NMS Science Program ←→ AF Development

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SFEI
February 9 2016

What does the Science Plan aim to be or do?

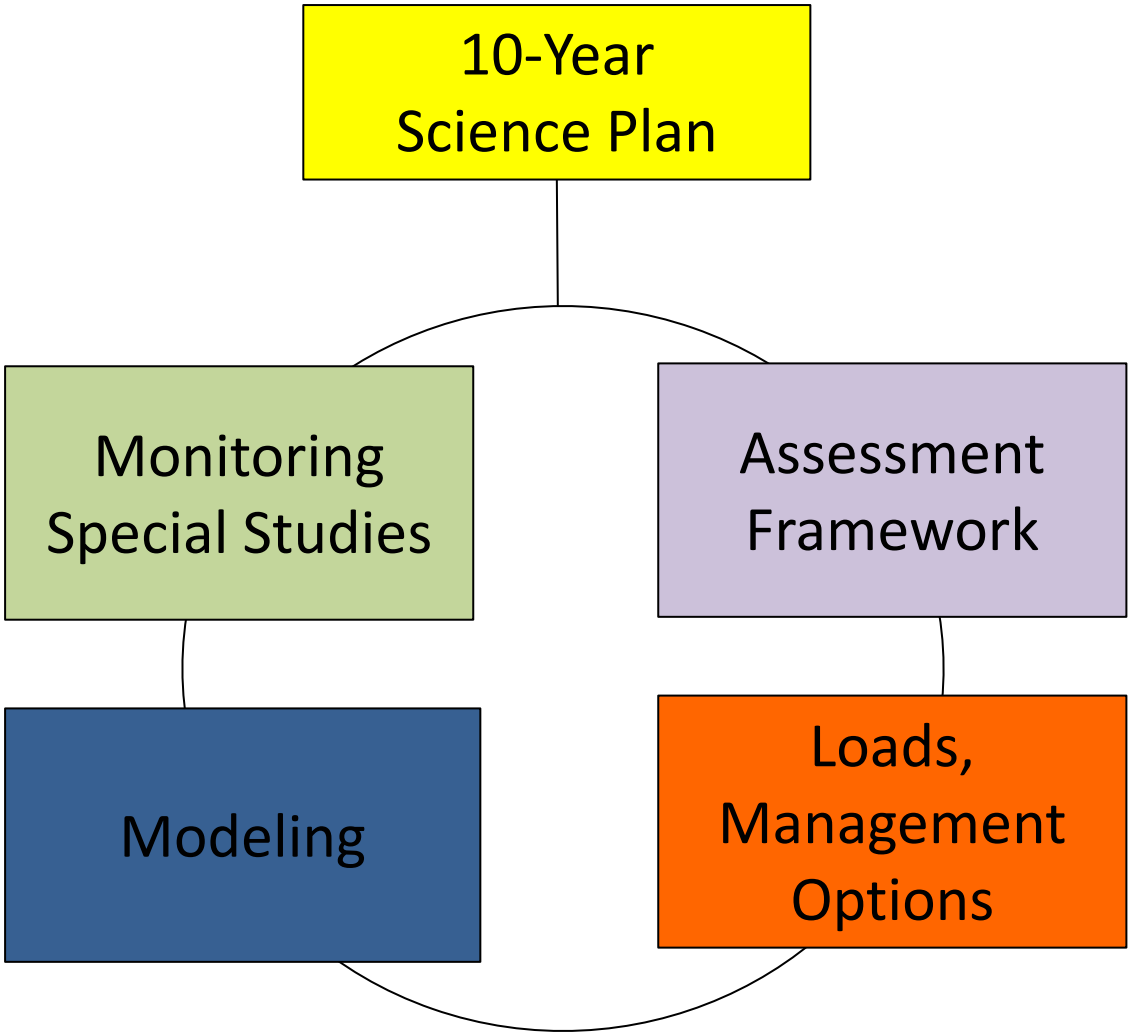
1. Multi-year (10+ year) plan
   - Logical sequencing of projects targeting management decisions
   - Build in check-in points for refining Science Plan based on new information
   - Road map that Steering Committee follows to implement the NMS

2. Shaped by broad input on science and management issues…
   - Management priorities ← Regulator/stakeholder
   - Science needs/approach ← Science advisors
   - External Review ← Science Panel

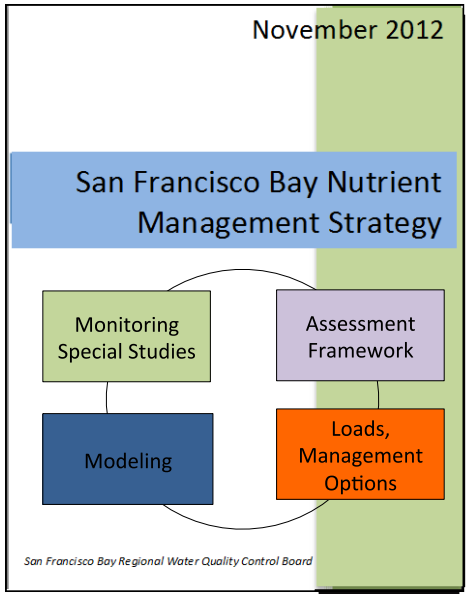
3. Establish overarching logic/rationale for prioritizing among major lines of inquiry and projects, and project sequencing.

4. Provide realistic estimates of time and funding needed to reach answers with sufficient confidence/certainty to justify major management decisions

NMS Science Program



4 basic components



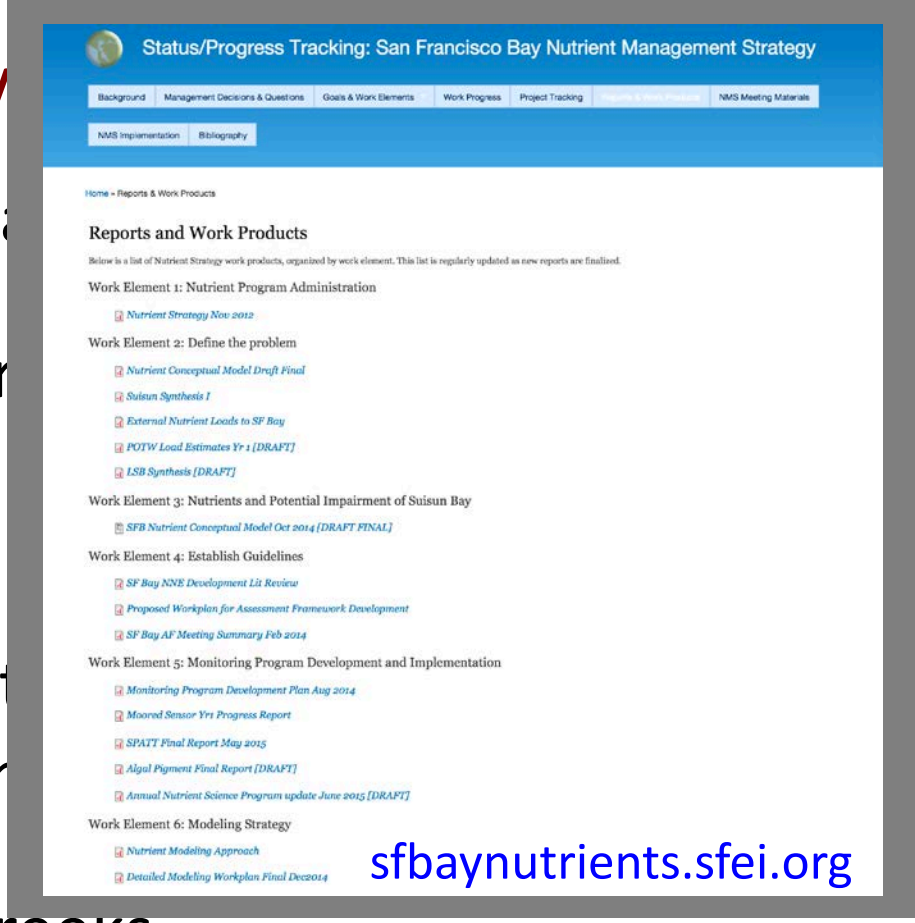
1. Nutrient sources, movement, transformations

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?

