Marsh Bank Erosion, Wave Energy, and Implication for Marsh Stability

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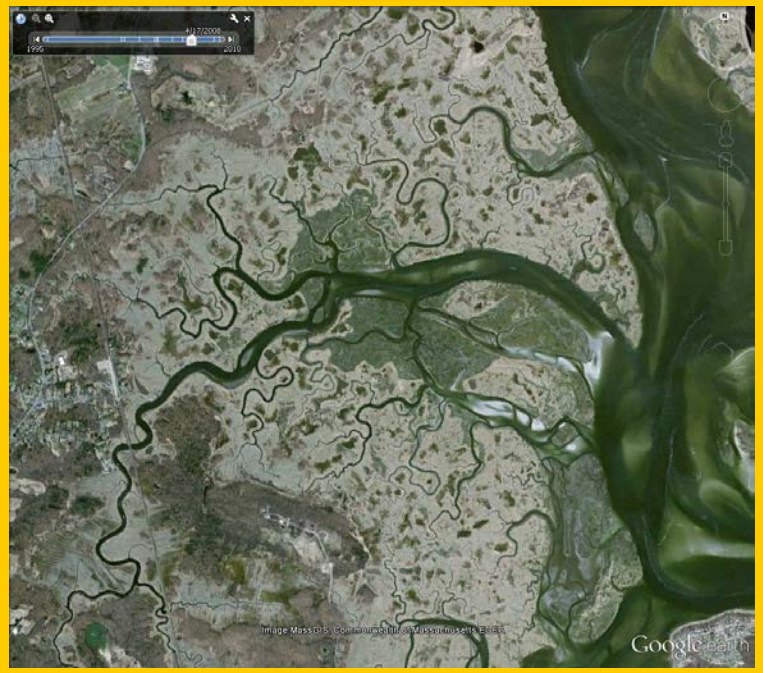
Boston University

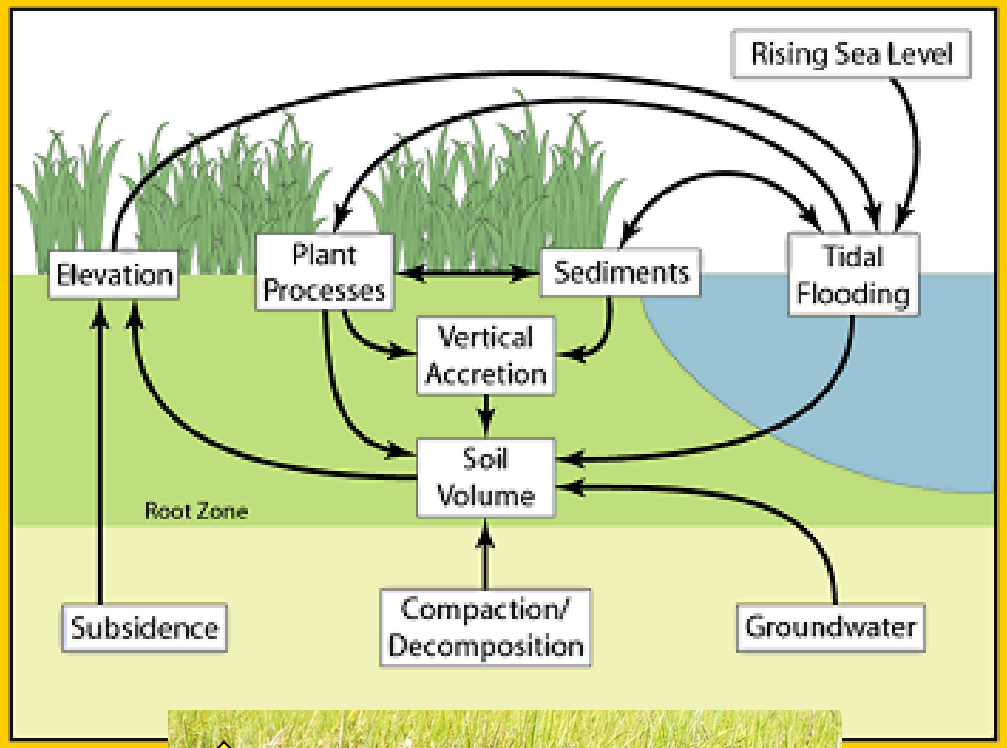
Barnegat Bay (Edwin B. Forsythe NWR)



Plum Island Sound (Parker River NWR and PIE-LTER)

Eastern Shore of Virginia
(Eastern Shore of Virginia NWR
And VCR-LTER)

SALT MARSH VERTICAL DYNAMICS

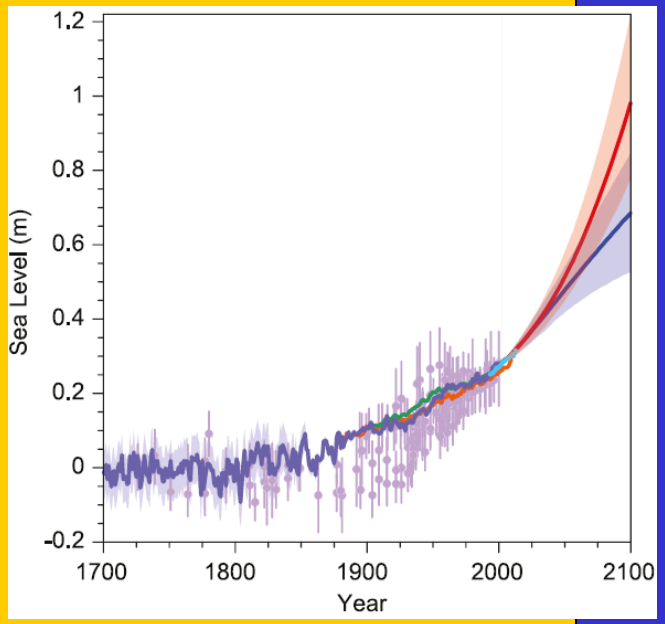


Sea Level Rise

Marsh Accretion

EQUILIBRIUM = SURVIVAL

Current paradigm:



