Has phytoplankton community composition "shifted" in Suisun Bay: 1975-2007

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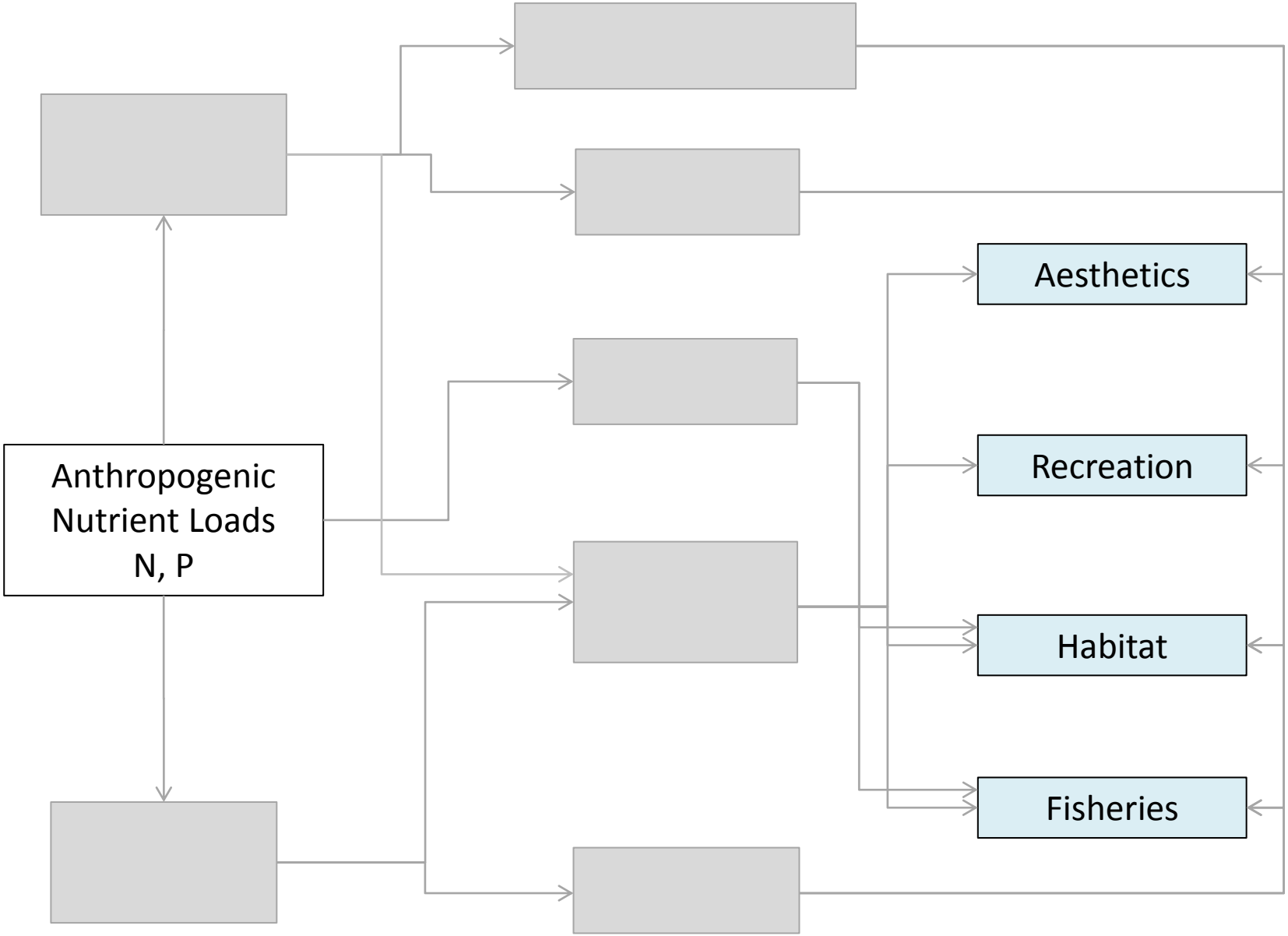
Potential Adverse Impact "Pathways" for Nutrients in SFB



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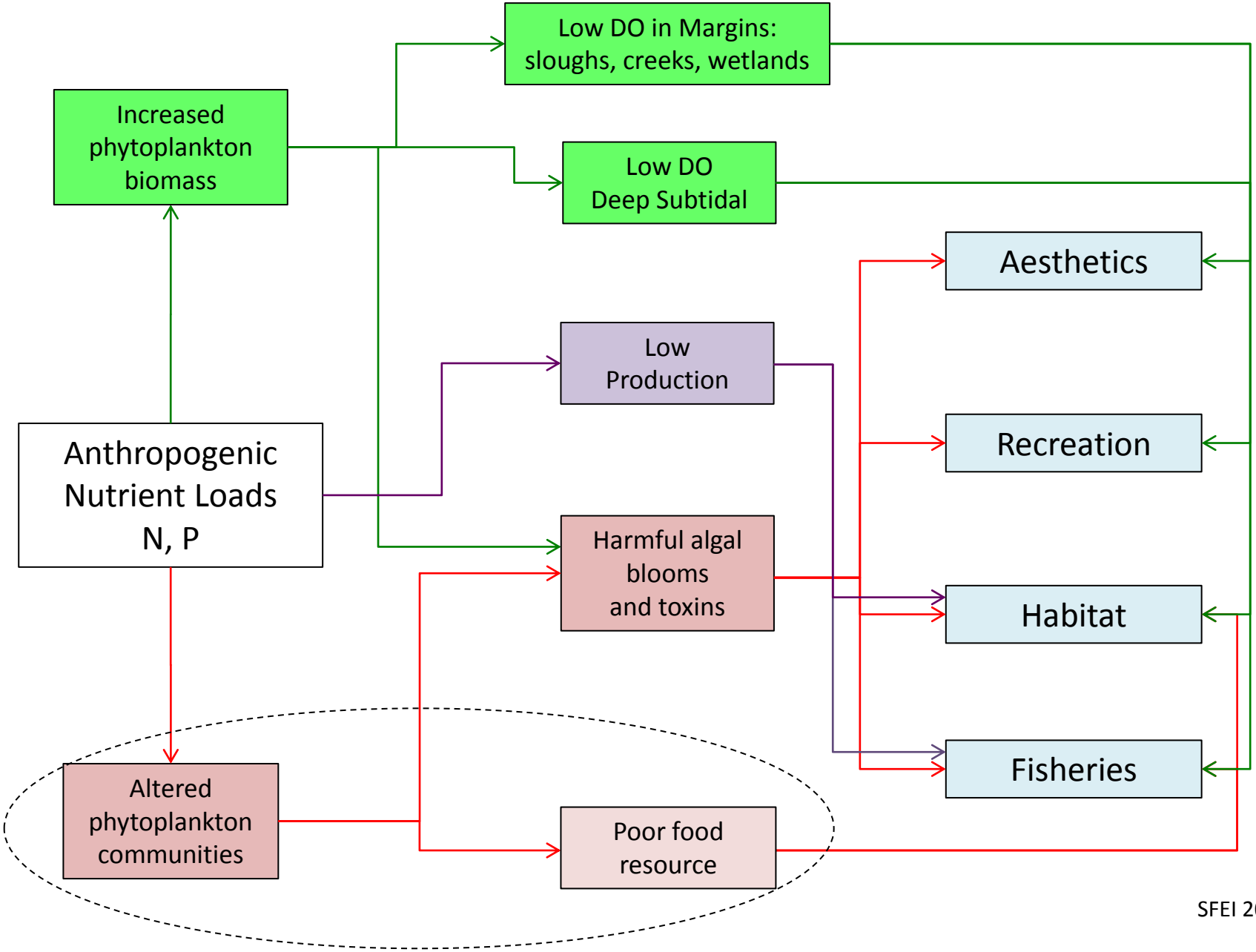
Potential Adverse Impact "Pathways" for Nutrients in SFB



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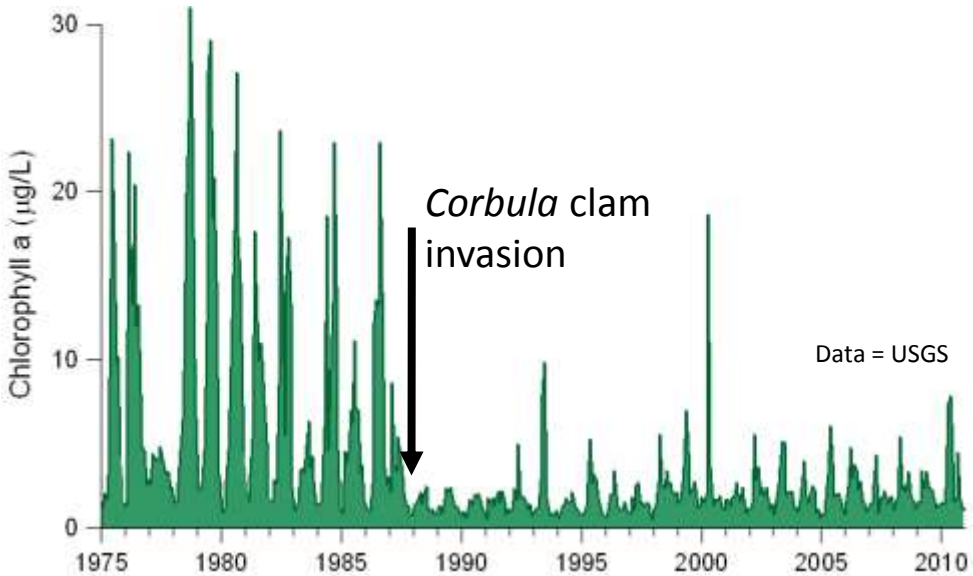
Phytoplankton in Suisun Bay

Drivers/stressors: Biomass

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

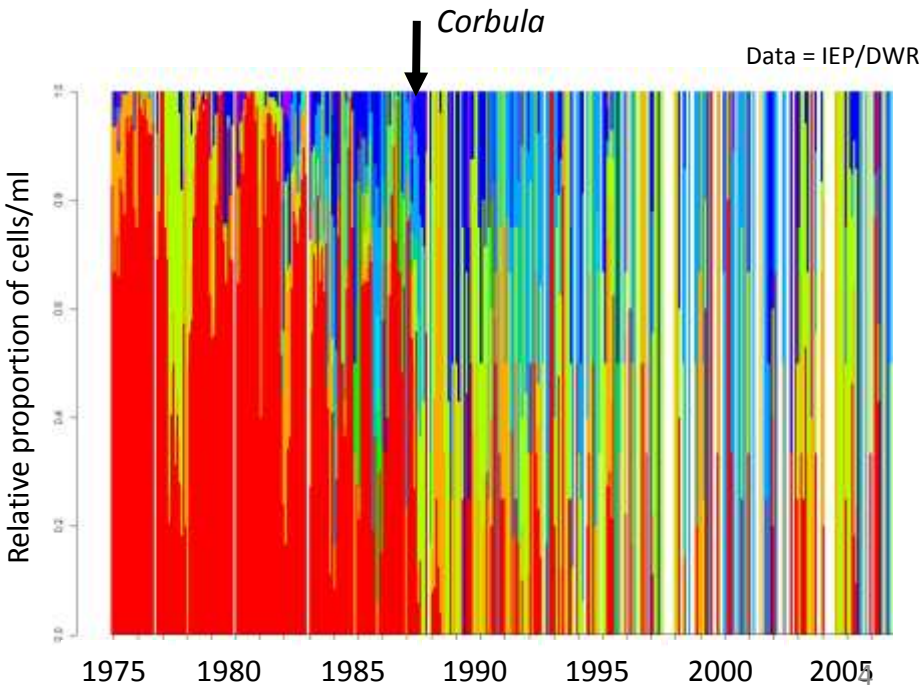
* e.g., Dugdale et al. 2007; Parker et al. 2012; Dugdale et al., 2012



