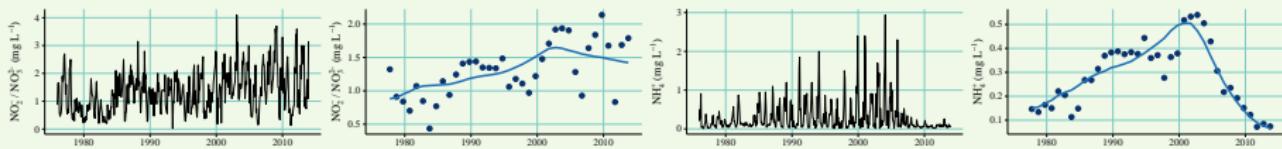


Evaluation of Delta RMP nutrient data using weighted regression for trend analysis

Marcus W. Beck, PhD

Southern California Coastal Water Research Project, marcusb@sccwrp.org, Phone:
7147553217

April 9, 2019



Evaluating Delta RMP data

Today's talk: Evaluation of forty years of Delta water quality data from the Routine Monitoring Program (RMP)

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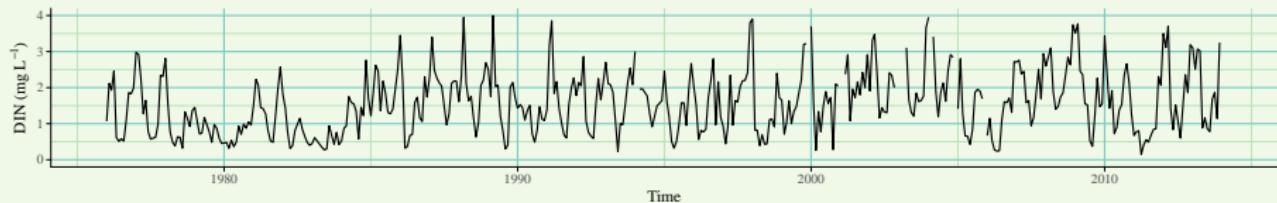
Water quality trends in the Delta:

- ***Part 1:*** Model theory and application
- ***Part 2:*** Trends over time and selected case study
- ***Part 3:*** Use of data science tools to reach environmental managers

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

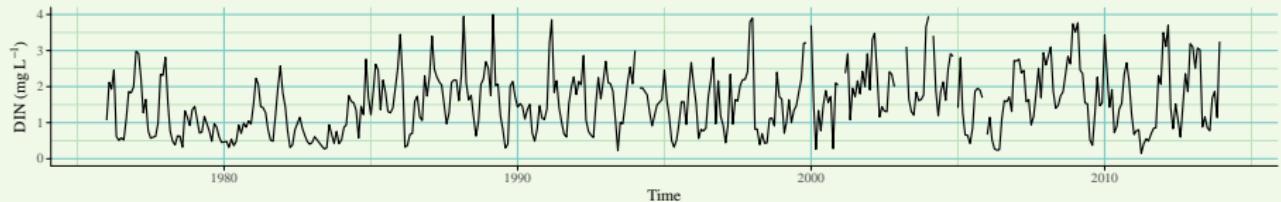
Regional/historical

watershed inputs
point sources
management actions
flow changes

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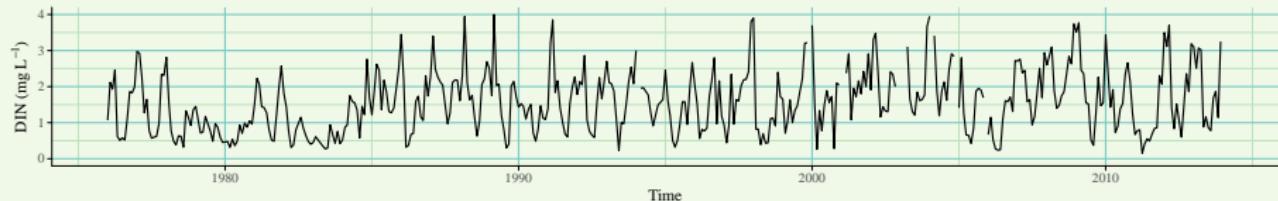


Models should describe components to evaluate effects

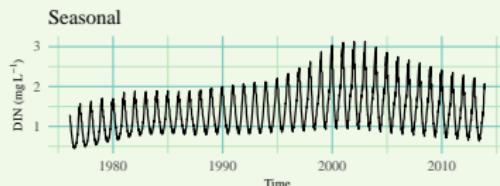
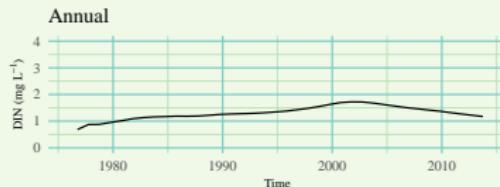
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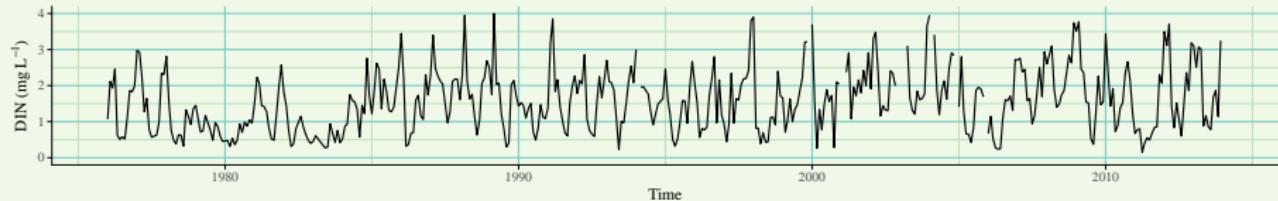
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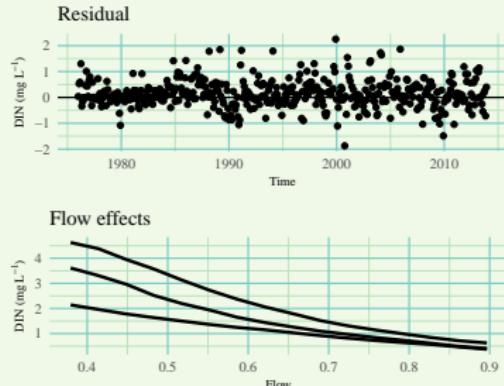
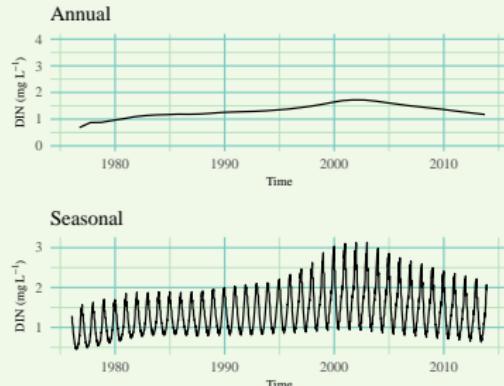
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Model theory and background

WRTDS adaptation for tidal waters

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

Solution: Apply a model that accounts for changes in relationships between drivers of pollution over time [Beck et al., 2018]

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Adaptation: Applied to Tampa Bay [Beck and Hagy III, 2015], further validated/compared in Patuxent Estuary [Beck and Murphy, 2017]

Model theory and background

WRTDS adaptation for tidal waters

How does weighted regression work?

$$\ln(N) = \beta_0 + \beta_1 t + \beta_2 Sal + \beta_3 \sin(2\pi t) + \beta_4 \cos(2\pi t)$$

N : nitrogen (or other response endpoint)

t : time

Sal : Salinity (or other flow-related variable)

