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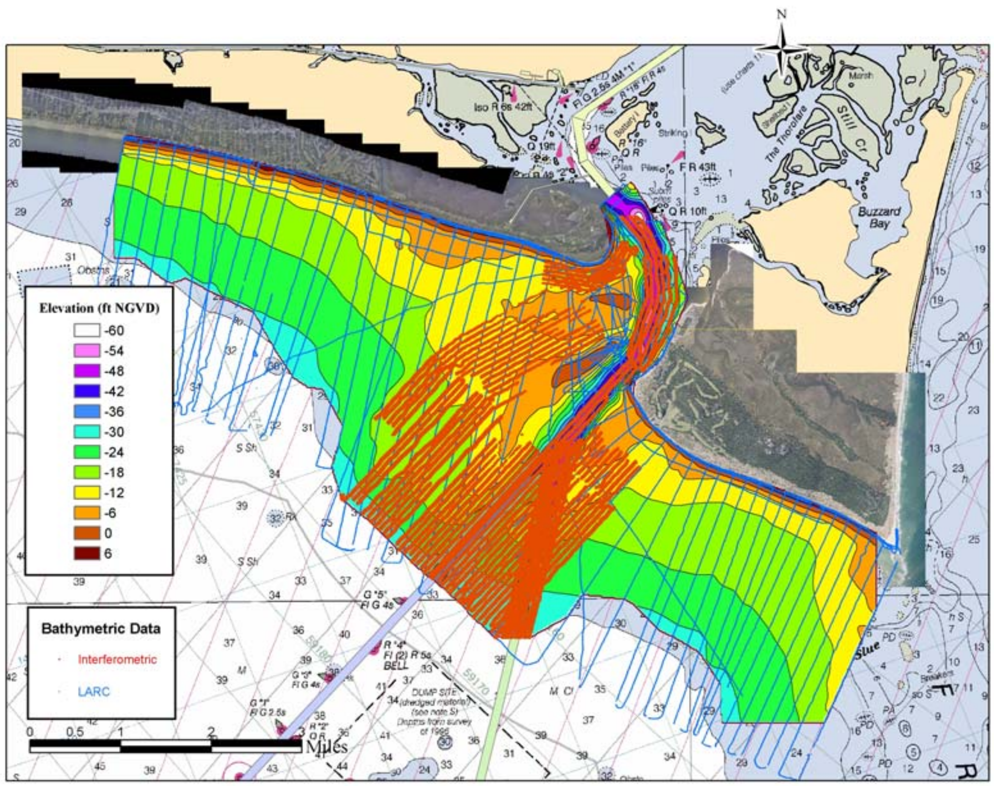
PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT
REPORT 2:
June 2003 – June 2004



FEBRUARY 2005

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EXECUTIVE SUMMARY

The mouth of the Cape Fear River and Wilmington Harbor entrance channel are located in eastern Brunswick County, near Cape Fear, about 25 miles south of Wilmington. Cape Fear is the southernmost of three large capes that predominate the North Carolina coastal plan-form. 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 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.

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 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 second in a series and serves to update the monitoring program with data collected between June 2003 and June 2004. The initial report published in July 2004 covered the period of August 2000 (pre-construction survey) through June 2003. 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 tidal 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 2003 to June 2004 have included: two beach profile surveys (December 2003-Jan 2004 and June 2004) , one offshore LARC survey (January 2004), one ebb shoal survey (January 2004), one entrance channel current measurement (January 2004), near continuous wave measurements (entire period) and two sets of aerial photography coverage (January 2004 and June 2004).

Results to Date

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

- Oak Island/Caswell Beach remains stable. Shoreline retreated an average of only 3.5 feet over the last year but is on the average 97 feet more seaward that it was at the start of the project four 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 significant erosion along the western third of South Beach while the remaining two-thirds remained accretionary over the 4-year monitoring period
- Erosion zone along South Beach has lost approximately 311,000 cy compared to the pre-project condition, however Bald Head Island has shown an overall net gain of 678,000 cy
- Comparing long-term shoreline change rates with those of the 4-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 4-year monitoring period show Bald Head Island is presently eroding less overall. However, the post-construction rates are significantly higher along the western third of South Beach
- High-sustained erosion has prompted the Village of Bald Head to install sand bags throughout the critically eroding reach. Also, deteriorated geo-textile groin field is being replaced in conjunction with the next beach disposal operation
- Spit growth along southwest corner of Bald Head Island has enlarged volumetrically to at least twice as large as previously observed
- Spit has increased in width comparable to the widening of opposite west channel bank
- Lack of noticeable overall change in ebb and nearshore bathymetry except deepening of flood margin channel along tip of Oak Island/Caswell Beach
- Similar flow regimes with current measurements taken before and after project channel dredging
- Lack of substantial decrease in current magnitude through the old 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 1 (June 2003) 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 2003 to June 2004) and for the entire period from August/September 2000 to June 2004.

For Oak Island/Caswell Beach, the shoreline change measured over the last year has been somewhat variable over the 6-mile monitoring area with an overall trend being one of retreat. When considering all profile lines, a minor average retreat of –3.5 feet has been measured since June 2003. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –50 to 150 feet), the average alongshore trend is somewhat greater at –7.6 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. 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 January 2004 than it was in 2000. Likewise, the shoreline position was 97 feet more seaward in June 2004, than it was about four 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 126,000 cubic yards was computed since the last report, between November 2001 and January 2004. This stable trend observed over the current period is typical of that measured for the entire 4-year monitoring period. As such, only minor changes have occurred following initial fill placement in 2001 associated with the project dredging. Specifically, by the end of the period, an excess of 1,052,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition with only minimal losses of the fill reported. The alongshore distribution of material basically follows the shoreline response where net gains are seen along most of the island.

Unlike Oak Island, shoreline change along Bald Head Island has shown areas of both significant erosion and accretion. Since the last reporting, most of the profile locations along Bald Head Island have shown shoreline retreat. This is true except for an area of spit growth near the southwest corner of the island, plus an accretionary region along the eastern end of Bald Head Island near Cape Fear. The largest area of shoreline retreat begins just east of the spit area bracketed by Profiles 43 and 66. Over this 2,300-foot reach shoreline recessions have reached a maximum of –120 feet since last June. In contrast, shoreline gains on the order of 50-ft to as much as 220 feet were measured along the stable eastern end of the island. Overall, the alongshore average shoreline changes measured over the entire monitoring area since June 2003 were –10.7 feet and –18.2 feet for the January 2004 and June 2004 surveys, respectively.

A similar pattern of shoreline change was measured along Bald Head Island over last 4-year period since the monitoring was initiated. This pattern includes the spit growth area with an adjacent erosion zone to its east, plus an extended area of accretion along the eastern portions of the island. Although the pattern is similar, the relative magnitudes of the shoreline changes are greater when considering the entire monitoring period. Specifically, the spit growth area is found to extend nearly 200 feet beyond its September 2000 position. Similarly, the shoreline recessions along the eroding portions of western South Beach reach a maximum of –250 feet and this eroded reach extends for about 7,000 linear feet (Profile 43 to Profile 110). These values of shoreline change indicate that the erosion has been severe in this area where the shoreline position is on the average 108 feet landward of its pre-project location. In contrast, beginning at about Profile 110, the shoreline response has been positive with accretion prevalent over the remaining eastern 11,000-feet of South Beach. Along this stable area, the average alongshore position of the present shoreline is 69 feet seaward of its

September 2000 location. In considering the monitoring area in total (Profiles 00 to Profile 218), the shoreline is presently on the average 3.4 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey (December 2002) of Report 1 to June 2004, most of Bald Head Island experienced a loss. The exceptions to the general loss were the continued growth of the spit between Profiles 32 and 45 and some volumetric gain near the eastern end of the island (east of Profile 162). The volume loss was greatest in the previously noted erosion zone just east of the spit.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, again three distinct reaches are evident including the area of spit growth (Profiles 32-45), an erosion zone (Profiles 47-114), and an area of stability (east of Profile 114). A fourth zone is also evident with the on/offshore volumes with relatively large losses measured along the last two profiles nearest to Cape Fear. Temporal trends are likewise evident with the spit area growing with the October 2001, December 2002, January 2004 and June 2004 surveys, (with a smaller net gain between the last two surveys). In contrast to the growth in the spit, the progressive loss is seen over time within the erosion area east of the spit. This trend is seen to reverse somewhat with the June 2004 survey. Even so, by the end of the current period, about a 6,900-foot-reach (between Profiles 45 & 114), is found to have overall negative volumetric changes with respect to the August 2000 survey. Over the remaining portions of South Beach (Profiles 114 to 194), covering about 8000 feet, positive volume changes are evident, with this reach having more sediment in place in June 2004 versus August 2000. Volume computations show that as of the June 2004 survey the spit area had gained approximately 311,200 cubic yards. This gain is offset by a comparable loss of 381,100 cubic yards within the critical erosion zone. The largest gain over the approximate four-year period is within eastern half of South Beach (Profiles 114-104) which remained positive with 819,500 cubic yards. In totaling all changes within the Bald Head Island monitoring area, a net gain of 677,800 was measured between the pre-project survey in August 2000 and the most current survey.

Shoreline change rates were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the NCDCM shoreline data covering a 62-year period. Although the monitoring period spans a relatively short time period of about 4 years, it is of interest to compare these trends with established long-term shoreline response for the area.

With respect to rates of shoreline change, initial 4-year period showed 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 +37 feet per year for the 4-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 shows that most of island is eroding less over the initial 4-year monitoring period. However, notwithstanding this overall positive response, the post-construction erosion rates are considerably greater along the western portions of South Beach. The measured rates within the erosion zone have increased both in magnitude and extent by comparing the rates previously reported through June 2003 and the current period through June 2004. 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. With the rates updated through the current period, the average is now 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 has also expanded eastward from Profile 47 thru 78 in 2003 and Profile 47 thru 97 in 2004. This represents an alongshore increase of about 1,900 feet, from 3,100 feet to 5,000 feet. 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) and plus 49 feet per year (thru June 2004). 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. These are in sharp contrast to the erosion indicated along this entire area by the pre-construction rates.

An additional analysis was done to document the response of the beach disposal placed along Bald Head Island in 2001 associated with the initial project construction. In this regard, erosion rates were computed with respect to the post fill survey through the current period. Normally post-fill erosion rates are higher as the widened berm is reworked by waves and currents over an initial adjustment period. The results indicate a similar alongshore erosion pattern as found with the overall rates computed over the entire monitoring period, although the rates are considerably higher. Specifically, the overall post-fill erosion pattern consists of 1) erosion rates exceeding a 100 feet a year along the western portions of South Beach near the inlet, 2) a transition reach where erosion exceeds 50 feet a year, and 3) a gradually diminishing erosion rate along the eastern portions of South Beach. These rates have remained generally the same during 2001 to 2003 and the 2001 to 2004 post fill periods.

The high-sustained erosion has prompted the Village of Bald Head to install sand bags to protect the beachfront road throughout the critically eroding reach. This installation is a rehabilitation of an earlier sand bag structure placed in the mid-1990's in response to erosion problems that have been prevalent over the last several decades in this area. Further, a geotextile groin field that was placed by the village in conjunction with the 1996 beach fill, but deteriorated within about four years, is also being replaced in an attempt to more effectively retain the beach within this problem area. The groin field is being rebuilt in conjunction with the present (2004-05) beach disposal/dredging operation. The combination of beach fill and geo-tube groins is expected to moderate the relatively high erosion experienced along the western portion of South Beach.

At Bald Head spit, navigation channel surveys show the spit has enlarged volumetrically to at least twice as large as previously observed. Several contributing factors have been identified related to the observed spit growth. One factor is the large volume of sediment introduced into the system along South Beach near the inlet during the initial beach fill disposal operation. Secondly, the sediment increase in the spit correlates with the deterioration of the groin field and subsequent loss of beach due to the ineffectiveness of the groins. And thirdly, the growth appears to coincide with the relocation of the west channel bank opposite the spit area. As such the growth of the spit into Bald Head Shoal channel has increased by the same distance as the west channel bank has been offset. Further, movement of the spit has been found to extend off of Bald Head Island and then in a seaward direction along the eastern side of the channel. It appears that contraction of the ebb tide current between the spit and the west side of the channel is one of the factors controlling the size of the spit.

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 finding of particular interest is the lack of change in the area of the shoal between the old and new channels just seaward of their intersection. This portion of the shoal is expected to be the most sensitive to changes because of its location between the channels where the magnitude of mean currents around the distal end of the ebb tidal delta are the highest.

Current measurements were taken over a 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 previous results reported in Monitoring Report #1, 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.

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 beach disposal operation of Clean Sweep II was completed in January 2005. With the timing of Clean Sweep II coming approximately two years after completion of the initial construction, this is considered the first maintenance dredging of the new channel. 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 a plan for the present disposal operation. Approximately 1,435,000 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. Future monitoring will assess the effectiveness of this work in comparison with prior beach fill performance.

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 2

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

PHYSICAL MONITORING
WILMINGTON HARBOR NAVIGATION PROJECT

REPORT 2

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 second in a series of monitoring reports that focuses on the navigation improvements in the immediate vicinity of the Cape Fear ocean entrance channel. Monitoring Report 1 was published in August 2004 and covered the first three years of monitoring (USACE 2004). 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

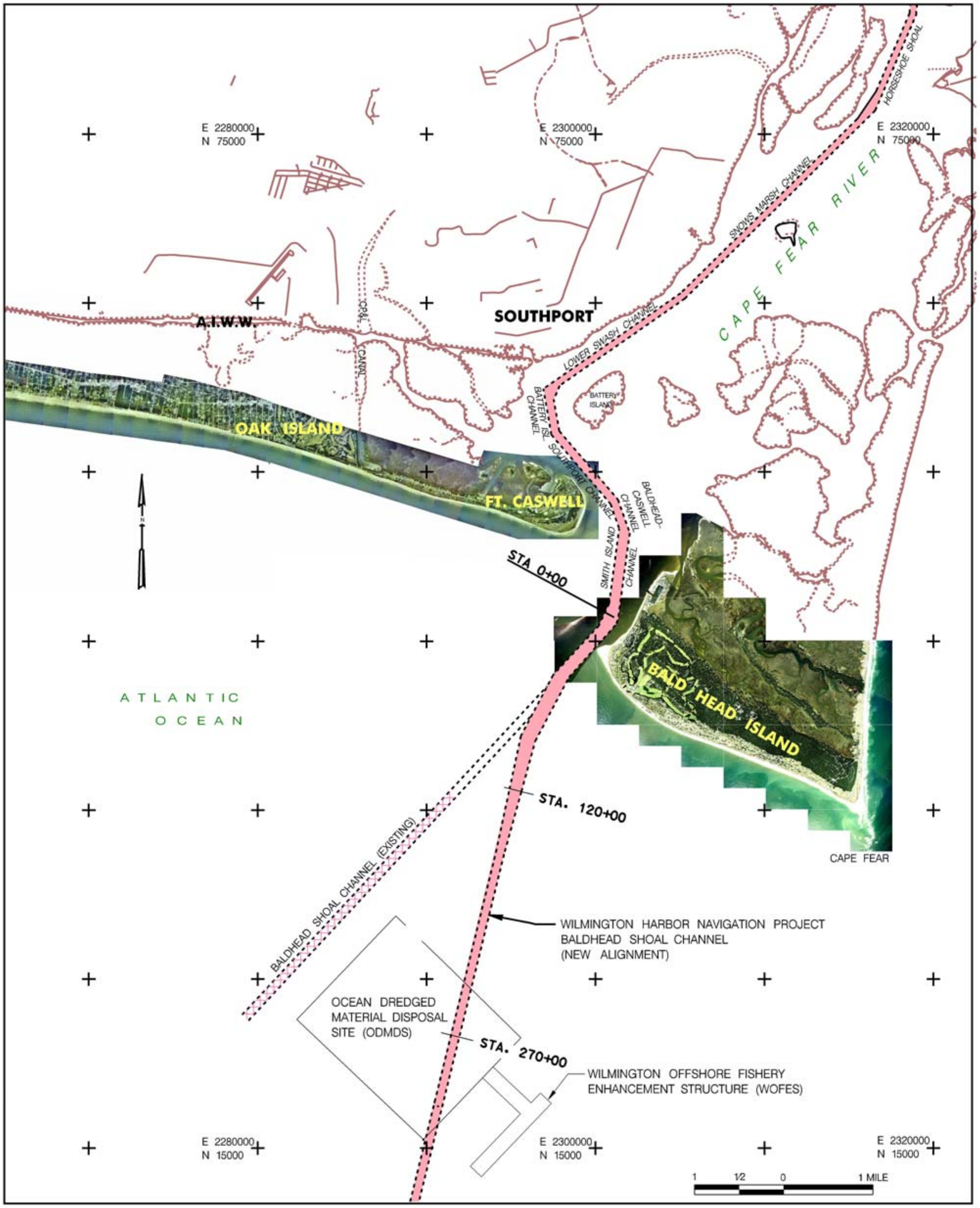


Figure 1.1 Project Location Map

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 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.

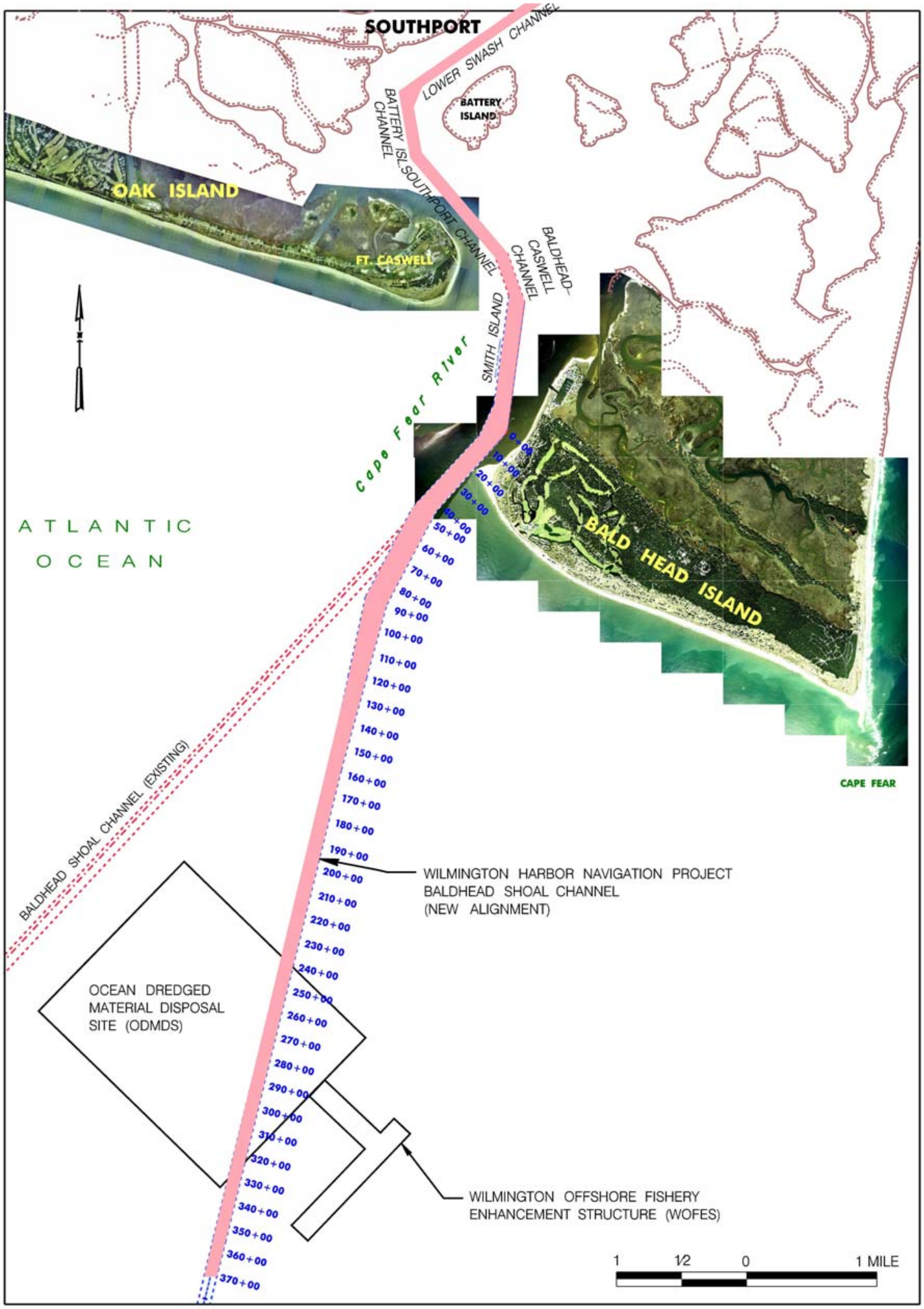


Figure 1.2 Realignment of the Federal Navigation Channel at the Cape Fear River Entrance

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	APPROX BL STA	PLACEMENT LIMITS NORTHING (ft, NAD83)	EASTING (ft, NAD83)	PLACEMENT DATES START mm/dd/yyyy	STOP mm/dd/yyyy	BEACH VOLUME (INPLACE) (cy)	DREDGE
BALD HEAD ISLAND	41+60	43,692.25	2,300,542.01	2/23/2001		1,849,000	*Stuyvesant & Merridian*
	205+50	35,750.21	2,314,236.42		7/4/2001		
OAK ISLAND EAST (CASWELL)	60+00	52,126.62	2,295,138.57	7/5/2001		133,200	*Merridian*
	80+00	52,847.44	2,292,954.85				
OAK ISLAND EAST	121+00	53,711.05	2,289,255.43			1,048,600	*Merridian*
	294+00	58,418.34	2,272,322.77		8/12/2001		
OAK ISLAND WEST	415+00	60,332.24	2,260,537.66	8/13/2001		1,269,800	*Merridian*
	665+50	59,778.68	2,235,486.44		4/25/2002		*Eagle*
HOLDEN BEACH	84+00	60,092.96	2,222,254.95	12/9/2001		501,400	*Eagle*
	195+00	58,820.26	2,211,433.72		2/20/2002		
(FIRST MAINTENANCE CYCLE)							
BALD HEAD ISLAND	46+00	43,836.00	2,300,813.68	11/12/2004		1,217,500 (prelim)	*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.

Sand Management Plan. A sand management plan developed for the Wilmington Harbor 96 Act project (USACE 2000) addressed the disposal of beach quality sand during both the construction and maintenance phases of the project. The future maintenance includes the periodic disposal of littoral material removed from the ocean entrance channel on the beaches adjacent to the Cape Fear River Entrance. The goal of the sand management plan is to make the best use of littoral sediments during maintenance of the project and return beach compatible material back to the adjacent beaches. This is in keeping with the state of

North Carolina policy to insure that beach quality sand is not removed from the active beach system.

The results of wave transformation/sediment transport analysis conducted by the U.S. Army Corps of Engineers Coastal and Hydraulics Lab (Thompson, Lin, & Jones 1999) for the Wilmington District found that the distribution of sediment transport at the Cape Fear entrance was such that two-thirds of the material comes from Bald Head Island and one-third is derived from Oak Island/Caswell Beach. In order to maintain the sediment balance on both islands, littoral material removed from the entrance channel will be placed back on the beach from whence it came in the same distribution. Accordingly, two out of every three cubic yards of littoral shoal material removed from the entrance channel will be placed back on Bald Head Island and the remaining cubic yard 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. The survey data are reported with respect to the National Geodetic Vertical Datum (NGVD) 1929 and North American Datum (NAD) 1983 horizontal datum.

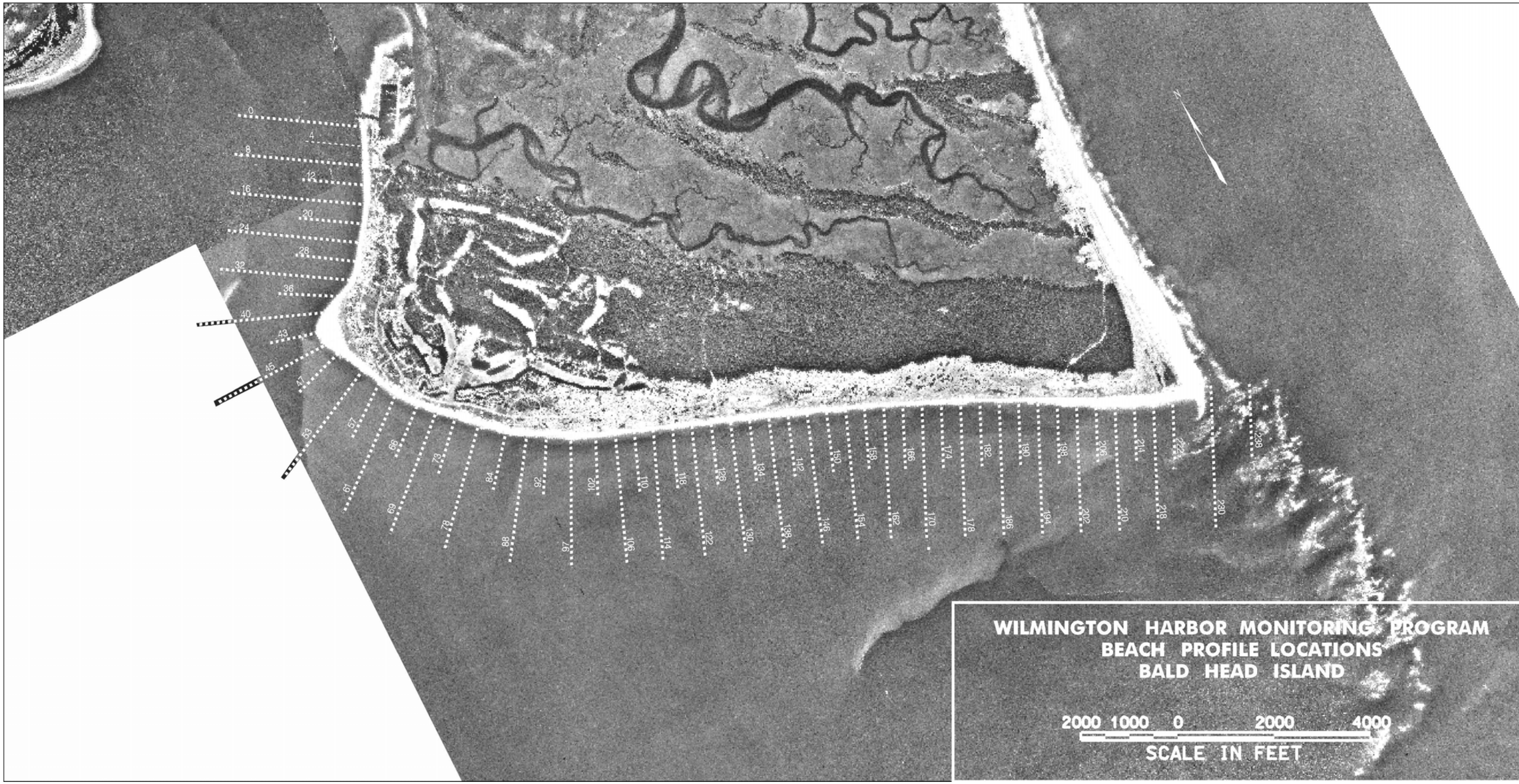


Figure 1.3 Bald Head Island Beach Profile Locations

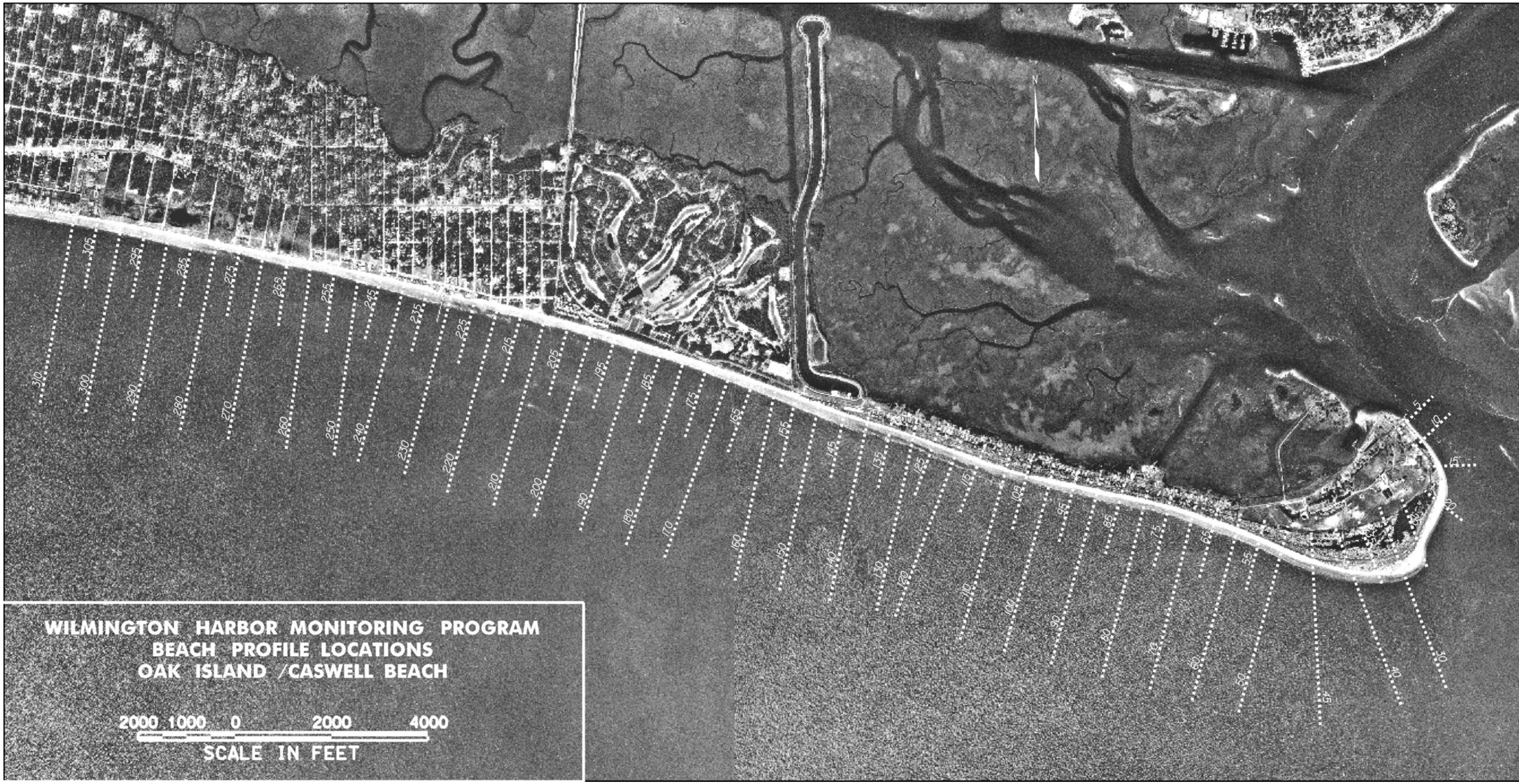


Figure 1.4 Oak Island/Caswell Beach Profile Locations

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. This gauge is not presently being utilized. 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 Carolina state

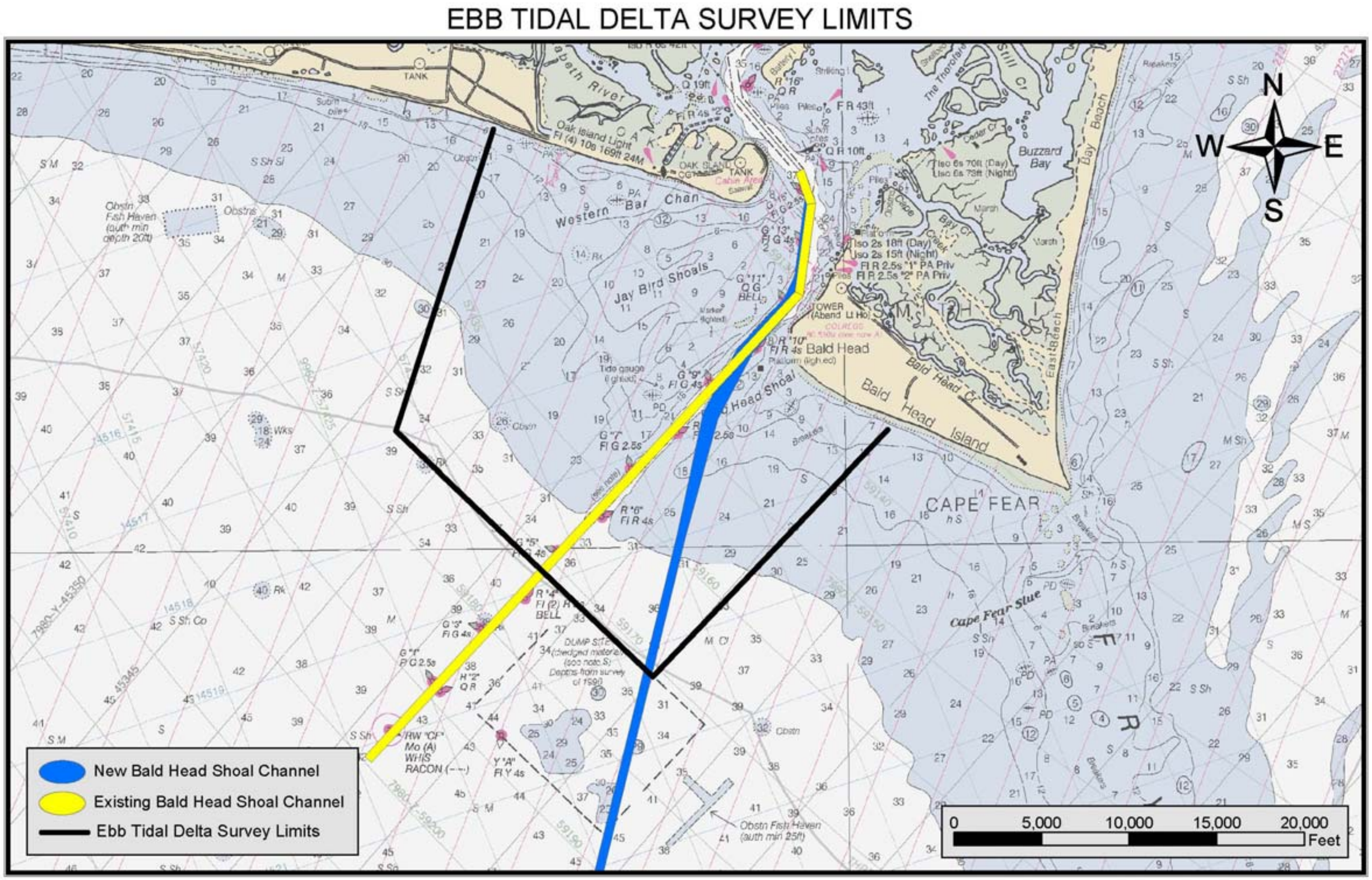


Figure 1.6 Entrance Channel and Ebb Tide Delta Survey Coverage

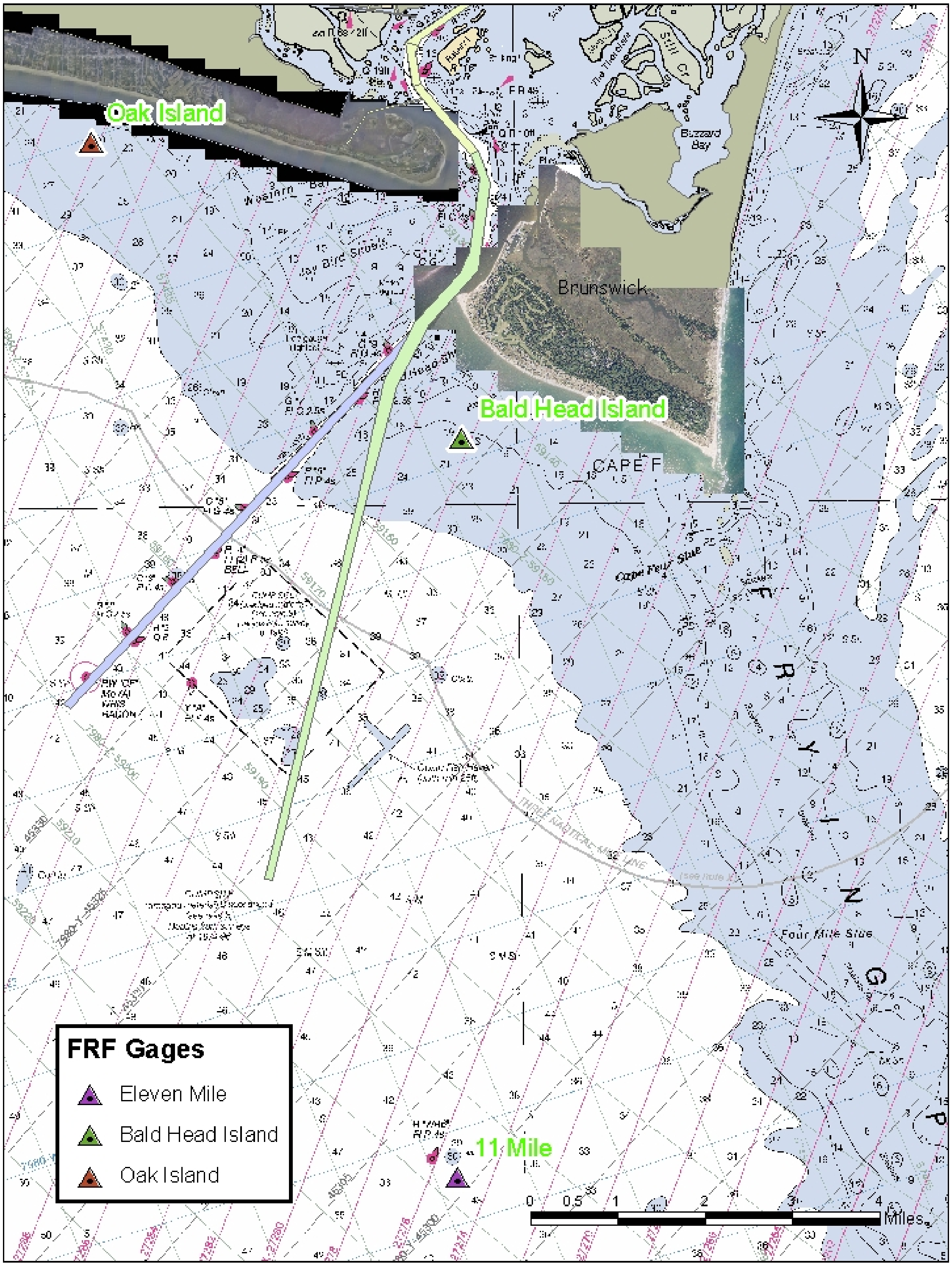


Figure 1.7 Wave and Current Gauge Locations

Ship-Board Current Profile Track Lines

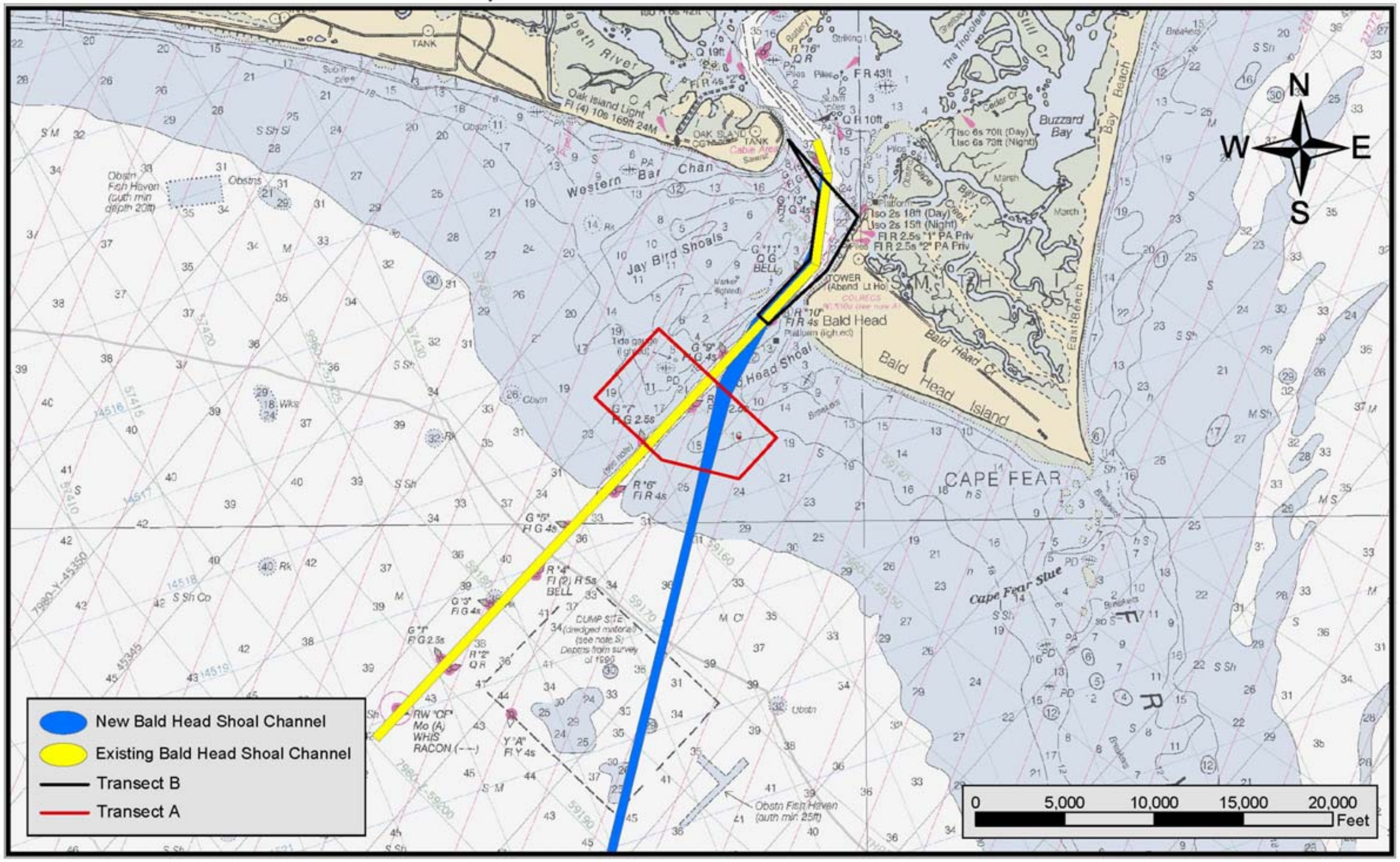


Figure 1.8 Shipboard Current Profile Locations

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. With the completion of this initial report, subsequent 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 report will 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. This report will also be 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.

Surveys from September 1996 to December 2002 were taken as part of a monitoring program implemented by the Village of Bald Head Island and were provided to the District by Olsen Associates, Inc. Table 1.2 is a listing of the dates and coverage for the Village of Bald Head Island monitoring surveys.

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

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 June 2004 beach survey and therefore spans an initial period of nearly four years. To date there have been seven onshore beach profile surveys (Aug-Sep 2000, Nov-Dec2001, June 2002, Jan-Feb 2003, June 2003, Dec2003-Jan 2004, and June 2004), five offshore beach profile surveys (Aug 2000, Oct-Nov-2001, Nov-Dec 2002, Jan 2004, and June 2004) and four surveys of the ebb tide delta (Aug-Sep 2000, Dec-Jan 2002, Jan 2003 and Jan 2004). 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.

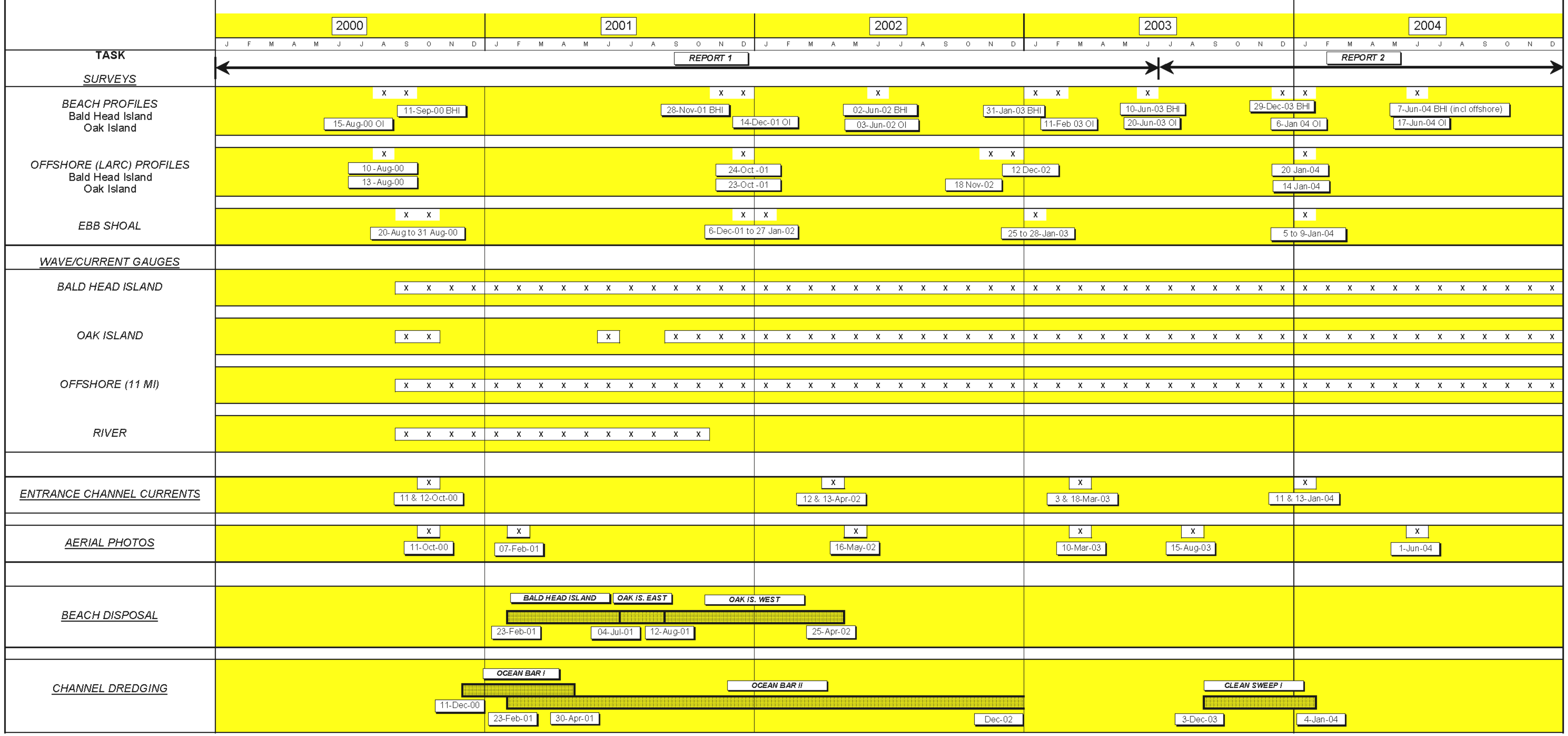
With respect to the wave/current meters, all four instruments were initially deployed in September 2000. The Bald Head gauge and the offshore 11-mile gauge have generally been in continuous operation throughout the initial monitoring period except for servicing and occasional data outage. The Oak Island 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.

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.

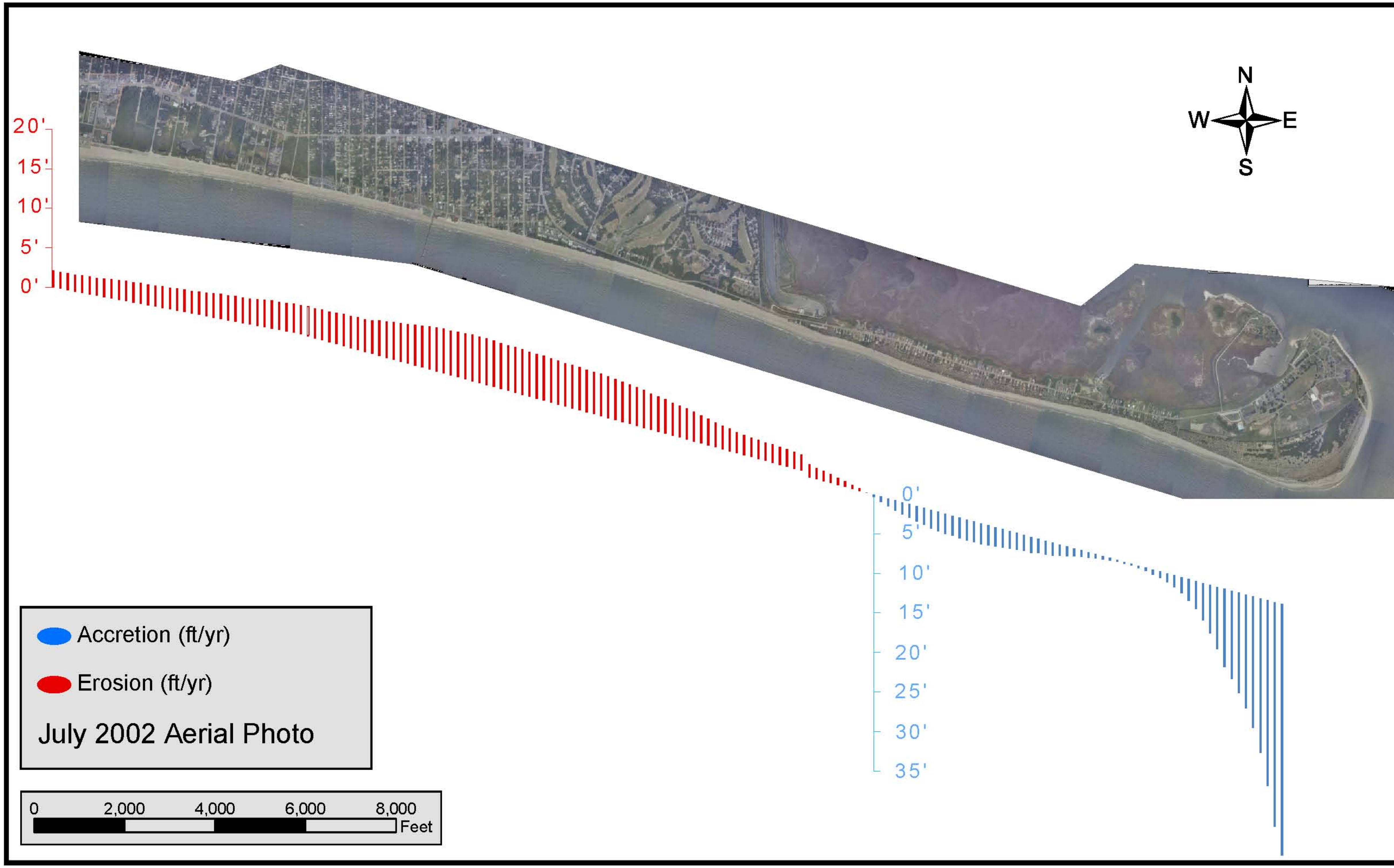


Figure 2.1 Long-Term Average Annual Shoreline Change Rates (1938-2000) Oak Island/Caswell Beach

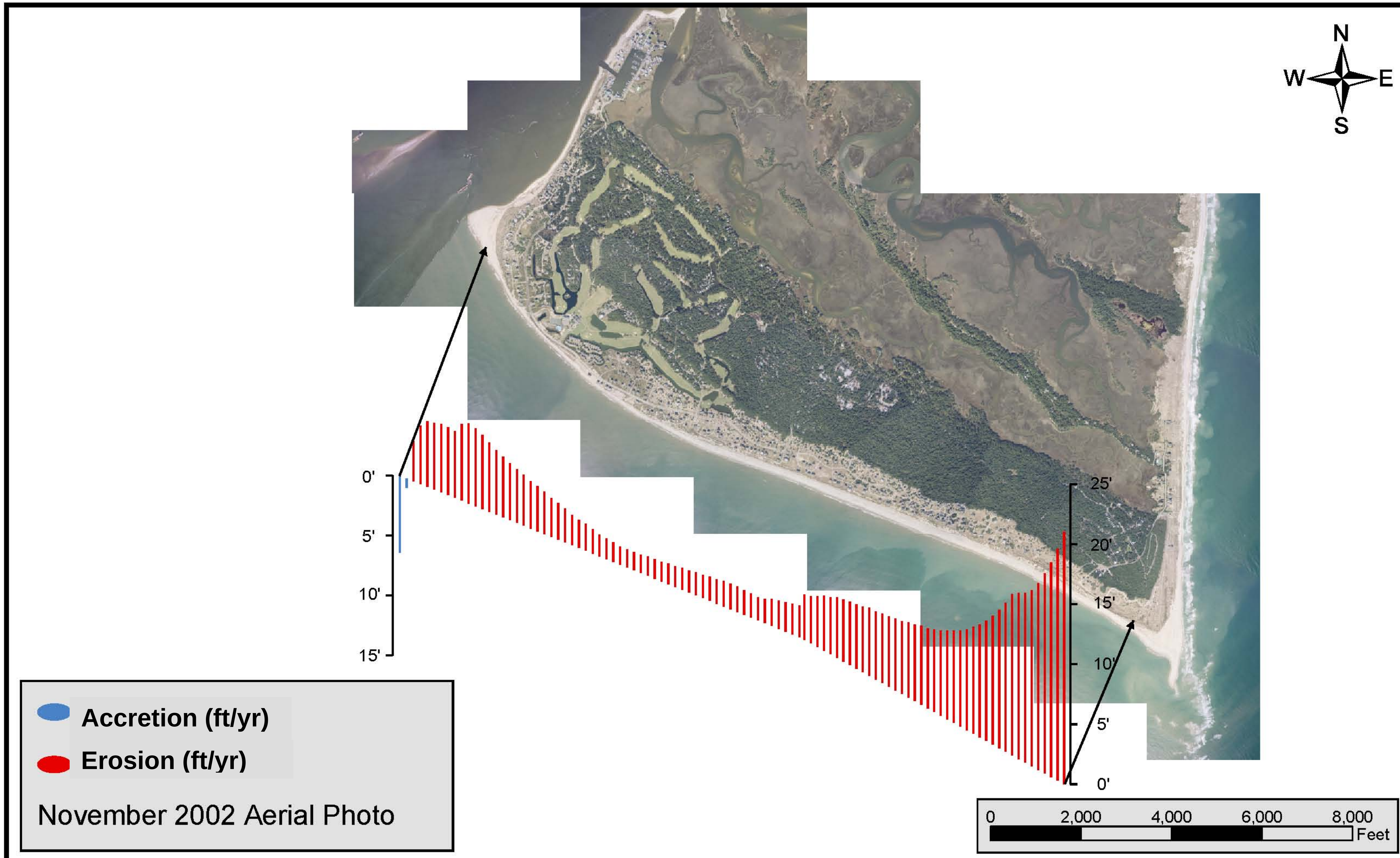


Figure 2.2 Long-Term Average Annual Shoreline Change Rates (1938-2000) Bald Head Island

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 four beach disposal projects and a groin field constructed on the island. 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. 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.

In 1996, sixteen geo-textile groins were constructed 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 400 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 has decided to rebuild the groin field following the beach fill placement in 2005.

A permit to repair a 641-foot-long existing sand bag revetment was applied for in January 2003. The sand bag revetment, shown in Figure 2.3, is located along South Bald Head Wynd between stations 62+00 and 69+00. The existing structure was authorized under permits issued in 1994 and 1995.

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

Part 3 DATA ANALYSIS AND RESULTS THRU SECOND 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 June 2004, the end of the second monitoring cycle. The data analyses generally describe changes that have occurred since those last reported in June 2003 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) 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 Figures 3.1 and Figures 3.2. The present monitoring period includes two surveys undertaken at six-month intervals in January 2004 and June 2004. Figure 3.1 shows the shoreline changes relative the June 2003 position, i.e. the last referenced location in Report 1. 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 shown shoreline retreat over the last year. This is true except for an area of spit growth near the southwest corner of the island recorded in Profiles 36 & 40, plus an accretionary region along the eastern end of Bald Head Island near Cape Fear. Stability is also shown at Profiles 66 & 69 with no change measured over the current period; however, this is due to presence of sand bags in this area restraining movement of the shoreline. The largest area of shoreline retreat begins just east of the spit area bracketed by Profiles 43 and 66. Over this 2,300-foot reach, shoreline recessions have reached a maximum of –120 feet since last June. In contrast, shoreline gains on the order of 50-ft to as much as 220 feet were measured along the stable eastern end of the island. Overall, the alongshore average shoreline changes measured over the entire monitoring area were –10.7 feet and –18.2 feet for the January 2004 and June 2004 surveys, respectively.

A similar pattern of shoreline change is shown in Figure 3.2 as measured over the last 4-year period since the monitoring was initiated. This figure likewise reveals a spit growth area with an adjacent erosion zone to its east, plus an extended area of accretion along the eastern portions of the island. Although the pattern is similar, the relative magnitudes of the shoreline changes are greater when considering the entire monitoring period. For example, the spit growth area is found to extend nearly 200 feet beyond its September 2000 position. Similarly, the shoreline recessions along the eroding portions of western South Beach reach a maximum of –250 feet and this eroded reach extends for about 7,000 linear feet (Profile 43 to Profile 110). These values of shoreline change indicate that the erosion has been severe in this area where the shoreline position is on the average 108 feet landward on its pre-project location. In contrast, beginning at about Profile 110, the shoreline response has been positive with accretion prevalent over the remaining eastern 11,000-feet of South Beach. The average alongshore position of the present shoreline is 69 feet seaward of its September 2000 location. With respect to the entire monitoring area (Profiles 00 to Profile 218), the shoreline is presently on the average 3.4 feet more seaward than it was in 2000.

Typical profile plots shown in Figures 3.3 and 3.4 are taken from both the highly eroding area and relatively stable area along Bald Heads' South Beach. Figure 3.3 shows Profile 61 within the rapidly eroding area 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 channel dredging during the February-July 2001 time frame. The fill area extended from about station 41+60 through station 205+50. Figure 3.3 shows the widened beach berm from the 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. Over the remaining time periods, the profile is shown to march progressively landward, retreating to about 250 feet from its initial position in September 2000. The nearly uniform retreat is displayed graphically in Figure 3.5. This figure shows the cumulative change in shoreline position over the 4-year monitoring period as measured from the September 2000 position. For comparison purposes both Profile 61 and 150 are given on the chart. For Profile 61 the graph shows the rapid, nearly uniform trend in the shoreline loss following the peak shoreline position in July 2001 associated with the beach fill.

For Profile 150 (Figure 3.4) a much more stable behavior is evident. In this instance much of the fill has remained intact and the shoreline retreat has occurred at a much slower rate. The response is clearly apparent in Figure 3.5 as well, especially when compared to Profile 61. Profile 150 actually widened some following the July 2001 fill, and remained stable for about the next 2 years, at which time it experienced a much slower loss of material. At the end of the period, the shoreline position remained about 80 feet seaward of its September 2000 position.

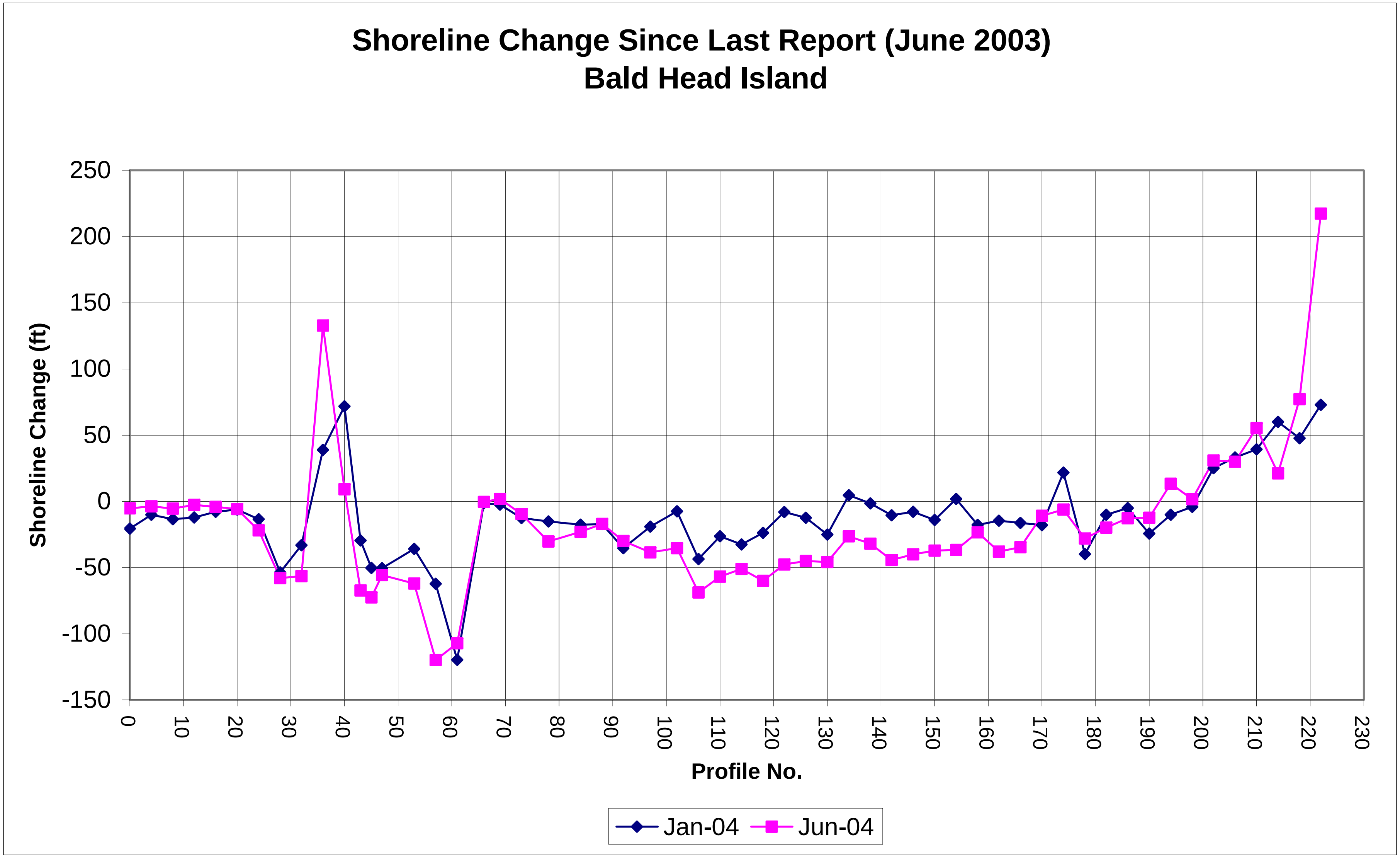


Figure 3.1 Shoreline Change Since Last Report (Jun 2003) Bald Head Island

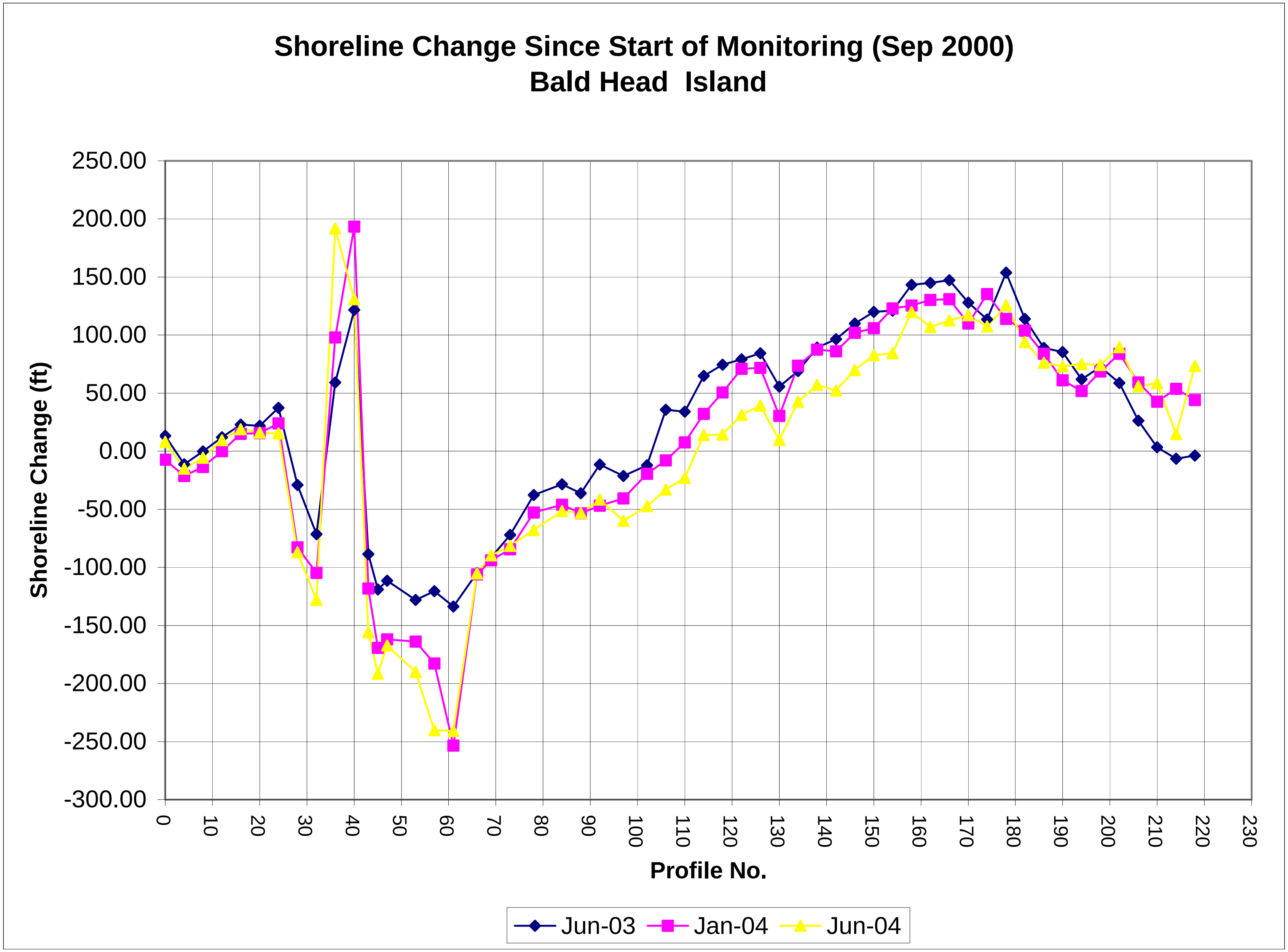


Figure 3.2 Shoreline Change Since Start of Monitoring (Sep 2000) Bald Head Island

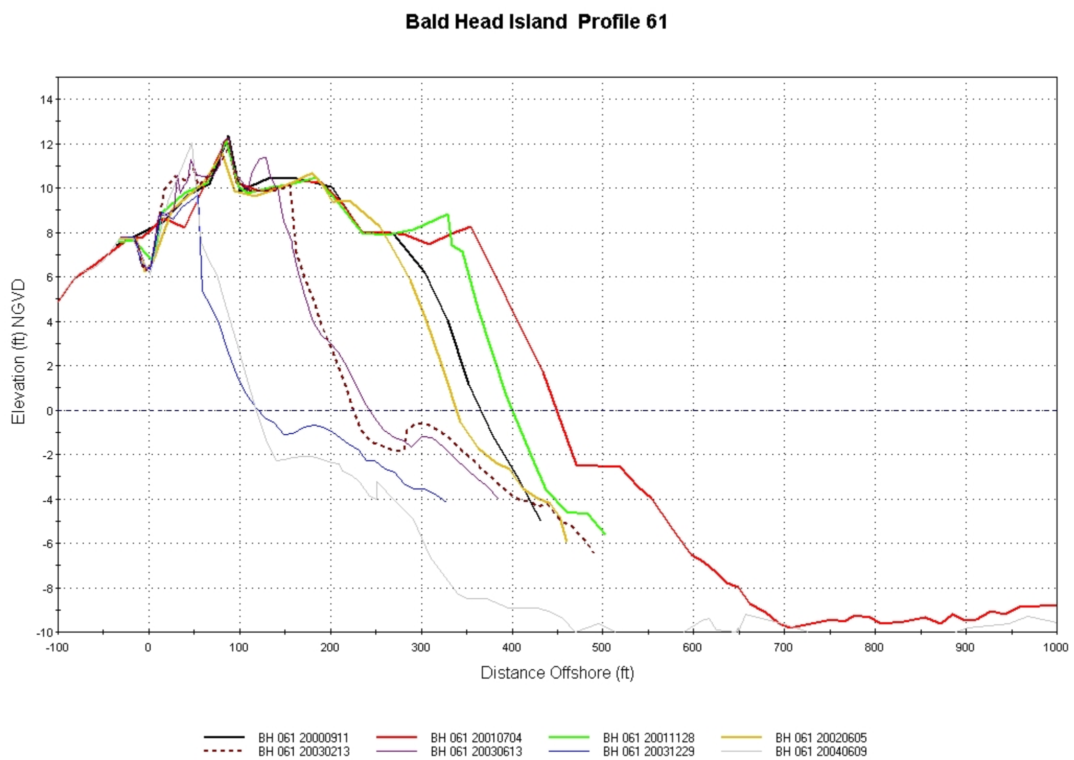


Figure 3.3 Bald Head Island Profile 061

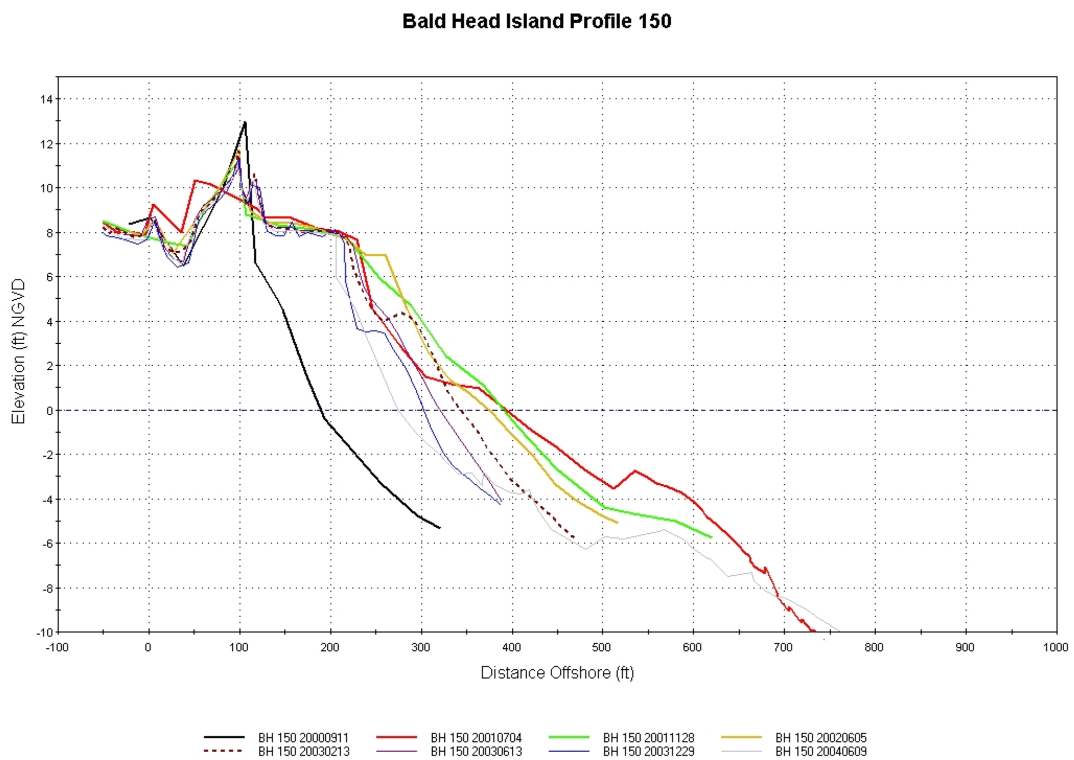


Figure 3.4 Bald Head Island 150

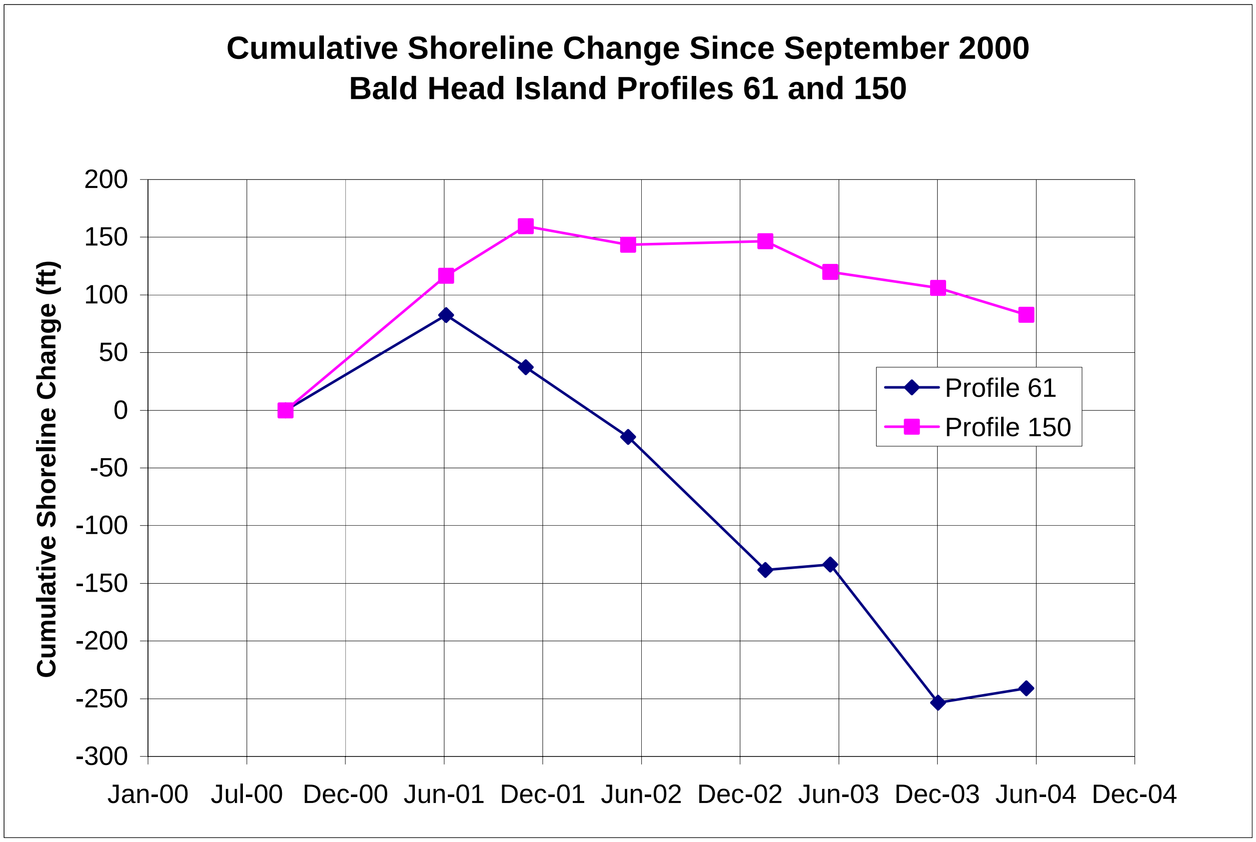


Figure 3.5 Cumulative Shoreline Changes Since September 2000 Bald Head Island Profiles 61 and 150

Oak Island. Shoreline changes measured along Oak Island over the current monitoring cycle are given in Figures 3.6 and Figures 3.7. The present monitoring period includes the January 2004 and June 2004 surveys. Figure 3.6 shows the shoreline changes relative the June 2003 position, i.e. the last referenced location in Report 1. 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 +150 feet. Overall however, positive change has been more prevalent with the alongshore average change being an accretion of about 19 feet from June 2003 to June 2004. Extending westward from Profile 50, the shoreline changes have been somewhat variable, with the overall trend being one of recession. Careful inspection of Figure 3.6 reveals that the period between June 2003 and January 2004 showed the greatest overall shoreline retreat followed by a general mild recovery by June 2004. For example, the alongshore average shoreline change for Profiles 50 thru 310 between June 2003 and January 2004 was –10.1 feet. In comparison, the average trend for June 2003 to June 2004 was slightly less at –7.6 feet. This trend also holds true when considering all profiles within the

Oak Island monitoring area (Profiles 5 thru 310) where the initial six-month period had an average shoreline change of –6.5 feet versus –3.5 feet for the entire one-year period of June 2003-2004.

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 January and June 2004 surveys, all shoreline changes measured west of Profile 40 are positive. To a large degree, this reflects the shoreline response and subsequent stable behavior of the fill placed along this entire reach associated with the channel deepening in 2001. In addition, a rather large wide fill was also placed just to the west of the monitoring limits (also completed in 2001) associated with the Sea Turtle Habitat Project. This fill has positively influenced the shoreline along the western monitoring limits which have 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 January 2004 than it was in 2000. Likewise, the shoreline position was 97 feet more seaward in June 2004, than it was about four 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 remains (about 2/3) at the end of the period by June 2004. 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 two years. Over this time period between June 2002 and 2004, the mean high water shoreline at Profile 80 has varied between about 70 and 90 seaward of its August 2000 position. Likewise, the shoreline at Profile 220 has also remained stable, ranging from a positive 156 to 132 feet, over the same period.

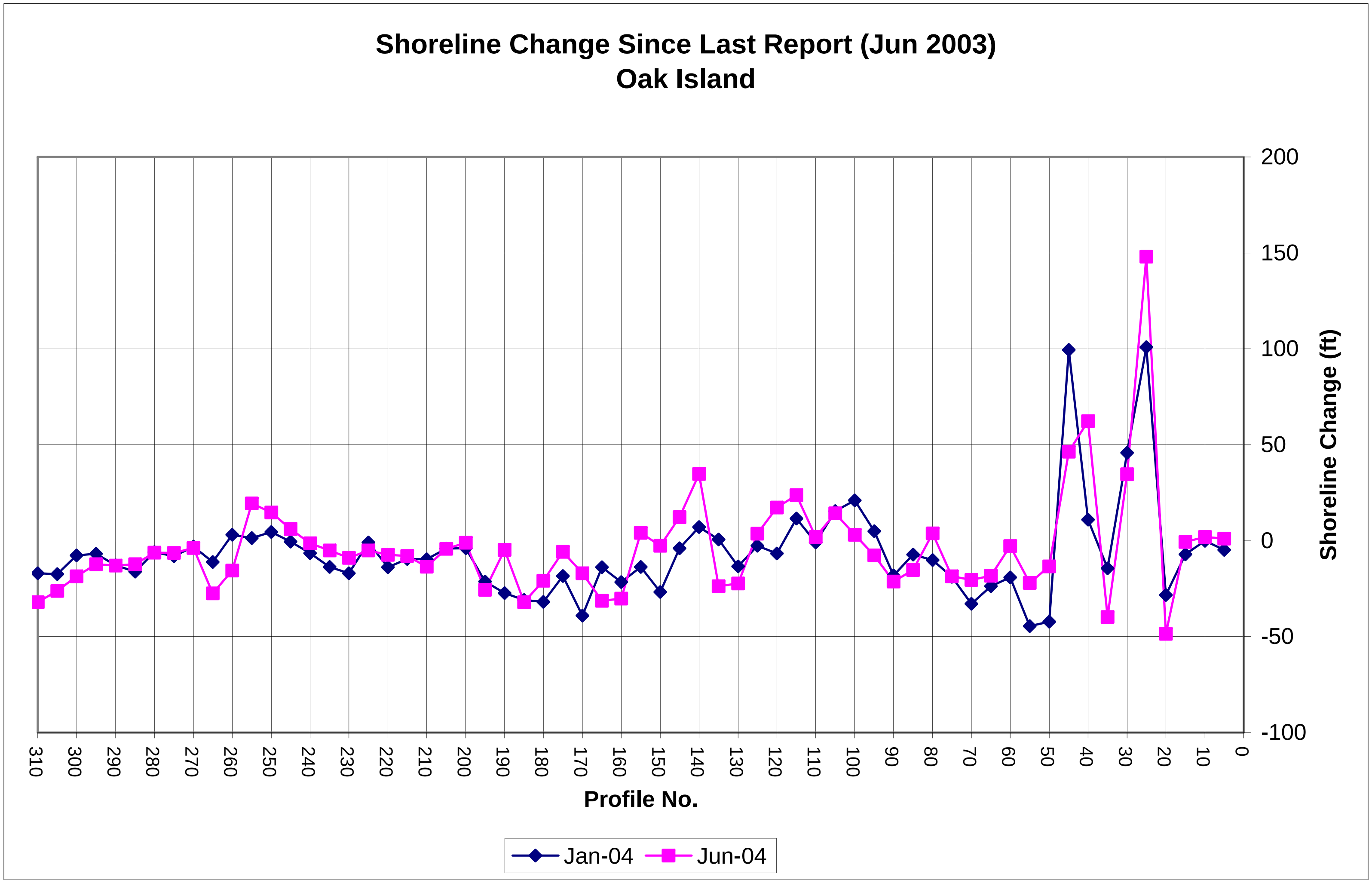


Figure 3.6 Shoreline Change Since Last Report (Jun 2003) Oak Island

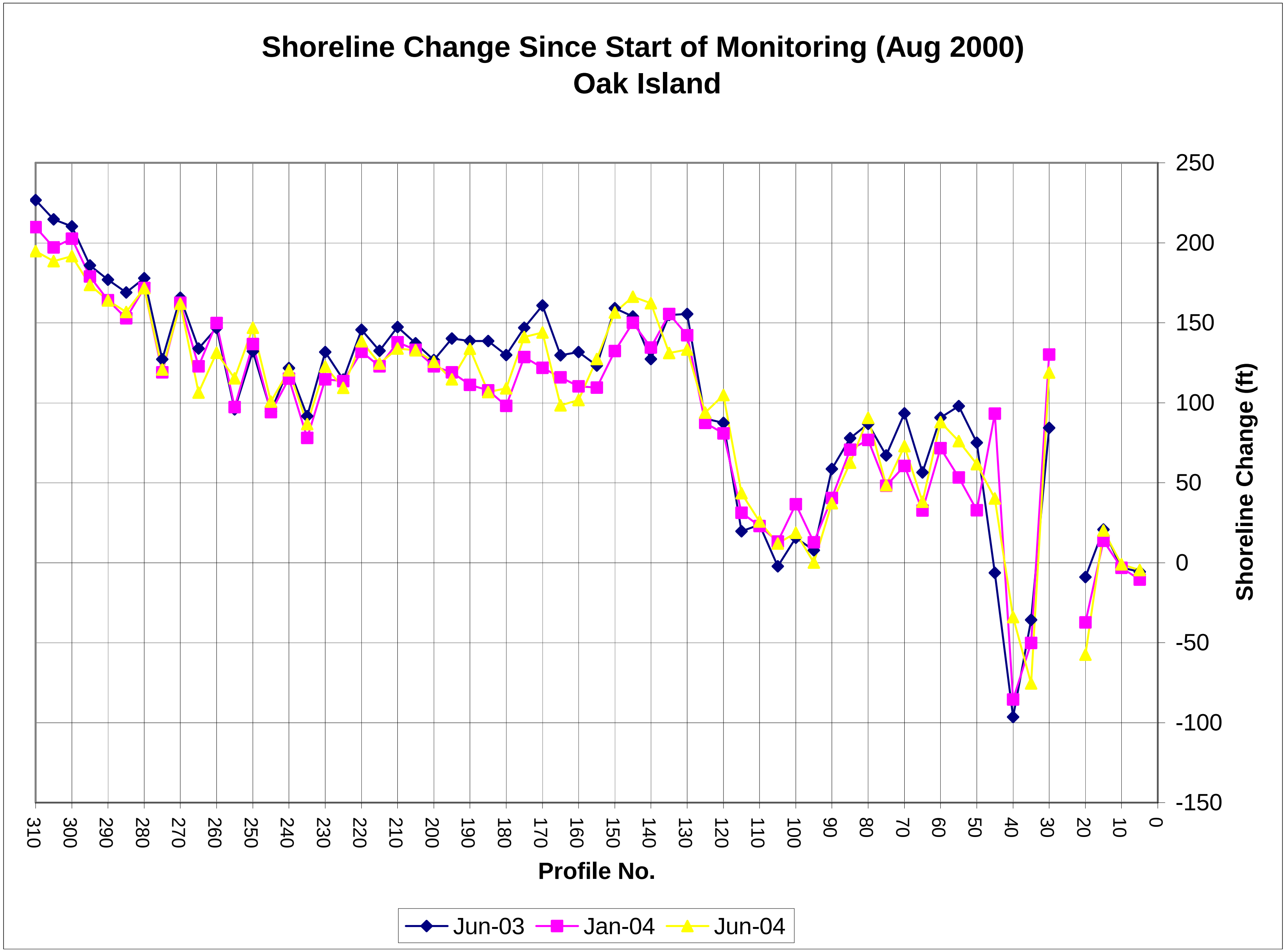


Figure 3.7 Shoreline Change Since Start of Monitoring (Aug 2000) - Oak Island

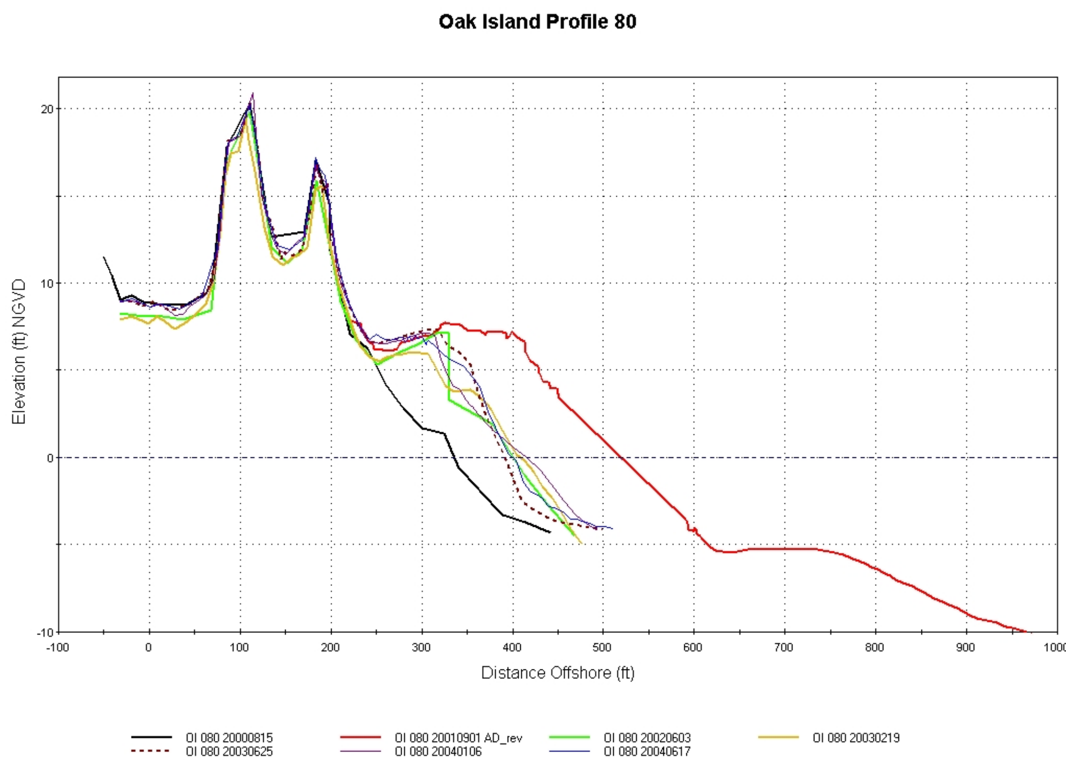


Figure 3.8 Oak Island Profile 80

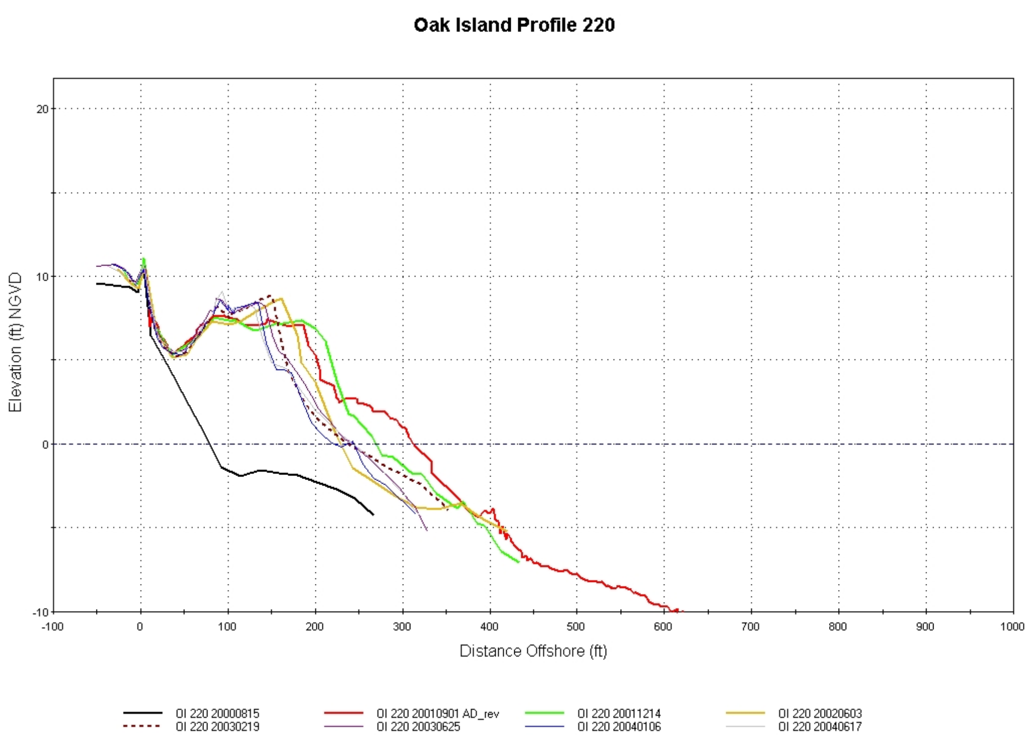


Figure 3.9 Oak Island Profile 220

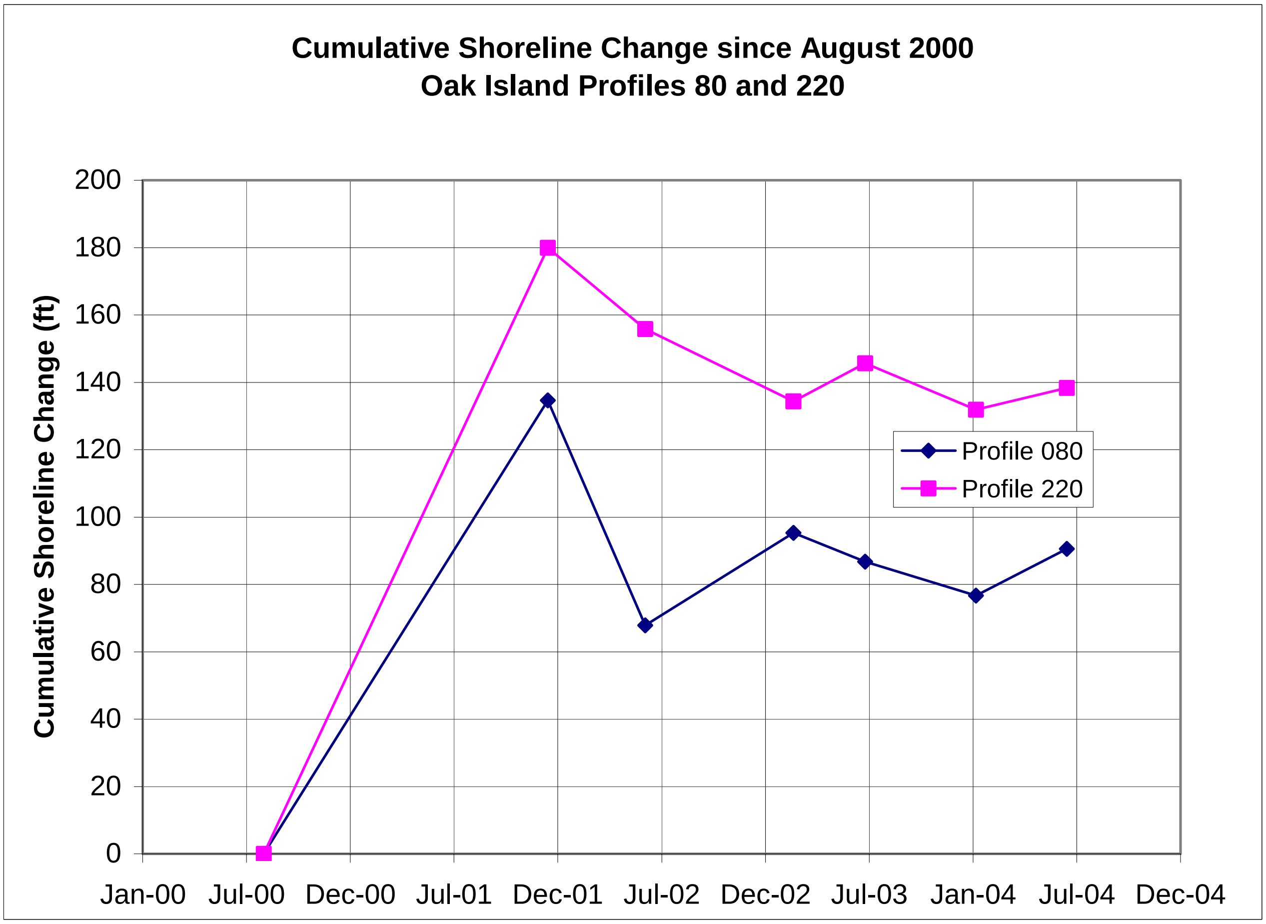


Figure 3.10 Cumulative Shoreline Change Since August 2000 Oak Island Profiles 80 and 220

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.

Over the current monitoring cycle there have been two onshore and two offshore profile surveys. The onshore surveys were done in December 2003 and June 2004 on Bald Head Island and January 2004 and June 2004 on Oak Island. The June 2004 monitoring survey was extended to cover the offshore as well for Bald Head Island, since it was used in preparation with the next beach fill planned for disposal along this island. The other total offshore survey was accomplished using the LARC during the scheduled monitoring effort in January 2004 and included 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 2003 onshore survey, i.e. the last referenced onshore survey in Report 1. 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 an overall loss along Bald Head Island except for the localized area of spit growth between Profiles 32 and 45, plus some accretion at the extreme eastern end of the island. Likewise, an area of relatively large onshore volume loss is present just east of the spit area extending for about 2,000-2,500 feet. The volume loss persists for much of the remaining parts of the island; however, the losses progressively decrease extending towards Cape Fear. Of further note is that for almost all profile locations, the onshore volume losses are found to increase between December 2003 and June 2004. The greatest difference between these two surveys is found to occur over the approximate middle third of South Beach. In considering the total volume changes for the two surveys over the current monitoring cycle, approximately 180,000 cubic yards were lost between June 2003 and December 2003. This total volume loss increased to about 260,000 cubic yards for the one-year period between June 2003 and June 2004.

The results of all onshore beach profiles surveys taken to date since the start of the monitoring in August/September 2000 are given in Figure 3.12. As noted above, this graph shows the volume changes relative to the start of the program in 2000. As with the prior shoreline and volume analysis, three distinct reaches are seen in the graph. These include the area of spit growth (Profiles 32-45), an erosion zone (Profiles 47-114), and an area of stability (east of Profile 114). In addition to this alongshore pattern of erosive and stable areas, a temporal trend is also evident from the onshore volume data. This trend shows the progressive loss in volume since the November 2001 survey through June 2004, for most of the South Beach area. The November 2001 is representative of the post-fill survey which reflects the added fill volume placed between Profiles 41 and 206. With each successive survey, the onshore volume loss has continued over the monitoring period. Beginning with the June 2002 survey, the volumes started to become negative over a small area (Profiles 61-66), indicating that not only had all the beach fill had been lost in this area, but the erosion had progressed to a point beyond the 2000 base condition for these particular profile locations. This erosion pattern continued to spread with each subsequent survey, intensifying in the acute area between Profiles 45 and 66. By the end of the current period, the zone of onshore volume loss extended eastward to about Profile 114 covering approximately 6,900 feet. Eastward beyond this point, most of the remaining portions of South Beach are showing progressive volume loss over time, but the onshore volumes are still significantly greater than they were in 2000.

To further illustrate the trend in progressive volume loss Figure 3.13 shows a plot of cumulative volume changes over time with respect to the August/September 2000 survey. Both the onshore and total (onshore plus offshore volume changes as 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 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.

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 1 (December 2002); whereas, Figure 3.15 gives changes relative to the August 2000 survey at the beginning of the monitoring. For each profile comparison, volumes were computed from a common stable landward point to an observed closure depth offshore.

Figure 3.14 shows that between December 2002 and January 2004 most of Bald Head Island experienced a volume loss. The exceptions to the general loss were the continued growth of the spit between Profiles 32 and 45 and some volumetric gain near the eastern end of the island (Profiles 186 & 194). The volume loss was greatest in the previously noted erosion zone just east of the spit. Some relatively large losses were also measured at the last two profiles nearest to Cape Fear. With the most recent survey of June 2004, most of the profiles experienced some recovery. The gain in volume is most evident beginning at Profile 78 and progressing eastward. With this survey, profiles east of 162 and those of the spit area all show positive volume changes with respect to the December 2002 survey.

As with the onshore volume discussed above, a number of trends are evident with Figure 3.15 when analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000. Again three distinct reaches are evident including the area of spit growth (Profiles 32-45), an erosion zone (Profiles 47-114), and an area of stability (east of Profile 114). A fourth zone is also evident with the on/offshore volumes with relatively large losses measured along the last two profiles nearest to Cape Fear. Temporal trends are likewise evident with the spit area growing with the October 2001, December 2002, January 2004 and June 2004 surveys, (with a smaller net gain between the last two surveys). In contrast to the growth in the spit, the progressive loss is seen over time within the erosion area east of the spit. This trend is seen to reverse somewhat with the June 2004 survey. Even so, by the end of the current period, about a 6,900-foot-reach (between Profiles 45 & 114), are found to have overall negative volumetric changes with respect to the August 2000 survey. Over the remaining portions of South Beach (Profiles 114 to 194), covering about 8000 feet, positive volume changes are evident, with this reach having more sediment in place in June 2004 versus August 2000.

Listed below in Table 3.1 are the computed volume changes for Bald Head Island for each survey separated into the specific reaches as discussed above. As of the June 2004 survey, the spit area had gained approximately 311,200 cubic yards. This gain is offset by a comparable loss of 381,100 cubic yards within the critical erosion zone. The largest gain over the approximate four-year period is within eastern half of South Beach (Profiles 114-194) which remained positive with 819,500 cubic yards. In totaling all changes within the Bald Head Island monitoring area, a net gain of 677,800 was measured between the pre-project survey in August 2000 and the most current survey.

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
Profile 0 – 24 (west beach)		-33,053	35,186	11,817	2,602
Profile 32 – 45 (spit)	150,029	7,926	-1,923	260,666	311,209
Profile 53 – 106 (erosion zone)	130,522	204,946	-81,098	-453,813	-381,134
Profile 114 – 194 (accretion zone)	1,200,383	1,075,112	783,630	572,189	819,523
Profile 198 – 218 (near cape)	20,727	-503	-209,780	-315,710	-74,440
Total	1,501,660	1,254,428	526,015	75,150	677,759

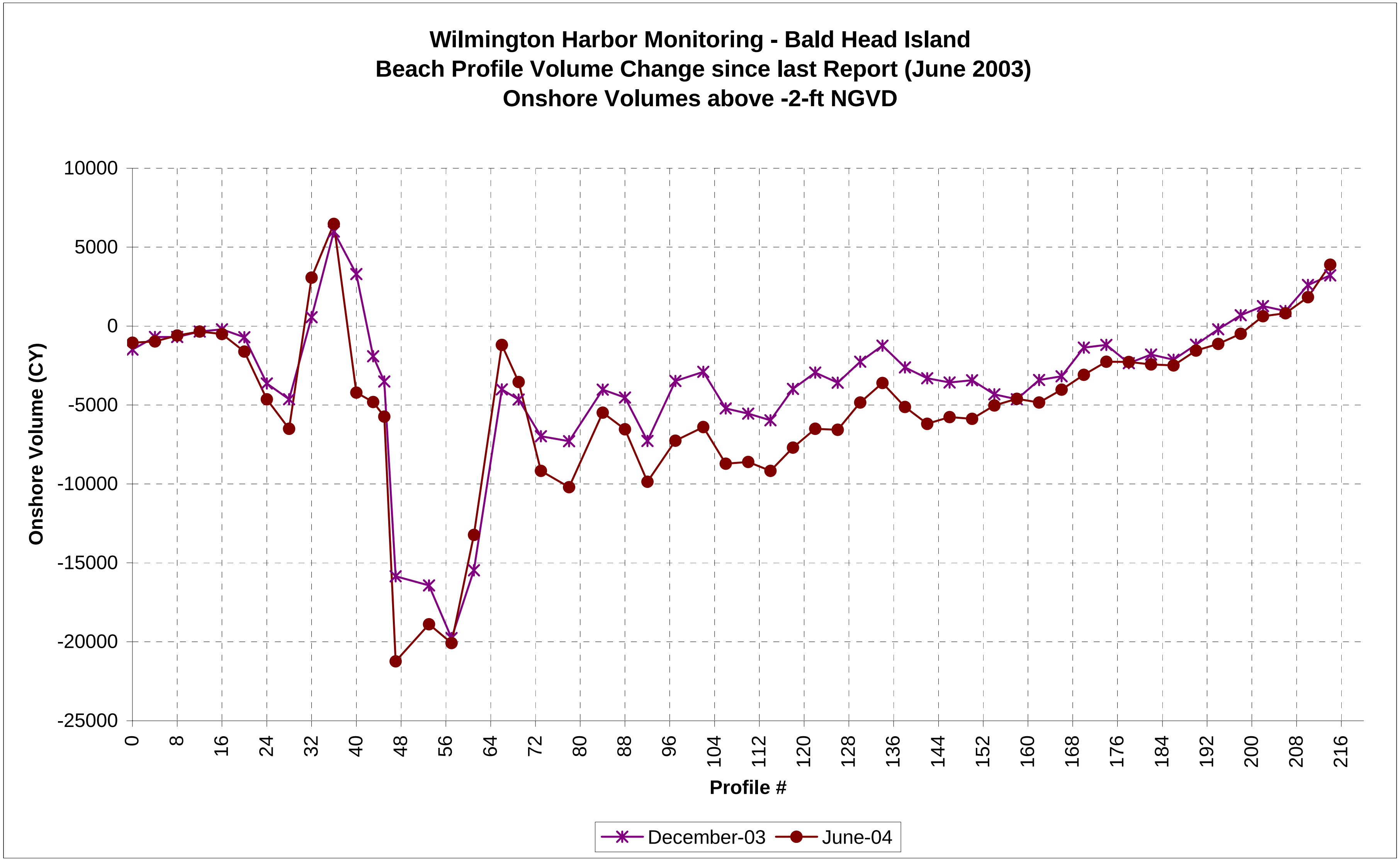


Figure 3.11 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change Since last Report (June 2003) Onshore Volumes above –2 ft NGVD

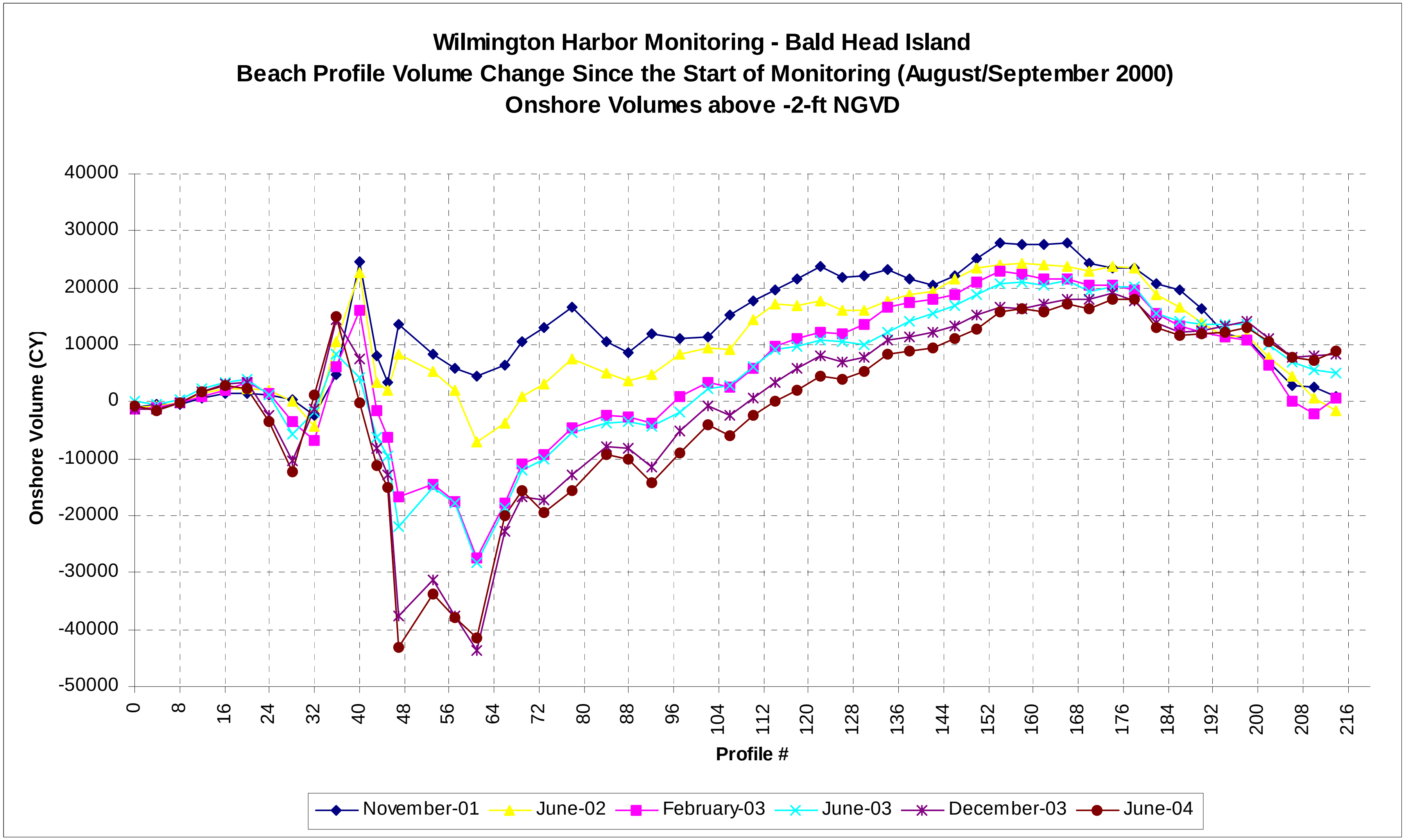


Figure 3.12 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Change since Start of Monitoring (August/September 2000) Onshore Volumes above –2 ft NGVD

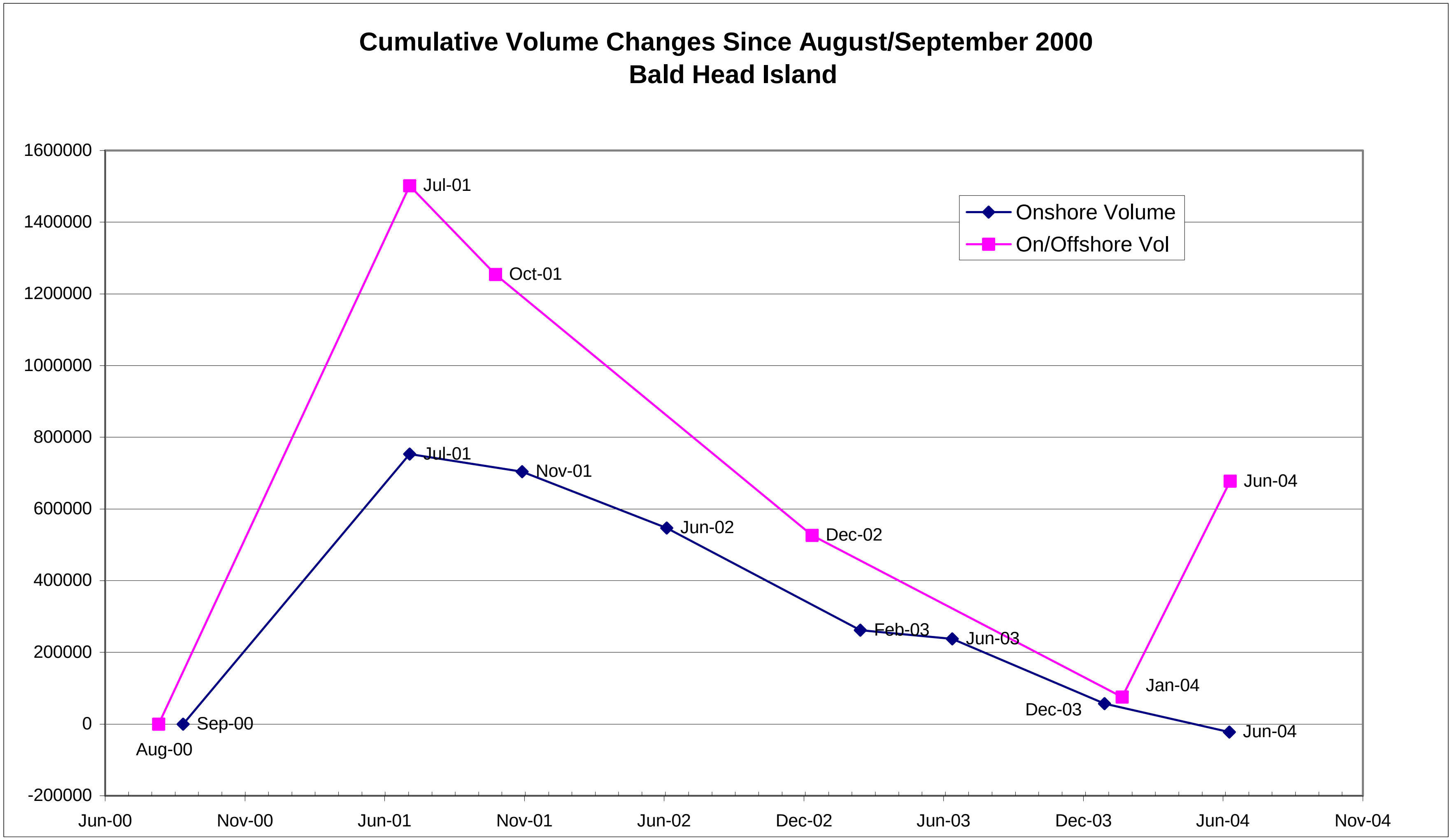


Figure 3.13 Cumulative Volume Changes Since August/September 2000 for Bald Head Island

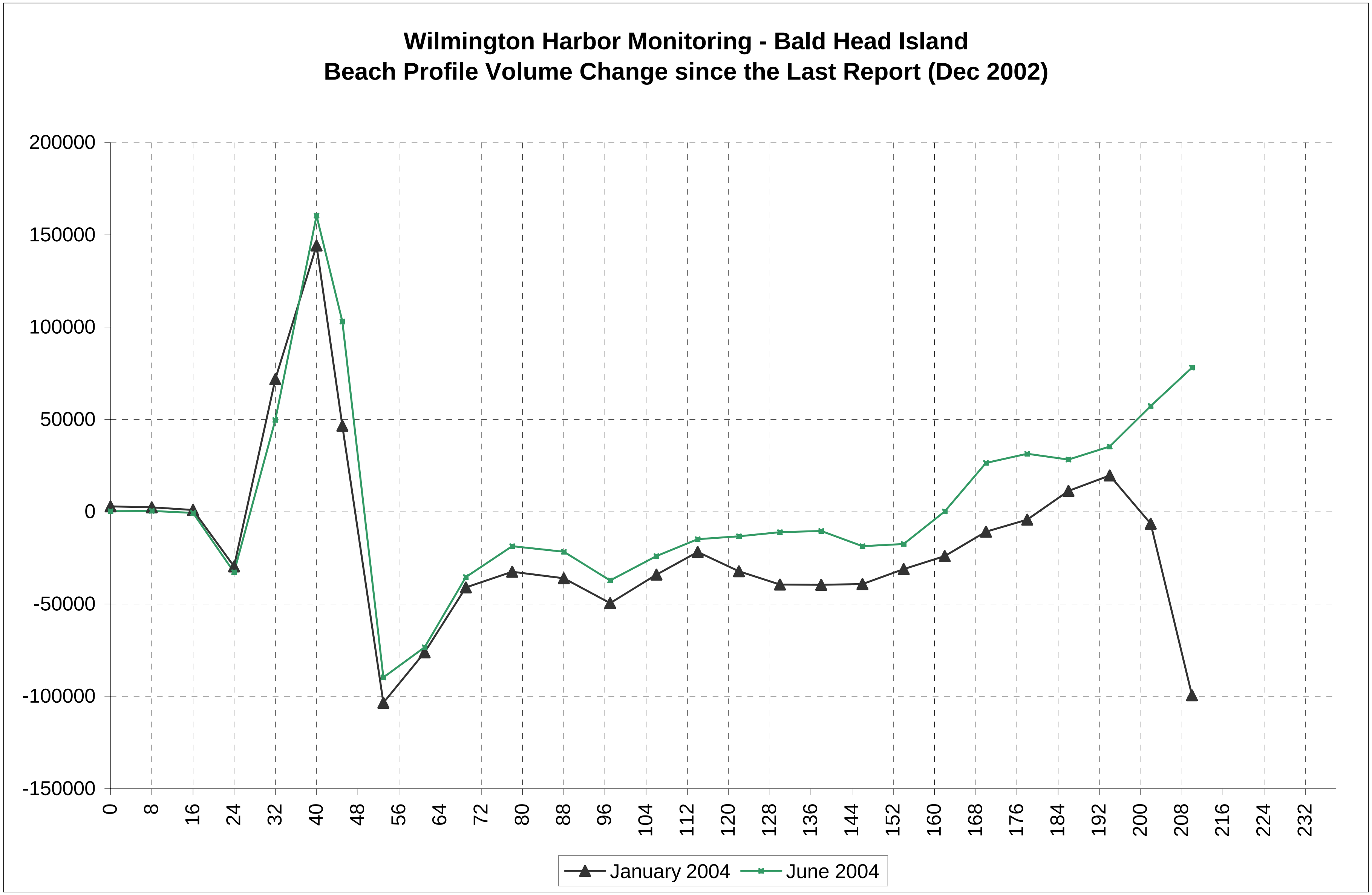


Figure 3.14 Wilington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since Last Report (Dec 2002)

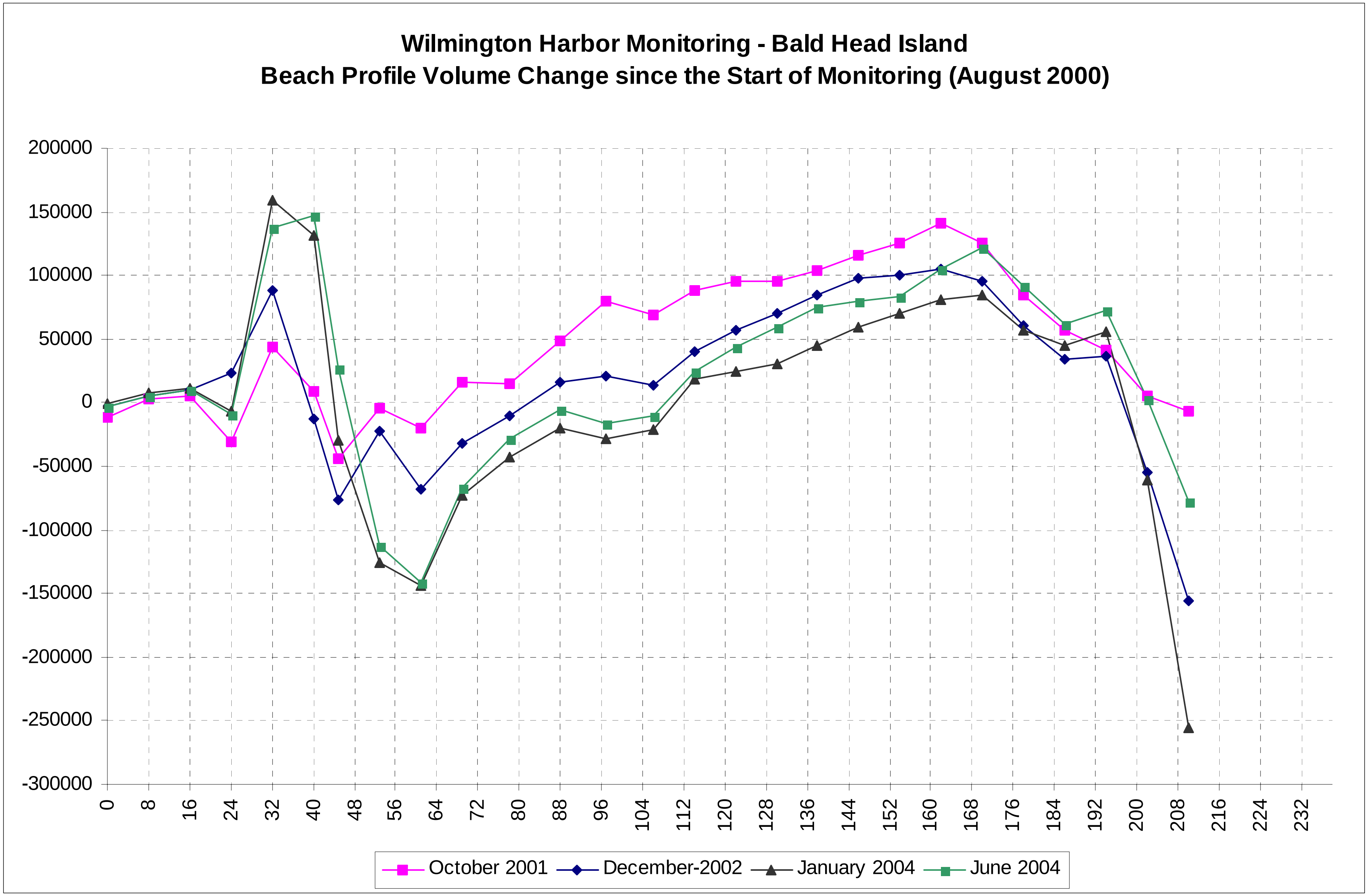


Figure 3.15 Wilmington Harbor Monitoring – Bald Head Island Beach Profile Volume Changes Since the Start of Monitoring (August 2000)

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 2003 onshore survey, i.e. the last referenced onshore survey in Report 1. 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) generally mimic those of the reported changes in the mean high water shoreline. In this regard, the volume changes show an overall pattern with both net losses and net gains over the entire monitoring region. Both the January 2004 and June 2004 surveys show similar patterns and almost over-plot each other on the graph, indicating general stability over the last year. This stability is reflected in the onshore volumetric quantities summed over the 6-mile monitoring region which show minimal total losses of only 35,000 cubic yards and 22,000 cubic yards for the January and June 2004 surveys, respectively.

