CALFED Progress Report
California Sea Grant College Program

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Preparer Information

PrepName_1A: Allison Luengen
PrepEmail_1B: aluengen@usfca.edu
PrepPhone_1C: 415-422-4332

Project Information

ProjectNo_2C: R/SF-22 | StartDate_3a: June 1, 2007 | EndDate_3b: August 31, 2012
ProjectTitle_4: Mercury interactions with algae: effects on mercury bioavailability in the San Francisco bay delta

CALFed Fellow contact information

FelTitle_5A: Dr. | FelLast_5B: Luengen | FelFirst_5C: Allison | FelInit_5D: C
FelInstitution_5E: University of San Francisco
FelDepartment_5F: Environmental Sciences Department
FelStreetAddr_5G: Harney Science Center, 2130 Fulton St.
FelCity_5H: San Francisco | FelState_5I: CA | FelZip_5J: 94117
FelPhone_5K: 415-422-4332 | FelFax_5L: 415-422-6387
FelEmail_5M: aluengen@usfca.edu
FelPositionTitle_5N: Assistant Professor

Research Mentor (for additional please see #8)

RMTitle_6A: Dr. | RMLastName_6B: Fisher | RMFirstName_6C: Nicholas | RMInit_6D: S
RMInstitution_6E: Stony Brook University
RMDepartment_6F: School of Marine and Atmospheric Sciences
RMStreetAddr_6G: Stony Brook University
RMCity_6H: Stony Brook | RMState_6I: NY | RMZip_6J: 11794-5000
RMPhone_6K: 631-632-8649 | RMFax_6L: 631-632-3072
RMEmail_6M: nfisher@notes.cc.sunysb.edu
RMPositionTitle_6N: Distinguished Professor

Community Mentor (for additional please see #9)

CMTitle_7A: Dr. | CMLastName_7B: Bergamaschi | CMFirstName_7C: Brian | CMInit_7D: B
CMInstitution_7E: USGS
CMDepartment_7F: Water Science Center
CMStreetAddr_7G: California State University, Placer Hall MS 6129, 6000 J St.
CMCity_7H: Sacramento | CMState_7I: CA | CMZip_7J: 95819-6129
CMPhone_7K: 916-278-3053 | CMFax_7L: 916-278-3071
CMEmail_7M: bbergama@usgs.gov
CMPositionTitle_7N: Research Chemist

Additional Research Mentors and Community Mentors

Additional Research Mentors_8

Additional Community Mentors_9

Project Objectives: Please type your responses, and answer the questions in a style appropriate for laymen.

ProjectObjectives_10

The overall goal of this project was to evaluate the factors controlling mercury bioavailability to phytoplankton and organisms at the base of the food chain in the San Francisco Bay Delta. The first objective was to determine how dissolved organic matter (DOM) affected the accumulation of methylmercury by phytoplankton. DOM is an important component of natural waters; it has many sources in the Delta, including natural production in wetlands, agricultural run-off, and inputs from wastewater treatment plants. Prior to our laboratory studies, many investigations of DOM were field studies so it was hard to separate the effects of DOM from other water quality parameters. Our goal was to use a laboratory approach to evaluate the effects of DOM while accounting for all other water quality parameters (e.g., Cl-, pH).

A second objective was to look at DOM in combination with other factors, such as Cl- concentrations. This allowed a synthesis of multiple water chemistry variables, to contribute to a biogeochemical model indicating the importance of various parameters in influencing methylmercury speciation and presumably concentrations in organisms.

A third objective was to evaluate the trophic transfer of methylmercury, or how mercury is transferred from one step of the food chain (e.g., phytoplankton) to another (amphipods). Trophic transfer is an important process because most methylmercury accumulated in organisms comes from dietary exposure.

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

At this point, all laboratory experiments have been completed (see previous report for a list of experiments) and the resulting data will allow me to address the objectives above. The laboratory approach that I employed was ideal for allowing me to isolate the effects of dissolved organic matter (DOM), and the interesting results led me to expand our laboratory studies from the initial proposal. Since the last progress report, the first objective has been addressed with a paper that is currently in press with Environmental Toxicology and Chemistry. A synthesis of those results was also presented at several conferences, including the World Mercury Conference in June 2011.

