

Effect of wastewater treatment plant effluent on algal productivity in the Sacramento River Part 1: Grow-out and wastewater effluent addition experiments

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August 18, 2009

River Grow-Out Experiments

20-L enclosures were used to investigate the potential timing and magnitude of Sacramento River phytoplankton blooms by removing light limitation.

- A. Does NH_4 inhibit NO_3 uptake?
- B. Is there a difference in rates of phytoplankton N assimilation for NH_4 and NO_3 ?
- C. Does NH_4 delay the initiation of phytoplankton blooms?



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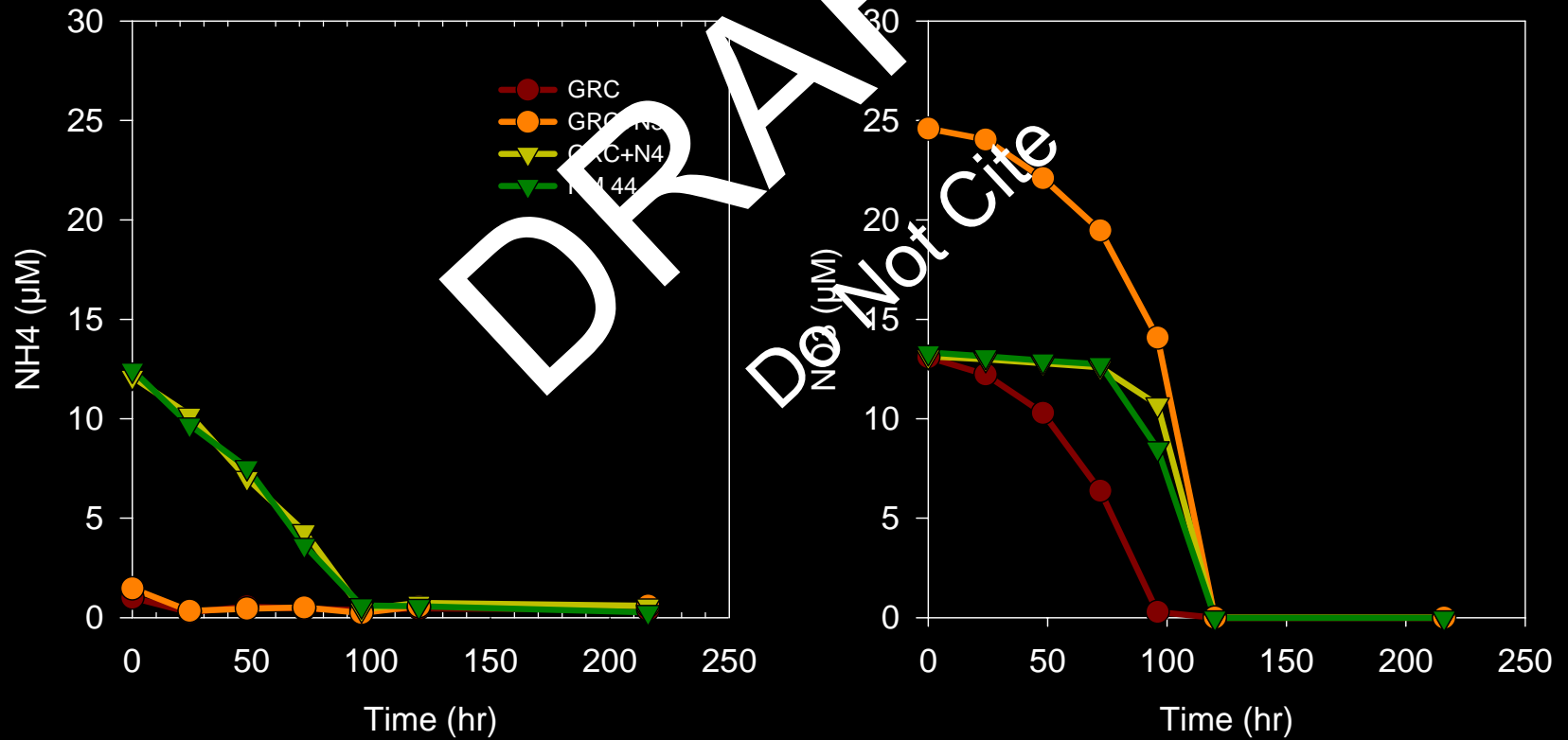
Phytoplankton will only assimilate NH_4 as long as NH_4 concentrations are found in excess of inhibitory concentrations.

Maximum specific NH_4 uptake rates by phytoplankton will be lower than maximum specific NO_3 uptake.

Initiation of phytoplankton increase will be delayed as a function of initial NH_4 concentration.

