A Framework for Research Addressing the Role of Ammonia/Ammonium in the Sacramento-San Joaquin Delta and the San Francisco Bay Estuary Ecosystem
April 13, 2009 – Meyer, Mulholland, Paerl, and Ward

1. Modeling analysis of historical controls on phytoplankton populations
2. Sources and fates of nitrogen and phosphorus
3. Nutrient dynamics in stands of aquatic macrophytes
4. Links between nutrient processing and phytoplankton populations
5. Bottom-up controls of higher trophic levels and POD organisms
6. Effects of climate change on phytoplankton
7. Lag times in phytoplankton bioassays
8. Inhibition versus preferential uptake of ammonium
9. POD habitat in stands of aquatic macrophytes
10. Sensitivity of POD organisms to ammonia and ammonium
11. Cyanobacterial toxins
12. Field observations of POD organisms

The panel recommended the highest priority for research should be given to research topics 1, 2, 4, and 11.
Competitive Grant Funding
Delta Science Program/Delta Stewardship Council

- Principal Investigator: Patricia M. Glibert
- Funding Amount: $489,418
- Status: Completed
- Recipient Organization: University of Maryland Center for Environmental Science
- PSP Year: 2010
- Start and End Dates: 07/01/2011 to 06/30/2015
- Peer Reviewed Publications: Eight at end of the project and more issued recently

- Principal Investigator: Alexander E. Parker
- Funding Amount: $900,000
- Status: Completed
- Recipient Organization: San Francisco State University
- PSP Year: 2010
- Start and End Dates: 07/01/2011 to 06/30/2015
- Peer Reviewed Publications: Six at the end of the project and more issued recently
A story about nutrient forms and ratios from the Rio Grande in New Mexico

Three published papers from the doctoral dissertation of Howard D. Passell, now at the Sandia National Laboratories


South Side Water Reclamation Plant for the greater Albuquerque, NM area was a major source for major solutes, dissolved organic carbon, and nutrients (especially total ammonia). Plant upgrade (1998) largely eliminated chronic and acute nutrient toxicity.
Massive Expansion of Aquatic Weeds

2015 Estimate
17,400 acres SAV & FAV
= Approximately 30% of open water in Delta!

Source: Khanna (UCD), Preliminary data AVIRIS-NG imagery
Nutrient Sinks in the Delta

Annual Phytoplankton Primary Production = ~70 g C m^{-2} yr
Annual Primary Production for Submersed Macrophytes = 200-1500 g C m^{-2} yr
Annual Primary Production for Water Hyacinth = 1500-4400 g C m^{-2} yr

Use of elemental stoichiometry to estimate nutrient demand
Delta Primary Production Workshop – October 2015
BLOOMS - Strategic Use of Flow to Stimulate the Delta Food Web?

With thanks to Ted Sommer and Colleagues

Typical transport from flow

Region with enriched plankton

Winter
Spring
Summer
Fall
Extensive Sampling to Evaluate Flow Pulse
Evidence of a Positive Effect

Chlorophyll $a$ at Rio Vista

Aulacoseira
Blooms - Increasing Problems With Harmful Algal Blooms

Cyanotoxin Levels 7/26/16
Source: DWR O&M

- Clifton Court Forebay
- Banks Pumping Plant
- Pacheco Pumping Plant
- O'Neill Forebay Outlet
- O'Neill North Beach

Cyanotoxin (ug/L)

- Adults
- Small Children

EPA Guidelines

Klamath River
Russian River
Delta
San Luis Reservoir
Pyramid Lake
Lake Elsinore
Delta Effects of *Microcystis*

- Worst blooms in South Delta
- Water quality effects include large swings in pH and dissolved oxygen (DO) in some channels
- Ammonium preferred nitrogen source
## Sensor Technology - Water quality sensor testing and deployments

<table>
<thead>
<tr>
<th>Parameter(s)</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The big five”</td>
<td>Temperature, pH, conductivity, dissolved oxygen, turbidity</td>
<td>Field ready</td>
</tr>
<tr>
<td>Nitrate</td>
<td>Determined by UV light absorption. Used for assessing management practices and assessing aquatic eutrophication.</td>
<td>Field ready</td>
</tr>
<tr>
<td>Dissolved organic matter</td>
<td>Correlated with colored dissolved organic matter fluorescence (FDOM). An important constituent related to drinking water quality, metals transport and ecosystem health.</td>
<td>Field ready</td>
</tr>
<tr>
<td>Algal pigments</td>
<td>Chlorophyll and other algal pigments (phycocyanin, phycoerythryn) for assessment of aquatic productivity and harmful algal blooms.</td>
<td>Field ready</td>
</tr>
<tr>
<td>Phosphate, ammonium</td>
<td>Wet chemical sensors for nutrients</td>
<td>Field ready / testing</td>
</tr>
<tr>
<td>Backscatter, particle size</td>
<td>Related to suspended sediment concentration, type and size. An important habitat index, important for modeling watershed processes and predicting sedimentation.</td>
<td>Field ready/ testing</td>
</tr>
<tr>
<td>Multi-wavelength absorbance and fluorescence</td>
<td>Custom measurements used for measuring specific constituents such as oil, pathogens, wastewater content, and mercury by proxy as well as for source tracking in complex systems.</td>
<td>Testing</td>
</tr>
</tbody>
</table>
**FIGURE 5. INSTANTANEOUS (GREY) AND TIDALLY AVERAGED (BLACK) FLOW OF THE SACRAMENTO RIVER AT FREEPORT (FPT) PLOTTED WITH NITRATE CONCENTRATIONS MEASURED AT THE CONTINUOUS MONITORING STATIONS LOCATED AT FPT (YELLOW) AND WALNUT GROVE (WGA, GREEN). FROM O’DONNELL, 2014. (SOURCE - BRIAN BERGAMASCHI – USGS)**
Elemental Stoichiometry – Florida

• Ichetucknee River
  – High Flow ~ 6 - 9 m³/s
  – Constant input chemistry
    • NO₃ ~ 620 ppb and PO₄ ~ 48 ppb
  – High Gross Primary Production
    (~5 ± 2 g C m⁻² d⁻¹)

• Metabolism, geochemistry
  – YSI 6920, Optical DO, SpC

• N fluxes from nitrate
  – Satlantic SUNA (UV NO₃)

• P fluxes from phosphate
  – Wetlabs Cycle-PO₄
Elemental Stoichiometry - Direct C:N Coupling: Assimilation from Diel NO₃ Variation

- Development of the **diel method** for autotroph assimilation in rivers

Heffernan and Cohen (2010)
Waste Water Treatment Plants – Nitrogen Isotope Tracers

~$400M commitment by local government to reduce wastewater effluent nitrogen

δ^{15}N Sewage Plume 1998 (summer)

Waste Water Treatment Plant Upgrades in Brisbane, Australia (a tool for assessing the Sac Regional upgrade?)

δ^{15}N Sewage Plume 2008 (summer)
Future Nutrient Studies in the Delta

• Sensors, primary production, respiration, and nutrient uptake
• Linking hydrodynamics and nutrient biogeochemistry
• Nutrient dynamics assessed in multiple aquatic habitat types
• Stable isotopes as tracers of nutrient sources and food webs

- Clifford N. Dahm¹, Alexander E. Parker², Anne E. Adelson³, Mairgareth A. Christman³, and Brian A. Bergamaschi⁴

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