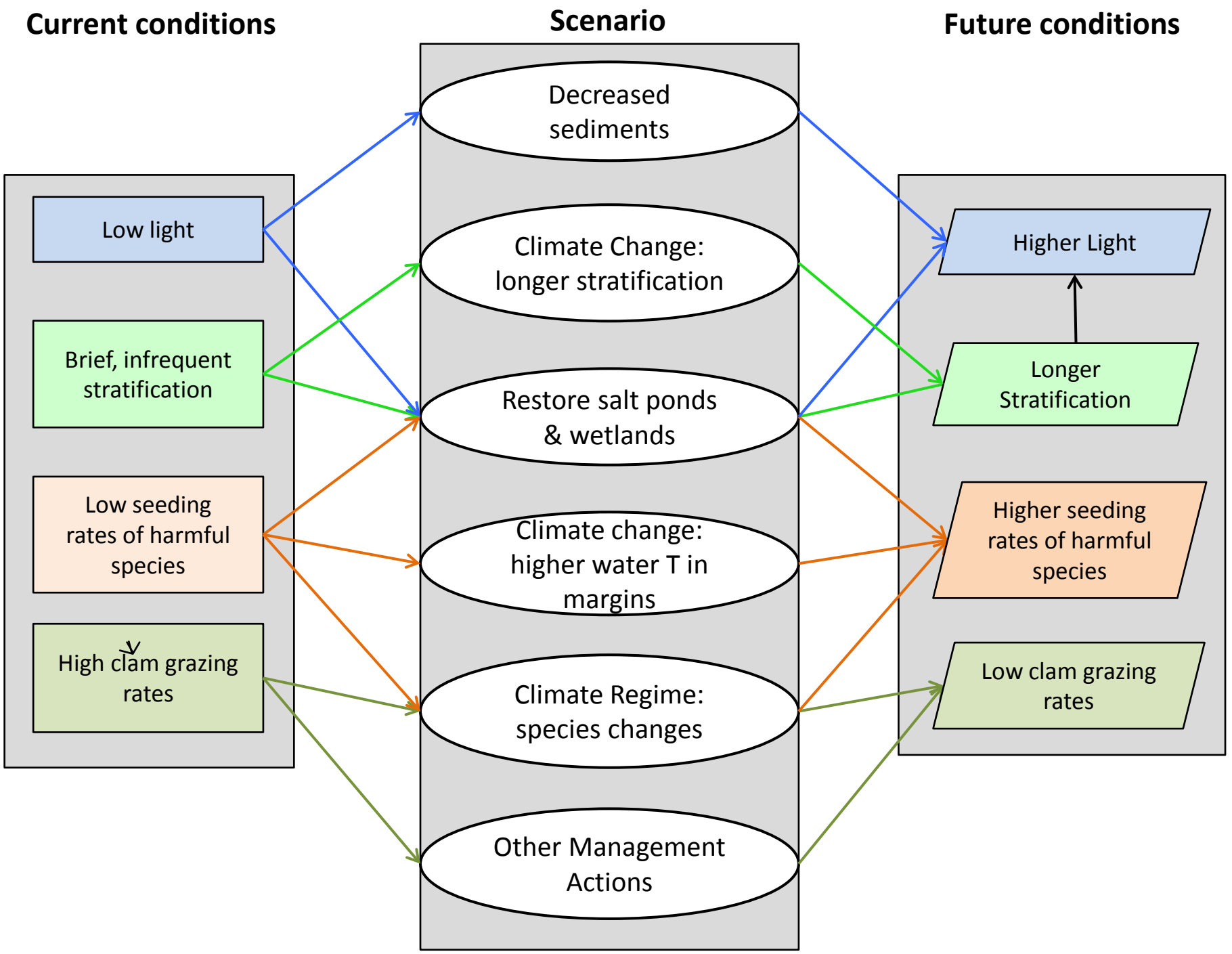
Major NMS Focus Activ

1. Nutrient Load Estima
2. Synthesis, Data inter
3. Monitoring
4. Characterizing HAB-t
   phytoplankton comm
5. DO in sloughs and creeks
6. Biogeochemical modeling
7. Assessment Framework development



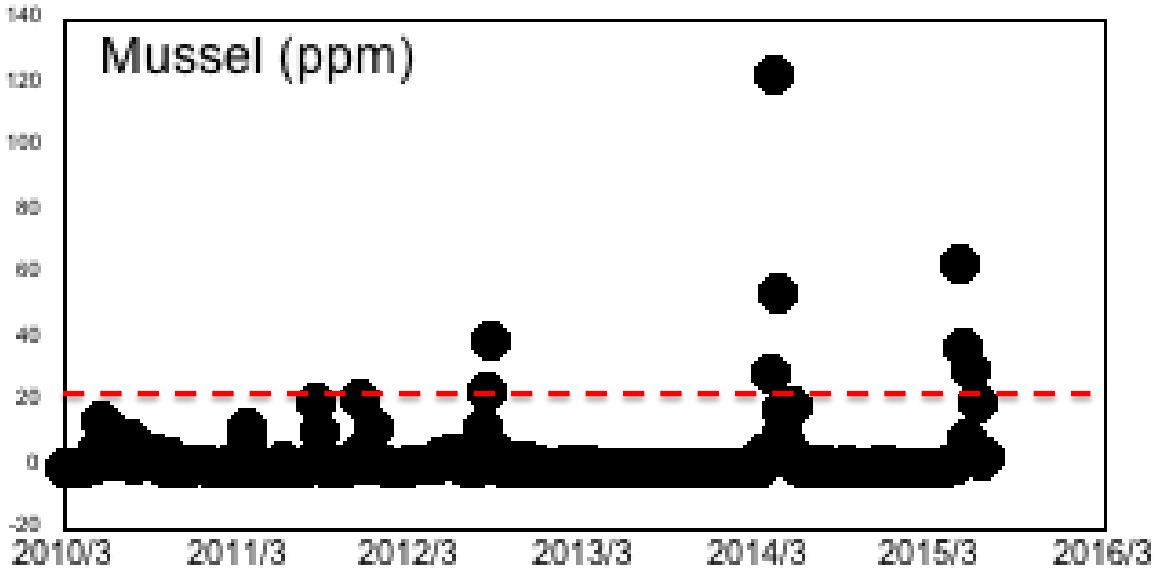
Planned activities, but later… not major current focus

- Growth experiments with HAB-forming species
- Intensive field investigations for improved mechanistic understanding
  - Nutrient dose:response
  - Nutrient transformations
  - Intensive phytoplankton/HAB/toxin work
- Biota surveys (fish abundance, toxins in marine mammals/birds)
- Identifying future scenarios for further examination
- Testing those scenarios with models and controlled experiments


Current conditions
Scenario
Future conditions
Low light
Brief, infrequent stratification
Low seeding rates of harmful species
High clam grazing rates
Decreased sediments
Climate Change: longer stratification
Restore salt ponds & wetlands
Climate change: higher water T in margins
Climate Regime: species changes
Other Management Actions
Higher Light
Longer Stratification
Higher seeding rates of harmful species
Low clam grazing rates

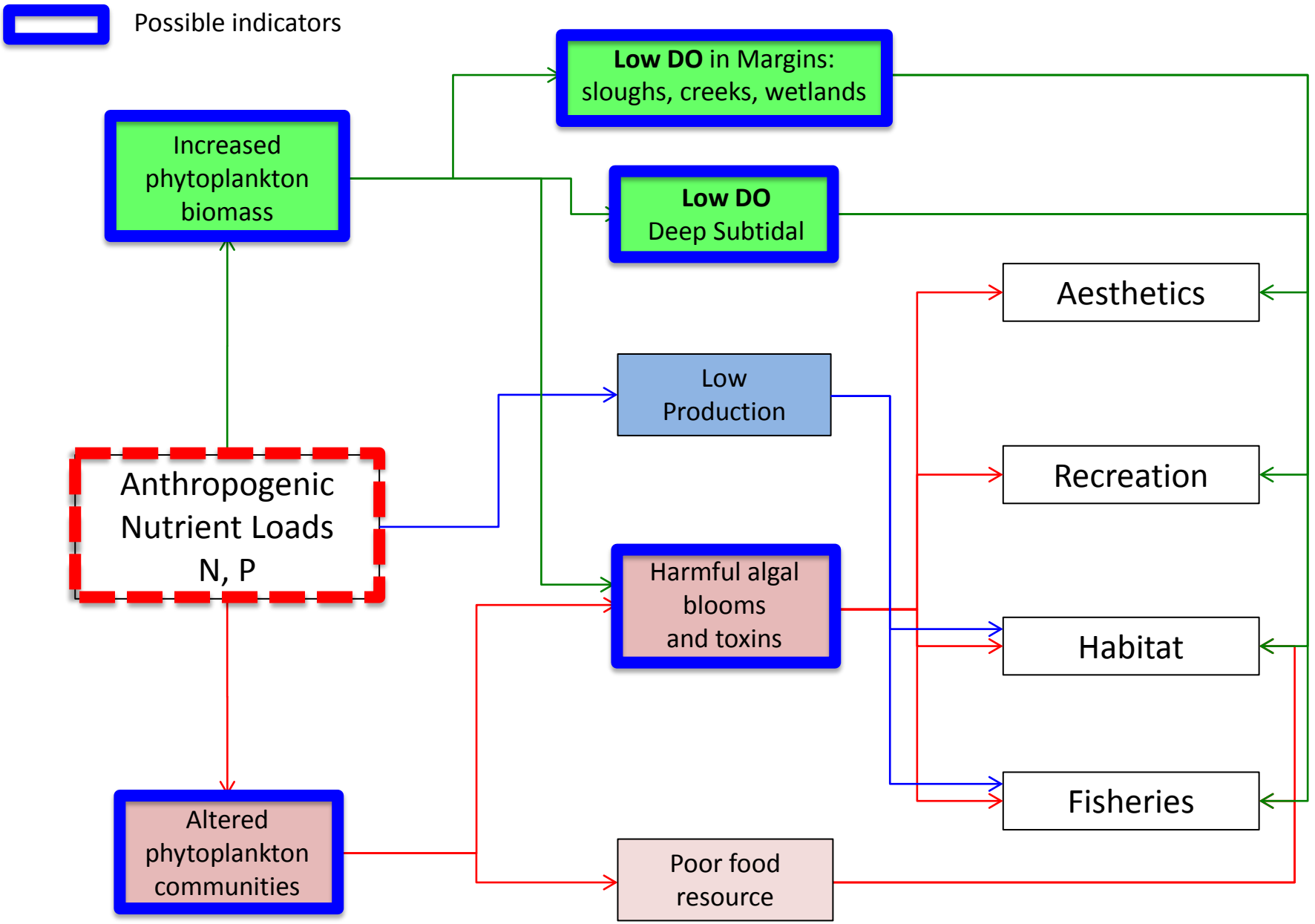
Manage for ‘Typical Conditions’, or Manage for Events?

Santa Cruz Wharf: 2010-2016 (weekly)



