7.0 BEACH PROFILE AND SHORELINE CHANGES

In general, available beach profile data along both Bogue Banks and Shackleford Banks are greatly limited by the dates, alongshore extent, offshore extent, apparent accuracy, and/or non-alignments between surveys. The data do not readily allow definitive quantitative conclusions of shoreline, beach profile and volume changes over great lengths of time or coastline. However, the available data exhibit consistent trends and order-of-magnitude values of beach volume changes west of the inlet. Detailed description of the data and analyses is presented in ***Appendix C*** and summarized below.

7.1 Database

Historical Shoreline Data. Historic shorelines are indicated on maps from the 1800's through the 1940's prepared by the National Ocean Survey (formerly U. S. Coast and Geodetic Survey and U.S. Coast Survey). Beyond the inherent limitations of the physical charts and measurement accuracy, the shoreline which was "mapped" on a chart

can vary from the limit of wave uprush ("rack line"), to a visual estimate of the shoreline from aerial photographs, to an actual surveyed high water shoreline. All of these factors introduce significant uncertainty and inaccuracy in the historical charts. These maps are useful in identifying general trends and gross shoreline movements (such as illustrated in Figure 17 on page 33, above). However, their accuracy is *not* deemed adequate for quantifying comparative changes in shoreline location. More accurate shoreline locations are derived from beach profile survey data, but these data are limited to the availability of reliable surveys, as described below.

Beach Profile Data – Shackleford Banks. Available beach profile data for Shackleford Banks are limited to Corps surveys in July 1991 and in October 2000. Both surveys include 24 transects spanning most of the island, and extend to -30 ft NGVD offshore depth.

Beach Profile Data – Bogue Banks. Along Bogue Banks, comparative beach profile surveys extending to a meaningful offshore depth are very limited in scope and time-frame. The surveys include:

- Corps profiles to deepwater from 1958 to November 2000 along the eastern 5 to 6 miles of Bogue Banks (to western Atlantic Beach), at about 8 consistently repeated transects. [Additional transects were profiled, but not on a regular basis. Some of the intermediate-date surveys are of suspect accuracy.[14]]
- Coastal Science & Engineering (CSE) profiles from June 1999 to June 2004 along all of Bogue Banks comprising four complete datasets. [Of these, however, only the December 2003 and June 2004 surveys consistently extended to deepwater; the remainder of the surveys extended to only -11 to -15 ft NGVD. Surveys in 2005 were not analyzed in the present study. The CSE profiles do not align with the Corps surveys, and inter-comparison with the Corps data was not possible.]
- One year of UNC-Chapel Hill profiles between May 2002 and April 2003 along Bogue Banks, at locations more or less coincident with the CSE surveys.

In sum, long-term (c. 1958) profiles along Bogue Banks extend only to about 5 miles west of the inlet. These profiles, conducted by the Corps, are spaced about 3500-ft apart and are of mixed quality. Comparative surveys comprising all of Bogue Banks, as conducted by CSE/UNC, comprise only the last five years; of which only a 2-year period includes profiles extending offshore to depths of closure (excluding the most recent 2005 surveys). Essentially all of these surveys include beach-fill placement, which greatly complicates interpretation of shoreline and volume changes.

[14] There is also a 2001 (Corps?) survey for which the profile locations did not appear to align with the prior surveys. This survey, referred to in the Corps' Section 111 report, was not used in the present study.

7.2 Shoreline Change, Beach Volume Change and Depth of Closure

The theoretical beach profile depth above which sand movement is expected -- the "depth of closure" -- is about 22.6 feet along Bogue Banks[15]. This suggests that beach volume changes likely extend to about 20+ feet of water depth -- at or beyond which there should normally be little change in profile elevation.

Most of the Corps' beach profiles fail to "close" at 20+ ft depths, with vertical differences in offshore elevations often exceeding 5 feet along eastern Bogue Banks. These profiles are located within 5-6 miles west of the inlet, and generally show a trend of offshore deepening ("vertical deflation"), described in Section 7.5, below.

The CSE/UNC data do not allow comparison of offshore volume changes and seabed elevations beyond about 2 years. Prior to 2002, the profiles extend to only about -11 ft or -15 ft NGVD. Later, where profiles extend further offshore, volume changes computed to -20 or -30 ft are several times greater than those computed above -11 or -15 ft depth. Some of the offshore changes may be survey 'noise' which is difficult to discriminate from real seabed fluctuation. However, along Bogue Banks, the available survey data indicate a fairly consistent trend of measurable volume losses below depths of -15 ft which reflect deepening ("deflation") of the offshore beach profile. It is thus important that future beach profile surveys extend to at least -25 to -30 ft NGVD for purposes of long-term comparison and analyses. While the complete *quantitative* accuracy of volume changes at these offshore depths remains somewhat uncertain, trends and order-of-magnitude volume changes can be readily discerned from these survey data.

Along both Bogue and Shackleford Banks, volume changes are poorly correlated with shoreline changes. Generally, volume erosion is greatly underpredicted by changes of the mean high waterline. For example, the 1958-2000 survey data – beyond 2 miles west of the inlet -- suggest volume losses of over -8 cy/ft for minimal (zero) net shoreline change. Island-wide, the 2002-04 survey data suggests volume losses that exceed -20 cy/ft for zero net shoreline change. Overall, this means that conventional shoreline change modeling at this location will not necessarily yield accurate estimates of beach volume change, and vice-versa. Likewise, this means that interpretations of shoreline change do *not* accurately describe the overall physical behavior of the beach.

Shoreline changes derived from beach profile data do not, of course, depend upon the surveys' offshore depth limit. Instead, however, shoreline changes are highly dependent upon the *date* of the surveys – particularly relative to beach fill or storm activity. The effects of beach fill can be approximately 'removed' from volumetric comparisons; but the fill effects cannot be readily removed from shoreline comparisons.

[15] Hallermeier, 1978. Tidal datum unspecified. Computed from local wave hindcast data.

7.3 Shackleford Banks

7.3.1 Shoreline Change (Shackleford Banks)

Comparison of the Corps' 1991 and 2000 surveys along Shackleford Banks shows mixed recession and advance of the shoreline (***Figure 27***). Along the 1-mile shoreline closest to the inlet, the shoreline exhibited erosion equating to -5 to -25 ft/yr. On overall average, the shoreline was mostly erosional; however, because of alongshore variations and the limited (single-interval) comparison, it is difficult to draw a single conclusion of recent shoreline trends for Shackleford Banks.

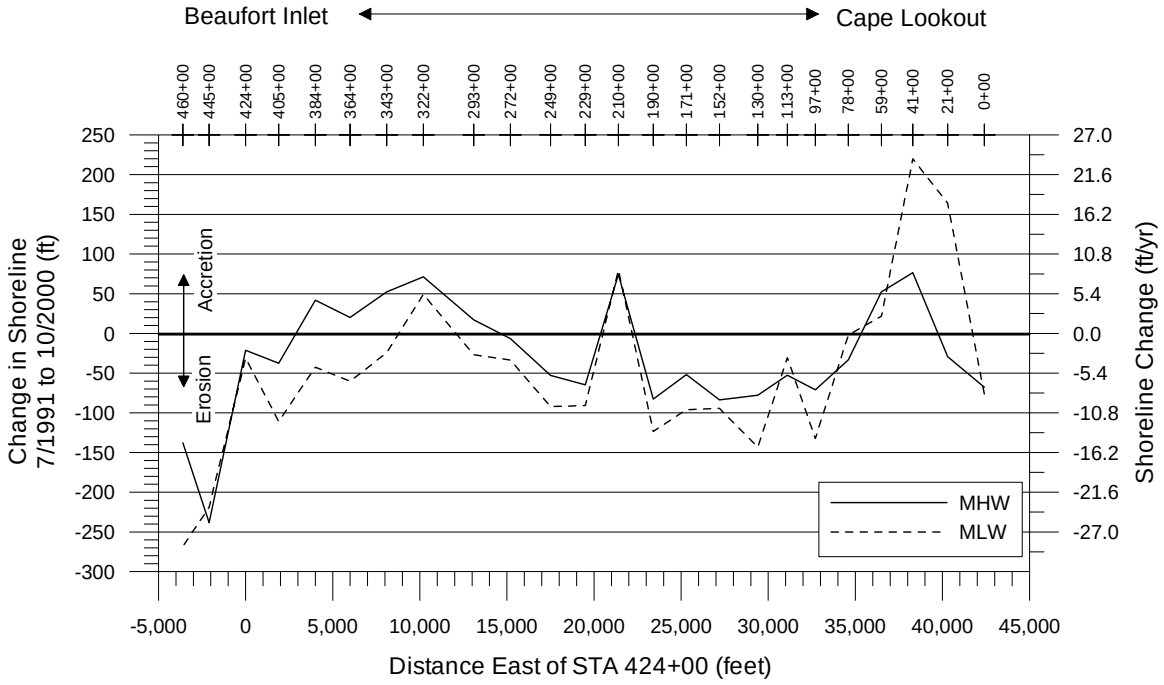


Figure 27: Change in Mean High Water (MHW) and Mean Low Water (MLW) shorelines along Shackleford Banks, east of the inlet; July 1991 to October 2000.

