ANNUAL REPORT COMPREHENSIVE RESEARCH ON RICE
January 1, 2013-December 31, 2013

PROJECT TITLE: Mercury in California rice systems

STATUS OF PROPOSAL: ___X__/New ____/Continuing

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

The overall objective of this research is to determine if MeHg in and 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 that were addressed in 2013 were:

1. Assemble a research team to address the issue of MeHg in Sacramento Valley rice systems.
2. Identify the annual cycle of MeHg concentration and loads in major Sacramento Valley rivers.
3. 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)

SUMMARY OF 2013 RESEARCH, BY OBJECTIVE:

Objective 1. Assemble a team

A team has been assembled which include representatives from the CRC, USGS, and UC Davis. A graduate student has been identified and is currently working on this project as part of her MSc thesis.

Objectives 2 and 3. Analyze data:

Data

Before data analysis could begin, data needed to be collected. We found four reports containing MeHg data for Sacramento Valley water bodies (Table 1). These data cover eight years in total over the ten year period from 1996 to 2006. In addition, a small amount of unpublished data was collected by the Central Valley Regional Water Quality Control Board in the fall of 2011. These data sets are listed in Table 1. This analyses primarily utilized data from sites surrounding rice growing areas.

Table 1. Methylmercury sampling programs in the Sacramento Basin.

Program	Sampling period	Number of sites	Number of samples
National Water Quality Assessment (NAWQA)	February 1996- June 1998	5	23-29
Sacramento River Watershed Program (SRWP)	July 2000-April 2003	10	14-18
CALFED Bay-Delta Program	March 2003-June 2006	16	23-31
SRWP Proposition 50 funding	April 2006-August 2007	12	17-18
Central Valley Regional Water Quality Control Board	August and September 2011	18	2

Results

Spatial variation: To determine if there are major variations of MeHg concentration in rice irrigation source waters, sites on the main rivers above rice areas were compared (Fig.1). Only

two sites were available in the Feather River watershed: Yuba River at Marysville which is immediately upstream of the confluence with the Feather River, and Feather River at Nicolaus which is downstream of all main inflows to the Feather River. Three sites on the Sacramento River were compared here: Bend Bridge which is the source waters for the Tehama Colusa Canal, Hamilton City which is the source waters for the Glen Colusa Canal, and Colusa which is downstream of rice irrigation source waters, but upstream of rice drainages. There was more variation in MeHg concentrations among sites on the Sacramento River than between the Sacramento River and sites on the Feather River and its tributary the Yuba River. The lowest MeHg concentrations were seen on the Sacramento River above Bend Bridge. Yuba River at Marysville, Feather River at Nicolaus and Sacramento River at Hamilton City all showed similar MeHg concentrations. Sacramento River at Colusa had the highest MeHg concentrations of sites on main rivers above agricultural drainages.