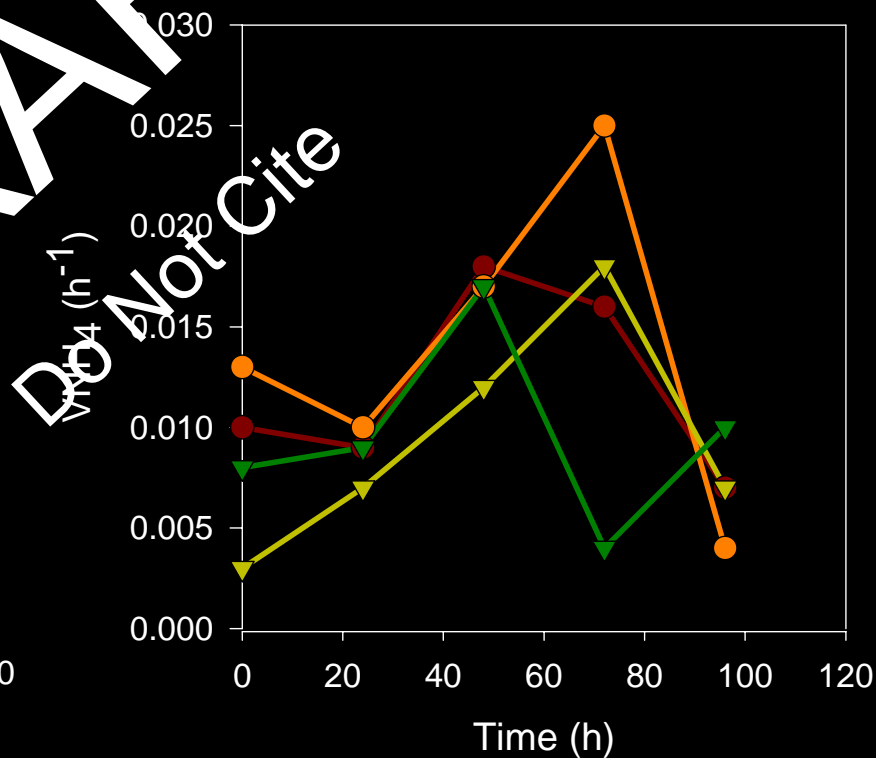
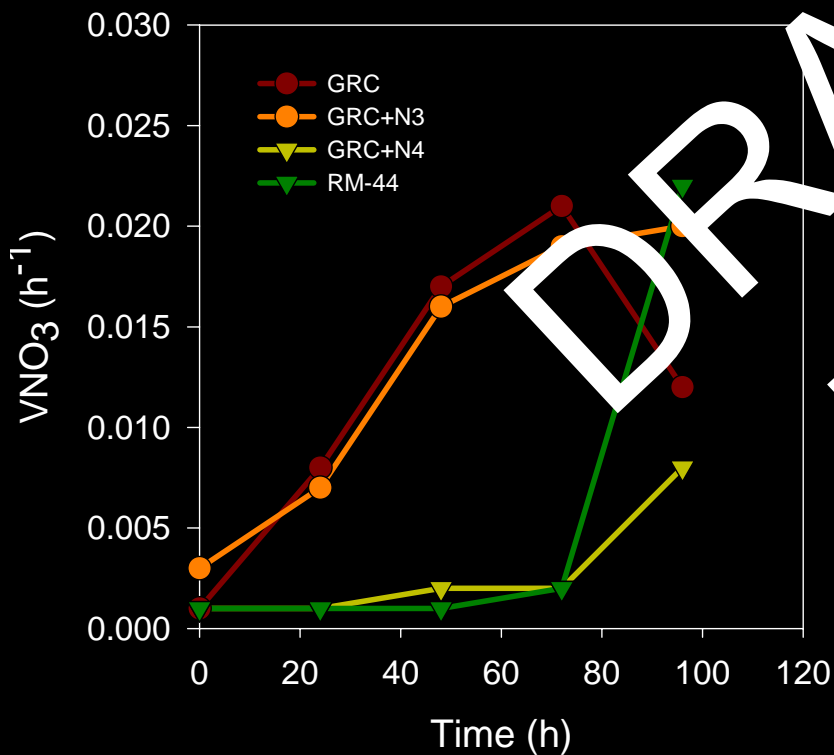
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March 2009 Enclosure Experiments