The results from all onshore beach profiles surveys taken to date since the start of the monitoring in August 2000 are given in Figure 3.17. As noted above, this graph shows the onshore volume changes relative to the start of the monitoring program. These data reflect the influence of the beach fill placed in 2001 and the stability of the fill over the past four years, as little change in onshore volume is shown for the plots with each survey date. Further, as of June 2004, only two profiles (34 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 four 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 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 940,000 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 June 2004 essentially no significant change in the onshore beach volume is measured. As of June 2004 survey, the remaining total onshore volume is 944,000 cubic yards, which is a slight (0.4%) volumetric increase over the December 2001 onshore volume.

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 1 (November 2002); 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. This figure displays the most predominant gains found along the tip of Caswell Beach (Profiles 15 thru 25) and western end of the monitoring region (Profiles240 thru 290), with some minor isolated zones of erosion in between. Examination of Profile 20, which shows the largest accretion over the period, reveals the development of an isolated middle-ground shoal in the inlet area in the vicinity of this line. The presence of this shoal, along with the general stability observed over the latest monitoring period, have resulted in an overall gain in volume between November 2001 and January 2004. The gain is computed to be 126,000 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 on/offshore surveys relative to the August 2000 pre-project survey. In this regard, all reported volume changes are positive with the exception of two small areas showing small losses. These isolated loss areas are located at Profile 40 and between Profile 100 and 110.

The volume changes measured along the tip of the island east of Profile 40, have essentially “flip-flopped” between November 2002 and June 2004, changing from negative to positive. This change is reflective of the dynamic nature of the island in the vicinity of the entrance channel as has been observed for many years.

Referring back to Figure 3.18, it is seen that only minor overall volume changes have occurred over time since the fill placement in 2001. As shown on the graph, approximately 1,066,000 cubic yards of material were measured in-place with the October 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 stayed about the same. With the most recent survey of January 2004, the total volume had dropped to only 1,052,000 cubic yards, a minimal loss of 14,000 cubic yards (-1.3%).

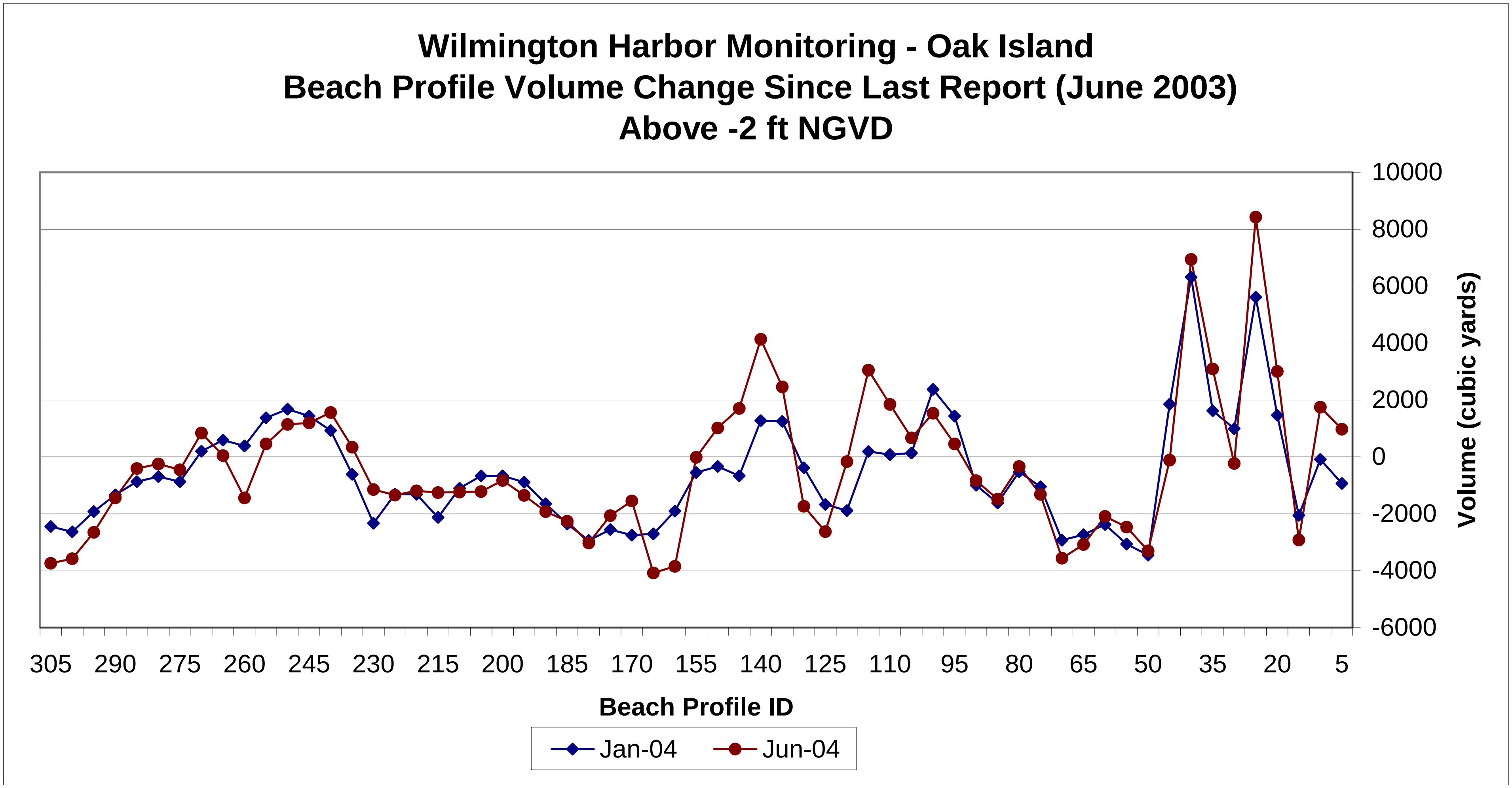


Figure 3.16 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change Since Last Report (June 2003) Onshore Volumes above – 2 ft NGVD

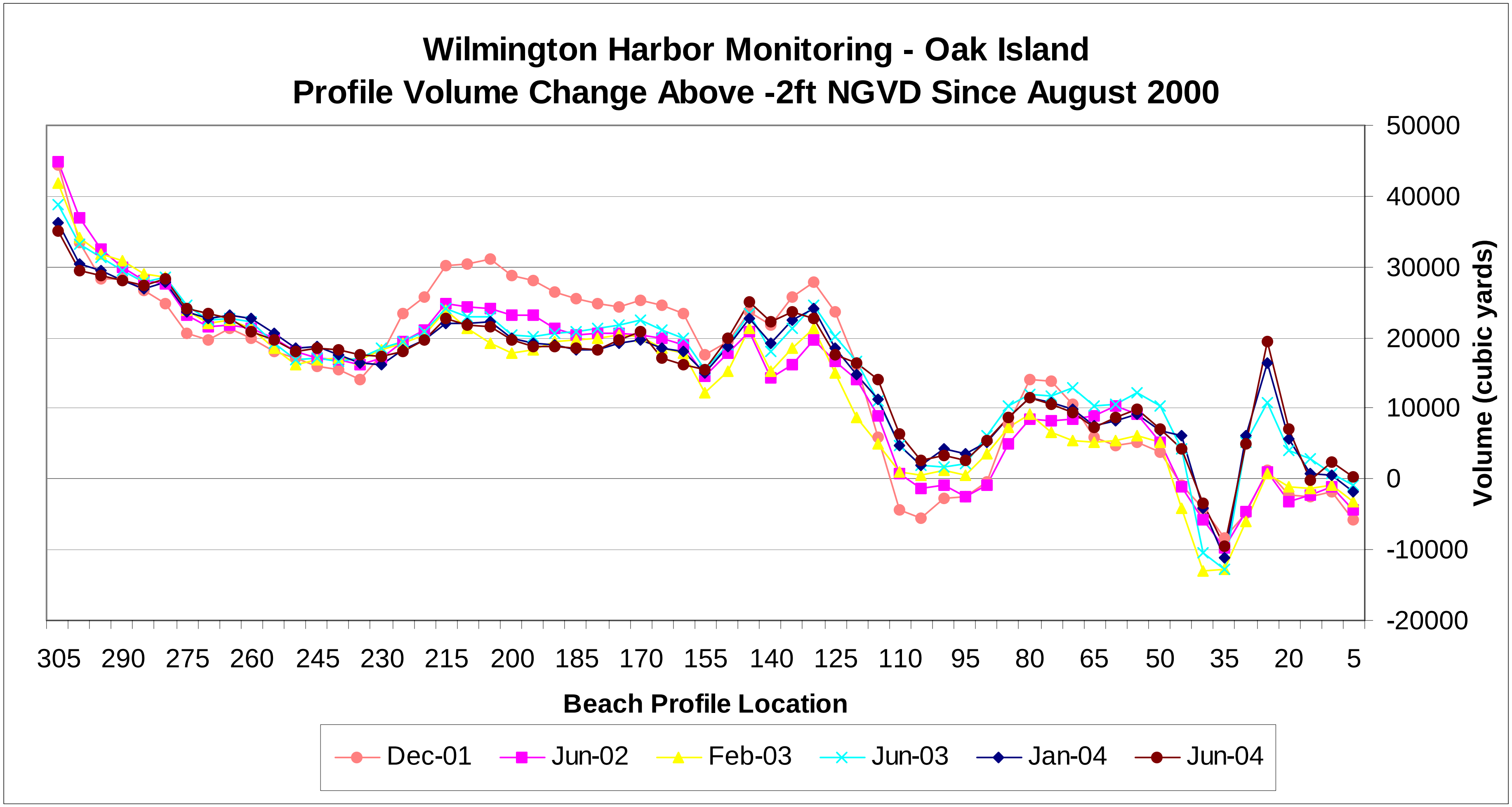


Figure 3.17 Wilmington Harbor Monitoring – Oak Island Beach Profile Volume Change since Start of Monitoring (August 2000)

Onshore Volumes above –2 ft NGVD

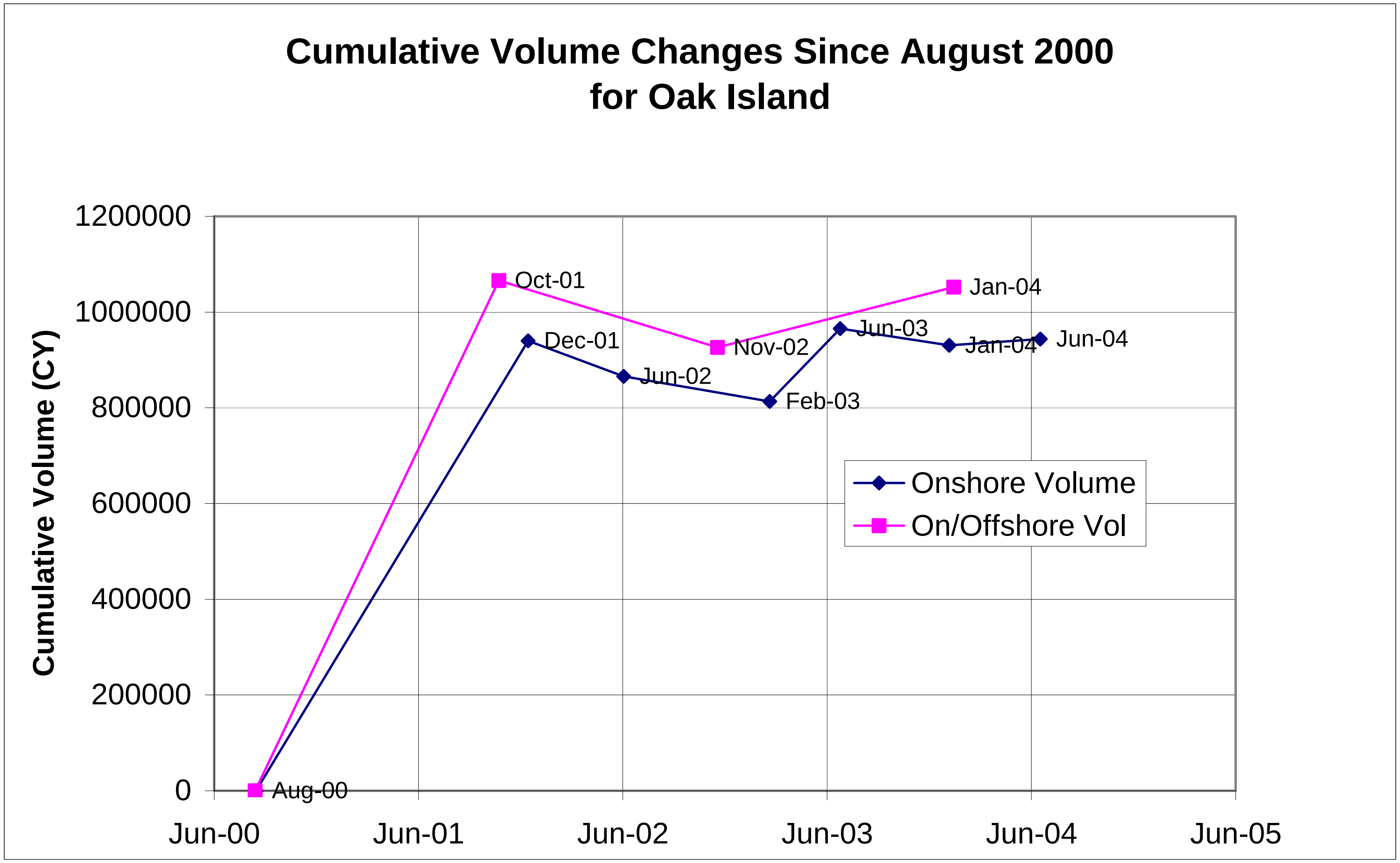


Figure 3.18 Cumulative Volume Changes Since August 2000 for Oak Island

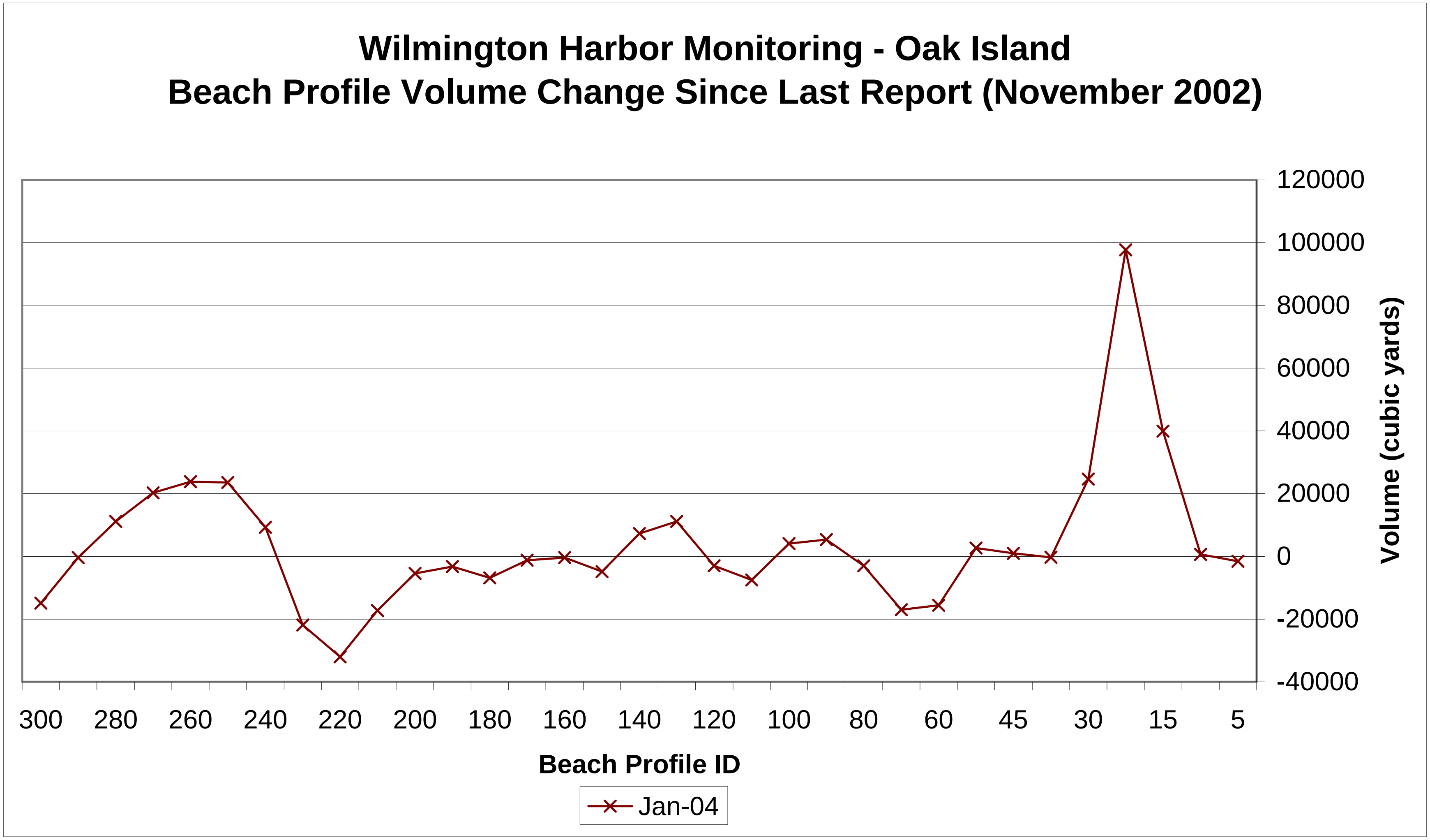


Figure 3.19 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since Last Report (November 2002)

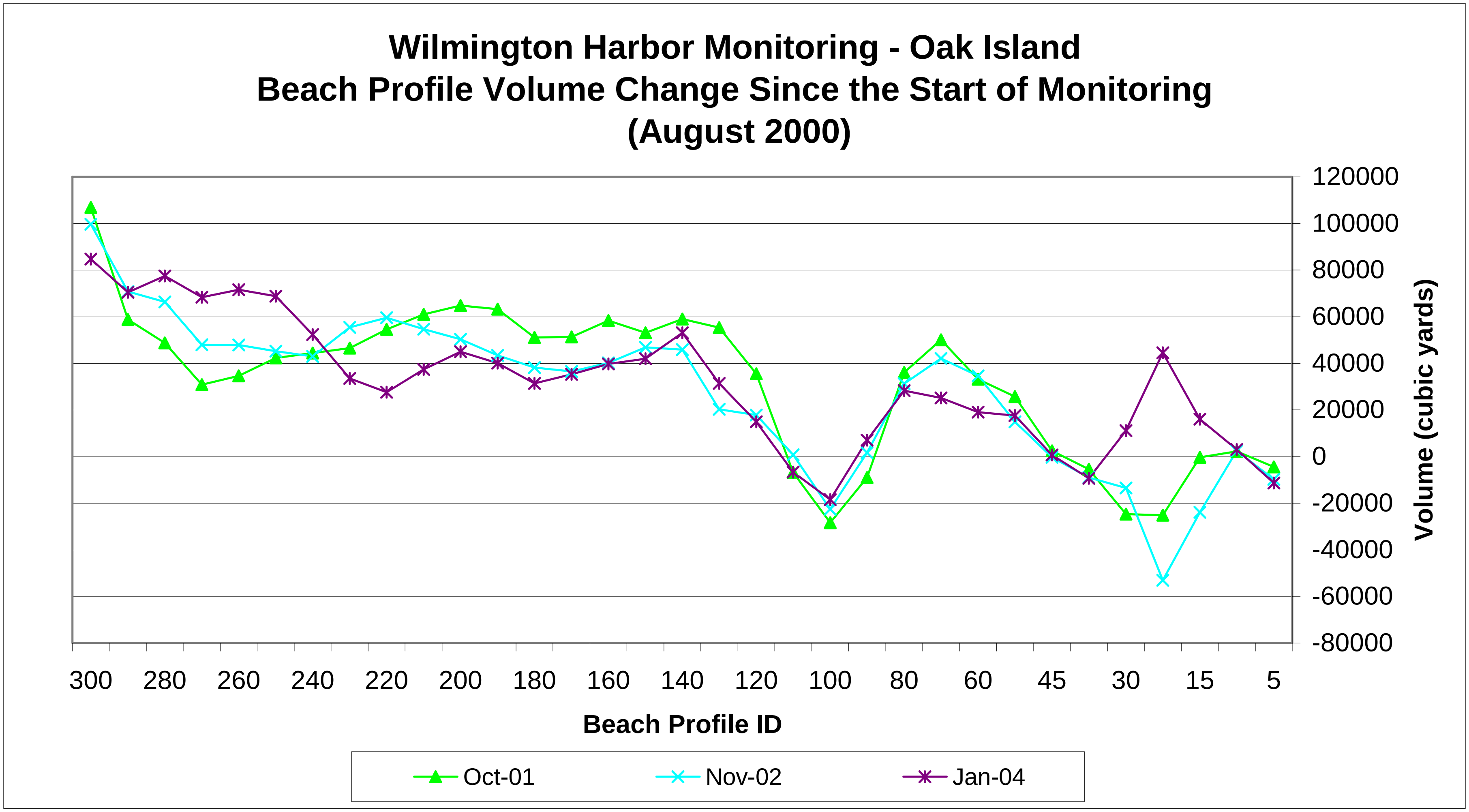


Figure 3.20 Wilmington Harbor Monitoring - Oak Island Beach Profile Volume Change Since the Start of Monitoring (August 2000)

Ebb and Nearshore Shoal Analysis

Bathymetric Data Collection. Detailed bathymetry of the Cape Fear River ebb tidal delta and channels were collected on four occasions specifically; August-September 2000, December 2001-January 2002, January 2003 and January 2004. 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.

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 of the most recent survey is shown in Figure 3.21 showing the LARC and interferometric system track lines. The results of the surveys are discussed below which are summarized from the previously referenced letter reports.

Results. The ebb tidal delta surrounding the mouth of the Cape Fear River is shown in Figure 3.22 from the most recent survey of 2004. Although these soundings were collected over a time span of several weeks and should not be used as an instantaneous measure of bathymetry, gross patterns of seafloor morphology can be seen in the figure. This survey clearly shows the newly realigned channel as well as 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 (Jay Bird Shoals). The third or Bald Head Shoal protrudes off the southwestern corner of Bald Head Island east of the main channel. Figure 3.23 shows a detail of the three shoals and nearshore bathymetry for the 2004 survey. This figure reveals the three-shoal system with the main channel hugging 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 3.24 for each of the four surveys (2000, 2002, 2003, and 2004). These comparisons showed a deepening of the flood margin channel on the Oak Island side and along the main shipping channel, the latter deepening being attributed to the dredging of the new channel.

A side-by-side comparison of the inlet bathymetry surrounding the new channel at the distal end of the ebb tidal delta for the first 3 surveys is shown in Figure 3.25. Construction of the new channel is readily apparent from the bathymetric charts with the 2000 survey reflecting the pre-dredge condition while the 2002 survey captures the time between the completion of the outer bar dredging contract (Ocean Bar I) and the start of the Bald Head Shoal contract (Ocean Bar II). This chart clearly shows the remaining section of the channel to be dredged connecting the existing and new channel alignments.

The bathymetry near the western portion of Baldhead Island is shown in Figure 3.26 for the 2004 survey and Figure 3.27 for the 2000, 2002 and 2003 surveys. The bathymetry along the eastern end of Oak Island is shown in Figure 3.28 for the 2004 survey and Figure 3.29 for the 2000, 2002 and 2003 surveys.

Comparisons between surveys of the ebb tide delta region are discussed further in Part 4. in the section Ebb and Nearshore Shoal Response.

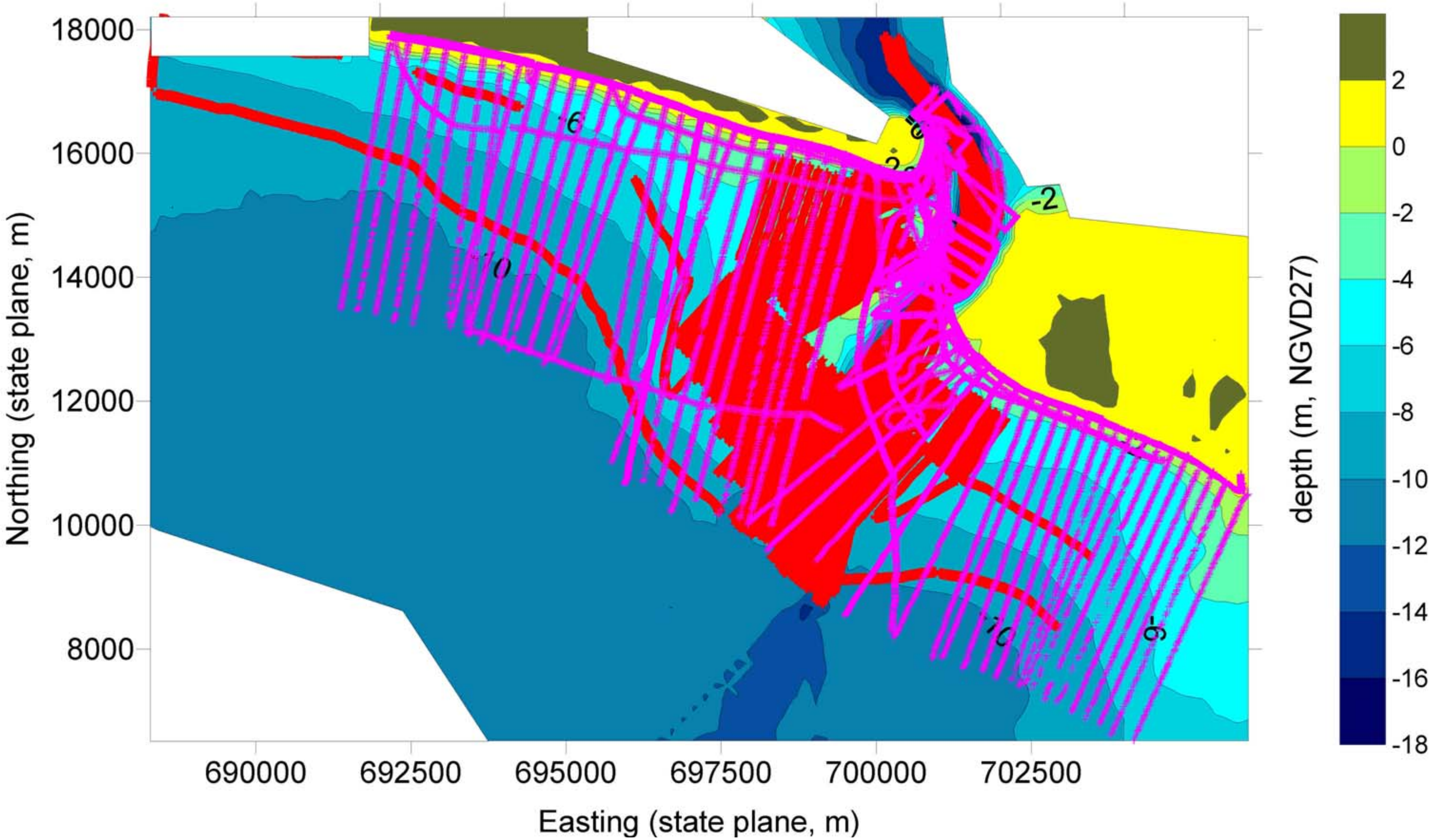


Figure 3.21 Survey Track Lines Collected by the LARC5 and the Interferometric System during the 2004 Survey

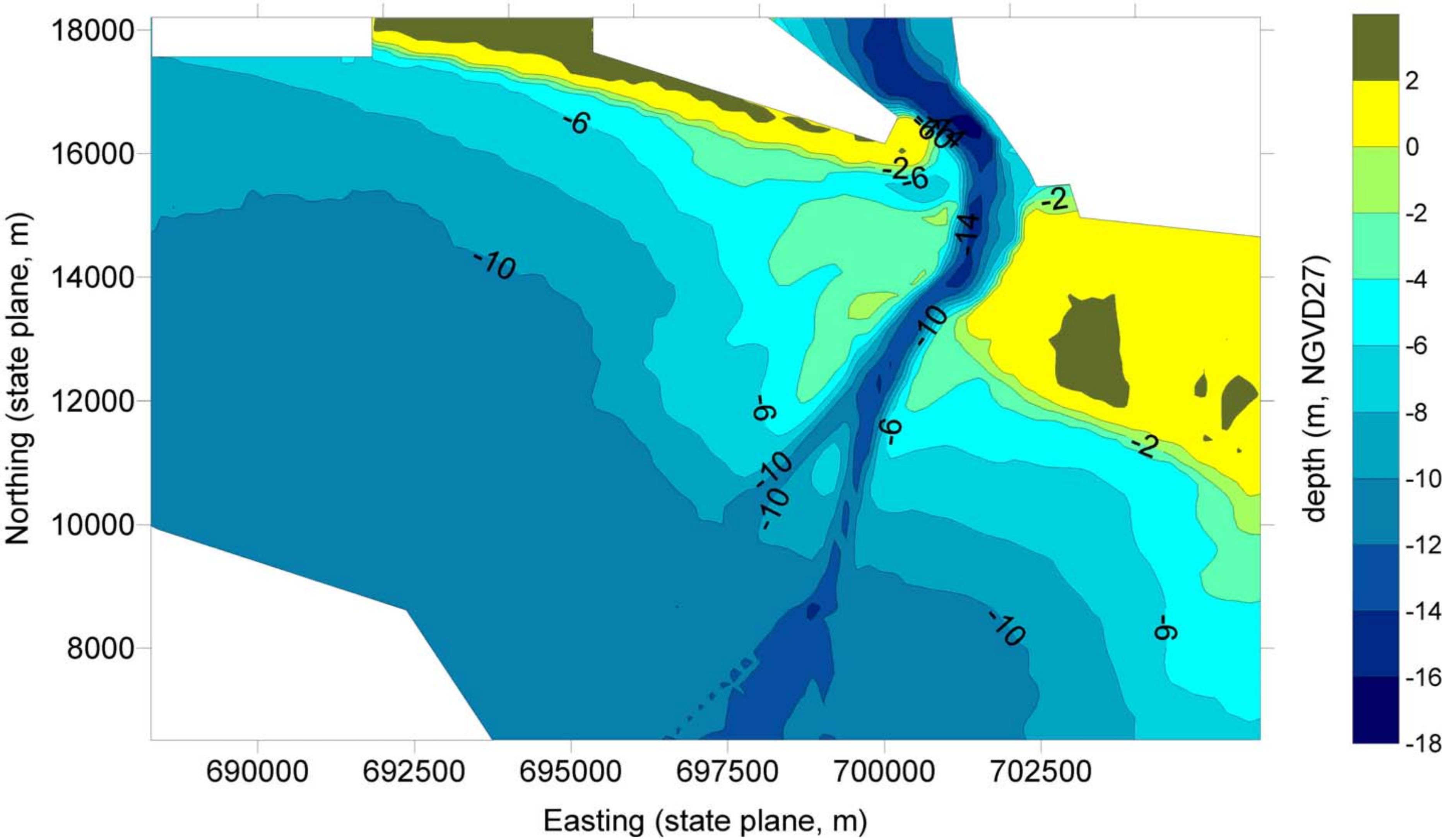


Figure 3.22 Bathymetry of the Cape Fear River Ebb Tidal Delta, 2004.

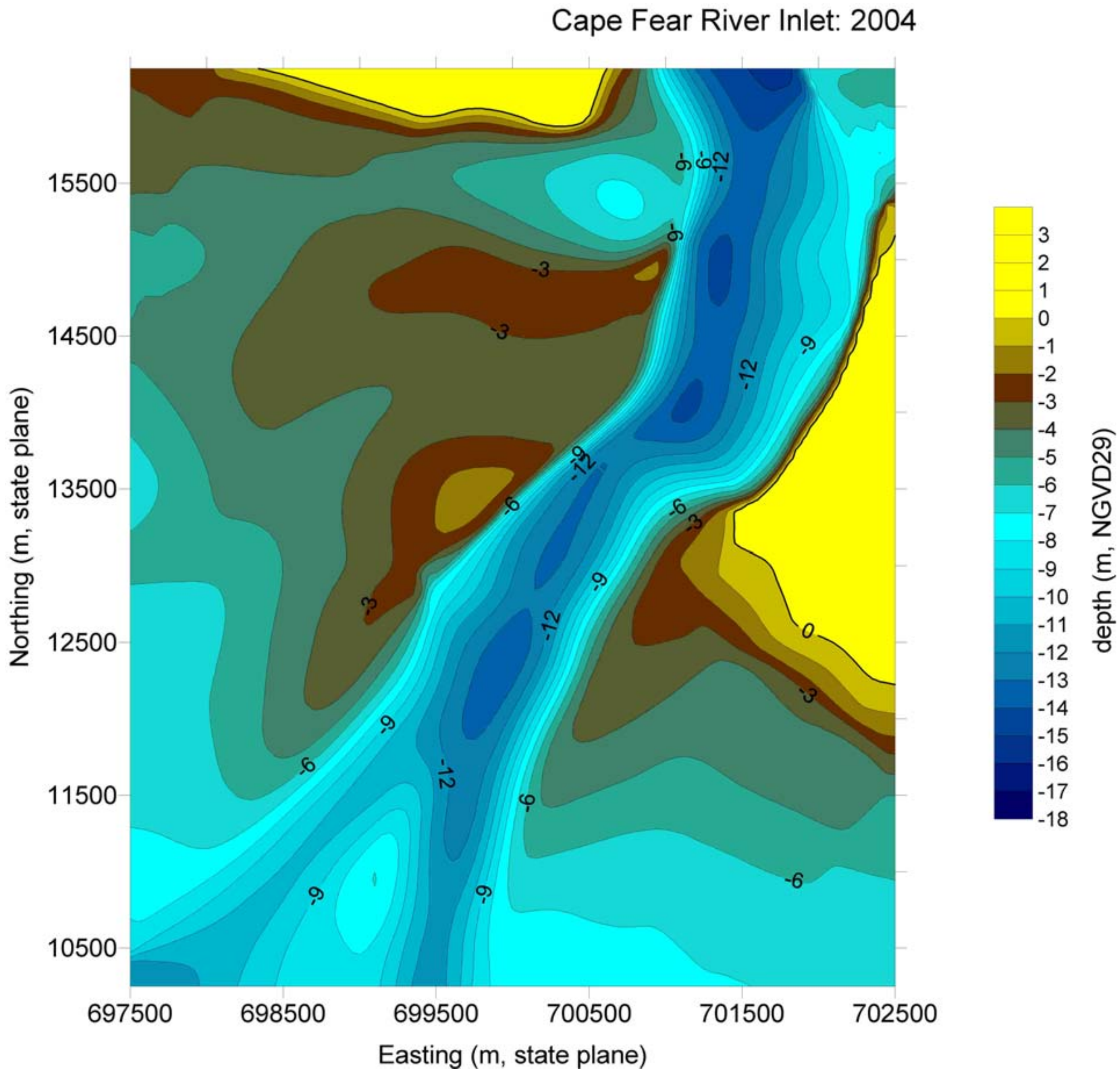


Figure 3.23 Inset of bathymetry near the Cape Fear River tidal inlet 2004

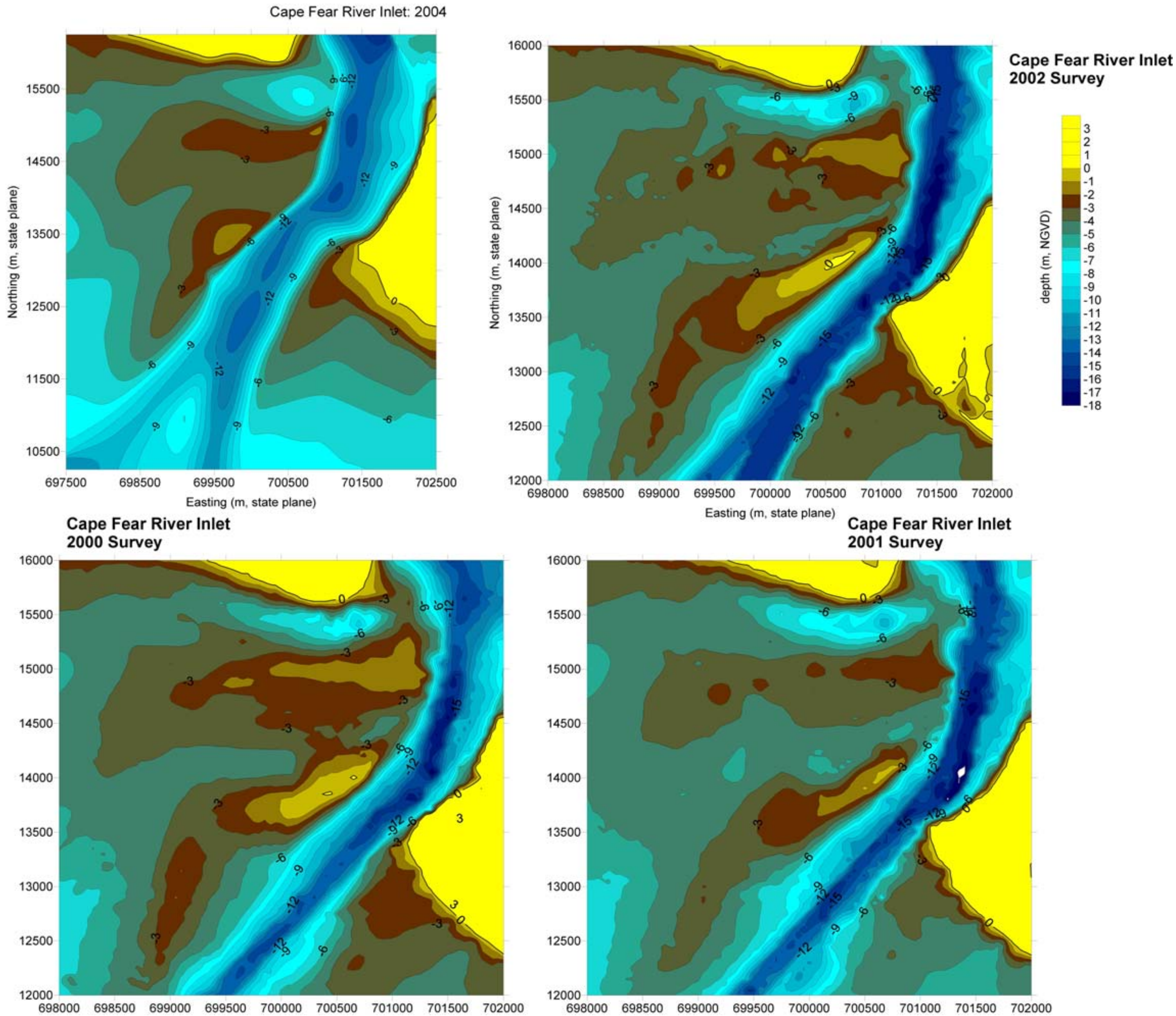


Figure 3.24 Comparison of bathymetry near the Cape Fear River tidal inlet showing bathymetry from the 2000, 2002, 2003 &2004

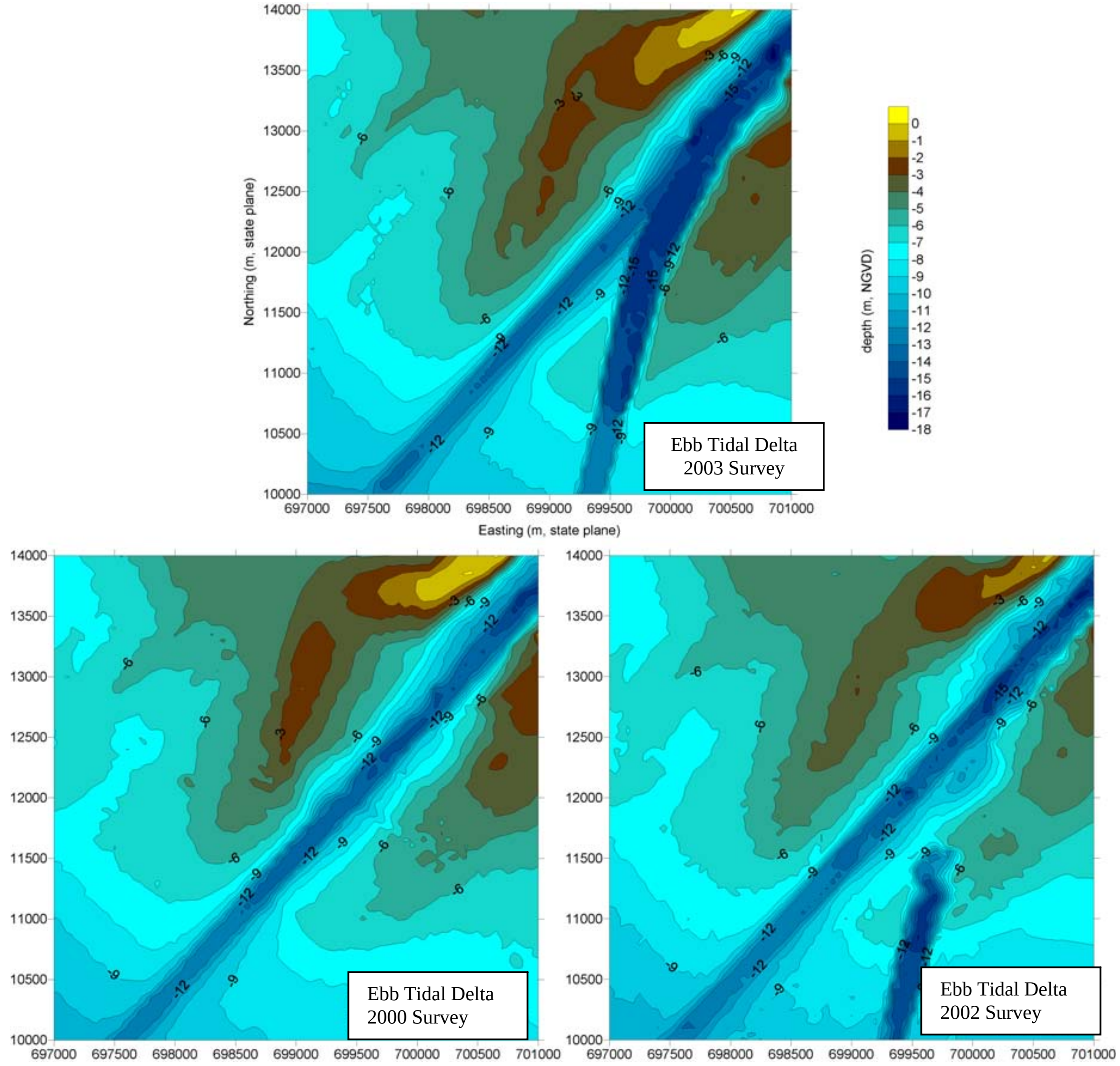


Figure 3.25 Inset of bathymetry near the new channel from of the first 3 surveys- 2000, 2002, & 2003.

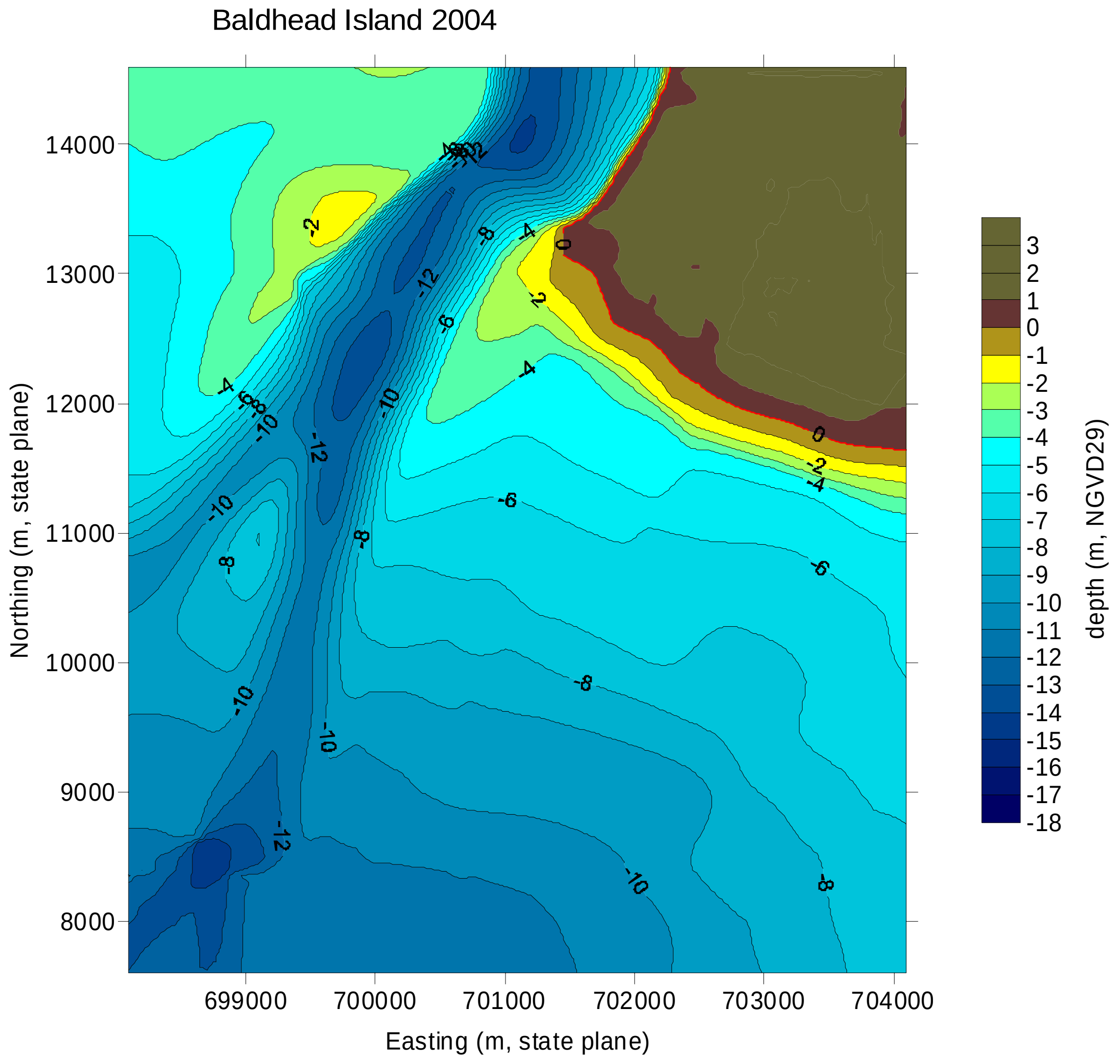


Figure 3.26 Inset of bathymetry along the western portion of Baldhead Island, 2004.

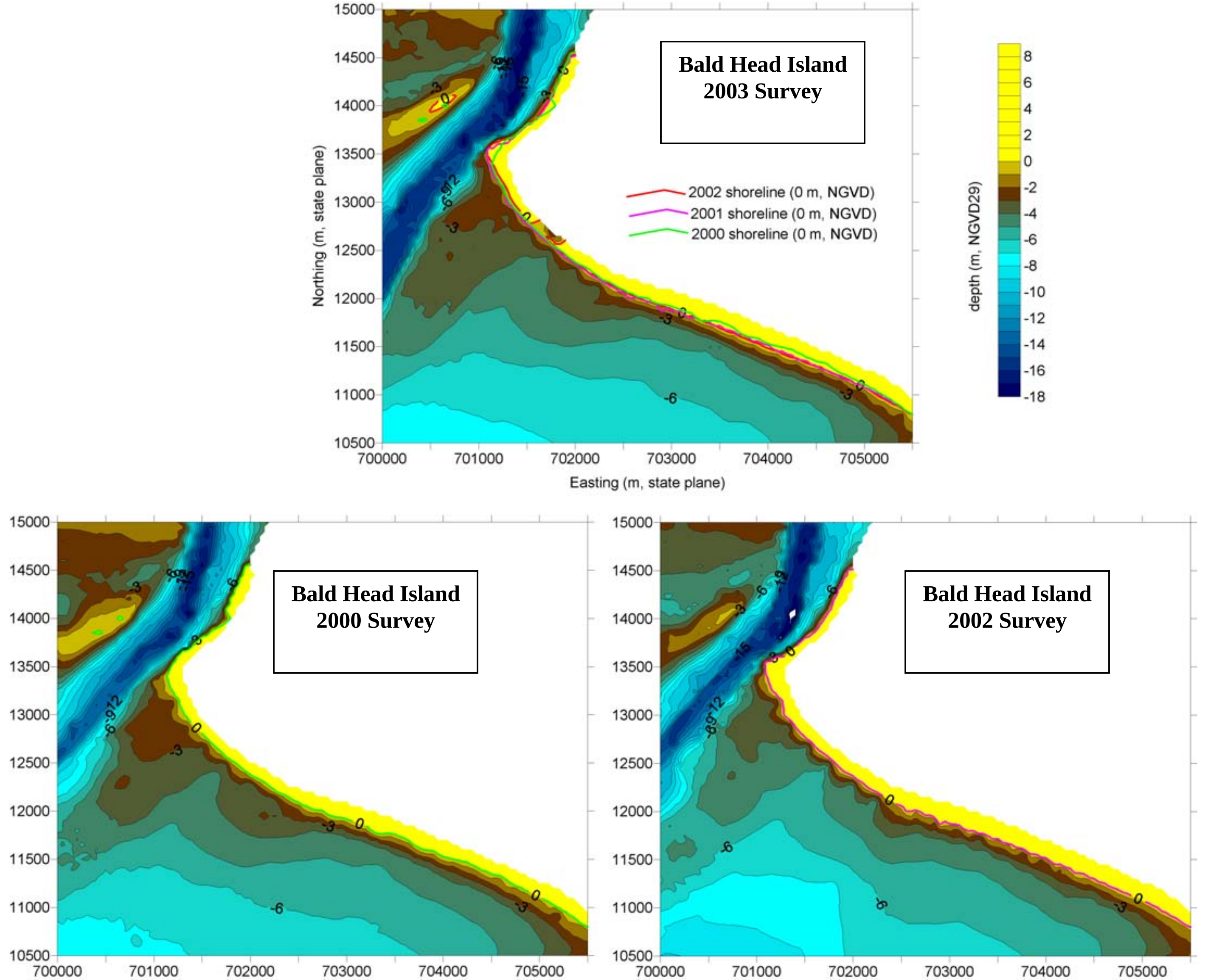


Figure 3.27 Comparison of bathymetry along the western portion of Bald Head Island from the 2000, 2002, and 2003 surveys.

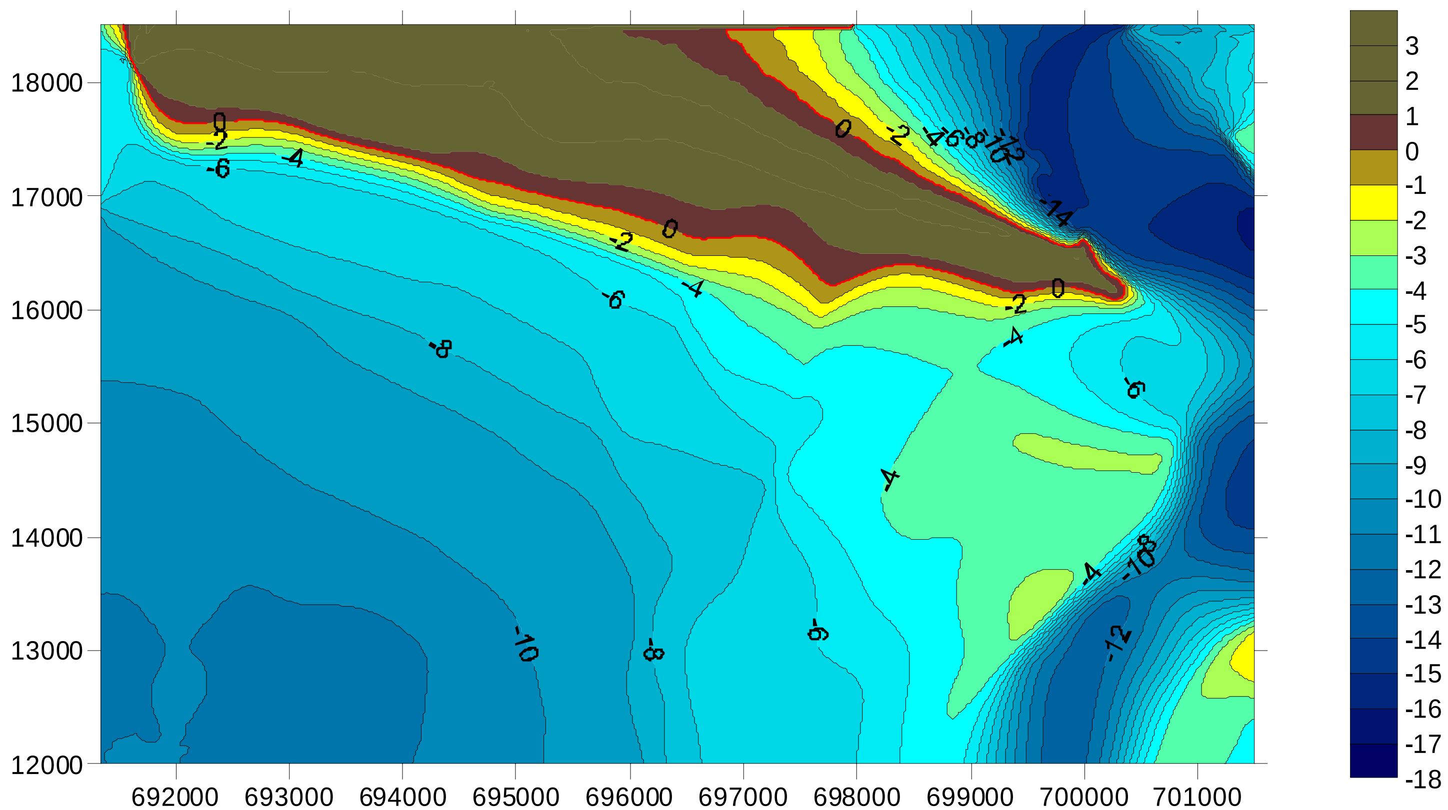


Figure 3.28 Bathymetry of eastern end of Oak Island for 2004 survey.

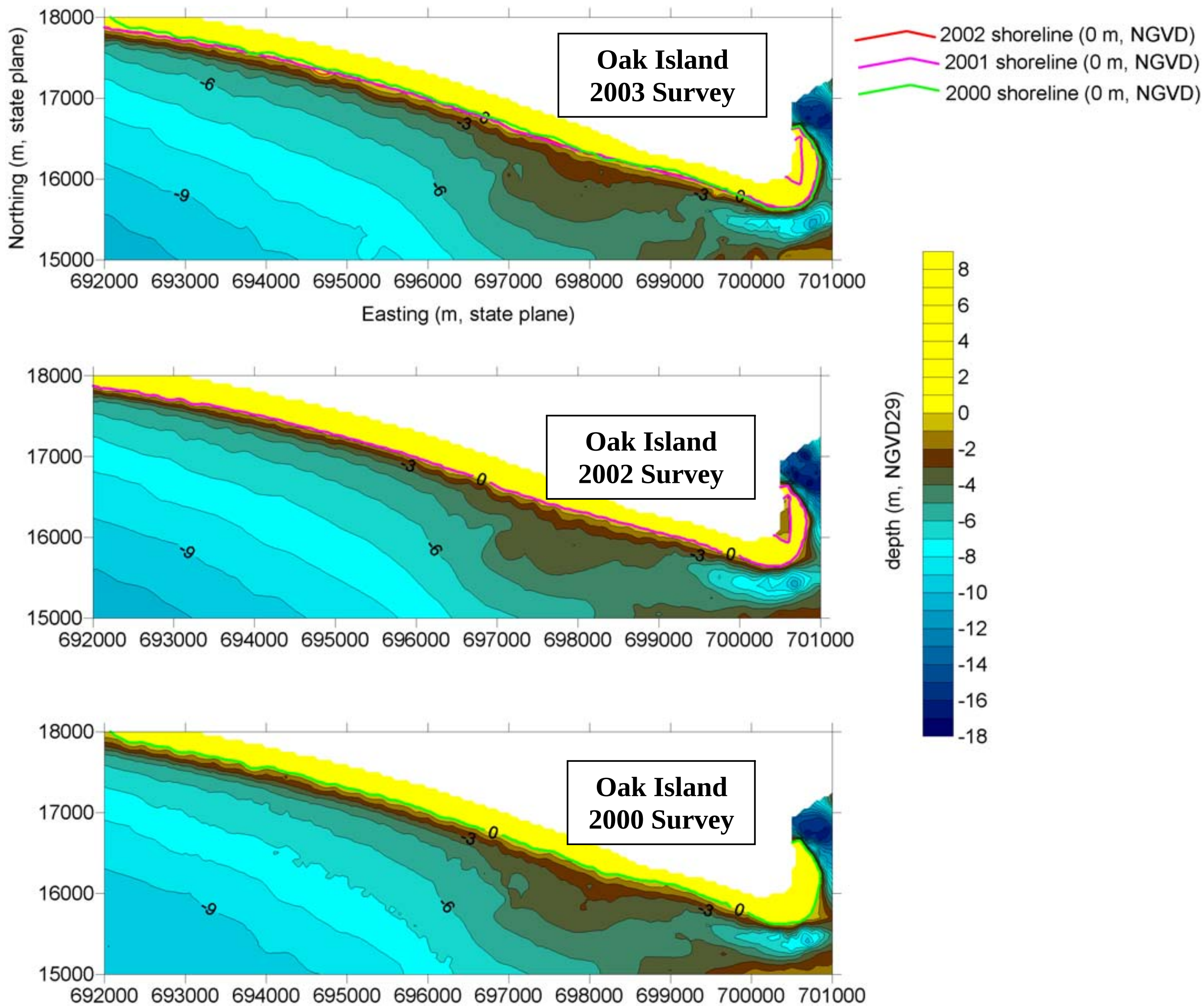


Figure 3.29 Comparison of bathymetry along the eastern portion of Oak Island from the 2000, 2002, and 2003 surveys.

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 3.30. 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 (October 11-12, 2000; April 12-13, 2002; March 4 and 18, 2003; and January 11-13, 2004) during spring tidal conditions. The October 2000 transects were taken prior to the new entrance channel deepening and realignment. 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.

The specific location of the two survey transects are shown on Figures 3.31 and 3.32. 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. The goal was to survey each transect within several days of the predicted spring high tide. Figures 3.33 – 3.36 show the actual survey period during the predicted tides for each of the 4 surveys. These figures show that the October 2000 occurred approximately 3 days prior to spring tide; the April 2002 survey occurred during the lower of the two spring tides in April; the March 2003 survey occurred during the two spring tides in March; and the January 2004 survey occurred approximately 4 days after the smaller spring tide closer to the January neap tide.

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.

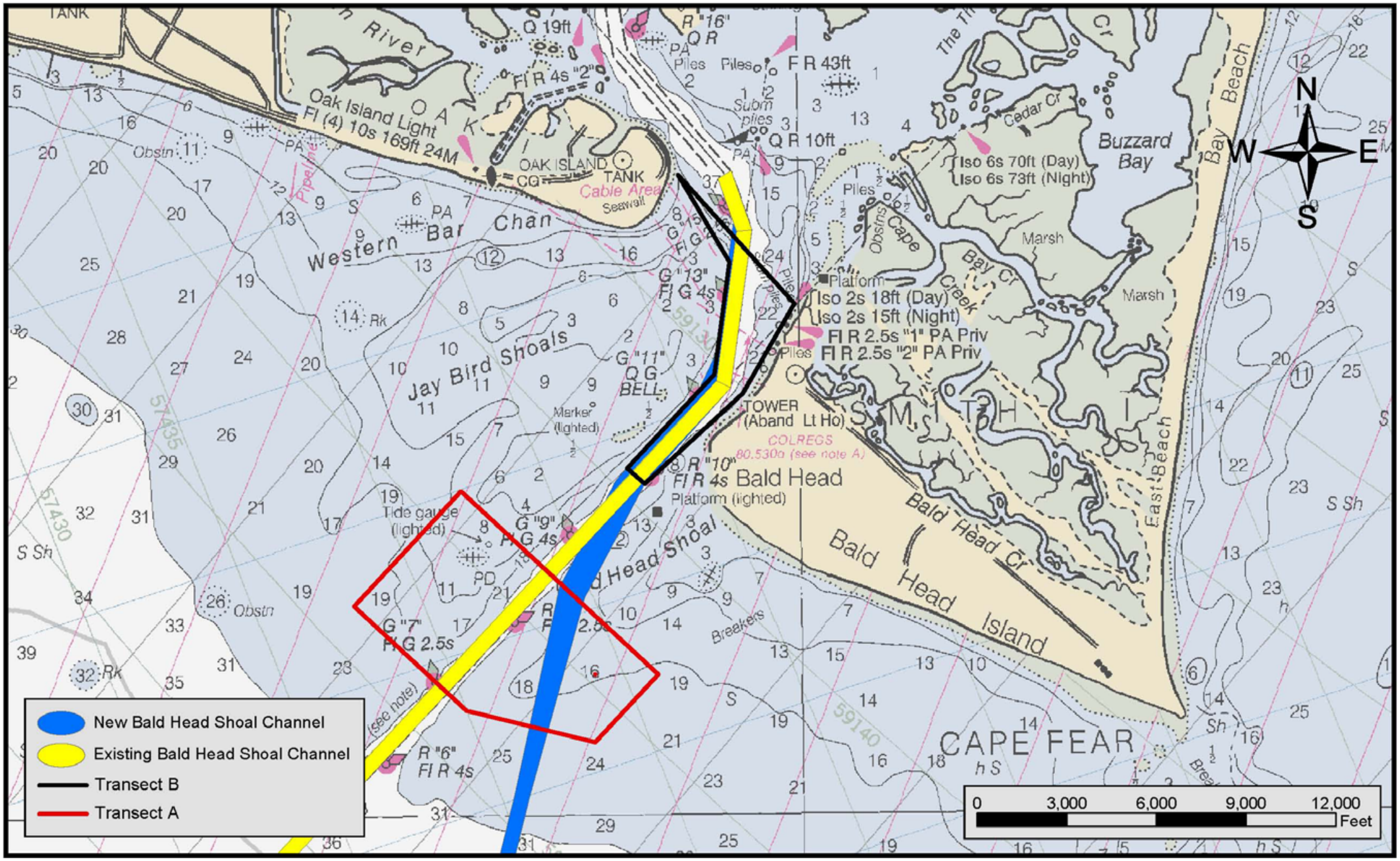


Figure 3.30 Ship-Board current profile track lines

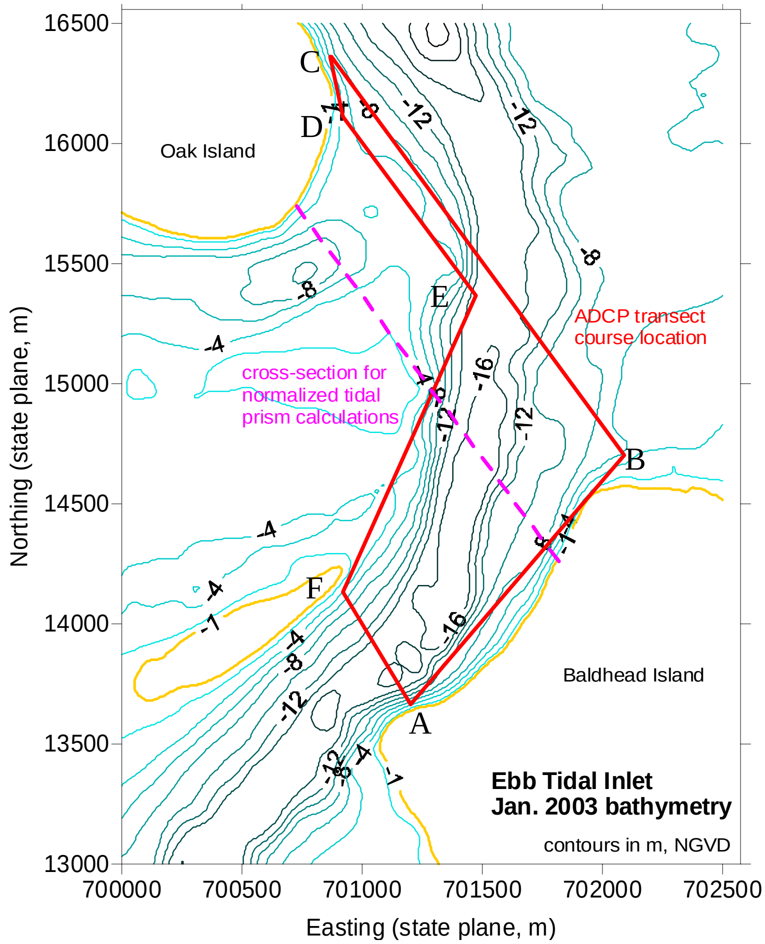


Figure 3.31 Location of inlet ADCP transect

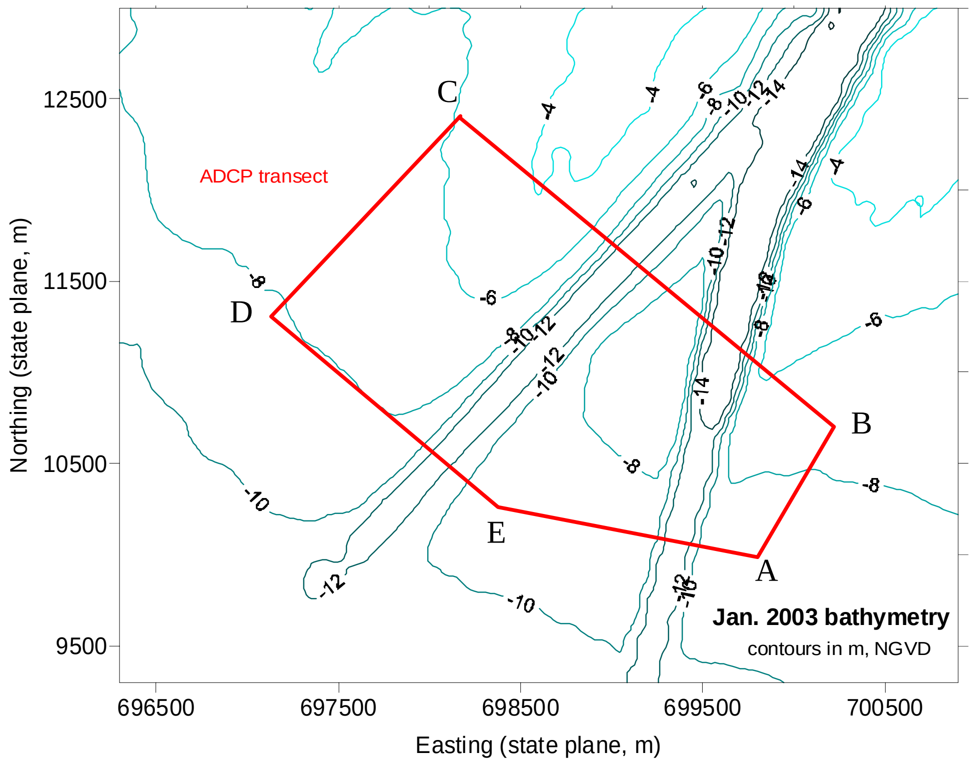


Figure 3.32 Location of offshore ADCP transect

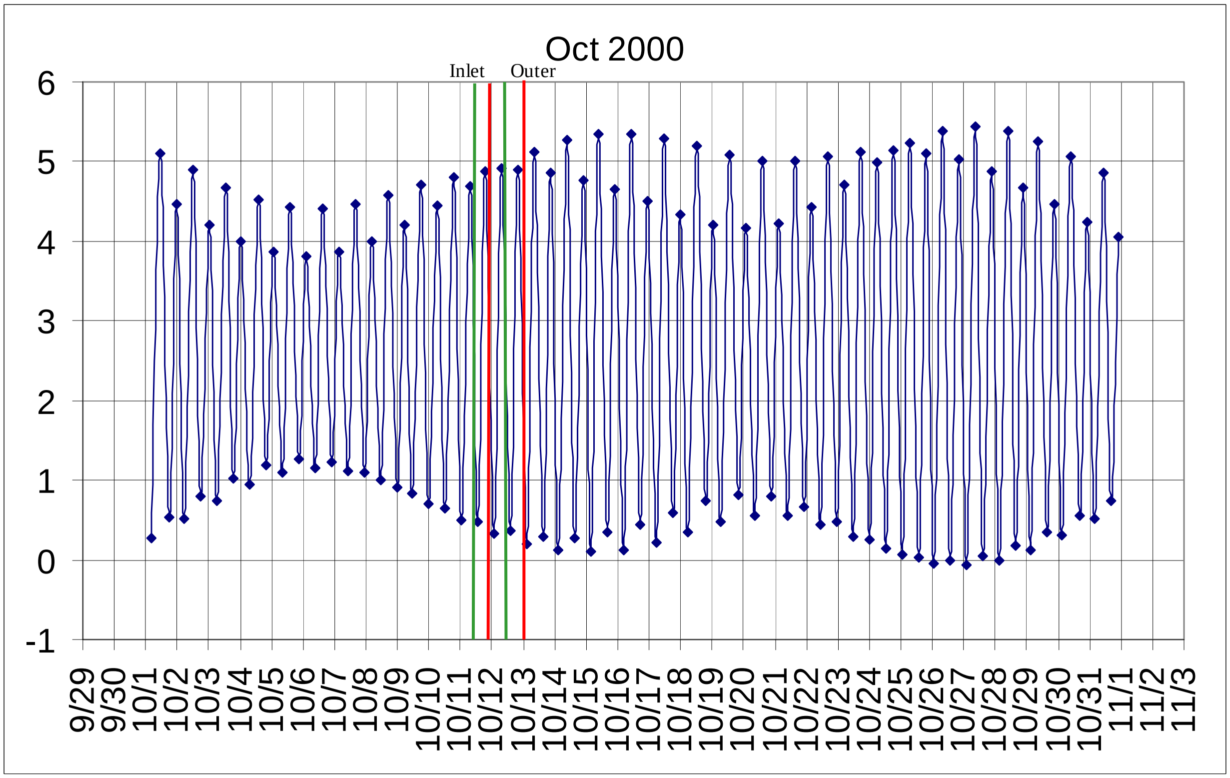


Figure 3.33 October 2000 ADCP survey time relative to predicted tides

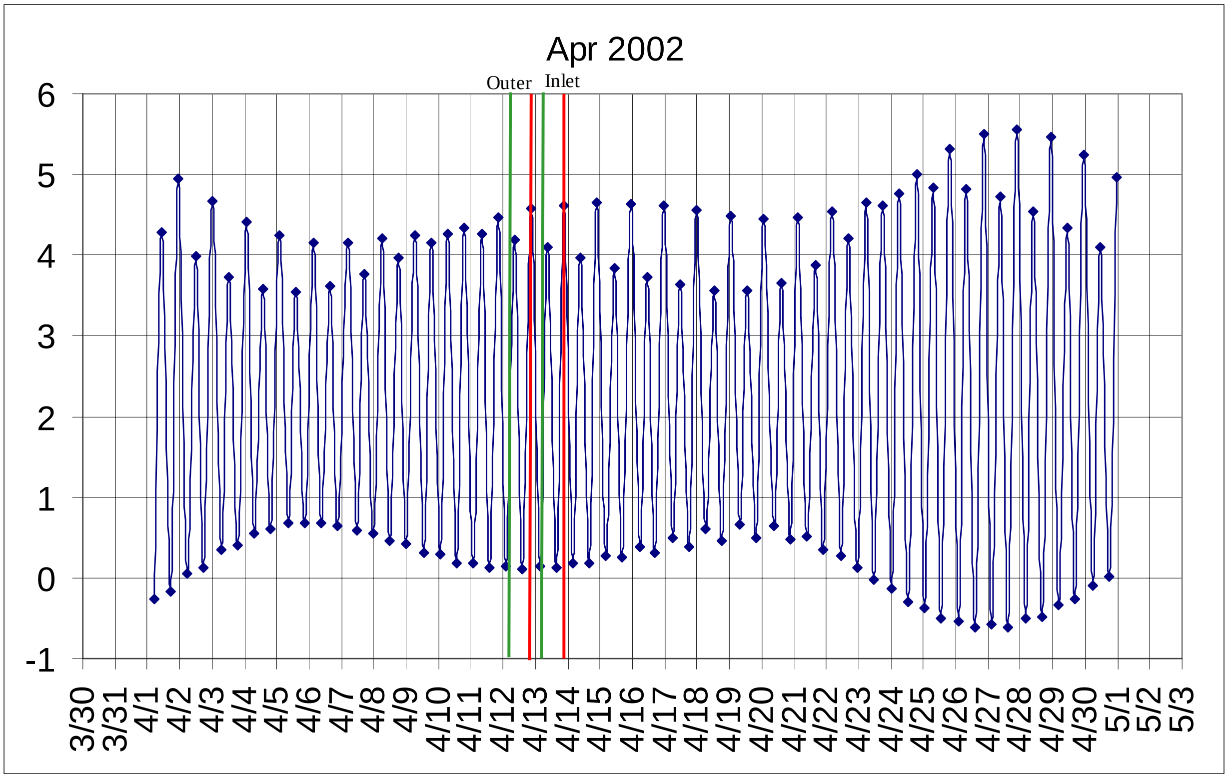


Figure 3.34 April 2002 ADCP survey time relative to predicted tides

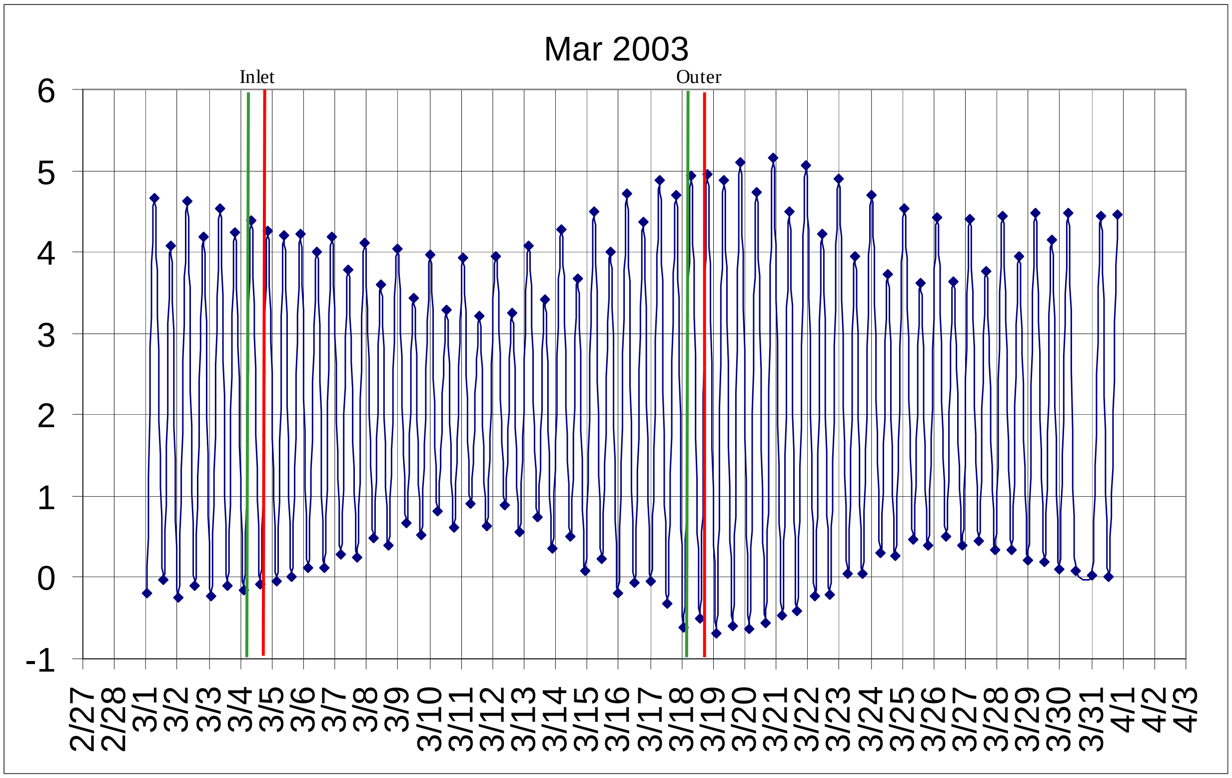


Figure 3.35 March 2003 ADCP survey time relative to predicted tides

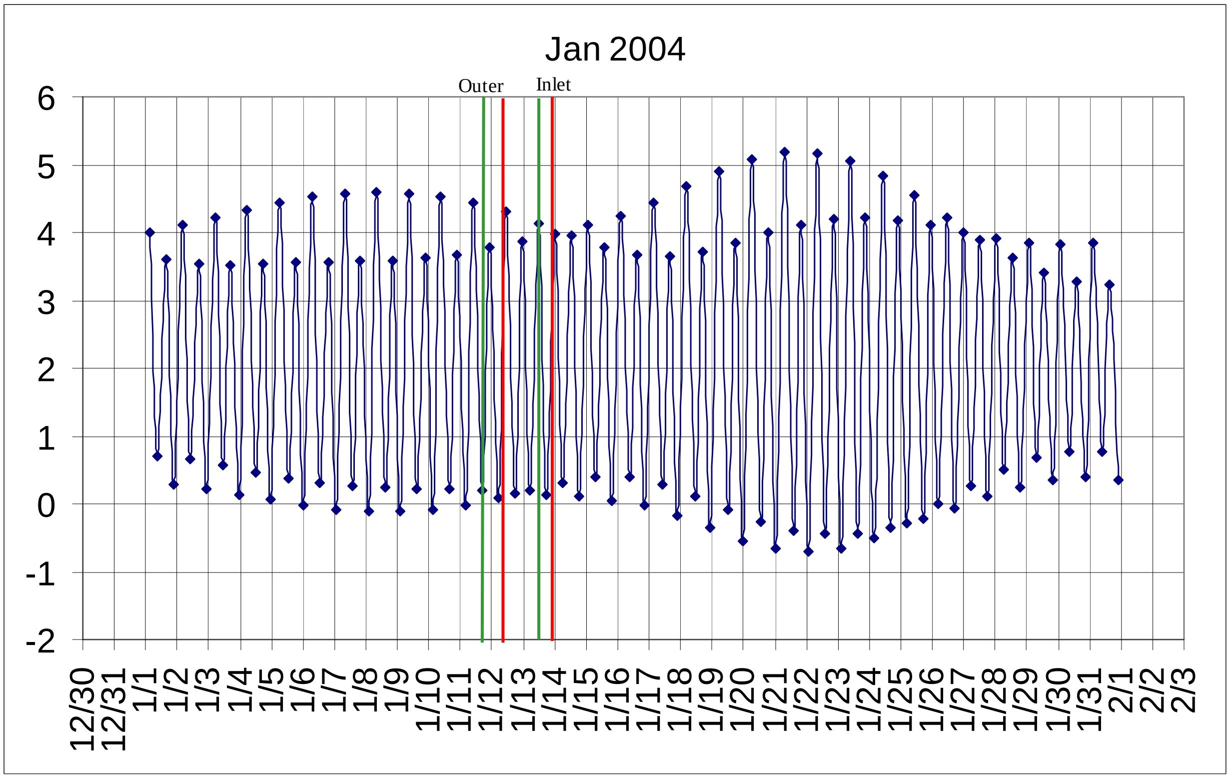


Figure 3.36 January 2004 ADCP survey time relative to predicted tides

Results. The October 2000 survey showed an ebb dominant flow with maximum near-surface ebb and flood velocities of 4.43 ft/s (1.35 m/s) and 3.61 ft/s (1.10 m/s), respectively as measured along the inlet transect (B-C, see Figure 3.31). Using these ADCP data and bathymetric surveys collected in August 2000, ebb and flood tidal prisms were calculated as approximately 6.7×10^9 ft^3 (1.9×10^8 m^3) and 4.7×10^9 ft^3 (1.3×10^8 m^3), respectively. Total tidal volume over the cycle was approximately 1.1×10^{10} ft^3 (3.2×10^8 m^3). Figures 3.37 and 3.38 show peak ebb and flood current velocities respectively for the inlet transect, and Figures 3.39 and 3.40 show peak ebb and flood current velocities respectively for the offshore transect.

The April 2002 survey also showed ebb dominated flow with maximum near-surface ebb and flood velocities of 6.46 ft/s (1.97 m/s) and 4.10 ft/s (1.25 m/s), respectively as measured along the inlet transect (B-C, see Figure 3.31). Figures 3.41 and 3.42 show peak ebb and flood current velocities respectively for the inlet transect. Figures 3.43 and 3.44 show the peak ebb and flood current velocities respectively for the offshore transect. Current speed and direction appear to be influenced by shoals on the western flank of the ebb delta particularly during flooding periods. Water appears to be funneled through the flood margin channel flanking Oak Island and around the two linear shoals before joining the main channel. The large shoal that extends from Bald Head Island suggests that a significant flood margin channel does not occur on the east side of the inlet. On the ebb tide flow, currents appear to be concentrated in the main ebb channel, which is a consistent observation for tidal inlets such as this at the Cape Fear River entrance.

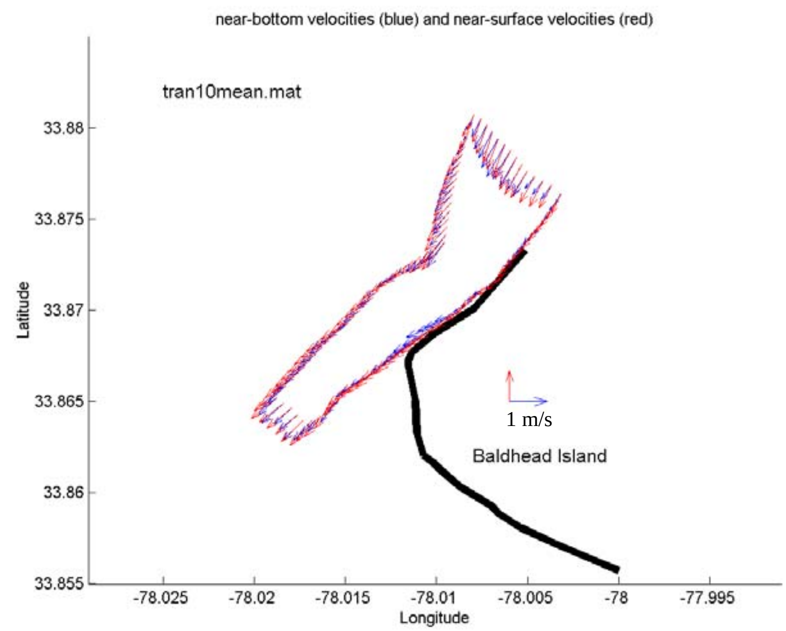


Figure 3.37 Peak ebb current velocities at inlet transect for October 2000 ADCP survey

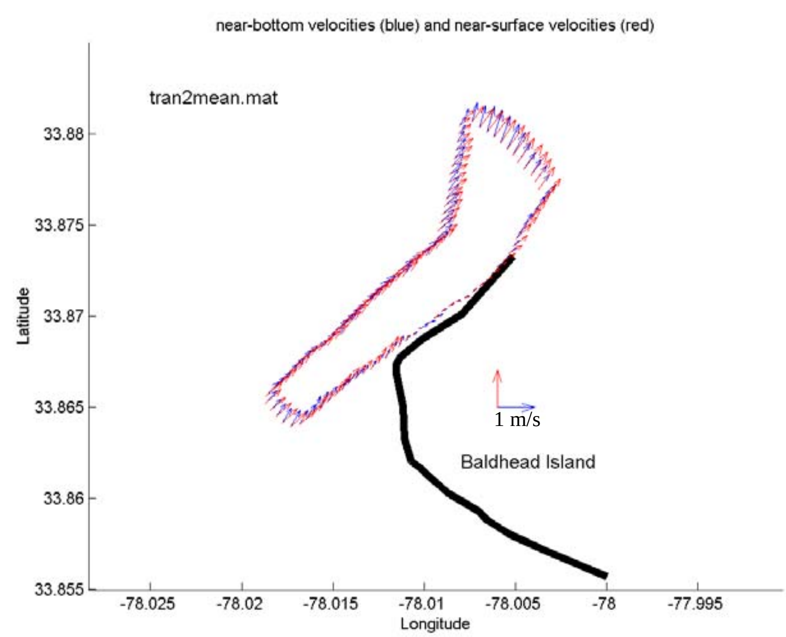


Figure 3.38 Peak flood current velocities at inlet transect for October 2000 ADCP

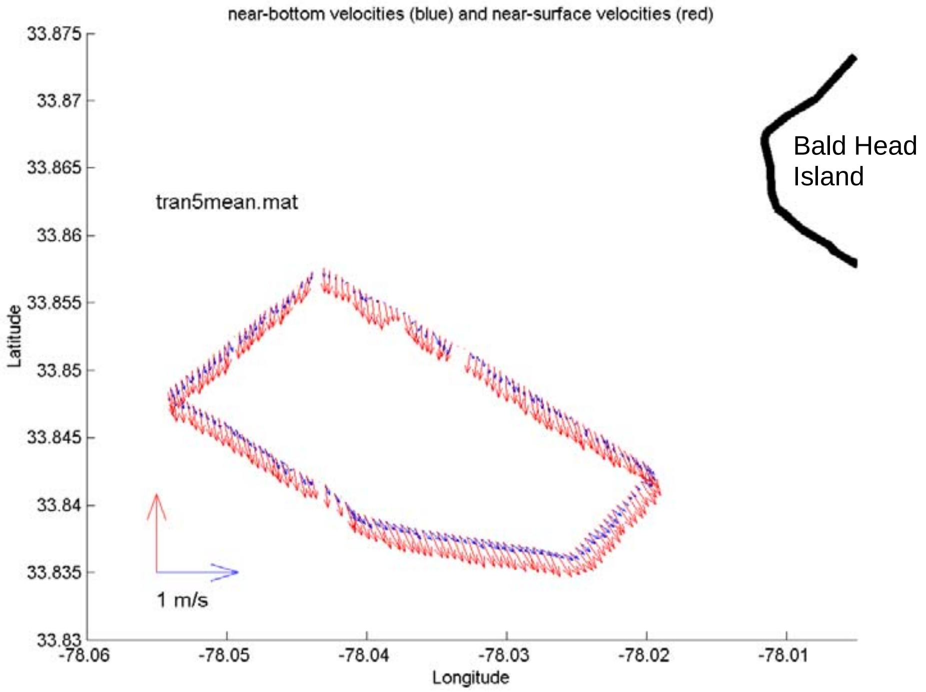


Figure 3.39 Peak ebb current velocities at offshore transect for October 2000 ADCP survey

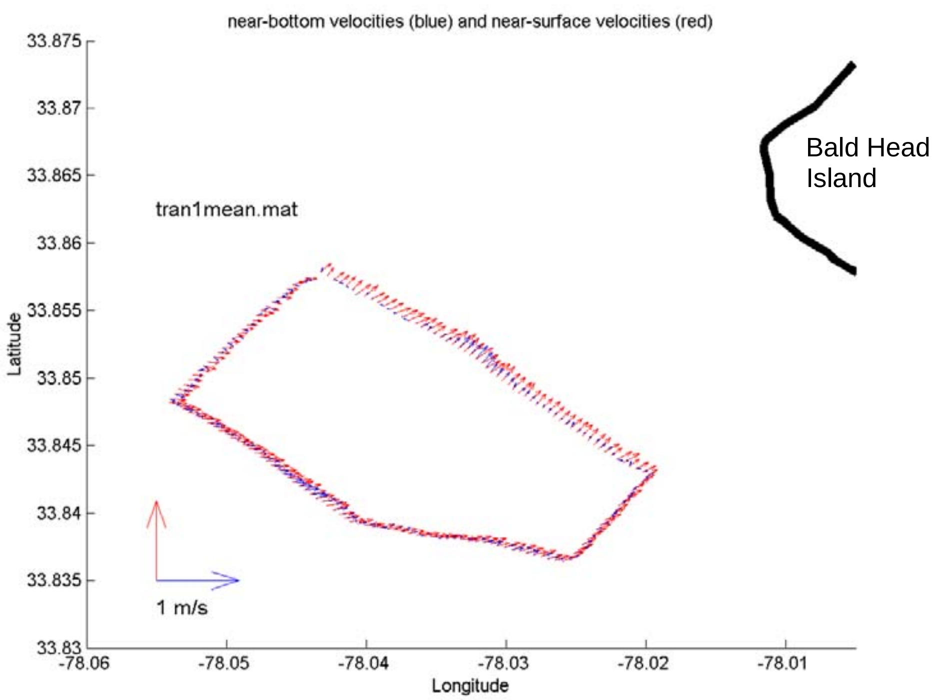


Figure 3.40 Peak flood current velocities at offshore transect for October 2000 ADCP

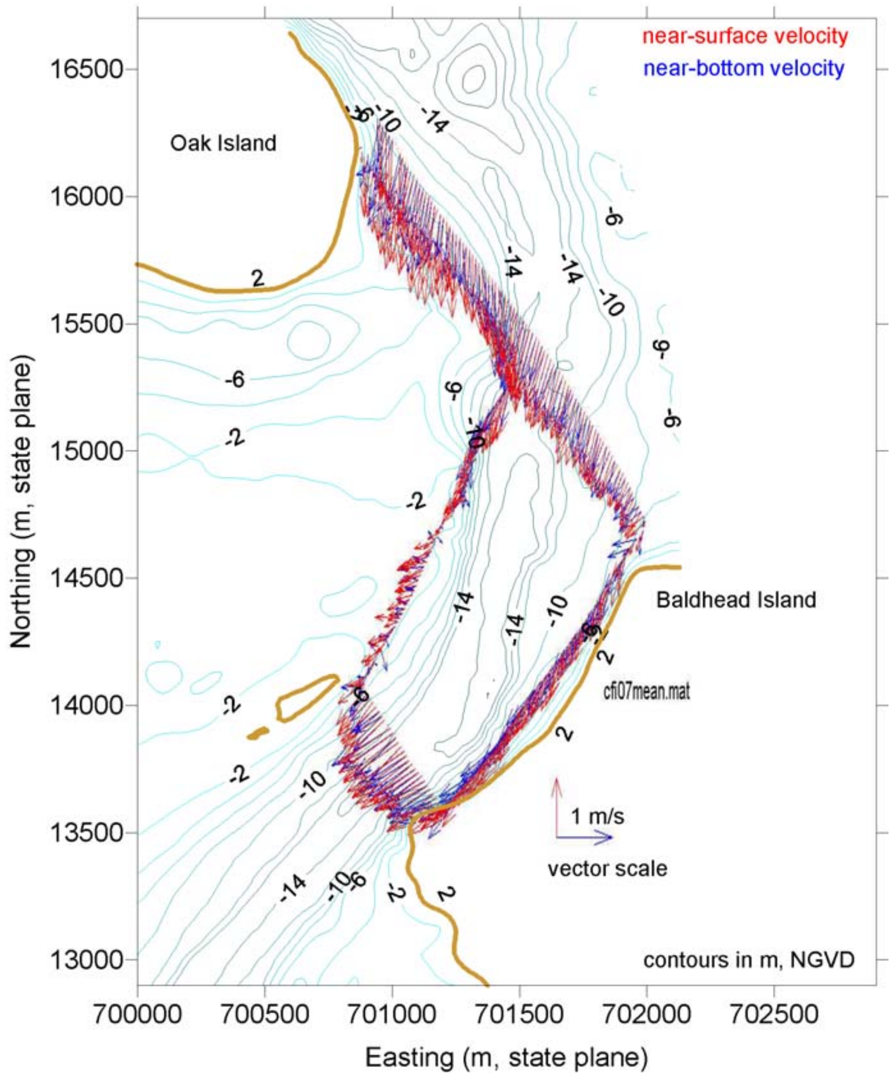


Figure 3.41 Peak ebb current velocities at inlet transect for April 2002 ADCP survey

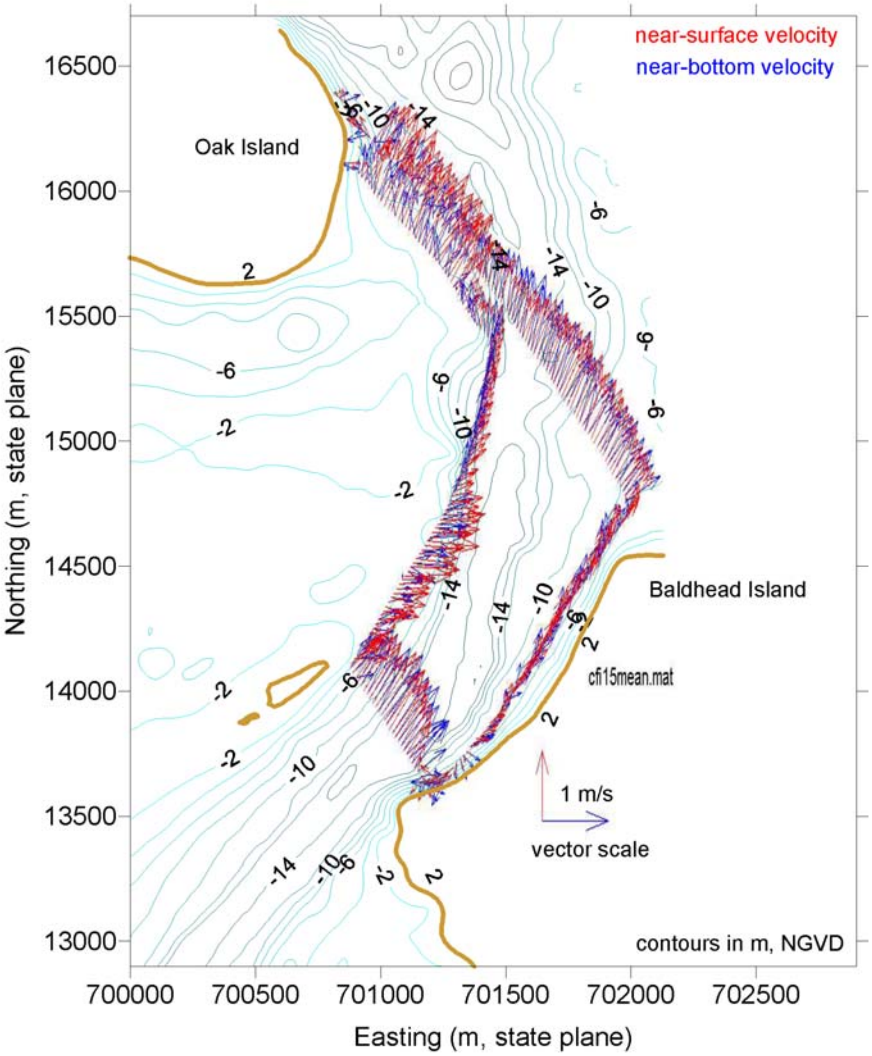


Figure 3.42 Peak flood current velocities at inlet transect for April 2002 ADCP survey

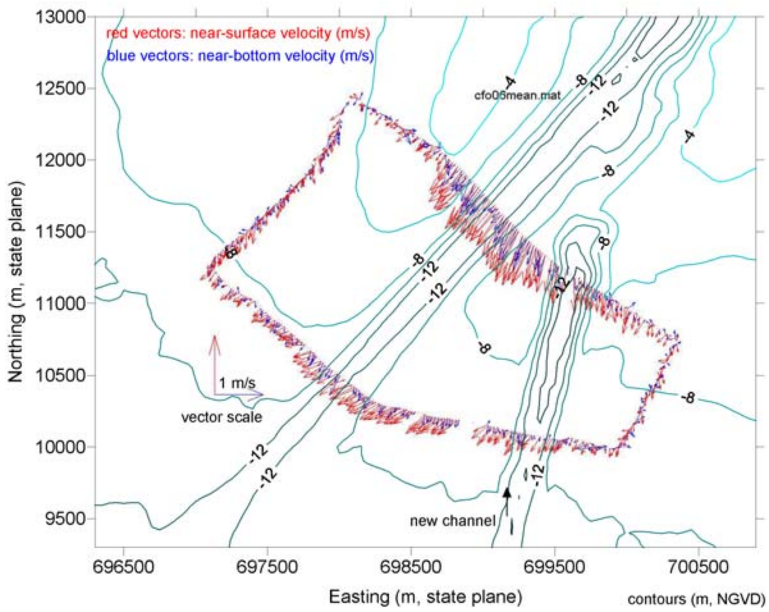


Figure 3.43 Peak ebb current velocities at offshore transect for April 2002 ADCP survey

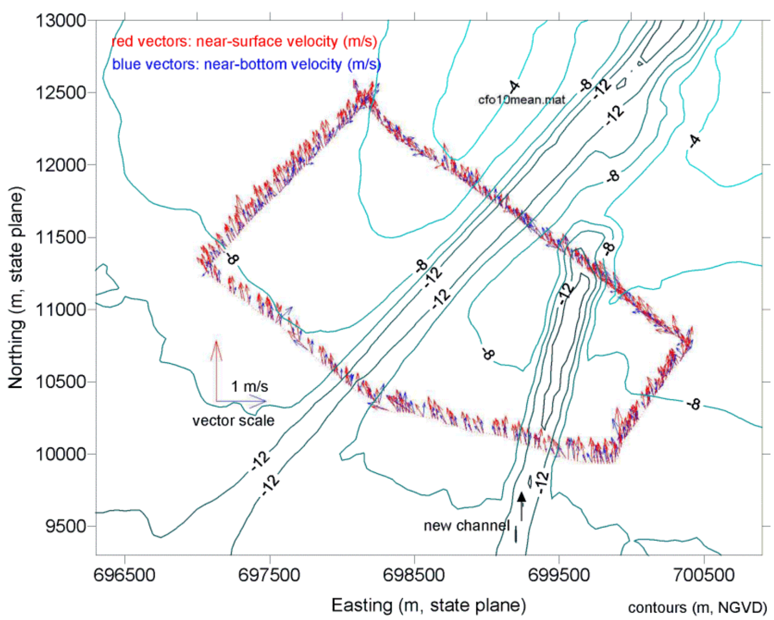


Figure 3.44 Peak flood current velocities at offshore transect for April 2002 ADCP survey

The measured tidal prism for the April 2002 survey continues to be ebb dominated with approximately 5.3x10^9 ft^3 (1.5x10^8 m^3) on the ebb flow and 3.9x10^9 ft^3 (1.1x10^8 m^3) on the flood flow and a total flow volume of 9.2x10^9 ft^3 (2.6x10^8 m^3).

In March 2003, ADCP surveys again showed mean currents that were strongly influenced by local bathymetry. Highest flood flows were recorded funneling primarily through the flood margin channel adjacent to Oak Island, while the highest ebb flows were concentrated in the central ebb channel as shown in Figures 3.45 and 3.46. Maximum near-surface ebb and flood velocities at the inlet transect (B-C) were 5.41 ft/s (1.65 m/s) and 4.17 ft/s (1.27 m/s), respectively. An interesting observation noted during the inlet transect survey was that a sustained ebb flow was measured on both the west and east side of the inlet during flood flows and was likely a result of fluvial discharges from the Cape Fear River. To further support this assertion, it was noted that B. Everette Jordan Lake (on the Haw River upstream of the Cape Fear River) experienced an increase in lake elevation approximately 7 to 10 days prior to this survey suggesting that the Deep and Haw Rivers (which combine to form the Cape Fear River) experienced increased discharge from rainfall runoff that could have influenced these measurements.

Tidal prism calculations for the March 2003 survey show an ebb volume of approximately 6x10^9 ft^3 (1.7x10^8 m^3), flood volume of approximately 4x10^9 ft^3 (1.2x10^8 m^3), and total volume of approximately 1x10^{10} ft^3 (2.8x10^8 m^3).

Figure 3.47 and 3.48 show peak ebb and flood current velocities for the offshore transect. These figures indicate that peak ebb flows on the order of 3.3 ft/s (1 m/s) are found concentrated in the vicinity of the existing channel. Further, peak ebb velocities along the new channel remain relatively small. With respect to peak flood currents, the measurements indicate that the magnitudes and directions are fairly uniform over the offshore transect.

ADCP surveys were taken in January 2004 and again reveal mean currents that are clearly influenced by localized bathymetry. During ebb flow, currents funnel through the two deepest channels – the flood margin channel along Oak Island and the main ebb channel (Figure 3.49). On flood flow, currents generally follow the contours through the channels (Figure 3.50). Maximum near-surface ebb and flood velocities at the inlet transect (B-C) were 3.88 ft/s (1.18 m/s) and 3.75 ft/s (1.14 m/s), respectively. Figure 3.50 also shows a region near Jay Bird Shoals where water flows into the main channel at a fairly high angle relative to the local bathymetry and likely generates substantial horizontal sheer. This same pattern was found in the same area in previous surveys. Current magnitudes consistently exceed 3.3 ft/s (1 m/s) during peak flows and are highest in the near-surface – this difference in near-surface and near-bottom magnitudes is most pronounced during the ebb (see Figure 3.49).

At the offshore transect, flow magnitudes are less than the inlet transect but velocities of around 3.3 ft/s (1 m/s) were measured in the vicinity of the channels at the height of the ebb and decreased rapidly outside the channels, particularly along the western side of the ebb tidal delta (Figure 3.51). During flood flow current magnitudes were nearly equal throughout the transect (Figure 3.52).

Tidal prism calculations for the January 2004 survey show an ebb volume of approximately 5×10^9 ft^3 (1.5×10^8 m^3), flood volume of approximately 3×10^9 ft^3 (0.9×10^8 m^3), and total volume of approximately 8×10^{10} ft^3 (2.4×10^8 m^3).

Relative changes between ADCP measurements from the October 2000 transects and the most recent measurements are discussed in Part 4 of the report.

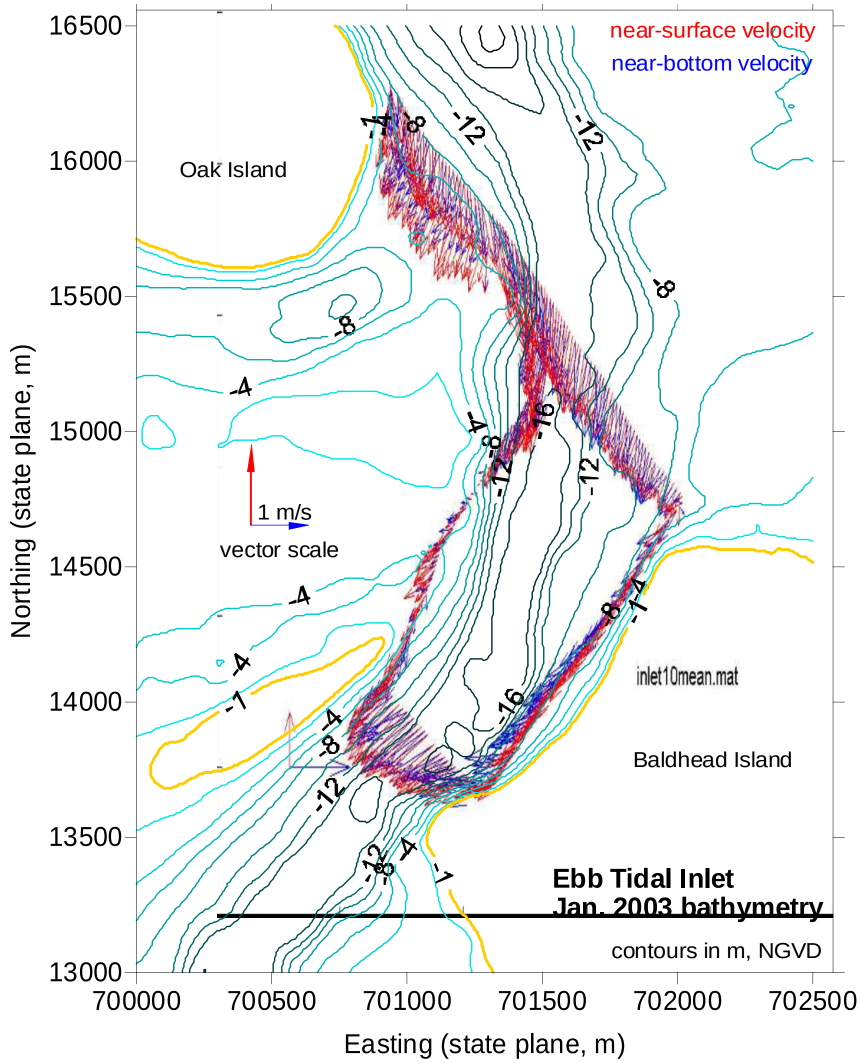


Figure 3.45 Peak ebb current velocities at inlet transect for March 2003 ADCP survey

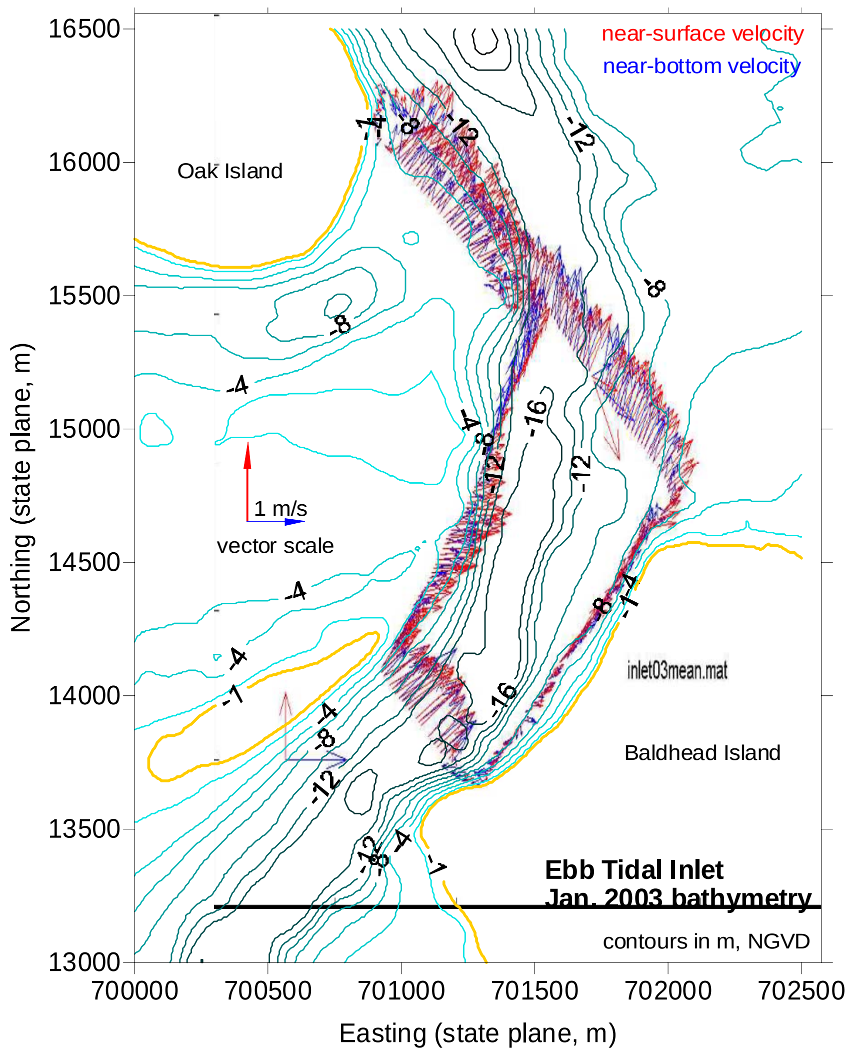


Figure 3.46 Peak flood current velocities at inlet transect for March 2003 ADCP survey

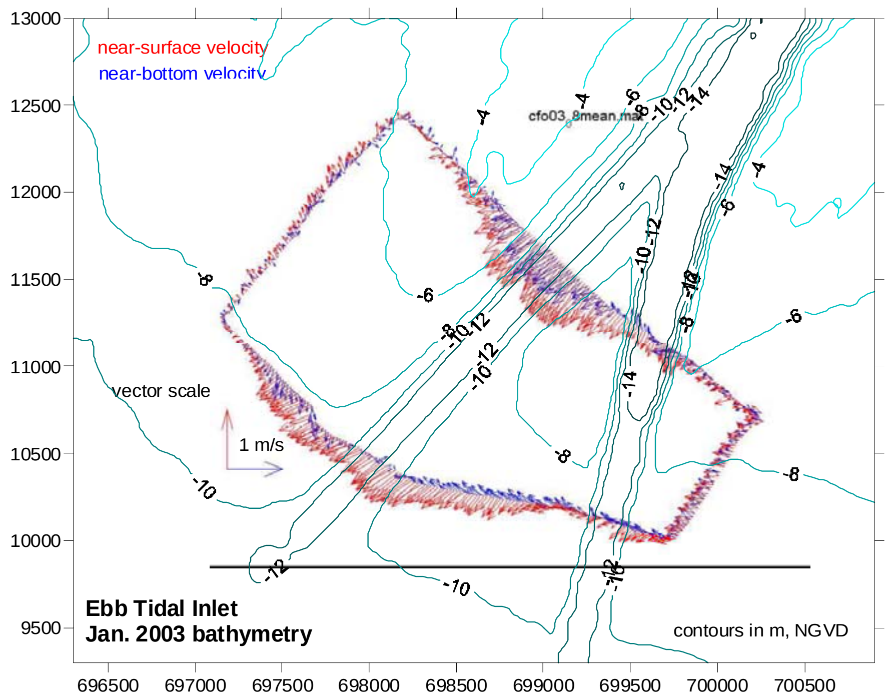


Figure 3.47 Peak ebb current velocities at offshore transect for March 2003 ADCP survey

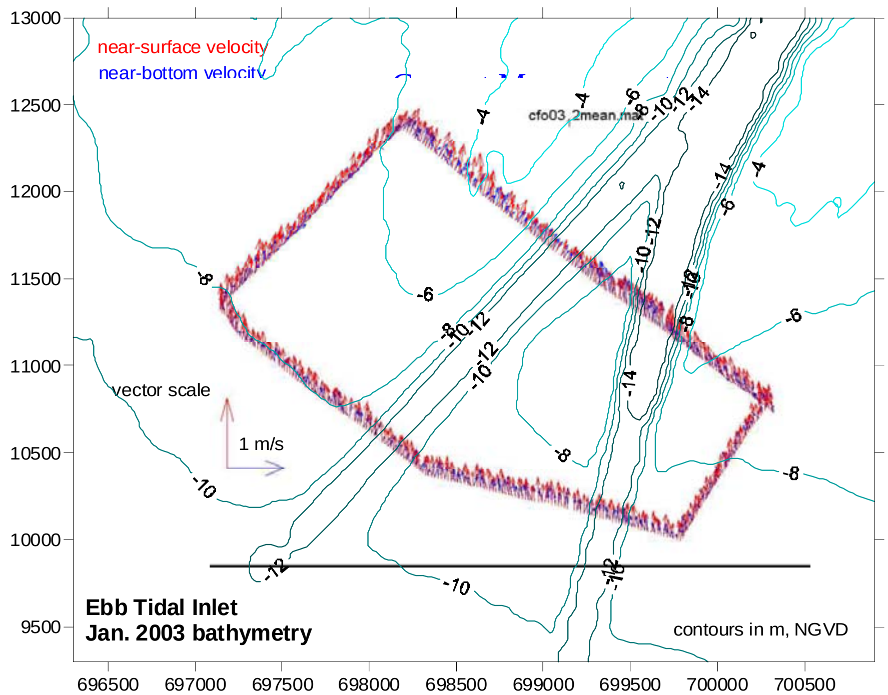


Figure 3.48 Peak flood current velocities at offshore transect for March 2003 ADCP survey

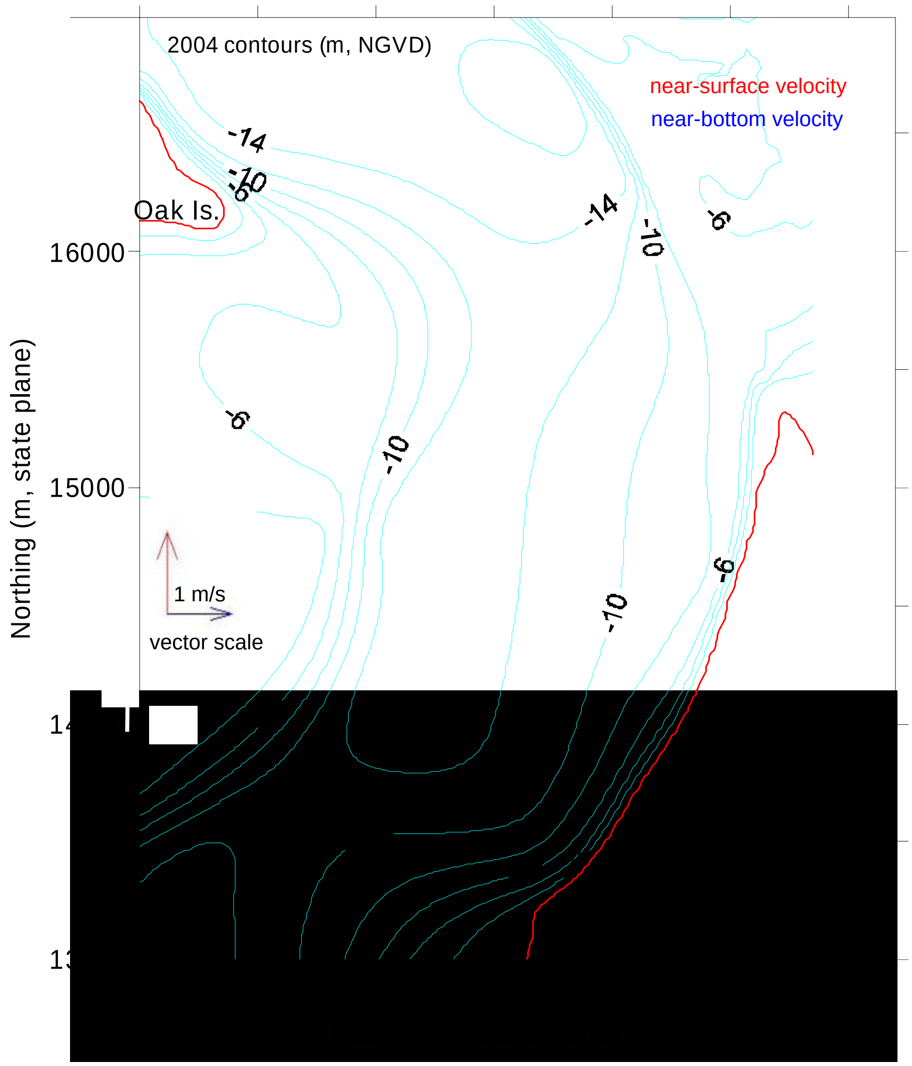


Figure 3.49 Peak ebb current velocities at inlet transect for January 2004 ADCP survey

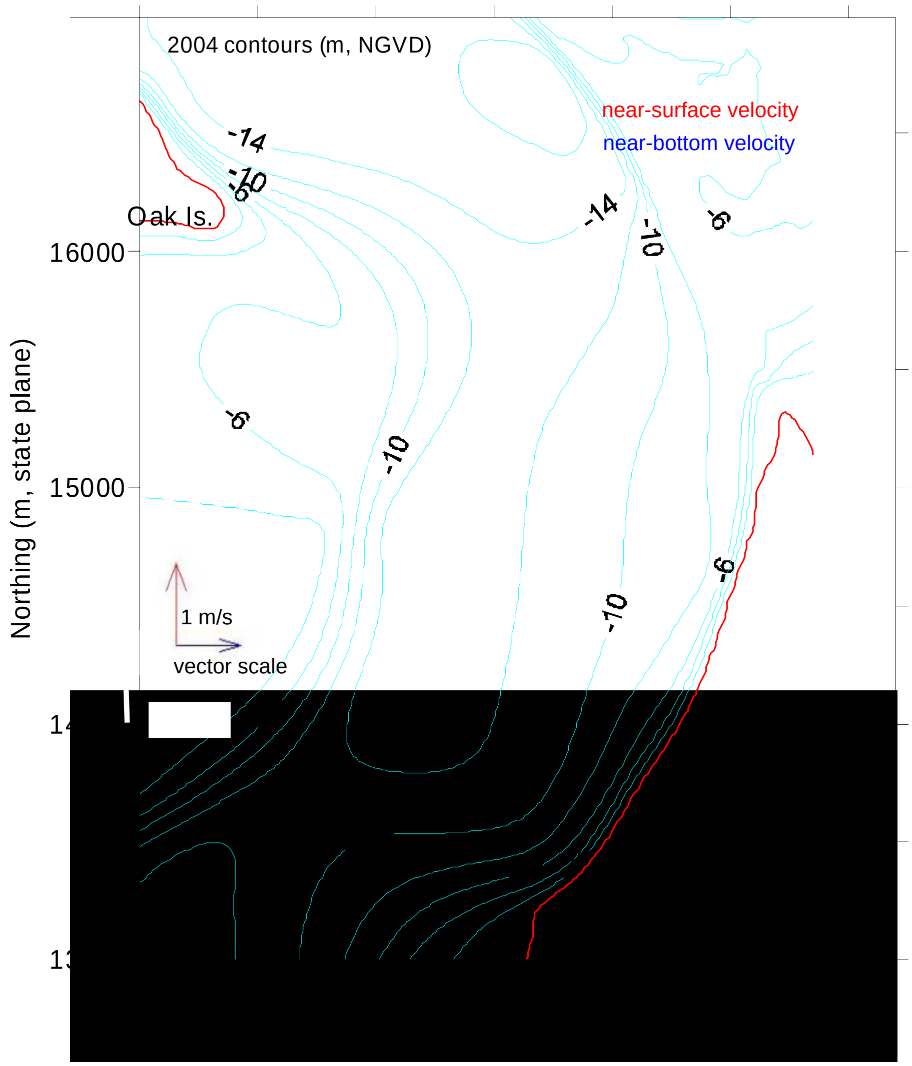


Figure 3.50 Peak flood current velocities at inlet transect for January 2004 ADCP survey

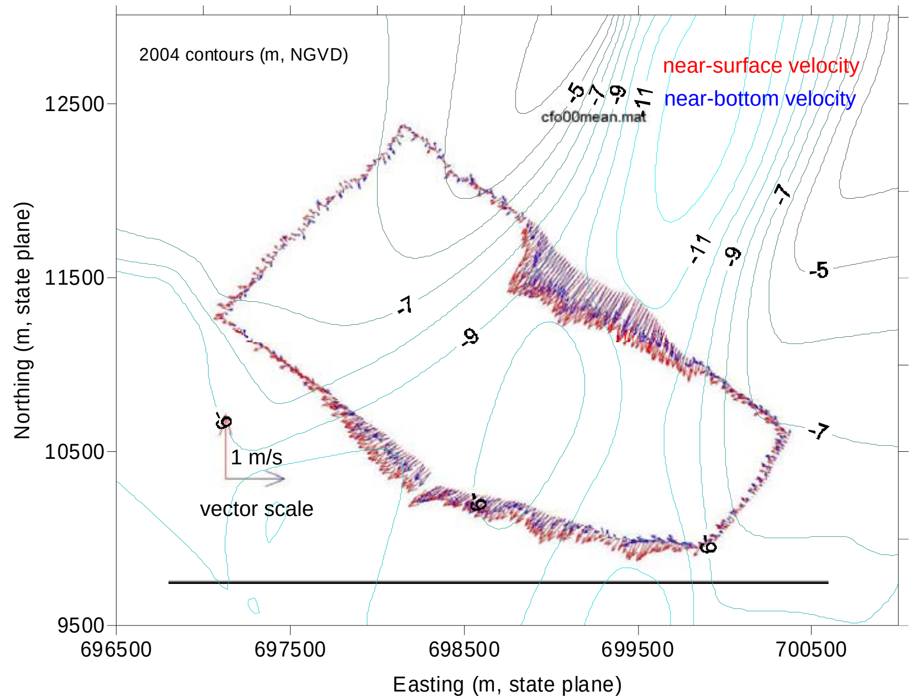


Figure 3.51 Peak ebb current velocities at offshore transect for January 2004 ADCP survey

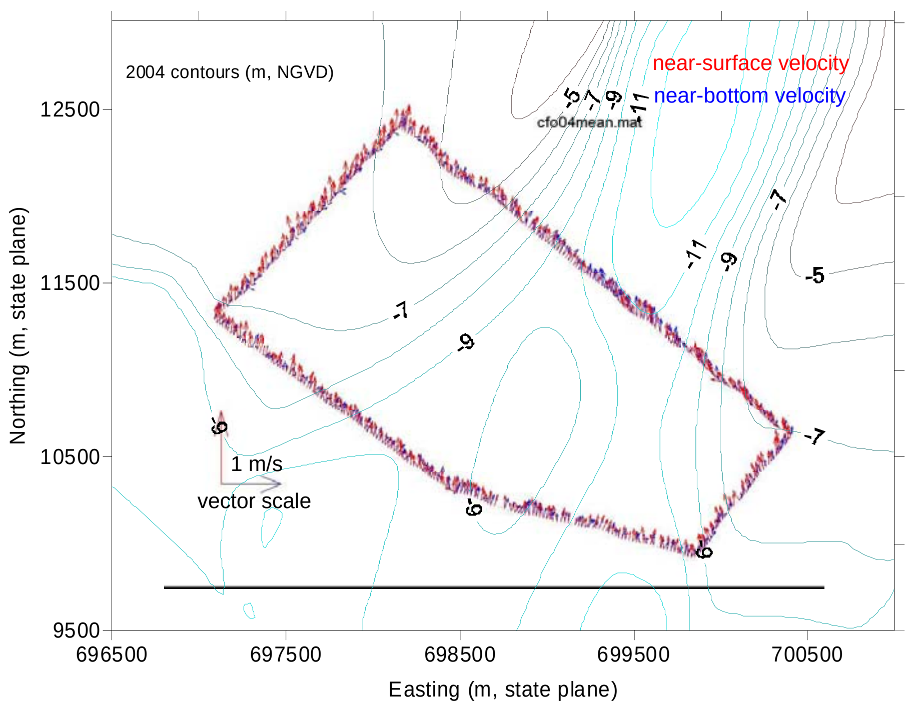


Figure 3.52 Peak flood current velocities at offshore transect for January 2004 ADCP survey

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 of each other and compared to longer-term hindcast data available at the site. Significant wave events are also identified for the initial 4-year monitoring period.

