Notes on Packet and Goals for Discussion

1) At the February 4, 2014 NTW meeting, members outlined a number of issues that they wanted the Technical Team specifically to address during the February 11-12, 2014 workshop. Have these issues been sufficiently addressed? See Appendix B

2) The February 11-12 Assessment Framework Technical Team workshop identified several core principles that will be used to frame the assessment framework. Any questions or issues with these principles that are captured in the meeting summary?

3) At the May 19, 2014 Assessment Framework Technical Team webinar, members discussed the details of quantitative analyses to inform the discussion on assessment framework classification boundaries (thresholds). These proposed analyses are presented in "Approaches for Quantitative Analyses to Support Decisions on SF Bay AF Classification." Any questions or issues with these proposed analyses.

San Francisco Bay Assessment Framework Technical Team (TT) Meeting Summary

February 11-12, 2014

Background and Workshop Goals: During previous technical team (TT) meetings, we agreed on the geographic scope of the assessment framework, focal habitats for this phase (shallow and deep subtidal habitats, excluding diked baylands and restored salt ponds), and a preliminary scheme for segmentation of the Bay. We agreed that we would consider indicators of phytoplankton, including phytoplankton biomass, productivity, assemblage, HAB species abundance, and toxin concentration. We agreed that nutrient forms and ratios would be recommended for monitoring, but would not be considered in this first draft of the assessment framework, pending additional research and scientific consensus. The goals of this workshop were to:

- **Reach consensus on assessment framework metrics and methods of measurement**
- **For each metric, reach consensus key graphics to communicate risk, and the temporal and spatial density of data needed to make an assessment and how the data would be used to make an assessment**

Participants

- Mine Berg
- Suzanne Bricker
- Jim Cloern
- Dick Dugdale
- Naomi Feger
- Larry Harding
- Jim Hagy
- Raphael Kudela
- Karen McLaughlin
- Emily Novick
- Dave Senn
- Martha Sutula

Summary By Technical Agenda Items

1. Context for Assessment Framework

1. Dave Senn presented an overview of the nutrient strategy technical elements (monitoring, assessment framework development, modeling and synthesis) in order to bring team members up to speed on the context for assessment framework development (see Appendix A—meeting presentations). TT members concurred that the assessment framework development should be considered an iterative process—to be informed and further refined by future monitoring and modeling.
2. Martha Sutula presented stakeholder feedback on nutrient assessment framework approach and initial issues or concerns as discussed during the Feb 4, 2014 Nutrient Technical Workgroup (NTW) meeting. She noted that the NTW requested that the TT address these comments during our workshop and report out on the response. The TT members agreed to this request. The summary response to issues raised is given in Appendix B of this meeting summary and noted elsewhere in the meeting summary where the issue was discussed.

2. Revisiting Classification

- During the January 2014 TT meeting, members agreed that rather than using the RMP segmentation as a proposed starting point for classification, a data-driven approach to segmentation is using variables relevant to eutrophication preferred. Members recommend re-analysis of these segments proposed by Jassby et al. (1997) with more recent data. SCCWRP agreed to discuss the possibility of this re-analysis with SFEI. In the interim, the Jassby et al. 1997 breakpoints will be used as the boundaries between new segments (Table 2 from Jassby et al. 1997.
- NTW members (Feb 4, 2014) questioned why it was important to redo then analyses, when there was substantial effort (and statistical analyses) put into defining the RMP segmentation scheme.
- The TT members discussed the issue. The consensus was that: 1) Jassby et al. 1997 similar to RMP, with the addition of one segment, 2) the TT members strongly recommend that segmentation be driven by data, 3) It is ntot clear that RMP segments reflect ecological elements we are trying to capture and therefore 4) The TT will use Jassby et al. (1997) as a starting point, pending additional data analyses with available data. SFEI is considering taking on this analyses and will confirm their commitment to do so.

3. **Defining Metrics and Methods for Measurement.** TT members came to consensus on the following metrics and methods for measurement.
    - Phytoplankton biomass
        - water column chlorophyll a (measured via discrete grab samples or in situ chlorophyll a fluorescence sensors)
    - Annual Primary Productivity
        - To be measured via empirical method utilizing chlorophyll a, photic depth, surface irradiance (per Cole and Cloern 1983), recalibrated on a frequency (to be optimized by monitoring program) with direct, discrete measures of GPP (e.g. REF)
    - Phytoplankton size fraction
        - % of Biovolume < 5 microns (measured via flow cytometry)
    - Composition-related metrics
        - Detection of known HABs, including Alexandrium, Cyanobacteria (standards exist), Pseudo-Nitzchia (10^5 ml^{-1}), Dinophysis
        - Percentage of biovolume as known HABs
        - Diversity or assemblage shifts as "soft metrics" as change—not recommended for use to assess "impairment"
        - Methods notes: Manual taxonomic methods problematic because taxonomic harmonization is needed; instead TT members recommend an imaging flow cytobot, which has real time flow through and can be deployed on ships, In situ with moorings, or in laboratory settings.

- Toxin concentrations by discrete grabs or SPATT (Kudela et al. 2011, needs to validated to grabs)

4. **Key Graphics for Linkages to Beneficial Uses.** TT members discussed how these metrics linked to beneficial uses, what the key graphics are for communicating this linkage to scientists and the public and what analyses of existing data or future data collection are needed to support identification of thresholds relevant for SF Bay. The conceptual model of SF Bay (Senn et al. 2013) described the problem statement associated with elevated phytoplankton biomass, productivity, and harmful algal blooms including:
   - sub-optimal dissolved oxygen concentrations associated with elevated oxygen demand from excessive organic matter accumulation (e.g. Figure 1)

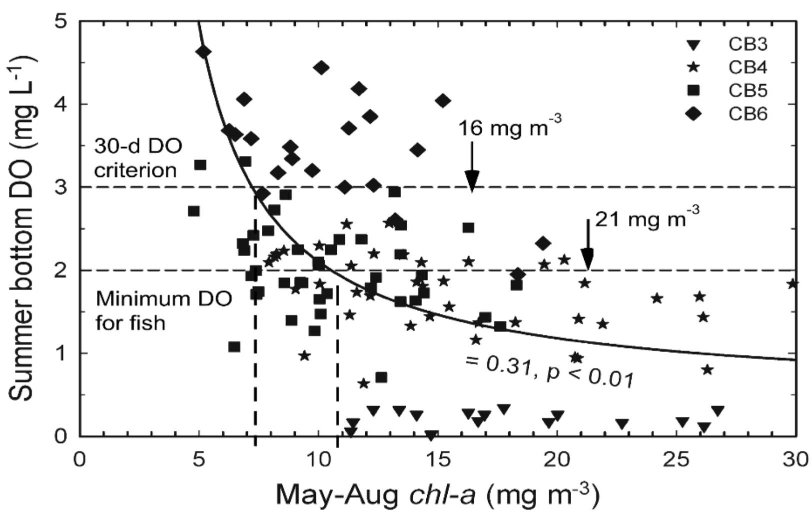

Figure 1. Example of dissolved oxygen as a function of chlorophyll a in Chesapeake Bay. From Harding et al. 2013. Scientific bases for numerical chlorophyll criteria in Chesapeake Bay. *Estuaries and Coasts* doi:10.1007/s12237-013-9656-6

   - Low fisheries yield associated with too low (oligotrophic; Figure 2) or excessive (hypereutrophic or dystrophic) primary productivity (Figure 3).

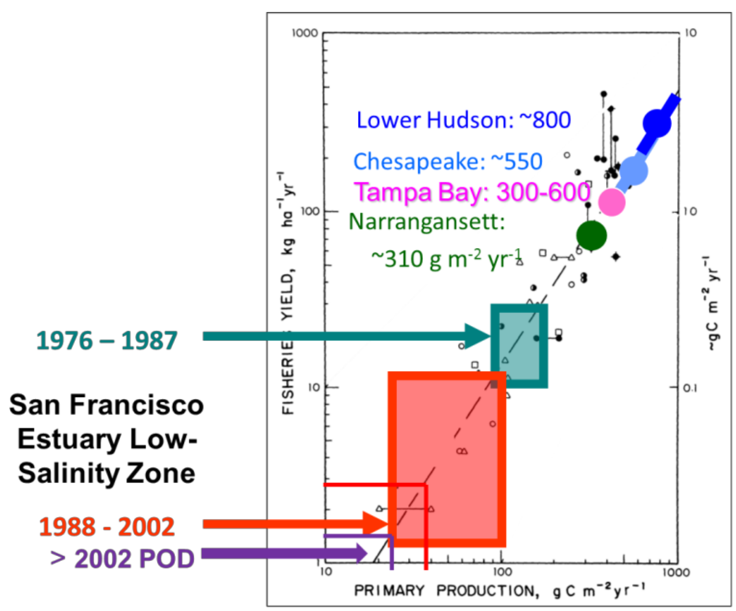

Figure 2. Changes in fisheries yield as a function of primary productivity in SF Estuary, showing post 2002 productivity in an oligotrophic state. Adapted from Nixon 1988 by Cloern, Parker and others. Source: R. Dugdale.

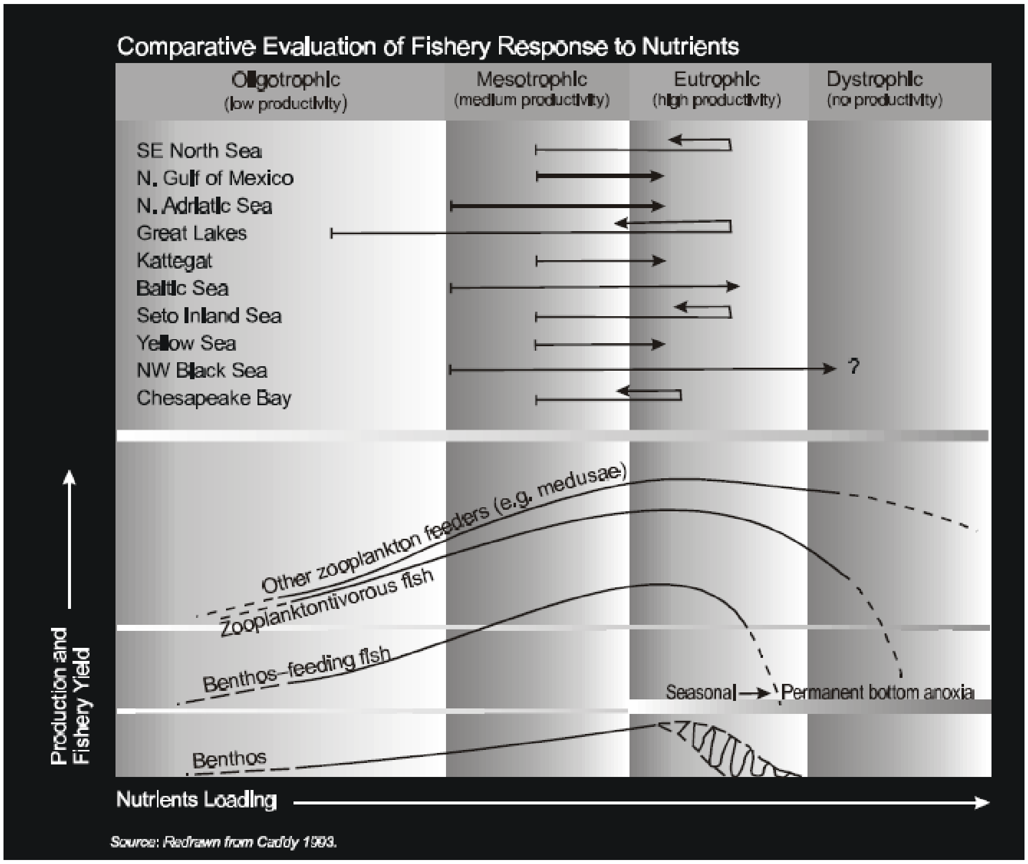

Figure 3. Comparative evaluation of fishery response to nutrients along continuum of oligotrophic, mesotrophic, eutrophic and dystrophic states of primary productivity (Nixon 1995). Although higher nutrient inputs initially increase the productivity of fisheries, ecological systems worldwide show negative effects as nutrient loading increases and hypoxic or anoxic conditions develop. Each generic curve in the lower half of the figure represents the reaction of a species guild to increasing nutrient supplies. The top half of the figure illustrates trends in various marine systems around the world. Reversals show that trends toward overenrichment have been turned around in several areas. From CENR 2000.

- Increased frequency and duration of harmful algal blooms. HABs are linked to beneficial uses through direct effects on human and aquatic life (see Sutula 2011 for comprehensive review). Increased HAB frequency and duration is be associated with elevated chlorophyll a (e.g. figure 4).

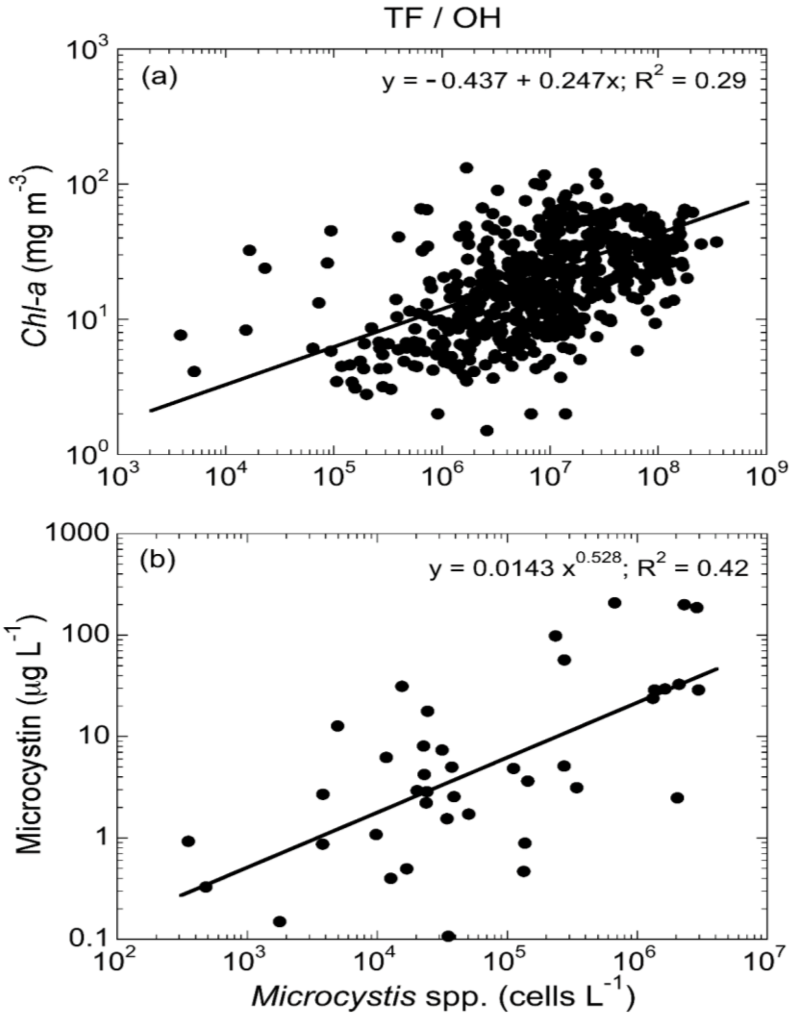

Figure 4. Example of relationships between chlorophyll a, cyanobacteria Microsystis spp. abundance, and toxin concentrations, From L. W. Harding et al. 2013. Scientific bases for numerical chlorophyll criteria in Chesapeake Bay. Estuaries and Coasts doi:10.1007/s12237-013-9656-6

- ***Temporal Elements of Assessment Framework.*** The purpose of this element was to discuss how the data should be used to make an assessment (e.g. what are the units on the graph: trends, 90th percentile of annual samples, geomean of March – October, etc.). TT members discussed the temporal aspects of biomass and productivity that should be captured. They agreed concepts in principal, with the specifics to be discussed at a future meeting:
    - Chlorophyll a, HAB cell counts and toxin concentrations—Absolute value and trends over time (e.g. 5- and 10-yr rolling average) of:
        - Magnitude of spring blooms (e.g. 90th percentile of January-December sampling)
        - Elevated baseline (e.g. mean, Aug-Dec sampling events)
        - Magnitude of fall bloom (90th percentile, May-October sampling events)
    - Productivity- Absolute value of annual estimates (e.g. Figure 5) and trends over time (5-yr rolling average)

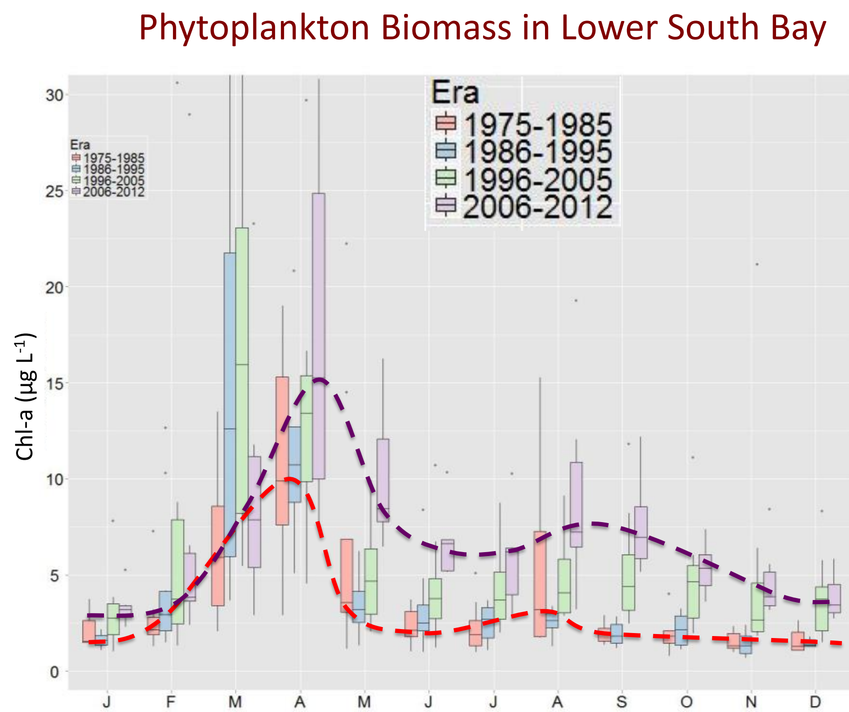

Figure 5. 10-year rolling average chlorophyll a by month of the year. Source: Jim Cloern, USGS

- **Temporal Frequency of Sampling Needed to Make an Assessment.** TT members came to consensus on recommendations a minimum sampling frequency to make an assessment:
    - Need to capture both deep channel as well as shallow parts of the Bay
    - Need to capture vertical gradients in the water column (grabs with depth or CTD profiles
    - No less frequent than monthly sampling, may need < weekly
    - Need to adequately capture the upstream and oceanic boundary conditions
    - Characterize potential "seed" sources of HABs, e.g. salt ponds, upstream and ocean

- ***Analyses of Existing Data or Future Data Collection Needed to Support Derivation of Thresholds.*** TT members agreed that two types analyses would help support decision making on assessment framework thresholds. SCCWRP and SFEI will investigate options vis-à-vis existing resources to conduct these analyses.
    - Calculation of chlorophyll a standing stocks that could cause sub-optimal dissolved oxygen concentrations in Bay segments. As summarized in the conceptual model (Senn et al. 2013), water column stratification events permit the development of intensive blooms in the Bay. Because of this association with stratification events, TT members would like an analyses of the current frequency and duration of stratification events by Bay segment and an analyses of conditions that would result in increased frequency and duration of stratification.

- Calculation of chlorophyll a biomass that would cause HAB species currently detected at low levels in SF Bay to increase to “action levels.”

February 12, 2014

8:30 Light Breakfast Available

9:00 Summary of progress of previous day and charge to break out groups—spatial elements of assessment framework: biomass, productivity, assemblage, HAB species, toxin concentration

- How would the key graphics (from previous day) communicate spatial variability to the public?
- What is the spatial density of data needed to make an assessment, specific to habitat types (shallow and deepwater habitat) and number and type of stations by Bay segment; do we need to refine the temporal density needed by the segment.
- How data would be used to make an assessment (e.g. shoals vs channel, depth-integrated, index area)?
- Assuming some level of uncertainty in the temporal and spatial intensity of data we are recommending to make an assessment, what additional analyses (statistical analysis of monitoring data, modeling output, etc.) are needed to optimize our recommendations?

(Groups will use maps of Bay segments to illustrate location and types of stations)

12:00 Catered Lunch

12:45 Report out of break out groups, discussion, and consensus-building

3:00 Break

3:15 Linkage of assessment framework with monitoring and modeling strategy

- Feedback on monitoring program development (Senn)
- Analyses to support decisions (or refinement of decisions) on thresholds

4:45 Wrap up and next steps

5:00 Adjourn for the day

Committee on Environmental and Natural Resources (CENR). 2000. Integrated assessment of hypoxia in the Northern Gulf of Mexico . National Science and Technology Council Committee on Environment and Natural Resources, Washington, DC, USA.

Panel Charge:

1) Submit via email to the group recommendations on metrics and methods for their measurement that will be considered for SF Bay assessment framework (e.g. chlorophyll a, productivity, phytoplankton assemblage, HAB species abundance, toxins)
2) For each metric of interest and Bay segment of interest, consider the following:
    a. What is the appropriate temporal density of data need to make an assessment (e.g. CTD casts- monthly, continuous moored sensor, etc.) and recommendation for how data would be used to make an assessment (e.g. trends assessment, 90th percentile of annual samples, geomean of March – October, etc.)
    b. What is the spatial density of data needed to make an assessment, specific to habitat types (shallow and deepwater habitat), number of stations and how data would be used to make an assessment
    c. Assuming we have some level of uncertainty in the temporal and spatial intensity of data we are recommending to make an assessment, what additional analyses (statistical analysis of monitoring data, modeling output, etc.) would be needed to optimize our recommendations?

Stakeholder Input/Questions for Technical Team from February 4, 2014 meeting:

- Why is the RMP segments not appropriate for the assessment framework? A considerable amount of effort was made to develop those segments?

San Francisco Bay Assessment Framework Technical Team Meeting Agenda

February 11-12, 2014

Workshop Location: San Francisco Estuary Institute, San Francisco Estuary Institute
4911 Central Avenue, Richmond, CA 94804
Local contact for logistics: Dave Senn (510-999-1105); davids@sfei.org

Context for Workshop

Context: During the January 16th 2014 webinar, we agreed on the geographic scope of the assessment framework, focal habitats for this phase (shallow and deep subtidal habitats, excluding diked baylands and restored salt ponds), and a preliminary scheme for segmentation of the Bay. We agreed that we would consider indicators of phytoplankton, including phytoplankton biomass, productivity, assemblage, HAB species abundance, and toxin concentration. We agreed that nutrient forms and ratios would be recommended for monitoring, but would not be considered in this first draft of the assessment framework, pending additional research and scientific consensus. We invited technical team members to suggest additional analyses of existing data not currently proposed in the November 2013 Analysis of Existing Data Work Plan.

Goal of February 2014 Workshop:

- **Consensus on metrics and methods of measurement**
- **For each metric, consensus what is the temporal and spatial density of data needed to make an assessment and how the data would be used to make an assessment**

February 11, 2014

8:30 Light breakfast and refreshments available

9:00 Introductions, workshop goals, review of 2-day agenda and logistics (Sutula)

9:10 Context for Assessment Framework

- Modeling and Monitoring Strategy Development (Senn)
- Stakeholder feedback on nutrient assessment framework (Feb 4, 2014 meeting; Sutula)

10:00 Phytoplankton Biomass and Productivity

- **Defining Metrics and Methods for Measurement** (Harding and Cloern)

(15 min break)

- **Temporal elements of assessment framework: phytoplankton biomass and productivity**
  - How are these metrics linked to beneficial uses? What analyses of existing data or future data collection are needed to support this linkage?
  - What are the key graphics for how we would communicate the status of the Bay?
  - What is the appropriate temporal density of data needed to make an assessment (e.g. CTD casts- monthly, continuous moored sensor, etc.); does this change by Bay segment?
  - How data should the data be used to make an assessment (e.g. what are the units on the graph: trends, 90th percentile of annual samples, geomean of March – October, etc.)
  - How do we treat inter-annual variability?

1200 Catered Lunch

12:45 Phytoplankton Biomass and Productivity Discussion Con't

1:45 Phytoplankton Assemblage, HAB abundance and toxin concentrations

- **Defining Metrics and Methods for Measurement** (Kudela)

(15 min break)

- **Temporal elements of assessment framework**
  - How are these metrics linked to beneficial uses?
  - What are the key graphics for how we would communicate the status of the Bay?
  - What is the appropriate temporal density of data needed to make an assessment (e.g. CTD casts- monthly, continuous moored sensor, etc.); does this change by Bay segment?
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  - How do we treat inter-annual variability?

4:45 Summary of day and adjustments to agenda

5:00 Adjourn

6:00 Group Dinner TBD

February 12, 2014

8:30 Light Breakfast Available

9:00 Summary of progress of previous day and charge to break out groups—spatial elements of assessment framework: biomass, productivity, assemblage, HAB species, toxin concentration

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Stakeholder Input/Questions for Technical Team from February 4, 2014 meeting:

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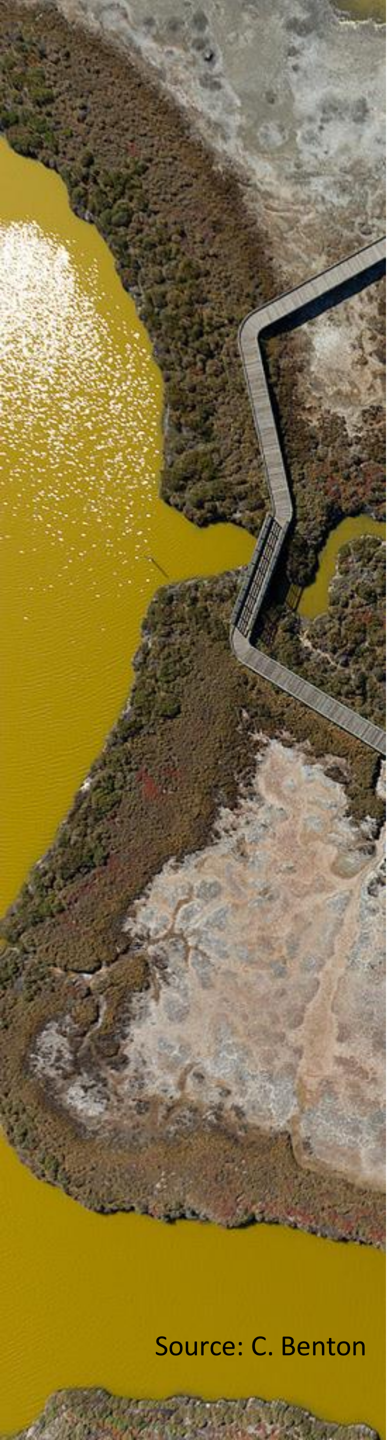

Source: C. Benton

Assessment Framework Intro

Goals:

- Orient team to overarching goals of Nutrient Program and on-going activities

- Identify linkages with Assessment Framework

- Identify what is included within Assessment Framework, and what will be addressed elsewhere

