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

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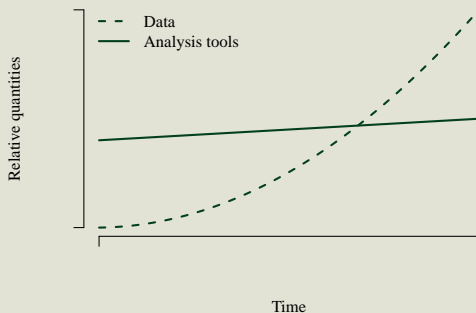[2]USEPA National Health and Environmental Effects Research Laboratory, Gulf Ecology Division

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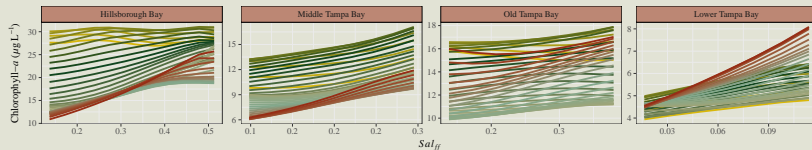
Managing coastal waters
How do we use data?

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!

Challenge 1: We have the data but often lack appropriate tools to unambiguously and quantitatively characterize trends

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

Our research explores novel techniques to address these challenges:

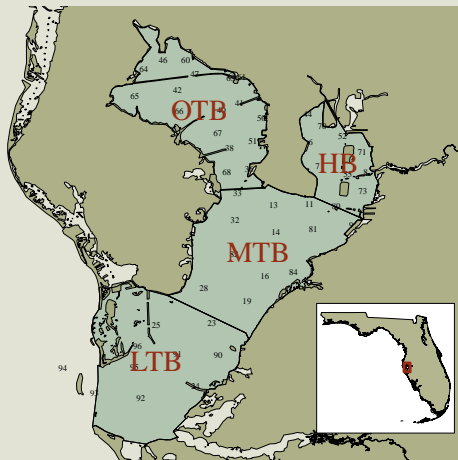***Case 1:*** Chlorophyll drivers in Tampa Bay

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

Data from [TBEP (Tampa Bay Estuary Program), 2011]
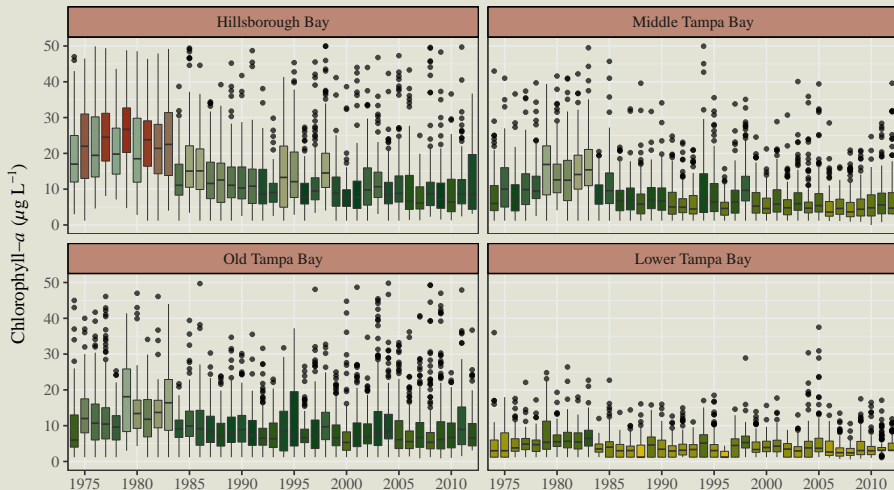
Case 1: Tampa Bay
Describing drivers of chlorophyll

Figure : Annual trends in chlorophyll for each bay segment.

