Temporal and Spatial Variability in Inorganic Sediment Contribution to The Great Marsh, Massachusetts

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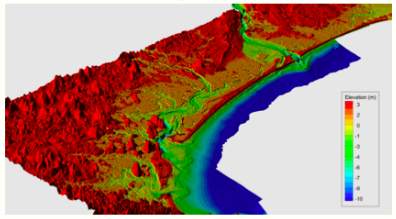
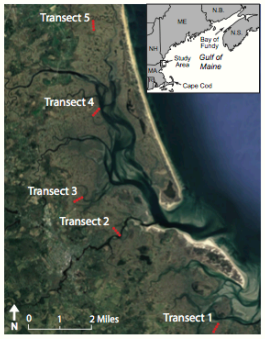
Abstract:

- In New England, the marsh platform is predominantly "high marsh," characterized by *Spartina patens* and *Distichlis spicata* with vertical accretion rates of ~2.5 mm/yr (Wilson et al. 2014).
- Addition of inorganic sediment to the marsh surface is aided by deposition of suspended sediment during spring high tides and storms. Coarser sediment is deposited by ice-rafts.
- Twenty ~180-cm long sediment cores along five transects provide a means for studying in organic sediment contribution at the Great Marsh in northern Massachusetts during the past ~ 2.5 ka.
- Transects were aligned perpendicular to bays and major channels at different compass quadrants to capture possible influences of wind and tidal flow during storms.
- Data show a strong correlation between grain size and distance from the nearest channel or bay throughout history of the marsh.
- Data show no consistent vertical trend in grain size, neither within individual sampling sites nor among all coring transects.

Study Area:



Digital Elevation Model of the Great Marsh. Note the flatness of marsh platform and how open waters decreases away from inlets.



The Great Marsh is located along the North Shore of Massachusetts. The marsh platform consists primarily of high marsh (*Spartina patens* & *Distichlis spicata*). Major estuaries include (north to south) Parker, Rowley, Ipswich, and Essex Rivers, which contribute freshwater and minor suspended sediment.

Location of coring transects. Note the different orientations of transects with respect to sediment source and water bodies.

Methods:

- Four cores taken along five transects with a 125 meter spacing.
- Transects perpendicular to channels & bays with different orientations.
- Cores were 180 cm long using a Half-Barrel Auger.
- Samples were taken every 20 cm.
- Grain sizes determined using a Malvern Masterziser 3000 laser particle analyzer.
- Percent organics determined by Loss On Ignition (LOI).

Photo of coring procedure at station #1, transect #2.

A sample with high sand content taken from bottom of core. Likely original tidal where the marsh first developed

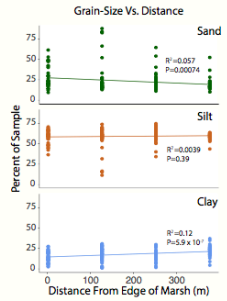
Role of Organic Matter:

Average grain size before and after Loss On Ignition

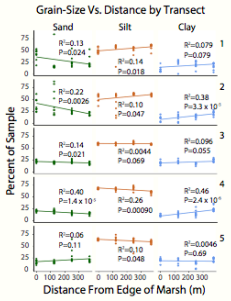
	With Organics				
	% Sand	% Silt	% Clay	D_{50}	% Organic
Average	40%	53%	8%	44.6	24%
Min	18%	8%	0%	16.1	2%
Max	92%	69%	19%	217.7	51%
Std	15%	11%	4%	31.3	10%
	No Organics				
	% Sand	% Silt	% Clay	D_{50}	
Average	24%	58%	17%	24.3	
Min	10%	11%	1%	8.8	
Max	88%	74%	37%	128.2	
Std	14%	9%	7%	19.2	

Comparison of grain sizes before and after LOI. After LOI, the data show a notable overall decrease in the sand fraction and slight increases in percent silt and clay. This trend may indicate that organics are attached to mineral grains producing apparent sand-sized grains. These grains become silt and clay sizes when organic material is removed.

