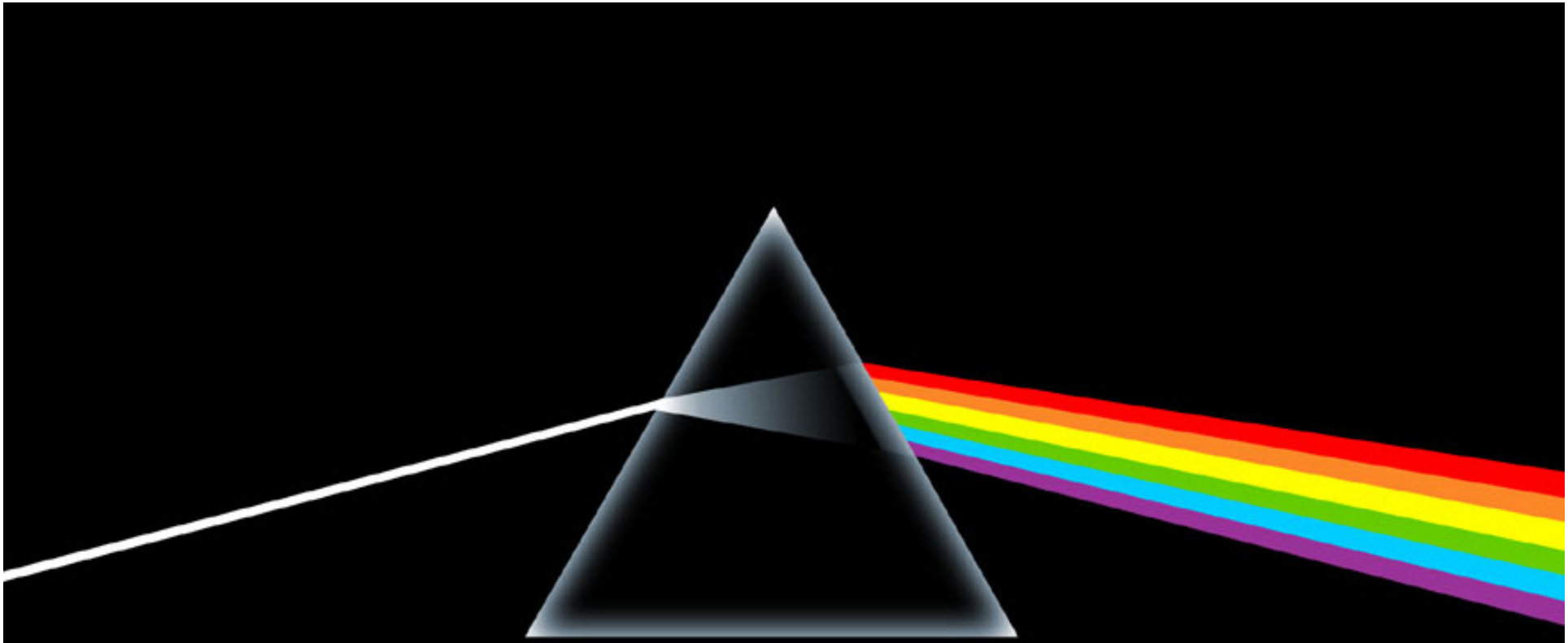
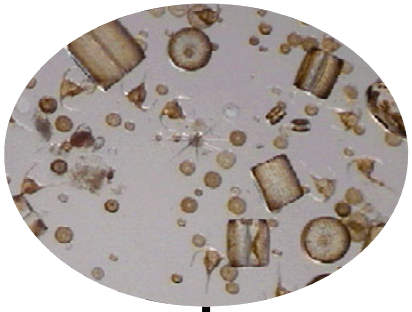


Continuous, in situ optical sensor networks in the San Francisco Estuary: How optical sensors can illuminate processes affecting water and habitat quality

Michael Sauer, Brian Bergamaschi, Brian Pellerin, Jacob Fleck, Bryan Downing, Roger Fujii, and many others

Light attenuation, turbidity, habitat, hydrodynamics

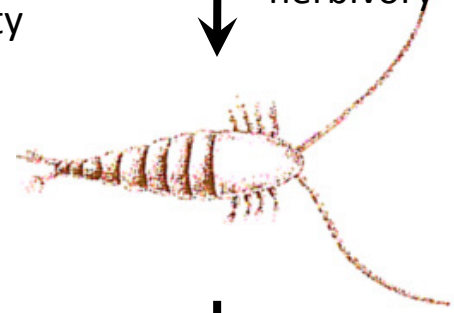


Phytoplankton

Nutrient availability, ratios

Transport, Food resources, Selectivity

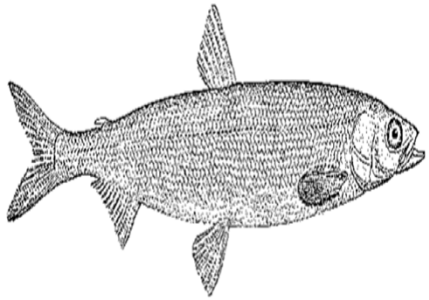
Clam herbivory



Zooplankton

Transport, Habitat, Feeding efficiency, selectivity

Predation pressure



Fish

Human impact
- Agriculture
- Toxins
- Effluent
- Loss of habitat
- Restoration

Larger Oceanographic Regime Change e.g Pacific Decadal Oscillation, Climate Effects, Sea Level Change

Hypotheses for POD

1) Changes in phytoplankton abundance and community structure (light, nutrients, reduction in habitat – off axis nurseries)
2) Low phytoplankton abundance due to grazing (clams) ; loss of food resource
3) Increased predation of smelt due to changes in turbidity, loss of habitat; reduced fish recruitment

Likely multiple stressors

Glibert Model of Food Web - Bottom-up Control

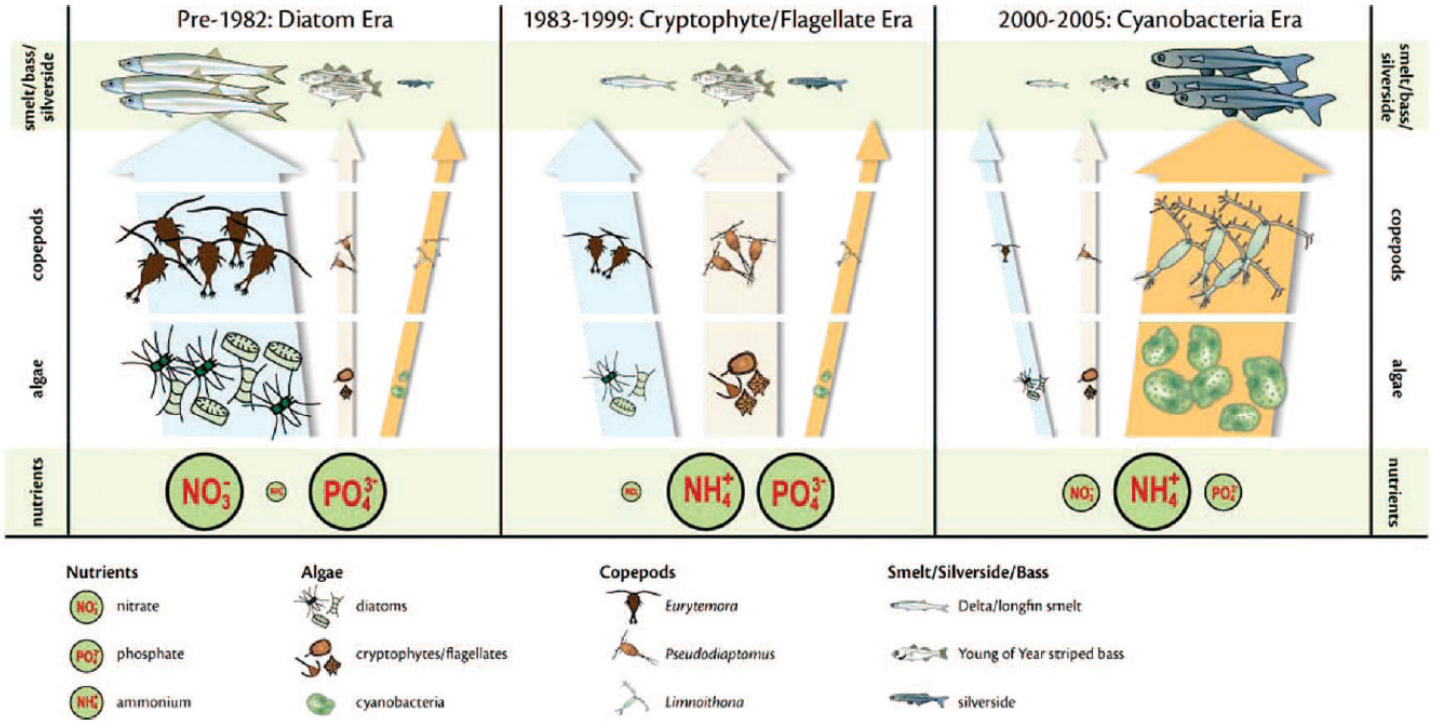
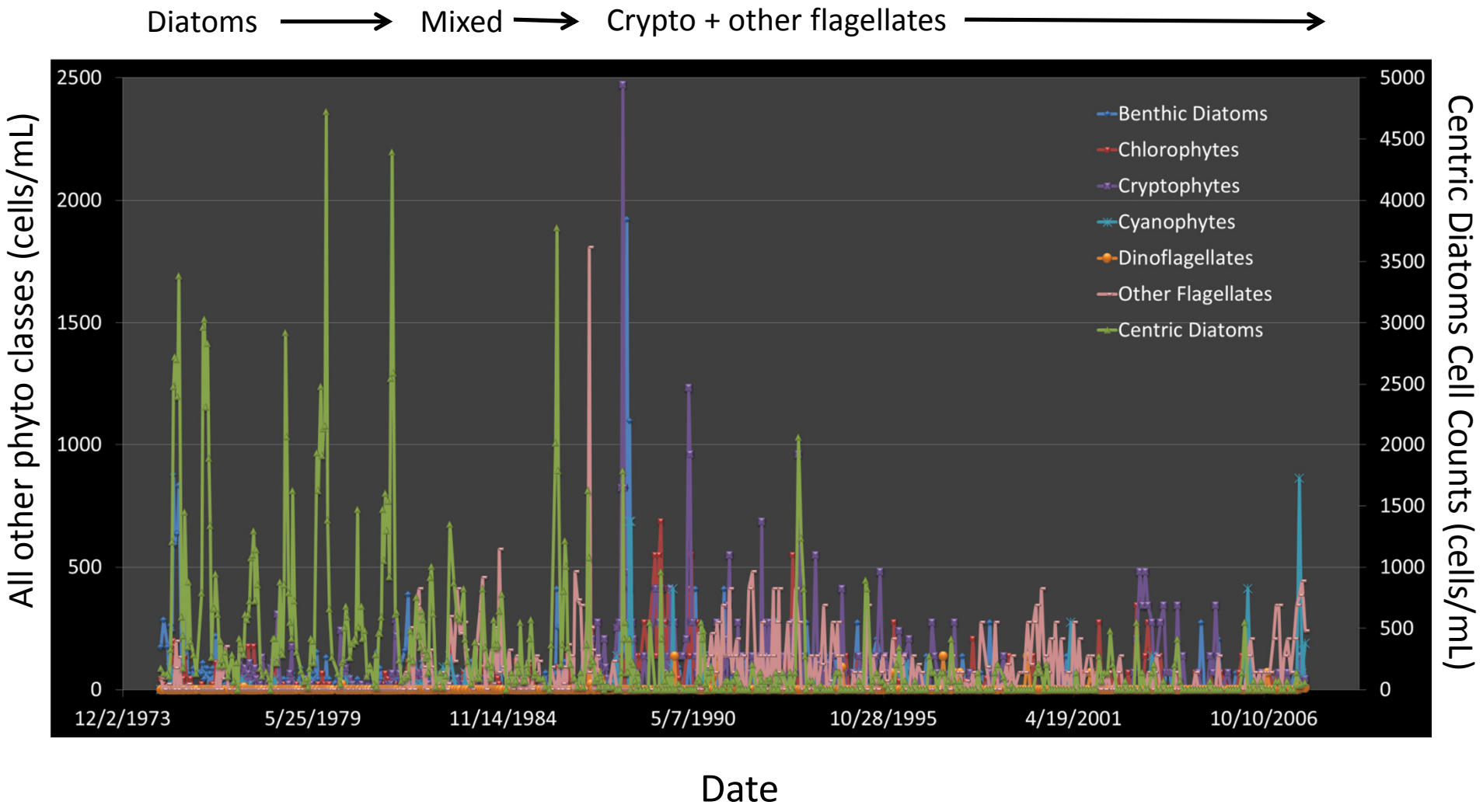