7.3.2 Beach Volume Change (Shackleford Banks)

Beach volume changes along Shackleford Banks, from 1991 to 2000, were uniformly erosional alongshore. Overall, on annual average, the profiles suggest volume losses of -930,000 cy/yr, measured above -30 ft NGVD depths. See ***Figure 28.*** This value agrees with the Corps' Section 111 report of -906,200 cy/yr, using the same data. Volume losses computed above -30 ft depth were 3.6 times greater than those computed above -11 ft depth.

Immediately along the inlet shoreline, near Shackleford's western tip, profile lines are too short to develop a volume change estimate. (This is the far left area of Figure 28, below.) Overall, shoreline changes are weakly correlated to volume changes. On average, the profile data suggest volumetric erosion of between -46 and -145 cy/ft for *zero* change in shoreline location. The accuracy of these data is unknown.

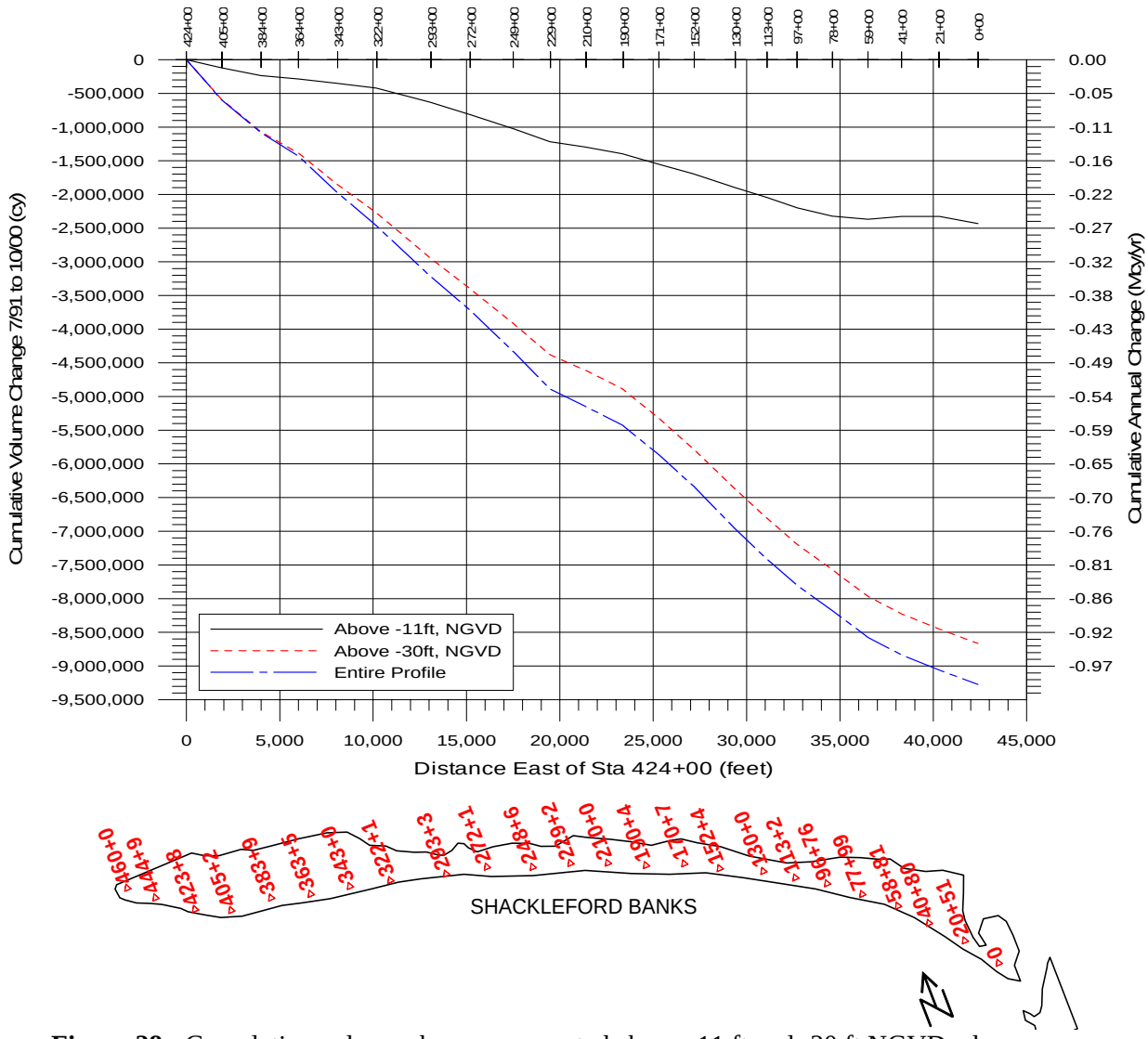


Figure 28: Cumulative volume changes computed above -11 ft and -30 ft NGVD, along Shackleford Banks, from July 1991 to October 2000.

7.4 Bogue Banks

7.4.1 Shoreline Change (Bogue Banks)

1958-2000. Shoreline data from 1958 to 2000 are limited to Ft. Macon and Atlantic Beach. Shoreline changes vary greatly depending upon the survey date and prior beach fill activity; and as such, are limited in physical meaning. ***Figure 29*** illustrates examples of mean high waterline (MHWL) changes for the periods 1958-1979-2000. Interpretation of the data is a function of the beach fill activities that preceded the survey dates.

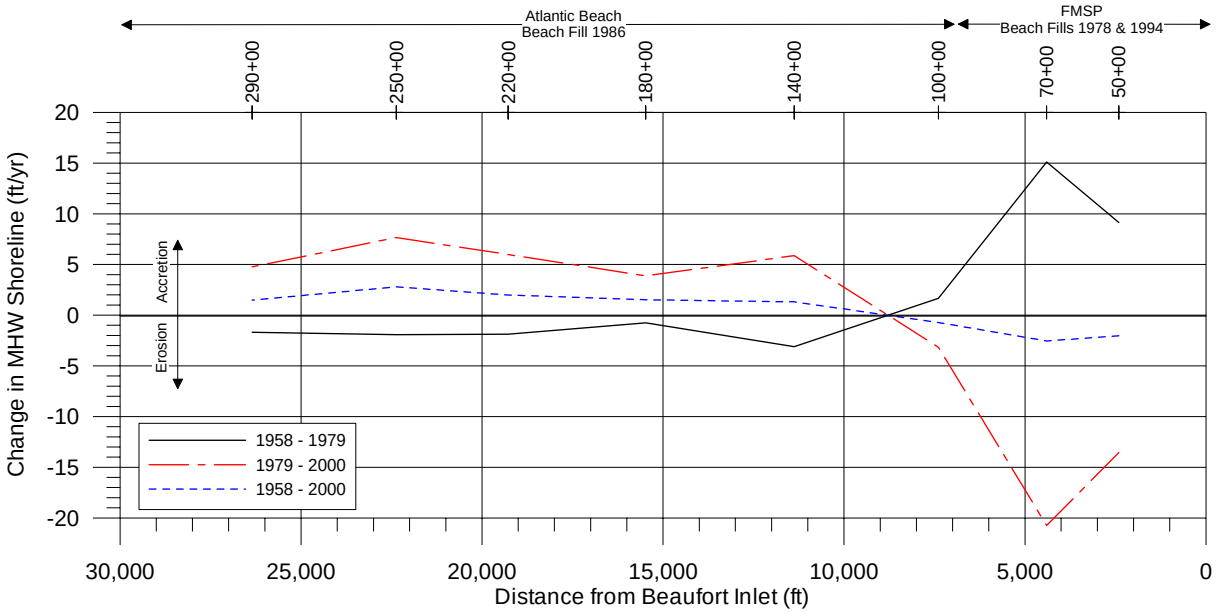


Figure 29: Average-annual mean high water shoreline change along eastern Bogue Banks, 1958-2000. (Effects of beach fill are included).

