Historical Mercury Occurrence in Sediment Cores from Anadromous and Non-anadromous Lakes in Southwest Alaska

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Abstract

Five sediment cores from the Southwest Alaska Inventory & Monitoring Network (SWAN) of National Parks were analyzed for total Hg concentrations. This preliminary study is focused on defining the occurrence and historical trends of Hg in anadromous and non-anadromous lake systems . It appears that the anadromous lakes contain higher (up to 250 ppb) Hg concentrations than the non-anadromous lakes (averaging ~ 25 ppb Hg). Although the exact sources of Hg have not yet been defined in this preliminary study further work is underway to help elucidate the possible geogenic and anthropogenic contributors of Hg as well as other trace elements.

Figure 1. Shaded relief map of study area illustrating the five lakes from which sediment cores were collected and utilized for this work.

Introduction

Historical sediment records of stable isotope ratios and other indicators of salmon escapement have been studied in the SWAN lakes for the past several years (Finney, 2006). Sediment cores from that project were utilized for a preliminary study of historical Hg accumulation in the lakes for this study. A broader goal of this work is to test whether or not salmon may be contributors of Hg to the anadromous lakes and further analysis of the lake sediments is underway to help answer that question. It has been shown that salmon contribute other persistent organic pollutants such as PCBs to aquatic systems after they spawn and die (Krummel et al., 2003). Other trace elements may help decipher the sources of heavy metals to the lakes including geogenic sources from the landscape as well as atmospheric sources that may include anthropogenic sources.

Methods

All sediment cores used in this study were collected, described, and processed according to methods described in Finney (2006). Samples from each core were shipped to the Geochemistry Laboratory at the University of Alaska Anchorage where they were subsampled and subsequently shipped to the Environmental Geochemistry Laboratory at Michigan State University for total Hg analysis by standard methods using a Lumex RA-915+ Zeeman Corrected Atomic Absorption (AA) analyzer with the Thermal Decomposition (TD) R-91C attachment. Standard QA/QC methods are implemented by this lab and meet the standards of approved EPA laboratories.

Results

Mercury results for both anadromous and non-anadromous lake systems were studied for this preliminary investigation. Overall, it is apparent that the anadromous systems of Brooks Lake, Lake Clark, and Naknek have the highest concentrations of mercury in lakebed sediments. For comparison, a study of Hg in lake sediments from northern Canada indicates that mean Hg concentrations range from 23 to 155 ppb in post 1950s age sediments and that mean Hg concentrations in pre 1950s sediment range from 15.8 to 130 ppb (Lockhart et al., 1998). The lake sediments in the SWAN fall within these ranges, with the exception of Brooks Lake which has elevated Hg concentrations at depth as well as in the upper parts of the sediment core. This may be a reflection of geogenic sources such as the volcanic bedrock and deposits and/or contributions from other unidentified sources.

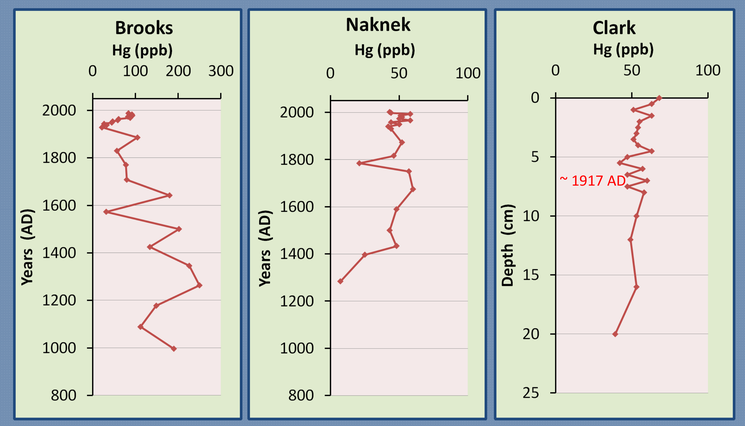

Figure 2. SWAN Tier 1 Lakes (anadromous) historical Hg concentrations as a function of time. Note that Brooks Lake has the highest recorded Hg concentrations of the three anadromous lakes and that the peak Hg concentration of ~250 ppb occurs at approximately 1250 years AD. Note Hg profile for Lake Clark is plotted as a function of depth (not time) of the core.

