Barrier response to sea-level rise:
Investigating the controls of overwash on evolution and stability

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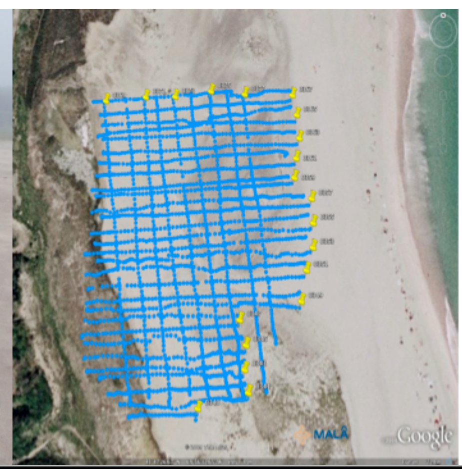
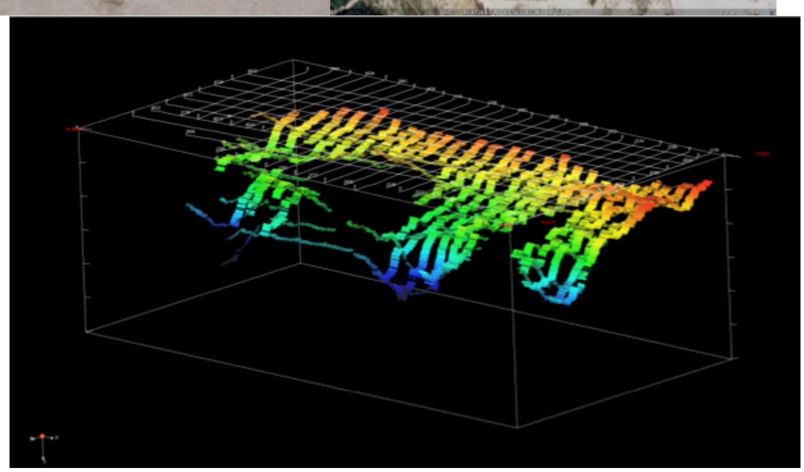
Where there are beaches (or anywhere the shore is not made out of rock), the coast is not a 'bathtub', and rising sea levels do more than merely flood the coast as often portrayed. The response of coastal landforms to an increase in sea level, such as that predicted over the coming decades and centuries, will be complex and dramatic, as higher seas enable waves and storm surges to reshape the coast. Barrier systems, thin stretches if sand separated from the mainland, have responded to the slow sea-level rise of the last few millennia by moving landward in a conveyor-belt fashion. As storms overwash the barriers, sediment is moved landwards, from offshore to backshore, allowing the barrier to move up and retreat as sea level rises. While the initial perception of this overwash process is that it results in beach erosion, over time, this overwash is necessary for a barrier to maintain itself with rising seas.

This research, conducted with the support of the Gratia Houghton Rinehart Coastal Research Endowed Fund, consisted of fieldwork along the beaches of Cape Cod and Martha's Vineyard combined with development of a numerical model of barrier coast evolution. Given the current increased rates of sea-level rise and the dramatic predictions that, by the end of the century, sea-level rise will be at a rate unprecedented for the last several thousand years, a vital question is



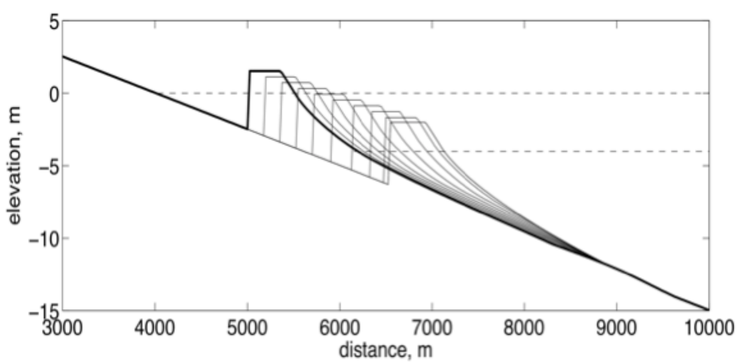
High-resolution grids of ground-penetrating radar surveys were conducted on Overwash fans at Nauset Beach and along the south shore of Martha's Vineyard, including Big Homer and Little Homer ponds. Processing of this data allowed us to compute the amount of sand transported onshore by

