Nutrients, estuaries, and coffee: Memoirs of a GED post-doc

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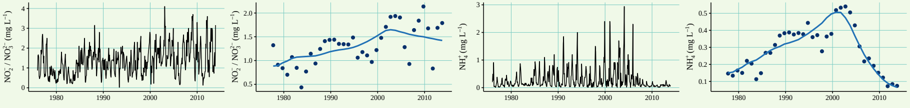
August 28, 2017

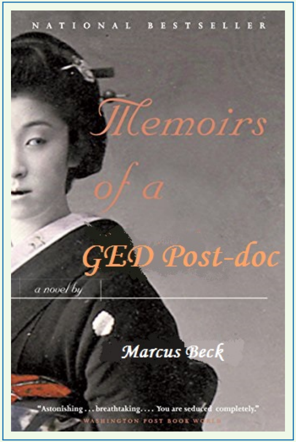


Why are we here today?

Freedom is what you do with what's been done to you.

– J. P. Sartre

Why are we here today?



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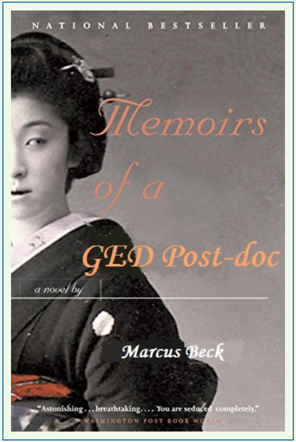

- Where did I come from?

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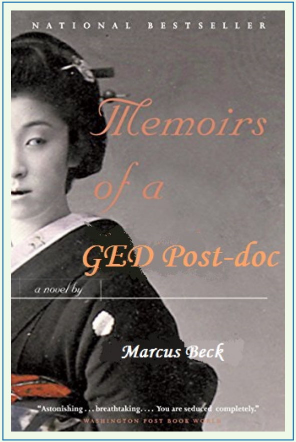
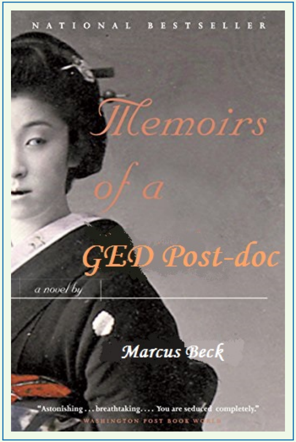


- Where did I come from?
- The ORISE experience

Why are we here today?



- Where did I come from?
- The ORISE experience
- The EPA experience

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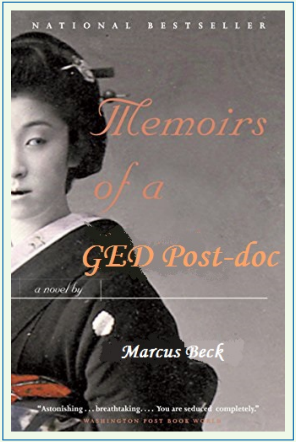
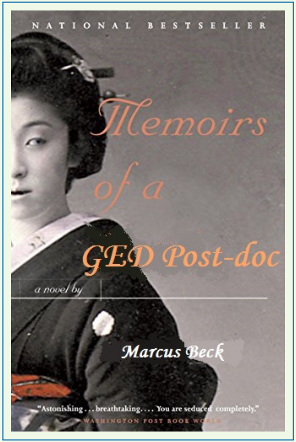


- Where did I come from?
- The ORISE experience
- The EPA experience
- The next chapter

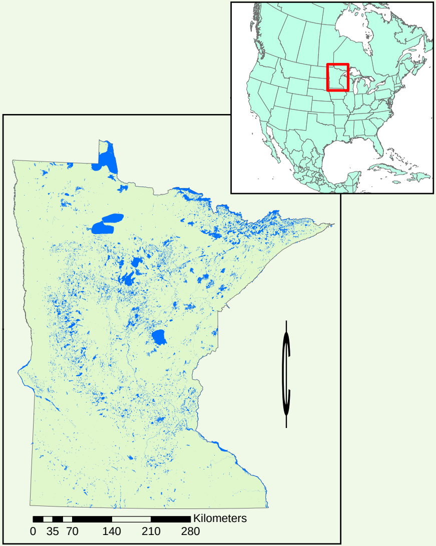
Why are we here today?

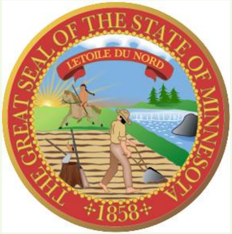


- Where did I come from?
- The ORISE experience
- The EPA experience
- The next chapter
- Final thoughts/ramblings

Where did I come from?

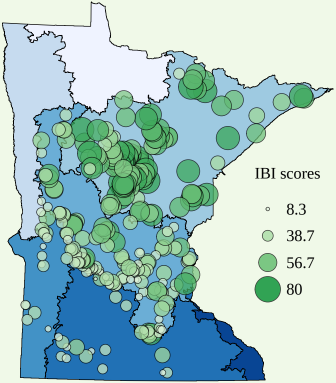
Minnesota, the land of 11,842 lakes





Where did I come from?

