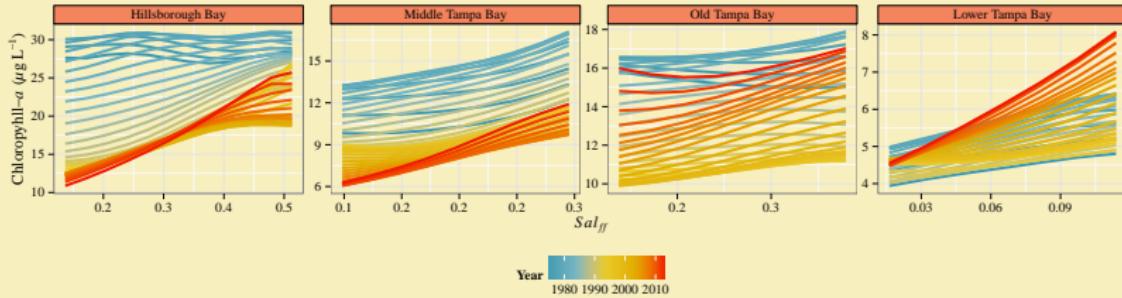


The search for truth in numbers: Quantitative approaches for evaluating trends in water quality data

Marcus W. Beck

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Oct. 24, 2014



The eutrophication paradigm

Research and management in coastal waters

Eutrophication (noun) - an increase in the rate of supply of organic matter to an ecosystem

– [Nixon, 1995]

Adapted from [Cloern, 2001]

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Nutrient Loading

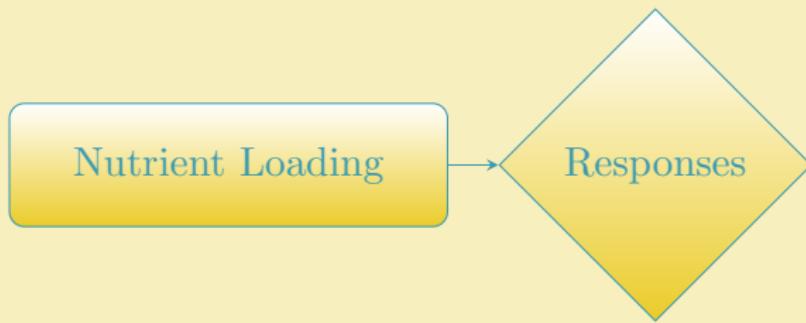
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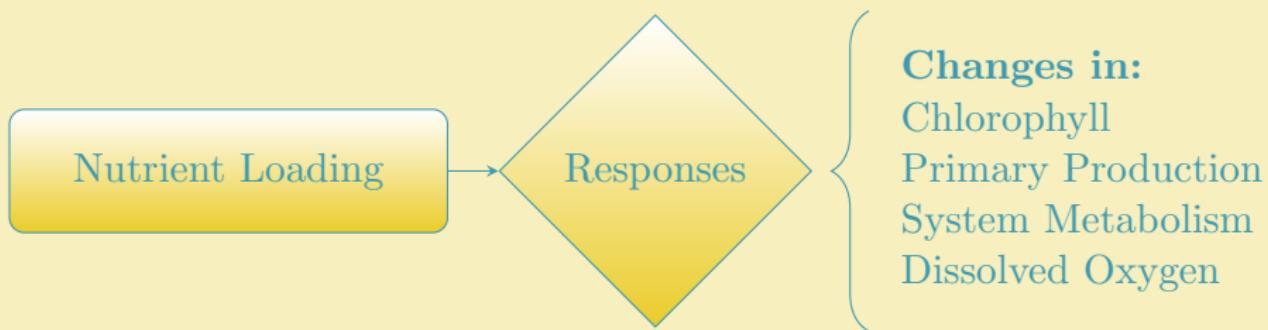
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Human inputs can greatly accelerate eutrophication... particularly for coastal waters

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- Depletion of bottom water dissolved oxygen
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- Propogated effects to upper trophic levels [Powers et al., 2005]

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Research and management in coastal waters

Red tide off northwest Florida may hit economy

Jason Dearen, Associated Press

2:40 p.m. CDT September 18, 2014



(Photo: Bruce Graner)

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CLEARWATER –

It's like Florida's version of The Blob. Slow moving glops of toxic algae in the northeast Gulf of Mexico are killing sea turtles, sharks and fish, and threatening the waters and beaches that fuel the

region's economy.