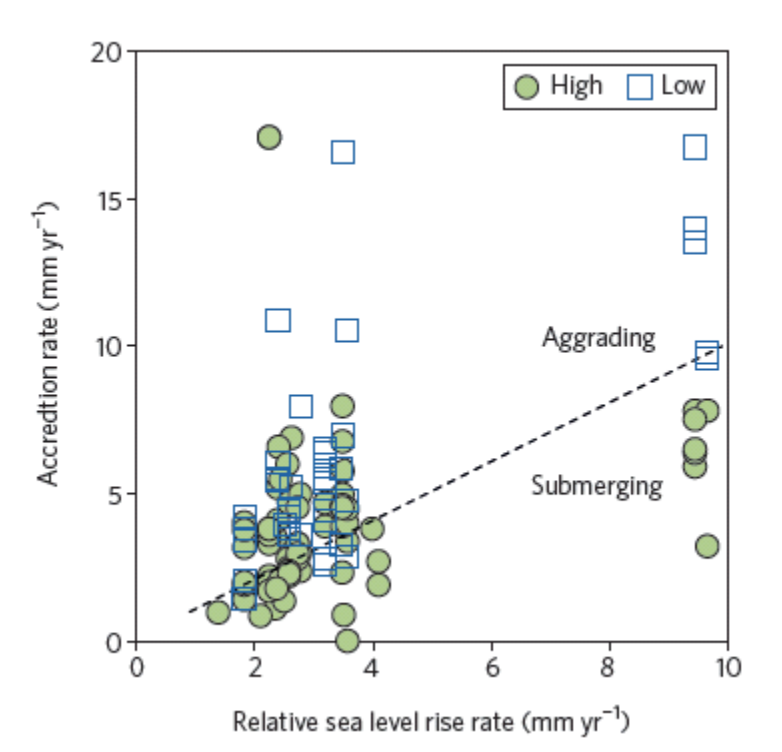
Accelerated Sea level Rise

=

Limington UK

Salt Marsh Collapse

Kirwan et al. Nature Climate Change 2016

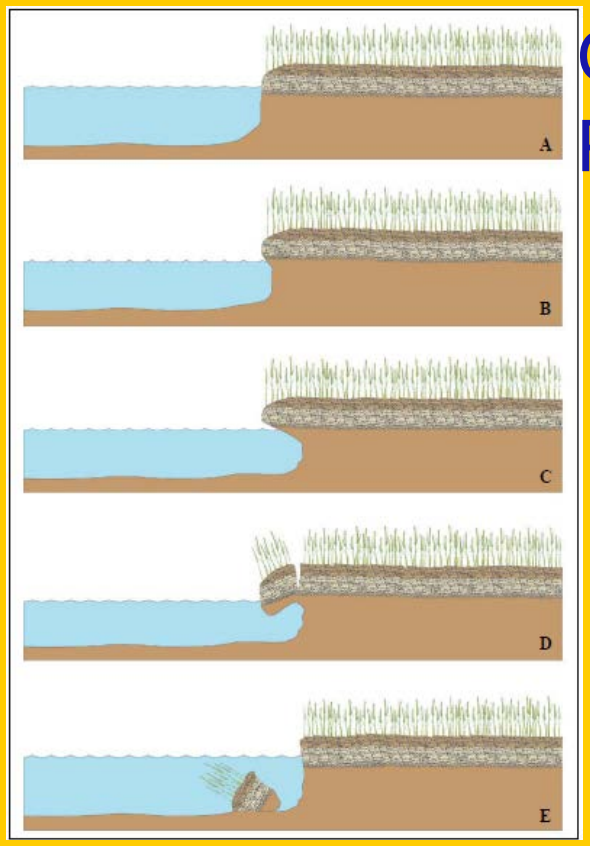


Marshes are very effective at counteracting sea level rise

Feedbacks between biology and sediment transport

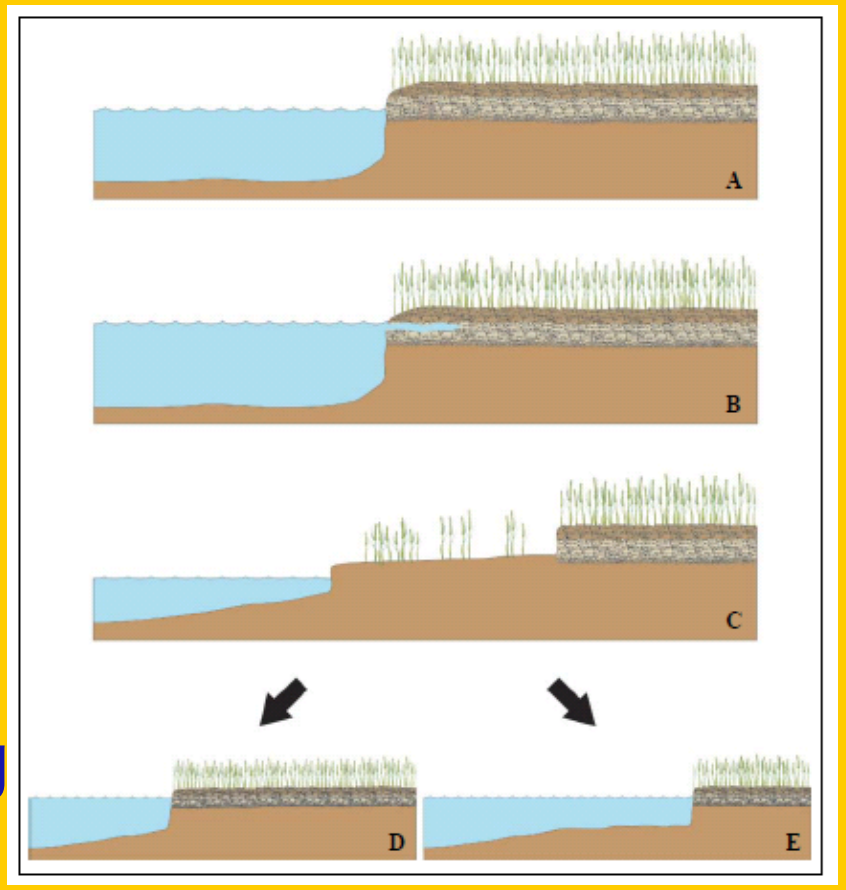
Lateral Erosion of marsh boundaries

Styles of marsh boundary erosion



Cantilever Failure

