

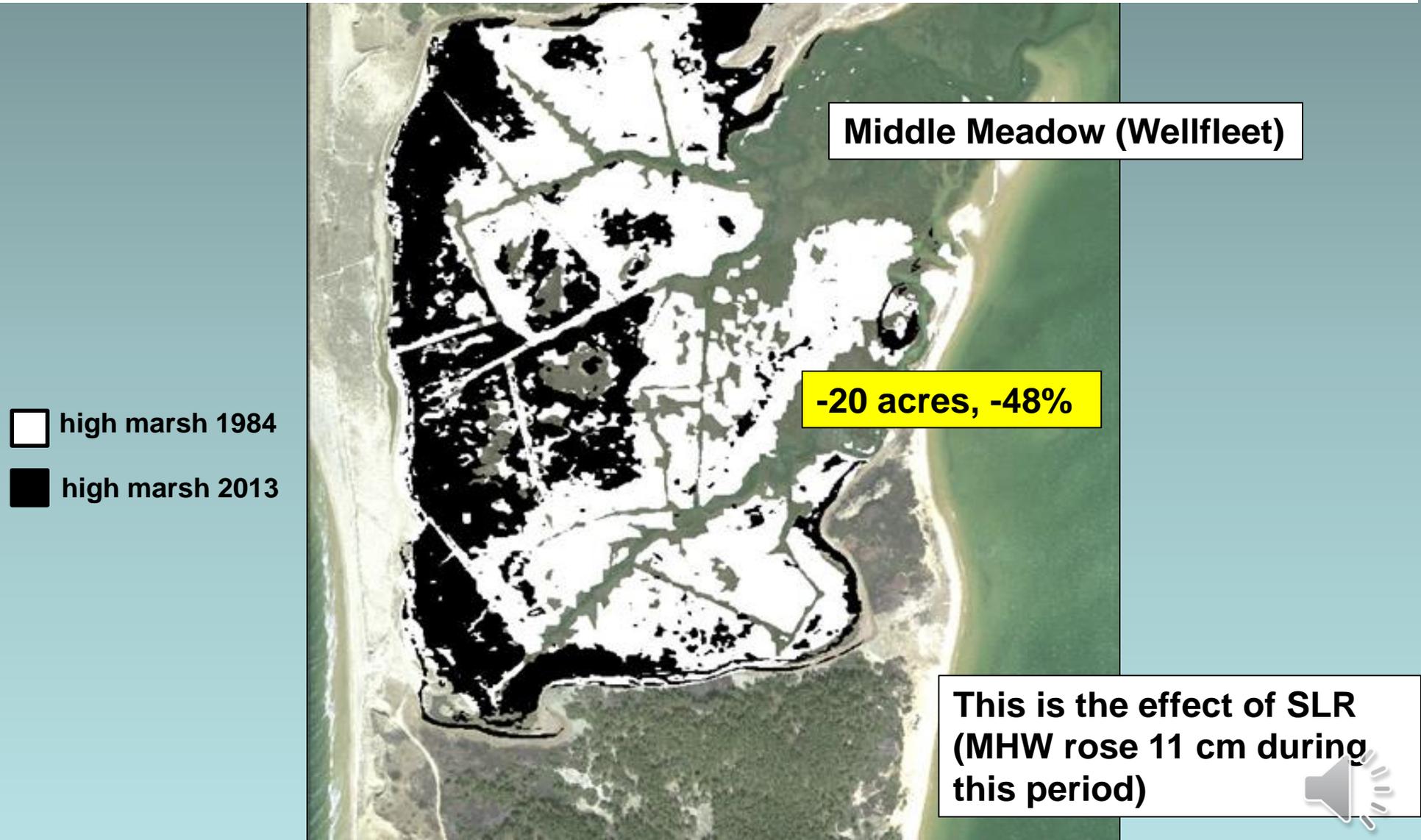
# Salt marsh vegetation losses on Cape Cod

Stephen Smith, PhD  
Cape Cod National Seashore  
[stephen\\_m\\_smith@nps.gov](mailto:stephen_m_smith@nps.gov)





# Non-herbivory-related (bottom-up) salt marsh vegetation losses on Cape Cod



Middle Meadow (Wellfleet)

-20 acres, -48%

This is the effect of SLR (MHW rose 11 cm during this period)

- high marsh 1984
- high marsh 2013

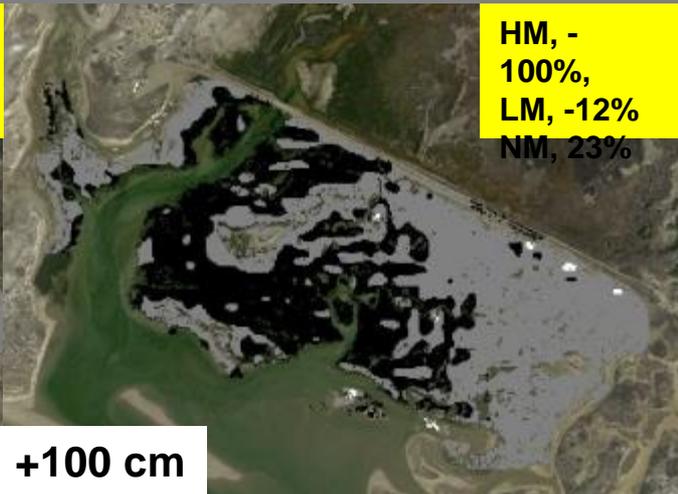
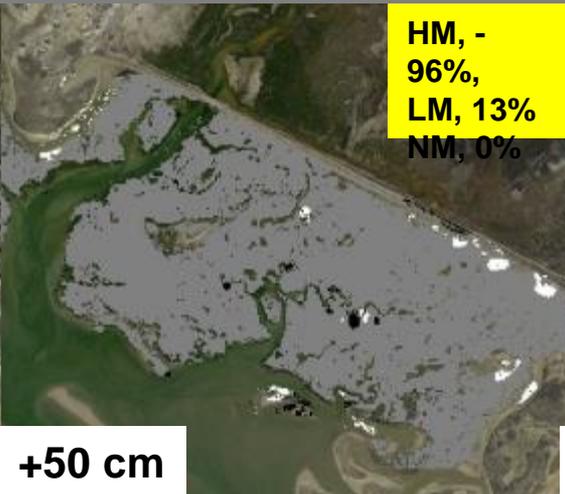