Known as "red tide," this particular strain called Karenia brevis is present almost every year off Florida, but large blooms can be particularly devastating. Right now, the algae is collecting in an area about 60 miles wide and 100 miles long, about 5 to 15 miles off St. Petersburg in the south and stretching north to Florida's Big Bend, where the peninsula ends and the Panhandle begins.



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Forum faces economic realities

Oct. 14, 2014, 8:40 p.m.



Businessman buys block in downtown Pensacola

Oct. 14, 2014, 8:27 p.m.

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Water Quality Act Amendments of 1972

- Federal mandates to protect and restore the chemical, physical, and biological integrity of surface waters
- Protection and restoration requires criteria

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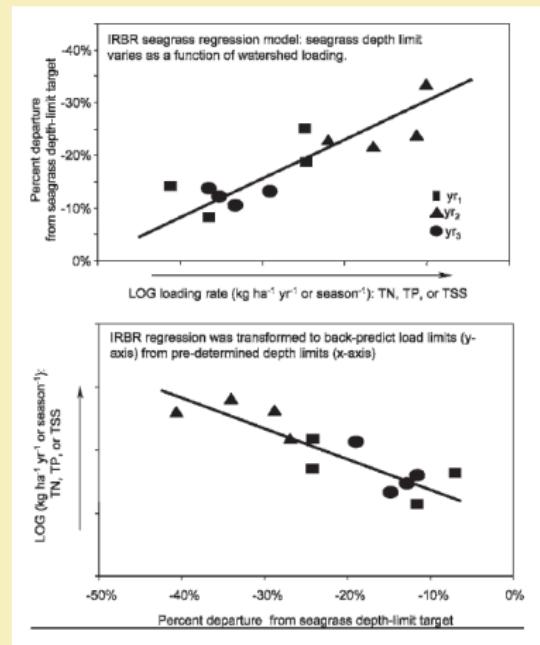
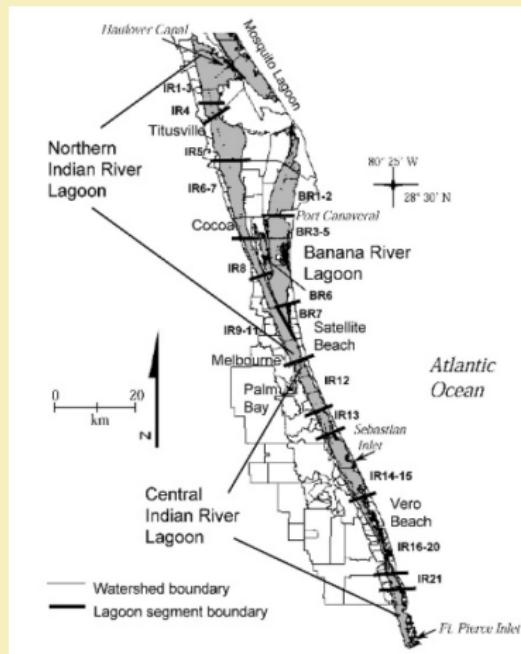
Numeric nutrient criteria

- The amounts of contaminants or pollutants that may be present without impairing aquatic life or human health
- E.g., nutrients limits for seagrass in Indian River Lagoon...

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Research and management in coastal waters

Nutrient limits using seagrass depth-limit targets [Steward and Green, 2007]



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Research and management in coastal waters

USEPA national strategy for the development of regional nutrient criteria

- Aid states' ability to control and reduce nutrient enrichments
- Responsibility of EPA to develop criteria guidance

[USEPA (US Environmental Protection Agency), 1998]

The eutrophication paradigm

Research and management in coastal waters

USEPA Gulf Ecology Division - guidance to Florida DEP and others
on criteria development for estuaries



The eutrophication paradigm

Challenges for criteria development

There are challenges to providing guidance...

