Coupled Barrier Island and Shoreface Dynamics: A comprehensive understanding of coast-wide response to transgression

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Introduction: Barrier islands along with their sub-environments are highly productive ecosystems that contribute substantial ecosystem services to coastal populations. Moreover, barriers serve as the primary landform where hurricane waves dissipate their energy and in many instances, drastically lessen storm surge (Georgiou and Schindler, 2009; Sleath et al., 2011). Barrier island and tidal inlet systems along the Mississippi River Delta Plain (MRDP) are undergoing rapid morphological change due to shoreface retreat and increasing bay tidal prism, driven by high rates of relative sea-level rise (RSLR) (1 cm/yr) and interior wetland loss. Protection and restoration of barrier habitats, sea-grass beds, and marshes are common (CPRA 2012). ***Advances in understanding that will result from this project will facilitate more informed planning, management, and mitigation efforts that are specific to barrier islands in Louisiana***. Recent analysis using observations spanning a century have increased our understanding of shoreline dynamics and barrier island area response to storms and long-term subsidence (Fearnley et al., 2009). Additionally, seafloor change analysis documented volumes of sediment eroded from proximal (barrier platform, inlets, ebb-deltas) and distal (shoreface) environments, highlighting key processes governing sediment loss from the barrier system during transgression (Miner et al., 2009). Later, cores were used to quantify the amount of sand and mud in the various environments providing a regional sediment framework emphasizing key sedimentation processes (Georgiou et al., 2011). Despite increased understanding from these and other studies (Jaffe et al., 1997; List et al., 1997), coupling barrier island and shoreface dynamics using a quantitative framework is still lacking, largely due to data limitations.

Objectives: We propose to analyse shoreline, seafloor, wave and sediment data, and corroborate the role of the shoreface in driving barrier island trajectory at both the regional (barrier chain) and local (~100 m) scales. We will also extend the analysis to include cross-shore profiles backed by marsh and and those that are primarily sandy, thereby determining differential erosion mechanisms. We will also focus on locations that restoration or nourishment took place previously, to determine whether the fate of nourished barriers exhibits comparative response to under-nourished barriers by comparing shoreface characteristics (migration rates, slope, barrier island slope) and provide insights into shoreface dynamics.

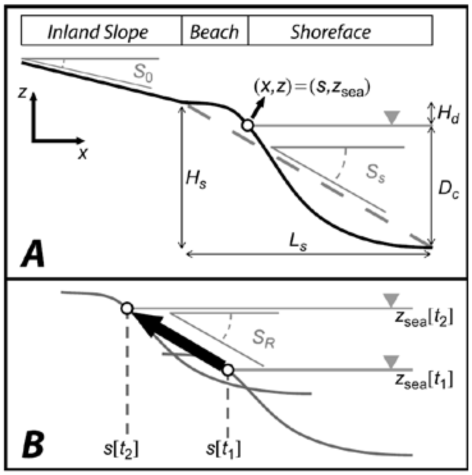

Figure 1 Cartoon showing the Shoreface slope, inland slope, barrier slope and depth of close for a typical barrier backed by a lagoon. (x,y) is the shoreline erosion rate and the black arrow shows the instantaneous retreat vector (between two time periods)

Relevance: CPRA routinely nourishes or performs complete restoration of many of Louisiana's barrier islands. Identifying and prioritizing restoration projects often rely on barrier subareal exposure. Our analysis will provide additional information on barrier dynamics that will aid in making decisions for restoration, help identify regional trends in coastal dynamics and prioritize future locations for restoration.

Background: Barriers are accumulations of sediment that are built vertically due to wave action and wind processes. Most barriers are linear features and parallel the coast and are found on every continent except Antarctica, in every type of geologic setting, and in every kind of climate (Davis and FitzGerald, 2008). Barriers are most commonly found on trailing margins in the United States and the rest of the world, and they occupy 15% of the world's coastlines (Cooper and Pilkey, 2004). In southeast Louisiana, barriers are found on both sides of the modern Mississippi River Delta (MRD). Penland et al. (1988) showed that these landforms are formed from reworked delta deposits, whereby channel sands, mouthbars, natural levees are reworked by wave action to form landscapes that resemble arcuate shapes (headlands) with flanking barrier splits. Storms and other oceanographic processes may cause barrier breaching, overwash and/or continue to grow these landscapes (laterally and vertically) until they detach from mainland (through processes that are presently still unknown), by widespread subsidence within the backbarrier setting. Meanwhile, the accumulation of sands comprising the developing barrier island lag this process and maintain subareal exposure through further reworking to form a robust subareal landform (a barrier island). The diminishing supply of sand to the system -

without additional nourishment or opportunities to recycle local or proximal sand from the system – eventually forces barriers to become submerged shoals.

