Long Term Risks: Novel Barrier Island Retreat Behaviors Arising from Increasing Rates of Sea Level Rise

Daniel J. Ciarletta[1], Jorge Lorenzo-Trueba[1], & Andrew D. Ashton[2]

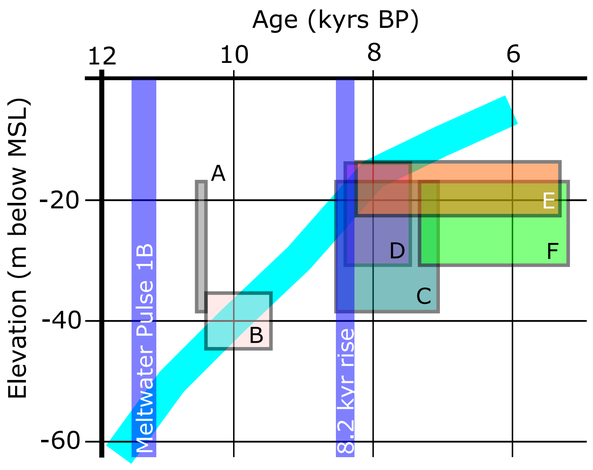
[1]Department of Earth and Environmental Studies, Montclair State University, Montclair, NJ 07043
[2]Geology and Geophysics Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543

Abstract

The hazards faced by retreating barrier island systems to the increased rates of sea level rise predicted over the coming century and beyond lacks historic precedent. Consequently, exploration of the sedimentological record can provide key insights into how barrier systems might behave in the future. Continental shelves around the world preserve records of former barriers as relict deposits, providing a window into past behaviors. These relict barrier deposits are usually considered to originate from purely allogenic processes, or external environmental forcing, with barrier abandonment typically attributed to episodes of increased rate of sea level rise. However, using a cross-shore morphodynamic model, we show that the internal dynamics of migrating barriers can also result in autogenic deposition of relict sediments even under a constant rate of sea level rise. Subsequently, we propose that allogenic forcing from sea level rise and autogenic forcing from internal dynamics might interact to produce novel barrier retreat behaviors, with the potential to be recorded on the seabed by relict deposits. We model barriers through a range of scenarios with interacting autogenic and allogenic forcing, showing that the morphology of deposits might be used to infer the relative influence of external and internal processes. Intriguingly, our results demonstrate that the internal dynamics of barriers can both amplify and dampen losses of shoreface sediment to the seabed during increased rates of rise, in some cases with internal processes increasing the risk of barrier destruction. Future classification of relict deposits in the field could help explain if and when these allogenic/autogenic interactions have taken place, revealing long term hazards to modern barrier systems that have not previously been described.

Chronology of Holocene Drowned Barrier Deposits

Where age control is available for drowned barrier deposits, clustering around meltwater pulses could suggest a relationship, but in many cases barrier deposits are produced several thousand years later. How is this possible? What are the implications for modern barriers experiencing increased rates of sea level rise?

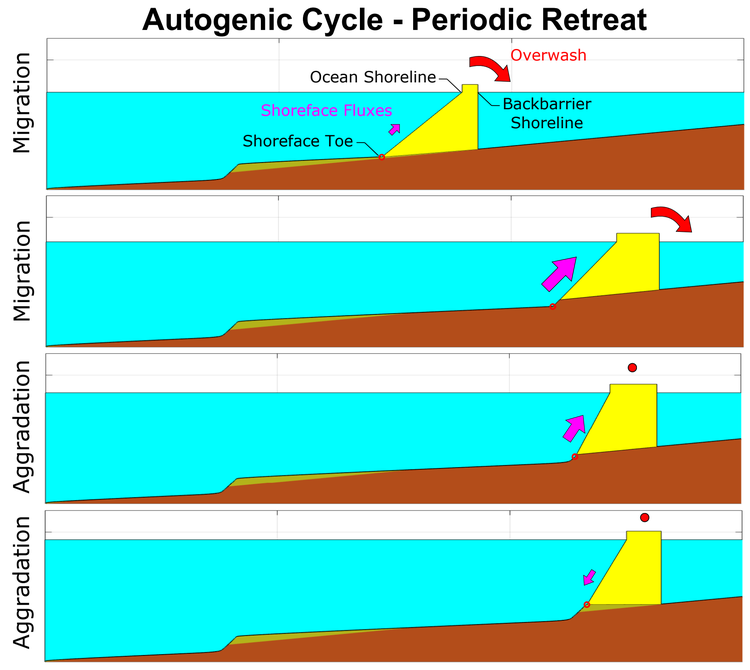


Age (based on 14C and OSL dating) of drowned barrier deposits and elevations, reproduced and modified from Mellet and Plater (2018). Generalized sea level curve modified from Gornitz (2007) after Fairbanks (1989).

