Methylmercury in Sinclair Inlet, Puget Sound, Washington

Patrick Moran[1], Anthony J. Paulson[1], and Dwight E. Leisle[2]

Introduction

Sinclair Inlet is an embayment of Puget Sound, Washington, and is adjacent to the Bremerton naval complex (BNC). Prior to the removal and capping of contaminated sediment during 2000–2001, Sinclair Inlet sediments had a high total Hg (THg) to total organic carbon (TOC) ratio, which placed Sinclair Inlet in the tier of Puget Sound estuaries with the highest level of mercury contamination (Paulson and others, 2009). In 2005, THg concentrations in mussels caged at Sinclair Inlet sites with average sediment THg concentrations were higher than those in mussels caged at BNC sites with above average THg sediment concentrations (Applied Biomonitoring, 2009). Between August 2008 and August 2009, a comprehensive field study was conducted to describe and quantify: (1) the biogeochemical processes that lead to methylation of mercury in sediments, (2) the release of methylmercury and ionic mercury from sediments, and (3) the bioaccumulation of methylmercury into the base of the pelagic food web. Marvin-DiPasquale and others (2010) assessed the seasonal probability that THg in the sediments throughout Sinclair Inlet may be methylated. In this poster, sediment porewater geochemistry and the release of methylmercury using incubated sediment-core experiments are examined seasonally at three sites within the BNC and three sites in greater Sinclair Inlet (fig. 1). In the water column, the temporal variability (as monthly sampling) of dissolved and particulate concentrations of MHg and other water-column constituents associated with organic matter are examined at four sites in relation to temporal variability of MHg concentrations in zooplankton.

Northwest view of Bremerton Naval Complex from Convergence Zone site.

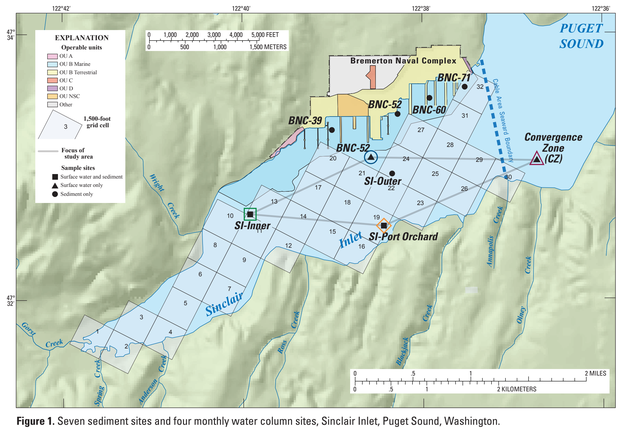

Figure 1. Seven sediment sites and four monthly water column sites, Sinclair Inlet, Puget Sound, Washington.

Westerly view of Bremerton Naval Complex from Cable Area.

Methods *SEE SHEET IN FOLDER*

Sediment-Porewater Concentrations and Fluxes to the Water Column

Porewater Geochemistry

- The highest filtered methylmercury (FMHg) concentrations were measured in August 2008 and June 2009 (fig. 2). Five samples contained FMHg concentrations greater than 10 ng/L.
- Sulfide was measured in porewater from four of the five high-FMHg sites. In contrast, sediment collected from the SI-Inner site with the highest FMHg concentration (28 ng/L), but contained sulfide concentration of only 0.08 mg/L and Fe concentrations of 3.9 mg/L.
- During August 2009, sediment from the SI-Port Orchard site (blue bar) contained the highest FMHg concentration (2.8 ng/L) and contained sulfide concentrations less than 0.15 mg/L and NO_3 concentrations as high as 4.2 mg/L.
- In February, three sites (yellow bars) contained sulfide concentrations greater than 0.25 mg/L, but the highest FMHg concentration was 0.24 ng/L (BNC-60).
- Interannual variation is high: FMHg concentrations in August 2009 (0.1 to 2.8 ng/L) were much lower than those in August 2008 (0.08 to 28 ng/L).

