
Source: C. Benton

NMS Science Program Update

1. Program Overview
2. Update on Major Activities
    1. Numerical Modeling
    2. Harmful Algae Blooms
    3. Dissolved oxygen in margin habitats
3. Work Ahead

D Senn, R Holleman, Zephyr Sylvester, L MacVean, M McKibben

San Francisco Estuary Institute

and MANY regional collaborators

sfbaynutrients.sfei.org

Key Collaborators

SFEI

R Holleman

L MacVean

M McKibben

Z Sylvester

D Senn

USGS-Menlo Park

J Cloern

L Lucas

T Schraga

C Martin

E Nejad

USGS-Sacramento

M Downing-Kunz

G Shellenbarger

D Schoellhamer

B Downing

B Bergamaschi

UC Santa Cruz

R Kudela

SCCWRP

M Sutula

UC Berkeley

M Stacey

Reports and Work Products

Nutrient Strategy work products are available below, organized by Work Element. This list is regularly updated as new reports become available in draft and final versions.

Annual Reports

2015 NMS FY2015 Annual Report

2016 NMS FY2016 AnnualReport

Work Element 1: Nutrient Program Administration

2012 Nutrient Strategy Nov 2012

2016 NMS Science Plan Report Sep2016

Work Element 2: Define the problem

2014 Nutrient Conceptual Model Draft Final

2014 Suisun Synthesis I

2014 External Nutrient Loads to SF Bay

2015 Lower South Bay Synthesis Report June 2015

2016 Nutrient sources, sinks and transformations in the Delta (MainReport Jan 2016)

2016 Summary and Evaluation of Delta Subregions for Monitoring and Assessment

- Link to technical appendices (Summary and Evaluation of Delta Subregions for Monitoring and Assessment)

Work Element 4: Establish Guidelines

2011 SF Bay NNE Development Lit Review

SF Bay AF Meeting Summary Feb 2014

Proposed Workplan for Assessment Framework Development

Work Element 5: Monitoring Program Development and Implementation

2014 Monitoring Program Development Plan Aug 2014

2014 Algal Pigment Final Report

2014 Moored Sensor Yr1 Progress Report

2015 SPATT (Algal Toxins) Final Report May 2015

Work Element 6: Modeling Strategy

2014_Detailed Modeling Workplan.pdf

FY2016 Modeling Plan

www.sfbaynutrients.sfei.org

NMS FY2016 Annual Report

Emily Novick
Phil Bresnah
Rusty Hollem
Zephyr Sylves
David Senn

SAN FRANCIS

Draft August
SFEI Publicat

NMS 10-year Science Plan

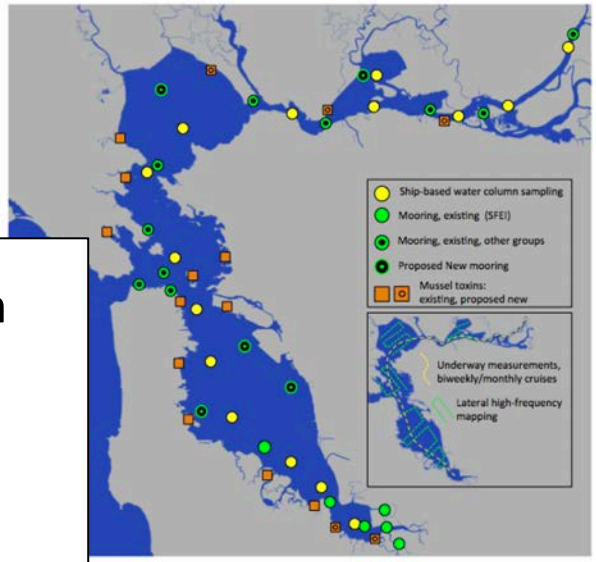
San Francisco Bay
Nutrient Management Strategy
Science Plan

March 15 2016

SFEI AQUATIC SCIENCE CENTER

1

San Francisco Bay Nutrient Management Strategy Observation Program



December 2016

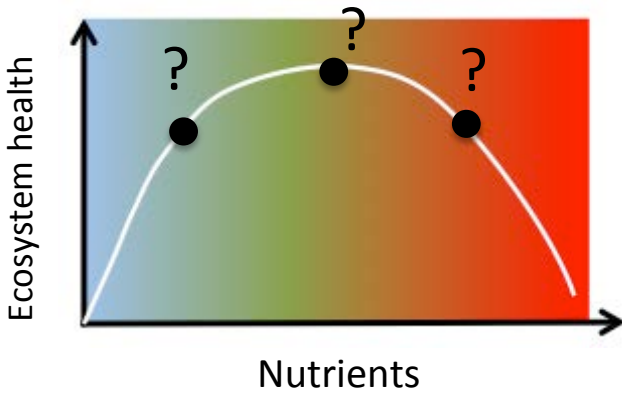
www.enviz.org

Does SFB have nutrient problems?

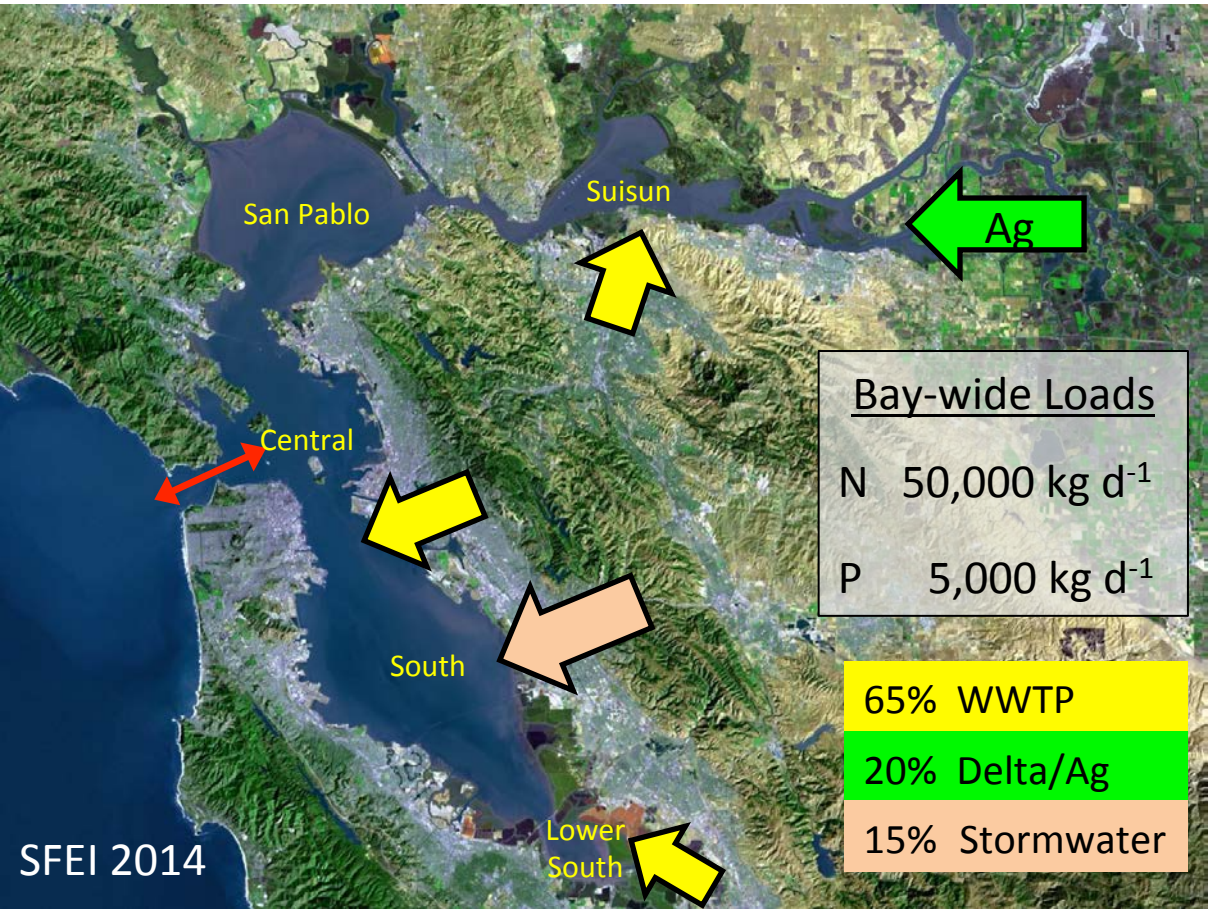
- now?
- future?

How can impacts be mitigated or prevented?

- $5-10bill question



- Large algae blooms
- Low DO
- Harmful algae, toxins



- Largest CA estuary
- Drains 40% of CA

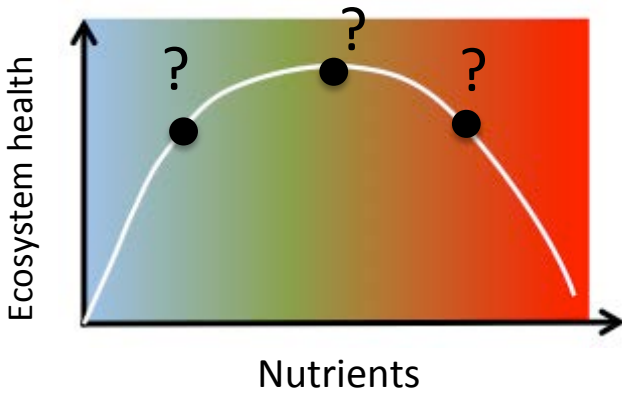
- WWTPs
  - Bay 37 7.4 mill
  - Delta 4 2.0 mill

Does SFB have nutrient problems?

- now?
- future?

How can impacts be mitigated or prevented?

- $5-10bill question



- Large algae blooms
- Low DO
- Harmful algae, toxins

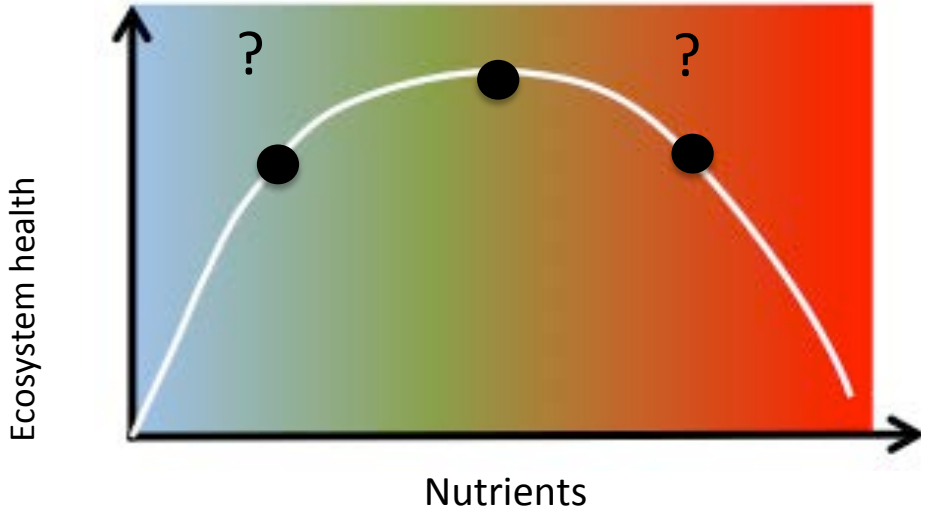
SFB doesn't use most of its nutrients

1. High turbidity
2. Strong tidal mixing
3. Filter-feeding clams

Historically: Resistant to classic eutrophication symptoms

Recently: Evidence of changing response to nutrients

What would a problem look like?

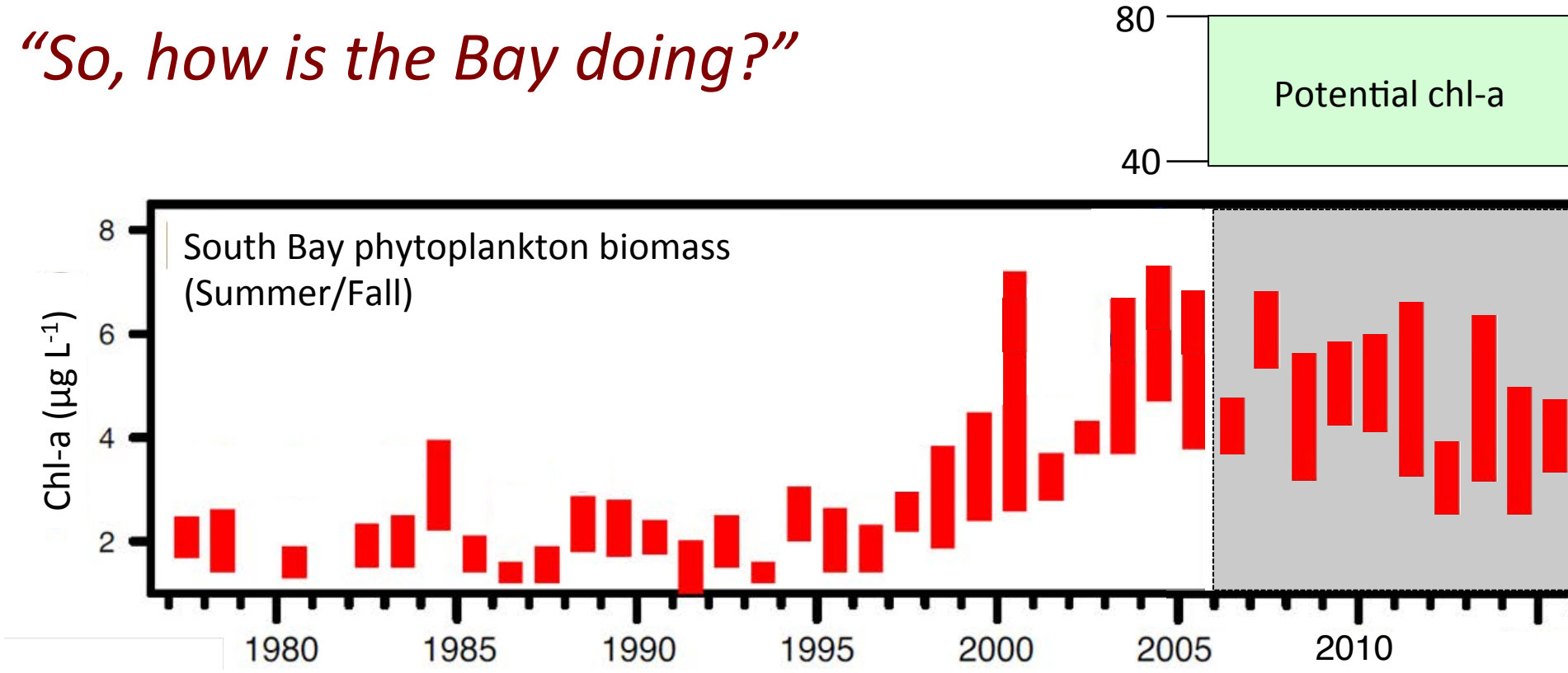


Problems Now

Problems in the Future

- Large algae blooms — Several weeks/months, 20+ µg/L
- Low DO — DO < 5 mg/L, extended periods of time
- Harmful algae, toxins — HAB-species → toxins → biota → adverse effects

"So, how is the Bay doing?"



Still changing…

- South Bay and Lower South Bay appear to have reached a new 'state'
  - 2-3x-higher Fall biomass, with unknown cause
- Causes poorly understood…
  - Climate Oscillations (changes in upwelling, coastal currents)
  - Decreased grazing by benthos
  - Decreased suspended sediments

Cloern et al. 2007

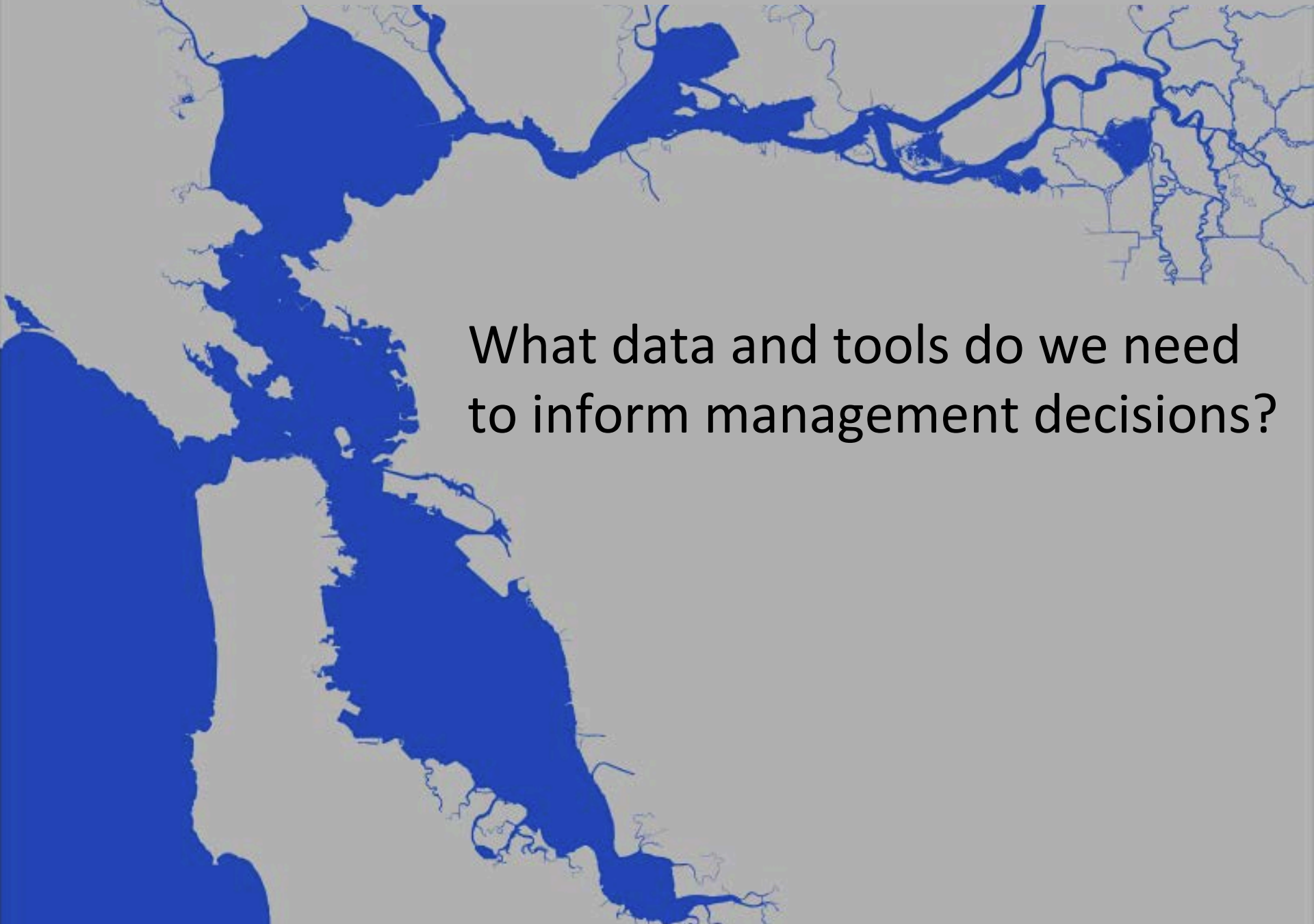
Data: USGS
SFEI 2016

Major Focus

1. Nutrient sources, movement, transformations

2. Ecosystem response to nutrients
   - Causing problems?
   - Develop best-possible understanding of dose:response
   - What are protective nutrient levels? (now, future)

3. What management actions will maintain nutrients at protective levels?
   - Which would be most efficacious and cost-effective?



