ANNUAL REPORT COMPREHENSIVE RESEARCH ON RICE
January 1, 2017 - December 31, 2017

PROJECT TITLE:
Mercury in California rice systems

PROJECT LEADER:
Bruce Linquist, UCCE Rice Specialist, Department of Plant Sciences, University of California, One Shields Ave, Davis, CA 95616
(530) 752-3450;balinquist@ucdavis.edu

PRINCIPAL UC INVESTIGATORS:

COOPERATORS:

Stephen McCord Ph.D., P.E.
President, McCord Environmental, Inc.
sam@mccenv.com

John Dickey Ph.D.
Consulting Soil Scientist & Agronomist, PlanTierra
jdickeyagro@gmail.com

Mark Marvin-DiPasquale, Ph.D.
Microbial Ecologist, USGS
mmarvin@usgs.gov

Lisamarie Windham-Myers Ph.D.
Biologist, USGS
lwindham-myers@usgs.gov

Jacob Fleck
Research Hydrologist, USGS
jafleck@usgs.gov

Luis Espino,
Farm Advisor, UCCE
Colusa, Glenn and Yolo Counties
laespino@ucdavis.edu

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OBJECTIVES AND EXPERIMENTS CONDUCTED, BY LOCATION, TO ACCOMPLISH OBJECTIVES:

Background

The overall objective of this research is to determine if MeHg discharged from CA rice systems pose a health risk to human and wildlife fish consumers, and if so, how we can cost-effectively minimize this risk. Specific objectives to meet this overall objective are:

1. Identify the annual cycle of MeHg concentration and loads in Sacramento Valley rivers.
2. Determine if MeHg production and discharge from rice systems (and associated health risks) are higher in certain parts of the region than in others (possibly due to Hg inputs from irrigation, soil or water management)
3. Compare data from the "typical" rice systems with those in the Delta.
4. If and where MeHg poses a risk, identify viable management practices that can cost-effectively minimize that risk.
5. If and where MeHg poses a risk, identify underlying causes.

In brief, between 2013 (when this project began) and 2016 this project has completed three studies since 2013 towards addressing these objectives:

1. Assessment of MeHg export from rice at the valley scale using historical data
2. MeHg and THg budgets/loads at the field scale
3. Alternate wetting and drying as a potential MeHg management practice

A summary (details in previous reports and publications) of our findings are as follows:

- Rice systems may be a source of mercury, however, loads from rice fields are small and much less than what is found in Delta rice systems where much of the previous work was conducted (Study 1 and 2).
- Peak periods of drainage water MeHg concentration and export from rice fields occur during the fallow season and possibly during the early growing season. This pattern has been consistent across studies conducted in the Sacramento Valley, Cosumnes River Preserve and Yolo Bypass (Study 1 and 2).
- Sacramento Valley rice fields have lower levels of Hg in soils and irrigation water than rice fields in the Yolo Bypass and Cosumnes River Preserve (Study 1 and 2).
- MeHg concentrations in rice drainage water from Sacramento Valley rice fields are lower than drainage water concentrations from the Yolo Bypass and Cosumnes River Preserve (Study 1 and 2).
- MeHg and THg concentrations in rice grain from the Sacramento Valley are well below levels of concern for human health (Study 2 and 3).
- Growing season rice drainage water MeHg concentrations are lower than in the fallow season (Study 1 and 2).
- During the growing season, most rice fields are MeHg sinks (they export less MeHg than they import) (Study 2).

- During the fallow season, most rice fields are MeHg sources (they export more MeHg than they import) (Study 2).
- AWD Reduces MeHg concentrations in water, soil and rice grain and is a potential mitigation practice to reduce MeHg (Study 3).

2017 Goals/objectives and experiments:

Goal 1: Publish two manuscripts

Publication of results are crucial as mercury in rice systems is likely to be more of a regulatory issue. As such, peer reviewed papers are critical in guiding scientifically based regulation. Our overall findings are that while rice systems may be a source of mercury, loads from rice fields are small; and certainly much less than what is found in Delta rice systems where much of the previous work was conducted. We further found that rice grain is very low in MeHg; that most of the MeHg leaves rice fields during winter fallow; and that if necessary, alternate wetting and drying of rice fields during growing season can reduce MeHg loads. All of the research has been conducted: One paper has been published:

Tanner K., Windham-Myers, L., Marvin-DiPasquale, M., Fleck, J.A. and Linquist, B.A. (In Press). Alternate wetting and drying decreases methylmercury in flooded rice (*Oryza sativa*) systems. Soil Science Society of America Journal.