Drivers/stressors: Composition

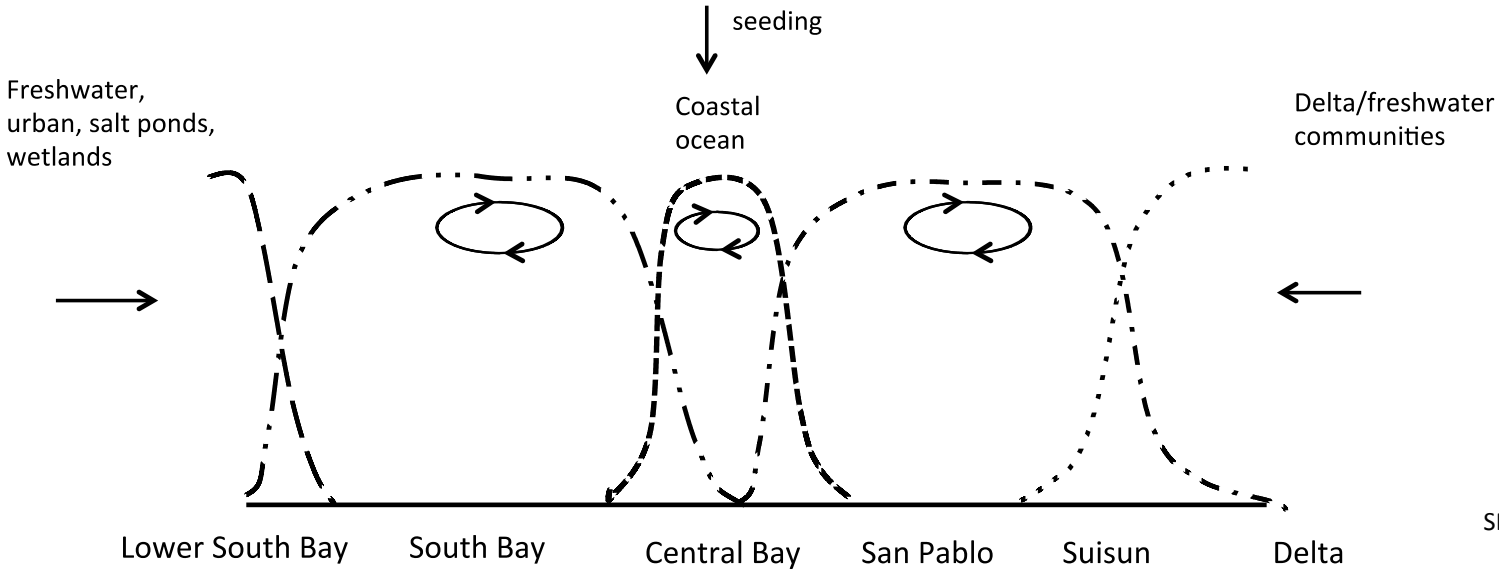
- Flows, clams, light
- Nutrients: N:P, NH_4^+ **

** e.g., Glibert 2010; Glibert et al. 2011



What shapes phytoplankton community composition?

Are nutrients adversely impacting phytoplankton composition in SFB?



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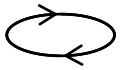
Internal processes



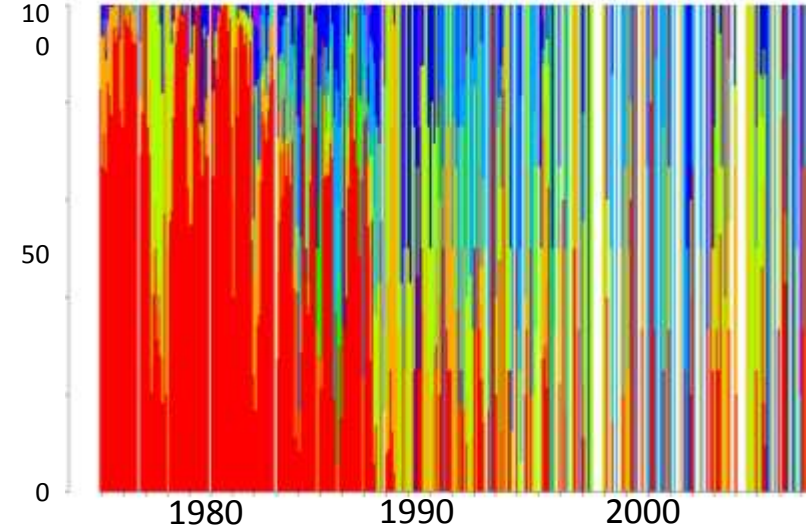
- Light
- Temperature
- Mixing
- Residence time
- Grazing
- Nutrients

Hypothesized Nutrient Effects

		↓ Diatoms	*,**
↑ N:P		↑ Flagellates	*,**
↑ NH_4^+		↑ Cryptophytes	*
		↑ Green algae	*

*Glibert 2010; **Glibert et al., 2011

D7

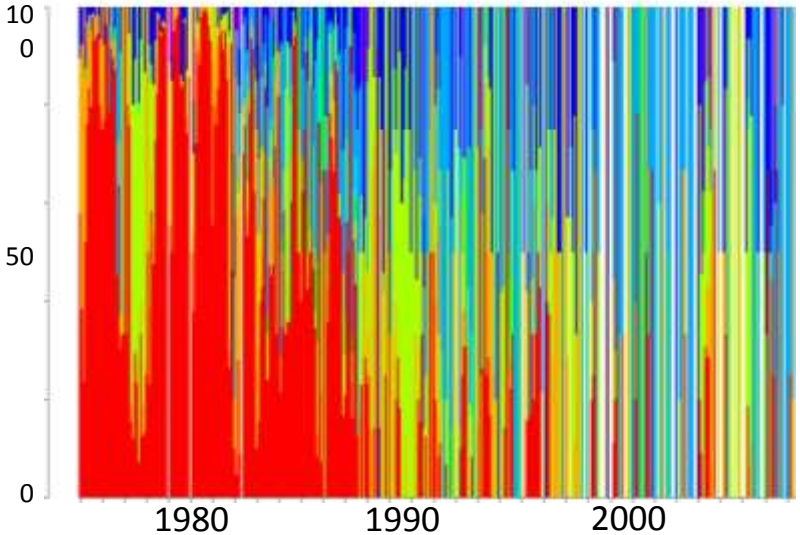


Data = IEP/DWR

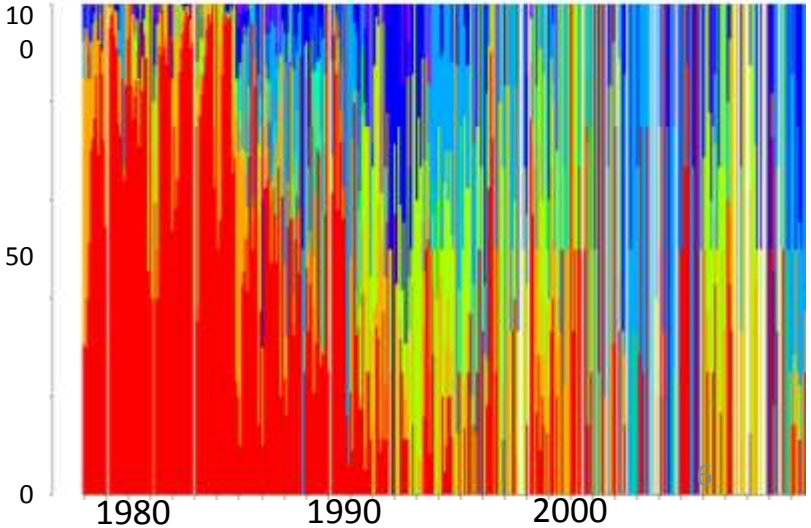
Cyanobacteria
Green Algae
Other Flagellates
Euglenoids
Dinoflagellates
Cryptomonads
Pennate Diatoms
Centric Diatoms

Monthly phytoplankton composition
(%total of cells/mL)

D8

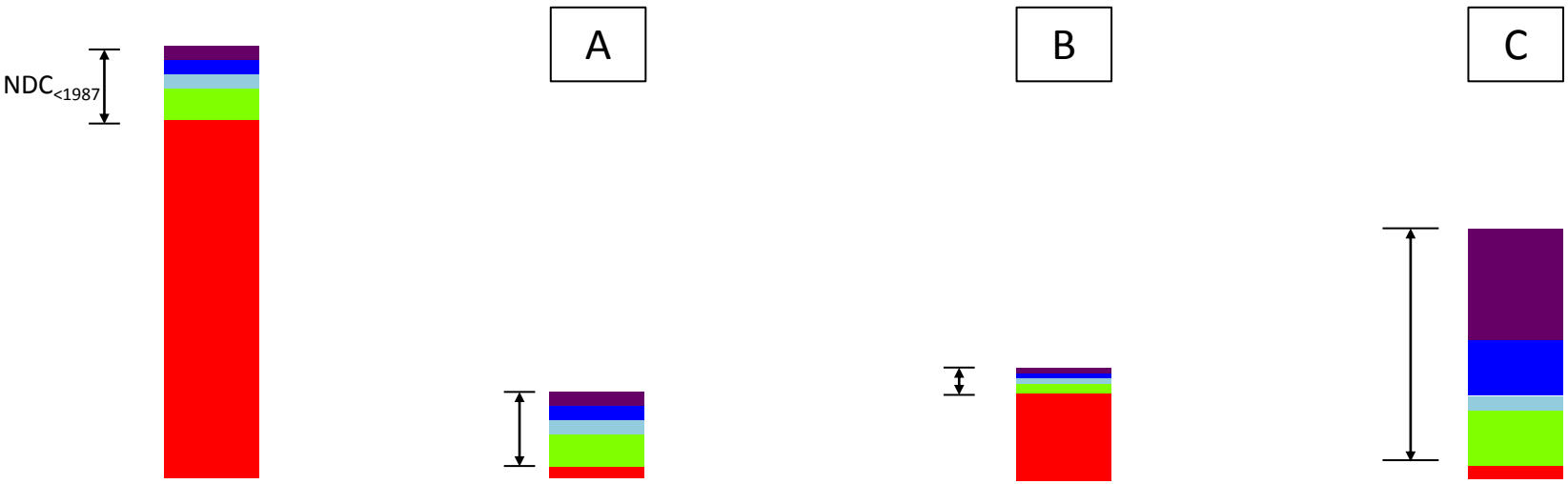


D4



- Did a phytoplankton community composition shift occur?
- Co-occur with varying physical/chemical drivers (space, time)?
- Identify protective nutrient levels?

NDC = Non-diatom composition



Biovolume (μm^3/mL)
or
Density (cells/mL)

- Near-complete loss of diatoms
- $NDC_{<1987}$ ~ $NDC_{>1987}$

- Proportional loss of all classes

- Near-complete loss of diatoms
- Substantial NDC change

- Did a phytoplankton community composition shift occur?
- Co-occur with varying physical/chemical drivers (space, time)?
- Identify protective nutrient levels?