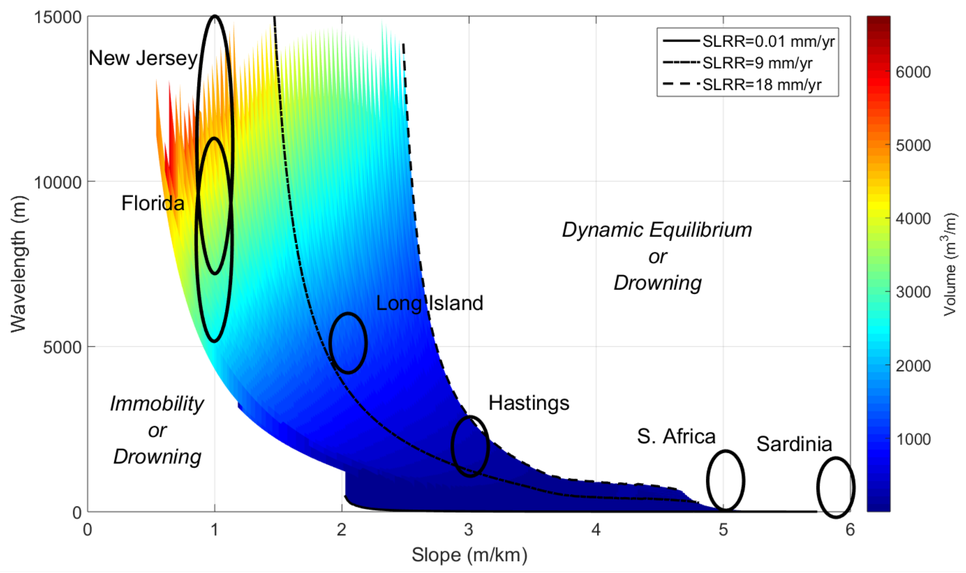
A. Adriatic Sea - Storms et al. (2008)
B. Kattegat, South Scandinavia - Bennike et al. (2000)
C. Heald Bank, Gulf of Mexico, USA - Rodriguez et al. (1999)
D. Rhine-Meuse, Netherlands - Hijma et al. (2010)
E. Hastings Bank, English Channel, UK - Mellet et al. (2012)
F. Old Rhine, Netherlands - Rieu et al. (2005)

