Sacramento Regional County Sanitation District

Addressing uncertainty regarding the pelagic food web: perspectives and suggestions

presented to the SWRCB by Diana Engle, Ph.D.
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on behalf of SRCSD

October 2, 2012

Context

- SWRCB requested comments on how to address uncertainty, change, and how to implement an adaptive management program.

My goal: provide several suggestions for addressing scientific uncertainty related to the pelagic food web

Outline

1. Tackle key uncertainties regarding Sacramento River as source of pelagic food.
2. When managing flows, consider direct effects of residence time on plankton
3. Incorporate benthic grazing into BDCP Effects Analysis
4. Branch out from cubitainer research

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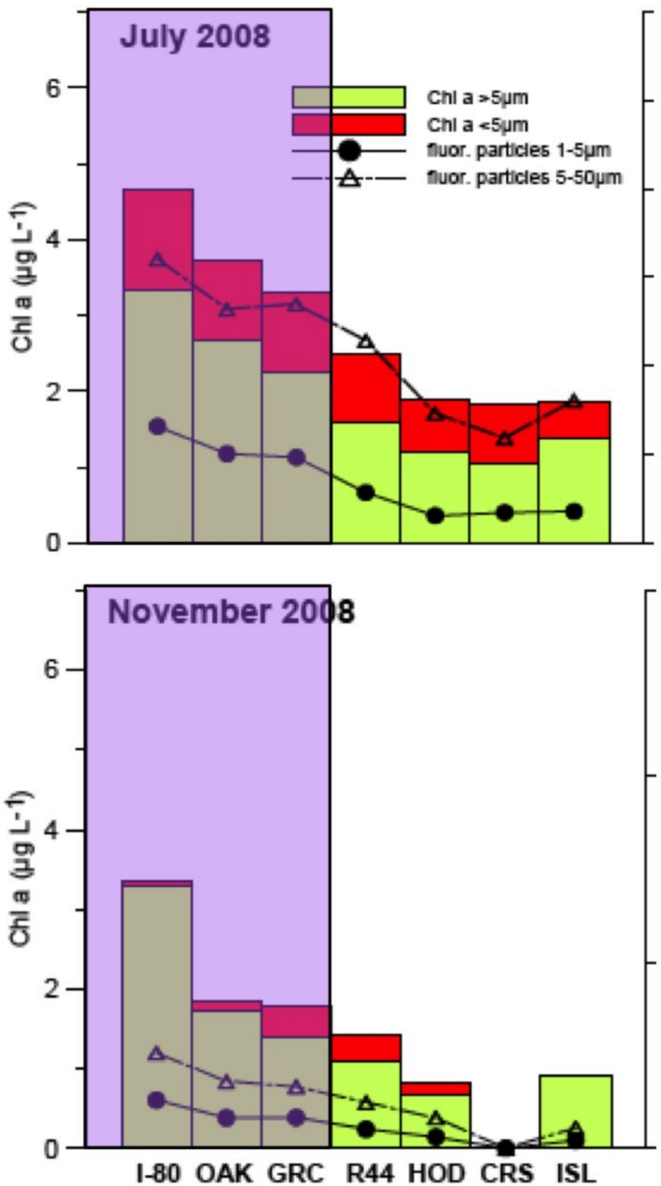
Tackle key uncertainties regarding upstream subsidies of suspended food

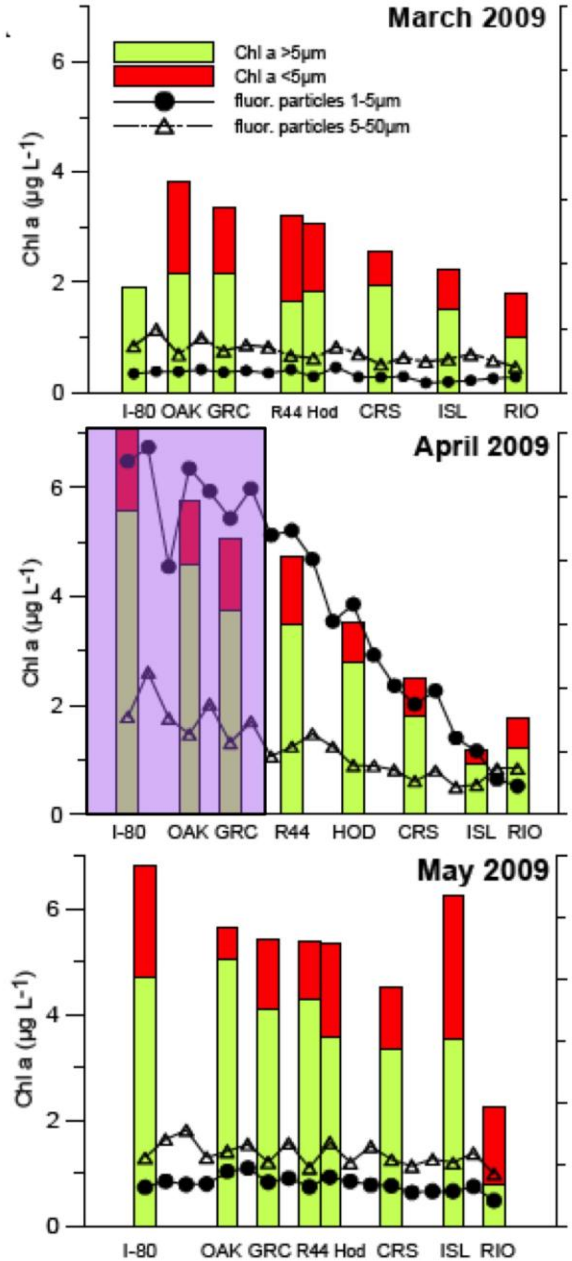
Presumably, plankton transported by the Sacramento River is an important food subsidy for downstream areas.

