From:	Axelrad, Don
To:	gilmourc@si.edu
Subject:	FW: Landmark U.S. Geological Survey Study Demonstrates How Methylmercury, Known to Contaminate Seafood, Originates in the Ocean
Date:	Friday, May 22, 2009 4:46:21 PM
Attachments:	Sunderland MeHg production in Atlantic water column v2 2009.pdf Kraepiel tuna Hg over time 2003.pdf Cossa 2009 L&O water column Hg methylation v2.pdf

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Cindy,

As requested by my Asst. Director, that which follows was my attempt to educate FDEP decision makers re the findings in Sunderland, et al., 2009 ….

I'd love to present Dave Krabbenhoft's seminar as given to Salazar and Jackson to FDEP senior staff.

Don

From: Axelrad, Don
Sent: Thursday, May 21, 2009 10:22 PM
To: Bartlett, Drew etc.
Subject: Landmark U.S. Geological Survey Study Demonstrates How Methylmercury, Known to Contaminate Seafood, Originates in the Ocean

"How Methylmercury, Known to Contaminate Seafood, Originates in the Ocean"

This headline, as widely distributed by the USGS, refers to a paper by Sunderland, et al., 2009 attached.

Background facts:
Methylmercury (MeHg) is produced from inorganic mercury (Hg) dominantly by sulfate reducing bacteria (SRB), in anoxic waters and sediments.
Atmospheric deposition of Hg is widely recognized as the dominant Hg source to open ocean regions.

An important finding of Sunderland, et al., 2009 is that Hg is methylated to MeHg, a more toxic and bioaccumulative mercury species, in the marine water column;
MeHg is the dominant mercury species in predatory fish, and elevated concentrations of MeHg are responsible for the great majority of fish consumption advisories.

It had been previously hypothesized by Krapiel et al., 2003 (attached), that Hg sourced from atmospheric deposition to the surface of the ocean was methylated "in deep waters or in sediments", and that the "minimum mixing time between the deep ocean and the surface… (is) 400 years".

The implications of the Krapiel et al., (2003) hypothesis were that there may have been no increase in MeHg in marine fish over time despite the 3-5 fold increase in atmospheric mercury concentrations post the industrial revolution, because insufficient time had transpired for Hg deposited in surface oceanic waters to travel to and from the sediments where Hg

methylation took place.

A second implication would be that actions we take to reduce Hg atmospheric deposition would not reduce MeHg in fish for several hundred years.

With the findings of Sunderland, et al., 2009 (and others, including Monperrus et al., 2007; and Cossa et al., 2009, attached), it is clear that actions we take to reduce atmospheric deposition will relatively quickly reduce MeHg levels in marine fish - because Hg deposited on the ocean's surface has relatively little transit time to waters where methylation is occurring.
(Temporal lag in e.g. the Atlantic may be decades nonetheless, but less time in e.g. the Gulf of Mexico).

Note that Curt Pollman will discuss this issue in his Gulf of Mexico seminar on Friday; details below.

As well, Bill Landing of FSU, a co-author of Sunderland, et al., 2009, will be in attendance.

GoM mercury preliminary screening model results seminar by Curt Pollman

Friday, May 22, 2009 11:00 AM-12:30 PM.

Room A204, DEP Lab Building
(call me on 443-4626 when you arrive for building access)

Explanatory text from Sunderland, et al., 2009:

"In the euphotic zone of marine waters, growing phytoplankton populations take up inorganic carbon and nutrients and produce oxygen and particulate organic carbon (POC). When these plankton die, a fraction of the POC produced sinks into deeper waters… Inorganic Hg(II) is strongly sorbed by organic matter in the water column and transported to deeper waters with sinking POC…. Remineralization of sinking POC by heterotrophic bacteria in subsurface waters results in consumption of oxygen and releases carbon, nutrients, and sorbed Hg(II) back to the water column. Thus, POC export can remove Hg(II) from surface waters and provides a source of potentially bioavailable Hg(II) in intermediate waters during organic carbon decomposition."

"….methylation in estuarine sediments is enhanced by the presence of organic carbon ''pockets'' that create microzonal redox gradients in the sediment stratigraphy. Similarly, it is plausible that water column MeHg production in pelagic marine waters can occur inside fecal pellets and marine snow aggregates, since they have very low internal oxygen levels."

"We found a significant, positive linear relationship (in data from vertical profiles in the Pacific of total Hg, methylated Hg, oxygen, total carbon, and nitrate) between methylated Hg concentrations and rates of organic carbon remineralization ($r^2 = 0.66$, $p < 0.001$). These results provide evidence for the importance of particulate organic carbon (POC) transport and remineralization on the production and distribution of methylated Hg species in marine

waters. Specifically, settling POC provides a source of inorganic Hg(II) to microbially active subsurface waters and can also provide a substrate for microbial activity facilitating water column (Hg) methylation."

Reference
Monperrus, M., E. Tessier, D. Amouroux, A. Leynaert, P. Huonnic, and O. Donard (2007), Mercury methylation, demethylation and reduction rates in coastal and marine surface waters of the Mediterranean Sea, Mar. Chem., 107, 49– 63, doi:10.1016/j.marchem.2007.01.018.