Model theory and background

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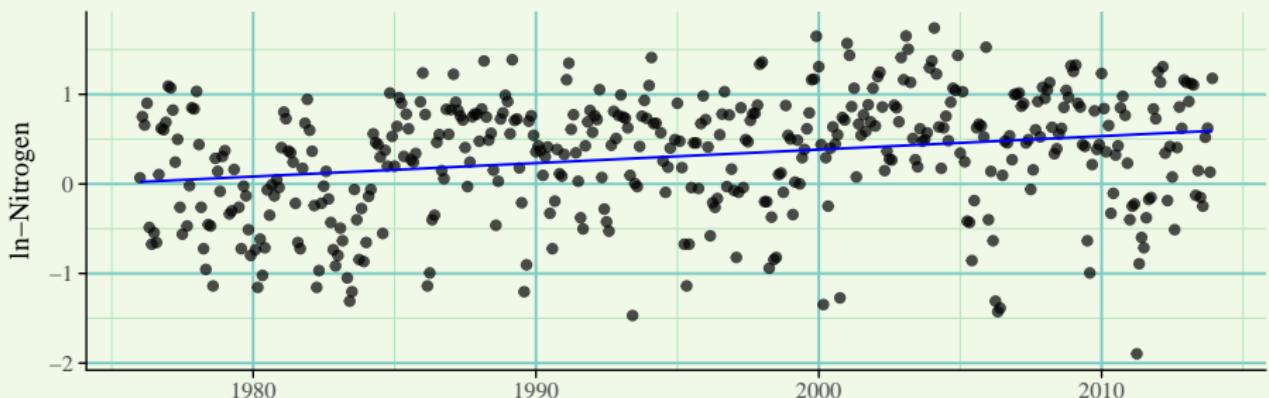
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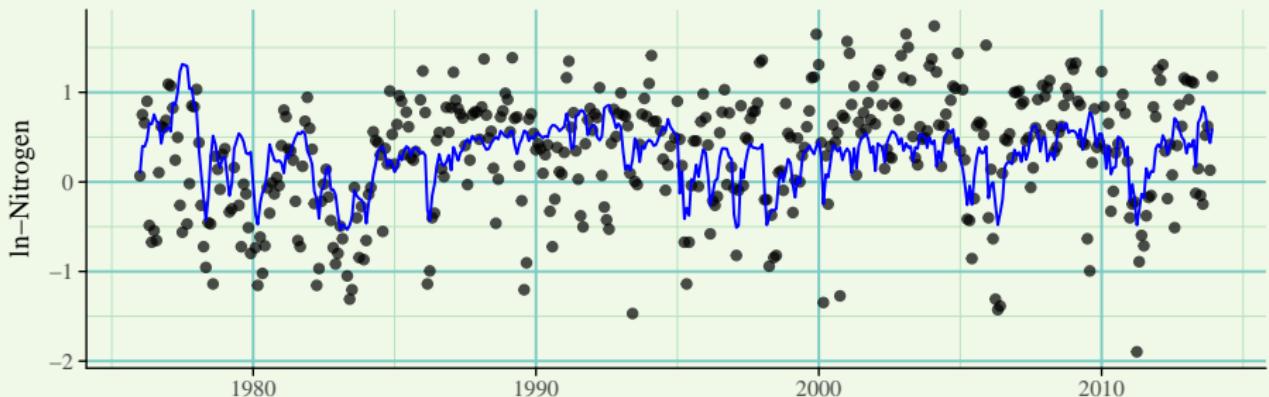
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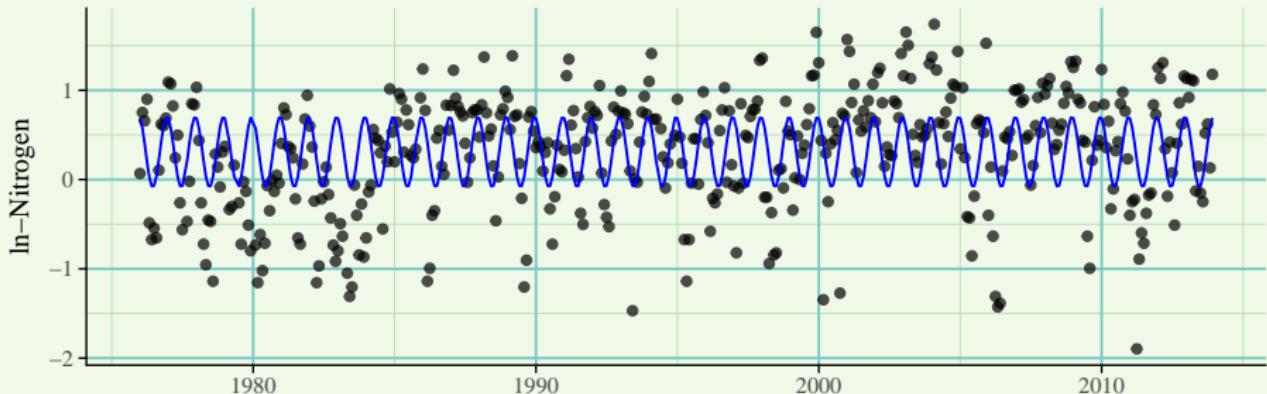
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Model theory and background

WRTDS adaptation for tidal waters

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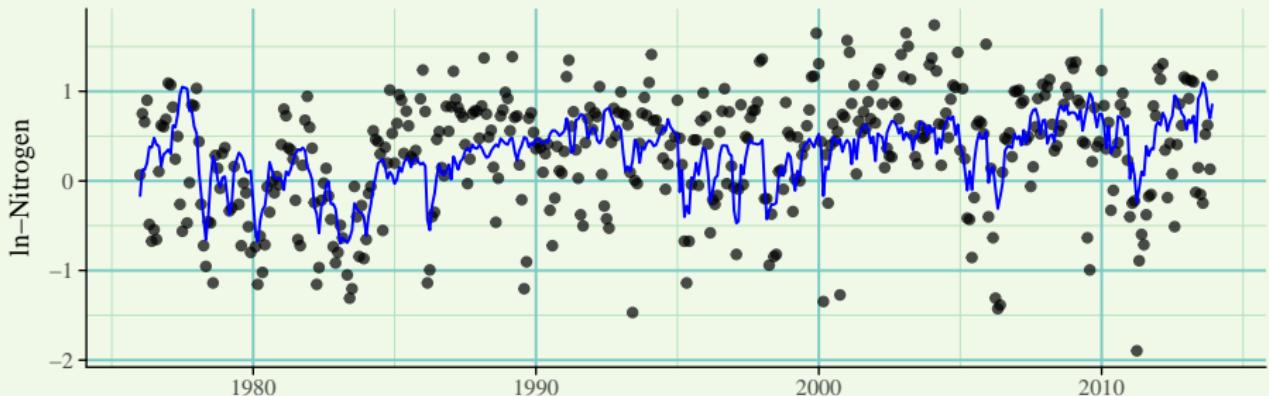
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$$\ln(N) \sim t + Sal$$



Model theory and background

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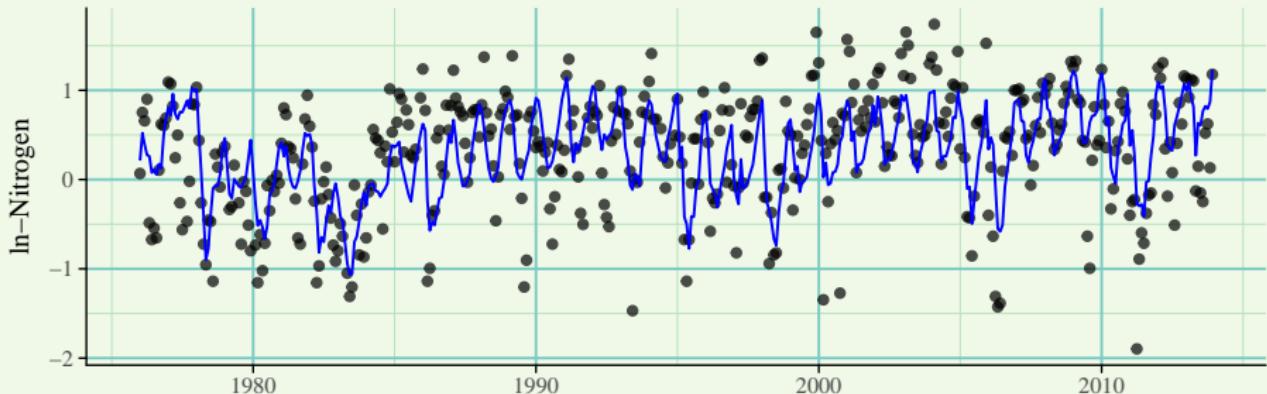
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$$\ln(N) \sim t + Sal + \cos(2\pi * t) + \sin(2\pi * t)$$



Model theory and background

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How does weighted regression work?

