SHORELINES – October 2015

State of the Beach (2015)

In late August, the engineering firm of Moffatt & Nichol provided the Carteret County Beach Commission a presentation highlighting the most significant results of a comprehensive beach survey conducted along Bogue Banks. The survey, or "monitoring event" was completed during the March to June 2015 timeframe and included our neighboring islands to the east and west of Bogue Banks as well - Shackleford Banks and Bear Island, respectively.

If we compare the March to June 2015 survey to that of the year prior (May to June 2014); we are capturing ALL of the events (e.g., a coastal low or distant tropical storm) that transpired during this roughly yearlong time period. It would be cost-prohibitive to survey after each and every individual event, thus we have to make inferences to what "minor" events triggered episodes of erosion and accretion throughout the year.

To this effect, we rely heavily on a "credit – debit" volumetric approach with respect to our overall beach management philosophy and to track change throughout time. During the aforementioned survey period, Bogue Banks did not experience any particularly notable "debits" in the form of tropical cyclones (hurricanes/tropical storms), nor winter storms. No large "credits" were realized in the past year either.

The last significant nourishment event (i.e., credit) was completed in May 2014 associated with the Morehead City Harbor Federal Navigation Project that placed 1,107,585 cubic yards (cy) of sand along 1.8 miles of Ft. Macon and Atlantic Beach. This addition of sand was recorded in the 2014 survey and the 2015 survey captures some erosion and equilibration of the fill along this reach. The remaining portion of Bogue Banks (Pine Knoll Shores westward towards the Point in Emerald Island) experienced accretion over the past year if we examine the beach in cross section from the submerged outer bar landward past the recreational beach area and up into the frontal dune. The justification for this "gain" is detailed later below.

Monitoring Background

So what exactly constitutes a beach survey? We can trace the origins our program to 1999 when 111 shore-perpendicular profiles were established along Bogue Banks to gain baseline information and begin assessing the overall health of the beach in the wake of the hurricanes that impacted the region in the decade of the 1990s – most notably *Bertha* (1996), *Fran* (1996), *Bonnie* (1998), *Dennis* "1 & 2" (1999), and *Floyd* (1999). Elevations of the dry and underwater (nearshore) portion of the beach have been obtained along these same profiles on a routine basis since 1999 and these measurements have been utilized to monitor two important beach parameters – **(1)** the **volume** of sand residing in the beach system, and **(2) shoreline** movement.

The monitoring program has grown since its formative years and now includes 122 profiles along Bogue Banks (Fig. 1), in addition to 24 profiles along Shackleford Banks, and

18 along Bear Island. The beaches are ideally surveyed in the "pre-hurricane season"timeframe prior to July of each year.

As implied above, the monitoring program has continued to serve several very important functions, including; **(A)** Establish a monitoring network to determine volume deficiencies during formulation of the Bogue Banks Restoration Project (early 2000s) and future nourishment efforts, **(B)** Help assess the volume of sand lost during Hurricanes *Floyd* (1999), *Isabel* (2003), *Ophelia* (2005), and *Irene* (2011); and where applicable, obtain FEMA reimbursement to replace the sand lost during many of these disasters, **(C)** Serve as spatial control during beach construction events, **(D)** Assess the fate of various beachfills constructed along Bogue Banks since 2001, **(E)** Provide a method to determine the overall condition (health) and changing geomorphology of Bogue Banks and adjacent islands, and **(F)** Serve as the primary database foundation in formulating the Bogue Banks "Master Plan".