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From: Bartlett, Drew
Sent: Monday, May 04, 2009 1:58 PM
To: Joyner, Daryll; Axelrad, Don; Frydenborg, Russel; Miller, Denise
Subject: Fw: FYI: Landmark U.S. Geological Survey Study Demonstrates How Methylmercury, Known to Contaminate Seafood, Originates in the Ocean

Once digested, please let me know how this impacts our marine TMDL effort.

From: Linda Eichmiller
To: TF Sustainable Watersheds ; TF Monitoring & Standards
Sent: Mon May 04 13:45:59 2009
Subject: FYI: Landmark U.S. Geological Survey Study Demonstrates How Methylmercury, Known to Contaminate Seafood, Originates in the Ocean

Landmark U.S. Geological Survey Study Demonstrates How Methylmercury, Known to Contaminate Seafood, Originates in the Ocean

Contact: Joan Moody (Interior) 202-208-6416 / Joan_Moody@ios.doi.gov
Enesta Jones (EPA) 202-564-7873 / 4355 / jones.enesta@epa.gov
David Krabbenhoft (USGS) 608-335-4234 / dpkrabbe@usgs.gov

(Washington, D.C. – May 1, 2009) A new landmark study published today documents for the first time the process in which increased mercury emissions from human sources across the globe, and in particular from Asia, make their way into the North Pacific Ocean and as a result contaminate tuna and other seafood. Because much of the mercury that enters the North Pacific comes from the atmosphere, scientists have predicted an additional 50 percent increase in mercury in the Pacific by 2050 if mercury emission rates continue as projected.

“This unprecedented USGS study is critically important to the health and safety of the American people and our wildlife because it helps us understand the relationship between atmospheric emissions of mercury and concentrations of mercury in marine fish,” said Secretary of the Interior Ken Salazar. “We have always known that mercury can pose a risk, now we need to reduce the mercury emissions so that we can reduce the ocean mercury levels.”

“This study gives us a better understanding of how dangerous levels of mercury move into our air, our water, and the food we eat, and shines new light on a major health threat to Americans and people all across the world,” said EPA Administrator Lisa P. Jackson. “With this information in hand, plus our own mercury efforts, we have an even greater opportunity to continue working with our international partners to significantly cut mercury pollution in the years ahead and protect the health of millions of people.”

Water sampling cited in the study shows that mercury levels in 2006 were approximately 30 percent higher than those measured in the mid-1990s. This study documents for the first time the formation of methylmercury in the North Pacific Ocean. It shows that methylmercury is produced in mid-depth ocean waters by processes linked to the “ocean rain.” Algae, which are produced in sunlit waters near the surface, die quickly and “rain” downward to greater water depths. At depth, the settling algae are decomposed by bacteria and the interaction of this decomposition process in the presence of mercury results in the formation of methylmercury. Many steps up the food chain later, predators like tuna receive methylmercury from the fish they consume.

One unexpected finding from this study is the significance of long-range transport of mercury within the ocean that originates in the western Pacific Ocean, off the coast of Asia.

“Mercury researchers typically look skyward to find a mercury source from the atmosphere due to emissions from land-based combustion facilities. In this study, however, the pathway of the mercury was a little different. Instead, it appears the recent mercury enrichment of the sampled Pacific Ocean waters is caused by emissions originating from fallout near the Asian coasts. The mercury-enriched waters then enter a long-range eastward transport by large ocean circulation currents,” said USGS scientist and coauthor David Krabbenhoft.

Scientists sampled Pacific Ocean water from 16 different sites between Honolulu, Hawaii and Kodiak, Alaska. In addition, the scientists constructed a computer simulation that links atmospheric emissions, transport and deposition of mercury, and an ocean circulation model.

In the United States, about 40 percent of all human exposure to mercury is from tuna harvested in the Pacific Ocean, according to Elsie Sunderland, a coauthor of the study. Methylmercury is a highly toxic form of mercury that rapidly accumulates in the food chain to levels that can cause serious health concerns for those who consume

the seafood. Pregnant women who consume mercury can pass on life-long developmental effects to their children. That is why in 2004 EPA and FDA issued the landmark Joint Guidance on the Consumption of Fish specifically targeted towards pregnant women and nursing mothers. Previous studies show that 75 percent of human exposure worldwide to mercury is from the consumption of marine fish and shell fish.

Scientists have known for some time that mercury deposited from the atmosphere to freshwater ecosystems can be transformed (methylated) into methylmercury, but identifying the analogous cycles in marine systems has remained elusive. As a result of this study we now know more about how the process which leads to the transformation of mercury into methylmercury.

The paper, “Mercury sources, distribution and bioavailability in the North Pacific Ocean--Insights from data and models and information on other USGS mercury research,” is available at:
http://toxics.usgs.gov/highlights/pacific_mercury.html

The study appeared today in Global Biogeochemical Cycles, which is published by the American Geophysical Union. In addition to USGS mercury expert David Krabbenhoft, the authors include Elsie Sunderland, Harvard University; John Moreau, University of Melbourne, Australia (until recently a USGS, NRC
Post Doctoral Candidate); William Landing, Florida State University; and Sarah Strode, Harvard University.