# Low marsh losses at seaward edges

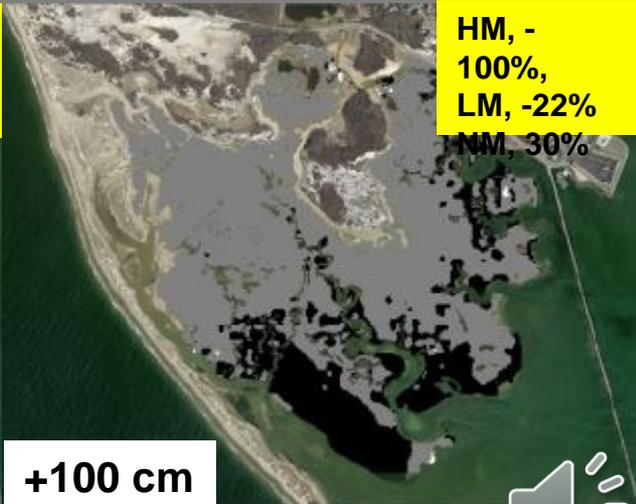
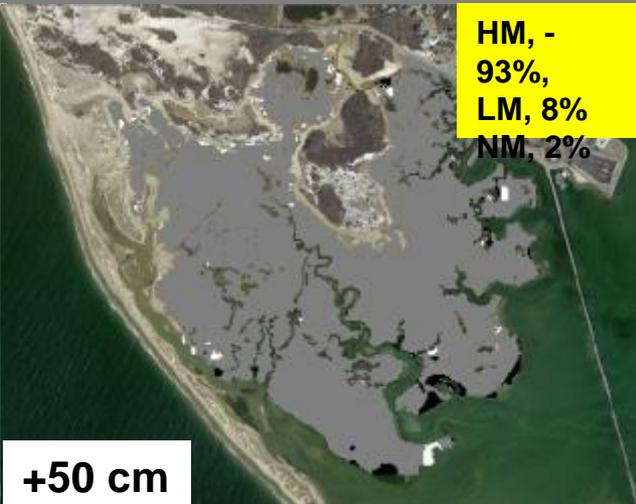


### Hatches Harbor

## Predictions



### West End





## Top-down salt marsh vegetation losses on Cape Cod



low marsh (*S. alterniflora*) losses



high marsh (*S. patens*, *D. spicata*, *J. gerardii*) losses

- first reported in 2002 along Cape Cod's south shore and in 2003 in Cape Cod National Seashore
- initially termed "sudden wetland dieback" – thought to have happened recently (2002) and more or less "all at once"
- subject of 3 conferences (2005-2007) and a great deal of media attention





