Final Report

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Accretion, Elevation Change, and Herbivory in the Quinnipiac Marshes

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Introduction

Tidal marshes are key components of the coastal landscape, and play several valuable roles: habitat for wading birds, juvenile fish, and invertebrates; sites of high primary production and nutrient processing; buffers for removal of land-derived pollutants; and flood protection. These vital ecosystems have been legally protected from direct anthropogenic impacts (dredge and fill), but several sites, including the Quinnipiac River marshes, are experiencing marsh drowning, characterized by an increase in wetness, loss of vegetation, and conversion to mudflat.

The Quinnipiac River's extensive tidal marshes (brackish and salt) provide a unique ecological and recreational resource. This area is habitat to numerous birds and aquatic organisms and provides a biogeochemical filter for the waters of the river, as well as being a popular site for birding and boating. Marsh loss threatens those values.

Healthy marshes can avoid drowning by accreting sediment (organic and inorganic) at rates that allow the marsh to "keep up" with relative sea level rise (SLR). The reasons that submerging marshes are unable to do this are presently unclear. In some cases, runaway herbivory (e.g., by Sesarma crabs) is thought to contribute to denudation and marsh loss. Our previous work on the Quinnipiac (report 20150148) suggested that herbivory, perhaps by Canada geese (*Branta Canadensis*), was preventing vegetation re-establishment on one lobe of the mudflat.

In this project, we examined some of the processes affecting marsh loss in the Quinnipiac. In particular, our proposal identified 2 objectives:
1. Monitor 9 long term plots in spring 2016.
2. Establish a mudflat herbivory experiment and use it to assess the role of herbivory in persistence of the mudflat.

Our methods and results in addressing these objectives are described below.

Elevation change (objective 1)

Methods

In April 2016, we measured elevation change at each of our previously-established Sediment Elevation Table (SET) plots (Figure 1) using established methods (Cahoon et al. 2002). Specifically, we sampled triplicate plots in each of 3 vegetation types: *Typha glauca* near the drowning area ("degrading Typha"), *Phragmites australis* near the drowning area ("degrading Phragmites"), and Phragmites away from the drowning area ("healthy Phragmites"). We have previously determined that sampling more than once per year results in unacceptable damage to vegetation, so we sampled only in April 2016 (before new shoots reached the elevation of our sampling platform).

Sampling involved deploying the sediment elevation table at each plot and collecting readings from 9 pins in each of 4 directions. These measurements were then compared to the initial readings; differences correspond to increases or decreases in sediment elevation.

