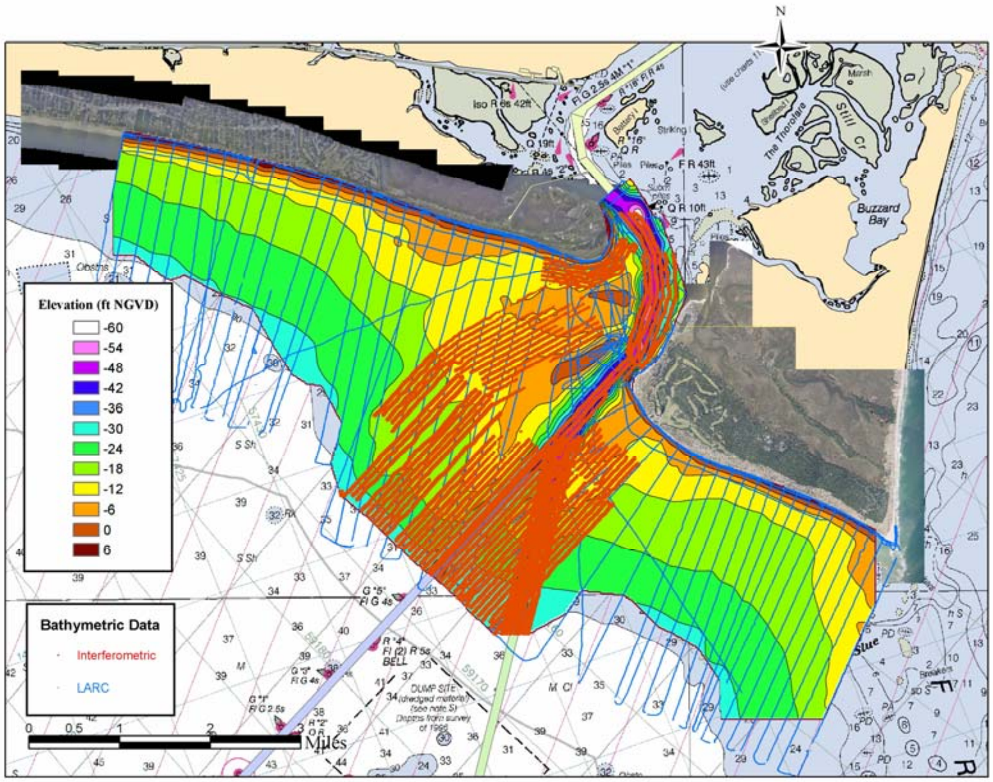
US Army Corps of Engineers®
Wilmington District

PHYSICAL MONITORING WILMINGTON HARBOR NAVIGATION PROJECT REPORT 3: June 2004 – August 2005



MAY 2006

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 3:
June 2004 – August 2005

MAY 2006

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. 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 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.

This comprehensive 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 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 third in a series and serves to update the monitoring program with data collected between June 2004 and August 2005. The initial report published in July 2004 covered the period of August 2000 (pre-construction survey) through June 2003. The second report covered the period of June 2003 to June 2004. 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 and are scheduled to coincide with the spring (April-May) and fall (October-November) seasons. Bathymetric surveys 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 collected annually with the Engineering Research and Development Center's LARC (Lighter Amphibious Re-supply Cargo) 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 June 2004 to August 2005 have included: two complete beach profile surveys (February 2005 and August 2005), one ebb shoal survey (March 2005), one entrance channel current measurement (March 2005), 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 serve provide further explanation of the results to date:

- Oak Island/Caswell Beach remains stable. Shoreline advanced an average of 0.8 feet over the last year and is on the average 98 feet more seaward that it was at the start of the project five years ago
- Most of the initial beach disposal material remains along Oak Island/Caswell Beach with more than 1 million cubic yards still present above then pre-project condition
- Bald Head Island experienced overall shoreline gains over the last year due largely to the placement of beach fill along South Beach. A similar pattern is also evident when comparisons are made over the 5-year monitoring period. Significant accretion is

evident along most of South Beach, however, an area of shoreline recession is present along the south-western corner of the island.

- Erosion zone along South Beach has lost approximately 168,000 cy compared to the pre-project condition, however Bald Head Island has shown an overall net gain of 864,000 cy
- Comparing long-term shoreline change rates with those of the 5-year monitoring period show Oak Island with present high rates of accretion versus historic minor erosion
- Comparing long-term shoreline change rates with those of the 5-year monitoring period show Bald Head Island is presently eroding less overall. However, the post-construction rates are higher along the western 2,400 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
- Village of Bald Head and the Wilmington District have entered in a legal settlement agreement which includes bi-monthly channel surveys. Results indicate a present minimum navigable width of 540 feet versus a threshold value of 500 feet.
- Rate of spit growth into Baldhead Shoal Channel has decreased following the 2005 dredging versus the 2001-02 dredging
- Lack of noticeable overall change in ebb and nearshore bathymetry except deepening of flood margin channel along tip of Oak Island/Caswell Beach, some minor erosion at the juncture of the old and new channel alignment, and a thin area of shoaling along the offshore end of Jay Bird Shoals
- Similar overall flow regimes with current measurements taken before and after project channel dredging, except for consistently higher peak velocities measured with the after condition
- Sustained high current flows through the old abandoned channel since opening of the new channel

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 2 (June 2004) 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 June 2004 to August 2005) and for the entire period from August/September 2000 to August 2005.

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 positive. When considering all profile lines, a minor average gain of 0.8 feet has been measured since June 2004. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –50 to +50 feet), the average alongshore trend is slightly erosional at –0.7 feet 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 (except for Profile 95 that was eroding slightly with the August 2005 survey). 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 95 feet more seaward in February 2005 than it was in 2000. Likewise, the shoreline position was 98 feet more seaward in August 2005, than it was five years ago at the start of the project.

In terms of net volume change, a general stability has been observed along Oak Island/Caswell Beach over the current period. When considering all profile lines, a net gain of 207,500 cubic yards was computed since the last report, between January 2004 and August 2005. This stable trend observed over the current period is typical of that measured for the entire 5-year monitoring period. As such, only minor (but positive) changes have occurred following initial fill placement in 2001 associated with the project dredging. Specifically, by the end of the period, an excess of 1,492,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity reflects a net gain above the fill volume placed in 2001. Most of this gain 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 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 accretionary or stable over the last year with the exception of West Beach and in the vicinity of the spit (at the southwestern tip of the island). The largest zone of accretion occurred between Profiles 46 and 142, reflecting the positive impact of the January 2005 beach fill. Over this 9,600 foot reach, the beach is up to 275 feet wider, with an alongshore average increase of 152 feet. Extending east of this fill area (between Profiles 146 and 220), the beach is found to be generally stable, with the shoreline being slightly seaward of its position a year ago, by an average of 3 feet. In contrast to the stable nature found along South Beach, the area along West Beach and in the vicinity of the spit near the southwest corner of the island display eroded shorelines. For West Beach (Profiles 0 thru 28), the shoreline has receded an average of 14 feet since June 2004. For the vicinity of the spit (between Profiles 32 & 43), the shoreline has shown a large degree of variability, gaining as much as 155 feet and losing more than 80 feet. Overall, the alongshore average shoreline changes measured over the entire monitoring area were a gain of 52 feet and 64 feet for the February 2005 and August 2005 surveys, respectively.

A similar pattern of shoreline change was measured over the last 5-year period, since the monitoring was initiated, i.e., some erosion along West Beach, the highly variable changes in the vicinity of the spit, and significant accretion along the entire South Beach area. The accretional area covers most of South Beach beginning just east of the spit at Profile 53. The largest positive shoreline changes are reflected within the January 2005 fill zone, extending to about Profile 140. Within this fill area, the shoreline is an average of 109 feet seaward of its September 2000 position. Even beyond the fill area, the shoreline change remains positive, ranging between 50 and 100 feet more seaward at this time. Other large accretions are evident within the spit area along the southwest tip of the island. Here shoreline advances of more than 200 feet are indicated (Profile 36), but even greater recessions are seen proceeding area around the tip with a maximum negative shoreline change of –240 feet recorded at Profile 43. For West Beach, the shoreline changes have been both positive and negative, with the average along this reach being a loss of 19 feet since the start of the monitoring. When considering all locations along Bald Head Island, the shoreline is presently on the average 68 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey of Report 2 (June 2004) to August 2005, Bald Head Island experienced both gains and losses. The gains are the result of the positive impact of the beach placement within the western half of South Beach (Profiles 53 to 130). In contrast, losses are evident on either side of the fill area. These erosional areas extend eastward throughout the remaining portions of south beach to the cape and westward into the area of the spit. The spit area also has a smaller in-filled area around the corner of the island along the margin of the channel. In terms of overall volumetric change, the positive area of the fill is significantly larger in magnitude that the adjacent negative areas. Specifically, the net gain between June 2004 and August 2005 was 273,000 cubic yards.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, most of Bald Head Island has shown a gain except for two areas. One is located at the extreme eastern end of south beach, where relatively large losses have occurred near the cape. The other, which is of more concern, is at the western end of south beach between Profiles 45 and 61. This 1,600-foot reach has been the site of chronic erosion in the past and has a volumetric deficit of about 168,000 cubic yards. Aside from these two areas, all other profile volume changes are positive throughout the remaining areas. 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 447,000 cubic yard gain in February 2005 and 864,000 cubic yard gain by August 2005, even including the volume losses experienced near the cape.

Rates of shoreline change were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the NCDCM shoreline data based on a 62-year period of record. Although the monitoring period spans a relatively shorter time period of about 5 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 5-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. Overall, the shoreline change rate averaged over the entire monitoring area was about +30 feet per year for the 5-year period. By comparison the long-term rate over the entire reach was –1.1 feet per year.

For Bald Head Island, the comparison of the pre- and post-construction rates show that most of island is eroding less over the initial 5-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 of this zone has decreased with rates computed through the present period. A direct comparison of the pre- and post-construction shoreline change rates show that only 4 profile lines are eroding at a higher rate during the post-construction period. These 4 lines located at the western end of South Beach (Profiles 53 thru 66) span a reach of about 2,400 feet. Over this reach, the average rate is -13.8 feet per year versus a comparable long-term rate of about -5 feet per year. Outside of this problem area, 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 placed beach fill and possibly to the positive effect of the rehabilitated groin field which was accomplished by the Village in conjunction with the 2005 beach disposal operation. Specifically, the rates computed for the most recent period are an average of +23 feet per year over the remaining portions of South Beach. Historically, this same area would have eroded about 6 feet per year.

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 spit migration 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 ft MLW elevation. To date nine condition surveys have been accomplished and reveal that 10 feet or more of 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. Presently the narrowest channel width recorded is 540 feet, at Baldhead Shoal Channel station 21+00 Reach 1, located in the immediate vicinity of the spit.

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. The comparison showed that to date 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. 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.

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 overall morphology of the ebb and nearshore shoals has been largely static over the initial monitoring period which suggests there have not been substantial changes in sediment transport pathways around the ebb tidal delta since the initial pre-construction 2000 survey. However, one observed change was deepening of the flood margin channel along the tip of Oak Island. A companion flood margin channel, of comparable magnitude, is not present through Bald Head Shoal on the opposite side of the entrance channel. Another area of interest is the shoal located between the old and new channels just seaward of their intersection. This portion of the shoal remained generally stable until this year. With the latest ebb shoal survey, this area has begun to erode. The area is located where the largest peak ebb currents have been measured around the distal end of the ebb tidal delta. Finally, a thin but broad area of accretion has developed along the offshore portions of Jay Bird Shoals.

To date currents have been measured on five occasions, with the initial occurring before the channel improvements and the remaining four 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.

The current measurements were used to calculate the tidal prism, i.e. the total flow volume passing through the inlet over the tidal period. 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.

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 have 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 local government with the intent of reducing the erosion of the in-place fill. The next maintenance cycle is scheduled for November 2006 (funds permitting) and is likewise to be placed on Bald Head 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 coordinated with local interests.

Future Monitoring Efforts.

The initial efforts of the monitoring program have developed a fundamental understanding of the existing coastal processes and short-term bathymetry and shoreline variability. The extensive data collection program has provided the data needed to develop calibrated wave transformation and hydrodynamic models. A gradual shift will be made over the six-year operational plan from field data collection efforts toward use of these modeling tools. The tools will be used to help quantify magnitudes and patterns of sediment transport and develop a detailed sediment budget for the area. This working suite of coastal engineering tools will provide assessment of future beach and inlet management actions and provide input to the sand management plan.

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 3

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT

REPORT 3

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 third in a series of monitoring reports that focuses on the navigation improvements in the immediate vicinity of the Cape Fear ocean entrance channel. Monitoring Reports 1 and 2 were published in August 2004 and February 2005, respectively and covered the first four years of monitoring (USACE 2004 and USACE 2005). 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

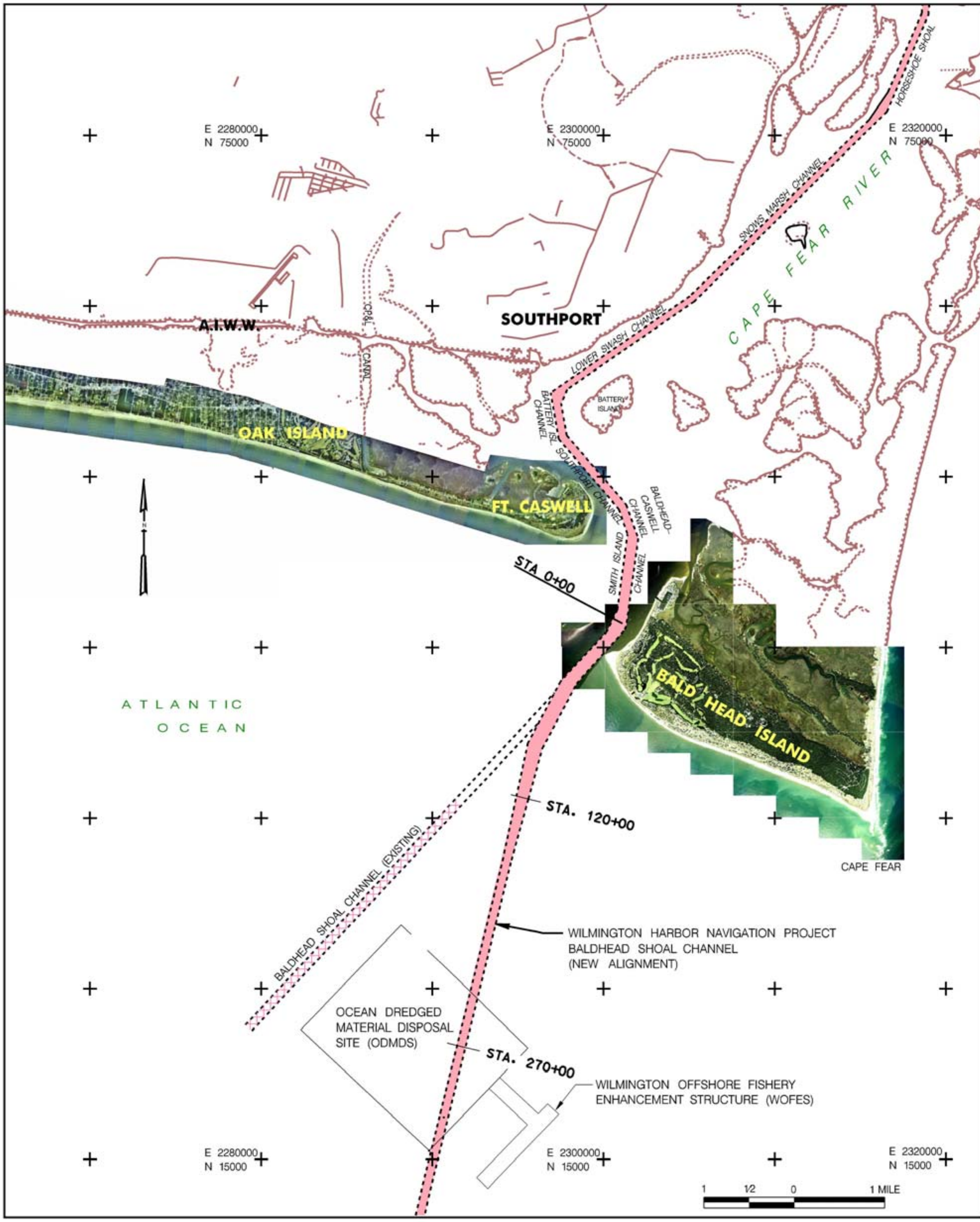


Figure 1.1 Project Location Map

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.

<u>Construction Activity.</u> 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.

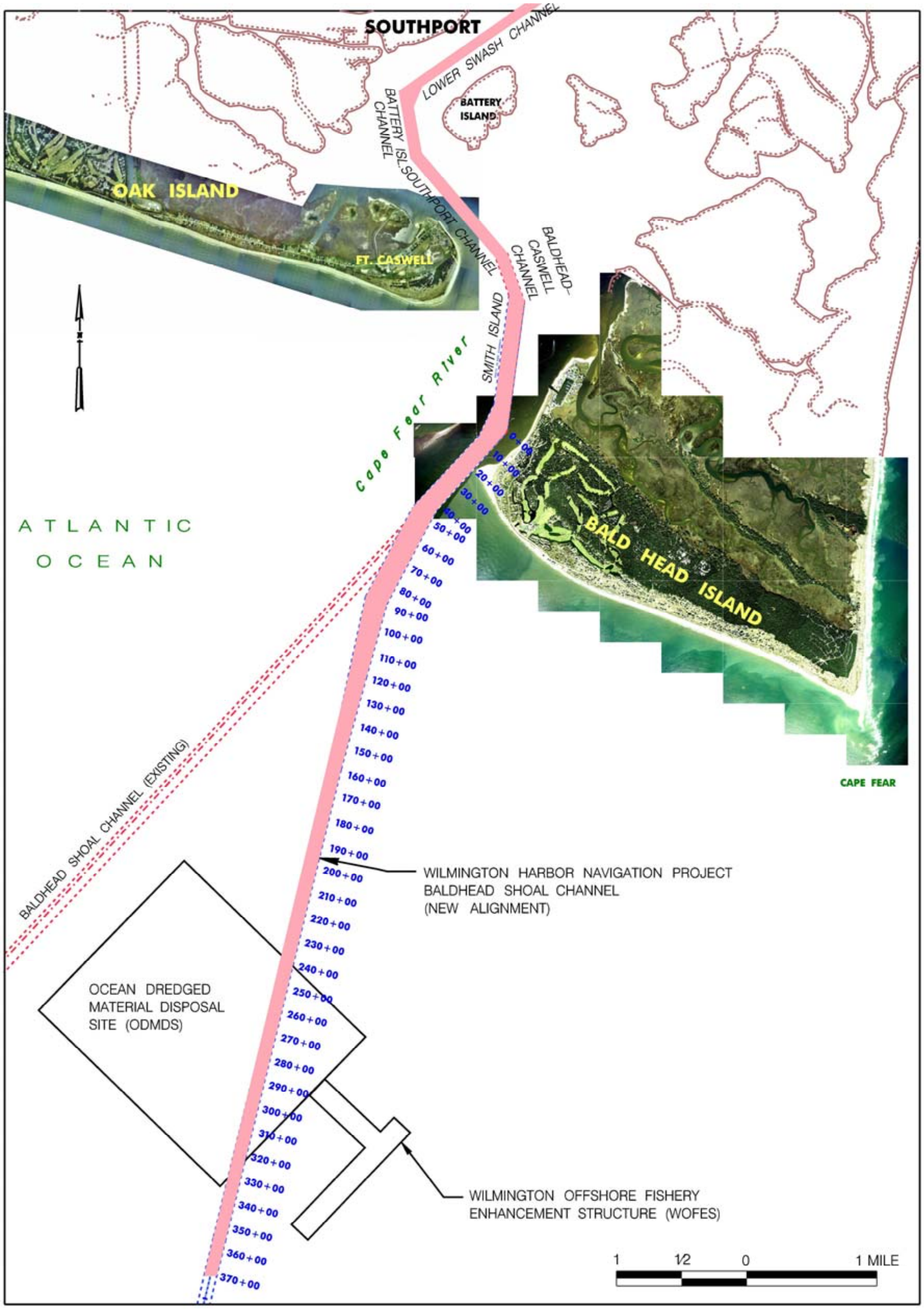


Figure 1.2 Realignment of the Federal Navigation Channel at the Cape Fear River Entrance

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		

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.

<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 offshore 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. The remaining monitoring tasks, specifically the onshore beach surveys and aerial photography, are obtained by the Wilmington District through the use of private companies. The onshore beach profiles have been surveyed by McKim & Creed Engineering; 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 ft along the inlet shoulder and 2,500 ft along the ocean-front) plus 26,000 ft 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 from the inlet entrance.

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

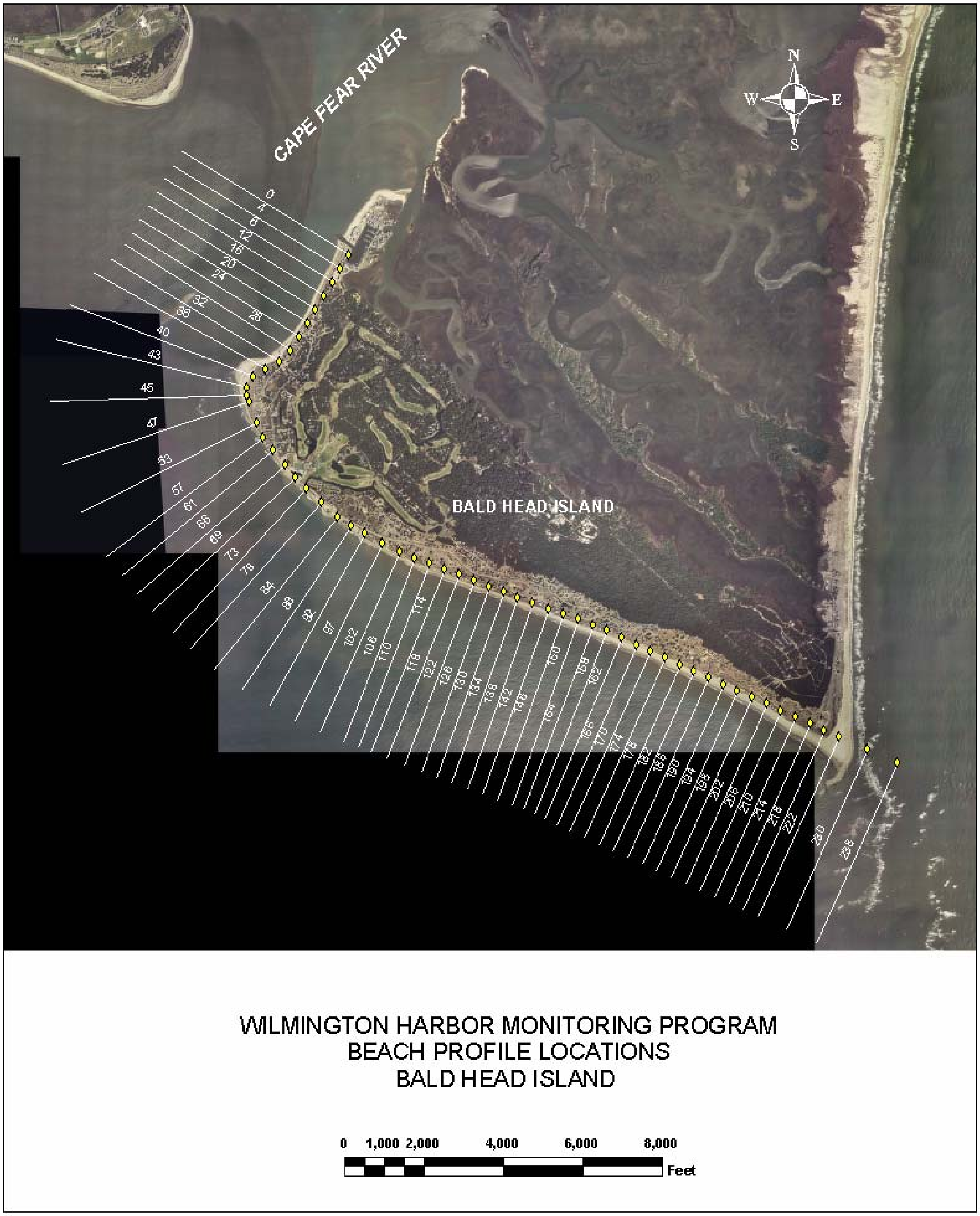


Figure 1.3 Bald Head Island Beach Profile Locations

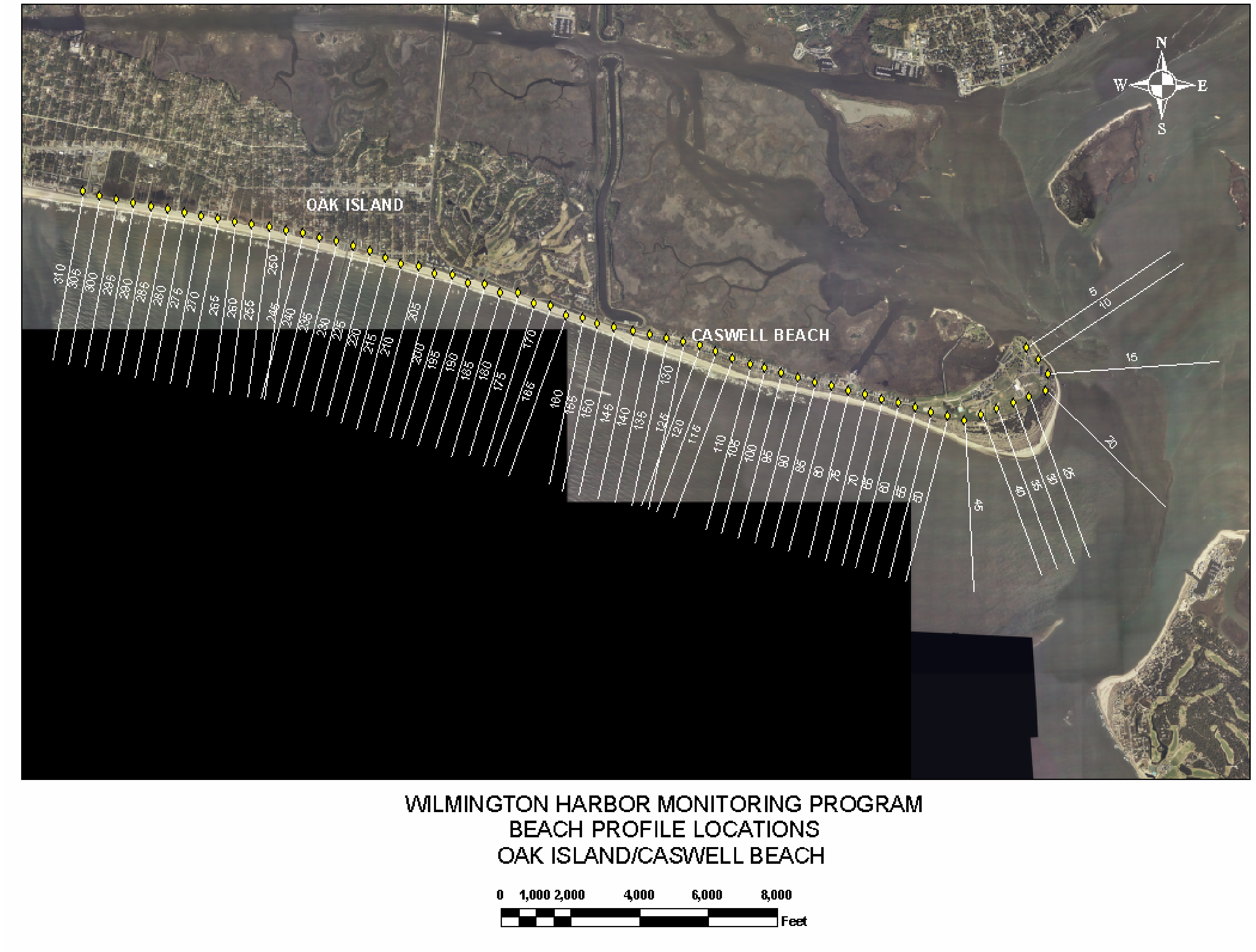


Figure 1.4 Oak Island/Caswell Beach Profile Locations

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

Figure 1.5 FRF Hydro-LARC Survey System

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

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

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

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

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

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

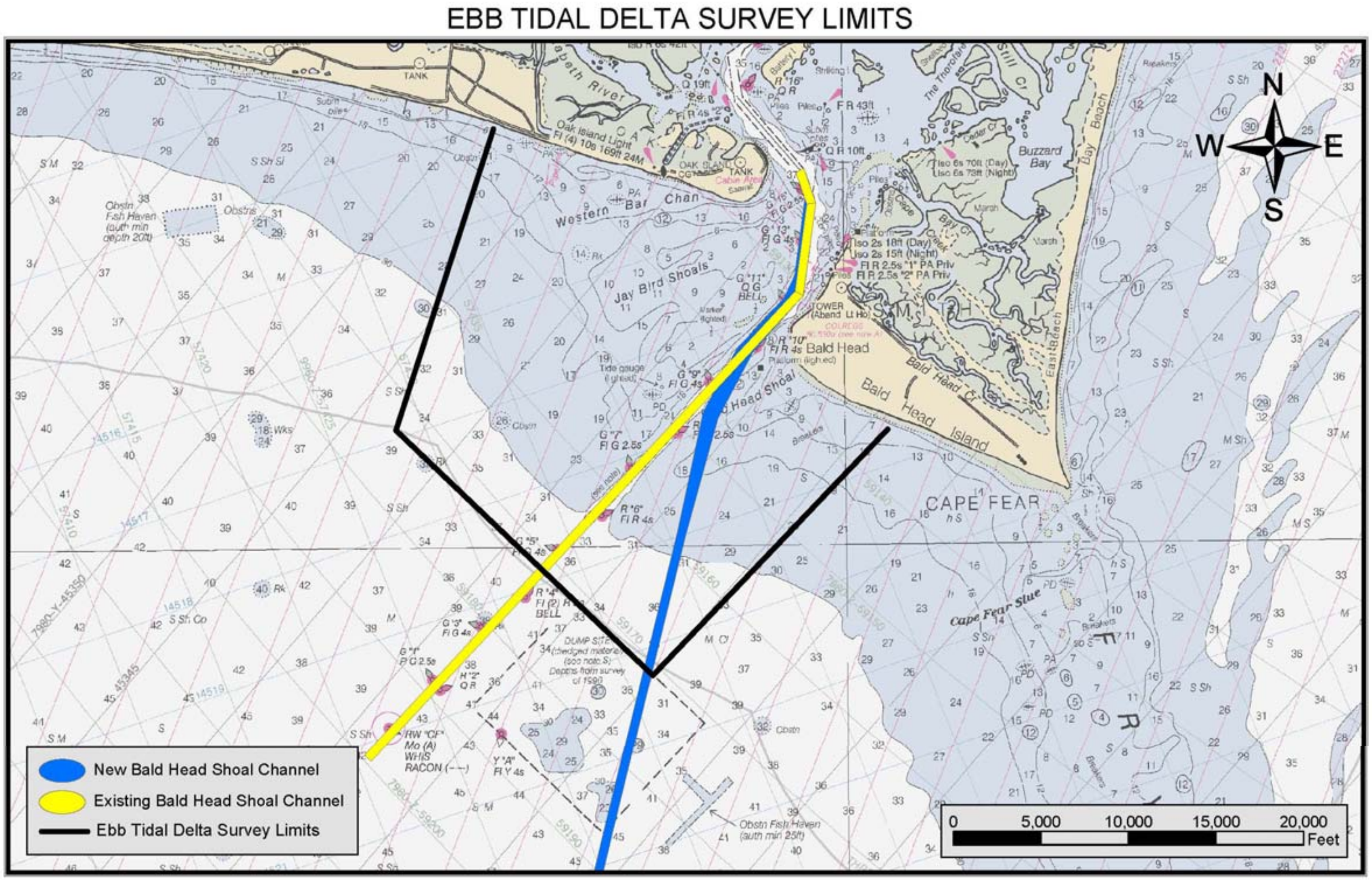


Figure 1.6 Entrance Channel and Ebb Tide Delta Survey Coverage

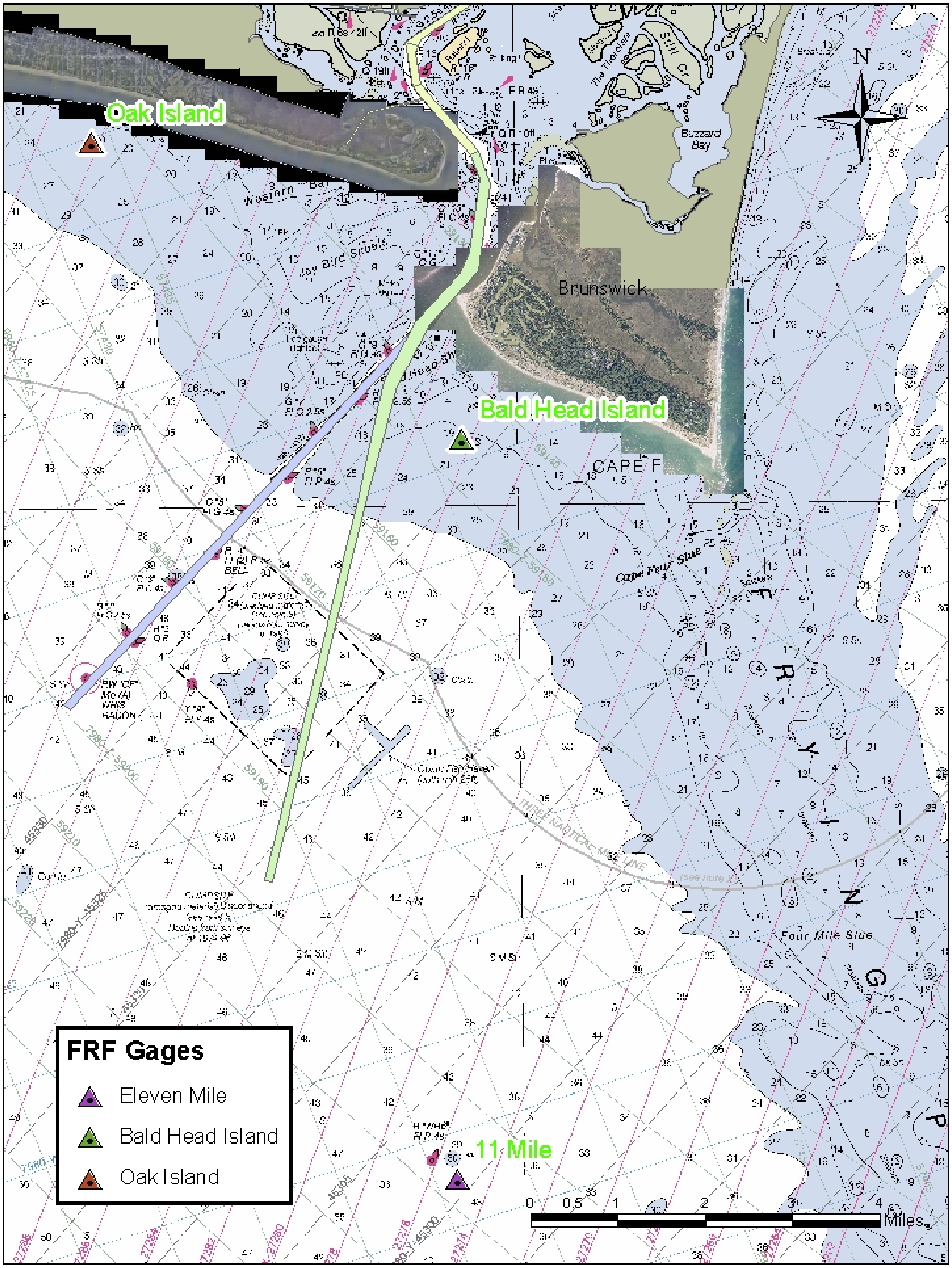


Figure 1.7 Wave and Current Gauge Locations

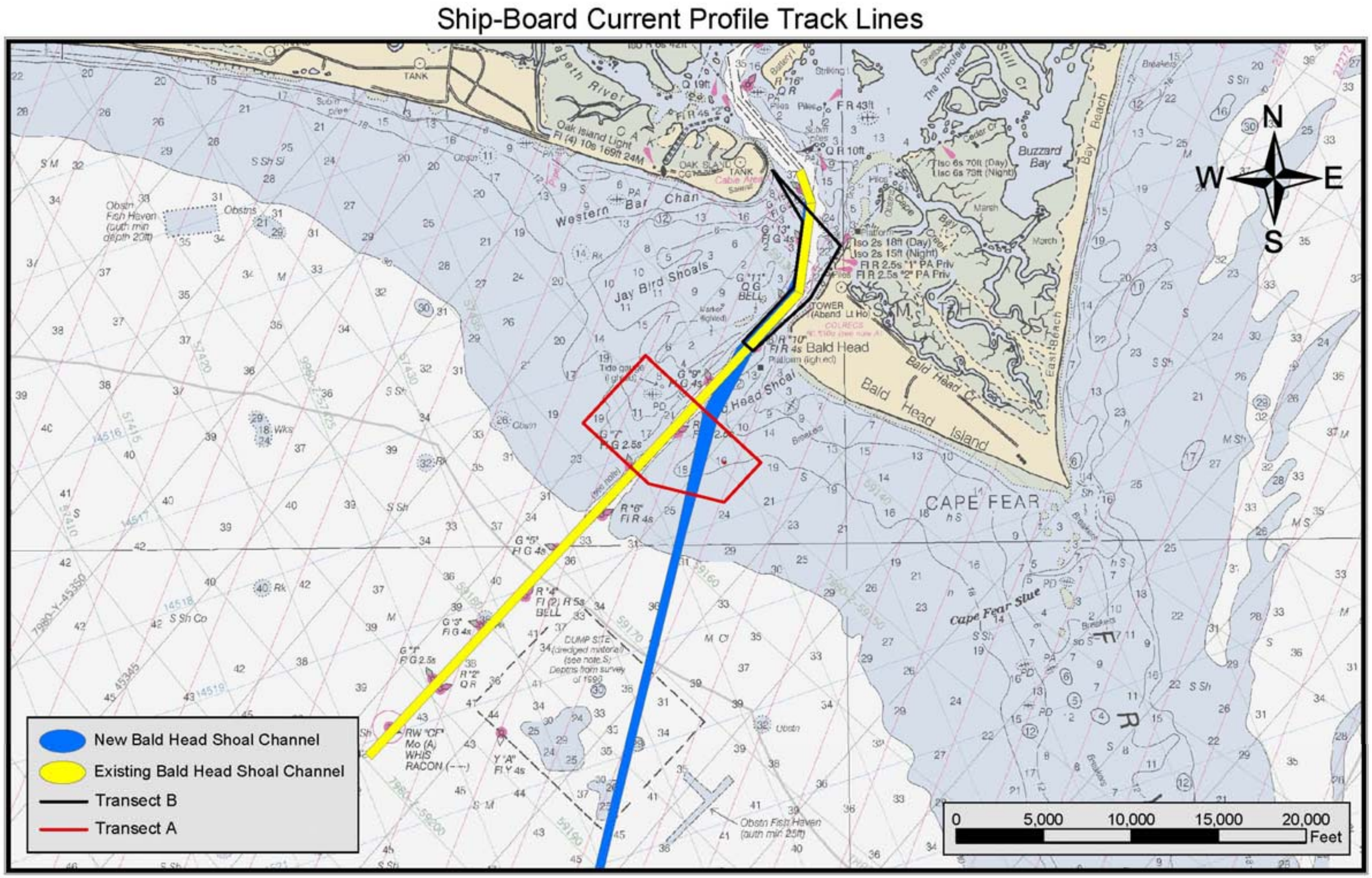


Figure 1.8 Shipboard Current Profile Locations

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

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

Bald Head Island Monitoring Survey Program.

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

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

Activities to Date. Figure 1.9 gives a time line activity chart that summarizes all tasks undertaken to date associated with the physical monitoring program. Data collection for the Wilmington Harbor monitoring program began in August 2000 prior to the dredging of the entrance channel. This report covers the monitoring activity through the August 2005 beach survey and therefore spans an initial period of five years. Table 1.3 lists the monitoring surveys to date. Since the initiation of the program there have been nine onshore beach profile surveys (Aug-Sep 2000, Nov-Dec2001, June 2002, Jan-Feb 2003, June 2003, Dec 2003-Jan 2004, June 2004, Feb 2005 and Aug 2005), seven offshore beach profile surveys (Aug 2000, Oct-Nov-2001, Nov-Dec 2002, Jan 2004, June 2004, Feb 2005 and Aug 2005) and five surveys of the ebb tide delta (Aug-Sep 2000, Dec-Jan 2002, Jan 2003, Jan 2004 and Mar 2005). The June 2004 offshore beach profile survey was undertaken in preparation of the recent maintenance dredging/beach disposal activity and as such only provided coverage along Bald Head Island. 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	

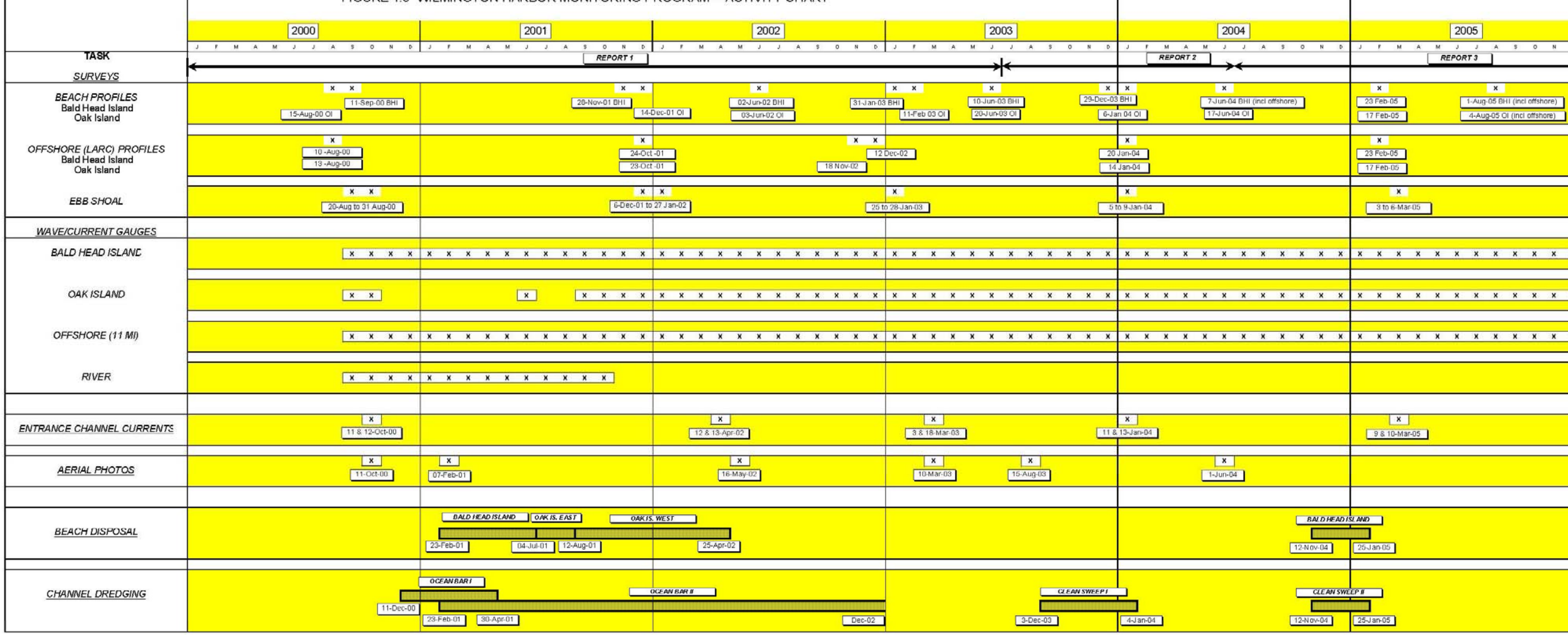
1/ Bald Head Only

With respect to the wave/current meters, all four instruments were initially deployed in September 2000. The Bald Head gauge and the offshore 11-mile gauge have generally been in continuous operation throughout the initial monitoring period except for servicing and occasional data outage. The Oak Island gauge was damaged in October 2000 by a trawler about one month after deployment. The gauge remained inoperative until September 2001. 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 four occasions. These data were collected in October 2000 with the initial data collection effort and in April 2002, March 2003 and January 2004. Additionally, aerial photographs were taken on the following six occasions: October 11, 2000, February 7, 2001, May 16, 2002, March 10, 2003, August 15, 2003 and June 1, 2004.

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.

FIGURE 1.9 WILMINGTON HARBOR MONITORING PROGRAM -- ACTIVITY CHART



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.

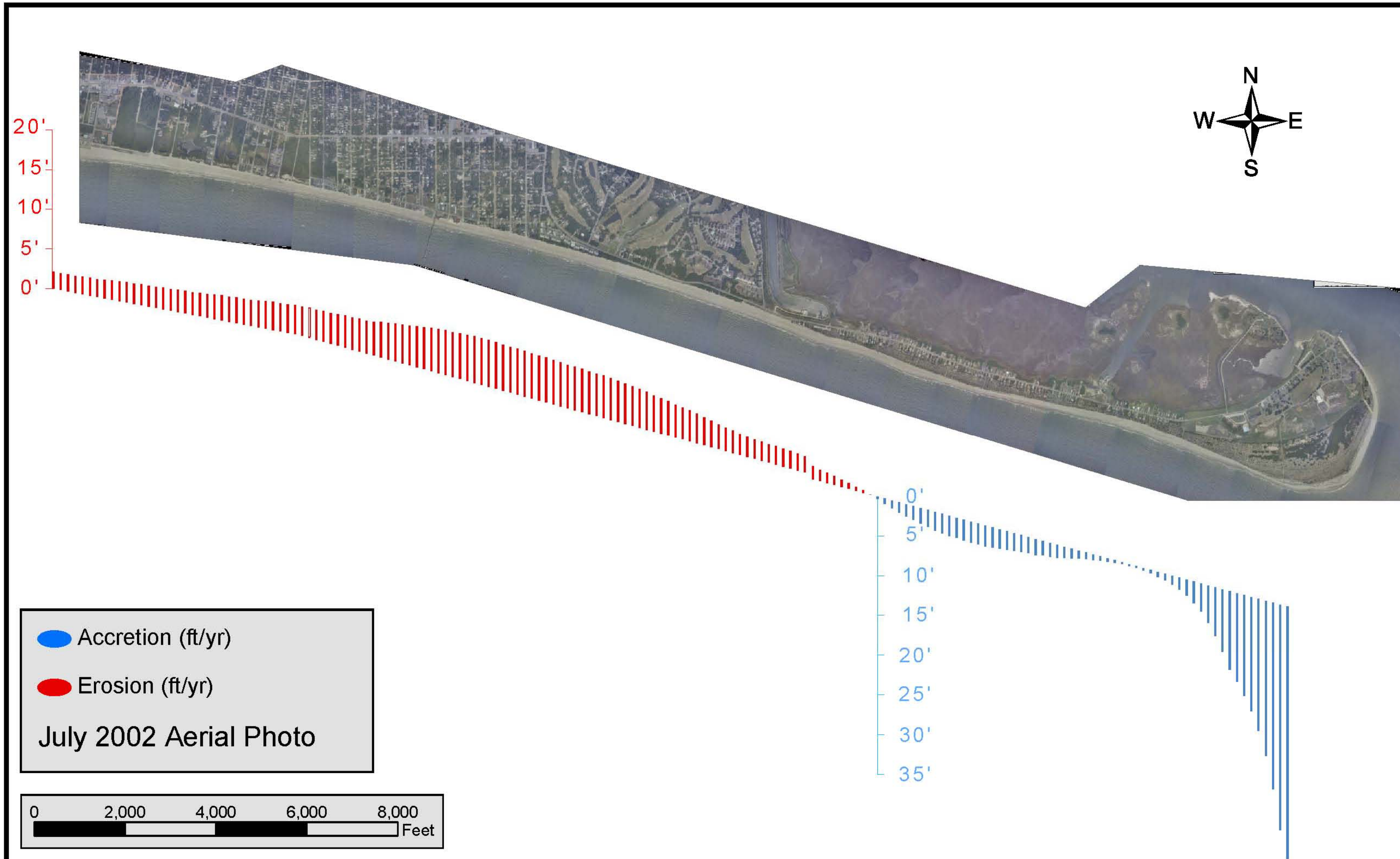


Figure 2.1 Long-Term Average Annual Shoreline Change Rates (1938-2000) Oak Island/Caswell Beach

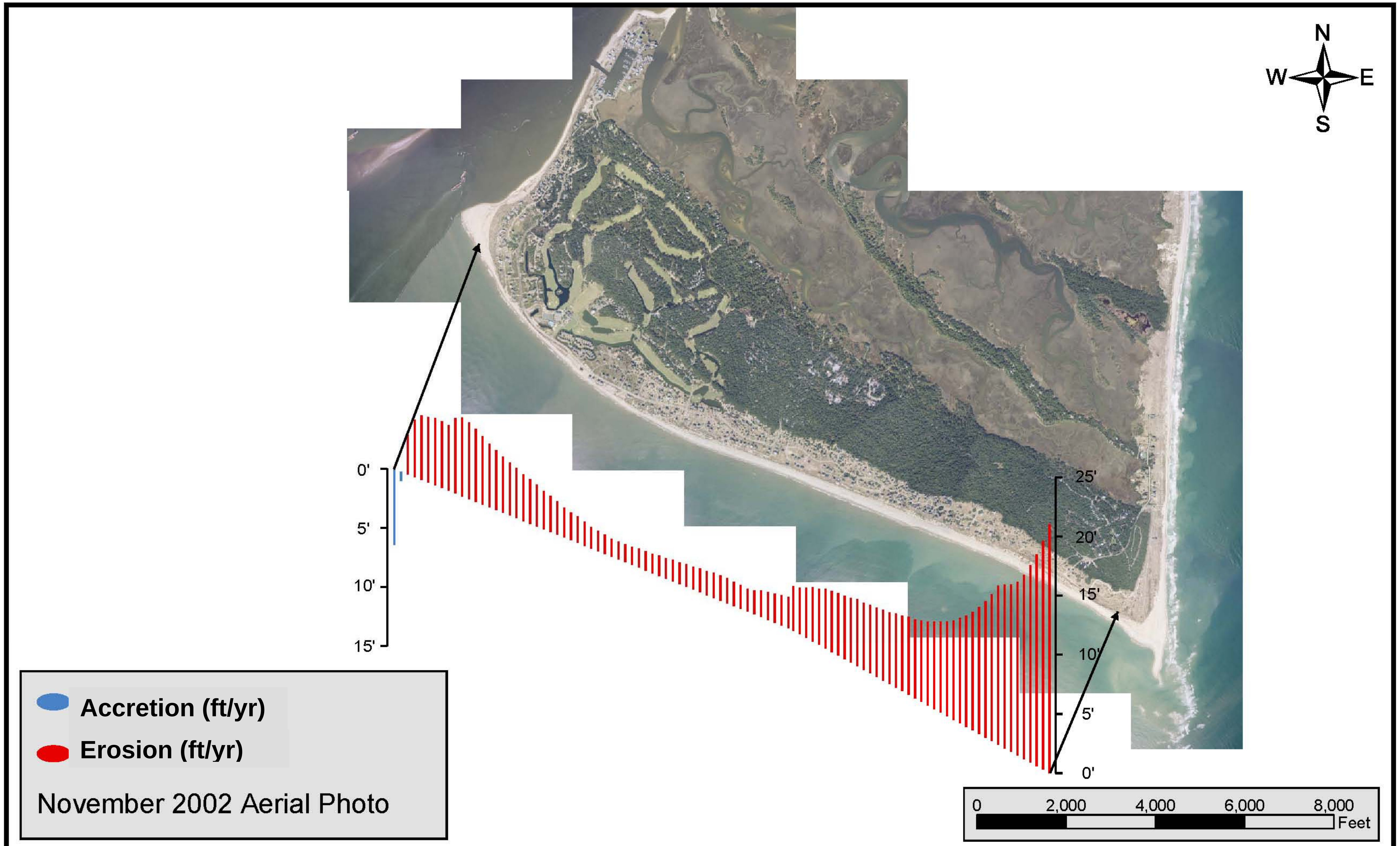


Figure 2.2 Long-Term Average Annual Shoreline Change Rates (1938-2000) Bald Head Island

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 recent (2005) placement of about 1.2 million 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. 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. A plan view of the reconstructed groin field, as reproduced from the Bald Head Island Monitoring Program Report 3, (Olsen 2005) is shown in Figure 2.4.

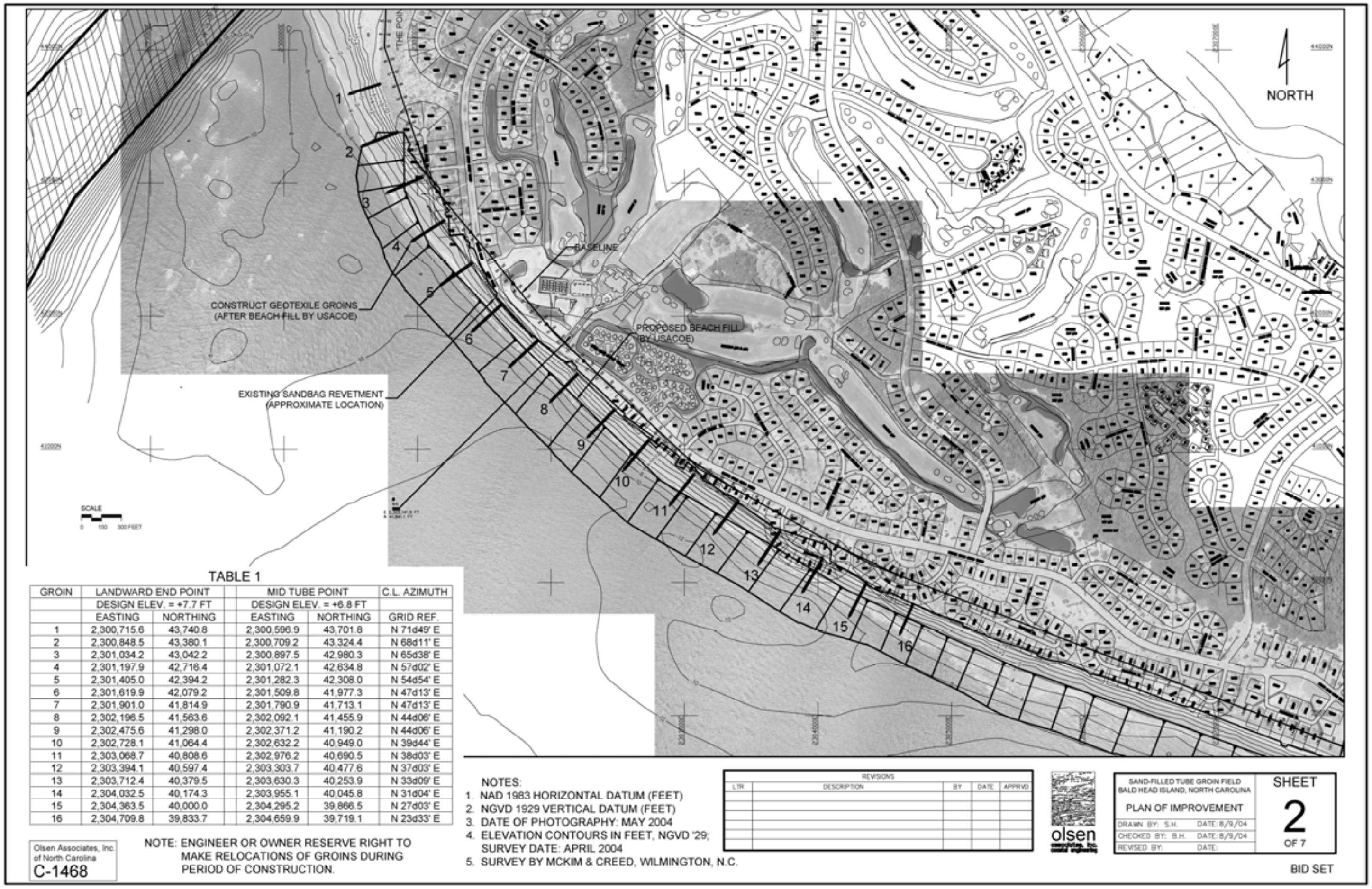


TABLE 1

GROIN	LANDWARD END POINT		MID TUBE POINT		C.L. AZIMUTH
	DESIGN ELEV. = +7.7 FT		DESIGN ELEV. = +6.8 FT		
	EASTING	NORTHING	EASTING	NORTHING	GRID REF.
1	2,300,715.6	43,740.8	2,300,596.9	43,701.8	N 71d49' E
2	2,300,848.5	43,380.1	2,300,709.2	43,324.4	N 68d11' E
3	2,301,034.2	43,042.2	2,300,897.5	42,980.3	N 65d38' E
4	2,301,197.9	42,716.4	2,301,072.1	42,634.8	N 57d02' E
5	2,301,405.0	42,394.2	2,301,282.3	42,308.0	N 54d54' E
6	2,301,619.9	42,079.2	2,301,509.8	41,977.3	N 47d13' E
7	2,301,901.0	41,814.9	2,301,790.9	41,713.1	N 47d13' E
8	2,302,196.5	41,563.6	2,302,092.1	41,455.9	N 44d06' E
9	2,302,475.6	41,298.0	2,302,371.2	41,190.2	N 44d06' E
10	2,302,728.1	41,064.4	2,302,632.2	40,949.0	N 39d44' E
11	2,303,068.7	40,808.6	2,302,976.2	40,690.5	N 38d03' E
12	2,303,394.1	40,597.4	2,303,303.7	40,477.6	N 37d03' E
13	2,303,712.4	40,379.5	2,303,630.3	40,253.9	N 33d09' E
14	2,304,032.5	40,174.3	2,303,955.1	40,045.8	N 31d04' E
15	2,304,363.5	40,000.0	2,304,295.2	39,866.5	N 27d03' E
16	2,304,709.8	39,833.7	2,304,659.9	39,719.1	N 23d33' E

Figure 2.4 Plan of Groinfield Reconstruction along Bald Head Island 2005 (from Olsen 2005)

Part 3 DATA ANALYSIS AND RESULTS THRU THIRD MONITORING CYCLE

General. Data collection for the monitoring program was initiated in August 2000 just prior to construction of the entrance channel improvements. This part of the report describes the data collected to date and results through August 2005, the end of the third monitoring cycle. The data analyses generally describe changes that have occurred since those last reported in June 2004 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 February 2005 and August 2005. Figure 3.1 shows the shoreline changes relative the June 2004 position, i.e. the last referenced location in Report 2. 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 accretionary or stable over the last year. The largest zone of accretion occurred between Profiles 46 and 142, reflecting the positive impact of the January 2005 beach fill. Over this 9,600 foot reach, the beach is up to 275 feet wider, with an alongshore average increase of 152 feet. Extending east of this fill area (between Profiles 146 and 220), the beach is found to be generally stable, with the shoreline being slightly seaward of its position a year ago, an average of 3 feet. In contrast to the stable nature found along South Beach, the area along West Beach and in the vicinity of the spit near the southwest corner of the island display eroded shorelines. For West Beach (Profiles 0 thru 28), the shoreline has receded an average of 14 feet since June 2004. For the vicinity of the spit (between Profiles 32 & 43), the shoreline has shown a large degree of variability, gaining as much as 155 feet and losing more than 80 feet. Overall, the alongshore average shoreline changes measured over the entire monitoring area were a gain of 52 feet and 64 feet for the February 2005 and August 2005 surveys, respectively.

A similar pattern of shoreline change is shown in Figure 3.2 as measured over the last 5-year period, since the monitoring was initiated. This figure likewise reveals some erosion along West Beach, the highly variable changes in the vicinity of the spit, and significant accretion along the entire South Beach area. The accretional area begins just east of the spit at Profile 53 and extends eastward throughout the remaining profile lines. The largest positive shoreline changes are reflected within the January 2005 fill zone, extending to about Profile 140. Within this fill area, the shoreline is an average of 109 feet seaward of its September 2000 position. Even beyond the fill area, the shoreline change remains positive, ranging between 50 and 100 feet seaward. Other large accretions are evident within the spit area along the southwest tip of the island. Here shoreline advances of more than 200 feet are indicated (Profile 36), but even greater recessions are seen proceeding around the tip with a maximum negative shoreline change of –240 feet recorded at Profile 43. For West Beach, located immediately along the river channel, the shoreline changes have been both positive and negative, with the average along this reach (Profile 0 thru 28) being a loss of 19 feet since the start of the monitoring. When considering all locations along Bald Head Island (Profiles 0 to Profile 218), the shoreline is presently on the average 68 feet more seaward than it was in 2000.

Typical profile plots shown in Figures 3.3 and 3.4 are taken along Bald Heads' 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 5-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 to the beach profile at this location, advancing the berm and shoreline to about 25 feet beyond its September 2000 location where it has remained throughout the present period.

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. At the end of the period, the shoreline position remained about 55 feet seaward of its September 2000 position.

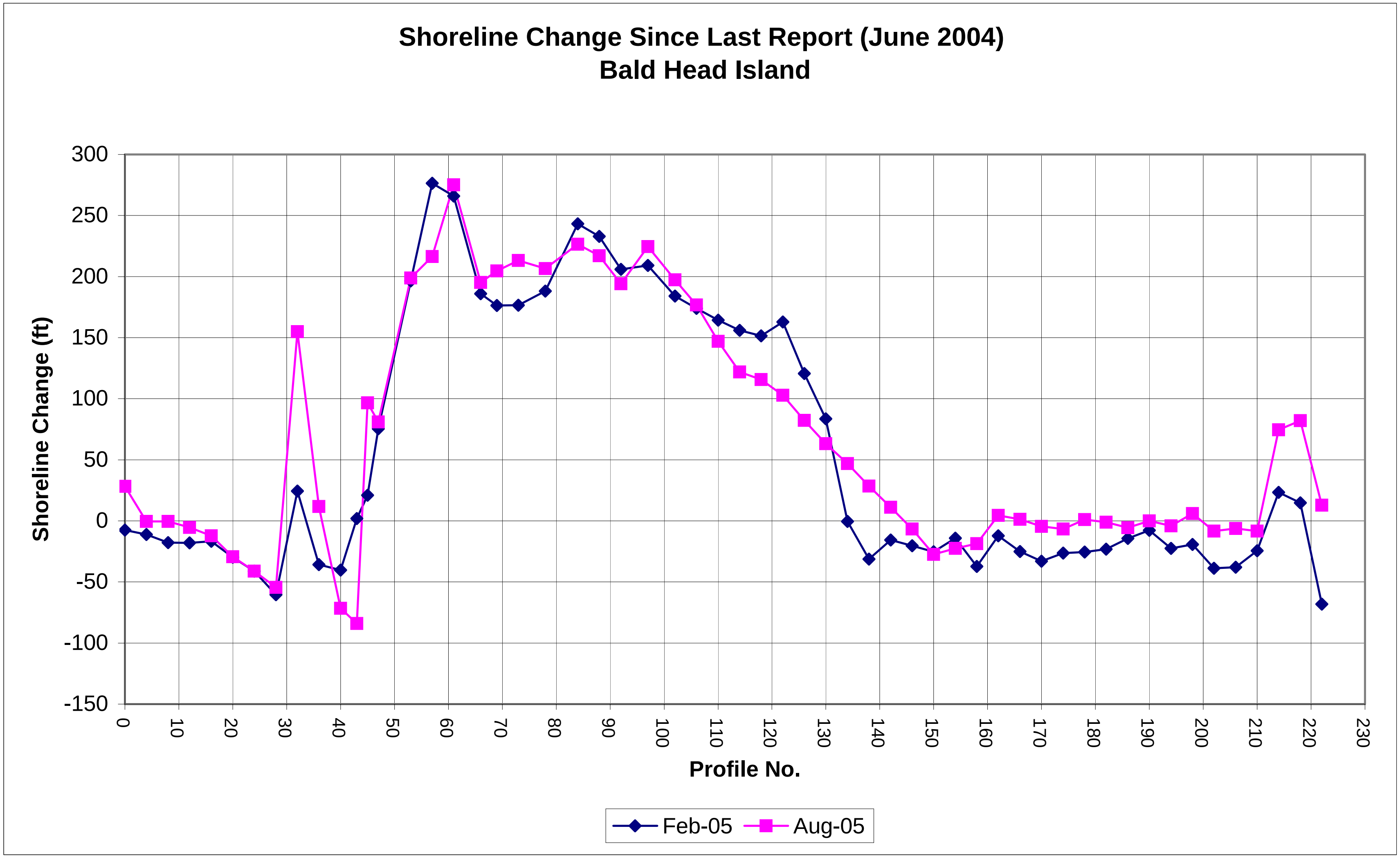


Figure 3.1 Shoreline Change Since Last Report (Jun 2004) Bald Head Island

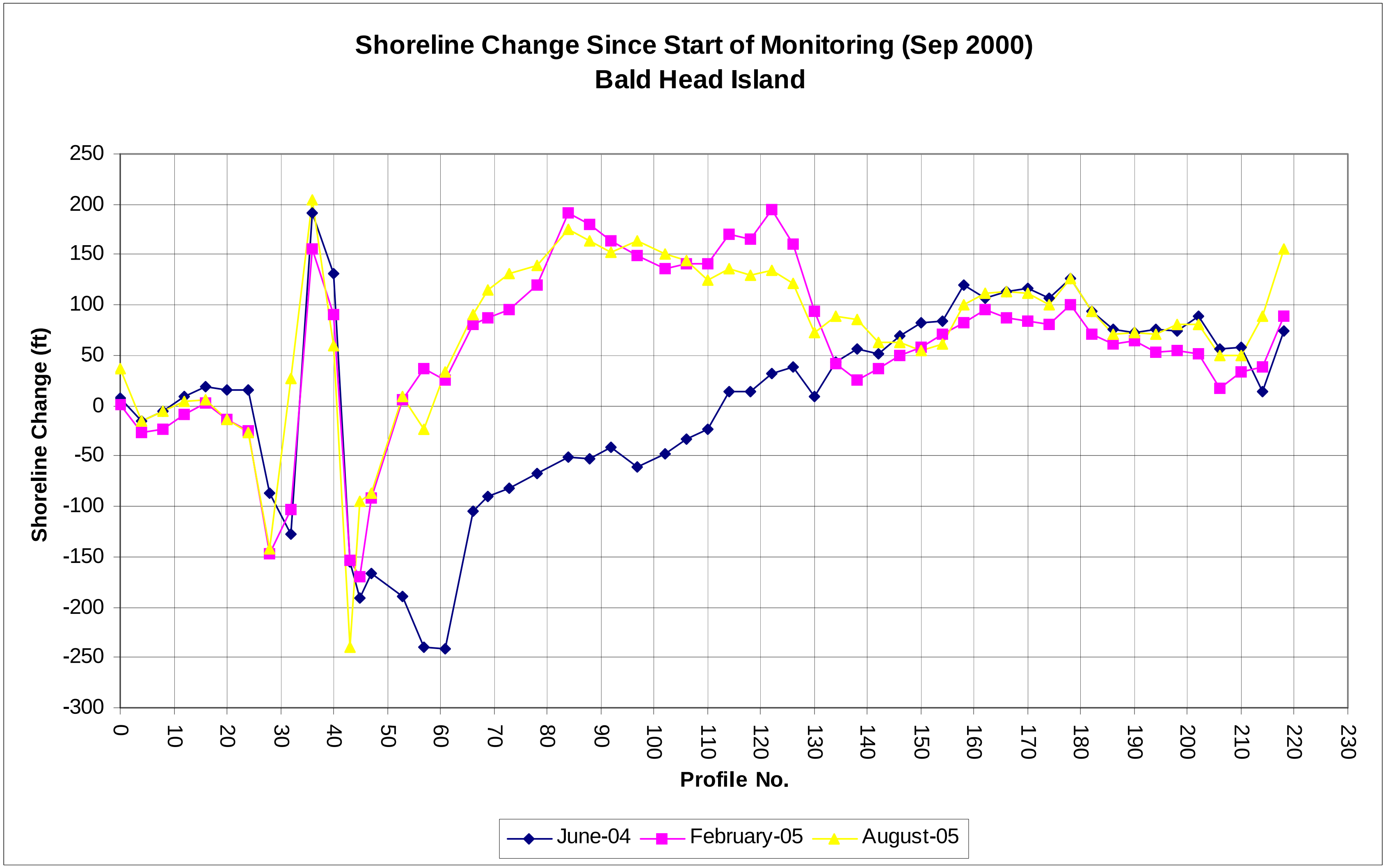


Figure 3.2 Shoreline Change Since Start of Monitoring (Sep 2000) Bald Head Island

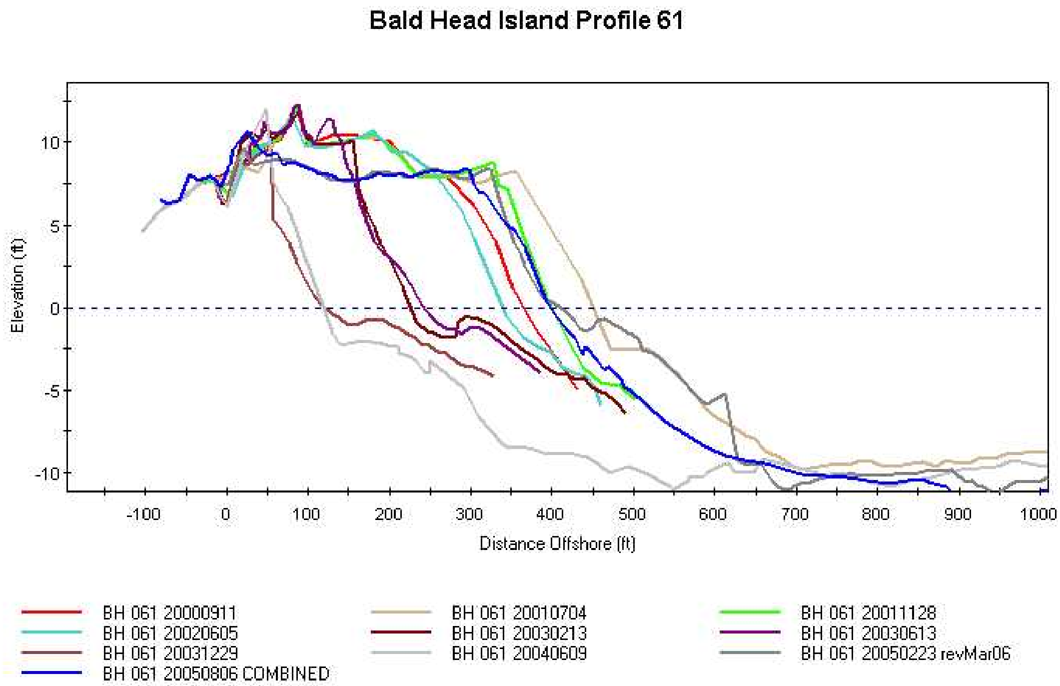


Figure 3.3 Bald Head Island Profile 061

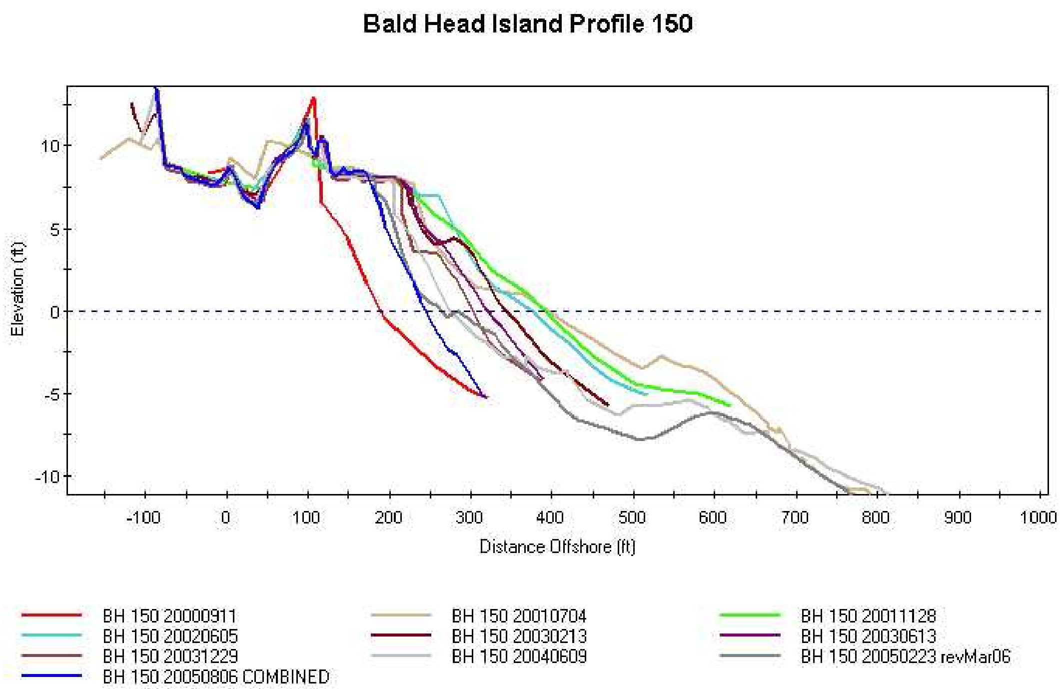


Figure 3.4 Bald Head Island 150

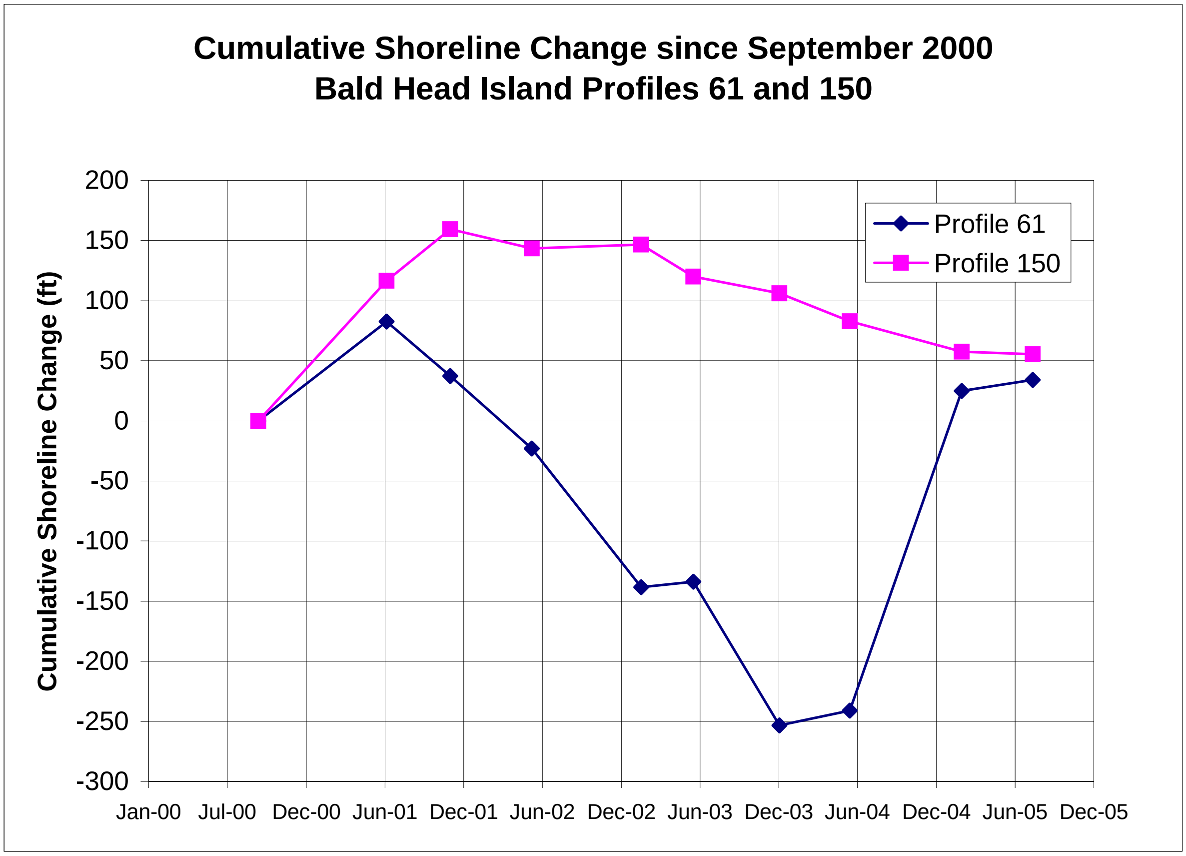


Figure 3.5 Cumulative Shoreline Changes Since September 2000 Bald Head Island Profiles 61 and 150

<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 February 2005 and August 2005 surveys. Figure 3.6 shows the shoreline changes relative the June 2004 position, i.e. the last referenced location in Report 2. 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 –50 feet to +50 feet. Overall however, positive change has been more prevalent with the alongshore average change being an accretion of about 9 feet from June 2004 to August 2005. For the remaining monitoring area extending westward from Profile 50, the shoreline changes have been somewhat variable, with the overall trend being one of slight recession. Inspection of Figure 3.6 reveals a generalized pattern of shoreline change in which the first third is accreting, the middle third eroding and the last third is again accreting. These changes range from about +50 feet to –50 feet, overall. The average shoreline change for all profiles within this “one-third” pattern is a slight loss of 0.7 feet. When considering all profiles within the Oak Island monitoring area (Profiles 5 thru 310) the average shoreline change is slightly positive at 0.8 feet for the present period of June 2004 to August 2005.

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 February and August 2005 surveys, all shoreline changes measured west of Profile 40 are positive, except for Profile 95 (which is eroding slightly with the Aug 2005 survey). 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 more that 200 feet beyond the August 2000 base condition. In considering all the profile data, the alongshore average shoreline position was 95 feet more seaward in February 2005 than it was in 2000. Likewise, the shoreline position was 98 feet more seaward in August 2005, than it was about five years earlier at the start of the project.

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 August 2005. 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 three years. Over this time period (between June 2002 and August 2005), 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, ranging from a positive 156 to 125 feet, over the same period.

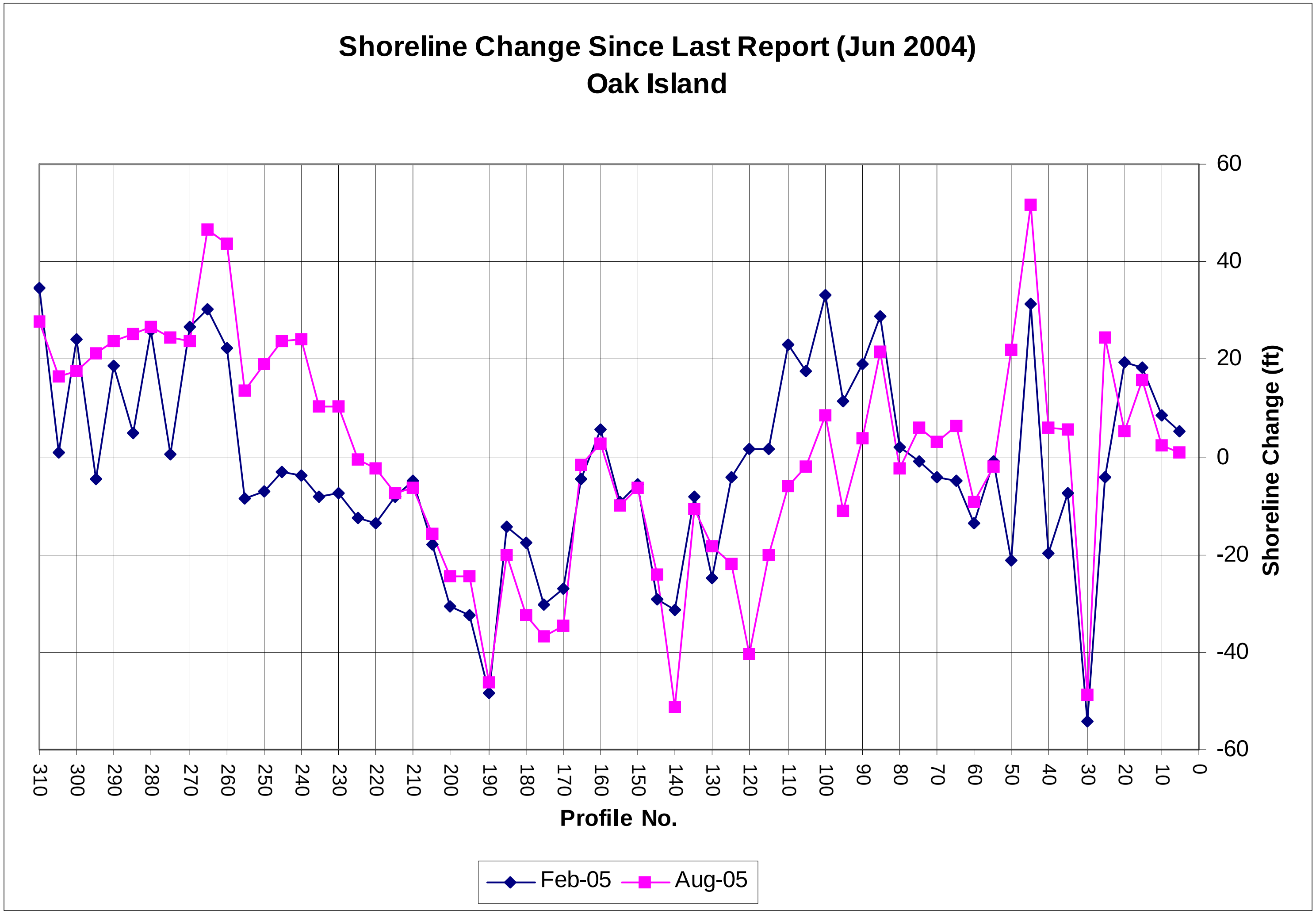


Figure 3.6 Shoreline Change Since Last Report (Jun 2004) Oak Island

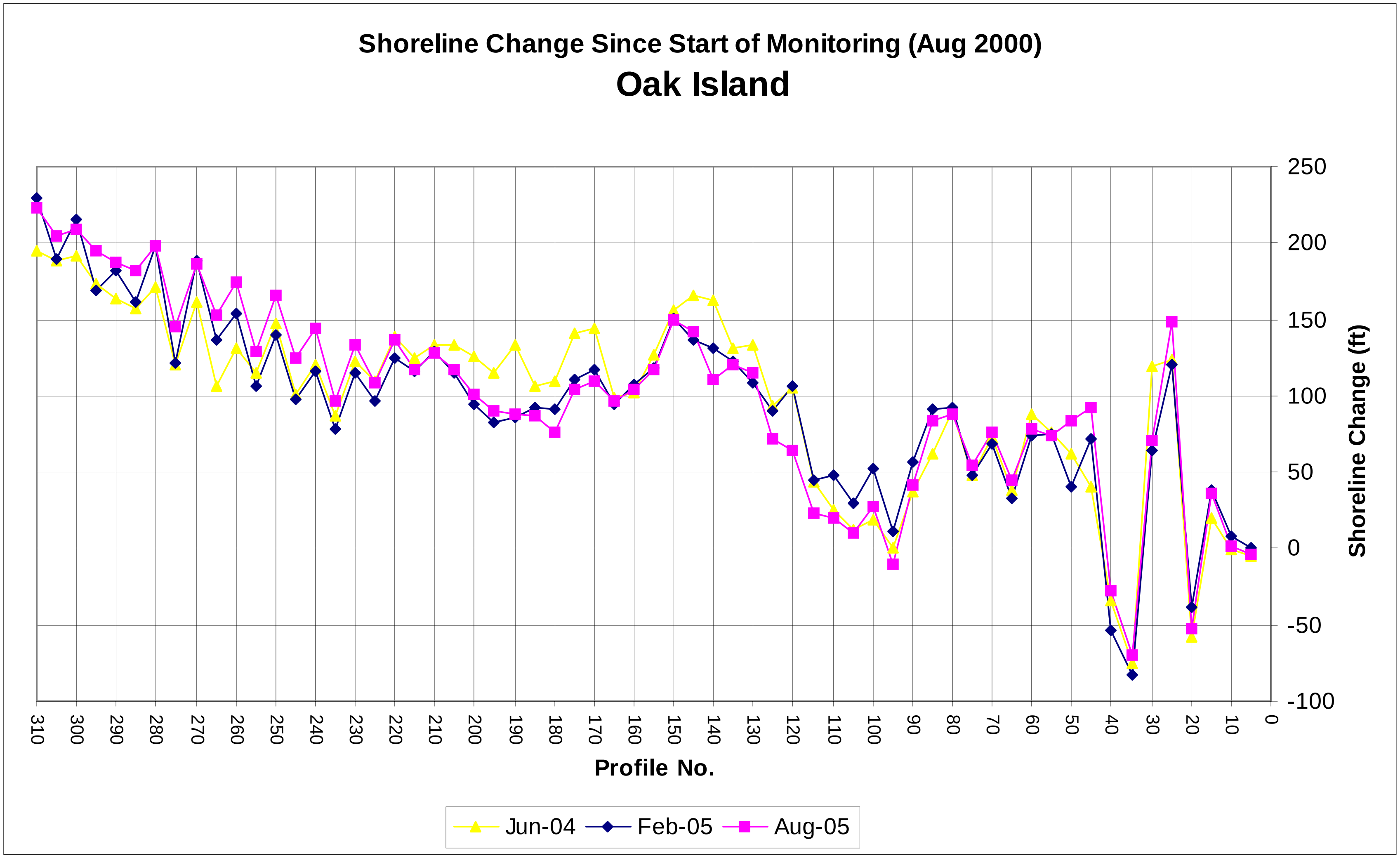


Figure 3.7 Shoreline Change Since Start of Monitoring (Aug 2000) - Oak Island

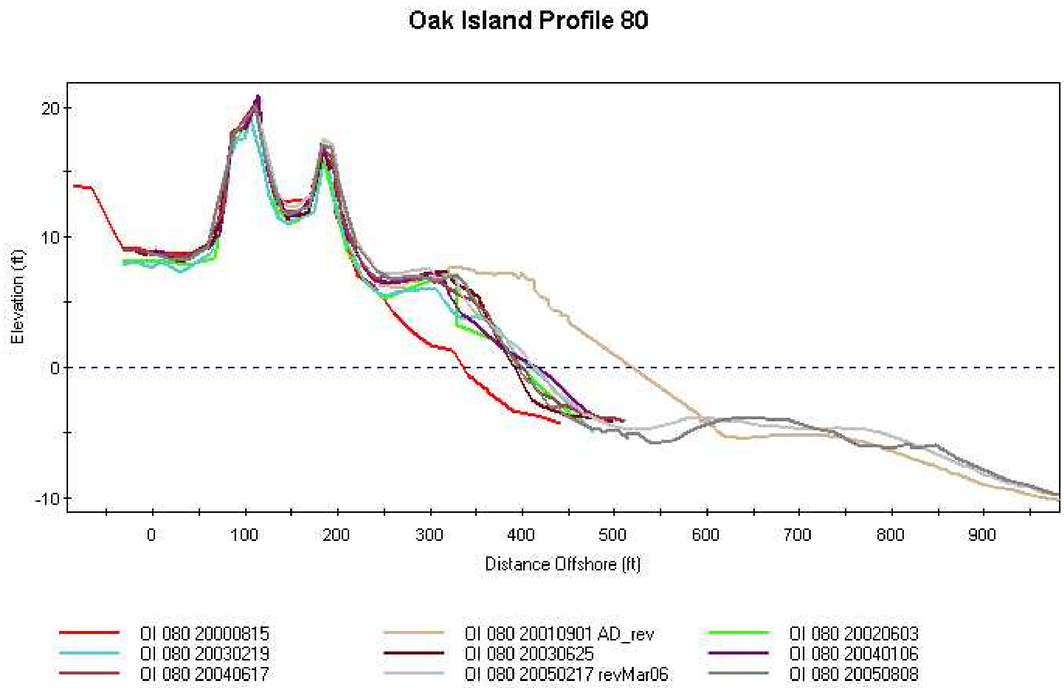


Figure 3.8 Oak Island Profile 80

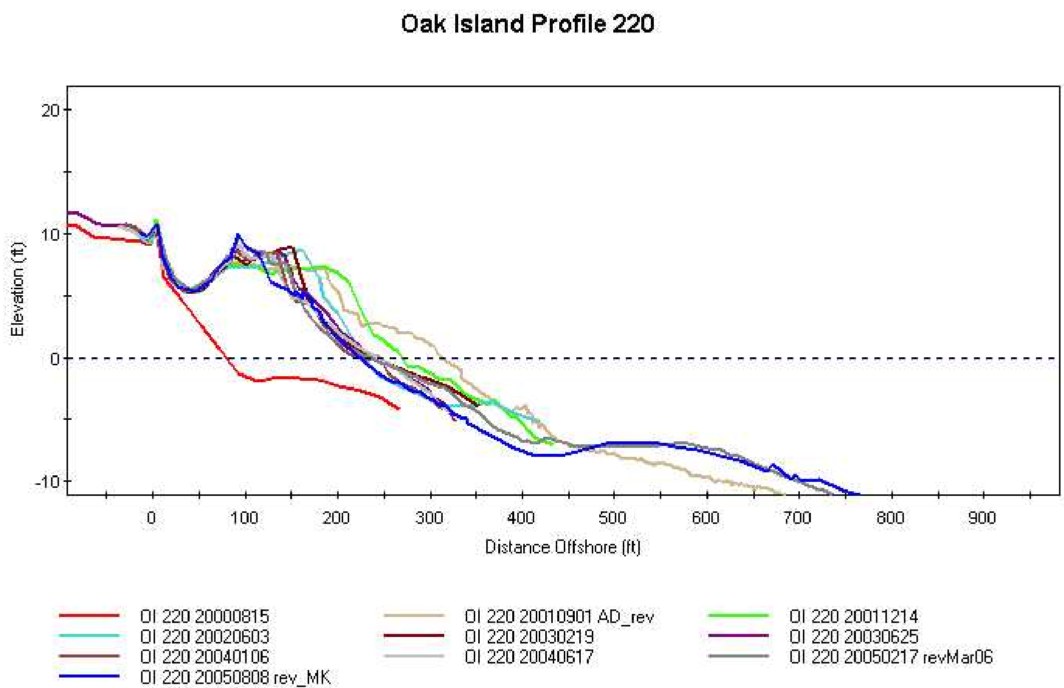


Figure 3.9 Oak Island Profile 220

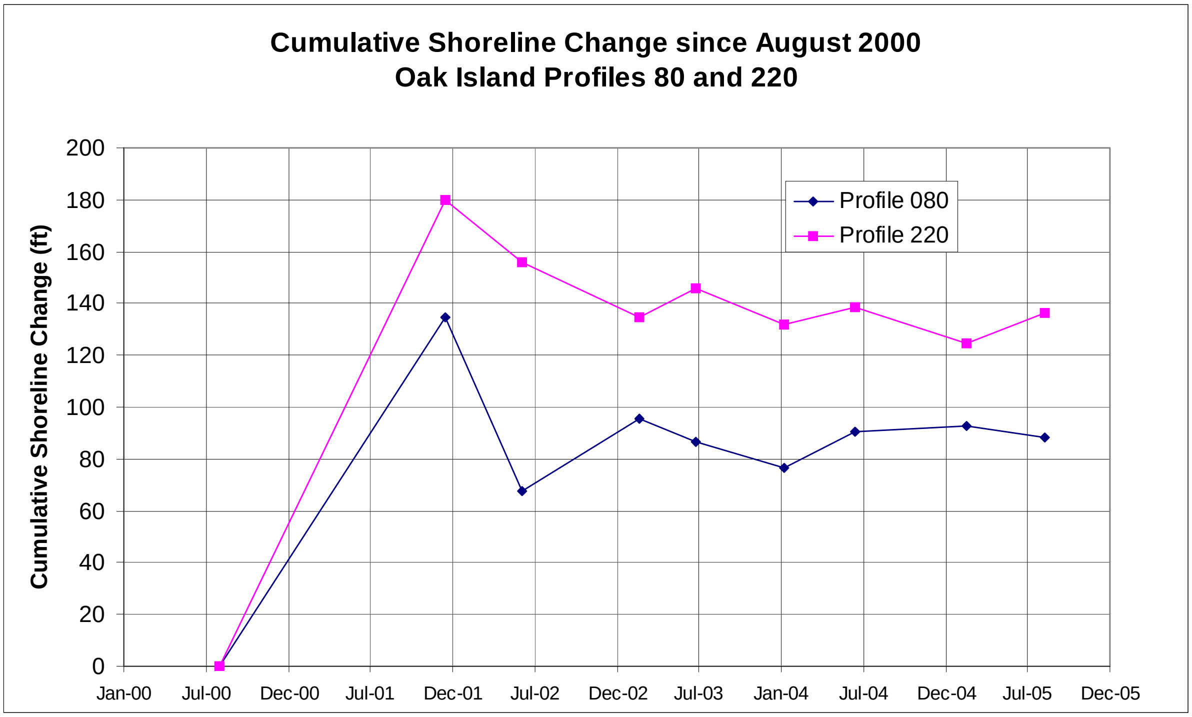


Figure 3.10 Cumulative Shoreline Change Since August 2000 Oak Island Profiles 80 and 220

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 February 2005 and August 2005 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 June 2004 onshore survey, i.e. the last referenced onshore survey in Report 2. 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 either gained sediment or have been stable over the present reporting period. The largest increases are found between Profiles 47 and 130 resulting from the direct placement of the January 2005 fill. Within these limits about 549,000 cubic yards of material are present within the onshore portions of the beach. East of the fill area, extending to the end of south beach, relatively small changes are evident reflecting the overall stability of the upper portions of the beach over the current period. In contrast some minor volume losses are present along west beach and in the vicinity of the spit area. For west beach (Profiles 0-28), there is a trend of increased volume loss proceeding towards the spit, although these are relatively small compared to the other measured changes. Collectively, west beach onshore volume changes amount to loss of about 12,000 cubic yards by the end of the current period. Within the adjacent spit area (Profiles 32 thru 45) both volumetric increases and losses are found which is typical of this dynamic area. Overall, a slight net increase in onshore volume of 5,500 cubic yards is present over this area. In considering the total volume changes for all profiles over the current monitoring cycle, approximately 564,000 cubic yards were gained between June 2004 and August 2005.