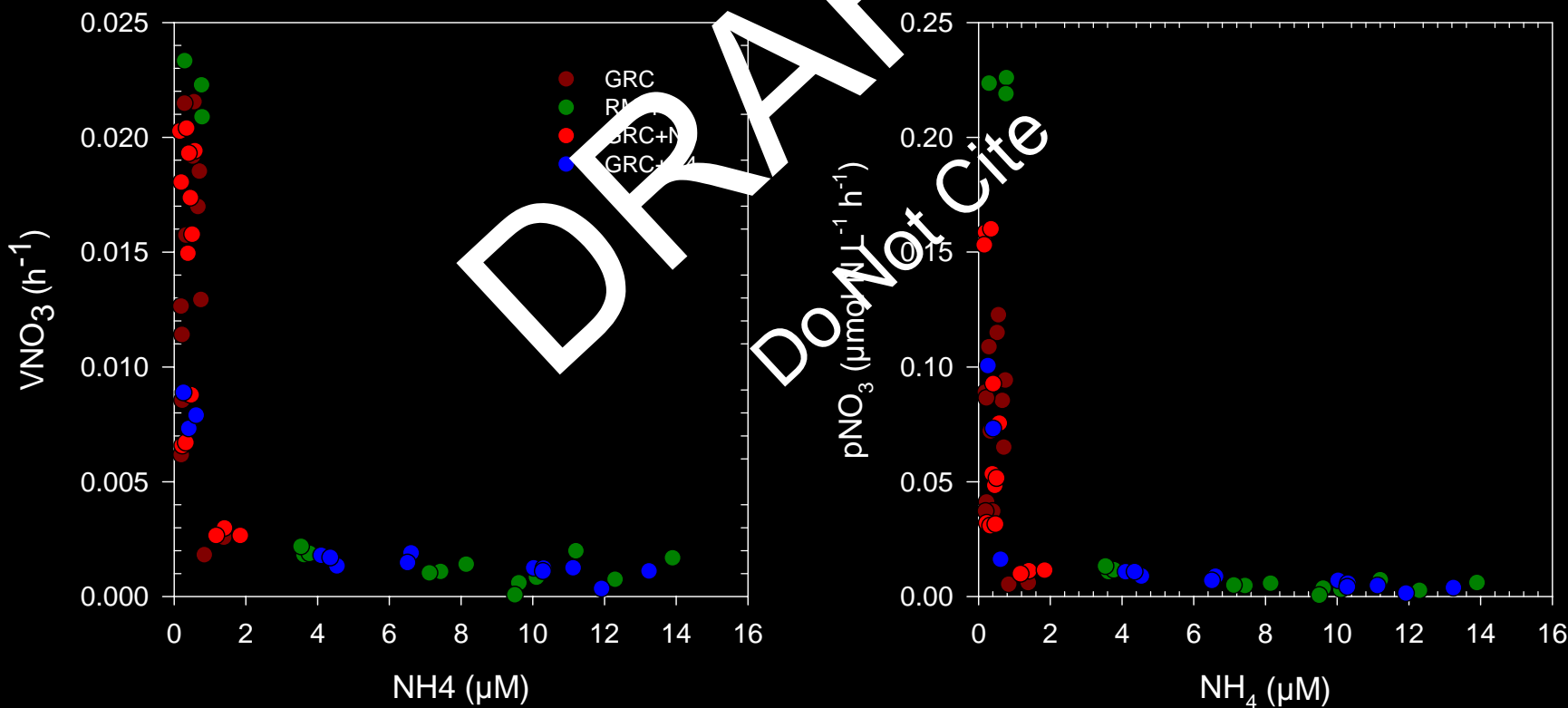
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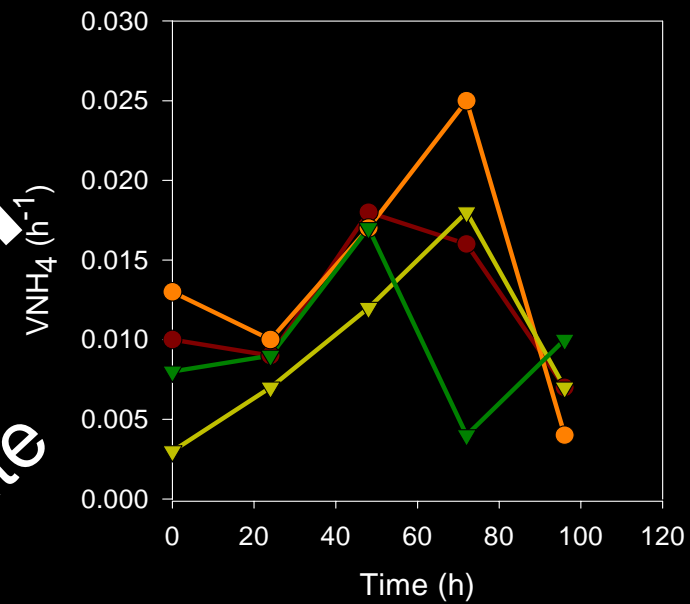
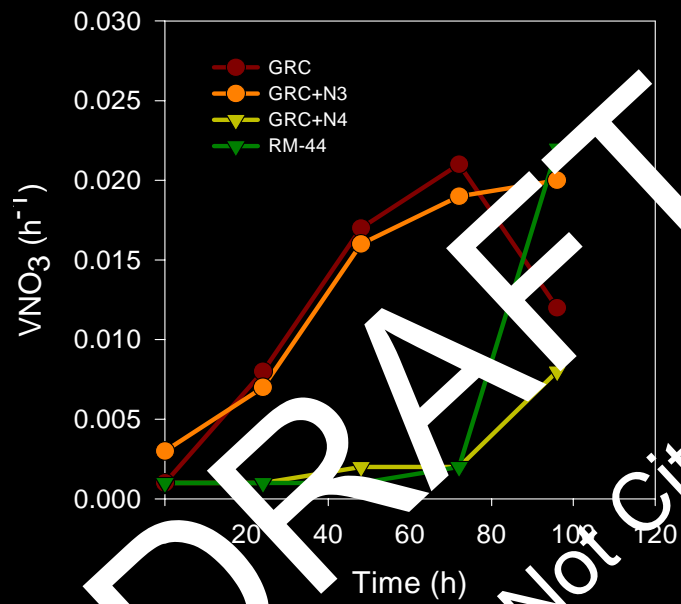