Changes in location of the mean high waterline (MHWL) and dune-face contours are irregularly correlated. ***Figure 30***, on the following page, compares the MHWL and +10 ft contour changes for the period 1991-2000. The +10' contour is mostly above the typical beach berm and fill elevations, but may be subject to localized dune fill. During this period, in some locations (such as central Atlantic Beach), the dune face exhibited 50 to 100 ft of recession while the MHWL was mostly unchanged. Elsewhere, the dune face exhibited similar or less recession than the MHWL.

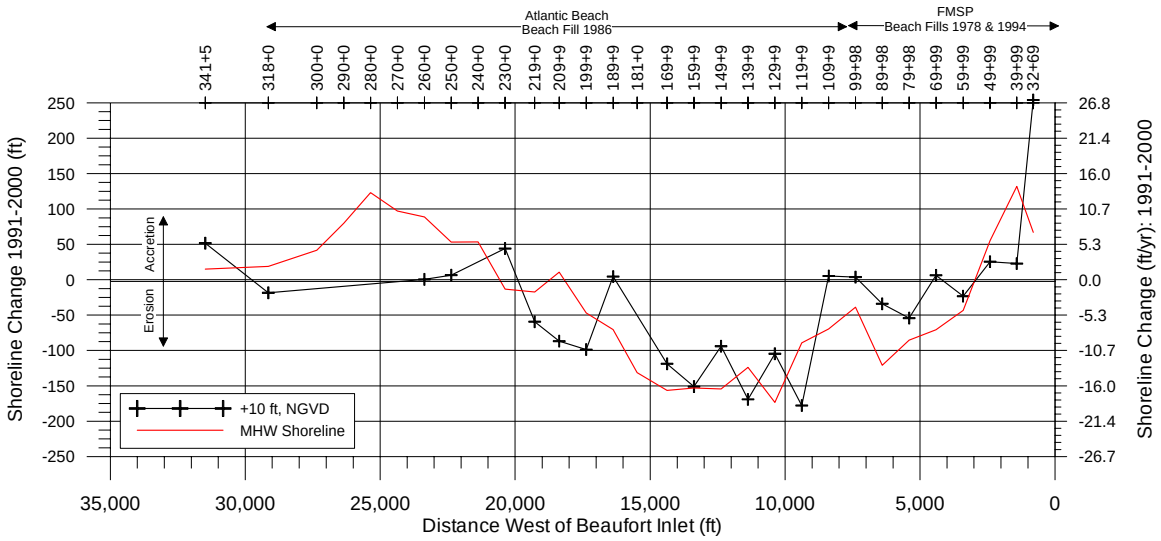


Figure 30: Change in shoreline and dune-face (MHW and +10 ft NGVD) from 1991 to 2000.

1999 to 2004. Survey data from 1999-2004 mostly include all of Bogue Banks. Like the earlier data, however, interpretation of the measured shoreline changes depends wholly upon the beach fill activity that preceded the surveys. Overall trends – among individual surveys or over the entire 5-year interval – are not obvious. ***Figure 31***, below, depicts typical changes in the mean high water shoreline location for various dates between 1999 and 2004. The changes are expressed as average-annual values (ft/yr).

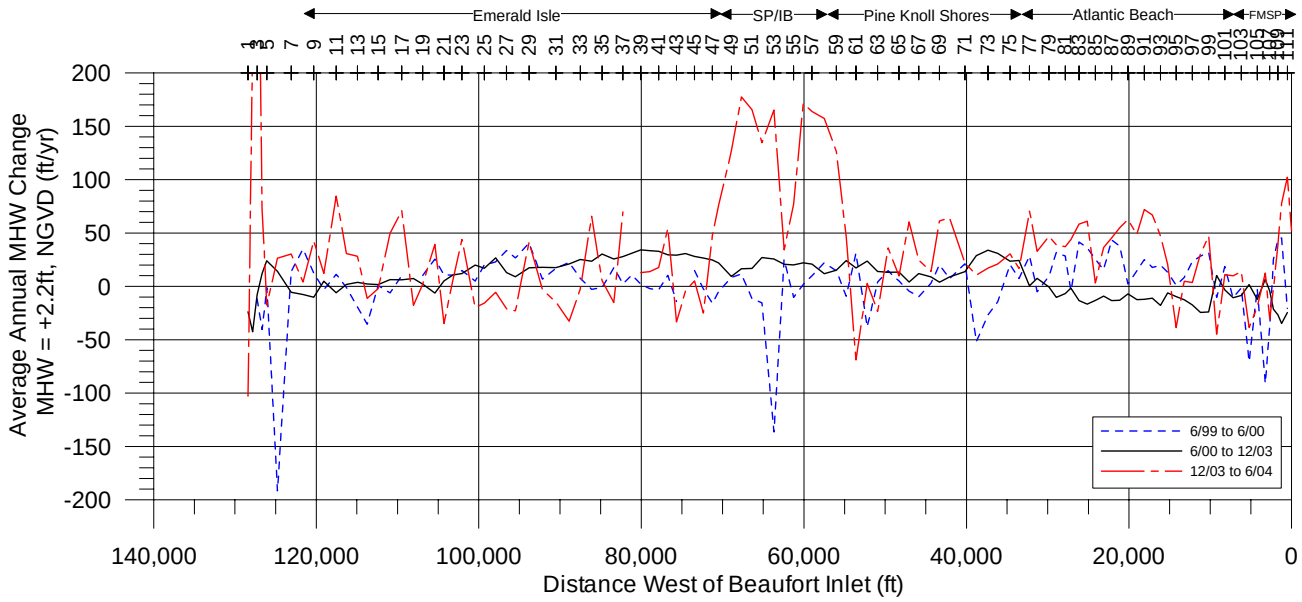


Figure 31: Average-annual change of the mean high water shoreline location along Bogue Banks: June 1999 – June 2000 – December 2003 – June 2004. The effects of beach fills (listed in Figure 32) are included in the shoreline change data.

Surveyed changes at the dune-face do not necessarily describe a more definitive picture than changes at the mean high waterline. ***Figure 32***, below, depicts island-wide changes in both the MHWL and +10 ft dune-face locations for 1999-2004. The effects of multiple beach fills are amply evident along the MHWL. Beach fill effects are not evident at the dune-face; but otherwise, dune changes are variable alongshore with no clear trend. Localized dune recession is noted at several discrete locations, including along most of Ft. Macon State Park and west-central Atlantic Beach. Some dune recession may not be readily 'mapped' by the 1100-ft approximate spacing between profiles or may be obviated by minor dune fill.

