

## The Restoration of Bogue Banks North Carolina 1999–2004

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### Abstract

A decade ago, Bogue Banks (North Carolina) entered a period of unprecedented change. Five hurricanes – *Bertha*, *Fran*, *Bonnie*, *Dennis*, and *Floyd* – impacted the 24-mile-long barrier island in quick succession between 1996 and 1999. Extensive erosion destroyed dunes and left hundreds of properties damaged or exposed on the beach. Prior to *Fran* in September 1996, Bogue Banks had been one of the most stable islands on the coast with erosion rates averaging less than 2 feet per year.

The hurricanes were a wake-up call for the three hardest hit communities – Emerald Isle, Pine Knoll Shores, and Indian Beach. In 1999, the local Beach Preservation Task Force assessed alternatives and settled on a multifaceted plan for beach restoration. Nourishment, using offshore as well as harbor sources of sand, became the cornerstone of the plan. Using formerly nourished Atlantic Beach as a model for other communities, several beach fills were completed in rapid order between 2001 and 2004. The majority of nourishment was locally funded with oceanfront owners bearing over 50 percent of the cost. Approximately 20 percent of the nourishment was performed in connection with federal, channel-maintenance projects.

By March 2004, over 4.6 million cubic yards (cy) had been placed along ~14 miles of the island. Beach monitoring by the authors has documented a net change of ~4.5 million cubic yards between June 1999 and June 2004. Thus, the five-year change over the length of Bogue Banks equals the nourishment volume. This means that, on average, there has been no net loss or gain by natural processes in five years. The entire change is accounted for by nourishment averaging ~35 cy/ft (island-wide), or ~50 cy/ft within the project areas. Addition of this much sand has widened the beach an average of ~50 ft and added ~150 acres of subaerial habitat. The magnitude of nourishment makes this one of the largest-ever, locally funded projects. Total costs to date are ~\$30 million.

Prior to nourishment, oceanfront owners were spending in the range \$2,500–\$5,000 per property after every storm to rebuild dunes and walkovers. Since nourishment, there has been negligible dune or walkover damage. Property owners now pay an equitable, pro-rata share on six-year or seven-year bonds used to fund the projects. Without nourishment, there may have been little net change in the shoreline over the past five years according to detailed surveys. However, numerous structures would have sustained damage during storms like *Isabel* (September 2003), dunes would have been lost, and some properties would have been condemned under North Carolina statutes. With nourishment, the communities are now paying for a wider beach and more habitat for sea turtles, seabeach amaranth, and seaside visitors.

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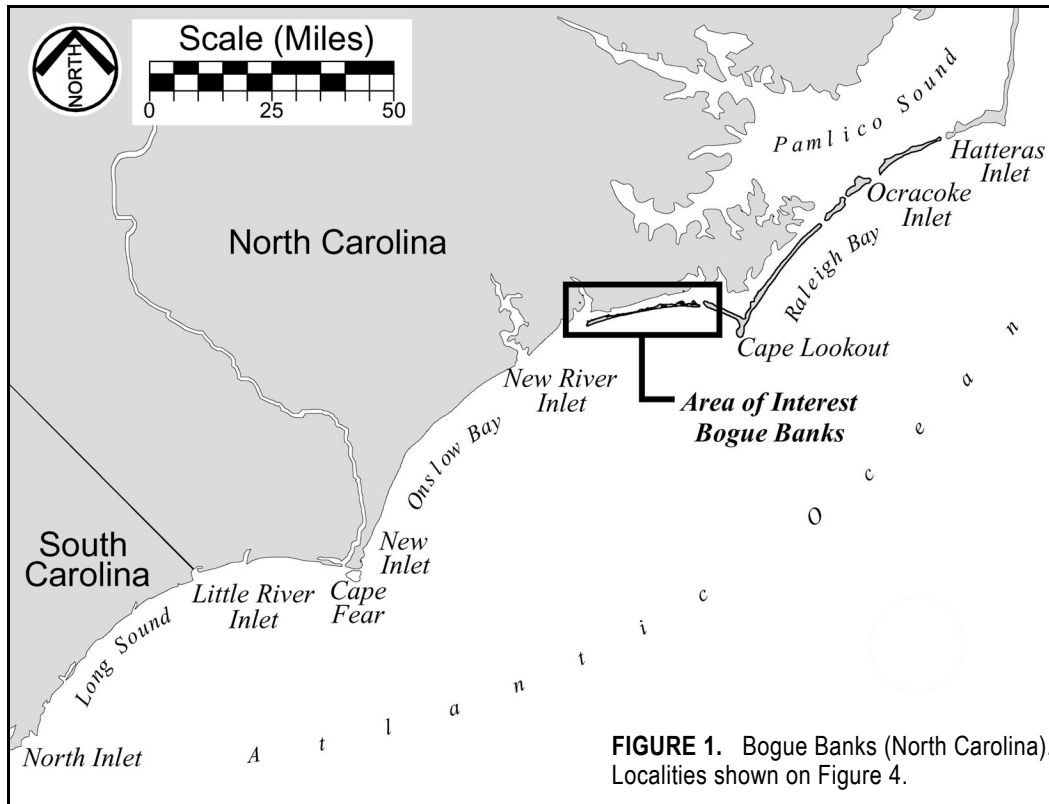
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## Introduction

