

# Quantitative approaches to understand nutrient pollution in estuaries: An example for the upper San Francisco Estuary

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# Evaluating estuarine condition

How do we collect and use data?

The foundation of environmental management is a strong monitoring network [National Research Council, 1990]

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

*What are the changes in environmental condition over time?*

*Are these changes ‘good’ or ‘bad’ based on our management objectives?*

*What may have caused these changes?*

# Evaluating estuarine condition

How do we collect and use data?

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

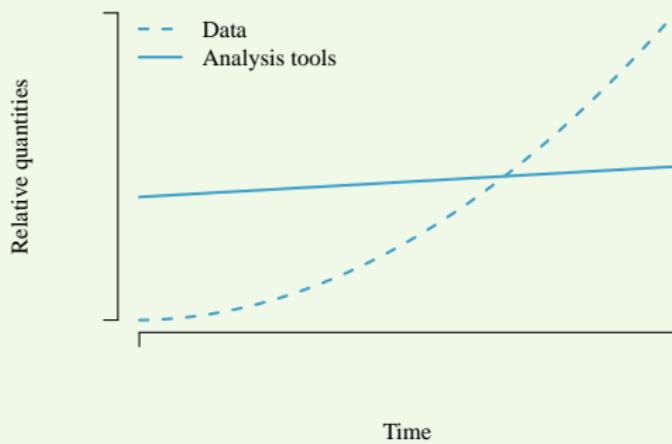
***The bad news:*** Our ability to use these data for decision-making has not kept pace with availability!

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## How do we collect and use data?

Most of my research career has focused on using monitoring data to understand effects of eutrophication in one form or another

*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

Adapted from [Cloern, 2001]

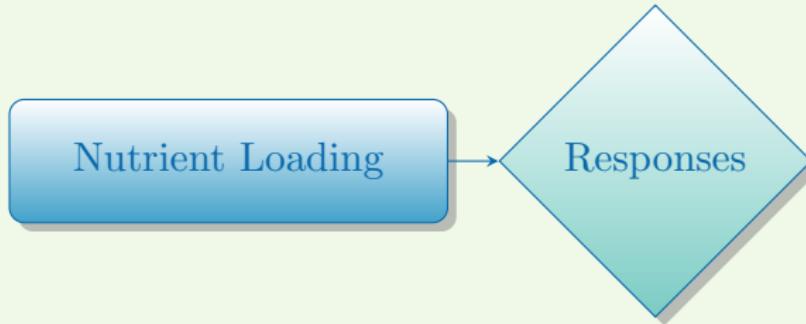
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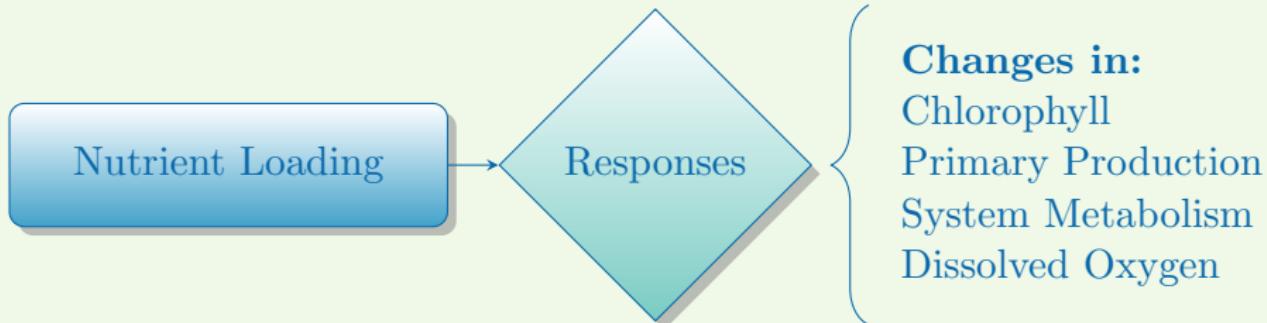
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How do we collect and use data?