- Dataset of 332 vegetation surveys, courtesy of MNDNR [Beck et al., 2013, Beck et al., 2014]
- Environmental data describing lake characteristics and anthropogenic stressors



- lake surface area
- maximum lake depth
- trophic state index
- growing degree days
- percent agriculture in wshed
- percent impervious surfaces in wshed
- density of groundwater wells in wshed
- wshed area to lake area
- crop productivity index of wshed
- dock density
- ...

The ORISE experience

July 2013, moved to Pensacola

The ORISE experience

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The ORISE experience

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- ORISE is a mysterious entity

The ORISE experience

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- ORISE is a mysterious entity
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- EPA employees cannot tell you what to do

The ORISE experience

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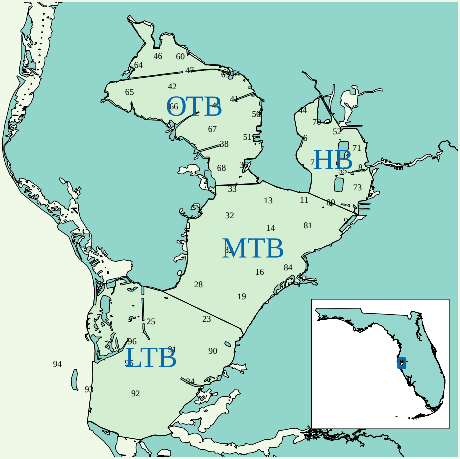
- ORISE is a mysterious entity
- You are not an EPA employee
- EPA employees cannot tell you what to do
- You are not responsible for anything

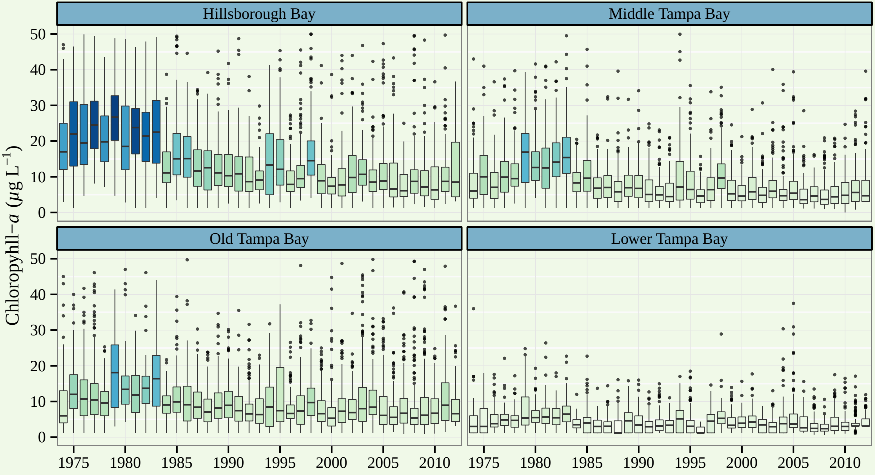
- Four bay segments
- Monthly wq data at 50 stations from 1974 to present
- Longitudinal profile of nutrient load and salinity

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



The ORISE experience

Tampa Bay trend analysis



Study objective

Adapt and apply a nutrient response model for estuaries that leverages the descriptive capabilities of large datasets [Beck and Hagy III, 2015]

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Adapt and apply a nutrient response model for estuaries that leverages the descriptive capabilities of large datasets [Beck and Hagy III, 2015]

Questions of concern – Can we...

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

Study objective

Adapt and apply a nutrient response model for estuaries that leverages the descriptive capabilities of large datasets [Beck and Hagy III, 2015]

Questions of concern – Can we...

- ...provide a natural history of water quality that is temporally consistent with drivers of change?
- ...improve our understanding of the nutrient-response paradigm in estuaries?

How does it 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)

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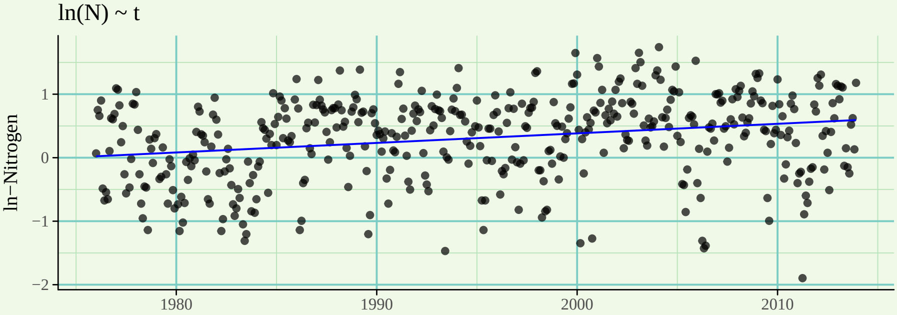

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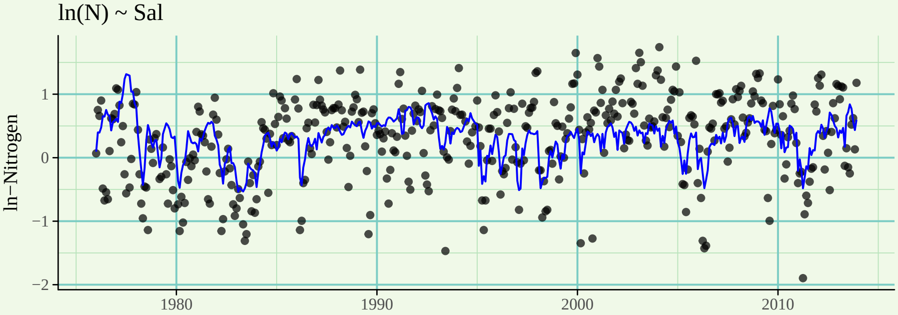