Source: R Kudela

Potential Adverse Impacts of Nutrients in SFB



Science Plan…Tradeoffs between important science needs

Program Areas

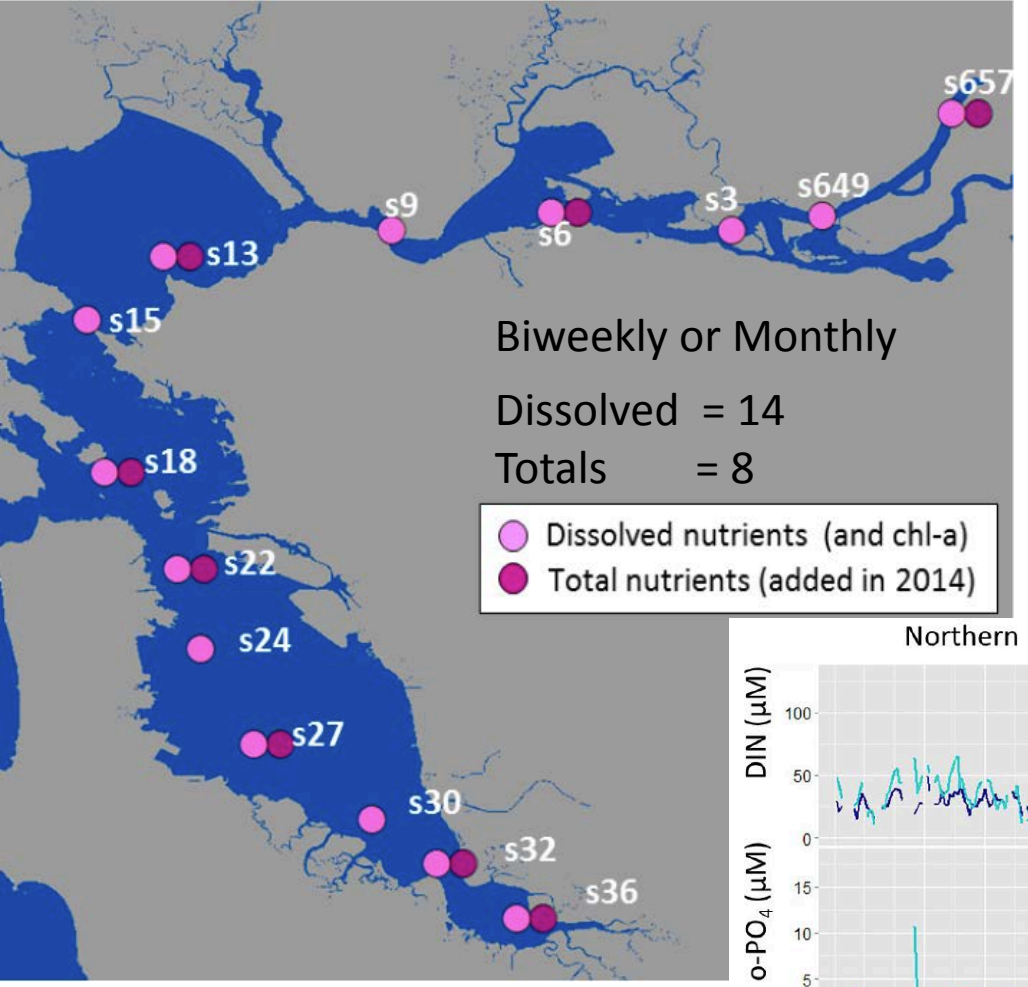
1. Nutrients loads/cycling
2. Low DO / high productivity (margins)
3. Phytoplantkon…HABs/toxins
4. NH4/N:P impacts

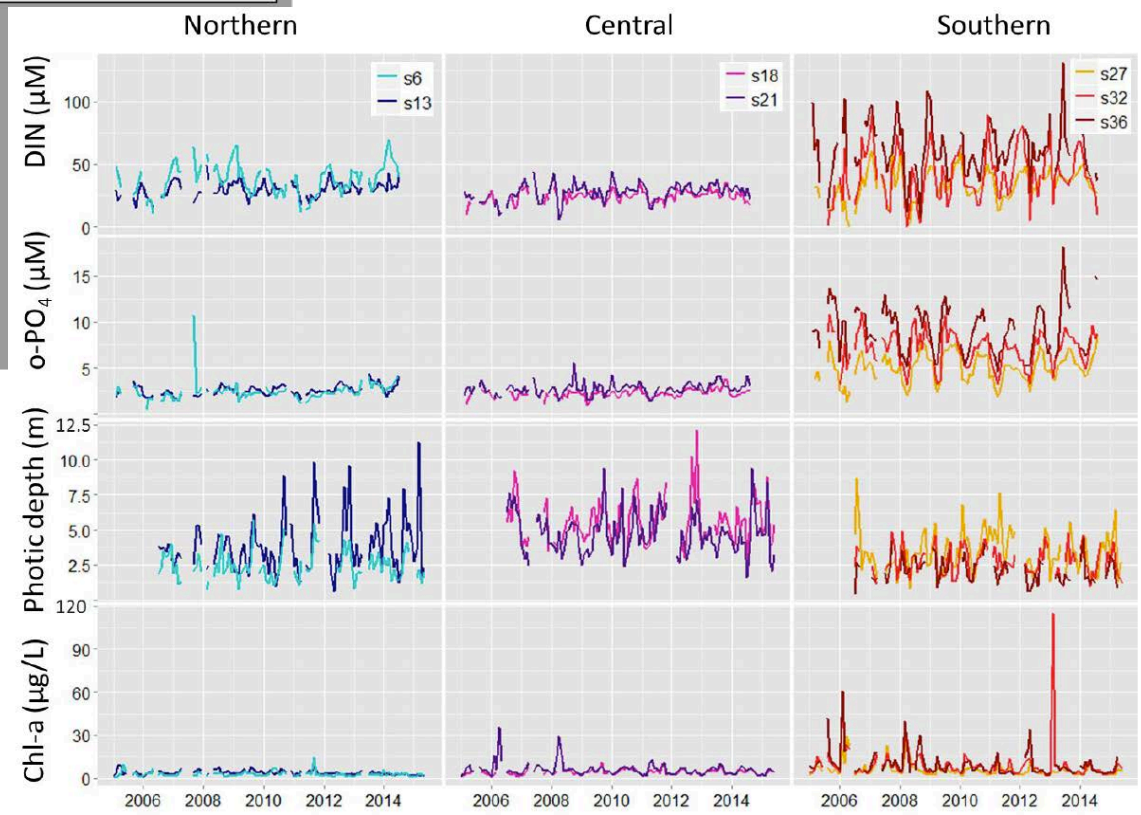
Work Categories

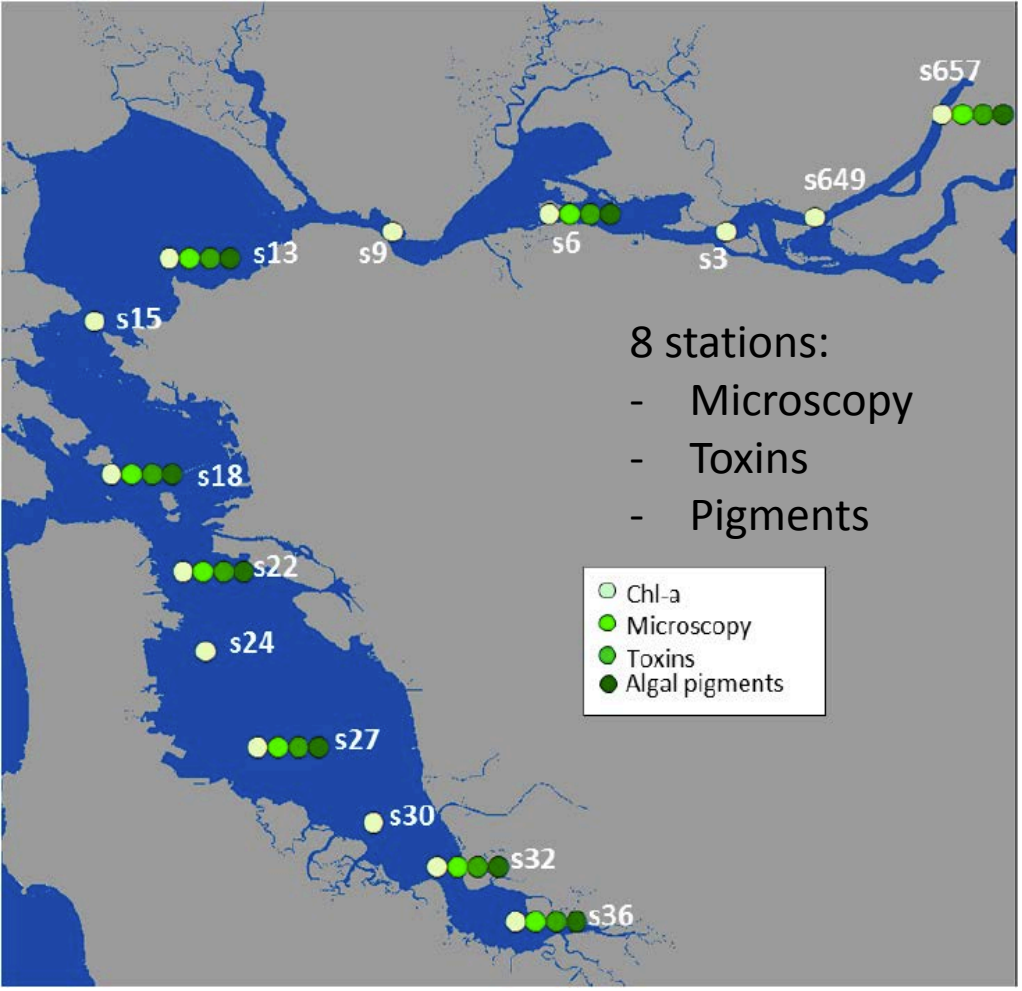
1. Monitoring
2. Modeling
3. Special studies
4. Identify protective conditions (i.e., AF)

Types of studies…

1. Monitoring: ship, moored sensors, new analytes
2. Field investigations: e.g., nutrients → HABs → toxins
3. Mechanistic lab studies: e.g., nutrients → HABs → toxins
4. Nutrient Transformations
5. Habitat condition assessment e.g., fish surveys, protective toxin conc.


s657
s649
s9
s6
s3
s13
s15
s18
s22
s24
s27
s30
s32
s36
Biweekly or Monthly
Dissolved = 14
Totals = 8
Dissolved nutrients (and chl-a)
Total nutrients (added in 2014)


Northern
Central
Southern
DIN (µM)
o-PO4 (µM)
Photic depth (m)
Chl-a (µg/L)
s6
s13
s18
s21
s27
s32
s36
2006
2008
2010
2012
2014



Phytoplankton, HABs, Algal Toxins:

Particulate toxins (discrete)

- 2015-present (discrete samples)
- 2012-2014 archived samples

Spatially-integrated (SPATT)

- 2016-present
- 2012-2015

Pigments

- 2015-present
- 2012-2014 archived samples

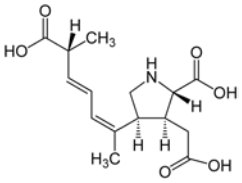
Microscopy

- 2014-present (new protocol)
- 1992-2014

Harmful Algal Blooms (HABs)

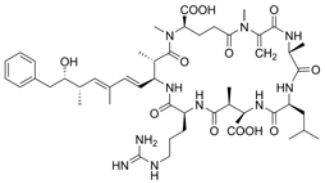
Example Toxin Producing Organisms

Domoic Acid
(Amnesic Shellfish Poisoning)



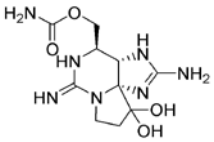
Pseudo-nitzschia spp.