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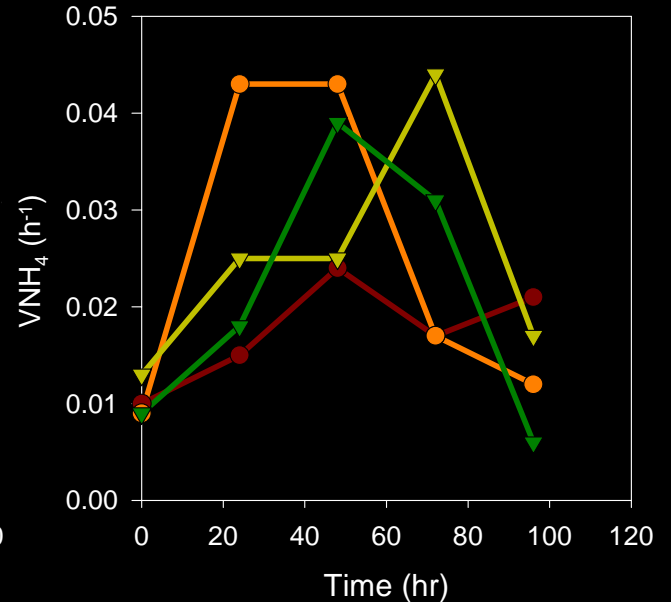
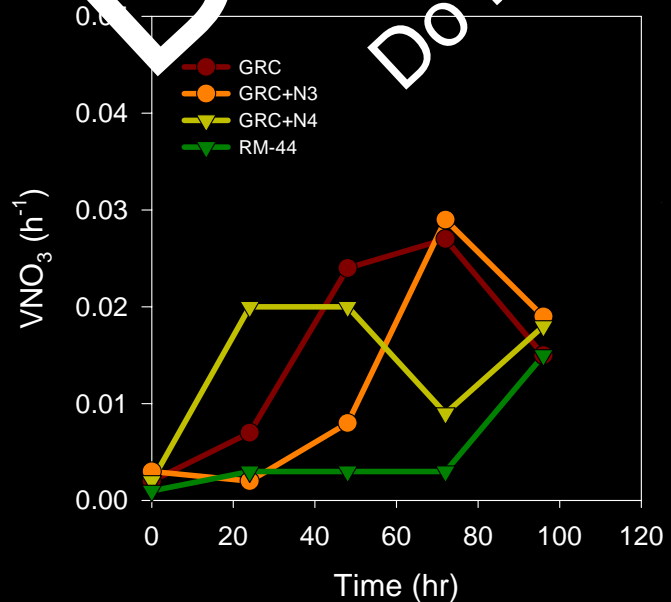
Experiment	Treatment	Initial NH_4	Time to deplete NH_4	NO_3 uptake inhibition? (Y/N)
WBD08-1 Jul 08	GRC	0.5 ± 0.1	<24hr	N (?)
	RM-44	9.1 ± 0.8	72hr	Y
WBD08-2 Nov 08	GRC	3.4	24hr	Y
	RM-44	71.9	>144hr	Y
WBD09-1 Mar 09	GRC	1.0 ± 0.4	24hr	Y
	GRC+N3	1.5 ± 0.4	24hr	Y
	GRC+N4	12.1 ± 1.2	96hr	Y
	RM-44	12.5 ± 1.5	96hr	Y
WBD09-3 May 09	GRC	1.4 ± 0.6	24hr	Y
	GRC+N3	1.5 ± 0.2	24hr	Y
	GRC+N4	6.8 ± 0.2	96hr	Y
	RM-44	9.5 ± 0.4	96hr	Y

Maximum specific NH_4 uptake rates by phytoplankton will be lower than maximum specific NO_3 uptake.

