Sea Grant California

CALFed Progress Questionnaire
California Sea Grant College Program

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Project Information

ProjectNo_2C R/SF-22 **StartDate_3a** June 1, 2007 **EndDate_3b** May 31, 2008
ProjectTitle_4 Mercury interactions with algae: Effects on mercury bioavailability in the San Francisco Bay Delta

CALFed Fellow contact information

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Additional Research Mentors_8

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

ProjectObjectives_10

The goal of this project is to understand the chemical parameters controlling mercury uptake to phytoplankton in the San Francisco Bay estuary and Delta. This project is focused on phytoplankton because they are at the base of the marine food chain, and high concentrations of mercury in fish are primarily attributable to dietary exposure. The form of mercury that accumulates in fish is methyl mercury (MeHg), and we are using radiolabeled MeHg to follow the movement of MeHg from water to phytoplankton.

Previous research has indicated that one parameter controlling mercury uptake to phytoplankton is dissolved organic matter (DOM). DOM in the Delta comes from a variety of sources, including natural production in wetlands, agricultural run-off, and inputs from wastewater treatment plants. This research will use isolates of organic matter collected from multiple sites in the Delta to evaluate the role of DOM in mercury bioavailability.

Specifically, this research will:
(1) assess how the bioavailability of mercury to phytoplankton is affected by DOM composition and concentration.

(2) assess how chemical parameters (e.g., pH and Cl- concentration) interact with DOM composition to affect MeHg uptake by phytoplankton.

(3) validate our laboratory studies with field sampling

(4) develop a model to predict the processes controlling MeHg uptake to phytoplankton and thus to the food chain. The model will serve as a tool to help regulators reduce mercury entry to the food chain.

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

To address the first objective of assessing how DOM composition and concentration affect MeHg uptake by phytoplankton, I have run a series of experiments with DOM isolates from different sites and at different concentrations. Because the isolates are in the form of a powder, it is possible to reconstitute them at different concentrations, while holding all other chemical parameters constant.

For these experiments, I used radiolabled mercury as a tracer. The Fisher laboratory receives radiolabled inorganic mercury, and my first step was to learn how to methylate the mercury by a series of chemical reactions. The methylation is an involved procedure, carried out over the course of two days. After creating radiolabeled MeHg, I began a series of experiments varying the site and concentration of the organic matter.

So far, I have run experiments with organic matter from a range of sites in the Delta: (1) Mandevillle Tip, a natural freshwater marsh; (2) Twitchell Island, an island drain on peat soil; (3) Shag Slough, a site which drains the Yolo bypass; (4) the Sacramento River, a non-tidal site; (5) and pure water without any added organic matter. For Mandeville Tip, I also have two different types of isolates: a hydrophobic XAD8 fraction, and a transphilic XAD4 fraction, which will allow me to look at how differences in the chemical composition of organic matter affect MeHg bioavailability. For each site, I have been able to study at least two different concentrations of organic matter.

My results show that the concentration of organic matter is the primary factor controlling MeHg bioaccumulation. Volume concentration factors (VCFs), or the concentration of MeHg in cells divided by the amount of MeHg in an equivalent amount of water, are highest when concentrations of organic matter are low. For example, after 24 hours, cells grown in water without any added organic matter had VCFs as high as 3 x 10(sup)5(/sup). When cells were grown in water with low organic matter concentrations (150 - 250 (mu)M DOC), VCFs ranged from 3 x 10(sup)4(/sup) to 8 x 10(sup)4(/sup). With high concentrations of organic matter (500 to 850 (mu)M DOC) VCFs were generally less than 2 x 10(sup)4(/sup). These results indicate that, at high concentrations, MeHg is complexed to organic matter and is not readily available for uptake by phytoplankton.

To help test the hypothesis that complexation to organic matter reduces MeHg uptake by phytoplankton, I am currently in the process of running some experiments with live/dead cells. By heating-killing some algal cells, I will be able to determine if live cells accumulate more MeHg than dead cells. I expect that, at low concentrations of organic matter, live cells will accumulate more MeHg than dead cells, because not all of the MeHg will be bound up and some of it will be available for active uptake by cells.