What data and tools do we need to inform management decisions?

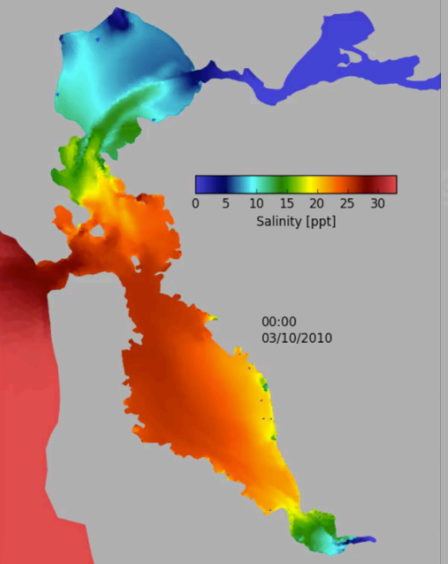
NMS Observation and Forecasting Program

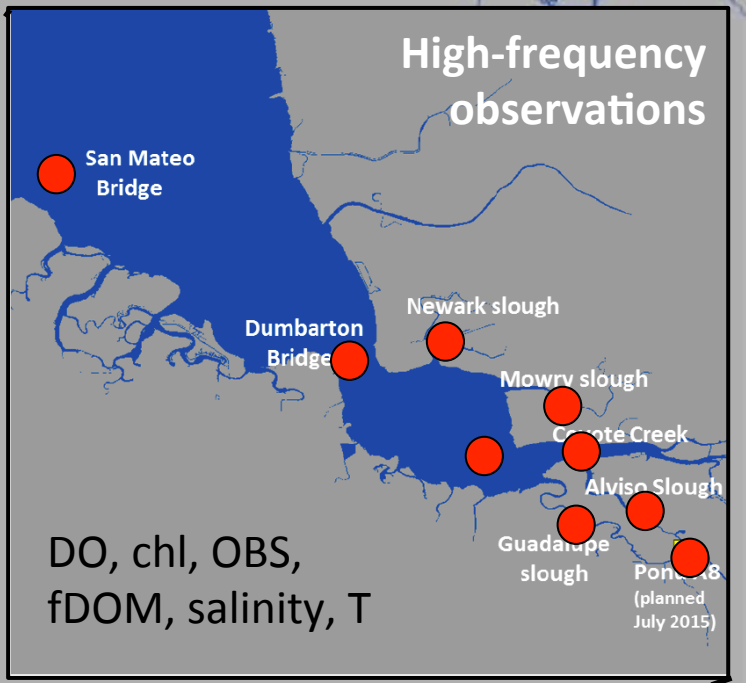
Ship-based monitoring, with USGS

Mussels

USGS *R/V* Peterson

Numerical Modeling





Understanding nutrient loads, transport, cycling and effects

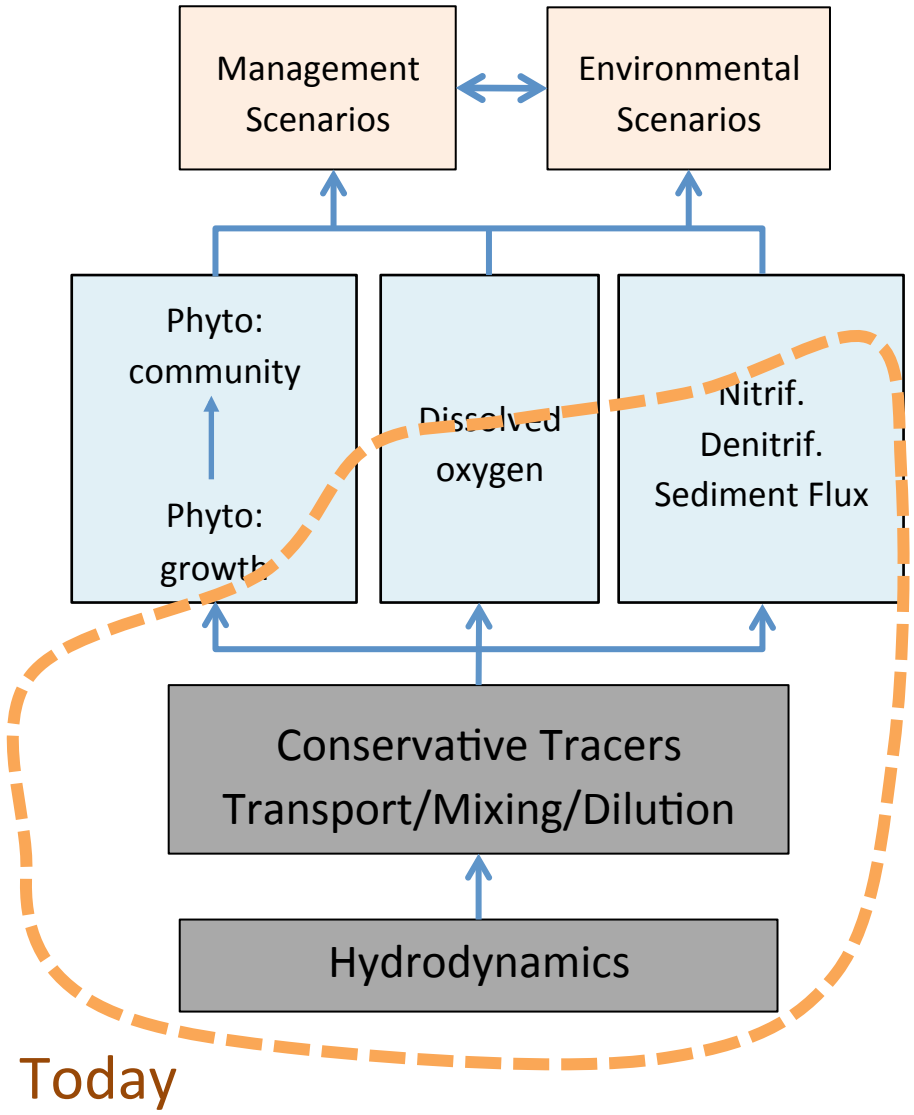
Modeling → Quantitatively integrate complex information

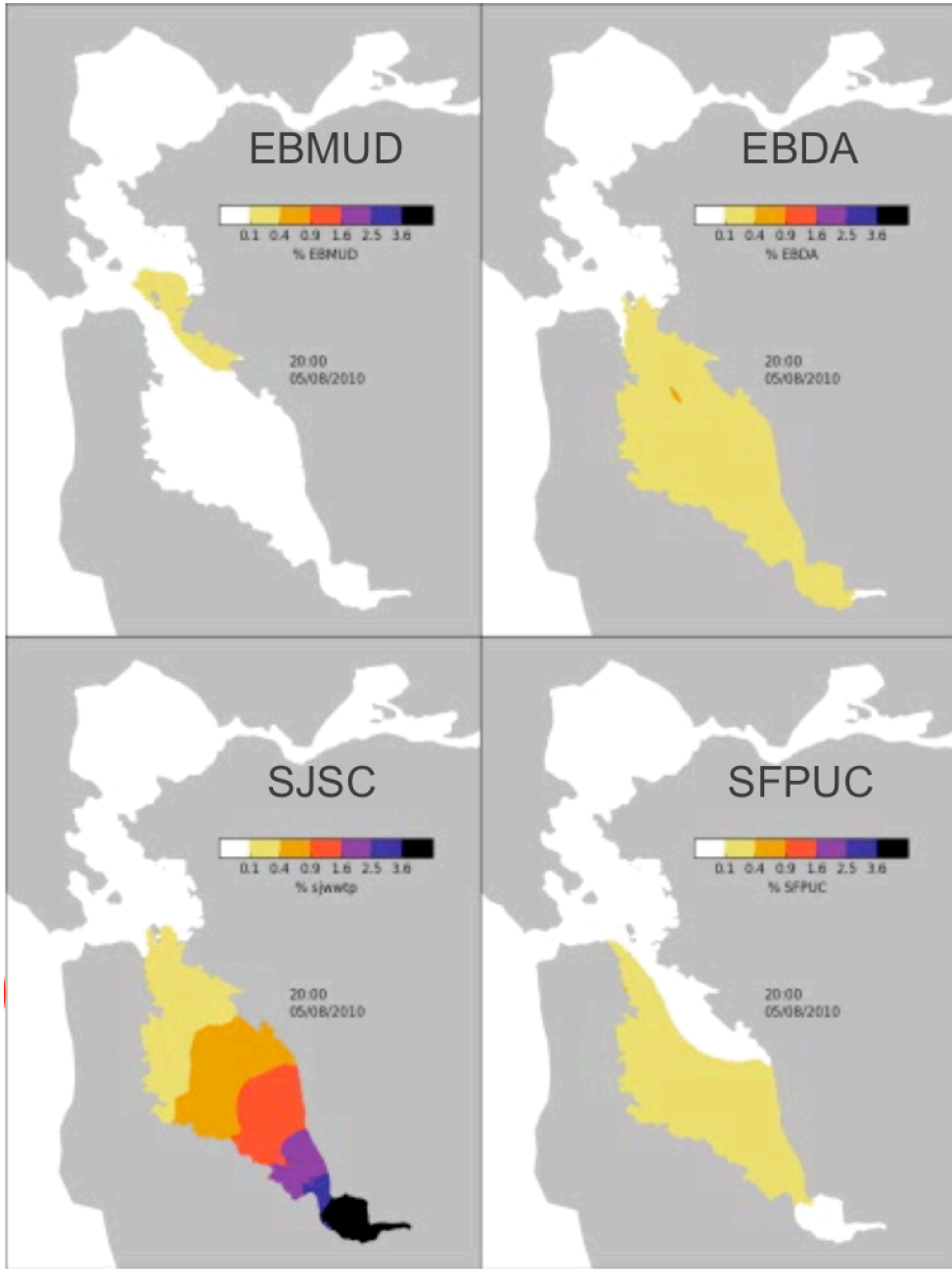
- Quantify important mechanisms
- Quantify effects of anthropogenic nutrients
- Conditions look like under future scenarios
- Analysis of management alternatives

But…

- Substantial development time, then application
- Data needs for model calibration and validation
- Weak link…humans

Coupled Hydrodynamic and Water Quality Modeling

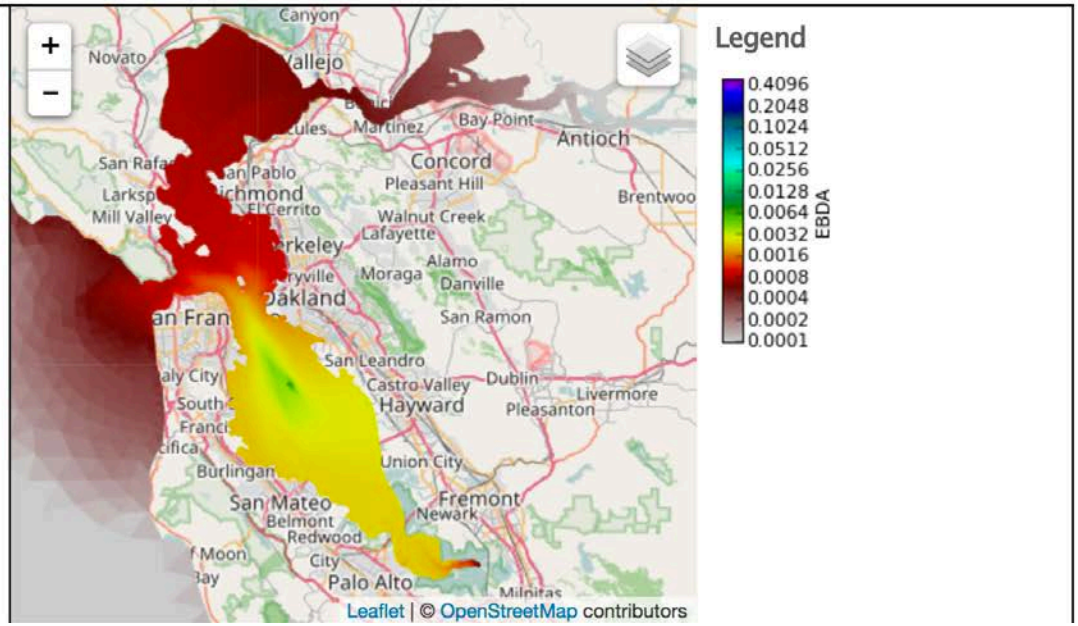




Conservative Tracers

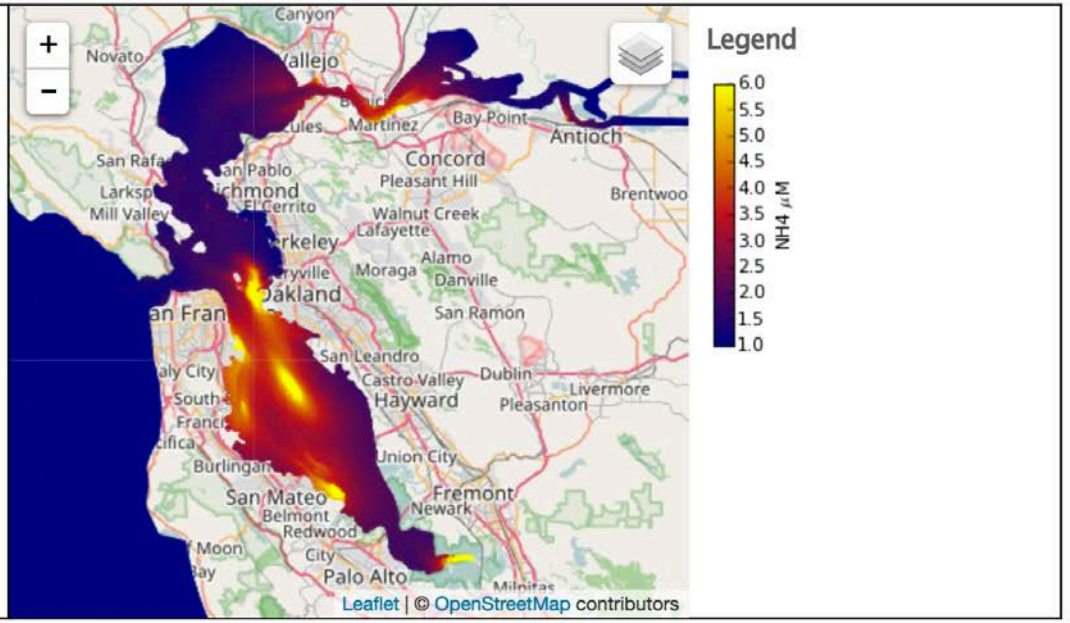
www.sfbaynutrients.sfei.org/modeling/map.html

A snapshot of conservative tracer distributions is displayed in this series of maps. The layer selector in the upper right corner of the map can be used to select a single POTW or refinery source. The colors displayed correspond to the dilution of that source throughout the bay. These simulations show a snapshot in time, corresponding to the start of July, 2013, from a simulation starting in October, 2012. The color scale is logarithmic, with each tick representing a factor of 2 dilution.



Reactive Nutrients

Here the results of a reactive nutrient water quality simulation is shown. The model run includes estimated NO3 and NH4 loads from the POTWs and refineries. In addition to transport by the underlying hydrodynamic model, the water quality model includes nitrification and denitrification with stock formulations for the rate constants. Hot-spots of NH4 are associated with non-nitrifiying POTW flows, but disperse and nitrify over relatively short periods. The result is a NO3 field which is relatively diffuse with the exception of several significant nitriying POTW flows.



