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Title: Morphodynamic Changes of the Parramore–Cedar Barrier-Island System and Wachapreague Inlet, Virginia from 1852 To 2011: A Model of Barrier Island and Tidal Inlet Evolution Along the Southern Delmarva Peninsula, USA

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ABSTRACT

This dissertation is a study of the shoreline and tidal inlet changes of the Parramore–Cedar barrier-island and Wachapreague tidal inlet system through the integration of a variety of geospatial data sets over a range of spatial and temporal scales. Fundamental changes to the historical trends of shoreline and tidal inlet behavior provide a means to quantitatively test the three-stage model of runaway transgression (Fitzgerald et al., 2004). The analysis of a robust set of shoreline data sets demonstrates the pattern of clockwise rotational instability over the long term as documented by Leatherman et al. (1982) has evolved into sustained rapid retreat along the entire outer shoreline of Parramore Island, whereas Cedar Island has transitioned from in-place narrowing to rapid barrier rollover and landward migration through overwash and inlet processes. The non-inlet-influenced, open-ocean shoreline of Parramore Island experienced a -4.1 m/yr retreat rate from 1852 to 1998 and a -12.2 m/yr retreat rate from 1998 to 2010, according to a linear regression analysis. Similarly, Cedar Island's non-inlet-influenced,

open-ocean shoreline underwent a -5.5 m/yr retreat rate from 1852 to 2007 and a -15.4 m/yr retreat rate from 2007 to 2010, also according to a linear regression analysis. The short-term retreat rates for both islands are nearly triple the long-term rates. These increases in short-term retreat rates constitute a fundamental change in the pattern of historical shoreline movement for the Parramore–Cedar barrier-island system.

The cross-sectional area of an inlet throat is used as a proxy to calculate tidal prism and ebb-tidal delta volume of tidal inlets. The historical cross-sectional areas for Wachapreague Inlet were 1845 m^2 in 1852, 4473 m^2 in 1871, 4737 m^2 in 1911, 4572 m^2 in 1934, 4047 m^2 in 1972, 4398 m^2 in 2007, 4735 m^2 in 2010 (April), 5014 m^2 in 2010 (August), and 5210 m^2 in 2011. Tidal prism and ebb-tidal delta volumes at Wachapreague Inlet fluctuated from 1871 to 2011 with tidal prism ranging between 4.82×10^7 m^3 and 6.09×10^7 m^3 and ebb-tidal delta volumes ranging between 1.85×10^7 m^3 and 2.46×10^7 m^3. From 1871 to 2007, the long-term linear regression rates of change were -2.4 m^2/yr for cross-sectional area, -2.67×10^4 m^3/yr for tidal prism, and -1.26 m^3/yr for ebb-tidal delta volume. However, from 2007 to 2011, the short-term linear regression rates of change switched to high rates of increase with 186.1 m^2/yr for cross-sectional area, 2.04×10^6 m^3/yr for tidal prism, and 9.89×10^5 m^3/yr for ebb-tidal delta volume. Overall, from 1871 to 2007, tidal prism and ebb-tidal delta volumes have fluctuated about means of 5.25×10^7 m^3 and 2.06×10^7 m^3, respectively, with a modest increase more recently (2007–2011) to 5.69×10^7 m^3 and 2.27×10^7, respectively. This research accounts for the natural variability in tidal prism on a monthly basis (e.g., neap vs. spring tides, perigee vs. apogee) and a seasonal basis (e.g., potential coastal setup caused by meteorological events,

thermal expansion of the water column [steric effect]) by utilizing a 15% natural variability in the tidal-inlet analyses.

These spatial analyses provide insight into how shoreline and bathymetric changes of the Parramore–Cedar barrier-island system are driven by 1) the southern extension of the large arc of erosion located south of Assateague Island in response to sediment trapping at the large recurved spit complex at Fishing Point, Virginia; 2) relative sea level rise along the southern Delmarva Peninsula; 3) updrift barrier-island breaching north of Wachapreague Inlet along Cedar Island and other breaches further north; and/or 4) increased storminess along the outer barrier islands of the Virginia Eastern Shore. Furthermore, this research presents a six-stage model of barrier evolution along the southern Delmarva Peninsula. The six-stage model accounts for changes in sediment supply, relative sea level rise, increased storminess, and the projected consequences to the Parramore–Cedar barrier-island system. The significance of short-term shoreline and bathymetric changes that depart from historical trends is important because these developments may indicate wider patterns of barrier-island change for the entire Virginia Eastern Shore and, perhaps, large expanses of mixed-energy coasts along the entire U.S. Atlantic seaboard.