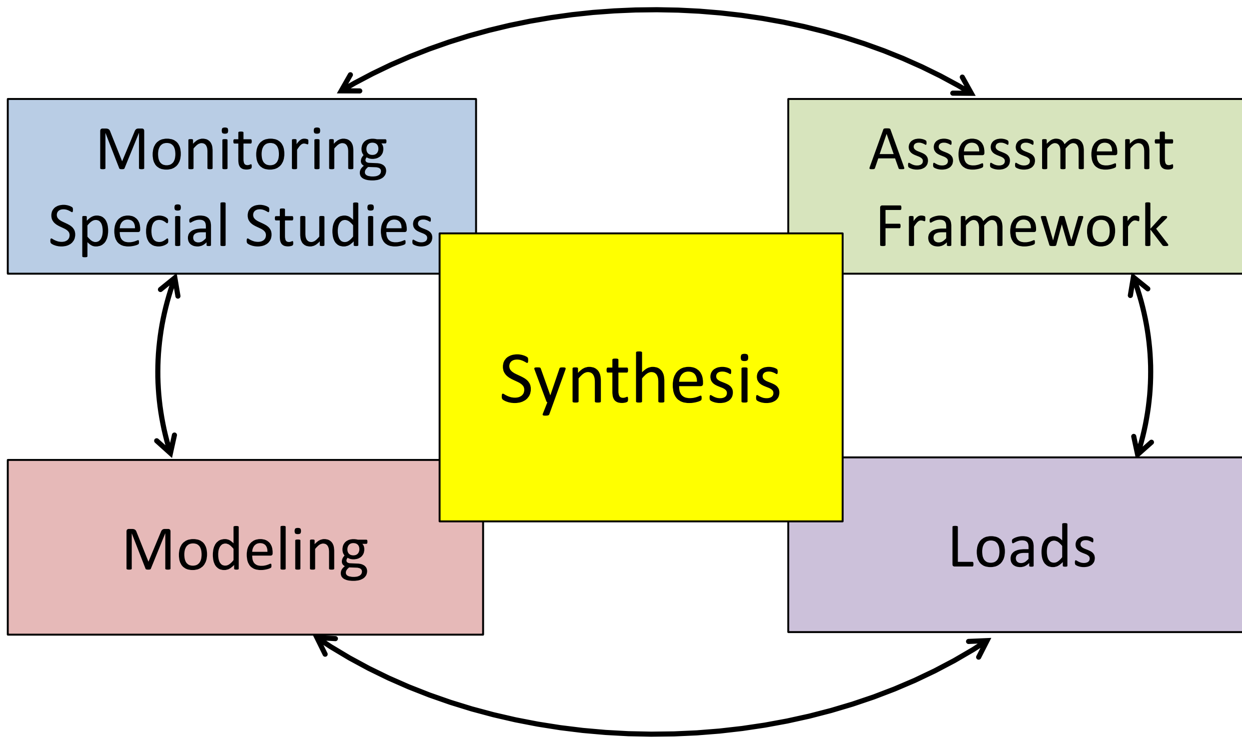
David Senn
February 11, 2014

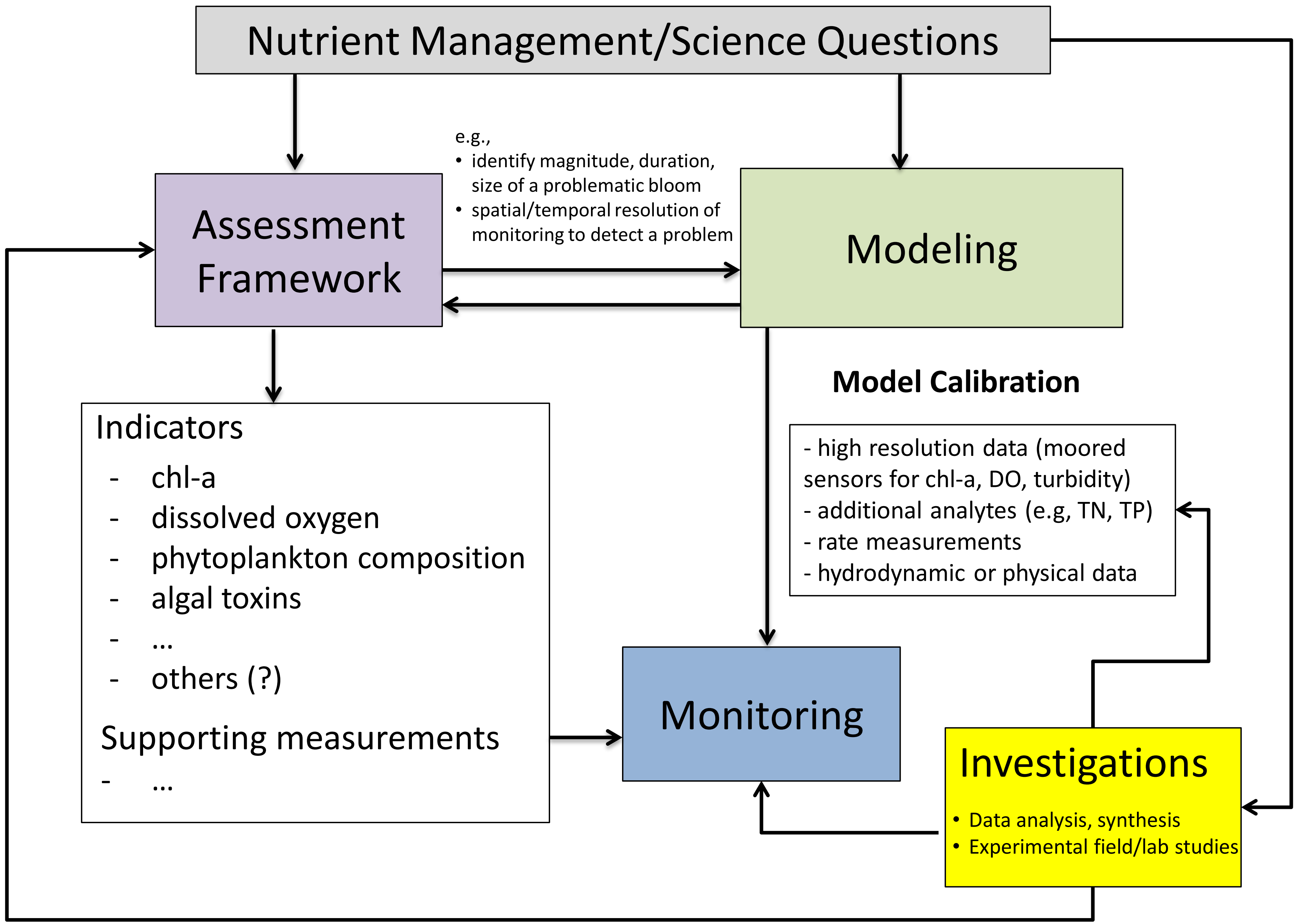

November 2012

San Francisco Bay Nutrient Management Strategy

San Francisco Bay Regional Water Quality Control Board

Nutrient Science Program




Nutrient Management/Science Questions
e.g.,
• identify magnitude, duration, size of a problematic bloom
• spatial/temporal resolution of monitoring to detect a problem
Assessment Framework
Modeling
Model Calibration
- high resolution data (moored sensors for chl-a, DO, turbidity)
- additional analytes (e.g, TN, TP)
- rate measurements
- hydrodynamic or physical data
Indicators
- chl-a
- dissolved oxygen
- phytoplankton composition
- algal toxins
- …
- others (?)
Supporting measurements
- …
Monitoring
Investigations
• Data analysis, synthesis
• Experimental field/lab studies

Assessment/Monitoring Considerations

Habitats
- Deep subtidal
- Shoals
- margins

Approach
- Ship-based
- Moorings, AUVs

Compartments
- Sediments
  - Biota
  - chemistry/process
- Water column
  - Basic chemistry
  - Other chemistry, processes, toxins
  - Phytoplankton biomass, composition
  - Other biota

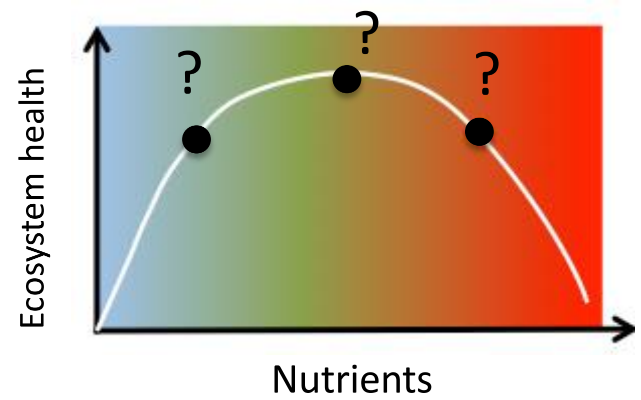
What to measure
- Analytes/processes
- Approach(es)

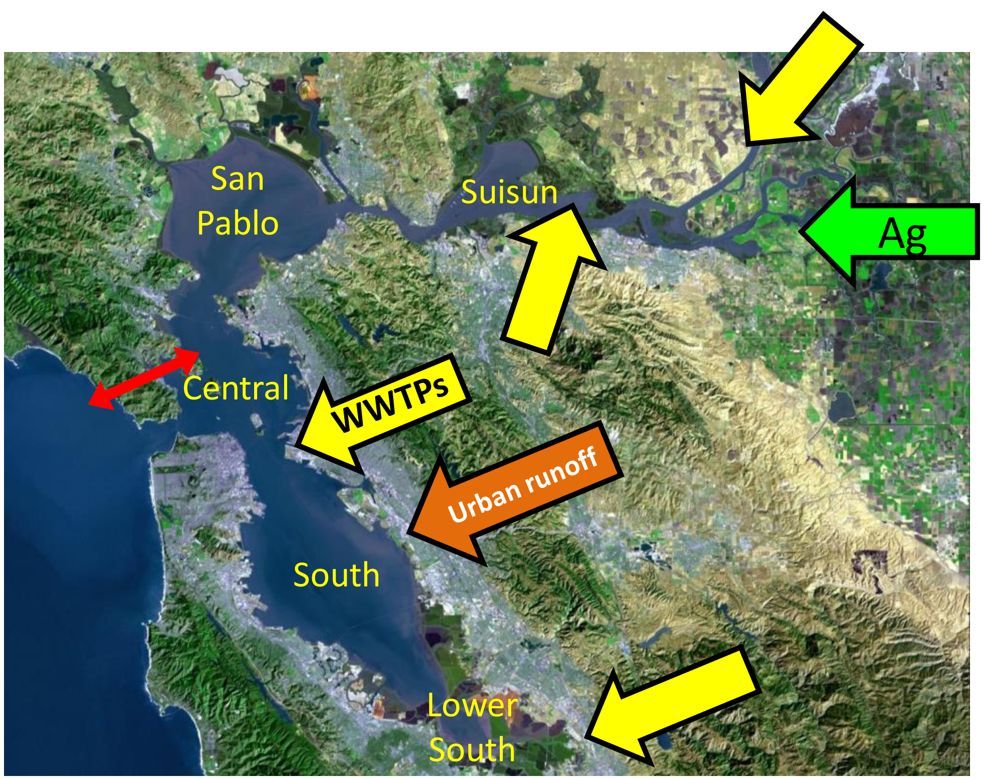
Organizational/Institutional
- Funding, partnerships, logistics

Does SFB have nutrient problems?

How can impairment best be mitigated or prevented?

- Options differ by $billions





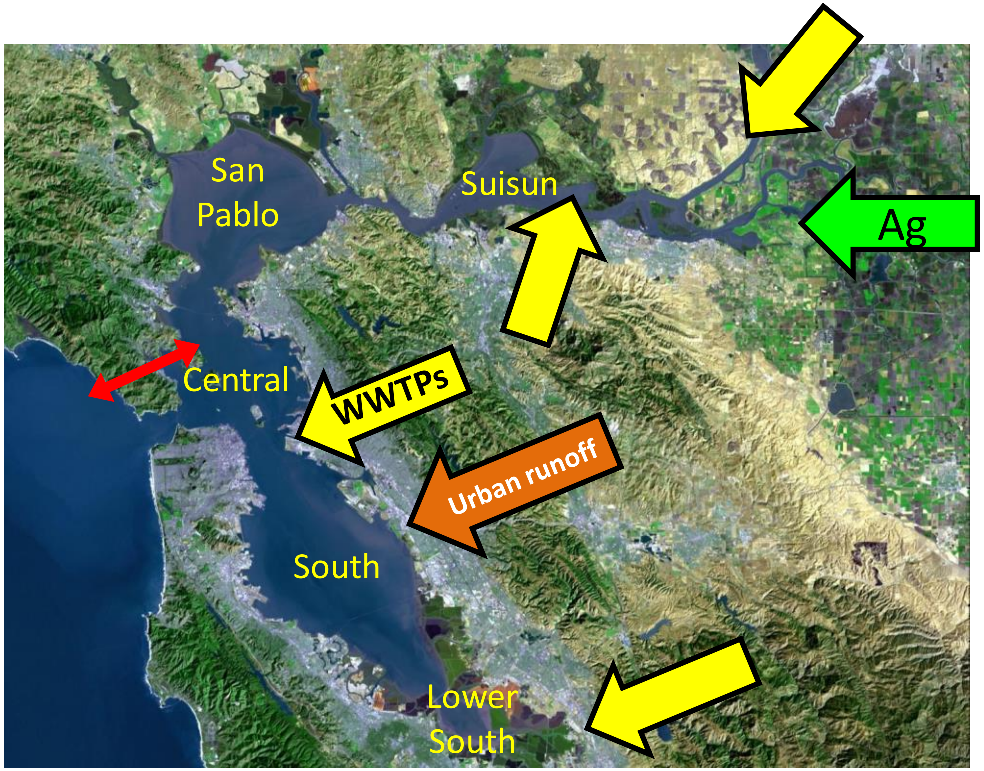
- Population = 7.6 mill
- 42 WWTPs
- Drains 40% of CA

- N, P: High loads and concentrations

- Historically: Attenuated response

- Evidence that response is changing

- Response differs substantially among subembayments
    - Same underlying mechanisms but different relative strengths of drivers



‘Resistance’ to High Nutrients

1. High turbidity
2. Strong tidal mixing
3. Abundant benthic grazers

Cloern, 1996; Cloern et al., 2007, 2010; Cloern and Jassby 2012; Lucas et al, 2008; Thompson et al. 2008; Kimmerer and Thompson, 2013; SFEI, 2014a

SFB's Response to Nutrients is Changing

- Phytoplankton biomass increases over past 20 years

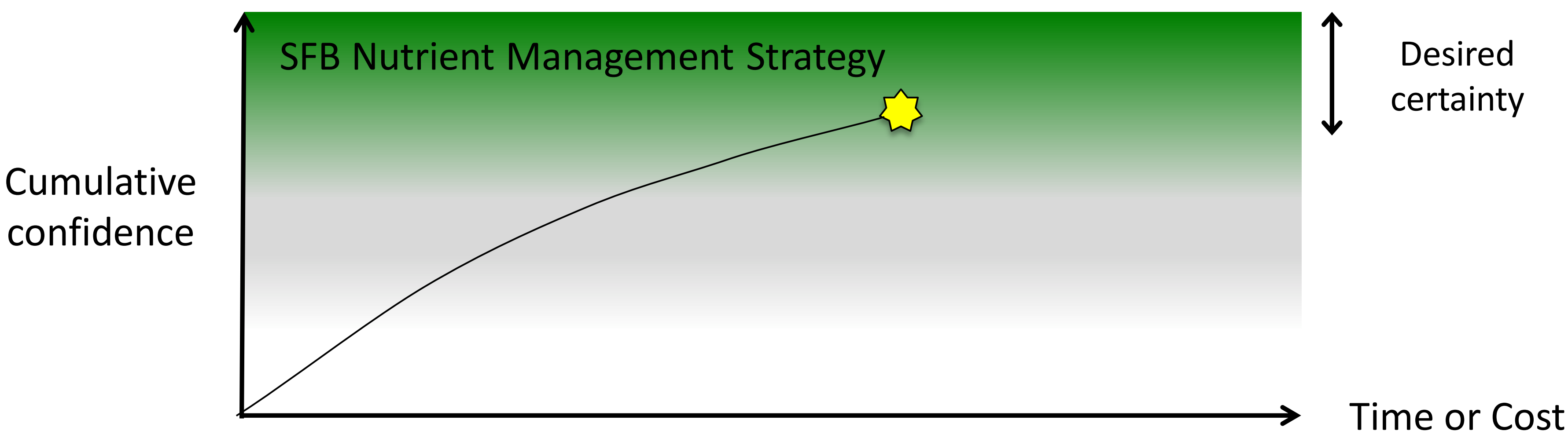
- DO > 80% saturation in deep subtidal areas
  - But dissolved oxygen decreasing (small, but significant)
  - Low DO in shallow margin habitats – natural vs. anthropogenic?

- HAB-forming species detected Bay-wide
  - Frequent *Microcystis* blooms in Suisun and Delta since 2000
  - Algal toxins detected Bay-wide

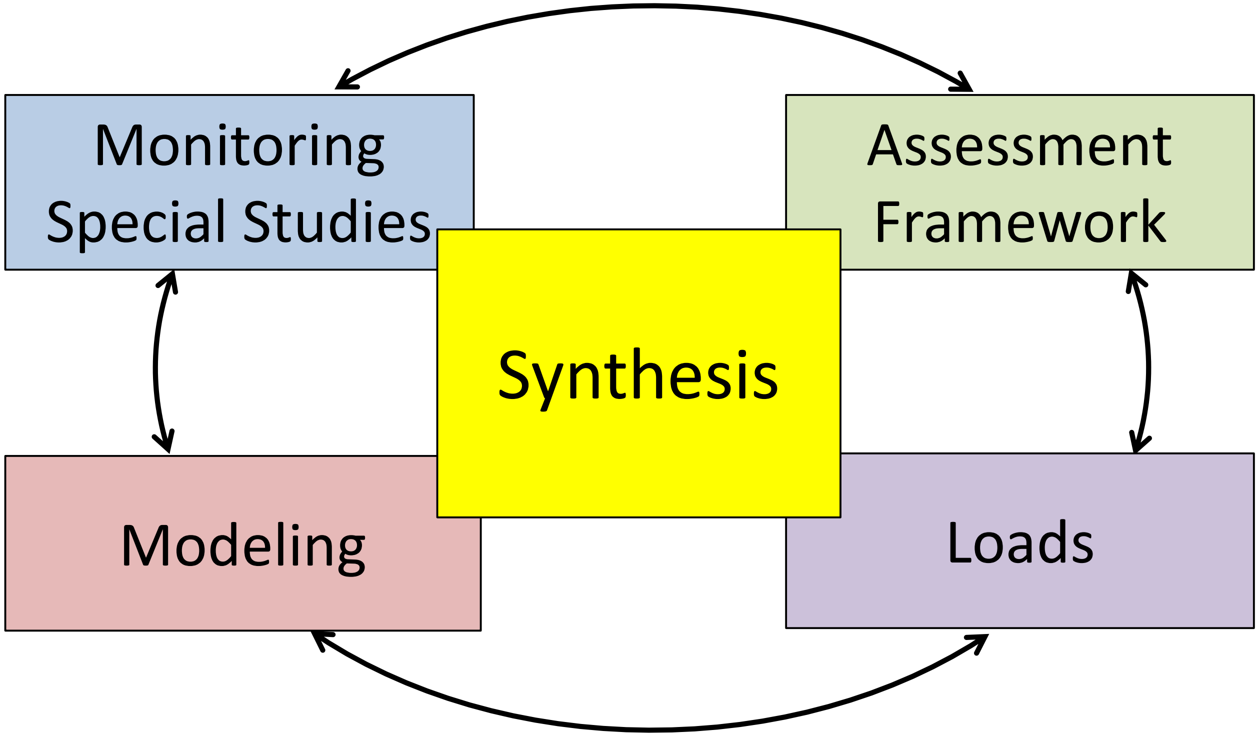
- Studies suggesting nutrient forms impact foodwebs in northern Estuary
  - NH4 vs. NO3, N:P

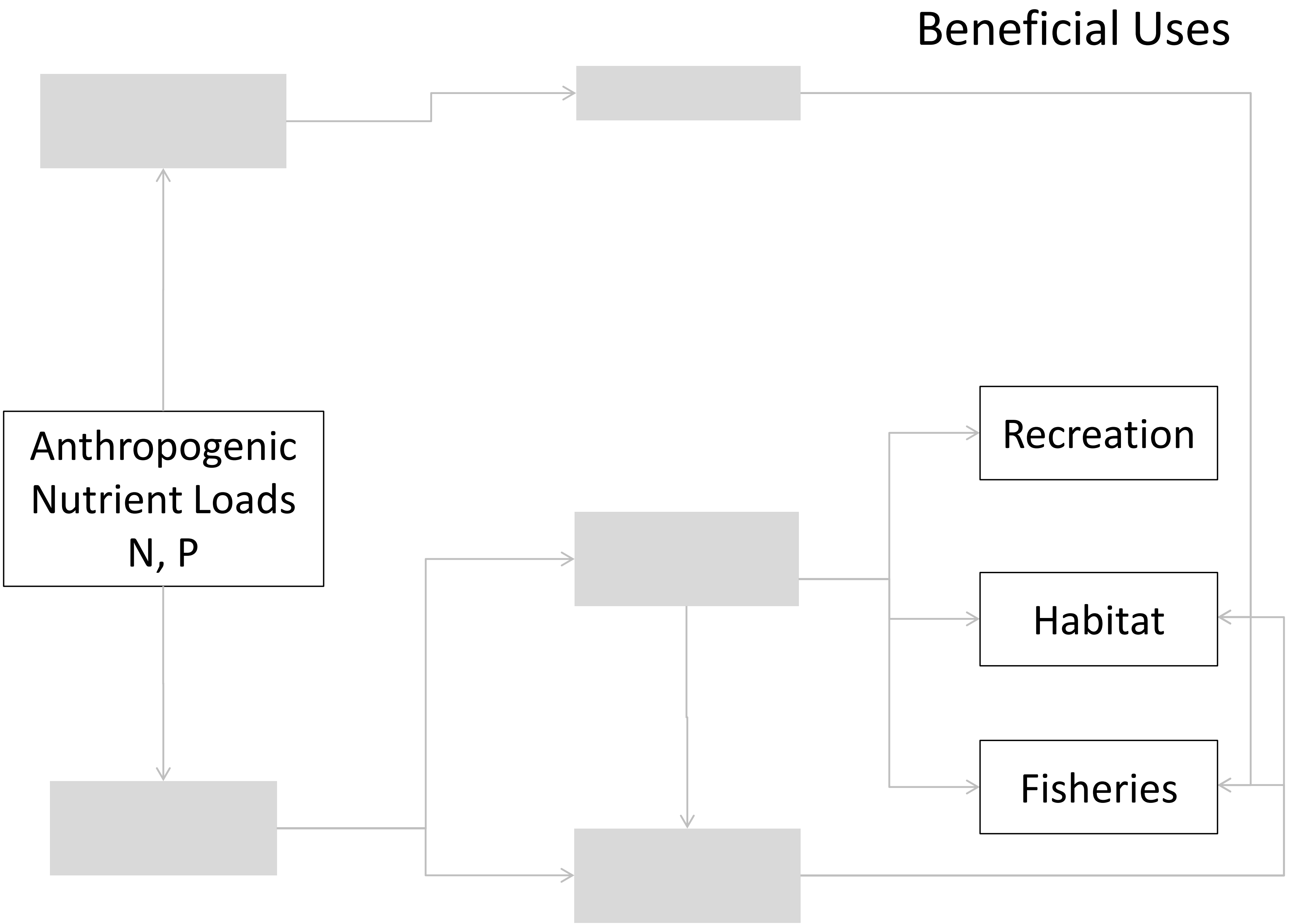
Major Decisions *Large Uncertainties*

1. What constitutes impairment? Which areas are impaired?
2. Does SFB's trajectory signal future impairment?
3. What nutrient load reductions are needed? Where, how much?
4. How much time for science, planning, and implementation?

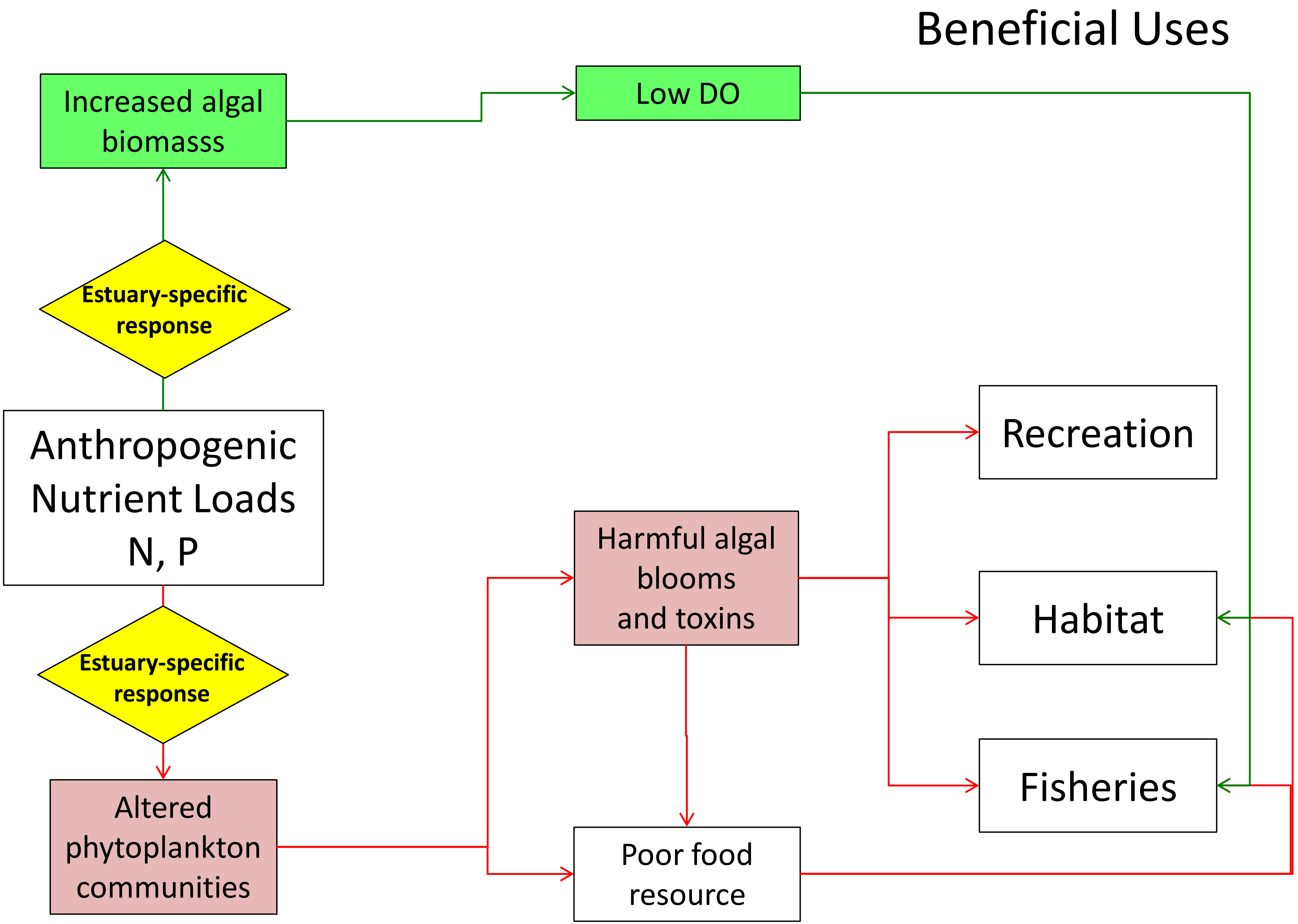


Nutrient Science Program



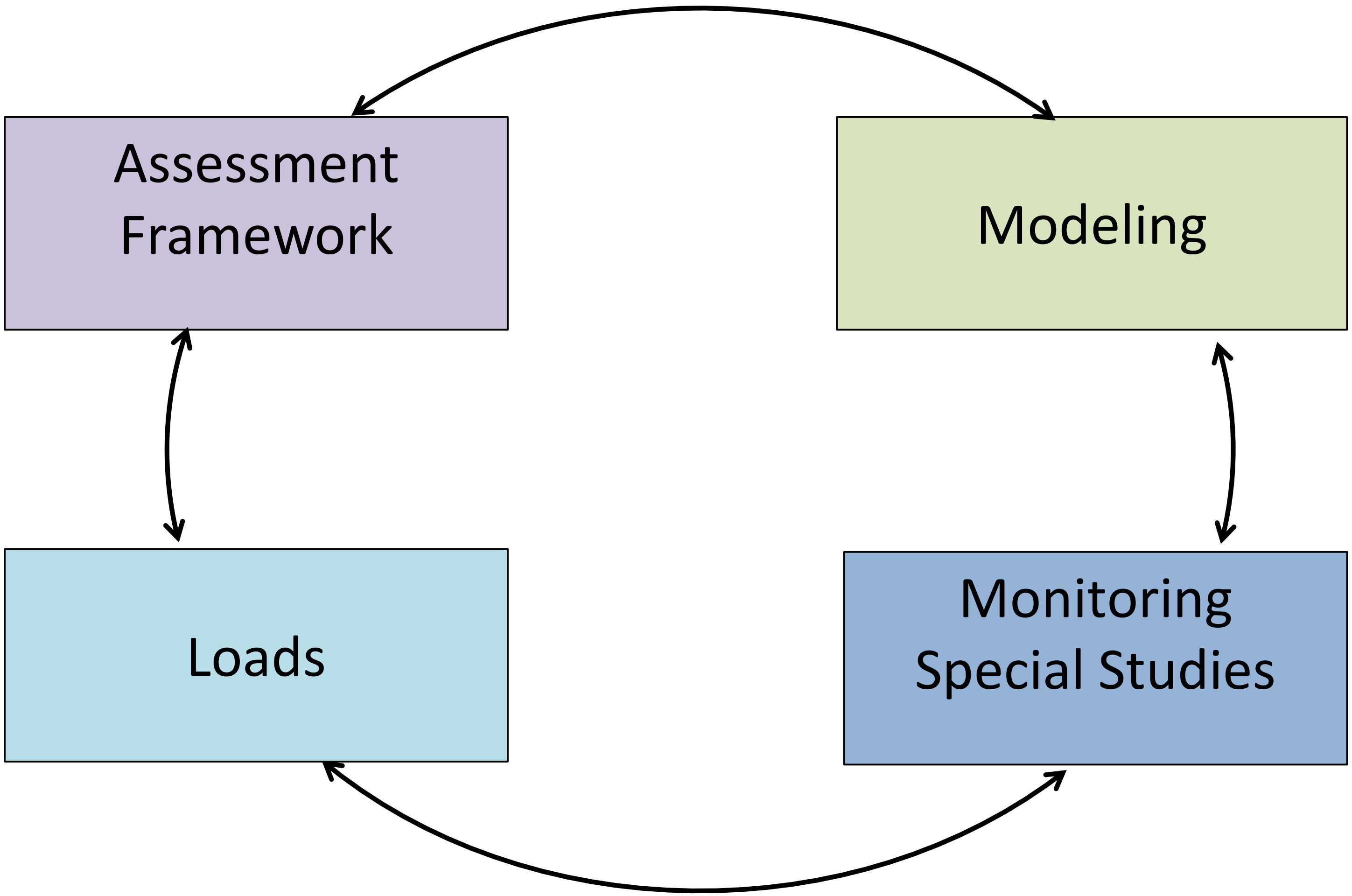


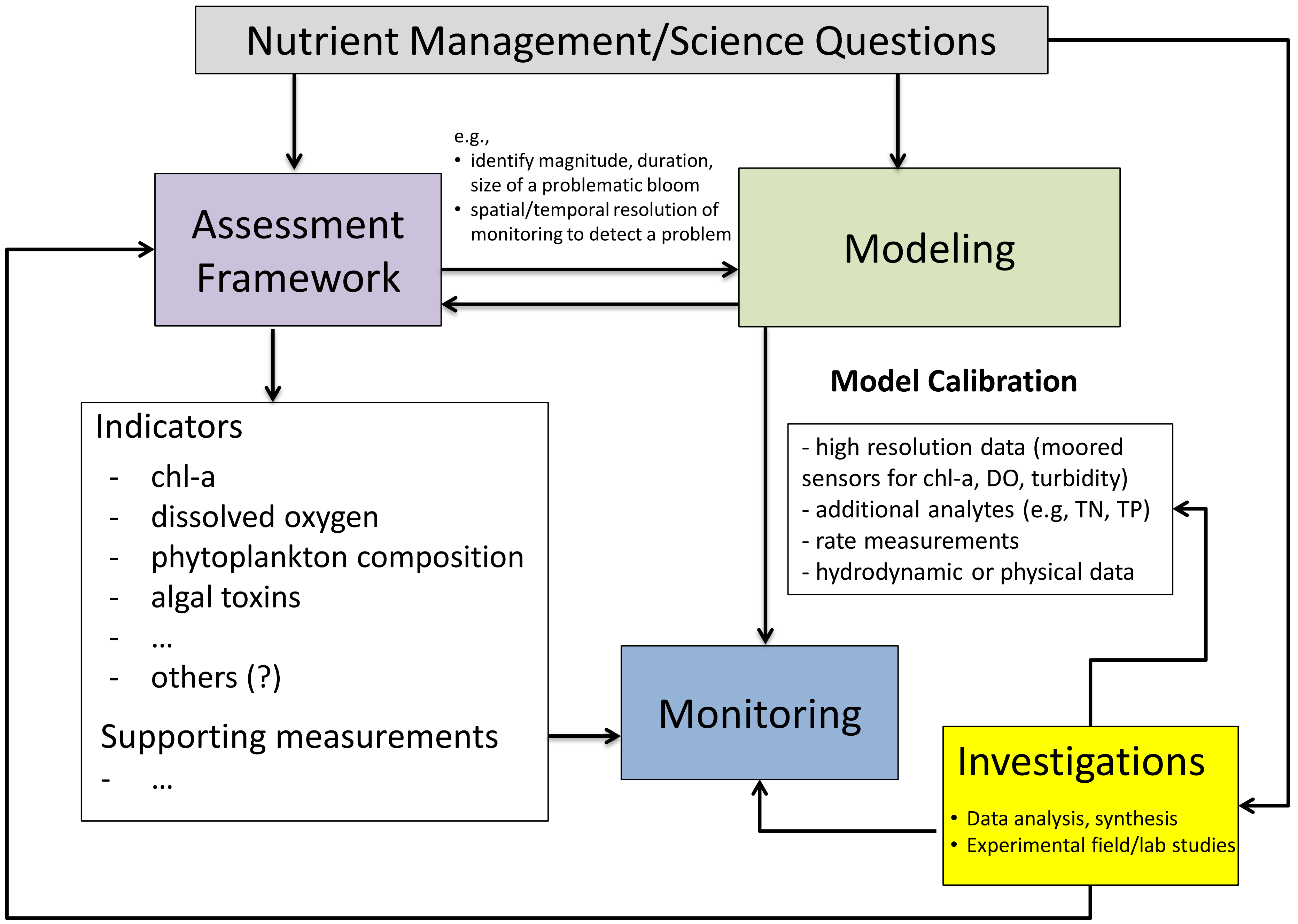
Beneficial Uses
Anthropogenic
Nutrient Loads
N, P
Recreation
Habitat
Fisheries


