

Ammonia (um) Summit: 18 August 2009

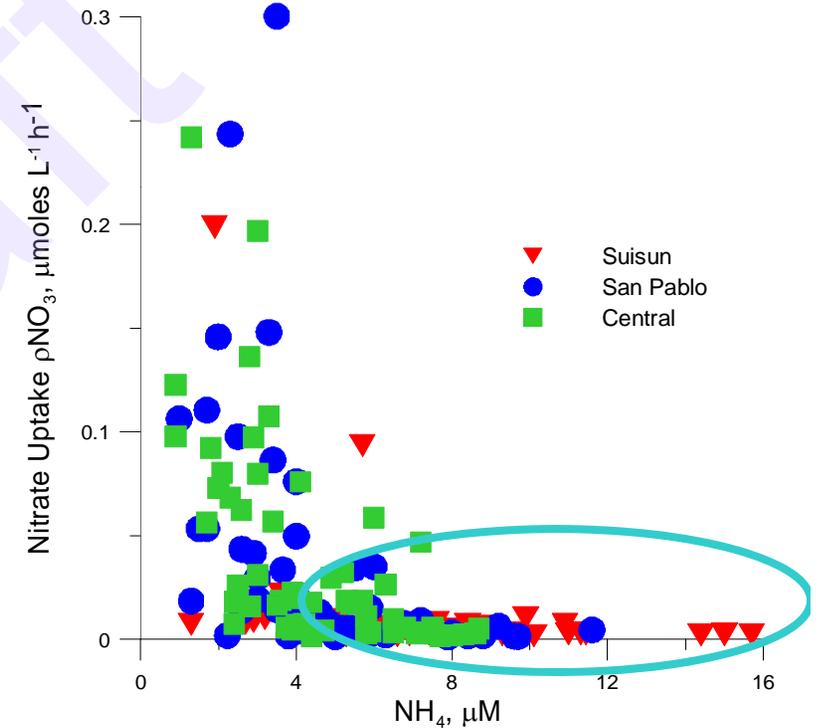
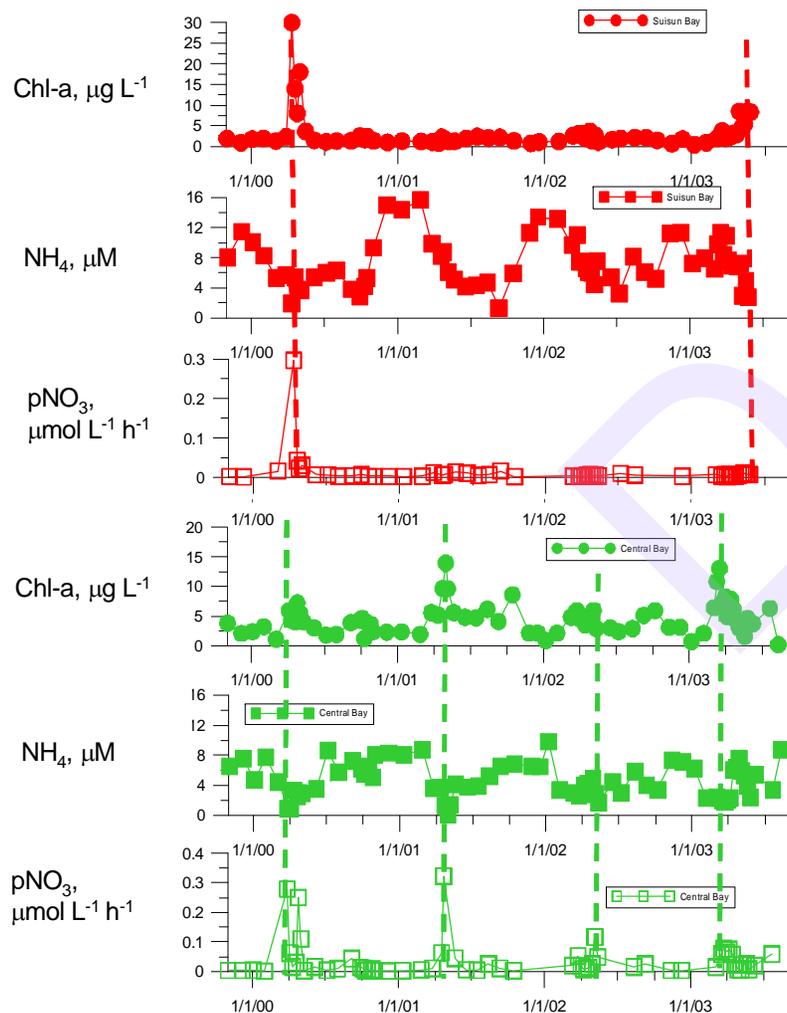
***Is there suppression of algal
production in Suisun Bay?***