A decade ago, Bogue Banks, North Carolina (Fig 1), entered a period of unprecedented change, beginning with Hurricane *Bertha* in June 1996 and *Fran* in September 1996. More hurricanes followed with *Bonnie* in August 1998, *Dennis* in September 1999, and *Floyd* on 15 September 1999. Each storm caused dune erosion and prompted many oceanfront property owners to rebuild the dunes by scraping. Other poststorm expenses included debris cleanup and reconstruction of dune walkovers and repairs to houses. Particularly unsettling was the fact that storms occurred in quick succession compared with historical trends. Many repairs made in 1997 after *Bertha* and *Fran* had to be repeated in 1998 and 1999 after the next storms.

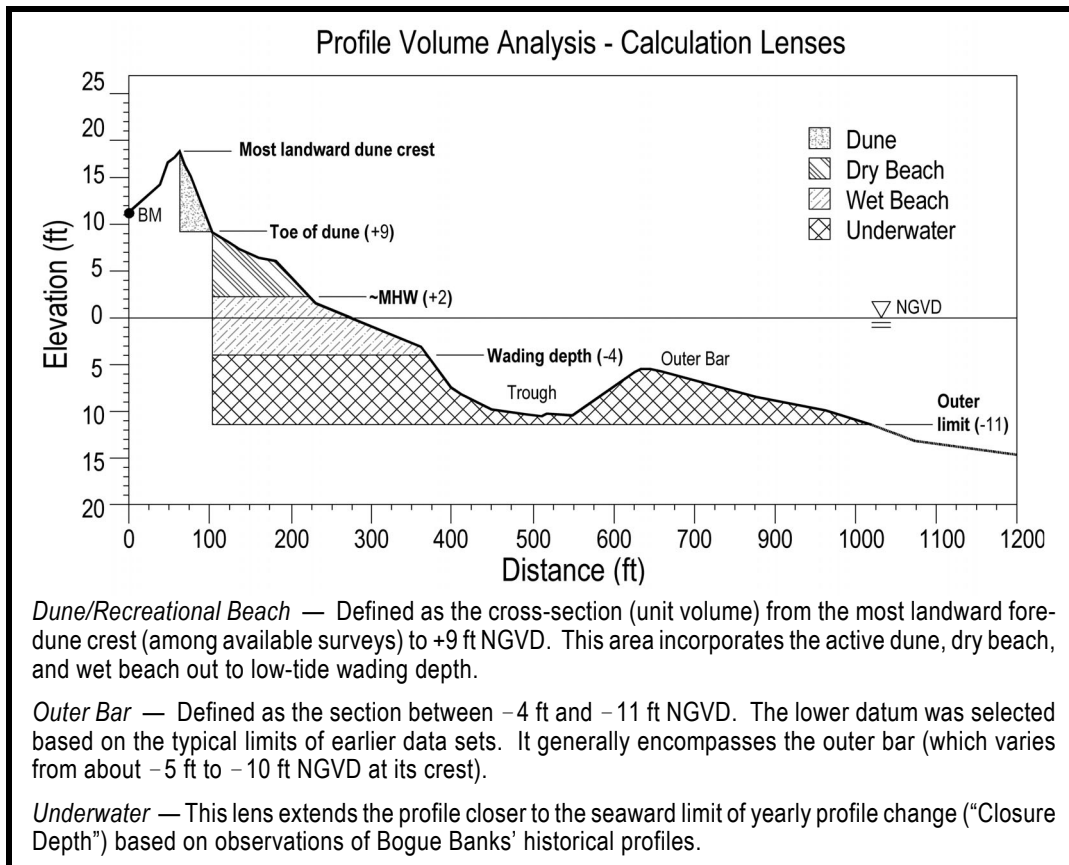
Bogue Banks has been quite stable compared with many barrier islands along the East Coast. Official state analyses show 50-year erosion rates in the range 2–3 ft per year for nearly all of the island. Yet by June 1999, much of Bogue Banks' development was imminently threatened. Beach width was too narrow along eastern Emerald Isle (EI), Indian Beach (IB), Salter Path (SP), and Pine Knoll Shores (PKS) to sustain small storms without damage to the dunes, walkovers, and some buildings.