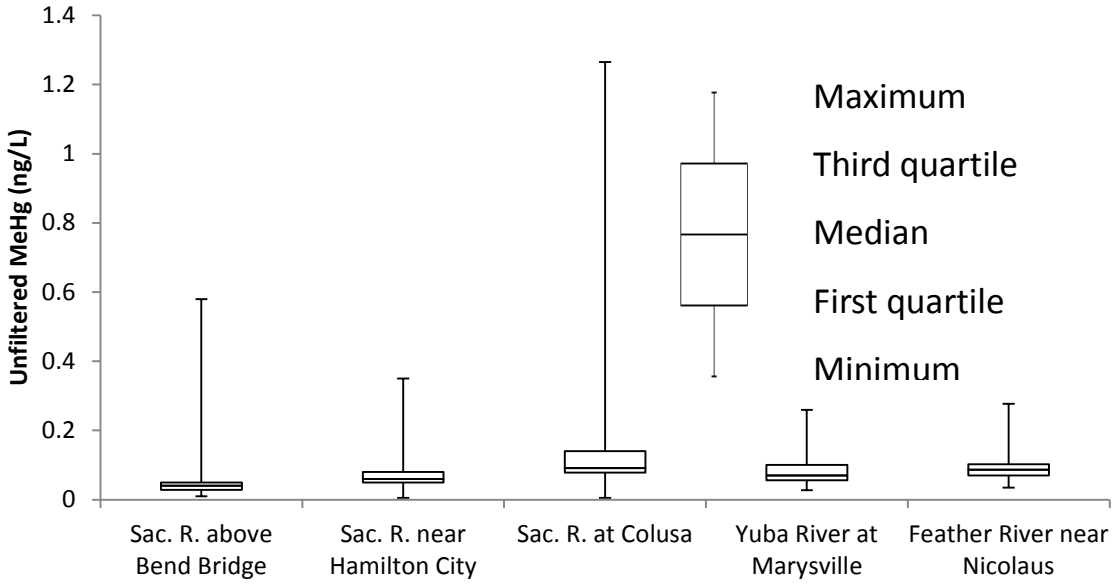

Figure 1. MeHg concentrations at sites above rice drainages.

Long term pattern: To determine if there have been long term changes in MeHg concentrations in water ways in the region, all of the data were plotted against time (Fig. 2). With the exception of some outliers seen in the early data, MeHg levels have remained consistent throughout this period. It is important to note that there were substantial changes in rice straw management during this period. Field burning was phased out and winter flooding increased. This does not appear to have affected MeHg concentrations in rice drainage waters.

Seasonal pattern: To determine if there is a seasonal pattern of MeHg concentrations in rivers and agricultural drains, all years of MeHg concentration data were plotted together using the month and day of sample collection (Fig. 3). There is a clear period of consistently low MeHg concentration values from June to October. From November through May the majority of MeHg measurements are also low, but there are spikes of much higher concentrations. This pattern is seen in both agricultural drainages and mainstream sites, and it does not line up with the rice growing season. Averaged across sites winter season MeHg concentrations are about double what is observed during the growing season (0.21 vs 0.12 ng/L).

