Landscape and Ecosystem-Level Processes on Everglades Periphyton Assemblages

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Abstract

Periphyton is a rapidly-responding indicator of water quality in Everglades wetlands, and is also believed to be the dominant base of aquatic food webs in these ecosystems. Our data from the southern Everglades confirms the importance of periphyton to ecosystem energetics, as annual production rates far exceed those we have measured in by marsh macrophytes. The highest periphyton metabolic rates are consistently at the TS/Ph 4 site adjacent to the C-111 canal, but this pattern is largely driven by very high production in June, at the onset of the wet season when the marsh first re-wets. Our water quality data do not suggest a recurring water quality problem in this region. Furthermore, the lowest periphyton productivity rates were consistently seen at the TS/Ph 1 site, which is proximal to L-31W canal inputs to Taylor Slough. We thus suggest that periphyton dynamics reflect water quality conditions in complex ways. Our most intriguing finding is that periphyton dynamics appear to be strongly controlled by nitrogen—particularly inorganic N species—rather than by phosphorus. These relationships warrant further investigation, but are evidence of the value of ecosystem regulation and nitrogen cycling studies.

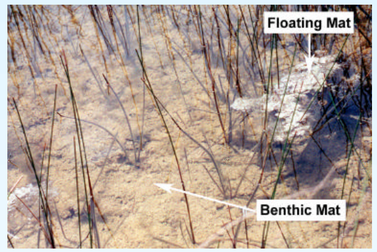

Figure 1: Periphyton Mat Located Near TS/Ph 5 Site. Within the oligotrophic Everglades periphyton can range from a few millimeters to 5 cm thick.

Introduction

Periphyton is an assemblage of algal, bacterial, and microfaunal communities within a mat matrix. Periphyton serves important roles in the freshwater oligotrophic Everglades:

- Periphyton is highly abundant and productive in this oligotrophic ecosystem.
- Periphyton is highly susceptible to small changes in water quality and is an indicator of ecosystem conditions.
- Periphyton is believed to be the dominant base of aquatic food webs in Everglades wetlands.
- Periphyton is an important regulator of nutrient dynamics in the oligotrophic Everglades

This material presented here is part of continuous long-term collaborative effort. Our research goals are to:

1. Investigate patterns and magnitudes of periphyton productivity along the FCE LTER TS/Ph transect.
2. Investigate effects of environmental drivers on productivity along the FCE LTER TS/Ph transect.

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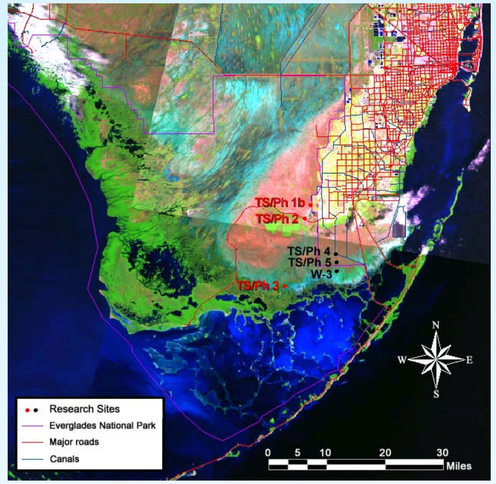

Figure 2: Map of Southern Florida Displaying Research Sites. Sites labeled in red are located within Taylor Slough, and sites labeled in black are located within the C-111 basin.

Methodology

Site Description:

Research sites are along the FCE LTER Taylor Slough transect (figure 2).

Taylor Slough Sites

- TS/Ph 1b is located canalside of the L31-W canal.
- TS/Ph 2 is located within sawgrass dominated marsh.
- TS/Ph 3 is located within the sawgrass-mangrove ecotone.

C-111 Basin Sites

- TS/Ph 4 is located at canalside of the C-111 canal.
- TS/Ph 5 is located within sawgrass dominated marsh.
- W-3 is located within the sawgrass-mangrove ecotone.