Carteret County established a Beach Preservation Task Force in 1997 to assess alternatives for beach stabilization. With input from every town along the oceanfront and many community representatives and experts, a draft plan for beach restoration was developed in September 1999, just as *Dennis* and *Floyd* were impacting the coast.



## Locally Funded Beach Restoration Plan

A key element of the “county” plan was a systematic inventory of the beach (Fig 2). Profiles were established along the length of the island by CSE Baird–Stroud (1999) for purposes of comparing the condition of the beach from town to town. The concept of “target minimum profile volume” was introduced using 1999 conditions along Atlantic Beach (AB) as a model for other communities along Bogue Banks (Fig 3). Atlantic Beach had received nourishment in 1986 and 1994 in connection with disposal of harbor sediments by the US Army Corps of Engineers (USACE 1993).



**FIGURE 2.** Three reference zones used for calculation of sand volume changes along Bogue Banks 1999–2004. Integrating all three lenses yields volumes that encompass nearly 100 percent of the sediment volume moving in the littoral zone from year to year. Estimated closure depth is -15 ft NGVD at yearly to decadal time scales.

By 2001, additional beach surveys (eg, CSE 2000) had confirmed that Bogue Banks’ background erosion rate is low. Surveys also demonstrated the onshore-offshore movement of sand between the outer bar and the beach.

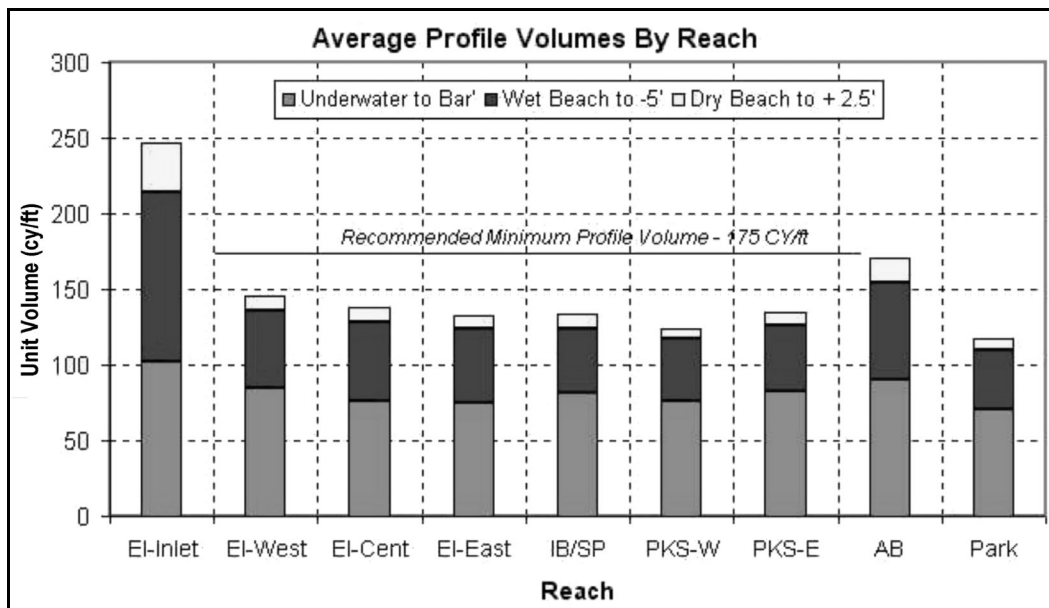
Drawing on Atlantic Beach’s nourishment experience, Pine Knoll Shores, Indian Beach, and Emerald Isle implemented a locally sponsored “County Project” between December 2001 and March 2003 (Fig 4). Phases 1 and 2 of the Bogue Banks beach restoration project added nearly 3.6 million cubic yards to the beach. This project