Challenge 1: We don't fully understand eutrophication processes

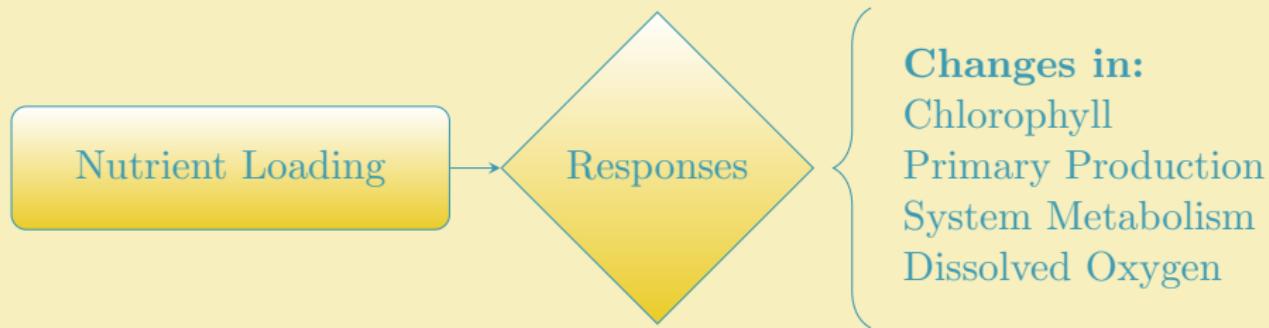
There are good reasons to believe that eutrophication will, in the near future, become a hazard in marine coastal areas in many parts of the world.

– [Rosenberg, 1985]

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Challenges for criteria development

Our conceptual model for understanding the effects of nutrient pollution is adopted from freshwater sciences.

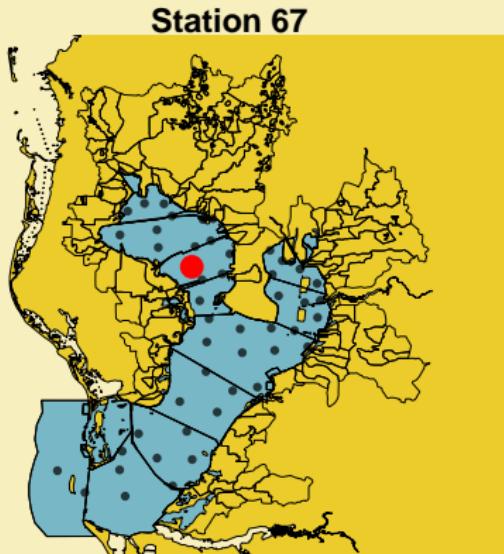
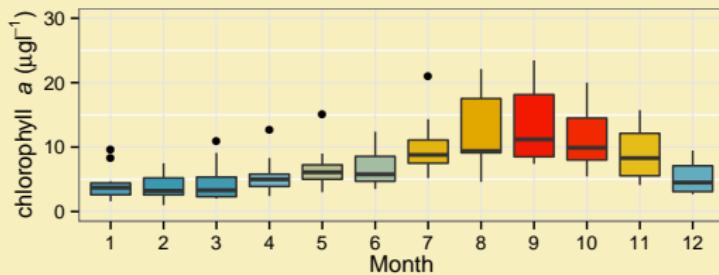
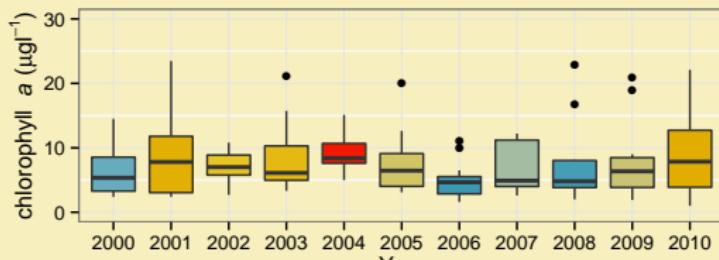


