

Should nutrient management strategies consider site-specific variability?

Case study of phytoplankton responses to nitrogen and phosphorus in distinct South Carolina coastal systems

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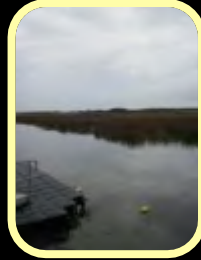
A Changing Landscape



- South Carolina (SC) has some of the most rapid coastal development in the US, but still retain relatively unaltered areas
- Differing land use patterns are likely to influence nutrient (N and P) delivery to receiving tidal creeks (Greenfield et al. 2012)
- The linkages between elevated N and P with harmful algal bloom (HAB) formation are well-established (e.g., Anderson et al. 2002, 2008; Heisler et al. 2008)
- Thus, continued development may make associated tidal creeks more susceptible to eutrophication and HABs

Does site and/or season affect biological (phytoplankton) responses to N and P within tidal creek systems? If so, can these responses be incorporated within nutrient management decisions?

Tidal Creek Water Quality Management



- Standards exist for various pollutants and heavy metals in SC lakes & reservoirs. Criteria for N and P are being considered for coastal systems
- Most available data for management decisions comes from monitoring, which can provide excellent information about spatial and temporal trends
- Numerous monitoring programs exist (state, research, etc.), varying widely with regard to spatial and temporal scales, parameters measured, analytical methods, and overall objectives

Advantages of Incorporating Biological Responses within Nutrient Management

- Sampling does not enable adequate determination of how a particular location, season, or species is influenced by N and P loading: information best derived through experimentation
- Responses facilitate evaluations of individual variables [nutrient forms, phytoplankton species, site-specific characteristics (T, S, turbidity)]
- Enable understanding of physiological and/or genomic factors
- Improve predictive capabilities of how tidal creeks may fare under various nutrient conditions

EPA Core Element #4: Water quality standards for wetlands – set benchmarks for wetlands conditions. *Considering biological responses has been identified as an EPA priority*

Project Overview

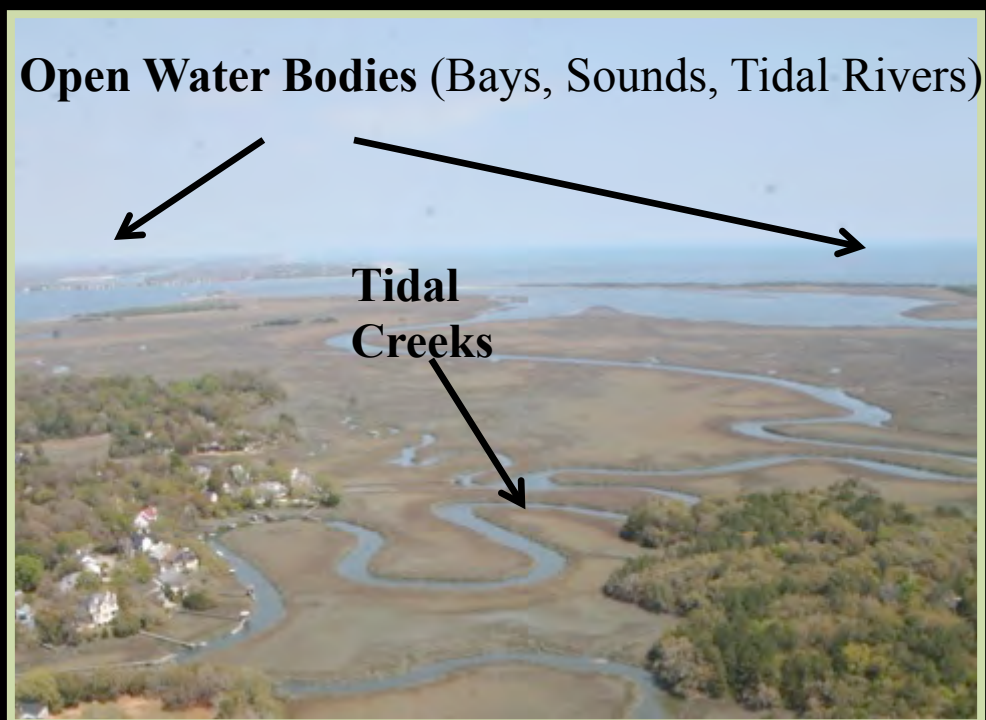
- How does the changing SC landscape relate to N and P *levels* in coastal systems?
- How do SC phytoplankton respond to N and P *form* and relative *ratios*?
- Does site and/or season influence responses?