If so, we should find out why phytoplankton biomass declines in the Sacramento River starting above the City of Sacramento.

Frequently, phytoplankton (including diatoms) decline in the river starting above Sacramento



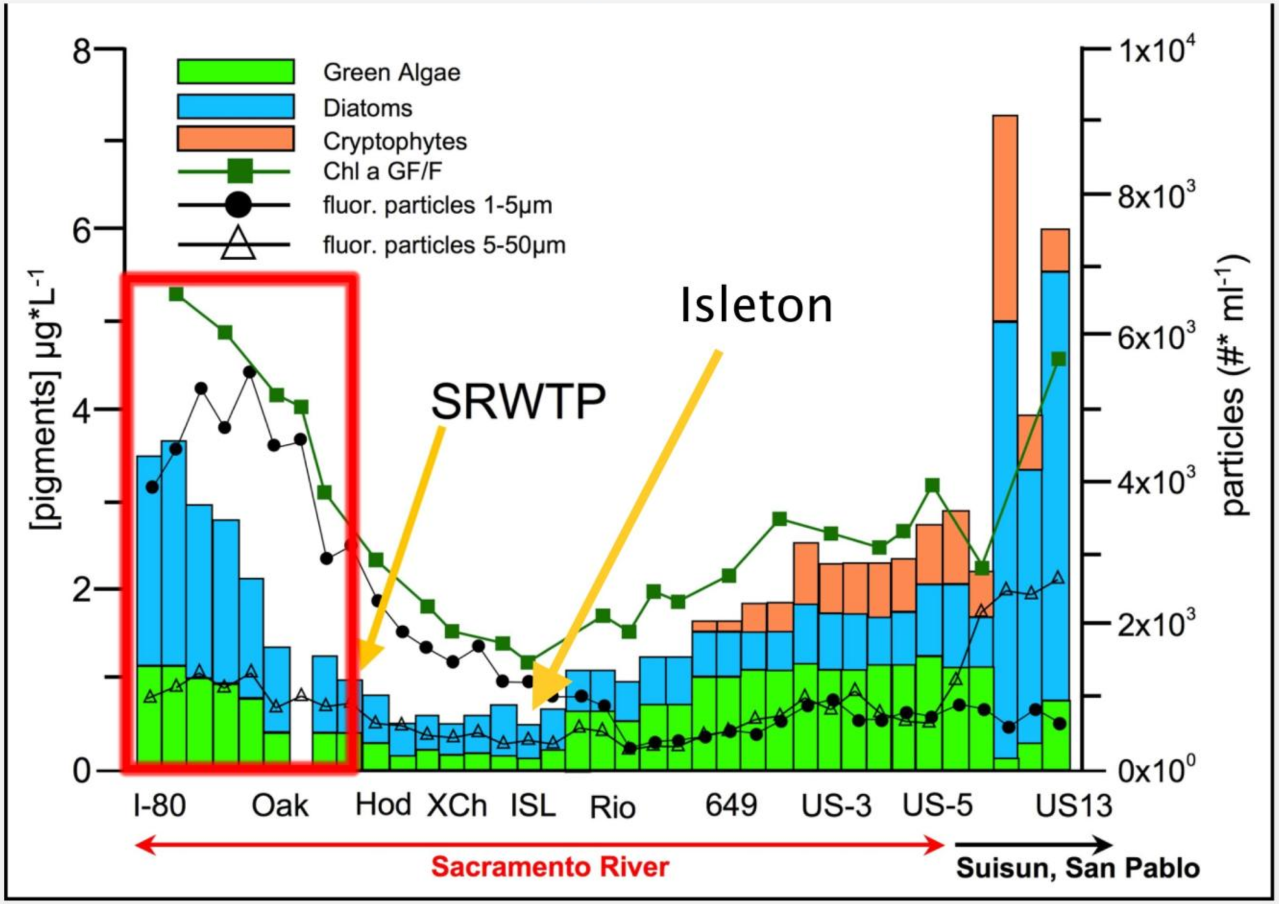
Reach above SRWTP



Figures from Parker et al. (2010) Effect of Ammonium and Wastewater Effluent on Riverine Phytoplankton in the Sacramento River, CA. Report to the Central Valley Regional Water Quality Control Board.