General Wave Climate. Determination of the incident wave climate is a critical first step in nearshore wave transformation and littoral transport studies. In this case, long-term, high-quality hindcast data are available to use in conjunction with the directional wave measurements for the area. The long-term wave data are available from the Wave Information Study (WIS) database. The WIS station locations along with the local wave gauge locations available for the study area are displayed in Figure 3.53.

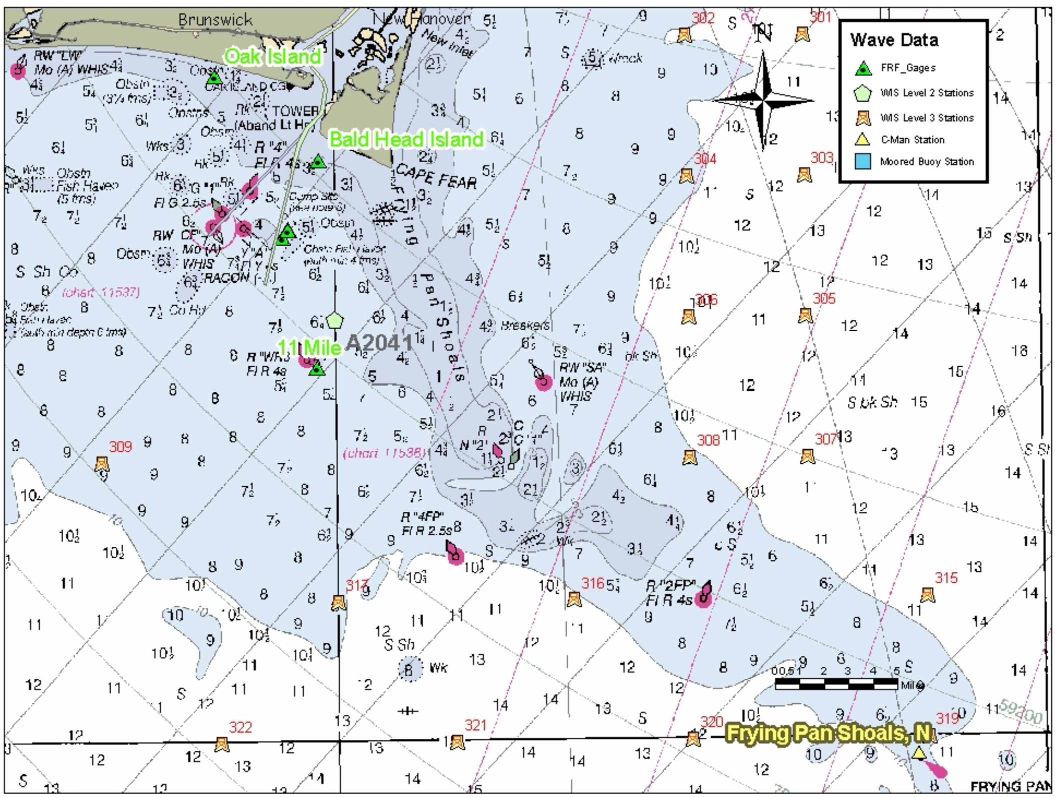


Figure 3.53. Wave Gauge and Hindcast Station Locations.

WIS Hindcasts. The Wave Information Studies (WIS) have developed wave information along U.S. coasts by computer simulation of past wind and wave conditions. This type of simulation is termed hindcasting. The hindcast data provide a valuable source of decades-long wave data needed in coastal engineering design, at dense spatial resolution and at a level of temporal continuity not available from field measurements. The most recent hindcast information consists of a 20-yr continuous time series from 1980-1999. Time series of bulk wave parameters, significant wave height, period, direction, as well as wind speed and direction, are available at 1-hour intervals for a densely-spaced series of nearshore points along the U.S. coastline (in water depths of 50-60 ft) and a less-dense series of points in deep water (water depths of 300 ft or more).

The WIS Level 3 output station used for this study was Station 317, as shown in Figure 3.53, located in 50 ft of water approximately 10 miles south of the Eleven Mile Gauge and west of the outer limits of Frying Pan Shoals. The location of Station 317 provides a good representation of offshore wave conditions, with minimal influence of sheltering by Bald Head Island or refraction around Frying Pan Shoals. Such conditions are very suitable for input to a wave transformation model to account for the influences of Frying Pan Shoals on nearshore wave climate and resulting longshore transport patterns.

To construct the wave climate, percent occurrence tables (broken down by height, period, and direction) were calculated for the entire hindcast using the Coastal Engineering Design and Analysis System (**CEDAS**), Nearshore Evolution Modeling System (NEMOS) software (NEMOS 2000). The Cape Fear wave climate is illustrated in Figure 3.54 as a wave rose with directional resolution of 22.5 deg. Figures 3.55 and 3.56 also show overall distributions by height, period, and direction in a histogram and block format, respectively.

The average annual wave height is approximately 3.6 ft as shown in Table 3.2 with the larger wave heights occurring in the months of January through March. Waves typically approach the study area from the east and southeast (between 90.0 and 135.0 deg azimuth). Wave heights exceeding 6 ft only exist 11 percent of the time, with those waves being predominantly from the south and southeast directions.

A wave period rose and block diagram are shown in Figures 3.57 and 3.58, respectively for Station 317. A tendency for long periods is most evident in waves from around 90 deg, a direction exposed to the open North Atlantic Ocean. Waves from the southeast, an important segment of the wave climate affecting the Cape Fear River entrance, also exhibit fairly long periods. Waves from the south and southwest tend to have relatively short periods.

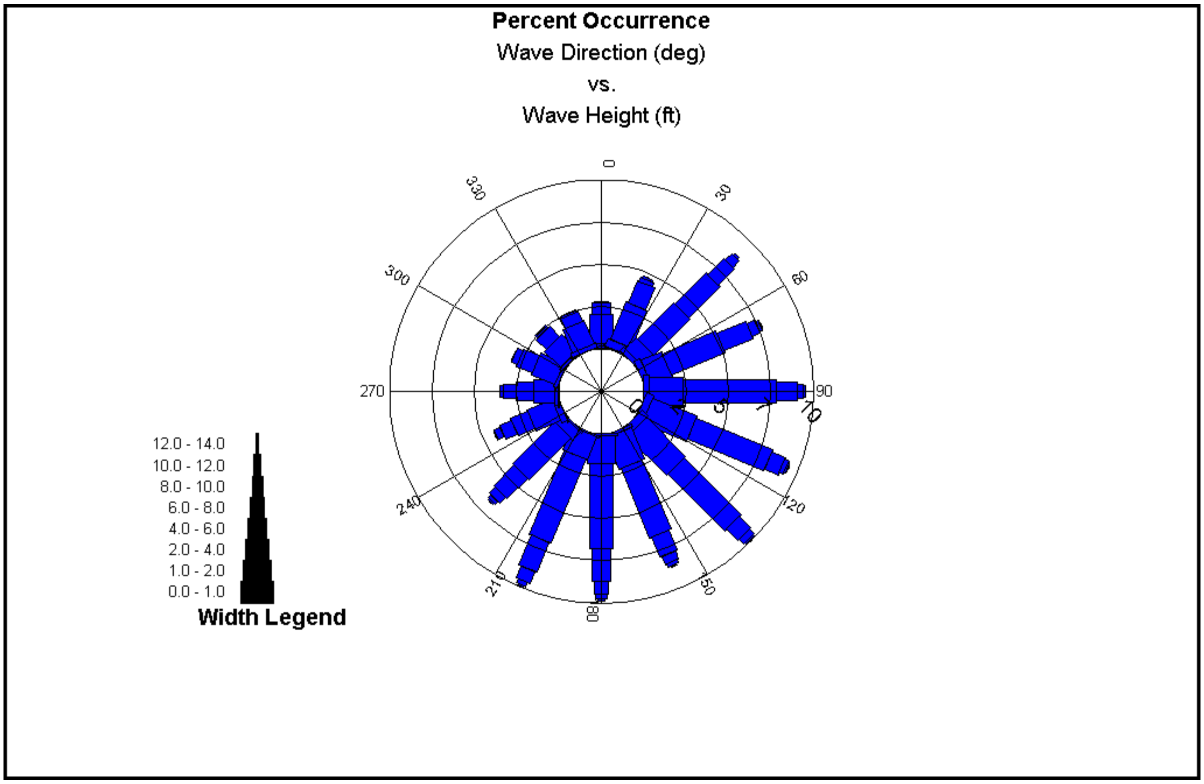


Figure 3.54. Wave Height Rose for WIS Level 3 Station 317.

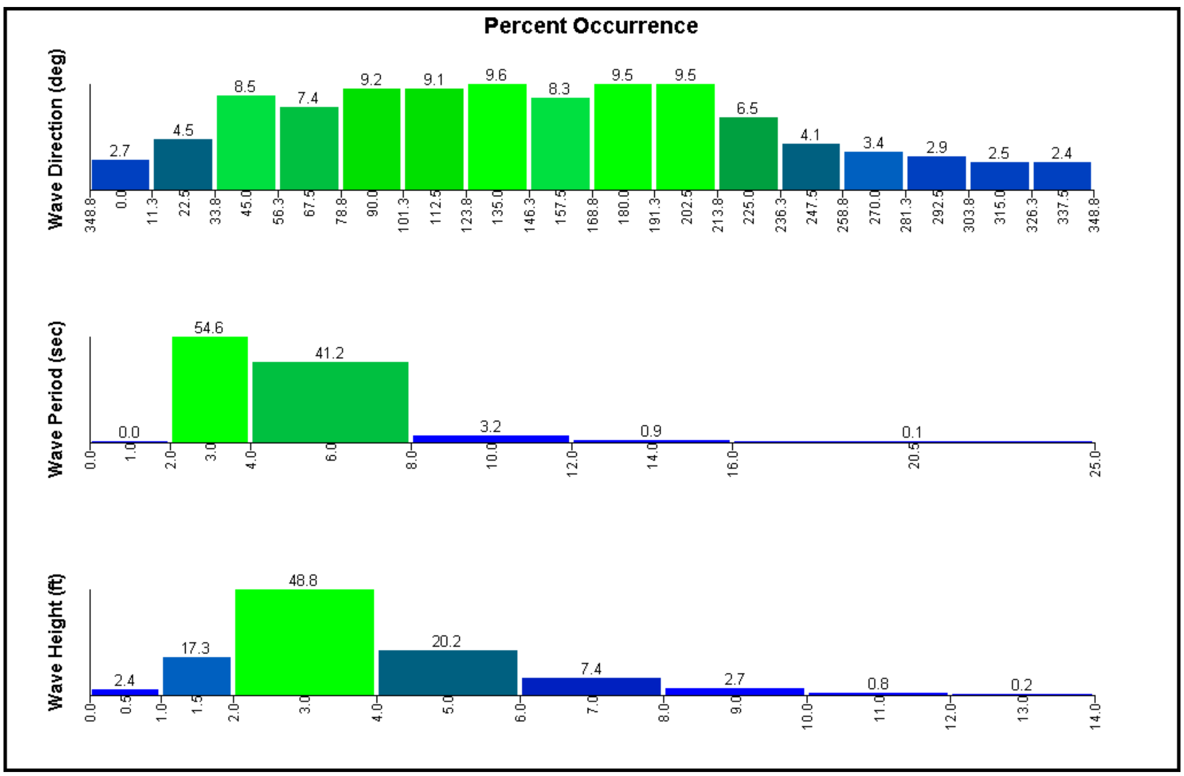


Figure 3.55. Wave Histogram for WIS Level 3 Station 317.

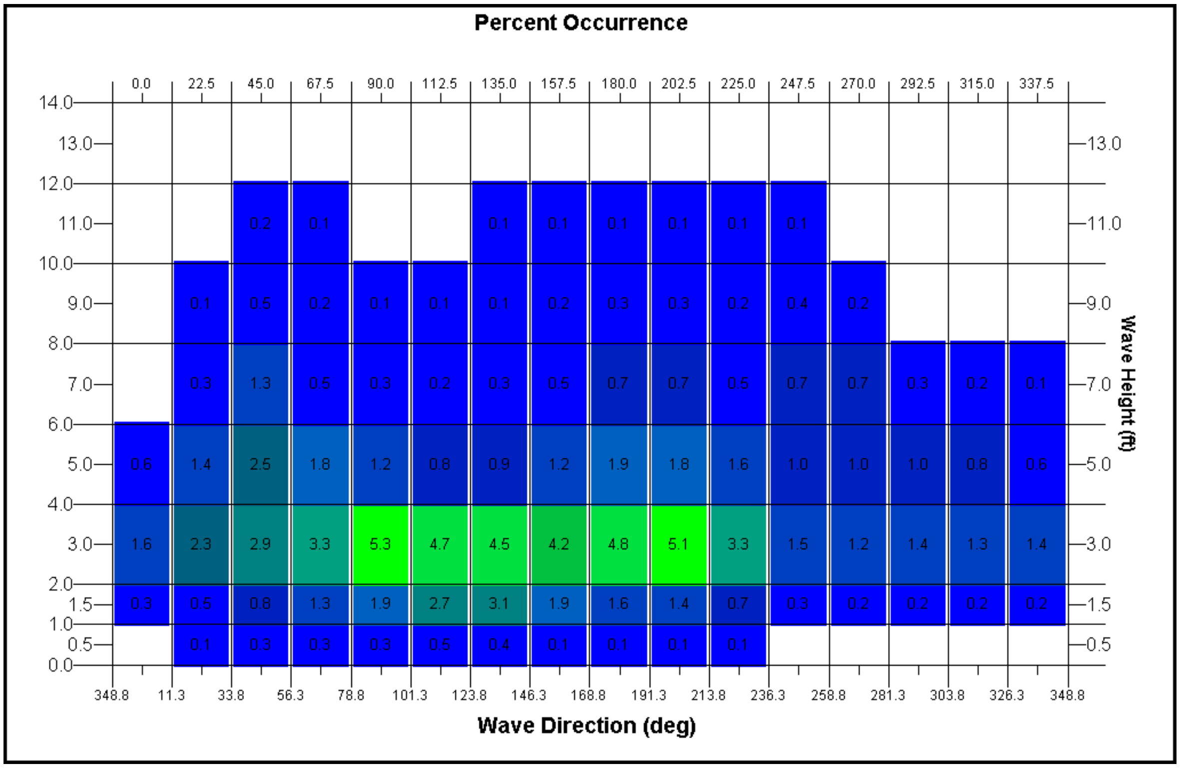


Figure 3.56. Wave Height Block Diagram for WIS Level 3 Station 317.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1980	4.0	3.6	5.0	3.8	2.6	3.2	2.8	2.9	2.6	3.3	4.2	4.0	3.5
1981	3.6	4.7	4.0	3.5	3.4	2.7	2.4	3.0	2.2	4.1	3.7	4.5	3.5
1982	4.4	4.8	3.5	4.2	2.2	3.2	2.7	2.5	2.8	3.6	4.2	4.2	3.5
1983	4.1	4.9	5.1	4.1	3.2	2.7	2.6	2.4	3.0	3.8	3.9	4.6	3.7
1984	4.0	4.6	4.4	3.9	3.4	2.3	3.0	2.1	4.8	2.8	4.1	2.8	3.5
1985	5.0	4.4	3.8	3.1	3.2	2.7	2.6	2.4	3.6	4.1	3.6	3.6	3.5
1986	4.1	3.3	4.0	3.0	2.7	3.2	2.9	3.6	2.5	3.4	3.7	4.1	3.4
1987	5.1	4.7	4.3	3.4	2.4	2.7	2.3	2.7	2.5	3.5	4.0	3.9	3.5
1988	4.2	3.9	3.8	3.5	3.1	2.3	3.0	3.0	3.1	3.2	4.0	3.2	3.4
1989	3.9	4.0	4.1	3.7	3.0	2.8	2.8	2.2	4.0	4.0	3.2	4.0	3.5
1990	3.4	4.6	3.7	3.8	3.0	2.6	2.9	2.0	2.4	3.5	2.8	3.8	3.2
1991	3.8	3.6	4.5	3.5	2.7	3.0	2.6	2.5	3.7	3.8	3.2	3.7	3.4
1992	4.6	4.6	4.3	3.7	3.7	3.2	3.0	2.9	3.5	3.7	4.7	4.6	3.9
1993	5.3	4.6	5.3	4.1	2.6	2.7	2.2	2.9	2.8	4.2	4.8	4.2	3.8
1994	5.0	4.2	4.7	3.2	3.6	3.3	3.3	2.8	2.6	4.1	4.8	5.0	3.9
1995	4.9	4.6	3.7	3.5	3.2	3.3	2.8	3.9	4.9	4.3	4.0	3.7	3.9
1996	5.1	4.5	5.4	3.8	3.4	3.4	4.2	2.9	4.4	4.3	4.1	4.1	4.1
1997	3.4	3.2	4.1	3.0	2.4	3.2	2.4	2.0	2.5	1.9	3.4	3.1	2.9
1998	4.4	5.2	4.4	3.8	2.7	2.3	2.9	3.9	3.0	3.0	2.9	4.0	3.5
1999	4.4	3.9	4.3	4.5	3.0	3.0	2.5	3.6	4.6	4.1	3.8	3.6	3.8
Month	4.3	4.3	4.3	3.6	3.0	2.9	2.8	2.8	3.3	3.6	3.9	3.9	**3.6**

Table 3. 2 Mean Yearly and Monthly Wave Heights (ft) for WIS Level 3 Station 317.

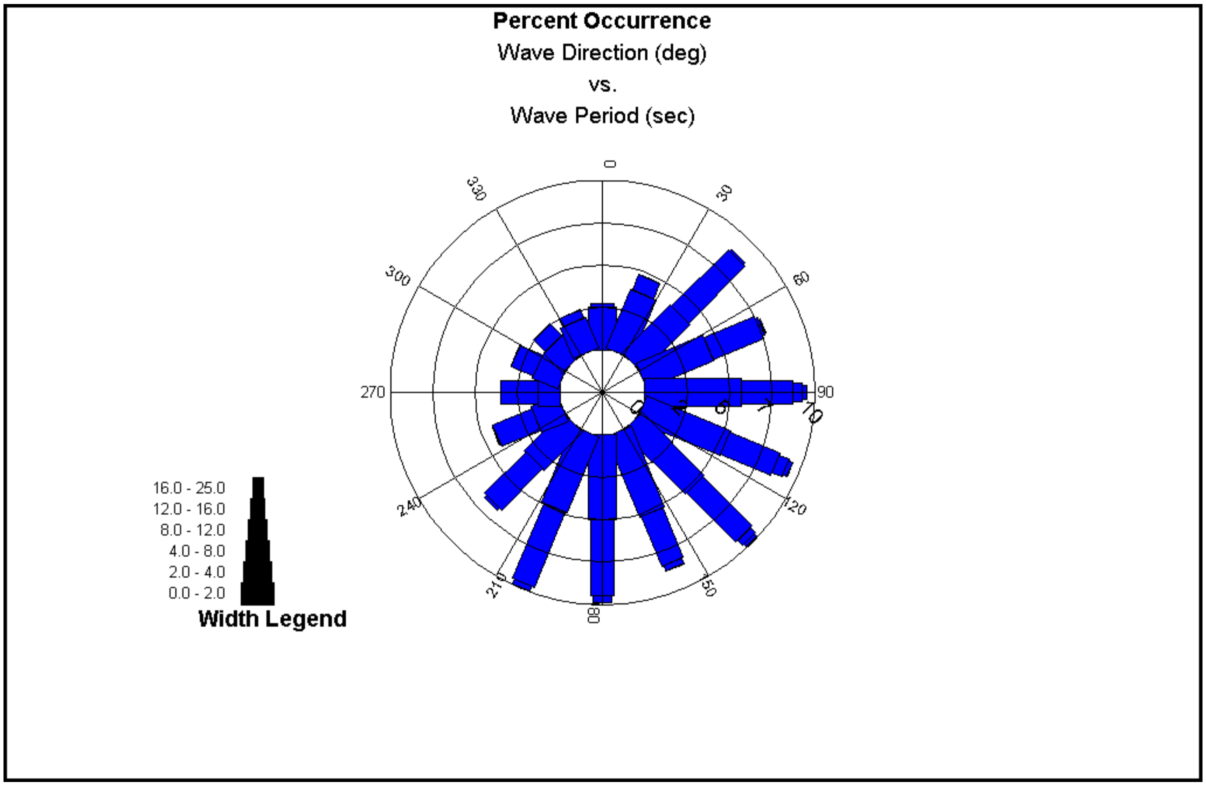


Figure 3.57 Wave Period Rose for WIS Level 3 Station 317.

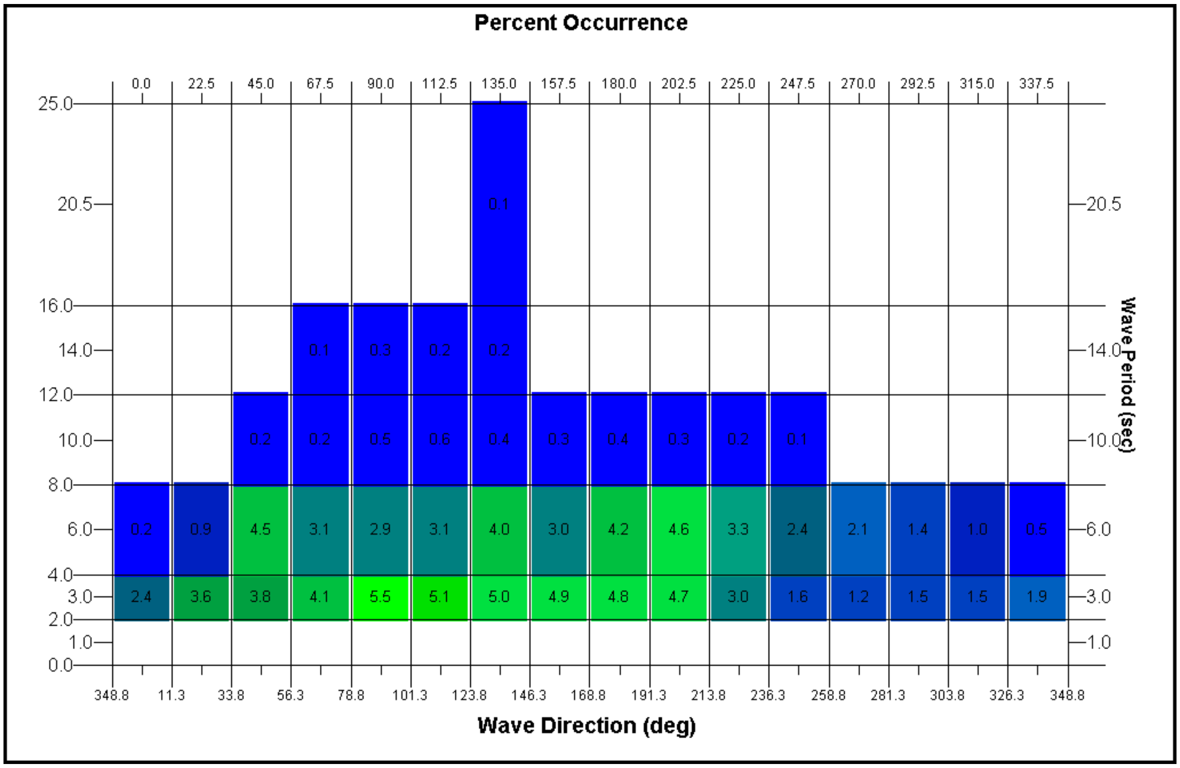


Figure 3.58 Wave Period Block Diagram for WIS Level 3 Station 317.

Wave Gauge Analysis. The field measurement program was initiated to monitor processes in the area immediately before construction of a new deep-draft entrance channel and for an extended time period after construction. The data also provide critical in situ documentation of offshore and nearshore processes that has been heretofore unavailable at this site.

Directional wave, water level, and current data were collected at one offshore location (referred to as the 11-Mile gauge) and two nearshore locations (Oak Island and Bald Head Island), as shown in Figure 3.59. 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. Spectral bin widths are 0.015625 Hz in frequency and 4 deg in direction. 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 Oak Island gauges collect 20-min time series at 3-hr intervals. The Bald Head 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. 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.

Wave Climate. Tables 3.3 through 3.5 summarize the mean monthly conditions for all gauges through June 2004. As noted for the WIS hindcast data, the most energetic months are December through March for all gauges. The average annual wave height (Hsmean) observed for the 11-mile gauge is 3.0 ft. Average annual wave heights for the Bald Head and Oak Island gauges are 1.9 and 1.7 ft, 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 7.6 ft, with waves typically arriving from the southeast to southwest directions. Bald Head and Oak Island had monthly maximum wave heights of 5.8 and 5.2 ft, 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.

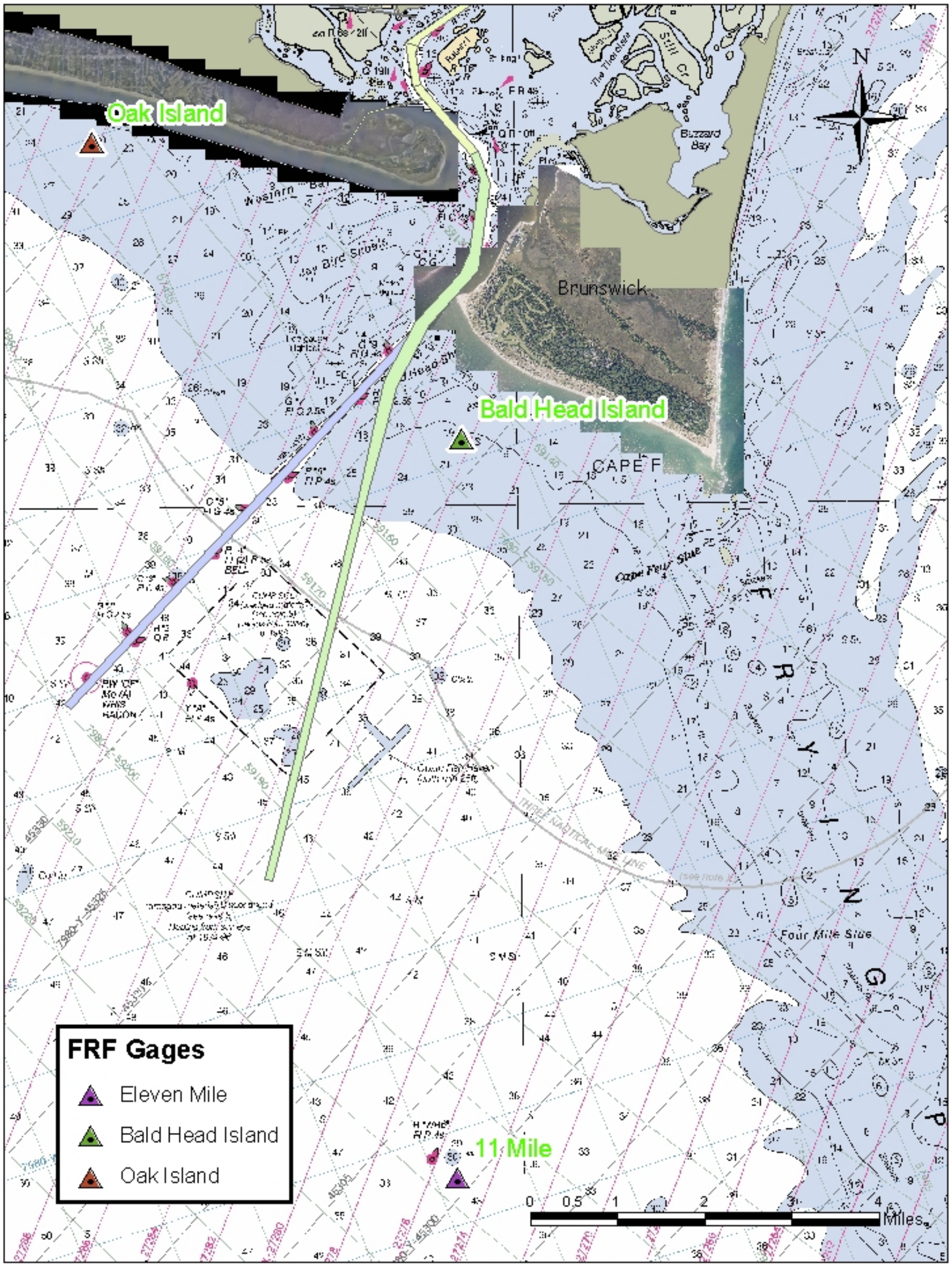


Figure 3.59   FRF Wave and Current Gauges.

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile Gage	HsMax	2000	--	--	--	--	--	--	--	--	6.6	5.3	9.0	11.3	**8.1**
Eleven Mile Gage	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 Gage	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 Gage	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 Gage	HsMax	2004	7.3	6.9	6.5	8.5	5.6	--	--	--	--	--	--	--	**7.0**
	AVERAGE		**8.3**	**8.1**	**9.3**	**7.3**	**7.0**	**6.8**	**7.0**	**5.3**	**7.2**	**6.1**	**8.8**	**9.4**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile Gage	DpMax	2000	--	--	--	--	--	--	--	--	213.0	89.0	166.0	253.0	**180.3**
Eleven Mile Gage	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 Gage	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 Gage	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 Gage	DpMax	2004	236.0	144.0	168.0	174.0	181.0	--	--	--	--	--	--	--	**180.6**
	AVERAGE		**211.8**	**169.5**	**159.5**	**190.8**	**163.3**	**178.3**	**197.0**	**158.7**	**183.8**	**150.5**	**171.8**	**204.0**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile Gage	HsMean	2000	--	--	--	--	--	--	--	--	3.6	2.5	2.5	3.1	**2.9**
Eleven Mile Gage	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 Gage	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 Gage	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 Gage	HsMean	2004	2.8	3.2	2.9	2.7	2.7	--	--	--	--	--	--	--	**2.9**
	AVERAGE		**3.0**	**3.0**	**3.2**	**3.0**	**2.9**	**3.1**	**3.1**	**2.7**	**3.3**	**2.7**	**3.0**	**3.2**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile Gage	TpMax	2000	--	--	--	--	--	--	--	--	12.8	**	14.2	**	**13.5**
Eleven Mile Gage	TpMax	2001	**	10.6	16.0	25.6	14.2	**	10.6	11.6	**	18.2	14.2	**	**15.1**
Eleven Mile Gage	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 Gage	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 Gage	TpMax	2004	11.6	14.2	14.2	12.8	11.6	--	--	--	--	--	--	--	**12.9**
	AVERAGE		**14.4**	**13.8**	**15.4**	**15.8**	**13.3**	**10.4**	**9.8**	**15.3**	**13.9**	**17.9**	**15.2**	**17.1**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Eleven Mile Gage	TpMean	2000	--	--	--	--	--	--	--	--	7.2	7.5	6.8	7.0	**7.1**
Eleven Mile Gage	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 Gage	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 Gage	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 Gage	TpMean	2004	6.5	7.1	7.3	6.8	7.6	--	--	--	--	--	--	--	**7.1**
	AVERAGE		**6.6**	**7.0**	**7.2**	**6.6**	**6.7**	**6.2**	**5.8**	**6.3**	**7.4**	**7.1**	**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. 3 Eleven Mile Gauge Monthly Summaries.

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head Gage	HsMax	2000	--	--	--	--	--	--	--	--	6.3	2.5	6.6	7.8	5.8
Bald Head Gage	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 Gage	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 Gage	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 Gage	HsMax	2004	6.5	5.0	5.4	6.7	4.6	4.5	4.4	6.5	7.7	--	--	--	5.7
	AVERAGE		7.2	6.1	7.1	5.8	5.6	5.4	5.1	5.0	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 Gage	DpMax	2000	--	--	--	--	--	--	--	--	192.0	203.0	173.0	198.0	191.5
Bald Head Gage	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 Gage	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 Gage	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 Gage	DpMax	2004	195.0	175.0	195.0	203.0	205.0	205.0	202.0	189.0	176.0	--	--	--	193.9
	AVERAGE		201.5	188.0	184.8	202.3	192.5	204.3	198.5	188.3	195.8	194.5	192.5	201.3	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head Gage	HsMean	2000	--	--	--	--	--	--	--	--	2.1	1.2	1.8	1.9	1.8
Bald Head Gage	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 Gage	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 Gage	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 Gage	HsMean	2004	1.8	1.7	1.8	1.9	2.3	2.0	1.9	1.9	2.5	--	--	--	2.0
	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	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Bald Head Gage	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	**	14.2	15.1
Bald Head Gage	TpMax	2001	**	25.6	18.2	16.0	16.0	25.6	**	10.6	**	**	**		18.7
Bald Head Gage	TpMax	2002	**	**	25.6	**	**	**	**	21.3	14.2	18.2	18.2	16.0	18.9
Bald Head Gage	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 Gage	TpMax	2004	11.6	14.2	14.2	12.8	10.6	10.6	9.8	14.2	18.2	--	--	--	12.9
	AVERAGE		13.8	18.6	18.5	14.4	14.2	17.4	9.5	15.5	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 Gage	TpMean	2000	--	--	--	--	--	--	--	--	7.6	9.0	7.5	7.4	7.9
Bald Head Gage	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 Gage	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 Gage	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 Gage	TpMean	2004	6.9	7.8	7.7	6.4	6.2	5.3	5.7	6.6	9.3	--	--	--	6.9
	AVERAGE		7.2	7.5	7.5	6.6	6.4	6.1	5.7	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. 4 Bald Head Gauge Monthly Summaries.

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island Gage	HsMax	2000	--	--	--	--	--	--	--	--	5.3	2.9	--	--	4.1
Oak Island Gage	HsMax	2001	--	--	--	--	--	6.0	3.7	--	1.0	4.2	3.9	5.8	4.1
Oak Island Gage	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 Gage	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 Gage	HsMax	2004	6.1	4.9	5.3	5.5	4.5	4.6	4.6	9.9	5.8	--	--	--	5.7
	AVERAGE		6.6	5.6	5.7	4.7	4.1	5.0	4.1	6.1	4.5	4.0	5.6	6.0	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island Gage	DpMax	2000	--	--	--	--	--	--	--	--	206.0	239.0	--	--	222.5
Oak Island Gage	DpMax	2001	--	--	--	--	--	192.0	236.0	--	172.0	190.0	181.0	197.0	194.7
Oak Island Gage	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 Gage	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 Gage	DpMax	2004	210.0	224.0	184.0	197.0	175.0	180.0	200.0	172.0	186.0	--	--	--	192.0
	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 Gage	HsMean	2000	--	--	--	--	--	--	--	--	2.3	1.2	--	--	1.8
Oak Island Gage	HsMean	2001	--	--	--	--	--	1.6	2.5	--	0.8	1.4	1.5	1.8	1.6
Oak Island Gage	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 Gage	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 Gage	HsMean	2004	1.6	1.4	1.6	1.7	2.2	2.0	1.8	1.8	2.4	--	--	--	1.8
	AVERAGE		1.7	1.5	1.7	1.8	1.8	1.9	2.1	1.7	1.7	1.3	1.5	1.7	

GAGE	STAT	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
Oak Island Gage	TpMax	2000	--	--	--	--	--	--	--	--	16.0	**	--	--	16.0
Oak Island Gage	TpMax	2001	--	--	--	--	--	**	5.1	--	**	**	**	**	5.1
Oak Island Gage	TpMax	2002	**	**	**	**	**	**	9.1	21.3	21.3	21.3	21.3	16.0	20.2
Oak Island Gage	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 Gage	TpMax	2004	11.6	14.2	16.0	12.8	25.6	9.1	9.1	25.6	16.0	--	--	--	15.6
	AVERAGE		13.8	15.1	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 Gage	TpMean	2000	--	--	--	--	--	--	--	--	6.1	9.9	--	--	8.0
Oak Island Gage	TpMean	2001	--	--	--	--	--	6.4	4.3	--	13.2	8.2	8.6	7.9	8.1
Oak Island Gage	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 Gage	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 Gage	TpMean	2004	6.7	7.8	7.5	6.2	6.0	5.1	5.4	6.5	9.7	--	--	--	6.8
	AVERAGE		7.1	7.7	8.0	7.3	8.0	6.8	5.1	6.0	9.1	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 da

Table 3. 5 Oak Island Gauge Monthly Summaries.

Although the duration of wave gauge operation is somewhat limited to date, sufficient data have been collected from the 11-Mile and nearshore gauges to provide insights on wave climate variability and the impact of Frying Pan Shoals. Wave Histograms were created using all available data from each gauge for the September 2000 to June 2004 time period as shown in Figure 3.60. Wave roses for available data also show characteristic differences in wave climate for the three locations (Figure 3.61). 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. By comparison, the multi-year hindcast wave climate for this area (WIS Level 3 Station 317), but seaward of any coastal bathymetry, shows strong wave dominance from east to southeast directions as discussed earlier. 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.

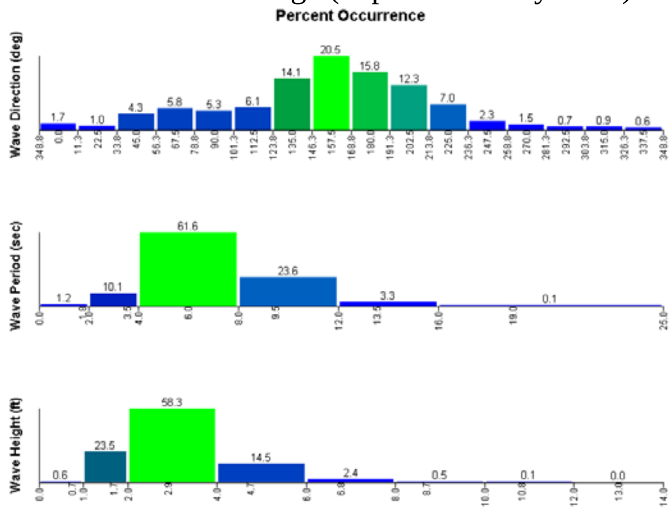
Time series for each gauge were separated into yearly components and analyzed to assess the statistical variation in wave climate. Figures 3.62 to 3.66 show annual wave height roses for all three gauges for 2000, 2001, 2002, 2003 and 2004. One interesting observation is that years that appear to have the offshore gauge dominated by the southeast waves have a nearshore wave distribution with waves dominated from the southwest. There do not appear to be any significant changes in wave distribution from pre- to post-dredging time periods.

<u>Wave Time Series.</u> Wave information obtained every 3 hours (hourly at Bald Head and Oak Island sites), and currents obtained every hour were assembled and presented in summary plots and ASCII data files. Wave parameters consisting of significant wave height (Hs), peak period (Tp), and peak direction (Dp) are presented in the plots. The water level (WL) was originally reported as the water level above the meter. Water level displayed in the plots has the mean water level of each deployment removed, resulting in approximately the water elevation with respect to mean sea level. Summary current information for two bins (near bottom (Sb) and near surface (Ss)) and a depth-average (Savg) value is presented in the plots. The ASCII data files developed contain current speed and directions for the full profile resolution (all bins) starting with bin 1 closest to the instrument (near bottom) and going up to near the surface. Figure 3.67 displays a sample of the monthly plots for the 11-Mile gauge during December 2002

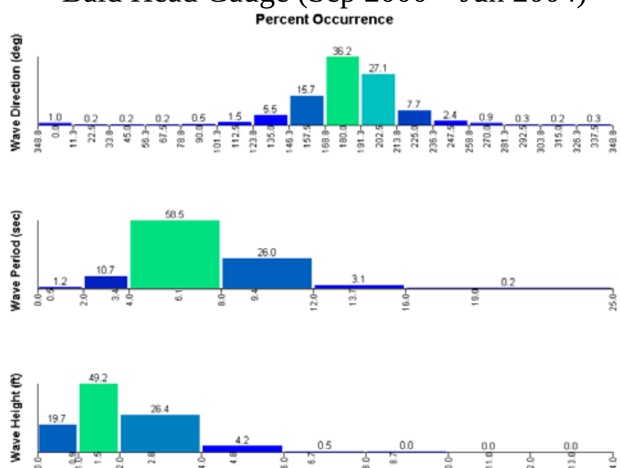
Time series plots of the three wave gauges together help provide a better understanding of the relative magnitude of conditions throughout the study area for a given time period. Data from all gauges were correlated to common time steps and plotted as monthly time series including significant wave height, peak period, peak direction, and water level. Figure 3.68 displays the December 2002 time series of all gauges. Several events occurred during this very energetic month. In addition to the relative magnitudes of offshore to nearshore wave heights, Figure 3.68 displays the filtering of waves from the east. Such plots are very valuable for calibration and verification of wave transformation models. Appendix A contains comparative plots for all months in the deployment history through June 2004.

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 were reported. Table 3.6 summarizes the 27 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 22 and 33 percent, respectively. Wave refraction effects are visible in the shifts of event peak wave direction, although more in-depth analysis of the actual wave spectra are needed to reveal the change in the primary incident direction during nearshore transformation.

Eleven-Mile Gauge (Sep 2000 – May 2004)



Bald Head Gauge (Sep 2000 – Jun 2004)



Oak Island Gauge (Sep 2000 – Jun 2004)

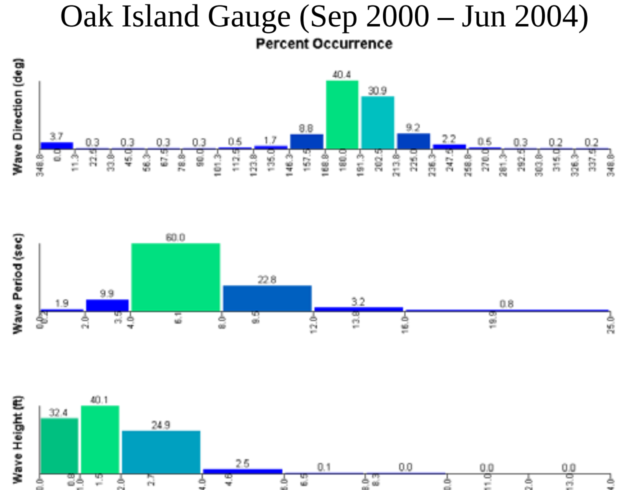
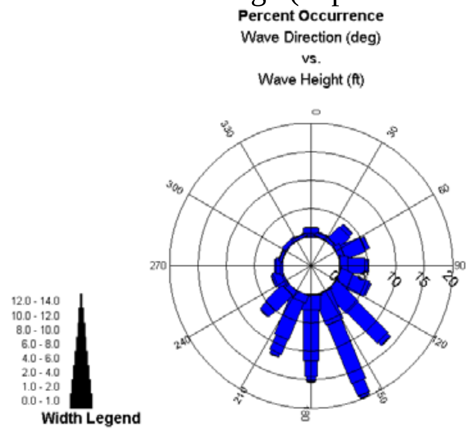
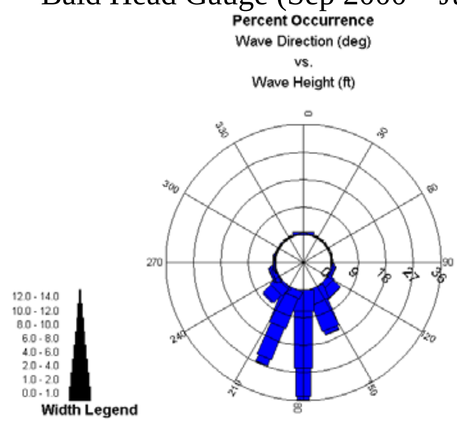


Figure 3.60 Wave Histograms for FRF Gauges throughout deployment.

Eleven-Mile Gauge (Sep 2000 – May 2004)



Bald Head Gauge (Sep 2000 – Jun 2004)



Oak Island Gauge (Sep 2000 – Jun 2004)

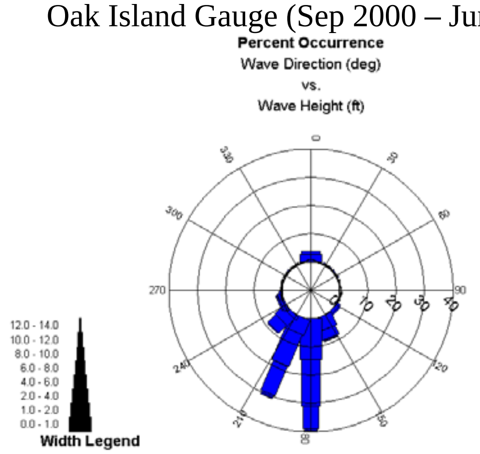
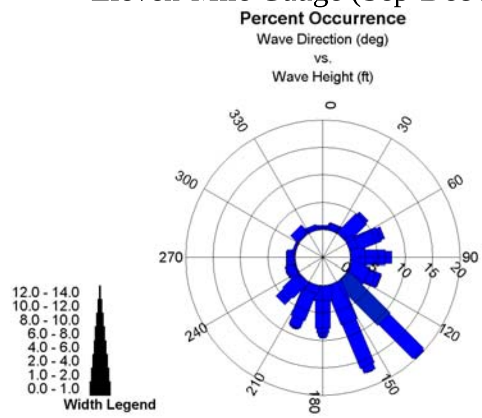
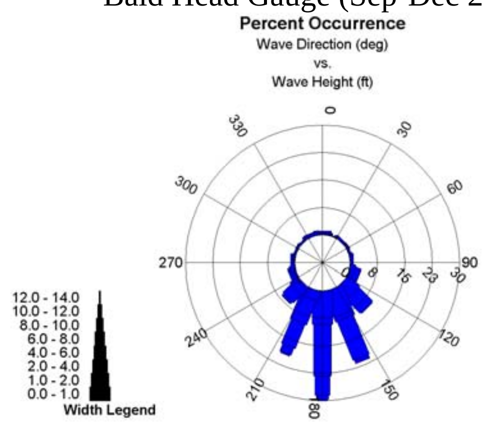


Figure 3.61 Wave Height Roses for FRF Gauges throughout deployment.

Eleven-Mile Gauge (Sep-Dec 2000)



Bald Head Gauge (Sep-Dec 2000)



Oak Island Gauge (Sep-Oct 2000)

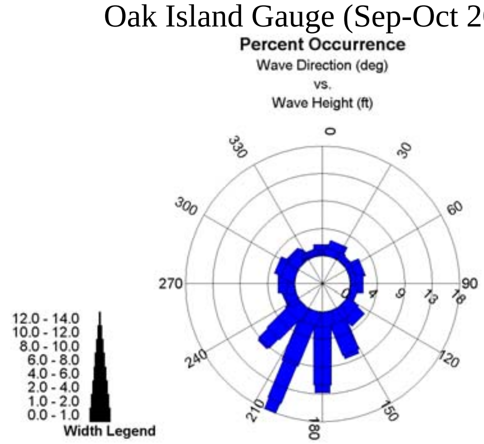


Figure 3.62 Wave Height Roses for FRF Gauges (2000).

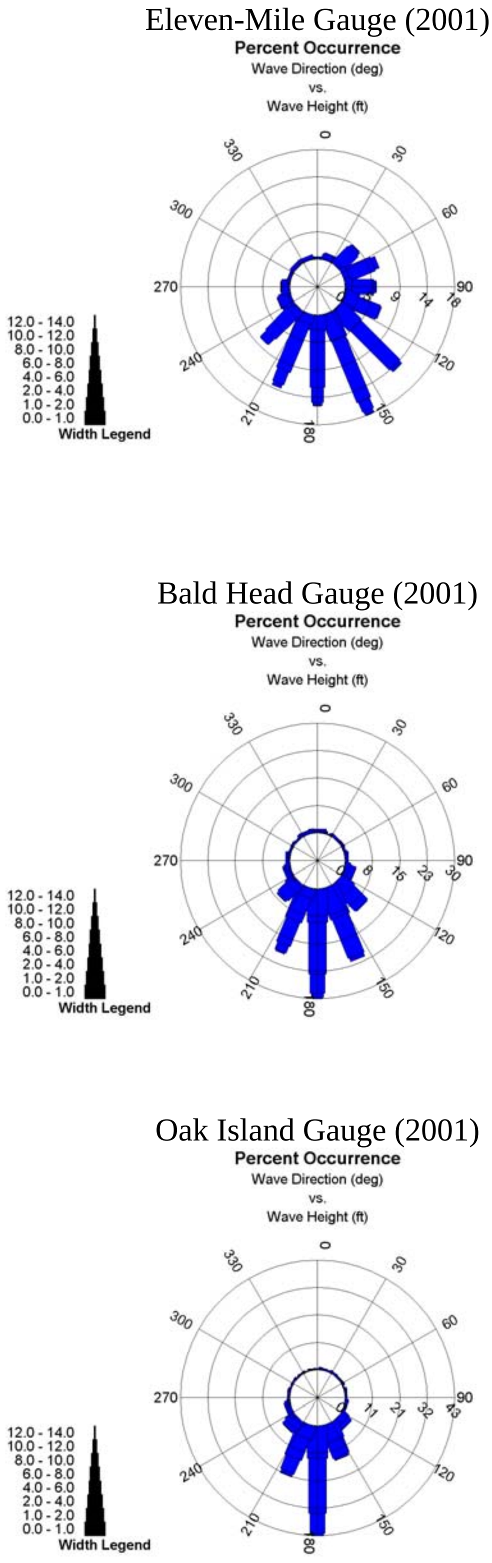
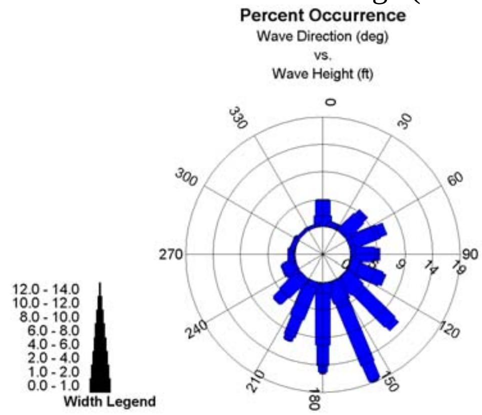
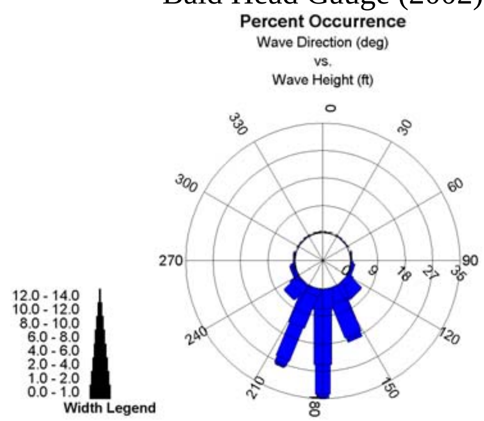


Figure 3.63 Wave Height Roses for FRF Gauges (2001).

Eleven-Mile Gauge (2002)



Bald Head Gauge (2002)



Oak Island Gauge (2002)

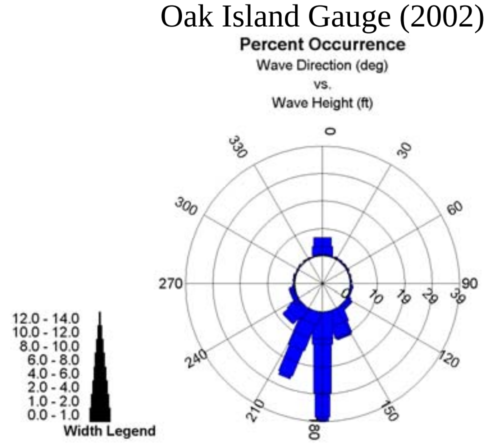


Figure 3.64 Wave Height Roses for FRF Gauges (2002).

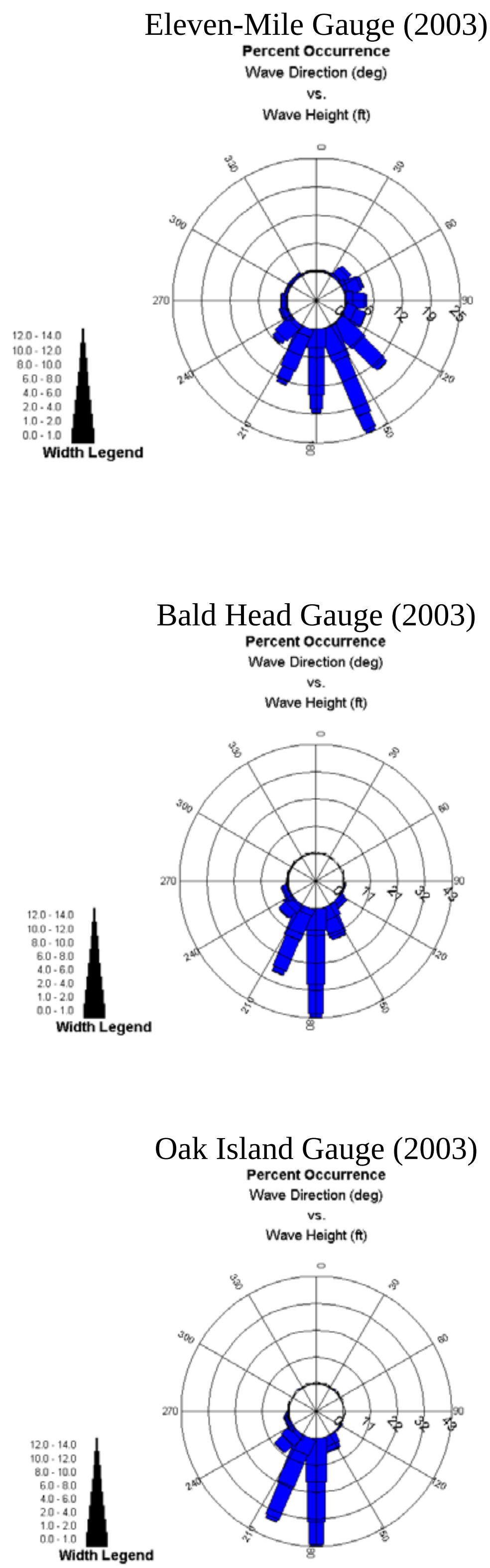
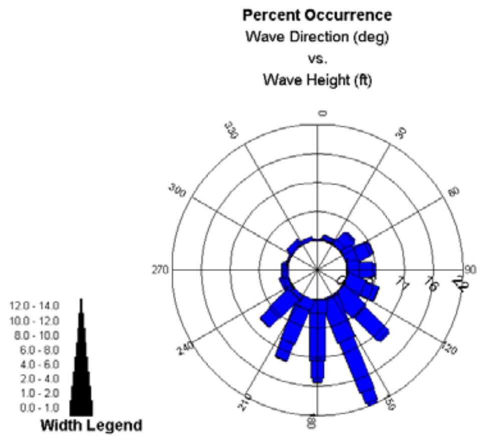
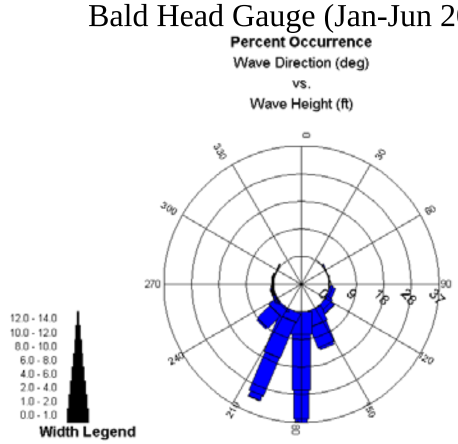


Figure 3.65 Wave Height Roses for FRF Gauges (2003).

Eleven-Mile Gauge (Jan-May 2004)



Bald Head Gauge (Jan-Jun 2004)



Oak Island Gauge (Jan-Jun 2004)

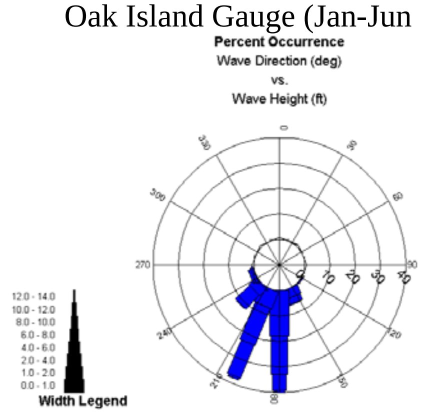


Figure 3.66 Wave Height Roses for FRF Gauges (2004).

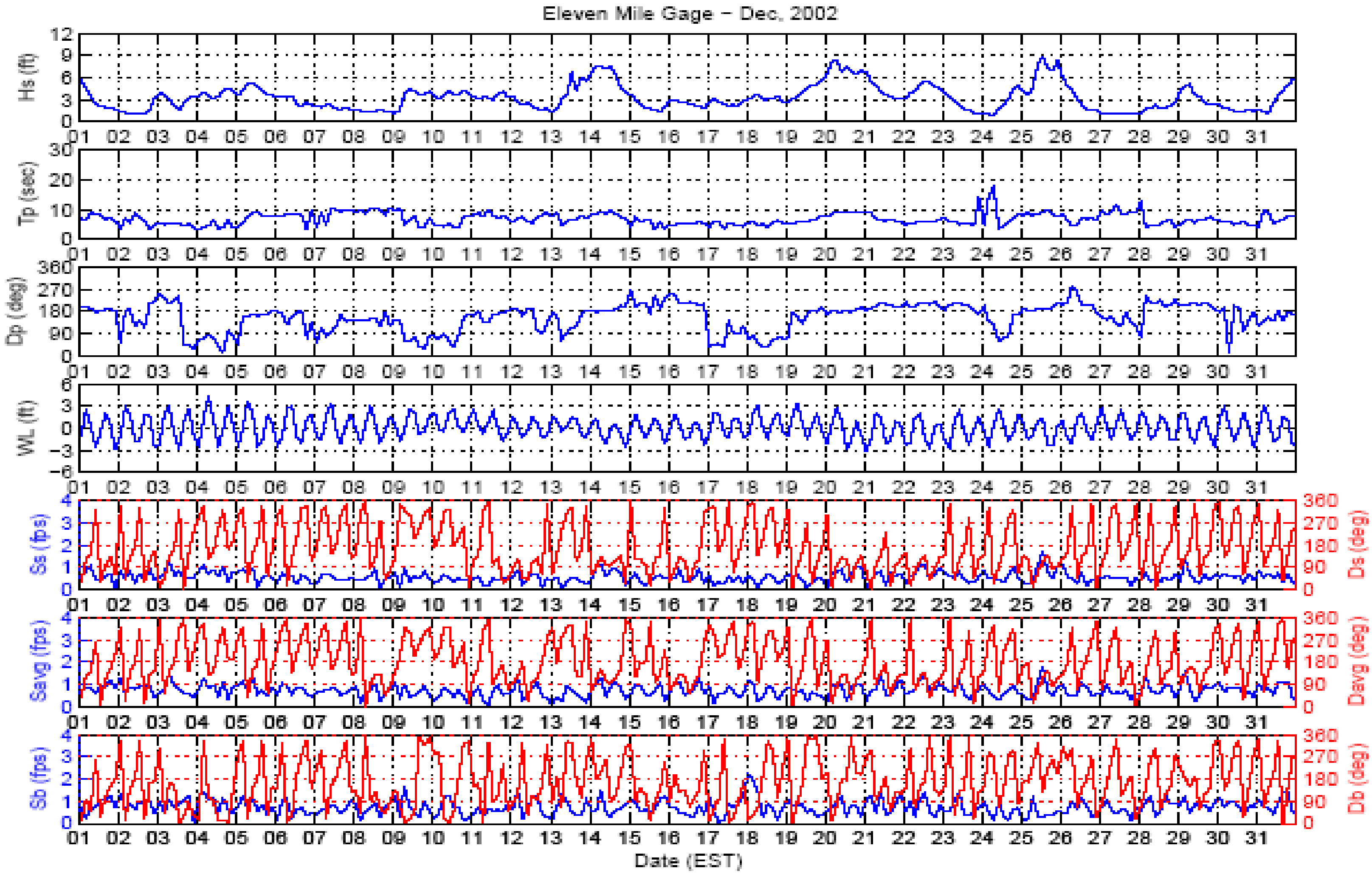


Figure 3.67 Monthly Time Series for 11-Mile Gauge (Dec 2002).

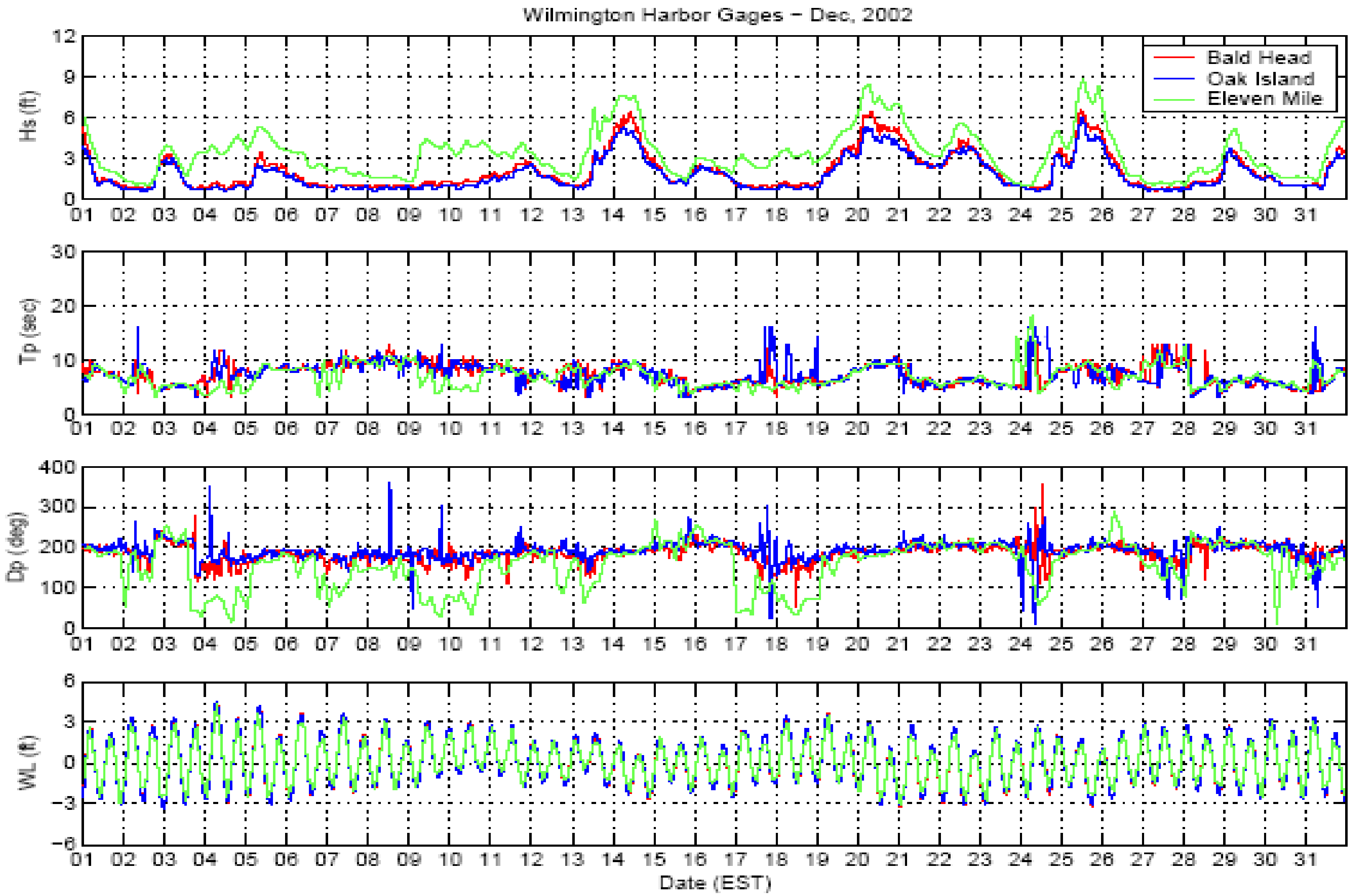


Figure 3.68. FRF Wave Gauge Time Series (Dec 2002).

						ELEVEN MILE GAGE					BALD HEAD GAGE			OAK ISLAND GAGE		
EVENT	START DATE	TIME	STOP DATE	TIME	Dur(hrs)	Hs(ft)	Tp(sec)	Dp(deg)	DATE PEAK	TIME	Hs(ft)	Tp(sec)	Dp(deg)	Hs(ft)	Tp(sec)	Dp(deg)
1	16-Dec-00	3:00:00	16-Dec-00	18:00:00	15.00	11.3	9.8	199.5	16-Dec-00	15:00:00	7.8	9.8	181.4	--	--	--
2	20-Jan-01	6:00:00	21-Jan-01	0:00:00	18.00	6.6	8.5	196.3	21-Jan-01	0:00:00	5.9	9.1	194.8	--	--	--
3	20-Mar-01	12:00:00	22-Mar-01	0:00:00	36.00	10.8	11.6	169.0	20-Mar-01	18:00:00	8.9	12.8	180.8	--	--	--
4	29-Mar-01	9:00:00	30-Mar-01	3:00:00	18.00	7.9	9.1	169.3	29-Mar-01	12:00:00	--	--	--	--	--	--
5	23-Jul-01	21:00:00	24-Jul-01	12:00:00	15.00	8.6	8.5	182.8	24-Jul-01	6:00:00	6.1	9.8	191.4	--	--	--
6	15-Sep-01	3:00:00	16-Sep-01	6:00:00	27.00	7.3	11.6	90.3	15-Sep-01	18:00:00	--	--	--	--	--	--
7	26-Dec-01	23:30:00	29-Dec-01	2:45:00	51.25	6.5	7.5	216.5	27-Dec-01	14:45:00	5.7	14.2	212.6	5.2	14.2	200.7
8	6-Jan-02	11:30:00	7-Jan-02	8:45:00	21.25	11.2	10.6	189.6	6-Jan-02	14:45:00	9.0	11.6	201.3	8.3	11.6	195.3
9	7-Feb-02	4:00:00	7-Feb-02	22:00:00	18.00	8.5	9.1	181.3	7-Feb-02	7:00:00	6.3	11.6	186.3	5.3	14.2	182.8
10	2-Mar-02	13:00:00	3-Mar-02	22:00:00	33.00	11.5	10.6	167.8	2-Mar-02	19:00:00	8.1	25.6	187.5	6.6	32.0	182.3
11	6-Nov-02	4:00:00	6-Nov-02	19:00:00	15.00	9.7	10.6	195.8	6-Nov-02	10:00:00	7.4	11.6	180.3	6.6	18.2	169.9
12	29-Nov-02	22:00:00	30-Nov-02	22:00:00	24.00	8.6	8.0	203.4	30-Nov-02	4:00:00	6.4	12.8	202.1	5.9	11.6	207.7
13	13-Dec-02	13:00:00	14-Dec-02	16:00:00	27.00	7.6	9.8	169.2	14-Dec-02	4:00:00	6.4	9.8	184.1	5.3	9.8	192.7
14	20-Dec-02	1:00:00	21-Dec-02	1:00:00	24.00	8.4	9.1	182.6	20-Dec-02	7:00:00	6.4	10.6	190.3	5.3	10.6	196.2
15	25-Dec-02	10:00:00	26-Dec-02	1:00:00	15.00	8.8	9.8	198.0	25-Dec-02	13:00:00	6.5	14.2	189.3	6.0	16.0	199.4
16	1-Jan-03	1:00:00	1-Jan-03	16:00:00	15.00	7.2	9.8	175.8	1-Jan-03	4:00:00	5.8	10.6	184.7	4.3	16.0	184.3
17	8-Jan-03	4:00:00	10-Jan-03	4:00:00	48.00	7.3	8.5	209.8	9-Jan-03	7:00:00	5.8	8.5	211.2	4.7	9.8	211.2
18	19-Jan-03	7:00:00	20-Jan-03	19:00:00	36.00	7.4	8.0	211.9	20-Jan-03	10:00:00	6.3	9.1	200.8	5.4	9.8	206.1
19	22-Feb-03	19:00:00	23-Feb-03	16:00:00	21.00	9.7	9.8	182.4	23-Feb-03	7:00:00	7.6	11.6	184.3	6.6	11.6	189.8
20	20-Mar-03	7:00:00	21-Mar-03	7:00:00	24.00	8.5	9.1	163.1	20-Mar-03	16:00:00	5.8	9.8	184.0	5.3	9.8	190.7
21	17-Sep-03	1:00:00	18-Sep-03	19:00:00	42.00	9.1	6.7	319.0	18-Sep-03	13:00:00	5.4	5.8	278.0	4.5	5.5	279.0
22	19-Nov-03	1:00:00	20-Nov-03	1:00:00	24.00	9.5	7.5	193.0	19-Nov-03	10:00:00	6.2	8.5	190.0	5.5	7.5	195.0
23	28-Nov-03	19:00:00	29-Nov-03	7:00:00	12.00	9.7	6.0	180.0	28-Nov-03	22:00:00	6.8	8.0	190.0	6.0	6.7	194.0
24	10-Dec-03	10:00:00	11-Dec-03	10:00:00	24.00	9.7	9.1	187.0	10-Dec-03	22:00:00	7.4	9.8	183.0	4.8	9.8	198.0
25	17-Dec-03	7:00:00	19-Dec-03	10:00:00	51.00	6.7	7.5	214.0	19-Dec-03	10:00:00	3.9	6.0	227.0	--	--	--
26	26-Feb-04	10:00:00	27-Feb-04	1:00:00	15.00	6.9	6.9	144.0	26-Feb-04	16:00:00	2.4	2.9	167.0	1.8	9.8	188.0
27	12-Apr-04	16:00:00	14-Apr-04	10:00:00	41.00	8.5	8.5	174.0	13-Apr-04	16:00:00	5.9	8.5	195.0	5.4	8.5	185.0

Table 3. 6 Significant Events at 11-Mile Gauge Exceeding Significant Wave Height of 6-ft.

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 two post-construction periods covering from the August/September 2000 survey through the survey of June 2003 (as presented in Report 1) and through the most recent monitoring survey of June 2004. 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 both 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 of shoreline characteristics of the beach including and encompassing the 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 2004), when compared to the pre rate data (1938 through 2000), and is also a result of shoreline equilibration that is expected with the beach disposal project.

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, the post construction shoreline change rates for both the 2000-2003 and 2000-2004 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; whereas, the rates through the June 2004 are somewhat moderated ranging from about +80 to –5 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 dredging of the channel 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 the June 2004 rates being generally less that those reported in June 2003 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 vary from +22 to +25 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 rates generally range from about +40 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 decreased by about half. This trend 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 profile 35-310) is +37 feet per year for the approximate 4-year post-construction period. By comparison the pre-construction rate over the entire reach was –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)
5		-5.7	-1.9	-3.6	-0.2
10		-1.0	-3.7	-0.7	-2.5
15		1.2	0.2	3.7	3.5
20		-9.2	-5.3	-9.2	-0.6
30		15.6	-10.7	27.4	-4.7
35	29.9	-33.4	-13.1	-24.3	-3.8
40	17.2	-27.9	-7.3	-21.1	1.0
45	7.9	-10.6	-4.3	8.0	0.2
50	2.5	19.4	10.7	14.9	11.0
55	0.8	30.8	20.9	23.5	18.3
60	0.3	41.6	30.9	29.7	22.0
65	0.2	23.3	33.1	15.6	23.2
70	0.4	39.2	36.2	26.5	25.0
75	0.9	30.4	35.1	20.6	24.2
80	1.6	46.3	35.7	32.4	24.7
85	1.9	36.4	27.5	26.0	19.5
90	2.2	26.2	23.1	18.1	17.1
95	2.5	-1.9	13.5	0.2	10.8
100	2.6	8.5	8.2	8.6	7.2
105	2.5	-1.6	4.5	1.3	5.5
110	2.1	9.9	12.2	8.1	11.4
115	1.5	7.6	17.9	9.2	15.7
120	0.7	36.6	33.1	29.8	26.1
125	-0.3	37.1	45.0	30.2	35.0
130	-0.9	74.2	55.6	53.3	42.8
135	-1.4	69.7	62.3	52.3	47.8
140	-2.1	60.6	69.0	48.5	52.1
145	-2.3	69.7	64.7	54.8	49.7
150	-2.5	70.6	63.2	51.5	47.7
155	-2.8	52.9	62.1	41.4	46.1
160	-3.3	62.2	62.0	42.4	45.0
165	-3.9	55.0	60.3	40.4	44.3
170	-4.3	69.3	61.1	49.5	44.0
175	-4.7	62.2	60.6	47.9	44.0
180	-5.0	56.9	61.9	39.7	44.8
185	-5.3	59.6	59.9	42.4	43.7
190	-5.4	61.3	60.3	44.6	43.4
195	-5.5	59.4	61.4	43.8	45.0
200	-5.6	64.3	64.1	46.4	47.1
205	-5.7	62.3	64.3	47.6	47.4
210	-5.8	73.1	66.9	52.8	49.1
215	-5.7	62.3	64.5	46.1	47.8
220	-5.5	72.4	64.9	52.5	47.7
225	-5.2	52.3	57.9	39.9	43.0
230	-4.8	64.7	56.8	47.0	42.2
235	-4.4	38.1	50.8	29.3	38.5
240	-4.1	56.6	52.9	42.5	40.2
245	-3.9	42.6	48.5	33.6	37.8
250	-3.7	62.5	54.2	48.5	42.3
255	-3.6	42.8	54.2	35.2	42.2
260	-3.5	66.7	61.0	51.7	47.1
265	-3.3	56.5	59.2	42.1	45.7
270	-3.2	76.5	66.6	57.8	50.9
275	-3.0	53.5	67.7	41.8	51.7
280	-2.8	79.8	72.6	61.2	55.3
285	-2.7	72.3	73.9	55.4	56.4
290	-2.6	80.8	83.3	60.2	62.8
295	-2.5	83.0	87.3	63.3	65.2
300	-2.3	100.7	97.3	74.1	71.0
305	-2.2	99.9	101.4	73.1	73.7
310	-2.1	122.0	107.5	84.4	77.2

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)
0		-3.1	-3.1	1.0	-2.2
4		-6.2	-1.7	-5.6	-1.2
8		0.0	-0.2	-2.0	0.2
12		2.6	1.5	1.9	1.0
16		5.6	5.6	5.8	4.1
20		5.7	4.4	5.0	1.2
24		14.4	1.2	9.9	-4.0
28		-6.5	-3.3	-16.7	-1.8
32		-13.3	15.1	-24.0	10.4
36		-16.6	18.2	16.9	6.5
40		97.4	22.2	66.0	6.1
43		29.9	21.6	-9.6	4.0
45		13.6	19.8	-18.8	-7.5
47		-16.3	-5.1	-34.3	-30.0
53	-2.4	-25.6	-18.1	-41.0	-39.4
57	-5.5	-27.0	-24.5	-46.1	-40.6
61	-5.6	-35.4	-23.0	-56.6	-37.4
66	-5.9	-18.1	-19.1	-24.9	-32.4
69	-6.4	-8.9	-12.7	-18.4	-24.7
73	-5.5	-6.1	-4.4	-16.1	-14.4
78	-4.6	5.0	-0.2	-7.4	-10.6
84	-3.7	6.2	3.9	-5.3	-7.4
88	-3.1	3.1	6.8	-6.0	-4.8
92	-2.6	11.3	8.5	-2.3	-3.2
97	-2.0	8.7	12.7	-2.9	-0.2
102	-1.6	13.5	18.2	0.2	3.3
106	-1.5	27.1	25.5	10.1	8.7
110	-1.6	30.5	33.8	11.6	14.6
114	-1.6	47.6	42.5	24.6	21.1
118	-1.8	50.1	48.1	26.5	25.6
122	-1.9	57.3	50.4	32.7	27.4
126	-2.0	54.9	51.4	32.3	28.8
130	-2.1	42.1	53.3	21.0	31.0
134	-2.0	52.4	53.0	31.6	31.4
138	-2.0	59.5	54.2	37.1	32.9
142	-2.3	56.3	58.9	35.1	37.3
146	-2.6	60.5	61.5	39.5	39.7
150	-2.9	65.8	64.8	43.3	42.8
154	-3.9	65.5	69.2	43.7	46.0
158	-4.7	75.9	72.4	52.3	48.6
162	-5.2	78.4	72.6	51.4	48.9
166	-5.4	76.3	71.4	52.3	49.2
170	-5.6	66.7	71.3	45.0	48.9
174	-5.9	59.7	67.3	45.0	46.8
178	-6.2	75.4	57.4	50.9	43.4
182	-6.5	58.2	52.7	40.9	40.3
186	-7.0	27.1	47.0	35.3	35.8
190	-7.8	42.9	37.5	29.3	30.3
194	-8.6	31.2	29.9	22.5	26.6
198	-10.0	28.3	25.2	23.7	21.7
202	-11.9	20.2	14.7	22.4	16.5
206	-13.7	3.2	6.6	10.7	12.2
210	-15.0	-9.3	-0.2	3.0	8.8
214	-17.8	-9.6	-5.3	1.2	5.3
218	-20.8	-5.5	-8.1	6.5	3.6
222					

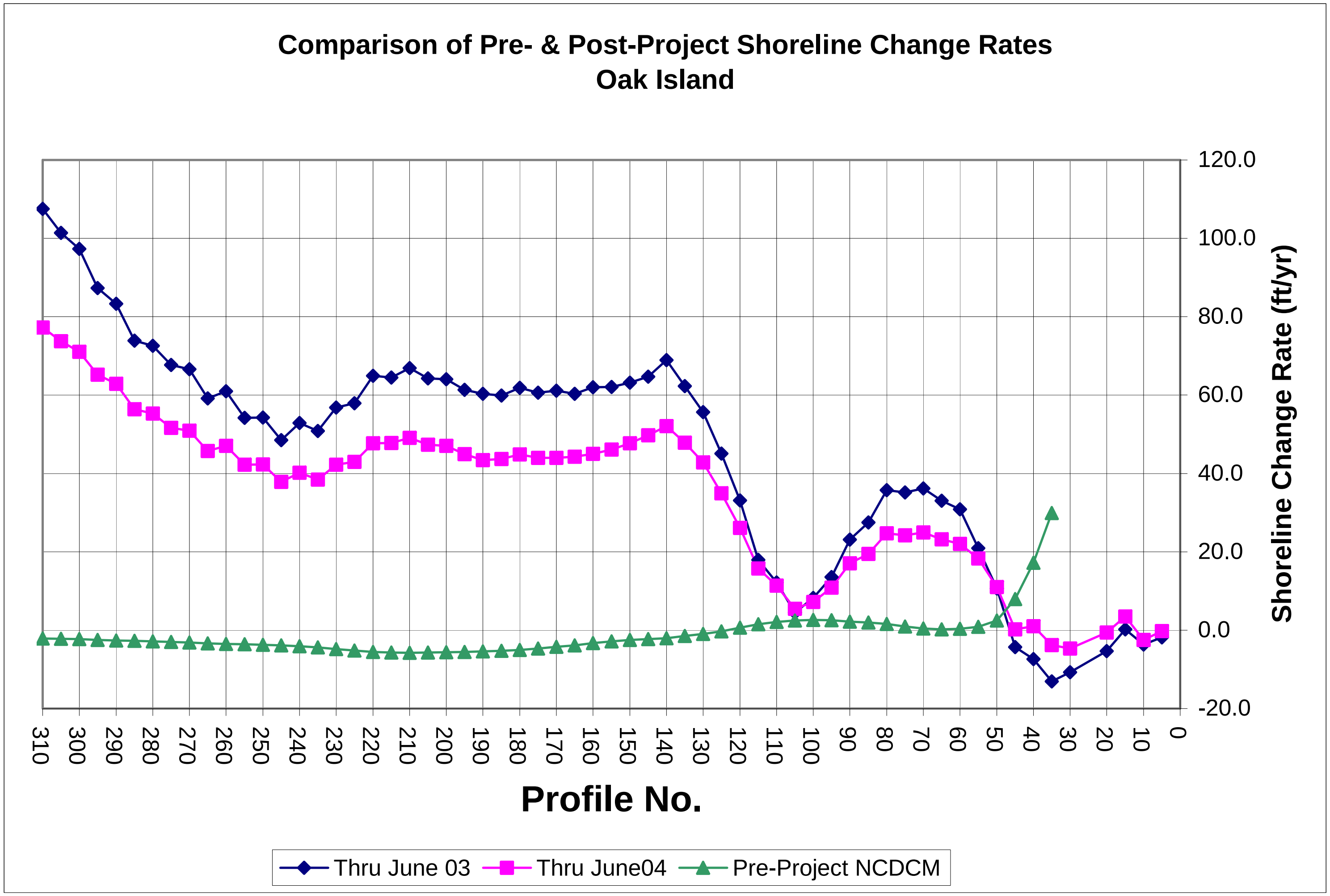


Figure 4.1 Wilmington Harbor Monitoring - Oak Island Comparison of Pre- and Post-Construction Shoreline Change Rates

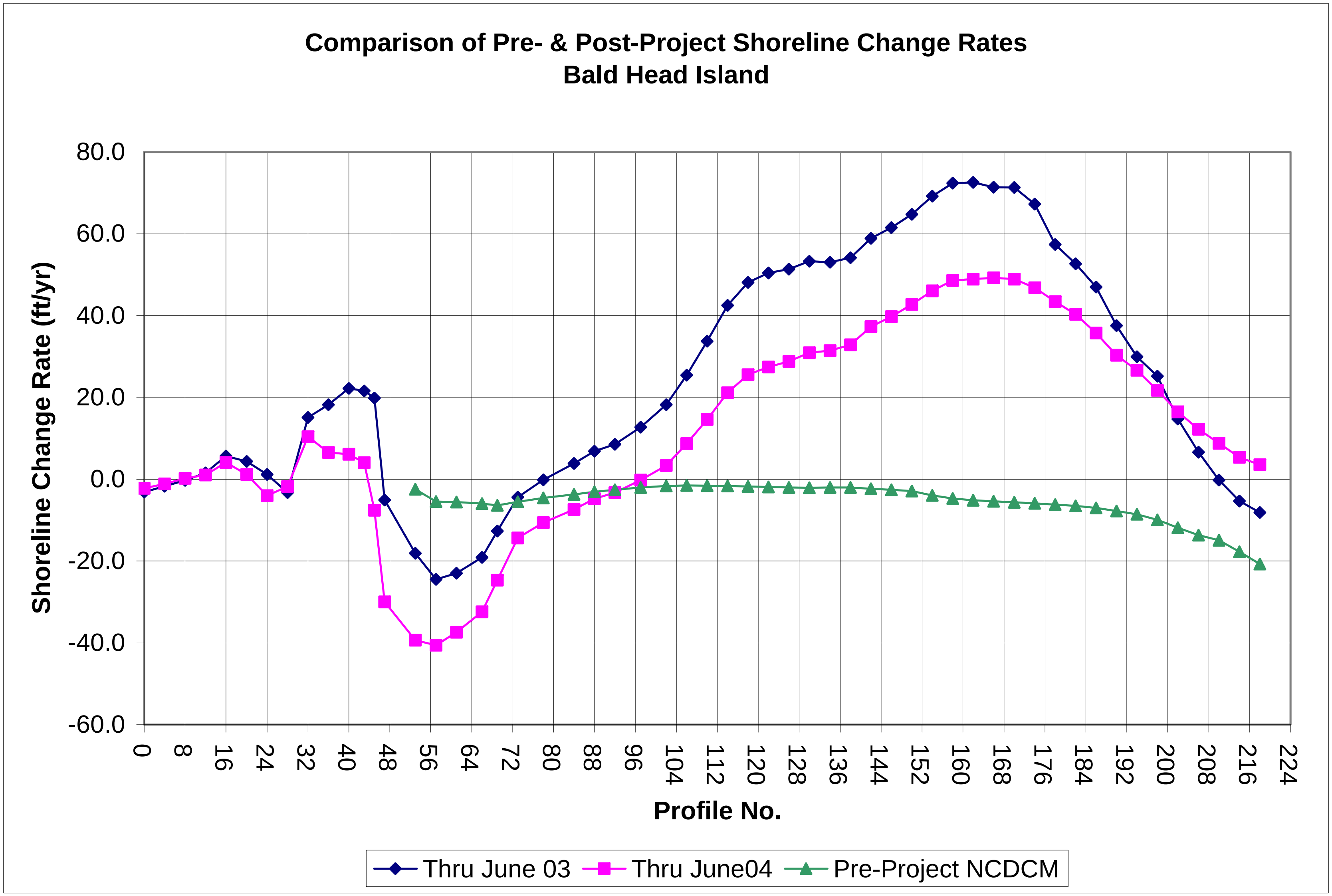


Figure 4.2 Wilmington Harbor Monitoring - Bald Head Island Comparison of Pre- and Post-Construction Shoreline Change Rates

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 both the June 2003 and June 2004 time frames. This in part reflects the influence of the beach fill placed throughout this area. In spite of the positive affects of the fill, the western end of South Beach, has experienced relatively high rates of erosion. The measured rates within the erosion zone have increased both in magnitude and extent by comparing the rates previously reported through June 2003 and the current period through June 2004. 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. With the rates updated through the current period, the average is now 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 has also expanded eastward from Profile 47 thru 78 in 2003 and Profile 47 thru 97 in 2004. This represents an alongshore increase of about 1,900 feet, from 3,100 feet to 5,000 feet.

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 03) and plus 49 feet per year (thru June 2004). In terms of average rates for this zone, the June 03 value of accretion was 38 feet per year with the June 04 value being a positive 29 feet per year. These 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 4-year monitoring period. However, notwithstanding this overall positive response, the post-construction erosion rates are considerably greater along the western corner of South Beach. This high erosion has prompted the Village of Bald Head to install sand bags to protect the beachfront road throughout this reach. This installation is a rehabilitation of an earlier sand bag structure placed in the mid-1990's in response to erosion problems that have been prevalent over the last several decades in this area. As discussed in the following section, the relatively high erosion rates measured in this area associated with the loss of beachfill are not that unusual and have been observed with prior fills placed in this area. Further, a geotextile groin field that was placed in conjunction with the 1996 beach fill in an attempt to more effectively retain the fill throughout this problem area has now deteriorated. This deterioration has progressed to a point where the groins are no longer functioning. Some of the increased erosion is likely related to the present ineffectiveness of the groins. Due to the apparent positive impact of the geo-tube structures while intact, the Village of Bald Head is presently rebuilding the groin field in conjunction with the 2005 beach disposal operation.

Beach Fill Response and Bald Head Shoal Channel Shoaling

This section examines 1) the response of the beach fill (placed February 23, 2001 to July 7, 2001 on Bald Head Island) and 2) the growth of the shoal extending from the west end of South Beach into Reach 1 of the Bald Head Shoal Channel which is referred to as the spit.

Beach Fill Response. This section analyzes the changes to the beach fill while the previous section analyzes the changes to pre-fill shoreline. The erosion rates in this section are calculated by fitting a trend line through the shoreline positions starting with the post-fill shoreline and measures changes to the fill, which will be primarily erosional. The erosion rates in the previous section Beach Response – Shoreline Change Rates are calculated by fitting a trend line through the shoreline positions starting with the pre-fill shoreline and will reflect shoreline accretion due the fill. The erosion rates in the two sections will not agree since only one of them takes into account the accretion due to the fill, but the two methods are necessary to report on both the effect of the project on the pre-project shoreline and the shorter term changes to the fill.

The overall erosion pattern base on erosion trends from 2001 to 2004 remained generally the same as for the 2001 to 2003 period. At some profiles in the reach from profile 30 to profile 80 the erosion rate exceeded 100 feet per year. The reach from profile 80 to profile 135 had some locations at which the erosion rate exceeded 50 feet per year. There was a gradual decrease in erosion rates with increasing profile numbers above profile 135. Figures 4.3 and 4.4 display the erosion trends and Figure 4.5 is an example of how the trends were calculated at profile 45+08. It can be determined from Figure 4.4 that the erosion trend, measured from the post-fill shoreline, over the last year decreased from profile 50 to profile 100 and increased above profile 135. The erosion rate from 6/1/2003 to 6/9/2004 is superimposed on the erosion trends in Figure 4.6. It can be seen in Figure 4.6 that at some profiles, such as 52+64, 69+47 and 73+40, the 2003 to 2004 erosion rate is almost zero. The low annual erosion rate is associated with the exposure of existing or the placement of new bags along the shoreline. Sand bag locations are shown in Figure 4.7. There are two profiles, 56+57 and 60+52, in the area with bags that have a high erosion rate. The bags at these two profile locations were set back from the shorelines as shown in Figure 4.8.

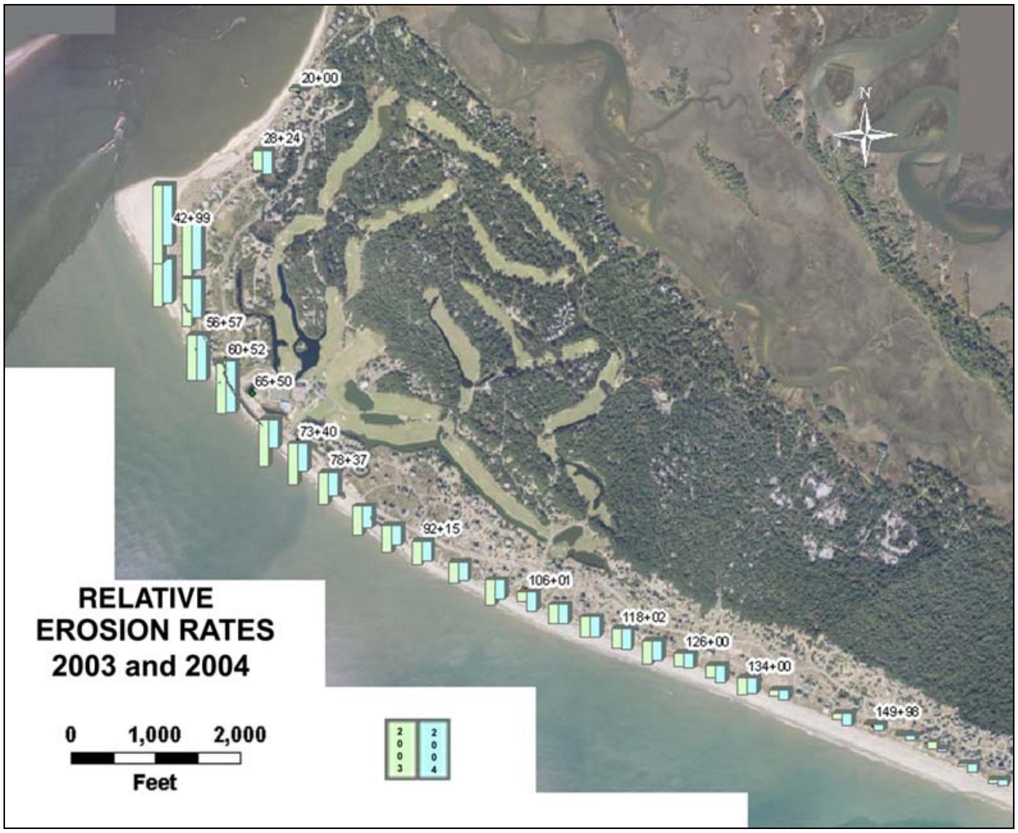


Figure 4.3 Relative Erosion Rate Trends 2001 to 2003 and 2001 to 2004 for Bald Head Island Beach Fill.

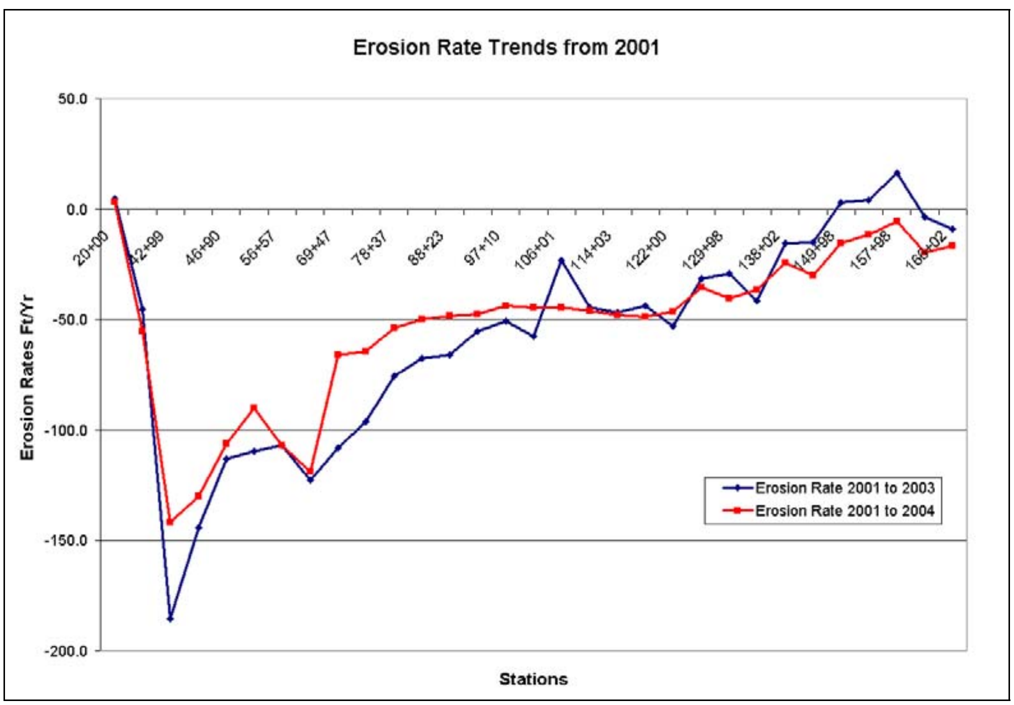


Figure 4.4 Erosion Rate Trends 2001 to 2003 and 2001 to 2004 by Station along Bald Head Island.

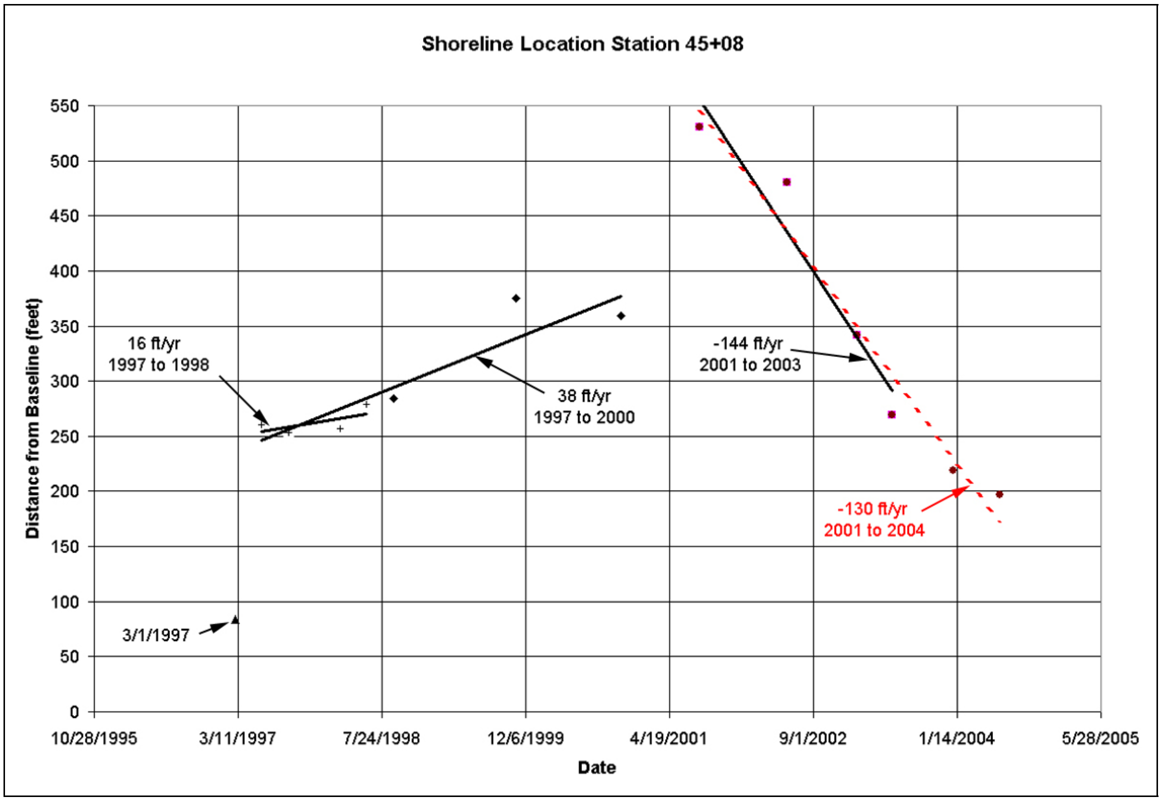


Figure 4.5 Example Erosion Rates at Station 45+08.

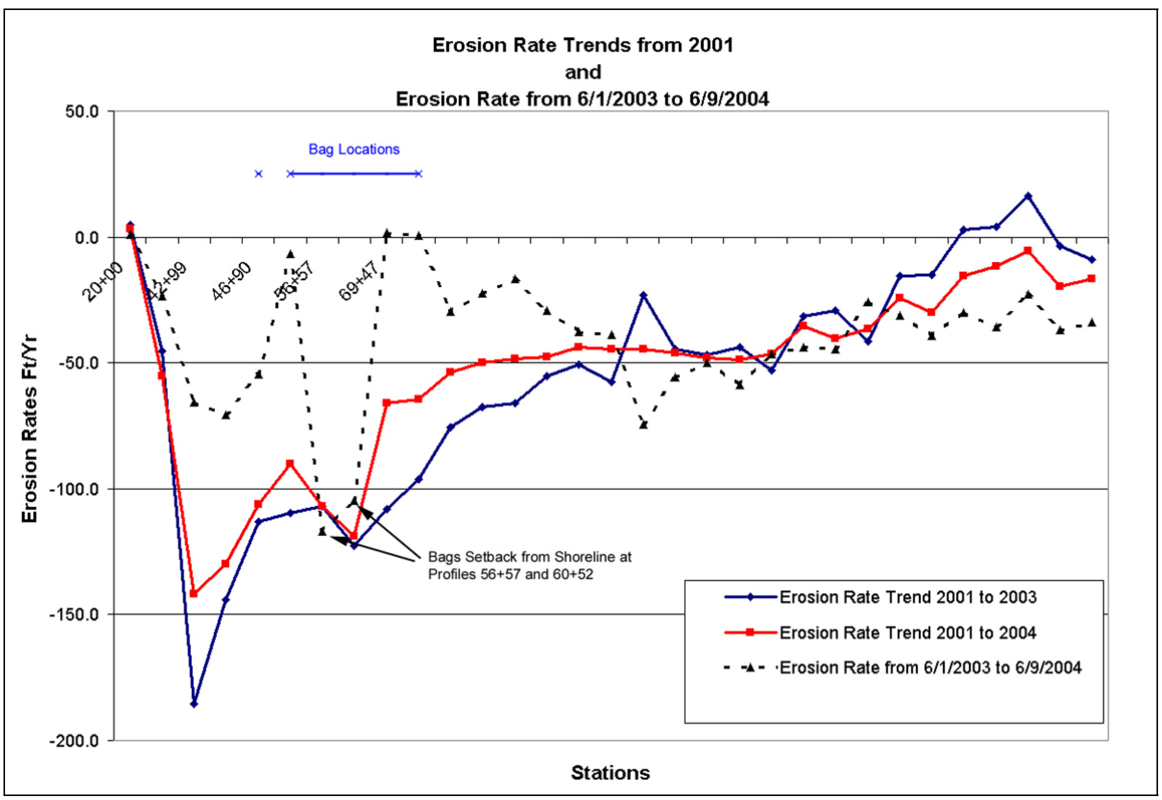


Figure 4.6 Erosion Rates from 6/1/2003 to 6/9/2004.

Figure 4.7 Sand Bag Locations along Bald Head Island South Beach.

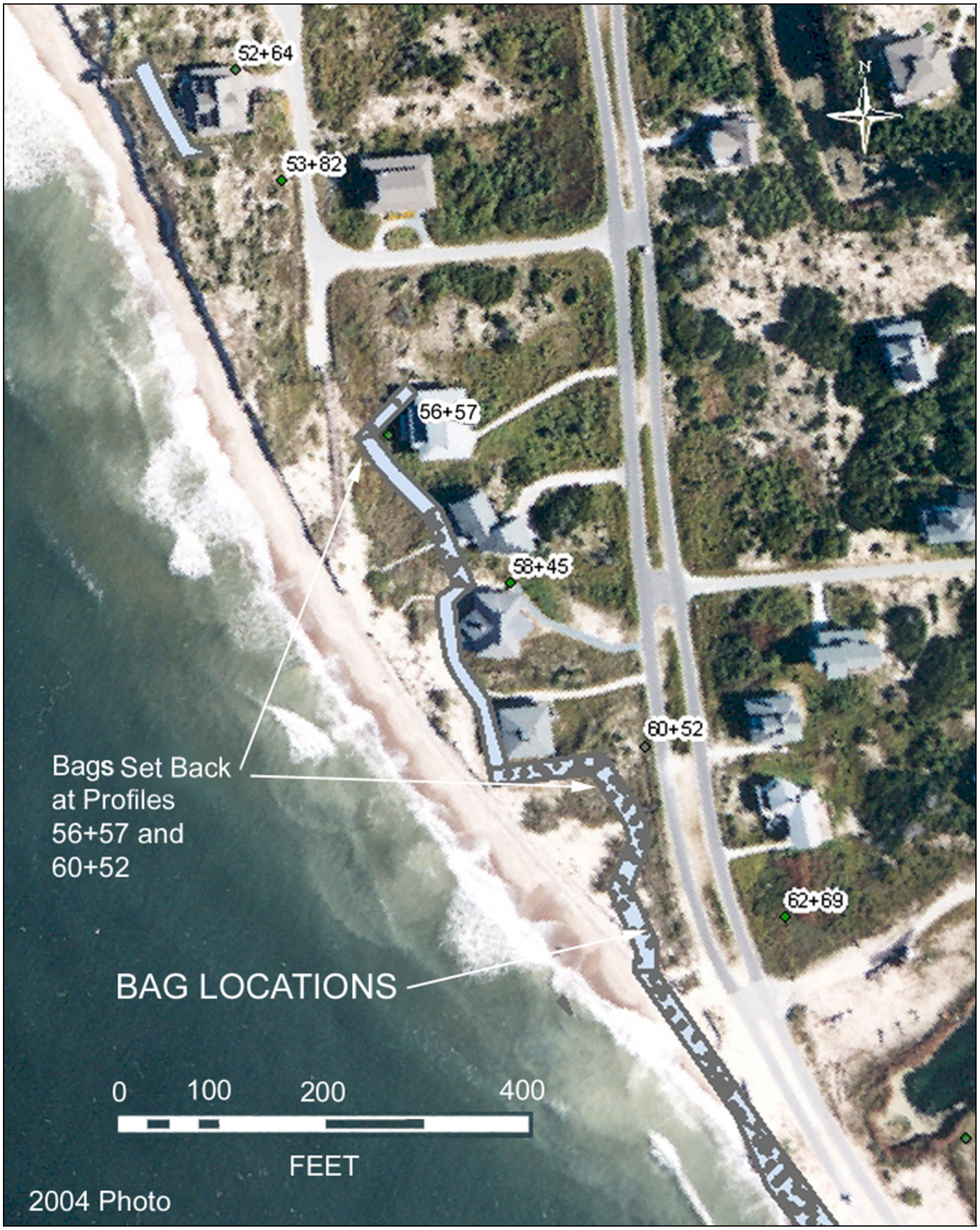


Figure 4.8 Sand Bags Set Back from Shoreline.

There also continues to be a correlation between the shoreline alignment and the erosion rates as first described in the section entitled Comparison of Prior and Current Beach Fill Response, page 107 of Report 1 (USACE 2004). Alignment 1, profiles 42+99 to 56+57, is strongly influenced by the inlet. Alignment 2, profiles 56+57 to 92+15, is an area that had been accreting or stable while the eastern ebb shoal was collapsing and sand was being transferred on shore (1872 to 1974), (Cleary, Hosier, and Gammill 1989). Without the sand supplied from the collapsing ebb shoal, zone 2 has reversed its state of accretion and since 1974 is in a state of erosion. Alignment 3, profiles 92+15 to 162+00, is an area that had eroded during the period 1872 to 1974. This erosion was associated with a build up of sediment offshore and a general realignment or rotation of the Baldhead Island shoreline as discussed in the Wilmington District's report "Wilmington Harbor-Bald Head Island Reconnaissance Report, Section 111, PL 90-483, January 1989" (USACE 1989). Since 1974, alignment 3 has continued to erode with a slower rate that alignment 2. The shoreline alignments are shown in Figure 4.9. The correlation between erosion rates and shoreline alignments will be less apparent as the effects of the bags and the new groin field affect the erosion rates.

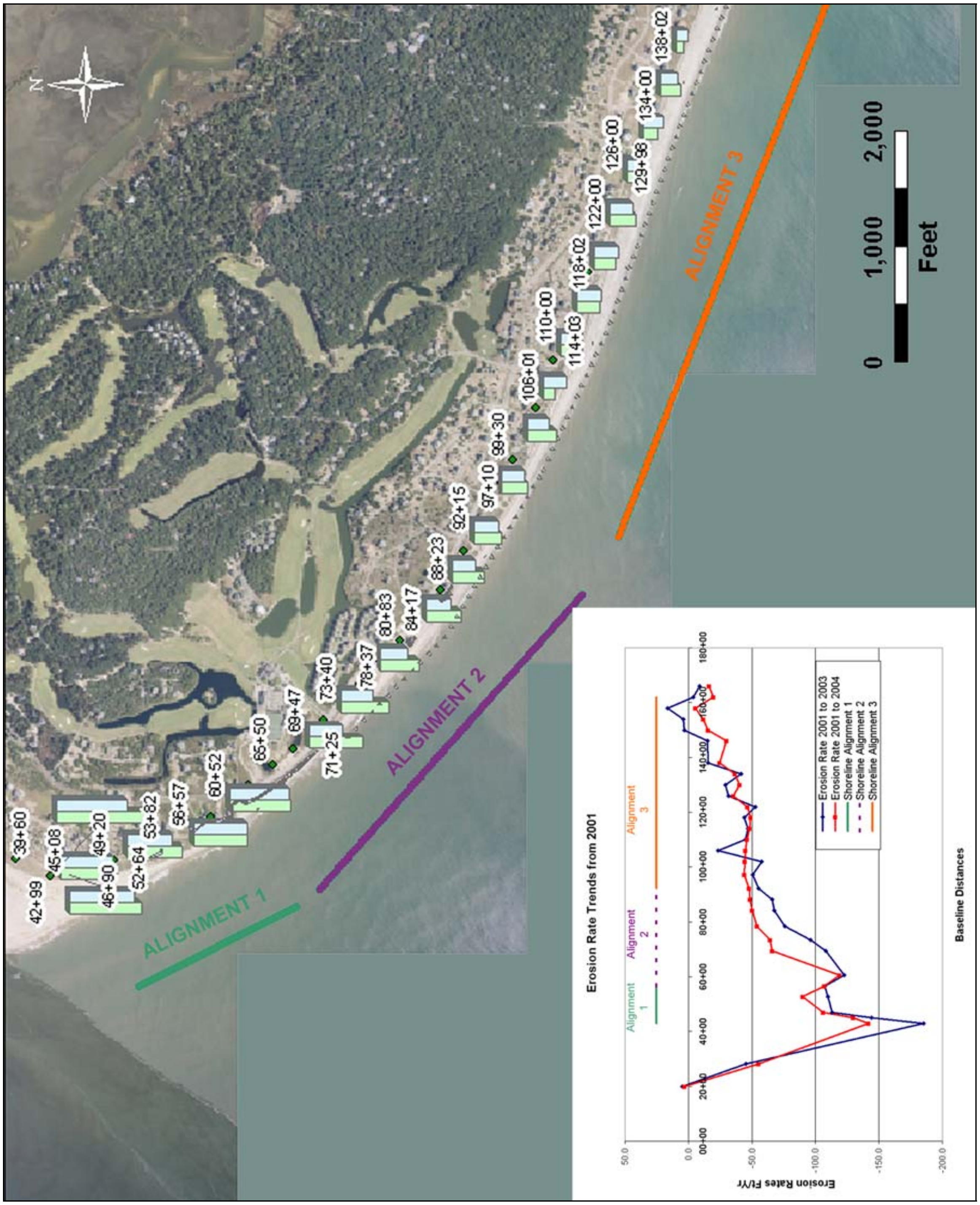


Figure 4.9 Shoreline Alignment and Erosion Rates along Bald Head Island.