Beneficial Uses
Increased algal biomasss
Low DO
Estuary-specific response
Anthropogenic Nutrient Loads N, P
Recreation
Harmful algal blooms and toxins
Habitat
Estuary-specific response
Fisheries
Altered phytoplankton communities
Poor food resource

What will shape Assessment and Monitoring Program?

Nutrient Science Program





Nutrient Management/Science Questions
Assessment Framework
e.g.,
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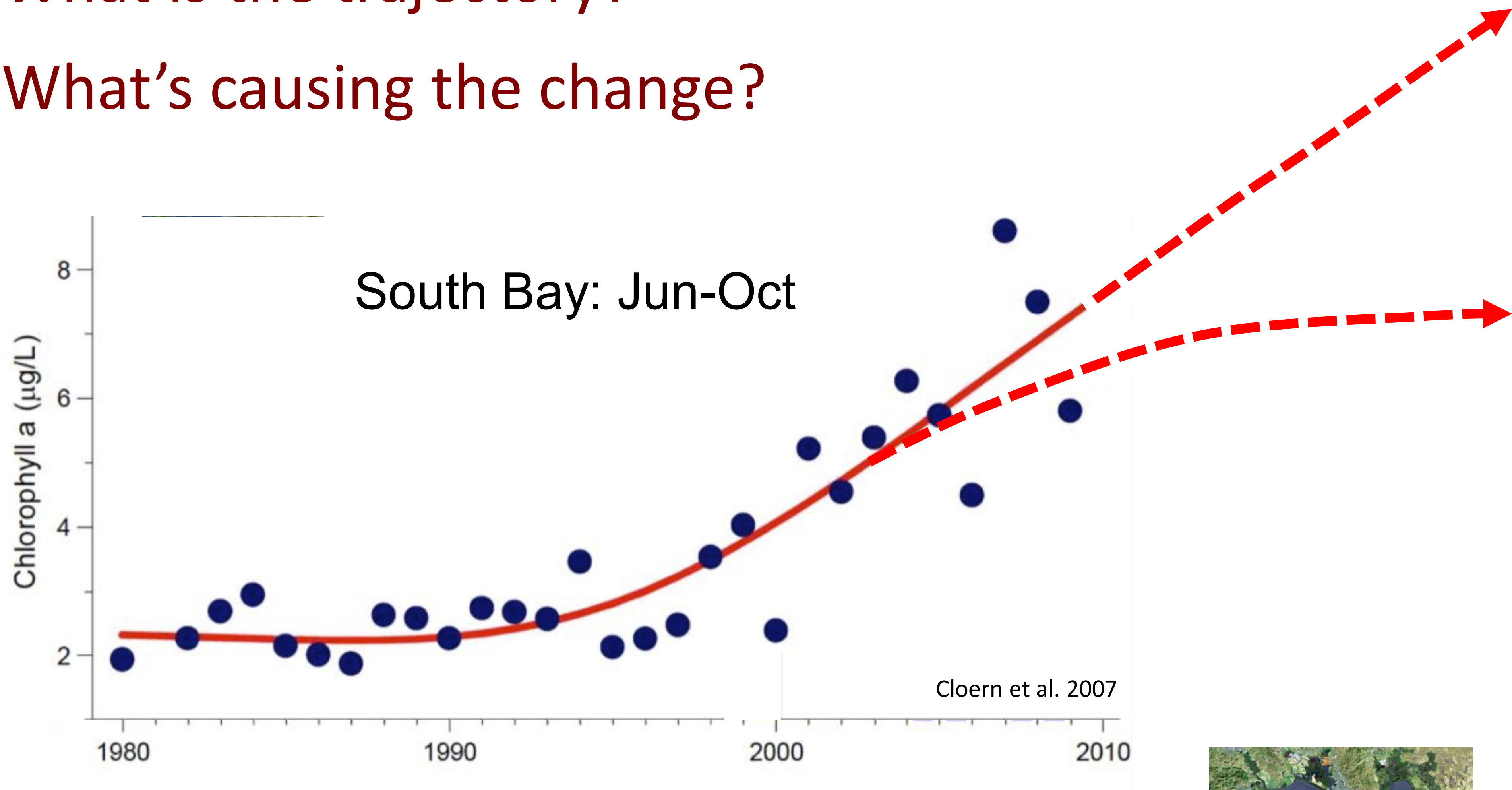
- algal toxins
- …
- others (?)
Supporting measurements
- …
Monitoring
Investigations
• Data analysis, synthesis
• Experimental field/lab studies

- What are we trying to detect?
- What is the canary in the coal mine?
- When we consider transport (modeling), what integrated signal are we measuring at existing or proposed stations?
  - Does that capture what we’re trying to detect?

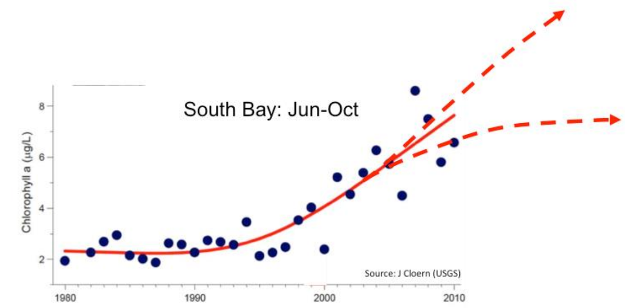
What is the trajectory?

What's causing the change?



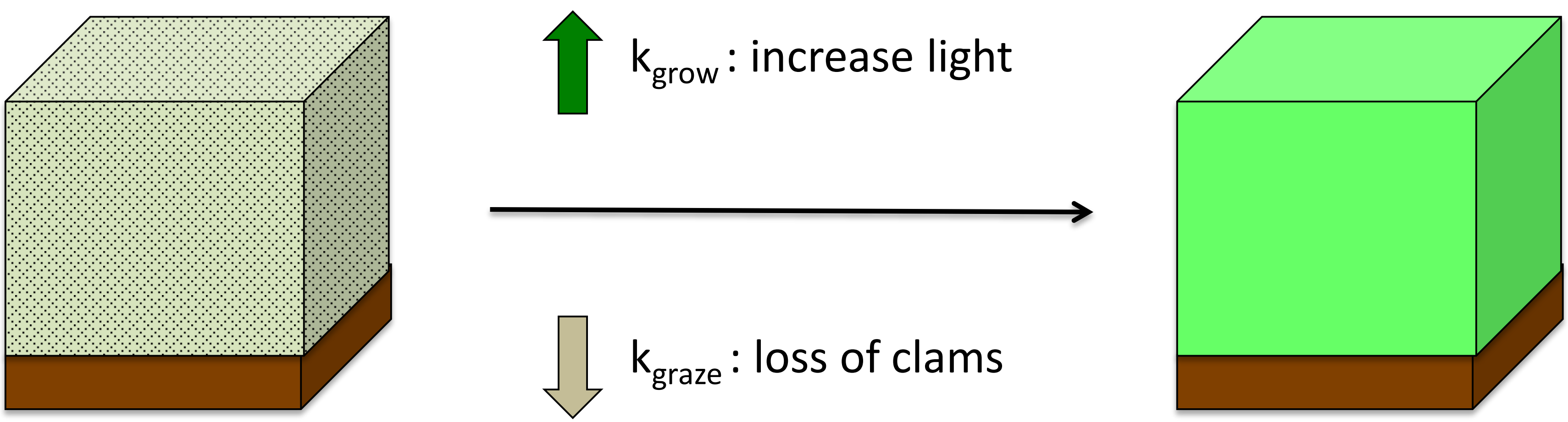
What factors contribute to increasing phytoplankton biomass in South Bay?

What data collection and modeling are needed to predict future conditions?



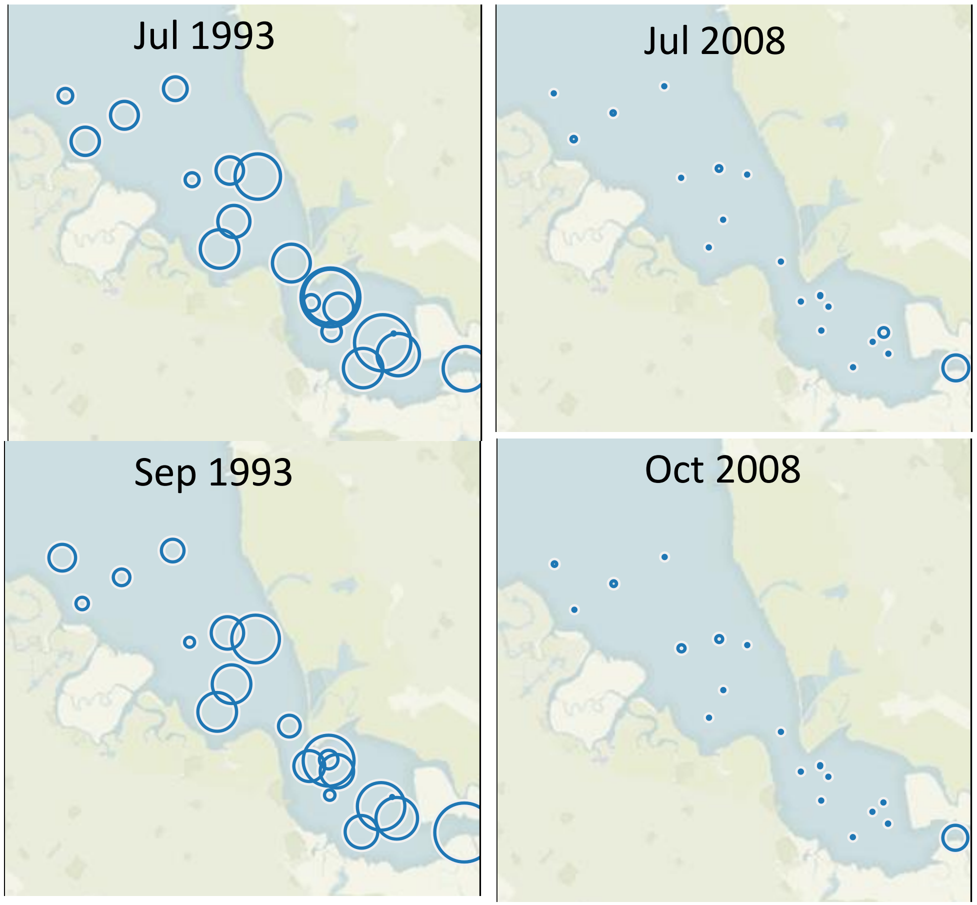
net growth

$$\text{Rate of biomass accumulation} = \underbrace{(k_{grow} + k_{graze})}_{\textit{net growth}} \cdot B \pm \textit{transport}$$

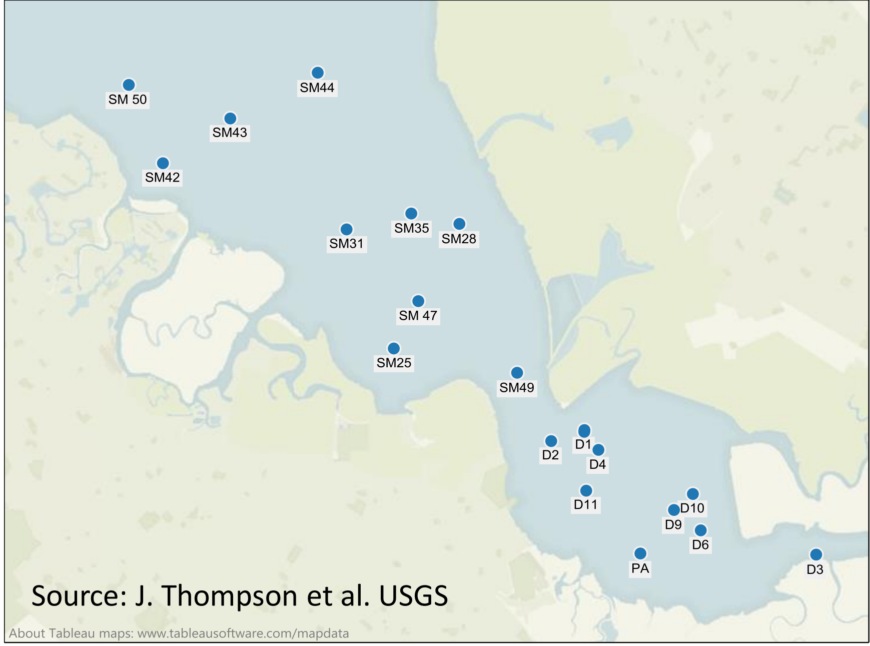


Hypothesis: Loss of clams causes increased phytoplankton biomass

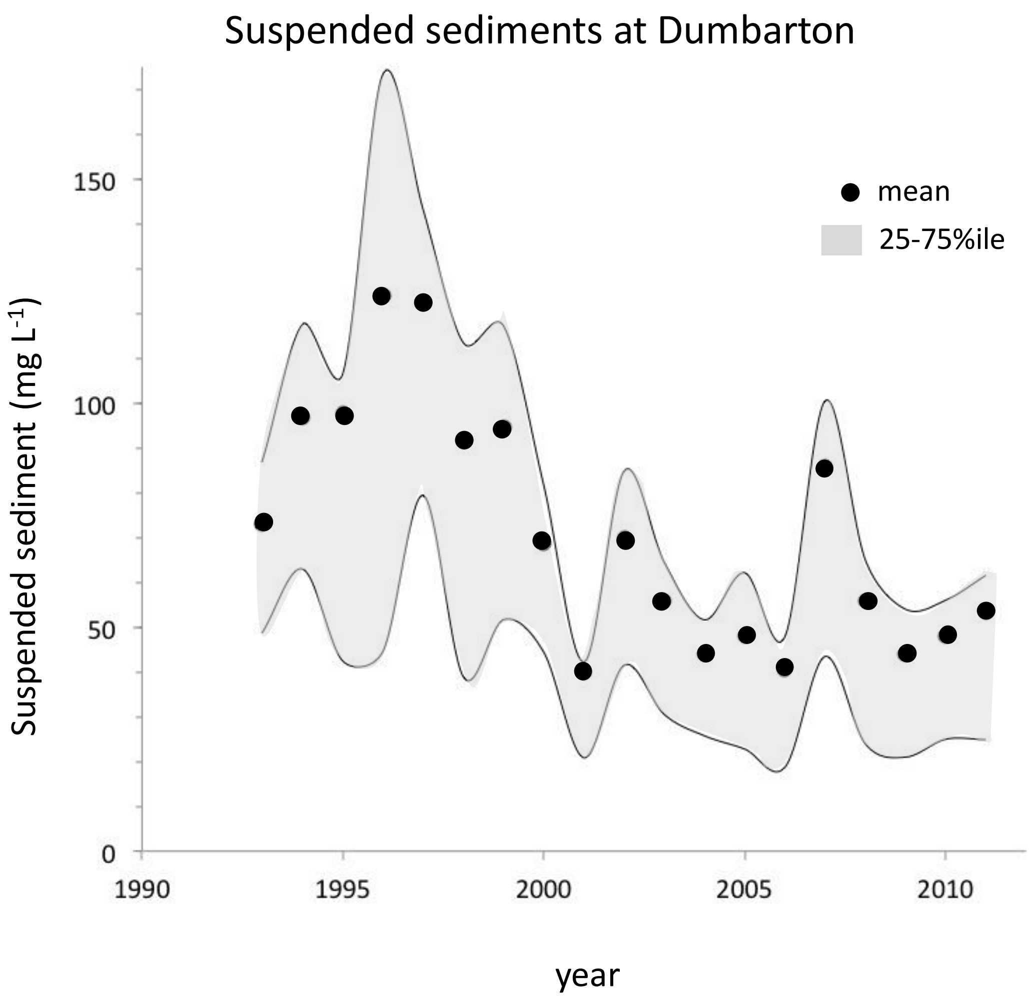
Cloern et al. 2007, 2010



Thompson et al., 2014; SFEI (2014)



Hypothesis: More light available for phytoplankton growth



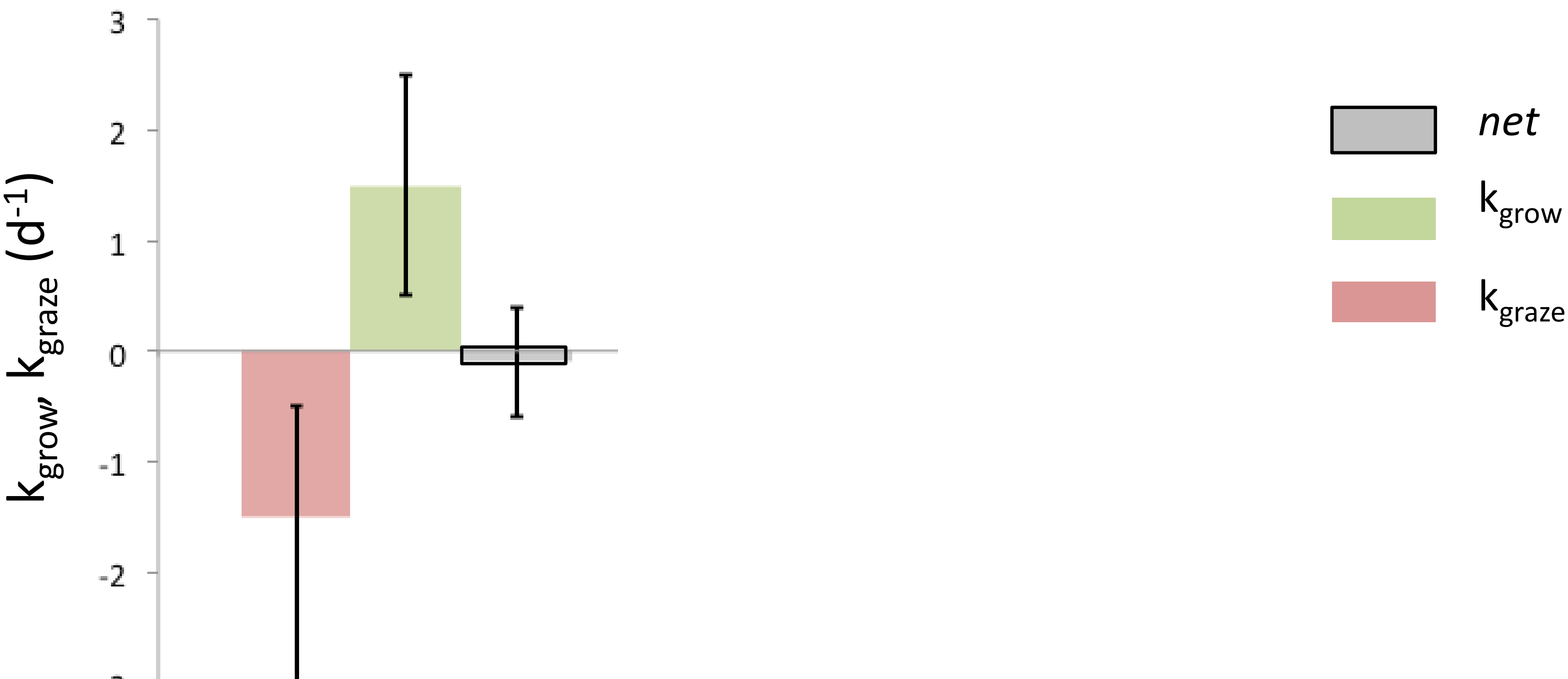
Data: D Schoellhamer et al. (USGS)

- 2x increase in light
- 2x increase in growth rate

SFEI (2014)

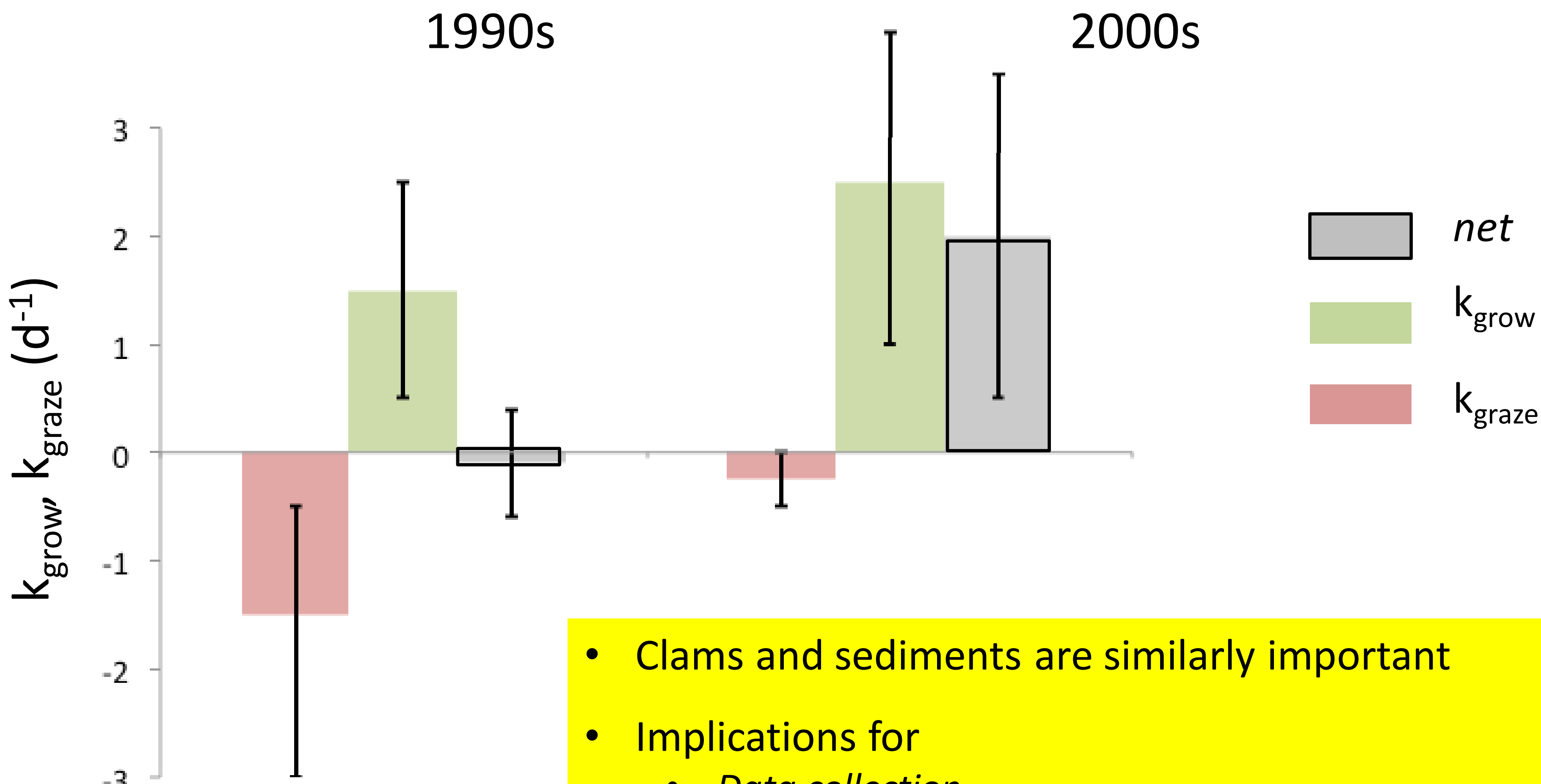
$$\underbrace{\text{Rate of biomass accumulation}} = \overbrace{(k_{grow} + k_{graze})}^{\textit{net growth}} \cdot B \pm \textit{transport}$$

1990s



SFEI (2014)

$$\text{Rate of biomass accumulation} = \overbrace{\left(k_{grow} + k_{graze}\right)}^{\textit{net growth}} \bullet B \pm \textit{transport}$$