In the next set of experiments, I will vary chemical parameters, such as pH and Cl-, in conjunction with DOM to further understand

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

There are no substantial modifications to the research plans and the experimental protocols have gone smoothly.

I may pursue a small side-project looking at uptake of MeHg into mayfly larvae, as a model to understand how MeHg moves into aquatic insects. This potential project would be headed by my collaborator Dr. David Buchwalter, Department of Environmental and Molecular Toxicology, North Carolina State University.

One obstacle that I have encountered is that Dr. Delon Barfuss, Georgia State University, who has previously supplied the Fisher laboratory with (sup)203(/sup)Hg will be retiring and no longer providing the isotope. Dr. Fisher has already indentified E&Z Isotope Products as an alternative supplier, so we anticipate that the change in suppliers will result in only minor delays.

One other minor complication is that the distilled water in the Fisher laboratory contains up to 100 (mu)M of DOC, making it difficult to test organic-free water. The current solution is to have my community mentor, Dr. Brian Bergamaschi, USGS, send me organic-free water.

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

CALFEDís management cue on contaminants describes mercury as having a major impact, and mentions the focus should include methyl mercury (MeHg), the form that preferentially bioaccumulates in the food chain. To manage MeHg, CALFED will need to understand how MeHg moves between different environmental compartments, particularly between water and phytoplankton, which are at the base of the food chain. Unfortunately, the mechanism by which phytoplankton actively uptake MeHg is unknown. Similarly, the effects of DOM and other environmental variables on MeHg uptake by phytoplankton are poorly understood. By elucidating these factors, this research will help CAFED predict the bioaccumulation potential of MeHg. Furthermore, by using DOM isolates from a variety of sites, this research will help CALFED evaluate spatial variations in mercury bioavailability.

Understanding how different types of DOM affect mercury bioavailability is also important to CALFEDís 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. By determining how DOM produced in wetlands will affect MeHg bioavailability to phytoplankton, this research will provide information on how the quality of Delta habitat will be affected by future scenarios. To evaluate various scenarios, this research will ultimately develop a MeHg biogeochemical model with various parameters affecting MeHg uptake to phytoplankton.

Several fish species in the San Francisco Bay-Delta are unsafe for human consumption because of mercury contamination. This project seeks to identify the chemical parameters controlling mercury uptake in phytoplankton—the pathway by which mercury enters the aquatic food chain. Some researchers speculate that phytoplankton accumulate more methyl mercury when the level of dissolved organic matter is high. The scientist is investigating the hypothesis that phytoplankton are accidentally acquiring methyl mercury as they feed. The findings may help regulators identify ways to reduce the entry of mercury into the food chain. (06 -07 Annual Report)

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

Luengen A. C., Raimondi P. T., and Flegal A. R. (2008). Linkages between algal community composition and water chemistry data on short spatial and temporal scales (poster). American Society of Limnology and Oceanography 2008 Ocean Sciences Meeting. Orlando, Florida, March 2-7, 2008.

Luengen A. C., Raimondi P. T., and Flegal A. R. (2007). Elevated trace metal concentrations in South San Francisco Bay are not measurably associated with algal community composition (poster). Eighth Biennial State of the San Francisco Estuary Conference, Oakland, California, October 16-18, 2007.

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, has served as the primary advisor and has 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. Peter Hernes, Assistant Professor, UC Davis, has provided advice on organic matter composition.
Dr. Alexander Smirnov, Postdoctoral Research Associate, Stony Brook University, has helped with Cl- analyses.
David J. Hirschberg, Sr. Research Scientist, Stony Brook University, has analyzed DOC samples.

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

Eighth Biennial State of the Estuary Conference Second Prize Poster, Student program

ProjectYear_2A 1st Year **ProjectNo_2C** R/SF-22
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KEYWORDS: List keywords that will be useful in indexing your project.

Keywords_17

Mercury, methyl mercury, MeHg, phytoplankton, dissolved organic matter, DOM, dissolved organic carbon, DOC, San Francisco Bay Delta, estuary, diatoms, (I)Cyclotella meneghiniana(/I), bioavailability, contaminants

PATENTS: List any patents associated with your project.

Patents_18

none

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

Additions_19