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 two areas, all profile locations have experienced net gains in the onshore over the last five years. The volumetric gains are measured along south beach in all lines east of Profile 57 and within the spit area (between Profiles 32 and 40). The two areas that experienced onshore losses since the beginning of the project are along west beach and south beach separated by the zone of spit growth as mentioned above. These two erosional areas have losses of 27,000 and 53,000 cubic yards for west beach and south beach, respectively. The latter south beach area has been an area 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 change in the trend of progressive volume loss 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 22,000 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 just under 500,000 cubic yards with the February and August 2005 surveys.

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 2 (June 2004); 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 the positive impact of the most recent fill with large volume increases present within the western half of south beach (Profiles 53 to 130). In contrast, losses are evident on either side of the fill area for both of the recent surveys. These erosional areas extend eastward throughout the remaining portions of south beach to the cape and westward into the area of the spit. The spit area also has a smaller infilling area around the corner of the island along the channel margin. At the extreme eastern end of the island, the dynamic nature of the cape and associated Frying Pan Shoals are evident with large swings in the volumetric measurements. With the February 2005 survey, very large losses are present, however, just about six months later this same area shows a large accretion. In terms of overall volumetric change (excluding the large variations measured near the cape), the positive area of the fill is significantly larger in magnitude that the adjacent negative areas. Specifically, the net gain between June 2004 and February 2005 was 175,000 cubic yards and from June 2004 to August 2005 was 273,000 cubic yards.

When comparing the changes in total profile volume back to the initiation of the project given in Figure 3.15, two areas of loss are present along Bald Head Island. One is located at the eastern end of south beach, where relatively large losses have occurred near the cape. The other, which is of more concern, is at the western end of south beach between Profile 45 to 61. This 1600-ft reach has been the site of chronic erosion in the past. Aside from these two areas, all other profile volume changes are positive throughout the remaining areas. 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 447,000 cubic yard gain in February 2005 and 864,000 cubic yard gain by August 2005, even including the volume losses experienced near the cape.

Listed below 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 the prior report based on similar beach response. Although with the addition of the beach fill, the reach response has changed somewhat, the same reach limits are used for consistency. It is of interest to note that with the two most recent surveys all of the reaches listed in the table are positive, except for the last one near the influence of the cape. The prior designated erosion zone (between Profiles 53 and 106) is now accretionary. Also as noted in the above paragraph, the beaches of Bald Head have 864,000 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)

	July-01	October-01	December-02	January-04	June-04	February-05	August-05
Profile 0 – 24 (west beach)		-33,053	35,186	11,817	2,602	14,646	34,221
Profile 32 – 45 (spit)	150,029	7,926	-1,923	260,666	311,209	88,069	152,350
Profile 53 – 106 (erosion zone)	130,522	204,946	-81,098	-453,813	-381,134	192,025	187,801
Profile 114 – 194 (accretion zone)	1,200,383	1,075,112	783,630	572,189	819,523	624,879	633,286
Profile 198 – 218 (near cape)	20,727	-503	-209,780	-315,710	-74,440	-472,701	-144,114
Total	1,501,660	1,254,428	526,015	75,150	677,759	446,918	863,544

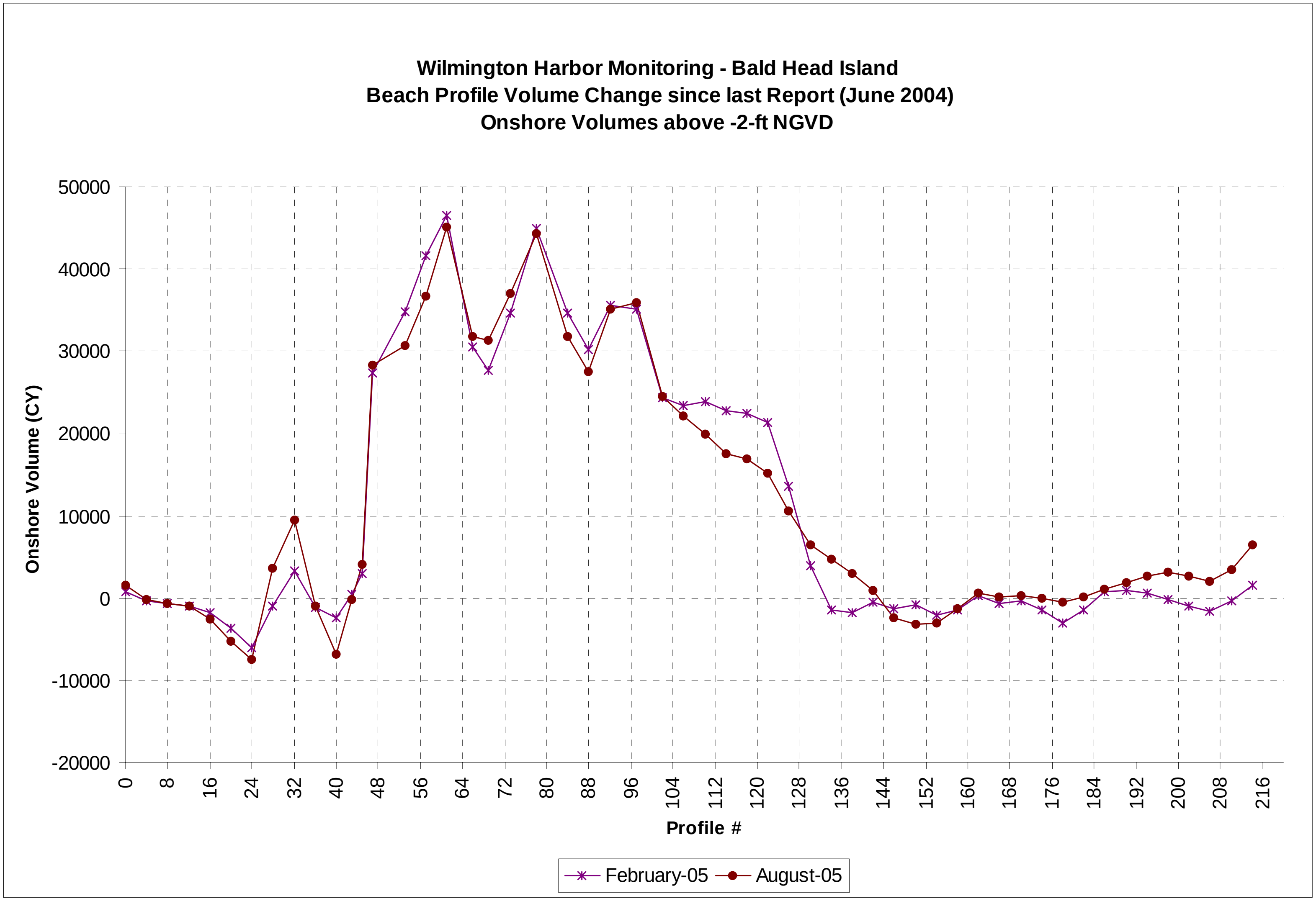


Figure 3.11 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change Since last Report (June 2004) Onshore Volumes above –2 ft NGVD

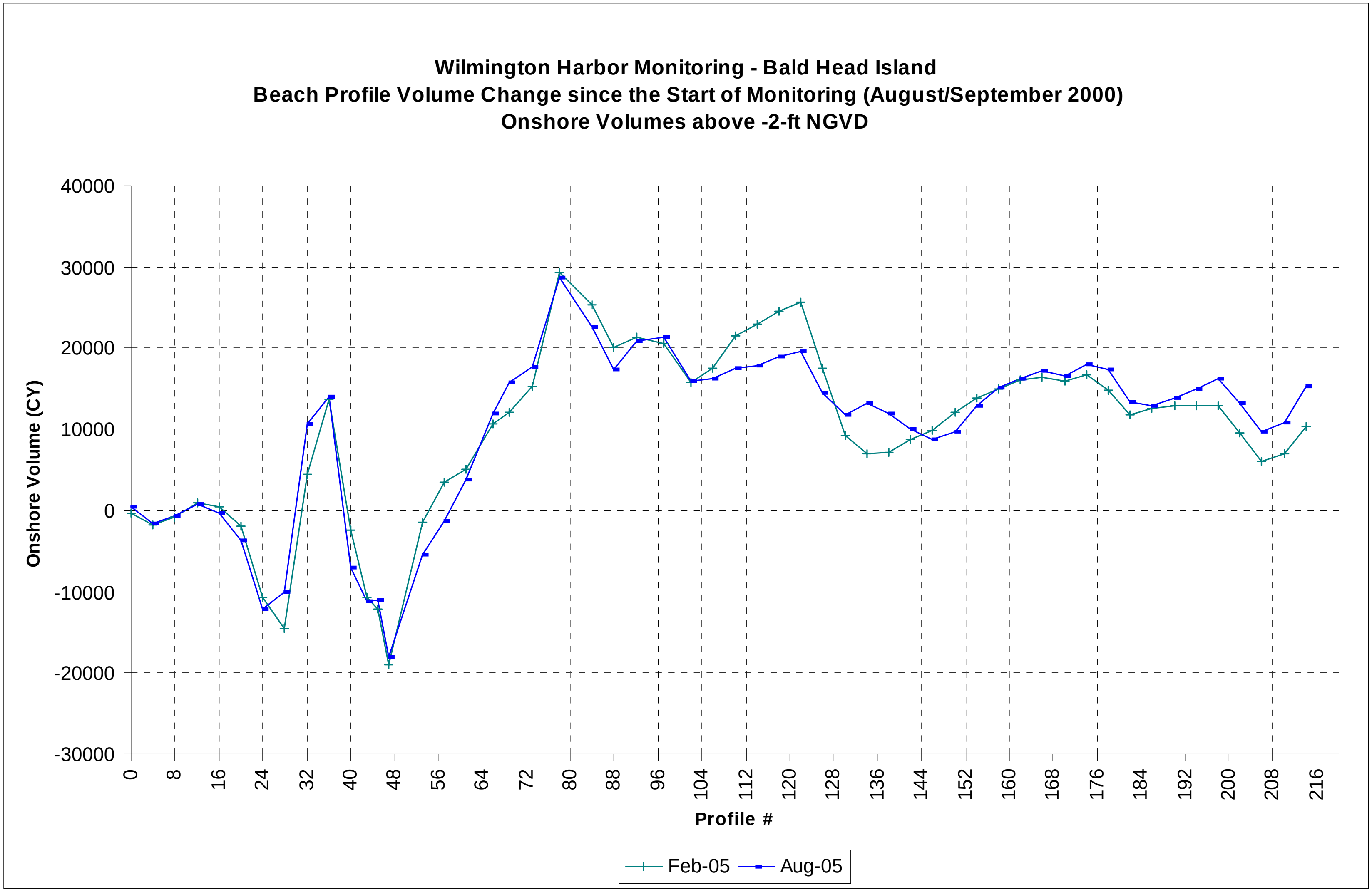


Figure 3.12 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change since Start of Monitoring (August/September 2000) Onshore Volumes above –2 ft NGVD

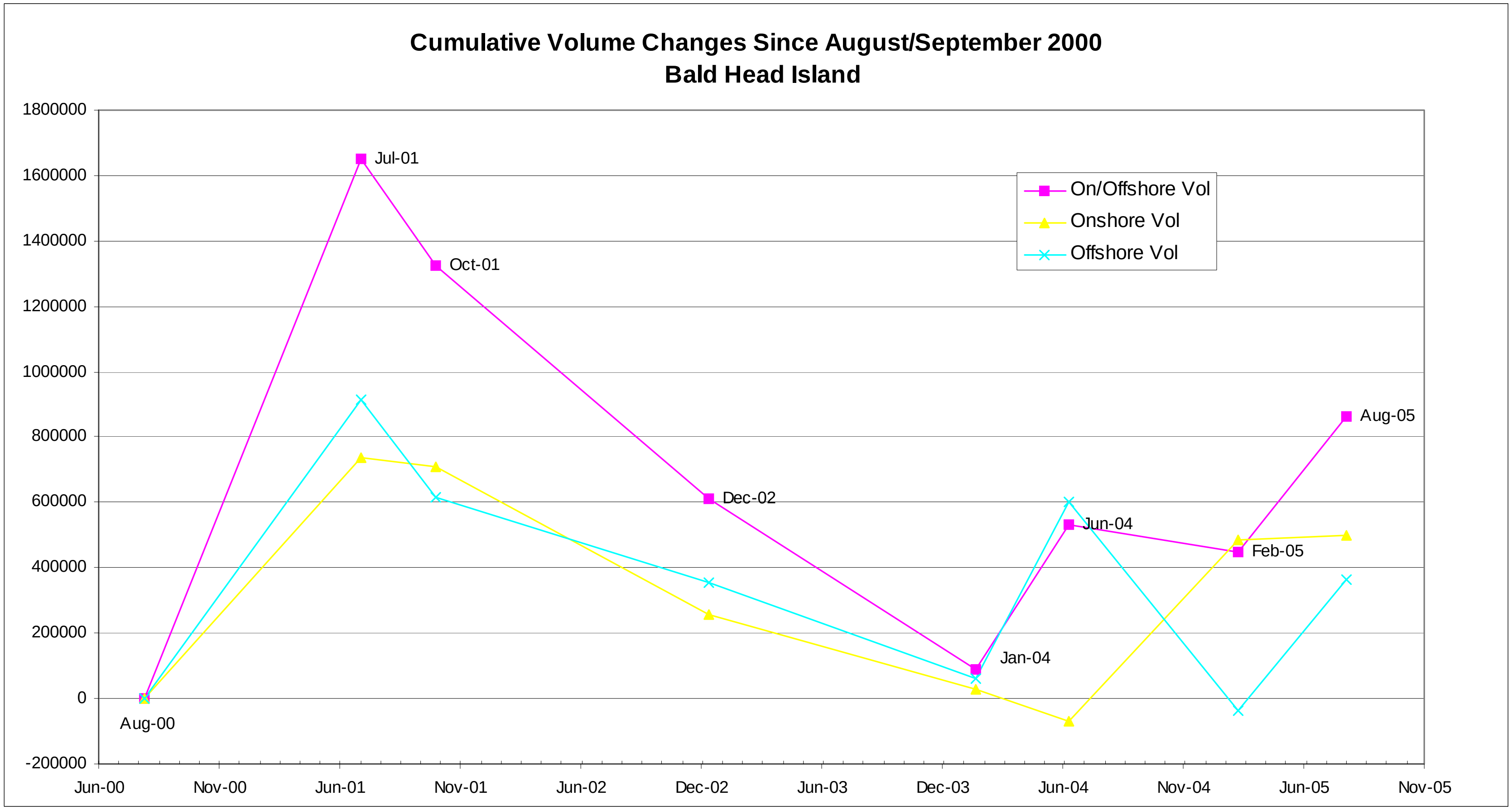


Figure 3.13 Cumulative Volume Changes Since August/September 2000 for Bald Head Island

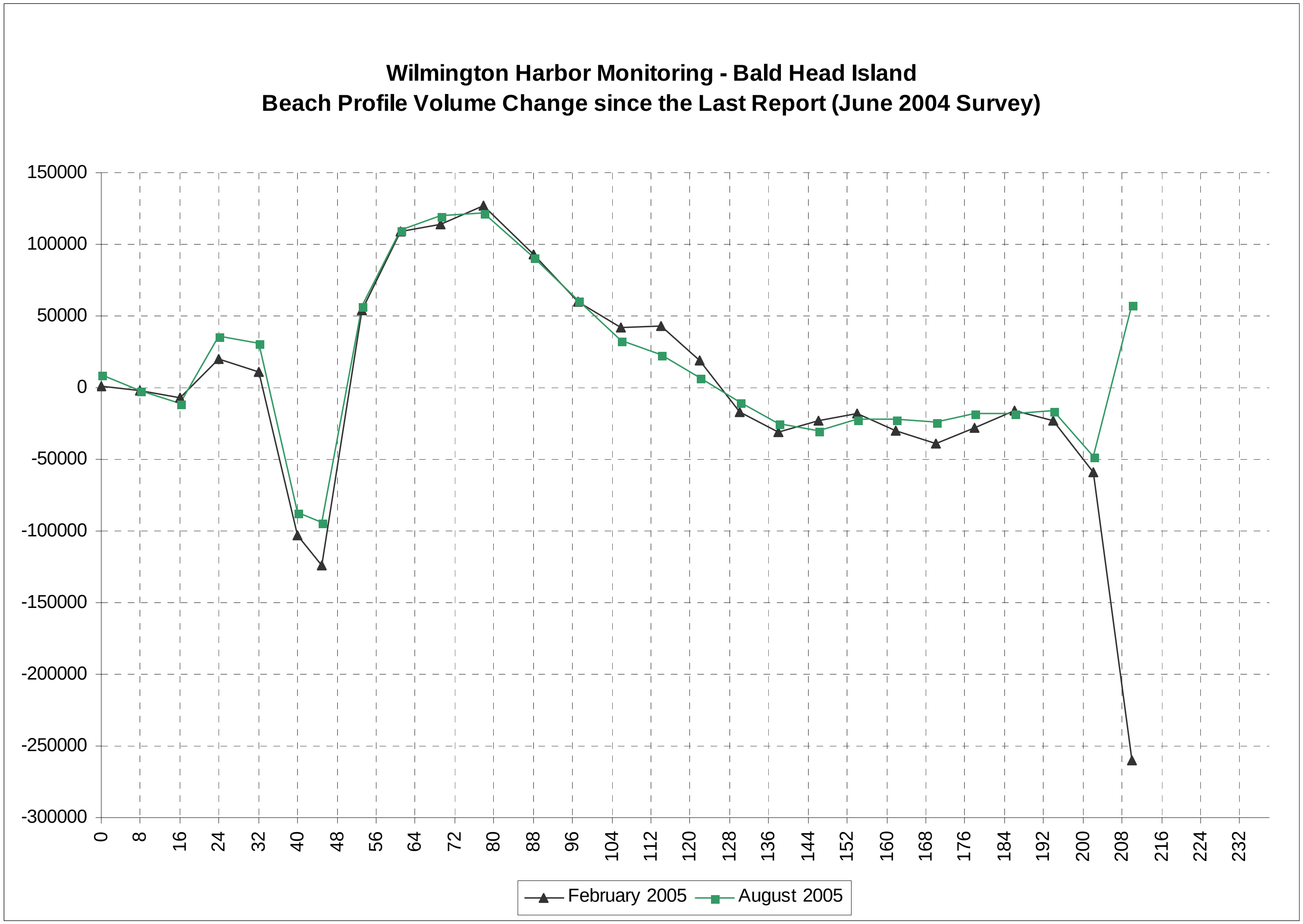


Figure 3.14 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since Last Report (June 2004 Survey)

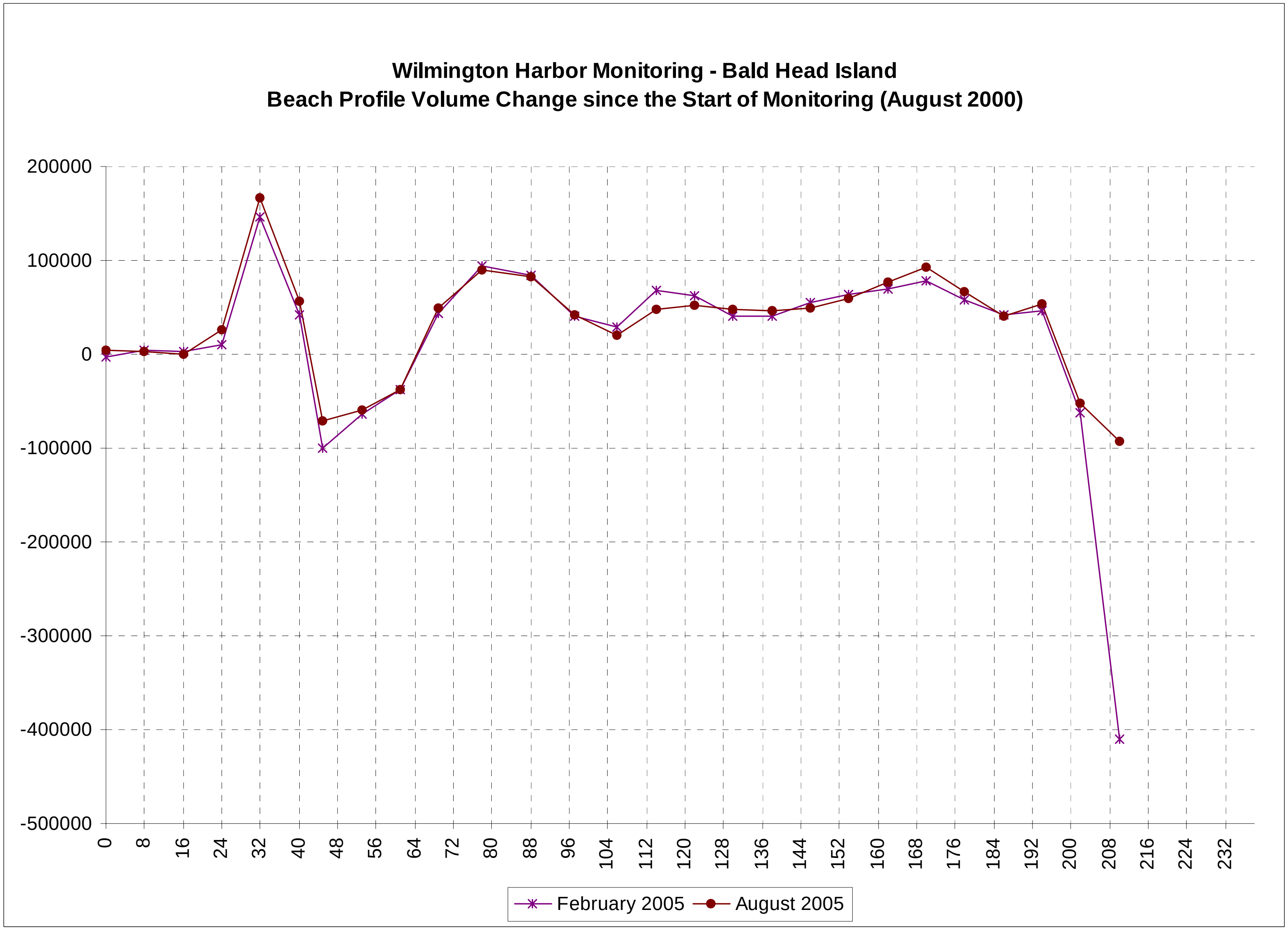


Figure 3.15 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since the Start of Monitoring (August 2000)

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 June 2004 onshore survey, i.e. the last referenced onshore survey in Report 2. 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 +6000 cubic yards to –4000 cubic yards for each of the recent surveys. Both the February 2005 and August 2005 surveys show similar patterns with small areas of accretion and erosion. However, overall the accretion is more predominant for both surveys. In this respect, the onshore volumetric quantities summed over the 6-mile monitoring region show gains of 120,400 cubic yards and 12,400 cubic yards for the February and August 2005 surveys, respectively.

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 January 2004 and June 2004 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 four years. Further, as of August 2005, only two profiles (35 and 40) near the tip of Fort Caswell have experienced onshore volume losses, with all other profiles showing significant gains to date.

To further illustrate the stable nature of the Oak Island beaches over the last five 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. Between June 2003 and August 2005 essentially no significant change in the onshore beach volume is measured. As of August 2005 survey, the remaining total onshore volume is 933,000 cubic yards, which is essentially the same volume computed with the December 2001 onshore survey.

Total volumetric changes computed over the entire active profile are given in Figures 3.19 and 3.20 for Oak Island. Figure 3.19 shows volume changes relative to the latest survey contained in Report 2 (January 2004); 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, relatively minor changes are found to occur since the last monitoring period. The overall response has been a positive change except some losses found between Profiles 45 and 100 and near the western end of the monitoring area with the August 2005 survey. The largest gains are seen to occur within the western half of the area between Profiles 130 and 280. This material appears to be a result of the redistribution of the beach fill from the western boundary of the monitoring area. With this eastern movement of material, along with the general stability observed over the latest monitoring period, there has been an overall gain in volume between January 2004 and August 2005. The gain is computed as 207,500 cubic yards when summed over all profiles.

As with the onshore volumes discussed previously, the total onshore/offshore profile volume changes have been generally positive and have shown relatively little change over time since the beginning of the monitoring program. Figure 3.20 shows the volume changes for last three onshore/offshore surveys relative to the August 2000 pre-project survey. In this regard, all reported volume changes are positive with the exception of several isolated profiles which show small losses. These isolated loss areas are located at Profiles 5, 40, 60 and 100.

Referring back to Figure 3.18, it is seen that not only has the beach remained stable over time, but the overall volume has actually increased since the fill placement in 2001. As shown on the graph, approximately 1,143,000 cubic yards of material were measured in-place with the November 2001 survey when compared to the August 2000 base year. Since that time, following a minor loss measured in November 2002, the volume along Oak Island has steadily gained except for a slight dip with the most recent survey. With the most recent survey of August 2005, the total volume had increased to 1,492,000 cubic yards. Most of this increase is within the western portion of the monitoring area. It is believed to be the result of the eastward spreading of the beach fill placed just beyond the boundary of the project area.

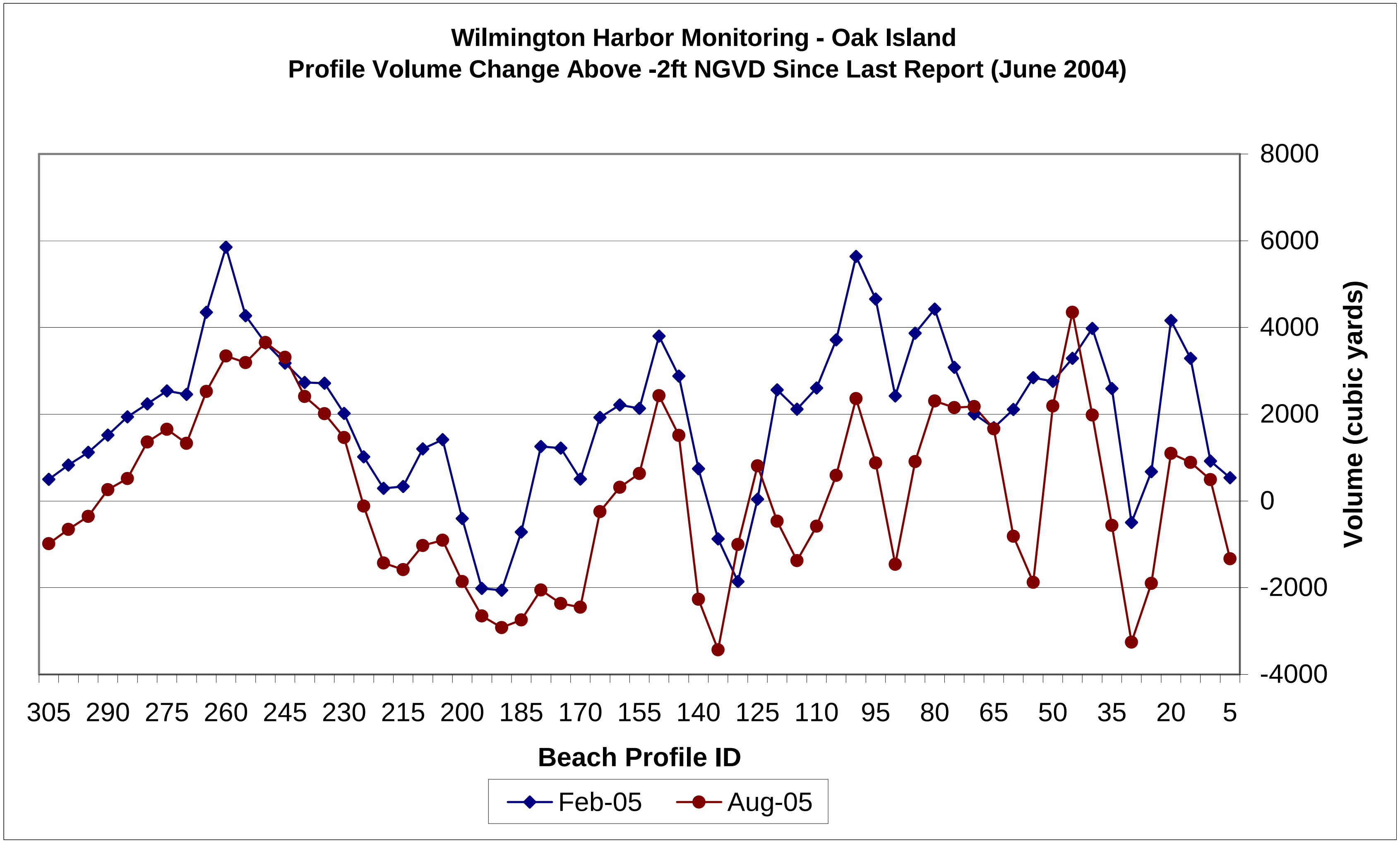


Figure 3.16 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change Since Last Report (June 2004)

Onshore Volumes above – 2 ft NGVD

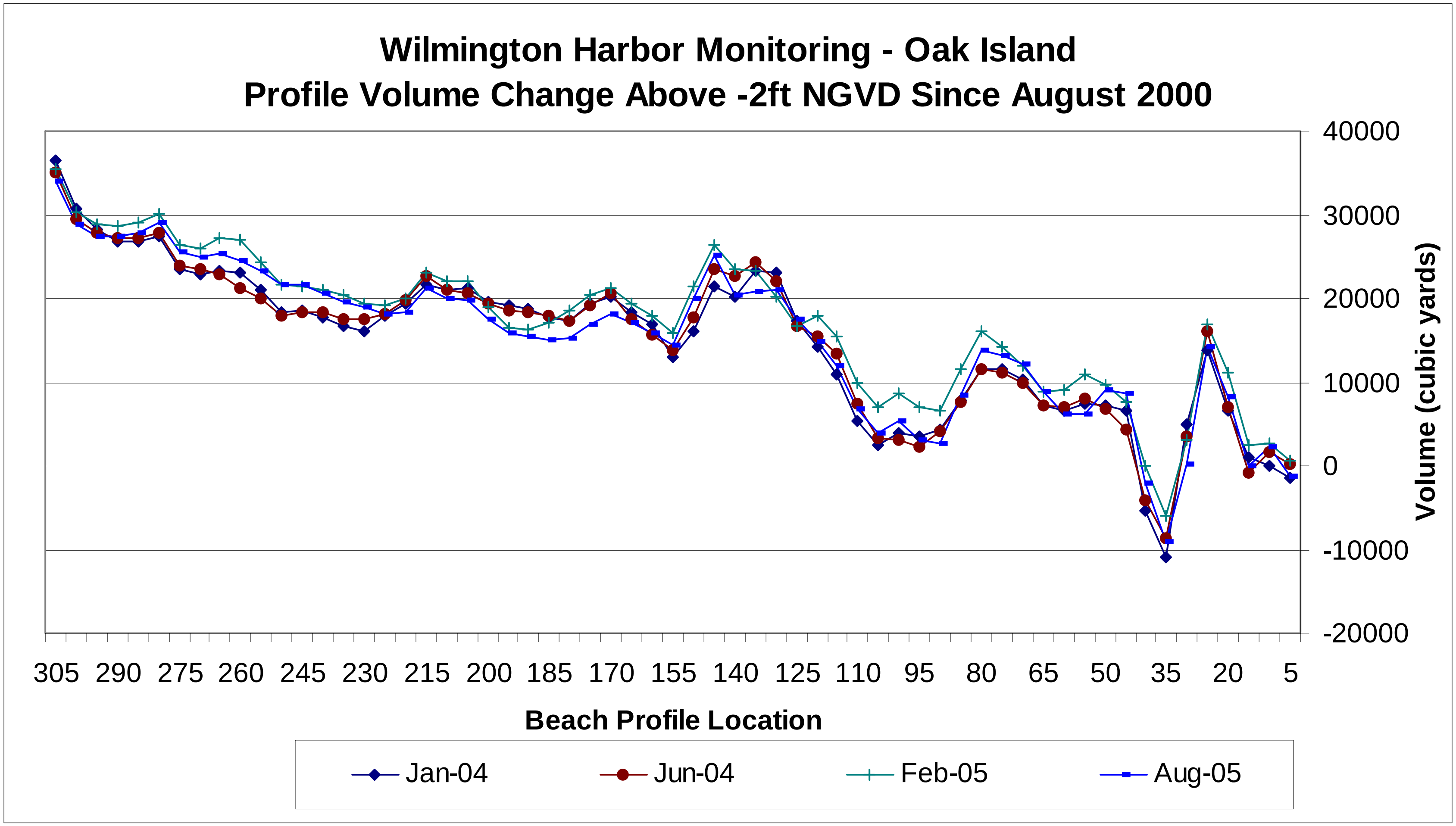


Figure 3.17 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change since Start of Monitoring (August 2000) Onshore Volumes above –2 ft NGVD

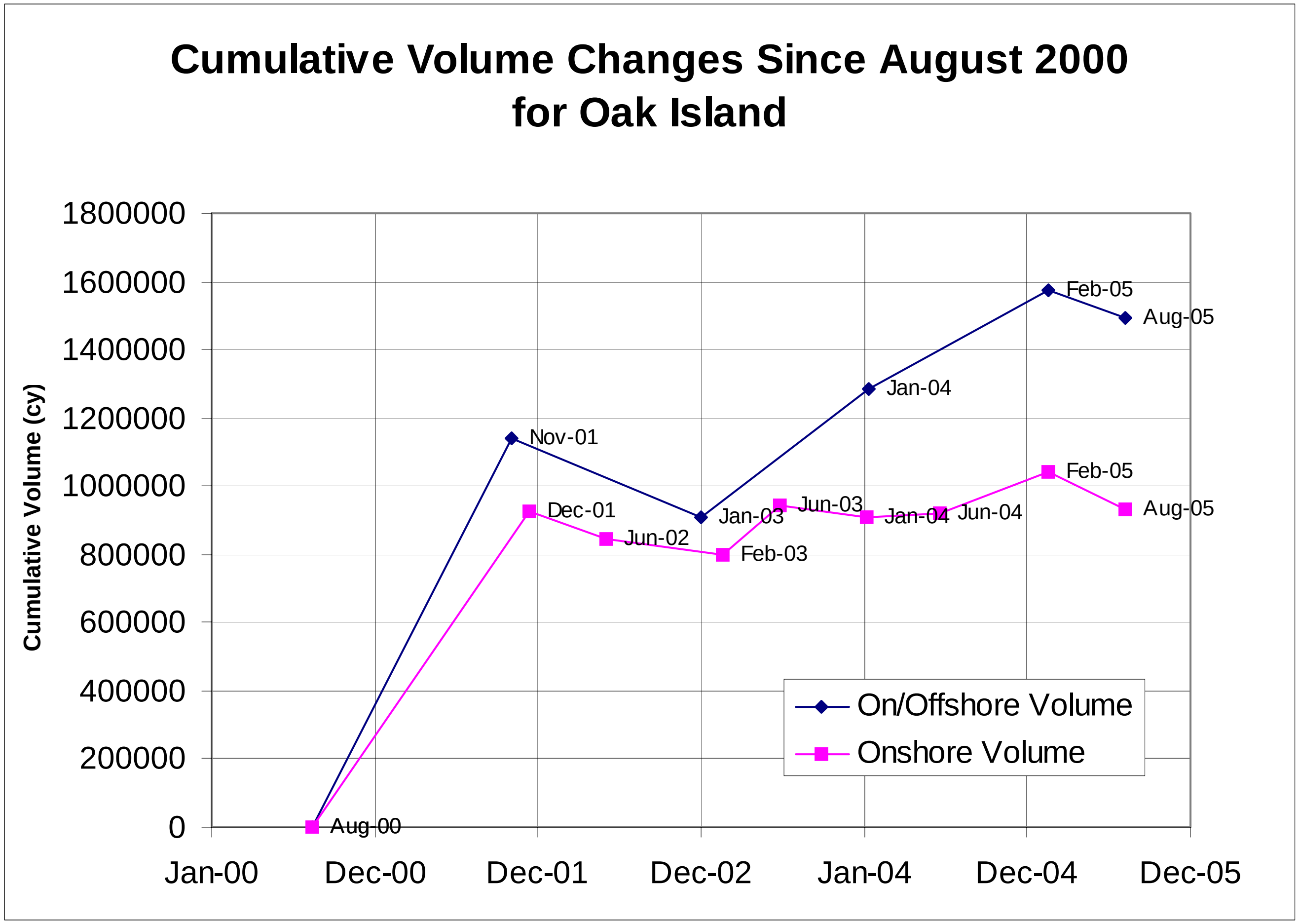


Figure 3.18 Cumulative Volume Changes Since August 2000 for Oak Island

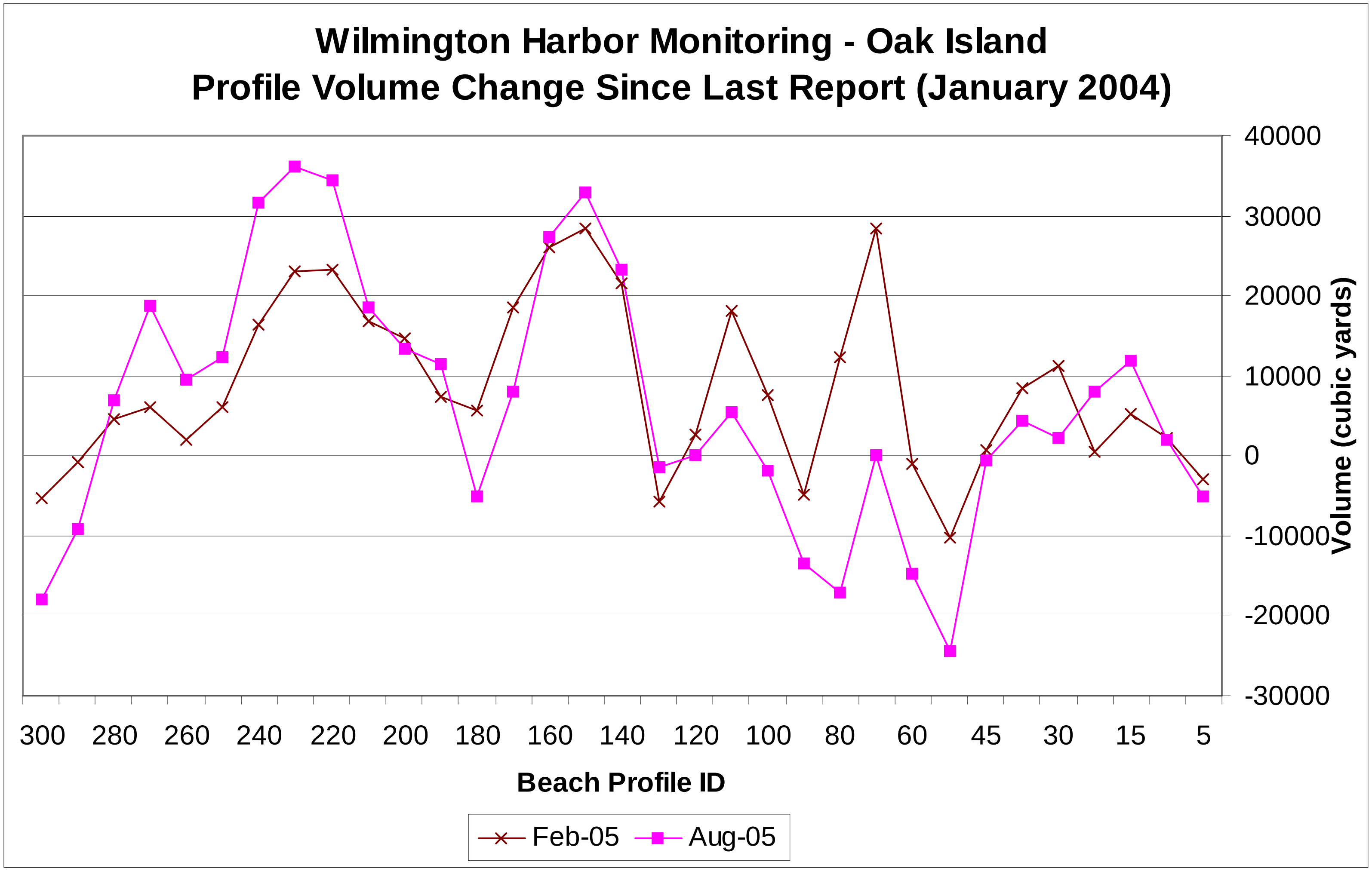


Figure 3.19 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since Last Report (January 2004)

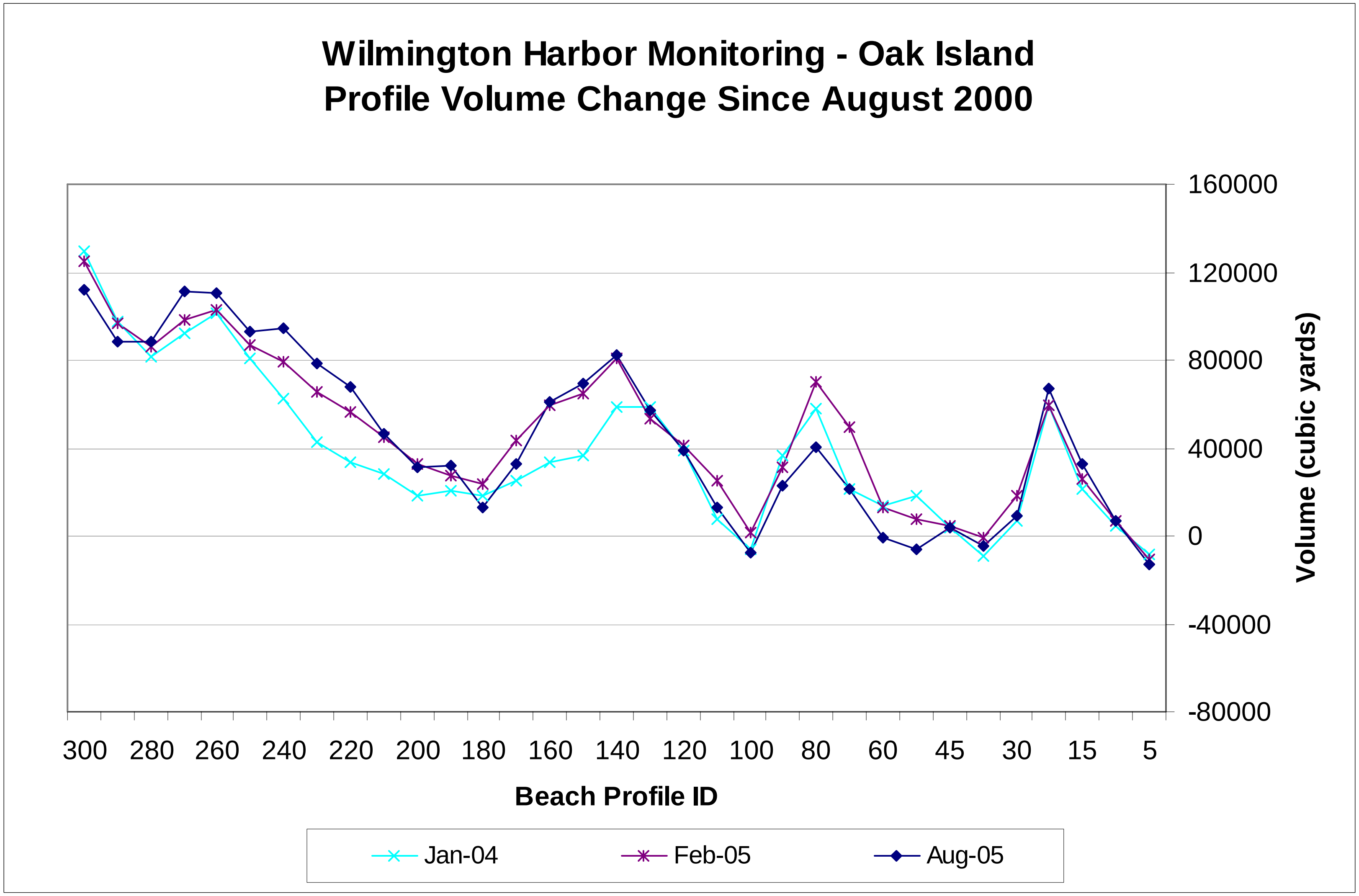


Figure 3.20 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since the Start of Monitoring (August 2000)

Ebb and Nearshore Shoal Analysis

Bathymetric Data Collection. Detailed bathymetry of the Cape Fear River ebb tidal delta and channels were collected on five occasions specifically; August-September 2000, December 2001-January 2002, January 2003, January 2004 and March 2005. 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. Further, the most recent ebb shoal survey data collection effort and results are detailed in Part 2 of USACE 2005a.

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

Results. The ebb tidal delta surrounding the mouth of the Cape Fear River is shown in Figure 3.22 from the most recent survey of March 2005. 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 this area is shown in Figure 3.23 for each of the four prior surveys taken in 2000, 2002, 2003, and 2004. 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.

Further comparisons between surveys are made by generating maps showing changes in the bathymetry over time. Difference plots were made comparing the most recent survey of March 2005 with the prior survey of January 2004 as well as with the initial pre-project survey of August 2000. Figure 3.24 shows the bathymetric changes for the most recent period between January 2004 and March 2005. Detailed insets of these

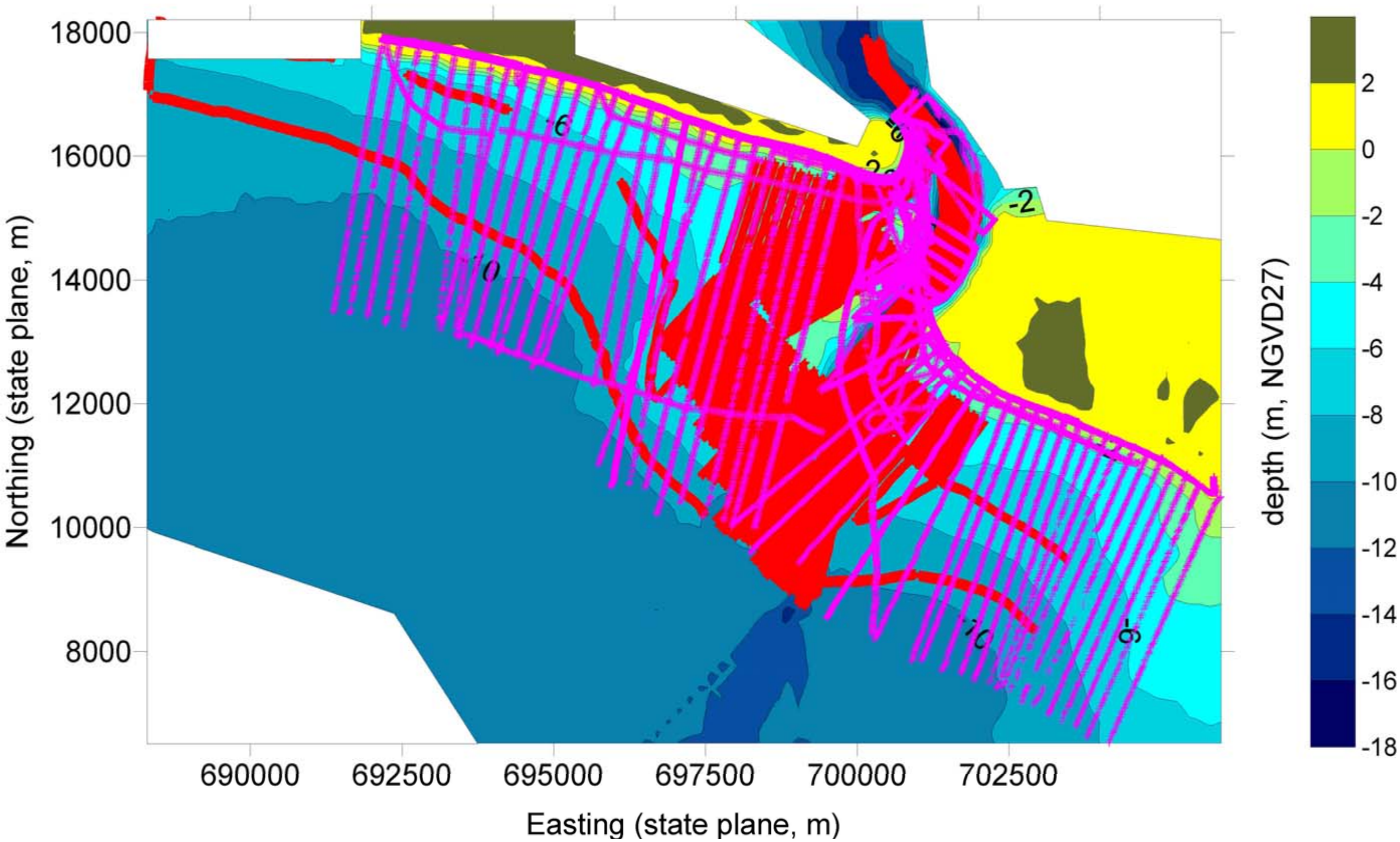


Figure 3.21 Survey Track Lines Collected by the LARC5 and the Interferometric System during the 2004 Survey

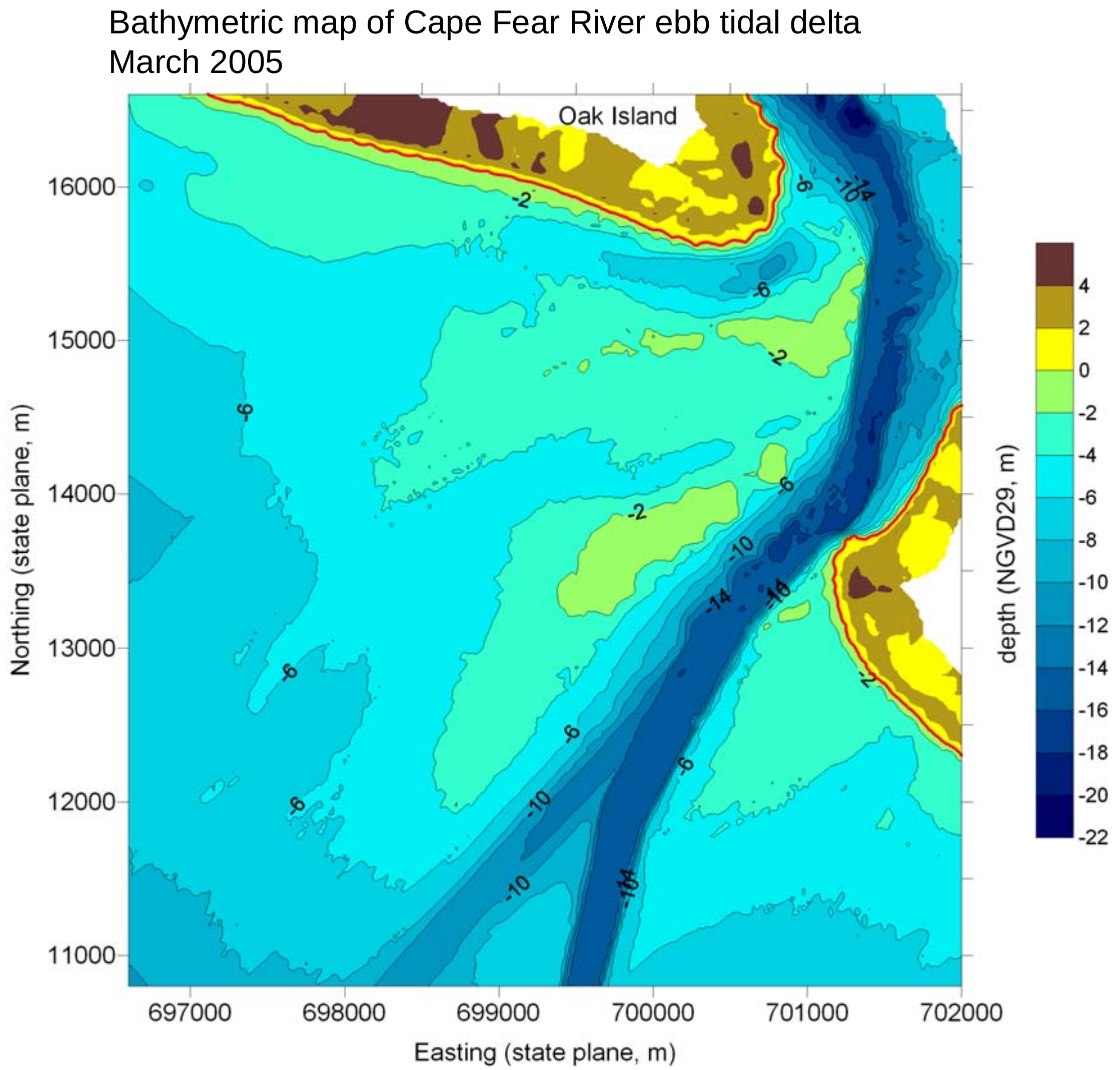


Figure 3.22 March 2005 Ebb Tide Delta Survey

Figure 3.23 Comparison of bathymetry near the Cape Fear River tidal inlet showing bathymetry from the 2000, 2002, 2003 &2004

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 where the upper panel shows the inlet region and the lower panel shows the new channel area. As noted on the legend, areas of erosion are indicated in shades of red and infilling areas are in shades of yellow.

As indicated in Figures 3.24 and 3.25 one of the primary changes over the most recent period is the infilling within both the old and new navigation channels. In this regard, the changes within the new channel reflect shoaling over the period as the January 2004 survey was taken just after completion of the Clean Sweep I dredging contract. In contrast, the gain shown within the old channel alignment resulted primarily from the use of this area as a disposal area for other dredging contracts within the Cape Fear. Another area of minor accretion is found along the outer edge of Jay Bird Shoals just to the northwest of the old channel. An additional area of change worth noting is in the v-shaped intersection of the old and new channels. Within the inside of the "v" the slumping and erosion of the shoal is evident. This shape persisted for some time following the initial cut of the new channel, but now is beginning to erode away by action of relatively strong tidal currents.

Along the edge of Oak Island, shown in the upper portion of the figures, accretion is evident along the immediate shoreline. However an area of erosion is found just offshore within the developing flood margin channel fronting the tip of the island.

For the area in the vicinity of the tip of Bald Head Island a somewhat complex pattern is evident for the change in bathymetry. Foremost is the deepening within the channel immediately off the point within the channel margin and along the edge of Bald Head Shoal. Most of this is attributed to the Clean Sweep II dredging activity which was completed in January 2005 just before the most recent ebb shoal survey. In contrast to this deepening, the changes in bathymetry also show two prominent areas of accretion. One is along the western edge of Bald Head Shoal near the deepened channel margin and the other is within the spit area at the western end of South Beach.

In addition to the most recent changes in the ebb tidal bathymetry, Figure 3.26 shows the changes which have occurred since the initiation of the monitoring program. This figure compares the August 2000 pre-project survey with the most recent, March 2005, survey. Detailed insets for the inlet region and the new channel area are given in Figure 3.27. Some of the same patterns described above for the more recent time period are also present over the total monitoring period. For example, infilling due to the disposal of dredged material is present within the old channel prism. A zone of accretion is apparent within the offshore portions of Jay Bird Shoals as well.

The major excavation of the realigned new channel is very prominent in the figure that was cut through relatively shallow portion of the ebb tidal to project depths of 42 feet (12.8 meters). The channel deepening is evident as well from the outer bar channel through the inlet between the two islands. The final most noteworthy change is the ribbon of accretion present along the west edge of Bald Head Shoal and along the immediate southwest tip of Bald Head Island. This ribbon of infilling also extends northward within in the inlet paralleling the eastern edge of the channel.

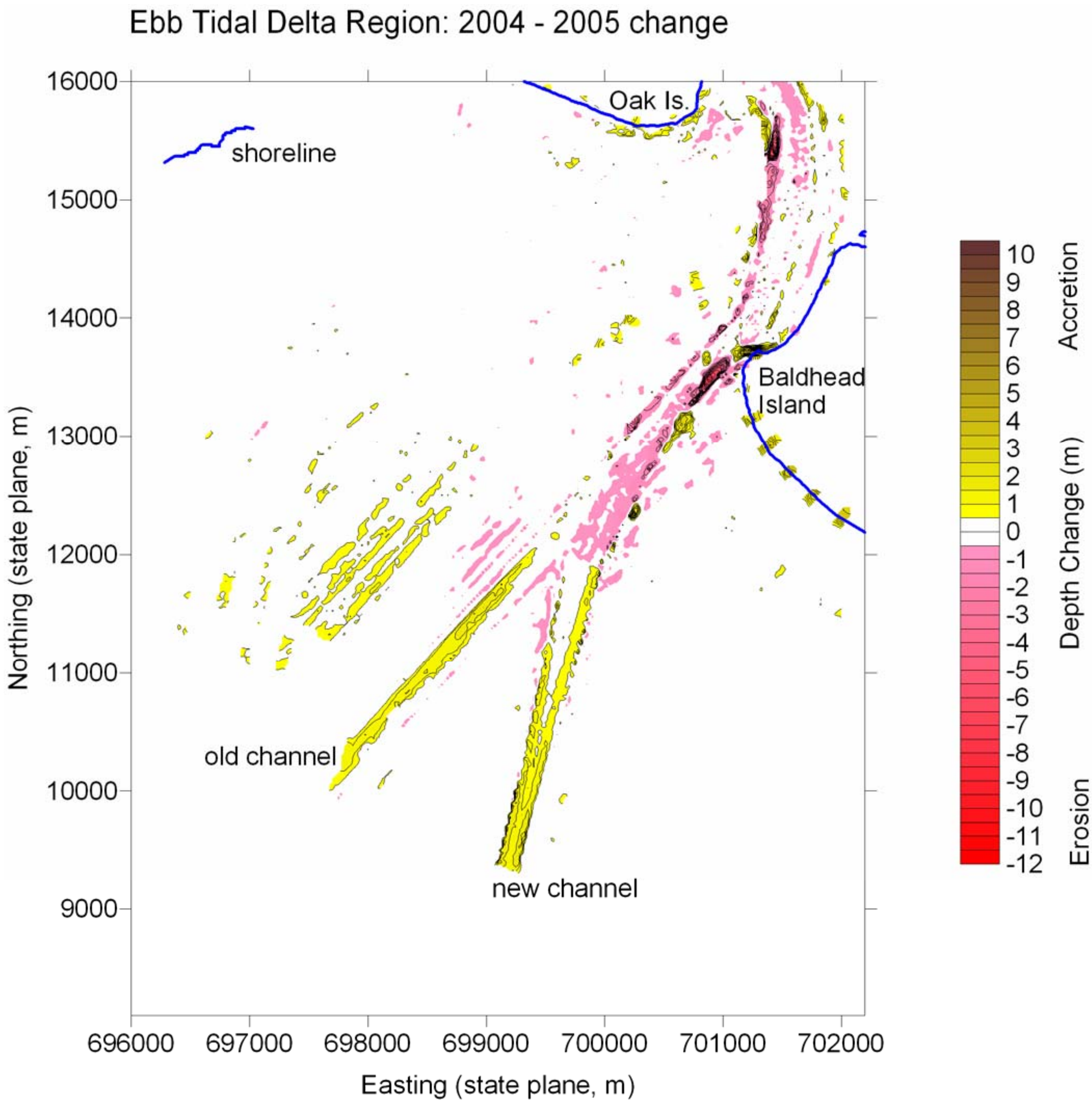


Figure 3.24 Bathymetric Changes of the Ebb Tidal Delta (January 2004 to March 2005)

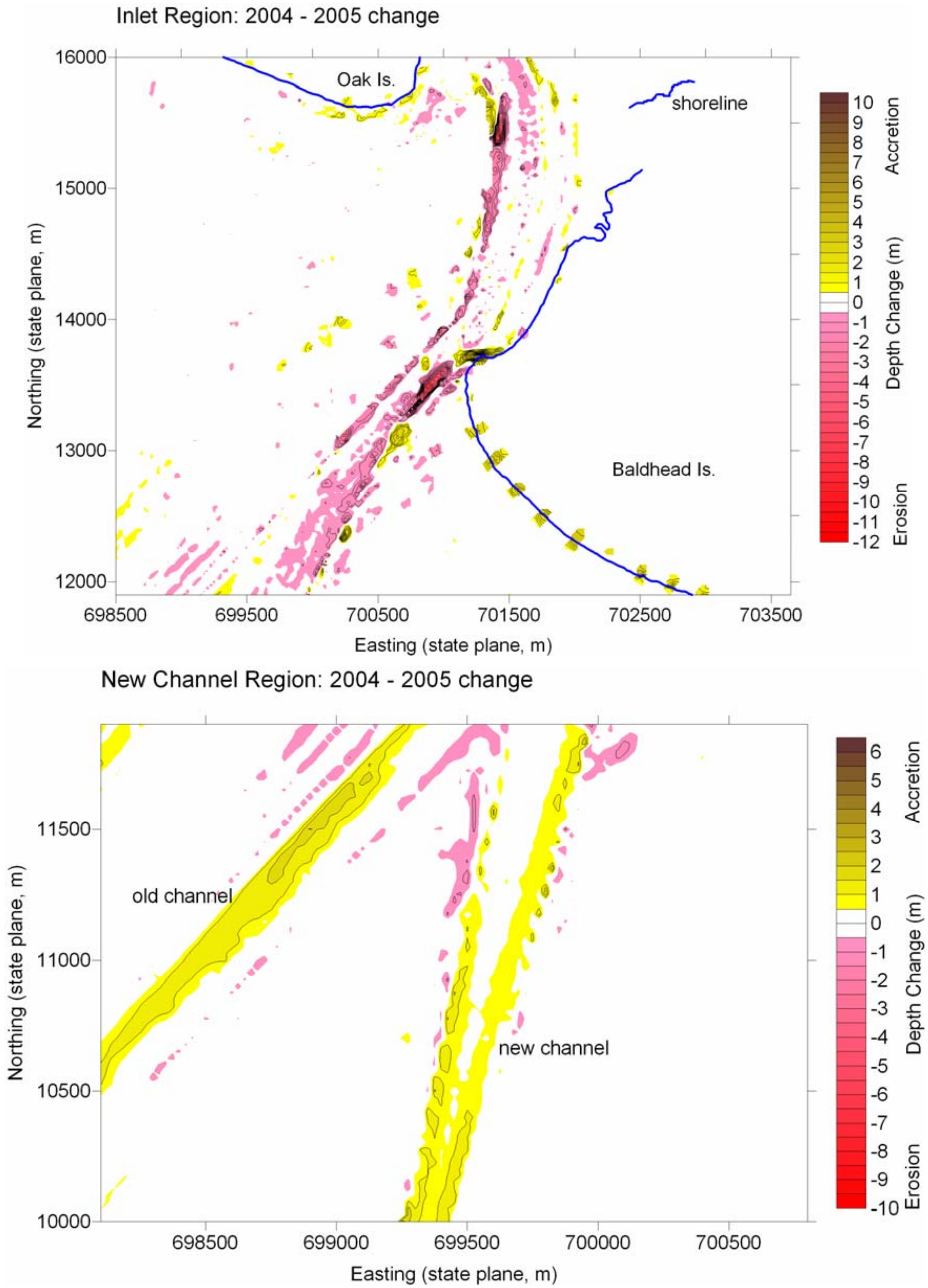


Figure 3.25 Bathymetric Changes of Inlet (upper panel) and New Channel (lower panel) between January 2004 and March 2005

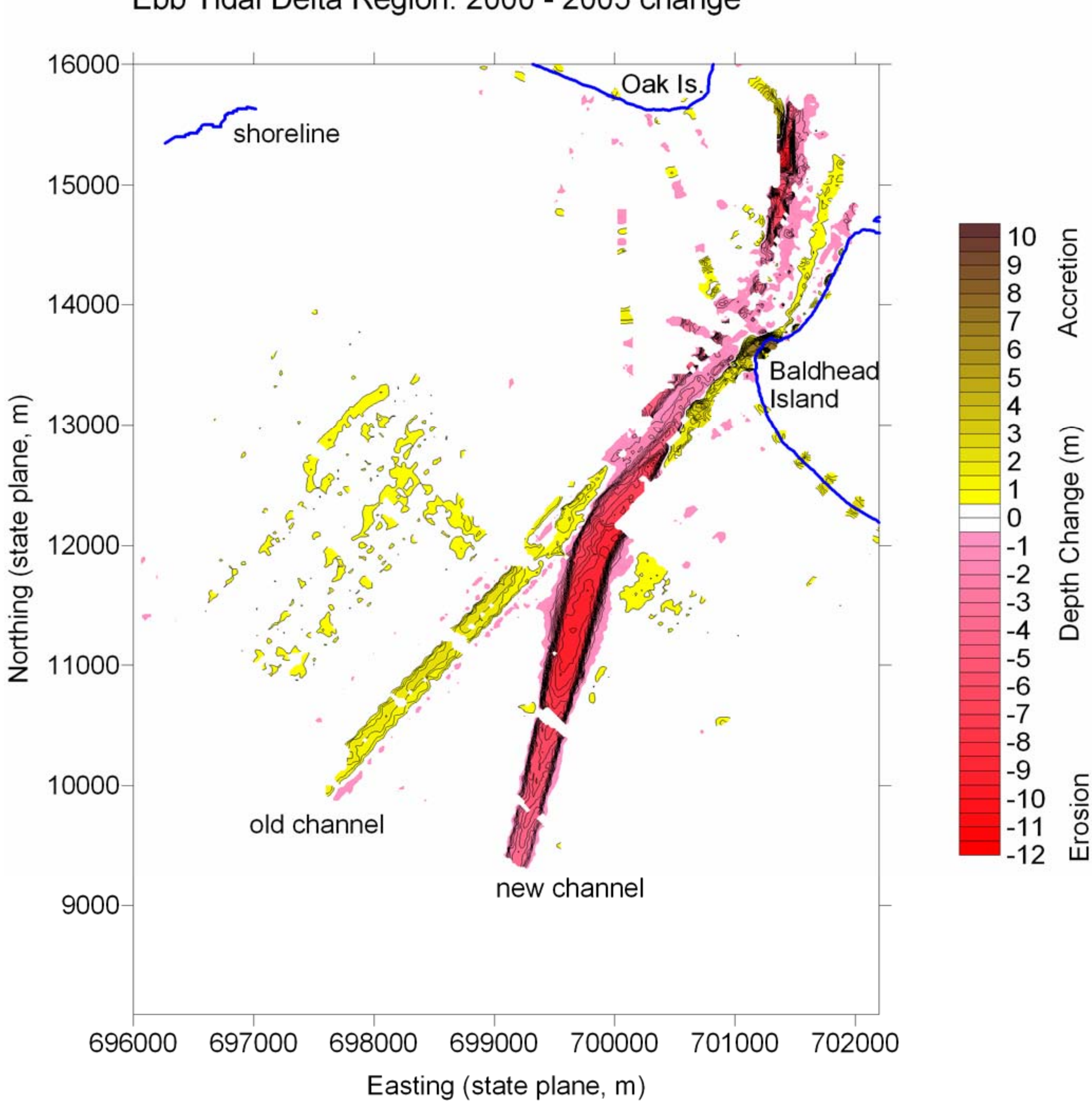
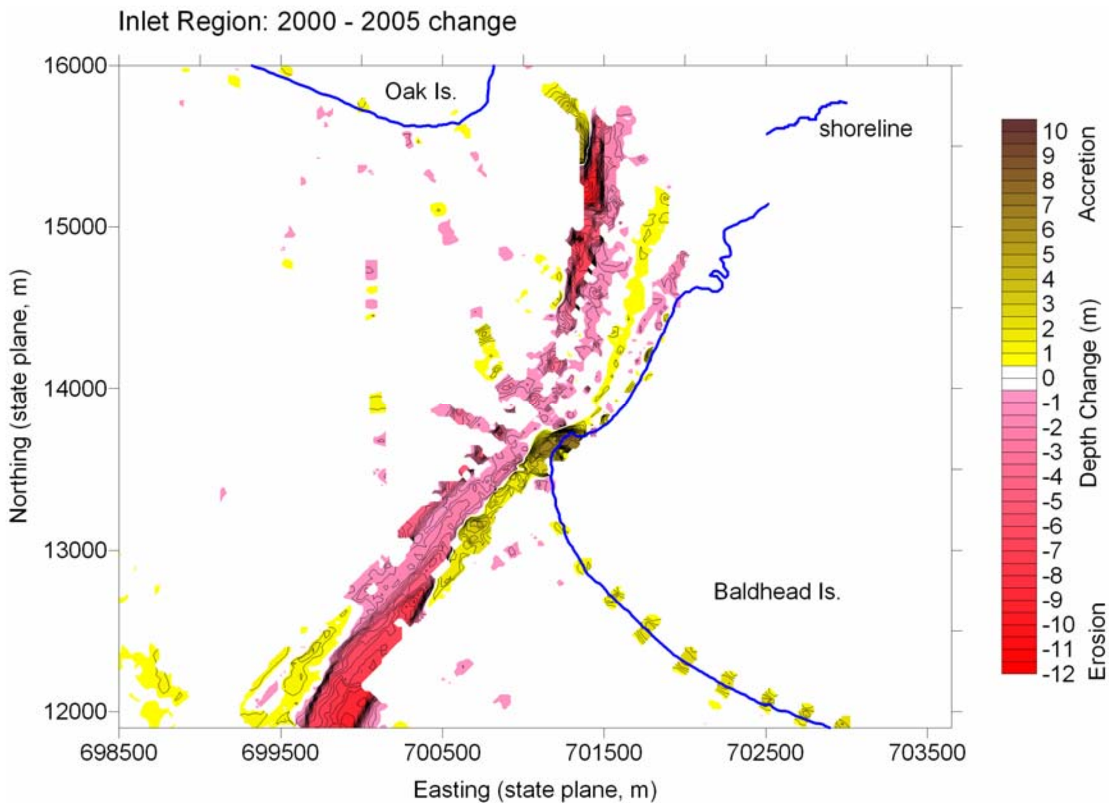


Figure 3.26 Bathymetric Changes of the Ebb Tidal Delta (August 2000 to March 2005)



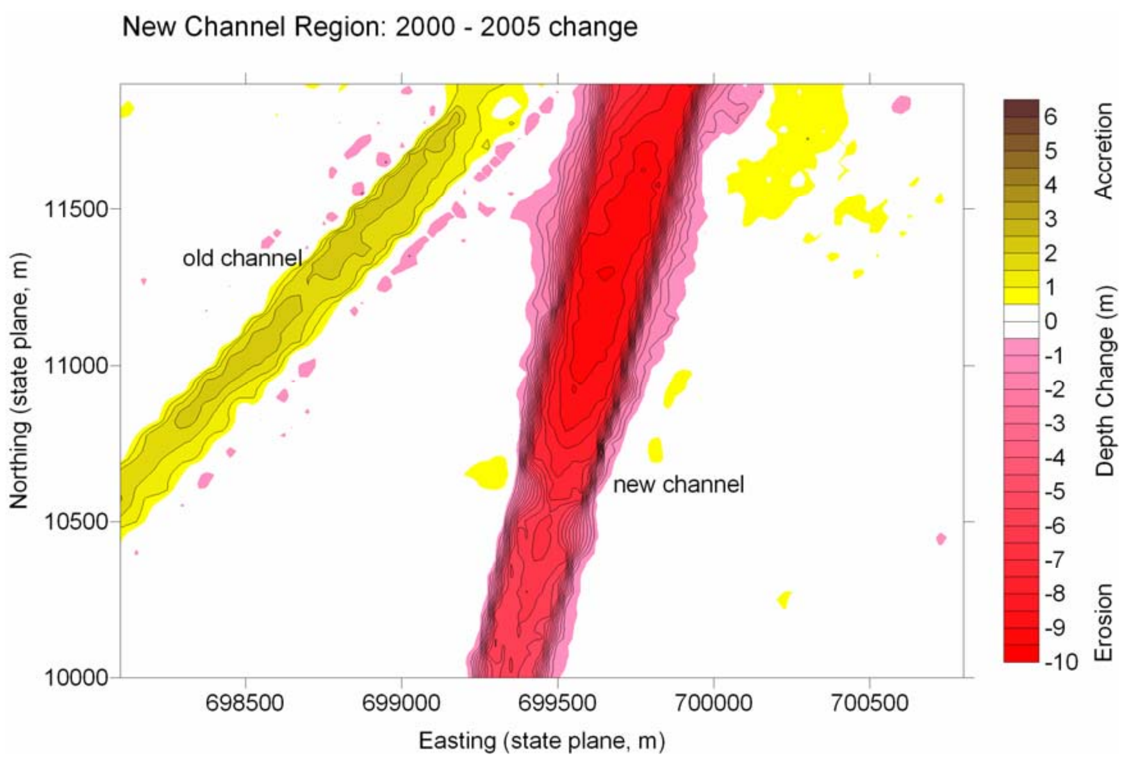


Figure 3.27 Bathymetric Changes of Inlet (upper panel) and New Channel (lower panel) between August 2000 and March 2005

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. The instrument used for these surveys was a 600 kHz *Workhorse Rio Grande* manufactured by RD Instruments. Two +13-hour transects were performed during each survey episode. To date five 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 9-10, 2005. 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 and McNinch 2004a. Further, the most recent current data collection effort and results are detailed in Part 3 of USACE 2005a.

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

The specific location of the two survey transects are shown on Figures 3.29 and 3.30 for the March 2005 measurements. The vessel steamed continuously around each transect for over 13 hours, making a complete loop every hour or less. This technique provided a measure of current magnitude and direction at every location along the transect every hour and spanned the periods of the primary tidal constituents (M2, S2). Other variables that typically force currents in tidal inlets, such as wind-driven flows and river discharge, were also incorporated within the 13-hour snapshot of currents.

Wind conditions prior to each of the surveys were relatively light and did not likely play a significant role in the measured flows. Although only a long-term time series of currents and water level around the inlet could precisely determine the relative percentage of influence the various tidal constituents and meteorological forces (wind, discharge) may play, the transect measurements are believed to reflect near maximum magnitudes for astronomical flows, and the spatial patterns seen across the transects fairly characterize recurring flow directions under similar conditions. The goals motivating the design of the transect locations and the ADCP measurements are to 1) measure ebb/flood exchange and calculate a tidal prism, 2) qualitatively assess changes or similarities in flow patterns around the ebb tidal delta through time, and 3) provide critical verification and calibration for future numerical simulations of mean currents as needed.

Tidal Inlet Region Results. The results of each transect were processed and analyzed in a time series for each hourly loop. A sample of the graphics used to visualize the results is given in Figure 3.31 for the inlet tidal region. In this figure the magnitude and direction of near-surface (red vectors) and near–bottom (blue vectors) flow patterns are shown every 50 meters (164 feet) in plan view shown in the upper left panel. Current magnitude across the channel, from points B to A is shown in the upper right panel while the time of the survey transect relative to water level elevation is shown in the lower panel.

Figures 3.32 and 3.33 show the details of the flow patterns during times of peak flood and peak ebb, respectively, for the March 2005 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, such that two peaks are evident along the inlet transect A-B. 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 other is an eddy off the main flow that is evident in the lee of the point at the juncture between South Beach and West Beach. For comparison purposes, the similar peak flood flow patterns from the prior measurements collected in Oct 2000, April 2002, March 2003 and Jan 2004 are shown in Figures 3.34 through 3.37, respectively.

As with the peak flood conditions, the peak ebb flow patterns (Figure 3.33) 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 and Jan 2004 are shown in Figures 3.38 through 3.41, respectively.

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.3 for the inlet region. The 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 near-bottom measurement, 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 four 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 –4.32 ft/s (ebb) and 3.90 ft/s (flood) versus 3.48 ft/s and 3.28 ft/s, respectively. For the near-surface case, the average values are likewise –5.33 ft/s (ebb) and 4.11 ft/s (flood), versus -4.43 ft/s (ebb) and 3.61 ft/s (flood) as shown in the table.

