Spring 2017

Using stable isotopes to quantify restoration progress in a restoring northern New England salt marsh

Briana Fischella
University of Southern Maine

Tristan Taber
University of Southern Maine

Meg Thurell
University of Southern Maine

Using stable isotopes to quantify restoration progress in a restoring northern New England salt marsh

Briana Fischella, Tristan Taber, and Meg Thurell (Biology Department),

Karen Wilson (Environmental Science Department)

Figure 1. Reference marsh (2016).

Abstract

The removal of salt marsh tidal impediments is common in New England, but many restoration efforts lack long term monitoring and fail to assess for marsh function. The 2005 blowout of the Sherman Lake dam created an opportunity to study marsh restoration processes after the return of tidal regimens. To quantify the dynamics in trophic integration representative of marsh structure and function, ∂13C and ∂15N stable isotope data were collected in 2007 and 2016. Data collection sites included transects in Sherman Marsh and a reference marsh, which had not experienced tidal restriction. ∂13C values of plants from both marshes reflected their photosynthetic pathways, with community composition in Sherman Marsh transitioning toward C4 species. ∂15N values of C3 Sherman Marsh plants in 2007 were elevated, signifying high nitrogen loading from a freshwater plant die-off with the return of tidal regimes. These values decreased suggesting a reduction in readily available nitrogen, as is expected in a marine system. Sediment ∂13C values decreased and ∂15N values increased between years. While these samples provide compelling evidence, to affirm results that a shift in marsh structure and function occurred, we will collect samples of *Fundulus heteroclitus* during the 2017 season to provide evidence of trophic integration.

Questions

- How have the carbon and nitrogen stable isotope ratios in flora tissue and soil samples changed in Sherman Marsh, Wiscasset, Maine over the past nine years?
- What do potential differences in ratios from 2007 and 2016 suggest about the community composition and connectivity of the food web in the restoring marsh?

Methods

- Sherman Marsh is a tidal salt marsh located in Wiscasset, Maine. It flows into the Sheepscot River and is a part of the Sheepscot Bay Watershed. Sherman Marsh was dammed in 1934, creating a shallow, well-vegetated lake for 70 years. In 2005, heavy rains breached the dam. Tidal flow was improved to match that of the reference marsh in 2008. Transect 10 (T10) is located within Sherman Marsh. The reference marsh exists northwest and downstream of the dam (Fig 1 and Fig 2). It typifies Maine inland tidal salt marsh vegetation without tidal restriction. Transect 17 (T17) is located in the reference marsh.
- Plants were collected from T10 (periphytic algae*, J. gerardii,* and *Typha sp.*) and from T17 (periphytic algae and *S. patens).* Leaves and stems were collected for *Typha sp.* Leaves, stems, and bases were collected for *S. patens* and *J. gerardii*. Plants were placed in resealable plastic bags and kept in the refrigerator until processed for drying.
- Soils were collected on T10 and T17. Samples were placed in resealable plastic bags and kept in the refrigerator until processed for drying.
- All samples were ground and packed at USM and sent to UC Davis for carbon and nitrogen stable isotope analysis.