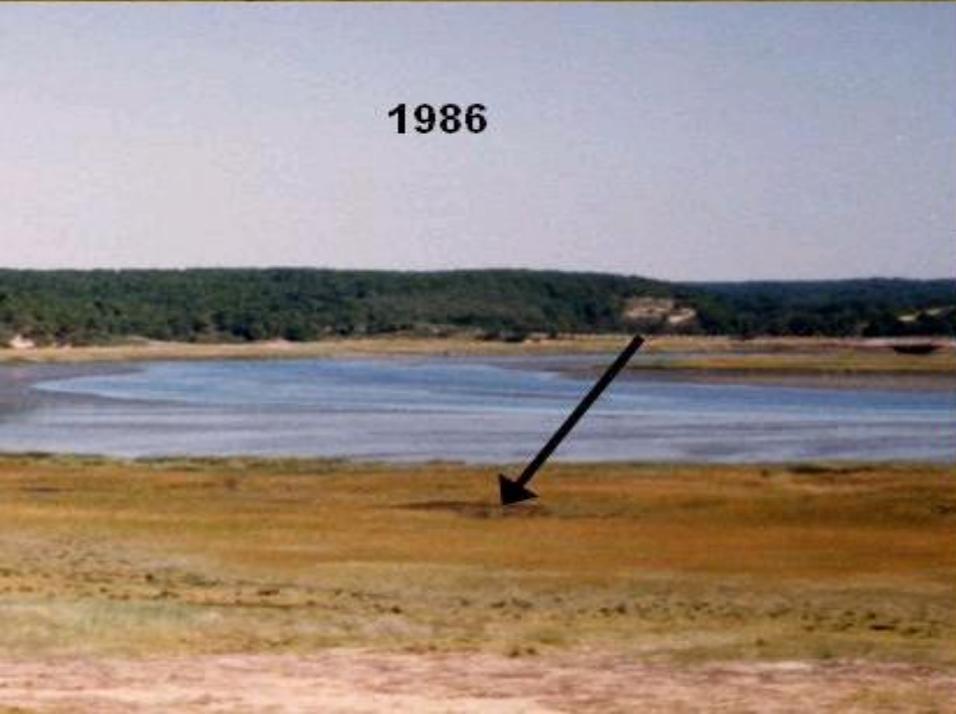
1984



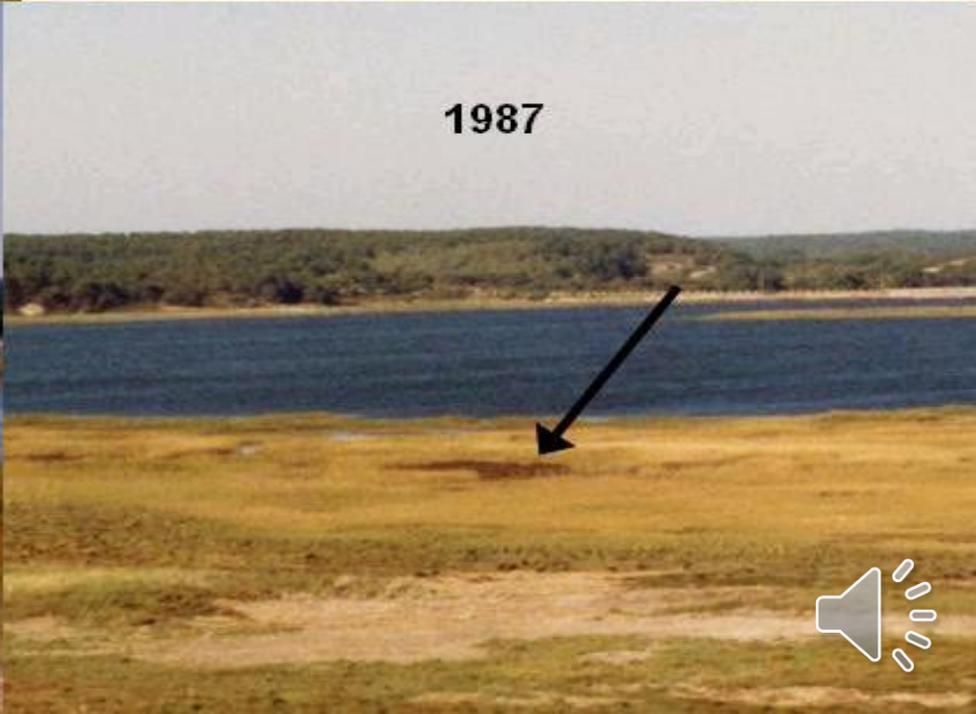
1985



1986



1987





# Low marsh (*Spartina alterniflora*) dieback



1991

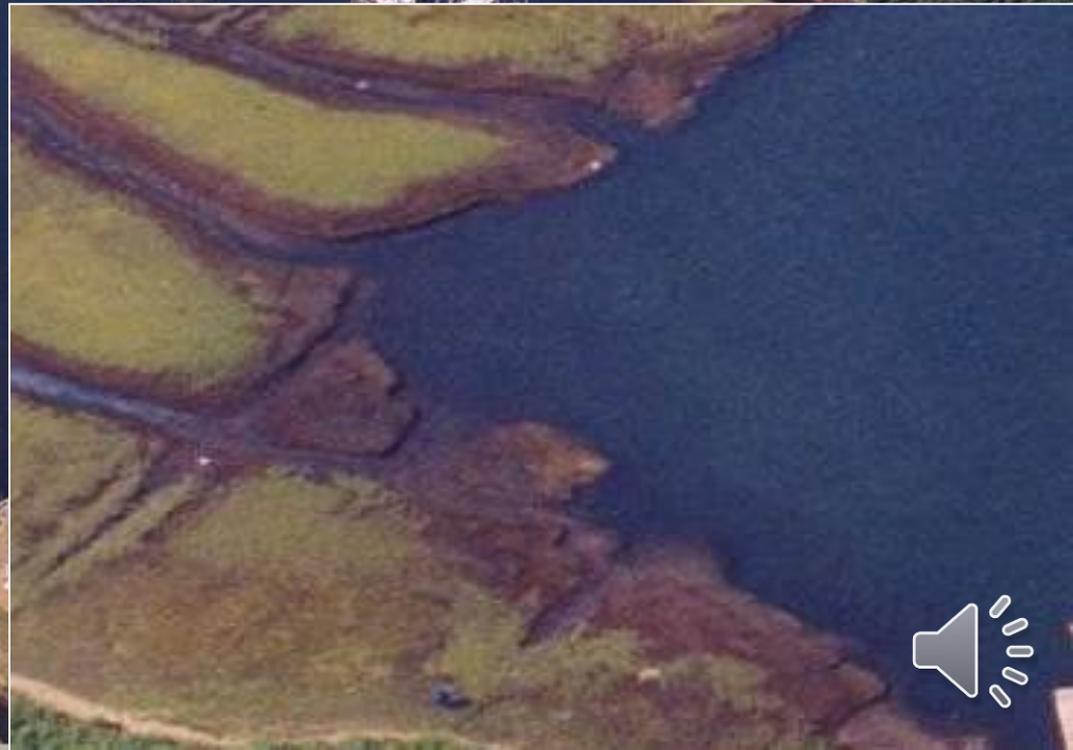


Photo by E. Lilley (Harwich)