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Funded by CALFED and State Water Contractors
(Stop work order- data collected –work in progress)

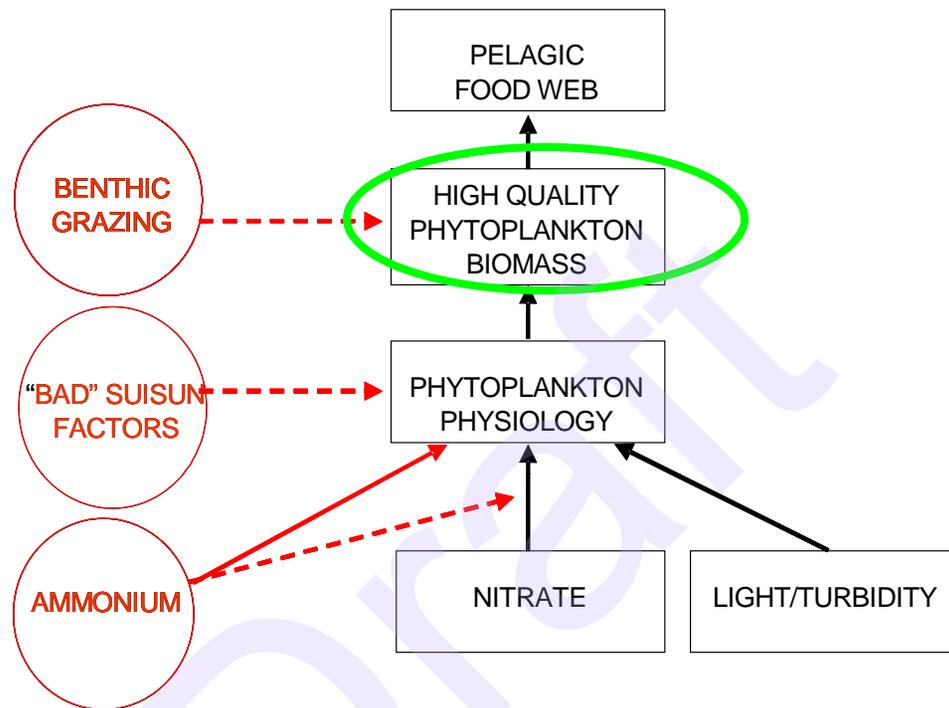
Background: spring bloom in **Suisun** observed only when ambient ammonium (NH_4) low and uptake of nitrate (NO_3) by phytoplankton is high. For chlorophyll accumulation, need to access NO_3 .



Possible mechanism: NH_4 inhibits phytoplankton access to NO_3

Wilkerson et al., 2006; Dugdale et al. 2007

Influence on Pelagic Food Web?



- Phytoplankton are important in the pelagic food web and POD
- A number of factors affect phytoplankton quantity and quality
- **Our question: what is the role of NH_4 in addition to these other factors**
- Our approach is to remove other factors-such as light and benthic grazing and look at potential of phytoplankton for production and chlorophyll accumulation. Use enclosures/grow outs.