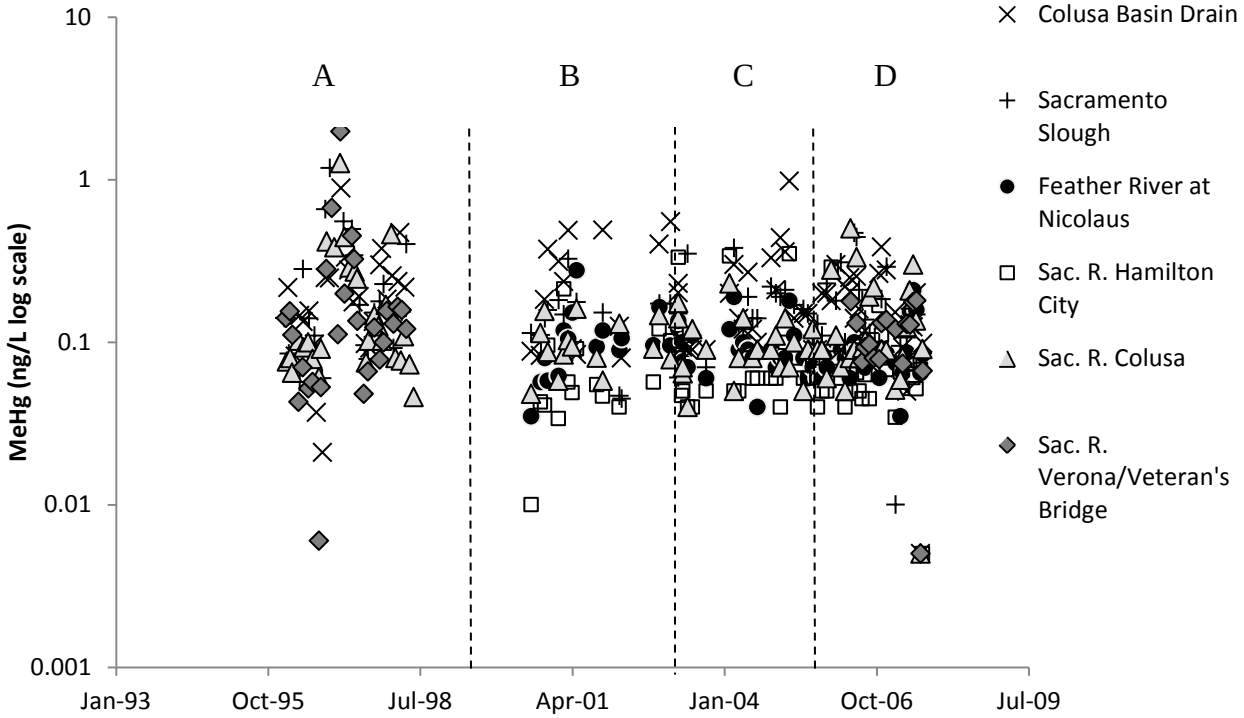

Figure 2. MeHg concentrations plotted against date of collection. A: National Water Quality Assessment, B: Sacramento River Watershed Program, C: CALFED Bay-Delta Program, D: Sacramento River Watershed Program Proposition 50 Funding.

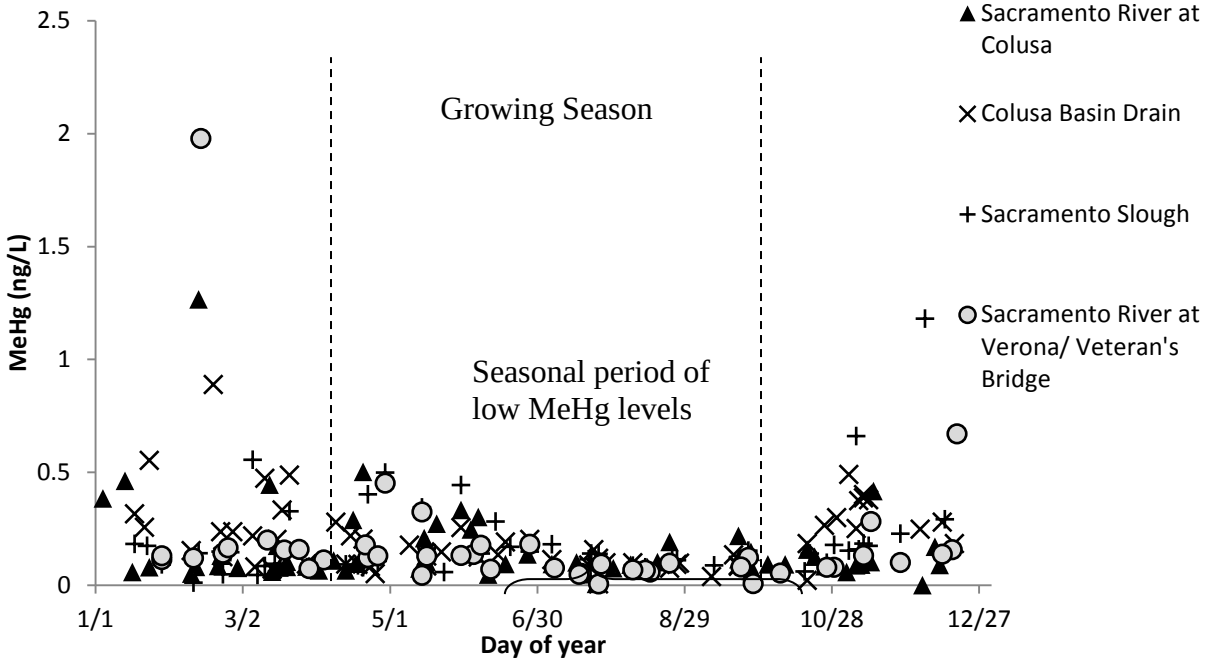

Figure 3. MeHg concentrations up stream of agricultural drains (Sacramento River at Colusa), with in agricultural drains (Colusa Basin Drain and Sacramento Slough), and downstream of agricultural drains (Sacramento River at Verona and Veteran's Bridge). Four to six years of data are shown, plotted by month and day to show seasonal patterns.