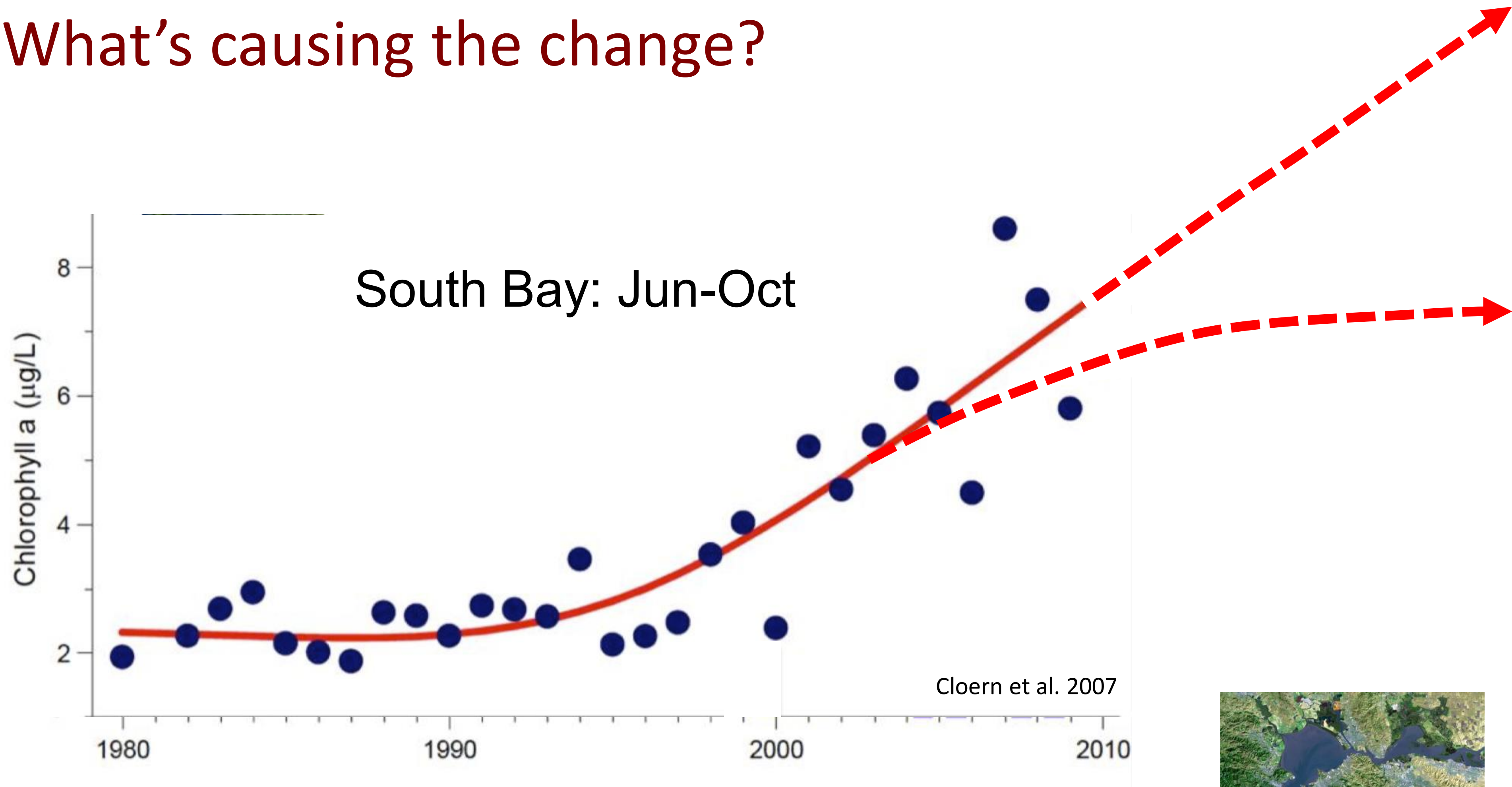


- Clams and sediments are similarly important
- Implications for
    - *Data collection*
    - *modeling*

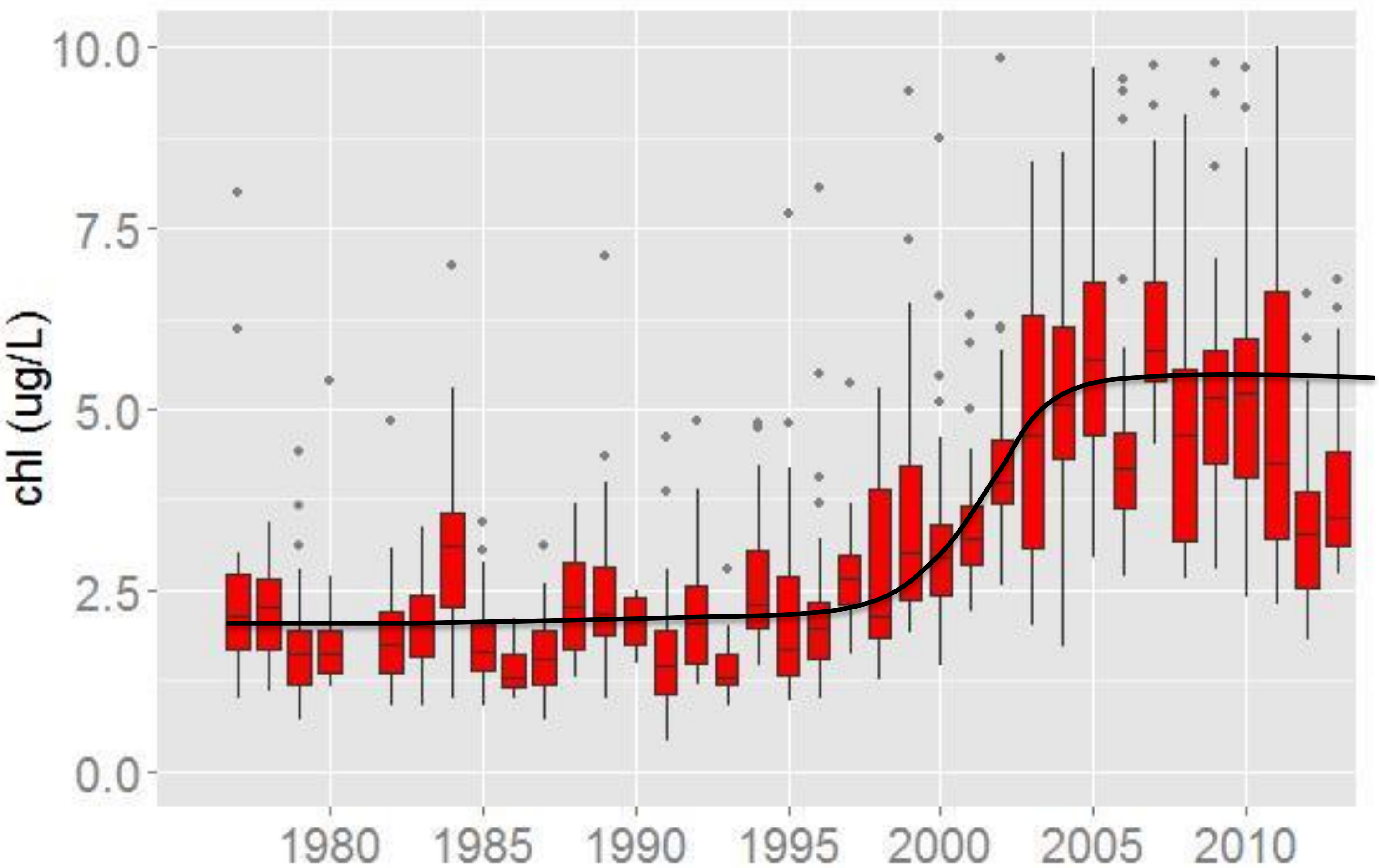
SFEI (2014)

What is the trajectory?

What's causing the change?



South Bay – summer/fall chl-a



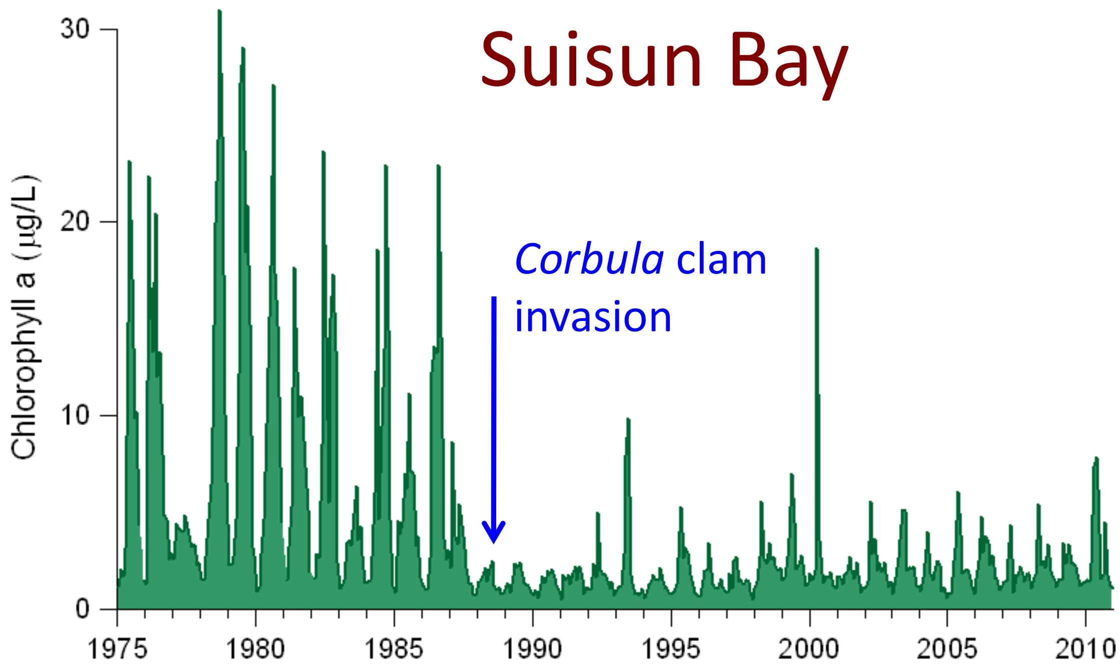
- Has South Bay reached a new steady-state/sensitivity?
  - *Monitoring, modeling*

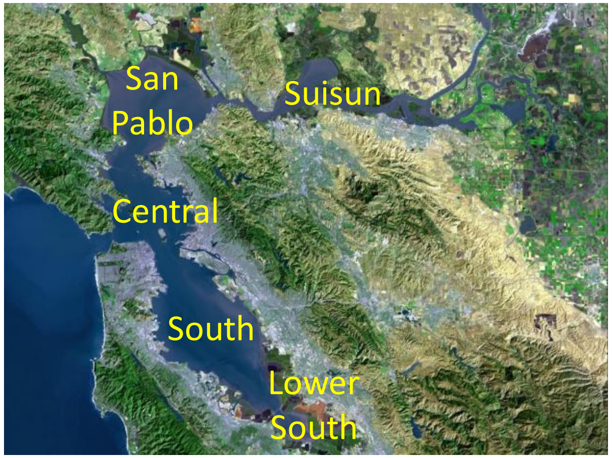
SFEI (

Phytoplankton

Drivers/stressors: Biomass

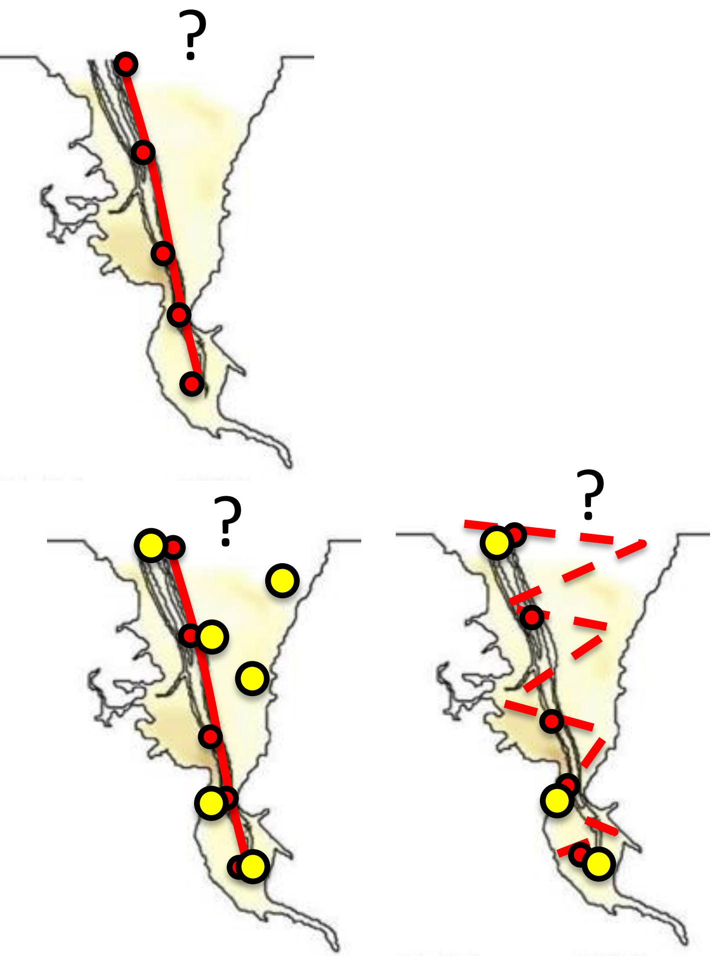
- Clams
- Light limitation
- Nutrients (NH_4^+)
- Residence time





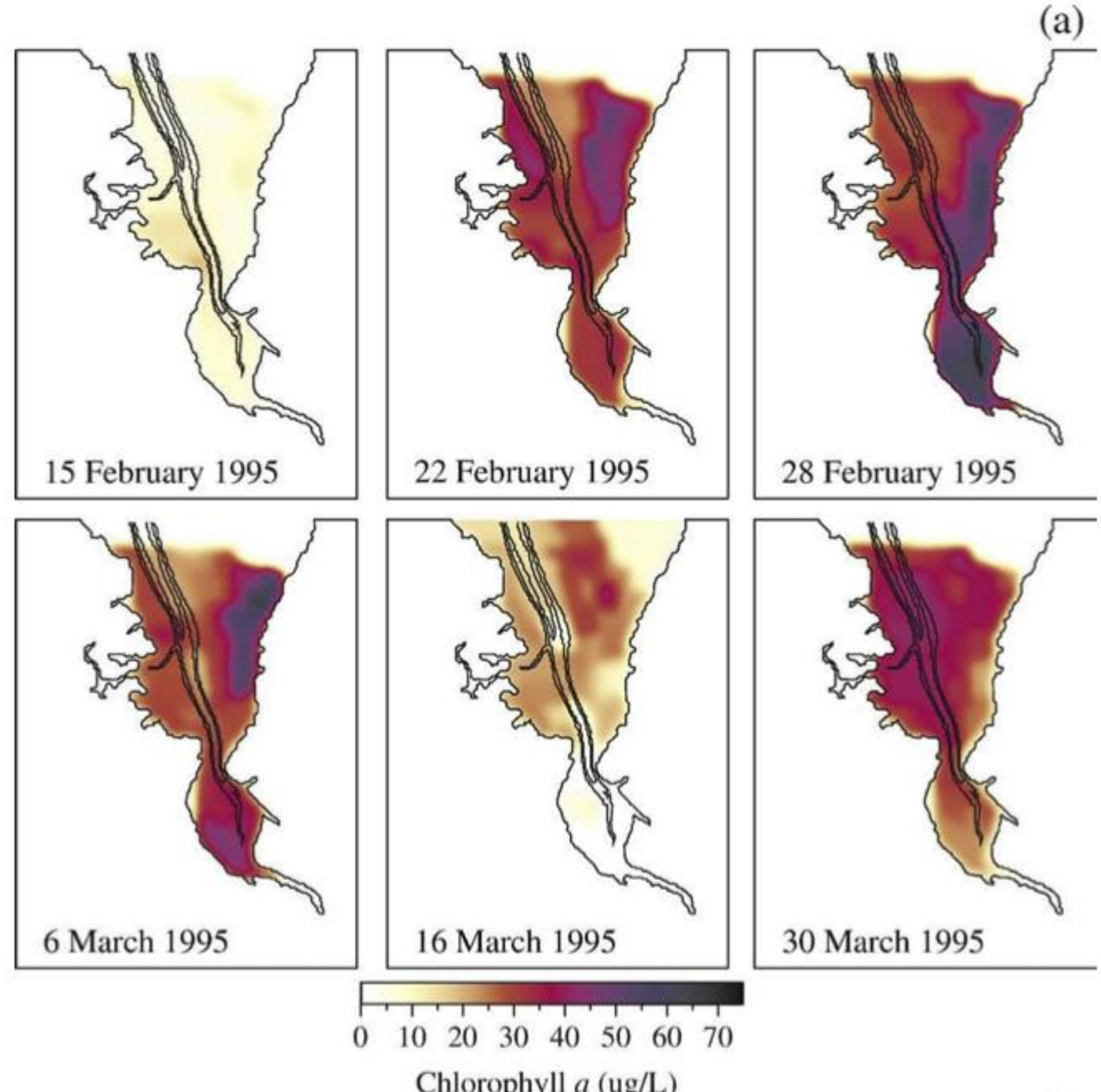
What monitoring is needed to detect this?

Either for…
- compliance
- model calibration



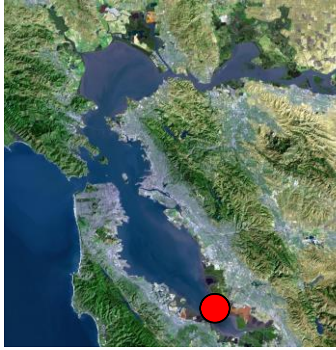
Long-term USGS cruises/stations

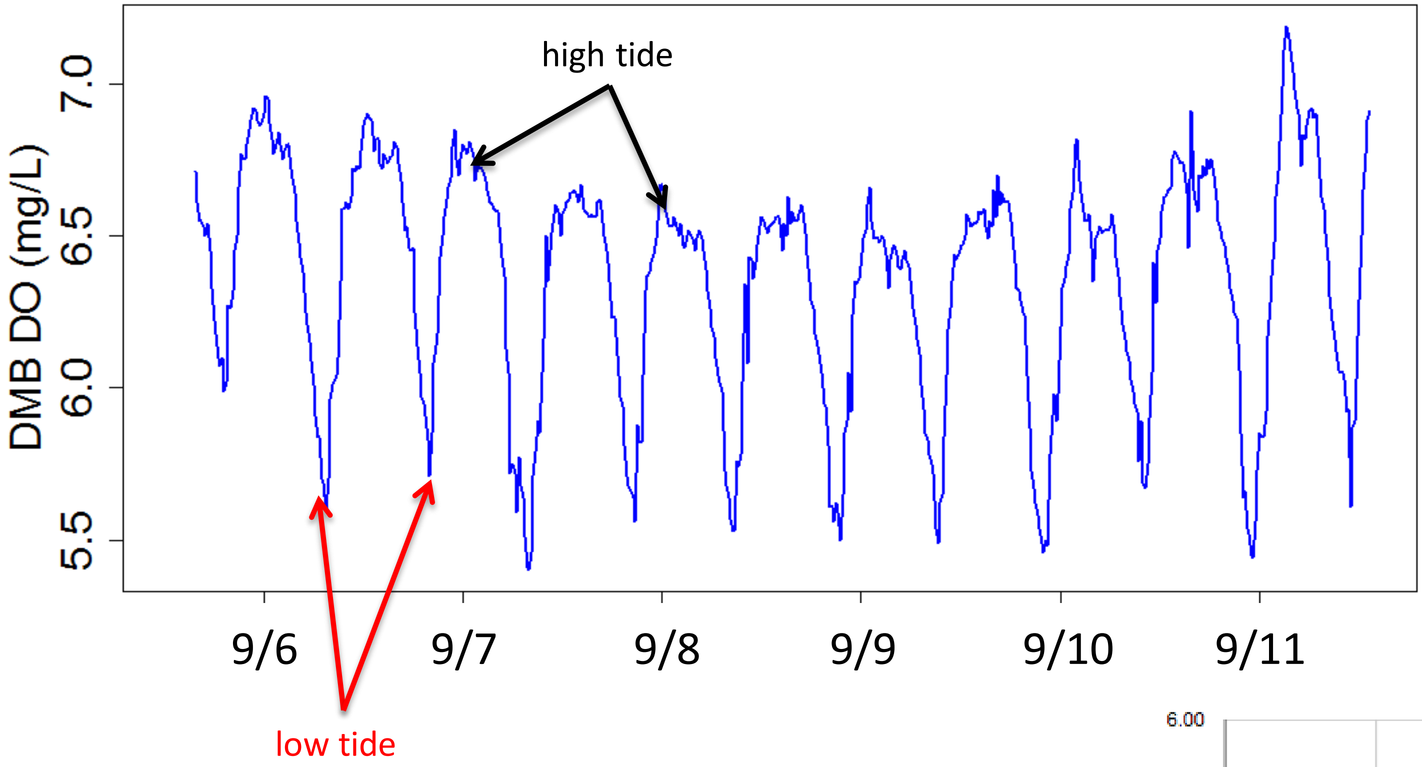
Moorings, continuous sensors



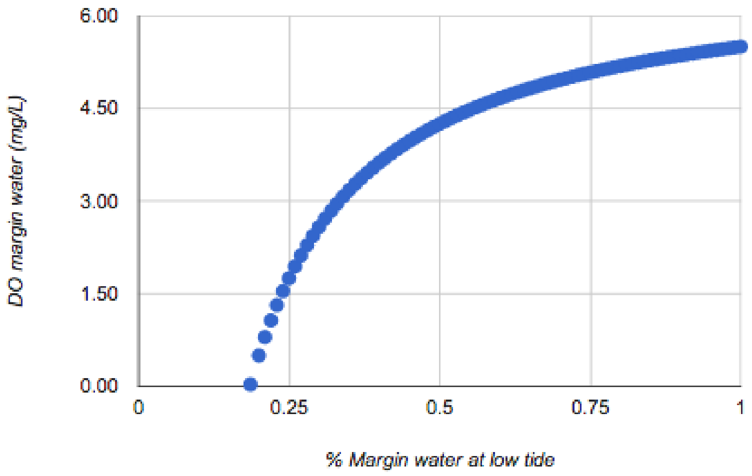
Thompson et al., 2008

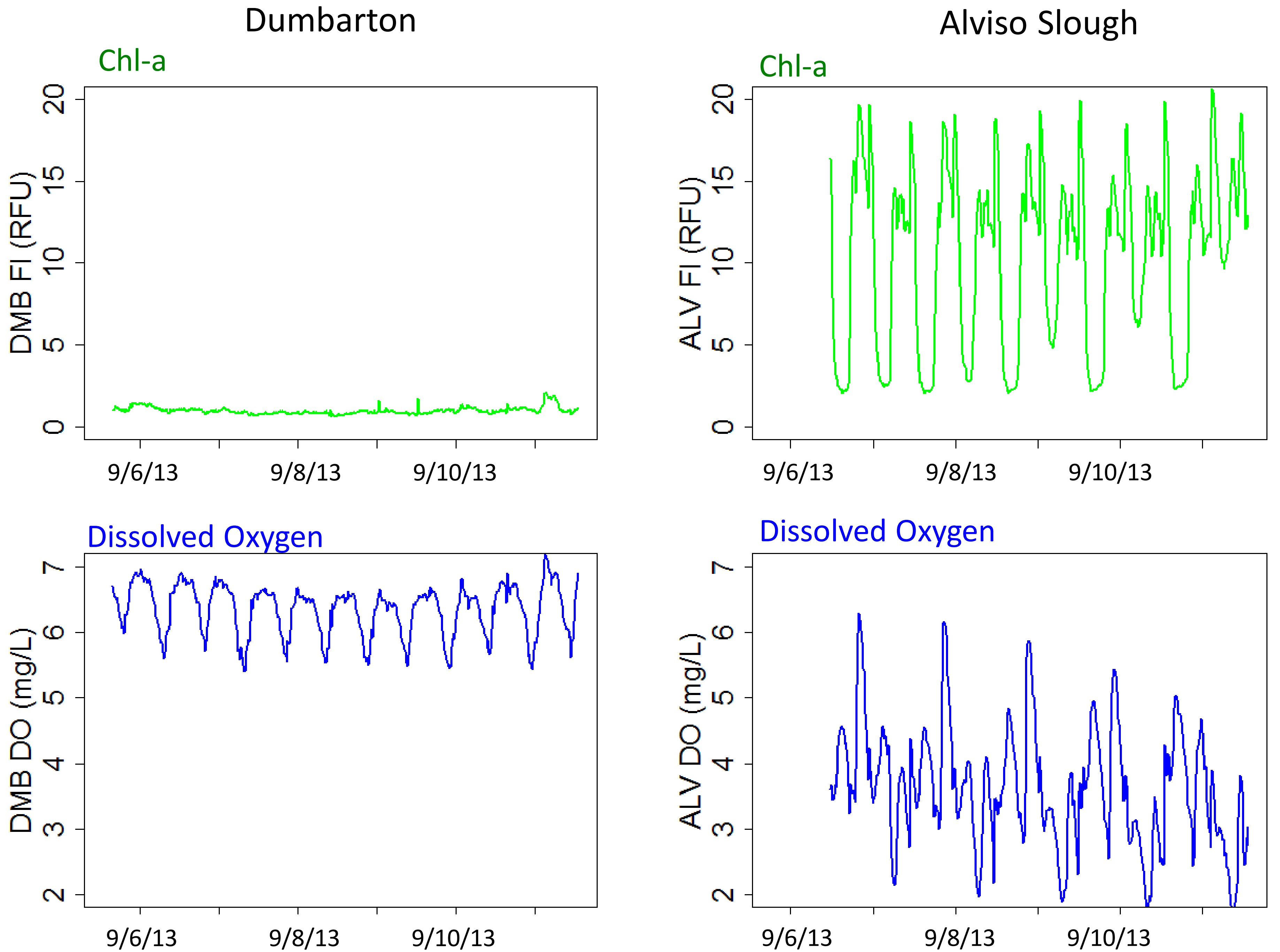
Continuous Dissolved Oxygen – Dumbarton Bridge (surface) September 2013



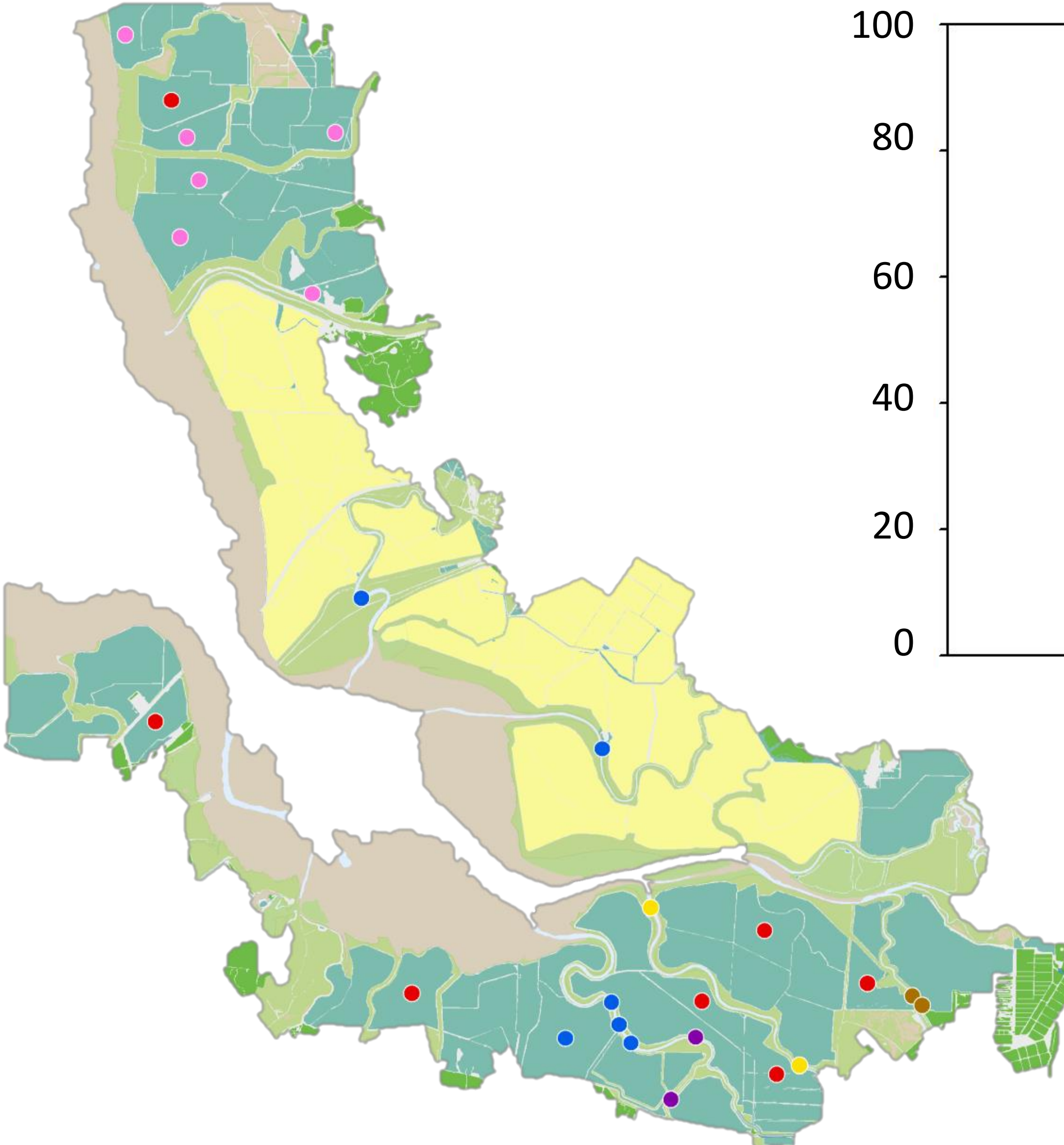


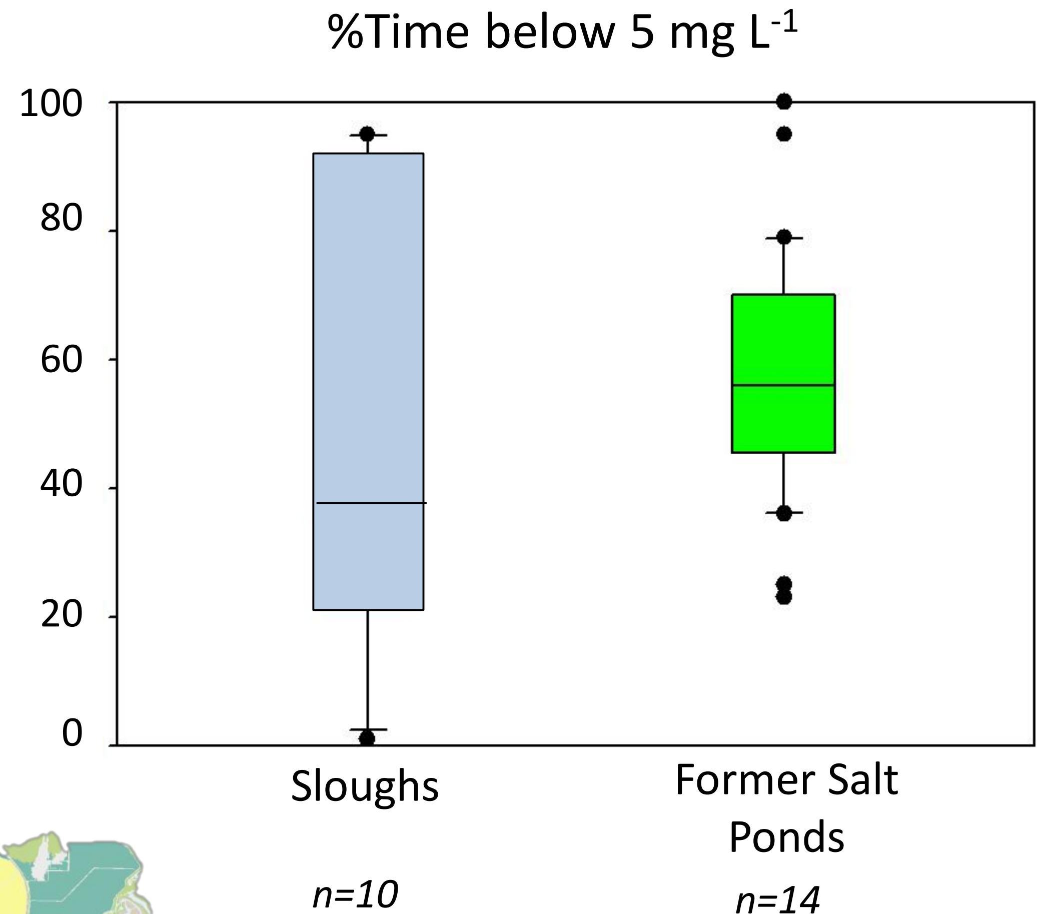
For figure on the right…Assuming conservative mixing/mass balance, if DO measured at low tide at the Dumbarton Bridge is a mixture of deep-subtidal water (~6.5-7 mg/L) and water draining from the intertidal margin habitats (sloughs/creeks, shoals), what would the average margin water composition need to be to explain the observed DO minima for different percentages of margin water present (x-axis)?