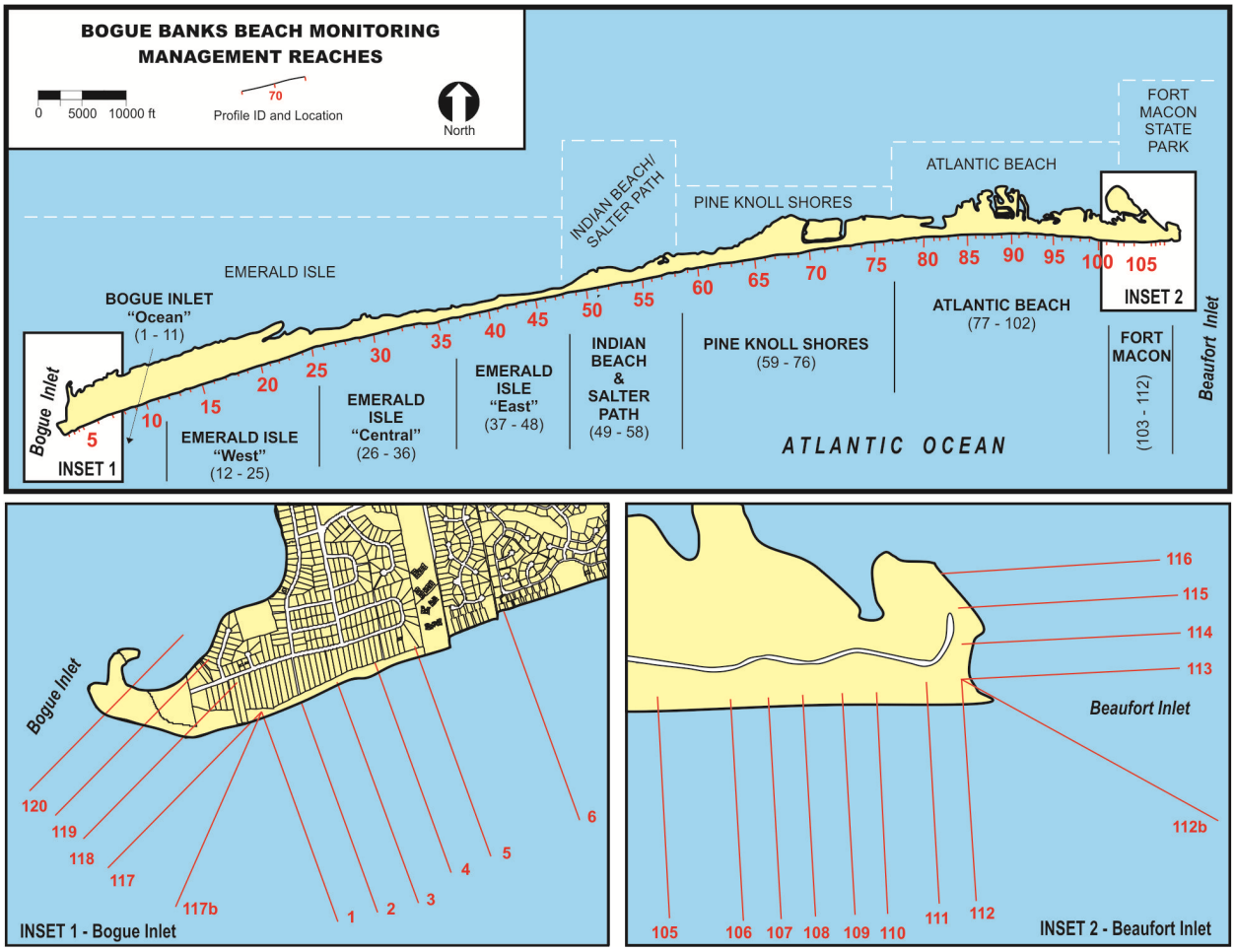

Figure 1 – Site map depicting the location/identification scheme of the 122 profiles positioned along Bogue Banks utilized for beach/nearshore monitoring purposes and the management reaches recently provided in the Bogue Banks Beach "Master Plan".

Beach Volume

One of the means to quantify beach health is to compare the volume of sand lost or gained over time along Bogue Banks and the adjacent islands. Engineers and scientists most often use the measuring unit of a ***cubic yard (cy)*** to describe volume change, which

can be envisioned as a 3 ft. by 3 ft. by 3 ft. block of sand, or 27 ft^3. A standard dump truck holds roughly 15 cubic yards of dry sand as a convenient mental image. The "volumetric approach" has been a primary tenet of our beach monitoring program, and the 128,393 linear feet of oceanfront along Bogue Banks (profiles 1 – 112, figure 1) gained 341,840 cy of sand in 2014-15, equating to an average gain of +2.7 ***cy per linear foot (cy/ft)***.

