CALFED Progress Report
California Sea Grant College Program

ConfirmationNumber: 20110908151115

Printed: 9/8/2011 3:22:31 PM

ProjectYear_2A: 2nd

ProjectNo_2C: R/SF-41

TypeQuestionnaire_2B: Annual Report

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Project Information

ProjectNo_2C: R/SF-41 StartDate_3a: July 1, 2009 EndDate_3b: June 30, 2011

ProjectTitle_4: Pilot-scale evaluation of an iron sediment amendment for control of mercury methylation in tidal wetlands

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Community Mentor (for additional please see #9)

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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

Previous research has demonstrated the potential for an exacerbation of methylmercury (MeHg) effects that may accompany an increase in restored wetland acreage within the Bay-Delta. However, limited research has been conducted into evaluating MeHg control mechanisms that could be implemented during wetland restoration. This work intends to evaluate the efficacy of using an iron sediment amendment to control net methylmercury production in tidal wetlands of the Bay-Delta using test plots in a tidal wetland along the Petaluma River to address the following objectives.

Aim 1. To determine the effect of an iron amendment on net MeHg production in an actual wetland environment. The principle behind the iron amendment has been demonstrated in laboratory systems, but not yet under actual conditions within an existing tidal salt marsh.

Aim 2. To evaluate the long term effect of iron cycling on sulfur chemistry. Iron has a finite capacity to remove porewater sulfide, so it is necessary to determine if it is possible to induce in situ cycling of iron via FeS(s) oxidation. Additionally, the mobility of iron within the sediments needs to be evaluated to determine if a single dose could be effective or if a repeated dosing regime would be necessary.

Aim 3. To determine the effect of wetland vegetation on net MeHg production. Wetland plants have the ability to alter the biogeochemistry of the rhizosphere and selecting for certain species may provide an additional control.

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

Field work was begun during July 2009, and six test plots were established in the high marsh plain (dominated by pickleweed, Sarcocornia pacifica) of an existing tidal salt marsh near Petaluma, CA. Within each plot, 3 porewater samplers were installed at a depth of 2.5cm, and a monitoring program was begun to follow changes in concentrations of iron, sulfur, and methylmercury from July 2009 through November 2010. Additionally, laboratory sediment incubation experiments were carried out to assess the production of methylmercury under sulfate-reducing and iron-reducing conditions, an in situ core incubations were used to evaluate the effect of the exposure of the sediment surface to the air on MeHg production.

Aim 1. An iron amendment was added to two test plots in October 2009. Results following the amendment were inconclusive, as a seasonal decrease in concentrations in the control plots occurred at the same time, making it hard to detect any changes in the amended plots. Due to low porewater concentrations throughout 2010, a second iron dose was not carried out. However, due tot he high availability of iron and low sulfide concentrations present in the sediments, it seems likely that an iron amendment strategy would not be effective for MeHg control in this type of marsh.

Aim 2. Iron and sulfur cycling was addressed in both the field monitoring study and in the incubation experiments. Overall, the sediments and porewater showed fairly oxic conditions, based on the very low concentrations of reduced sulfur in the sediments, and high concentrations of Fe[III]. The in situ incubations, which were conducted with open and closed cores during July and November 2010, demonstrated that during the summer months when plants were active, separation of sediments from live plant roots and gas exchange with the atmosphere resulted in more reduced sediment conditions. Additionally, sediments at the surficial layers (0-1 cm and 3-4 cm depths) exhibited more reducing conditions during the winter than in the summer, suggesting that the oxidation of reduced iron species occurs more rapidly during the summer.

Aim 3. This research was carried out only in the test plots established in a high-marsh plain dominated by pickleweed. However, a slight effect was seen in the porewater data that suggests that the switch of pickleweed from vegetative growth to reproductive growth (i.e., flowering) caused changes in porewater concentrations during the flowering period. This suggests that pickleweed has the potential to affect MeHg production, with short term increases in MeHg concentrations possible around the time of flowering. Additionally, the in situ core experiments suggest that the presence of pickleweed during the summer season results in less reducing conditions in the sediments, either through the loss of oxygen from pickleweed roots or due to evapotranspiration transporting oxygen deeper into the sediment layers.

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

Problems encountered have included seasonal changes in porewater MeHg concentrations potentially masking any effect of our initial iron amendment. Additionally, porewater MeHg concentrations stayed at or below detection through much of 2010 and did not return to the high levels initially seen in 2009. Thus, it was not possible to re-dose the plots with iron to further test the iron amendment hypothesis. However, based on the measured geochemical parameters in the marsh, it is likely that an iron addition would not have proved effective under these field conditions.

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

This research illustrated that an iron addition strategy is not likely to be effective in the high marsh areas of tidal wetlands in San Francisco Bay dominated by pickleweed. However, our previous research suggests the potential for an iron amendment to be effective in sulfidic salt marsh sediments, such as those encountered at lower marsh elevations.

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

P.D. Ulrich and D.L. Sedlak. "Assessment of the Potential for Using Iron Amendments to Decrease Net Methylmercury Exports from Tidal Wetlands in San Francisco Bay" Bay-Delta Science Conference 2010, Sacramento, CA, September 2010. Oral Presentation.

P.D. Ulrich and D.L. Sedlak. "Methylmercury production in a pickleweed-dominated tidal salt marsh in San Francisco Bay" Manuscript currently in preparation for submission to peer-reviewed journal.

P.D. Ulrich "Methylmercury Production in Tidal Salt Marsh Sediments and Potential Control Using Iron Amendments" Ph.D. Dissertation, University of California, Berkeley. August 2011.

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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

N/A

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

N/A

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

Keywords_17

Tidal marsh, wetland sediments, mercury, methylmercury, iron amendment, sulfur cycling, iron cycling

PATENTS: List any patents associated with your project.

Patents_18

N/A

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

Additions_19