Core Incubation Experiments

- Like porewater concentrations, the highest fluxes of FMHg occurred in August 2008 and June 2009 (fig. 3).
- Methylmercury fluxes were low in February.
- Three of the five highest FMHg fluxes were associated with sites having high porewater sulfide concentrations (yellow bars). However, near-zero FMHg fluxes were associated with four sites containing high sulfide porewater concentrations.
- During 15 sampling events, (including four events at BNC-39 and BNC-71), FMHg fluxes were not significant.
- During four of five sampling events with significant FMHg fluxes, high FMHg porewater concentrations were measured.
- However, the FMHg fluxes and porewater concentrations were not always coincidental. During two sampling events (August 2008, SI-Inner; June 2009, SI-Port Orchard) insignificant FMHg fluxes were measured from sediment where high FMHg porewater concentrations (> 1.5 ng/L) were observed.

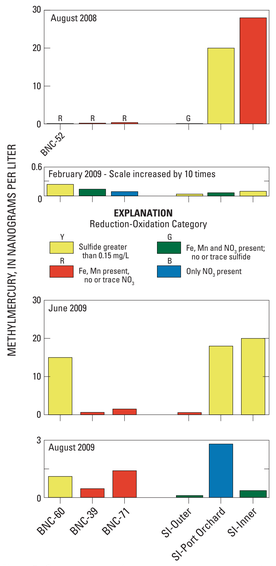

Figure 2. Concentrations of methylmercury in porewater of sediment of Sinclair Inlet, Puget Sound, Washington, between August 2008 and August 2009 relative to reduction-oxidation state. BNC-60 replaced BNC-52 in 2009.

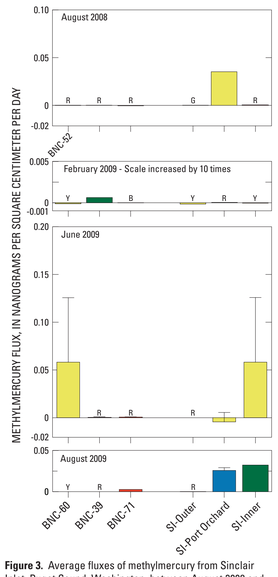

Figure 3. Average fluxes of methylmercury from Sinclair Inlet, Puget Sound, Washington, between August 2008 and August 2009 relative to reduction-oxidation state. BNC-60 replaced BNC-52 in 2009. See figure 2 for color code for reduction-oxidation state.

Water Column

- FMHg and PMHg (figs. 4 and 5) were collected monthly at four sites around Sinclair Inlet. FMHg concentrations were most often at or below the detection limit of 0.04 (ng/L).
- FMHg and PMHg concentrations show seasonal increases in concentrations related to the summer growing seasons.
- For PMHg in the water column, the season increases are strongly related to the increases in chlorophyll concentrations (fig. 6)
- The typically warmer, shallower, and most-landward site, SI-Inner, seems to be more biologically productive than other sites as indicated by higher chlorophyll *a* and typically has the most elevated FMHg and PMHg concentrations.
- The range of concentrations of methylmercury in water and suspended sediment at this site are similar to that measured in other locations around Puget Sound (data not shown here).

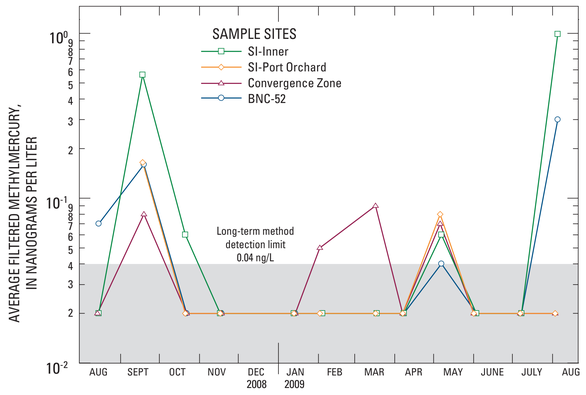

Figure 4. Average dissolved methylmercury in water column.

