Benthic and pelagic responses to nitrogen inputs in an urbanizing estuary

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BACKGROUND:

- Urbanization in the Guana Estuary has increased nitrogen (N) loads, degrading water quality and affecting ecosystem functions
- Understanding how biogeochemical processes in the water and sediment respond to excess N loading is imperative to protect and improve estuarine ecosystems

OBJECTIVE:

- **To establish how benthic and pelagic nutrient cycling may respond to increasing N inputs from the watershed**

Figure 1. Sampling sites going from the northern site Mickler's Weir (low salinity) to the southern site River North (high salinity).

METHODS:

Benthic Nutrient Flux (Fig. 2, 4, 6)

1. Collected 16 sediment cores from four sites (n = 4 per site) along a salinity gradient in March & July 2022
2. Used a continuous flow incubation to measure nutrients: NO_x, NH_4^+, PO_4^{3-} under ambient and nitrate elevated water conditions from local data

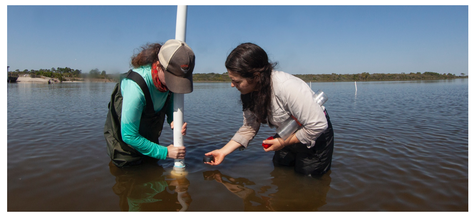

Figure 2. Collecting sediment cores using a pole corer at the Lake South site in the Guana Estuary. Photo by: UF/IFAS Communications

Nutrient Limitation Bioassay (Fig. 3, 7)

1. 24 1-Liter Cubitainers were filled from four sites in June & September 2022
2. Cubitainers were exposed to six treatments and incubated for 2.5 days. Treatments: Control, +NO_x, +Urea, +PO_4^{3-}, +NO_x + P, and +Urea + P, raising N by 1ppm and P by 2ppm where applicable
3. End points: chl-a and nutrient concentrations
4. Chl-a used to calculate algal growth response ratios (RR). Nutrient limitation quantified using ln(RR) of nutrient treatments relative to the control: $ln\left(\frac{Chla\ of\ Treatment}{Chla\ of\ Control}\right)$

Figure 3. Cubitainers filled from each site and a) dosed with different nutrient treatments, b) deployed together to incubate for 2.5 days, and then c) filtered for chl-a and nutrient availability.

RESULTS

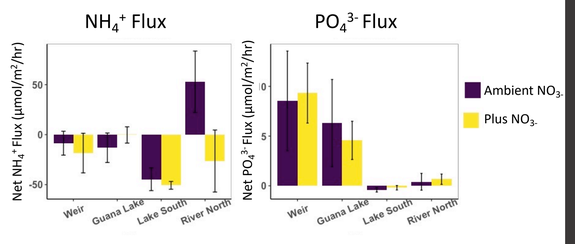

Figure 4. Sediment fluxes of NH_4^+ and PO_4^{3-} differed across sites for March but were not strongly influenced by NO_x additions.

The Guana Estuary is ready to bloom.

Benthic and pelagic processes exhibit high demand for nitrogen.

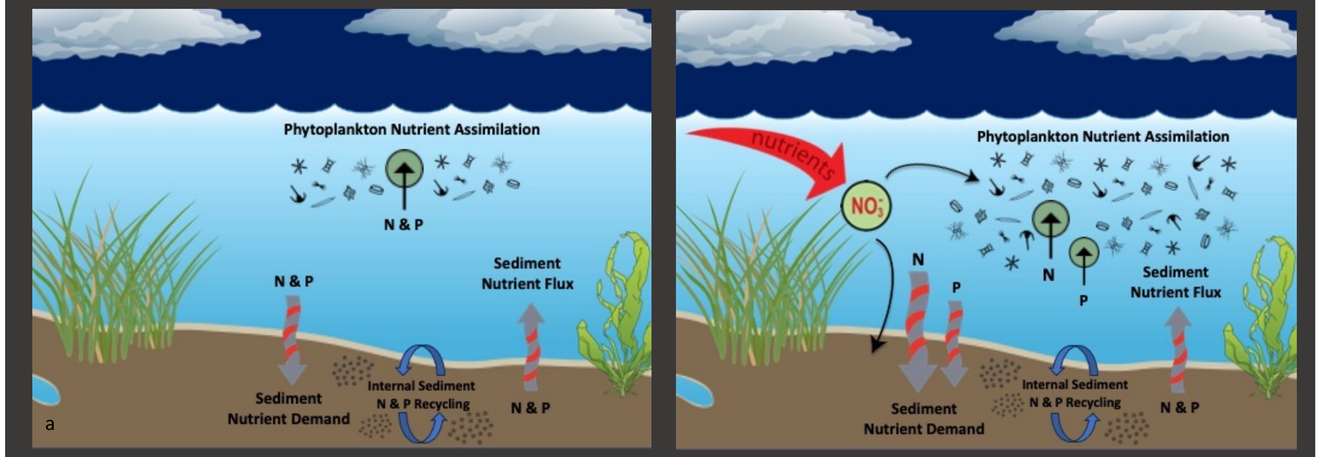

Figure 5. Conceptual diagrams demonstrating nutrient fluxes and the various interactions between sediments and the water column under ambient (a) and elevated nutrient inputs (b). With increasing nitrogen inputs sediment demand and phytoplankton assimilation will increase.