Roots Scalping



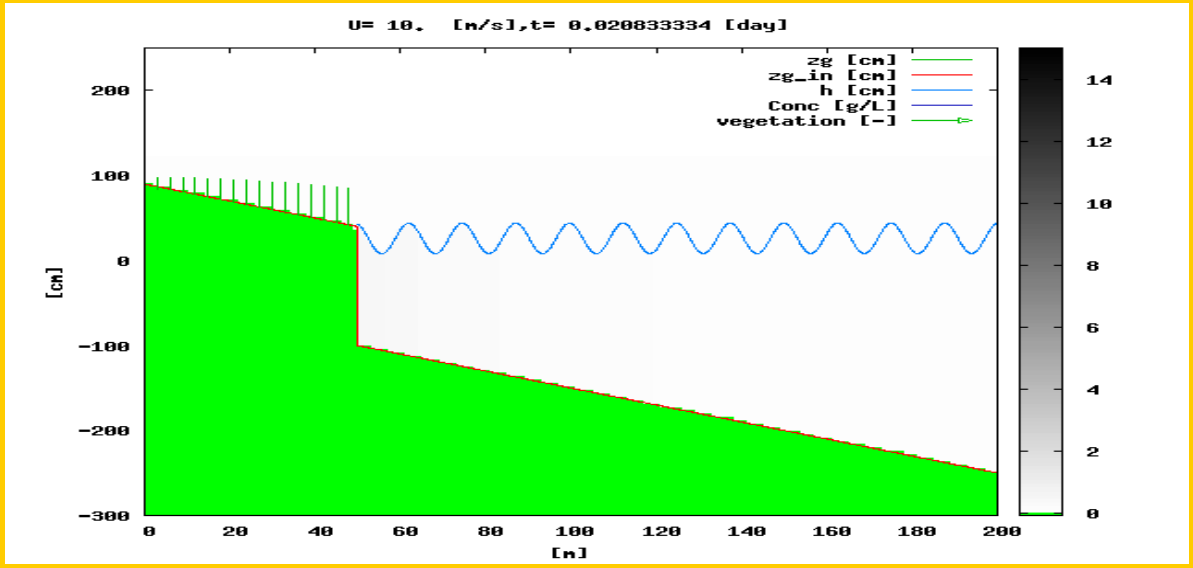
McLoughlin 2008

Biological processes

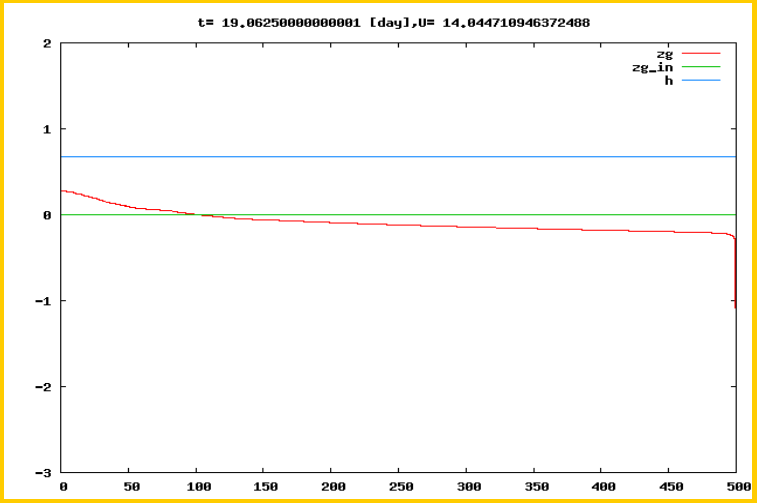
-Mussels
-Snail
-Crabs

Bertness et al 2009

Coupled Tidal Flat – Marsh Model



Meaningful results: On scales of decades to millennia

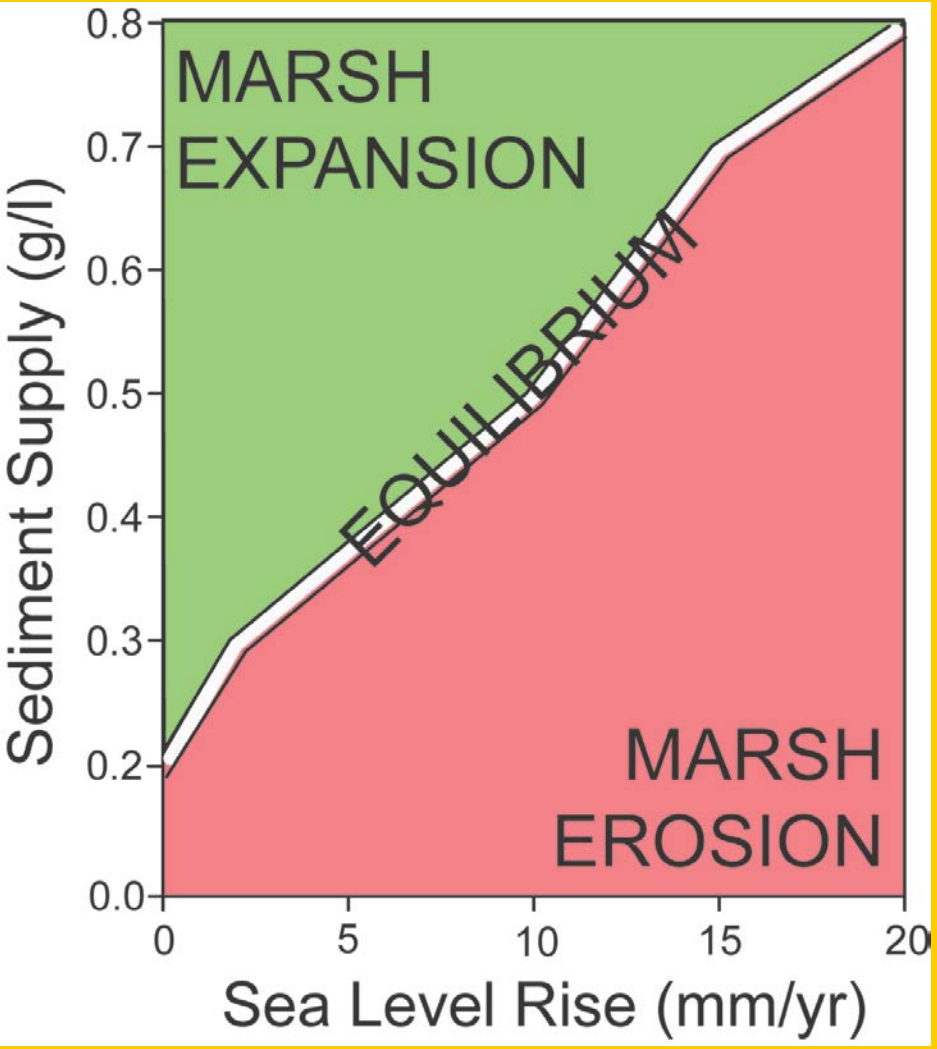


Model Processes: Calculated each tidal cycle during storms Multiplier for fair weather conditions

