SHORELINES – September 2017

State of the Beach (2017)

In late July, the engineering firm of Moffatt & Nichol provided the Carteret County Beach Commission a presentation highlighting the results of a comprehensive beach survey conducted along Bogue Banks. The survey, or "monitoring event" was completed over the course of several weeks during Spring 2017 and included our neighboring islands to the east and west of Bogue Banks as well - Shackleford Banks and Bear Island, respectively.

So what exactly constitutes a beach survey? Jokingly of course, we can't interview sand grains and ask them about their travels over the course of the year. Rather the origins of our program date back 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 impacting 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 are utilized to monitor two important beach parameters we will be discussing in more detail below – **(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.

If we compare the 2017 survey to that of the year prior (Spring 2016) AND to a rapid response Post-*Matthew* Survey conducted in October 2016; we are capturing all of the events/storms transpiring during this yearlong time period and their impacts to those two important parameters introduced above - volume change and shoreline change. It would be cost-prohibitive to survey after each and every individual storm, thus we have to make inferences to what "minor" events may have triggered episodes of erosion and accretion throughout the year.

Results (Volume and Shoreline Changes)

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 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.

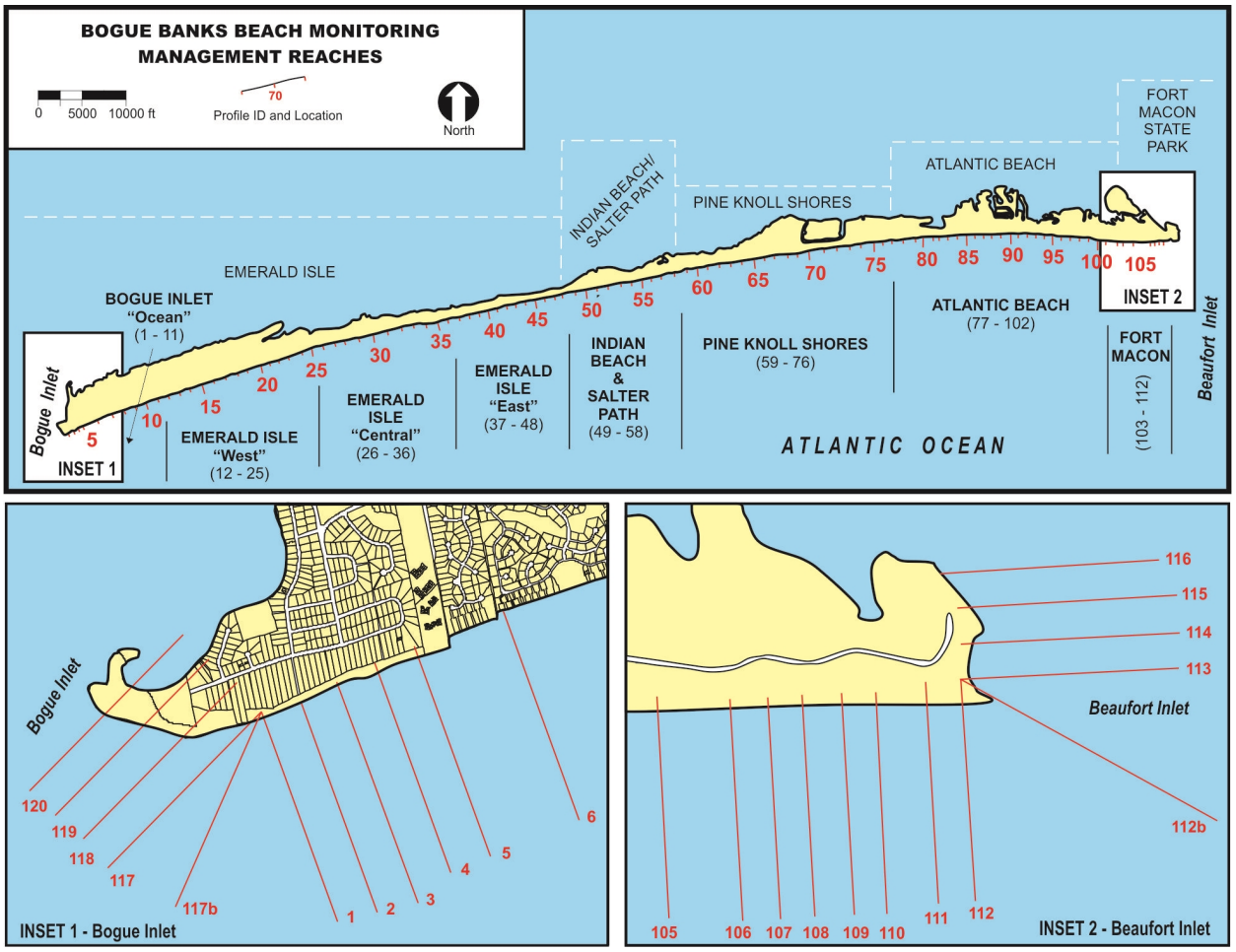

Figure 1 – Site map depicting the location/identification scheme of the 122 profiles positioned along Bogue Banks utilized for beach/nearshore monitoring purposes.