Nitrate demand increases with nutrient inputs, but the ultimate fate is unknown

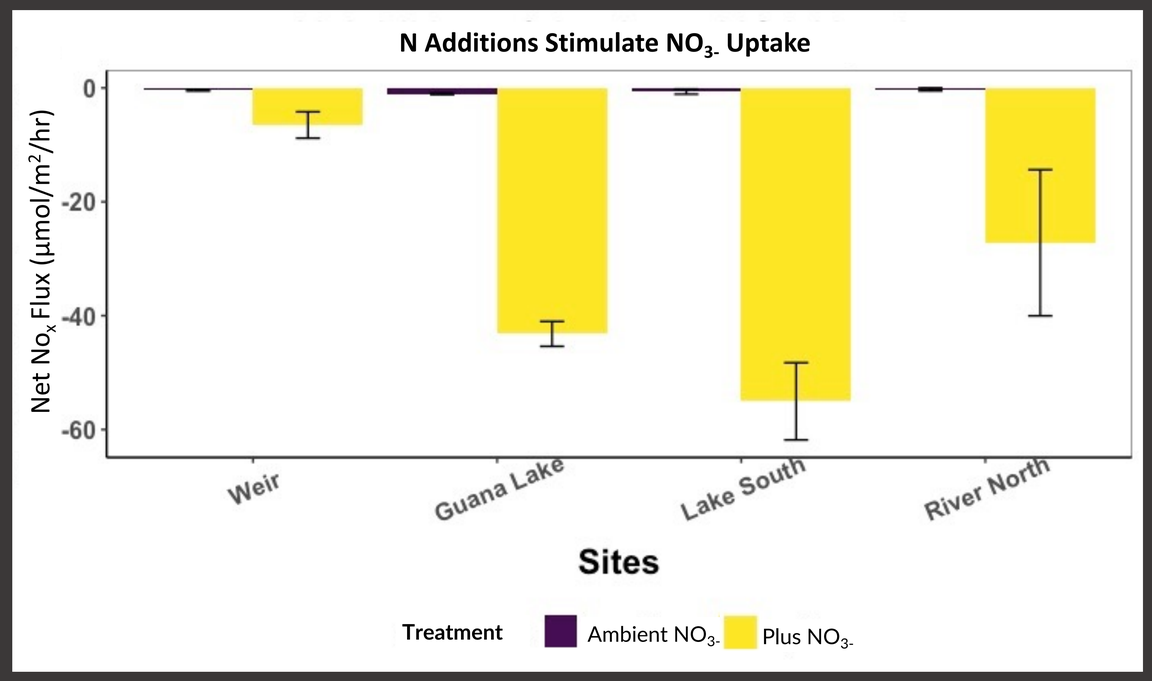

Figure 6. Seasonal average net NO_X fluxes measured from sediment cores under ambient and elevated nitrate conditions from continuous flow incubation.

RESULTS:

- Benthic Nutrient Fluxes
  - There was demand for nitrate by the sediments; the magnitude was lowest at the freshwater Weir site (Fig. 6) suggesting N limitation to benthic processes
- Pelagic Responses
  - A two-way ANOVA showed N limitation at all sites, which is expected for estuarine systems
  - Urea + P treatments caused the largest increase in algal growth for all sites and seasons than the control ($p<0.05$), indicating organic N can also stimulate pelagic responses (Fig. 7)

Nutrient Additions Stimulate Phytoplankton Responses

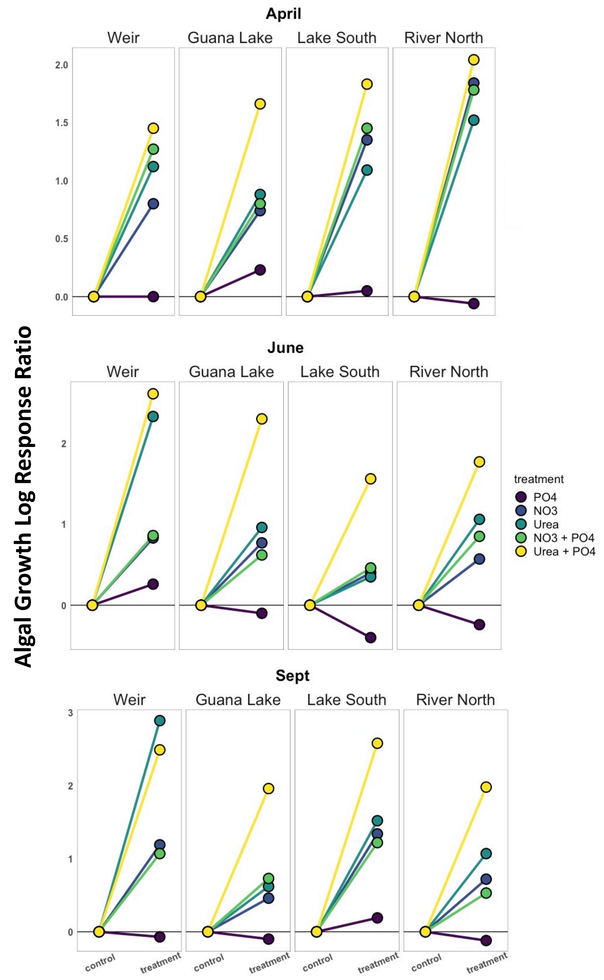

Figure 7. Phytoplankton growth response ratios calculated from chlorophyll-a for each sampling month along the four sites of the Guana Estuary.

CONCLUSION:

- **The Guana estuary structure and function seem to be strongly affected by anthropogenic nutrient inputs**
- **The Guana Estuary is poised for N additions, but we do not know if N removal can keep up with increased loading, therefore upstream urbanization could impact water quality by increasing the severity and occurrence of algal blooms**

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