Figure 23 Conceptual diagram of some of the hypothesized changes in the food chain from phytoplankton to fish that have occurred in the Sacramento-San Joaquin Estuary over the past 30 years. Each of these hypothesized food chains has different dominant nitrogen forms or amounts relative to phosphorus. 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.

Glibert 2010

Monthly Phytoplankton Cell Counts in the Lower Sacramento/northern SFE 1973-2006



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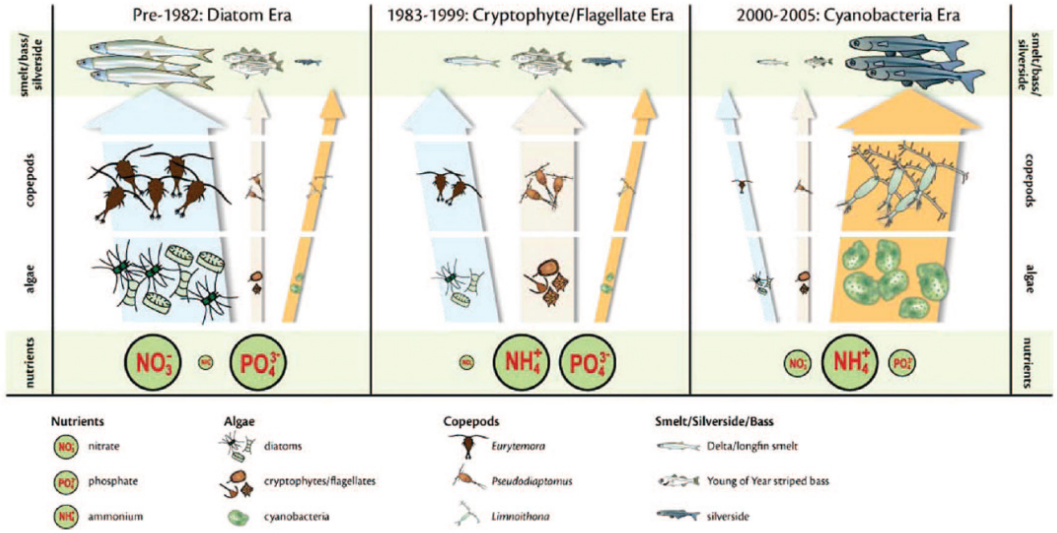

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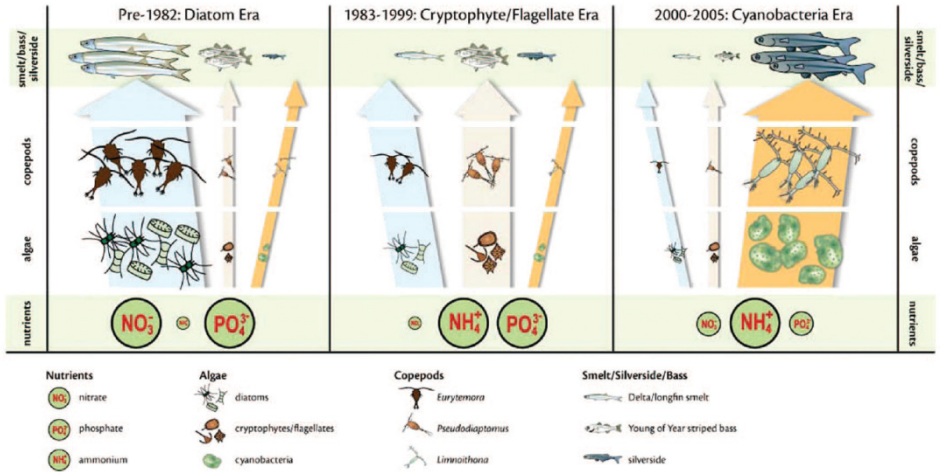

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Opportunity 1. Multiple factors/stressors impact all levels of the ecosystem – the system is complex

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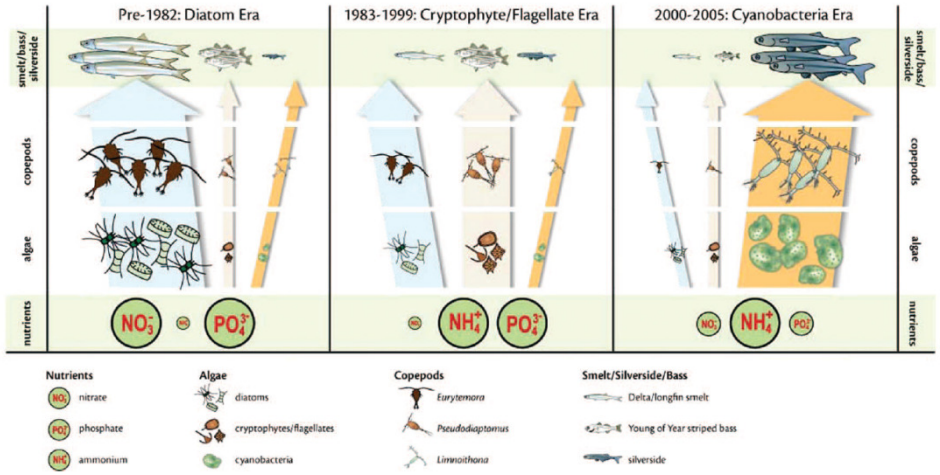

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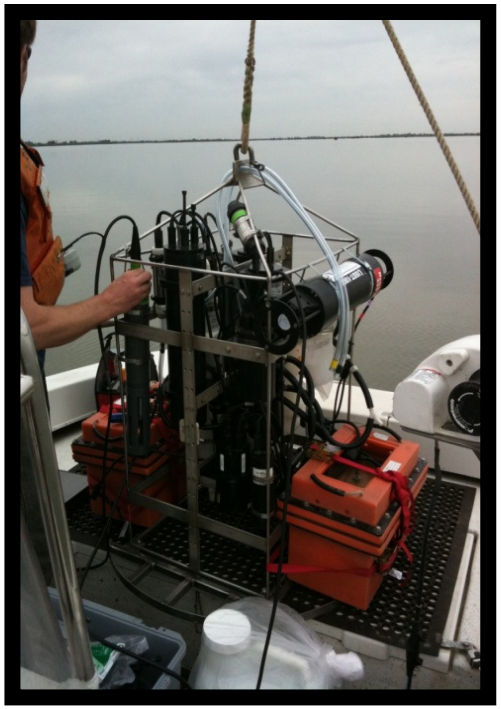
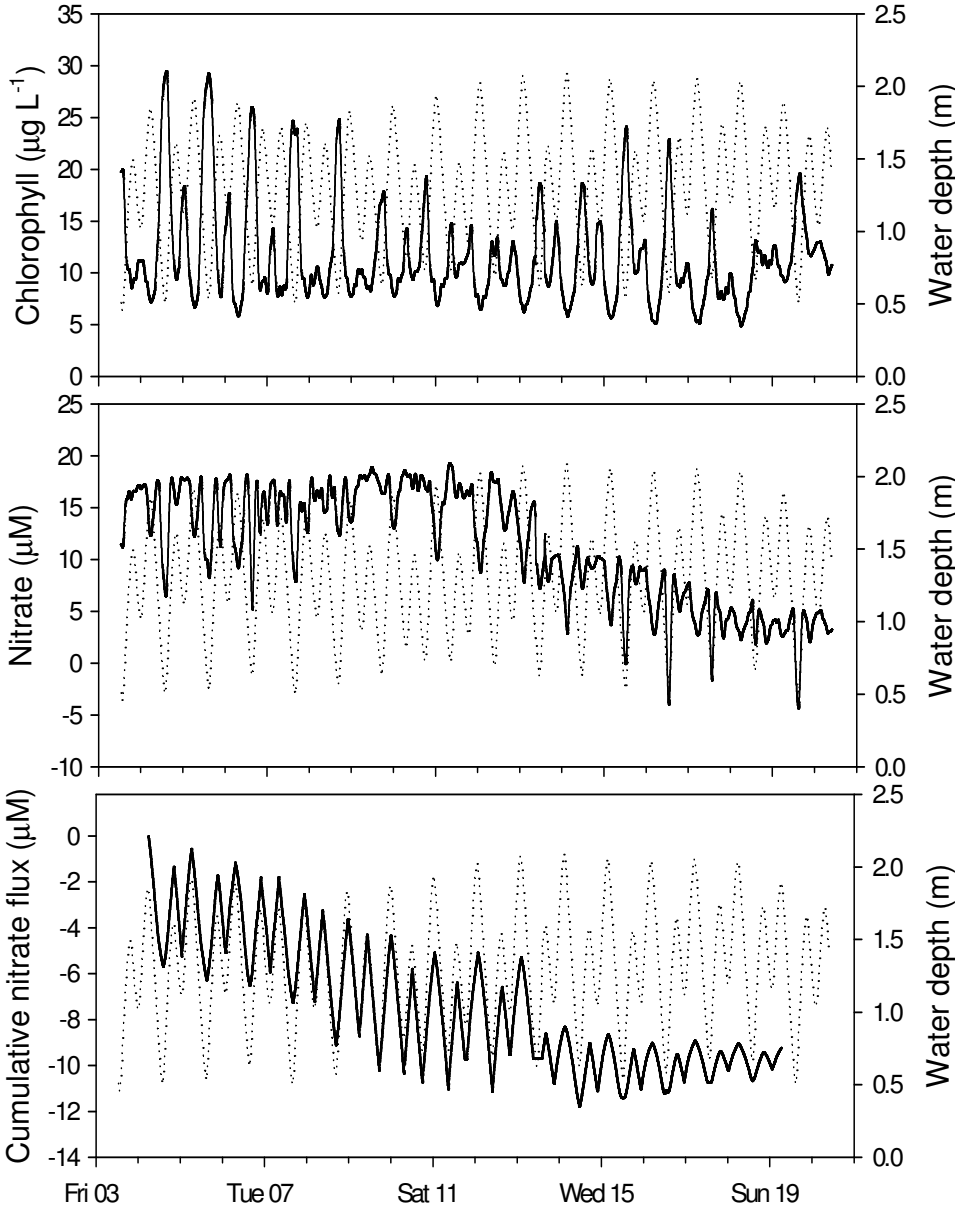
Opportunity 1. Multiple factors/stressors impact all levels of the ecosystem – the system is complex