To these effects, we rely heavily on a "credit – debit" volumetric approach with respect to our overall beach management philosophy and to track change throughout time. This "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 780,577 cy of sand in 2016-17, equating to an average gain of +6.1 ***cubic yards per foot (cy/ft)***. How did we gain sand? This is where the adage – "it's not the destination but the journey" comes into play.

Again keeping in mind our "credit – debit" sand accounting system, although nearby hurricanes are often envisioned as debit, our survey from *Matthew* revealed the exact opposite along Bogue Banks in October 2016 – the island *gained* sand (404,485 cy), averaging +3 cy/ft from the top of the dune seaward to -12 feet NAVD88, and is actually considered as a credit. A more purposeful credit also occurred associated with the dredging maintenance of the Morehead City Harbor Federal Navigation Project in spring 2017 that concurrently placed 621,000 cy of sand along 1.7 miles of Atlantic Beach (i.e., 621,000 cy of direct beach nourishment). In other words, *Matthew* and beach nourishment activities were the credits in 2016-17.

The debits then if you will, came in the form of several winter/spring storms – particularly five distinct events from March to May 2017 when wave heights exceeded 12 feet, which is an uncommon.

In total, if we take the volume of sand gained by beach nourishment and *Matthew* (1,025,485 cy collectively), and subtract the reported gain at the conclusion of reporting period (780,577); we can loosely conclude we experienced 244,908 cy of loss attributed to winter/spring storms – or roughly 60% of what we gained during *Matthew*. Please be cognizant these are just average numbers for the entire island - Table 1 includes a reach-by reach summary.

Reach	Profiles	Linear Feet	Average Shoreline Change (May 2016 - Spring 2017)	Average Volume Change (May 2016 - Spring 2017)
Bogue Inlet - Ocean	1 - 11	11,488	-22 feet landward (-)	-7 cubic yard / linear foot
Emerald Isle - West	12 - 25	18,288	+2 feet seaward (+)	+1 cubic yard / linear foot
Emerald Isle - Central	26 - 36	15,802	+2 feet seaward (+)	0 cubic yard / linear foot
Emerald Isle - East	37 - 48	13,220	+2 feet seaward (+)	-1 cubic yards / linear foot
Indian Beach/Salter Path	49 - 58	12,850	-12 feet landward (-)	+6 cubic yards / linear foot
Pine Knoll Shores	59 - 76	23,878	-11 feet landward (-)	+3 cubic yards / linear foot
Atlantic Beach	77 - 102	26,176	+51 feet seaward (+)	+29 cubic yards / linear foot
Ft. Macon State Park	103 - 112	6,691	-15 feet landward (-)	-11 cubic yards / linear foot
Totals or Average =	**112**	**128,393**	**+5 feet seaward (+)**	**+6.1 cubic yards / linear foot**

Table 1 – Average shoreline and volume change from May 2016 to Spring 2017 for eight oceanfront reaches positioned along Bogue Banks. Notice the impact of the 621,000 cubic yards of beach nourishment placed along Atlantic Beach during the reporting period and the magnitude of change near Bogue and Beaufort (Ft. Macon) Inlets.

As a quick note with respect to shoreline change - the "shoreline" is determined as the mean high water elevation established at +1.5 ft. NAVD88 (Fig. 2). This measurement parameter is sometimes referred to as a "datum-derived shoreline" as we can numerically determine where along a profile the +1.5 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.).

Where does the sand go?

The winter/spring storms of 2017 prompted some concern regarding the shoreline – the flat part of the beach (berm, recreational beach, etc.) was narrow across most of Bogue Banks prompting the question, "Where did the sand go?" First 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 change 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).