Effect of Rice: During the winter (November – March), rice drainages had higher concentrations of MeHg than along the main stream (Fig.4). In the growing season (April – October), MeHg concentrations in rice drainages were similar to concentrations at main-stream sites.

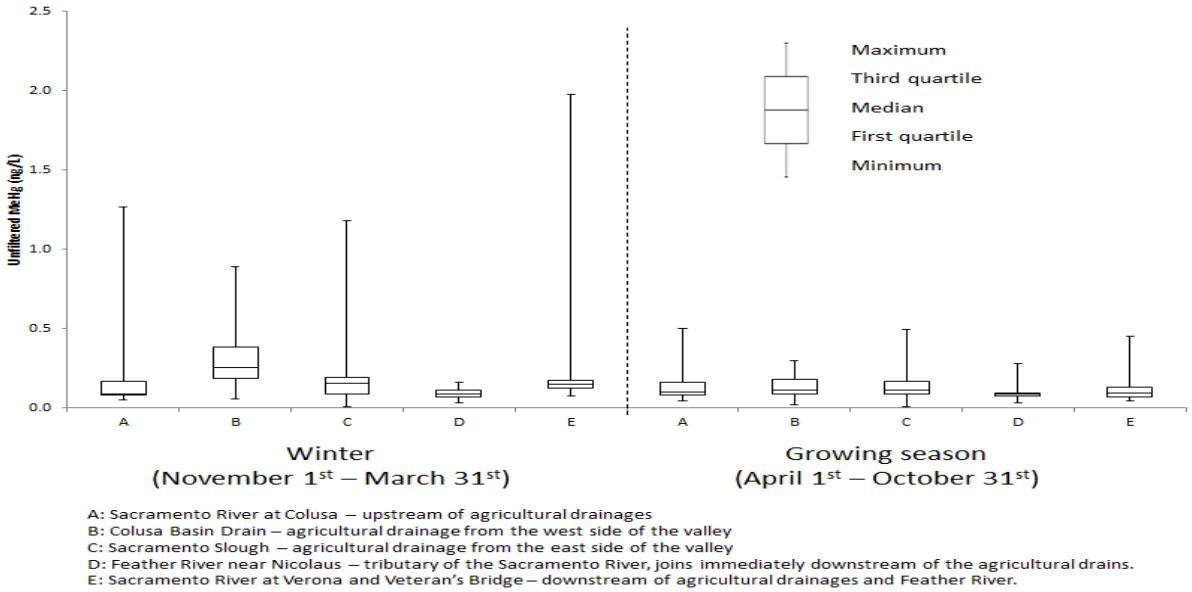

Figure 4.MeHg concentrations during summer and winter periods for agricultural drainages (B and C) and rivers above (A and D) and below agricultural drainages (E). Site E is downstream of the convergence of sites A through D.

Data limitations: A load (concentration x stream flow) based analysis is the best way to determine if rice is an important source of MeHg, but stream flow data for agricultural drain sites is largely unavailable. Data analysis so far has shown that MeHg concentrations in rice drainages tend to be elevated in the winter, but without stream flow data it is difficult to determine if this results in an increased export of MeHg to the Sacramento River. Therefore it will be necessary to design an experiment where loads can accurately be determined throughout the year.

PUBLICATIONS OR REPORTS: None

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

- MeHg concentrations are similar in the Sacramento and Feather watersheds.
- While rice straw management practices changed greatly during the study period, MeHg concentrations remained relatively constant from year to year.
- MeHg concentrations follow similar seasonal patterns in both agricultural drains and rivers. From June through October MeHg concentrations are consistently low, while November through May spikes in MeHg concentrations are common.
- Rice systems appear to be a relatively minor source of MeHg during the growing season, but may be an important source during the winter. Existing data are not sufficient to determine the effect of rice systems in the winter, so field studies will be needed.