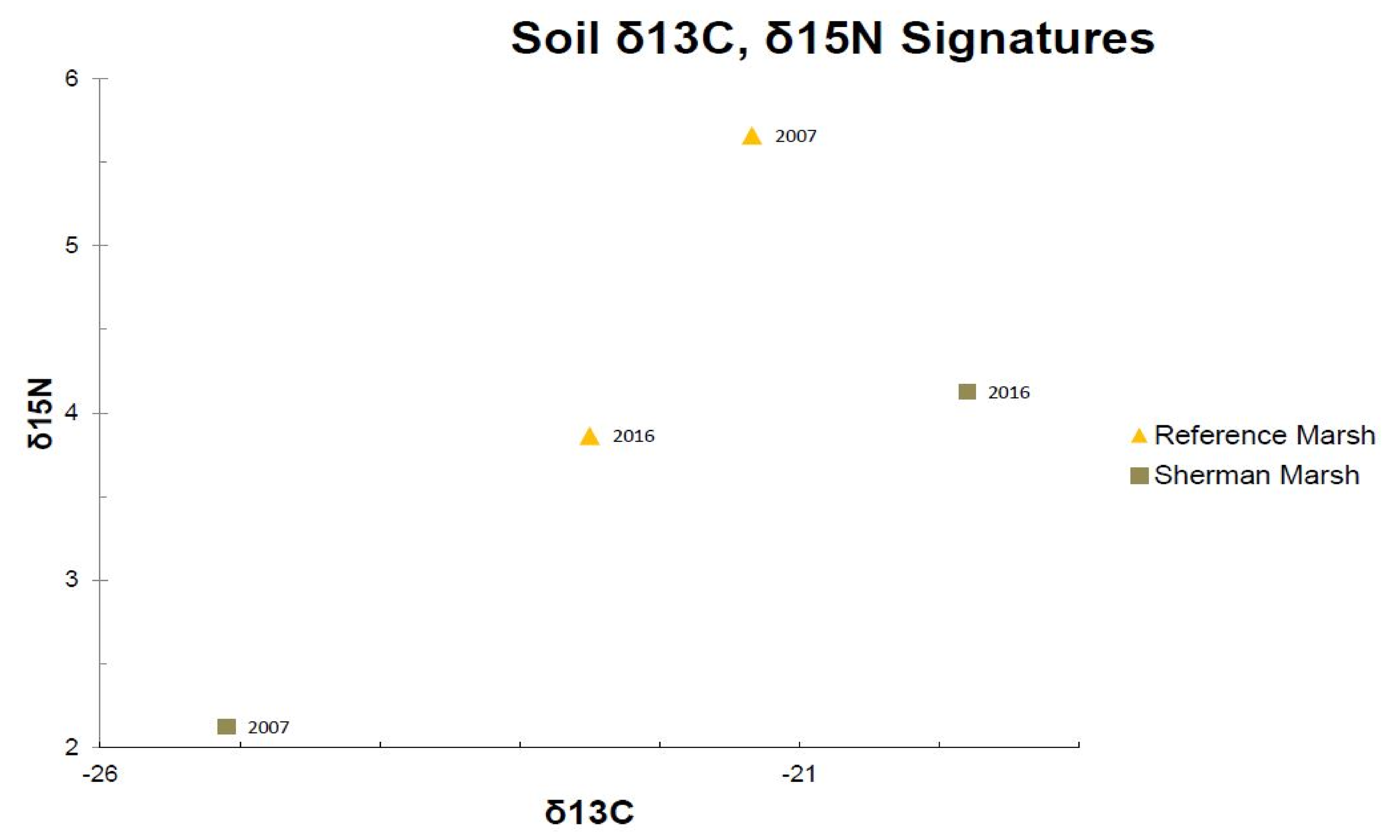

Figure 3. Changes in soil ∂^{13}C and ∂^{15}N values from 2007 to 2016. Sherman Marsh samples are represented by squares and reference marsh samples are represented by triangles.