By now you might be questioning why and how the island gained a considerable amount of sand last year without any tangible sources of beach nourishment to point to as a credit (???). We have to view the beach in cross-section and realize we normally reference the compartment encompassing volume changes above **-12 ft. NAVD88** to help make the data more manageable/understandable and to consistently measure changes over time. Although we extend our surveys much deeper, the zone above –12 ft. NAVD88 can be considered as the main "shock absorber" for storms and undergoes the most change from year to year (Fig. 2).

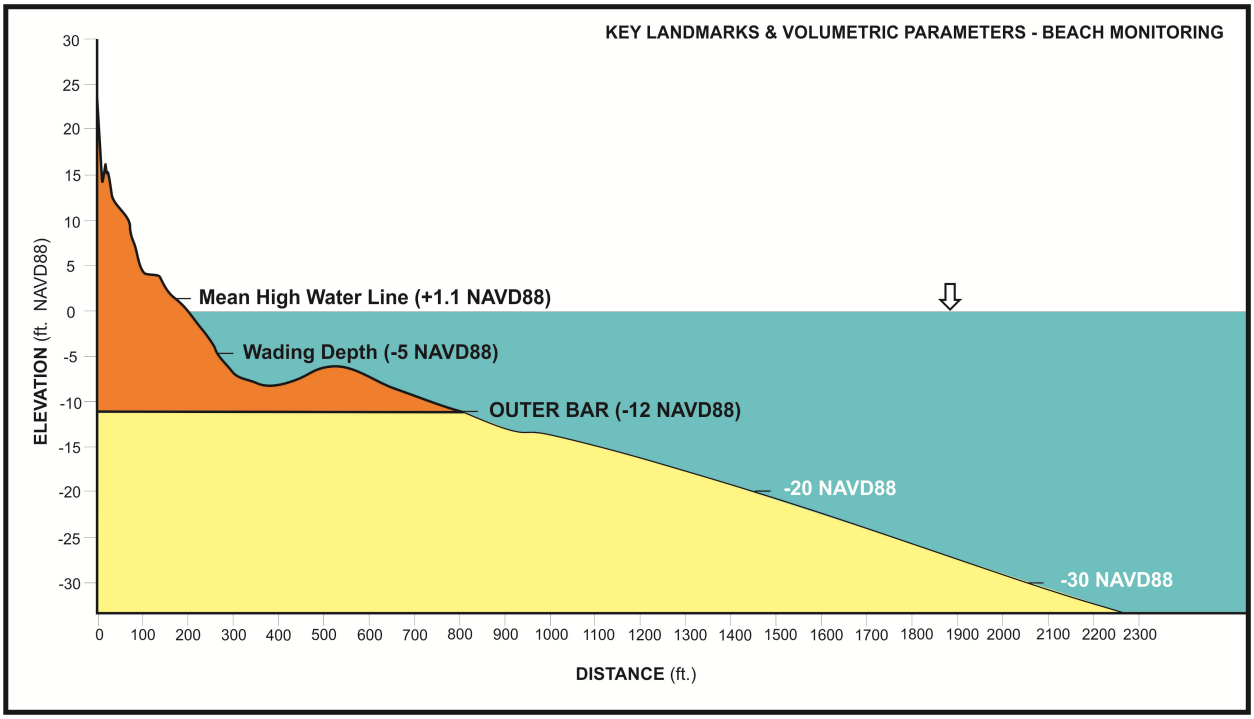

Figure 2 – Characteristic Bogue Banks profile in cross-section depicting the key "landmarks" that are monitored for changes in sand volume. Although changes are recorded above each of the landmarks depicted in the figure, the orange-colored fillet represents the positive or negative changes occurring at the elevation above "-12 ft. NAVD88", and is utilized as a common reporting baseline.