directly impacted ~12.5 miles of shoreline, making it one of the longest and largest-volume nourishment projects in the United States. Its cost was approximately \$23 million or (~)\$6.50/cy (including engineering, permitting, and environmental monitoring).

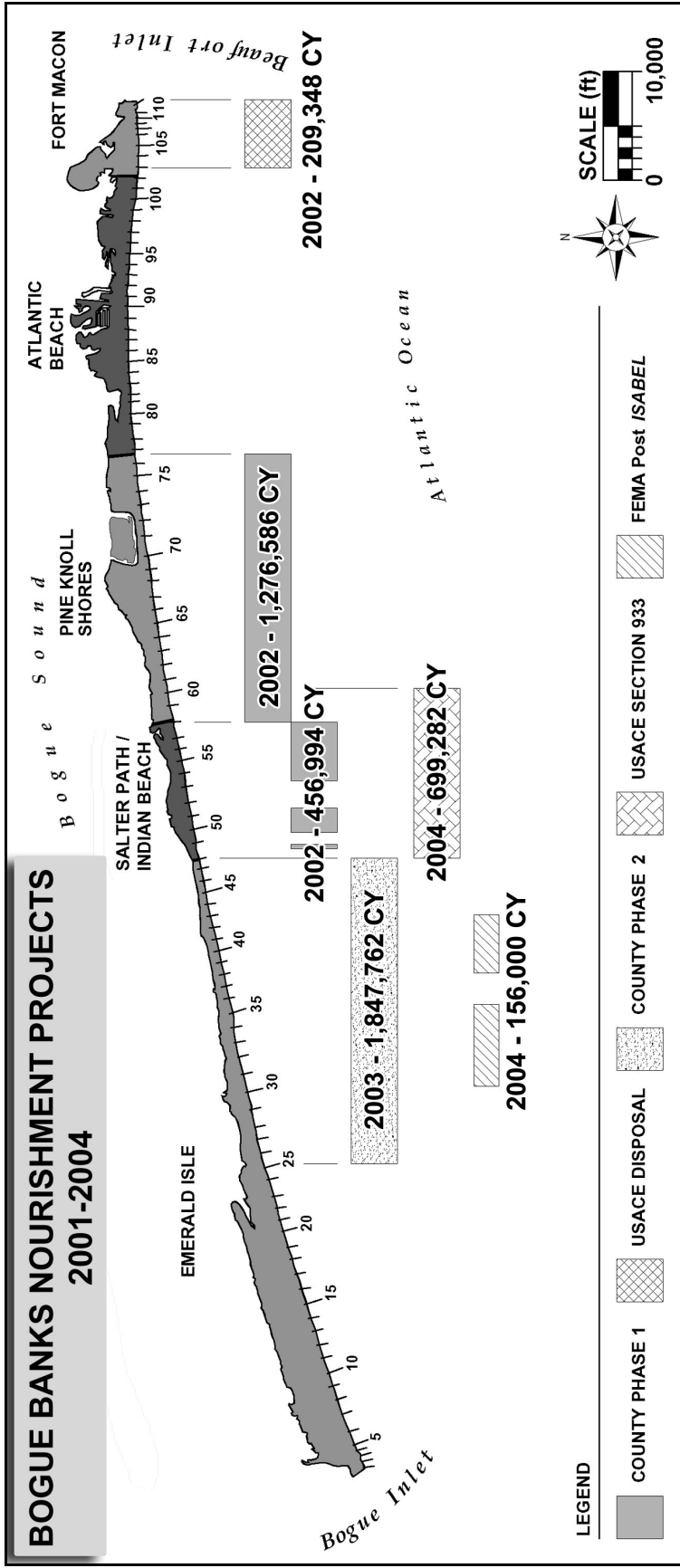
The County Project added an average of ~55 cy/ft to the eastern half of Emerald Isle, Pine Knoll Shores, and Indian Beach/Salter Path. Thus, the investment per oceanfront foot of beach was (~)\$350/ft. This is equivalent to about \$35,000 per oceanfront property on average. What truly sets the Bogue Banks project apart from most nourishment projects is the fact that it was paid for entirely with locally generated funds. More than 50 percent of the cost is being paid for by oceanfront property owners.