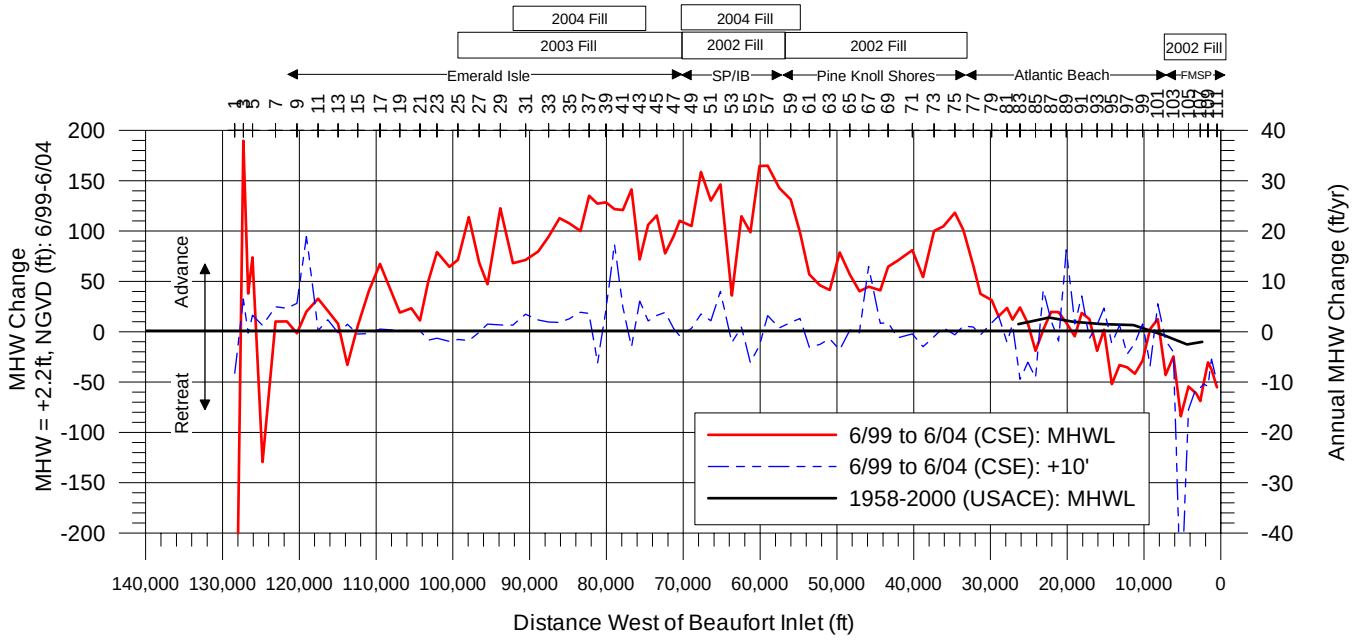


Figure 32: Average-annual change of Mean High Water Line (MHWL) and dune-face contour (+10 ft NGVD) from June 1999 to June 2004; Bogue Banks. Effects of beach fill from 1999-2004 are included, for which the dates and alongshore locations are indicated. The 1958-2000 MHWL change from the Corps' survey data is also illustrated along eastern Bogue Banks.

7.4.2 Beach Volume Change (Bogue Banks)

1958-2000. From the Corps' surveys along eastern Bogue Banks, the measured beach volume change from January 1958 to November 2000 was a net loss of about -13.3 Mcy within 26,400 ft (5 miles) west of the inlet. During this period, about +9.2 Mcy of sand fill was placed along this area. Subtracting this fill, the effective volume loss was about -22.5 Mcy; or, -525,000 cy/yr on annual average. See ***Figure 33***. These volume changes are computed above -30 ft NGVD.

For the 1958-2000 interval, the observed volume losses computed above -30 ft depth are about *3 times* greater than those computed above -15 ft depth, and about *13 times* greater than those computed above -11 ft depth.[16] This observation generally applies to the *entire* 5-mile reach of surveyed coastline west of the inlet. It is not solely attributed to offshore losses across the ebb shoal platform within 2-½ miles of the inlet. The significant additional losses between -11, -15 and -30 ft indicate (1) the importance of conducting surveys and analysis to deeper water, and (2) significant offshore volume losses – beyond the alongshore limits of the ebb shoal.

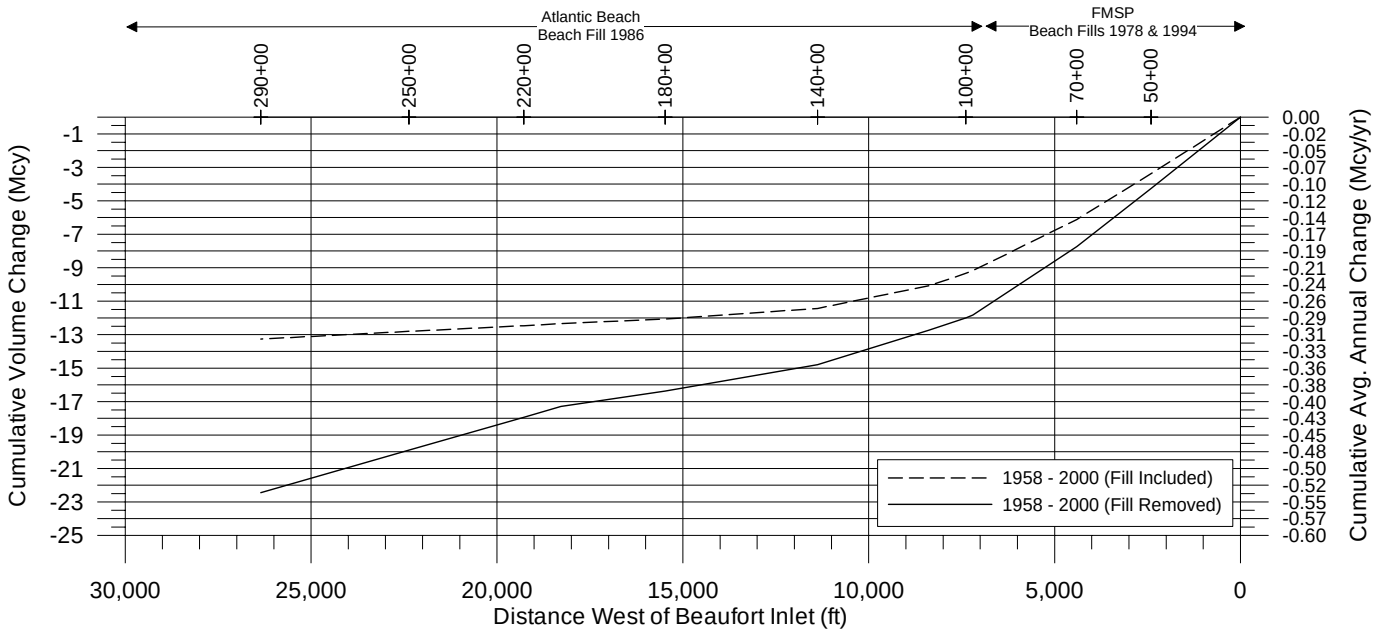


Figure 33: Cumulative volume change along eastern Bogue Banks, Jan. 1958 to Nov. 2000.

1991-2000. The Corps' survey data for 1991-2000 features greater profile density and shoreline coverage than the overall 1958-2000 interval.[17] For this 9-yr period, measured volume changes within 31,500 ft (6 miles) west of the inlet were -8.7 Mcy, despite placement of about +4.6 Mcy of beach fill. Adjusting for this fill, the volume loss was -13.3 Mcy; or, about -1,450,000 cy/yr on annual average. See ***Figure 34***. Like the prior 1958-2000 data, these values are computed above the -30 ft NGVD depth contour, and thus partly include changes to the ebb shoal complex west of the inlet.

[16] Within 26,400 ft (5 miles) west of the inlet, for 1958-2000, the total measured volume losses were -1.04 Mcy above -11' NGVD, -4.32 Mcy above -15' NGVD, and -13.5 Mcy above -30' NGVD.

[17] The 1991-2000 profiles are spaced about 1000-ft apart and extend to about 6 miles west of the inlet. The 1958-2000 comparative profiles are spaced about 3000- to 4000-ft apart and extend to 5 miles west of the inlet.

For the 1991-2000 interval, measured volume losses computed above -30 ft depth are *2.4 times* greater than those computed above -15 ft depth, and *4 times* greater than those computed above -11 ft depth. Like the 1958-2000 data, the offshore volume losses are observed along the entire survey area, and are not limited to the ebb shoal platform. As illustrated in Figure 34, beyond the ebb shoal (>12,500' west of the inlet), losses above the -30 ft contour were uniformly 4 times greater than losses computed above the -11 ft contour.