Large array of observations are needed to support various levels of the model

Liberty Island – Phyto and Nutrient Variability

<u>Opportunity 2.</u> Model components change faster than the monthly time scale!





Nitrate Variability – San Joaquin River

Assessing diurnal nitrate variability in the San Joaquin River, Crows Landing, CA
(Satlantic ISUS nitrate analyzer)

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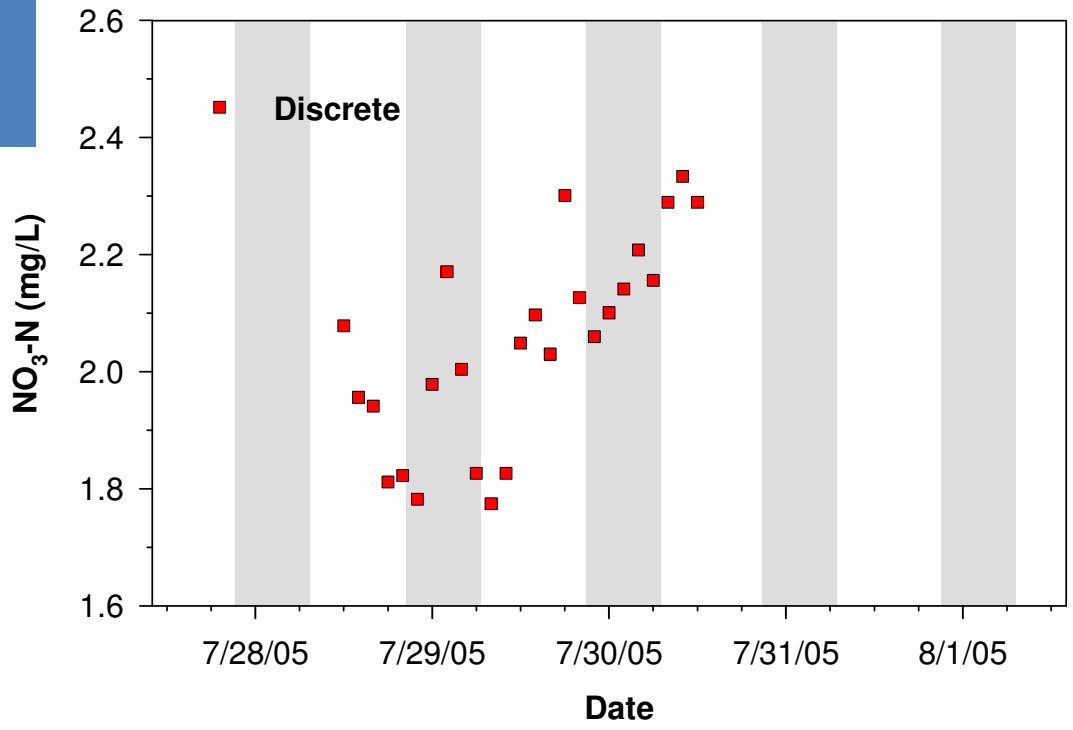

Monthly or even weekly observational approach do not allow for effective management

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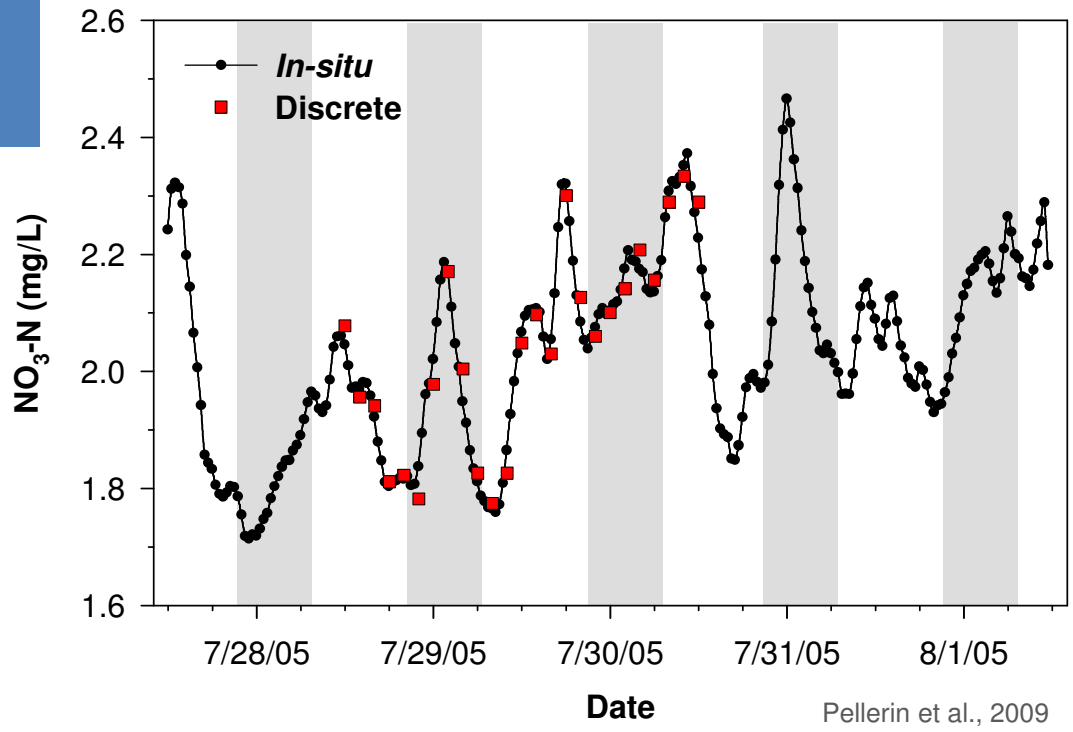

Pellerin et al., 2009

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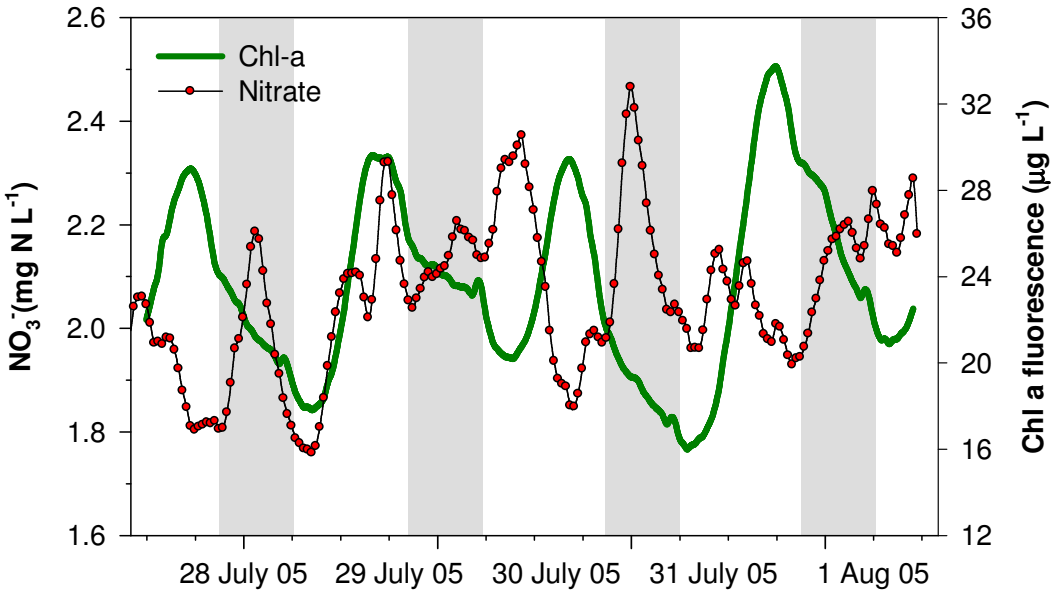
Opportunity 2. Model components change faster than the monthly time scale!

