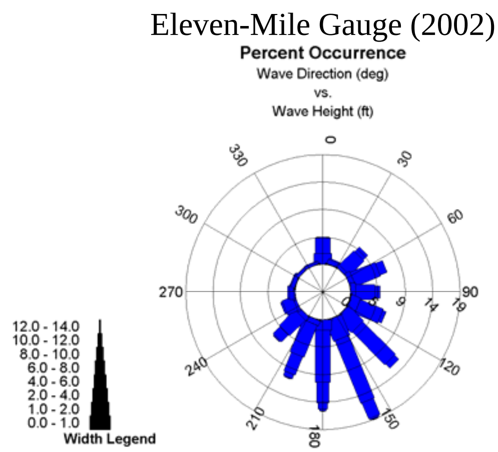
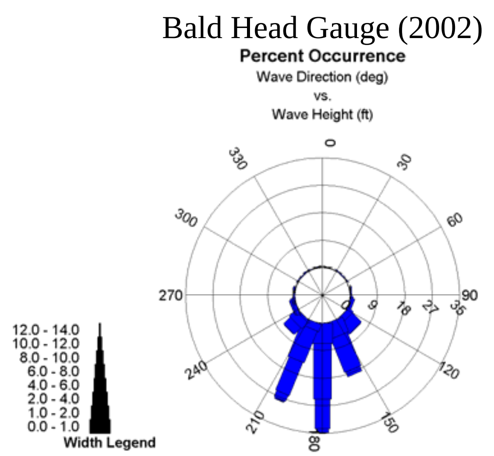


Figure A-3 Wave Height Roses for FRF Gauges (2001).





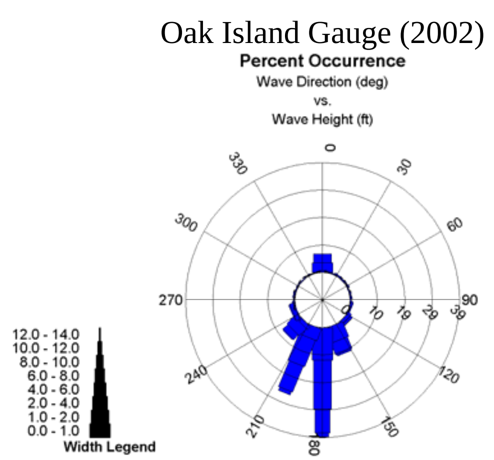
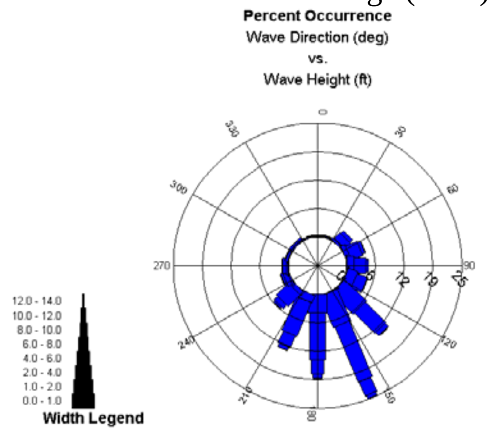
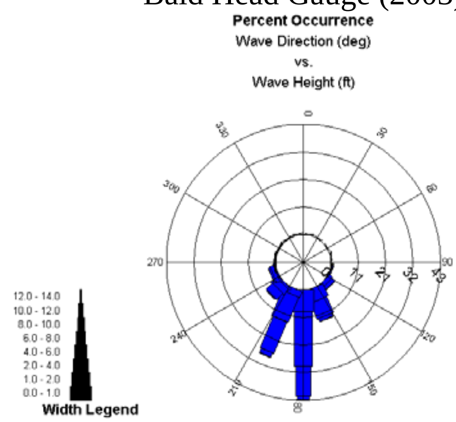


Figure A-4 Wave Height Roses for FRF Gauges (2002).

Eleven-Mile Gauge (2003)



Bald Head Gauge (2003)



Oak Island Gauge (2003)

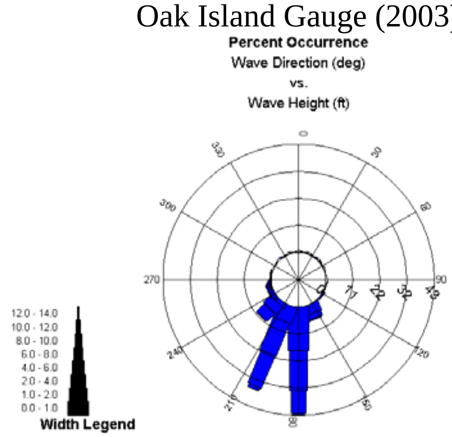
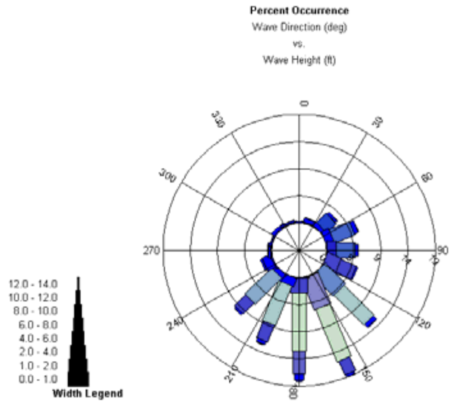
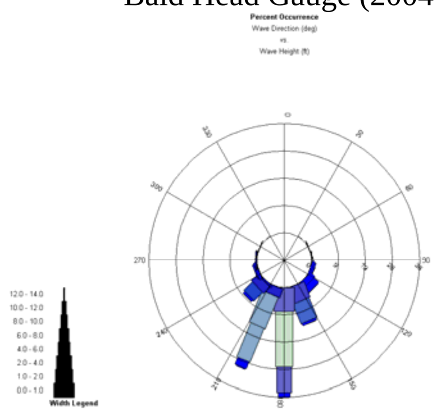


Figure A-5 Wave Height Roses for FRF Gauges (2003).

Eleven-Mile Gauge (2004)



Bald Head Gauge (2004)



Oak Island Gauge (2004)

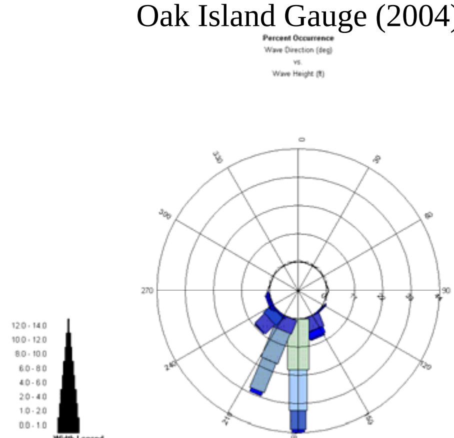
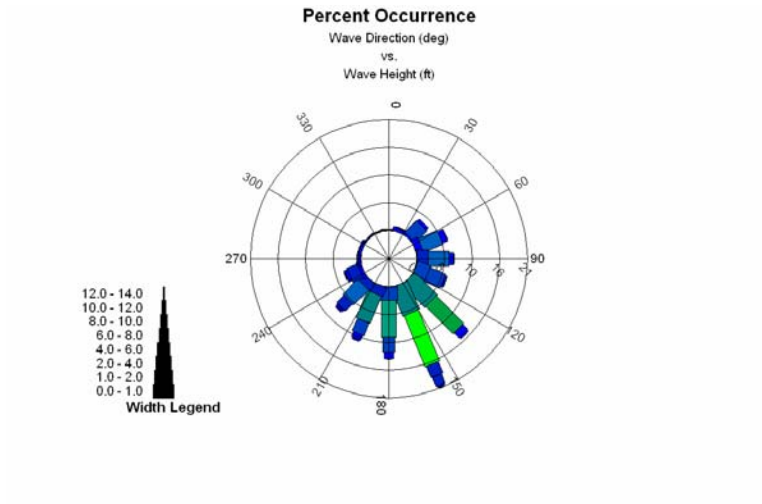
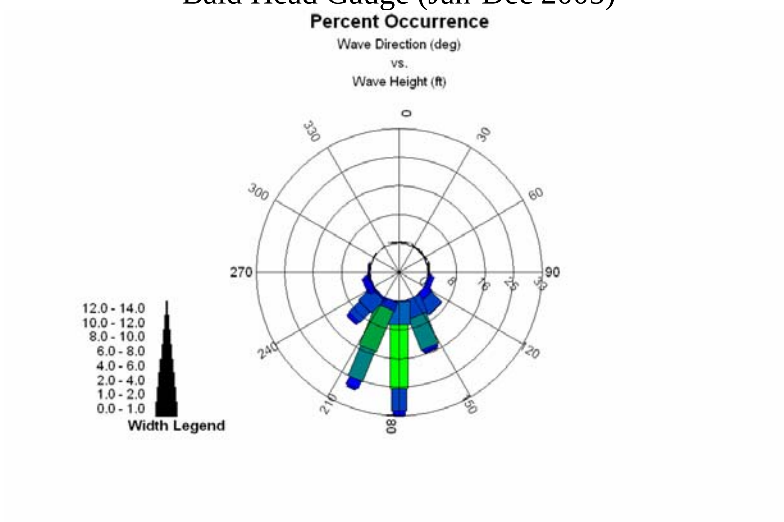


Figure A-6 Wave Height Roses for FRF Gauges (2004).

Eleven-Mile Gauge (Jan-Dec 2005)



Bald Head Gauge (Jan-Dec 2005)



Oak Island Gauge (Jan-Dec 2005)

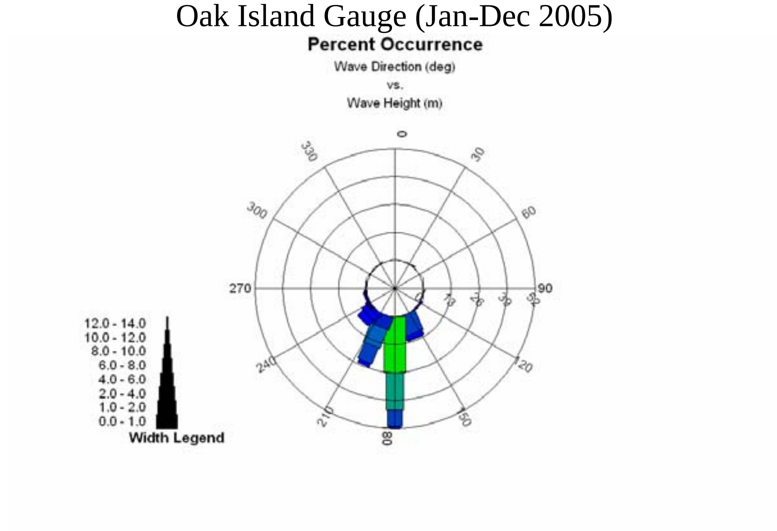
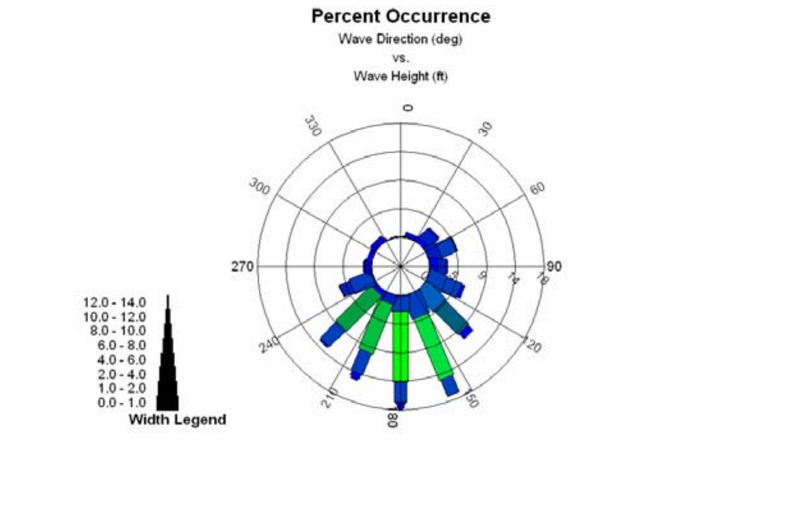
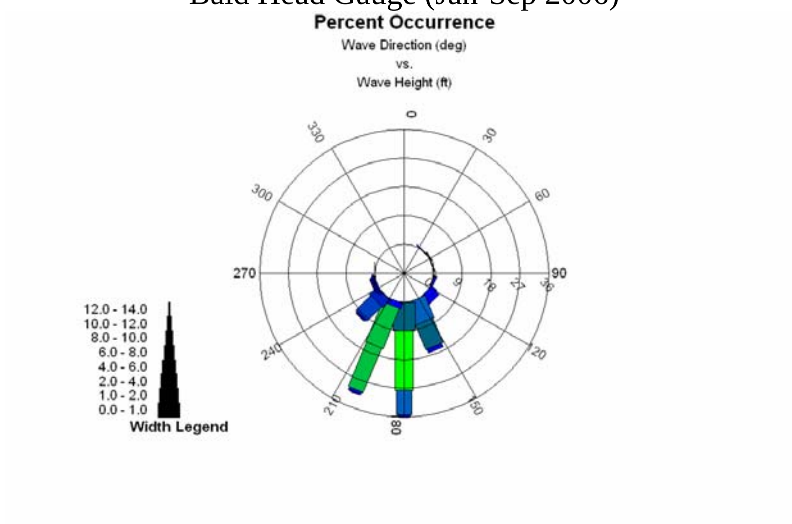


Figure A-7 Wave Height Roses for FRF Gauges (2005).

Eleven-Mile Gauge (Jan-Sep 2006)



Bald Head Gauge (Jan-Sep 2006)



Oak Island Gauge (Jan-Sep 2006)

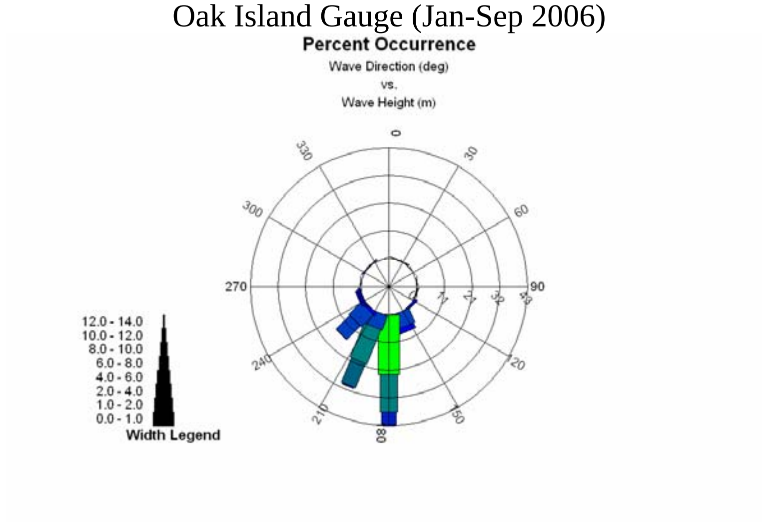
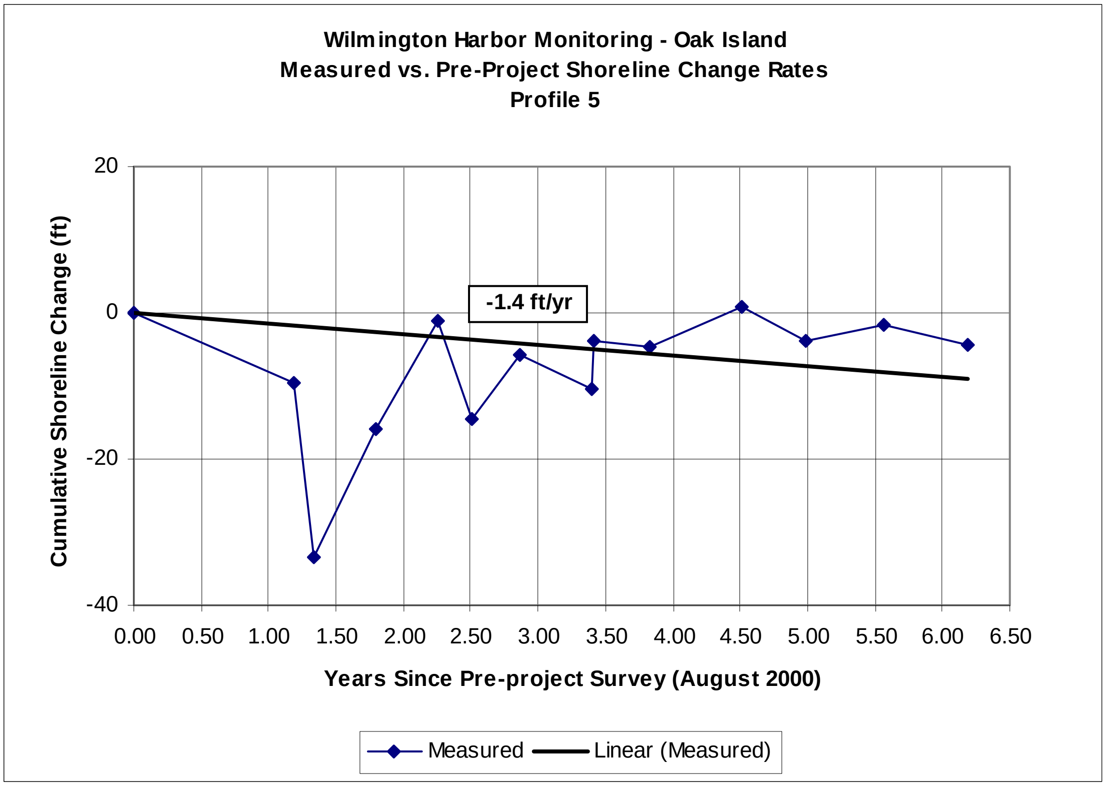
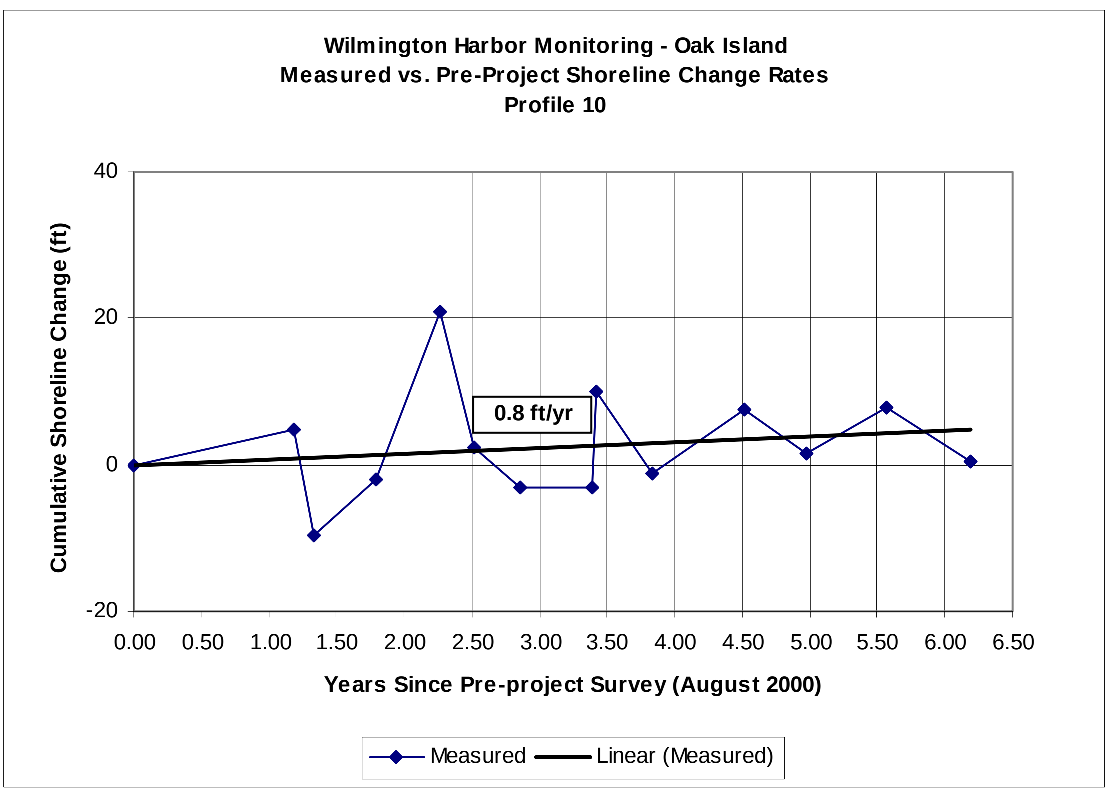


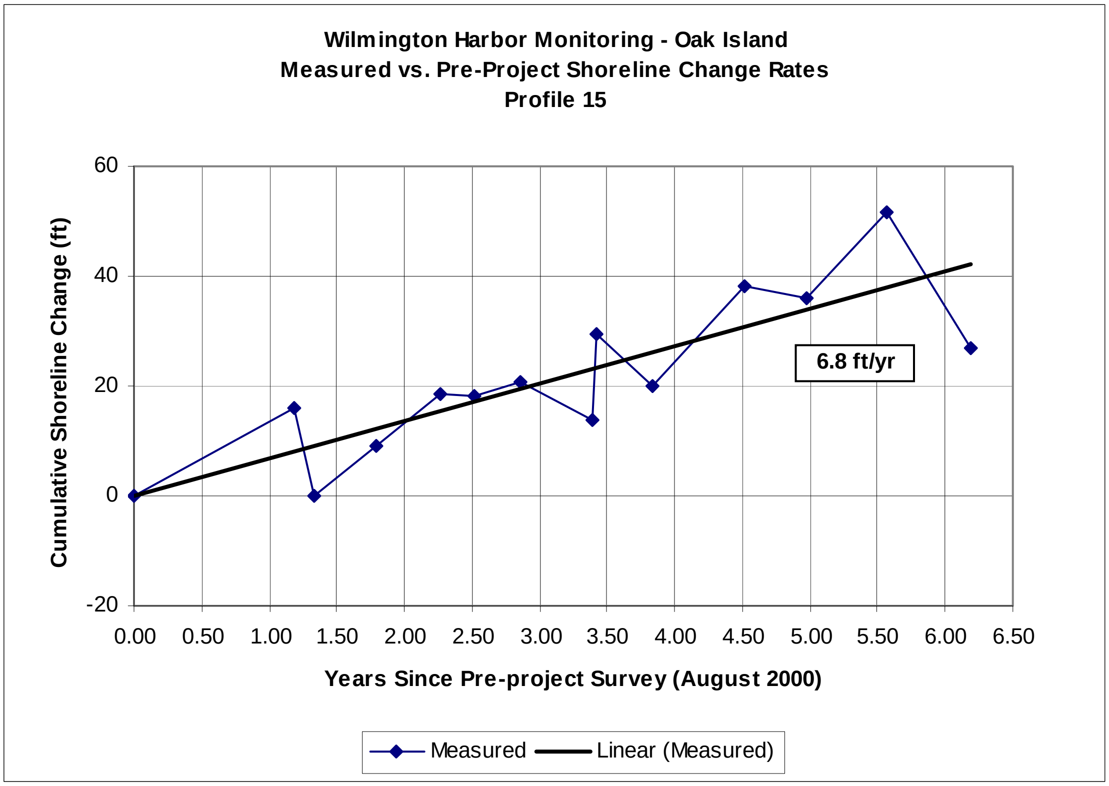
Figure A-7 Wave Height Roses for FRF Gauges (2006).

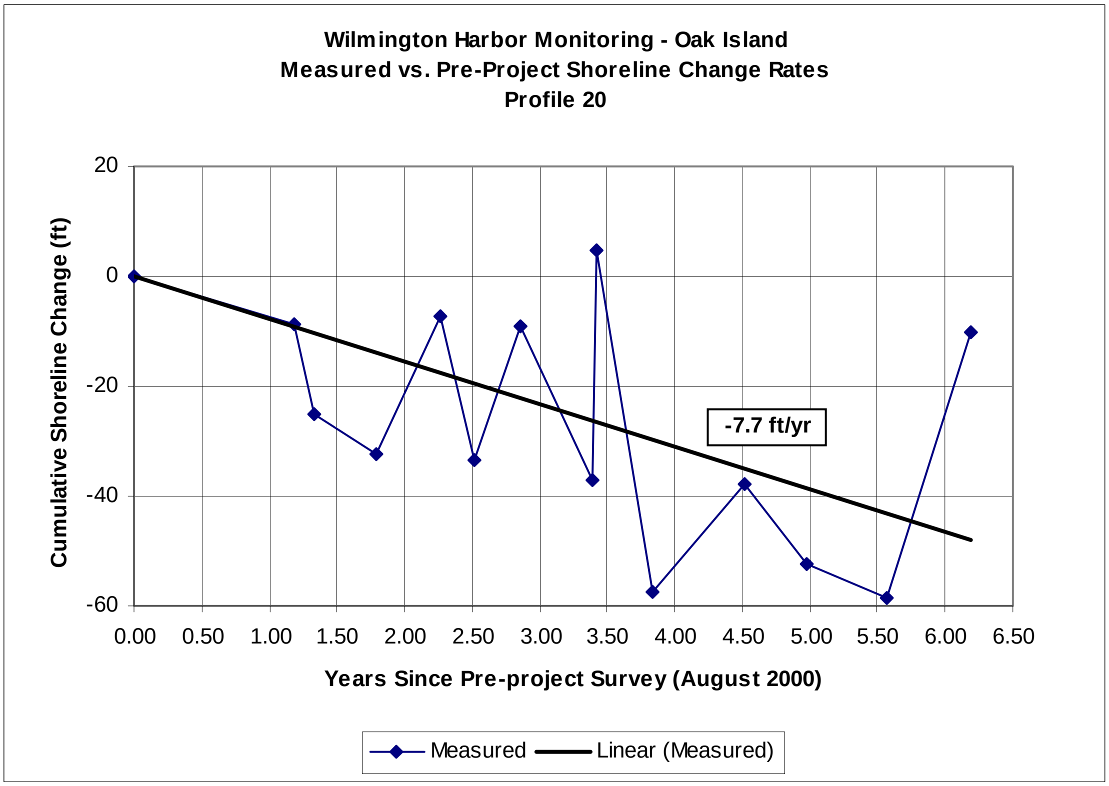
Appendix B

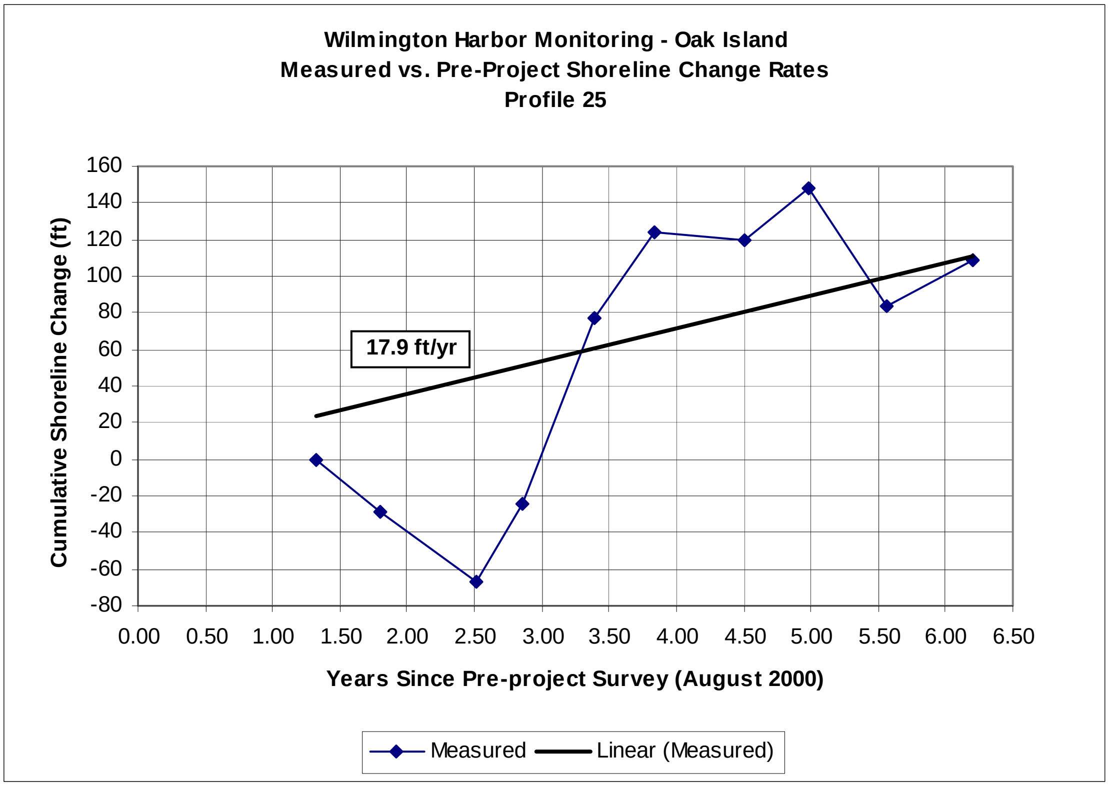
SHORELINE CHANGE RATES
(Oak Island)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 5
-1.4 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
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

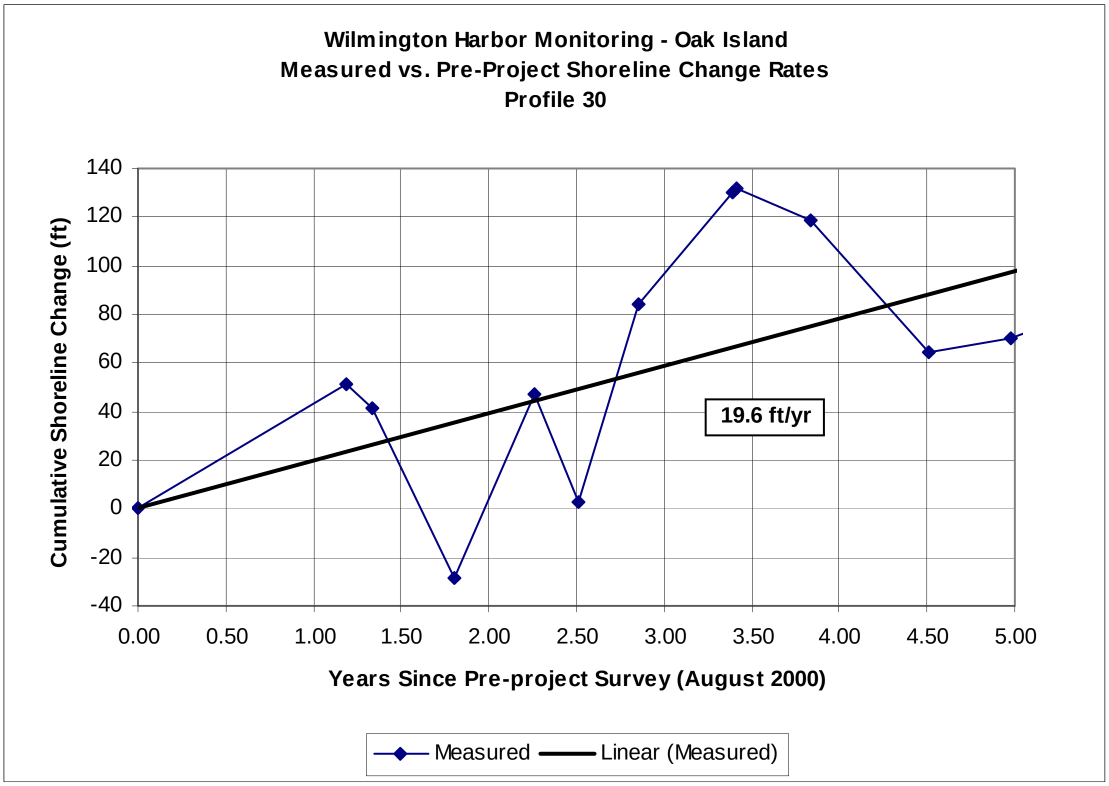

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 10
0.8 ft/yr
Cumulative Shoreline Change (ft)
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)


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
6.8 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

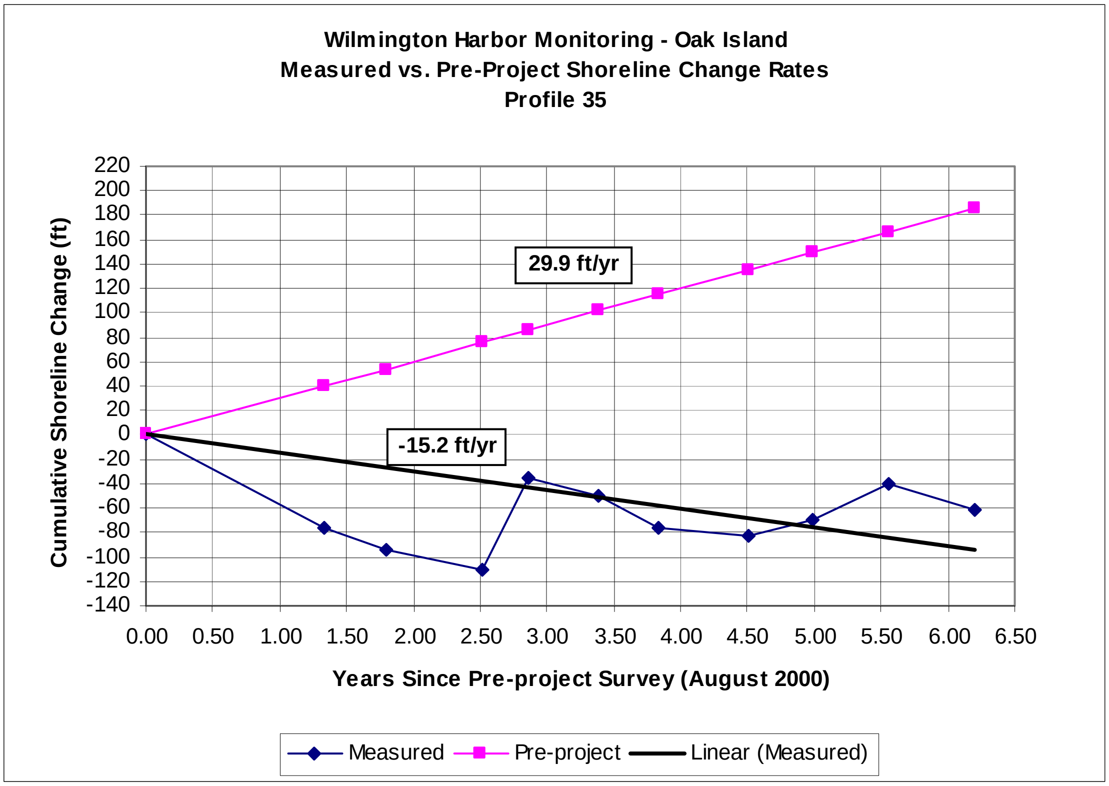

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
-7.7 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

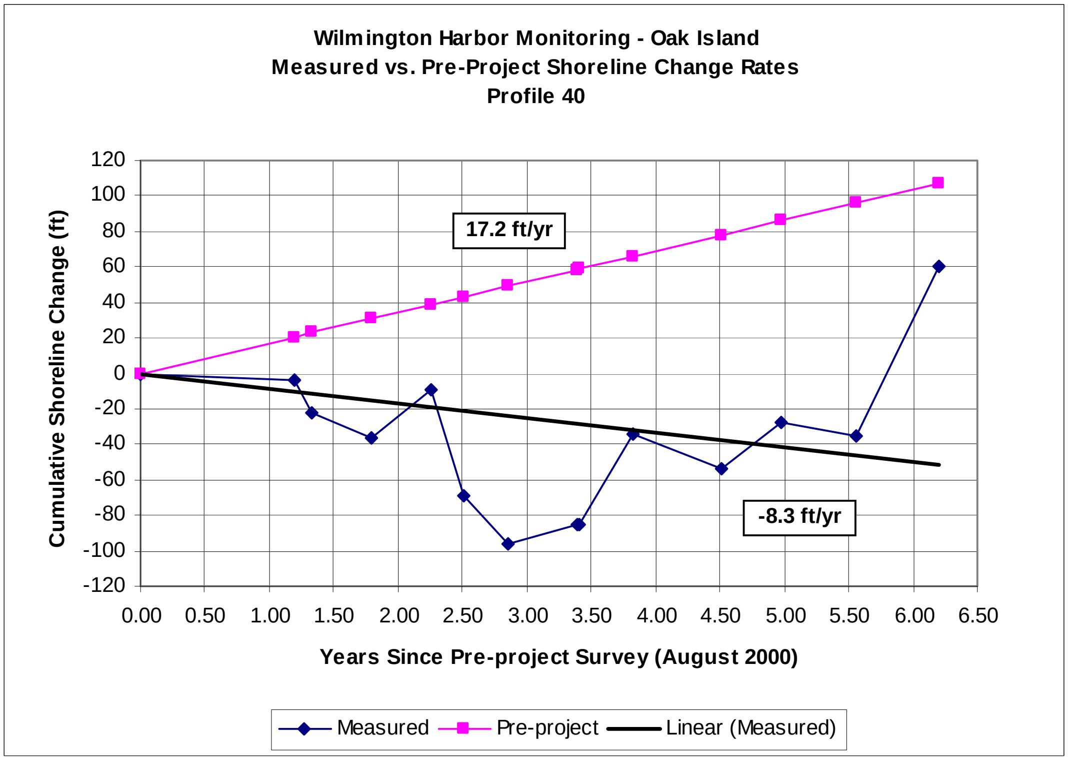


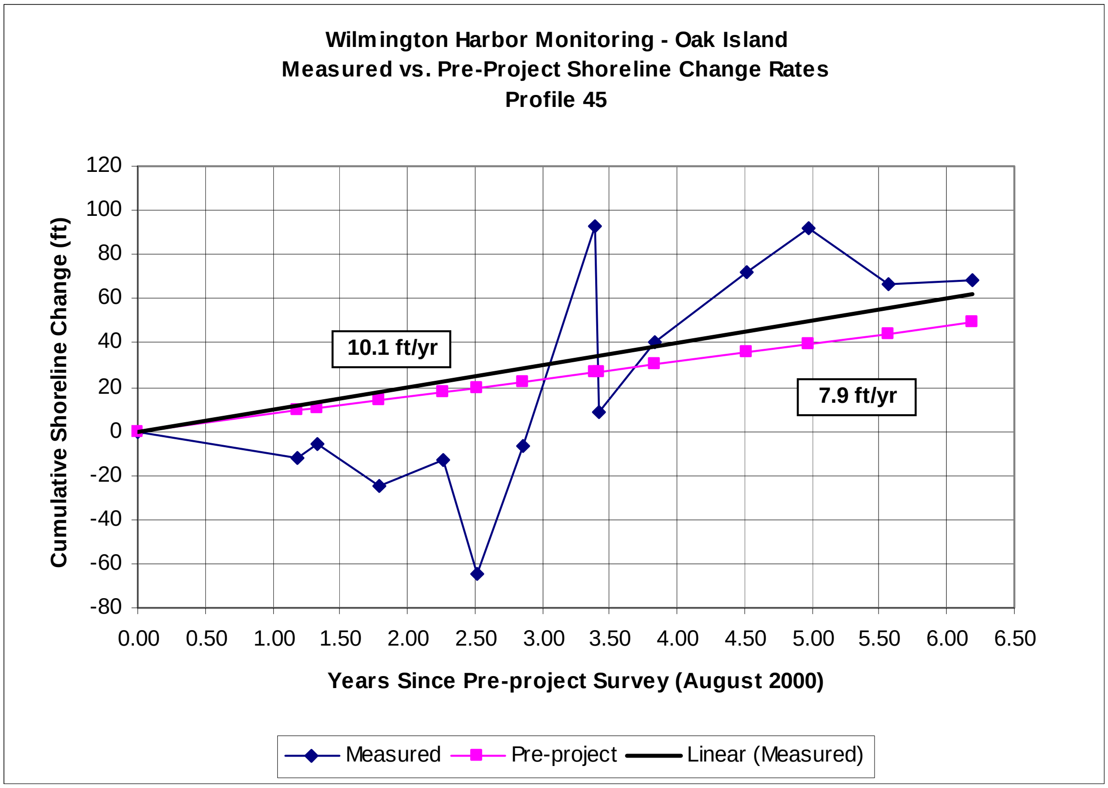
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 25
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
17.9 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)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

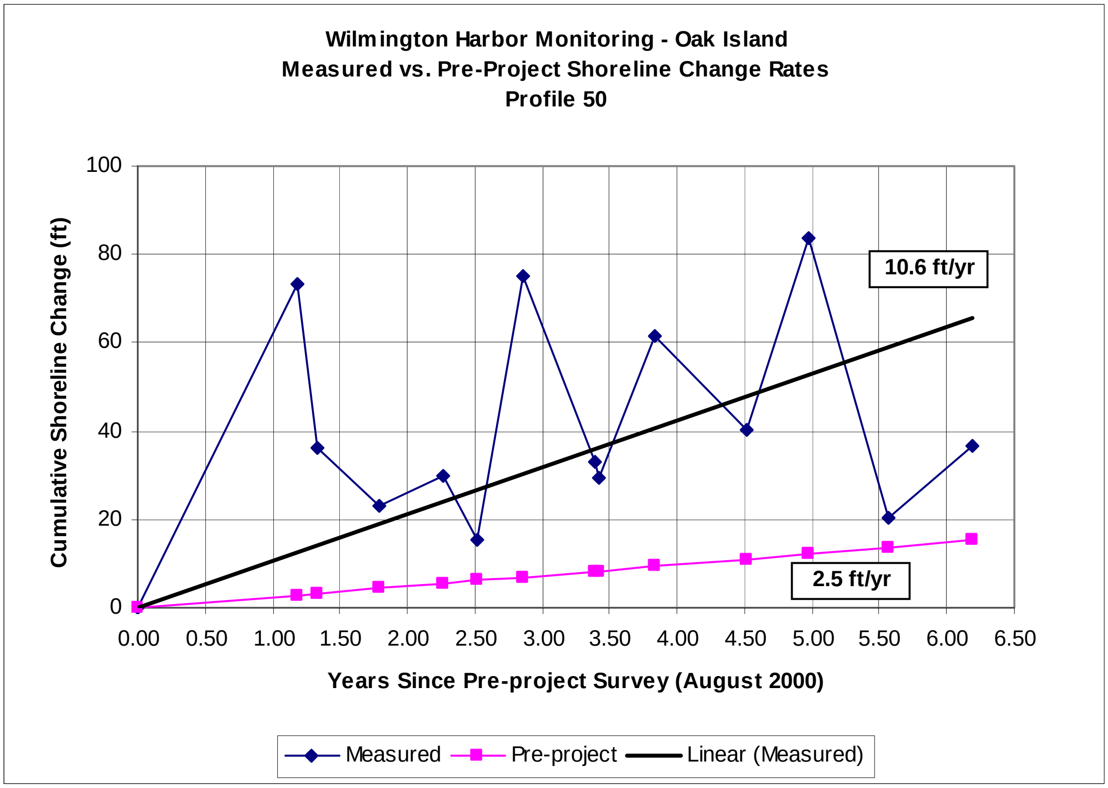


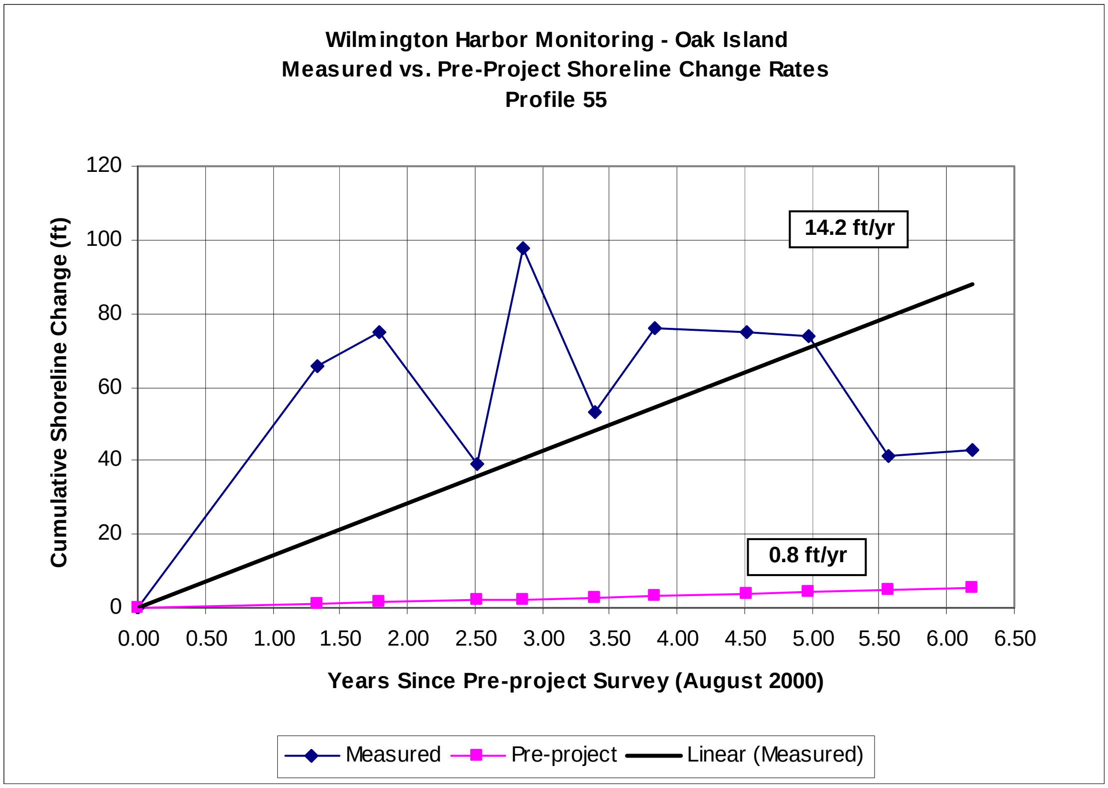
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 30
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
19.6 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