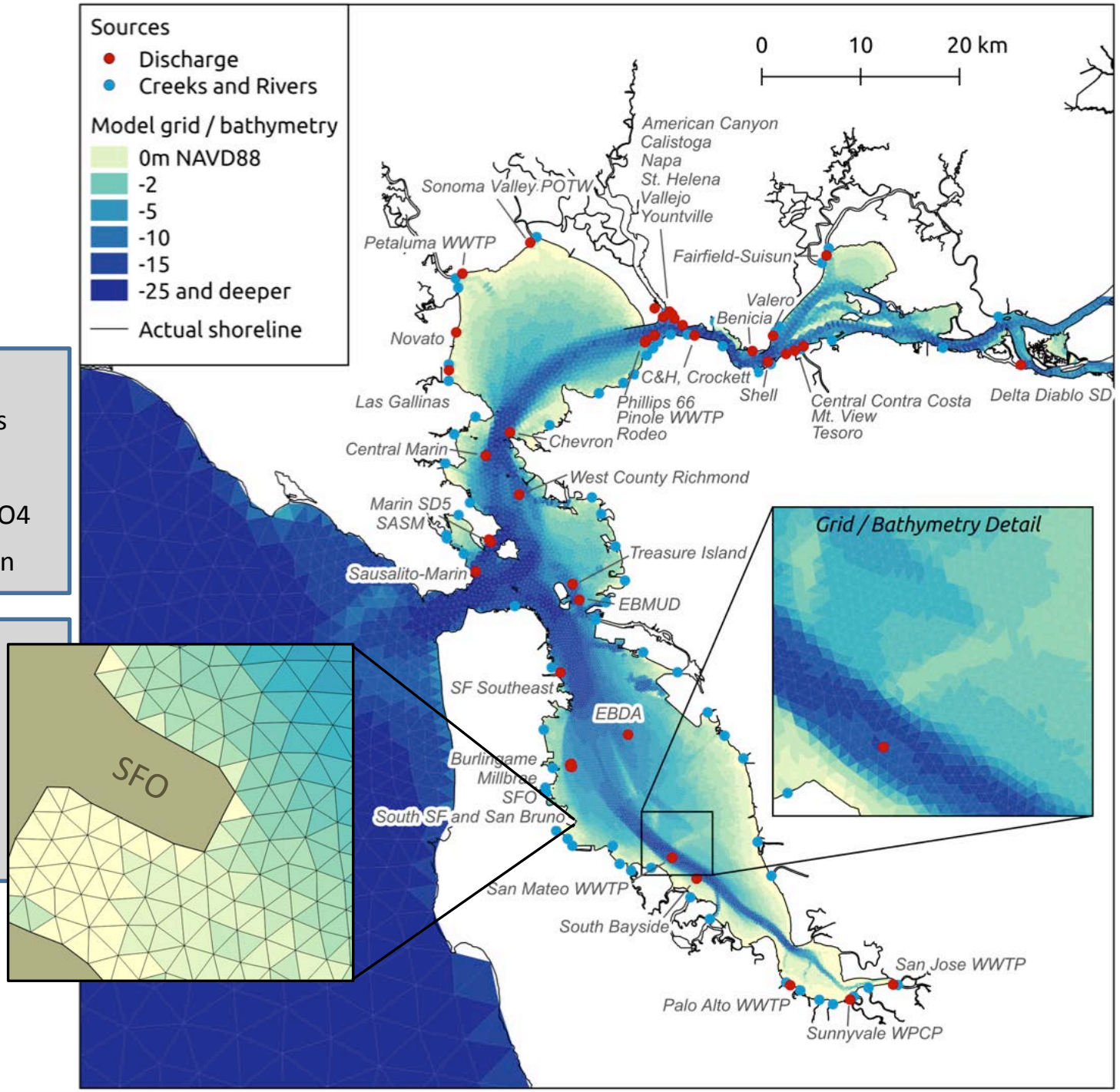
Hydrodynamics

Forcings

- 36 POTWs + 5 refineries
- 73 rivers & creeks
- Est. flows, NO3, NH4, PO4
- Wind, tides, evaporation

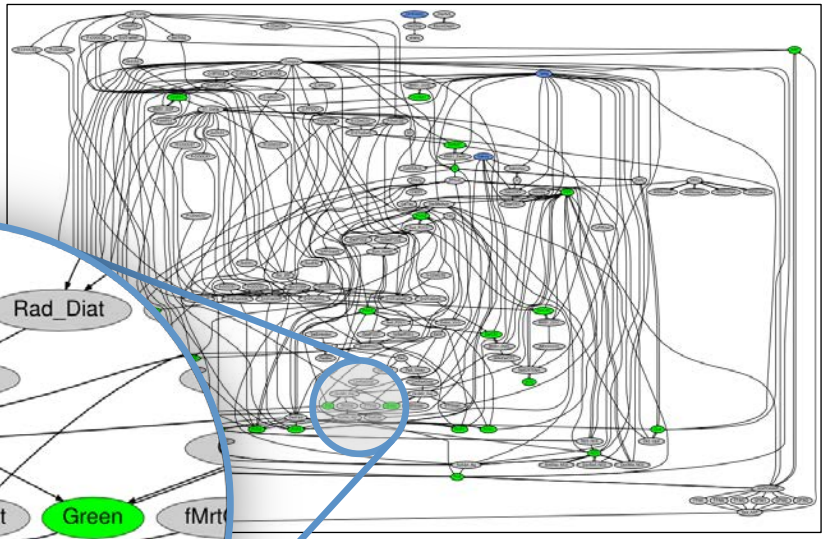
SUNTANS Domain

31 z-layers, (0.5m+)
25k 2D cells
200k 3D cells
70x real-time on 1 core
4km to 200m resolution



Phased Model Development and Implementation

Complex: Phytoplankton, sediment, …



Management Scenarios

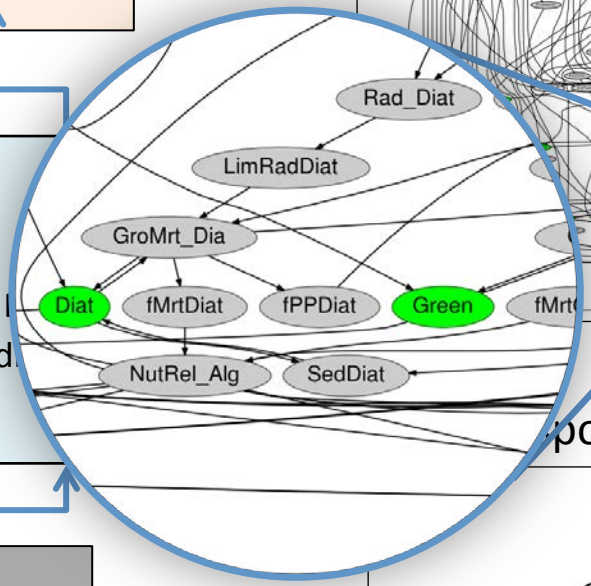
Environmental Scenarios

Phyto: community

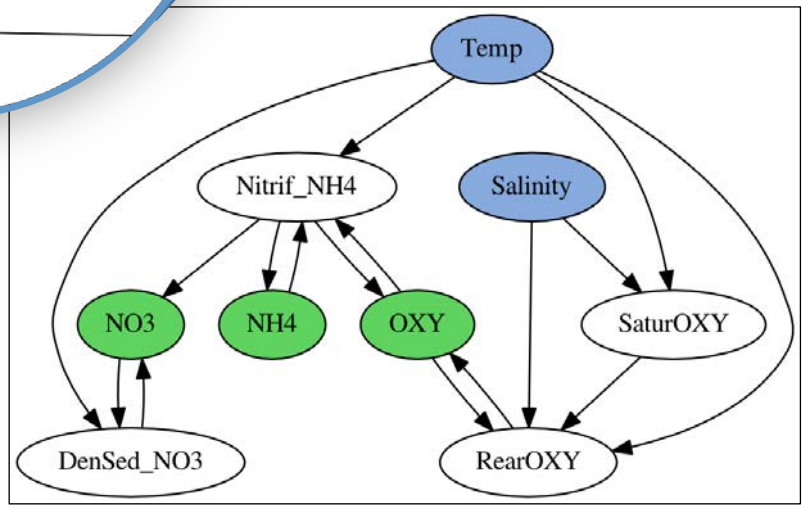
Phyto: growth

Dissolved oxygen

Sed



port, de/nitrification, reaeration

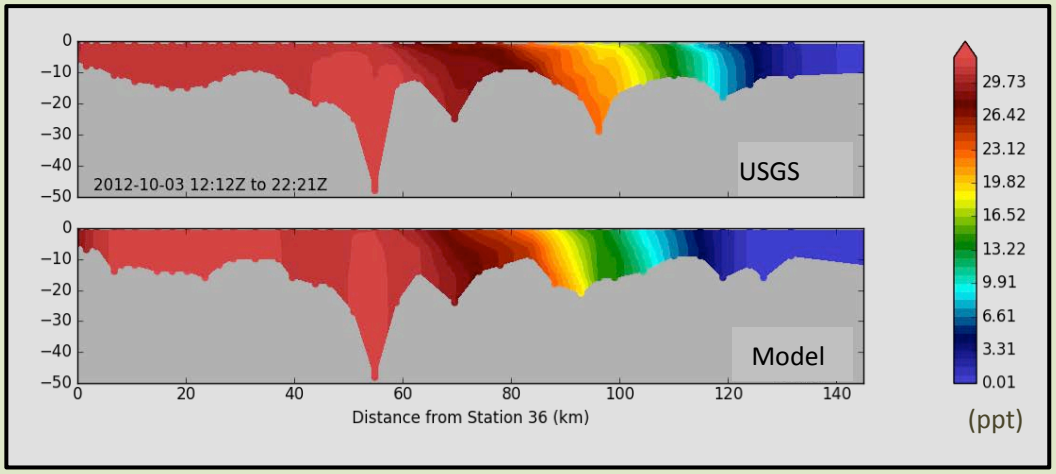


Conservative Tracers Transport/Mixing/Dilution

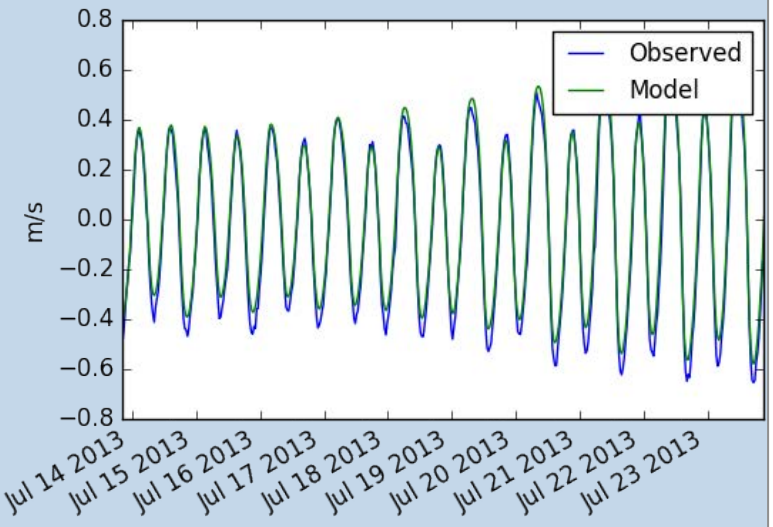
Hydrodynamics

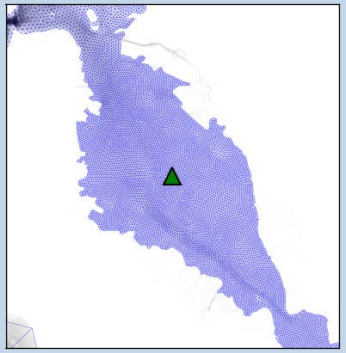
How “good” is the model?? Model calibration and validation