In parallel with the County Project, the Carteret County Shore Protection Office has coordinated federal studies for a long-term beach restoration approach along Bogue Banks. This effort led to successful completion of a Section 933 project at Indian Beach and western Pine Knoll Shores, whereby dredged sediments from the Beaufort Harbor entrance channel were disposed on the beach instead of being dumped offshore. The American Shore & Beach Preservation Association (ASBPA) has named the Section 933 project one of its four winners for the “Top Restored Beach Awards” for 2004 (visit [www.asbpa.org](http://www.asbpa.org)).

Two other small nourishment projects in the past five years bring the total nourishment volume to 4.65 million cubic yards (Fig 4). Averaged the length of Bogue Banks, this is an addition of over 35 cy/ft. In simple terms, this equates to about 50 ft more beach width on average. The total area represented by new dry beach is of the order 150 acres.



**FIGURE 3.** Average profile volumes by reach (west to east) for June 1999 calculated between the base of the foredune and -11 ft NGVD contour (from CSE Baird-Stroud 1999). Recommended minimum profile volume excludes the foredune volume above +9-ft NGVD.



**FIGURE 4.** Nourishment projects along Bogue Banks (2001-2004). Total volume placed was 4.65 million cubic yards or 35 cy/ft if apportioned over the entire ~25-mile length of the island. [From CSE 2004]