Dumbarton
Alviso Slough
Chl-a
DMB FI (RFU)
0
5
10
15
20
9/6/13
9/8/13
9/10/13
Chl-a
ALV FI (RFU)
0
5
10
15
20
9/6/13
9/8/13
9/10/13
Dissolved Oxygen
DMB DO (mg/L)
2
3
4
5
6
7
9/6/13
9/8/13
9/10/13
Dissolved Oxygen
ALV DO (mg/L)
2
3
4
5
6
7
9/6/13
9/8/13
9/10/13

DO in Sloughs and Former Salt Ponds (data = 2004-2012)





SFEI (2013)

APPENDIX B

Technical Team (TT) Response to Nutrient Technical Workgroup Comments at February 4, 2014 Meeting

Technical Team (TT) Response to Nutrient Technical Workgroup Comments at February 4, 2014 Meeting

1. Stakeholders would like the technical team to report back on their responses to issues raised during the meeting (2-11 below).

TT Response: Agreed.

2. The assessment framework needs to communicate what matters.
    a. The conversation centered around the linkage of chlorophyll to DO; we should more direct about how we link to DO.
        i. The group talked about how we could go about discussing site-specific DO objectives for the Bay; group agreed that we could consider this sequentially (after phytoplankton), considering that it is an involved effort (assuming we would take the Virginia Province Approach).
        ii. However, it was clear that we need to have a strong linkage to DO as a part of how we set the phytoplankton thresholds for the Bay
        iii. Should at least consider adding a fisheries person—Jim Hobbs suggested?

TT Response: Site-specific objectives are outside the scope of this current project but can be incorporated into a revised framework at a later time. We are proposing analyses of existing data to calculate linkage between dissolved oxygen, phytoplankton biomass and productivity. See meeting notes for details. TT members are open to adding a fisheries member; contact Martha Sutula (marthas@sccwrp.org) with any suggestions.

    b. Biomass – the group would really want assessment framework to consider how to treat both too high and too low.

TT Response: We agree and plan to take that on. Stay tuned for results of next workshop.

    c. Group had a conversation of what is the "canary in the coal mine" that we are trying to be protective of?

TT Response: What we assume is meant by this is can we be selective to choose the most sensitive indicators of environmental change. If this assumption is correct, then we believe the indicators that are being proposed are sufficiently sensitive. We may want to also consider spatially how to fine-tune sampling to better capture places that are more likely to have a problem.

    d. With respect to indicators on the table, it was not clear to the group how we would use either productivity or phytoplankton assemblage data to tell whether the Bay has a problem. What do these metrics really mean. For example, assemblage is controlled by a variety of factors, so they do not uniquely link to nutrient inputs.

Productivity on seasonal or annual time-scales is linked to fisheries yield (Nixon 1995)—something of great interest to the public of the Bay area. We agree that assemblage is controlled by a variety of

factors; we are proposing its measurement for the purposes of tracking ecosystem change and not impairment assessment per se.

3. With respect to the technical team's recommendation on segmentation (Jassby et al. 1997):
    a. RMP boundaries- why were these not considered (see reference for 2005)—recommendation was to have Meg Sedlak discuss this with the Tech Team during the workshop.

TT Response: The TT members discussed the issue. The consensus was that: 1) Jassby et al. 1997 similar to RMP, with the addition of one segment, 2) the TT members strongly recommend that segmentation be driven by data, 3) It is not clear that RMP segments reflect ecological elements we are trying to capture and therefore 4) The TT will use Jassby et al. (1997) as a starting point, pending additional data analyses with available data. SFEI is considering taking on this analyses and will confirm their commitment to do so.

    b. Per discussion of habitats included in this first assessment framework, do we include Sloughs? How far up the sloughs do we go?

TT Response: Excellent question. The answer is yet to be determined by recommended density of monitoring sites.

4. How can you incorporate reference condition (natural background) into the assessment framework? The conversation focused mostly on DO. Some within the group suggested monitoring gradients –looking at minimally disturbed or influenced by nutrient loads as a gradient.

This topic is most relevant for consideration of site-specific fine-turning of expectations for dissolved oxygen, rather than phytoplankton metrics. Suggestion of monitoring gradients is a reasonable approach.

5. Relative to monitoring program development:
    a. Is there room for event-based monitoring (e.g. blooms) in how we approach this and, if so, how would the assessment framework capture this?
    b. How do you treat continuous data versus ship-based data in the assessment framework?

TT Response: Excellent question. Event-based monitoring is difficult to do routinely (outside of specific research studies). Moored stations with DO, fluorometers, and flow cytobots may partially address the need to capture events. The answer is yet to be determined with respect to how continuous versus ship-based data would be used.

N.B. Some in the group were interested in having Larry Harding give presentation on chl a work; the recommendation was to set up a webinar.

Larry's Response: Agreed.

Phytoplankton Composition as an index of impairment

Raphael Kudela
Misty Peacock

Background

- Using USGS data
  - Only measured when total Chl > ~5 ug/L
  - Same taxonomist for the entire record
- IEP data exist, but are questionable
  - Changes in taxonomists
  - Questionable biovolume data
- Baseline is that >1E6 cells/L of any "organism" is a flag for impairment
- NOT examining ecological questions (i.e. shifts in species composition, time-series analysis)
- High-level analysis (not analyzing by basin, etc)

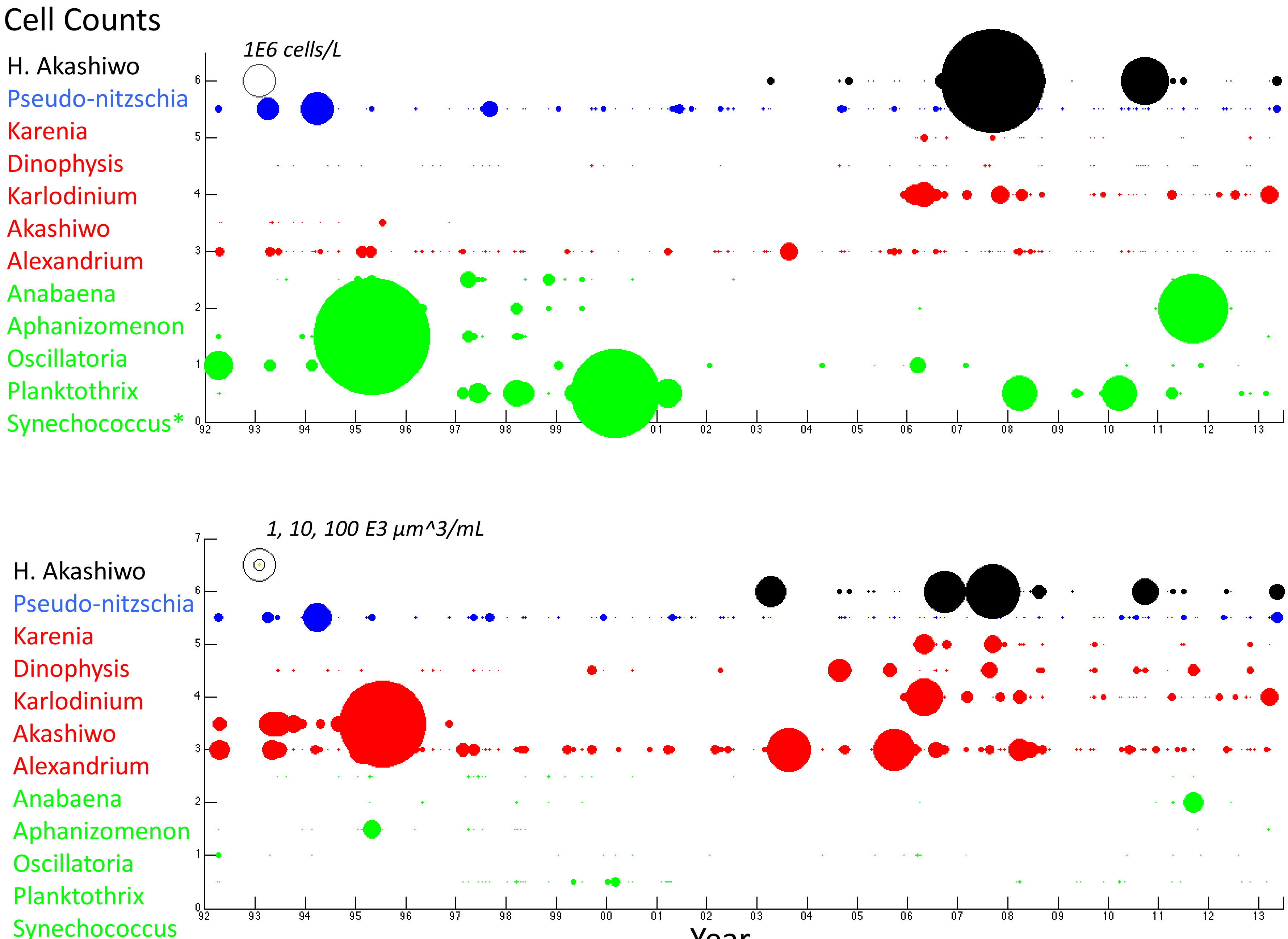
Parameters for Evaluation

- Identify the frequency of known HAB organisms in the database, and estimate:
  - temporal trends (increase/decrease in abundance)
  - climatological cell densities (mean and standard deviation), so that anomalies (such as >2SD abundance) could be used as impairment flags

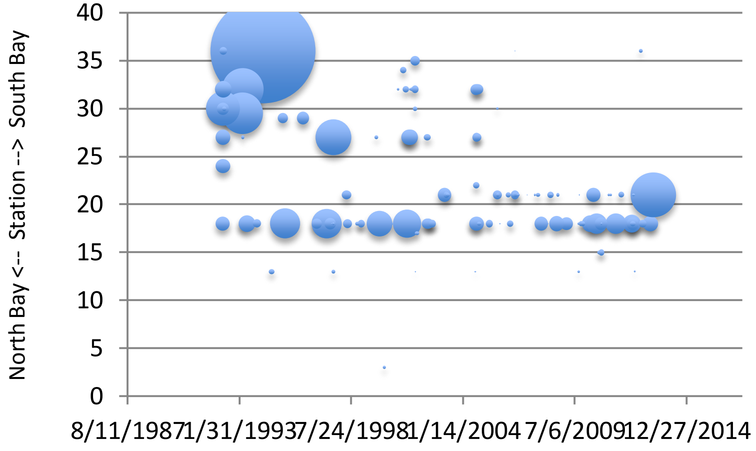
- Generate a cell density versus biovolume analysis to determine whether cell density is a reasonably proxy for biovolume (biomass)

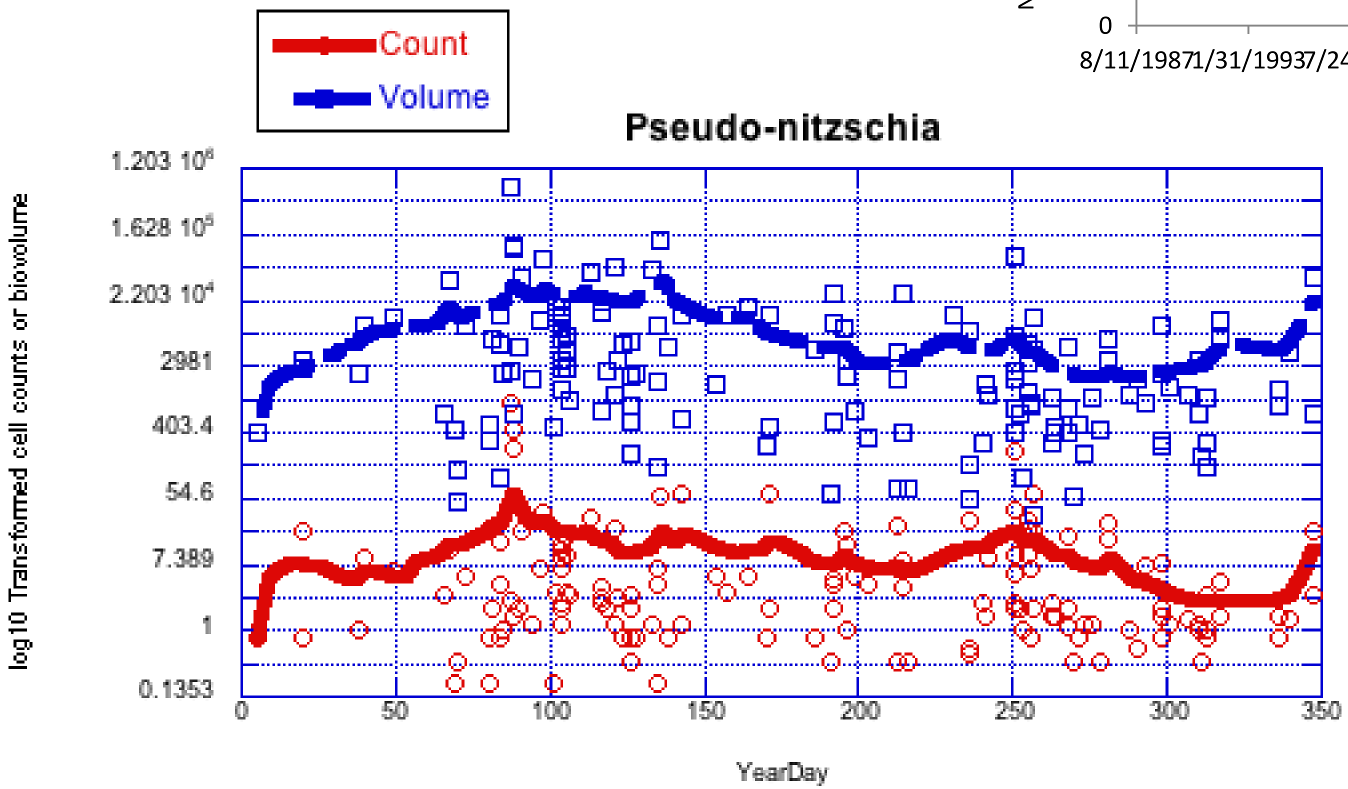
- Bin the phytoplankton groups, so as to develop numeric impairment categories based on cell size (i.e. >104 for diatoms, >106 for small flagellates, etc)
  - bin by size/biovolume category
  - bin by phytoplankton functional type (diatoms, dinoflagellates, cryptophytes, etc)

- Using the criteria developed from 1-4, test a subset of the data using the various criteria to determine how often SF Bay would be flagged as "impaired" using different scenarios

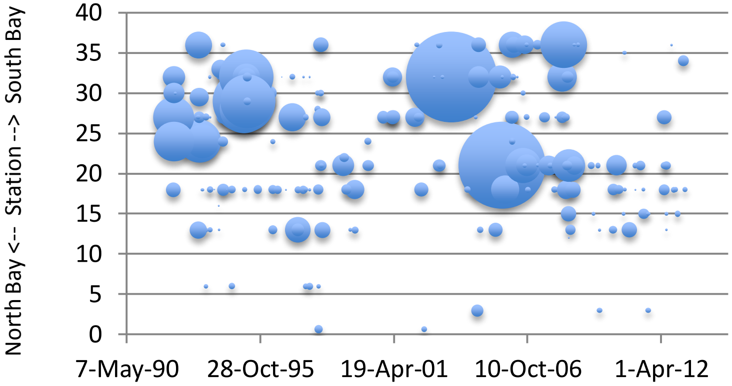


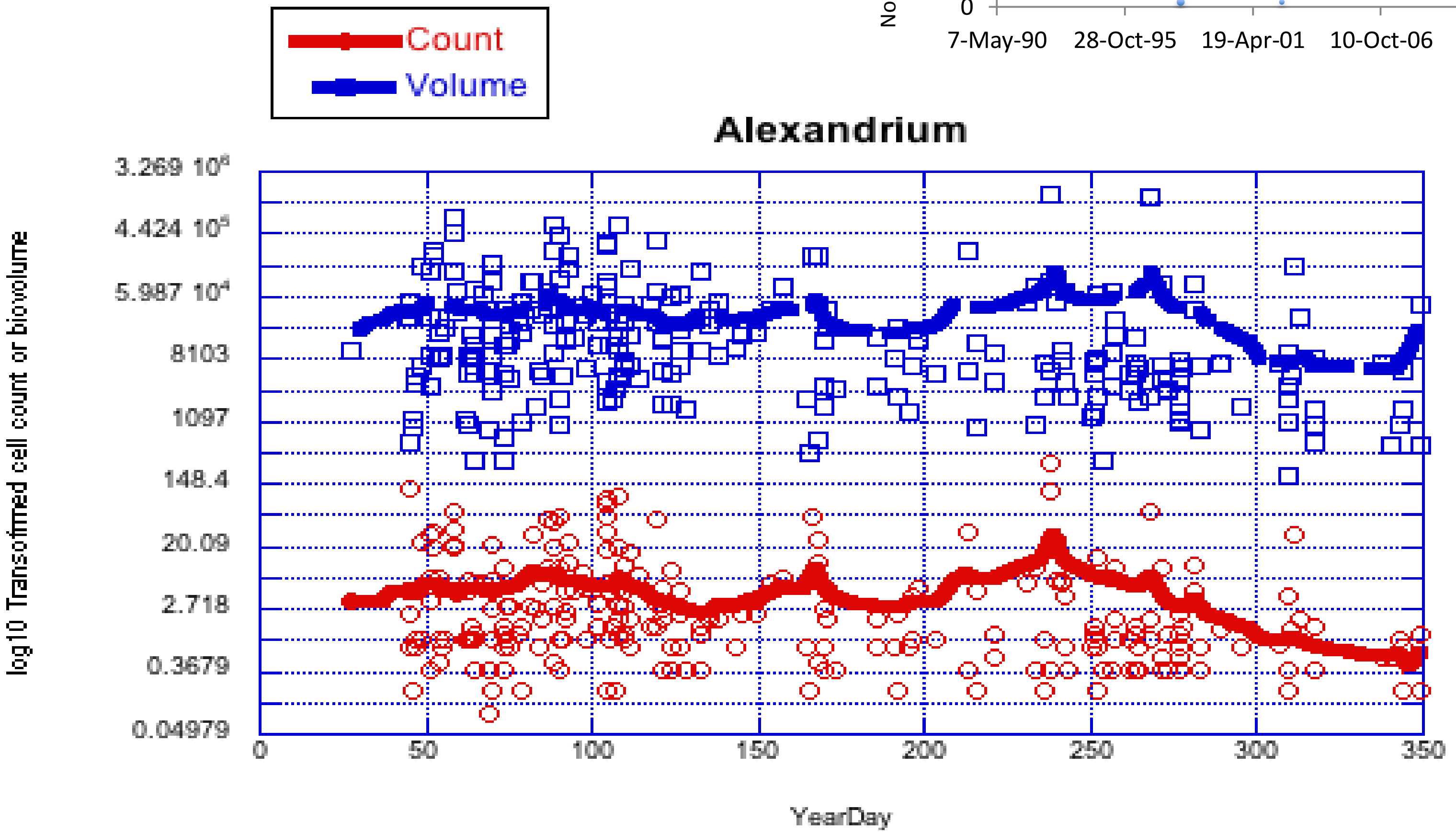
Cell Counts
1E6 cells/L
H. Akashiwo
Pseudo-nitzschia
Karenia
Dinophysis
Karlodinium
Akashiwo
Alexandrium
Anabaena
Aphanizomenon
Oscillatoria
Planktothrix
Synechococcus*
1, 10, 100 E3 µm^3/mL
H. Akashiwo
Pseudo-nitzschia
Karenia
Dinophysis
Karlodinium
Akashiwo
Alexandrium
Anabaena
Aphanizomenon
Oscillatoria
Planktothrix
Synechococcus
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13
Year



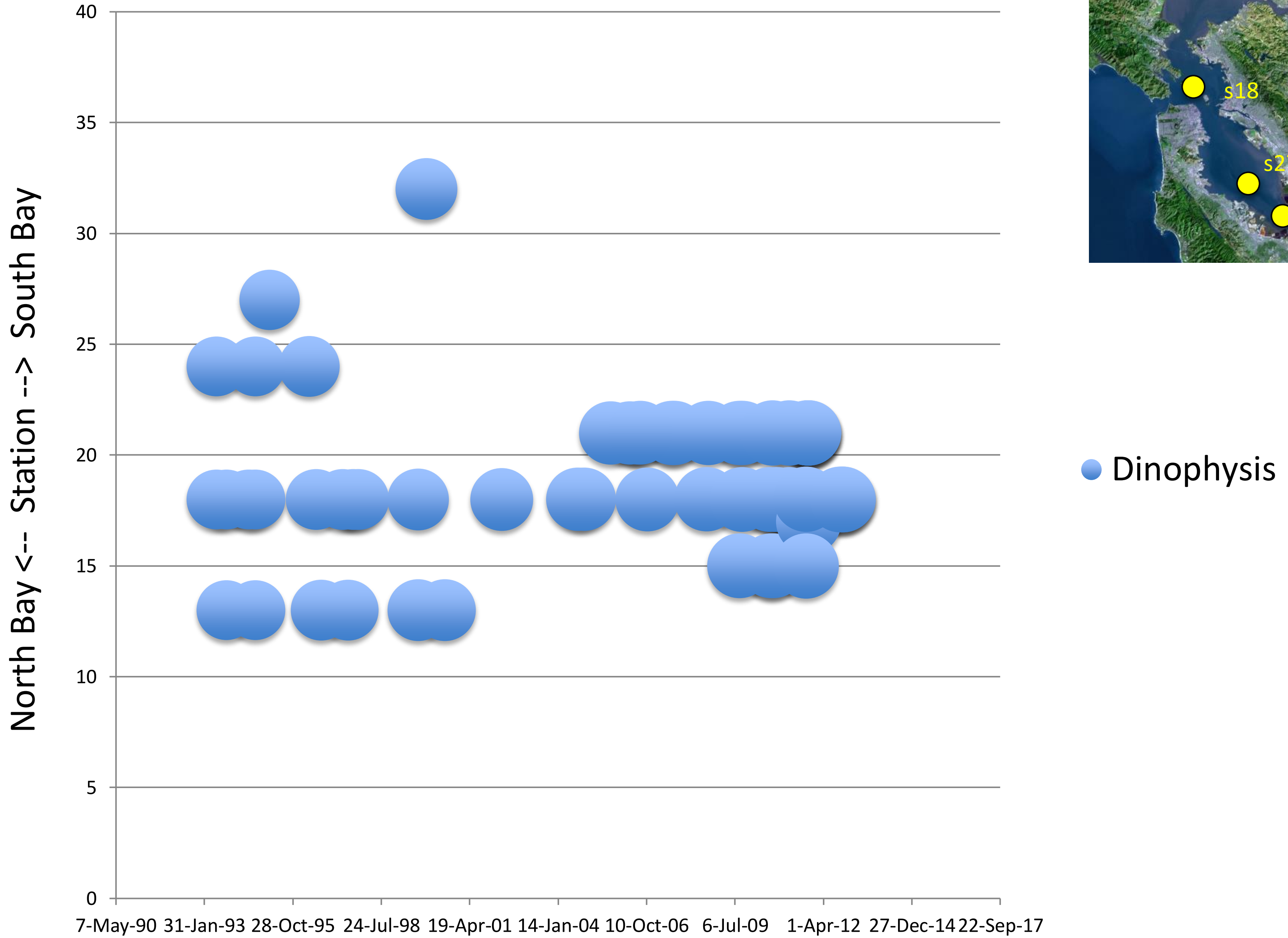


Pseudo-nitzschia is present at relatively constant concentrations (minor peaks in spring and autumn) throughout the time-series, primarily in Central and South Bay

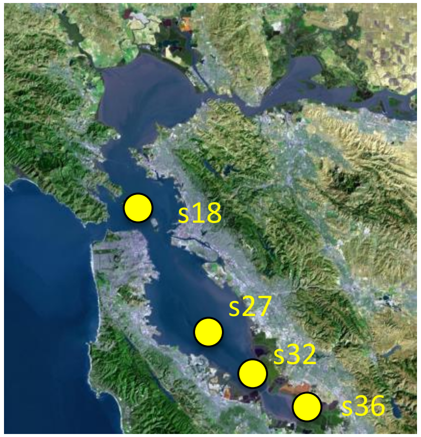




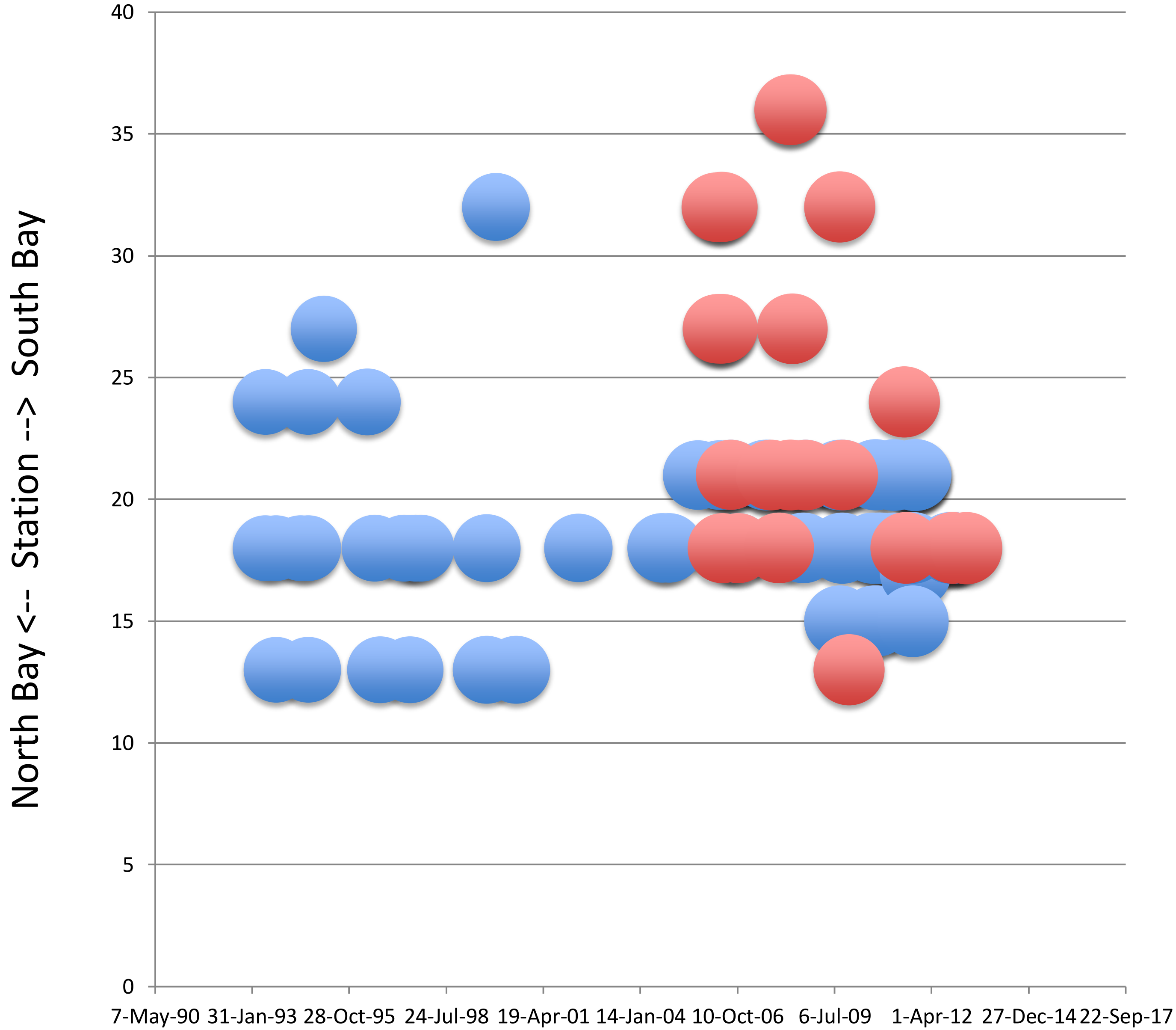
Alexandrium is present at relatively constant concentrations (minor peak in autumn) throughout the time-series, primarily in South Bay but occasionally seen in all basins