# The culprit: *Sesarma reticulatum* (purple marsh crab/ squareback crab/wharf crab)

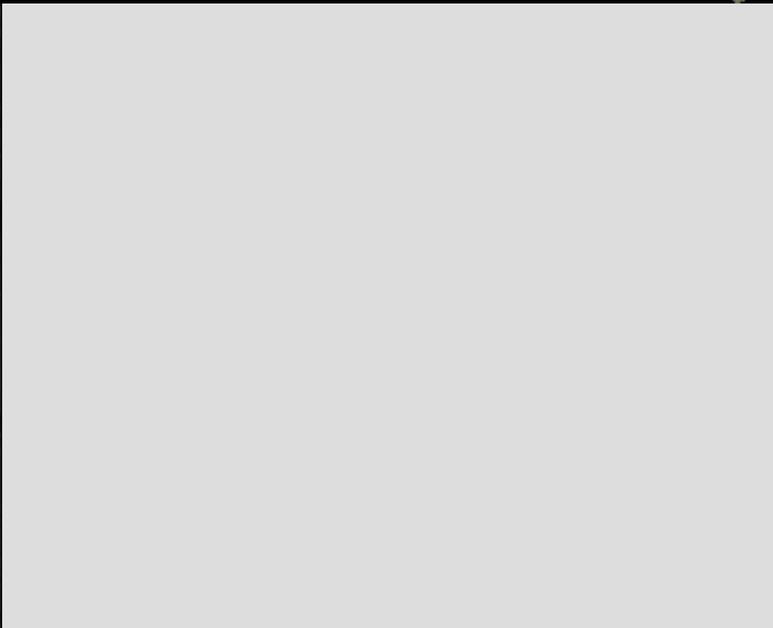


Purple marsh crab (photo by Tyler Coverdale)



- native; nocturnal, herbivorous
- previously thought to be relatively rare in Southern New England





**Vegetation losses in the low marsh:**

- frequently along creekbanks but can be throughout extent of low zone; patchy
- no standing dead phase (i.e., no brownmarsh)
- shredded, tattered leaves and stems
- severed stems in wrack lines



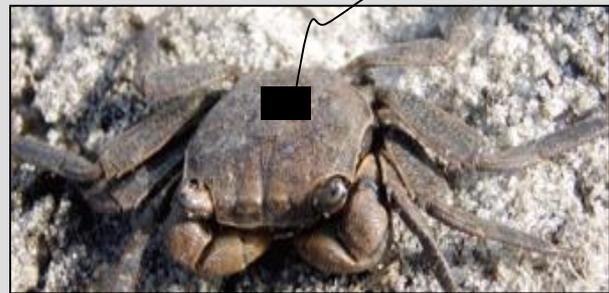
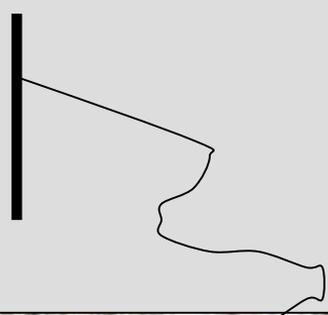


**Experiments: Christine Holdredge & Mark Bertness (Brown University)**



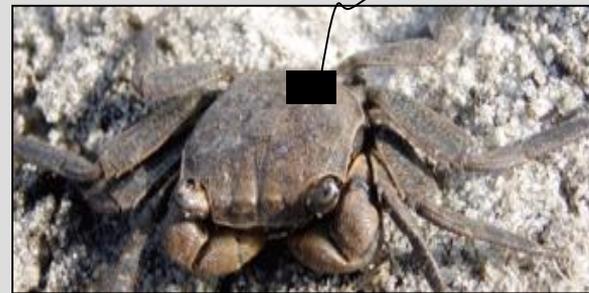
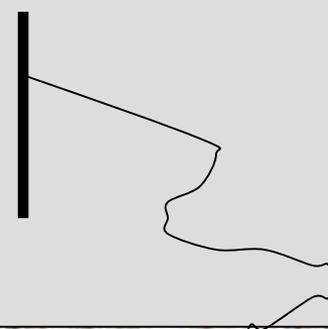
# Bertness et al.: crab densities are very high on Cape Cod – WHY?

Cape Cod (dieback)



~95% survivorship

Rhode Island (no dieback)



~10-30% survivorship

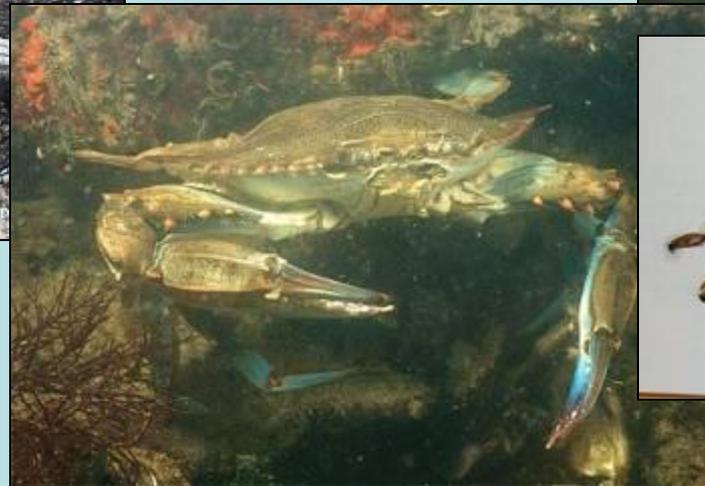
\* crabs not getting preyed upon in Cape Cod





