Isotope Fractionation and Aquatic Vegetation Decay Rates in Patuxent Freshwater Wetlands

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Introduction

Local sea level rise in the Chesapeake Bay region is 3-4 mm a year (Glick et al., 2008), which must be matched by local sedimentation rates in order to maintain elevation equilibrium. Both mineral and organic sediments contribute to local elevation, with decomposition of organic sediment a key factor in organic material accumulation in tidal channels that is often overlooked (Walker et al., 2005).

The Patuxent River is one of the main tributaries to the Chesapeake Bay, and its wetlands contain 3 major plant genera (*Zizania*, *Nuphar*, and *Hydrilla)* that impact channel flow and sedimentation. *Zizania* grows at channel depths of .1 to .45 meters, *Nuphar* at .25 to .7 meters, and *Hydrilla* at .4 to 1.2 meters (Stakieweiz, personal comm.). These plants trap organic and mineral sediment. The plant tissues have initial isotopic signatures (Benner et al., 1987), which, due to isotopic fractionation during the Calvin and Nitrogen Cycle, could be unique to each species. These isotopic signatures may change during decomposition. These changes in isotopic composition can be studied through litter bag experiments.

Sediment cores provide a record of sedimentation; analysis of bulk organic mass coupled with plant identification through isotope signatures could determine how much organic sediment is contributed and from which plant, thus allowing an assessment of a particular plant species' contribution to local elevation.

Hypotheses

H1: All 3 plants utilize the C-3 carbon fixation pathway(Benner et al., 1987; Rao et al., 2002). Initial $\delta^{13}C$ values of all three plants will thus be similar.

H2: C:N ratios and $\delta^{15}N$ of the plants will be distinct due to differences in N uptake among the plants. *Hydrilla* utilizes nitrate instead of ammonia, resulting in a different N isotopic composition than *Nuphar* or *Zizania* (Rao et al., 2002).

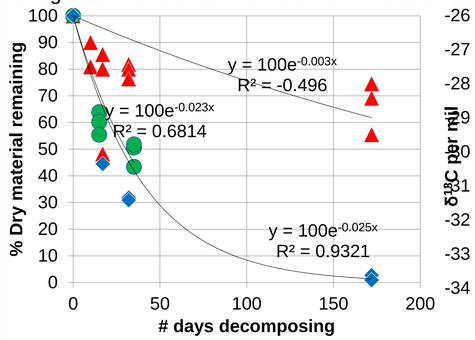
H3: $\delta^{13}C$ values in residual plant matter will increase overtime with decomposition. Plant components such as lignin that are ^{13}C-enriched decay slower than other plant components (Benner et al. 1987).

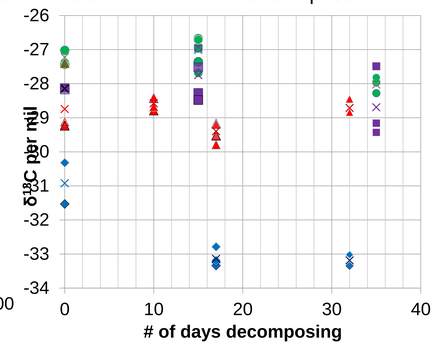
H4: *Nuphar* will decompose the fastest, giving a higher $\delta^{13}C$ value than *Hydrilla* or *Zizania*, the latter of which is expected to have the lowest $\delta^{13}C$ change due to decomposition. N isotopic composition will separate Hydrilla from the two other species.

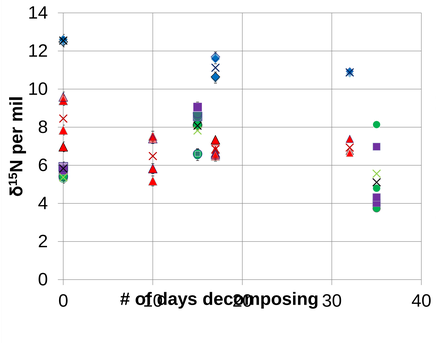
H5: *Zizania* and *Nuphar* will have unique isotopic compositions in core samples. Organic matter from sediment cores will have similar isotopic compositions to the end members of the litter bag experiments.

