Understanding the role of eutrophication on aquatic food web interactions in the Florida Everglades

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Everglades Water Quality: Eutrophication of an oligotrophic ecosystem

Beginning in the late 1800s, canalization of the Everglades for flood control, agriculture, and development has drastically altered the hydrologic regime of the system. These canals and other water control structures transport nutrient enriched water from the Everglades Agricultural Area (EAA), south of Lake Okeechobee, south through the system. The resulting eutrophication seen throughout many parts of the northern and central Everglades (Figure 1) has been shown to drastically change the community structure of emergent macrophytes and reduce or even eliminate periphyton.

Periphyton, a matrix of filamentous algae, diatoms and other unicellular algae, is a prominent feature throughout the Everglades, contributing to over 50% of the primary producer standing stock in the system (Figure 2). Periphyton rapidly assimilates phosphorus from the water column at low to moderate levels of enrichment. High levels of phosphorus, however, cause periphyton mats to break up and disappear. While the ability of periphyton to improve water quality is currently being examined and employed in periphyton storm water treatment areas (PSTAs), the impacts of enrichment on higher trophic levels are not yet fully understood.

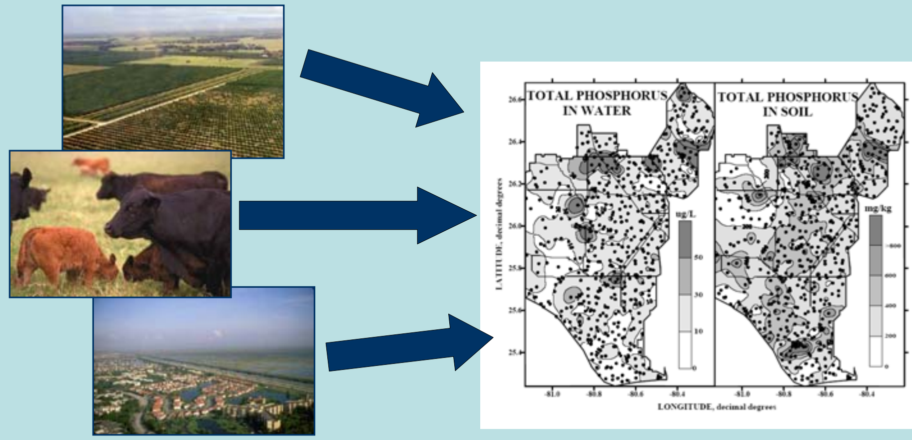

Figure 1. Major sources of Everglades eutrophication (agriculture, cattle ranching, urban development) and resultant water and soil total phosphorus (TP) across the Everglades landscape *(photographs courtesy of www.sfwmd.gov, maps courtesy of www.epa.gov)*


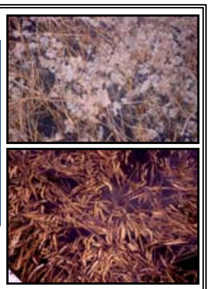

Figure 2. Extensive floating periphyton mat coverage in Everglades marshes. Floating mats can form as bladderwort (*Utricularia* spp.)–associated (left), periphyton-only (top right), or floating "sweaters" (bottom right).

Trophic Interactions: the role of periphyton

Periphyton is a very important component at the base of the Everglades food web, serving as a primary food source for numerous species of invertebrates, small fish and amphibians (Figure 3). Periphyton mats also serve as a refuge to a community of macroinvertebrates residing within the mat, forming a 'periphyton mat complex' with a variety of direct and indirect trophic interactions (Figure 4). Since the periphyton mat plays such an integral role in the Everglades system as both food source and refuge, the impact of the loss of this microhabitat with eutrophication must be better understood.