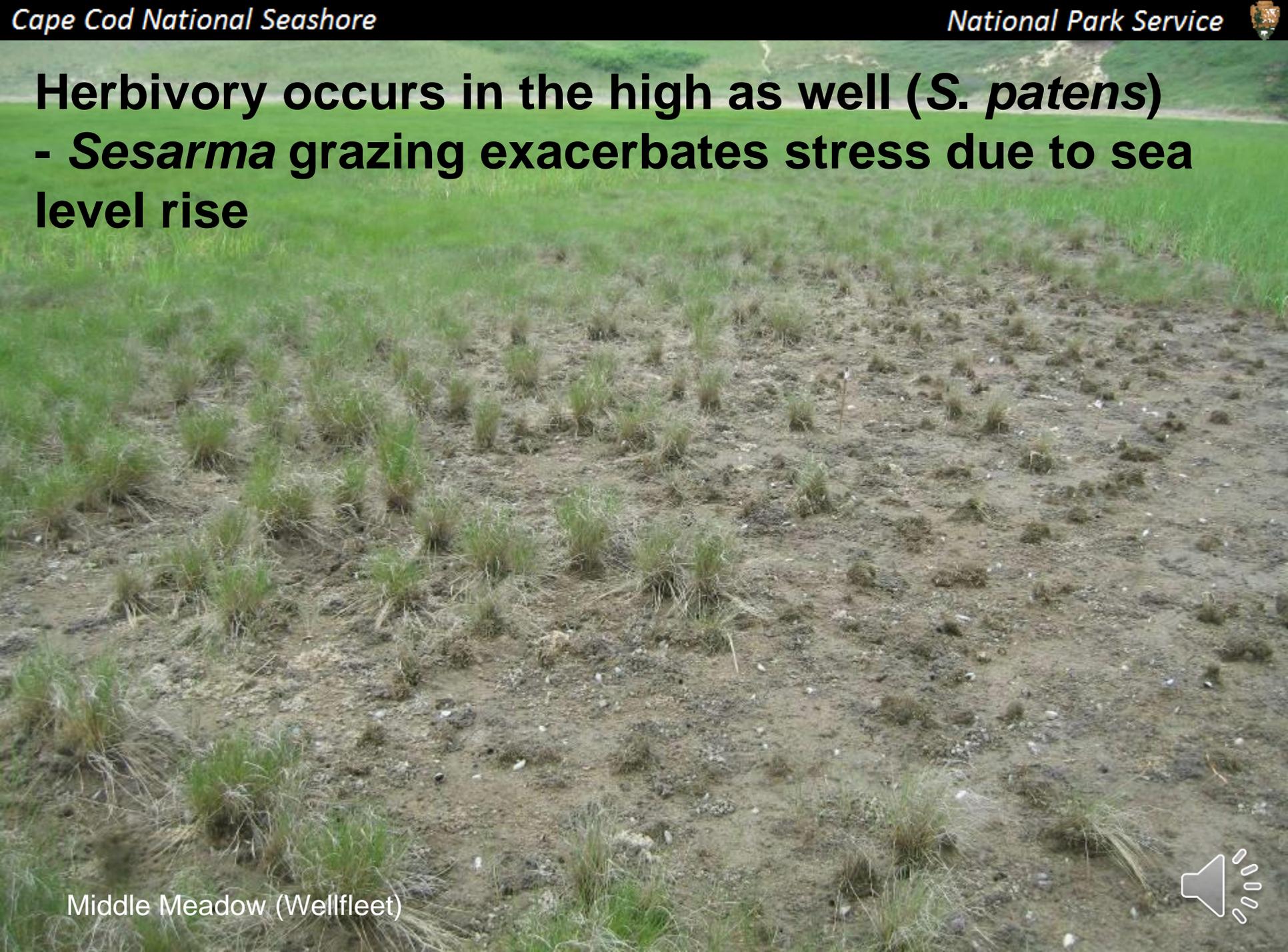
# Conceptual Model of *Sesarma*-driven dieoff:

- *Sesarma* populations have greatly increased over the last several decades due to the loss of a predator(s) and/or expansion of *Sesarma* range northward faster than predators (e.g., blue crabs)





**Herbivory occurs in the high as well (*S. patens*)  
- *Sesarma* grazing exacerbates stress due to sea  
level rise**



Middle Meadow (Wellfleet)





Herbivory occurs in the high as well (*S. patens*)

