

Draft Proposal for NH₄ Paradox and Ecological Stoichiometry Workshop

Background: Two nutrient-focused hypotheses have recently been proposed to help explain shifts in the food web in Suisun Bay and the Delta. One hypothesis concerns the effect of elevated concentrations of ammonium on phytoplankton biomass and community composition. This hypothesis is referred to as the “*Ammonia Paradox*” after Dugdale *et al.*, 2012¹. The hypothesis is that elevated concentrations of ammonium (NH₄) suppress nitrate (NO₃) uptake in some algal groups commonly present in the Delta. The resulting lack of access to NO₃ results in a decrease in primary production rates and, if some algal functional groups are differentially sensitive to NH₄, to shifts in community composition from more to less NH₄ sensitive algal forms.

The second hypothesis, concerns the influence of nutrients on algal community composition and algal nutritional quality to herbivores, referred to as the “*Ecological Stoichiometry*” hypothesis (Glibert 2010; Glibert *et al.*, 2011²). The hypothesis is that changes in the forms and ratios of nutrients (NH₄:NO₃, N:P) cause “shifts” in algal community composition, and that these effects occur even when nutrient concentrations are in surplus and not limiting algal growth rates. Increasing N:P and increasing NH₄ in relation to NO₃ are hypothesized to reduce the competitive advantage of larger, fast growing algal forms, like diatoms, and selects for smaller, slower growing groups like flagellates, greens and cyanobacteria. The latter algal forms are identified as being of a lower nutritional value for some high-quality zooplankton herbivores resulting in a reduction in secondary production and “bottom up” ecological effects further up the food chain, including decreases in fishery production.

Goals: The purpose of the Workshop is to review studies conducted in the Bay-Delta Estuary and summaries of the peer reviewed literature to determine areas of agreement and disagreement related to the two nutrient hypotheses; identify key unresolved science questions; and recommend follow up studies to answer the science questions. The key findings from the workshop will be captured in a white paper that will guide science and monitoring activities in both the Delta and San Francisco Bay.

Workshop Structure: The workshop will be advertised and open to Bay Area Nutrient Management Steering (NMS) Committee and Delta Stakeholder and Technical Advisory Group (STAG) members. The workshop will take place over 2-3 days. The first day will be devoted to oral presentations by researchers. Additional oral presentations, as needed, will occur during the morning of the second day. The afternoon of the second day (and morning of third day, if needed) will be a closed session for panelists and the white paper author(s) to discuss the presentations and the contents of the white paper. One or more 30-minute periods will be set

¹ Dugdale, R, F. J. Wilson, A. Parker, A. Marchi, and K. Taberski. 2012. *Estuarine, Coastal and Shelf Science*, 115, 187-199.

² Glibert, P. (2010). *Review of Fishery Science* 18, 211-231.

aside during the first day for Stakeholders to question the presenters. In the morning of the second day, Stakeholders will be given an opportunity to discuss their observations about the researcher presentations with the panel and white paper author. The public may also submit written comments to the panel. Written comments will be attached as an appendix to the white paper.

A month before the workshop all presenters will be requested to provide a PDF of their reports and other published information that they wish to have considered at the workshop for uploading to the web. Two weeks before the workshop panel members and other presenters will be requested to forward questions to the presenters based upon the submitted reports. These questions will be designed to elucidate the likely difference in study results and conclusions between the different research groups and further the workshop goal of identifying additional needed research. At the workshop each presenter will provide a 30-minute summary of their findings related to the two hypotheses. In the course of their presentation, each presenter will also be asked, as much as possible, to address the questions submitted to them two weeks prior by panelists or other presenters. Twenty minutes will be reserved after each presentation for questions from panelists and other presenters.

Products: The primary product of the workshop will be a white paper. The paper will describe the problem, summarize the main observations of the reports and presentations, discussions between panel members and presenters, and areas of agreement and disagreement based upon the presentations and reports submitted for the workshop and the best professional judgment of the panel. The white paper will precisely articulate key science questions and mechanisms that need to be tested, and to the extent possible, identify the types of follow-up studies needed to resolve differences and to guide research to inform management on whether additional nutrient control actions might be needed in the Bay-Delta Estuary.