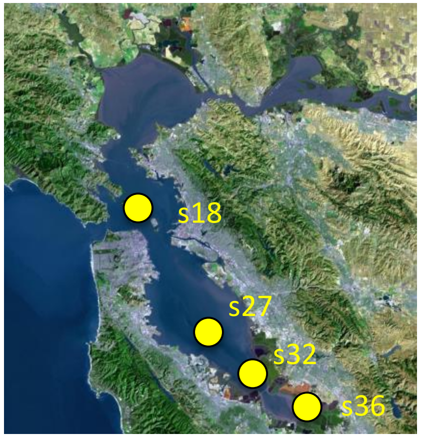


40
35
30
25
20
15
10
5
0
North Bay <-- Station --> South Bay
7-May-90
31-Jan-93
28-Oct-95
24-Jul-98
19-Apr-01
14-Jan-04
10-Oct-06
6-Jul-09
1-Apr-12
27-Dec-14
22-Sep-17
Dinophysis

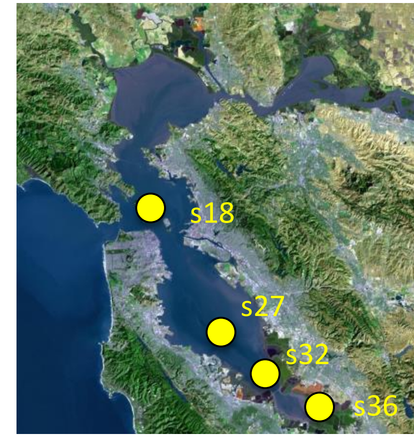


s18
s27
s32
s36


North Bay <-- Station --> South Bay
40
35
30
25
20
15
10
5
0
7-May-90
31-Jan-93
28-Oct-95
24-Jul-98
19-Apr-01
14-Jan-04
10-Oct-06
6-Jul-09
1-Apr-12
27-Dec-14
22-Sep-17
Dinophysis
Karenia


s18
s27
s32
s36


North Bay <-- Station --> South Bay
0
5
10
15
20
25
30
35
40
7-May-90
31-Jan-93
28-Oct-95
24-Jul-98
19-Apr-01
14-Jan-04
10-Oct-06
6-Jul-09
1-Apr-12
27-Dec-14
22-Sep-17
Dinophysis
Karenia
Karlo


s18
s27
s32
s36

Identify the frequency of known HAB organisms in the database, and estimate:

temporal trends (increase/decrease in abundance)

climatological cell densities (mean and standard deviation), so that anomalies (such as >2SD abundance) could be used as impairment flags

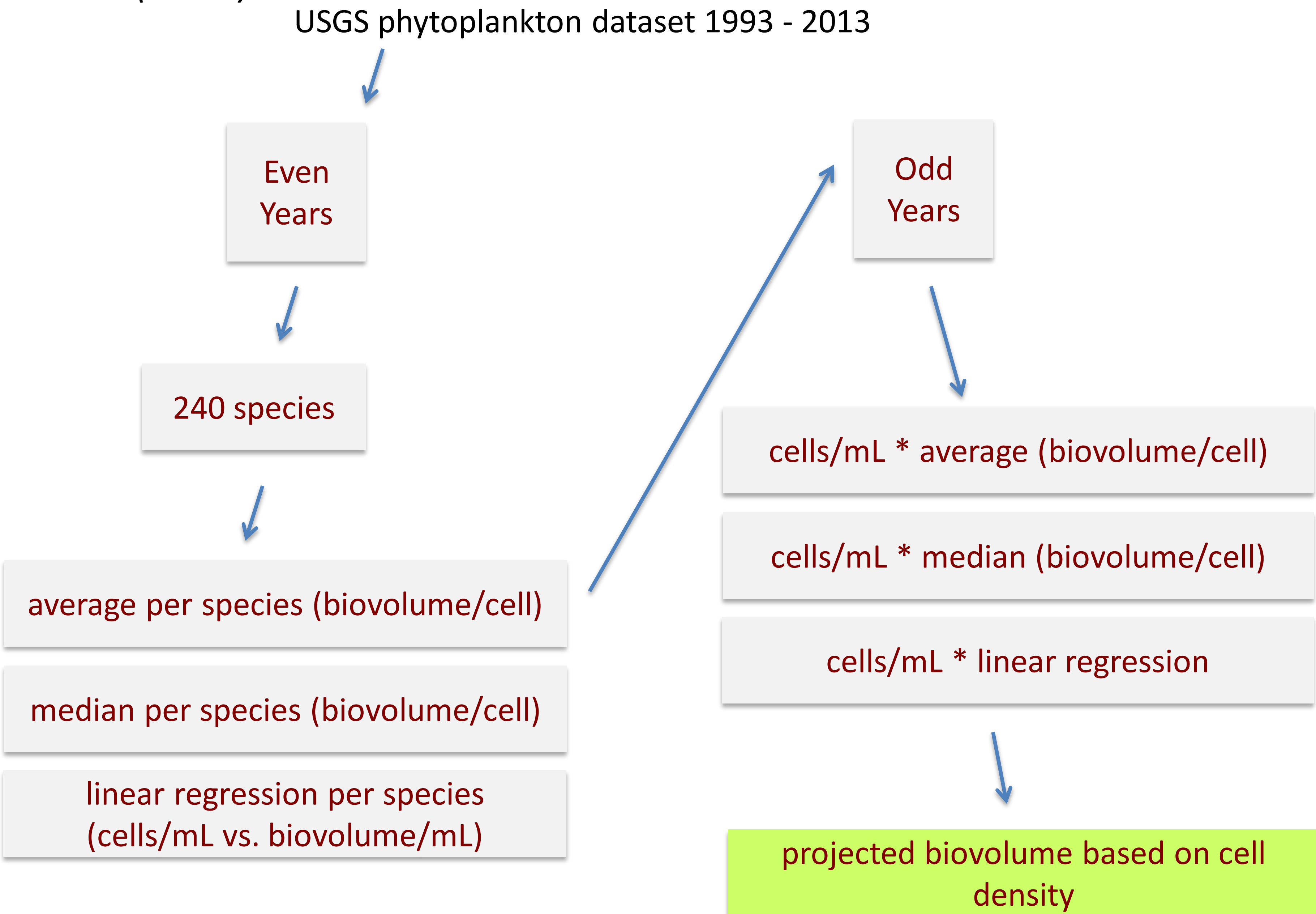
Do HABs tell us something about nutrient impairment?

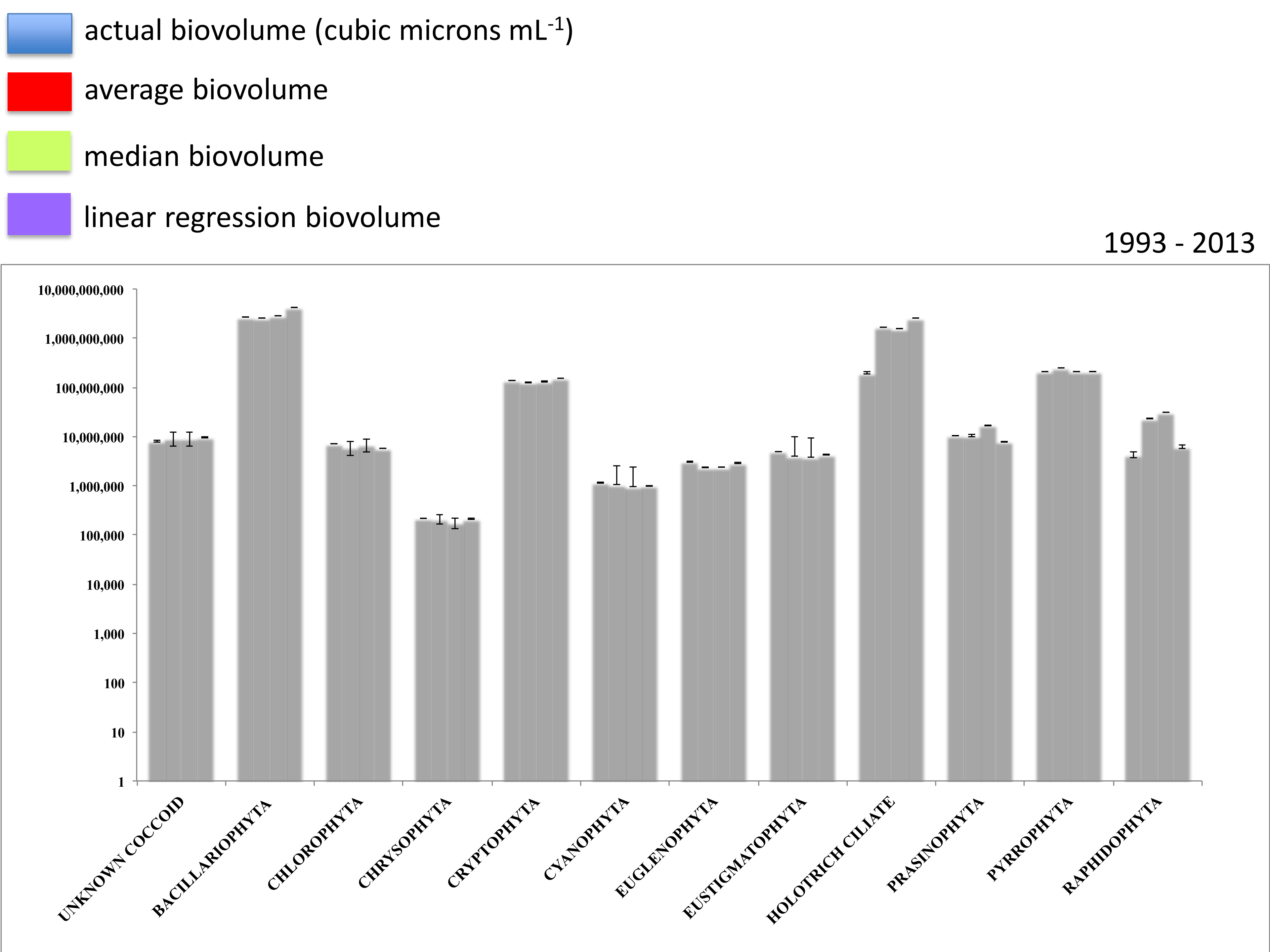
• Some HAB organisms are commonly present—increases in biomass would likely increase HABs also

• Some HABs are probably NOT directly linked to nutrients, but rather to changes in flow (salt ponds)

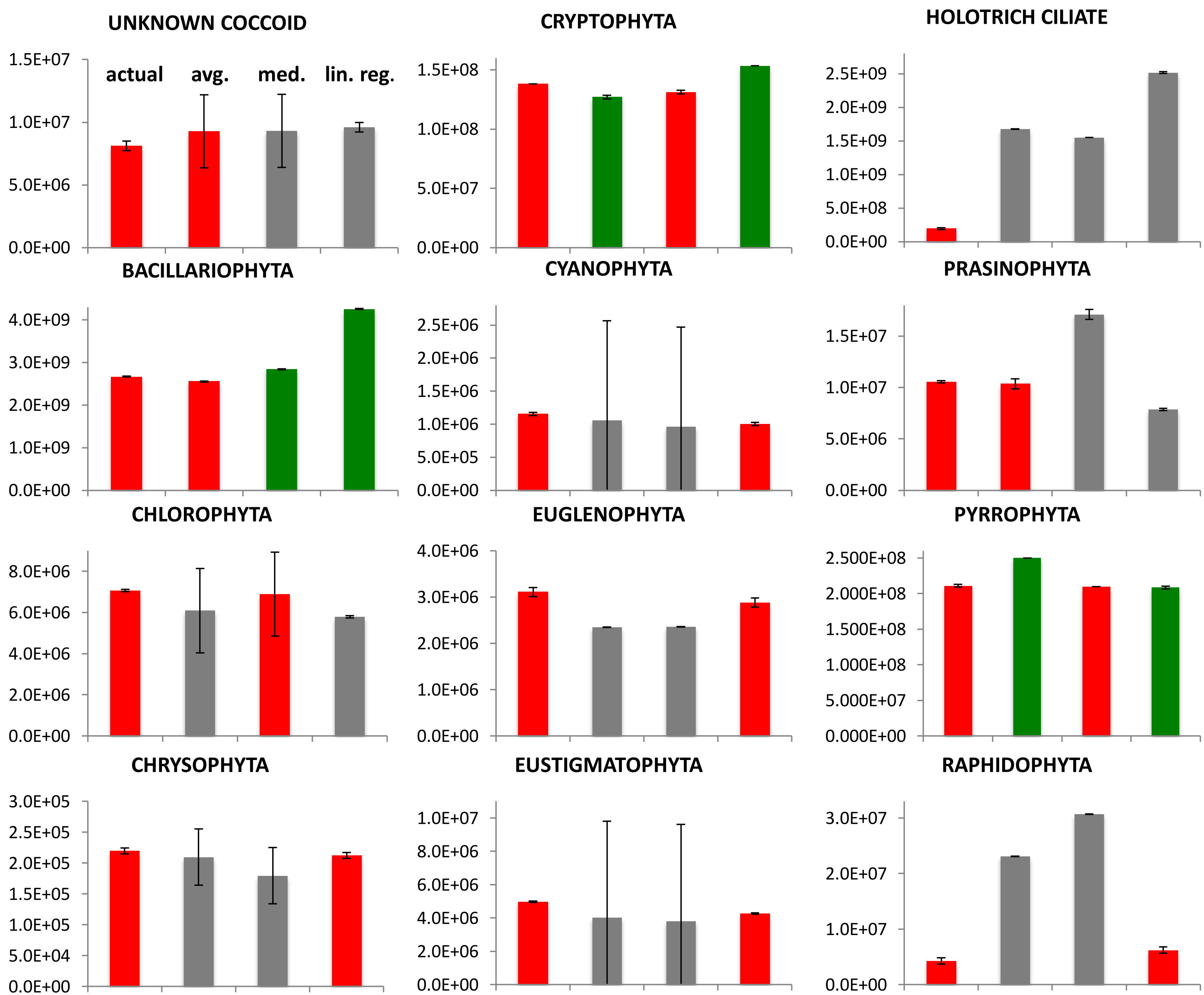
• HAB toxins are present nearly all the time—it would be prudent to keep track of them!

Generate a cell density versus biovolume analysis to determine whether cell density is a reasonably proxy for biovolume (biomass)

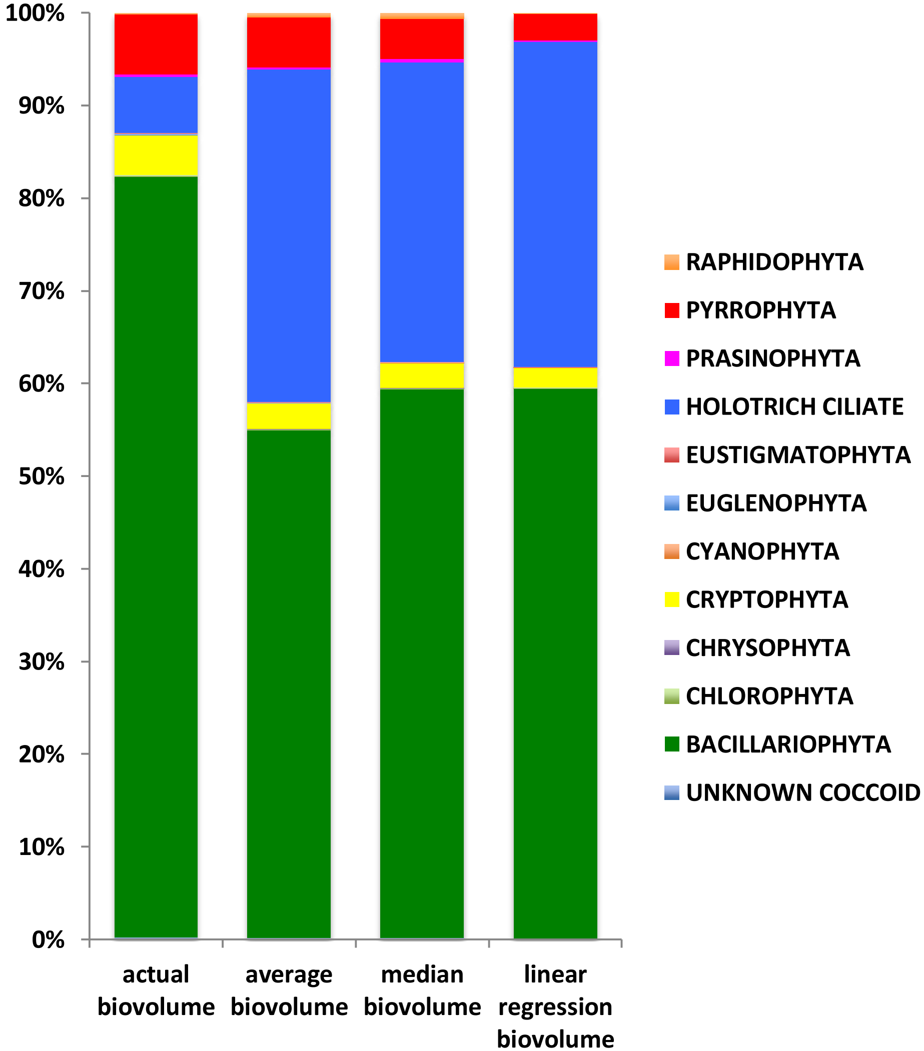


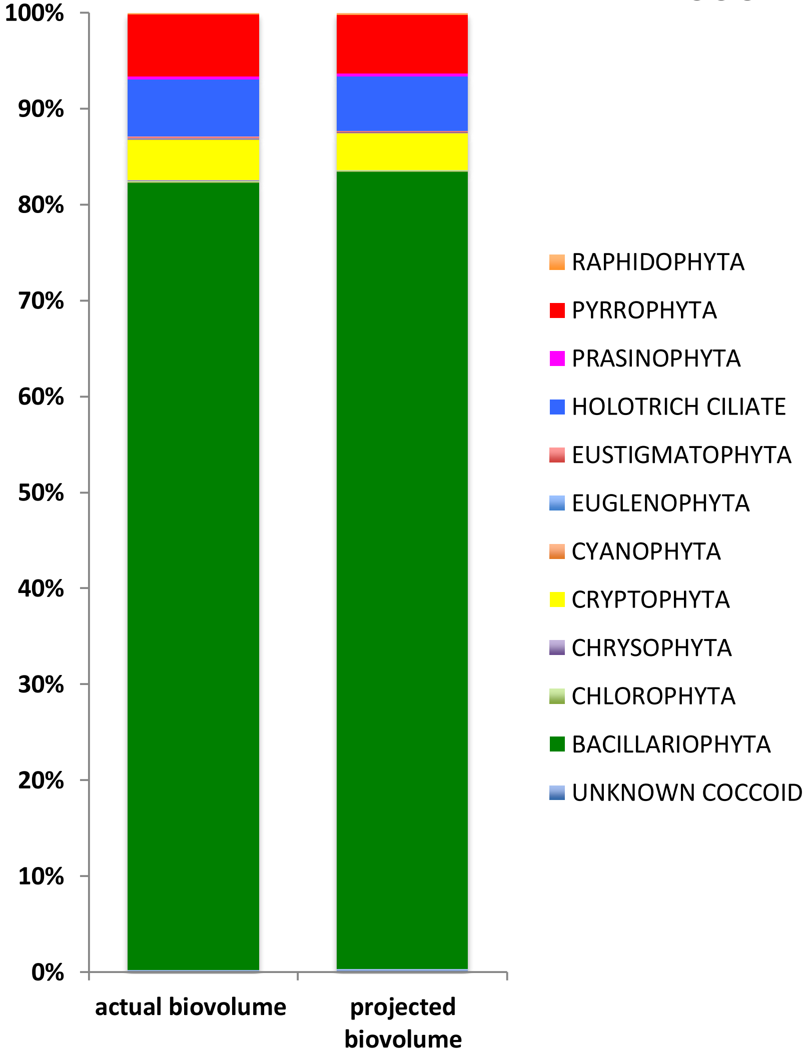


actual biovolume (cubic microns mL-1)
average biovolume
median biovolume
linear regression biovolume
1993 - 2013
10,000,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
UNKNOWN COCCOID
BACILLARIOPHYTA
CHLOROPHYTA
CHRYSOPHYTA
CRYPTOPHYTA
CYANOPHYTA
EUGLENOPHYTA
EUSTIGMATOPHYTA
HOLOTRICH CILIATE
PRASINOPHYTA
PYRROPHYTA
RAPHIDOPHYTA


UNKNOWN COCCOID
actual
avg.
med.
lin. reg.
1.5E+07
1.0E+07
5.0E+06
0.0E+00
CRYPTOPHYTA
1.5E+08
1.0E+08
5.0E+07
0.0E+00
HOLOTRICH CILIATE
2.5E+09
2.0E+09
1.5E+09
1.0E+09
5.0E+08
0.0E+00
BACILLARIOPHYTA
4.0E+09
3.0E+09
2.0E+09
1.0E+09
0.0E+00
CYANOPHYTA
2.5E+06
2.0E+06
1.5E+06
1.0E+06
5.0E+05
0.0E+00
PRASINOPHYTA
1.5E+07
1.0E+07
5.0E+06
0.0E+00
CHLOROPHYTA
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
EUGLENOPHYTA
4.0E+06
3.0E+06
2.0E+06
1.0E+06
0.0E+00
PYRROPHYTA
2.500E+08
2.000E+08
1.500E+08
1.000E+08
5.000E+07
0.000E+00
CHRYSOPHYTA
3.0E+05
2.5E+05
2.0E+05
1.5E+05
1.0E+05
5.0E+04
0.0E+00
EUSTIGMATOPHYTA
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
RAPHIDOPHYTA
3.0E+07
2.0E+07
1.0E+07
0.0E+00

1993 - 2013





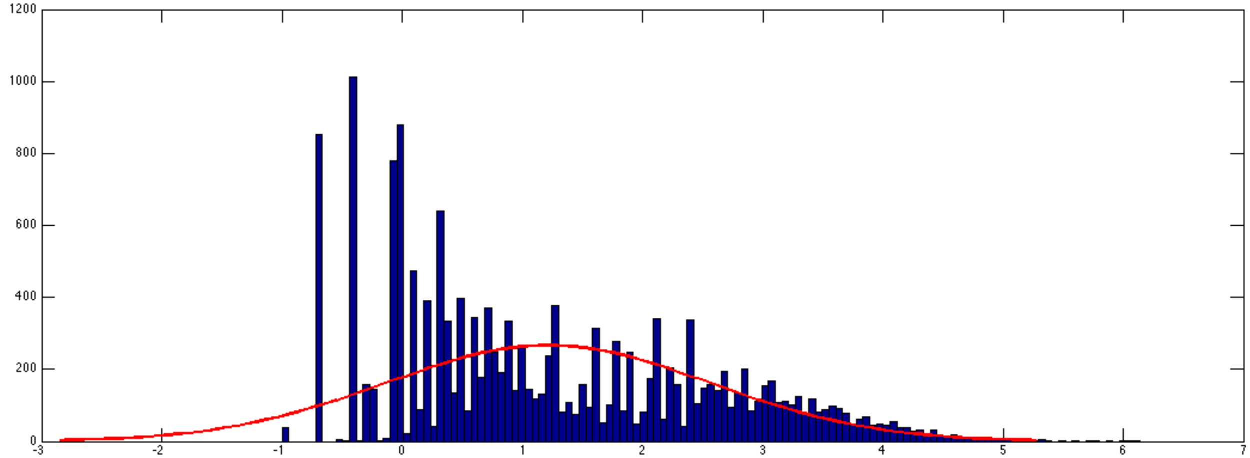
Depending on the method to estimate biovolume, percent of groups compared to biovolume can be wildly different

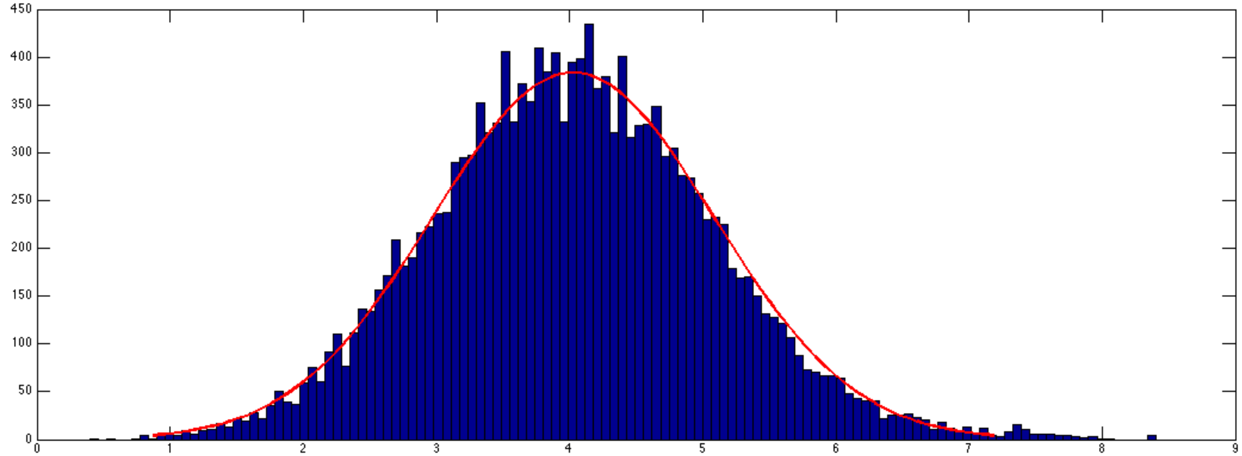
Projected biovolume using the best fit (except ciliates – actual biovolume used)