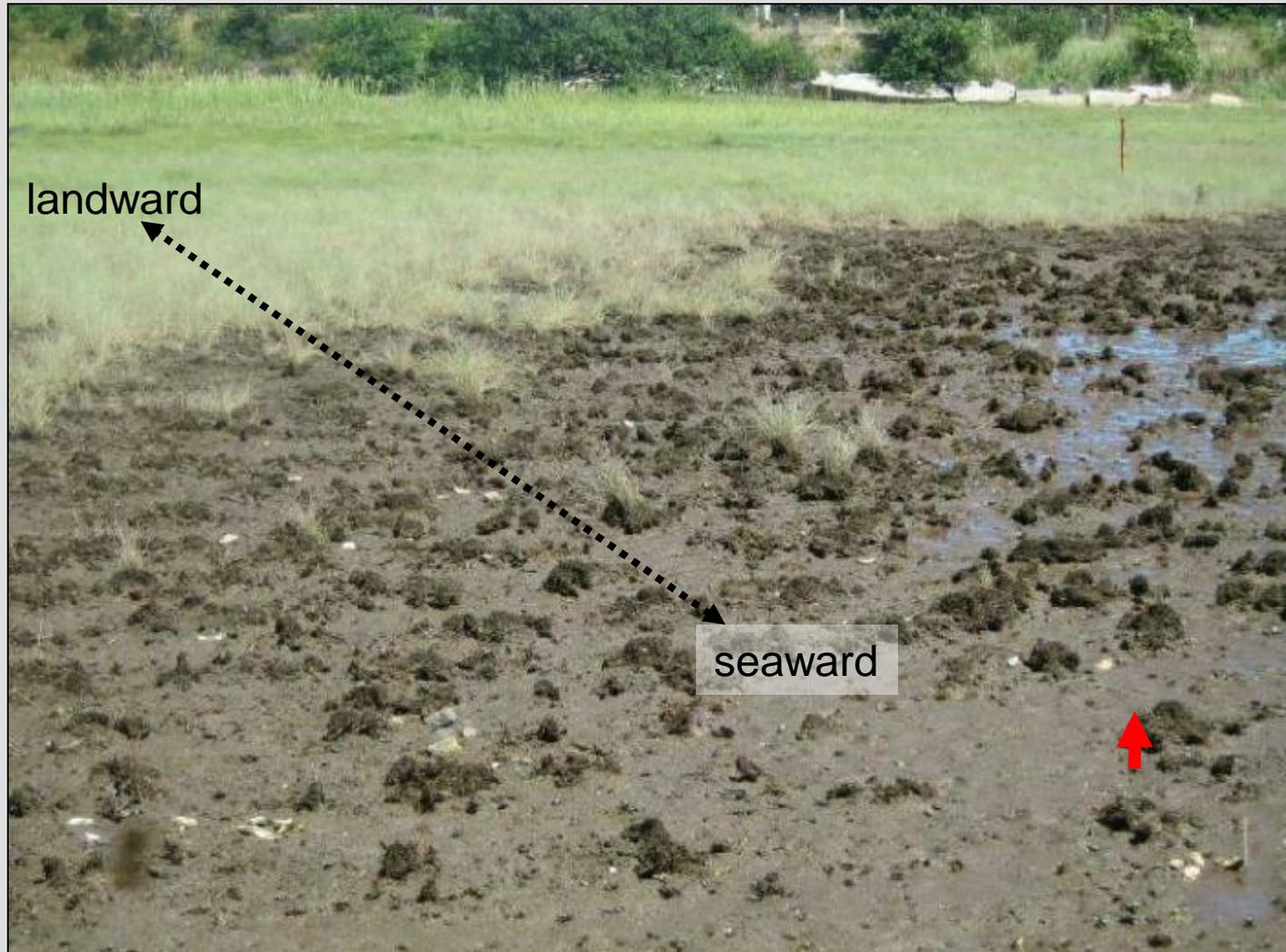


Symptoms of herbivory





- *Sesarma* grazing exacerbates stress due to sea level rise



Plant demise is consistently along the seaward edge, suggesting a link with hydrology (sea level)





# Interaction between hydrology and grazing?

- naturally growing *S. patens* along dieback edges and in the healthy high marsh was clipped (to simulate grazing) and then caged; 10 reps per treatment per site



seaward edge



upslope from edge

% plots with re-sprouts on Sep 11  
(all sites)

**37%**

**100%**

- plants along the seaward “dieback” edge have a reduced ability to re-sprout if grazed





# Consequences of vegetation losses.....



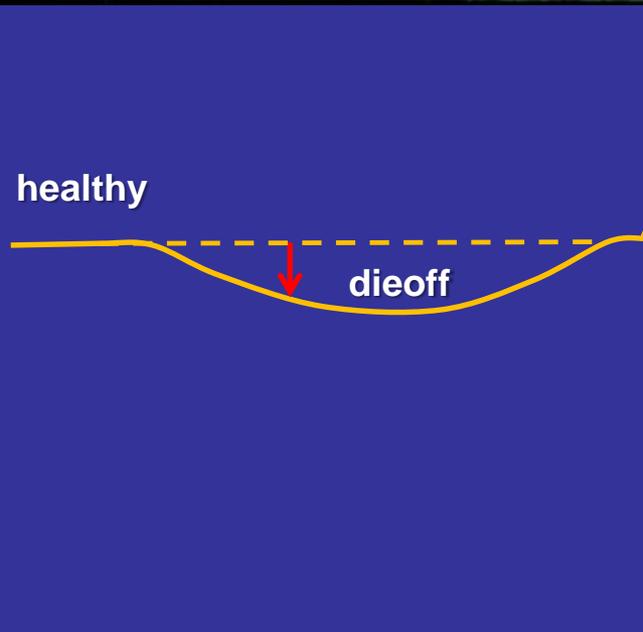
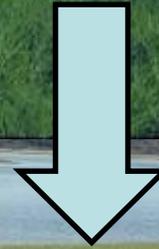