↓

Monthly or even weekly observational approaches do not allow for effective management, **lead to bias and interpretation errors**

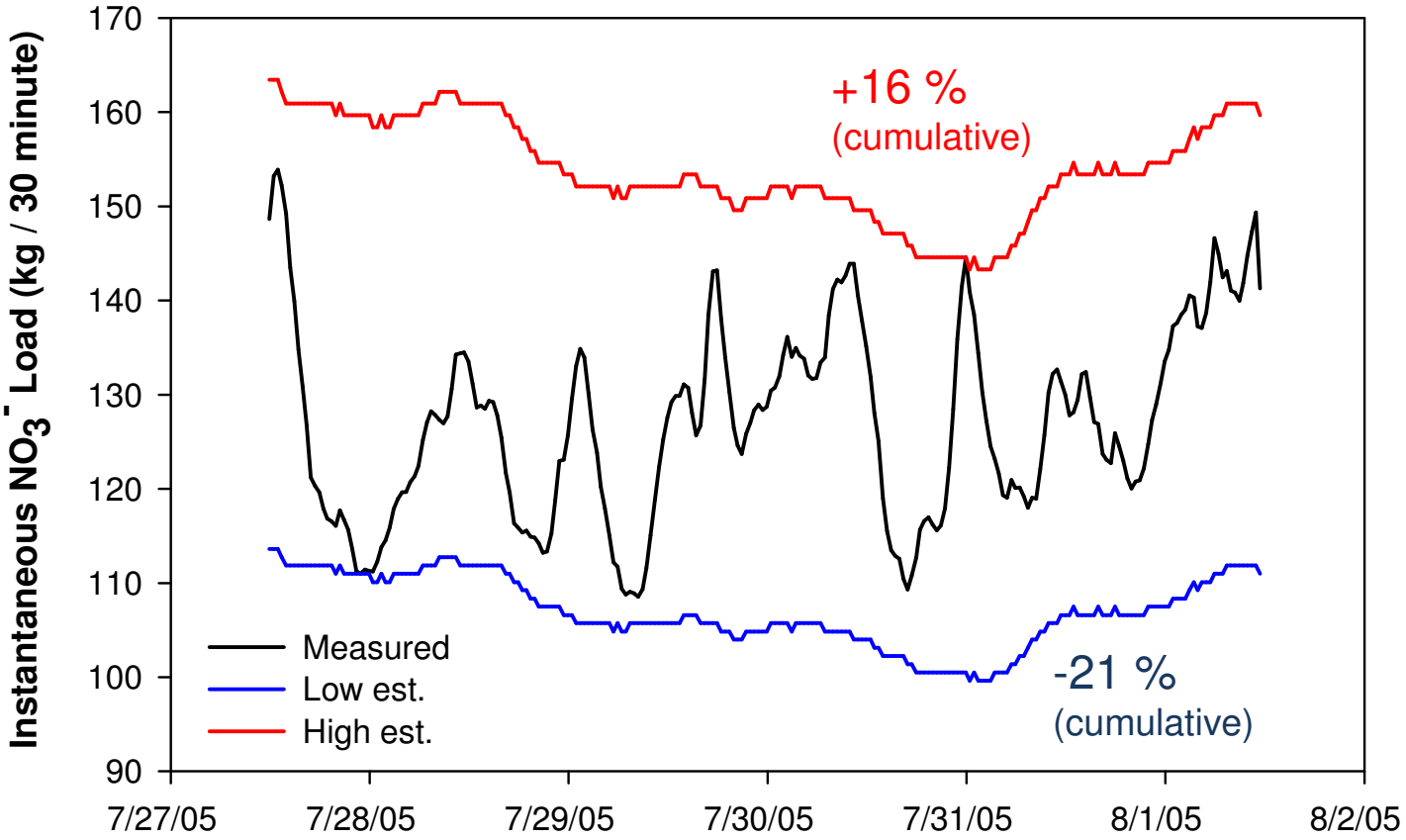


Combination of discrete and in situ data show high biological activity in the SJR, but no evidence for direct link between NO_3^- concentrations and chlorophyll not apparent.

Nitrate Loads – SJR – Induced Errors

Difference in instantaneous and cumulative nitrate load at Crows Landing during the study period. **Daily loads were -23 to +30 % relative to measured load** using continuous data.

	Daily Load (kg nitrate / day)			% Difference	
	Measured	Low est.	High est.	Low est.	High est.
28-Jul	5875	5305	7631	-10	30
29-Jul	6563	5064	7284	-23	11
30-Jul	6160	4956	7130	-20	16
31-Jul	6047	5024	7228	-17	20



Pellerin et al., 2009

SOLUTION: Goals and Objectives

Goal: understand the driving forces of pelagic organism decline

Objective: Develop a broad, continuous monitoring network for observing changes in light, nutrients, and phytoplankton

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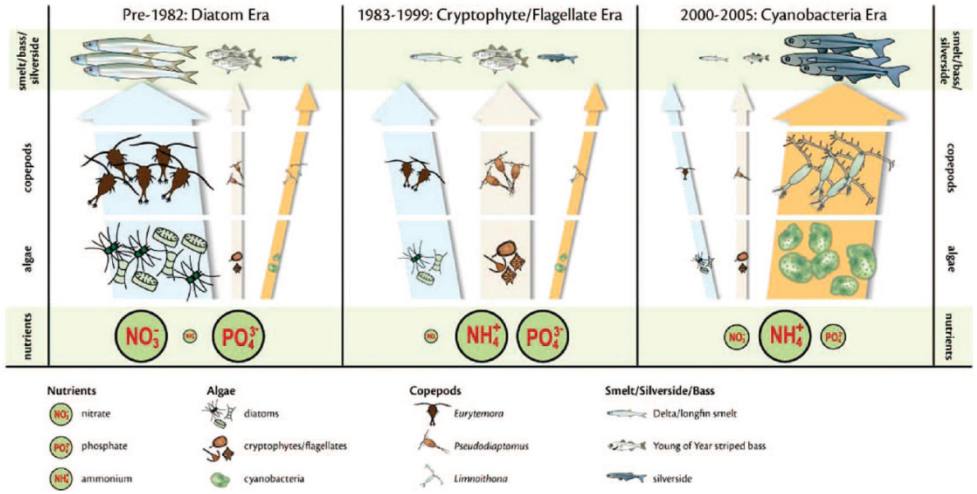
1. Develop tools for assessing habitat quality in real time
2. Evaluate and calibrate inexpensive measurement techniques
3. Make available a data platform which numerical models can use and with which hypotheses can be tested
4. Provide context and utility for more intensive research projects

Approach

Continuously monitor components of the ecosystem that are most important to the base of the food web - phytoplankton

1. Phytoplankton abundance, composition, productivity
2. Particle size and composition
3. Nutrient dynamics



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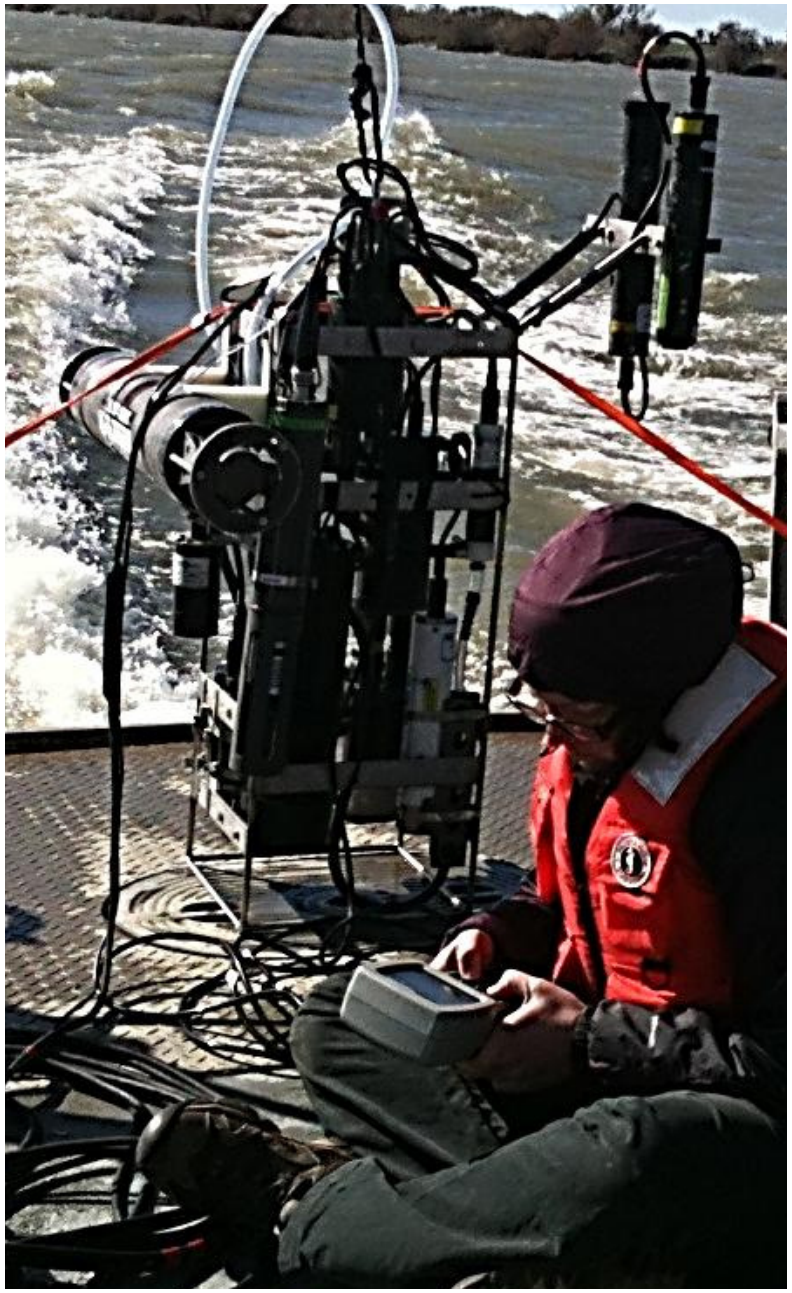
A Brief List of Food Web Model Parameters Needed

1. **Light**
2. **Nutrients**
3. **Turbidity/Particle Size/Composition**
4. **Algae**
5. Zooplankton
6. Fish