Tackle key uncertainties regarding upstream subsidies of suspended food

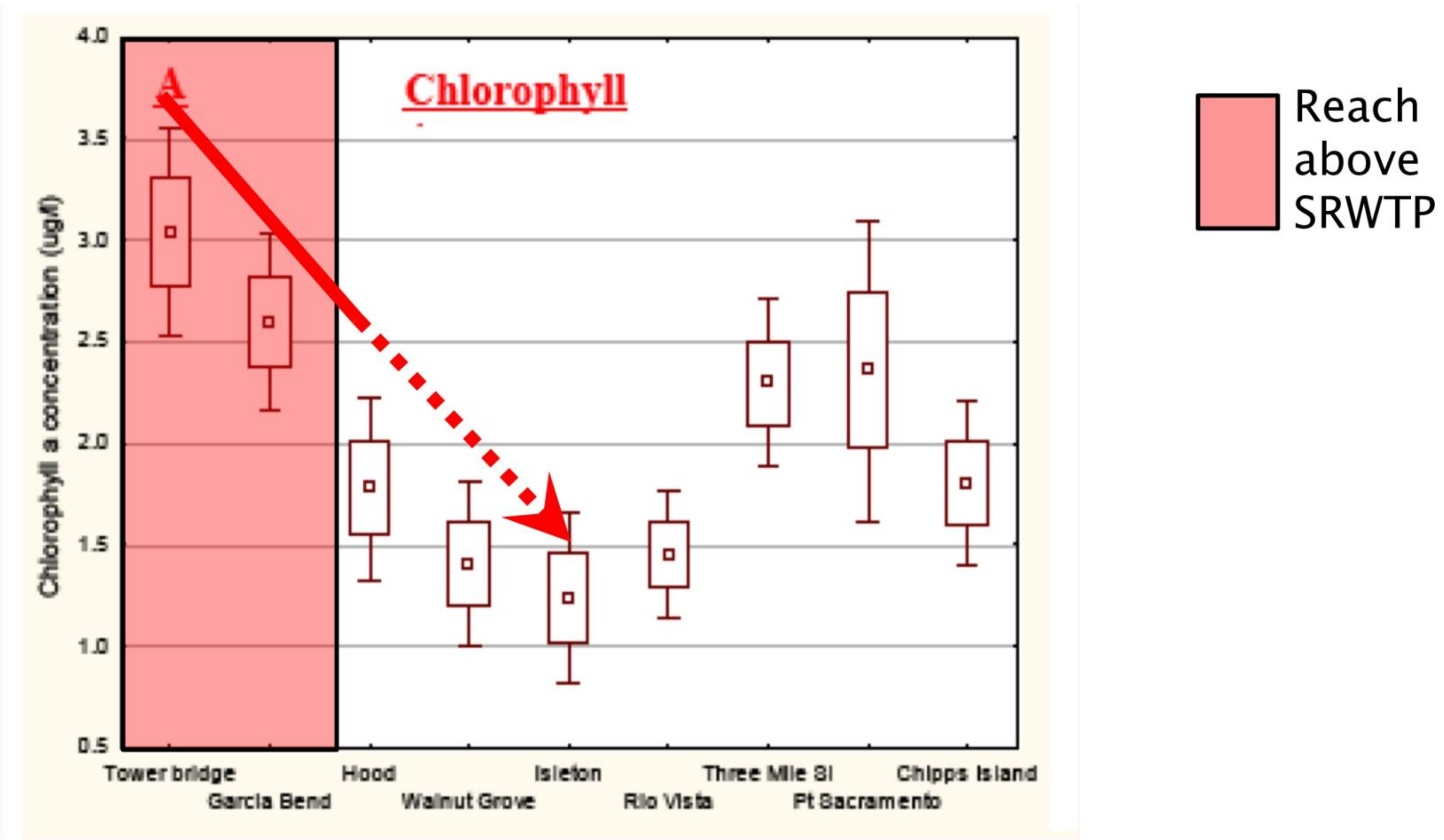
In this dataset, almost all of the downstream diatom loss occurred upstream from SRWTP



Spring 2009

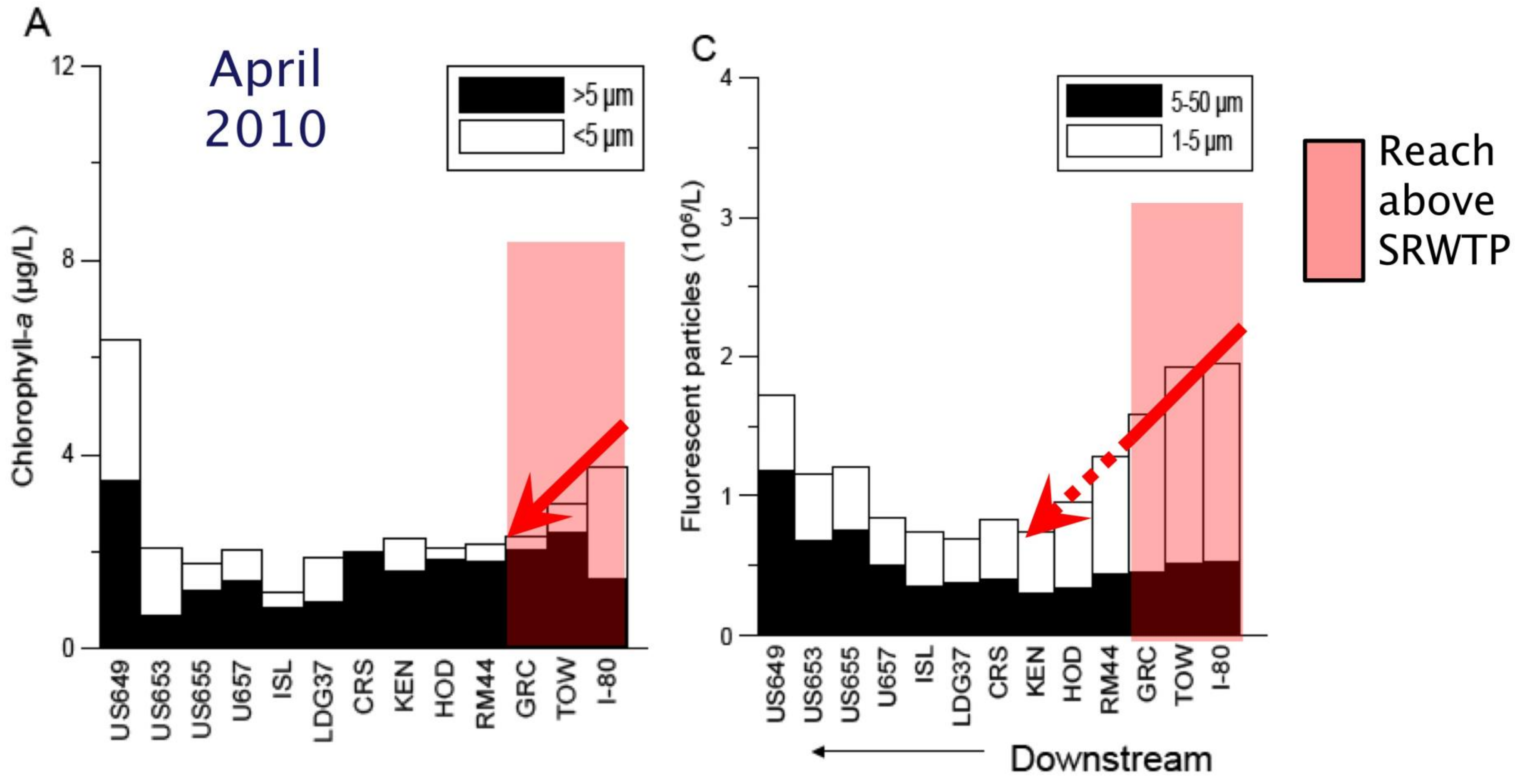
(adapted from Parker et al. (2009) 9th Biennial State of the San Francisco Estuary Conference, Oakland, CA)

