But why the decline? Shifts in macroalgal biomass in a eutrophic microtidal estuary

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Introduction: Like much of the coastal northeast U.S., Waquoit Bay watershed has undergone a sequence of radical land-use changes over the past four centuries from the introduction of European-style agriculture to the more recent effects of residential development. A severe decline in the bay's eelgrass populations, from its abundant distribution throughout the bay in the 1950s to its almost vestigial presence at present, has been linked to eutrophication largely derived from the rising number of residential septic systems (Valiela et al. 1992). Correlated with eelgrass loss in Waquoit Bay has been a sharp increase in the abundance and distribution of macroalgae population (Peckol 1995, Hauxwell et al. 2001).

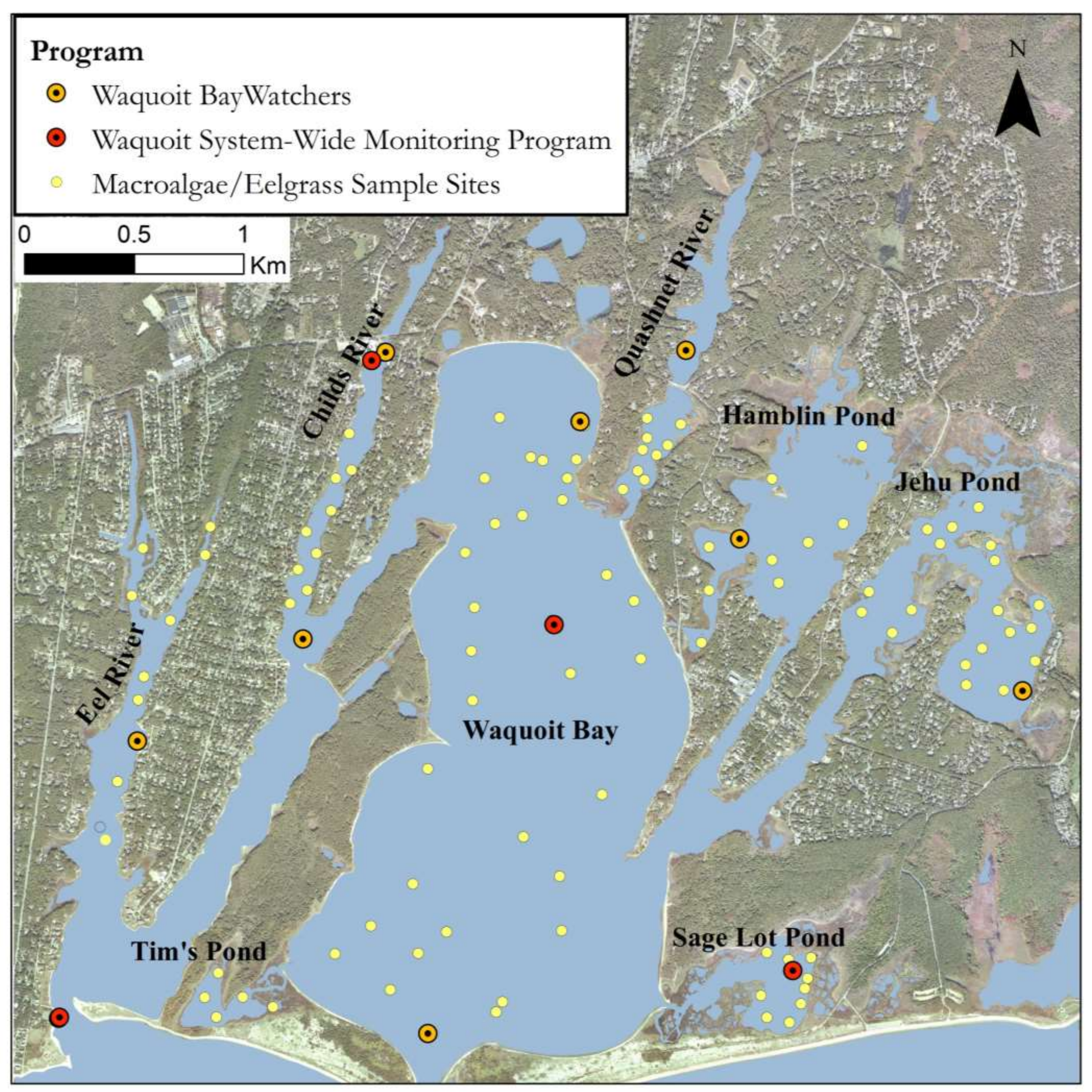

Figure 1: Map of macroalgae/eelgrass and water quality sampling sites in Waquoit Bay, Cape Cod, Massachusetts.

Methods: The macroalgae and eelgrass surveys are conducted every 3-5 years during September and early October. The samples are collected using a 9 in x 9 - in Ponar grab, rinsed in saltwater, spun dry with a salad spinner, and then bagged. The labeled bags are stored cold at 4°C for no more than two weeks before sorting and weighing. All samples are sorted by species and weighed dried. The data from Waquoit Bay and Tim's Pond have been omitted due to inconclusive results. Nitrogen data are collected as part of two long-term water quality monitoring programs, the System Wide Monitoring Program (SWMP) and the Waquoit BayWatchers (see Figure 1).