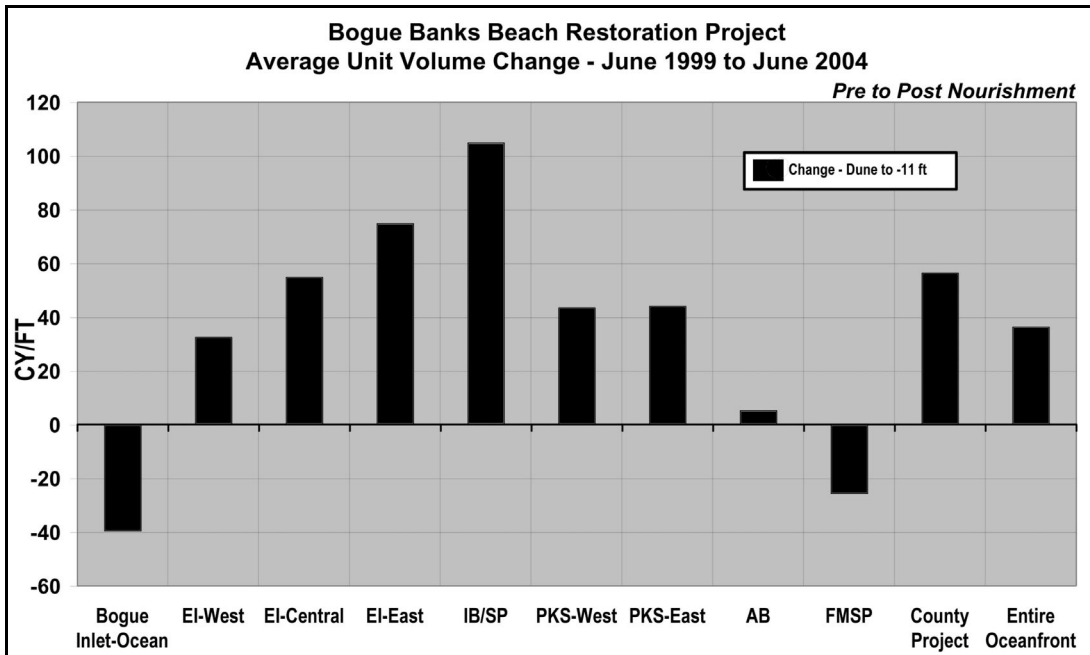
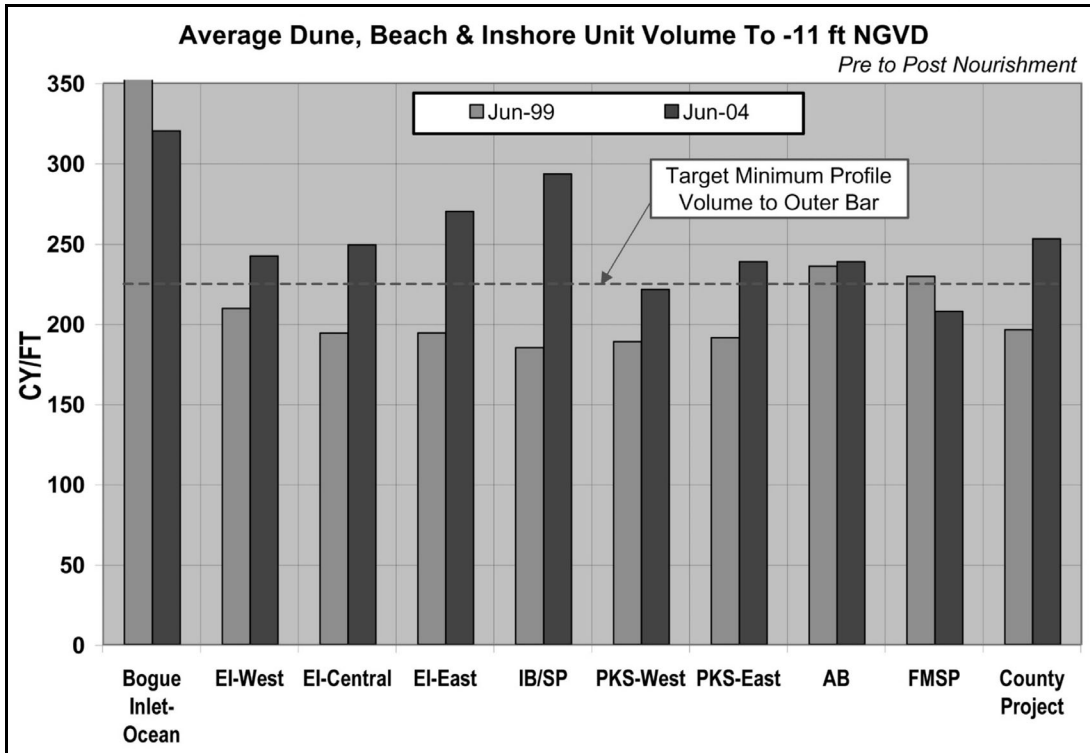
## Condition Surveys

Periodic surveys were completed by the authors between June 1999 and June 2004. Up to ten sets of surveys are available for certain reaches and dates in connection with beach nourishment projects and storm events. CSE (2004) describes the data collection methodology and analysis techniques. Results have been compiled by town and for the island overall.