Hydrodynamics: Salinity

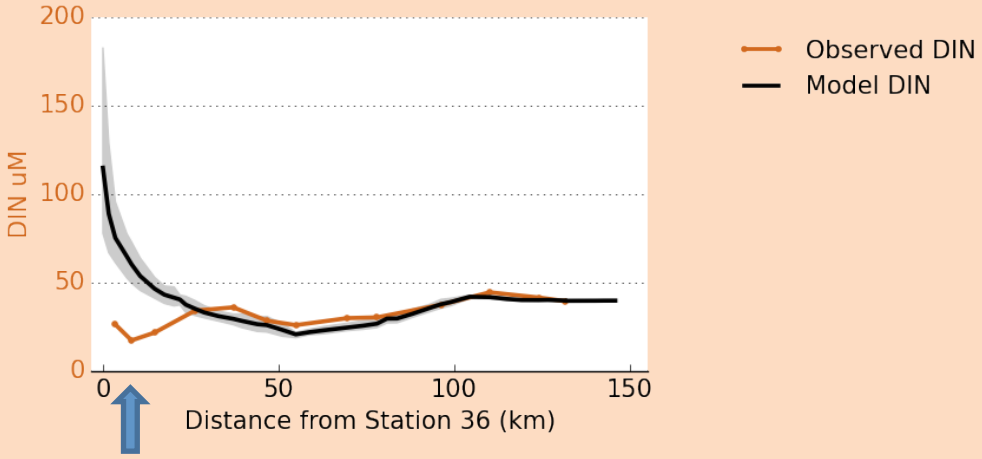


Velocities

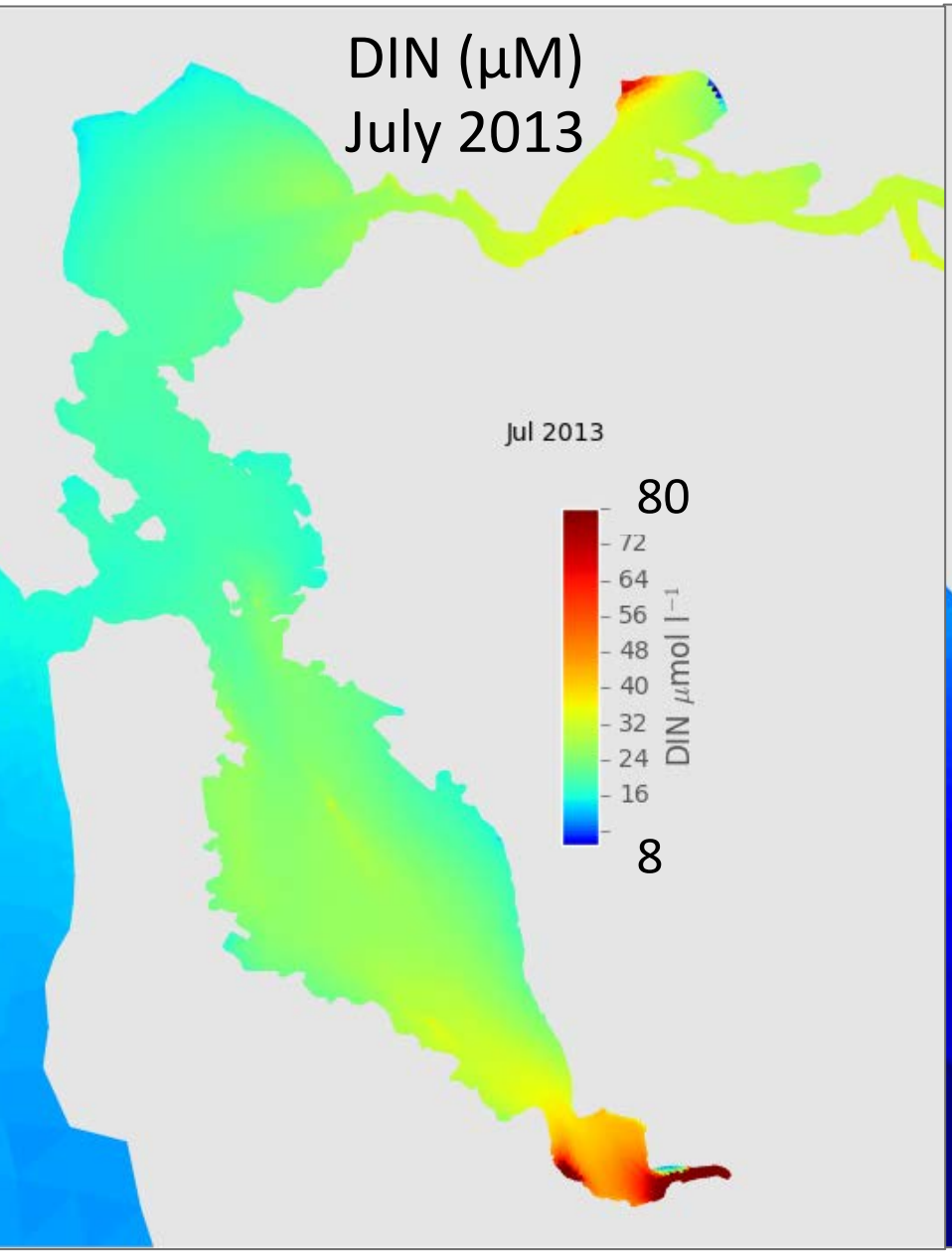


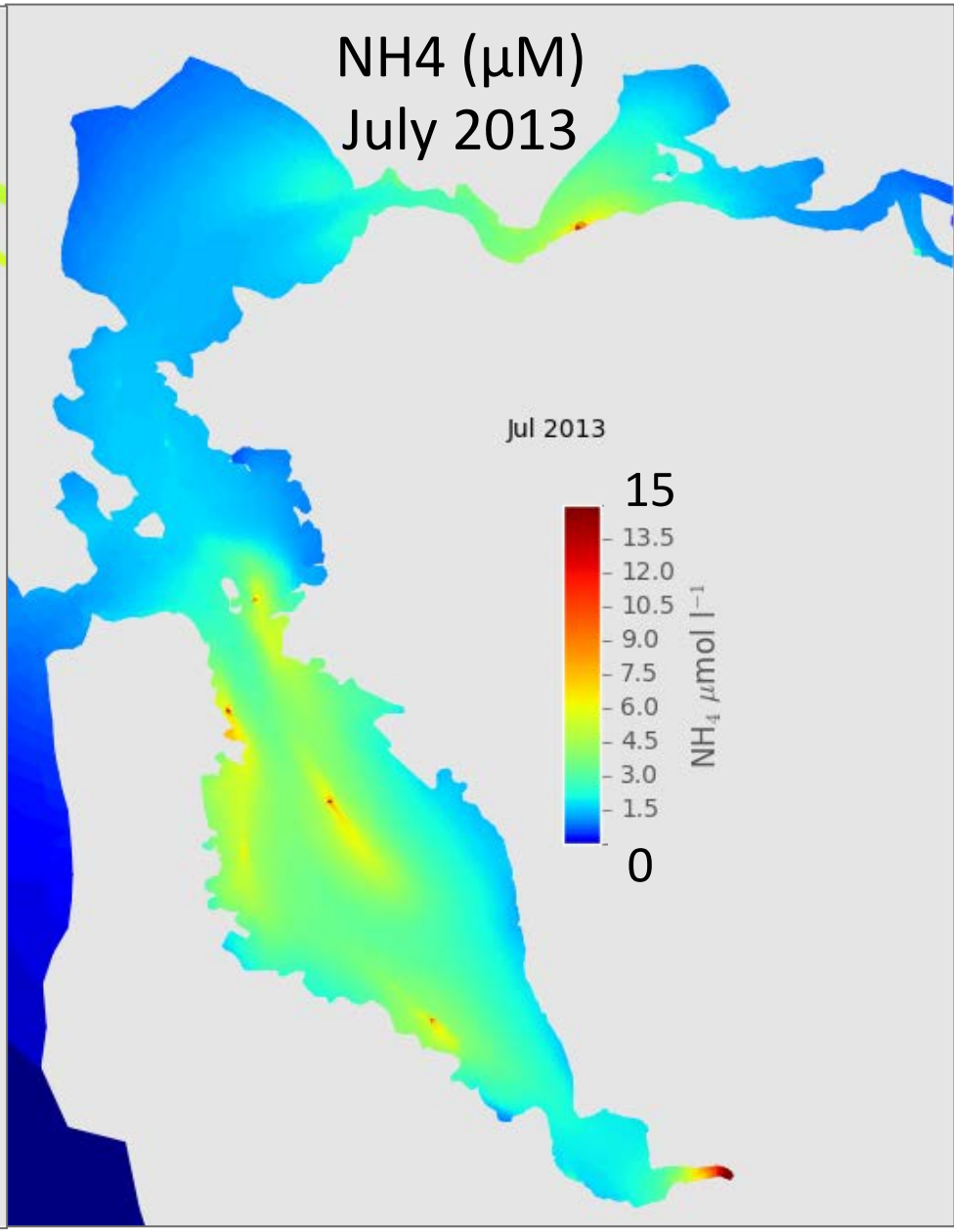


Nutrient Concentrations

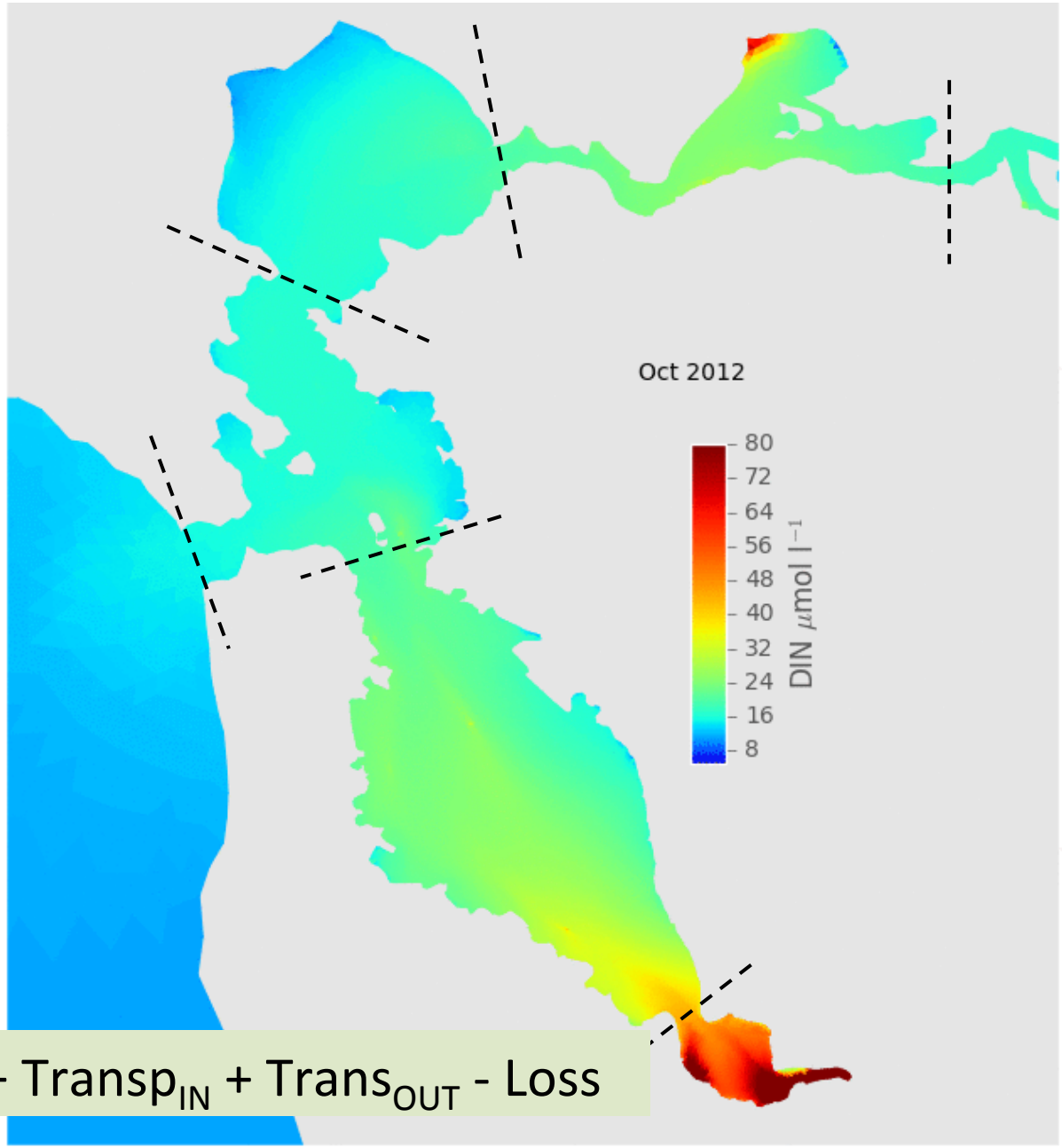


Simulated Nutrients: Spatial View





What are the fates of N loads to SFB?

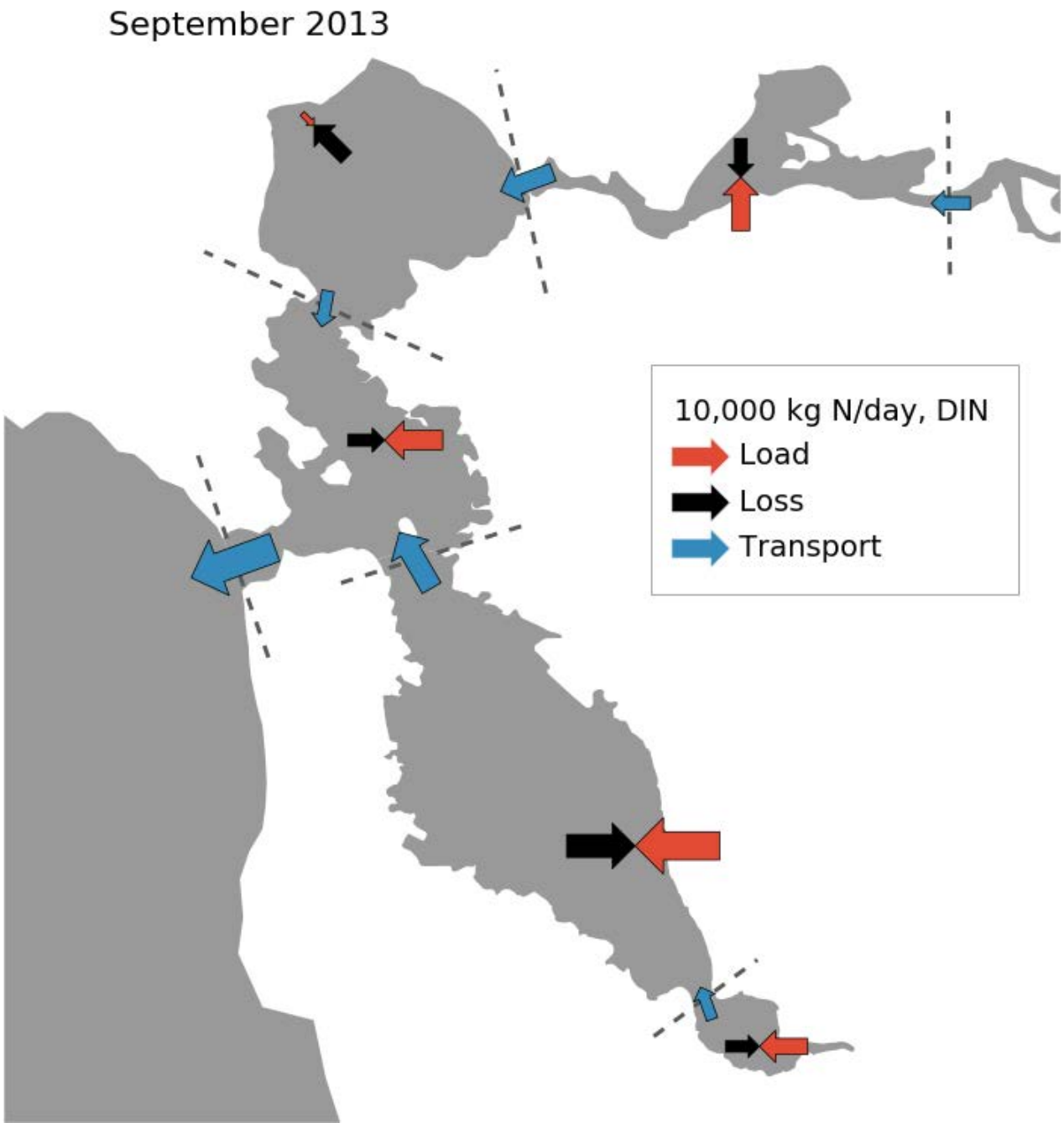


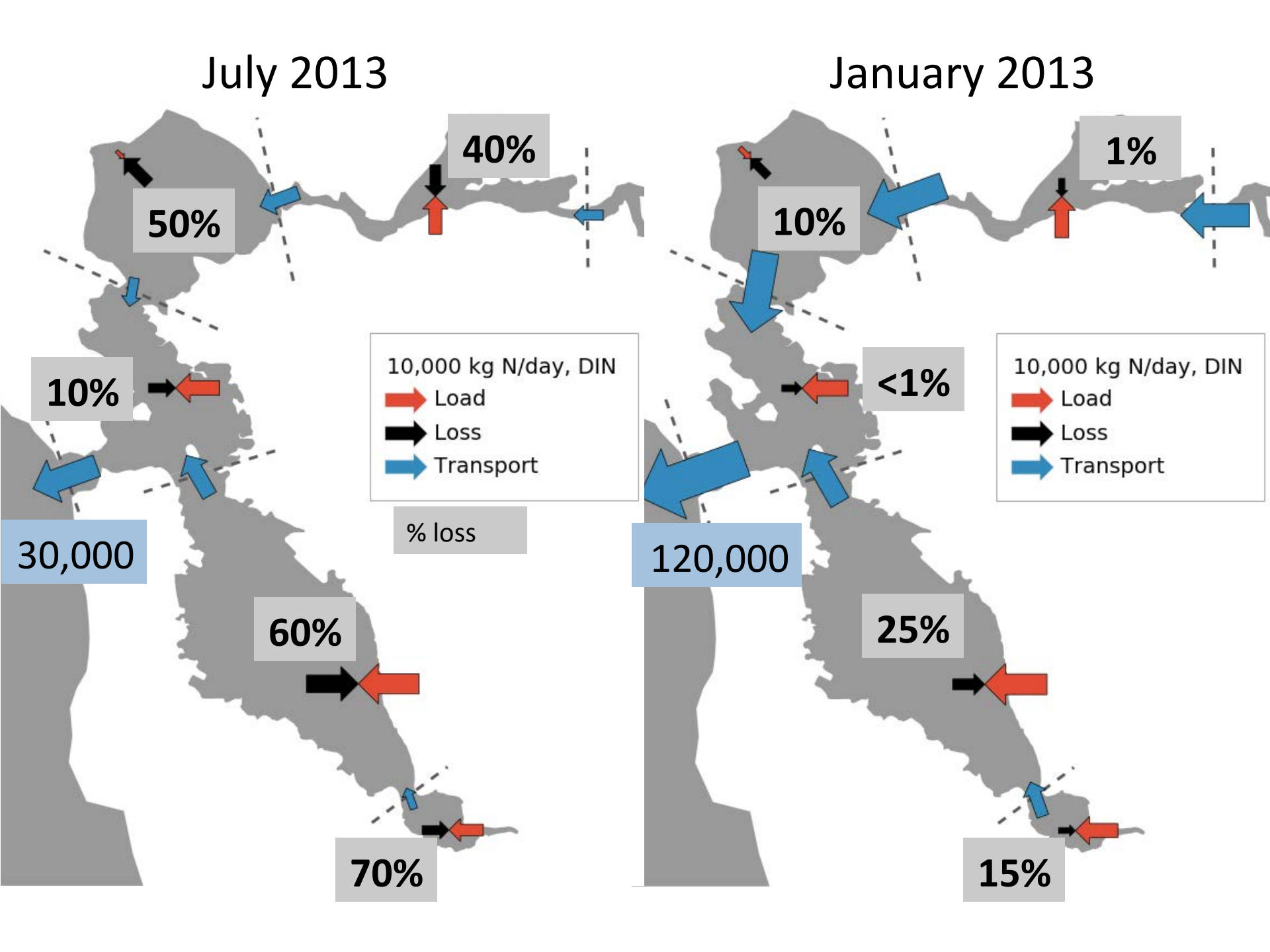
DIN (µM)
WY2013

$$Mass = Load + Transp_{IN} + Trans_{OUT} - Loss$$

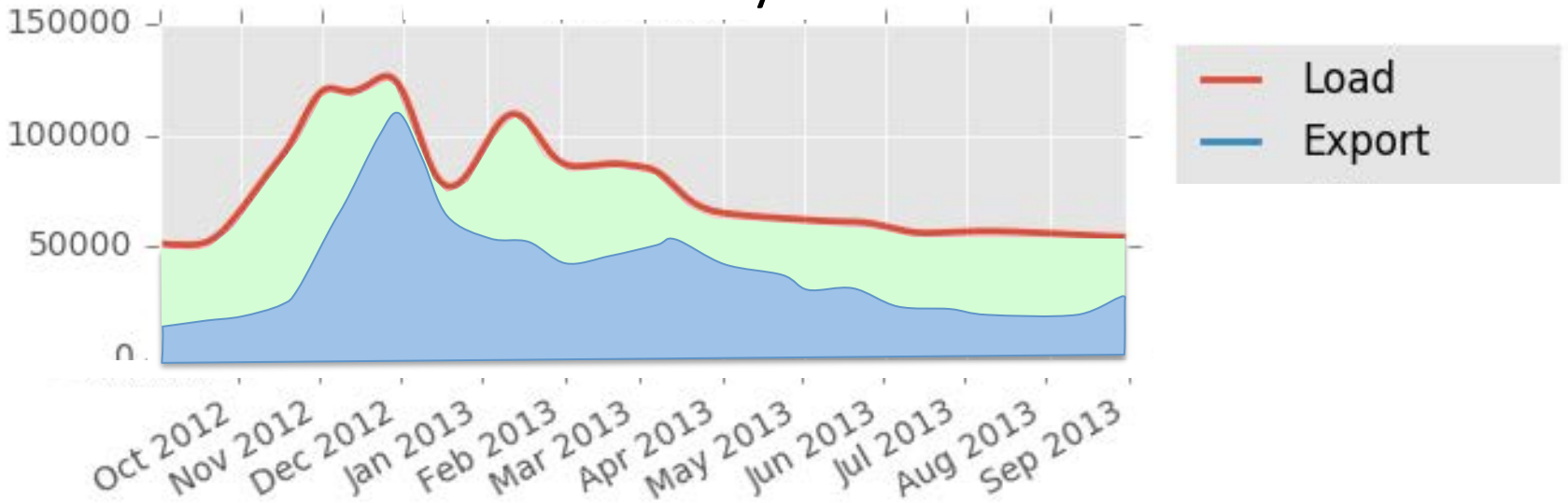
Monthly-Average Mass Balances (based on 30 min accounting)

WY2013



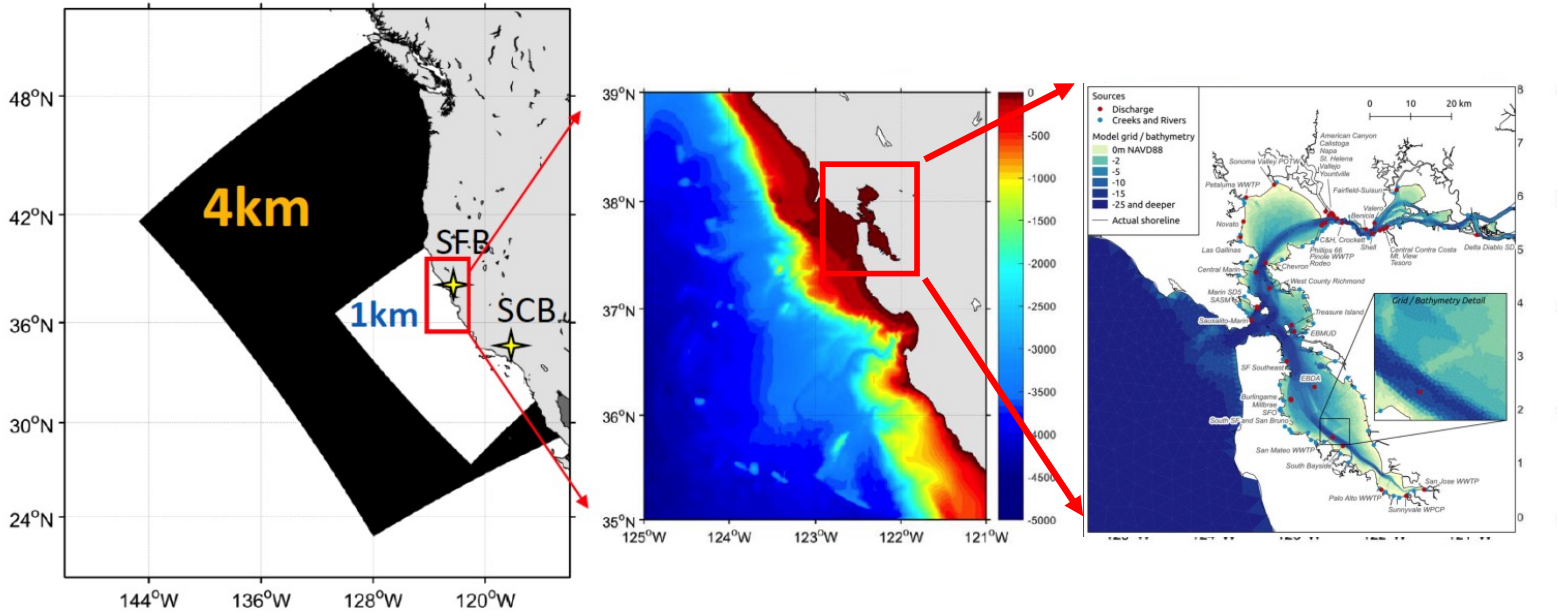

July 2013
January 2013
40%
50%
10%
30,000
60%
70%
10,000 kg N/day, DIN
Load
Loss
Transport
% loss
1%
10%
<1%
120,000
25%
15%
10,000 kg N/day, DIN
Load
Loss
Transport