Brian Horsley, Sept 2011

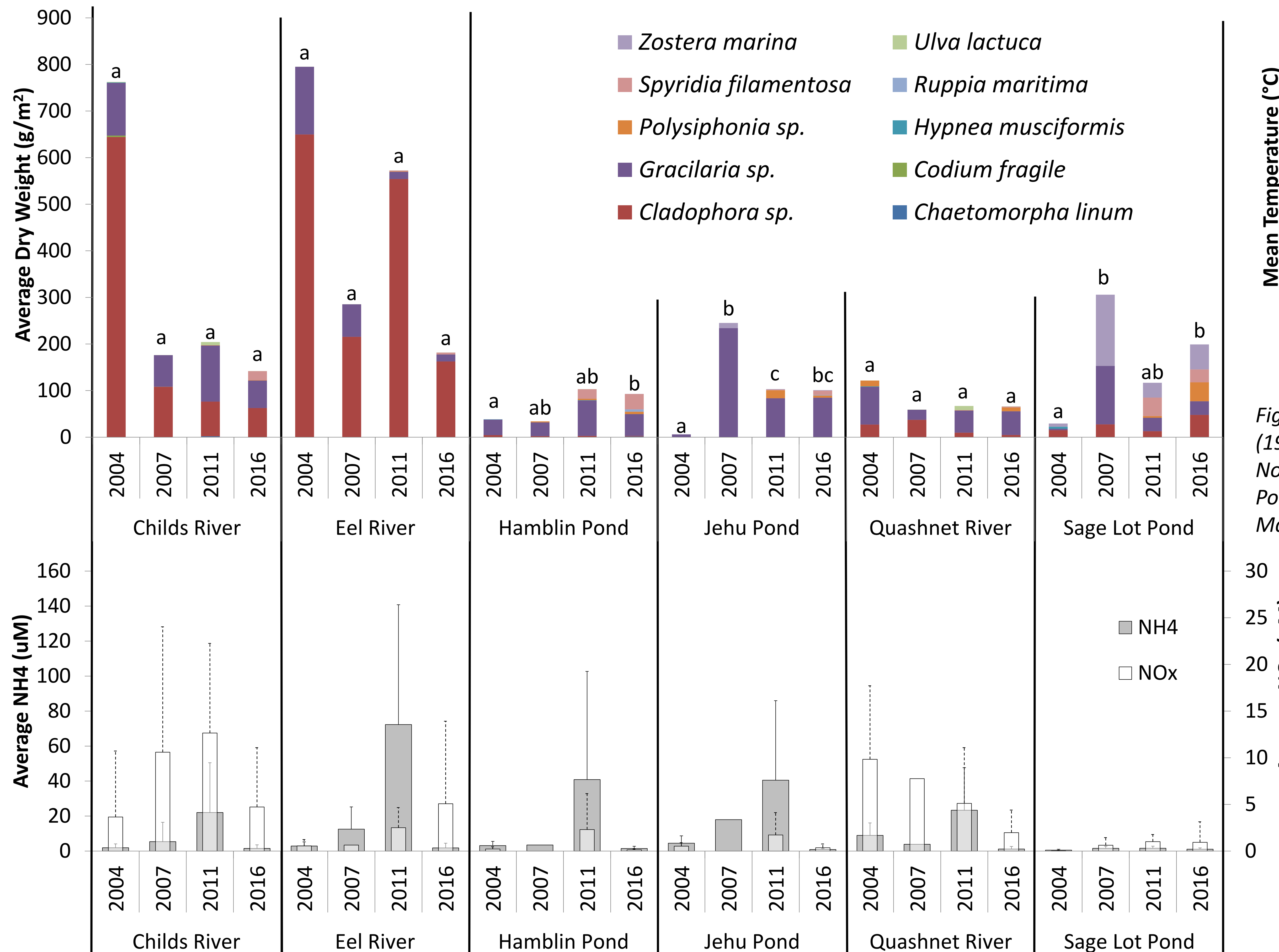

Figure 2: Top graph shows average dry weight of macroalgae and eelgrass species within each sub-estuary across survey years; ANOVA results (α = 0.05; different letters within sub-estuary indicate significant difference) based on normalized transformation (inverse fractional rank, SPSS). Bottom graph shows the average annual concentrations of Nitrate+Nitrite (NOx) and Ammonium (NH4) within each sub-estuary across survey years, including spring, summer, and fall sampling data (Error bars = ±1 SD).

Results Summary:

1) Total dry weights (mainly composed of macroalgae) have increased significantly in Hamblin Pond, Jehu Pond, and Sage Lot Pond. Additionally, in these areas of increased growth, shifts in species distribution have occurred. In Hamblin Pond, the new species, *Spyridia filamentosa,* accounts for most of the increased dry weight in 2016. In Sage Lot Pond, the increased total dry weight is primarily composed of *Polysiphonia* species, *Spyridia filamentosa,* and *Cladophora* species. Jehu Pond has seen a sharp increase in the total weight of *Gracilaria* species. Additionally, *Ruppia maritima* was found for the first time in Hamblin Pond and Jehu Pond in 2016.