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The eutrophication paradigm

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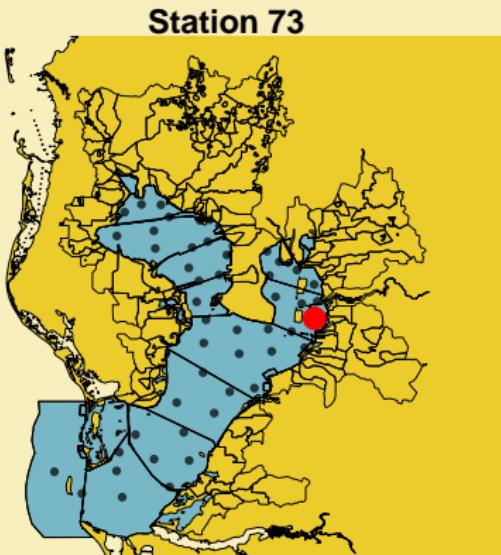
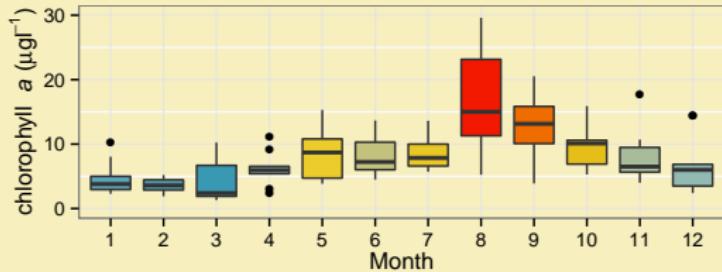
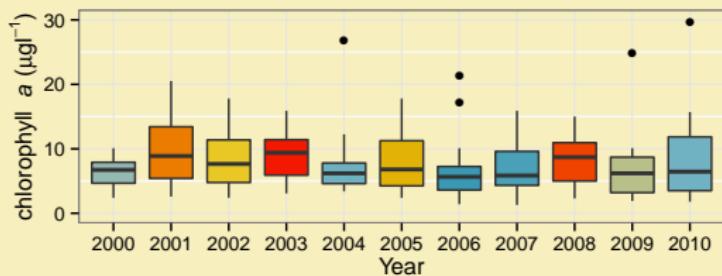
Spatial and temporal variation in chlorophyll for Tampa Bay