Grow Out/Productivity Indicators: used to investigate whether NH_4 delays the initiation of phytoplankton blooms



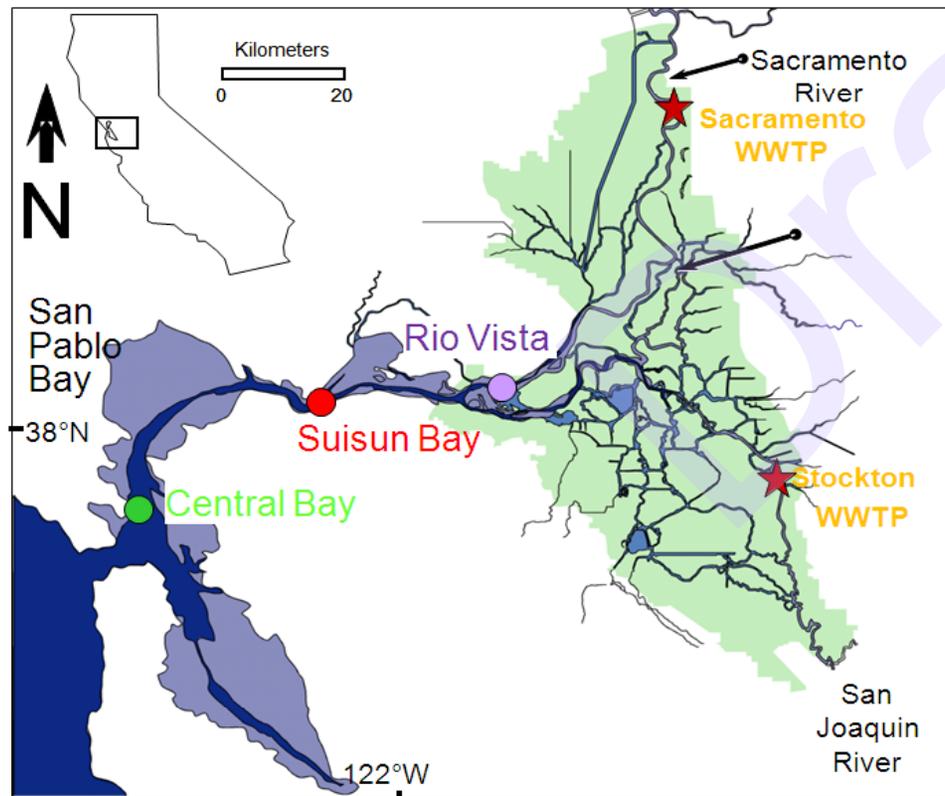
20-L cubitrainers filled with surface water, maintained at 50% surface light, sampled for 5 -7days. This removes any light limitation and benthic grazing

Questions addressed:

1. Given ideal conditions can chlorophyll accumulate as phytoplankton drawdown all available N?
2. Does NH_4 limit access to NO_3 , and delay the time for chlorophyll accumulation?

CALFED Funded Bad Suisun (BS) Project Station and Grow Out Data

Seven BS cruises (2007-8) to compare **Suisun Bay** with **Central SF Bay** and **Rio Vista**



Data shown today- mostly grow out data of **chlorophyll** **nitrate & ammonium** (NO_3 & NH_4 uptake) **(C uptake/fixation)**

NOTE: concentration units used are μM , relevant level for phytoplankton physiology

$1.5 \mu\text{M} = 0.02\text{mg N/L} = 0.02\text{ppm}$

Central Bay Grow Outs (“healthy” controls)