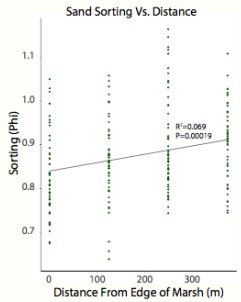
Grain-Size Trends:



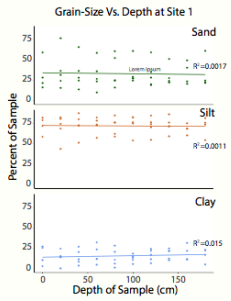
Grain-size plotted against distance from water body. As expected, grain size generally decreases with distance into the marsh. Most significantly was a decrease in fine sand and an increase in clay content. Silt percentage tended to be constant.



Grain-size trends shown for individual transects. Transects #1 and #2 have a clear trend of decreasing sand content and increasing silt and clay toward marsh interior. Transects #3 and #4 show a slight trend of decreasing sand and increasing clay. Finally, #5 indicates a slight increase in sand, decrease in silt & constant clay.



Grain sorting plotted against distance perpendicular from water body. The p-value suggests that the distance from water definitely has an impact on grain size sorting, however, the low R^2 value indicates that this is not a simple relationship and other factors (such as depth in core or fetch at each location) are creating a great deal of variance in our dataset.



Grain-size versus depth for all coring sites adjacent to the water body and sediment source. Flatness of the curve and R^2 values indicate no significant trend exists. This finding suggests sediment deposited on the marsh surface through time was not affected by channel depth.

References:

Leonard, L.A. and Croft, A.L. 2006. The effect of standing biomass on flow velocity and turbulence in Spartina alterniflora canopies. Estuarine, Coastal and Shelf Science. 69:325-336.

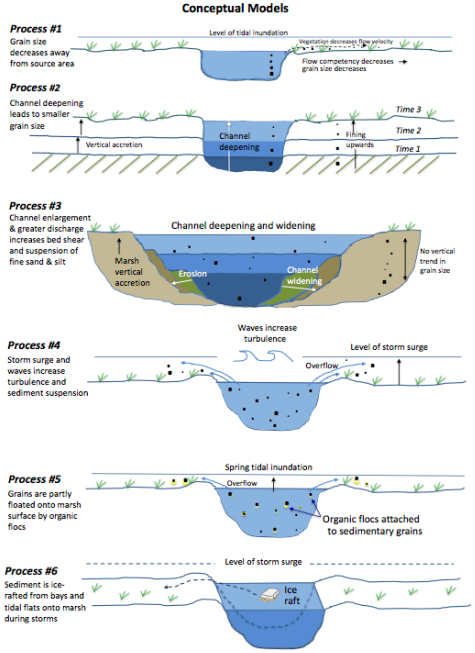
Moskalski SM, Sommerfield CK. 2012. Suspended sediment deposition and trapping efficiency in a Delaware salt marsh. Geomorphology, 139-140:195-204. DOI:10.1016/j.geomorph.2011.10.018

Wilson C, Hughes ZJ, FitzGerald DM, Hopkinson CS, Valentine V, Kolker A. 2014. Saltmarsh pool and tidal creek morphodynamics: Dynamic equilibrium of northern latitude saltmarshes? Geomorphology, 213:99–115. DOI: 10.1016/j.geomorph.2014.01.002.

Conclusions:

- Deceleration in tidal current velocity across the marsh surface due to obstructing vegetation leads to a decrease in mineral grain size deposition toward the marsh interior. This is a well known trend (Leonard and Croft 1995, Moskalski and Sommerfield 2011).
- Our data set suggests that this trend exists through the ~ 2000 yr history of the marsh, although variability in the trend may be due to ice rafting, creek evolution, bioturbation, and other processes.
- Transect #5 did not exhibit this trend, which may be related to its isolated location and being very distant from a major water body compared to the other transects.
- The data do not show any obvious vertical trends, which might be suspected if channel deepening affected suspended sediment distribution vertically through the water column.

Conceptual Models



Conceptual models of sediment transport onto the marsh platform based on grain size trends. We envision channel deepening due to marsh vertical accretion.