Table 3.3 Maximum Magnitude of Mean Flows at Inlet Transect

		October 2000	**April 2002**	**March 2003**	**January 2004**	**March 2005**
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)	4.42 ft/s (1.35 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)
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)
	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)
*Near-bottom defined by lower half of water column; near-surface defined by upper half of water column						

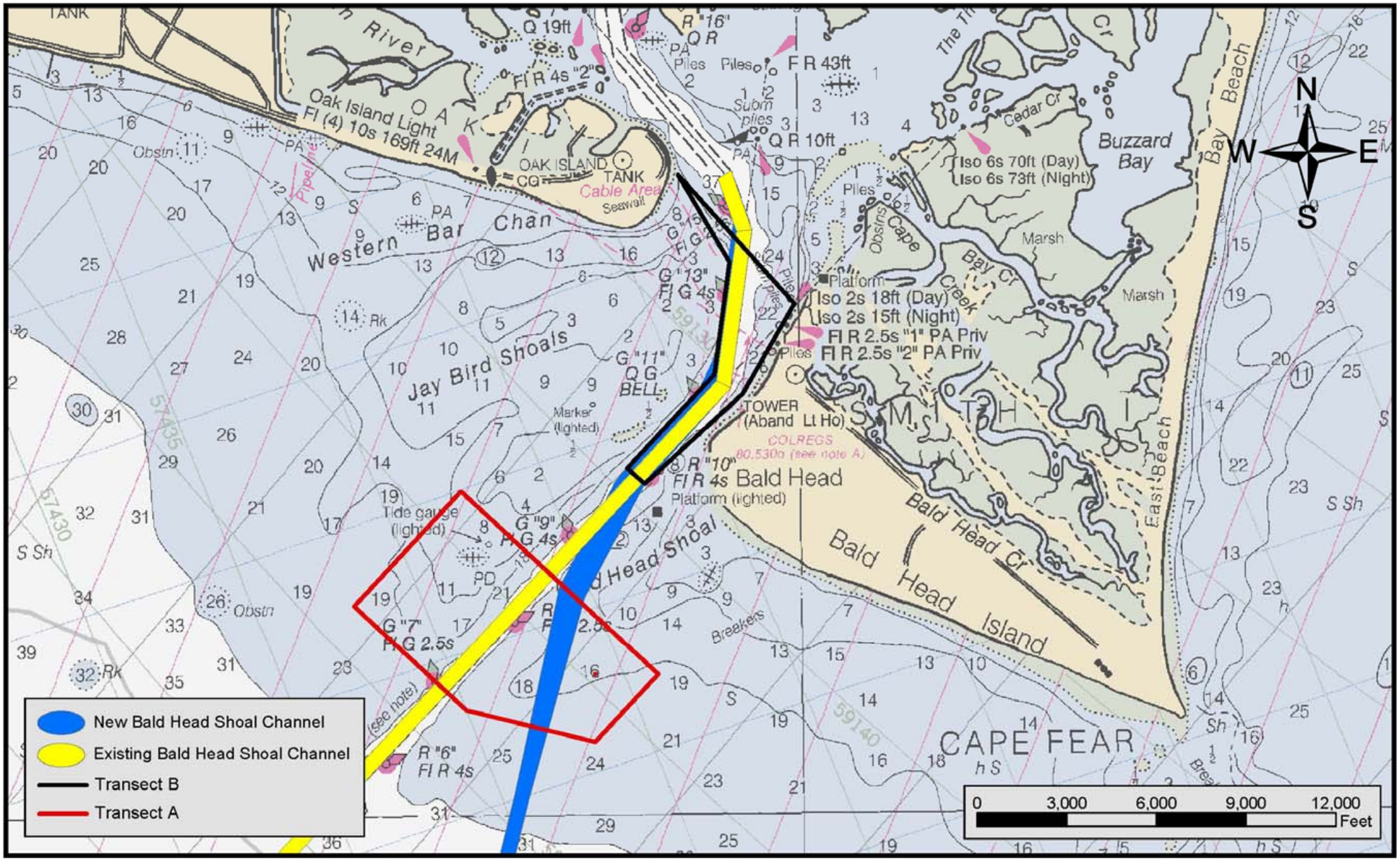


Figure 3.28 Ship-Board current profile track lines

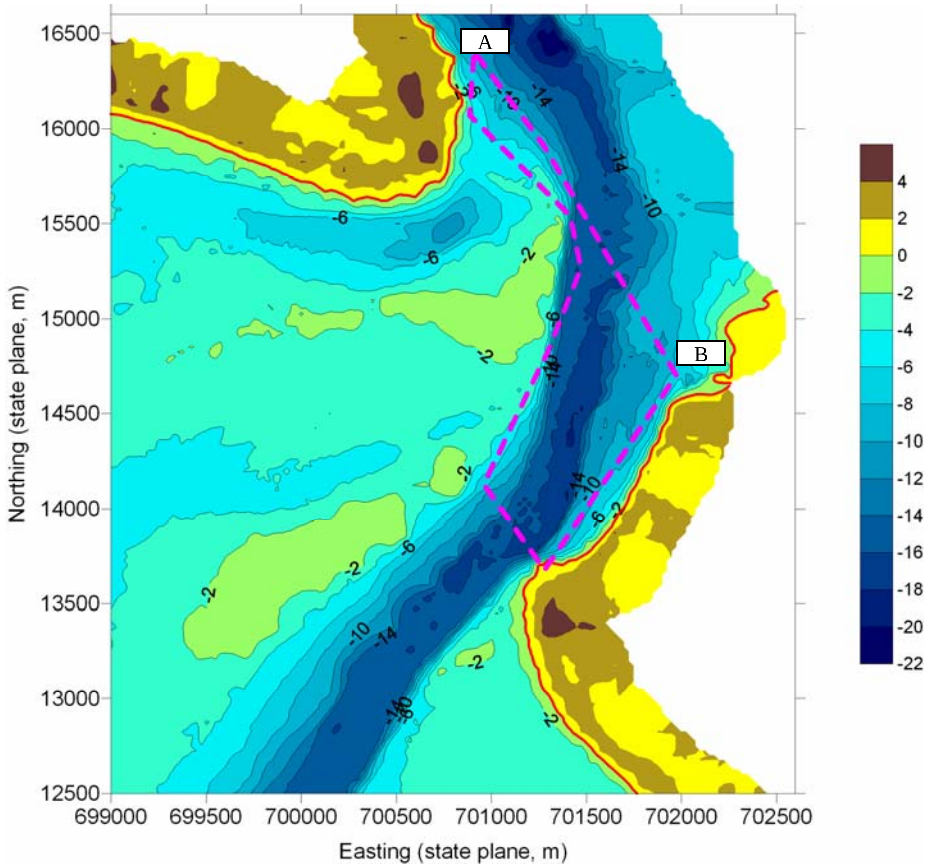


Figure 3.29 Plan View Showing the ADCP Transect in the Inlet Collected 10 March 2005

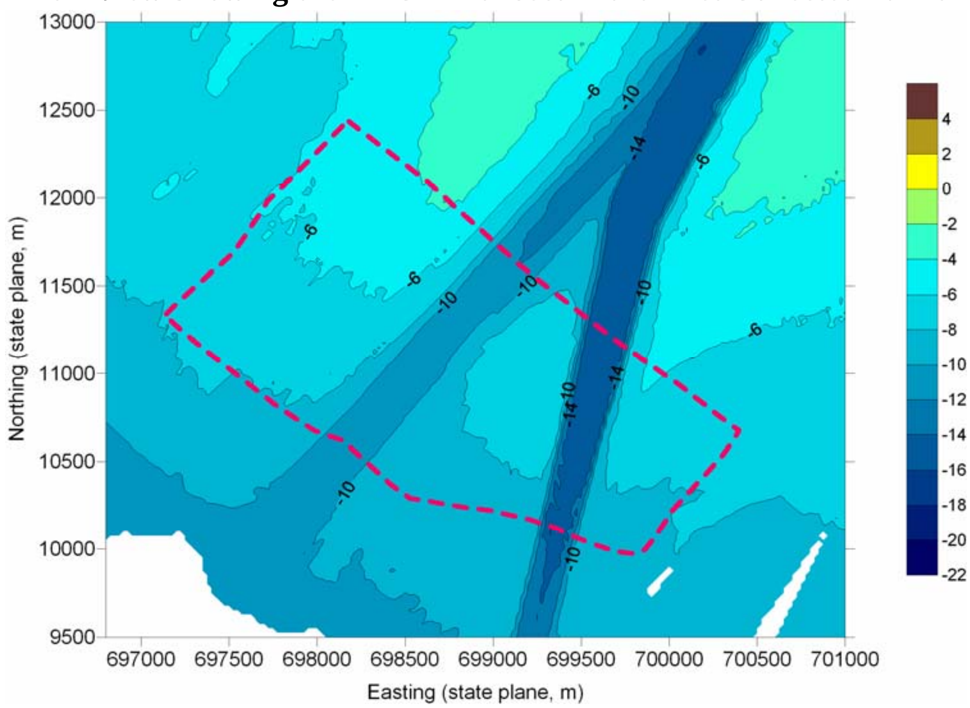
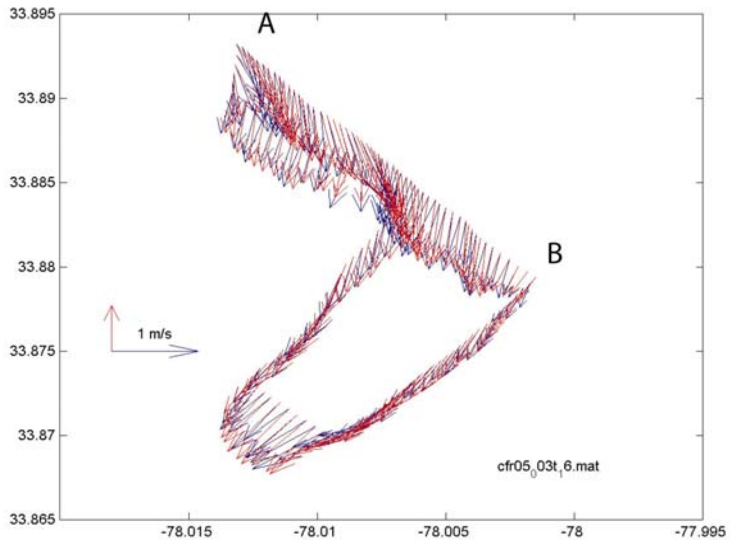
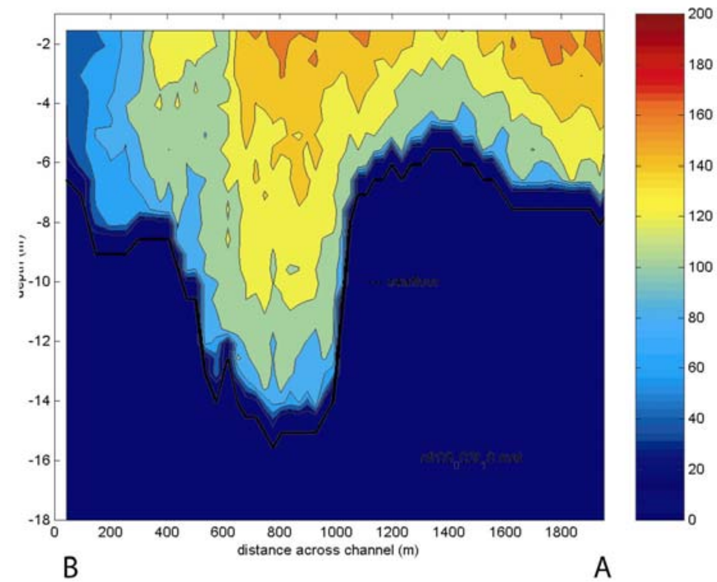


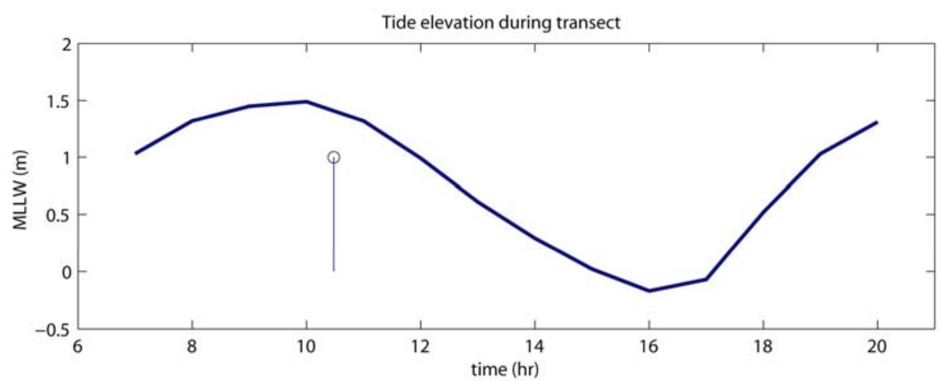
Figure 3.30 Plan View Showing the ADCP Transect in the New Channel Collected 9 March 2005

Upper left panel shows current velocities
As vectors along the transect (~ 50 m) where red represents the near-surface and blue is near-bottom



Upper right panel shows current magnitude in cross-section from A to B. Magnitude is shown in units of cm/s.





Lower panel shows the time relative to water level during which the transect was conducted.

Figure 3.31 ACDP results from one transect around the tidal inlet area

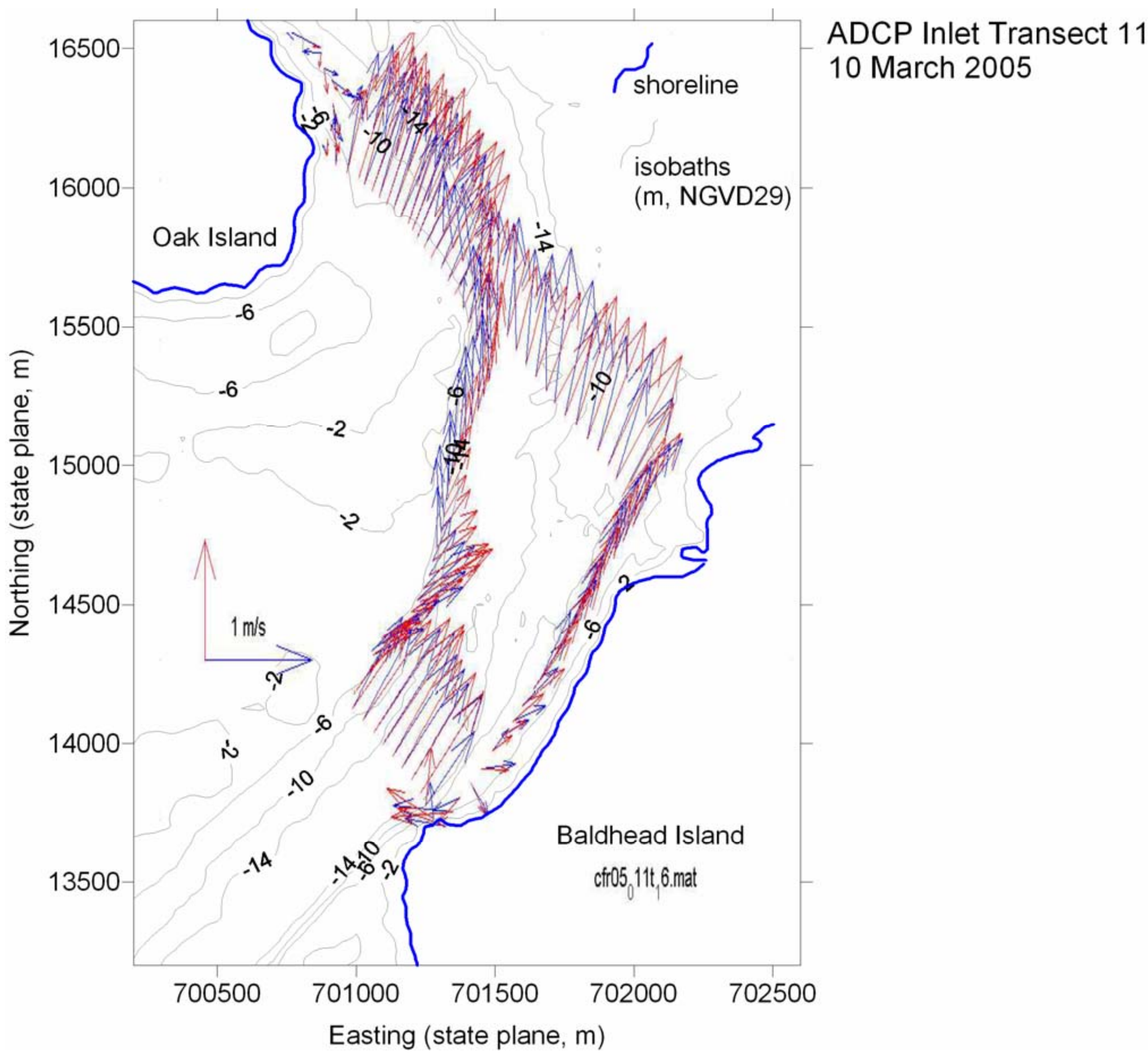


Figure 3.32 March 2005 ADCP survey at the inlet transect during peak flood flow

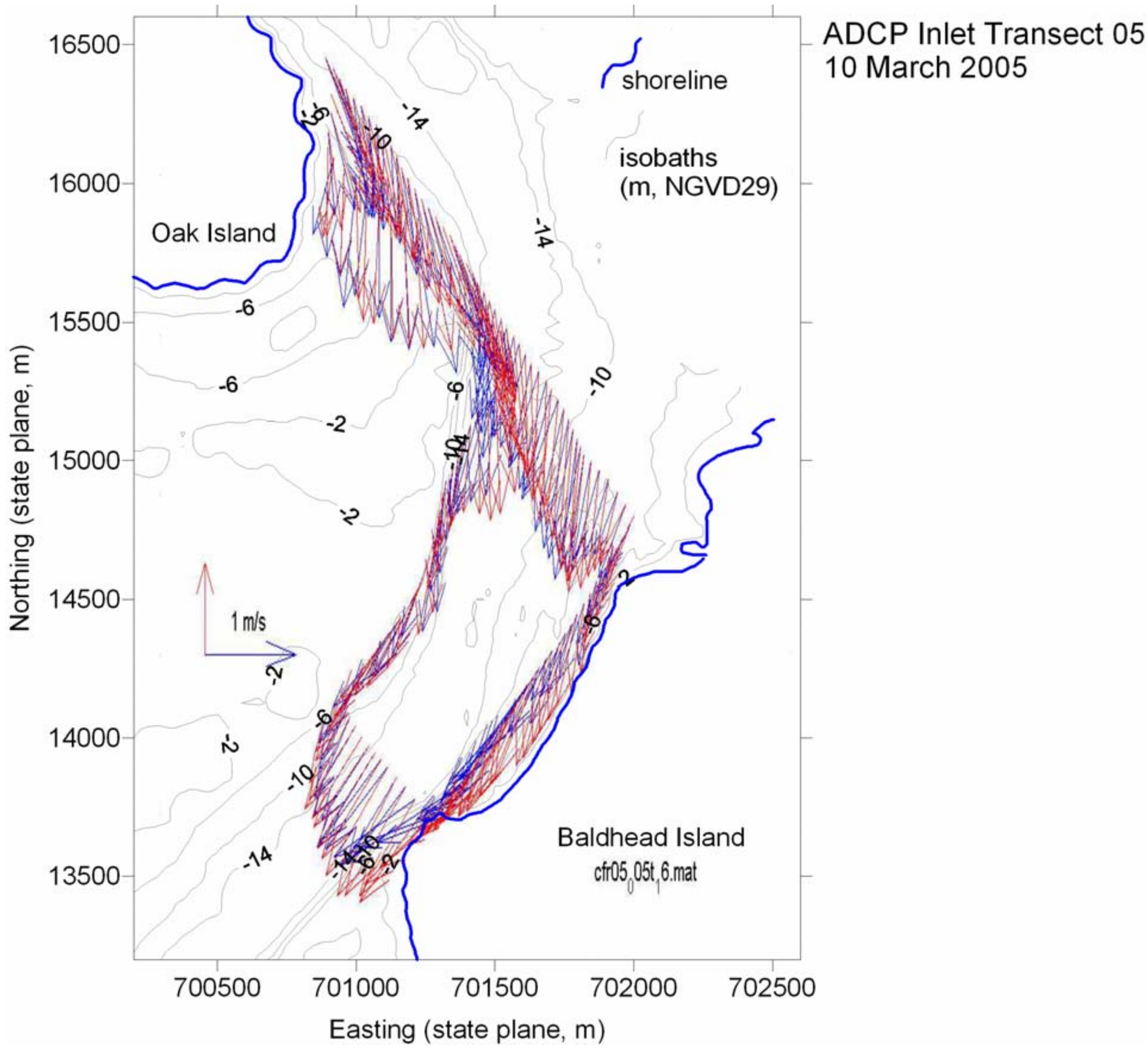


Figure 3.33 March 2005 ADCP survey at the inlet transect during peak ebb flow

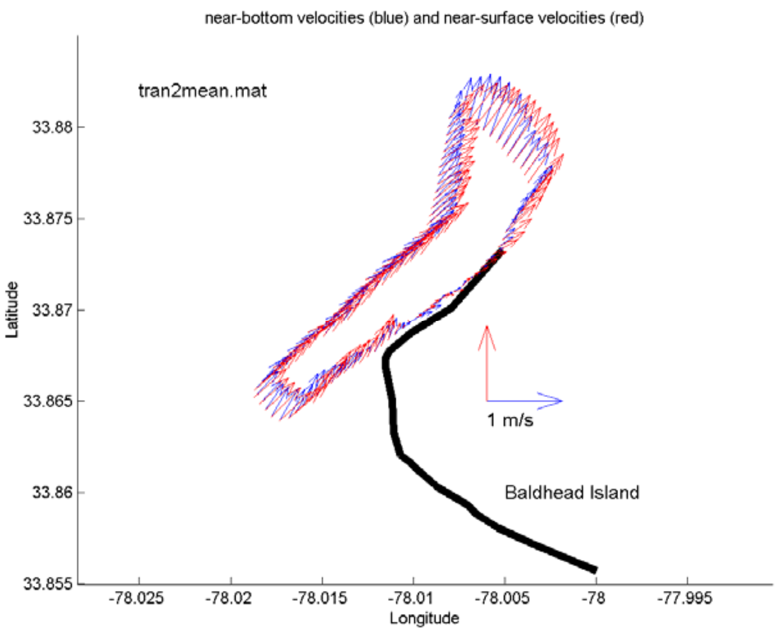


Figure 3.34 October 2000 ADCP survey at inlet transect during peak flood flow. Note that survey transect does not cover same area as the April 2002, March 2003 and January 2004 surveys.

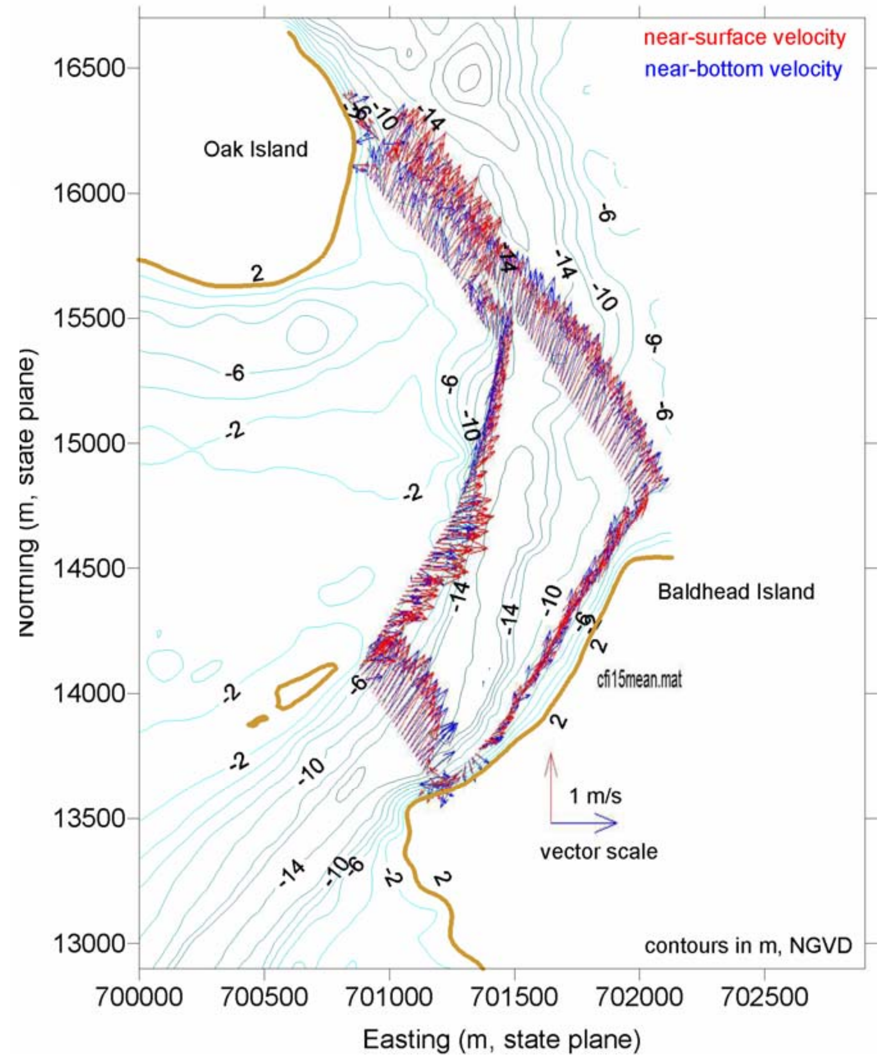


Figure 3.35 April 2002 ADCP survey at inlet transect during peak flood flow.

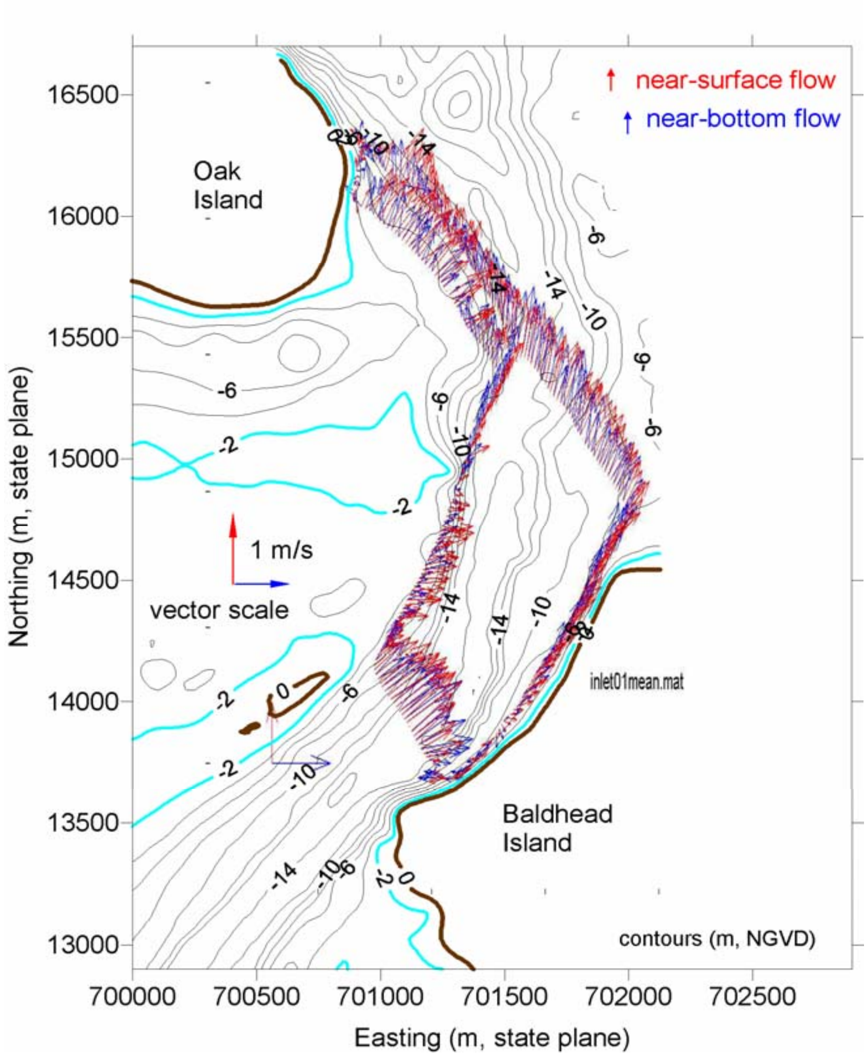


Figure 3.36 March 2003 ADCP survey at inlet transect during flood flow.

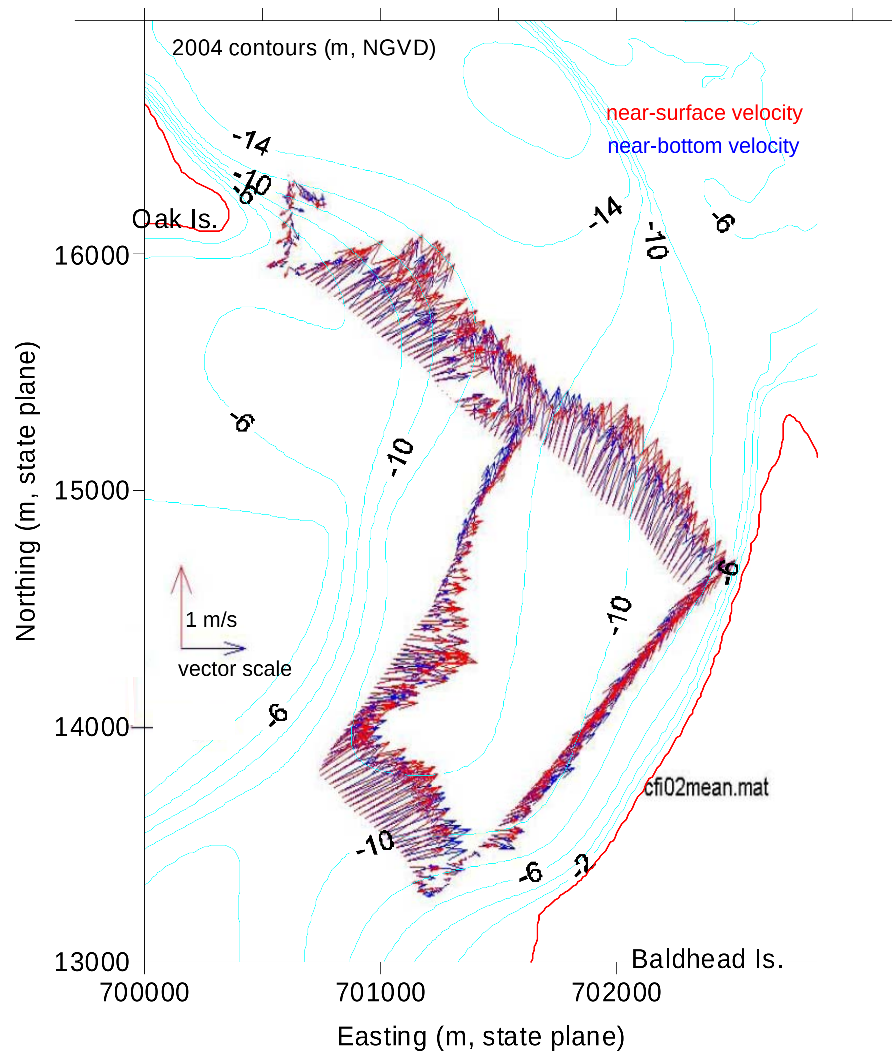


Figure 3.37 January 2004 ADCP survey at inlet transect during flood flow.

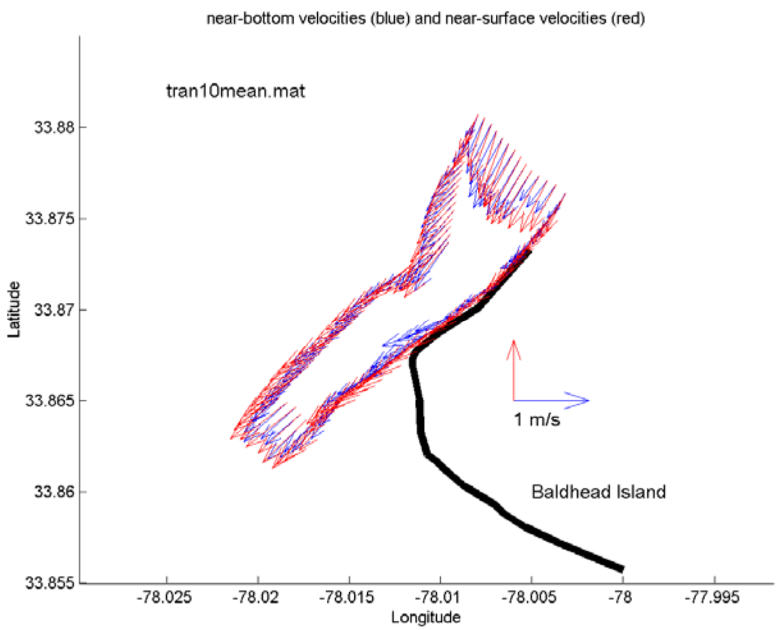


Figure 3.38 October 2000 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the April 2002 survey.

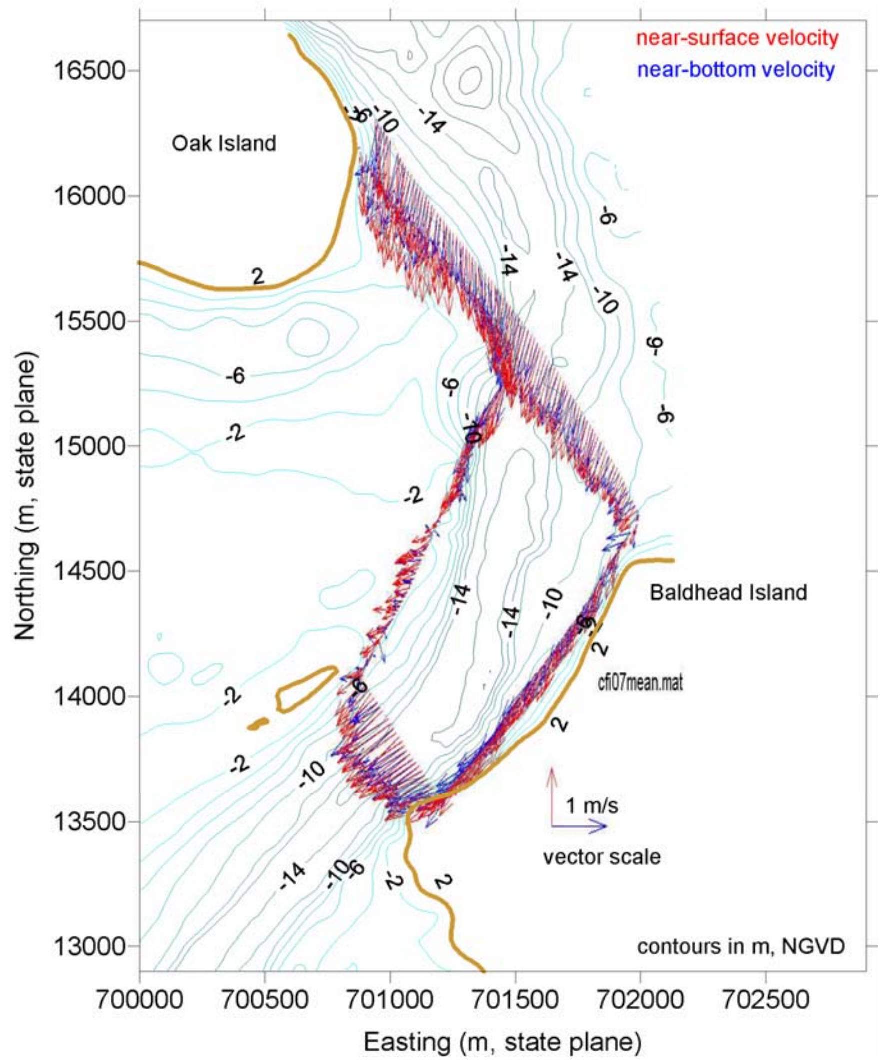


Figure 3.39 April 2002 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the October 2000 survey.

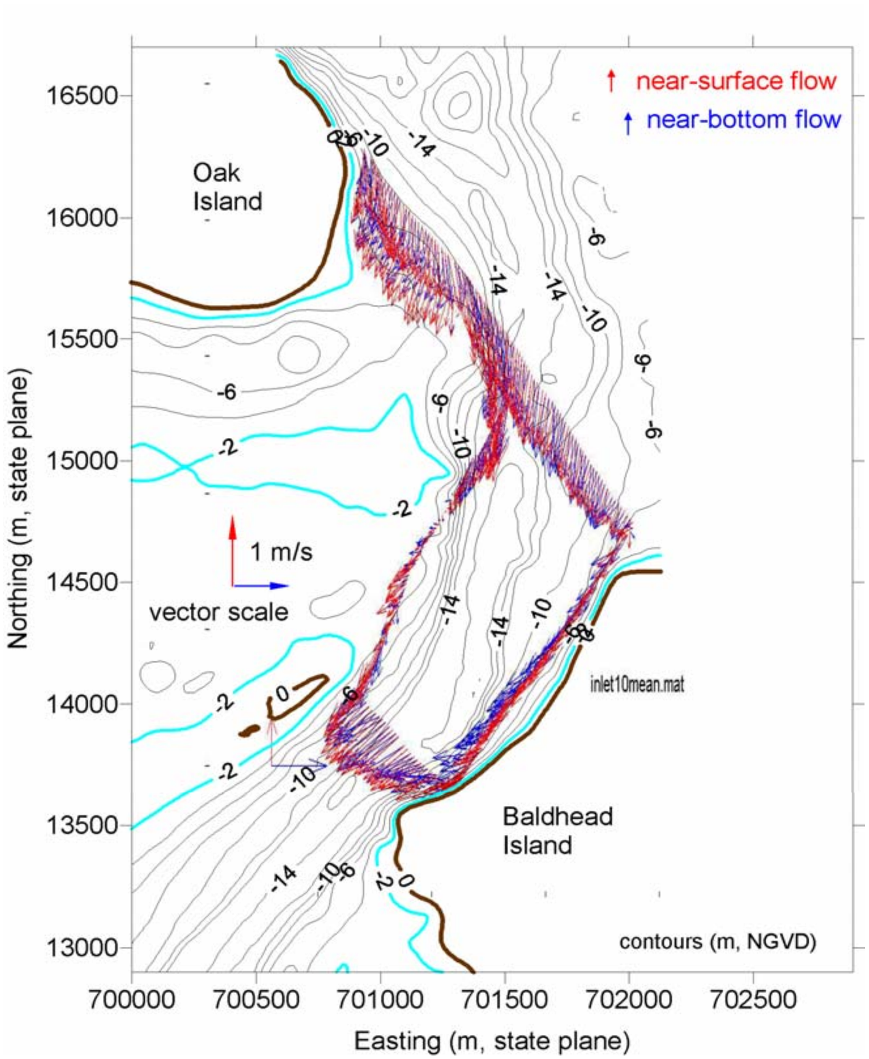


Figure 3.40 March 2003 ADCP survey at inlet transect during ebb flow.

to predict

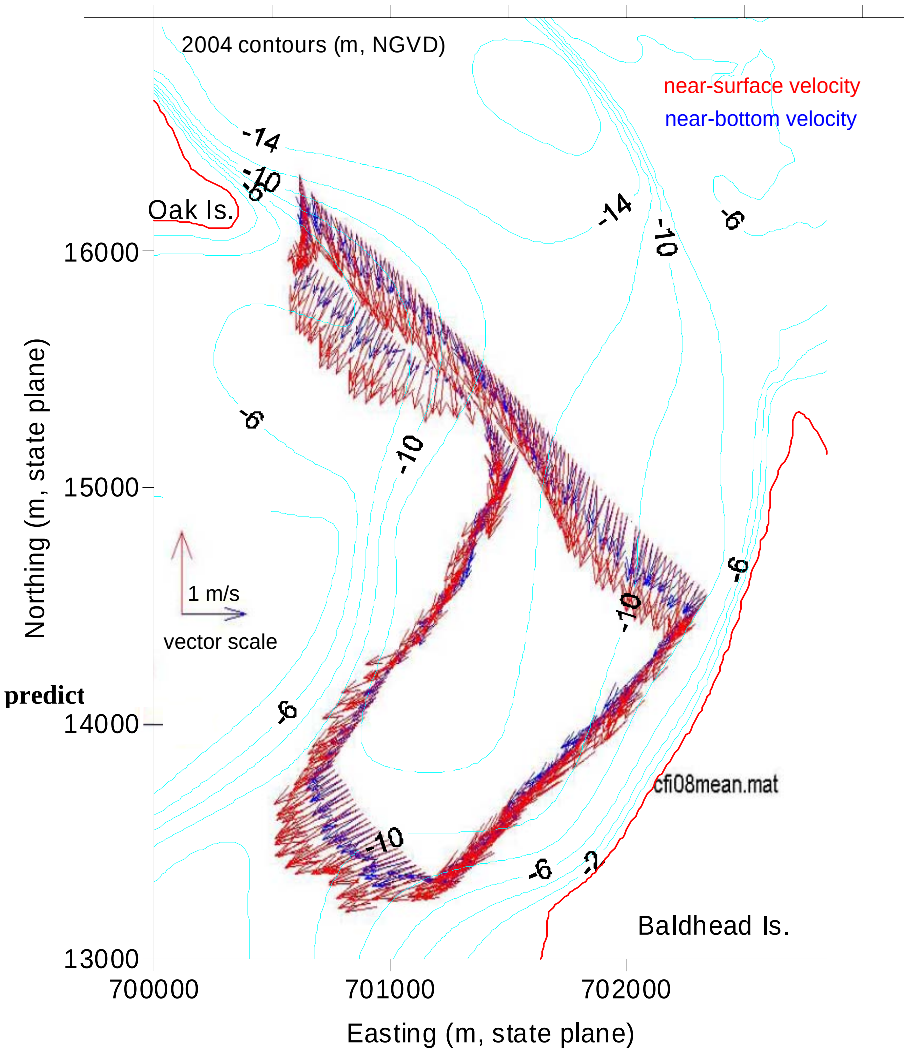


Figure 3.41 January 2004 ADCP survey at inlet transect during ebb flow.

Tidal Prism. Tidal prisms were computed using the inlet throat transect (A-B Figure 3.29) for each of the five current measurements—pre-construction (October 2000) and post-construction (April 2002, March 2003, January 2004, and March 2005) ADCP surveys. The tidal prism is the total volume of water passing through the inlet over the tidal period and is displayed graphically for each of the survey dates in Figure 3.42. 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 3.4 summarizes the tidal prism computations and the results are shown graphically in Figure 3.43.

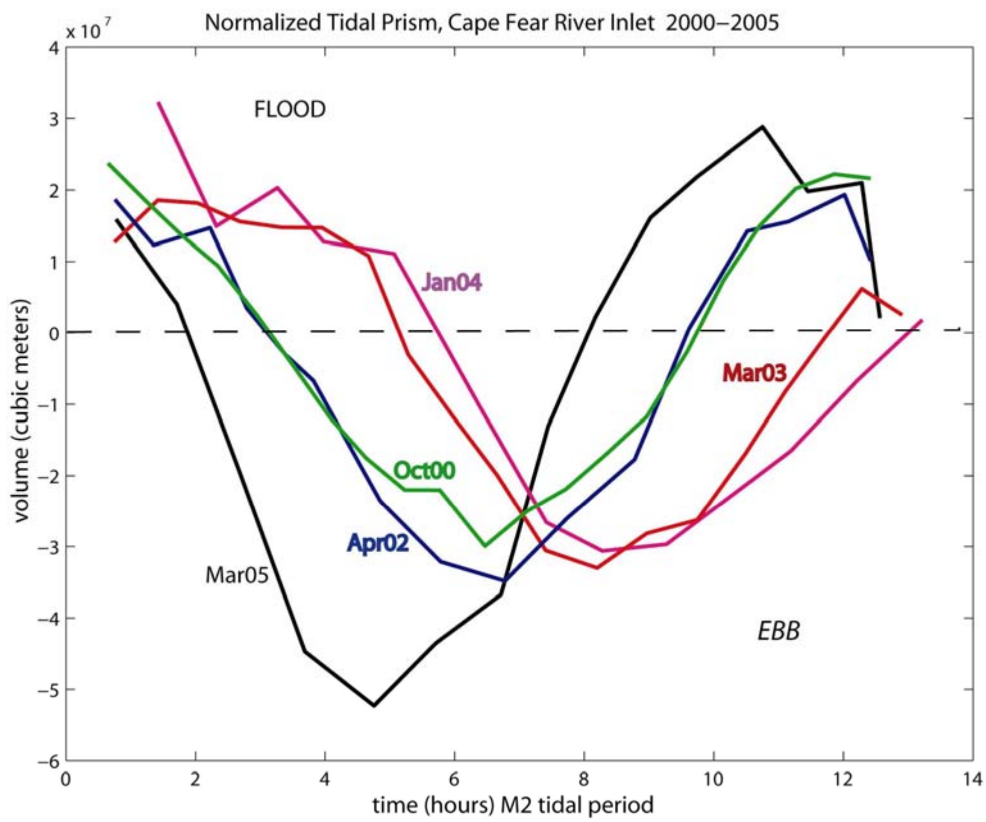


Figure 3.42 Volume of Water Passing through the inlet over the tidal period for all ADCP surveys to date

Table 3.4 Normalized Tidal Prism Values for each of the ADCP Surveys

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

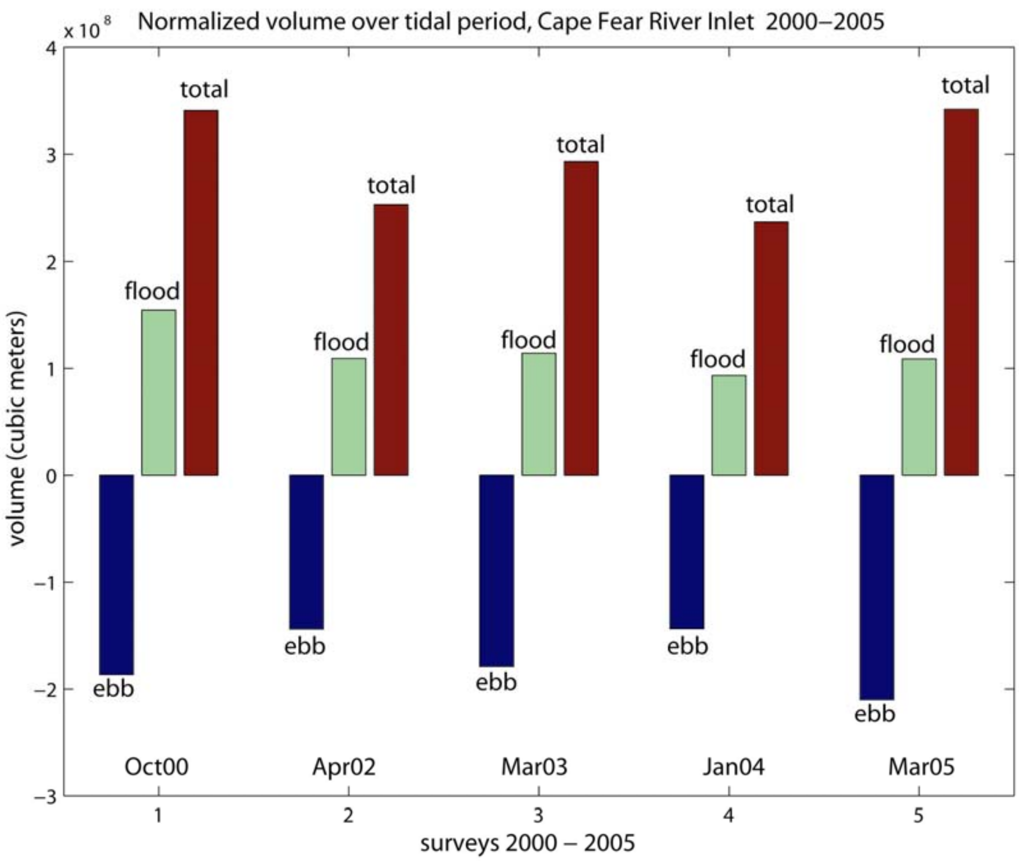


Figure 3.43 Normalized tidal prism for five surveys—(1) October 2000, (2) April 2002, (3) March 2003, (4) January 2004 and (5) March 2005. Blue—ebb, Green—flood, Red—total

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 3.43.

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.

One of the strengths of ADCP surveys is to provide calibration and verification data for use in applying numerical simulation models of tidal currents and circulation. With a calibrated and verified hydrodynamic model, multiple scenarios of different bathymetric conditions and channel alignments can be examined to explore relative differences in tidal currents and prism. For example, an acceptable hydrodynamic model like ADCIRC could be run with waves, bathymetry and channel configurations at the time of each ADCP survey and thus calibrated so that different bathymetric and channel configurations (e.g., old channel alignment) with the same wave conditions could be examined for comparison of tide ranges and tidal prisms. This type of modeling is planned for future monitoring reports if funding is available.

Offshore-New Channel Region Results. 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. A sample of the graphics used to visualize the results is given in Figure 3.44 for the offshore-new channel region. In this figure the magnitude and direction of near-surface (red vectors) and near –bottom (blue vectors) flow patterns are shown every 50 meters (164 feet) in plan view shown in the upper left panel. Current magnitude across the channel, from points B to A is shown in the upper right panel while the time of the survey transect relative to water level elevation is shown in the lower panel.

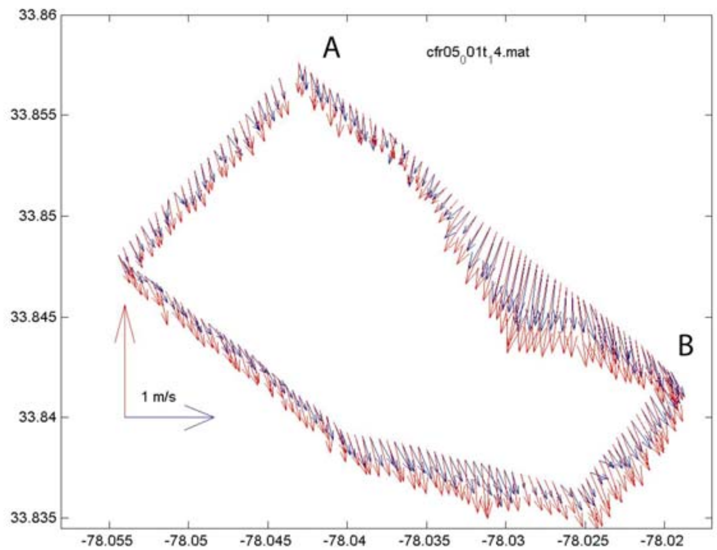
Figures 3.45 and 3.46 show the details of the flow patterns during times of peak flood and peak ebb, respectively, for the March 2005 measurements. These flow patterns are generally similar with those measured on previous occasions and reach peak velocities on the order of 1 m/s (3.3 fps). During peak 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 and Jan 2004 are shown in Figures 3.47 through 3.50, respectively.

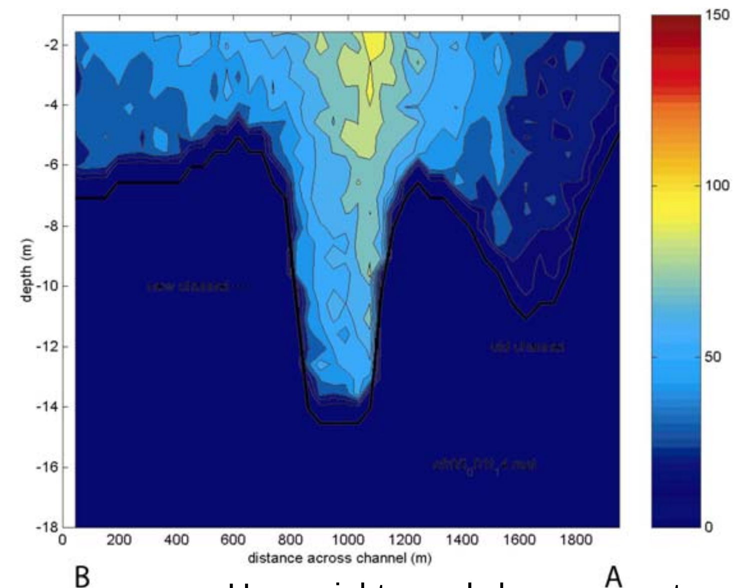
The peak ebb in the offshore transect is found to start in the new channel and shift to the old ebb channel location. At peak flow the strongest ebb is located between and within the old and new channel regions. Outside of this region the ebb flows are greatly reduced particularly around Jay Bird Shoals (Figure 3.46). The similar peak ebb flow patterns from the prior measurements collected in Oct 2000, April 2002, March 2003 and Jan 2004 are shown in Figures 3.51 through 3.54, respectively.

The maximum near-surface and near-bottom current velocities measured throughout each of the surveys are listed in Table 3.5 for the outer transect. 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 four post-construction measurements, all of the maximum velocities are found to be greater than the measured pre-project magnitudes. As noted previously since only one pre-project survey was taken as part of the monitoring effort it is difficult to draw a firm conclusion regarding the increase in peak flows in the area of the new channel. However, this issue warrants further investigation during the proposed future modeling efforts to determine the significance of this trend in the post-project measurements. Nevertheless, it is of interest to compare the average of all the post-project values with the October 2000 values. Specifically for the near-bottom case, the average values are –3.00 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 3.5 Maximum Magnitude of Mean Flows at New Channel Transect

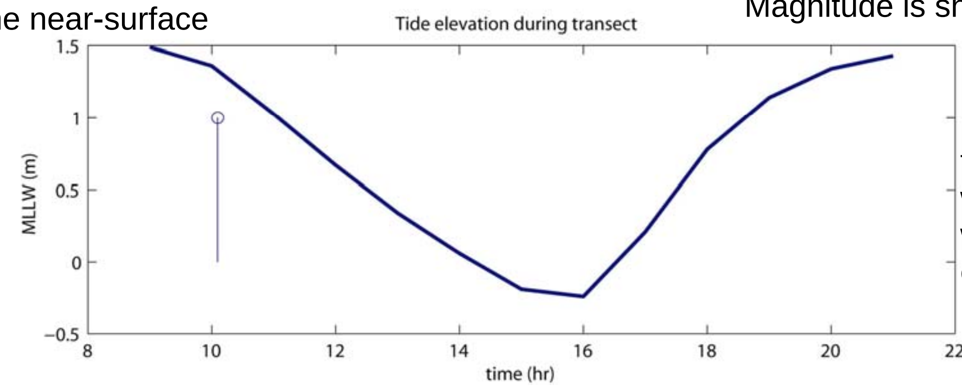
		October 2000	**April 2002**	**March 2003**	**January 2004**	**March 2005**
Near-bottom*	***ebb***	2.03 ft/s (0.62 m/s)	3.08 ft/s (0.94 m/s)	3.15 ft/s (0.96 m/s)	3.00 ft/s (0.91 m/s)	3.00 ft/s (0.85 m/s)
	flood	1.31 ft/s (0.40 m/s)	1.93 ft/s (0.59 m/s)	2.69 ft/s (0.82 m/s)	1.32 ft/s (0.40 m/s)	1.32 ft/s (0.66 m/s)
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)
	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)
*Near-bottom defined by lower half of water column; near-surface defined by upper half of water column						





Upper left panel shows current velocities
As vectors along the transect (~ 50 m) where red represents the near-surface

Upper right panel shows current magnitude in cross-section from A to B. Magnitude is shown in units of cm/s.



Lower panel shows the time relative to water level during which the transect was conducted.

Figure 3.44 ACDP results from one transect around the offshore-new channel area

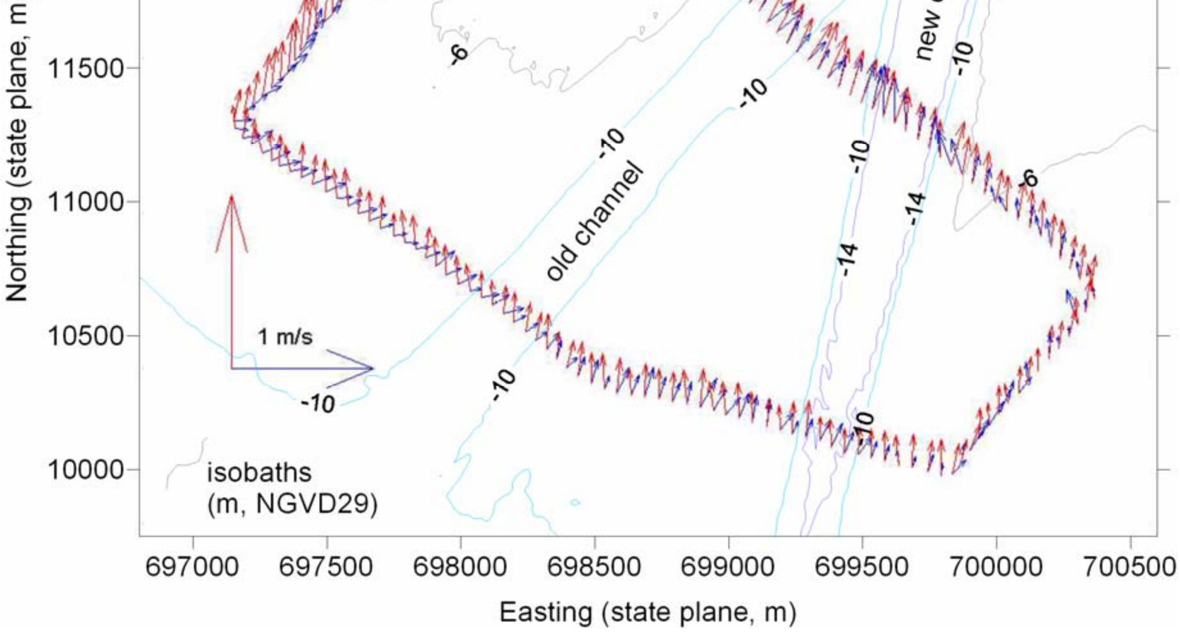


Figure 3.45 March 2005 ADCP survey at the offshore-new channel transect during peak flood flow

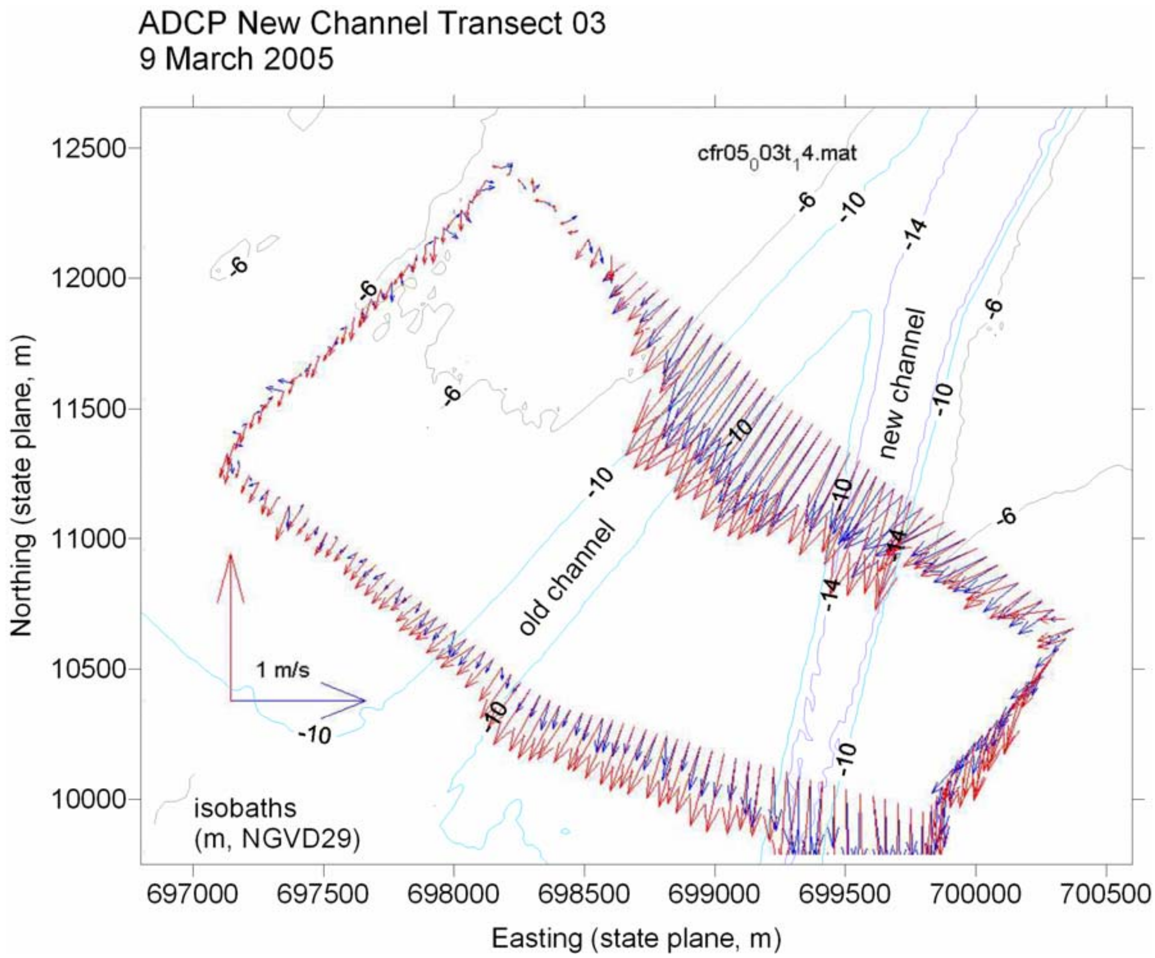


Figure 3.46 March 2005 ADCP survey at the offshore-new channel transect during peak ebb flow

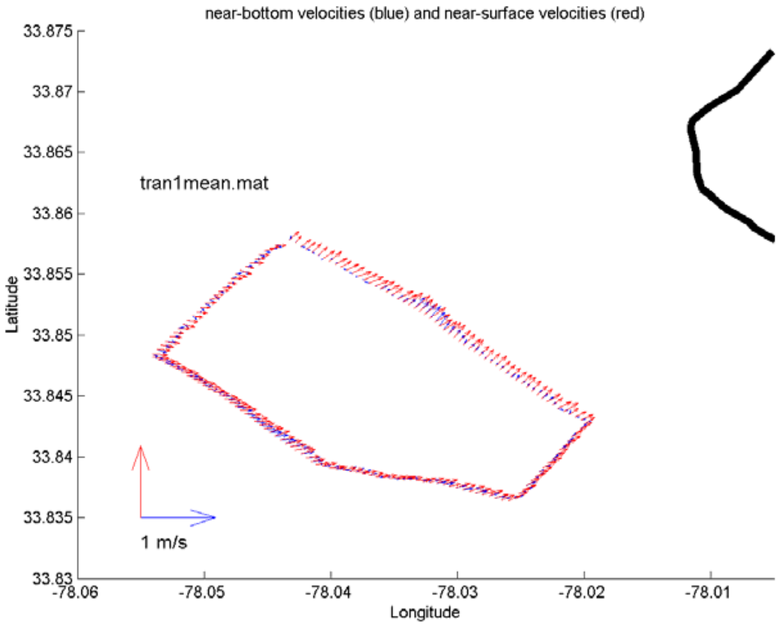


Figure 3.47 October 2000 ADCP survey at offshore transect during peak flood flow.

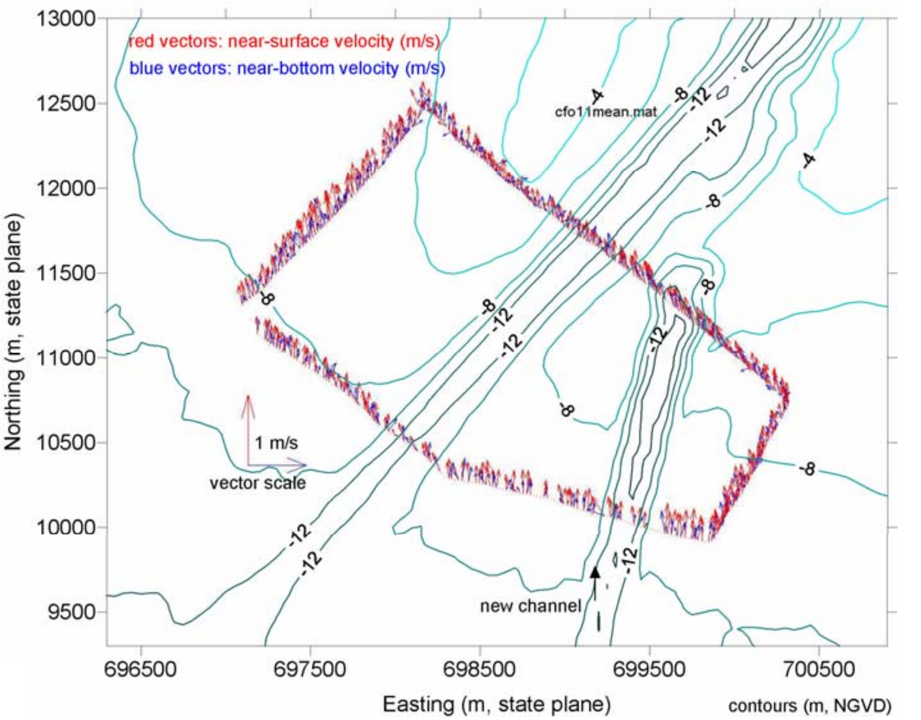


Figure 3.48 April 2002 ADCP survey at offshore transect during peak flood flow.

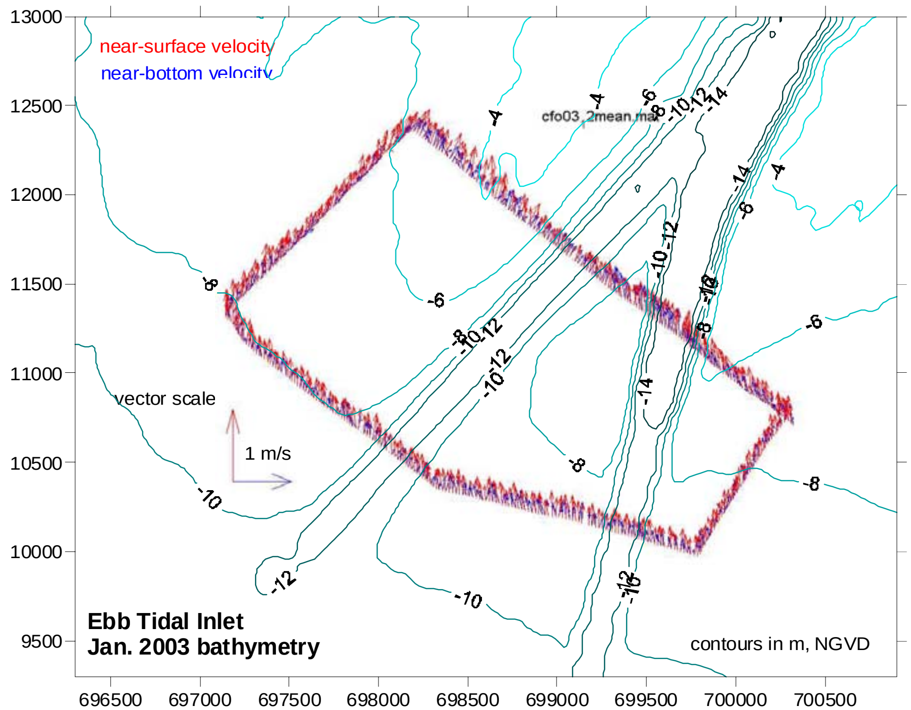


Figure 3.49 March 2003 ADCP survey at offshore transect during flood flow.

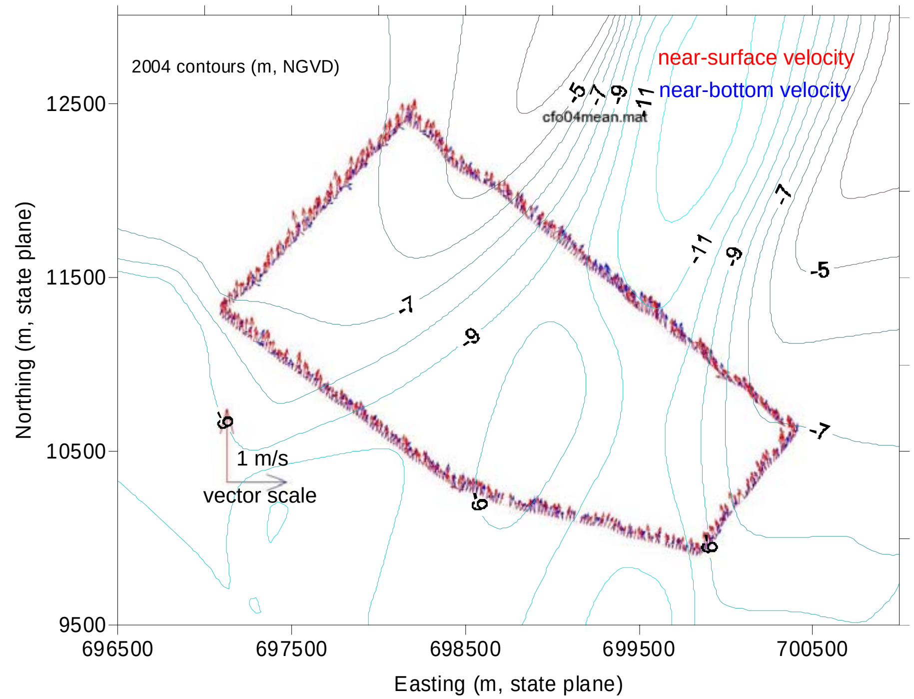


Figure 3.50 January 2004 ADCP survey at offshore transect during flood flow.

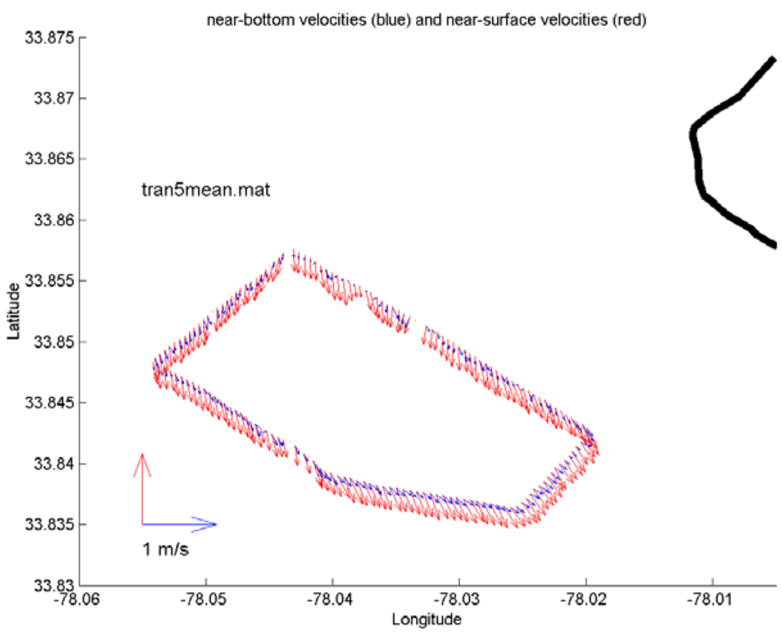


Figure 3.51 October 2000 ADCP survey at offshore transect during peak ebb flow.

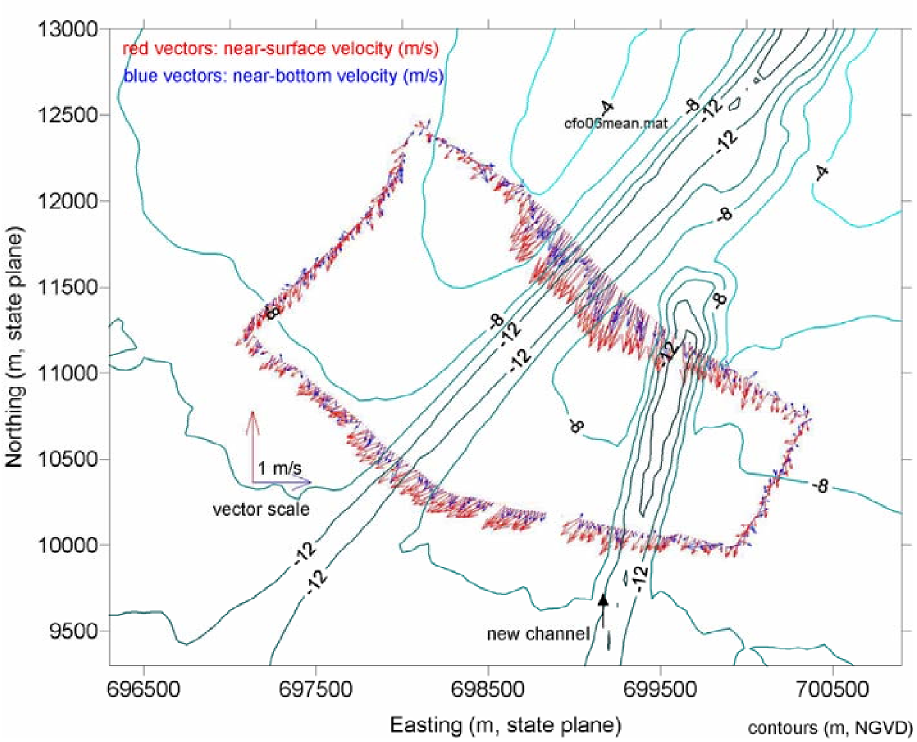


Figure 3.52 April 2002 ADCP survey at offshore transect during peak ebb flow.

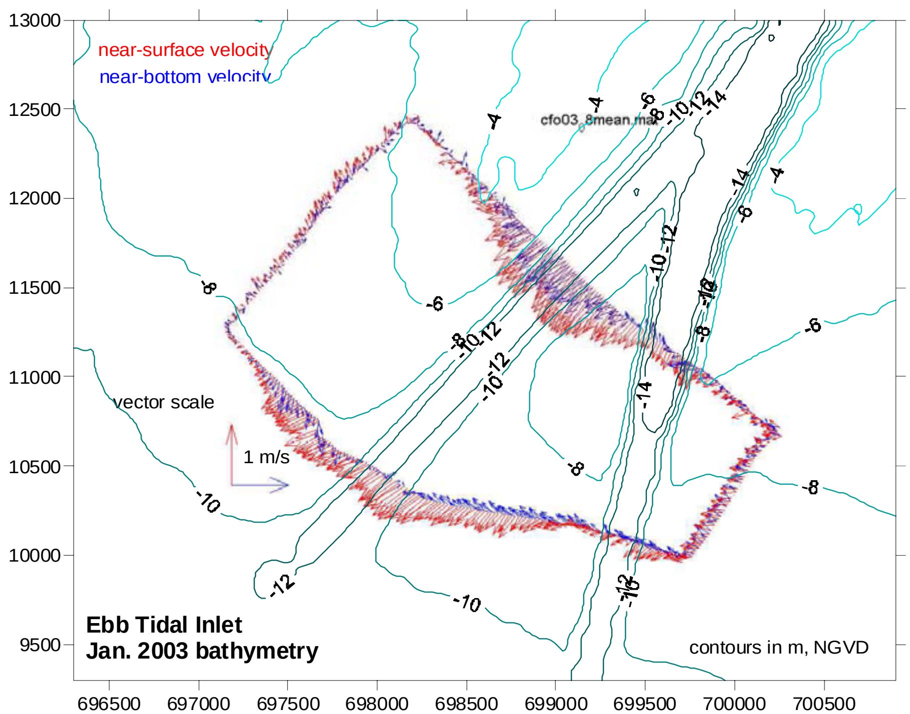


Figure 3.53 March 2003 ADCP survey at offshore transect during ebb flow.

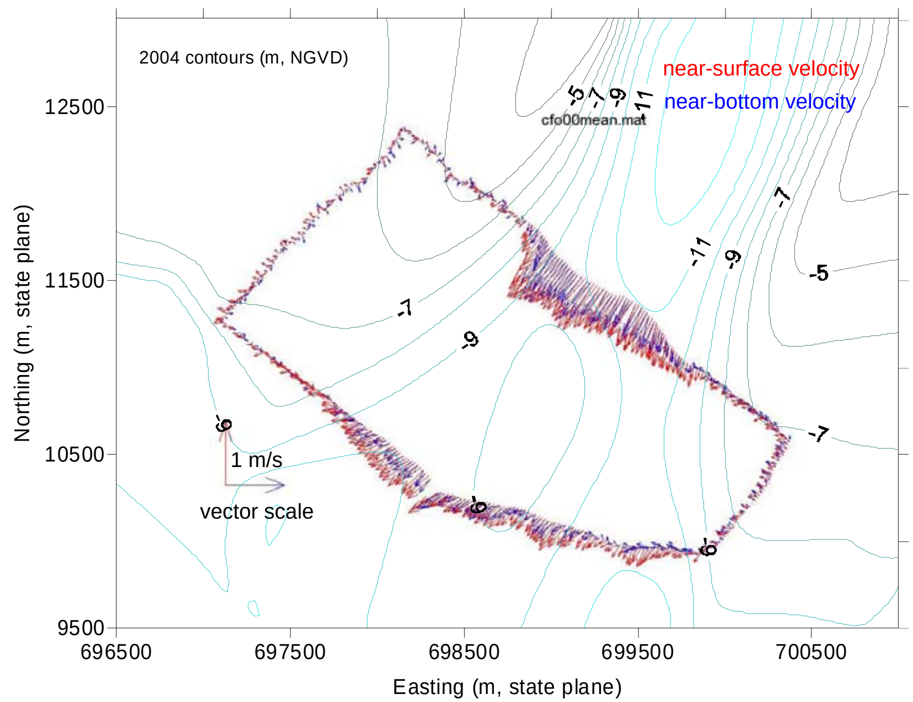


Figure 3.54 January 2004 ADCP survey at offshore transect during ebb flow.

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 5-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 3.55. Water depths are about 42 ft at 11-Mile, 23 ft at Oak Island, and 19 ft at Bald Head Island gauges. The 11-Mile gauge was placed just south of a proposed dredged material disposal area, seaward of the navigation channel and ebb shoal influence. The nearshore gauges provide data in the vicinity of the navigation channel, nearshore shoals and adjacent beaches. All three gauges are Acoustic Doppler Current Profiler (ADCP) instruments accompanied by a pressure transducer. Directional wave spectra are calculated from time series of velocity at various depths obtained by the ADCP. Corresponding significant wave height Hm0, peak period Tp, and peak direction Dp parameters are determined from the directional spectrum. Peak frequency represents the highest energy density in the frequency spectrum integrated over all directions. Peak direction is determined as the vector mean at the peak frequency. Water level is determined from the pressure transducer record. Time series of current velocity at the surface, mid-depth, and bottom are also provided from the ADCP gauges. The 11-Mile and Bald Head Island gauges currently collect 20-min time series at 3-hr intervals. The Oak Island gauge collects 20-min time series at 1-hr intervals.

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

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 August 2005 deployment. Tables 3.6 through 3.8 summarize the mean monthly conditions for all gauges. These tables include the mean monthly wave height, period and direction (Hsmean, Tpmean & Dpmean). The average annual wave height (Hsmean) observed for the 11-mile gauge is 3.0 feet. Average annual wave heights for the Bald Head and Oak Island gauges are 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 associated peak period (Tpmax) and wave direction (Dpmax) with each event were also computed. The 11-Mile gauge had monthly maximum wave heights on the order of 7.7 feet, with waves typically arriving from the southeast to southwest directions. Bald Head and Oak Island had monthly maximum wave heights of 5.9 and 5.2 feet, respectively. Both nearshore gauges display the filtering effect of the nearshore shoals, with the predominant number of events having wave directions confined to the south-southwest directions.

The seasonality of the wave climate is illustrated in Figure 3.56. This graph shows the mean monthly wave heights for the all the data collected to date (2000-2005) 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 waves heights during the summer months when the local winds turn predominately onshore. Of further interest, the wave heights measured at Oak Island are slightly lower than Bald Head for all months of the year. The seasonal shift is also seen in Figure 3.57 which is a plot of mean monthly wave direction for each gauge. The directions are given in a meteorological reference with degrees measured from north from indicating the direction from which the waves are traveling. For the nearshore gauges, the mean wave directions are from the 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.

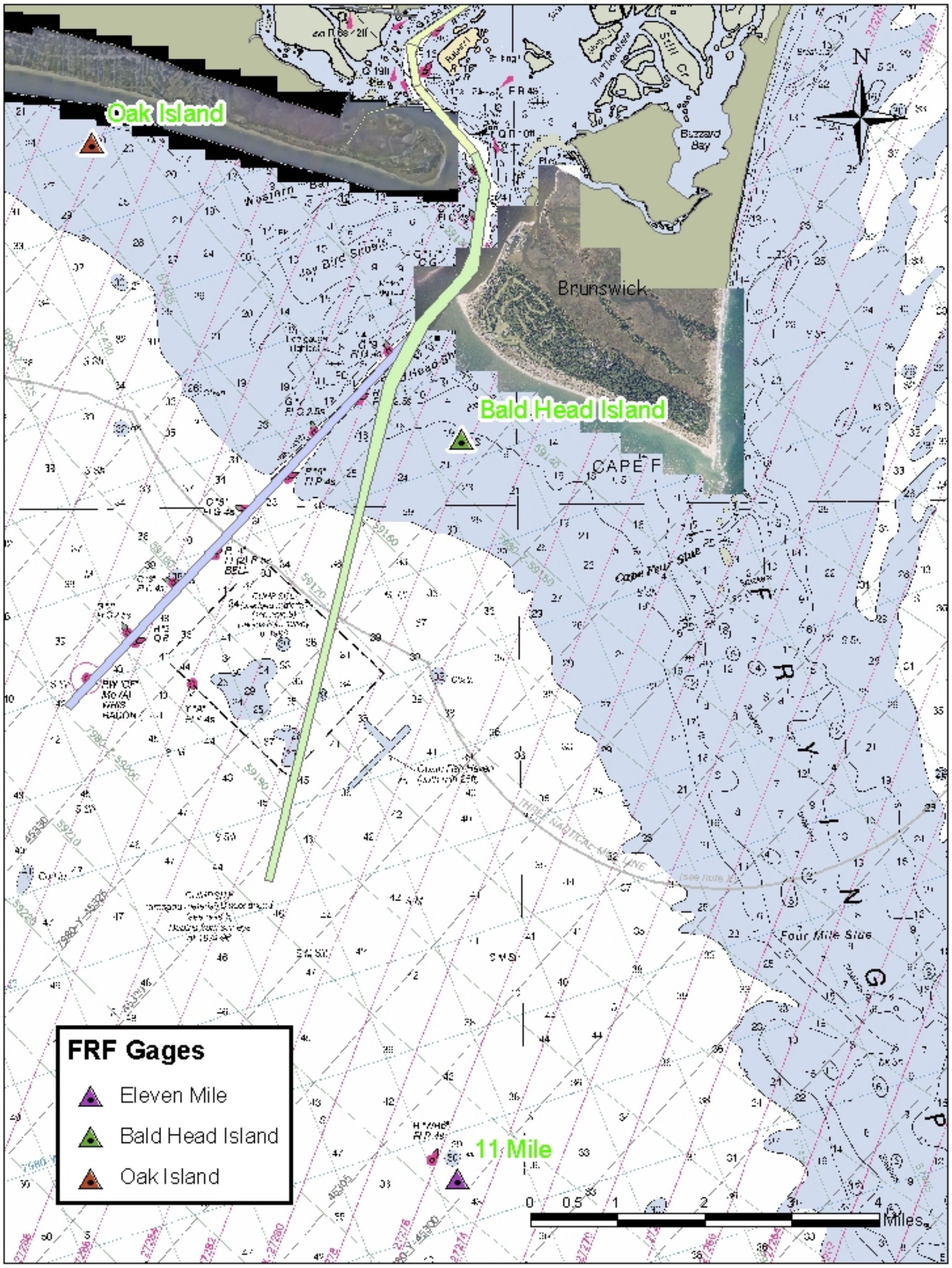


Figure 3.55 FRF Wave and Current Gauges.

Table 3.6 Eleven Mile Gauge Monthly Summaries

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	HsMax	2000	--	--	--	--	--	--	--	--	6.6	5.3	9.0	11.3	**8.1**
Eleven Mile	HsMax	2001	7.1	7.3	10.8	5.1	5.7	8.1	8.6	5.5	7.3	5.9	6.6	8.3	**7.2**
Eleven Mile	HsMax	2002	11.2	8.5	11.5	8.4	7.2	5.9	6.4	4.6	5.6	6.8	9.7	8.8	**7.9**
Eleven Mile	HsMax	2003	7.4	9.7	8.5	7.3	9.3	6.3	6.0	5.9	9.1	6.3	9.7	9.1	**7.9**
Eleven Mile	HsMax	2004	7.3	6.9	6.5	8.5	6.1	5.2	5.2	11.1	9.9	6.8	8.6	--	**7.5**
Eleven Mile	HsMax	2005	--	9.9	11.7	9.5	8.1	5.6	6.0	5.0					**8.0**
	AVERAGE		**8.3**	**8.5**	**9.8**	**7.8**	**7.3**	**6.2**	**6.4**	**6.4**	**7.7**	**6.2**	**8.7**	**9.4**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	DpMax	2000	--	--	--	--	--	--	--	--	213.0	89.0	166.0	253.0	**180.3**
Eleven Mile	DpMax	2001	221.0	159.0	146.0	205.0	33.0	190.0	165.0	227.0	21.0	203.0	154.0	186.0	**159.2**
Eleven Mile	DpMax	2002	182.0	188.0	164.0	212.0	203.0	154.0	217.0	72.0	182.0	153.0	187.0	190.0	**175.3**
Eleven Mile	DpMax	2003	208.0	187.0	160.0	172.0	236.0	191.0	209.0	177.0	319.0	157.0	180.0	187.0	**198.6**
Eleven Mile	DpMax	2004	236.0	144.0	168.0	174.0	231.0	199.0	214.0	198.0	197.0	205.0	184.0	--	**195.5**
Eleven Mile	DpMax	2005	--	161.0	185.0	225.0	17.0	64.0	265.0	194.0					**158.7**
	AVERAGE		**211.8**	**167.8**	**164.6**	**197.6**	**144.0**	**159.6**	**214.0**	**173.6**	**186.4**	**161.4**	**174.2**	**204.0**	

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				--	**3.2**
	AVERAGE		**3.0**	**3.2**	**3.4**	**3.1**	**3.0**	**3.0**	**3.0**	**2.8**	**3.5**	**2.8**	**2.9**	**3.2**	

(Continued)

Table 3.6 Eleven Mile Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile	TpMax	2000	--	--	--	--	--	--	--	--	12.8	**	14.2	**	**13.5**
Eleven Mile	TpMax	2001	**	10.6	16.0	25.6	14.2	**	10.6	11.6	**	18.2	14.2	**	**15.1**
Eleven Mile	TpMax	2002	16.0	16.0	**	10.6	**	11.6	9.8	18.2	12.8	21.3	18.2	18.2	**15.3**
Eleven Mile	TpMax	2003	12.8	14.2	16.0	14.2	14.2	9.1	9.1	16.0	16.0	14.2	14.2	16.0	**13.8**
Eleven Mile	TpMax	2004	11.6	14.2	14.2	12.8	11.6	25.6	9.8	25.6	16.0	25.6	25.6	--	**17.5**
Eleven Mile	TpMax	2005	--	10.6	16.0	16.0	14.2	12.8	10.6	25.6					**15.1**
	AVERAGE		**13.5**	**13.1**	**15.6**	**15.8**	**13.6**	**14.8**	**10.0**	**19.4**	**14.4**	**19.8**	**17.3**	**17.1**	

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					**6.6**
	AVERAGE		**6.6**	**6.9**	**7.2**	**6.6**	**6.5**	**6.0**	**5.9**	**6.7**	**7.6**	**7.3**	**7.3**	**7.2**	

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

Table 3.7 Bald Head Gauge Monthly Summaries

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	HsMax	2000	--	--	--	--	--	--	--	--	6.3	2.5	6.6	7.8	5.8
Bald Head	HsMax	2001	6.9	5.4	8.9	4.4	4.3	7.0	6.1	4.8	1.3	4.3	4.3	6.4	5.3
Bald Head	HsMax	2002	9.0	6.3	8.1	6.3	6.0	5.0	4.6	4.1	4.3	5.2	7.4	6.5	6.1
Bald Head	HsMax	2003	6.3	7.6	5.8	5.9	7.4	5.0	5.4	4.6	6.5	4.9	7.2	8.0	6.2
Bald Head	HsMax	2004	6.5	5.0	5.4	6.7	4.6	4.5	4.4	6.5	7.7	5.7	6.8	5.9	5.7
Bald Head	HsMax	2005	6.9	4.9	8.5	7.5	5.9	3.4	5.9	4.5					5.9
	AVERAGE		7.1	5.8	7.3	6.2	5.6	5.0	5.3	4.9	5.2	4.2	6.4	7.2	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	DpMax	2000	--	--	--	--	--	--	--	--	192.0	203.0	173.0	198.0	191.5
Bald Head	DpMax	2001	206.0	195.0	192.0	222.0	159.0	201.0	195.0	195.0	149.0	201.0	209.0	205.0	194.1
Bald Head	DpMax	2002	202.0	179.0	183.0	183.0	189.0	211.0	208.0	204.0	212.0	188.0	194.0	202.0	196.3
Bald Head	DpMax	2003	203.0	203.0	169.0	201.0	217.0	200.0	189.0	165.0	250.0	186.0	194.0	200.0	198.1
Bald Head	DpMax	2004	195.0	175.0	195.0	203.0	205.0	205.0	202.0	189.0	176.0	197.0	198.0	189.0	194.1
Bald Head	DpMax	2005	193.0	203.0	212.0	192.0	235.0	190.0	235.0	214.0					209.3
	AVERAGE		199.8	191.0	190.2	200.2	201.0	201.4	205.8	193.4	195.8	195.0	193.6	198.8	

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		--	--	--	1.9
	AVERAGE		2.0	1.8	1.9	2.0	2.1	2.1	2.2	1.9	1.8	1.4	1.8	2.0	

(Continued)

Table 3.7 Bald Head Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	**	14.2	15.1
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					15.2
	AVERAGE		13.5	18.0	18.0	14.8	14.7	17.1	11.0	15.3	16.1	16.2	15.5	15.4	

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

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

Table 3.8 Oak Island Gauge Monthly Summaries

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	HsMax	2000	--	--	--	--	--	--	--	--	5.3	2.9	--	--	4.1
Oak Island	HsMax	2001	--	--	--	--	--	6.0	3.7	--	1.0	4.2	3.9	5.8	4.1
Oak Island	HsMax	2002	8.3	5.3	6.6	4.4	4.1	4.7	2.7	3.9	4.2	4.7	6.6	6.0	5.1
Oak Island	HsMax	2003	5.4	6.6	5.3	4.2	3.8	4.5	5.3	4.5	6.0	4.2	6.4	6.1	5.2
Oak Island	HsMax	2004	6.1	4.9	5.3	5.5	4.5	4.6	4.6	9.9	6.5	5.3	5.6	5.0	5.8
Oak Island	HsMax	2005	6.2	4.1	7.3										5.9
	AVERAGE		6.5	5.2	6.1	4.7	4.1	5.0	4.1	6.1	4.6	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										187.0
	AVERAGE		203.0	202.0	183.7	194.3	195.3	192.0	219.8	190.0	195.8	206.0	188.3	197.7	

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										1.7
	AVERAGE		1.7	1.5	1.8	1.8	1.8	1.9	2.1	1.7	1.7	1.3	1.5	1.7	

(Continued)

Table 3.8 Oak Island Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	--	--	16.0
Oak Island	TpMax	2001	--	--	--	--	--	**	5.1	--	**	**	**	**	5.1
Oak Island	TpMax	2002	**	**	**	**	**	**	9.1	21.3	21.3	21.3	21.3	16.0	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										17.7
	AVERAGE		17.7	13.9	16.0	14.4	20.8	9.5	9.1	21.0	17.3	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										7.4
	AVERAGE		7.2	7.8	7.7	7.3	8.0	6.8	5.1	6.0	9.0	8.4	8.0	7.6	

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

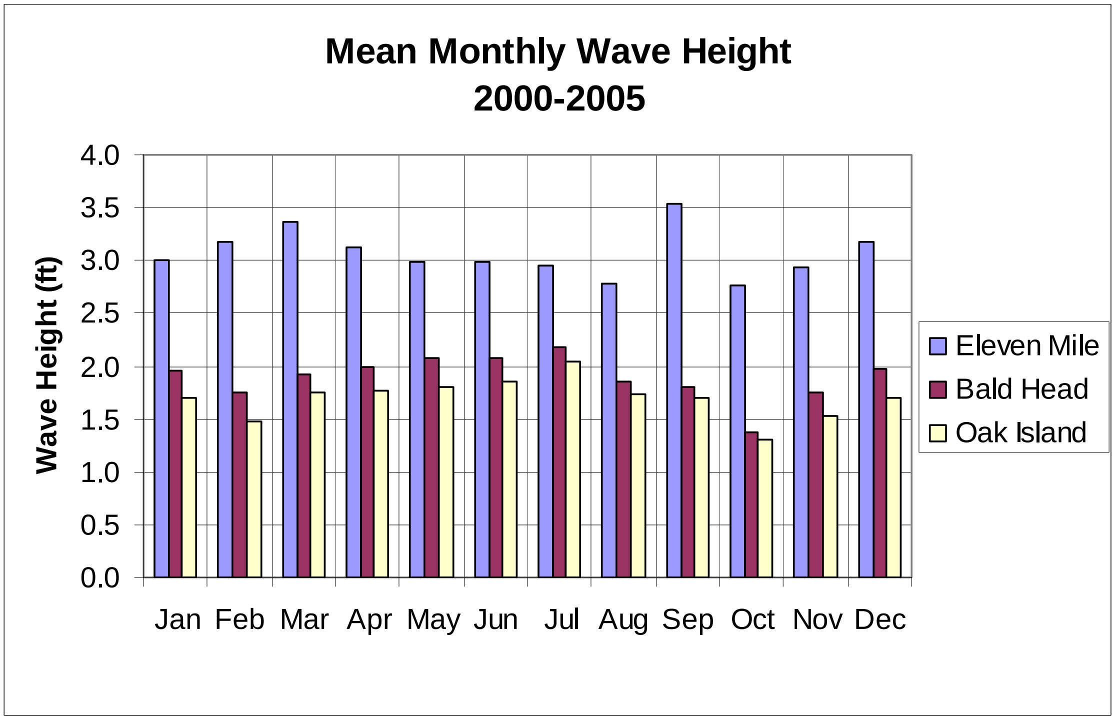


Figure 3.56 Mean Monthly Wave Height 2000-2005 for the Eleven Mile, Bald Head and Oak Island Gauges

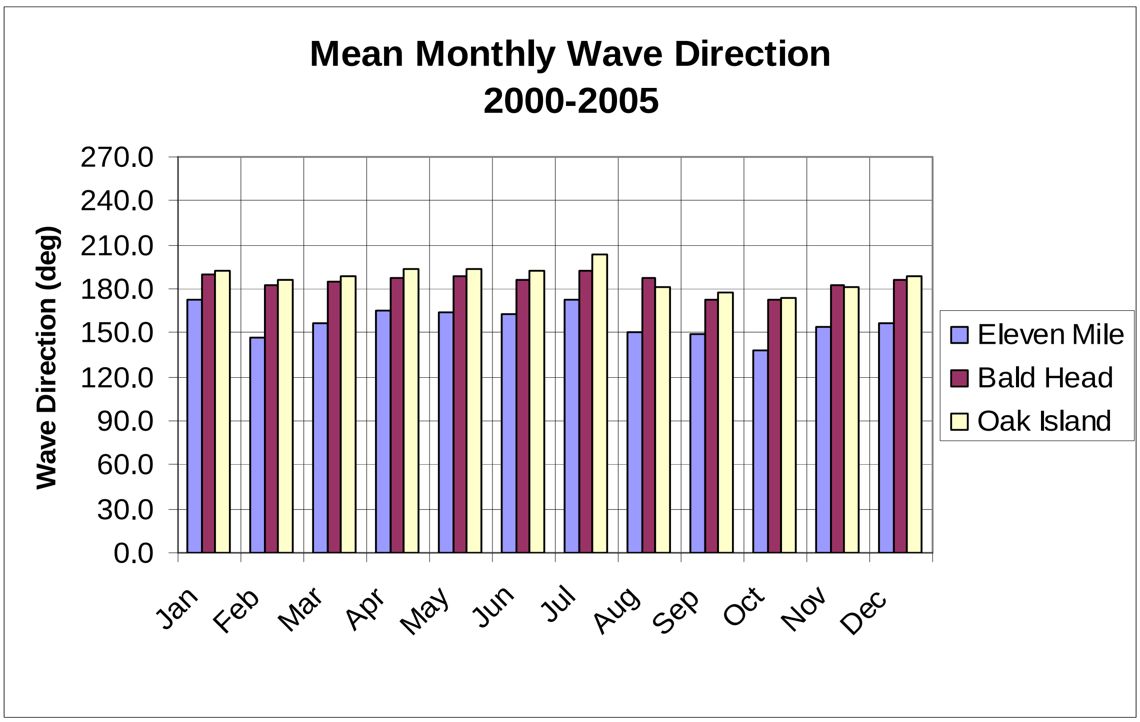


Figure 3.57 Mean Monthly Wave Direction 2000-2005 for the Eleven Mile, Bald Head and Oak Island Gauges

Further insights on the wave climate variability and the impacts of Frying Pan Shoals are shown on Figures 3.58 and 3.59. Figure 3.58 show wave histograms that were created using all available data from each gauge for the September 2000 to September 2005 time period. Figure 3.59 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.