Another paper was submitted in October for publication and we are awaiting word from the journal:

Tanner K.C., L. Windham-Myers, M. Marvin-DiPasquale, J.A. Fleck, K.W. Tate, and B.A. Linquist (Submitted Oct 3). Methylmercury dynamics in upper Sacramento Valley rice fields with low background soil mercury levels. Journal of Environmental Quality.

Goal 2: Quantify MeHg in filtered and particulate water samples going into and out of rice fields.

The current regulatory focus on MeHg is all based on unfiltered water samples. Thus, all of our research to date has focused on analyzing MeHg and Hg in unfiltered water samples. However, much of the MeHg in these samples is likely to be bound to suspended sediment. This MeHg may be less bioavailable than MeHg that is dissolved in the water. Therefore, from an ecosystem standpoint, it is the dissolved MeHg that is a better indicator of ecosystem health.

With this in mind, 2017 research focused on evaluating in-field MeHg concentrations from filtered samples, while also quantifying the filtered MeHg concentrations in water leaving rice fields. We are testing the hypothesis that higher levels of MeHg in irrigation water will result in higher MeHg concentrations in field flood water and tail water. To test this hypothesis, we identified 3 pairs of commercial rice fields. The pair of rice fields consisted of a field receiving fresh irrigation water and the other receiving recycled irrigation water. Based on previous research findings, recycled irrigation water likely has higher MeHg concentrations than fresh

irrigation water. Samples will be taken from the six commercial rice fields over the course of a year (both winter and growing season).

Fields were identified in Richvale Irrigation District (Butte County), RD-1004 (Colusa County) and RD-108 (Colusa/Yolo County) (Figure 1). While the main criteria in identifying these fields was related to the type of irrigation water received, these fields also were:

1. Representative of major rice growing areas within California
2. Had rice grown on them in the previous season
3. Kept straw on the field during the winter and flooded the field

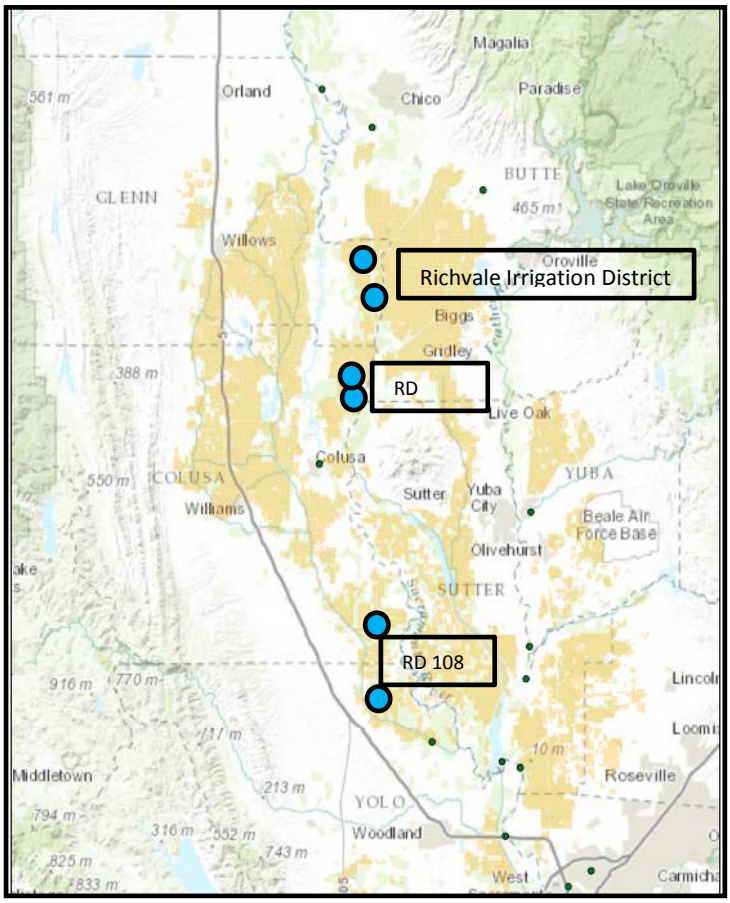

Figure 1. Location of commercial fields for the MeHg 2017/2018 sampling campaign.