Mariotti and Fagherazzi JGR 2010

HORIZONTAL DYNAMICS

Saltmarshes are either expanding or eroding



Horizontal equilibrium very unlikely

Fagherazzi et al.. 2013

At the geological scale the marshes are continuously expanding and contracting

Lack of horizontal stability

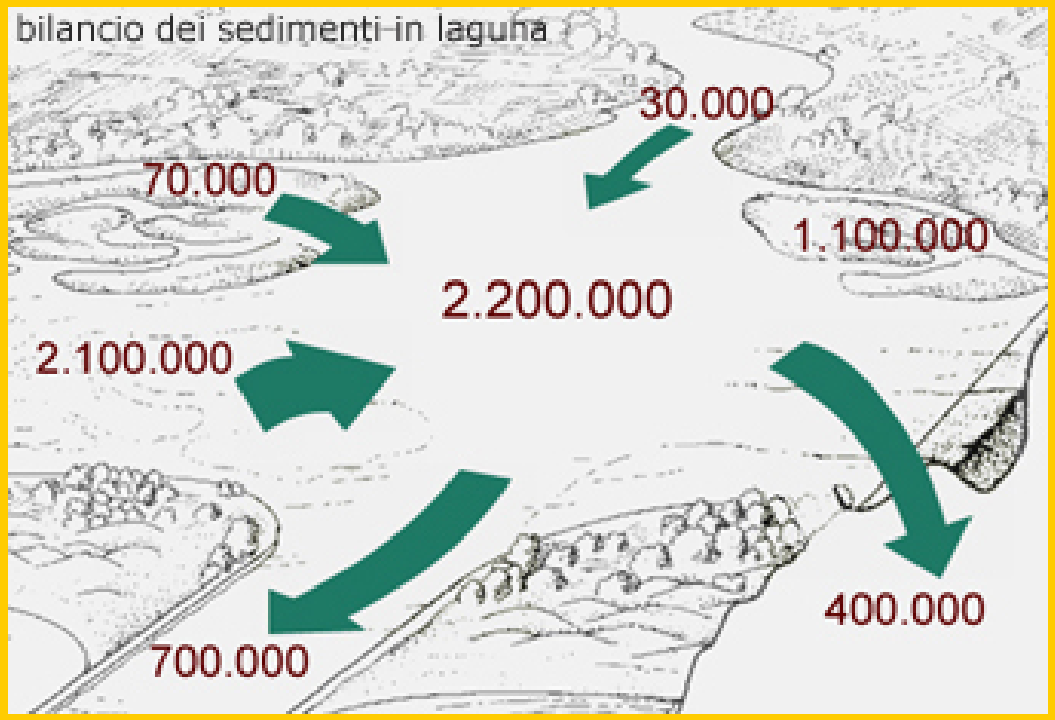
marsh formation ⇄ marsh erosion

Sediment availability

Waves, Currents, Sapping

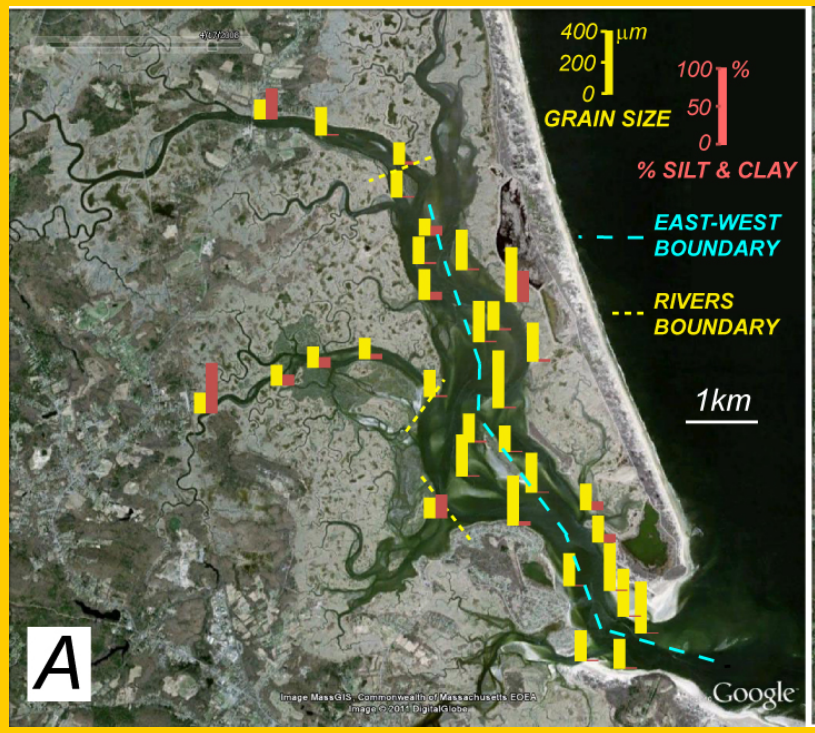
Equilibrium=Negative Feedback (self regulating)

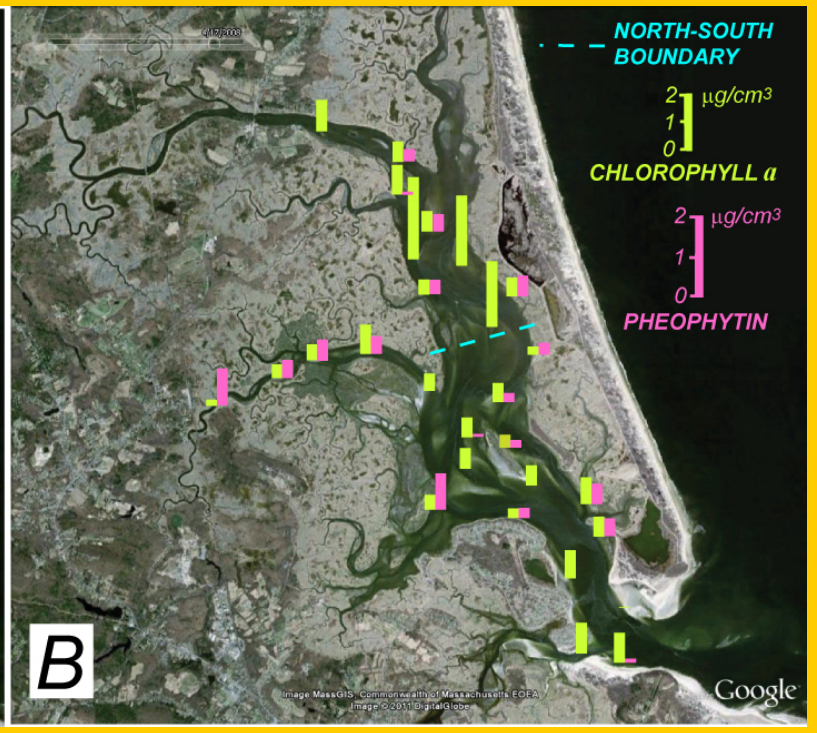
A sediment budget approach



Marsh survival = sediment input > sediment output

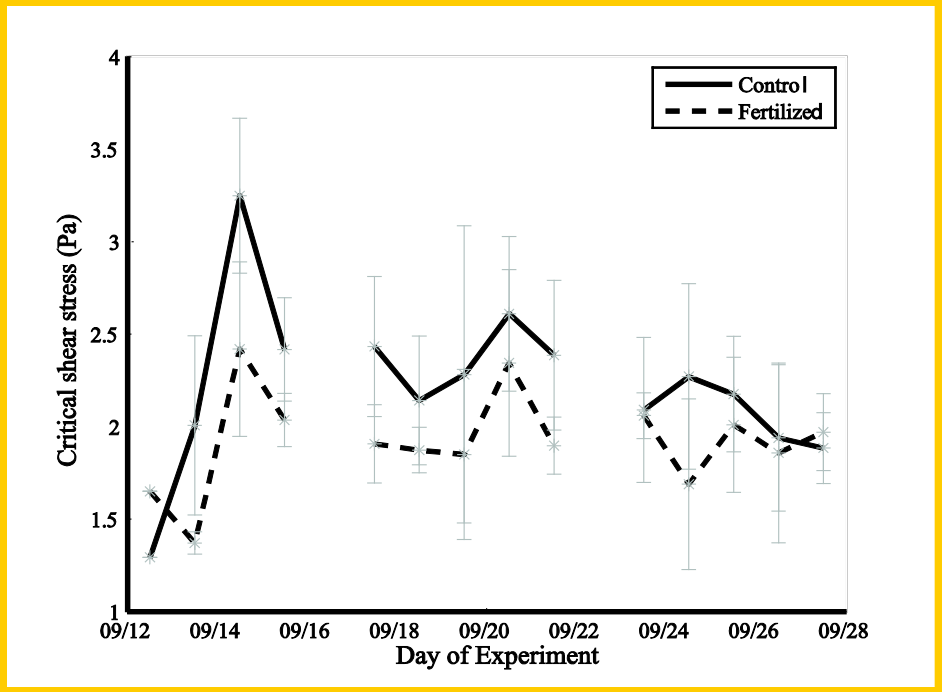
Analysis of Sediment Composition and Density Variation of Tidal Bars in Plum Island Sound Estuary