Bald Head Shoal Channel Shoaling. In 2001, the west edge of Reach 1 in the Bald Head Shoal Channel was moved approximately 140 feet to the west and a beach fill of 1,849,000 cubic yards was placed on Bald Head Island from profile 41+50 to 207+00. Since the channel shift and beach fill, the shoal on the east side of Reach 1 of Bald Head Shoal Channel, referred to as the spit, has doubled in volume. The channel shift and spit location are shown in Figure 4.10. Figure 4.11 contains a hydrographic survey plot of the spit in October 2004 and the bounding rectangle for spit volume calculations is drawn on the plot. The spit volumes within the bounding rectangle and above –46 feet mean lower low water (mllw) are plotted in Figure 4.12 for the years 1994 through 2004. The October 2004 volume of almost 400,000 cubic yards is double the pre-2001 volumes which were consistently less than 200,000 cubic yards.

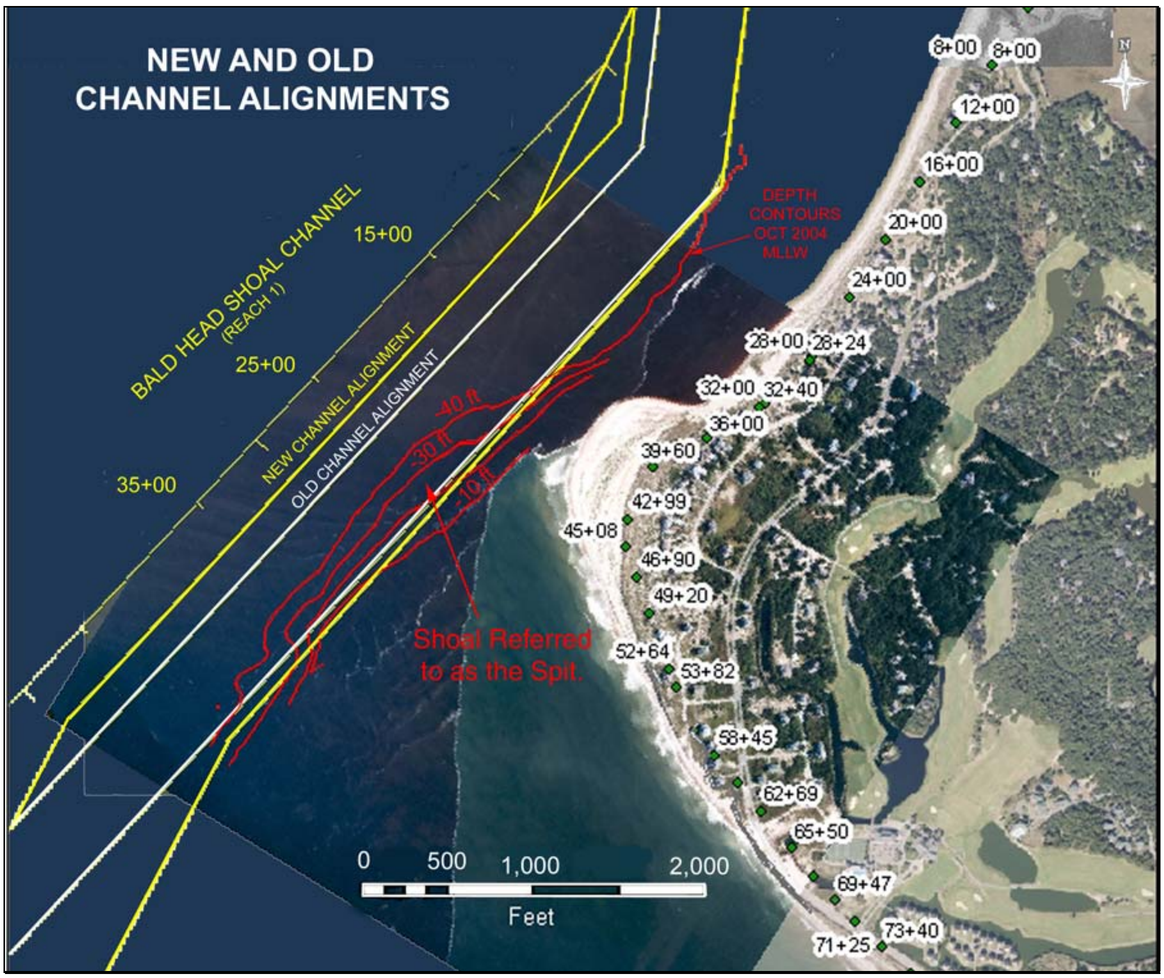


Figure 4.10. **Bald Head Shoal (Reach 1) Channel Realignment and Spit Location.**

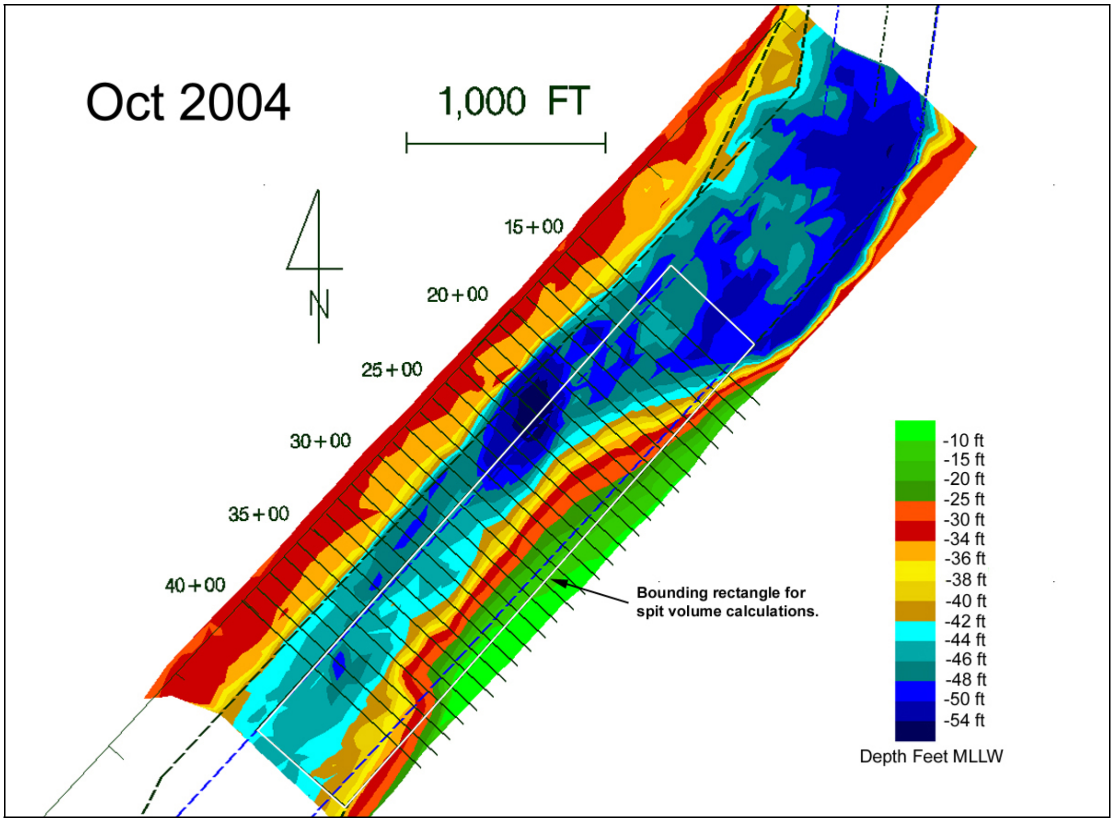


Figure 4.11 Hydrographic Survey of Bald Head Shoal Channel October 2004.

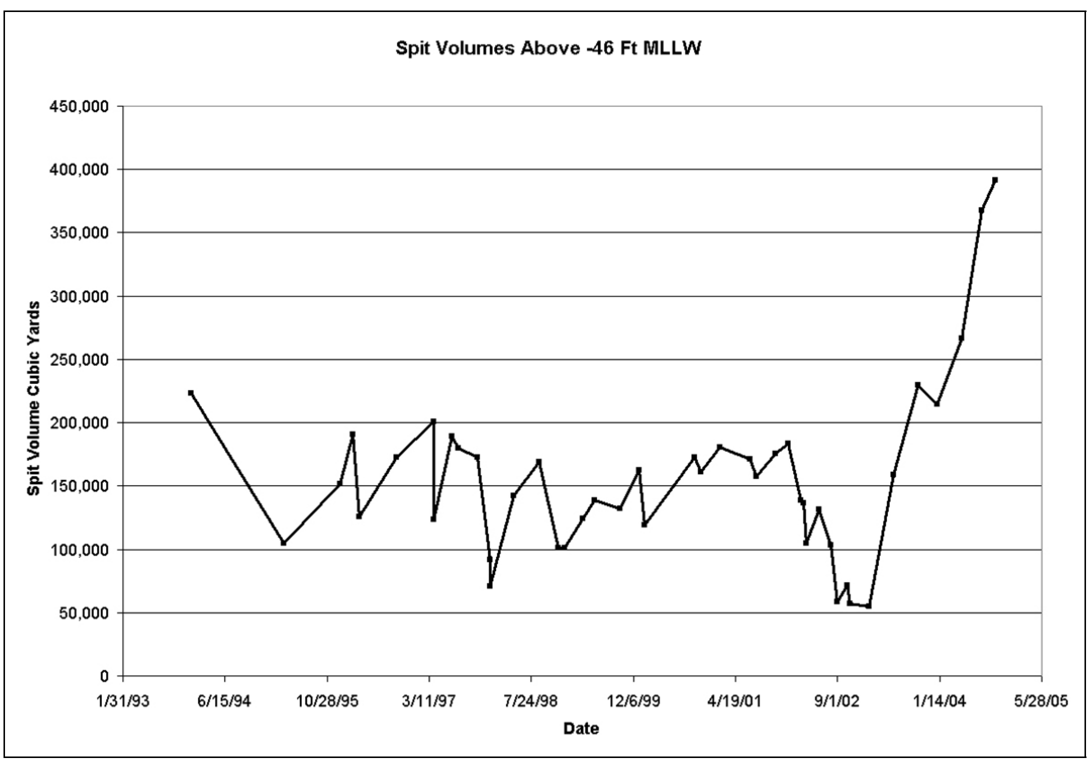


Figure 4.12. Bald Head Shoal Channel Spit Volumes 1994 to 2004.

The increase in spit size after 2001 may be attributed to a growth in the spit in response to moving of the west side of the channel. Figure 4.13 contains plots of spit widths in 1997 and 2004 with distances to the west bank of the channel in 1997 and 2004. It can be seen that the cross channel increase in the width of the spit (145 feet) is of the same magnitude as the offset of the west bank of the channel (141 feet). The gap between the spit and the west edge of the channel in1997 was 551 feet and in 2004 the gap was 555 feet. While the evidence that the spit growth is following the movement of the west side of the channel is compelling, the large amount of beach fill material that was placed adjacent to the spit in 2001 could also have influenced the spit growth. The spit growth after the next dredging/beach disposal cycle in 2004/05 should be a confirming factor as to whether the spit is following the west channel bank.

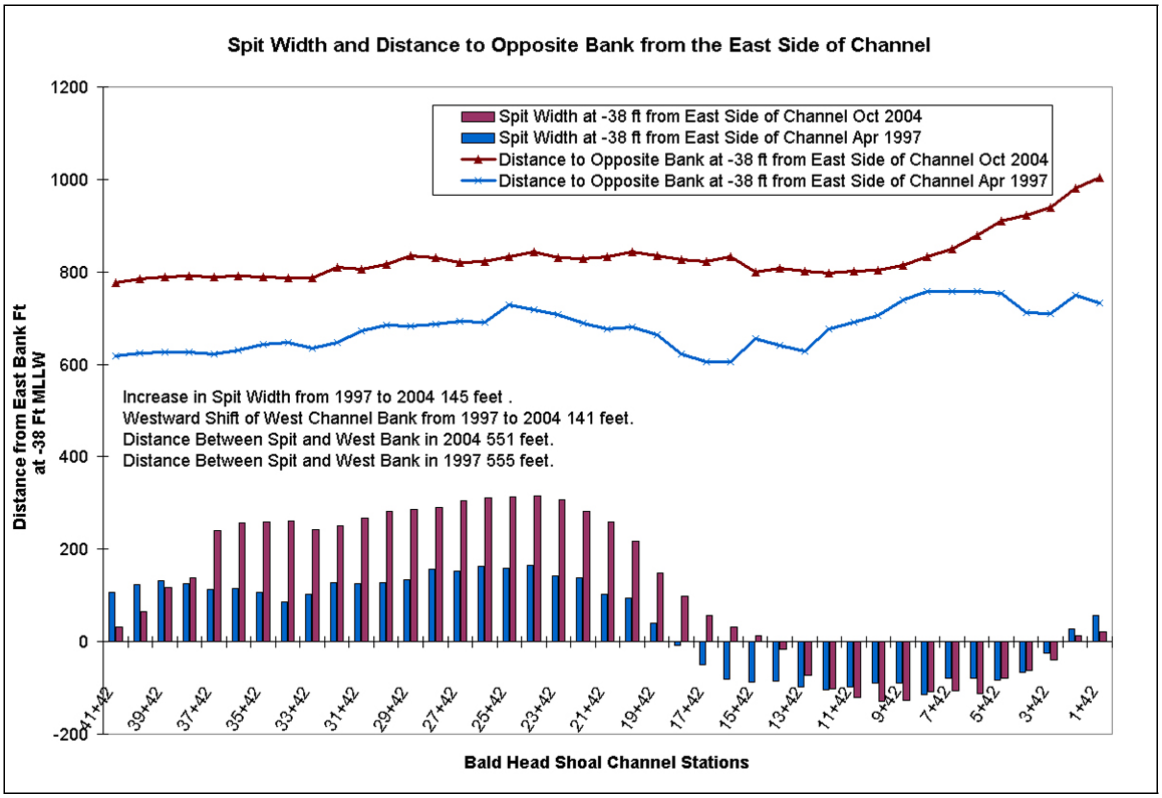


Figure 4.13 Spit Width and Distance to Opposite Bank.

The growth of the spit over the last year (2003 to 2004) can be seen by comparing the contour plot of the Bald Head Shoal Channel in October 2003 (Figure 4.14) to the contour plot of the Bald Head Shoal Channel in October 2004 (Figure 4.11). It is visually apparent that the shoal has grown along the channel but not across the channel. The width of the spit measured from the east side of the channel at -38 feet mllw for 2003 and 2004 are shown in Figure 4.15. It is readily seen that the spit has not grown across the channel but has increased seaward along the channel. The along channel growth can also be seen in a plot of the location of the spit centroid versus time in Figure 4.16.

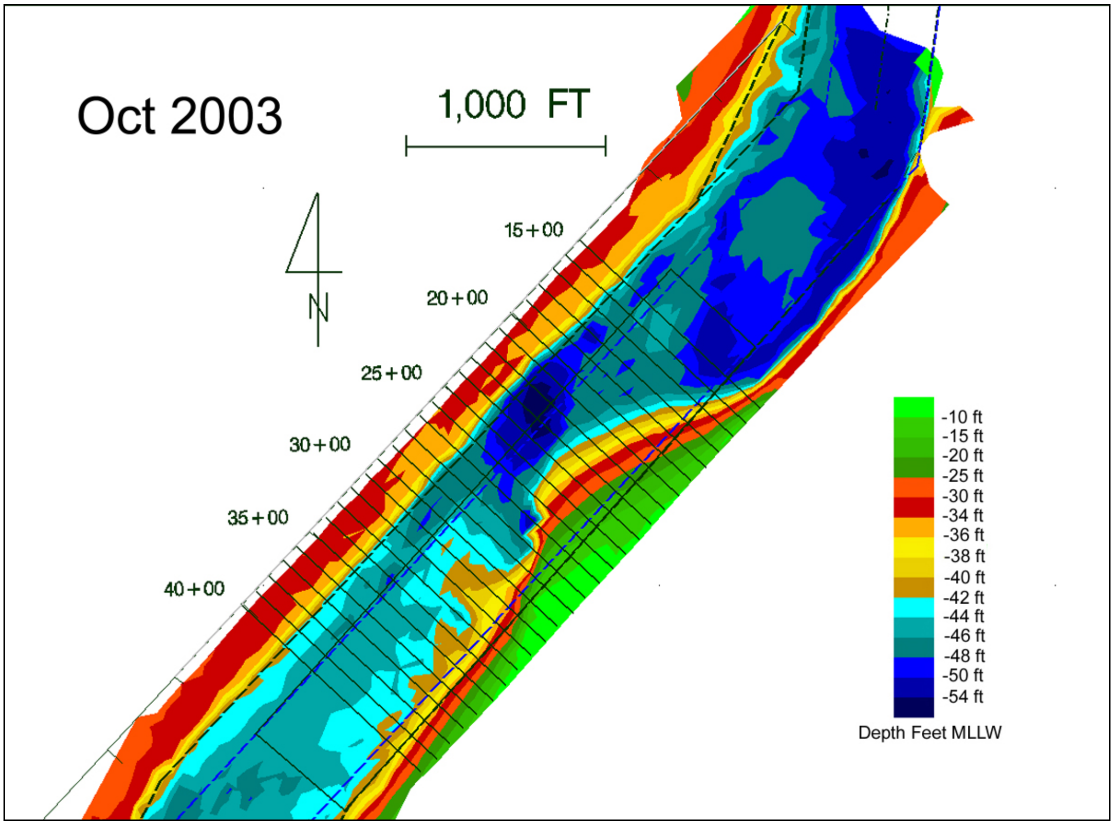


Figure 4.14 Hydrographic Survey of Bald Head Shoal Channel October 2003.

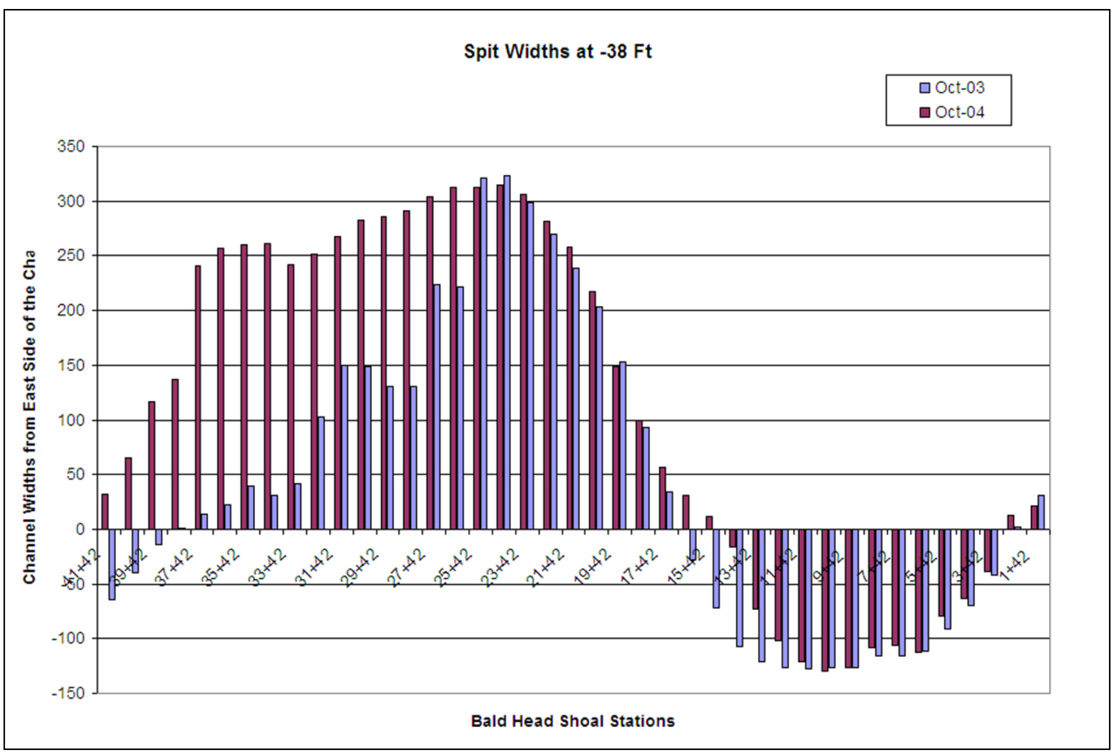


Figure 4.15 Bald Head Shoal Channel Spit Widths (Oct-03 and Oct-04).

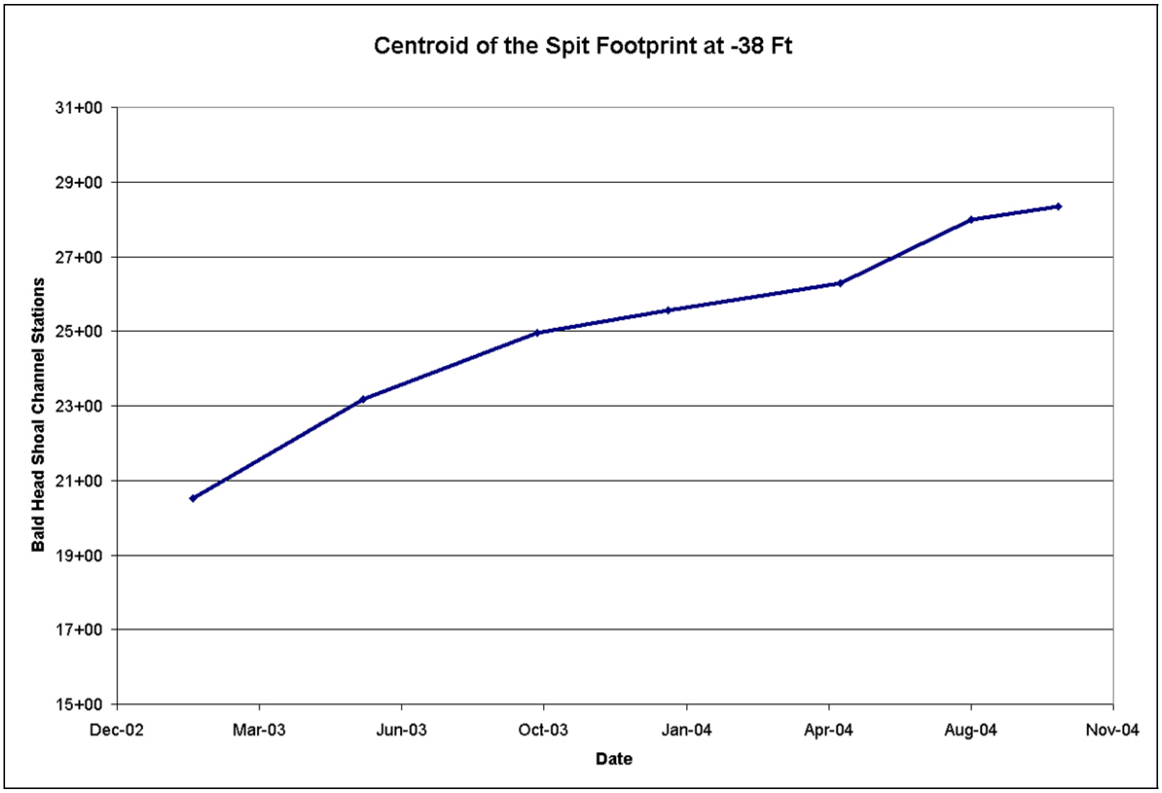


Figure 4.16 Movement of the Spit Centroid.

Figures 4.17 through 4.20 are cross section plots of the channel from February 2003 to October 2004 at stations 21+42, 25+42, 31+42 and 36+42. These figures contain an inner graph, which plots the spit width at –44 feet mllw versus time and denotes the timing of dredging operation in December 2003. At stations 21+42 and 25+42 there is a large scour hole on the west side of the channel, which is diminished at station 31+42 and is not discernable at station 36+42. The scour hole at the lower stations is due to the ebb tide current being constricted between the spit and the west side of the channel. This constriction of the ebb tide current is a controlling factor for the growth of the spit width.

In summary, while the sandbagging of the shoreline has changed the short term erosion rate at specific locations, the overall erosion pattern of 1) erosion rates exceeding a 100 feet a year near the inlet, 2) a transition reach where erosion exceeds 50 feet a year, and 3) a gradually diminishing erosion rate along south beach has remained generally the same during 2001 to 2004 period as for the 2001 to 2003 period. This erosion pattern is expected to change in 2005 with the reconstruction of a geo-textile groin field that was originally placed in conjunction with the 1996 beach fill. The groin field should more effectively retain the fill throughout the eroding area.

The growth of the spit into Bald Head Shoal channel has increased by the same distance that the west channel bank has been offset. The contraction of the ebb tide current between the spit and the west side of the channel is one of the factors controlling the size of the spit.

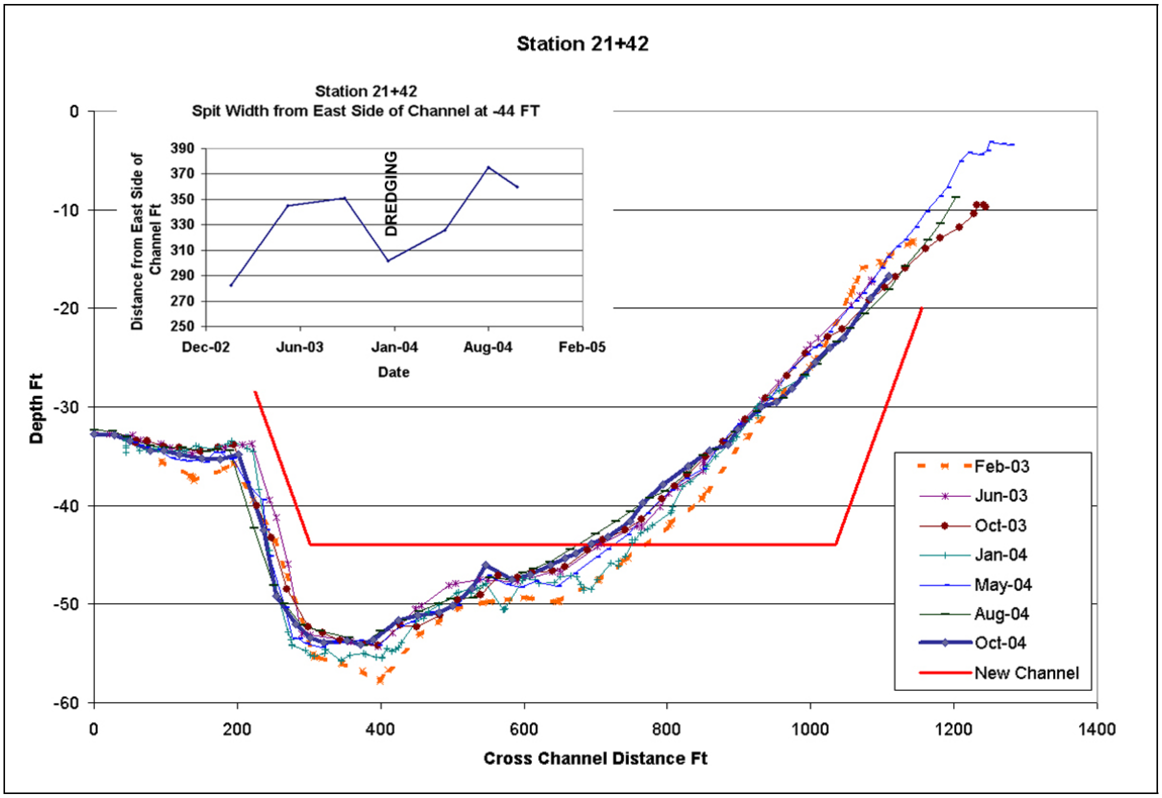


Figure 4.17 Cross Sections at Station 21+42 Bald Head Shoal Channel.

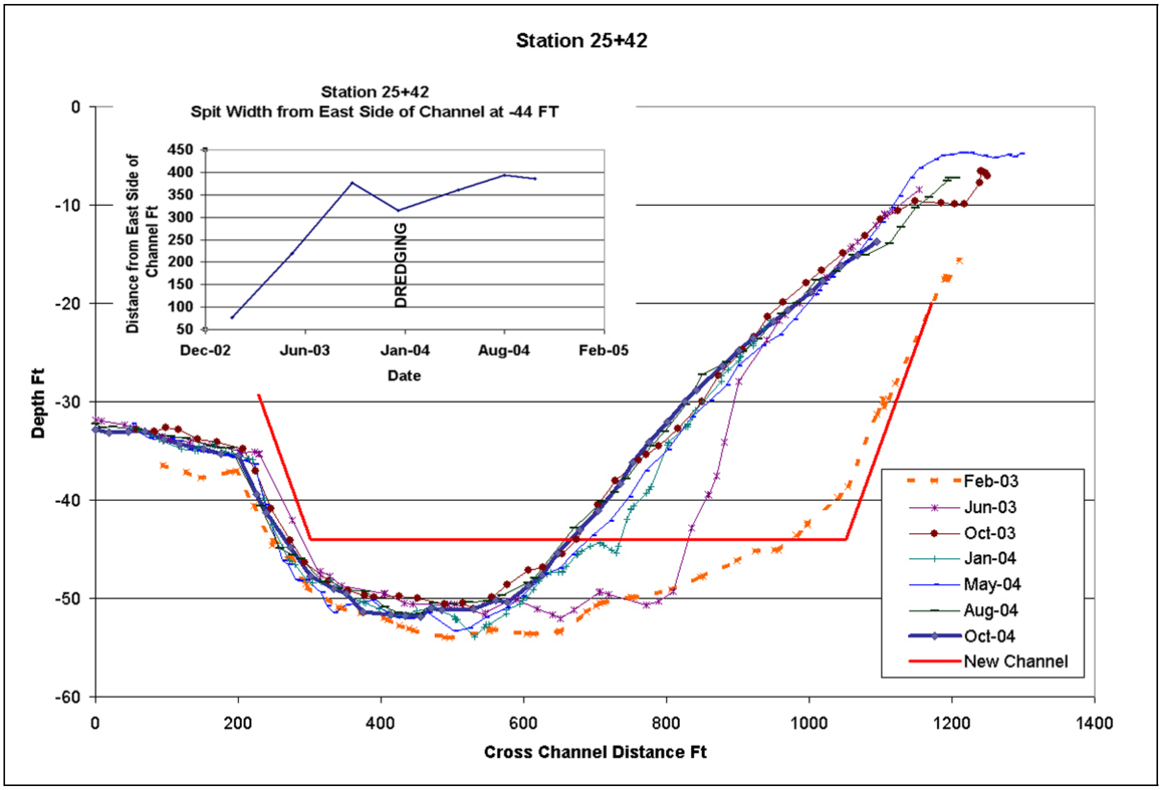


Figure 4.18 Cross Sections at Station 25+42 Bald Head Shoal Channel.

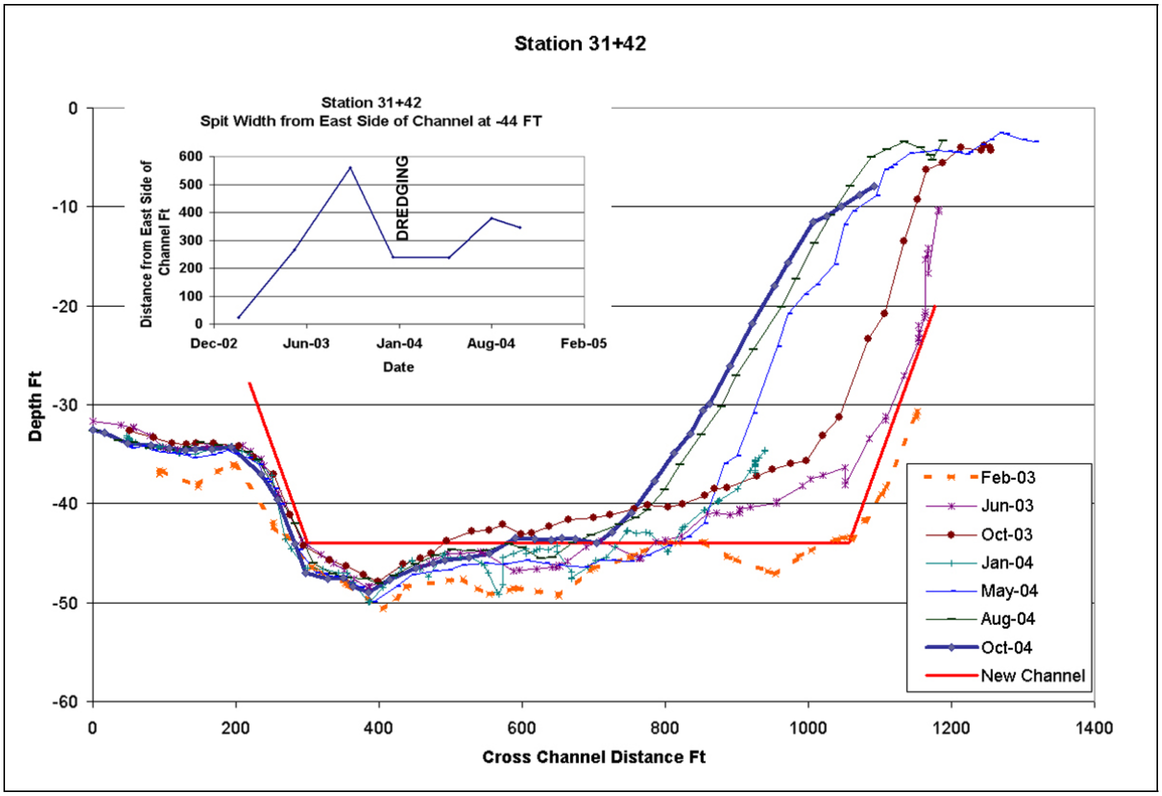


Figure 4.19 Cross Sections at Station 31+42 Bald Head Shoal Channel.

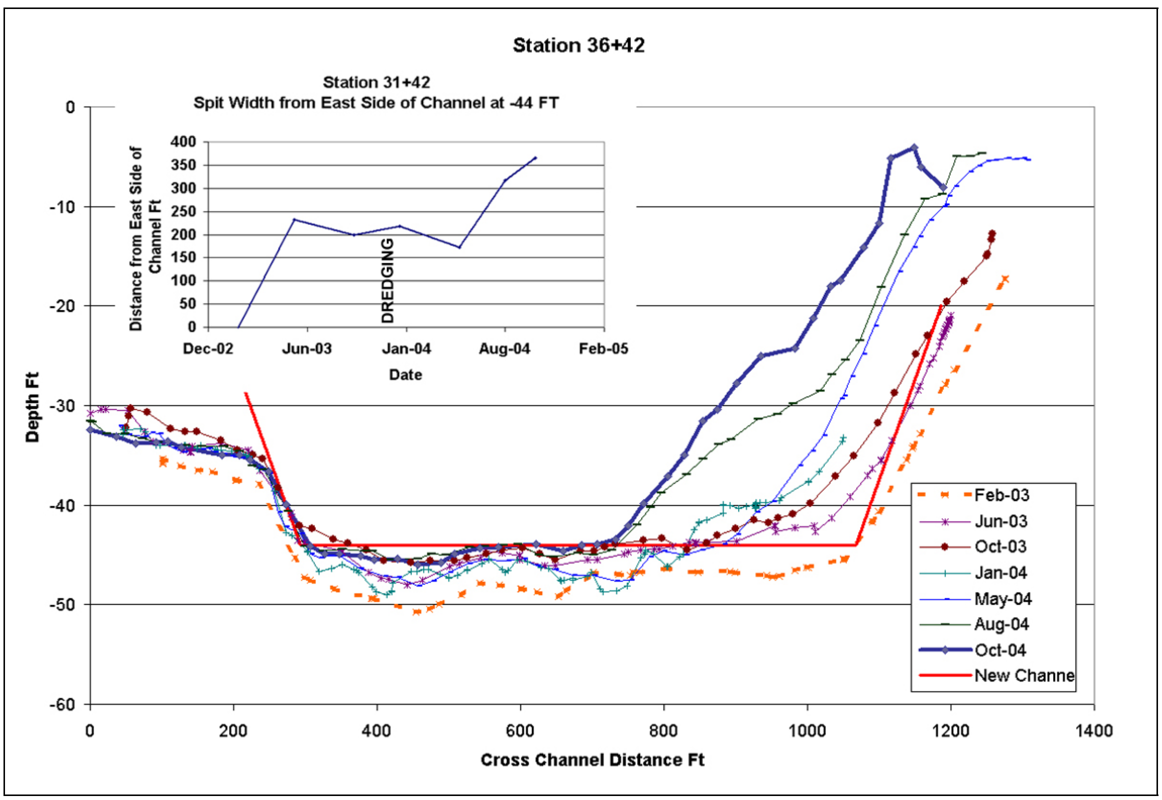


Figure 4.20 Cross Sections at Station 36+42 Bald Head Shoal Channel.

Ebb and Nearshore Shoal Response

General. As discussed in Part 3, detailed bathymetry of the Cape Fear River ebb tidal delta and channels were collected on four occasions specifically; August-September 2000, December 2001-January 2002, January 2003 and January 2004. These surveys were combined with bathymetric data from the LARC offshore profile lines to produce comprehensive surveys of the monitoring area. The results of the surveys are discussed below which are summarized from the previously referenced letter reports (McNinch 2002, McNinch 2003, and McNinch 2004). The results focus on two survey regions that exhibited change in bathymetry between the 2000 and 2004 surveys. These regions covered the area surrounding the mouth of the Cape Fear River (inner region) and the area at the junction of the old and new channel alignments (outer region).

Results-Ebb Tidal Delta Inlet (inner) Region. The ebb tidal delta surrounding the mouth of the Cape Fear River consists of three linear shoals. Two shoals are present on the west side of the shipping channel (Jay Bird Shoals) and the third or Bald Head Shoal protrudes off the southwestern corner of Bald Head Island east of the main channel. The main channel exits into the ocean immediately adjacent to Bald Head Island along West Beach. A companion flood margin channel, typical of most tidal inlets, is not present through Bald Head Shoal; however, a well-developed flood channel exists along the tip of Oak Island on the opposite side of the entrance channel.

A comparison of this inner region showing changes between the 2000 survey and each subsequent, post-construction survey is Figure 4.21. These contour change maps shows deepened scour areas as negative values in shades of red and shoaled areas as positive green tones. The comparison shows a continued deepening of the flood margin channel on the Oak Island side and along the main shipping channel; the latter deepening being attributed to the dredging of the new channel between 2001 and 2002. Also, the nearshore along Bald Head Island’s south and west beaches adjacent to the inlet and Bald Head Shoal continue to have been dynamic during this period exhibiting areas of both accretion and erosion. This pattern reflects the loss of beach fill placed during construction along south beach and the attendant growth of the sand spit from the southwest corner of the island. Finally the overall morphology of the ebb tidal delta appears to be largely static which suggests there have not been substantial changes in sediment transport pathways around the ebb tidal delta since the initial pre-construction 2000 survey.

Results-Ebb Tidal Delta Inlet (outer) Channel Region. A similar bathymetric change map showing changes in contours between 2000 and 2004 for the distal end of the ebb tidal delta is presented in Figure 4.22. The most dominant feature shown in the figure is the newly dredged channel alignment. Very little change is shown elsewhere in the outer region. Of particular interest is the lack of change in the area of the shoal between the two channels. This portion of the shoal is expected to be the most sensitive to changes because of its location between the channels where the magnitude of mean currents around the distal end of the ebb tidal delta are the highest. In a similar manner, the larger shoals surrounding the new channel show minimal change over the three survey years and, like the minimal change near the inlet, suggest little change in sediment transport pathways along the offshore end of the ebb tidal delta.

Although annual surveys show only endpoint differences or similarities and do not reflect the more temporally dynamic changes that may occur between surveys, these charts indicate minimal evolution of the shoals flanking the inlet in the Baldhead Island region.

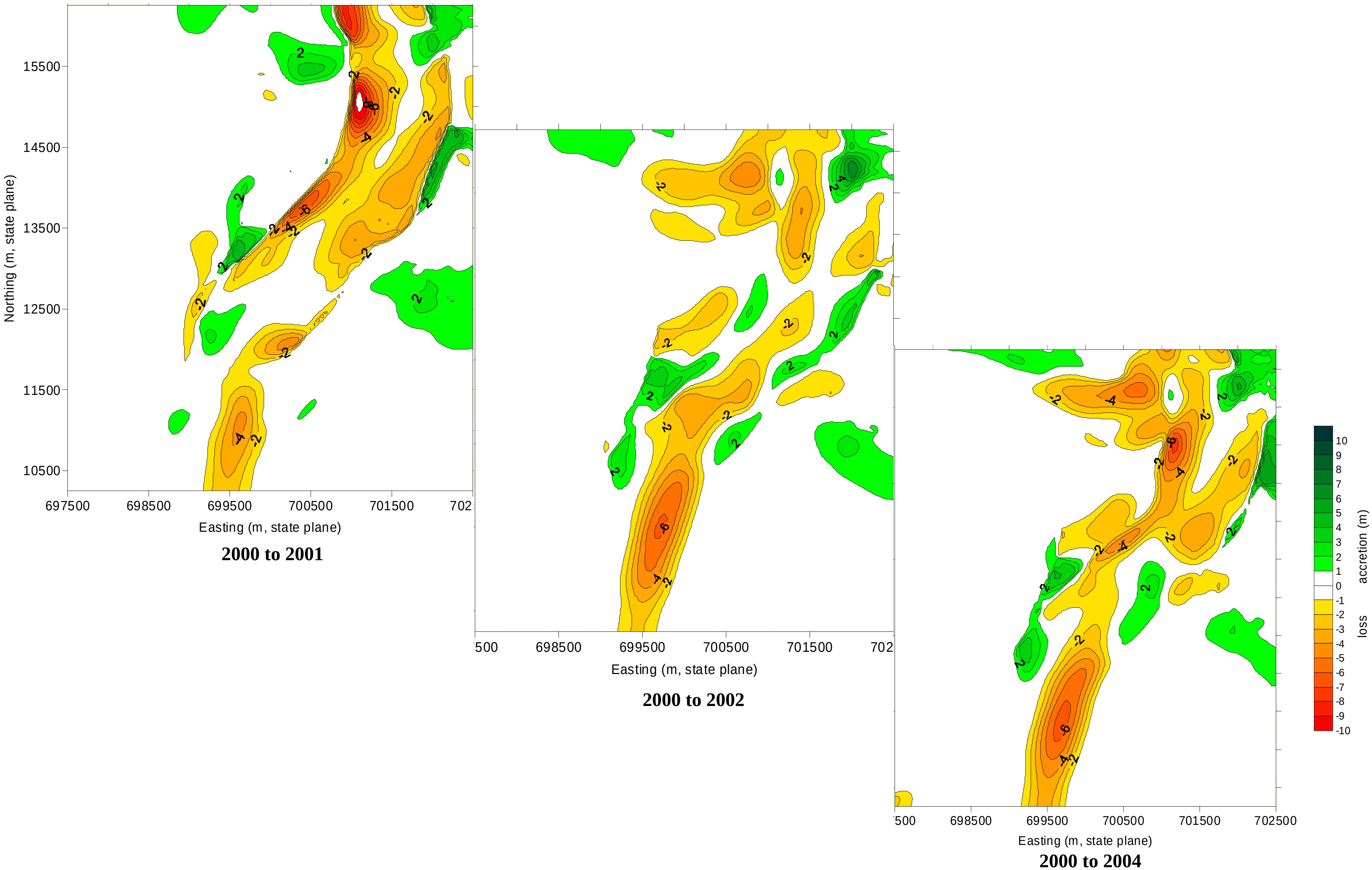


Figure 4.21 Change map showing a bathymetric change at the Cape Fear River tidal inlet region.

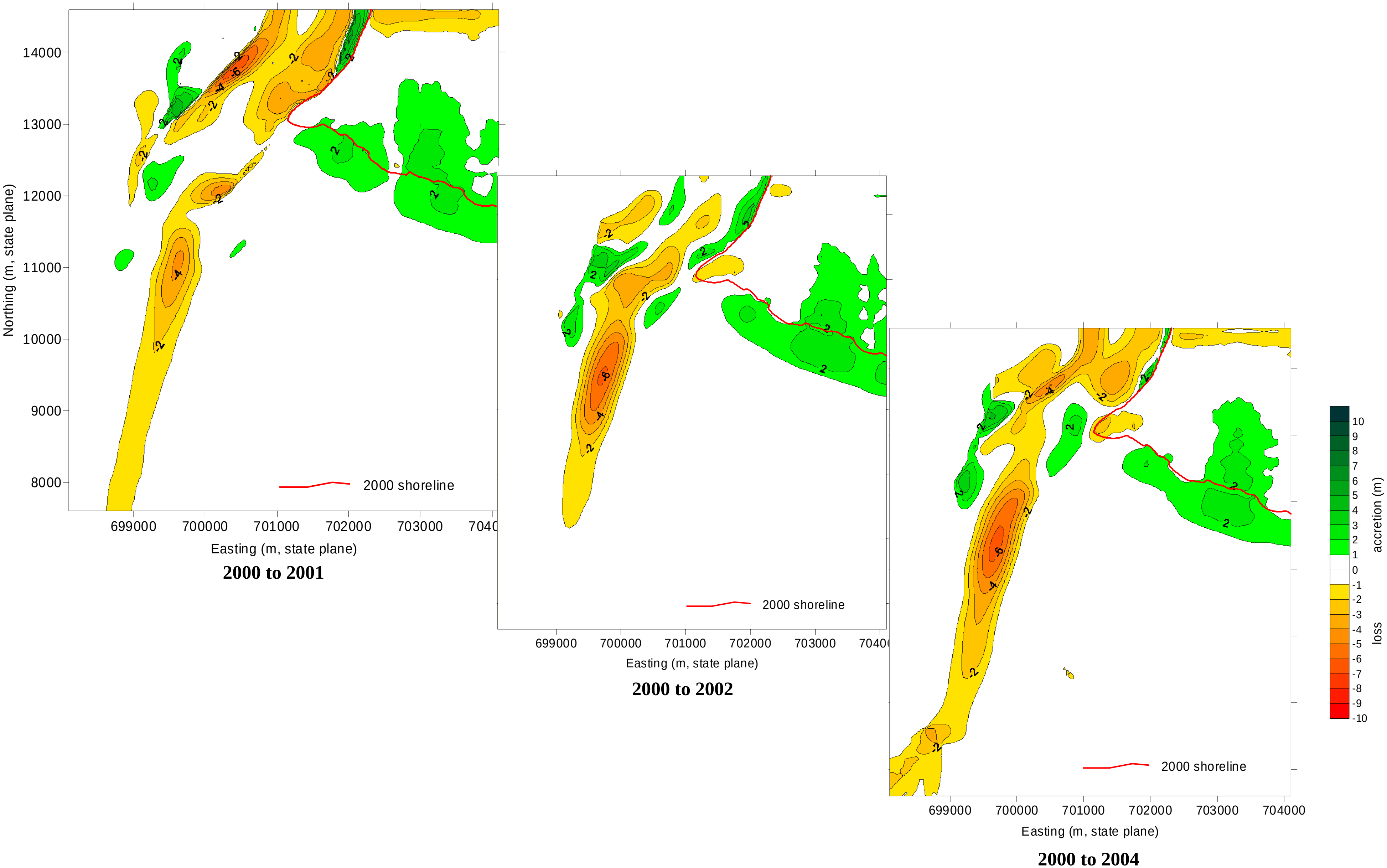


Figure 4.22 Change map showing a bathymetric change at the new channel region.

Changes in Currents and Tidal Prism

Currents were measured in the Cape Fear River entrance near Bald Head Island and Caswell Beach before dredging of the new alignment (October 11 and 12, 2000) and after dredging was completed (April 12 and 13, 2002, March 4 and 18, 2003, and January 11-13, 2004). A vessel mounted Acoustic Doppler Current Profiler (ADCP) was used to measure currents along a transect throughout a tidal cycle. See Part 3 for discussion of the measurement techniques and results for each of the four measurement episodes.

Current Velocities (Direction and Magnitude). Maximum current magnitudes are compared for both near-surface and near-bottom currents during ebb and flood flows in Table 4.3 for the inlet transect. The near-bottom ebb current magnitudes differ by less than about 11.5 percent for the first 3 surveys, while the January 2004 survey showed a nearly 50% increase. A possible explanation for the increased ebb flow velocity near the bottom during this survey is the spit growth from Bald Head Island projecting into the channel. This spit growth as discussed earlier in Part 4 would tend to constrict the channel and thus cause ebb velocities (measured just upstream from the spit) to increase as water is funneled through.

One would not expect a similar increase in flows near-surface because of the spit constriction is near the bottom. The post-construction near-surface ebb flows vary by between 12 and 46 percent from the pre-construction survey. The increase observed for the March 2003 survey may be due to increased discharges down the Cape Fear River during this time (see Current Measurement discussion in Part 3). The April 2002 and January 2004 survey differences may be related to tide phase differences when the surveys were made (see Figures 3.33 – 3.36).

Table 4.3 Maximum Magnitude of Mean Flows at Inlet Transect

		October 2000	April 2002	March 2003	January 2004
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)
	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)
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)
	flood	3.61 ft/s (1.10 m/s)	4.10 ft/s (1.25 m/s)	4.17 ft/s (1.27 m/s)	3.75 ft/s (1.14 m/s)
*Near-bottom defined by lower half of water column; near-surface defined by upper half of water column					

One would also not expect an impact to the near-bottom flood flows from the spit growth because the measurement transect is "downstream" of the spit for flood flow. The near-bottom flood velocities for post-construction surveys were between zero and 12 percent greater than the pre-construction survey, except for the March 2003 survey, which was 47 percent greater. Though the observed tide range exceeds the predicted tide range for all surveys (except March 2003 because the Bald Head Island wave gage was not operational during that time), we cannot determine if actual wave and tide conditions were significantly greater in March 2003. However, because the post-construction near-surface flood flows varied by only between 4 and 16 percent of the pre-construction flows, it is likely that wave events were not a factor.

Flow comparisons for the offshore transect are shown in Table 4.4. For the near-bottom ebb flows, all post-construction surveys are within 5 percent of each other, but 48 to 55 percent greater than the pre-construction survey. These differences may be due to the presence of the new channel alignment (which did not yet exist in October 2000) (see Figures 3.39, 3.43, 3.47 and 3.51).

For the near-bottom flood flows, April 2002 and March 2003 show larger velocities, but overall magnitudes are up to 50 percent smaller than the near bottom ebb flows. Interestingly, the January 2004 velocity is essentially equal to the October 2000 velocity.

For the near-surface, all post-construction ebb flow velocities were larger than the pre-construction velocities, with March 2003 being about 25 percent larger. Similarly, for the near-surface flood flows, all post-construction velocities were larger than the pre-construction velocity (13 to 33 percent) with April 2002 being nearly 77 percent greater. The influence of two channels, tide phase differences, winds, river discharges all are factors in the differences observed.

As stated previously, these magnitudes provide only a snapshot at the time of the survey and vary temporally and spatially especially considering other forcing functions (tide phase, winds, discharges, etc.).

Table 4.4 Maximum Magnitude of Mean Flows at Offshore Transect

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

Tide elevations at the Bald Head wave gauge were examined for the period during the ADCP surveys to compare tide ranges during the surveys with predicted tide ranges (Table 4.5). This comparison was made to identify any temporal wind or wave influenced differences that might help to explain current magnitude differences observed in Tables 4.3 and 4.4 and tidal prism differences observed in Figure 4.39.

Table 4.5 Predicted and Observed Tide Ranges during ADCP Survey

Date	Times (Local)	Predicted Tide Range		Observed Tide Range	
		Flood (ft)	Ebb (ft)	Flood (ft)	Ebb (ft)
Inlet Transect					
11 Oct 2000	1000 – 2300	4.40	4.55	4.60	4.90
13 Apr 2002	0630 – 2000	4.50	3.96	4.76	4.30
4 Mar 2003	0500 – 1830	4.34	4.47	*	*
13 Jan 2004	1000 – 2330	3.84	4.01	4.37	3.91
Offshore Transect					
12 Oct 2000	1130 – 0030 (13 Oct 2000)	4.53	4.69	5.10	5.20
12 Apr 2002	0630 – 2000	4.47	4.09	4.57	4.35
18 Mar 2003	0500 – 1830	5.46	5.45	6.40	6.29
11 Jan 2004	1530 – 0500 (12 Jan 2004)	3.58	3.69	3.74	4.68
*Gauge not operational					

At the inlet transect, flood flow patterns from all 4 surveys appear similar (see Figure 4.23 for October 2000; Figure 4.24 for April 2002; Figure 4.25 for March 2003 and Figure 4.26 for January 2004), except for the shoals adjacent to Oak Island, which were not surveyed in October 2000. During ebb flow at this transect, flow patterns appear similar for all surveys except that for January 2004, there is grater difference between the near surface and near bottom current magnitudes in the main channel (see Figure 4.27 for October 2000; Figure 4.28 for April 2002; Figure 4.29 for March 2003 and Figure 4.30 for January 2004).

At the outer transect, flood flow patterns have uniform magnitudes throughout each transect, but the magnitude of the January 2004 survey appears smaller than previous surveys, which may be a result of the survey being taken closer to neap tide (see Figure 4.31 for October 2000; Figure 4.32 for April 2002; Figure 4.33 for March 2003 and Figure 4.34 for January 2004).

At the outer transect during ebb flow, the October 2000 survey shows uniform current magnitudes throughout the transect, while the 3 post-construction surveys show influence of the 2 navigation channels with a preference for flow along the old alignment, particularly at the inshore leg of the transect. Otherwise, all three post-construction surveys show similar flow patterns (see Figure 4.35 for October 2000; Figure 4.36 for April 2002; Figure 4.37 for March 2003 and Figure 4.38 for January 2004).

The similarities of the flow regime between pre- and post-dredging do not indicate substantial changes have occurred and are consistent with the minimal change seen in the bathymetry of the ebb tidal delta. There also does not appear to be a substantial decrease in current magnitude through the old shipping channel since the opening of the new channel.

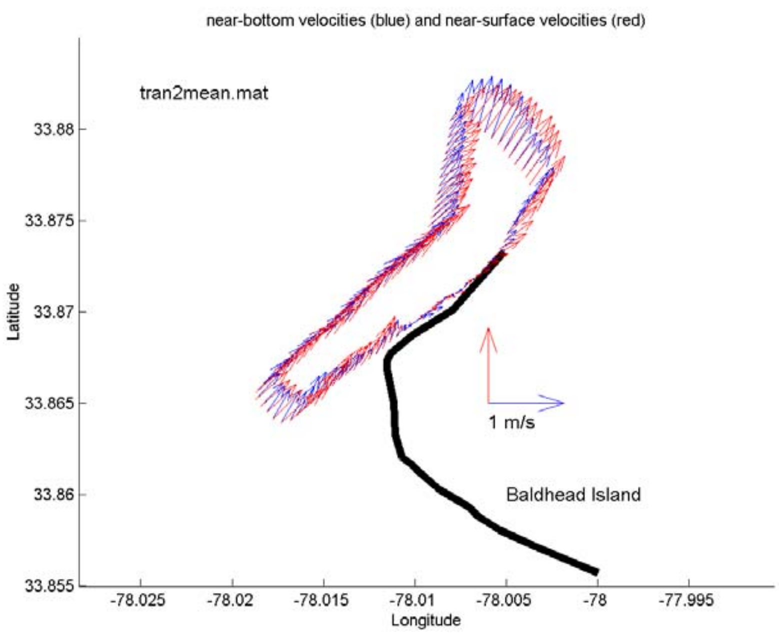


Figure 4.23 October 2000 ADCP survey at inlet transect during peak flood flow. Note that survey transect does not cover same area as the April 2002, March 2003 and January 2004 surveys.

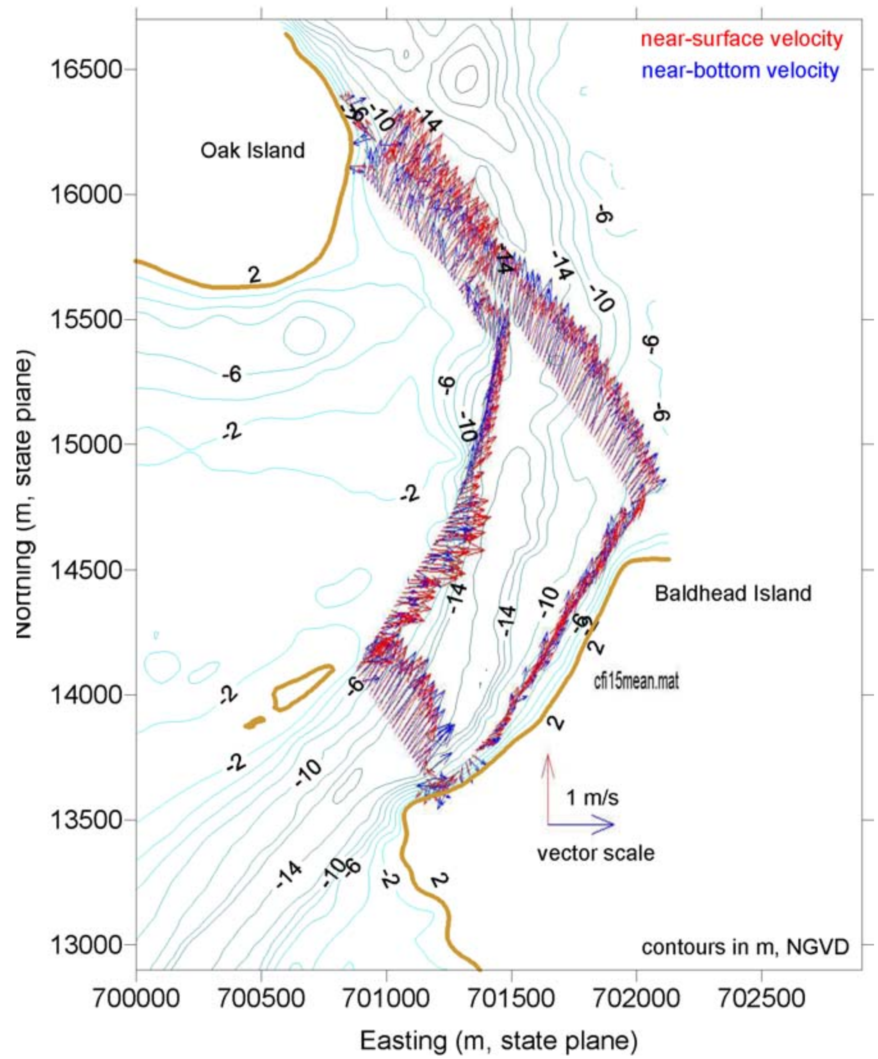


Figure 4.24 April 2002 ADCP survey at inlet transect during peak flood flow.

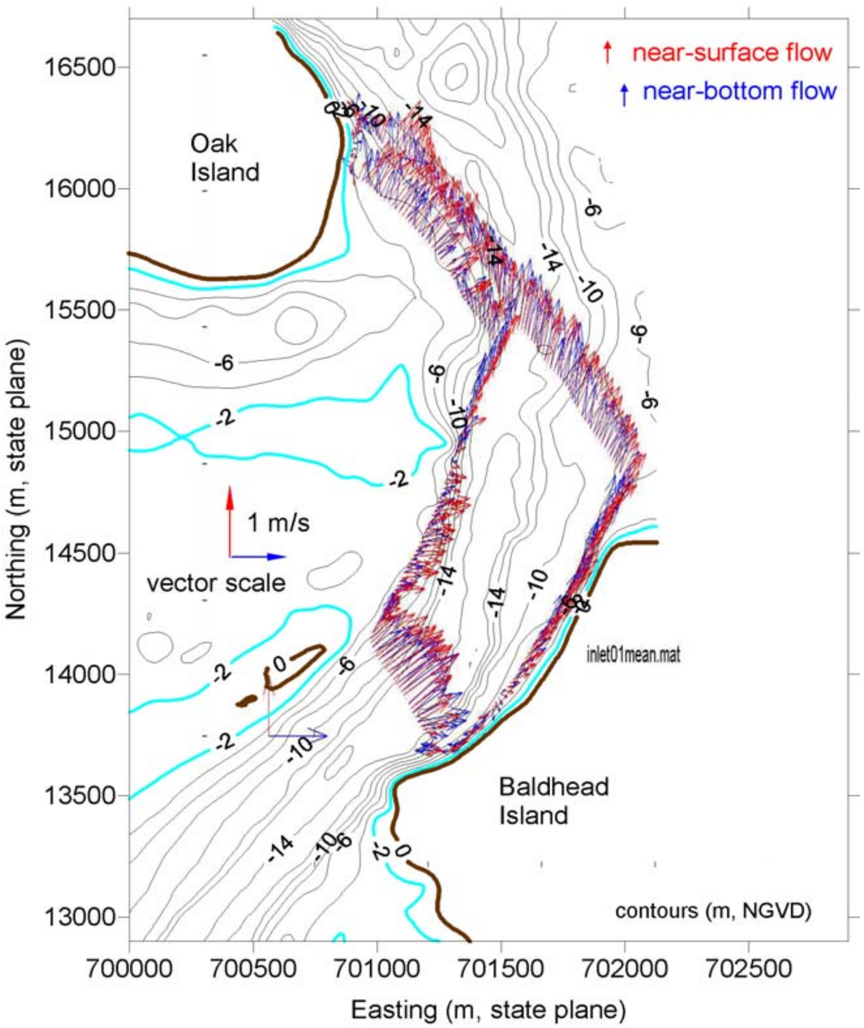


Figure 4.25 March 2003 ADCP survey at inlet transect during flood flow.

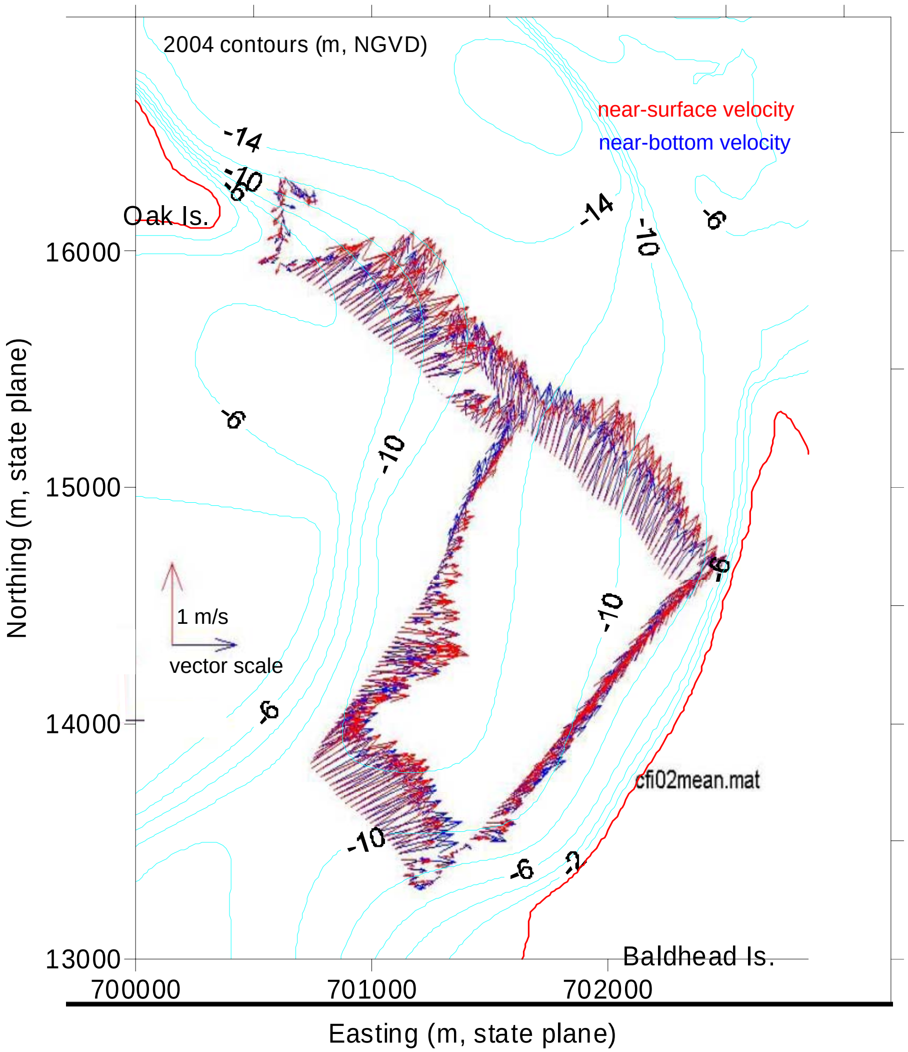


Figure 4.26 January 2004 ADCP survey at inlet transect during flood flow.

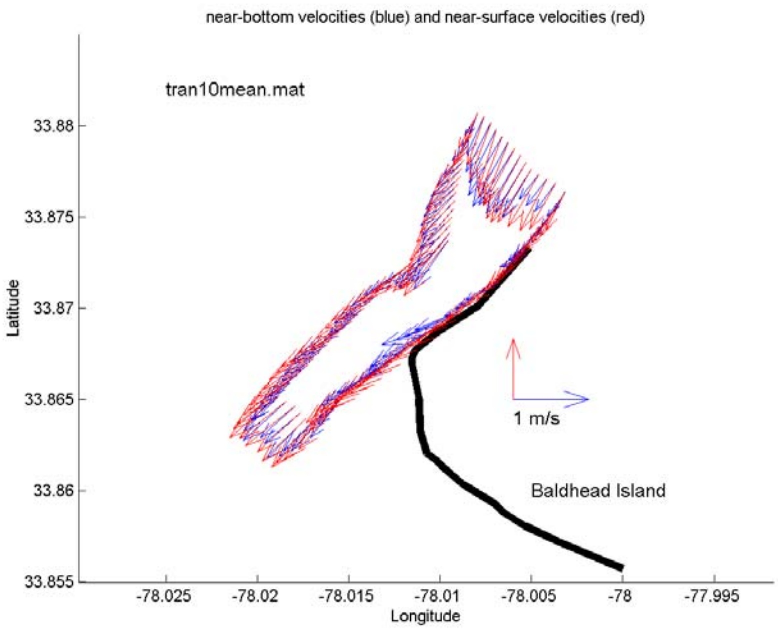


Figure 4.27 October 2000 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the April 2002 survey.

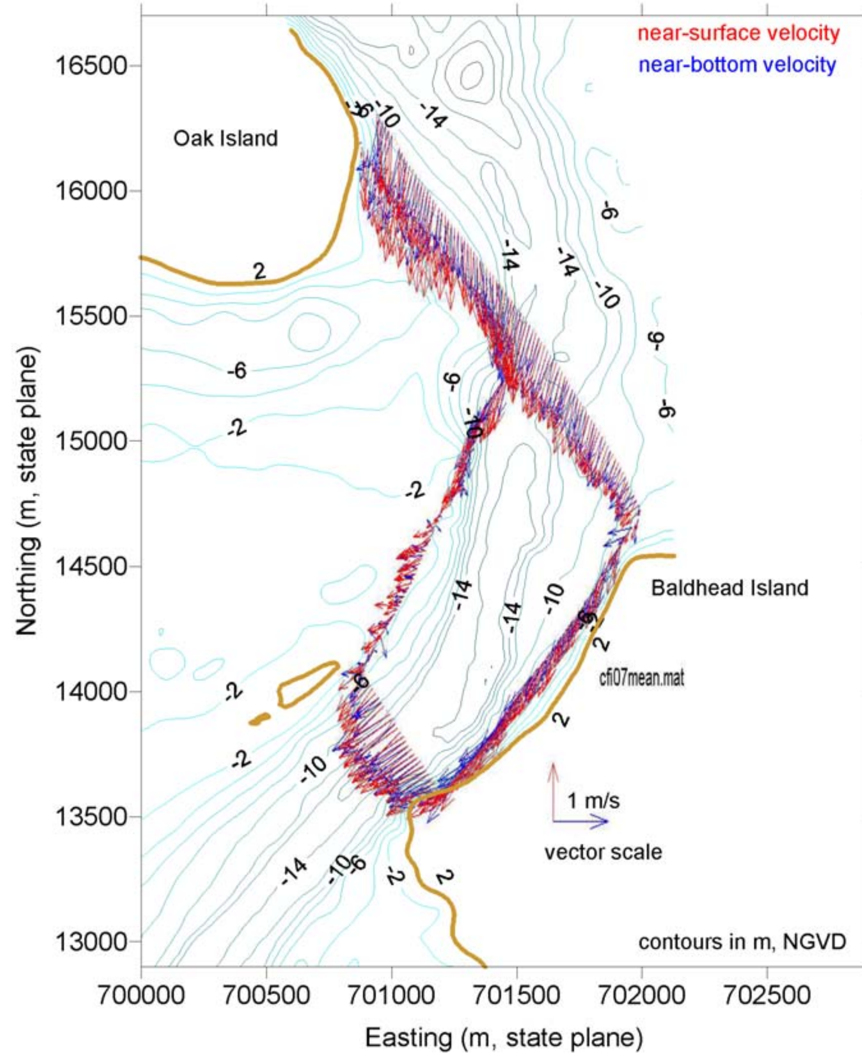


Figure 4.28 April 2002 ADCP survey at inlet transect during peak ebb flow. Note that survey transect does not cover same area as the October 2000 survey.

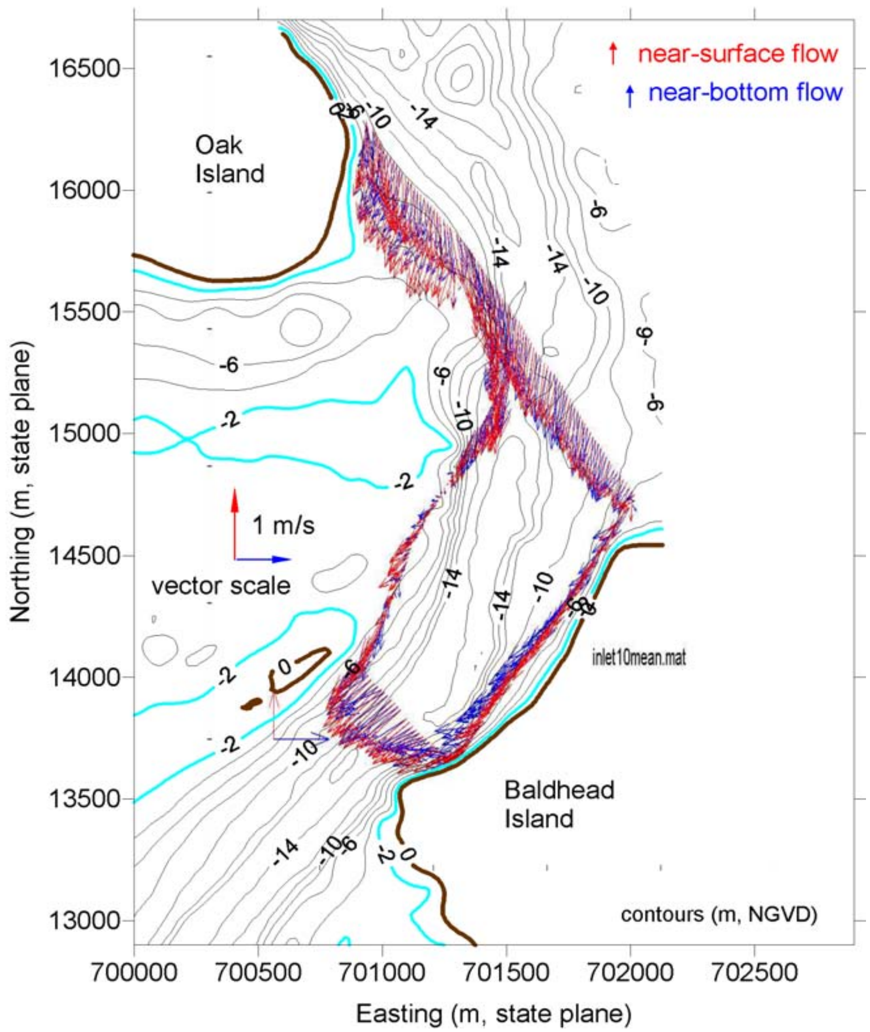


Figure 4.29 March 2003 ADCP survey at inlet transect during ebb flow.

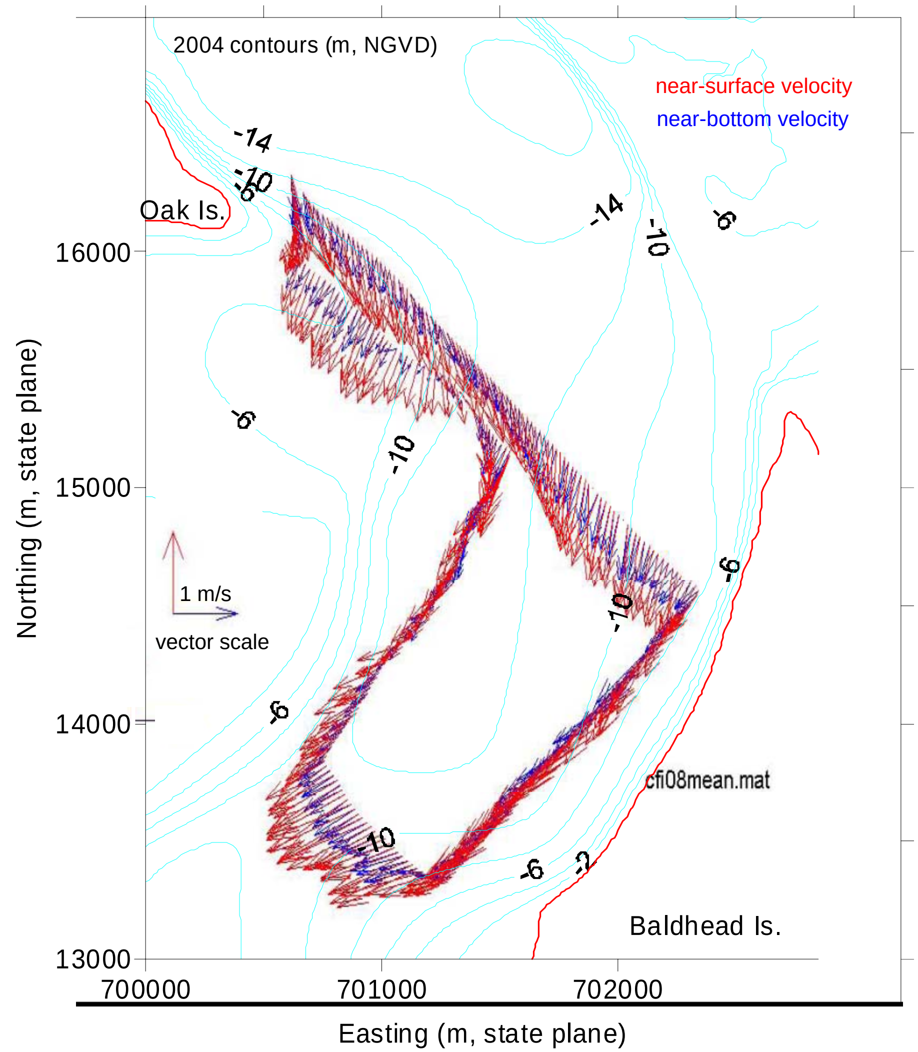


Figure 4.30 January 2004 ADCP survey at inlet transect during ebb flow.

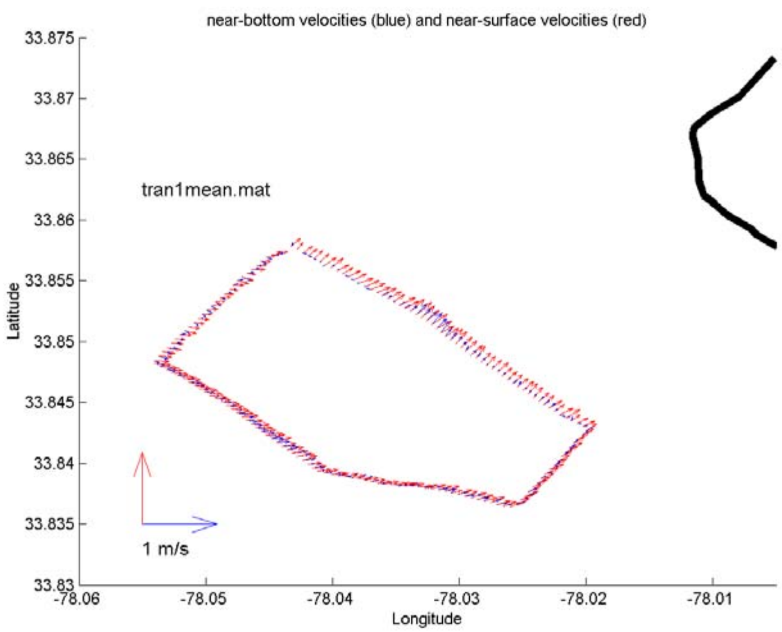


Figure 4.31 October 2000 ADCP survey at offshore transect during peak flood flow.

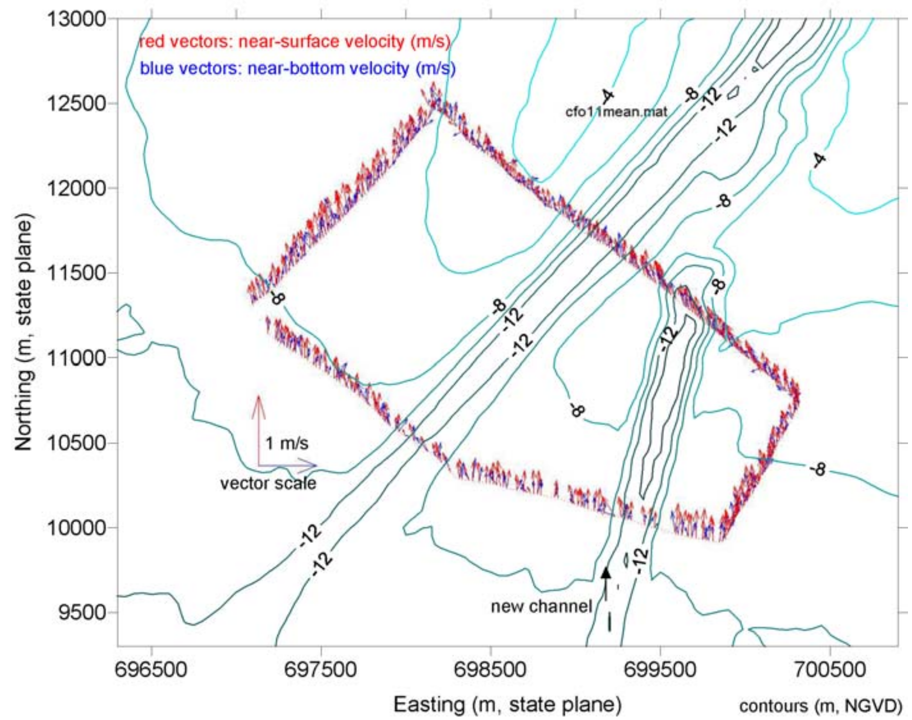


Figure 4.32 April 2002 ADCP survey at offshore transect during peak flood flow.

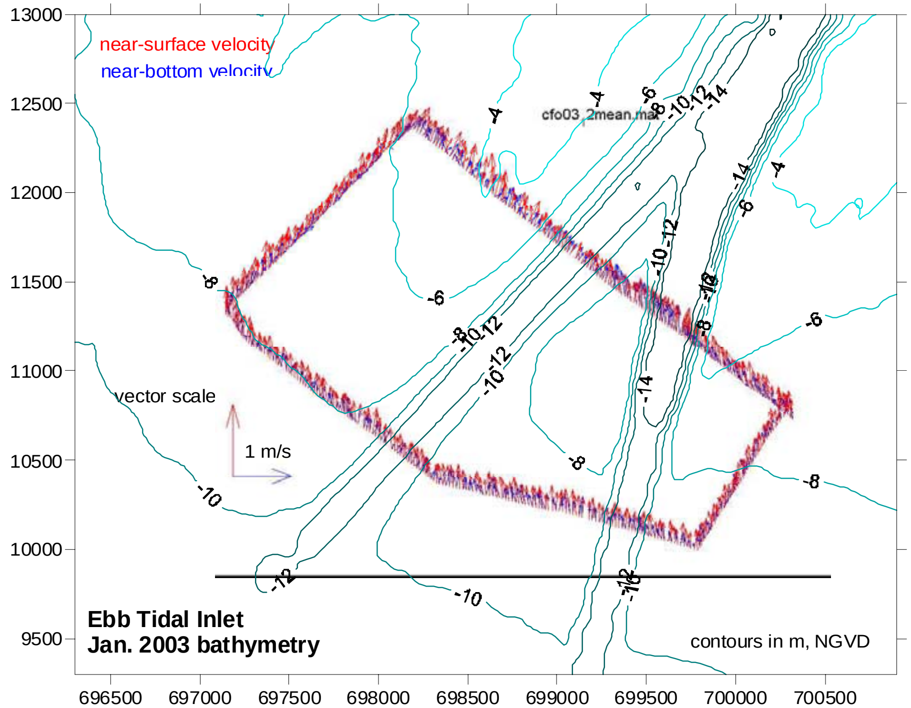


Figure 4.33 March 2003 ADCP survey at offshore transect during flood flow.

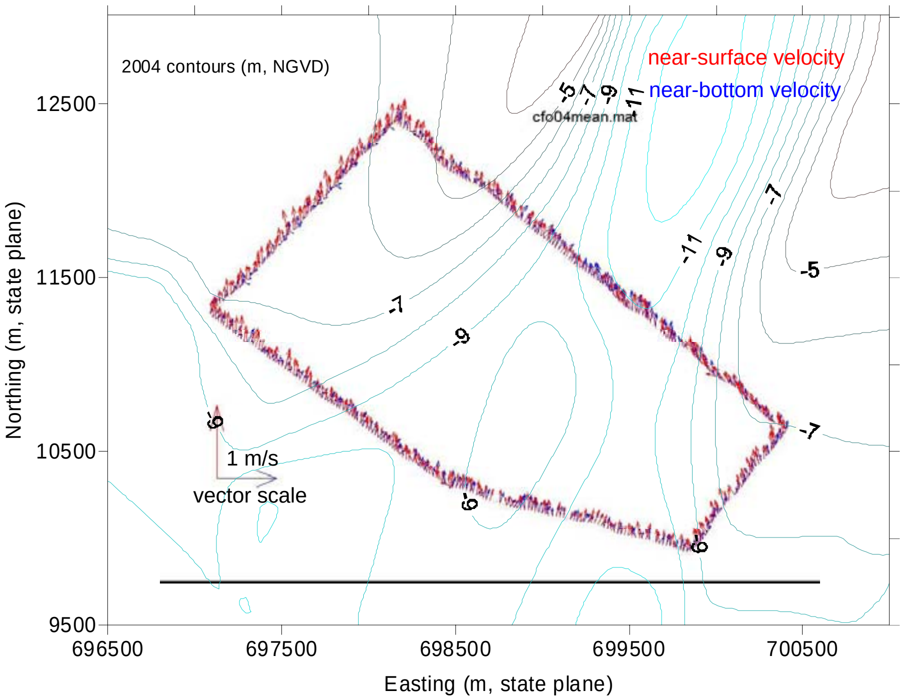


Figure 4.34 January 2004 ADCP survey at offshore transect during flood flow.

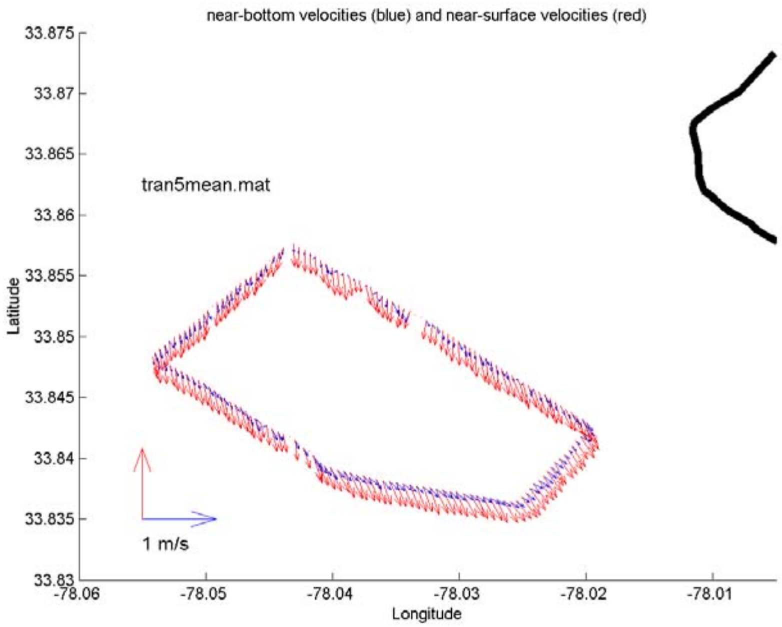


Figure 4.35 October 2000 ADCP survey at offshore transect during peak ebb flow.

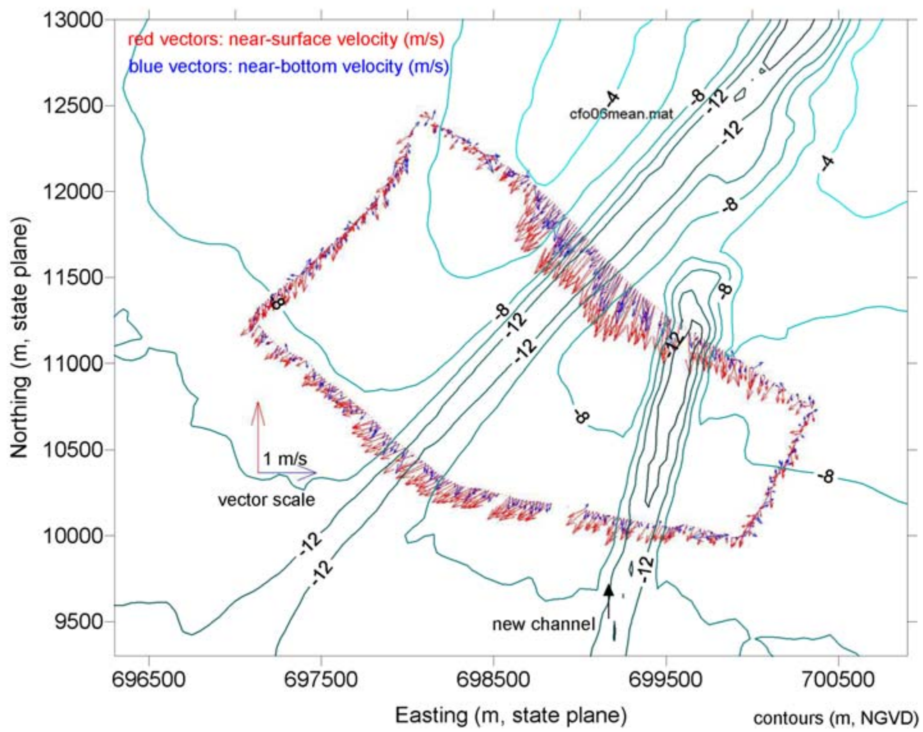


Figure 4.36 April 2002 ADCP survey at offshore transect during peak ebb flow.

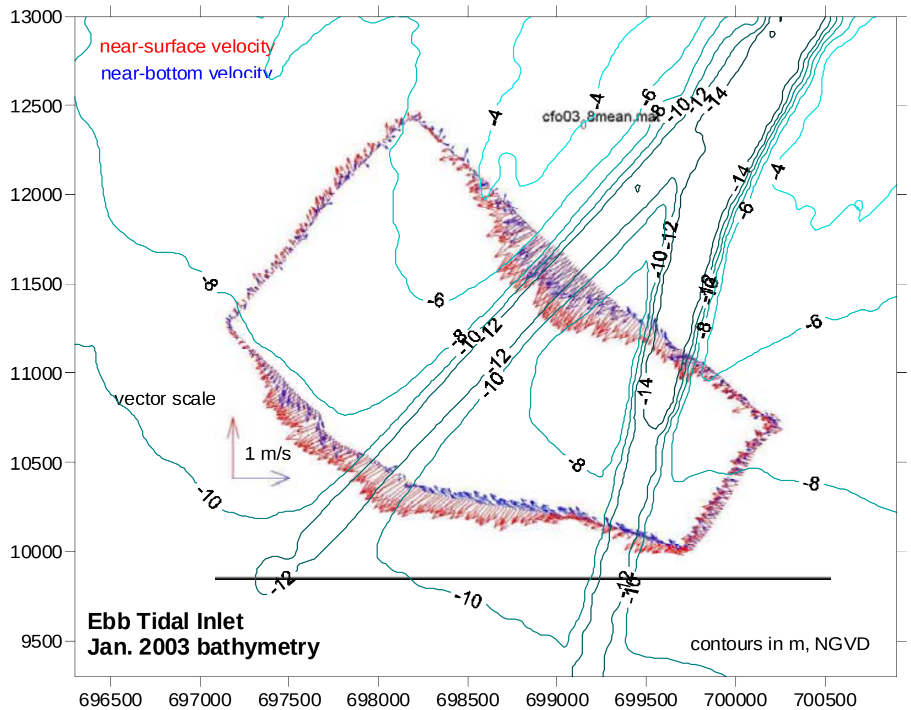


Figure 4.37 March 2003 ADCP survey at offshore transect during ebb flow.

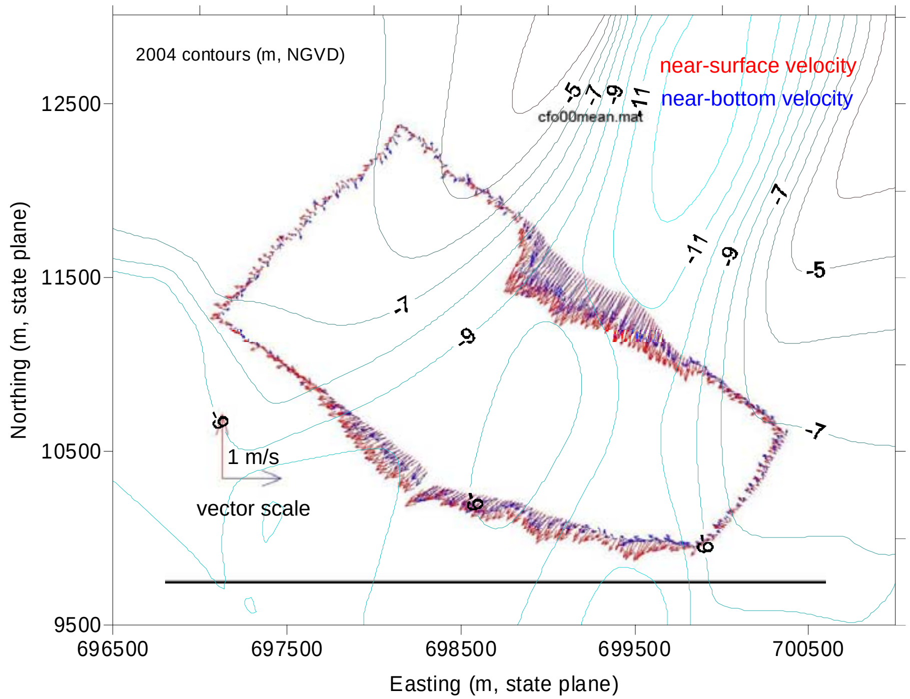


Figure 4.38 January 2004 ADCP survey at offshore transect during ebb flow.

Tidal Prism. Tidal prisms were computed using the inlet throat transect for each of the four current measurements—pre-construction (October 2000) and post-construction (April 2002, March 2003 and January 2004) ADCP surveys. 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 three surveys, the tidal prism computations were normalized across the inlet cross-section area as defined by the January 2003 bathymetry and transect shown in Figure 3.31. Figure 4.39 shows the results of this normalized comparison.

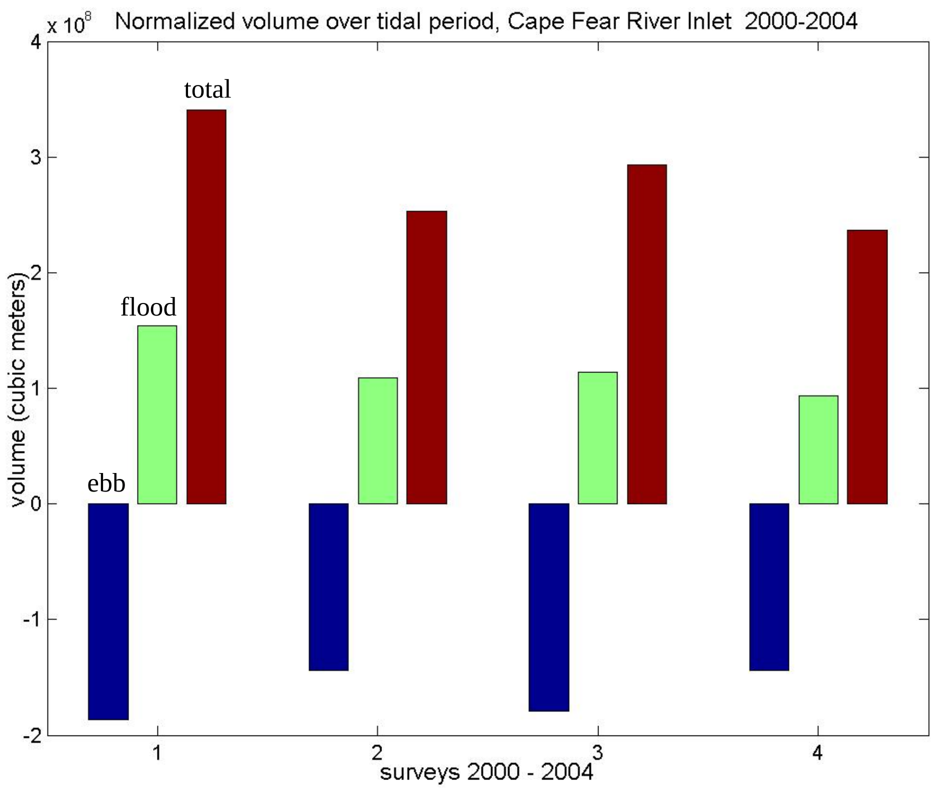


Figure 4.39 Normalized tidal prism for four surveys—(1) October 2000, (2) April 2002, (3) March 2003 and (4) January 2004. Blue—flood, Green—ebb, Red—total

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 the April 2002, March 2003 and January 2004 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 4.39.

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.

Part 5 SUMMARY

This report is the second 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 fourth year of data collection from June 2003 to June 2004. It 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 CY of sand were placed on Oak Island/Caswell and 1,849,000 CY were placed along Bald Head 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 1 (June 2003) 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 2003 to June 2004) and for the entire period from August/September 2000 to June 2004.

For Oak Island/Caswell Beach, the shoreline change measured over the last year has been somewhat variable over the 6-mile monitoring area with an overall trend being one of retreat. When considering all profile lines, a minor average retreat of –3.5 feet has been measured since June 2003. Excluding the area within the first mile nearest the channel entrance which demonstrated greatest variability (ranging from –50 to 150 feet), the average alongshore trend is somewhat greater at –7.6 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. 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 January 2004 than it was in 2000. Likewise, the shoreline position was 97 feet more seaward in June 2004, than it was about four years earlier 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 126,000 cubic yards was computed since the last report, between November 2001 and January 2004. This stable trend observed over the current period is typical of that measured for the entire 4-year monitoring period. As such, only minor changes have occurred following initial fill placement in 2001 associated with the project dredging. Specifically, by the end of the period, an excess of 1,052,000 cubic yards of material remains on Oak Island above the August 2000 pre-project condition with only minimal losses of the fill reported. The alongshore distribution of material basically follows the shoreline response where net gains are seen along most of the island.

Unlike Oak Island, shoreline change along Bald Head Island has shown areas of both significant erosion and accretion. Since the last reporting, most of the profile locations along Bald Head Island have shown shoreline retreat. This is true except for an area of spit growth near the southwest corner of the island, plus an accretionary region along the eastern end of Bald Head Island near Cape Fear. The largest area of shoreline retreat begins just east of the spit area bracketed by Profiles 43 and 66. Over this 2,300-foot reach shoreline recessions have reached a maximum of –120 feet since last June. In contrast, shoreline gains on the order of 50-ft to as much as 220 feet were measured along the stable eastern end of the island. Overall, the alongshore average shoreline changes measured over the entire monitoring area since June 2003 were –10.7 feet and –18.2 feet for the January 2004 and June 2004 surveys, respectively.

A similar pattern of shoreline change was measured along Bald Head Island over last 4-year period since the monitoring was initiated. This pattern includes the spit growth area with an adjacent erosion zone to its east, plus an extended area of accretion along the eastern portions of the island. Although the pattern is similar, the relative magnitudes of the shoreline changes are greater when considering the entire monitoring period. Specifically, the spit growth area is found to extend nearly 200 feet beyond its September 2000 position. Similarly, the shoreline recessions along the eroding portions of western South Beach reach a maximum of –250 feet and this eroded reach extends for about 7,000 linear feet (Profile 43 to Profile 110). These values of shoreline change indicate that the erosion has been severe in this area where the shoreline position is on the average 108 feet landward of its pre-project location. In contrast, beginning at about Profile 110, the shoreline response has been positive with accretion prevalent over the remaining eastern 11,000-feet of South Beach. Along this stable area, the average alongshore position of the present shoreline is 69 feet seaward of its September 2000 location. In considering the monitoring area in total (Profiles 00 to Profile 218), the shoreline is presently on the average 3.4 feet more seaward than it was in 2000.

In terms of volumetric change from the last survey (December 2002) of Report 1 to June 2004, most of Bald Head Island experienced a loss. The exceptions to the general loss were the continued growth of the spit between Profiles 32 and 45 and some volumetric gain near the eastern end of the island (east of Profile 162). The volume loss was greatest in the previously noted erosion zone just east of the spit.

When analyzing the total volumetric profile changes since the beginning of the monitoring in August 2000, again three distinct reaches are evident including the area of spit growth (Profiles 32-45), an erosion zone (Profiles 47-114), and an area of stability (east of Profile 114). A fourth zone is also evident with the on/offshore volumes with relatively large losses measured along the last two profiles nearest to Cape Fear. Temporal trends are likewise evident with the spit area growing with the October 2001, December 2002, January 2004 and June 2004 surveys, (with a smaller net gain between the last two surveys). In contrast to the growth in the spit, the progressive loss is seen over time within the erosion area east of the spit. This trend is seen to reverse somewhat with the June 2004 survey. Even so, by the end of the current period, about a 6,900-foot-reach (between Profiles 45 & 114), is found to have overall negative volumetric changes with respect to the August 2000 survey. Over the remaining portions of South Beach (Profiles 114 to 194), covering about 8000 feet, positive volume changes are evident, with this reach having more sediment in place in June 2004 versus August 2000. Volume computations show that as of the June 2004 survey the spit area had gained approximately 311,200 cubic yards. This gain is offset by a comparable loss of 381,100 cubic yards within the critical erosion zone. The largest gain over the approximate four-year period is within eastern half of South Beach (Profiles 114-104) which remained positive with 819,500 cubic yards. In totaling all changes within the Bald Head Island monitoring area, a net gain of 677,800 was measured between the pre-project survey in August 2000 and the most current survey.

Shoreline change rates were likewise computed over the monitoring period. These rates were compared with long-term shoreline change rates computed from the NCDCM shoreline data covering a 62-year period. Although the monitoring period spans a relatively short time period of about 4 years, it is of interest to compare these trends with established long-term shoreline response for the area.

With respect to rates of shoreline change, initial 4-year period showed 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 +37 feet per year for the 4-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 shows that most of island is eroding less over the initial 4-year monitoring period. However, notwithstanding this overall positive response, the post-construction erosion rates are considerably greater along the western portions of South Beach. The measured rates within the erosion zone have increased both in magnitude and extent by comparing the rates previously reported through June 2003 and the current period through June 2004. 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. With the rates updated through the current period, the average is now 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 has also expanded eastward from Profile 47 thru 78 in 2003 and Profile 47 thru 97 in 2004. This represents an alongshore increase of about 1,900 feet, from 3,100 feet to 5,000 feet. 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) and plus 49 feet per year (thru June 2004). In terms of average rates for this zone, the June 2003 value of accretion was 38 feet per year with the June 04 value being a positive 29 feet per year. These are in sharp contrast to the erosion indicated along this entire area by the pre-construction rates.

An additional analysis was done to document the response of the beach disposal placed along Bald Head Island in 2001 associated with the initial project construction. In this regard, erosion rates were computed with respect to the post fill survey through the current period. Normally post-fill erosion rates are higher as the widened berm is reworked by waves and currents over an initial adjustment period. The results indicate a similar alongshore erosion pattern as found with the overall rates computed over the entire monitoring period, although the rates are considerably higher. Specifically, the overall post-fill erosion pattern consists of 1) erosion rates exceeding a 100 feet a year along the western portions of South Beach near the inlet, 2) a transition reach where erosion exceeds 50 feet a year, and 3) a gradually diminishing erosion rate along the eastern portions of South Beach. These rates have remained generally the same during 2001 to 2003 and the 2001 to 2004 post fill periods.

The high-sustained erosion has prompted the Village of Bald Head to install sand bags to protect the beachfront road throughout the critically eroding reach. This installation is a rehabilitation of an earlier sand bag structure placed in the mid-1990's in response to erosion problems that have been prevalent over the last several decades in this area. Further, a geotextile groin field that was placed by the village in conjunction with the 1996 beach fill, but deteriorated within about four years, is also being replaced in an attempt to more effectively retain the beach within this problem area. The groin field is being rebuilt in conjunction with the present (2004-05) beach disposal/dredging operation. The combination of beach fill and geo-tube groins is expected to moderate the relatively high erosion experienced along the western portion of South Beach.

At Bald Head spit, navigation channel surveys show the spit has enlarged volumetrically to at least twice as large as previously observed. Several contributing factors have been identified related to the observed spit growth. One factor is the large volume of sediment introduced into the system along South Beach near the inlet during the initial beach fill disposal operation. Secondly, the sediment increase in the spit correlates with the deterioration of the groin field and subsequent loss of beach due to the ineffectiveness of the groins. And thirdly, the growth appears to coincide with the relocation of the west channel bank opposite the spit area. As such the growth of the spit into Bald Head Shoal channel has increased by the same distance as the west channel bank has been offset. Further, movement of the spit has been found to extend off of Bald Head Island and then in a seaward direction along the eastern side of the channel. It appears that contraction of the ebb tide current between the spit and the west side of the channel is one of the factors controlling the size of the spit.

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 finding of particular interest is the lack of change in the area of the shoal between the old and new channels just seaward of their intersection. This portion of the shoal is expected to be the most sensitive to changes because of its location between the channels where the magnitude of mean currents around the distal end of the ebb tidal delta are the highest.

Current measurements were taken over a 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 previous results reported in Monitoring Report #1, 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.

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 beach disposal operation of Clean Sweep II was completed in January 2005. With the timing of Clean Sweep II coming approximately two years after completion of the initial construction, this is considered the first maintenance dredging of the new channel. 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 a plan for the present disposal operation. 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. Future monitoring will assess the effectiveness of this work in comparison with prior beach fill performance.

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.

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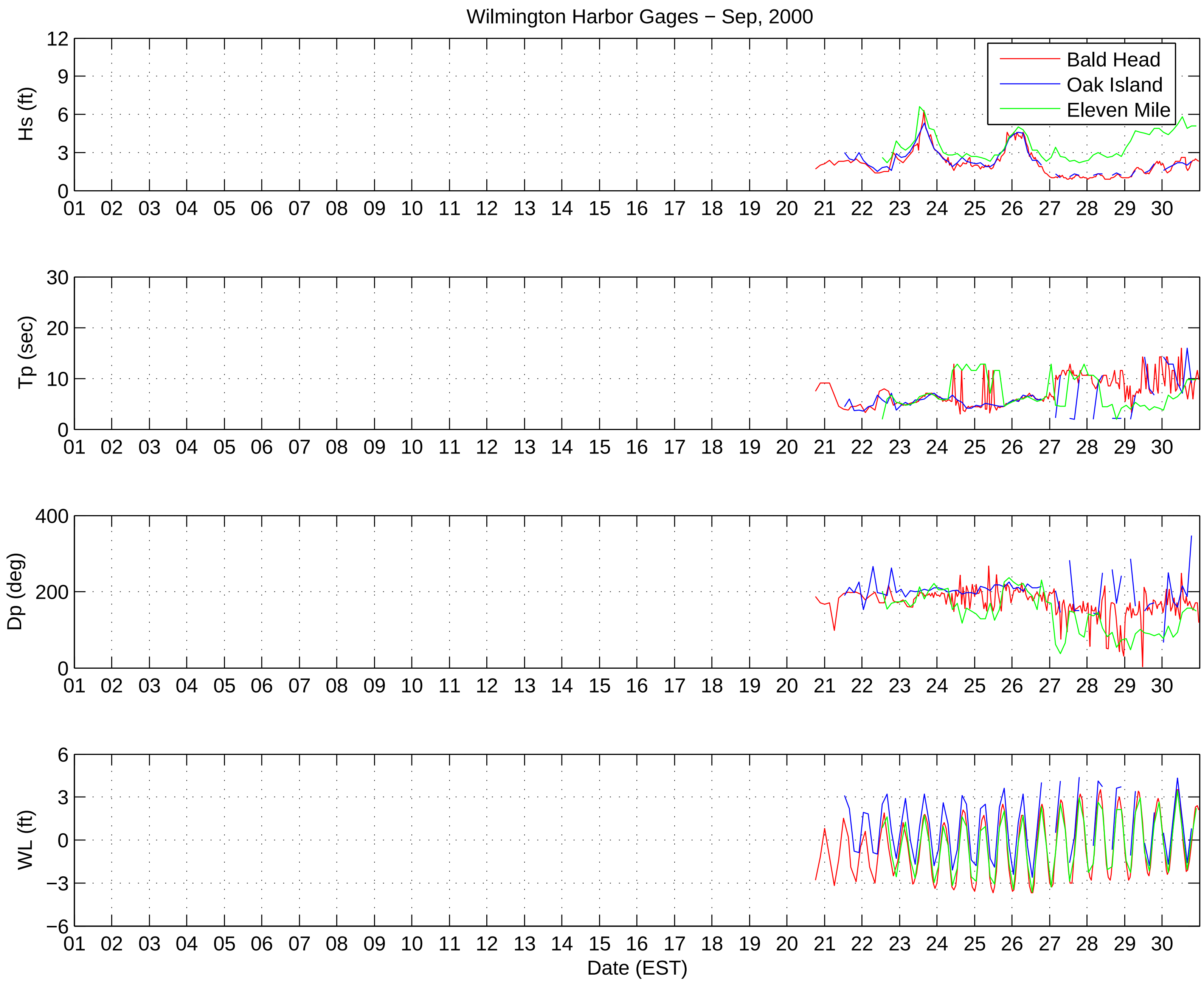
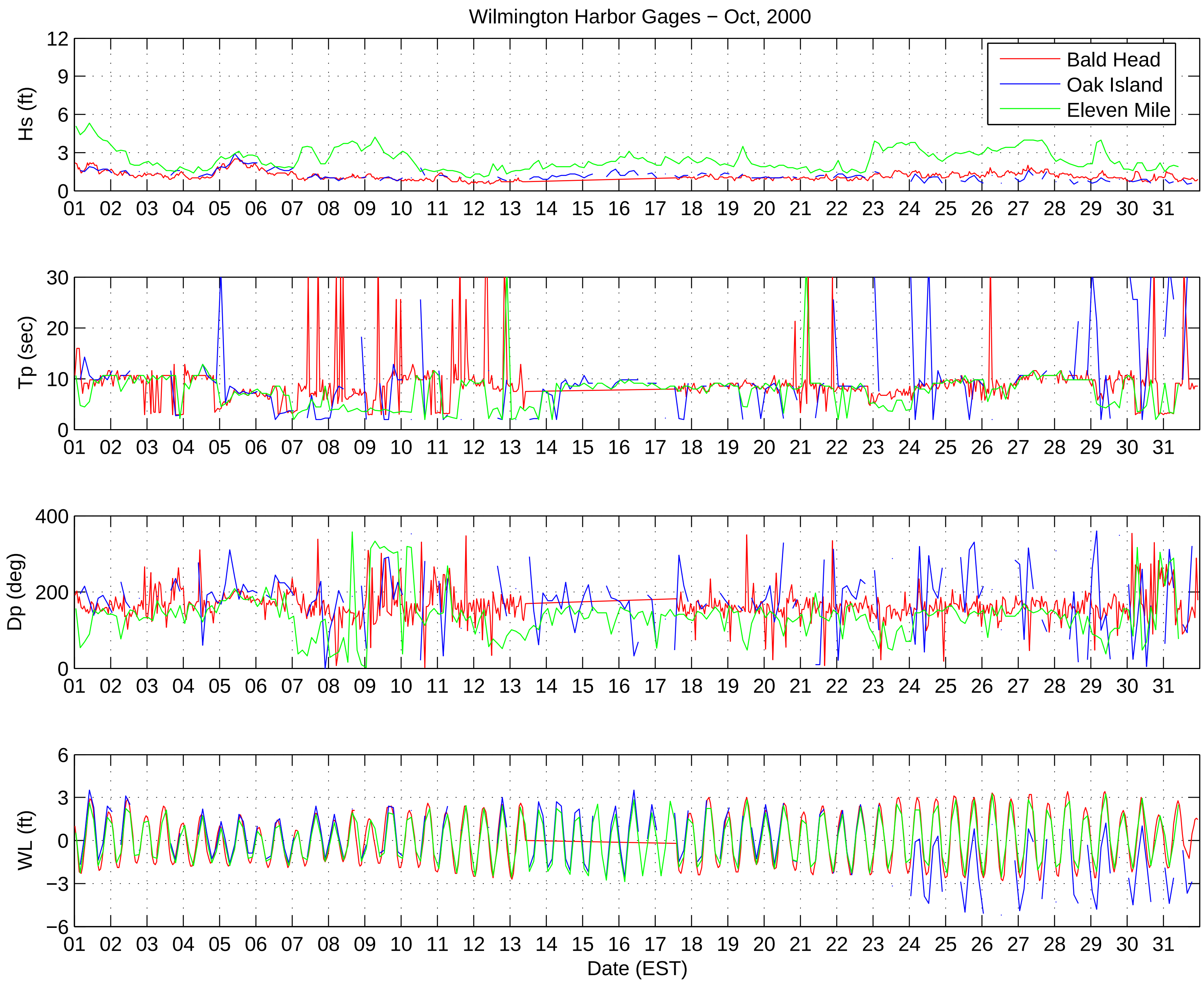
USACE 2004, Physical Monitoring, Wilmington Harbor Navigation Project, Report 1: August 2000-June 2003, U.S. Army Corps of Engineers, Wilmington District, August 2004.