Combined field sampling and experimentation

- Monitoring (SCECAP, focused studies)
- *In situ* field experimentation
- Laboratory physiology studies using key HAB species

Monitoring: SC Estuarine and Coastal Assessment Program

Two major habitat types



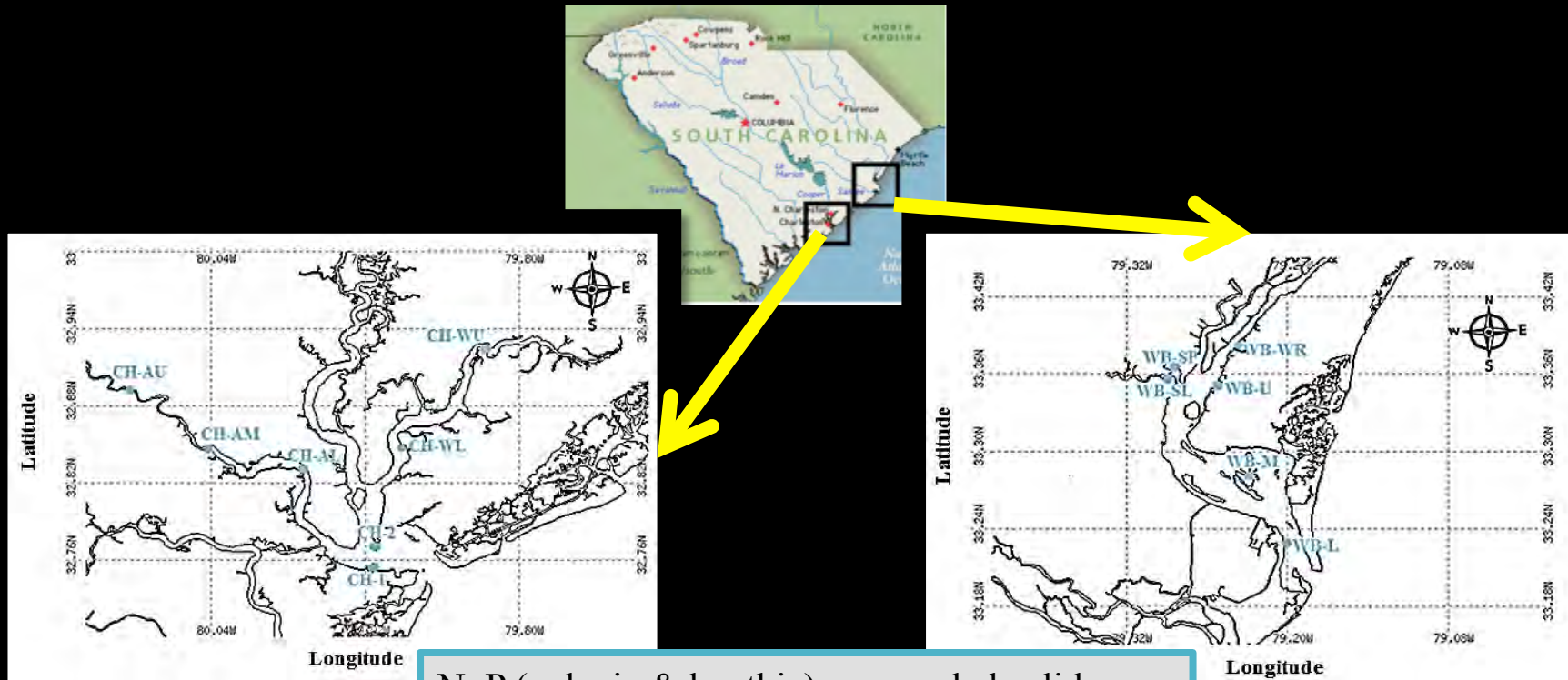
Interagency coordination for seasonal water samples:
N, P, suspended solids, DOC, chlorophyll *a*, phytoplankton

Random - Probability Based Sampling Design

- 30 stations relocated each year
- Determines integrated habitat quality using water, biological, and sediment indicators

Focused Monitoring: Charleston Harbor & Winyah Bay

- Repeated sampling over an annual cycle
- Enables upstream/downstream comparisons to assess nutrient transformations & phytoplankton



N, P (pelagic & benthic), suspended solids,
DOC, chlorophyll *a*, phytoplankton, light

