Opening the Benthos Box: Assessing Stream Response to Reduced Nitrate Levels

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ISSUE ADDRESSED

- Nitrate levels have increased in lotic systems including Florida's unique springs
- Nutrient reduction strategies are a centerpiece of water quality standards to protect and restore stream ecosystems
- In-stream methods exist to characterize nutrient uptake behavior at levels from ambient to saturation, but no methods exist to estimate ecosystem behavior below ambient levels
- Therefore, it is difficult to determine whether nitrate reductions will have desired effects and meet management goals

QUESTION & OBJECTIVES

How does stream nutrient uptake behavior respond to nitrate concentrations below ambient levels?

- To test new chamber-based method to determine stream response to nitrate concentrations below ambient levels
- To delineate daytime nitrate uptake (from plant uptake and denitrification) and nighttime uptake (from denitrification only)
- To compare changes in nitrate uptake across four vegetative regimes (Fig. 1a-d):
  - A. Low algae biomass
  - B. *SAV with algae
  - C. High biomass algae
  - D. *SAV only

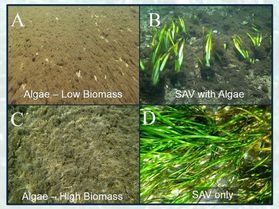

Figure 1. Four vegetation types present at study site. *Photographs by Jenny Adler*

*SAV = submerged aquatic vegetation including *Vallisneria americana* and *Sagittaria kurziana*

METHODS

STUDY AREA DESCRIPTION

- Gum Slough Springs is a 2nd magnitude springs complex (Fig. 2)
- Inflows include 6 main springs and several smaller springs
- Drains to Withlacoochee River and is 8 km in length
- Located in Sumter County, Florida
- Upstream flow = 27.3 cfs
- Downstream flow = 96 cfs
- Spring vent [DO] = 2.85 mg/L
- Spring vent [NO_3] = 1.52 mg/L
- Average stream temp = 23°C

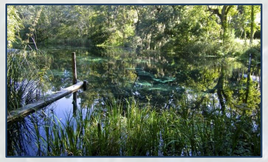

Figure 2. Gum Slough Springs, a spring-fed river located in Sumter County, Florida. *Photograph by Jenny Adler*

BENTHOS BOX DESIGN AND SET-UP

- Box was designed as a ¼" clear Plexiglas chamber with 2' x 2' x 3' dimensions (Fig. 3a and c)
- When inserted into upper sediments, blocks flow and nutrient supply, allows light in and sediment-water-air interactions to occur (Fig. 3c)

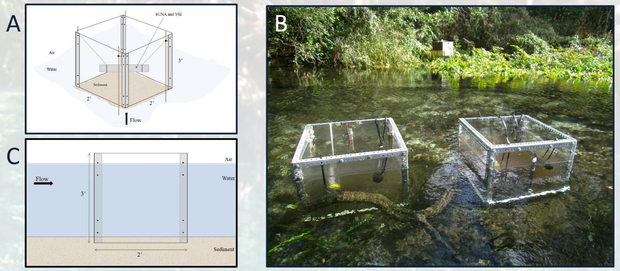

Figure 3. The chamber was designed as a a) a clear Plexiglas chamber that b) allows sediments-air-water interactions to occur but c) blocks flow and supply of nutrients. *Photograph by Jenny Adler*

IN-STREAM SENSORS AND METHODS

- Satlantic Submersible Ultraviolet Nitrate Analyzer (SUNA) and YSI 6560 V2 measured water quality at 15 min. intervals (Fig. 4a-b; Table 1)
- Submersible pump continuously ran to simulate flow and mixing
- Bromide additions, water sampling, and water level monitoring were used to estimate hydrologic exchange and sensor accuracy (Fig. 4c)
- Deployments included 5-7 day measurements across a vegetative gradient (Fig. 1)
- Nitrate uptake rates (U_{NO3}; mg/m^2/hr) were calculated over daytime and nighttime periods

Table 1. Water quality parameters measured with *in situ* sensors during box deployment

Water Quality Parameters	
Nitrate (mg/L)	Specific Cond. (mS/cm)
Temperature (ºC)	ORP (mV)
Dissolved Oxygen (mg/L)	pH

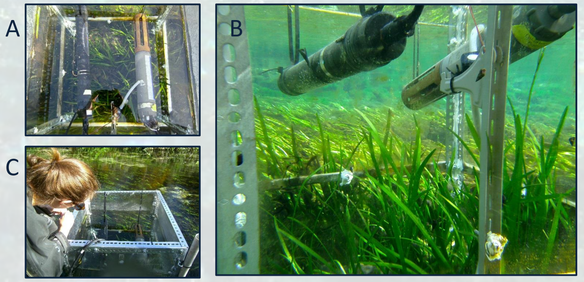

Figure 4. In-stream methods included use of a) SUNA and YSI sensors and aquatic pump b) submerged half-way in the water column and c) bromide additions, water collections, and water level monitoring. *Photographs by Jenny Adler*

All photographs courtesy of Jennifer Adler. Author contact: creijo@ufl.edu
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RESULTS

- Nitrate signal (Fig. 5a) was used to decouple daytime and nighttime retention (Fig. 5b-c)
- Removal was consistently greater during the day than at night (Fig. 5b and c)
- SAV daytime uptake was greater than and significantly different from algae systems (Fig. 5d-e)
- Daytime uptake rates were not linearly correlated with nitrate levels (Fig. 5e)
- Nighttime uptake rates were linearly correlated to nitrate levels and did not differ between vegetation type (Fig. 5F)

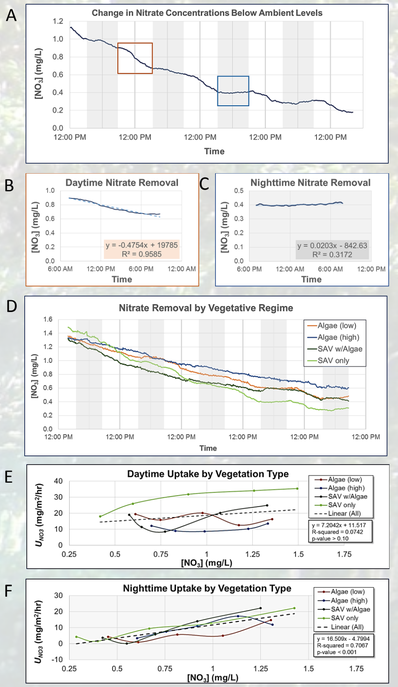

Figure 5. The a) nitrate signal was used to decouple b) daytime and c) nighttime nitrate removal. Daytime uptake (e) differed by vegetation type while f) nighttime uptake was similar by type and linearly correlated to nitrate levels.

DISCUSSION & FUTURE WORK

- Implications for variation in nitrate retention and transport from changing nitrate level and shifts in vegetative communities
- The benthos box shows promise as a tool for *in situ* ecosystem-scale assessments of nutrient retention below ambient levels
- May enable future investigations focused on predicting stream response to enrichment and restoration across environmental gradients

Future work will include:

1. Refining the decoupling of nitrate removal pathways across gradients
2. Determining influence of grazers and light regime on C:N dynamics
3. Applying methods to other sites and comparing to reach-scale estimates