2) Although not statistically significant, Childs River and Eel River are experiencing declines in macroalgae biomass (Figure 2). This part of the estuary shows high variability across sample sites (0 g/m² – 2000 g/m²) which complicates statistical analyses. To add to the perplexity, nitrogen levels have remained high or increased in this part of the estuary (Figure 2), which indicates that some other changes to the estuary may be causing reductions in macroalgae abundance.

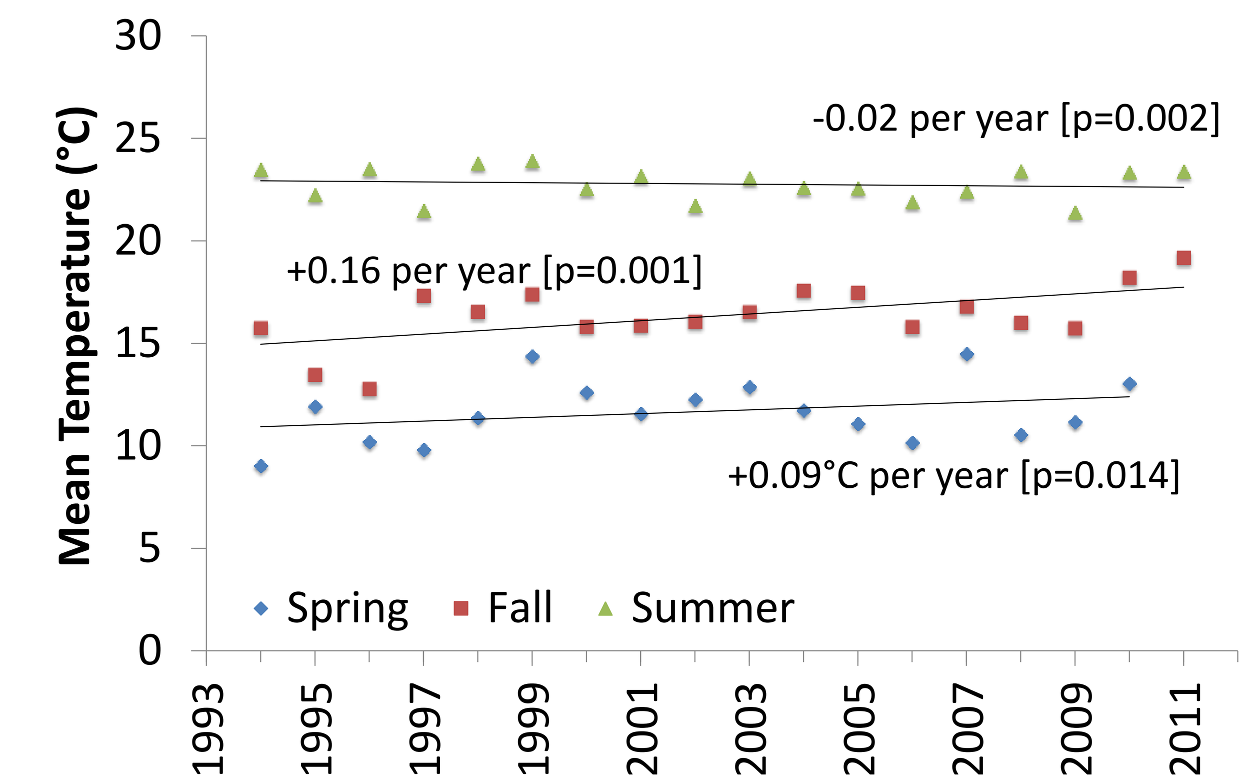

Figure 3: Annual water temperature regression by season (1994-2011) averaged from five sites in Waquoit Bay: Northern Basin of Waquoit Bay, Quashnet River, Hamblin Pond, Jehu Pond, Seapit River/Childs River. Spring = Mar – May; Summer = June – August; Fall = Sept – Nov.

Working Theories:

1) The increase in macroalgae weight seen in Hamblin Pond, Jehu Pond, and Sage Lot Pond is likely due to a combined effect of increased nitrogen in these historically oligotrophic sub-estuaries, as shown by the changes in nitrate/nitrite and ammonium concentrations (Figure 2), and increasing spring and fall water temperatures from climate change (Figure 3).

2) In regards to the areas with declining macroalgae, additional research by Foster and Fulweiler (2014) suggests that primary productivity and respiration have decreased significantly in Childs River over the last twenty years. Possible factors contributing to the reduced productivity and respiration include climate change drivers (increasing temperatures, increasing precipitation, and decreasing summer wind speeds). These environmental changes may be suppressing already low dissolved oxygen levels, causing shifts towards anaerobic respiration and increased toxic sulfide accumulations in the bottom sediments.

Literature Cited:

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