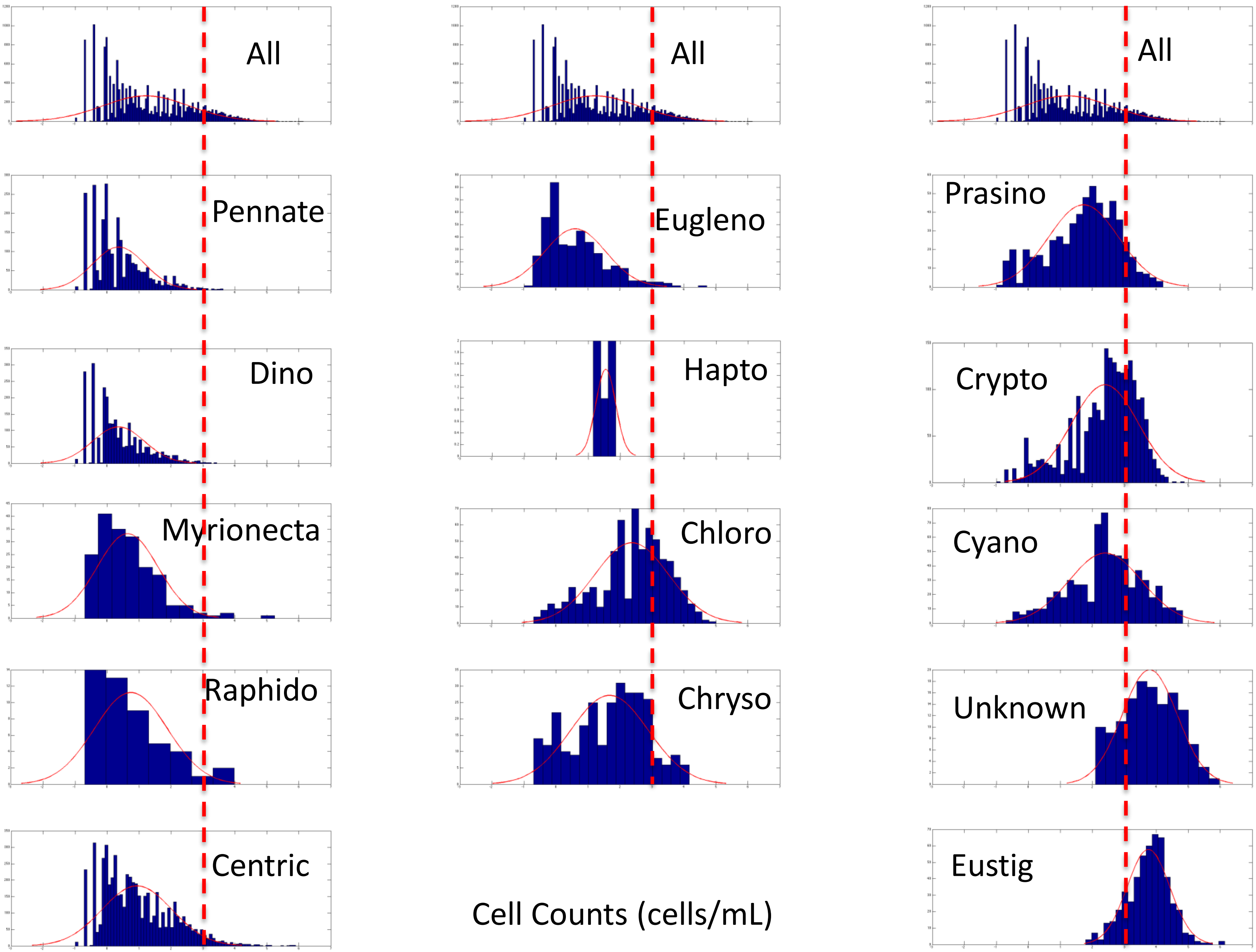
Bin the phytoplankton groups, so as to develop numeric impairment categories based on cell size (i.e. >104 for diatoms, >106 for small flagellates, etc)

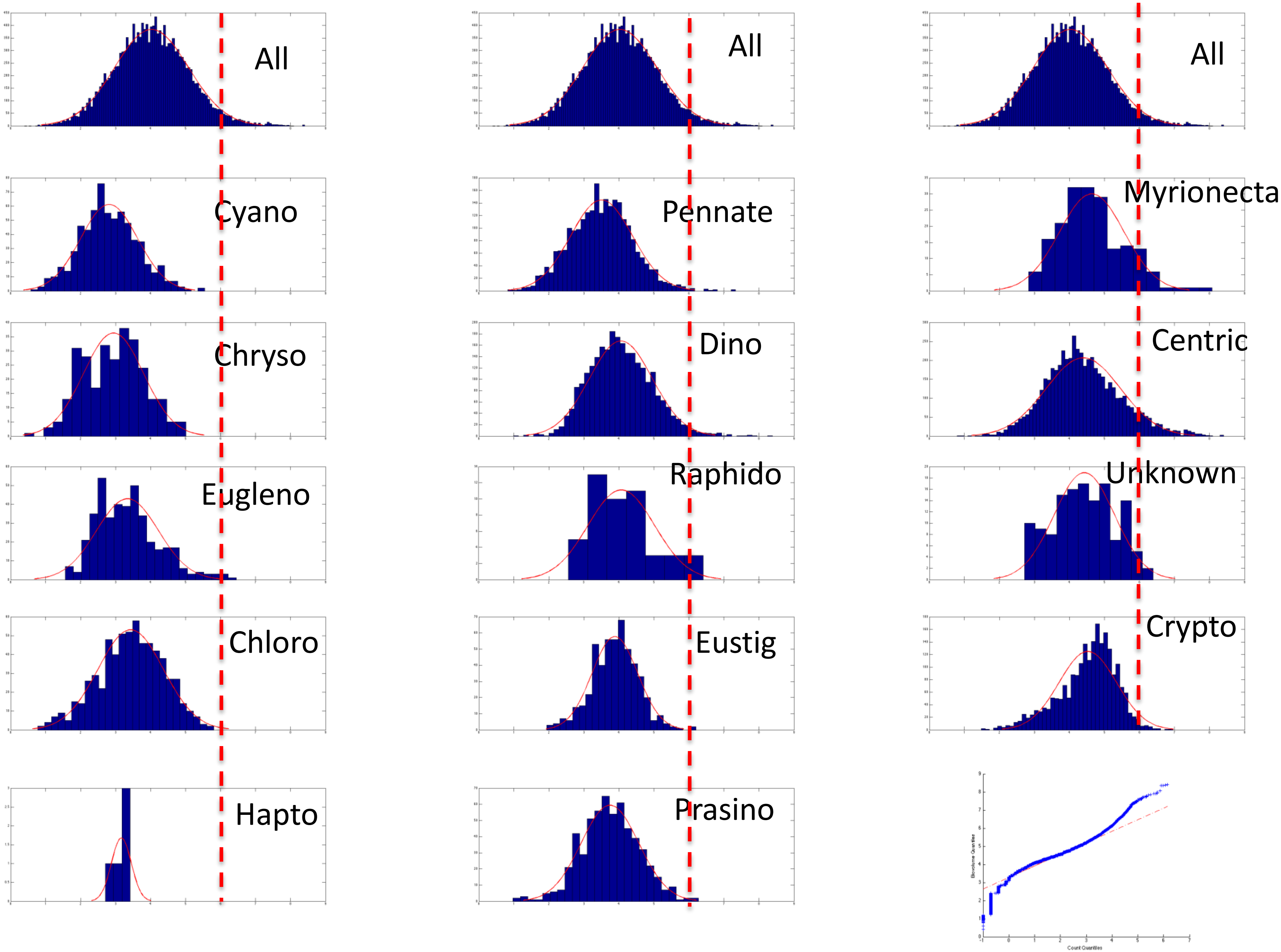
bin by size/biovolume category

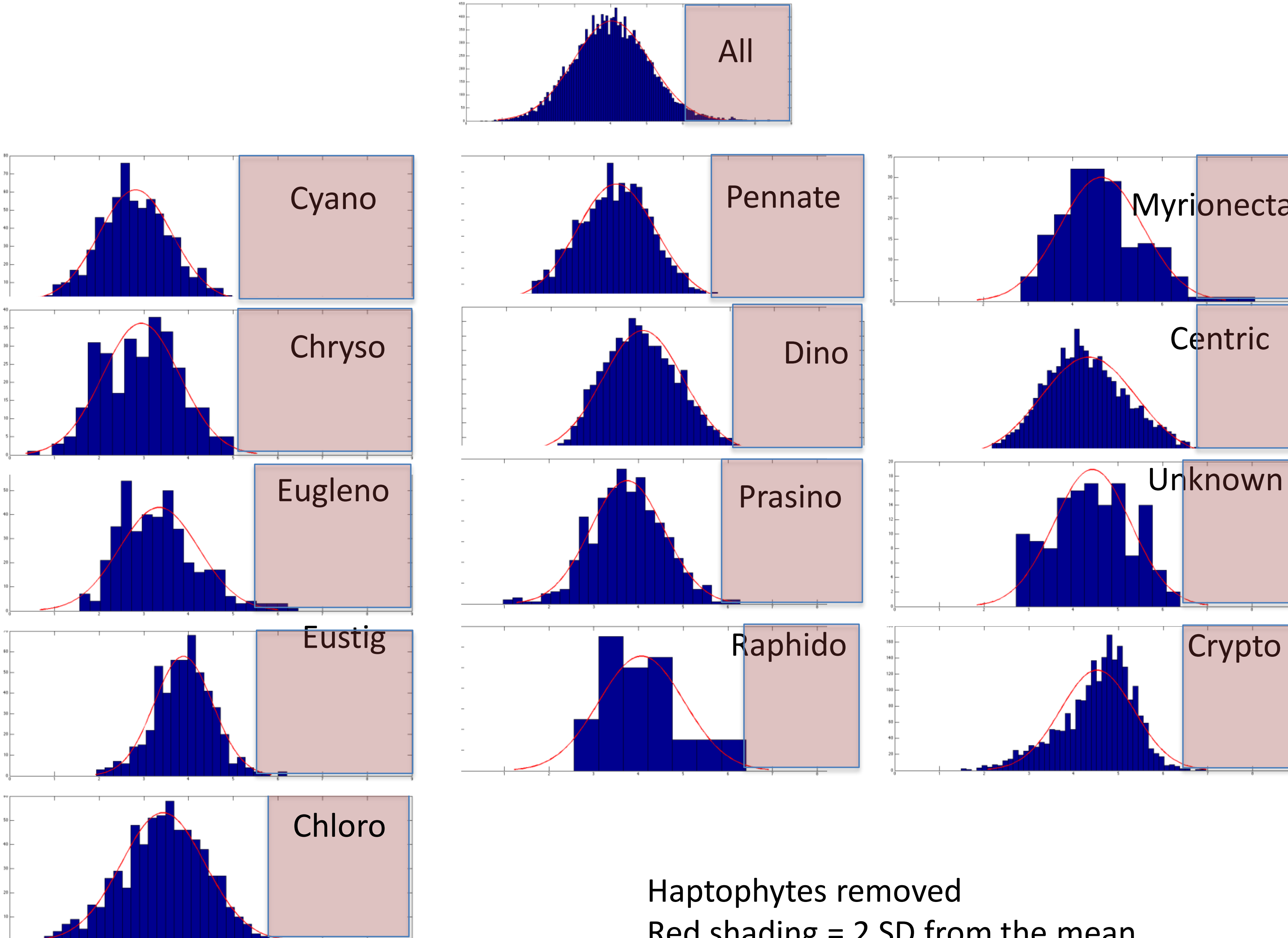
bin by phytoplankton functional type (diatoms, dinoflagellates, cryptophytes, etc)





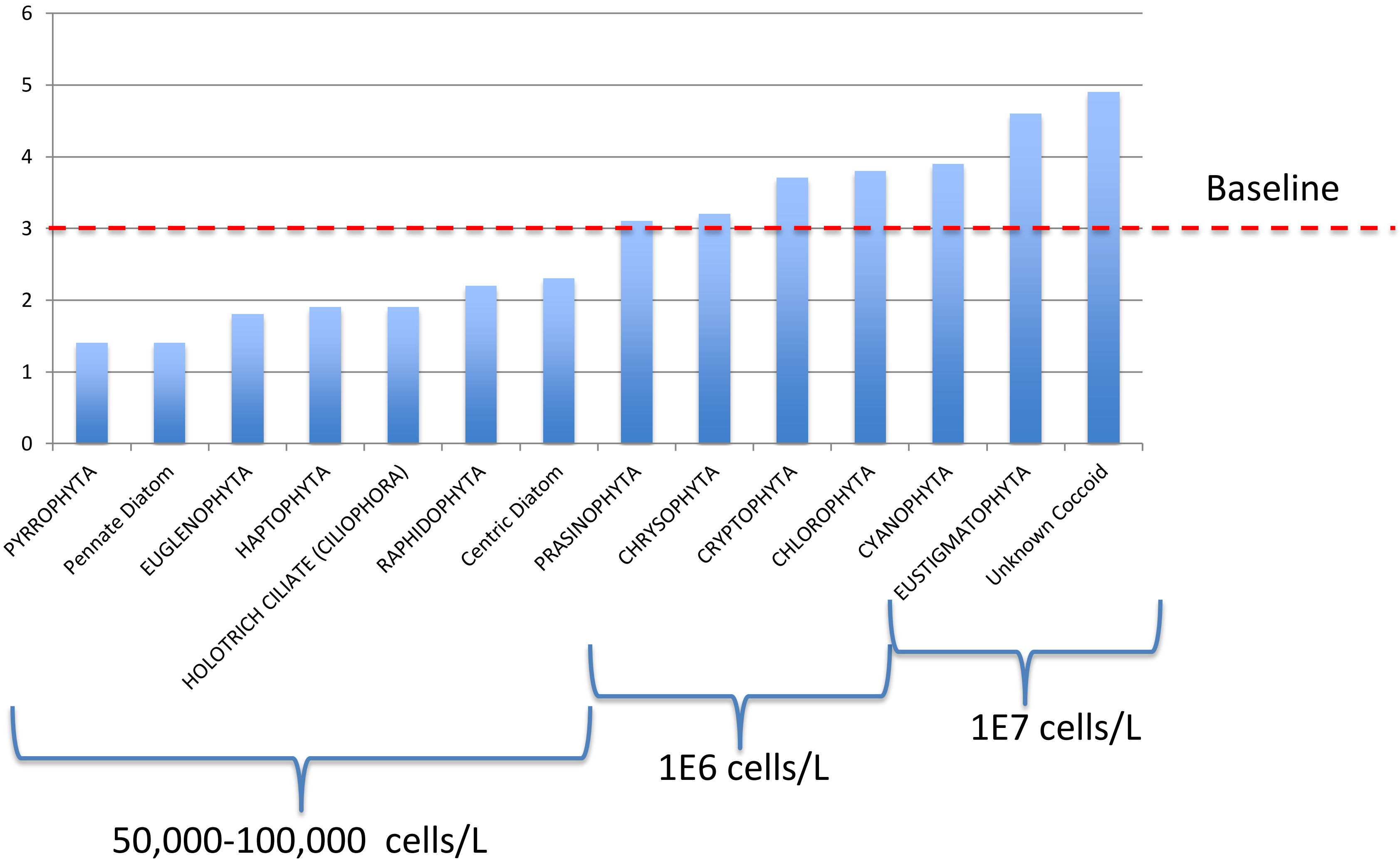

All
All
All
Pennate
Eugleno
Prasino
Dino
Hapto
Crypto
Myrionecta
Chloro
Cyano
Raphido
Chryso
Unknown
Centric
Eustig
Cell Counts (cells/mL)


All
All
All
Cyano
Pennate
Myrionecta
Chryso
Dino
Centric
Eugleno
Raphido
Unknown
Chloro
Eustig
Crypto
Hapto
Prasino

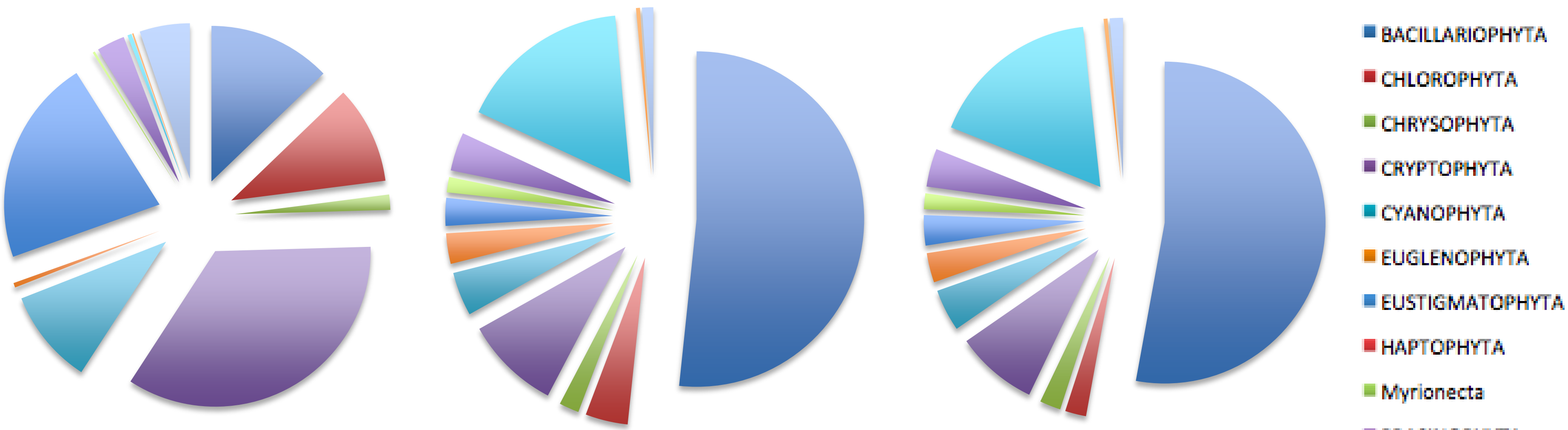


Haptophytes removed
Red shading = 2 SD from the mean

Cell Number as a Proxy: Can be grouped into 3 categories



Using the criteria developed from 1-4, test a subset of the data using the various criteria to determine how often SF Bay would be flagged as "impaired" using different scenarios



DEFAULT (>1E6 cells)

Basin	Percent
Suisun	8.97
San Pablo	11.26
Central Bay	6.14
South Bay	15.47

13% of stations “impaired”
~50% of “impaired” stations are < 10 µg CHL

90th Percentile Cell Count

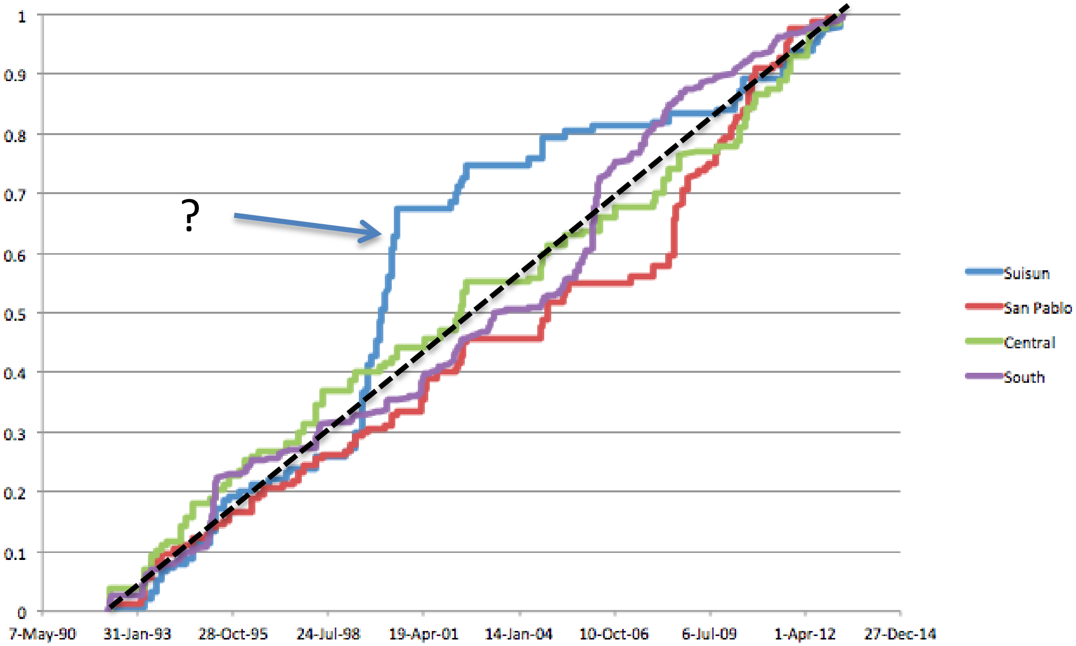
Basin	Percent
Suisun	4.58
San Pablo	4.68
Central Bay	6.30
South Bay	12.61

9.7% of stations “impaired”
~50% of “impaired” stations are < 10 µg CHL

90th Percentile Biovolume

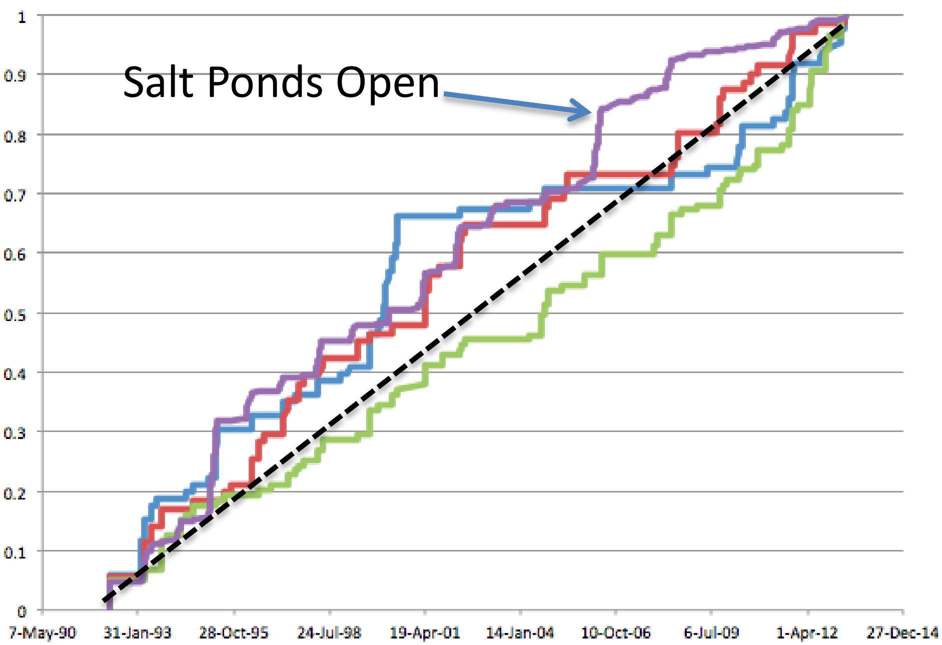
Basin	Percent
Suisun	4.57
San Pablo	4.66
Central Bay	5.43
South Bay	11.78

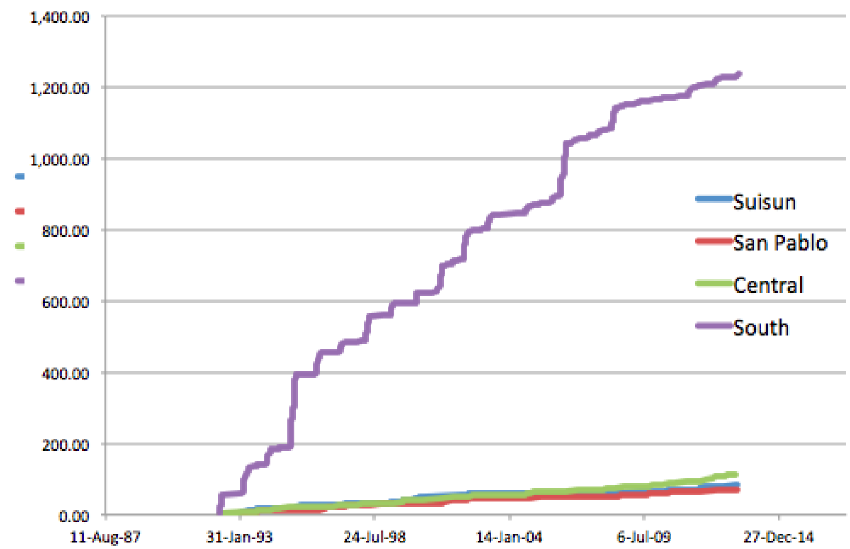
9.4% of stations “impaired”
~50% of “impaired” stations are < 10 µg CHL



Cell Count (>1E6)

Biovolume (90th Percentile)





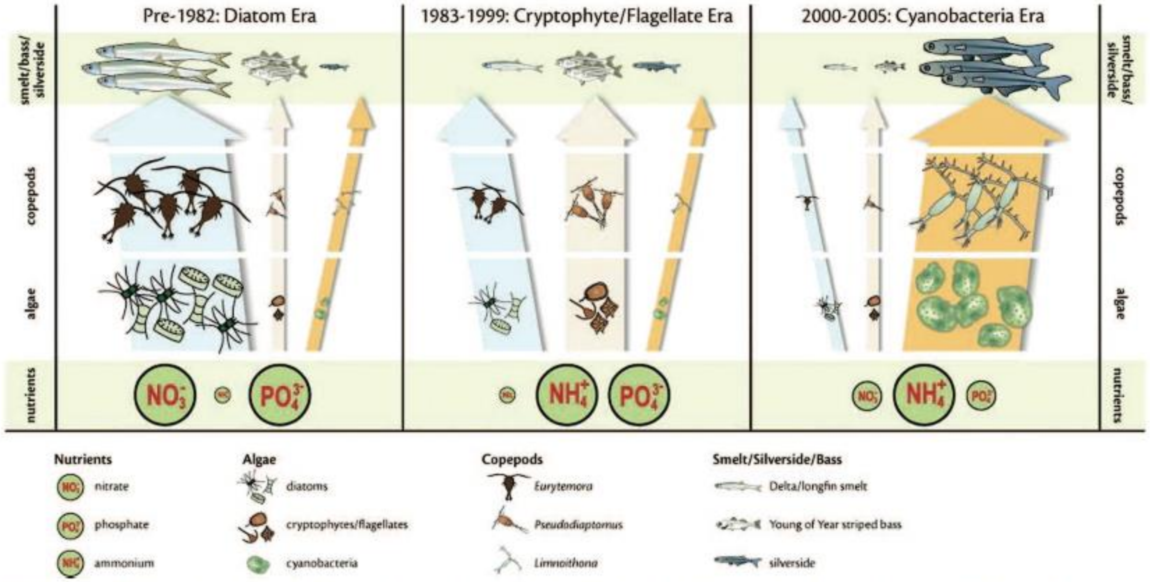


Figure 23 Conceptual diagram of some of the hypothesized changes in the food chain from phytoplankton to fish that have occurred in the Sacramento-San Joaquin Estuary over the past 30 years. Each of these hypothesized food chains has different dominant nitrogen forms or amounts relative to phosphorus. This conceptual model is intended simply to highlight some of the major flows of energy and materials and does not include all organisms, pathways or flows. The size of the symbols is meant to infer relative importance.