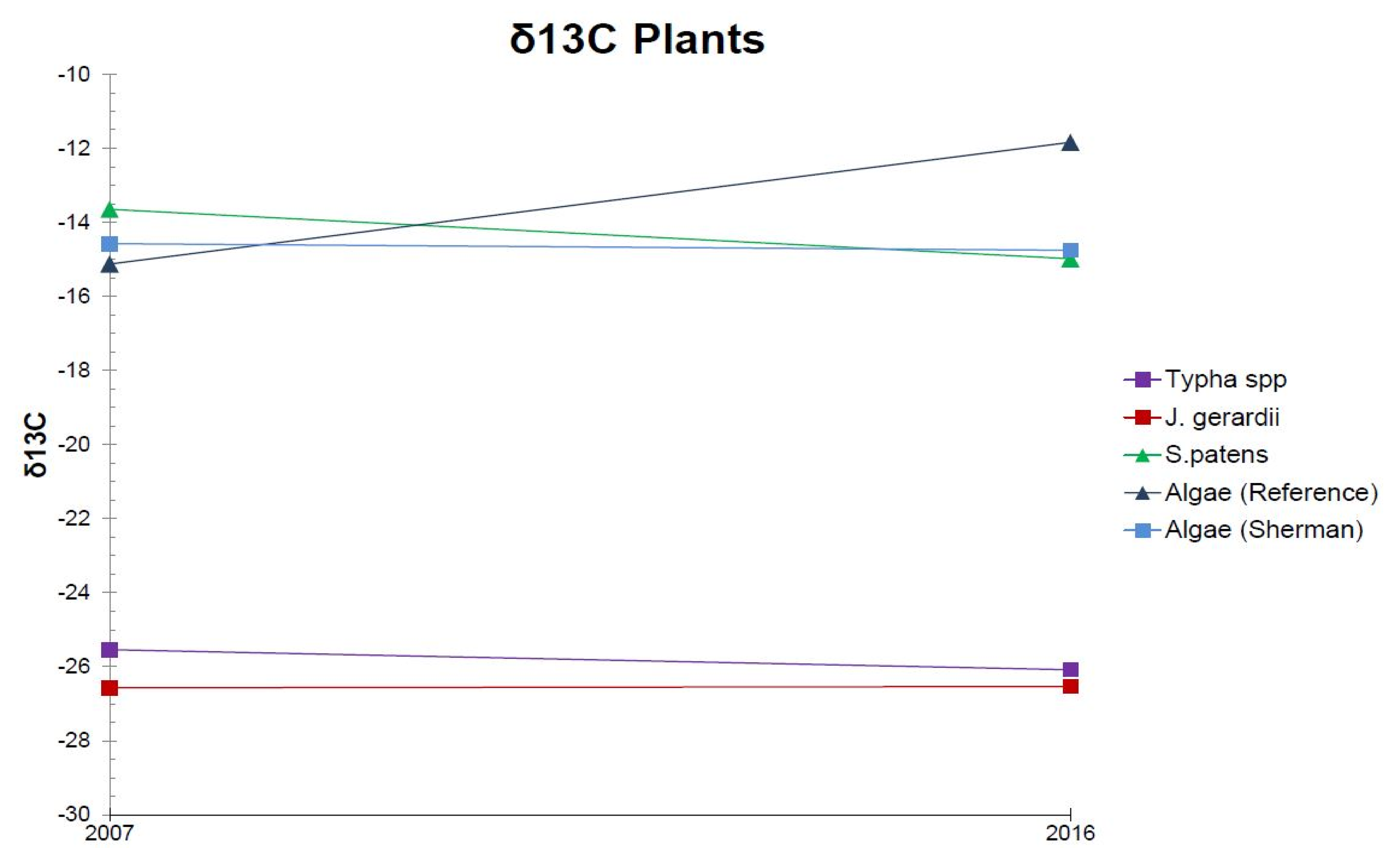

Figure 4. Comparison of δ13C (‰) values for plant species in Sherman and reference marsh in years 2007 and 2016. Sherman Marsh samples are represented by squares and reference marsh samples are represented by triangles.