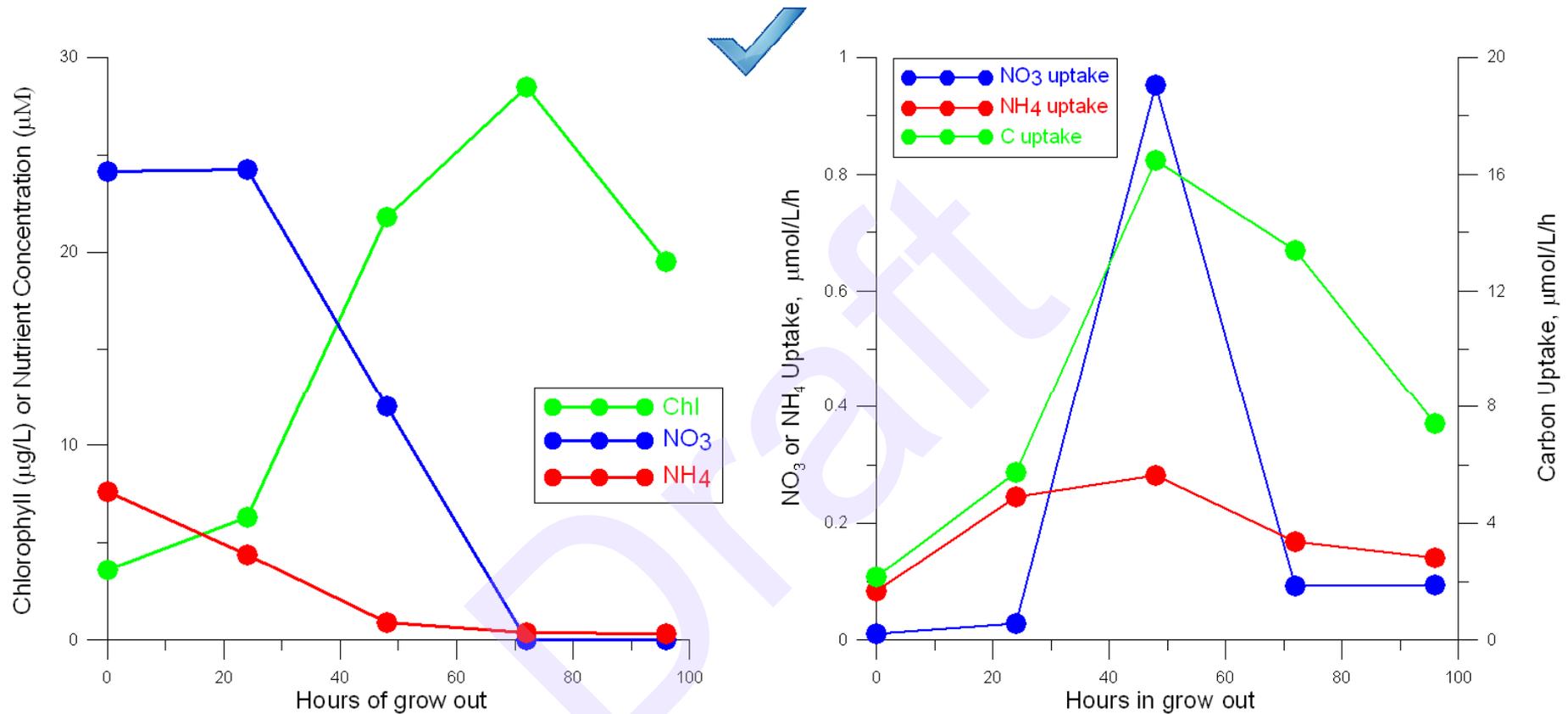
Central Bay used as a “healthy” control in which:
chlorophyll accumulates on a time scale of 48h

- First NH_4 is drawn down to zero
- Then NO_3 can be accessed and is drawn down to zero
- Greatest chlorophyll accumulation when NO_3 used.
- Carbon uptake tracks NO_3 uptake, and both show increased rates

Time scale is critical for chlorophyll accumulation.
In nature, need favorable light and water column stability. If time scale is drawn out there is a decreased chance for favorable light conditions

These are used to assess time scale and phytoplankton condition from other parts of SFB.

Central Bay Grow Out from BS3: June 2007



- Chlorophyll accumulation by 48h, matches DIN depletion
- NH₄ drawdown, then NO₃ drawdown completed by 72h
- Maximal NO₃ uptake > NH₄ uptake, C fixation tracks NO₃