Whole-Bay

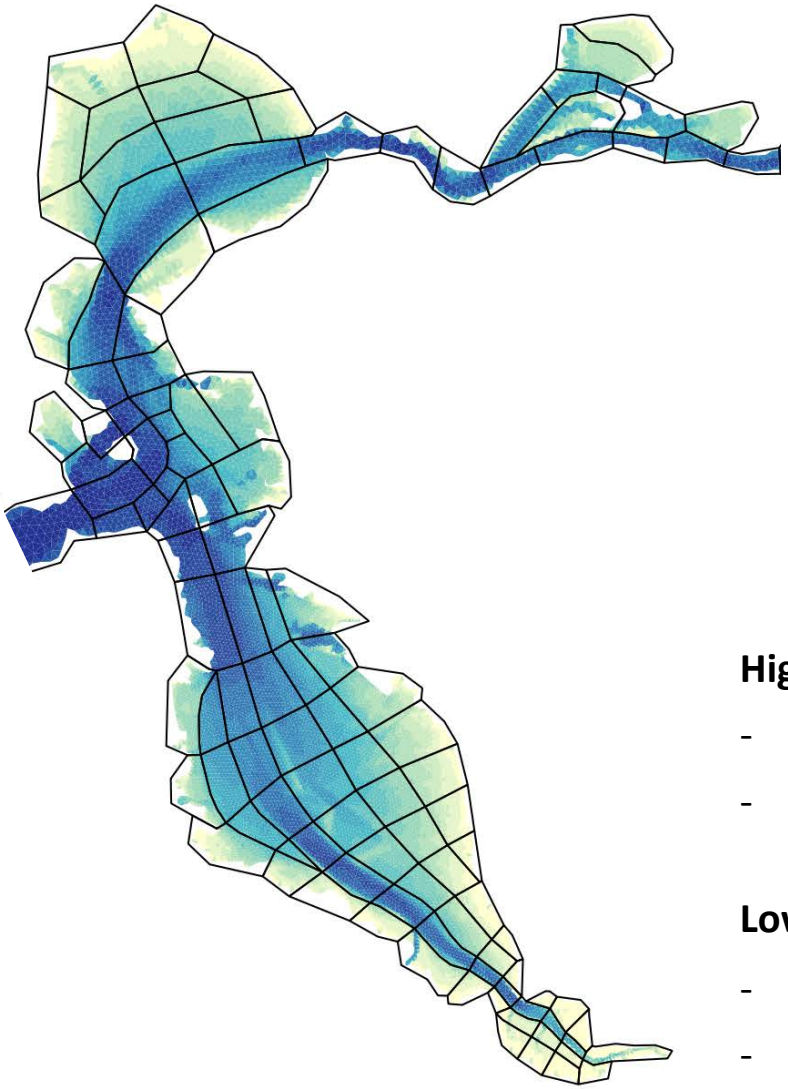


What are the fates and effects of Bay nutrients along the coast?

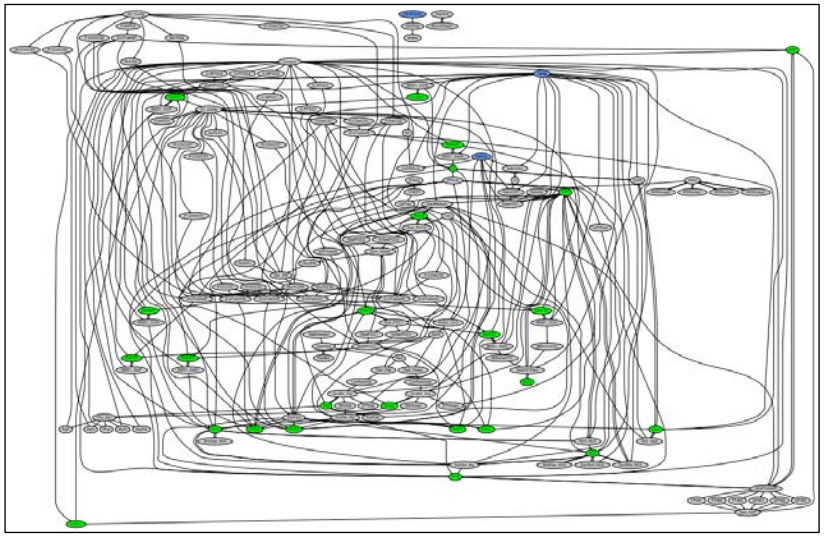
Collaboration with UCLA-SCCWRP project



Current Focus…Next ~1 year



Complex: Phytoplankton, sediment, …



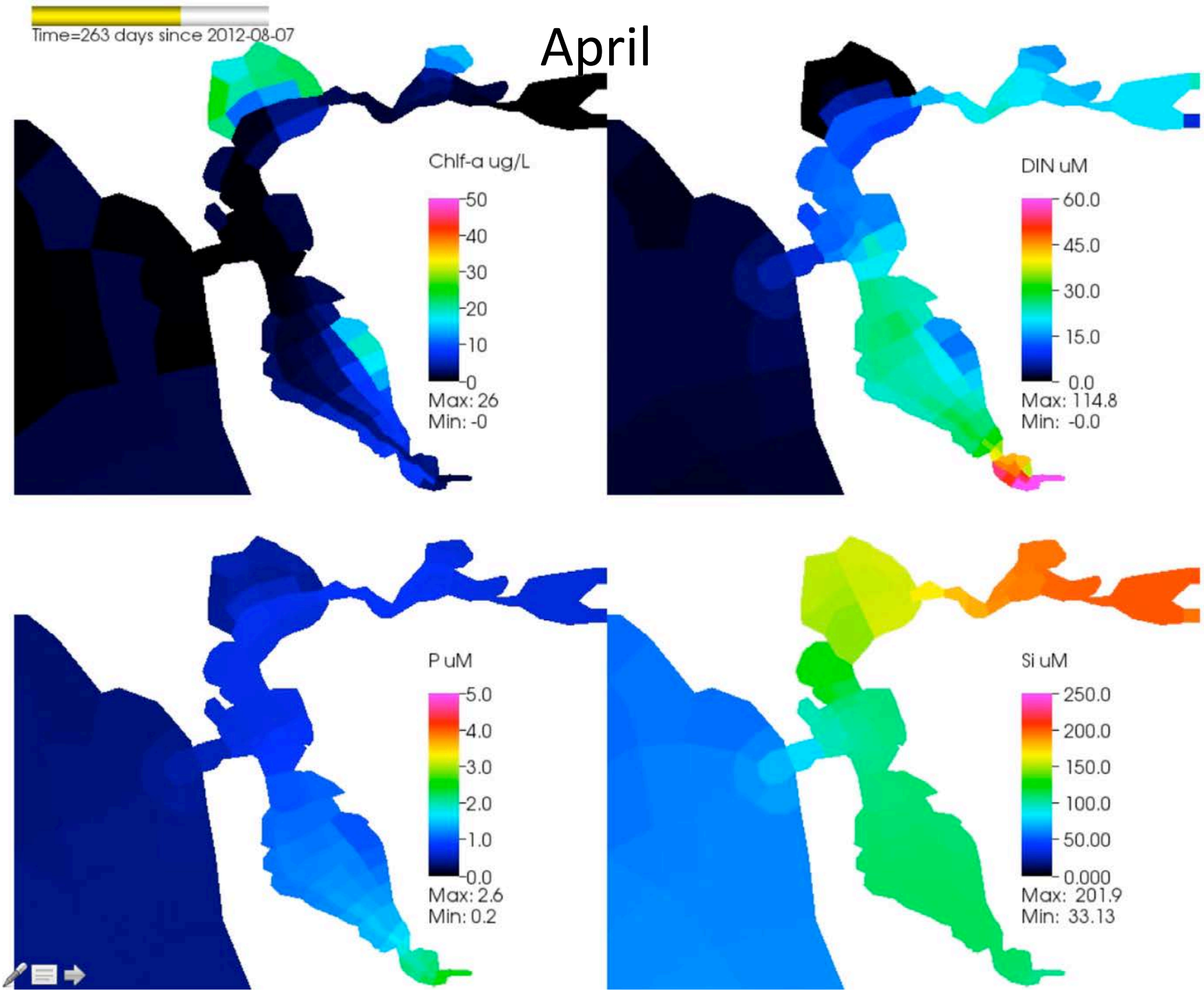
High-res…

- 5-10 days to simulate 1 year of water quality
- 100+ GB per run

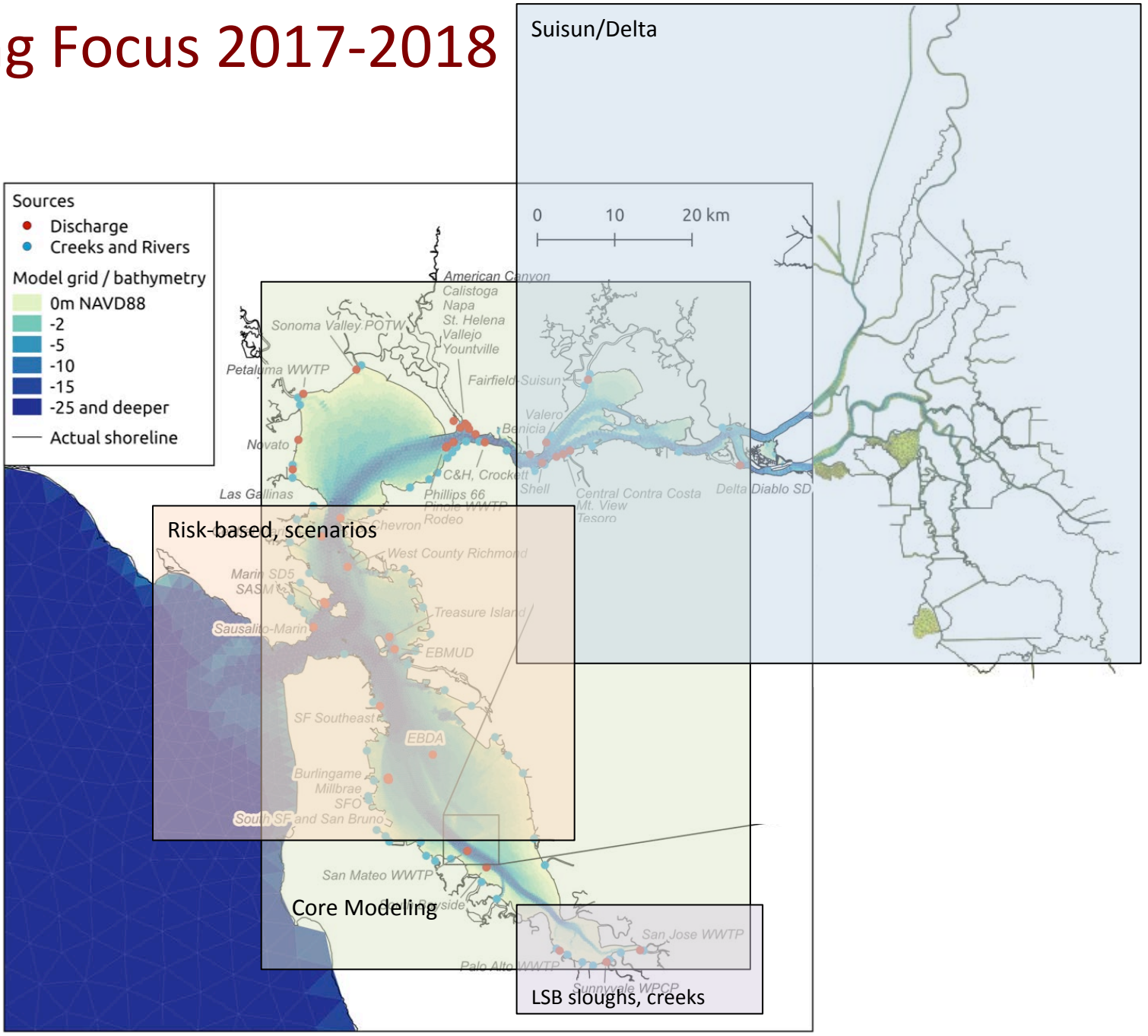
Low-res…

- 5–20 minutes to simulate 1 year
- Practical for sensitivity analysis, exploration

April


Time=263 days since 2012-08-07
Chlf-a ug/L
50
40
30
20
10
0
Max: 26
Min: -0
DIN uM
60.0
45.0
30.0
15.0
0.0
Max: 114.8
Min: -0.0
P uM
5.0
4.0
3.0
2.0
1.0
0.0
Max: 2.6
Min: 0.2
Si uM
250.0
200.0
150.0
100.0
50.00
0.000
Max: 201.9
Min: 33.13

Modeling Focus 2017-2018



Source: C. Benton

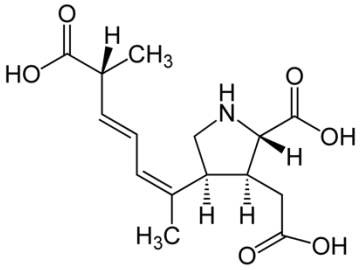
1. Program Overview

2. Update on Major Activities
    1. Numerical Modeling
    2. Harmful Algae Blooms
    3. Dissolved oxygen in margin habitats

3. Work Ahead

Domoic Acid

(Amnesic Shellfish Poisoning)



Pseudo-nitzchia

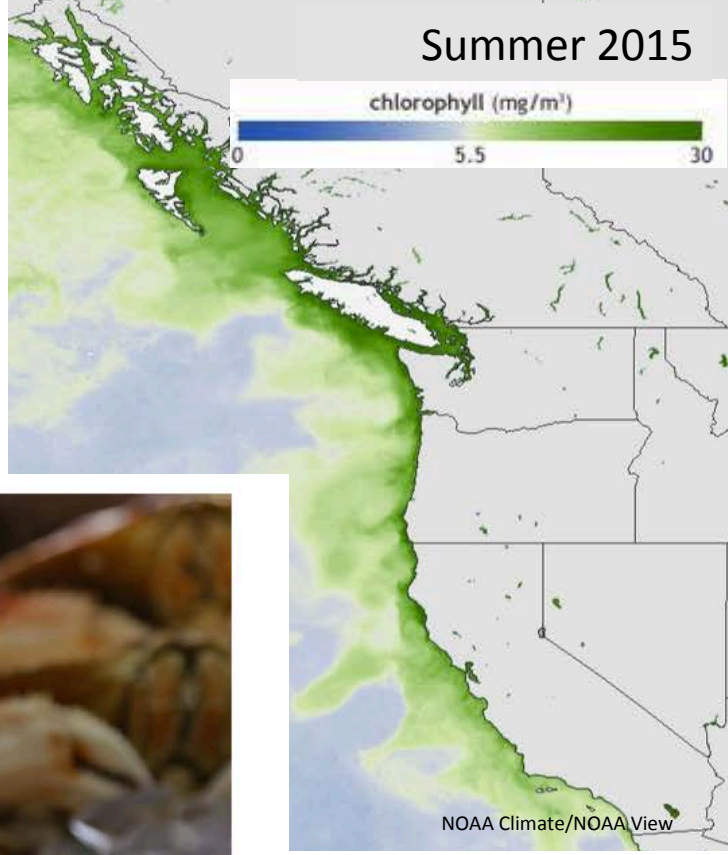


Photo: Eric Risberg, Associated Press

The Mercury News

Tests for bacteria in Discovery Bay channels create stir

Lake Temescal reopens after toxic scare

Background: HABs

- Increasingly important water quality issue worldwide

- Indications that SFB needs to be on the lookout
  - in general, or as far as we know, noteworthy resistance, in general, to severe HAB events
  - But HAB-organisms and toxins commonly detected

- HABs among the NMS' higher priorities (SFEI 2016)
  - Substantial increase in observations to evaluate system
  - Sufficient time to answer management questions with sufficient confidence?

Are HABs and toxins problems in SFB? SFB nutrients cause or contribute?

? HAB-forming species?

? Toxins in water?

