Pre- and Post- Dredging Monitoring of *Spartina alterniflora* Productivity in a Threatened Salt Marsh

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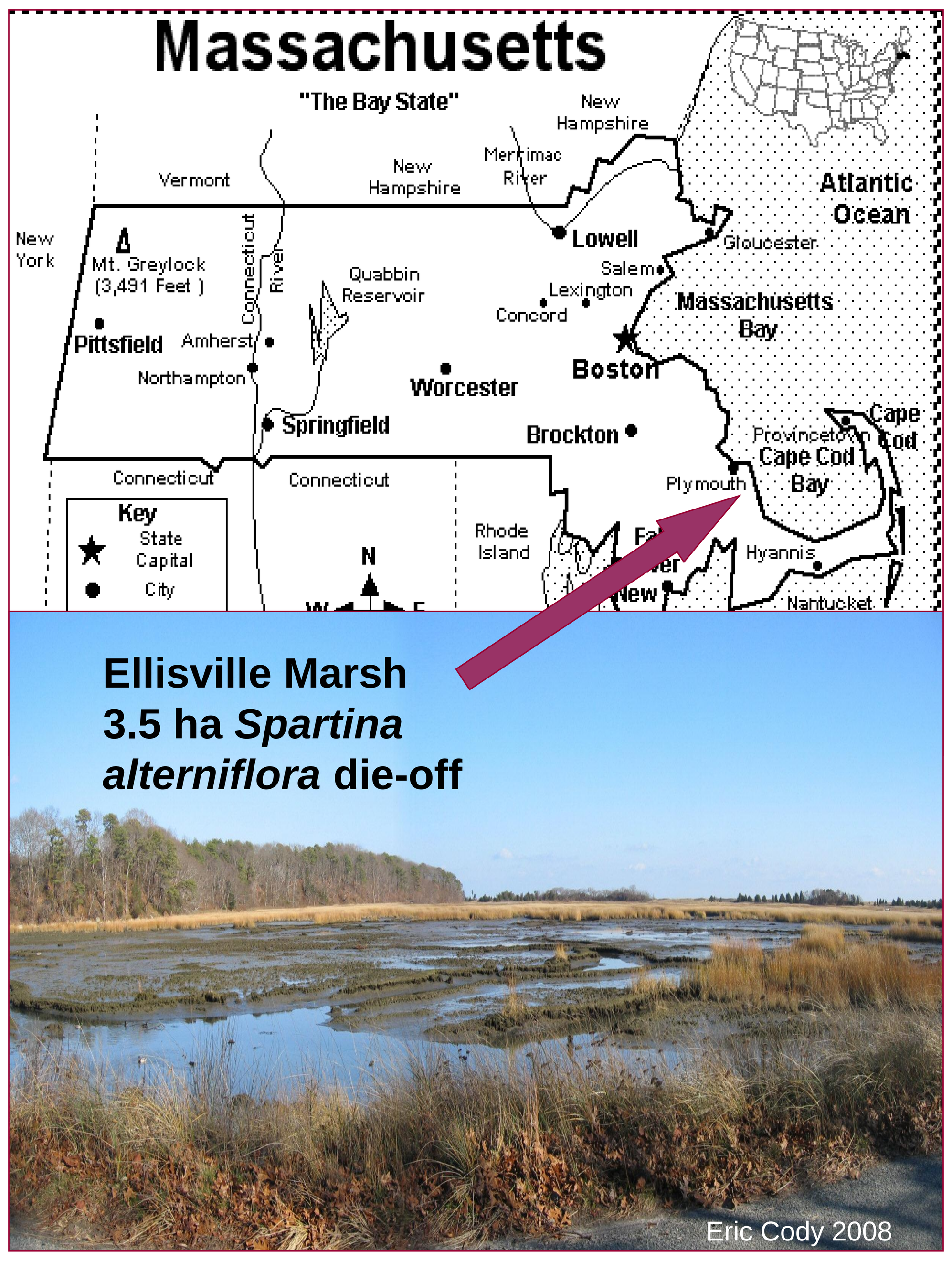
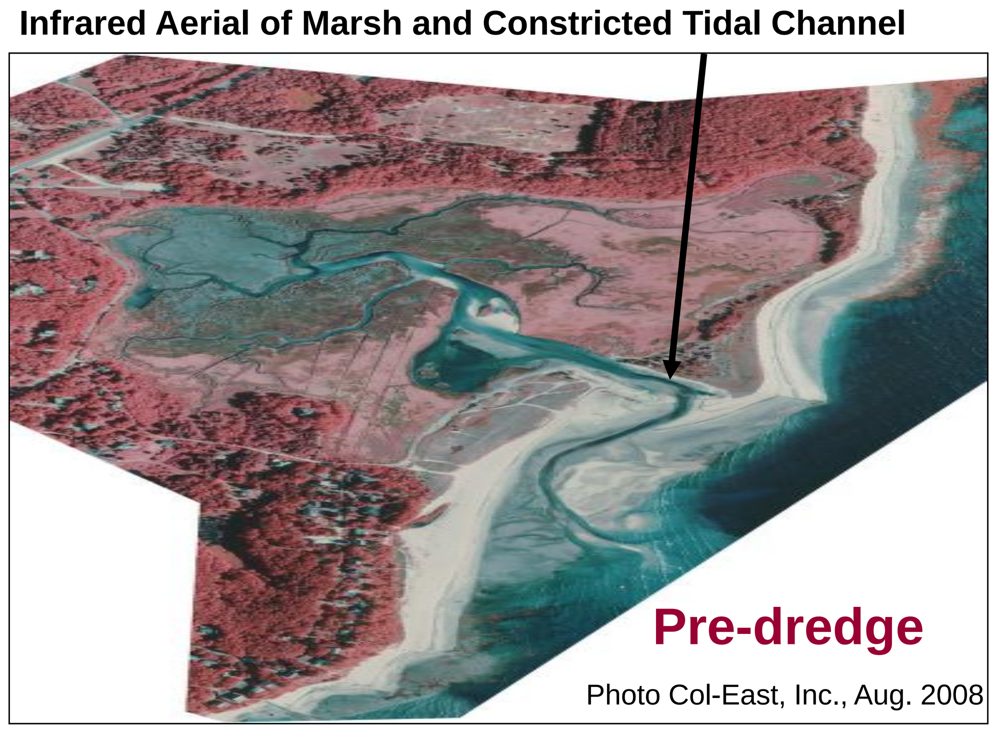
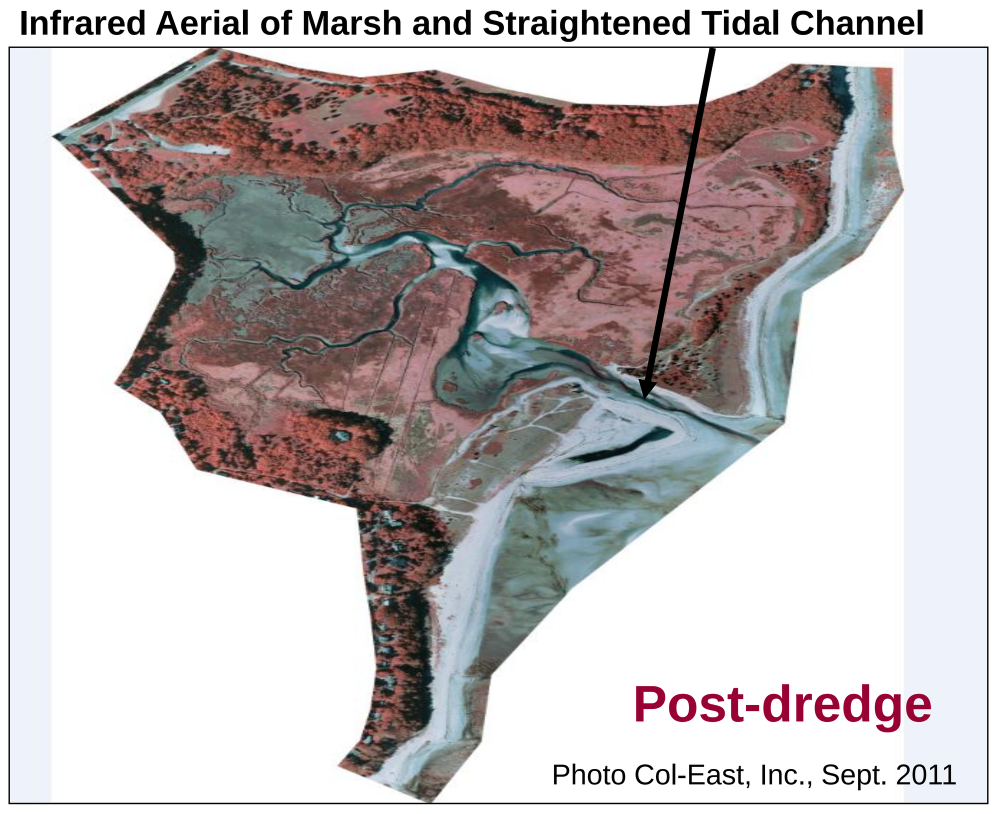


