Mercury In Motion: Quantifying Mercury Flux in Alviso Slough

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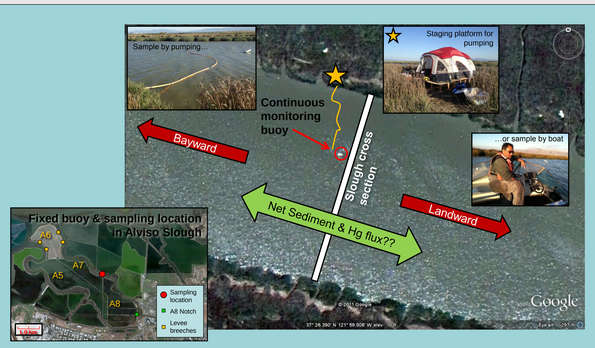
South Bay Salt Pond Restoration Project — Restoring the Wild Heart of the South Bay

Introduction

The ongoing 6,500 hectare wetland restoration project in South San Francisco Bay represents one of the largest wetland restoration efforts in the world. One of the challenges faced by project managers is legacy mercury (Hg) buried in primary slough channels and former salt ponds within the restoration area. Levee breaches associated with the restoration project are causing vast changes in the hydrology of the restoration area, and these changes are projected to mobilize Hg buried in the sloughs and marshes (via slough widening). The current study focused on quantifying Hg flux associated with suspended sediment in Alviso Slough.



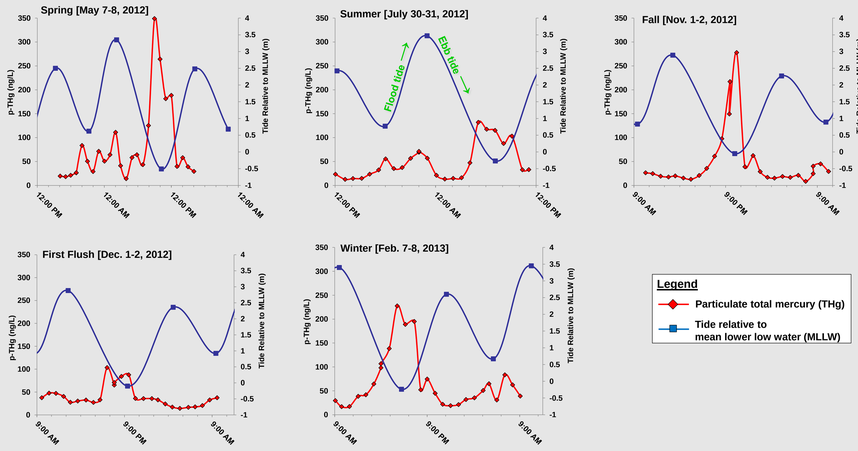
Objectives

- To quantify total mercury (THg), methylmercury (MeHg) and 'reactive' mercury (HgR) flux (quantity and direction) across an imaginary cross-sectional plane at a fixed station located mid-way up Alviso Slough
- To conduct these measurements once for each of the 4 major seasons and during the first major 'flush' event of the 2012-2013 water year
- To relate the flux of Hg species to the chemical composition of the water column particulate and dissolved phases
- To examine the partitioning of Hg species between the particulate and dissolved phases as a function of chemical composition and season

Methods

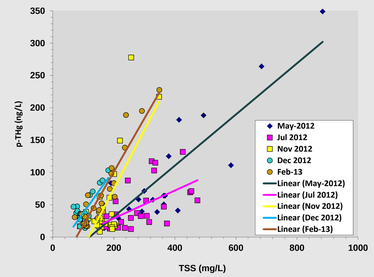
- Water column velocity, suspended sediment concentration (SSC), conductivity, temperature and dissolved oxygen has been being measured at 15 min. intervals since October 2010, at a fixed-buoy station in Alviso Slough, approximately 4.0 km upstream of the slough mouth (see map). Occasional breaks in this (otherwise continuous) dataset exist due to instrument fouling or failure.
- On 5 occasions, surface water samples (top 10-20 cm of water column) was collected every hour for 25 hrs (over two full tidal cycles) either by pumping from an on-shore staging platform or by boat (surface grab sample) using trace metal clean techniques.
- Water samples were immediately filtered on-site for a wide suite of particulate and dissolved constituents (see results).
- Sample collection periods included Spring (May 2012), Summer (July 2012), Fall (November 2012), winter (February 2013), and the first significant flush event for water year 2012-13 (December 2012).
- All post-collection analysis of dissolved and particulate sample constituents were conducted with standard methods and extensive quality control. Details available upon request.

Particulate THg Time Series



- Surface water particulate THg concentration responded strongly to tidal cycles, generally increasing during ebb tide and decreasing during flood tide.
- Subsequent tides are asymmetrical. Peak THg concentrations corresponded to the lowest of the two low tides during each sampling event.
- The December 'first flush' event exhibited the least amount of concentration variability.