<u>Approach:</u>

- DWR-EMP Phytoplankton community composition data: 1975-2007

- Aggregated to class level
  - Same approach/groupings as past investigations

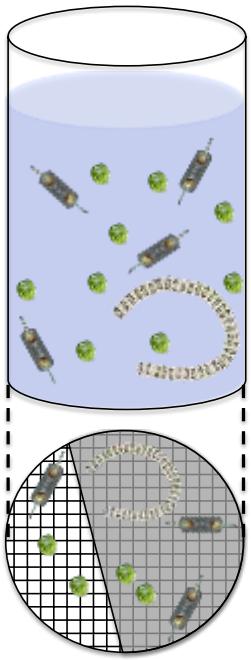
- Explored data with a range of multivariate statistical approaches

Clues of some data quality issue…D7, 1987-2007 (n=227)

1. Multiple instances when the community was ….
   - Entirely diatoms 15%
   - Entirely flagellates 10%
   - Entirely cryptophytes 12%

2. Frequent non-detects for entire classes
   - No diatoms 41%
   - No flagellates 57%
   - No cryptophytes 44%
   - No green algae 74%

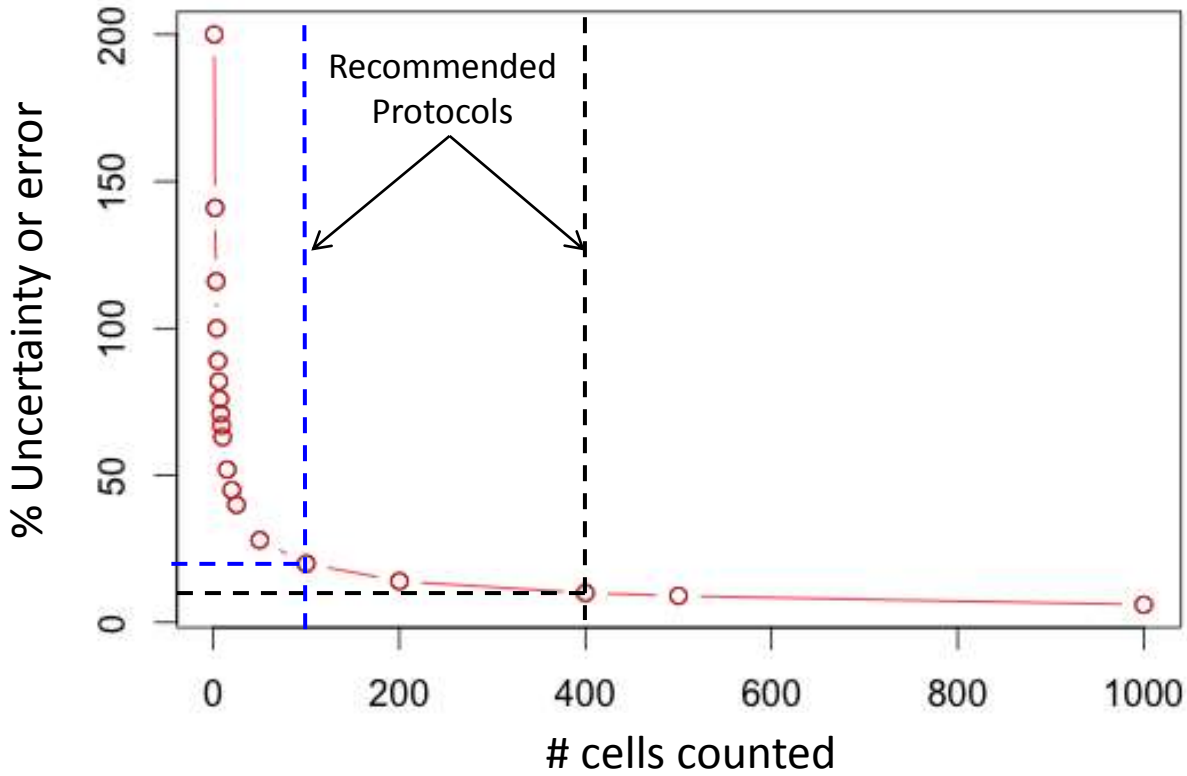
$$\text{Estimated Density } (\#\, cells/ml) = \frac{\#\, cell\ counted}{\%area\ counted \times volume\ analyzed}$$



Volume analyzed (ml)

settling

%Area counted

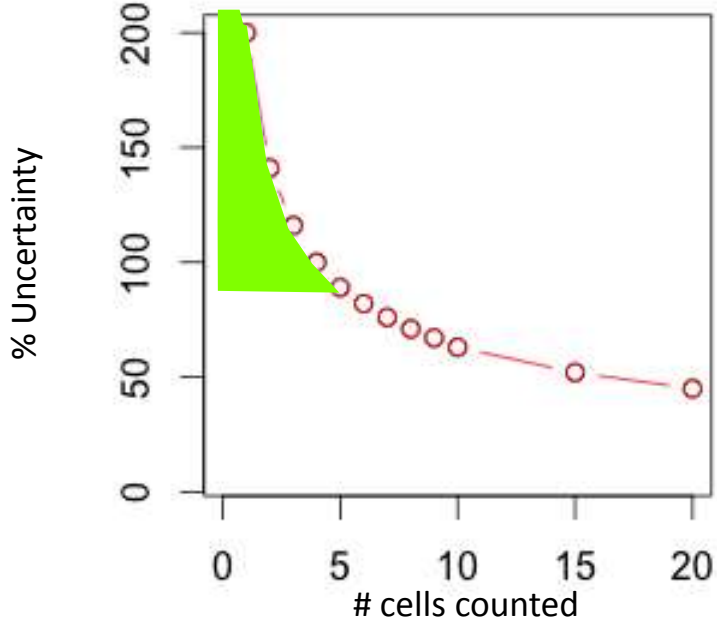


1975-2007: "modified" standard method…

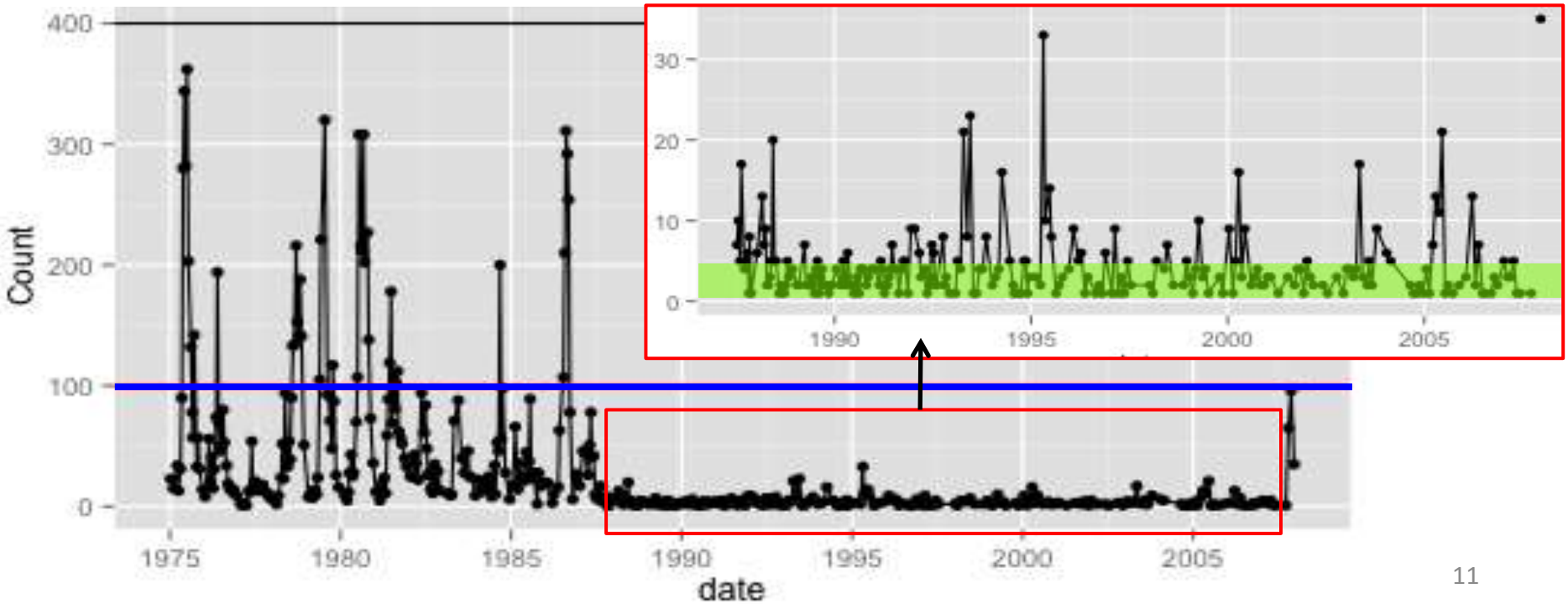
- Count ~20 microscope fields
- Not related to minimum number of cells

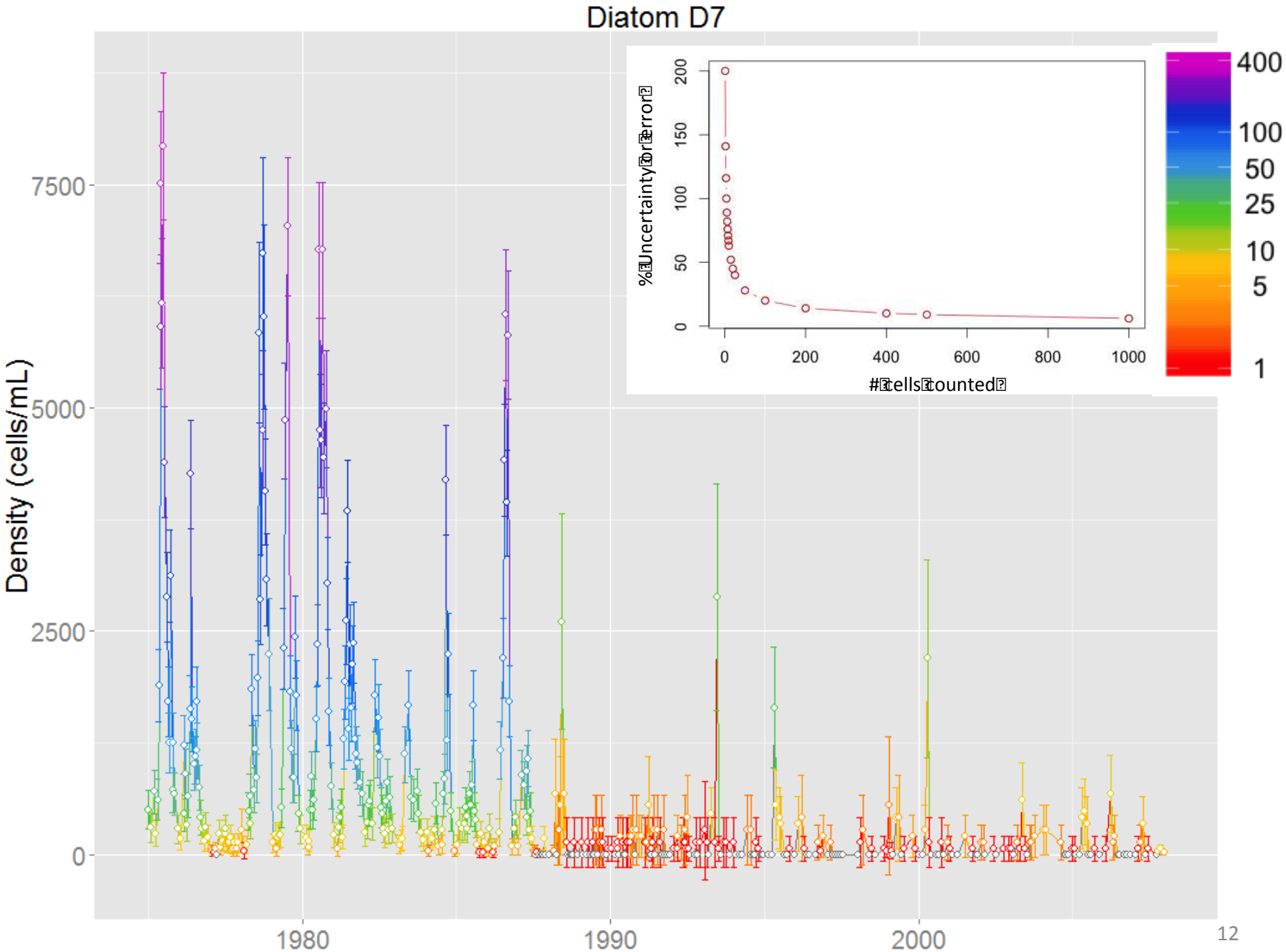
- Problems identified: 2001. Method changed: 2007

