



SHORELINES – November 2018

As presented to the *Island Review* magazine

Hurricane Florence

As this article is being prepared some two weeks after *Florence*, there are still many coping with roof leaks, downed trees and debris, “storm water” or often groundwater rising above grade, loss of personal property, the stress of insurance claims and repair, school calendar concerns, business loss, and a spate of other issues. The “F” hurricanes have not been kind to us the past few decades starting with hurricane *Fran* in 1996 (aided by *Bertha* just beforehand) followed by *Floyd* in 1999 (coincidentally aided by *Dennis* “1 & 2” weeks earlier), and now *Florence* (2018); which as we will see, could be considered as the worse of them all. While the emotional toll of *Florence* can’t be overstated enough, we will take a little breather from that aspect and assess the physical impacts of *Florence* to the beaches of Bogue Banks.

(1) STORM OF RECORD - *Florence* became the storm of record (twice) for the highest water level ever recorded at the Beaufort, N.C. tide gauge. NOAA's National Ocean Service maintains a list of the top ten highest water levels for 110 of their longest-term tide gauge stations, and the highest water level ever recorded at the Beaufort gauge was 3.39 feet relative to MHHW (Mean Higher High Water) – achieved exactly twice during *Hazel* (1954) and *Ione* (1955). *Florence* exceeded this benchmark the first time early Friday morning (9/14/18 @ 5:54 GMT) with a 3.75 feet MHHW reading, and proceeded to tie the *Hazel/Ione* record the subsequent high tide later that afternoon (3.39 feet MHHW @ 16:12 GMT). This resulted in an unprecedented “one-two” punch to Carteret County (Fig. 1).

Granted it is very difficult to translate the water level at the Beaufort gauge to the oceanfront especially keeping in mind “the waves on top” and the storm surge generated by a hurricane. The term “storm surge” is often erroneously used to describe almost any high water event in any water body, but should be constrained to defining the wall of water being pushed forward by a hurricane in the northeast quadrant (estimated by some to be 10 feet for *Florence*). *Storm tide* incorporates both the surge value and the additive or subtractive

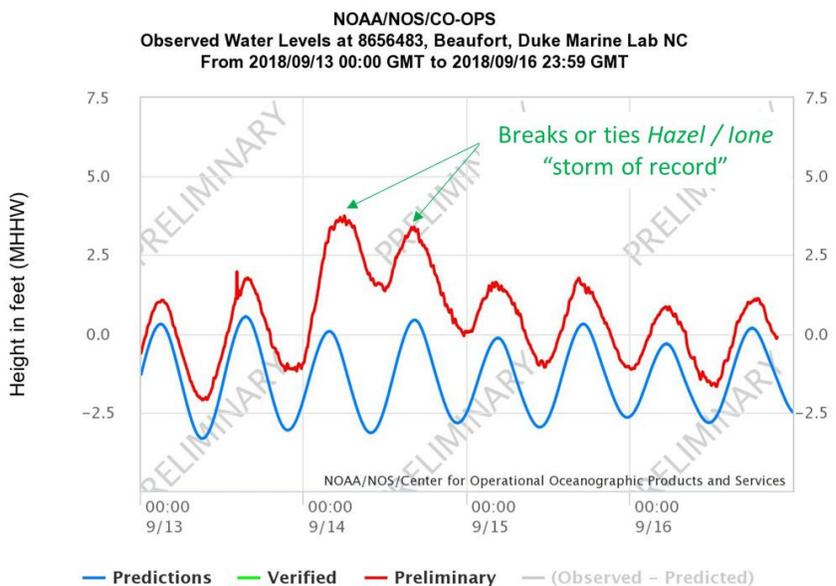


Figure 1 – Beaufort, NC tide gauge during *Florence*'s closest approach (and stall) resulting in the highest water levels ever recorded, superseding and tying *Hazel* (1954) and *Ione* (1955) during two consecutive high tides.

impacts of the tide. The magnitude of storm surge is predicated on numerous factors such as; storm intensity, forward speed, angle of approach, and slope of the continental shelf. The storm surge plus wave action drives peak erosion during hurricanes. With respect to waves, the nearest offshore buoy to Bogue Banks is located roughly 40 miles due south of Beaufort Inlet ([LEJ3](#)) and recorded a wave height of 28 feet on Thursday afternoon (9/13/18) as *Florence* approached Bogue Banks. The maximum wave height for the last hurricane significantly impacting Bogue Banks was 25 feet (*Irene* 2011).

The fact we had the highest water levels ever at the Beaufort gauge twice on consecutive high tides and we were located on the northeast quadrant of the hurricane for an uncommonly long duration, puts *Florence* in a class by herself – almost certainly worse than *Fran* (1996) and *Floyd* (1999), arguably worse than *Hazel* (1954) and *Ione* (1955), and perhaps comparable to *Donna* (1960), which caused breaching of Bogue Banks.