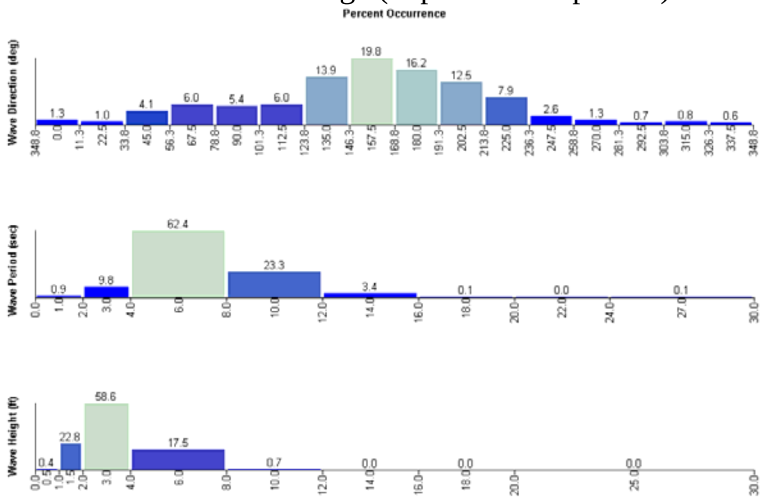
Time series for each gauge were separated into yearly components and analyzed to assess the statistical variation in wave climate. Annual wave height roses for all three gauges for 2000, 2001, 2002, 2003, 2004 and 2005 were generated and are given in Appendix A. The year to year comparison of the roses 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 3.60 and 3.61 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 five year time span. For the 11-mile gauge, slightly more energetic years are evident in 2001 and 2005 (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.

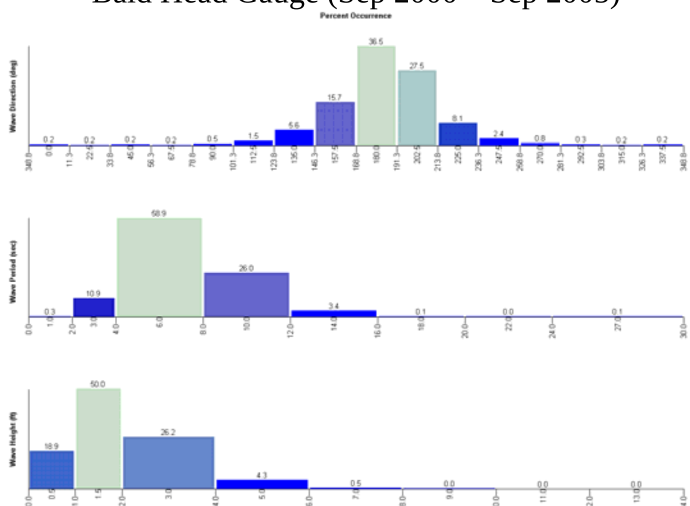
Significant Events. Several large storm events occurred during the monitoring period that may have significantly altered adjacent beach shorelines and beach profiles. An analysis was conducted to identify storm event parameters that exceeded a 6-ft significant wave height threshold with a minimum duration of 12-hrs. Events were selected through screening of the 11-Mile Gauge time series. Associated peak parameters for the Bald Head and Oak Island gauges are reported. Table 3.9 summarizes the 42 events that exceeded the set criteria over the 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. Corresponding conditions at the nearshore gauges indicate significant reduction in wave height, with Bald Head and Oak

Island being reduced by 31 and 40 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.

Eleven-Mile Gauge (Sep 2000 – Sep 2005)



Bald Head Gauge (Sep 2000 – Sep 2005)



Oak Island Gauge (Sep 2000 –Apr 2005)

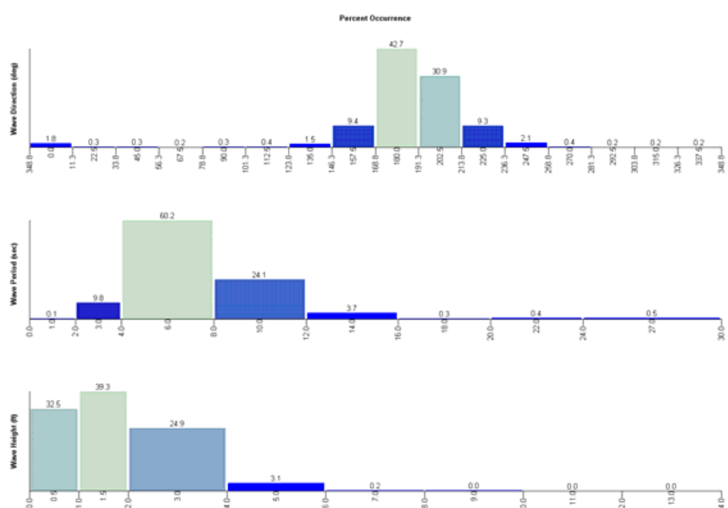
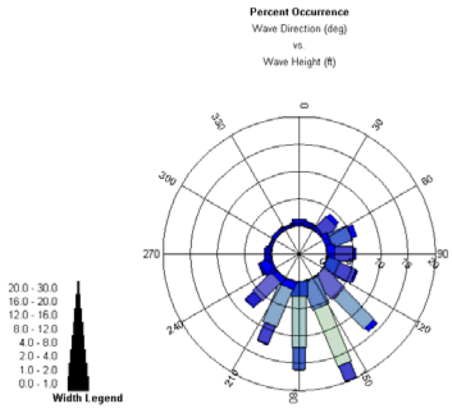
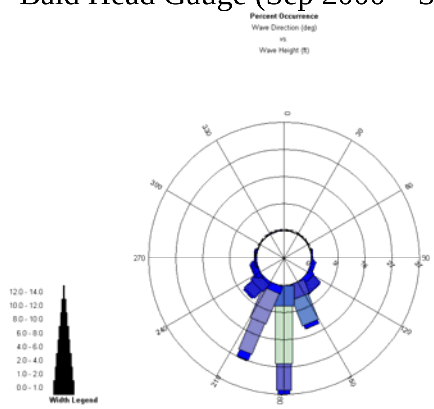


Figure 3.58 Wave Histograms for FRF Gauges throughout deployment.

Eleven-Mile Gauge (Sep 2000 – Sep 2005)



Bald Head Gauge (Sep 2000 – Sep 2005)



Oak Island Gauge (Sep 2000 –Apr 2005)

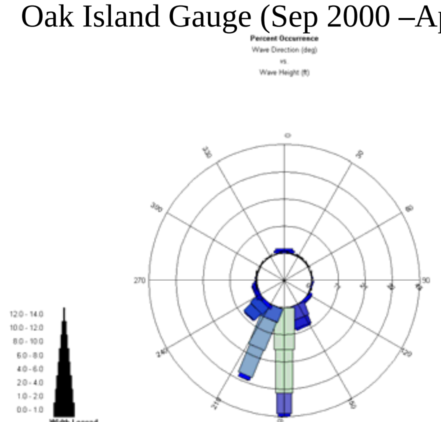


Figure 3.59 Wave Height Roses for FRF Gauges throughout deployment.

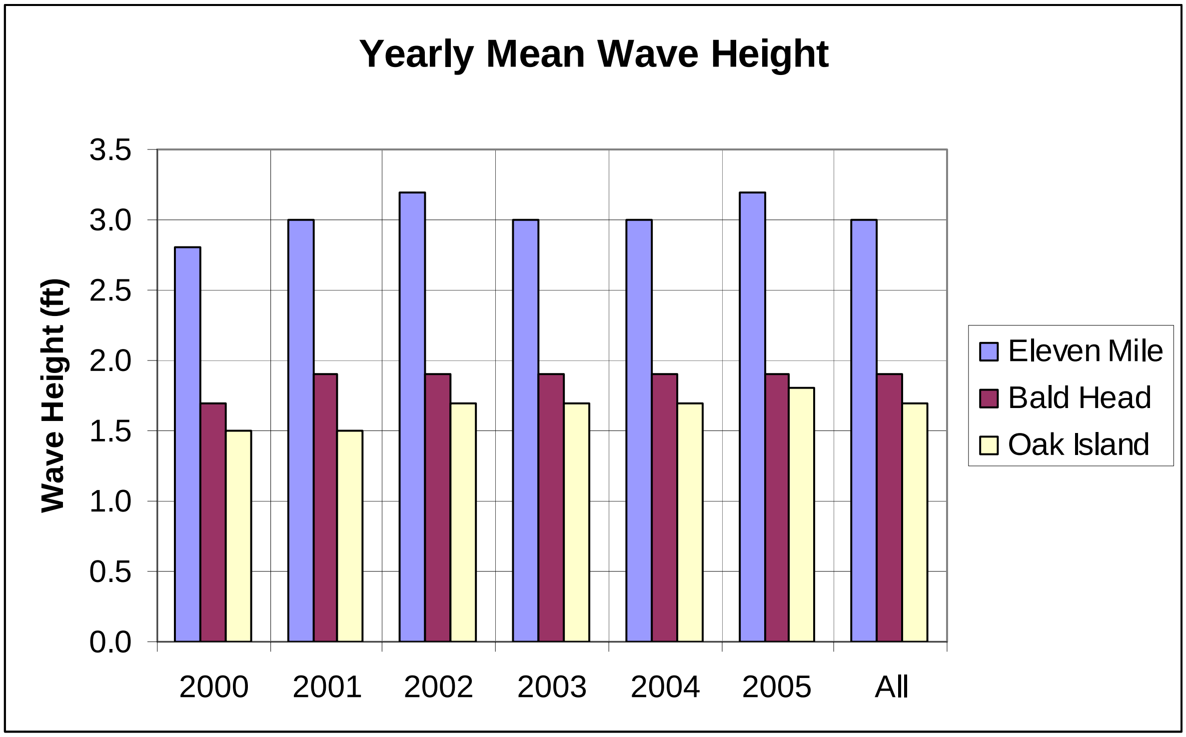


Figure 3.60 Yearly Mean Wave Height for Years 2000 through 2005

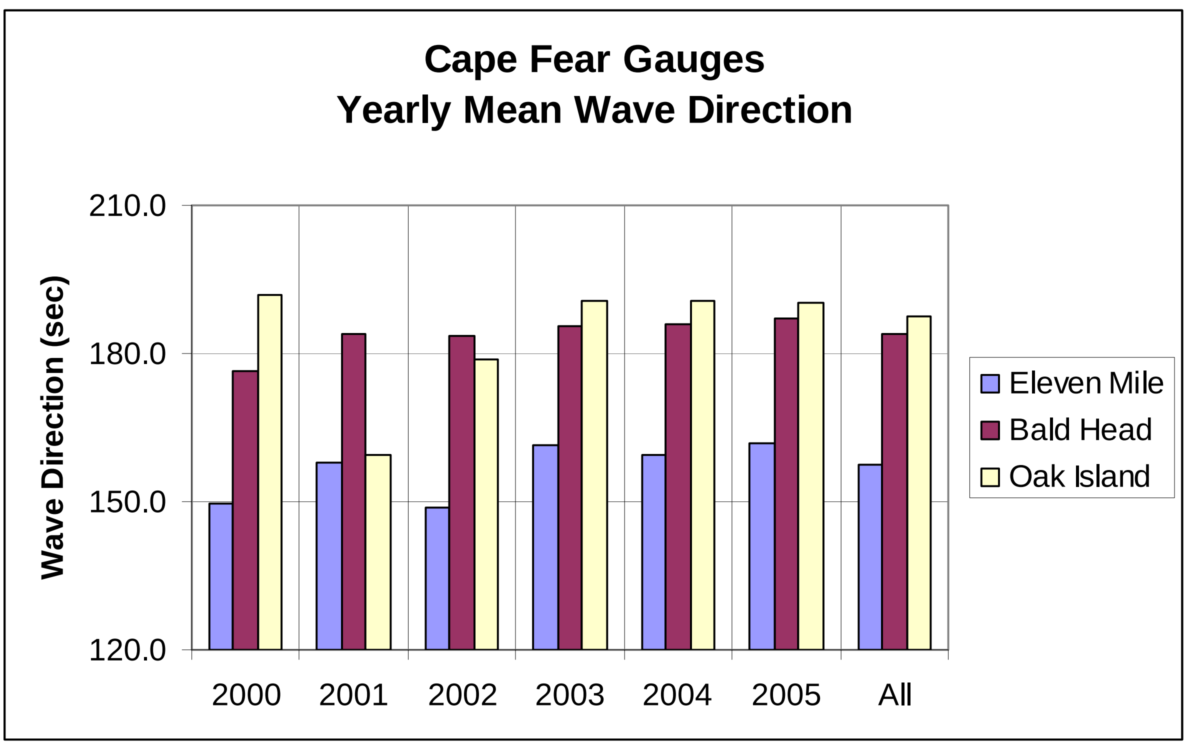


Figure 3.61 Yearly Mean Wave Direction for Years 2000 through 2005

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

EVENT	START DATE	TIME	STOP DATE	TIME	Dur (hrs)	ELEVEN MILE GAGE Hs (ft)	Tp (sec)	Dp (deg)	DATE PEAK	TIME	BALD HEAD GAGE Hs (ft)	Tp (sec)	Dp (deg)	OAK ISLAND GAGE Hs (ft)	Tp (sec)	Dp (deg)
1	16-Dec-00	3:00	16-Dec-00	18:00	15.00	11.3	9.8	199.5	16-Dec-00	15:00	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	2.6	6.7	228

29	29-Aug-04	1:00	30-Aug-04	4:00	25.00	8.6	7.1	169	29-Aug-04	19:00	6.3	6.7	222	6.1	6.7	210
30	8-Sep-04	1:00	9-Sep-04	4:00	25.00	7.3	6.7	189	9-Sep-04	4:00	5.2	7.5	202	4.8	7.1	191
31	17-Sep-04	13:00	18-Sep-04	7:00	18.00	9.9	7.1	197	17-Sep-04	19:00	1.7	8.5	238	6.5	6.7	201
32	25-Sep-04	7:00	28-Sep-04	19:00	84.00	9.2	7.5	189	28-Sep-04	16:00	7.7	7.5	176	5.9	7.5	187
33	15-Oct-04	13:00	16-Oct-04	22:00	33.00	6.8	7.5	205	15-Oct-04	19:00	5.7	8	197	4.8	7.5	203
34	24-Nov-04	22:00	25-Nov-04	19:00	21.00	8.6	9.1	184	25-Nov-04	13:00	6	9.8	193	4.7	5.3	227
35	27-Feb-05	19:00	1-Mar-05	22:00	46.00	9.9	10.6	161	28-Feb-05	4:00	3.9	10.6	195	3	11.6	175
36	8-Mar-05	4:00	8-Mar-05	19:00	15.00	11.7	8.5	185	8-Mar-05	7:00	8.5	9.1	212	7.1	8.5	196
37	11-Mar-05	16:00	14-Mar-05	1:00	57.00	9.4	7.5	217	12-Mar-05	16:00	6.2	7.5	207	5.1	7.5	207
38	22-Mar-05	22:00	23-Mar-05	19:00	21.00	7.5	8	150	23-Mar-05	13:00	5.7	8	187	4	7.5	191
39	27-Mar-05	16:00	29-Mar-05	4:00	36.00	8.8	7.1	193	28-Mar-05	22:00	6.9	8	200	5.3	8	195
40	2-Apr-05	4:00	3-Apr-05	10:00	30.00	9.5	7.1	225	2-Apr-05	19:00	7.5	8	192	5.1	8.5	204
41	8-Apr-05	1:00	8-Apr-05	13:00	12.00	6.5	7.5	189	8-Apr-05	1:00	3.7	7.5	191	2.4	8.5	195
42	5-May-05	16:00	6-May-05	7:00	15.00	8.1	4.9	17	6-May-05	1:00	2.6	9.1	187	--	--	--

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

Part 4 PROJECT EFFECTS/PERFORMANCE TO DATE

Beach Response – Shoreline Change Rates

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

Shoreline change rates were computed for three post-construction periods covering from the August/September 2000 survey through the survey of June 2003 (as presented in Report 1), through the survey of June 2004 (as presented in Report 2) and through the most recent survey of August 2005. 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 graphs 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 two 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 final period (thru August 2005) ranging from +60 to –1 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 was placed at 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 +20 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 +35 to +60 feet per year, while the pre-construction shoreline change rates for this area range from 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 +30 feet per year for the 5-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 #	Longshore Average Pre-Construction Rate (1938-2000) (ft/yr)	Post-Construction Rate (2000-2003) (ft/yr)	Longshore Average Post-Construction Rate (2000-2003) (ft/yr)	Post-Construction Rate (2000-2004) (ft/yr)	Longshore Average Post-Construction Rate (2000-2004) (ft/yr)	Post-Construction Rate (2000-2005) (ft/yr)	Longshore Average Post-Construction Rate (2000 2005) (ft/yr)
5		-5.7	-1.9	-3.6	-0.2	-2.0	1.9
10		-1.0	-3.7	-0.7	-2.5	0.9	-0.8
15		1.2	0.2	3.7	3.5	7.0	3.1
20		-9.2	-5.3	-9.2	-0.6	-9.1	8.0
30		15.6	-10.7	27.4	-4.7	19.0	3.8
35	29.9	-33.4	-13.1	-24.3	-3.8	22.1	-0.7
40	17.2	-27.9	-7.3	-21.1	1.0	-20.2	3.0
45	7.9	-10.6	-4.3	8.0	0.2	-15.3	2.0
50	2.5	19.4	10.7	14.9	11.0	9.2	1.5
55	0.8	30.8	20.9	23.5	18.3	14.2	10.3
60	0.3	41.6	30.9	29.7	22.0	19.6	15.8
65	0.2	23.3	33.1	15.6	23.2	24.0	18.2
70	0.4	39.2	36.2	26.5	25.0	11.9	18.6
75	0.9	30.4	35.1	20.6	24.2	21.5	20.1
80	1.6	46.3	35.7	32.4	24.7	15.7	19.7
85	1.9	36.4	27.5	26.0	19.5	27.2	20.3
90	2.2	26.2	23.1	18.1	17.1	22.2	16.0
95	2.5	-1.9	13.5	0.2	10.8	14.8	14.5
100	2.6	8.5	8.2	8.6	7.2	0.1	9.5
105	2.5	-1.6	4.5	1.3	5.5	8.0	6.5
110	2.1	9.9	12.2	8.1	11.4	2.7	5.2
115	1.5	7.6	17.9	9.2	15.7	7.2	10.1
120	0.7	36.6	33.1	29.8	26.1	8.1	13.2
125	-0.3	37.1	45.0	30.2	35.0	24.3	20.8
130	-0.9	74.2	55.6	53.3	42.8	23.6	27.1
135	-1.4	69.7	62.3	52.3	47.8	40.6	33.2
140	-2.1	60.6	69.0	48.5	52.1	39.0	36.8
145	-2.3	69.7	64.7	54.8	49.7	38.5	40.6
150	-2.5	70.6	63.2	51.5	47.7	42.2	39.1
155	-2.8	52.9	62.1	41.4	46.1	42.9	38.0
160	-3.3	62.2	62.0	42.4	45.0	33.1	36.4
165	-3.9	55.0	60.3	40.4	44.3	33.5	35.6
170	-4.3	69.3	61.1	49.5	44.0	30.3	34.1
175	-4.7	62.2	60.6	47.9	44.0	38.2	33.4
180	-5.0	56.9	61.9	39.7	44.8	35.3	32.9
185	-5.3	59.6	59.9	42.4	43.7	29.9	33.4
190	-5.4	61.3	60.3	44.6	43.4	30.6	32.0
195	-5.5	59.4	61.4	43.8	45.0	33.0	31.9
200	-5.6	64.3	64.1	46.4	47.1	31.1	33.2
205	-5.7	62.3	64.3	47.6	47.4	35.1	35.3
210	-5.8	73.1	66.9	52.8	49.1	36.1	35.8
215	-5.7	62.3	64.5	46.1	47.8	41.2	37.8
220	-5.5	72.4	64.9	52.5	47.7	35.4	36.9
225	-5.2	52.3	57.9	39.9	43.0	41.2	37.2
230	-4.8	64.7	56.8	47.0	42.2	30.8	33.7
235	-4.4	38.1	50.8	29.3	38.5	37.3	33.8
240	-4.1	56.6	52.9	42.5	40.2	24.0	31.3
245	-3.9	42.6	48.5	33.6	37.8	35.6	33.3
250	-3.7	62.5	54.2	48.5	42.3	28.6	31.9
255	-3.6	42.8	54.2	35.2	42.2	41.1	35.8
260	-3.5	66.7	61.0	51.7	47.1	30.1	36.0
265	-3.3	56.5	59.2	42.1	45.7	43.7	40.2
270	-3.2	76.5	66.6	57.8	50.9	36.4	38.9
275	-3.0	53.5	67.7	41.8	51.7	49.6	43.4
280	-2.8	79.8	72.6	61.2	55.3	35.0	43.8
285	-2.7	72.3	73.9	55.4	56.4	52.2	46.6
290	-2.6	80.8	83.3	60.2	62.8	45.8	46.9
295	-2.5	83.0	87.3	63.3	65.2	50.5	52.0
300	-2.3	100.7	97.3	74.1	71.0	50.9	53.1
305	-2.2	99.9	101.4	73.1	73.7	60.7	57.4
310	-2.1	122.0	107.5	84.4	77.2	57.4	59.1

Table 4.2 Bald Head Island Shoreline Change Rates

Profile ID #	Longshore Average Pre-Construction Rate (1938-2000) (ft/yr)	Post-Construction Rate (2000-2003) (ft/yr)	Longshore Average Post-Construction Rate (2000-2003) (ft/yr)	Post-Construction Rate (2000-2004) (ft/yr)	Longshore Average Post-Construction Rate (2000-2004) (ft/yr)	Post-Construction Rate (2000-2005) (ft/yr)	Longshore Average Post-Construction Rate (2000-2005) (ft/yr)
0		-3.1	-3.1	1.0	-2.2	2.3	-1.6
4		-6.2	-1.7	-5.6	-1.2	-5.0	-1.0
8		0.0	-0.2	-2.0	0.2	-2.3	-0.1
12		2.6	1.5	1.9	1.0	0.7	-0.3
16		5.6	5.6	5.8	4.1	3.9	1.2
20		5.7	4.4	5.0	1.2	1.0	-3.1
24		14.4	1.2	9.9	-4.0	2.7	-6.7
28		-6.5	-3.3	-16.7	-1.8	-23.8	-1.9
32		-13.3	15.1	-24.0	10.4	-17.0	7.0
36		-16.6	18.2	16.9	6.5	27.8	1.2
40		97.4	22.2	66.0	6.1	45.1	1.3
43		29.9	21.6	-9.6	4.0	-26.1	-0.6
45		13.6	19.8	-18.8	-7.5	-23.1	-10.6
47		-16.3	-5.1	-34.3	-30.0	-26.5	-24.1
53	-2.4	-25.6	-18.1	-41.0	-39.4	-22.2	-24.9
57	-5.5	-27.0	-24.5	-46.1	-40.6	-22.5	-20.9
61	-5.6	-35.4	-23.0	-56.6	-37.4	-30.2	-15.6
66	-5.9	-18.1	-19.1	-24.9	-32.4	-3.2	-10.3
69	-6.4	-8.9	-12.7	-18.4	-24.7	0.1	-3.8
73	-5.5	-6.1	-4.4	-16.1	-14.4	4.3	5.6
78	-4.6	5.0	-0.2	-7.4	-10.6	10.0	9.1
84	-3.7	6.2	3.9	-5.3	-7.4	17.0	12.3
88	-3.1	3.1	6.8	-6.0	-4.8	14.3	14.3
92	-2.6	11.3	8.5	-2.3	-3.2	15.8	15.4
97	-2.0	8.7	12.7	-2.9	-0.2	14.2	16.1
102	-1.6	13.5	18.2	0.2	3.3	15.5	17.3
106	-1.5	27.1	25.5	10.1	8.7	20.8	19.5
110	-1.6	30.5	33.8	11.6	14.6	20.0	22.5
114	-1.6	47.6	42.5	24.6	21.1	27.0	26.1
118	-1.8	50.1	48.1	26.5	25.6	28.9	28.1
122	-1.9	57.3	50.4	32.7	27.4	33.7	28.1
126	-2.0	54.9	51.4	32.3	28.8	31.1	27.3
130	-2.1	42.1	53.3	21.0	31.0	19.7	26.8
134	-2.0	52.4	53.0	31.6	31.4	22.9	24.7
138	-2.0	59.5	54.2	37.1	32.9	26.8	24.1
142	-2.3	56.3	58.9	35.1	37.3	22.9	25.7
146	-2.6	60.5	61.5	39.5	39.7	28.2	27.4
150	-2.9	65.8	64.8	43.3	42.8	27.6	29.2
154	-3.9	65.5	69.2	43.7	46.0	31.5	32.5
158	-4.7	75.9	72.4	52.3	48.6	35.9	34.2
162	-5.2	78.4	72.6	51.4	48.9	39.4	35.8
166	-5.4	76.3	71.4	52.3	49.2	36.9	36.0
170	-5.6	66.7	71.3	45.0	48.9	35.5	36.8
174	-5.9	59.7	67.3	45.0	46.8	32.2	34.8
178	-6.2	75.4	57.4	50.9	43.4	40.1	32.4
182	-6.5	58.2	52.7	40.9	40.3	29.2	29.7
186	-7.0	27.1	47.0	35.3	35.8	25.1	27.1
190	-7.8	42.9	37.5	29.3	30.3	22.0	22.9
194	-8.6	31.2	29.9	22.5	26.6	18.9	20.8
198	-10.0	28.3	25.2	23.7	21.7	19.1	17.6
202	-11.9	20.2	14.7	22.4	16.5	18.7	14.3
206	-13.7	3.2	6.6	10.7	12.2	9.0	12.1
210	-15.0	-9.3	-0.2	3.0	8.8	5.8	11.2
214	-17.8	-9.6	-5.3	1.2	5.3	7.6	9.3
218	-20.8	-5.5	-8.1	6.5	3.6	14.7	9.4
222							

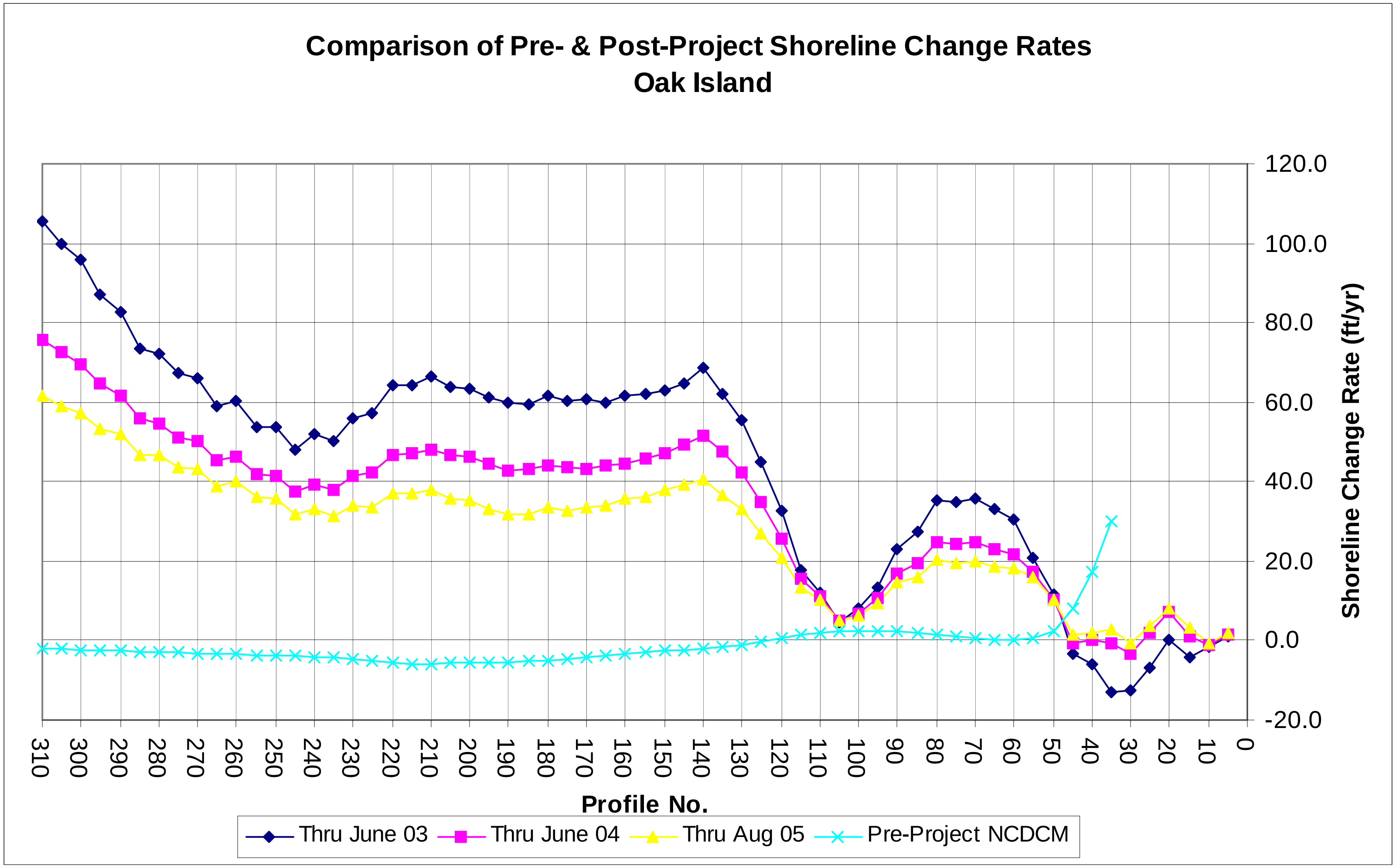


Figure 4.1 Wilmington Harbor Monitoring - Oak Island Comparison of Pre- and Post-Construction Shoreline Change Rates

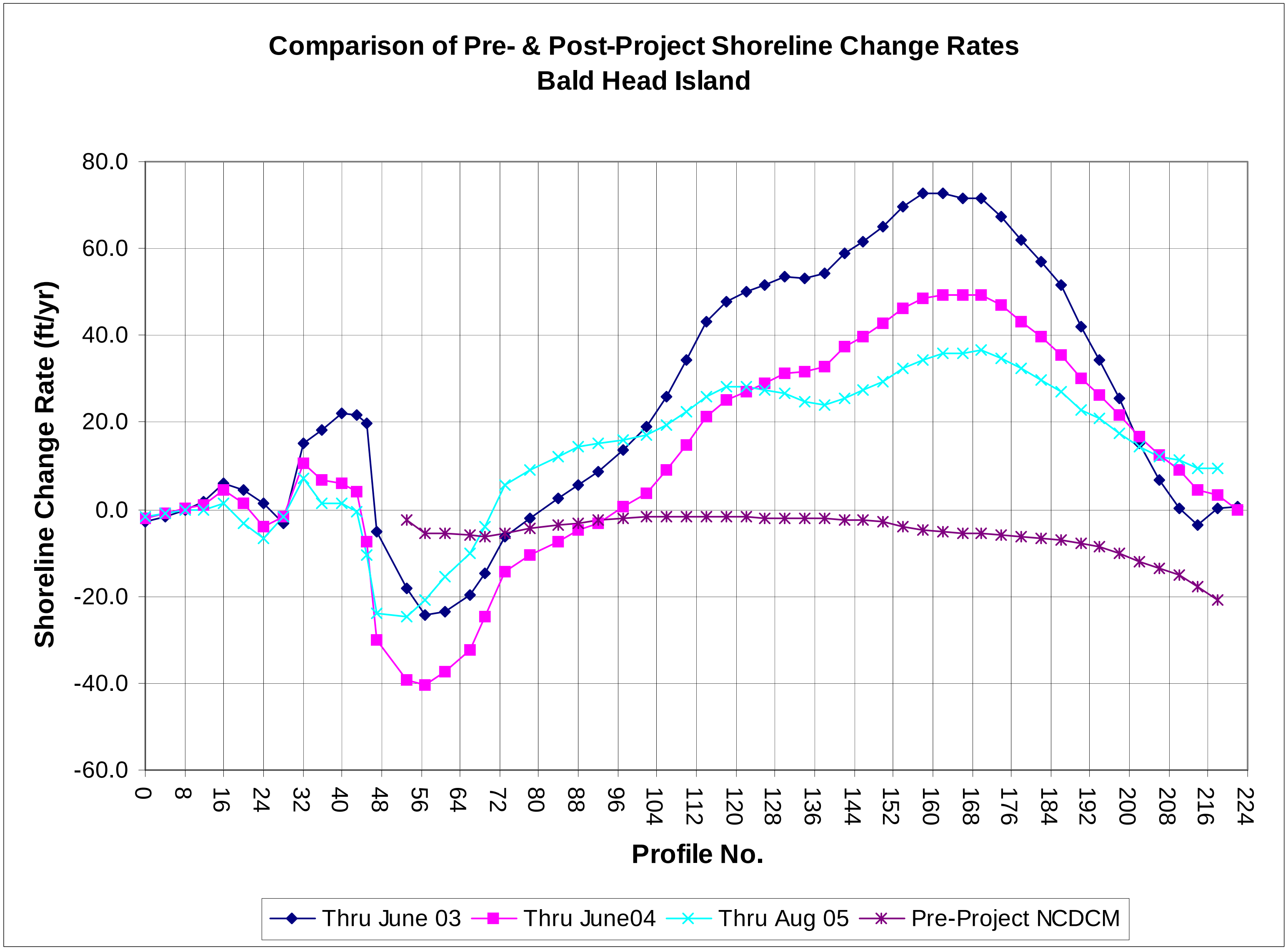


Figure 4.2 Wilmington Harbor Monitoring - Bald Head Island Comparison of Pre- and Post-Construction Shoreline Change Rates

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 and August 2005). 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 current August 2005 survey period, this expanding erosional trend has now reversed. This reversal resulted primarily in response to the most resent beach fill and possibly the replacement of the geo-tube groins along this area. The erosion rate zone now covers 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.

Eastward of this erosion zone the post-construction rates turn positive reflecting the overall stability of the fill placed along this reach. The computed peak shoreline change rate for this area was a plus 72 feet per year (thru June 2003), a plus 49 feet per year (thru June 2004) and a plus 37 feet per year for the entire period. In terms of average rates for this zone, the June 2003 value of accretion was 38 feet per year with the June 2004 value being a positive 29 feet per year. Through the most recent period of August 2005, the average rate is 23 feet per year with the shoreline change rates being less than the historic rates for all locations east of Profile 66. 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 5-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 of this zone has decreased with rates computed through the present period. A direct comparison of the pre- and post-construction shoreline change rates show that only 4 profile lines are eroding at a higher rate during the post-construction period. These 4 lines at located at the western end of south beach (Profiles 53 thru 66). 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 placed and possibly to the positive effect of the rehabilitated groin field which was accomplished in conjunction with the 2005 beach disposal operation.

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 ft at –42 ft MLW.

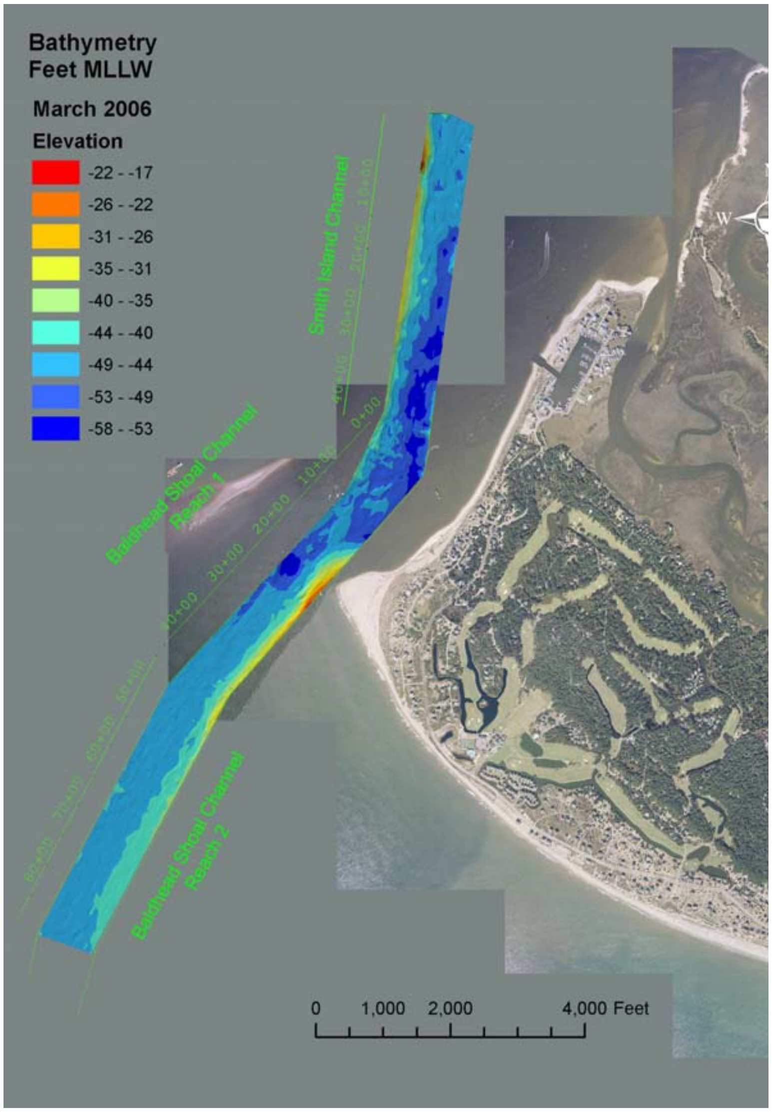


Figure 4.3 Locations for Baldhead Shoal (Reach 1 & 2) and Smith Island Channels

The first settlement agreement survey was conducted in March 2005. It and all subsequent surveys are being compared to the post-dredging survey conducted in January 2005 to track changes. Subsequent bi-monthly surveys have been made on the dates shown in Table 4.3.

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	16 Mar 2006	17 Mar 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

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 and March 2005, respectively. The January 2005 survey serves as the baseline for comparisons with all subsequent surveys. The channel widths by reach for Baldhead Shoal Channel 1 in January and March 2005 are shown in Figure 4.6. Figure 4.7 shows the condition of the navigation channels in March 2006. A difference plot of the total amount of change (January 2005 – March 2006) in all three channels is shown in Figure 4.8.

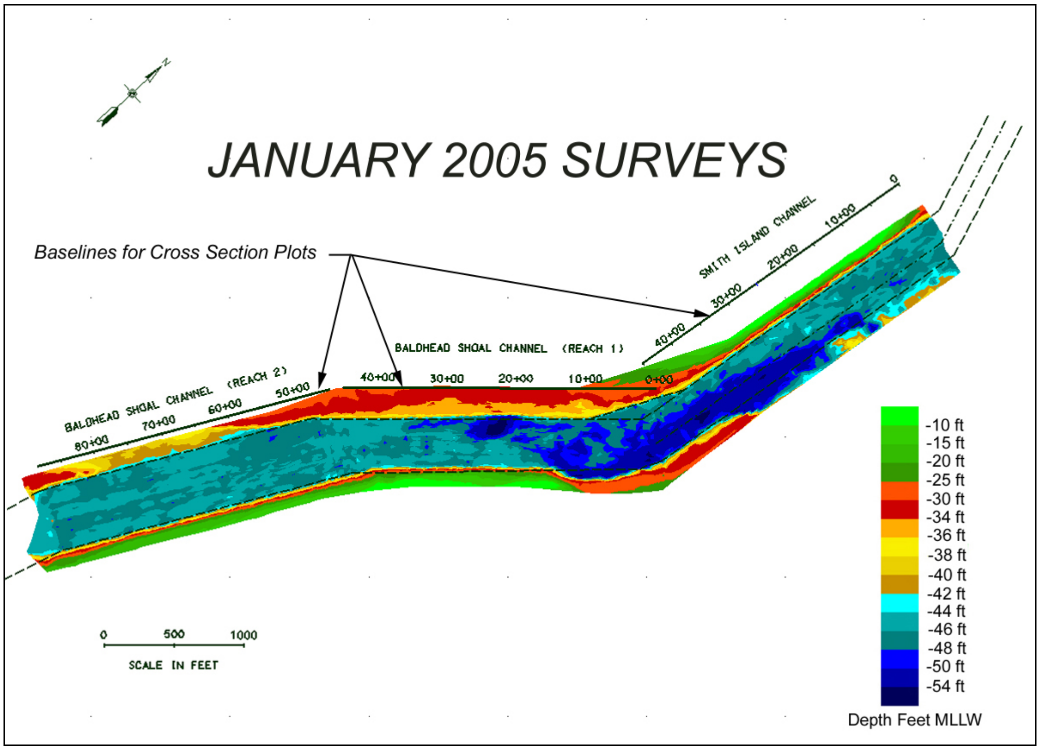


Figure 4.4. January 2005 channel conditions

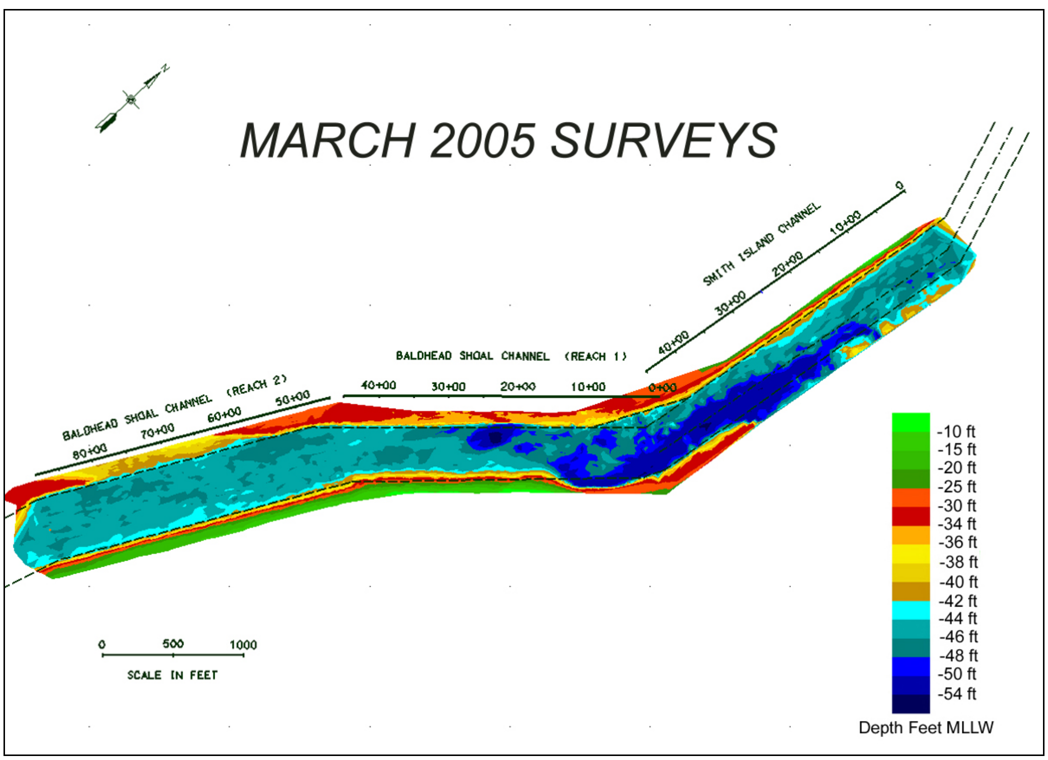


Figure 4.5. March 2005 channel conditions

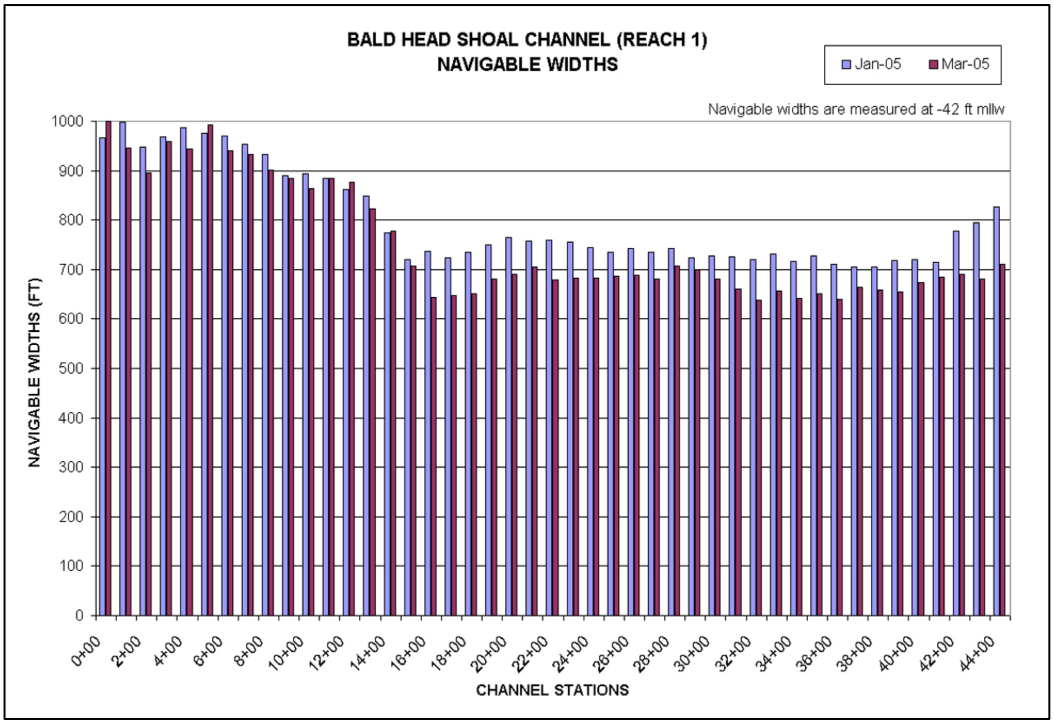


Figure 4.6. Baldhead Shoal Channel 1 channel widths

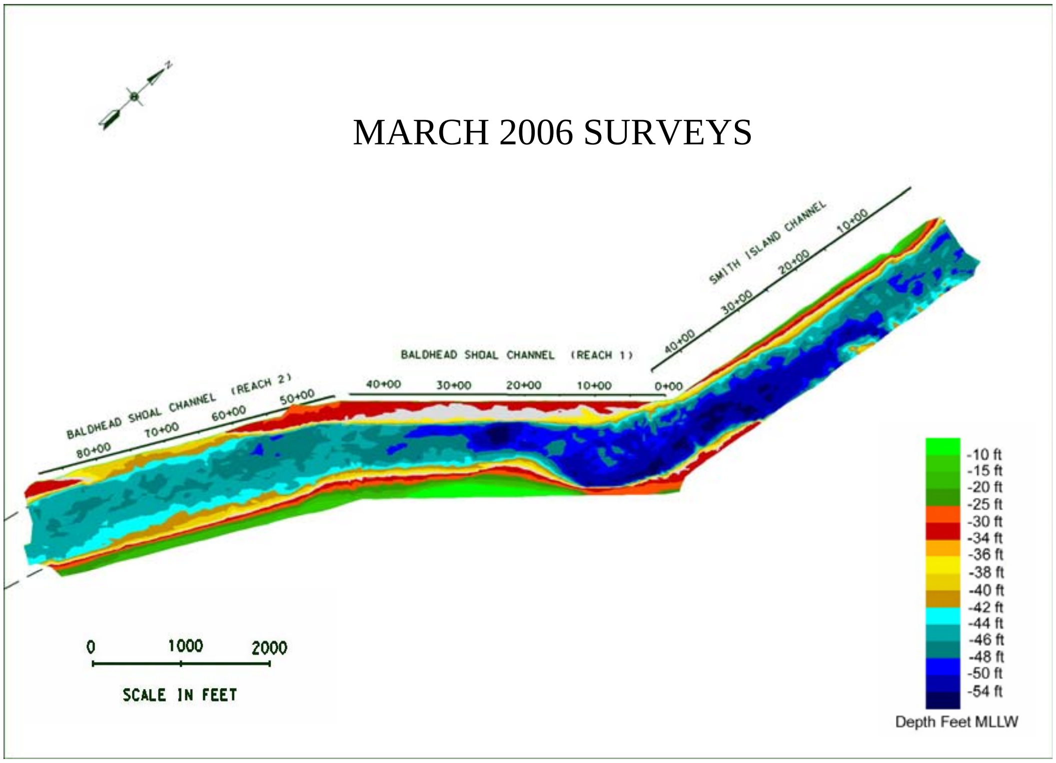


Figure 4.7. March 2006 channel conditions

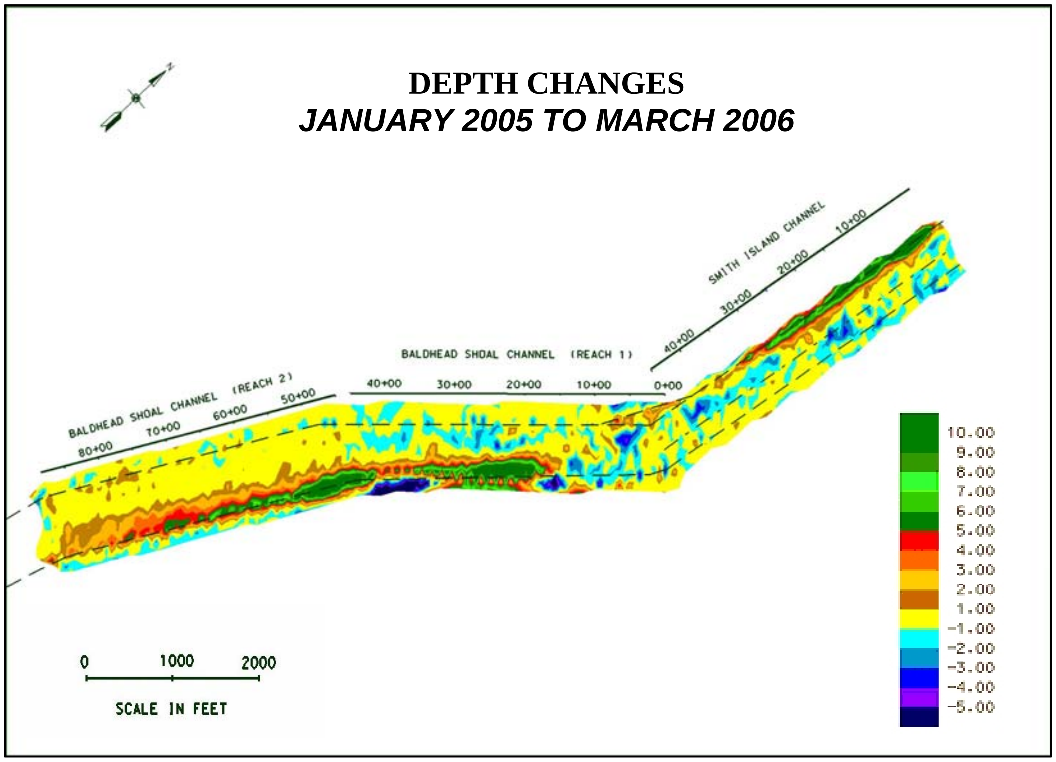


Figure 4.8. Depth changes from January 2005 to March 2006

Channel widths for every survey by station for Baldhead Shoal Channel 1 are shown in Figure 4.9 (Stations 0+00 to 23+00) and Figure 4.10 (Stations 24+00 to 45+00).

Figure 4.6 shows that there was little change in channel width for Baldhead Shoal Channel 1 during the initial 2 months after dredging for the upstream stations (0+00 to 15+00). However, even in this short 2-month interval, Stations 16+00 to 44+00 show channel width reductions approaching 100 ft in some locations. At that time, there was no channel width less than about 650 feet.

Figure 4.8 shows the total shoaling and scour that occurred in the three channels between January 2005 and March 2006. The spit area of Bald Head Island is located near Station 21+00 and is showing 10 feet or more of shoaling. Similar magnitude shoaling is occurring seaward of Bald Head Island along the southeastern border of Baldhead Shoal Channel 2. Note that in both locations the shoaling is elongated along the respective channels. This figure also shows an area of scour that has occurred between these two shoaling locations near the transition from Baldhead Shoal Channel 1 and Channel 2. A ribbon of shoaling can also be seen on the northwestward side of Smith Island Channel which may be from material moving into the channel from Jay Bird Shoal.

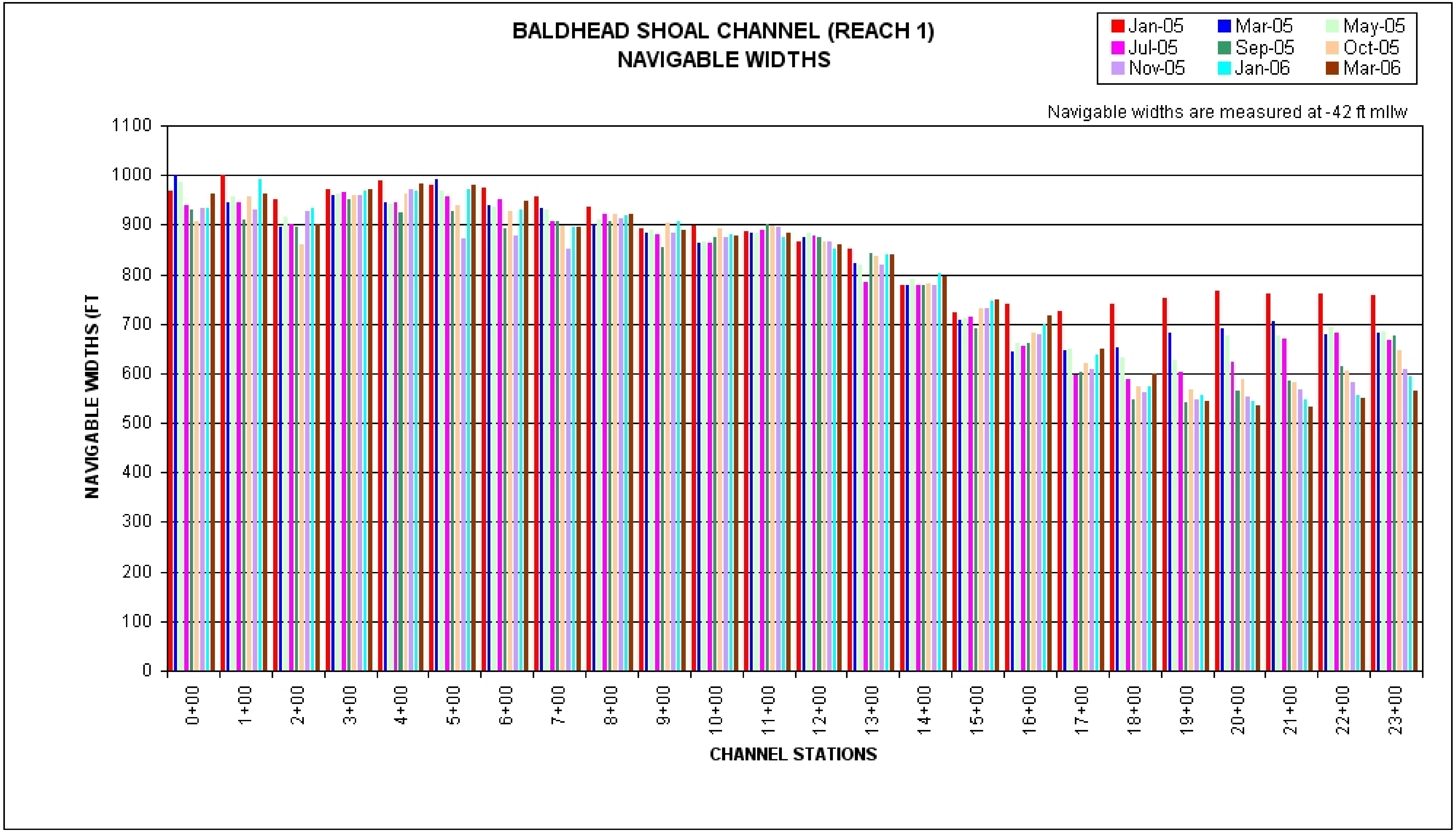


Figure 4.9. Baldhead Shoal Channel 1 channel width by station: Station 0+00 to 23+00

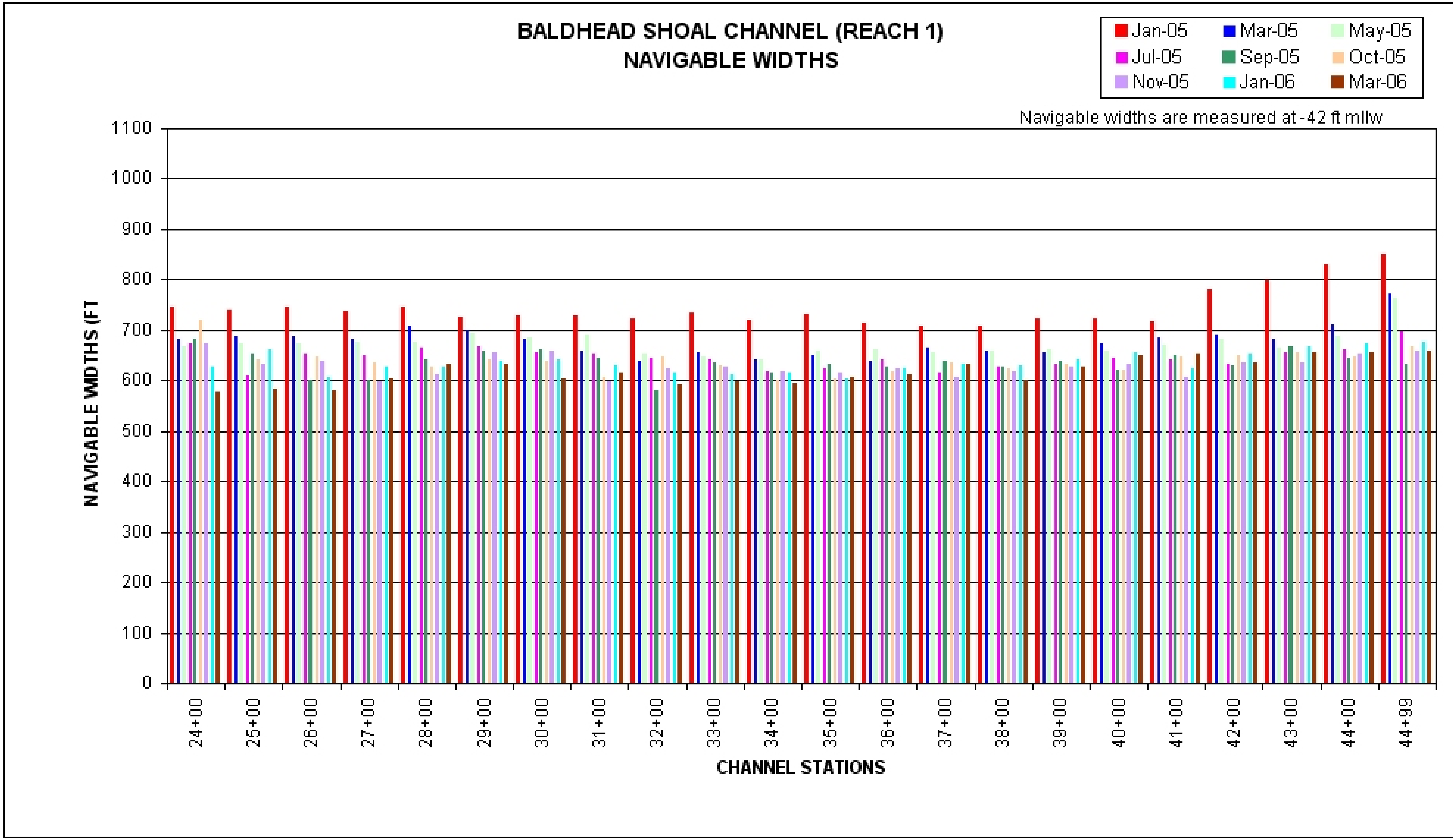


Figure 4.10. Baldhead Shoal Channel 1 channel width by station: Station 24+00 to 45+00

Figure 4.9 shows that the channel width has remained fairly stable between Stations 0+00 and 15+00 throughout the survey period. Seaward of Station 15+00, a very quick narrowing of the channel was observed until about July 2005. Since that time, the rate of channel narrowing appears to have slowed, most notably between Stations 16+00 and 19+00. For all surveys, the narrowest channel width was approximately 540 feet at Station 21+00.

For Stations 24+00 to 45+00 (Figure 4.10) similar quick initial channel narrowing was observed, however subsequent surveys showed that the rate of narrowing appeared to slow somewhat up through Station 33+00 with a more stable channel width seaward. The narrowest channel width for this portion of Baldhead Shoal Channel 1 was approximately 580 feet at Station 24+00.

<u>Spit Growth.</u> In 2001-02 approximately 1.8 million cubic yards of sand were dredged and subsequently placed on Bald Head Island from station 41+60 to 205+50. After placement, the spit on the east side of Baldhead Channel 1 doubled in volume (400,000 cubic yards in October 2004 versus 200,000 cubic yards pre-2001). From November 2004 through January 2005, approximately 1.2 million cubic yards of material were dredged and placed from station 47+00 to 130+00. After this placement cycle, the Village of Bald Head Island reconstructed 16 shore-perpendicular sand tube groins between profile station 47+50 and 104+00.

Spit volumes were calculated within the bounding polygons shown in Figure 4.11. The change in spit volumes above -44 ft MLLW for Baldhead Shoal Reach 1 is shown in Figure 4.12 with the two dredging/placement events noted. Figure 4.13 shows a comparison of the two post-placement responses from Figure 4.12. 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 versus the second rate of about 10,000 cubic yards per month, i.e., a 38 % reduction in the shoaling rate. 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.

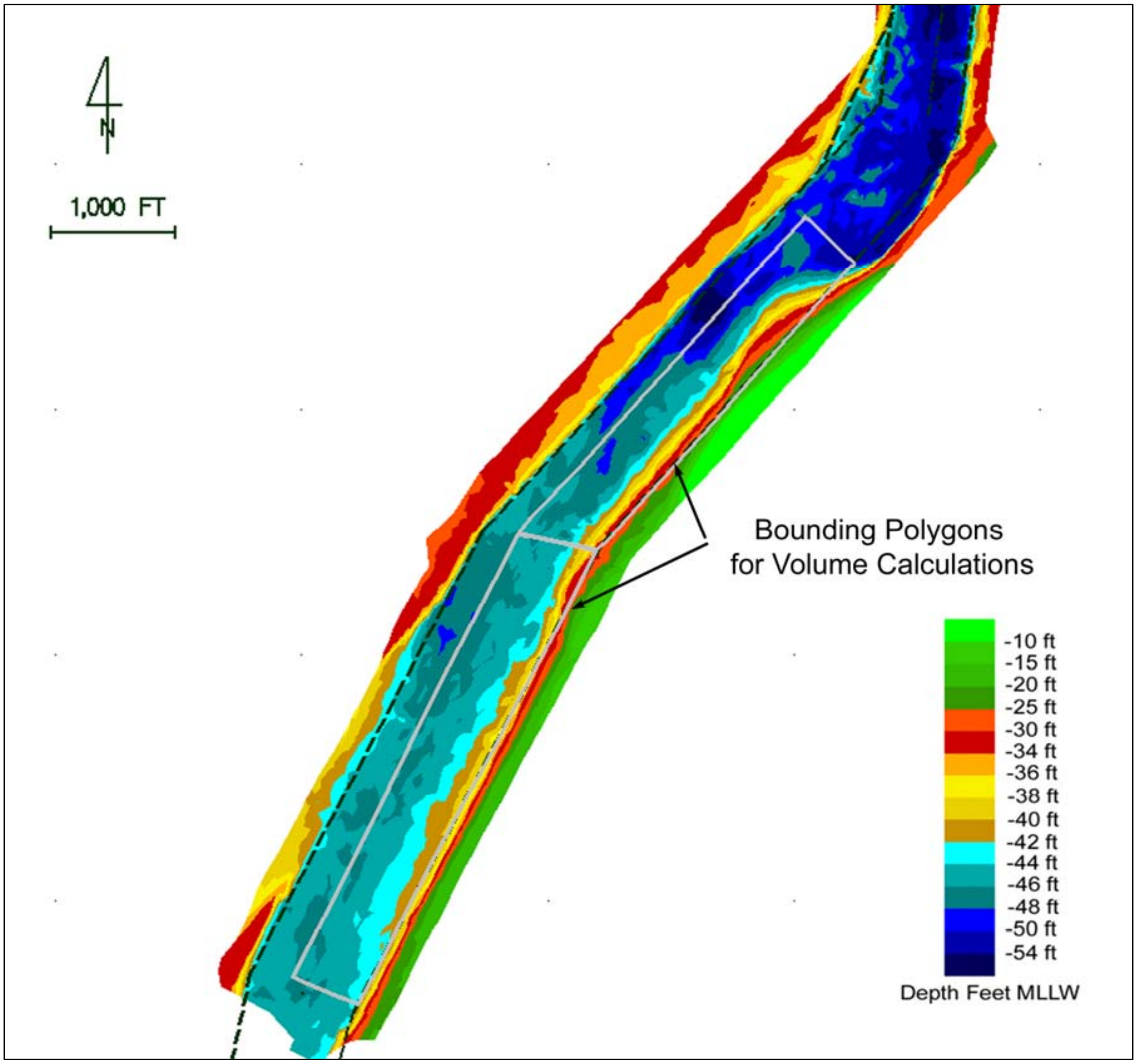


Figure 4.11. Spit volume bounding polygons

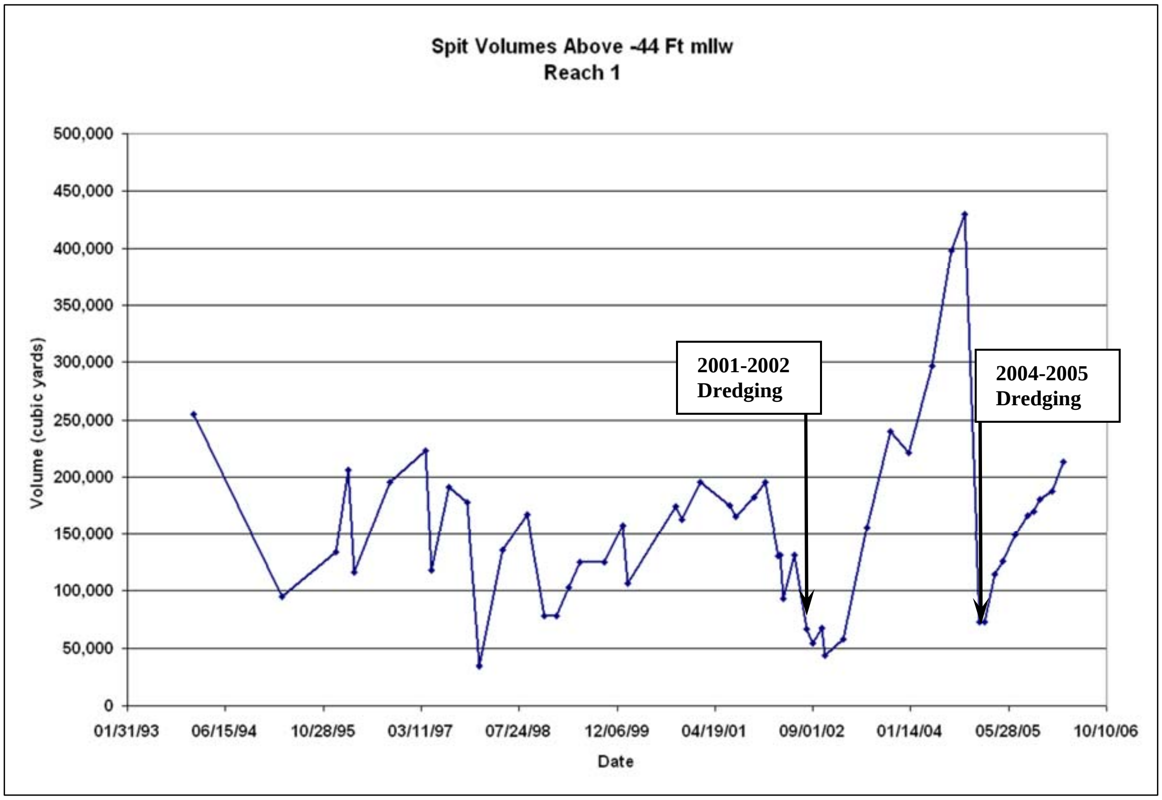


Figure 4.12. Baldhead Shoal Channel 1 spit volumes

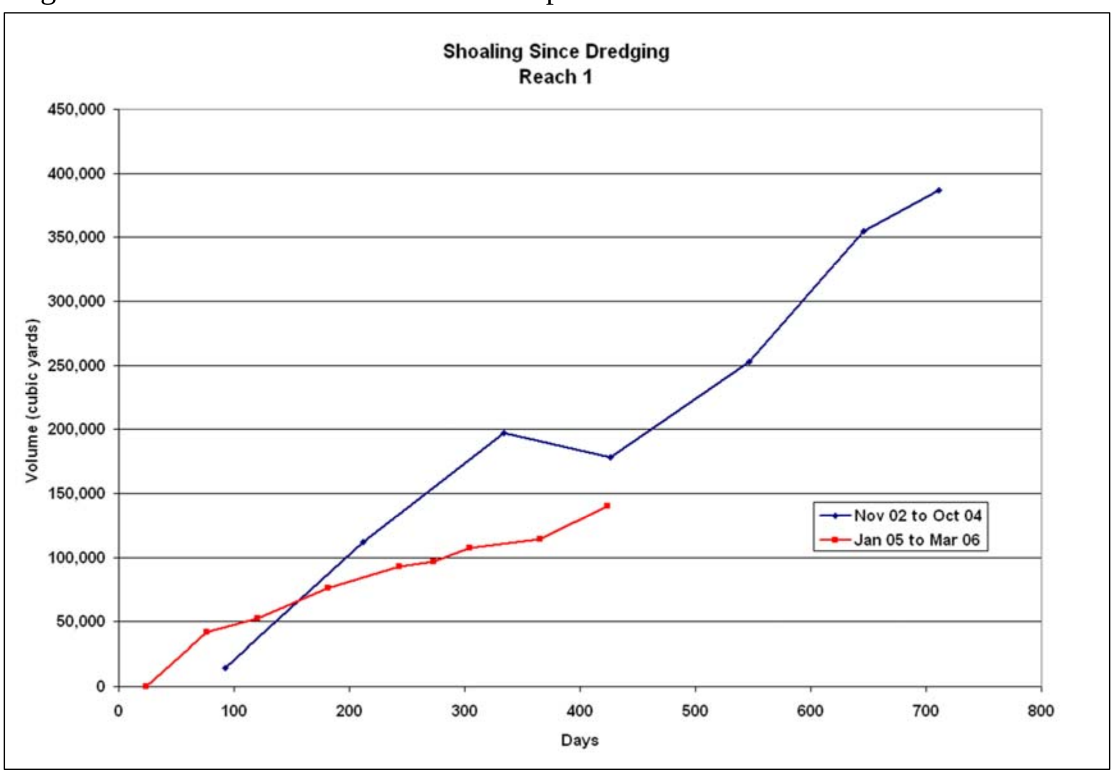


Figure 4.13. Comparison of post-placement spit growth from Figure 4.12

Part 5 SUMMARY

This report is the third 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 fifth year of data collection and focuses on the most recent period from June 2004 through August 2005. 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 1.2 million 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.

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 2 (June 2004) 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 June 2004 to August 2005) and for the entire period (from August/September 2000 to August 2005).

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 positive. When considering all profile lines, a minor average gain of 0.8 feet has been measured since June 2004. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –50 to +50 feet), the average alongshore trend is slightly erosional at –0.7 feet 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 (except for Profile 95 that was eroding slightly with the August 2005 survey). 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 95 feet more seaward in February 2005 than it was in 2000. Likewise, the shoreline position was 98 feet more seaward in August 2005, than it was five years ago at the start of the project.

In terms of net volume change, a general stability has been observed along Oak Island/Caswell Beach over the current period. When considering all profile lines, a net gain of 207,500 cubic yards was computed since the last report, between January 2004 and August 2005. This stable trend observed over the current period is typical of that measured for the entire 5-year monitoring period. As such, only minor (but positive) changes have occurred following initial fill placement in 2001 associated with the project dredging. Specifically, by the end of the period, an excess of 1,492,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition. This quantity reflects a net gain above the fill volume placed in 2001. Most of this gain 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 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 accretionary or stable over the last year with the exception of West Beach and in the vicinity of the spit (at the southwestern tip of the island). The largest zone of accretion occurred between Profiles 46 and 142, reflecting the positive impact of the January 2005 beach fill. Over this 9,600 foot reach, the beach is up to 275 feet wider, with an alongshore average increase of 152 feet. Extending east of this fill area (between Profiles 146 and 220), the beach is found to be generally stable, with the shoreline being slightly seaward of its position a year ago, by an average of 3 feet. In contrast to the stable nature found along South Beach, the area along West Beach and in the vicinity of the spit near the southwest corner of the island display eroded shorelines. For West Beach (Profiles 0 thru 28), the shoreline has receded an average of 14 feet since June 2004. For the vicinity of the spit (between Profiles 32 & 43), the shoreline has shown a large degree of variability, gaining as much as 155 feet and losing more than 80 feet. Overall, the alongshore average shoreline changes measured over the entire monitoring area were a gain of 52 feet and 64 feet for the February 2005 and August 2005 surveys, respectively.

A similar pattern of shoreline change was measured over the last 5-year period, since the monitoring was initiated, i.e., some erosion along West Beach, the highly variable changes in the vicinity of the spit, and significant accretion along the entire South Beach area. The accretional area covers most of South Beach beginning just east of the spit at Profile 53. The largest positive shoreline changes are reflected within the January 2005 fill zone, extending to about Profile 140. Within this fill area, the shoreline is an average of 109 feet seaward of its September 2000 position. Even beyond the fill area, the shoreline change remains positive, ranging between 50 and 100 feet more seaward at this time. Other large accretions are evident within the spit area along the southwest tip of the island. Here shoreline advances of more than 200 feet are indicated (Profile 36), but even greater recessions are seen proceeding area around the tip with a maximum negative shoreline change of –240 feet recorded at Profile 43. For West Beach, the shoreline changes have been both positive and negative, with the average along this reach being a loss of 19 feet since the start of the monitoring. When considering all locations along Bald Head Island, the shoreline is presently on the average 68 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey (June 2004) of Report 2 to August 2005, Bald Head Island experienced both gains and losses. The gains are the result of the positive impact of the beach placement within the western half of South Beach (Profiles 53 to 130). In contrast, losses are evident on either side of the fill area. These erosional areas extend eastward throughout the remaining portions of south beach to the cape and westward into the area of the spit. The spit area also has a smaller in-filled area around the corner of the island along the margin of the channel. In terms of overall volumetric change the positive area of the fill is significantly larger in magnitude that the adjacent negative areas. Specifically, the net gain between June 2004 and August 2005 was 273,000 cubic yards.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, most of Bald Head Island has shown a gain except for two areas. One is located at the extreme eastern end of south beach, where relatively large losses have occurred near the cape. The other, which is of more concern, is at the western end of south beach between Profiles 45 and 61. This 1,600-foot reach has been the site of chronic erosion in the past and has a volumetric deficit of about 168,000 cubic yards. Aside from these two areas, all other profile volume changes are positive throughout the remaining areas. 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 447,000 cubic yard gain in February 2005 and 864,000 cubic yard gain by August 2005, even including the volume losses experienced near the cape.

Rates of shoreline change were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the NCDCM shoreline data based on a 62-year period of record. Although the monitoring period spans a relatively shorter time period of about 5 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 5-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. Overall, the shoreline change rate averaged over the entire monitoring area was about +30 feet per year for the 5-year period. By comparison the long-term rate over the entire reach was –1.1 feet per year.

For Bald Head Island, the comparison of the pre- and post-construction rates show that most of island is eroding less over the initial 5-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 of this zone has decreased with rates computed through the present period. A direct comparison of the pre- and post-construction shoreline change rates show that only 4 profile lines are eroding at a higher rate during the post-construction period. These 4 lines located at the western end of south beach (Profiles 53 thru 66) span a reach of about 2,400 feet. Over this reach, the average rate is -13.8 feet per year versus a comparable long-term rate of about -5 feet per year. Outside of this problem area, 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 placed beach fill and possibly to the positive effect of the rehabilitated groin field which was accomplished by the Village in conjunction with the 2005 beach disposal operation. Specifically, the rates computed for the most recent period are an average of +23 feet per year over the remaining portions of South Beach. Historically, this same area would have eroded about 6 feet per year.

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 spit migration 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 ft MLW elevation. To date nine condition surveys have been accomplished and reveal that 10-feet or more of 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. Presently the narrowest channel width recorded is 540 feet, at Baldhead Shoal Channel station 21+00 Reach 1, located in the immediate vicinity of the spit.

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. The comparison showed that to date 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. 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.

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 overall morphology of the ebb and nearshore shoals has been largely static over the initial monitoring period which suggests there have not been substantial changes in sediment transport pathways around the ebb tidal delta since the initial pre-construction 2000 survey. However, one observed change was deepening of the flood margin channel along the tip of Oak Island. A companion flood margin channel, of comparable magnitude, is not present through Bald Head Shoal on the opposite side of the entrance channel. Another area of interest is the shoal located between the old and new channels just seaward of their intersection. This portion of the shoal remained generally stable until this year. With the latest ebb shoal survey, this area has begun to erode. The area is located where the largest peak ebb currents have been measured around the distal end of the ebb tidal delta. Finally, a thin but broad area of accretion has developed along the offshore portions of Jay Bird Shoals.

To date currents have been measured on five occasions, with the initial occurring before the channel improvements and the remaining four 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.

The current measurements were used to calculate the tidal prism, i.e. the total flow volume passing through the inlet over the tidal period. 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 sets 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.

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 have 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 local government with the intent of reducing the erosion of the in-place fill. The next maintenance cycle is scheduled for November 2006 (funds permitting) and is likewise to be placed on Bald Head 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 coordinated with local interests.

Future Monitoring Efforts.

The initial efforts of the monitoring program have developed a fundamental understanding of the existing coastal processes and short-term bathymetry and shoreline variability. The extensive data collection program has provided the data needed to develop calibrated wave transformation and hydrodynamic models. A gradual shift will be made over the six-year operational plan from field data collection efforts toward use of these modeling tools. The tools will be used to help quantify magnitudes and patterns of sediment transport and develop a detailed sediment budget for the area. This working suite of coastal engineering tools will provide assessment of future beach and inlet management actions and provide input to the sand management plan.

REFERENCES

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

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

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

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

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

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

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

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

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

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

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

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

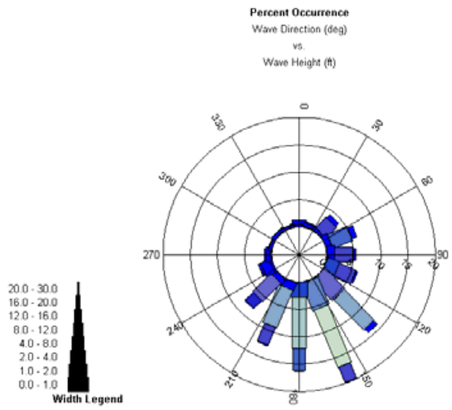
USACE 2005, Physical Monitoring, Wilmington Harbor Navigation Project, Report 2: June 2003-June 2004, U.S. Army Corps of Engineers, Wilmington District, February 2005.

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

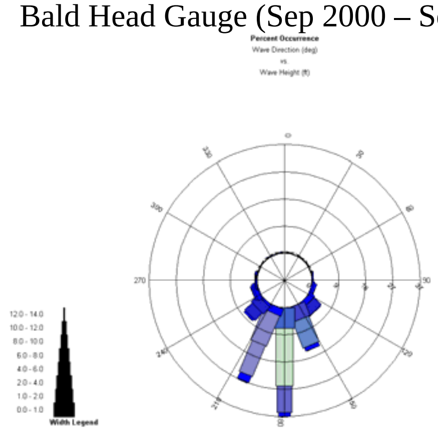
Appendix A

WAVE GAUGE DATA
Wave Roses (2000 thru 2005)

Eleven-Mile Gauge (Sep 2000 – Sep 2005)



Bald Head Gauge (Sep 2000 – Sep 2005)



Oak Island Gauge (Sep 2000 –Apr 2005)

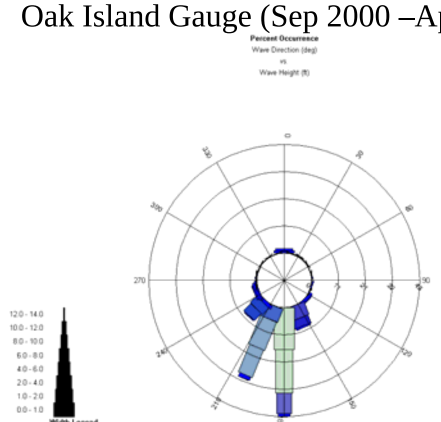
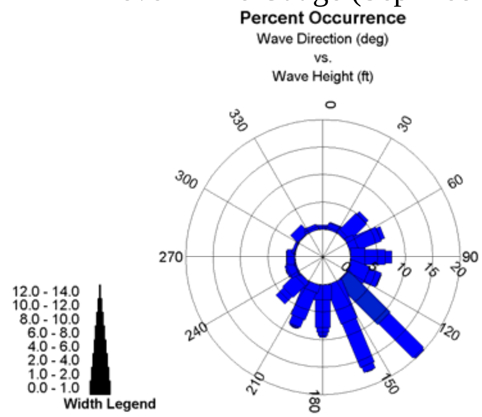
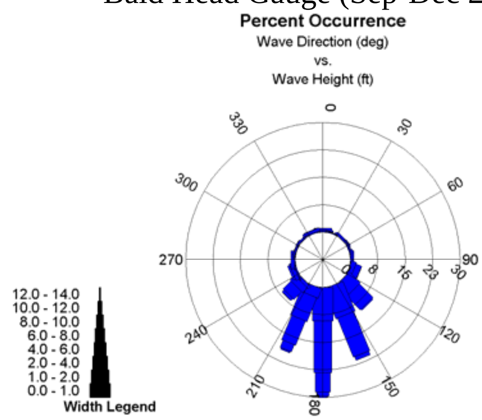


Figure A-1 Wave Height Roses for FRF Gauges throughout deployment.

Eleven-Mile Gauge (Sep-Dec 2000)



Bald Head Gauge (Sep-Dec 2000)



Oak Island Gauge (Sep-Oct 2000)

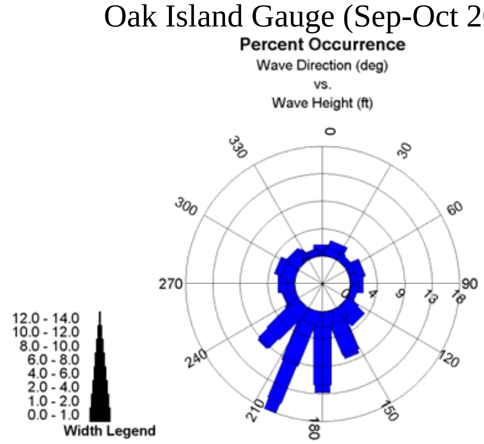
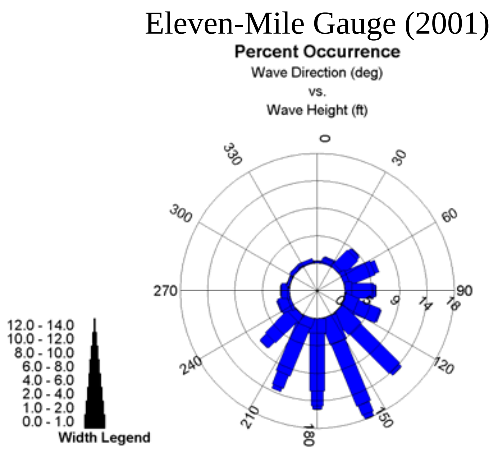
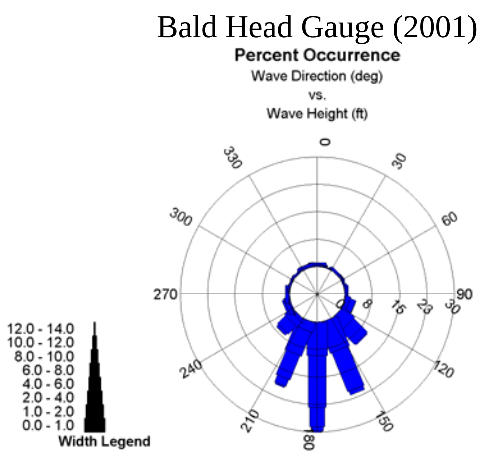


Figure A-2 Wave Height Roses for FRF Gauges (2000).