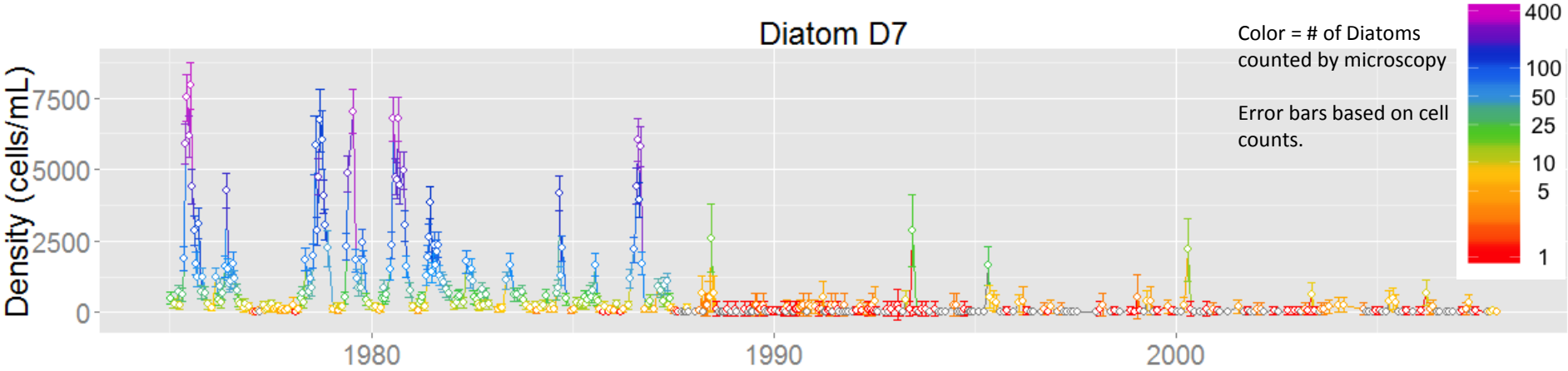
- General thinking has been…pre-2007 data are 'good at the functional group level'

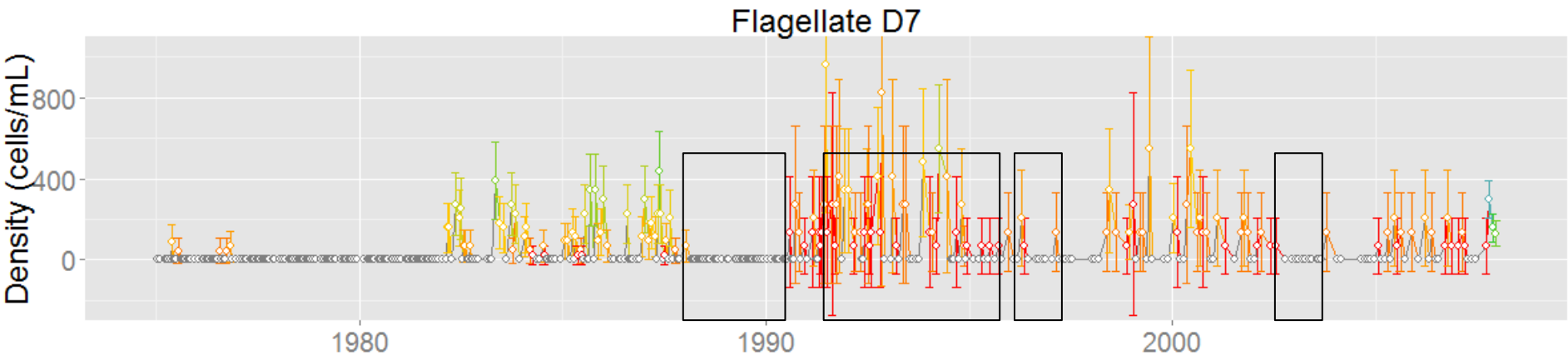


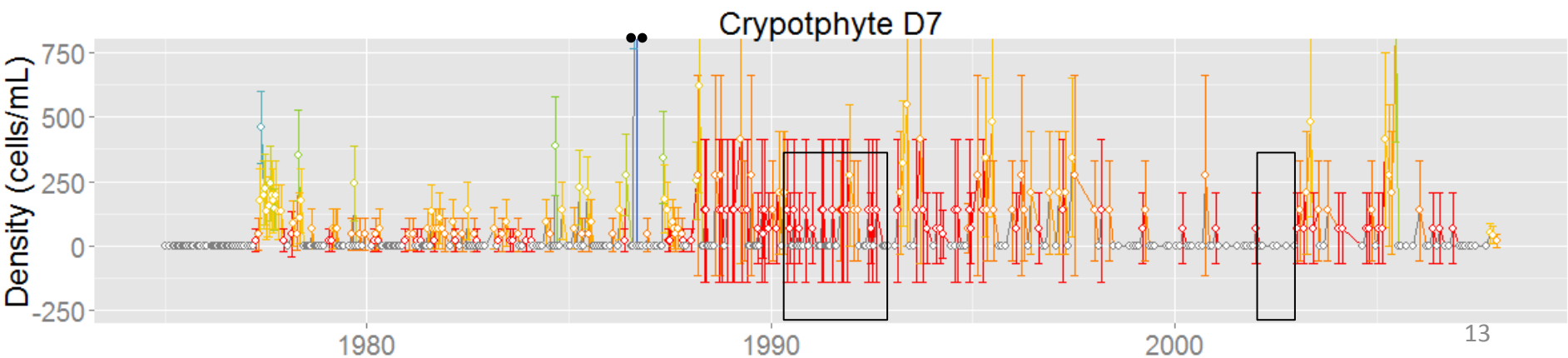
D7: # of cells counted




Diatom D7
Density (cells/mL)
7500
5000
2500
0
1980
1990
2000
% Uncertainty for error
0
50
100
150
200
0
200
400
600
800
1000
cells counted
400
100
50
25
10
5
1

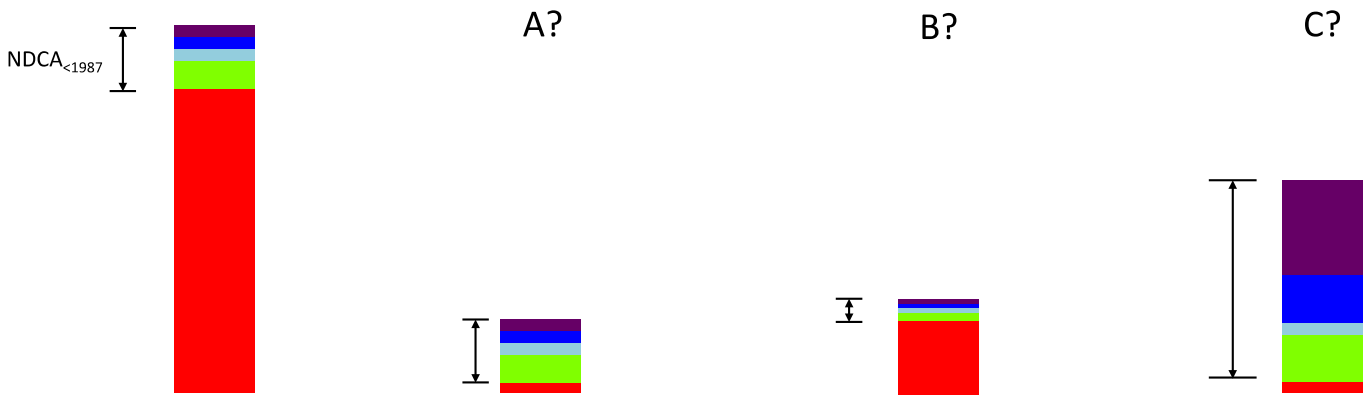

Diatom D7
Color = # of Diatoms counted by microscopy
Error bars based on cell counts.
400
100
50
25
10
5
1
Density (cells/mL)
7500
5000
2500
0
1980
1990
2000


Flagellate D7
Density (cells/mL)
800
400
0
1980
1990
2000


Crypotphyte D7
Density (cells/mL)
750
500
250
0
-250
1980
1990
2000

Did composition shift(s) occur? What "type"?

NDCA = Non-diatom composition or abundance



Biovolume (µm³/mL)
or
Density (cells/mL)