Microcystin toxins
(hepatotoxin)



Microcystis spp.

Saxitoxin
(Paralytic Shellfish Poisoning)



Alexandrium spp.

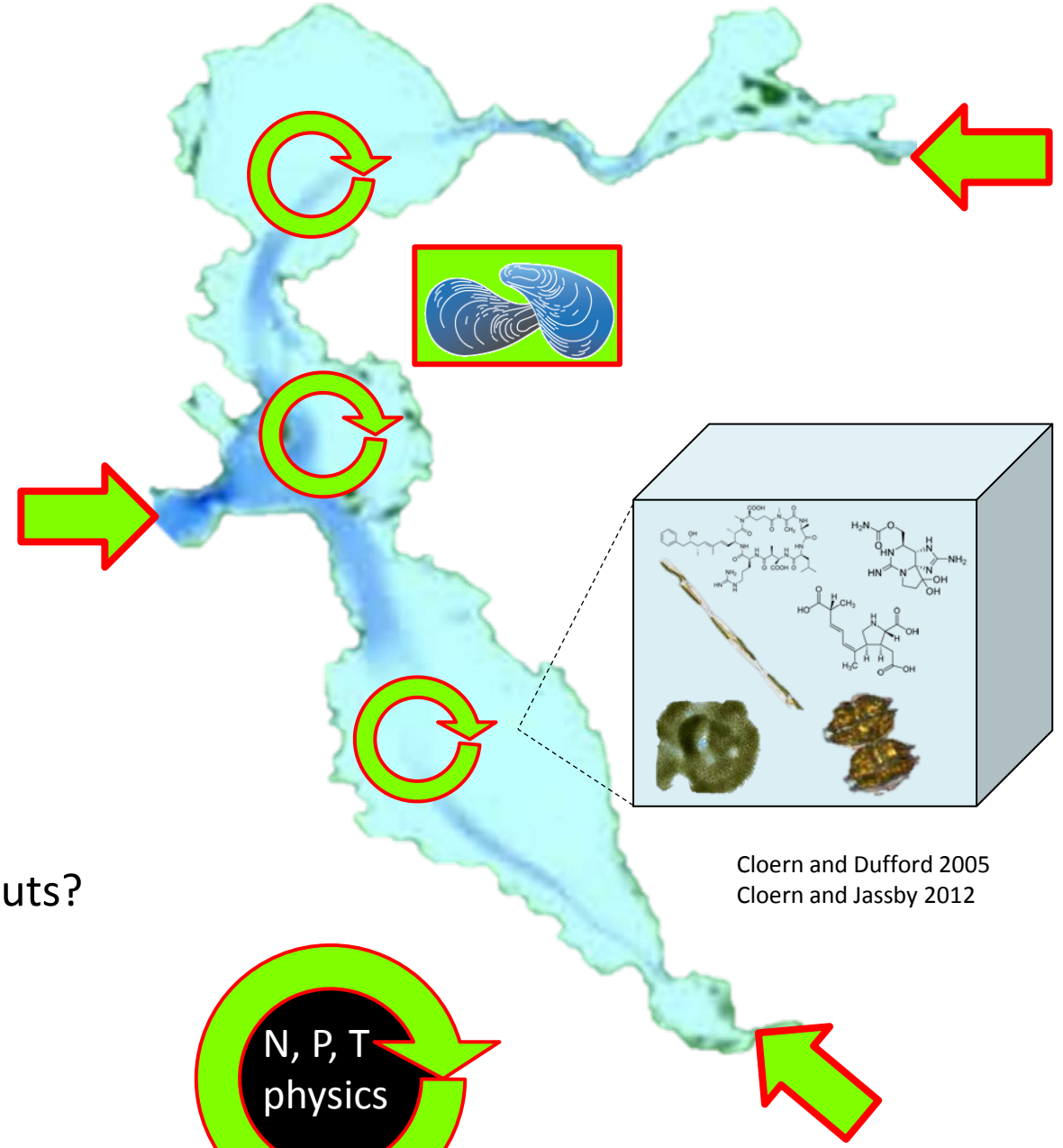
When are toxins produced?

When they are stressed…e.g.,

- Salinity, Temperature
- Nutrients (- P, - Si; + N, +metals)
- Light conditions

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

- HAB-forming species?
- Toxins in water?
- Toxins in biota?
- External Sources?
- Internal production, role of nutrients?
- Acceptable risk, protective nutrient inputs?



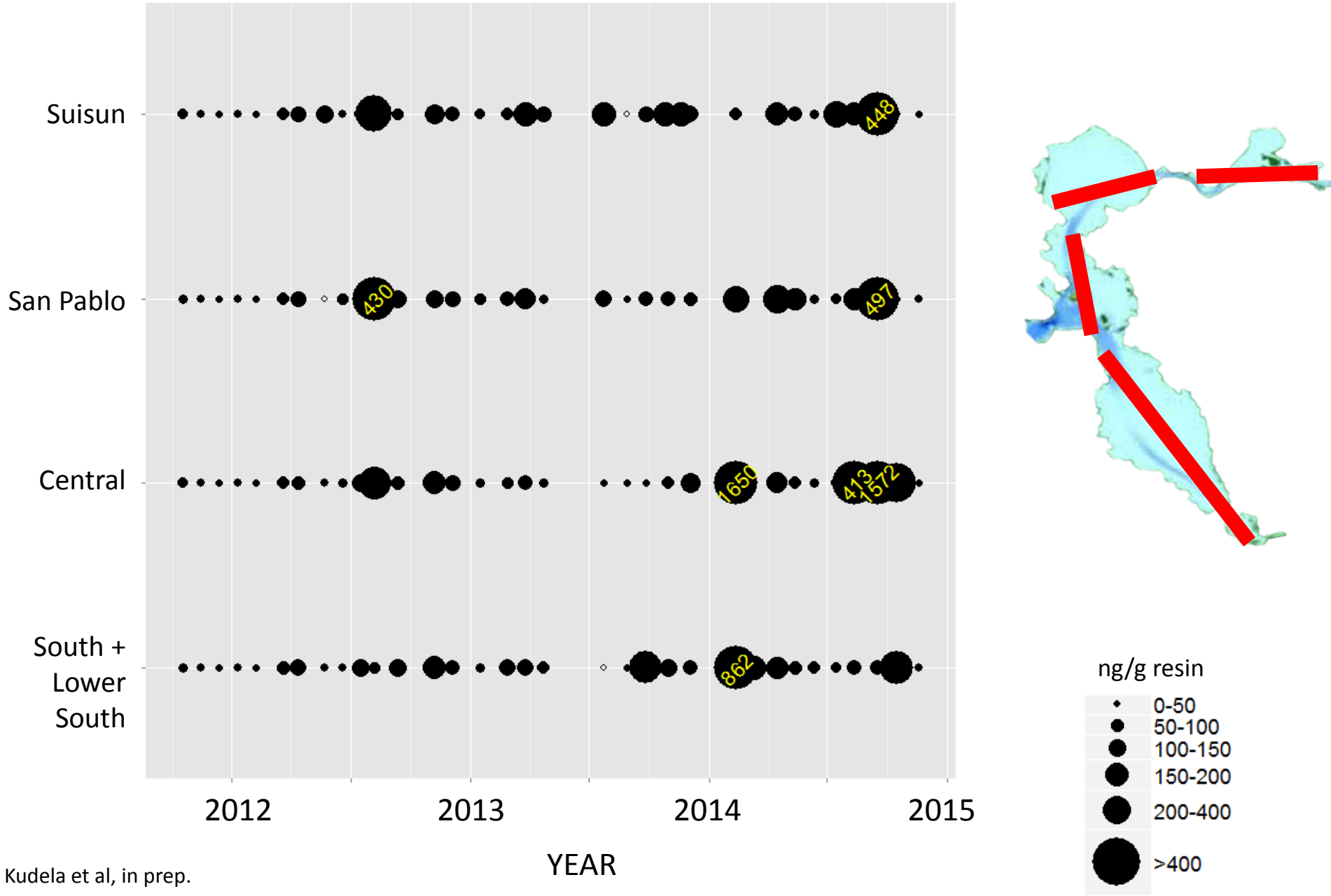
Cloern and Dufford 2005
Cloern and Jassby 2012

Best approach for HAB / toxin investigations?

- Microscopy
- Spatially-integrated water (SPATT)
- Discrete water samples…. “grab samples”
- Biota

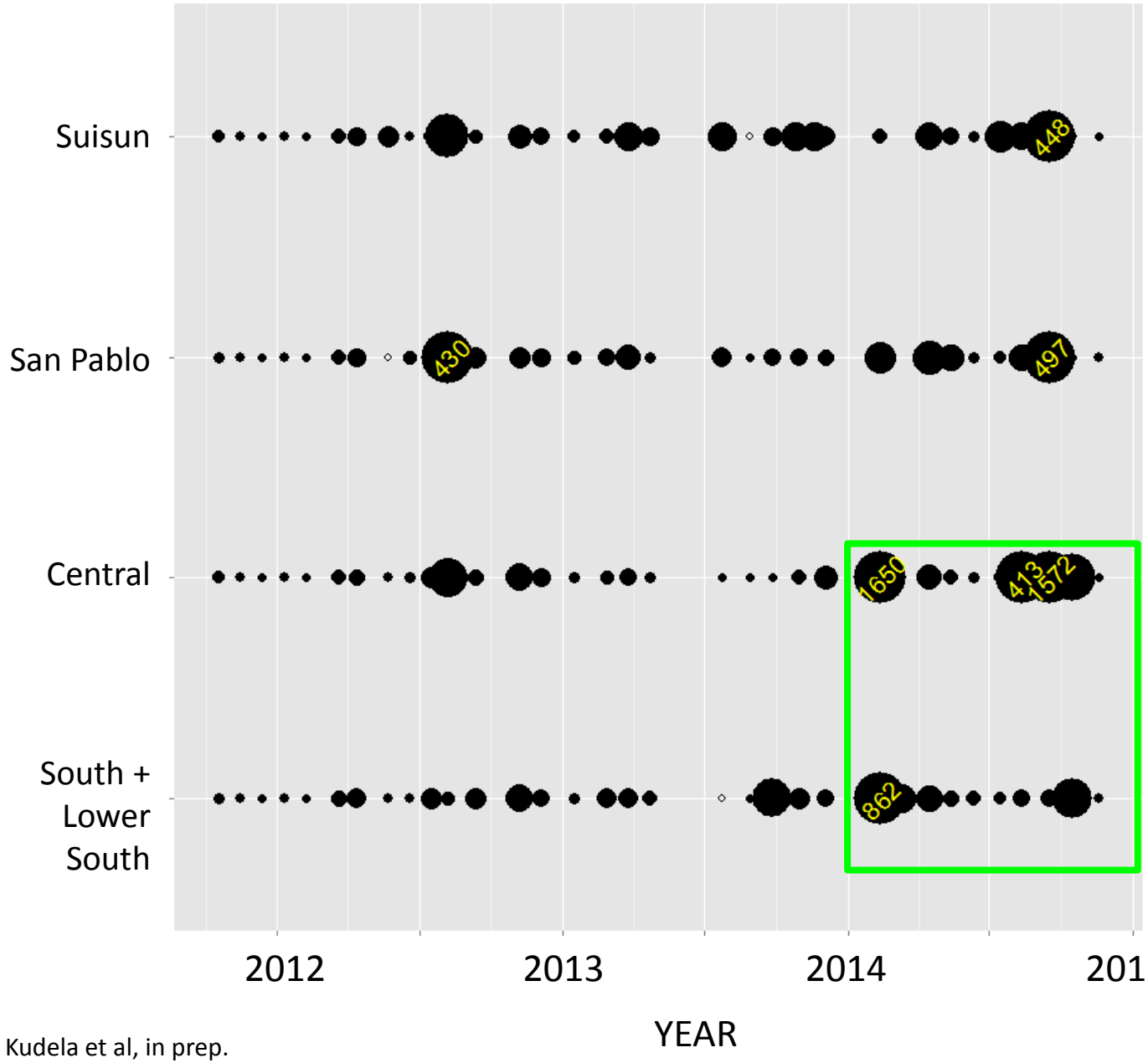
- All approaches have pros and cons…
  - Spatial averaging
  - Time-averaging
  - Translate to actual concentrations
  - Effort/cost