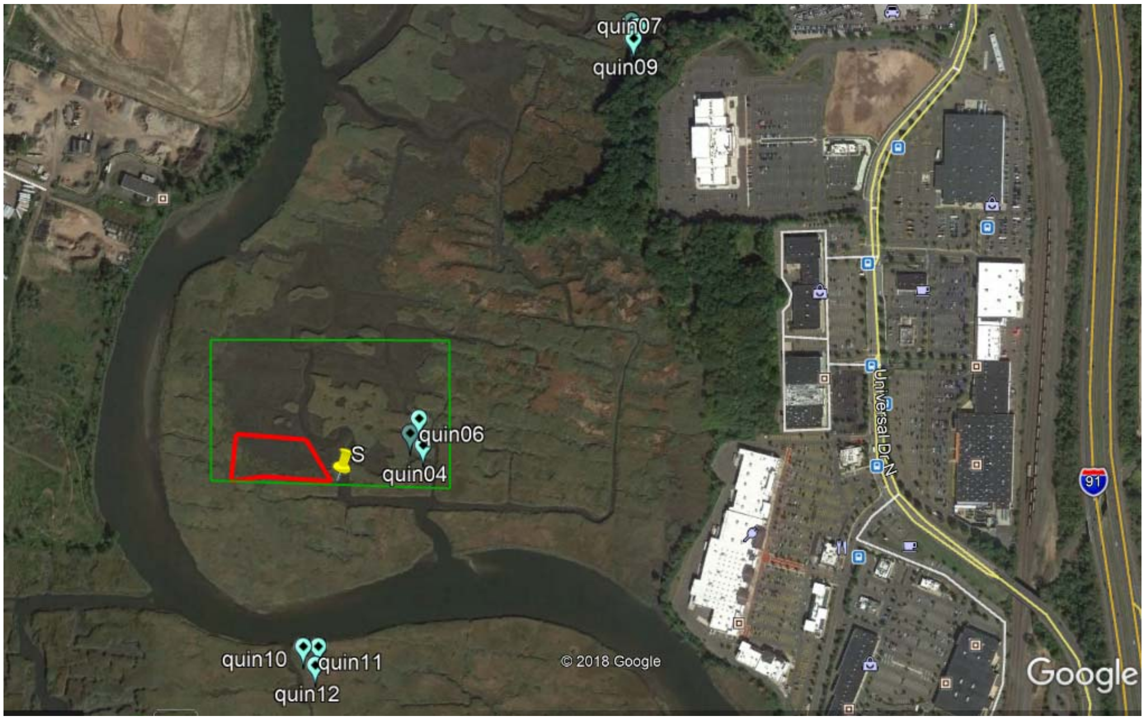

Figure 1. Sampling locations in the Quinnipiac marshes. Blue markers indicate SET plots (triplicate plots at each site). Sites from north to south are: Typha, degrading Phragmites, healthy Phragmites. The letter S indicates the location of the salinity logger. The red polygon indicates the approximate area where the herbivory experiment was carried out, while the green rectangle demarcates the approximate boundary of the drone photography.

Results

As shown in Figure 2, the Typha site continued to show a rate of elevation change considerably larger than regional SLR. The healthy Phragmites site grew more slowly than the Typha site, but still faster than SLR. On the other hand, the degrading Phragmites site – which has risen most slowly over the last 9 years – showed a decline in elevation for the first time since monitoring began.

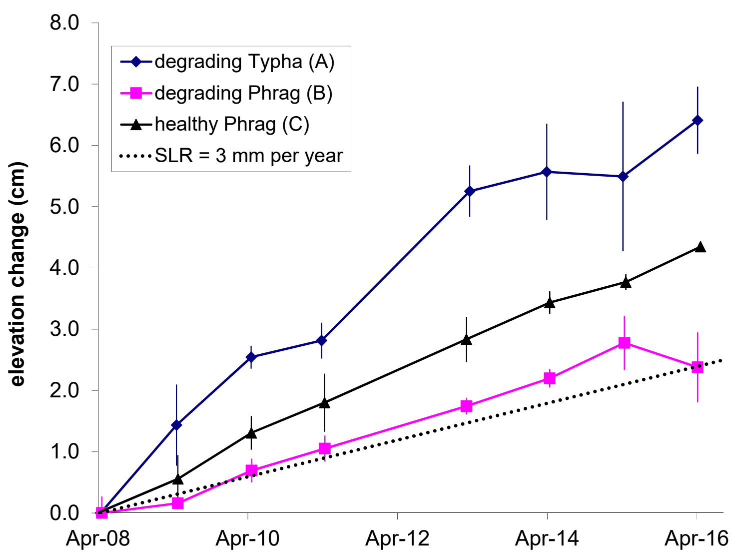

Figure 2. Elevation change at the three sites (mean and standard error of triplicate plots at each site). Dashed line shows a constant SLR of 3 mm yr^{-1}.

Hebivory experiment (objective 2)

Methods

Our goal was to follow up on our previous experiment, which had suggested that protecting the mudflat from herbivory using an enclosure can lead to revegetation with Phragmites (see report 20150148). In May 2016, we established an experiment with 6 types of plots, each 1.5m x 1.5m:

- no-fence controls: plot is neither fenced nor planted, just demarcated and monitored
- no-fence planted: plot is planted with 9 Phragmites stems collected from the nearby vegetated marsh
- full fence: plot is surrounded with 4-foot high plastic fencing
- fenced planted: plot is surrounded with 4-foot high plastic fencing and is planted with 9 Phragmites stems
- bottom fence: plot is surrounded with 1-foot high plastic fencing, allowing birds to land but preventing access for aquatic herbivores
- top fence: plot is surrounded with 4-foot high plastic fencing, of which the bottom 1 foot is removed to allow access for aquatic herbivore but not birds.

Each treatment type was represented by 5 replicates (except for "fenced planted," for which we only put in 4 plots), for a total of 29 plots distributed randomly over the southwest lobe of the mudflat.