2009: Decline in *mean annual* chl.a starting at Tower Bridge



Foe et al. (2010) Nutrient concentrations and biological effects in the Sacramento-San Joaquin Delta. Report to the Central Valley Regional Water Quality Control Board

More recent data also show decline in phytoplankton starting at I-80



adapted from Kress et al. (2012) Assessing phytoplankton communities in the Sacramento and San Joaquin Rivers using microscopic and indirect analytical approaches. IEP Newsletter 25(2): 43-55.

Tackle key uncertainty regarding upstream subsidies of suspended food

Suggestions

1. Conduct research addressing processes that apply to the whole portion of the Sacramento River where patterns are observed.

2. Frequent, finely spaced monitoring starting well above the legal Delta.

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When managing flows, consider effects of residence time on plankton

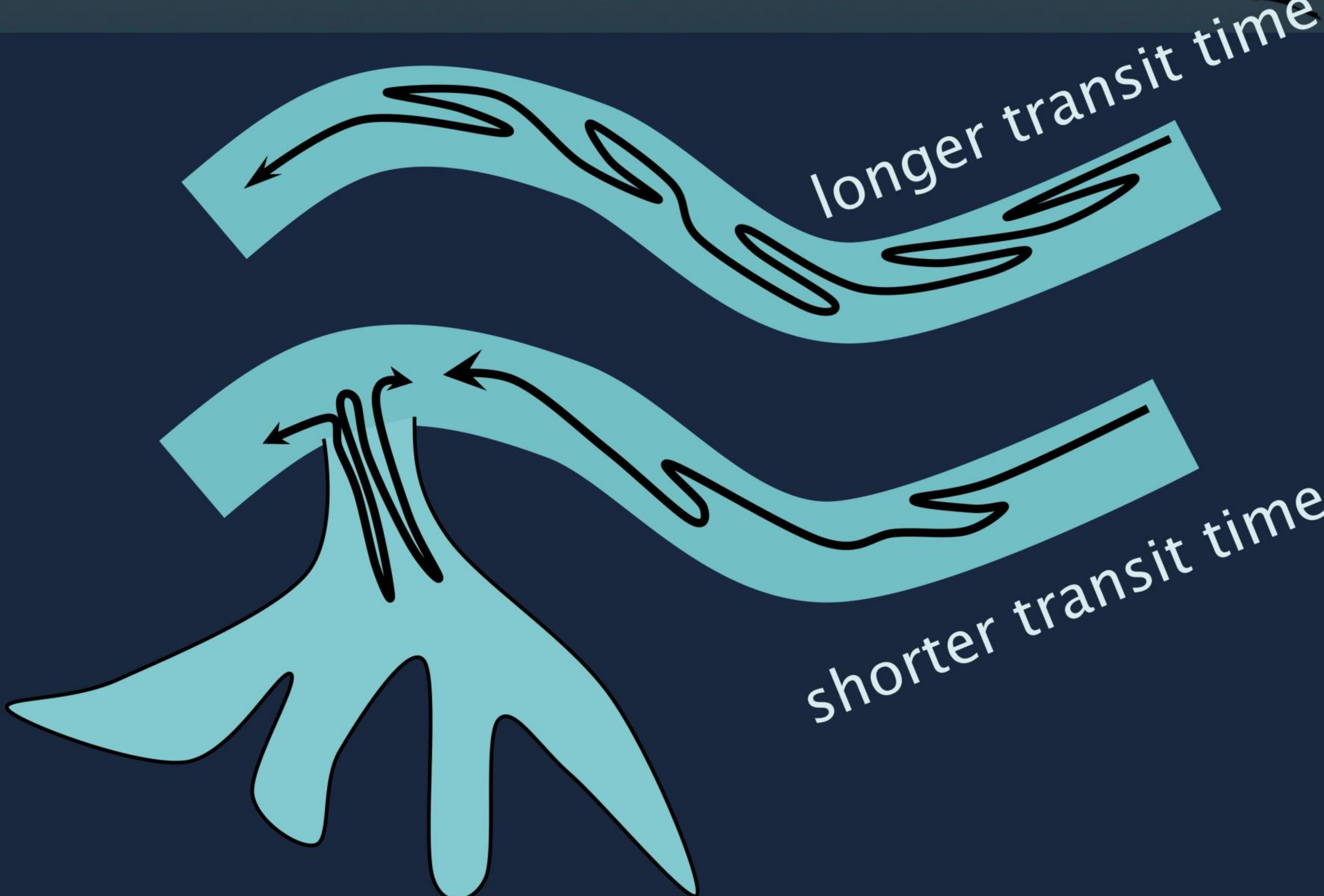
Residence times in Delta water bodies are an outcome of flow management distinct from other outcomes such as maintaining the position of X2.