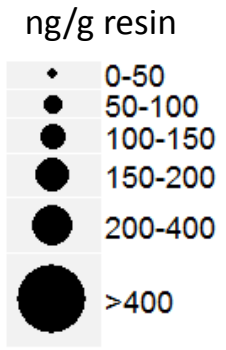
Are toxins present? **Domoic Acid…**spatial average (SPATT)



Kudela et al, in prep.

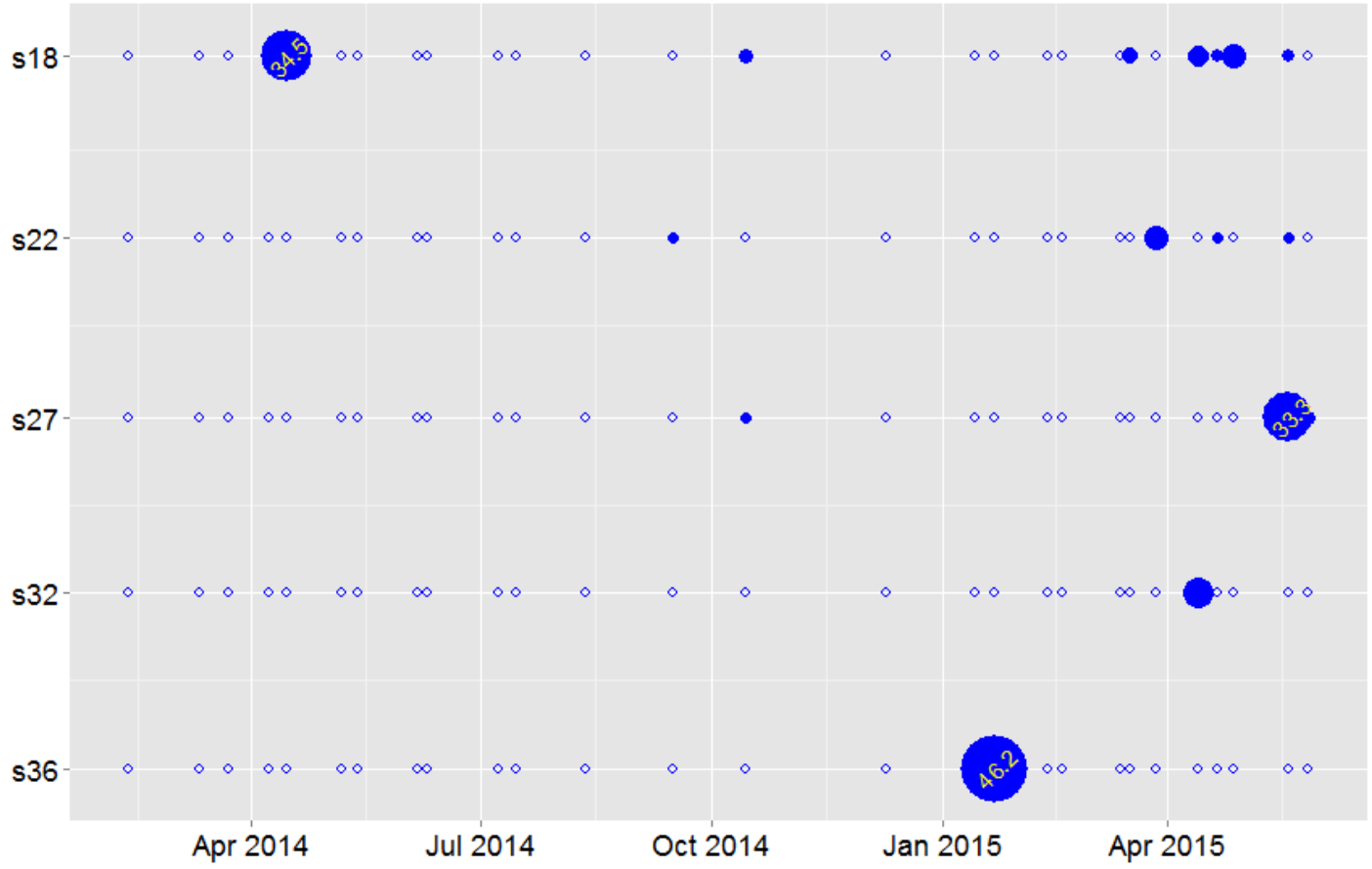
Are toxins present? **Domoic Acid…**spatial average (SPATT)

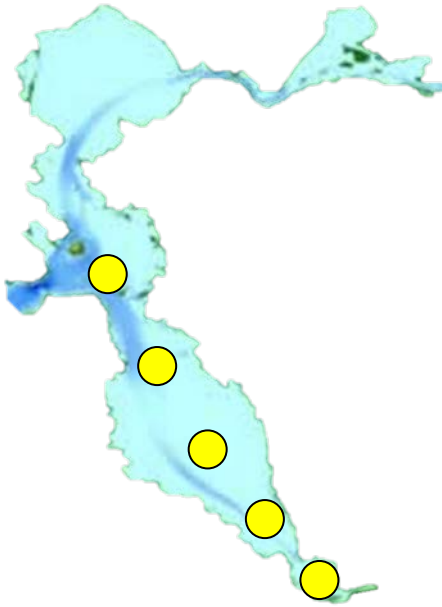


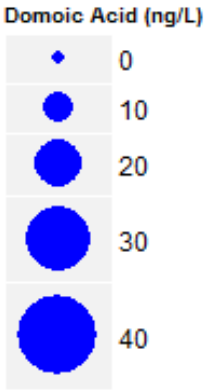


Kudela et al, in prep.

Are toxins present? Grab samples…**Domoic Acid**

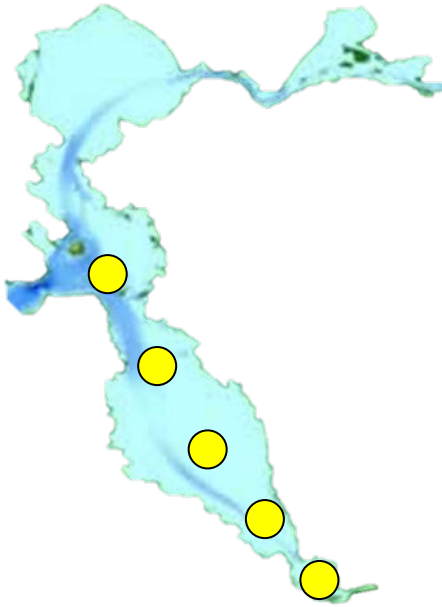






Peacock et al, in prep.

Are toxins present? Grab samples…**Domoic Acid**



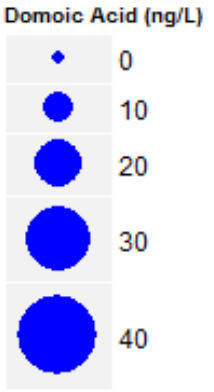


Table 3.9. Toxin Classification Table for Domoic Acid. Classification should be applied to each subembayment. If multiple hits in different media (particulate, SPATT, tissue) are detected within subembayment on an annual basis, lowest rating for the year should be applied.

Toxin Concentration	Ecological Condition Based on Annual Frequency of Occurrence in Monthly Samples			
	1 of 12	2-3	4-6	6+
Particulate concentration				
Non-detect	Very high	Very high	Very high	Very high
0-100 ug/L	High	Moderate	Moderate	Low
100 - 1000 ug/L	Moderate	moderate	Low	Very Low
> 1000 ug/L	Low	Very Low	Very Low	Very Low

Toxins entering the food web?