Model theory and background

WRTDS adaptation for tidal waters

Points: observed time series (black are weighted, grey is zero weight)

Green point: observation at the center of the regression

Blue line: Global model with weights specific to the window

Red line: Accumulated WRTDS model

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

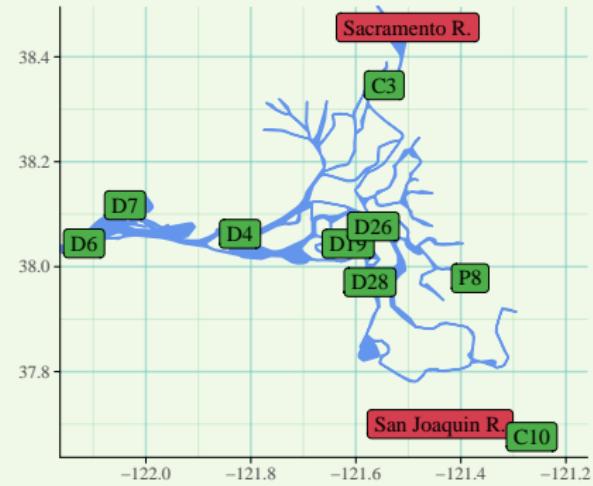


Figure: Stations (green) and flow estimates (red) modelled with WRTDS

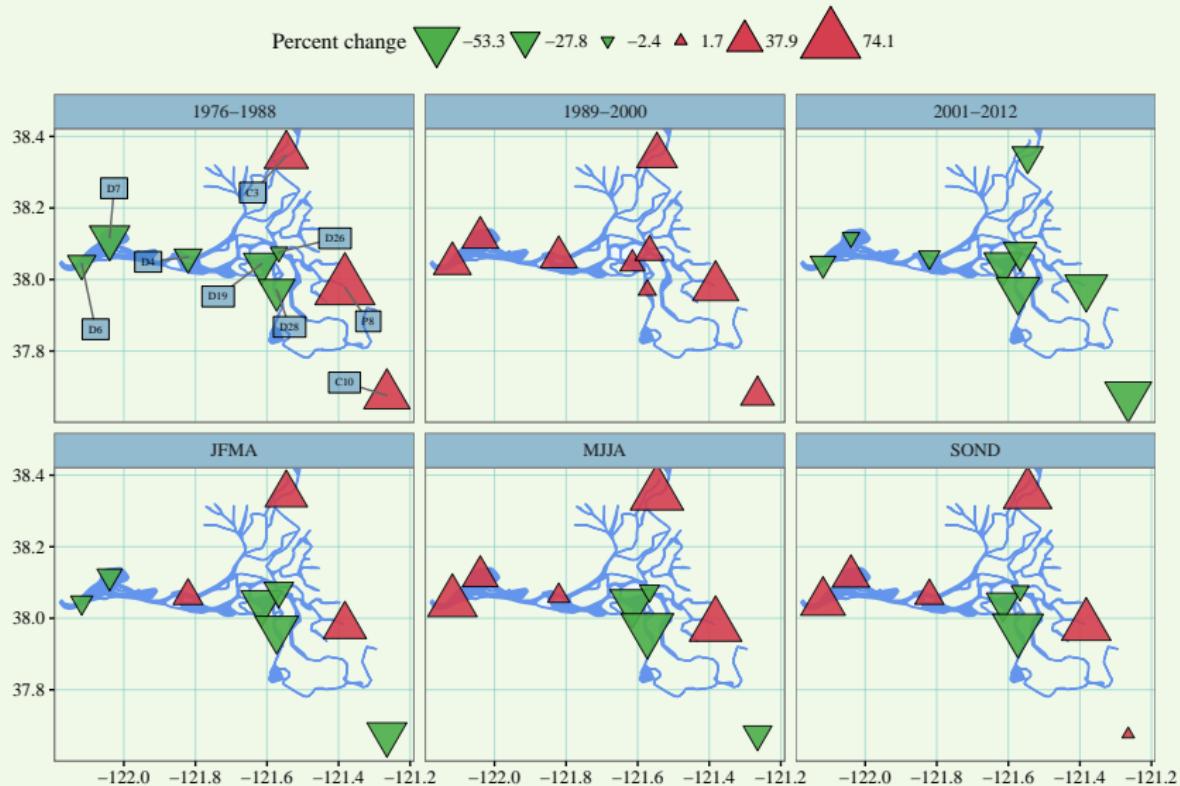
Trends over time

Nitrogen dynamics in the Delta

Predicted DIN trends, 1980-1990

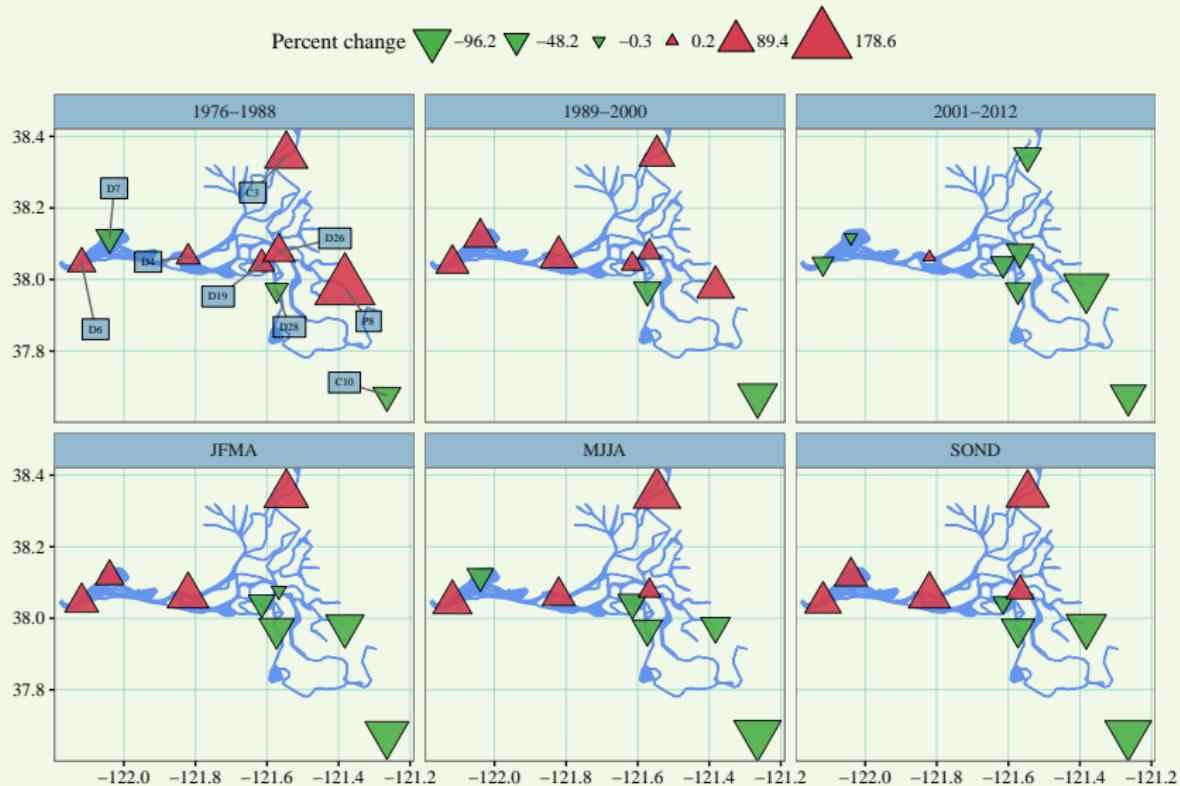
Trends over time

Nitrogen dynamics in the Delta - DIN



