Nutrient limitation of benthic marine primary production in the upper Florida Keys: Preliminary results of an *in-situ* nutrient enrichment experiment

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INTRODUCTION

South Florida contains some of the most expansive documented seagrass communities in the world. Six years of seagrass tissue stoichiometry from the upper Florida Keys suggest that benthic coastal communities are phosphorus-limited inshore and nitrogen-limited offshore (figure 1) . This spatial variability hypothesis of nutrient limitation is presently being tested with a one year in-situ sediment fertilization experiment. The objectives of this investigation are (1) to experimentally determine the limiting nutrient for benthic primary production, and (2) to assess the responses of inshore and offshore benthic communities to nutrient addition. Results may be used to model changes that anthropogenic eutrophication may cause in the subtropical coastal marine waters of the upper Florida Keys.

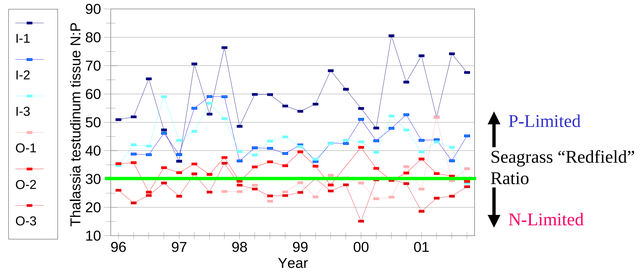
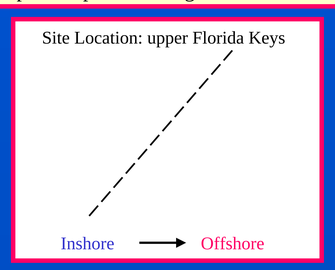
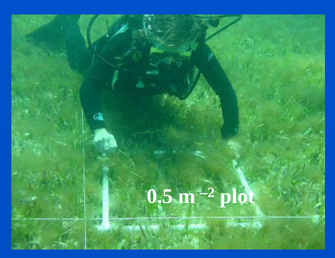


Figure 1: Seagrass elemental content data were collected from the Florida Keys National Marine Sanctuary Seagrass Status and Trends Monitoring Program. Oceanside upper Florida Keys consists of 3 inshore (I-1, I-2, I-3) and 3 offshore (O-1, O-2, O-3) permanent monitoring sites.

EXPERIMENTAL DESIGN

- Six sites were selected, with three sites in each of the two strata: inshore (< 1km from mainland; I-1, I-2, I-3) and offshore (< 2km from reef tract; O-1, O-2, O-3).
- Each site (n=6) consists of 4 treatments (N, P, N+P, Control). Treatment plots are separated by 10 meters.
- Six replicates of each nutrient treatment (determined by a power analysis test); 24 experimental 0.5 m^{-2} plots per site; 144 individual treatment plots total for experiment.
- Nutrients are added monthly to the sediment at loading rates of 0.77 N and 0.09 P g m^{-2} d^{-1} (N:P=19). These ecologically relevant rates are based on current estimates of dominant nutrient sources in the Florida Keys.
- Seagrass growth and nutrient data are collected every three months. Data presented were collected in March 2002, following 10 months of fertilization. This project will terminate in August 2002.
- A two way ANOVA was used to test for significant main effects (location and treatment) and their interactions. Significant differences were analyzed with LSD multiple comparison using SPSS.





SITE DESCRIPTION	Inshore	Offshore
Water depth (m)	lower	higher
Light Attenuation (k)	higher	lower
Sediment Type	sandy mud	sand
Sediment Porosity	higher	lower
Sediment Bulk Density (g/ml)	lower	higher
Sediment % Organic Content	higher	lower

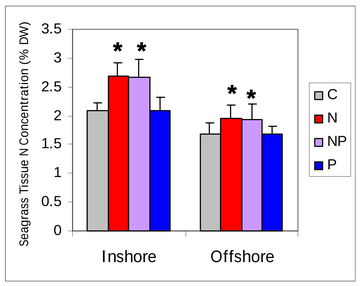
RESULTS: Significance test from two-way ANOVA

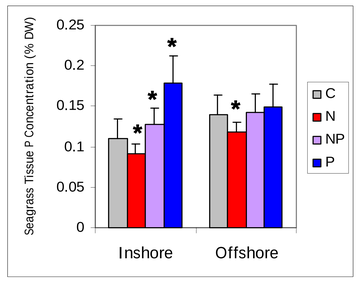
Preliminary data collected in March 2002 (end of winter season); 10 mo. of fertilization