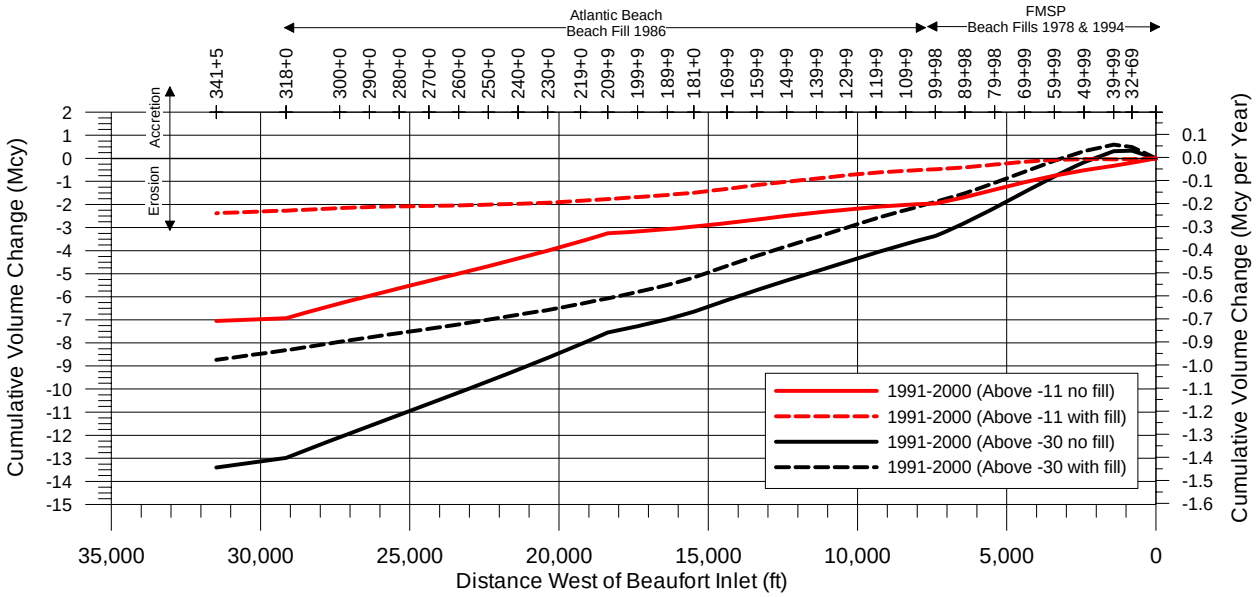
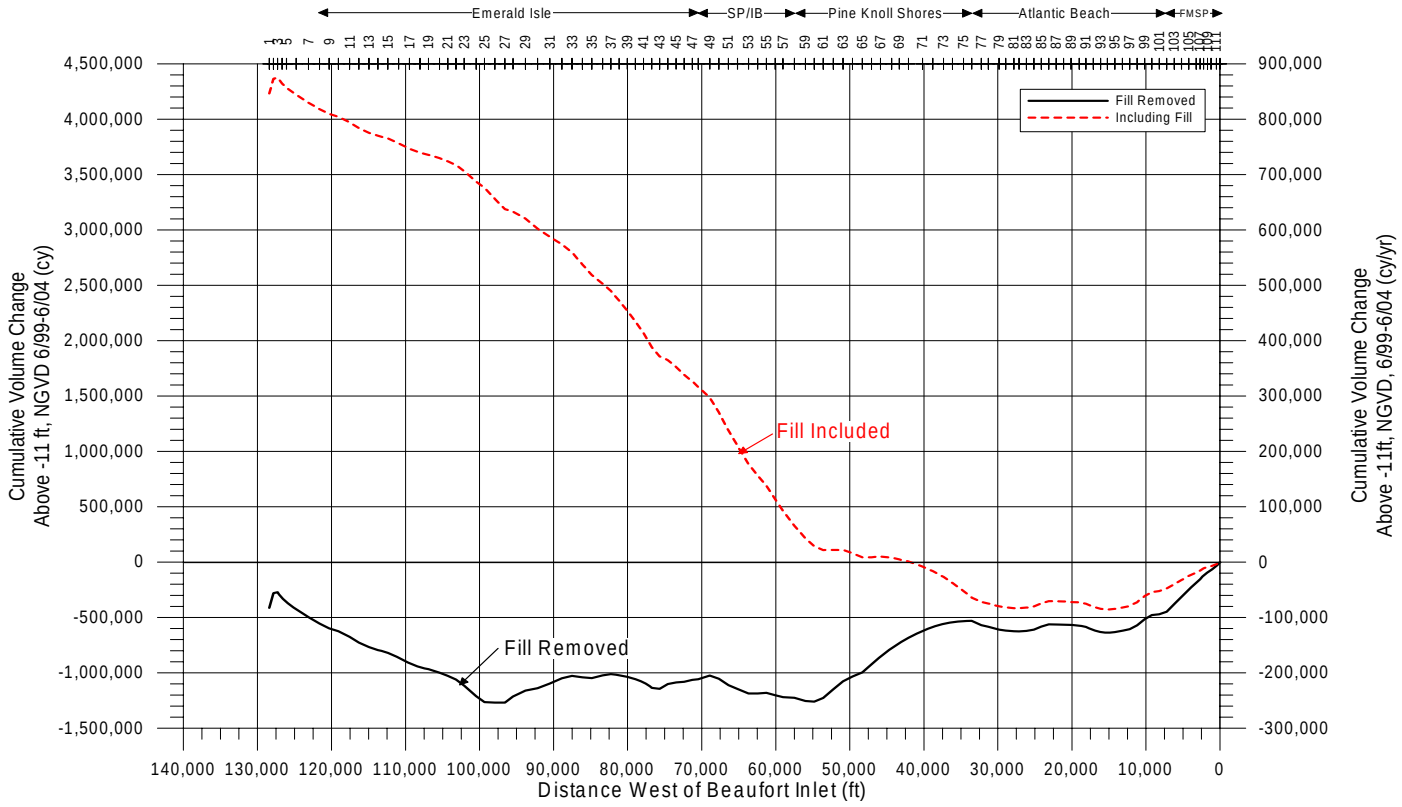


Figure 34: Cumulative volume change along eastern Bogue Banks, July 1991 to Nov.2000. Measured volume changes above -30 ft NGVD (black) are about four times greater than measured changes above -11 ft NGVD (red).

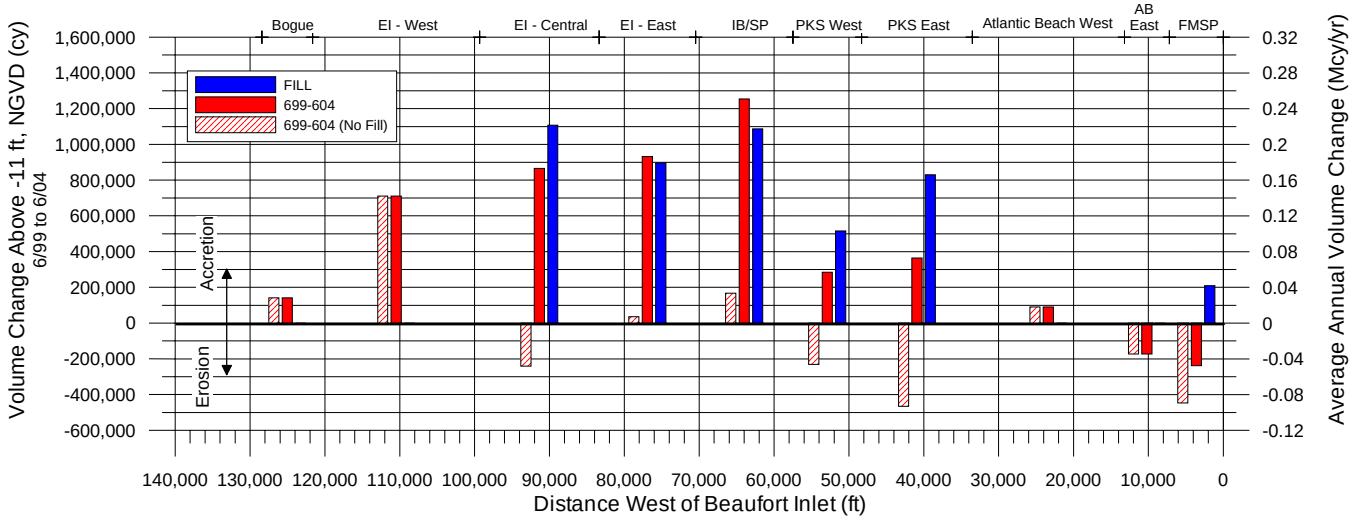
June 1999 - June 2004. Beach profile data from June 1999 to June 2004 include most of Bogue Banks at approximately 1100-ft alongshore spacing. (Surveys in 2005 are not included in this study). Because of differing baselines, the 1999-2004 profiles cannot be readily compared with the Corps' earlier 1958-2000 profiles. It is noted, however, that the Corps' data include only limited surveys along the eastern 5 to 6 miles of the island.