Infrared Aerial of Marsh and Constricted Tidal Channel



Infrared Aerial of Marsh and Straightened Tidal Channel



Background and Objectives

Ellisville Marsh, Plymouth, Massachusetts is a 28 ha salt marsh bounded by roadways and upland forest. Dredging of the estuary's tidal channel for fishing industry and recreational boating has occurred since 1770. In 1987, cessation of fishing and associated maintenance dredging led to tidal restriction, an apparent 3.5 ha loss of *Spartina alterniflora* over a 5 to 10 year period, and down-coast property erosion caused by the meandering channel. An emergency opening of the channel in 2003 addressed immediate property losses. This was followed by obtaining a five year dredge permit beginning in 2011 to alleviate continual constriction of tidal flow and possibly restore *Spartina alterniflora*. In essence, this restoration case represents conditions following a manipulated sea level rise scenario. **The objectives of this study are to document and describe relationships between hydroperiod, associated environmental variables, and assess their possible impact on the productivity of *Spartina alterniflora* in Ellisville Marsh.**

Methods and Materials

Pre-dredge (2010) and post-dredge (2011) conditions are compared. The study, however, has a 5-year time frame (2010-2014) to assess changes in the following variables:

•Species relative abundance (% cover) using repeated measures of ninety-six 1.0 m^2 vegetation plots located every 18.3 m (60 ft) interval along 5 transects

•Productivity determined by peak above ground biomass harvest in August (before flowering) and below ground harvest in September (after flowering) followed by drying 24 hrs at 60˚C and weight measurement.

•Leaf height of *S. alterniflora* measured haphazardly, along with per unit area stem density measurements (live/dead).

•Interstitial pore water S^{2-}, NH_4^+, PO_4^{3-} concentrations in each plot and concurrent estuary water quality monitoring.

•In situ measurement of root zone redox condition during varying tides using electrodes and assay of root alcohol dehydrogenase activity in root using ethanol as substrate.

•Percent organic matter, stable plant fragment content and particle size analyses of 160 soil samples (10 random locations/year x 4 samples/location x 4 years).

• Tidal hydroperiod as determined using HOBO pressure gauges for tidal range evaluation and IMAX Thermochron button temperature loggers documenting soil surface, water and ambient temperature variation.

•Steep temperature declines registered by plot surface loggers during mid-day August tides (after compensation for changes in ambient temperatures) were used to determine onset of tidal inundation. Pressure readings from a centrally located marsh logger that corresponded to initiation of temperature decline were the indicator for when a logger became inundated and subsequently uncovered as tides receded (Fig.1). This pressure value was compared across all tides for August and the total time interval the logger was under water was considered the hydroperiod for that location.