Appendix A

WAVE GAUGE DATA



Wilmington Harbor Gages − Sep, 2000
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Oct, 2000
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

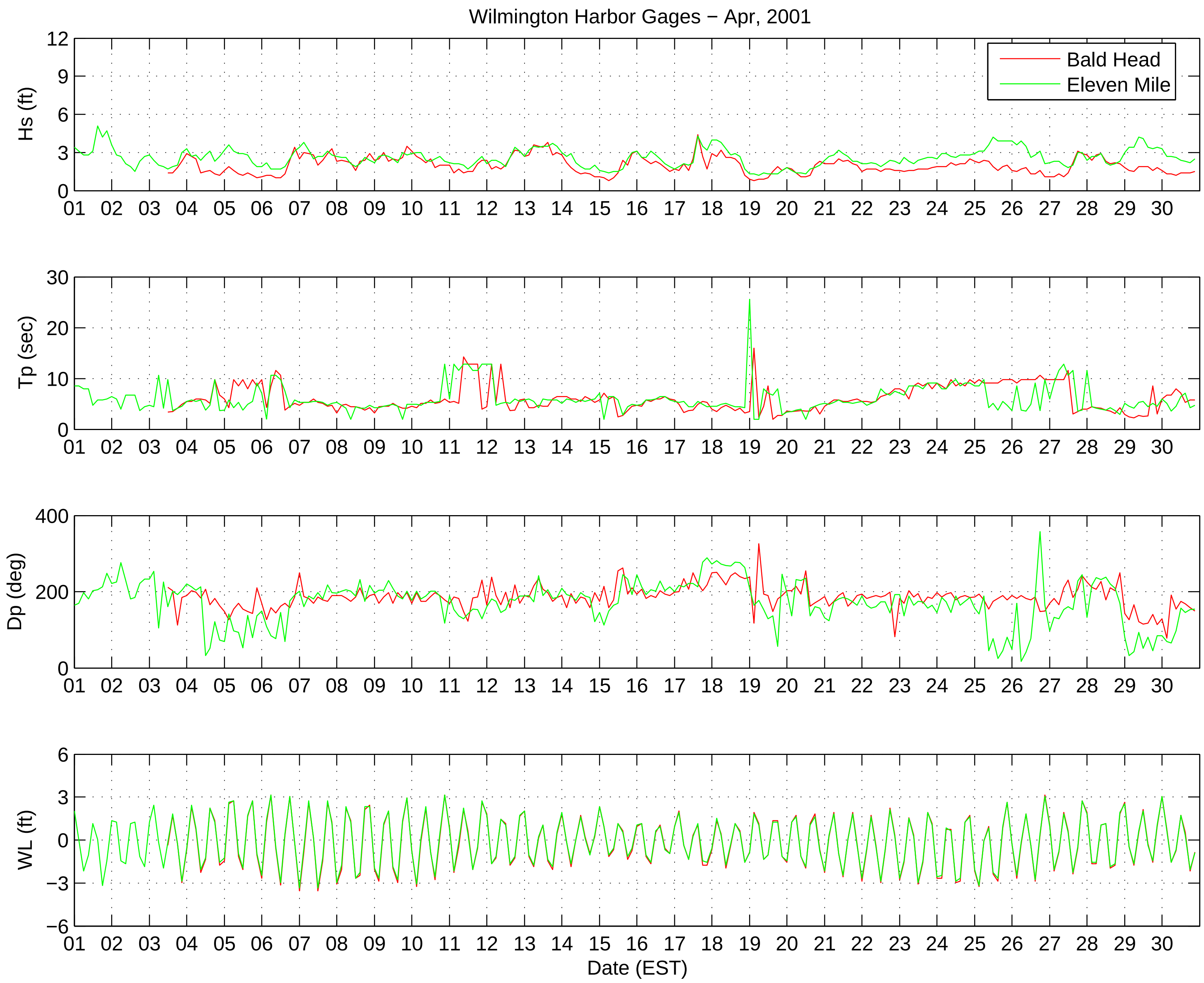
Wilmington Harbor Gages − Nov, 2000
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

Wilmington Harbor Gages − Dec, 2000
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

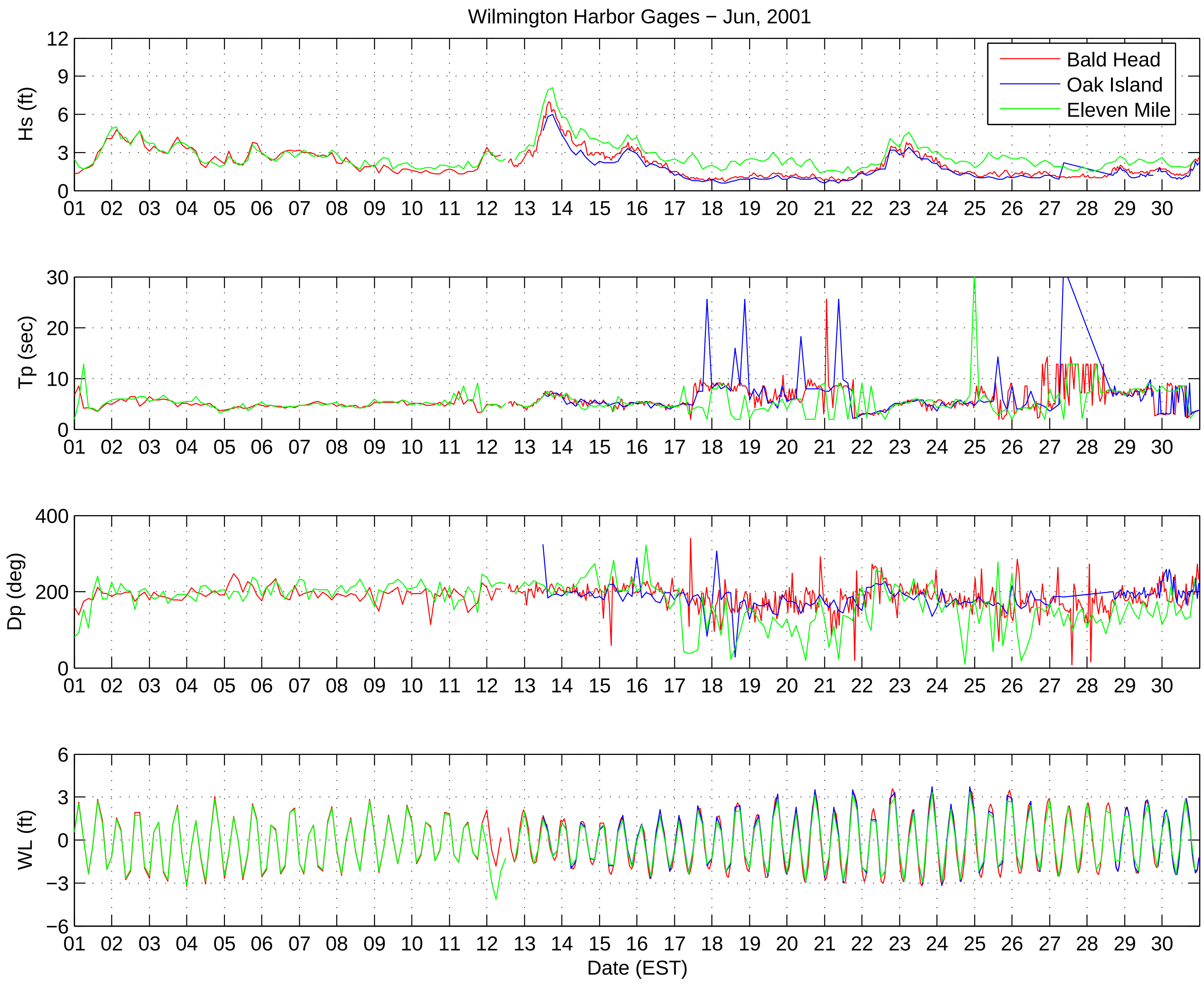
Wilmington Harbor Gages − Jan, 2001
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Feb, 2001
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

Wilmington Harbor Gages − Mar, 2001
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Apr, 2001
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

Wilmington Harbor Gages − May, 2001
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Jun, 2001
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)
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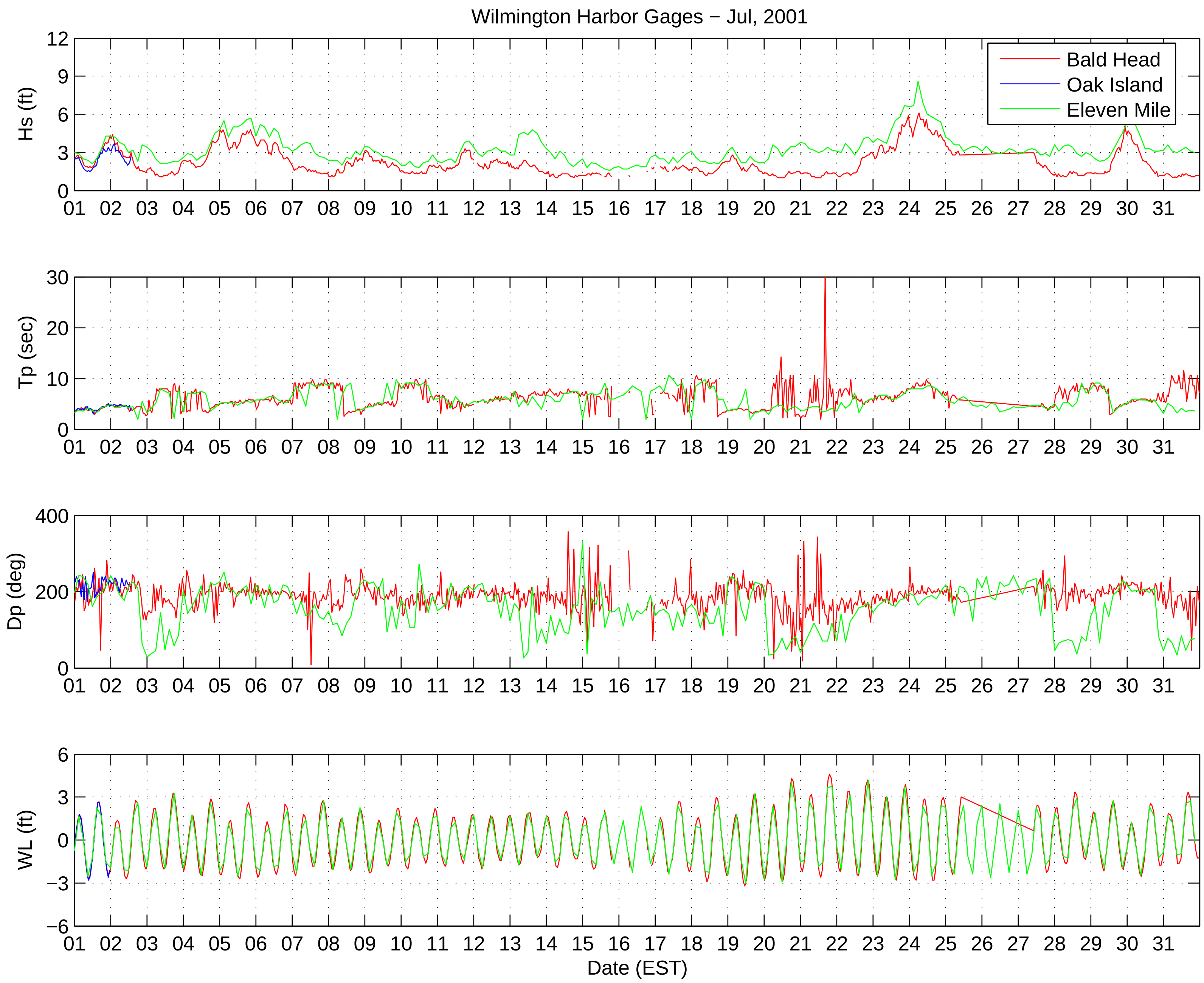
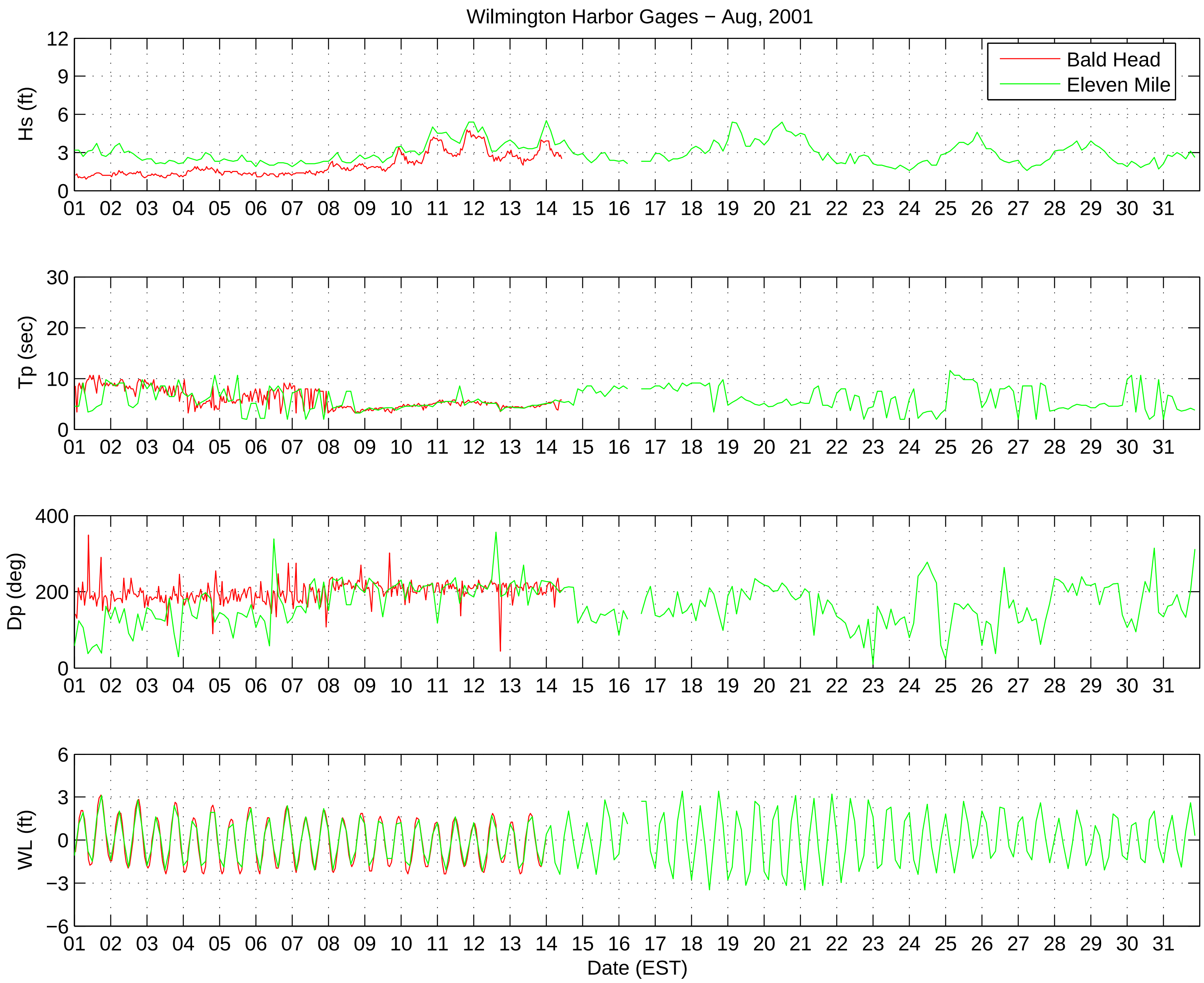

Wilmington Harbor Gages − Jul, 2001
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Aug, 2001
Bald Head
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

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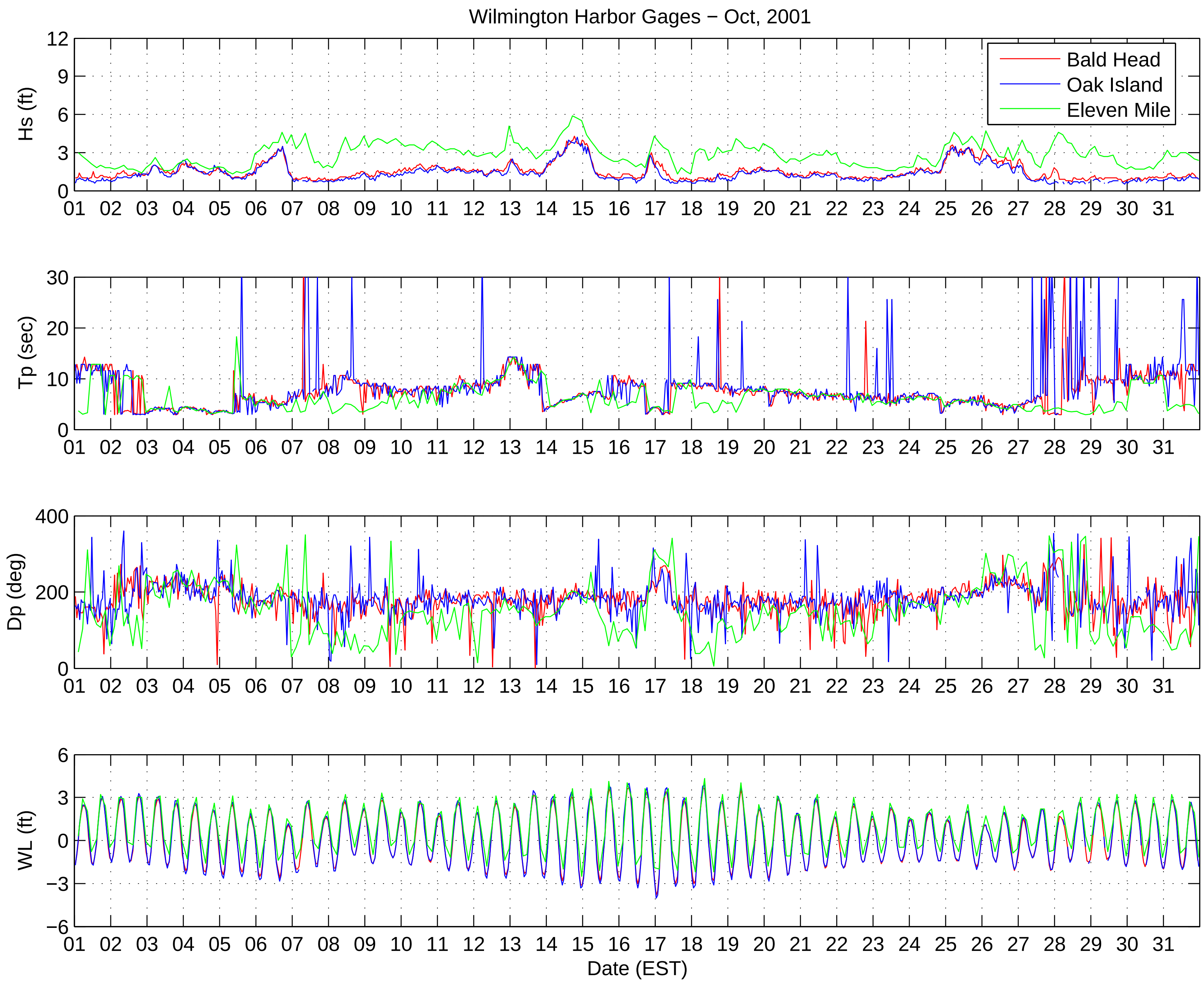
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



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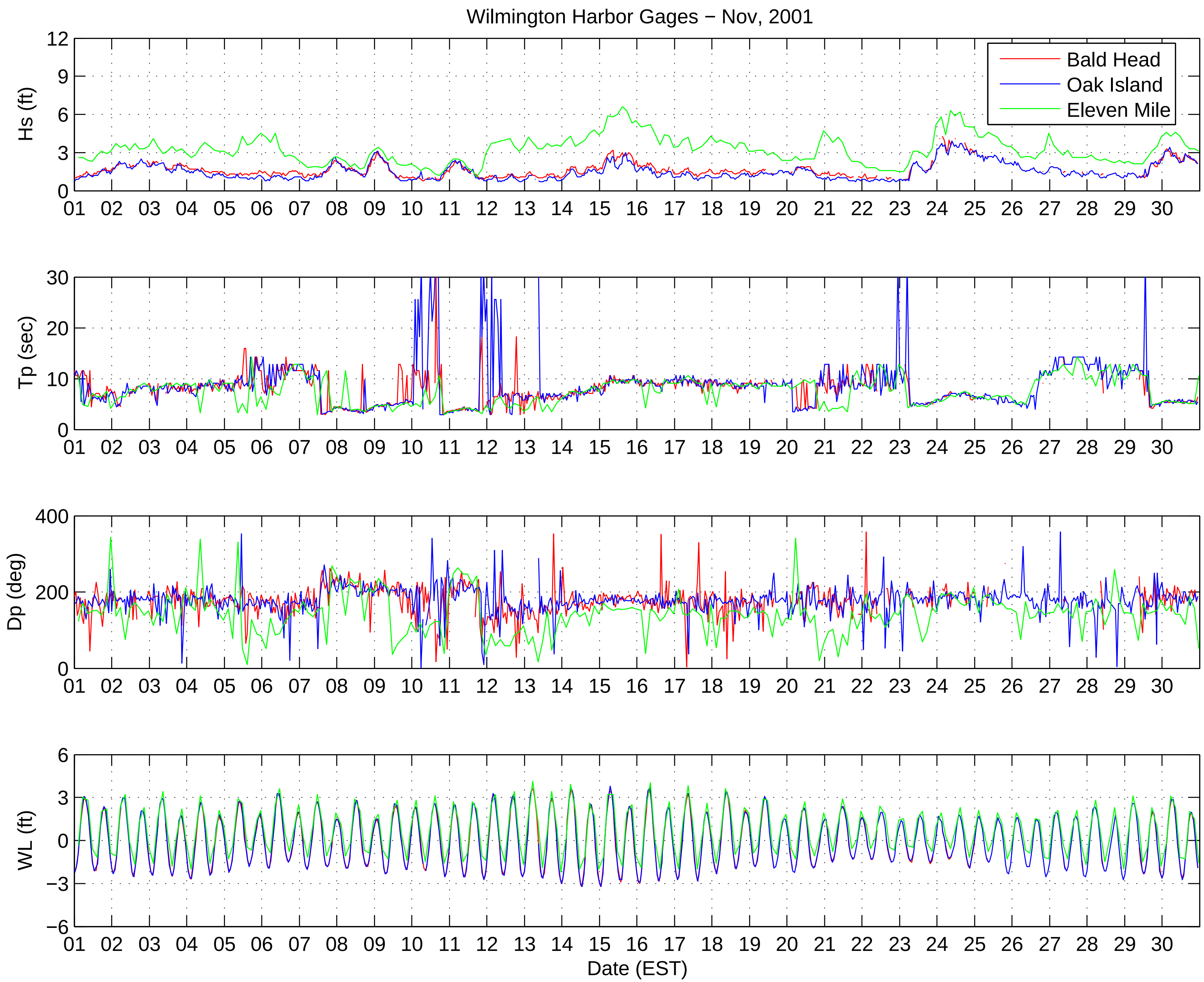
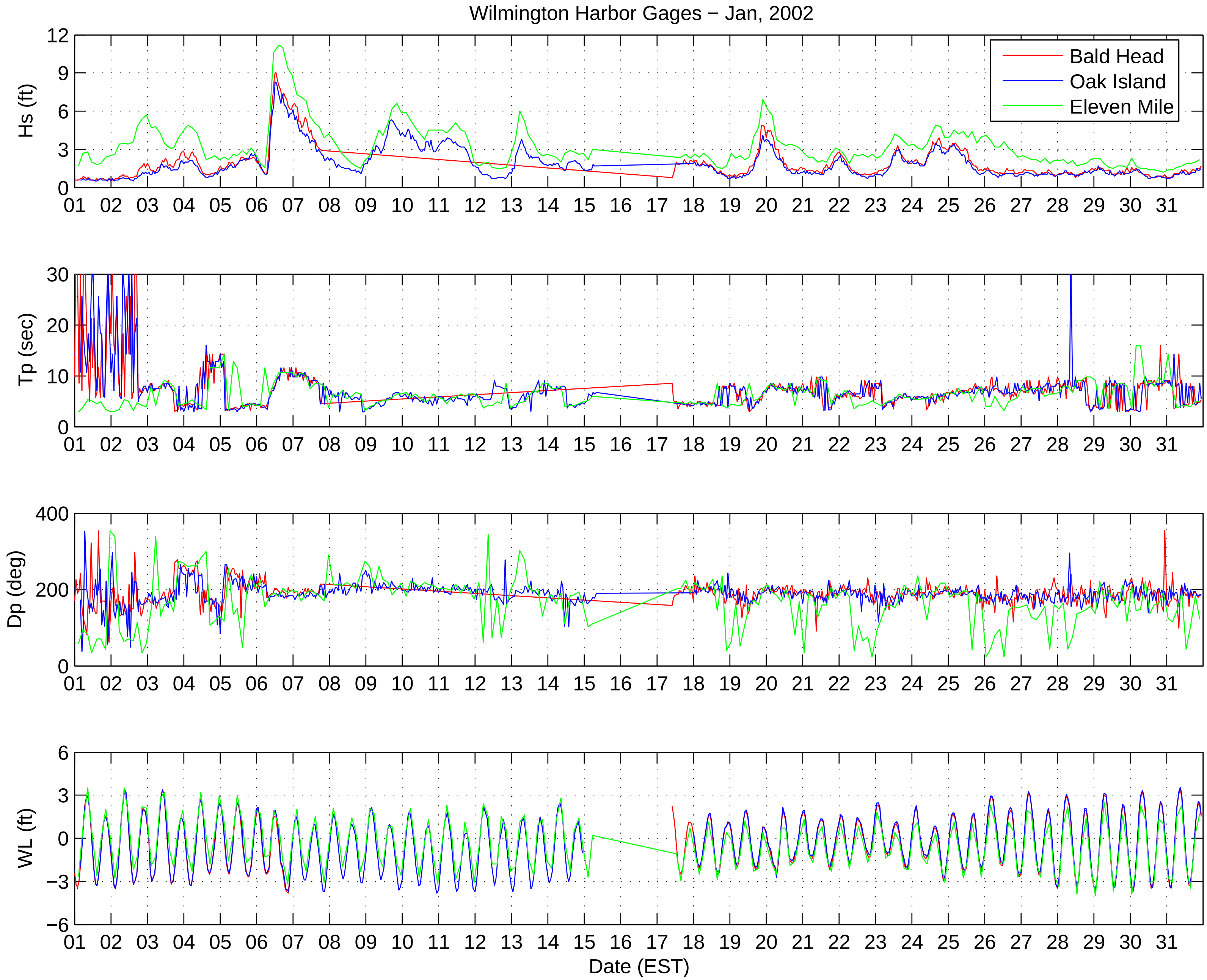
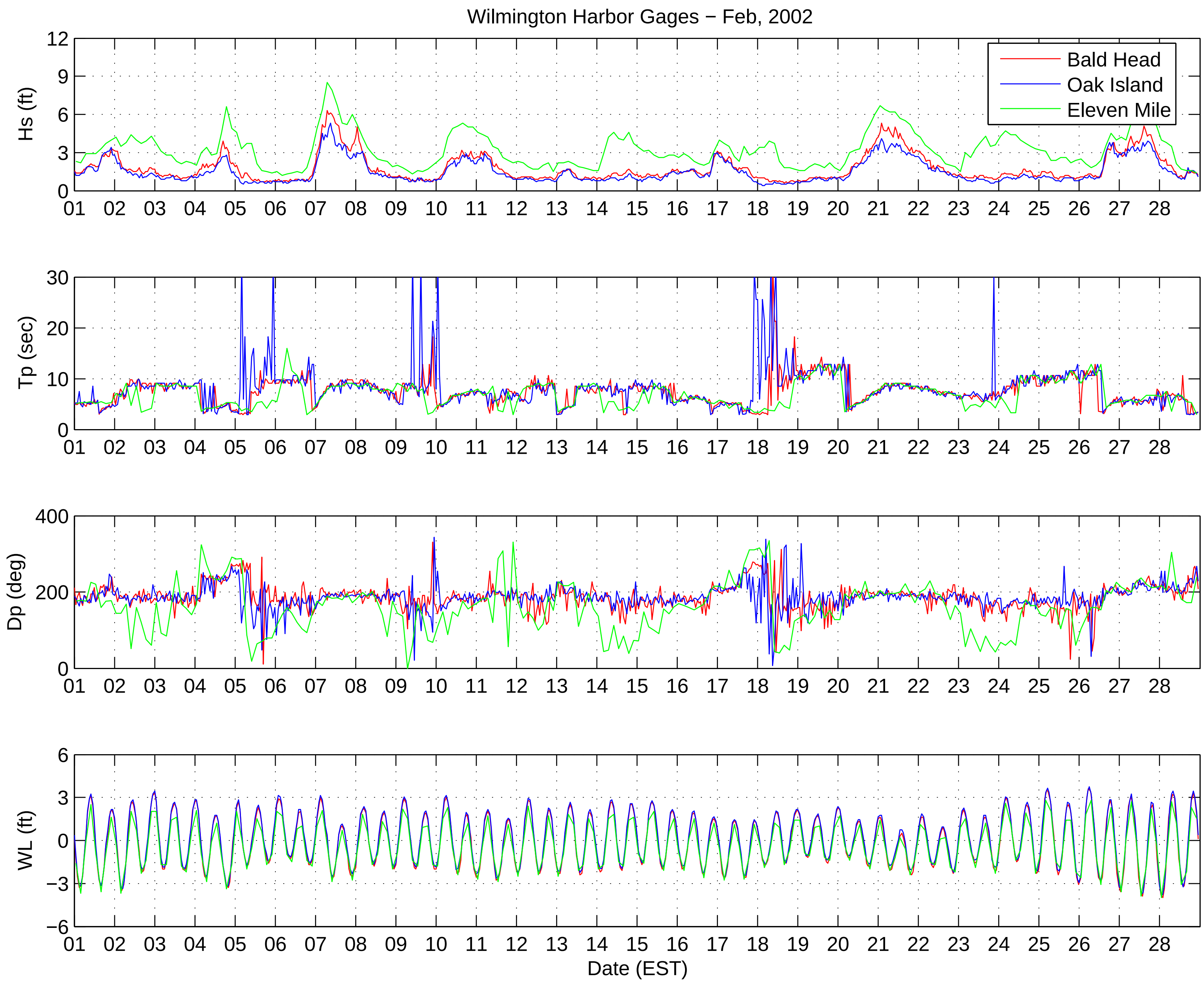
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Nov, 2001
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

Wilmington Harbor Gages − Dec, 2001
Hs (ft)
Bald Head
Oak Island
Eleven Mile
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



Wilmington Harbor Gages − Jan, 2002
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



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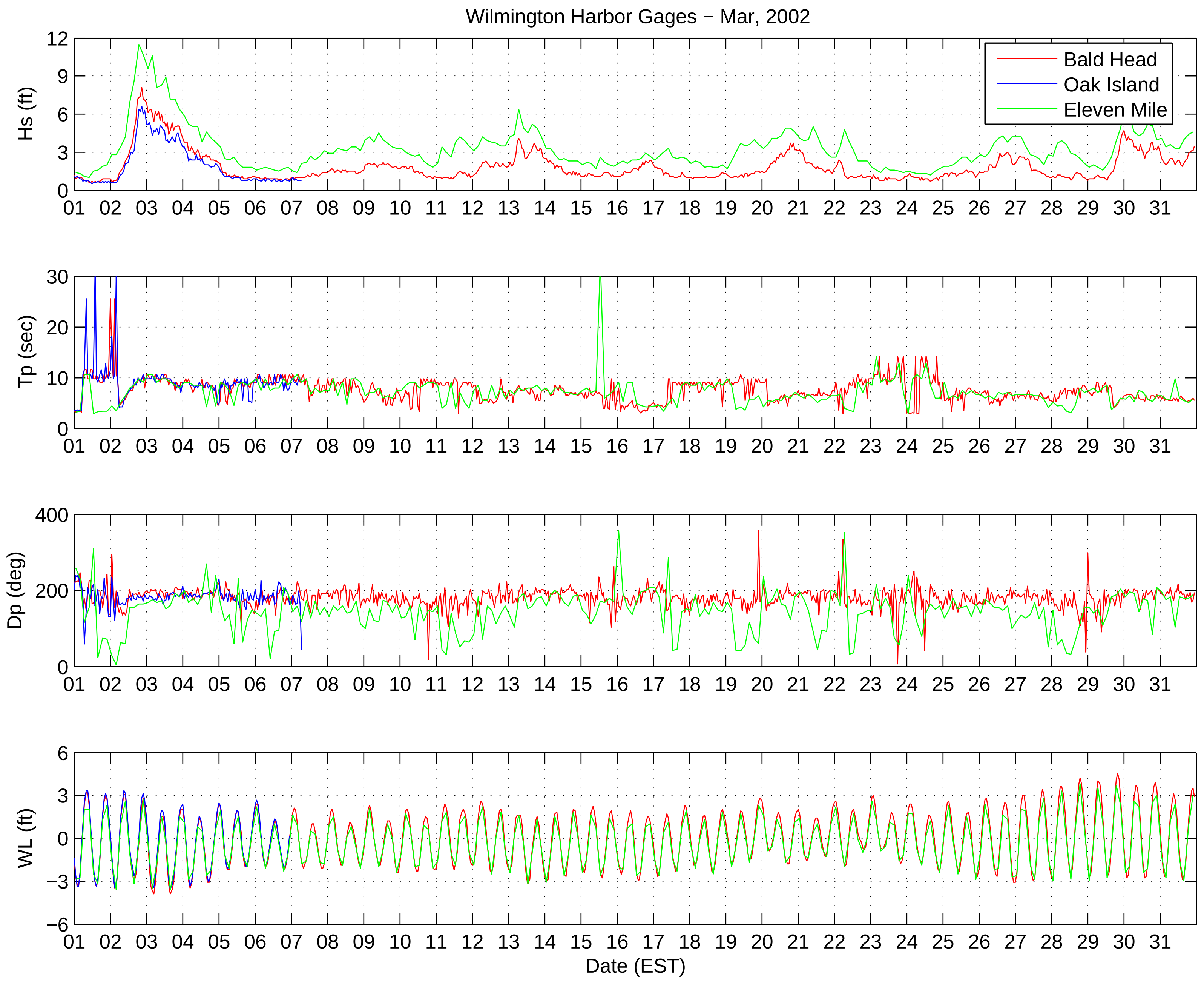
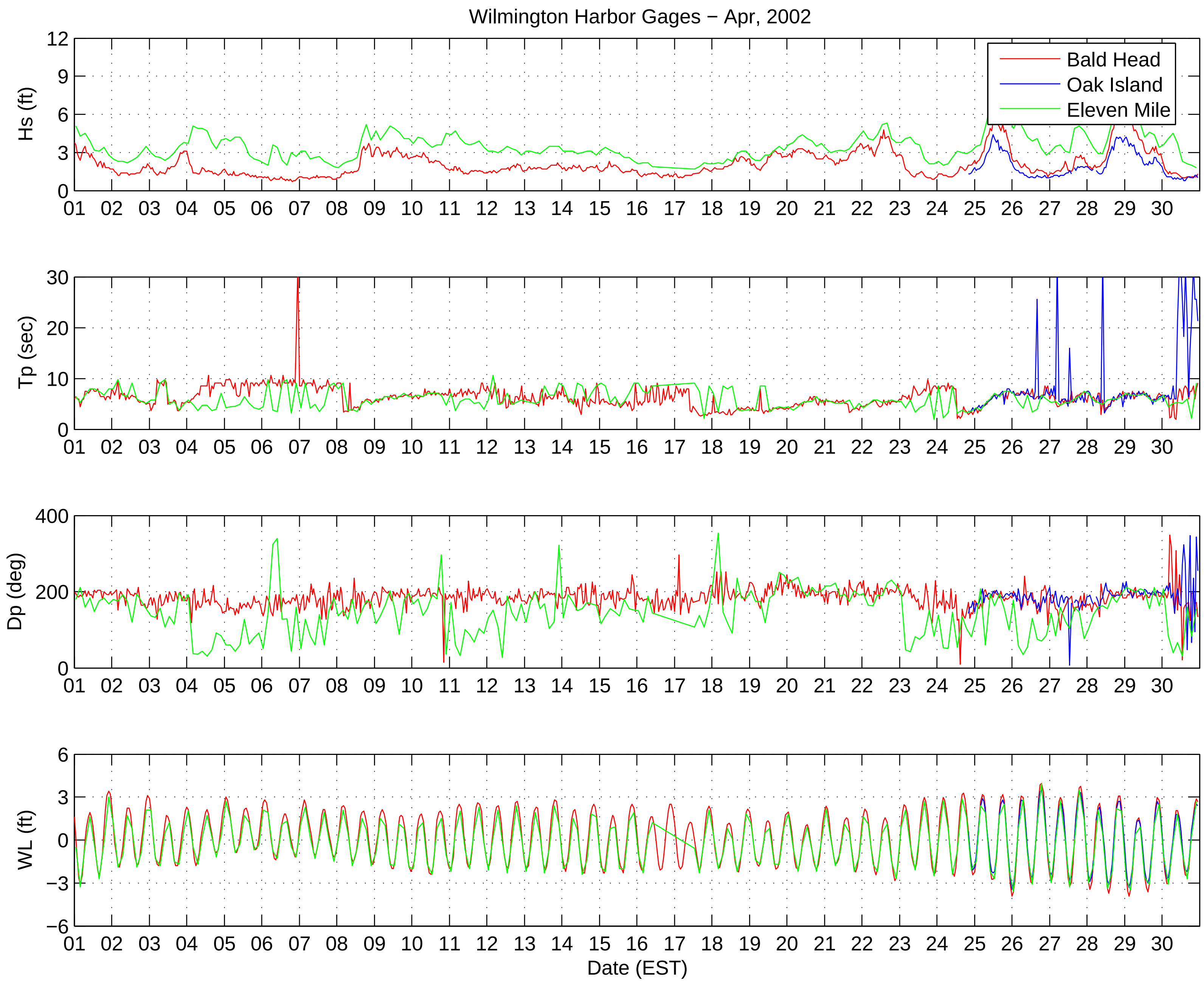
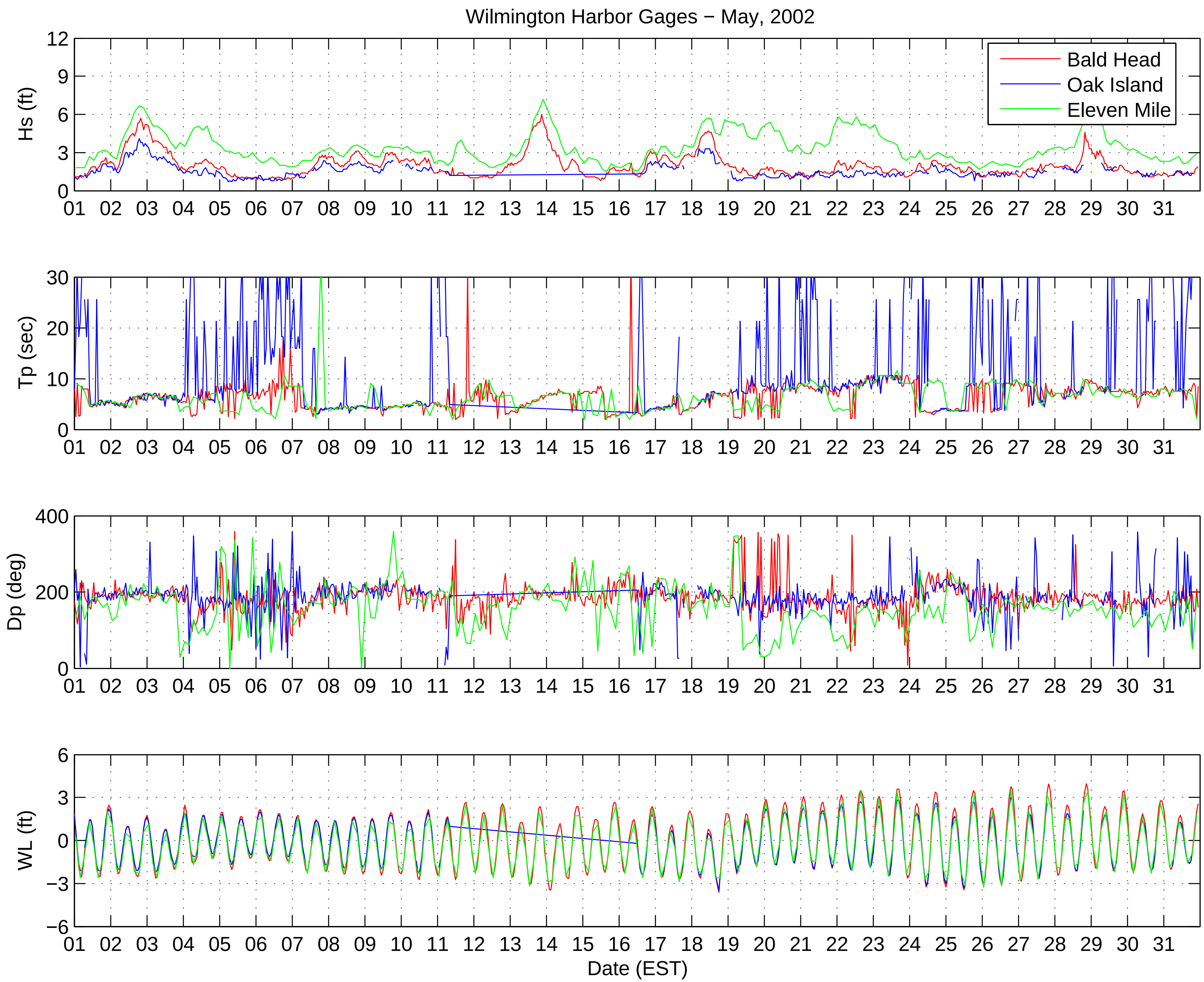
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

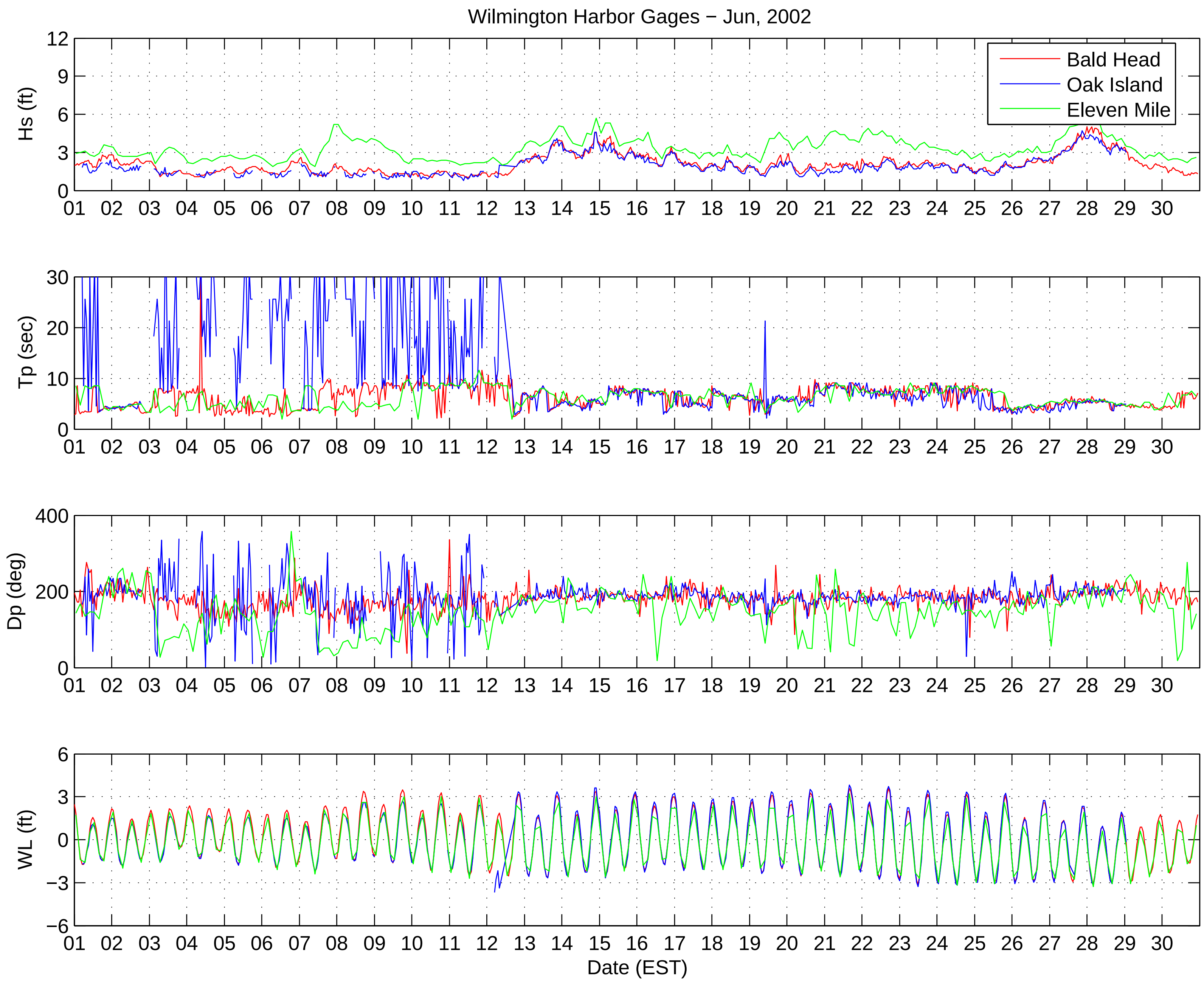


Wilmington Harbor Gages − Mar, 2002
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

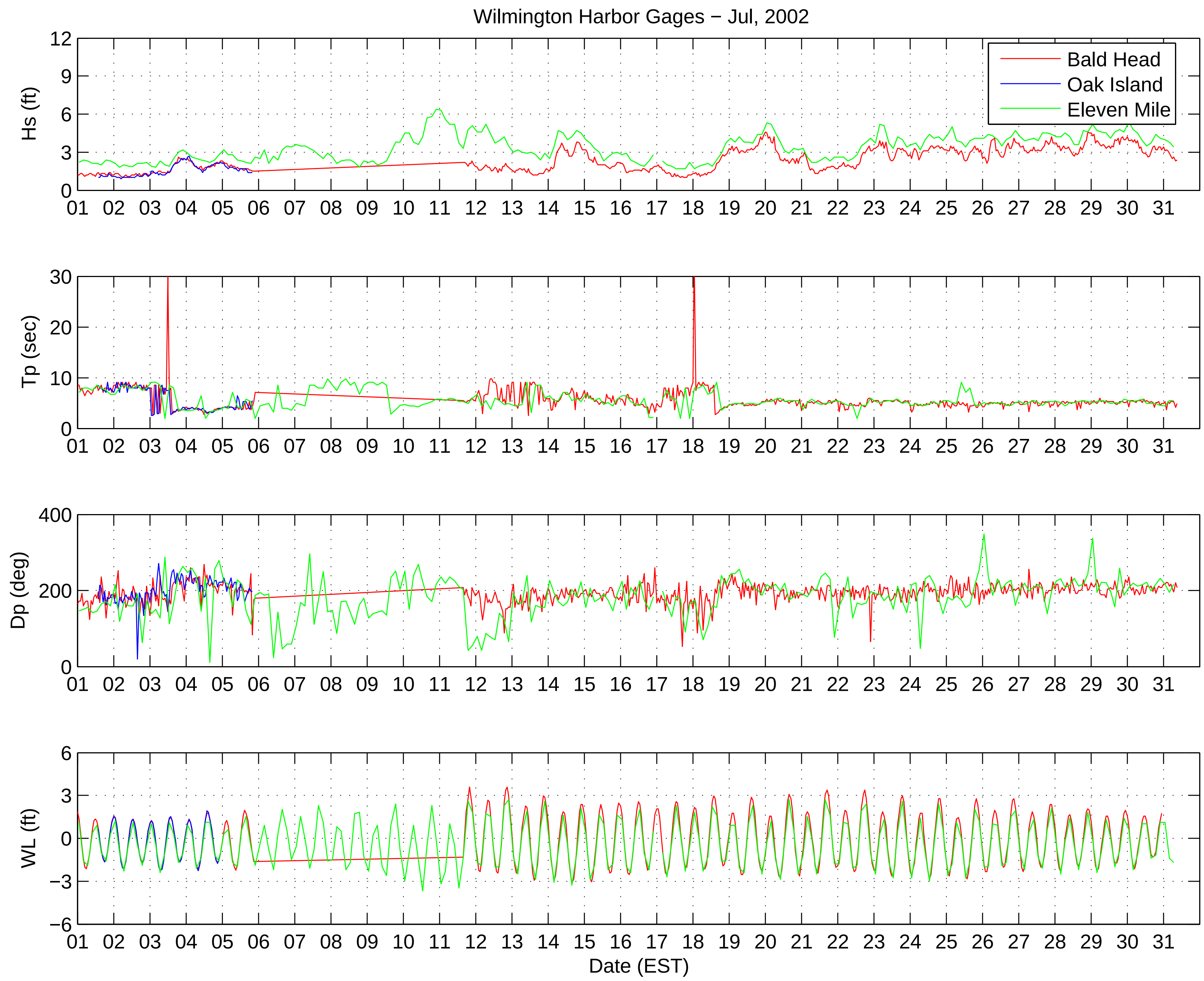


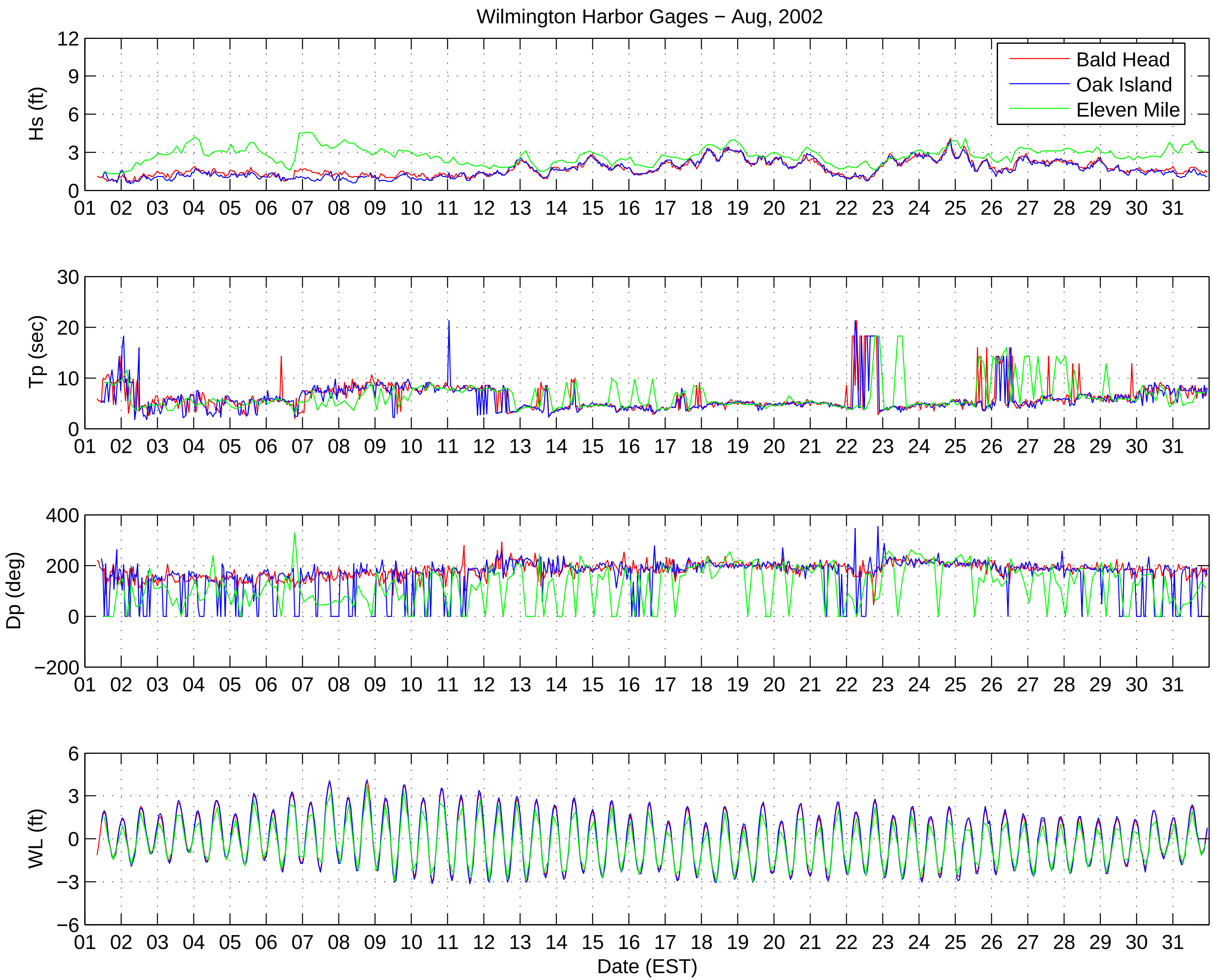
Wilmington Harbor Gages − Apr, 2002
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − May, 2002
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



Wilmington Harbor Gages − Jun, 2002
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Jul, 2002
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



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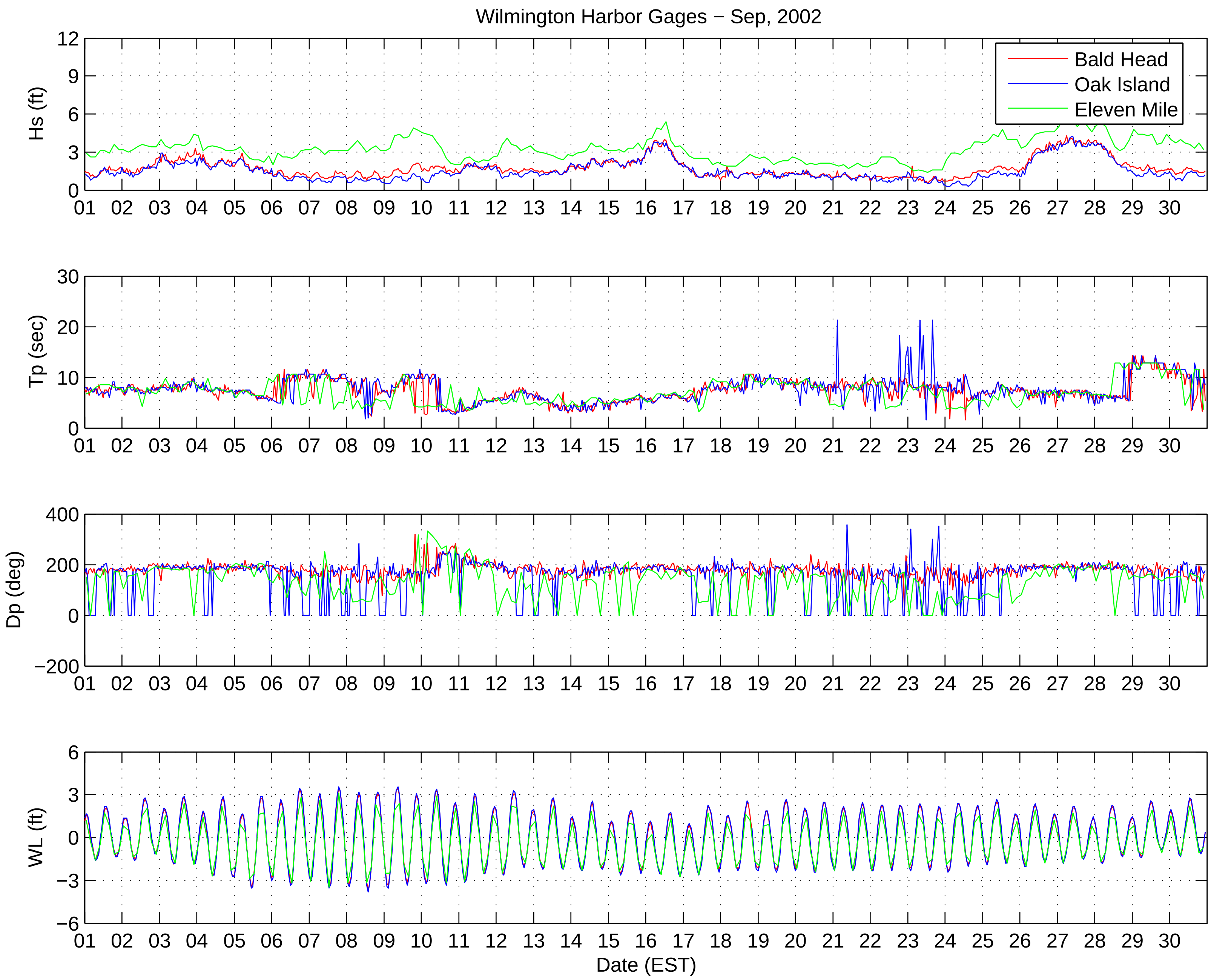
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



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Bald Head
Oak Island
Eleven Mile
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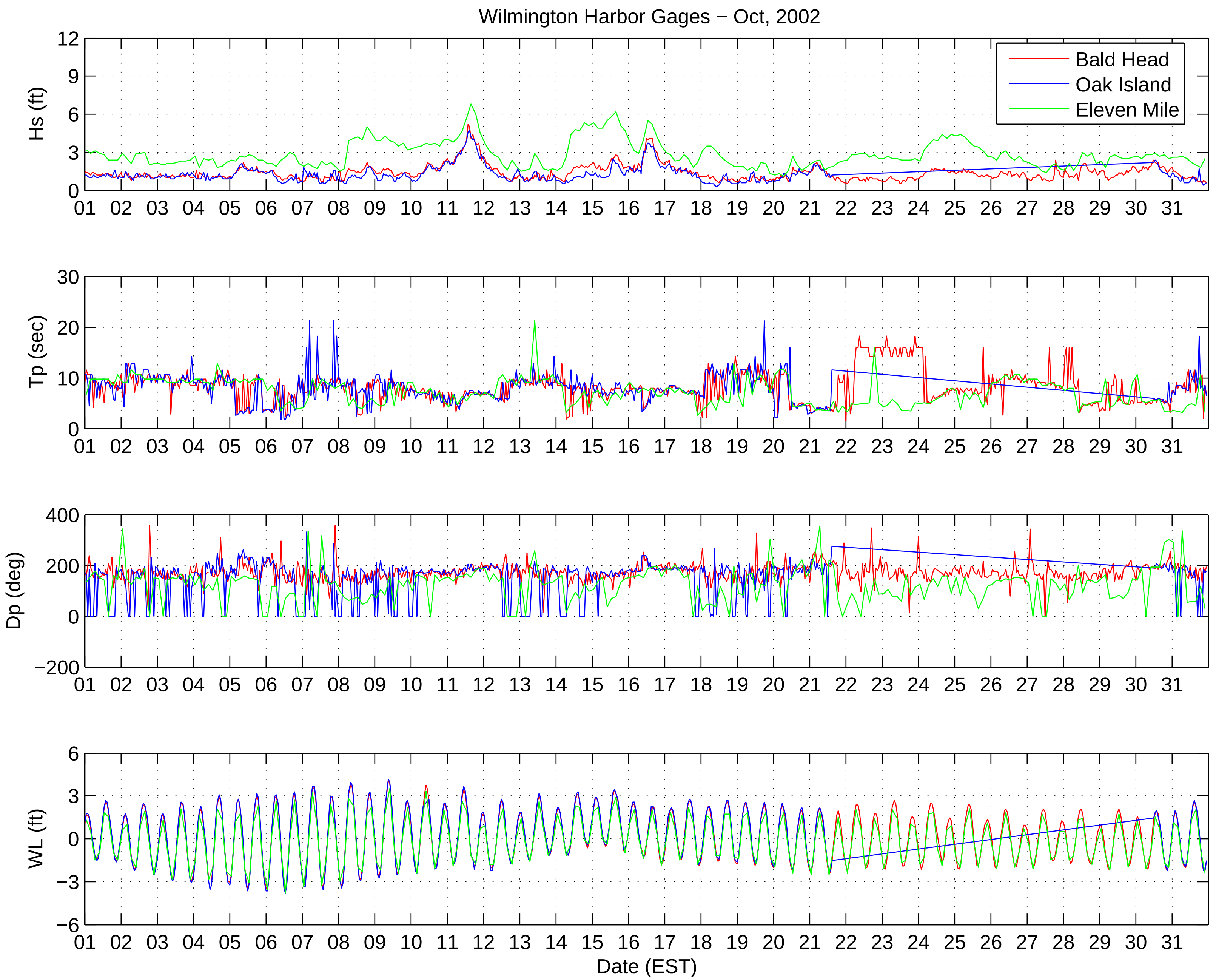
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)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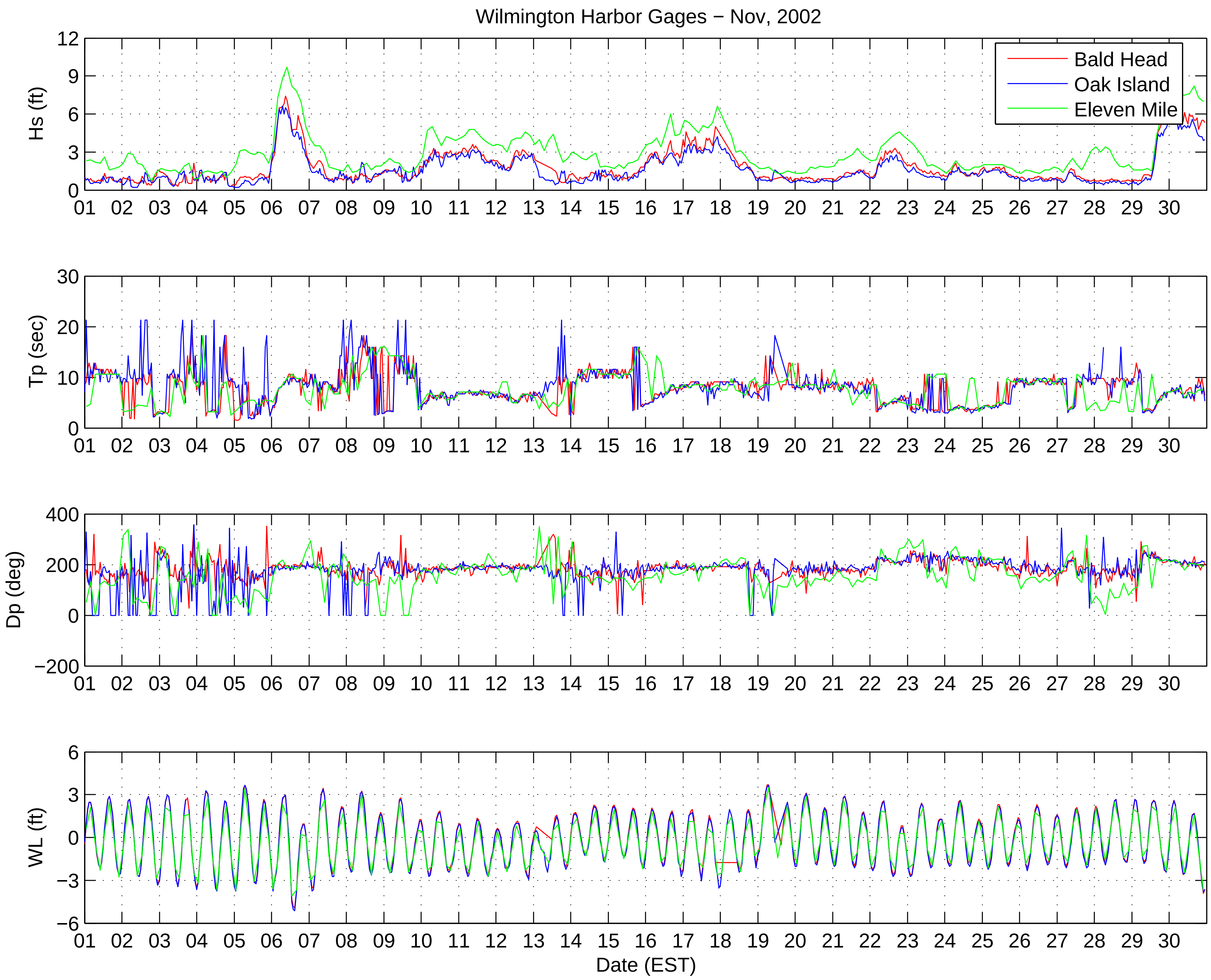
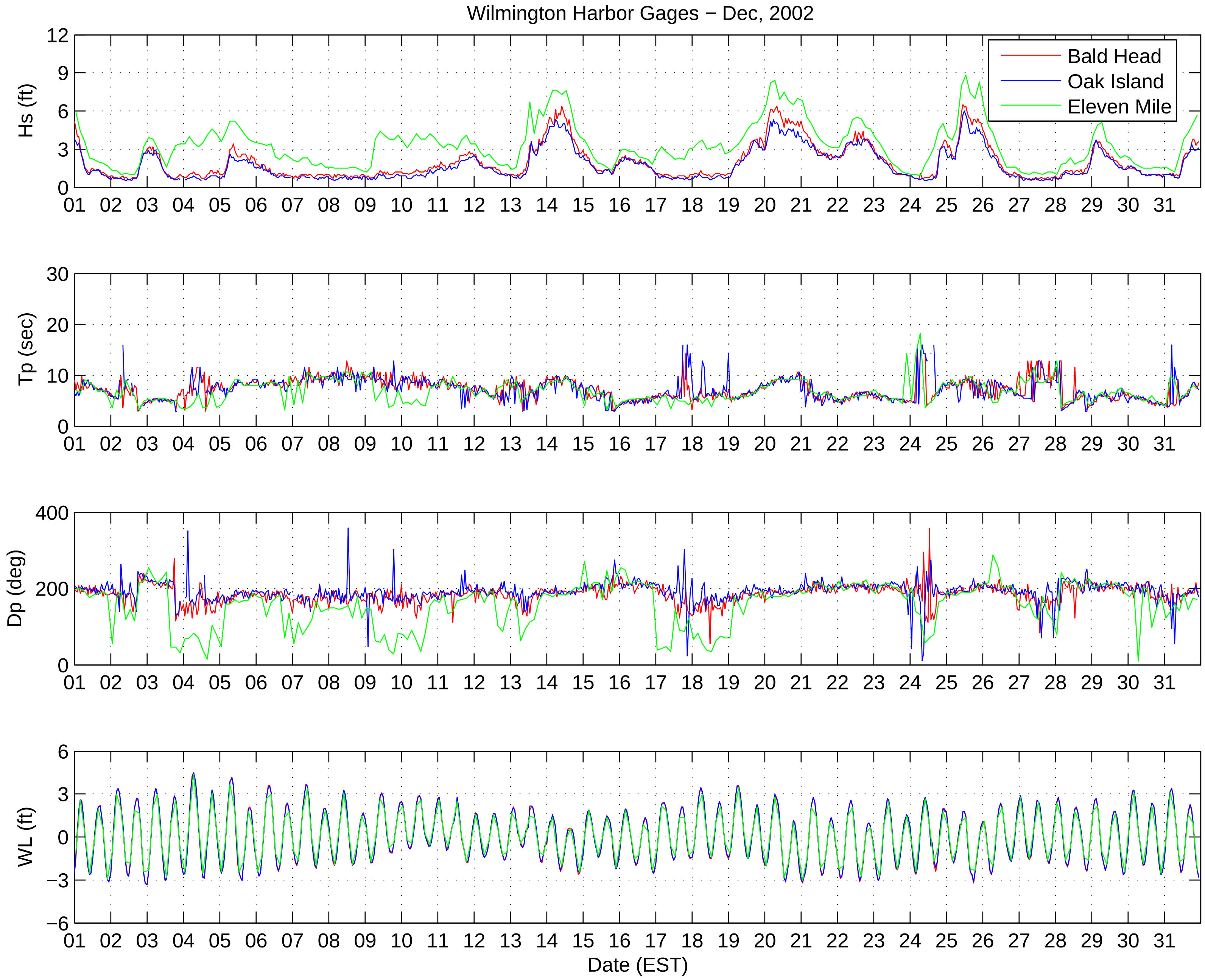
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Nov, 2002
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



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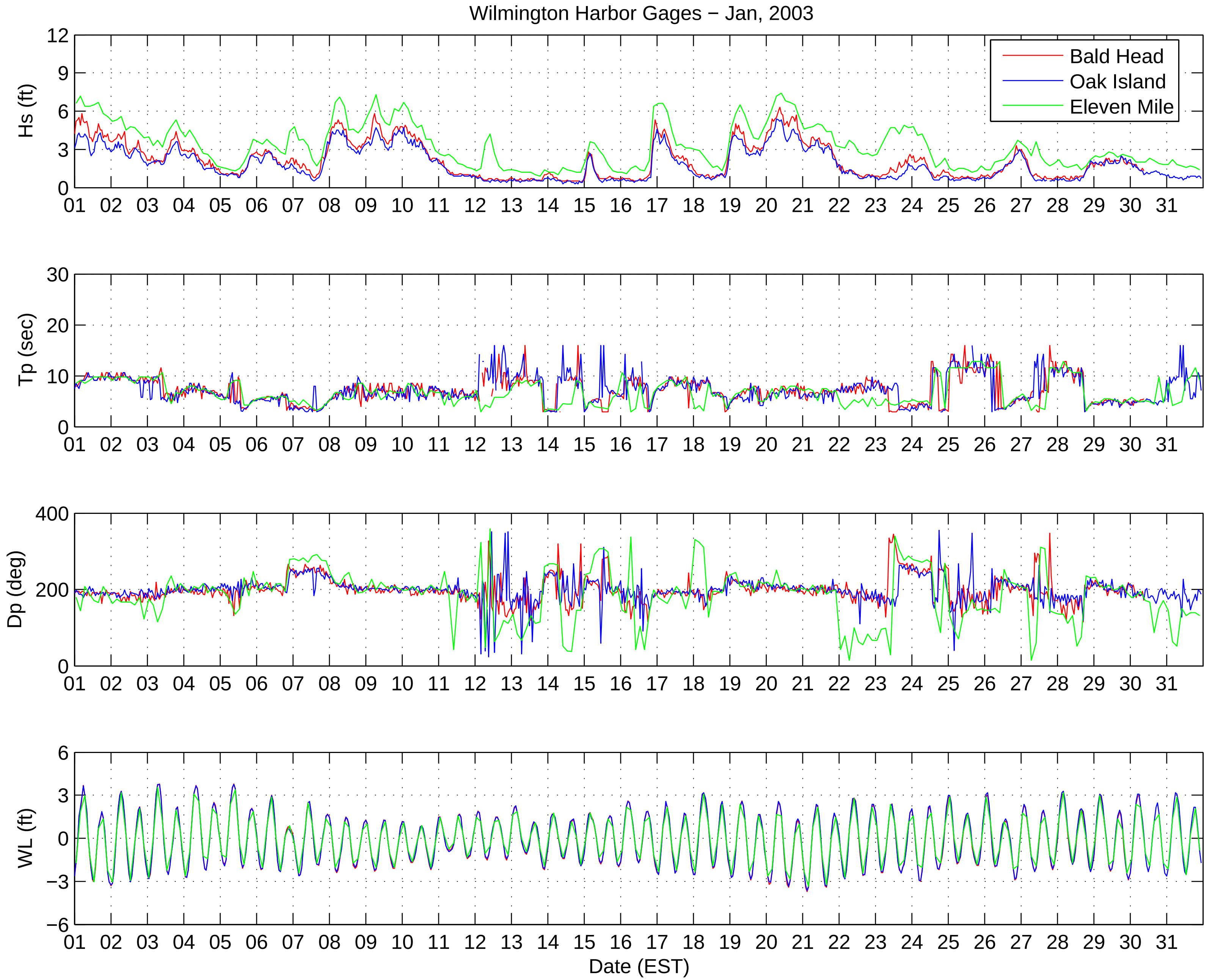
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)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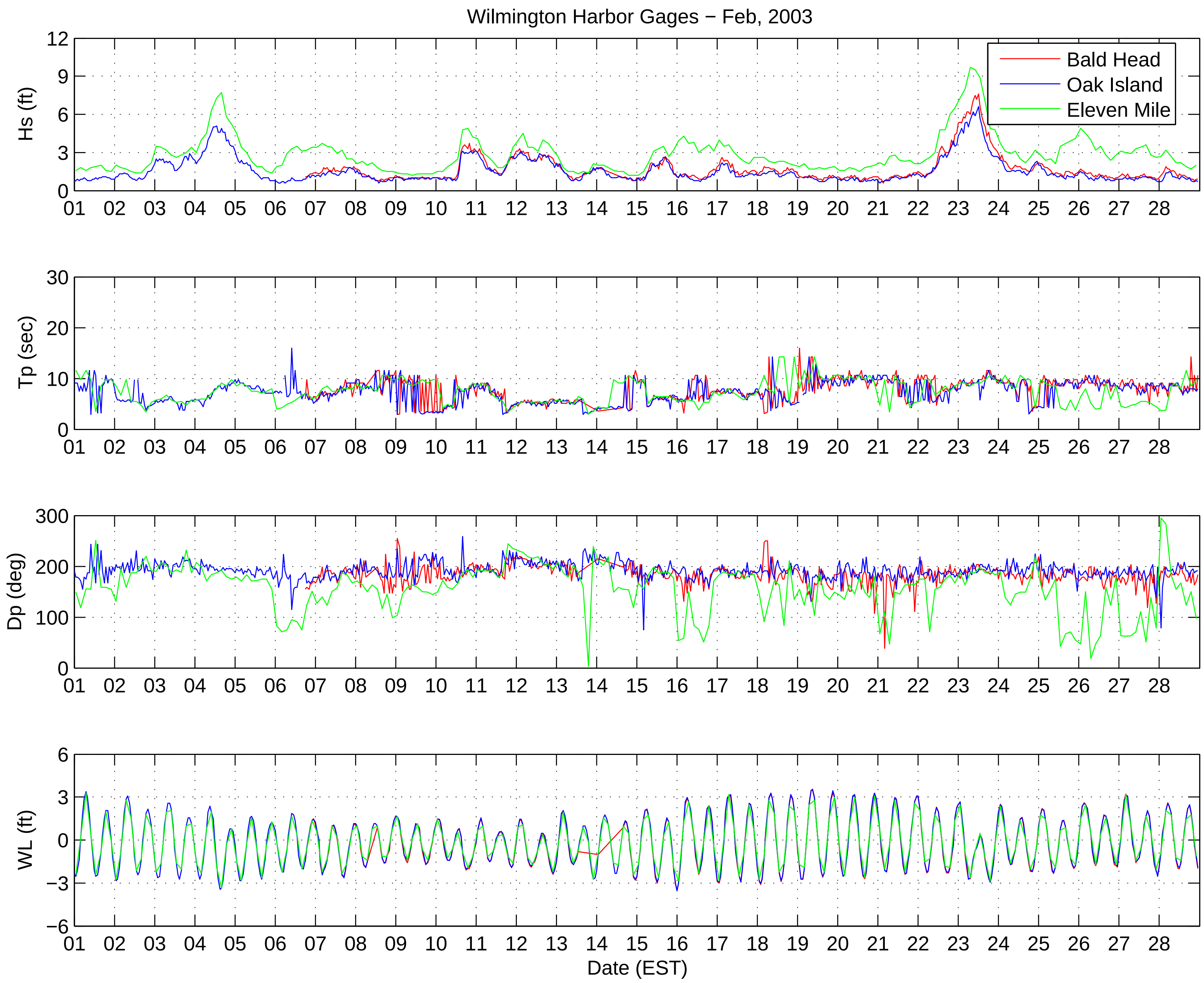
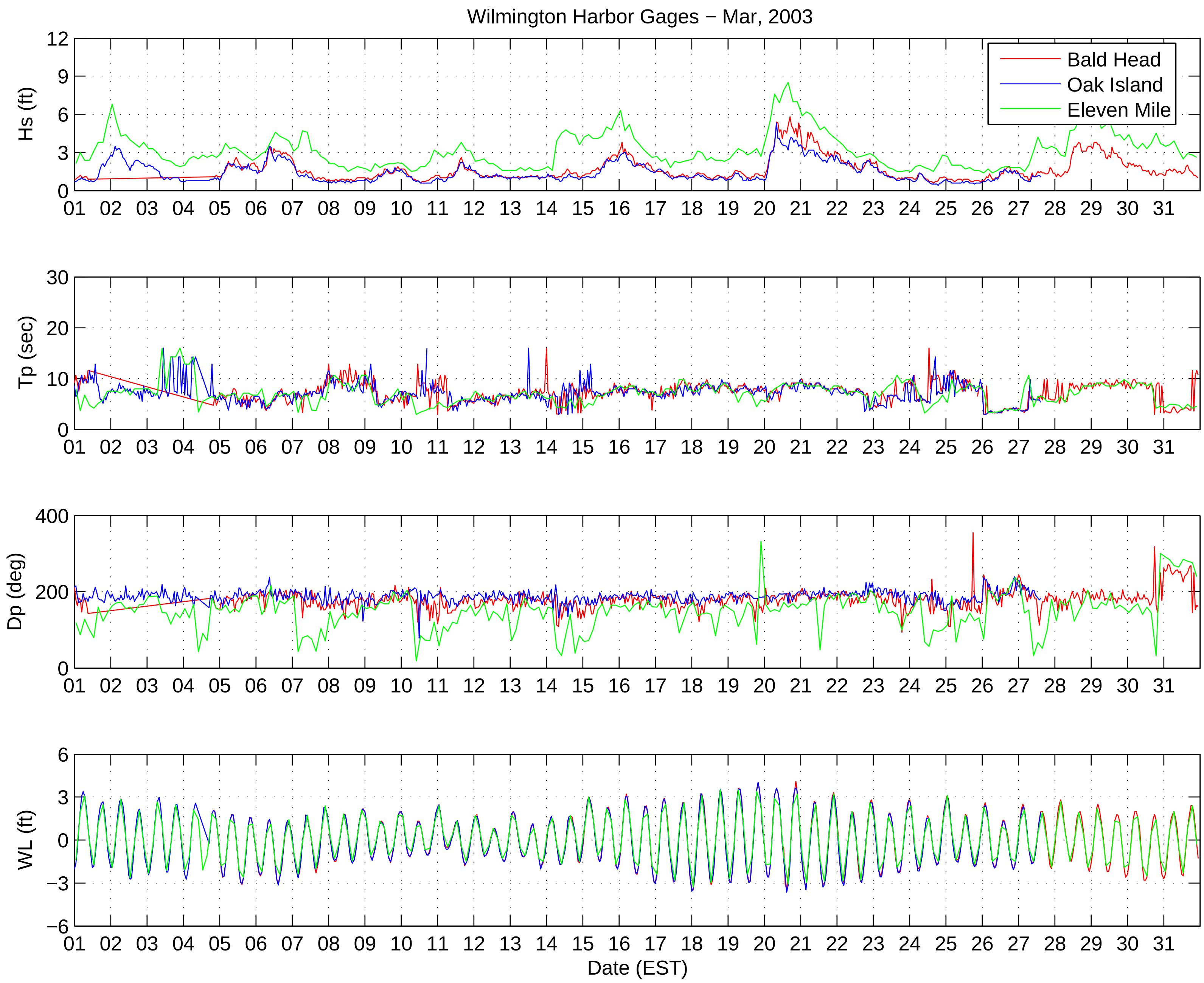
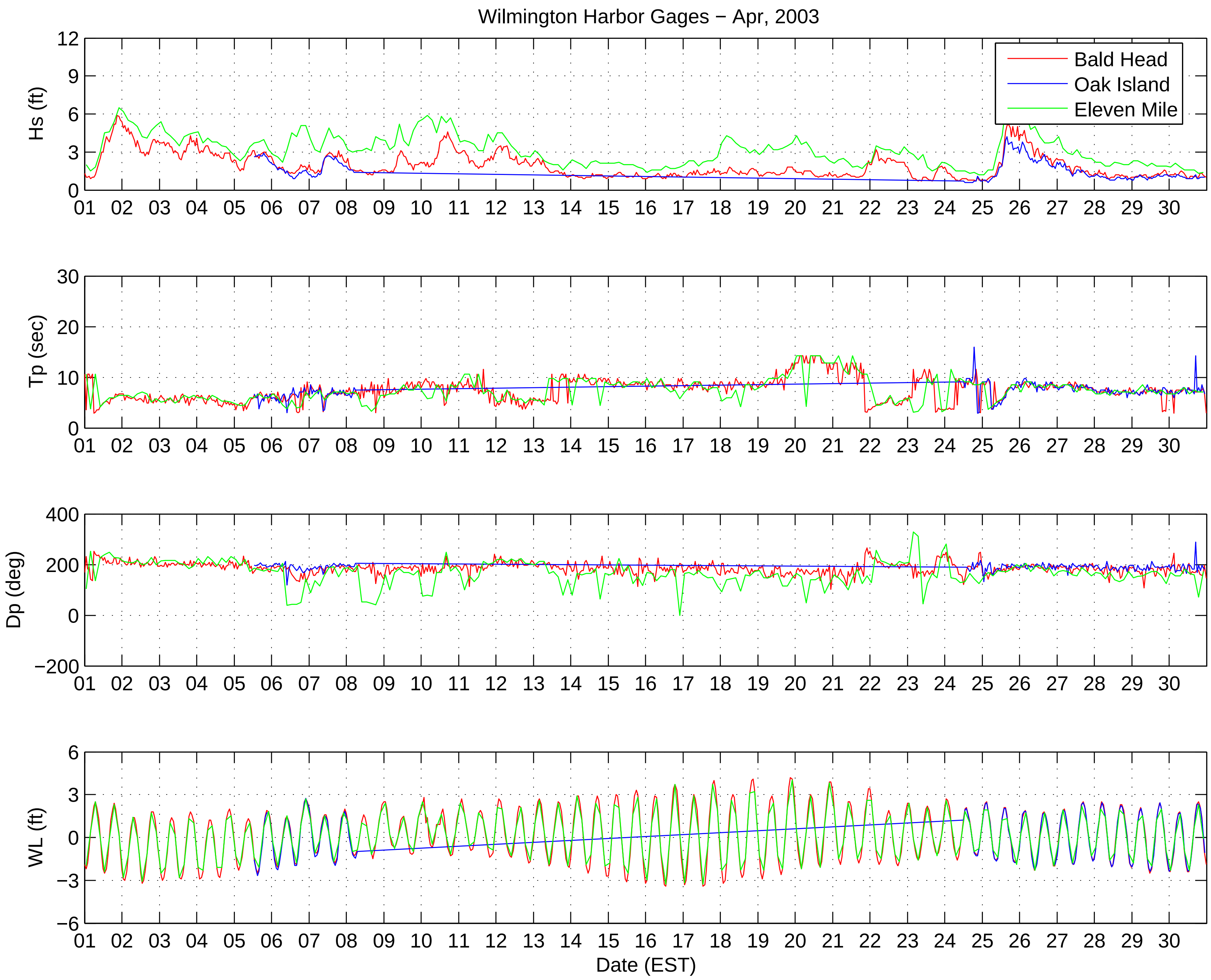
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



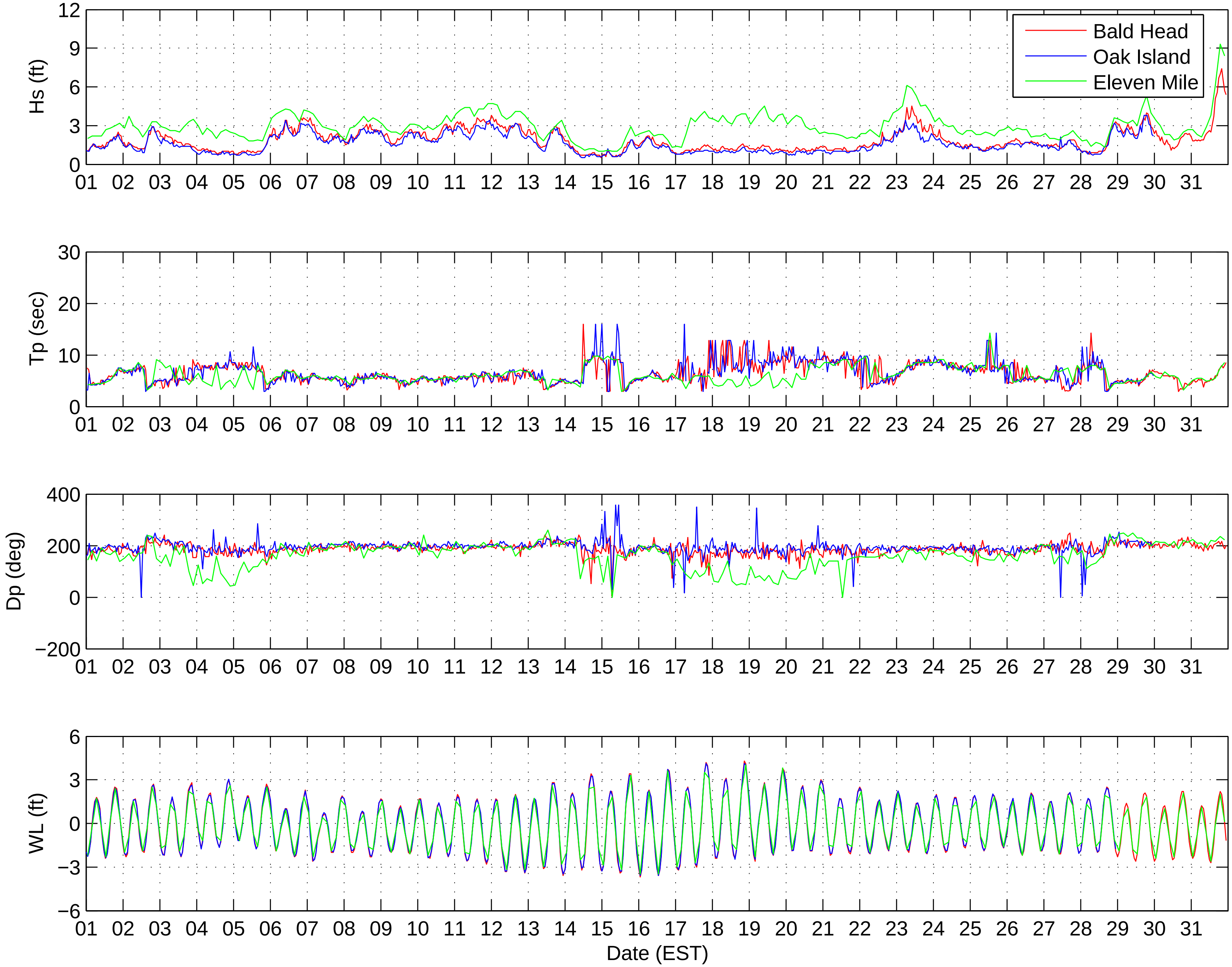
Wilmington Harbor Gages − Feb, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

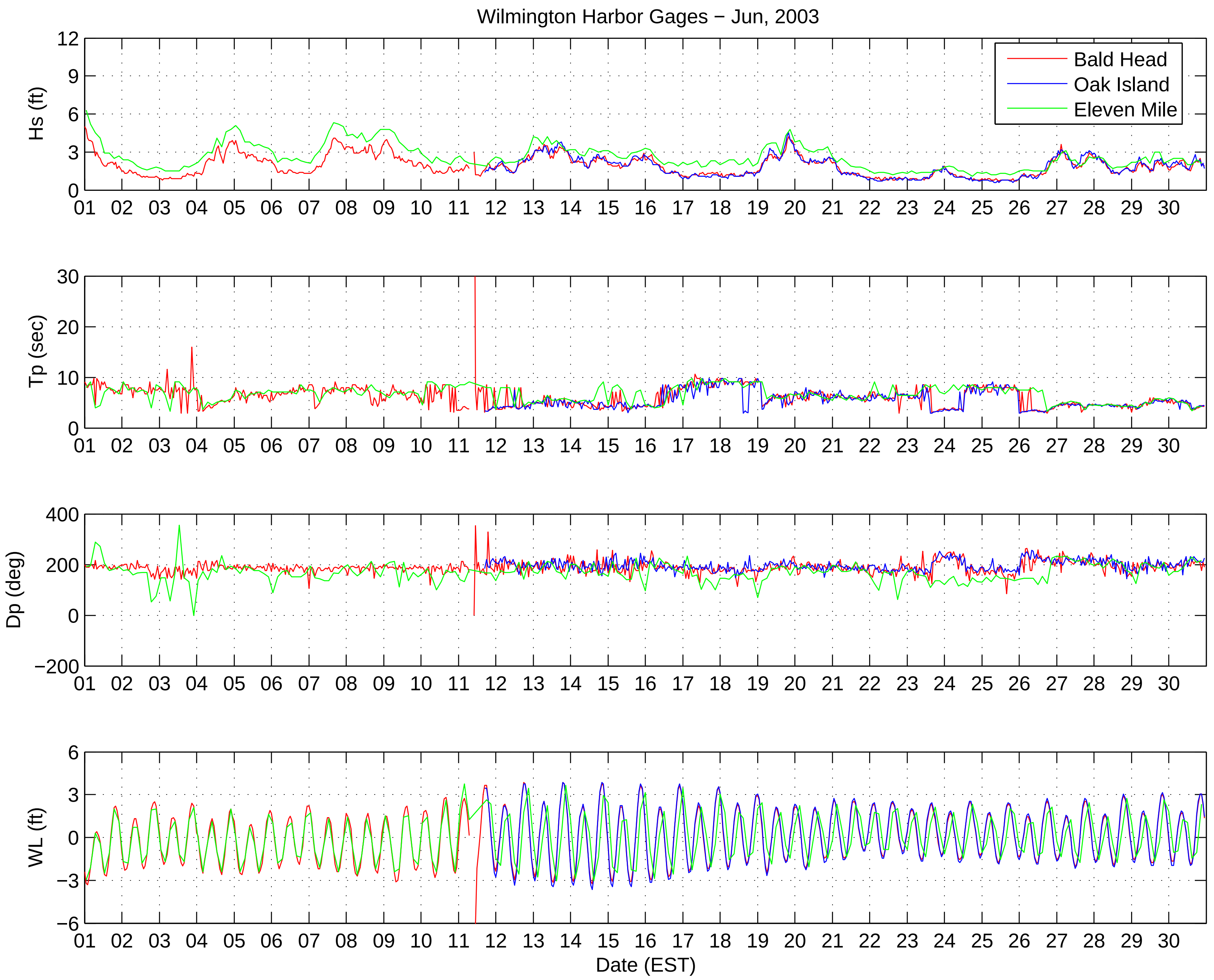

Wilmington Harbor Gages − Mar, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

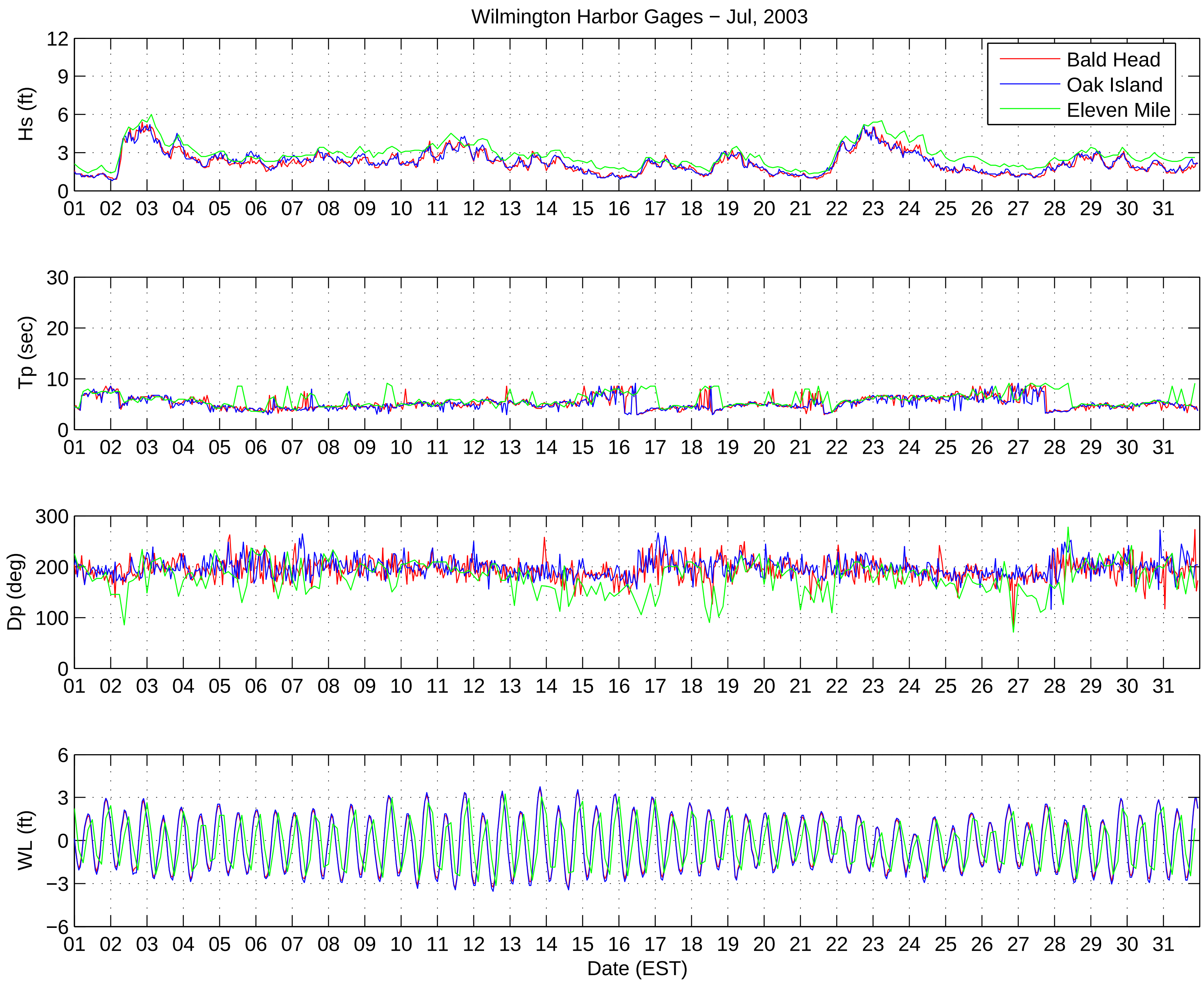


Wilmington Harbor Gages − Apr, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

Wilmington Harbor Gages − May, 2003




Wilmington Harbor Gages − Jun, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)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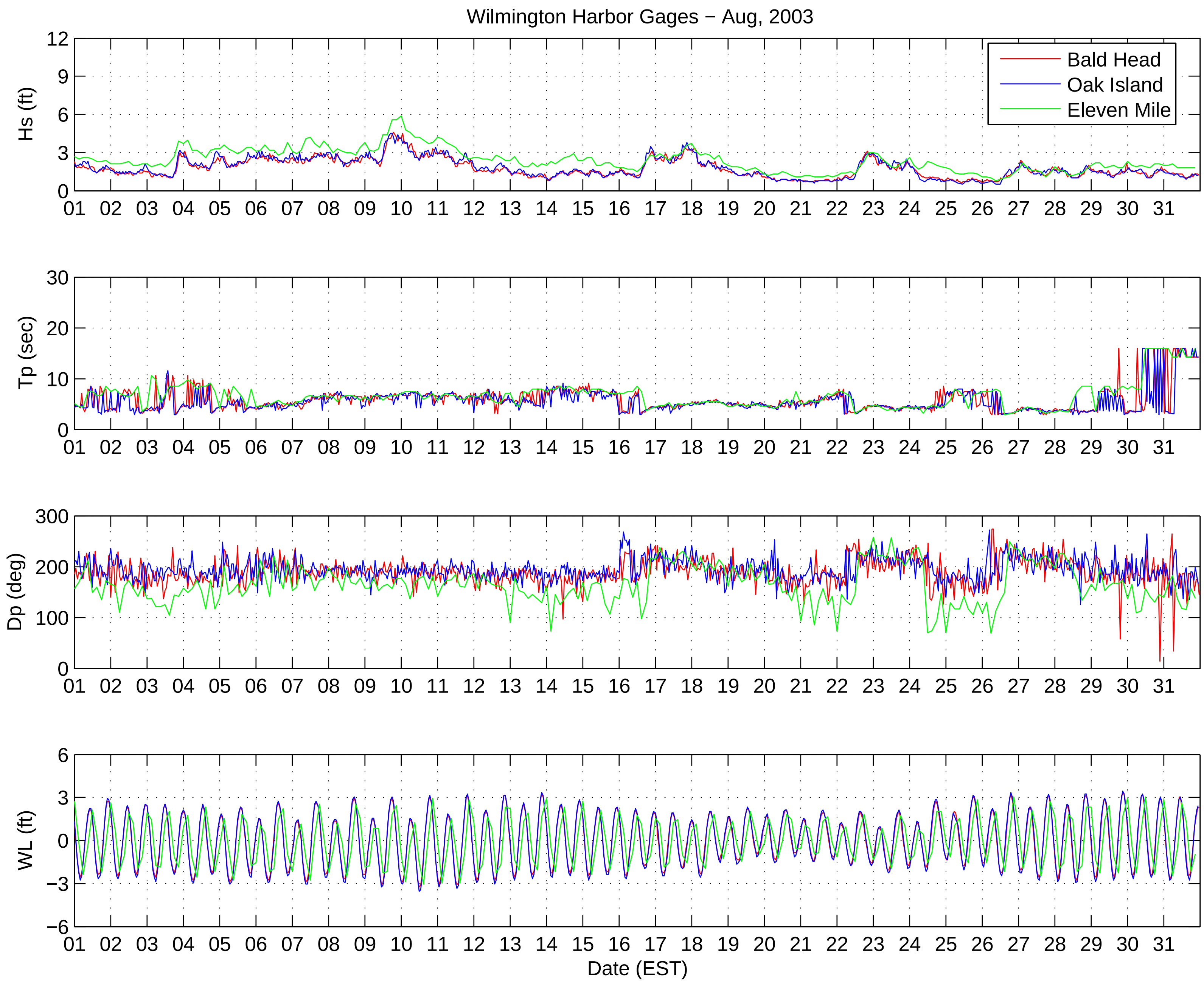
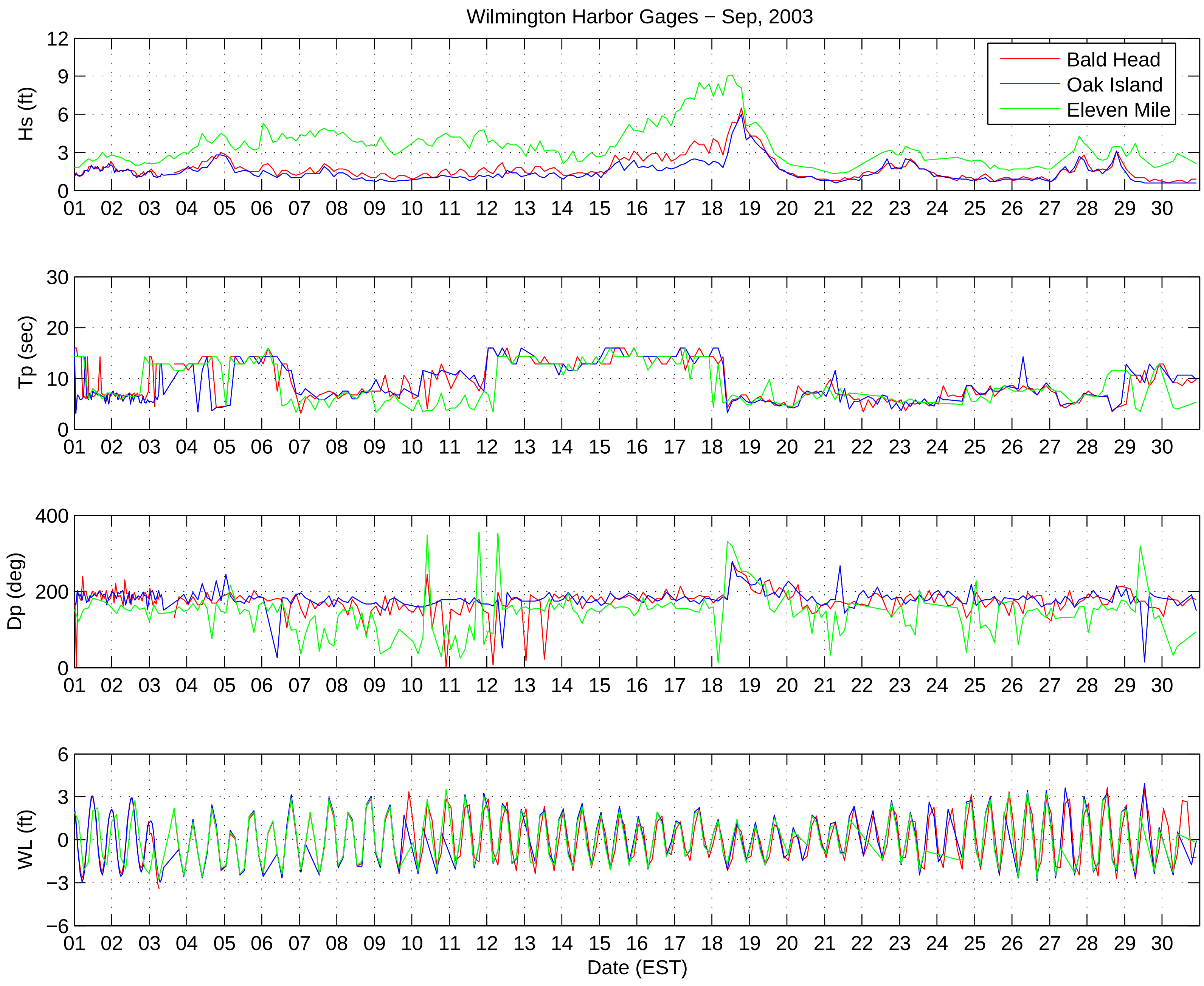
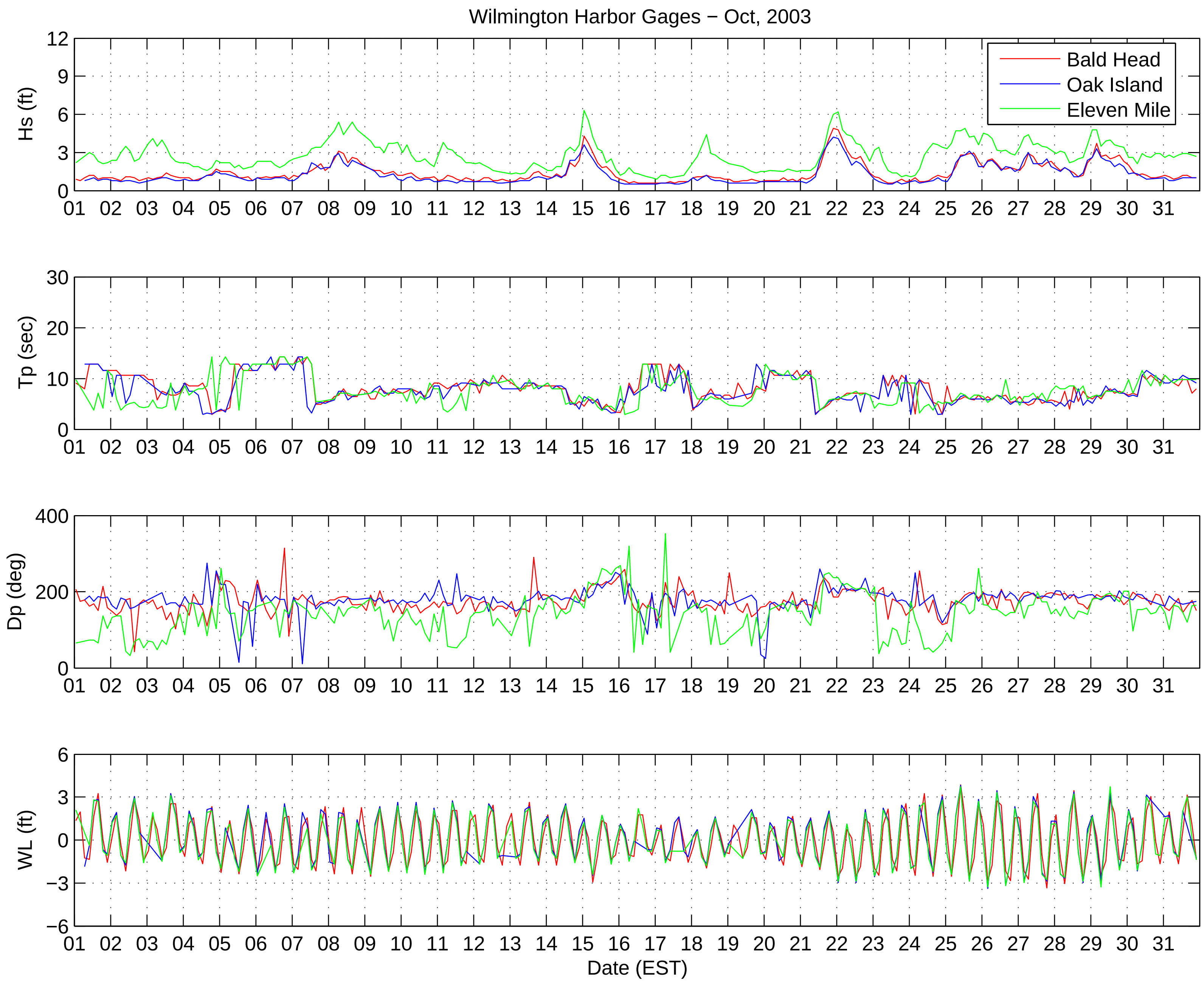
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

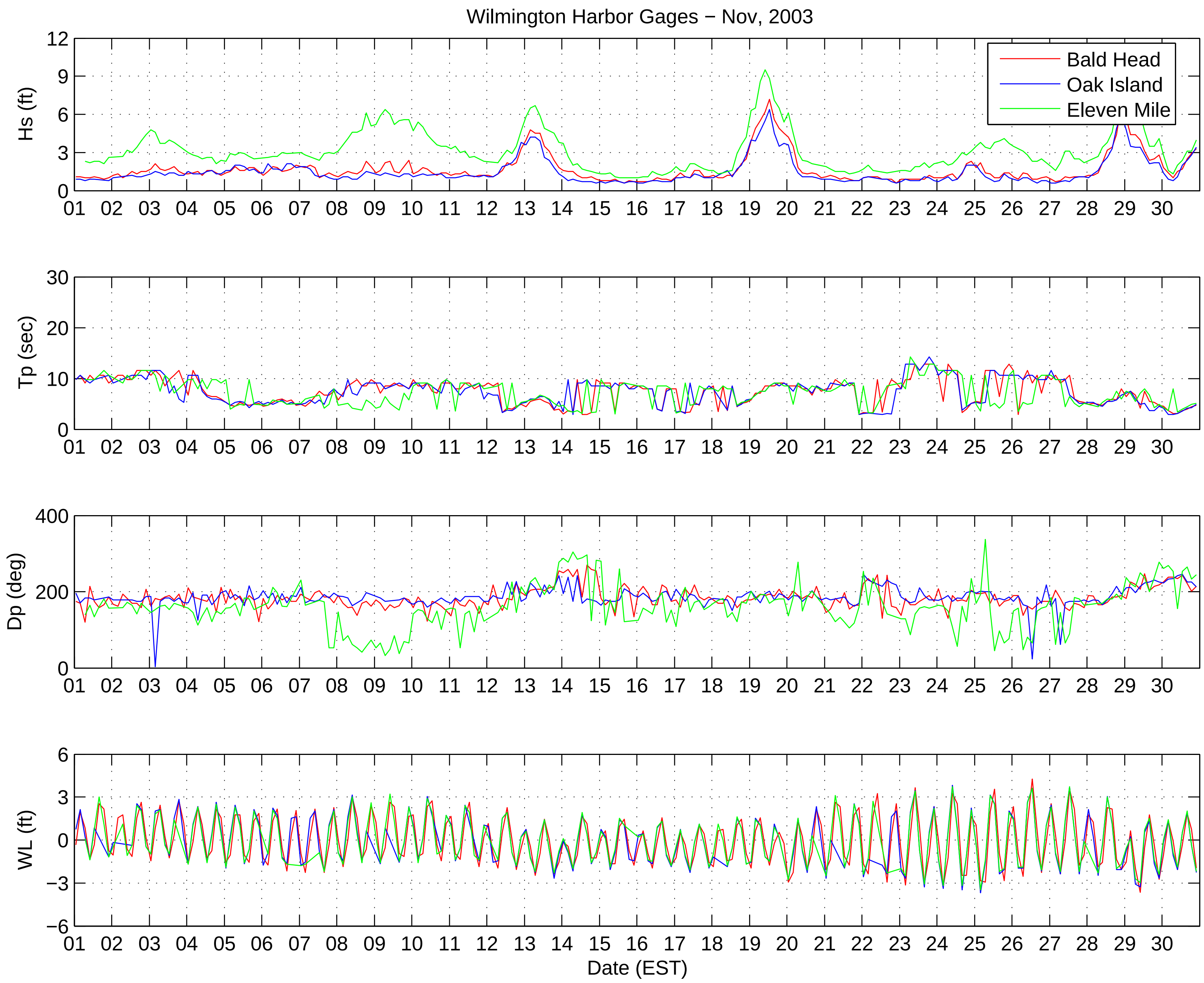

Wilmington Harbor Gages − Aug, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



Wilmington Harbor Gages − Sep, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



Wilmington Harbor Gages − Oct, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
12
9
6
3
0
Tp (sec)
30
20
10
0
Dp (deg)
400
200
0
WL (ft)
6
3
0
−3
−6
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Date (EST)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Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
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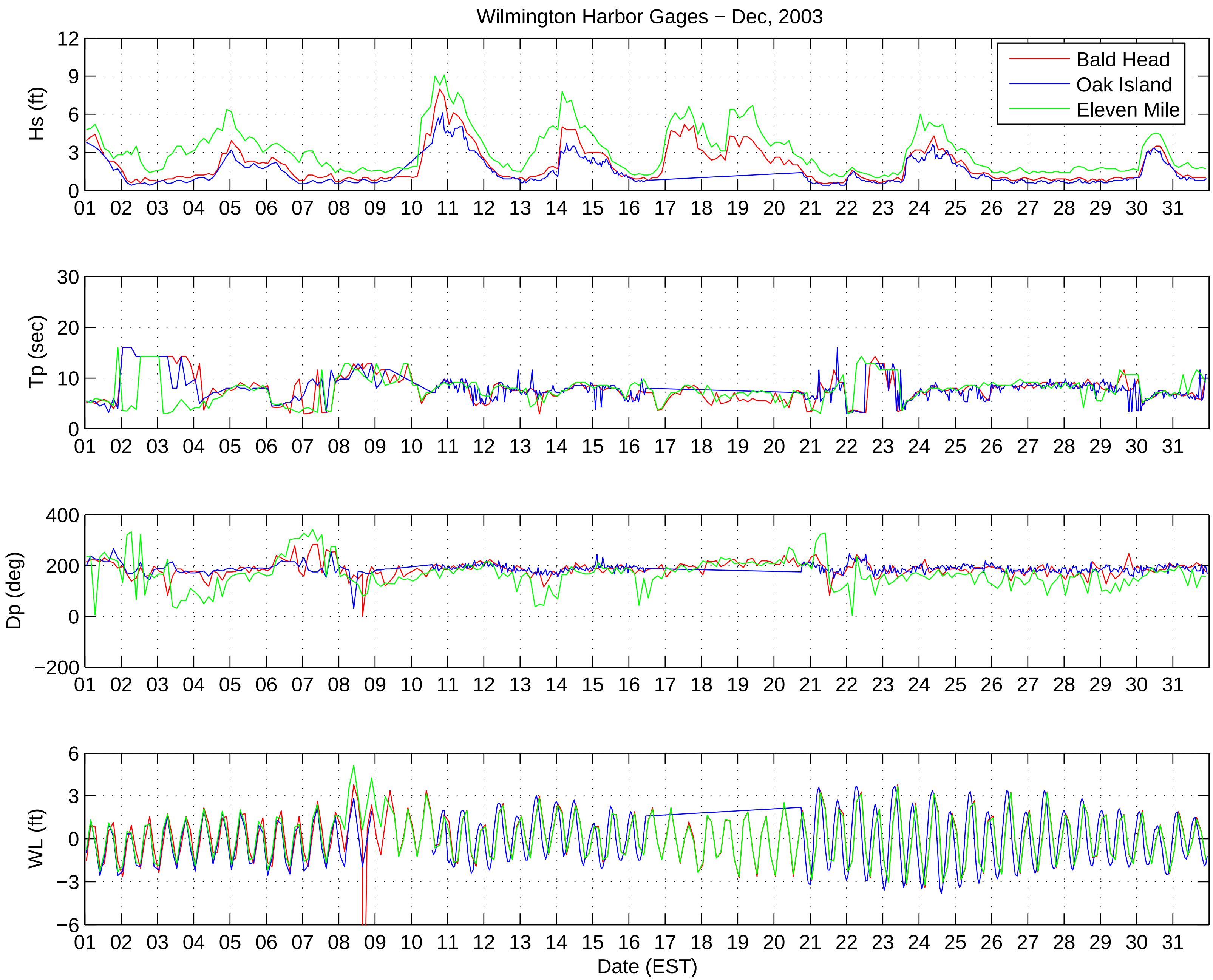
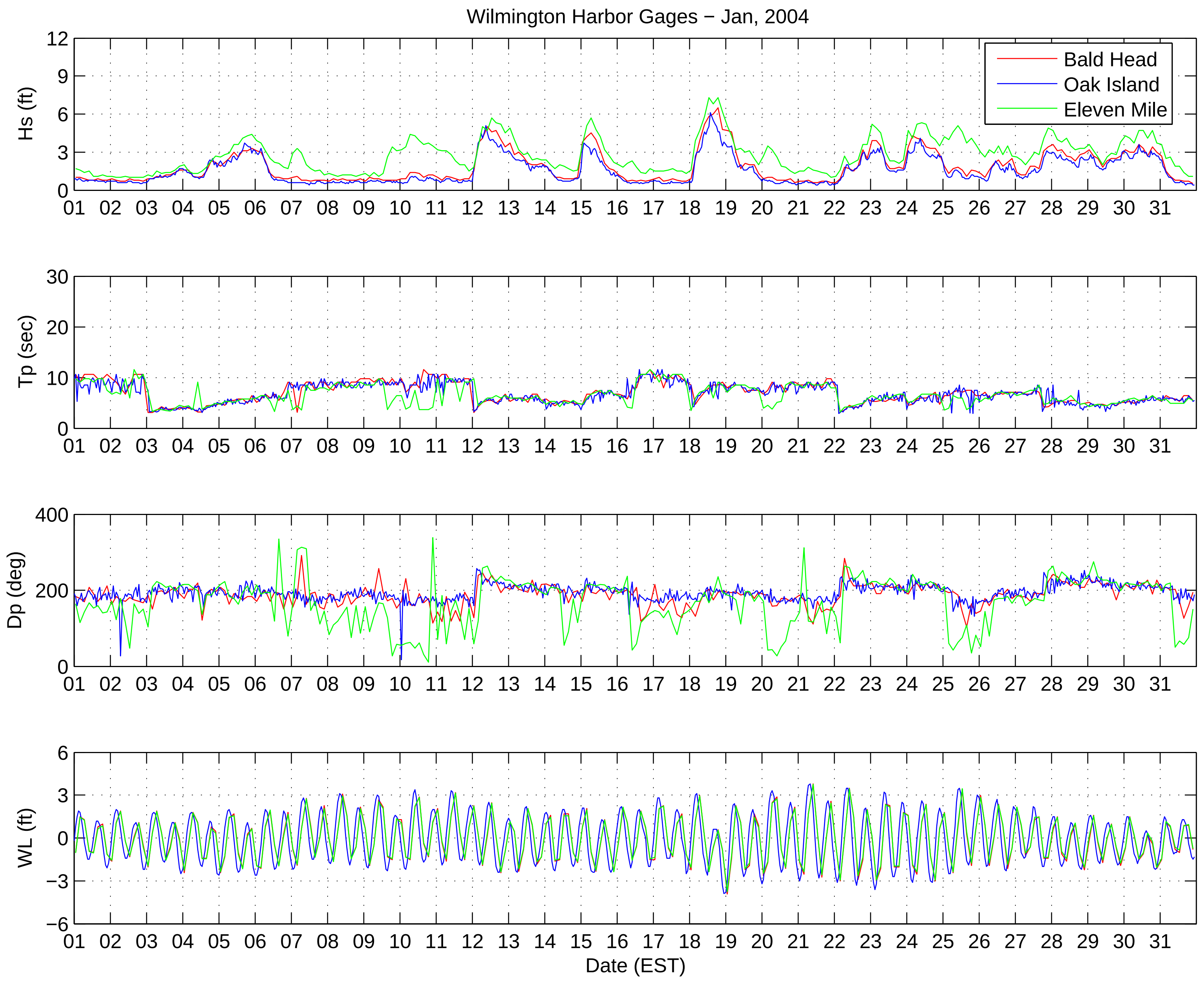
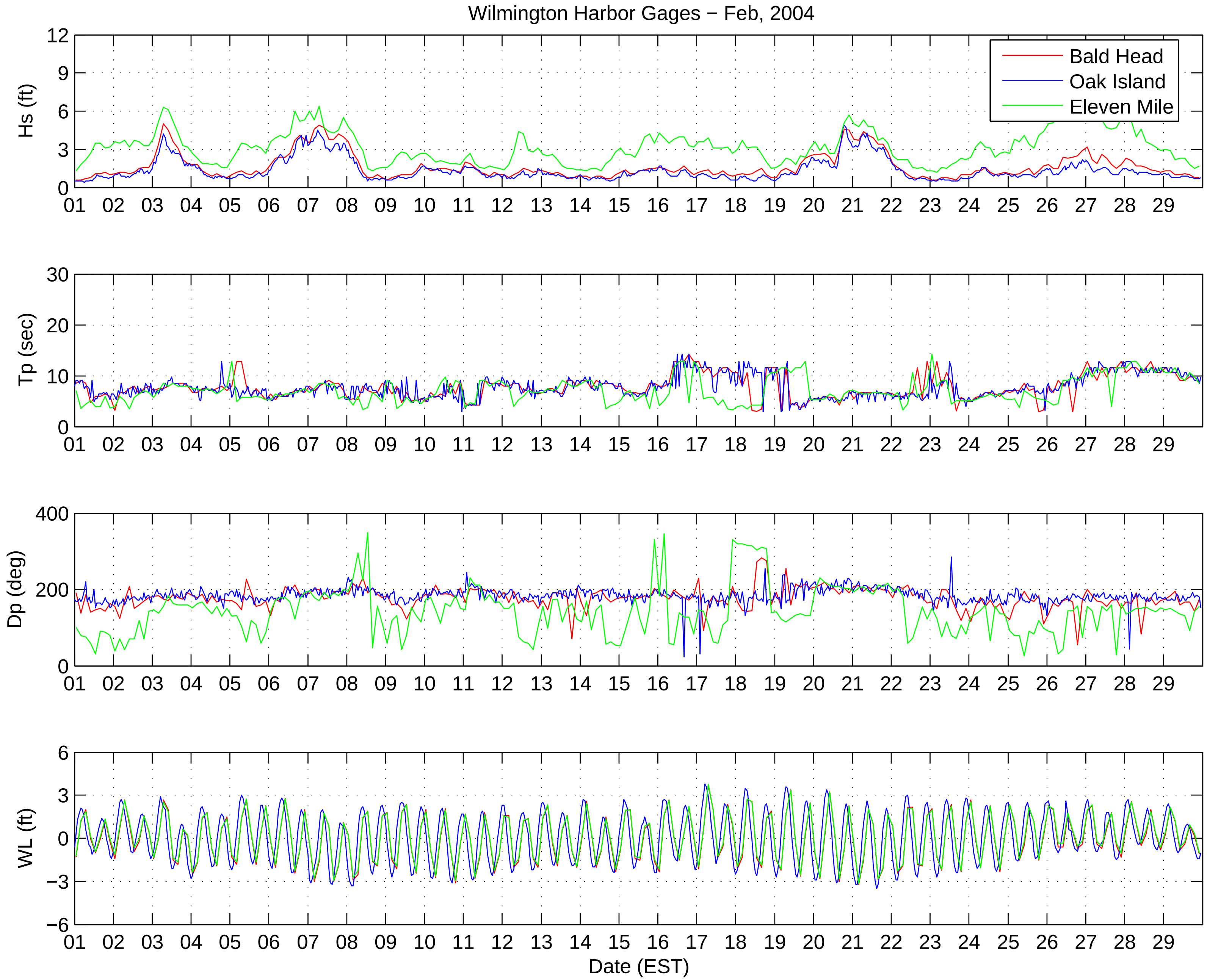
Date (EST)