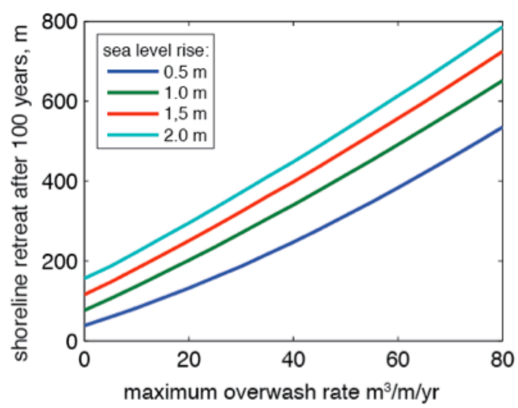


whether barrier systems will be able to withstand sea-level rise intact. Is there a threshold rate of sea-level rise beyond which barriers simple cannot 'keep up' and will drown in place?

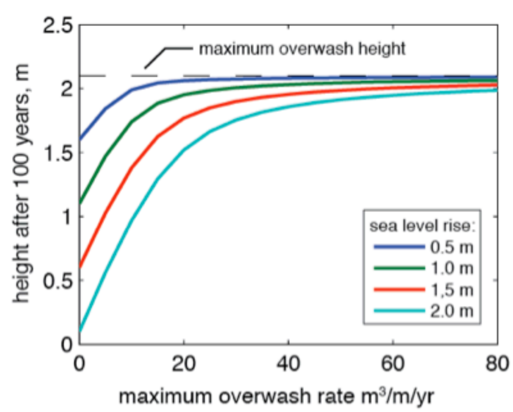
Because of the important role overwash plays in barrier evolution, the first objective was to quantify the volumes of overwash fans. Using Ground-Penetrating Radar (GPR), a device which can be used to image subsurface sedimentary deposits, myself and undergraduate guest students surveyed overwash fans at Nauset Beach and along the southern coast of Martha's Vineyard. These small barrier systems are ideal locations to study overwash as they are locations where sediment budgets can be reasonably constrained. The data, which consisted of dense 3-dimensional grids, were processed back at the lab, allowing us to quantify the volumes of the overwash fans. By comparing these volumes with the frequency of overwashing storm events, we are able to approximate the long-term rate of sediment transfer behind these barriers.

These overwash rates were then used to help constrain a numerical model which simulates coastal barrier evolution over the timescales of decades, centuries, and longer. The model considers two main components of barrier systems: the marine domain, or 'shoreface', which is constantly being reworked by waves, and the terrestrial system, dominated overwash. Model results suggest that overwash drives the long-term shoreface evolution. If overwash flux is low, coastal recession due to sea-level rise will be lessened, but a barrier will drown in place; correspondingly, larger overwash rates result in barriers that can maintain themselves, although with rapid shoreline retreat. Simulations reveal an interesting phenomenon: if the characteristic timescales of overwash and shoreface evolution are similar, instabilities in barrier evolution can





A computer model simulates barrier response to sea-level rise. If overwash rates are large, shoreline retreat will be rapid, but barriers remain intact. Shoreline retreat is reduced if overwash remains low, but barriers will eventually drown in place.



arise. Even with constant forcing, barrier response to sea-level rise can be complex, with alternating periods of rapid overwash, followed by accretion as the shoreface responds, followed again by rapid roll-over and so forth.

The research conducted under this award provides an excellent example of a case where a ‘seed’ investment in research has lead to further research funding opportunities for the Coastal Systems Group in Geology and Geophysics. The results of this research formed the basis of a successful, multi-PI grant in conjunction with the Marine Policy Center from the National Science Foundation’s Coupled Human and Natural Systems to study how human impacts on overwash and sediment transport may affect the behavior of barriers over the coming century. Under another grant, from the Department of Defense’s Strategic Environmental Resources Development Program, we will study the impacts of sea-level rise on barriers fronting military installations, including Elgin Air Force Base Santa Rosa Island, Florida, and Camp Lejeune, North Carolina.