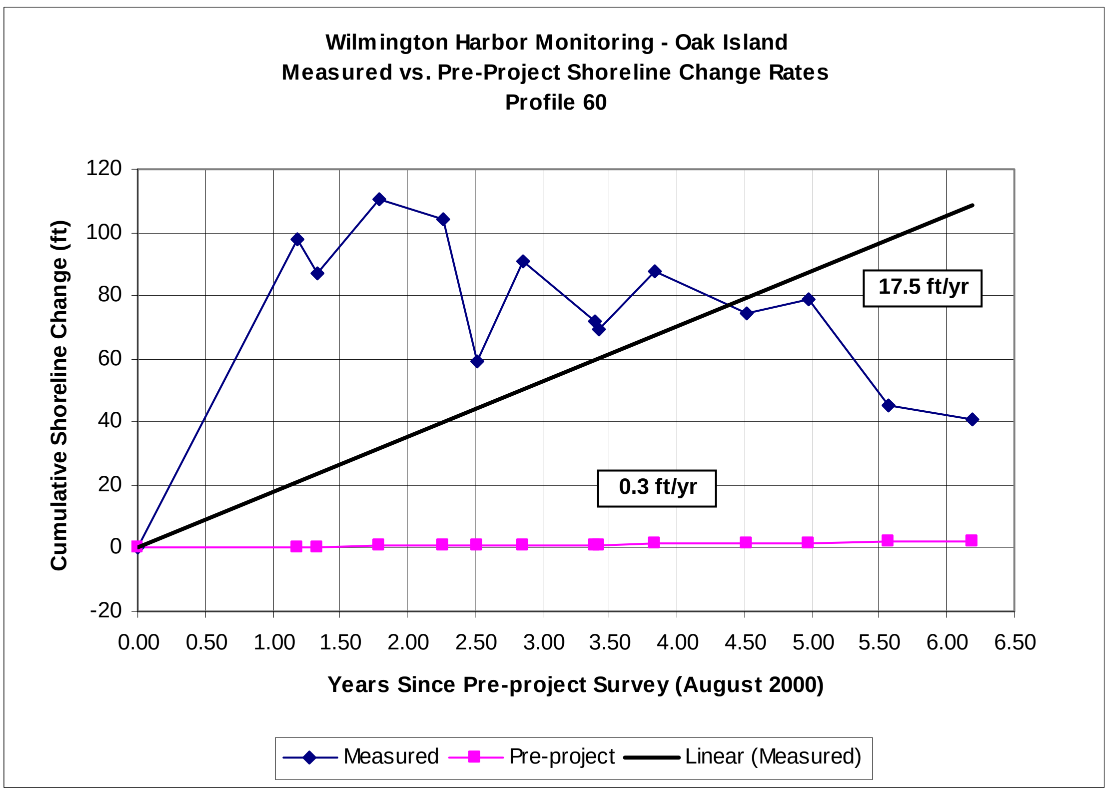

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 35
29.9 ft/yr
-15.2 ft/yr
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

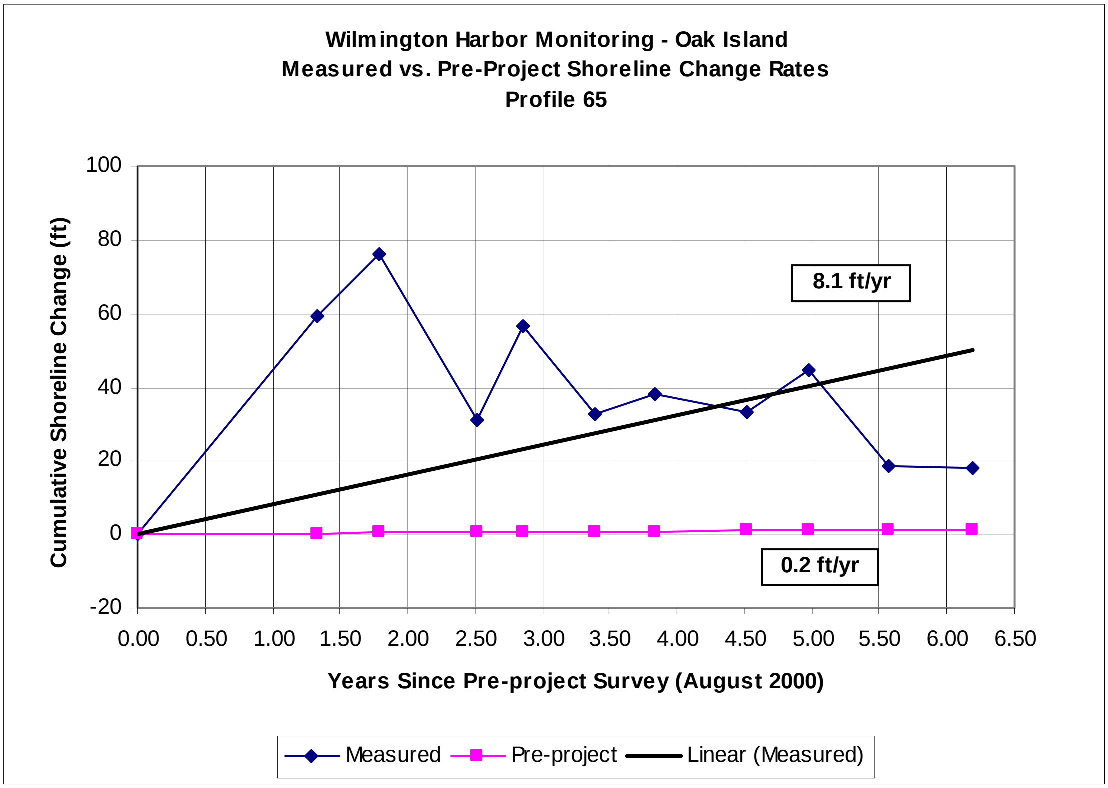

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
17.2 ft/yr
-8.3 ft/yr
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

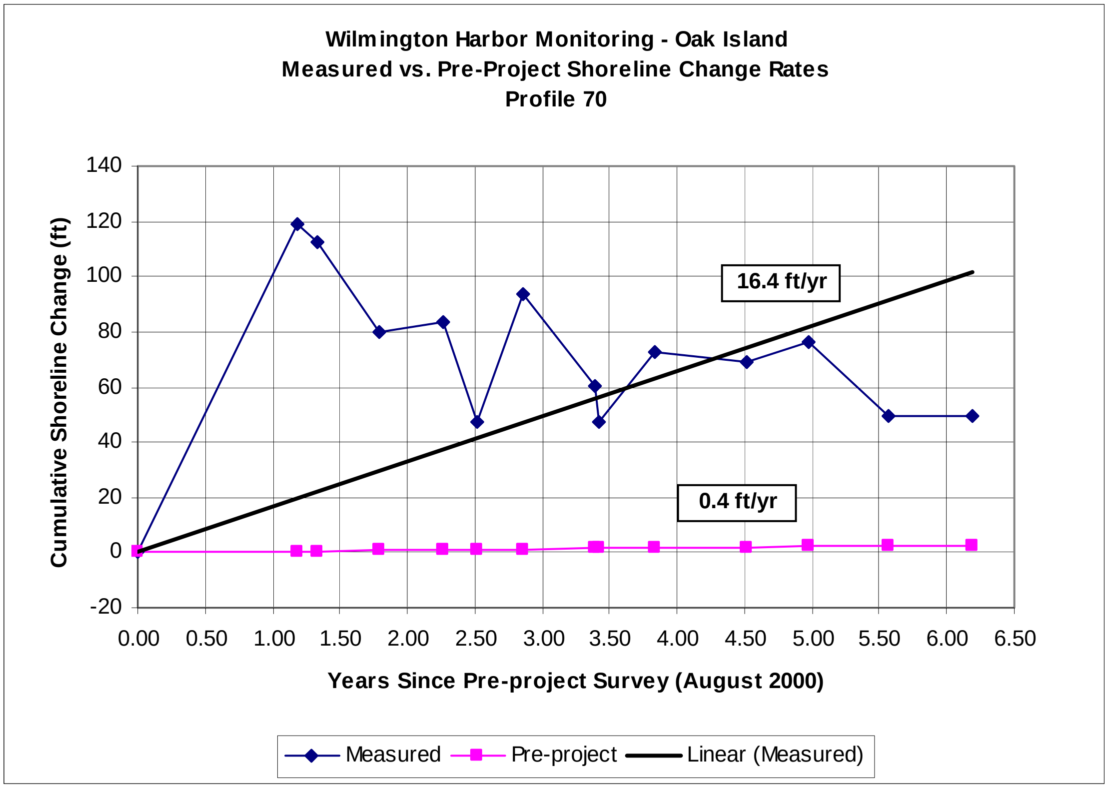

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
10.1 ft/yr
7.9 ft/yr
Years Since Pre-project Survey (August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

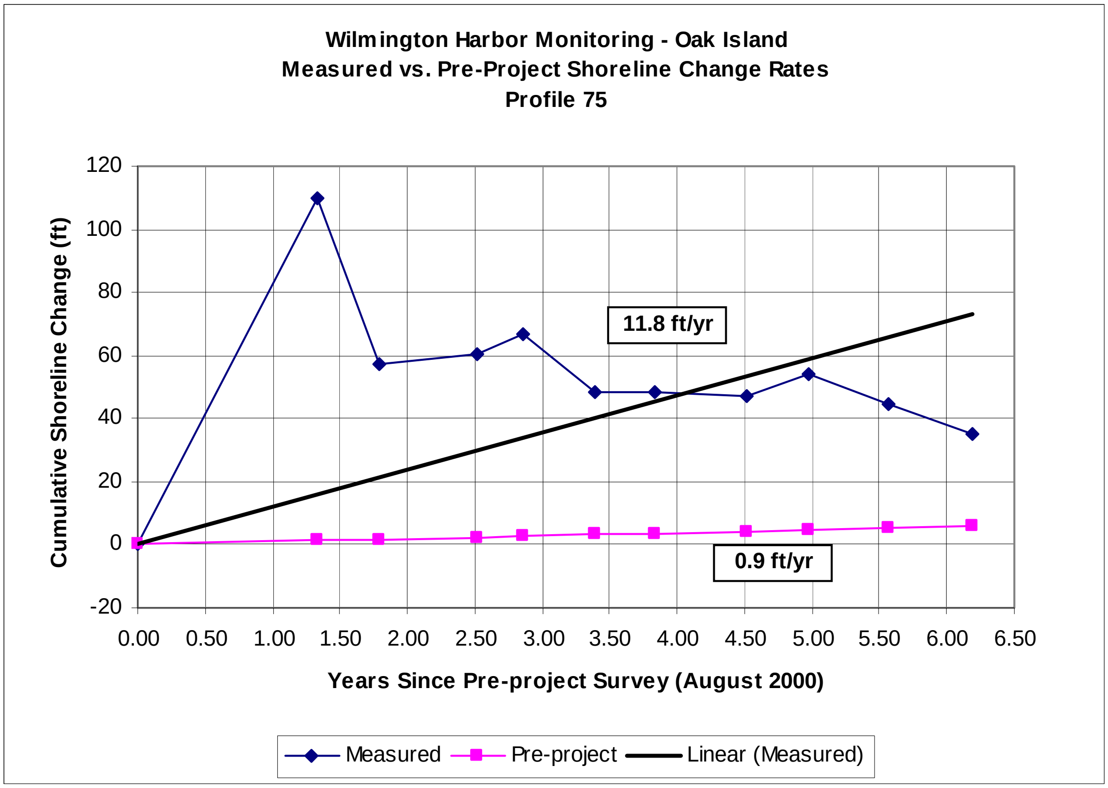

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 50
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
10.6 ft/yr
2.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

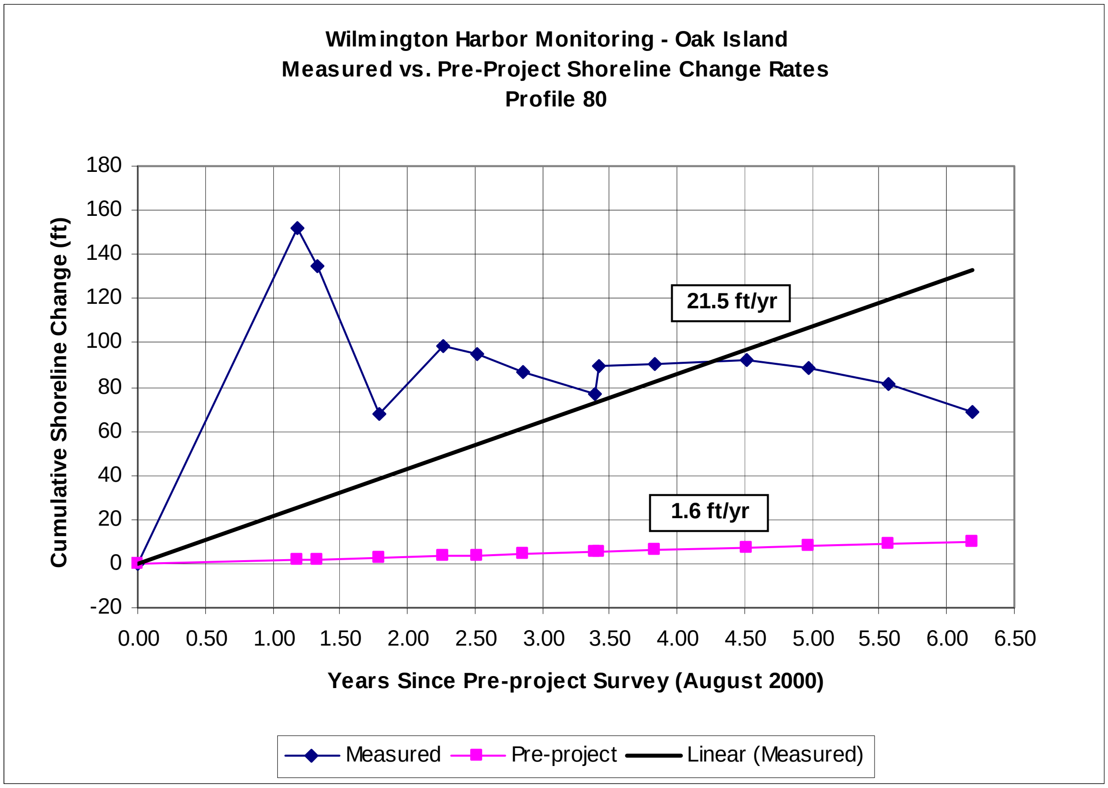

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 55
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
14.2 ft/yr
0.8 ft/yr
Measured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

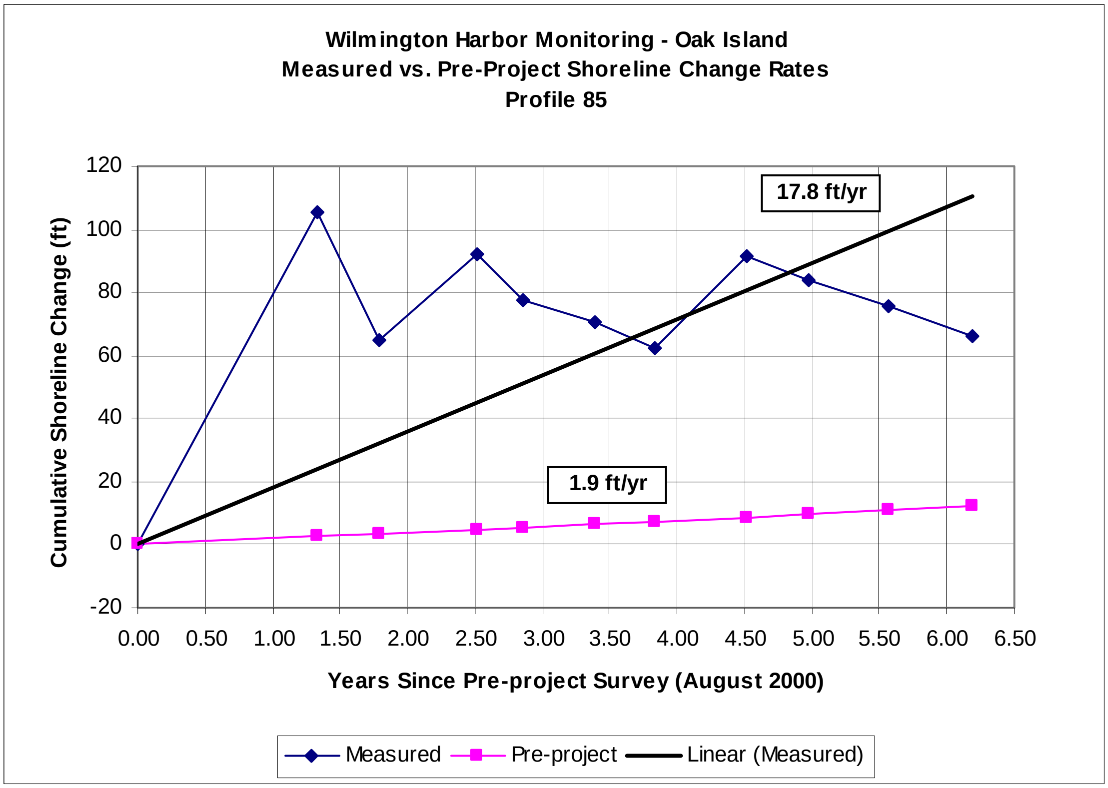

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 60
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
17.5 ft/yr
0.3 ft/yr
Measured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

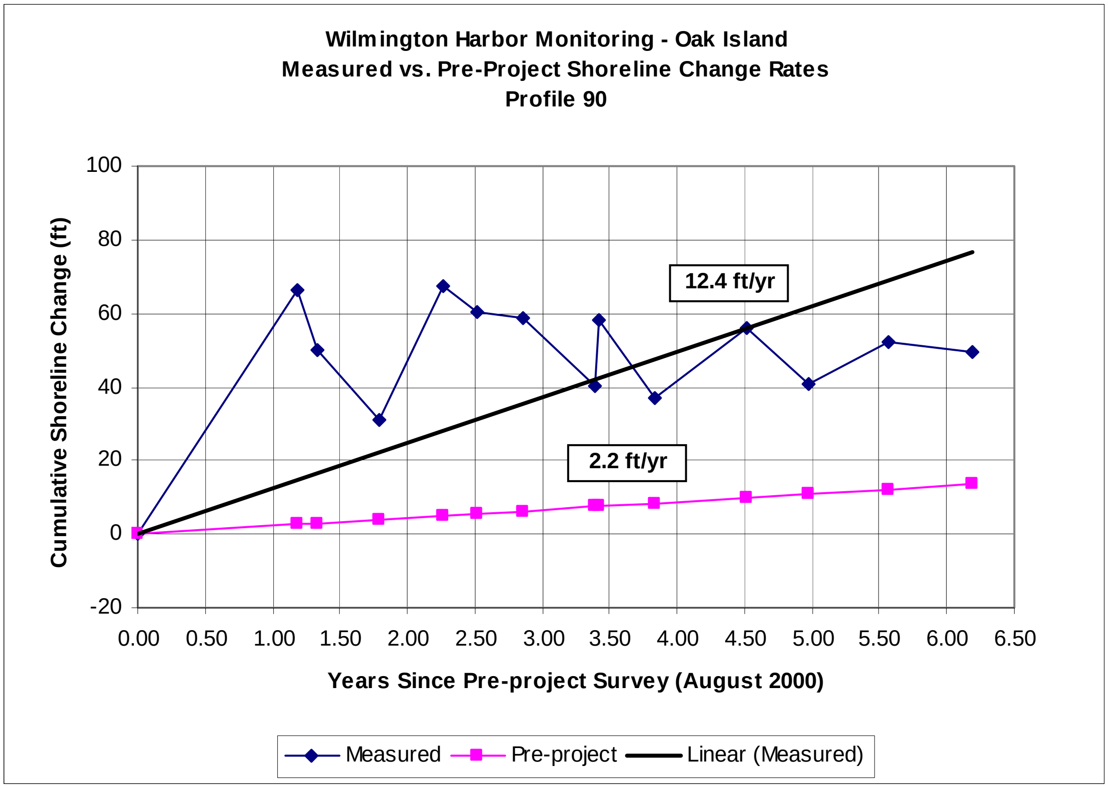

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 65
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
8.1 ft/yr
0.2 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

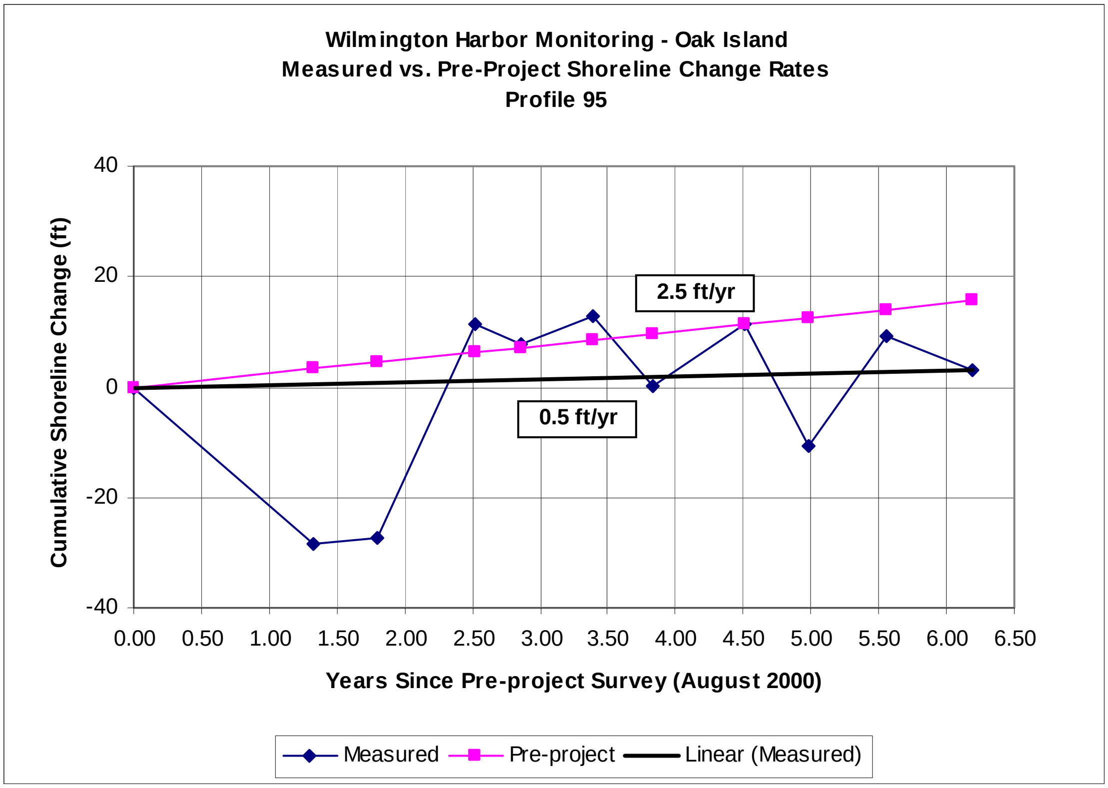

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 70
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
16.4 ft/yr
0.4 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured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

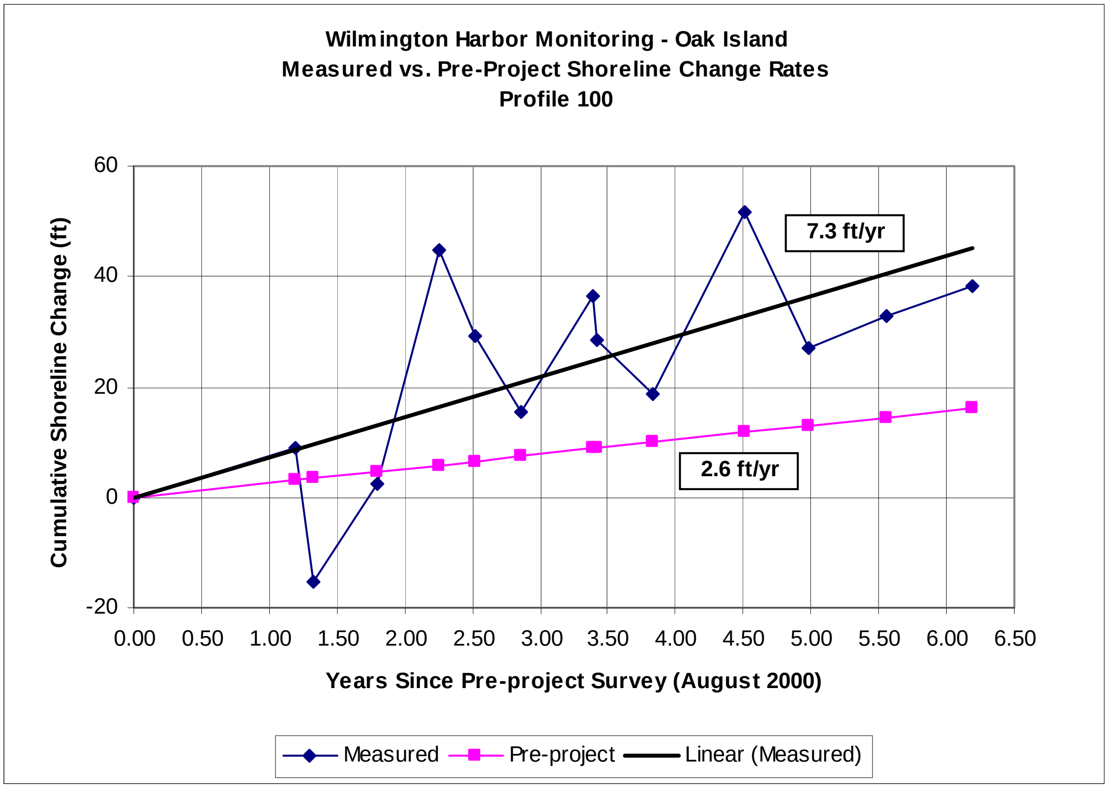

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 75
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
11.8 ft/yr
0.9 ft/yr
Measured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

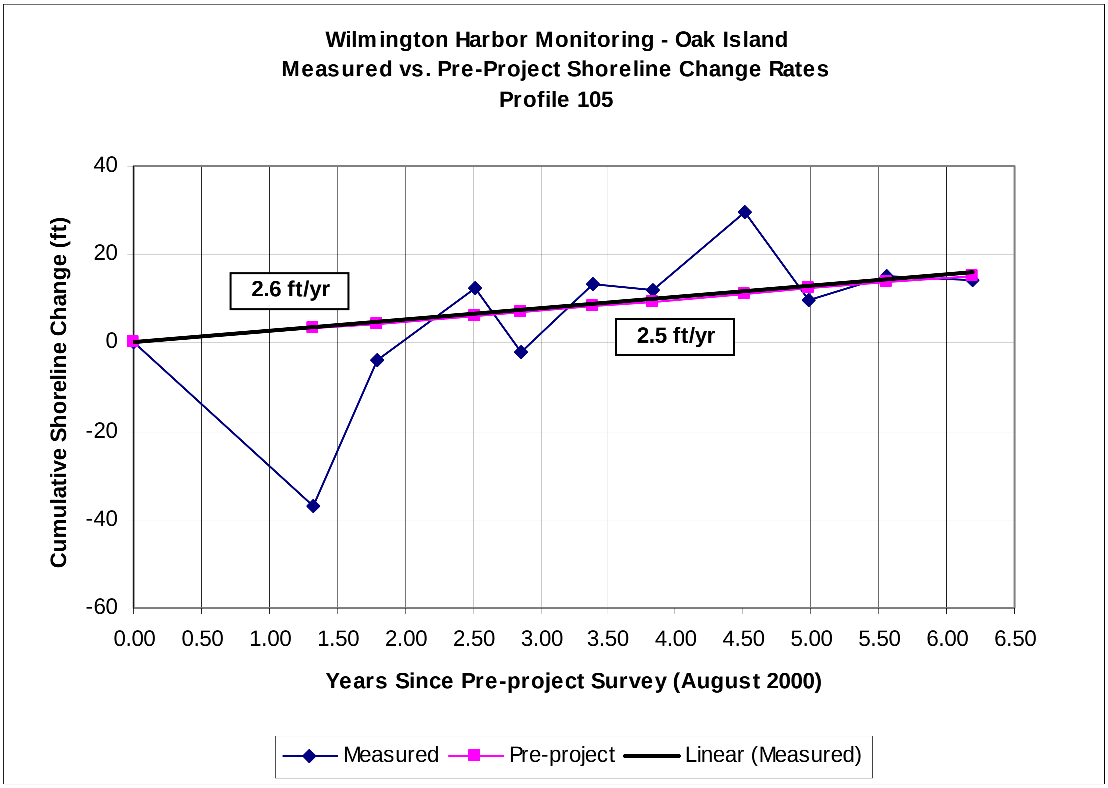

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 80
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
21.5 ft/yr
1.6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

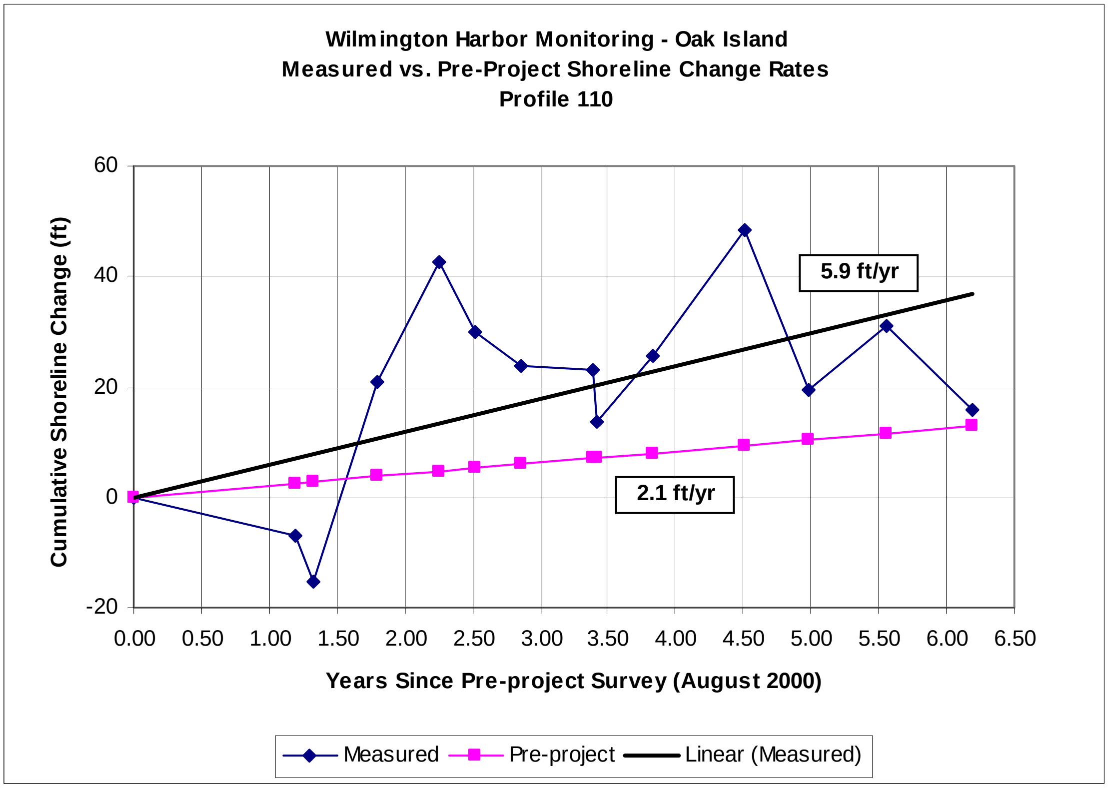

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 85
17.8 ft/yr
1.9 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

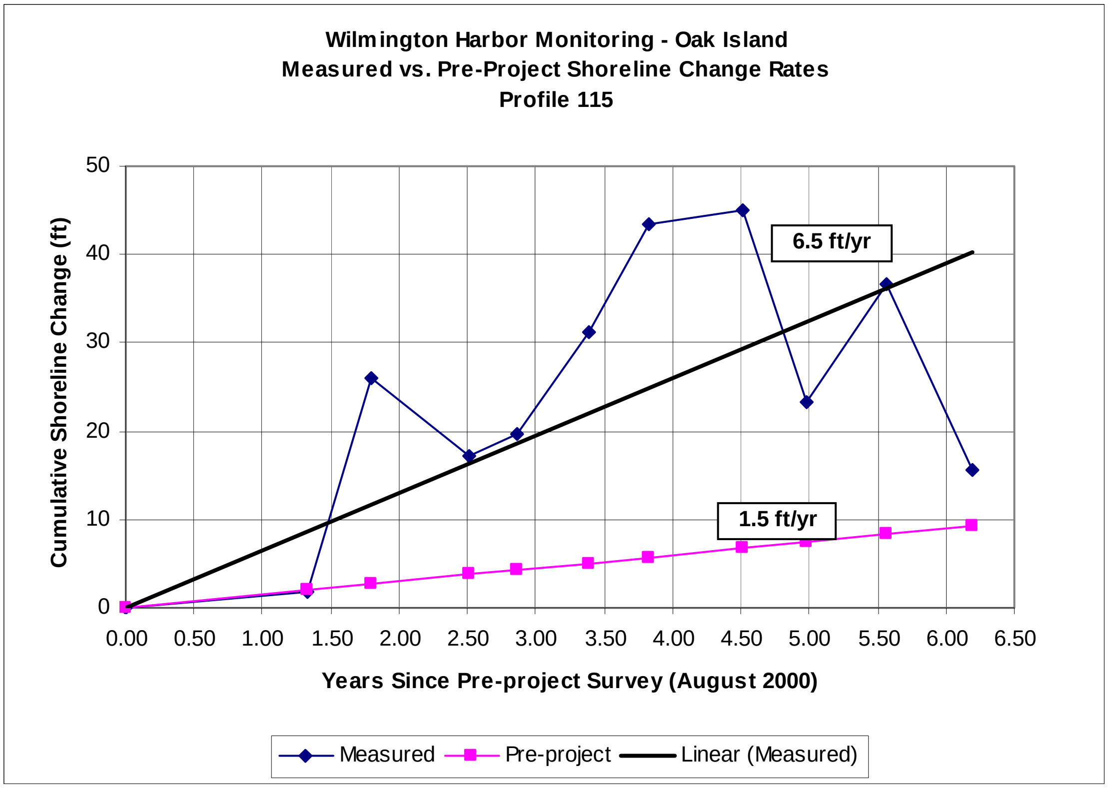

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 90
12.4 ft/yr
2.2 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

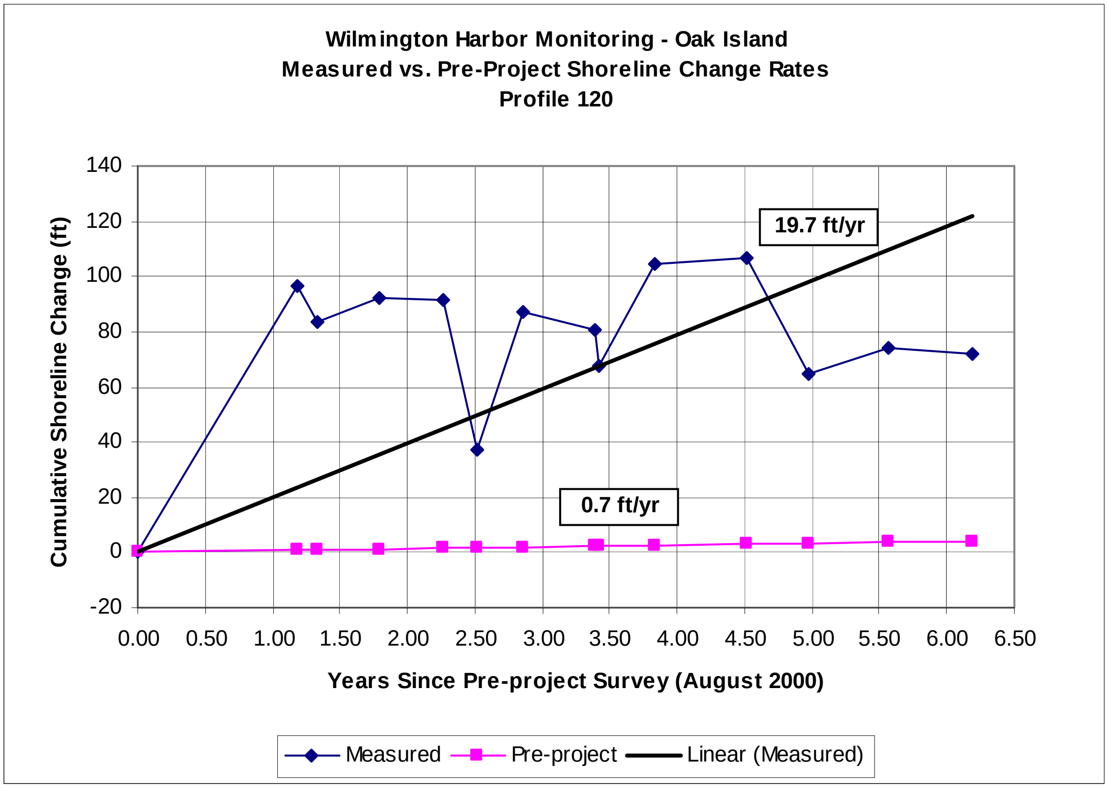

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 95
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
2.5 ft/yr
0.5 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

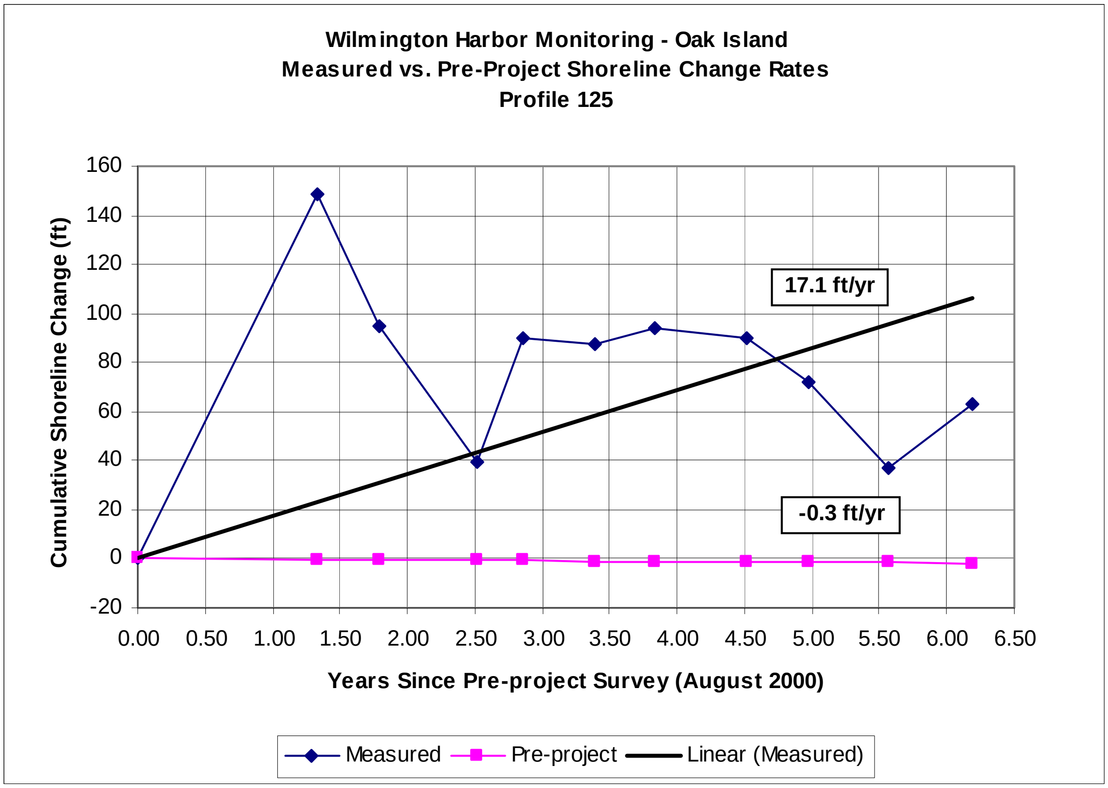

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 100
Cumulative Shoreline Change (ft)
60
40
20
0
-20
7.3 ft/yr
2.6 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

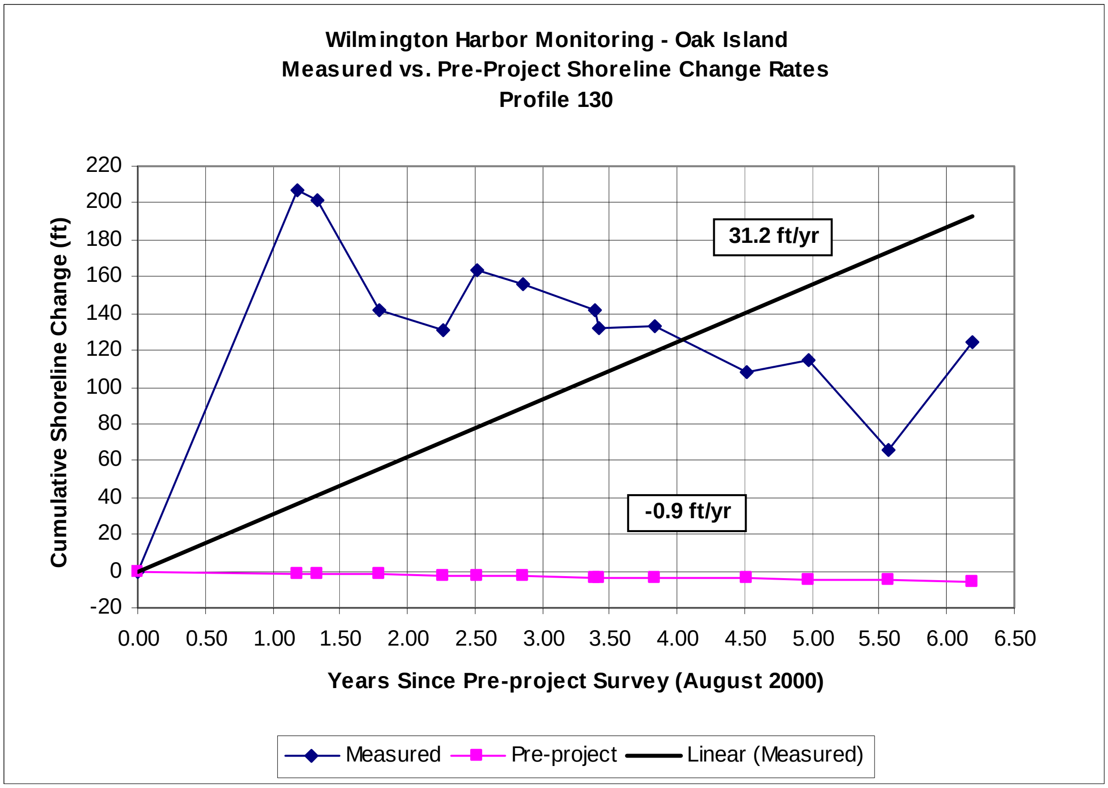

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 105
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
2.6 ft/yr
2.5 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