The eutrophication paradigm

Challenges for criteria development

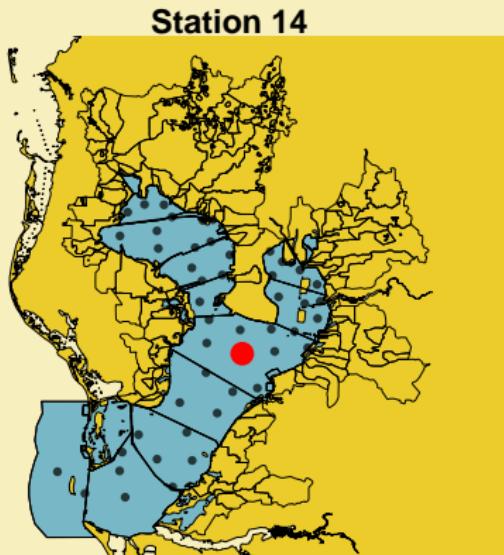
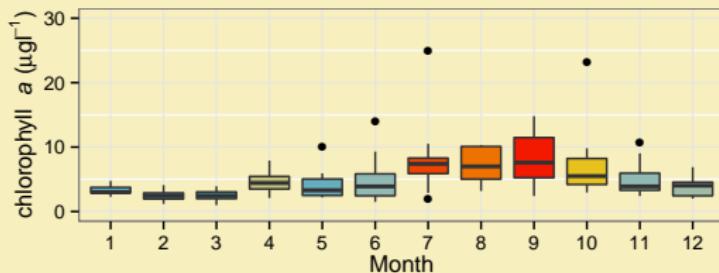
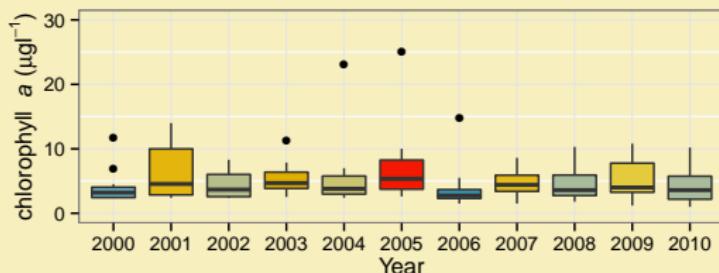
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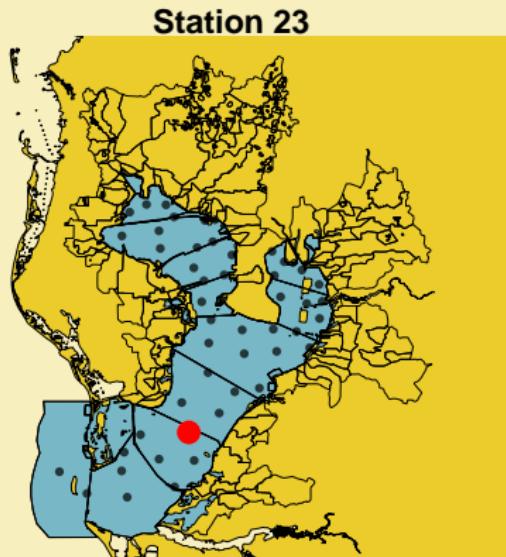
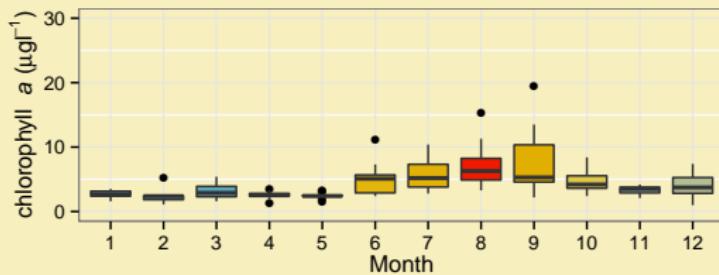
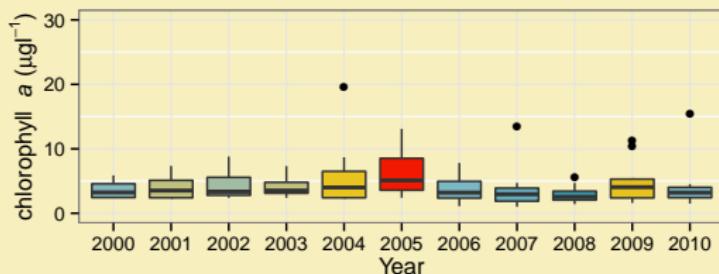
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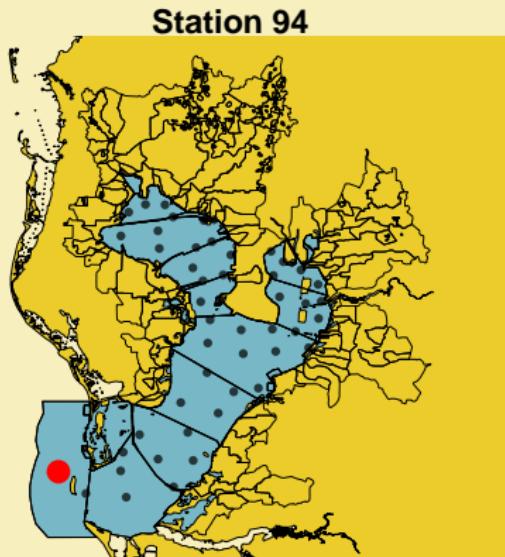
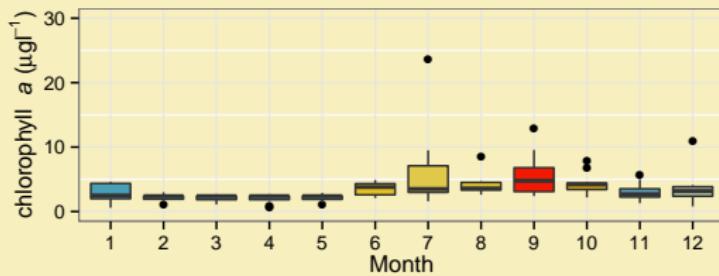
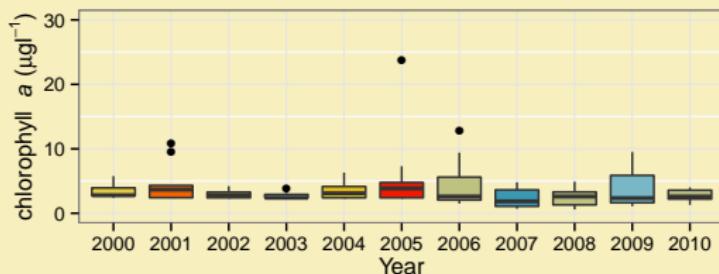
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Challenges for criteria development