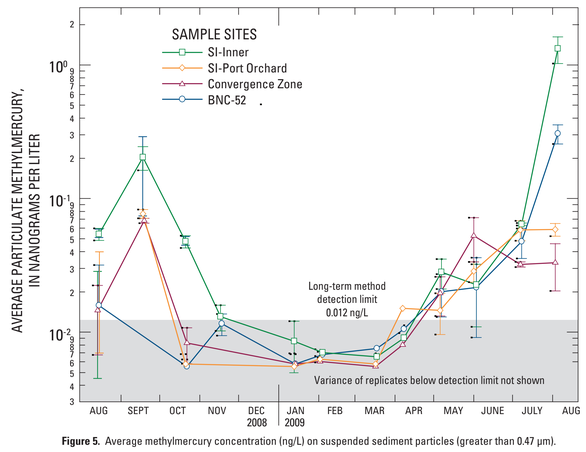

Figure 5. Average methylmercury concentration (ng/L) on suspended sediment particles (greater than 0.47 µm).

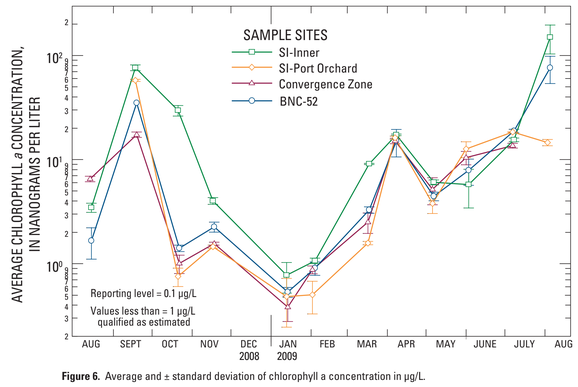

Figure 6. Average and ± standard deviation of chlorophyll a concentration in µg/L.

Water Column Zooplankton

- Zooplankton concentrations of methylmercury more weakly followed the seasonal increases seen in water and suspended sediments (fig. 7). The occasionally elevated concentrations observed in the water and suspended sediment at the SI-Inner and SI-Port Orchard sites, and to a lesser extent at BNC-52, are reflected here in zooplankton tissue concentrations.

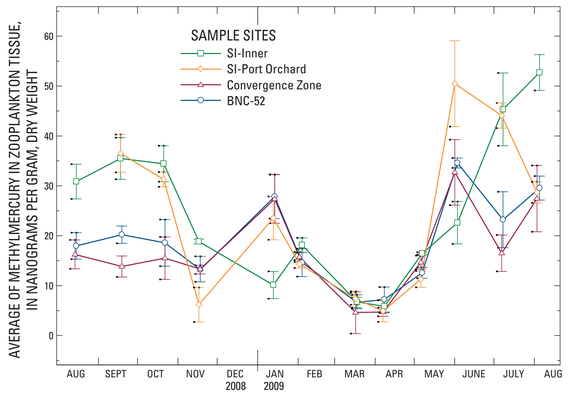

Figure 7. Methylmercury in zooplankton in Sinclair Inlet.

Summary

Both filtered methylmercury porewater concentrations and fluxes from sediment were high in August 2008 and June 2009, and were much lower in February 2008 and August 2009. Four of the five sediment samples with filtered methylmercury porewater concentrations greater than 10 ng/L contained significant amounts of porewater sulfide. Neither the relation between sulfide porewater concentrations and methylmercury porewater concentrations, nor the relation between filtered methylmercury porewater concentrations and fluxes from the sediment is straightforward. Dissolved methylmercury concentrations in the water column reflected these seasonal increases in summer flux, with additional increases in spring (March, April, and May in fig. 4). These spring increases correspond to weak increases in chlorophyll production and are suggestive of favorable growth conditions. The extent to which this increase in water column concentrations of methylmercury corresponds to water column biological production and porewater release is being further evaluated. Zooplankton show a similar, although considerably weaker trend in their seasonal increases in methylmercury concentrations. Zooplankton tissue concentrations decrease more slowly after the summer growing season in the autumn and early winter and are likely reflective of their longer life span in the water column relative to chlorophyll or suspended particulates. Concentrations described here were within the range of concentrations observed at other locations around Puget Sound.

References

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Contacts

[1]U.S. Geological Survey, Washington Water Science Center, Tacoma, WA 98402 (pwmoran@usgs.gov; apaulson@usgs.gov)
[2]U.S. Navy, NAVFAC NW, Silverdale, WA 98315 (dwight.leisle@navy.mil)

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