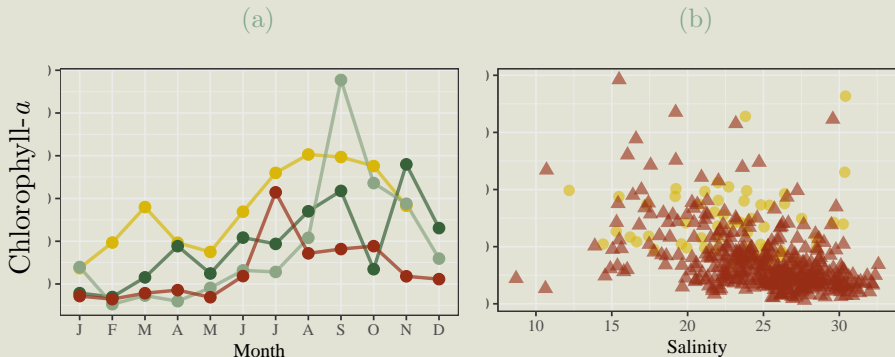What affects our interpretation of chlorophyll response to nutrients?

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

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?

Case 1: Tampa Bay
Describing drivers of chlorophyll

How does weighted regression work?

Case 1: Tampa Bay
Describing drivers of chlorophyll

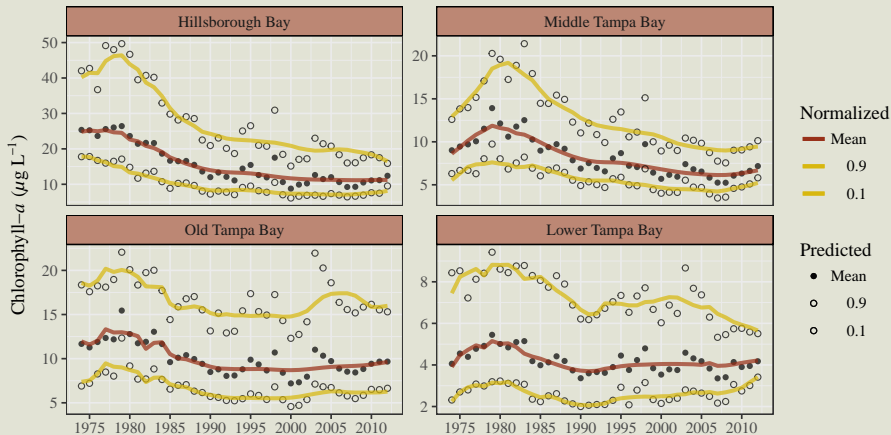Results show temporally consistent trends over time

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

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

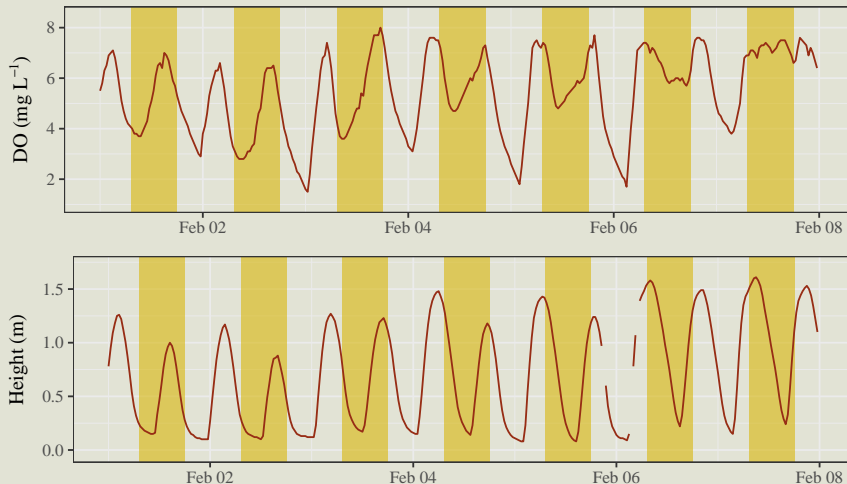$$\frac{\delta DO}{\delta t} = P - R + D$$

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??

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

The 'Odum' method assumes DO represents biological processes...