Field experimentation: 4 focal sites



mixed



Northinlet.sc.edu/research/swmp.html

Winyah Bay-TA

3rd largest E. Coast watershed, marsh, upstream industrial, old rice plantation

urban



Charleston Harbor-BC

River-dominated, urbanized

relatively unaltered



ACE Basin-WC

Natural & impounded, marsh, forest, agriculture

Kiawah Island-K75

Residential, golf courses, detention ponds

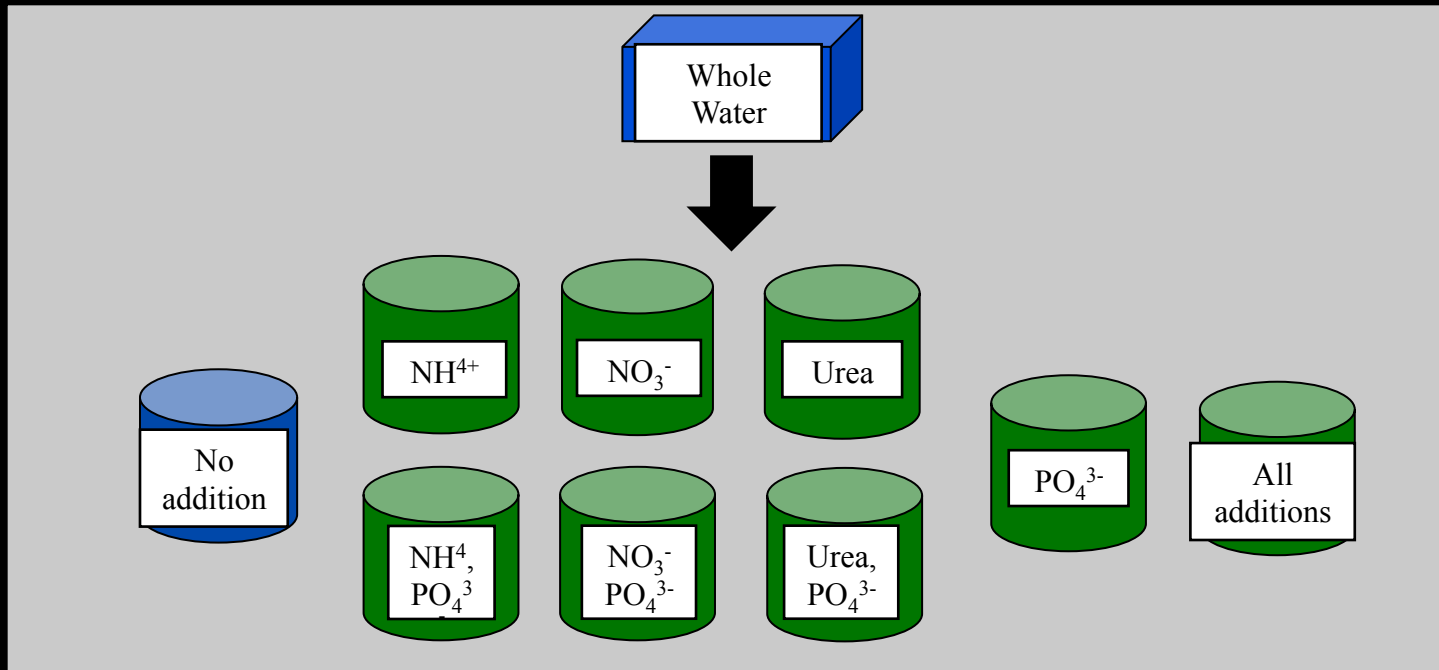
detention pond



Similarities: salinity, depth

Differences: land use patterns, N & P

Seasonal Bioassays (2011-2013)



- Water quality (T, S, DO, pH, turbidity, depth) and nutrients (N, P, DOC)
- N added at 20 mM, P added at 1.25 mM (Redfield 16:1)
- Net phytoplankton growth & community composition (chlorophyll *a*, microscopy, HPLC pigments)
- Bacteria (SYBR green/flow cytometry)

- **Samples/experiment at 0.3 m depth**
- **Nutrients added to replicates in the field**
- **Deployed with YSI datasonde, anchor & floats**
- **ISCO autosampler, collections every 3 hrs over 24 hr period**