When managing flows, consider effects of residence time on plankton

Residence time is a driver of the pelagic food web

- Phytoplankton taxa have different intrinsic growth rates. Rates of through-put (residence time) can affect species composition and potential for blooms at specific locations.
- Riverine transport time affects biogeochemical processes.
- Residence time affects contact-time between plankton and "filters" such as beds of clams or aquatic weeds.
- Zooplankton are plankton! (their location and population size also affected by water movement)

When managing flows, consider effects of residence time on plankton



When managing flows, consider effects of residence time on plankton

Suggestion:

Consider whether residence times associated with flow criteria are conducive to “growing” the desired types of plankton in the right places and transporting plankton to the right places.

Infrastructure (by-passes, gates, barriers, diversion points, layout of restored wetlands) might be operated to deliver a range of residence times in key locations in the Delta without compromising other metrics (X2, percent unimpaired flow, etc.).

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Incorporate benthic grazing into BDCP Effects Analysis

Issue:

Habitat restoration component of the BDCP assumes (in part) that new habitat will be net producer of food to fuel pelagic food web.

BDCP Effects Analysis assigned habitat value to future wetlands using a formula that did not account for benthic grazing.

Incorporate benthic grazing into BDCP Effects Analysis

BDCP assigned "prod-acre" scores to ROAs (see Table E.6-1) based on habitat depth in ROAs and a formula from Lopez et al. (2006)* converting depth to primary production.

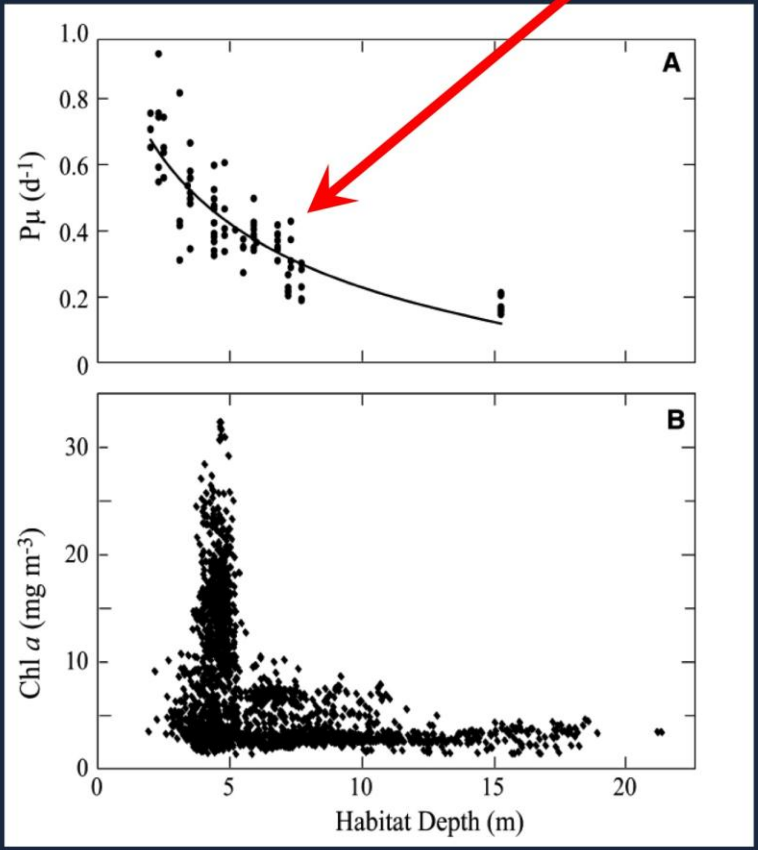
TableE.6-1. Estimated Depth and Area Used to Calculate Phytoplankton Grov

	EBC			
Tidal Strata	**Depth (feet)**	**Phytoplankton Growth Rate**	**Acres**	**Prod-Acres**
Cache Slough Restoration Opportunity Area				
Deep	17.7	0.40	1,773	717
Intertidal	1.8	1.02	5,573	5,692
Shallow tidal	2.6	0.92	178	164
Total	7.37		7,524	6,573
Total without dry	7.37		7,524	

* Lopez et al. (2006) Ecological values of shallow-water habitats: Implications for the restoration of disturbed ecosystems. Ecosystems 9:422-440

Incorporate benthic grazing into BDCP Effects Analysis

Phyto growth rate = 0.86 – 0.27* ln[habitat depth]



The formula estimates *gross* phytoplankton production in shallow habitat – not *net* production after benthic grazing.

Incorporate benthic grazing into BDCP Effects Analysis

In same study referenced by the BDCP, Lopez et al. also determined *net* phytoplankton production after clam grazing rates (Corbicula) were included in their model.

Where water was <6 m deep, sites with clams had ~6X lower maximum net primary production.