Spatial and temporal variation in chlorophyll for Tampa Bay



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Challenges for criteria development

Challenge 2: We have the data but often lack tools to unambiguously and quantitatively characterize

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Challenges for criteria development

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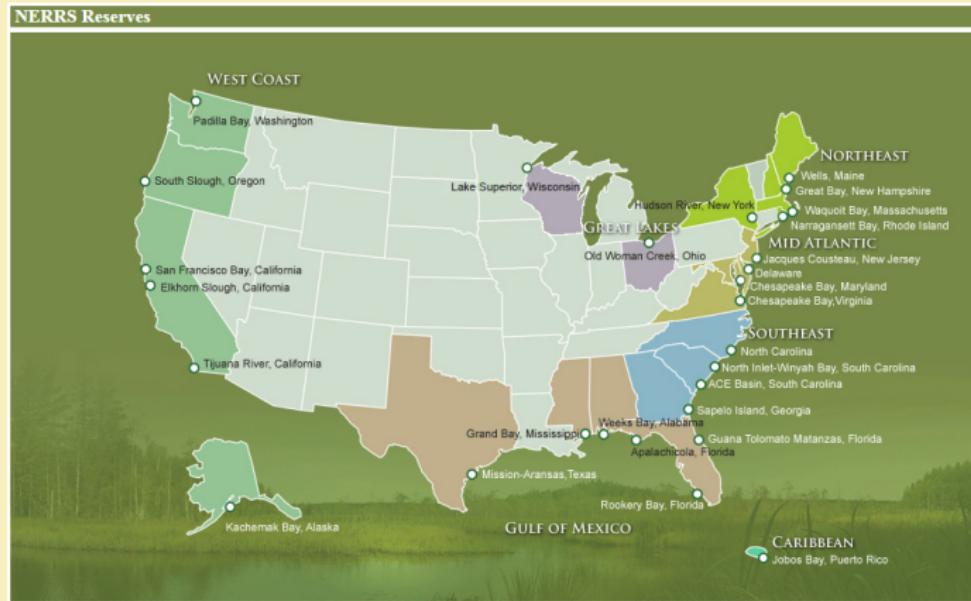
Data without models are chaos, but models without data are fantasy.

