ABSTRACTS

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Global Perspectives and Regional Results: Science and Management in the Bay-Delta System

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Mercury Cycling in Agricultural and Non-Agricultural Wetlands in the Yolo Bypass Wildlife Area, California: Concentrations and Loads of Inorganic Surface-water Constituents

Different wetland types in the Yolo Bypass Wildlife Area (YBWA) provide ecological benefits within a flood conveyance zone designed to protect urban areas. Principal habitats in the YBWA are permanently flooded wetlands and seasonally flooded wetlands managed for white and wild rice production (flooded during May/June through Sept./Oct.), shallow-flooded fallow fields (flooded during July/August), and non-agricultural natural wetland habitats (flooded commonly during October-April). Sediments in YBWA are contaminated with mercury (Hg) from historical gold mining in the Sierra Nevada and Hg mining in the Coast Range. The juxtaposition of Hg and wetlands can pose threats to human and ecosystem health because the environmental conditions that prevail in wetlands convert inorganic Hg(II) to methylmercury (MeHg), a more toxic form that bioaccumulates in food webs. During June 2007 - April 2008 we measured concentrations of total Hg (THg), MeHg, major and trace elements, and numerous ancillary parameters in three agricultural wetland types (wild rice, white rice, shallow-flooded fallow) and two managed non-agricultural wetlands (seasonally and permanently flooded) in the YBWA. Inflows, outflows, and water levels were monitored at each field so that loads could be calculated. Outflows varied greatly between the fields, ranging from about 5 to 40% of the applied irrigation waters. During summer 2007, agricultural fields (rice and fallow) showed increases in THg and MeHg concentrations (in filtered waters) from inflows to outflows, whereas the permanently flooded wetland showed no differences. The agricultural fields were consistently higher in aqueous THg and MeHg concentration than the permanently flooded wetland. Effects of sulfate reduction were apparent in all wetlands based on temporal trends in sulfate/chloride ratio and sulfur isotopes of aqueous sulfate, but there was no apparent impact of sulfate-bearing fertilizers on aqueous MeHg concentrations. This is probably because sulfate is not limiting the activity of sulfate reducing bacteria in this system.

CALFED Statement of Relevance
This research quantifies mercury cycling on and off various wetland types in the Yolo Bypass, a known "hot spot" for mercury in the Delta, and is the first study to assess sulfate-bearing fertilizers in agricultural wetlands with regard to possible stimulation of sulfate-reducing bacteria and related effects on rates of mercury methylation.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 10:20 AM, Rooms 311-313

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Mercury Cycling in Agricultural and Non-Agricultural Wetlands in the Yolo Bypass Wildlife Area, California: The Influence of Organic Matter in the Water Column

Organic matter (OM) composition plays a significant role in mercury (Hg) cycling in natural systems. Aromatic dissolved OM can enhance Hg solubility leading to greater cycling in the water column, whereas bioavailable forms of OM may enhance methylmercury (MeHg) production by increasing the activity of Hg(II)-methylating bacteria. Differences in wetland management (e.g. fertilization, plant type, water depth, and residence time) can influence the composition of OM within the wetland, and thus affect Hg cycling. We measured total Hg and MeHg concentrations, OM concentration and composition, and numerous ancillary parameters in three agricultural wetland types (wild rice, white rice, shallow-flooded fallow) and two managed non-agricultural wetlands (seasonally and permanently flooded) in the Yolo Bypass Wildlife Area (YBWA). Results suggest that while OM plays a significant role in Hg cycling in YBWA wetlands, its relative influence is spatially and temporally variable. Despite high dissolved organic carbon (DOC) concentrations normally associated with wetlands (up to 30 mg/L as C), the dissolved OM at the YBWA was low in aromaticity and hydrophobicity relative to other wetland environments. Based on measured optical properties, OM in the YBWA wetlands appears to be derived from a mixture of algal sources, plant exudates, and diffusion from the flooded soils, with the proportion of each source dependent on the specific land use management practices. All wetlands that were subjected to prolonged wet-dry cycles, both agricultural and non-agricultural, exhibited similar trends in organic matter properties and in Hg partitioning to the dissolved fraction, whereby the soluble Hg fraction increases with duration of inundation. The permanently flooded wetland was unique in its lack of variability in organic matter and mercury trends.

CALFED Statement of Relevance

This research addresses the role of dissolved organic matter as it impacts Hg cycling in different wetland types. Achieving CALFED objectives of restoring wetland ecosystems in the Bay-Delta watershed while improving water quality requires a process-level understanding of the synergistic and/or competing factors influencing methylmercury production and export.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 10:40 AM, Rooms 311-313

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Mercury Cycling in Agricultural and Non-agricultural Wetlands of the Yolo Bypass Wildlife Area, California: Sediment Biogeochemistry