March 2009

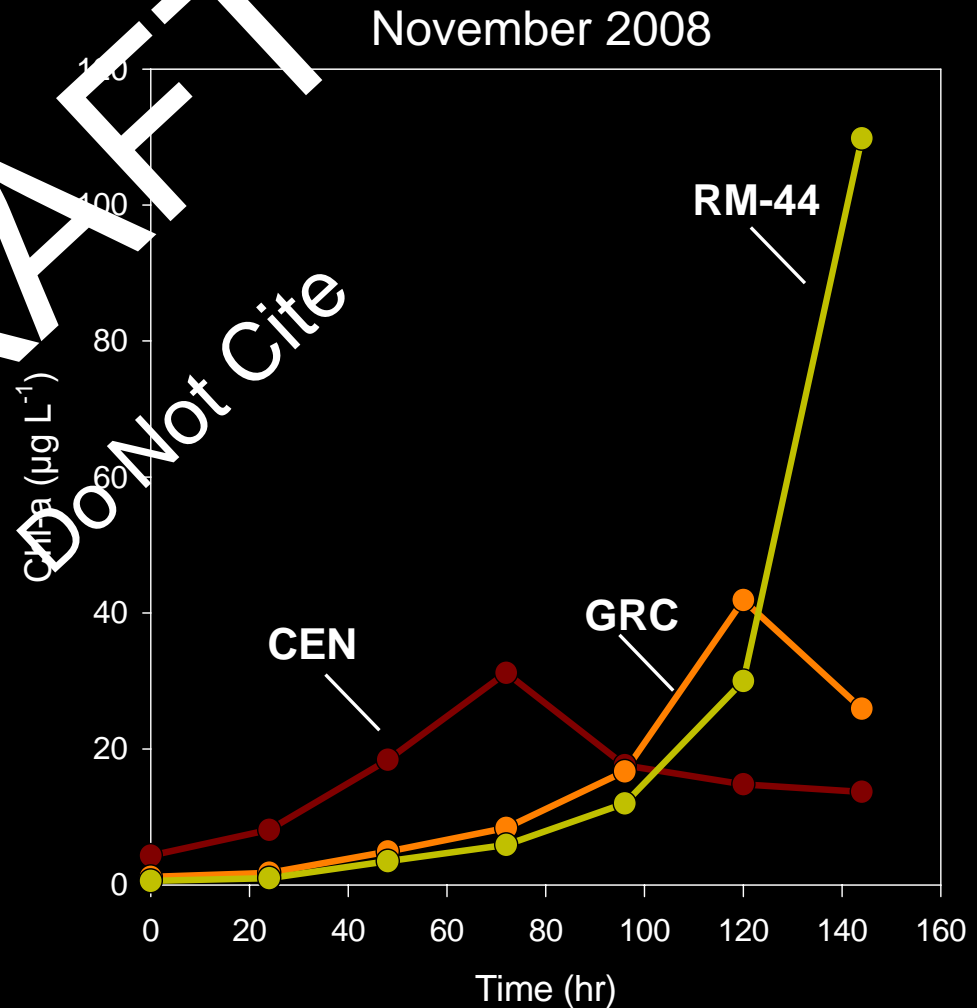


May 2009

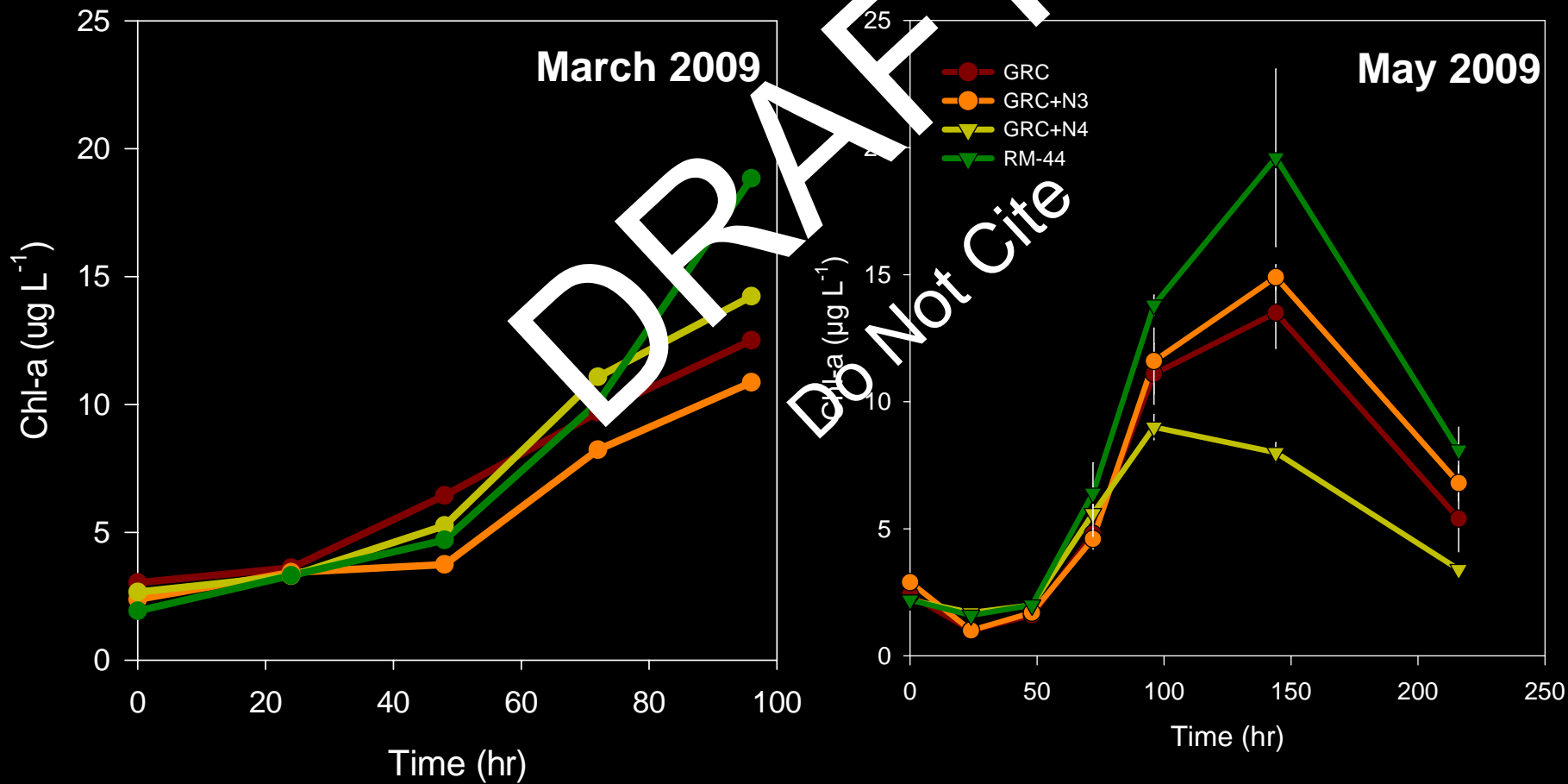


Initiation of phytoplankton increase will be delayed as a function of initial NH_4 concentration.

	CEN	GRC	RM44
Initial NO_3 (μM)	22.7	12.8	4.6
Initial NH_4 (μM)	7.1	3.4	1.9
Initial DIN (μM)	29.8	16.2	6.5
Initiation Chl-a ($\mu\text{g L}^{-1}$)	4.3	1.8	0.6
Time to NH_4 Depletion	24	72	>168



Initiation of phytoplankton increase will be delayed as a function of initial NH_4 concentration.



River Grow-Out Experiments

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- ✓ Phytoplankton will only assimilate NH_4 as long as NH_4 concentrations are found in excess of inhibitory concentrations.
- ✗ Maximum specific NH_4 uptake rates by phytoplankton will be lower than maximum specific NO_3 uptake.
- ✗ Initiation of phytoplankton increase will be delayed as a function of initial NH_4 concentration.

Wastewater / NH_4Cl Amendment Experiments

Serial addition experiments using SRWTP effluent and NH_4Cl were conducted in 6-hr incubations to investigate direct impact of wastewater and NH_4 on primary production and phytoplankton N uptake.

Questions that we can address with this approach:

- A. Does SRWTP effluent or NH_4 inhibit NO_3 uptake?
- B. Does SRWTP effluent or NH_4 inhibit NH_4 uptake?
- C. Does SRWTP effluent or NH_4 inhibit C uptake (primary production)?

Wastewater / NH_4Cl Amendment Experiments

Serial addition experiments using SRWTP effluent and NH_4Cl were conducted in 6-hr incubations to investigate direct impact of wastewater and NH_4 on primary production and phytoplankton N uptake.

NO_3 uptake will be inhibited with NH_4 at $1\ \mu\text{M}$:

For effluent

For NH_4Cl

NH_4 uptake will increase at low concentrations and be inhibited at high NH_4 :