The 1999-2004 data include more-or-less annual surveys by CSE and a subset of quarterly surveys by UNC from May 2002-April 2003. Not all of these surveys include the entire island or extend beyond -11 to -15 ft depth. Surveys encompassing most of Bogue Banks, and extending to deepwater, are basically limited to May 2002, January 2003, December 2003, and June 2004 – a total span of only two years, during which about 2.7 Mcy of fill was placed to the beaches.

For the overall period 1999-2004, above a depth of -11 ft, the measured island-wide volume change was a net gain of about +4.4 Mcy versus total beach fill placement of +4.65 Mcy. Subtracting the fill volume, the overall island exhibited a net loss of about -0.25 Mcy; or -50,000 cy/yr on average, above -11 ft NGVD. See ***Figure 35a***, below.



(a)



(b)

Figure 35: Beach volume changes along Bogue Banks from June 1999 to June 2004, computed above -11 ft NGVD (the limiting depth of data for this survey interval). Upper graph (a): cumulative volume changes summed from Beaufort Inlet westward. Lower graph (b): fill volumes versus net measured volume change for various municipal limits. Adapted from CSE, 2004.

From Figure 35a (prior page), with the effects of beach fill removed, net volumetric changes for June 1999-June 2004, *above -11 ft NGVD,* were:

- losses of about -90,000 cy/yr along Ft Macon State Park
- losses of about -20,000 cy/yr along Atlantic Beach
- losses of about -140,000 cy/yr along Pine Knoll Shores
- generally stable along Salter Path/Indian Beach/east-central Emerald Isle
- gains of about +200,000 cy/yr along western Emerald Isle.

These values probably under-estimate volume losses by a factor of 2 to 4, because the calculations extend to only -11 ft -- which is the limiting depth of the 1999 survey.

For these same data (1999-2004), ***Figure 35b*** contrasts the total fill placement and net measured volume change for various municipal reaches along Bogue Banks. Volume changes are limited to those measured above -11 ft NGVD depth.

May 2002 – June 2004. The 2-year interval of May 2002 to June 2004 comprises a UNC and CSE survey, respectively, for which both surveys extend beyond -20 ft depth. During this period, 2.7 Mcy of beach fill were placed along Bogue Banks, between western Pine Knoll Shores and central Emerald Isle. ***Figure 36*** on the following page (upper graph), depicts the cumulative volume change along Bogue Banks, for 2002-04, computed above -20 ft NGVD depth.

Island-wide, over 2002-04, the net measured volume change above -20 ft was a gain of about +0.7 Mcy versus a total fill placement of +2.7 Mcy. Removing the fill results in a net effective loss of -2.0 Mcy; or, about -1,000,000 cy/yr along the overall island. Essentially all of this erosion was exhibited within 55,000 ft (10.4 miles) west of the inlet, from Fort Macon through Pine Knoll Shores. The remainder of the shoreline exhibited general net volumetric stability, after accounting for the beach fill.

Where no fill was placed, volume losses computed above -30 ft were 3.3 times, 3.7 times, and 1.7 times greater than losses computed above -11 ft, -15 ft, and -20 ft depths, respectively.

Volume changes computed between these various offshore depths exhibit informative behavior. ***Figure 36*** (lower graph) depicts cumulative volume changes, from east to west, computed *between* the -11 & -15 ft contours, -15 & -20 ft contours, and -20 & -30 ft contours. Fill volumes are not removed from these data.

Along and near the fill-placement areas, there were net volumetric gains between -11 & -15 ft and between -15 & -20 ft. There were decreased losses between -20 & -30 ft. This suggests that the effect of fill placement (equilibration) extended to at least -20 ft, and slightly deeper. This is consistent with a predicted closure depth of 22-23 ft.

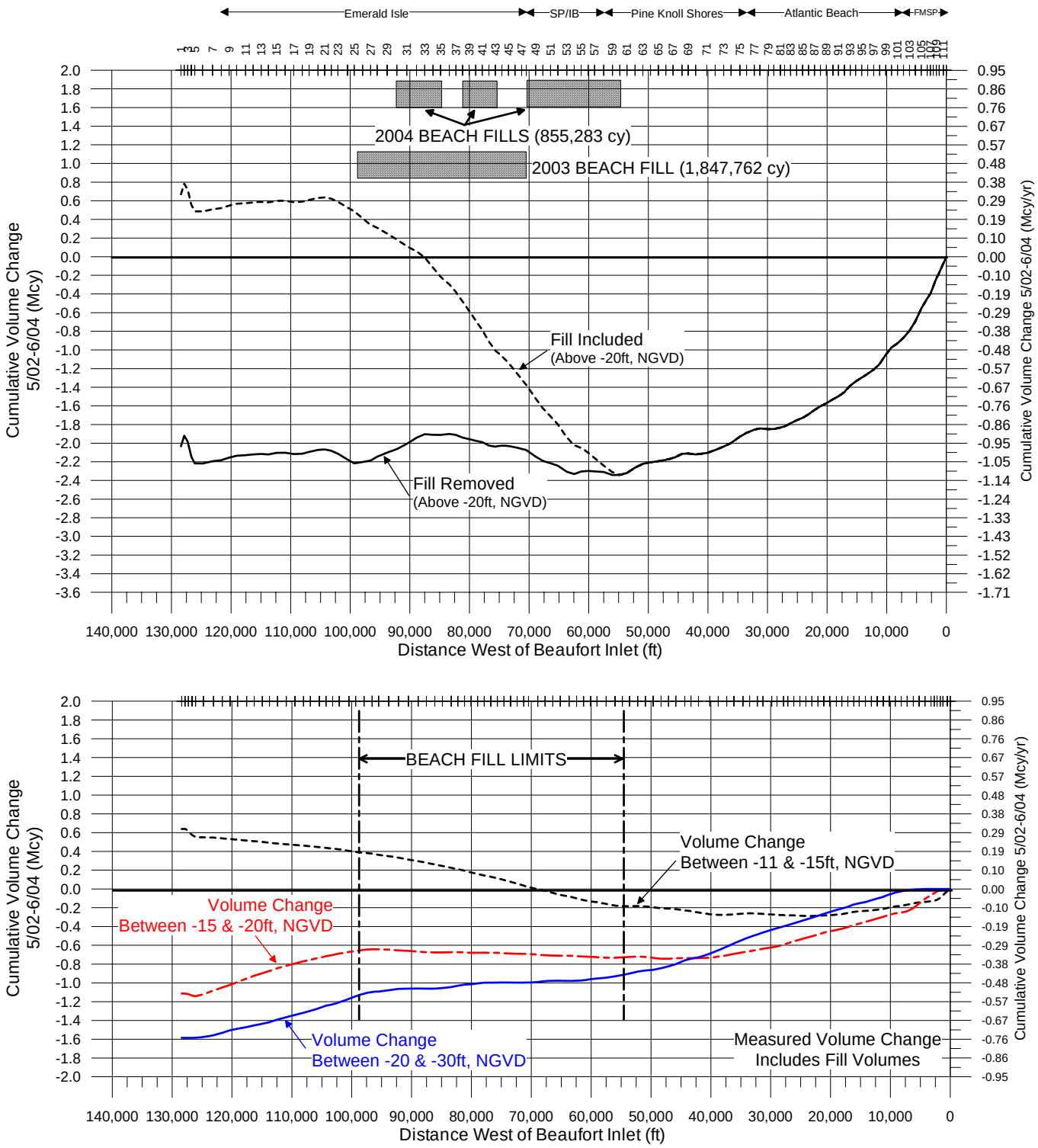


Figure 36: Cumulative volume change along Bogue Banks, beginning at Beaufort Inlet and progressing westward, from May 2002 to June 2004.