Data and Analysis: ***Shorelines*** – we will focus on shorelines developed under the Barrier Island Comprehensive Monitoring Program (BICM) and used during the Coastal Masterplan 2012, and where available, extend the analyses further (if imagery or data are available) to determine barrier erosion rates for both the seaward side and the landward side of the barrier. This analysis will yield a dual barrier erosion rate that would reveal a rate of thinning for all barriers every 100 m for four periods (1880s - 2007). A derivative metric from this analysis is the barrier island area per unit distance along a barrier chain that can be further correlated to the shoreface dynamics.

Seafloor Bathymetry – For the same periods, BICM produced sequential bathymetry maps and through further analysis seafloor change maps (Miner et al., 2009). We propose to use the historic bathymetry to determine a horizontal migration rate for the upper and lower shoreface (migration of the ~3 m and 9 m isobaths) along the same locations (every 100 m) that shoreline erosion rates are available to test if the shoreface and barriers are coupled. Along the cross shore profile we will use the volume of erosion produced by the seafloor change analysis every 100 m to produce a normalized erosion/deposition volume per unit distance that can be correlated for each barrier.

Shoreface Slope and Barrier Island slope – for each cross-shore profile within the database, we will identify a shoreface slope (define as the slope of the profile from the toe to the surfzone, ~1 m depth), and a barrier island slope (defined as the slope from the profile toe to the backbarrier shoreline – Wollinsky and Murray, 2009). This will test the hypothesis that barrier thinning is coupled with shoreface steepening.

Nearshore (and offshore) Wave Climate – we will correlate the shoreline erosion rates, upper and lower shoreface erosion rates, and the resulting observed volume of erosion along the profile with the local wave climate. Georgiou et al. (2013) developed SWAN wave models that cover the entire domain of sandy shorelines in Louisiana with a nearshore resolution of 100 m. We will use wave results to determine if barrier and shoreface response determined from this study correlates with local wave climate. The SWAN models were validated using WAVCIS gauges for 2010, and simulations were conducted using offshore wave buoy data from NOAA buoys.

Sediment Characteristics – we will use BICM2009 sediment samples and compare those to BICM2015, in particular, in areas where restoration has taken place to determine if surface sediment cover on the shoreface has changed over time, and attempt to link to shoreface and/or barrier response.

Anticipated curriculum: The student in this project will be enrolled in the Masters Program in the Department of Earth and Environmental Science (EES) at the University of New Orleans, and the Pontchartrain Institute for Environmental Sciences (PIES, PI Georgiou is the director). Both the department and PIES are particularly strong in coastal sedimentary processes and coastal geology. The degree program carries 30 credit hours (24 courses; 6 research). In addition to PI Georgiou, resident faculty with relevant experience to this study include Alex McCorquodale (coastal engineering/sediment transport), Mark Kulp (coastal subsidence/stratigraphy), and Royhan Gani (Sedimentology) and Adjunct Professor, Duncan FitzGerald. The student will have numerous classes to choose from, including Coastal processes, Coastal Sediment Transport, Computational Fluid Dynamics, Data Analysis in Earth Sciences, Coastal Geomorphology, Environmental Modeling, Surface Processes and Earth Dynamics, Barrier Island Dynamics, Sedimentology and Stratigraphy, Sequence Stratigraphy, Sediment Transport, Coastal Engineering, Experimental Statistics. This diversity translates into a rich educational environment, in which the student will be exposed to many mentors and will have access to abundant resources. PI Georgiou currently has one proposal in review at NSF related to barrier dynamics, and a *recently awarded project by the Bureau of Ocean Energy Management in collaboration with Dr. Mike Miner (BOEM) and Rex Caffey (LSU) to study the geomorphic benefits of using offshore versus nearshore sand sources for nourishing barrier islands*. Additional funds will be sought via the Water Institute of the Gulf. Finally, UNO-EES provides students with funding opportunities to support conference travel to present research. UNO-EES and UNO-PIES have robust and diverse tools and technologies such as GIS software (ArcGIS, ERDAS), coring equipment, hydro-acoustic Doppler profilers, wave sensors, hydrographic sensors, space for sedimentological analysis, computer workstations, and vessels for conducting field observations.

Disclosure: Georgiou has no conflict to disclose nor is affiliated with any of the companies listed above.