Mussel Watch (RMP)

- Deployed mussels Bay-wide
- Time-integrated “sampler”

Mytilus californianus

Peacock et al. *in prep*

Domoic Acid

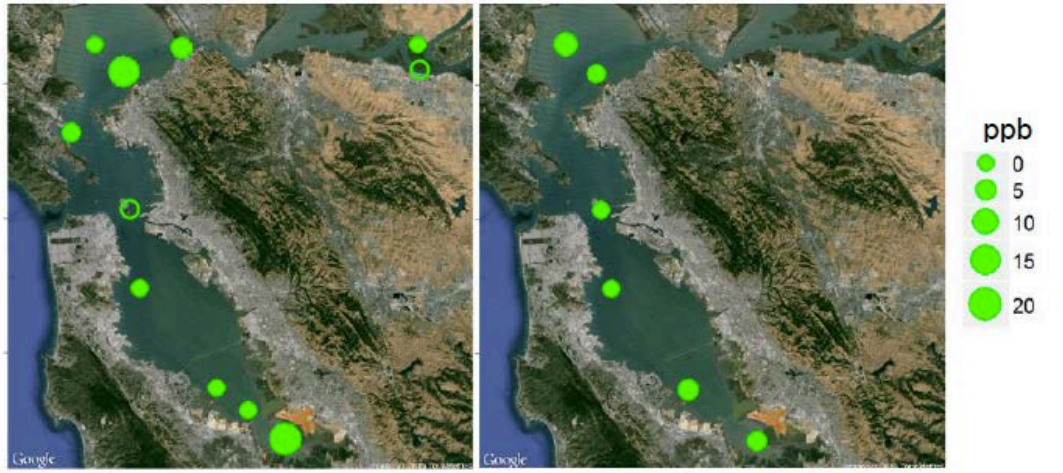
DA detected in all samples

- DA << 20 ppm regulatory limit for shellfish

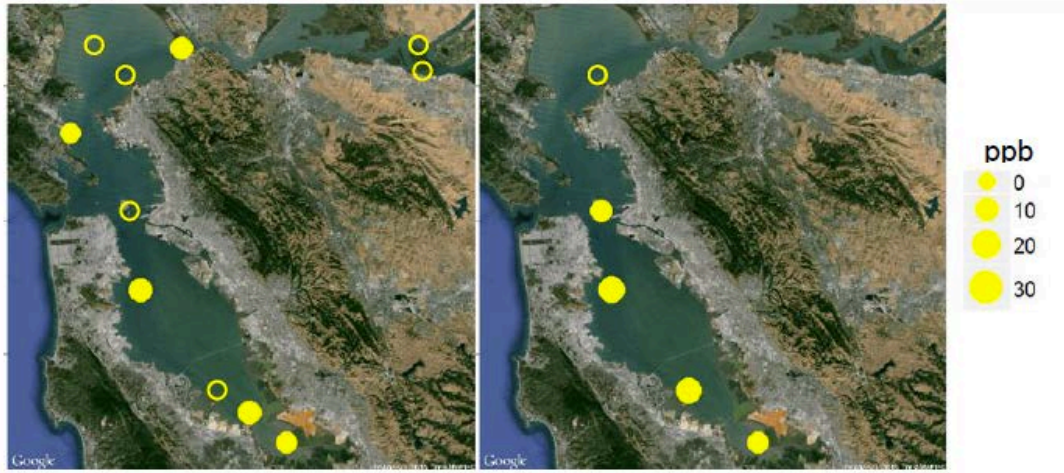
Microcystin

MC detected in most samples

- Some samples with MC > 10 ppb OEHHA limit



Saxitoxin



Deployment period: 90 days.

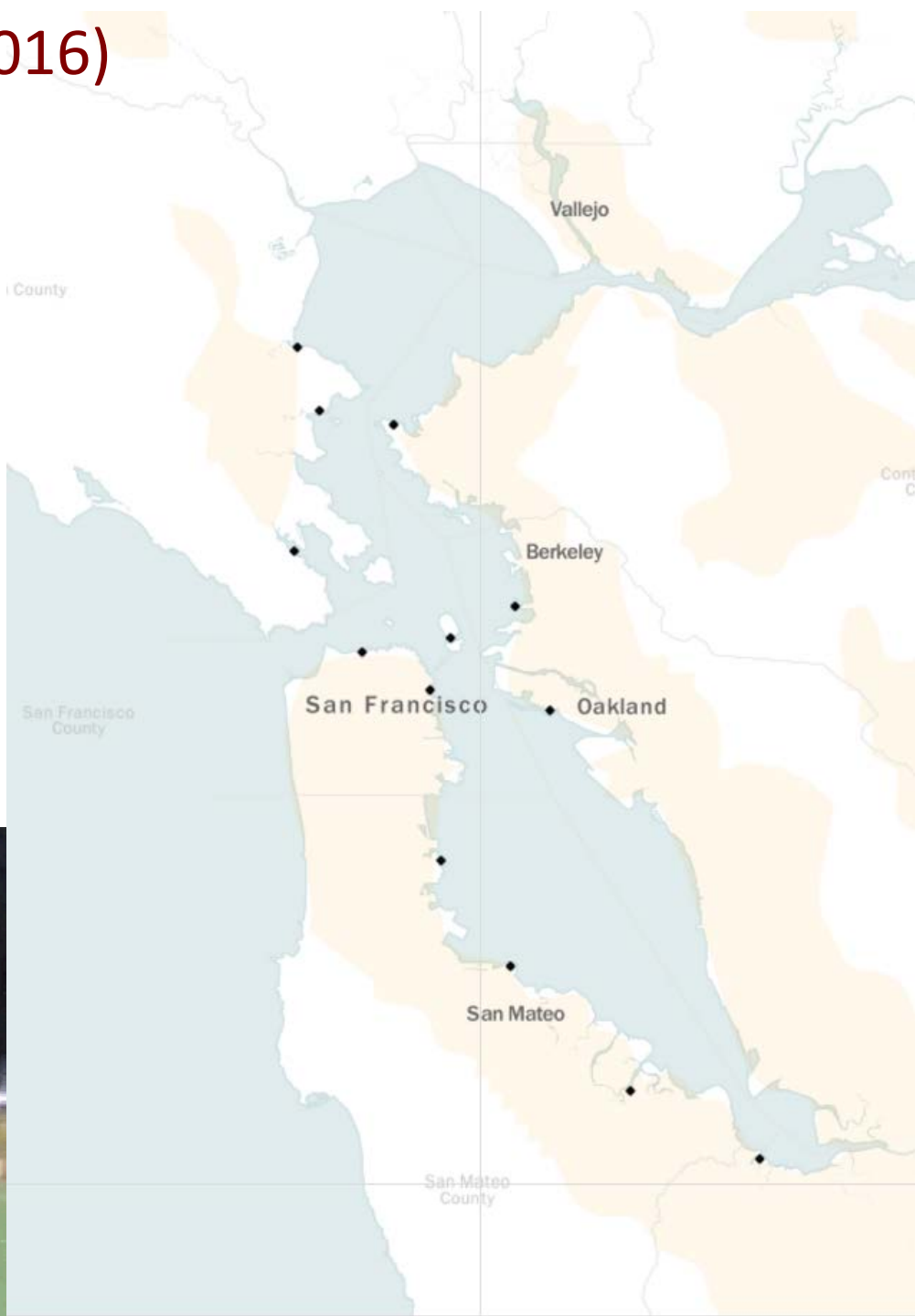
Peacock et al. *in prep*

Bay-wide mussel survey (FY2016)

- Naturally occurring mussels
- Accessible from land, floating docks.

Approach:

- Bi-weekly sampling
- Deliberate approach to analyzing



Bay-wide mussel survey (Sep 2016-present)

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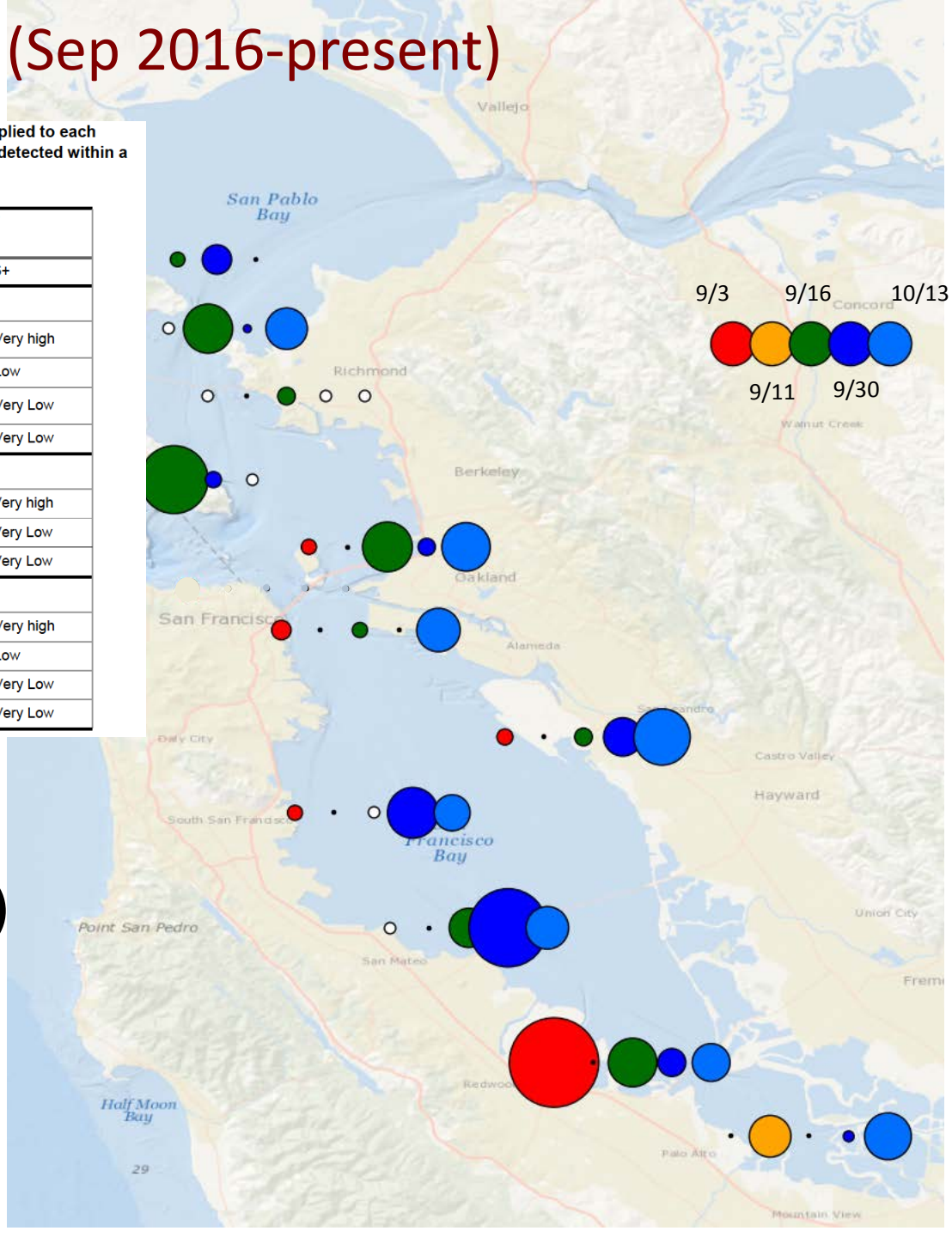
0-100 ug/L	High	Moderate	Moderate	Low
100 - 1000 ug/L	Moderate	moderate	Low	Very Low
> 1000 ug/L	Low	Very Low	Very Low	Very Low
SPATT				
<30 ng/g	Very high	Very high	Very high	Very high
30-75 ng/g	Moderate	Low	Very low	Very Low
>75	Low	Very Low	Very Low	Very Low
Mussel Tissue				
Non-detect	Very high	Very high	Very high	Very high
< 10 ppm	High	Moderate	Moderate	Low
10-20 ppm	Moderate	moderate	Low	Very Low
> 20 ppm	Low	Very Low	Very Low	Very Low