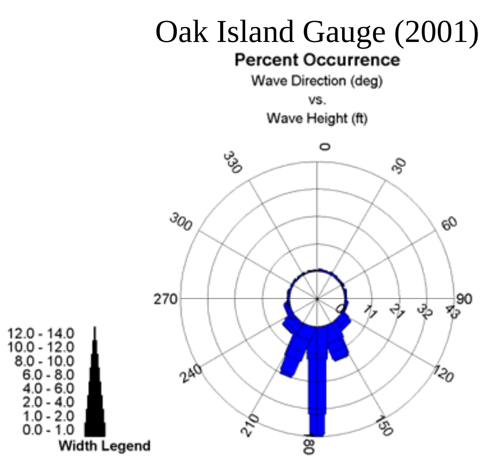
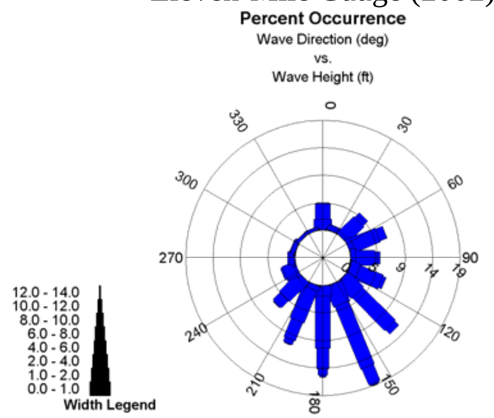
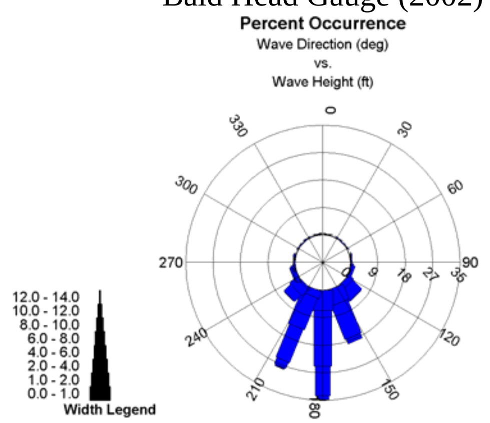


Figure A-3 Wave Height Roses for FRF Gauges (2001).

Eleven-Mile Gauge (2002)



Bald Head Gauge (2002)



Oak Island Gauge (2002)

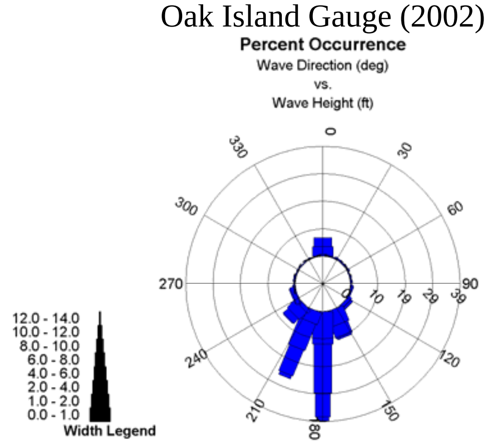
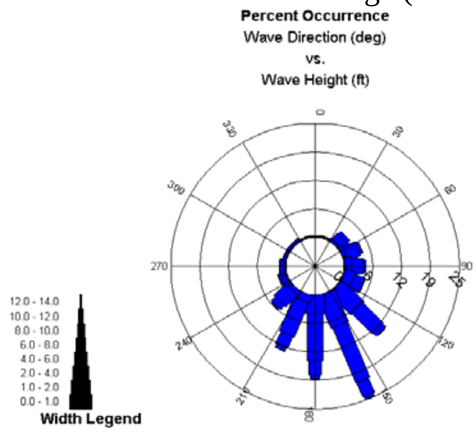
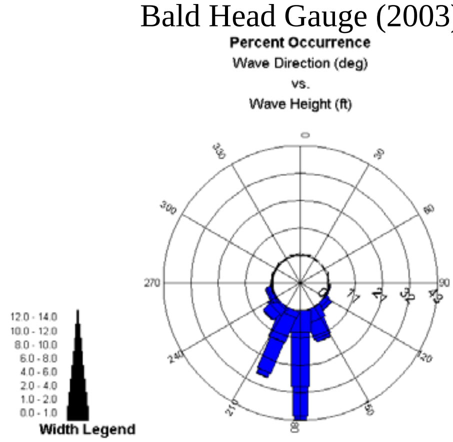


Figure A-4 Wave Height Roses for FRF Gauges (2002).

Eleven-Mile Gauge (2003)



Bald Head Gauge (2003)



Oak Island Gauge (2003)

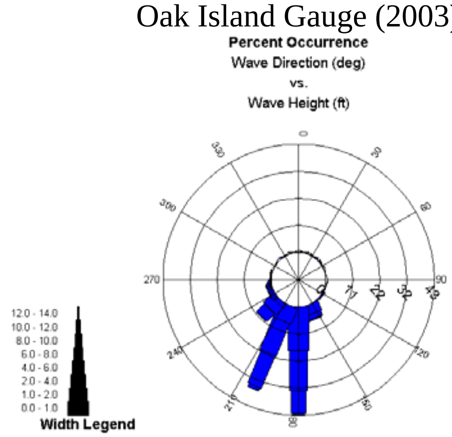
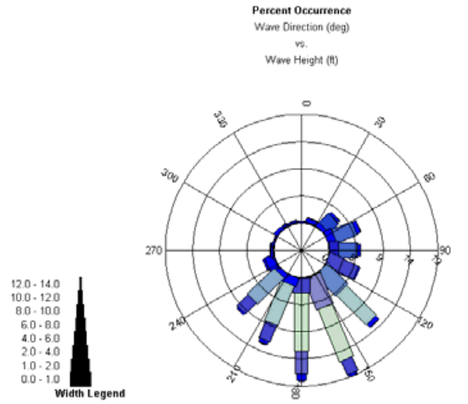
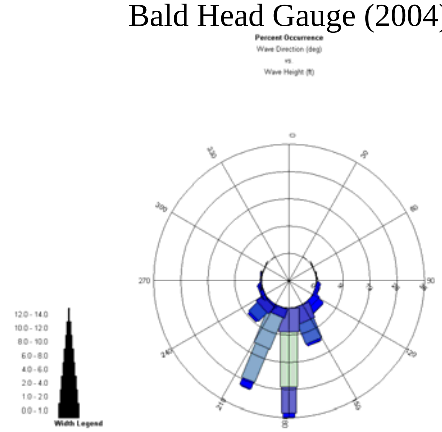


Figure A-5 Wave Height Roses for FRF Gauges (2003).

Eleven-Mile Gauge (2004)



Bald Head Gauge (2004)



Oak Island Gauge (2004)

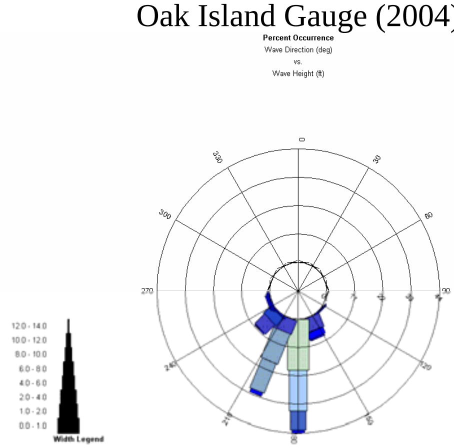
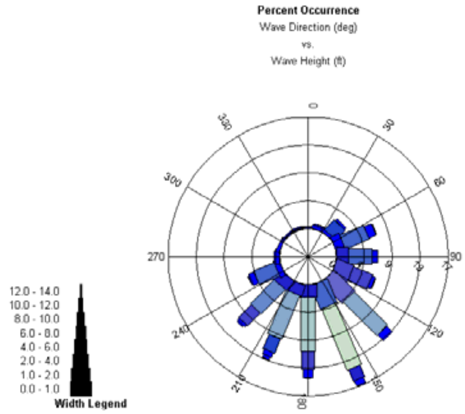
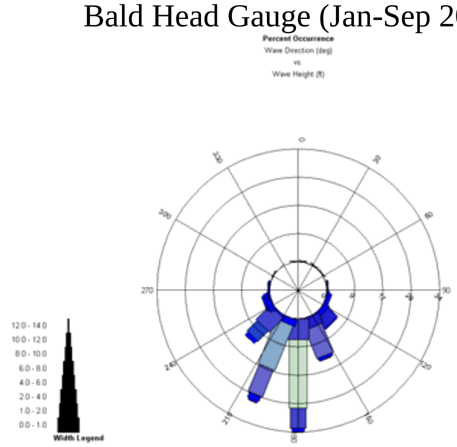


Figure A-6 Wave Height Roses for FRF Gauges (2004).

Eleven-Mile Gauge (Jan-Sep 2005)



Bald Head Gauge (Jan-Sep 2005)



Oak Island Gauge (Jan-Apr 2005)

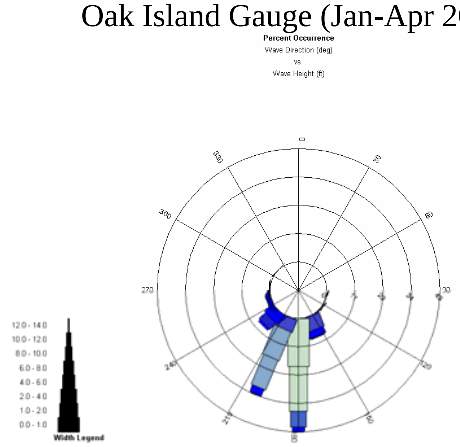
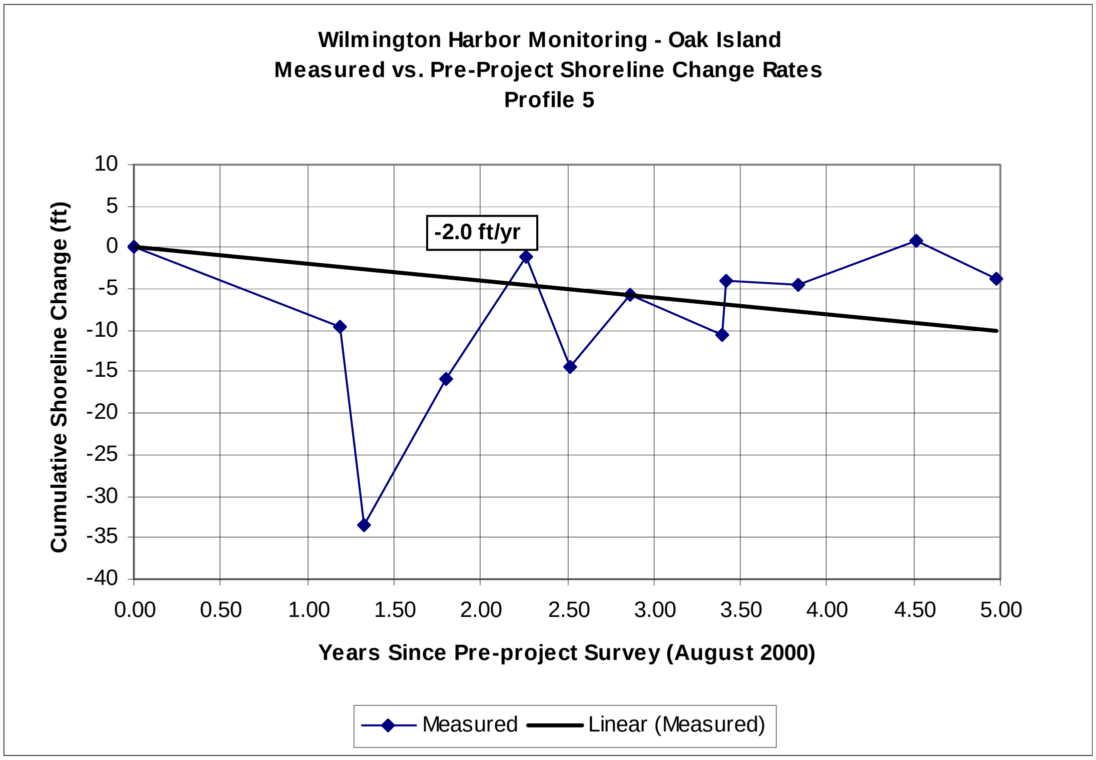
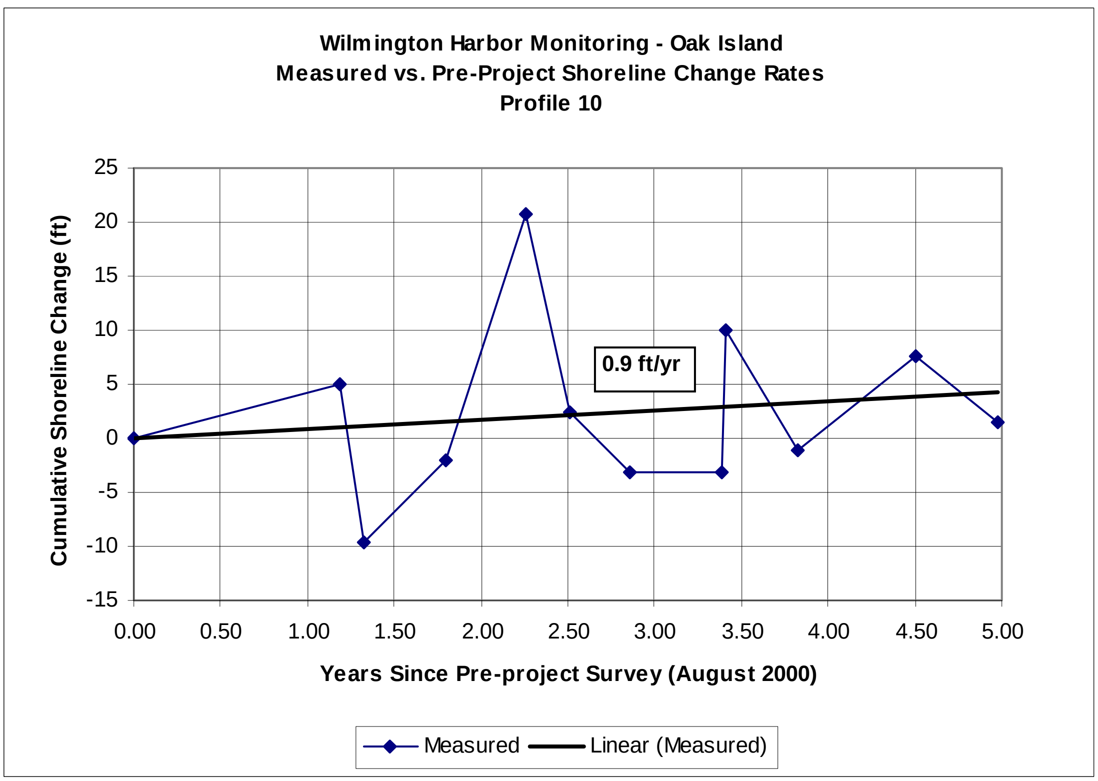


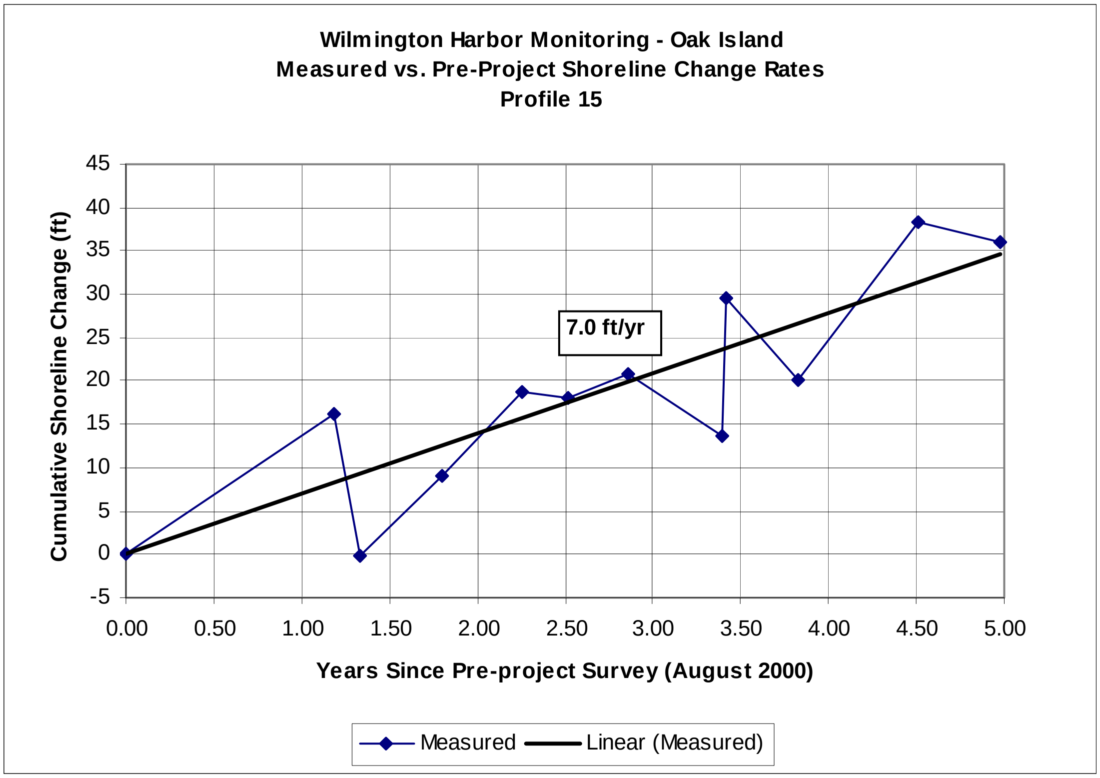
Figure A-7 Wave Height Roses for FRF Gauges (2005).

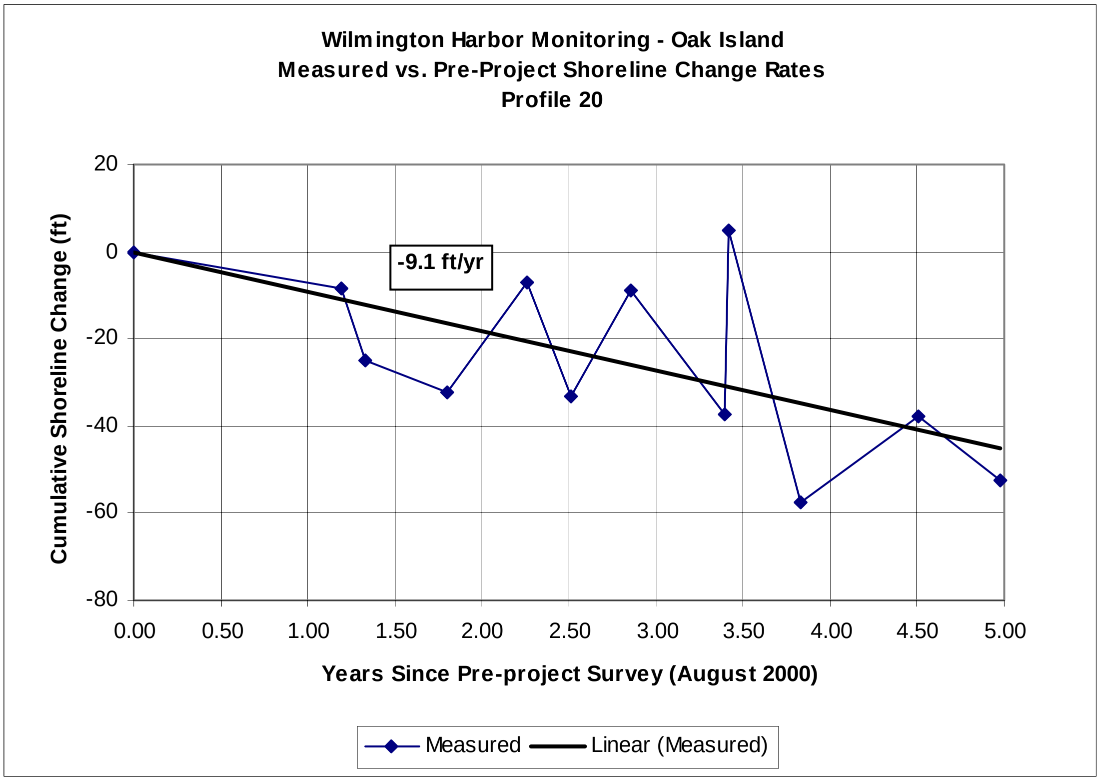
Appendix B

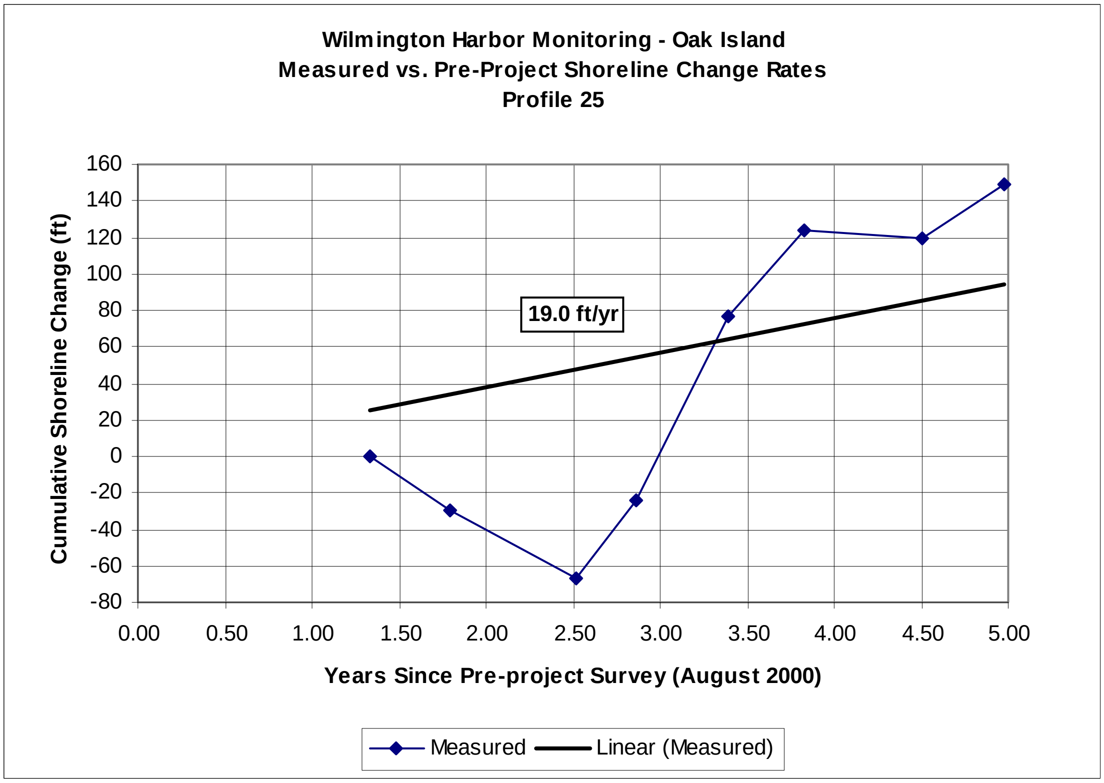
SHORELINE CHANGE RATES
(Oak Island)

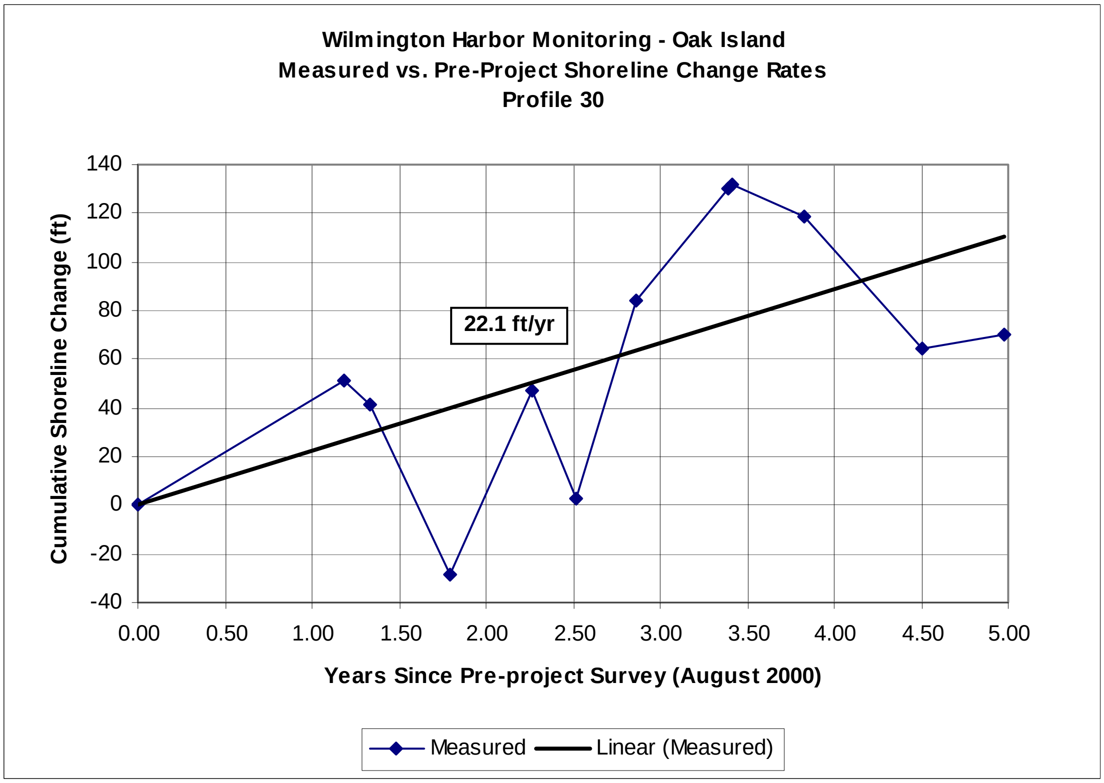

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 5
-2.0 ft/yr
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

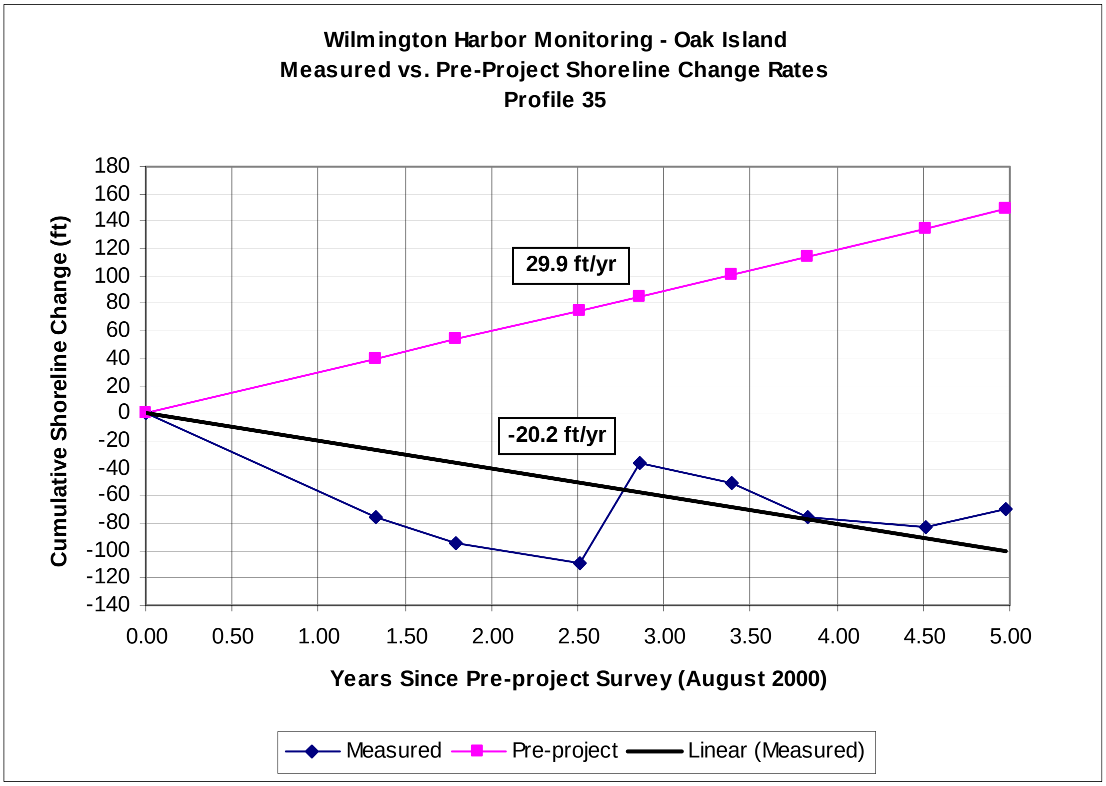

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 10
0.9 ft/yr
Cumulative Shoreline Change (ft)
25
20
15
10
5
0
-5
-10
-15
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 15
Cumulative Shoreline Change (ft)
45
40
35
30
25
20
15
10
5
0
-5
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
7.0 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

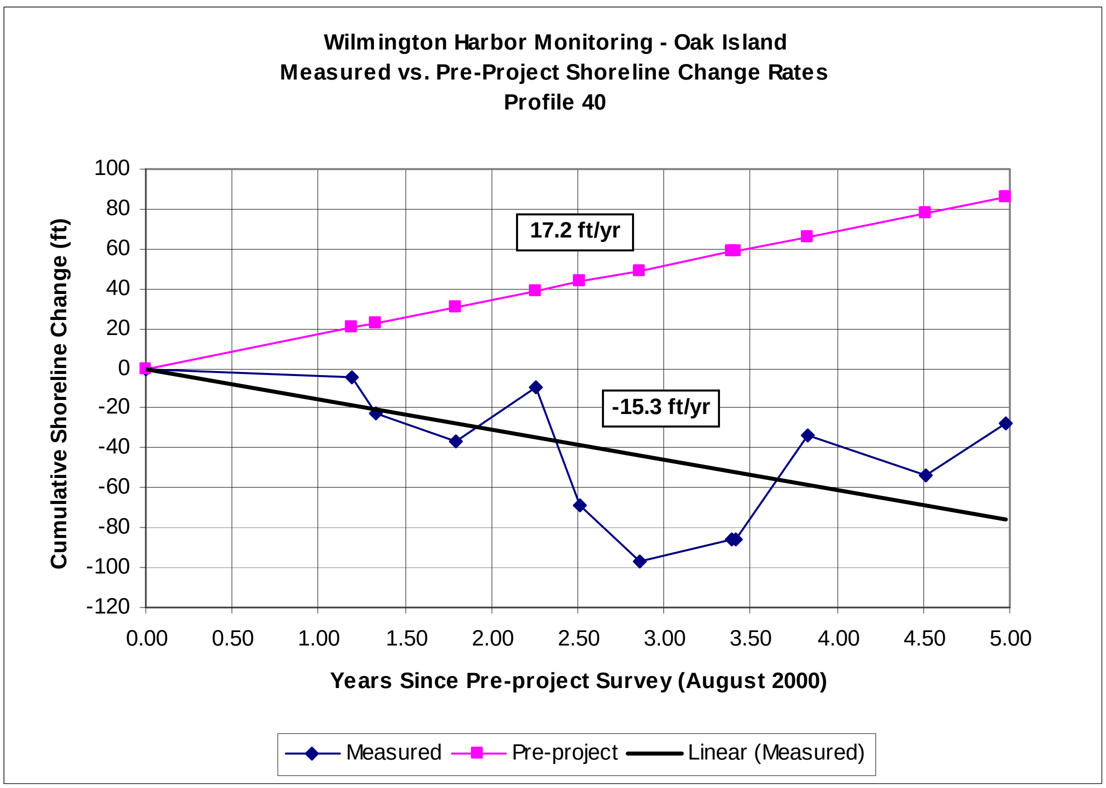

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
-9.1 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)


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
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)
19.0 ft/yr
Measured
Linear (Measured)

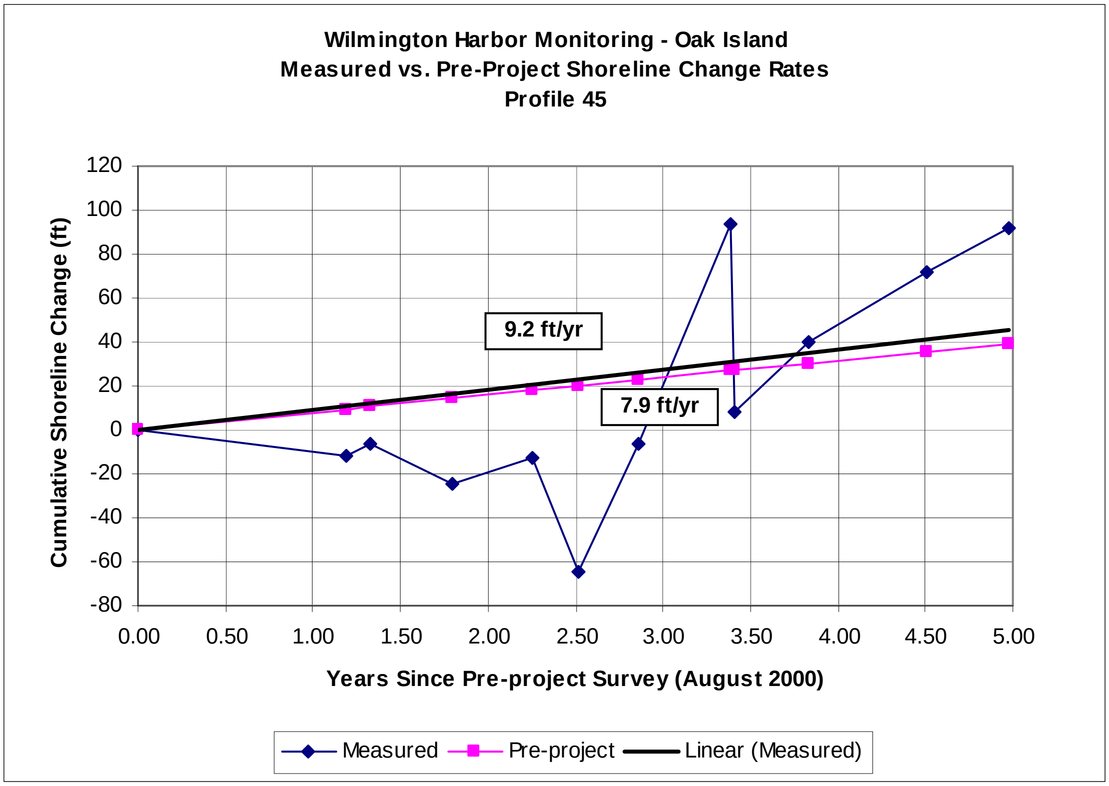

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 30
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
22.1 ft/yr
Measured
Linear (Measured)

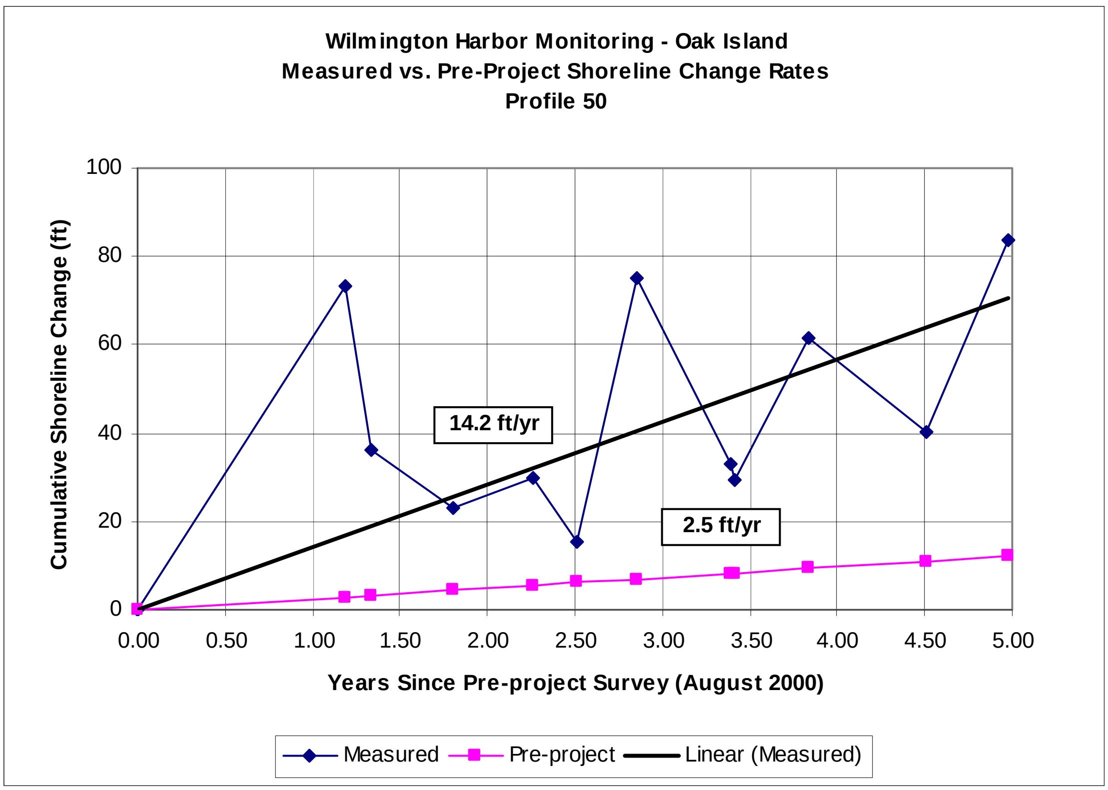


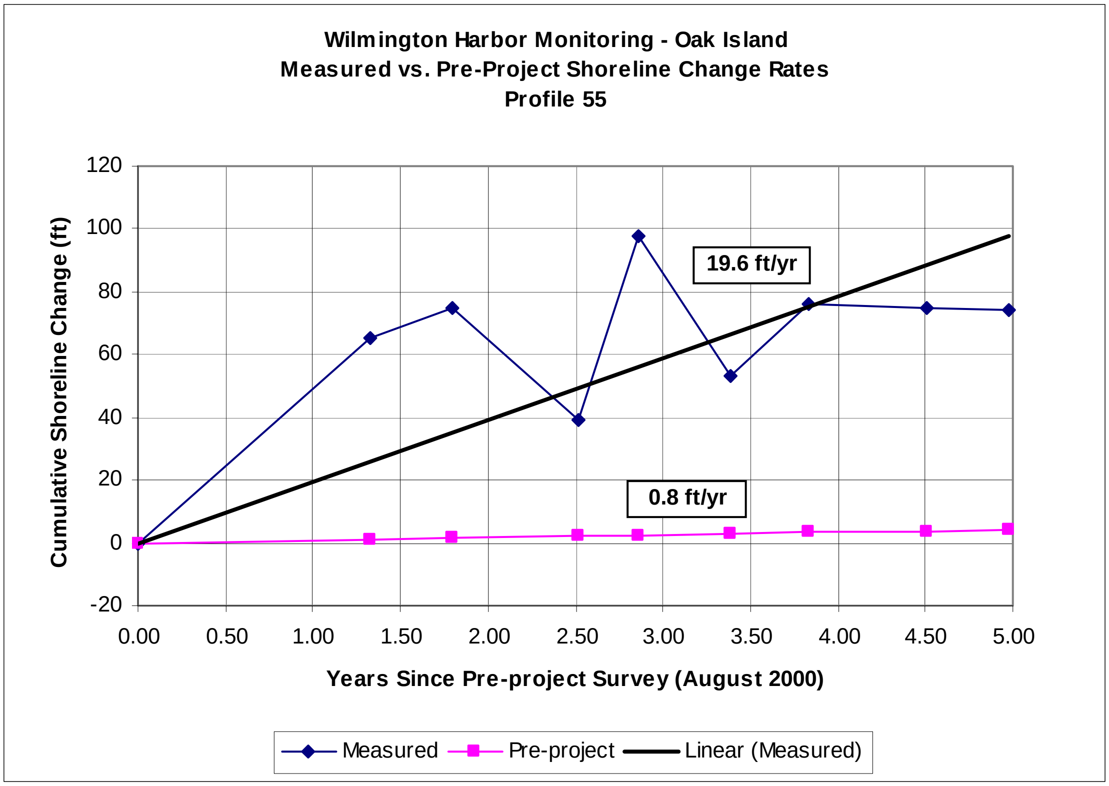
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 35
29.9 ft/yr
-20.2 ft/yr
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

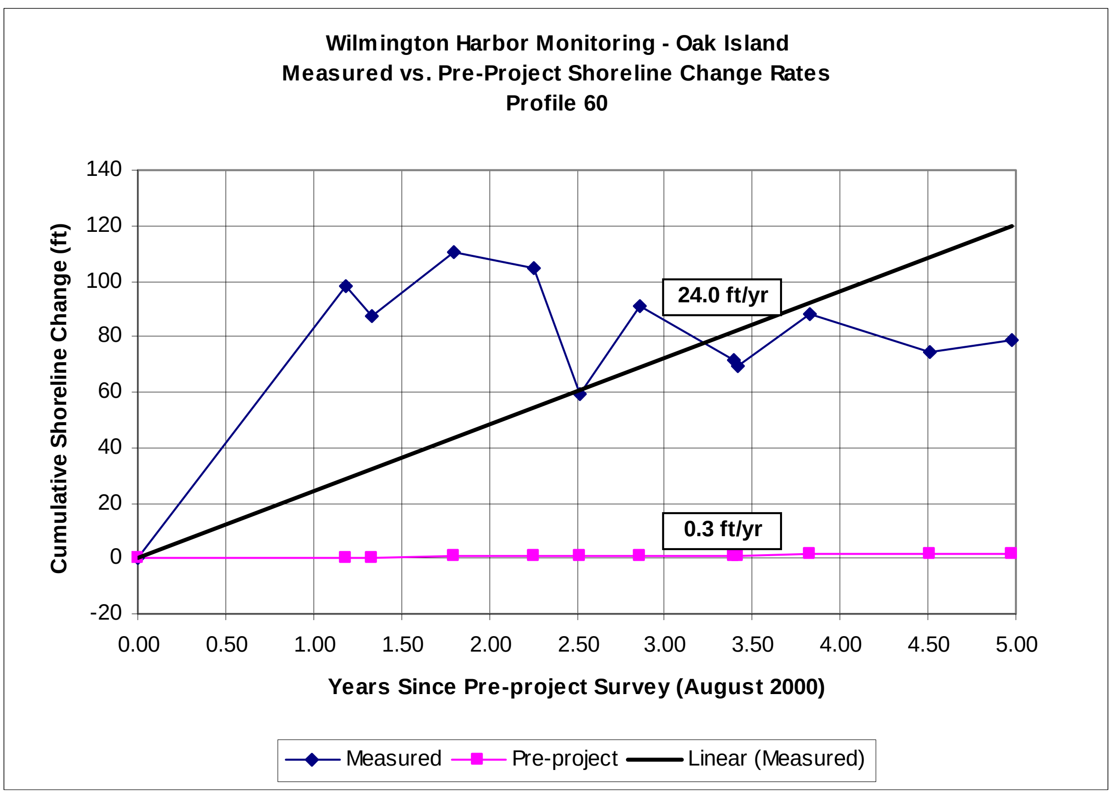


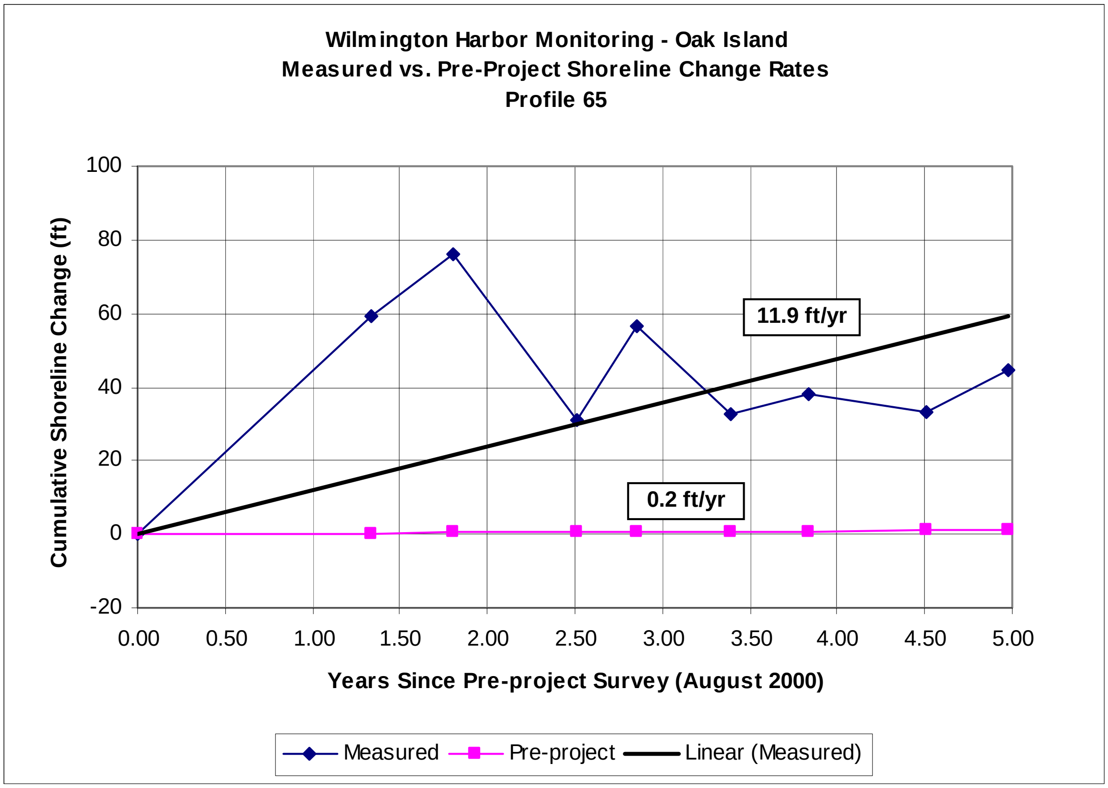
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
17.2 ft/yr
-15.3 ft/yr
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

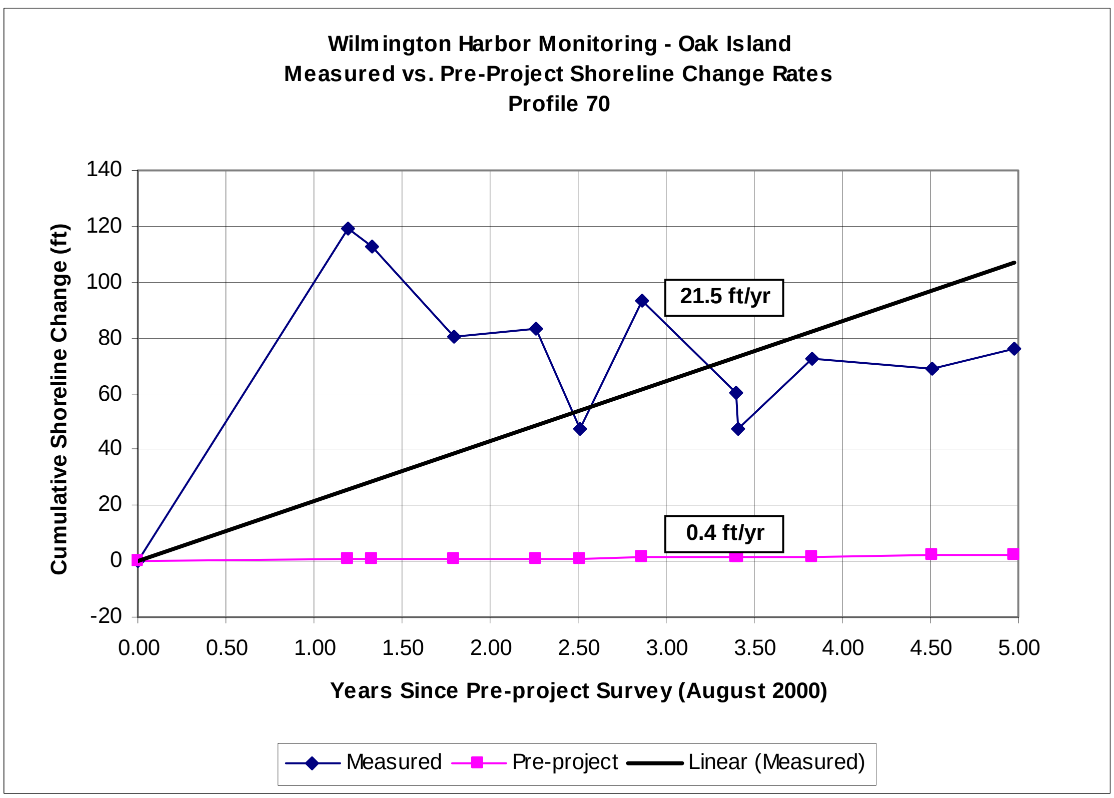

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
9.2 ft/yr
7.9 ft/yr
Years Since Pre-project Survey (August 2000)
Measured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

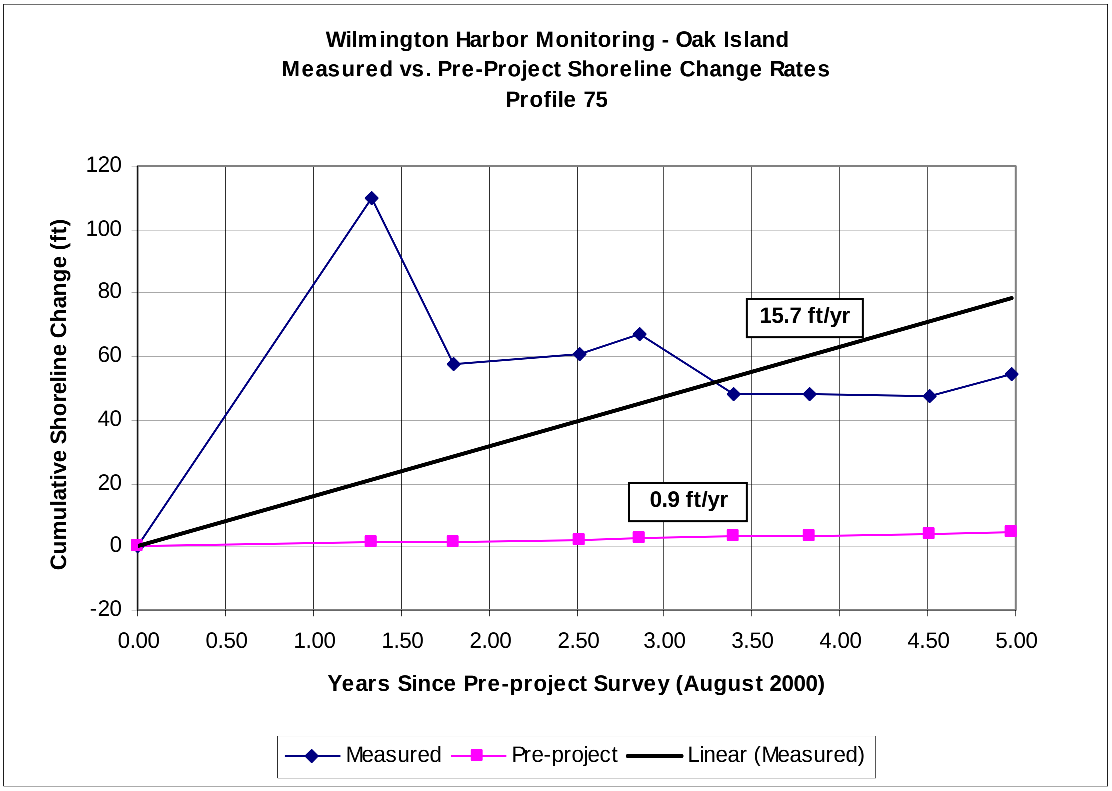

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 50
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
14.2 ft/yr
2.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear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

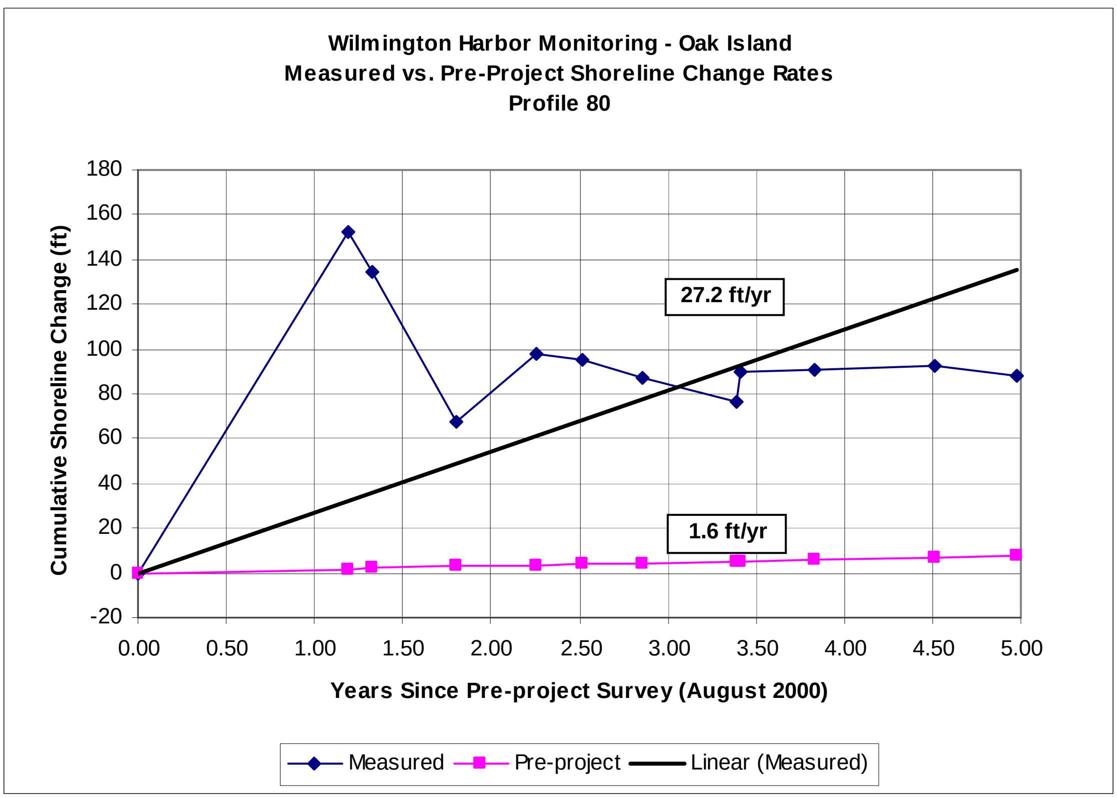

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 55
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
19.6 ft/yr
0.8 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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

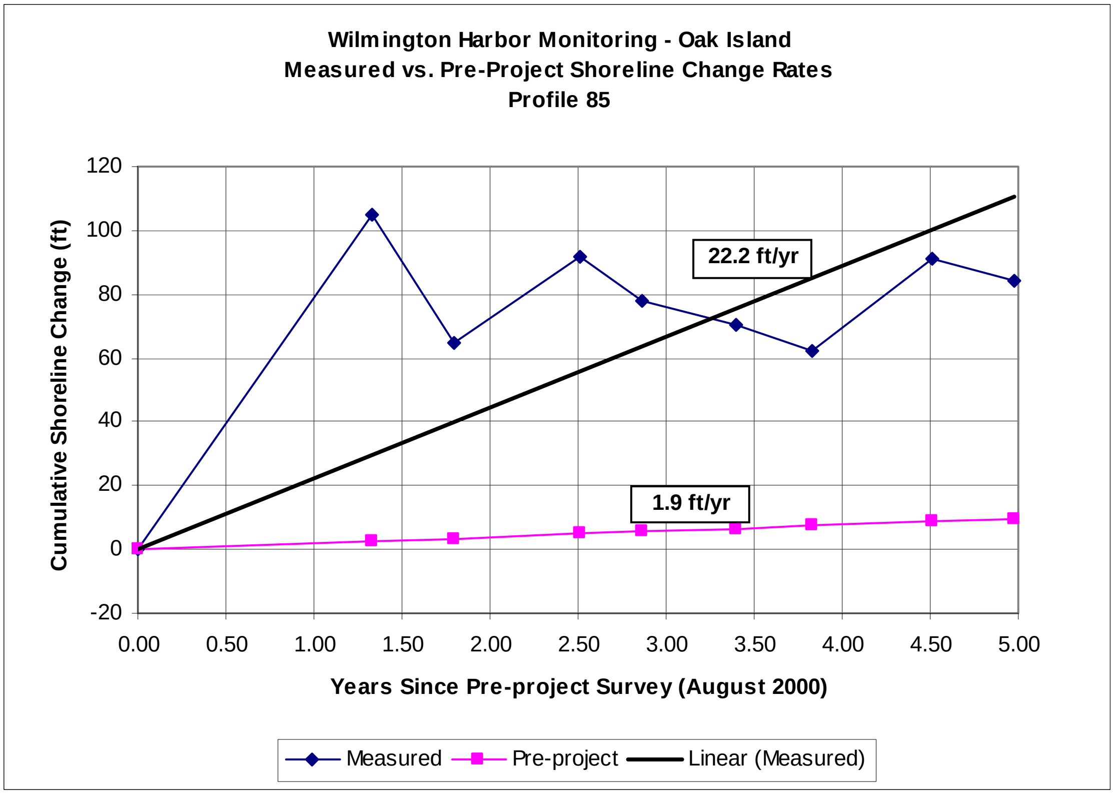

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 60
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
24.0 ft/yr
0.3 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project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


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

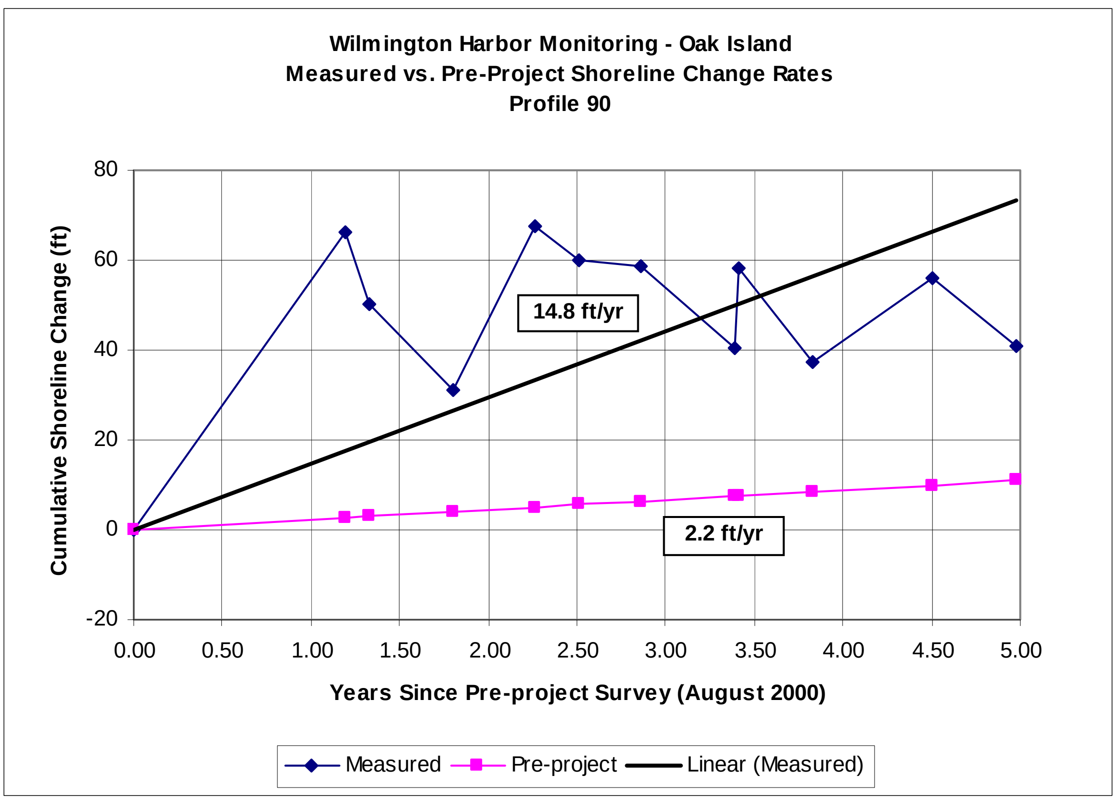

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 70
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
21.5 ft/yr
0.4 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 75
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
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)
15.7 ft/yr
0.9 ft/yr
Measured
Pre-project
Linear (Measured)

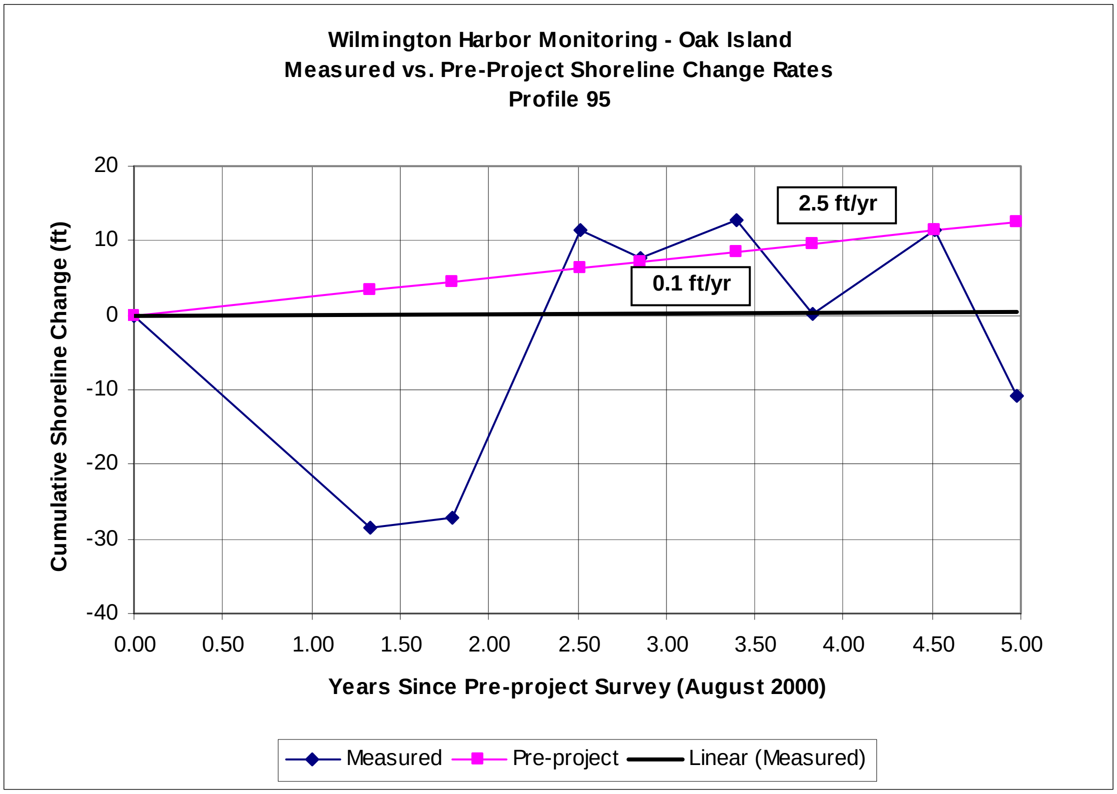

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 80
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
27.2 ft/yr
1.6 ft/yr
Measured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

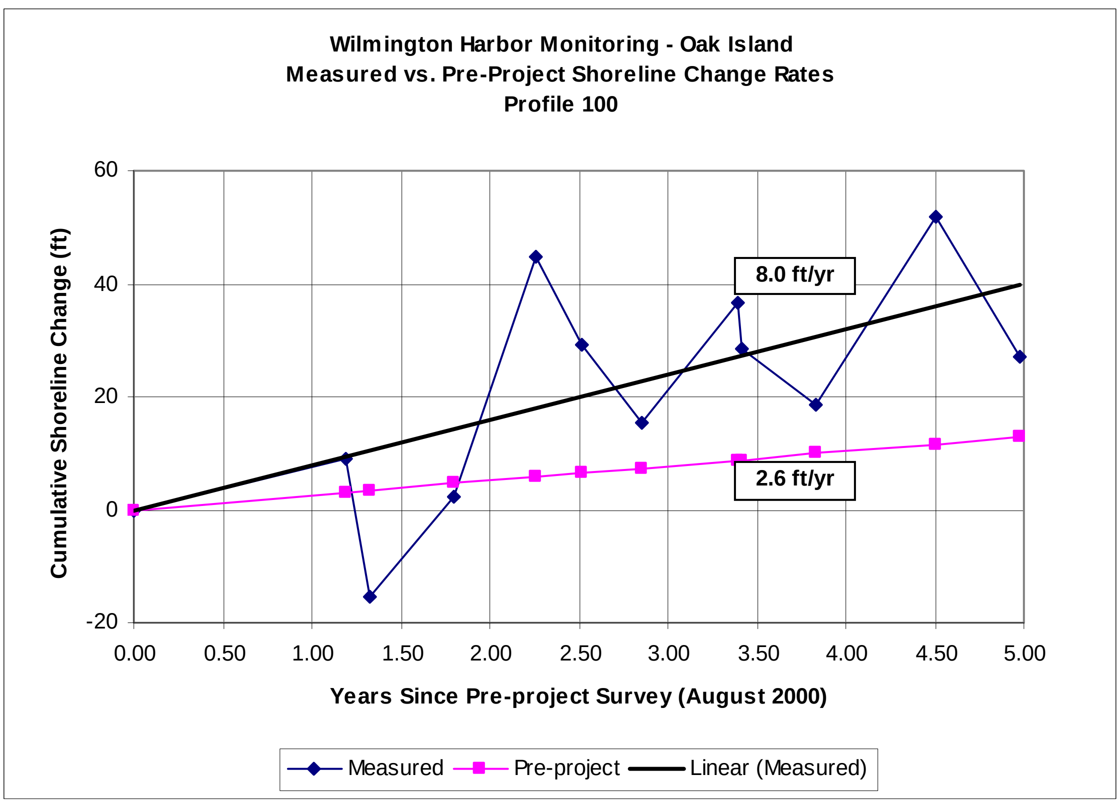


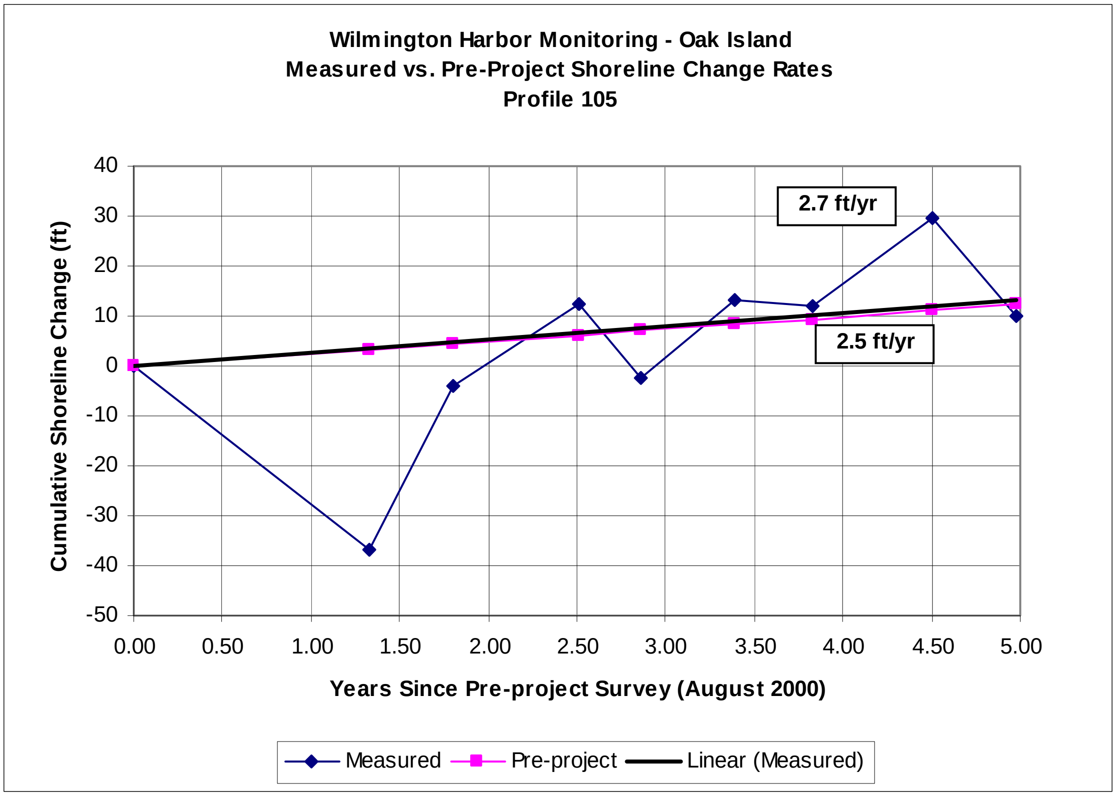
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 85
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
22.2 ft/yr
1.9 ft/yr
Measured
Pre-project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



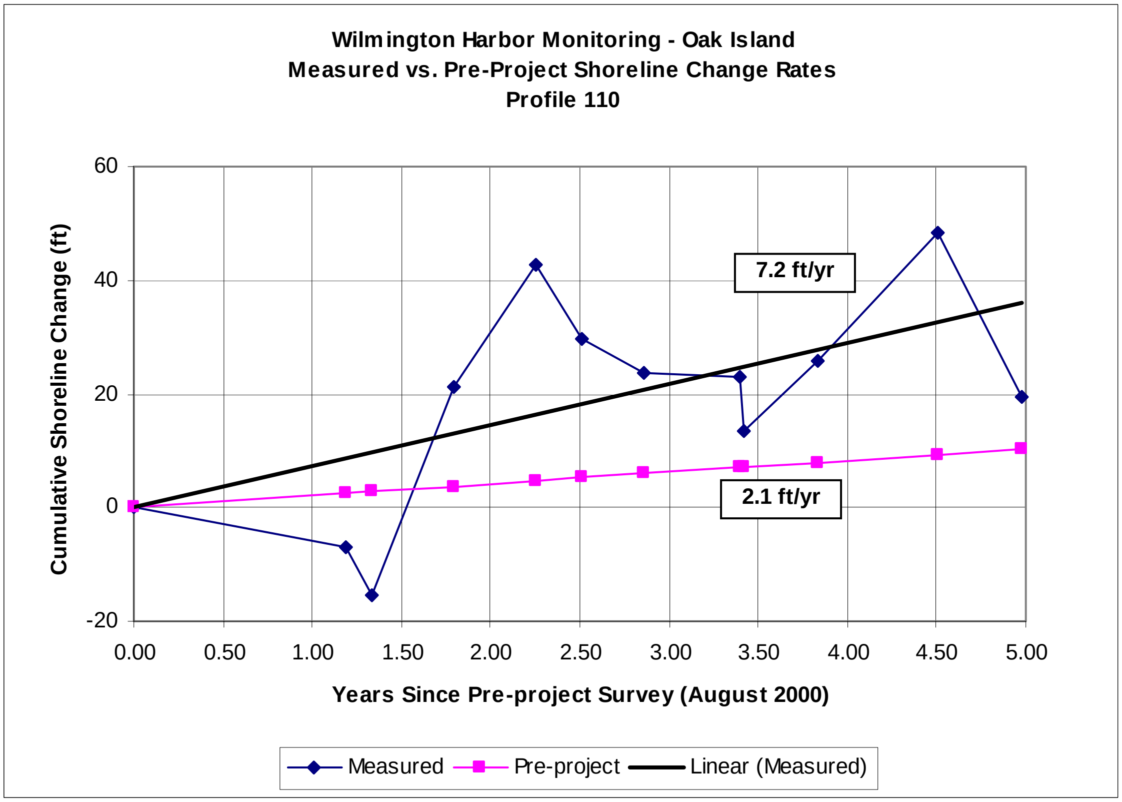
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 90
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
14.8 ft/yr
2.2 ft/yr
Measured
Pre-project
Linear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


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 95
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
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)
2.5 ft/yr
0.1 ft/yr
Measured
Pre-project
Linear (Measured)

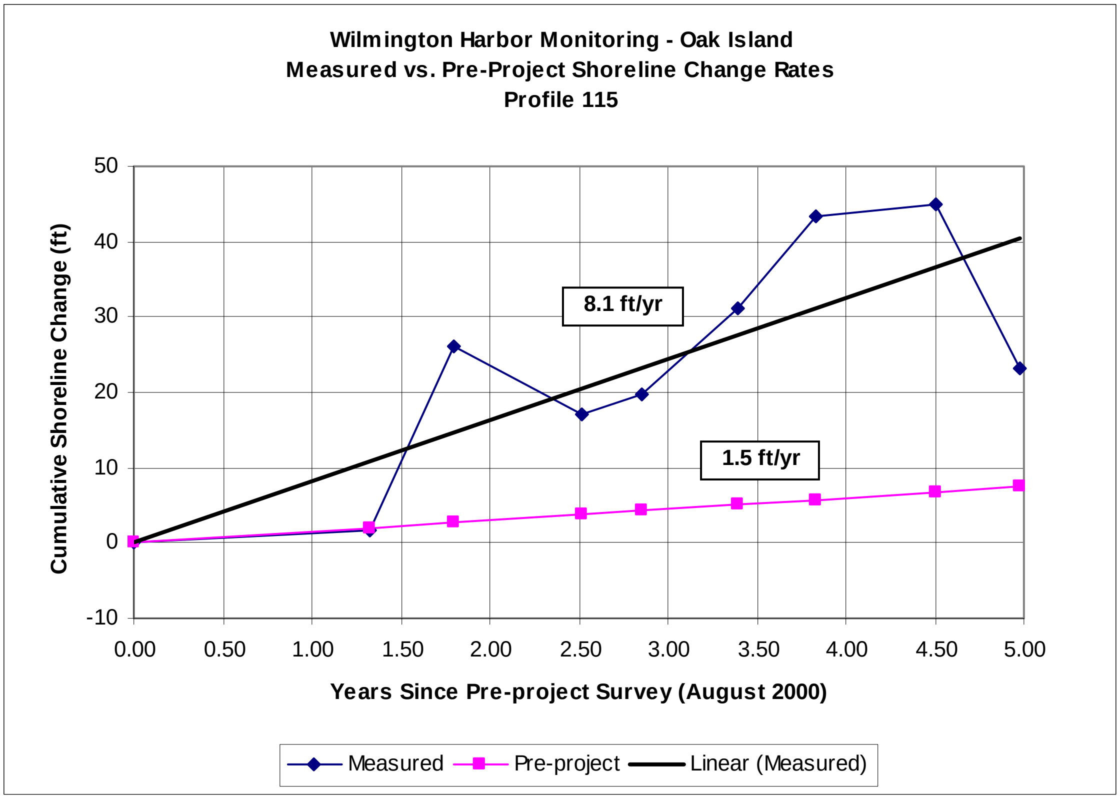

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 100
Cumulative Shoreline Change (ft)
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
8.0 ft/yr
2.6 ft/yr
Measured
Pre-project
Linear (Measured)



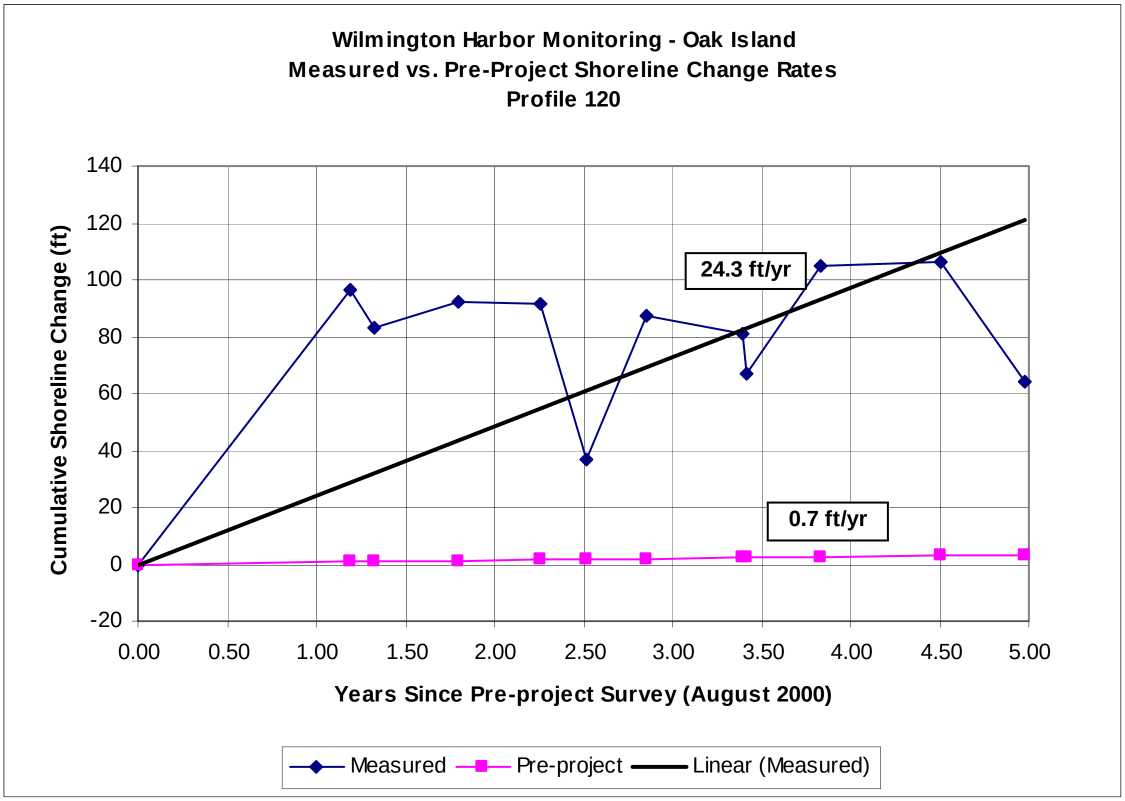
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 105
2.7 ft/yr
2.5 ft/yr
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
-40
-50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)



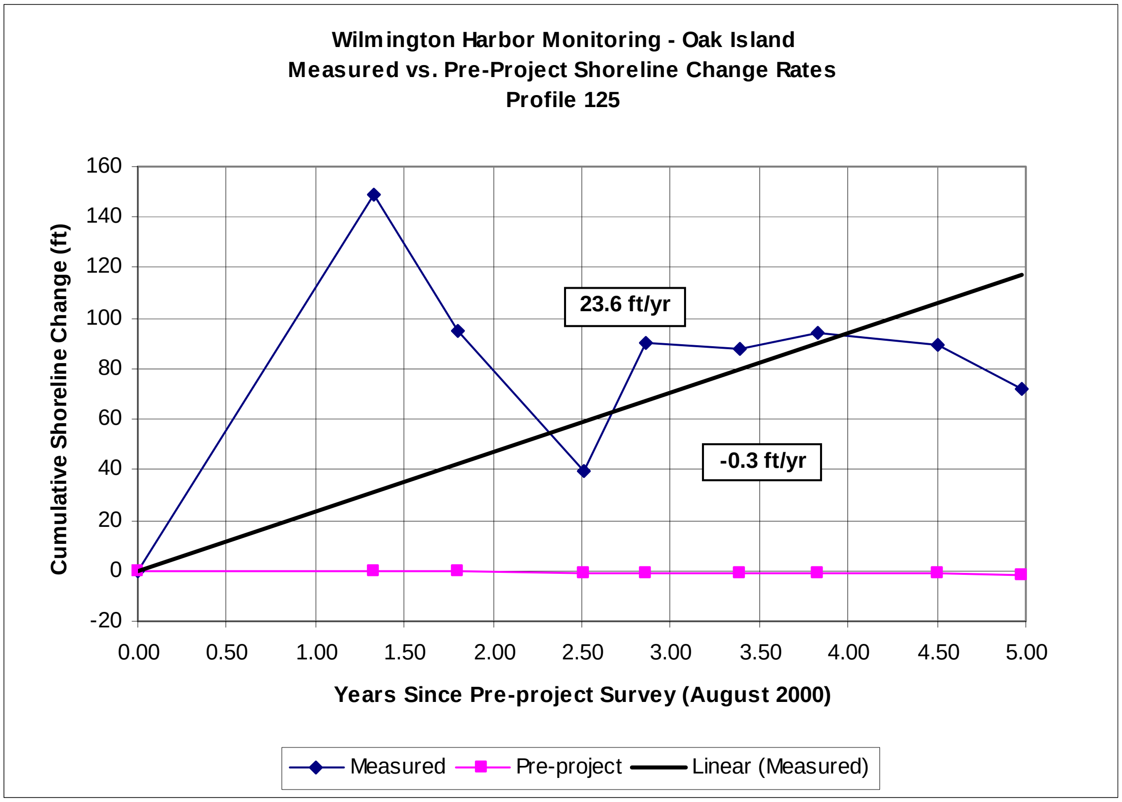
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
7.2 ft/yr
2.1 ft/yr
Cumulative Shoreline Change (ft)
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

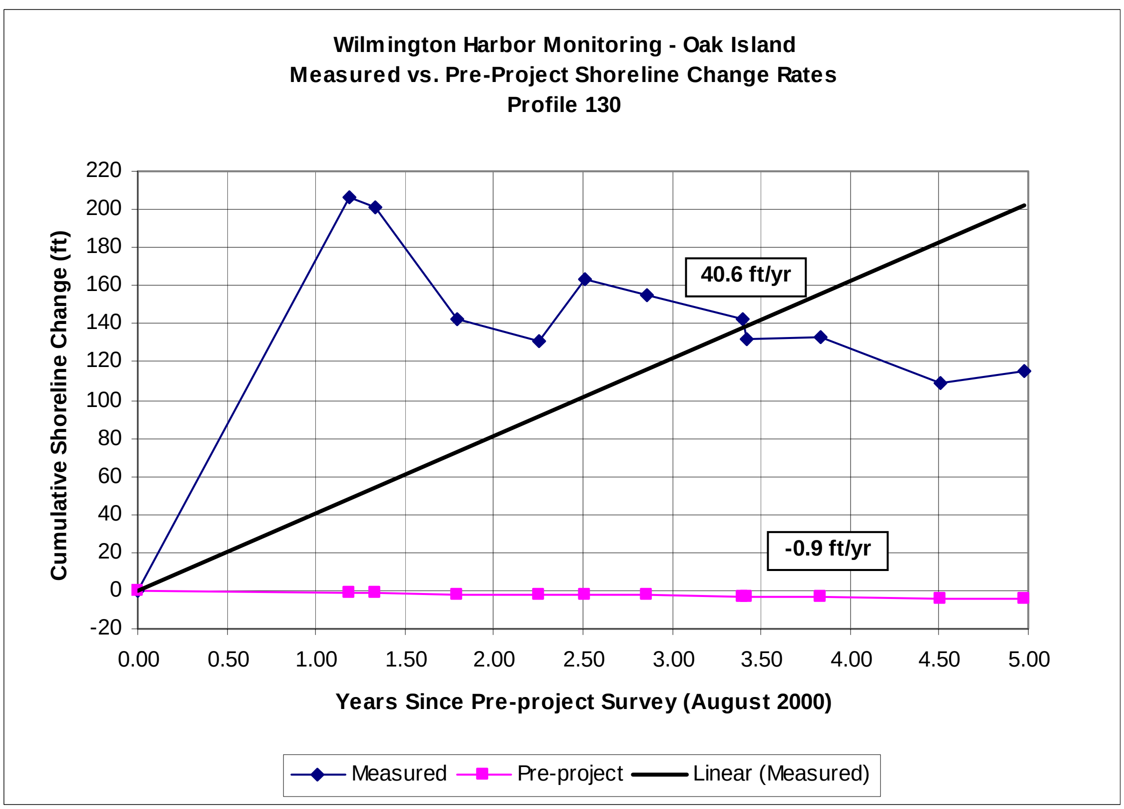


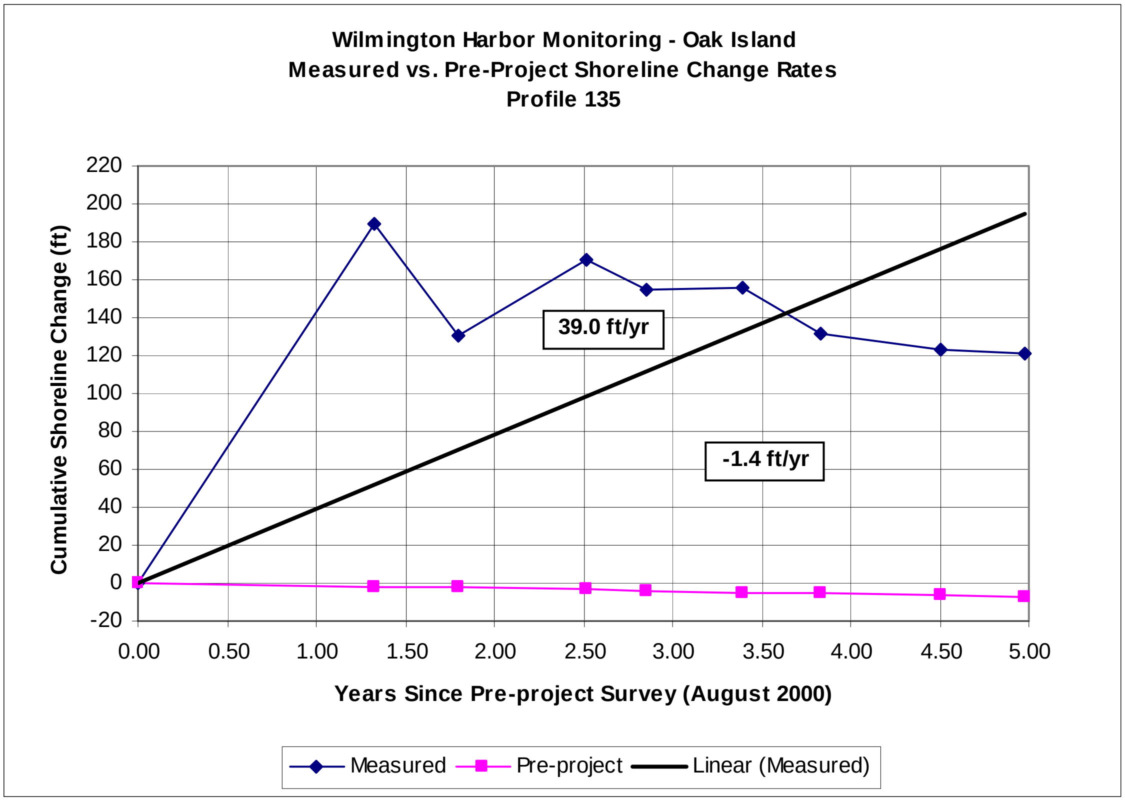
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 115
8.1 ft/yr
1.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