Since the last report, substantial progress has been made on analyzing the experimental data and conducting statistical analyses. These include calculations on DOM binding that are now part of the first paper. Also, modeling efforts were initiated to evaluate the effect of Cl- ion concentration on methylmercury speciation. To model Cl- ion concentrations, a geochemical modeling program, PHREEQC, was used, with the help from Carrie Miller, Oak Ridge National Labs. These results will contribute substantially to the second objective.

To complete the project, the remaining time will be focused on writing the manuscripts that will address the second and third objectives. Currently, the goal is to publish two more papers with the available data.

PROJECT MODIFICATIONS: Please explain any substantial modifications in research plans, including new directions pursued. Describe major problems encountered, especially problems with experimental protocols and how they were resolved. Describe any ancillary research topics developed.

Modifications_12

The laboratory portions of this study, which used radiotracers to study methylmercury (MeHg) bioaccumulation, were significantly expanded. The additional laboratory studies replaced the field sampling, which had been initially proposed. This change allowed me to follow-up on some of the intriguing (and unexpected) results from the first round of experiments. My results showed that dissolved organic matter (DOM) decreased MeHg uptake by phytoplankton, which was contrary to my initial hypothesis. One follow-up experiment tested different types of DOM to determine if organic matter with vastly different composition would have the same effect as organic matter from San Francisco Bay (they did). The expanded laboratory focus also reflected the uncertainty of continued funding, which made it difficult to plan field sampling, especially because the original plan was to leverage the field sampling efforts of another CALFED field study (run by Brian Bergamaschi, the community mentor), which was also suspended. Finally, more effort than was originally planned was spent on some of the calculations/modeling. This part included calculations (in the first paper) on the amount of reduced sulfur and modeling of MeHg speciation (for the next paper). While not originally anticipated, these components were added to relate laboratory results to environmental conditions. Judging from reviewers' comments on the first paper, they were an important addition to the work.

BENEFITS AND APPLICATIONS: Suggest the relevance of these new findings to management. Describe any accomplishment, that is significant effects your project has had on resource management or user group behavior. CALFED is looking for "management cue" (see http://science.calwater.ca.gov/pdf/soemgmtcues.pdf).

BenefitsApplic_13

My results can be applied to CALFED's management cue of understanding contaminant accumulation patterns and processes to refine management strategies. My results show an inverse relationship between MeHg accumulation and DOM concentration for all types of organic matter, indicating that MeHg bound to DOM is not readily bioavailable. From a mercury bioavailability perspective, increase DOM in the San Francisco Bay and Delta is a good thing.

While more research is needed to fully understand food web-contaminant pathways, this work is an important first step in quantifying pathways of MeHg accumulation. I found that amphipods assimilate 65 – 70% of the MeHg in their prey, regardless of the amount of DOM. While it is necessary to compare this benthic pathway with other food web pathways, this is an important starting point.

This work is also relevant to CALFED's management cue on restoration of habitats and processes. For example, one of the proposed changes in the Delta is restoration of 10,000 ha of agricultural areas to wetlands. One concern with the wetland restoration is that previous research has linked wetland habitats with higher MeHg concentrations. My research brings up an important additional factor to consider: the bioavailability of that MeHg. In wetlands that produce high concentrations of DOM, any additional methylation of mercury that occurs in the wetland may be mitigated by its limited bioavailability once bound to DOM.

PUBLICATIONS: List any publications, presentations, or posters that have resulted from this funded research. Give as many details as possible, including status of paper (e.g., in review; in press), journal name, conference location and date of presentation. Please note (as outlined in the conditions of the award) that each fellow is required to submit an abstract for an oral or poster presentation at each State of the Estuary conference and CALFED Science Conference during the duration of the fellowship.

Publications_14

Luengen, A. C. (2012) Fisher N. S., Bergamaschi B. A. 2012. Dissolved organic matter reduces algal accumulation of methylmercury. Environ Toxicol Chem: in press.

Luengen, A. C. (2011) Mercury in aquatic food chains (invited talk). USGS, Menlo Park, California, October 13, 2011.

Luengen, A. C., Fisher, N. S., and Bergamaschi B. A. (2011) Partitioning and kinetics of methylmercury in phytoplankton in the presence of dissolved organic matter (poster). Tenth Biennial State of the San Francisco Estuary Conference, Oakland, California, September 20 – 21, 2011.