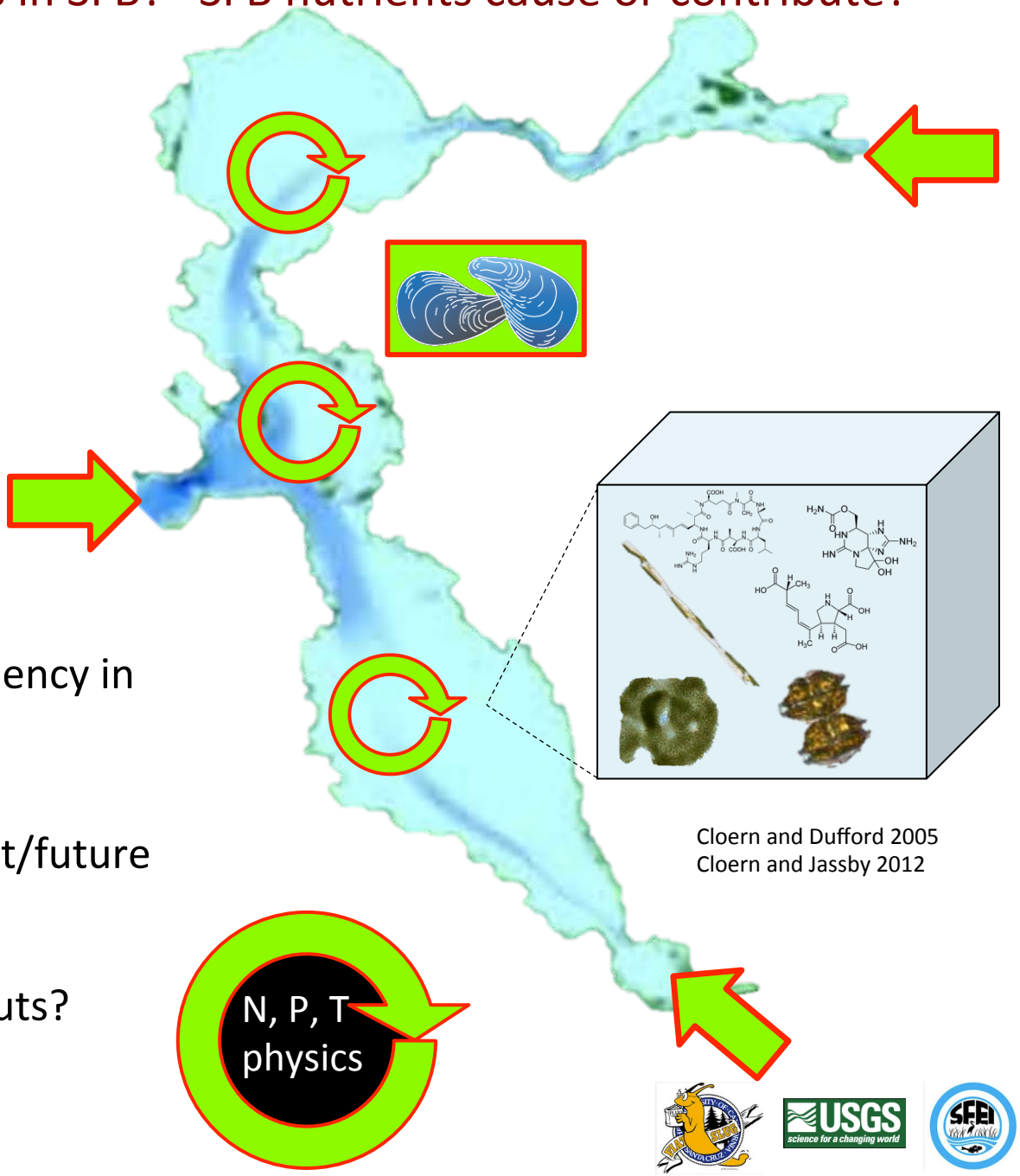
? Toxins in biota?

? External Sources vs. Internal production, role of nutrients?

? Increased events/frequency in future?

? Acceptable risk, present/future

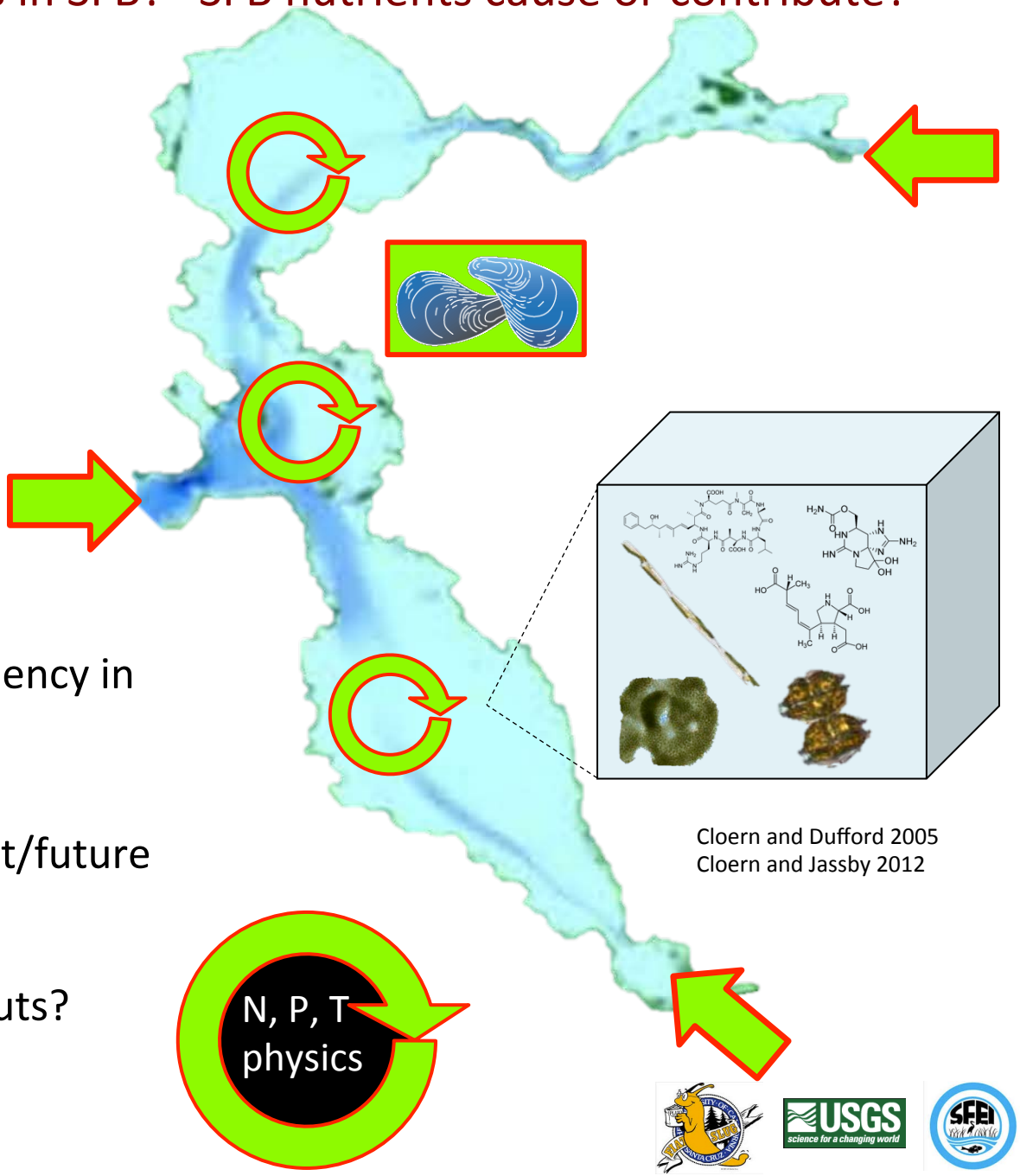
? Protective nutrient inputs?



Cloern and Dufford 2005
Cloern and Jassby 2012

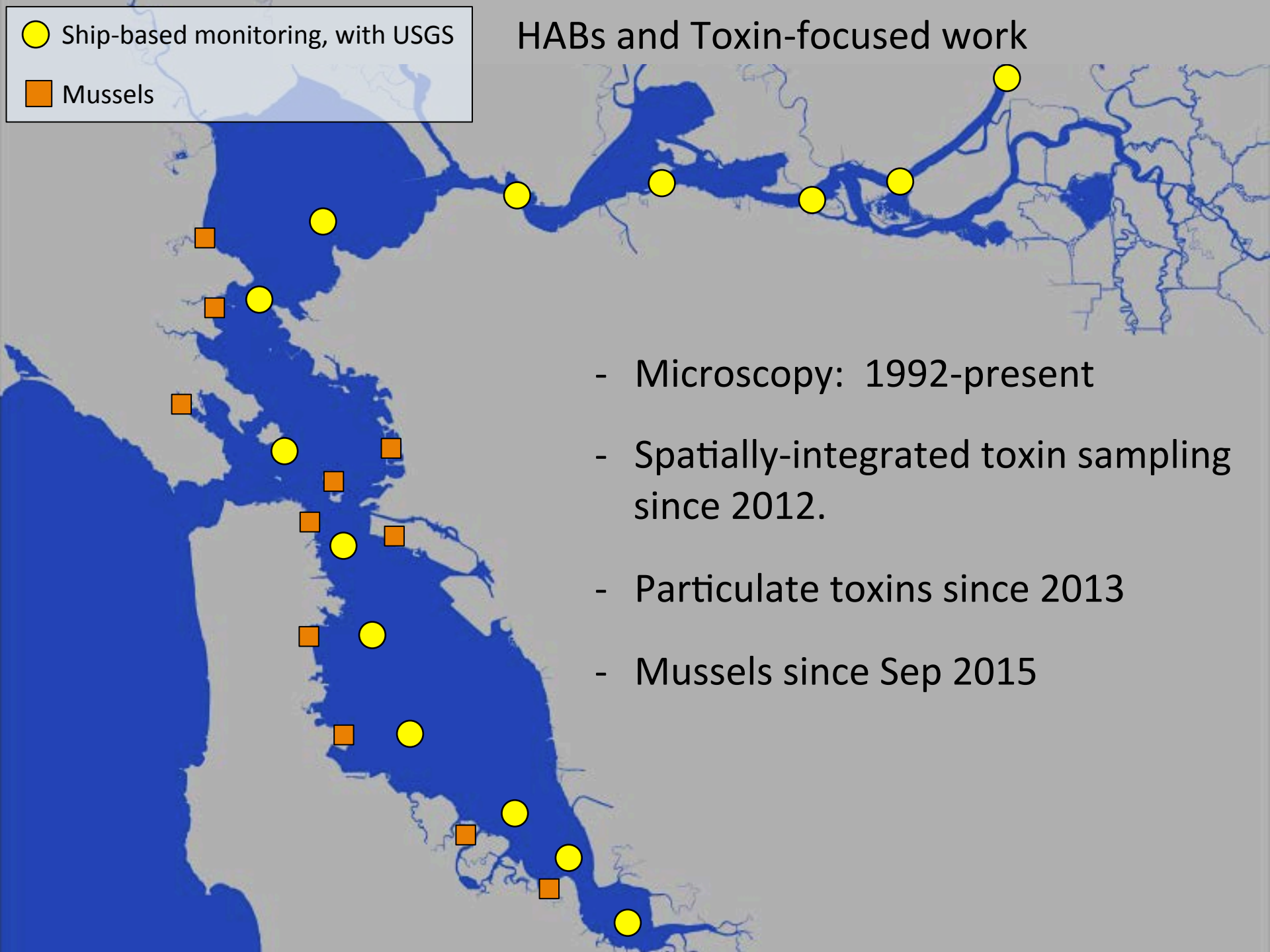
Are HABs and toxins problems in SFB? SFB nutrients cause or contribute?

- [x] HAB-forming species?
- [x] Toxins in water?
- [x] Toxins in biota?
- [x] External Sources vs. Internal production, role of nutrients?
- [ ] Increased events/frequency in future?
- [ ] Acceptable risk, present/future
- [ ] Protective nutrient inputs?



Cloern and Dufford 2005
Cloern and Jassby 2012

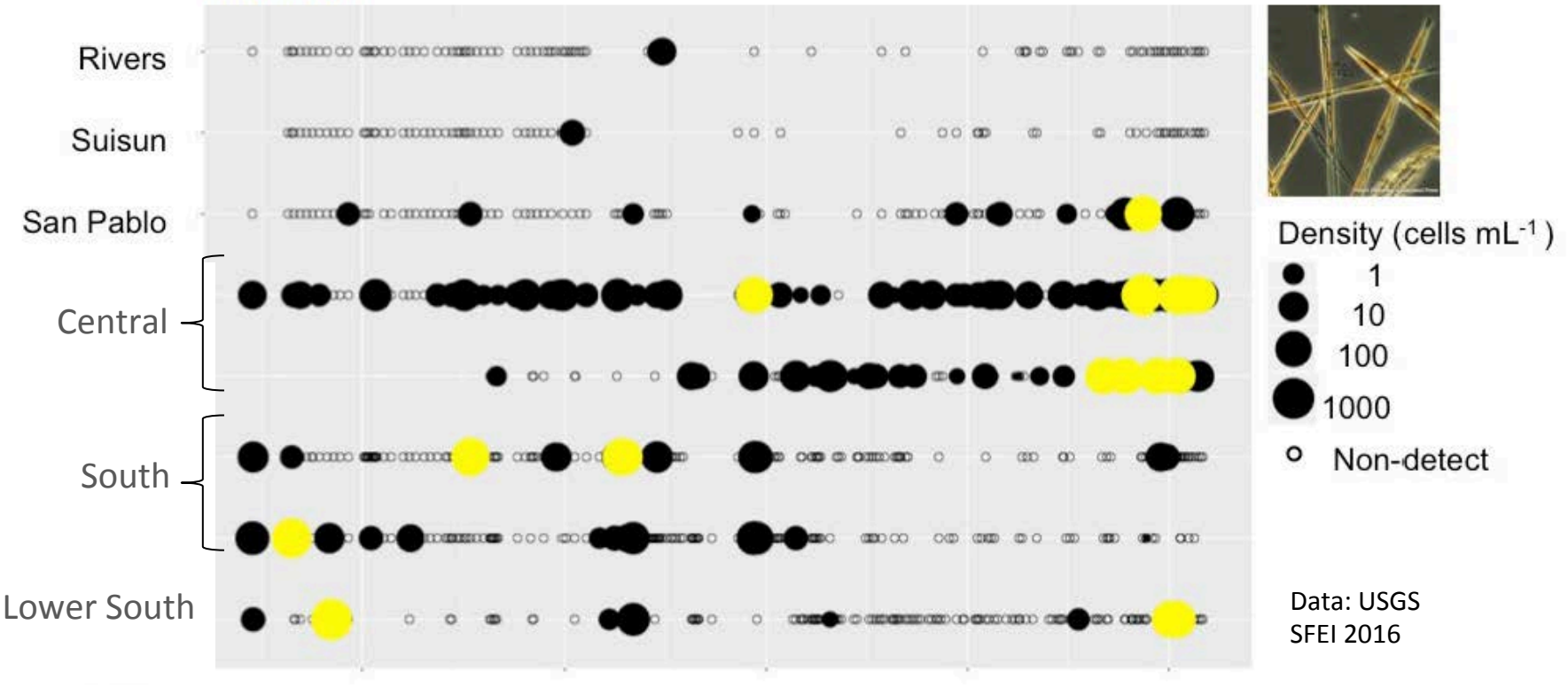
HABs and Toxin-focused work



- Microscopy: 1992-present
- Spatially-integrated toxin sampling since 2012.
- Particulate toxins since 2013
- Mussels since Sep 2015

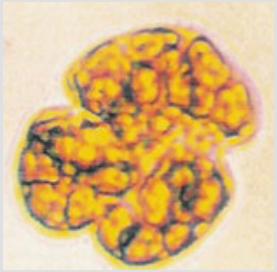
Are HAB-forming organisms present in SFB?

Pseudo-nitzchia



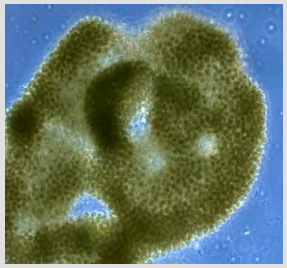
Other frequent visitors

Dinophysis

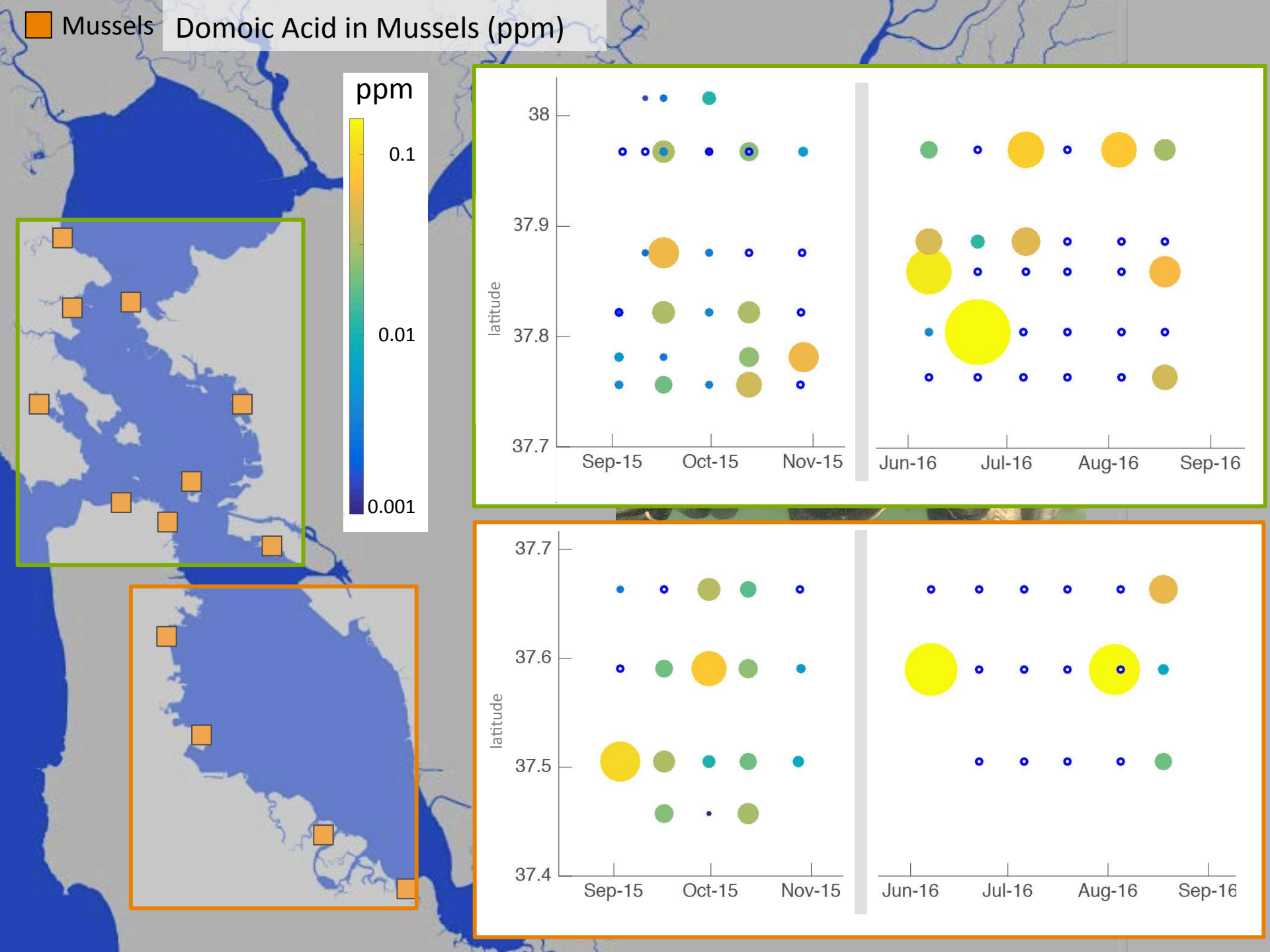


Karlodinium

Alexandrium



Microcystis


Mussels
Domoic Acid in Mussels (ppm)
ppm
0.1
0.01
0.001
38
37.9
37.8
37.7
latitude
Sep-15
Oct-15
Nov-15
Jun-16
Jul-16
Aug-16
Sep-16
37.7
37.6
37.5
37.4
latitude
Sep-15
Oct-15
Nov-15
Jun-16
Jul-16
Aug-16
Sep-16