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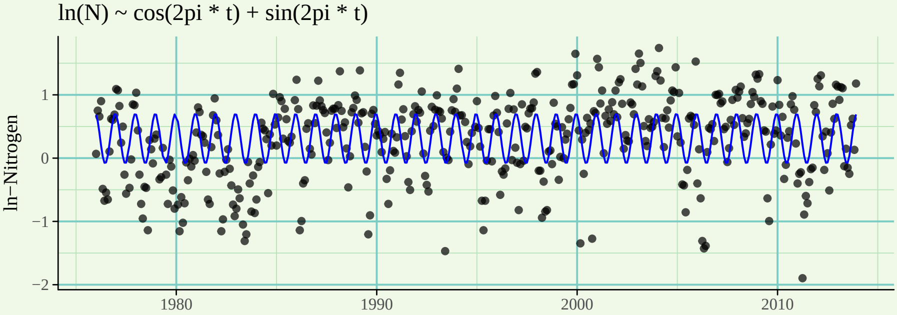

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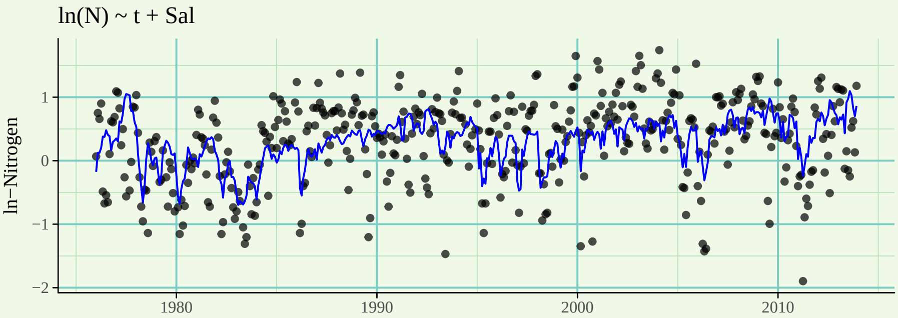

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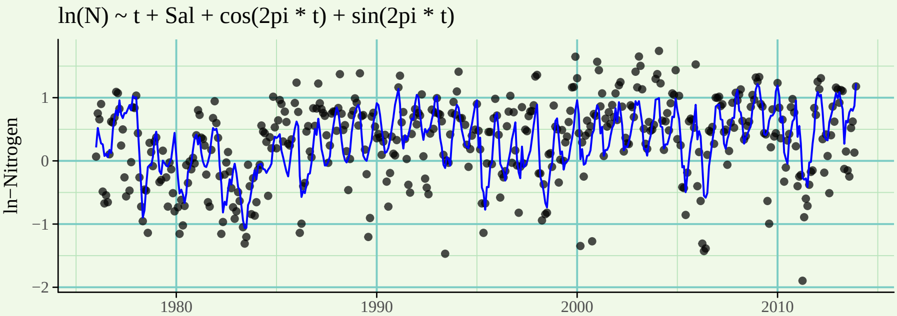
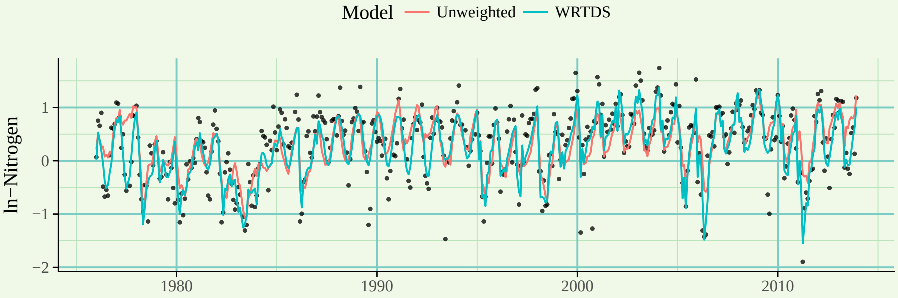


The ORISE experience

Tampa Bay trend analysis

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

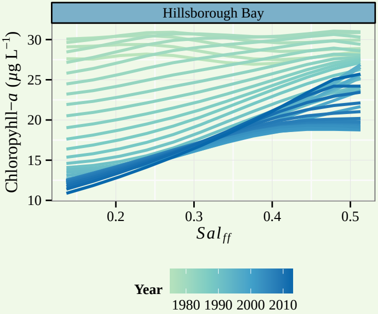
RMSE fit for unweighted = 0.58, WRTDS = 0.36



The ORISE experience

Tampa Bay trend analysis

Because the model is dynamic, we have parameters describing the relationship of chlorophyll with other factors specific to different time periods



- Early period (light blue) - point-sources
- Late period (dark blue) - non-point sources
- Chlorophyll shows increasing response to freshwater input in recent years