(2) BEACH EROSION - The incipient dune field, or “the baby dunes” is generally a product of pioneer vegetation along the beach berm (the flat part of the beach), which initiates dune growth and/or is stimulated by various sand fencing and dune planting activities coordinated through the local municipalities, home owner groups, and individuals. Importantly, the incipient dunes act as a line of defense to the large foredune that fronts most of Bogue Banks and often exceeds elevations of 20 feet. *Florence* significantly impacted the berm and incipient dune field, and only in very isolated areas impacted the foredune (Fig. 2).

The County/Bogue Banks predominantly take a volumetric approach to ascertain beach health relying on measuring the amount of cubic yards (cy) of sand gained or lost (mental image: a dump truck holds roughly 12 cy of wet sand). 2018 marks the 19th anniversary of hurricane *Floyd* and since 1999; Bogue Banks has gained roughly 9.6 million cy of sand, which is mostly attributed to the many beach nourishment projects that have been constructed along the island beginning in 2001. A total of approximately 14.5 million cy of sand have been placed directly on Bogue Banks as a result of beach nourishment, meaning 4.9 million cy have since eroded off the beach (14.5 million cy placed on the beach minus 9.6 million cy remaining). If we average the volume loss (-4.9 million cy) across the entire 128,393 feet (24.3 miles) of Bogue Banks oceanfront, the



Figure 2 – Memorial Park Beach Access, Pine Knoll Shores looking west depicting the erosion of incipient dunes during *Florence* that protected the large, naturally occurring frontal dune.

island has lost sand at a rate of -2.0 cy per linear foot per year (cy/ft/yr) since 1999 (a 19-year window).

Our contractor, *Geodynamics LLC* completed surveying all 122 transects along Bogue Banks the week after *Florence*, which are spaced roughly 1,000 feet apart. We are waiting for the results of the survey once the data has been processed and analyzed as this edition of *Shorelines* is being prepared. The post-*Florence* survey will be compared to our annual “pre-hurricane” survey completed in Spring 2018 in order to determine how much sand was lost. The results should be very interesting just based on our visual observations of the beach. Also, in addition to gaining a better understanding of how much sand was lost/eroded during *Florence*, we will be able to place this event in a greater long term context and begin planning for future beach nourishment projects immediately.

(3) BEACH NOURISHMENT - The infusion of sand via beach nourishment and subsequent development of incipient dunes since hurricane *Floyd* (1999) protected ~24 miles of homes, hotels, public accesses, and infrastructure for the storm of record. There was no *flood* damage to oceanfront structures, nor any breaches of the frontal dune. Structural damage was limited to walkways only. Figure 3 is an example of the differences between *Floyd* (1999) and *Florence* (2018) – same location, *Florence* was almost certainly a more severe hurricane, but there is more sand in 2018 than 1999. The result? No damage, and while the large foredune was impacted by the *Florence*, a significant part of the dune remains protecting homes, beach accesses, infrastructure, and the maritime forest all across Bogue Banks.

The impacts of beach nourishment can also be seen by looking at the dune escarpments (the vertical cuts of dunes) across the island created by *Florence*, which are just about continuous from the Point in Emerald Isle eastward until you reach the Circle in Atlantic Beach (~20 miles). From the Circle to Ft. Macon, there are no dune escarpments. The reason for this can be attributed to the 3.2 million cy of sand placed in this reach since 2011 via three individual events associated with the dredging of the Morehead City Harbor Federal Navigation Project.

There is still much recovery to be done in the wake of *Florence*, and one of those tasks will be replacing the sand lost during *Florence* so we can continue protecting our oceanfront assets.

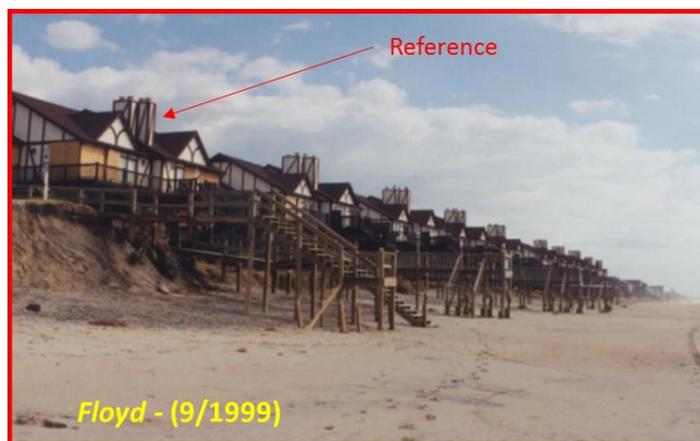


Figure 3 – Ocean Reef condominium complex in Emerald Isle taken from the same general perspective just after hurricane *Floyd* (1999) and 19 years later after *Florence* (2018), or effectively “before” and “after” beach nourishment.