Zostera marina (eelgrass) in two small sub-estuaries of Long Island Sound: detecting responses to the nitrogen load.

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Abstract

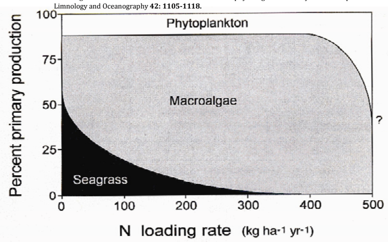
Mumford Cove and Niantic River are two of the few remaining sub-estuaries of Long Island Sound which still support populations of *Zostera marina*. The presence of eelgrass in Mumford Cove is of special interest as it had been totally eliminated coincident with an increasing nutrient load from a waste water treatment facility draining into the northeast portion of the cove. After the removal of the wastewater outlet, decline of *U. lactuca* was rapid and by 1992, *Z. marina* was present in the cove. In shallow, coastal embayments of the northeast United States, the presence of seagrass is considered to be an indicator of the ecological status of the system. Because of *Z. marina*'s sensitivity to reduced light levels and increasing nutrient loads, small coastal embayments with seagrass are considered to be relatively "healthy" while those dominated by macroalgae are considered to be "nutrient –impaired." However, seagrass is able to exist under a range of nutrient loads. So the presence of seagrass alone does not guarantee a system will continue to support seagrass in the future.

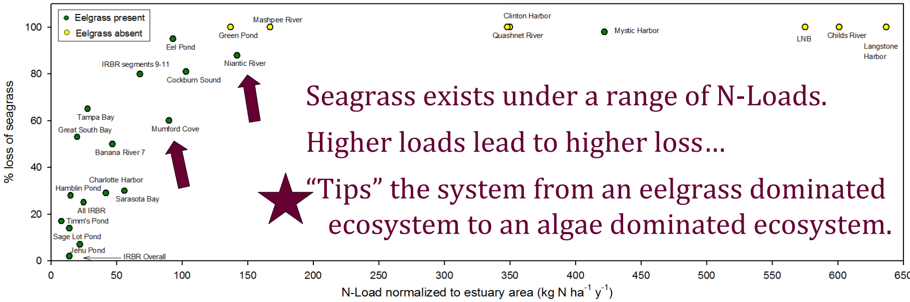
The question becomes, how close is the ecosystem to experiencing a shift in overall community composition? Various seagrass indices have been developed to try to bracket the answer (%N, NPI), along with developing relationships between nutrient loads and ecosystem status. Data on the nutrient content of macroalgae and seagrass in Niantic River and Mumford Cove indicate that Niantic River macroalgae are engaging in luxury uptake of nitrogen, indicating an excess supply of nitrogen in the water column. These data suggest that Niantic River is at a critical point in its nutrient load and any significant increases may cause a shift in the community composition. Mumford Cove macroalgae, while experiencing some luxury uptake of nitrogen, shows less evidence of excess nutrients in the environment.

Background - Biology

- Seagrass is usually light limited.
- Macroalgae and phytoplankton are usually nitrogen limited.
- Excess nitrogen stimulates growth of algae, which at high biomasses can shade the seagrass.

Figure modified from: Valiela, I., J. W. McClelland, J. Hauxwell, P. J. Behr, D. Hersh, and K. Foreman. 1997. Macroalgal blooms in shallow estuaries: Controls and ecophysiological and ecosystem consequences. Limnology and Oceanography **42: 1105-1118**.





Seagrass exists under a range of N-Loads.

Higher loads lead to higher loss…

"Tips" the system from an eelgrass dominated ecosystem to an algae dominated ecosystem.

Connecticut data were from this study. Data for IRBR (Indian River / Banana River) and Banana River from Steward and Green (2007) Estuaries and Coasts **30: 657-670**. All other data were compiled from the literature by Valiela and Cole (2002) Ecosystems **5: 92-102**.