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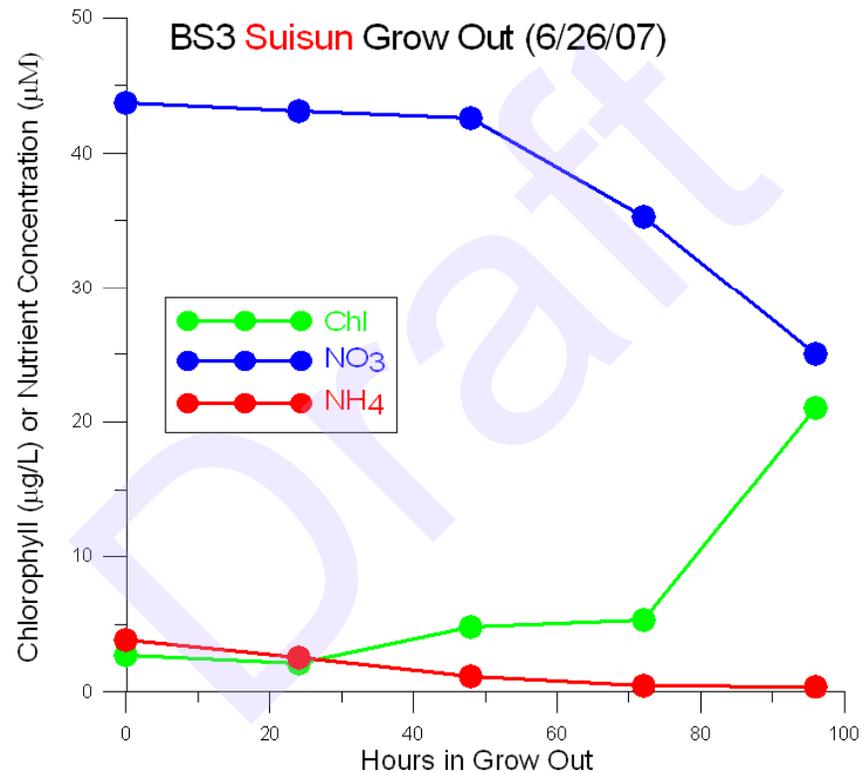
How do **Suisun Bay** phytoplankton compare? How do **Rio Vista** phytoplankton compare?

For each BS cruise/grow out, the time scale of chlorophyll accumulation and nutrient drawdown, will be shown.

For some also the nutrient and C uptake rates- available but we have a lot of data to analyze....

- ✓ If the data is similar to Central Bay, with chl accumulation (and N draw down) by 48 hours
- (X) Poor performer-chl accumulation delayed, some chlorophyll accumulation by 96 hours
- X Bad performer-no chlorophyll accumulation (or N draw down) by 96 hours

Susiun Bay Grow Outs: Example, June 2007



(X)

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Susiun Bay Grow Out Summary

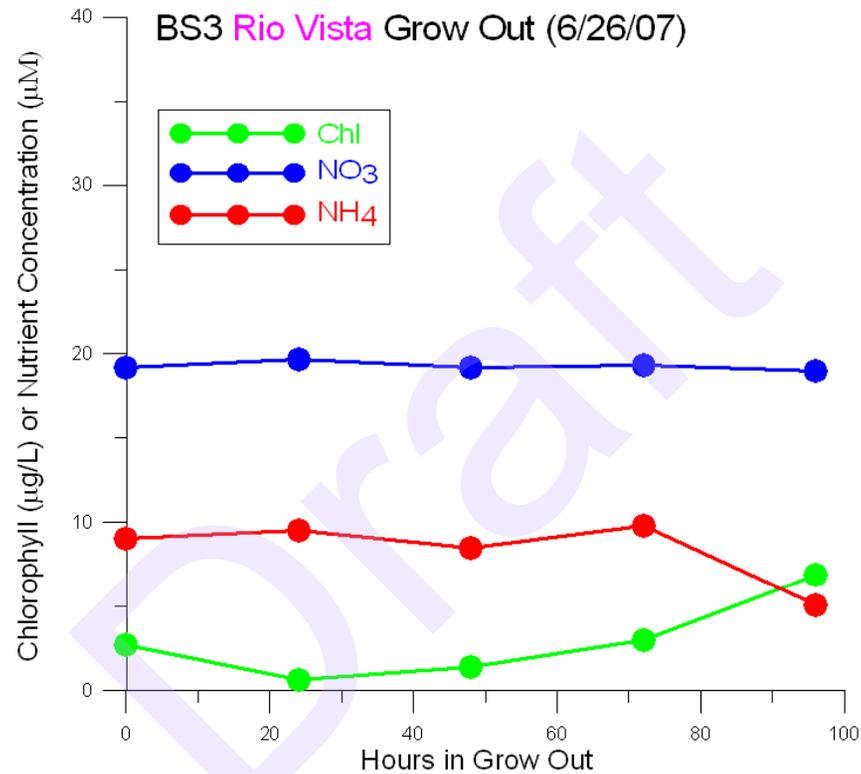
	CENTRAL	BS1	BS2	BS3	BS4	BS5	BS6	BS7
Performance		(X)	(X)	(X)	(X)	(X)	X	(X)
Chl accumul = N drawdown	Y	Y	N	Y	Y	Y	N	N
NH ₄ to zero by 48h?	Y	N	N	N	N	N	N	N
NO ₃ to zero by 72h?	Y	N	N	N	N	N	N	N
Initial NH ₄ , μM		3.9	6.3	3.8	3.9	8.7	4.4	6.6