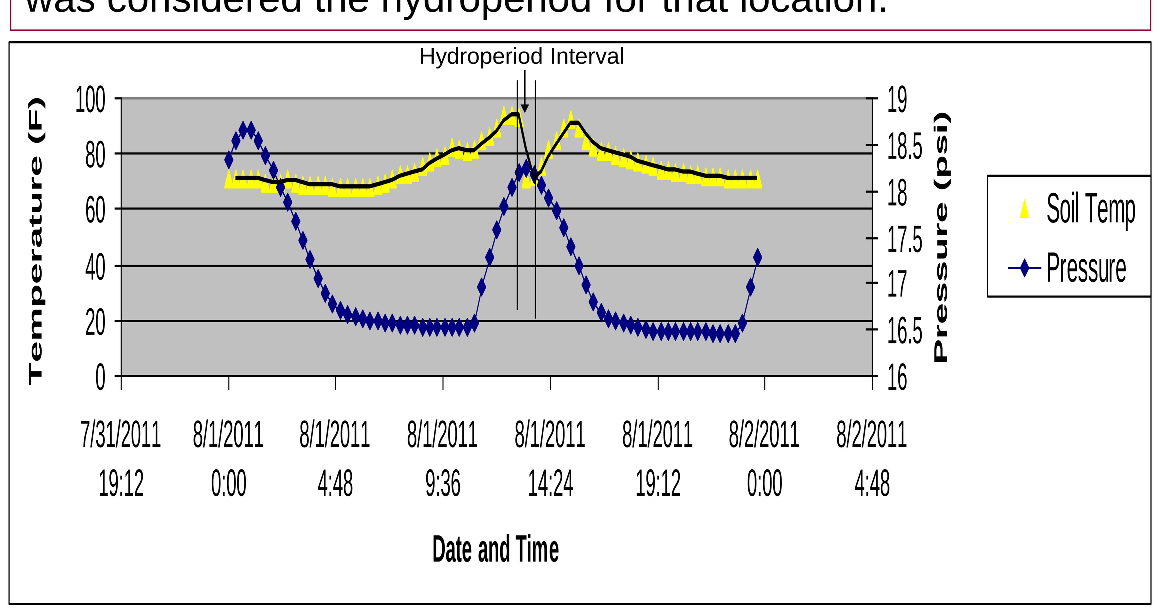


Fig. 1 – Example of tidal pressure and onset of temperature decline used to determine hydroperiod across tidal cycles, August 2011

Results and Discussion

A combination of parametric and non-parametric statistical approaches were used to assess the data. Data was normally distributed, but did not meet strict requirements for homogeneity of variance and independence in all cases. Spatial autocorrelation of above ground biomass results with distance from central channel was not observed in pre-dredge data, but was detected in post-dredge results. Non-parametric MRPP (multi-response permutation procedures with Euclidean distance measure) found significant differences between environmental conditions when environmental variables were grouped between year 2010 and 2011 ($p<0.001$, A=0.049) (Figure 2).

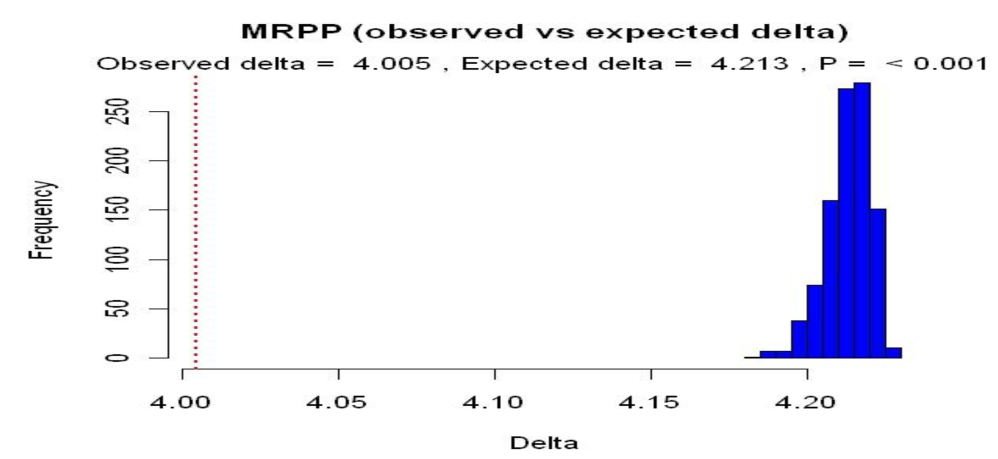


Fig. 2 - Multiple response permutation procedure results found significant ($p<0.001$) differences between environmental variables across pre-dredge (2010) and post-dredge years (2011)