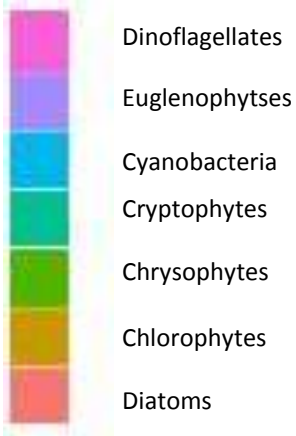
$NDCA_{<1987}$ ~ $NDCA_{>1987}$

- Near-complete loss of diatoms
- Similar NDCA

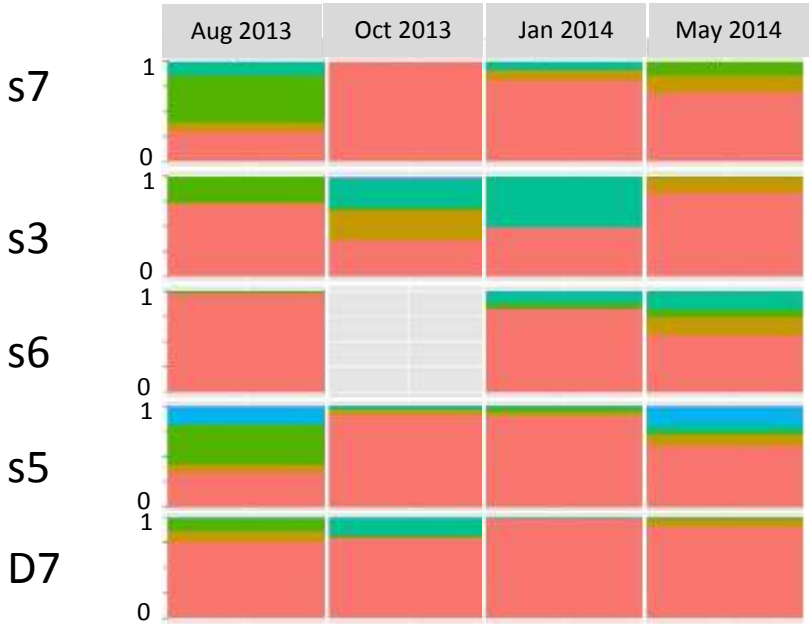
- Proportional loss of all classes

- Near-complete loss of diatoms
- Substantial NDCA change

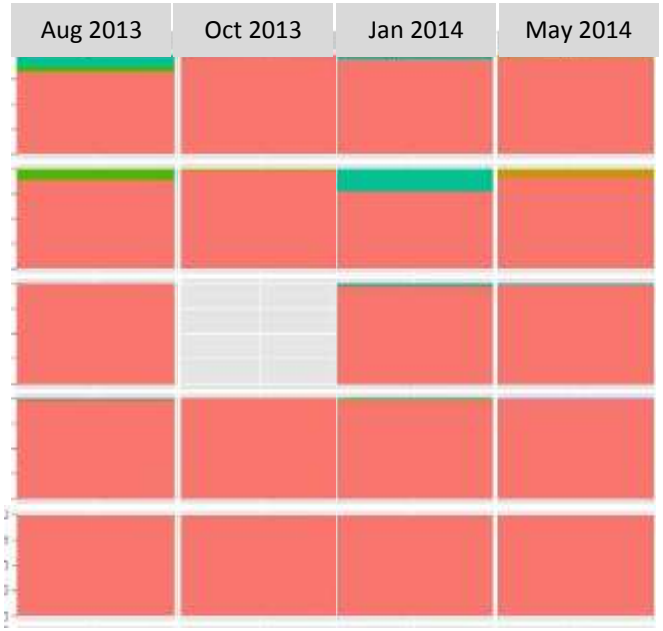
- Uncertainties in DWR-EMP data prior to 2007 are too great to differentiate between A, B, or C
- What changes could have been detected – had they occurred – given this counting methodology?.....*Work in progress*
- What do other observations tell us?



Relative densities (cells/mL)



Relative biovolume (µm³/mL)



Data: Berg and Kudela, pers. communication

Summary

- DWR-EMP phytoplankton assemblage data 1975-2007:
  - very large uncertainties at class level, especially 1987-2007.
  - <u>Method changed 2007</u>

- What trends can be detected from DWR-EMP data?
  - Diatoms:
    - Large uncertainties, but suggests abrupt diatom loss ≥ ~1987
  - Cryptophytes, flagellates, other minor species:
    - Low counts/high uncertainty…can't evaluate change
  - Can't readily distinguish between "shift" vs. diatom loss vs. all decreased
  - "what could have been detected, if it occurred?"…*work in progress*

- Mechanistic interpretations of nutrient-driven phytoplankton community "shifts" based on this data need to be reevaluated

What's next?

- Pigment based measurements and increased microscopy being carried out now (Bay Nutrient Strategy: USGS, UCSC, SFEI)

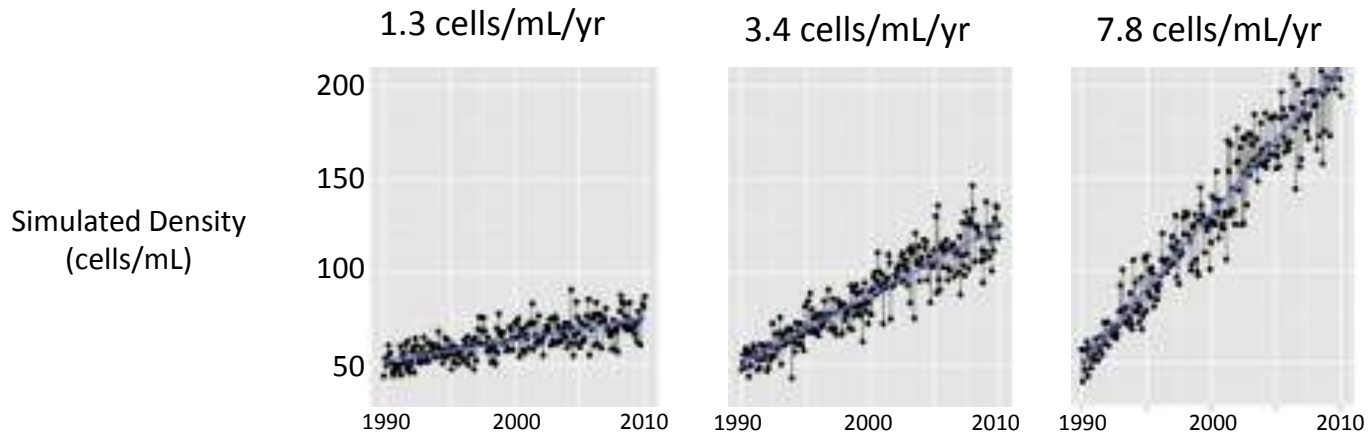
- Analysis of long-term USGS (and post 2007 DWR) data…
  - Assemblage = f(x,y,z) …*T, sal, climate oscillations, nutrients, seeding*

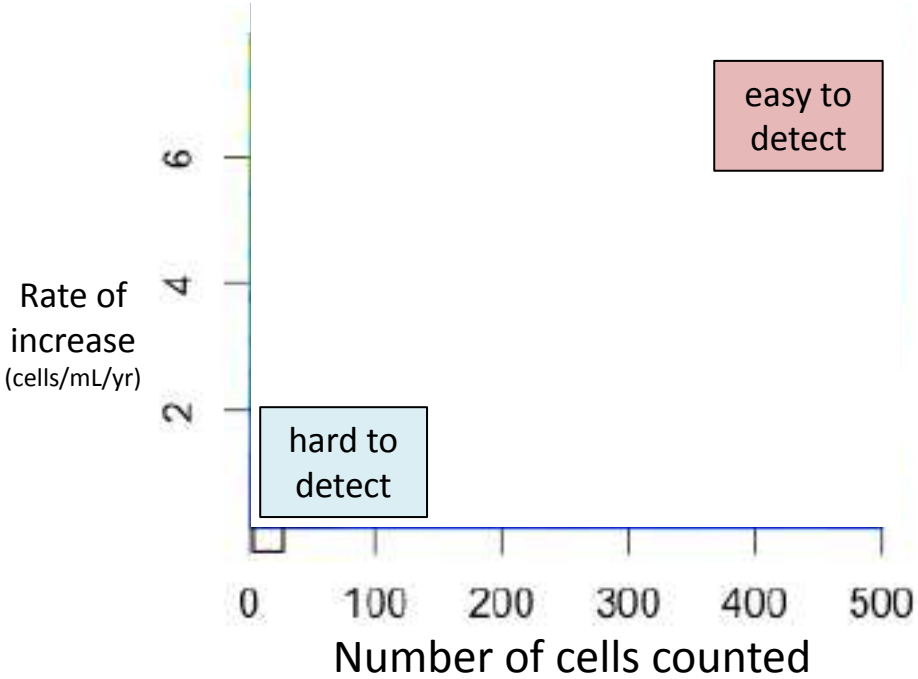
- Nutrient effects in the Bay-Delta:
  - Strongly differing conceptual models,
  - Strongly differing management implications

- Need for constructive dialogue among scientists…
  - Areas of agreement, Areas of disagreement
  - Studies targeting the most important areas of disagreement

What counting intensity is required to detect a change?

Simulated Densities: Flagellate increase





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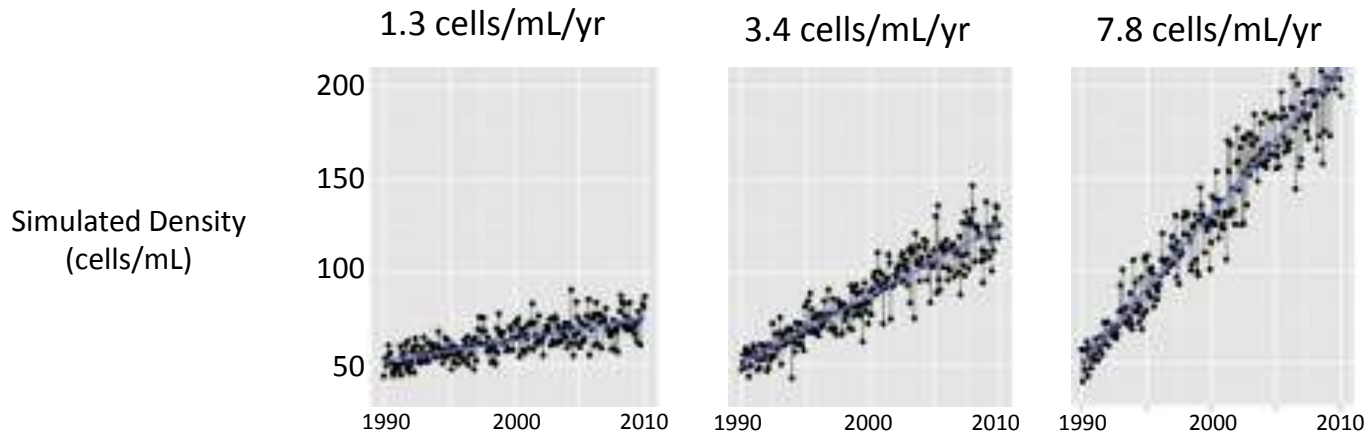