Fagherazzi et al. 2014

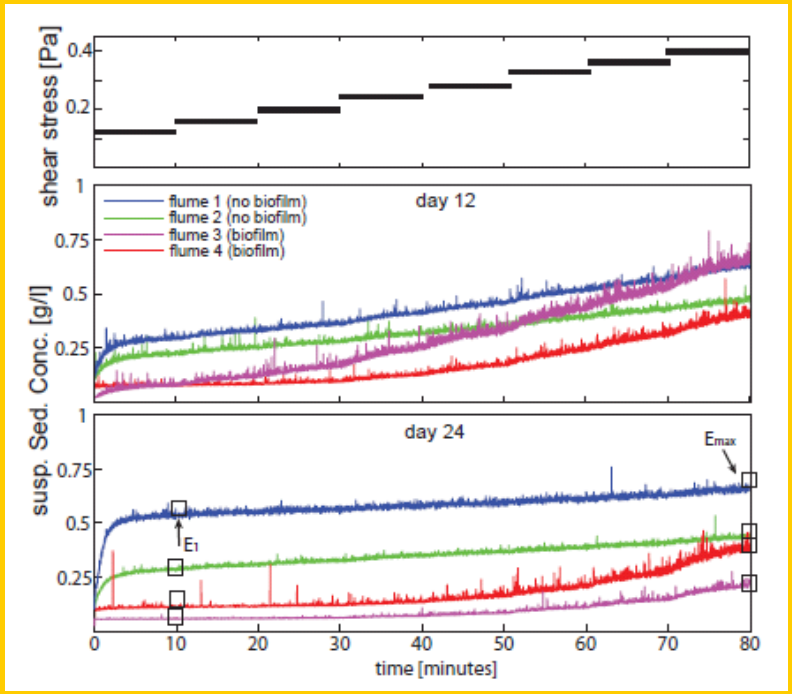
Field Experiments

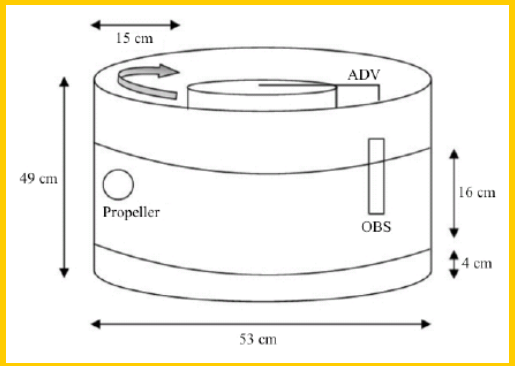


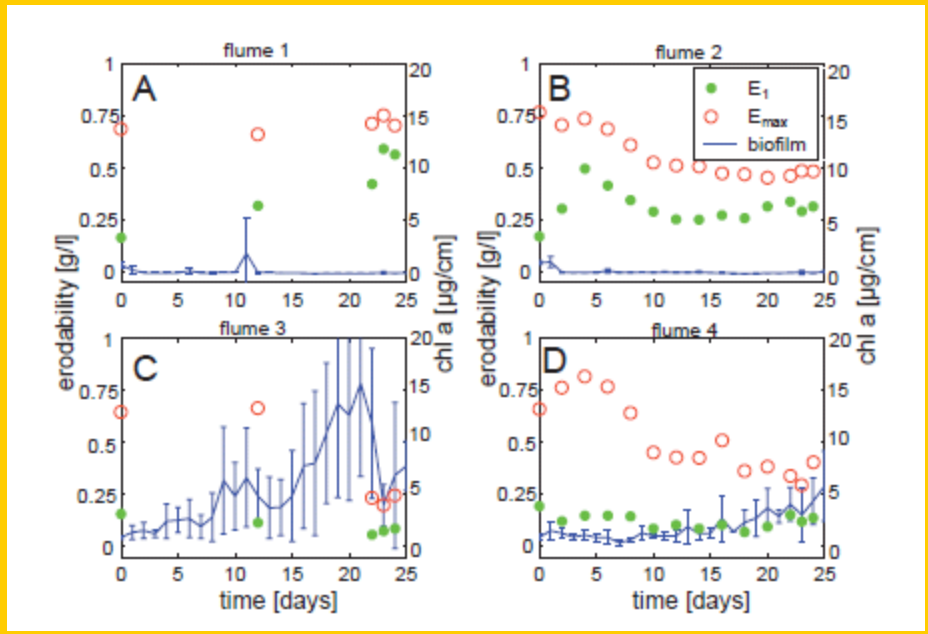
Viggato et al. 2013

Lab Experiments

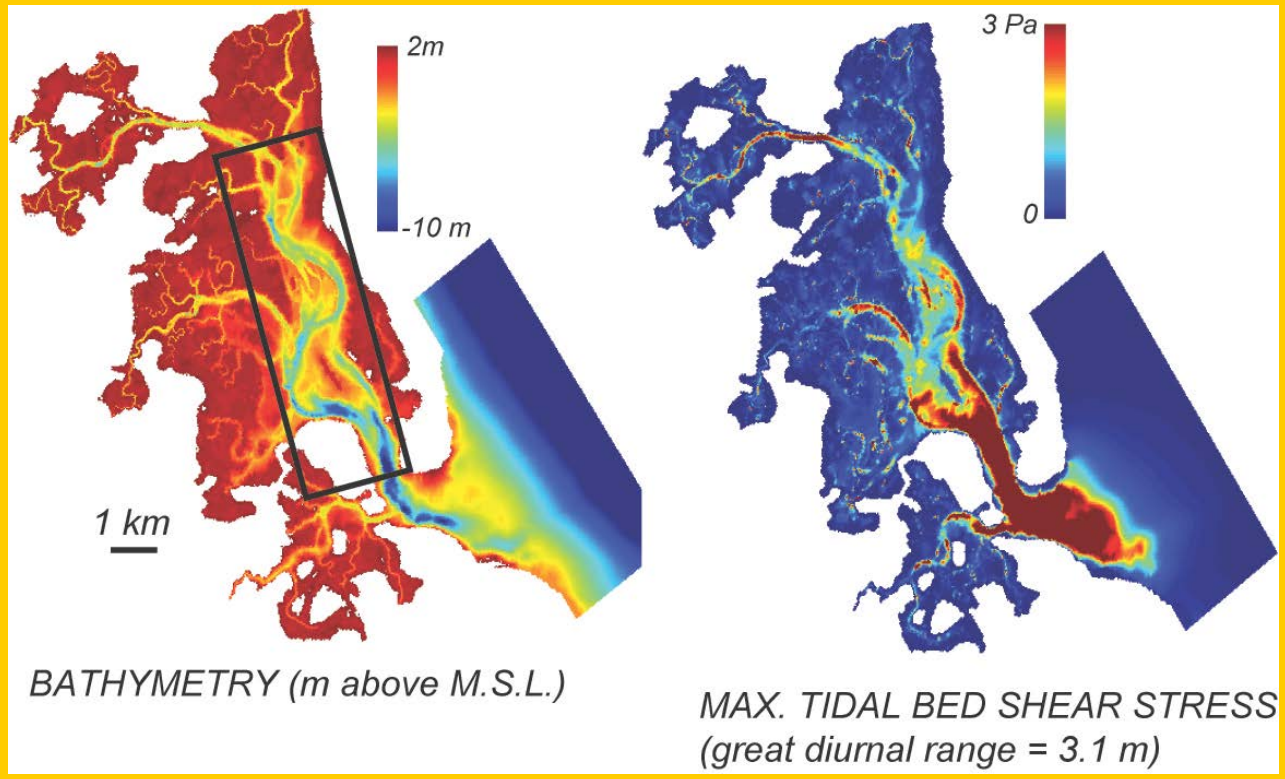
Valentine et al. 2014







Biofilms stabilize the mud !



BATHYMETRY (m above M.S.L.)