– NWQMC 2014 plenary, R. Hirsch via [Nisbet et al., 2014]

The eutrophication paradigm

Challenges for criteria development

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



<http://nerrs.noaa.gov/ReservesMap.aspx>

The eutrophication paradigm

Challenges for criteria development

SWMP - As of this month, over 56 million records

- Weather > 13 million
- Water quality > 43 million
- Nutrients > 93 thousand

The eutrophication paradigm

Challenges for criteria development

SWMP - As of this month, over 56 million records

- Weather > 13 million
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- Nutrients > 93 thousand

Despite the quantity and quality of the data, very few comparative analyses. Exceptions...

- Comparison of net metabolism [Caffrey, 2003], [Caffrey, 2004]
- DO variation between estuaries [Wenner et al., 2004]
- Synthesis reports [Wenner et al., 2001], [Sanger et al., 2002]

The eutrophication paradigm

Challenges for criteria development

Guidance may come in many forms - not just a number

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Case 1: Chlorophyll drivers in Tampa Bay

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Case 3: ‘Open-science’ tools for analysis of water quality

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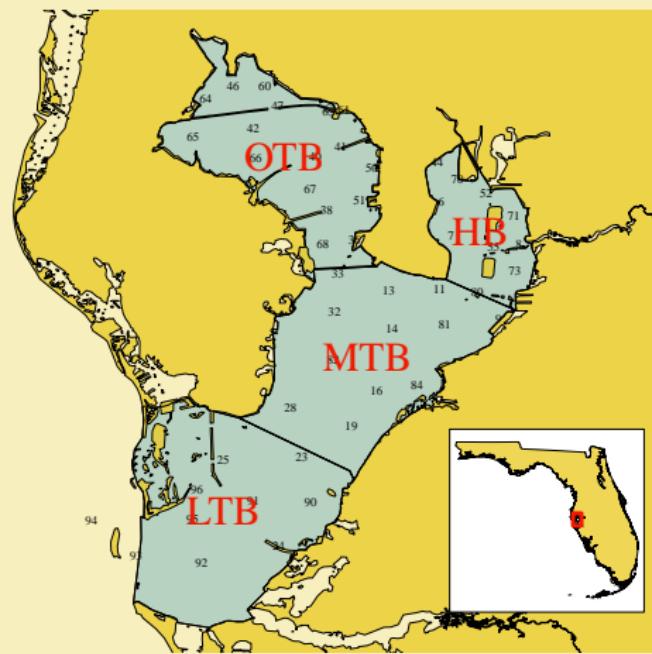
Each provides an example of addressing the dual challenges of understanding nutrient dynamics and developing quantitative tools for trend evaluation