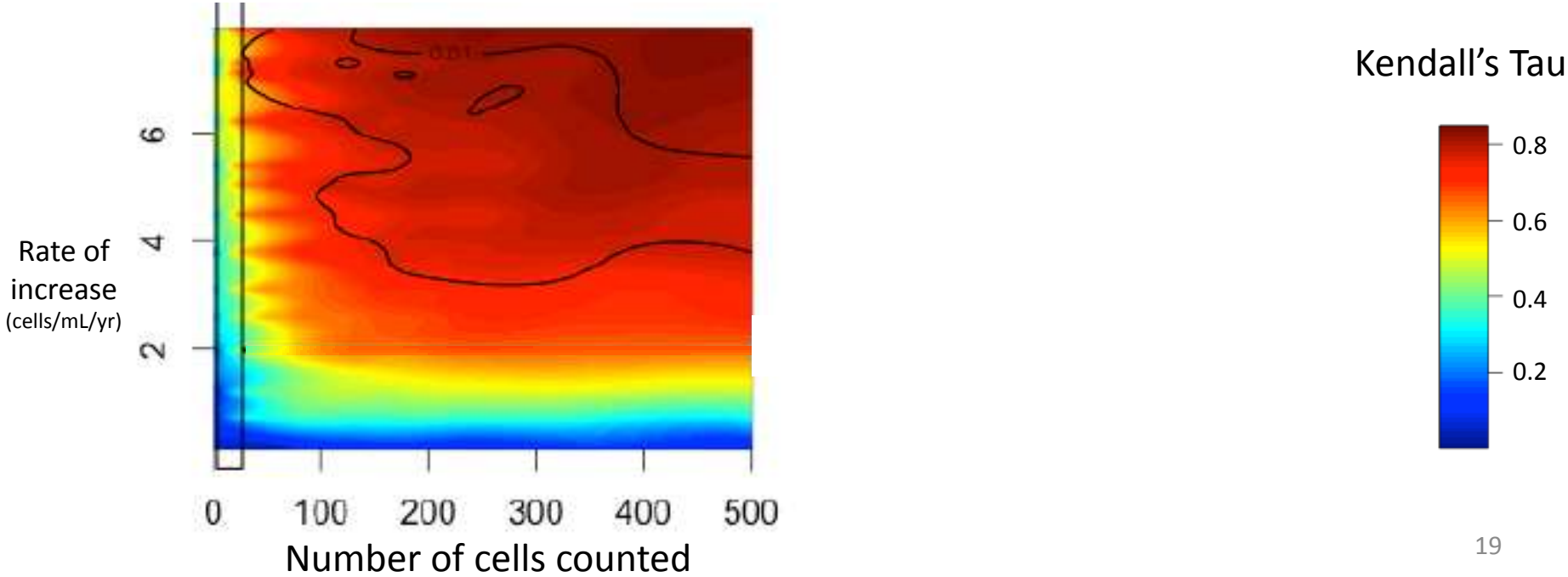

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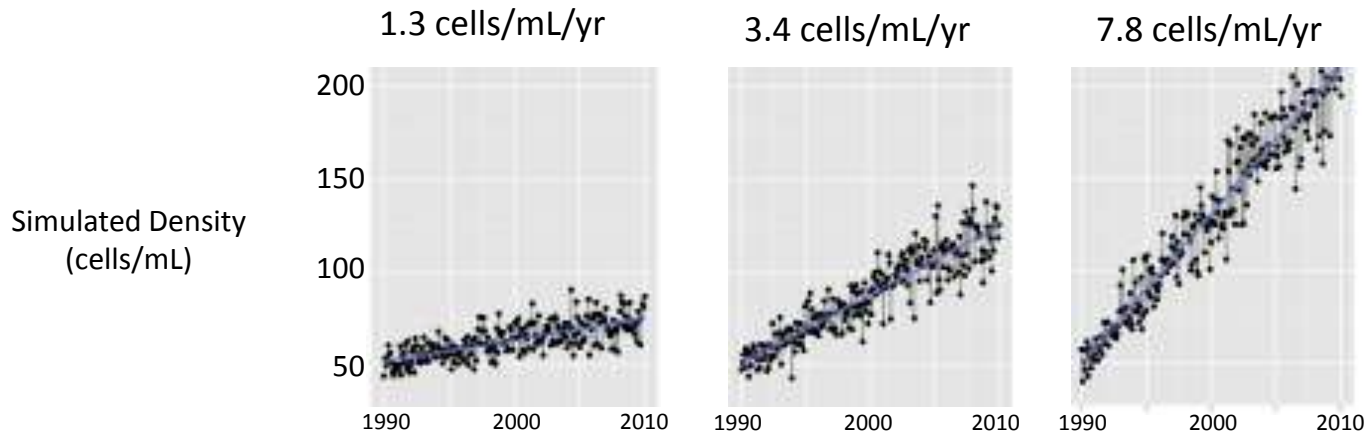

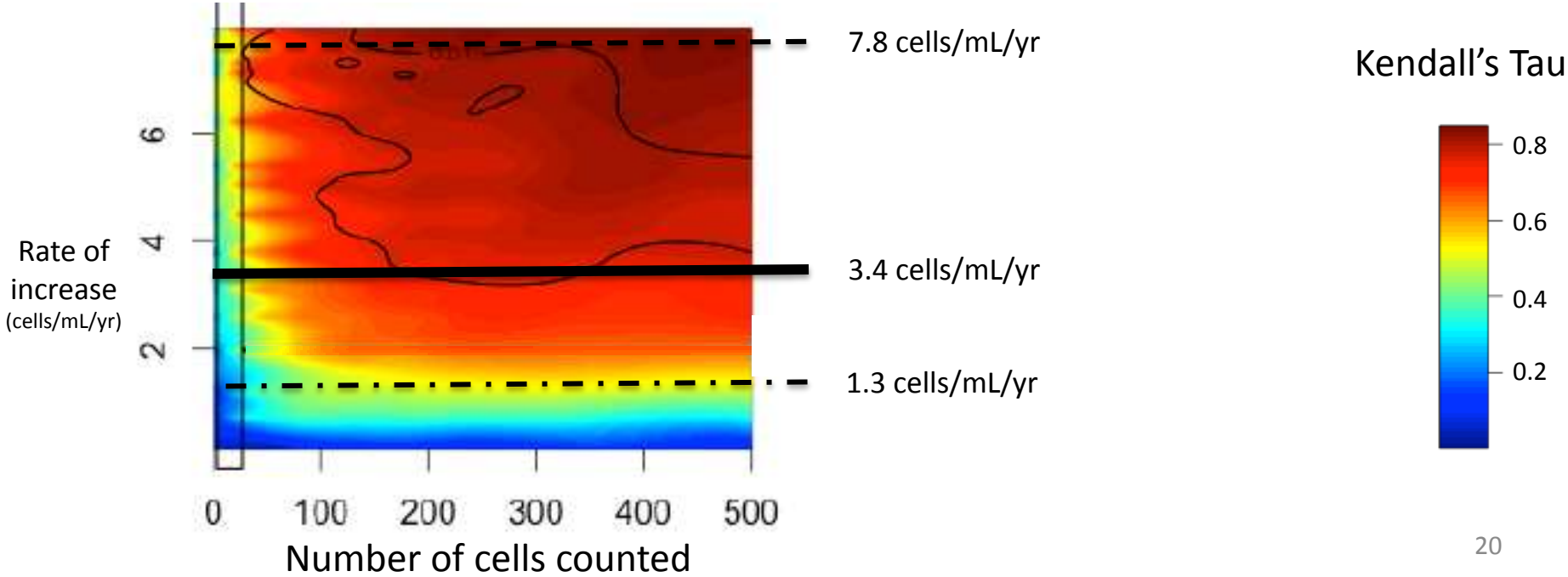

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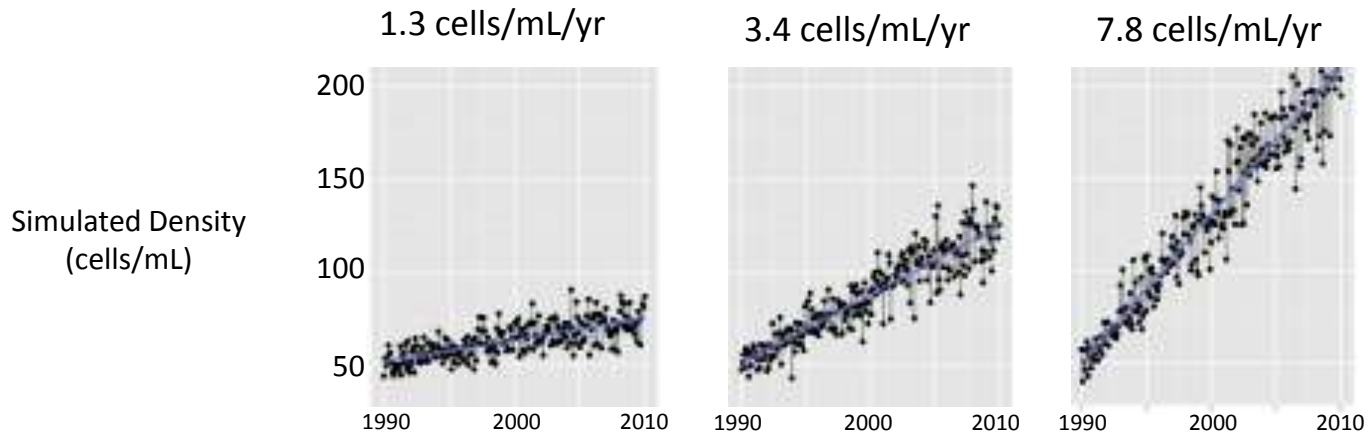
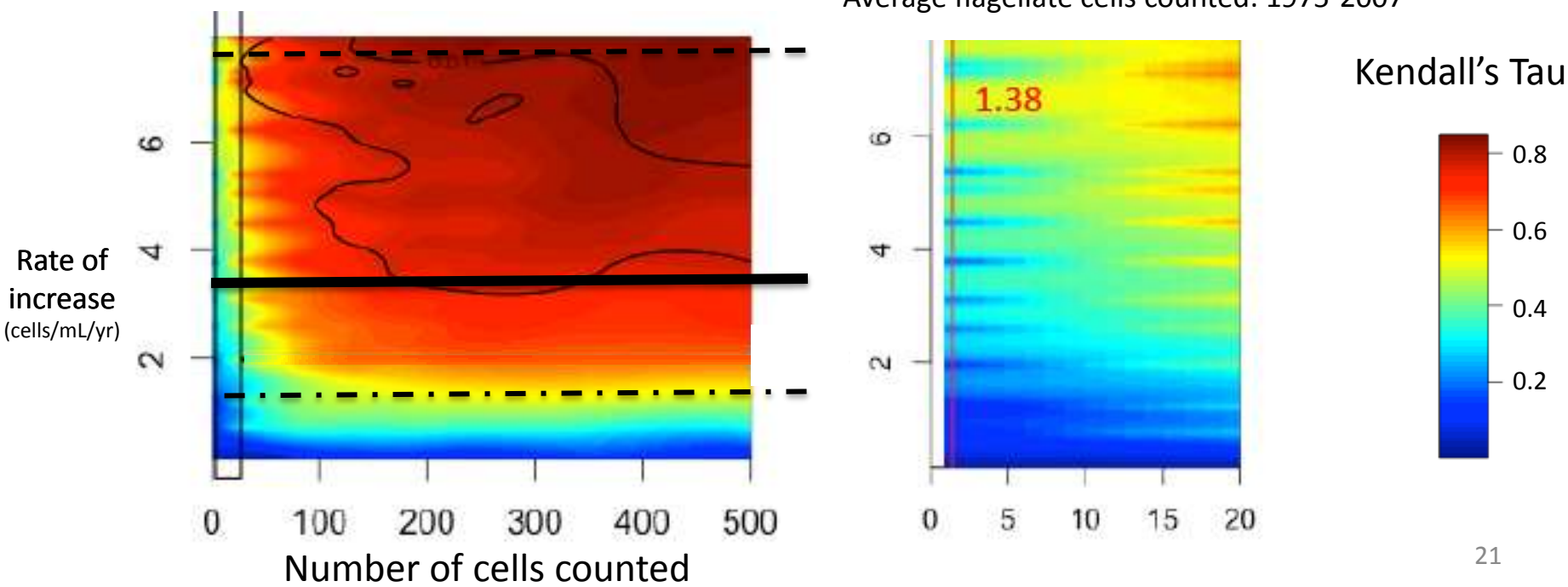
Simulated Densities: Flagellate increase



