SHELL HASH: A NATURE-BASED SOLUTION FOR BEACHFRONT COASTAL RESILIENCE?

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INTRODUCTION AND BACKGROUND

Based upon examination of beach profiles measured in June, 2016 (*i.e.* pre-Hurricane Matthew), November, 2016 (post-Matthew), and in September, 2017 (post Hurricane Irma) it was found that the 6.8 km of natural beaches in the Guana, Tolomato, Matanzas National Estuarine Research Reserve (GTM), extending from State range monuments R-46 to R-67 in St. Johns County, FL, experienced essentially no erosion of the primary dune, whereas dunes and bluffs in the developed beaches further south in St. Johns County were severely eroded and many beachfront homes experienced heavy damage – see Figs. 1 & 2.

Fig. 1 - Oblique aerial photographs of a section of South Ponte Vedra Beach (a) pre-Hurricane Matthew, and (b) post-Matthew. (R-104).

Fig. 2. - Post-Hurricane Irma photograph of slab-on-grade house destroyed by bluff erosion (R-110).

Closer inspection of the pre-storm profiles in the GTM revealed the ubiquitous existence of a small dune-like feature that fronted the large primary dune – see Fig. 3 for an example at R-60. Although this fronting feature was partially eroded by Matthew, and then largely "finished-off" by Irma, no erosion of the primary dune was observed at any location where such a feature had existed prior to the storms.

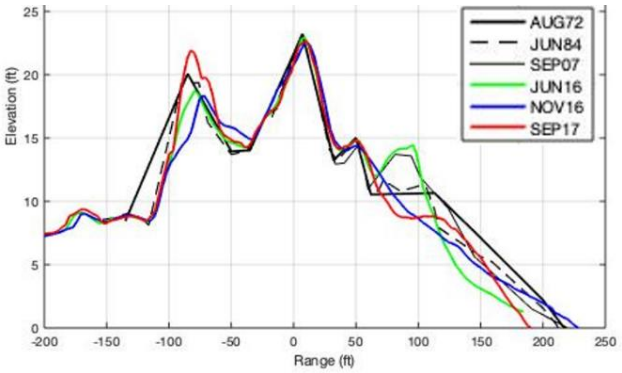

Fig. 3- Historic beach profiles and pre-and-post hurricane profiles at R-60 on the GTM's pristine beach showing no erosion of the primary dune.

South of approximately R-84, where there was no evidence of a pre-Matthew fronting feature, the dune and bluff erosion inflicted by the storms was evident, and often dramatic – see Fig. 4 for an example at R-86.

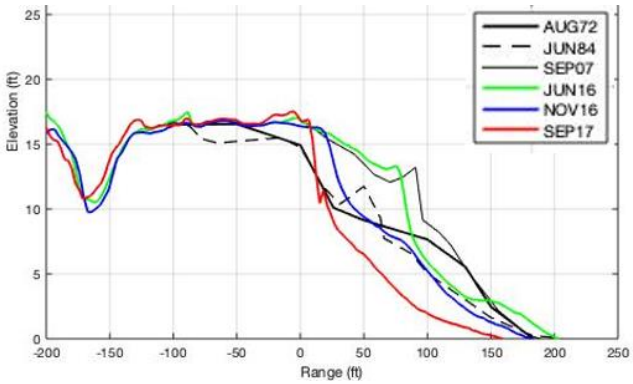

Fig. 4- Historic beach profiles and pre-and-post hurricane profiles at R-86 in the developed section of South Ponte Vedra Beach.

Initial site investigations for a new Beachfront Data Collection Facility (BDCF) located at R-57 in the center of the GTM's pristine shoreline revealed that the sediment comprising the subaerial beach is primarily coarse shell hash (d_{50}~ 0.6-1.6 mm), whereas that in the subaqueous nearshore and in the large primary dune are nearly identical fine-grained quartz (d_{50}~ 0.16-0.2 mm).

It is hypothesized that the shell-dominated composition of the subaerial beach provides naturally enhanced erosion protection along this undeveloped shoreline.

