Abrupt Climate Change in Atlantic Tidal Marsh Communities

*Maureen Correll
PhD Candidate, Ecology and Environmental Science
maureen.correll@maine.edu

Maureen Correll*, Brian Olsen, and Thomas P. Hodgman
The University of Maine, Adaptation to Abrupt Climate Change IGERT program
The Climate Change Institute
The Saltmarsh Habitat and Avian Research Program

Research Question

How do spatial attributes of tidal marshes affect marsh community resistance to extreme storm events such as Hurricane Sandy?

Background

Tidal marshes are one of North America's most productive and dynamic habitat types. Those located along the northeastern seaboard of the United States are particularly vulnerable to degradation and loss due to coupled human (e.g. urban development) and natural (e.g. rising tide line) systems. Marshes are arranged linearly along the Atlantic coast, but within this arrangement present an example of a patchy habitat matrix (Fig. 1)**. Patchy environments in both terrestrial and island ecosystems will support varying amounts of community diversity depending on the size and connectivity of the habitat matrix[1].**

Climate change may alter the spatial characteristics of marshes through abrupt, non-linear processes, such as increases in the frequency and intensity of storm-related flooding events[2]. Hurricane Sandy, which impacted the east coast of the United States in October of 2012, is an example of such an event. We will take advantage of this naturally occurring manipulative experiment (Fig. 2) to begin to assess ecosystem resistance to extreme storm events.

[1]*R. MacArthur and E.O. Wilson, 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, NJ.*

[2]*IPCC 2007. Climate Change 2007:Synthesis Report. IPCC, Geneva Switzerland, 104 p.*

[3]*Conway 2009. The North American Marsh Bird Monitoring Protocol. USGS, Tuscon, AZ.*

[4]*Johnson et al 2009. Waterbirds 32(2):203-215.*

[5]*Kump 2010. The Earth System. Pearson Education, Inc, Upper Saddle River, NJ.*

Fig. 1 Tidal marsh (pictured left) occurs linearly along the coast, but within this arrangement often exists in discrete patches, such as along the coast of Cape May (pictured right) in New Jersey (inset).

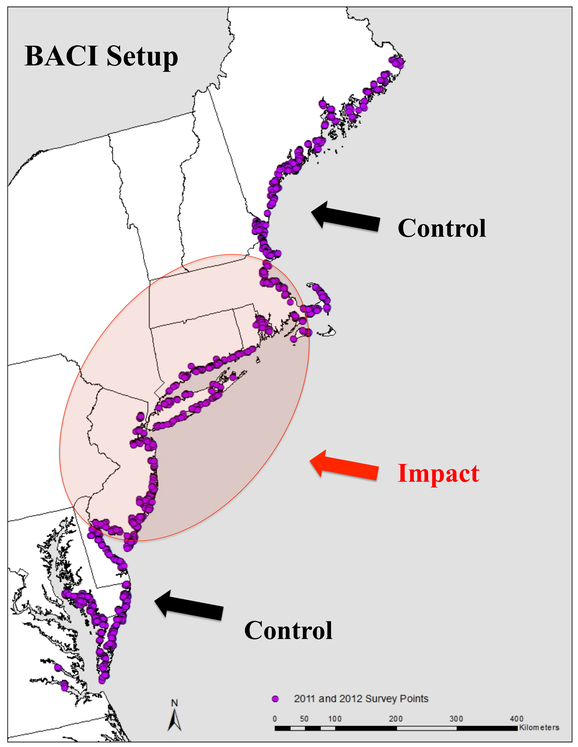

Fig. 2. Map of survey coverage area for 2011 and 2012. The impact zone of Hurricane Sandy (red oval and arrow) runs through the center of our 2011-2012 survey coverage area, leaving unaffected areas of coast to the north and the south (black arrows). Purple dots represent points at which point count surveys conducted in 2011-2012.