- Upper figure: Total volume changes computed above -20 ft NGVD.
- Lower figure: Offshore volume changes computed between -11 & -15 ft; between -15 & -20 ft; and between -20 & -30 ft NGVD depths.

Outside of the fill placement limits, the offshore seabed – below -15 ft NGVD – exhibited consistent erosion. For this 2002-2004 period, the average rate of offshore erosion, between -15 ft and -30 ft, was about -17 cubic yards per ft alongshore per year (cy/ft/yr) both east and west of the fill placement area. The rate of erosion between the -15 & -20 ft contours was about the same as between the -20 & -30 ft contours.

Typically, the offshore distance between the -15 and -30 ft contours is about 1500 feet. An offshore loss of -17 cy/ft/yr, distributed over this distance, equates to a decrease in seabed elevation of about -0.3 ft/yr. The average decrease in elevation was larger nearer shore (-0.43 ft/yr between -15 & -20 ft), and less farther from shore (-0.24 ft/yr between -20 & -30 ft)[18].

Overall, measured above the -20 to -30 ft contours, and after removing beach fill placement, volume changes from May 2002 to June 2004 were characterized as follows:

- Net loss of about -440,000 cy/yr along Ft Macon State Park
- Net loss of between -460,000 and -700,000 cy/yr along Atlantic Beach
- Net loss of between -210,000 and -420,000 cy/yr along Pine Knoll Shores
- Stable/variable between +100,000 and -100,000 cy/yr along Salter Path/Indian Beach and east-central Emerald Isle
- Localized net gain of about +100,000 cy/yr along extreme western Emerald Isle.
- Net island-wide loss of between -1,000,000 and -1,650,000 cy/yr.

December 2003 – June 2004. Beach volume changes computed over the 6-month interval between December 2003 and June 2004 are similar in pattern to those of the 2002-04 interval. Island-wide, above about -25 ft, there was a measured loss of about -0.38 Mcy despite placement of about +0.86 Mcy of beach fill. Adjusting for beach fill, this represents a net loss of -1.24 Mcy. See ***Figure 37***, on the following page. During this period, almost all of these volume losses (-1.14 Mcy) were between -15 and -25 ft depths.

Volume losses were most severe within 18,000 ft west of the inlet (-650,000 cy) and, more broadly, within 55,000 ft west of the inlet (-900,000 cy). Along this area, there was no fill placement during the survey interval. Because of the short interval, these volume changes do not necessarily yield meaningful annual-equivalent values.

[18] The average volume loss was about -8 cy/ft/yr across 500-ft typical width, between -15 & -20 ft. The average volume loss was about -9 cy/ft/yr across 1000-ft typical width, between -20 & -30 ft.

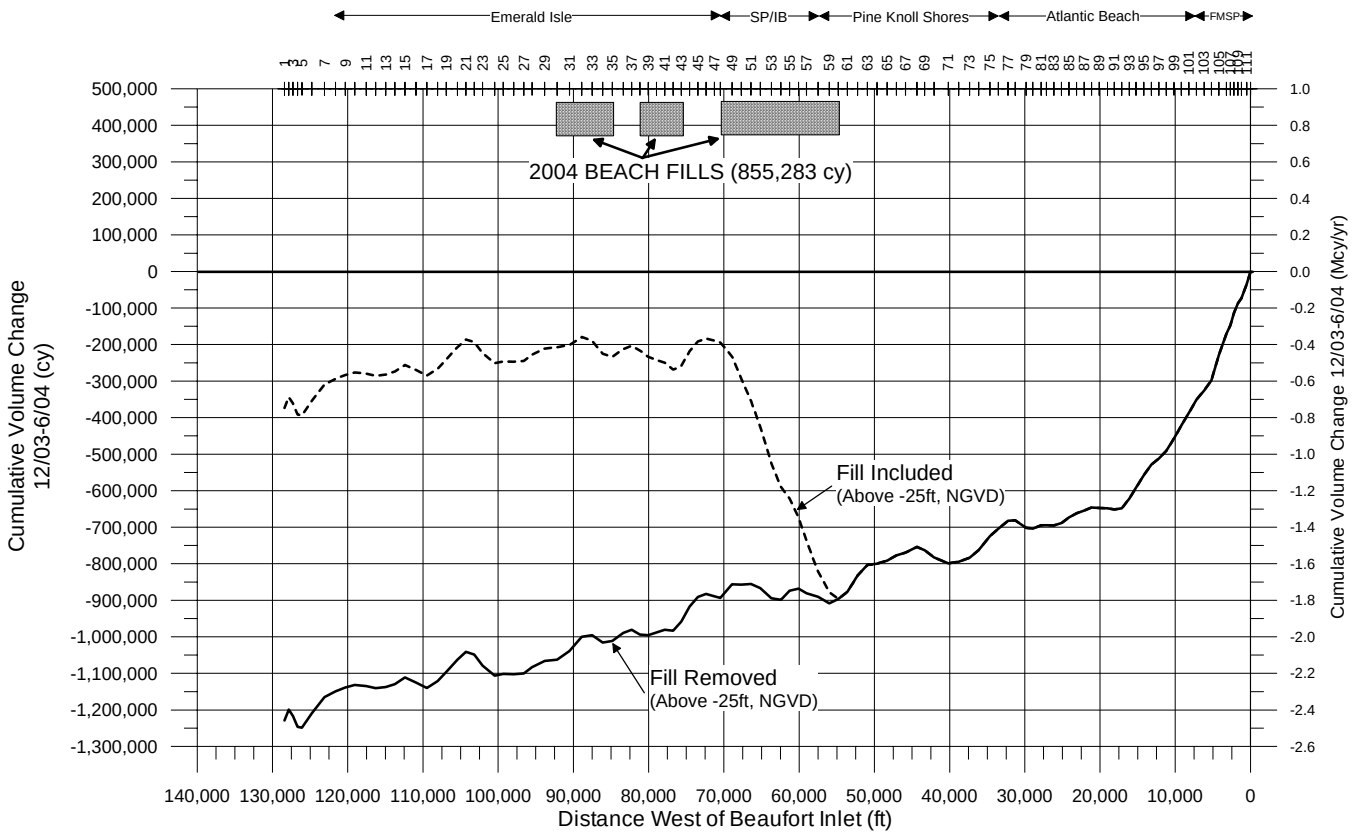


Figure 37: Cumulative beach volume losses, from east to west along Bogue Banks, between December 2003 and June 2004. Computed above -25 ft NGVD depth.

Summary (Bogue Banks Volume Changes). ***Table 1***, following page, summarizes the computed volume changes from the beach profile surveys described above. The limited data exhibit a fairly wide range of values; however, there is order of magnitude agreement between datasets for discrete reaches of shoreline.

Table 1								
Beach Volume Change along Bogue Banks; Cubic Yards Per Year **(from available beach profile survey data)**								
Survey Dates:		Jan 58 to Nov 00	Jul 91 to Nov 00	May 02 to Jun 04			Jun 99 to Jun 04	Mean value*
Volume computed above:		*-30 ft*	*-30 ft*	*-20 ft*	*to*	*-30 ft*	*-11 ft*	*-20' to -30'*
	Distance west of inlet							
Ft. Macon State Park	0 - 7,500'	-280,000	-360,000	-440,000	to	-450,000	-90,000	-362,000
Easterly Transport Reversal Zone	0 - 12,500'	-370,000	-550,000	-625,000	to	-670,000	-125,000	-523,000
Central-West Atlantic Beach	12,500' -- 34,000'	-165000*^	-900,000	-325,000	to	-540,000	15,000	-667,000
Pine Knoll Shores	34,000' -- 58,000'	•	•	-210,000	to	-420,000	-140,000	-315,000
Salter Path/Indian Beach	58,000' -- 71,000'	•	•	135,000	to	100,000	35,000	117,000
Central-East Emerald Isle	71,000' -- 99,000'	•	•	-75,000	to	-150,000	-40,000	-113,000
West Emerald Isle	99,000' -- 125,000'	•	•	0	to	-75,000	170,000	-38,000
Island wide sum	0 - 125,000'							-1,539,000
* mean value does not include Jun 99 - Jun 04 survey data -- which extend only to -11' NGVD								
*^ data extend only to 26,500 ft west of inlet; not included in mean value								
• no comparative beach profile survey data								

7.5 Profile Deflation

The Corps' Section 111 report describes deepening of the offshore beach profiles along the eastern 5.5± miles of Bogue Banks, including those profiles at and westward of the ebb shoal complex. Offshore depth increases were also described along Shackleford Bank.[19]

Comparison of long-term offshore profile change is limited to the eastern 5 miles of Bogue Banks, more or less, from the Corps' 1958-2000 survey data. Vertical changes in the offshore beach elevation for this period are illustrated in ***Figure 38***, on the following page. The figure illustrates the decrease in seabed elevation ("deflation") measured at three fixed offshore locations across the surveyed profiles that correspond to nominal depths of -15 to -35 ft NGVD.