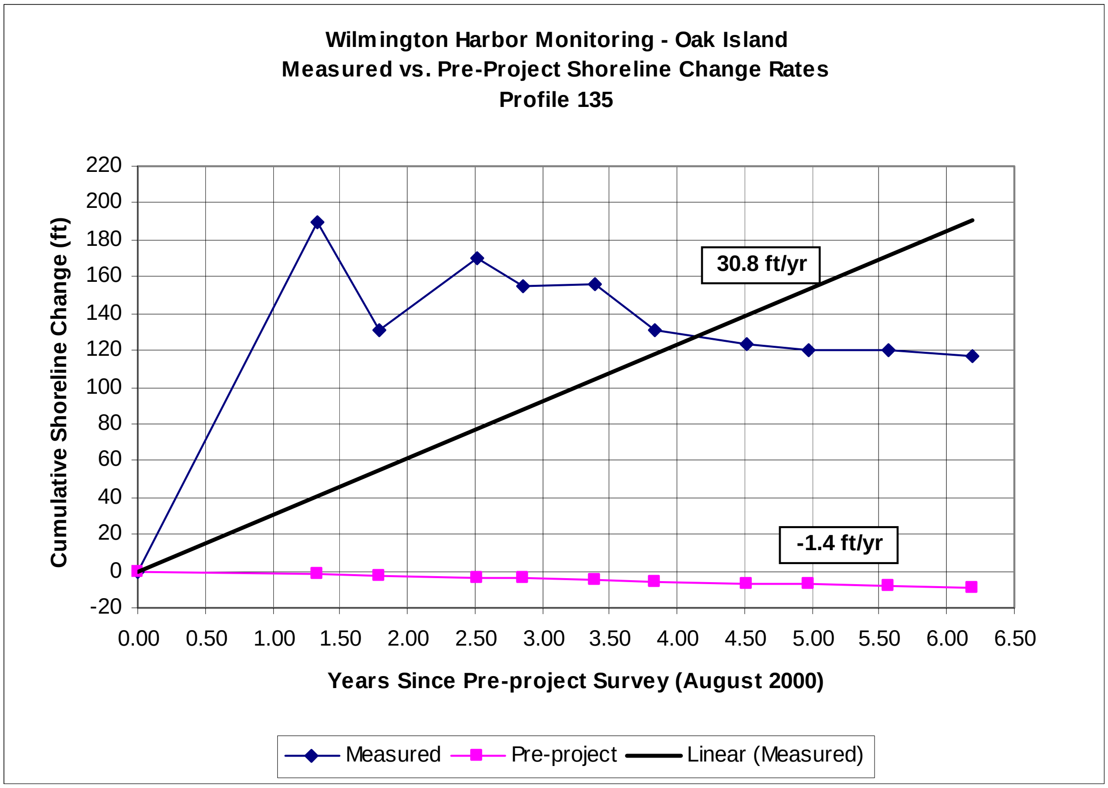

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
60
40
20
0
-20
5.9 ft/yr
2.1 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

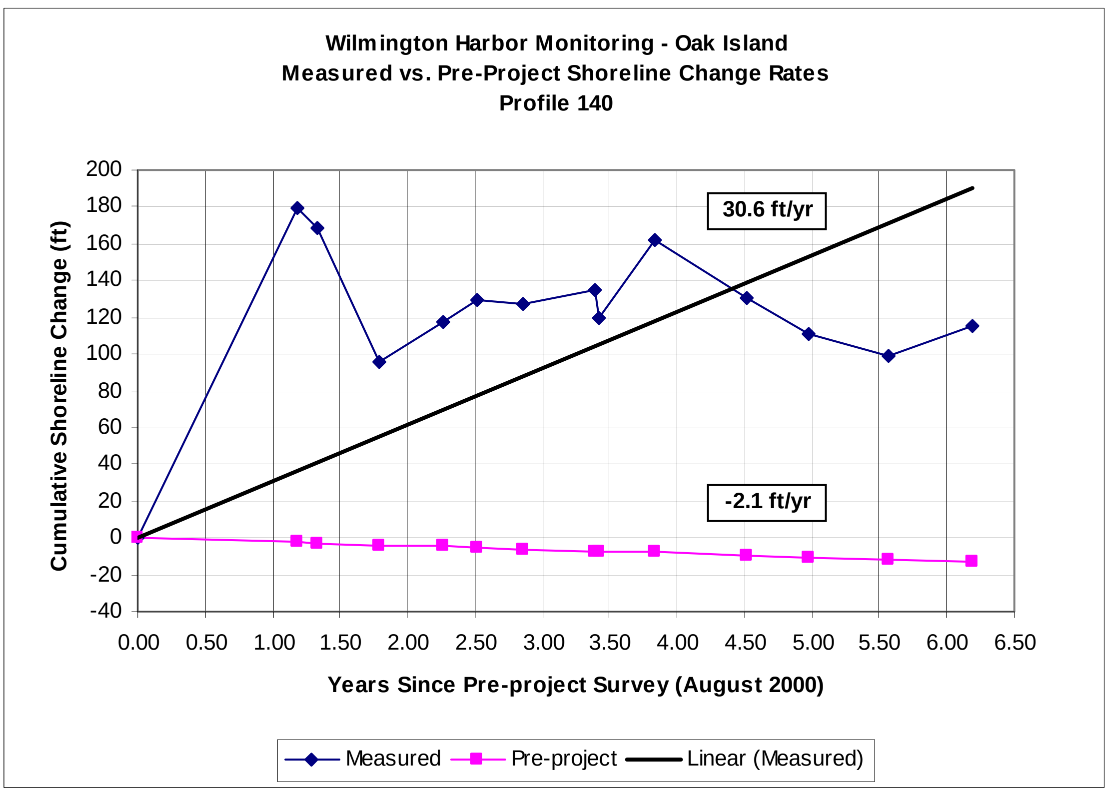

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 115
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
6.5 ft/yr
1.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

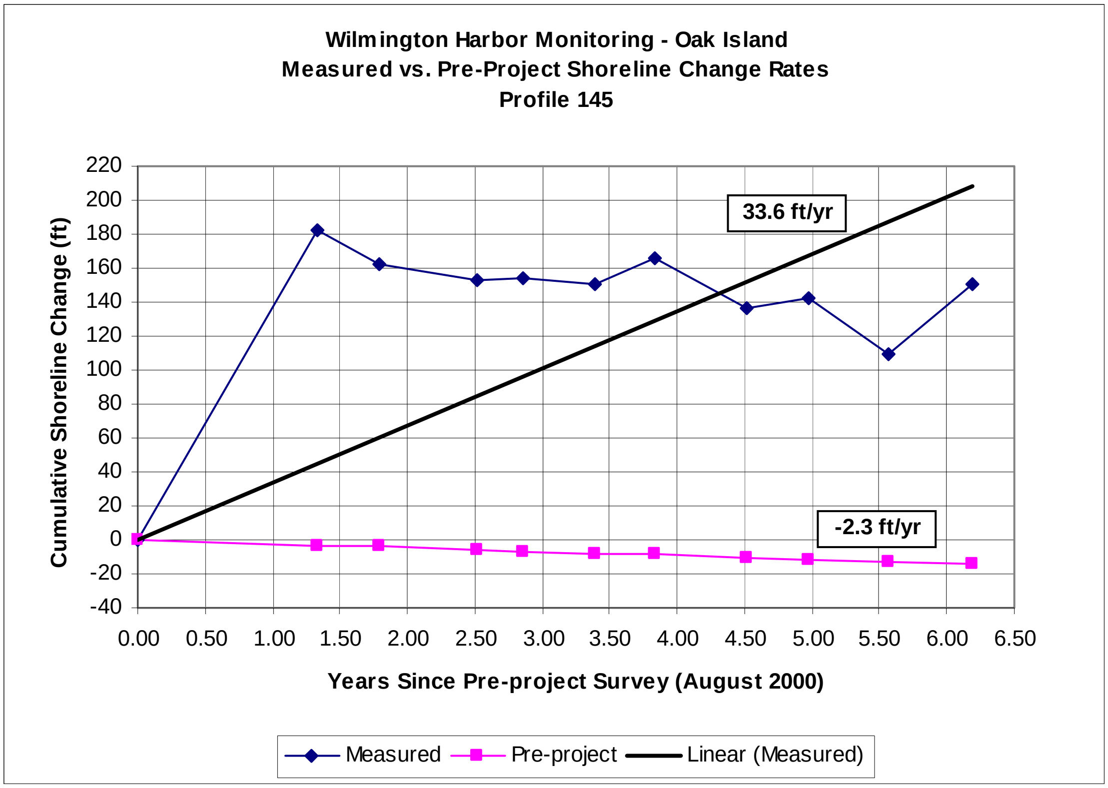

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 120
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
19.7 ft/yr
0.7 ft/yr
Years Since Pre-project Survey (August 2000)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

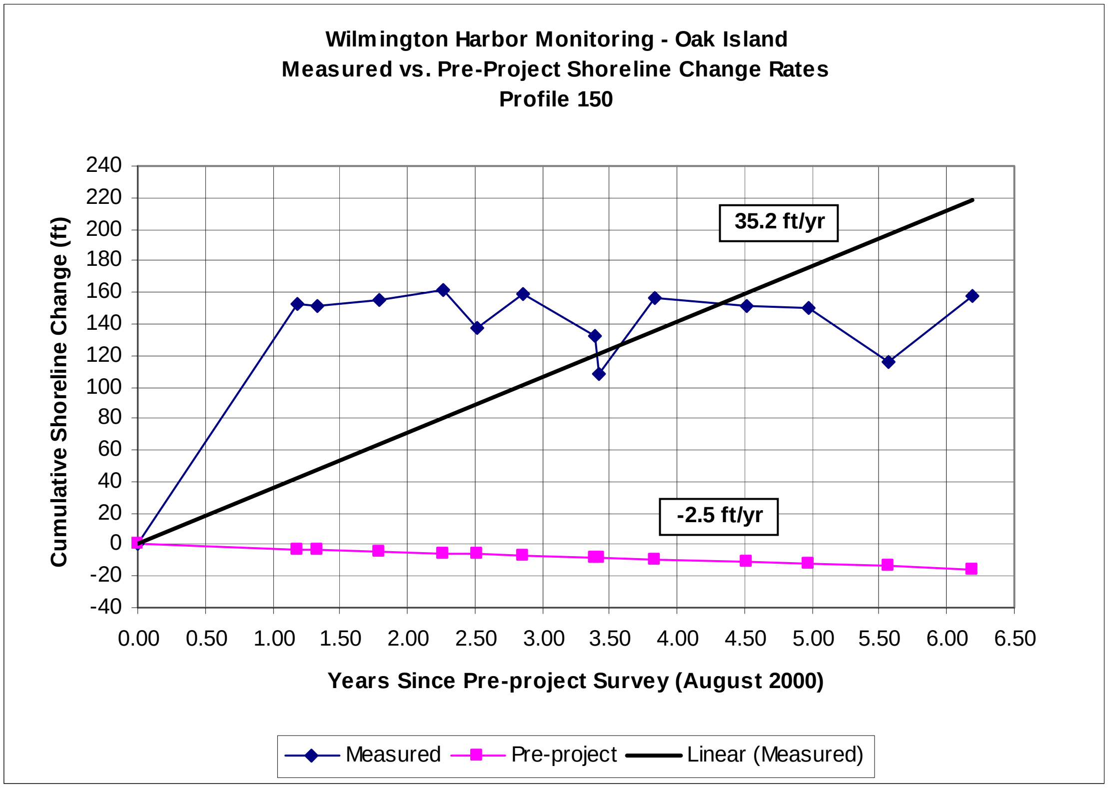

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 125
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
17.1 ft/yr
-0.3 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

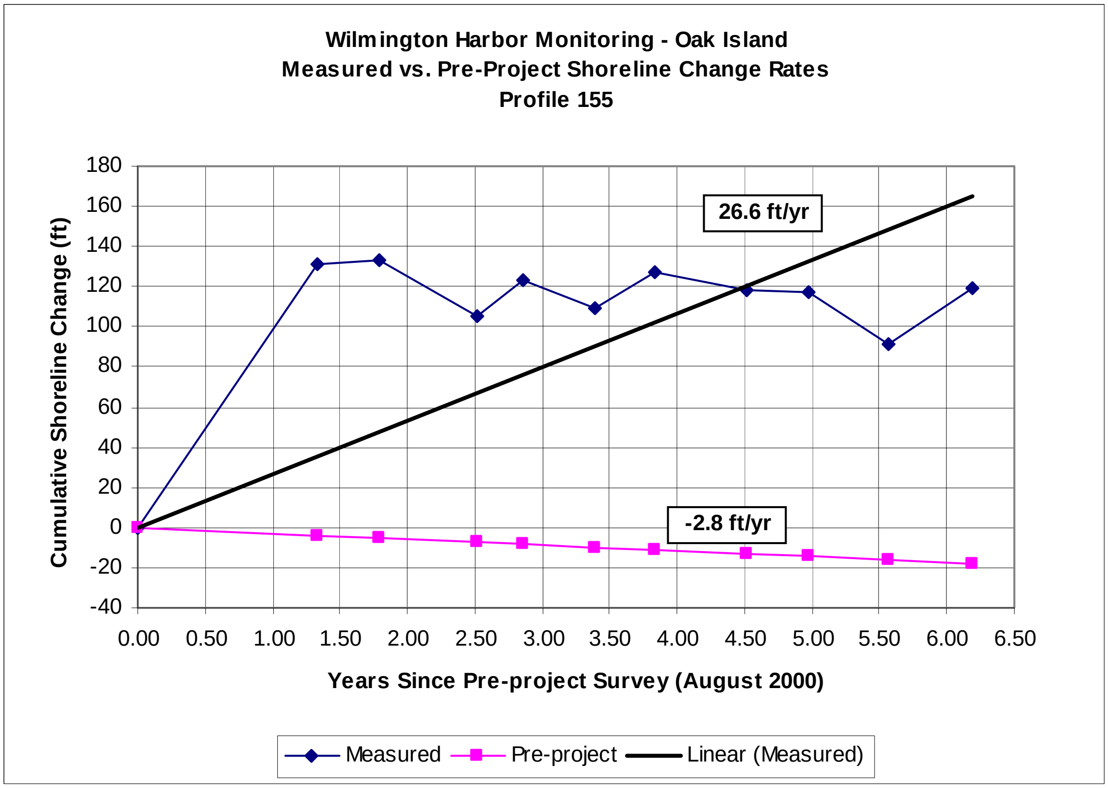

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
31.2 ft/yr
-0.9 ft/yr
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

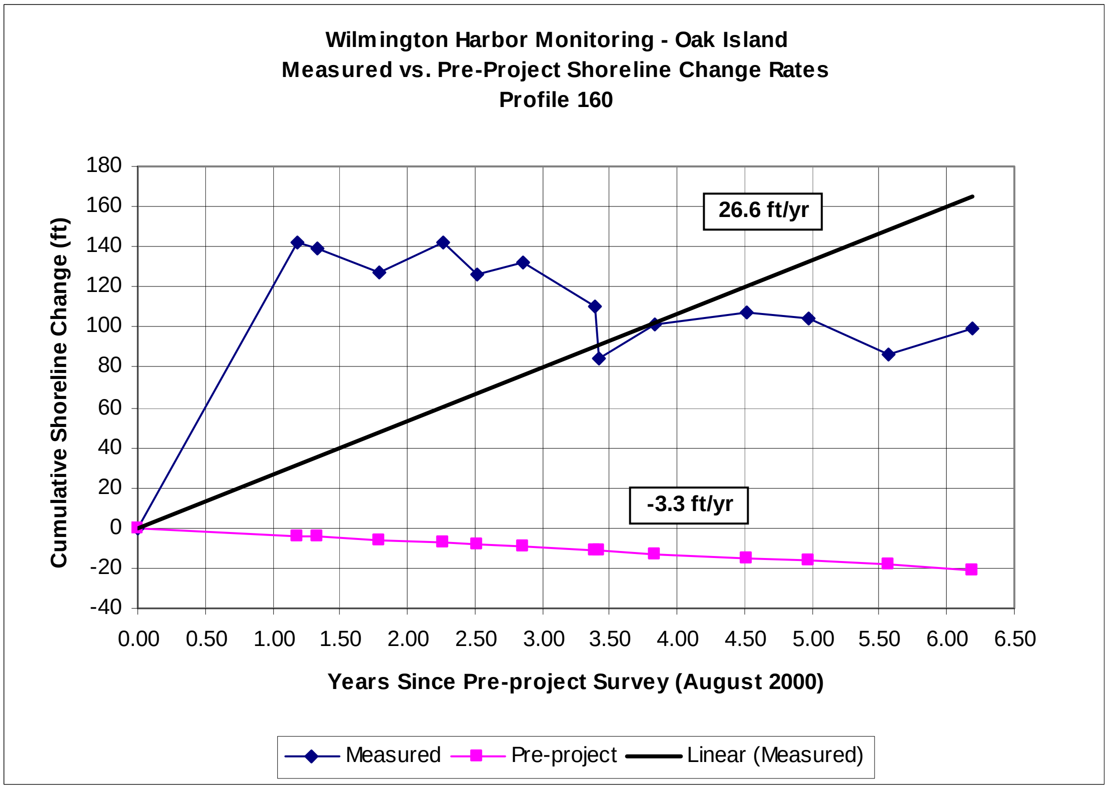

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 135
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
30.8 ft/yr
-1.4 ft/yr
Measured
Pre-project
Linear (Measured)

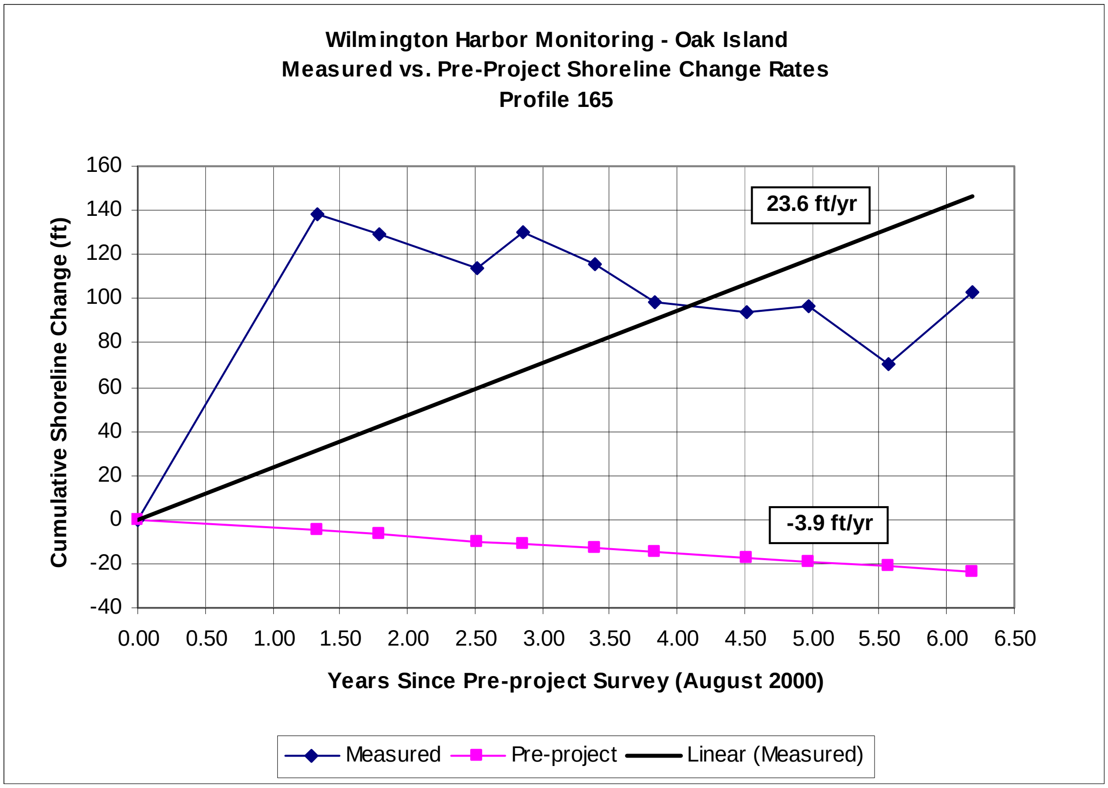

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 140
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
30.6 ft/yr
-2.1 ft/yr
Measured
Pre-project
Linear (Measured)

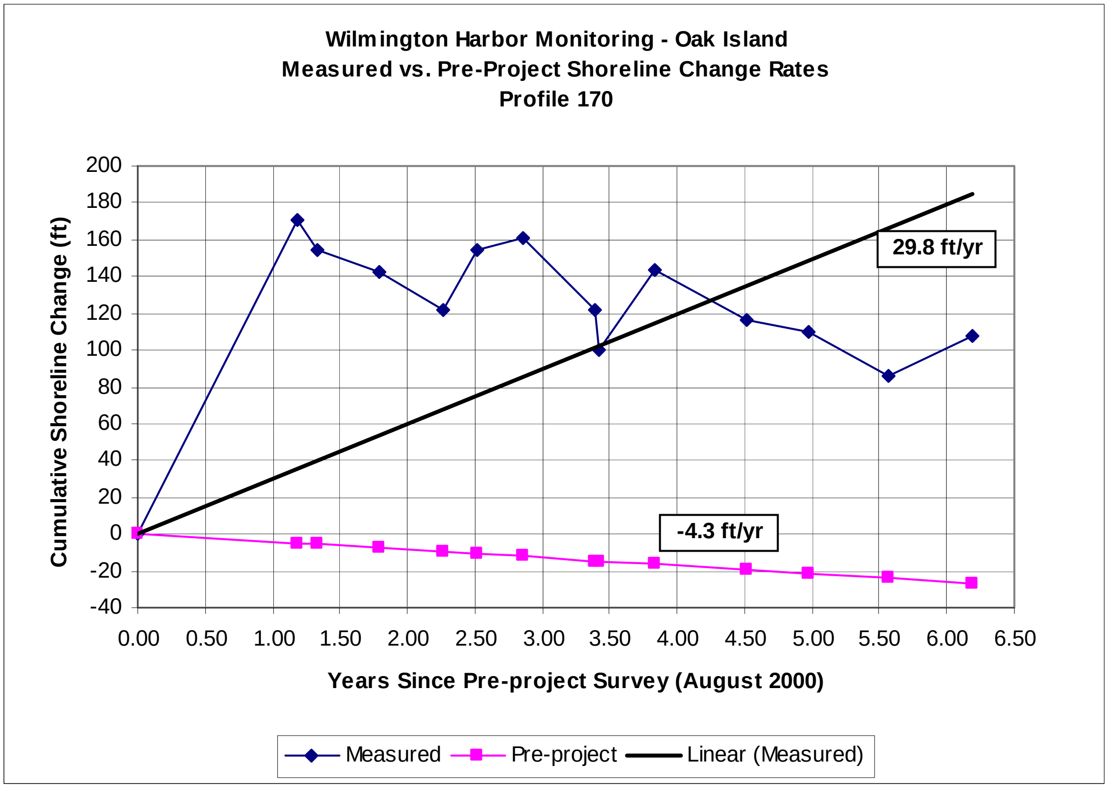

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 145
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
33.6 ft/yr
-2.3 ft/yr
Measured
Pre-project
Linear (Measured)

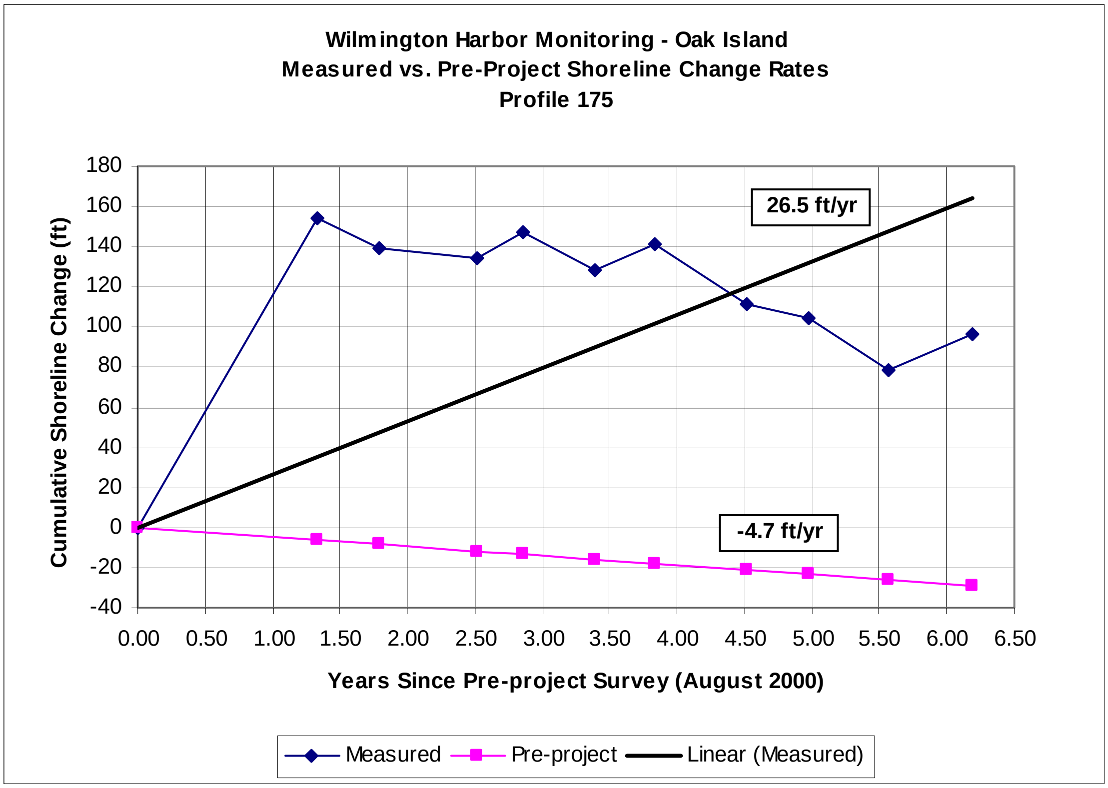

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
35.2 ft/yr
-2.5 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 155
26.6 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
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

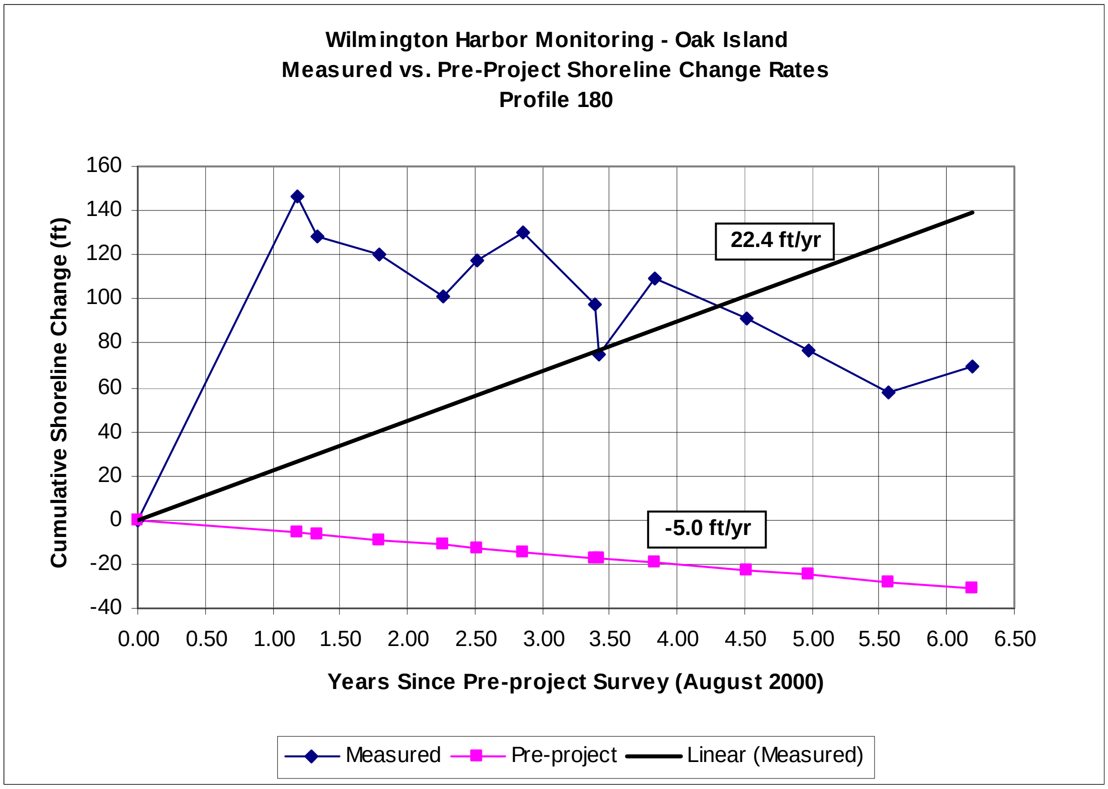

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 160
26.6 ft/yr
-3.3 ft/yr
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August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


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 165
Cumulative Shoreline Change (ft)
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
Years Since Pre-project Survey (August 2000)
23.6 ft/yr
-3.9 ft/yr
Measured
Pre-project
Linear (Measured)

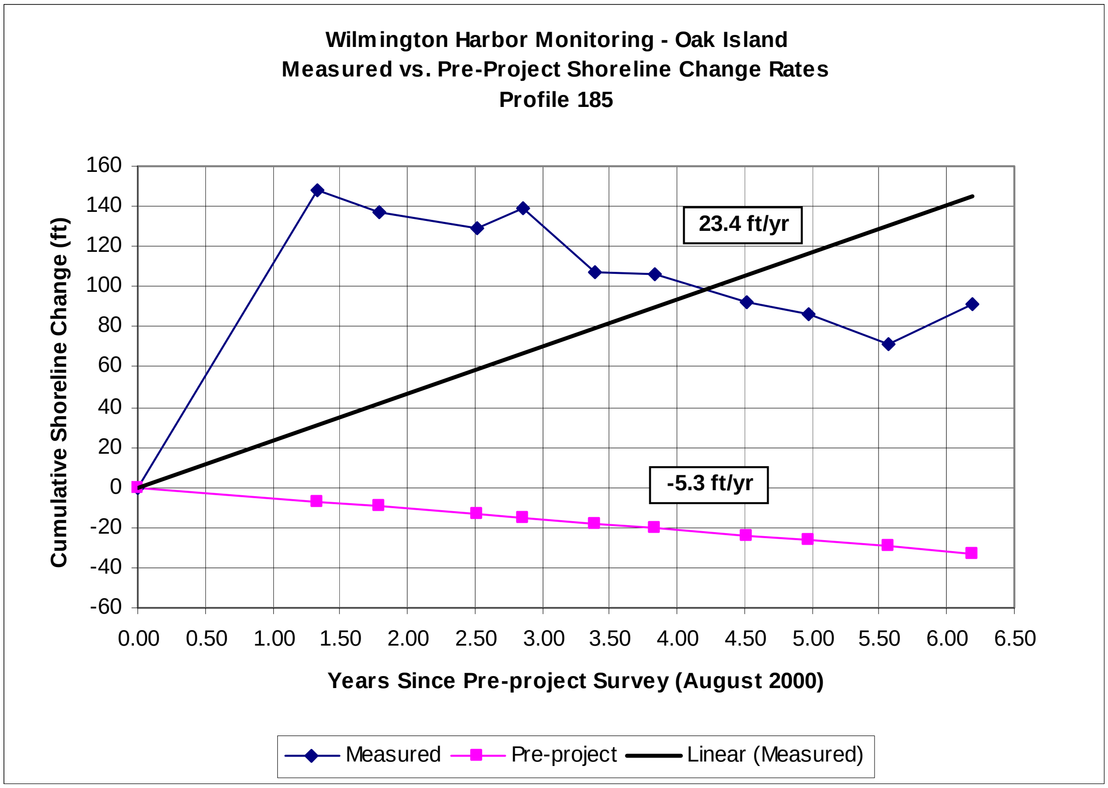

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
29.8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



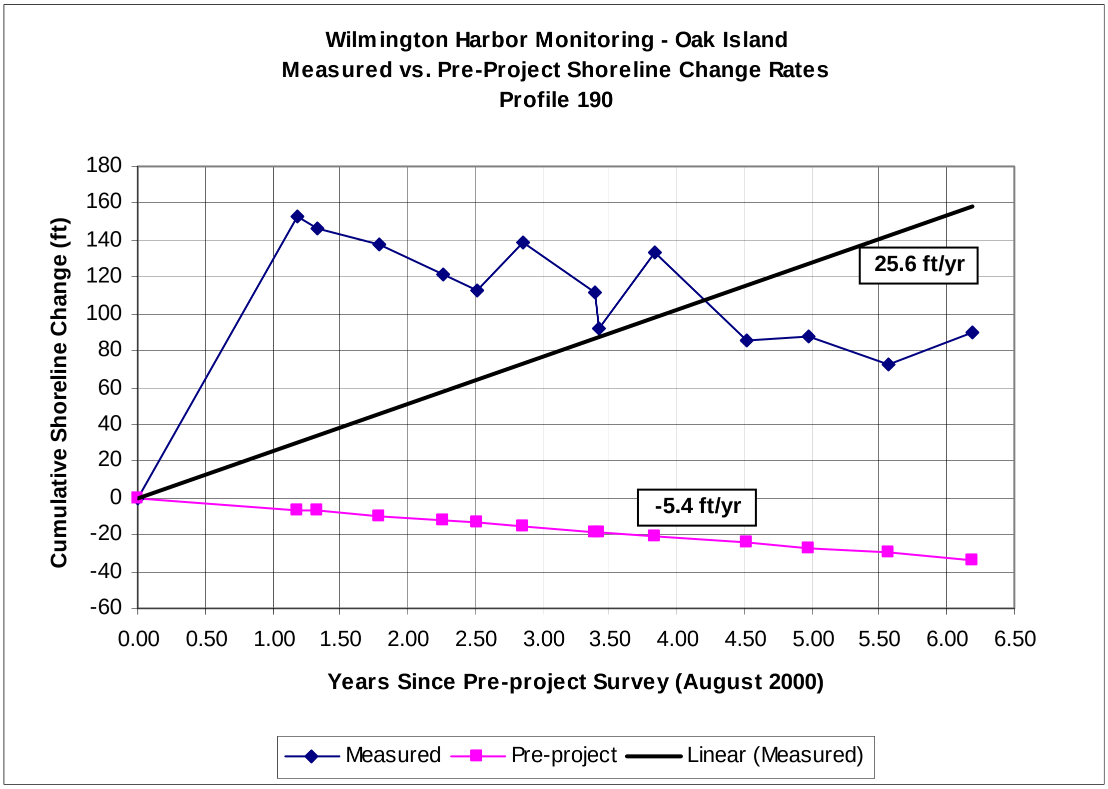
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 175
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
26.5 ft/yr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



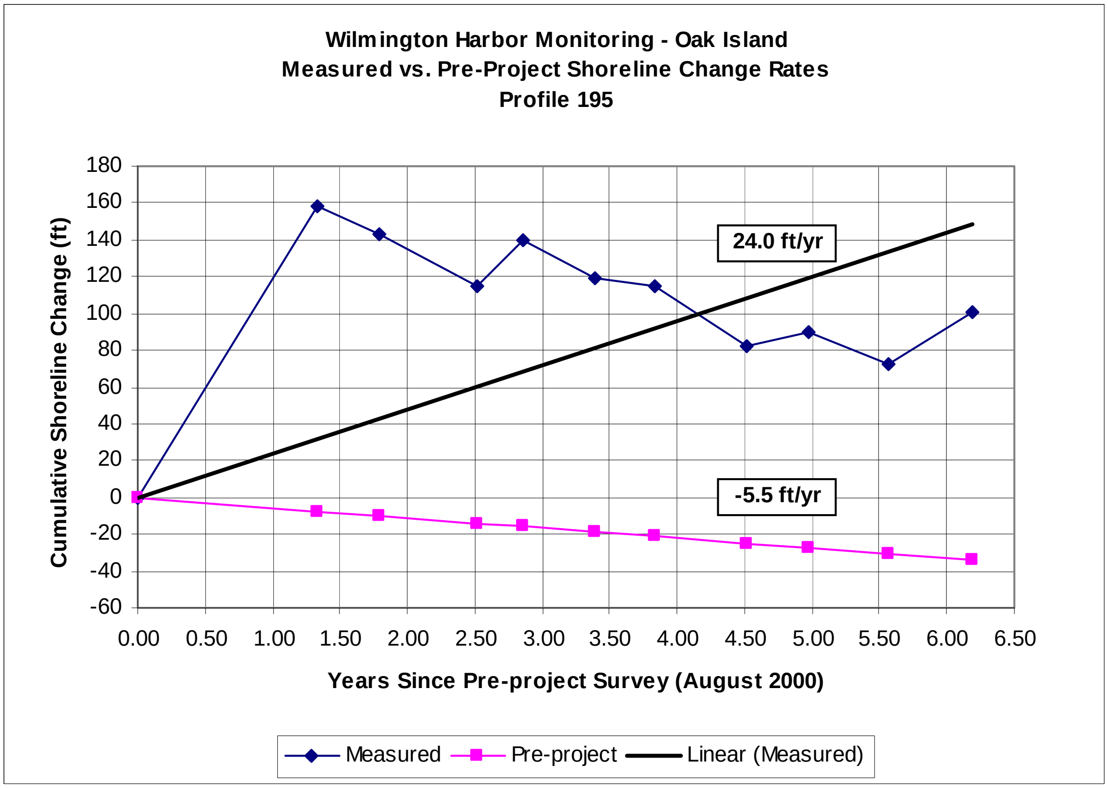
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 180
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
22.4 ft/yr
-5.0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



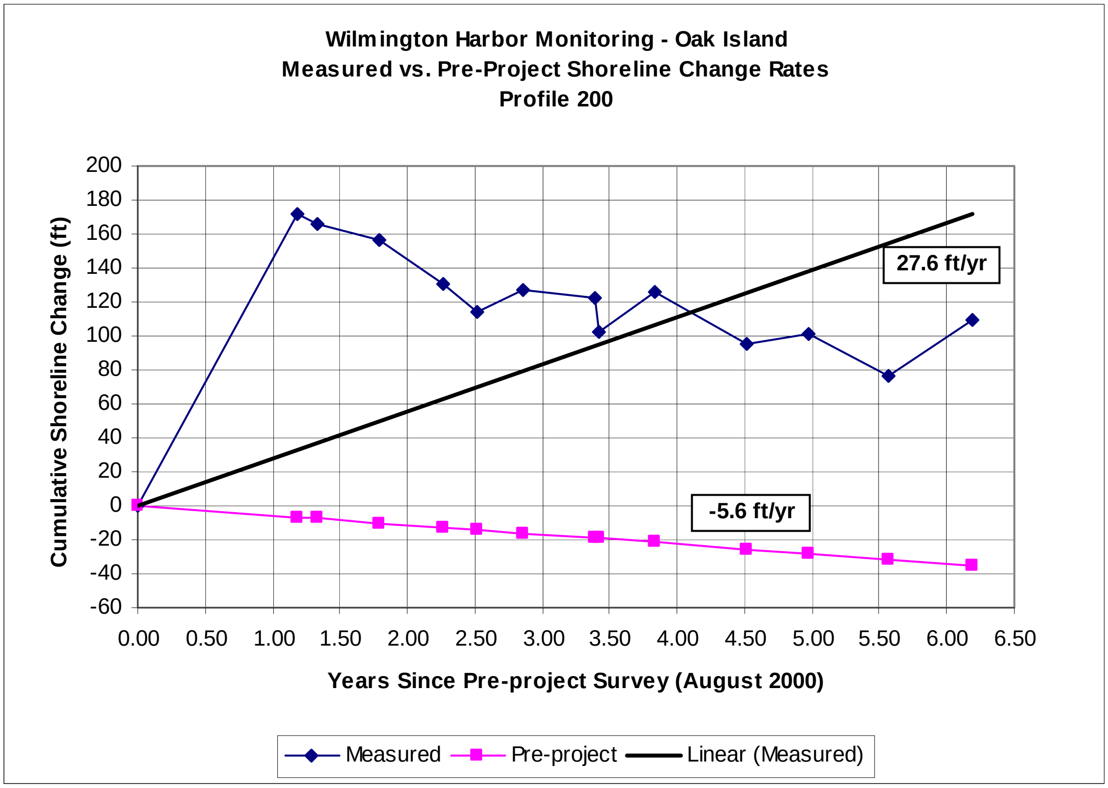
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 185
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (August 2000)
23.4 ft/yr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



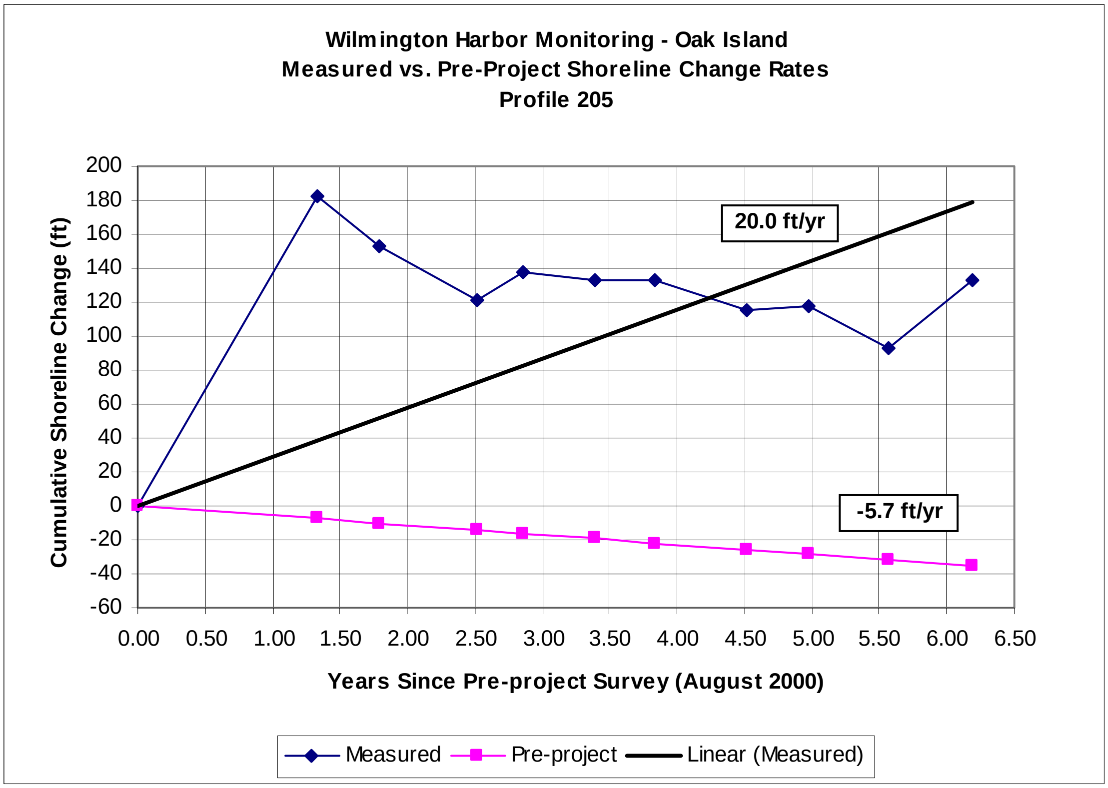
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (August 2000)
25.6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