The ORISE experience

Tampa Bay trend analysis

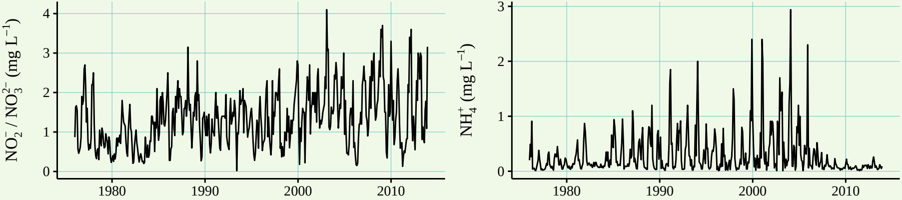
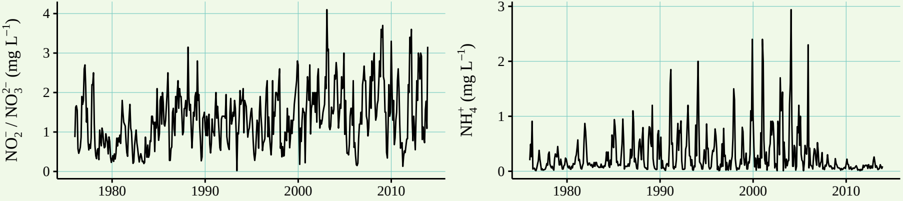


Figure : Observed nitrogen time series at P8 (SF Bay Delta RMP)



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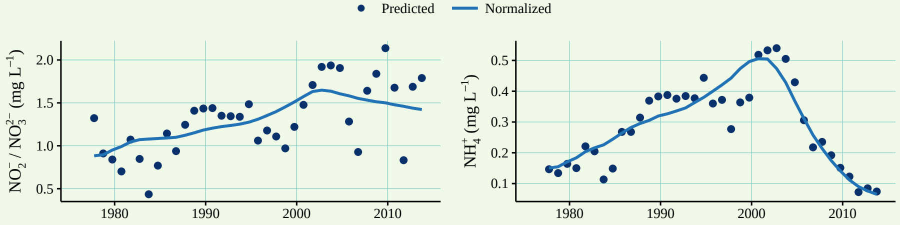


Figure : Annual predicted and flow-normalized nitrogen from WRTDS.

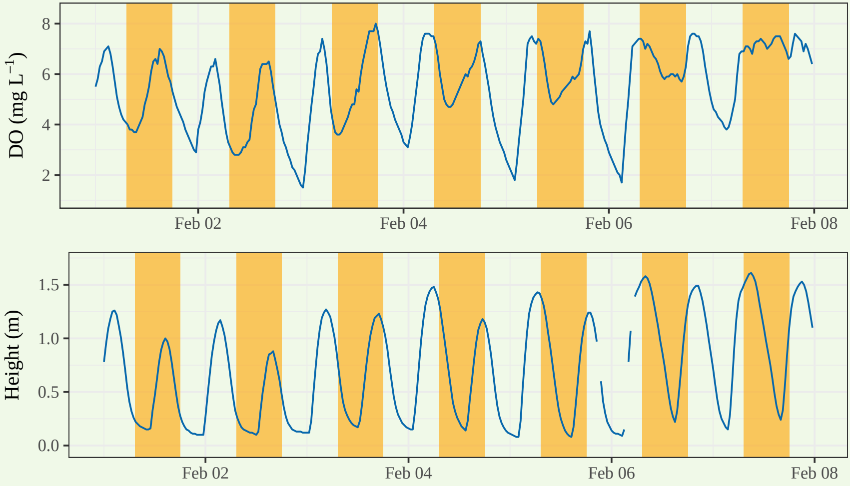
The ‘Odum’ open-water method has been used for decades to estimate rates of ecosystem metabolism [Odum, 1956]

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

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??

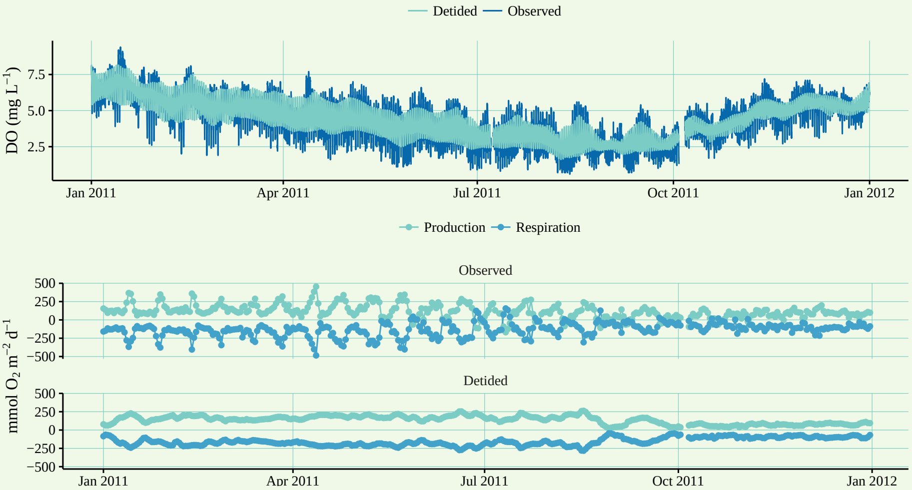
The ‘Odum’ method assumes DO represents biological processes...