Capabilites

A Brief List of Food Web Model Parameters Needed

1. Light
2. Nutrients
3. Turbidity
4. Algae
5. Zooplankton
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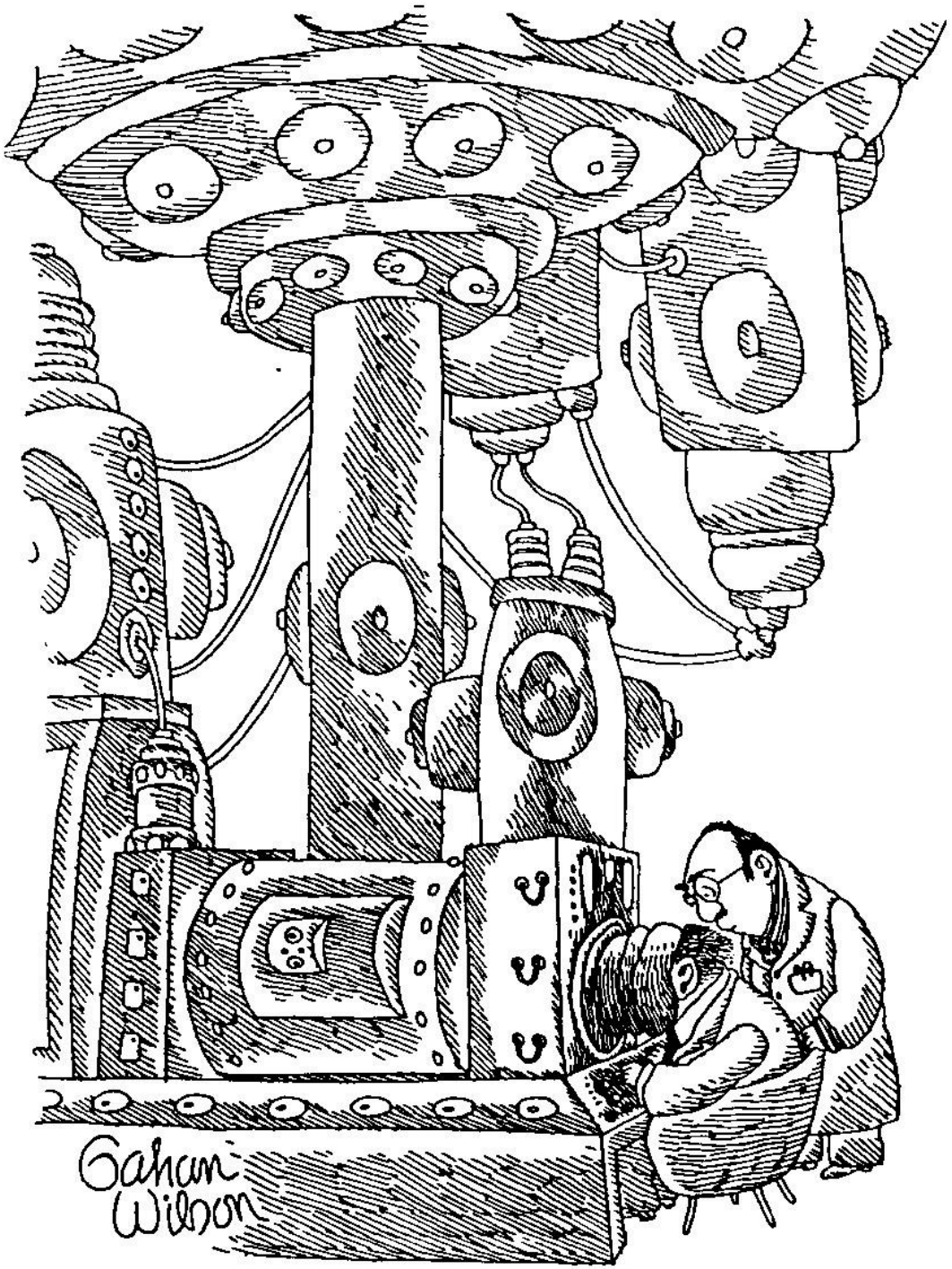
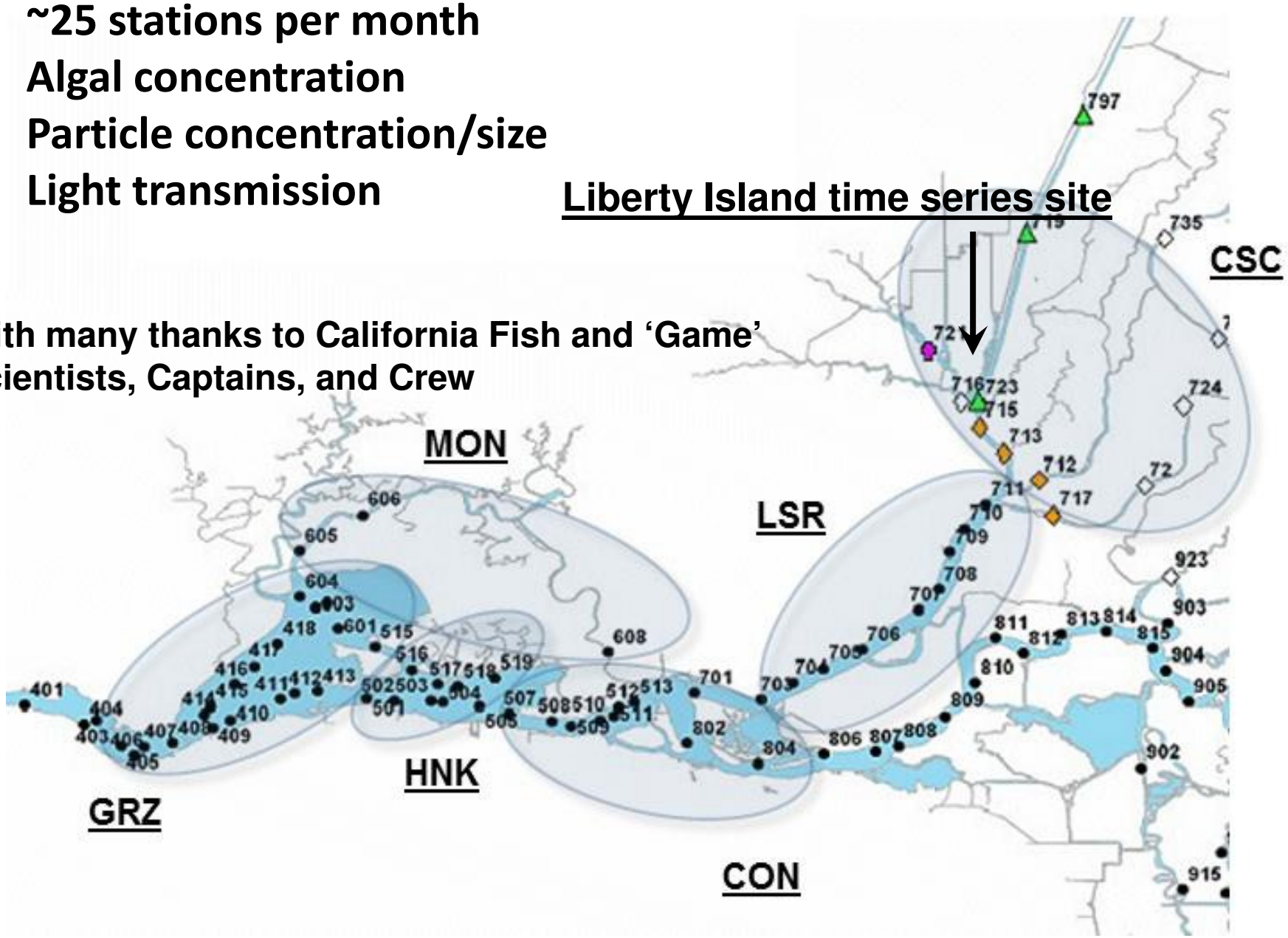
All indicators shown in red in the forthcoming lists can be observed continuously



We are developing and calibrating inexpensive methods from more sophisticated instrumentation and techniques…

X2 Project

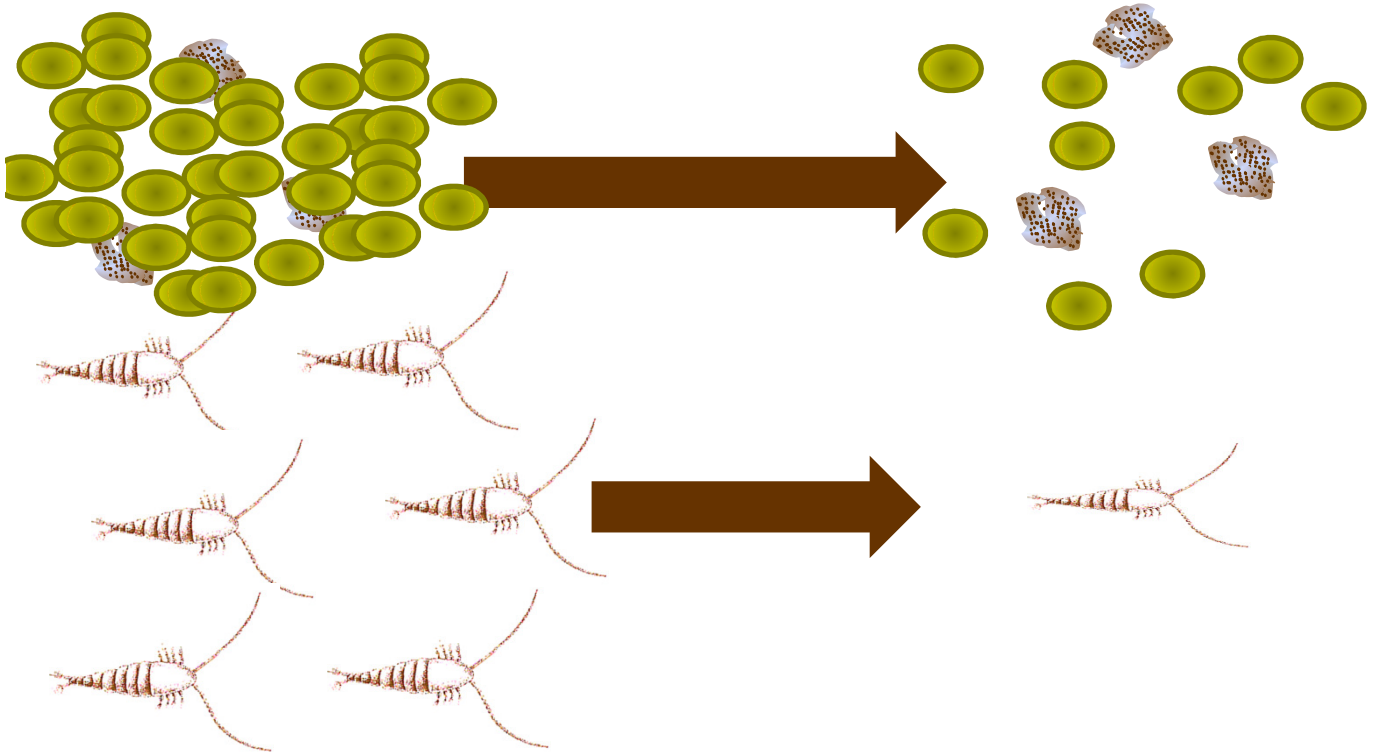
- ~25 stations per month
- Algal concentration
- Particle concentration/size
- Light transmission



With many thanks to California Fish and 'Game' Scientists, Captains, and Crew

Phytoplankton productivity

- Light limitation inhibits phyto growth
- Blooms don't form due to grazing, etc.
- Growth rates lower due to NH_4^+
- Reduced zooplankton food encounter rate
- Lower zooplankton abundance and quality
- Lower energy supply to fish