For effluent

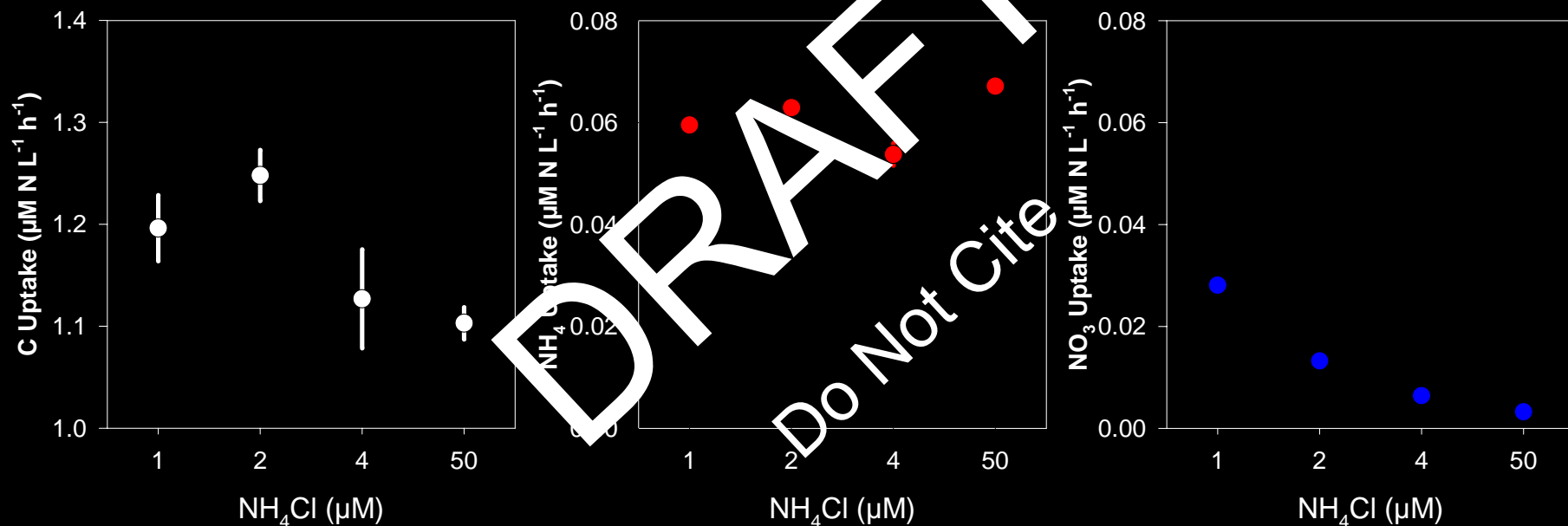
For NH_4Cl

Primary Production will be inhibited at high NH_4 :