MAX. TIDAL BED SHEAR STRESS
(great diurnal range = 3.1 m)

Deltares
Enabling Delta Life

SWAN
Simulating WAves Nearshore

Salt Marsh Resilience to Hurricanes and Violent Storms

with NEIL GANJU, USGS Woods Hole Coastal and Marine Science Center

Hurricane Sandy

USGS
science for a changing world

COAWST Modeling System

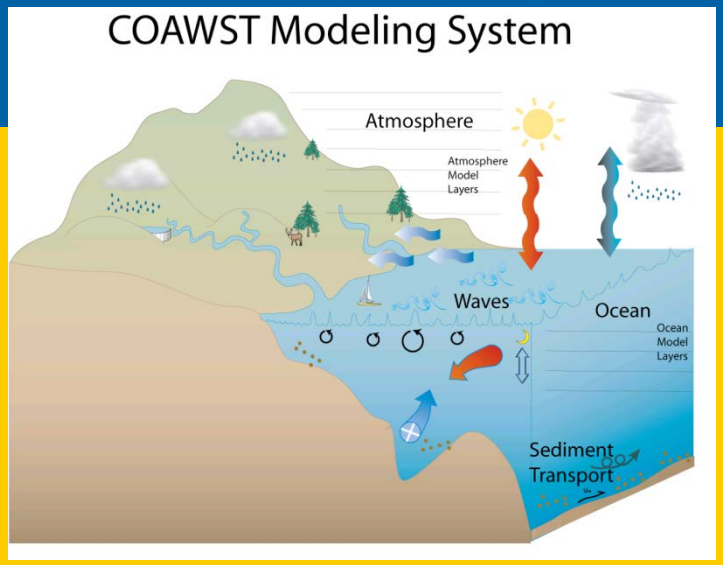
COAWST

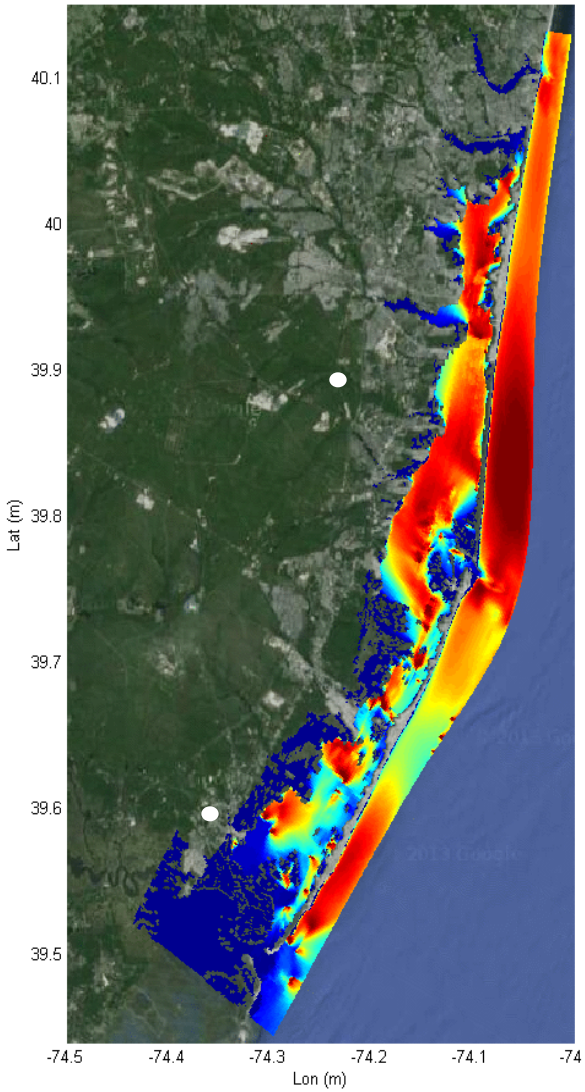
Coupled Ocean – Atmosphere – Wave – Sediment Transport
Modeling System to investigate the impacts of storms on coastal environments.

C = Coupled	MCT v 2.6.0	http://www-unix.mcs.anl.gov/mct/
O = Ocean	ROMS svn 455	http://www.myroms.org/
A = Atmosphere	WRF v 3.2.1	http://www.wrf-model.org/
W = Wave	SWAN v 40.81	http://vlm089.citg.tudelft.nl/swan
ST = Sediment Transport	CSTMS	http://woodshole.er.usgs.gov/project-pages/sediment-transport/