Average flagellate cells counted: 1975-2007



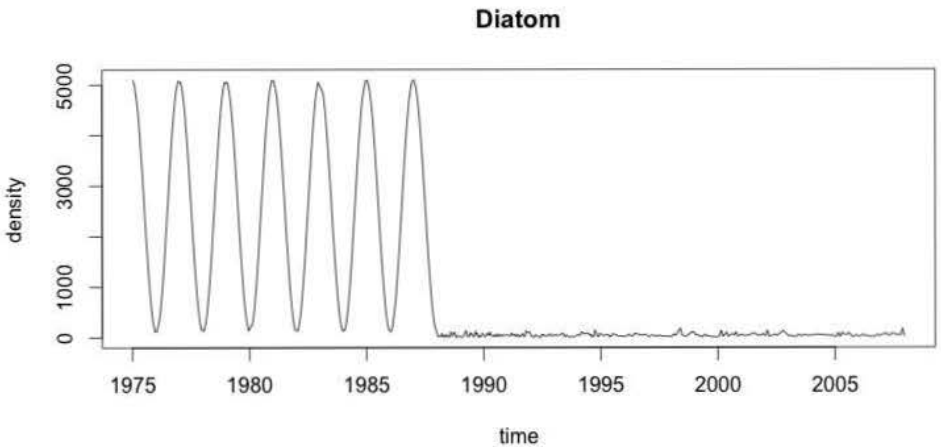
Acknowledgements

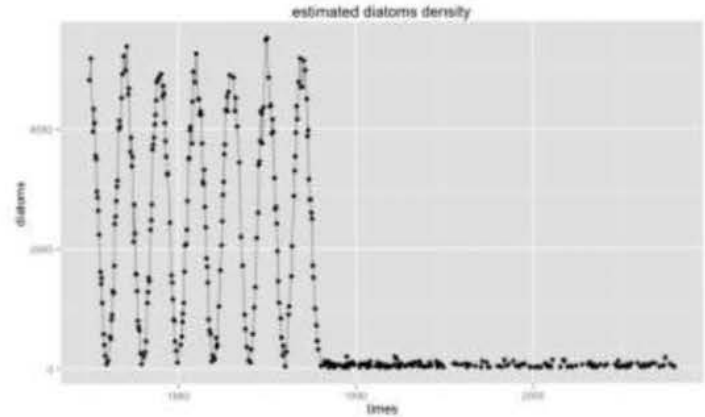
- Numerous regional stakeholders, regulators, managers, and scientific collaborators who have been engaged in SFB nutrient-related work over the past several years.

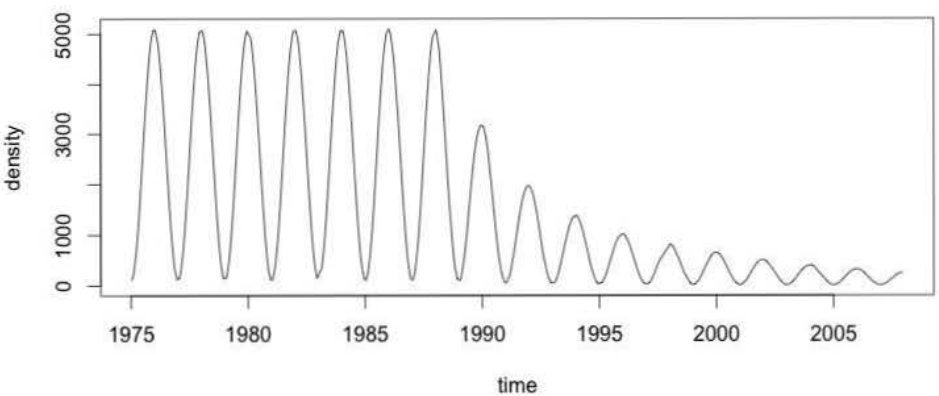
- Funding: Nutrient Management Strategy (BACWA, RMP)