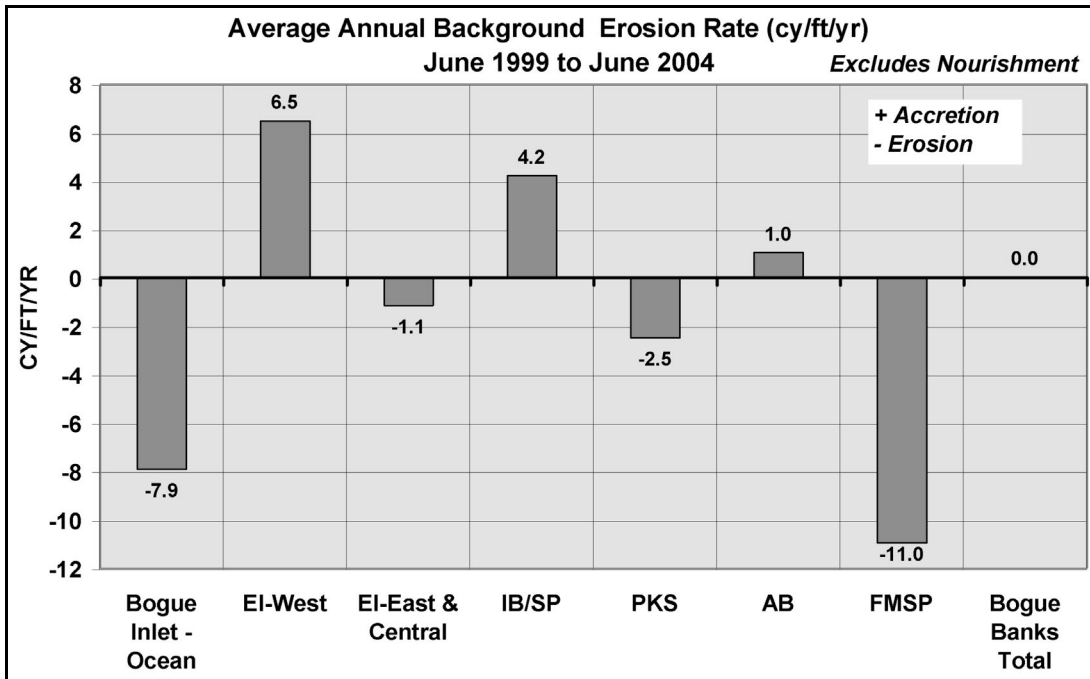
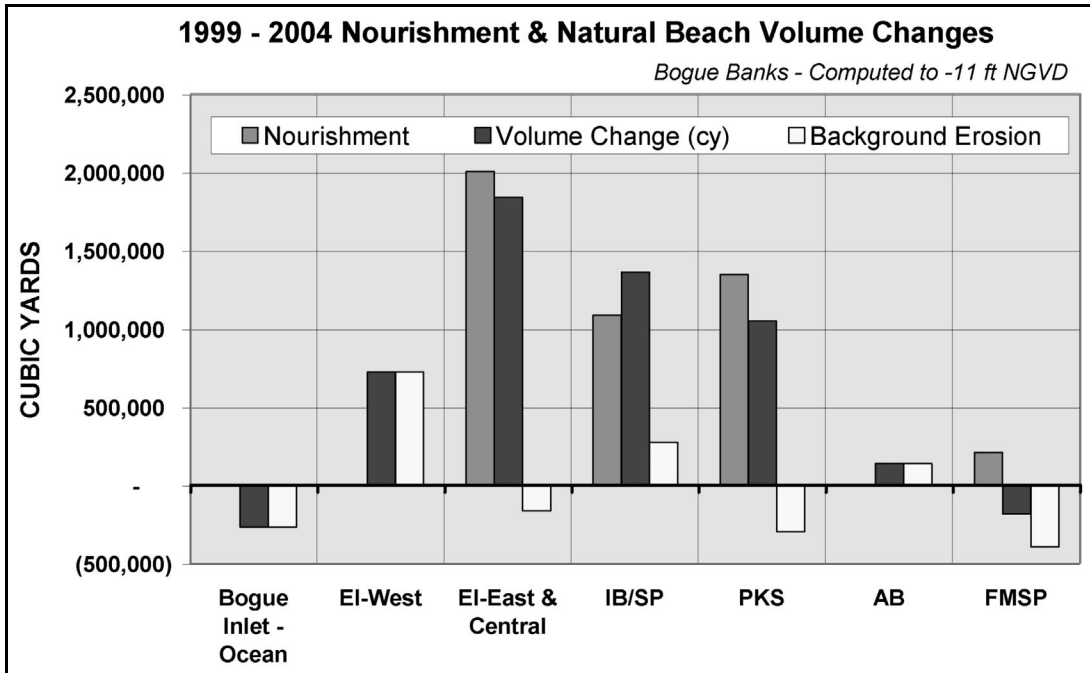
Between June 1999 and June 2004, Bogue Banks was impacted by Hurricanes *Dennis* (1999), *Floyd* (1999), and *Isabel* (2003). Beach nourishment totaling approximately 4,650,000 cy was placed along Pine Knoll Shores (2001–2002), Indian Beach/Salter Path (2002), Fort Macon State Park (2002), eastern and central Emerald Isle (2003), Indian Beach and western Pine Knoll Shores (2004), and eastern Emerald Isle (2004). The surveys comparing June 1999 conditions with June 2004 conditions showed a net gain of ~4,500,000 cy (island-wide measured to the outer bar at depths of –11 ft NGVD). This means that the measured change over five years was almost identical to the volume of sand added to Bogue Banks by nourishment (Fig 5).