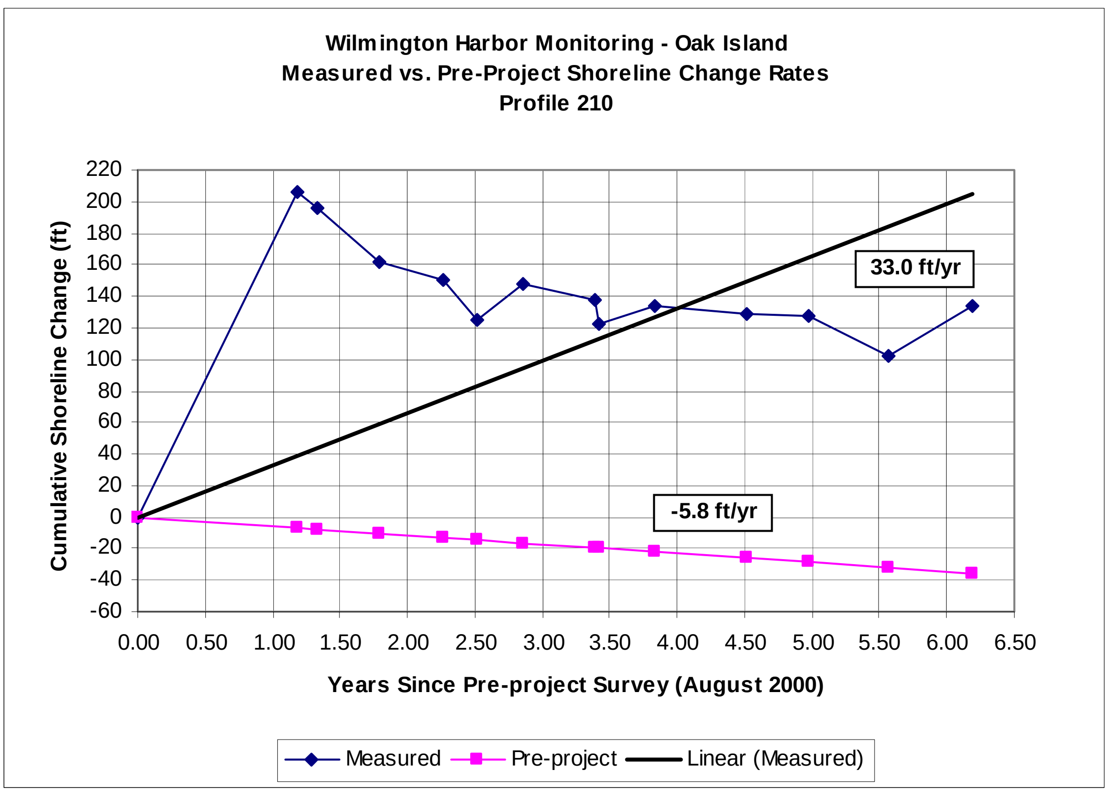


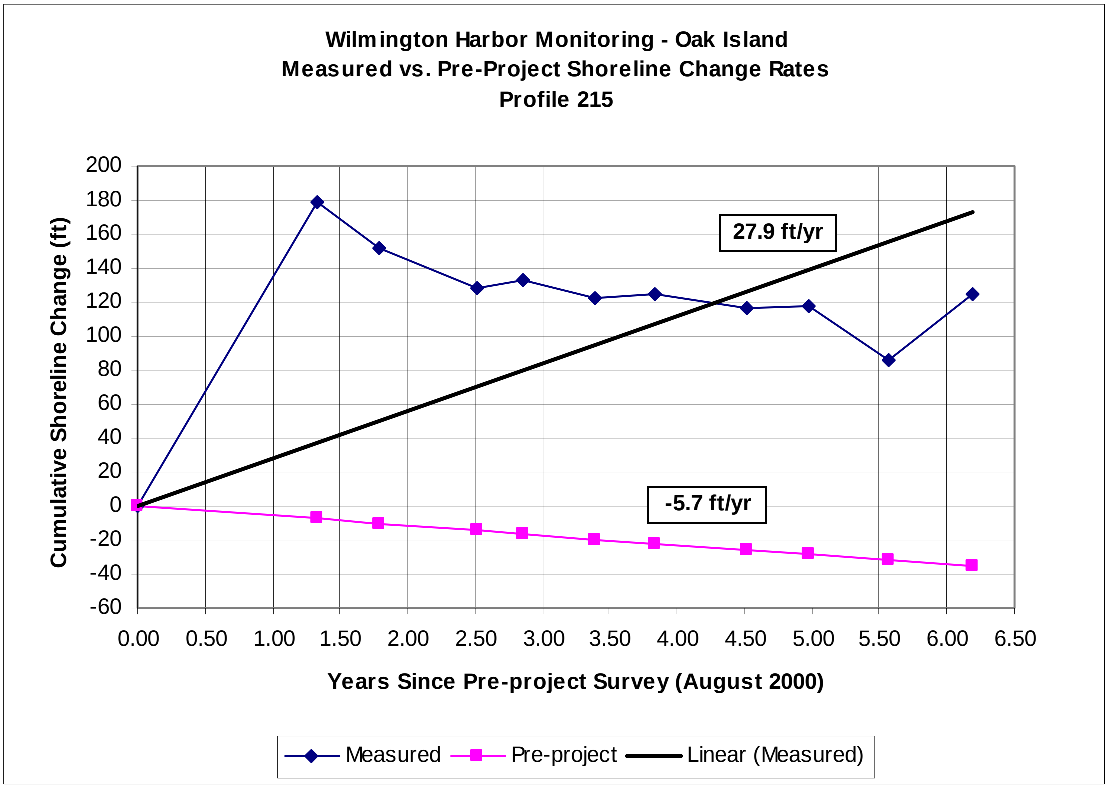
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 195
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
24.0 ft/yr
-5.5 ft/yr
Measured
Pre-project
Linear (Measured)

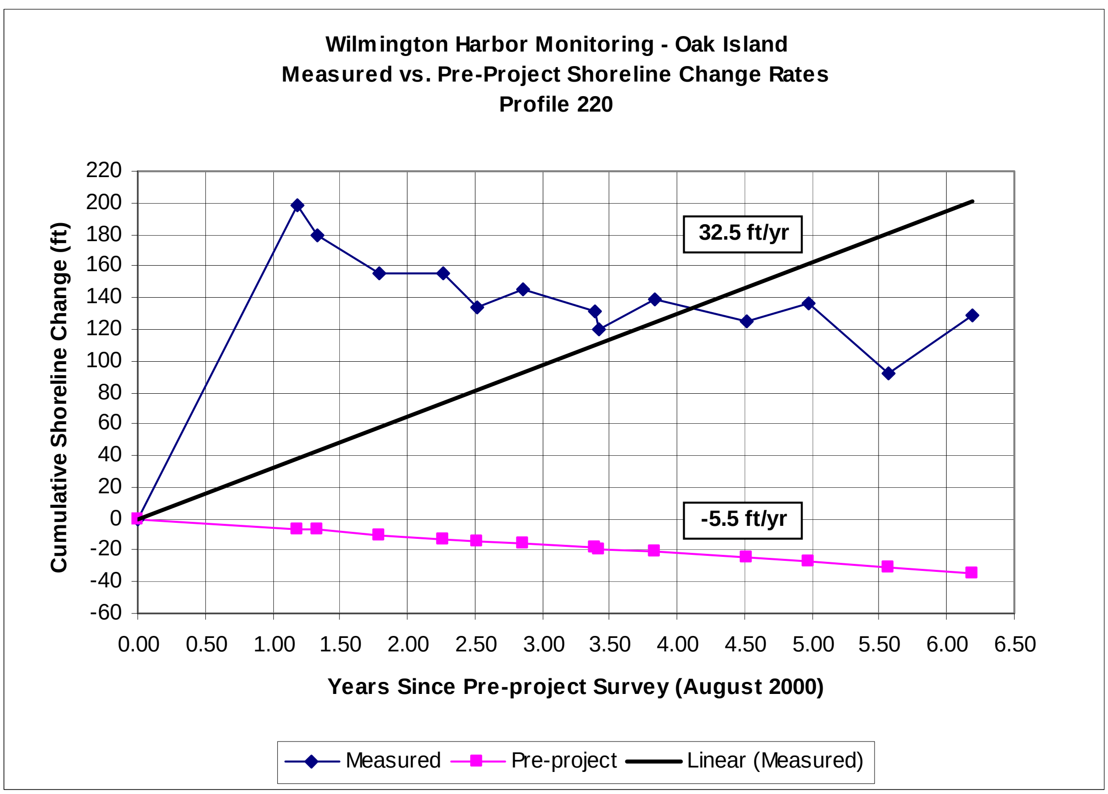


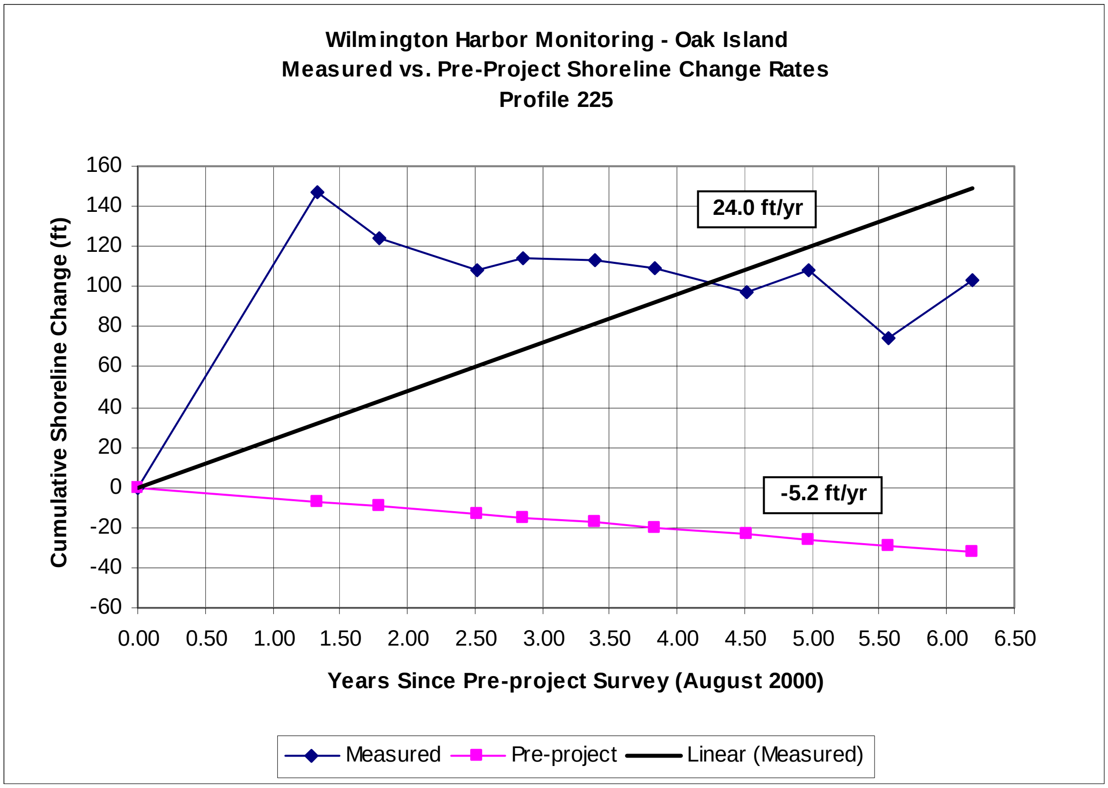
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 200
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
27.6 ft/yr
-5.6 ft/yr
Measured
Pre-project
Linear (Measured)

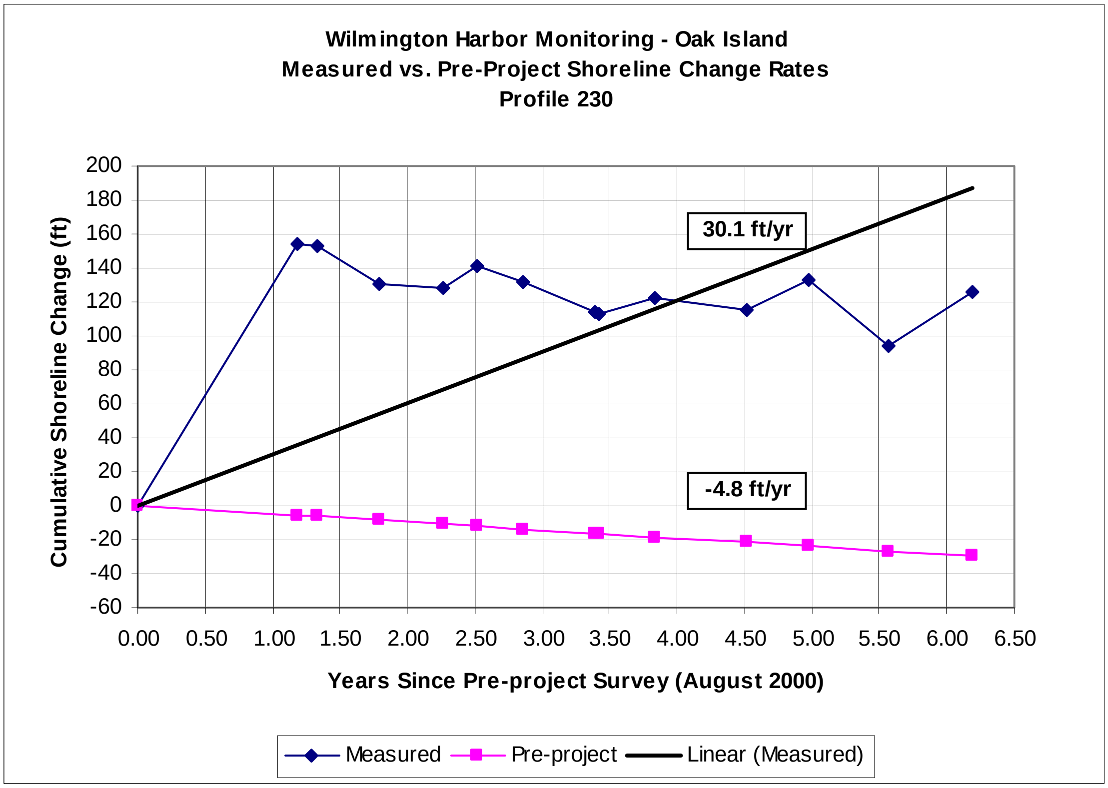

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 205
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
20.0 ft/yr
-5.7 ft/yr
Measured
Pre-project
Linear (Measured)

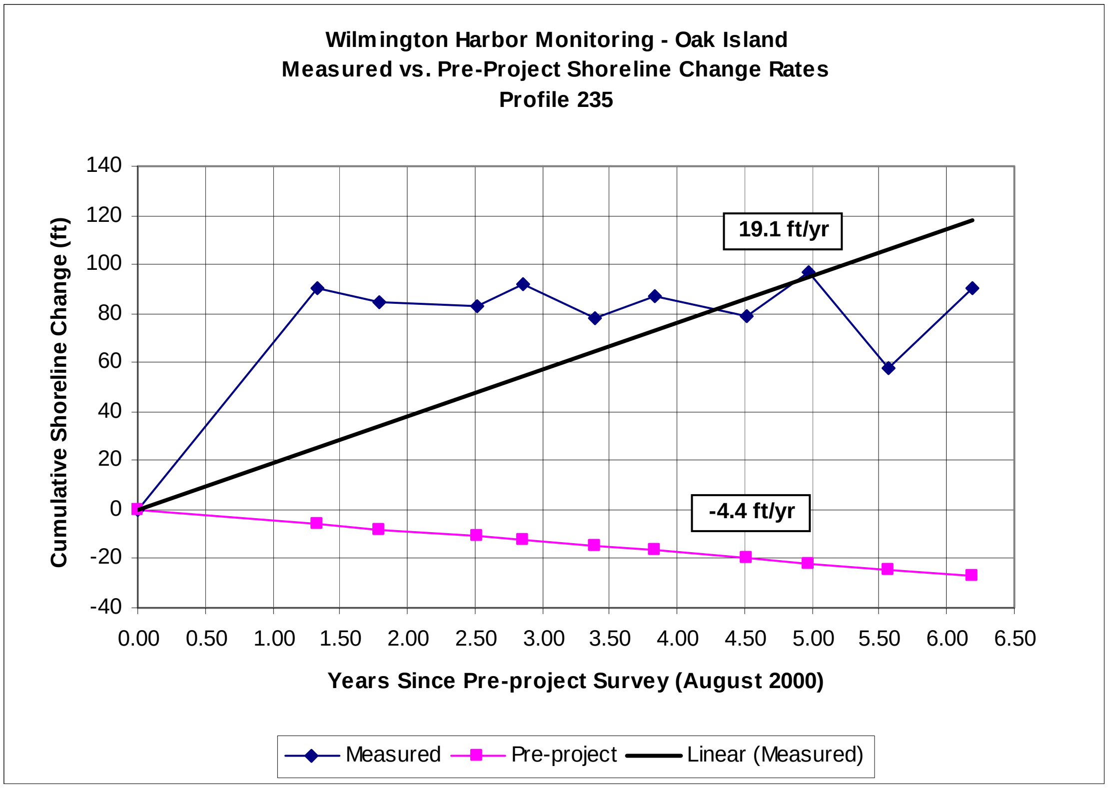

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
33.0 ft/yr
-5.8 ft/yr
Measured
Pre-project
Linear (Measured)

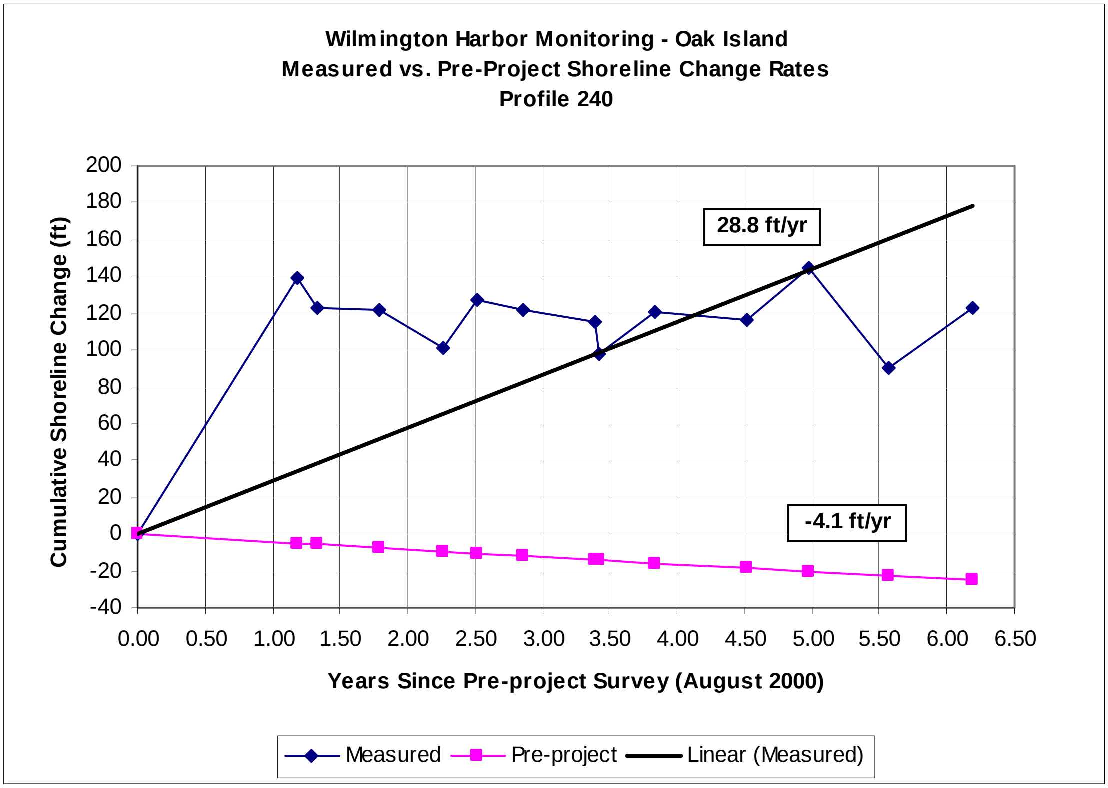

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 215
27.9 ft/yr
-5.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

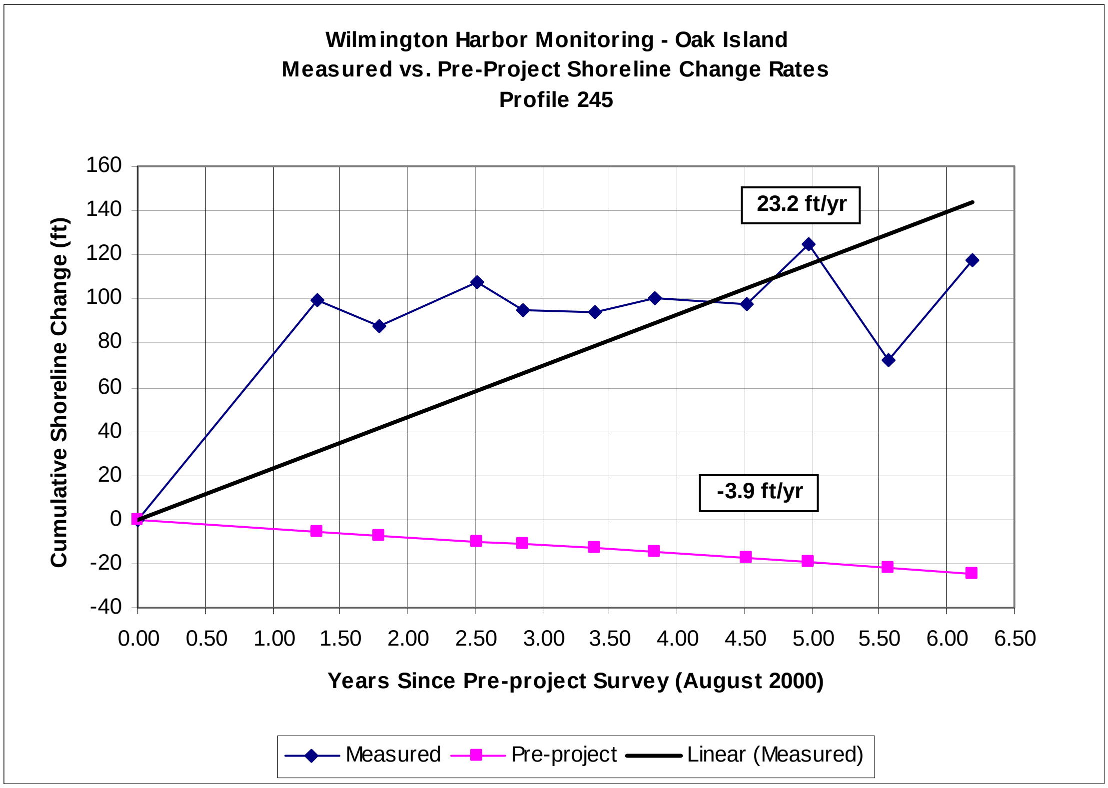

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 220
32.5 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

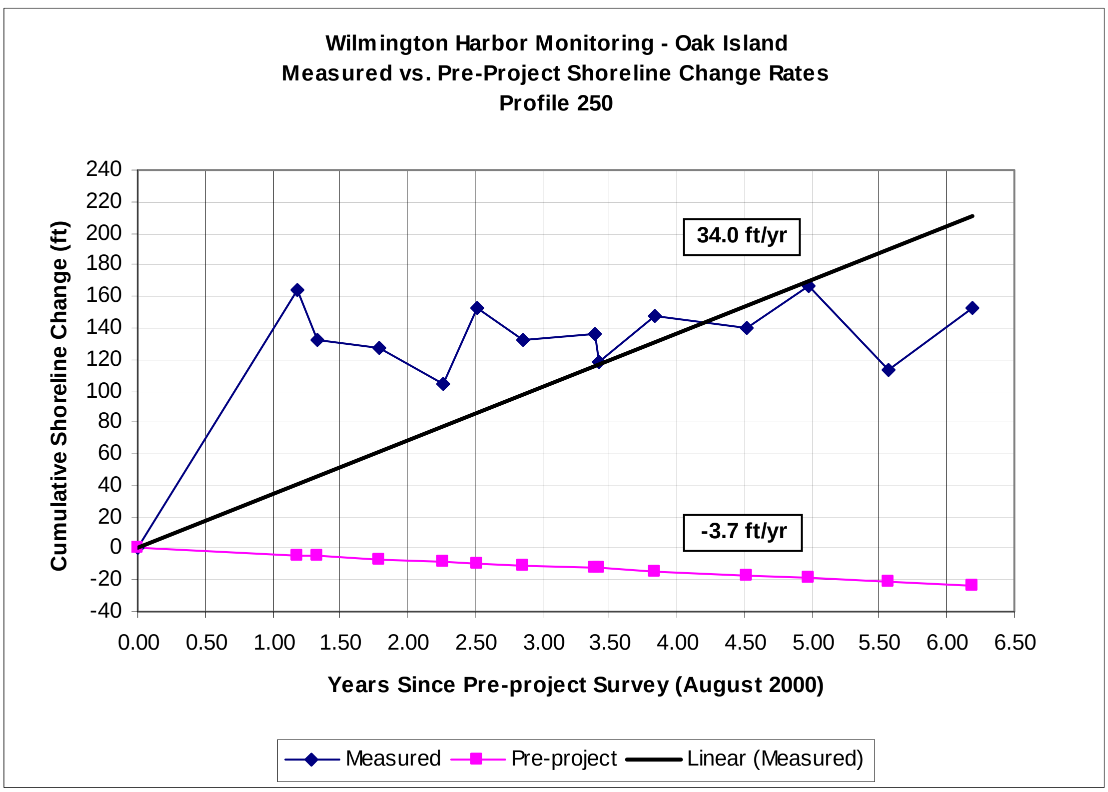

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 225
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
24.0 ft/yr
-5.2 ft/yr
Measured
Pre-project
Linear (Measured)

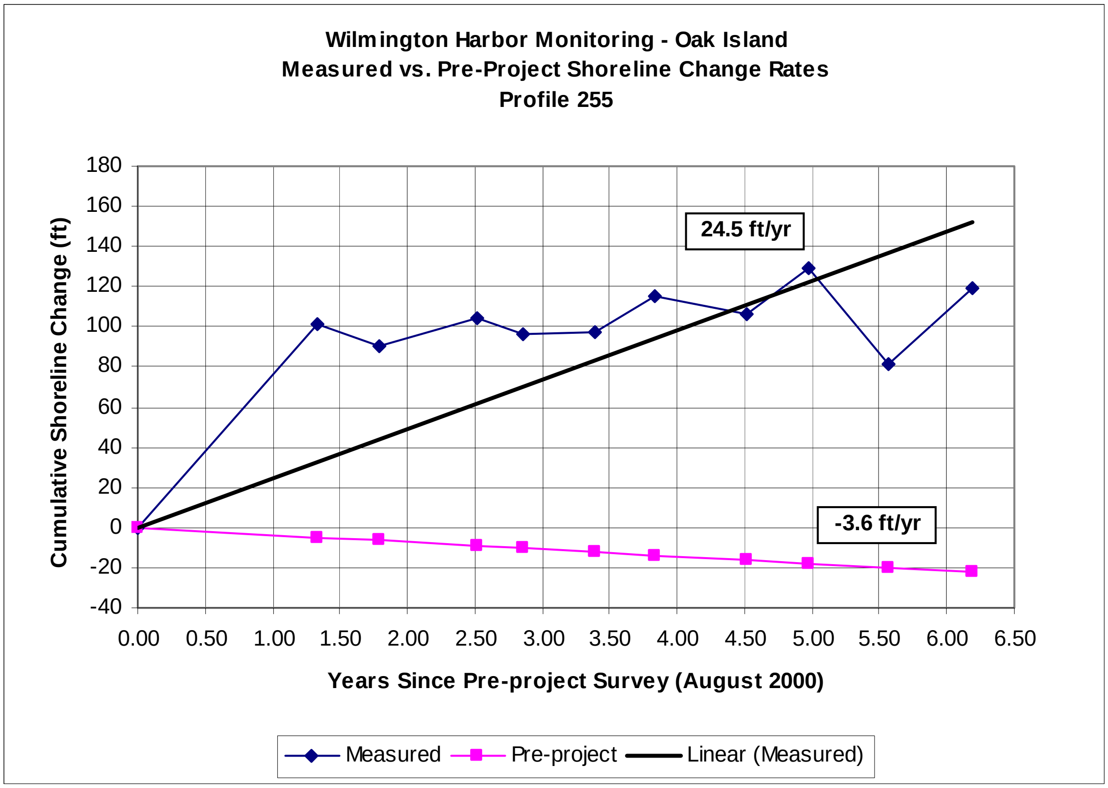

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 230
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
30.1 ft/yr
-4.8 ft/yr
Measured
Pre-project
Linear (Measured)


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

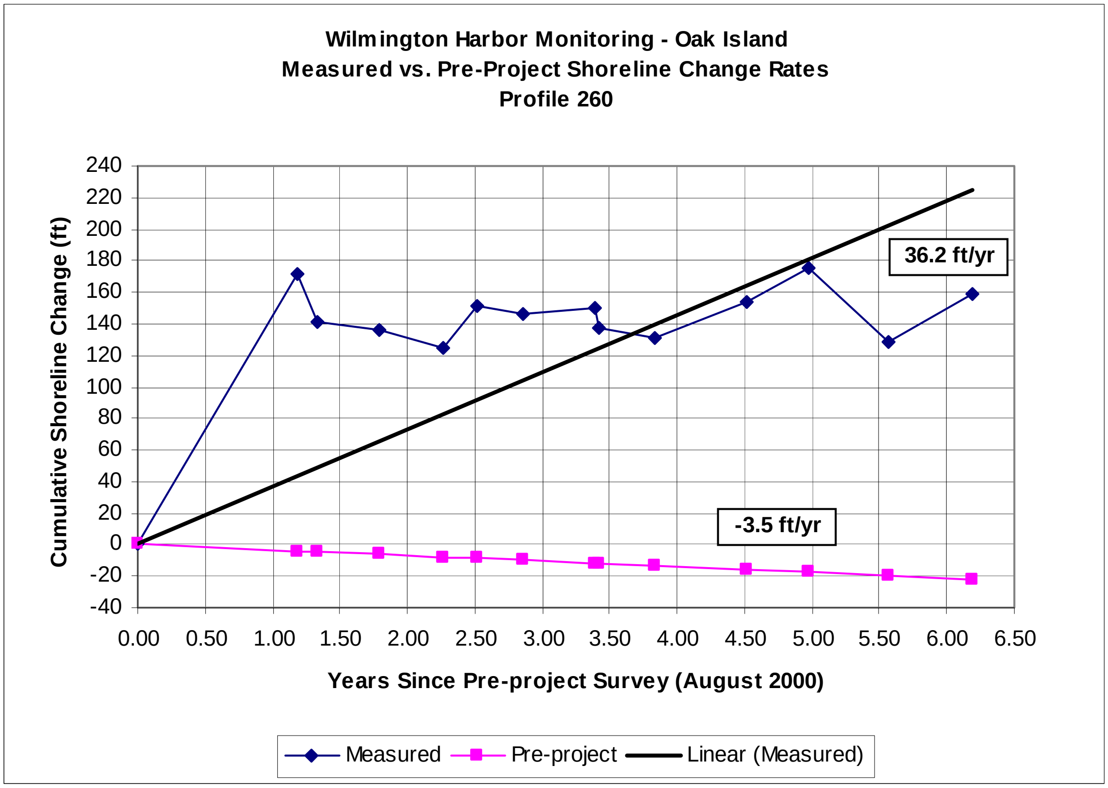

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 240
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (August 2000)
28.8 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
23.2 ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

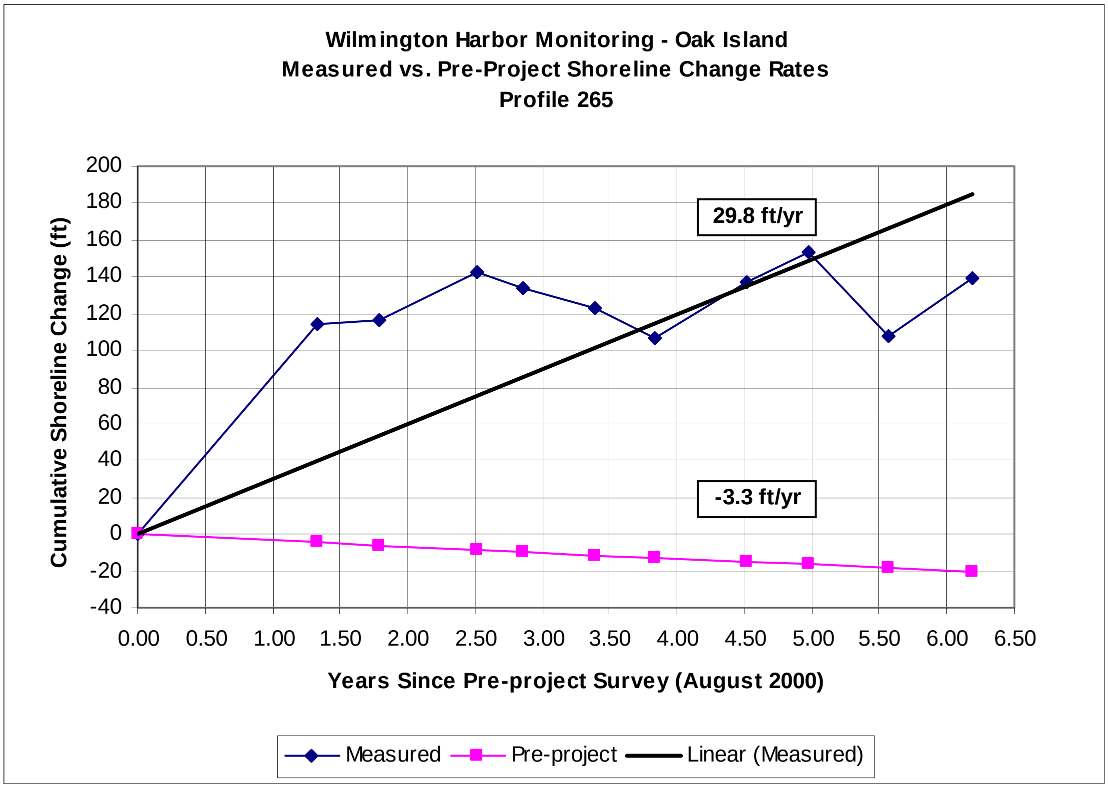

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 250
34.0 ft/yr
-3.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

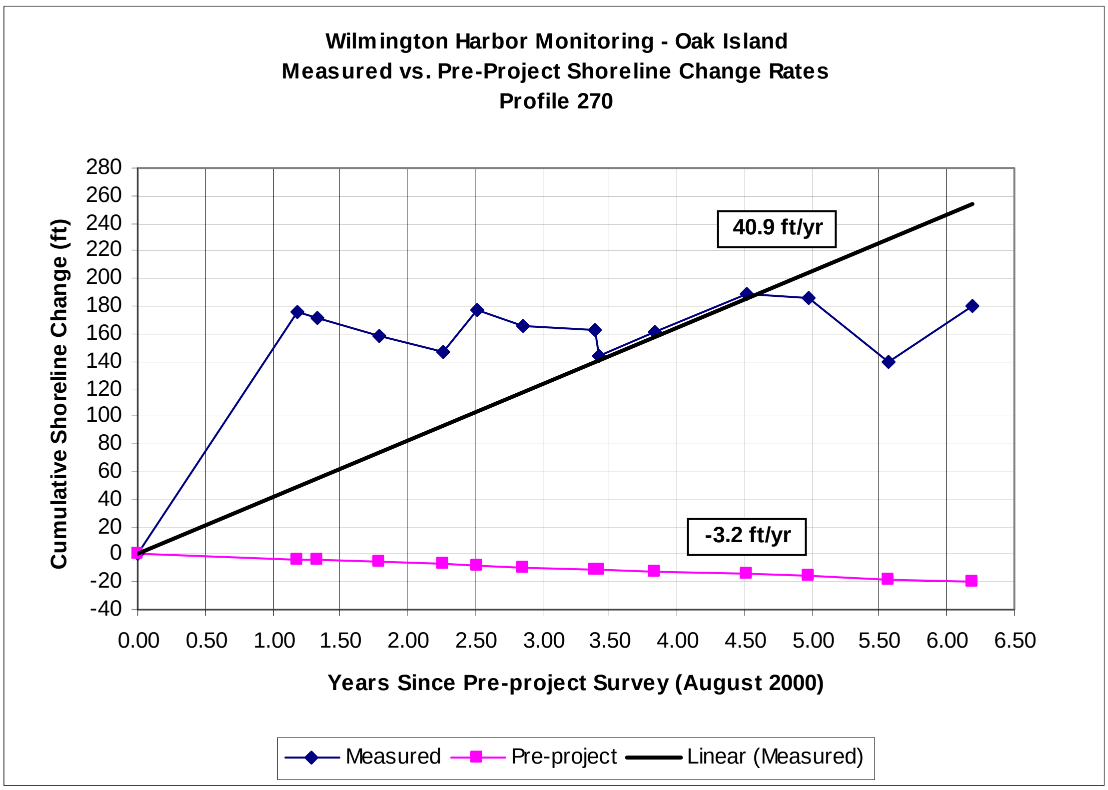


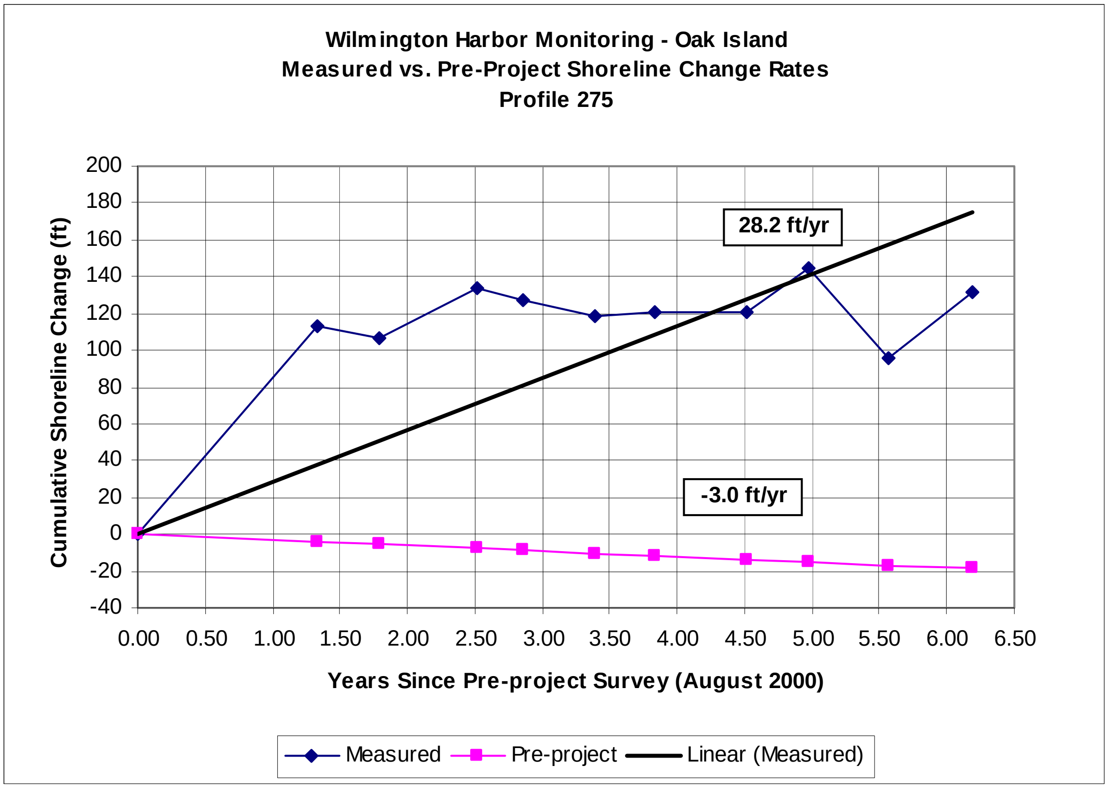
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 255
24.5 ft/yr
-3.6 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

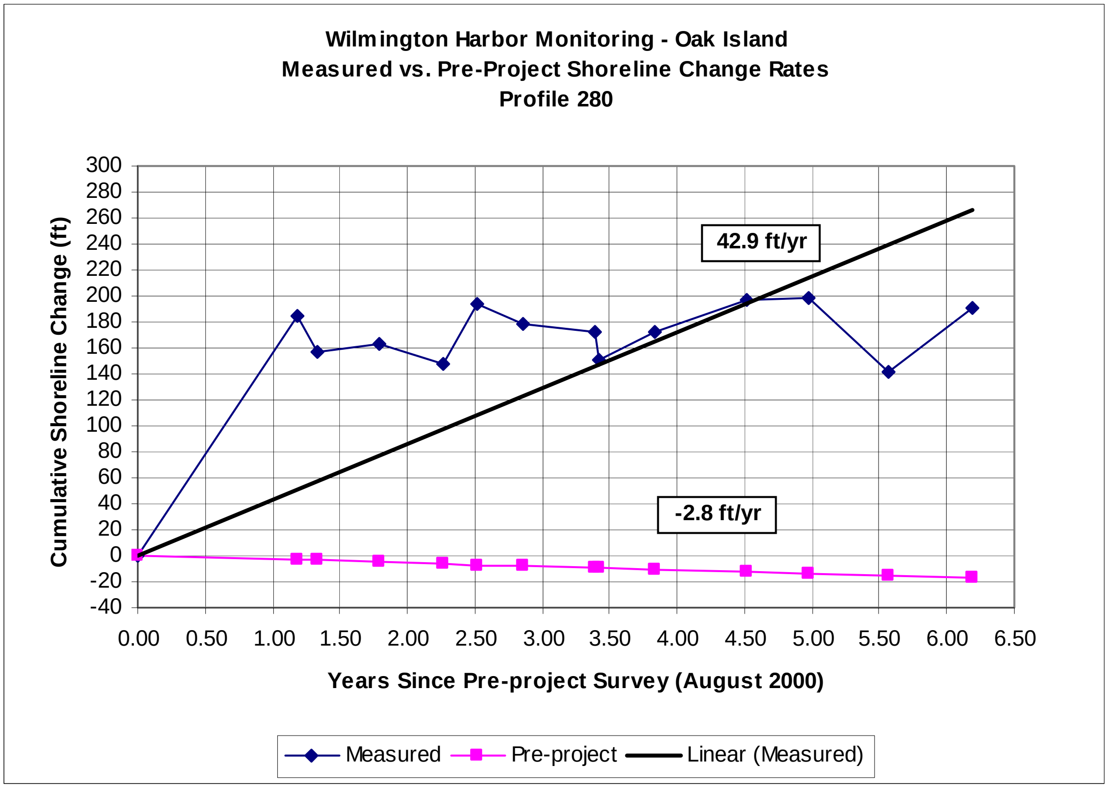


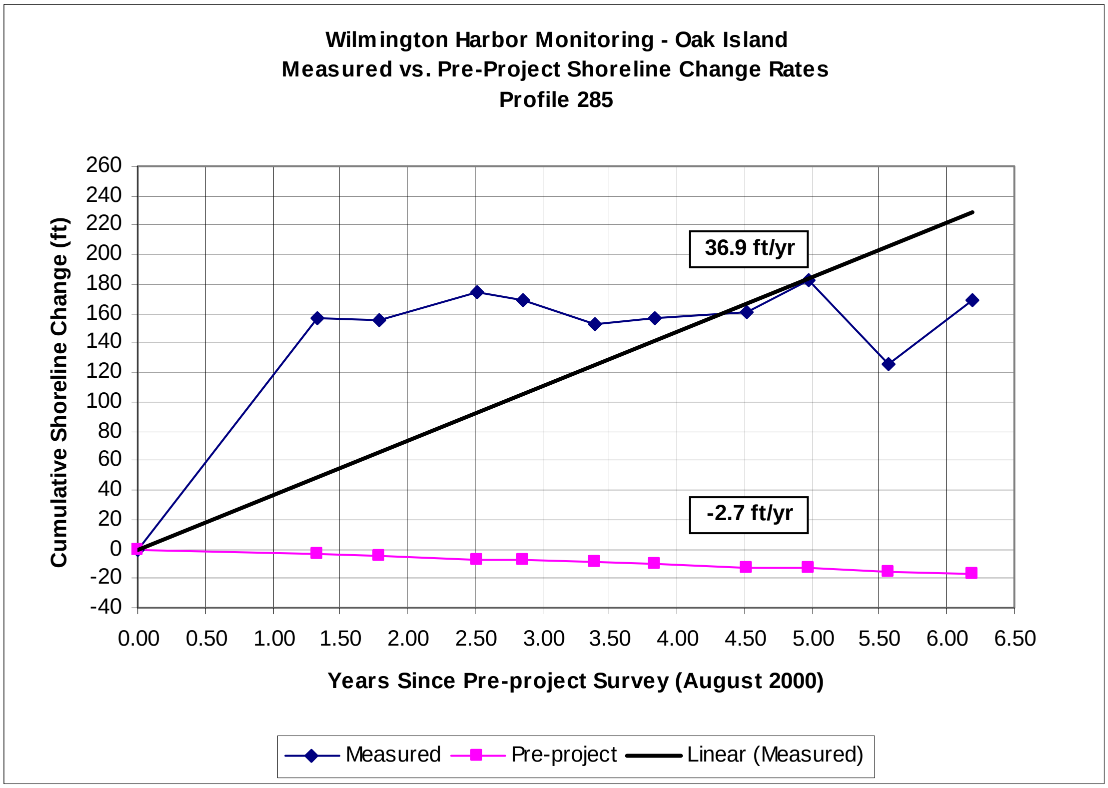
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 260
36.2 ft/yr
-3.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

