

Final Report Summary

Long Island Sound's tidal marshes are key components of the coastal landscape, providing valuable habitat and serving important functions. Several sites in Long Island Sound have been experiencing marsh drowning, in which the marsh becomes too wet to support vegetation and is converted to open mudflats. The causes of this phenomenon are unclear. While sea level rise is occurring in Long Island Sound, the rate of this rise is relatively low (~ 2.3 mm yr⁻¹) and has apparently not changed since the mid-19th century. In the absence of other stressors, one would expect marshes to be able to adjust to this rate of sea level rise by accumulating inorganic sediment and organic material in order to maintain their relative elevation.

This project was designed to test the hypothesis that excessive loading of nutrients (nitrogen (N) or phosphorus (P)) plays a role in causing marsh loss, either through a decrease in belowground production or through an increase in belowground decomposition. In addition, we examined the similarities and differences between the phenomenon of marsh drowning described above and the phenomenon of marsh restoration, in which the return of tidal flow to a marsh leads to a wetter system – but one that is on a trajectory of restoration rather than drowning.

The project involved both observational and experimental components. In the former, we compared 3 Connecticut marshes in different hydrologic settings: a stable marsh (Hoadley Creek, Guilford), a restoring marsh (Jarvis Creek, Branford), and a drowning marsh (Sherwood Island, Westport). In the latter, we established fertilization plots at Hoadley (24 plots treated for 3 years with N, P, both, or neither) in order to determine the effects of added nutrients on marsh processes. In both the inter-marsh comparison and the fertilization experiments, we examined a variety of marsh parameters and processes: porewater concentrations of nutrients, salinity, and sulfide; aboveground and belowground biomass and productivity; aboveground and belowground nutrient and metal content; decomposition and respiration; accretion and elevation change; and tidal hydrology.

We found that nutrient addition to marsh plots had significant effects on some aspects of marsh structure and function. N and P treatments led to increased nutrient concentrations (N and P, respectively) in porewater and aboveground vegetation. N fertilization led to higher aboveground productivity. P treatments led to higher P concentrations bound to mud.

Perhaps more interesting, however, are the effects that we did not observe. N and P Fertilization generally did not appear to substantially affect belowground processes, including productivity, decomposition, and soil respiration. Likewise, there was no indication that N and P fertilization affected sediment accretion or net elevation change. As a result, we now consider it unlikely that excess nutrient loading is a major contributor to marsh drowning. Also supporting this conclusion is the fact that the drowning marsh (Sherwood) had lower nutrient concentrations than the reference marsh (Hoadley).

In our inter-marsh comparison, we found several important differences between the sites:

- Jarvis is much wetter than Hoadley and Jarvis, with a longer high water period.
- Jarvis has high rates of both accretion and elevation change, while Sherwood has moderate rates of both. Hoadley has moderate rates of accretion but low (even negative) elevation change, reflecting substantial subsidence (belowground loss of elevation e.g., through compaction or decomposition).
- Jarvis has lower belowground biomass and more mud than Hoadley and Sherwood, perhaps because of its higher rates of trapping of inorganic sediment.

We believe that the high rates of accretion and elevation change at Jarvis (the “restoring” marsh) are related to the favorable hydrology of this site. The marsh surface at Jarvis is flooded on $\sim 80\%$ of high tides, and is under water about 1/3 of the time. This provides ample opportunity for sediment deposition on the marsh surface. In addition, the change in the slope of the Jarvis hydrograph at roughly the elevation of the marsh surface (not seen at the other marshes) may reflect the slowing of the tidal

waters as they overtop the channel and spread across the marsh surface. In sum, Jarvis is a successful restoration site. Although current conditions are certainly on the wetter end of the acceptable range for *S. alterniflora*, the marsh is not drowning. The site appears to be on a trajectory of increasing elevation relative to water level.

The substantial subsidence that we observed at Hoadley (the "stable" marsh) is an extremely important phenomenon, but one that we have no explanation for. The subsidence appears to be unrelated to nutrient treatment.

Despite the mudflat that has developed nearby, our plots at Sherwood (the "drowning" marsh) are not yet drowning. Flooding frequencies and durations are low to moderate – no wetter than Hoadley and certainly drier than Jarvis. In fact, the marsh would have to lose about 40 cm of elevation relative to water level to be faced with the same flooding duration as Jarvis. Productivity at Sherwood is reasonably high both aboveground and belowground, and generally quite comparable to Jarvis. At the same time, the low accretion rates that we measured, especially in one of our plots, may indicate an absence of sediment delivery to this marsh.

We speculate that the nature of drowning at Sherwood Island is closely linked to its hydrology. Due to the relatively small size of this marsh system, the nature of the tidal regime, and perhaps changes to the surrounding hydrology (i.e., the Millpond), there appears to be a large volume of water moving relatively rapidly through this system. The parts of the marsh (like our plots) that are relatively high are only flooded on ~15% of high tides, and when the flooding tides do come, they may be moving too rapidly to deposit sediment. On the other hand, the parts of the marsh that are a bit lower (e.g., the mudflat), are no doubt flooded frequently, but the water seems to be moving too rapidly to deposit sediment, and instead is likely to erode existing sediment.

Thus, we believe that the causes of marsh drowning at this site are likely to be found in inorganic sediment delivery (and erosion) processes rather than productivity and decomposition processes. This is consistent with our conclusion that nutrients (which are more likely to affect productivity and decomposition) do not play a major role in marsh loss at Sherwood Island.