***Today's talk:*** My experience evaluating monitoring data to inform our understanding of the eutrophication paradigm

Water quality trends in the Delta:

- ***Example 1:*** Model theory and application
- ***Example 2:*** Trends over time
- ***Example 3:*** Selected case studies

# Model theory and background

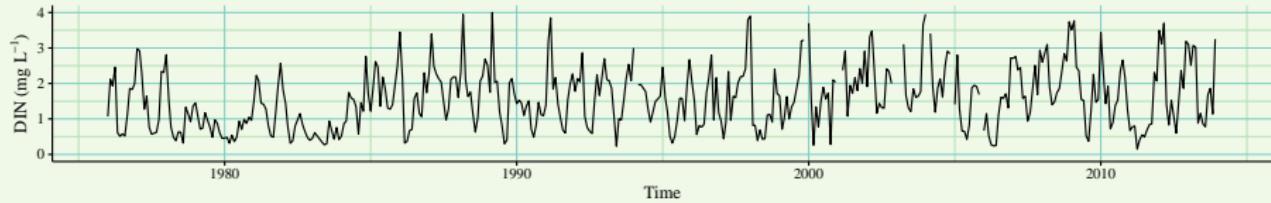
## WRTDS adaptation for tidal waters

Increasing availability of records describing *long-term changes*

Observed data can provide a means to an end, potentially *high power* with large sample size

Can we *develop* and *apply* tools that leverage the descriptive capabilities of these large datasets?

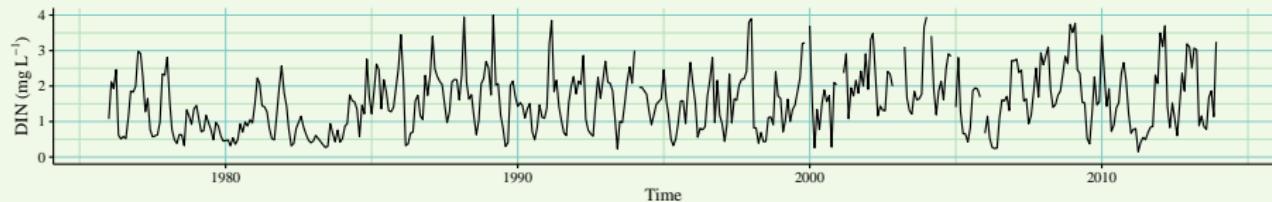
Can we *link descriptions* to *causal events* to inform management or understanding?



# Model theory and background

WRTDS adaptation for tidal waters

**Observed data represents effects of many processes**



## Climate

precipitation  
temperature  
wind events  
ENSO effects

## Local

light/turbidity  
residence time  
invasive species  
trophic effects

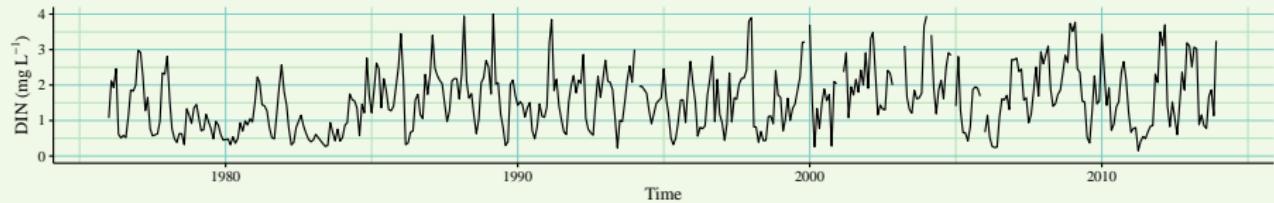
## Regional/historical

watershed inputs  
point sources  
management actions  
flow changes

# Model theory and background

WRTDS adaptation for tidal waters

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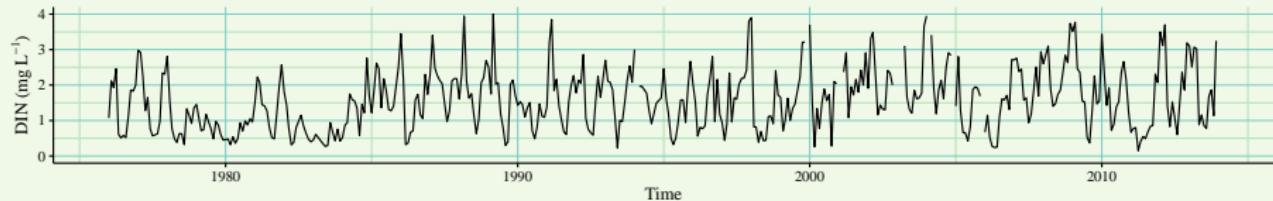