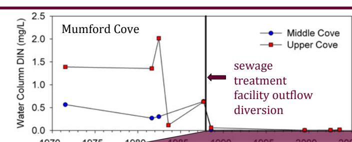
2 "Eelgrass" Sites in Connecticut

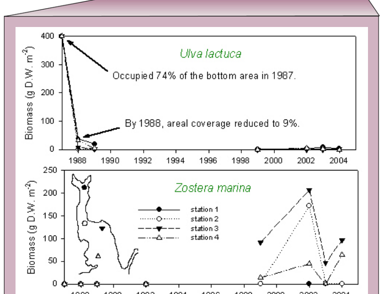
Niantic River – a history of eelgrass, variable in recent decades

Mumford Cove – natural recolonization by eelgrass following removal of a nutrient point source

	Mumford Cove	Niantic River
Area (ha)[a]	50	270
Mean Depth (m)[a]	1.0	2.6
Freshwater Residence Time (d)	3.5[c]	27[b]
N-Load Rate (kg N y^{-1})[d]	4,500	38,400
N-Load Rate (mmoles N m^{-2} y^{-1})[d]	640	1020
Average Mean % Biomass ± 1 standard deviation[e]		
vascular macrophyte (*Zostera marina*)	80 ± 20	62 ± 9
macroalgae (red, green, and brown)	19 ± 20	32 ± 10
microalgae (benthic and planktonic)	1 ± 0.2	6 ± 6

[a] Calculated from bathymetry surveys conducted by Vaudrey (2007).
[b] Kollmeyer, R. C. 1972. A study of the Niantic River estuary, Niantic, Connecticut. report number RDCGA 18. Office of Research and Development, U.S. Coast Guard Headquarters. 1-78 pp.
[c] French, D., M. M. Harlin, E. Gundlach, S. Pratt, H. Rines, K. Jayko, C. Turner, and S. Puckett. 1989. Mumford Cove Water Quality: 1988 Monitoring Study and Assessment of Historical Trends. report number 88-17. Applied Science Associates. 126 pp.
[d] Unpublished estimate from a model (N-Load) estimating nitrogen load to an estuary based on land use characteristics using the CLEAR land use data set coupled with housing estimates obtained from towns in the watersheds (Branco and Kremer 2006).
[e] Estimate based on 6 days of surveys conducted in 2003 and 2004 by Vaudrey (2007).





The Question

How much N is available to the primary producers?

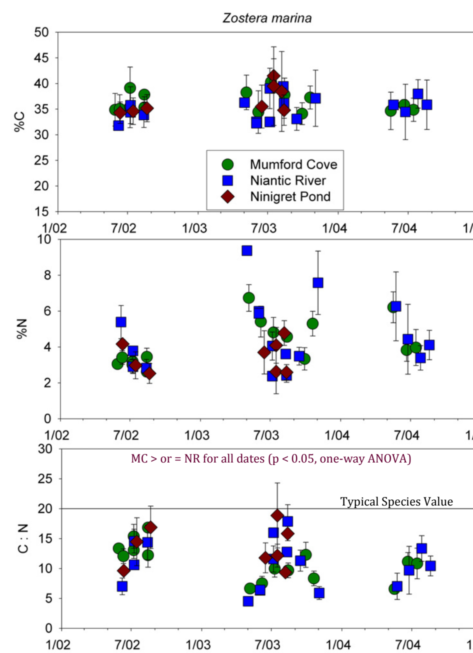
N available is a function of:

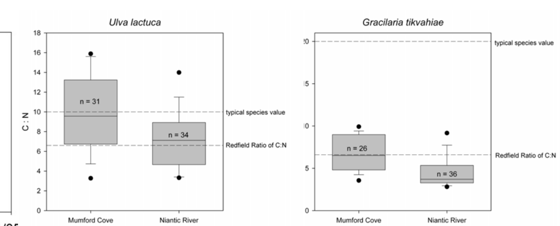
- N-Load to the ecosystem
- residence time of N in the ecosystem
  - freshwater residence time
  - fate of N in the estuary (export, recycling, sequestration)
- N uptake rates of the primary producers
  - Available N is quickly assimilated. Primary producers with fast uptake rates have a competitive advantage.

Estimates of N-Load to the estuary often lack other components (residence time, uptake kinetics).

Direct measurements of water column N are often very low because all N is assimilated quickly.

A possible solution: Use Eelgrass to Detect Available N





Primary producers engage in luxury uptake of N, when excess N is available.

This decreases the C : N ratio.

Eelgrass C:N is an indicator that integrates the plants response to N over the past few weeks.

Lower C:N in Niantic River indicate the system is closer to the "tipping point" between an eelgrass system and a macroalgae system. But both systems are experiencing nutrient enrichment.

Eelgrass C:N indicates the amount of N available to the primary producers.

C:N inherently includes the N-load from t he watershed, the physical environment of the estuary, and the biological transformations of N that occur in the environment.

This work was funded by the Dept. of Marine Sciences at UCONN, CT Sea Grant (FY2001 R/ER-23), and CT DEP (FY2003 EPA 319 NPS #03-33 and FY2004 LISS Enhancement Project #AG0606257).