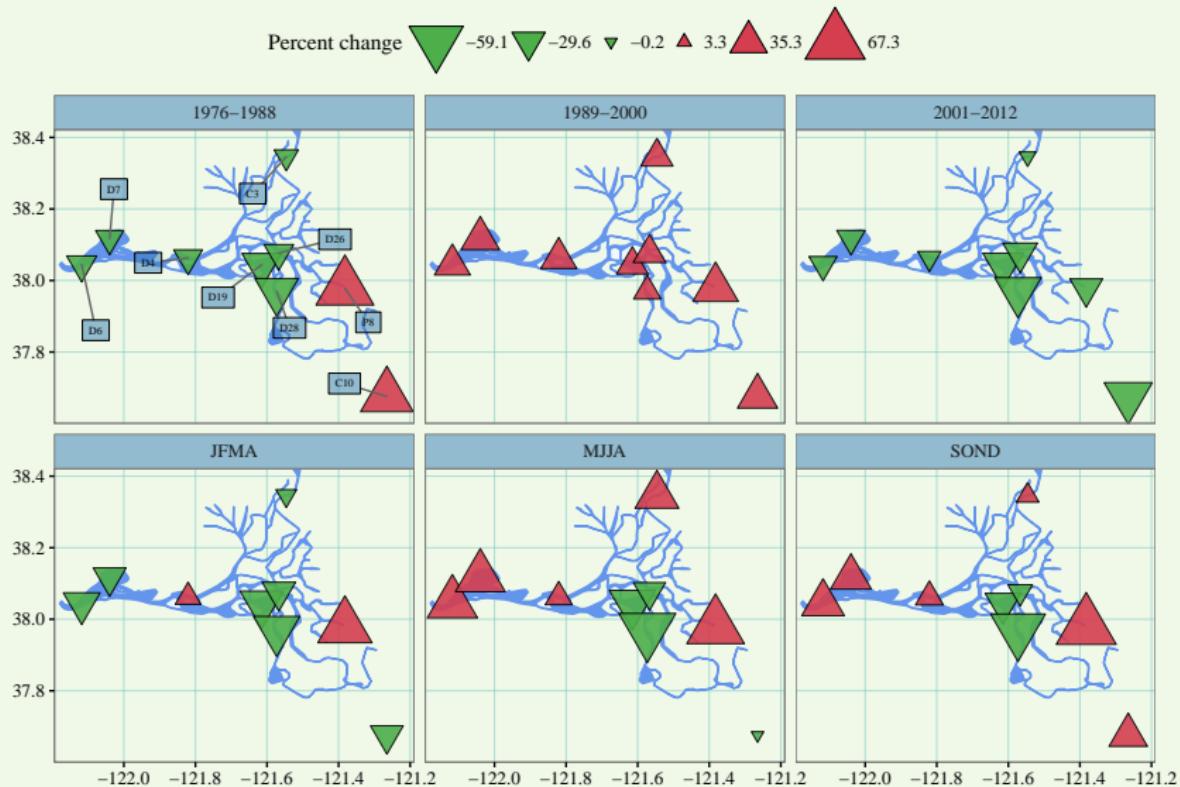
Trends over time

Nitrogen dynamics in the Delta - ammonium



Trends over time

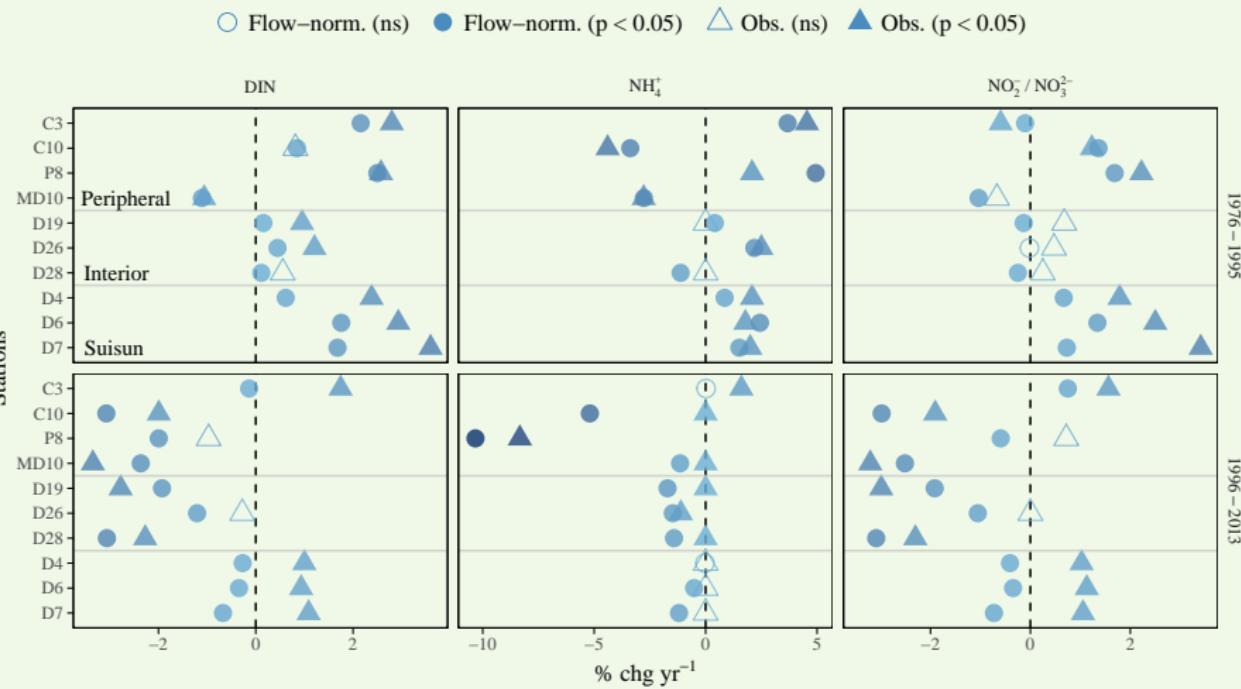
Nitrogen dynamics in the Delta - nitrite/nitrate



Trends over time

Nitrogen dynamics in the Delta

Better description of nutrient endpoints can change conclusions

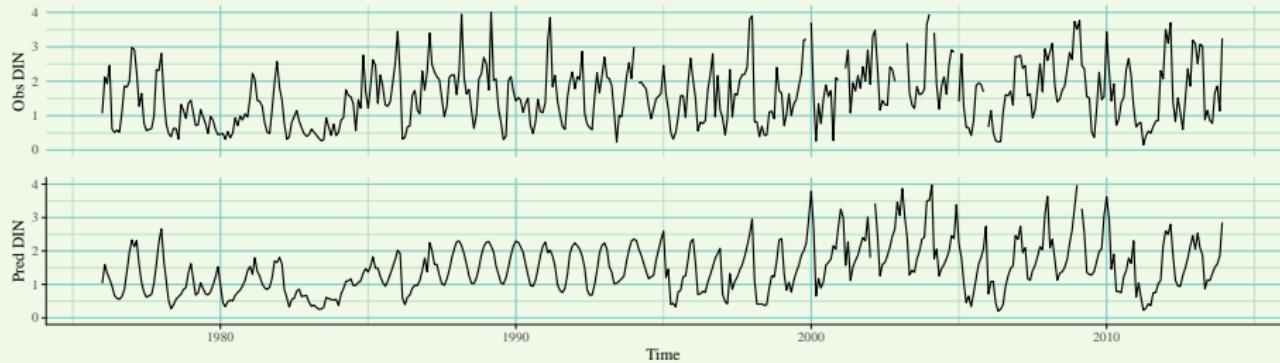


Trends over time

Nitrogen dynamics in the Delta - nitrite/nitrate

The **WRTDS** approach lets us model historical trends in relation to *time, discharge, and season*

Predicted trends follow observed... how can we leverage the results to understand drivers of environmental change?