METHODS AND PRELIMINARY FINDINGS

Students from the University of North Florida have been collecting and analyzing sediment samples along the shoreline of St. Johns County from R-1 (Ponte Vedra Beach) to R-123 (the north side of St. Augustine Inlet) since February of 2020 to test this hypothesis. Samples are taken every third R-monument (*i.e.*, 57, 60, 63, etc.), with four samples taken at each - one sample taken in the dune, a second from the mid-berm, the third at the toe of the swash zone, and the fourth from the inner surf zone. These samples are being subjected to standard sieve analyses, seeking any correlation of the mean grain size to the beach profile behavior at that location. Sample results are presented in Fig. 5 from R-57. Note 1) the remarkable similarity between the grain size distribution of the dune and that from the inner surf zone, 2) the similarity between that from the toe of the swash and the mid-berm, and 3) the marked *dissimilarity* between the two populations, both in terms of mean grain size and sorting characteristics.

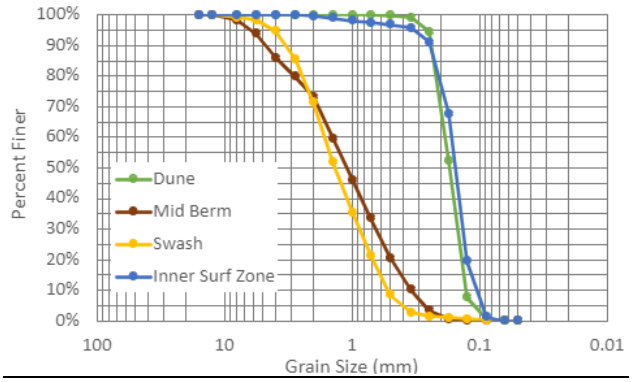

Fig. 5 – Example grain size distributions of the sediments found on the beaches of the GTM (R-57).

Because shell hash does not collect in a natural primary dune due to its resistance to Aeolian transport, it is hypothesized that the naturally fronting features present before the hurricanes struck were formed by extreme, yet constructive run-up, probably associated with spring high tides and long-period swell events. As evident in Fig 6, beach profiles surveyed after the hurricanes indicate that it required nominally three years for the frontal feature to rebuild itself. It is especially intriguing that the fronting feature grew back to its pre-Matthew shape, and remarkably to the same maximum elevation of nearly +14 ft NAVD88 that existed before the storms (ref. Fig. 1).

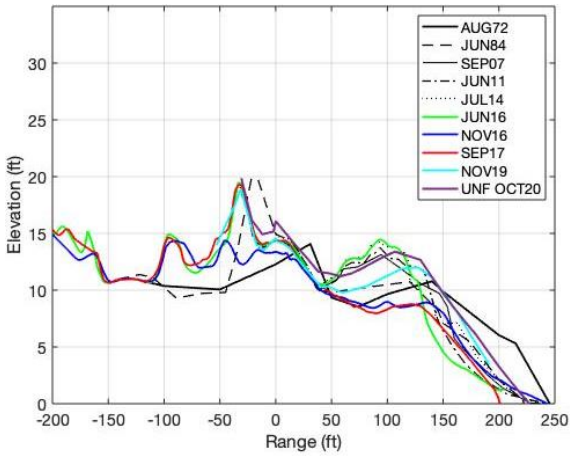

Fig. 6 - Beach profiles at R-57 (dirt access road in the middle of the GTM's pristine beach), indicating post-storm recovery.

IMPLICATIONS AND CONCLUSIONS

Based upon these observations and findings, it appears that the design of "engineered" dunes, and particularly artificial berms, could be significantly improved by utilizing larger-grained sediment such as shell hash, as opposed to attempting to match the native fine-grained quartz sand, as is conventional practice. It is common knowledge that coarse material is not only more resistant to erosion, but is the first material to recover after a storm. As importantly, the naturally rebuilt feature in the GTM is now covered with grasses and other vegetation (see Fig. 7) and is thriving with coastal fauna. Based upon ongoing monitoring, it is also clear that shell hash does not impede the ability of sea turtles to dig nests.

Fig. 7 – Sea turtle nests along the shell hash beach of the GTM (R-58).