Coupled Biogeochemical-Hydrodynamic Modeling

Hydrodynamics:

3-D

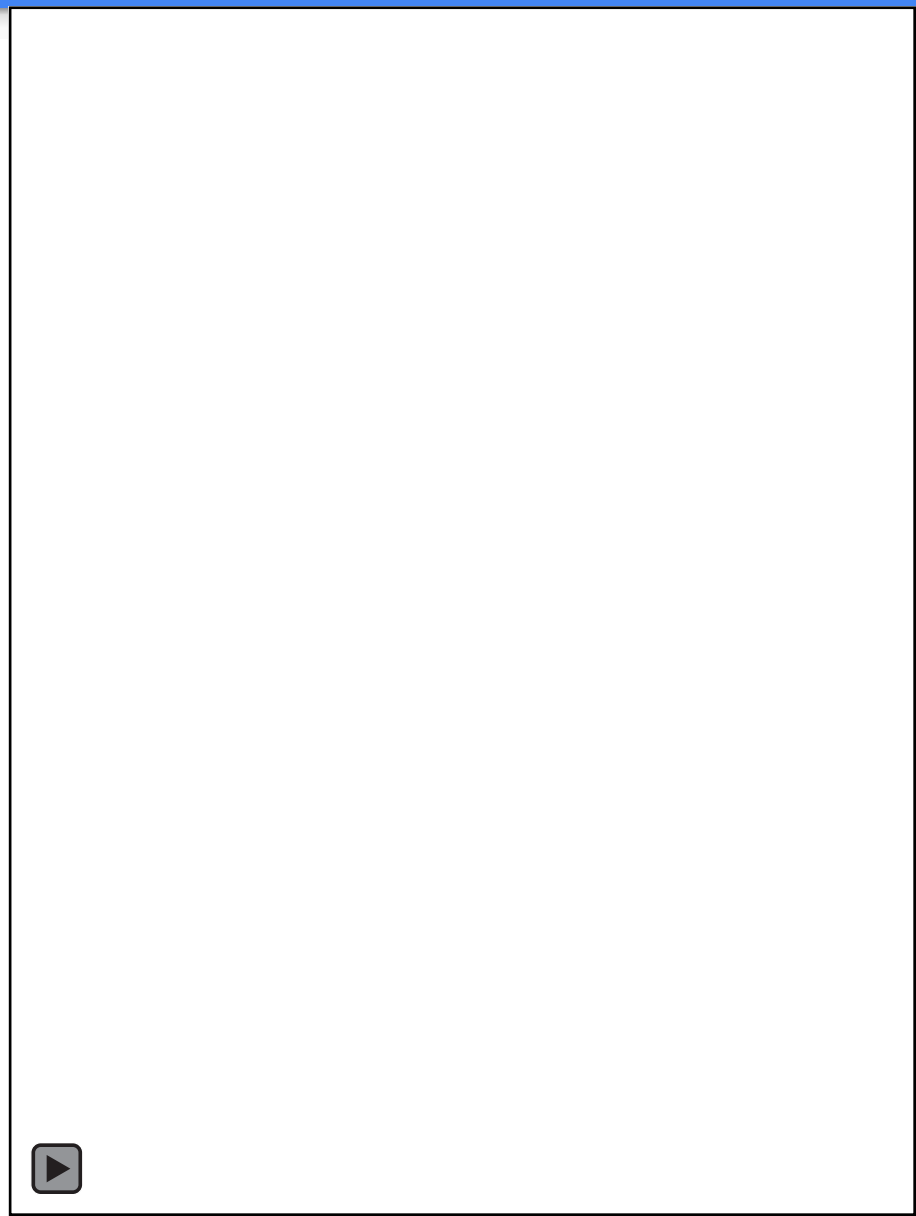
Tides, wind, freshwater sources

(SUNTANS, migrating to Deltares-FM, in collaboration with USGS & Deltares)

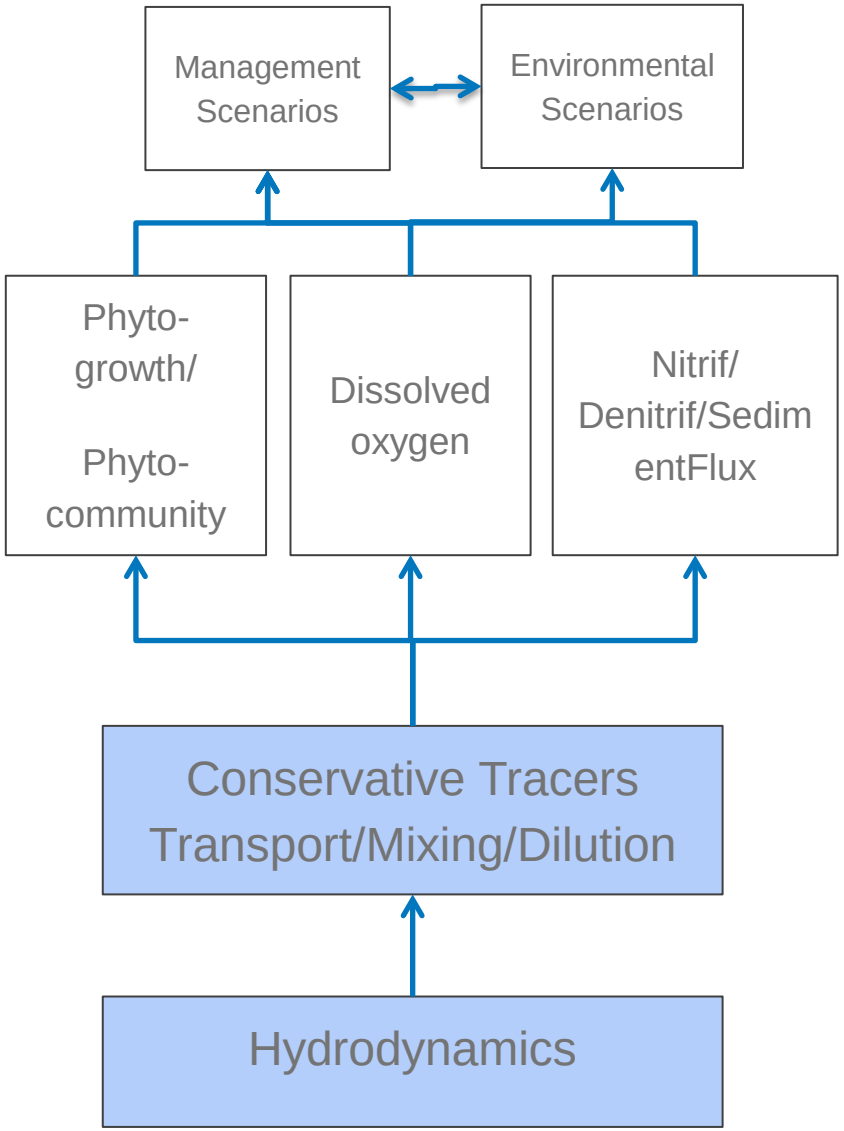
Transport:

Delft Water Quality

- Major POTWs
- Freshwater sources



Initial Results



Initial Results

Uptake/Phyto-growth

↑

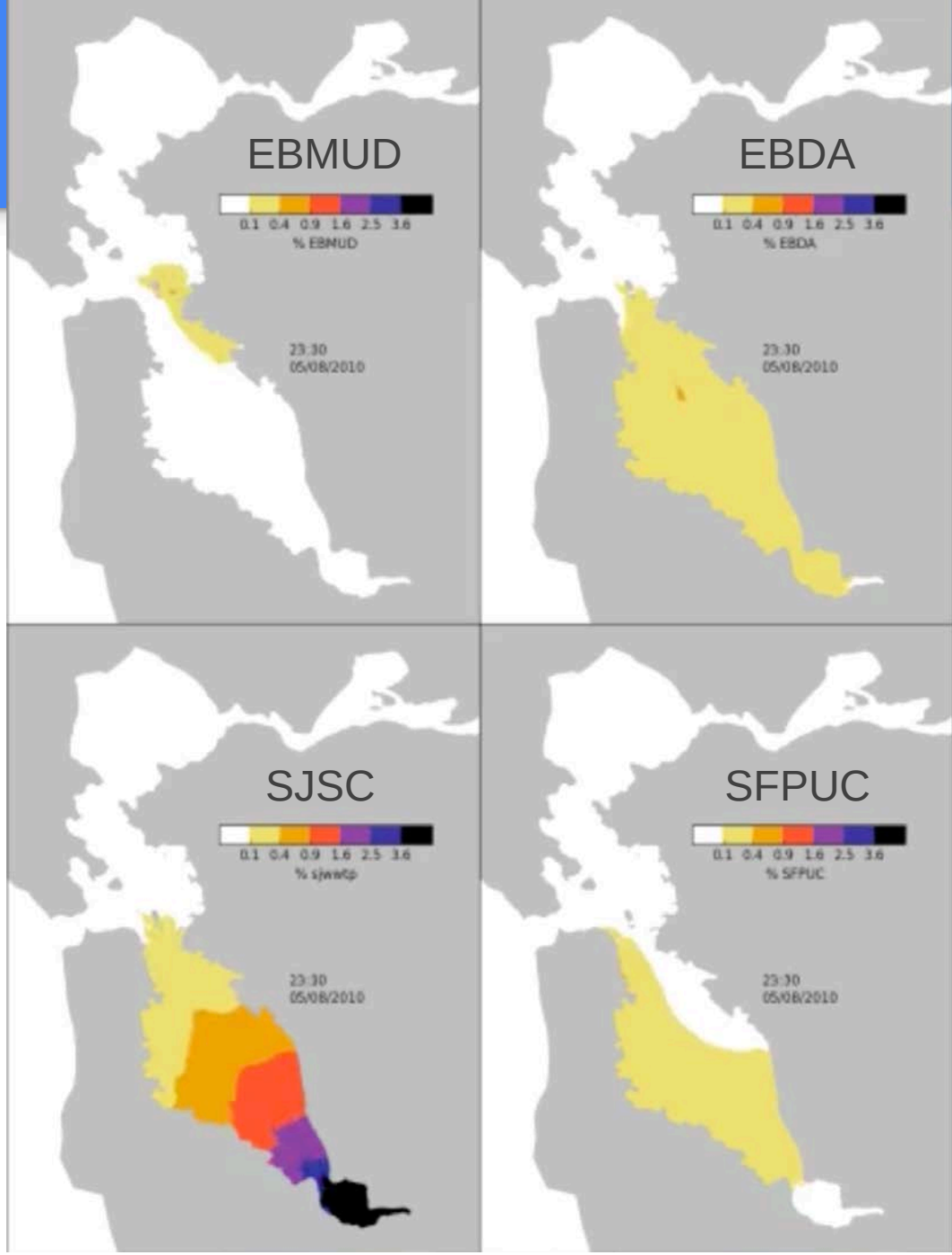
Nitrif/Denitrif/SedimentFlux

↑

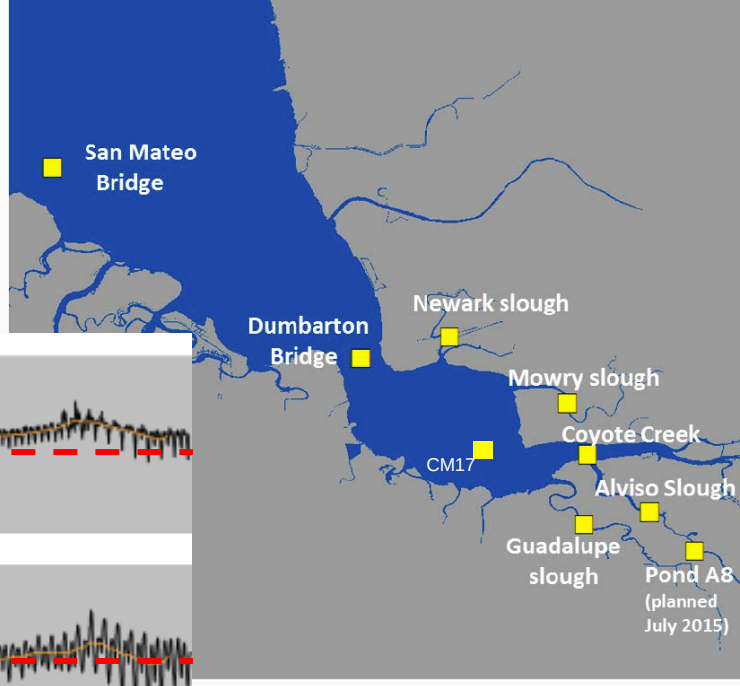
Transport/Mixing/Dilution

↑

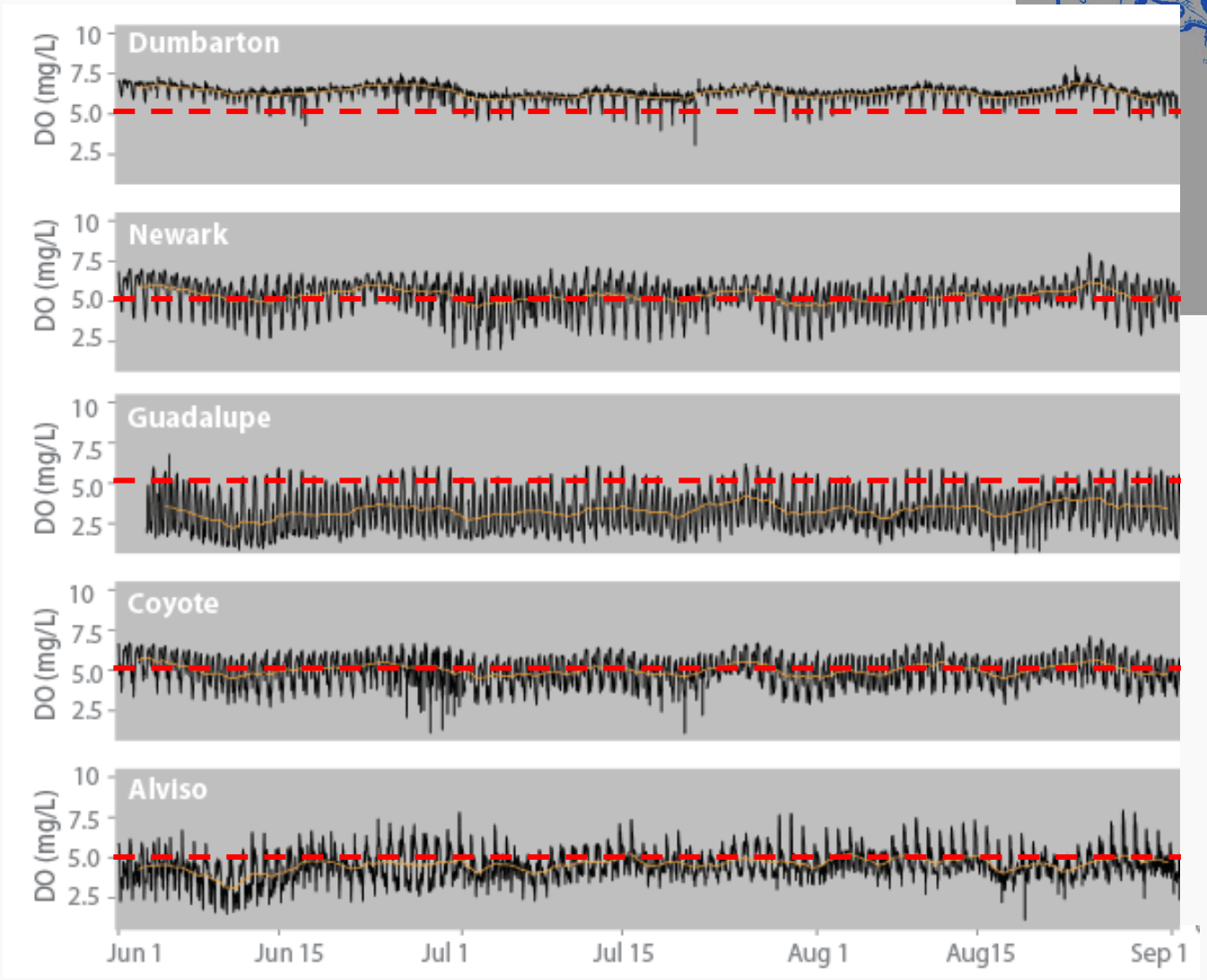
Conservative Tracers



High-frequency monitoring



Dissolved Oxygen – Summer 2015



Major NMS Focus Activities – 2013-present

1. Nutrient Load Estimates
2. Synthesis, Data interpretation
3. Monitoring
4. Characterizing HAB-toxins Bay-wide
5. Phytoplankton community composition
6. DO in shallow margin habitats
7. Model development application
8. Assessment Framework development

Things planned, but later… not major current focus

- Growth experiments with HAB-forming species
- Identifying future scenarios for further examination
- Testing those conditions with models and controlled experiments
- Intensive field investigations for improved mechanistic understanding
  - Nutrient dose:response
  - Nutrient transformations
  - Intensive phytoplankton/HAB/toxin work

Status/Progress Tracking: San Francisco Bay Nutrient Management Strategy

Reports and Work Products

Below is a list of Nutrient Strategy work products, organized by work element. This list is regularly updated as new reports are finalized.

Work Element 1: Nutrient Program Administration

- *Nutrient Strategy Nov 2012*

Work Element 2: Define the problem

- *Nutrient Conceptual Model Draft Final*
- *Suisun Synthesis I*
- *External Nutrient Loads to SF Bay*
- *POTW Load Estimates Yr 1 [DRAFT]*
- *LSB Synthesis [DRAFT]*

Work Element 3: Nutrients and Potential Impairment of Suisun Bay

- *SFB Nutrient Conceptual Model Oct 2014 [DRAFT FINAL]*

Work Element 4: Establish Guidelines

- *SF Bay NNE Development Lit Review*
- *Proposed Workplan for Assessment Framework Development*
- *SF Bay AF Meeting Summary Feb 2014*

Work Element 5: Monitoring Program Development and Implementation

- *Monitoring Program Development Plan Aug 2014*
- *Moored Sensor Yr1 Progress Report*
- *SPATT Final Report May 2015*
- *Algal Pigment Final Report [DRAFT]*
- *Annual Nutrient Science Program update June 2015 [DRAFT]*

Work Element 6: Modeling Strategy

- *Nutrient Modeling Approach*
- *Detailed Modeling Workplan Final Dec2014*

sfbaynutrients.sfei.org

Different hypotheses

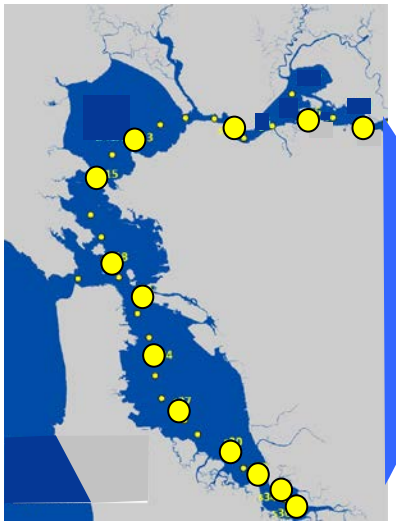
1. HAB-forming organisms and toxins are commonly observed at non-trivial levels in SFB

1. HABs and toxins are present at levels that are causing adverse impacts in SFB

2. The probability of elevated HABs/toxins can be predicted by measuring *chl-a.*

3. Anthropogenic nutrients are causing increased frequency of HABs/toxins.

Multiple Lines of Evidence



Direct: toxins

Direct: HAB-organisms

chl-HAB