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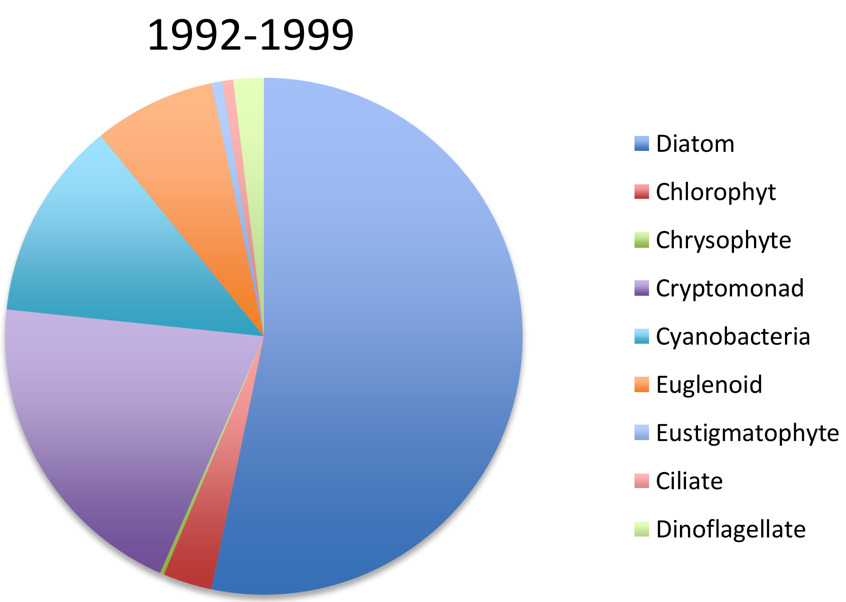
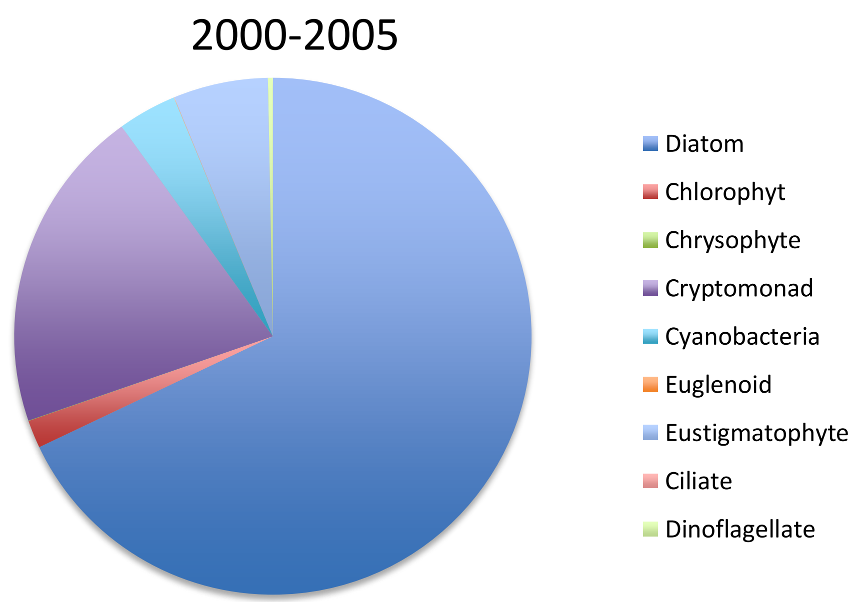
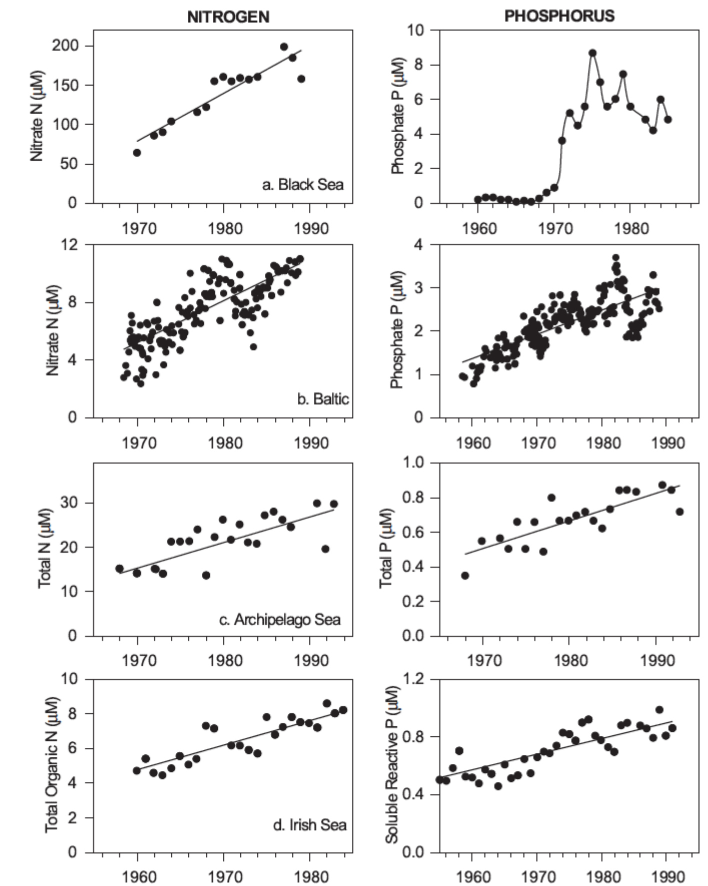
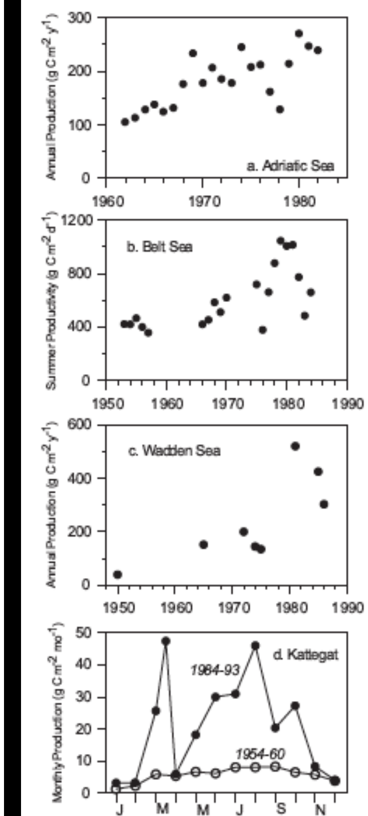
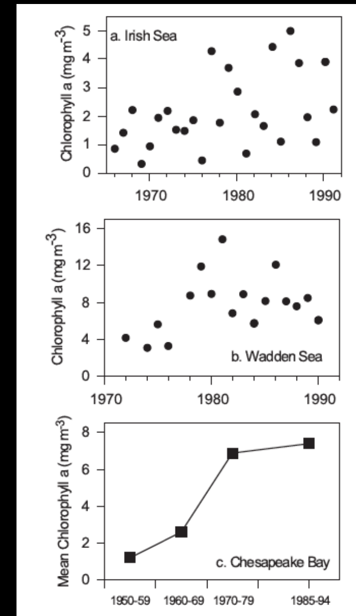
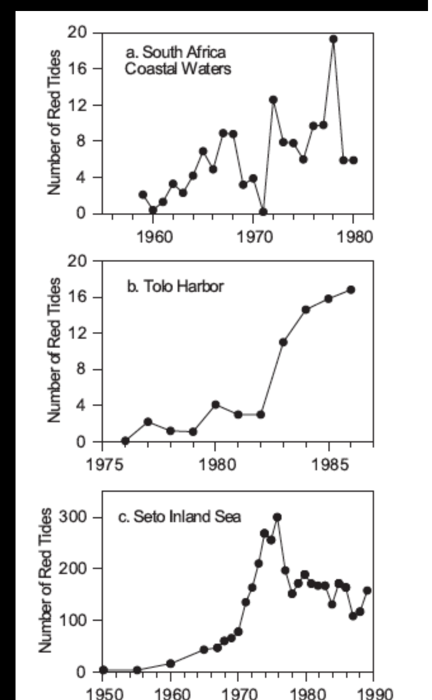


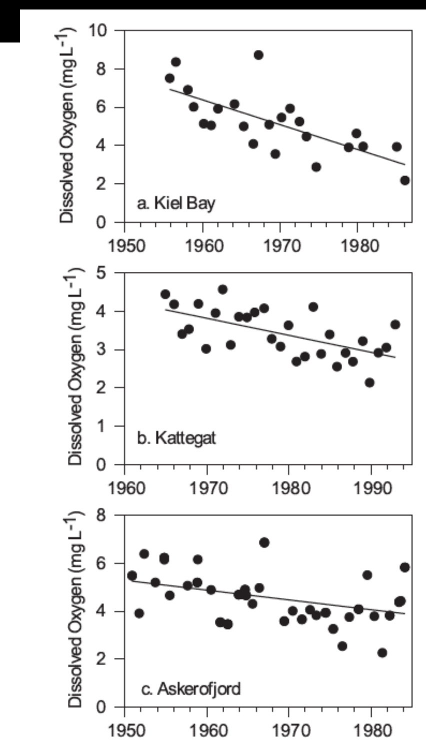




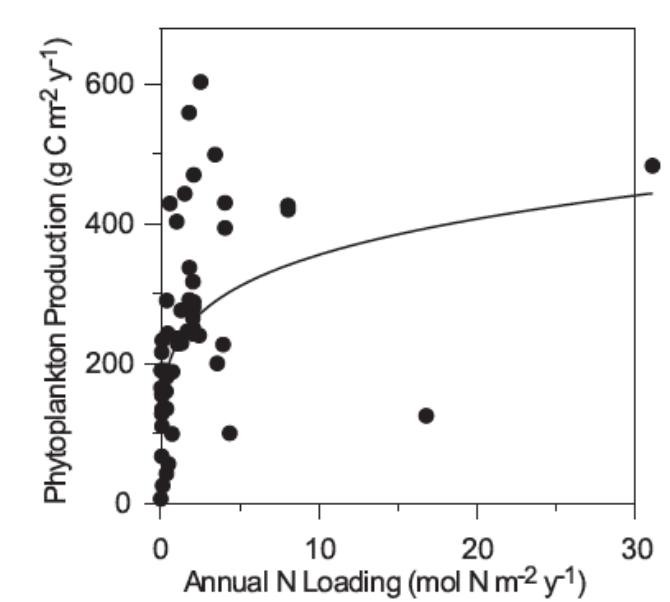






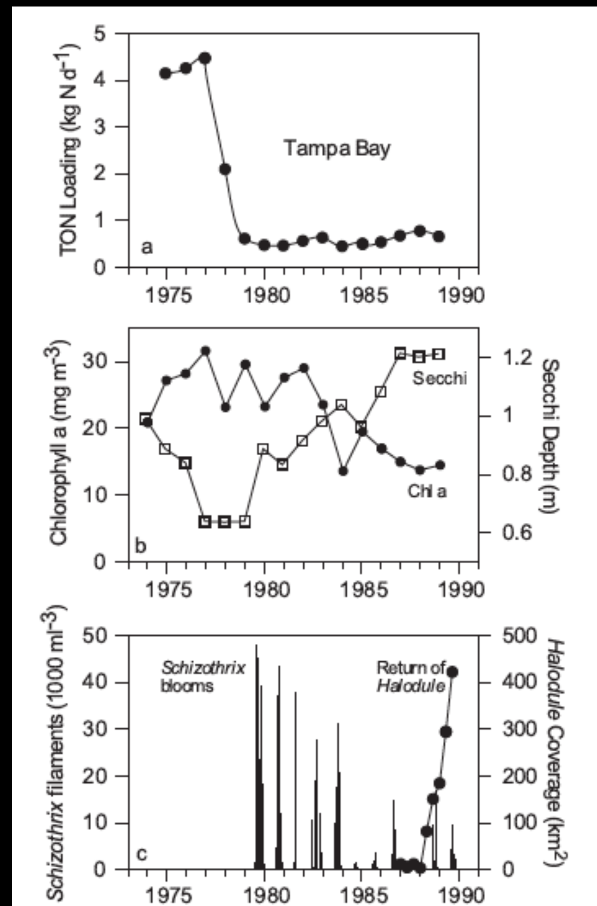


lots of info about trends of increasing nutrients, chla, production, HABs and decreasing DO

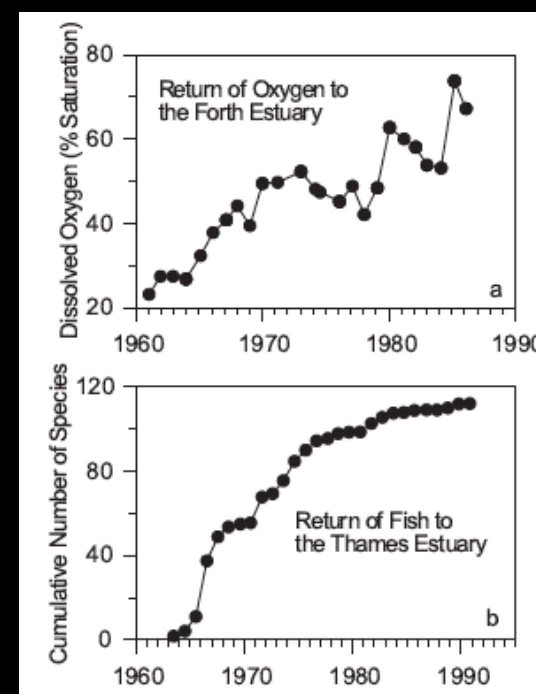


but no universal relationship between nutrients and primary prod

a trajectory: classical example Tampa Bay



oxygen return
fish return



Pacific Science (1981), vol. 35, no. 4

Kaneohe Bay Sewage Diversion Experiment: Perspectives on Ecosystem Responses to Nutritional Perturbation[1]

Stephen V. Smith,[2] William J. Kimmerer,[2] Edward A. Laws,[2]
Richard E. Brock,[2] and Ted W. Walsh[2]

terrific example of how
a coastal system responded
to reduced nutrient inputs
from sewage

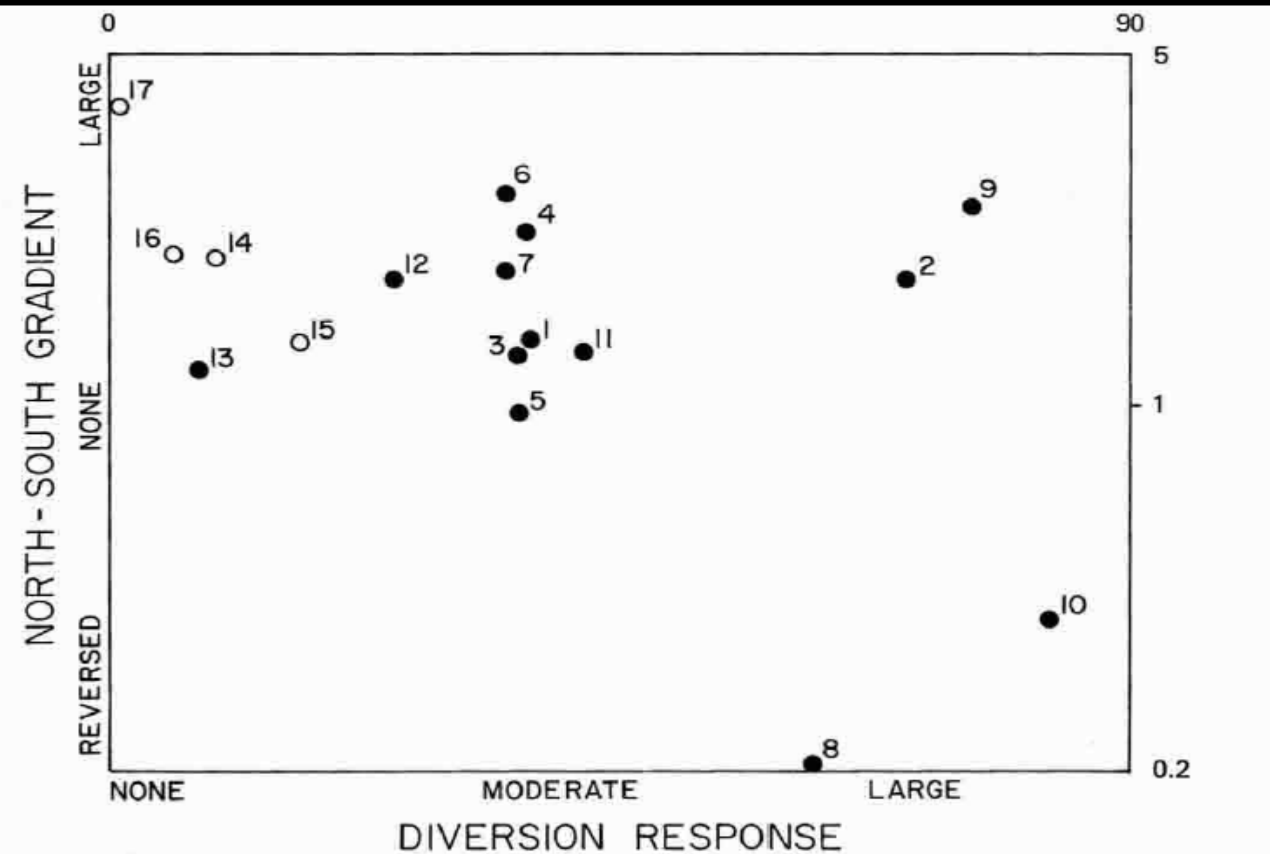


Figure 49. Summary of responses of selected variables to sewage diversion and to the north-south spatial radient. Solid circles represent variables for which the responses can be quantified (scales at top and right), while pen circles represent qualitative variables. See Table 51 for identification of the variables, the values, and sources f information.

Connecting the Dots: Responses of Coastal Ecosystems to Changing Nutrient Concentrations

Jacob Carstensen,[*,†] María Sánchez-Camacho,[†] Carlos M. Duarte,[‡,§] Dorte Krause-Jensen,[†] and Núria Marbà[‡]

trajectories of change in eutrophication and oligotrophication phases

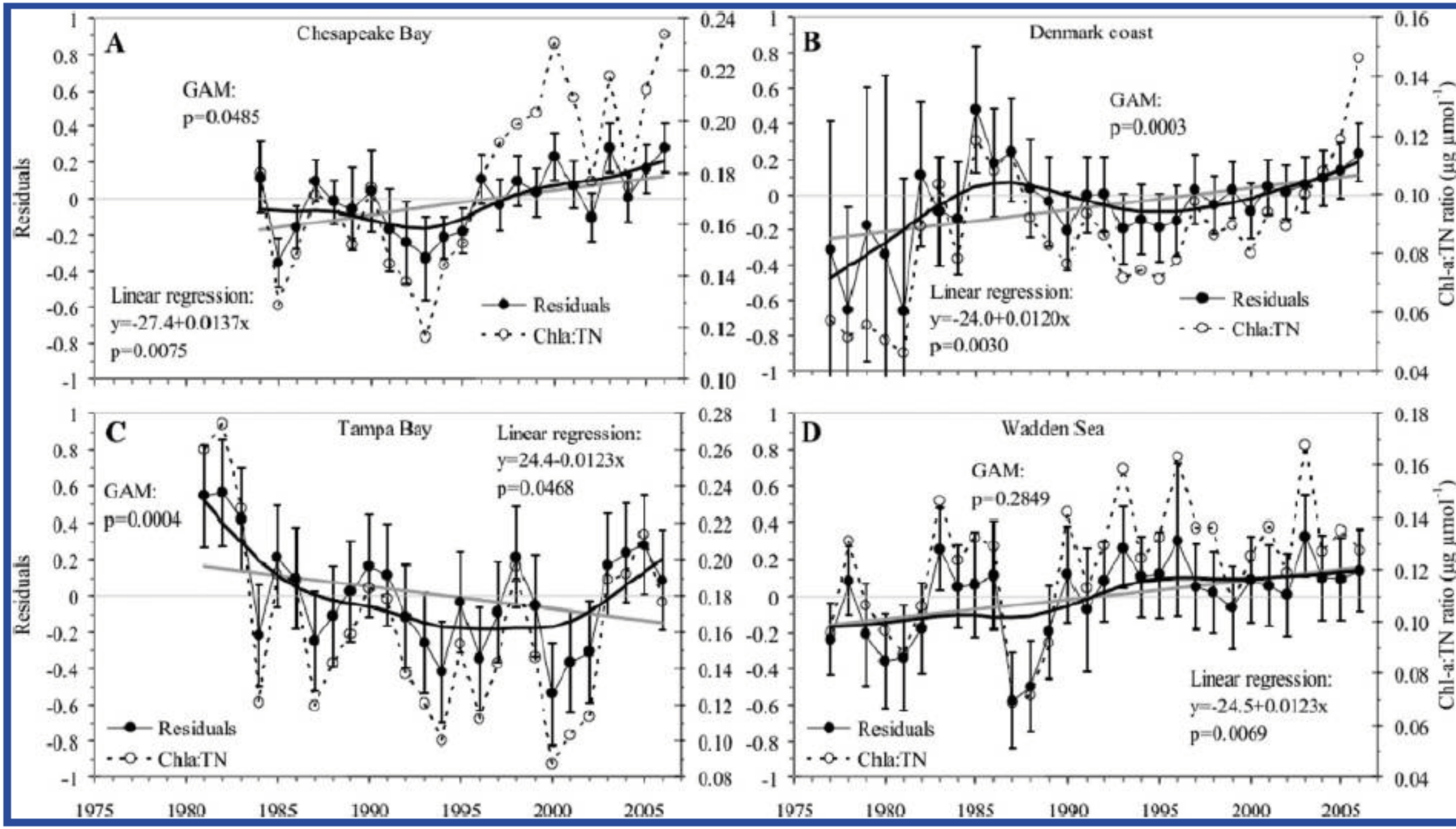
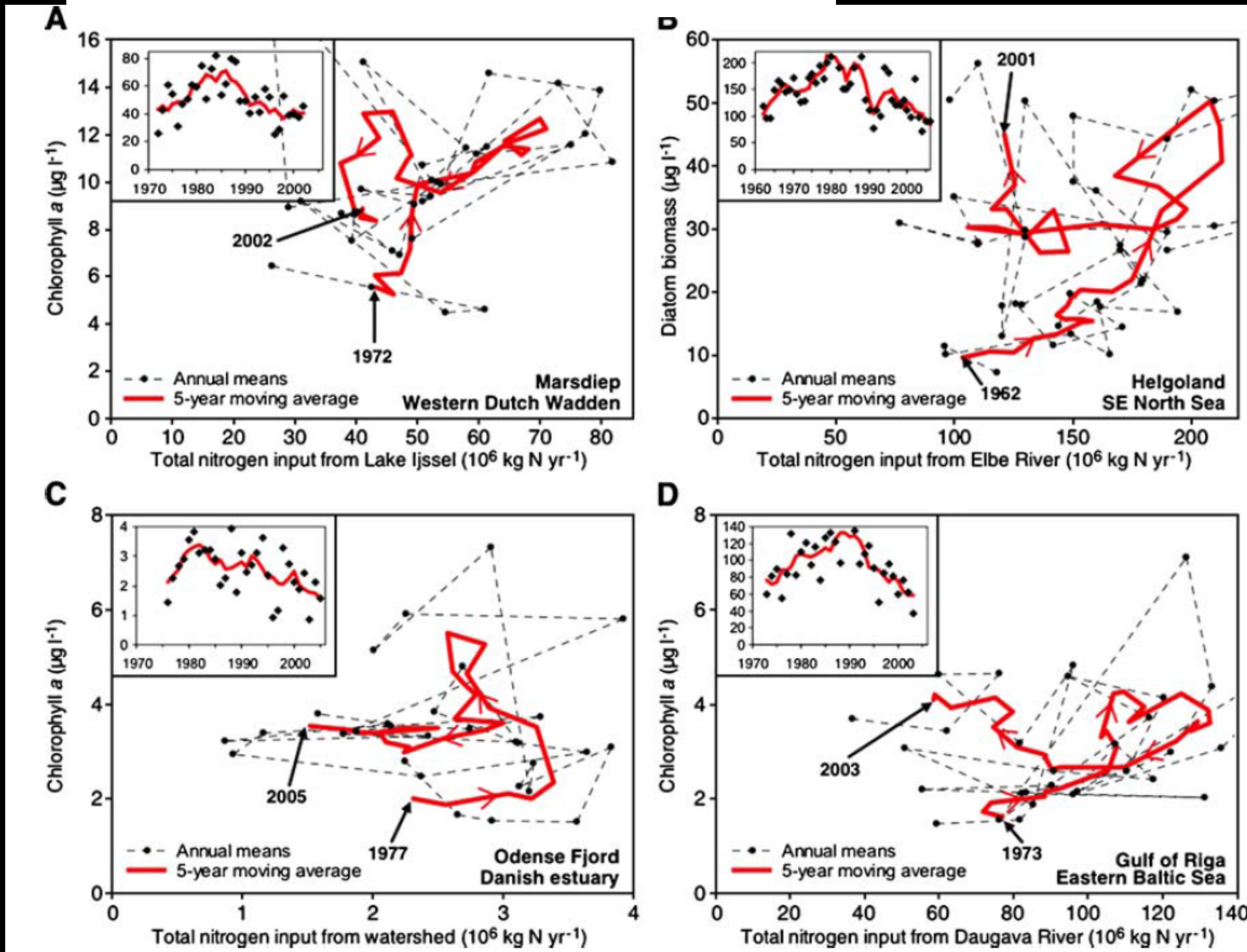


Figure 5. Trends in residuals (annual means with 95% confidence interval of the mean value) from region-specific regressions (Figure 1C) between log(Chla) and log(TN) investigated by linear regression and a nonparametric GAM with statistics listed. For comparison the ratio between annual mean Chla and TN is also shown.

Return to *Neverland*: Shifting Baselines Affect Eutrophication Restoration Targets

Carlos M. Duarte · Daniel J. Conley ·
Jacob Carstensen · María Sánchez-Camacho

loading-response relationships change over time



we need to do scenarios of change

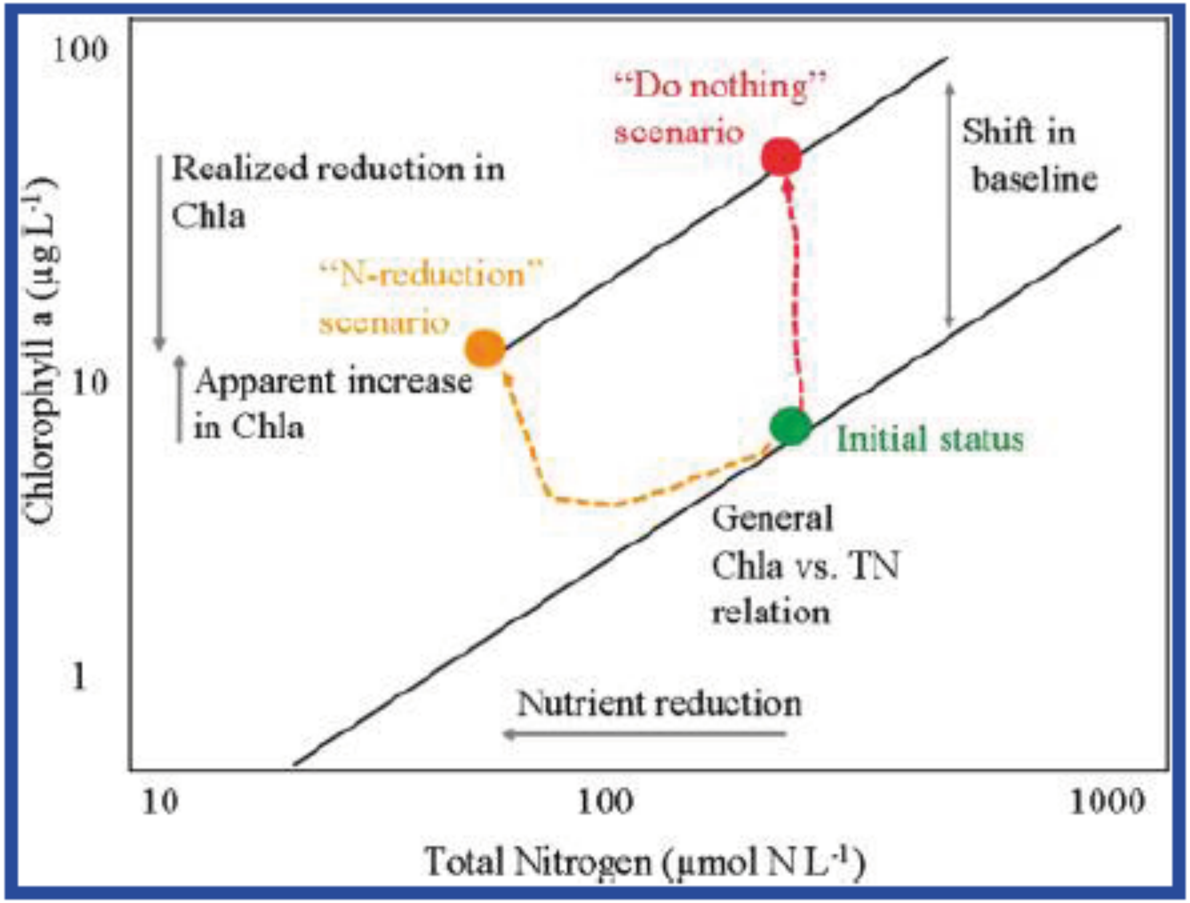
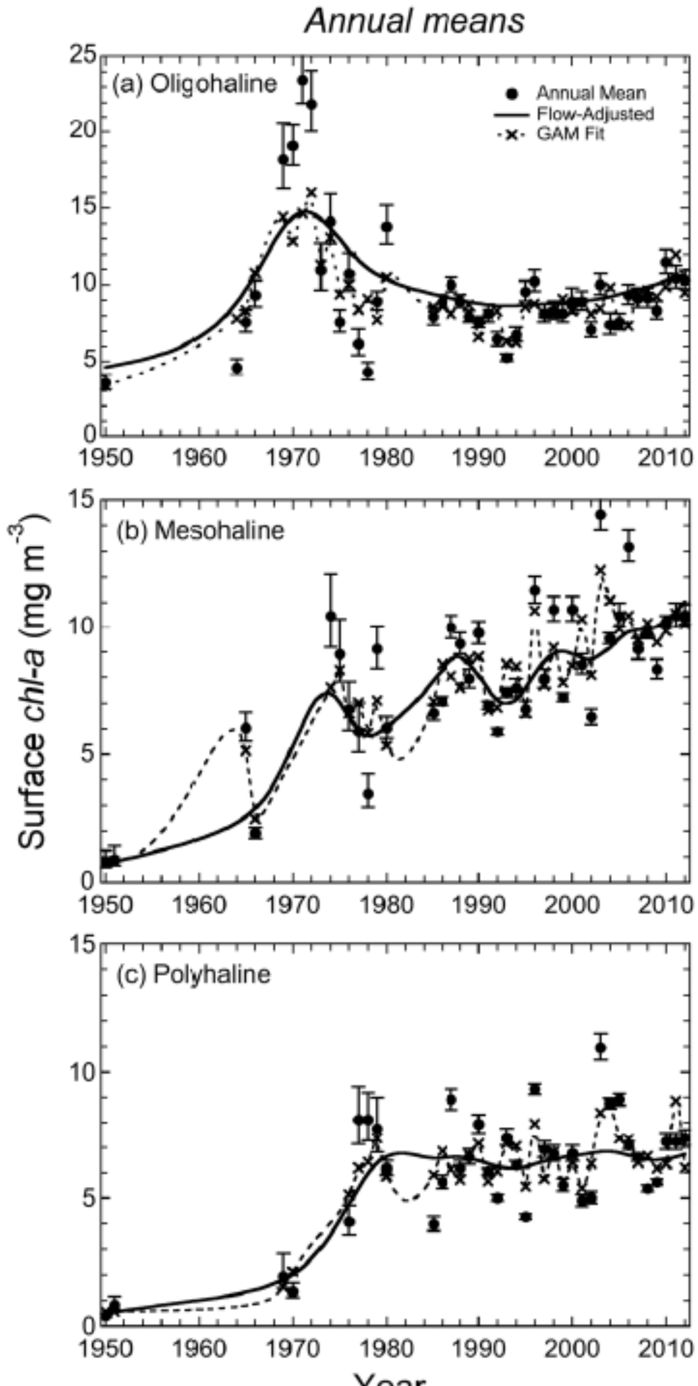


Figure 7. Conceptual model demonstrating the implications of shifts in the yield of Chlorophyll a per unit total nitrogen in coastal ecosystems for the evaluation of the outcome of managerial actions to reduce nitrogen concentrations. The possible outcomes of two alternative strategies, "do nothing" and "nutrient reduction", are shown.



g. 11

just in from Larry
Chesapeake Bay trajectories