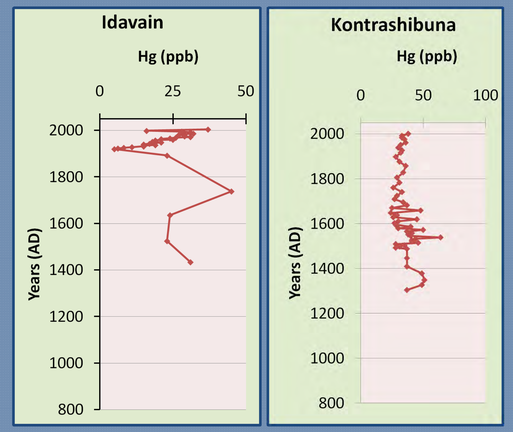

Figure 3. SWAN Tier 1 Lakes (non-anadromous) historical Hg concentrations as a function of time. Note the lower overall concentrations of Hg in these lake sediments as compared to the anadromous lakes and the relatively constant Hg concentrations in Kontrashibuna Lake sediments.

Discussion

It is not yet known what the sources of Hg to these lake systems may be. The likely sources include geogenic sources such as bedrock and soil, however, anthropogenic sources of Hg from atmospheric deposition may also contribute. Brooks Lake, in particular, has elevated concentrations with respect to the other lakes in the SWAN as well as other northern latitude lakes in Canada. It is possible that some of the Hg is derived from volcanic material transported into the lake system. We will further investigate a possible link between Hg levels and historical salmon abundance because Hg concentrations were up to an order of magnitude higher in anadromous systems. These preliminary results prompt us to suggest further investigation of the sediment/water interface and biota to better our understanding of Hg cycling and subsequent methyl-mercury production in the aquatic ecosystem (see Hg cycle below). In particular the presence of sulfur reducing bacteria at the sediment water interface play a key role in transforming Hg into methyl-mercury which has the highest bioavailability of any Hg species. This step is limited by the concentration of SO_4^{2-}.

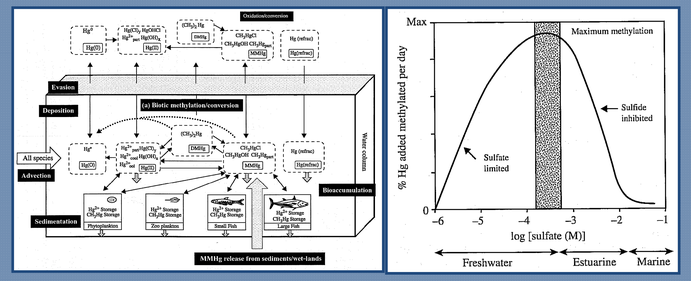

Figure 4. Biogeochemical cycle for mercury, and sulfate curve indicating optimal methylation conditions for sulfur reducing bacteria from Fitzgerald and Lamborg (2005).

Summary

Although the results presented here are preliminary and further analysis of the sediment cores is underway in order to complete the objectives of the work, there are some significant observations that have been made;

1)The anadromous lakes contain higher levels of Hg vs. non-anadromous lakes within their historical and modern lake bed sediments.

2)There are elevated concentrations of Hg in the Brooks Lake sediment record with the highest concentration occurring at approximately 1250 AD and the modern lake bed sediments contain ~100 ppb Hg.

Future Work

The sediment cores are currently being processed for trace element concentrations to help decipher historical trends and sources of environmentally significant elements and to establish background concentrations as a reference for future major and trace element studies in the area. Additional modeling of the geochemistry data is also underway in order to understand any possible links of trace elements to historical salmon escapement in the lakes.

References

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