	Location	Nutrient	Interaction
Seagrass: tissue nutrients			
N (% DW)	***	***	***
P (% DW)	***	***	***
C:N (mole:mole)	***	***	ns
C:P (mole:mole)	***	***	***
N:P (mole:mole)	***	***	***
Seagrass: blade morphology, biomass and growth rate			
Length (mm)	*	**	***
Standing Crop (g m^{-2})	*	**	ns
SS Productivity (mg SS^{-1} d^{-1})	***	**	ns
Specific Productivity (mg g^{-1} d^{-1})	**	*	*
Areal Productivity (g m^{-2} d^{-1})	*	***	**
Leaf Area Productivity (cm^2 m^{-2} d^{-1})	ns	**	***
Epiphyte			
Biomass (g g^{-2})	***	***	ns
Chlorophyll a (µg Chl *a*/ g^{-2})	***	ns	ns
Sediment			
N (%DW)	***	***	ns
P (%DW)	ns	**	***
N:P (mole:mole)	***	***	***
Chlorophyll a (µg Chl *a*/ml)	*	***	ns

* P < 0.05; ** P < 0.01; *** P <0.001, ns=not significant at P<0.05

SEAGRASS TISSUE NUTRIENT CONCENTRATION

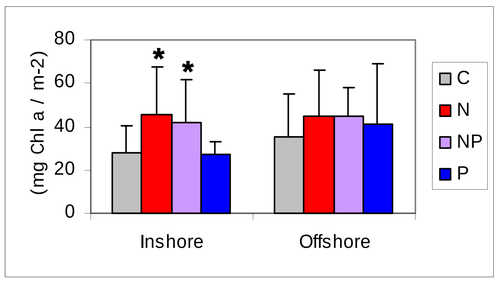




Thalassia tissue N content significantly increased with all nitrogen additions (+N, +NP) at all sites; tissue P content increased with all phosphorus additions (+NP, +P) at inshore sites only. P content decreased with nitrogen addition (+N) at all sites.

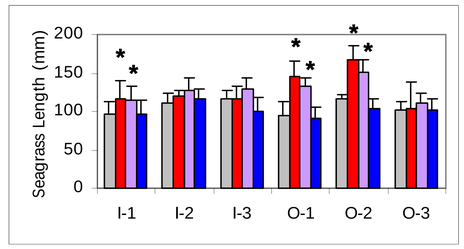
Mean values within each strata (n=3 sites) are pooled. When LSD Multiple Comparison Analysis identified no significant difference (P < 0.05) of control values between sites within a strata. Bars represent SD.

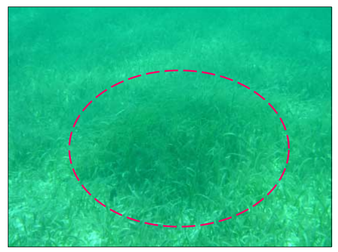
SEDIMENT CHLOROPHYLL-A



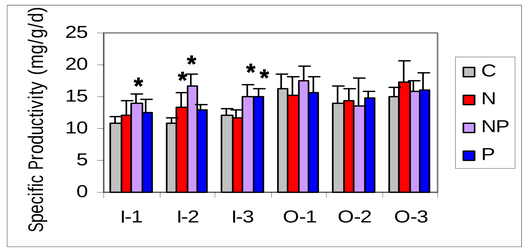
Significant effects of +N and +NP at INSHORE sites only

SEAGRASS LENGTH: Significant effects only during nitrogen addition (+N, +NP) at 1 inshore and 2 offshore sites. (photo: +NP treatment at site O-2)





SEAGRASS GROWTH: Significant effects at INSHORE sites only



CONCLUSIONS

- Highly significant interaction effects (Location*Nutrient) for *Thalassia* nutrient content, morphology and productivity.
- N enrichment (+N or +NP) had several significant effects (leaf length, production rates) at both inshore and offshore sites, suggesting some winter N limitation. Despite predictions from stoichiometry of inshore P limitation, inshore *Thalassia* communities appear to be N-limited.
- Inshore sites responded exclusively to some parameters (*Thalassia* P content, *Thalassia* specific producitivty, sediment chlorophyll-a).
- No clear spatial delineation of nutrient limitation (N vs P) at this time.

Ongoing Research

Fertilization was terminated in July 2002 (15 months total). This will represent a summer sampling period, the season in which seagrass growth is the highest and nutrient demand is the greatest. Samples are currently being analyzed for *Thalassia* leaf nutrient content, productivity, leaf grazing estimates, epiphyte load and chlorphyll a; *Thalassia* rhizome nutrient and soluble carbohydrate content; below and above-ground biomass; sediment nutrient and chlorophyll-a. Analysis will be complete by October 2002.

Epiphyte response: Observations from recent (July) sampling

Diatom and blue-green algae blooms present exclusively at inshore nutrient addition treatments

ACKNOWLEDGEMENTS

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