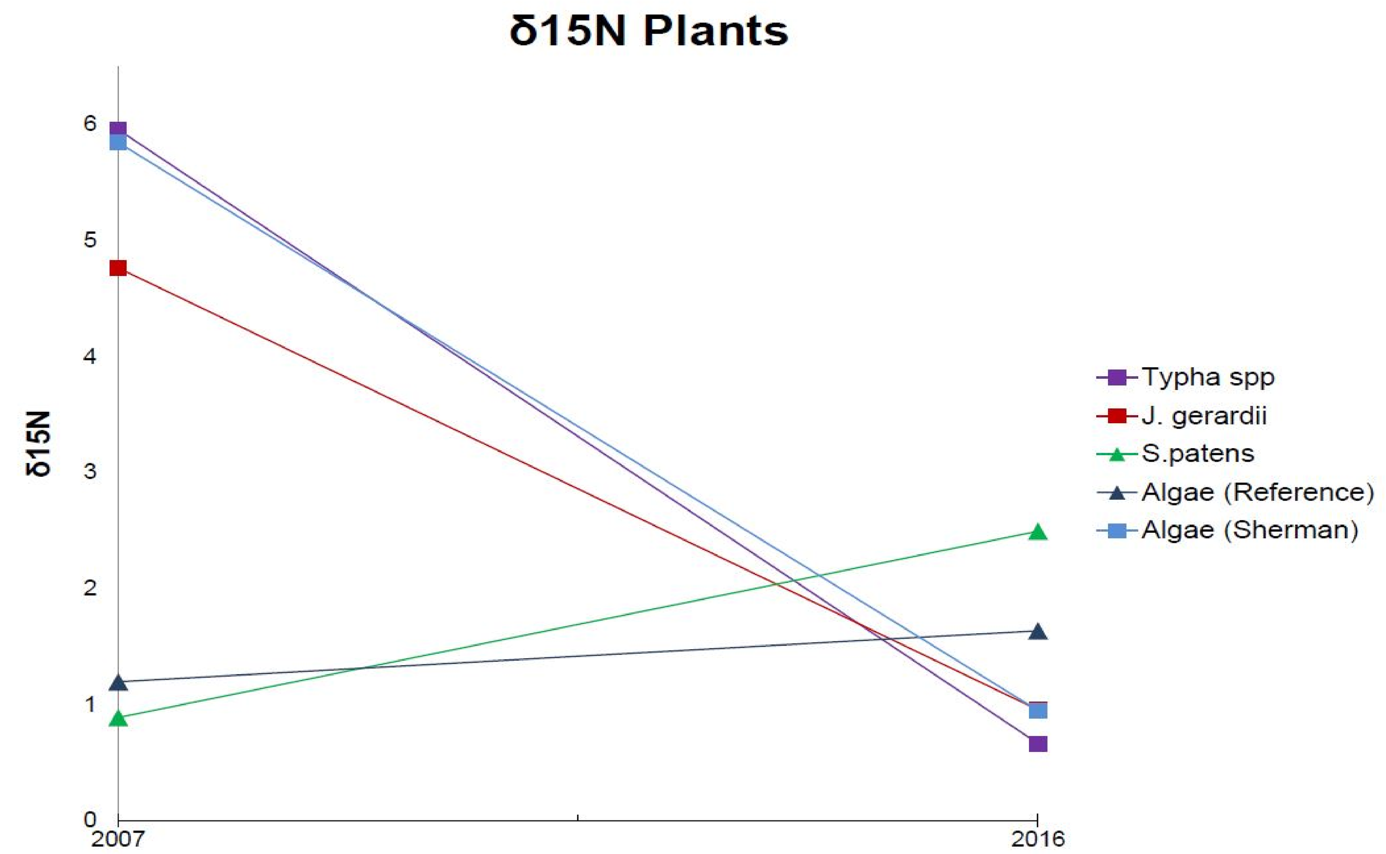

Figure 5. Comparison of δ15N (‰) values for plant species in Sherman and reference marsh in years 2007 and 2016. Sherman Marsh samples are represented by squares and reference marsh samples are represented by triangles.

Figure 2. Reference marsh (2016).

Sherman Marsh Results

- Soil samples became depleted in ∂^{13}C (-25.1 to -19.8 ‰) and ∂^{15}N (2.1 to 4.1 ‰) (Fig 3).
- *J. gerardii* and *Typha spp.* ∂^{13}C values showed little change (-26.6 to -26.5 and -25.5 to -26.1 ‰, respectively) (Fig 4).
- Periphytic algae ∂^{13}C stayed consistent between years (-14.6 to -14.8 ‰) (Fig 4).
- All plant ∂^{15}N values decreased *(Typha spp.* +5.96 to +0.66‰, *J. gerardii* +4.76 to +0.95‰, and periphytic algae +5.84 to +0.94‰) (Fig 5).

Reference Marsh Results

- Soils ∂^{15}N values became depleted (5.7 to 3.9 ‰) and ∂^{13}C values remained consistent (-21.3 to – 22.5 ‰) (Fig 3).
- *S. patens* ∂^{13}C became depleted between years (-13.7 to -15 ‰) and periphytic algae ∂^{13}C became enriched (-15.1 to -11.9 ‰) (Fig 4).
- Periphytic algae and *S. patens* ∂^{15}N values increased (1.2 to 1.6 ‰, 0.9 to 2.5 ‰) (Fig 5).

Discussion

Transitions from C3 to C4 plant communities enrich organic matter sources in ∂^{13}C (Wozniak et al. 2006). C3 and C4 plants fractionate CO_2 differently via unique photosynthetic pathways (Wilson et. al. 2016). C3 plants have more negative ∂^{13}C values (~-27(‰)), whereas C4 have slightly more positive ∂^{13}C values (~-13(‰)). Wozniak et al. (2006) found that tide restricted vegetation had more negative ∂^{13}C values than reference marshes.

Sherman Marsh provides a good metric for the changes that take place within the community and food web structure as a dammed marsh reverts to a tidally unimpeded salt marsh. The nitrogen spike supported by plant ∂^{15}N values seen in Sherman Marsh in 2007 was likely caused by a die-off of non-halophytic flora. Soil data from Sherman also showed a transformation toward salt marsh habitat from 2007 to 2016, providing trends towards enrichment in both ∂^{15}N and ∂^{13}C values (Montoya 2007, Anderson and Polis 1998). The marsh shifted from a C3 to C4 plant dominated landscape which in prospective research we expect to be supported by enriched ∂^{13}C values in the *F. heterclitus* (Wozniak 2006). Data from Sherman Marsh indicate a regime change from a previously dammed freshwater system to a salt marsh ecosystem and provide signals that may be used in future studies.

Acknowledgements

We would like to thank the USM Title III High Impact Teaching mini-grant awarded to K. Wilson for the funds to conduct stable isotopes analyses.

References:

Anderson, W. B., & Polis, G. A. 1998. Marine subsidies of island communities in the Gulf of California: evidence from stable carbon and nitrogen isotopes. Oikos. 75-80.

Montoya, Joseph P. 2007. Natural abundance of 15N in marine planktonic ecosystems. Stable isotopes in ecology and environmental science. 176.

Tonra, C. M., K. Sager-Fradkin, S. A. Morley, J. J. Duda, and P. P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation. 192:130–134.

Wilson, K.A. 2016. Stable Isotopes in Ecology Ecosystems. Lecture at USM for Field Ecosytems Ecology. https://sites.google.com/a/maine.edu/esp412-ecosystem-ecology/lecture-topics/10-stable-isotopes-in-ecosystems-ecology

Wozniak, A. S., C. T. Roman, S. C. Wainright, R. A. Mckinney, and M.-J. James-Pirri. 2006. Monitoring food web changes in tide-restored salt marshes: A carbon stable isotope approach. Estuaries and Coasts. 29:568–578.