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

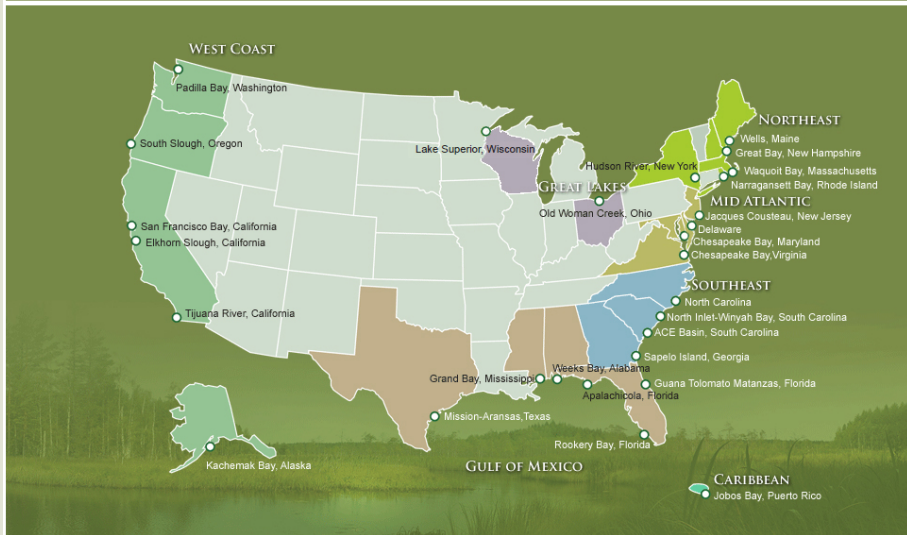*Solution:* The weighted regression approach could be used here...

$$\ln\left(Chl\right) = \beta_0 + \beta_1 Sal_{ff} + \beta_2 t$$

$$DO = \beta_0 + \beta_1 H + \beta_2 t$$

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

NERRS Reserves

WEST COAST

Padilla Bay, Washington

South Slough, Oregon

Lake Superior, Wisconsin

Hudson River, New York

GREAT LAKES

Old Woman Creek, Ohio

NORTHEAST

Wells, Maine
Great Bay, New Hampshire
Waquoit Bay, Massachusetts
Narragansett Bay, Rhode Island

MID ATLANTIC

Jacques Cousteau, New Jersey
Delaware
Chesapeake Bay, Maryland
Chesapeake Bay, Virginia

San Francisco Bay, California
Elkhorn Slough, California

Tijuana River, California

SOUTHEAST

North Carolina
North Inlet-Winyah Bay, South Carolina
ACE Basin, South Carolina
Sapelo Island, Georgia
Guana Tolomato Matanzas, Florida

Weeks Bay, Alabama

Grand Bay, Mississippi

Apalachicola, Florida

Mission-Aransas, Texas

Rookery Bay, Florida

Kachemak Bay, Alaska

GULF OF MEXICO

CARIBBEAN

Jobos Bay, Puerto Rico

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

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Application to Gulf Coast estuaries
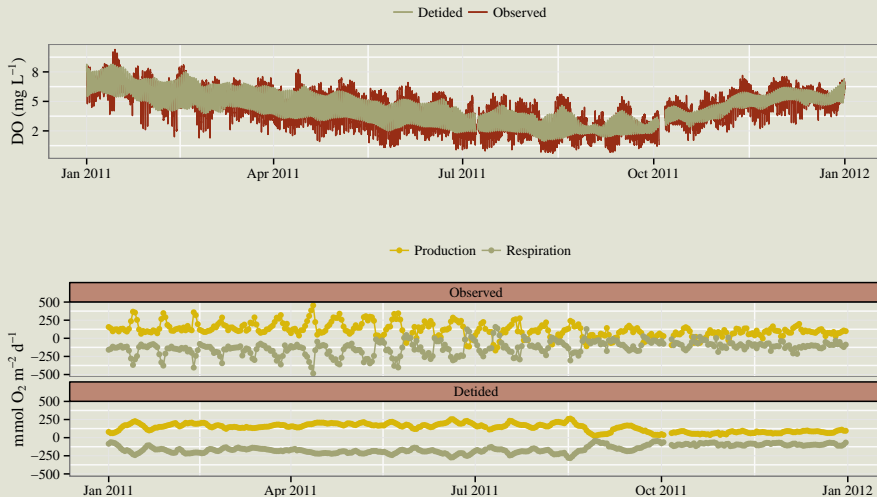
Conclusions

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

Acknowledgments:

Wes Anderson Cavalcanti color theme borrowed and adapted from github.com/karthik

Image credit: https://m1.behance.net/

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References I

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