Methods

We conducted avian point count and call-response surveys (Fig. 3) in selected tidal marshes along the coast following the Standardized North American Marsh Bird Monitoring Protocol[3] using a Generalized, Random, Tessellated, Stratified sampling scheme[4]. This protocol involves one observer conducting a 5-minute passive point count followed by a series of broadcast calls for secretive marsh birds. We also conducted vegetation surveys to estimate cover type and community composition. **Surveys at 1707 points took place from May 1 – August 1 in 2011 and 2012. We will repeat this effort in 2013.** We will then analyze these data using a Bayesian hierarchical modeling framework.

Fig. 3. An observer conducts a point count survey in a tidal marsh.

Expected Results

We expect to see lessened resistance (lower community stability) to perturbation in marshes with lower total area and connectivity. We also expect to see a greater response to vegetation community change in obligate tidal marsh birds such as the Saltmarsh Sparrow and Willet, and less of a response in non-obligate users such as wading birds and swallows.

Broader Impacts

Tidal marshes provide significant ecosystem services to humans, particularly through protection of coastline from storm surges. Reliable indicators of marsh health are necessary to secure the maximum societal benefit from tidal marshes during a period of change**. As top members of marsh food webs, birds can act as excellent biological indicators of overall ecosystem health and sustainability of tidal marshes[4].**

Acknowledgements

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The Saltmarsh Habitat & Avian Research Program ***(SHARP)*** **is a collaborative initiative to conserve the tidal-marsh bird community of the Atlantic seaboard.**

See *www.tidalmarshbirds.org*

Seaside Sparrow (*Ammodramus maritimus*)

Nelson's Sparrow (*Ammodramus nelsoni*)

Saltmarsh Sparrow (*Ammodramus caudacutus*)

Willet (*Tringa semipalmata*)

Clapper Rail (*Rallus longirostris*)

American Black Duck (*Anas rubripes*)

What is Abrupt Climate Change?

"Technically, an abrupt climate change occurs when the climate system is forced to cross some threshold triggering a transition to a new state at a rate determined by the climate system itself and faster than the cause… An abrupt change is one that takes place so rapidly and unexpectedly that human or natural systems have difficulty adapting to it." *Alley et al 2002*

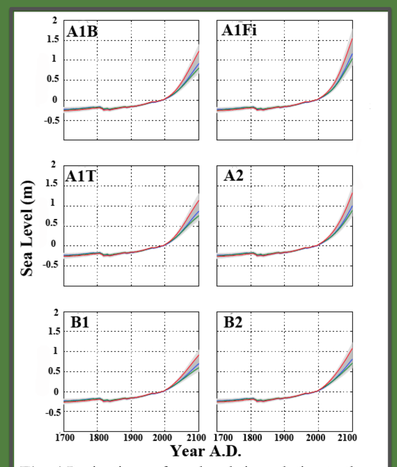

Fig. 4 Projections of sea level rise relative to the period 1980– 2000 during the 21st century using six IPCC radiative forcing scenarios (modified from Jevrejeva et al 2010)

Abrupt climate change is any rapid, non-linear change in the earth's climate system. Several abrupt changes such as the Younger Dryas and Dansgaard-Oeschger events are captured in past climate records. Both are examples of rapid climate fluctuations not consistent with the trend of the time period[5].

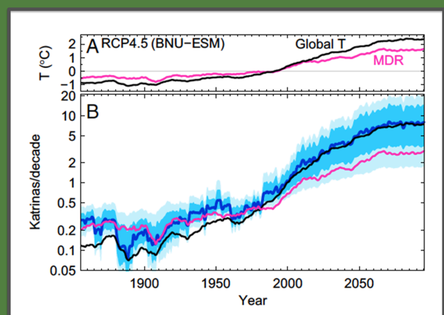

Fig. 5 Number of Katrina magnitude surge events per decade as caused by increases in global temperature. (From Grinsted et al 2013)

Current climate predictions indicate a significant increase in sea level rise (Fig. 4) and extreme storm events over the next century (Fig. 5). An abrupt change in the frequency of extreme storm events will strongly impact coastal areas due to their placement along the terrestrial/marine interface.