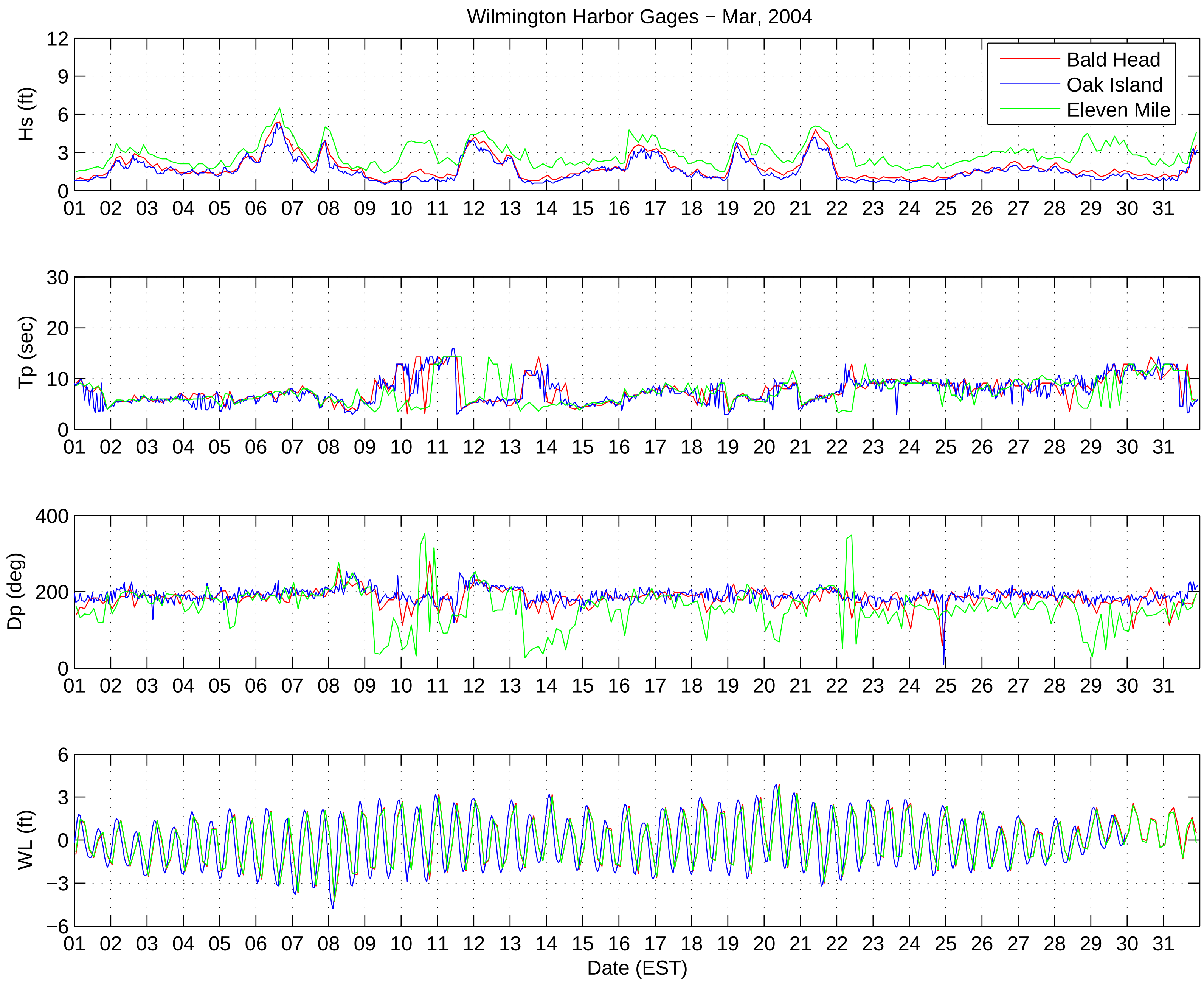
Wilmington Harbor Gages − Dec, 2003
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)

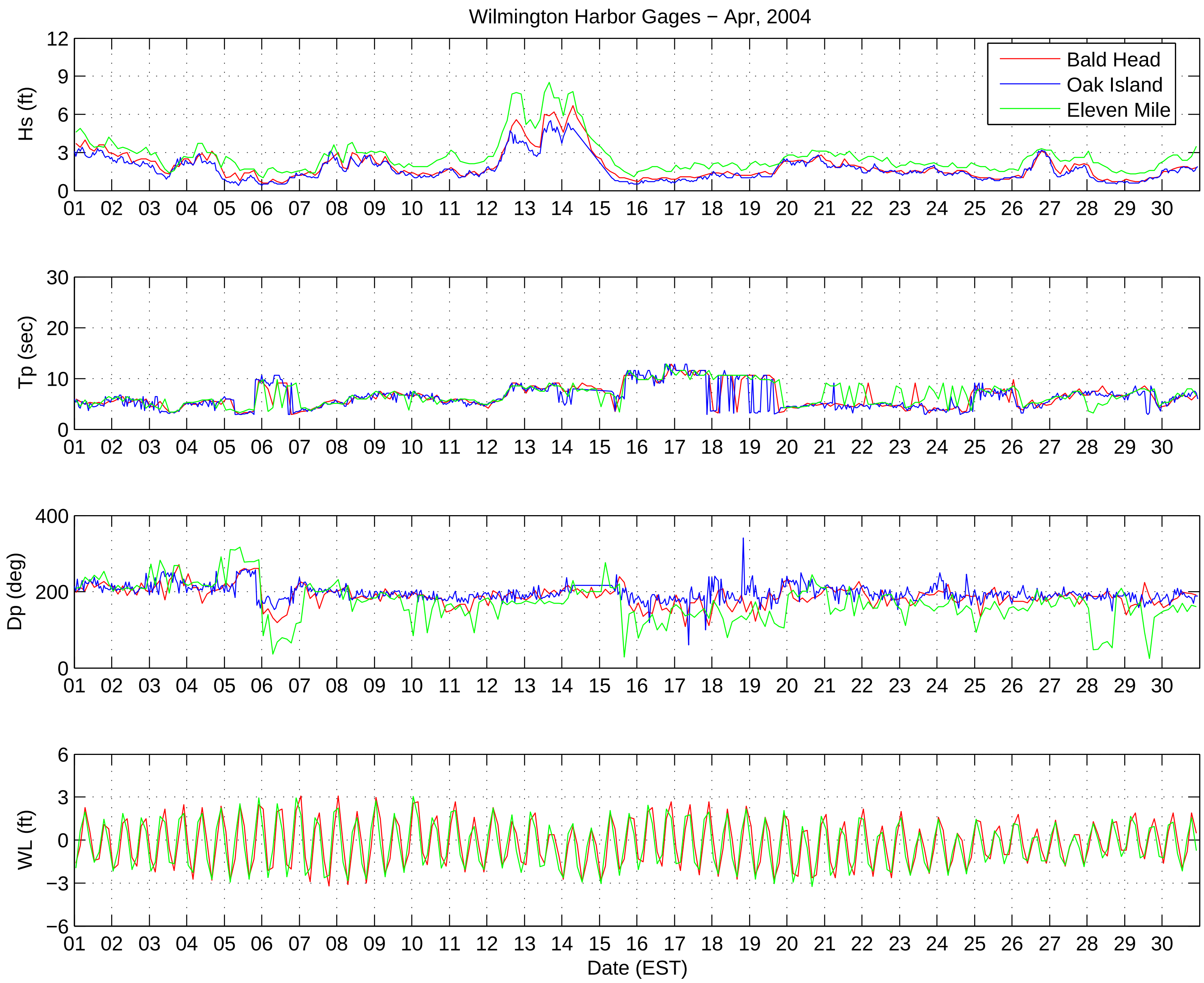


Wilmington Harbor Gages − Jan, 2004
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



Wilmington Harbor Gages − Feb, 2004
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Mar, 2004
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Apr, 2004
Bald Head
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Eleven Mile
Hs (ft)
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WL (ft)
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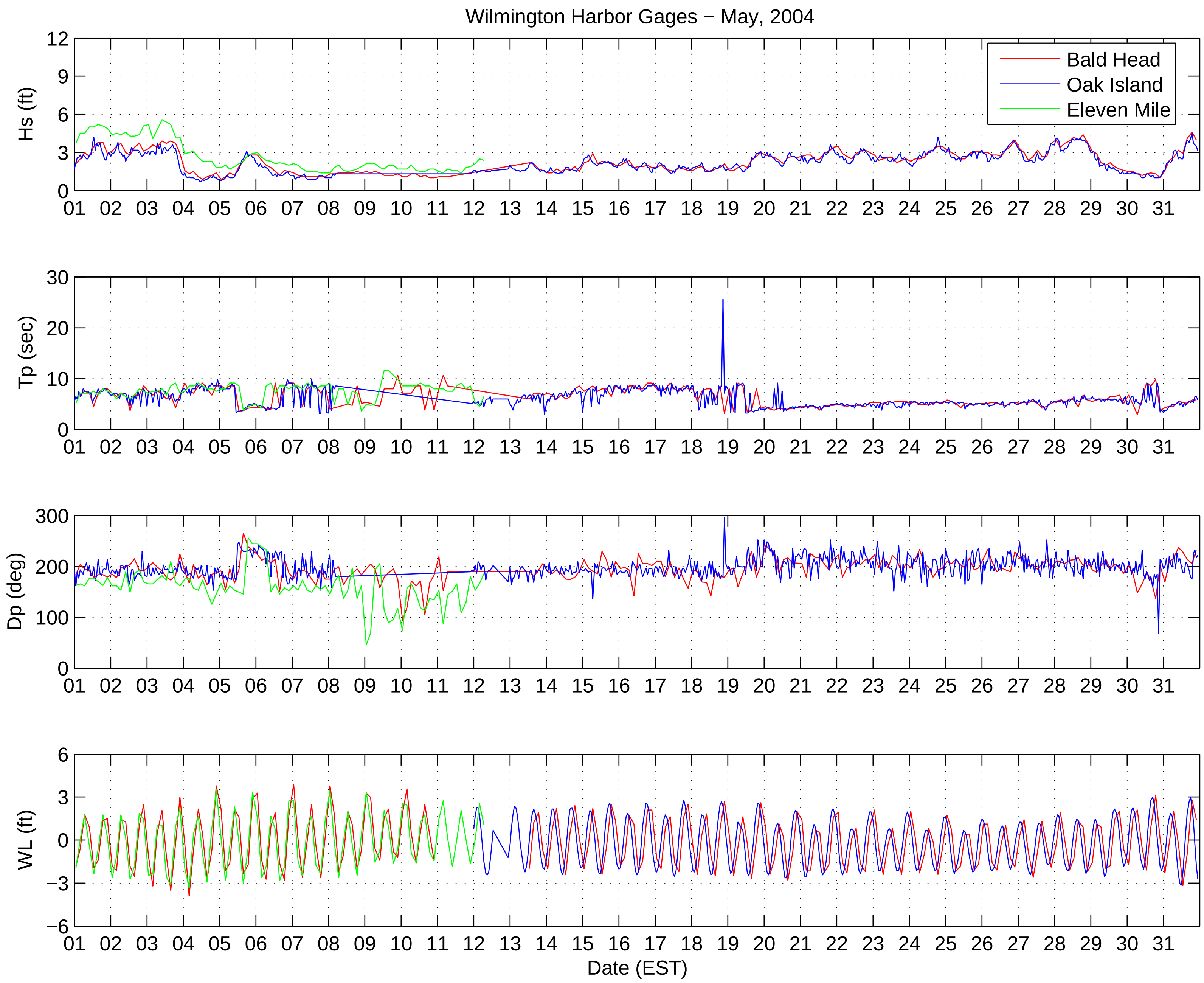
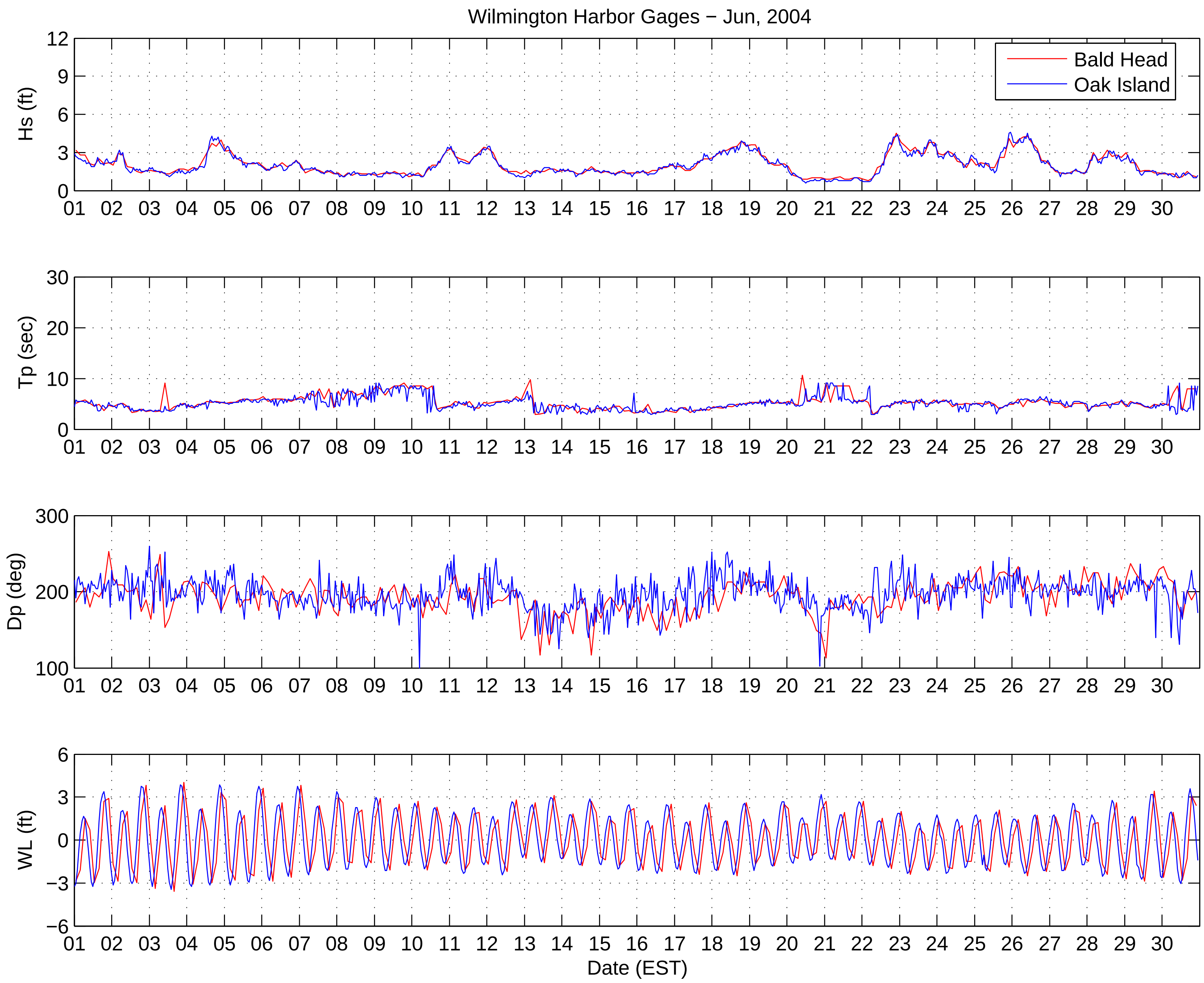
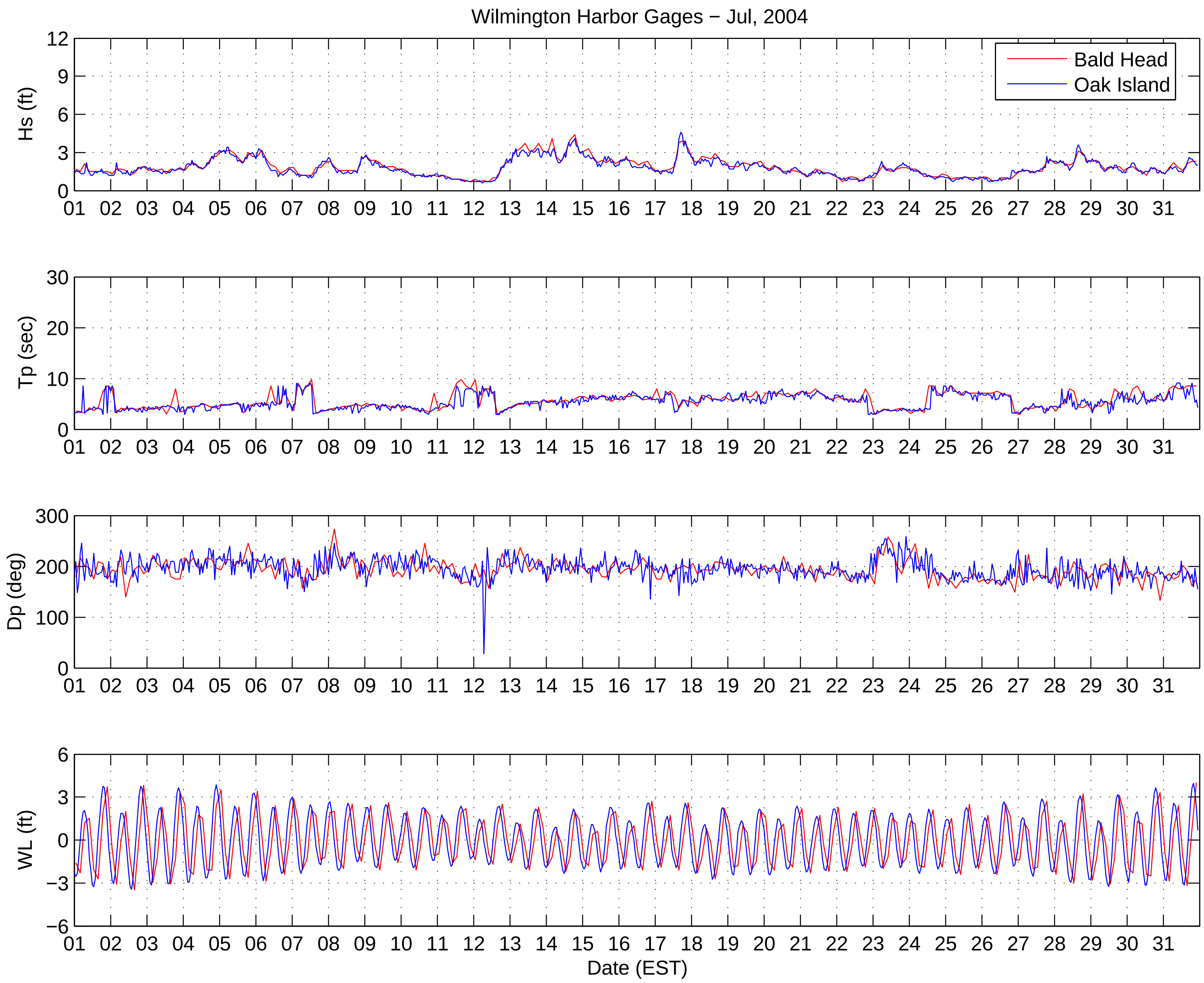


Wilmington Harbor Gages − May, 2004
Bald Head
Oak Island
Eleven Mile
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)



Wilmington Harbor Gages − Jun, 2004
Bald Head
Oak Island
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)


Wilmington Harbor Gages − Jul, 2004
Bald Head
Oak Island
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
Date (EST)
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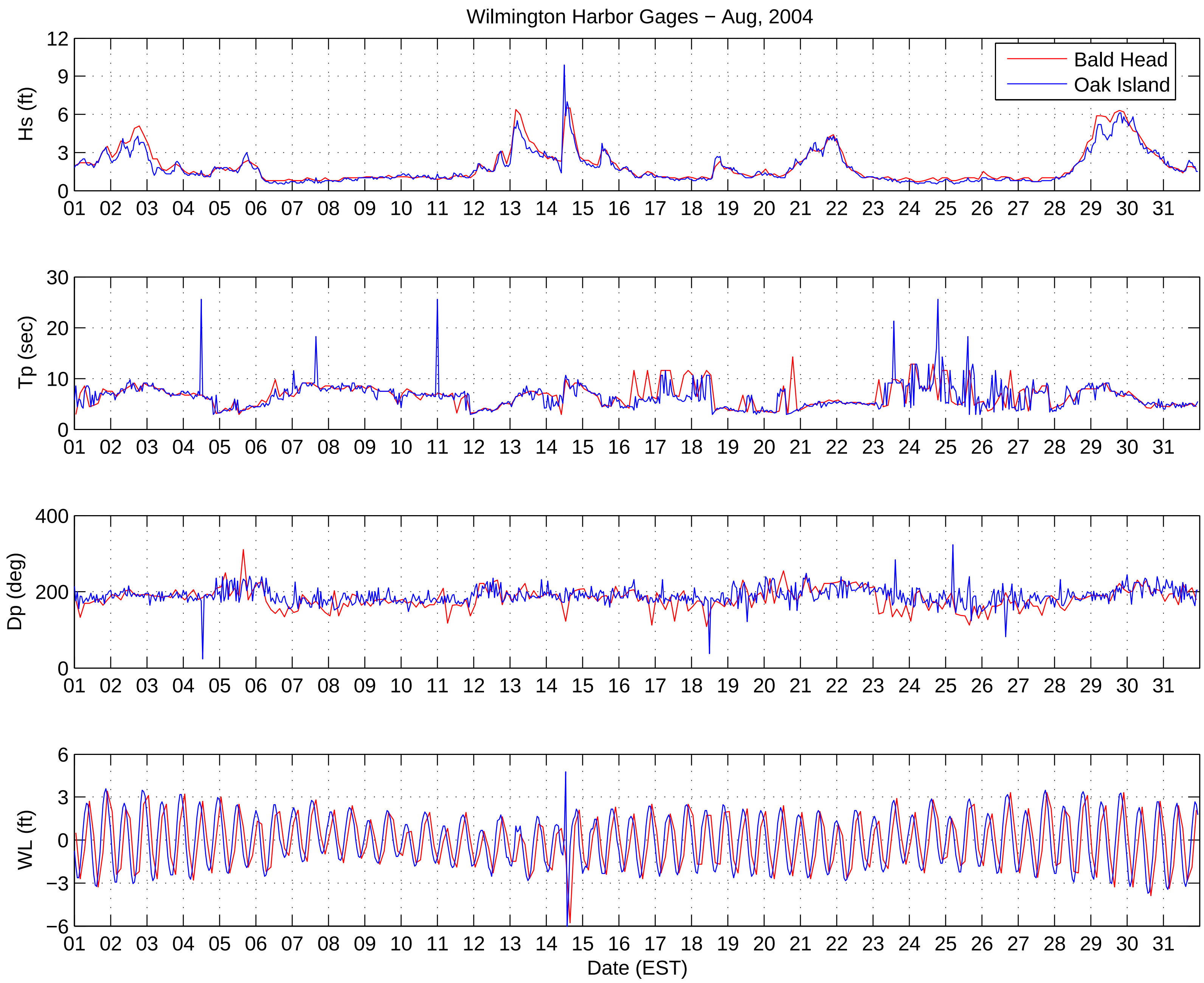
Wilmington Harbor Gages − Aug, 2004
Bald Head
Oak Island
Hs (ft)
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Dp (deg)
WL (ft)
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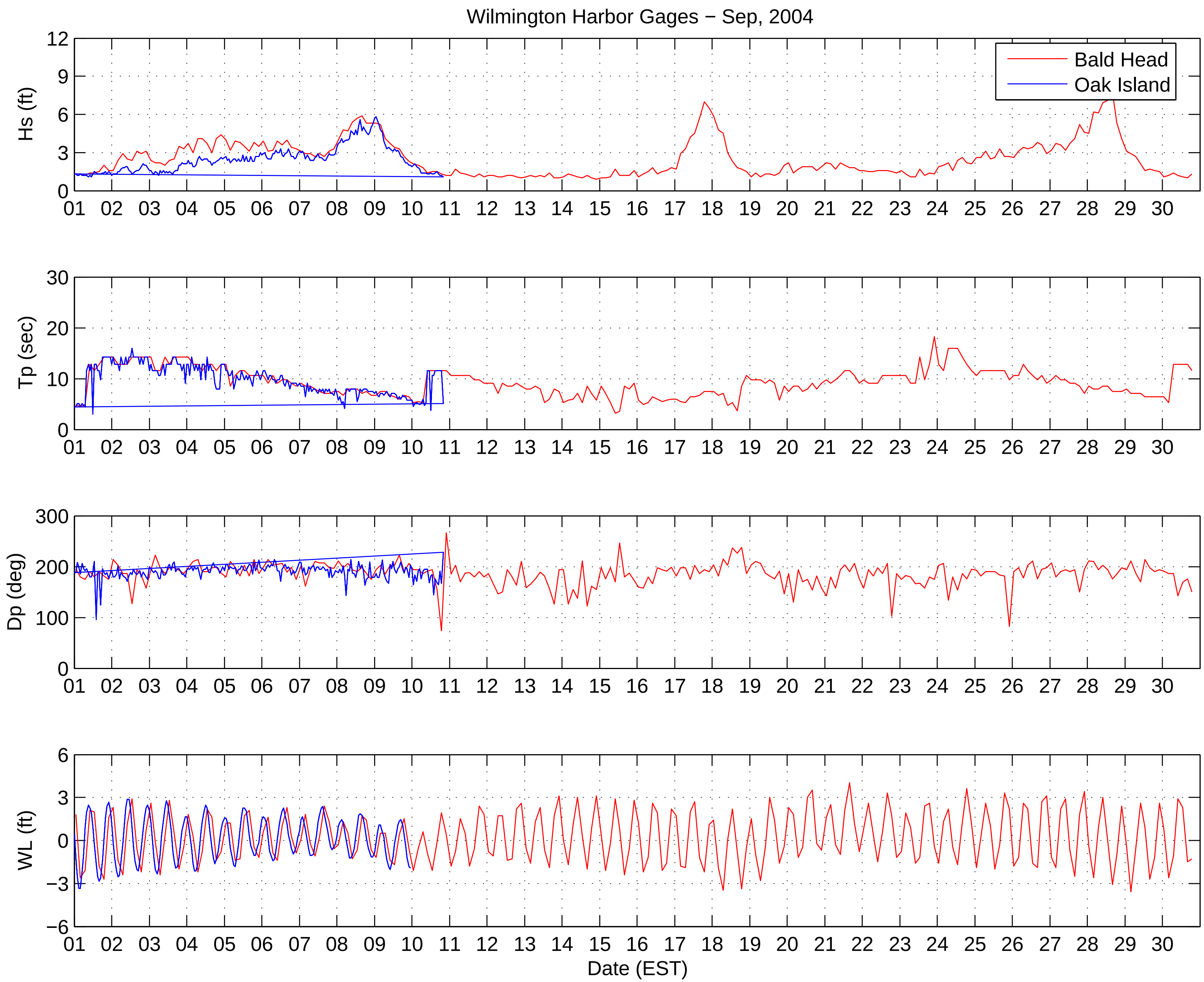
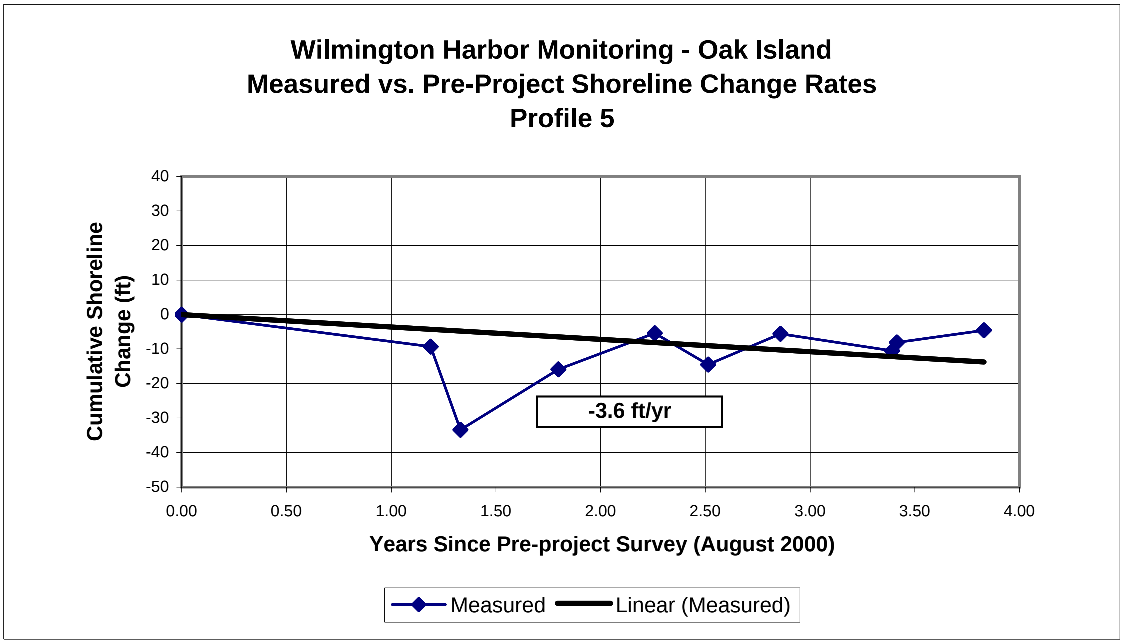
Date (EST)

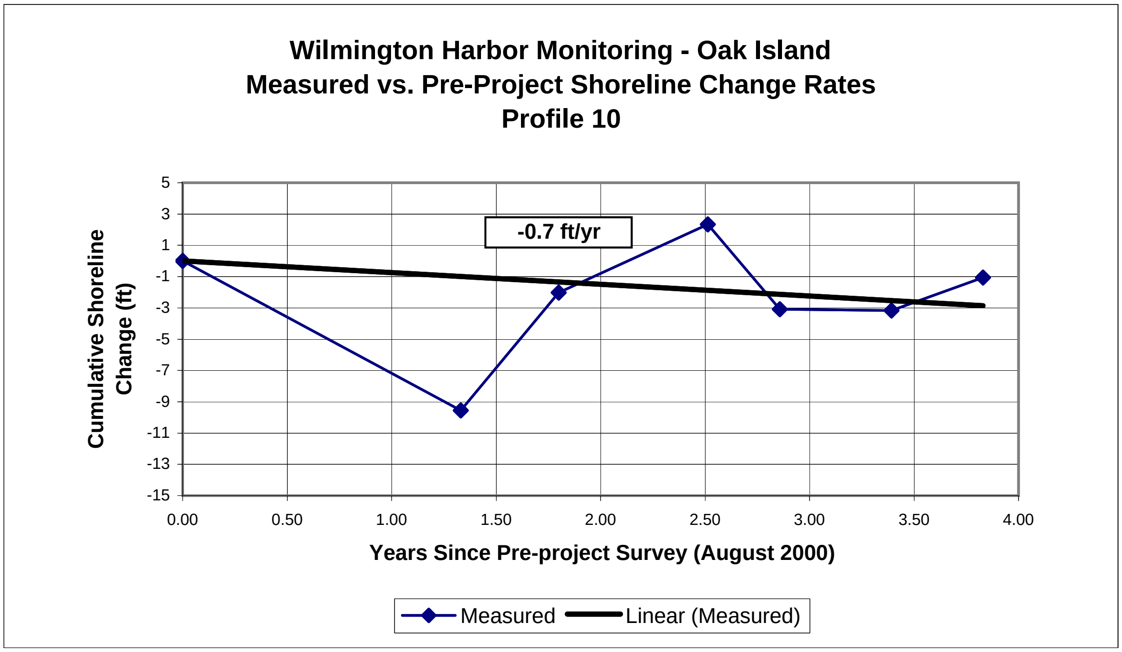


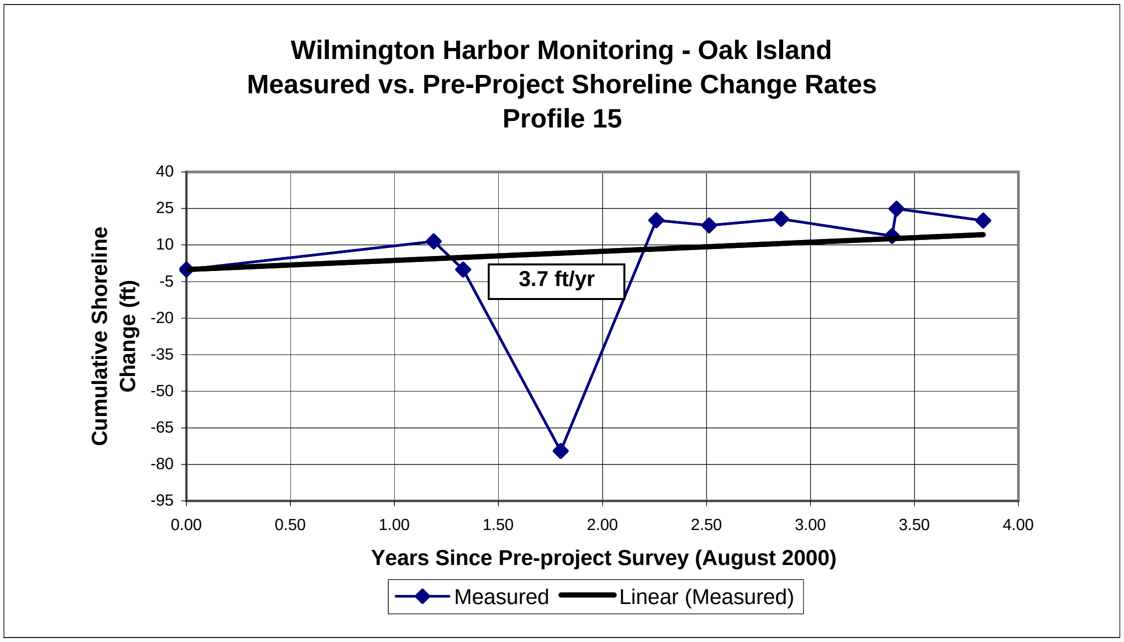
Wilmington Harbor Gages − Sep, 2004
Bald Head
Oak Island
Hs (ft)
Tp (sec)
Dp (deg)
WL (ft)
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Date (EST)

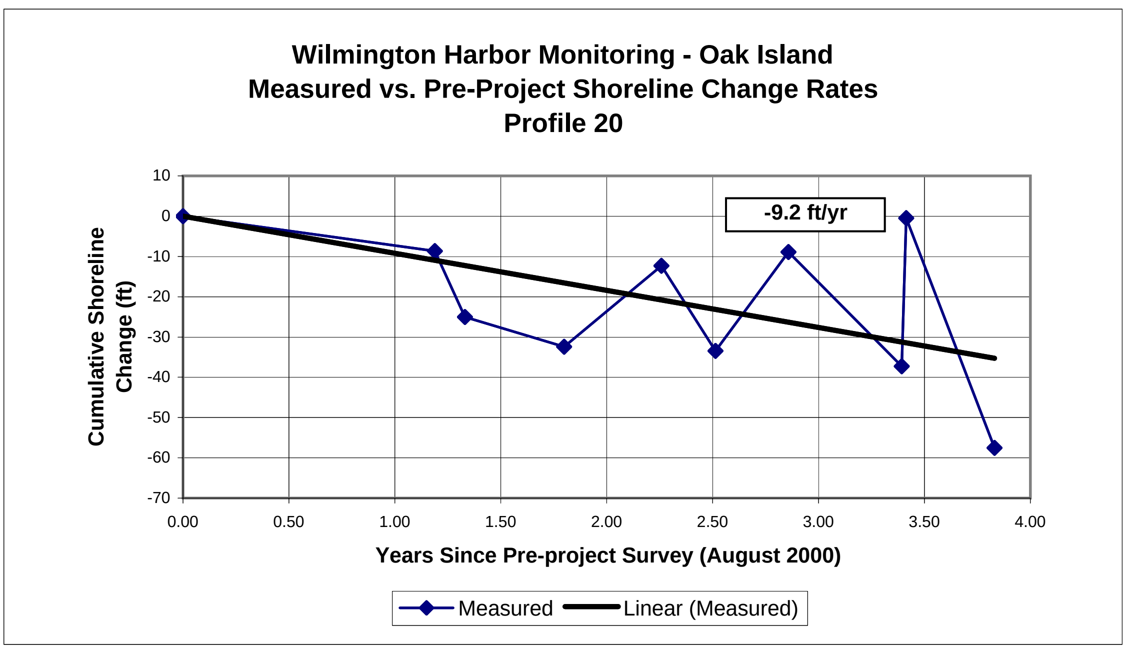
Appendix B

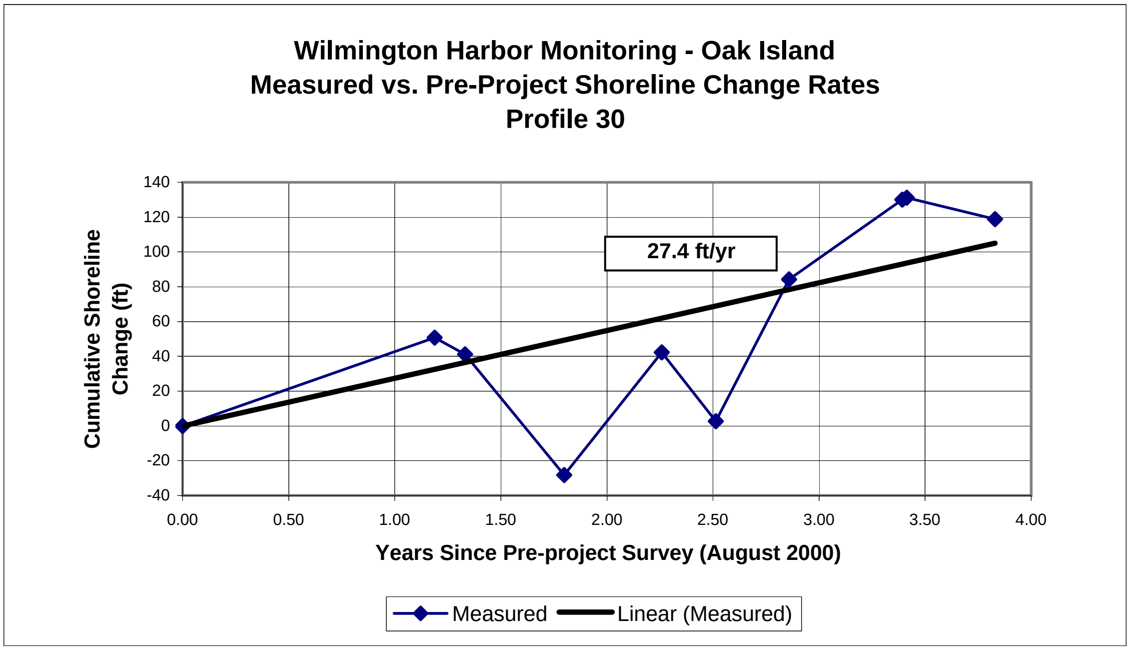
SHORELINE CHANGE RATES
(Oak Island)

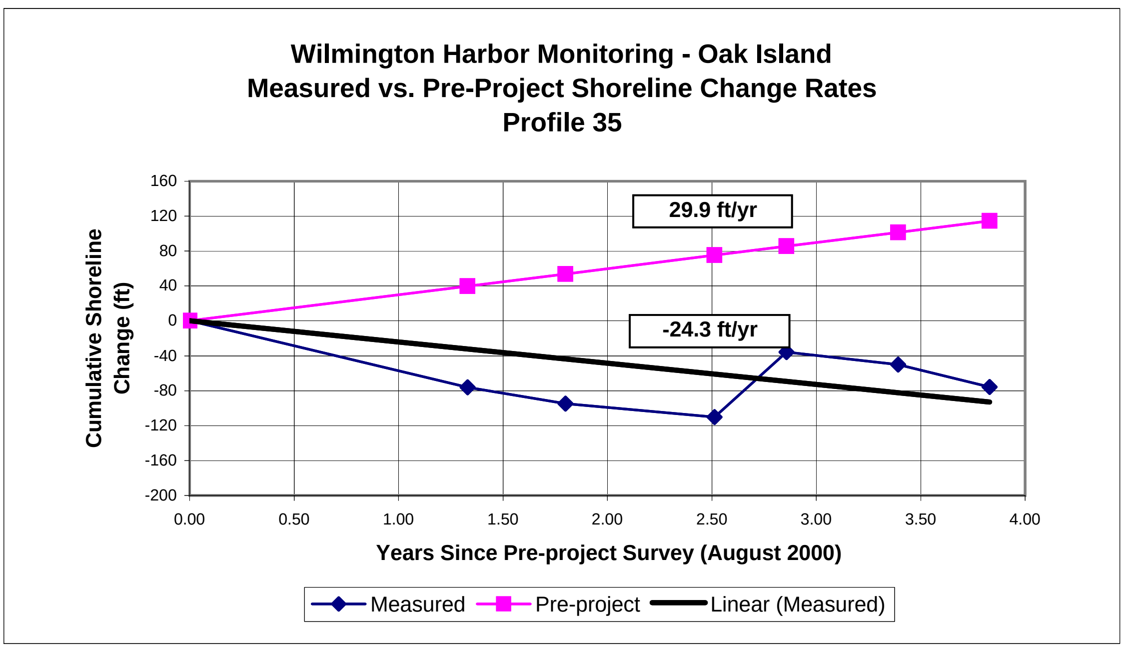

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 5
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
-40
-50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
-3.6 ft/yr
Measured
Linear (Measured)

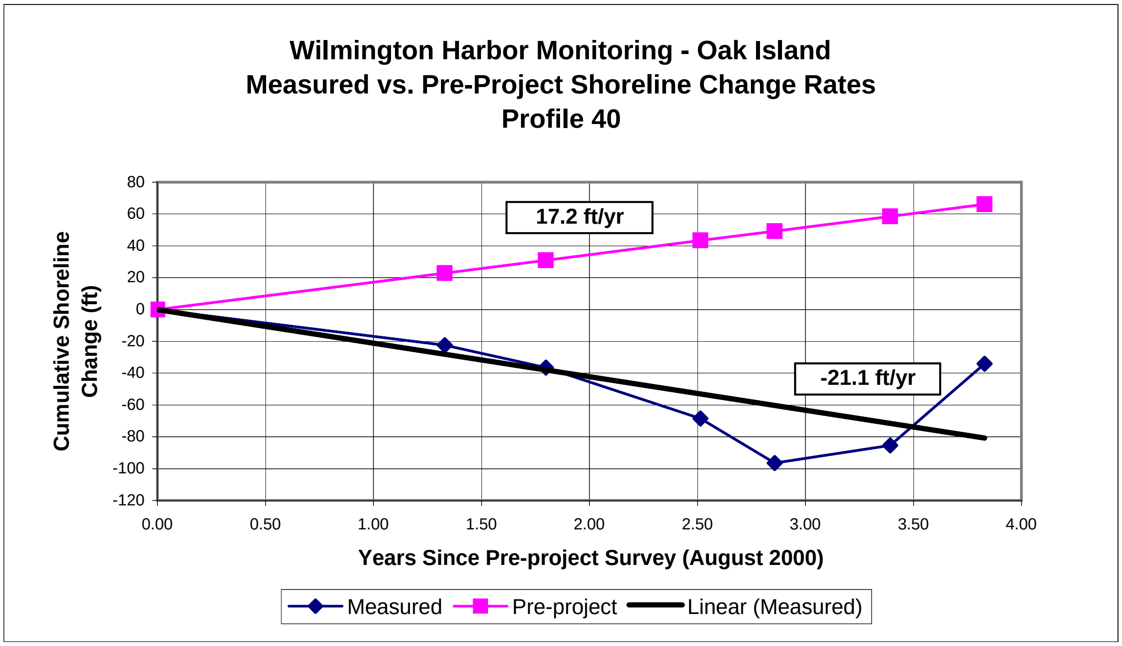

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 10
Cumulative Shoreline Change (ft)
5
3
1
-1
-3
-5
-7
-9
-11
-13
-15
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
-0.7 ft/yr
Measured
Linear (Measured)

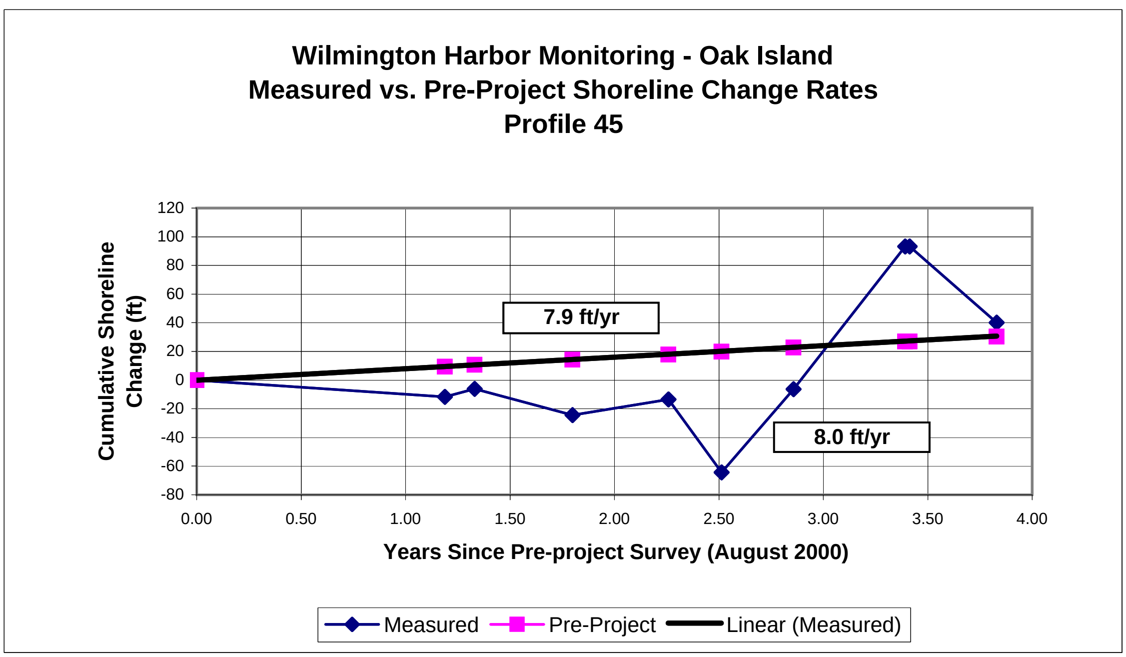

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 15
Cumulative Shoreline Change (ft)
40
25
10
-5
-20
-35
-50
-65
-80
-95
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
3.7 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

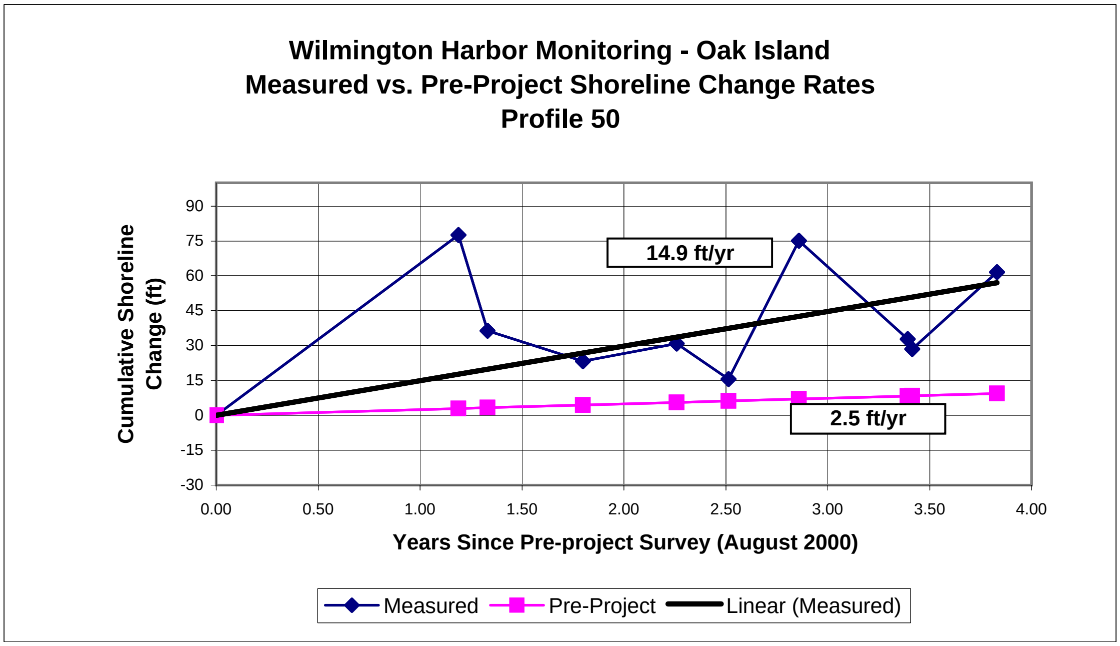

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
Cumulative Shoreline Change (ft)
10
0
-10
-20
-30
-40
-50
-60
-70
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
-9.2 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

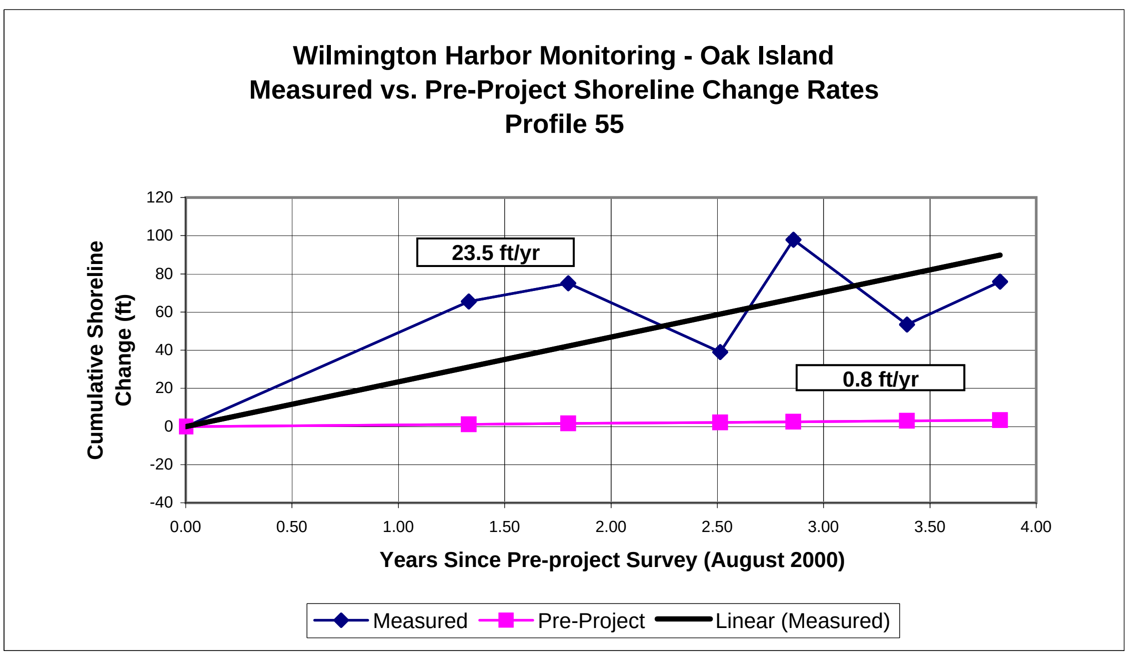

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 30
27.4 ft/yr
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Linear (Measured)

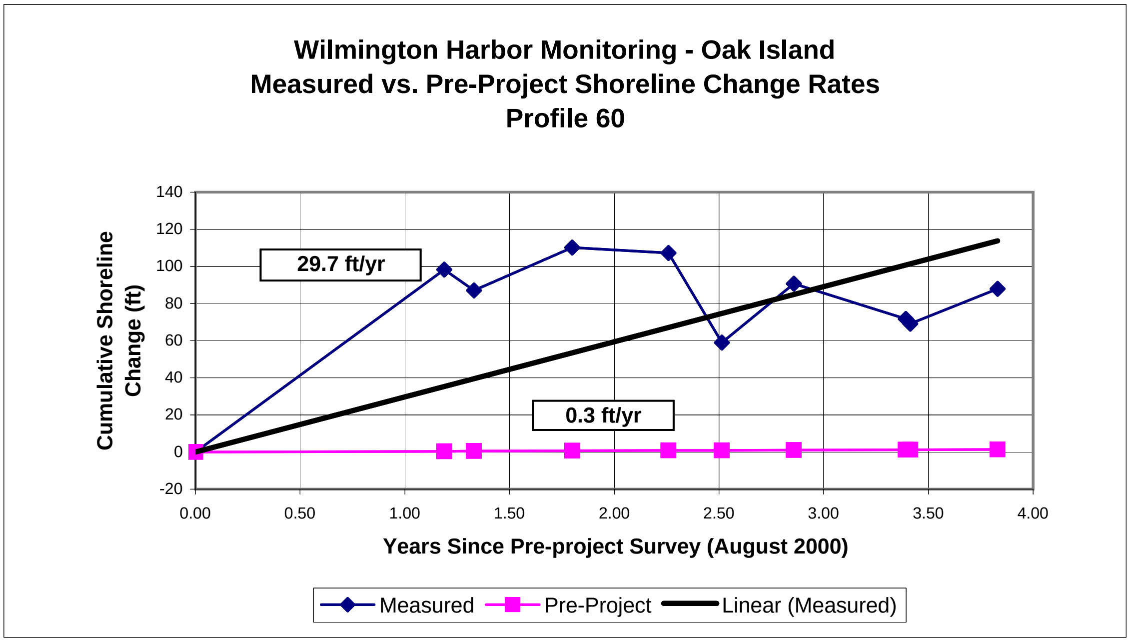

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 35
29.9 ft/yr
-24.3 ft/yr
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
-160
-200
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

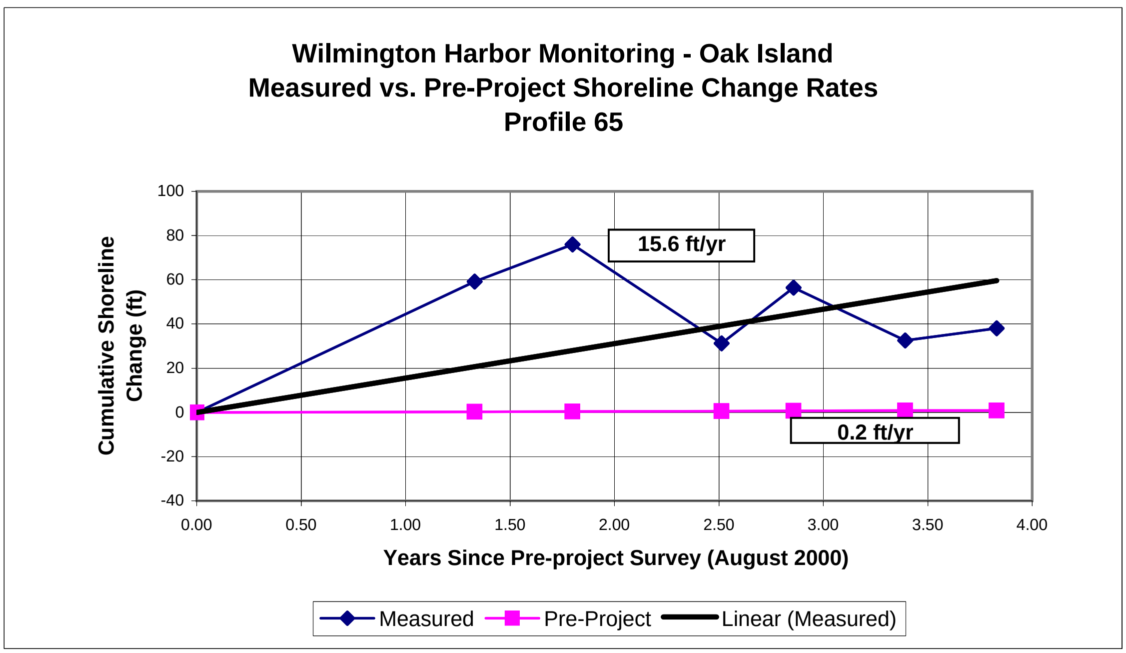

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
17.2 ft/yr
-21.1 ft/yr
Cumulative Shoreline Change (ft)
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-project
Linear (Measured)

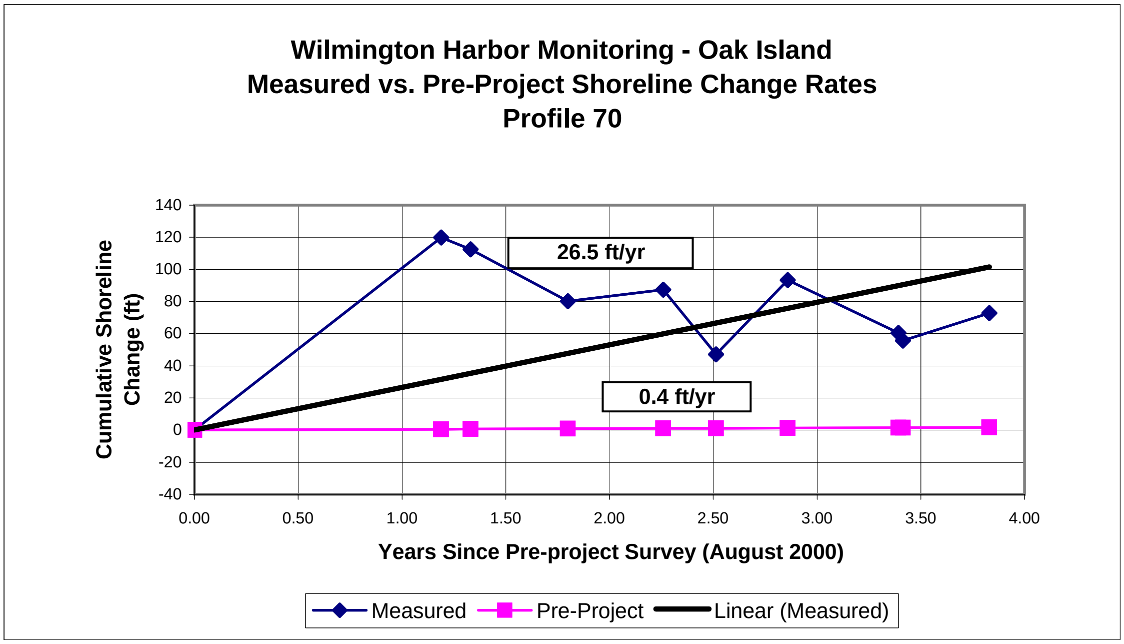

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
7.9 ft/yr
8.0 ft/yr
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
-60
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project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

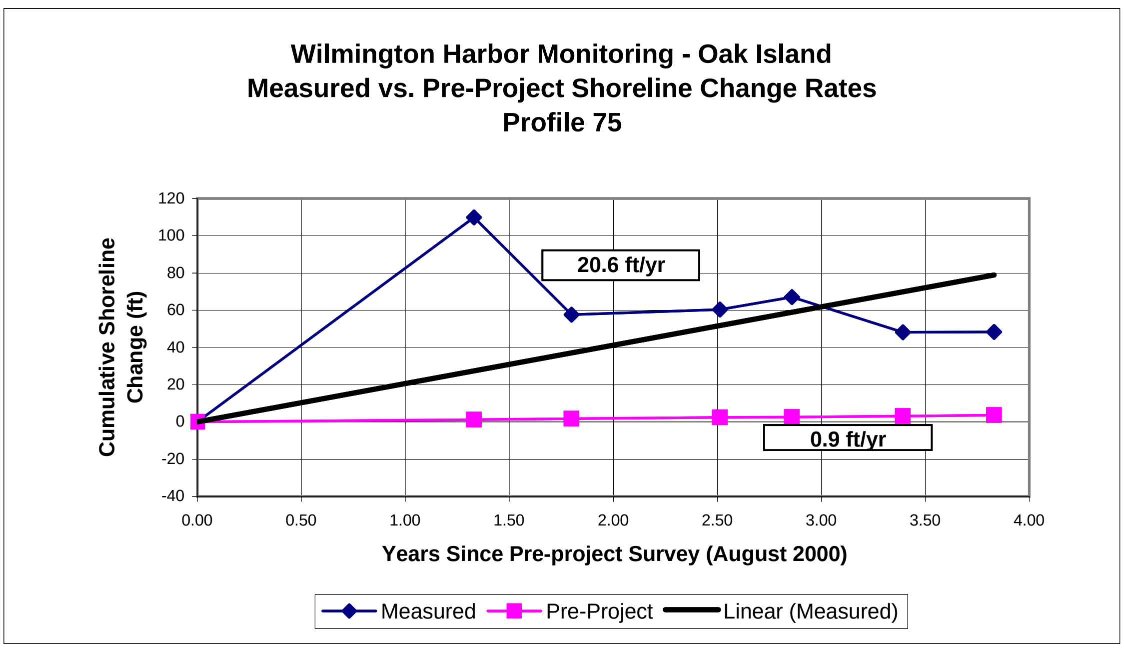

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 50
Cumulative Shoreline Change (ft)
90
75
60
45
30
15
0
-15
-30
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
14.9 ft/yr
2.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

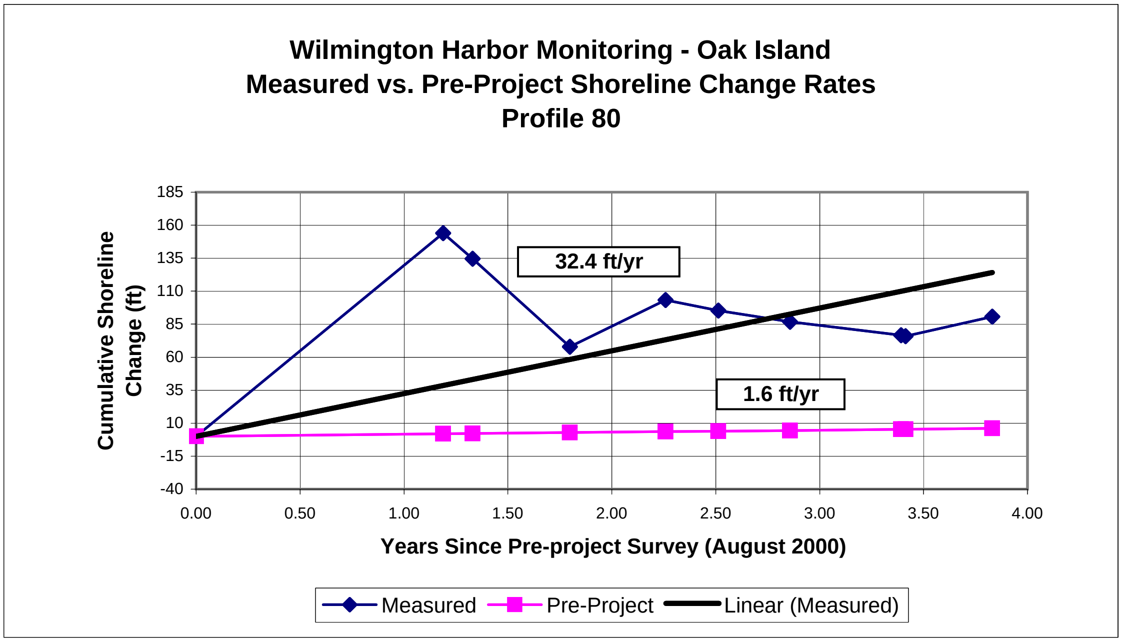

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 55
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
23.5 ft/yr
0.8 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear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

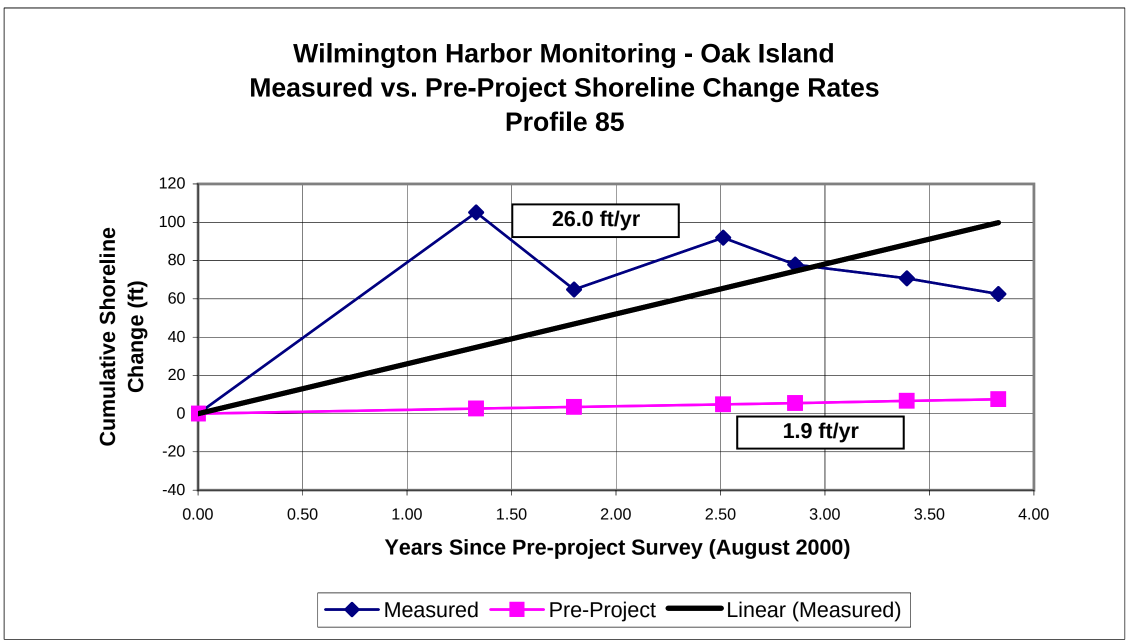

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 60
29.7 ft/yr
0.3 ft/yr
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear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

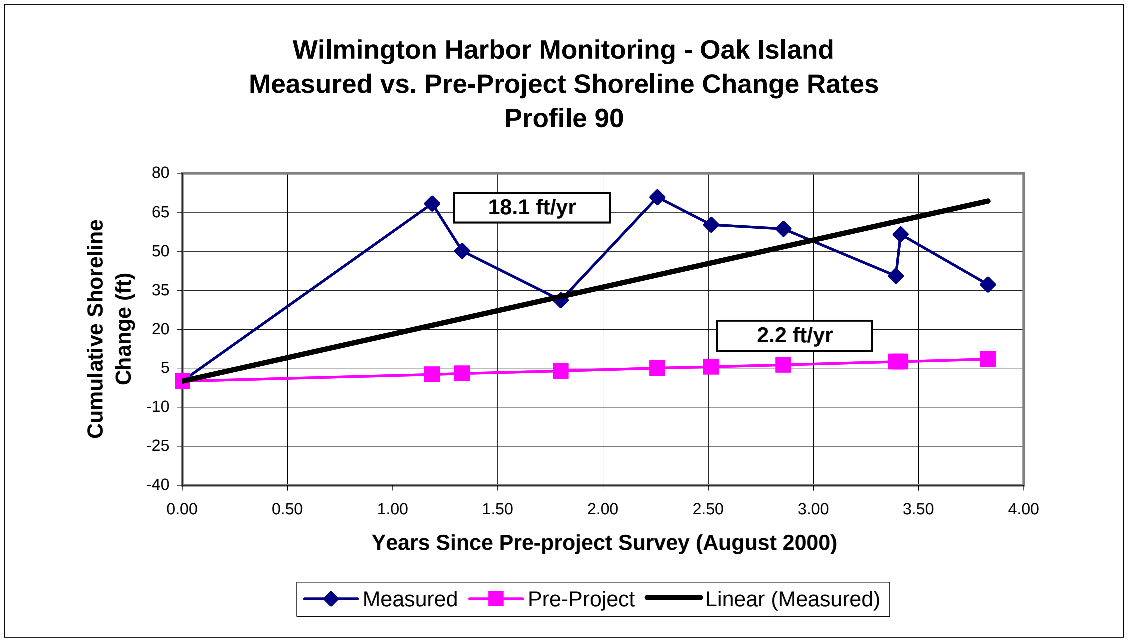

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 65
15.6 ft/yr
0.2 ft/yr
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

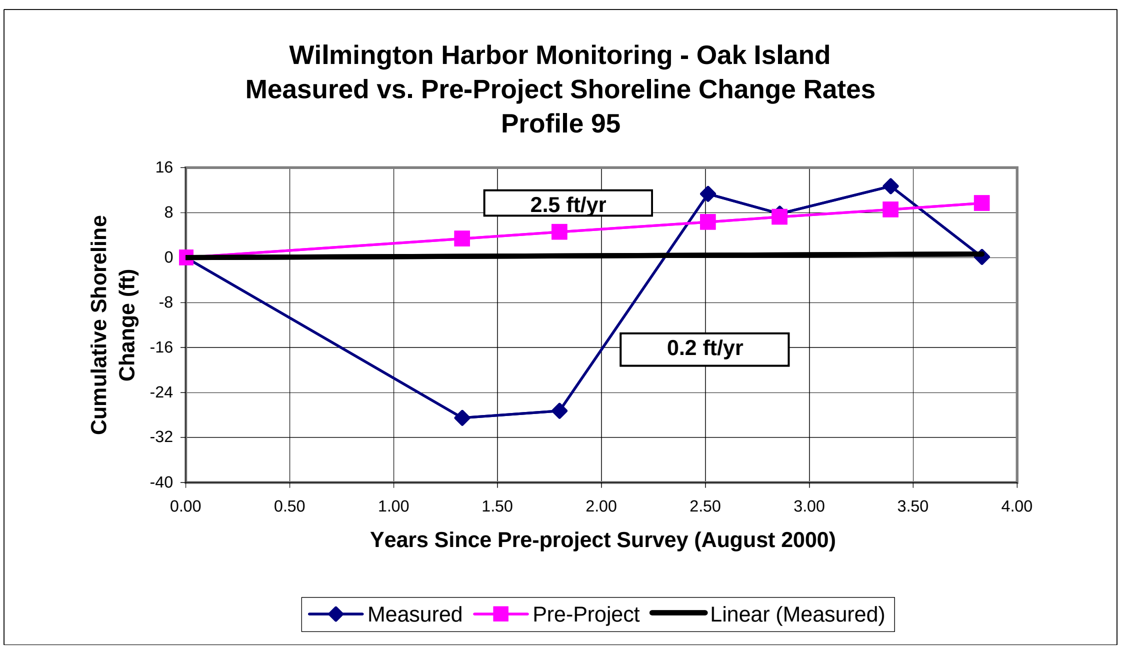

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 70
26.5 ft/yr
0.4 ft/yr
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear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

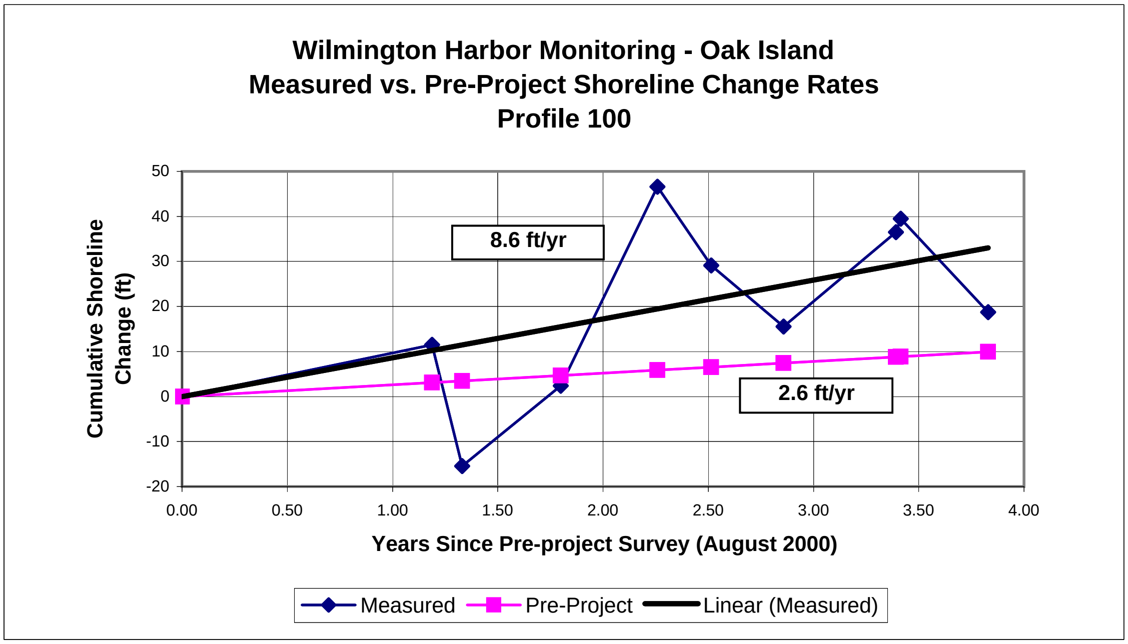

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 75
20.6 ft/yr
0.9 ft/yr
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear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

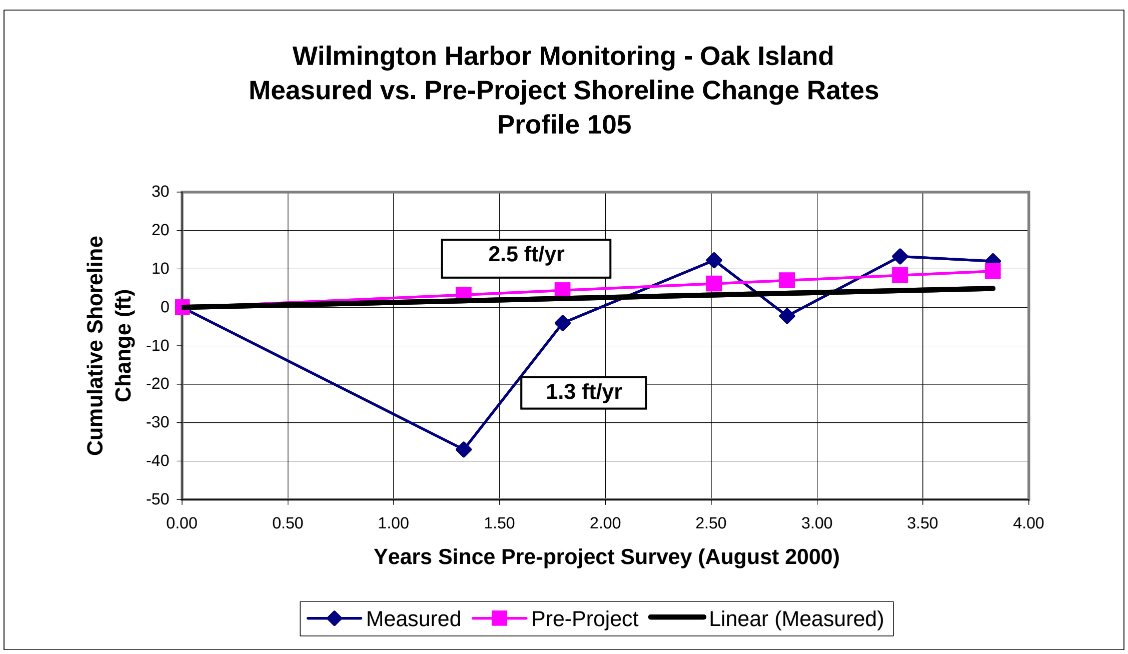

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 80
32.4 ft/yr
1.6 ft/yr
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

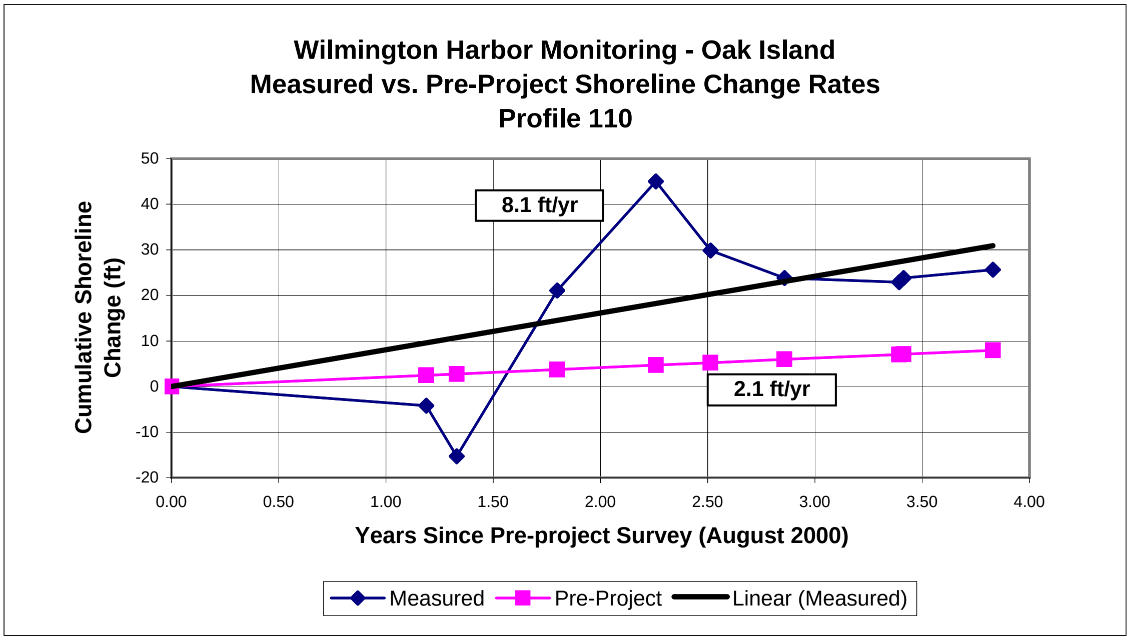

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 85
26.0 ft/yr
1.9 ft/yr
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear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

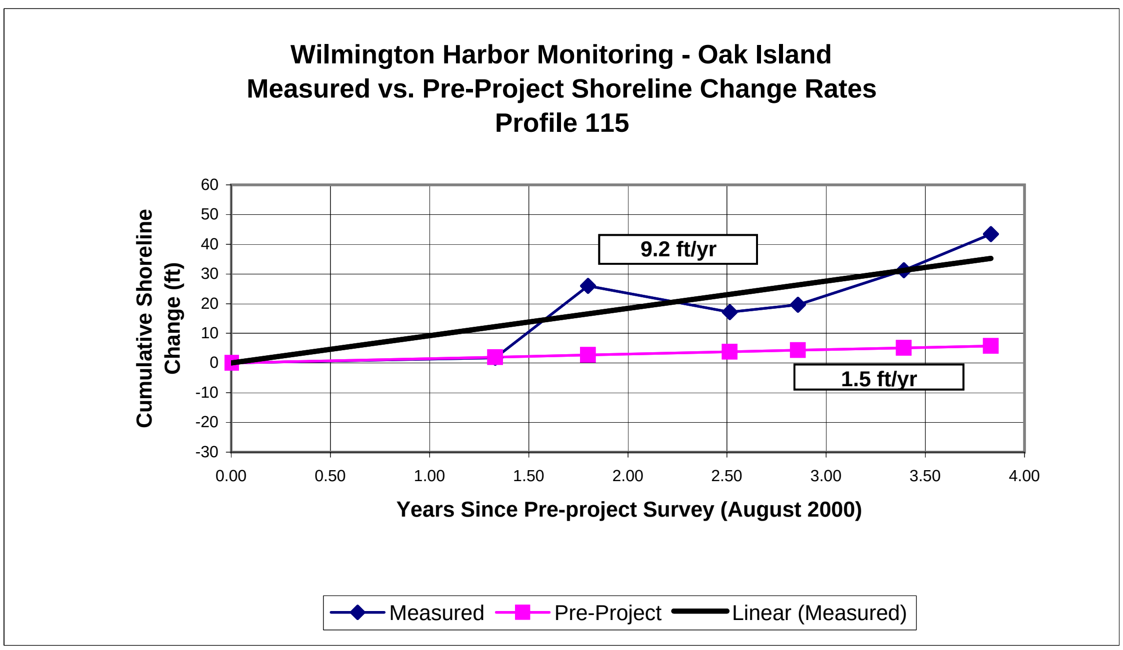

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 90
18.1 ft/yr
2.2 ft/yr
Cumulative Shoreline Change (ft)
80
65
50
35
20
5
-10
-25
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

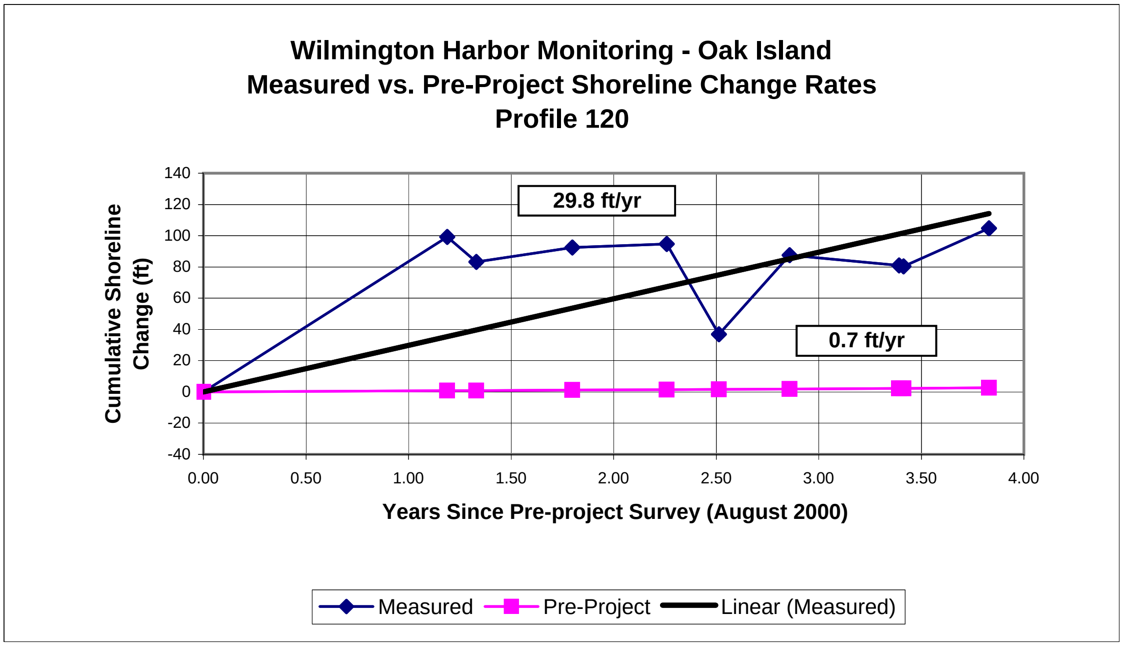

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 95
2.5 ft/yr
0.2 ft/yr
Cumulative Shoreline Change (ft)
16
8
0
-8
-16
-24
-32
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

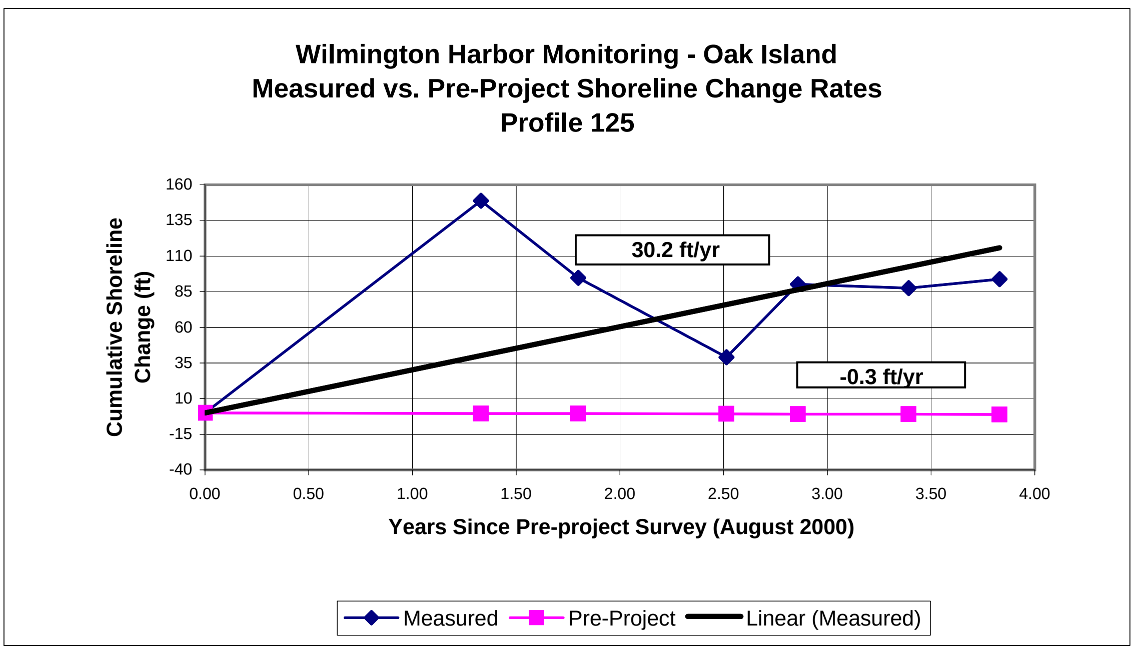

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 100
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
-10
-20
8.6 ft/yr
2.6 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

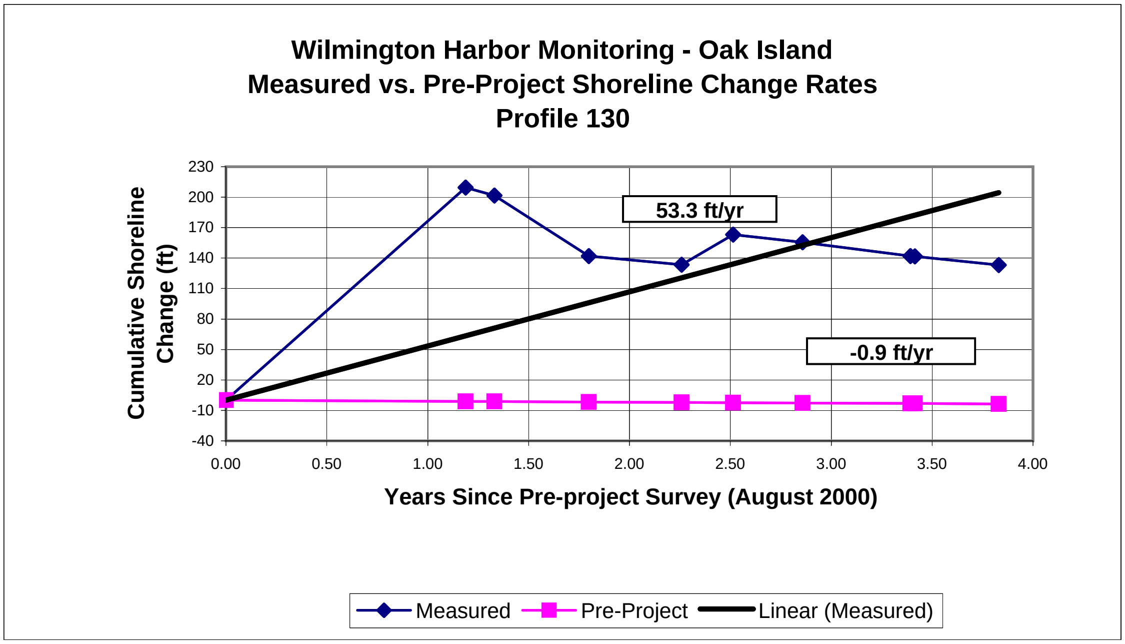

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 105
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
-30
-40
-50
2.5 ft/yr
1.3 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear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

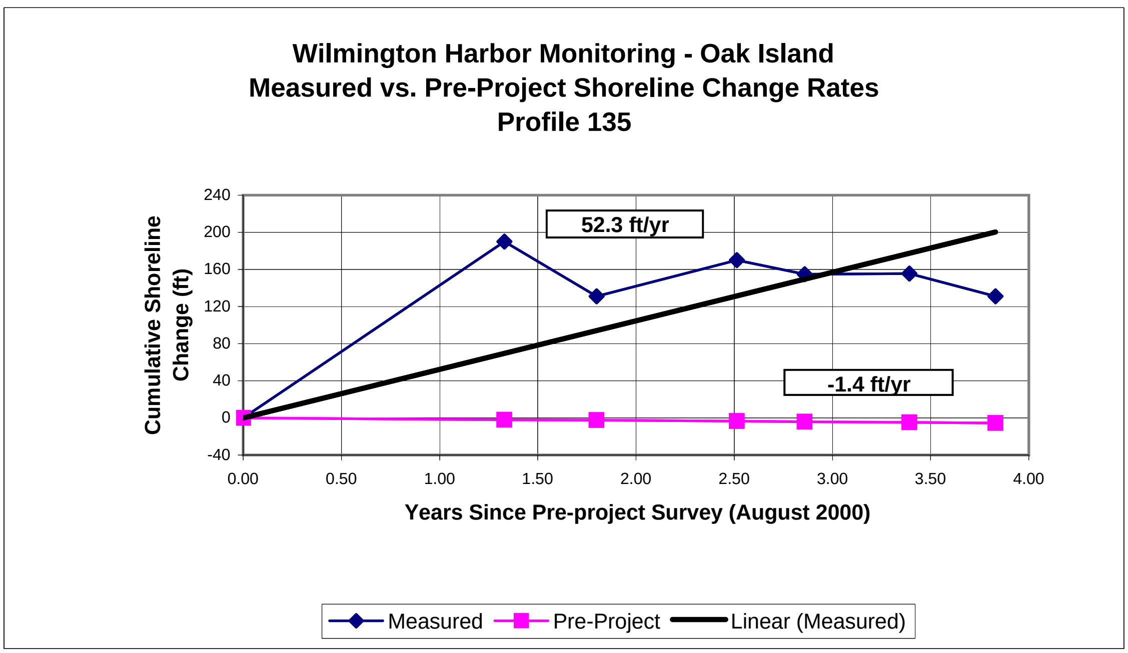

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
8.1 ft/yr
2.1 ft/yr
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
-10
-20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

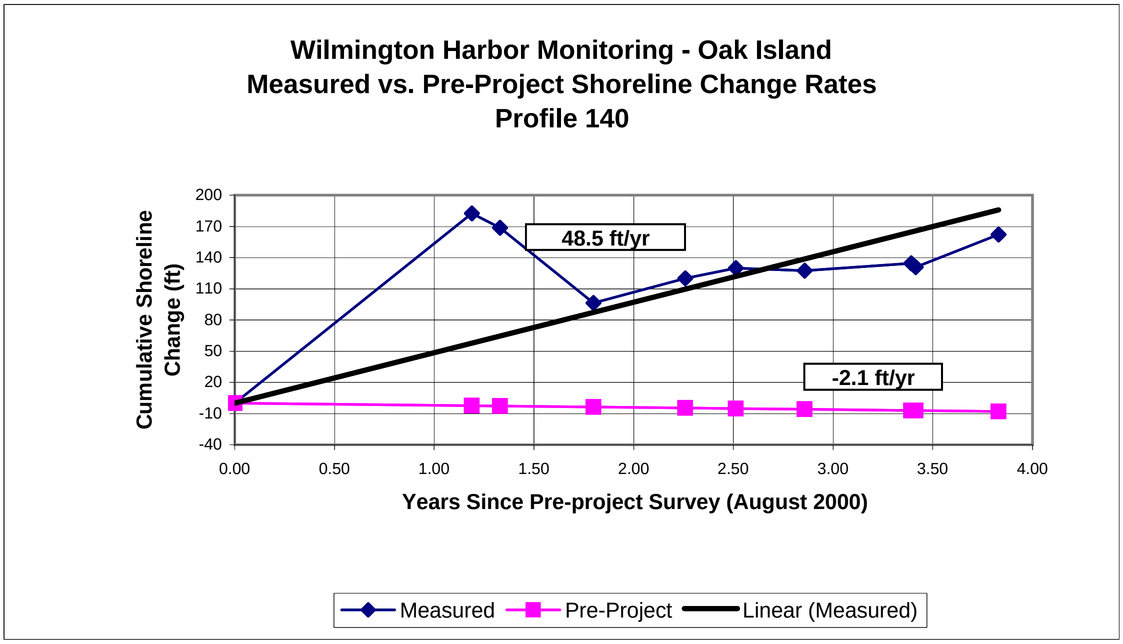

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 115
9.2 ft/yr
1.5 ft/yr
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
-10
-20
-30
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

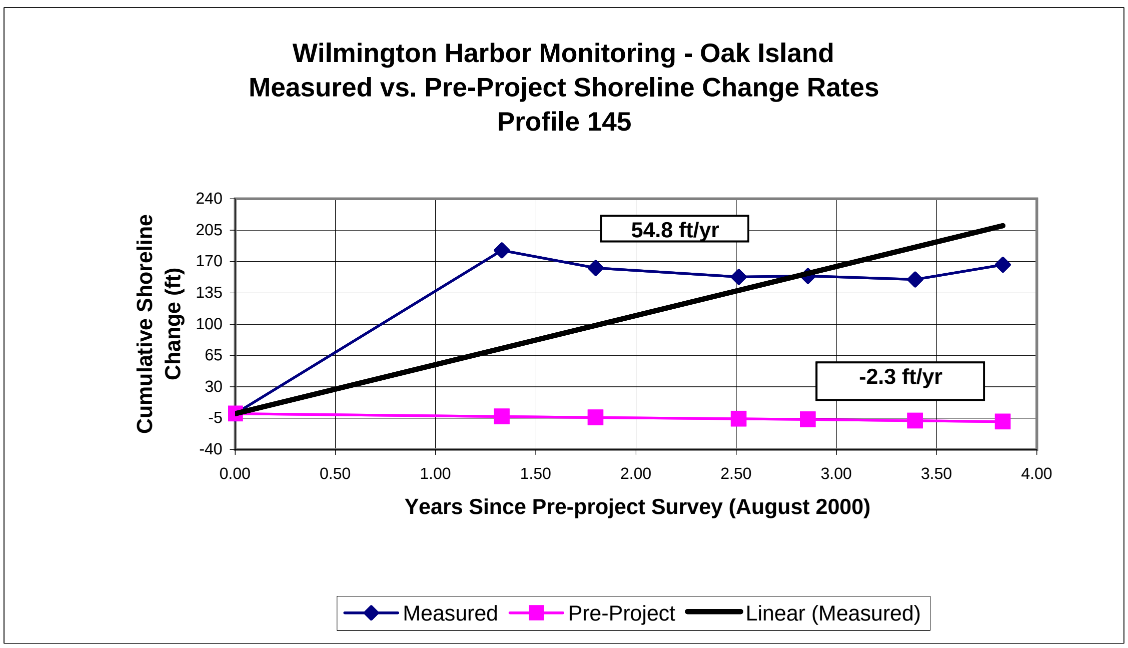

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 120
29.8 ft/yr
0.7 ft/yr
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project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

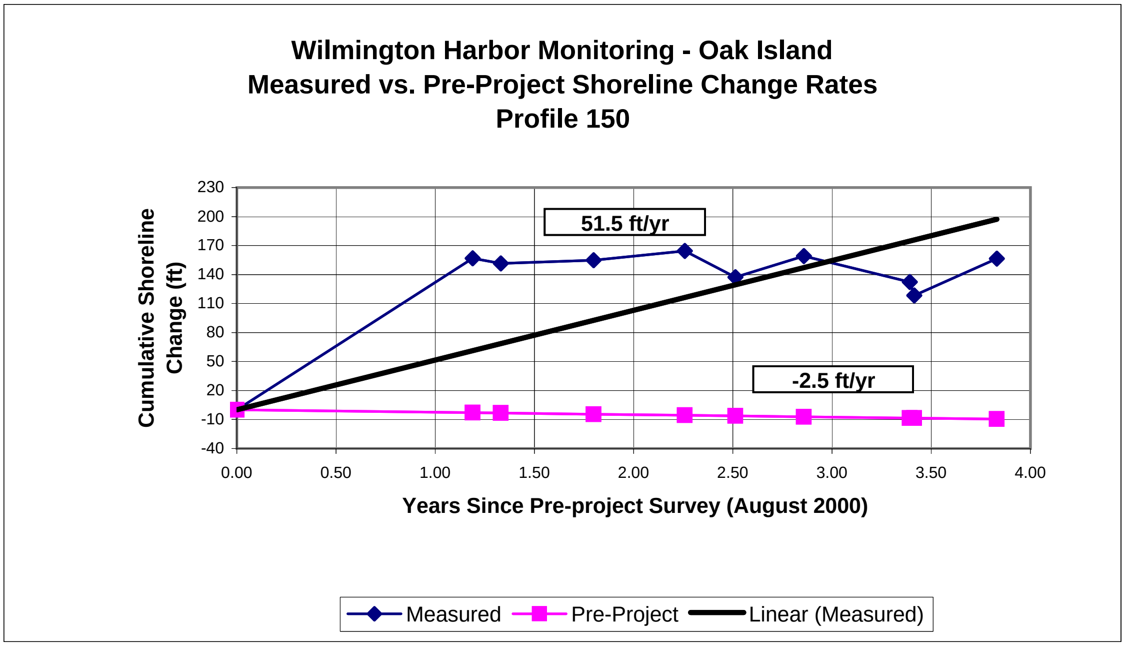

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 125
30.2 ft/yr
-0.3 ft/yr
Cumulative Shoreline Change (ft)
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

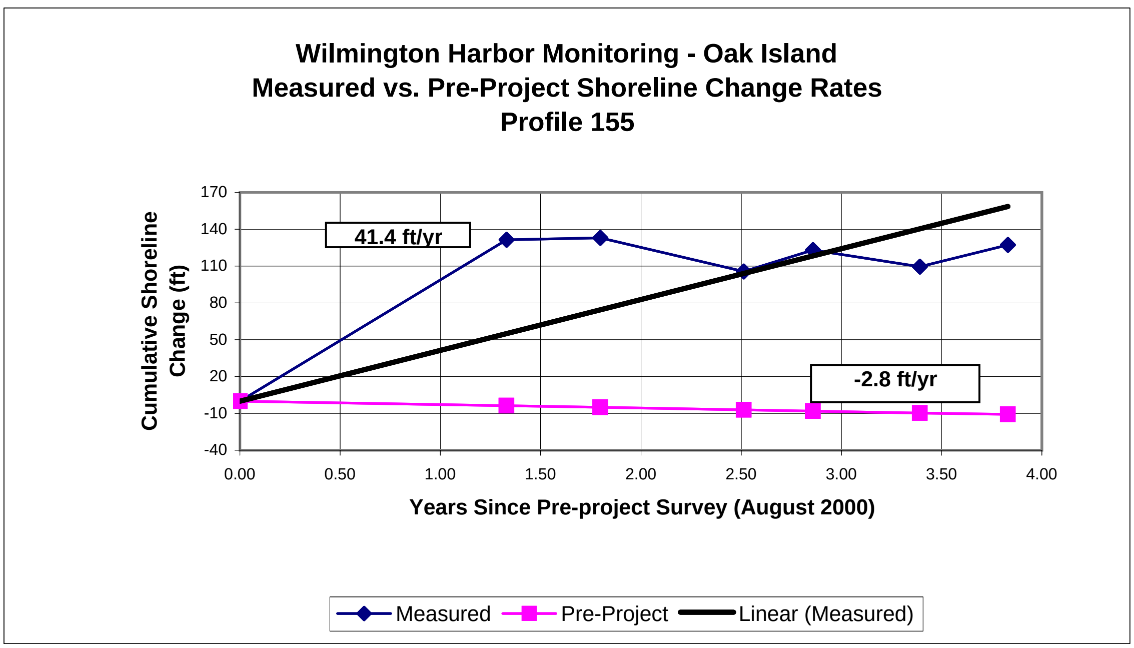

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
53.3 ft/yr
-0.9 ft/yr
Cumulative Shoreline Change (ft)
230
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

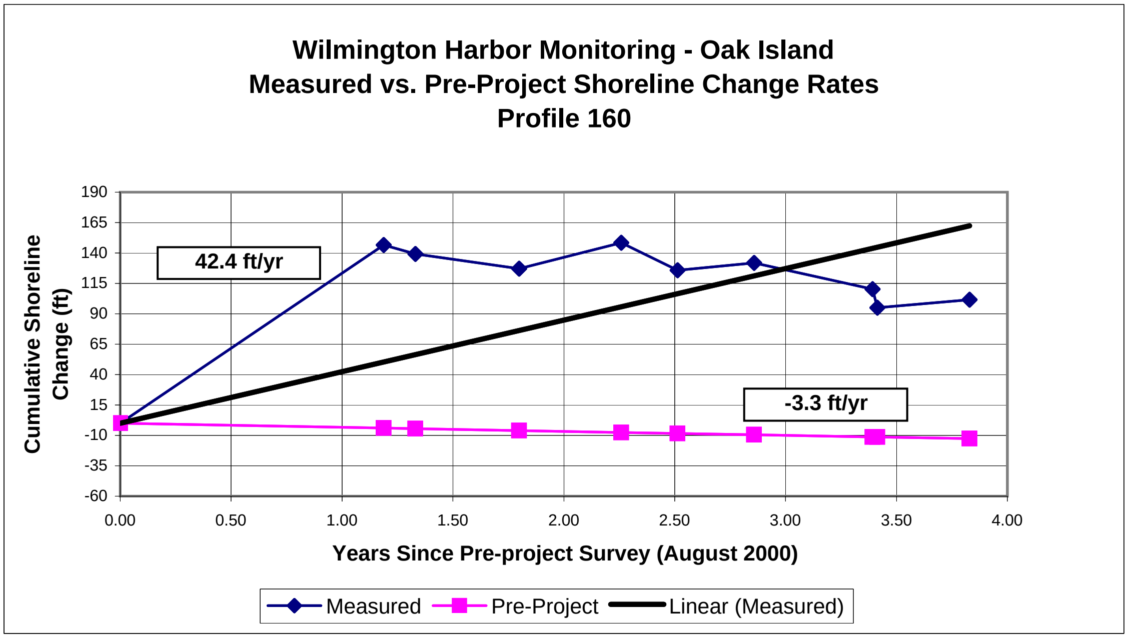

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 135
52.3 ft/yr
-1.4 ft/yr
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

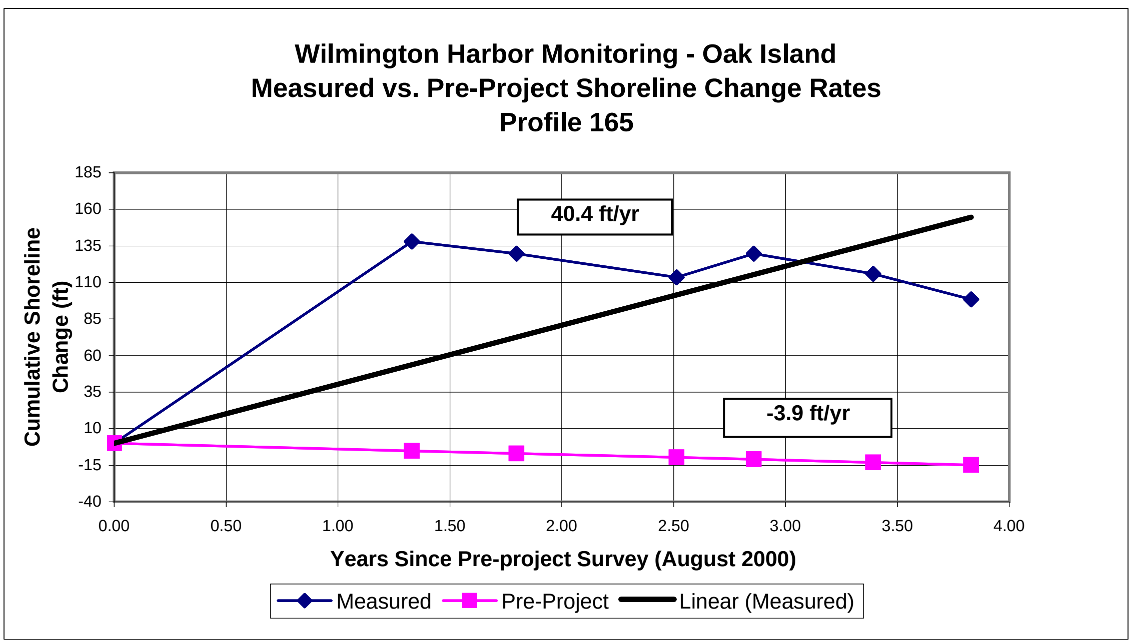

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 140
48.5 ft/yr
-2.1 ft/yr
Cumulative Shoreline Change (ft)
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

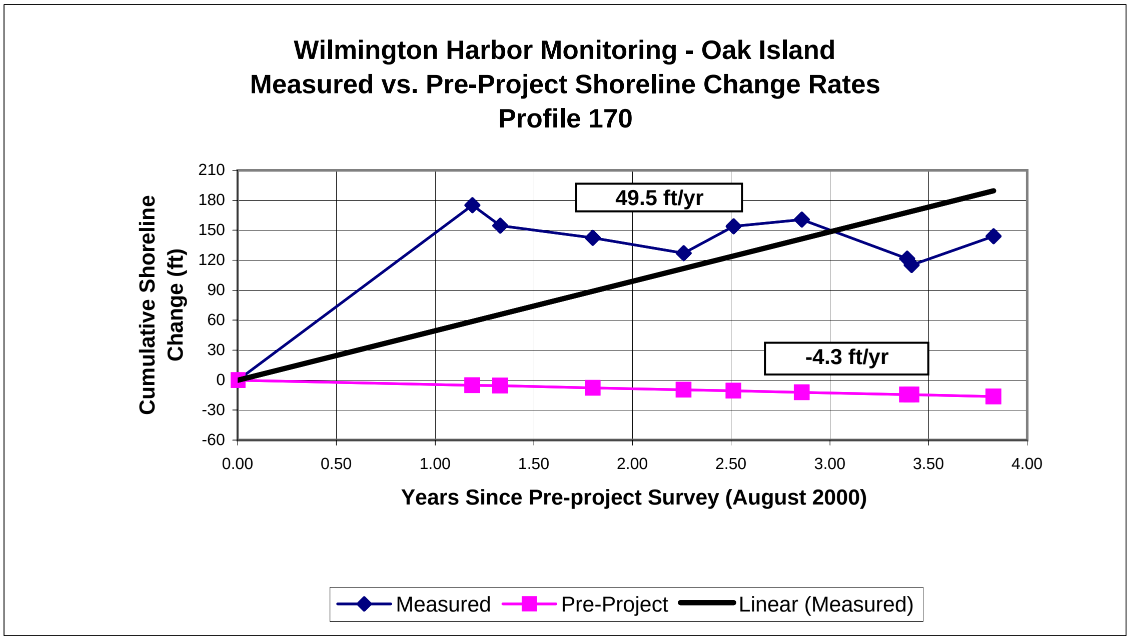

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 145
54.8 ft/yr
-2.3 ft/yr
Cumulative Shoreline Change (ft)
240
205
170
135
100
65
30
-5
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

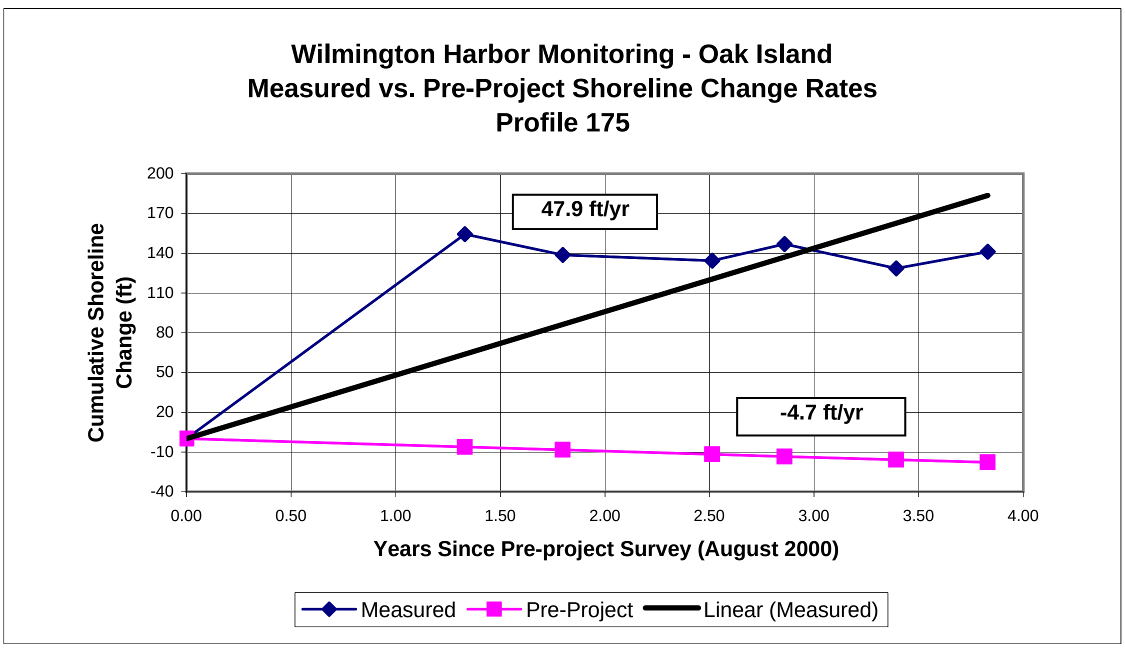

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
230
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
51.5 ft/yr
-2.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

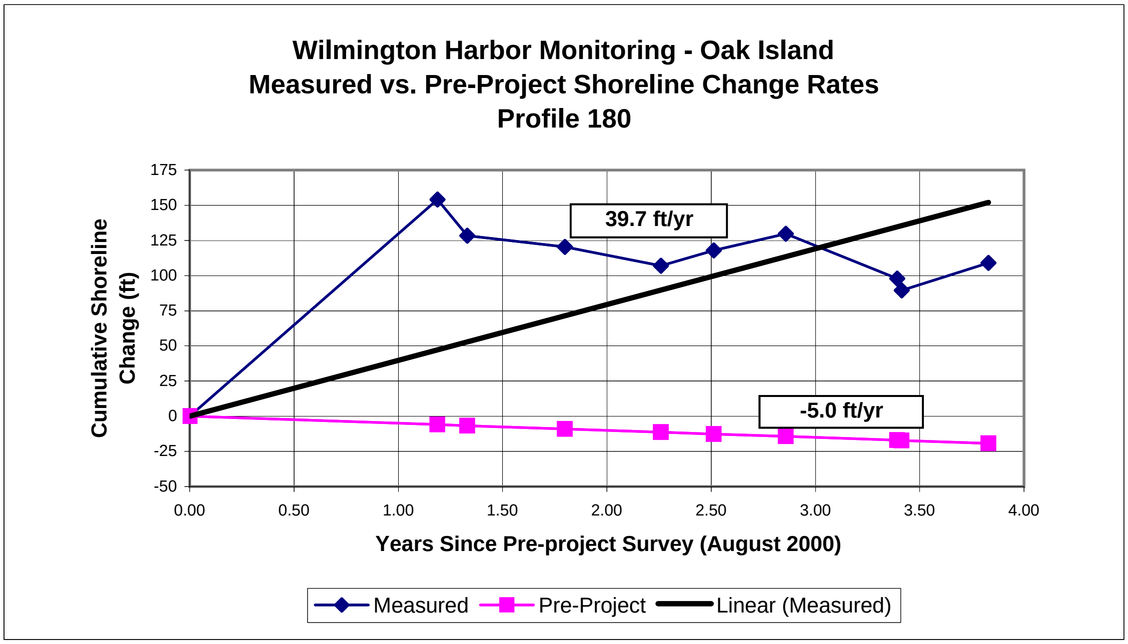

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 155
Cumulative Shoreline Change (ft)
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
41.4 ft/yr
-2.8 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

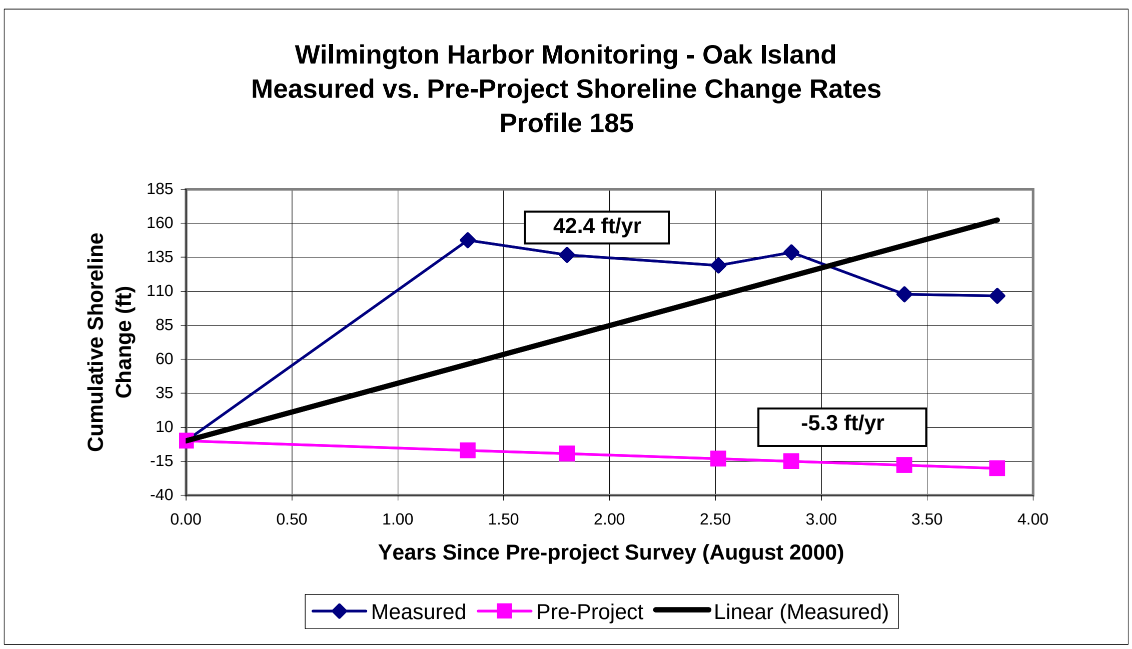

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 160
42.4 ft/yr
-3.3 ft/yr
Cumulative Shoreline Change (ft)
190
165
140
115
90
65
40
15
-10
-35
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

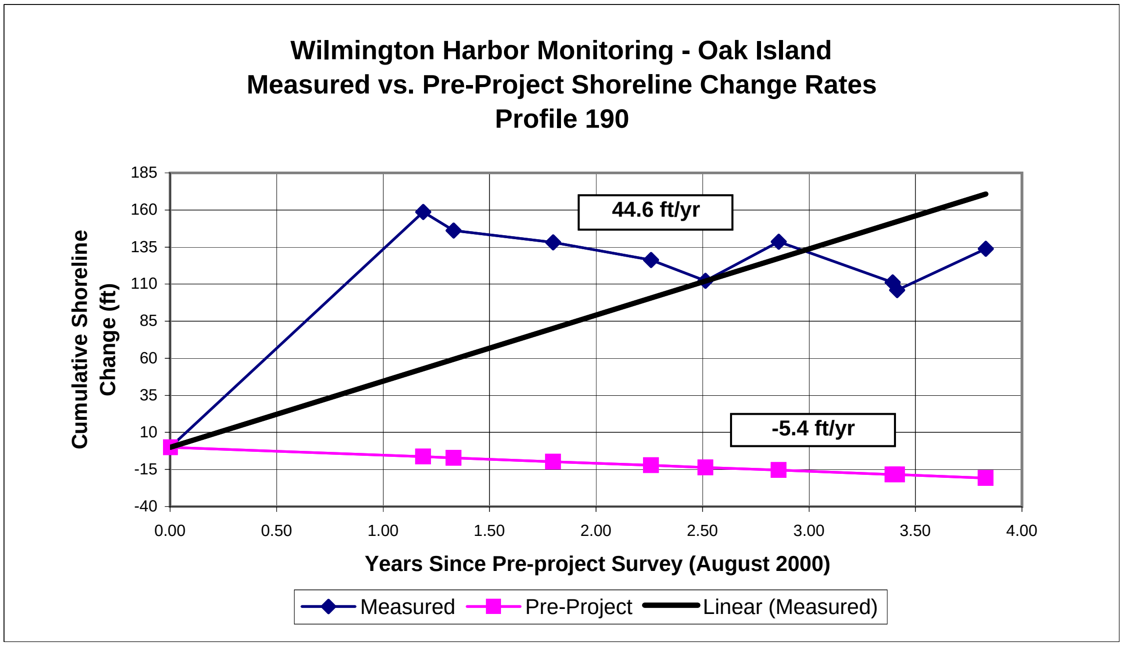

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 165
40.4 ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