The overall goal is for the white paper to inform nutrient science plans under development by the Bay NMS Committee and Delta nutrient STAG. While the two efforts have similar goals, the white paper's final format may differ between the Bay NMS Committee and Delta STAG. The NMS Committee may use the white paper as the last chapter in the Suisun Bay Synthesis II report, and/or as an appendix to its science plan. The Synthesis II report is a compilation of reports commissioned by the Bay Area NMS Committee. For the Delta STAG, the white paper would serve as a stand-alone document for development of the Delta Nutrient Research Plan.

White Paper: Responsibilities for the author of the white paper would be to provide advice on the organization and structure of the workshop, help develop an outline for the white paper, write the white paper and present its conclusions to stakeholder and technical groups (maybe 2 Web-Ex presentations). The white paper should, where possible, represent the consensus of the panel. In areas where consensus is not reached, the white paper should reflect the diversity of opinions among panel members. The primary responsibility of the white paper author is to capture the range of opinions, not provide the author's own interpretation of the presentations. Table 1 is a list of possible authors that have been recommended to draft the

white paper. No individuals have been contacted to determine their interest and availability nor has a preferred candidate been selected.

Panel: The panel will be comprised of 4-6 individuals with relevant scientific expertise. Table 2 presents a draft list of desirable areas of expertise for the panel. Panelists will be a combination of regional and outside experts. The role of the panel will be to discuss and evaluate both the oral presentations and written material to determine areas of agreement and disagreement about the physical and chemical factors, including nutrients, controlling phytoplankton production, biomass and species composition in Suisun Bay and the Delta. These discussions and conclusions will form the basis of the white paper. The panel will also articulate research questions that need to be pursued over the next 3-5 years and make recommendations on how to address them.

Presenters: Table 3 is a draft list of potential presenters. In its current form, the list is too long and needs to be pared down.

Facilitator: The public sessions of the workshop should have a facilitator. Possible candidates are the facilitator for the Delta STAG or San Francisco Bay NMS meetings.

Date/Location: For the date, we propose holding the workshop in late November or early December with a draft white paper ready for review by the panel and presenters in late December. Of course, the date depends on the availability of reports for review and the schedule of both the presenters and review panel. As for location, a neutral midpoint between Sacramento and Oakland might be best. A possibility is the San Francisco Estuary Institute offices in Richmond.

Stakeholder Input: The Delta STAG was very interested in this workshop when the concept was presented to them last January and they wanted to help with its organization. The STAG recommended that a small sub-committee be formed to help work out the details. Central Valley Water Board staff will follow that recommendation once this proposal has been presented to both the Delta STAG and Bay NMS Committee and their advice received.

Table 1. Potential candidates to write the Ammonia Paradox and Ecological Stoichiometry white paper.

Individual/affiliation	Recommended by	Websites with Profiles on Potential Candidates
Mike Mallin, UNC Wilmington	Patricia Glibert	http://uncw.edu/bio/faculty_mallin.html .
Cynthia Heil, Bigelow Labs	Patricia Glibert	http://www.researchgate.net/profile/Cynthia_Heil
Mike Kennish, Rutgers	Patricia Glibert	http://marine.rutgers.edu/main/IMCS-People-Details/People-Details-Michael-J.-Kennish.html .
Antonietta Quiqq, Texas A&M	Patricia Glibert	http://www.tamug.edu/phytoplankton/People/Antonietta_Quigg.html
Robert Twilley, LSU	Martha Sutula	http://www.gulfbase.org/person/view.php?uid=rtwilley
Walter Dodds, Kansas State	Cliff Dahm	http://www.k-state.edu/dodds/
Jan Stevenson, Michigan State	Cliff Dahm	https://www.msu.edu/~rjstev/
Amelia Ward, retired U of Alabama	Cliff Dahm	http://bsc.ua.edu/about/faculty-directory/amelia-ward/

Table 2. Desirable areas of expertise for the review panel.