"Whereas shallow pelagic systems routinely functioned as net sources of phytoplankton biomass, this trend was not true when we accounted for losses to Corbicula"

"Our results show that Corbicula colonization will determine a habitat's value to the pelagic food web"

Incorporate benthic grazing into BDCP Effects Analysis

Corbicula are ubiquitous in the freshwater Delta:

Spring 2012 IEP Newsletter characterized Corbicula as "abundant year-round" in 2011 at:

- D24 – Rio Vista
- D16 – near Twitchell Island
- D28A – Old River
- P8 - Stockton
- C9 – Clifton Court forebay intake
- D4 – Confluence (upstream from Chipps Island)

Incorporate benthic grazing into BDCP Effects Analysis

Suggestions

- Adjust habitat value scores for the ROAs:
  1. use rational estimates for clam colonization rates in ROAs, and
  2. apply tipping points to predict how much new habitat will be a net sink (not net source) of phytoplankton

- Employ adaptive management:

  Observe clam colonization rates in early restoration. Alter restoration strategy (connectivity, inundation depths, locations) if new habitat is operating as net sink for primary production.

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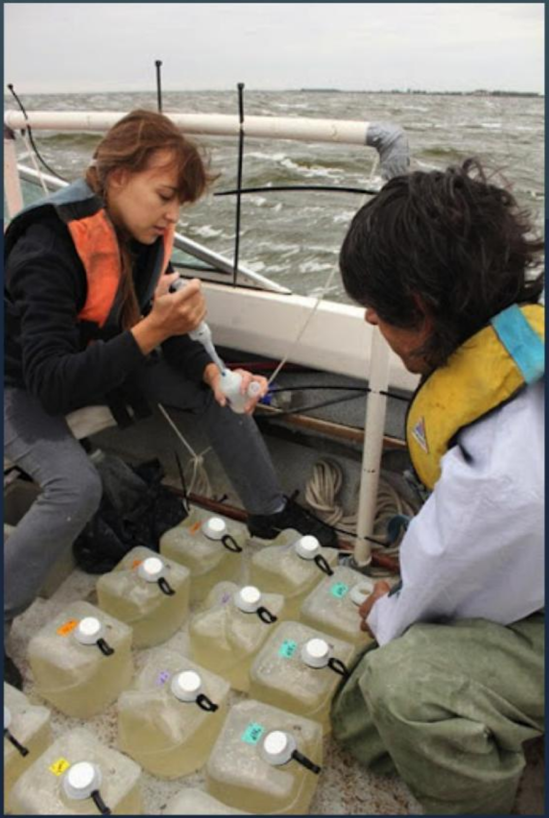
Branch out from cubitainer research



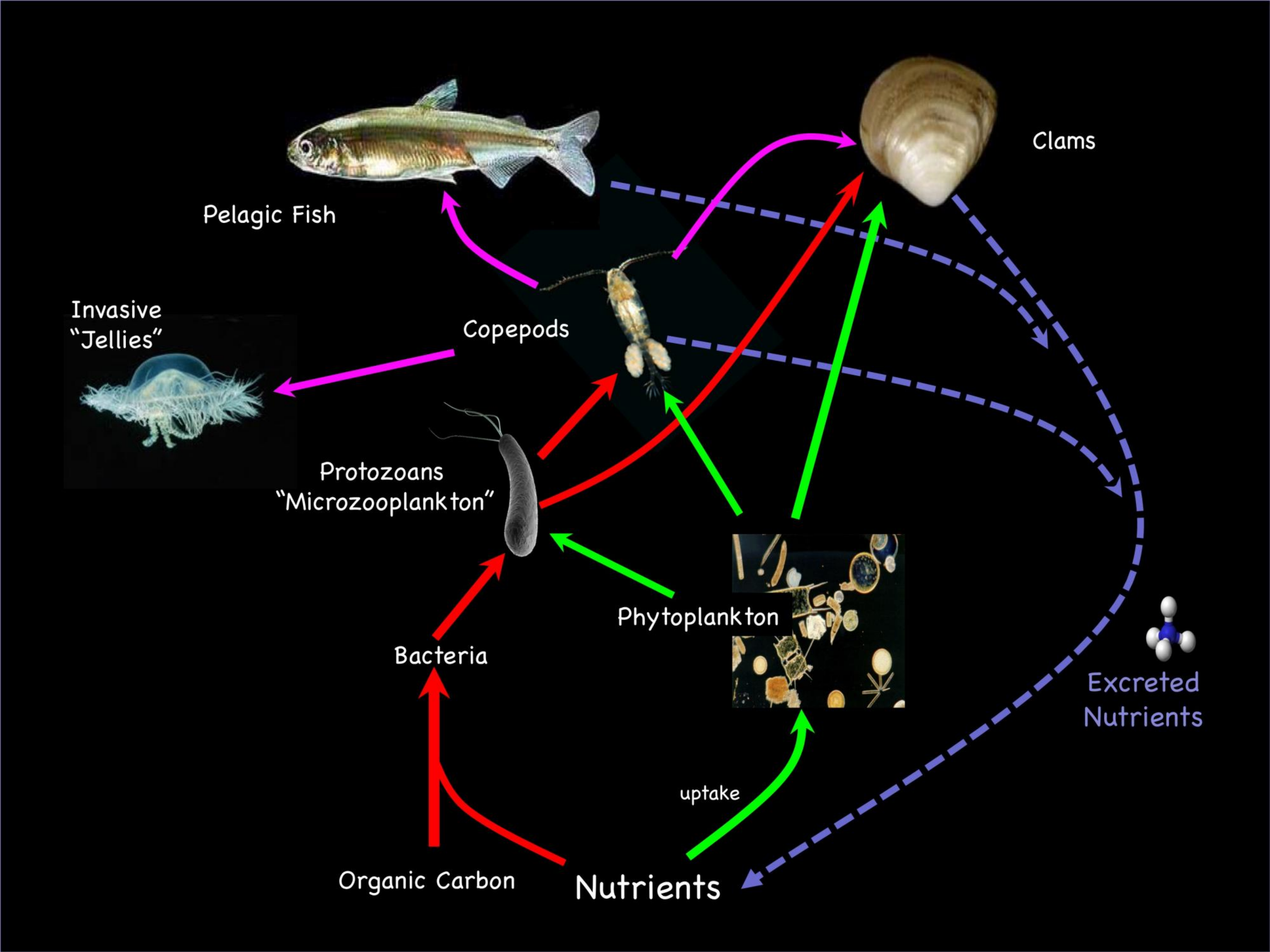
Issue: Short-term experiments using small, closed containers ("cubitainers") have been the principal direct approach used to investigate nutrient effects on phytoplankton in the Delta