Models should describe components to evaluate effects

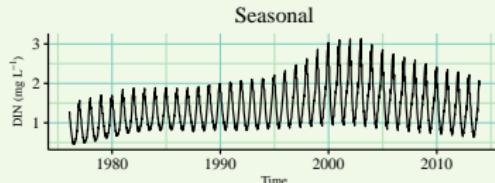
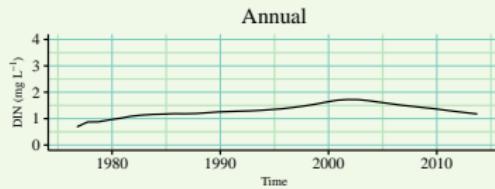
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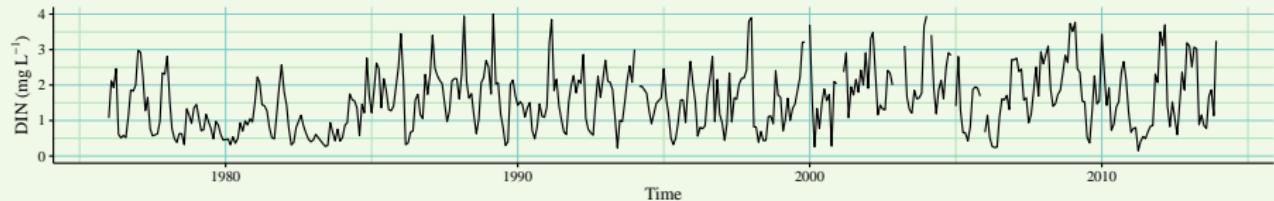
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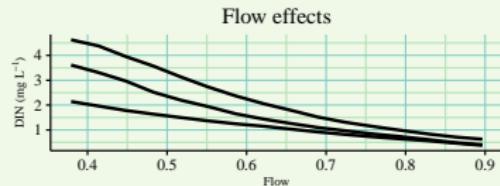
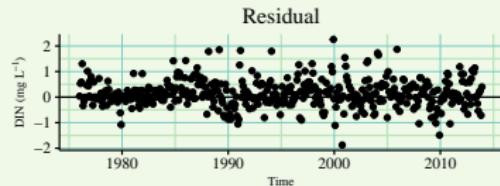
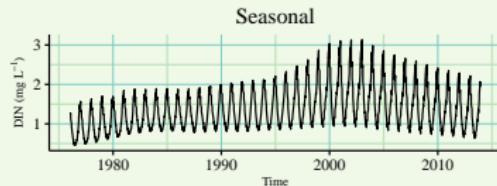
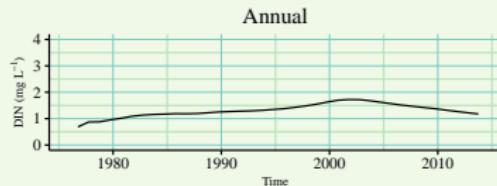
# Model theory and background

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Models should describe components to evaluate effects



# Model theory and background

## WRTDS adaptation for tidal waters

**Problem:** Response endpoints of eutrophication vary naturally over time and with discharge or tidal patterns

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

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

Models pollution concentration as a function of ***time, discharge, and season***

**Adaptation:** Applied to Tampa Bay [Beck and Hagy III, 2015], further validated/compared in Patuxent Estuary [Beck and Murphy, In review]

# Model theory and background

## WRTDS adaptation for tidal waters

How does weighted regression work?

# Model theory and background

## WRTDS adaptation for tidal waters

### Application to Delta

- Nine stations (three Suisun, three middle, three delta)
- Three analytes (DIN, ammonium, nitrite/nitrate), two flow records
- Four decades of data, 1976-2013

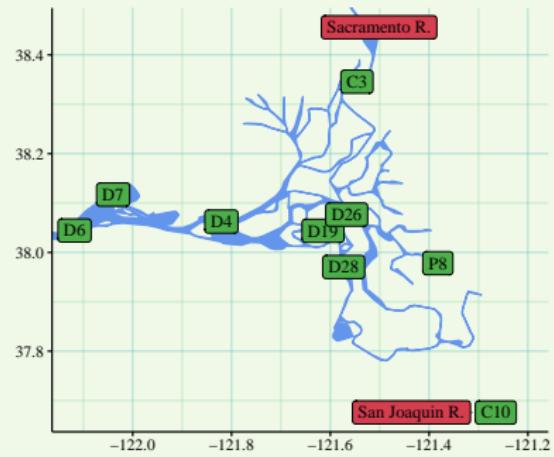


Figure : Stations (green) and flow estimates (red) modelled with WRTDS

# Trends over time

## Nitrogen dynamics in the Delta

Predicted DIN trends, 1980-1990

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