Selected case studies

Effects of biological invasion in Suisun Bay

Hypothesis: Biological invasions by benthic filter feeders have shifted abundance and composition of phytoplankton in Suisun Bay

We should be able to *predict*:

- A decline in annual, flow-normalized chlorophyll following increase in invaders
- Varying effects of flow given complex relationships between chlorophyll and invaders

Selected case studies

Effects of biological invasion in Suisun Bay

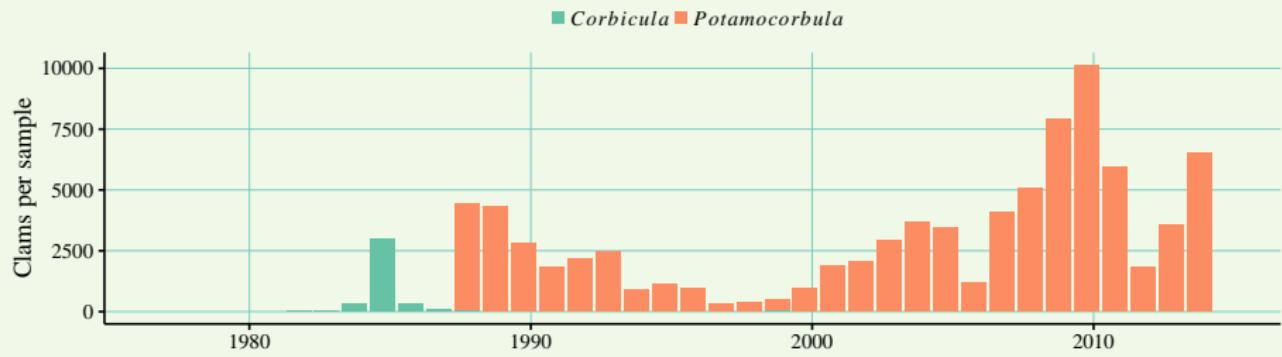


Figure: Clam density by year at D7, Suisun Bay [Crauder et al., 2016].

Selected case studies

Effects of biological invasion in Suisun Bay

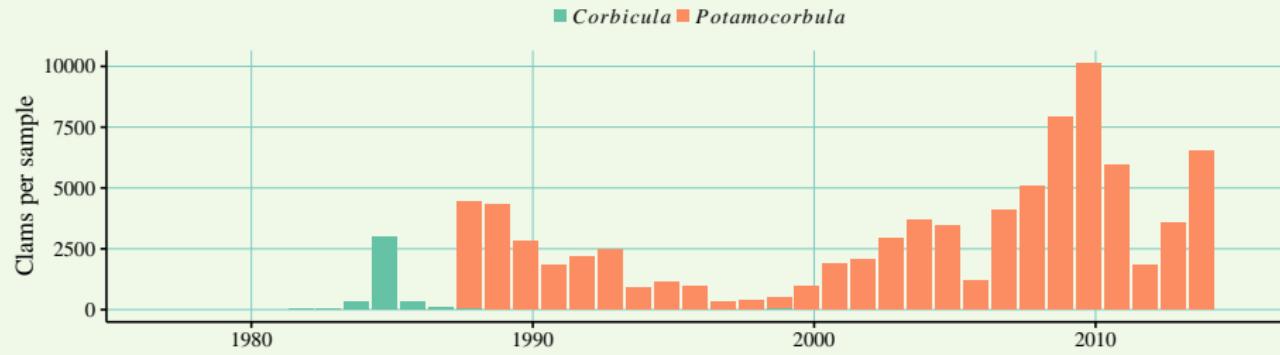


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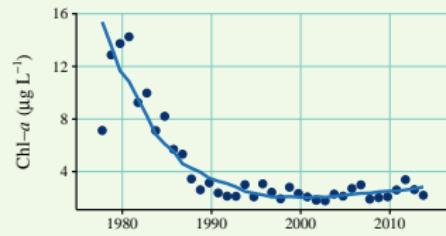


Figure: Annual predicted (points) and flow-normalized (lines) water quality data at D7.

Selected case studies

Effects of biological invasion in Suisun Bay

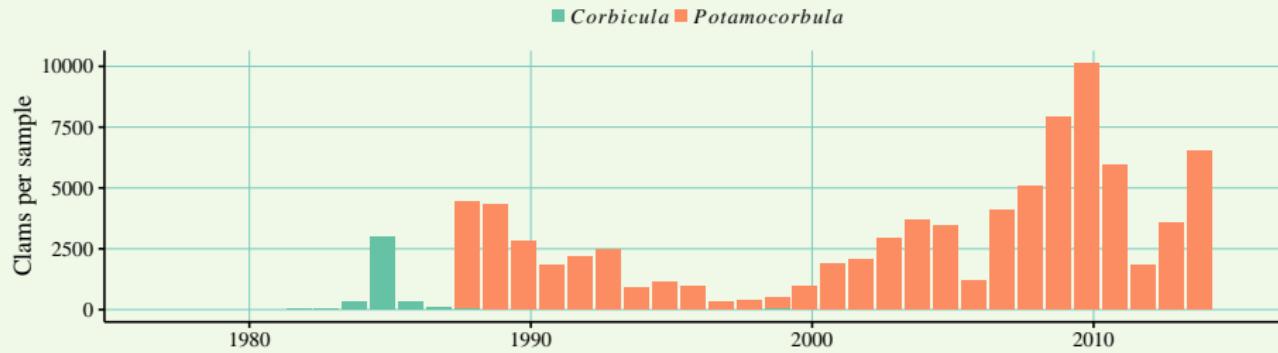


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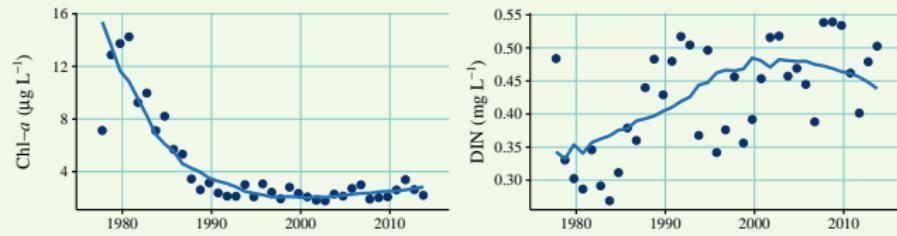


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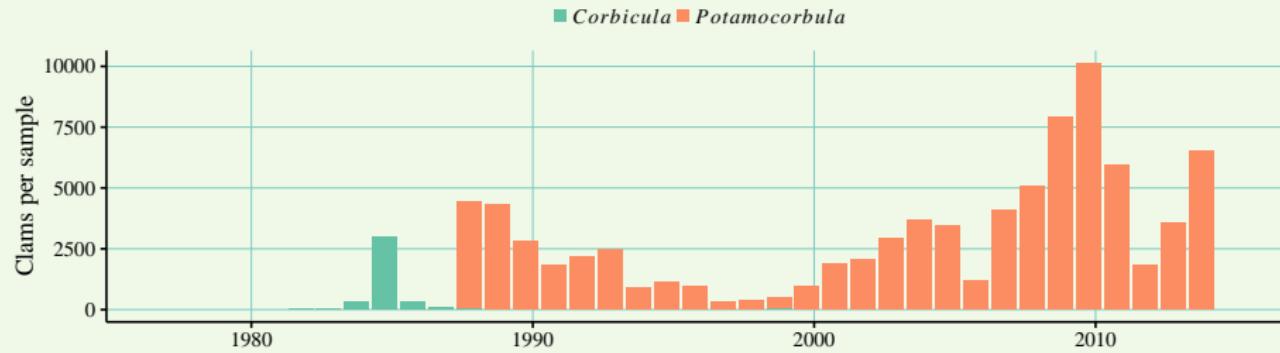


