A Novel Approach for Evaluation of Water Quality Trends in Gulf Coast Estuaries

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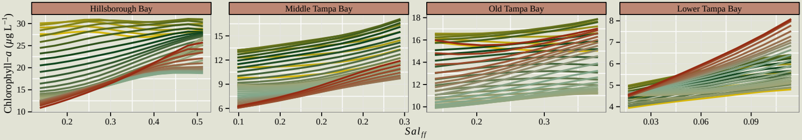


Managing coastal waters

How do we use data?

The foundation of most management programs is a strong monitoring network

Monitoring provides information for decision-making based on apparent trends...

What are the changes in water quality over time?

Are these changes 'good' or 'bad' based on our management objectives?

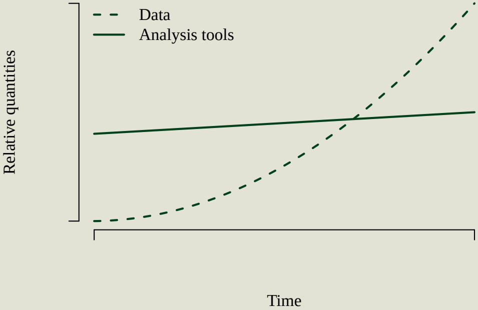
What may have caused these changes?

Managing coastal waters

How do we use data?

The good news: We are getting better at monitoring - standardized, automated, increased coverage, real-time/continuous

The bad news: Our ability to use these data for decision-making has not kept pace with availability!



Managing coastal waters

How do we use data?

We have the data but often lack appropriate tools to unambiguously and quantitatively characterize trends

Challenge 1: We must first define 'trend' - what does this mean in the context of our management objectives?

Challenge 2: We must use tools that can leverage the descriptive capabilities of large datasets

Our research explores novel techniques to address these challenges:

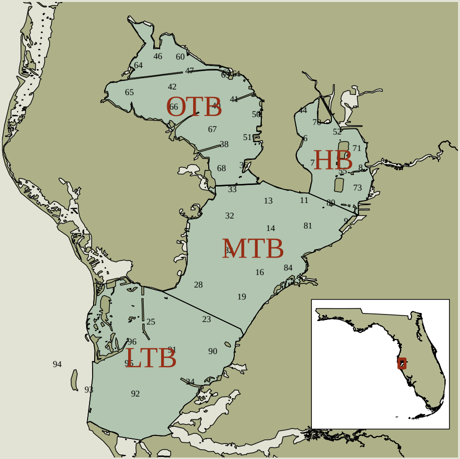
Case 1: Chlorophyll drivers in Tampa Bay

Case 2: Improving estimates of ecosystem metabolism

Case 1: Tampa Bay
Describing drivers of chlorophyll

- Four bay segments
- Monthly wq data at 50 stations from 1974 to present
- Longitudinal profile of nutrient load and salinity

Data from [TBEP (Tampa Bay Estuary Program), 2011]



Case 1: Tampa Bay

Describing drivers of chlorophyll

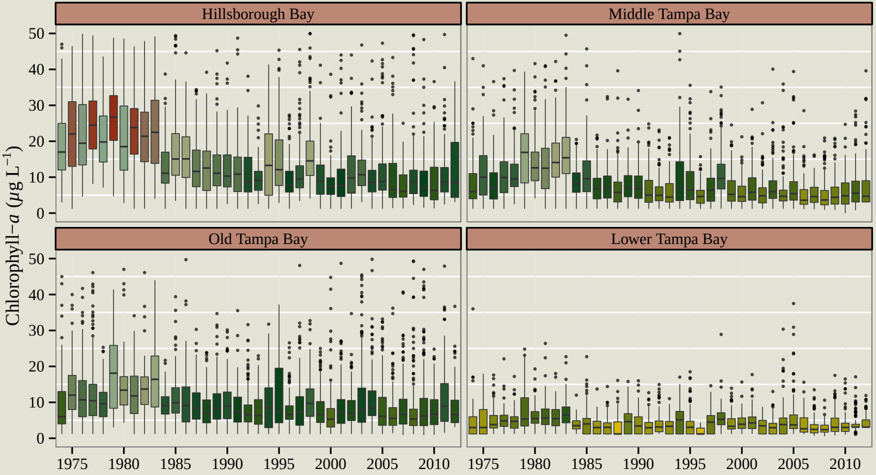


Figure : Annual trends in chlorophyll for each bay segment.