Particulate THg vs Total Suspended Solids



Sampling Event	Slope ± (std. error) (ng THg / mg TSS)	Regression R^2
May 2012	0.40 (0.04)	0.79
July 2012	0.22 (0.07)	0.30
Nov. 2012	0.91 (0.18)	0.52
Dec. 2012	0.66 (0.11)	0.58
Feb. 2013	0.82 (0.07)	0.85

- Surface water total suspended solids (TSS) accounted for 30–85% of the variability in particulate THg concentration (in ng/L) across all 5 sampling events.
- The slope of the TSS vs p-THg plot provides an average THg concentration (in ng/[mg TSS]) for each sampling period.
- Slope values were lower during spring (May) and summer (July), compared to fall (Nov.), first-flush (Dec.) and winter (Feb.).

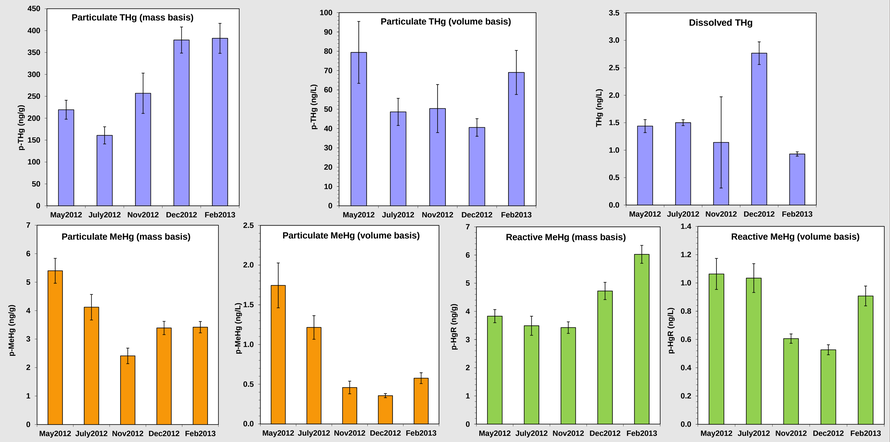
Daily Sediment and Hg Species Flux

Sampling Event	Suspended sediment flux (kg / day)	Particulate THg flux (g / day)	Particulate MeHg flux (g / day)	Particulate HgR flux (g / day)	Flux Direction
Spring [May 2012]	-62,780	-13.7 ± 2.1	-0.339 ± 0.043	-0.240 ± 0.022	Landward
Summer [July 2012]	N.D	N.D.	N.D.	N.D.	N.D.
Fall [Nov. 2012]	28,280	7.3 ± 0.8	0.068 ± 0.005	0.097 ± 0.004	Bayward
1st flush [Dec. 2012]	15,420	5.8 ± 0.7	0.052 ± 0.006	0.073 ± 0.008	Bayward
Winter [Feb. 2013]	8,970	3.4 ± 1.2	0.031 ± 0.007	0.054 ± 0.011	Bayward

N.D. = no data, due to a faulty velocity sensor on the fixed-buoy

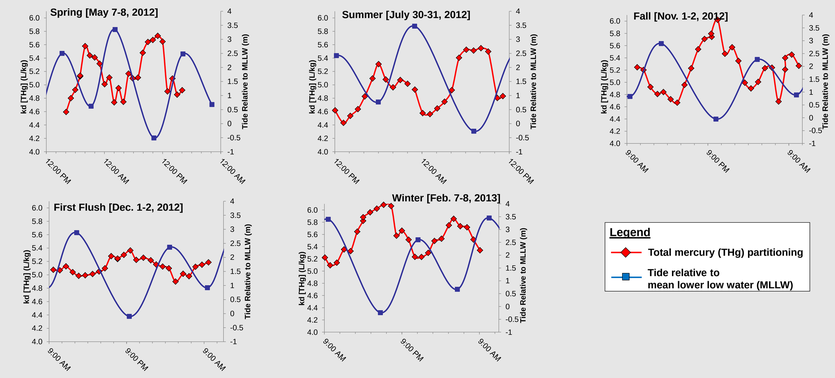
- Hg species flux values calculated from 24 hour (15 min integrated) buoy turbidity (SSC) data and mean (± std. error) surface water Hg species concentration data (ng g^{-1} dry wt.) for each sampling event.

Average Seasonal Concentrations



- Particulate THg was highest during 'first flush' (Dec.) and winter (Feb.) on a particle dry wt. (mass) basis, and during winter and spring (May) on a whole water (volume) basis.
- Dissolved THg was highest during the first flush.
- Particulate MeHg was highest during spring (May) and summer (July), both on a mass and volume basis.
- HgR is a surrogate for the pool of inorganic Hg(II) readily available for microbial Hg(II)-methylation.
- Particulate HgR was highest during 'first flush' (Dec.) and winter (Feb.) on a mass basis, and lowest during fall (Nov.) and first flush on a volume basis.

Total Hg Partitioning Coefficients



- Partitioning coefficients (k_d's) reflect the ratio of particulate to dissolved THg, with increasing numbers reflecting a shift towards particulates, and decreasing values a shift towards the dissolved phase.
- All sampling events demonstrated peak k_d's during low tide and low kd's during high tide, suggesting a tidally influenced affect on Hg partitioning over short time scales.
- To the degree that dissolved Hg is more bioavailable (for uptake into phytoplankton) than is particle bound Hg, this suggests an enhanced degree of Hg bioavailability during flood / high tides.
- Tidal variations in kd's were least pronounced during the Dec. 'first flush' event.

Acknowledgments

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