Autogenic Deposition

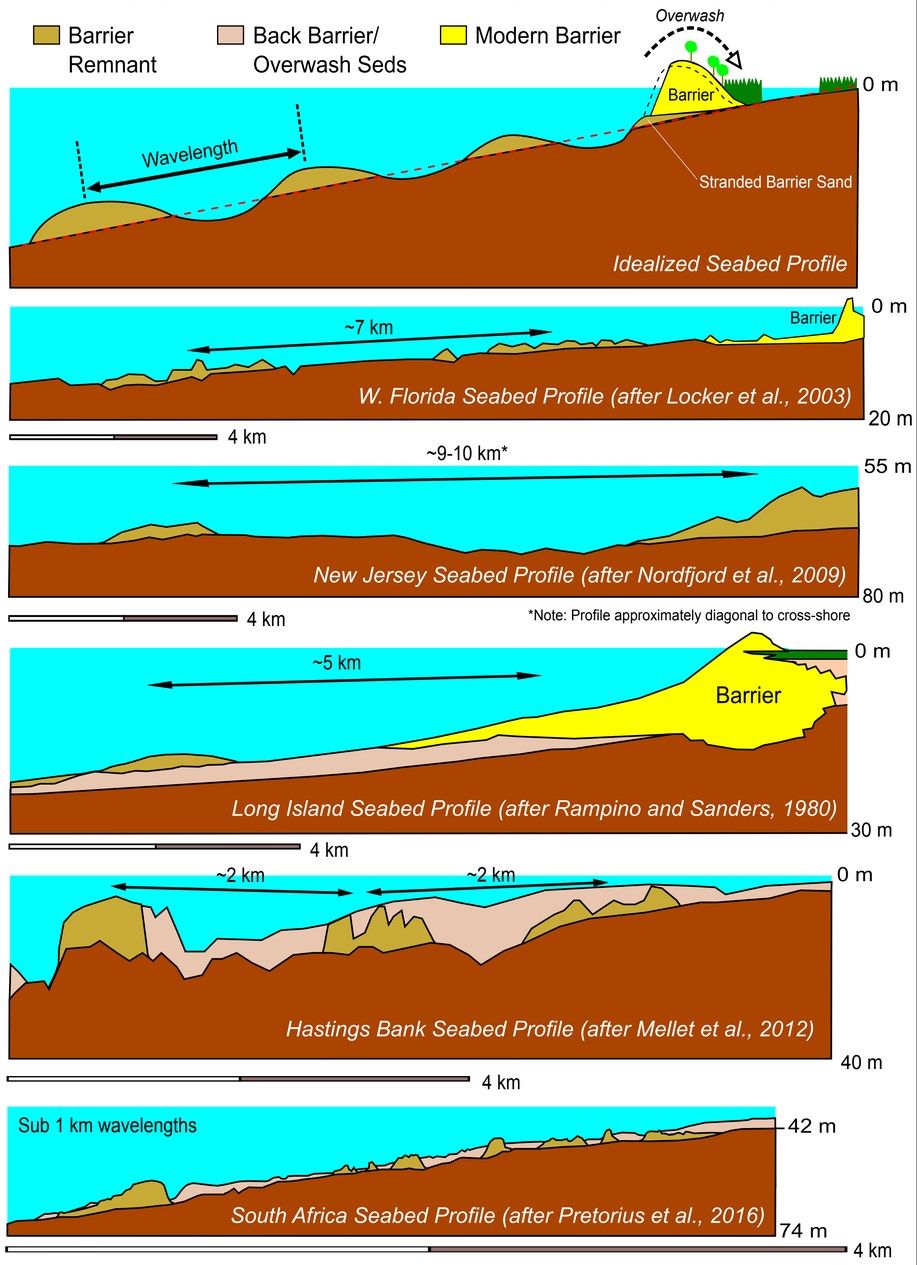
Autogenic Cycle - Periodic Retreat



Autogenic Deposition: Wavelength and Volume vs. Slope

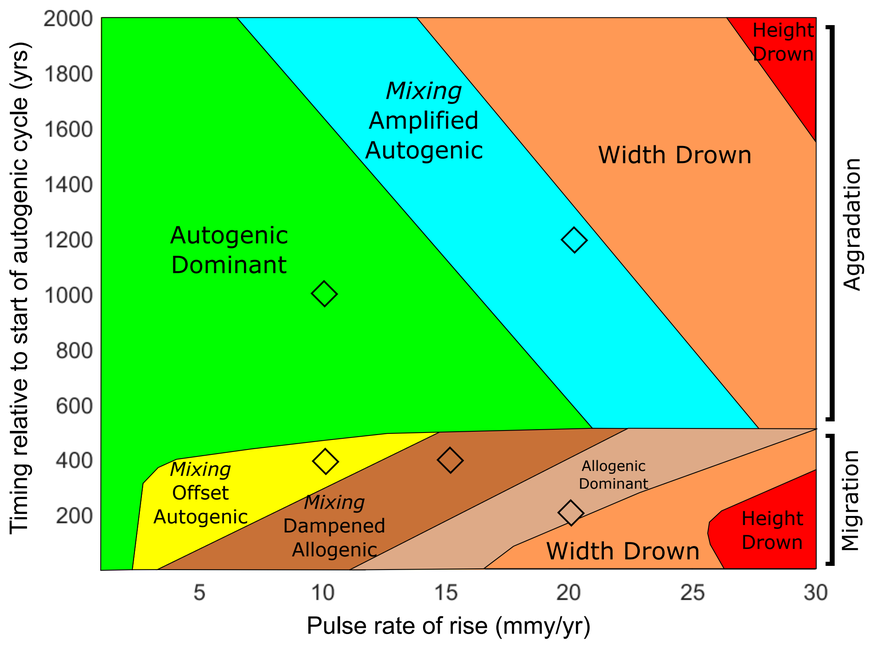


Seabed Profiles of Relict Barriers Around the World