Modeling System

USGS

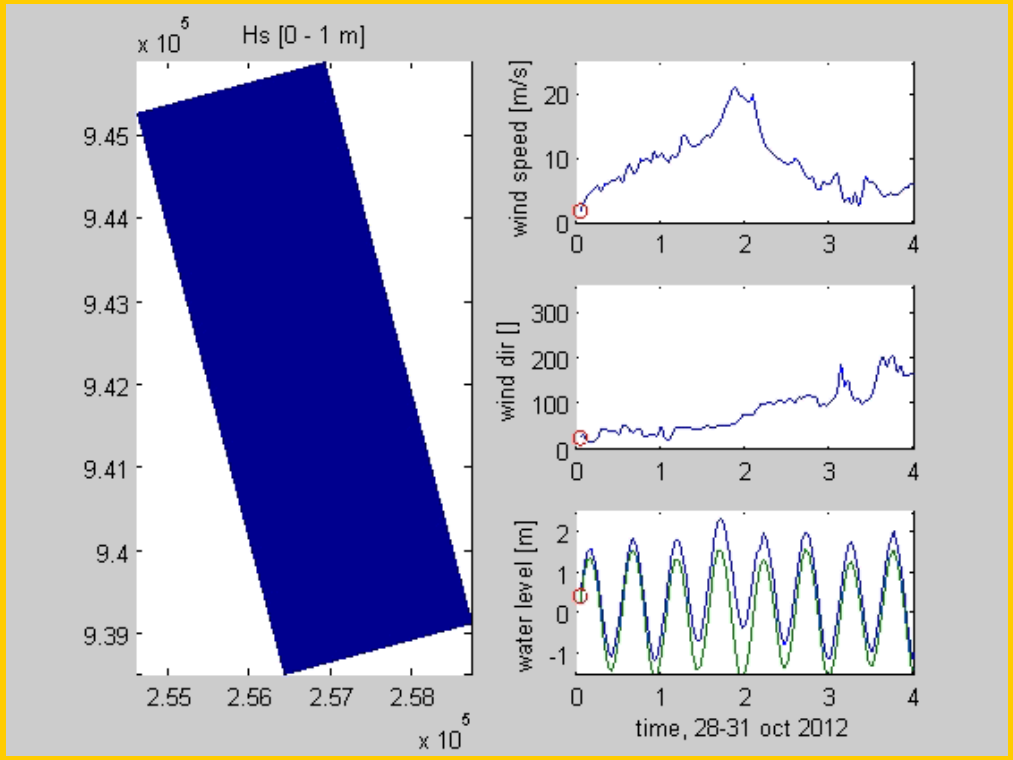




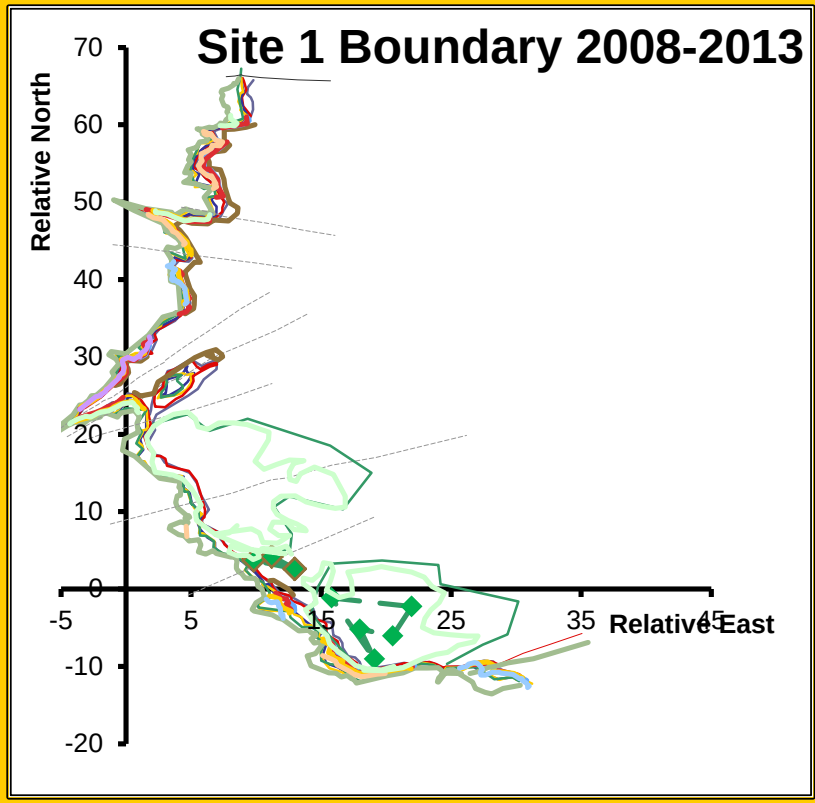
Barnegat Bay, NJ

USGS science for a changing world

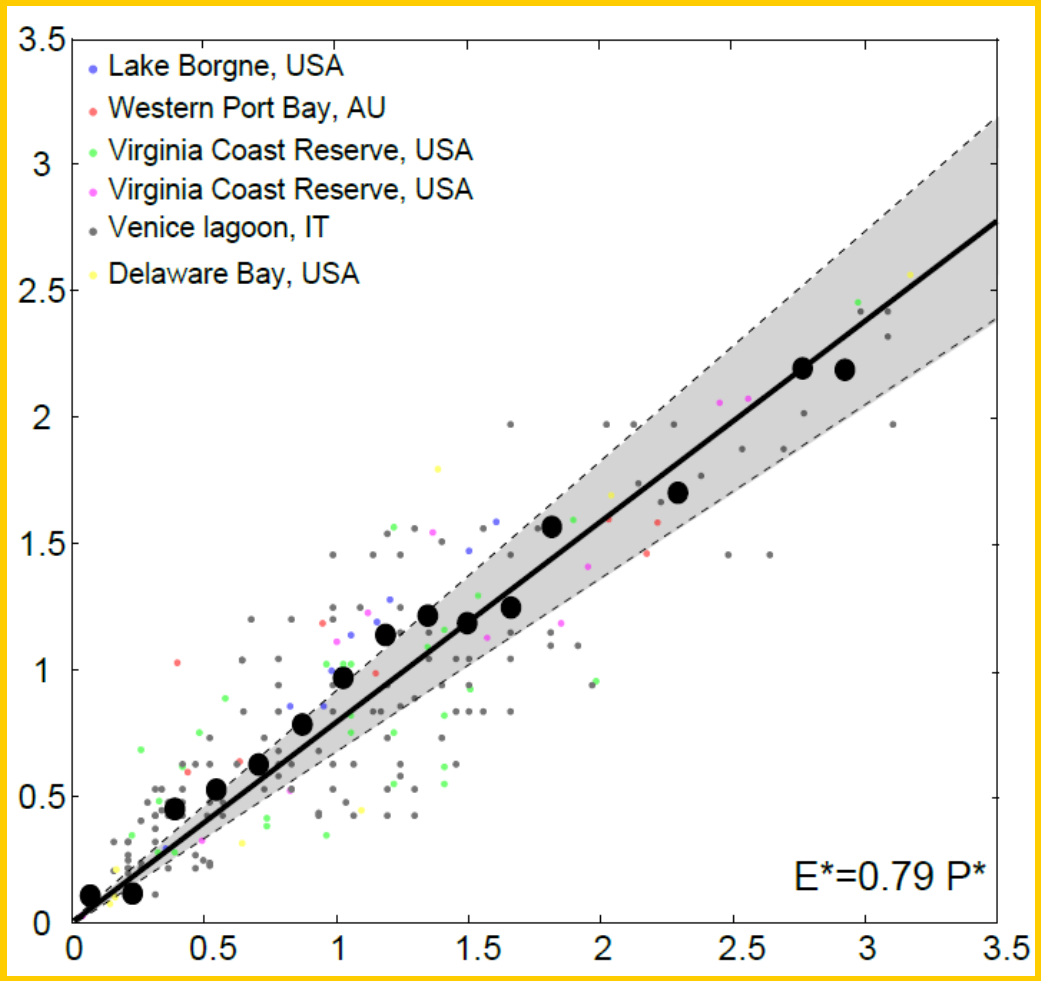
Erosion of marsh scarp in Plum Island Sound