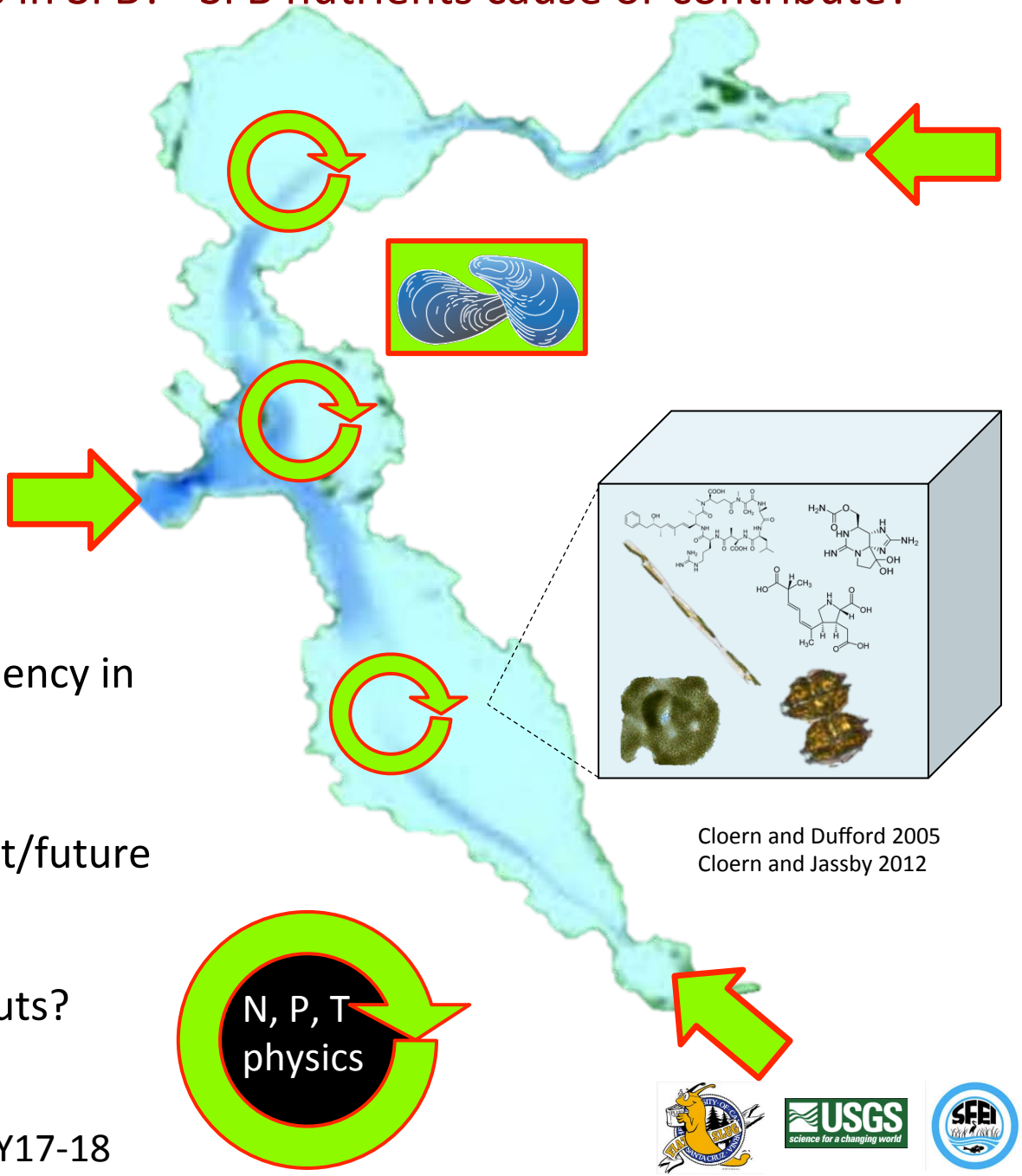
What do current ambient conditions tell us about HAB-related condition in SFB?

- Regularly detect multiple toxins at low/moderate levels in biota and in the water
  - Domoic Acid — Low
  - Microcystin — Moderate/Elevated
  - Saxitoxin — Low
  - Okadaic Acid — Moderate
  - DTX2 — Low

- Workshop and Expert Panel Spring 2017
  - Broad range of expertise: physiologists/toxicologists, HAB specialists
  - Comparison of SFB conditions with other estuaries and thresholds
  - Major uncertainties and recommendations

Are HABs and toxins problems in SFB? SFB nutrients cause or contribute?

- HAB-forming species?
- Toxins in water?
- Toxins in biota?
- External Sources vs. Internal production, role of nutrients?
- Increased events/frequency in future?
- Acceptable risk, present/future
- Protective nutrient inputs?

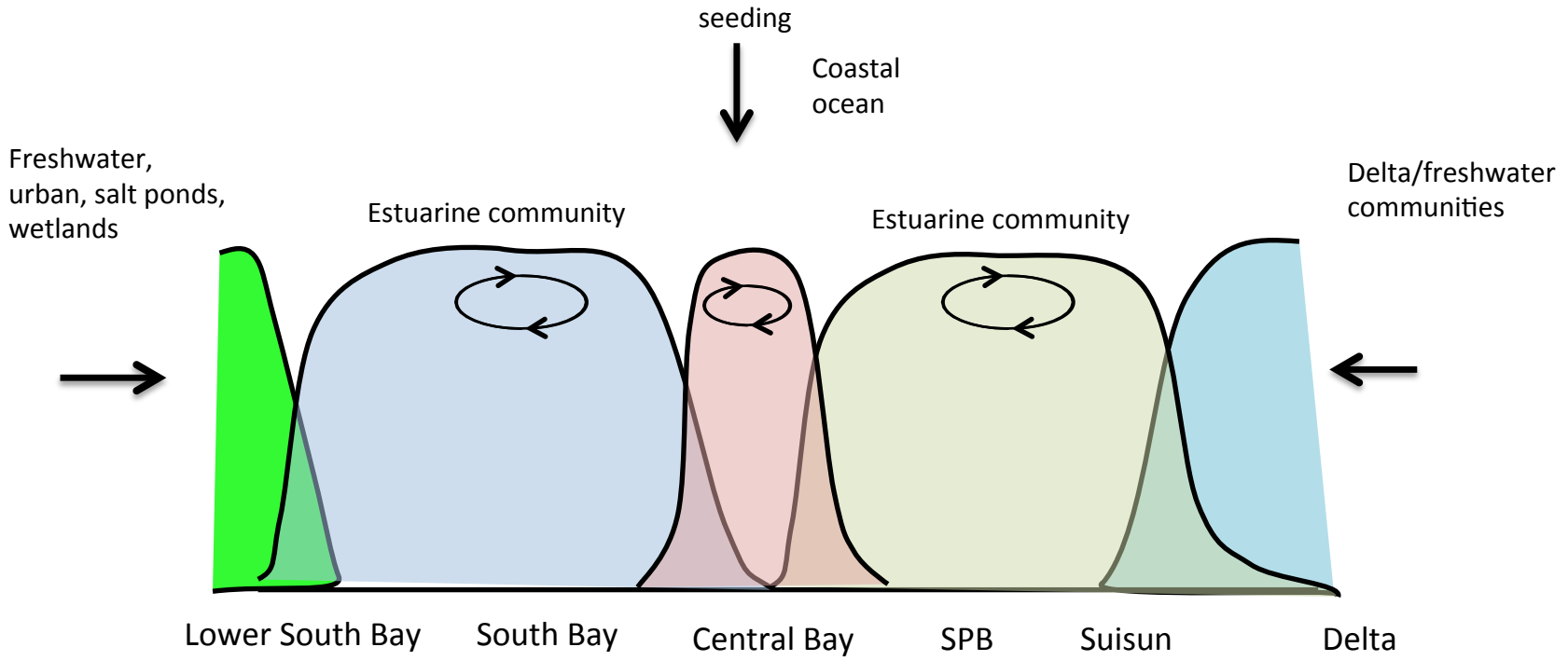


Cloern and Dufford 2005
Cloern and Jassby 2012

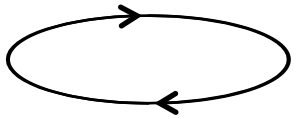
- Continue current effort
- New or increased effort in FY17-18

What shapes community phytoplankton community composition?

Are conditions in SFB adversely impacting phytoplankton composition?

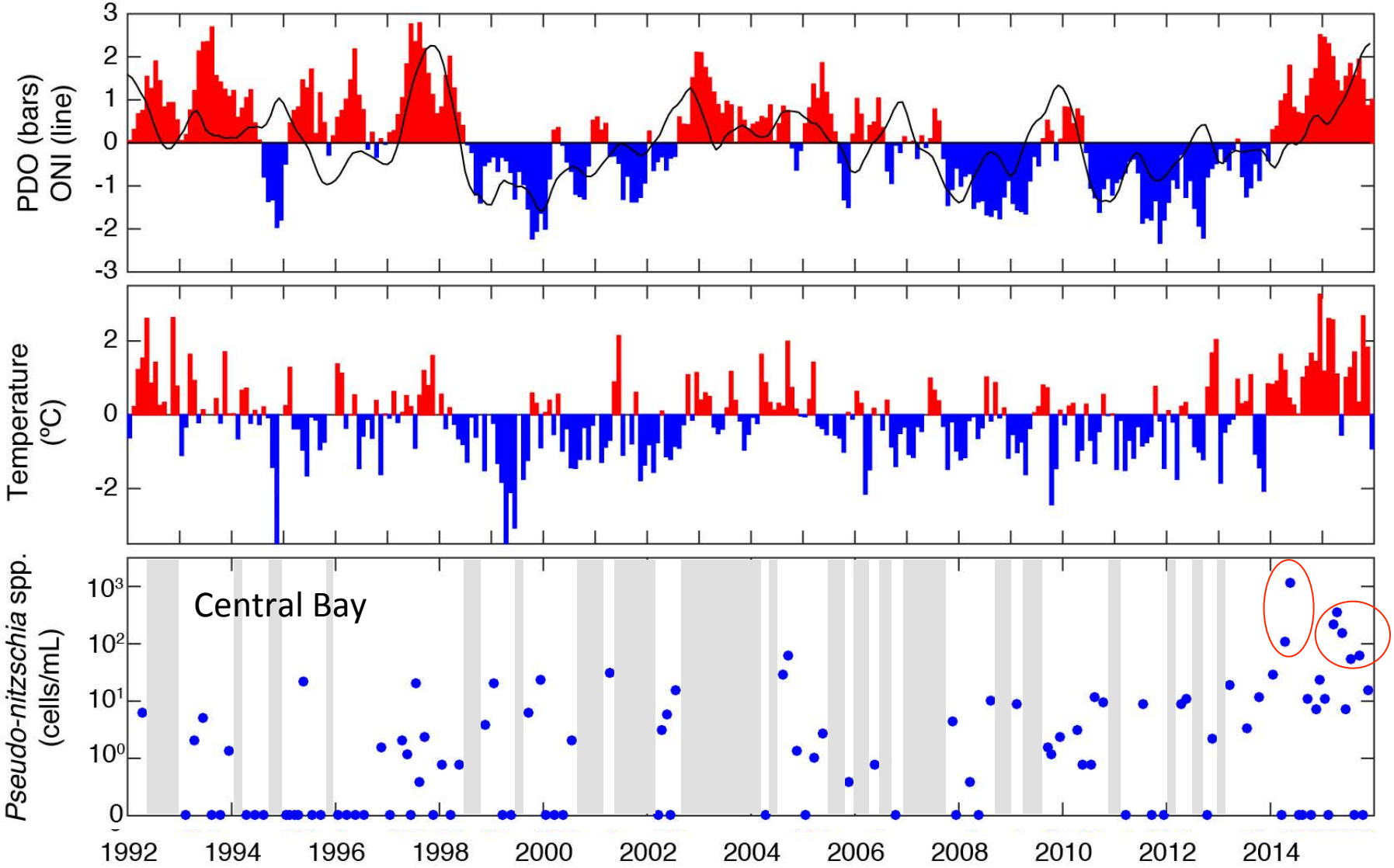


Internal processes



- Light
- T
- Residence time
- Size-selective grazing by clams
- Nutrients

PDO and Central Bay T anamolies

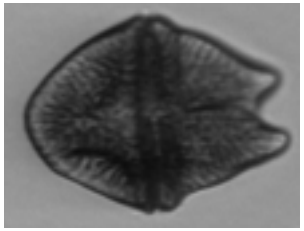


PDO = Pacific Decadal Oscillation
ONI = Oceanic Niño Index

Central Bay – October 18 2017

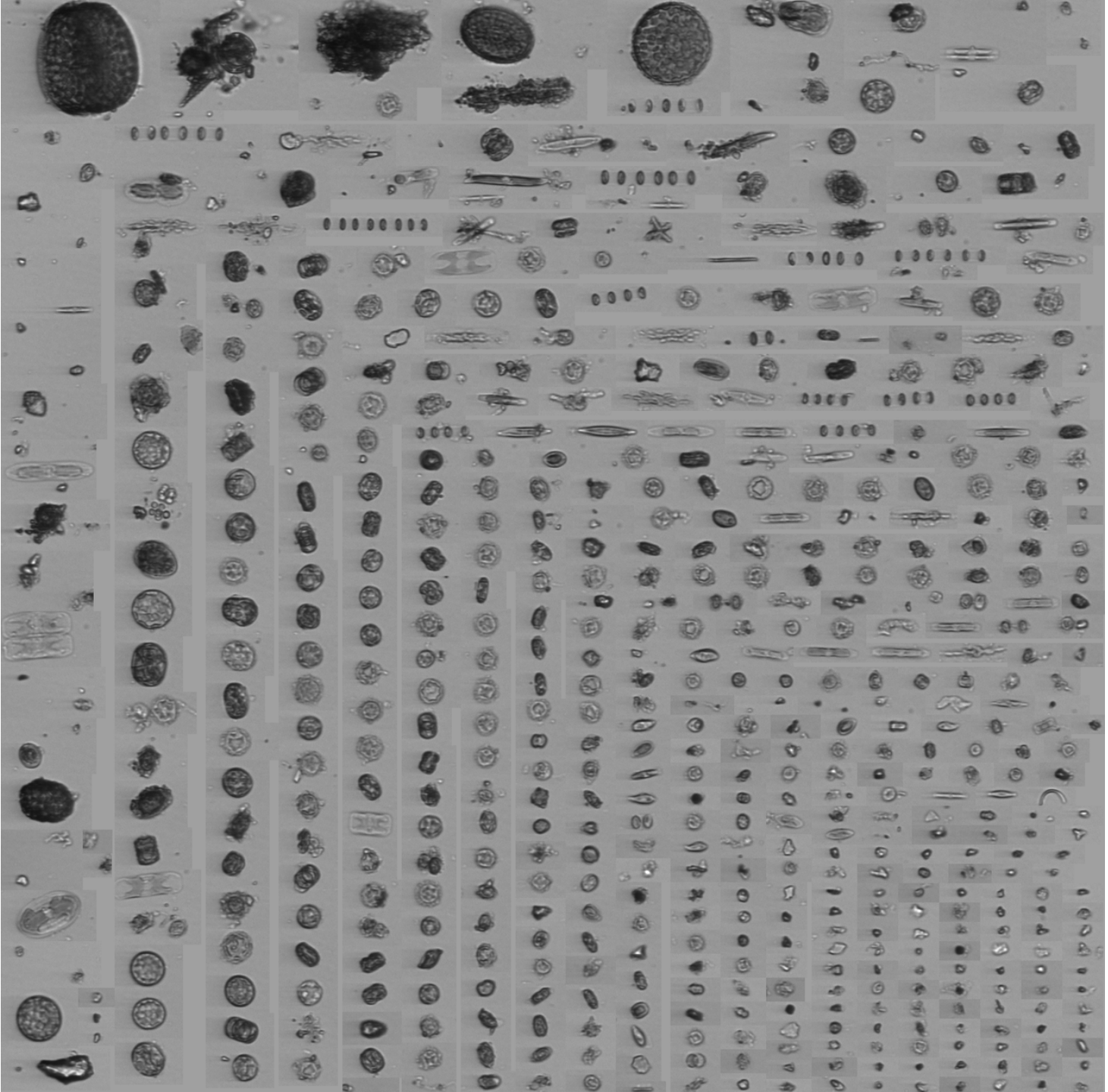
Red tide ?