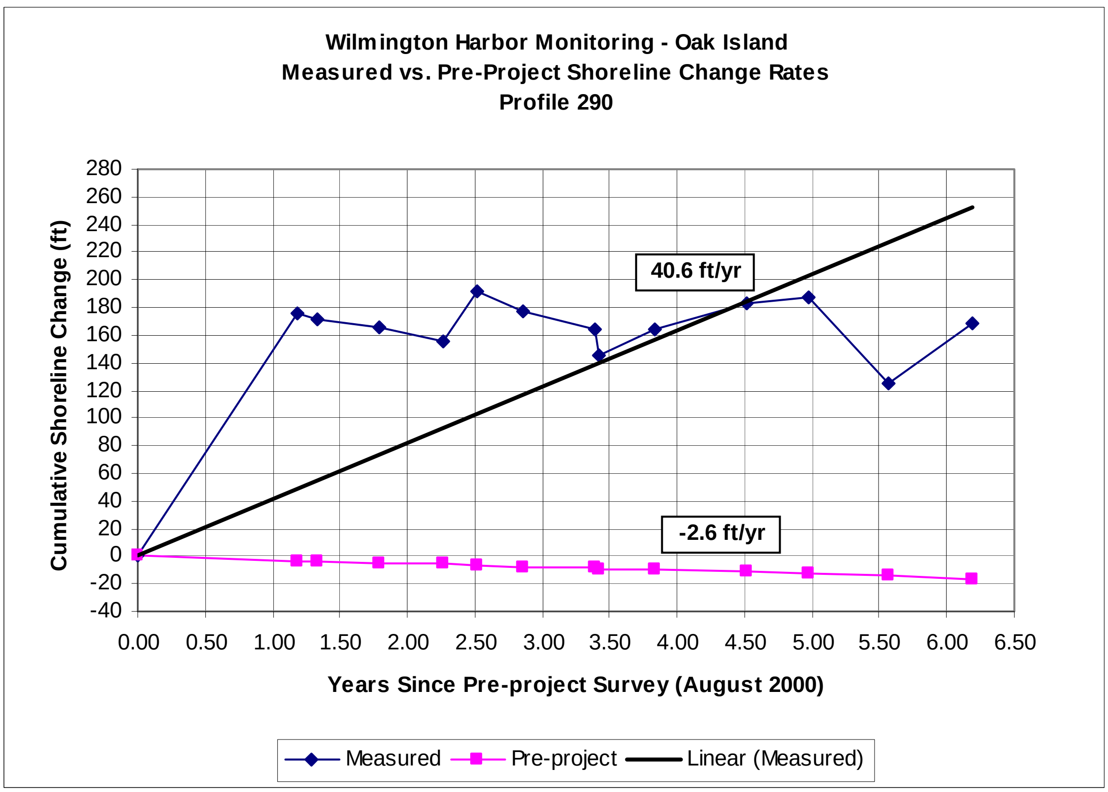

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 265
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
29.8 ft/yr
-3.3 ft/yr
Measured
Pre-project
Linear (Measured)

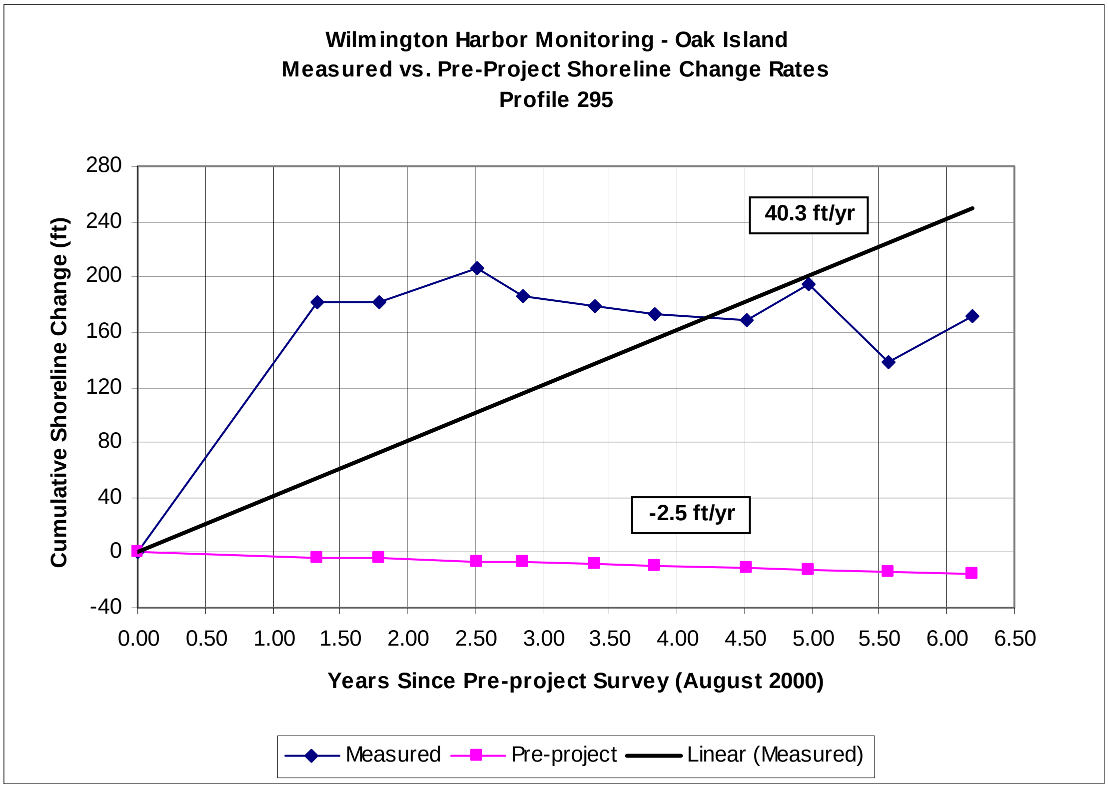

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 270
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
40.9 ft/yr
-3.2 ft/yr
Measured
Pre-project
Linear (Measured)

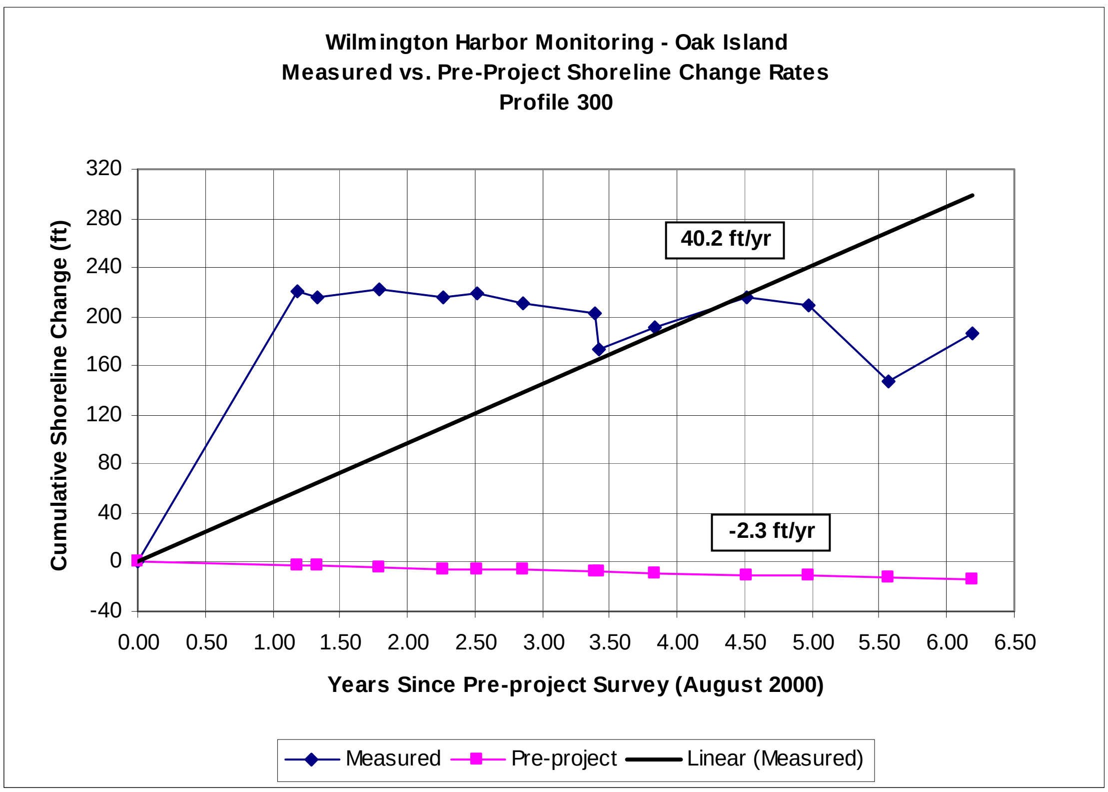

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 275
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
28.2 ft/yr
-3.0 ft/yr
Measured
Pre-project
Linear (Measured)

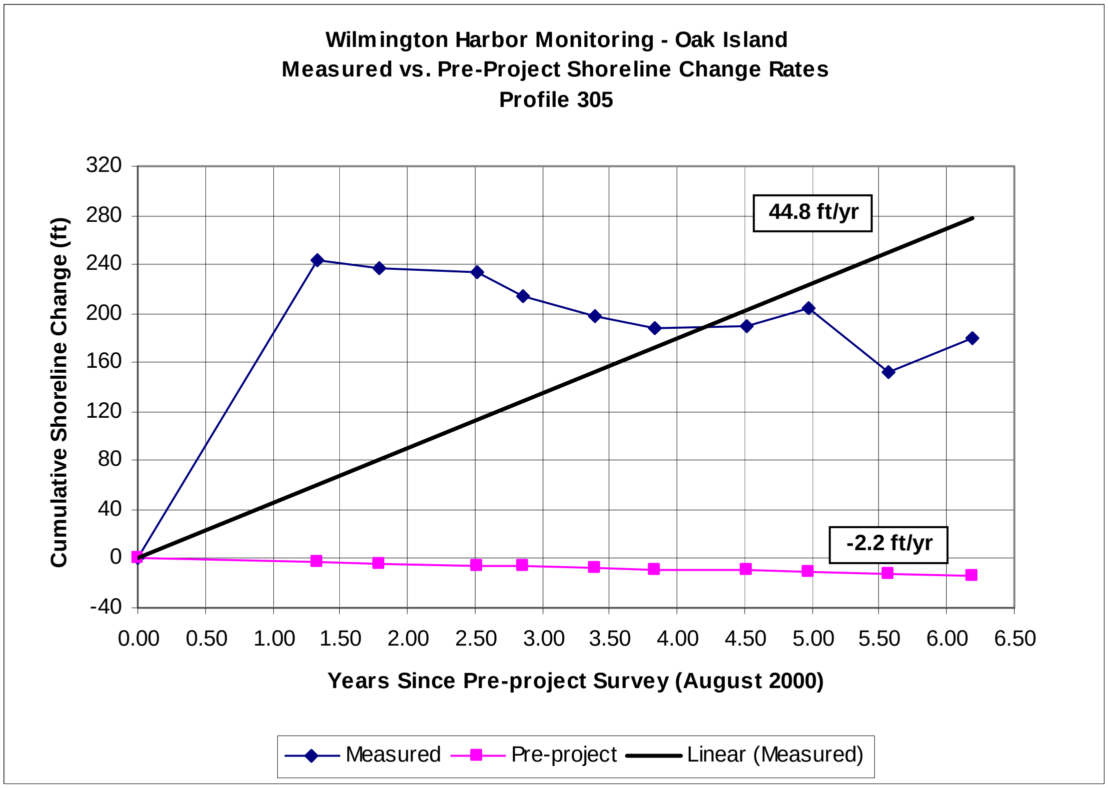

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 280
Cumulative Shoreline Change (ft)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
42.9 ft/yr
-2.8 ft/yr
Measured
Pre-project
Linear (Measured)

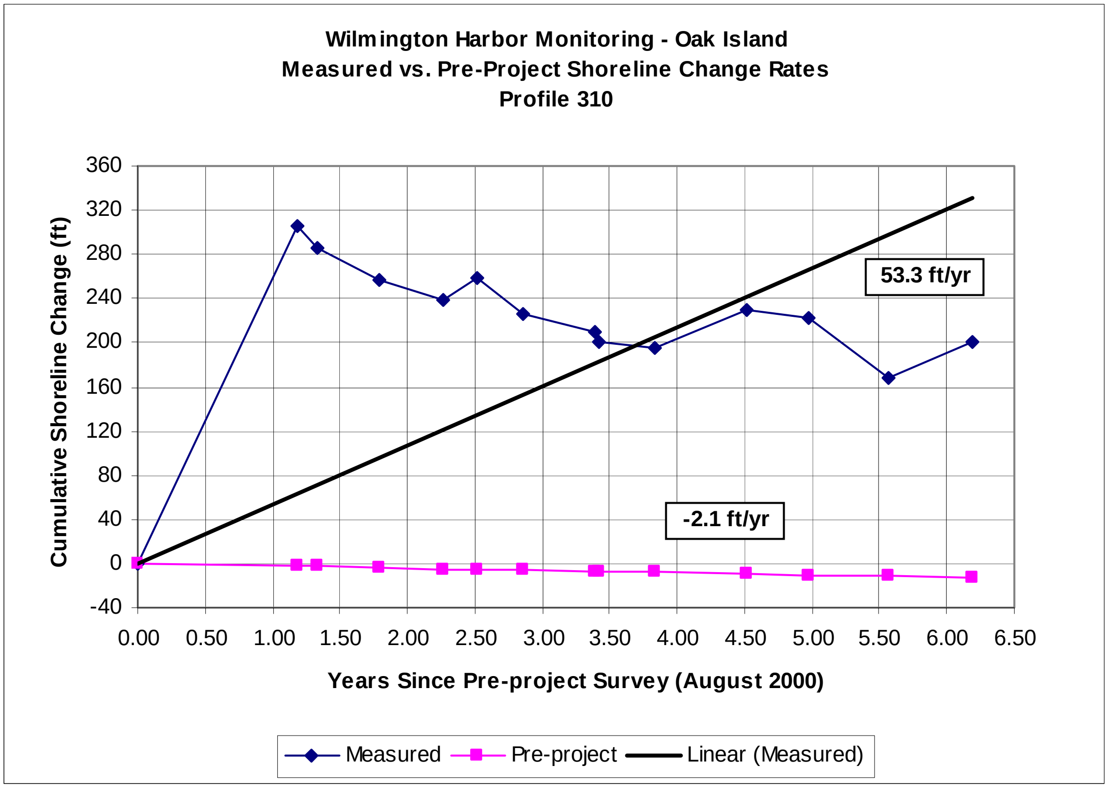

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 285
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
36.9 ft/yr
-2.7 ft/yr
Measured
Pre-project
Linear (Measured)


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


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

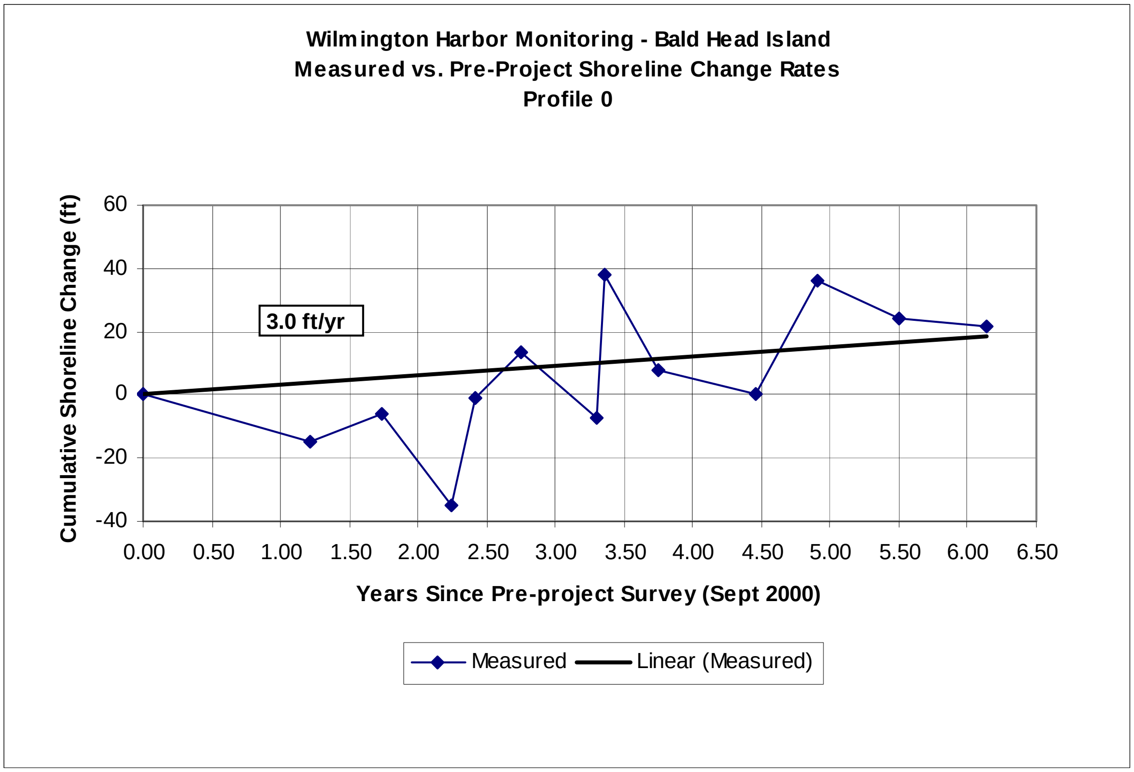

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 300
40.2 ft/yr
-2.3 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

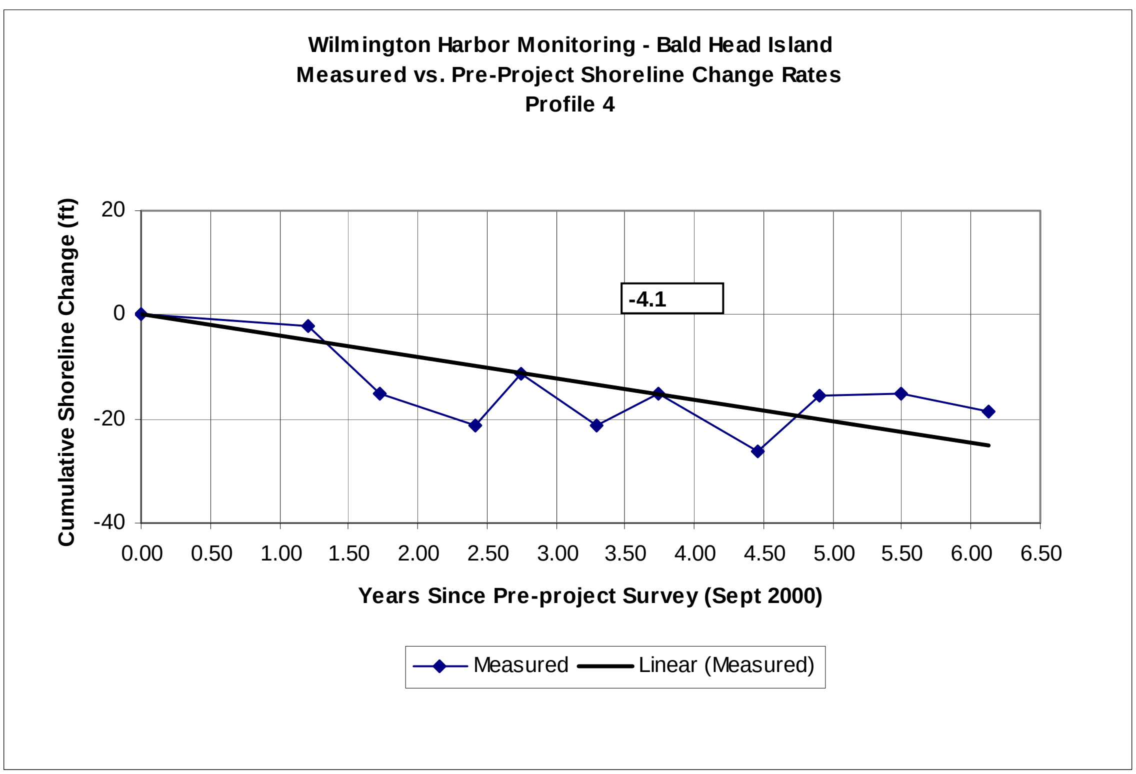

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 305
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
44.8 ft/yr
-2.2 ft/yr
Measured
Pre-project
Linear (Measured)

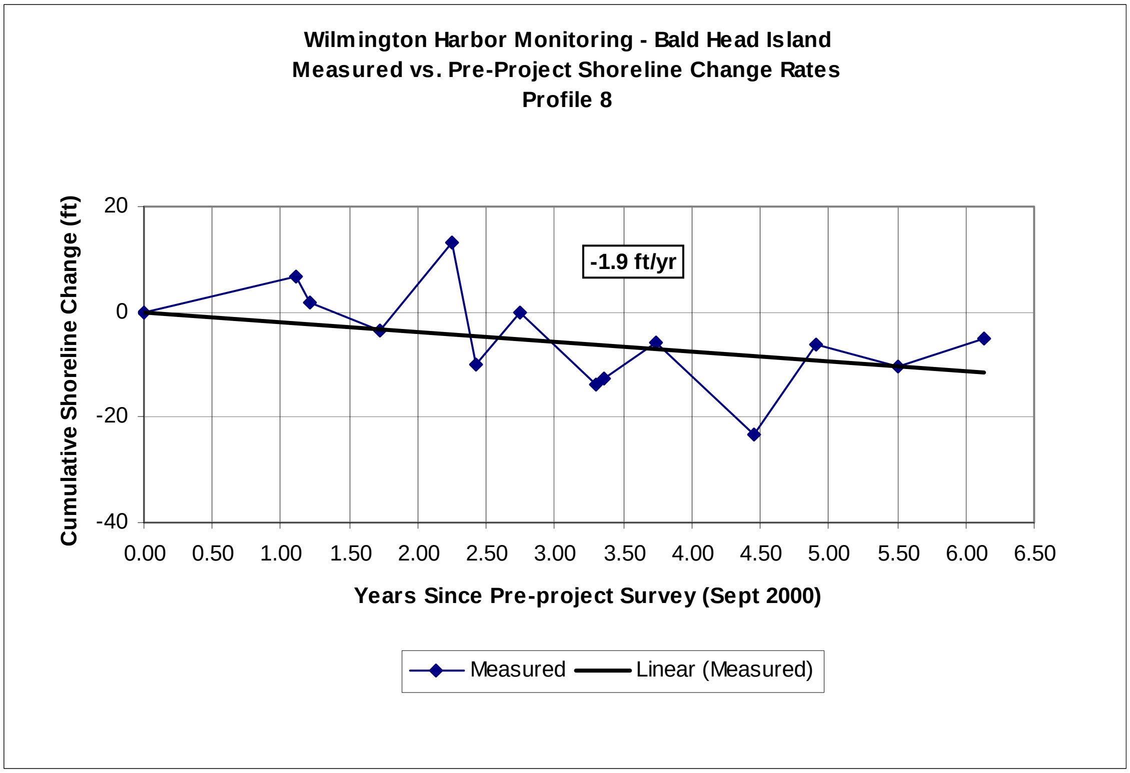

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 310
Cumulative Shoreline Change (ft)
360
320
280
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (August 2000)
53.3 ft/yr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

<u>Appendix C</u>

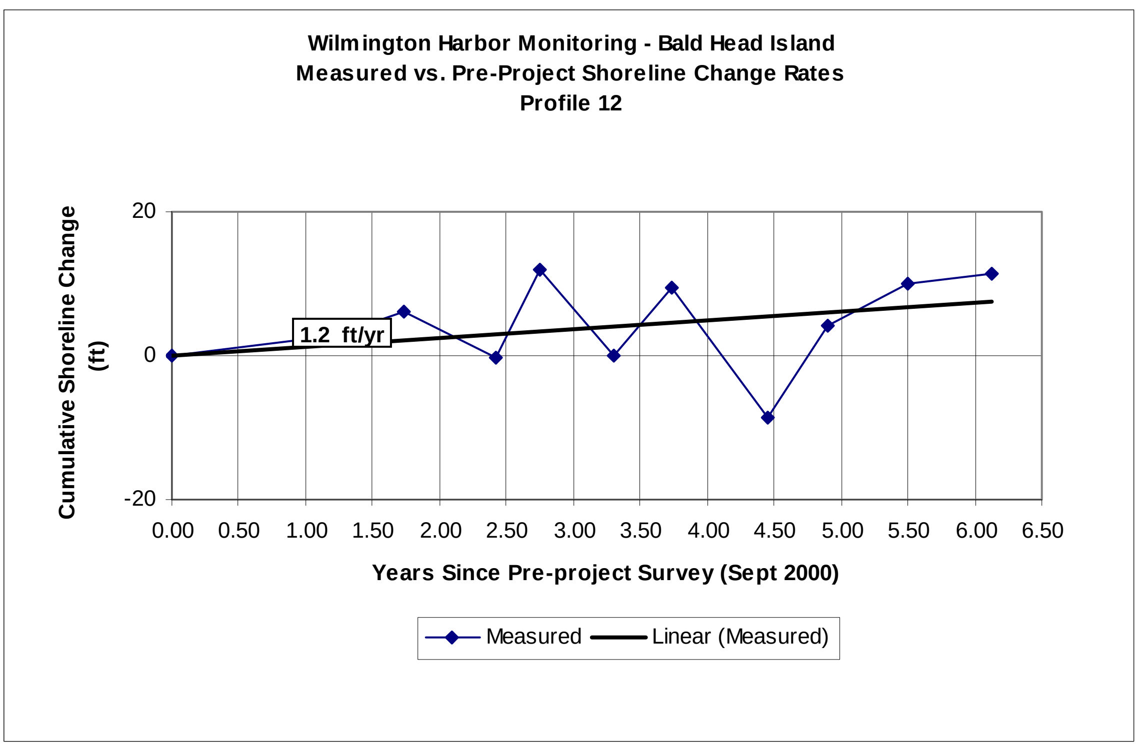
SHORELINE CHANGE RATES
(Bald Head Island)


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
3.0 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 (Sept 2000)
Measured
Linear (Measured)

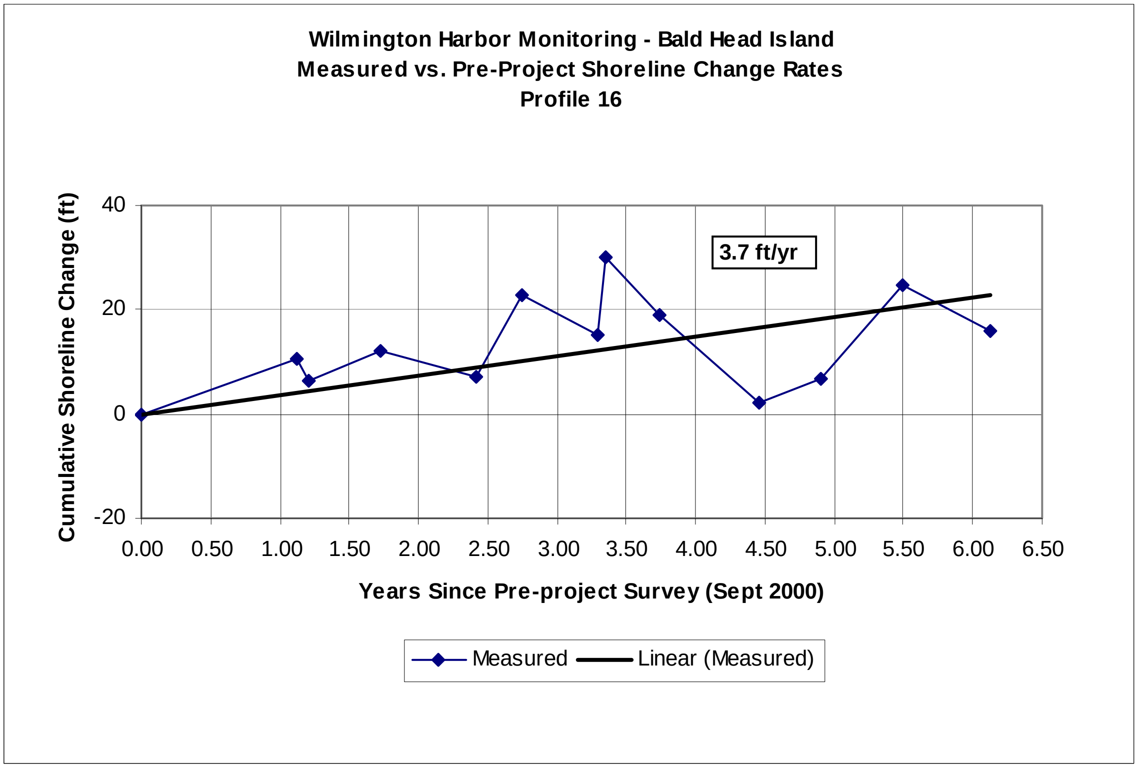

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 4
Cumulative Shoreline Change (ft)
20
0
-20
-40
-4.1
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

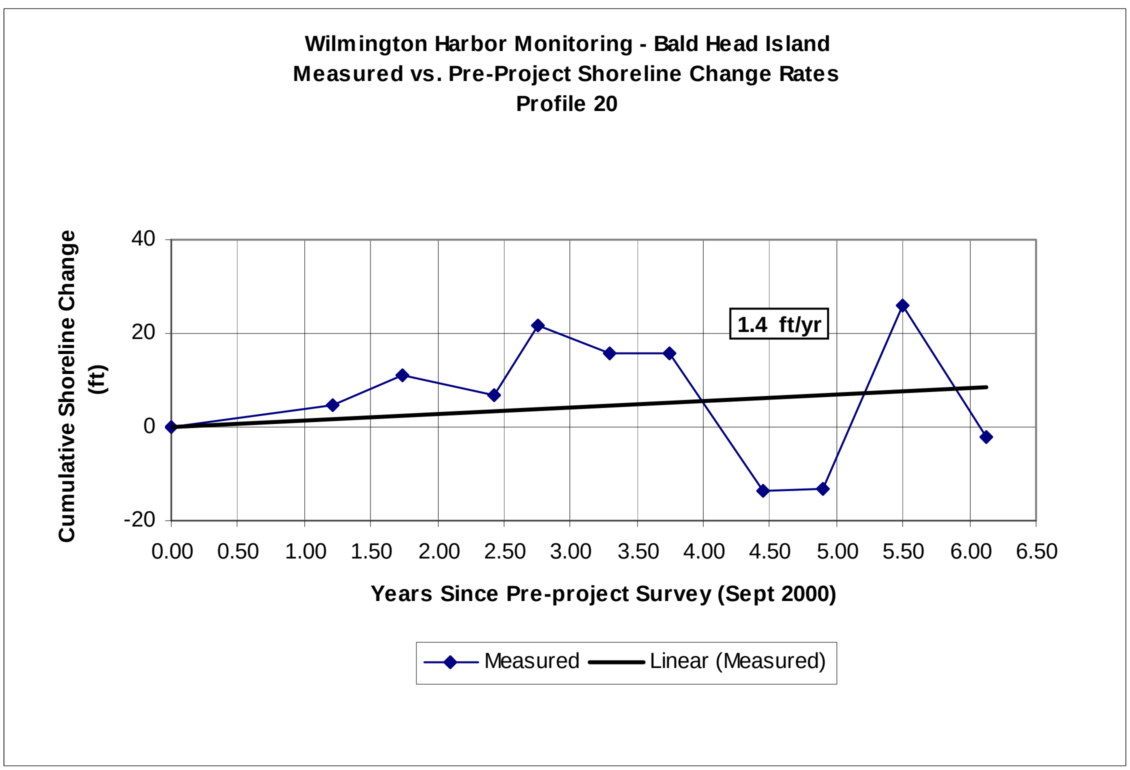


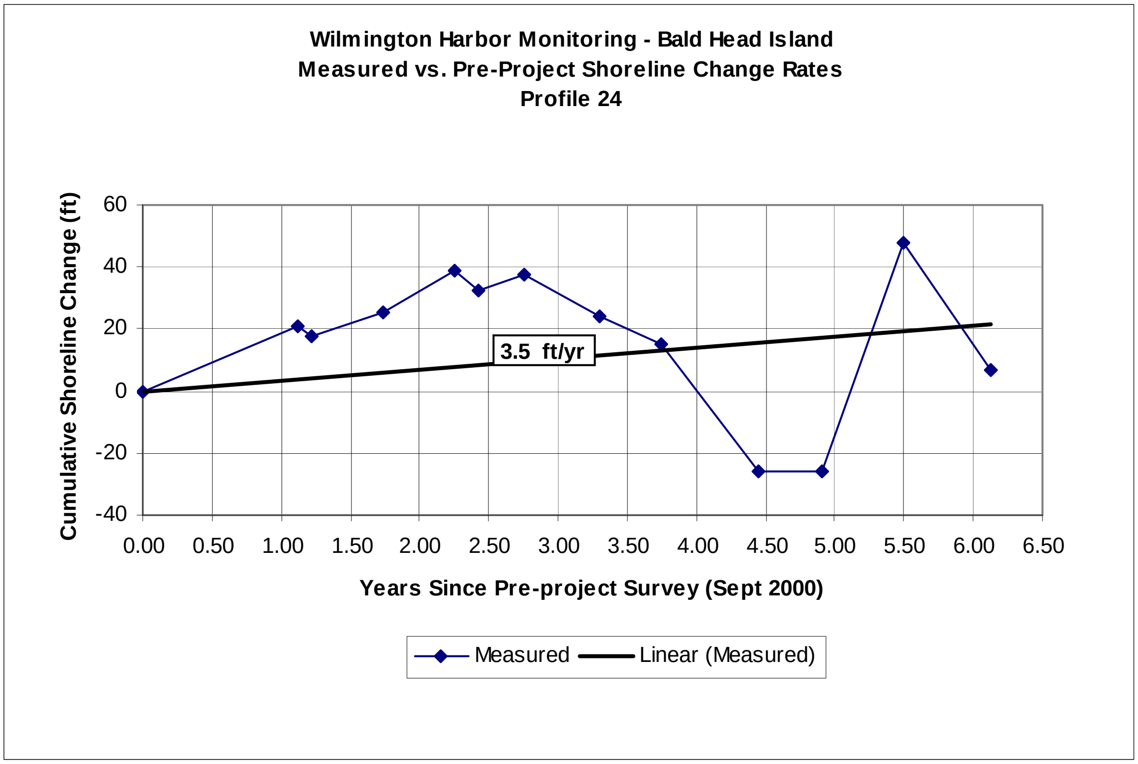
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 8
Cumulative Shoreline Change (ft)
20
0
-20
-40
-1.9 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

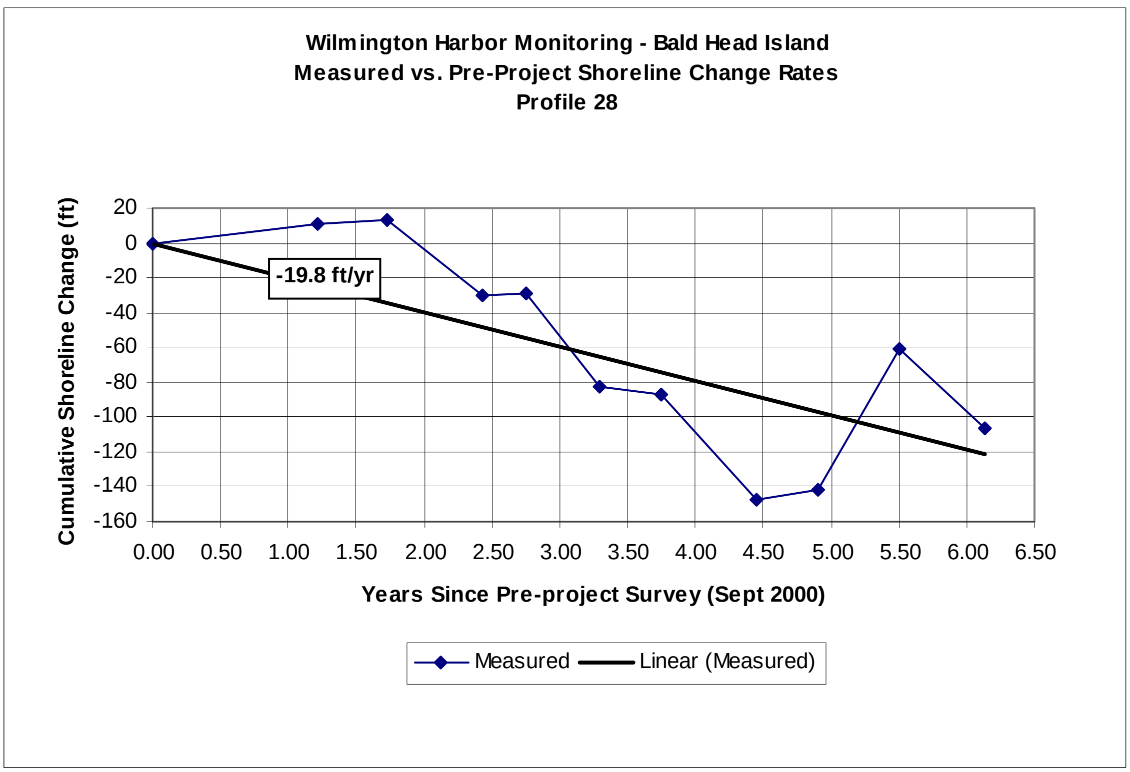


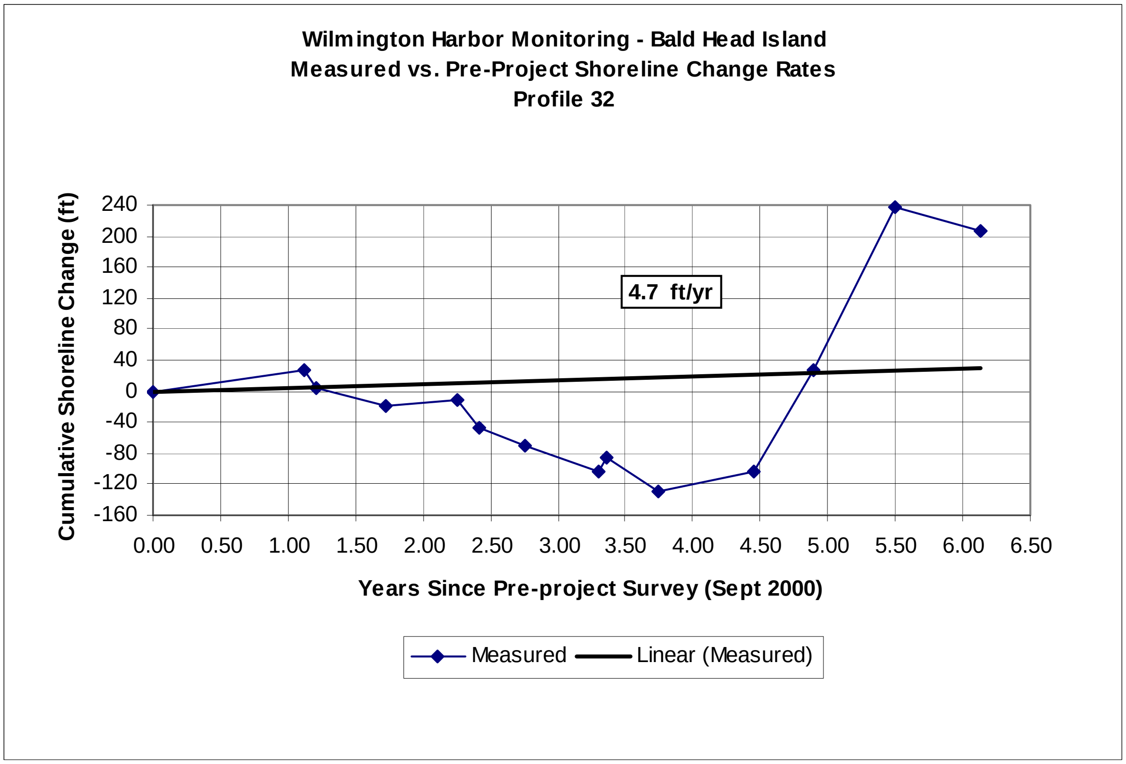
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 12
Cumulative Shoreline Change (ft)
20
0
-20
1.2 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

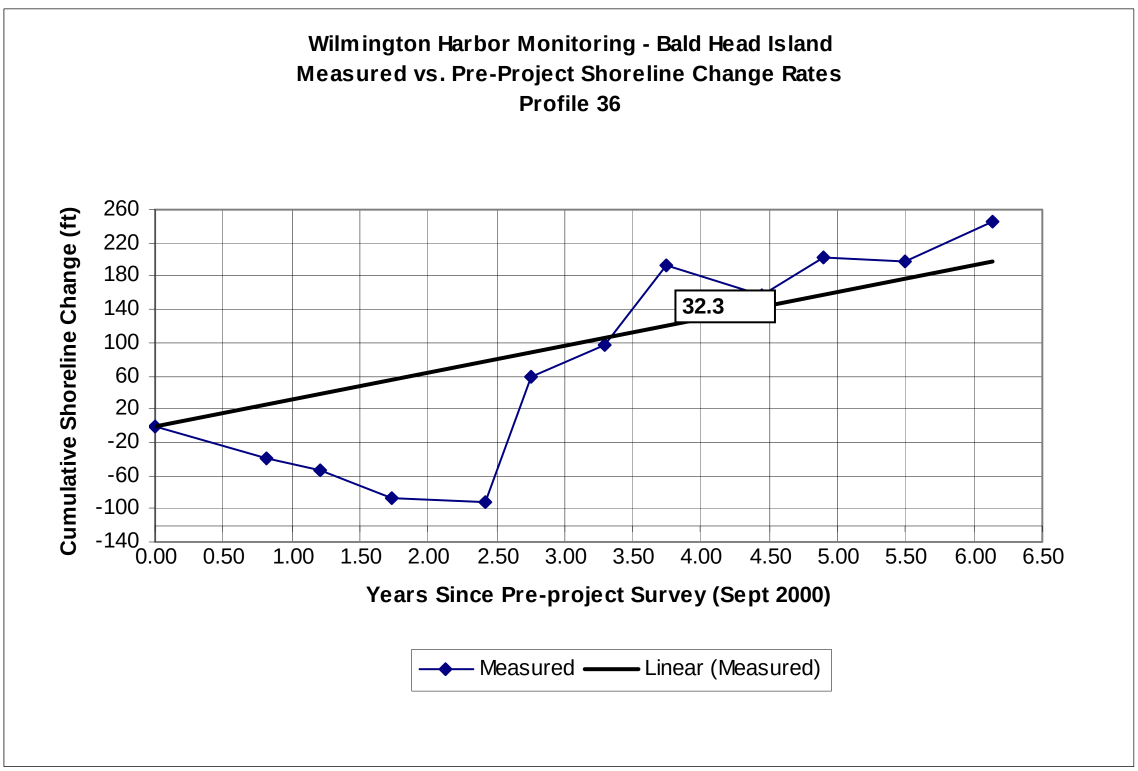

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 16
3.7 ft/yr
Cumulative Shoreline Change (ft)
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