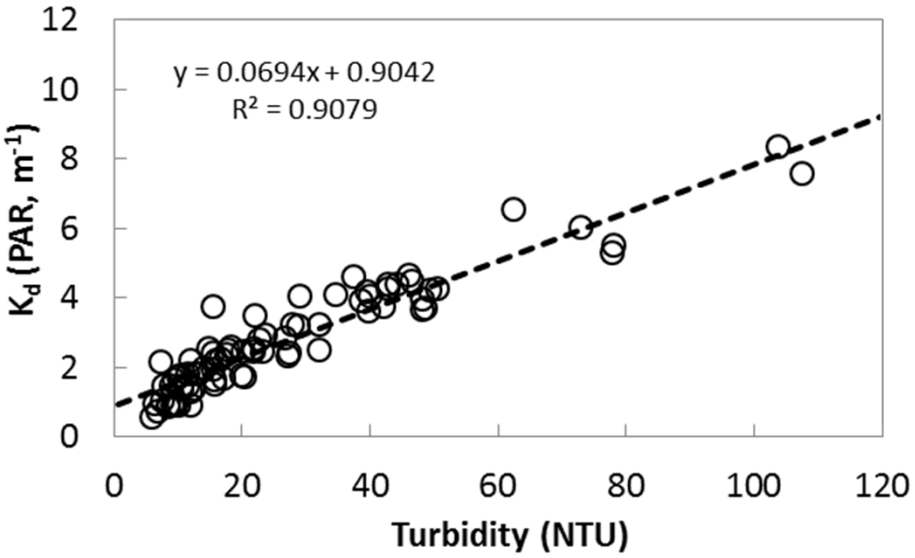
Want to Measure

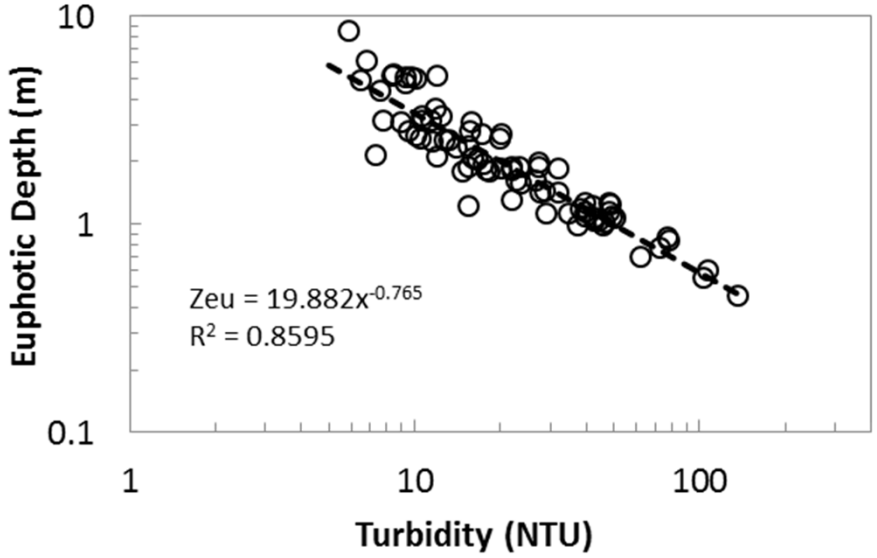
- Light attenuation
- Chl a
- NO_3^-
- **PO_4^{3-}
- **NH_4^+
- Primary productivity (PP)
- Phyto Community
- Phyto Phys. Status
- PP location
- PP timing

Phytoplankton productivity

ELEMENTS: Light availability, turbidity, euphotic zone depth, Chl a, nutrients

GOALS: Enhance capability of productivity models, assess off-channel production



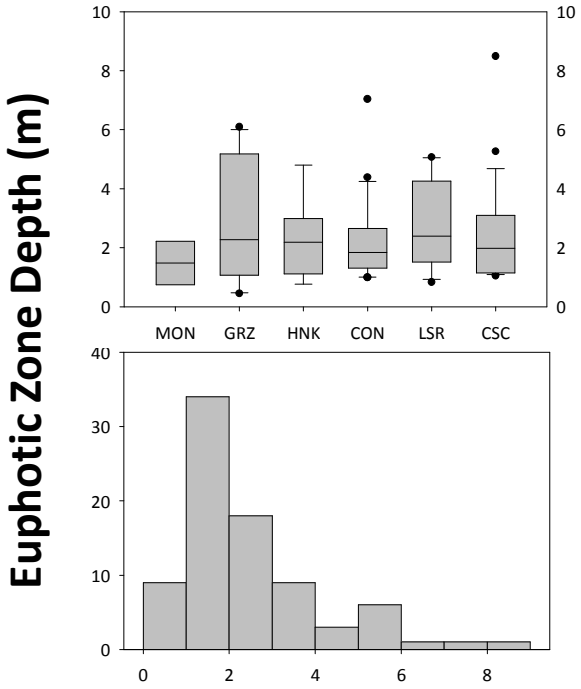


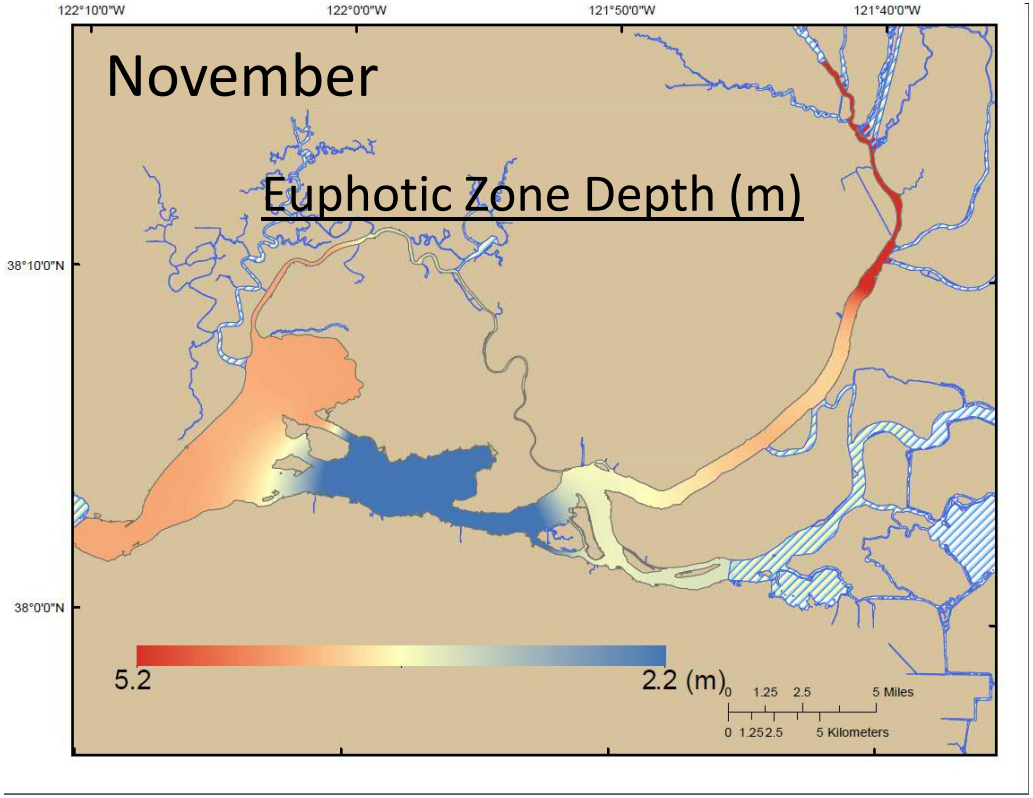
We can utilize surface turbidity to estimate light attenuation across the entire SFE and Delta

Phytoplankton productivity

ELEMENTS: Light availability, turbidity, euphotic zone depth, Chl a, nutrients

GOALS: Enhance capability of productivity models, assess off-channel production, remote sensing, trends, etc.





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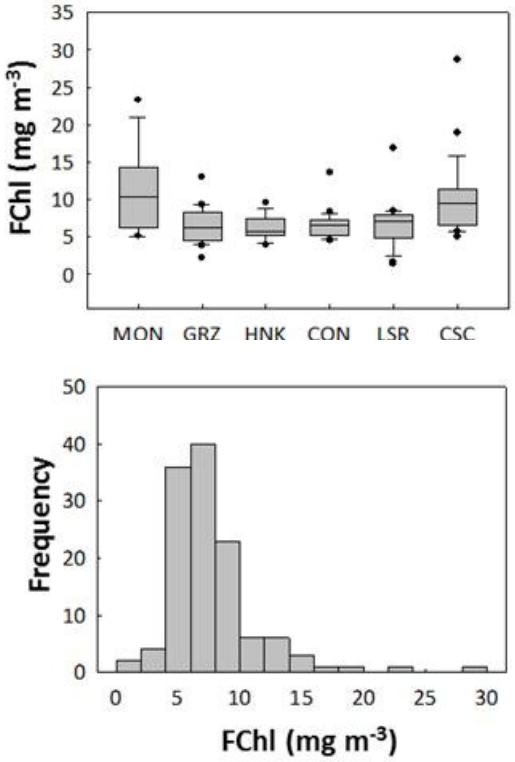