- Subsidence, erosion, carbon loss and release





Major topographic changes  
following herbivory-driven dieoff



## Swan River (Dennis)

1952

1971

1984

1994

2001

2005

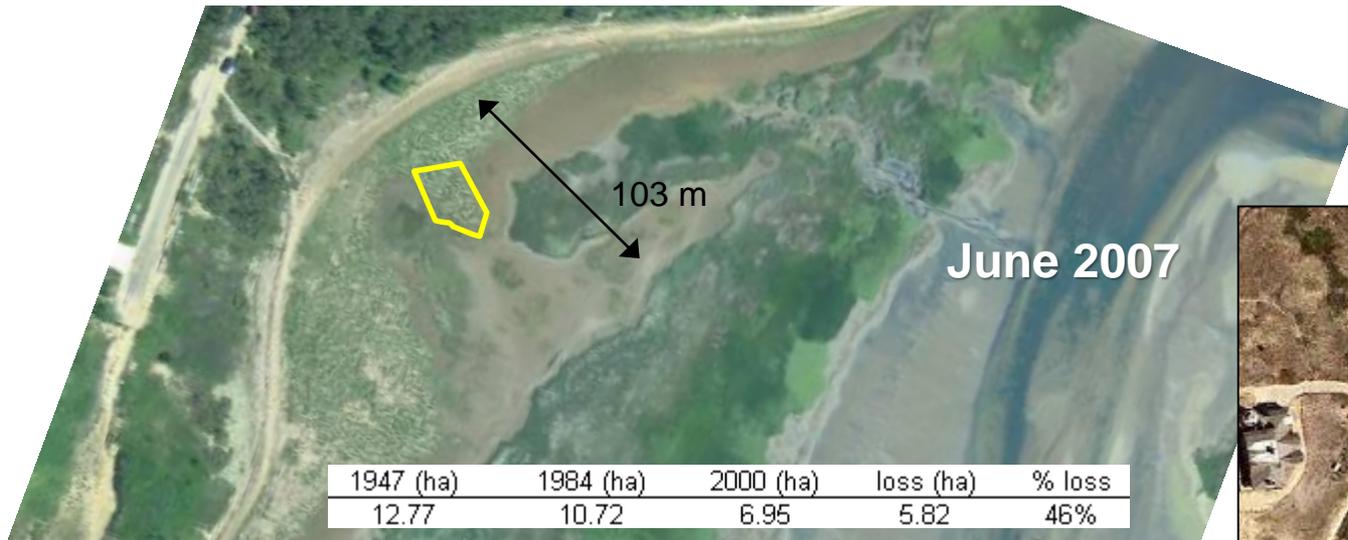
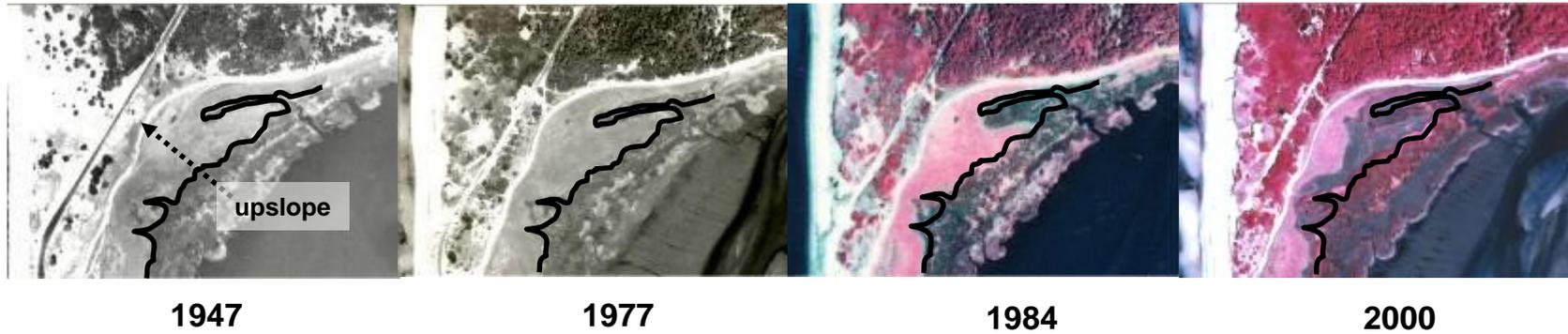


May 2007

**Smith, S.M.** 2009. Multi-decadal changes in salt marshes of Cape Cod, Massachusetts: a photographic analysis of vegetation loss, species shifts, and geomorphic change. *Northeastern Naturalist* 16(2):183-208.