Results

We intended to assess experiment results by measuring vegetation cover in each plot at the end of the growing season. However, by early August, our monitoring showed clearly that *Spartina alterniflora*, which in previous years had been a minor component of this area's vegetation, was expanding in a patchy way across the same section of mudflat where we had set up our experiment. Some of our plots were more affected by this expansion than others, but this clearly had to do with location rather than treatment type. The photos in Figure 3 illustrate the phenomenon. This meant that our plots were worthless in evaluating our hypothesis.

However, we recognized that this vegetation expansion represented an important process in its own right (and not just as a destroyer of our experiment!). We hypothesized that the lack of rain during spring/summer 2016 led to lower river flows and thus unusually high salinities in the estuary, which had allowed *S. alterniflora* (a plant typical of salt, rather than brackish, marshes) to expand its range. To evaluate this, we carried out three additional activities (not found in our original proposal):

a. collected USGS data for river flow from 2012 to 2016
b. installed a salinity logger in the mudflat area and collected salinity data every 5 minutes from 9/14/16 to 11/8/16
c. flew a drone over the mudflat on 9/20/16 and collected low-level aerial photos to assess the range of *S. alterniflora*

Figure 3. Photos (taken August 2, 2016) illustrating the expansion of S. alterniflora*. Top: Patchy expansion across the mudflat both inside and outside of our plots. Bottom: Plot (orange fencing in background) that was originally placed in unvegetated area and is now surrounded by* S. alterniflora*.*

USGS flow data for the Quinnipiac for June through November (2012-2016) are shown in Figure 4. It is clear that 2016 was indeed an unusually dry year, especially during the crucial summer months.

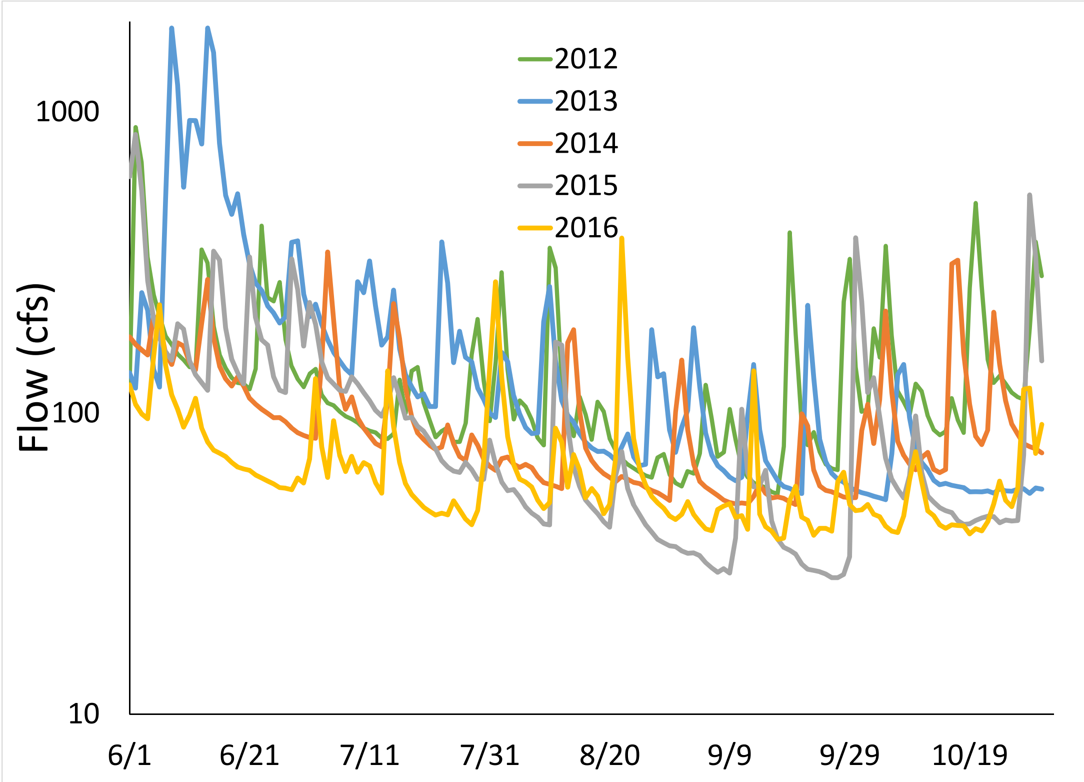

Figure 4. USGS flow data for the Quinnipiac River at Wallingford (01196500) for June through November, 2012-2016

Our salinity data are shown in Figure 5. The tidal influence is clear: salinity is very low at low tide but rises at high tide. Of note, high-tide salinity levels in September and early October are generally above 20psu, a value that seems rather high for this brackish marsh system. Of course, in the absence of data from other years (or, indeed, from the crucial summer period during this year), it is hard to interpret these data. We hope to collect similar data in future years for comparison.