[19] USACE, 2001; pp. 39-40.

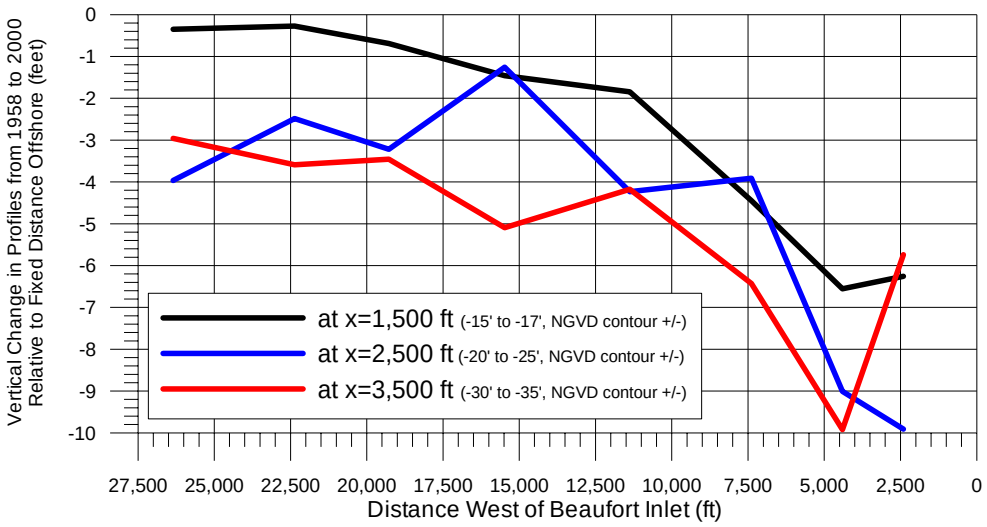


Figure 38: Elevation change at several fixed points along Corps' beach profiles at eastern Bogue Banks from January 1958 to November 2000.

From 1958-2000, profile deepening is greatest within about 12,500 feet west of the inlet – along the western lobe of the ebb tidal shoal platform. Beyond 12,500 feet (west of the Triple S Pier in Atlantic Beach), the magnitude of profile deepening decreases yet remains fairly consistent along the -20' to -35' depth range. These data include the effects of beach fill, which may partly explain the relative decrease in profile deepening along the shallower -15' to -17' depth range.

Between 2.5 and 5 miles west of the inlet along Bogue Banks, the apparent vertical deflation of the offshore profile is on the order of -3 feet between 1958 and 2000. On average, this equates to about -0.07 ft/yr.

There are no data from which to meaningfully assess long-term offshore profile changes along the western remainder of Bogue Banks. Limited recent data, from May 2002 to June 2004, described above, suggest offshore profile deflation on the order of -0.3 ft/yr across the -15' to -30' depth range. None of the data indicate stability or increases in the offshore profile depths along Bogue Banks.

The potential physical effect of profile deepening to the beach is described by the "Bruun Rule"[20], illustrated by example in ***Figure 39***. In the figure, a 3-ft vertical decrease in profile elevation at the -25 ft depth contour theoretically results in a 305 ft horizontal recession of the beach at the mean high water line. The example presents a typical profile along Pine Knoll Shores. The 3-ft vertical deflation is similar to that measured at the -25' contour from the Corps' 1958-2000 survey data, and (based upon the values presented above), may conceivably correspond to a 10- to 40-year horizon.

[20] Bruun, 1962.

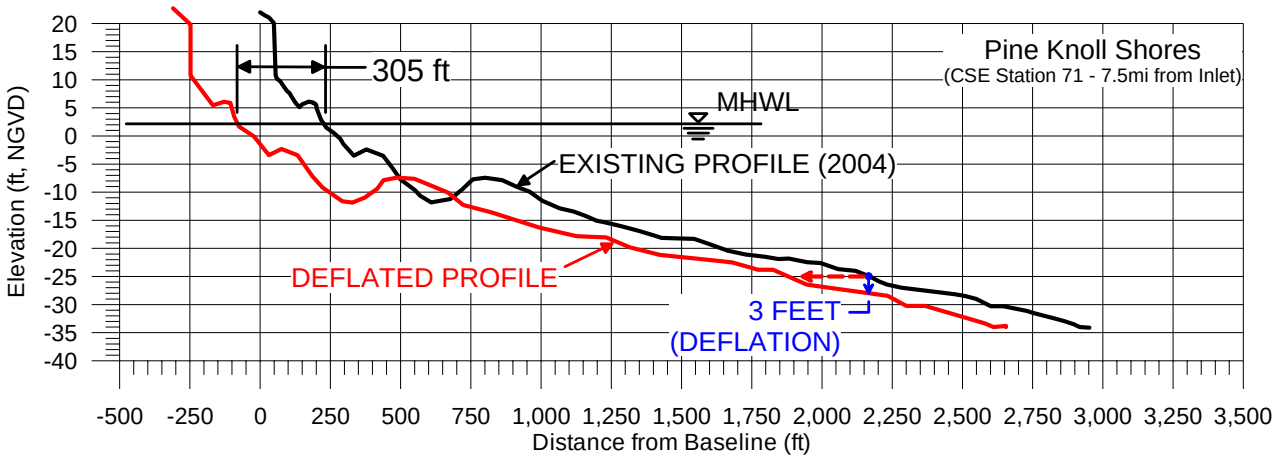


Figure 39: Example of the predicted effect of offshore profile deepening upon the beach.

Interestingly, the historical volume of beach fill placed along eastern Bogue Banks is roughly equivalent to the volume of beach erosion predicted from a 3-ft offshore profile deflation. That is, from the "Bruun Rule", a horizontal profile recession of 305 ft equates to a theoretical volume loss along a 'normal' beach of about 305 cy/ft to 360 cy/ft (for a presumed depth of closure of -20 ft to -25 ft, respectively). In comparison, the volume of beach-compatible fill placed along eastern Bogue Banks equates to about 380 cy/ft on average[21]. As the beach disposal attempts to hold the shoreline position in place, on temporal average, this suggests that the "Bruun Rule" prediction of beach response to profile deepening may be of order-of-magnitude accuracy.

The concept of severe beach erosion in response to offshore profile deflation is both troublesome and familiar in North Carolina. A direct analogy is the shoreline at Bald Head Island, North Carolina, east of the Cape Fear River Federal Navigation Project[22]. After the navigation project progressively severed the ebb-shoal bypassing bar circa 1926, portions of the stranded shoal migrated northward and the island accreted. The shoreline was generally stable from the 1940's through the early 1970's. At the same time, the remnants of the ebb shoal and the offshore profile progressively deflated in elevation[23]. Subsequently, the southwest shoreline of Bald Head Island began a sudden, severe and chronic trend of erosion – retreating over 500 feet between 1974 and 1994. Simplistically, the concept of severe beach erosion by offshore profile deepening is akin to the undermining of a house by progressive, unseen decay of its foundation. There is no evidence that this is *not* the case along the shorelines adjacent to Beaufort Inlet.

[21] Approximately 11 Mcy placed along the eastern 29,000 ft of Bogue Banks, to-date. See page 17.
[22] Olsen Associates, Inc., 2003.
[23] USACE, 1989.