Connecting Process Understanding, Field Observations, and Management Needs to Develop Mercury Cycling Models for the Delta and Yolo Bypass

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A key to creating useful mercury cycling models for the Delta and Yolo Bypass is building connections among modelers, scientists and managers as an integral part of the model development process. In response to recent Delta methylmercury Total Maximum Daily Load (TMDL) requirements, the Department of Water Resources is developing mercury cycling models for both the Delta and the Yolo Bypass. The Delta model will add sediment transport and mercury cycling submodels to an existing flow and water quality model, the Delta Simulation Model 2 (DSM2). The Yolo Bypass model will combine a newly developed TuFlow model of flows in the Bypass with the Dynamic Mercury Cycling Model (D-MCM). During the initial model development phase of these projects, the modelers have fostered connections with scientists and managers in order to create modeling tools that are scientifically sound and support management decision making. This talk explores the critical role that building connections as part of the model development process has in:

· understanding the physical, chemical and biological mercury cycling processes,
· evaluating available field data to support model calibration and validation,
· identifying knowledge and data gaps, and
· anticipating data products useful for addressing regulatory and management objectives.

Keywords: Model development, methylmercury, mercury cycling, sediment transport, TMDL, Yolo Bypass
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Addressing the Delta Methylmercury Conundrum – Prioritizing Nonpoint Source Management Practices for On-site and Receiving Water Objectives

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Problem Statement: The Sacramento-San Joaquin Delta (Delta) provides multiple beneficial uses for humans and wildlife, some of which are impaired by elevated methylmercury (MeHg) concentrations bioaccumulated in fish. The Delta MeHg total maximum daily load (TMDL) implementation plan obligates dischargers to conduct MeHg control studies to address allocated load reductions.

Approach: Over 150 stakeholders representing MeHg nonpoint sources (NPS) recently collaborated to identify 24 management practices (MPs) for reducing MeHg production on-site and/or discharges off-site. MPs were divided into three categories: biogeochemistry (6), hydrology (14), and soil/vegetation (4). Applicable land uses were divided into six categories: permanently and seasonally flooded wetlands, flooded and irrigated agricultural lands, floodplains, and brackish-fresh tidal marshes. Stakeholders scored each MP-land use option by seven criteria: scientific certainty, costs, load reduction potential, spatial applicability, technical capacity to implement, negative impacts to beneficial uses, and conflicting requirements. Semi-quantitative scoring ("-" discouraging; "0" neutral; "+" encouraging) for applicable MPs (>400 individual scores) led to a consensus-based prioritization by diverse and accomplished NPS stakeholders of the most promising MPs for application or study.

Results: MPs that address hydrology and soil/vegetation were generally prioritized higher because experiences were positive and implementation appeared more feasible. Several other MPs were prioritized lower because they conflicted with other important management objectives.

Conclusions/Relevance: The prioritized suite of most promising MPs for study and application are described for use by all nonpoint source dischargers in the Delta. The management implications of these findings are that current regulations are presenting new obstacles to meeting current land management objectives. The scientific implication of this work is that MeHg control studies need to address the TMDL conundrum that MPs effective at reducing MeHg exports could exacerbate MeHg exposure on-site or conflict with other management objectives.

Keywords: methylmercury, nonpoint sources, TMDL, Delta, management practices, control study
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Too Much or Too Little? Assessing the Impact of Reduced Nutrient Loading from Wastewater Effluent on Foodweb Dynamics in the Delta

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Prior studies suggest that ammonium in wastewater reduces phytoplankton growth rates and alters phytoplankton species composition in the Sacramento River and San Francisco Estuary, reducing available food stocks for endangered fish. To comply with its new discharge permit, the Sacramento Regional Wastewater Treatment Plant (SRWTP) is building a new tertiary treatment facility that will reduce its loadings of total nitrogen (including both ammonium and nitrate) to the Sacramento River. To better understand how effluent inputs to the Sacramento River affect nutrient and phytoplankton dynamics, we conducted Lagrangian-based sampling campaigns in the presence and absence of wastewater discharges, by coordinating wastewater holds with the SRWTP. Over six-day periods in October 2013 and May 2014 we tracked changes in water quality, nutrient concentration, phytoplankton concentration, and phytoplankton species composition in parcels of water representing normal wastewater discharge conditions (+WW) and no wastewater discharge conditions (-WW) as they traveled 45 miles from the City of Sacramento, past the SRWTP outfall by Freeport, past Isleton, and into the Cache Slough Complex. Results indicate that phytoplankton abundance declined with downstream travel both in the presence and in the absence of wastewater. This finding suggests that declines in phytoplankton concentrations observed as water travels past SRWTP and into the Delta may be attributable to other factors besides wastewater-derived ammonium. Expected reductions in nutrient inputs to the Delta due to changes in wastewater treatment plant operations need to be considered in combination with changes in hydrodynamics and biogeochemical cycling associated with large-scale tidal wetland restoration, as there is potential for there to be complex effects on food-web dynamics and ecosystem function.