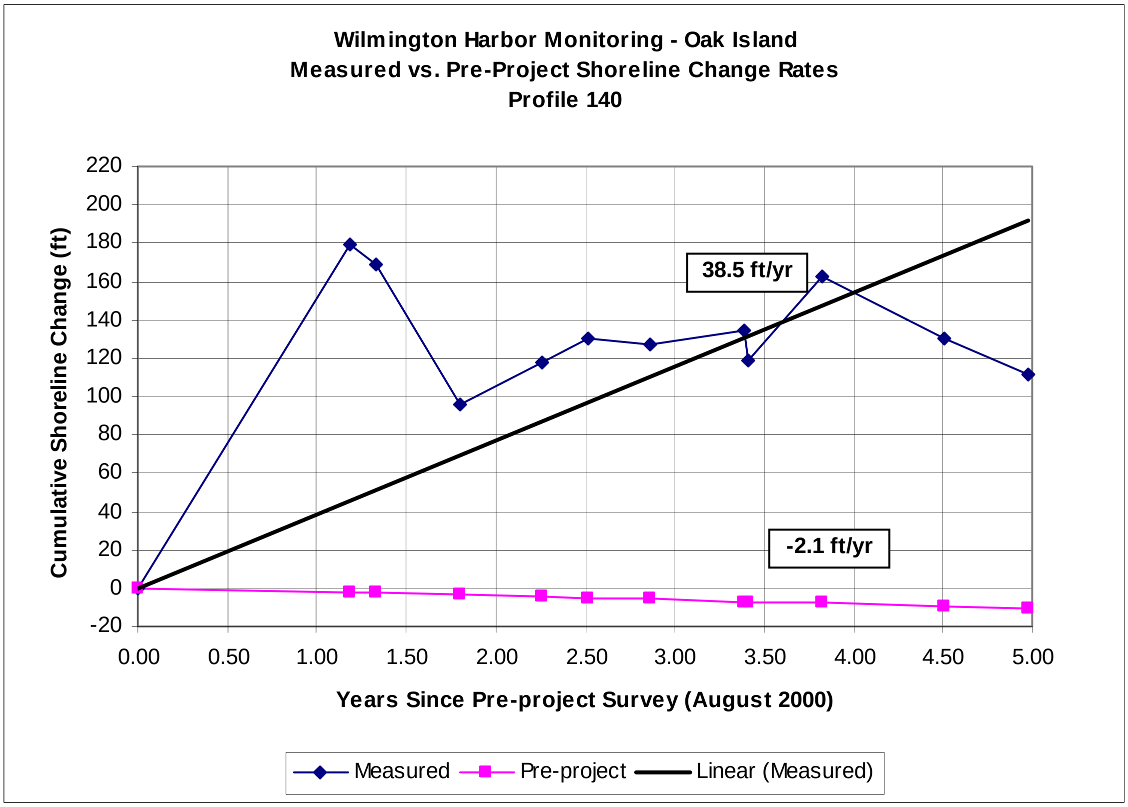


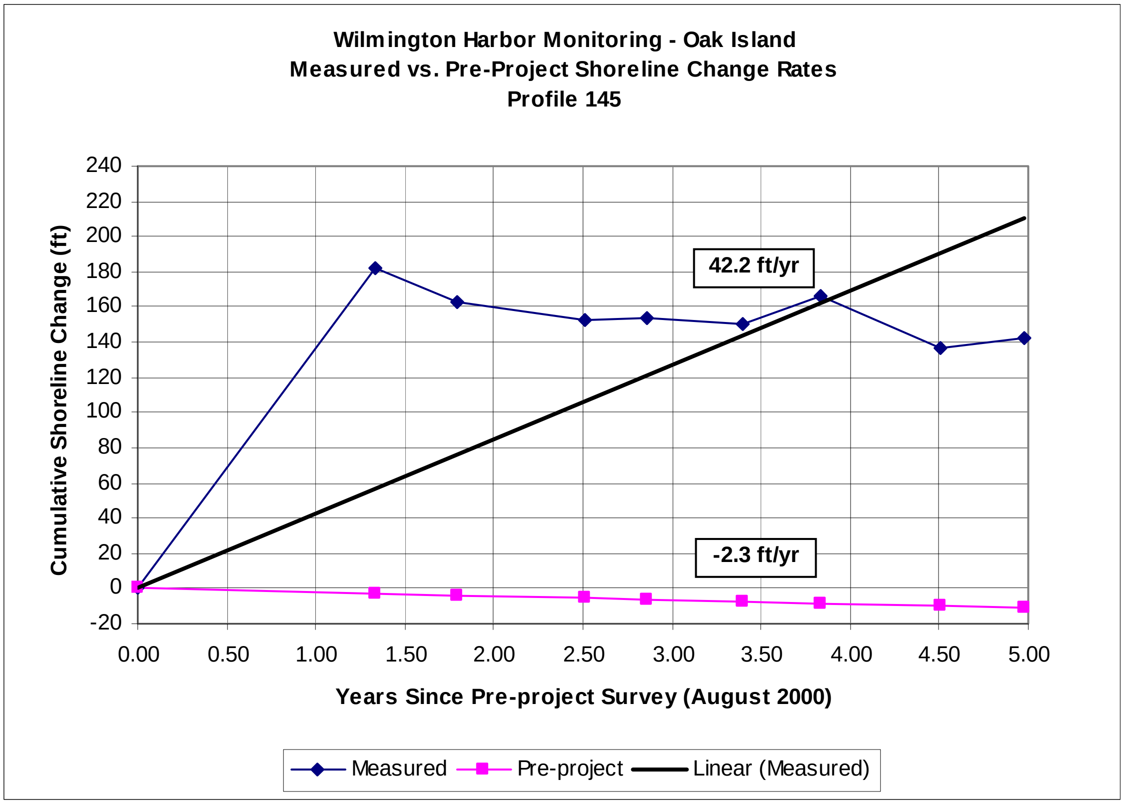
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 120
24.3 ft/yr
0.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

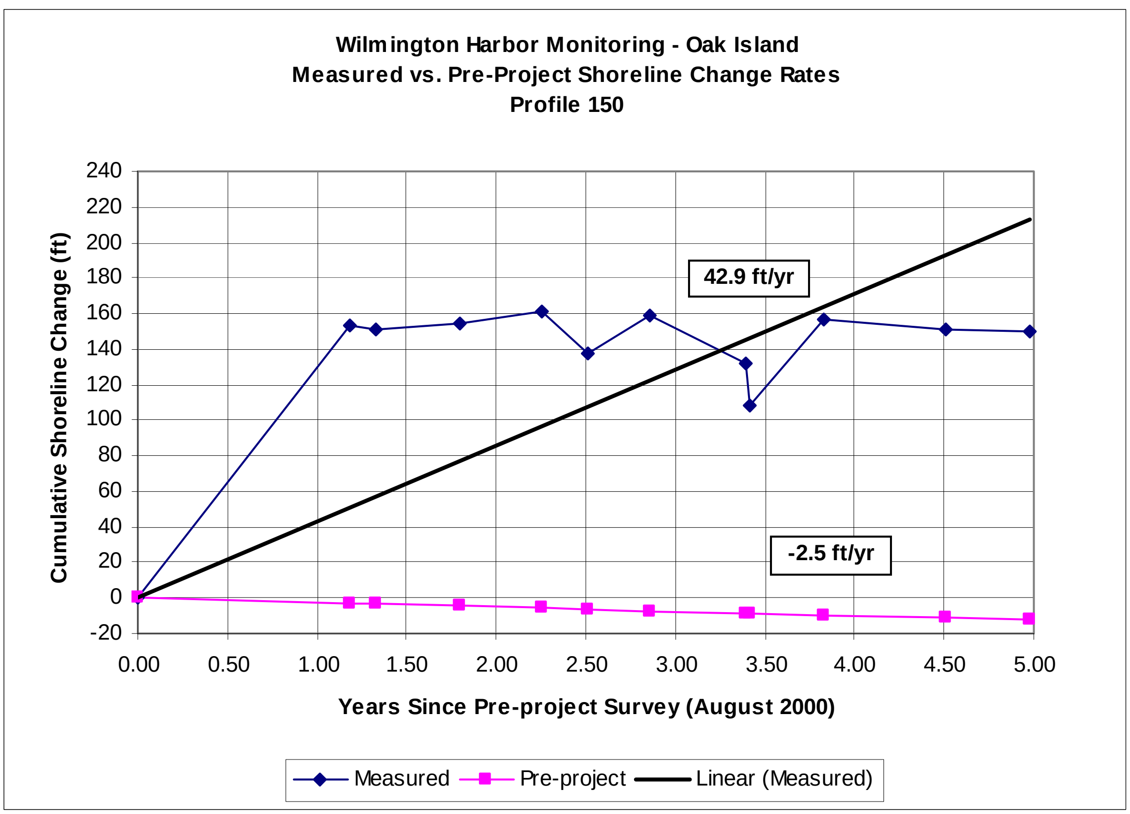

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 125
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
23.6 ft/yr
-0.3 ft/yr
Measured
Pre-project
Linear (Measured)

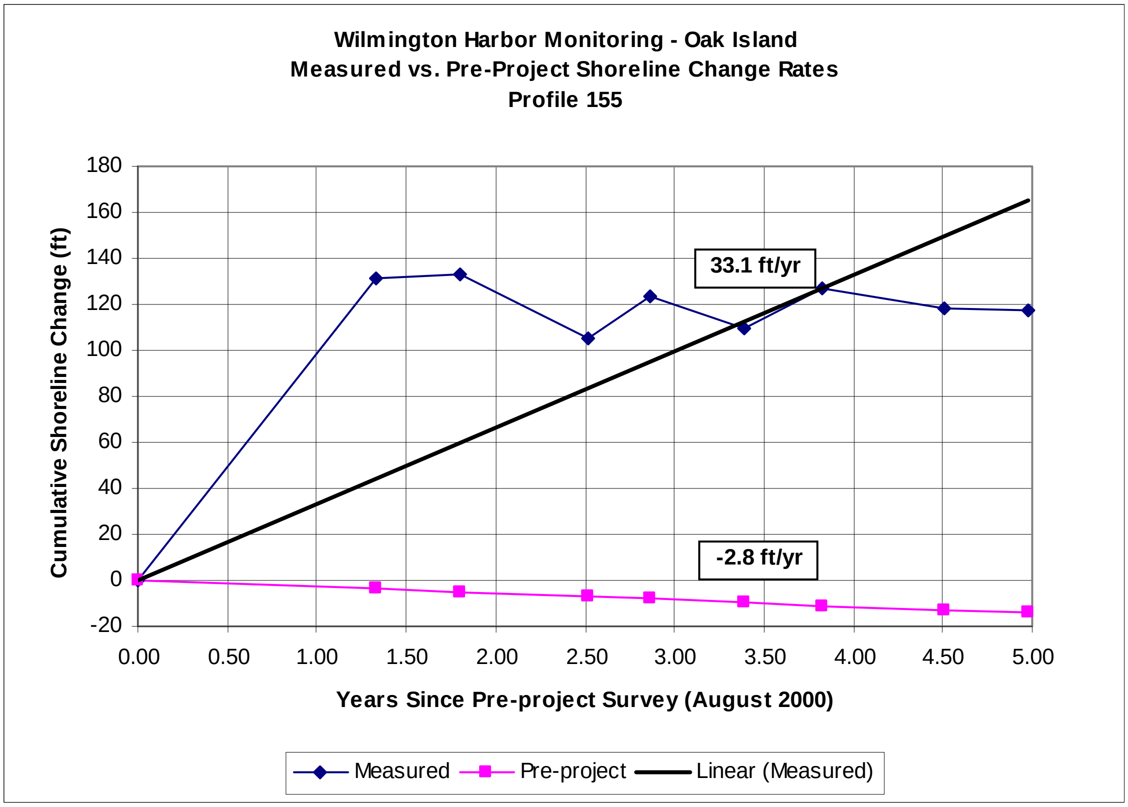

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
40.6 ft/yr
-0.9 ft/yr
Measured
Pre-project
Linear (Measured)

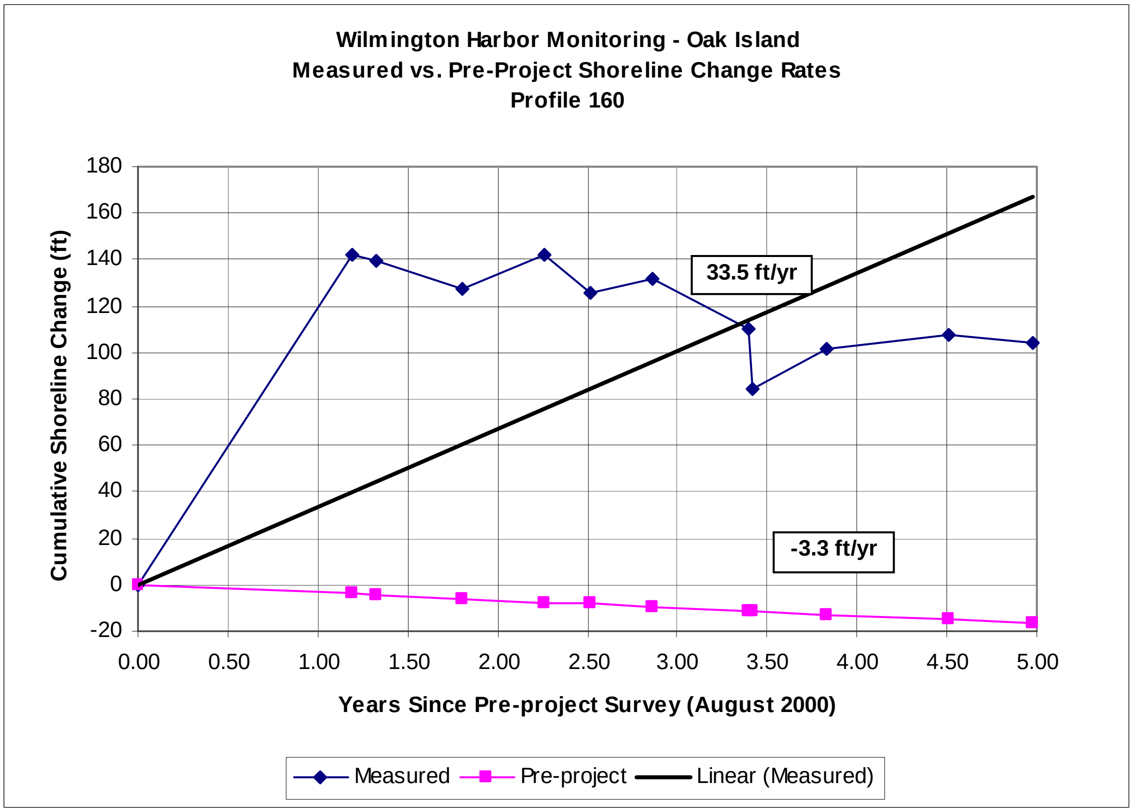

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 135
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
39.0 ft/yr
-1.4 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

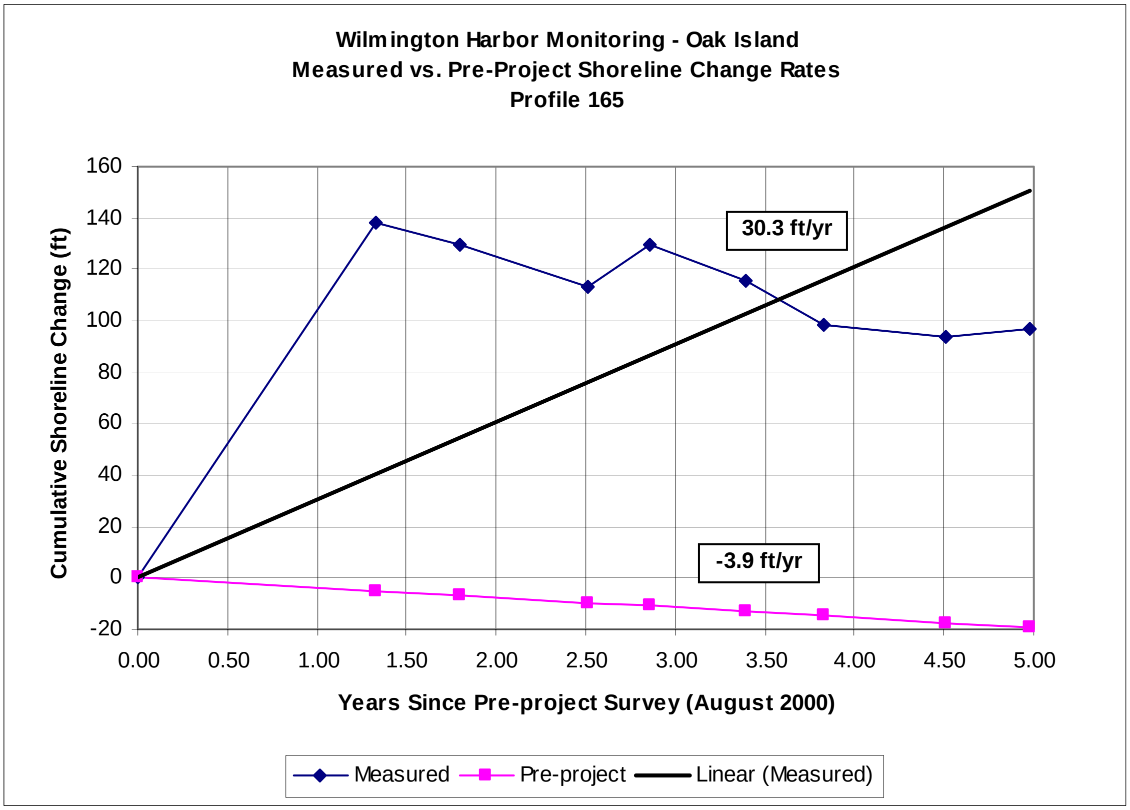

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 140
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
38.5 ft/yr
-2.1 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

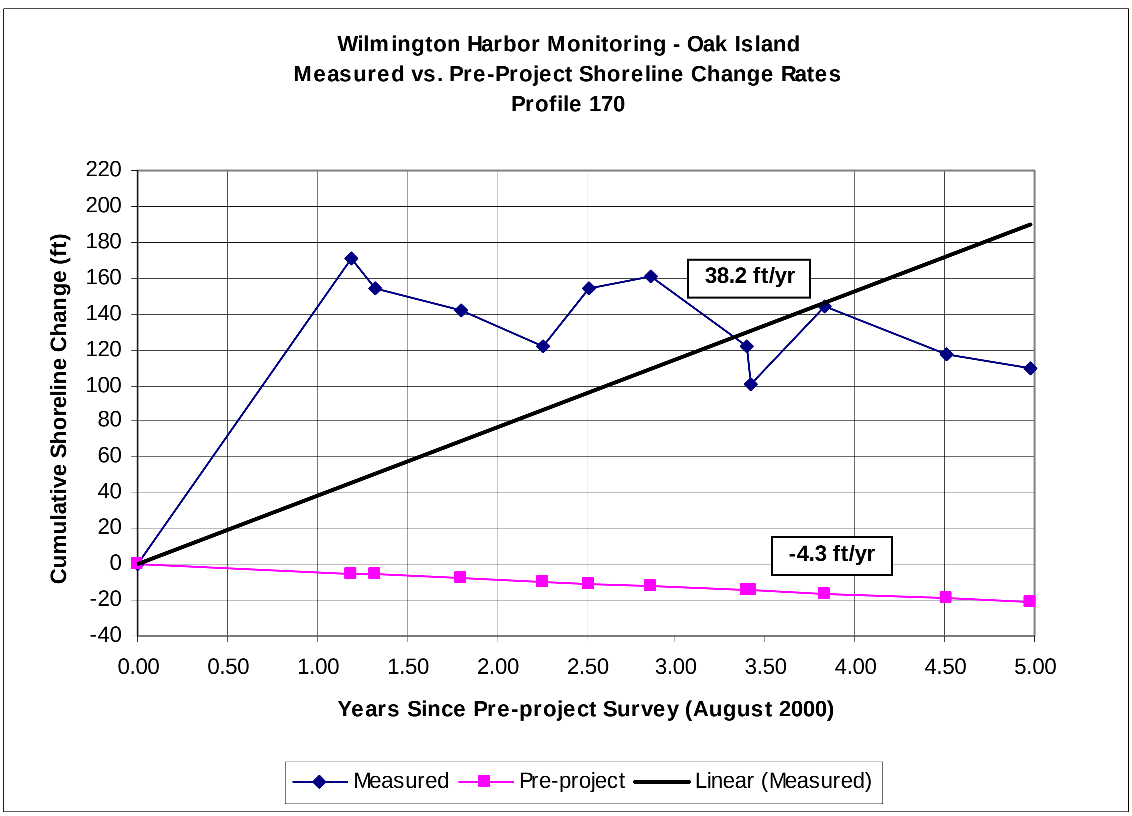

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 145
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
42.2 ft/yr
-2.3 ft/yr
Measured
Pre-project
Linear (Measured)

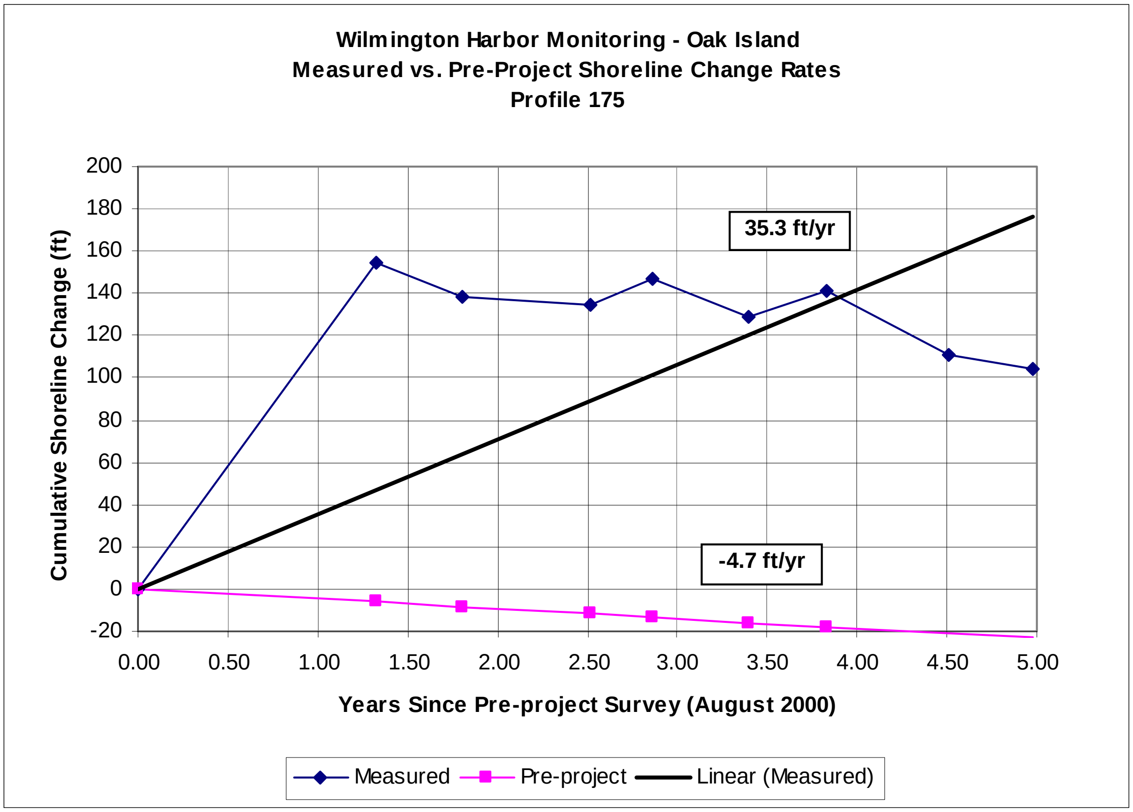

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
42.9 ft/yr
-2.5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


Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 155
Cumulative Shoreline Change (ft)
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
33.1 ft/yr
-2.8 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

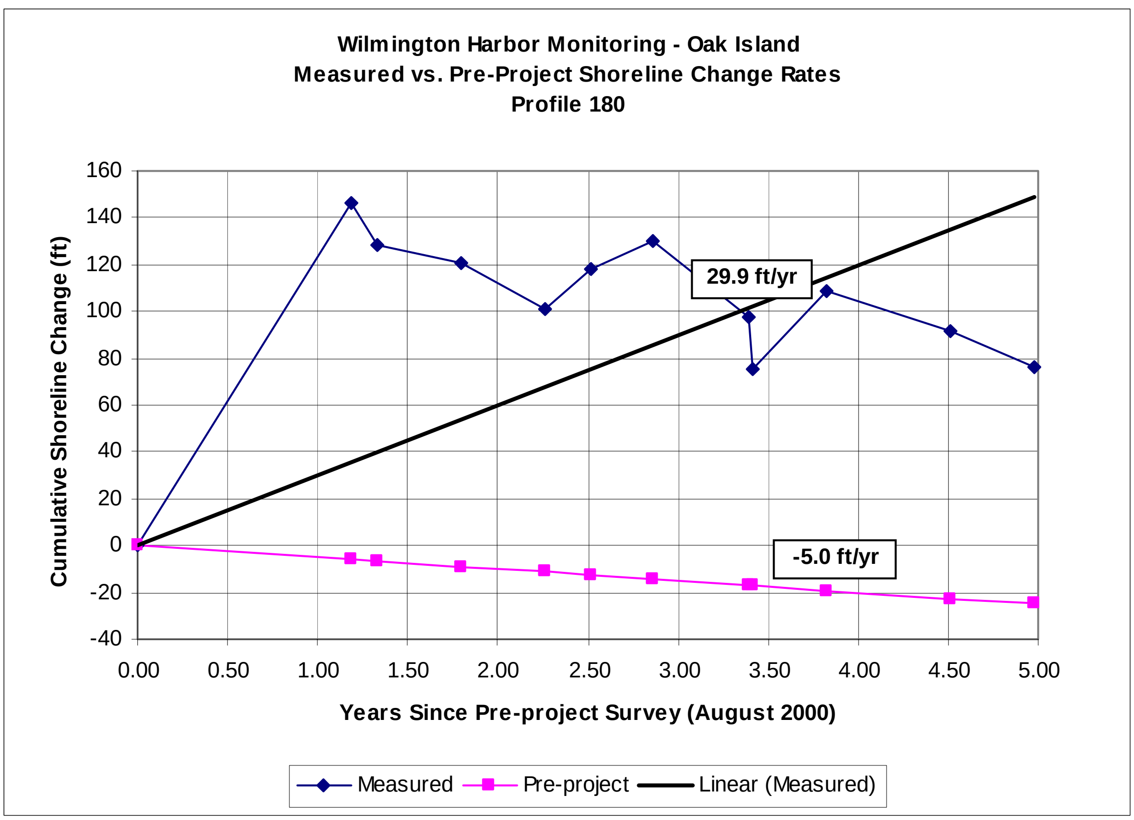

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 160
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
33.5 ft/yr
-3.3 ft/yr
Years Since Pre-project Survey (August 2000)
Measured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


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

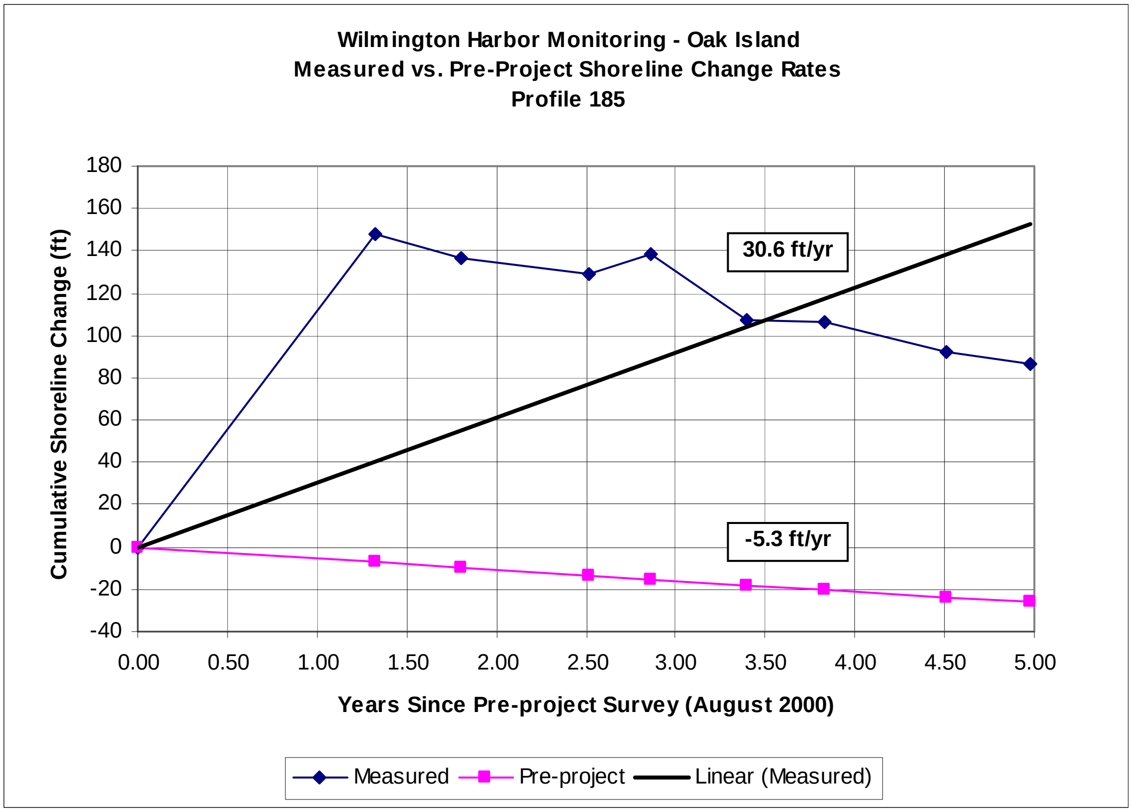

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
38.2 ft/yr
-4.3 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

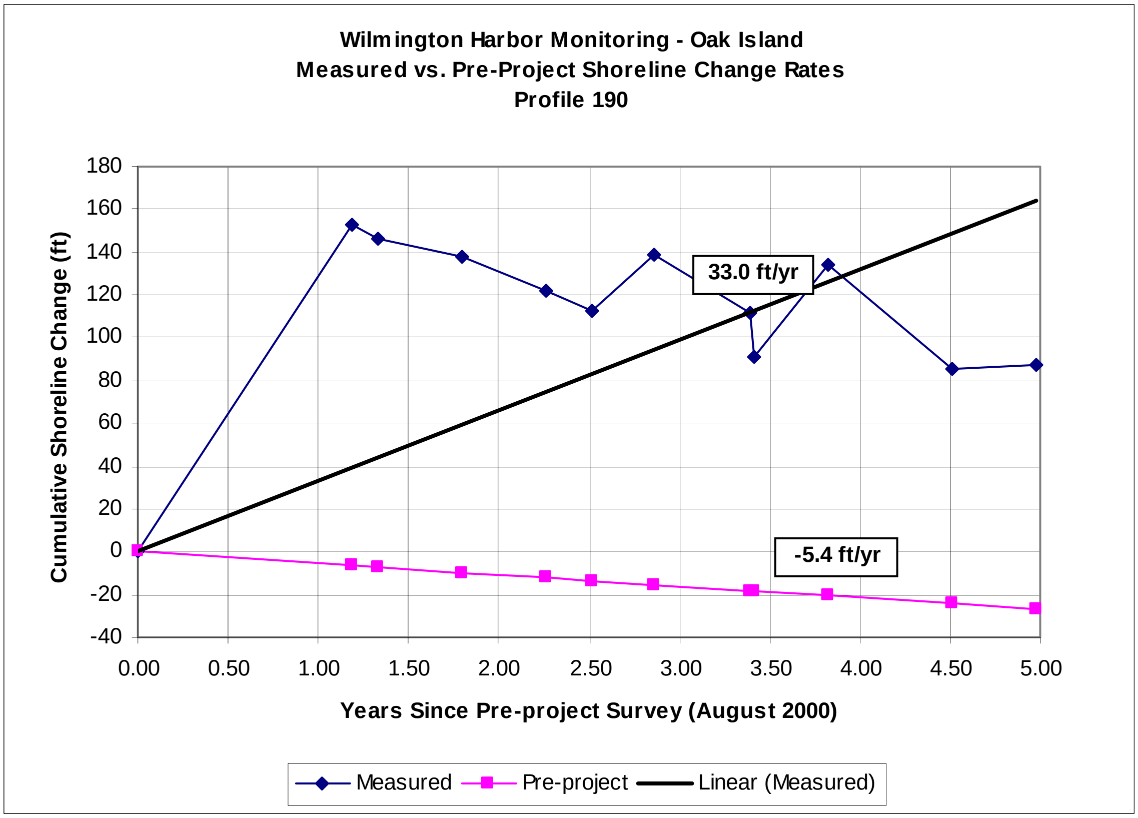


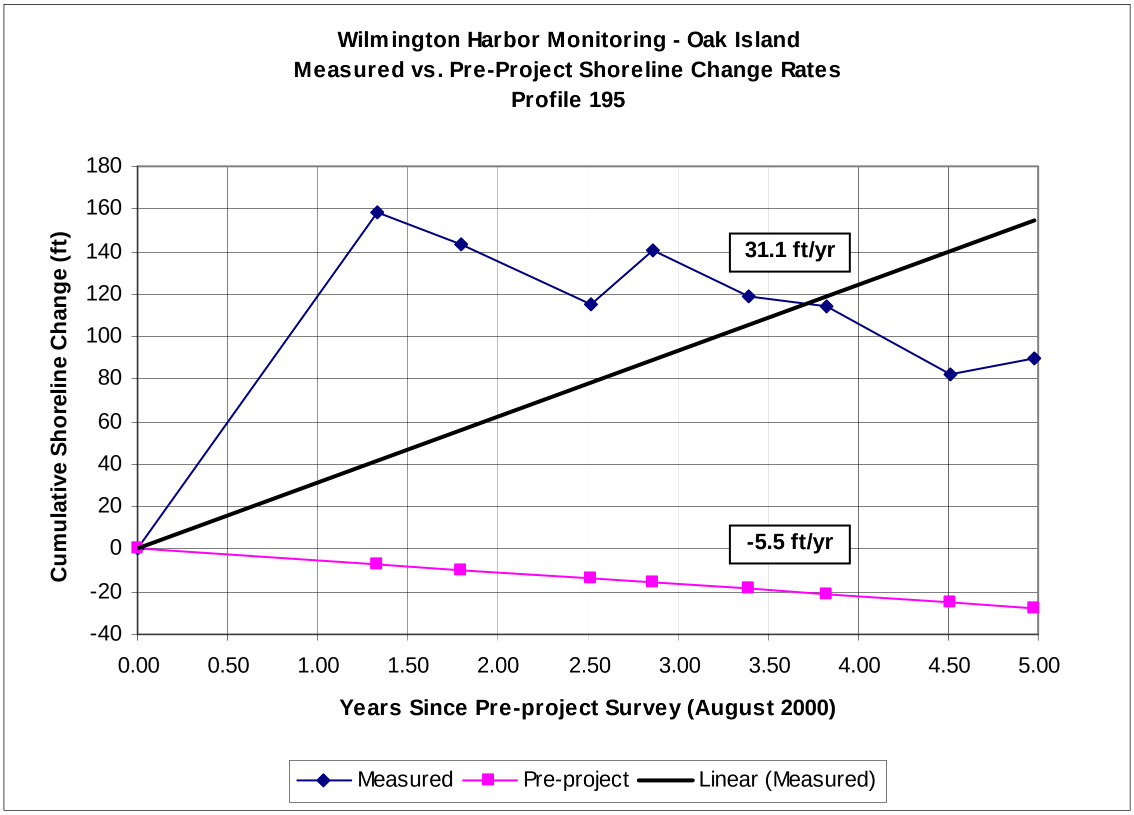
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 175
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
35.3 ft/yr
-4.7 ft/yr
Measured
Pre-project
Linear (Measured)

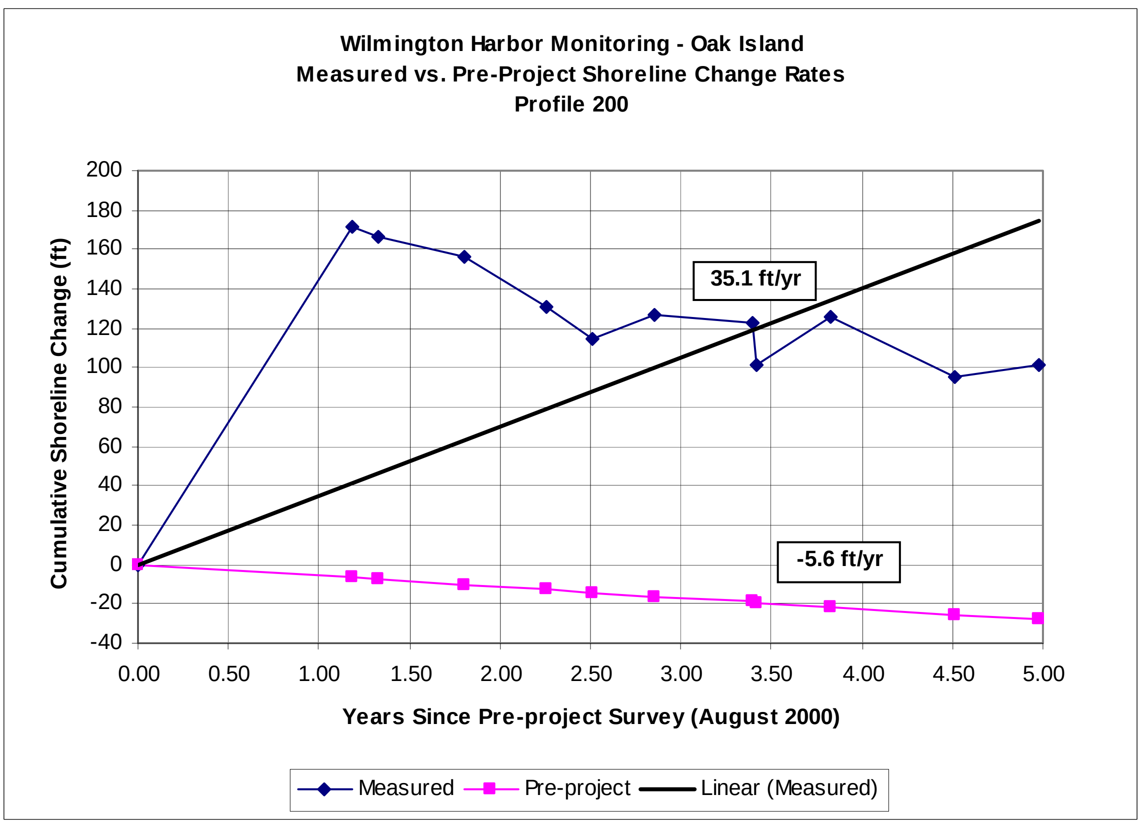


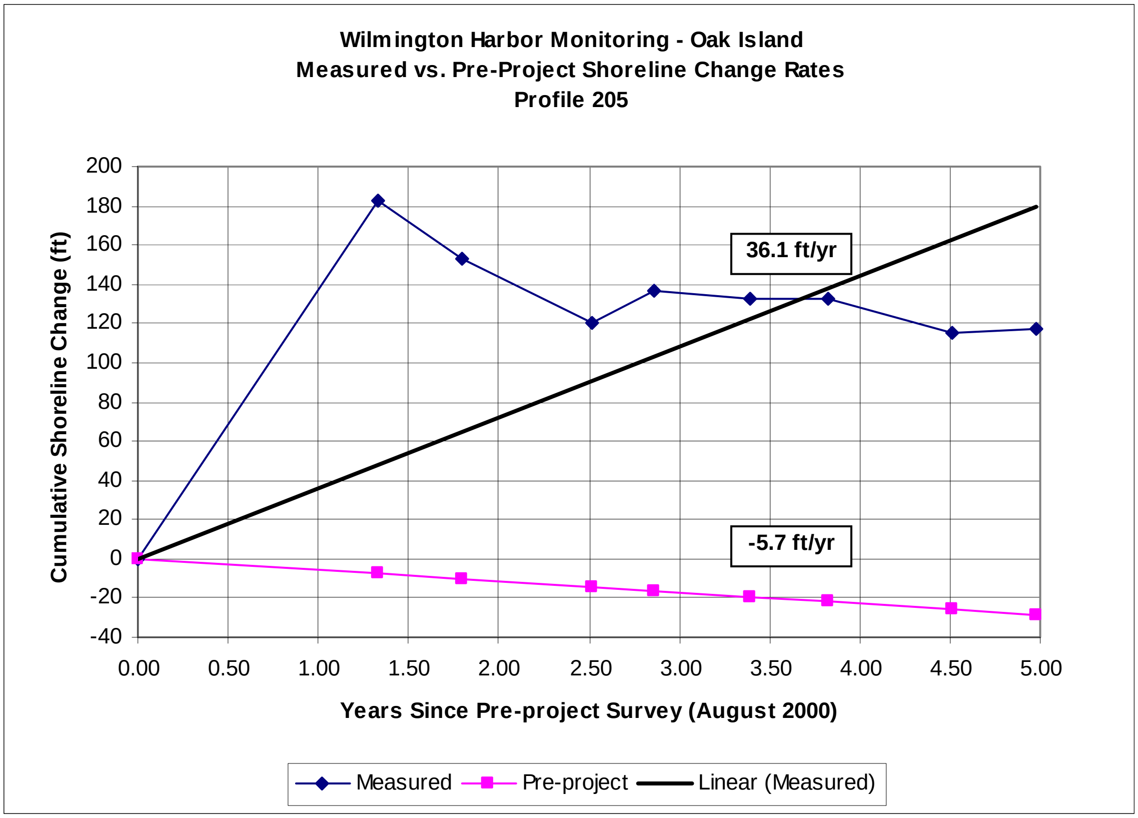
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 180
Cumulative Shoreline Change (ft)
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
29.9 ft/yr
-5.0 ft/yr
Measured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

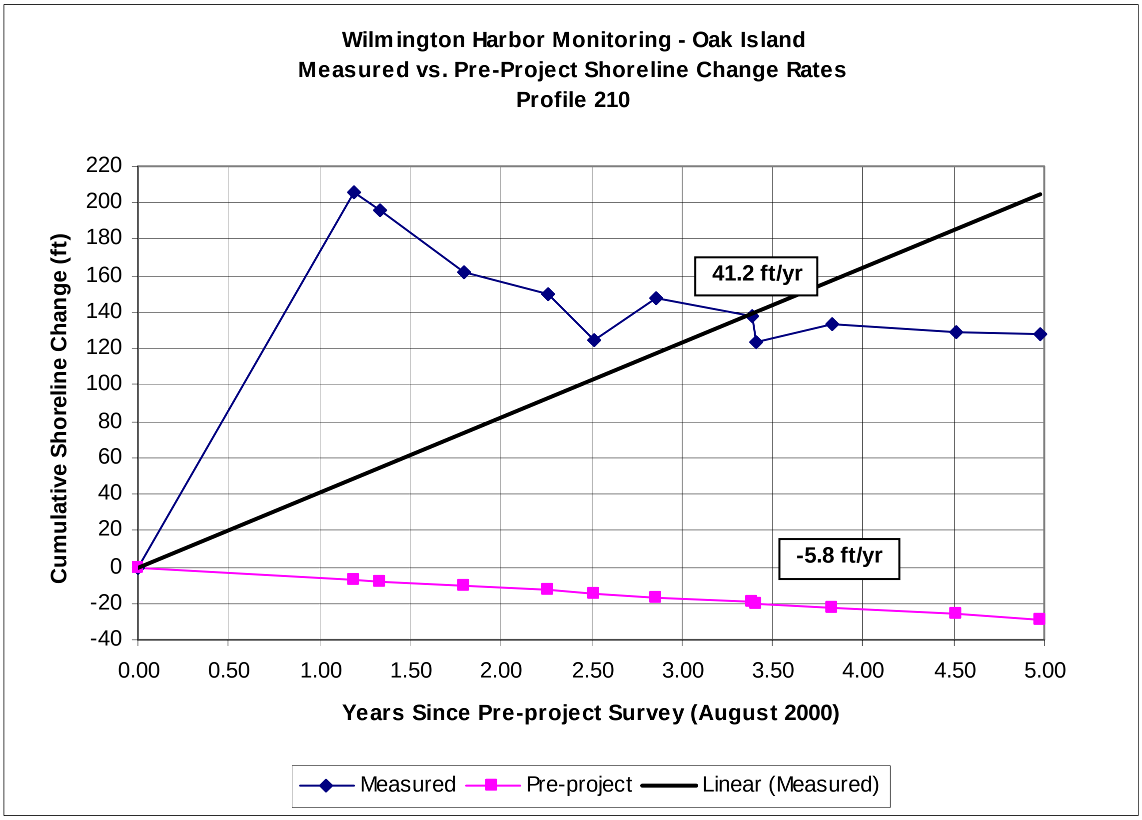

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 185
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
30.6 ft/yr
-5.3 ft/yr
Measured
Pre-project
Linear (Measured)

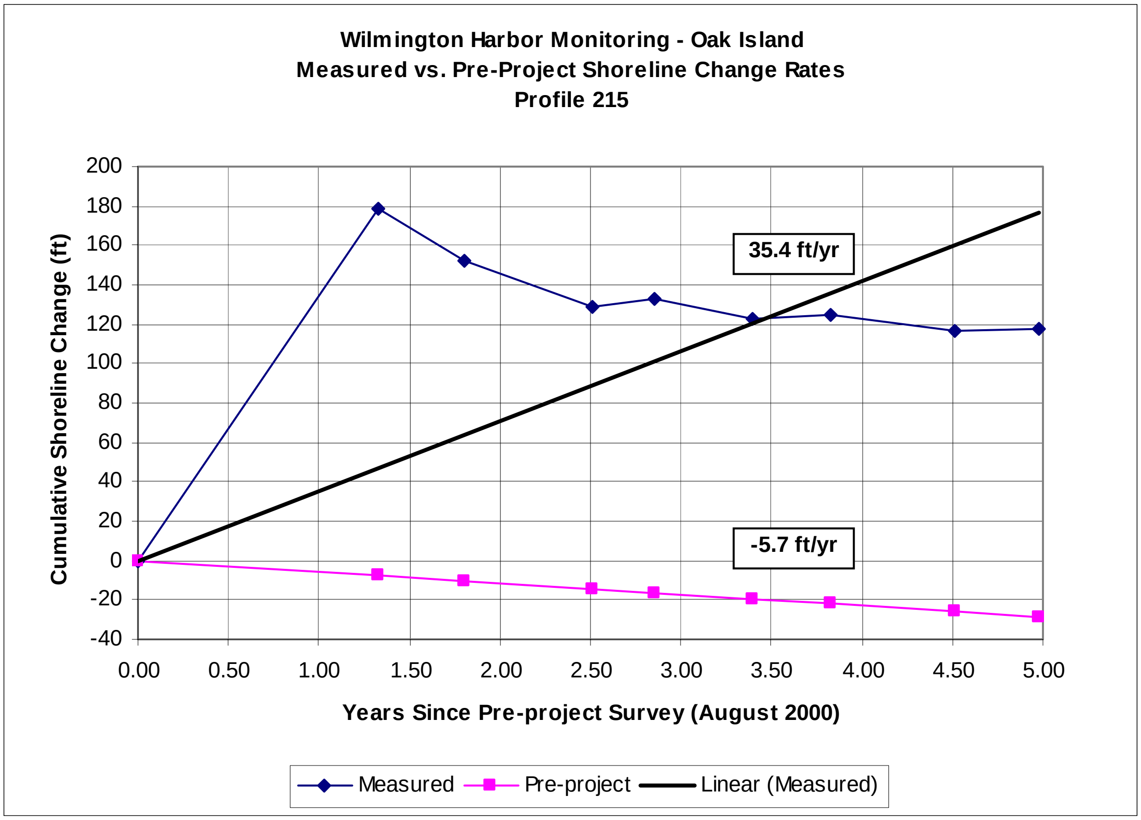

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
33.0 ft/yr
-5.4 ft/yr
Measured
Pre-project
Linear (Measured)

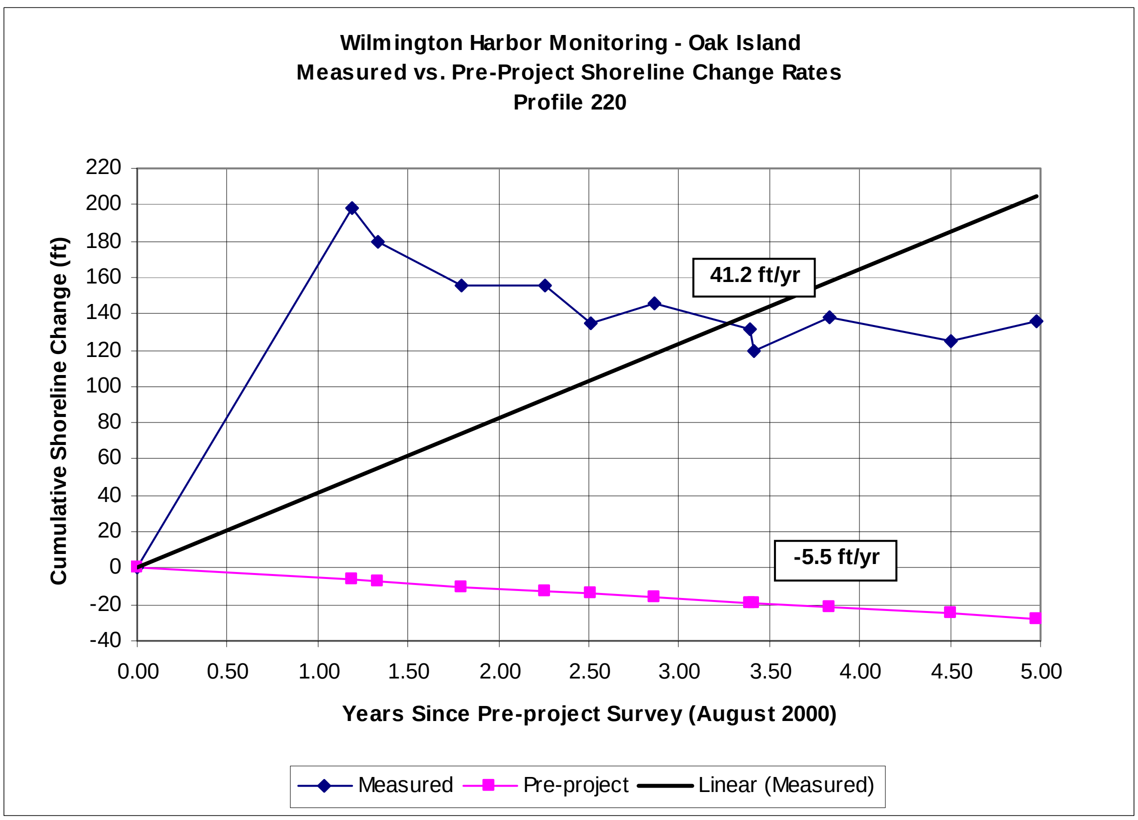

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 195
Cumulative Shoreline Change (ft)
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
31.1 ft/yr
-5.5 ft/yr
Measured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

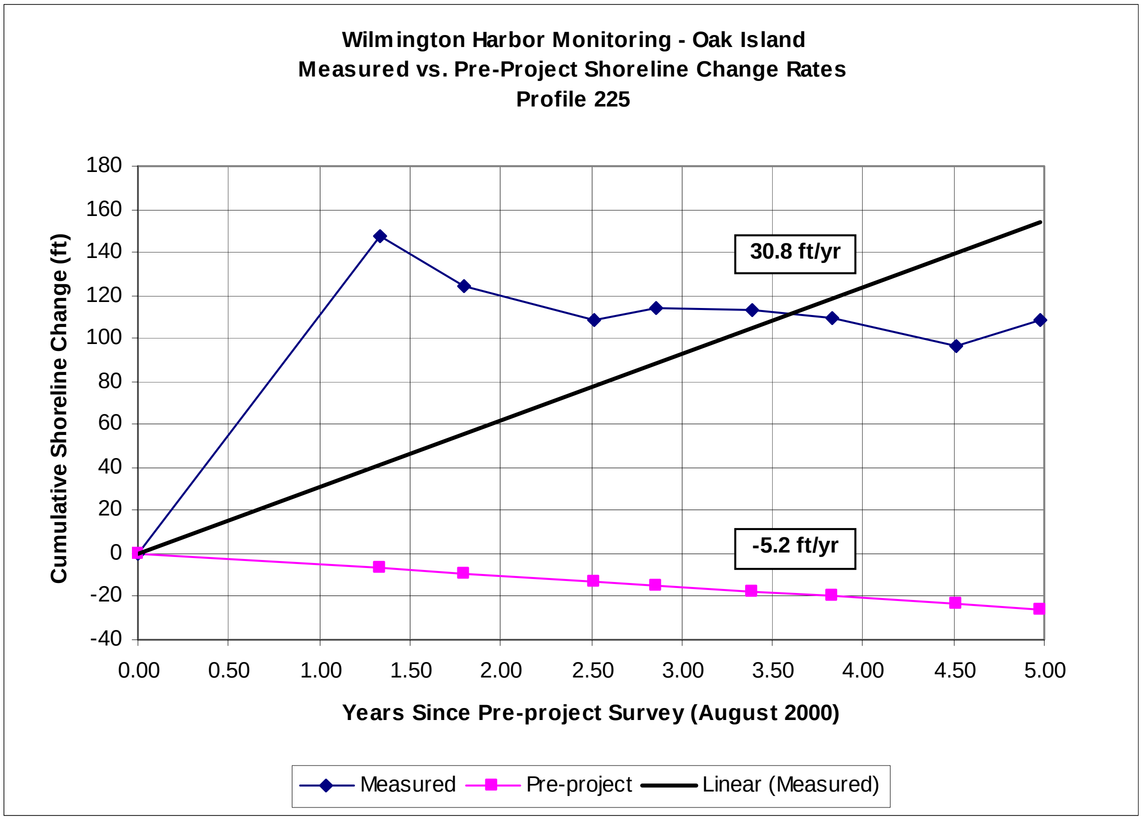

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 200
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
35.1 ft/yr
-5.6 ft/yr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

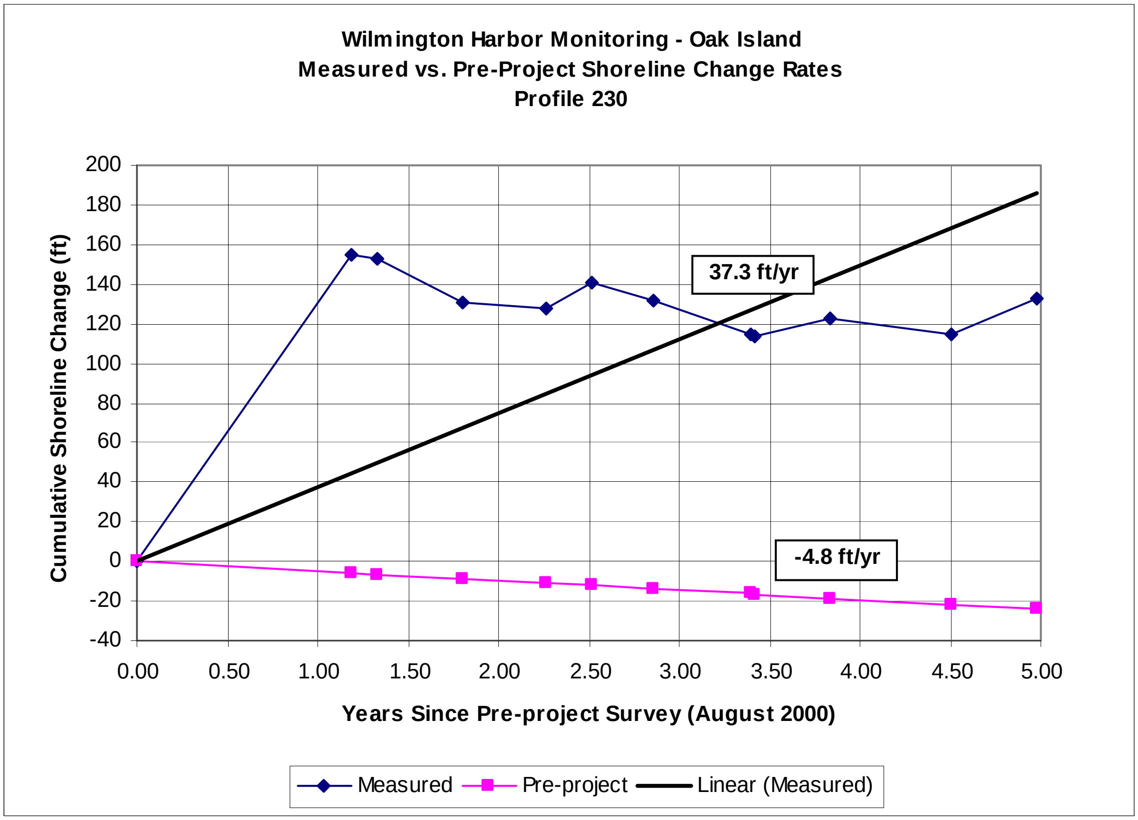

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 205
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
36.1 ft/yr
-5.7 ft/yr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

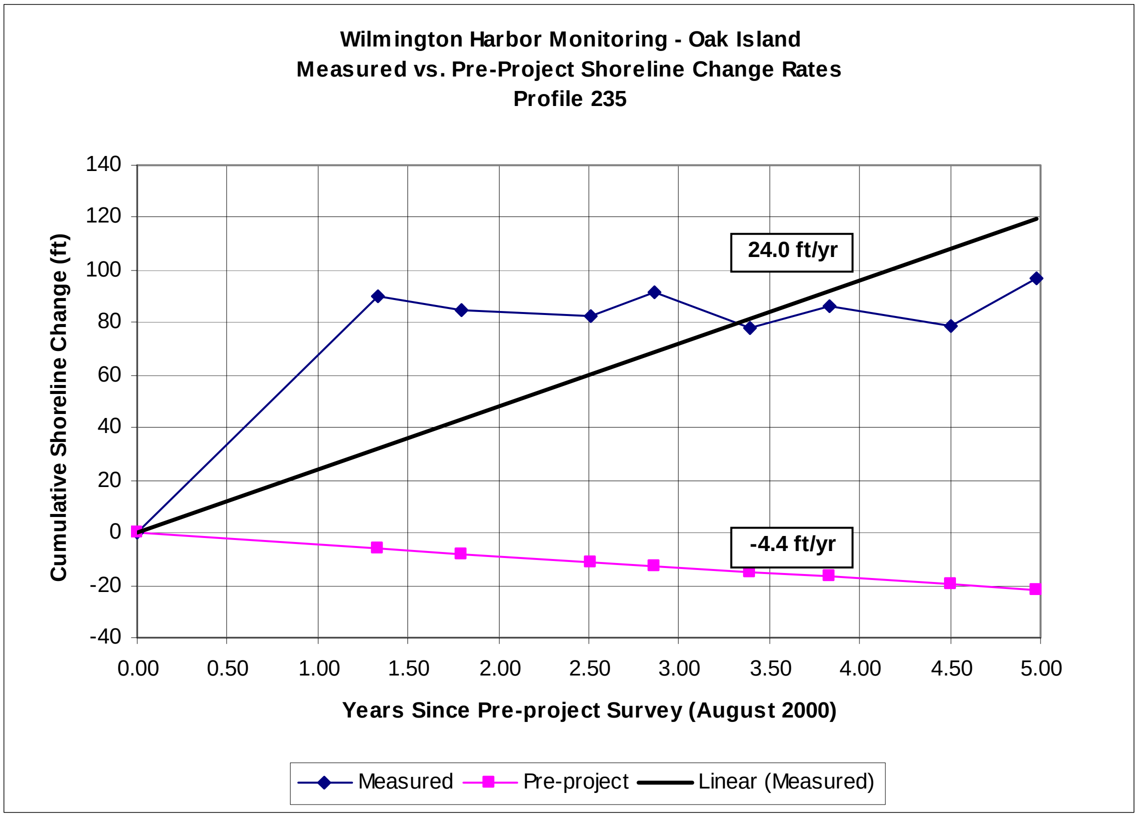

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
41.2 ft/yr
-5.8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

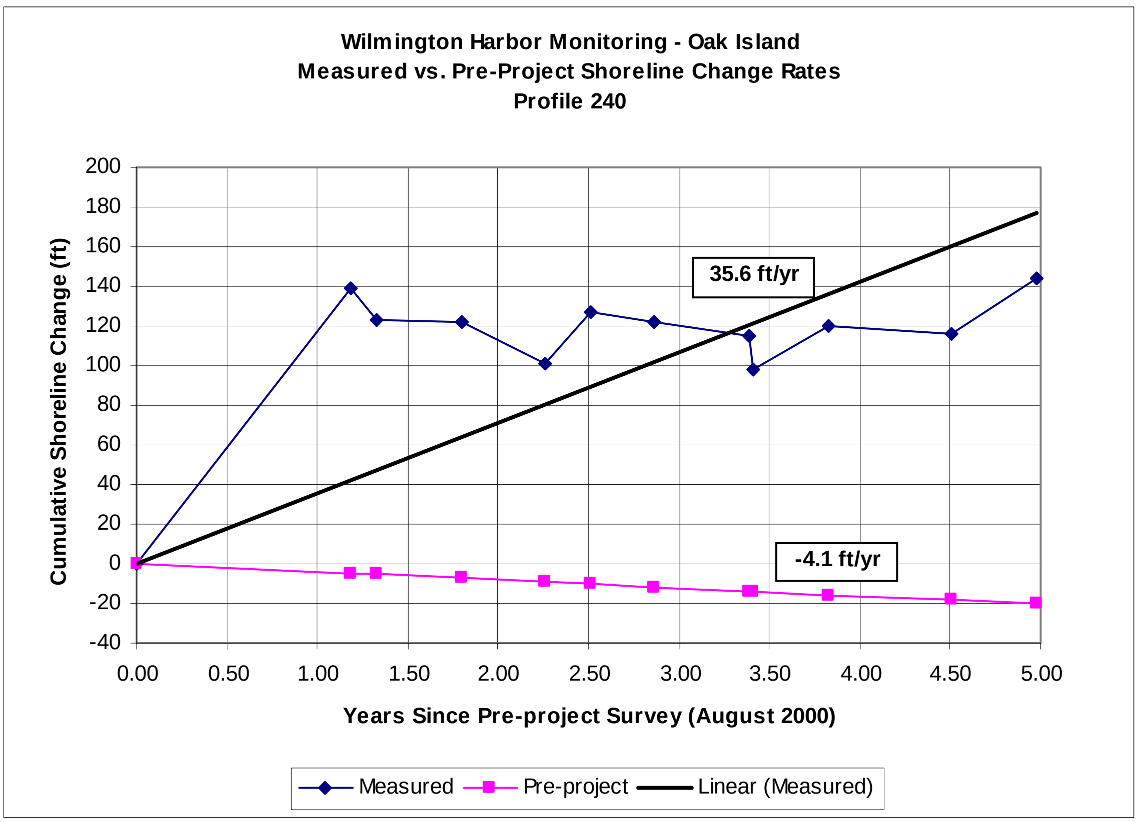

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 215
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
35.4 ft/yr
-5.7 ft/yr
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00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

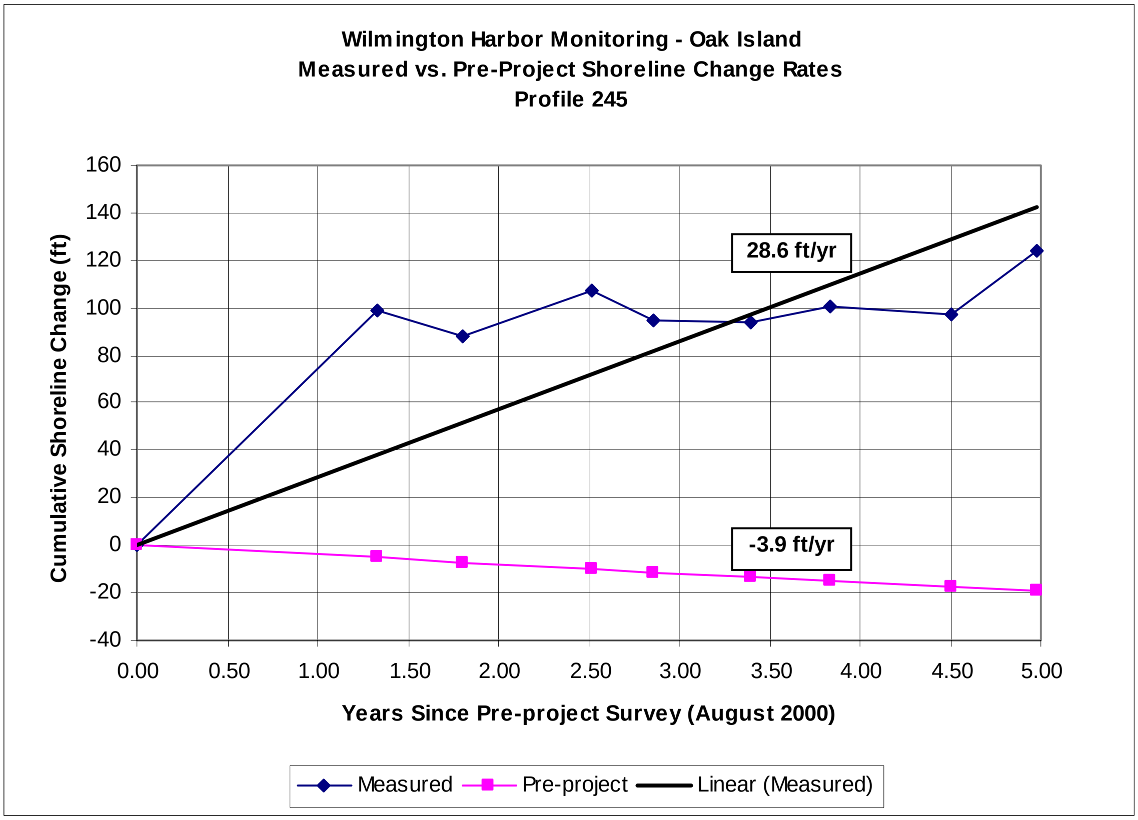

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 220
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
41.2 ft/yr
-5.5 ft/yr
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50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

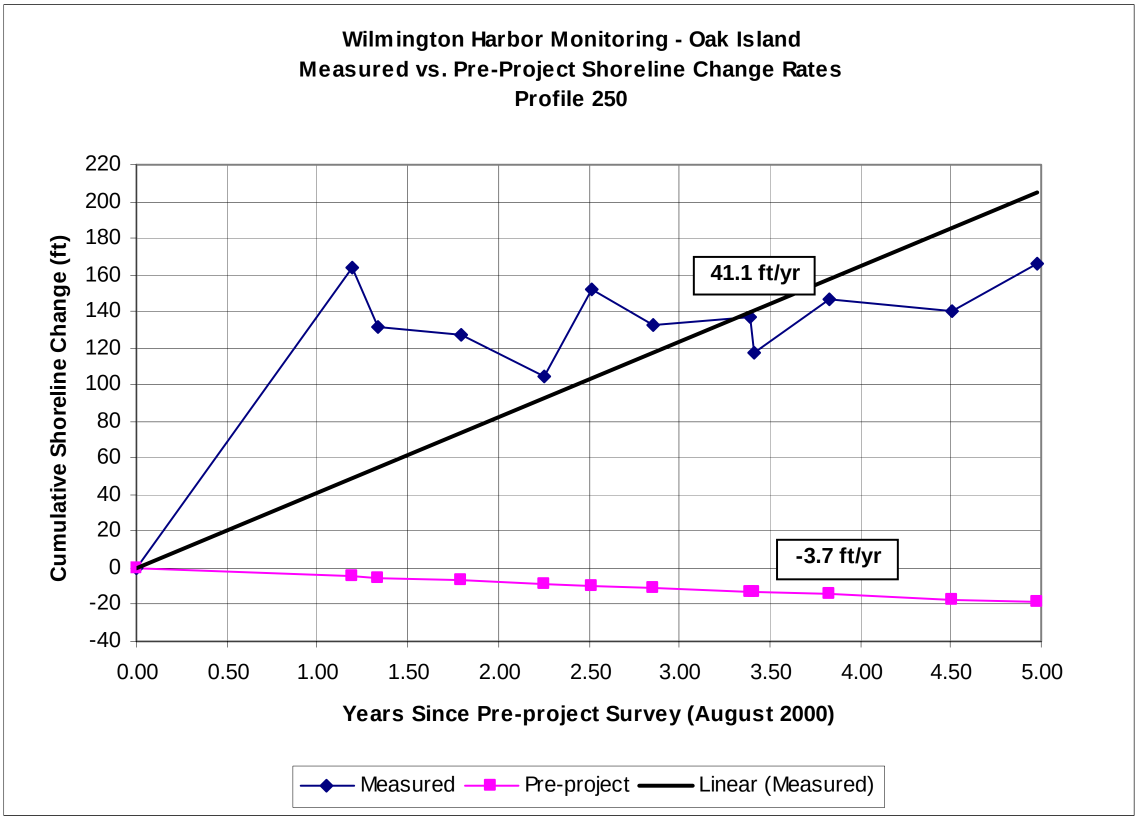

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 225
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
30.8 ft/yr
-5.2 ft/yr
Measured
Pre-project
Linear (Measured)

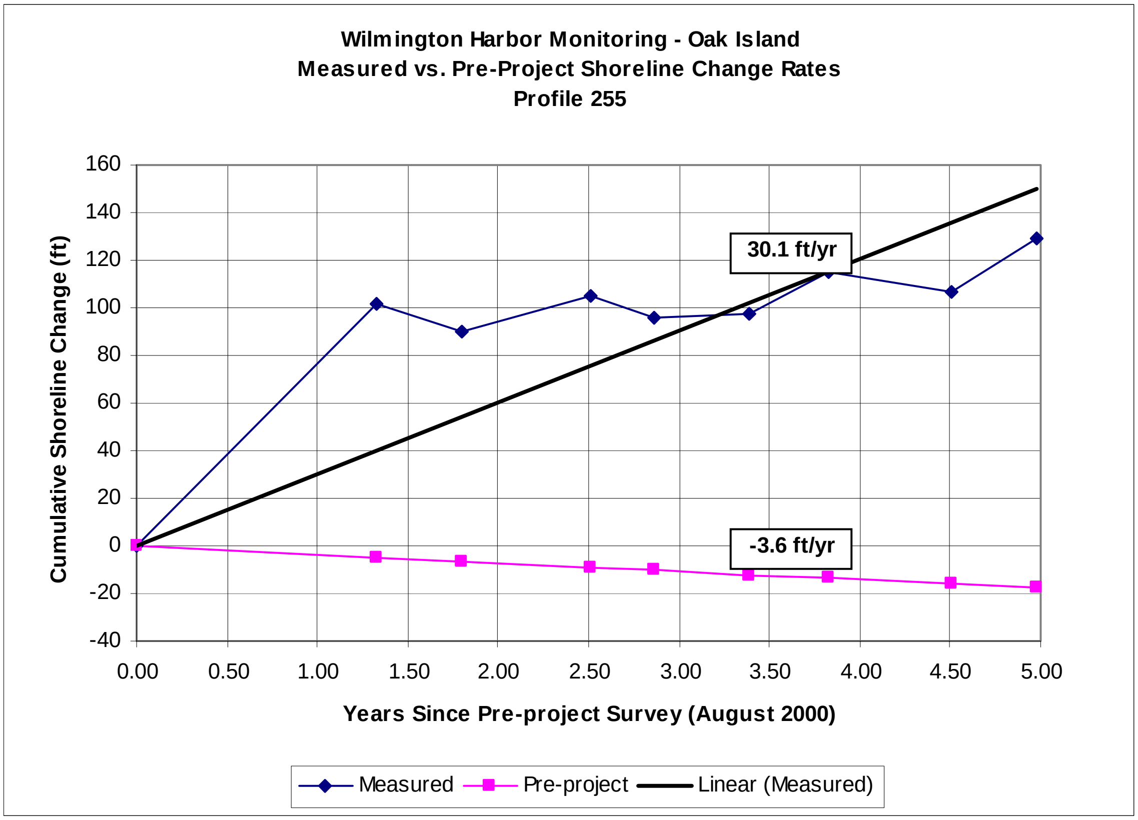

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 230
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
37.3 ft/yr
-4.8 ft/yr
Measured
Pre-project
Linear (Measured)


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
24.0 ft/yr
-4.4 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

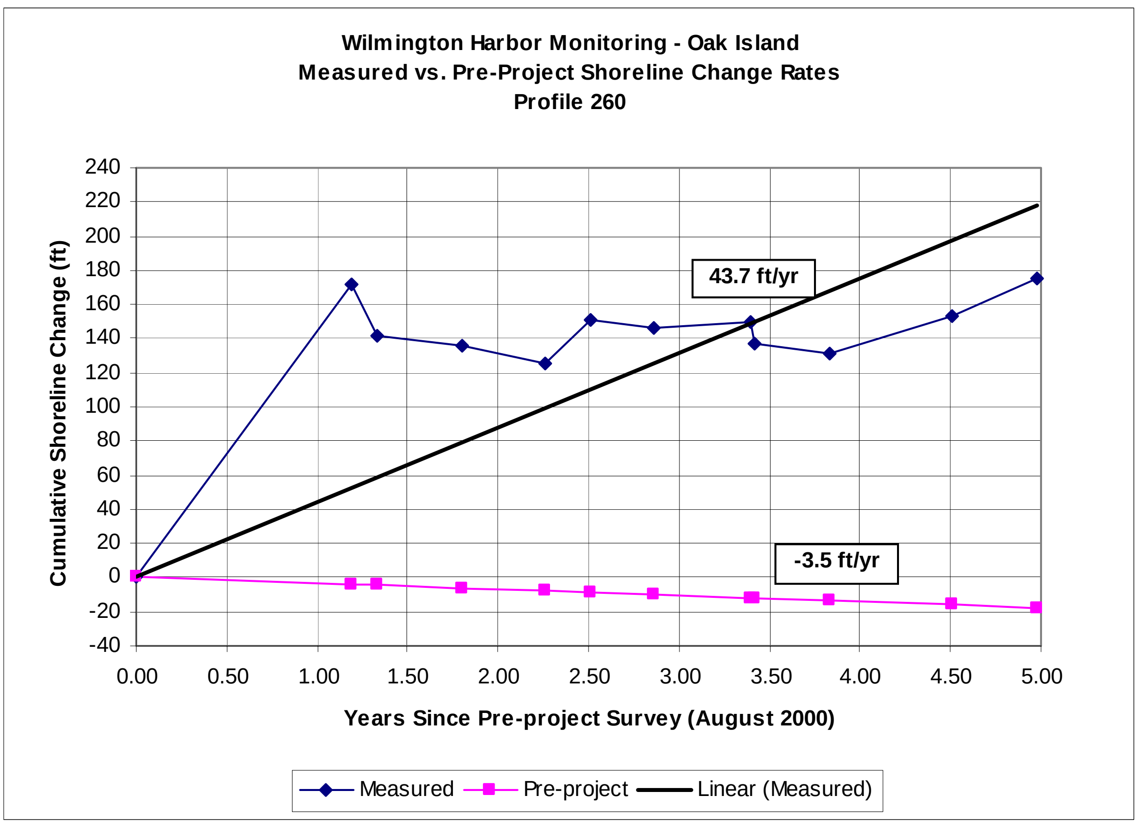

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 240
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
35.6 ft/yr
-4.1 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)


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

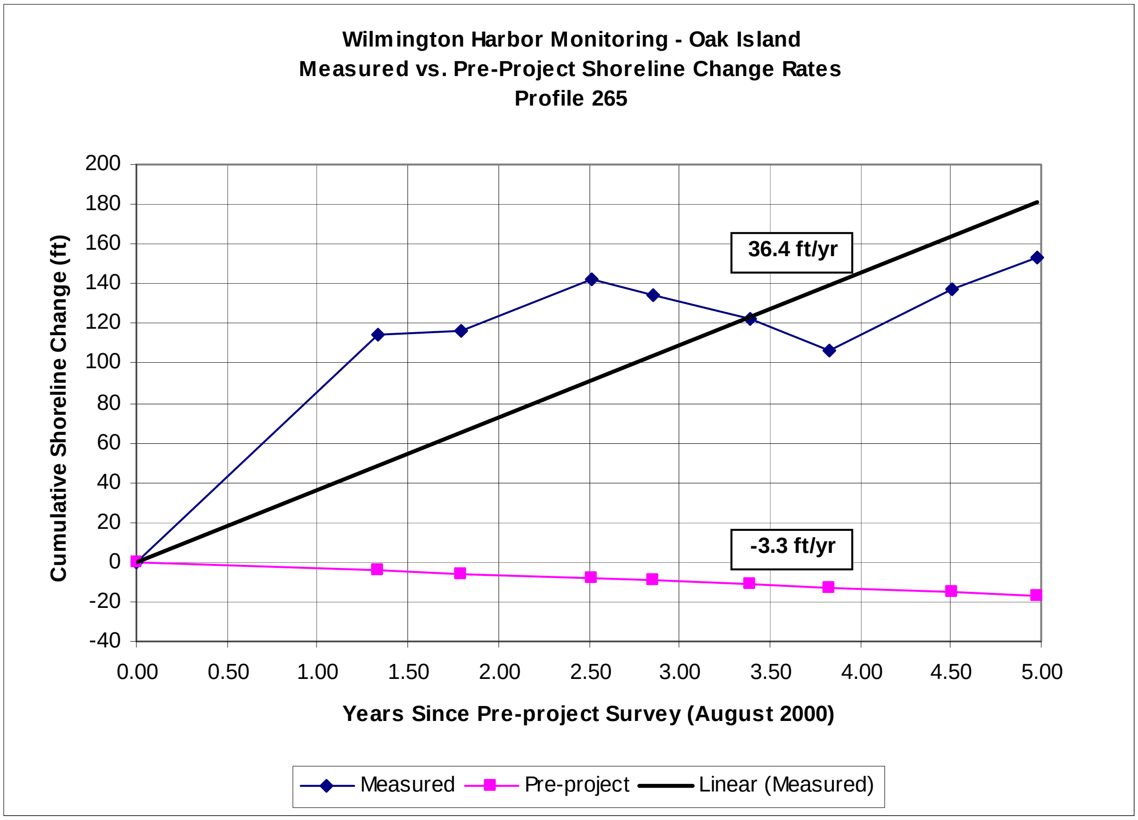

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 250
41.1 ft/yr
-3.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

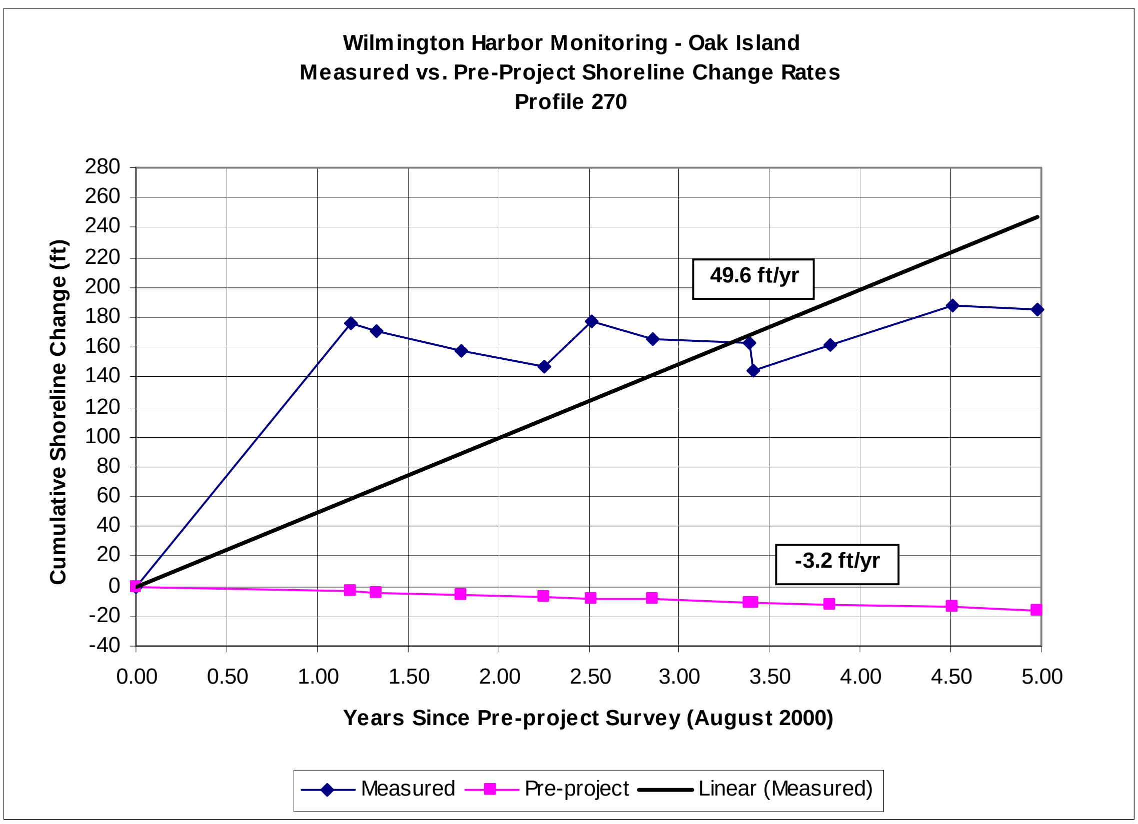


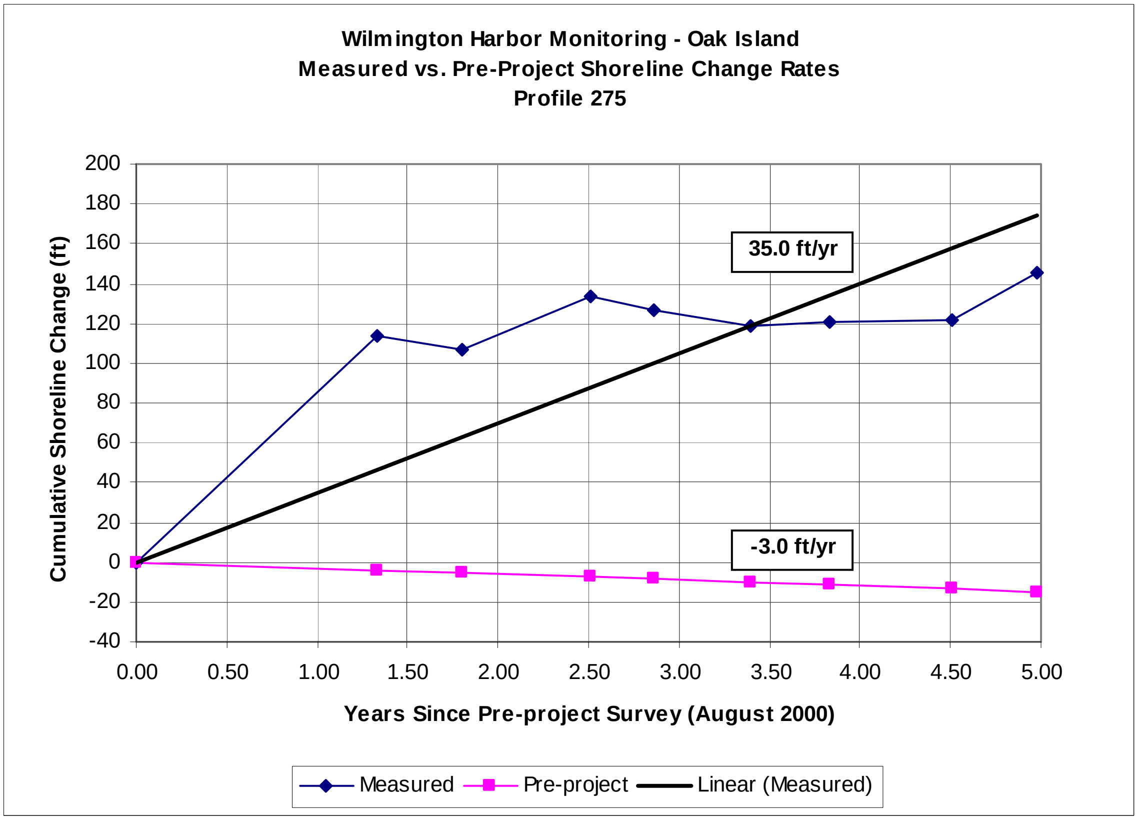
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 255
30.1 ft/yr
-3.6 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

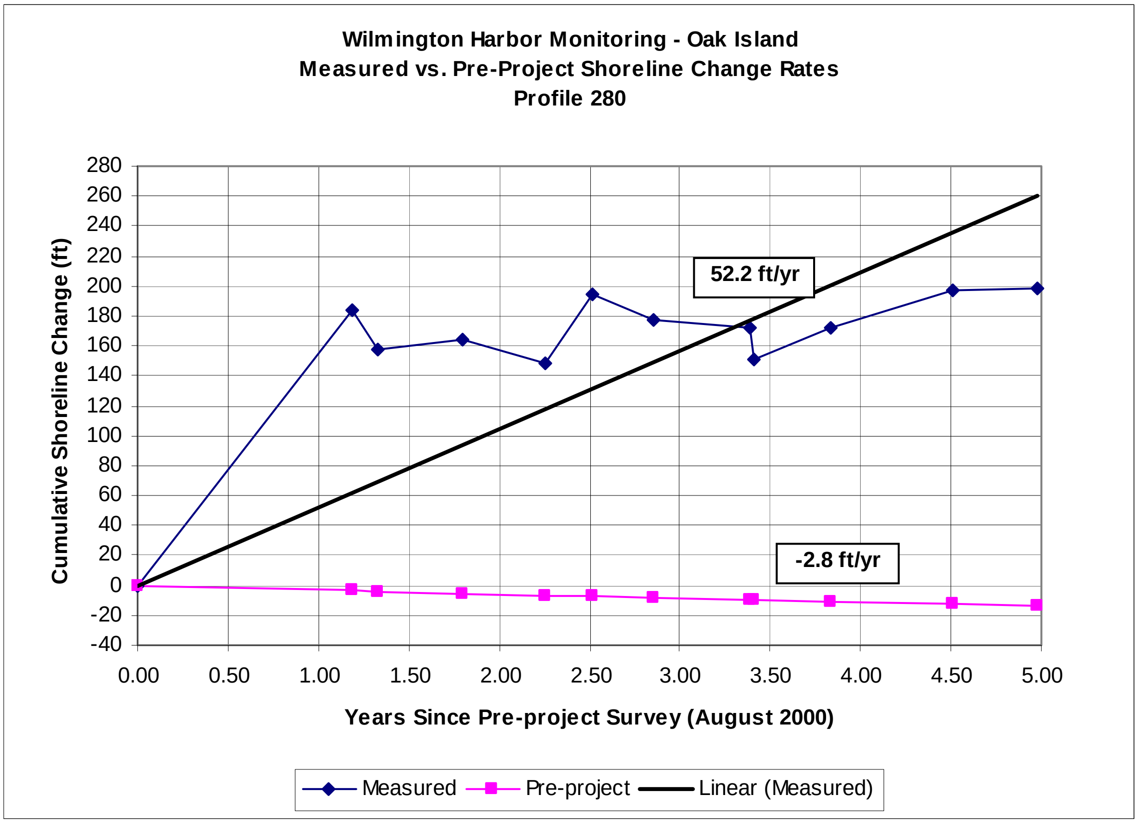


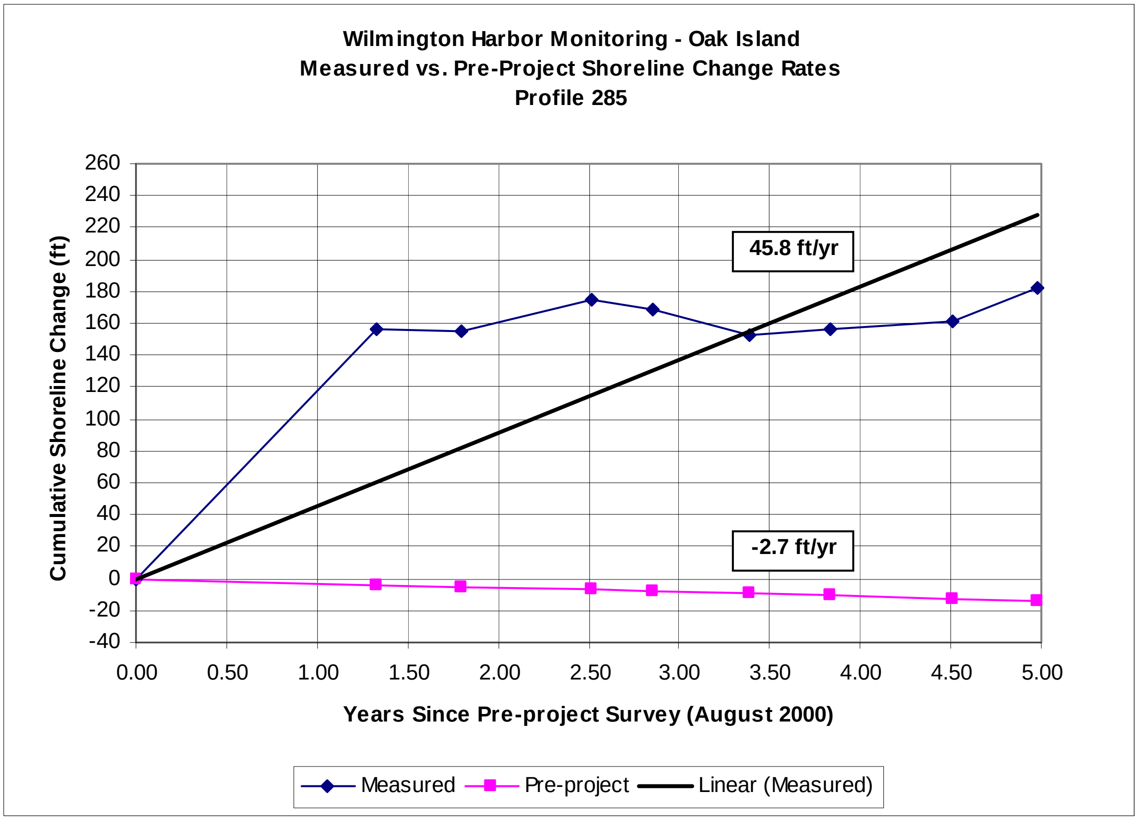
Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 260
43.7 ft/yr
-3.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