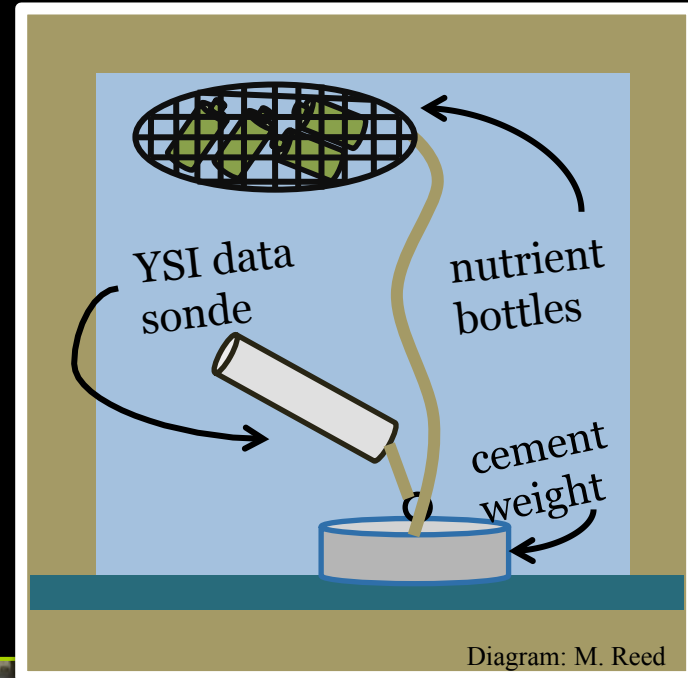


Diagram: M. Reed



Analyses

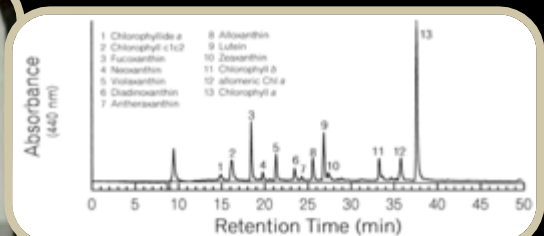
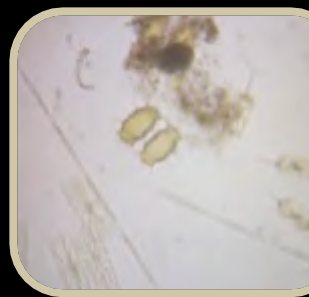
t0 and Incubation Water

Water
Chemistry

- Temperature (T), salinity (S), dissolved oxygen (DO), pH
- Total N and P
- Dissolved nutrients: NH_4^+ , $\text{NO}_2^- + \text{NO}_3^-$, PO_4^{3-} , DOC

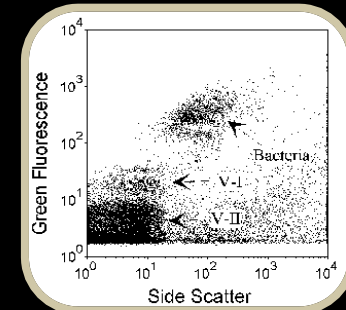


Phytoplankton



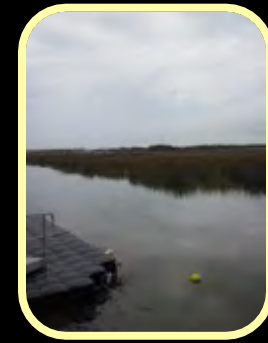
Pinckney et al., 2001

Bacteria



Marie et al., 1999

Take Home Messages



- *Location matters* - phytoplankton responses to N and P levels are site-specific
- Response is further mediated by season & year
- N (particularly organic) typically fuels phytoplankton growth more than P in the saline waters, consistent with patterns observed elsewhere, suggesting N-limitation (N is a major driver of algal growth)
- **There does not seem to be a ‘one size fits all’. Site-specific variability in biological responses should be taken in to account for coastal nutrient management decisions**

Ongoing and future directions

- DOC, bacteria levels and complete HPLC analyses for field experiments
- GIS assessment of land use patterns around focused study sites
- Performance comparison (TKN and persulfate TN)
- Laboratory experiments to identify growth and productivity responses of dominant phytoplankton (HAB) species (*Pseudo-nitzschia pseudodelicatissima*, *Fibrocapsa japonica*, *Karlodinium veneficum*) to varying N to P ratios
- Role of hydrography? Headwaters? Groundwater? Benthic and salinity-driven processes (P-transformation, denitrification, etc)?



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