Mean semi-diurnal tidal range increased by 0.4 m and hydroperiod increased for all plot locations following dredging of the barrier spit with hydroperiod ranging from 1,000 to greater than 10,000 min for the month of August. Direct observation of 10% of plots confirmed logger derived inundation time periods. Non-linear fitting of a parabolic functional relationship (for just plots containing *S. alterniflora,* n=75*)* of the root-to-shoot ratio to hydroperiod, similar to the functional relationship reported by Morris (2007), Mudd et. al.(2009), Fagherazzi (2012), found an optimum root-to-shoot ratio range corresponding to 3000 to 6000 minutes of inundation for the month of August when considering both years' data (Fig. 3). Pre-dredge root-to-shoot ratios were generally lower than post-dredge values.

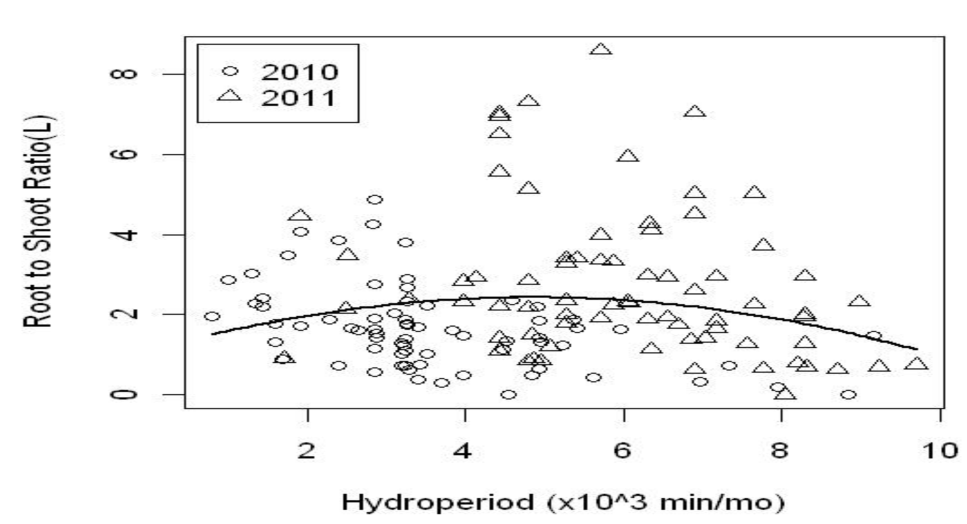


Fig. 3 - *Spartina alterniflora* root to shoot ratio response to hydroperiod, $y \sim bx^2 + ax + c$, a=0.5424*, b= -0.0558, c=1.111, sigma = 1.58***

While mean above and below ground biomass for all plots decreased following dredging, a positive linear relationship between leaf height and hydroperiod ($p<0.001$, $r^2 = 0.20$, $\alpha = 0.05$) for *S. alterniflora* was present, likely an elongation response to elevated water levels (Fig.4). The number of plots with the tall form of *S. alterniflora* dominant (>55% cover) increased by 10% following dredging. *Haliaspis spartinae* (Figure 5) was discovered throughout the marsh and may play a role in *S. alterniflora* health. Concentrations of NH^{4+} and $PO4^{3-}$ significantly decreased after dredging (NPMANOVA, $p<0.0001$, $\alpha = 0.05$) possibly due to increased flushing of nutrients from interstitial pore water. Stem density, salinity and [S^{2-}] were not significantly different post dredging.