Nourishment volumes are fully accounted for by the survey data when combined over the length of the island. However, from town to town, there were some differences between the nourishment volume and the surveyed volume. These differences are, in effect, the background erosion (or accretion) rates by reach for the five-year period; this is depicted in Figure 6.

When averaged over the entire oceanfront, the net change rate was virtually 0.0 cy/ft/yr. This suggests there was no loss (or gain) due to natural processes along Bogue Banks between 1999 and 2004. While this should not be accepted as a precise result, given the limitations of all field surveys, it does confirm the long-standing notion that Bogue Banks is one of the more stable barrier islands on the North Carolina coast (Pilkey et al 1975). Ironically, the reach that received the most nourishment (per foot), Indian Beach/Salter Path, also experienced a high background **accretion** rate of 5 cy/ft/yr. Erosion rates along most of Emerald Isle and Pine Knoll Shores were ~1.1 and ~2.5 cy/ft/yr (respectively). Both ends of the island had high background erosion rates, even after factoring out nourishment at FMSP. EI–West (western half of Emerald Isle) accreted partly because of the Phase 2 nourishment project (EI–Central and EI–East).



**FIGURE 5.** Average change in sand volume by reach between 1999 and 2004. (Note: 50 cy/ft is equivalent to about 75 ft of beach width in this setting.) Target minimum profile volume in upper graph includes the fore-dune volume above +9-ft NGVD measured to the typical dune crest for the area.



**FIGURE 6.** [UPPER] Total nourishment volumes and surveyed volume changes by reach for June 1999 to June 2004. The difference between the two quantities is the “background” erosion rate. [LOWER] Average, annual, background erosion rate after factoring out nourishment. [From CSE 2004]



## **Conclusion**

In June 1999, CSE Baird-Stroud (1999) determined that the central and western two-thirds of Bogue Banks had a sand deficit and inadequate beach width compared with Atlantic Beach. Between 2001 and 2004, ~4.6 million cubic yards of nourishment sand were added to the worst-eroding areas of the island. By June 2004, most of Bogue Banks contained a sand surplus compared with Atlantic Beach. Presently, the worst erosion is occurring along Fort Macon State Park (where there is a deficit) and near Bogue Inlet (where there is still a surplus). Losses along Fort Macon State Park at the eastern end of Bogue Banks have shifted toward Beaufort Inlet and have built a spit along the channel. Oceanfront losses near Bogue Inlet, by contrast, have not built up the shoreline along the inlet channel, where erosion continues to undermine houses. This section of shoreline is scheduled for nourishment in 2005 (CPE 2004).

The results herein support the finding that Bogue Banks has a relatively low, natural erosion rate. This means that nourishment can be effective and relatively long-lived in mitigating erosion. Annual monitoring should be continued to track the performance of nourishment and to establish trigger points for future beach restoration. As the graph in Figure 5 shows, there is considerably more sand on most of the beach today than there was in June 1999. Monitoring will determine how much sand shifts from community to community over time and will identify the most vulnerable sections of Bogue Banks. For more information on the project and details on the present surveys, see CSE (2004) or visit [www.protectthebeach.com](http://www.protectthebeach.com).

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