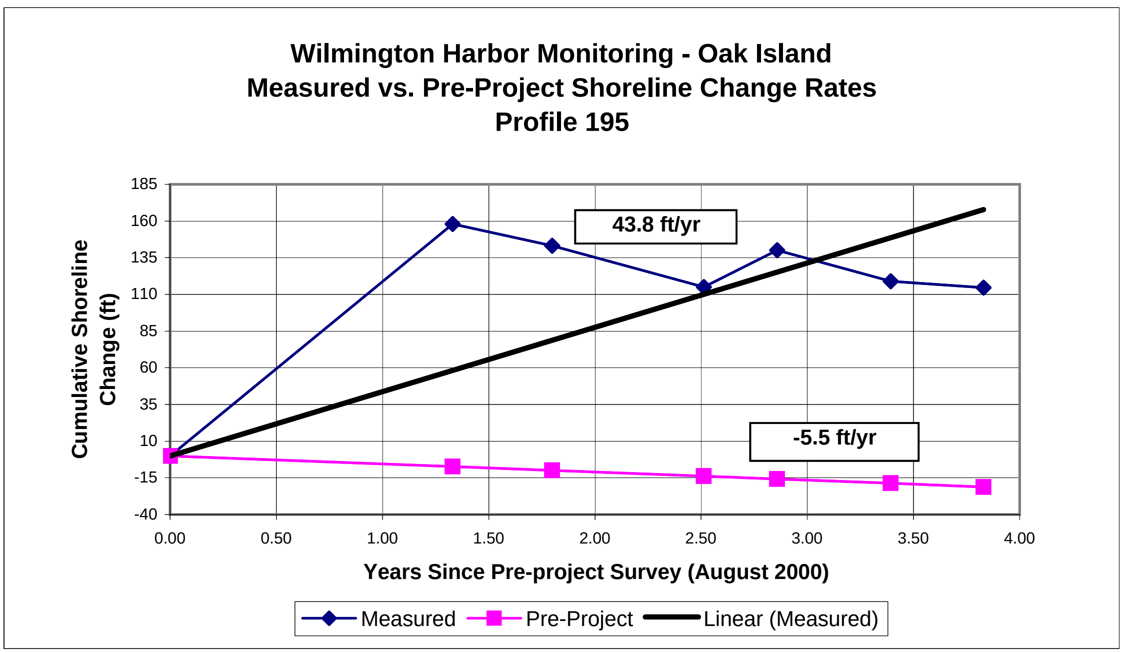

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 170
49.5 ft/yr
-4.3 ft/yr
Cumulative Shoreline Change (ft)
210
180
150
120
90
60
30
0
-30
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

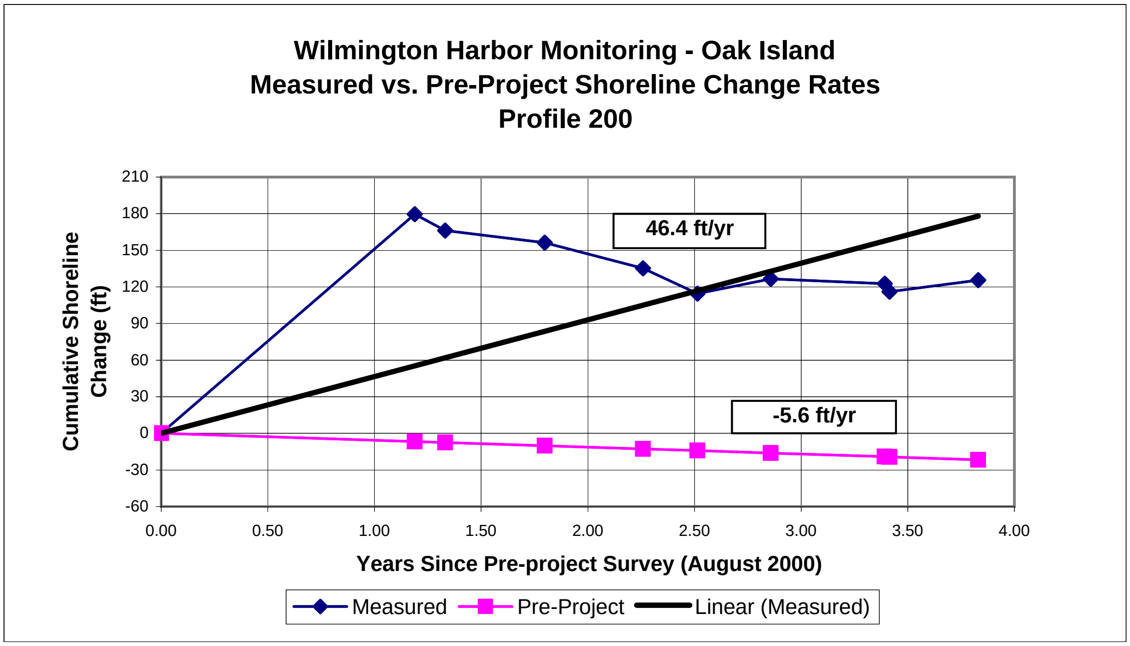

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 175
47.9 ft/yr
-4.7 ft/yr
Cumulative Shoreline Change (ft)
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

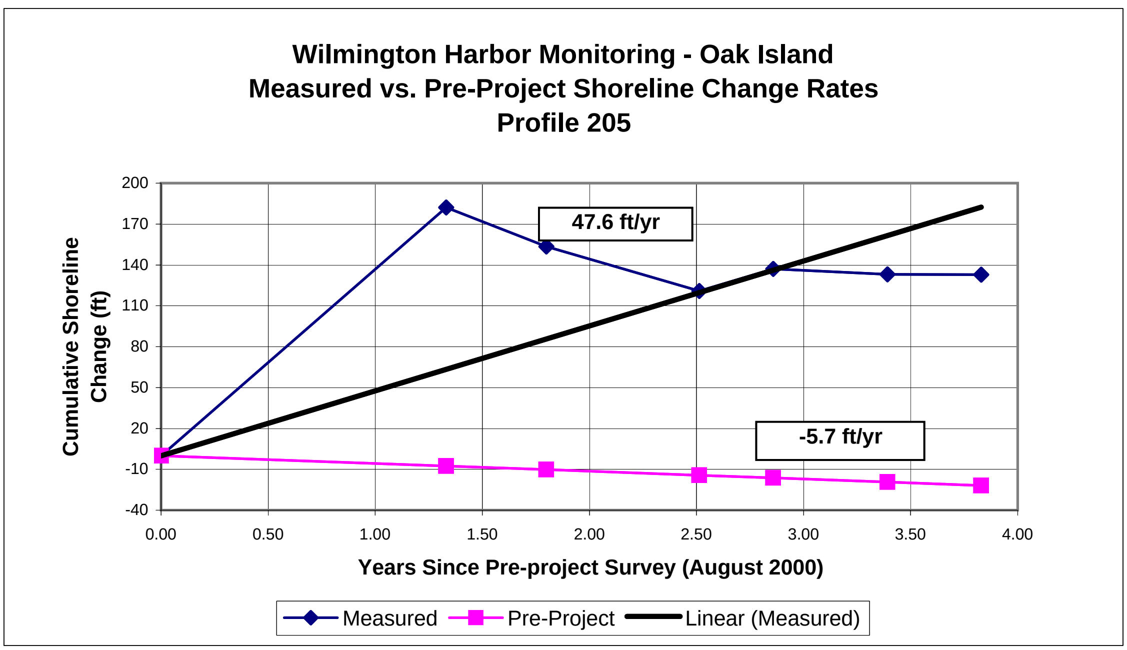

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 180
39.7 ft/yr
-5.0 ft/yr
Cumulative Shoreline Change (ft)
175
150
125
100
75
50
25
0
-25
-50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

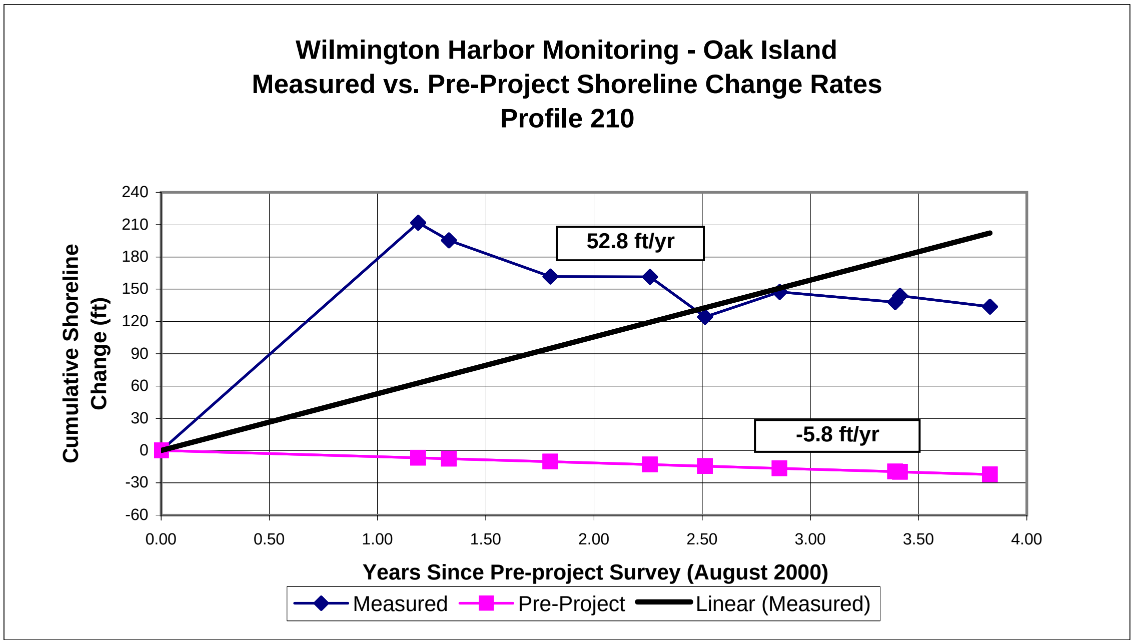

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 185
42.4 ft/yr
-5.3 ft/yr
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

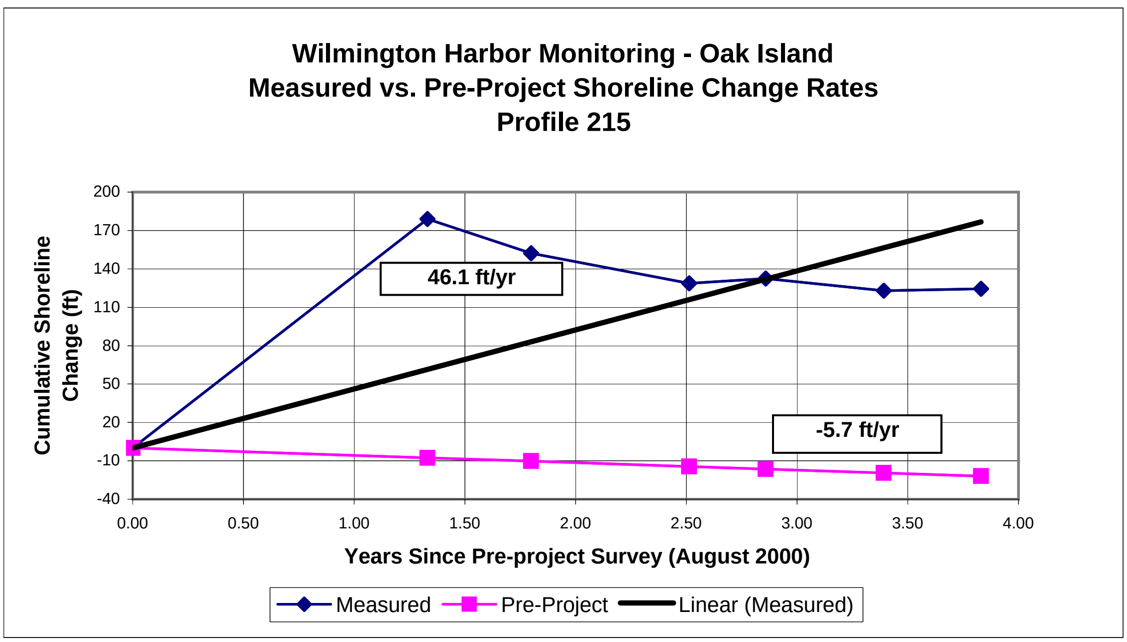

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
44.6 ft/yr
-5.4 ft/yr
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

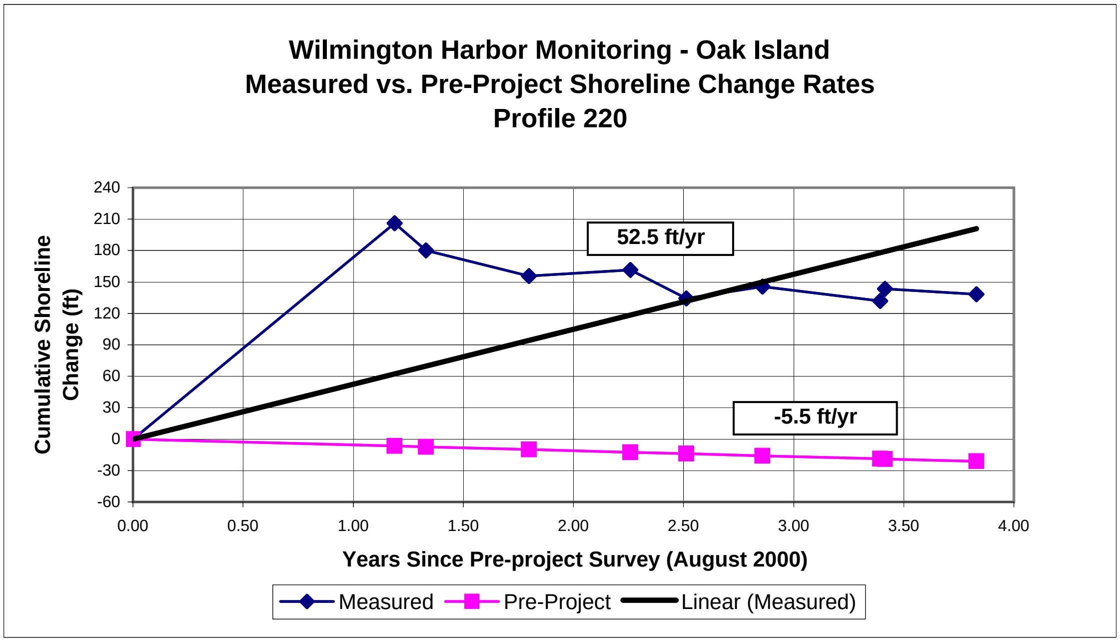

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 195
43.8 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

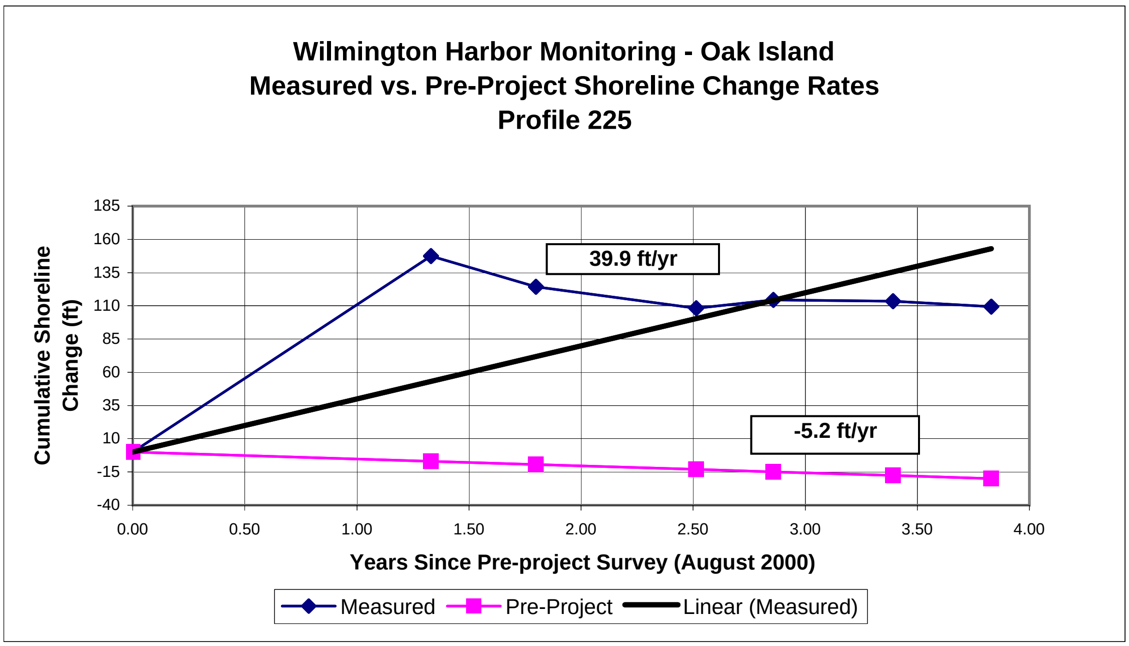

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 200
46.4 ft/yr
-5.6 ft/yr
Cumulative Shoreline Change (ft)
210
180
150
120
90
60
30
0
-30
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

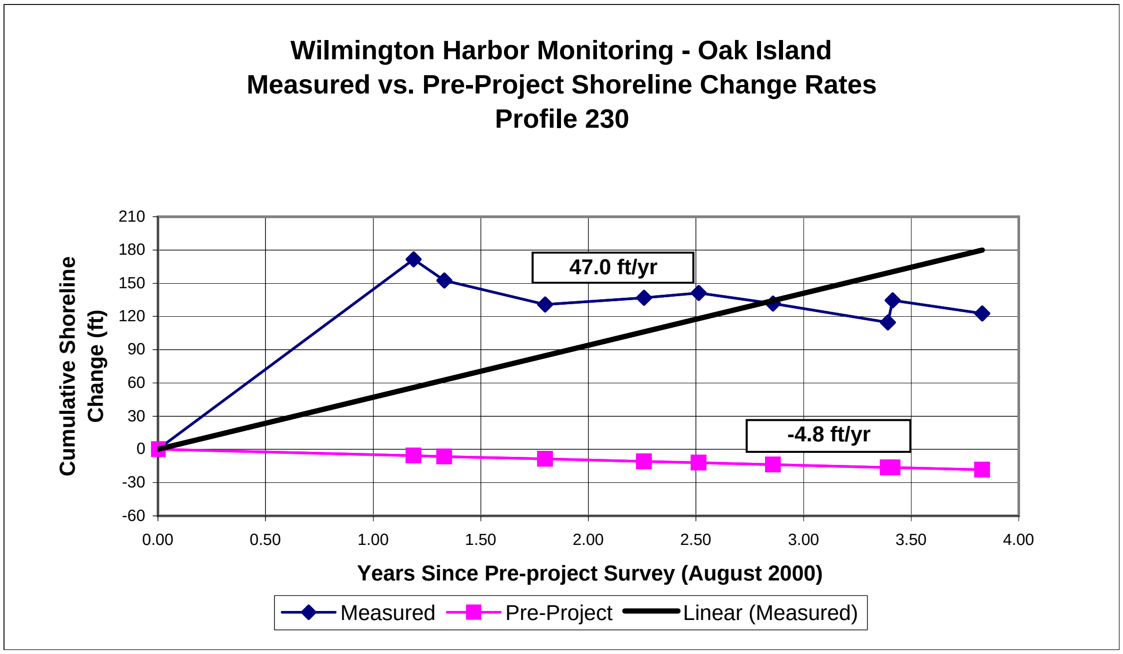

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 205
47.6 ft/yr
-5.7 ft/yr
Cumulative Shoreline Change (ft)
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

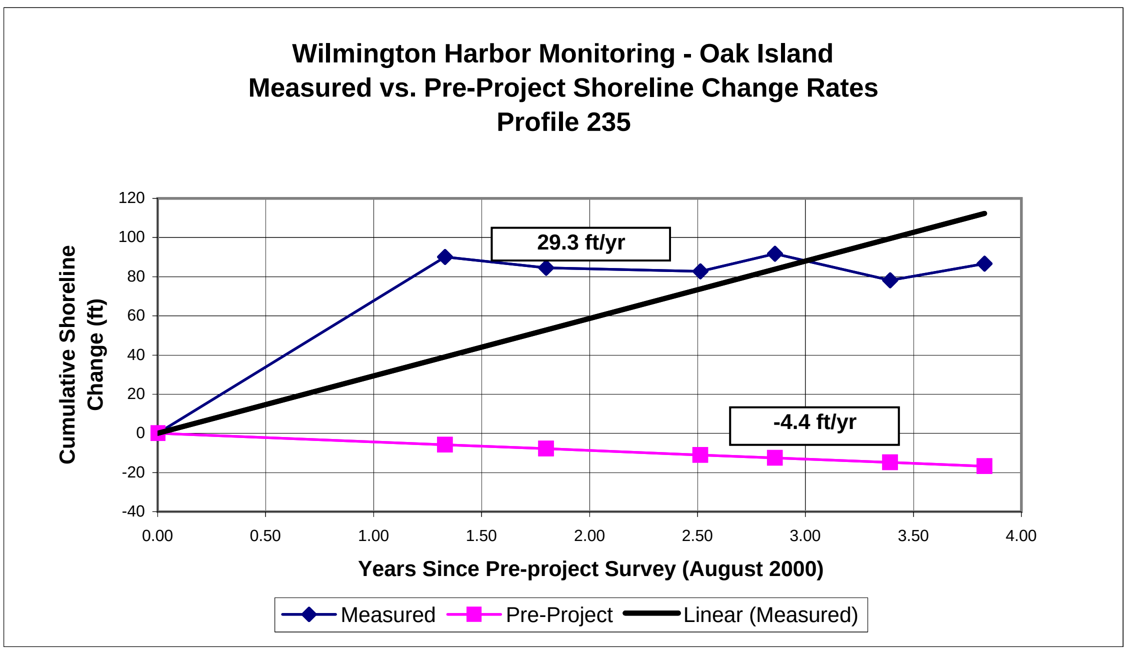

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 210
52.8 ft/yr
-5.8 ft/yr
Cumulative Shoreline Change (ft)
240
210
180
150
120
90
60
30
0
-30
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

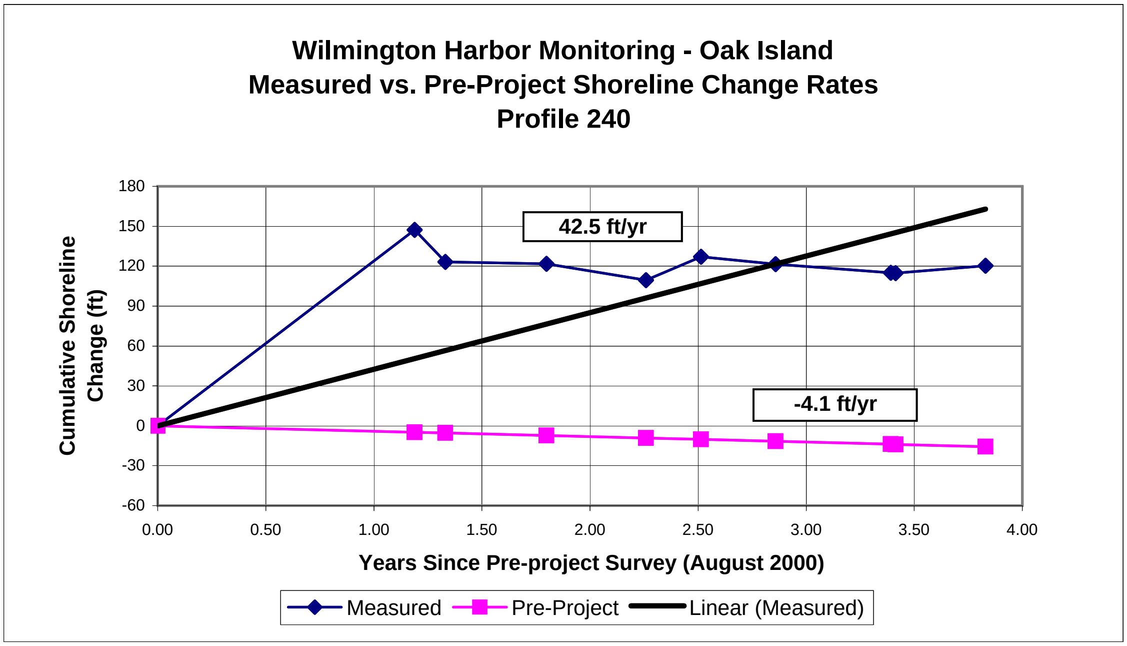

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 215
46.1 ft/yr
-5.7 ft/yr
Cumulative Shoreline Change (ft)
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

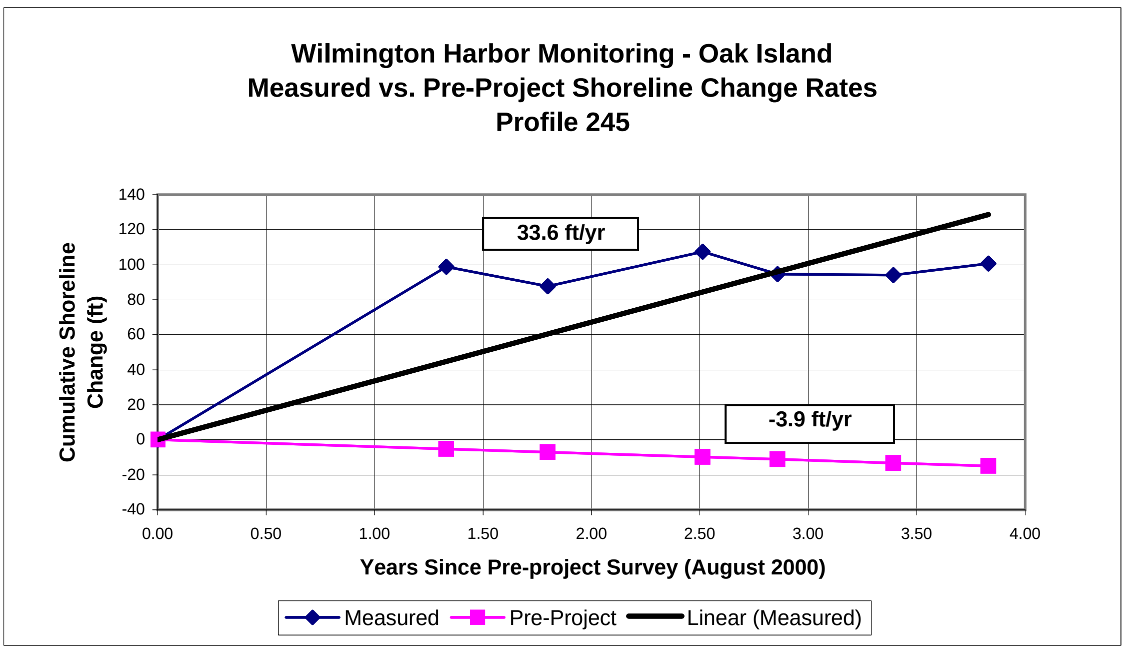

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 220
52.5 ft/yr
-5.5 ft/yr
Cumulative Shoreline Change (ft)
240
210
180
150
120
90
60
30
0
-30
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

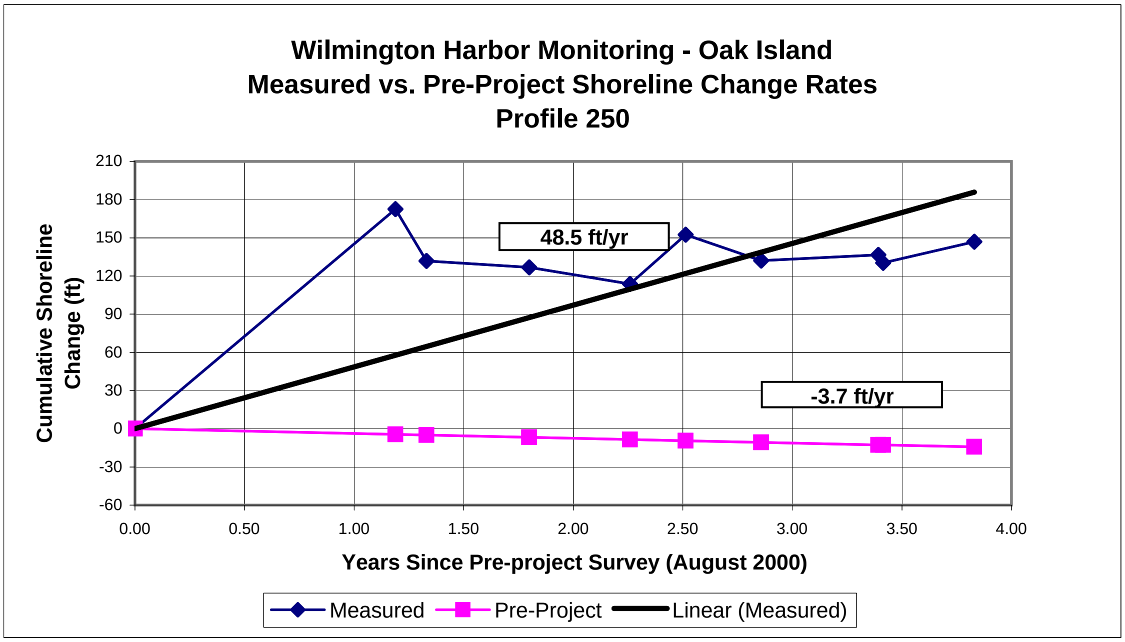

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 225
39.9 ft/yr
-5.2 ft/yr
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

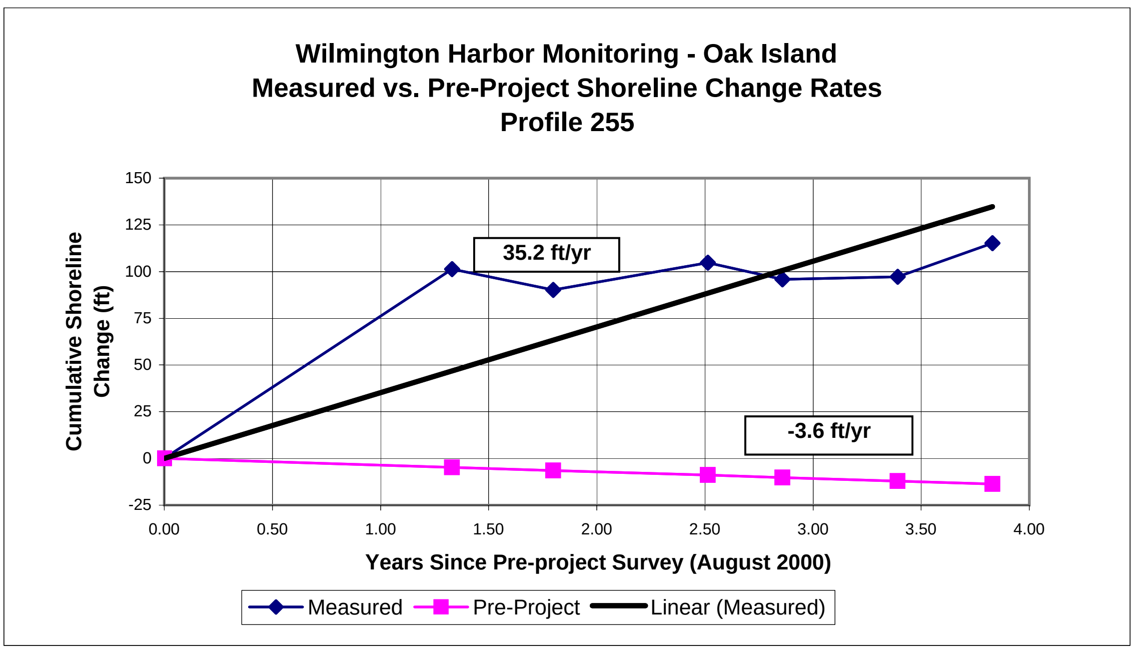

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 230
Cumulative Shoreline Change (ft)
210
180
150
120
90
60
30
0
-30
-60
47.0 ft/yr
-4.8 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

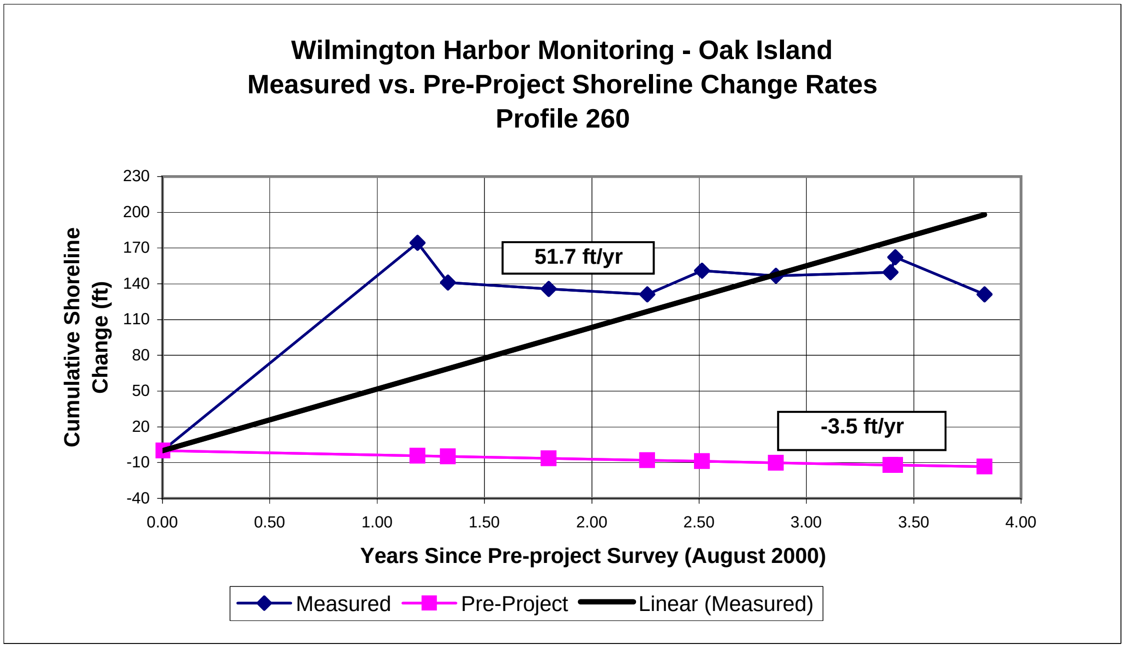

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 235
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
29.3 ft/yr
-4.4 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear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

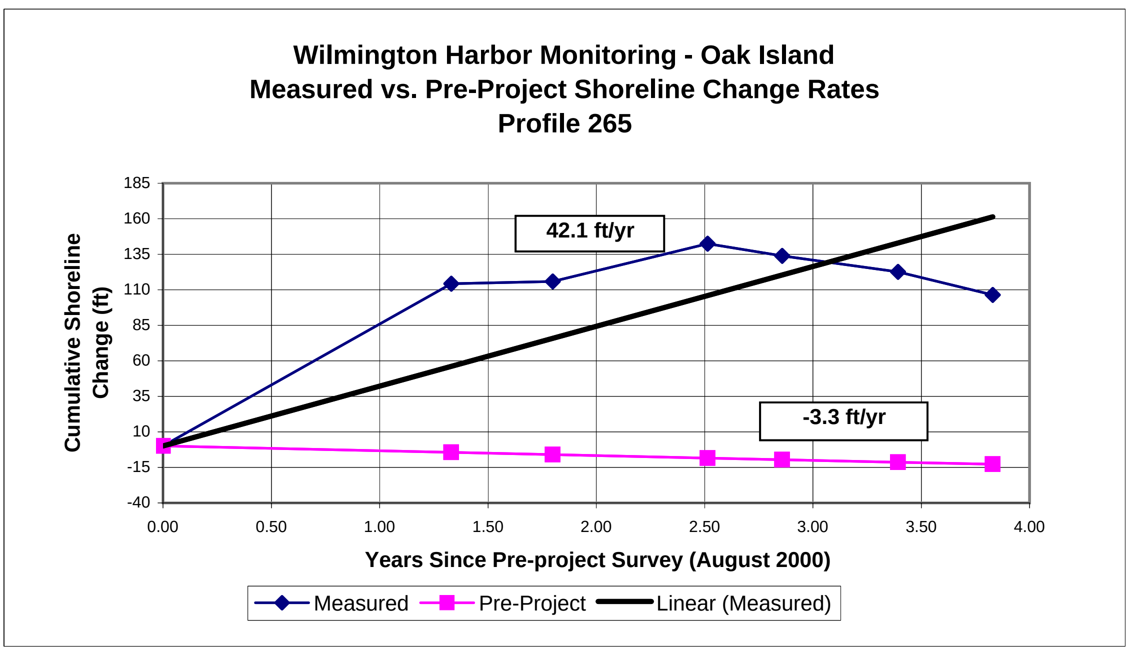

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 240
42.5 ft/yr
-4.1 ft/yr
Cumulative Shoreline Change (ft)
180
150
120
90
60
30
0
-30
-60
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

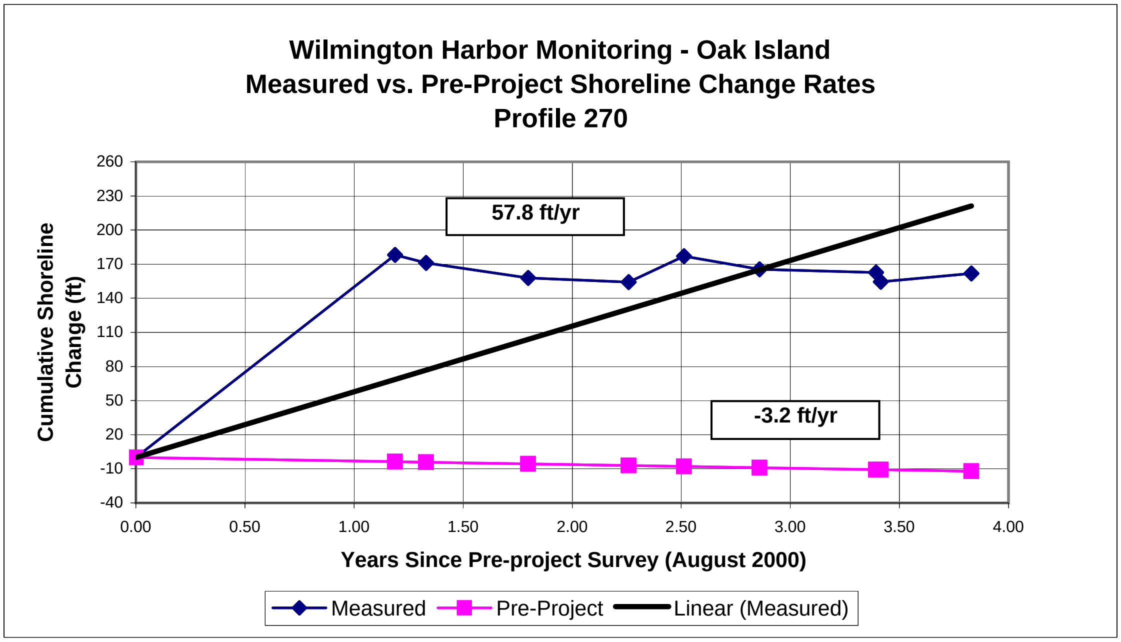

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 245
33.6 ft/yr
-3.9 ft/yr
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
-20
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project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

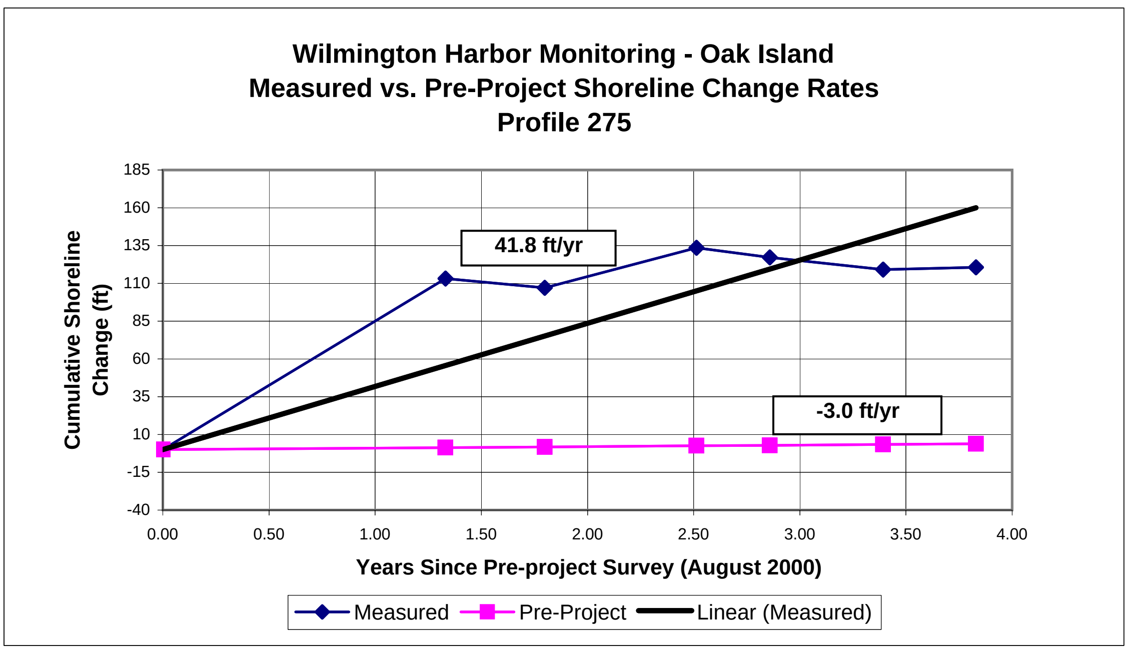

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 250
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
48.5 ft/yr
-3.7 ft/yr
Measured
Pre-Project
Linear (Measured)

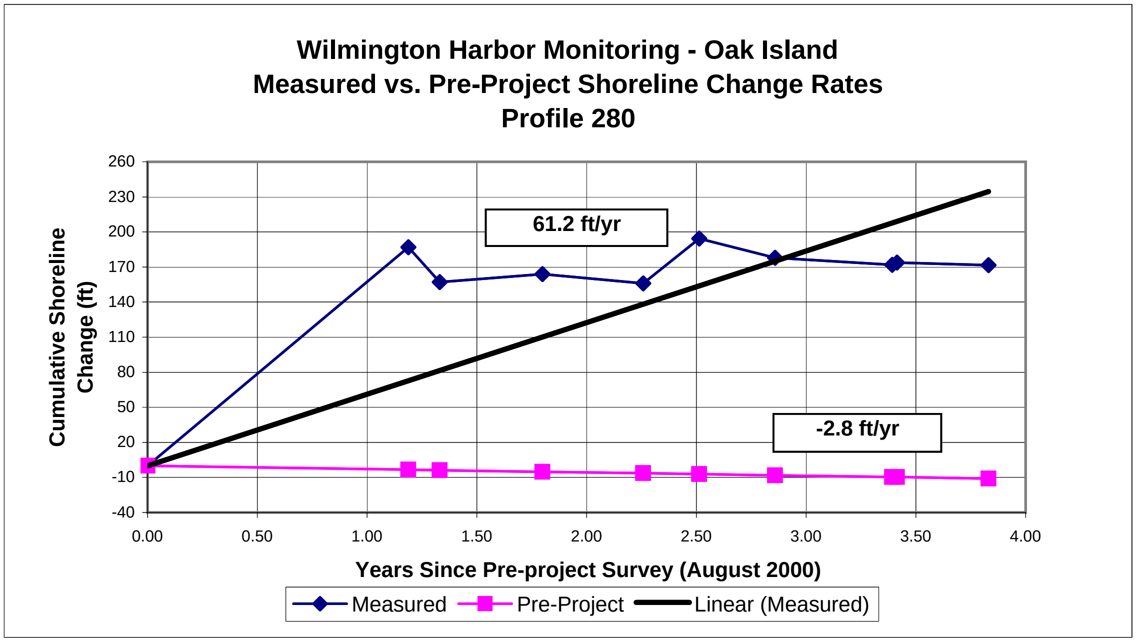

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 255
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
35.2 ft/yr
-3.6 ft/yr
Measured
Pre-Project
Linear (Measured)

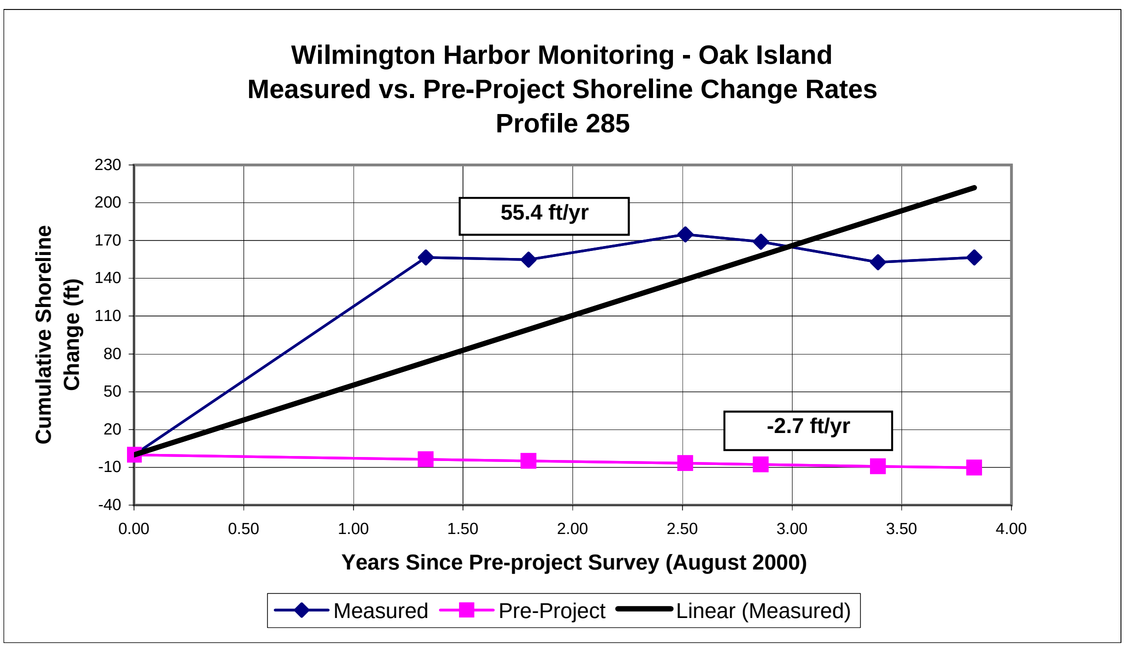

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 260
Cumulative Shoreline Change (ft)
230
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
51.7 ft/yr
-3.5 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

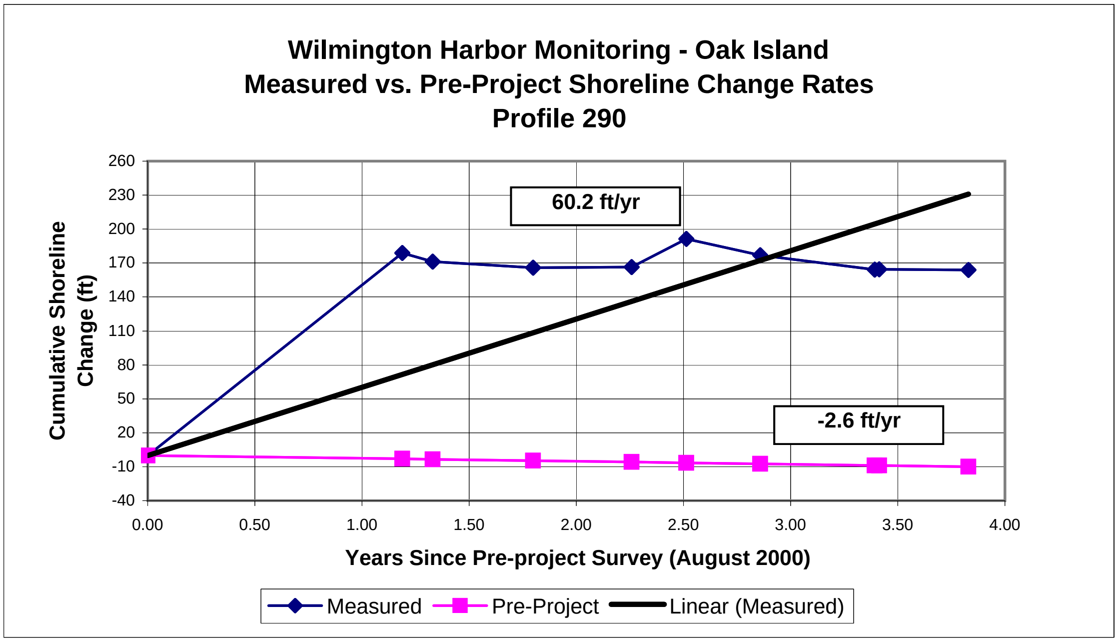

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 265
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
42.1 ft/yr
-3.3 ft/yr
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

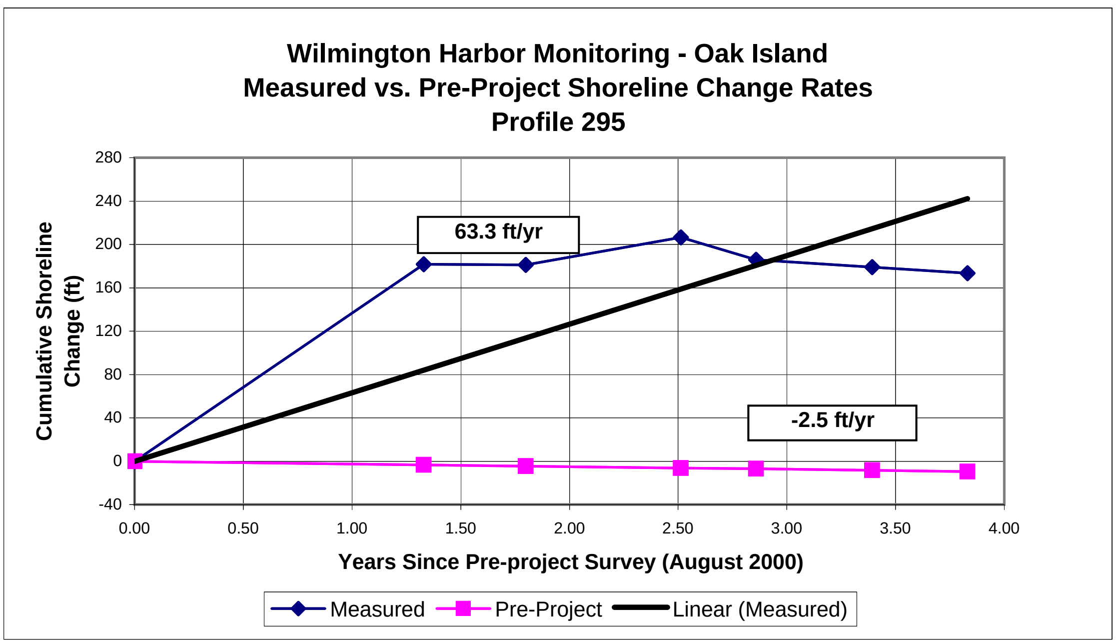

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 270
57.8 ft/yr
-3.2 ft/yr
Cumulative Shoreline Change (ft)
260
230
200
170
140
110
80
50
20
-10
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

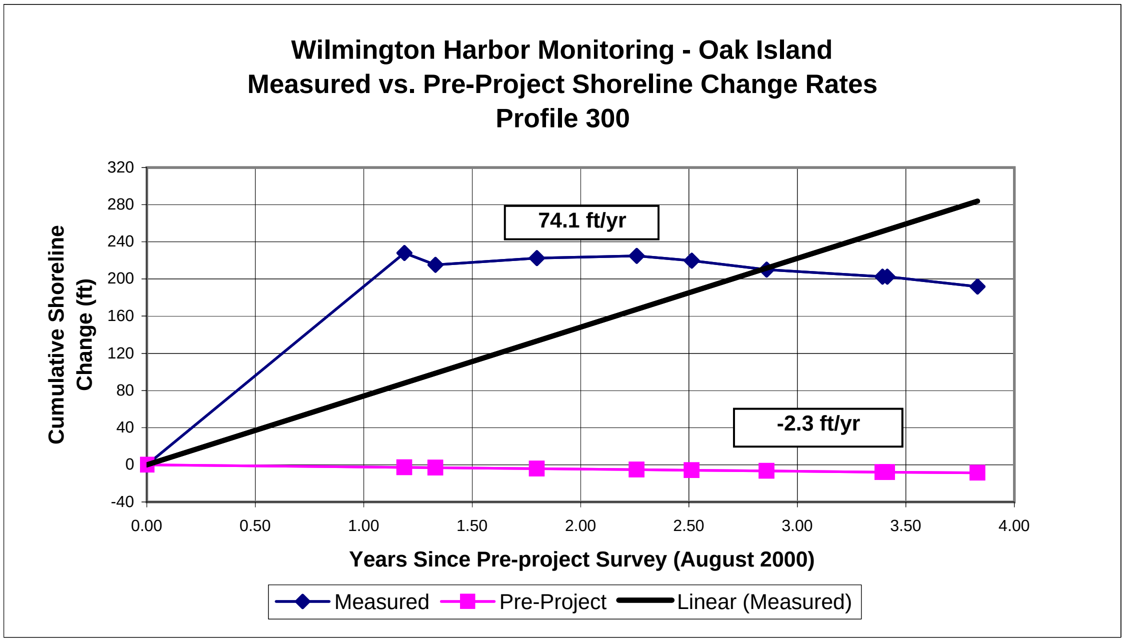

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 275
41.8 ft/yr
-3.0 ft/yr
Cumulative Shoreline Change (ft)
185
160
135
110
85
60
35
10
-15
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

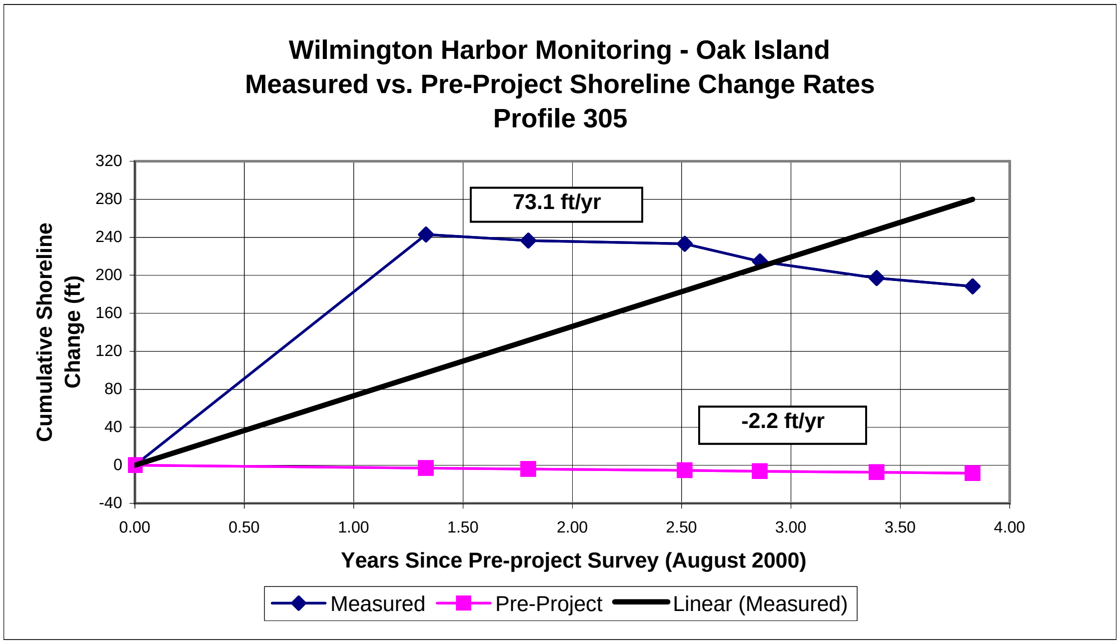

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 280
61.2 ft/yr
-2.8 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

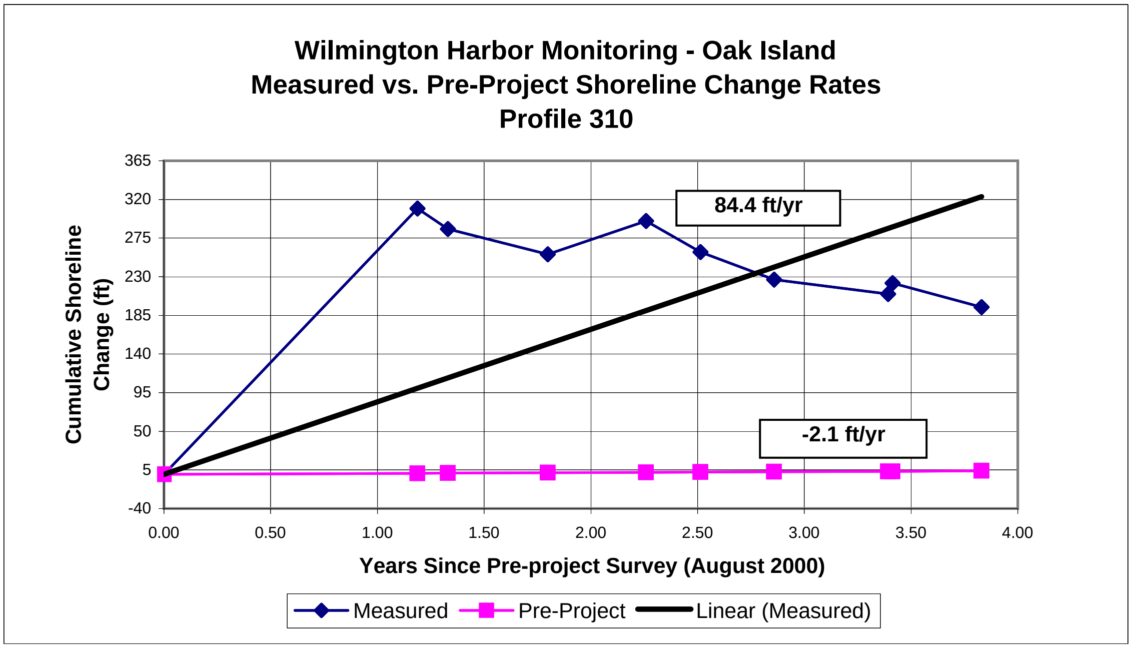

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 285
55.4 ft/yr
-2.7 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)


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


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

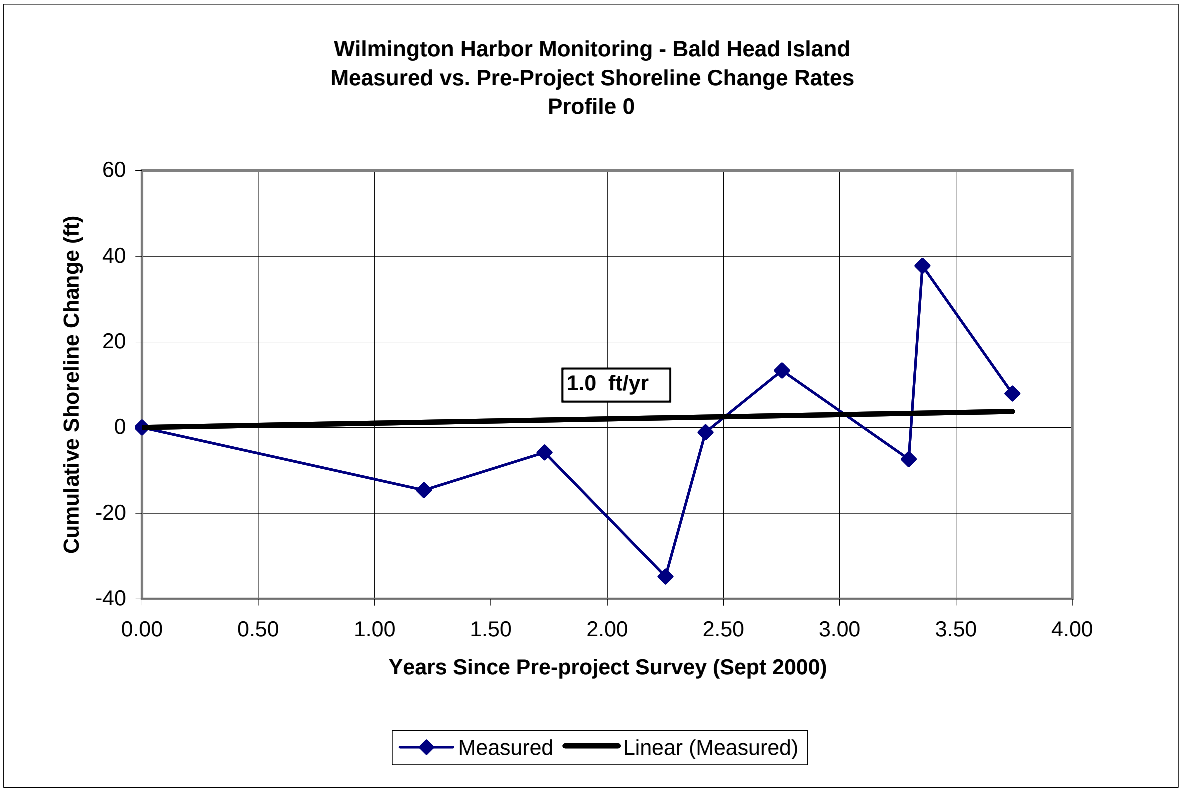

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 300
74.1 ft/yr
-2.3 ft/yr
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)


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

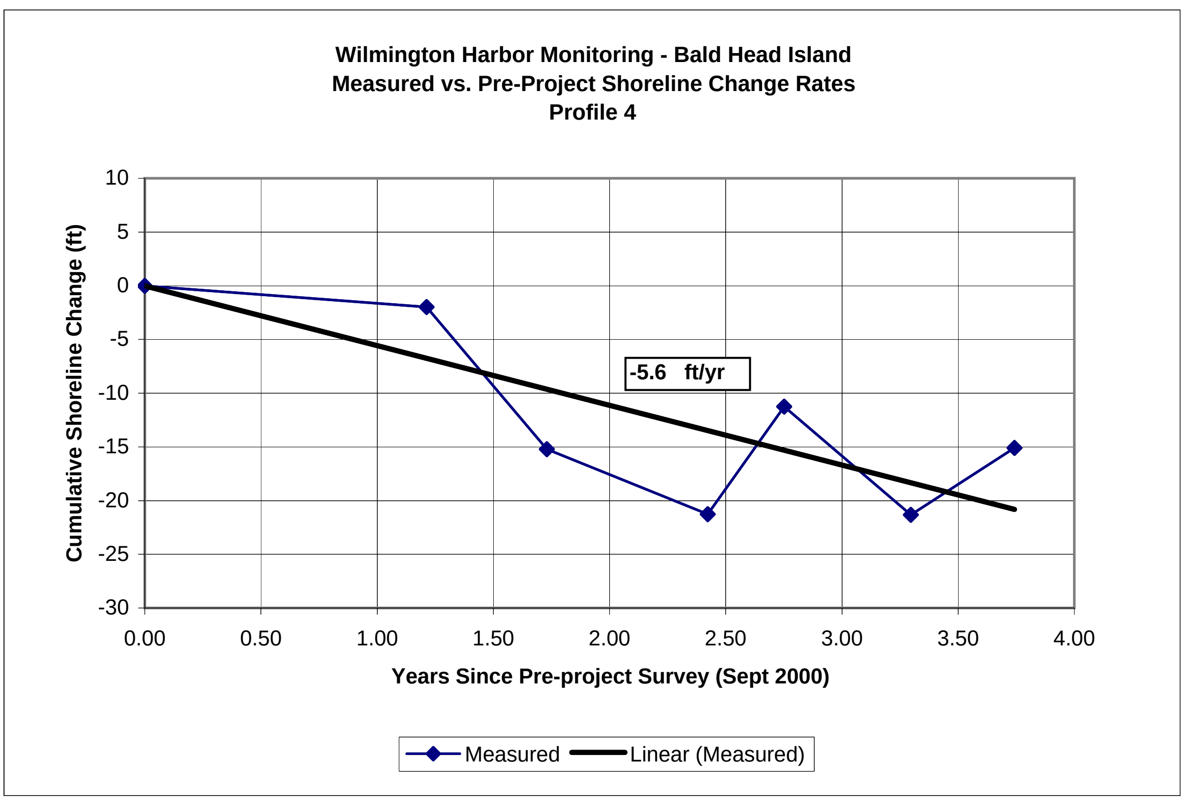

Wilmington Harbor Monitoring - Oak Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 310
84.4 ft/yr
-2.1 ft/yr
Cumulative Shoreline Change (ft)
365
320
275
230
185
140
95
50
5
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (August 2000)
Measured
Pre-Project
Linear (Measured)

Appendix C

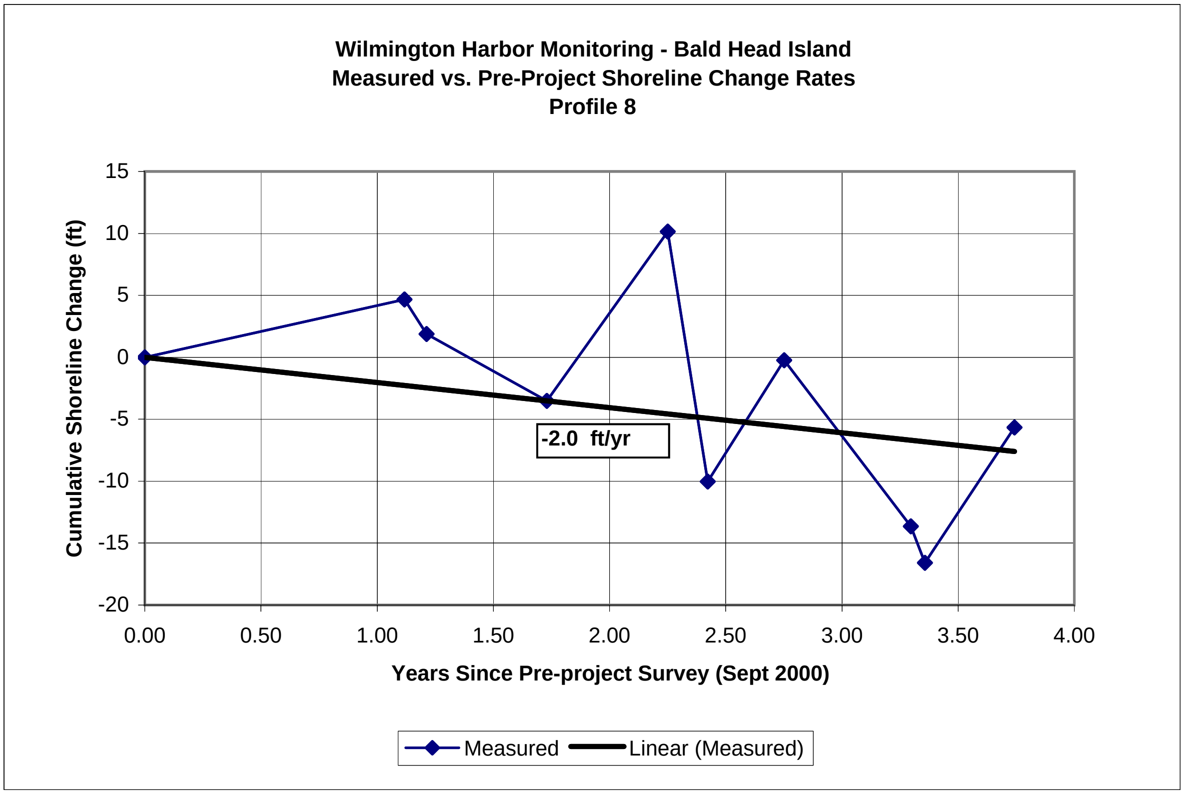
SHORELINE CHANGE RATES
(Bald Head Island)

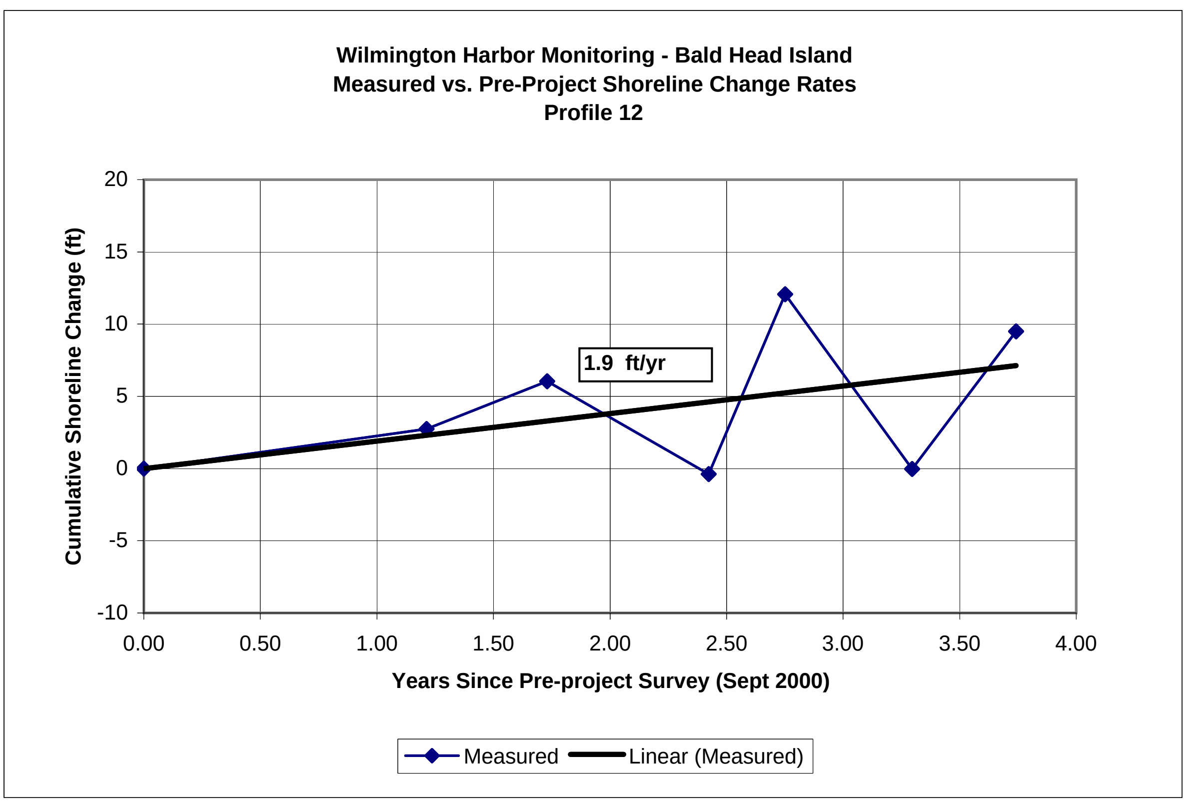


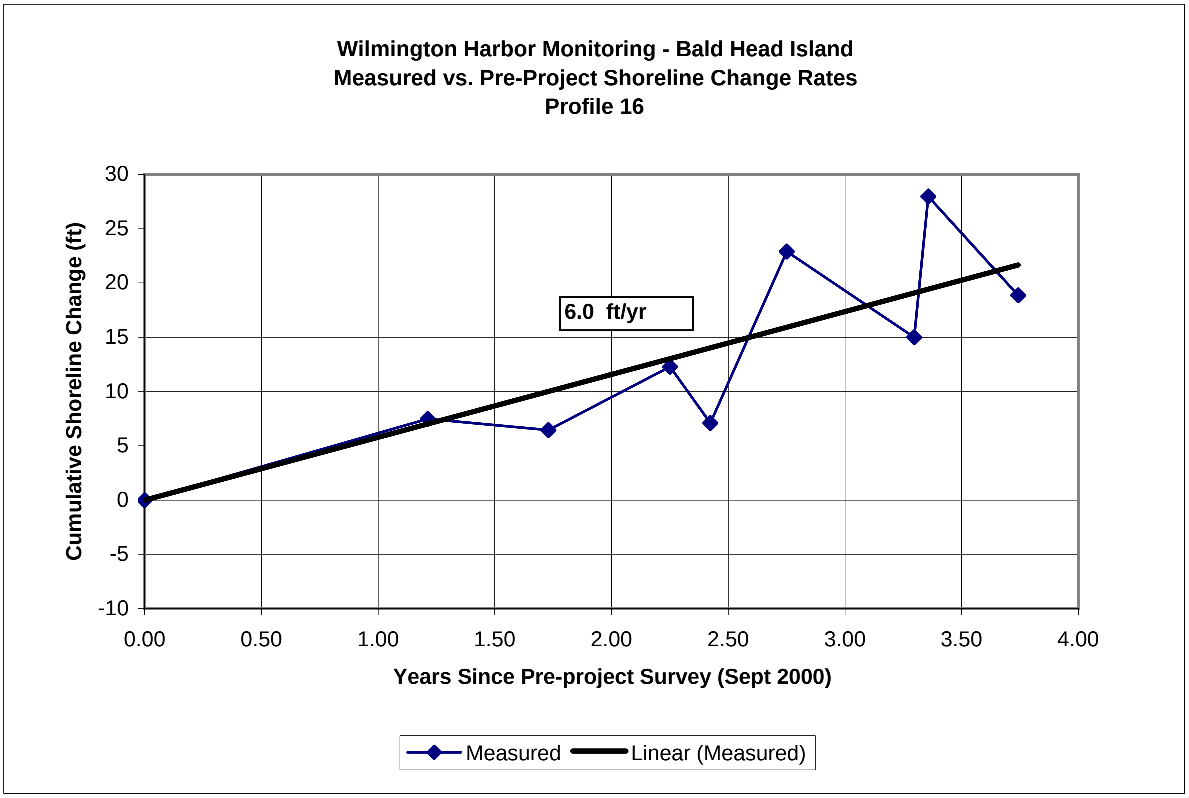
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 0
60
40
20
0
-20
-40
Cumulative Shoreline Change (ft)
1.0 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

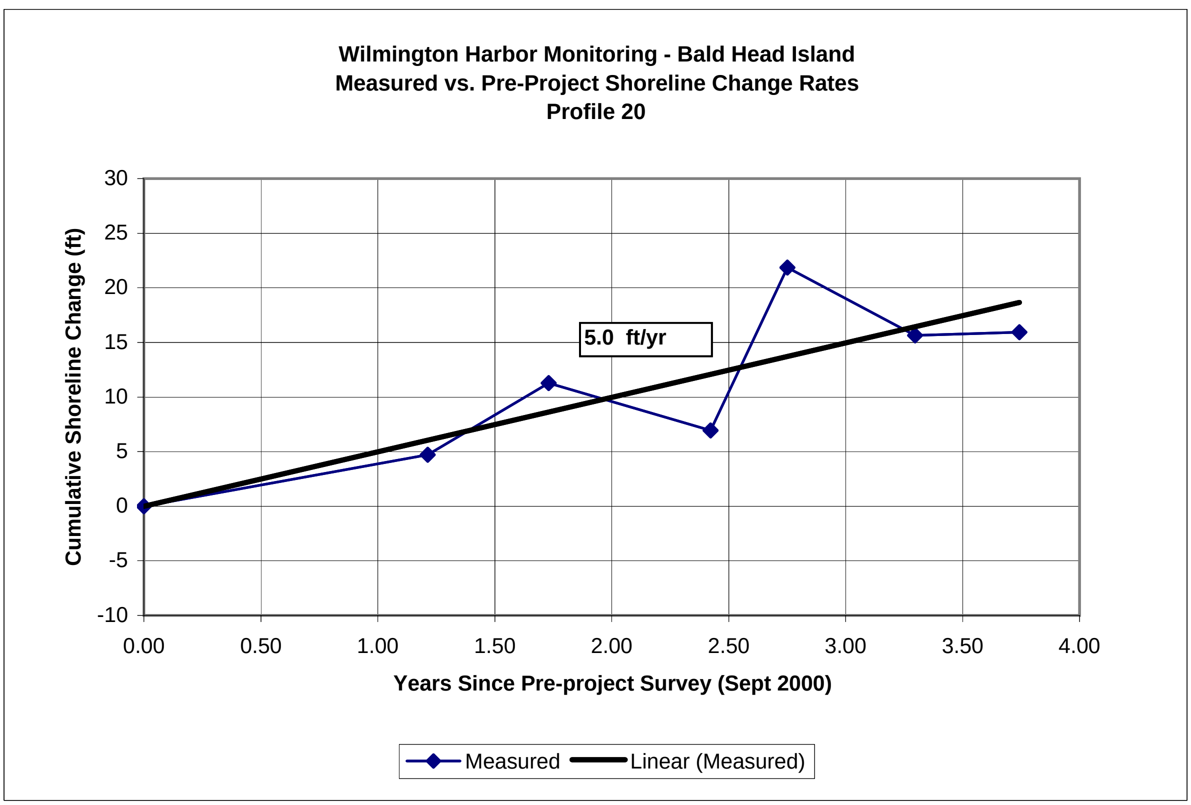


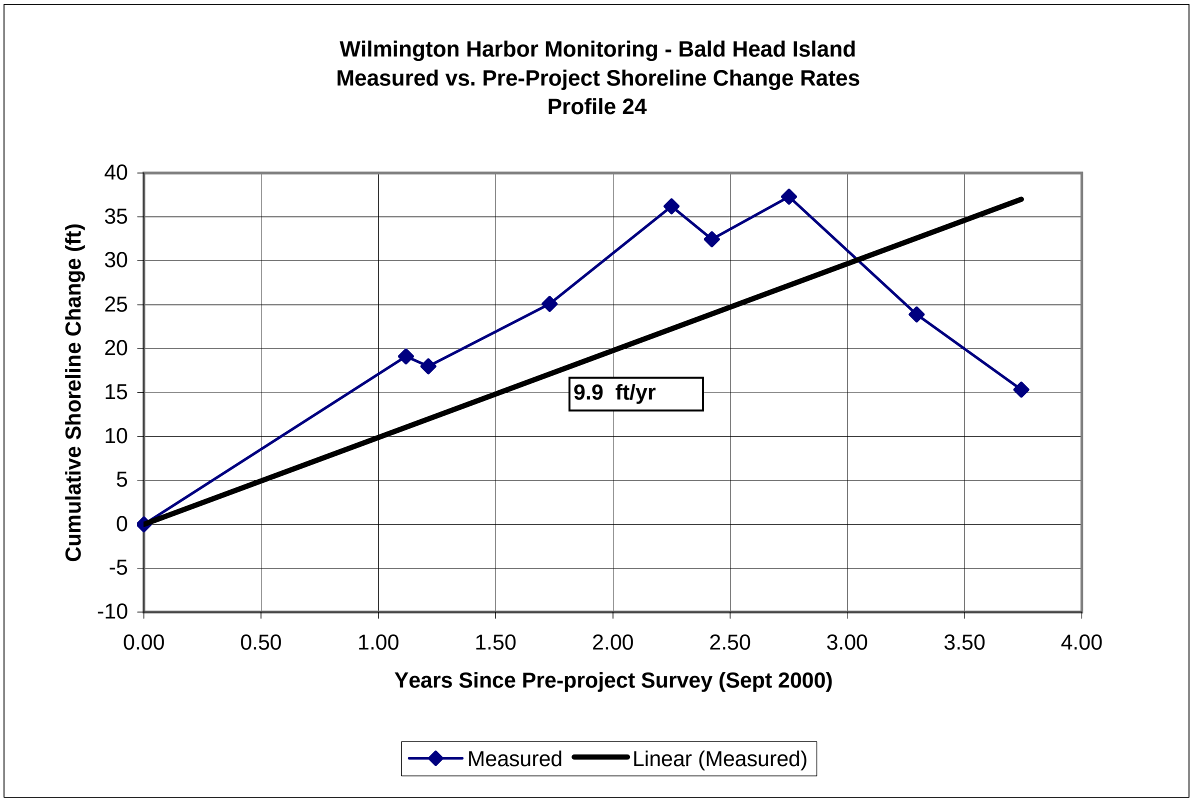
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 4
10
5
0
-5
-10
-15
-20
-25
-30
Cumulative Shoreline Change (ft)
-5.6 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 8
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
-15
-20
-2.0 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

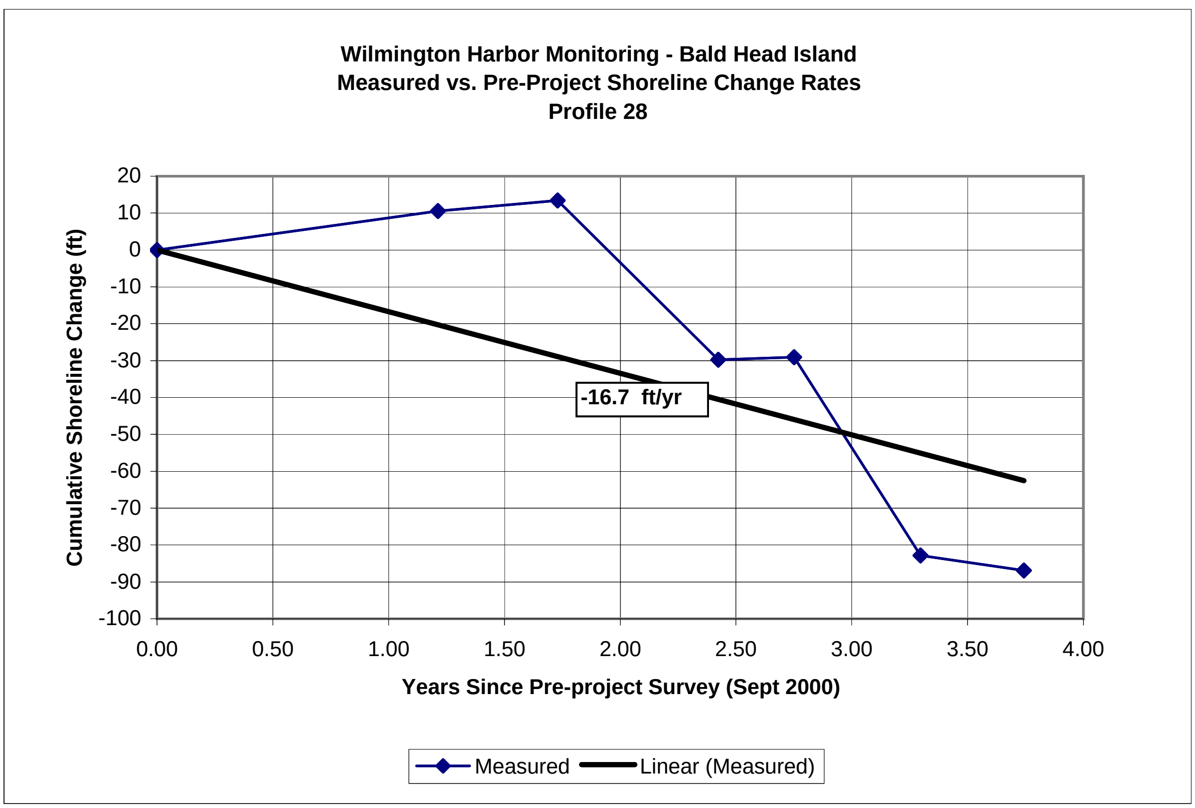

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 12
Cumulative Shoreline Change (ft)
20
15
10
5
0
-5
-10
1.9 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 16
6.0 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
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
Measured
Linear (Measured)

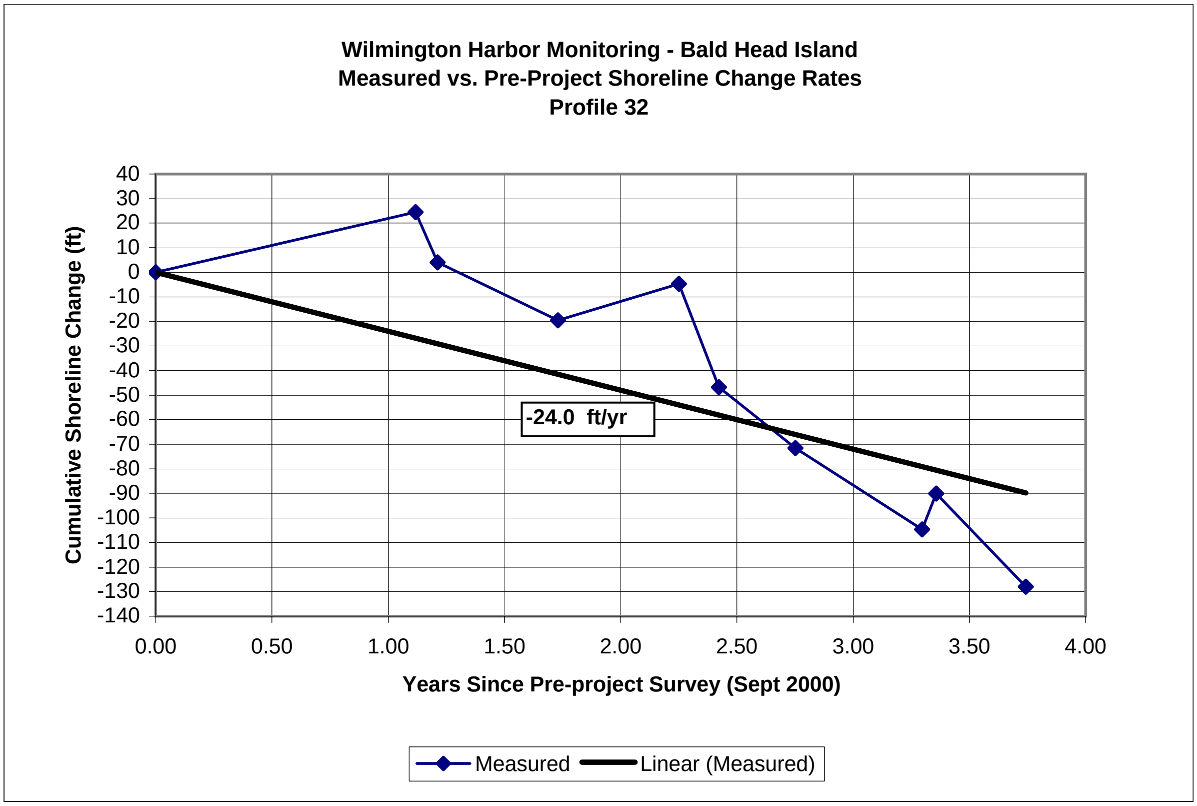

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 20
5.0 ft/yr
Cumulative Shoreline Change (ft)
Years Since Pre-project Survey (Sept 2000)
30
25
20
15
10
5
0
-5
-10
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Measured
Linear (Measured)

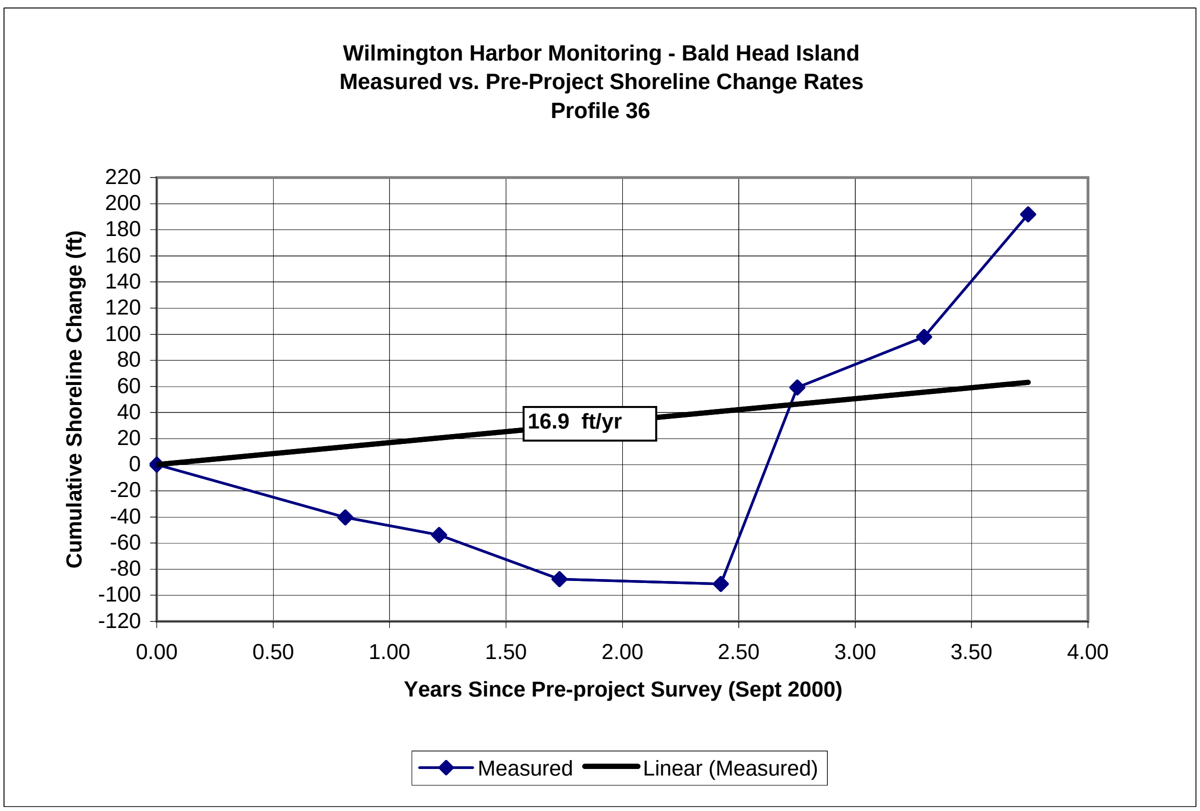


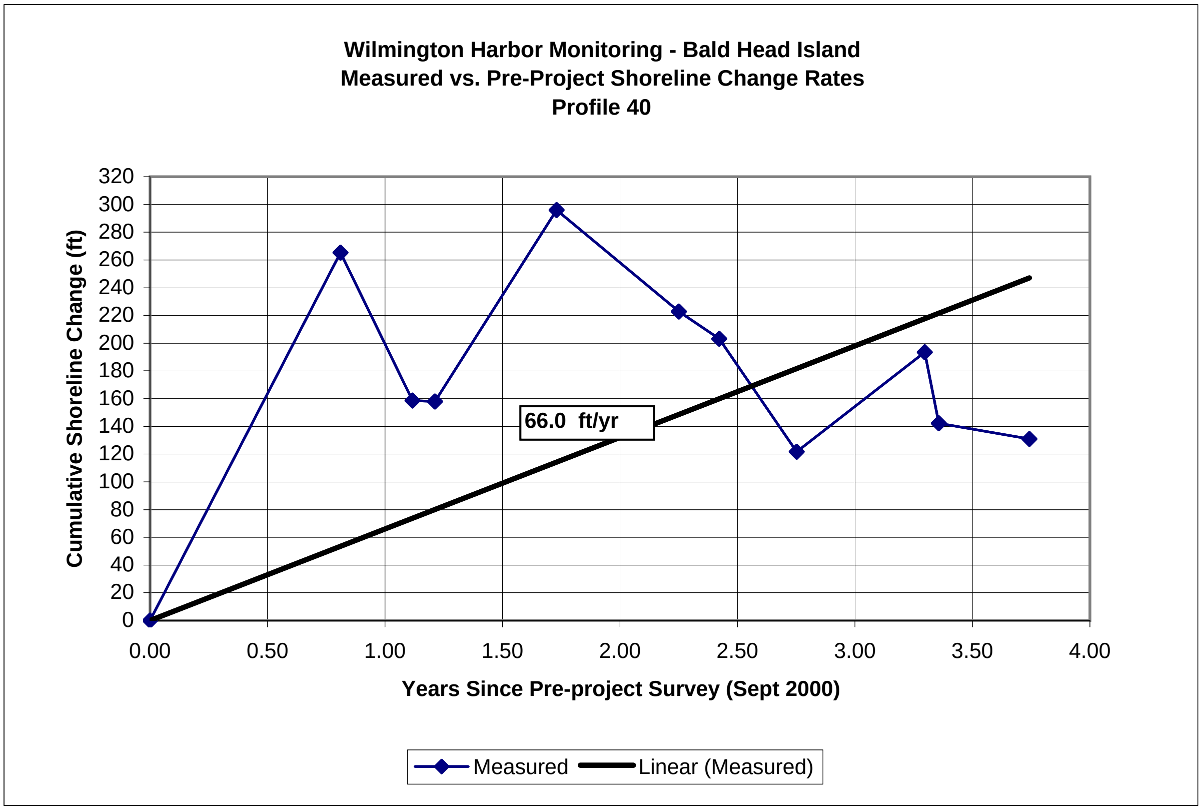
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 24
Cumulative Shoreline Change (ft)
40
35
30
25
20
15
10
5
0
-5
-10
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
9.9 ft/yr
Measured
Linear (Measured)

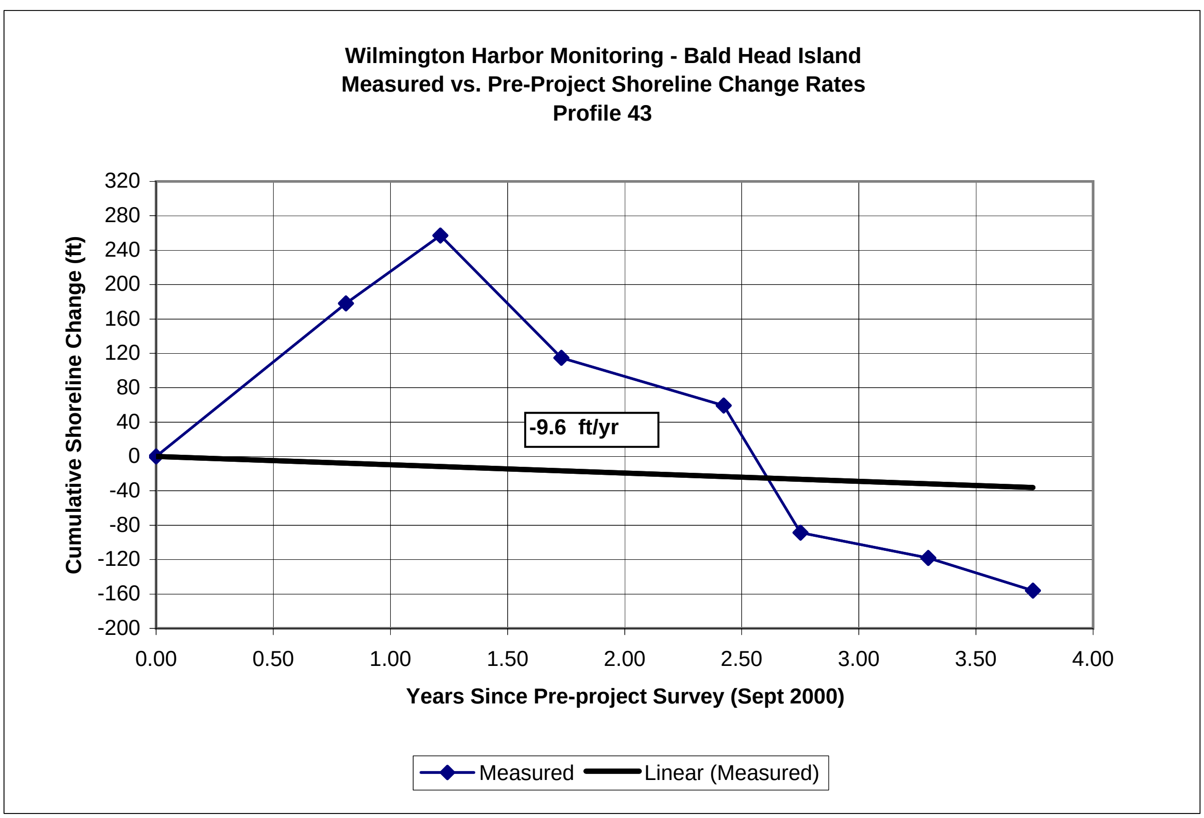


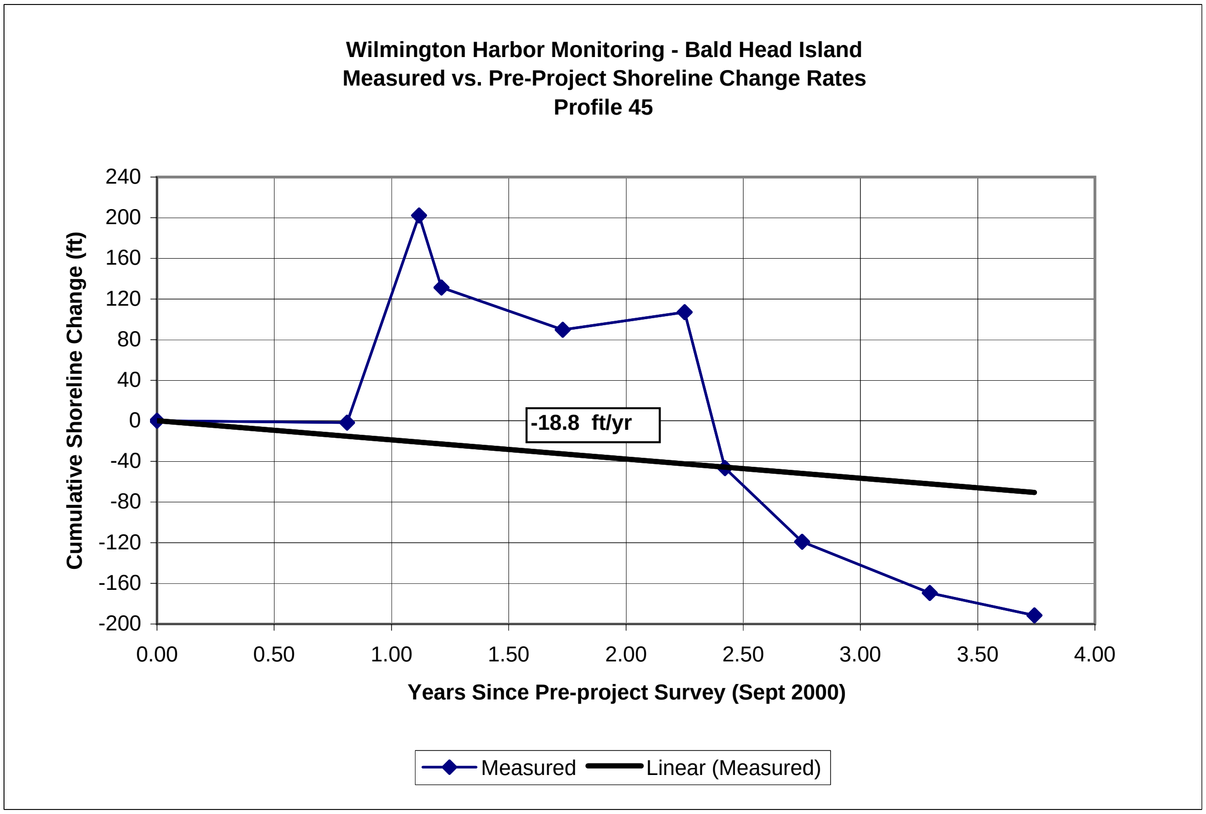
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 28
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-16.7 ft/yr
Measured
Linear (Measured)

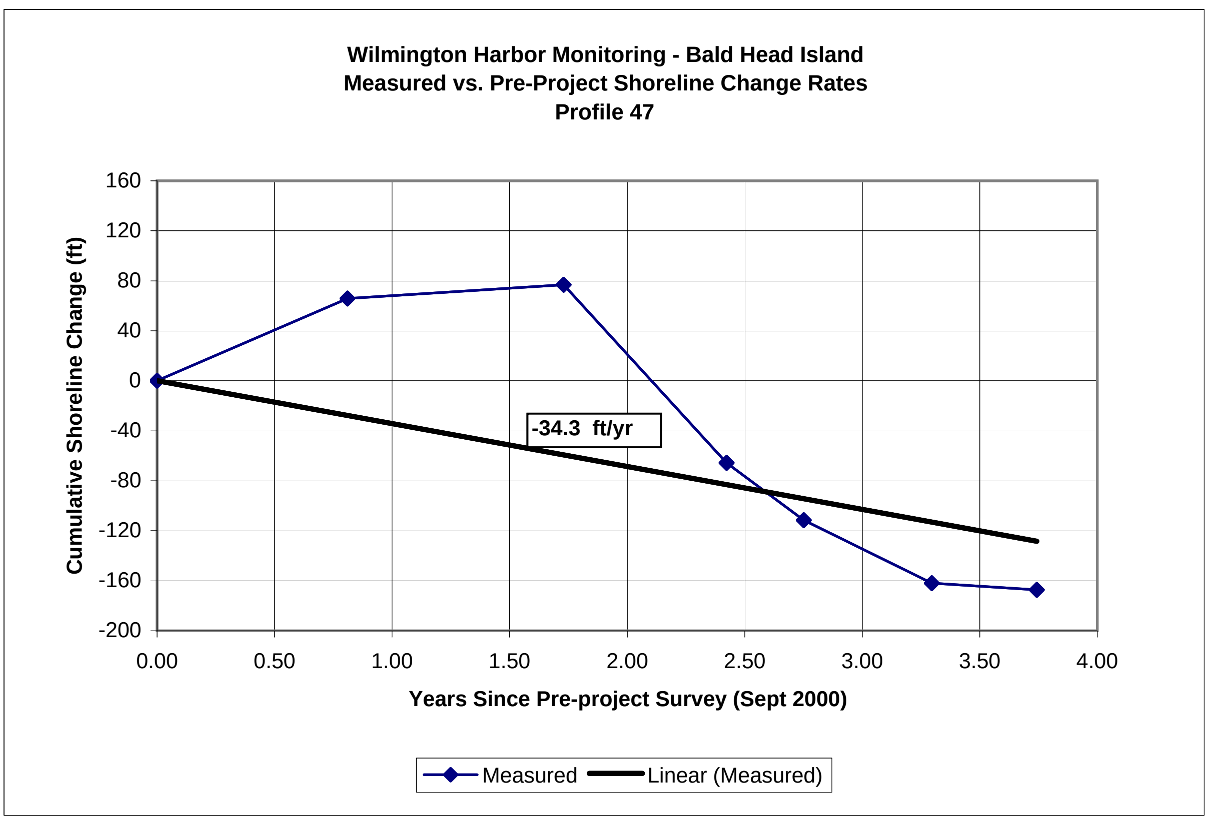

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 32
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
-24.0 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

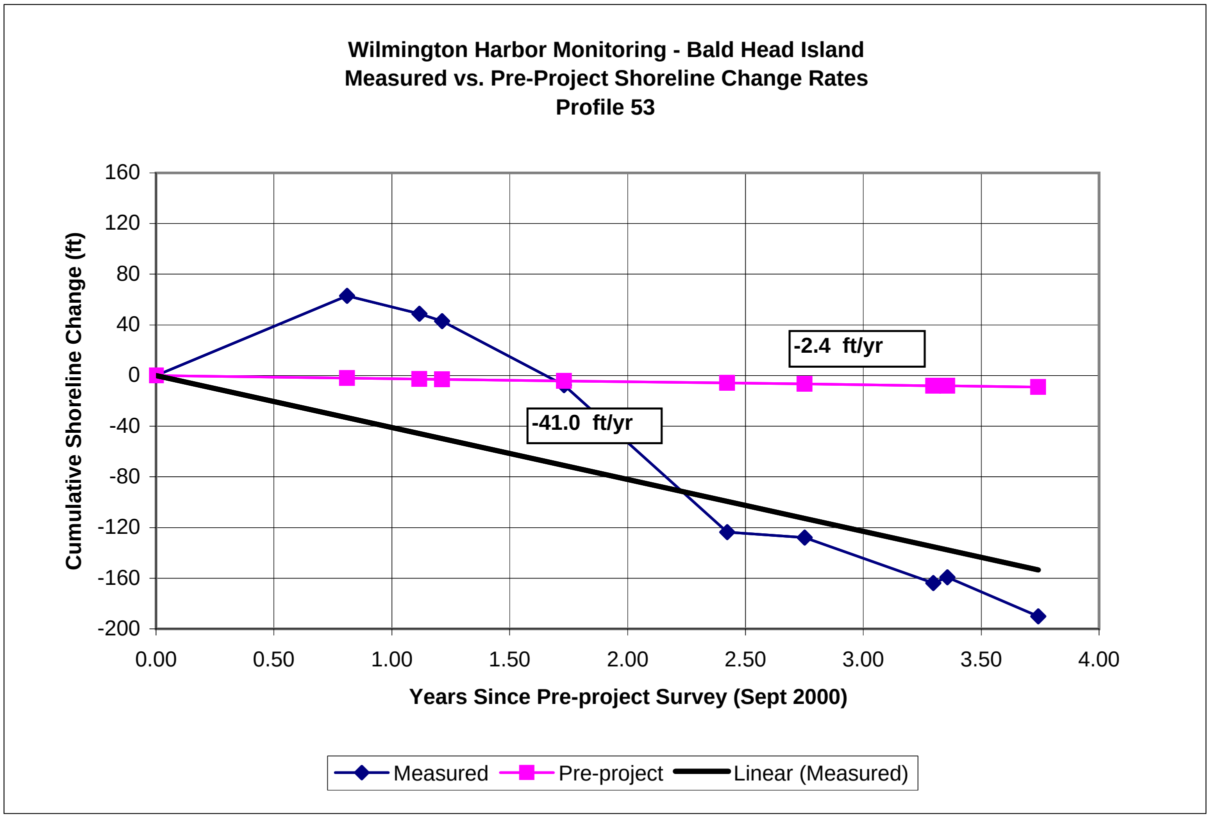

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 36
Cumulative Shoreline Change (ft)
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
16.9 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Linear (Measured)

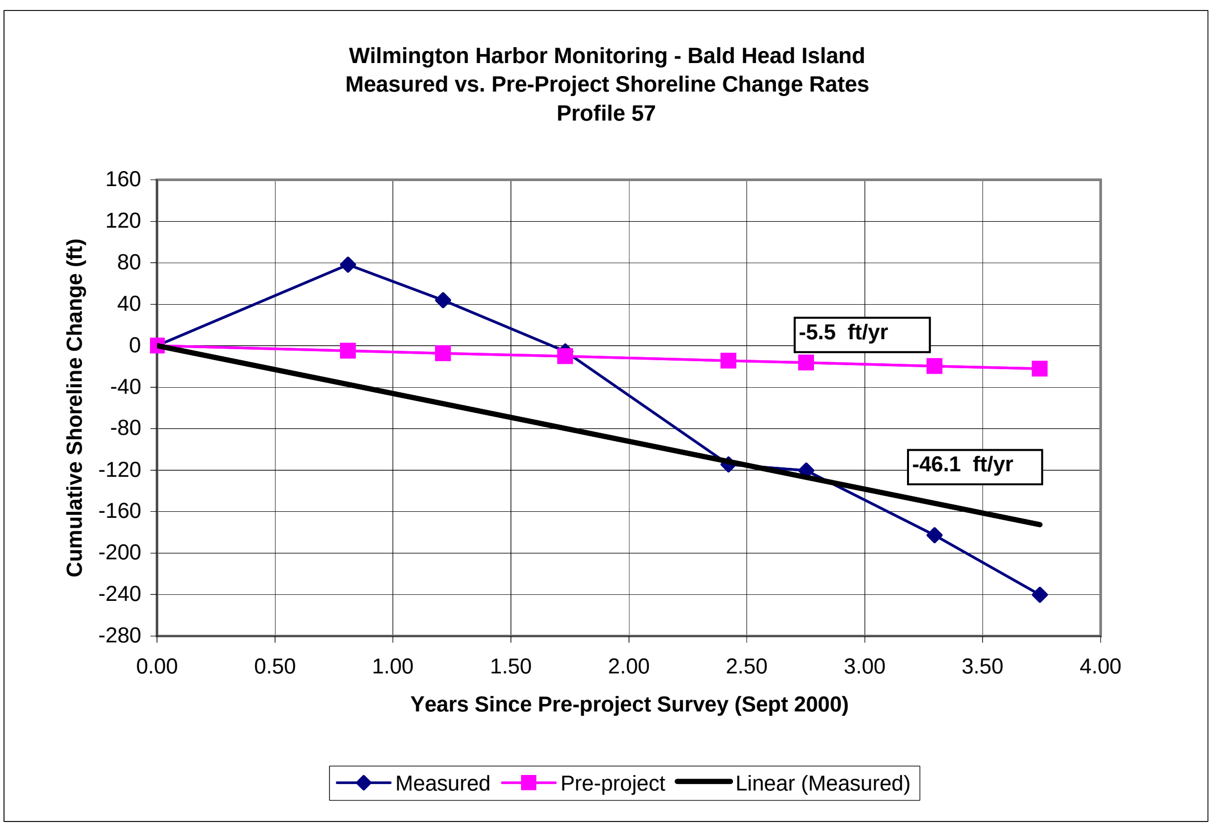

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 40
Cumulative Shoreline Change (ft)
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
66.0 ft/yr
Measured
Linear (Measured)

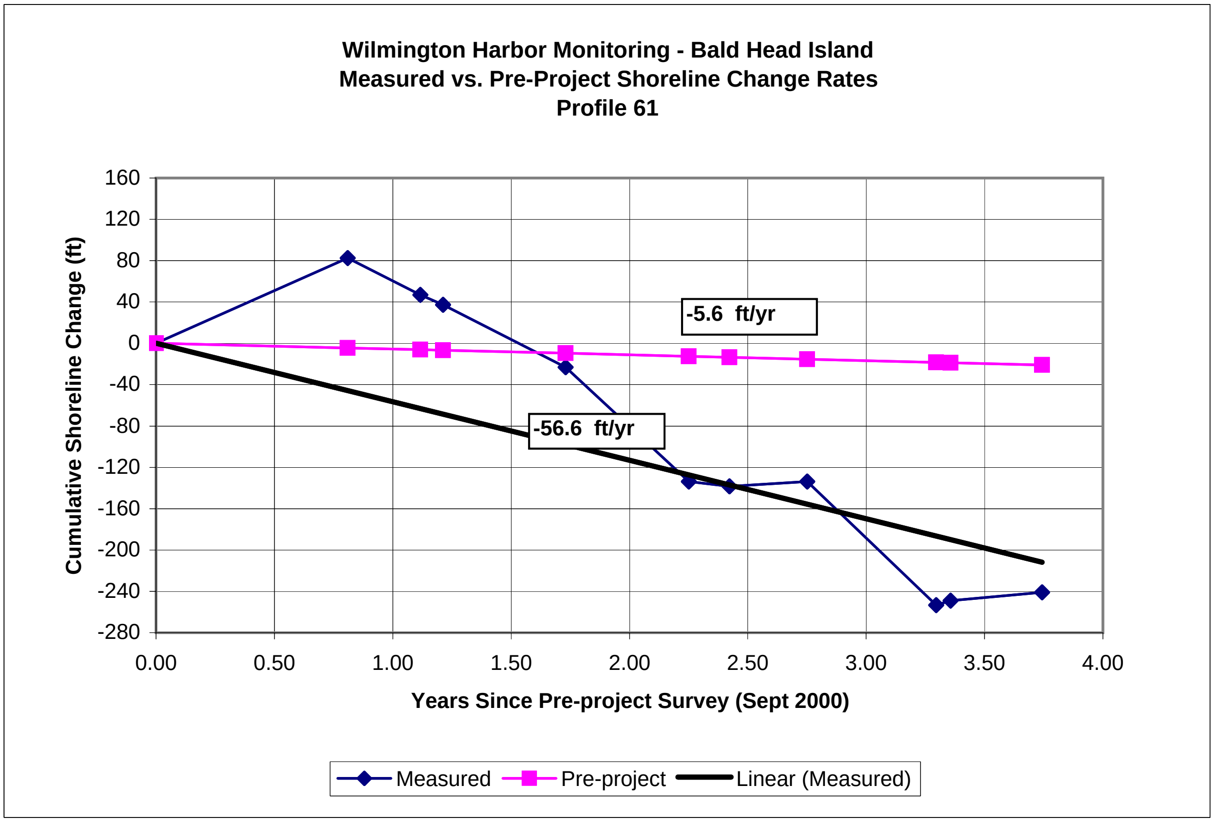

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 43
Cumulative Shoreline Change (ft)
320
280
240
200
160
120
80
40
0
-40
-80
-120
-160
-200
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-9.6 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 45
Cumulative Shoreline Change (ft)
240
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
Years Since Pre-project Survey (Sept 2000)
-18.8 ft/yr
Measured
Linear (Measured)

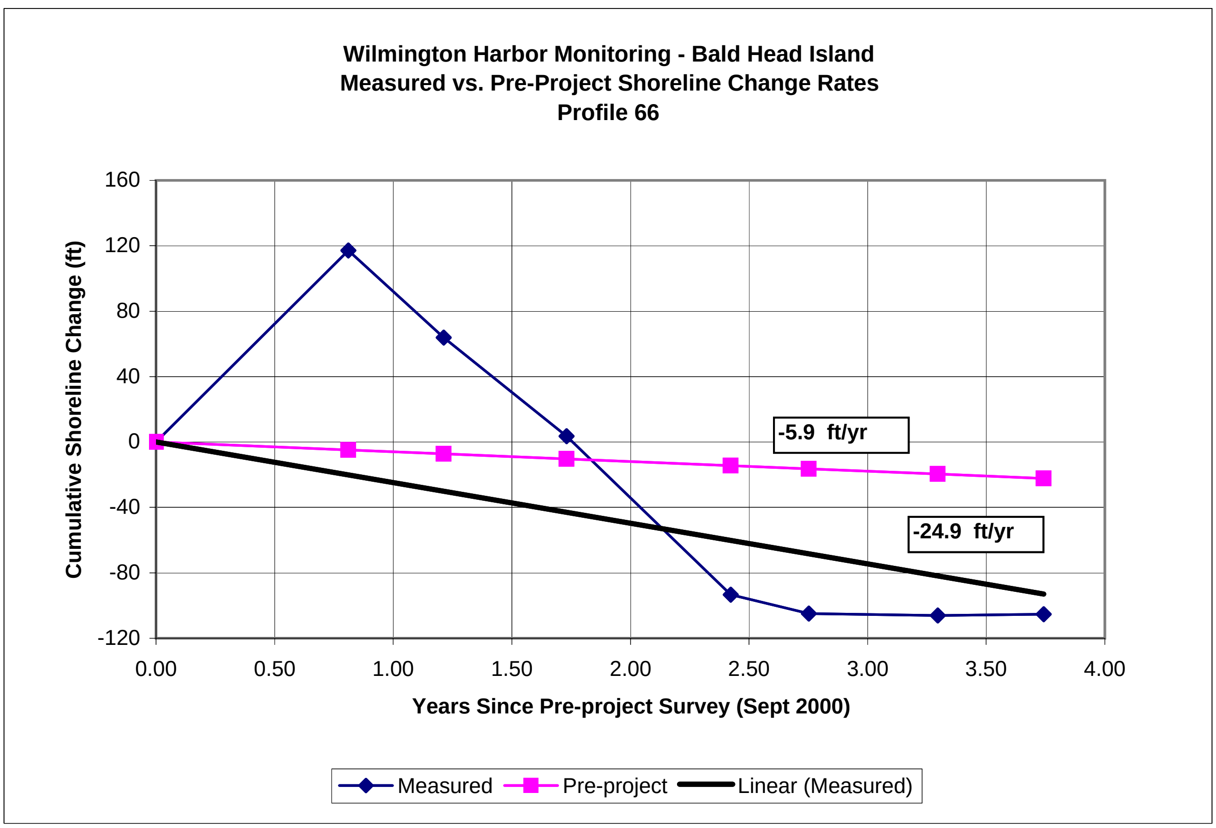

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 47
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
-160
-200
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-34.3 ft/yr
Measured
Linear (Measured)


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 53
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
Years Since Pre-project Survey (Sept 2000)
-2.4 ft/yr
-41.0 ft/yr
Measured
Pre-project
Linear (Measured)

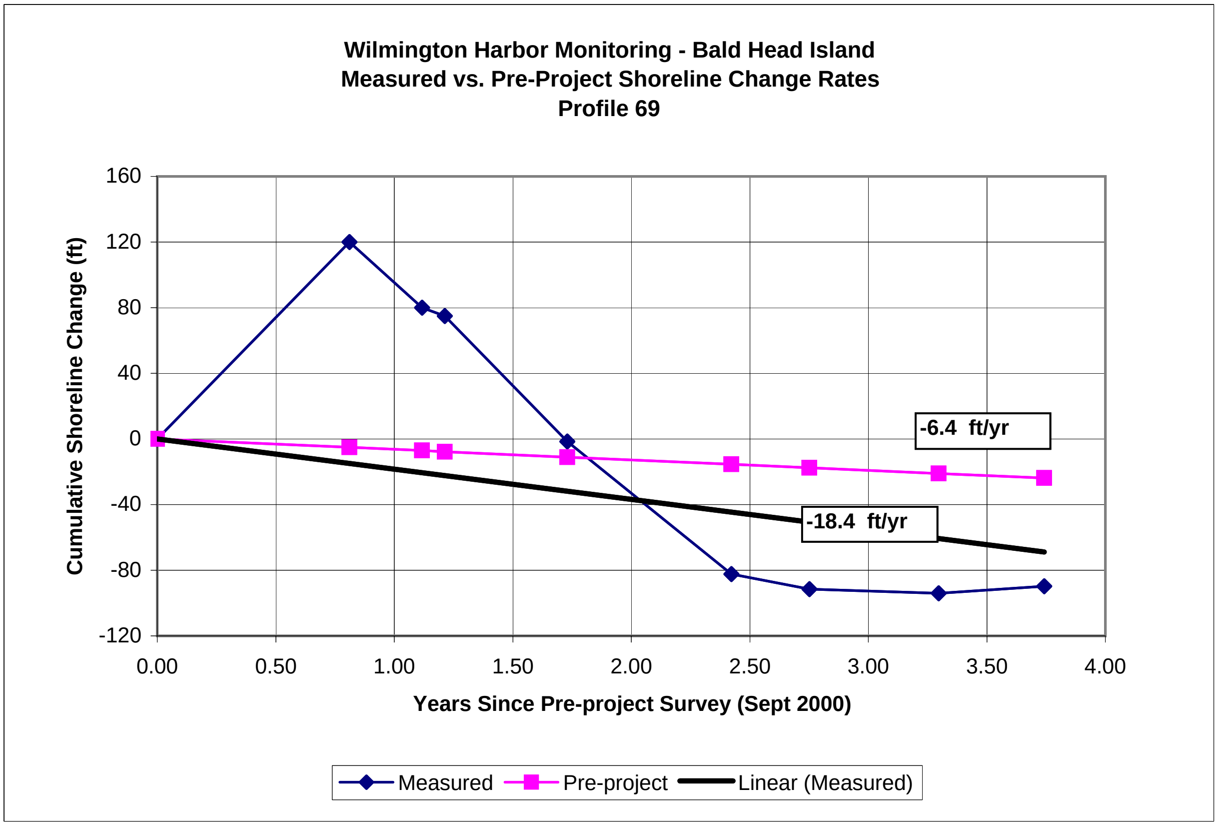

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 57
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-5.5 ft/yr
-46.1 ft/yr
Measured
Pre-project
Linear (Measured)