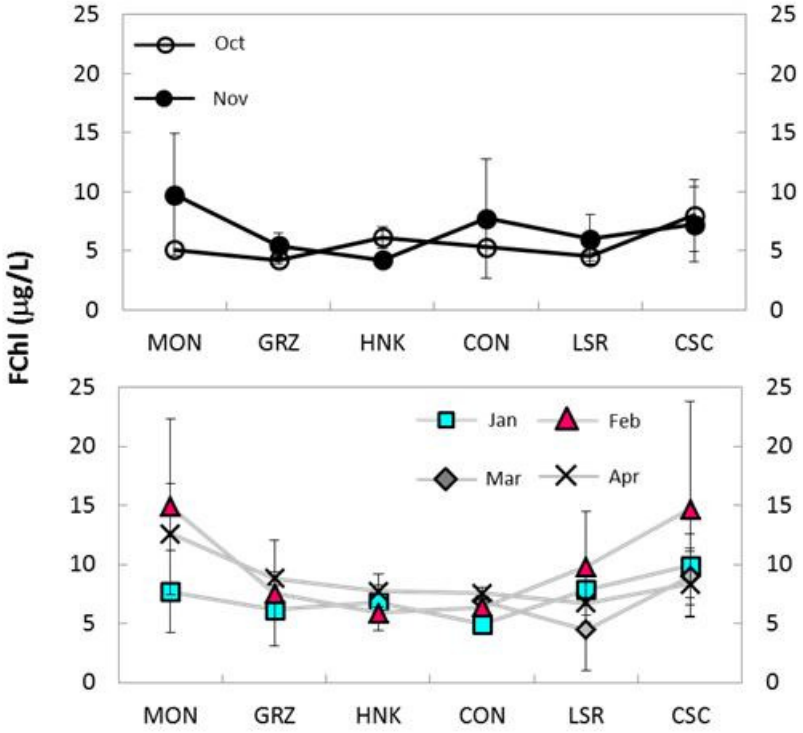

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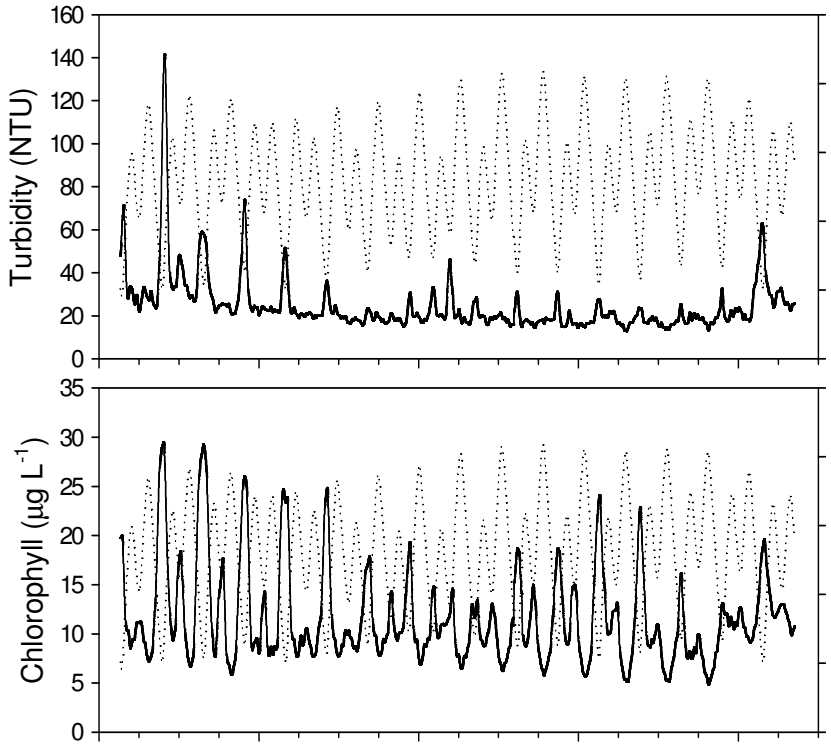
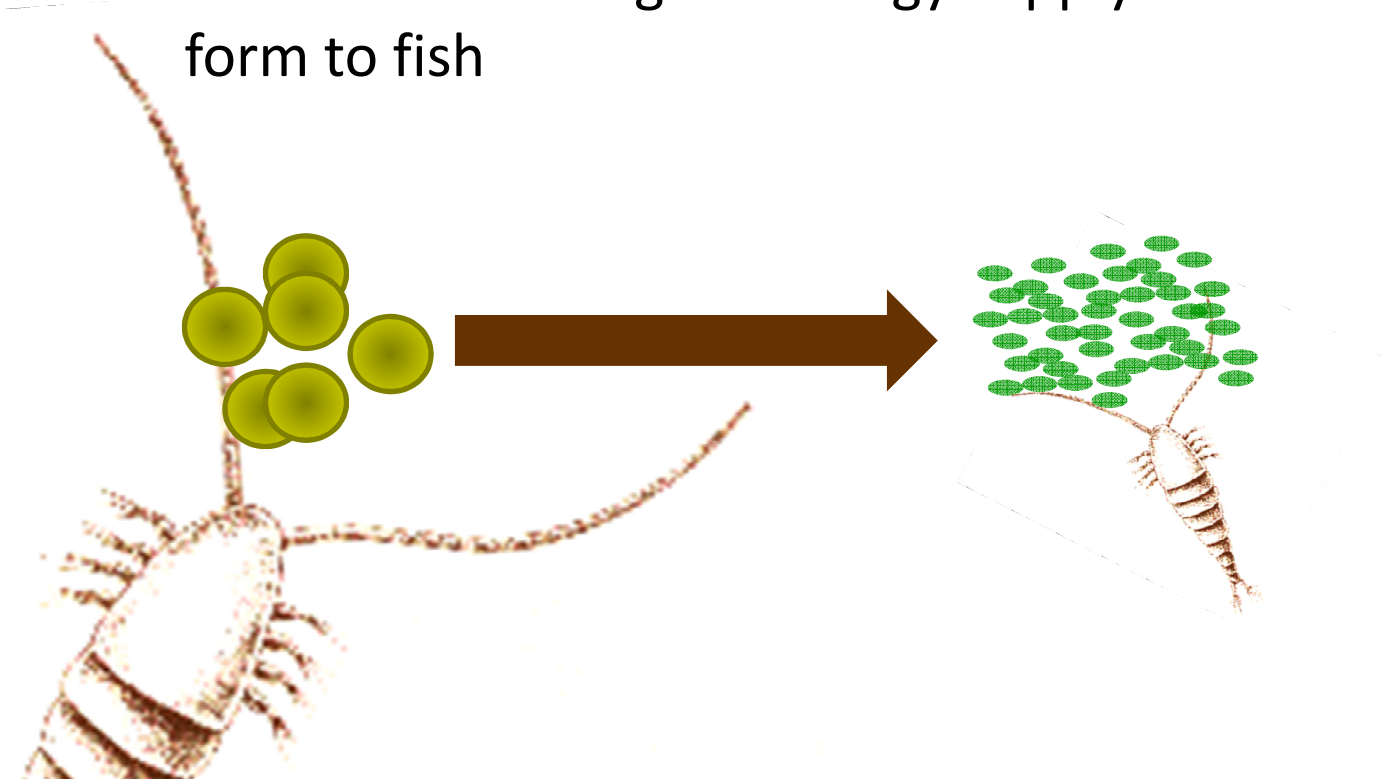


Nutrients change the food web

- Changes in N and P supply, Nitrogen forms, and N:P ratios cause changes in phytoplankton community
- Cascading changes in zooplankton community, trophic dynamics
- Net result is change in energy supply and form to fish



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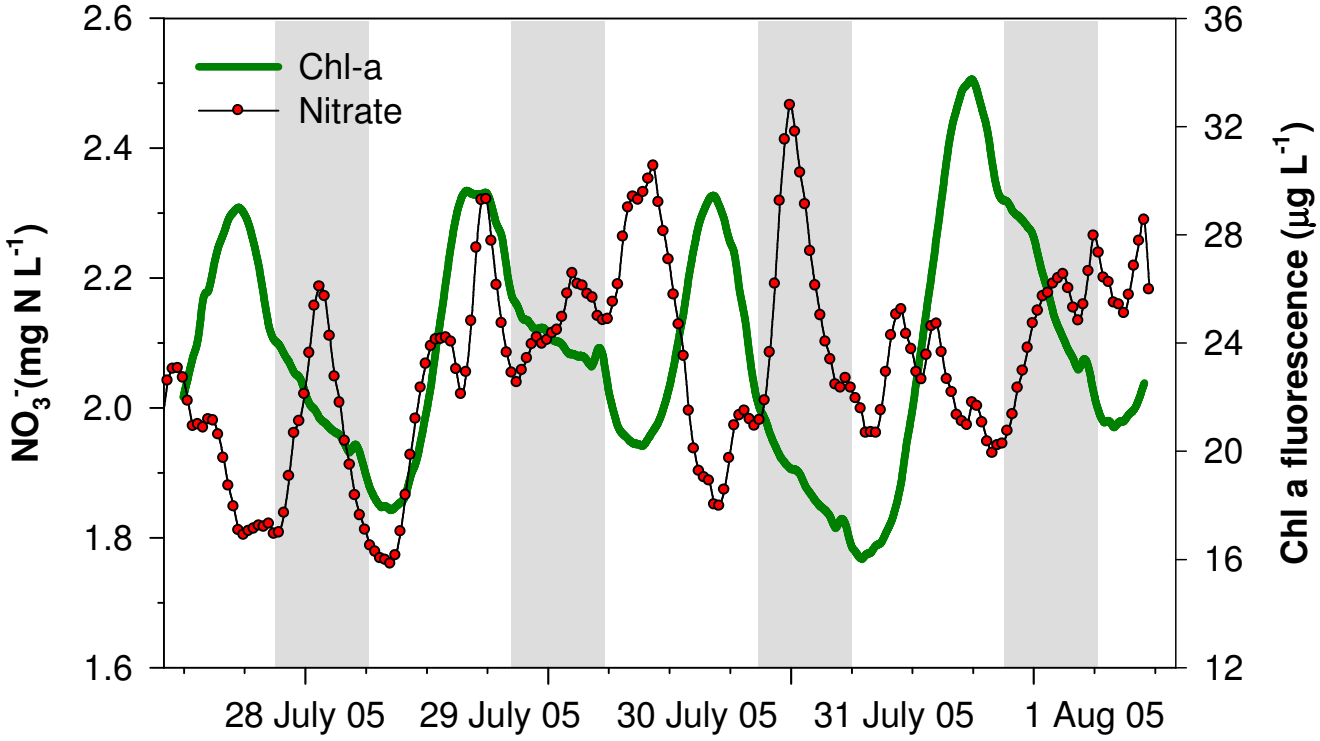

