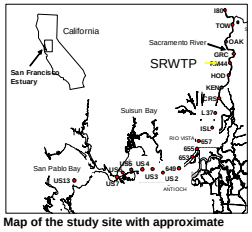
Transport and Fate of Ammonium Supply from a Major Urban Wastewater Treatment Facility in the Sacramento River, CA.

Alexander E. Parker, R. C Dugdale, F. P. Wilkerson, A. Marchi, J. Davidson-Drexel, J. Fuller, S. Blaser.

Romberg Tiburon Center, San Francisco State University. 3152 Paradise Drive, Tiburon, CA 94920, aeparker@sfsu.edu

INTRODUCTION

Effluent from wastewater treatment plants (WWTP) represent a major source of anthropogenic nitrogen to coastal and estuarine waters. In the Sacramento River, ammonium (NH_4) loading from the Sacramento Regional Wastewater Treatment Plant (SRWTP) has increased three-fold since the 1980's and represents 90% of the river's total NH_4 load. Despite the large WWTP influence on river nitrogen, little is known about how riverine phytoplankton may respond to nutrient enrichment or the potential consequences of elevated NH4 downstream in the San Francisco Estuary and Delta.



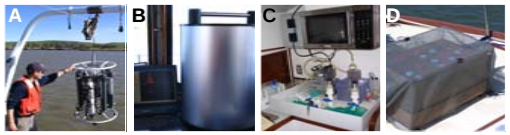
Map of the study site with approximate station locations (red circles) and names. Sampling occurred in March (data shown here) and April 2009.

GOALS

1. Characterize nutrients, primary production and phytoplankton standing stocks along a 75 km Sacramento River transect during spring (March, April, May)

2. Investigate experimentally, the primary production response by phytoplankton to additions of wastewater effluent.

APPROACH

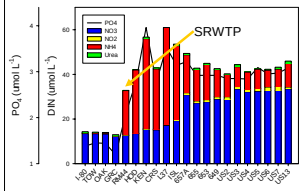


Two transects were completed in March (data presented here) and April 2009 using the *RV Questuary*. Stations were occupied on an outgoing tide. At each station a CTD profile was made (A), with samples collected for flow cytometry (B), nutrients and chl-*a* (C), and 24-hr primary production and phytoplankton nitrogen uptake rates (D).

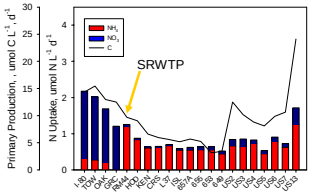
A effluent addition experiment was conducted using water collected at GRC (NH_4 ≤1 uM). Serial additions of 24-hr composite SRWTP effluent (2mM NH_4) was made (1:25 to 1:5000 dilution) to 160ml incubation bottles and incubated with ^{13}C and $^{15}NH_4$ or $^{15}NO_3$ for 4-hr around local noon.

RIVER TRANSECTS – MARCH 2009

Nutrient concentrations along Sacramento River, March 2009. DIN and P scaled to 16:1 i.e. Redfield Ratio.



Primary production (line) and NO3 (blue) and NH4 (red) uptake along the Sacramento River, C and N uptake scaled to 6.6:1, i.e. Redfield Ratio



-Substantial NH_4 (red) and PO_4 (line) loading from SRWTP at RM44

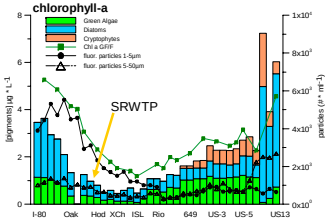
-[DIN] similar downstream of SRWTP with conversion of NH_4 to NO_3 (blue) , potentially due to nitrification.

-DIN:P ca. 16; favorable for phyto-plankton growth.

-Primary production decreased along Sacramento River and increased in Suisun and San Pablo Bays.

-Phytoplankton N use shifted from NO_3 uptake (blue) to NH_4 uptake (red) at RM44.

Phytoplankton community assessed by flow cytometer, bbe Fluororobe, and extracted chlorophyll-a



Phytoplankton biomass decreased along Sacramento River and then Increased in Suisun and San Pablo Bays.

Diatoms dominant upstream and in western Suisun and San Palbo Bays.

Shift in numerical dominiance of cells <5 in upstream staitons and >5 in Western Suisun and San Pablo Bays

MAJOR FINDINGS

-The SRWTP has a large effect on both the ***magnitude*** of nutrient concentration and ***type of inorganic nitrogen (NO_3 or NH_4)*** in the Sacramento River.

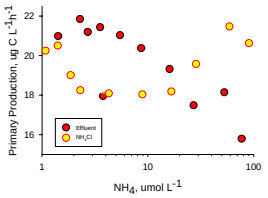
-The result of the SRWTP is ***eutrophication*** of the Sacramento River and, for phytoplankton, a ***conversion*** of the river from an environment driven by NO_3 uptake to one ***driven by NH_4.***

-***Nitrification is likely important*** in controlling the type of nitrogen in the river.

-It is unclear from these data what drives declines in primary production or chl-a. The Sacramento River and San Francisco Estuary exhibited *diverse phytoplankton communities along the transect.*

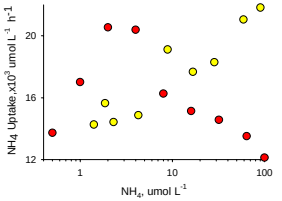
EFFLUENT ADDITION EXPERIMENT

Primary production versus NH_4 additions either as effluent (red circles) or as NH_4Cl (yellow circles).



Decreased primary production with increasing effluent NH_4. No effect for NH_4Cl.

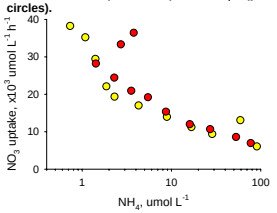
Phytoplankton NH_4 uptake versus NH_4 additions either as effluent (red circles) or as NH_4Cl (yellow circles).



SRWTP effluent stimulated NH_4 uptake up to 8uM NH_4.

Decreased NH_4 uptake with increasing effluent >8uM NH_4 (1:250 dilution). No effect for NH_4Cl.

Phytoplankton NO_3 uptake versus NH_4 additions either as effluent (red circles) or as NH_4Cl (yellow circles).



Phytoplankton NO_3 uptake was inhibited by both effluent and NH_4Cl.

	Primary Production	NH_4 Uptake	NO_3 Uptake
Effluent <8uM NH_4	-	+	-
Effluent >8uM NH_4	-	-	-
NH_4Cl, 0 to 100uM	No effect	+	-

Summary of SRWTP effluent effects on primary production and phytoplankton N uptake.

MAJOR FINDINGS

-***SRWTP effluent reduced primary production*** by ca. 25% over no addition.

-SRWTP effluent enhanced NH_4 uptake at concentrations <8umol, then ***effluent inhibited NH_4 uptake at concentrations ≤ 8umol L^{-1}.***

- NO_3 uptake was inhibited by both effluent and NH_4Cl, suggesting that the presence of ***NH_4 inhibits phytoplankton NO_3 uptake***

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