Case 1: Tampa Bay

Understanding chlorophyll response to eutrophication

- 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

Understanding chlorophyll response to eutrophication

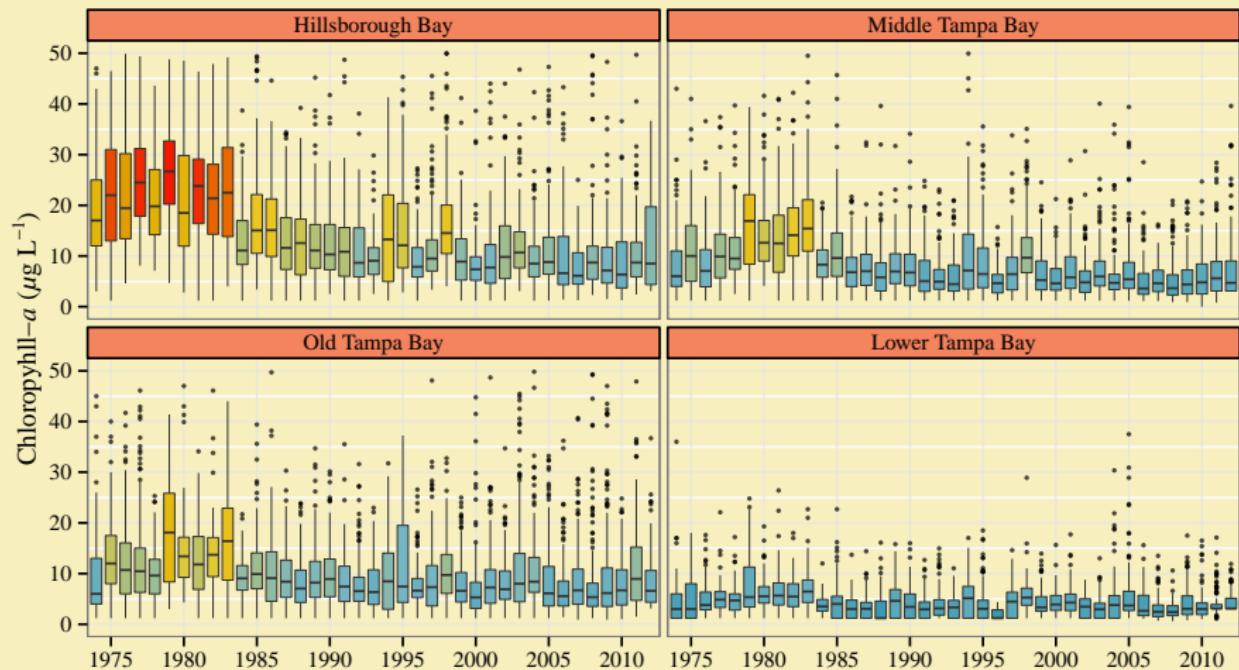


Figure : Annual trends in chlorophyll for each bay segment.

Case 1: Tampa Bay

Understanding chlorophyll response to eutrophication

What affects our interpretation of chlorophyll response to nutrients?

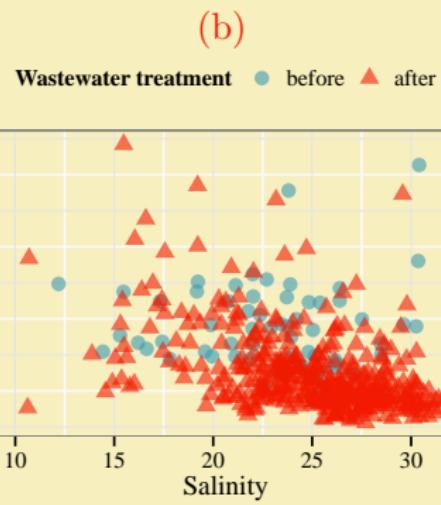
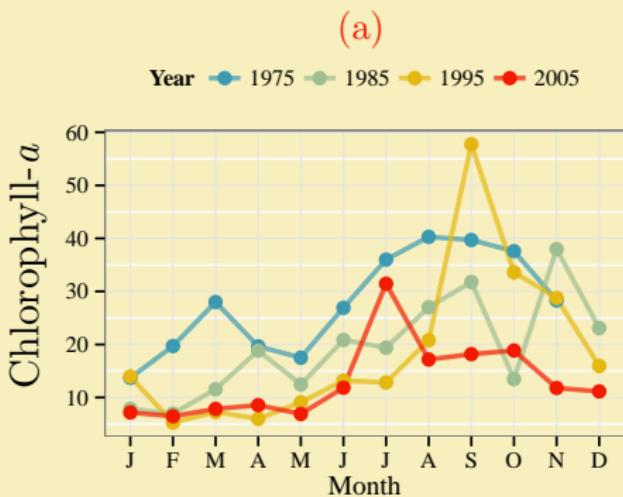


Figure : Variation in chlorophyll by (a) time and (b) salinity and management in Hillsborough Bay. Panel (a) is colored before and after wastewater treatment in 1979.

Case 1: Tampa Bay

Understanding chlorophyll response to eutrophication

Study objective

Adapt and apply nutrient response model for estuaries that leverages the descriptive capabilities of large datasets

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Questions of management concern – Can we...

- ...provide a natural history of water quality that is temporally consistent with drivers of change?

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Questions of management concern – Can we...

- ...provide a natural history of water quality that is temporally consistent with drivers of change?
- ...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

Understanding chlorophyll response to eutrophication

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

Case 1: Tampa Bay

Understanding chlorophyll response to eutrophication

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

Understanding chlorophyll response to eutrophication

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