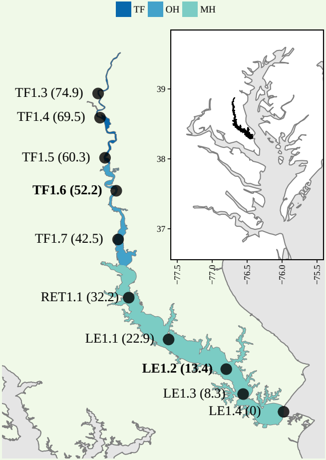
The ORISE experience

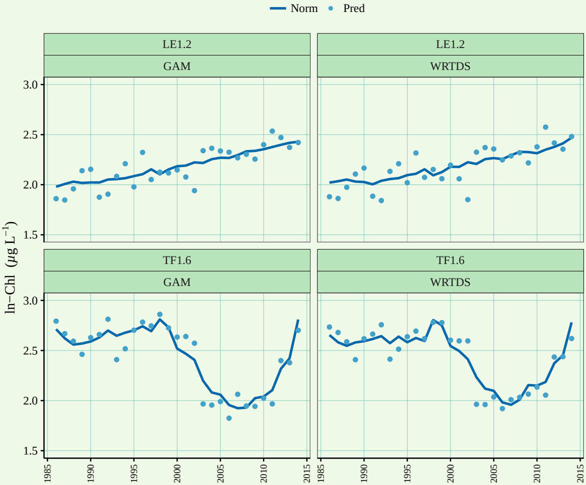
Time series detiding

DO time series and ecosystem metabolism [Beck et al., 2015]



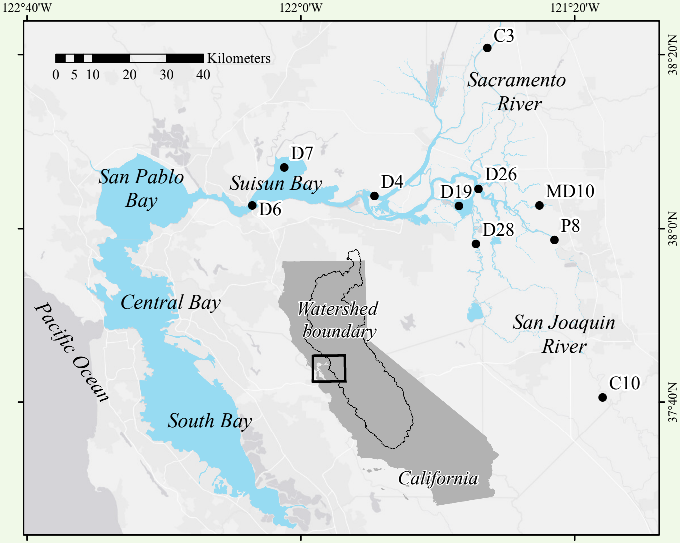
Comparing WRTDS and GAMs for trend evaluation
[Beck and Murphy, 2017]





The ORISE experience

Additional WRTDS applications - DIN changes in Delta



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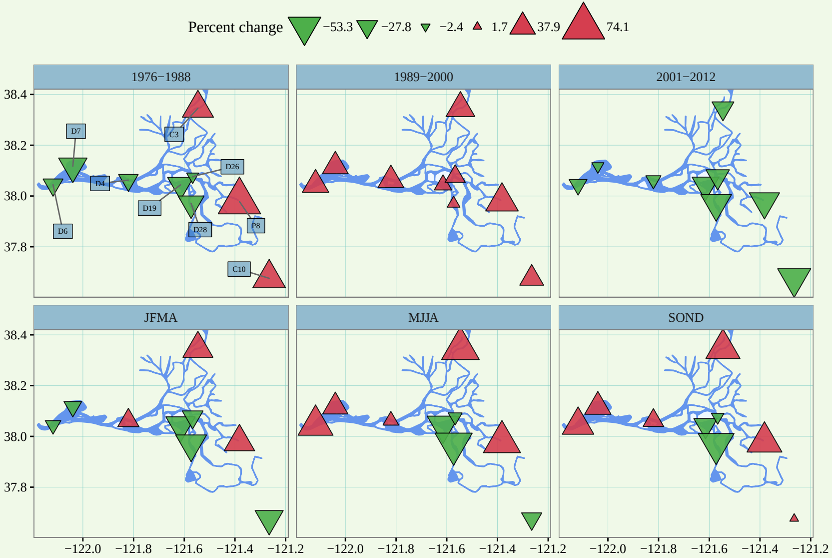
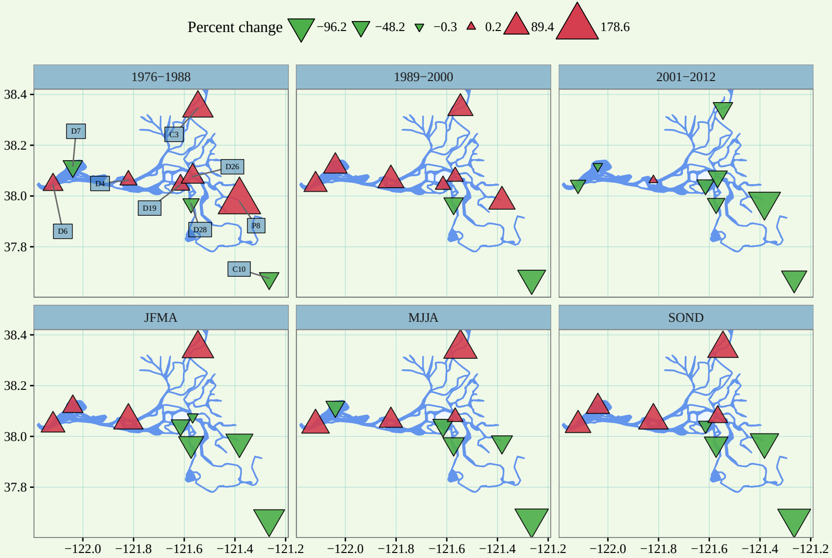
Additional WRTDS applications - ammonium changes in Delta