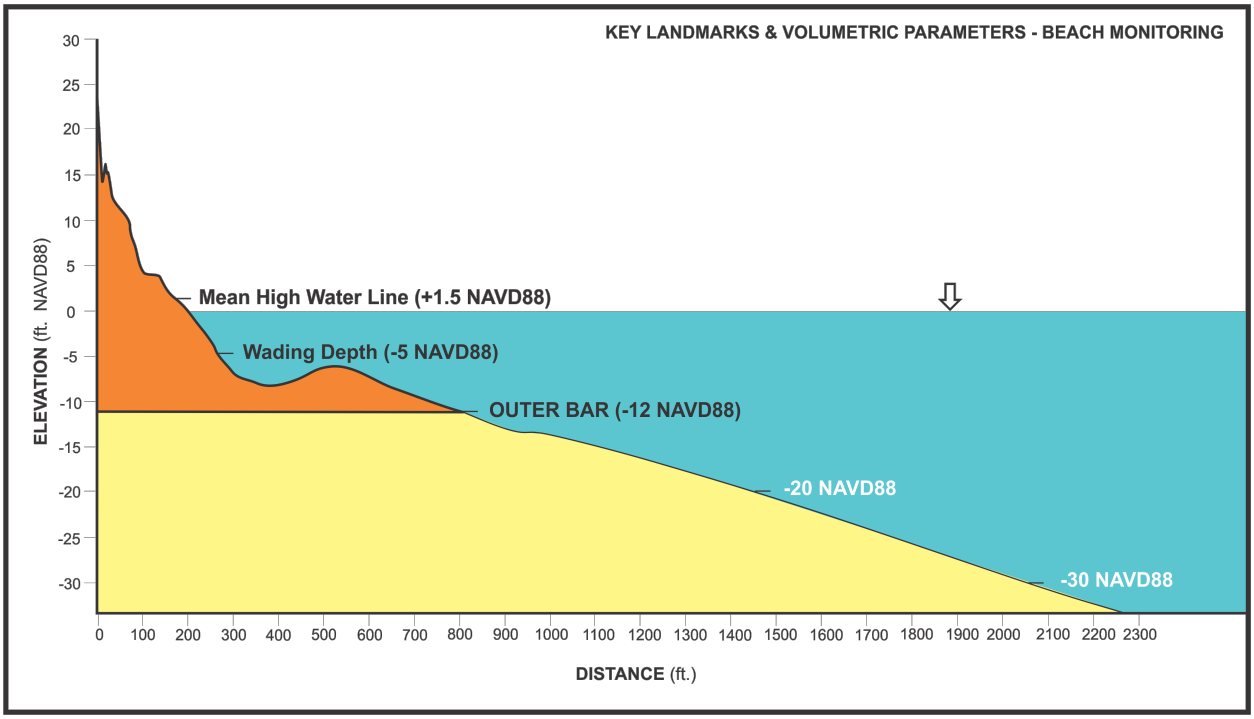

Figure 2 – Characteristic Bogue Banks profile in cross-section depicting the key "landmarks" monitored for changes in sand volume. Although changes are recorded above each of the landmarks depicted in the figure, the orange-colored fillet represents the positive or negative changes occurring at the elevation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

In even greater detail we can also see sand moving to and from the upper (dry) and lower (underwater) parts of the beach profile year in and year out. Over time, there has been a significant amount of sand accumulating on the dry sand beach and forming new dunes. At the same time, the shoreline position has actually been fairly static. The end result? Generally the same length of subaerial beach but more dunes with significant height but less berm (flat beach). The pictures below (Fig. 3) are from the Clamdigger at Pine Knoll Shores looking west – notice the dune/berm interface before and after *Irene* in 2011 and where that same interface is located now (2017).

The other more short-term factor at play is the storm profile vs. the fair weather profile. Any high-water, minor storms will take sand from the upper part of the beach and slide the sand seaward, likely near the "wading depth" depicted in Figure 2. Normally most of this sand will weld itself back to the beach during fair weather conditions. The larger, more intense storms can at times take sand completely below our -12 feet NAVD 88 system = outside the sand box. There is lower probability this sand will make it back up the profile slope.

Historically we do not think there is "much" sand from a gross standpoint migrating (and staying) from one management reach to the other (shore-parallel). In other words, we almost never experience a large loss in one management reach coupled with a significant gain in an adjacent reach. Or *vice versa* – immediately adjacent reaches to those that received direct nourishment rarely experience significant gains the following year. Obviously this is just a general rule of thumb and is not valid for profiles/reaches near inlets (subject for another day). 2017 provides no exception to these trends – most of the gains and losses can be traced up and down the beach slope (shore perpendicular).

Figure 3 – Photographic time series from the Clamdigger, Pine Knoll Shores looking west depicting the progression of the dune/berm interface and overall growth of the dune system. ***Top Panel (8/25/2011)*** – Two days before Hurricane *Irene* impacted the area. ***Middle Panel (8/27/2011)*** – Substantial dune erosion hours after *Irene* passed. ***Bottom Panel (7/26/2017)*** – Almost 6 years after *Irene*; notice seaward and vertical expansion of dune system and general position of dune//berm interface.