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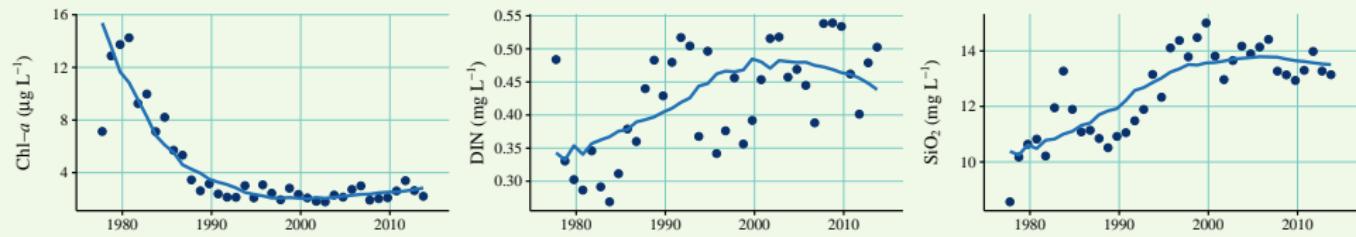
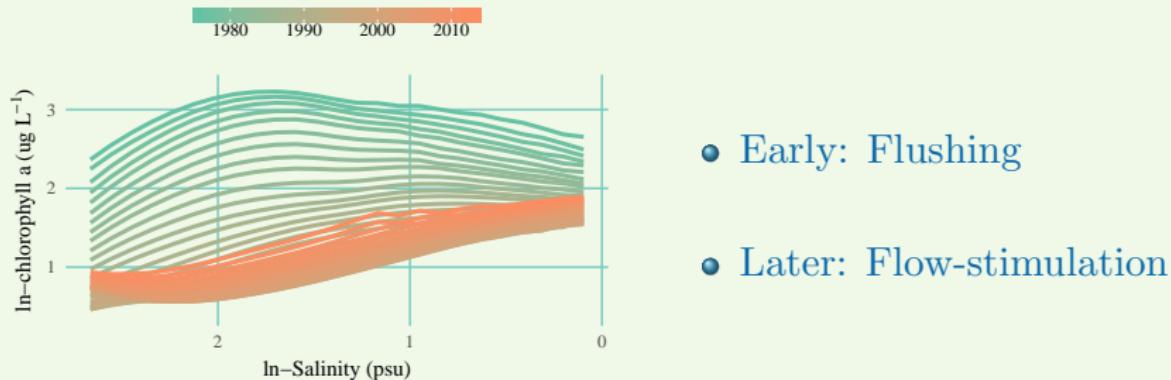


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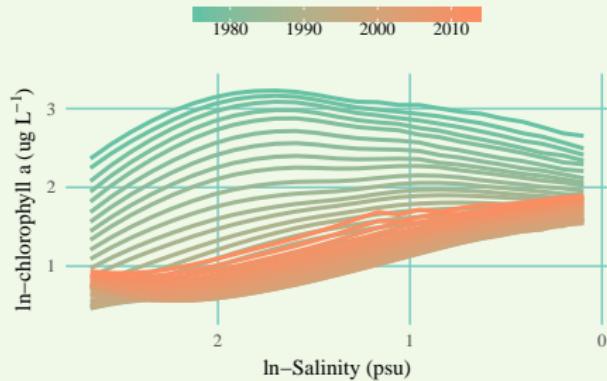
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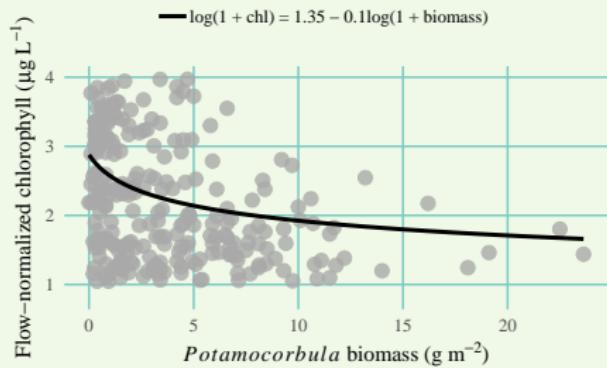


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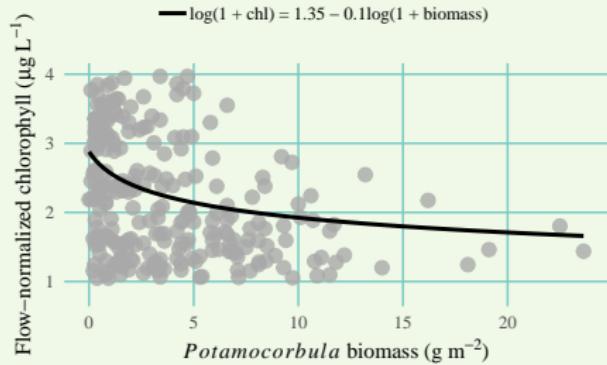
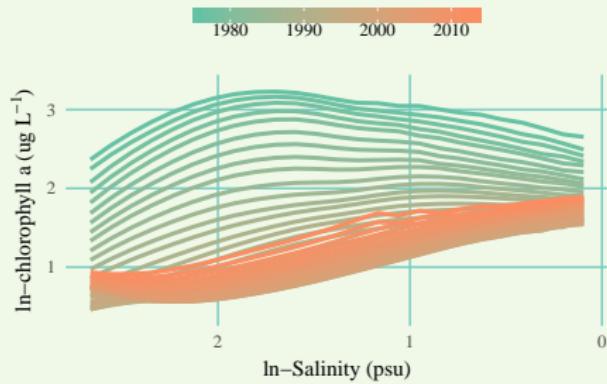


- Early: Flushing
- Later: Flow-stimulation

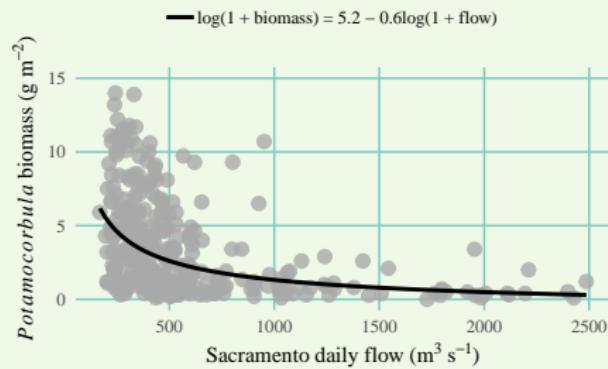


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Effects of biological invasion in Suisun Bay