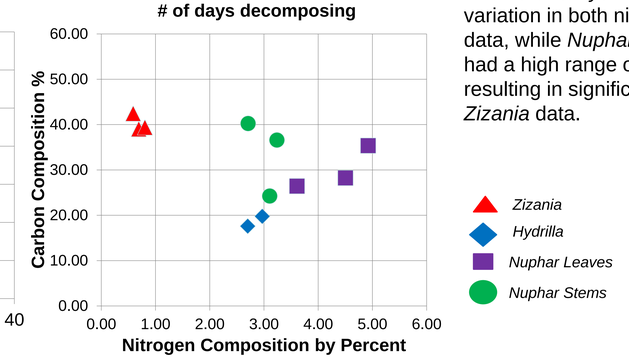
Litter Bag Decomposition Results

Decomposition rates of *Zizania* were significantly slower than the other two species. The decay constant , k , for *Zizania* is 0.003, indicating significantly less material lost through decomposition than *Nuphar* (0.023) and *Hydrilla* (0.025). **Fresh vegetation samples of all three plants had distinct isotopic signatures.** Isotopic composition became more similar with decomposition. No significant difference in $\delta^{13}C$ or $\delta^{15}N$ values was determined between decomposed *Zizania* and *Nuphar*. There were no trends of increasing or decreasing values with decomposition. *Hydrilla* was isotopicaly distinct, and demonstrated a significant decrease in both $\delta\ ^{13}C$ and $\delta^{15}N$ with decomposition. After four weeks of decomposition, no significant difference was found between *Zizania* and *Nuphar* or *Hydrilla* and *Nuphar* in C:N ratio. However, *Zizania* and *Hydrilla* do demonstrate a significant difference in C:N ratio from each other. Variation within plant species samples varied; *Zizania* and *Hydrilla* samples had low variation in both nitrogen and carbon data, while *Nuphar* stems and leaves had a high range of values obtained, resulting in significant overlap with *Zizania* data.



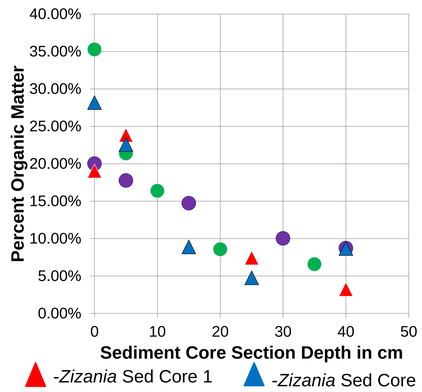


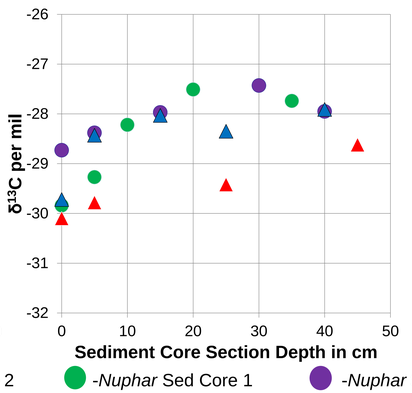


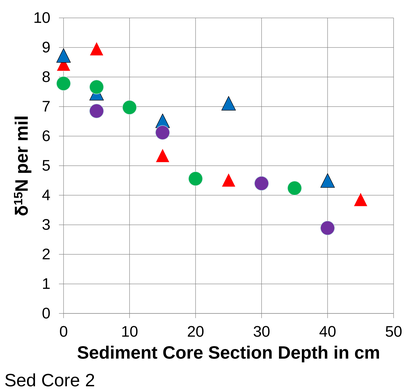


Sediment Core Analysis

Percent organic matter decreased with depth to 20-30 cm where values were 5-10%, although *Zizania* trends were linear. **Isotope results** from the top layer of the sediment cores match end member litter bag experiment results. Carbon isotopic values shifted upwards with core depth, while $\delta^{15}N$ values decreased until depths of 20-30 cm, which suggests continued processing after deposition. Both %.organic matter and $\delta^{15}N$ follow similar trends, indicating a correlation between $\delta^{15}N$ content and decomposition processes within the cores. These data suggest that decomposition proceeds after initial deposition and burial, probably for decades.







-*Zizania* Sed Core 1 -*Zizania* Sed Core 2 -*Nuphar* Sed Core 1 -*Nuphar* Sed Core 2

Methods

Vegetation samples were obtained from the wetlands, dried, weighed, and sewn into 2mm nylon mesh bags. Decomposition experiments were performed using the litter bag method (Longhi et al., 2008). These were buried in the tidal channel sediment and retrieved after certain time intervals, dried, weighed, and analyzed for isotopic composition.

Percent material remaining was determined for each litter bag at each time interval, plotted, and fit to a first order decay function. Isotopic analysis of plant litter and fresh vegetation were analyzed by grinding the dry material into powder, measuring aliquots of powder into tin capsules, and sending the material through a mass spectrometer. Isotopic data was graphed vs. time to identify decomposition trends, and ANOVA calculations were performed to determine any statistically significant differences between populations.

Sediment cores were obtained from a *Zizania* and a *Nuphar* dominated marsh. These were sectioned into 5 cm intervals , examined to determine the organic material rich layers. The sections with bands of dark organic matter were dried and isotopically analyzed , and bulk percent organic mass was determined by loss on ignition. The results were graphed over section depth.

Conclusions

Hydrilla decomposes faster than the other two species.

Fresh plant material of *Zizania Nuphar* and *Hydrilla* have distinct $\delta^{13}C$ and $\delta^{15}N$ values. *Hydrilla* isotopic values are statistically distinct from *Zizania* after 6 months decomposition.

Organic matter % decreases with depth in the cores. the N isotopic data follows similar patterns for both *Zizania* and *Nuphar*, but C isotopic values of *Zizania* are linear., while values for *Nuphar* marshes decline to 20-30 cm, similar to organic matter trends.

The core data indicate both declining bulk organic matter percent and heavier C remaining in cores, both indicators of decomposition after deposition.

References

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