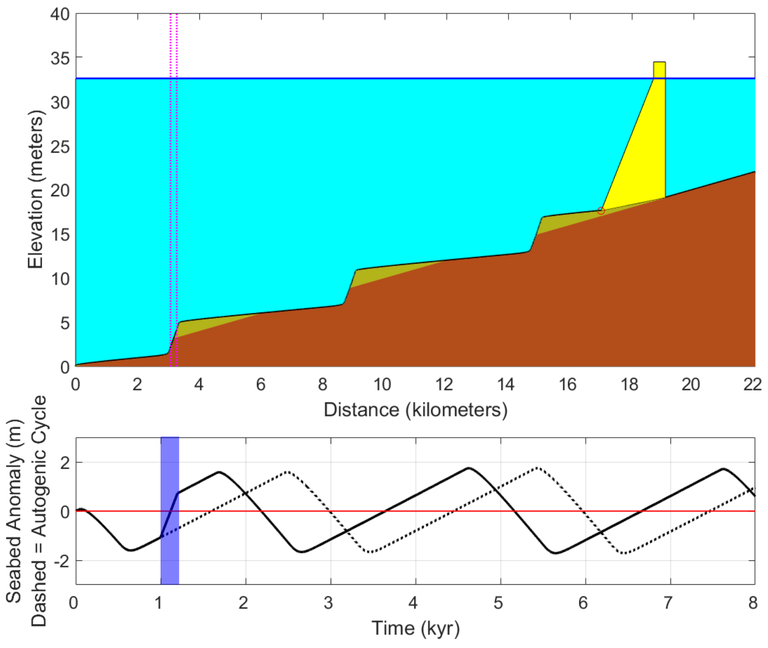


Autogenic & Allogenic Interaction: *Deposition During Rapid Sea Level Rise*

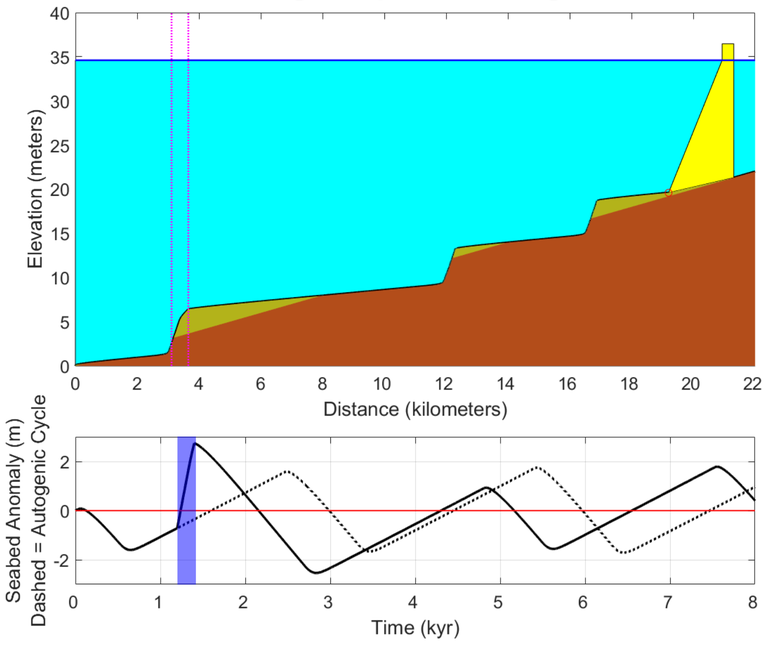
Response to 200 yr Pulse in Rate of Sea Level Rise