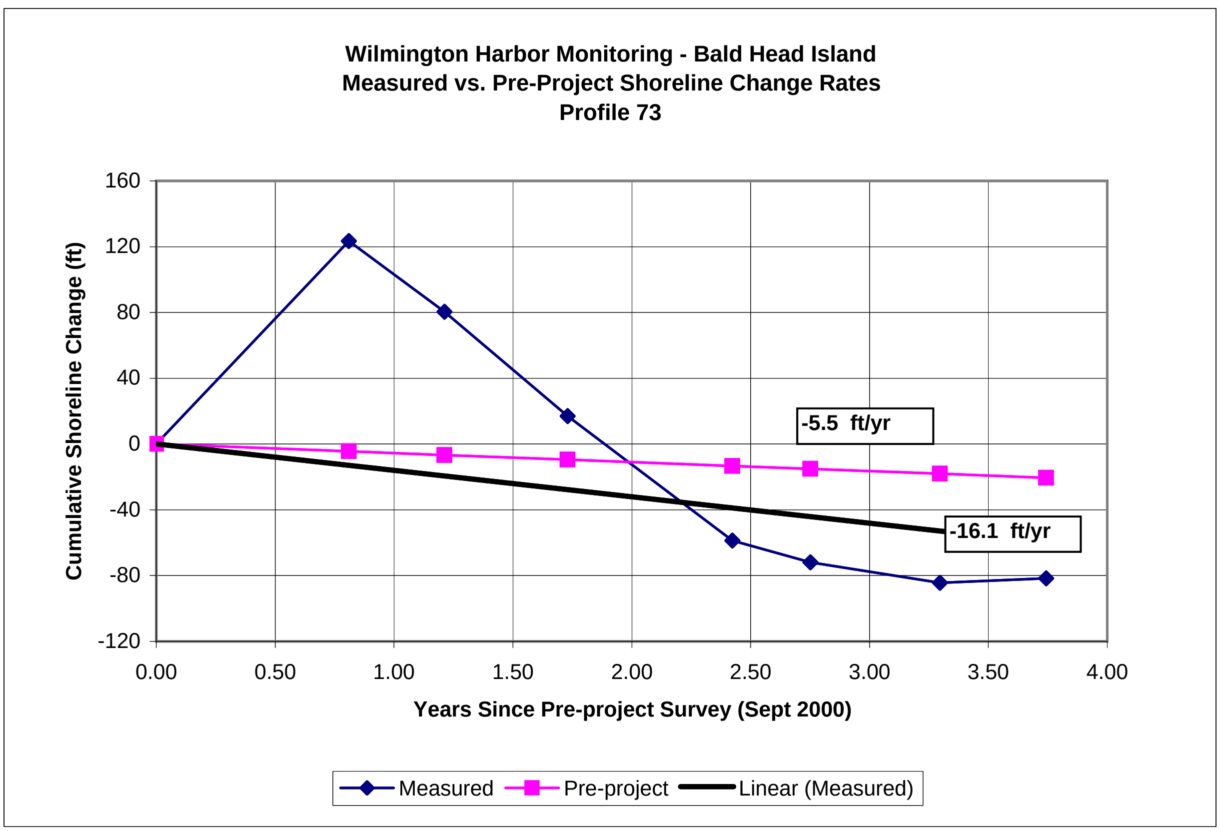


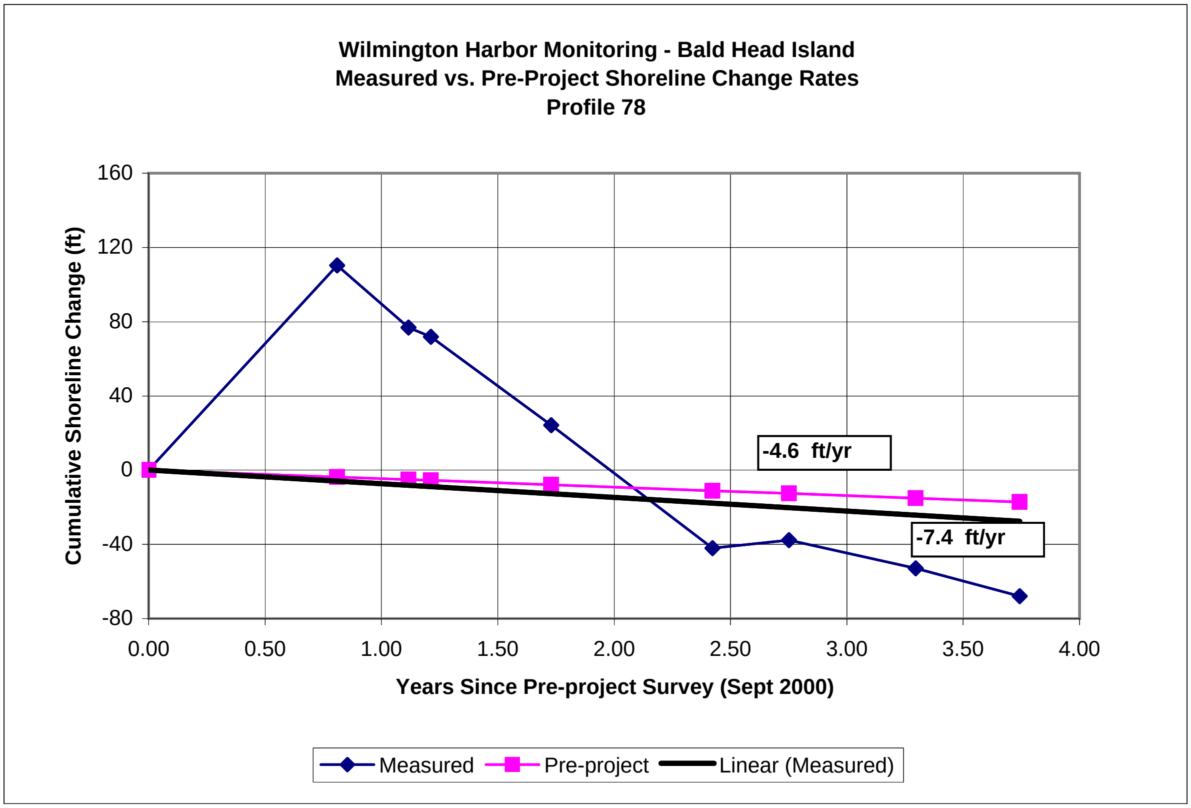
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 61
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
-160
-200
-240
-280
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-5.6 ft/yr
-56.6 ft/yr
Measured
Pre-project
Linear (Measured)



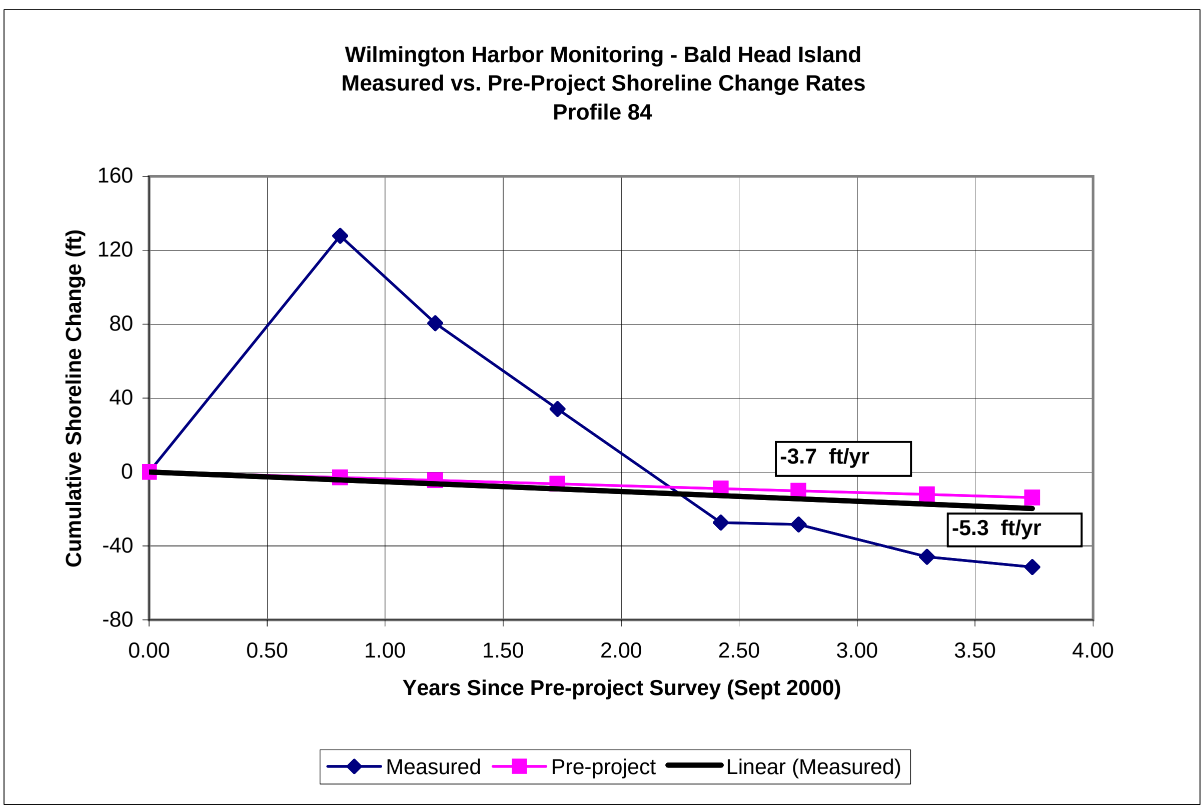
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 66
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-5.9 ft/yr
-24.9 ft/yr
Measured
Pre-project
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
-6.4 ft/yr
-18.4 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

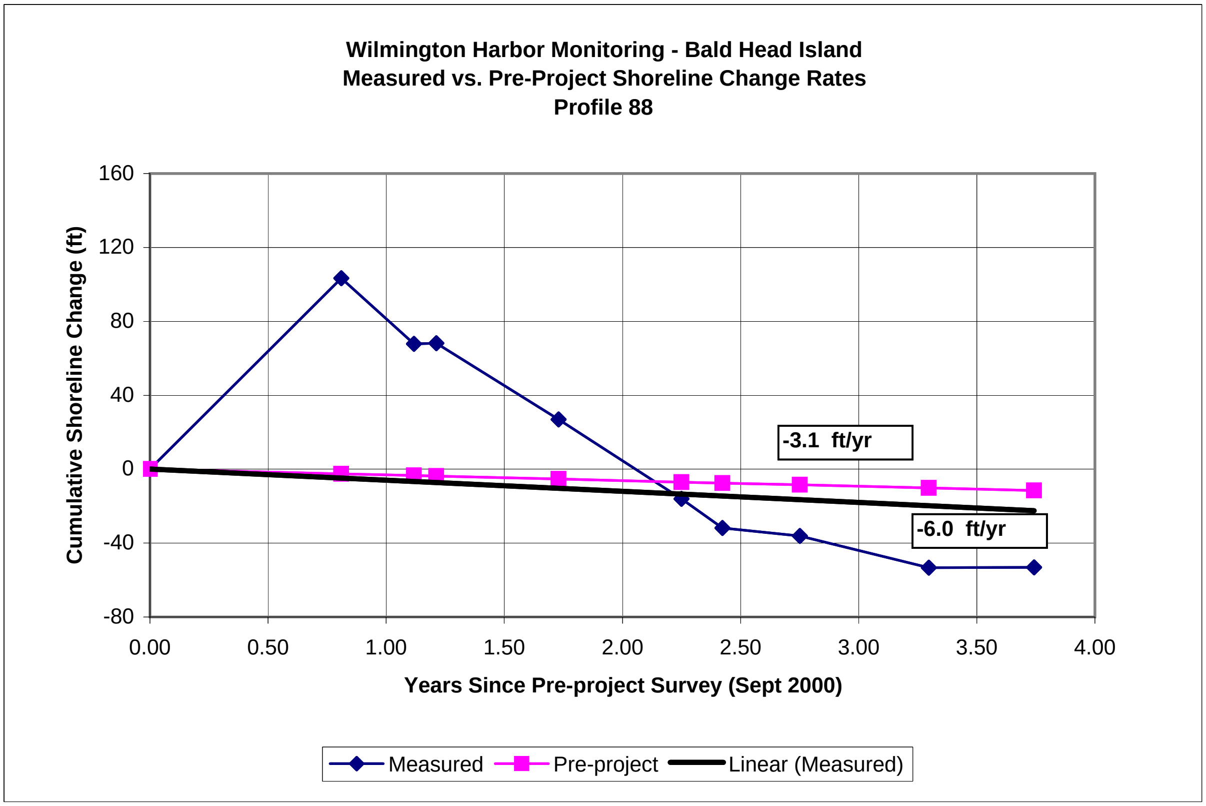

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 73
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
-120
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
-5.5 ft/yr
-16.1 ft/yr
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

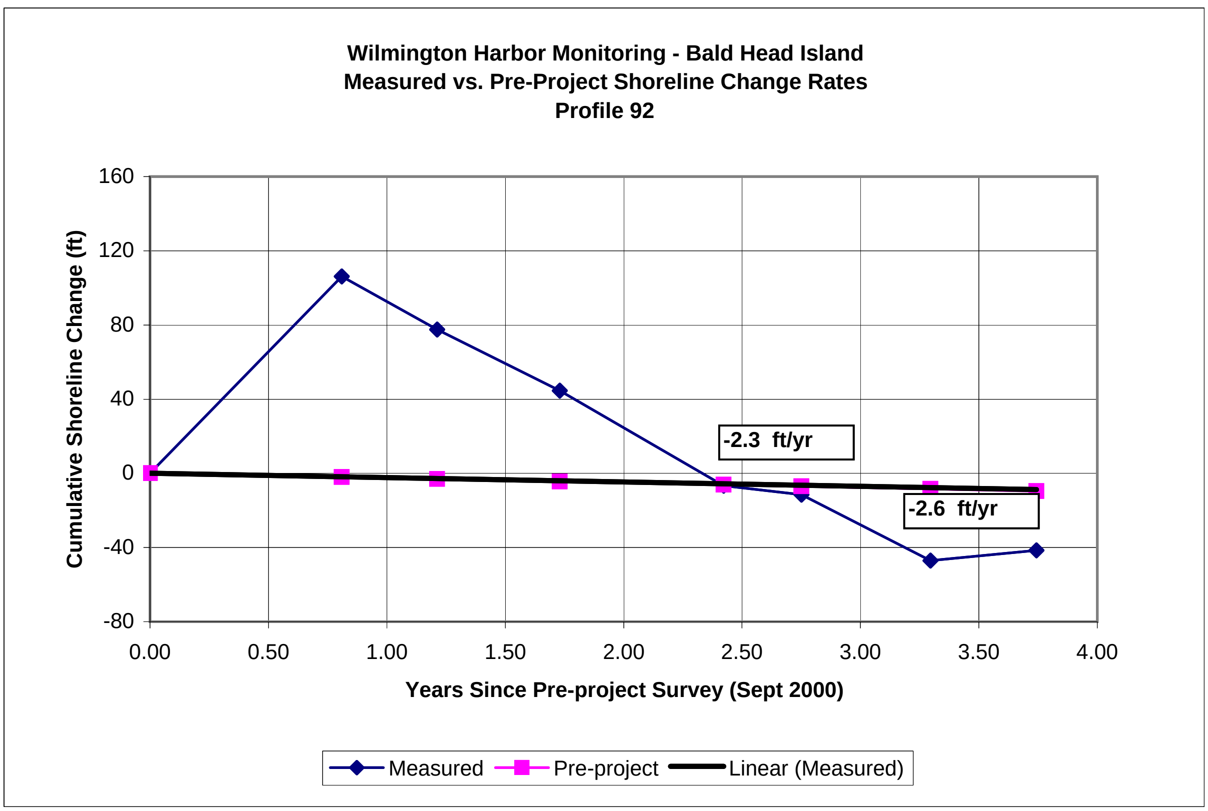


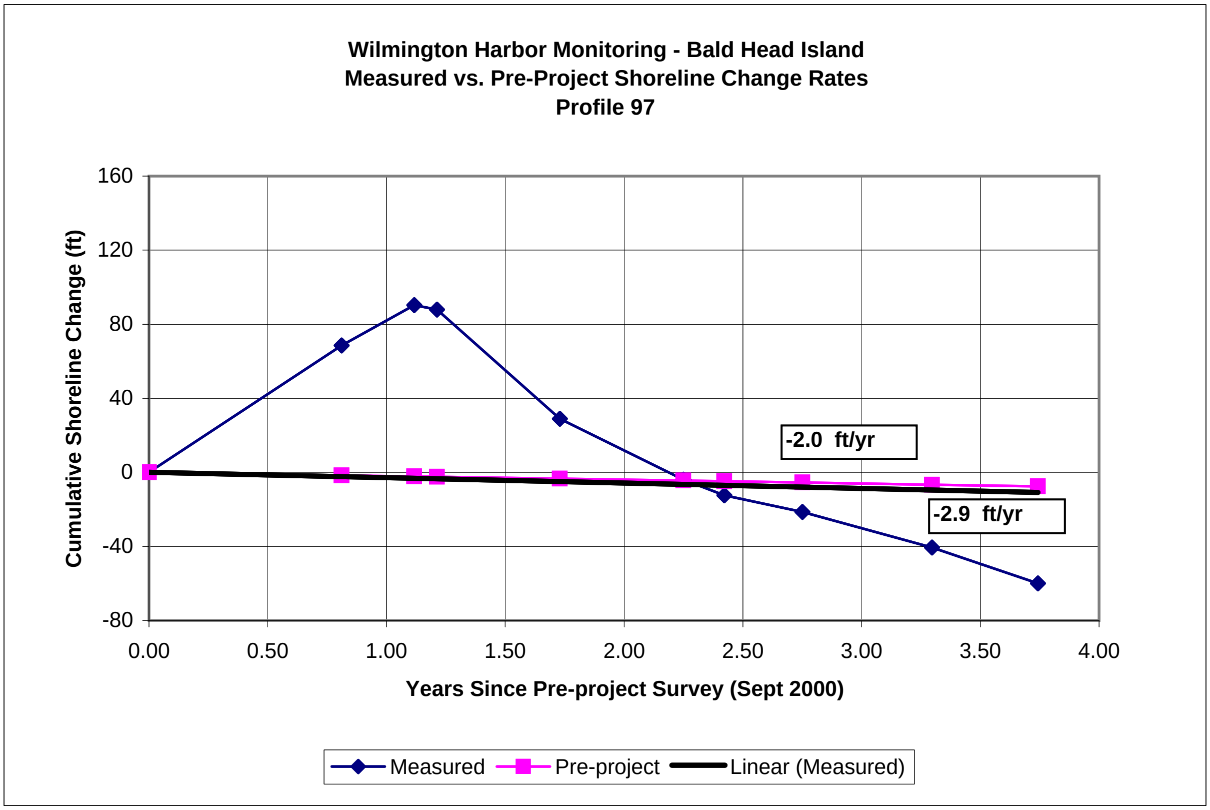
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 78
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-4.6 ft/yr
-7.4 ft/yr
Measured
Pre-project
Linear (Measured)

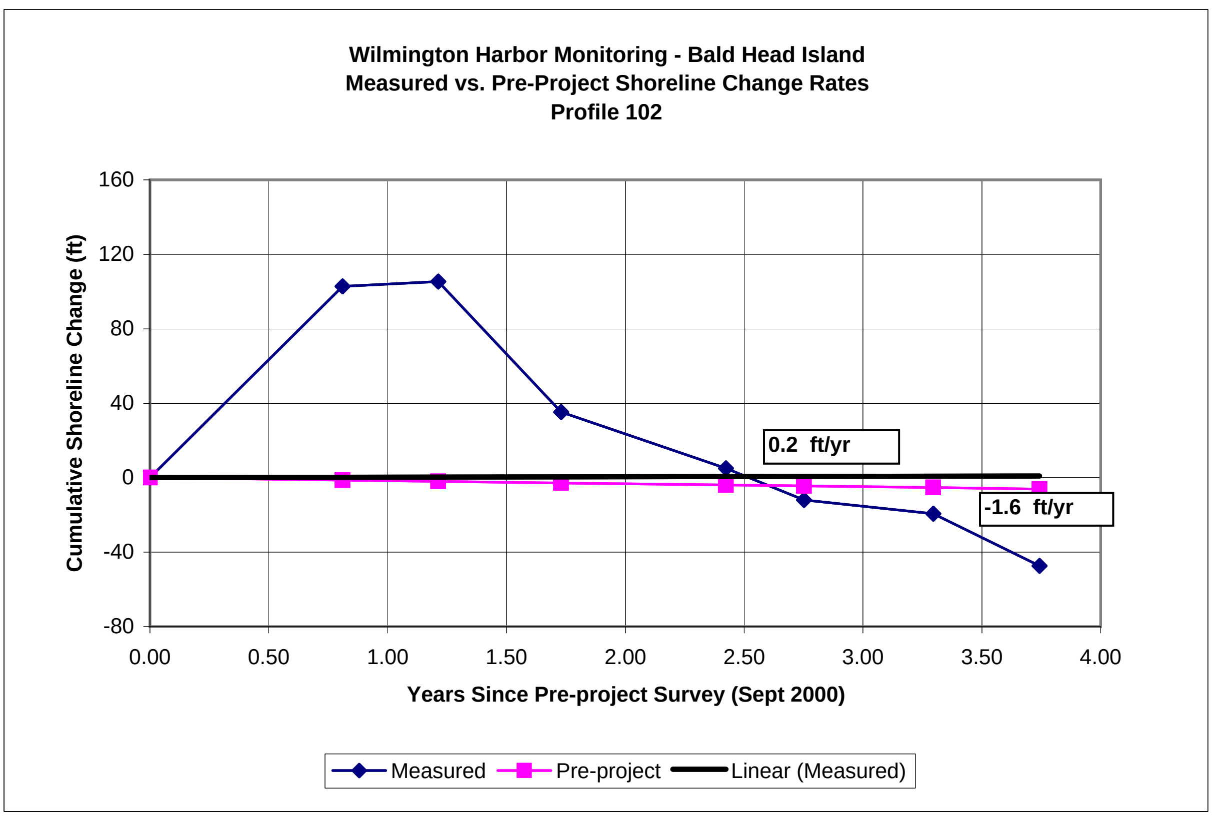


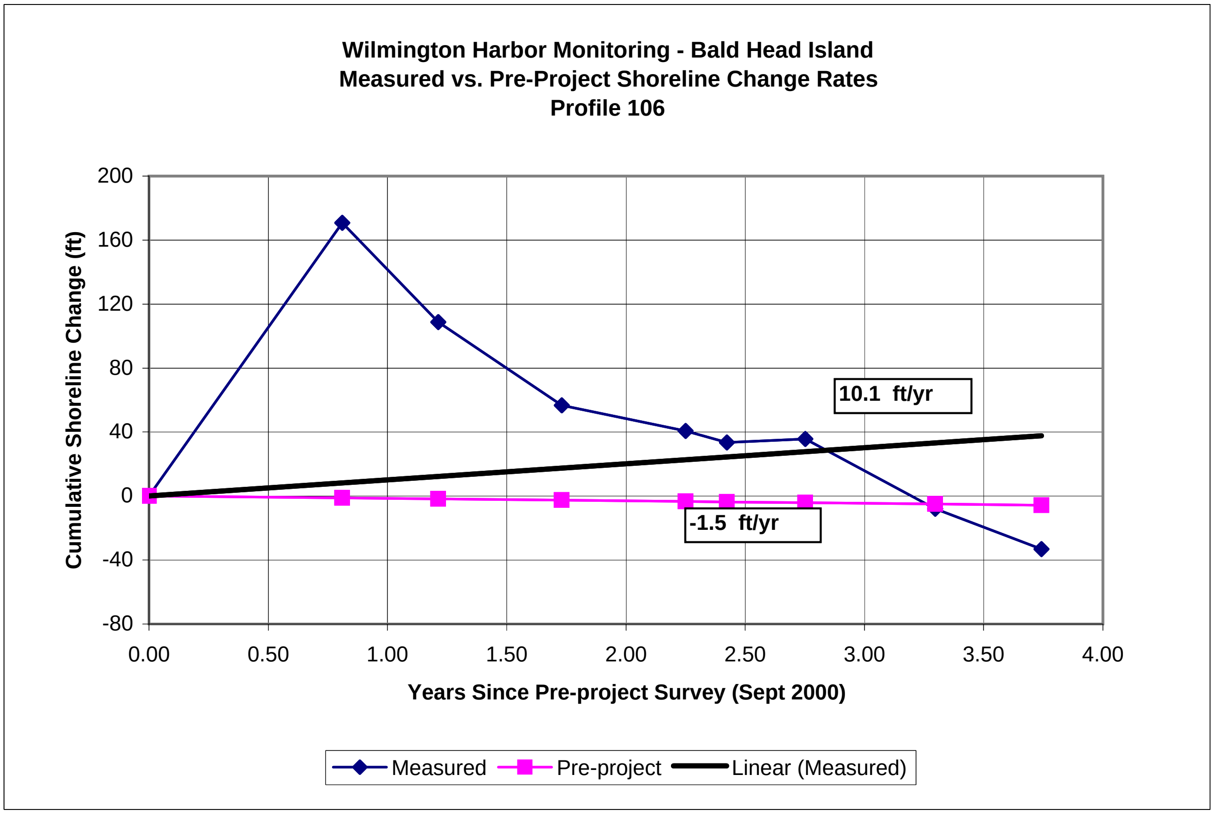
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 84
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-3.7 ft/yr
-5.3 ft/yr
Measured
Pre-project
Linear (Measured)

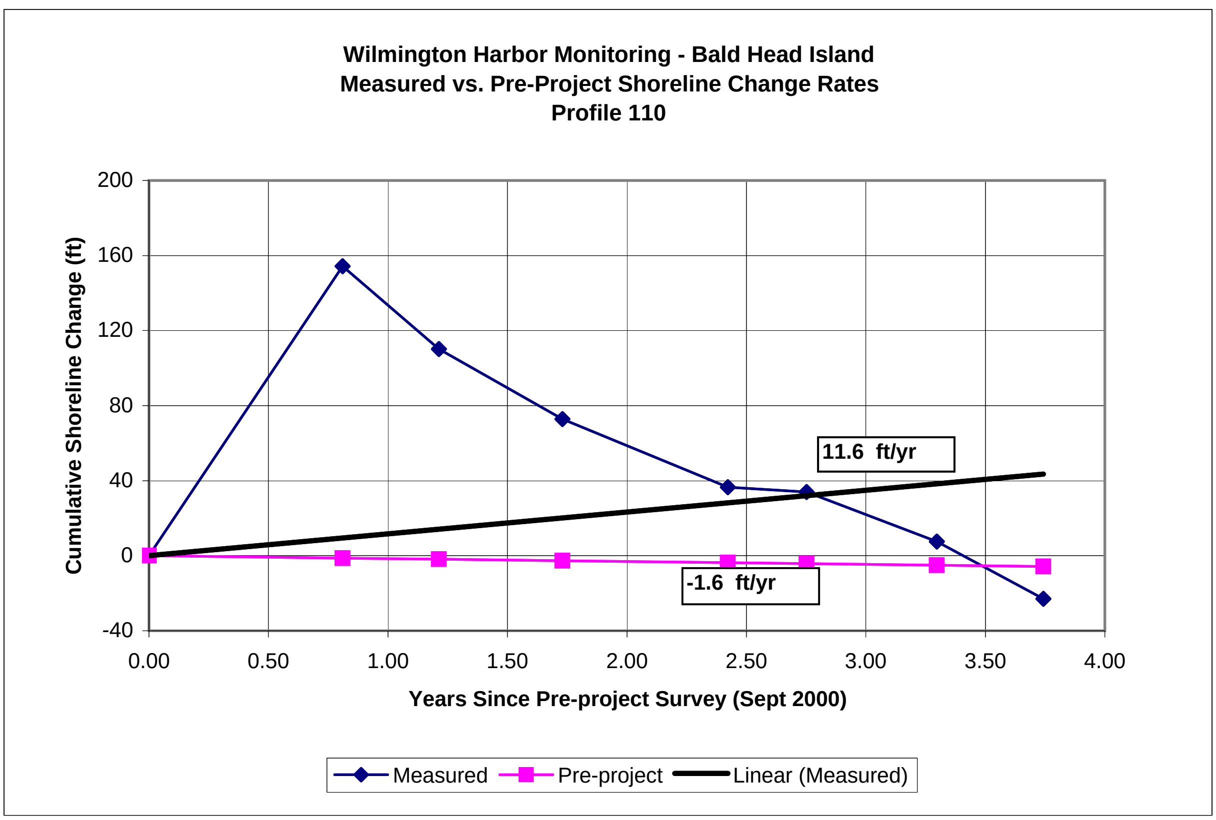

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 88
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-3.1 ft/yr
-6.0 ft/yr
Measured
Pre-project
Linear (Measured)

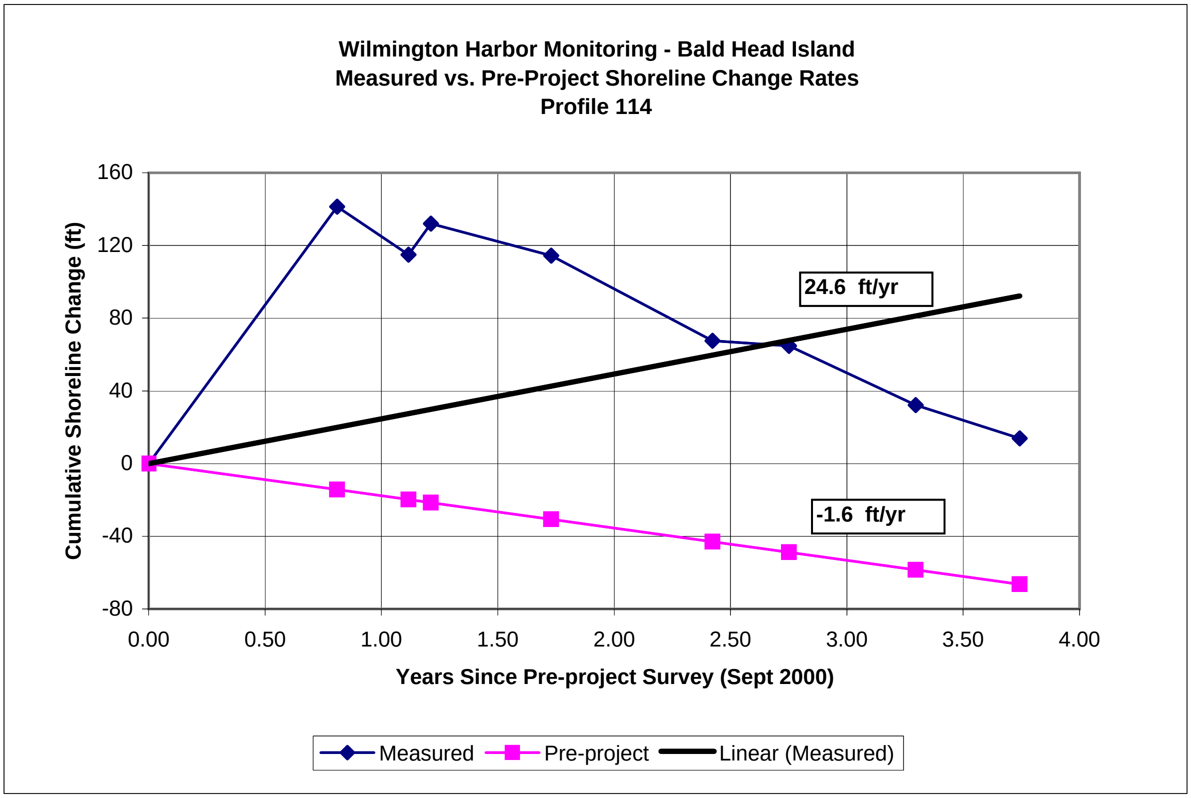

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 92
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-2.3 ft/yr
-2.6 ft/yr
Measured
Pre-project
Linear (Measured)

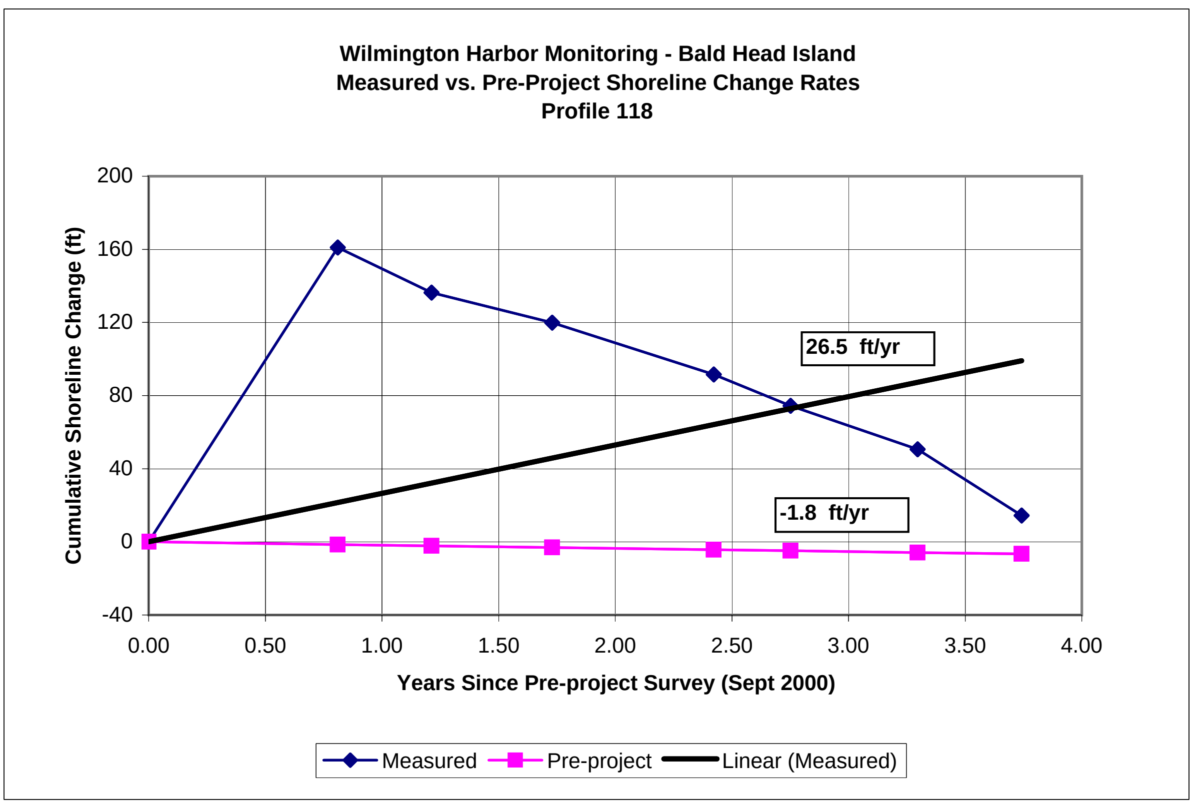

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 97
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
-2.0 ft/yr
-2.9 ft/yr
Measured
Pre-project
Linear (Measured)

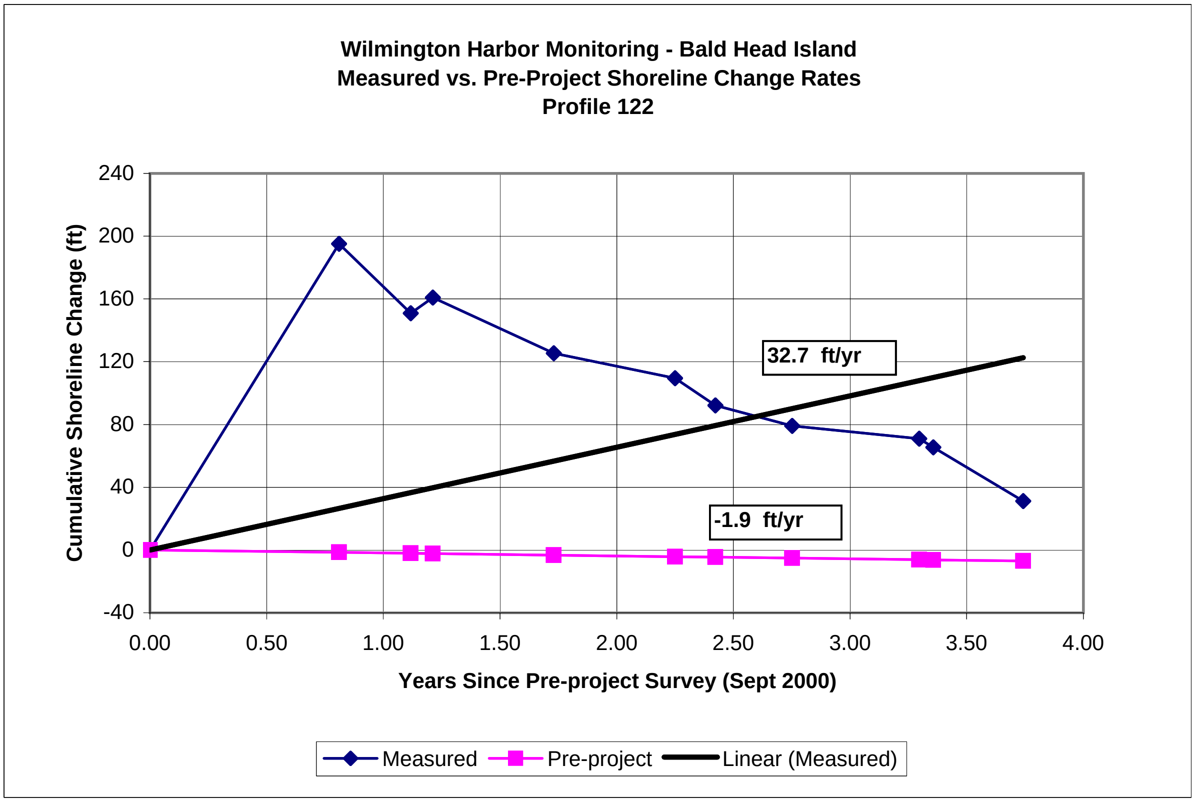

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 102
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
0.2 ft/yr
-1.6 ft/yr
Measured
Pre-project
Linear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

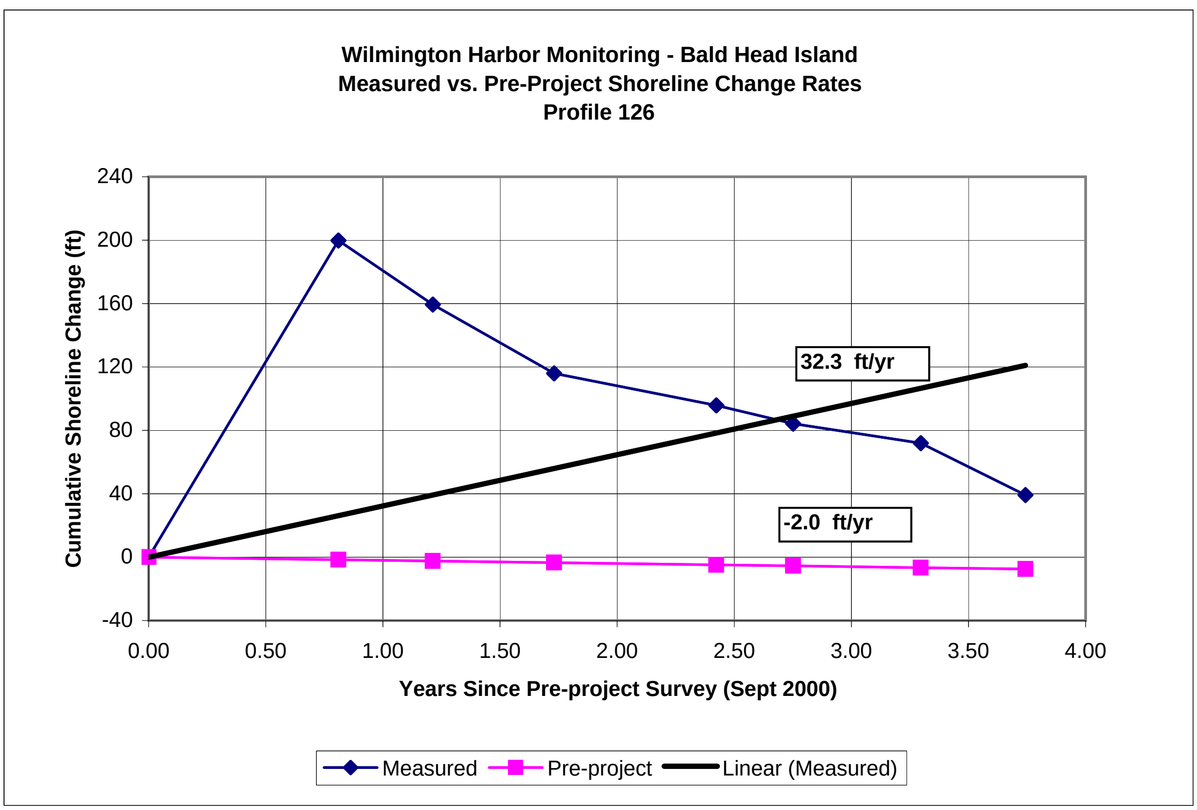

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 106
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
10.1 ft/yr
-1.5 ft/yr
Measured
Pre-project
Linear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

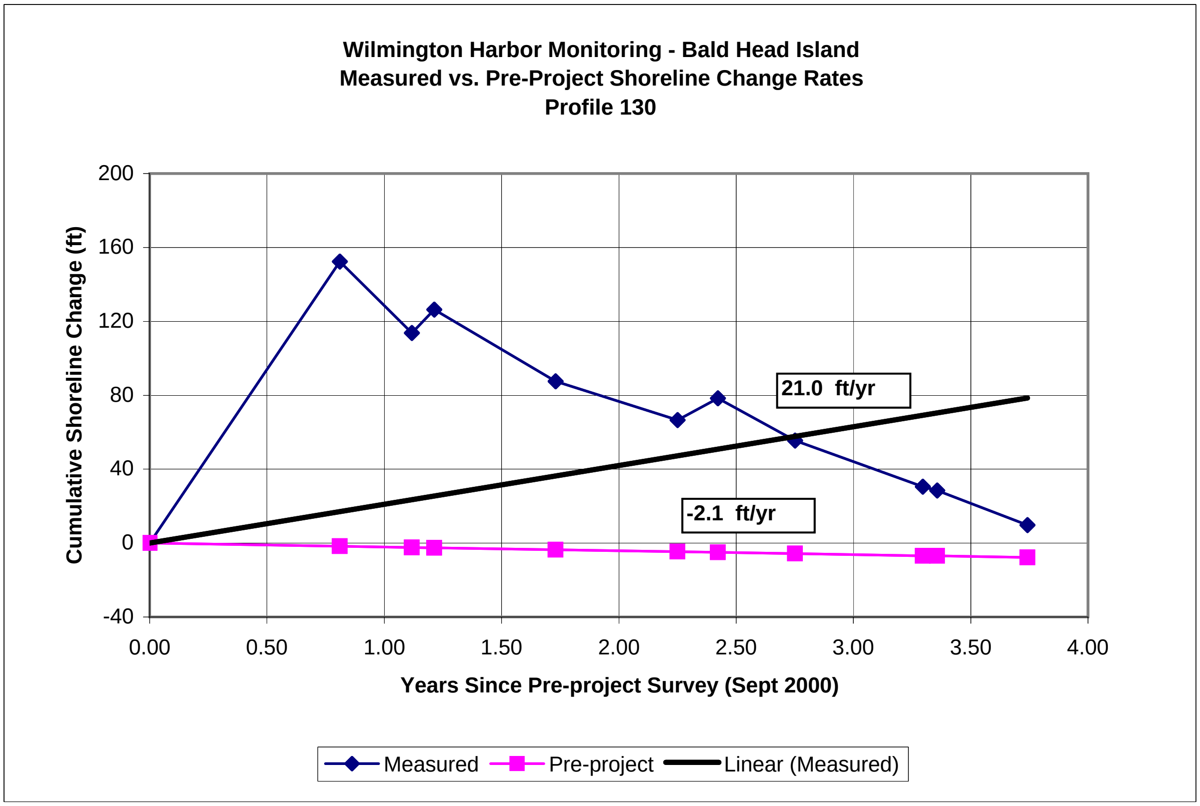

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 110
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
11.6 ft/yr
-1.6 ft/yr
Measured
Pre-project
Linear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

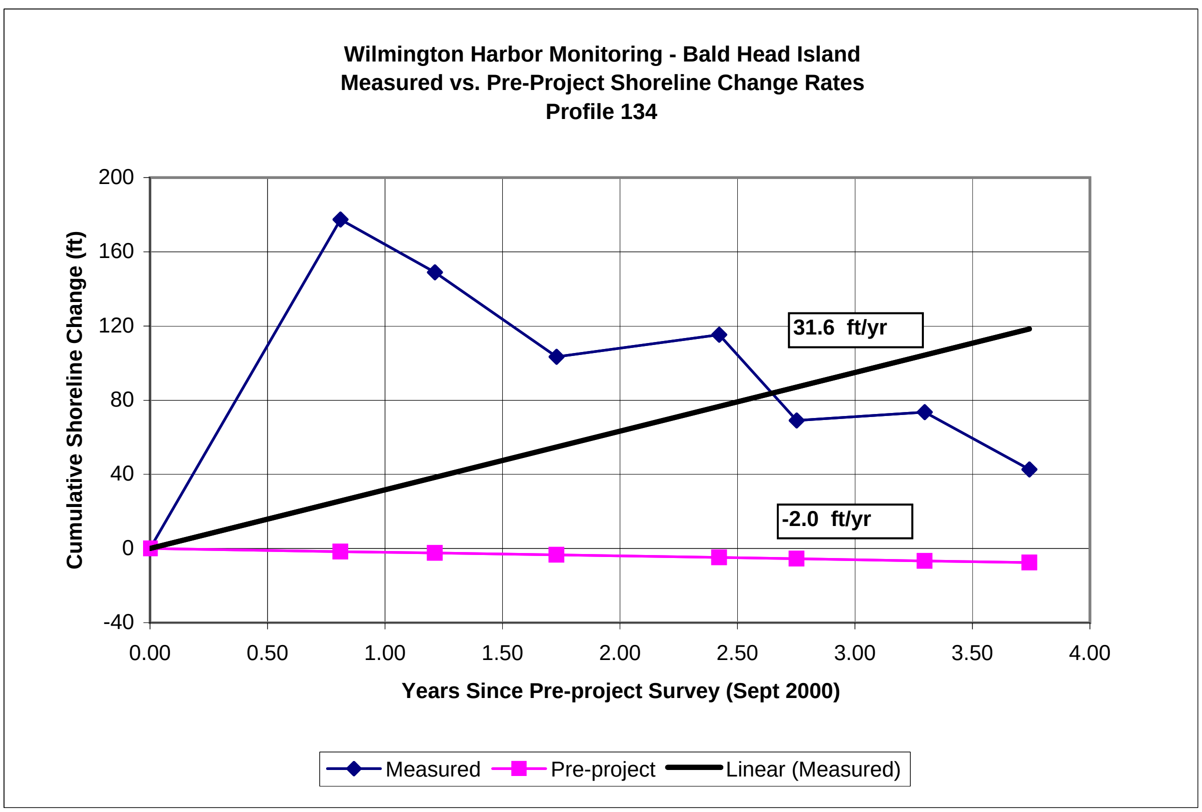

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 114
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
-80
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
24.6 ft/yr
-1.6 ft/yr
Measured
Pre-project
Linear (Measured)

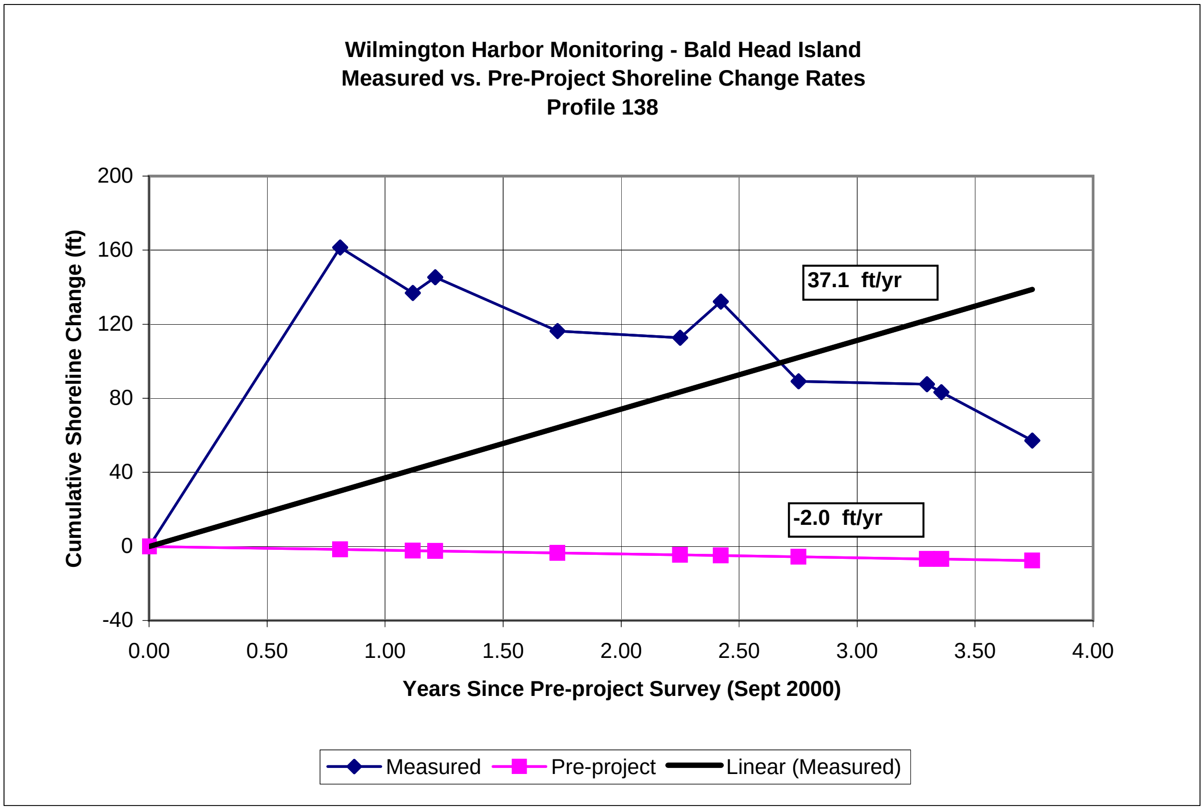

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 118
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
26.5 ft/yr
-1.8 ft/yr
Measured
Pre-project
Linear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

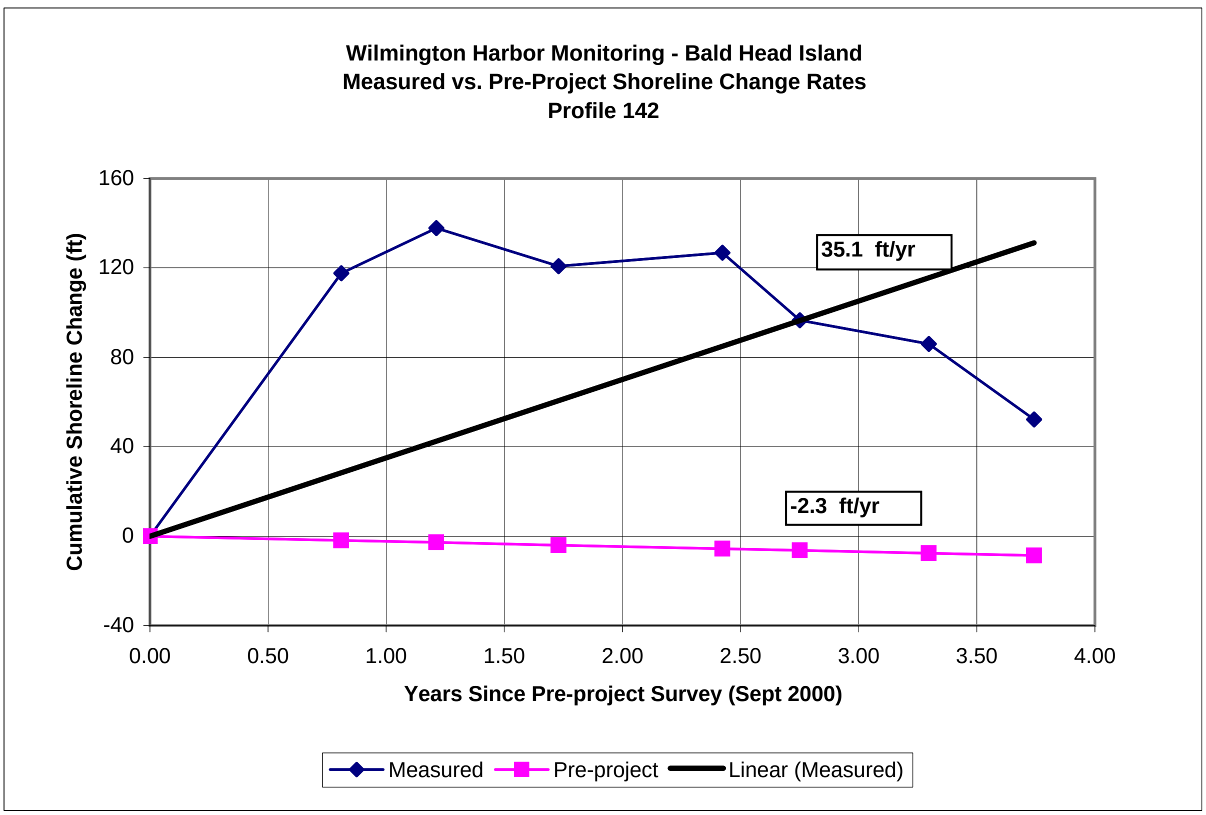

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 122
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
32.7 ft/yr
-1.9 ft/yr
Measured
Pre-project
Linear (Measured)

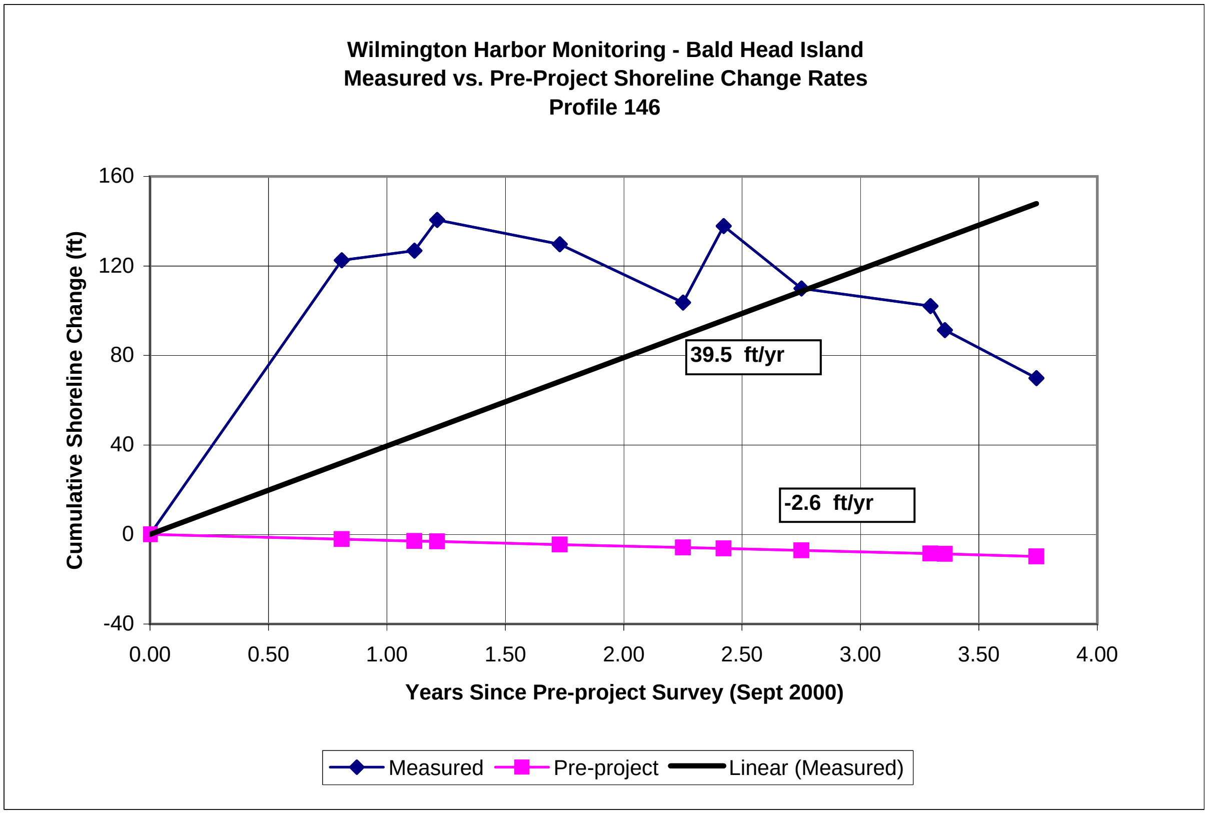

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 126
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
32.3 ft/yr
-2.0 ft/yr
Measured
Pre-project
Linear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

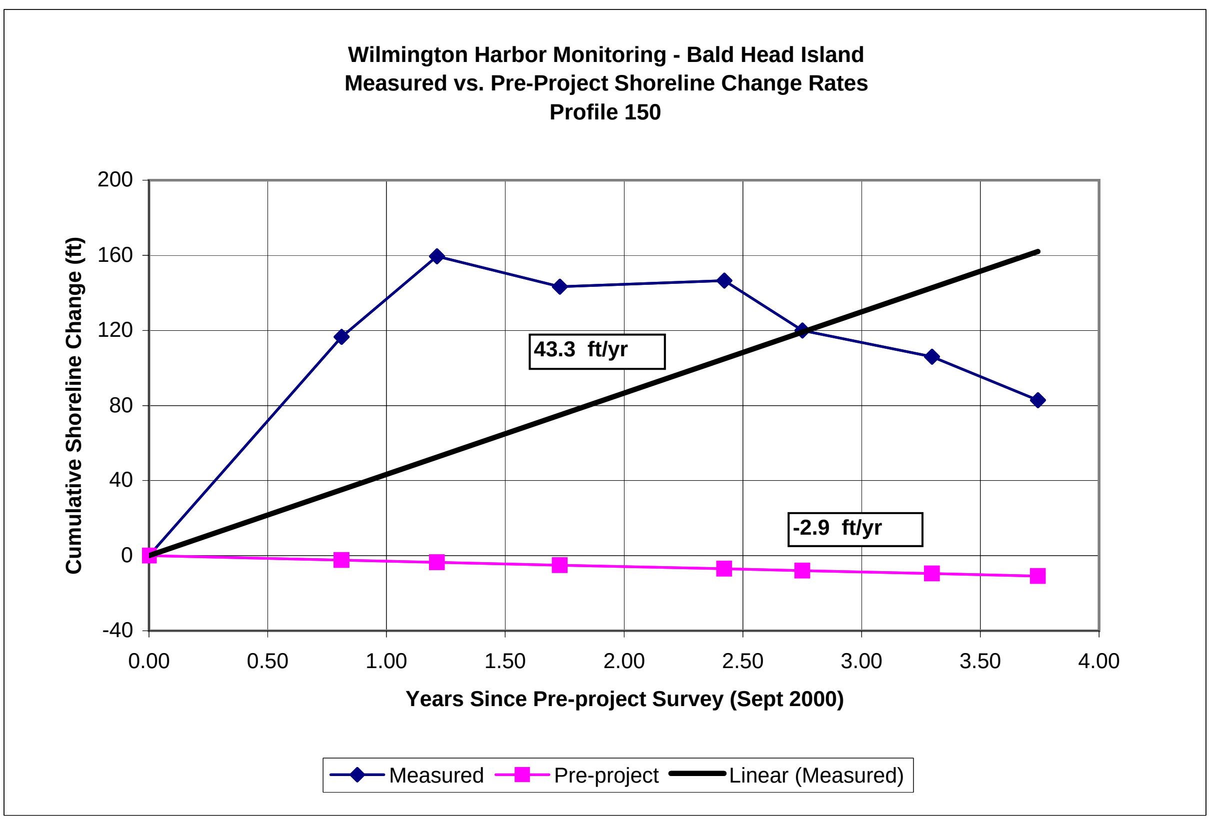

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 130
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
21.0 ft/yr
-2.1 ft/yr
Measured
Pre-project
Linear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

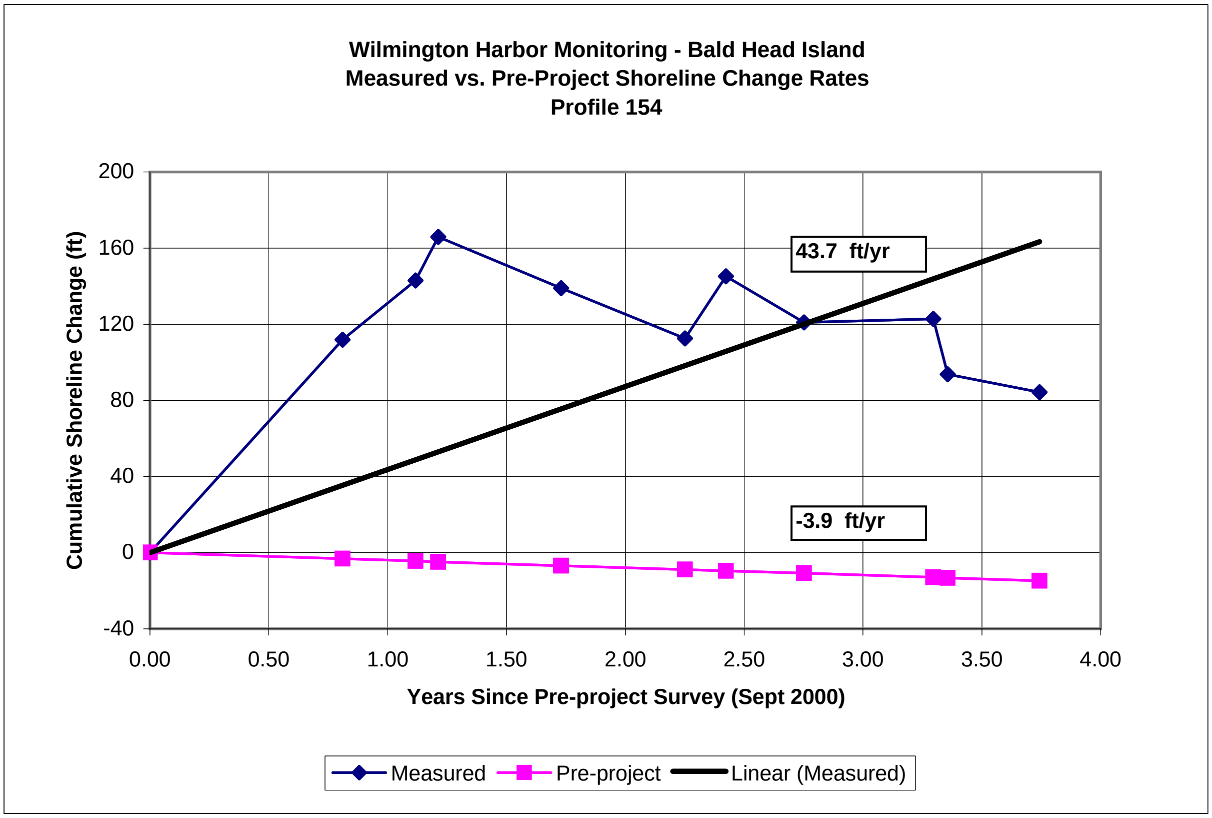

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 134
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
31.6 ft/yr
-2.0 ft/yr
Measured
Pre-project
Linear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

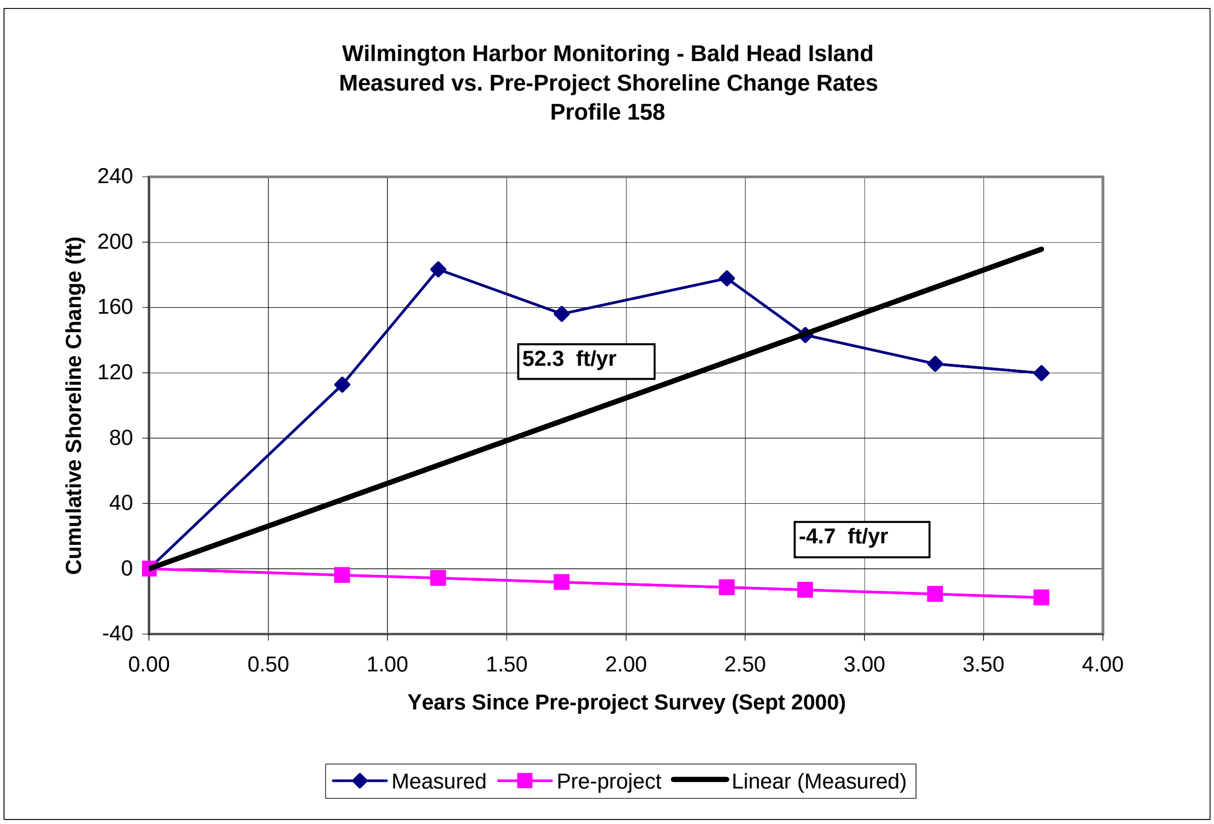

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 138
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
37.1 ft/yr
-2.0 ft/yr
Measured
Pre-project
Linear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

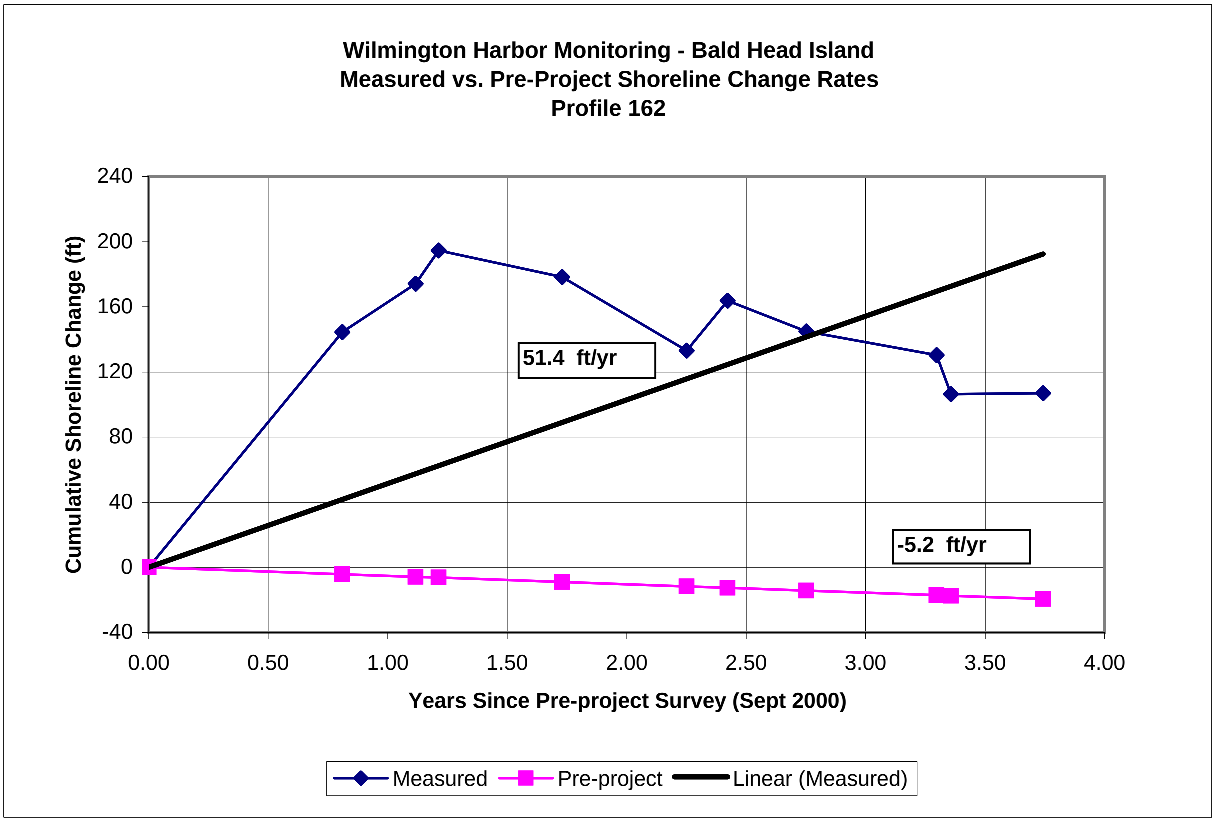

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 142
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
35.1 ft/yr
-2.3 ft/yr
Measured
Pre-project
Linear (Measured)

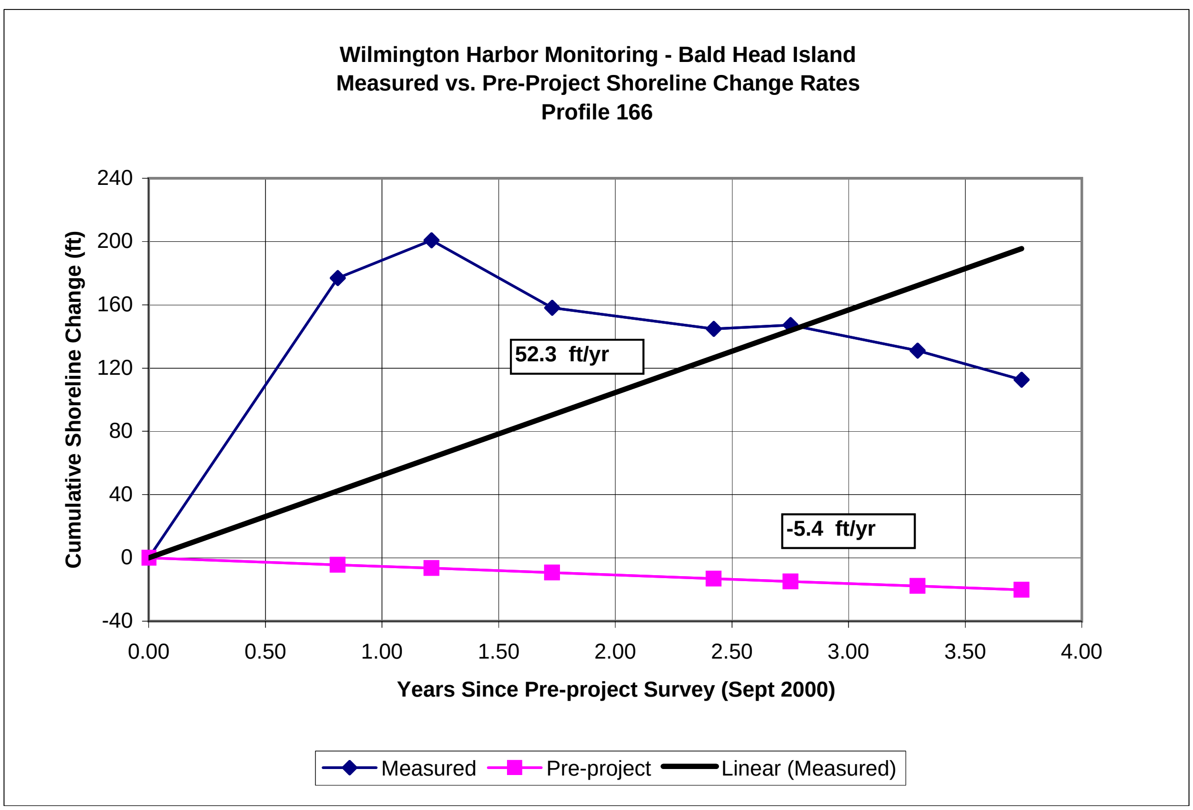

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 146
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
39.5 ft/yr
-2.6 ft/yr
Measured
Pre-project
Linear (Measured)

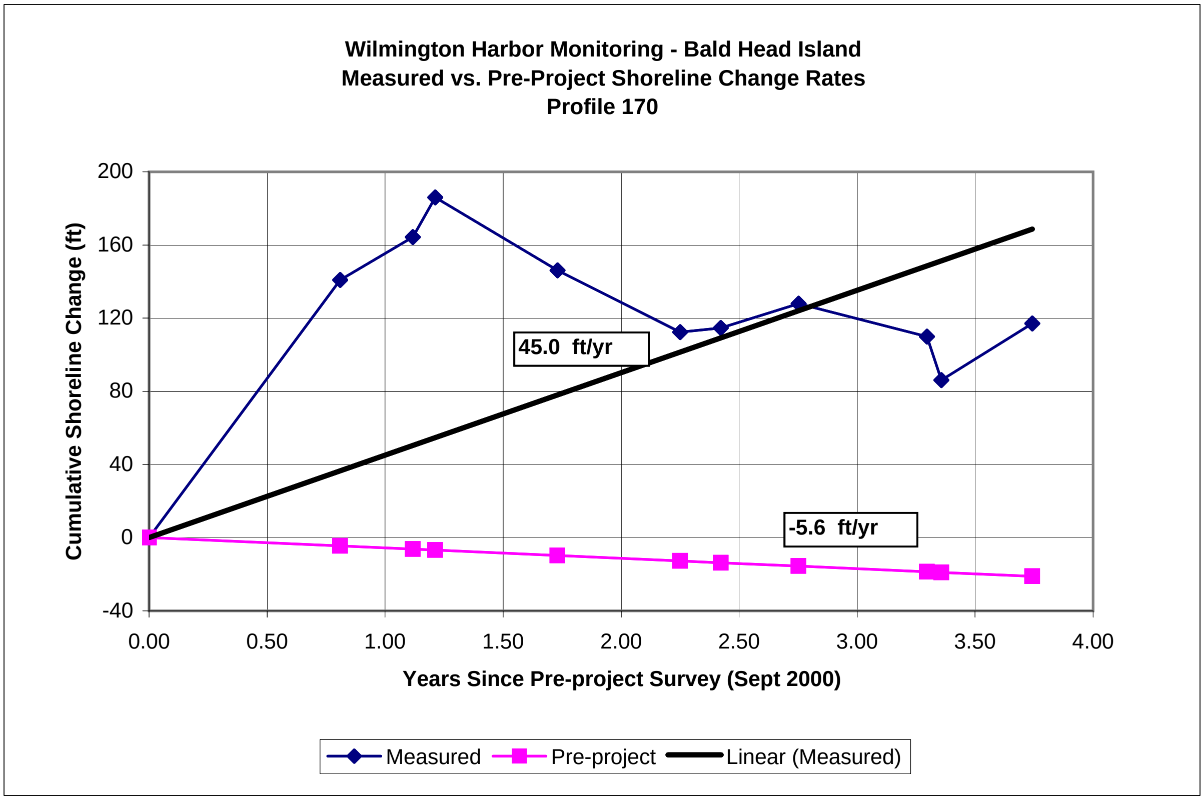

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 150
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
43.3 ft/yr
-2.9 ft/yr
Measured
Pre-project
Linear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

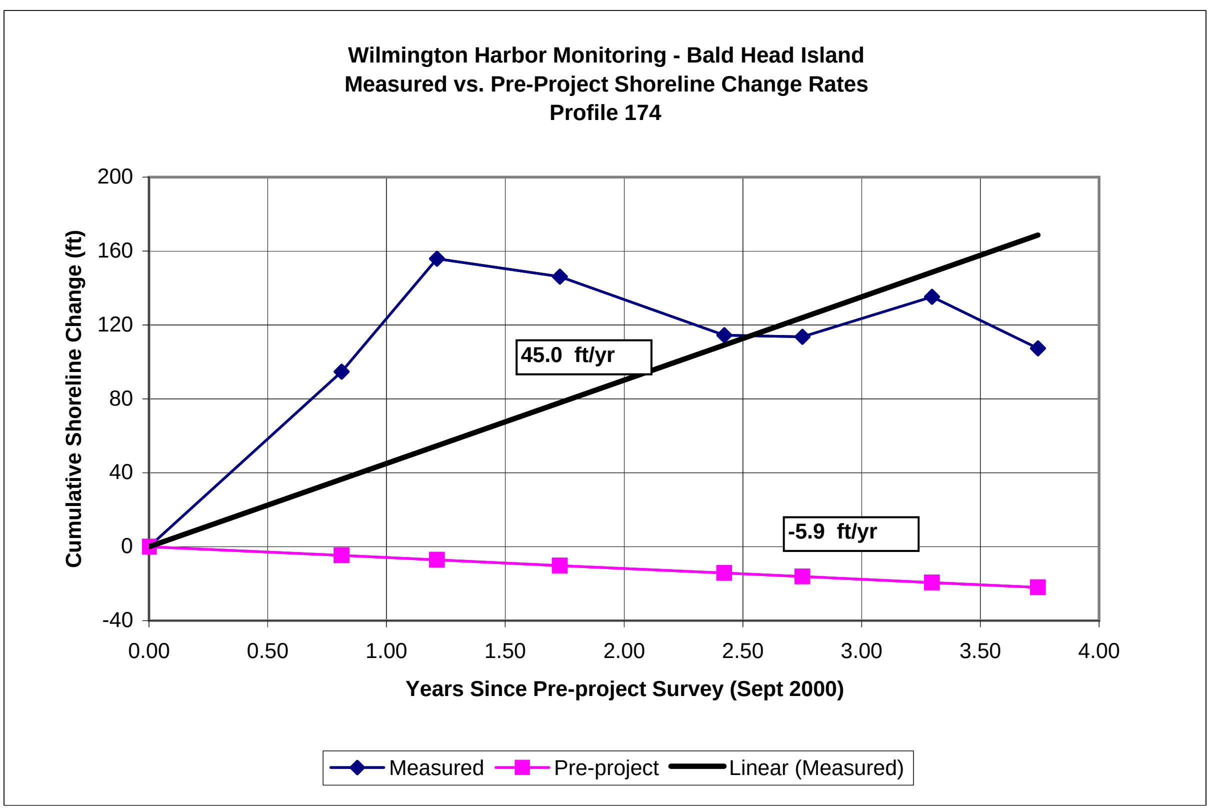

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 154
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
43.7 ft/yr
-3.9 ft/yr
Measured
Pre-project
Linear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

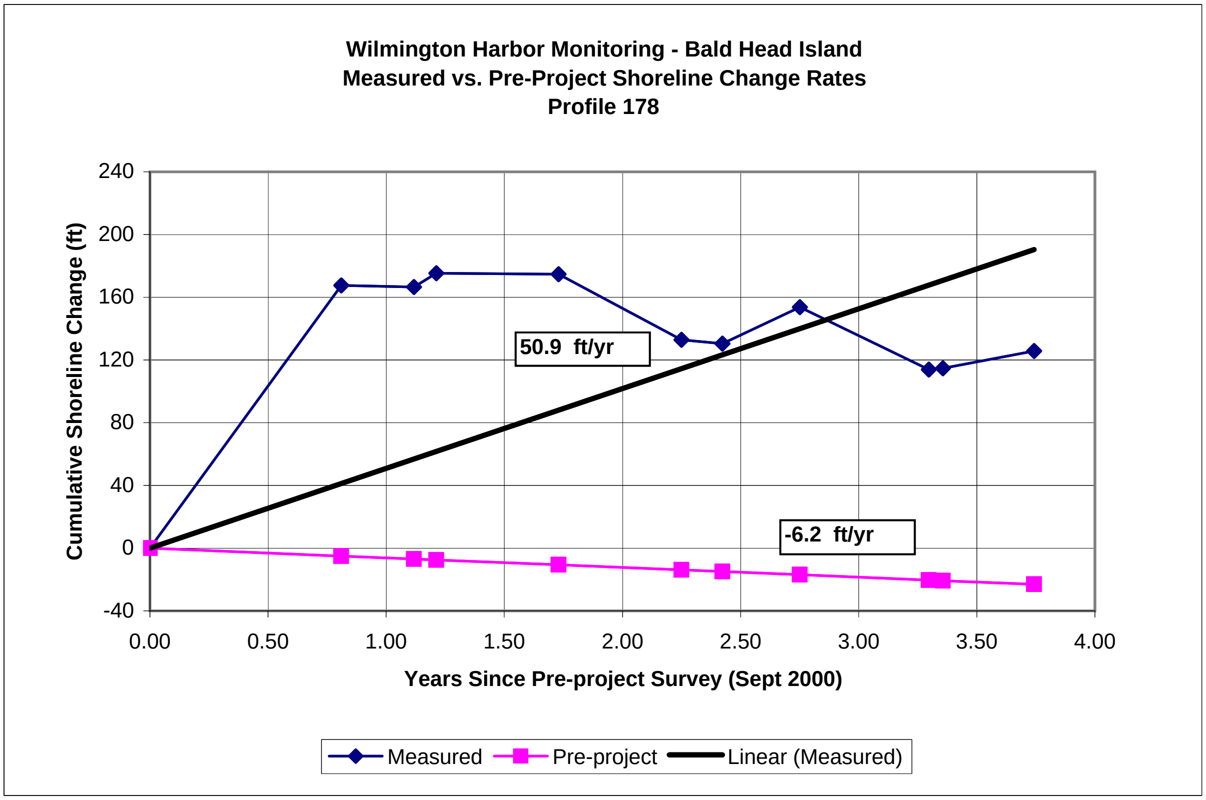

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 158
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
52.3 ft/yr
-4.7 ft/yr
Measured
Pre-project
Linear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

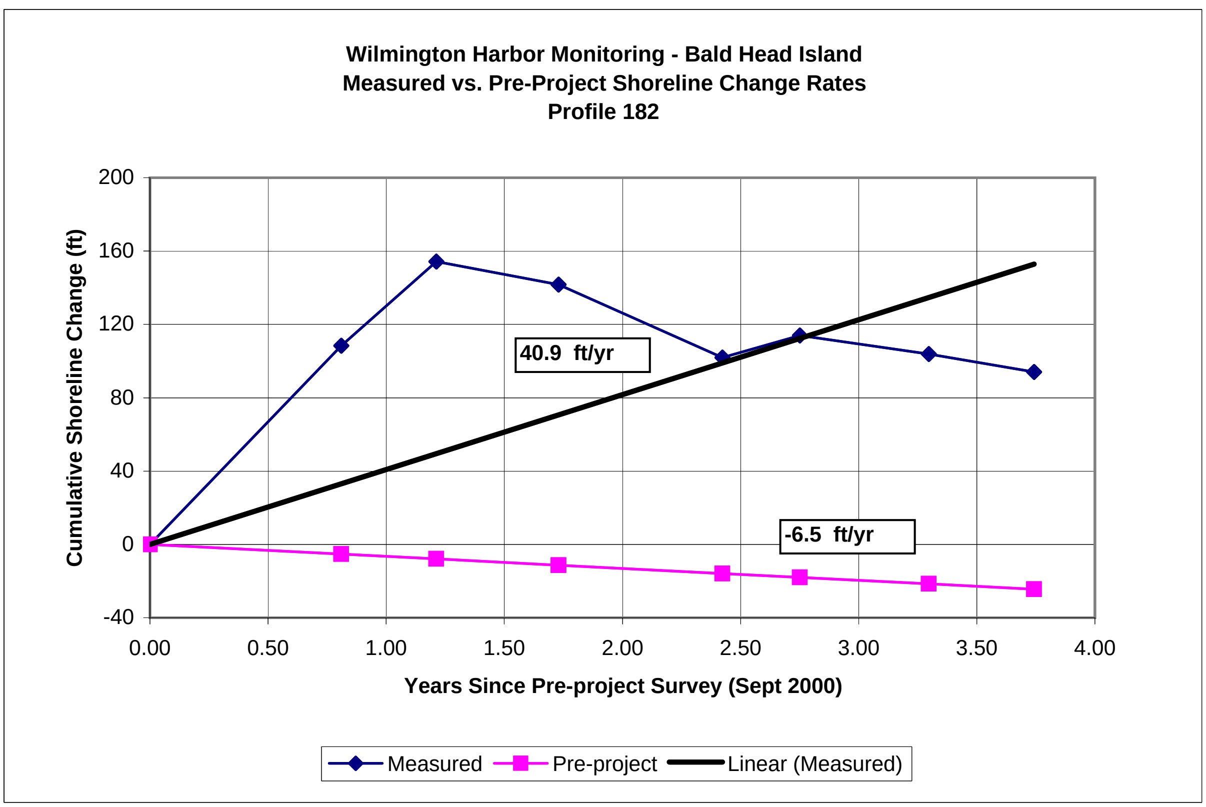

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 162
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
51.4 ft/yr
-5.2 ft/yr
Measured
Pre-project
Linear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

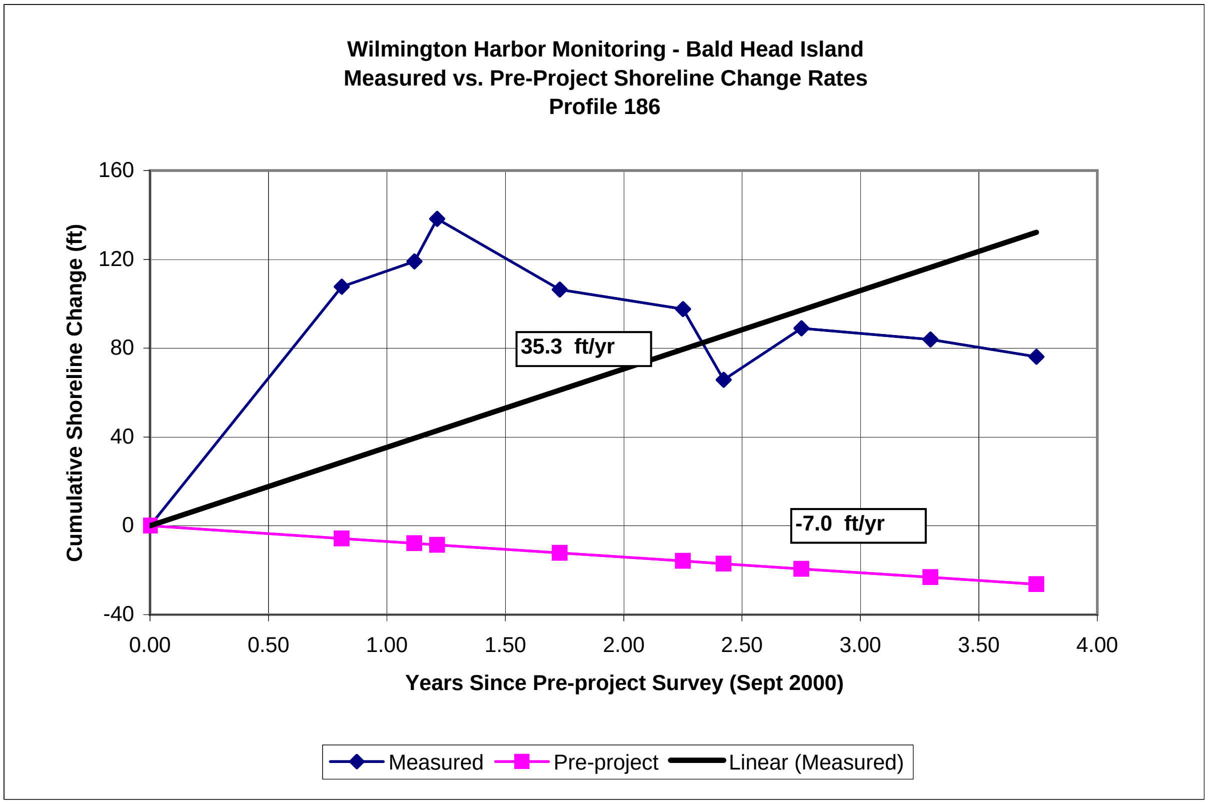

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 166
Cumulative Shoreline Change (ft)
240
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
52.3 ft/yr
-5.4 ft/yr
Measured
Pre-project
Linear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


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

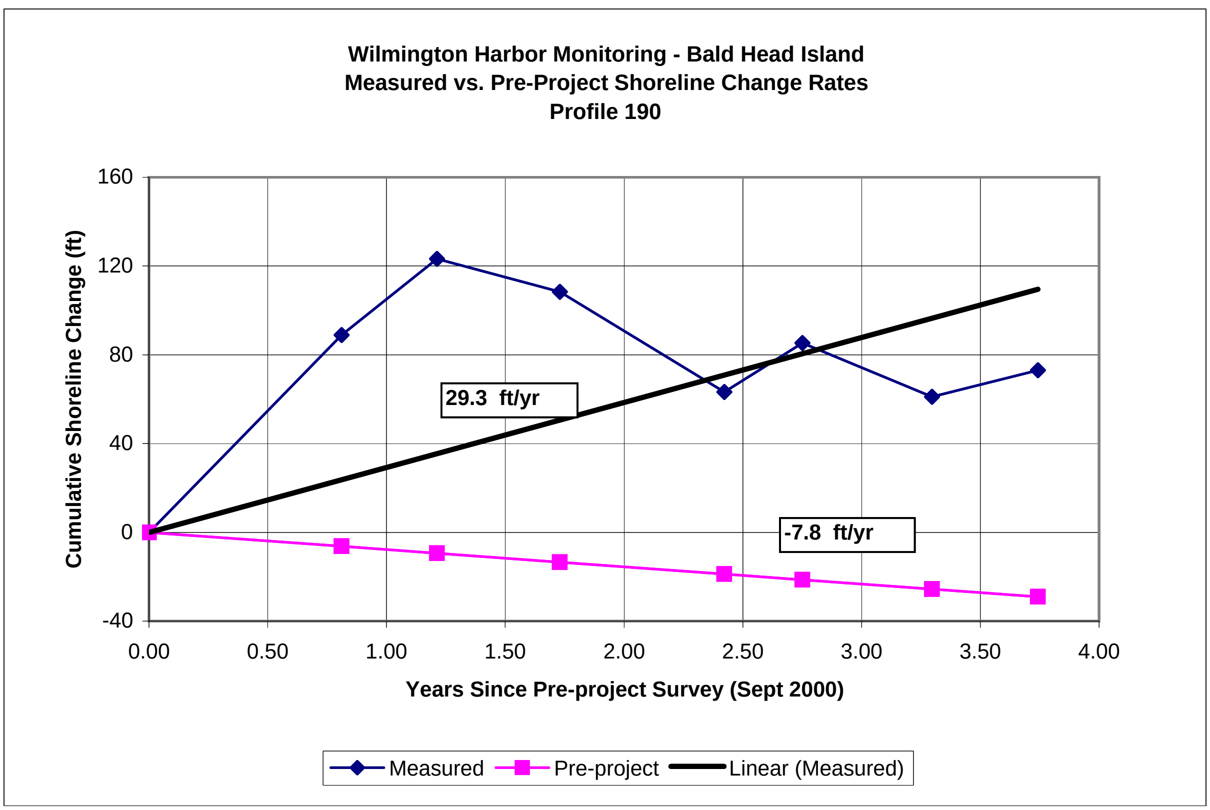

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 174
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
45.0 ft/yr
-5.9 ft/yr
Measured
Pre-project
Linear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


Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 178
Cumulative Shoreline Change (ft)
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
Years Since Pre-project Survey (Sept 2000)
50.9 ft/yr
-6.2 ft/yr
Measured
Pre-project
Linear (Measured)

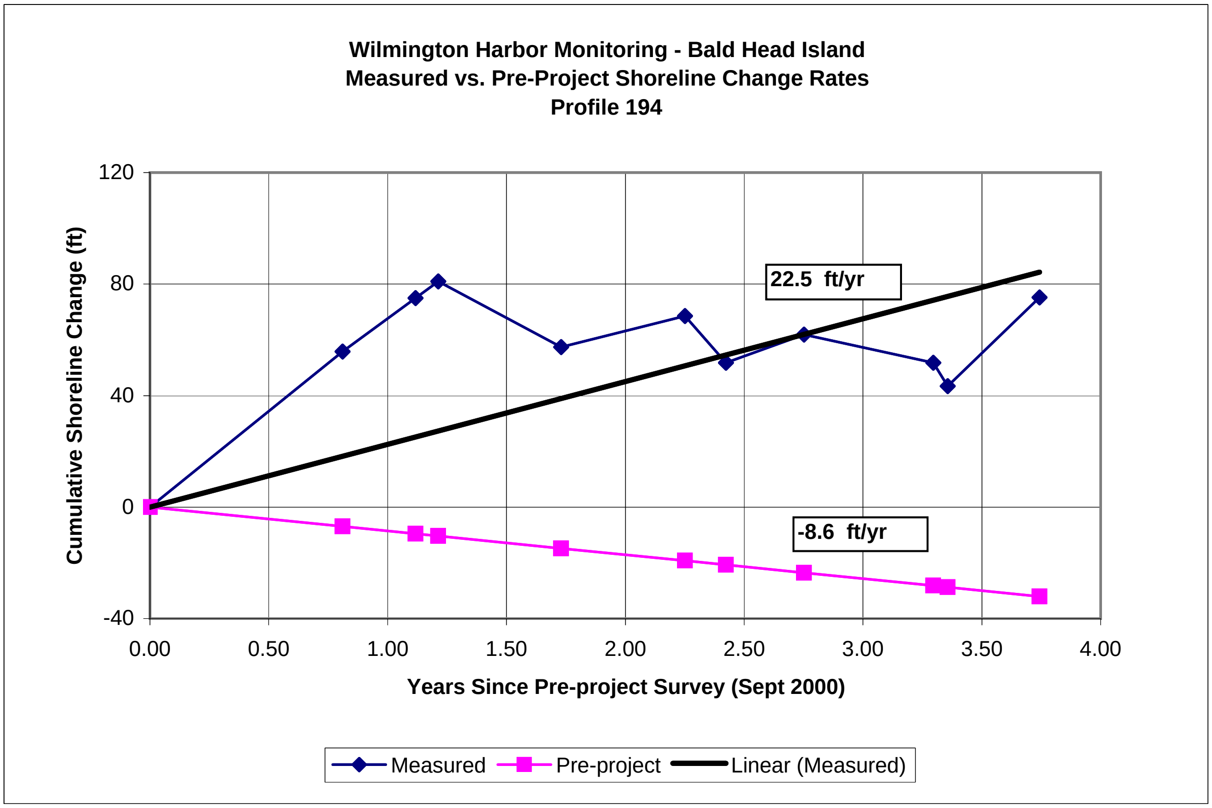

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 182
Cumulative Shoreline Change (ft)
200
160
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
40.9 ft/yr
-6.5 ft/yr
Measured
Pre-project
Linear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

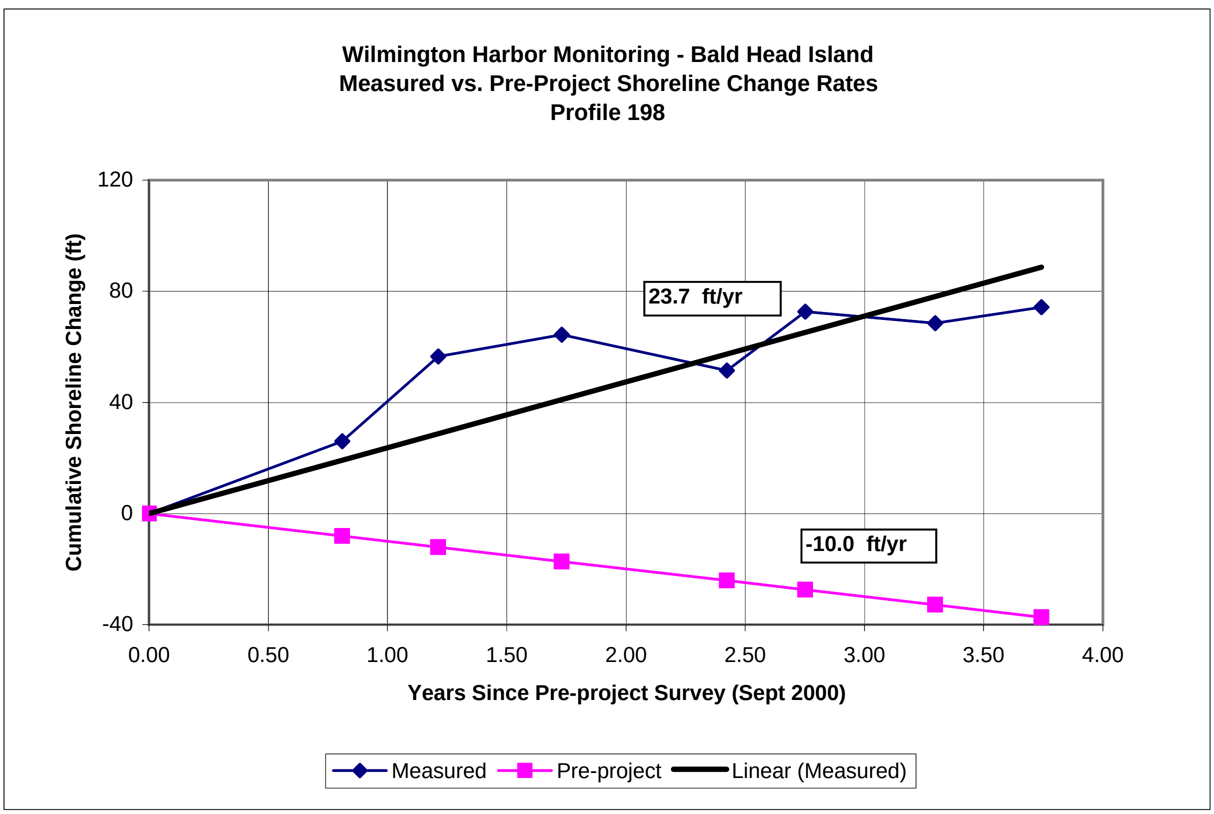


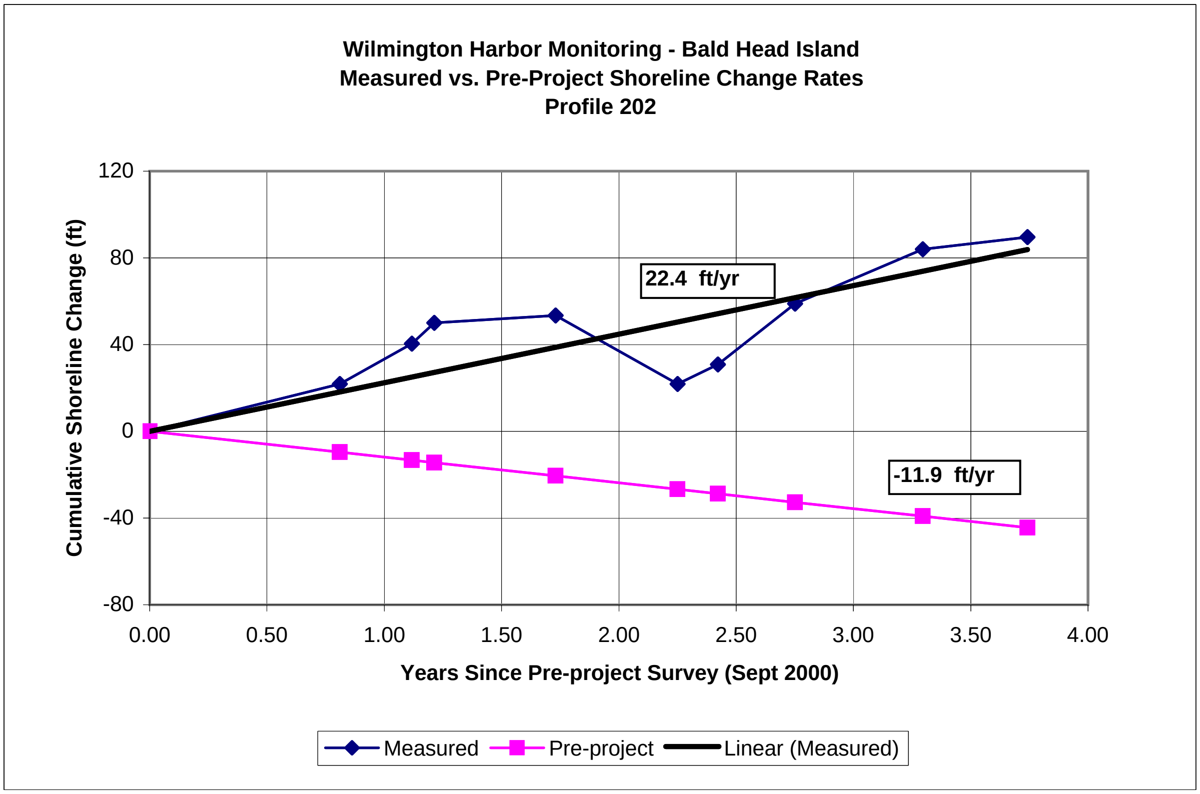
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 186
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
35.3 ft/yr
-7.0 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

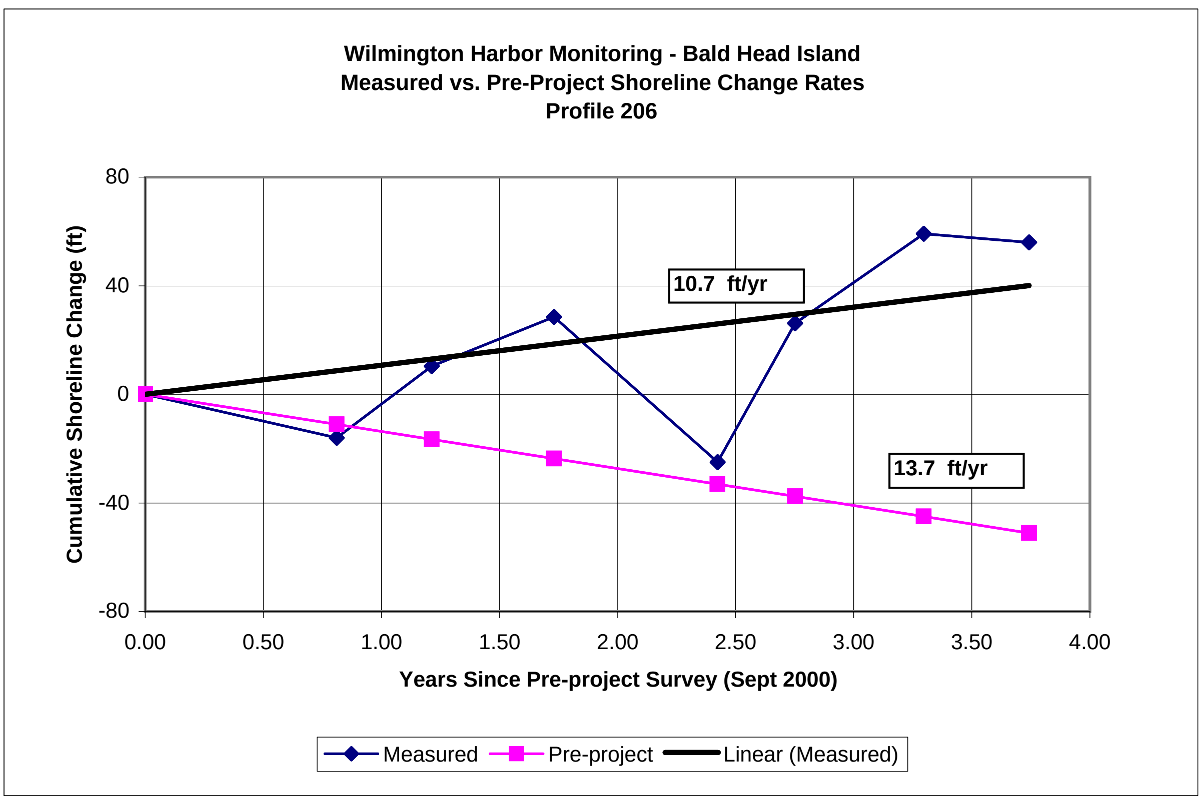


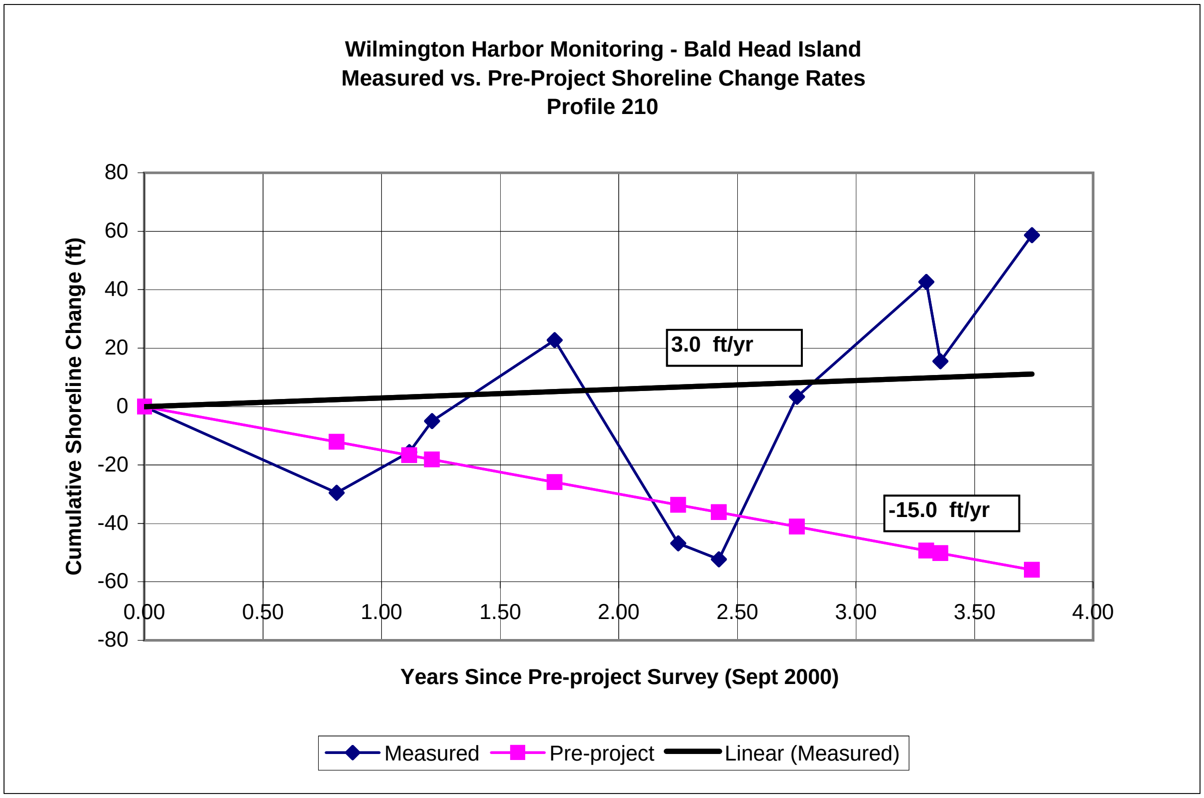
Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 190
Cumulative Shoreline Change (ft)
160
120
80
40
0
-40
29.3 ft/yr
-7.8 ft/yr
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
Measured
Pre-project
Linear (Measured)

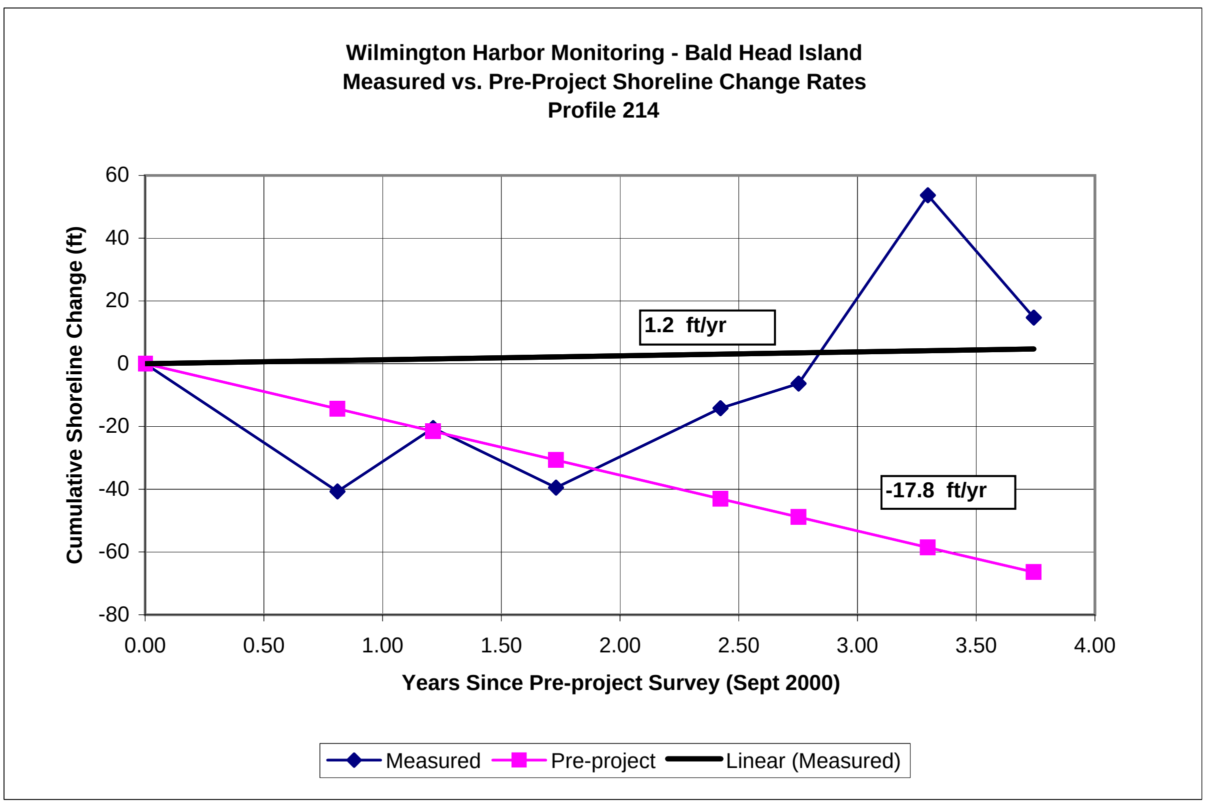

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 194
Cumulative Shoreline Change (ft)
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
22.5 ft/yr
-8.6 ft/yr
Measured
Pre-project
Linear (Measured)

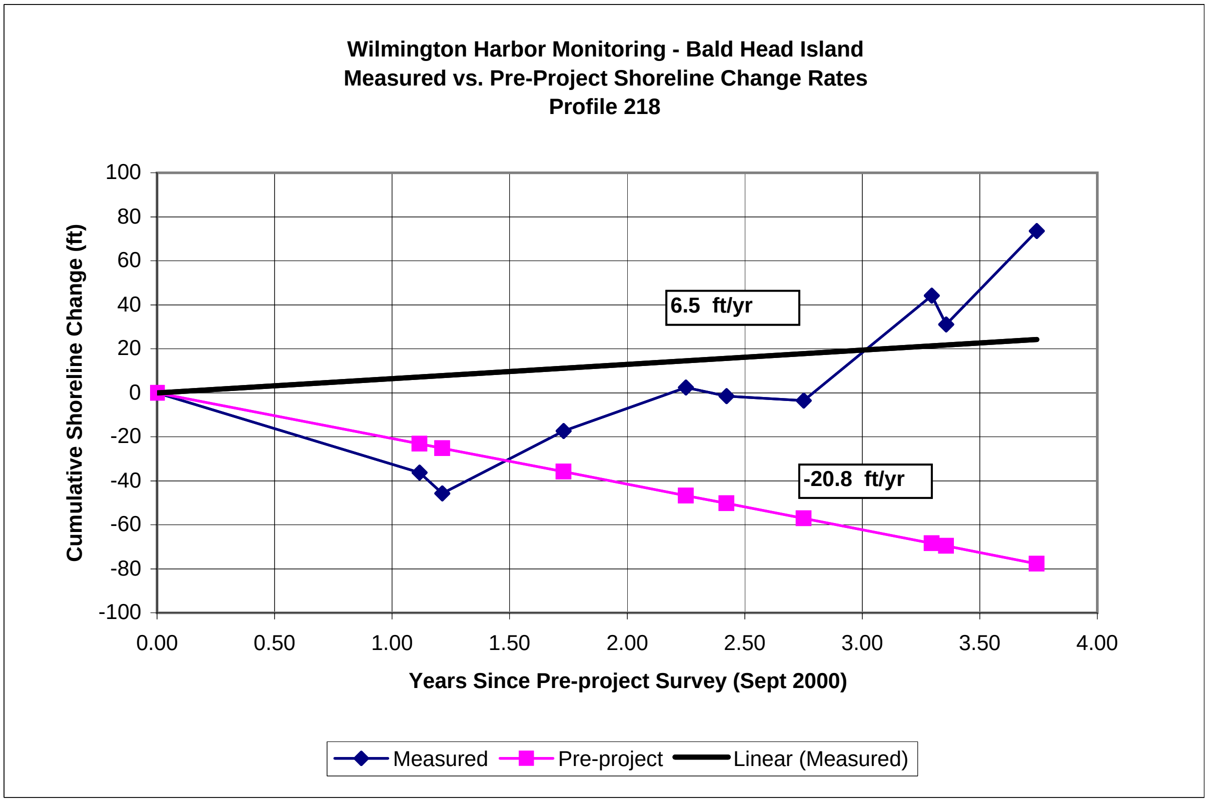

Wilmington Harbor Monitoring - Bald Head Island
Measured vs. Pre-Project Shoreline Change Rates
Profile 198
Cumulative Shoreline Change (ft)
120
80
40
0
-40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Years Since Pre-project Survey (Sept 2000)
23.7 ft/yr
-10.0 ft/yr
Measured
Pre-project
Linear (Measured)


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


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


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


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


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