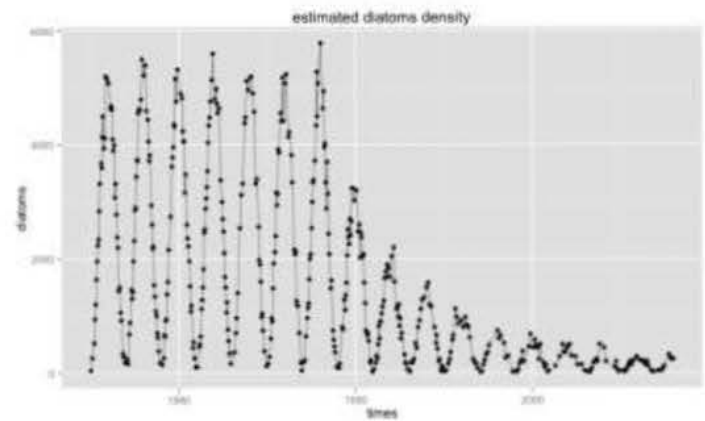
Simulated densities

Estimated densities from simulated counting procedure

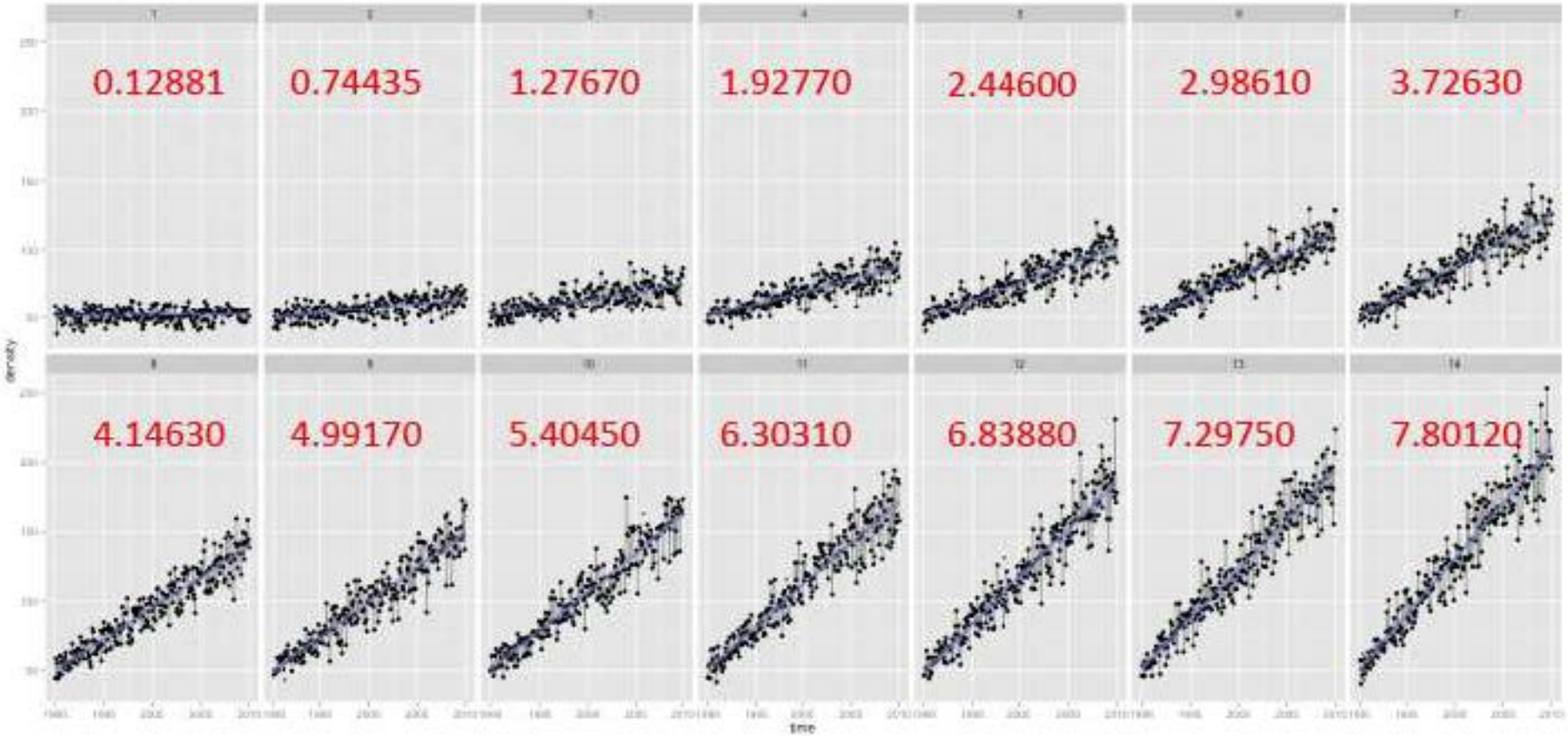




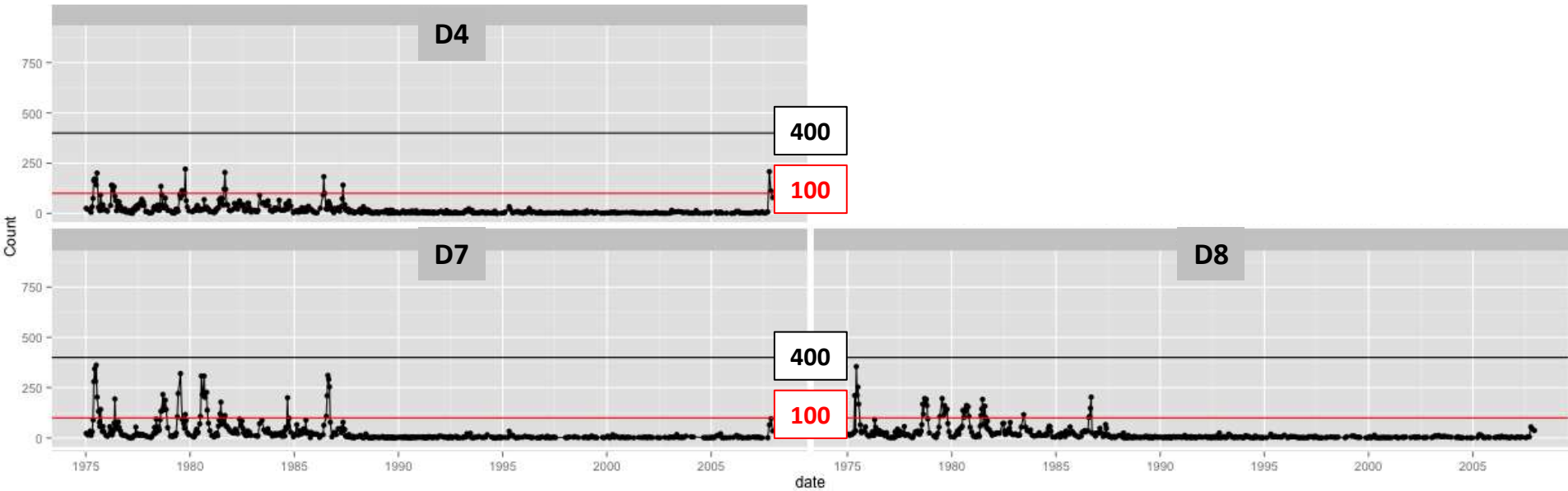




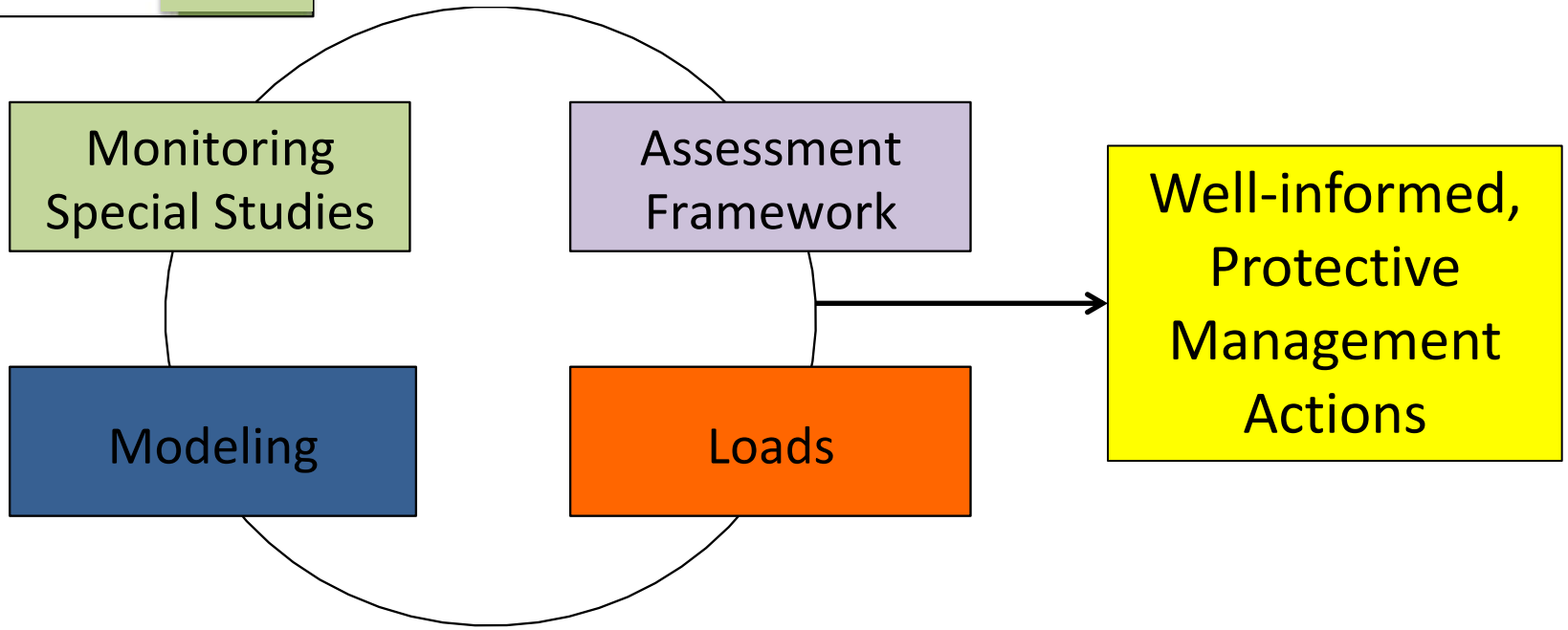
Slopes (per year)



In general, low # of cells counted at all sites, especially after mid-1980s



November 2012
San Francisco Bay Nutrient Management Strategy
San Francisco Bay Regional Water Quality Control Board


Monitoring
Special Studies
Assessment
Framework
Modeling
Loads
Well-informed,
Protective
Management
Actions

External Science Panel

Steering Committee
Regulators
Stakeholders

Science Team
SFEI, SCCWRP, Collaborators
(e.g., USGS, UCSantaCruz, UCBerkeley, SFSU-RTC)

Synthesis, Science Plan

Funding
- Regional Monitoring Program
- Bay-wide Nutrient Permit (wastewater)
- Grants (e.g, IEP, NOAA)

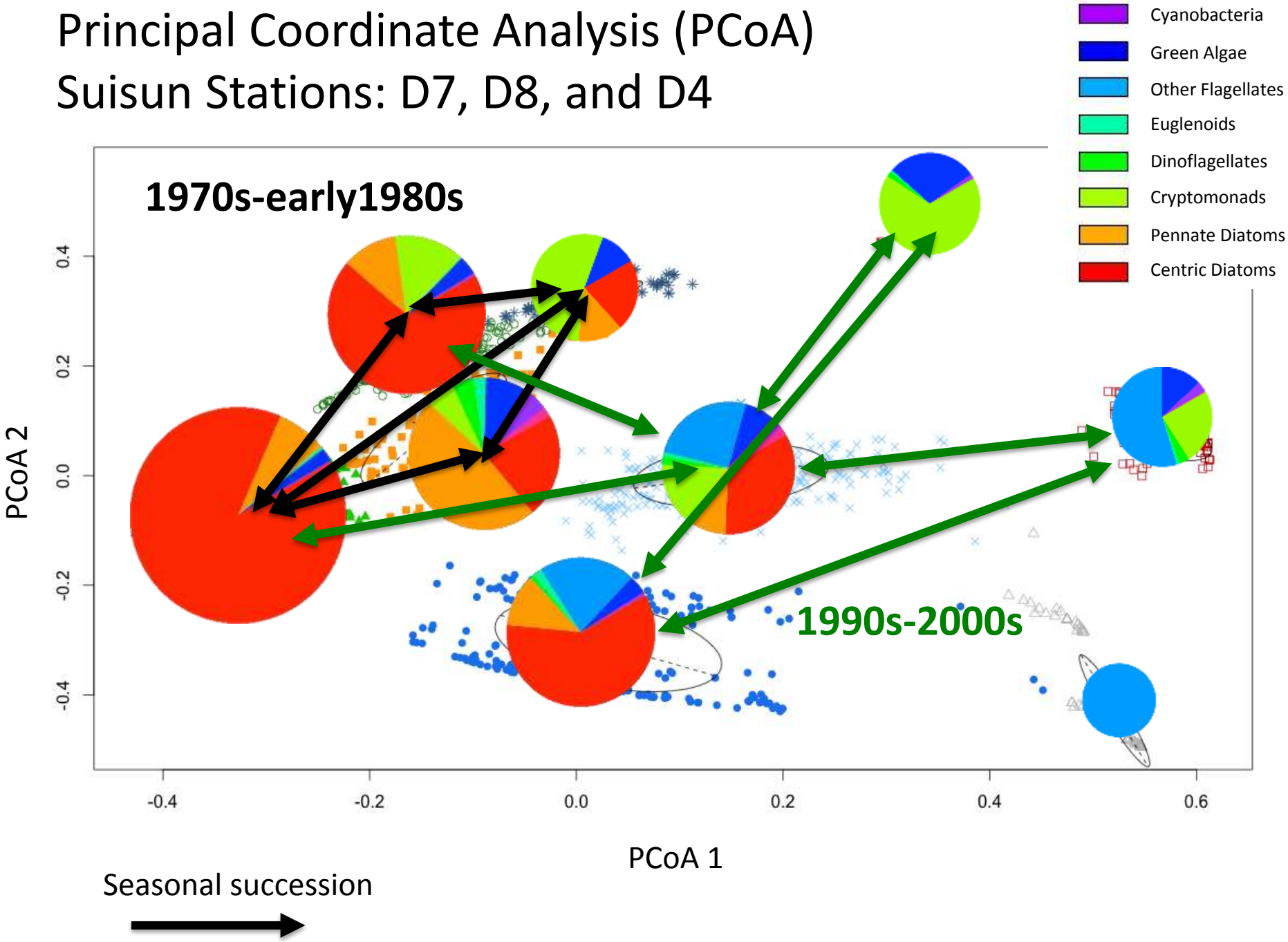
Monitoring Special Studies

Assessment Framework

Modeling

Loads

Principal Coordinate Analysis (PCoA)
Suisun Stations: D7, D8, and D4

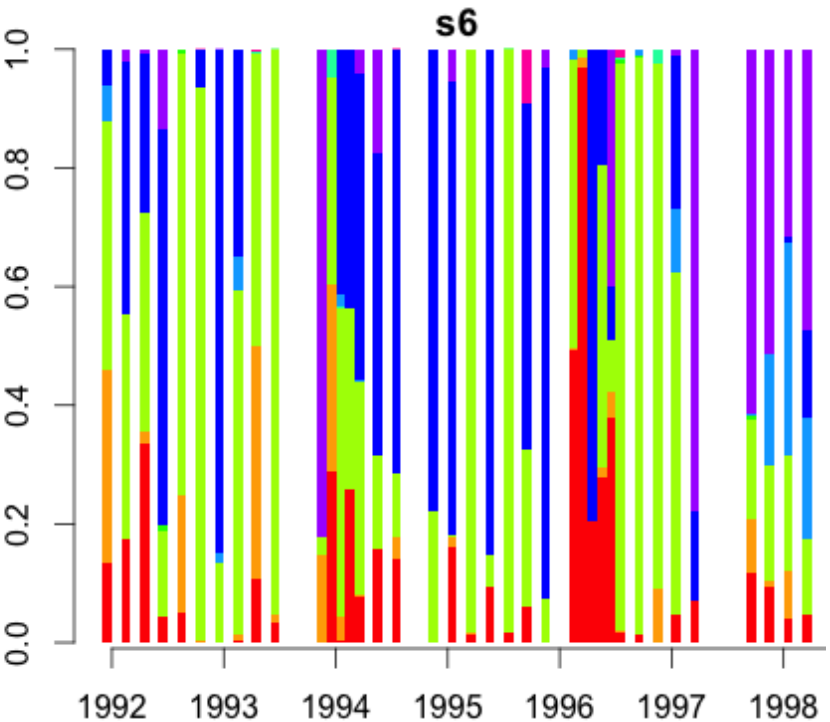
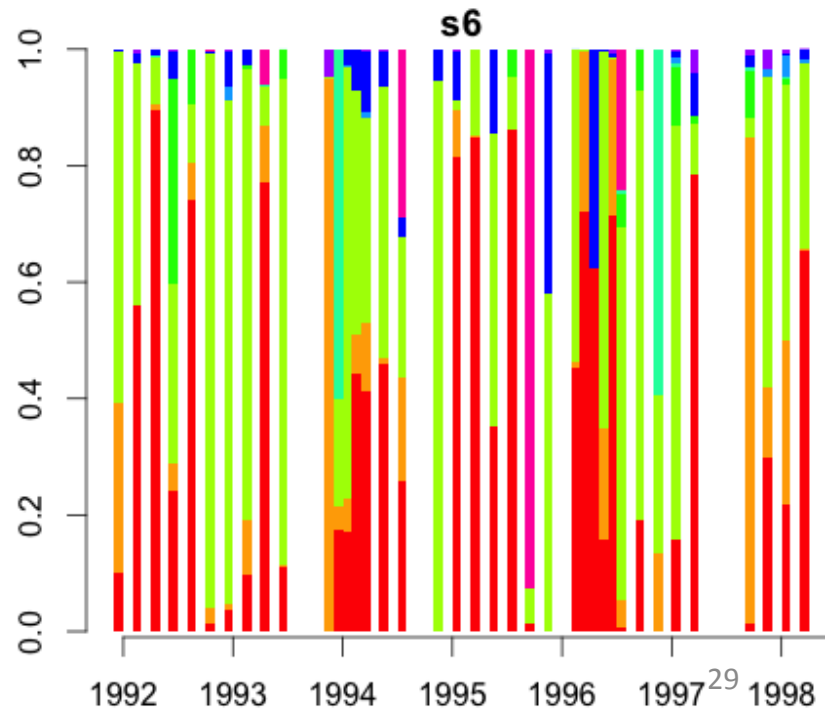


Counts vs. biovolume: USGS s6 (Suisun)

- Other
- Cyanobacteria
- Green Algae
- Other Flagellates
- Euglenoids
- Dinoflagellates
- Cryptomonads
- Pennate Diatoms
- Centric Diatoms

- Individual cell biovolume can vary by factors of 10^1-10^6
- In terms of food, biovolume is most important

Counts (cells/mL)



Biovolume (μm^3/mL)