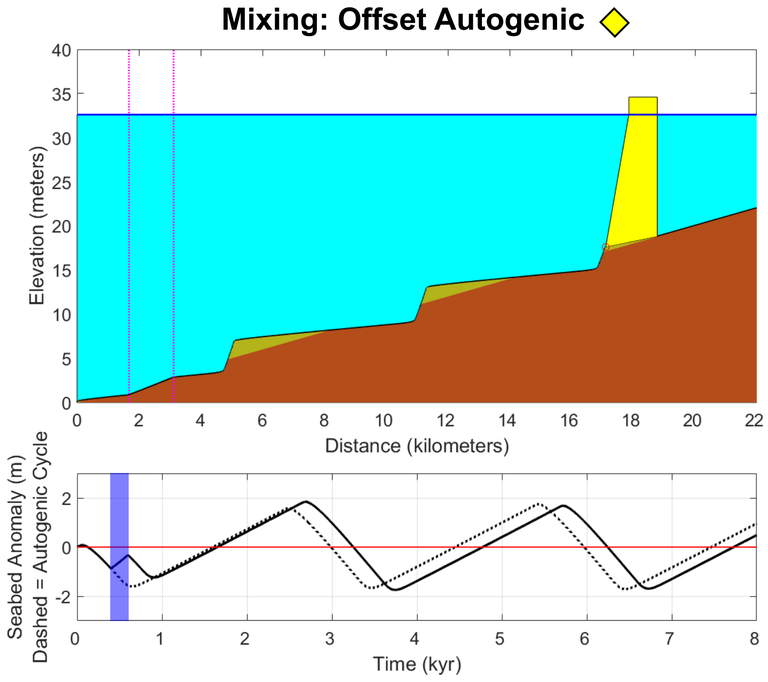
Autogenic Dominant



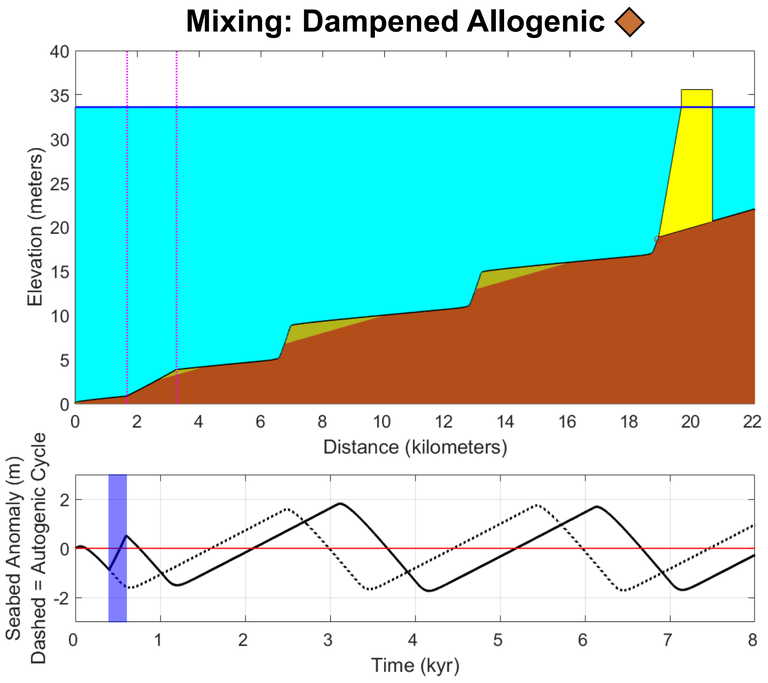
Mixing: Amplified Autogenic



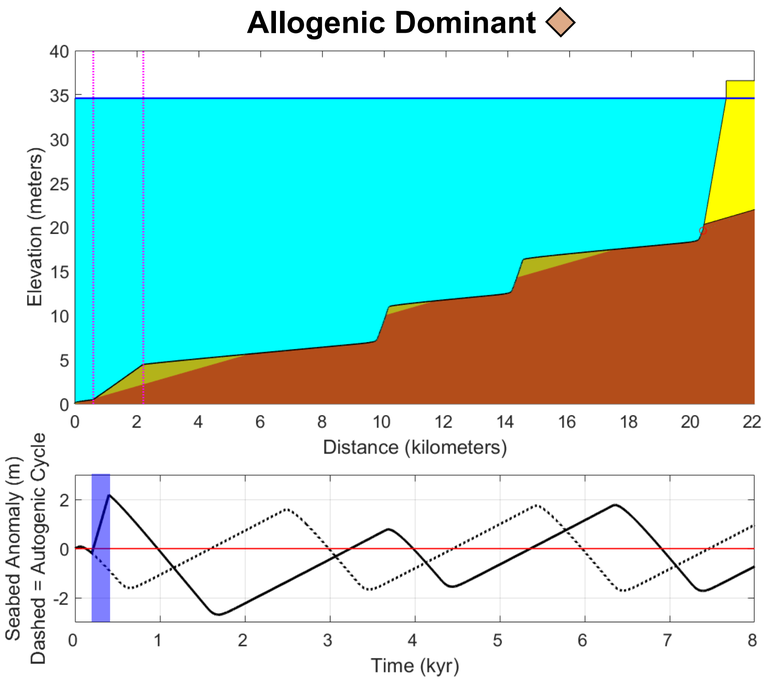
Mixing: Offset Autogenic



Mixing: Dampened Allogenic



Allogenic Dominant



Research possible in part through NSF Award #1518503, Coastal Processes and Human Response to Shoreline Change

Dissertation Committee: Dr. Sandra Passchier, Dr. Mark Chopping, and Charles Dill (AOSS Inc.)

Additional thanks to MSU colleagues for their time and support: Jesse Kolodin, Arye Janoff, William Anderson, Christopher Tenebruso, and Isamar Cortes