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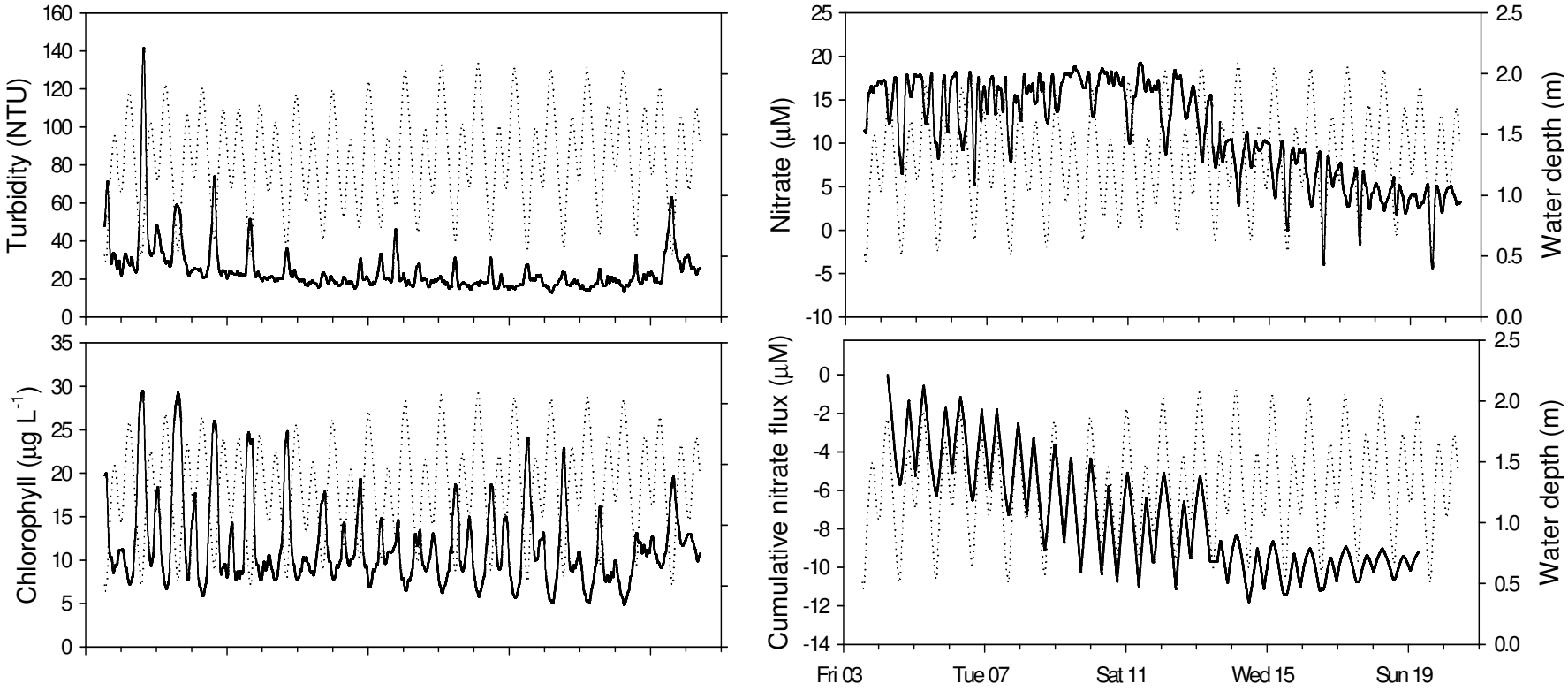
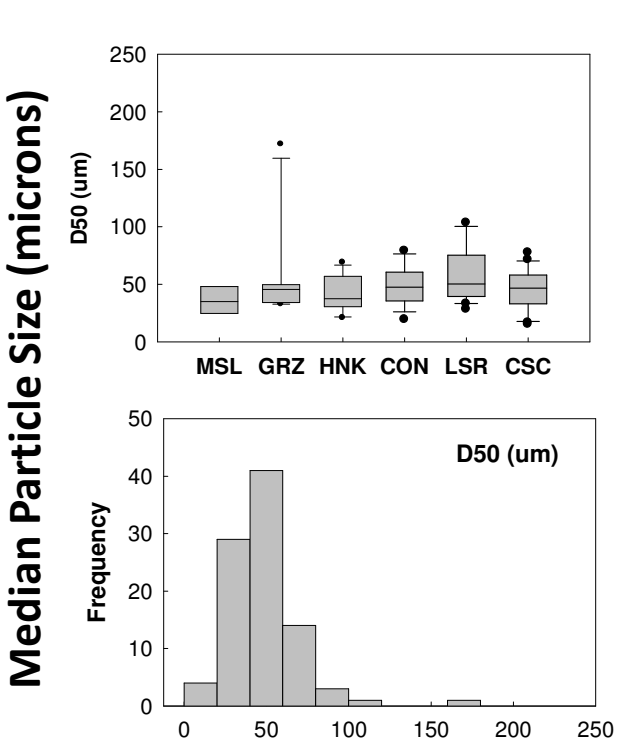
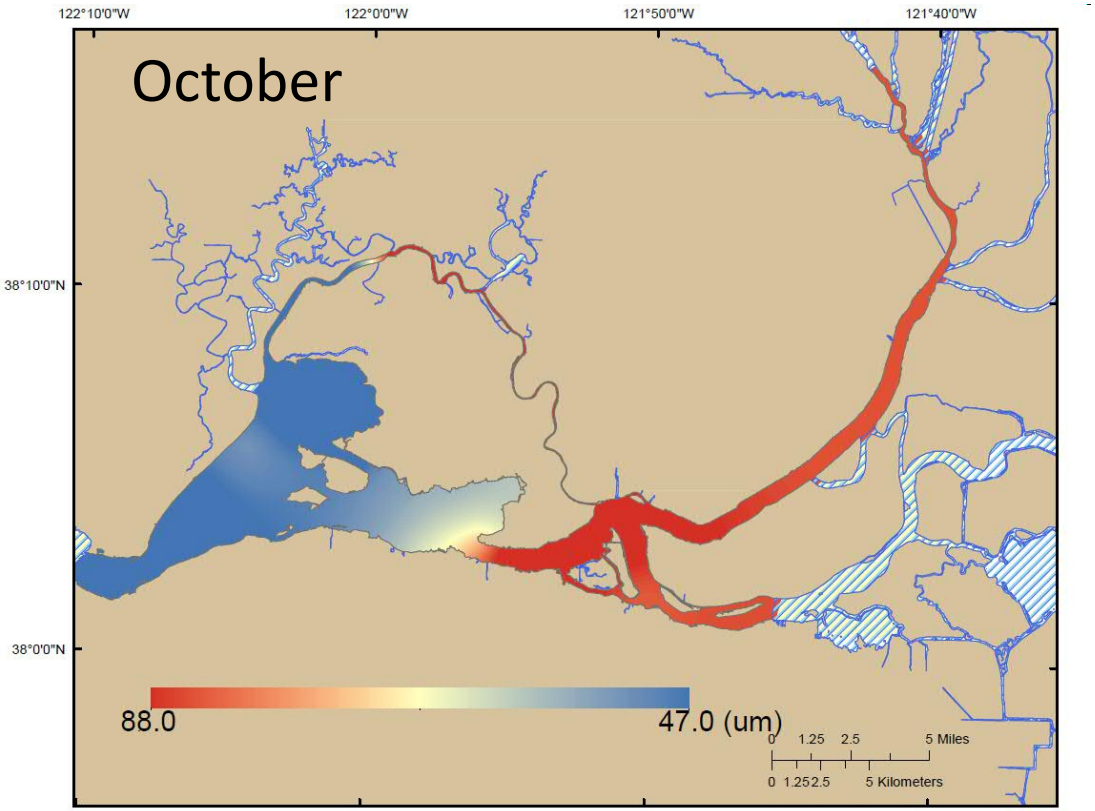


Particle Size and Quality

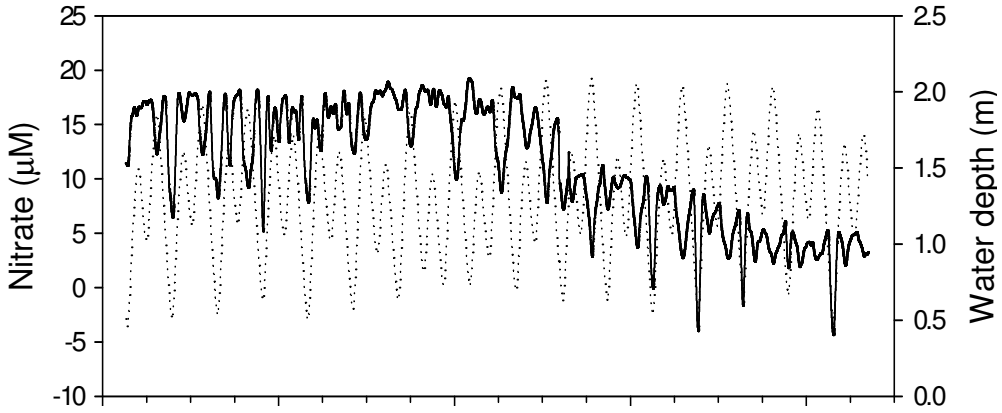
ELEMENTS: Particle size distribution, source, type
organic content, fraction of algal origin

GOAL: Identify locations and times where algal
conditions are favorable to specific zooplankton communities
Where does the food go?





Why measure continuously?



- Understand frequency and location of favorable habitat conditions
- Understand and quantify processes in a tidal setting
- Identify long term trends
- Link discrete sampling to antecedent and current conditions
- Continuous monitoring is more affordable and efficient
- Be able to adapt your funded research project to current conditions = less missed opportunities, greater research success

Need to know

Light

NO_3^-

**NH_4^+

**PO_4^{3-}

PP amt.

PP location

PP timing

Particle size

Part. type

Part. qual.

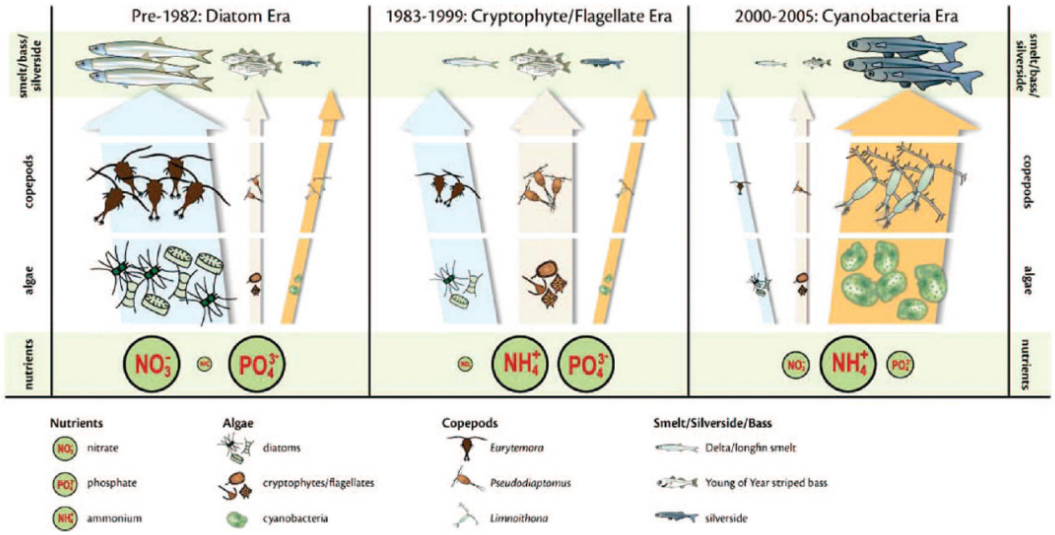
Light attenuation

Turbidity

DOM

MOST CAN BE MEASURED *IN SITU* CONTINUOUSLY and INEXPENSIVELY

(now doing it…… expensively and discretely)



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Ancillary Benefits/Other uses!!!!!

Information about sources and long term changes in…

DOM → **Disinfection Byproducts**

Nutrients in reservoirs → **Algal blooms, production of DOC, HABs**

Mercury → **Track mercury, methyl-mercury through ecosystems**

“Discrete monitoring programs must take into account variability on scales shorter than the (discrete) sampling interval because of potential uncertainty and bias …

…Monitoring programs must, at some point, include focused, higher-frequency studies to understand the effects of shorter time scales…

…Given the scope and pace of change occurring in the world’s estuarine-coastal ecosystems, the imperative for monitoring data and their analysis has never been greater”

Cloern and Jassby 2012