- Wilkerson et al. (2006) Estuaries and Coasts
- Dugdale et al. (2007) Estuarine, Coastal & Shelf Science
- Parker et al. (2012) Marine Pollution Bulletin
- Parker et al. (2012) Estuarine, Coastal & Shelf Science
- Dugdale et al. (2012) Estuarine, Coastal & Shelf Science (in review/ in press)

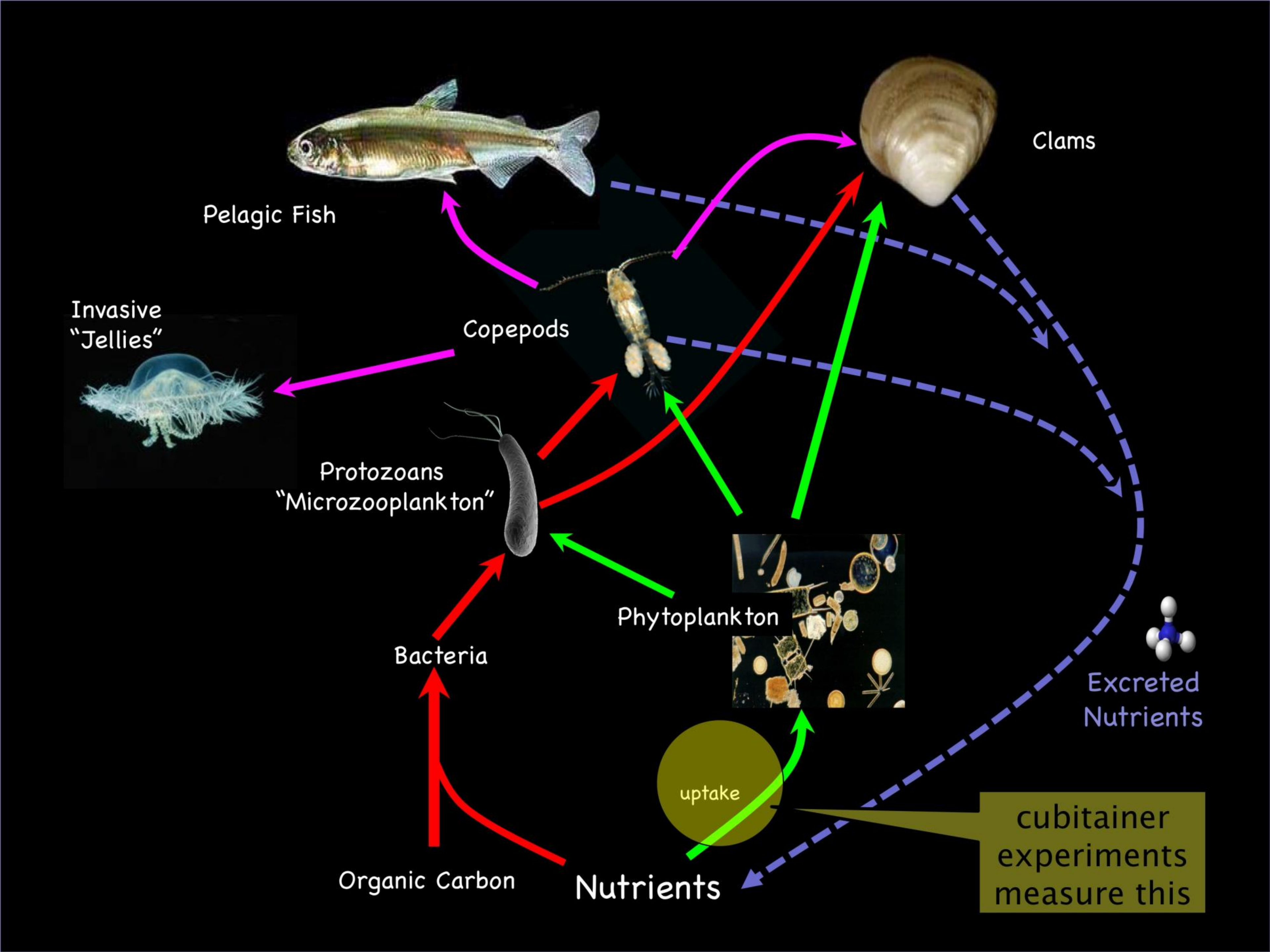
Branch out from cubitainer research

Short-term, small, closed-container experiments won't lead to consensus regarding whether the SFE ***food web*** is driven by nutrient concentrations or ratios...