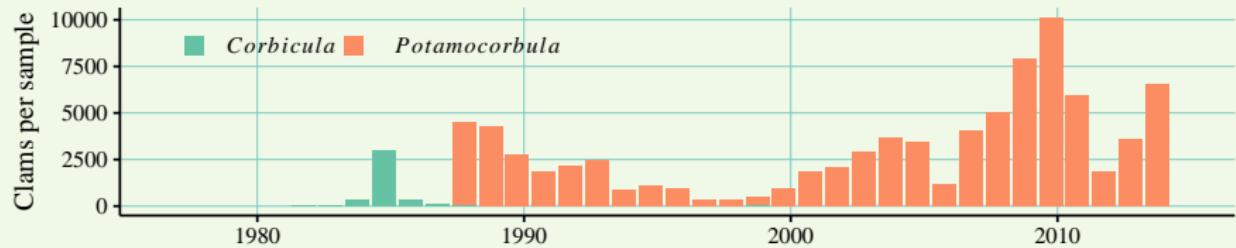


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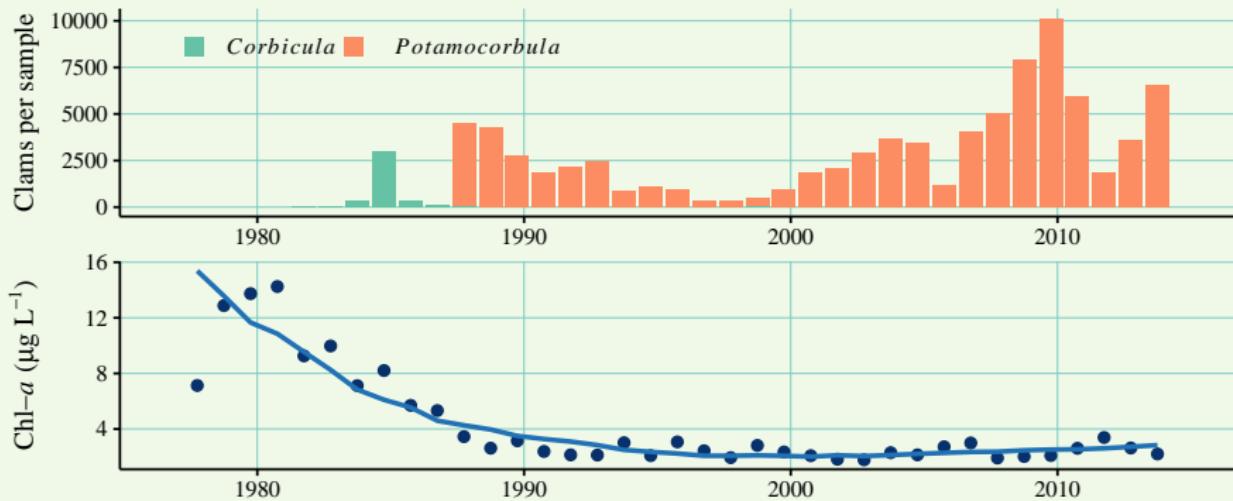
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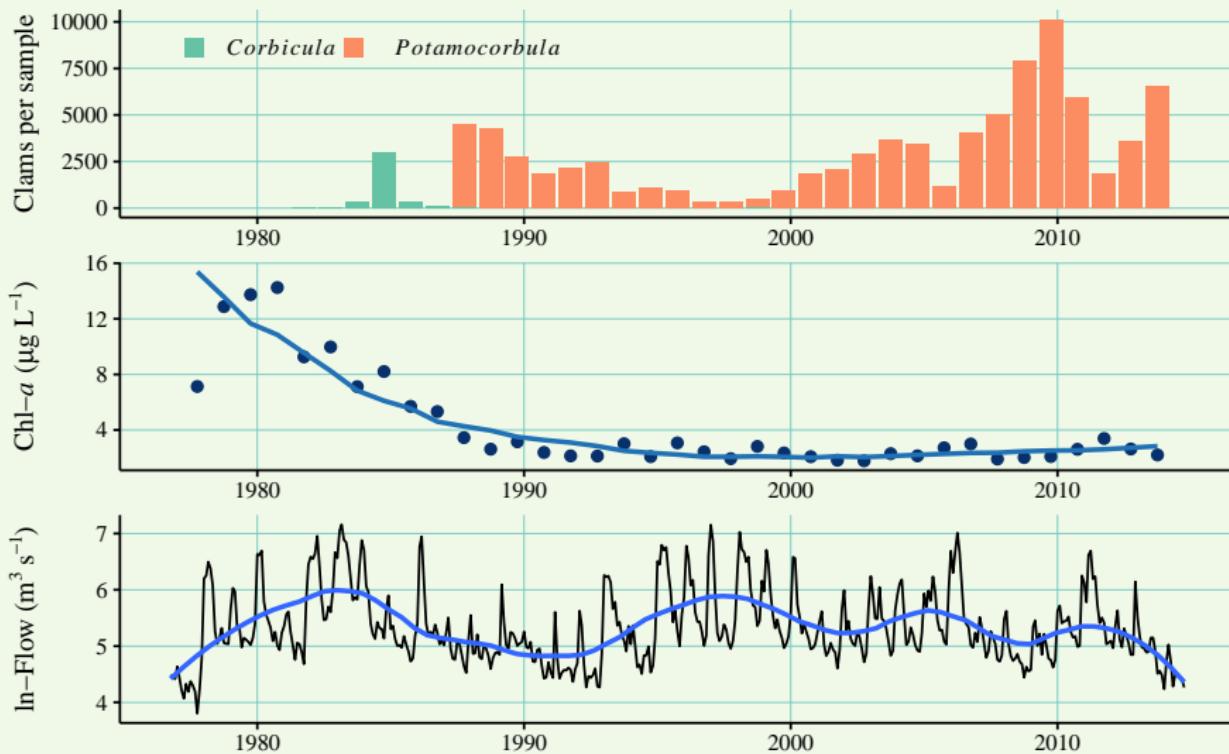
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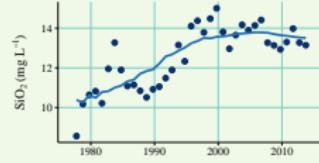
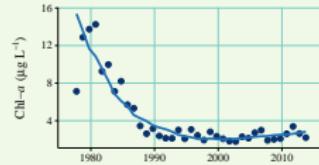


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Effects of biological invasion in Suisun Bay

Results at D7 show complex response of chlorophyll:

- Increase in clam abundance, decrease in chlorophyll
- Increase in DIN... but also increase in SiO₂

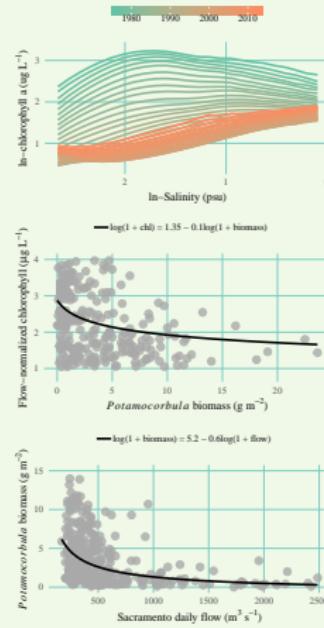


Selected case studies

Effects of biological invasion in Suisun Bay

Results at D7 show complex response of chlorophyll:

- Increase in clam abundance, decrease in chlorophyll
- Increase in DIN... but also increase in SiO₂
- Relationship with flow changed depending on physical or biological forcing



Conclusions

Lessons for monitoring and future work

Monitoring data are not particularly telling...

...so we use models or other methods to *decompose* the observations

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But we need to communicate these results to the management community and other decision makers

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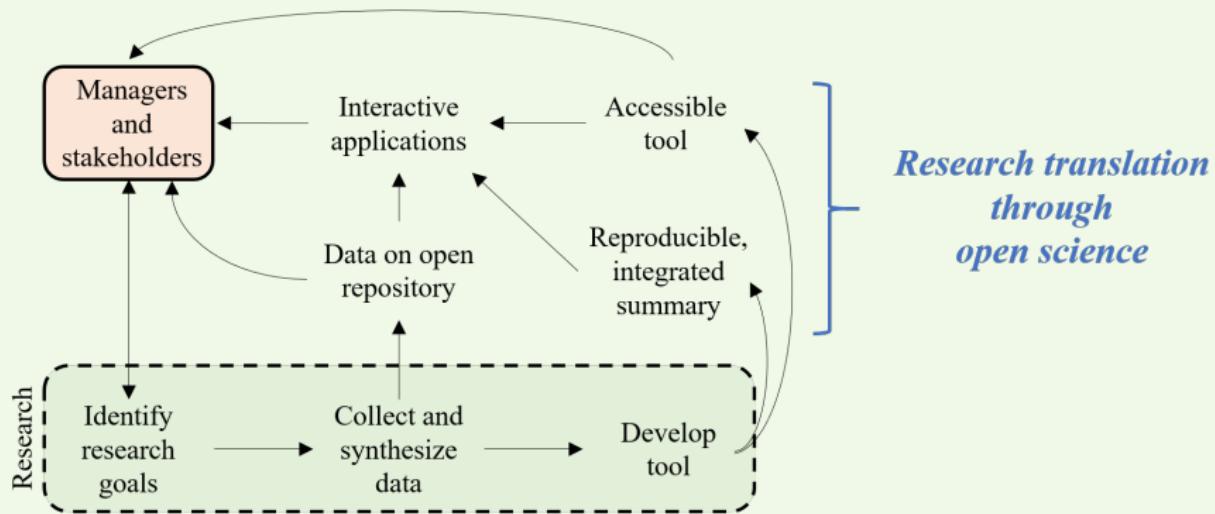
But we need to communicate these results to the management community and other decision makers

“Don’t give me another 500-page report, I won’t read it.”