Area of Expertise	Possible candidates
Phycologist with expertise on algal species composition and biomass in the Bay-Delta Estuary and how both have changed over the last half century.	??
Phycologist with knowledge about biochemistry and physiology of nutrient uptake and effect of nutrient concentrations, forms and ratios on carbon synthesis and biomass production. Expertise on laboratory culture of algae and measurement of primary production	??
Phycologist with expertise in measurement of primary production in the laboratory and field. Knowledgeable about how physical and chemical factors influence production and species composition in the field.	??
Expert on zooplankton culture and zooplankton nutrition. Be capable of evaluating the effect of changing N:P ratios on algal food quality for zooplankton production and recommending follow up studies to resolve uncertainties.	??
Other areas of expertise?	??

Table 3. Summary of possible individuals for presentations at the Ammonia and Ecological Stoichiometry workshop.
This list is too long but is provided to help make a selection.

Individual	Agency/Institution	Research Area	Comment
Jeff Miller	AquaScience	NH ₄ Paradox—TIE and Laboratory NH ₄ algal dosing experiment in flow through system with algal samples collecting in the field. SFCWA has a draft final report	Research sponsored by SFCWA. Need to contact to determine whether would make presentation
Patricia Glibert	U. Maryland	Ecological Stoichiometry—Literature review of N:P ratios. David Senn has a draft final report.	Review commissioned by SF Bay Nutrient Science and Management strategy group
Katie Bentley (Glibert graduate student)	U. Maryland	Ecological Stoichiometry— Lab results of culture study with zooplankton <i>Acartia</i> and <i>Eurytemora</i> fed on diatom <i>Thalassiosira</i> at different N:P ratios	Oral presentation at 2014 bay-delta nutrient conference. Not sure whether paper has been produced or whether someone other than Patricia available to make presentation.
Dick Dugdale/Frances Wilkerson	Romberg Tiburon Center	NH ₄ Paradox-- Review of 10 years of Romberg Tiburon work	Research sponsored by SWAMP and SFCWA. Review commissioned by SF Bay Nutrient Science and Management strategy group
Alex Parker	California Maritime Academy	Has lab grow out results with <i>Microcystis</i> amended with increasing concentrations of NH ₄	Research sponsored by IEP and SFCWA. I think paper will be out by November. I will contact Alex to see whether he might want to present if others agree.
Raphael Kudela	UC Santa Cruz	NH ₄ Paradox--Summary of lab and field experiments conducted with Mine Berg. Stephanie Fong has draft report	Research sponsored by SFCWA.
Mine Berg	Applied Marine Sciences	NH ₄ Paradox—Literature review of effect of NH ₄ on algal growth	Review commissioned by SF Bay Nutrient Science and Management strategy group. Not sure of status of write up.

Individual	Agency/Institution	Research Area	Comment
Tamara Kraus	U.S. Geological Survey	Sacramento River Lagrangian study measuring change in nutrients and algal biomass and species composition between City of Sacramento and Rio Vista with and without discharge from Regional San	Contacted Lisa Thompson. Final report not due until December 2015. Might present same PowerPoint that she showed at 2014 CalFed Bay-Delta Science conference .
Richard Connon	U.C. Davis	NH ₄ Paradox Review paper	Review sponsored by SFCWA.
James Cloern	U.S. Geological Survey	NH ₄ Paradox—Recent IEP newsletter article	Not sure whether he wants to attend. Need to consider whether he should be on review panel or presenter.
SFEI staff	SFEI	Summary of nutrients in Suisun Bay for background	Not sure whether there is a report
Malkassian	SFEI	Summary of changes in algal species composition in Suisun bay over time.	Not sure what status of report is or who would make presentation.
??	Contra Costa Sanitary District	Algal response to discharge to local creeks	Paper published; not sure who might be available to make presentation