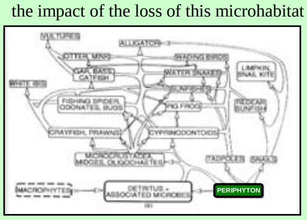

Figure 3. Depiction of the Everglades food web showing prominent role of periphyton at the base (from Gunderson & Loftus 1993)

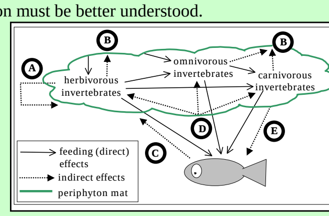

Figure 4. Direct and indirect interactions among members of the periphyton mat complex. Indirect effects: (A) defensive physical structure of the algal assemblage, (B) nutrient recycling by invertebrates within the mat, (C) nutrient recycling by fish, (D) the role of the mat as a refuge for invertebrates, (E) physical structure of the mat makes many invertebrates unavailable for external foragers.

Unraveling the system:

We designed four studies to describe the invertebrate community inhabiting the periphyton mat and unravel the relationship between the periphyton mat complex and externally feeding consumers (Figure 5):

A. Development of sampling protocol & community characterization

The complex physical structure of the $CaCO_3$-encrusted periphyton mat makes sampling this system directly quite difficult. We developed a sampling protocol for taking 6-cm diameter cores of the mat and manually removing invertebrates from the substrate under a dissecting microscope. We found that the macroinvertebrate community composition of the mat was significantly different than that of epiphyton associated with submerged macrophytes, and that these two communities become even more distinct as the mat develops through the wet season.

B. Community variation with hydroperiod and enrichment

We sampled the macroinvertebrate community in the floating periphyton mat and benthic floc at sites with varying hydroperiod and levels of natural enrichment. We found the composition of these two communities are different and that the mat community responds primarily to water quality (densities increasing with increased soil, floc and periphyton TP) while the benthic community responds primarily to hydroperiod (densities decreasing with increased hydroperiod).

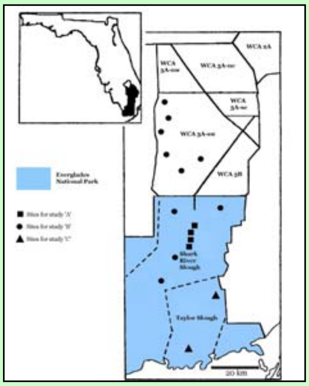

Figure 5. Location of study sites.

C. Field Mesocosm Experiment

An *in situ* mesocosm experiment was conducted (Figure 6A&B), varying densities of grass shrimp and eastern mosquitofish and examining the impact on the floating periphyton mat and benthic floc-dwelling macroinvertebrate communities. While we saw an increase in invertebrate densities with enrichment, we are still analyzing the impact of consumers on these communities.


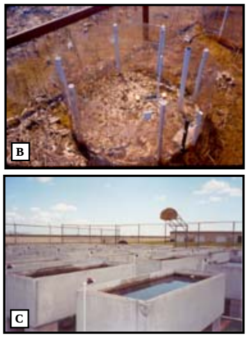


Figure 6. Experimental mesocosms and consumers used in studies: field mesocosms (A,B); tank mesocosms (C); grass shrimp (*Palaemonetes paludosus*, D); eastern mosquitofish (*Gambusia holbrooki*, E); sailfin molly (*Poecelia latipinna*, F).

D. Differential roles of consumers

Finally, we conducted a tank mesocosm experiment (Figure 6C) to delineate the relationship between the periphyton mat complex and three common consumers with different feeding habits: eastern mosquitofish ("picking" omnivore), sailfin molly ("picking" herbivore), and grass shrimp ("milling" omnivore). While statistical analyses are still being conducted, preliminary tests indicate an increase in invertebrate densities with enrichment, with sailfin mollies showing the greatest impact on both periphyton biomass and resident macroinvertebrate community densities, especially amphipods.

Implications of this research…

The Comprehensive Everglades Restoration Plan (CERP), a major ecosystem restoration initiative authorized by Congress, is currently in its initial stages. Our research will play an important role in assessments for CERP and other major projects (e.g. REMAP) which will need to continually draw on our understanding of ecosystem components and their interactions throughout the adaptive management process. This research was made possible by an EPA STAR-GRO Fellowship.

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