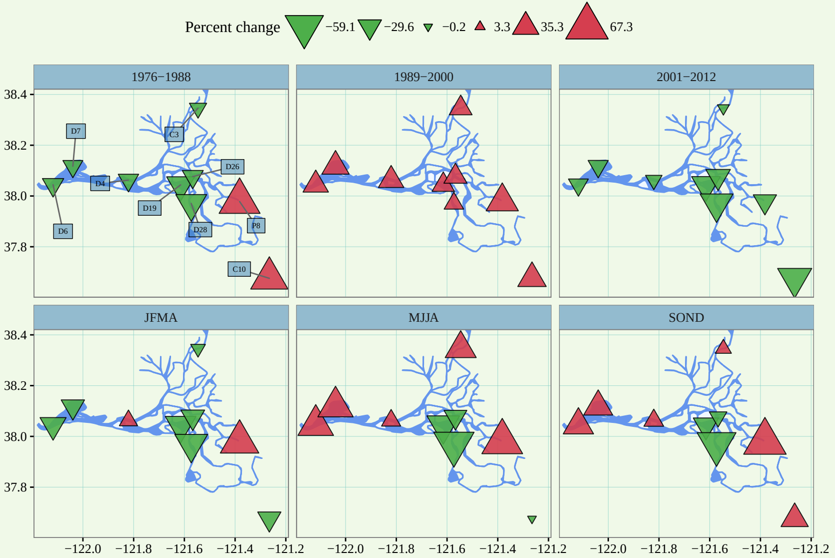
The ORISE experience

Additional WRTDS applications - nitrite/nitrate changes in Delta

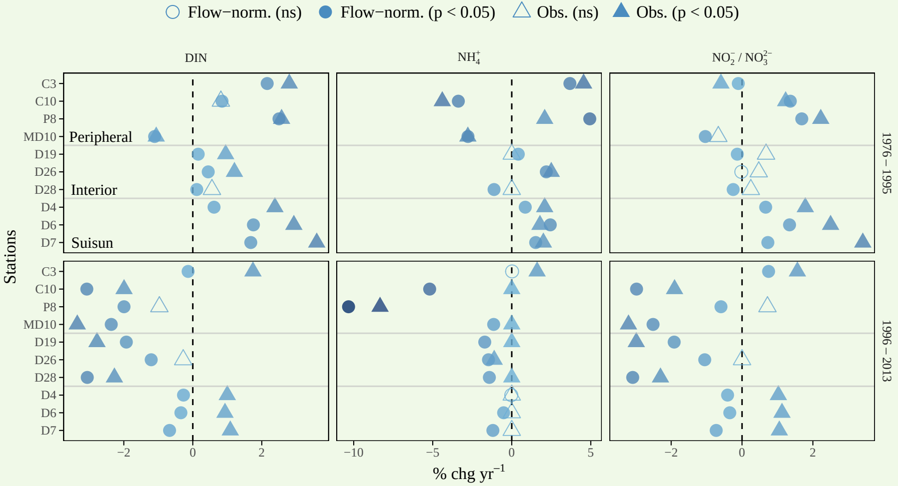


The ORISE experience

Additional WRTDS applications



Better description of nutrient endpoints can change conclusions



R-term post-doc, Dec. 2015

The EPA experience

R-term post-doc, Dec. 2015

- You are a federal employee

The EPA experience

R-term post-doc, Dec. 2015

- You are a federal employee
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The EPA experience

R-term post-doc, Dec. 2015

- You are a federal employee
- You are not a permanent federal employee
- You can't tell contractors what to do
- You move out of cubeland