What affects our interpretation of chlorophyll response to nutrients?

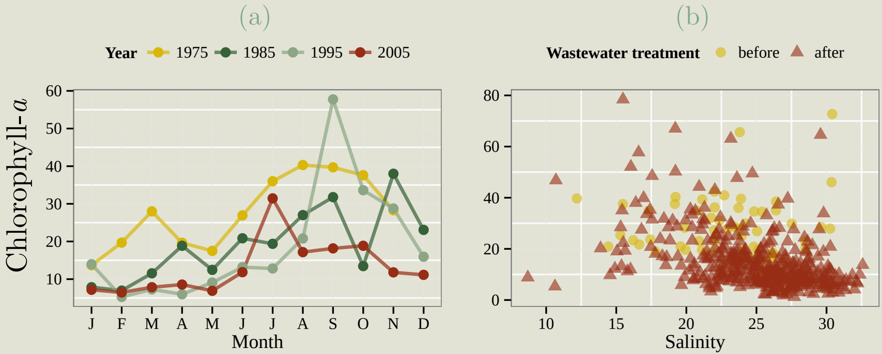


Figure : Variation in chlorophyll by (a) time and (b) salinity and management in Hillsborough Bay. Panel (a) is colored before and after wastewater treatment in 1979.

Case 1: Tampa Bay

Describing drivers of chlorophyll

Given the observed changes over time and the available data – Can we...

- ...provide a natural history of water quality that is temporally consistent with drivers of change (i.e., context for trend evaluation)?
- ...characterize changes in extreme events in addition to describing the mean response?
- ...improve our understanding of the nutrient-response paradigm in estuaries?

Case 1: Tampa Bay

Describing drivers of chlorophyll

The ***weighted regression (WRTDS)*** model is being developed by USGS for pollutant modelling in rivers [Hirsch et al., 2010]

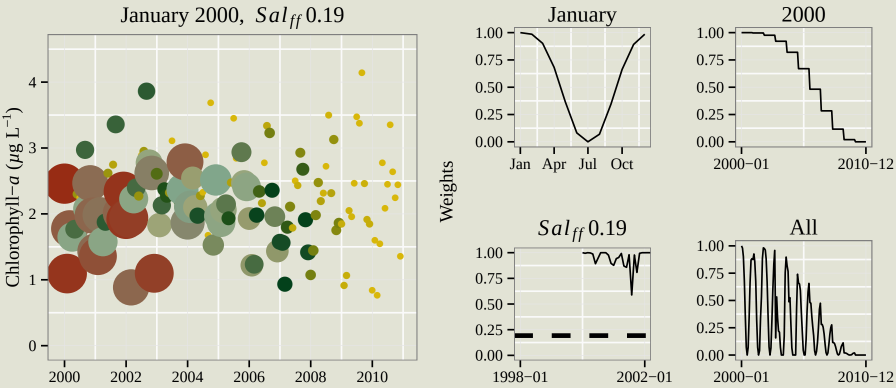
Based on the idea that pollution concentration is a function of ***time***, ***discharge***, and ***season***

Problem: We want to see if management has an effect on reducing pollutant load over time, but pollutant load varies with discharge.

Solution: Develop a model that accounts for changes in relationships between drivers of pollution over time.

Adaptation: Can this approach be used to evaluate chlorophyll trends in Tampa Bay?

How does weighted regression work?