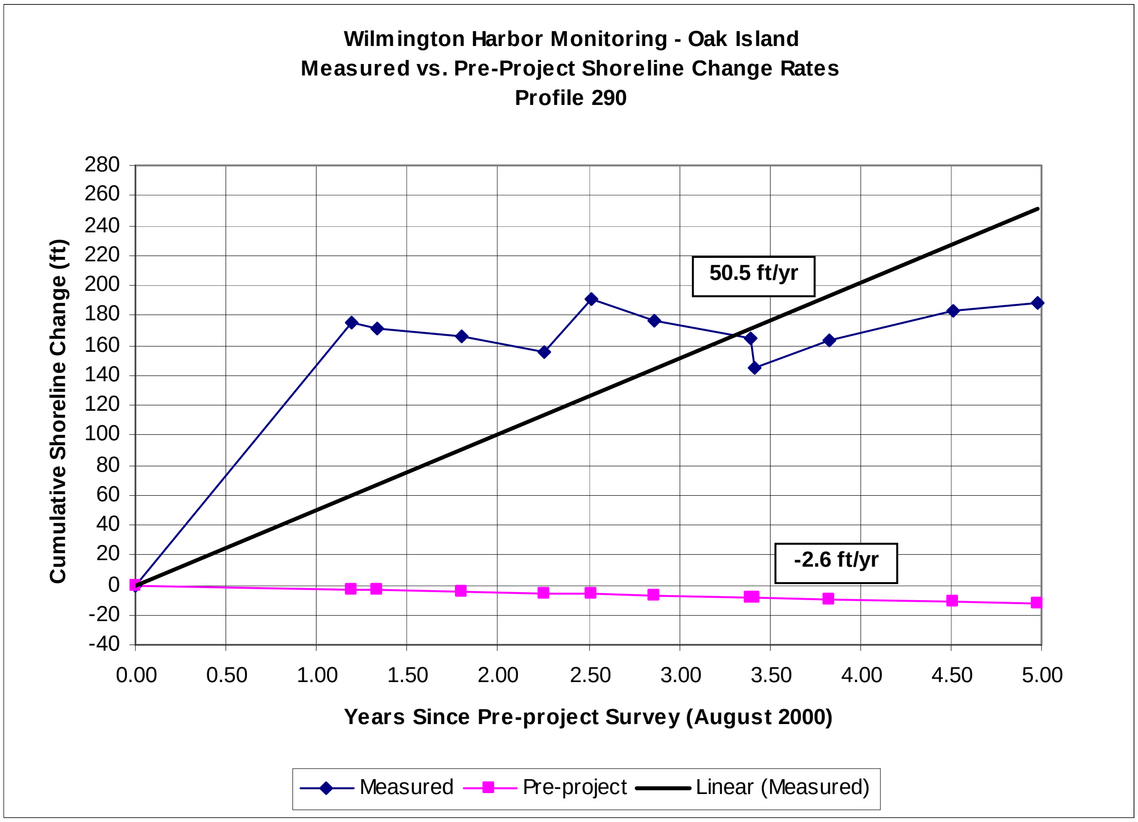

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 265
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
36.4 ft/yr
-3.3 ft/yr
Years Since Pre-project Survey (August 2000)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

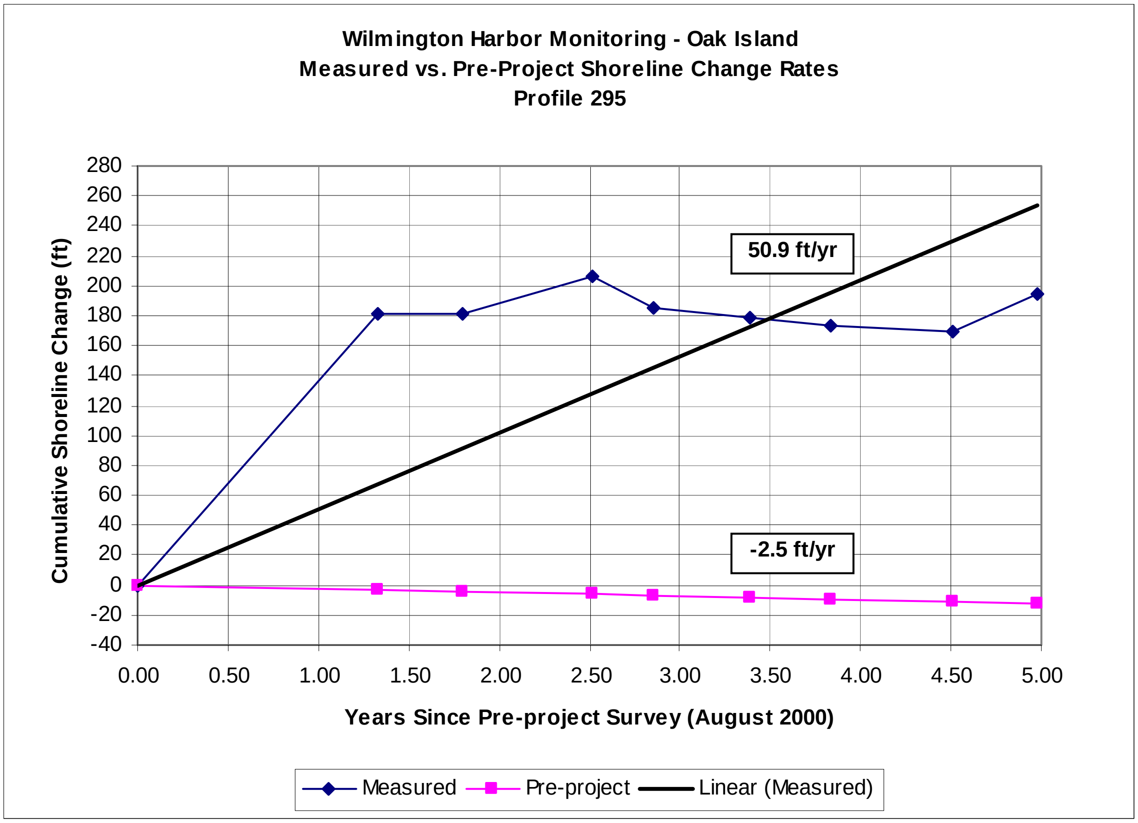

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 270
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
49.6 ft/yr
-3.2 ft/yr
Years Since Pre-project Survey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

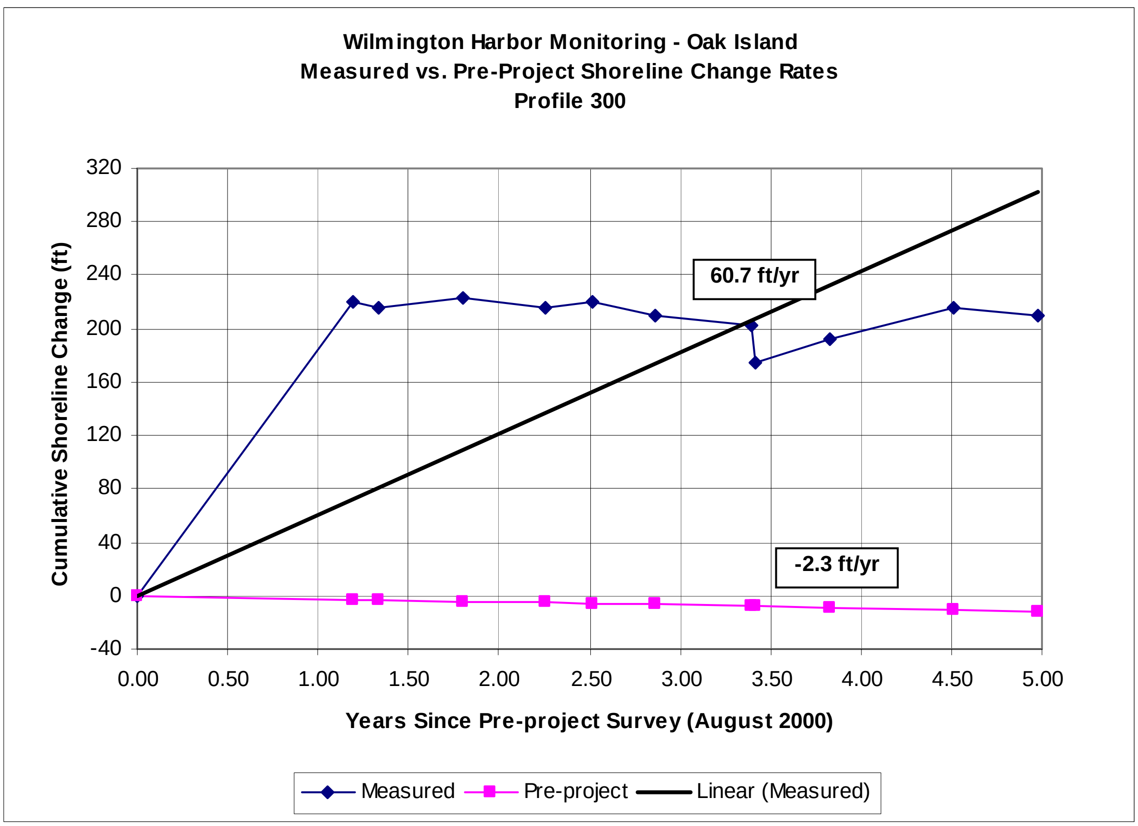

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 275
Cumulative Shoreline Change (ft)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
35.0 ft/yr
-3.0 ft/yr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

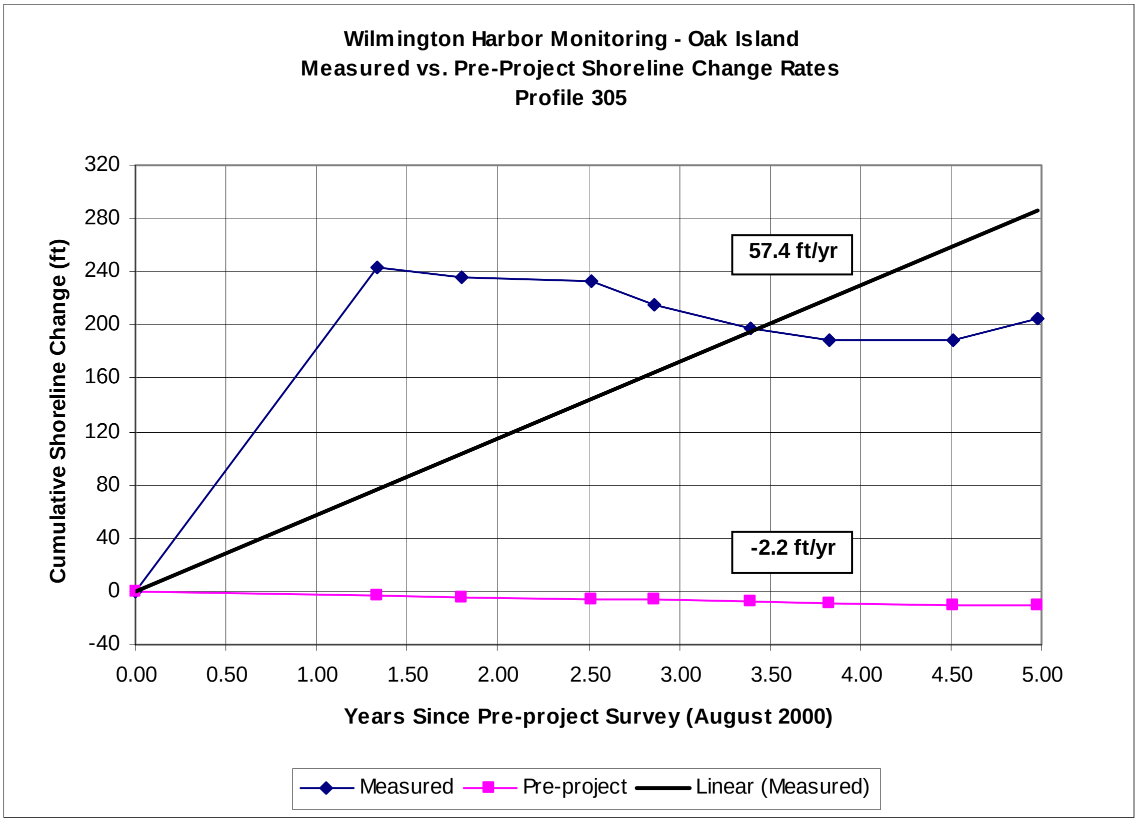

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 280
Cumulative Shoreline Change (ft)
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
52.2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

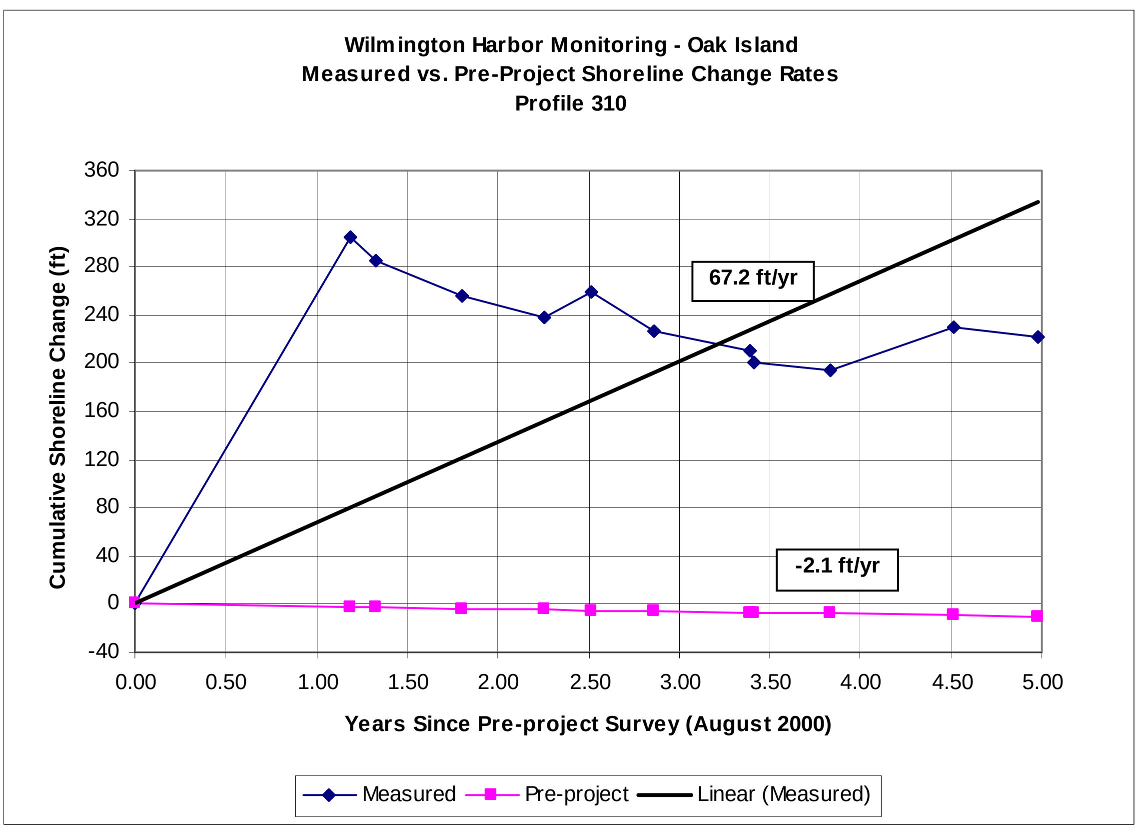

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 285
Cumulative Shoreline Change (ft)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (August 2000)
45.8 ft/yr
-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
Years Since Pre-project Survey (August 2000)
50.5 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
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
50.9 ft/yr
-2.5 ft/yr
Measured
Pre-project
Linear (Measured)

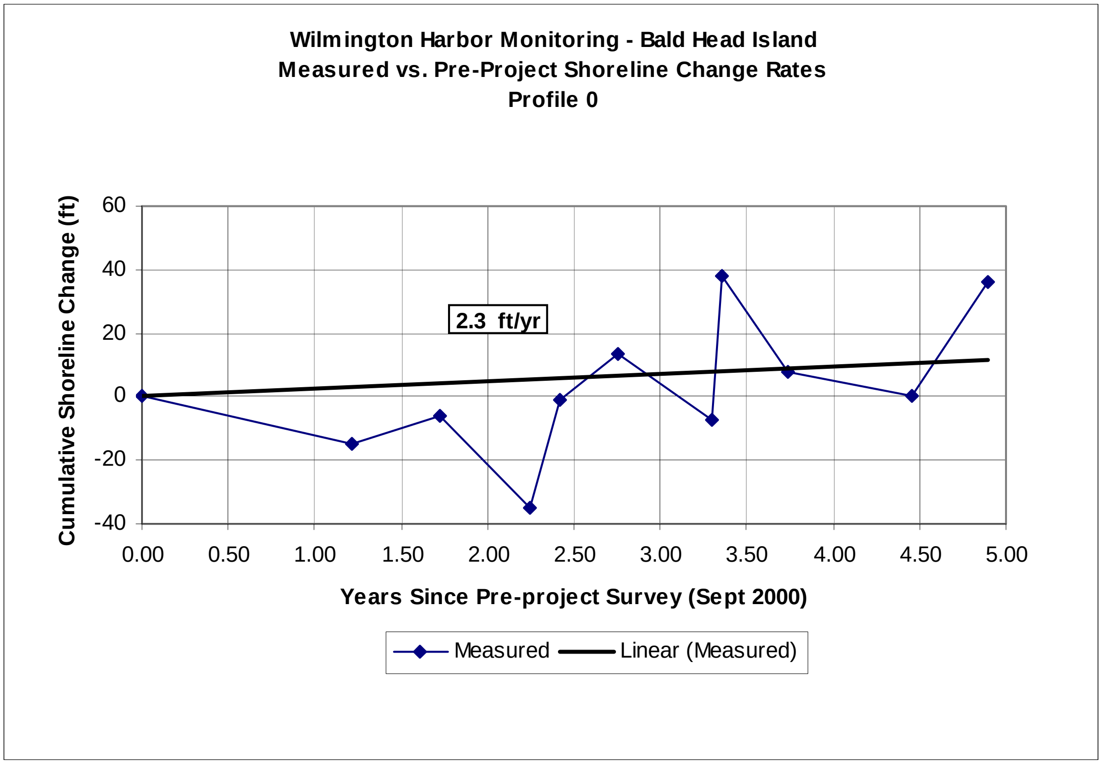

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 300
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
60.7 ft/yr
-2.3 ft/yr
Measured
Pre-project
Linear (Measured)

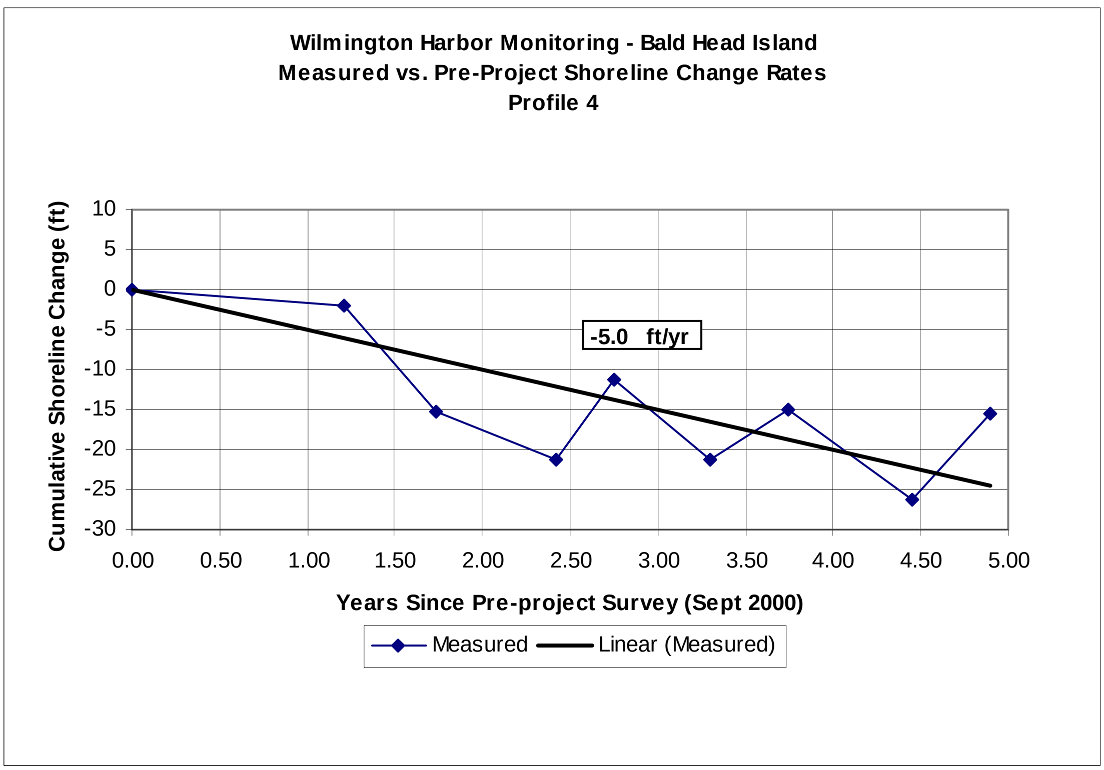

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 305
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
57.4 ft/yr
-2.2 ft/yr
Years Since Pre-project Survey (August 2000)
Measured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

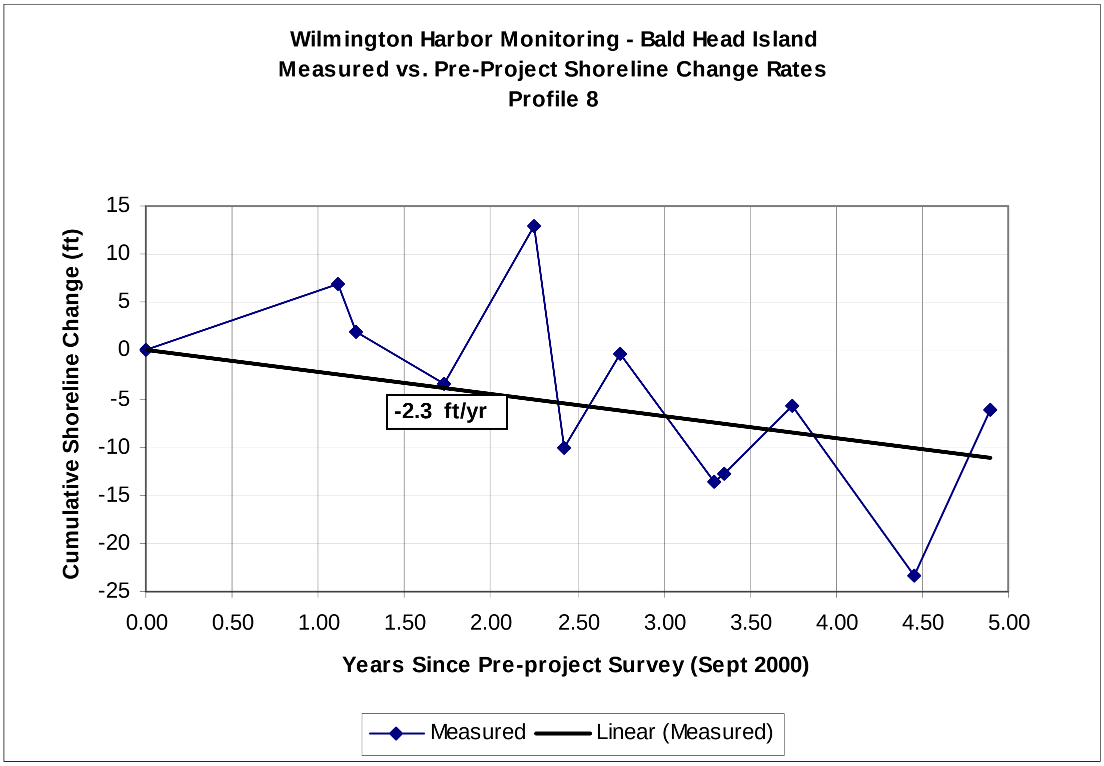

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 310
Cumulative Shoreline Change (ft)
360
320
280
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
67.2 ft/yr
-2.1 ft/yr
Years Since Pre-project Survey (August 2000)
Measured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

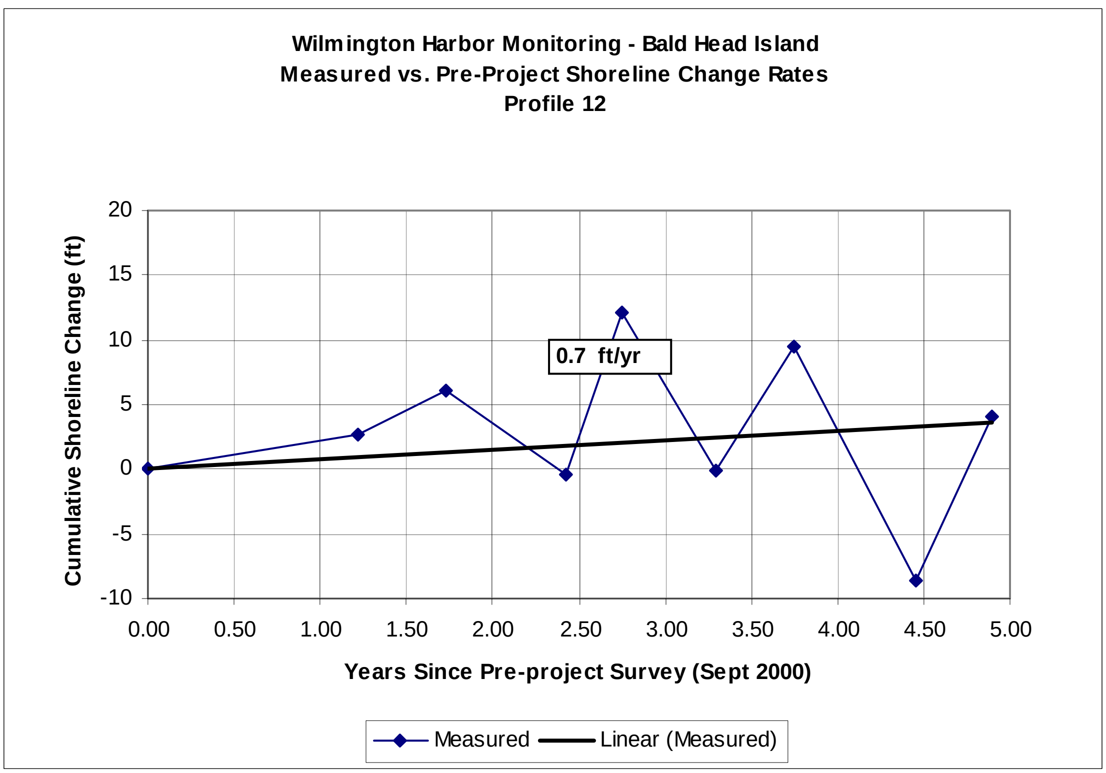
Appendix C

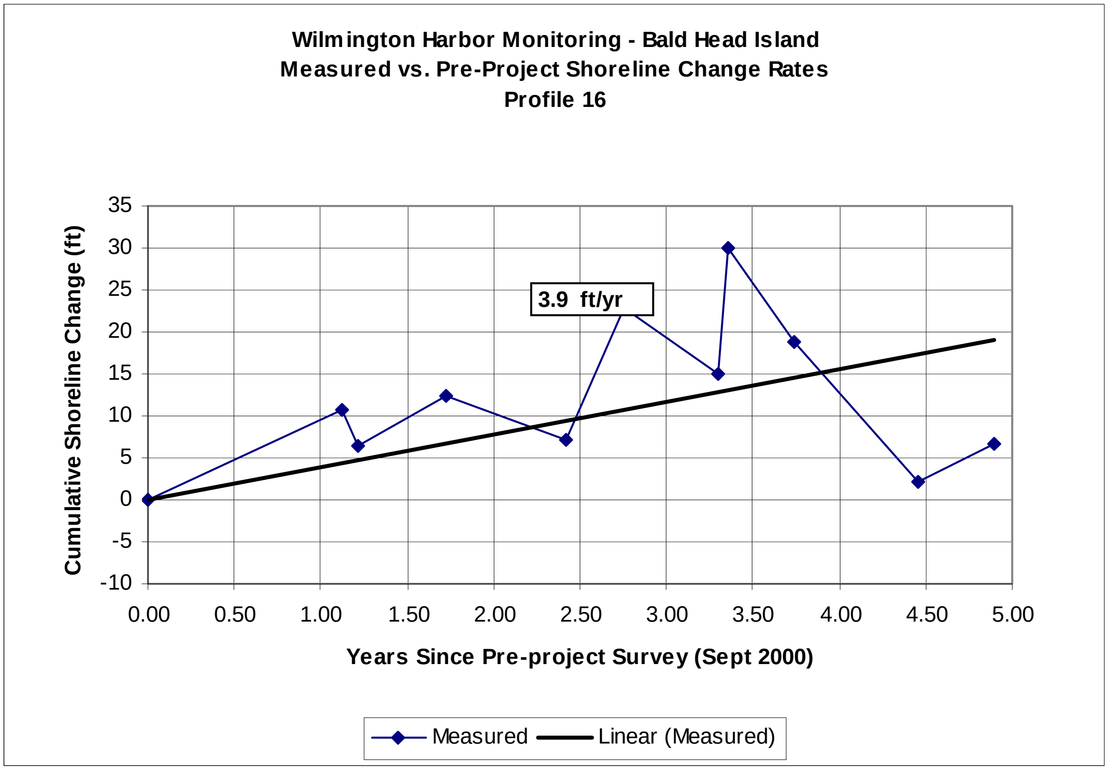
SHORELINE CHANGE RATES
(Bald Head Island)

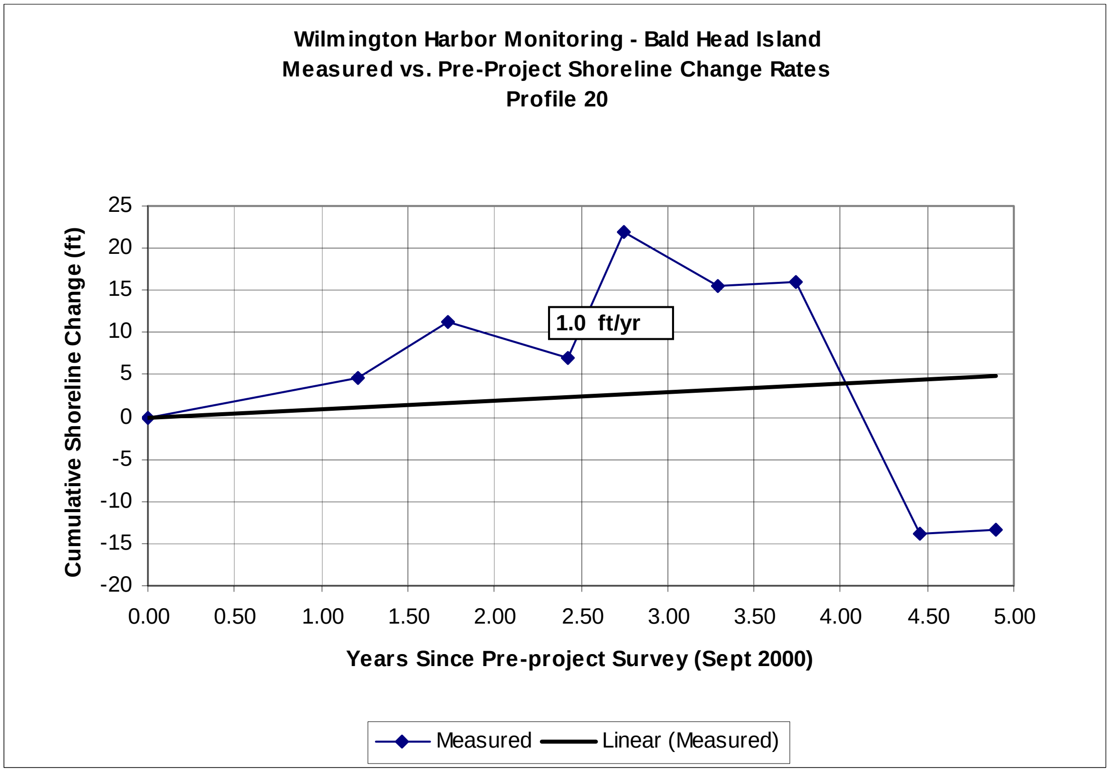

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 0
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
2.3 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

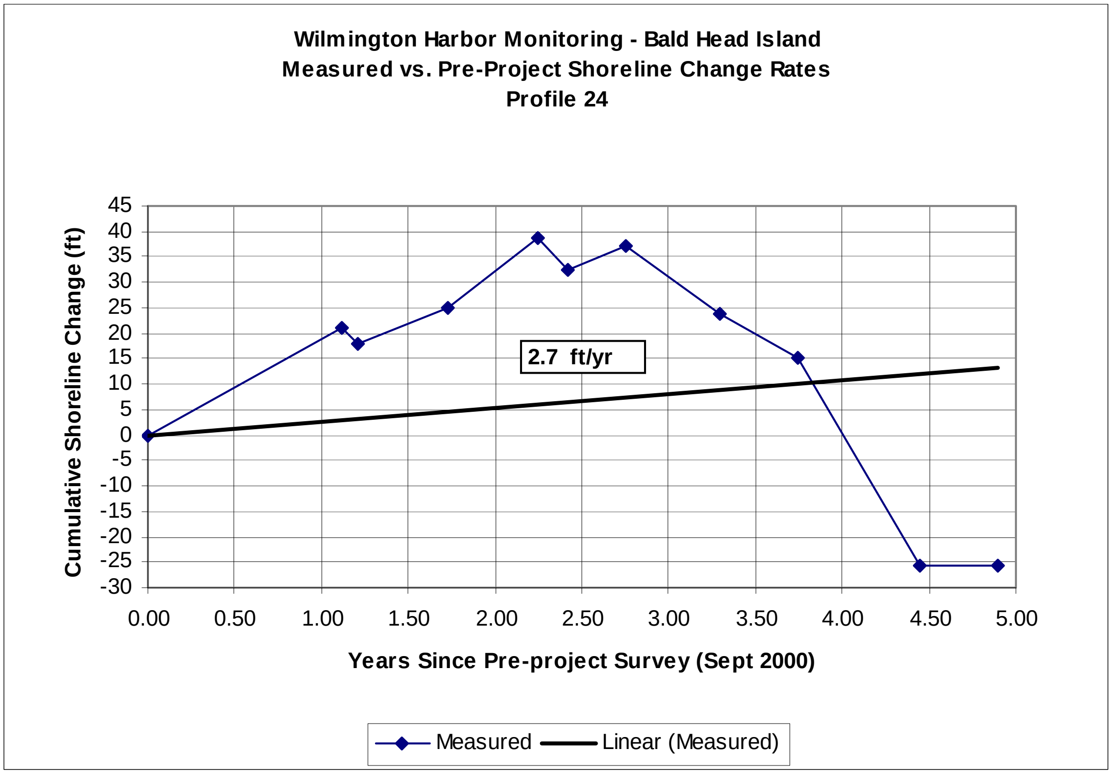

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 4
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
-20
-25
-30
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
-5.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 8
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
-15
-20
-25
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
-2.3 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

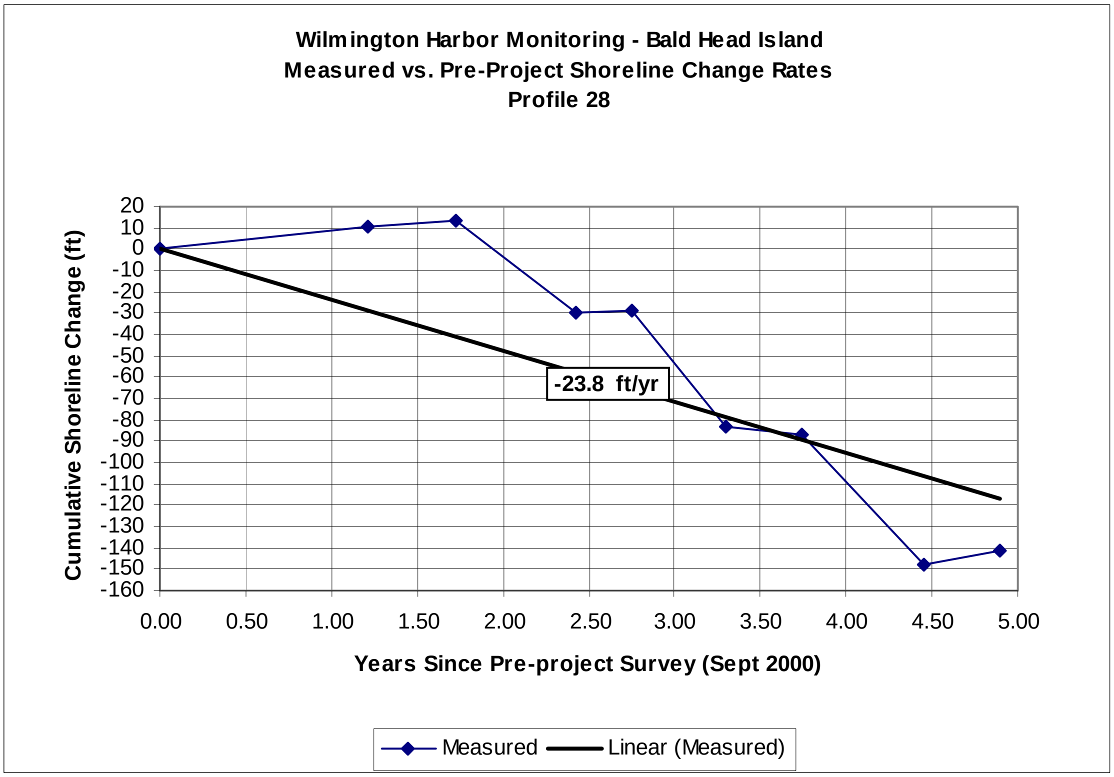

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 12
Cumulative Shoreline Change (ft)
20
15
10
5
0
-5
-10
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
0.7 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 16
3.9 ft/yr
Cumulative Shoreline Change (ft)
35
30
25
20
15
10
5
0
-5
-10
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 (Sept 2000)
Measured
Linear (Measured)

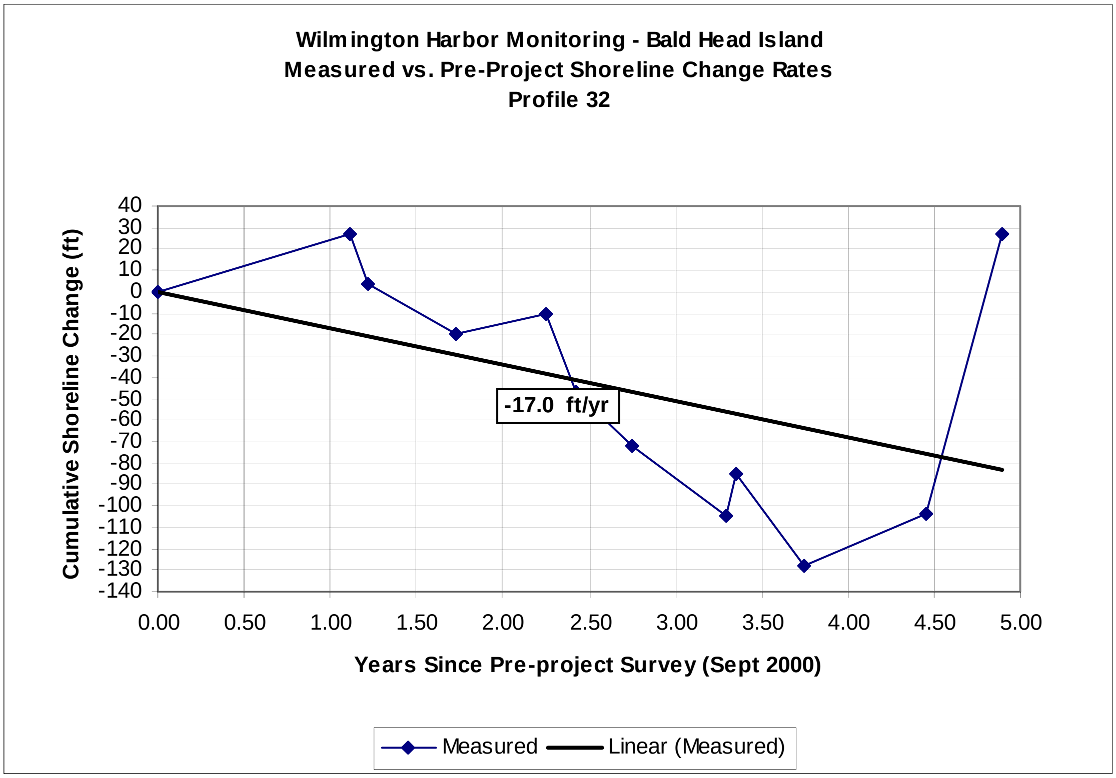

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
1.0 ft/yr
Cumulative Shoreline Change (ft)
25
20
15
10
5
0
-5
-10
-15
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

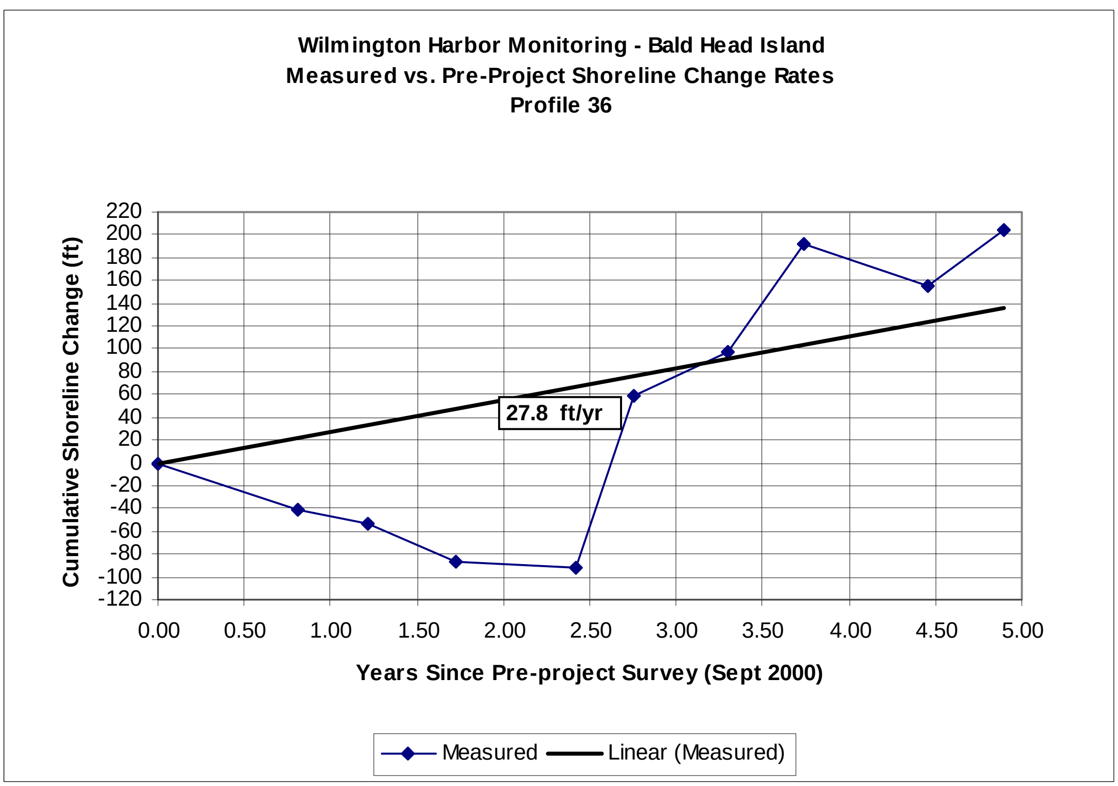


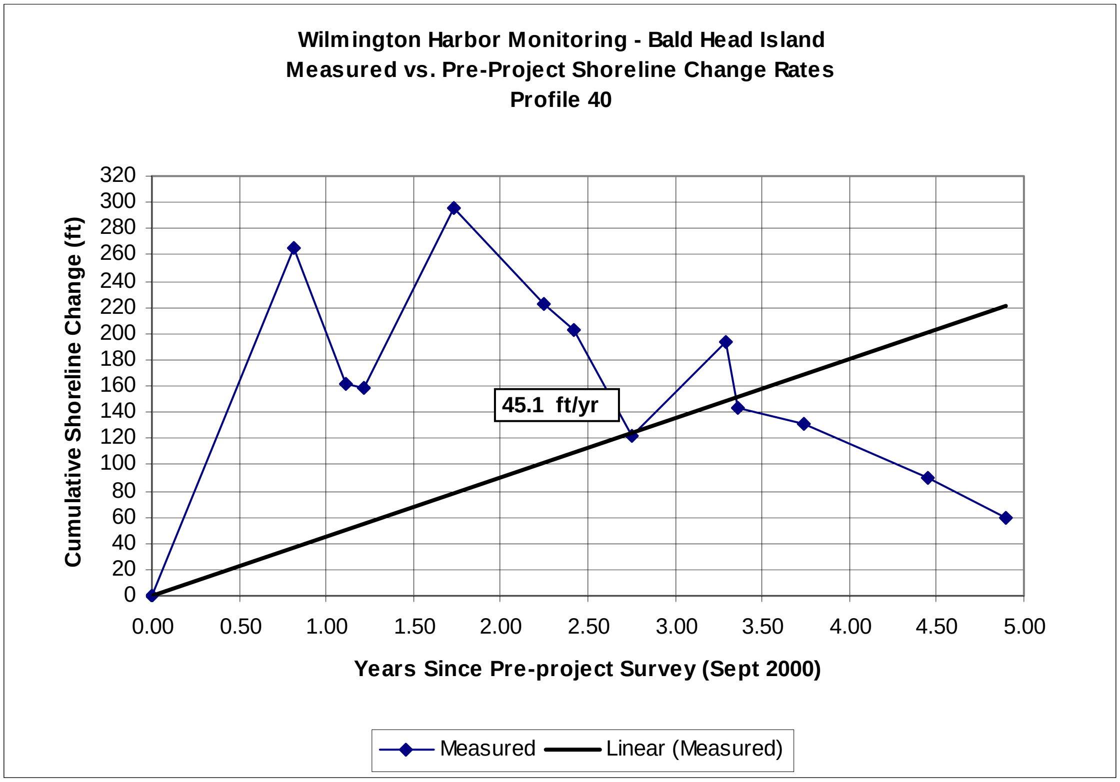
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 24
Cumulative Shoreline Change (ft)
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
2.7 ft/yr
Measured
Linear (Measured)

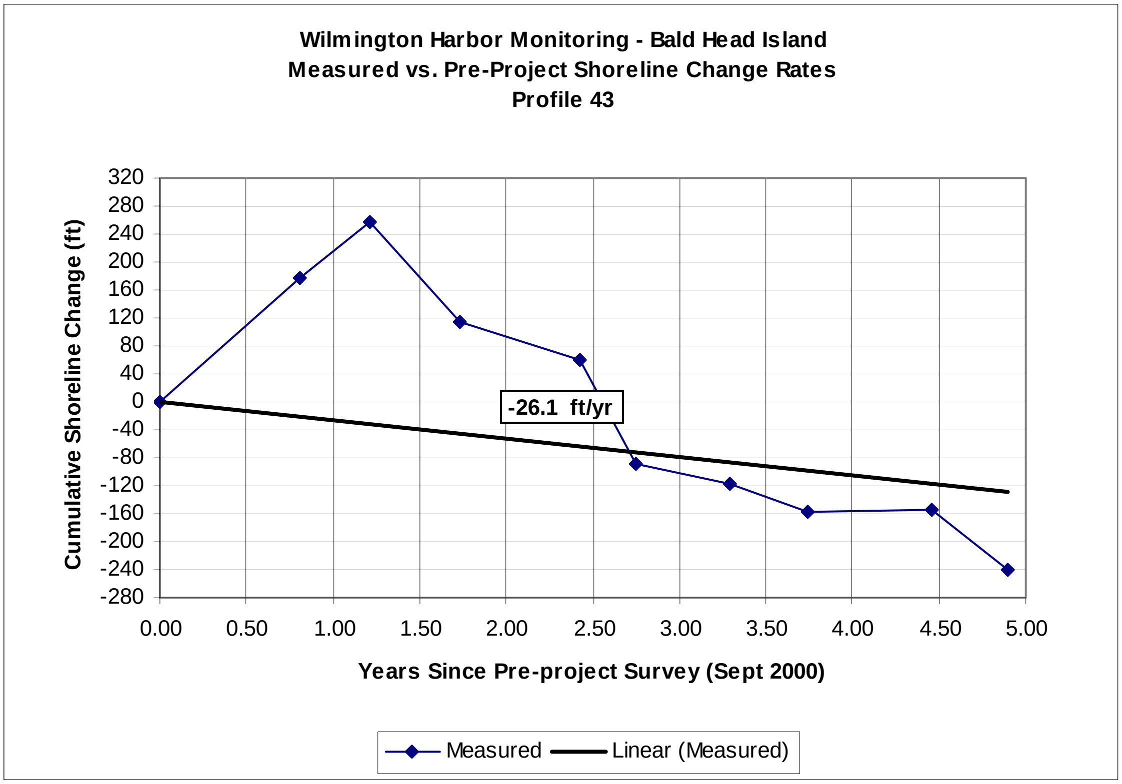


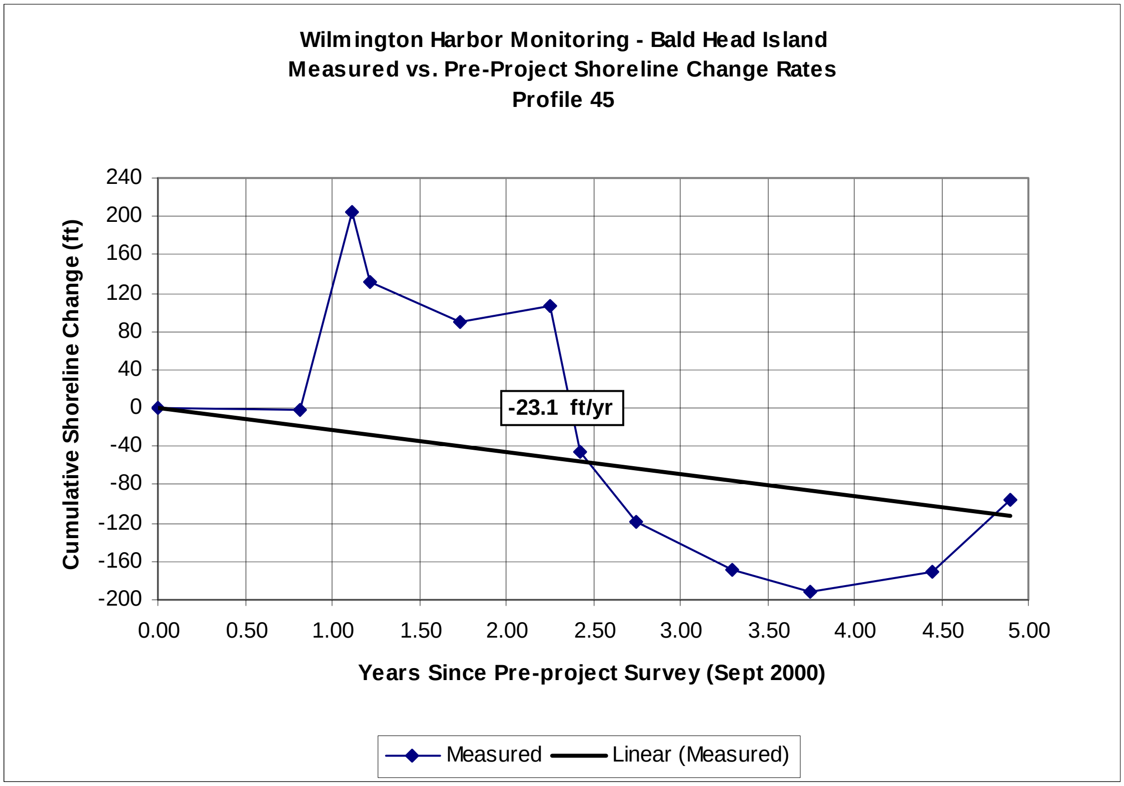
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 28
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
-23.8 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 32
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
-17.0 ft/yr
Measured
Linear (Measured)

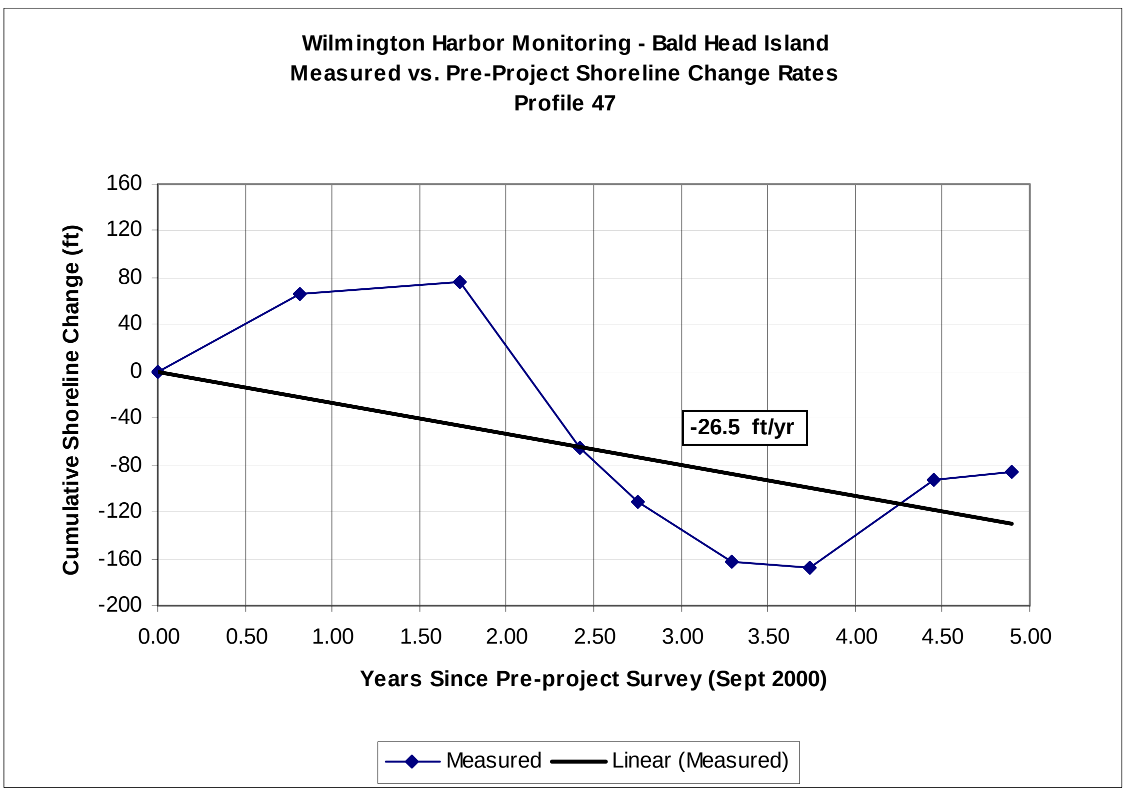

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 36
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
27.8 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
Cumulative Shoreline Change (ft)
320
300
280
260
240
220
200
180
160
140
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
45.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

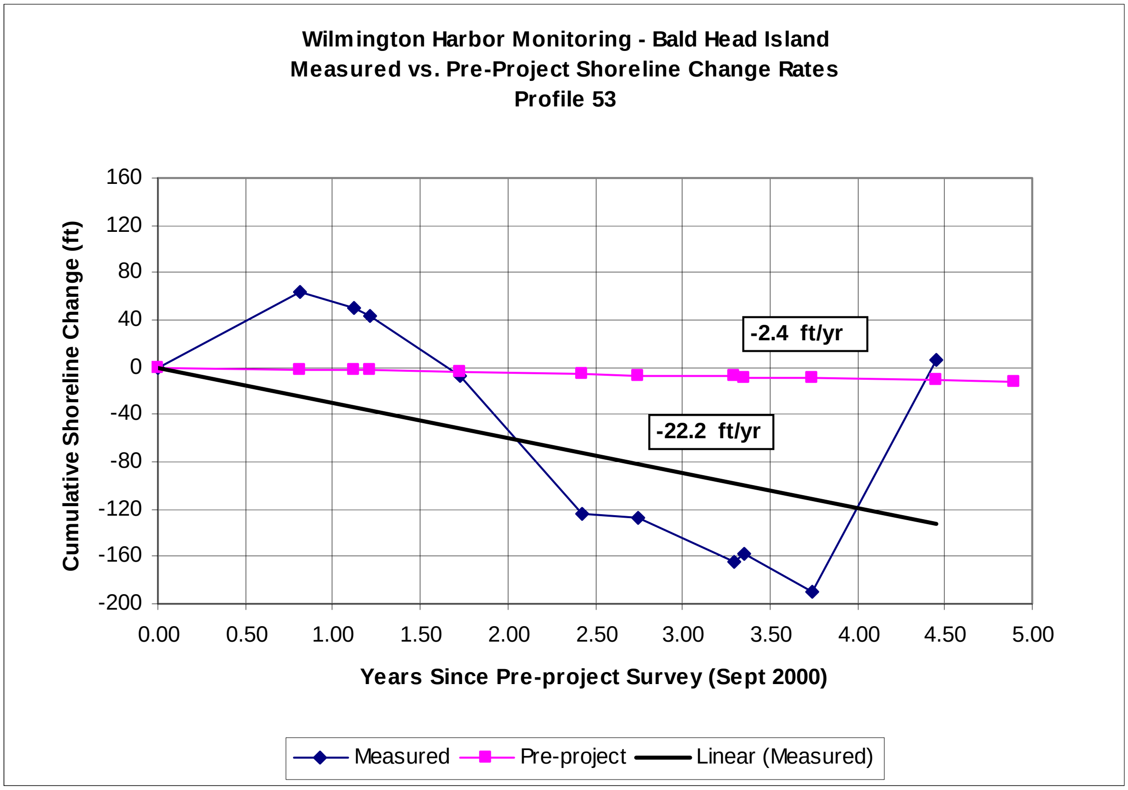

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 43
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
-26.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)



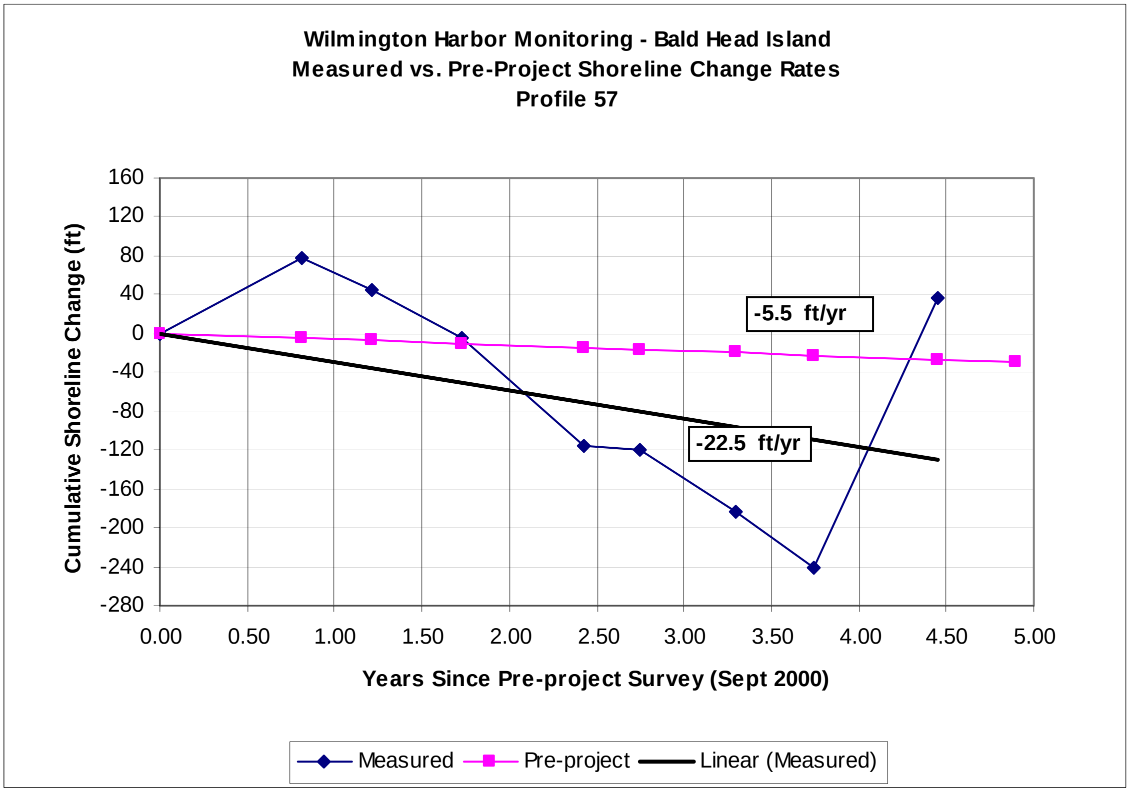
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
-120
-160
-200
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
-23.1 ft/yr
Measured
Linear (Measured)



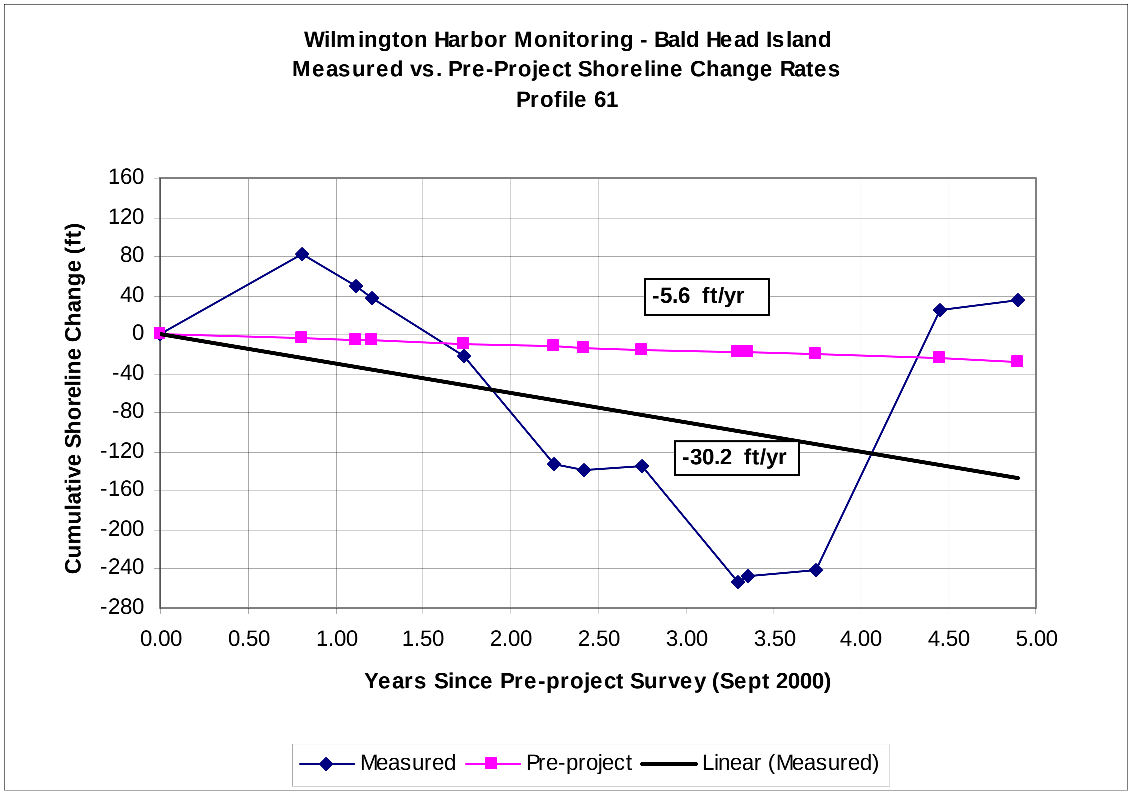
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 47
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
-160
-200
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
-26.5 ft/yr
Measured
Linear (Measured)

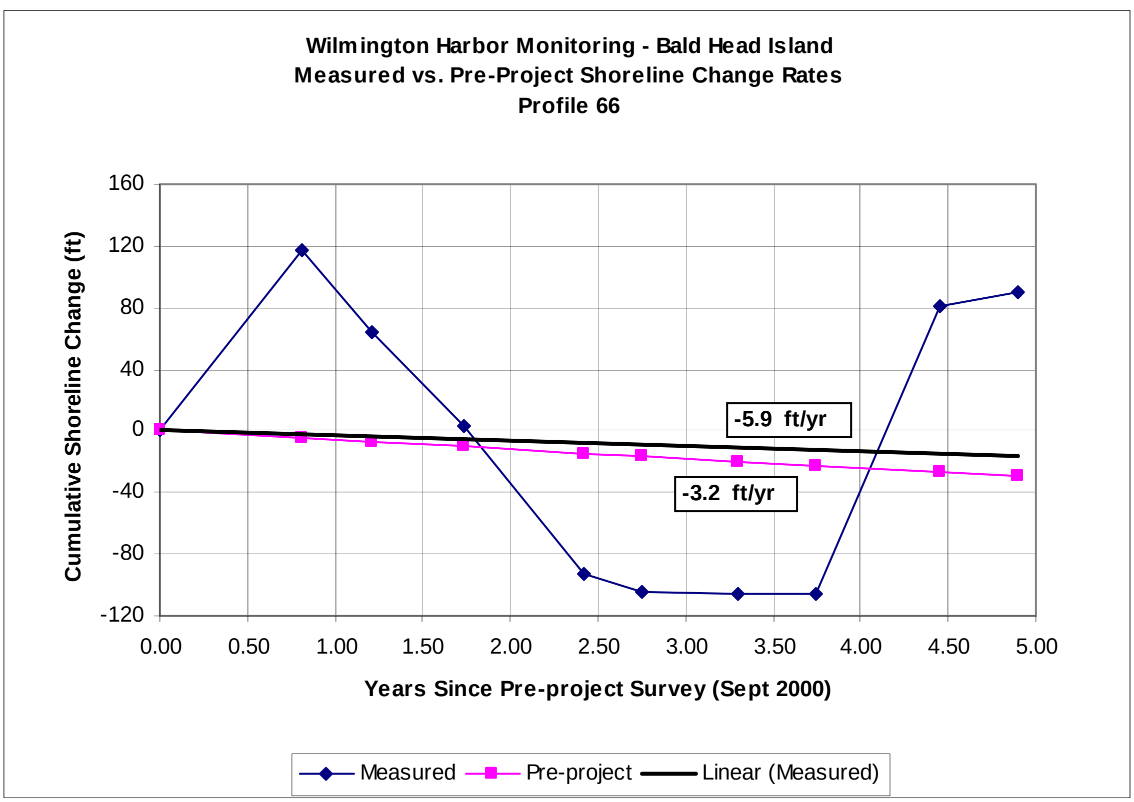


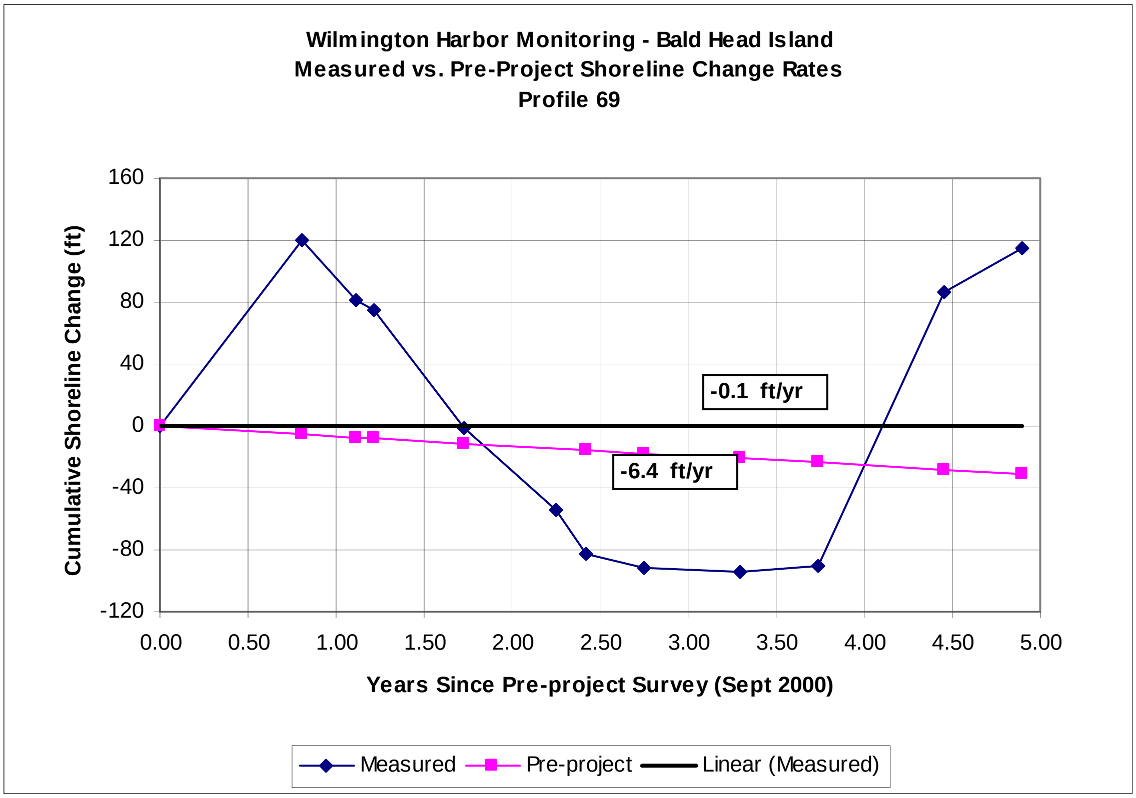
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 53
-2.4 ft/yr
-22.2 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

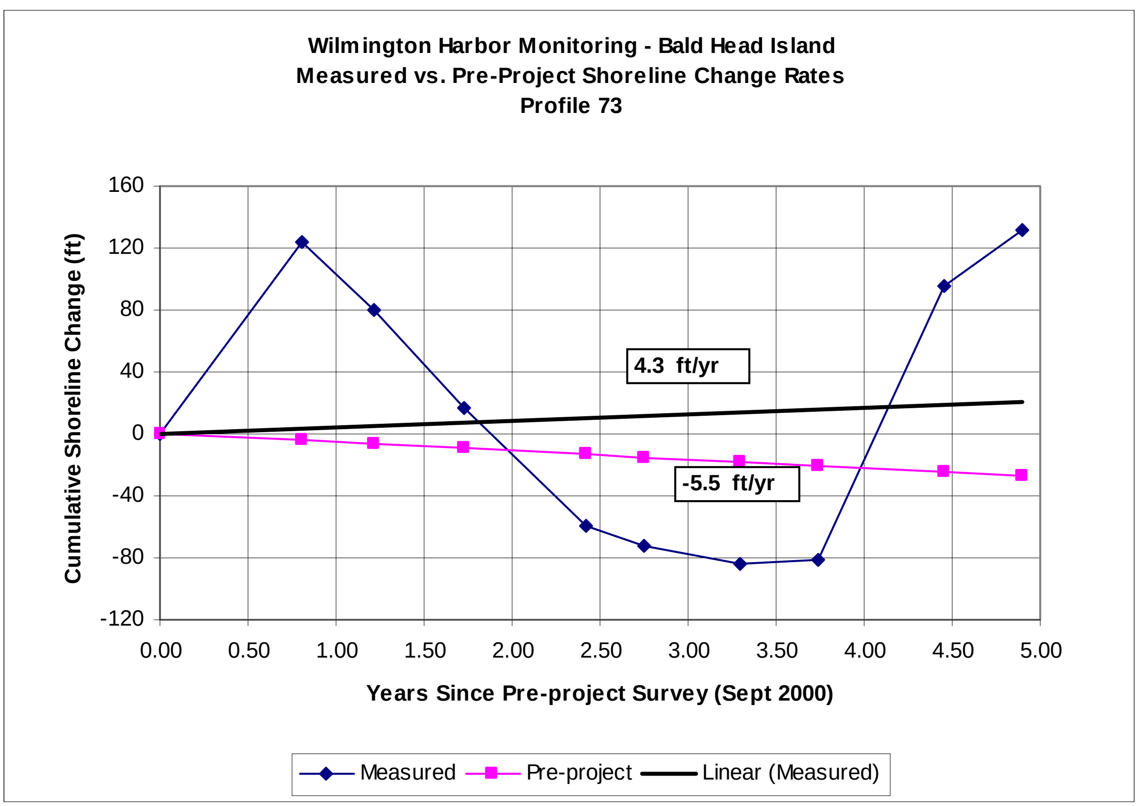


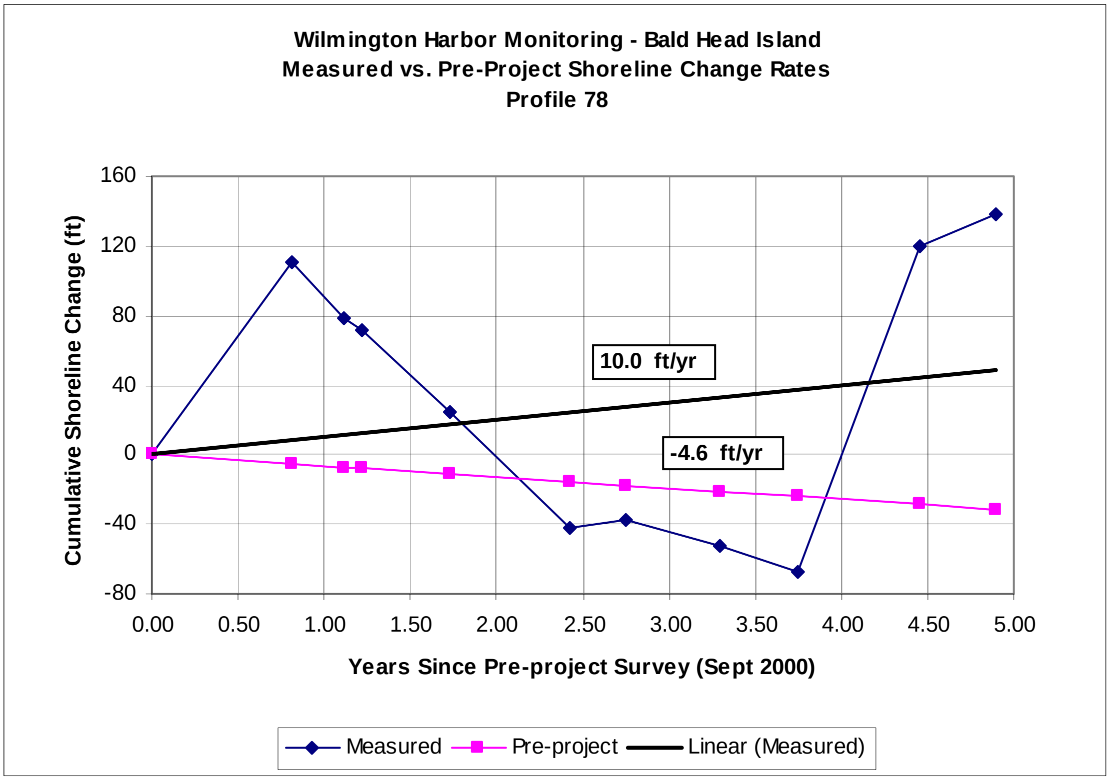
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 57
-5.5 ft/yr
-22.5 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

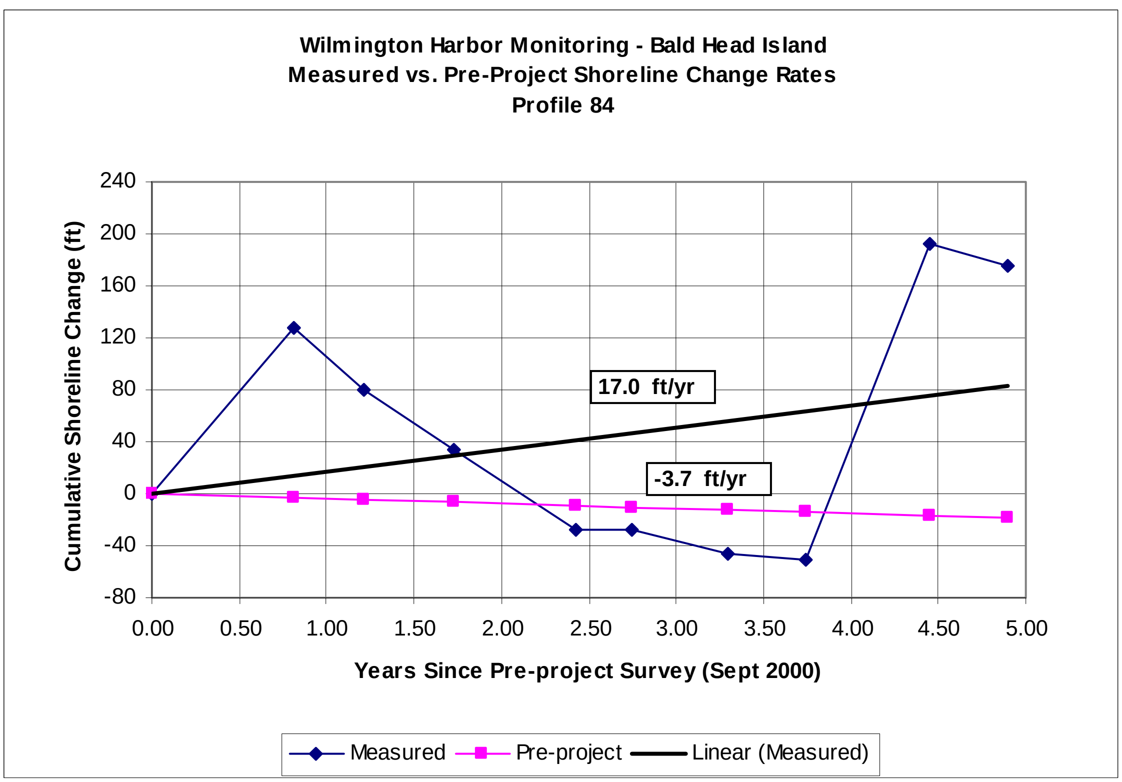

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 61
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
-5.6 ft/yr
-30.2 ft/yr
Measured
Pre-project
Linear (Measured)

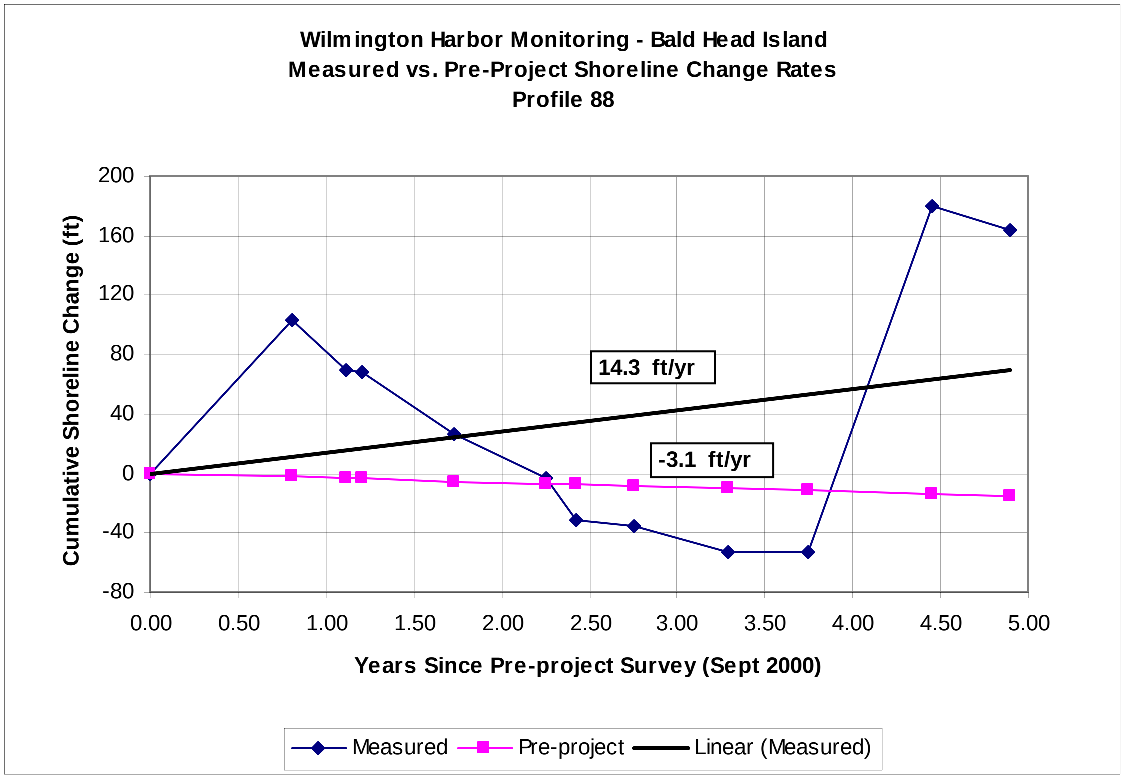

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 66
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
-5.9 ft/yr
-3.2 ft/yr
Measured
Pre-project
Linear (Measured)

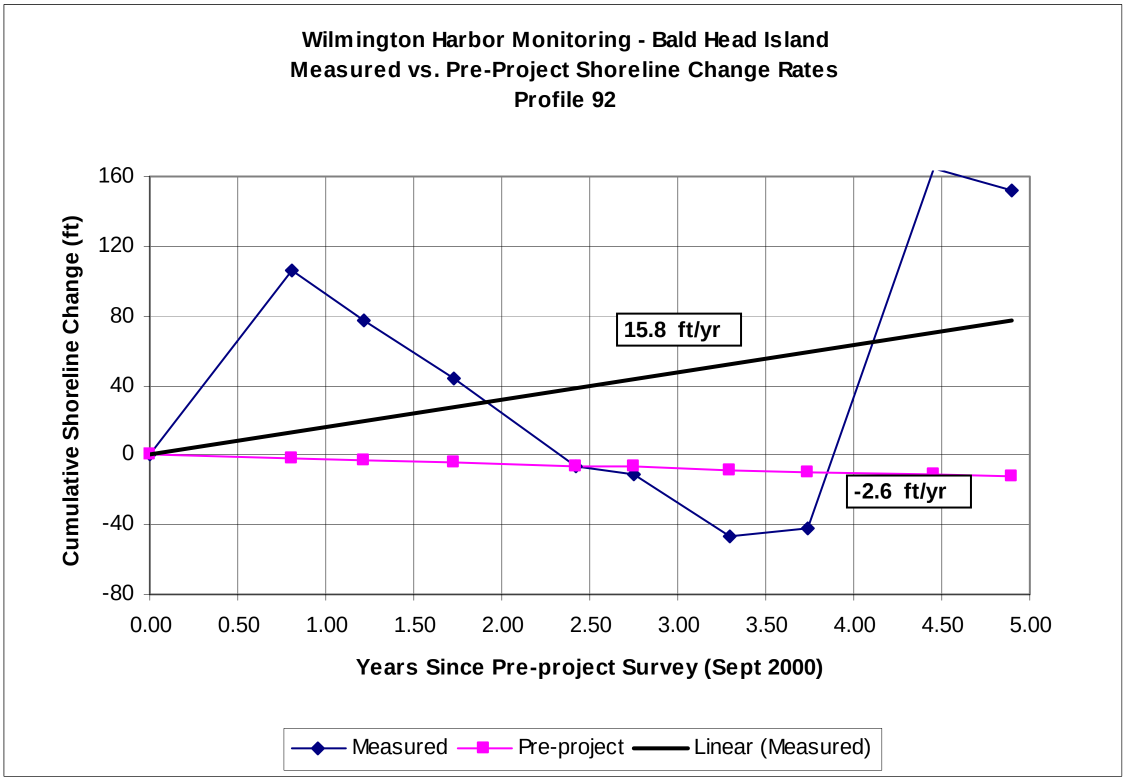

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 69
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
-0.1 ft/yr
-6.4 ft/yr
Measured
Pre-project
Linear (Measured)

