Physiological Assessment of the "Bad Suisun" Phenomenon: Light and Nutrient Interactions.

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Lead IEP Agency:
Questions:
The present project focuses on quantifying physiological stress in phytoplankton and relating it to environmental factors. Broadly speaking we ask:

1) Do phytoplankton communities in SFE experience physiological stress? If so,
2) What is the degree of stress experienced by the natural phytoplankton communities?
3) How does it vary depending on location (South, Central, San Pablo or Suisun Bay)?
4) What factors are associated with phytoplankton stress in Suisun Bay?

Pilot data collected in May 2012 mapped F_v/F_m, an indicator of phytoplankton stress, along a transect from South Bay to Suisun Bay. F_v/F_m decreased 3-fold from South Bay to Suisun Bay. The low F_v/F_m region in Suisun originated in the middle of the Bay, dissipating outwards. Surprisingly, F_v/F_m increased moving towards the Sacramento River, a major source of NH_4^+ to Suisun Bay. These findings led to a series of more specific questions regarding the nature of phytoplankton stress experienced in Suisun:

1) Does Suisun always have lower F_v/F_m compared with the other embayments in SFE?
2) Does the low F_v/F_m region in the center of Suisun Bay move over time or does it remain stationary?
3) Does the slight increase in F_v/F_m witnessed towards the Sacramento River continue upstream?
4) Are changes in ambient NH_4^+ concentrations related with low F_v/F_m and with levels of physiological stress in Suisun Bay/Sacramento River?
5) Can we demonstrate that growth is inhibited by NH_4^+ in individual phytoplankton species isolated from the low F_v/F_m, high stress, region within Suisun Bay?
6) What is the NH_4^+ tolerance limit of phytoplankton isolated from the high-stress region in Suisun Bay?
7) Are factors other than NH_4^+ involved in bringing about stress in the natural community in Suisun Bay?
8) Can a change in irradiance be responsible for changes observed in previous incubation experiments (Parker et al. 2012a) where a switch in N utilization coincided with increased productivity and Chl *a* biomass?

Description:
This project will examine whether elevated levels of NH_4^+ can be related to phytoplankton physiological stress on a basin-wide scale (**Task 1**) and to characterize what levels of NH_4^+ are needed to cause a decline in primary production in individual phytoplankton under controlled conditions (**Task 2**). Basin-wide phytoplankton stress (questions 1-4) will be assessed using underway, continuous (i.e. several times a minute) measurements of F_v/F_m along the spine of SFE on a monthly basis. These measurements will allow us to determine whether Suisun always exhibits greater levels of stress compared with the other embayments in SFE and whether the high-stress region in Suisun (dubbed the misery spot) is stationary. Continuous F_v/F_m measurements will be compared with continuous measurements of temperature, salinity, turbidity, Chl *a*, and discrete NH_4^+, to determine the relationships between stress and environmental

parameters. In addition to the transect along the spine of SFE, continuous F_v/Fm measurements will be performed along several transects traversing Suisun Bay and up the Sacramento River; these high-resolution measurements will be plotted using Ocean Dataview to create surface maps of each variable for Suisun Bay. Comparison of the surface maps of the variables will allow us to determine which are most closely related to F_v/F_m.

The levels of NH_4^+ needed to negatively affect phytoplankton primary production and growth (questions 5-8) will be assessed in phytoplankton cultures isolated from Suisun Bay. These isolates will be taken from within the misery spot as well as from outside the misery spot in Suisun. Dose-Response relationships using NH_4^+ will be performed to determine the tolerance level of individual phytoplankton to NH_4^+. Rates of carbon fixation and growth will be assessed in cultures grown on NH_4^+ compared with NO_3^- as the sole source of nitrogen to determine whether growth is affected by N source. Lastly, changes in growth with irradiance and N source will be assessed to determine interactive effects of these parameters on phytoplankton growth.

Time period: March 2013 to February 2014

Resources and permits required:

Cost: $189,212

PI(s):

Raphael M. Kudela, Professor, Ocean Sciences Department, University of California, Santa Cruz.

Gry Mine Berg, Oceanographer, Applied Marine Sciences, Santa Cruz

Karen Taberski, SF Bay Regional Water Quality Control Board

Contract needed / in place:

Contract manager:

Term of contract:

Personnel:

Kendra Hayashi, Scientist, UCSC

Traci Lindner, Scientist, AMS

Equipment:

Endangered species take:

None

Endangered species take permit(s) and conservation benefit:

Not applicable

Deliverables and dates:

- Task 1 deliverables: 1) Ocean Dataview surface maps of environmental variables (temperature, salinity, turbidity, Chl *a*, F_v/F_m and NH_4^+) for Suisun Bay at four different times of the year and a Scientific Report comparing and contrasting the maps (03/2014). 2) One peer-review publication of the results in an appropriate journal (2015).
- Task 2 deliverables: 1) Report summarizing culture experiment results (03/2014) 2) Peer-review publication describing results and findings of culture experiments (2016). 3) Submission of several cultures to the National Center for Marine Algae in order to make them broadly available to the research community (11/2013).

Which priority research topics and questions listed in the 2012 Call for Study Concepts does this project address?

a. Physical and chemical habitat effects on fish populations
b. Food-web effects on fish populations (bottom-up effects)

Expected contribution to improving basic scientific understanding:

The proposed work takes advantage of a new tool that will enable direct, *in situ* characterization of phytoplankton health in San Francisco Estuary for the first time. Direct measurements of health can be compared with other variables to advance our understanding of what does and does not contribute to lowered primary productivity in impacted regions. Specifically, this study will compare the ability of NH_4^+ with the ability of a number of other potential stressors to lower phytoplankton productivity. This investigation will go a long way in reducing uncertainties associated with the contribution of NH_4^+ to phytoplankton stress and lowered primary productivity.

Expected contribution to improving the scientific basis for Bay-Delta policy and management:

The "ammonium hypothesis" has led to a great deal of controversy regarding regulatory decisions on NH_4^+ objectives, effluent limits and treatment options for sewage treatment plants and is based on the assumption that phytoplankton, particularly diatoms, fix carbon more rapidly when growing on nitrate than on ammonium.
This study will:

1) Establish a direct link between NH_4^+ concentration and phytoplankton/diatom stress and/or inhibition to provide a scientifically-based rationale for choosing a regulatory NH_4^+ concentration.
2) Identify interactive effects (such as light-nutrient interactions) that will guide expectations and management actions related to NH_4^+ reduction, and will provide a basis for interpreting predictive scenarios such as the CASCaDE Project.
3) Provide the basis for an inexpensive and convenient metric for monitoring ecosystem health (through the direct link between F_v/F_m and impaired phytoplankton health).
4) Point towards management strategies aimed at regulating community composition rather than strictly regulating NH_4^+ concentrations (if there is a lack of a direct link between NH_4^+ concentrations and phytoplankton physiological impairment).
5) Establish physiological parameters that will be direct inputs to future numerical models; in turn, these models can be used to inform policy decisions.

Comments:

This investigation builds on earlier projects funded by the IEP as well as the Water Boards' Surface Water Ambient Monitoring Program (SWAMP), State and Federal Contractor Water Agencies (SFCWA), Bay Area Clean Water Agencies (BACWA), and Central Costa County Sanitation District (CCCSD), to identify how multiple stressors are interacting to contribute to reductions in phytoplankton and zooplankton levels in Suisun Bay.