Keywords: nutrients, foodweb, wastewater, ammonium, nitrate, phytoplankton, chlorophyll, nitrate
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No Skeletons in this Closet—Identifying Key Drivers of Methylmercury Reductions in Municipal Wastewater Treatment Facilities in the Delta Region

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The Sacramento-San Joaquin Delta Methylmercury TMDL, effective since October 2011, requires all dischargers of methylmercury to the Delta to evaluate potential control strategies to reduce those loads. The Central Valley Clean Water Association (CVCWA) Methylmercury Special Project Group responded to this requirement with an organized, comprehensive evaluation of historical data from municipal wastewater treatment plants that employ a range of treatment processes. The Special Project Group includes all 14 wastewater treatment plants in the Delta and Yolo Bypass with NPDES permits that have been assigned load allocations under the TMDL, plus six NPDES facilities that discharge to Delta tributary watersheds. Members of the Special Project Group are all currently monitoring influent and effluent methylmercury monthly to supplement previously compiled data, while a subset are also monitoring in-process concentrations. Of particular interest are facilities that have monitored before and after treatment process changes. Consistent with one study hypothesis, effluent monitoring data indicate a strong positive correlation between nitrogen and methylmercury. Specifically, treatment facilities that provide nitrification and denitrification processes consistently show effluent methylmercury levels at or below method detection limits of 0.01 ng/L. These results, from a broad spectrum of municipal wastewater facilities throughout the Delta region, have important scientific and management implications statewide and nationwide: treatment processes that drive nitrogen removal will concomitantly remove methylmercury, and source controls (commonly thought to be an important component of municipal treatment facility mercury control strategies) are not effective at further impacting effluent concentrations.

Keywords: methylmercury, wastewater, treatment, nitrogen, nitrate, delta, TMDL, mercury, CVCWA
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Using Permanent Wetlands as Polishing Ponds to Remove MeHg: Results of a Large Scale Replicated Field Experiment at the Yolo Bypass Wildlife Area

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Managed seasonal wetlands in the Yolo Wildlife Area (Davis, CA) typically export monomethylmercury (MMHg) during the fall inundation period. In this experiment, we routed tailwater on three separate years from a seasonal wetland through nine 100 m x 25 m constructed permanent ponds to examine the effects that residence time has on MMHg removal . The ponds were kept 1-m deep using an alternate water source from an adjacent ditch prior to receiving the tailwater. We measured unfiltered and filtered total mercury and MMHg as well as nutrients, suspended sediment, and dissolved organic carbon in each of the receiving ponds and tailwater. Pond residence times were estimated, under different flow regimes, using Rhodamine dye as a pulsed tracer and YSI sondes with Rhodamine sensors. Conductivity was used to cross-validate the residence time estimates during the initial pulse of tailwater into the ponds. Residence times ranged from as short as 0.7 days up to 13.0 days in each pond (Q = 0.08 cfs – 1.39 cfs) and was controlled using V-notch risers. Reductions of dissolved MMHg concentrations were 0.024 ng L^{-1} d^{-1}– 0.455 ng L^{-1} d^{-1} and particulate MMHg reductions were 0.028 ng L^{-1} d^{-1} –1.02 ng L^{-1} d^{-1} in the constructed ponds. The constructed ponds were also effective at reducing tailwater total suspended sediments (0.21 mg L^{-1} d^{-1}– 9.13 mg L^{-1} d^{-1}). There was no net additional reductions in MMHg typically >14 days past the initial pulse, which usually occurred mid-November, when tailwater MeHg concentrations are much lower and at equilibrium with the pond water (0.30 ng L^{-1}– 0.40 ng L^{-1}). These results suggests small ponds with short residence times can be efficient at removing MMHg; however, the size of actual ponds will vary depending on the volume of wetland being drained and needs of the wetland manager.

Keywords: Mercury, Methylmercury, Polishing Ponds, Wetland Management
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