For effluent

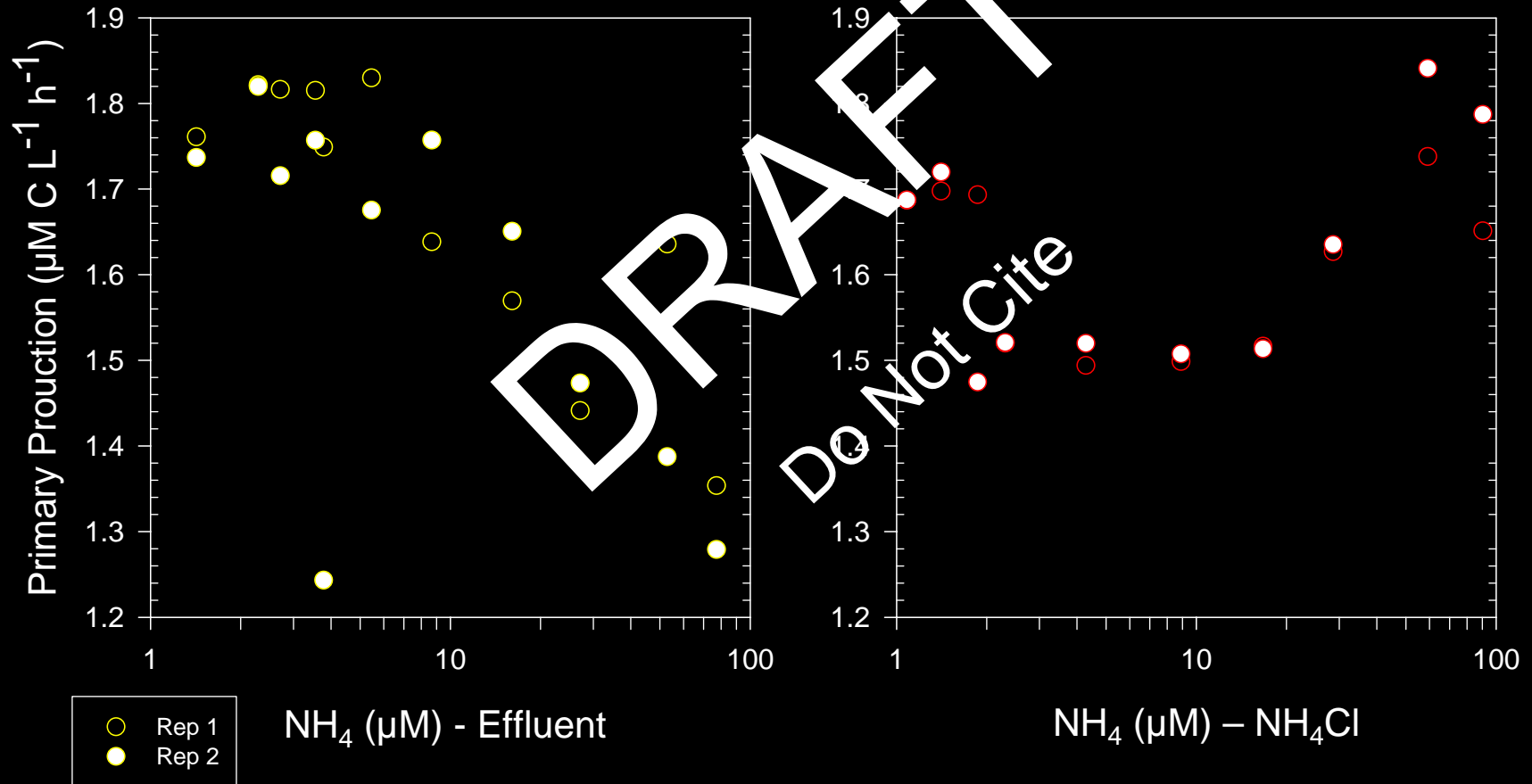
For NH_4Cl

“Clean” NH₄ Addition Experiments

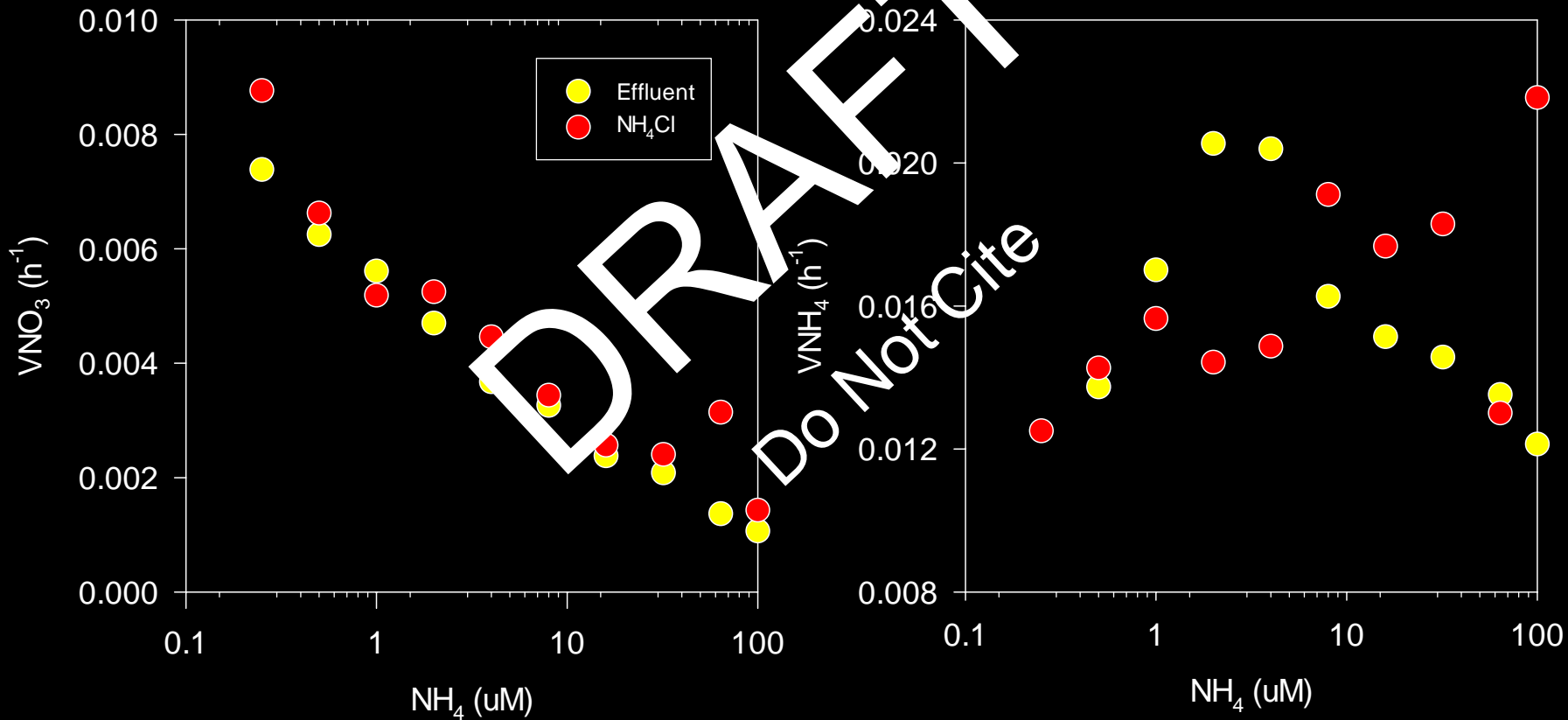


- C production may show some effect at elevated NH₄
- No effect observed for NH₄ uptake
- Clear inhibition of NO₃ uptake

Wastewater NH₄ Addition Experiments



Wastewater NH₄ Addition Experiments



Wastewater / NH₄Cl Amendment Experiments

Serial addition experiments using SRWTP effluent and NH₄Cl were conducted in 6-hr incubations to investigate direct impact of wastewater and NH₄ on primary production and phytoplankton N uptake.

NO₃ uptake will be inhibited with NH₄ at 1 μM:

For effluent 

For NH₄Cl 


NH₄ uptake will increase at low concentrations and be inhibited at high NH₄:

For effluent 

For NH₄Cl 

Primary Production will be inhibited at high NH₄:

For effluent 

For NH₄Cl 

Summary

- NH_4 inhibition of NO_3 uptake holds everywhere
- Unlike Suisun and Rio Vista, chl-a accumulation is not delayed as a result of DIN composition.
- Effluent reduces C and NH_4 uptake (and NO_3 uptake) at concentrations $>8 \mu\text{M}$ but NH_4Cl does not.