Metabolic Rates:

We quantify productivity rates from two hour periphyton incubations in biological oxygen demand bottles every 6-8 weeks during the wet season. We calculate metabolic rates using standard oxygen change techniques, and then normalize to organic content (ash free dry weight, AFDW) of the incubated periphyton. Biomass is measured by collecting all periphyton within a 0.0625 m^2 quadrat tossed haphazardly in triplicate concurrent with each incubation. Net annual production (AP) is calculated as the integral of periphyton productivity (NPP) per m^2 for each year.

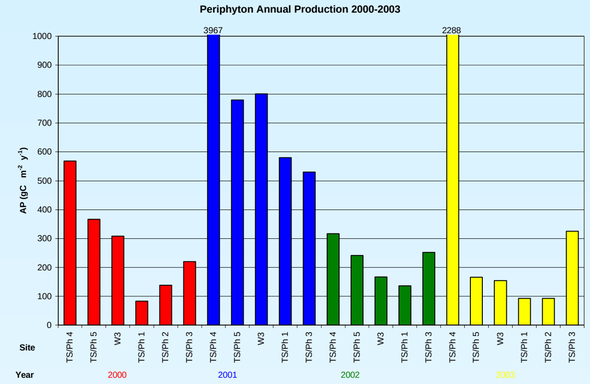

Figure 3: Net Annual Production of Periphyton at Research Sites for 2000 through 2003. Periphyton mat was not present at site TS/Ph 2 in 2001 or 2002.

		NPP		Resp	
Parameters	**df**	**slopes**	**p-values**	**slopes**	**p-values**
TP	59	-20.822	0.04		NS
TOC	29	-0.006	0.0089	-0.001	0.0006
N&N	29	0.547	<0.0001	0.052	0.0062
NO_2	29	7.413	0.002		NS
DOC	26	-0.013	0.0115	-0.002	0.0027
NO_3	29	0.569	<0.0001	0.054	0.0056
Water Level	143		NS	-0.019	0.0498
Light	127	0.002	0.0497		NS
Temperature	257		NS	0.032	0.0082

Table 1. Relationships between periphyton metabolic rates and various environmental drivers, derived via simple regression.

Results and Discussion

Taylor Slough and in the C-111 basin has shown some interesting landscape-scale patterns in periphyton annual production (Figure 3). Periphyton AP is consistently and significantly highest ($p<0.0001$) at the canalside TS/Ph 4 site in the C-111 Basin but is consistently lowest at the canalside TS/Ph 1 site in Taylor Slough. This contrasts with our general finding that water quality tends to be better in the C-111 marshes than in upper Taylor Slough. We generally see declining periphyton production with distance from the C-111 canal, but in Taylor Slough production often increases down-slough. In most years, the upper estuarine ecotone TS/Ph 3 site shows the highest AP in Taylor Slough—this relationship is statistically significant ($p=0.047$). Across the southern Everglades, periphyton production was highest in 2001, which was a somewhat dry year (although water levels and hydroperiods in 2001 were not drought-like). Carbon fixation rates by periphyton throughout the southern Everglades are consistently higher—often much higher—than by sawgrass, the dominant macrophyte.

As expected, we found a significant positive relationship between light levels and NPP, and between temperature and respiration. Most of the other significant relationships we found were with nitrogen components (Table 1). Positive relationships with NPP might suggest that N-availability is controlling periphyton production, while positive relationships with respiration might suggest that heterotrophic remineralization of nutrients by periphyton mats is capable of affecting concentrations. Notably, the relationship between TP and NPP was weak and negative (Table 1). We also used multiple regression to look for synergistic environmental controls on periphyton metabolism. Nitrogen constituents explained over 89% of the variability of periphyton NPP rates. Nitrogen and organic carbon constituents explain over 60% of the variability of periphyton respiration rates. Research into the importance of nitrogen dynamics in the P-limited southern Everglades will provide valuable information to understand how these oligotrophic ecosystems will respond to human activities.

Special thanks to all my friends in the Wetland Ecosystems Lab.