Lastly and continuing with 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. 4). All the island management reaches are also in excess of our Master Plan "volumetric thresholds" -- or perhaps better conceptualized as beach nourishment triggers. Our Master Plan management reaches as referenced in Figures 1, 4 and Table 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 2017 management reach values in terms of average cy/ft and our minimum volumetric thresholds (i.e., nourishment triggers) are presented graphically in Figure 4 as well.

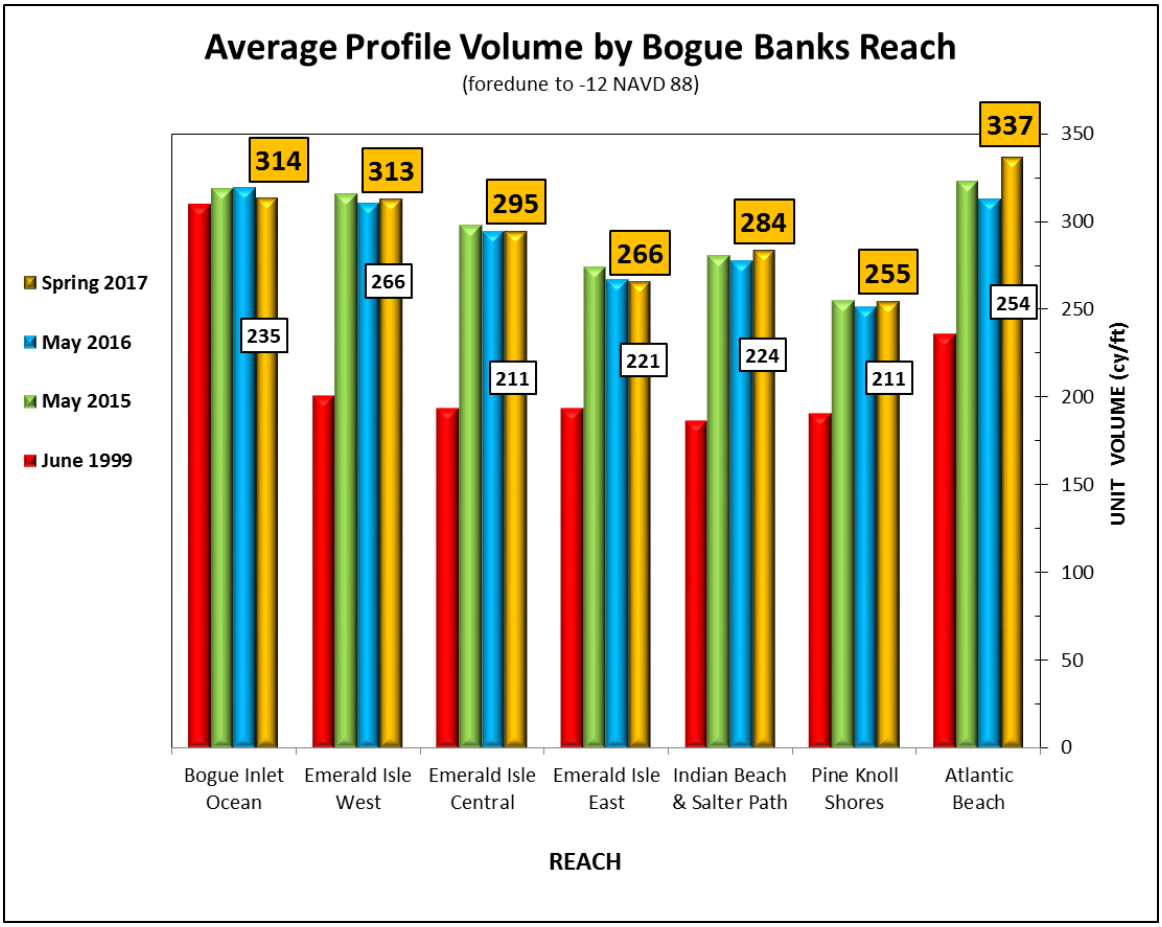

Figure 4 – Average profile volumes for September 1999 (baseline year), 2017 (the most recent survey), 2016, and 2015 for seven oceanfront management reaches along Bogue Banks. The minimum volumetric thresholds (i.e., nourishment triggers) are provided in the white call-out boxes while the 2017 average volume is represented in the orange call-out boxes.

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.