(in my opinion)



Clams
Pelagic Fish
Invasive
"Jellies"
Copepods
Protozoans
"Microzooplankton"
Phytoplankton
Bacteria
Excreted
Nutrients
uptake
Organic Carbon
Nutrients



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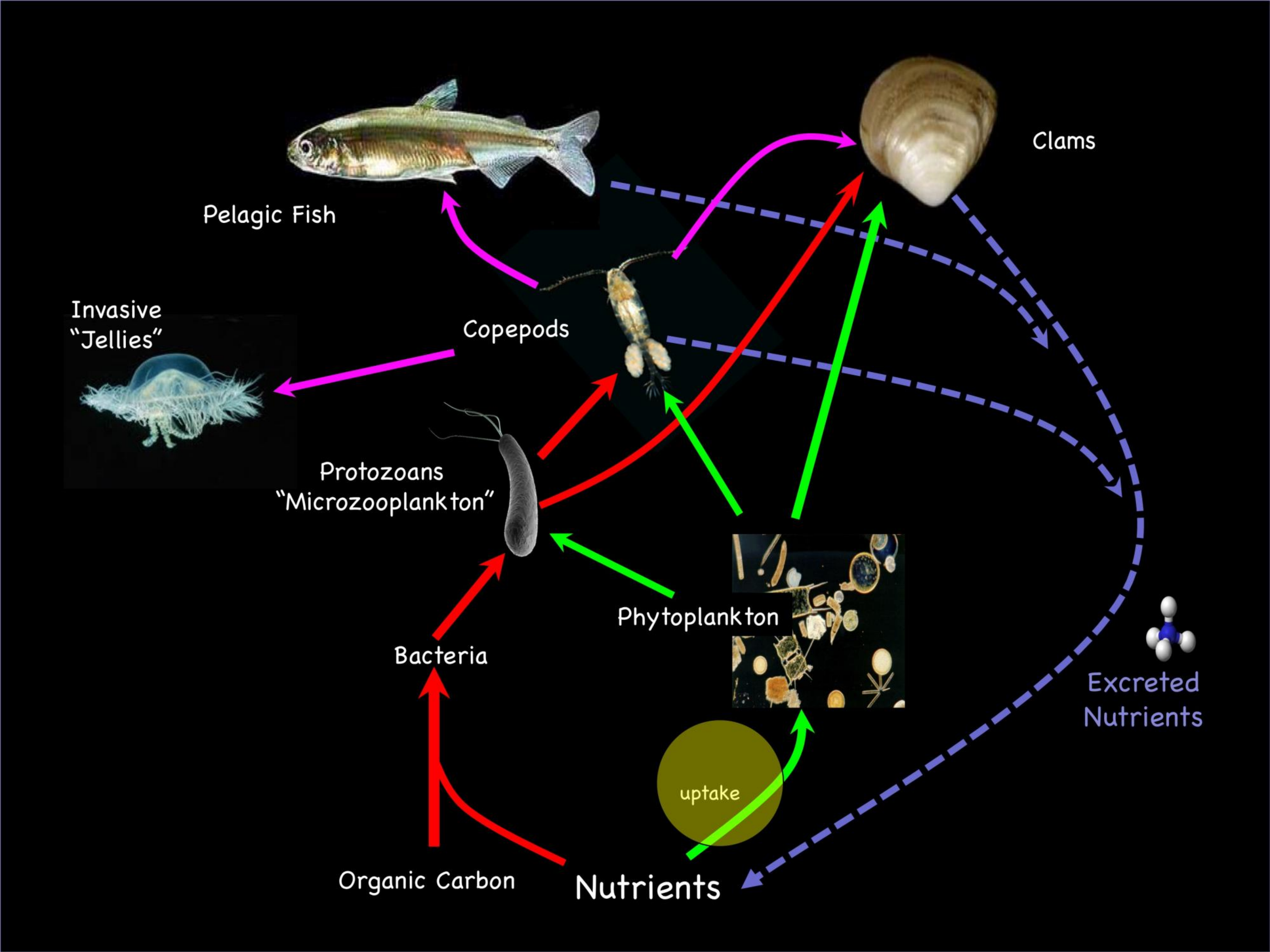
Branch out from cubitainer research

Small container experiments also can't demonstrate influence of...

1. competition between zooplankton
2. toxic effects of some diatoms on copepods
3. clam grazing on phytoplankton and zooplankton
4. exposure to variable light levels from circulation in the water column
5. effect of residence time (no flow-through in current design)
6. vertical migrations of phytoplankton and zooplankton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Suggestion for future experimental work:

Conduct larger scale, long-term (ideally flow-through) mesocosm research

- deep to allow vertical migrations by plankton and variable light and temperature fields
- populated with zooplankton and maybe even clams (perhaps using suspended colonization plates?)
- plumbed to allow manipulation of residence time
- run long enough to have multiple generations of zooplankton and successional sequences of algae








Summary

1. Tackle key uncertainties regarding Sacramento River as source of pelagic food. Address the whole pattern, not part of it.
2. When managing flows, consider direct effects of residence time on plankton. Within constraints of X2 or other metrics, achieve residence times that are beneficial for plankton quality and quantity.
3. Incorporate benthic grazing into BDCP effects analysis. Account for possibility that new habitat can become a net sink for phytoplankton when colonized by Corbicula.
4. Branch out from cubitainer research. We can perform experiments that include more of the food web.

Thank you!