— Overheard at recent meeting

An Open Science paradigm

Bridge the research-management divide



An Open Science paradigm

Bridge the research-management divide

Make your methods accessible!

<https://cran.r-project.org/web/packages/WRTDStidal/index.html>

WRTDStidal: Weighted Regression for Water Quality Evaluation in Tidal Waters

An adaptation for estuaries (tidal waters) of weighted regression on time, discharge, and season to evaluate trends in water quality time series.

Version: 1.1.1
Depends: R (\geq 3.1.2), [ggplot2](#)
Imports: [caret](#), [dplyr](#), [fields](#), [foreach](#), [forecast](#), [gridExtra](#), [lubridate](#), [purrr](#), [quantreg](#), [RColorBrewer](#), [survival](#), [tidyverse](#)
Suggests: [doParallel](#), [grDevices](#), [magrittr](#)
Published: 2018-07-16
Author: Marcus W. Beck [aut, cre]
Maintainer: Marcus W. Beck <marcusb@sccwrg.org>
BugReports: https://github.com/fawda123/wtreg_for_estuaries/issues
License: [CC0](#)
NeedsCompilation: no
In views: [Hydrology](#)
CRAN checks: [WRTDStidal results](#)

Downloads:

Reference manual: [WRTDStidal.pdf](#)
Package source: [WRTDStidal_1.1.1.tar.gz](#)
Windows binaries: r-devel: [WRTDStidal_1.1.1.zip](#), r-release: [WRTDStidal_1.1.1.zip](#), r-oldrel: [WRTDStidal_1.1.1.zip](#)
OS X binaries: r-release: [WRTDStidal_1.1.1.tgz](#), r-oldrel: [WRTDStidal_1.1.1.tgz](#)
Old sources: [WRTDStidal archive](#)

An Open Science paradigm

Bridge the research-management divide

Make your methods transparent!

<https://github.com/fawda123/WRTDStidal>

The screenshot shows a GitHub repository page for 'fawda123 / WRTDStidal'. The repository has 262 commits, 2 branches, 6 releases, 1 environment, and 1 contributor. The latest commit is 'fawda123 ready for CRAN submit v1.1.1' from Jul 15, 2018. The commit history includes several changes related to R code, raw data, and documentation.

Commit	Message	Date
R	removed doc linkage to envstats	9 months ago
data-raw	recommit	3 years ago
data	recommit	3 years ago
descrip_cache/html	fixed some typos in descrip	a year ago
descrip_files/figure-html	fixed plotly colors and axes in descrip, readme now only md, fixed em...	a year ago
man	removed doc linkage to envstats	9 months ago

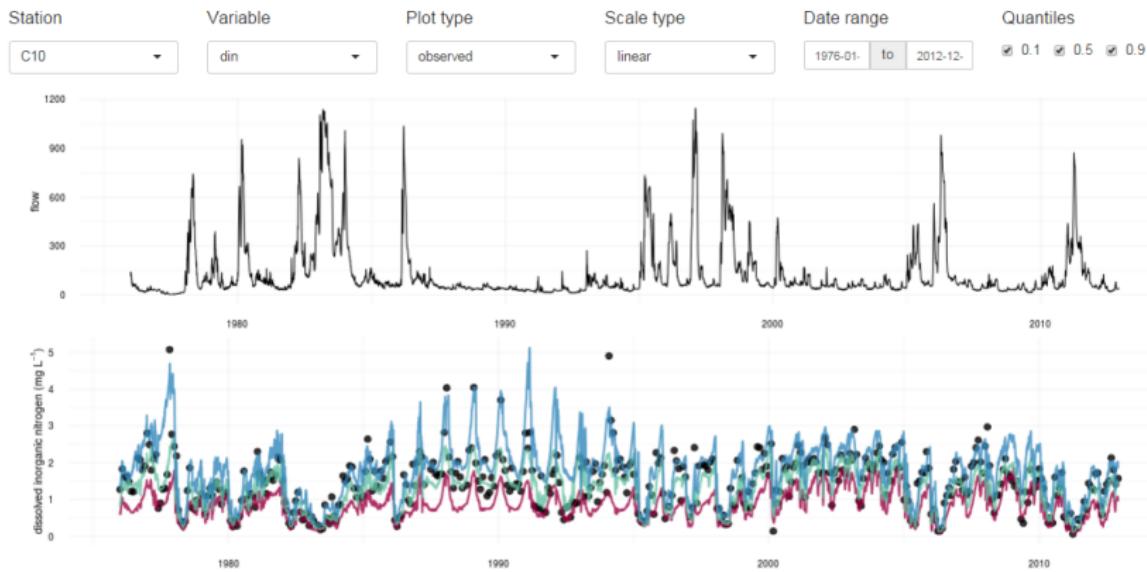
An Open Science paradigm

Bridge the research-management divide

Communicate your results!

https://beckmw.shinyapps.io/sf_trends/

Delta and Suisun weighted regression results



An Open Science paradigm

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<https://sccwrp.shinyapps.io/sfbaytrends/>

GAM evaluation - SF South Bay

Exploratory plots

The following plots show the raw data for all monitoring stations and parameters in South Bay, 1990 - 2017. Select the parameter, plot type (total time series, by year, or by month), and variable transformation. The year and month plots are aggregated boxplots of all observations at a station for each selected time period. The variable transformation can be used to show the observations in arithmetic or logarithmic space.

Choose station:

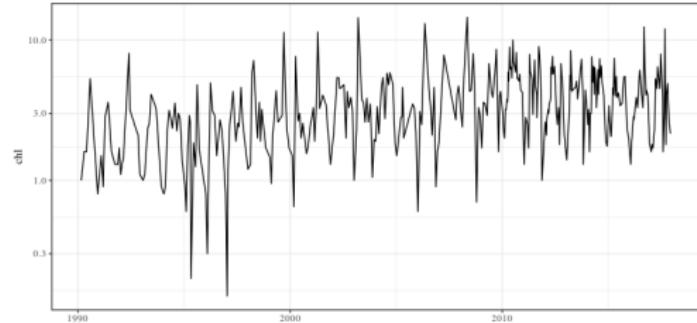
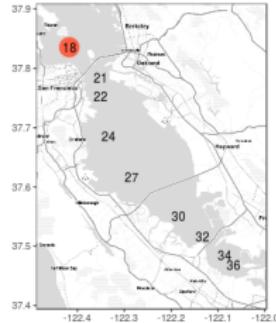
18

Choose plot type:

tot

Log-space:

TRUE



Conclusions

Lessons for data scientists

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...it is not an end in itself

Conclusions

Lessons for data scientists

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How do you use your products to reach those that need it?

Conclusions

Lessons for data scientists

Science (and data science) is a tool that is a means to an end...
...it is not an end in itself

How do you use your products to reach those that need it?

- Use relevant methods within the scope of your question
- Strive for transparency, reproducibility, and accessibility
- Use open source tools with vibrant user communities
- Be a champion within your institution to promote open science

Acknowledgments and contact info:

Research staff and employees at USEPA Gulf Ecology Division, San Francisco Estuary Institute, Southern California Coastal Water Research Project

David Senn, Thomas Jabusch, Phil Bresnahan, Emily Novick



marcusb@sccwrp.org

Phone (SCCWRP):
7147553217

Links:

This presentation: https://github.com/fawda123/sfei_pres

Shiny app: https://beckmw.shinyapps.io/sf_trends/

Detailed results: http://fawda123.github.io/sf_trends/README

Manuscript: http://fawda123.github.io/sftrends_manu

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