As part of a larger investigation into mercury (Hg) cycling as a function of habitat type in the Yolo Bypass Wildlife Area, we examined the factors controlling benthic methylmercury (MeHg) production in three types of agricultural fields (white rice, wild rice and fallow) and two types of non-agricultural managed wetlands (permanently and seasonally flooded). Sediment total Hg (THg) concentrations were consistently elevated in the agricultural fields, compared to the managed wetlands. It is unclear if this trend reflects a general east-west THg gradient in the Bypass, historic deposition patterns, or current land use practices. Geochemical data for sediment sulfur and iron suggest that agricultural fields were generally more poised for microbial Fe(III) reduction than for sulfate reduction, whereas permanently flooded wetlands were more poised for sulfate reduction. The addition of sulfate-bearing fertilizers to agricultural fields did not stimulate sulfate reduction (nor Hg(II)-methylation) because this microbial process was not sulfate limited in these fields. The pool of microbially available inorganic 'reactive' mercury (Hg(II)R) was inversely related to sediment total reduced sulfur concentration, closely tracked sediment redox conditions, and was lowest when sediment was most reducing. The permanent wetland exhibited the highest activity of Hg(II)-methylating bacteria, but had comparatively low concentrations of Hg(II)R. Agricultural fields had comparatively lower activities of Hg(II)-methylating bacteria but generally higher concentrations of Hg(II)R. MeHg concentrations and production rates were highest in fallow agricultural fields compared with rice-sown fields and the permanent wetland during rice-growing season (June – August). There was a significant increase in MeHg concentrations in agricultural fields, post-harvest (December – February), possibly linked to the release of labile organic matter from decaying plant remains. These results imply that MeHg production varies as a function of wetland habitat type, hydrology (wetting-drying cycles), and land use practices, and may be enhanced in agricultural rice fields during the post-harvest period.

CALFED Statement of Relevance
This research addresses the factors that control microbial methylmercury production in both agricultural and non-agricultural wetland settings in the northern Delta region. Specifically it distinguishes factors that mediate the activity of Hg(II)-methylating bacteria from those that mediate the availability of Hg(II) to those bacteria.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 11:00 AM, Rooms 311-313

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Mercury Cycling in Agricultural and Non-agricultural Wetlands of the Yolo Bypass: Plant Influences on Biogeochemistry

Wetlands of the Yolo Bypass differ profoundly in their hydroperiod and vegetation structure. From June 2007 to February 2008, we examined mercury (Hg) cycling as related to vegetation metrics in 5 habitat types, including three types of agricultural fields (white rice, wild rice, and fallow) and two types of managed wetlands - permanently flooded (tule and cattail-dominated) and seasonally flooded. We compared vegetated and devegetated sites in all the wetlands. Within the permanent wetland, open water sites were also compared to the cattail- and tule-vegetated sites. Plants appear to have active and passive roles in supplying labile organic carbon that fuels microbial Hg(II)-methylation, and in reoxidizing Fe(II) for reuse by iron-reducing bacteria. Within the permanent wetland, open water habitats had 20-50% lower microbial biomass, lower MeHg production rates and lower MeHg concentrations, compared to vegetated sites. Devegetation reduced methylmercury sediment concentrations and production rates in all wetlands studied. From June-August 2007, root density was correlated with microbial Hg(II)-methylation in the sediments in agricultural fields, but not in managed wetlands. However, despite lower root densities in winter, the highest MeHg concentrations and production rates were observed in agricultural fields in February 2008 (post-rice harvest), when aboveground tissues were in various states of decay. Estimated pools of surficial detritus in agricultural fields were correlated with sediment MeHg concentrations in February 2008, suggesting a seasonal shift in carbon supply to the Hg(II)-methylating bacterial community, from belowground sources (via active plant exudation of labile organic matter) during the growing season, to aboveground sources (via plant decomposition) during winter months.

CALFED Statement of Relevance
This research addresses structural and functional differences between wetlands that influence microbial rates of mercury methylation. Achieving CALFED objectives of restoring and enhancing wetland ecosystems in the Bay-Delta watershed while also maintaining and improving water quality requires process-level understanding of factors controlling methylmercury production and export, such as vegetation and carbon supply.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 11:20 AM, Rooms 311-313

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Mercury Cycling in Agricultural and Non-Agricultural Wetlands in the Yolo Bypass Wildlife Area, California: Bioaccumulation in Small Fish and Invertebrates

Agricultural and non-agricultural wetlands provide both economic and ecosystem benefits, however they also are thought to increase methylmercury production – the most bioavailable and toxic form of mercury (Hg) to wildlife and humans. Currently, it is unclear which wetland habitats produce the most methylmercury. We examined the bioaccumulation of mercury in small fish and invertebrates within white rice, wild rice, and permanent wetland habitats at the Yolo Wildlife Area. We introduced 30 Western mosquitofish in cages placed at the inlet, center, and outlet of each wetland habitat type in June (18 cages total), immediately after the white rice fields were flooded. After 60-days of exposure, Hg concentrations in caged mosquitofish had increased by 12, 6, and 3 times over reference fish levels (from the same fish stock originating at Sacramento County Vector Control) in white rice, wild rice, and permanent wetland outlets, respectively. Hg concentrations and Hg burdens differed among wetland habitats, with white rice and wild rice having significantly elevated Hg in caged mosquitofish. Caged mosquitofish at the outlets had much higher Hg concentrations and body burdens than fish at the inlets for white rice, but not permanent wetlands. Hg in caged moquitofish was elevated at all sites in wild rice. We found similar patterns of higher Hg levels in white rice and wild rice than in permanent wetlands, and higher Hg concentrations at outlets compared to inlets for wild-caught mosquitofish and Mississippi silversides which occurred naturally in the agricultural fields at high densities. Our results indicate that methylmercury bioaccumulation is higher in agricultural wetlands than permanent wetlands, and small fish at the outlets of white rice fields in the Yolo Bypass have Hg concentrations averaging 1.78 μg/g dry wt – well above the TMDL target level of 0.15 μg/g dry wt (0.03 μg/g wet wt) for the Delta.

CALFED Statement of Relevance
Improving water quality is one of CALFED's primary goals, and our results are directly applicable to managing water from agricultural and natural wetlands with respect to mercury contamination. We show that agricultural wetlands within the region are zones of high methylmercury bioaccumulation and may be substantial sources of methylmercury to the Delta ecosystem.

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