Because we "cut off" our analysis at the above -12 ft. NAVD88 benchmark, any sand below -12 ft. NAVD88 migrating upslope can be considered as a source of credit. Likewise sand eroding off the dry beach but doesn't migrate underwater past -12 ft. NAVD88 is also a credit. This in effect is our justification for the gain last year – sand migrated from both upslope and downslope into the outer bar zone above -12 feet NAVD88.

Of course sand also moves in a shore parallel direction as well in between profiles. However, we do not think there is much sand from a gross standpoint that migrated (and stayed) from one management reach to the other. In other words, we did not experience a large loss in one management reach coupled with a significant gain in an adjacent reach. Accordingly we think most of the gains realized in 2015 was along the shore perpendicular axis.

Also continuing on the concept of **"cubic yards per linear foot" (cy/ft)**, the volume of sand residing along the entire island is significantly higher than our self-termed yardstick year of 1999, and is attributable to the many beach nourishment projects that have been constructed since 2001 (Fig. 3). All the island management reaches are also well in excess of our new Master Plan "volumetric thresholds" or perhaps better conceptualized as beach nourishment triggers. Our Master Plan management reaches as depicted in Figure 1 were developed by; (A) evaluating dune/berm shape and height to group similar profiles into discrete reaches, and then (B) we subsequently utilized a 25-year storm event to model the volumetric needs in each of the new management reaches. Our 2015 management reach values in terms of average cy/ft and our minimum volumetric thresholds (i.e., nourishment triggers) are presented graphically in Figure 3 as well.