The EPA experience

3.01D Watershed Sustainability

- Coral Biocriteria development

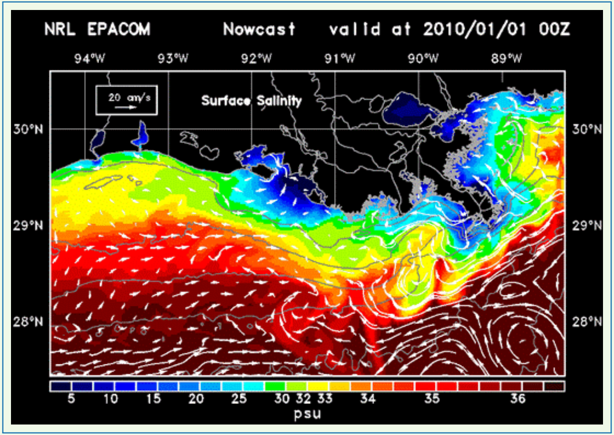
4.02A Microbial Indicators

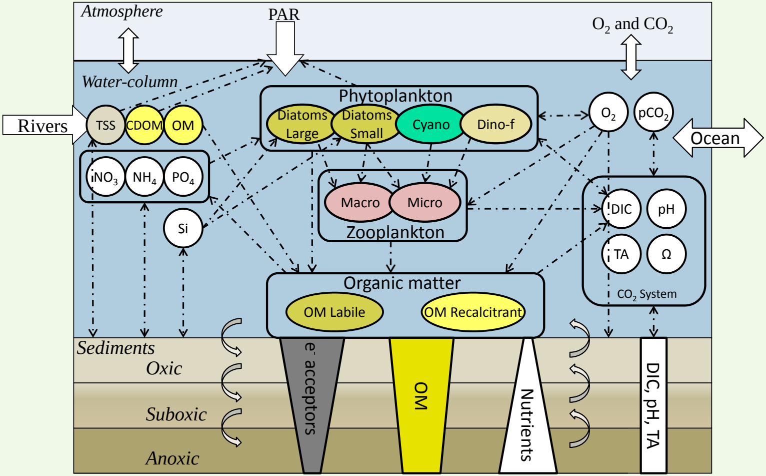
- Data munging

4.02B Nutrient Response and Recovery

- Simulation modelling of NGOM hypoxia

Community General Ecology Model

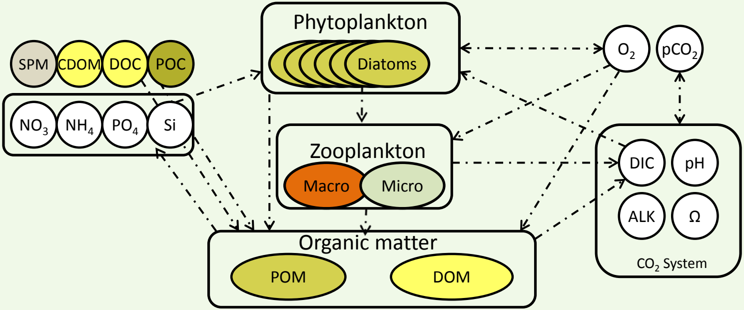




Atmosphere
PAR
O_2 and CO_2
Water-column
Rivers
TSS
CDOM
OM
Phytoplankton
Diatoms Large
Diatoms Small
Cyano
Dino-f
O_2
pCO_2
Ocean
NO_3
NH_4
PO_4
Si
Macro
Micro
Zooplankton
DIC
pH
TA
Ω
CO_2 System
Organic matter
OM Labile
OM Recalcitrant
Sediments
Oxic
Suboxic
Anoxic
e^- acceptors
OM
Nutrients
DIC, pH, TA

CGEM
ZERO DIMENSION
COMMUNITY GENERAL ECOLOGY MODEL

- 36 state variables
- 108 structural equations
- 251 parameters



Basic concepts:

Models seek to provide generality, precision, realism [Levins, 1966]

We can evaluate model uncertainty to address what a model should provide in this context

Parameter uncertainty - uncertainty in the parameter space that provides bounds on structural equations

Assumptions:

- Parameter values based on field/lab data, literature, expert judgment
- Precision/accuracy limitations due to model domain, reproducibility
- Models are over-parameterized to address all objectives

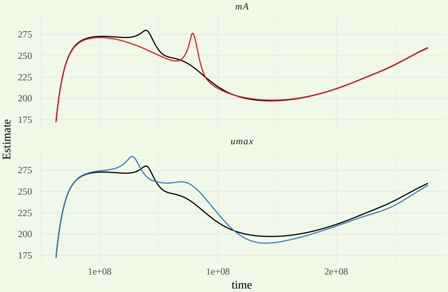
Objective: Evaluate FishTank as 0D unit for larger CGEM model, provide guidance for further refining or application to new environments

- Local sensitivity analysis and identifiability
- Parameter selection heuristics

Method: Local sensitivity analysis, single perturbation of model parameters [Soetaert and Petzoldt, 2010]

$$S_{ij} = \frac{\partial y_i}{\partial \Theta_j} \cdot \frac{w_{\Theta_j}}{w_{y_i}}$$