From these fields we will sample water from the inlet, within the field, and outlet and determine MeHg concentrations and loads in filtered and unfiltered samples. We are planning three major sampling events in each of the seasons (growing and fallow). Soil samples will be taken from during the flooded period in each season. Grain will be sampled in each field to analyze for MeHg and Hg concentration.

In brief, the inlet and outlets are set up with equipment to measure water flow rate throughout the year. The type of equipment used varies depending on the field. Importantly, the equipment provides real time flow rates and cumulative flow. The equipment is also non-obtrusive, allowing the grower to manage irrigation water as usual. Water samples will be collected throughout the year: 3 times in growing season and 3 times during winter fallow. Samples will be collected near the beginning, middle and end of each season. This is roughly once a month during each season.

Fields were identified and sampling (plant, soil and water) began in the Fall of 2017; therefore **we do not have any data to report as of yet**. Sampling will continue through the growing season of 2018.

Goal 3: Engagement with Stakeholders

In addition, to these research activities, we are involved with various stakeholder groups that are concerned with MeHg in the delta. In conjunction with the California Rice Commission we have meet several times with growers to discuss our findings and gather their thoughts on any mitigation options (at this point there is no foreseen need for mitigation give the relatively low levels). In addition, we attend meetings and are involved with the Delta Tributaries and Mercury Council (DTMC).

PUBLICATIONS OR REPORTS:

Tanner K.C., L. Windham-Myers, M. Marvin-DiPasquale, J.A. Fleck, K.W. Tate, and B.A. Linquist (Submitted Oct 3). Methylmercury dynamics in upper Sacramento Valley rice fields with low background soil mercury levels. Journal of Environmental Quality.

Tanner K.C., L. Windham-Myers, J.A. Fleck, K.W. Tate, S. McCord, B.A. Linquist (2017) The contribution of rice agriculture to methylmercury in surface waters: a review of data from the Sacramento Valley, California. Journal of Environmental Quality 46:133-142.

Tanner, K. C., Windham-Myers, L., Fleck, J. A., Tate, K. W., McCord, S., Linquist, B. A. 2016.The Contribution of Sacramento Valley Rice Systems to Methylmercury in the Sacramento River. Poster at the Revisiting the 2003 Mercury Strategy for the Bay-Delta Ecosystem, Sources Workshop (January 26-28th, 2016)

Tanner, K. C., Windham-Myers, L., Fleck, J. A., Tate, K. W., McCord, S., Linquist, B. A. 2016. Methylmercury Export From Rice: Field Scale Methylmercry Budgets for the Sacramento Valley. Poster at the Revisiting the 2003 Mercury Strategy for the Bay-Delta Ecosystem, Biogeochemistry Workshop (January 26-28th, 2016)

Tanner, K. C., Windham-Myers, L., Marvin-DiPasquale, M., Fleck, J. A., Tate, K. W., Linquist, B. A, 2016. Alternate wetting and drying decreases methylmercury in rice ecosystems. Presentation at the American Society of Agronomy, Crops Science Society of America and Soil Science Society of America annual meeting. Phoenix, AZ. November 9th, 2016.

Tanner, K. C., Windham-Myers, L., Jacob Fleck, J. A., Tate, K. W., McCord, S., Linquist, B. A. The Contribution of Sacramento Valley Rice Systems to Methylmercury in the Sacramento River. Poster at the Rice Field Day. Aug 26, 2015. Rice Experiment Station. Biggs, CA.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

- From this study, two papers have been published and another one has been submitted for publication.
- Six commercial fields have been identified for MeHg monitoring during the 2017/2018 fallow growing season period. These fields are in 3 different irrigation districts. Fields within each district are paired such that one receives fresh irrigation water and the other receives recycled. Sampling and monitoring began in the Fall of 2017. Data not yet available.
- We remain in close engagement with various stakeholder groups that would be interested in these results and regularly provide information and give presentations at those meetings.