Suisun Bay phytoplankton when given optimal conditions in grow outs show suppressed response vs. **Central Bay**.

- a delay in chlorophyll accumulation
- inability to drawdown all NH₄ by 48h

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Example of Rio Vista Grow Outs: June 2007



X

Init NH₄ = 9 µM

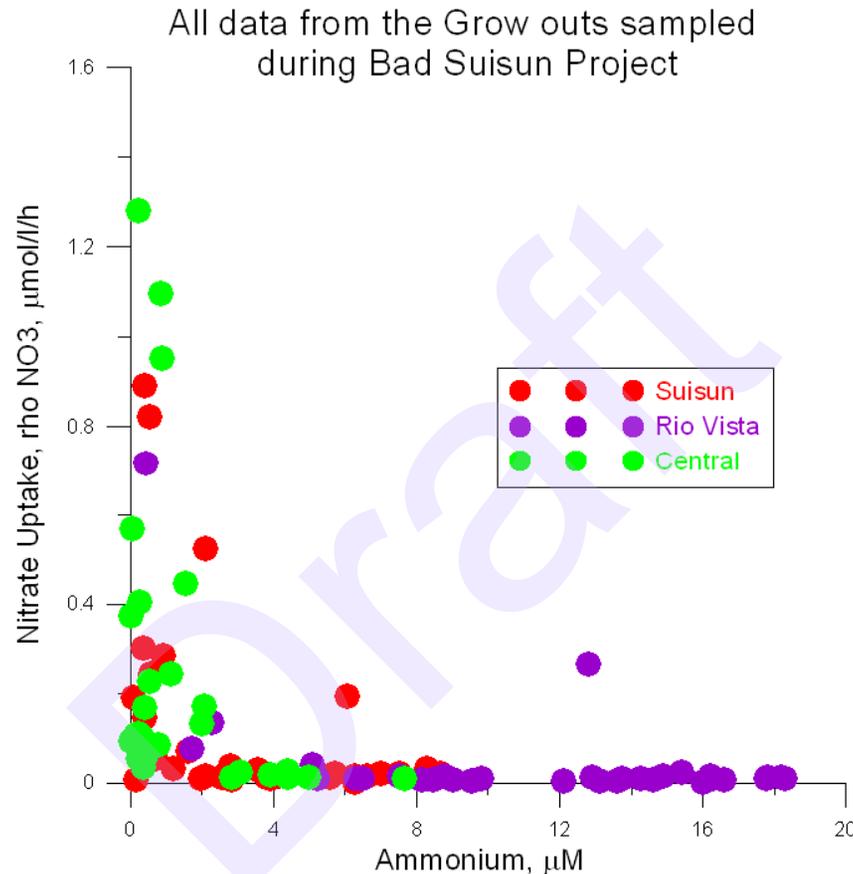
Rio Vista Grow Out Summary

	CENTRAL	BS1	BS2	BS3	BS4	BS5	BS6	BS7
Performance	✓ 	X	(X)	X	X	(X)	X	X
Chl accumul = N drawdown	Y	N	N	N	Y	N	N	N
NH ₄ to zero by 48h?	48	N	N	N	N	N	N	N
NO ₃ to zero by 72h?	72	N	N	N	N	N	N	N
Initial NH ₄ , μM		14.6	7.5	9.0	7.0	16.2	15.4	18.2

Rio Vista phytoplankton when given optimal conditions in grow outs show more suppressed response than Suisun Bay .