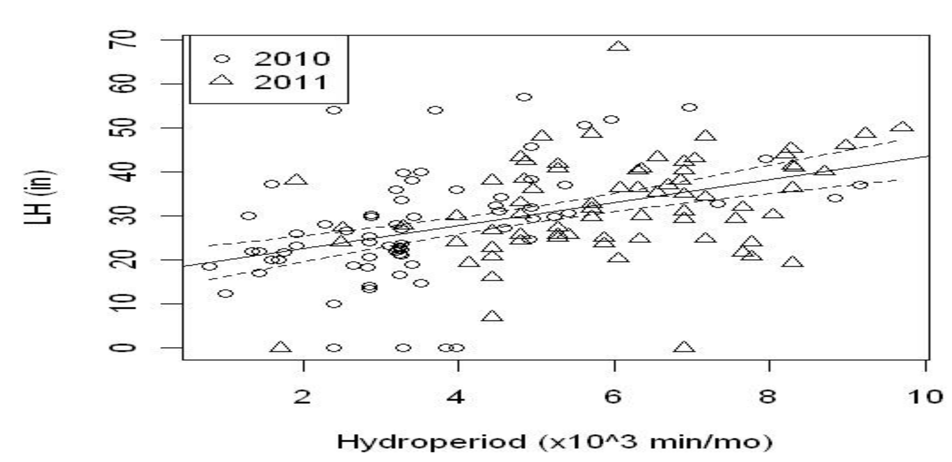


Fig. 4 - *Spartina alterniflora* leaf height response to hydroperiod $y \sim 2.62x + 17.28$, $p < 0.001$, $r^2 = 0.21$

Conclusions

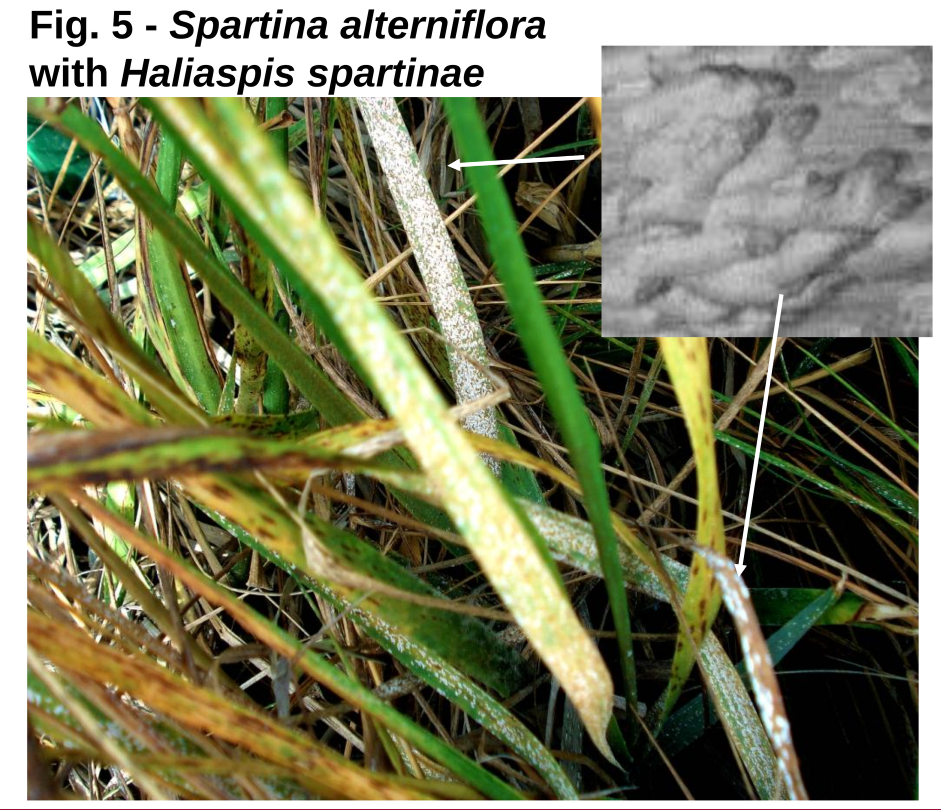
•A non-linear parabolic fit of the root-to-shoot ratios for both years' data revealed a wide range (3000 to 6000 min) of hydroperiod representing optimum ratios.

• A positive linear relationship between leaf height and hydroperiod was observed.

• *Spartina alterniflora* stem densities were not significantly different in marsh plots following dredging as compared to those before dredging.

• Additional years of monitoring results will be combined to further refine the growth relationships to hydroperiod. Pore water chemistry, soil characterization and alcohol dehydrogenase assay results will help clarify whether these variables also play a role in a parabolic growth response.

Fig. 5 - *Spartina alterniflora* with *Haliaspis spartinae*



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