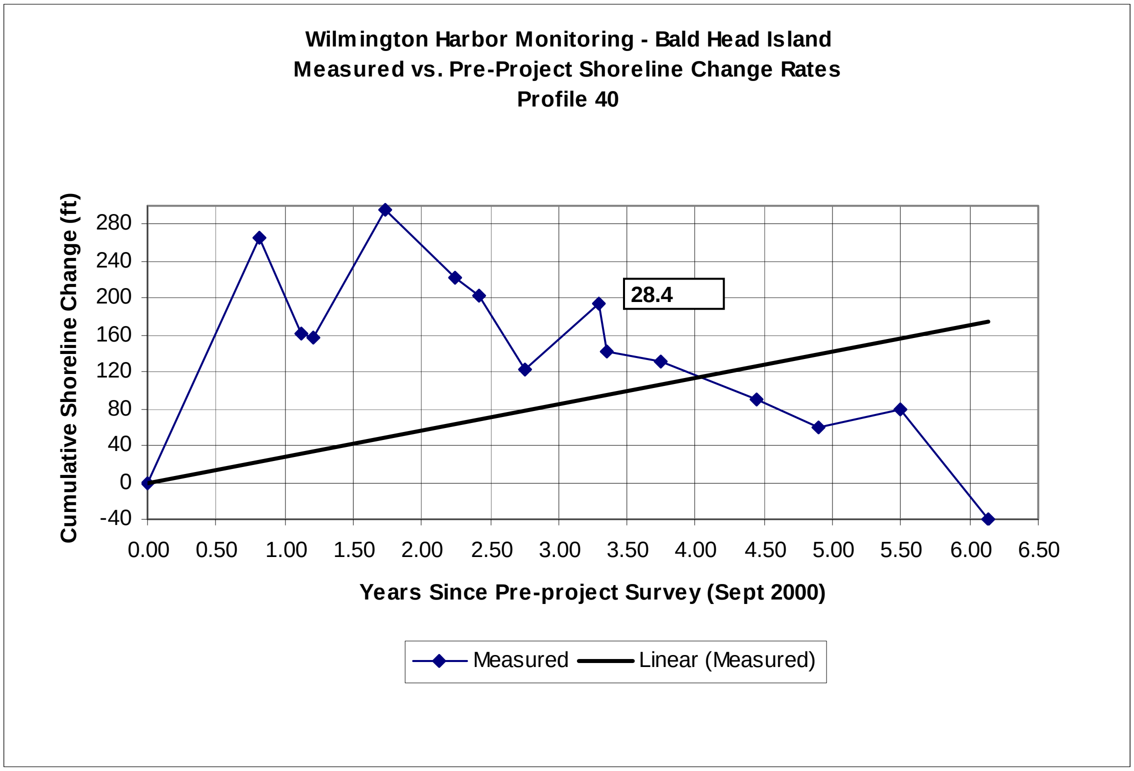

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
1.4 ft/yr
Cumulative Shoreline Change (ft)
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 24
Cumulative Shoreline Change (ft)
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
3.5 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

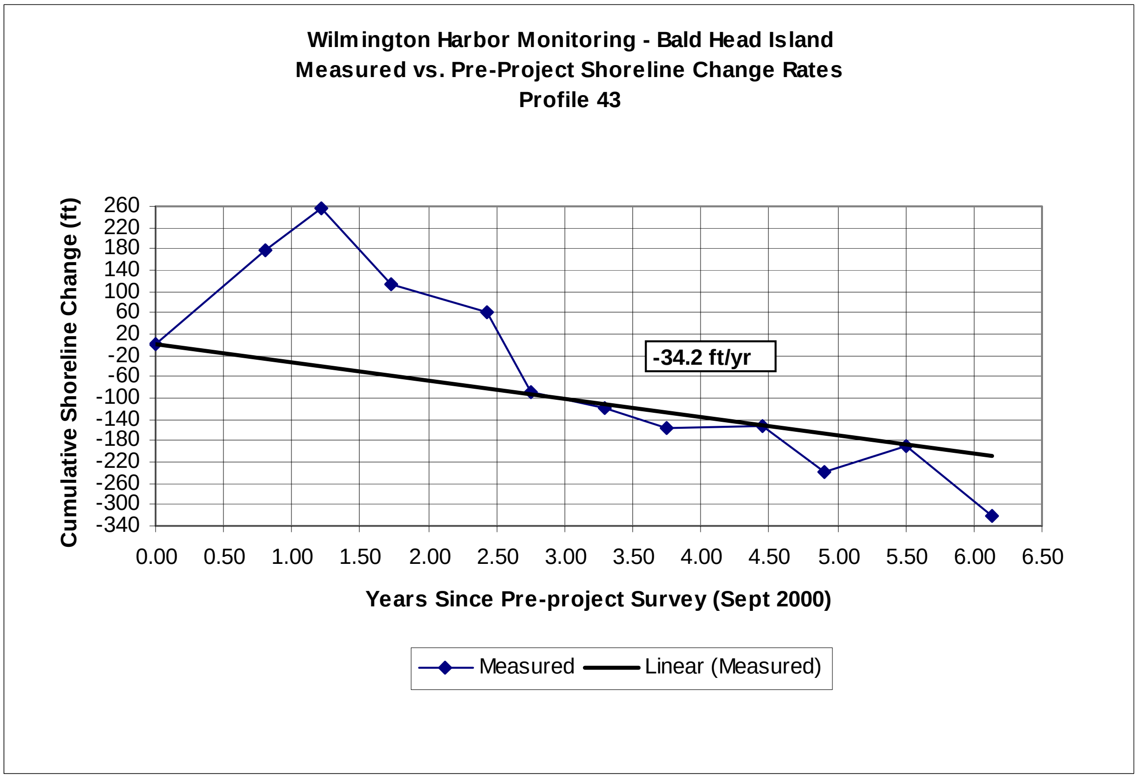

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 28
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
-140
-160
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
-19.8 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 32
4.7 ft/yr
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
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

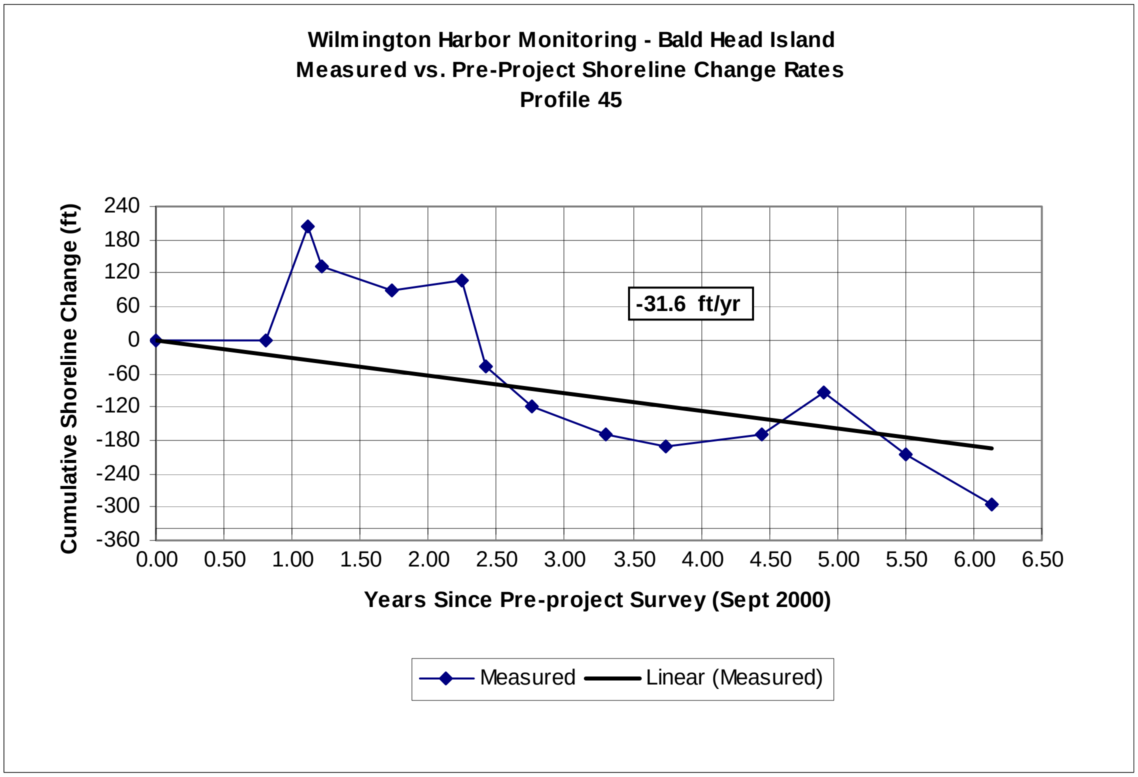

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 36
32.3
Cumulative Shoreline Change (ft)
260
220
180
140
100
60
20
-20
-60
-100
-140
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

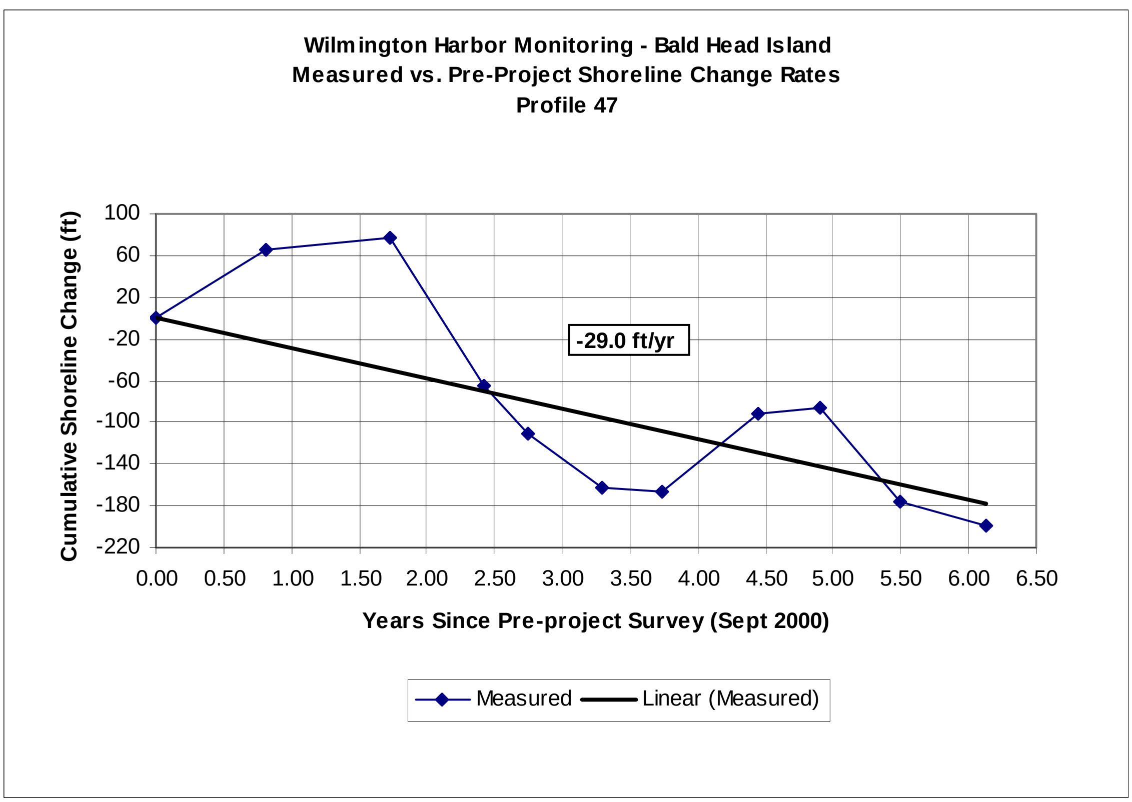


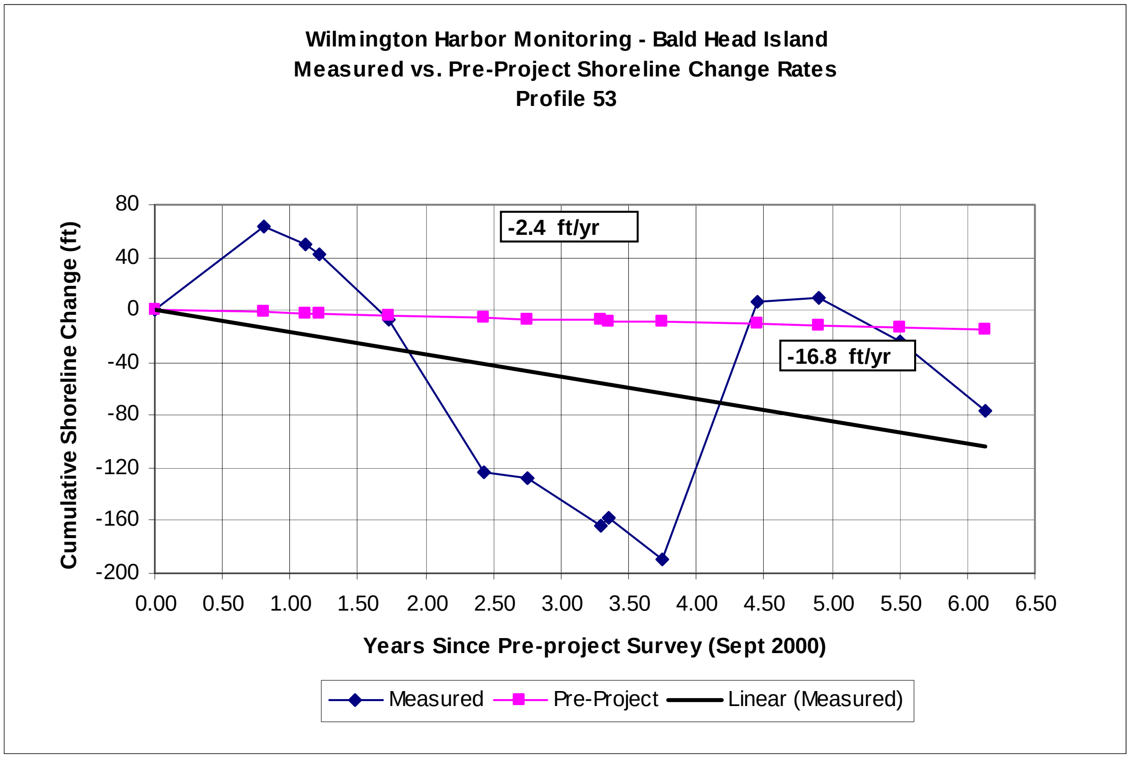
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
28.4
Cumulative Shoreline Change (ft)
280
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

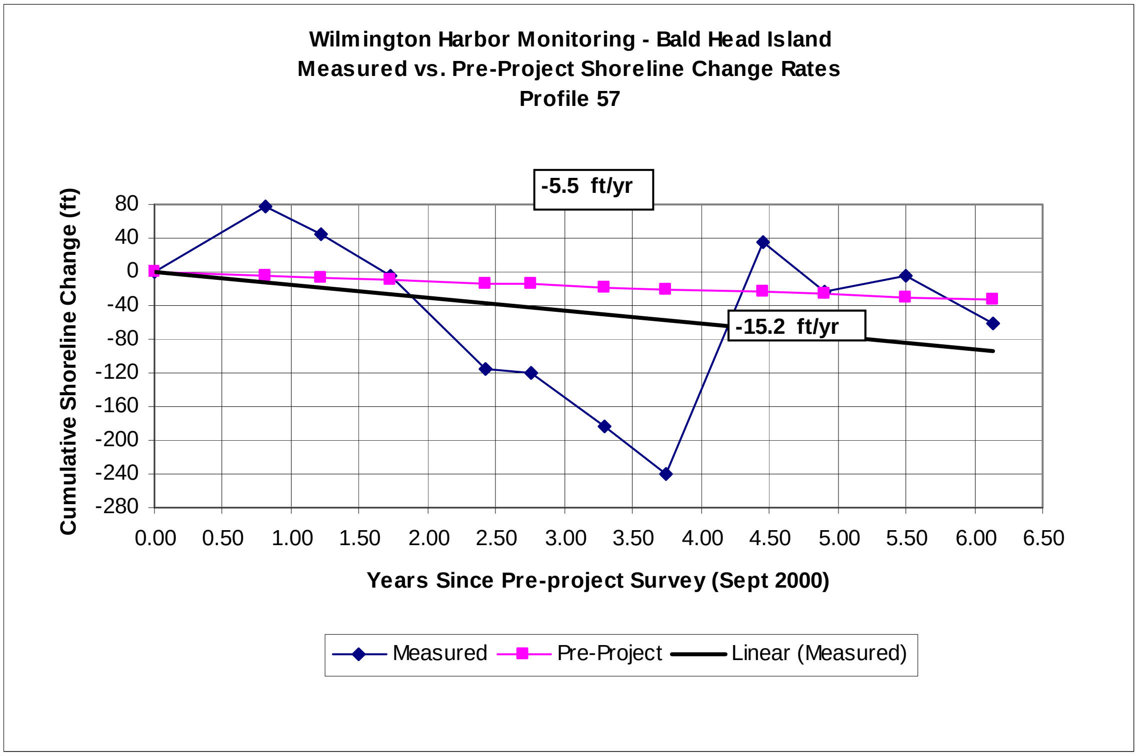


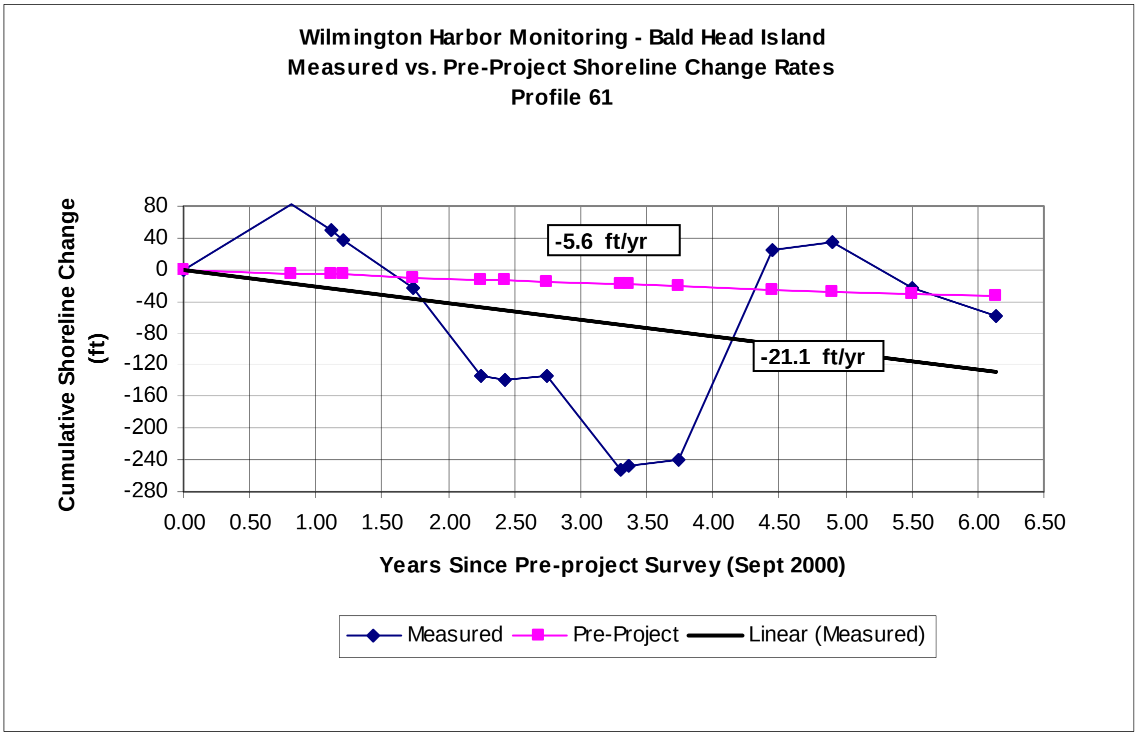
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 43
-34.2 ft/yr
Cumulative Shoreline Change (ft)
260
220
180
140
100
60
20
-20
-60
-100
-140
-180
-220
-260
-300
-340
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

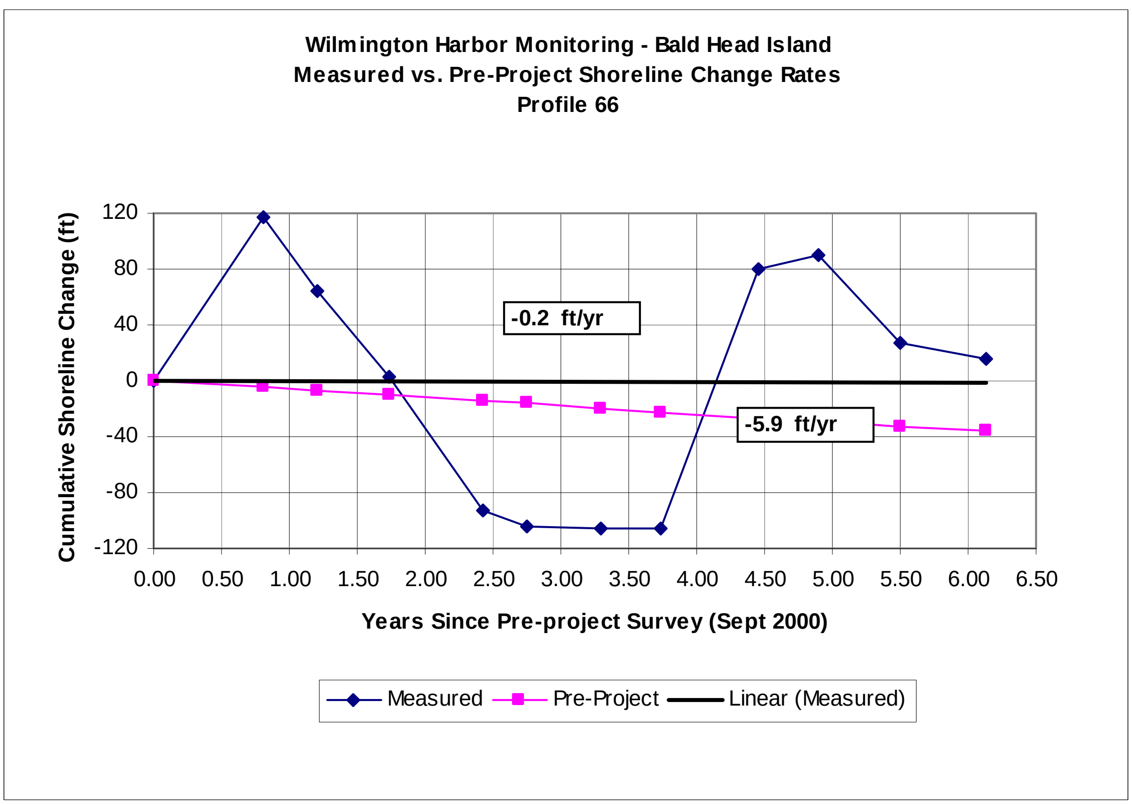

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
240
180
120
60
0
-60
-120
-180
-240
-300
-360
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
-31.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

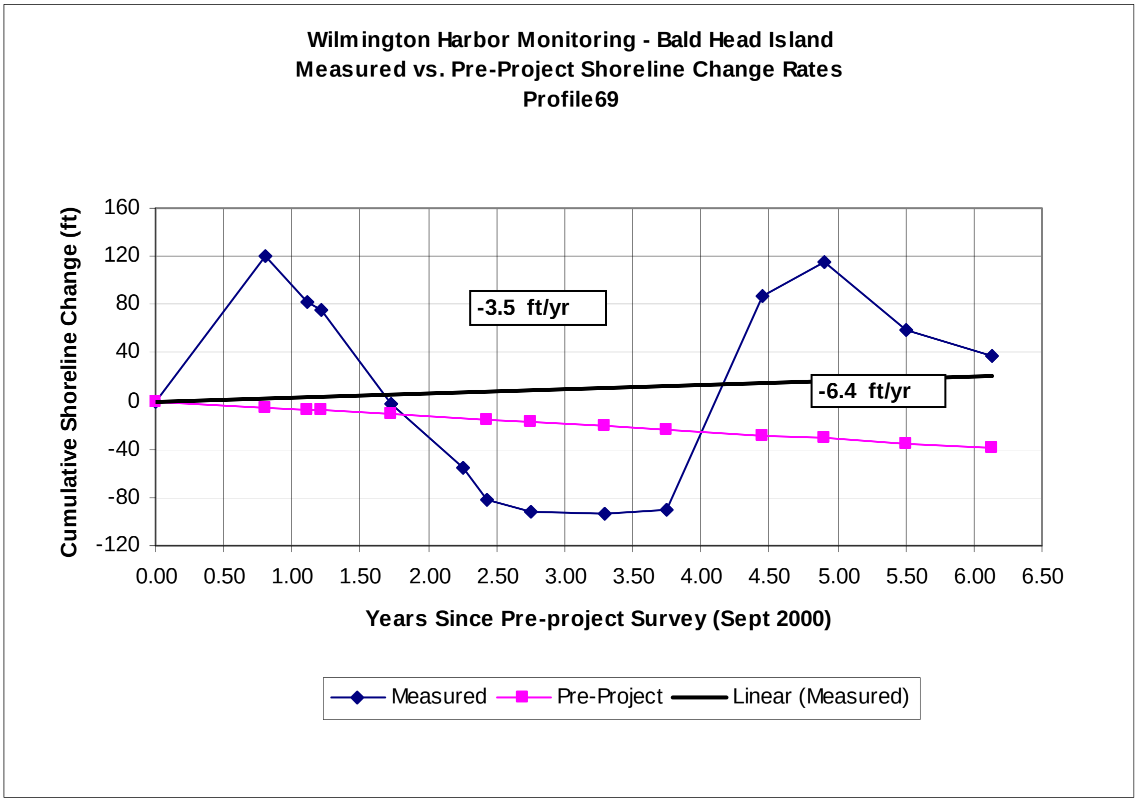

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 47
Cumulative Shoreline Change (ft)
100
60
20
-20
-60
-100
-140
-180
-220
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
-29.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

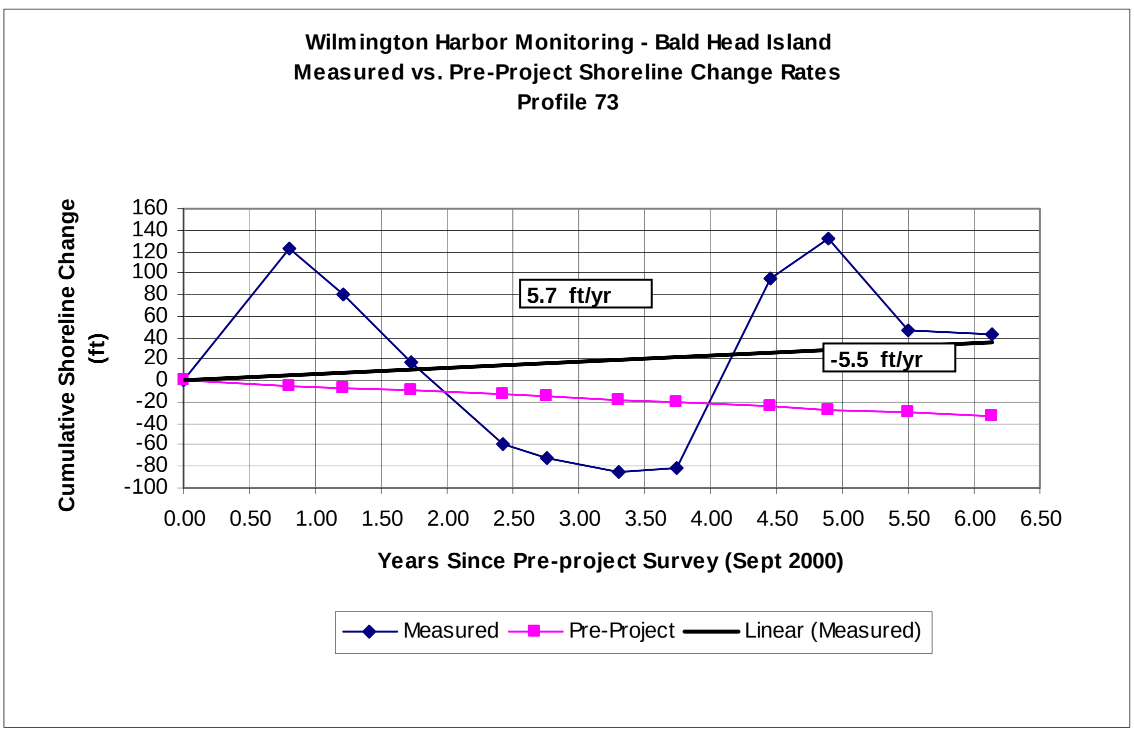

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 53
-2.4 ft/yr
-16.8 ft/yr
Cumulative Shoreline Change (ft)
80
40
0
-40
-80
-120
-160
-200
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

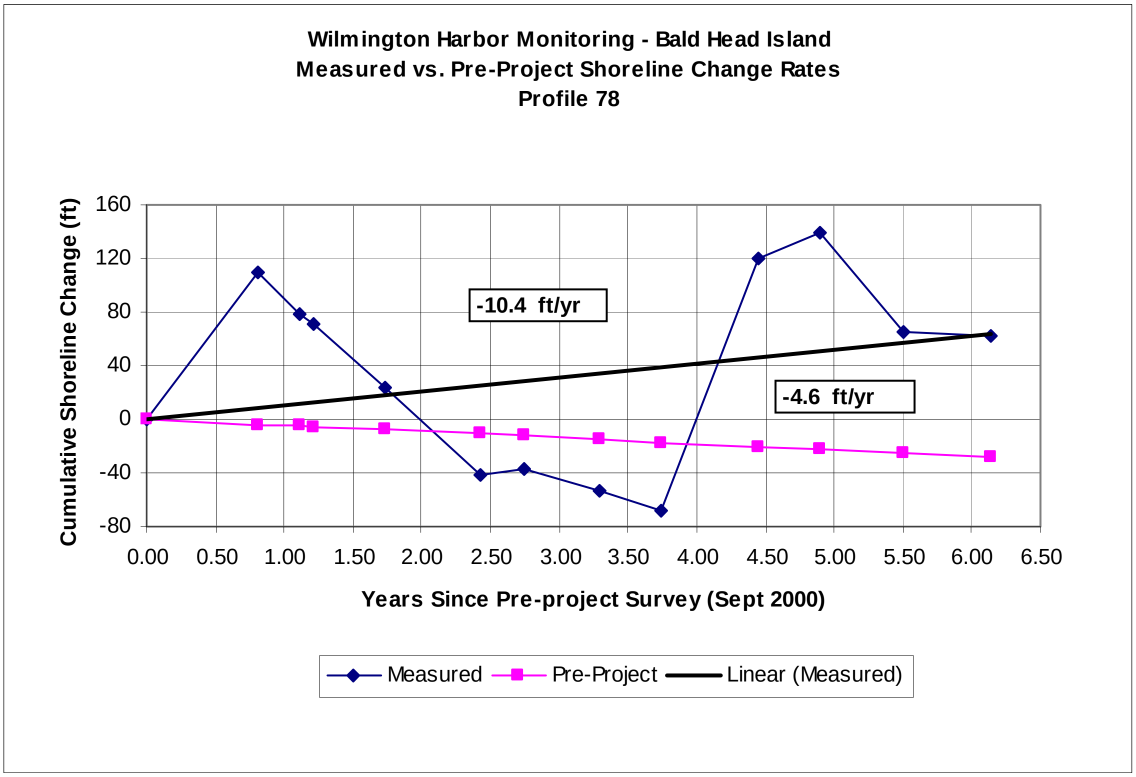

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 57
-5.5 ft/yr
-15.2 ft/yr
Cumulative Shoreline Change (ft)
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

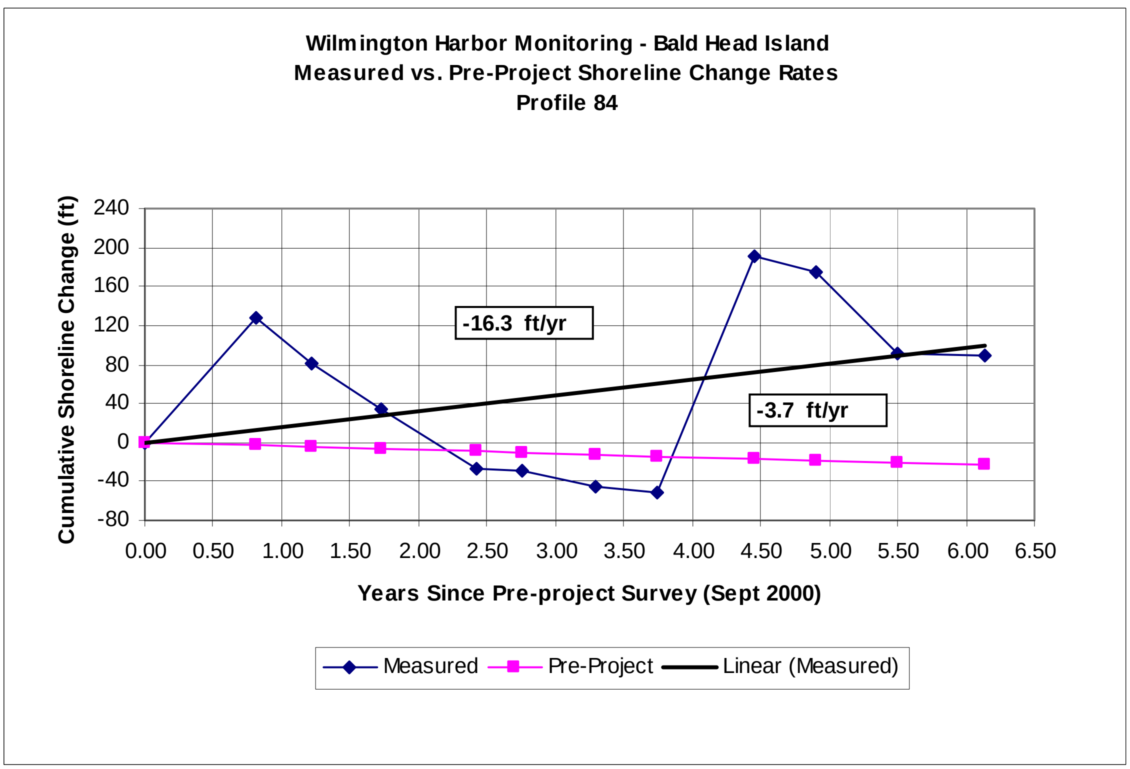

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 61
Cumulative Shoreline Change (ft)
-5.6 ft/yr
-21.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

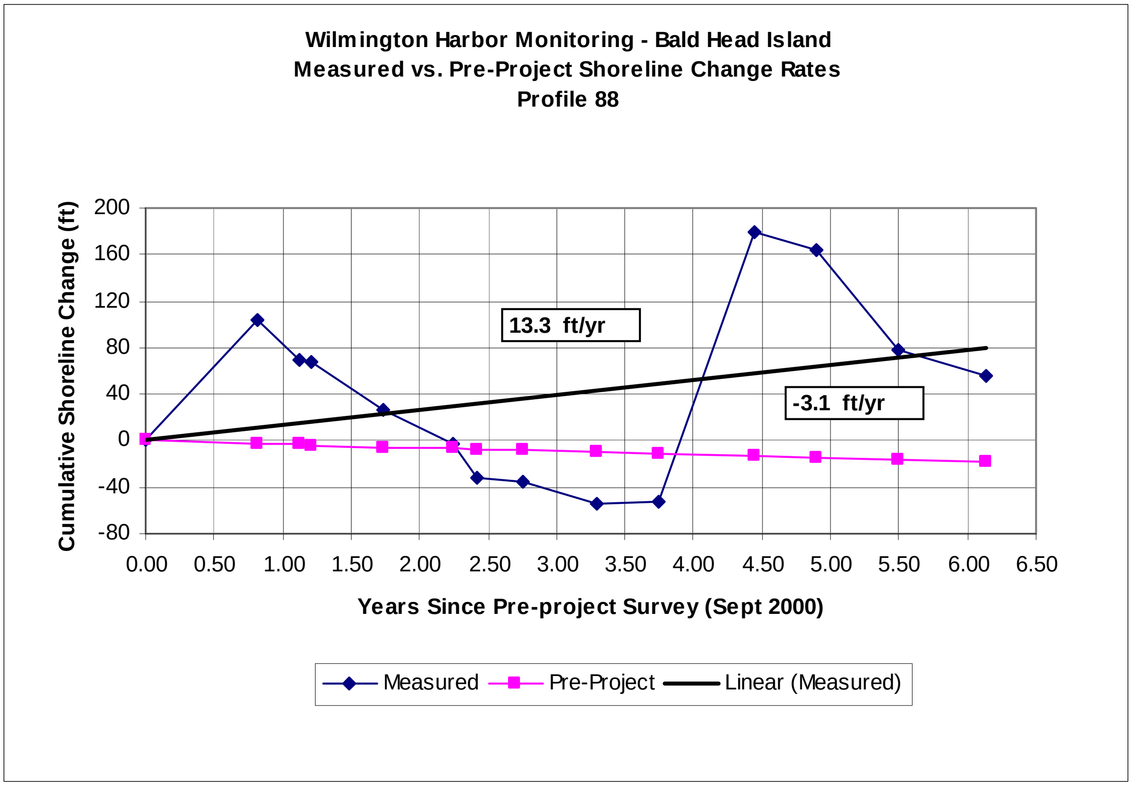

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 66
Cumulative Shoreline Change (ft)
-0.2 ft/yr
-5.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

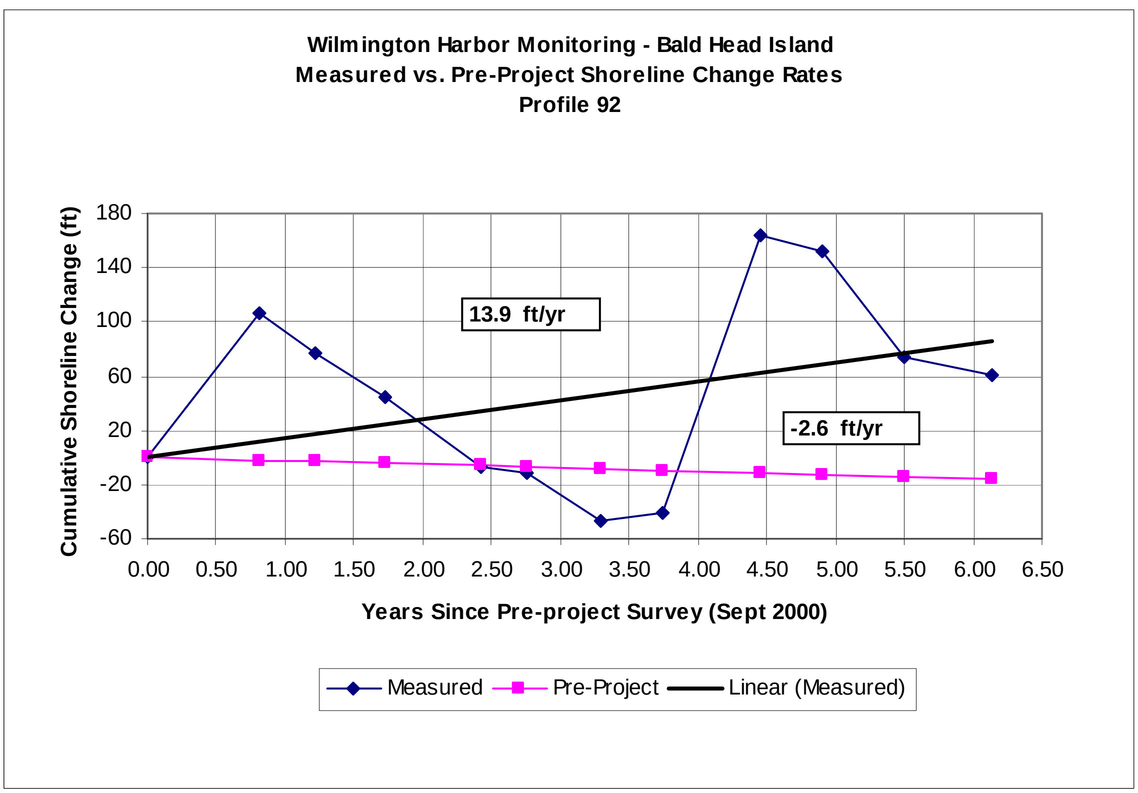

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile69
-3.5 ft/yr
-6.4 ft/yr
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

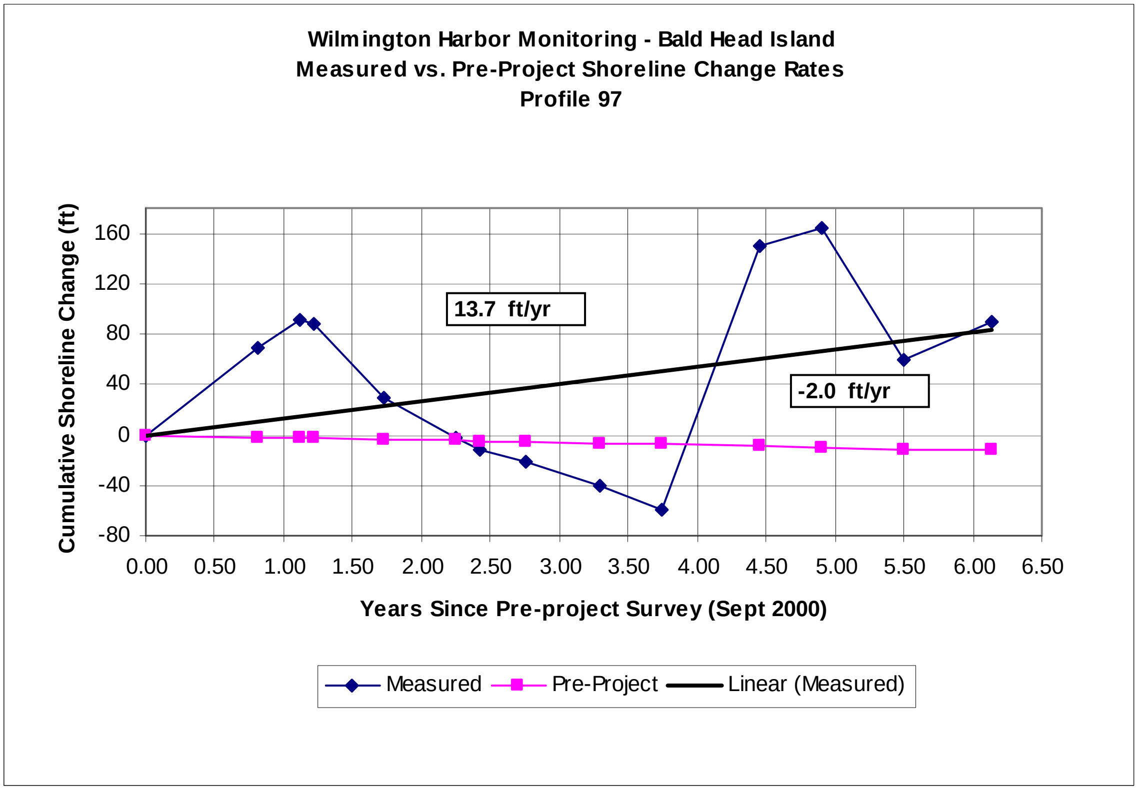

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 73
5.7 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