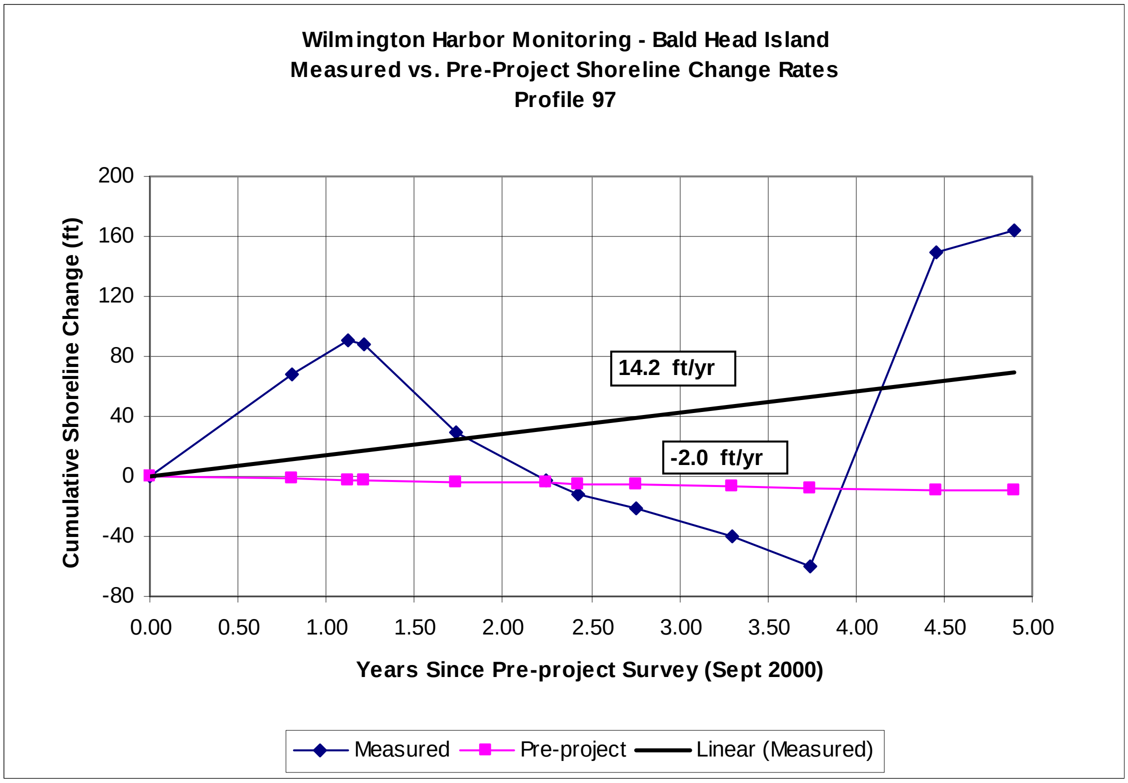

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 73
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
4.3 ft/yr
-5.5 ft/yr
Measured
Pre-project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

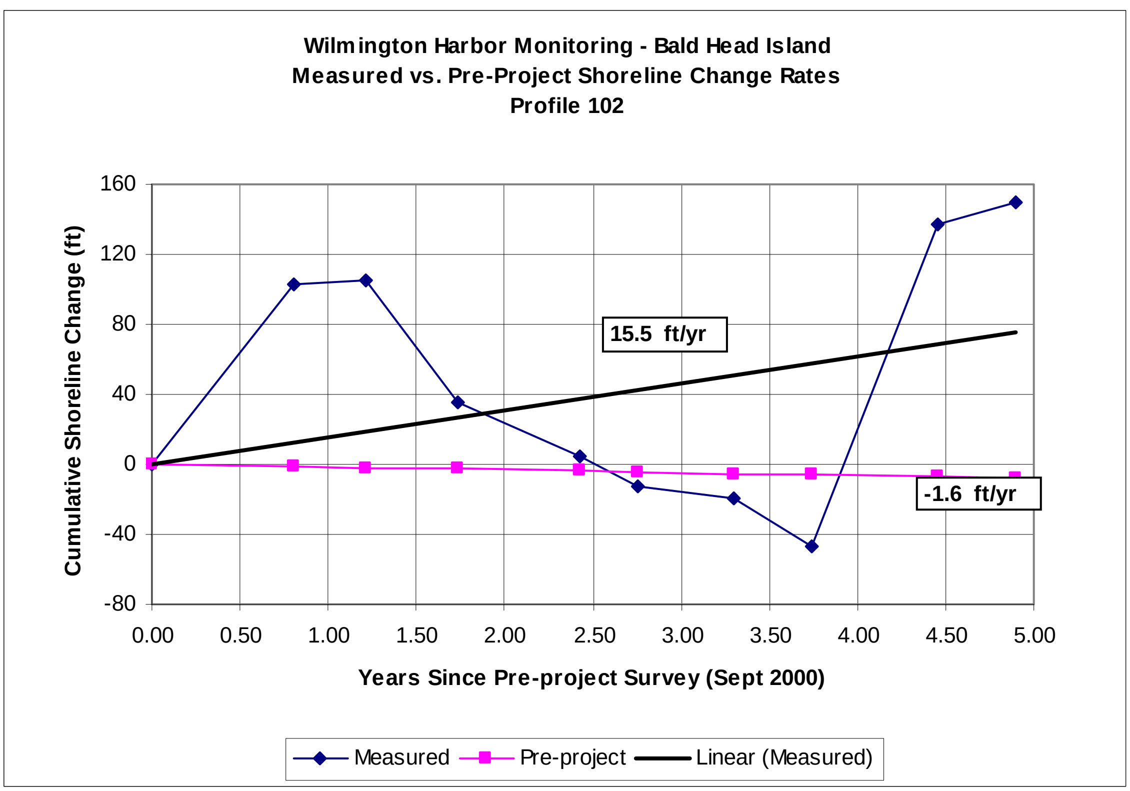

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 78
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
10.0 ft/yr
-4.6 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project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

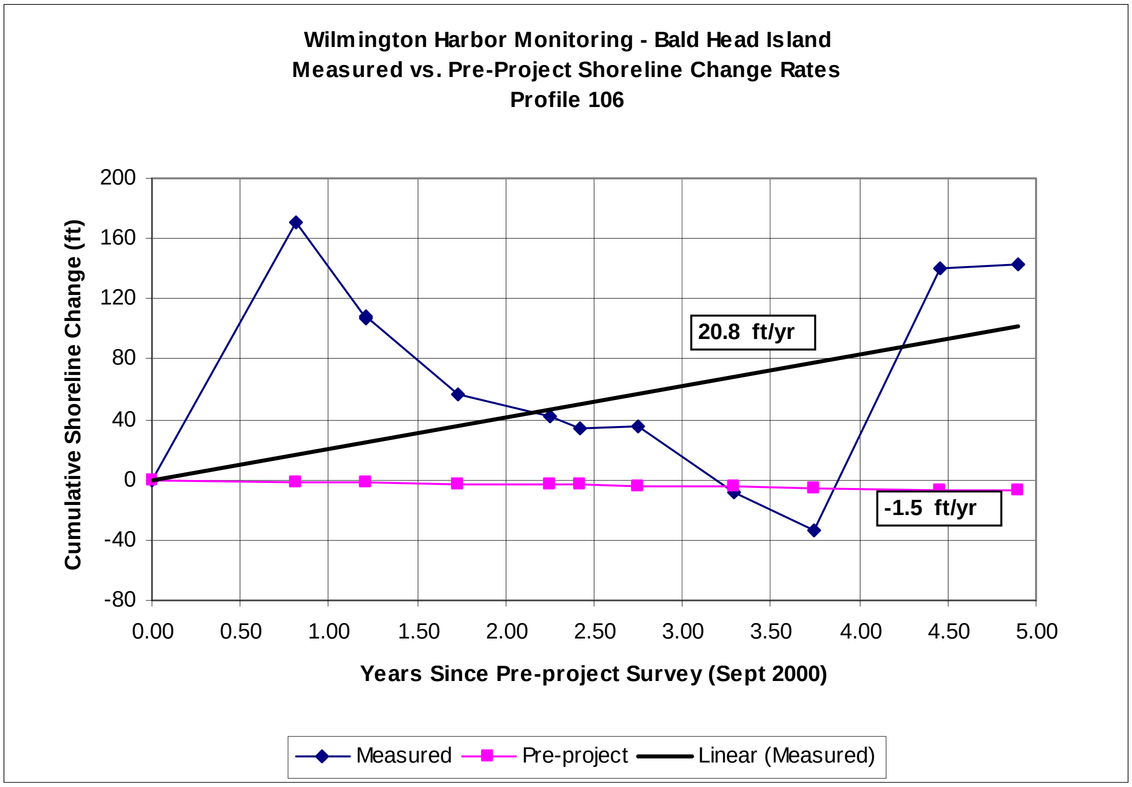

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 84
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
17.0 ft/yr
-3.7 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured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

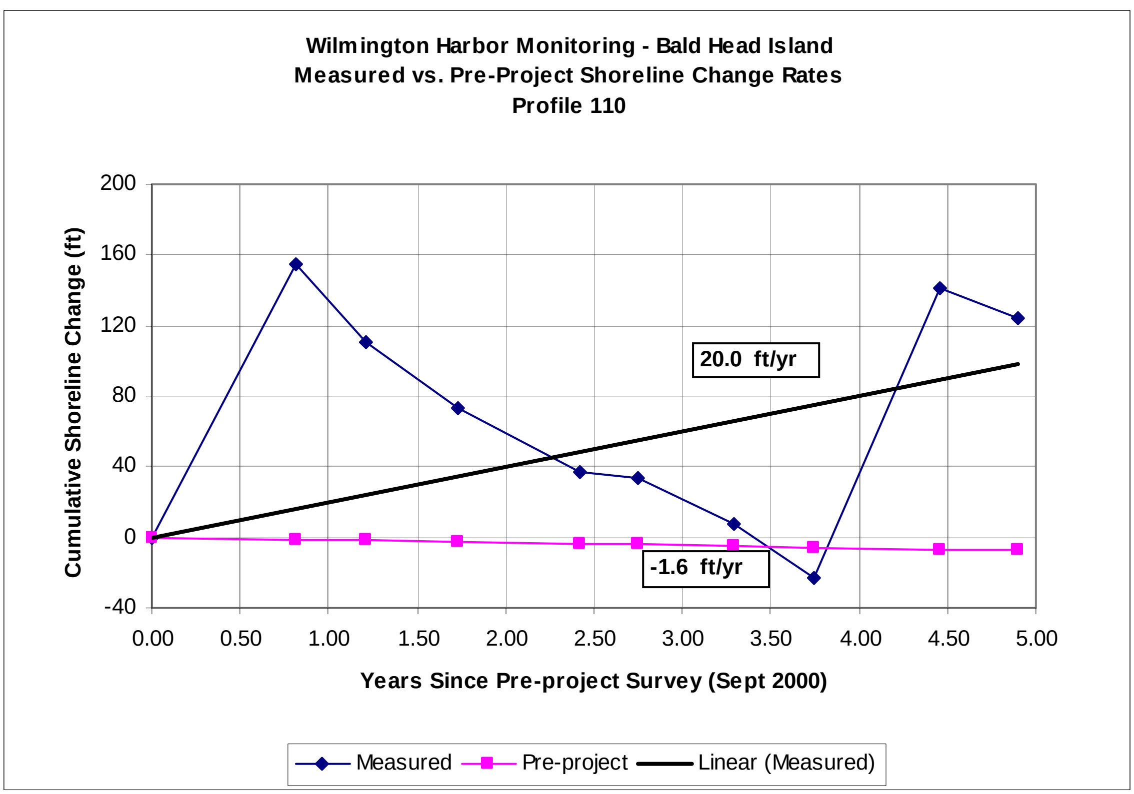

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 88
14.3 ft/yr
-3.1 ft/yr
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project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

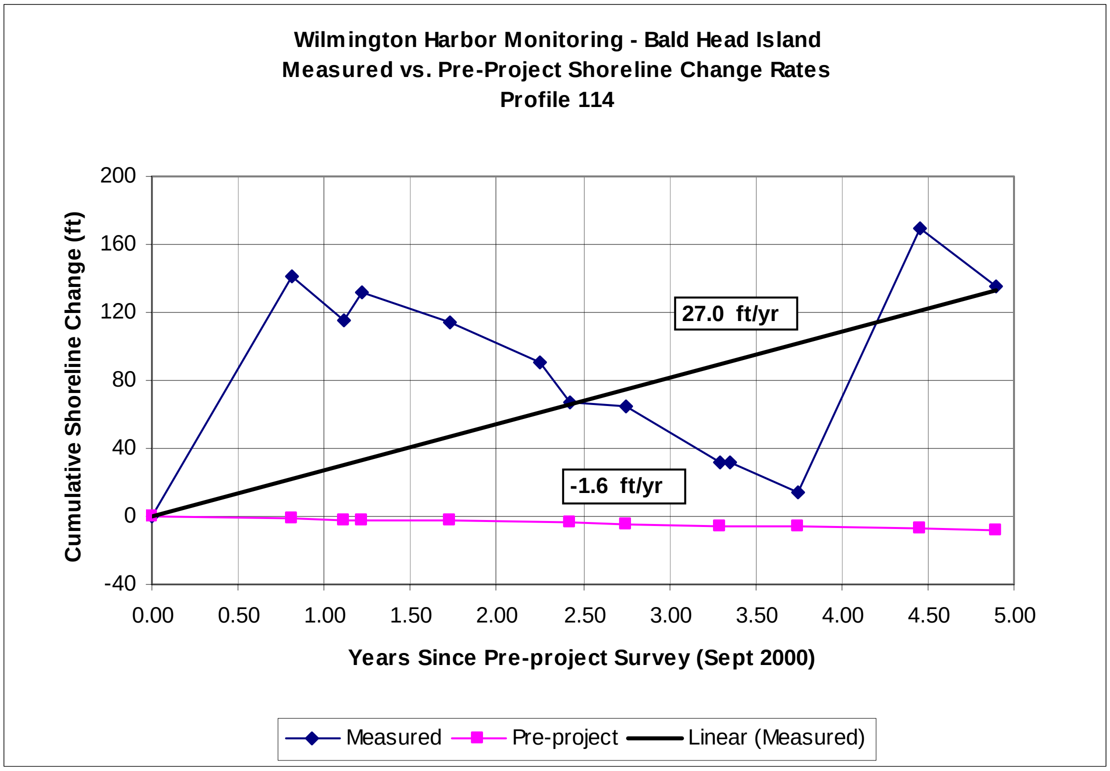

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 92
15.8 ft/yr
-2.6 ft/yr
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

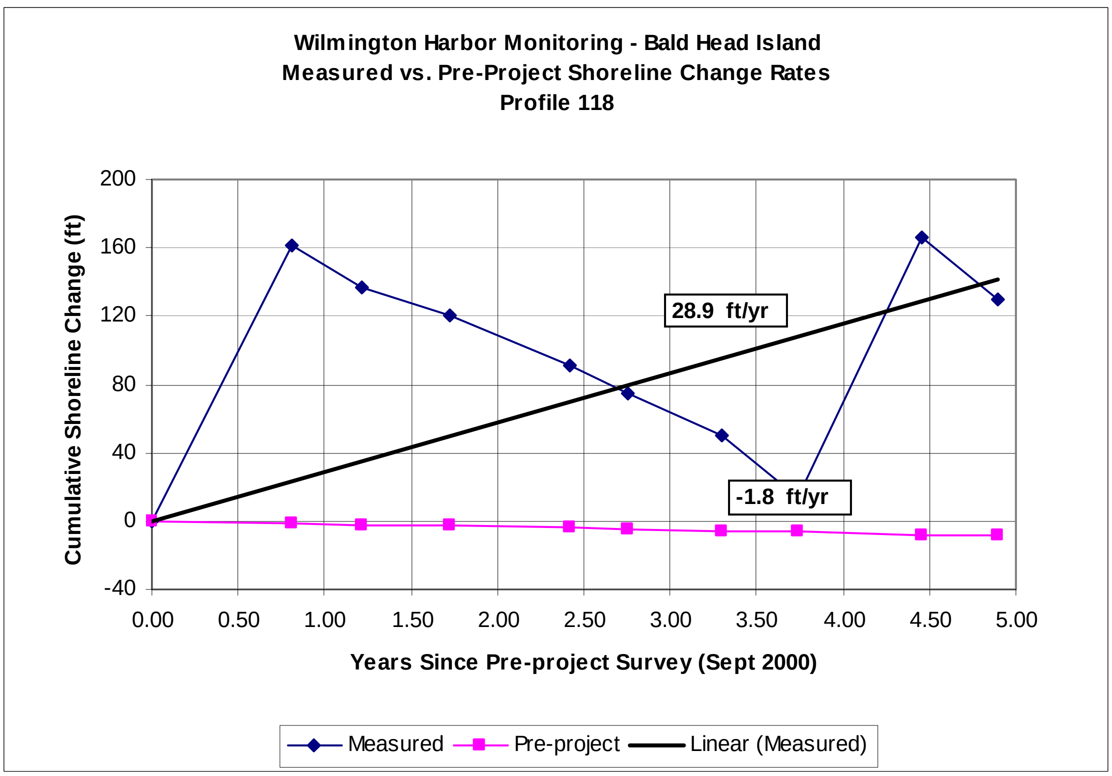

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 97
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
14.2 ft/yr
-2.0 ft/yr
Measured
Pre-project
Linear (Measured)

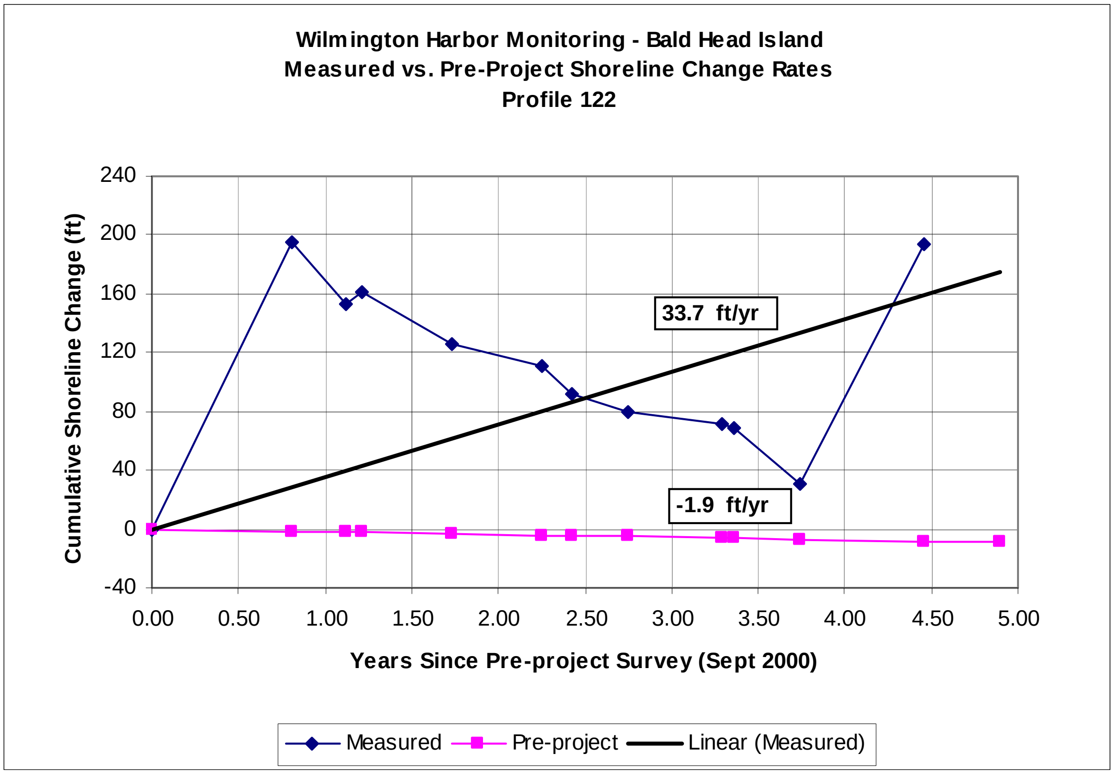

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 102
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
15.5 ft/yr
-1.6 ft/yr
Measured
Pre-project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

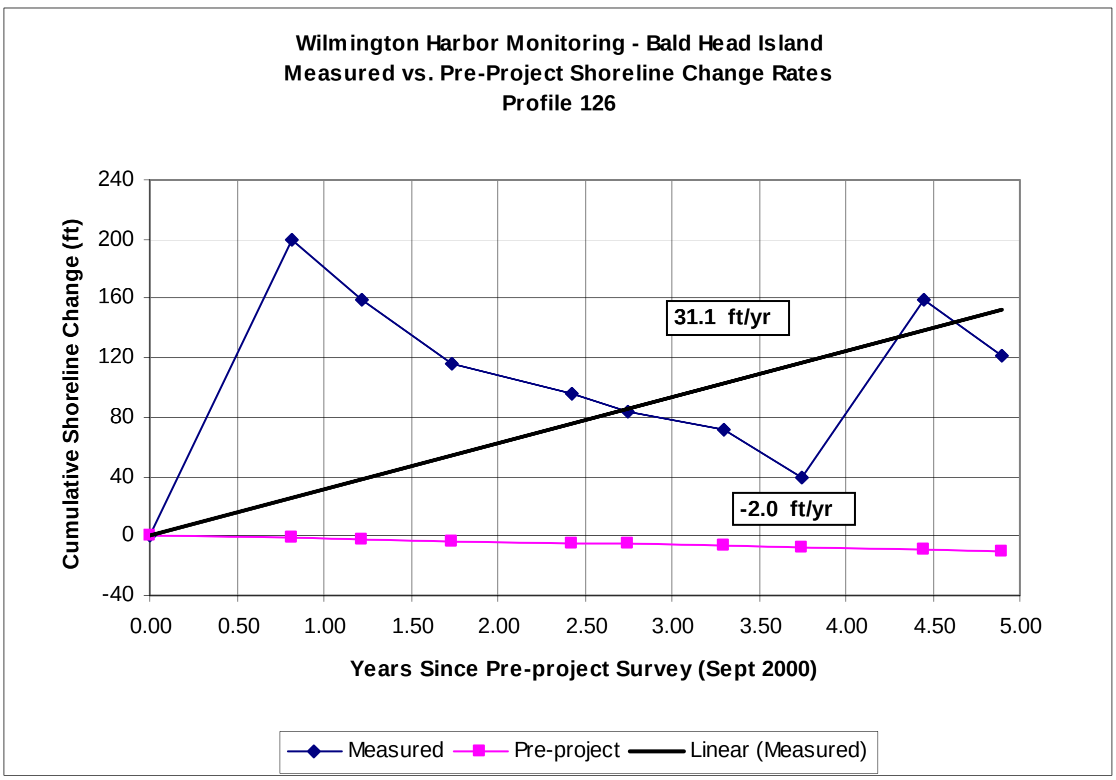

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 106
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
20.8 ft/yr
-1.5 ft/yr
Measured
Pre-project
Linear (Measured)

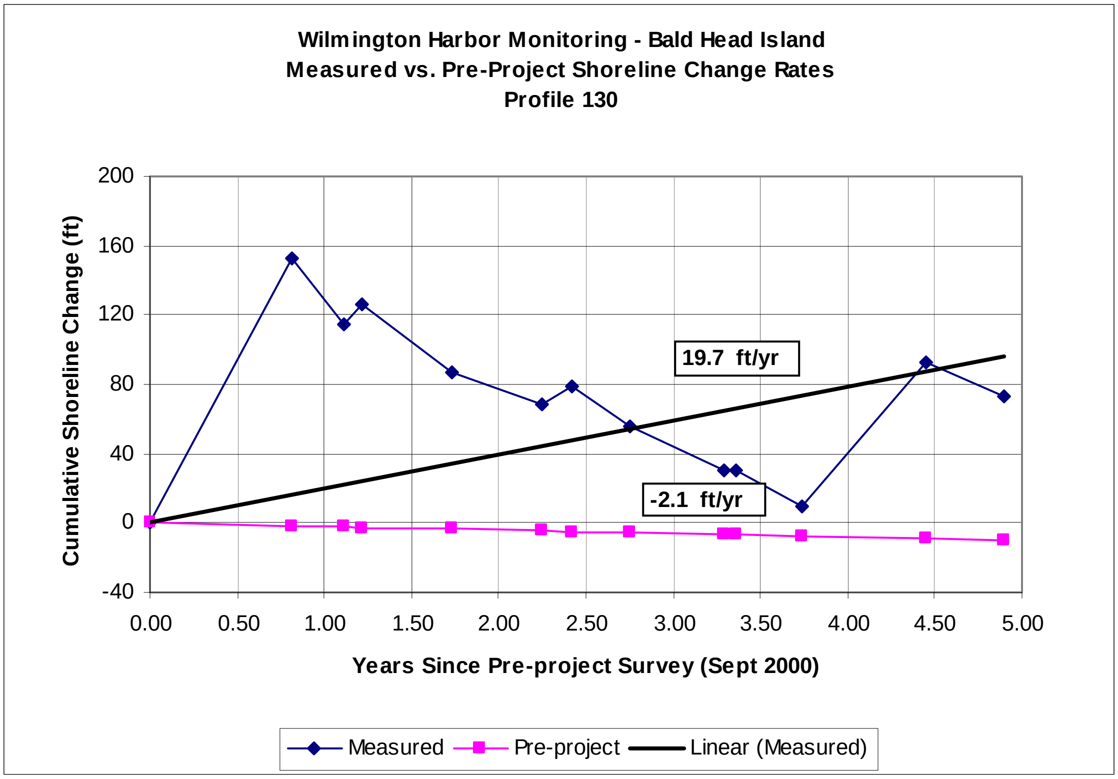

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
20.0 ft/yr
-1.6 ft/yr
Measured
Pre-project
Linear (Measured)


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

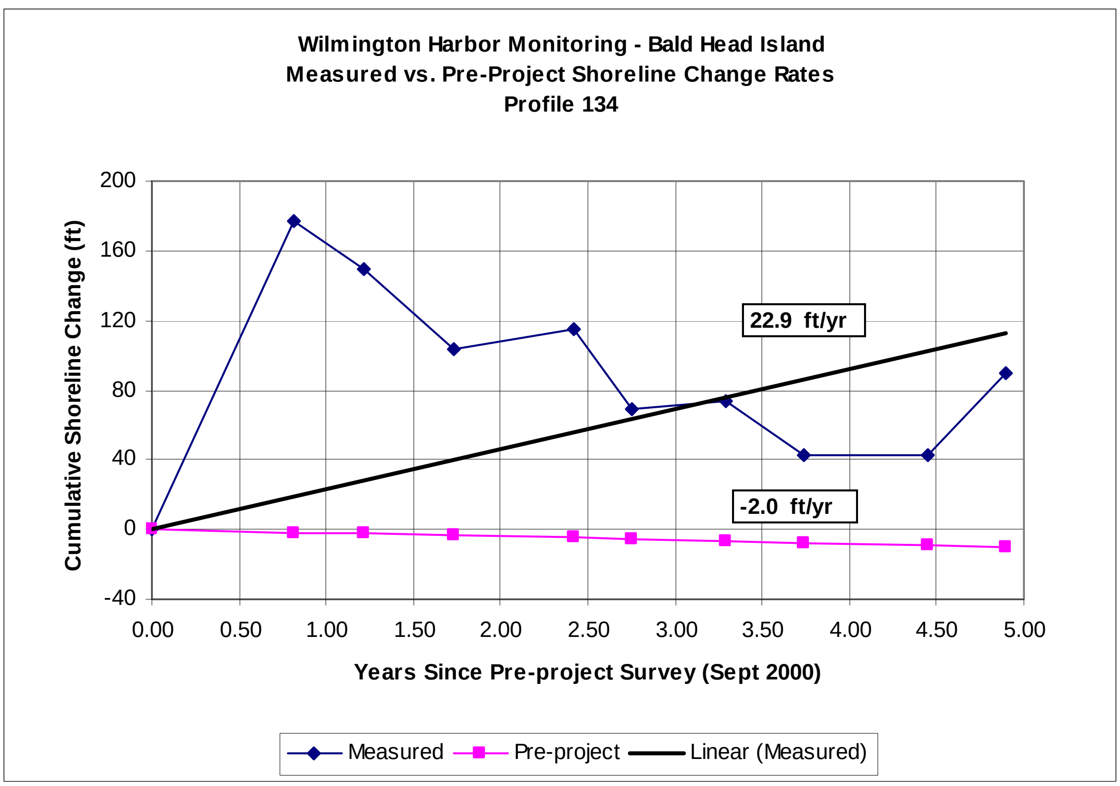

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 118
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
28.9 ft/yr
-1.8 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 122
Cumulative Shoreline Change (ft)
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
Years Since Pre-project Survey (Sept 2000)
33.7 ft/yr
-1.9 ft/yr
Measured
Pre-project
Linear (Measured)

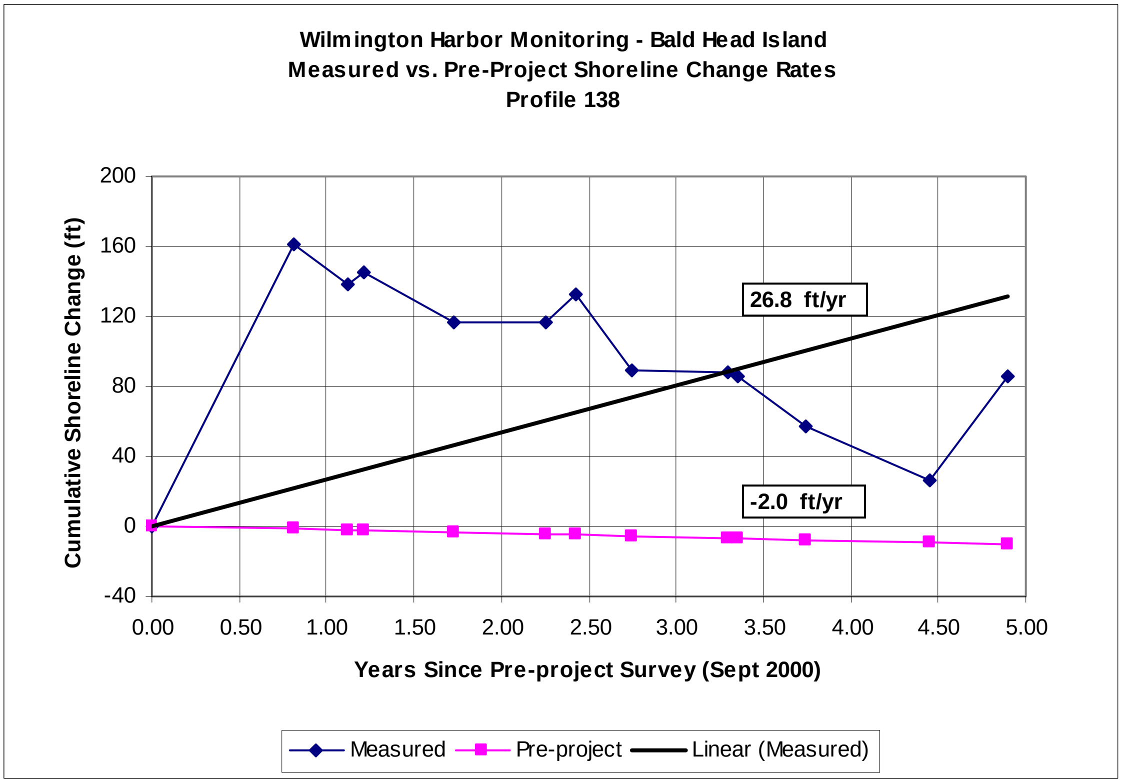

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 126
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
31.1 ft/yr
-2.0 ft/yr
Measured
Pre-project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

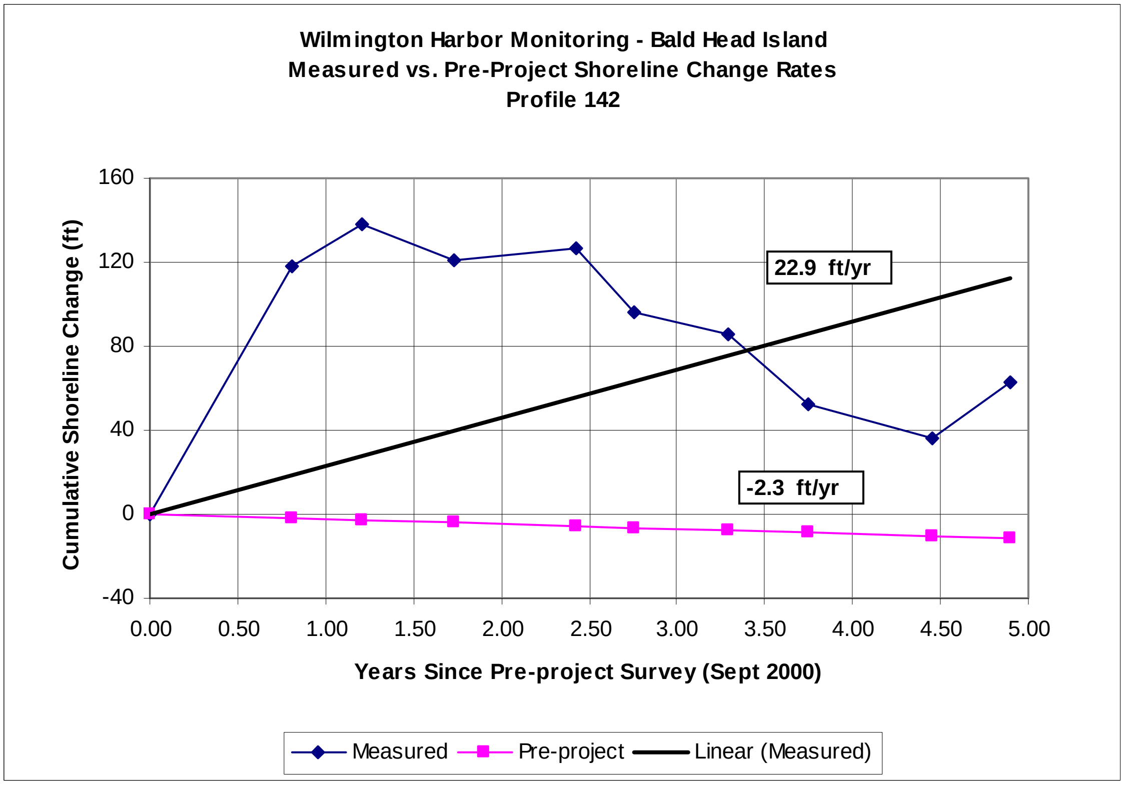


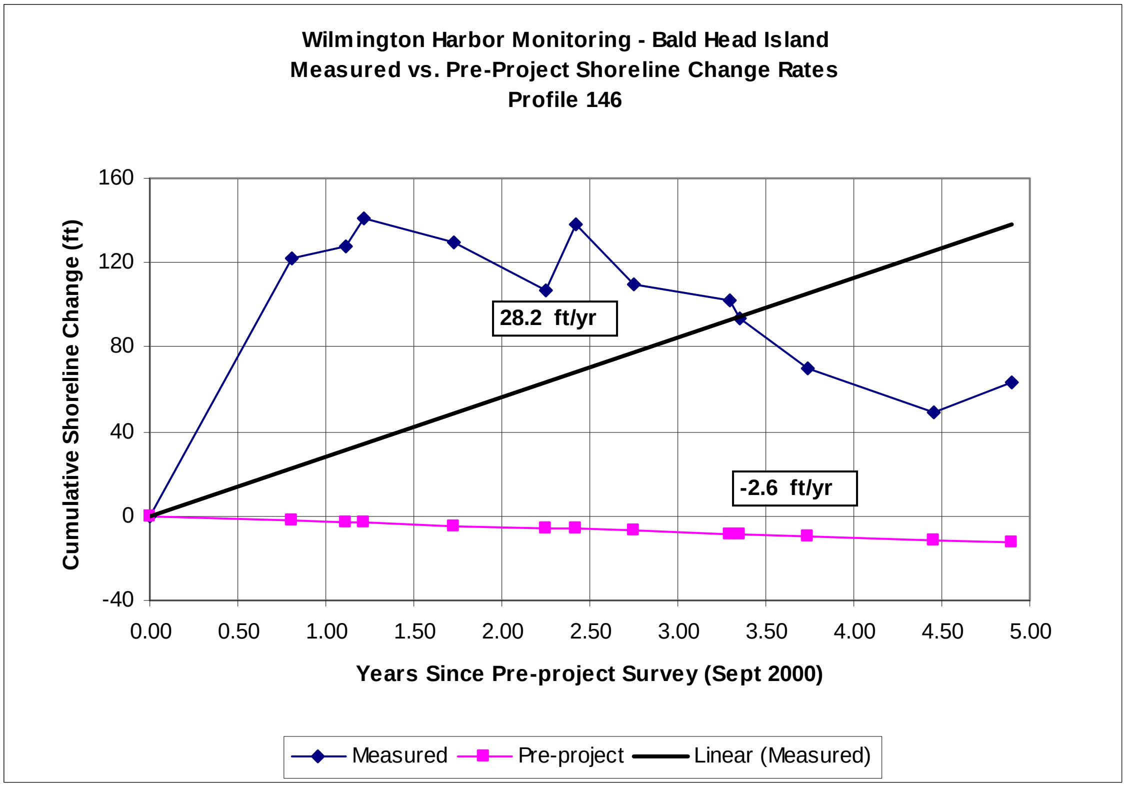
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
19.7 ft/yr
-2.1 ft/yr
Measured
Pre-project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



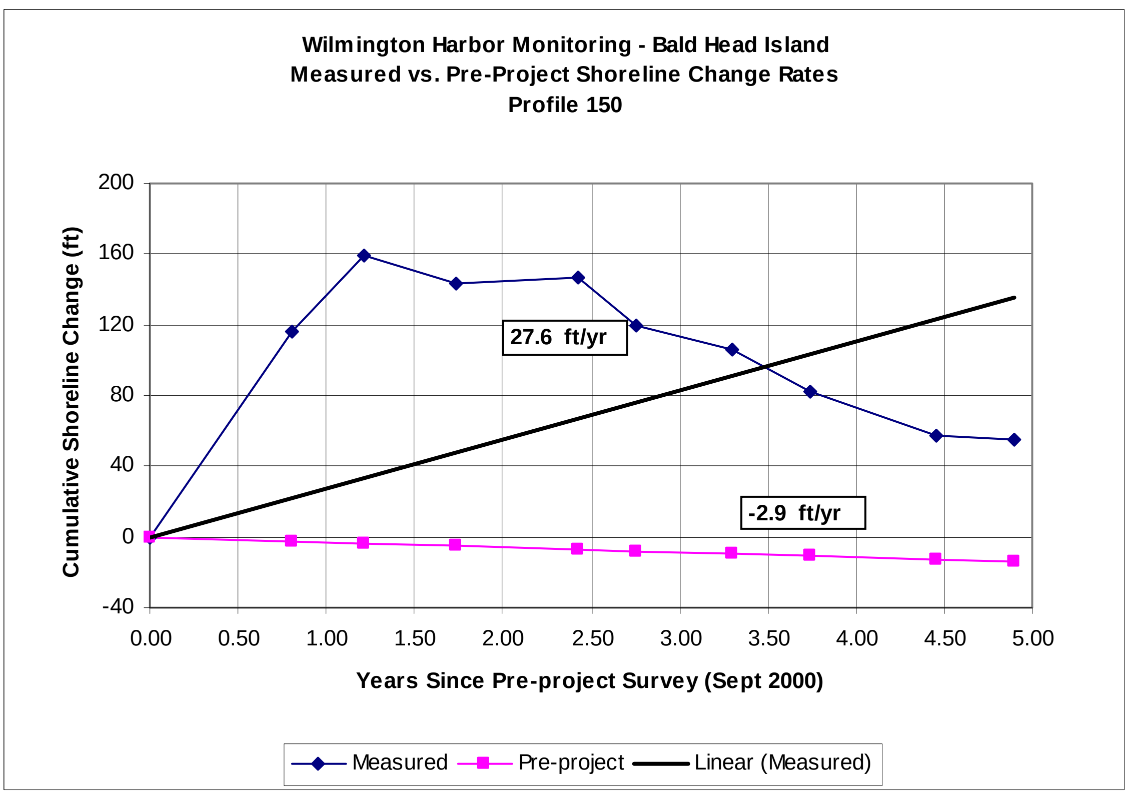
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 134
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
22.9 ft/yr
-2.0 ft/yr
Measured
Pre-project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


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

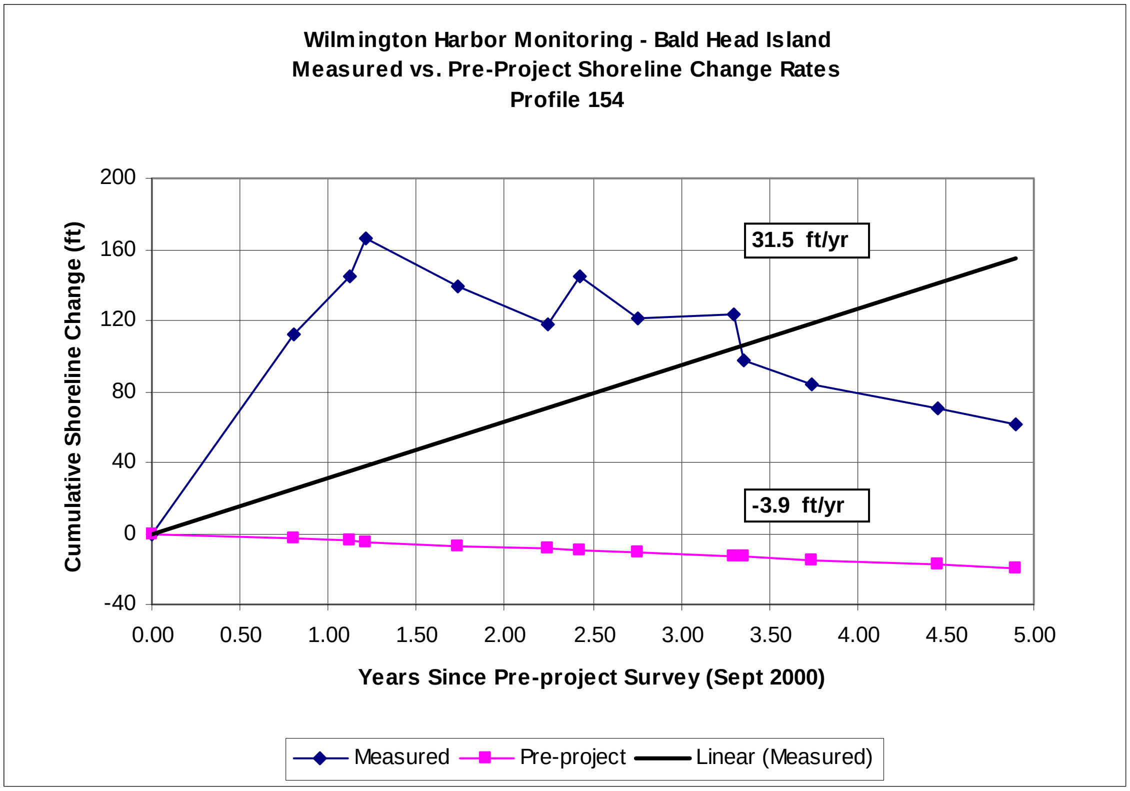

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 142
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
22.9 ft/yr
-2.3 ft/yr
Measured
Pre-project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

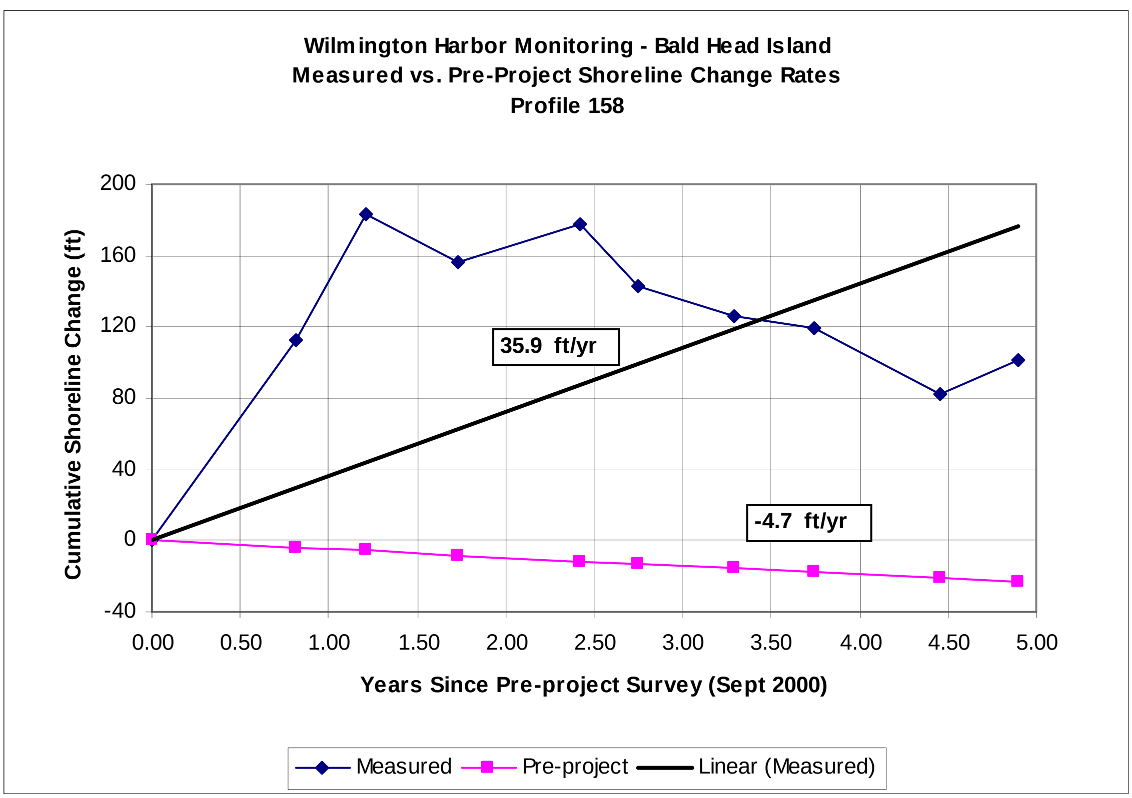


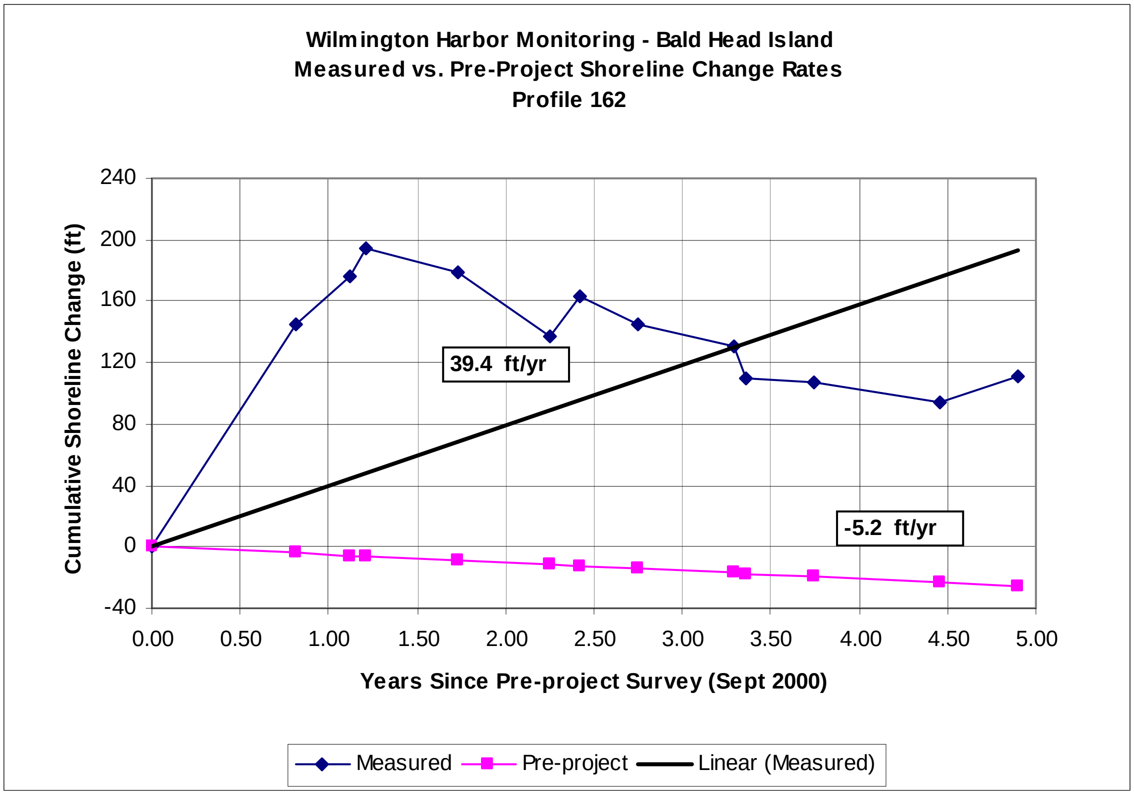
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 146
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
28.2 ft/yr
-2.6 ft/yr
Measured
Pre-project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



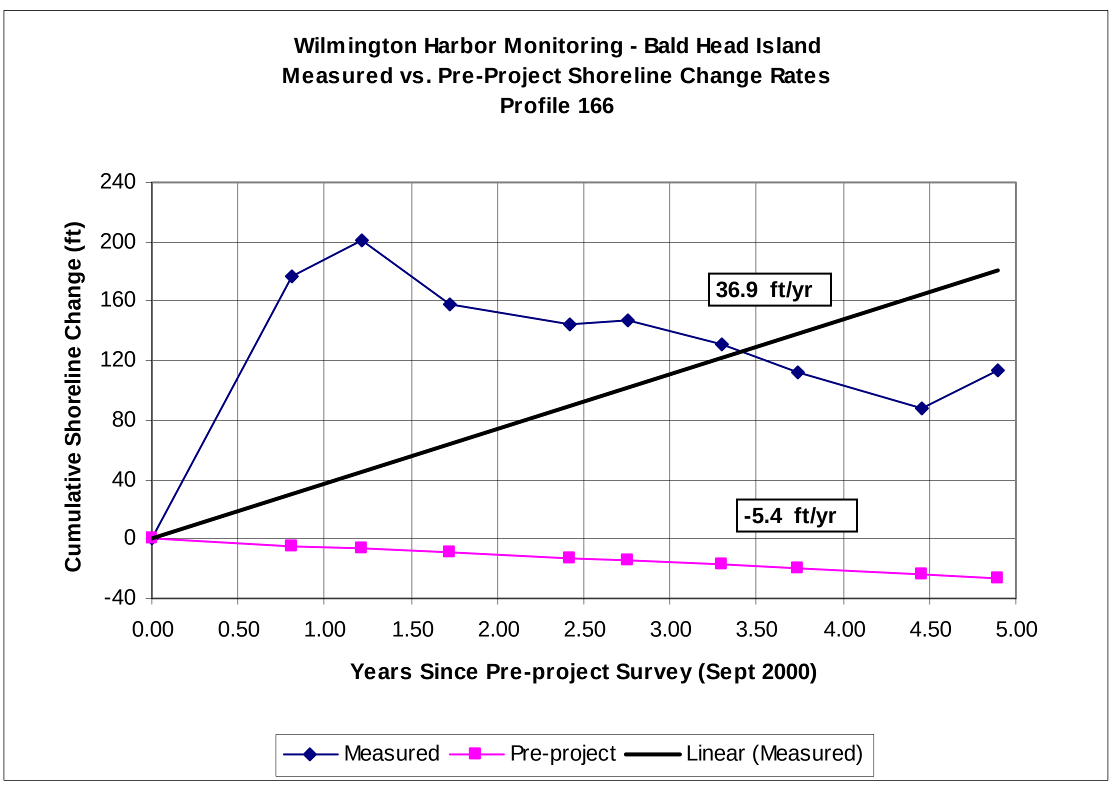
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
27.6 ft/yr
-2.9 ft/yr
Measured
Pre-project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


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

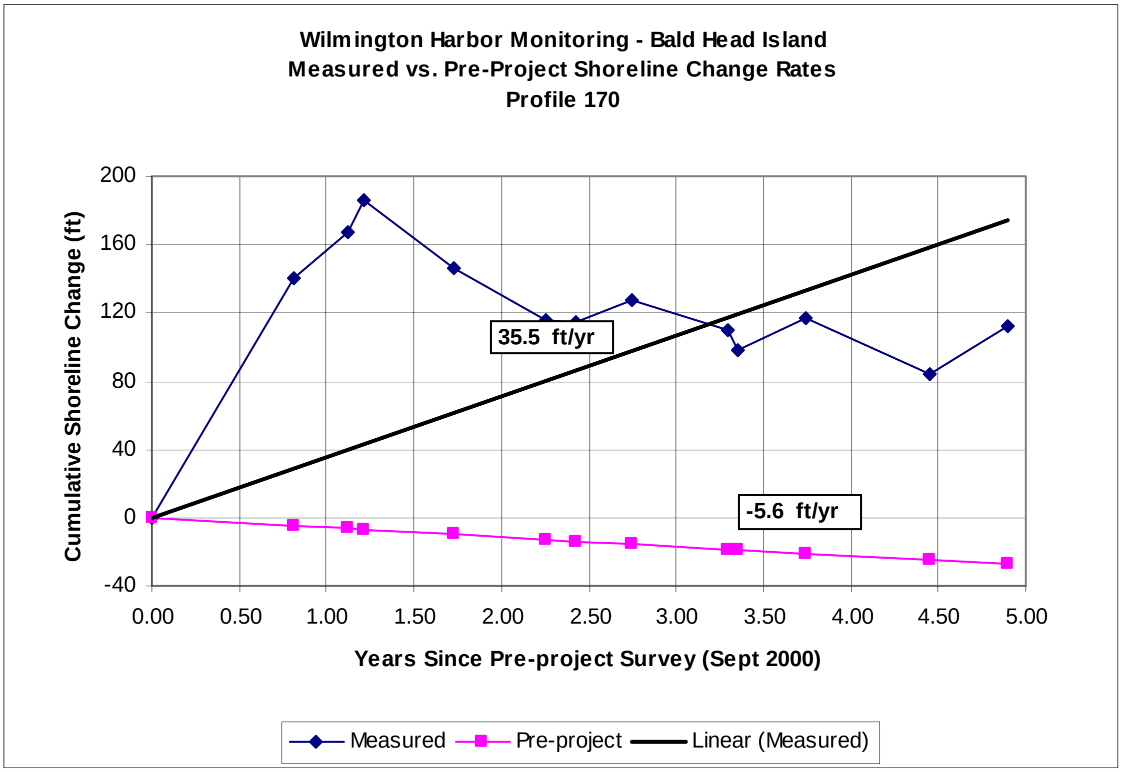

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 158
35.9 ft/yr
-4.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

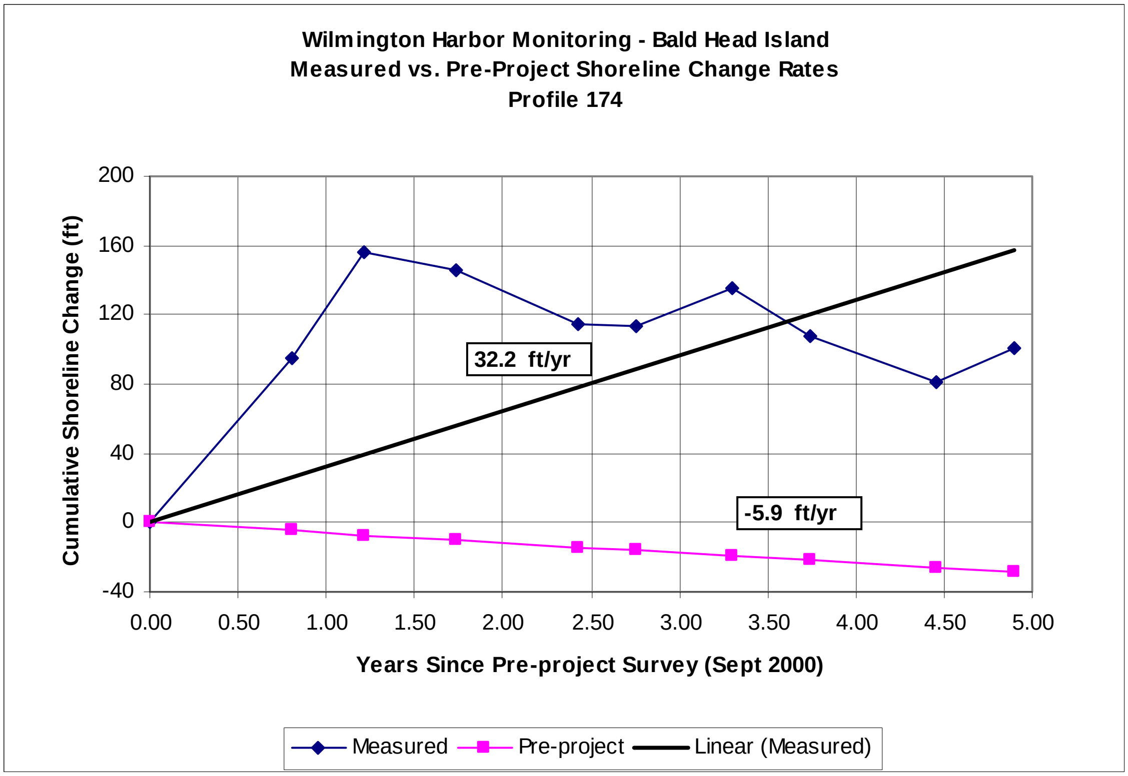


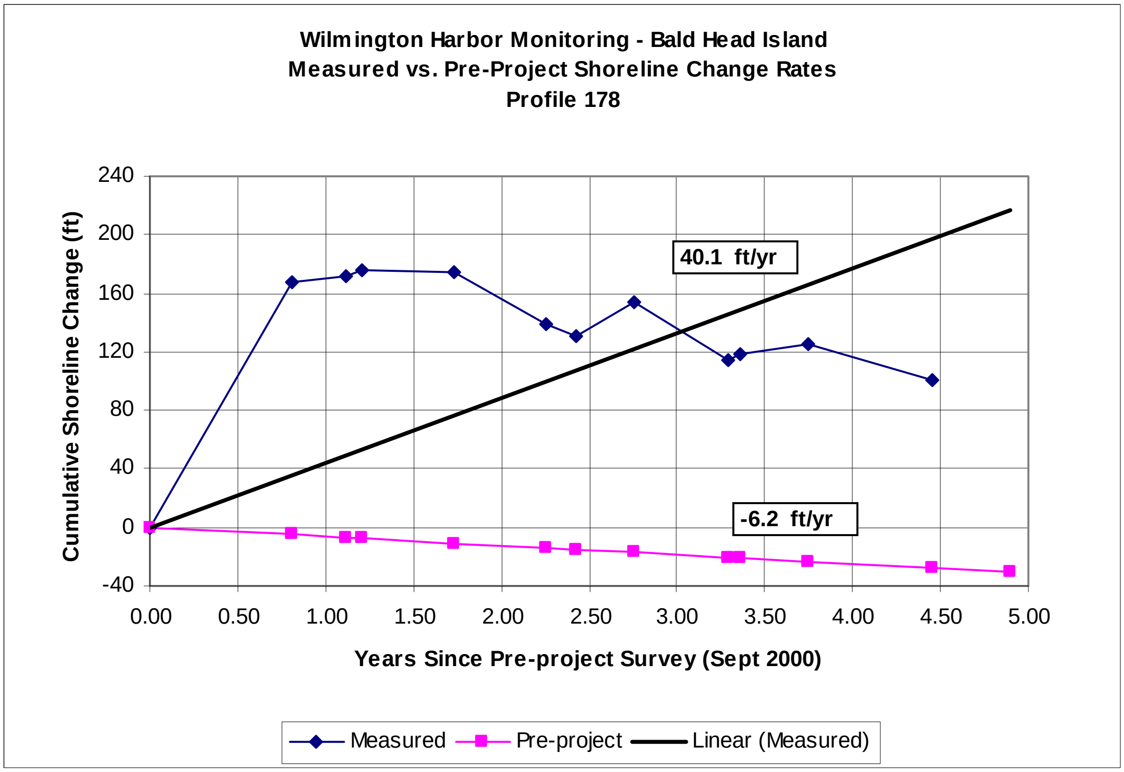
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 162
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
39.4 ft/yr
-5.2 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

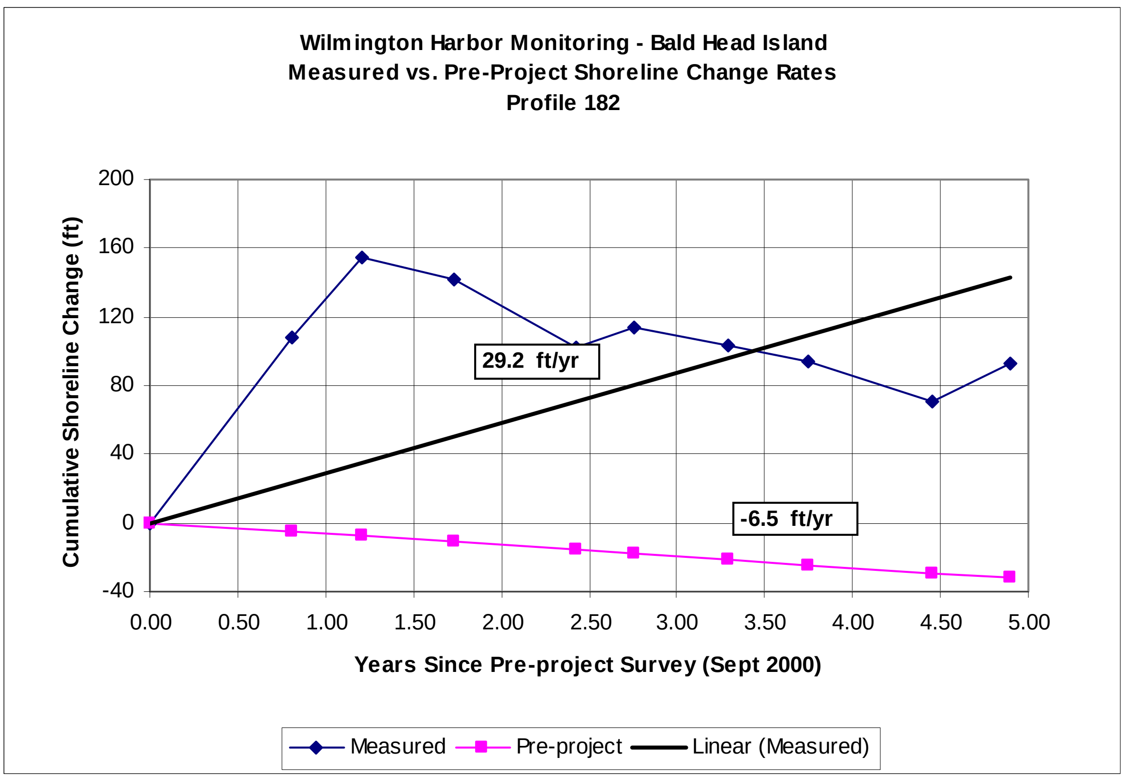


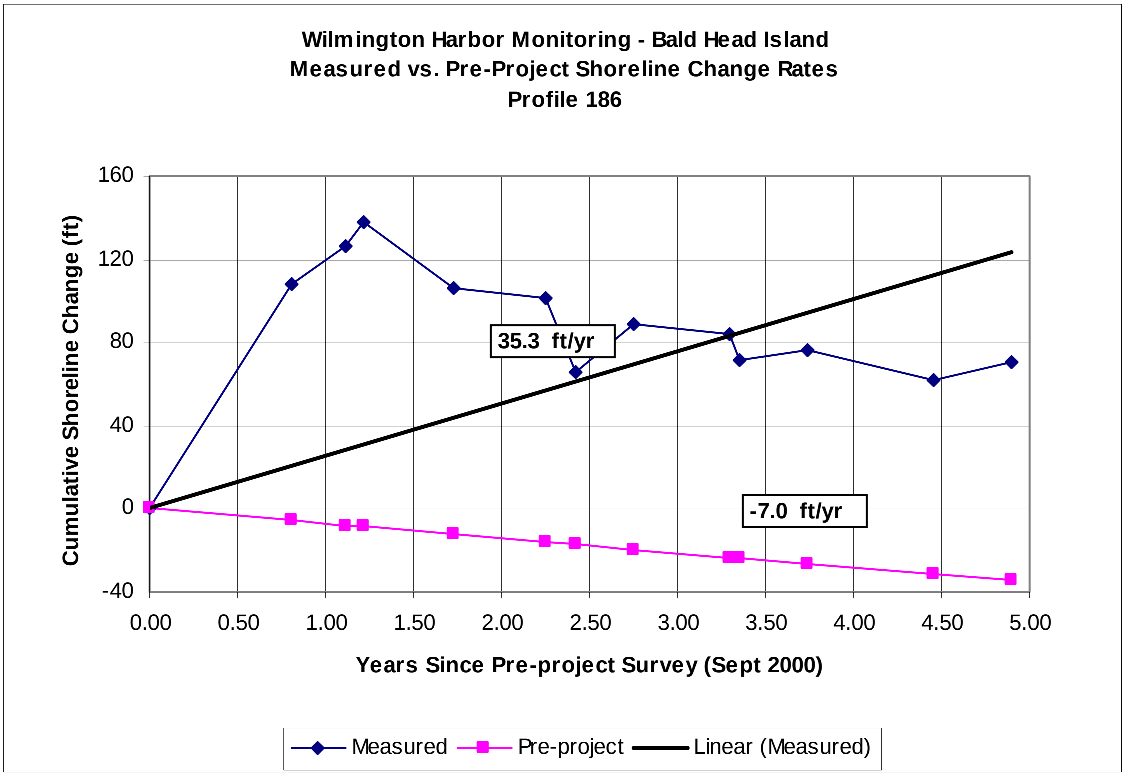
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 166
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
36.9 ft/yr
-5.4 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

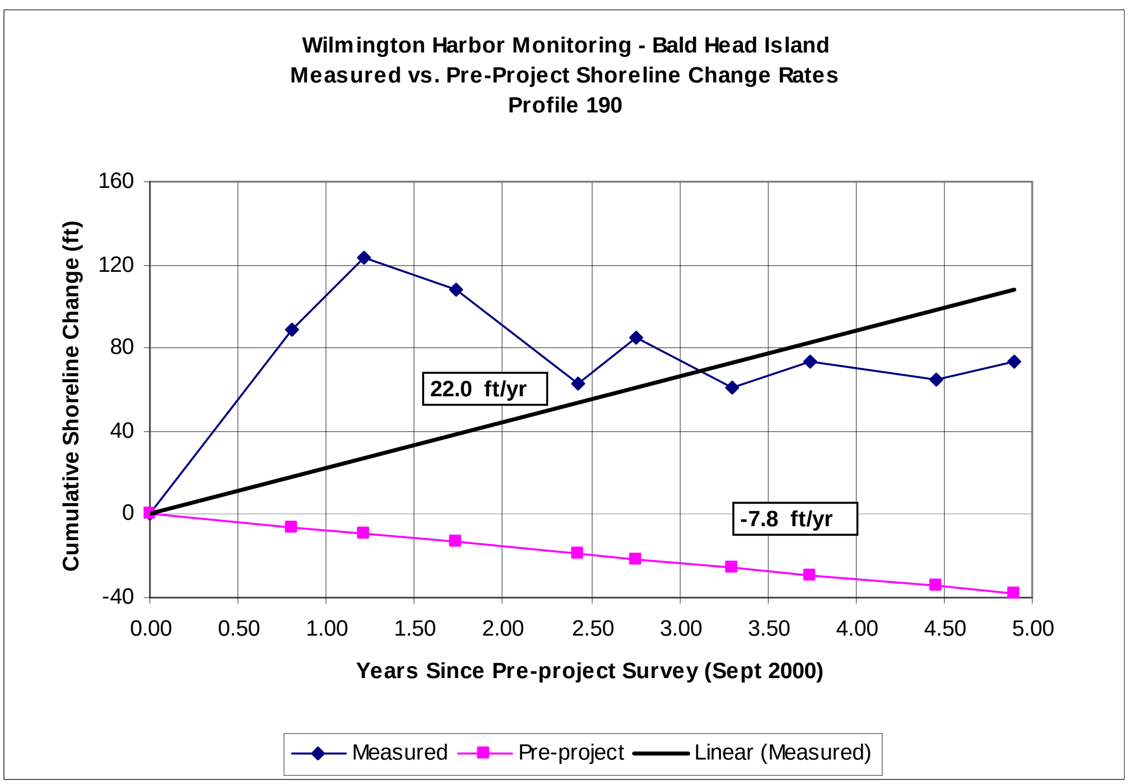

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
35.5 ft/yr
-5.6 ft/yr
Measured
Pre-project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

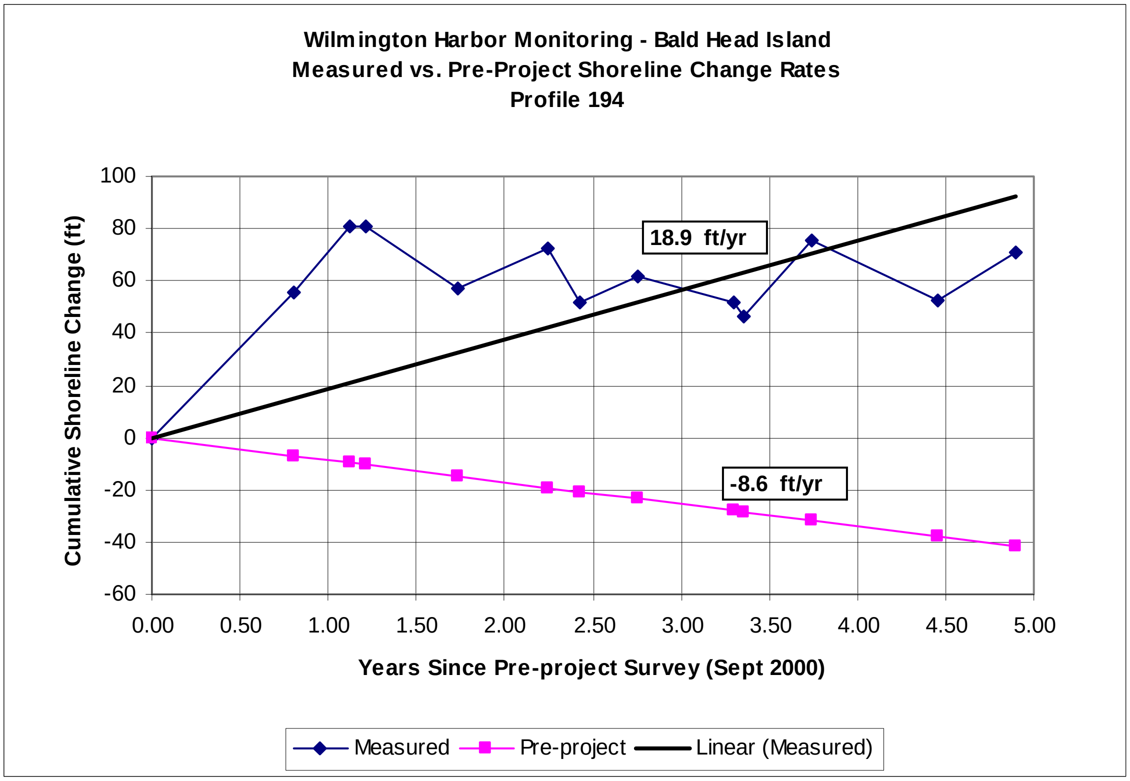

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 174
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
32.2 ft/yr
-5.9 ft/yr
Measured
Pre-project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

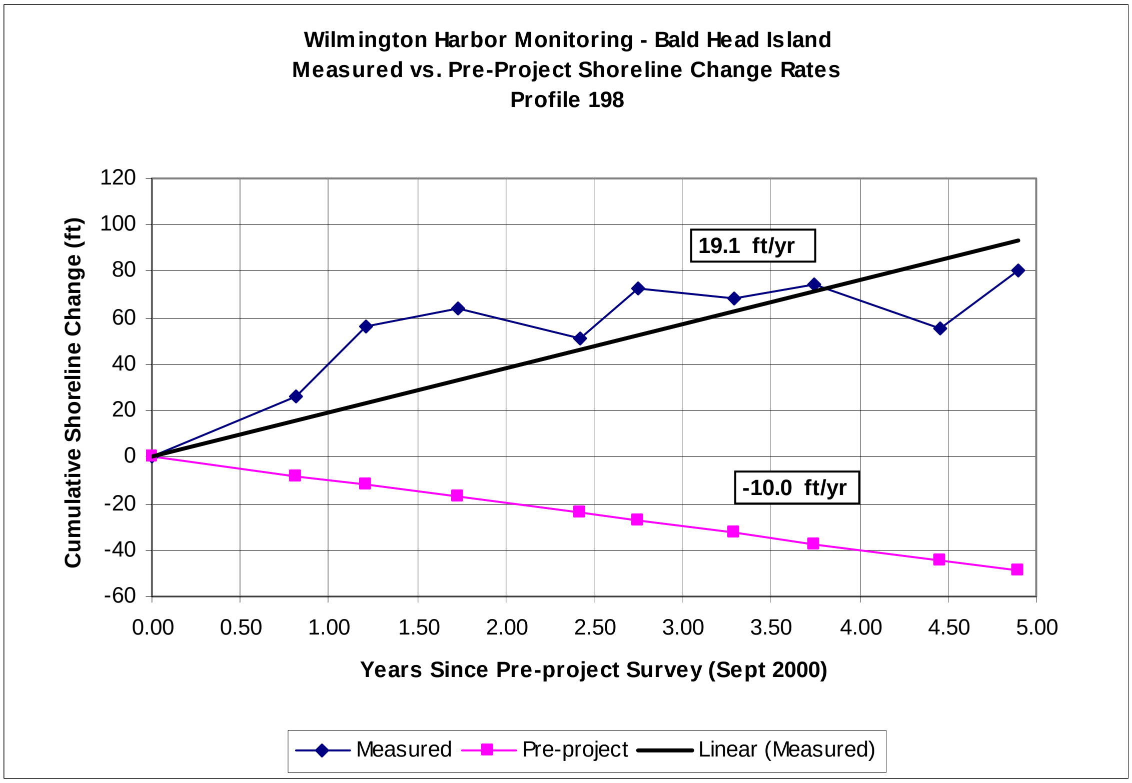

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 178
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
40.1 ft/yr
-6.2 ft/yr
Measured
Pre-project
Linear (Measured)

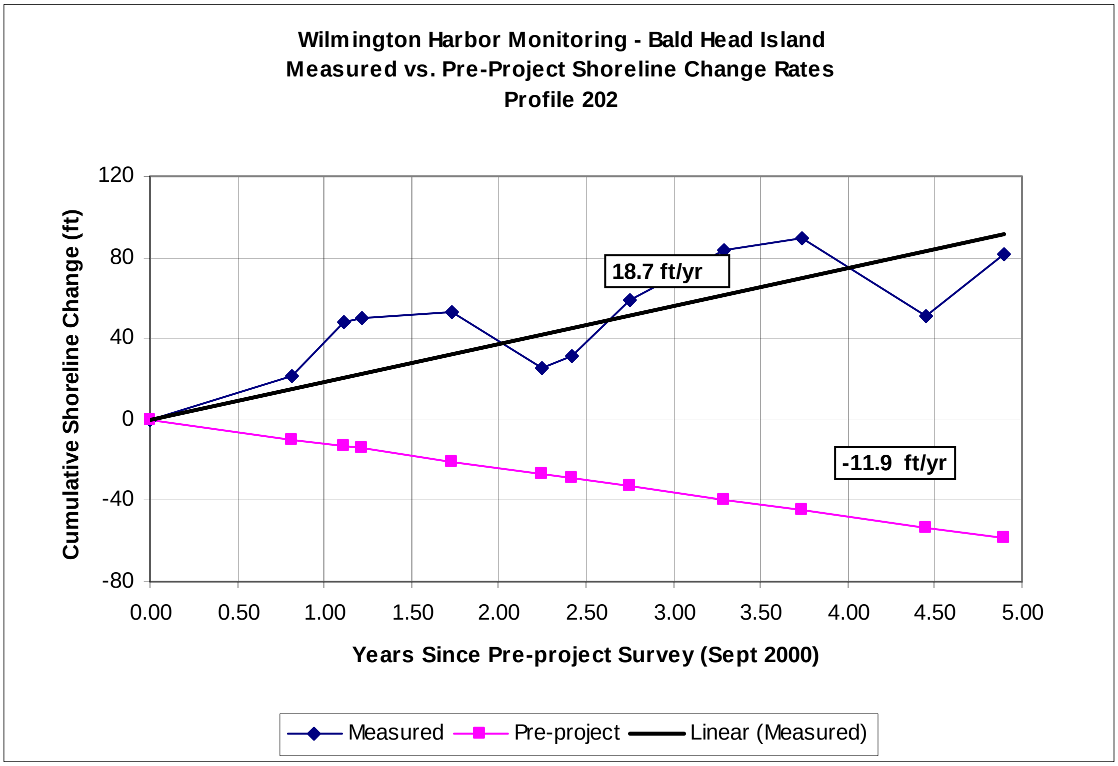

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 182
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
29.2 ft/yr
-6.5 ft/yr
Measured
Pre-project
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 186
Cumulative Shoreline Change (ft)
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
35.3 ft/yr
-7.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

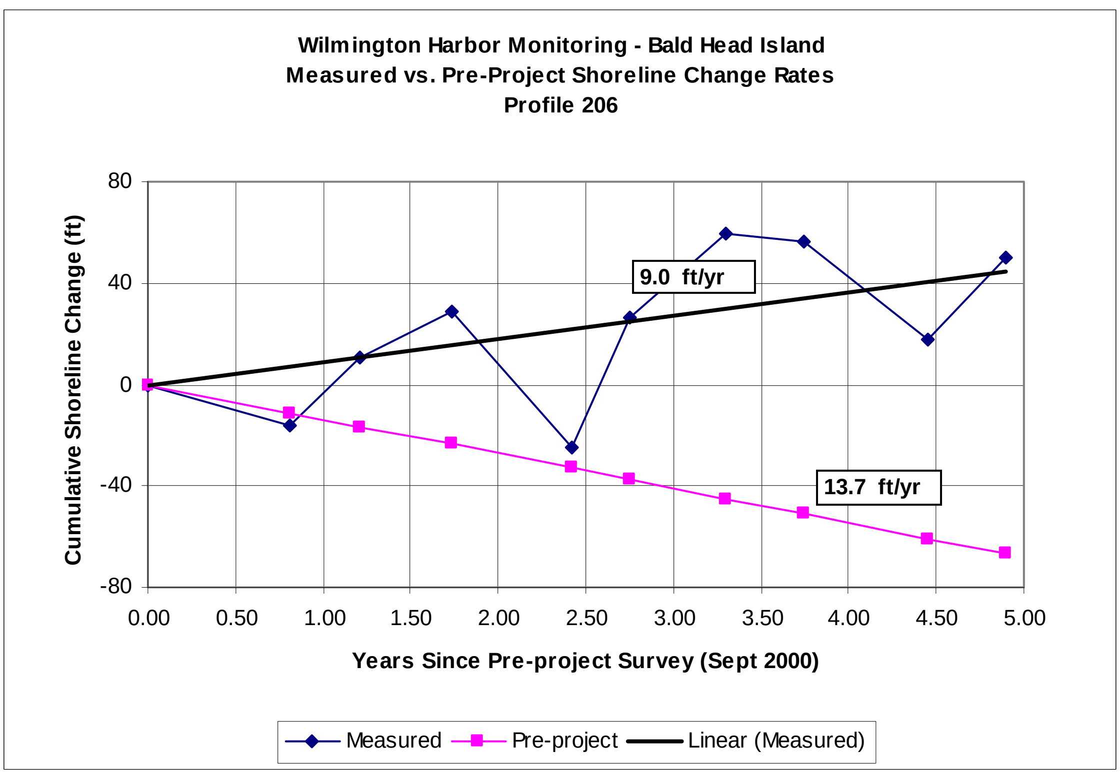

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
22.0 ft/yr
-7.8 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)


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

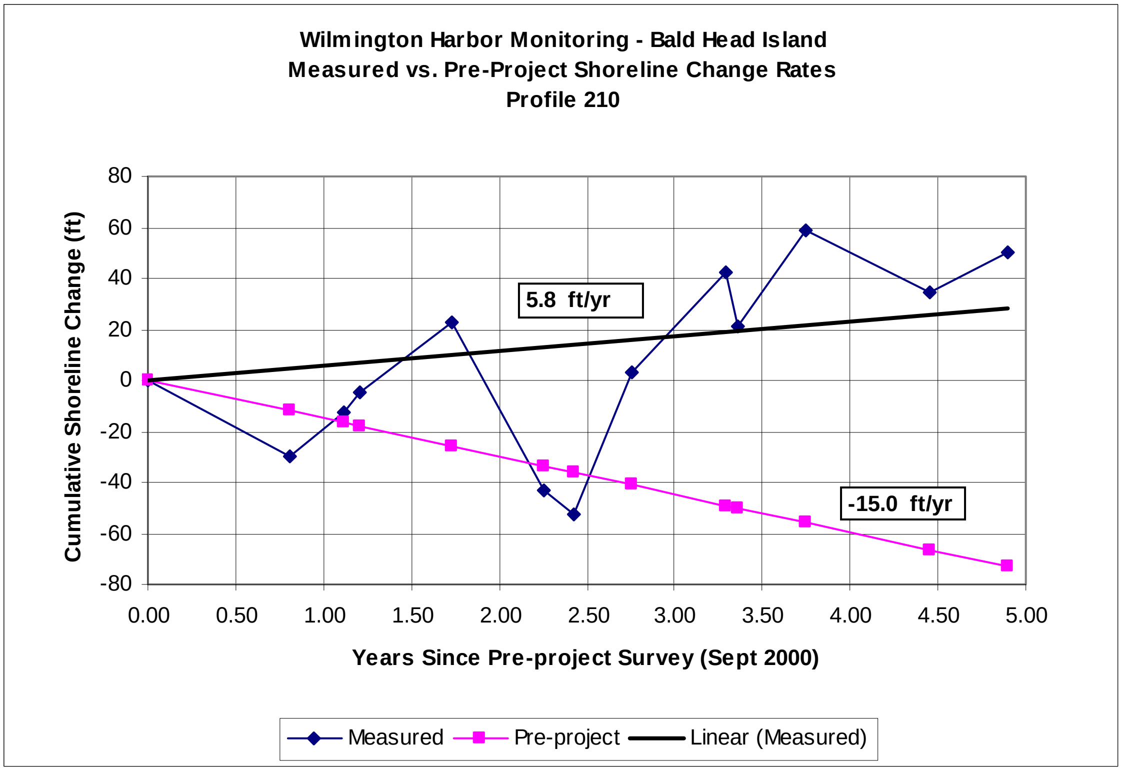

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 198
19.1 ft/yr
-10.0 ft/yr
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

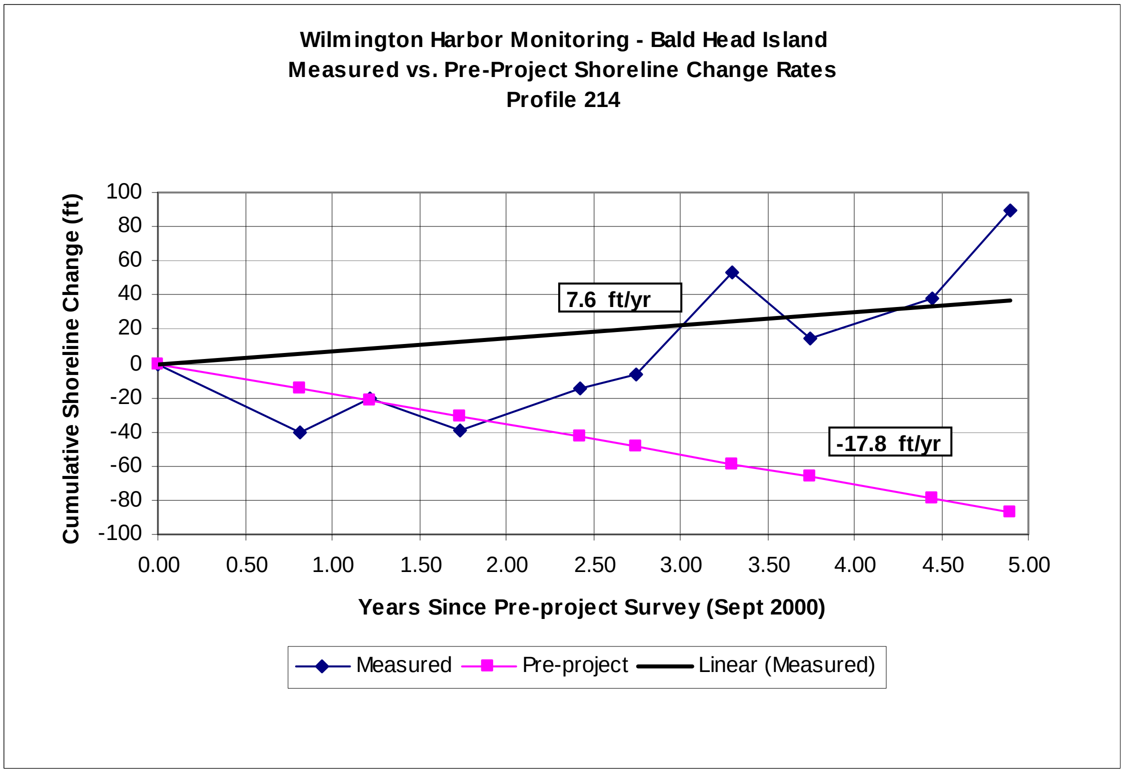


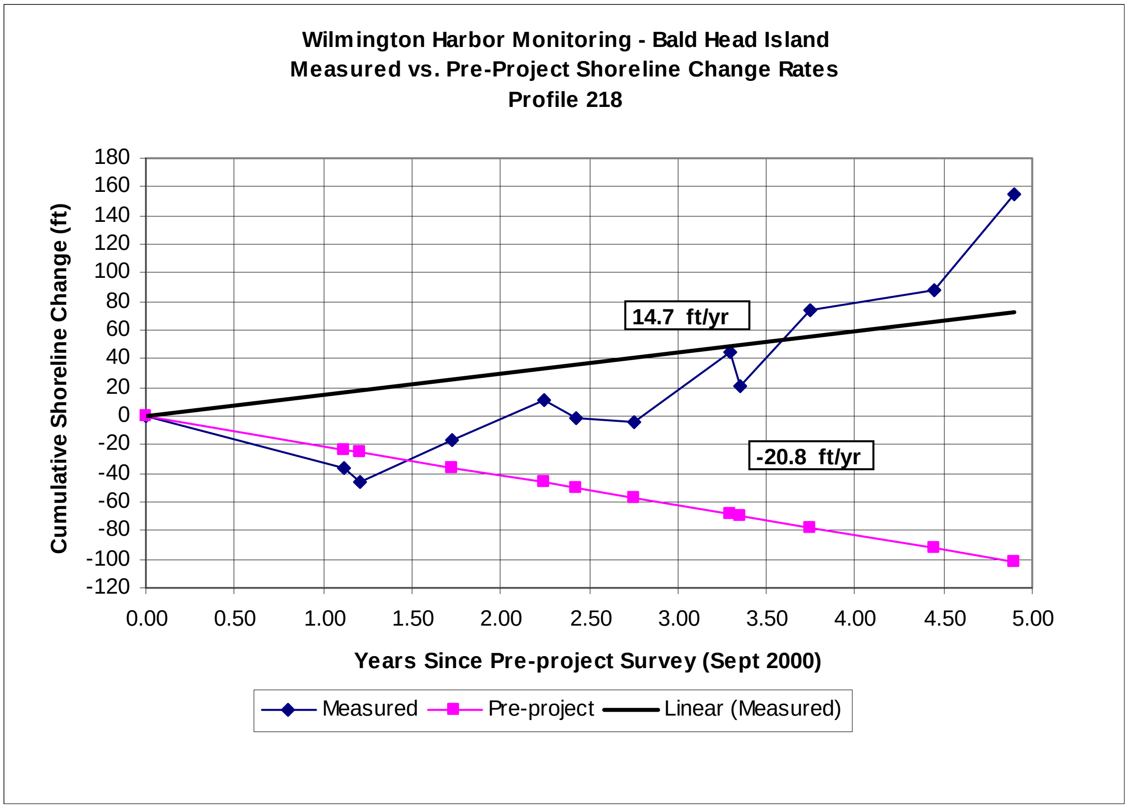
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 202
Cumulative Shoreline Change (ft)
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
18.7 ft/yr
-11.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)



Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 206
Cumulative Shoreline Change (ft)
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
9.0 ft/yr
13.7 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 210
Cumulative Shoreline Change (ft)
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
Years Since Pre-project Survey (Sept 2000)
5.8 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)
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
Years Since Pre-project Survey (Sept 2000)
7.6 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)
Years Since Pre-project Survey (Sept 2000)
14.7 ft/yr
-20.8 ft/yr
Measured
Pre-project
Linear (Measured)
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00