- longer delay in chlorophyll accumulation
 - chlorophyll accumulation does not match N drawdown
 - unlike Suisun, NH₄ rarely drawn down to zero
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Does the ambient NH_4 play a role?



Central Bay and Suisun can take up NO_3 ,
Rio Vista with more NH_4 shows less capacity.
Higher ambient NH_4 , and consequent low NO_3 uptake
extends the time for N draw down and chlorophyll
accumulation.

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Another approach – look at ability to use NO_3 – f-ratio

One way to look at productivity state is to use concept from oceanography that determines the percent NO_3 uptake relative to the total DIN uptake (f-ratio = $\rho\text{NO}_3 / \rho\text{NO}_3 + \rho\text{NH}_4$).

Two productivity patterns;

- low f-ratio, low NO_3 uptake-based production with low C uptake (ρC) and chlorophyll vs
- higher f-ratio, NO_3 based production with high C uptake and chlorophyll.

Suisun and Rio Vista are poor performers with low f-ratio

	NO₃	NH₄	Chl	C Uptake	NO₃ Uptake	NH₄ Uptake	f-ratio
	μM	μM	μg/L	μmol/L/h	μmol/L/h	μmol/L/h	
Central	10.6	0.72	20.4	15.194	0.652	0.147	0.82
Suisun	36.8	4.36	3.1	0.994	0.031	0.125	0.20
Rio Vista	25.8	11.68	1.6	0.394	0.008	0.048	0.15

The low f-ratio productivity pattern occurs in **Suisun** and **Rio Vista**
Little use of NO₃, low C uptake and chlorophyll accumulation

What about the river?

Initial conditions..... transect data from 2009

	NO ₃	NH ₄	Chl	C Uptake	NO ₃ Uptake	NH ₄ Uptake	f-ratio
	μM	μM	μg/L	μmol/L/h	μmol/L/h	μmol/L/h	
GRC	9.36	0.84	4.6	0.376	0.037	0.031	0.54
RM44	8.57	7.4	4.4	0.283	0.009	0.048	0.16

Interestingly the river rates show low C uptake and N uptake but Garcia Bend is using NO₃ to fuel production (f-ratio =0.5) vs River Mile 44 which is using mostly NH₄, and has very low f-ratio like **Suisun**.

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However, in grow outs the river phytoplankton can accumulate chlorophyll

Garcia
Bend



River
Mile 44



Behavior upstream appears to be different. When given optimal conditions in grow outs, chlorophyll accumulates like **Central** Bay (draw down all DIN) with slightly longer time scale (72h vs 48h in **Central** Bay).

Summary

Questions addressed using the grow outs during the BS Project:

1. Given ideal conditions can chlorophyll accumulate as phytoplankton draw down all available N?
2. Does NH_4 limit access to NO_3 and delay the time for chlorophyll accumulation?

Chlorophyll accumulation over 48h can occur in **Central Bay** with complete drawdown to zero of first NH_4 , then NO_3 .

Suisun and **Rio Vista** are poor performers and barely start to accumulate chlorophyll after 48h that may be associated with higher ambient NH_4 , low f-ratios and less use of NO_3 and delays the time for chlorophyll accumulation to at least 96h or longer.

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Consequence for phytoplankton biomass and the POD?

This extended time scale for chlorophyll accumulation in **Suisun** and **Rio Vista** grow outs suggests that in situ there is a decreased chance for the algae to have sufficient water stability and available light for growth. NH_4 is likely a bottom up factor to the POD.

Is there suppression of algal production in Suisun Bay?

Yes- algal production (and nutrient drawdown) in **Suisun Bay** is suppressed, but more so at **Rio Vista** and this can be linked to their availability to use nitrogen on appropriate time scales.