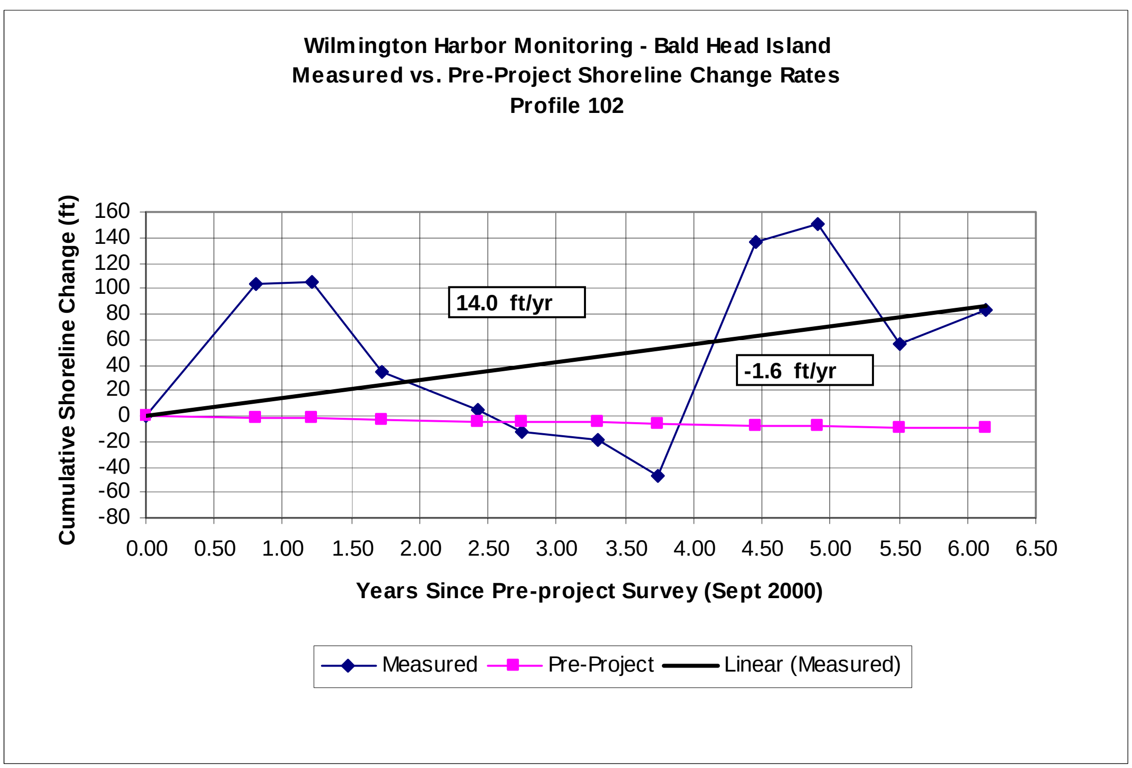

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 78
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
-10.4 ft/yr
-4.6 ft/yr
Measured
Pre-Project
Linear (Measured)

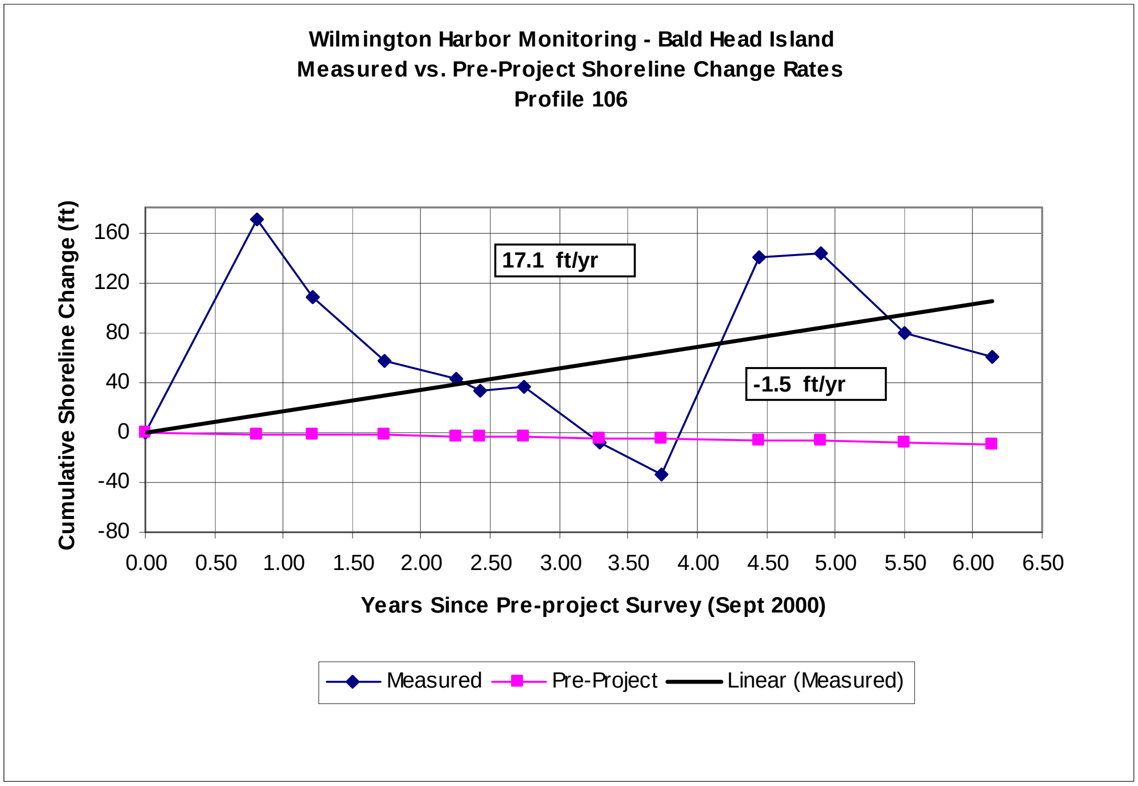

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 84
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
-16.3 ft/yr
-3.7 ft/yr
Measured
Pre-Project
Linear (Measured)

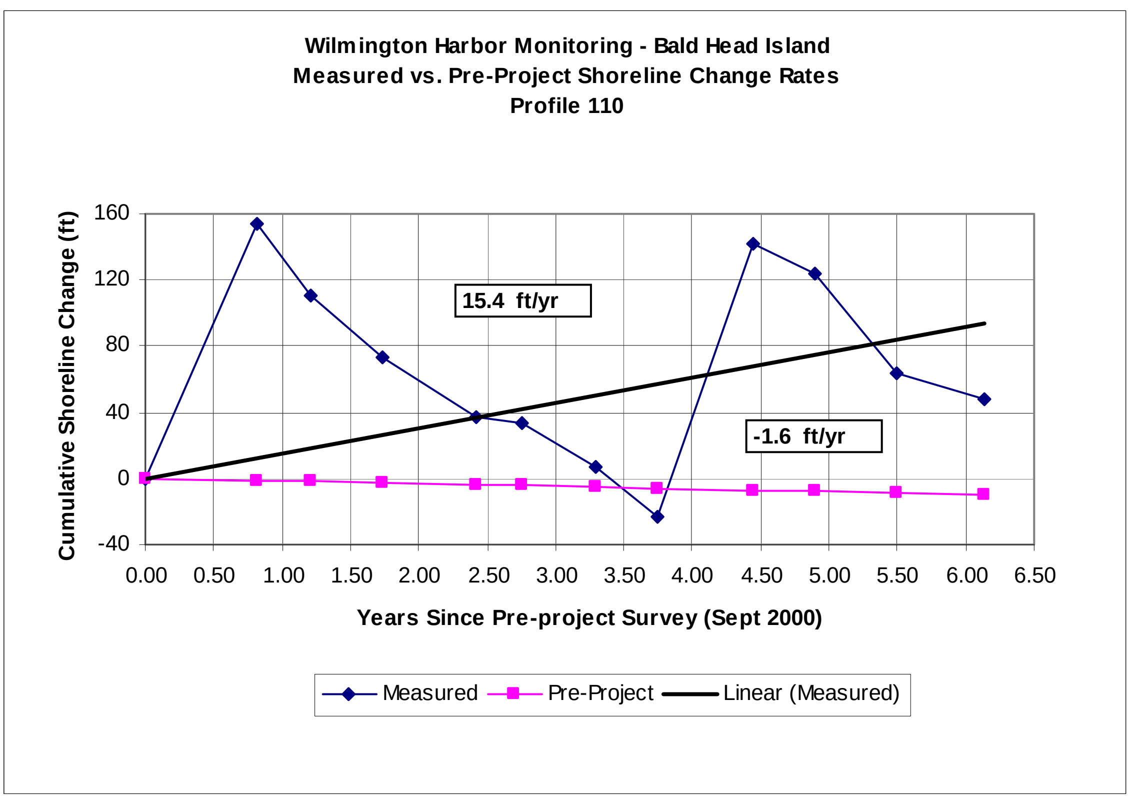

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 88
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
13.3 ft/yr
-3.1 ft/yr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

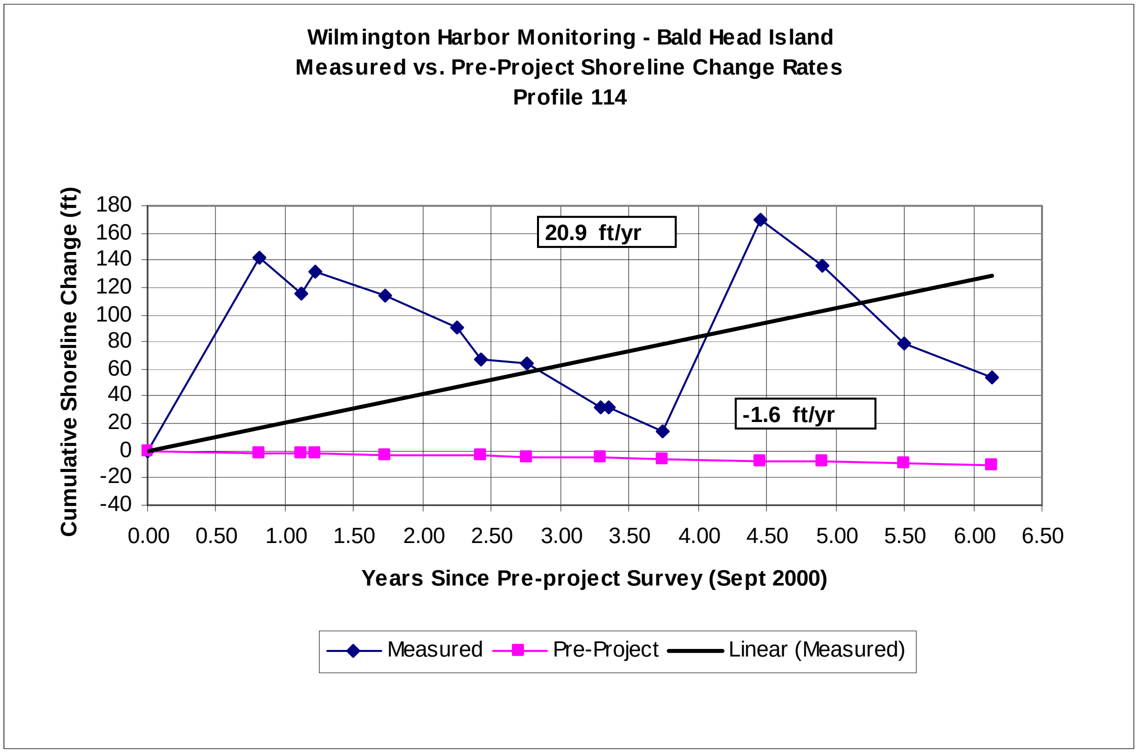

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 92
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
13.9 ft/yr
-2.6 ft/yr
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
Years Since Pre-project Survey (Sept 2000)
13.7 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

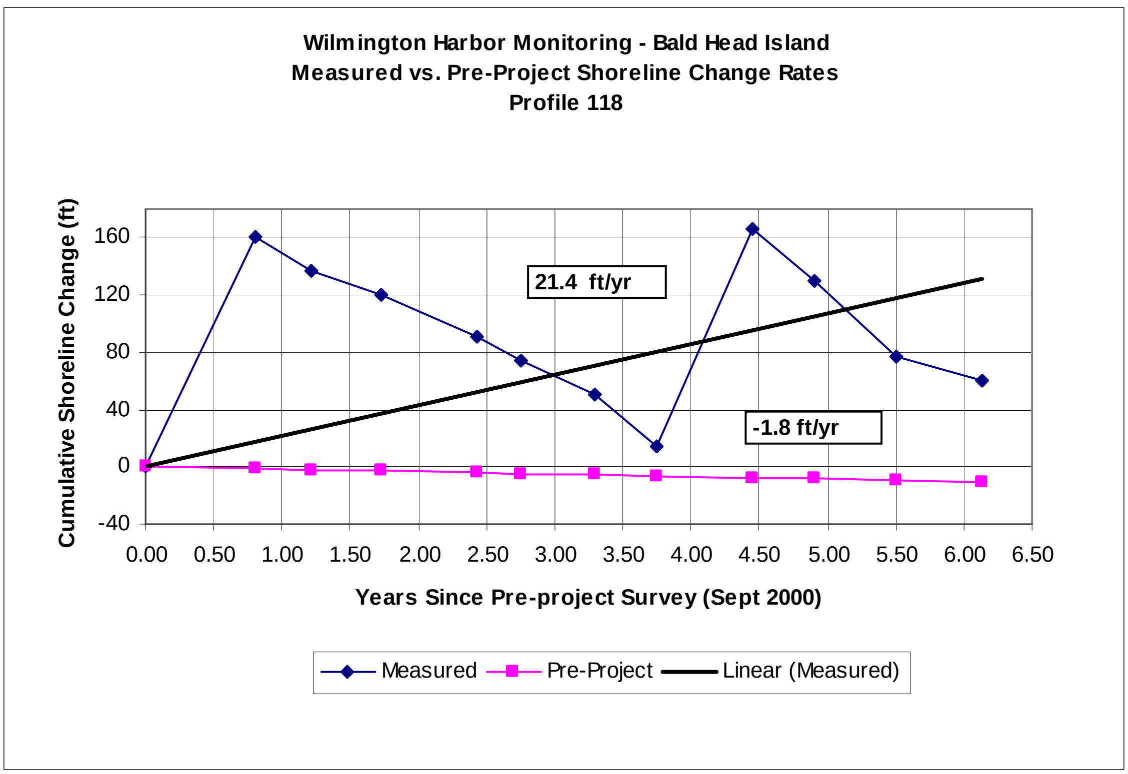

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 102
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
14.0 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
Years Since Pre-project Survey (Sept 2000)
17.1 ft/yr
-1.5 ft/yr
Measured
Pre-Project
Linear (Measured)

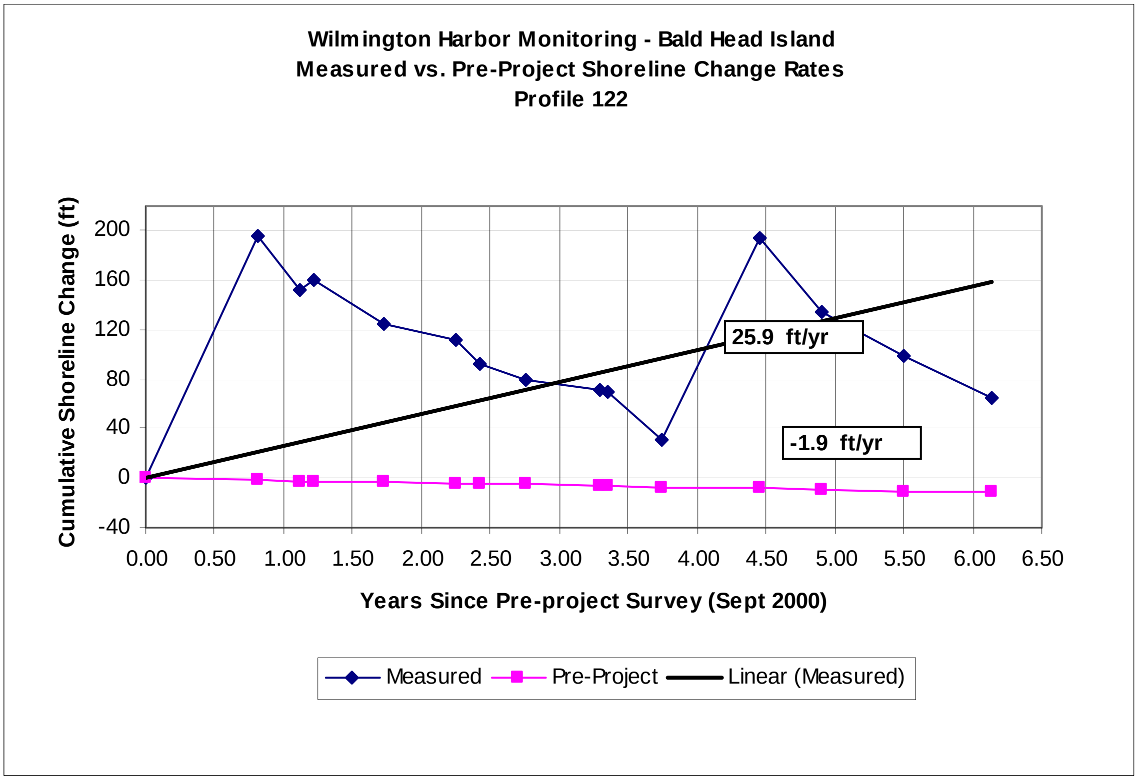

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
15.4 ft/yr
-1.6 ft/yr
Measured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

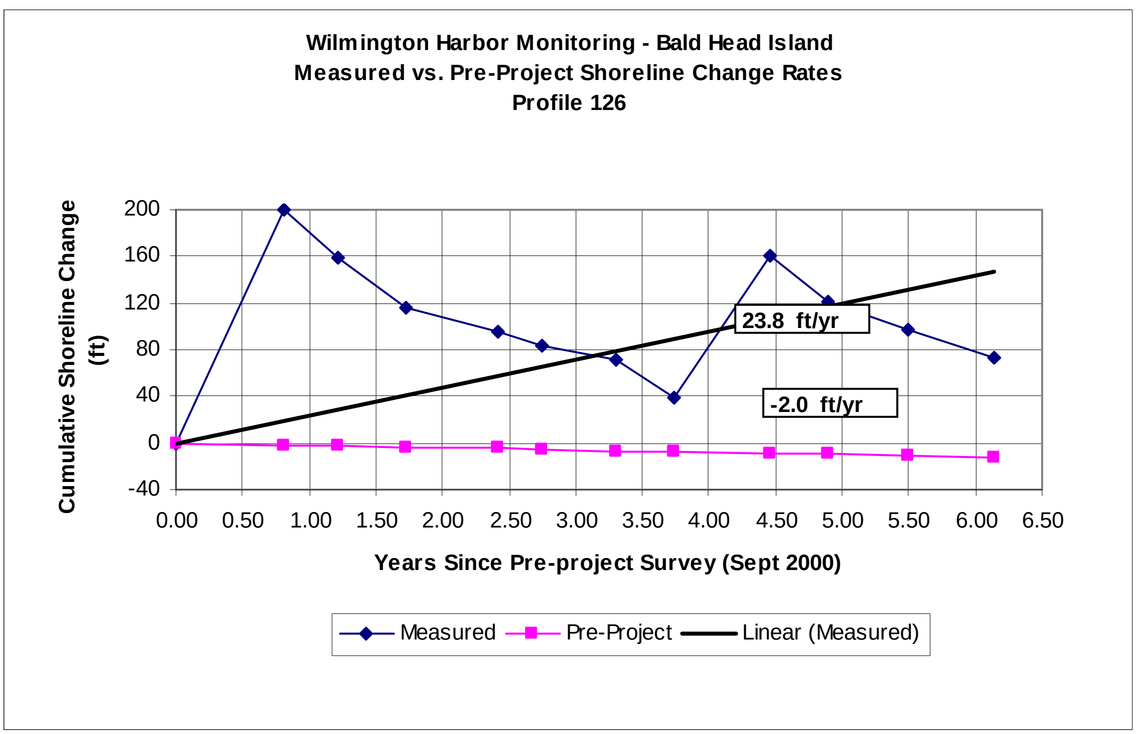


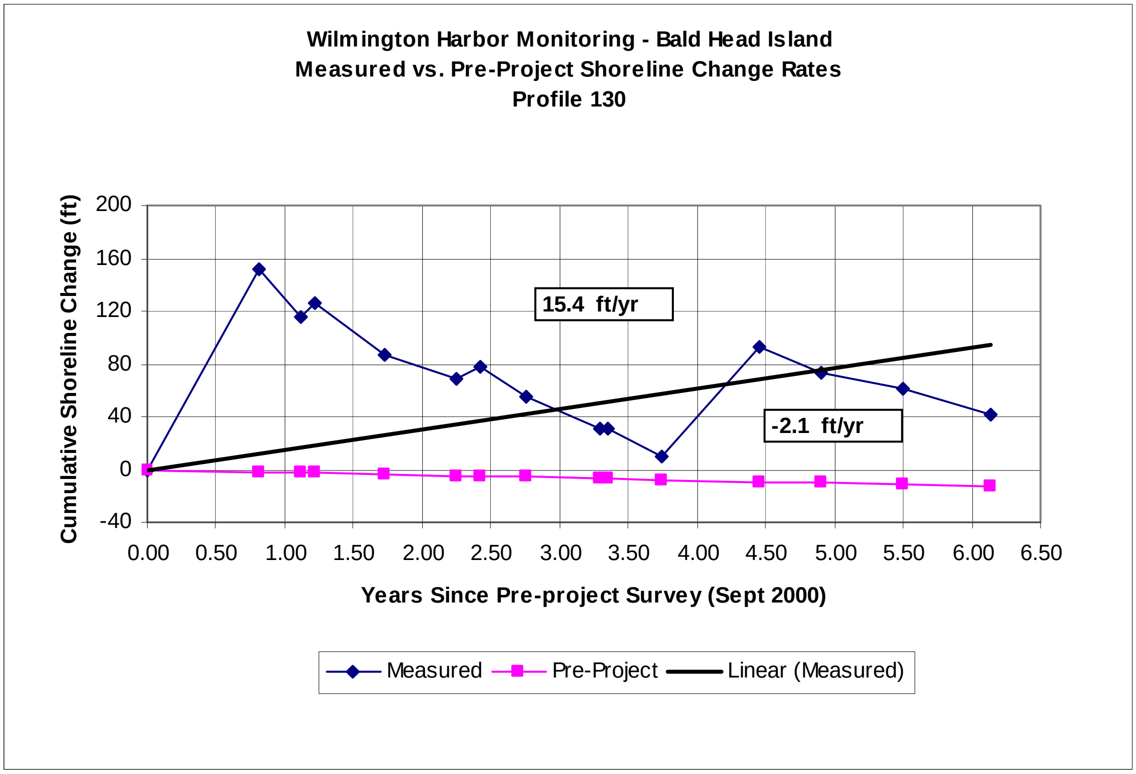
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 114
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
20.9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

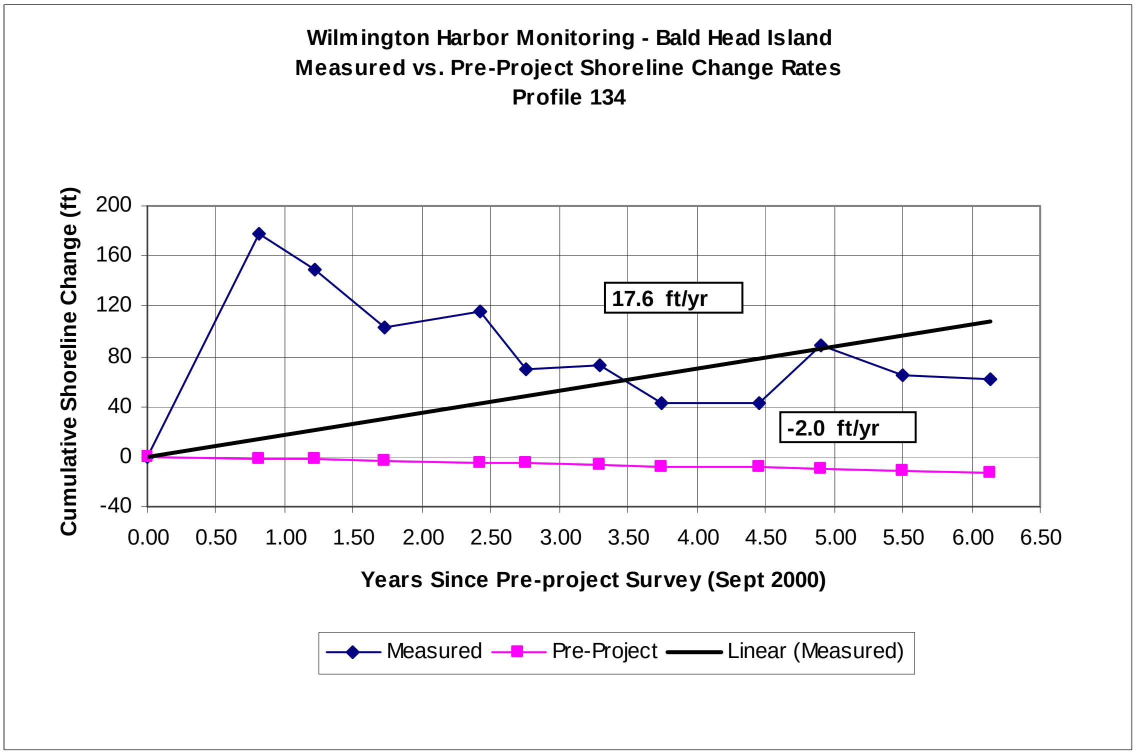


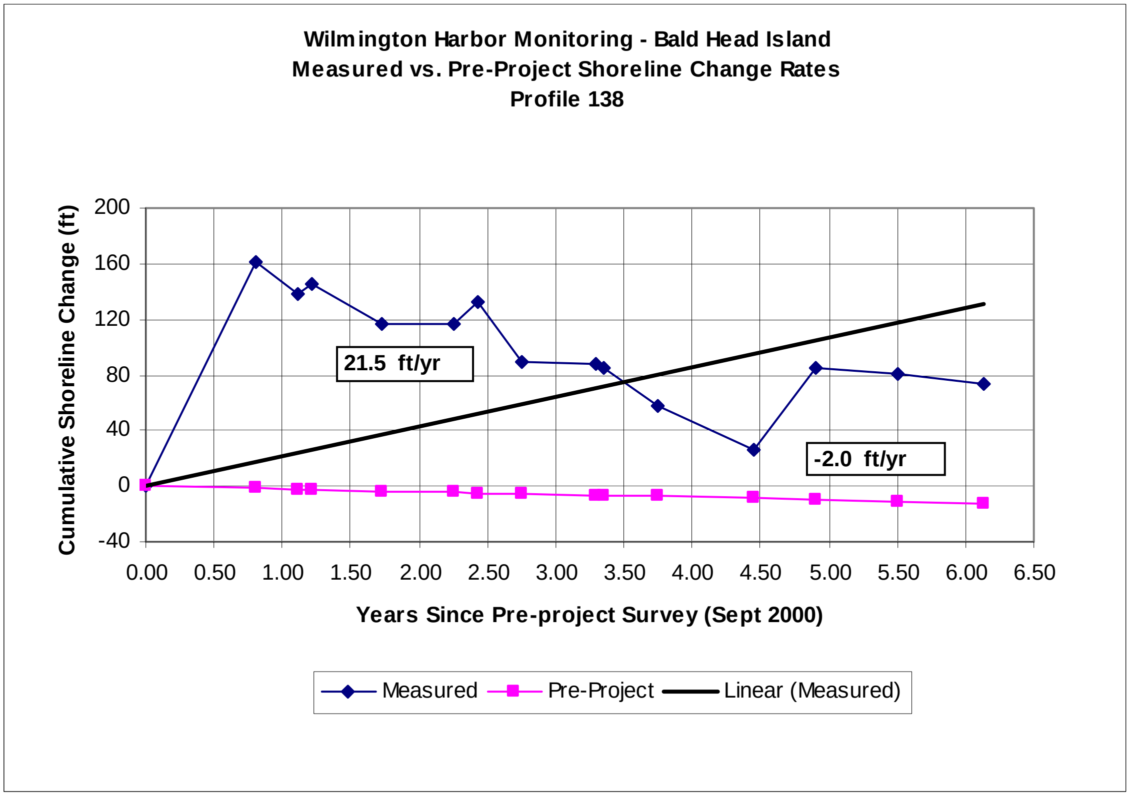
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 118
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
21.4 ft/yr
-1.8 ft/yr
Measured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

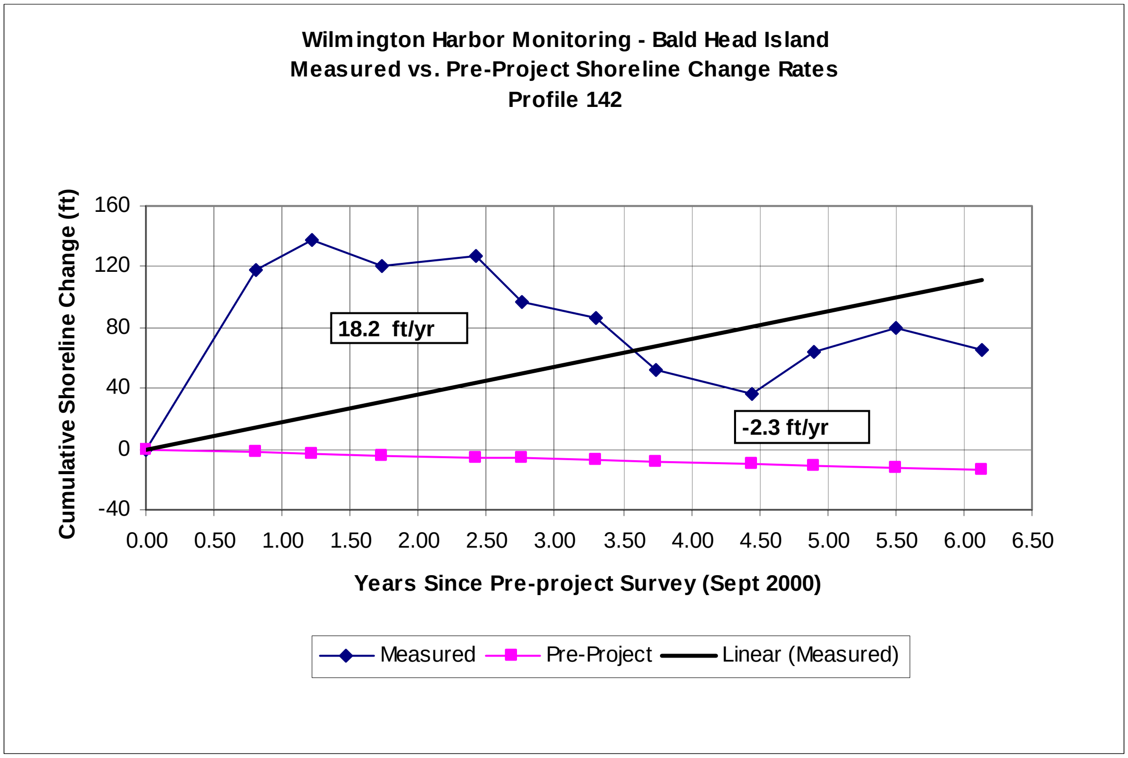

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 122
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
25.9 ft/yr
-1.9 ft/yr
Measured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

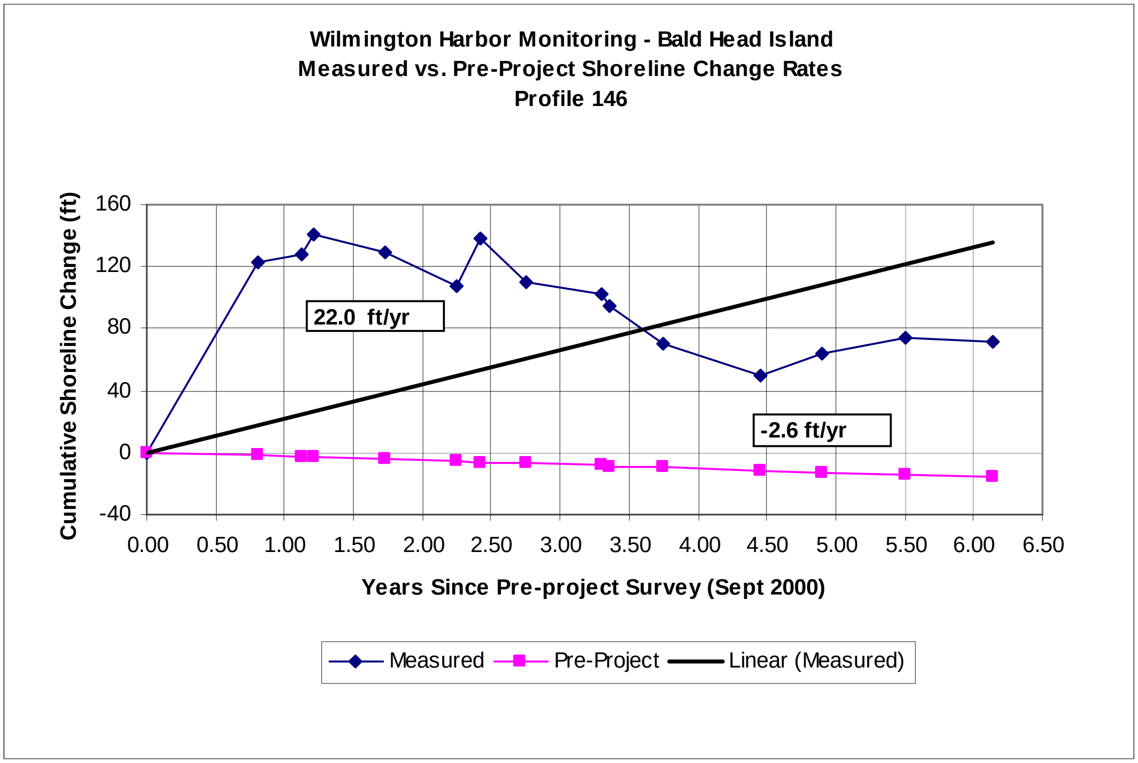

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 126
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
23.8 ft/yr
-2.0 ft/yr
Measured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

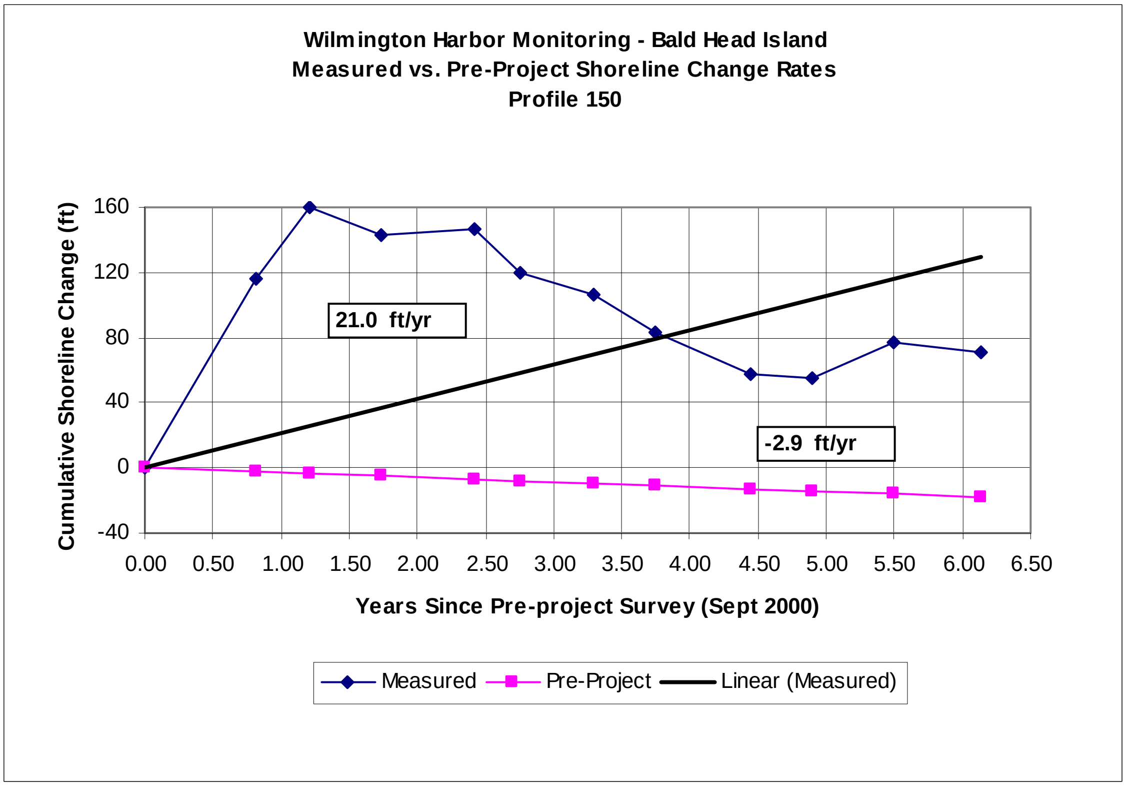

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (Sept 2000)
15.4 ft/yr
-2.1 ft/yr
Measured
Pre-Project
Linear (Measured)

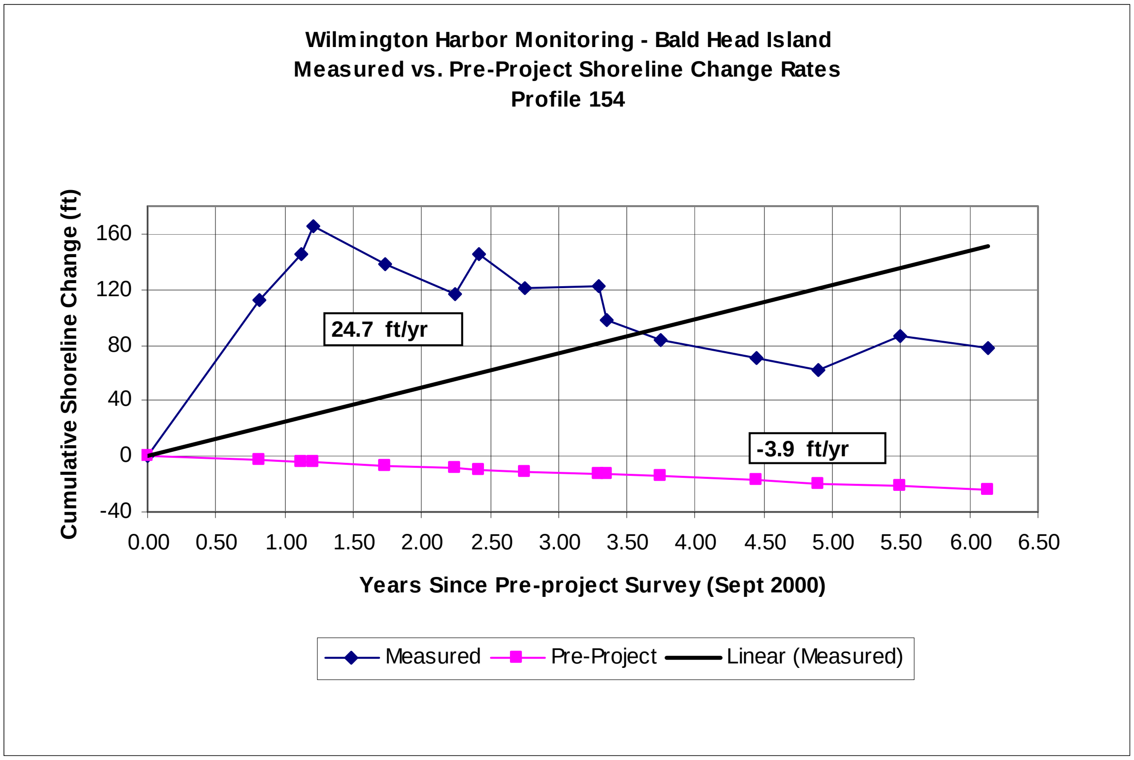

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 134
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (Sept 2000)
17.6 ft/yr
-2.0 ft/yr
Measured
Pre-Project
Linear (Measured)

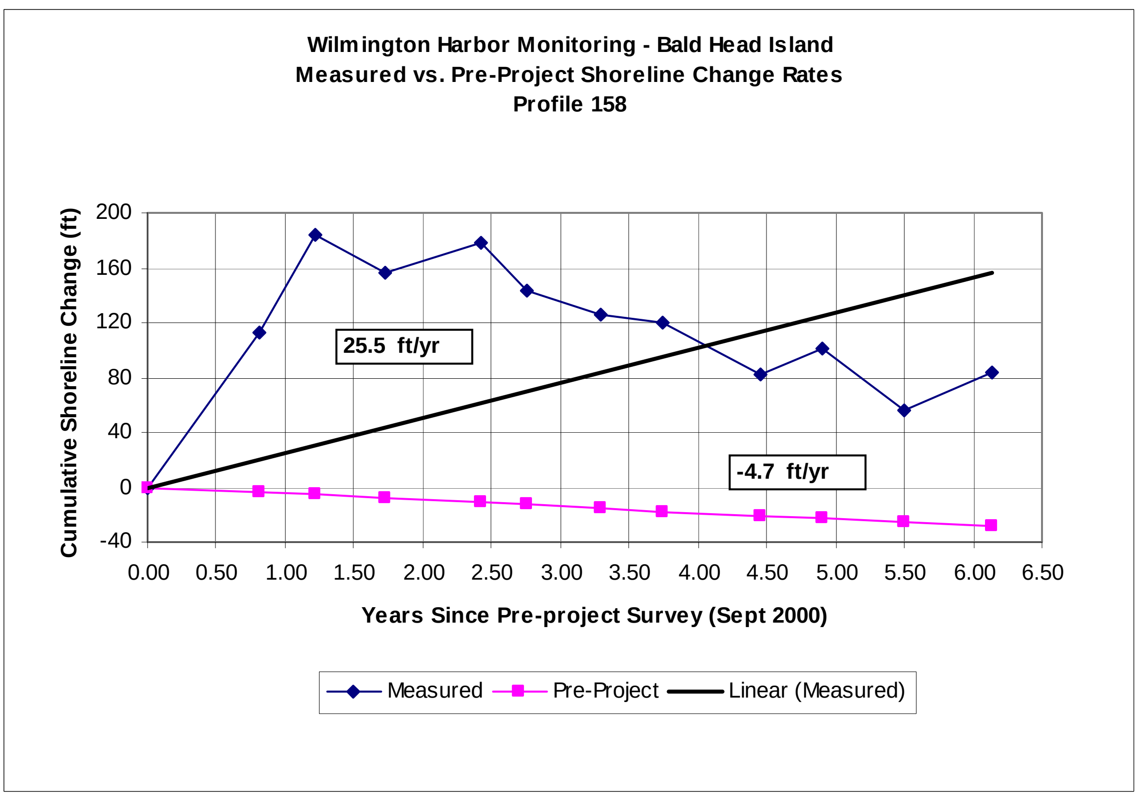

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 138
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
21.5 ft/yr
-2.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured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