Wave distribution during Sandy



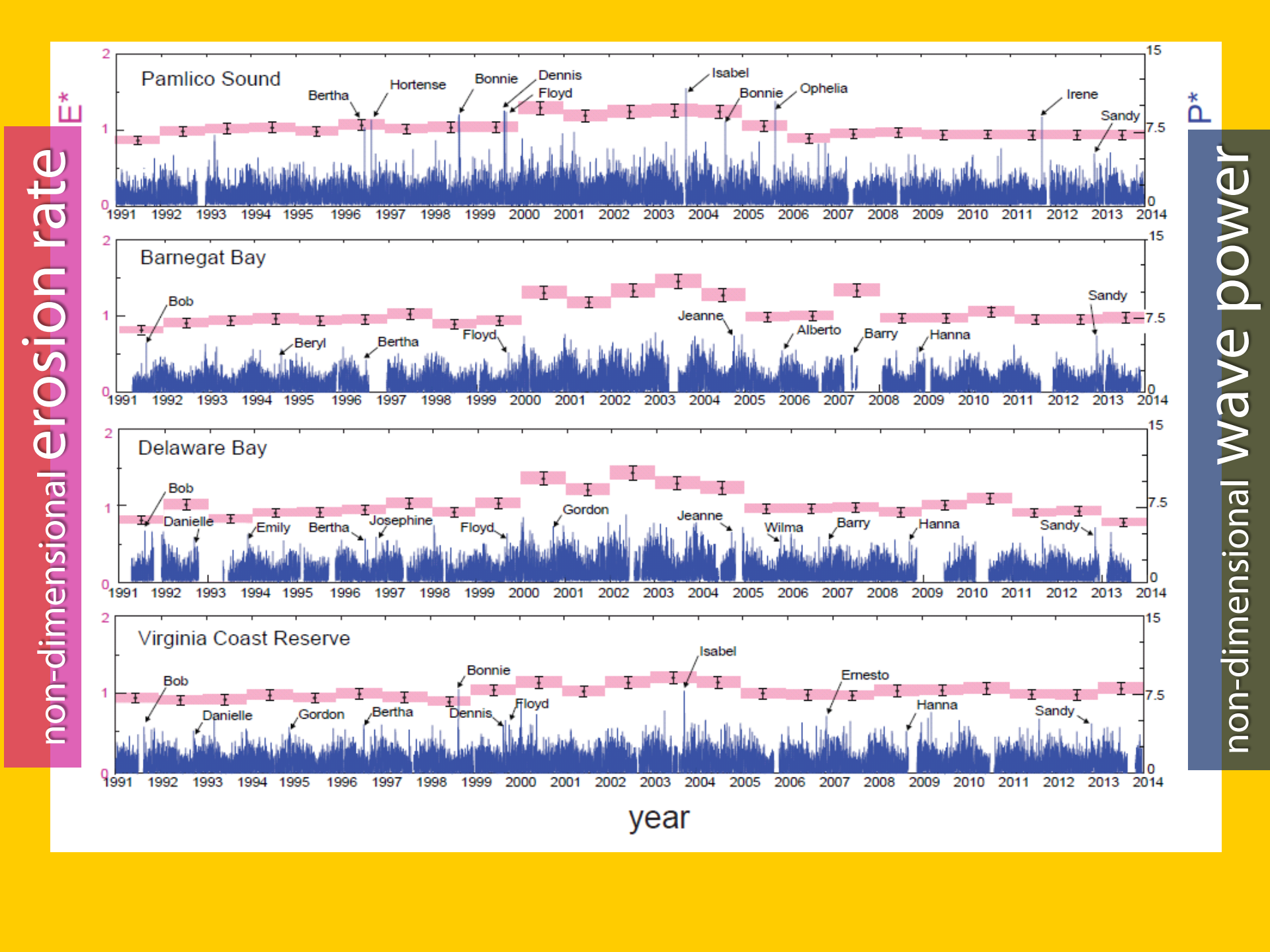
Non-dimensional EROSION RATE

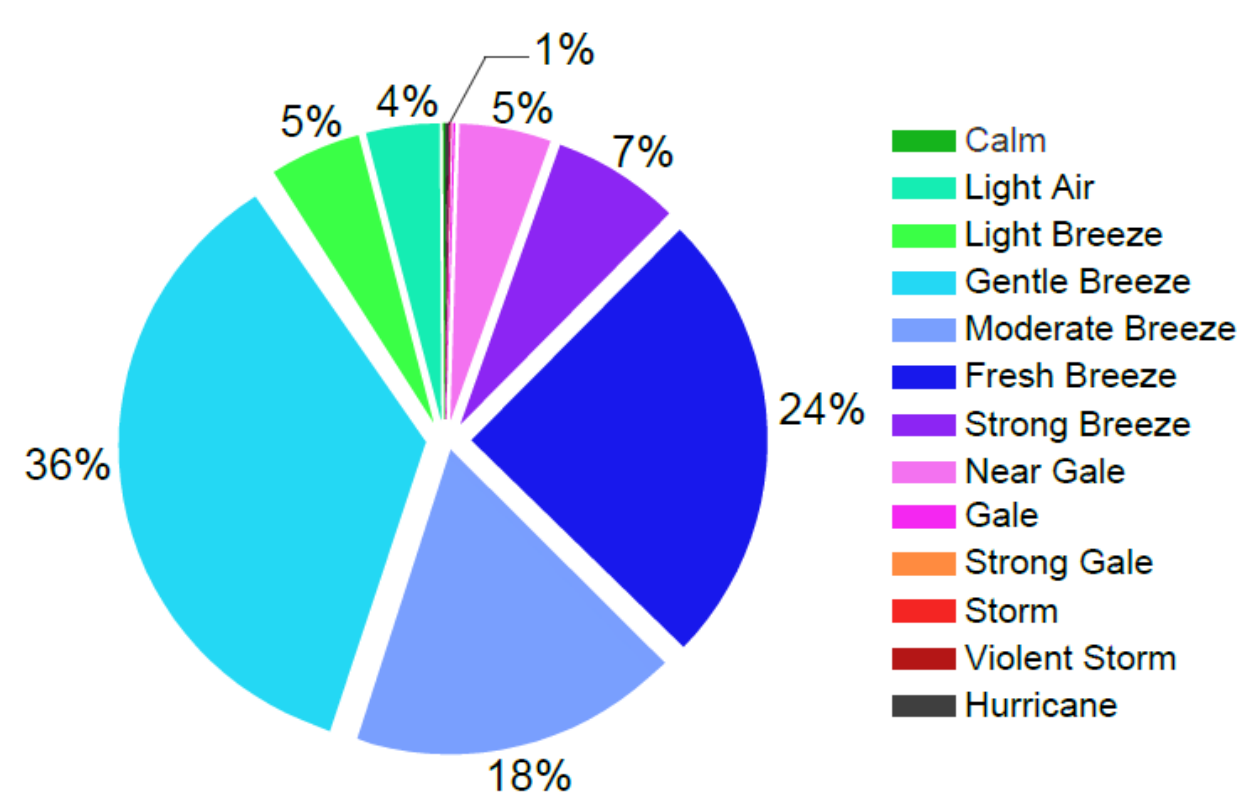


Non-dimensional WAVE POWER

global database of marsh erosion

Linear relationship

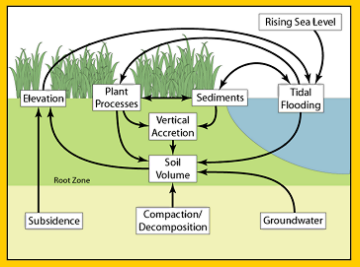

non-dimensional erosion rate E*
non-dimensional wave power P*
Pamlico Sound
Bertha
Hortense
Bonnie
Dennis
Floyd
Isabel
Bonnie
Ophelia
Irene
Sandy
Barnegat Bay
Bob
Beryl
Bertha
Floyd
Jeanne
Alberto
Barry
Hanna
Sandy
Delaware Bay
Bob
Danielle
Emily
Bertha
Josephine
Floyd
Gordon
Jeanne
Wilma
Barry
Hanna
Sandy
Virginia Coast Reserve
Bob
Danielle
Gordon
Bertha
Bonnie
Dennis
Floyd
Isabel
Ernesto
Hanna
Sandy
0
1
2
7.5
15
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
year



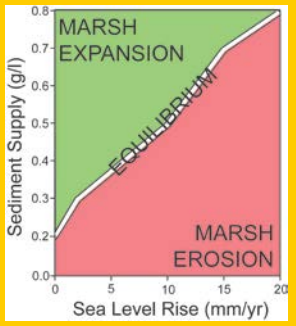
Average contribution of different wind categories to salt marshes erosion rates

Conclusions:

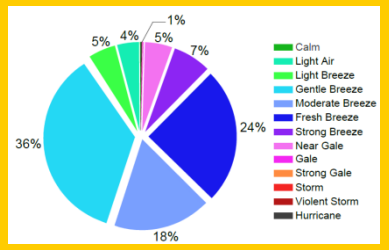
- Salt marshes are likely in vertical equilibrium



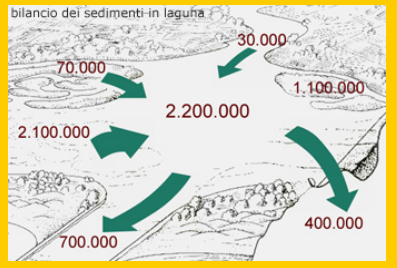
- No horizontal equilibrium, either eroding or expanding



- Lateral erosion driven by moderate storms (erosion magnitude low, constant, and predictable)



- Only a sediment budget can assess the survival of salt marshes



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"An element opposes another element"