Case 1: Tampa Bay

Describing drivers of chlorophyll

Results show temporally consistent trends over time

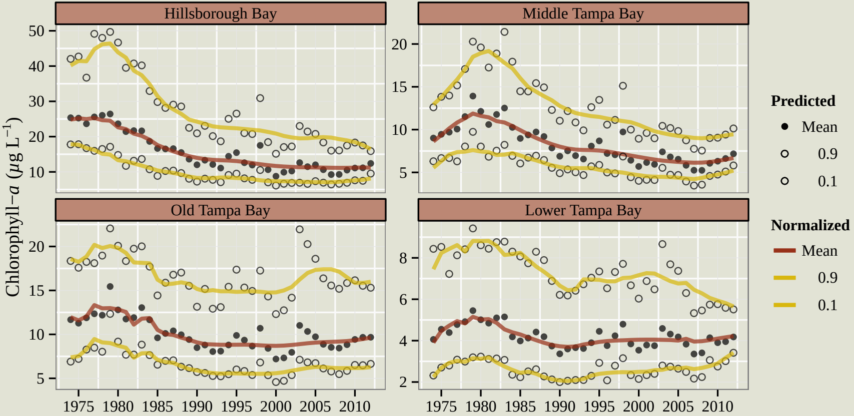
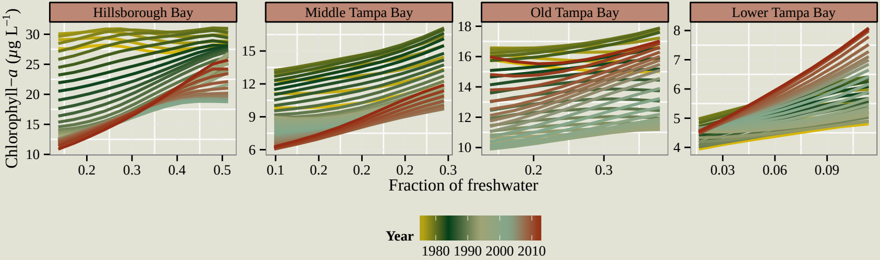


Figure : Predicted and salinity-normalized annual chlorophyll by segment.

Case 1: Tampa Bay
Describing drivers of chlorophyll

What does this mean for Tampa Bay and other Gulf Coast estuaries?

- Predictions followed observed chlorophyll – but increased clarity in the description
- More detailed evaluation of trends allows greater insight into drivers of change



Case 2: Improving estimates of metabolism
Application to Gulf Coast estuaries

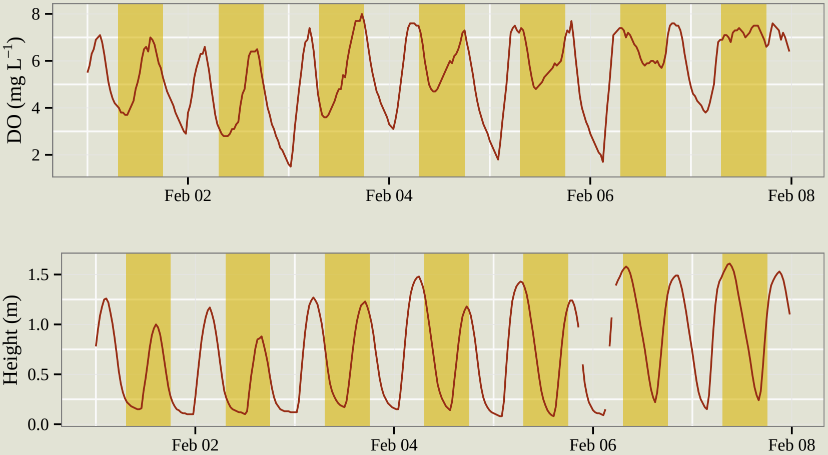
The 'Odum' open-water method has been used for decades to estimate rates of ecosystem metabolism [Odum, 1956]

$$\frac{\delta DO}{\delta t} = P - R + D$$

Metabolic rates provide a measure of productivity in a system - are estuaries sources or sinks of organic matter? [Caffrey et al., 2013]

Applications to estuarine monitoring data have been somewhat successful - why??

The ‘Odum’ method assumes DO represents biological processes...



Case 2: Improving estimates of metabolism
Application to Gulf Coast estuaries

Challenge 1: We want to provide an accurate estimate of metabolism using DO time series to evaluate trends over time

Challenge 2: DO time series may represent variation from physical and biological processes

The weighted regression approach could be used here...