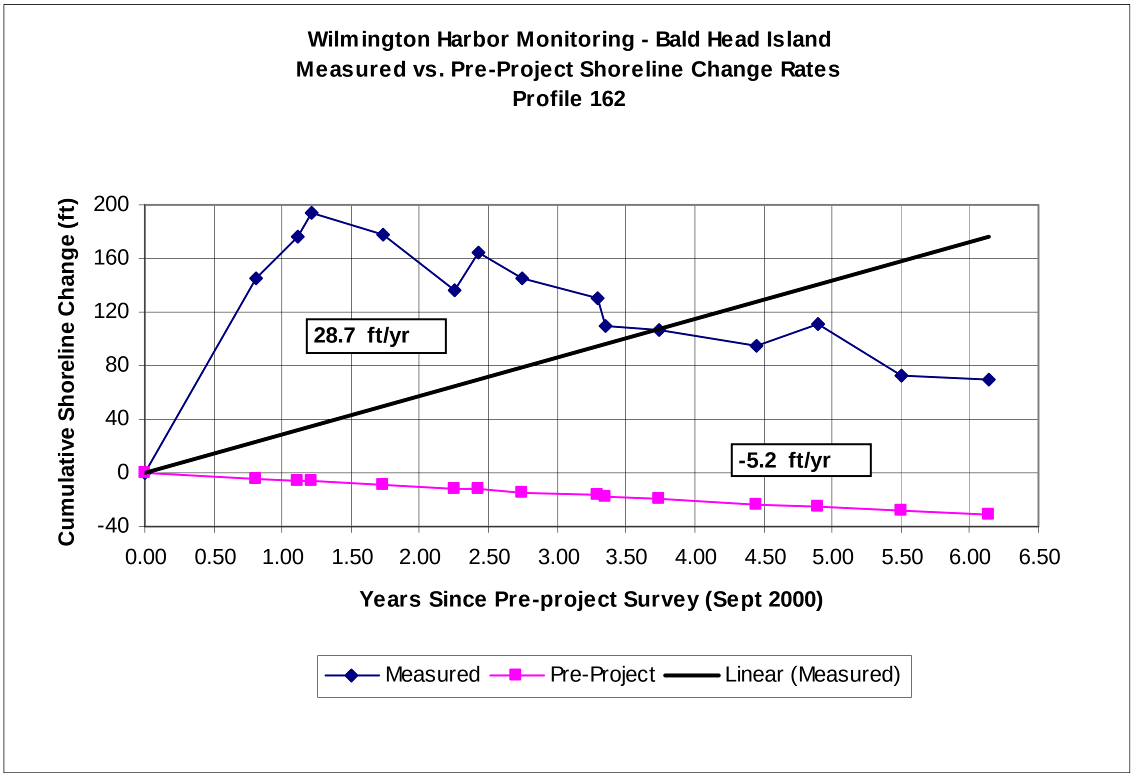

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 142
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
18.2 ft/yr
-2.3 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured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


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 146
Cumulative Shoreline Change (ft)
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
Years Since Pre-project Survey (Sept 2000)
22.0 ft/yr
-2.6 ft/yr
Measured
Pre-Project
Linear (Measured)

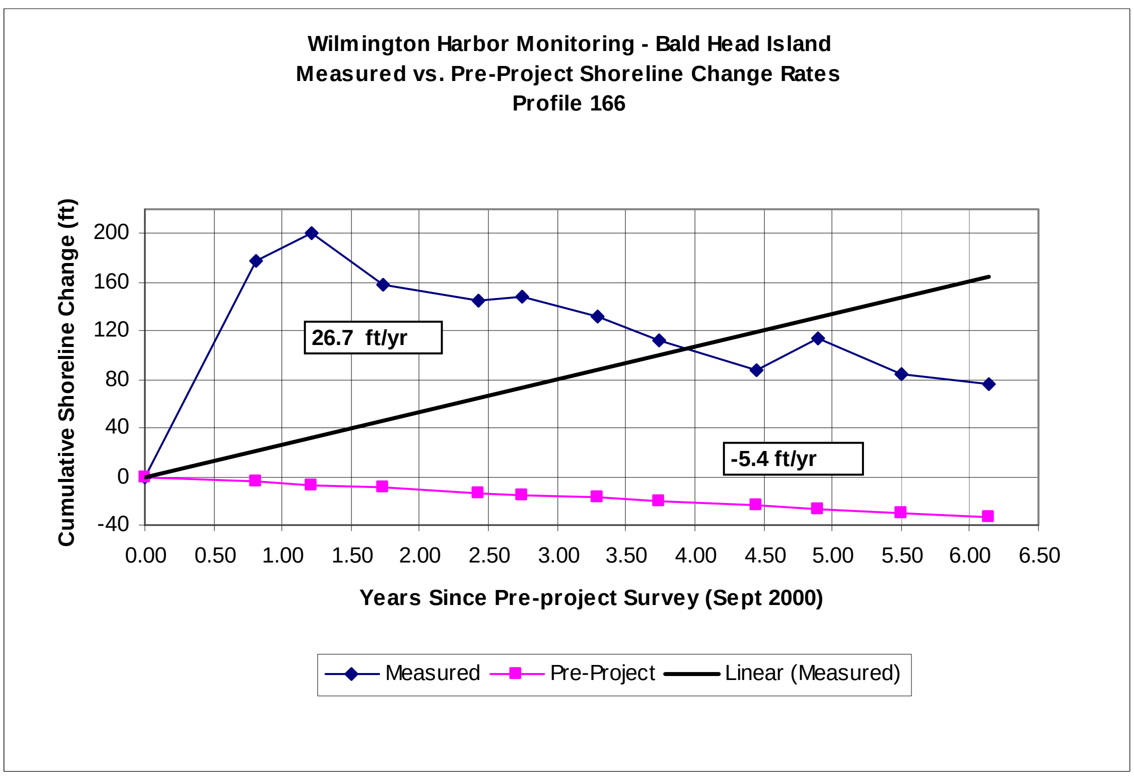

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (Sept 2000)
21.0 ft/yr
-2.9 ft/yr
Measured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


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 154
Cumulative Shoreline Change (ft)
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
24.7 ft/yr
-3.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

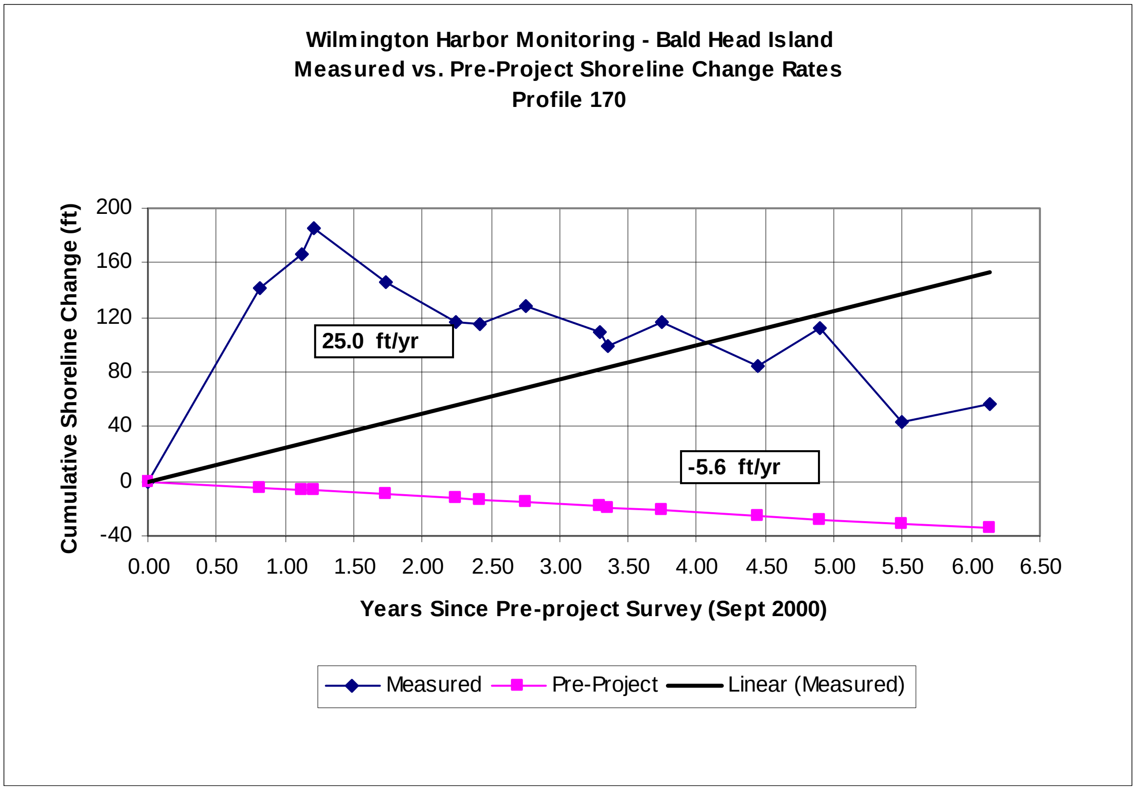

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 158
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
25.5 ft/yr
-4.7 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured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

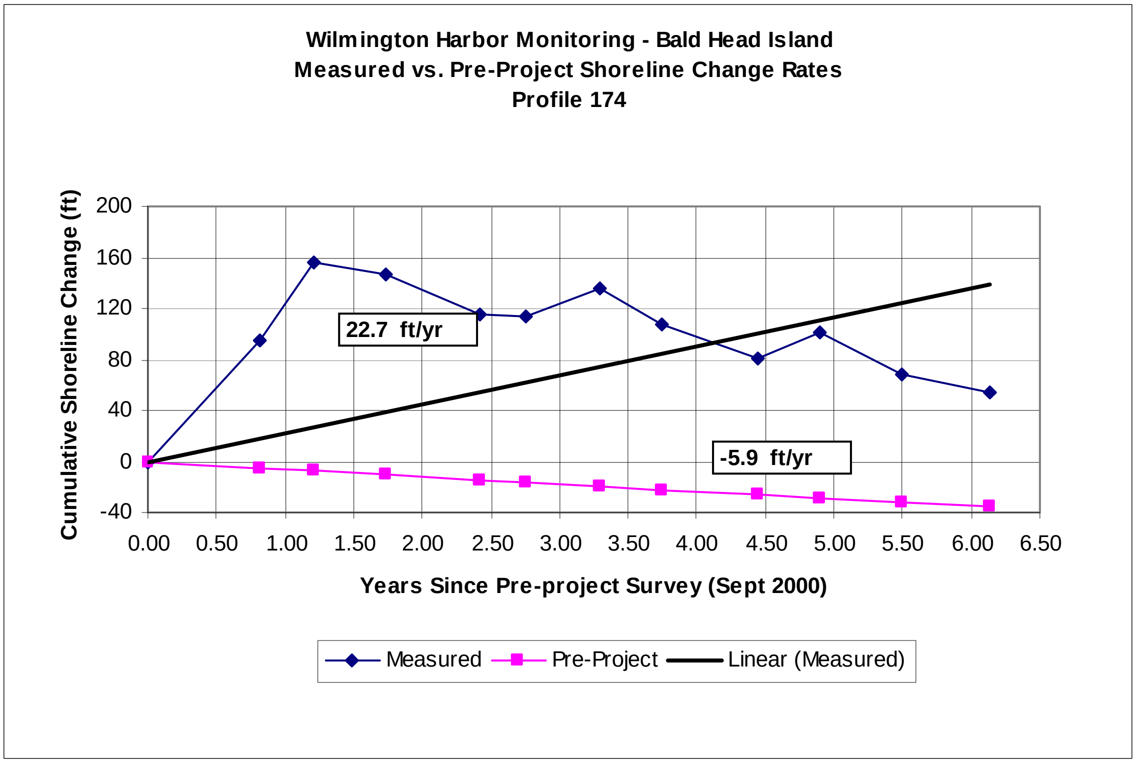


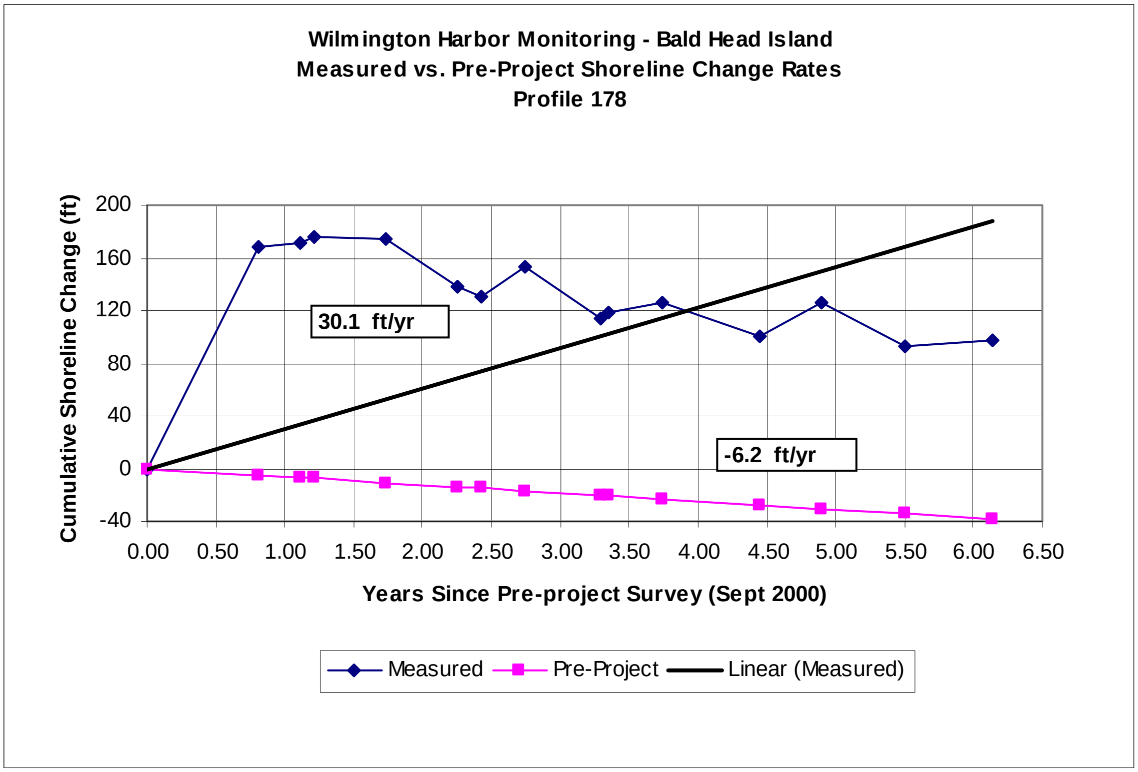
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 162
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
28.7 ft/yr
-5.2 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)



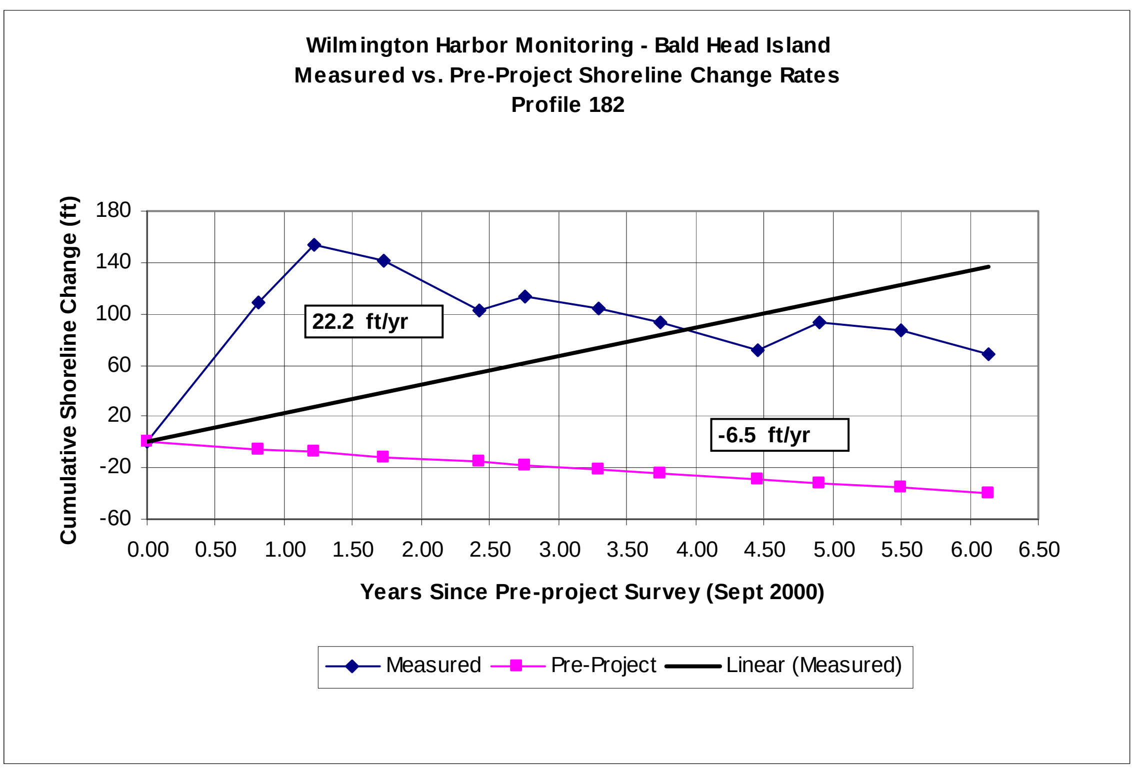
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 166
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
26.7 ft/yr
-5.4 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
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
Years Since Pre-project Survey (Sept 2000)
25.0 ft/yr
-5.6 ft/yr
Measured
Pre-Project
Linear (Measured)

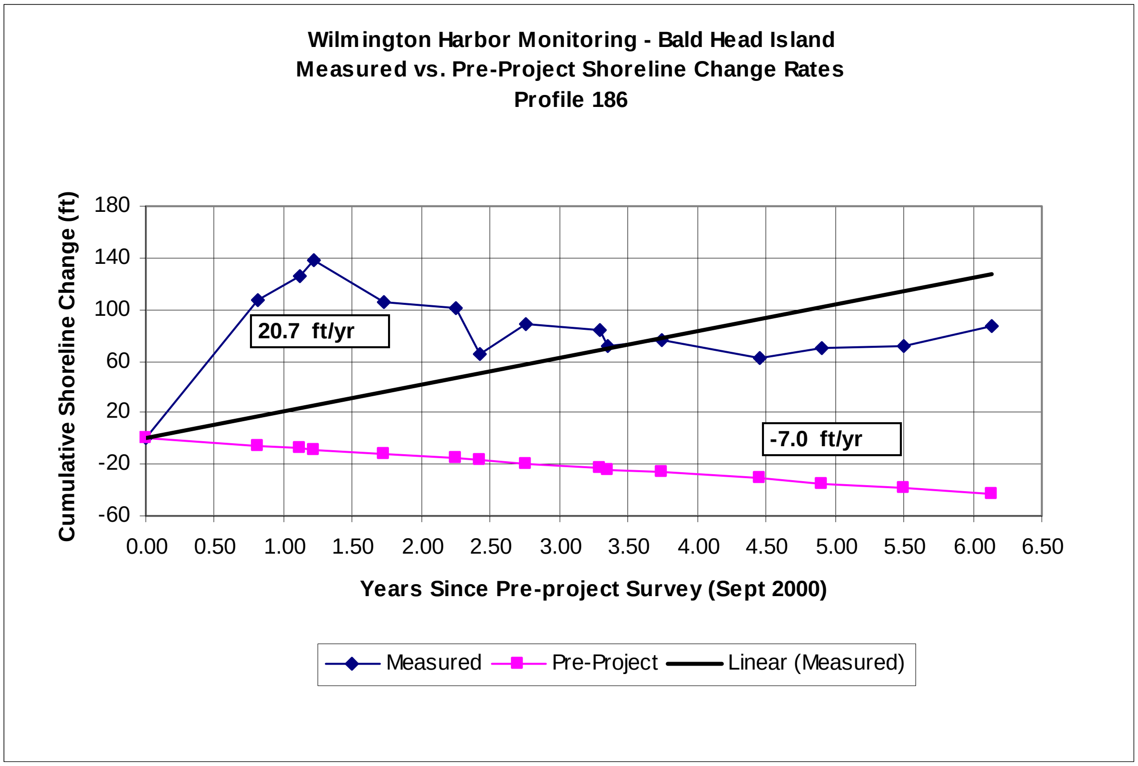

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 174
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
22.7 ft/yr
-5.9 ft/yr
Measured
Pre-Project
Linear (Measured)

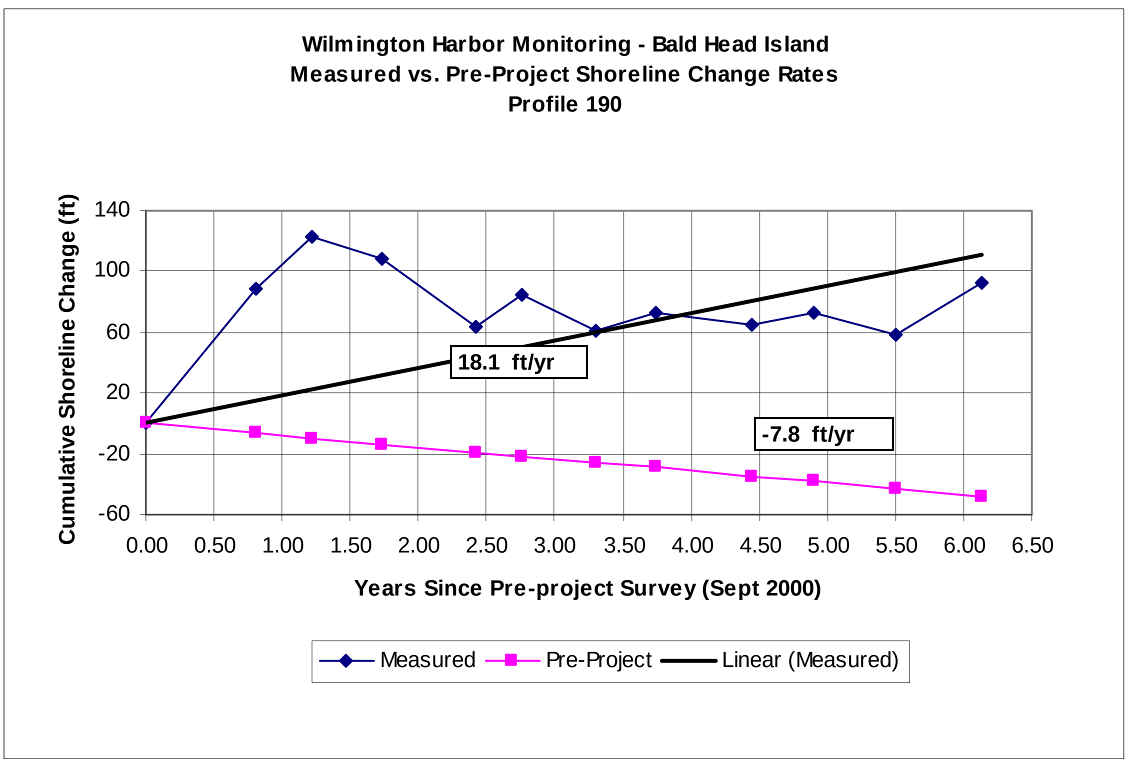


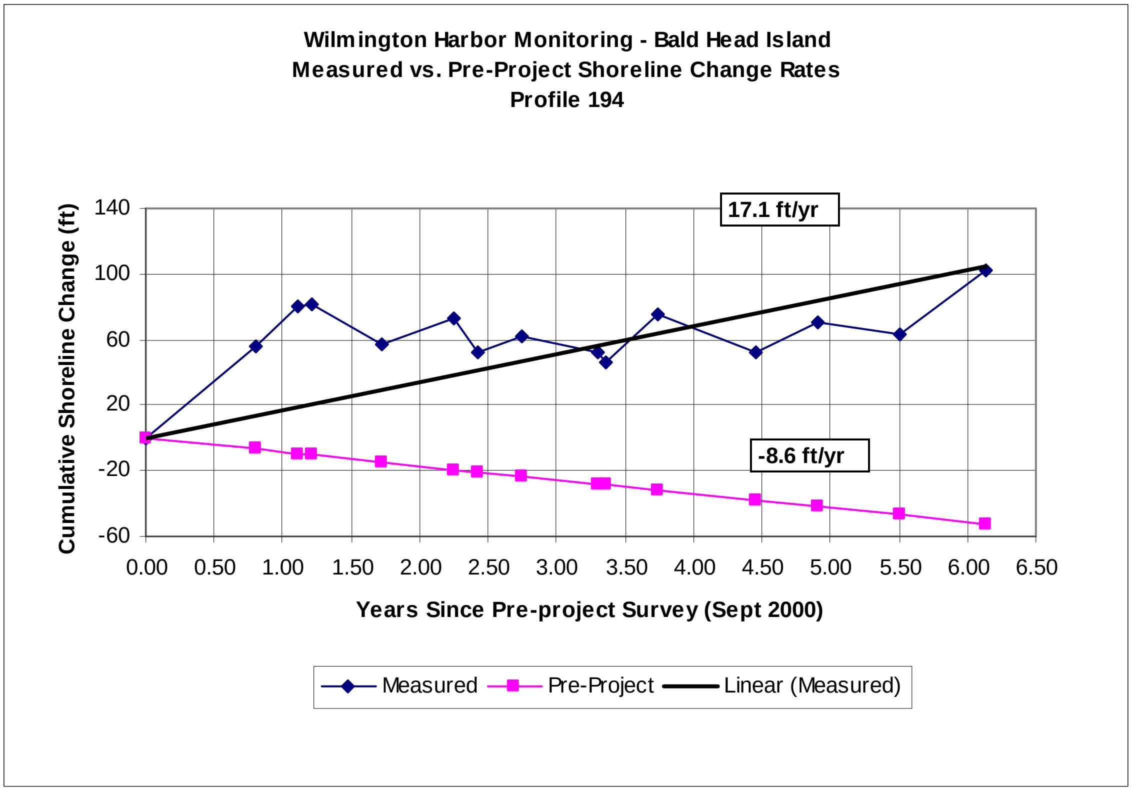
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 178
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
30.1 ft/yr
-6.2 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)

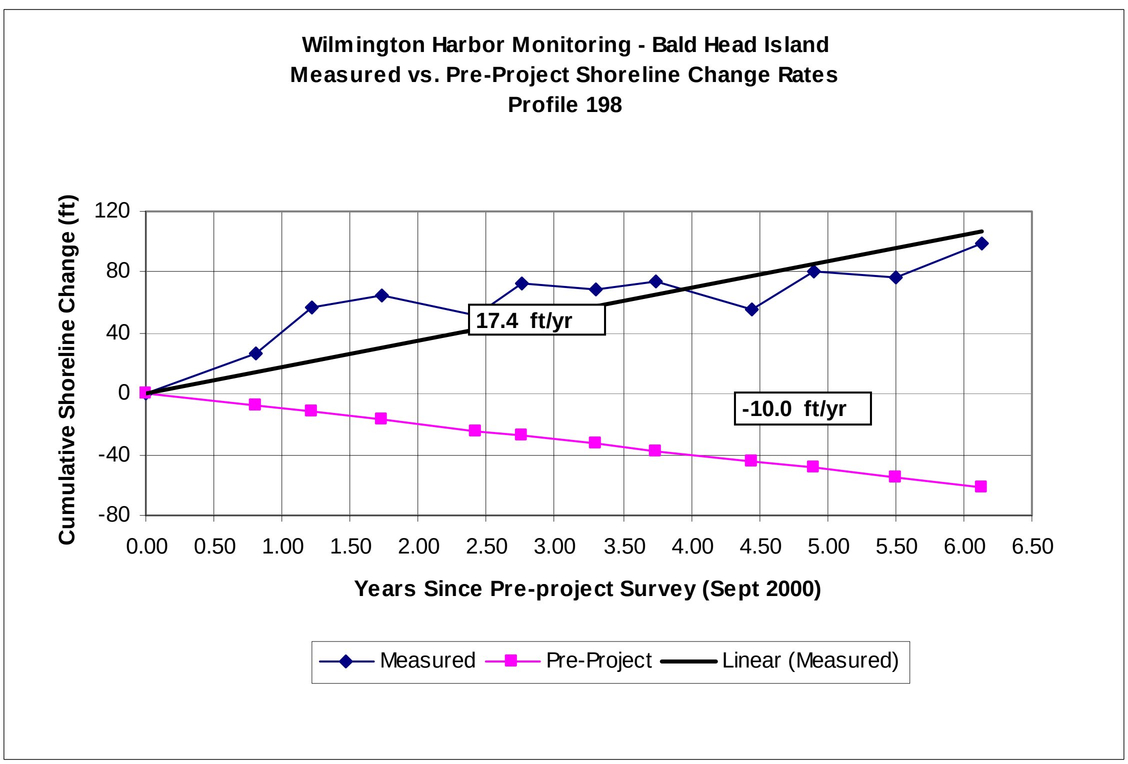


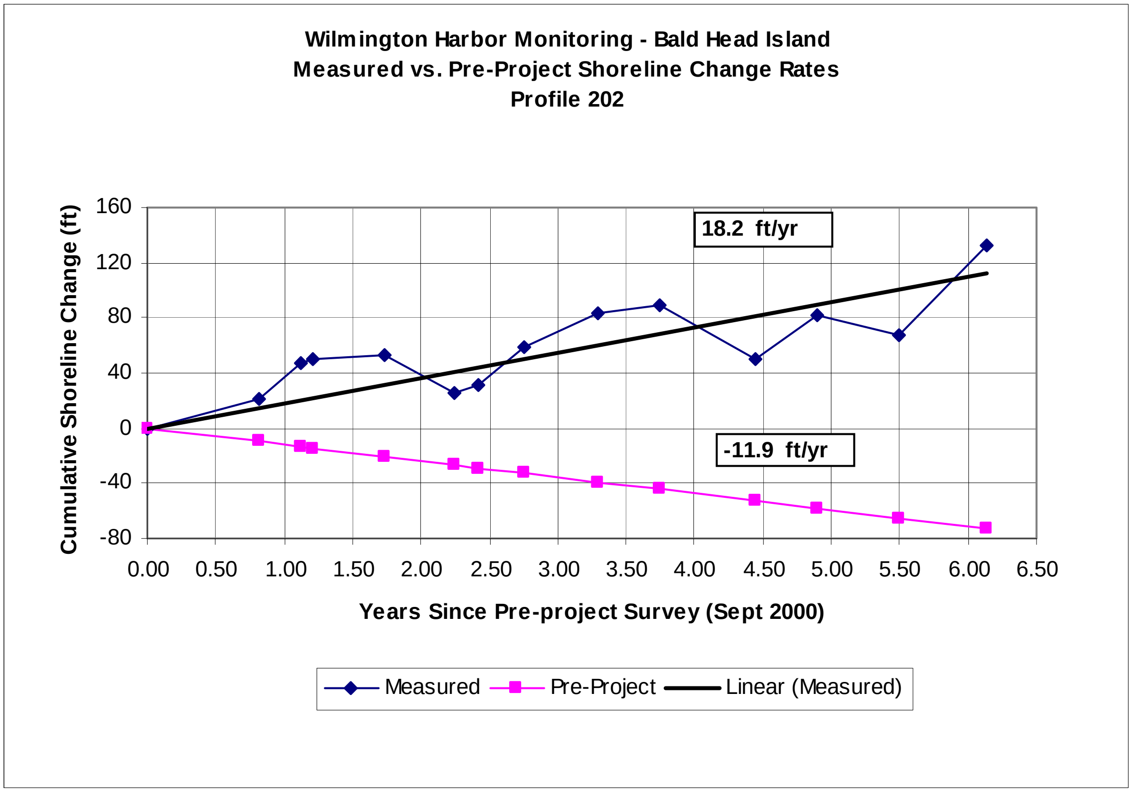
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 182
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
22.2 ft/yr
-6.5 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)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

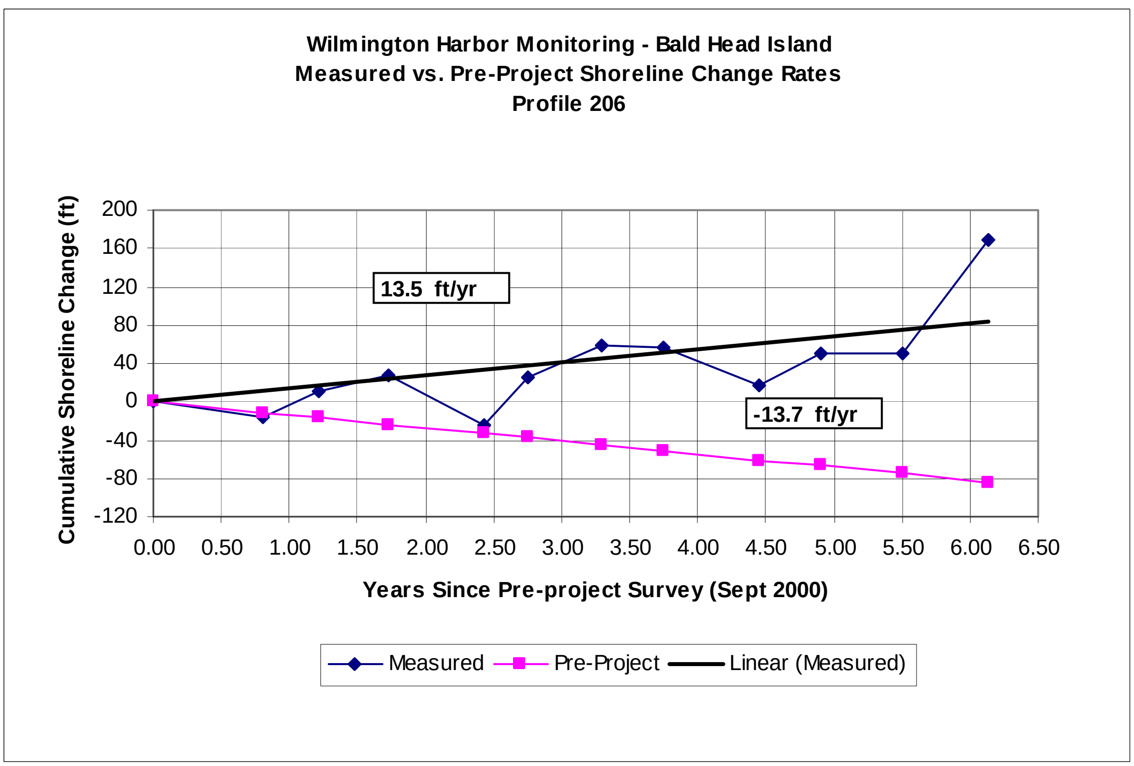

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 186
Cumulative Shoreline Change (ft)
180
140
100
60
20
-20
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
20.7 ft/yr
-7.0 ft/yr
Years Since Pre-project Survey (Sept 2000)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

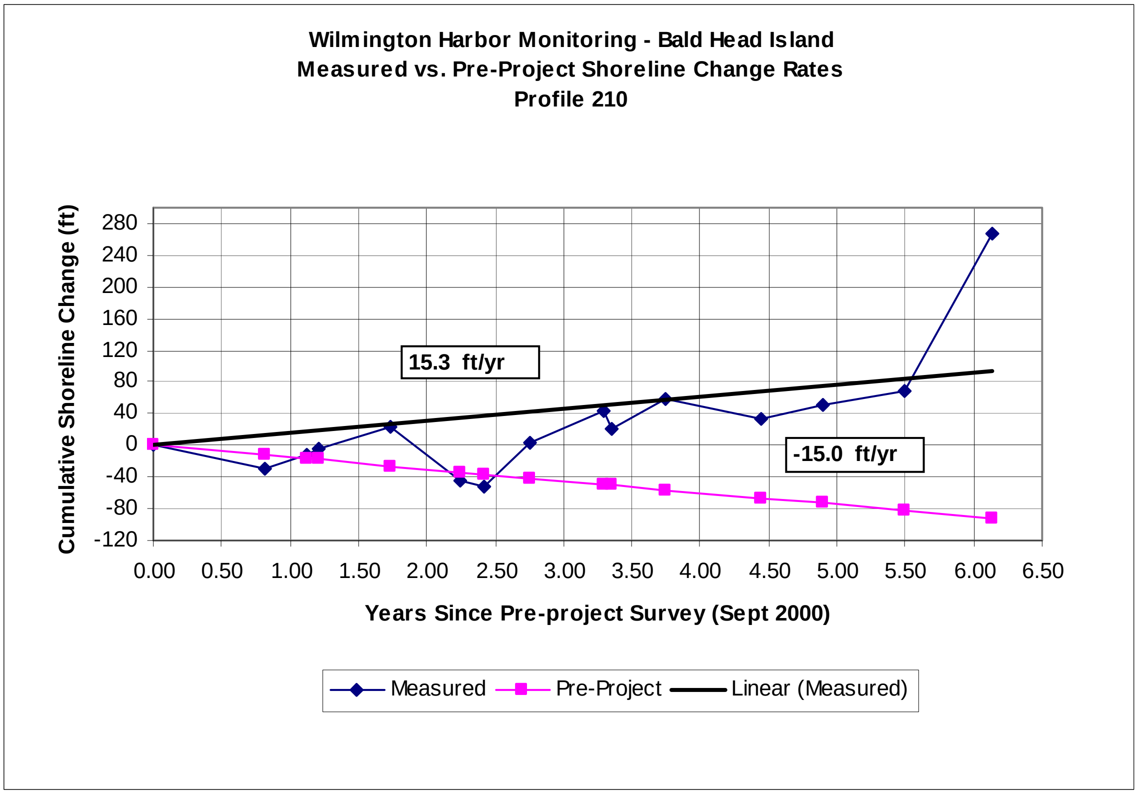

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
140
100
60
20
-20
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
18.1 ft/yr
-7.8 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured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


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

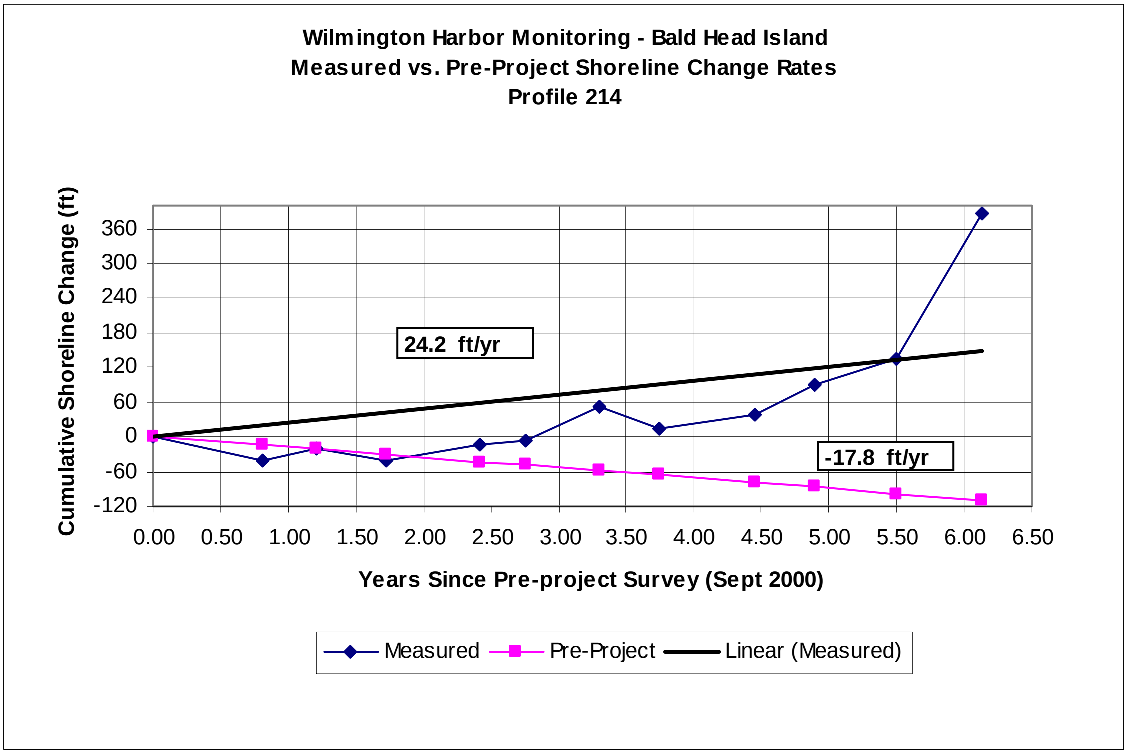

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 198
17.4 ft/yr
-10.0 ft/yr
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Years Since Pre-project Survey (Sept 2000)
Measured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


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

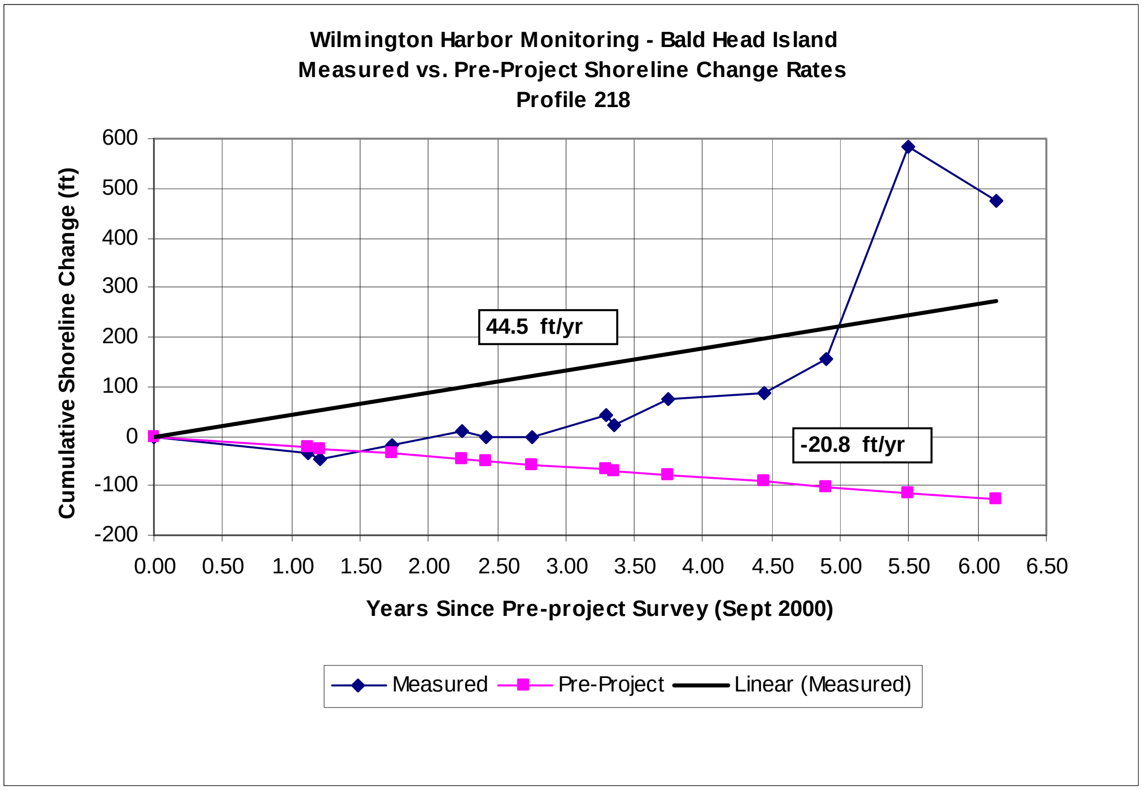

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 206
13.5 ft/yr
-13.7 ft/yr
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
-120
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-Project
Linear (Measured)



Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
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
Years Since Pre-project Survey (Sept 2000)
15.3 ft/yr
-15.0 ft/yr
Measured
Pre-Project
Linear (Measured)



Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 214
Cumulative Shoreline Change (ft)
360
300
240
180
120
60
0
-60
-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
Years Since Pre-project Survey (Sept 2000)
24.2 ft/yr
-17.8 ft/yr
Measured
Pre-Project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 218
Cumulative Shoreline Change (ft)
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
Years Since Pre-project Survey (Sept 2000)
44.5 ft/yr
-20.8 ft/yr
Measured
Pre-Project
Linear (Measured)