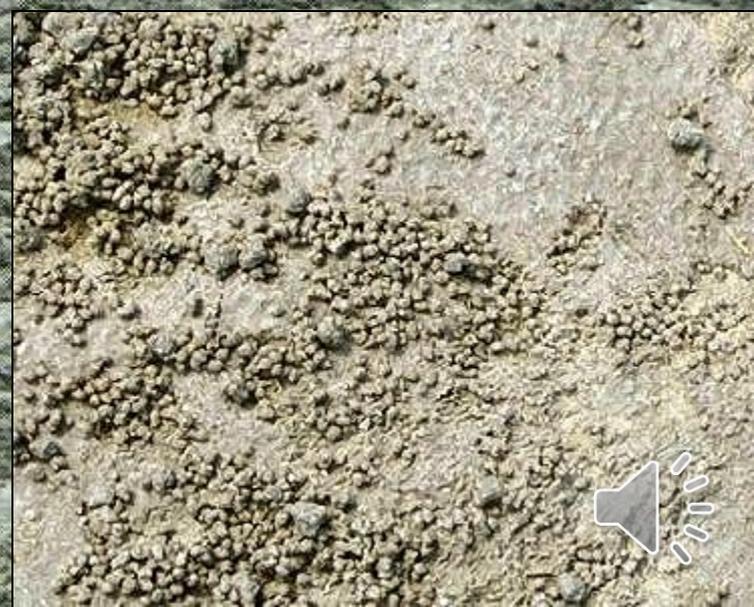


# The Gut (Wellfleet) – effects of sea level rise + herbivory





# Cascading effects of vegetation losses





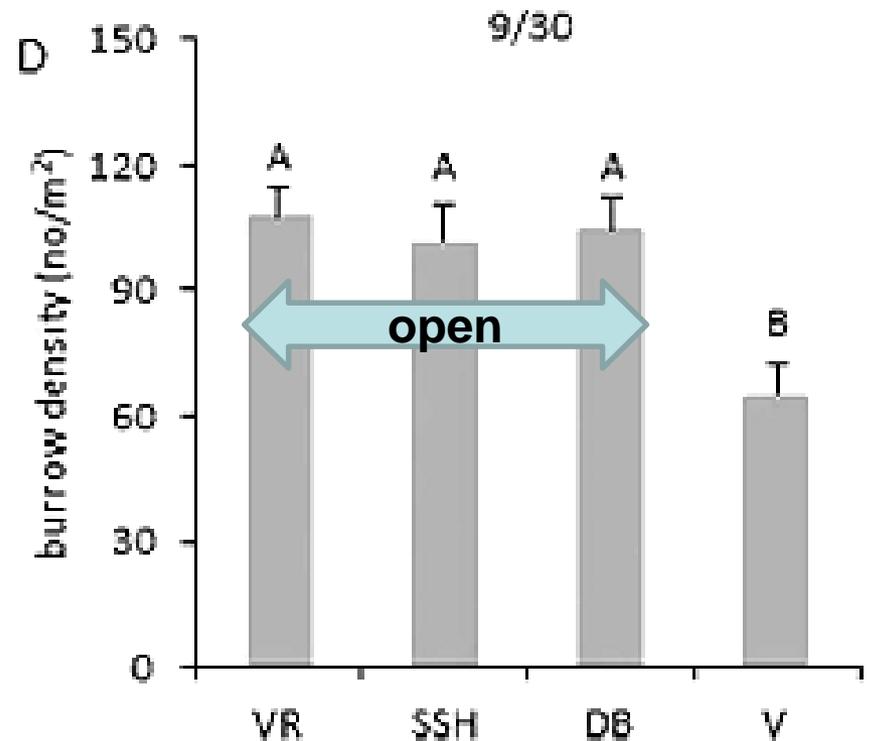
## Colonization/utilization of dieoff areas by fiddler crabs (*Uca pugnax*)

SSH=simulated *Sesarma* herbivory (clipped)

VR=vegetation and topsoil removed, replaced with DB soil

DB=dieback area (no veg)

V=vegetated





# Effects of fiddler crabs on the germination of halophyte seeds (bioturbation effects)

	<i>Uca</i>	Control
Seed germination		
<i>S. alterniflora</i> (initial no. seedlings = 0)	1.8 ( $\pm 1.3$ )	7.0 ( $\pm 1$ )
<i>Suaeda</i> (initial no. seedlings = 0)	2.3 ( $\pm 1.2$ )	26.0 ( $\pm 1.5$ )
Pre-established seedlings		
<i>S. alterniflora</i> (initial no. seedlings = 6)	-94.4% ( $\pm 5.6\%$ )	0% ( $\pm 0\%$ )
<i>Suaeda</i> (mean initial no. seedlings = 7, ranging between 4 and 13)	-78.7% ( $\pm 13.9\%$ )	37.6% ( $\pm 40.1\%$ )



**Smith, S.M.** and M.C. Tyrrell. 2012. Effects of mud fiddler crabs (*Uca pugnax*) on the recruitment of halophyte seedlings in salt marsh dieback areas of Cape Cod (Massachusetts, USA). *Ecological Research* 27: 233–237

**Smith, S.M.**, M.C. Tyrell, and M. Congratel. 2013. Palatability of salt marsh forbs and grasses to the purple marsh crab (*Sesarma reticulatum*) and the potential for re-vegetation of herbivory-induced salt marsh dieback areas in Cape Cod (Massachusetts, USA). *Wetlands Ecology and Management* 21:263-275.

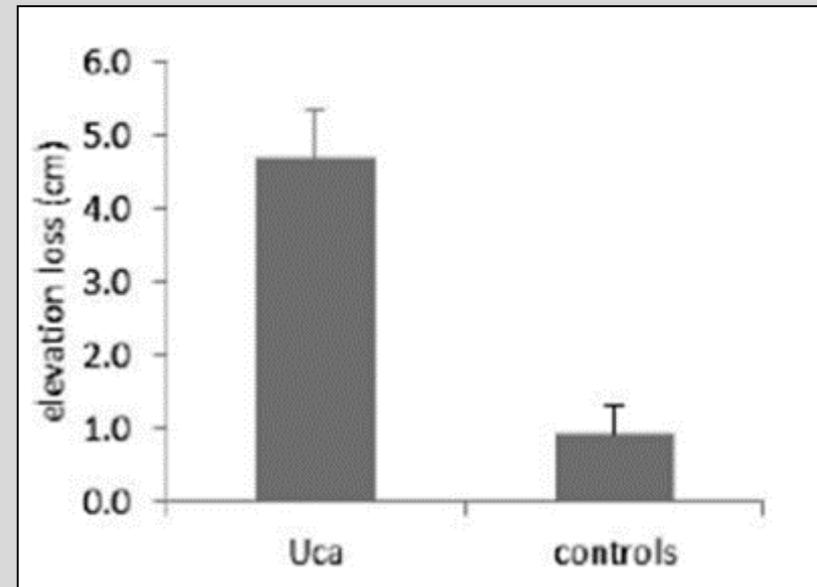




## Effects of fiddler crabs on sediment erosion and elevation loss



### Soil elevation loss from cages with fiddler crabs vs. controls (no crabs)



Smith, S.M., and C.W. Green. 2015. Sediment Suspension and Elevation Loss Triggered by Atlantic Mud Fiddler Crab (*Uca pugnax*) Bioturbation in Salt Marsh Dieback Areas of Southern New England. *Journal of Coastal Research* 31:88-94.





## Effects of ditching

Provides more “creekbank” habitat for *Sesarma* than what would otherwise be available.





## Species composition changes are NOT really recovery

- Cessation of herbivory mostly caused by decline in suitable substrate (and food)
- Green crabs displace and consume *Sesarma* (Bertness, M.D. and Coverdale, T.C., 2013. An invasive species facilitates the recovery of salt marsh ecosystems on Cape Cod. *Ecology* 94(9):1937-1943.)
- Population of blue crabs (predator of *Sesarma*) a factor as well
- Being at the northern extent of their range, populations likely go through substantial fluctuations depending on winter conditions (?)





***Thank you!***