Figure 6 presents a mosaic of the low-level aerial photos we collected by drone. Two things are clear from this mosaic: (a) *S. alterniflora* does have patchy but significant coverage in the southwest corner of the mudflat, where our experiment took place, as well as in other similar areas around the outskirts of the mudflat; (b) the central portion of the mudflat (representing the vast majority of the area) is unaffected by *S. alterniflora*.

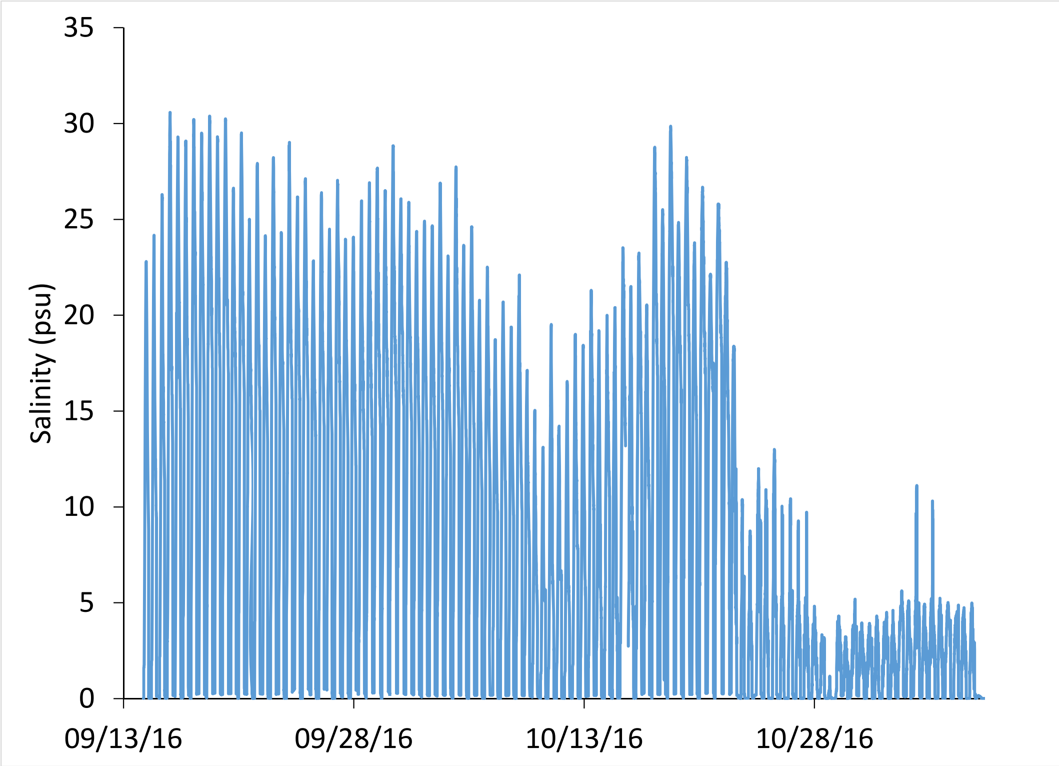

Figure 5. Salinity, Quinnipiac River mudflat, fall 2016.

Figure 6. Composite of low-level photos collected by drone photography. Note areas of S. alterniflora *around the outskirts of the mudflat.*

Conclusions

Our long-term monitoring of elevation change (objective 1) continues to suggest that vegetated areas of the marsh – even areas that are adjacent to the expanding mudflat – are keeping up with sea-level rise. However, the degrading Phragmites plots lost elevation for the first time, suggesting that vegetation loss in this area may soon follow.

Our herbivory experiment (objective 2) did not succeed in its original objective, but did reveal an unexpected result: *Spartina alterniflora* – a plant typical of higher salinity conditions – expanded in area during the dry summer of 2016. Higher salinities may, paradoxically, be beneficial to the marsh in the short term, as *S. alterniflora* typically can extend into lower elevations than can Phragmites and thus may be able to colonize portions of the mudflat.

Acknowledgments

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