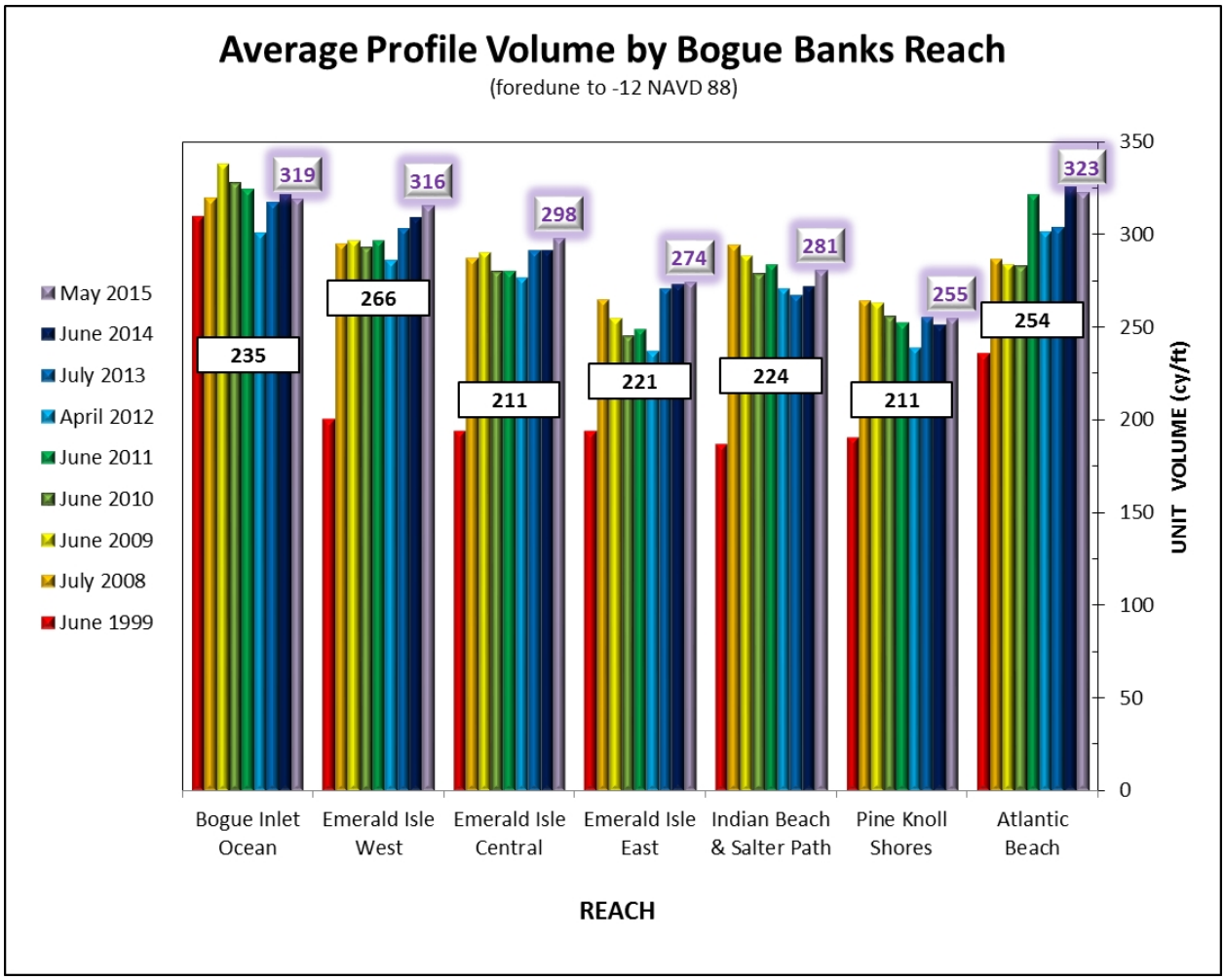

Figure 3 – Average profile volumes for September 1999, July 2008, July 2009, June 2010, June 2011, April 2012, July 2013, June 2014, and May 2015 for seven oceanfront management reaches along Bogue Banks. The minimum volumetric thresholds (i.e., nourishment triggers) are provided in the white call-out boxes with black font lettering while the 2015 average volume is represented in the call-out boxes including purple font lettering.

Shoreline Change

Another and more common/familiar measurement of beach health is shoreline change. To quantify and consistently compare shoreline positions over time, the "shoreline" is determined as the mean high water elevation established at +1.1 ft. NAVD 88 (Fig. 2).

This measurement parameter is sometimes referred to as a "datum-derived shoreline" as we can numerically determine where along a profile the +1.1 feet elevation resides rather than depending upon more subjective determinations that are required by other methods, such as aerial photography (i.e., wet/dry line, the wrack line, etc.).

Utilizing a datum-derived shoreline, the average shoreline change from Spring 2014 to Spring 2015 for Bogue Banks ranged from +21.3 feet seaward ("accretion") to -41.0 feet landward ("erosion") resulting in a net average change of -9.0 landward for the entire oceanfront. However if we tease out Atlantic Beach (-24.3 feet) and Ft. Macon (-41.0 feet) from the analysis, the average is actually -0.1 feet landward for Bogue Banks. It is believed the shoreline erosion rate for Ft. Macon and Atlantic Beach are attributable to fill loss associated with the 2014 Morehead City Harbor nourishment event. These losses are also seen in the volumetric data as well (Atlantic Beach -2.5 cy/ft and Ft. Macon -0.1 cy/ft). These are the only two oceanfront reaches along the entire island that lost sand volumetrically in 2014-15 above the -12 ft NAVD88 elevation except for the reach immediately adjacent to Bogue Inlet.

Shoreline positions have reacted to an influx of nourishment sand or efflux of sand related to storms/background erosion over the past several years and movement of that sand in the alongshore and shore-perpendicular directions. Sand may be moving east or west along the beachfront or in some places, could be migrating in the offshore direction or conversely even welding itself to the visible dry beach. Again, the 2015 numbers most certainly reflect the migration sand from; **(A)** the downslope part of the beach profile up above our -12 feet NAVD88 analytical cutoff. And **(B)** the gains reported are also partially derived from the migration of sand from the upper part of the beach (near the mean high water demarcation of +1.1 NAVD88) downward, but not past the -12 feet NAVD88 cutoff. This very lattermost process helps explain why the shoreline position is signaling "erosion" yet the volume changes are indicating accretion (gains).

This is obviously a brief review of the monitoring report, but don't hesitate to visit http://www.carteretcountync.gov/329/Monitoring if you would like more information regarding the report itself or the monitoring program in general.