Luengen, A. C., Fisher, N. S., and Bergamaschi B. A. (2011) Dissolved organic matter, regardless of origin, limits algal accumulation of methylmercury (oral presentation). Tenth International Conference on Mercury as a Global Pollutant (ICMGP), Halifax, Nova Scotia, July 24 - 29, 2011.

Luengen A. C., Fisher N. S., Bergamaschi B. A. (2010). Trophic transfer of methylmercury in a simple food chain. Geochimica et Cosmochimica Acta 74: A641-A641.

Luengen A. C. , Fisher N. S., Bergamaschi B. A. (2010). Trophic transfer of methylmercury in a simple food chain (oral presentation). Twentieth Goldschmidt Conference, Knoxville, Tennessee, June 13 - 18, 2010.

Luengen, A. C., Fisher, N. S., and Bergamaschi B. A. (2010) Factors affecting the bioavailability of methylmercury to phytoplankton and amphipods (poster). Sixth Biennial Bay-Delta Science Conference, Sacramento, California, September 27 - 29, 2010.

Luengen, A. C. (2010) Factors affecting the bioaccumulation of methylmercury at the base of the food web (oral presentation). Regional Monitoring Program Annual Mercury Meeting. David Brower Center, Berkeley, CA, January 27, 2010.

Luengen, A. C., Fisher, N. S., and Bergamaschi B. A. (2009) Dissolved organic matter reduces the bioaccumulation of methylmercury by phytoplankton (oral presentation). Society of Environmental Toxicology and Chemistry North America 30th Annual Meeting, New Orleans, Louisiana, November 19 – 23, 2009.

Luengen, A. C., Fisher, N. S., and Bergamaschi B. A. (2009) Trophic transfer of MeHg in a simple food chain (poster). Ninth Biennial State of the San Francisco Estuary Conference, Oakland, California, September 29 – October 1, 2009.

Luengen, A. C., Fisher, N. S., and Bergamaschi B. A. (2009) Effects of organic matter on methylmercury accumulation by phytoplankton (oral presentation). American Society of Limnology and Oceanography Aquatic Sciences Meeting 2009. Nice, France, 25 – 30 January, 2009.

Luengen, A. C. and Fisher, N. S. (2008) Effects of dissolved organic matter on methyl mercury uptake by phytoplankton (poster). Fifth Biennial CALFED Science Conference, Sacramento, California, October 22 - 24, 2008.

COOPERATING ORGANIZATIONS: List those agencies and/or persons who provided financial, technical or other assistance to your project since inception. Describe the nature of their collaboration.

CoopOrganiz_15

Nicholas S. Fisher, Distinguished Professor, Stony Brook University, served as the primary advisor and provided his laboratory facilities and expertise on mercury uptake by phytoplankton.
Brian Bergamaschi, Ph.D., USGS California Water Science Center, has served as the community mentor and provided DOM isolates and expertise on organic matter. Dr. Bergamaschi also donated in-kind analysis of DOM concentrations.
Dr. Peter Hernes, Assistant Professor, UC Davis, provided advice on organic matter composition.
Dr. Alexander Smirnov, Postdoctoral Research Associate, Stony Brook University, helped with Cl- analyses.
Dr. Carrie Miller, Oak Ridge National Labs, helped with MeHg speciation modeling.

AWARDS: List any special awards or honors that you, or mentor or members of the research team, have received during the duration of this project.

Awards_16

NA

KEYWORDS: List keywords that will be useful in indexing your project.

Keywords_17

Mercury, methylmercury, MeHg, phytoplankton, dissolved organic matter, DOM, dissolved organic carbon, DOC, San Francisco Bay Delta, estuary, diatoms, Cyclotella meneghiniana, bioavailability, contaminants

PATENTS: List any patents associated with your project.

Patents_18

NA

ProjectYear_2A 3rd **ProjectNo_2C** R/SF-22

TypeQuestionnaire_2B Completion Questionnaire

Additions: Additional information can be added here. Please begin the text with the number of the question you are adding to.

Additions_19

Modifications_12. One ancillary research topic developed was looking at the effects of DOM in the Hudson River Estuary, which led to a fully funded proposal through the New York State Energy Research and Development Authority. It is anticipated that the data generated in this project can be used later with the Hudson River Estuary data to compare the effects of DOM on methylmercury in multiple ecosystems.