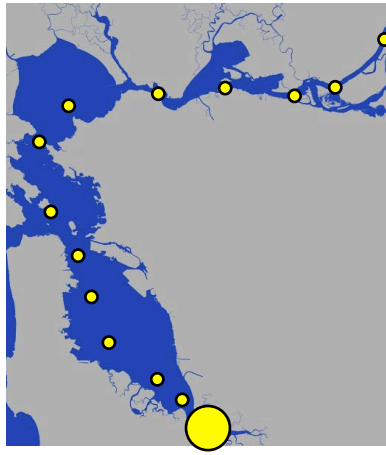
Akashiwa Sanguinea



Imaging Flow Cytobot (IFCB)

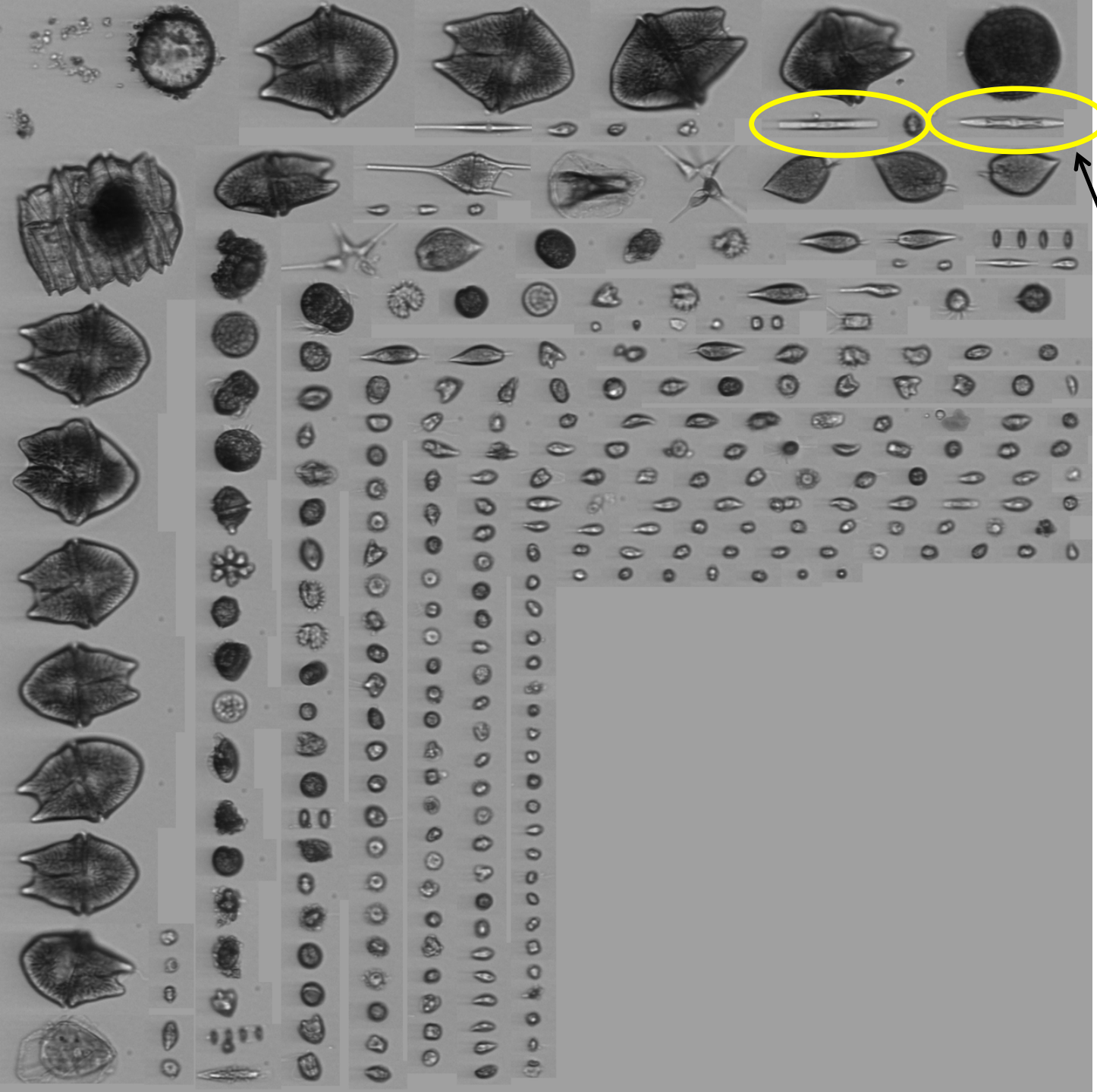
- 2 instruments
- NOAA-funded, PI: UC Santa Cruz, co-PIs: USGS, SFEI
- Genus level counts and ID
- Integration into the Bay monitoring program
  - Ship-board (USGS) beginning October 2016
  - Moored application, late 2017

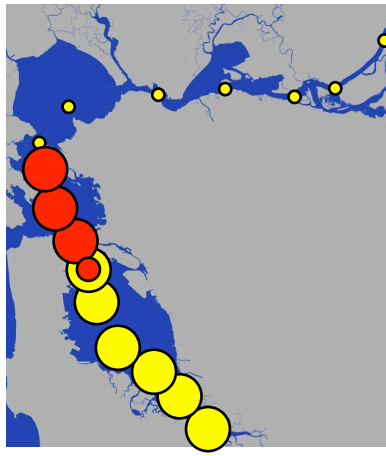




In collaboration with
UCSC and USGS

Thanks to D Schultz and
R Kudela (UCSC)



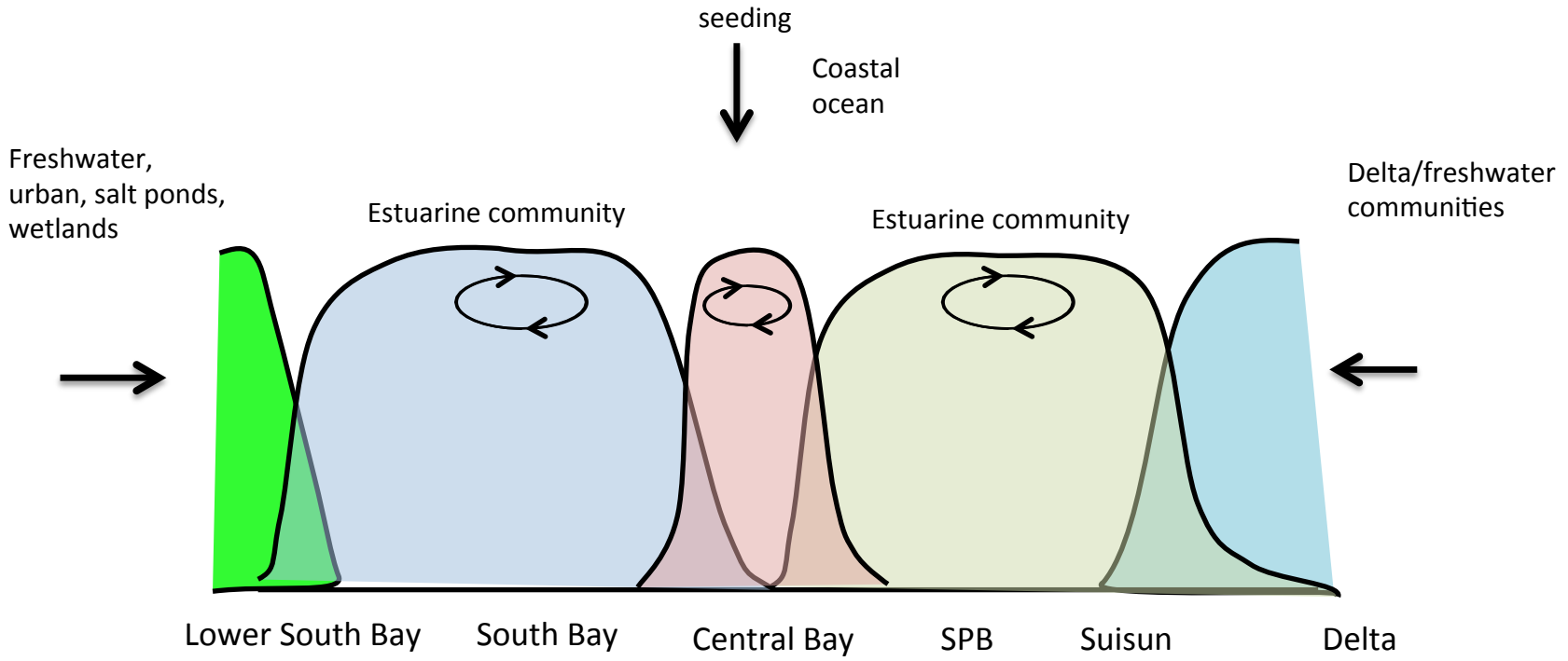


Pseudo-nitzchia

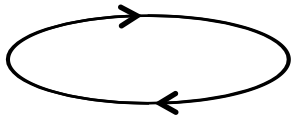
In collaboration with U
USGS

What shapes community phytoplankton community composition?

Are conditions in SFB adversely impacting phytoplankton composition?



Internal processes



- Light
- T
- Residence time
- Size-selective grazing by clams
- Nutrients

Source: C. Benton

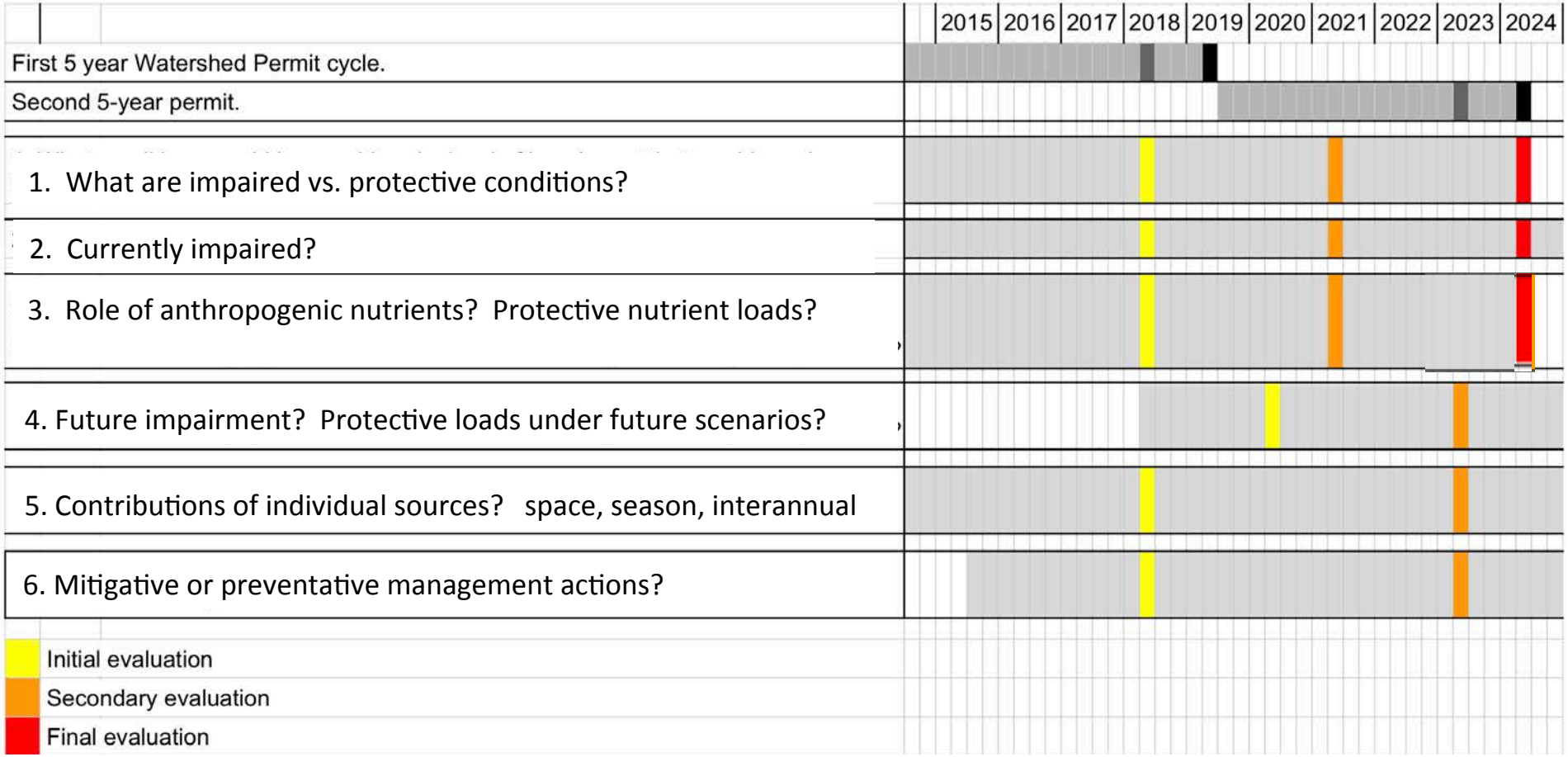
1. Program Overview

2. Update on Major Activities
    1. Numerical Modeling
    2. Harmful Algae Blooms
    3. Dissolved oxygen in margin habitats

3. Work Ahead

Key Assumption for Science Plan:

- Water Board's goal of 'Standards within 10 years'
- Work and timeline based on this goal, not current budget.



Current Major Science Gaps (un- or underfunded)

	Condition: Current , Protective	Mechanisms: N-link, rates	Management options ID
• Biogeochemistry field studies	X	X	X
• HABs investigations: mechanisms, causes, effects	X	X	
• Expanded monitoring	X	X	
• Biological endpoints	X	X	
• Quantifying nonpoint source nutrient loads			X
• Expanded modeling, including future scenarios	X	X	X

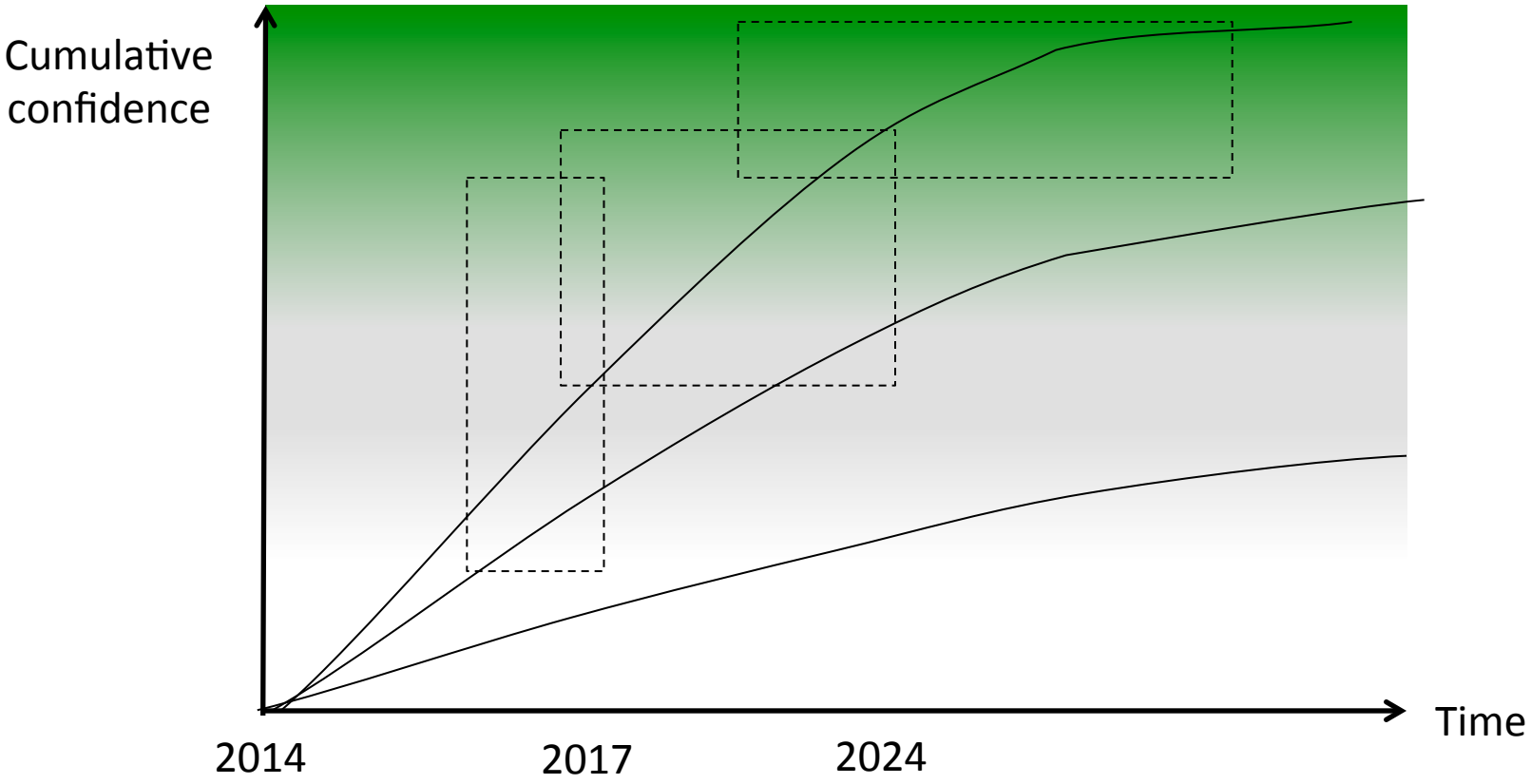
What is the necessary level of certainty to inform major management decisions?

- Depends on the cost
- Depends on the potential environmental risk

What are the relevant timelines?

- Which decisions?
- Environmental risk?

What science program can achieve the goals/certainty in the appropriate time?




Source: C. Benton

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NMS Steering Committee, NMS Planning Subcommittee, and Stakeholders

SFEI: P Trowbridge, J Hunt, J Davis, T Hale, G Shusterman, C Grosso, S Bezalel

Collaborators and Technical Advisors: M Sutula (SCCWRP), J Cloern (USGS), W Kimmerer (SFSU), R Kudela (UCSC), L Lucas (USGS), A Mueller-Solger (IEP), M Stacey (UC Berkeley), E Gross (RMA), A Parker (CSMA), T Schraga (USGS), J Thompson (USGS), D Schoellhamer (USGS), M Downing-Kunz (USGS), K Weidich (USGS), P Buchanan (USGS), J Crauder (USGS), M Peacock (UCSC), Erica Spotswood (SFEI), P de Valpine (UC Berkeley), B Bergamaschi (USGS), B Downing (USGS), T Kraus (USGS), I Wren (Baykeeper)