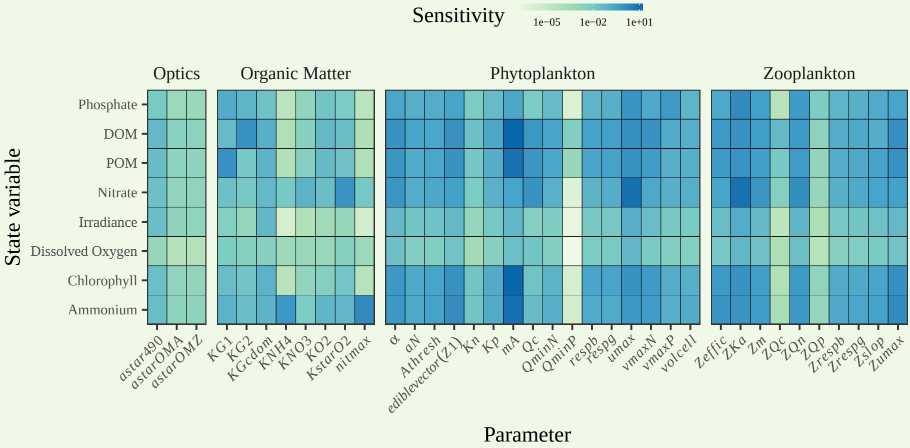
$$L_j = \sum |S_{ij}|/n$$



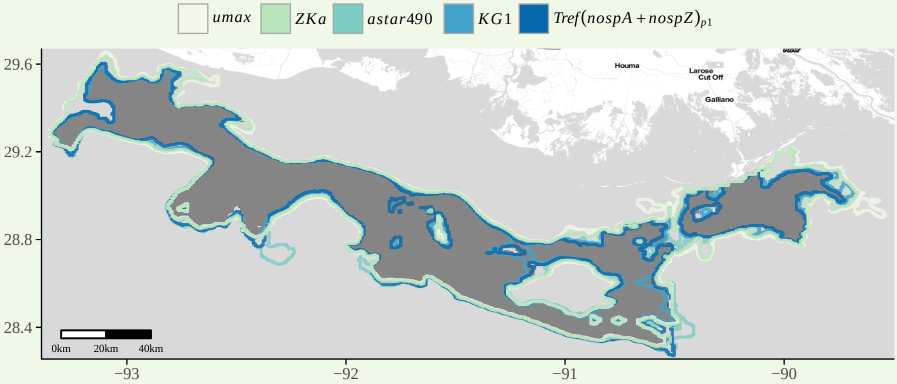
timestep	default	*umax*	*mA*
1	172.0	172.0	172.0
2	183.3	183.3	183.3
3	193.3	193.3	193.4
4	202.2	202.1	202.2
5	210.0	209.9	210.1
6	217.0	216.9	217.1

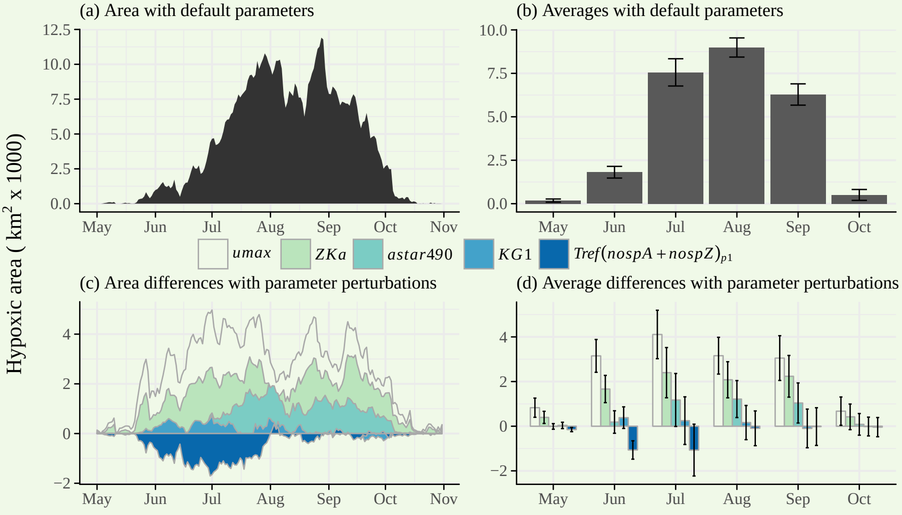
The EPA experience

4.02B Nutrient Response and Recovery



Estimated areal extents on August 28, default extent in grey



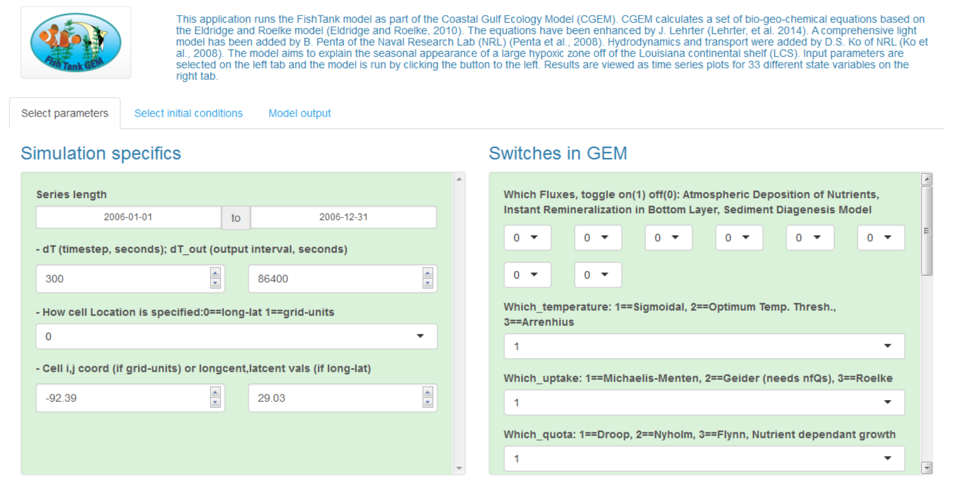

(a) Area with default parameters
(b) Averages with default parameters
(c) Area differences with parameter perturbations
(d) Average differences with parameter perturbations
Hypoxic area (km^2 x 1000)
12.5
10.0
7.5
5.0
2.5
0.0
4
2
0
−2
May
Jun
Jul
Aug
Sep
Oct
Nov
$umax$
ZKa
$astar490$
$KG1$
$Tref(nospA + nospZ)_{p1}$

Ongoing

- How do these analyses depend on interactions between variables?
- How can this inform evaluation of structural or observational uncertainty?
- Can we use this information to develop better understanding of hypoxia development?
- Manuscript in revision, interactive GUI for FishTank

The EPA experience

4.02B Nutrient Response and Recovery



The next chapter

Final thoughts

Sincere thank-yous

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