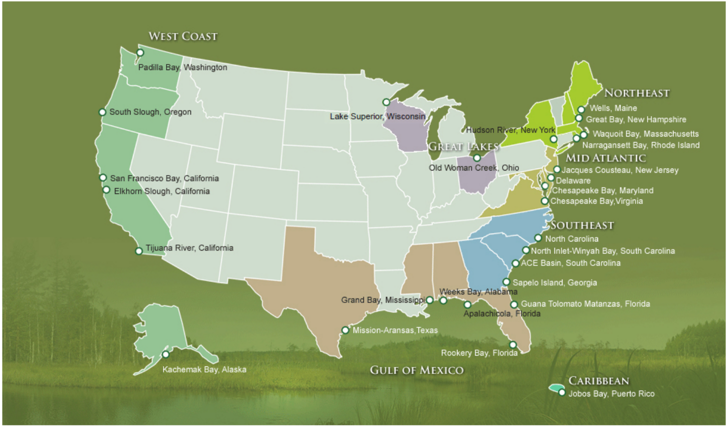
$$\ln(Chl) = \beta_0 + \beta_1 Sal_{ff} + \beta_2 t + \beta_3 \sin(2\pi t) + \beta_4 \cos(2\pi t)$$

$$DO = \beta_0 + \beta_1 H + \beta_2 t + \beta_3 \sin(2\pi t) + \beta_4 \cos(2\pi t)$$

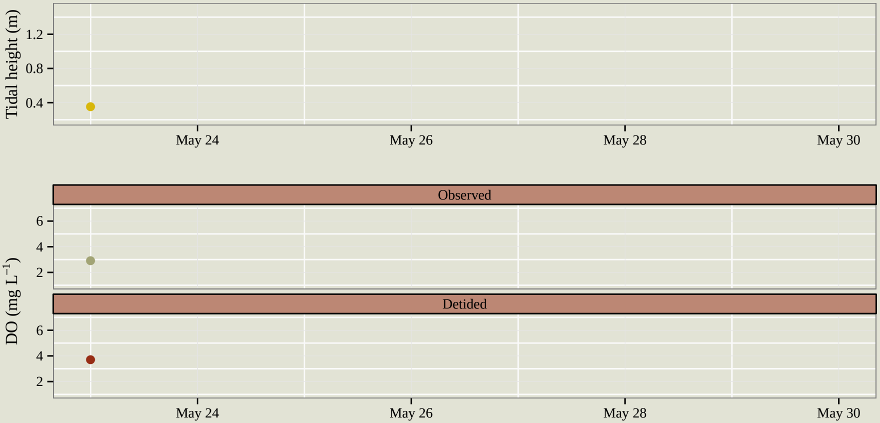
Case 2: Improving estimates of metabolism
Application to Gulf Coast estuaries

System Wide Monitoring Program, initiated in 1995 to provide continuous data at over 300 stations in 28 US estuaries

NERRS Reserves

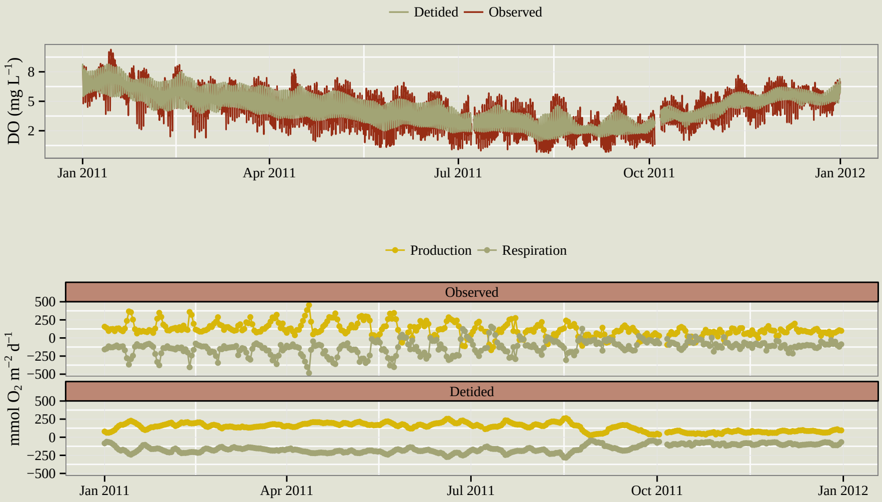


Case 2: Improving estimates of metabolism
Application to Gulf Coast estuaries



Case 2: Improving estimates of metabolism

Application to Gulf Coast estuaries



Conclusions

The analysis of water quality will continue to require the use of novel techniques, such as weighted regression

These needs are motivated by:

- The continued relevance of stressors that influence ecosystem conditions
- Our increasing ability to gather raw, uninterpreted data

Our methods must include a clear definition of ***trend*** in the context of drivers of change

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