Patterns of total and methyl mercury in periodically flooded Mackenzie Delta lakes and across the Mackenzie Estuary, NT

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Background

High levels of organic methylmercury (MeHg) in large marine mammals in the Beaufort Sea[1-2] represent a health concern for native populations that rely on them as traditional foods. However, relatively few studies have delineated sources of mercury (Hg) to this region[3]. Inputs from the Mackenzie River (Fig.1) represent the largest fluxes of water, sediment and nutrients to the Beaufort Sea and may also represent an important source of contaminants, including Hg. Additionally, the influence of Mackenzie Delta lakes and the estuary on Hg flux remains unclear.

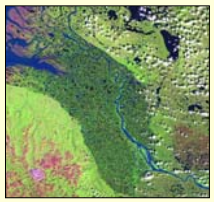

Figure 1. Mackenzie Delta region.

Objectives

(1) Characterize unfiltered total Hg (THg; all forms of Hg in a sample) and MeHg across the Mackenzie Estuary in mid-summer within the context of the Arctic River-Delta Experiment (ARDEX).

(2) Characterize unfiltered THg and MeHg in Mackenzie Delta lakes over a flooding frequency gradient and in Mackenzie River water throughout the open water season.

1) Mackenzie Estuary (ARDEX)

Figure 2. CCGS *Nahidik*

Introduction

The Mackenzie Estuary is a region of significant biogeochemical change. The goal of the ARDEX cruise (Fig. 2) was to evaluate processes controlling organic matter across the Mackenzie Estuary. The cruise was comprised of a 12 site transect (4 fresh (R1-4); 4 estuarine (R5x); 4 marine (R6-9); Fig. 2,3).

Methods

Unfiltered surface water was collected at 9 sites from 26-Jul to 2-Aug-04 using strict clean technique. THg and MeHg analyses are described in refs. 4 and 5-6, respectively.

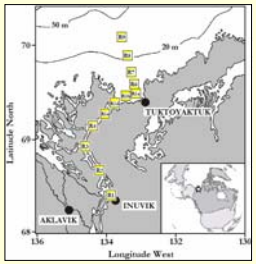

Figure 3. ARDEX sampling sites.

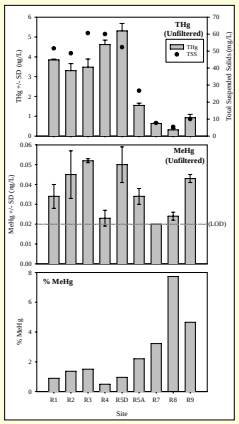

Figure 4. Unfiltered THg, MeHg and % MeHg in surface water collected from the ARDEX cruise.

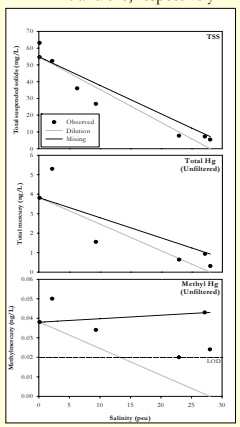

Figure 5. Mixing lines for TSS, THg and MeHg in surface water collected from the ARDEX cruise.

Results & Discussion

Unfiltered THg decline across the estuary followed particle (TSS) settling (Fig. 4). Both TSS and THg concentrations were often below the end-member mixing line (Fig. 5). MeHg concentrations were low with no clear pattern across the estuary (Fig. 4). The river and the ocean end-members had very similar MeHg concentrations (Fig. 5). % MeHg increased offshore because THg decreased offshore while MeHg remained relatively constant between stations (Fig. 4). The specific role of the estuary in Hg delivery to the Beaufort should be investigated over a longer time frame, especially during annual delta flooding.

2) Mackenzie Delta lakes

During annual spring freshet, ice jamming in Mackenzie River induces widescale flooding of the delta. Individual delta lakes are classified based on their elevations and flood when river water exceeds these levels[7] (Fig. 6). Six lakes in the mid-eastern delta, representing a flooding gradient, were selected for this study (Fig. 7; Table 1). Two river sites were also selected for comparison (East Channel at Inuvik and Mackenzie at Arctic Red River).

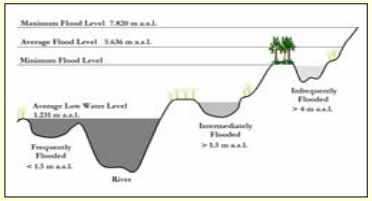

Figure 6. Mackenzie Delta lake classification scheme[4].

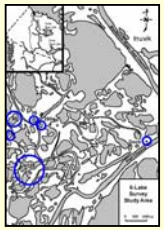

Figure 7. Delta lakes sampled near Inuvik.

Methods

Unfiltered surface water from all lakes was collected 3 times; 3-Jun (peak flood), 1-Jul & 7-Aug-04. Analyses for THg and MeHg were the same as in the previous section.

Table 1. Statistics for selected delta lakes. Sill elevation represents the highest portion of the outlet connecting the lake with the adjacent channel.

Lake	Flooding Category	Area (ha)	Average Depth (m)	Summer Sill Elevation (m)	Flooding Duration (days)
129	Frequently	316.6	1.29	1.272	19-May to 13-Jul, 1-Aug to 5-Aug (61)
80	Frequently	19.3	1.52	1.620	19-May to 31-Jun, 2-Aug to 3-Aug (45)
87	Intermediately	3.9	1.31	2.606	23-May to 13-Jun (22)
280	Intermediately	2.4	1.64	3.189	25-May to 10-Jun (17)
56	Infrequently	3.1	1.08	4.210	29-May to 6-Jun (9)
Dock	Infrequently	0.5	2.23	4.920	Not flooded (0)

Results & Discussion

THg concentrations were highest in rivers and all lakes during peak flood and declined over the open water season. THg in rivers was always greater than in lakes; with no difference in THg levels between lake types (Fig. 8). MeHg declined in the river and the frequently flooded lakes over the open water season, but MeHg and average % MeHg peaked in the intermediate and infrequently flooded lakes in mid-summer, when temperatures were highest (Fig. 8).

Lakes with greater disconnection from the channels tended to have higher MeHg levels, although specific mechanisms were not examined here and should be the focus of further study. Climate change is expected to decrease the degree of seasonal delta flooding, thus enhancing negative water balances of delta lakes. If lakes become more disconnected from channels, there may also be corresponding changes in Hg dynamics, with shifts towards the patterns observed for the infrequently flooded lakes in this study.

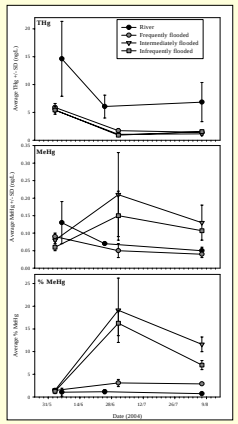

Figure 8. Unfiltered THg, MeHg and % MeHg in surface water of channels and lakes over a flooding gradient in the Mackenzie Delta over the open water season.

References

1) Braune, B.M. *et al.* 2005. *Sci. Tot. Environ.* 351-352:4. 2) Wagemann, R. *et al.* 1997. *Environ. Toxicol. Chem.* 16(9):1859. 3) Stern, G.A. and Macdonald, R.W., 2005. *Environ. Sci. Technol.* 39:4707. 4) U.S. E.P.A. Method 1631 5) Horvat, M. *et al.* 1993. *Anal. Chim. Acta.* 281:135. 6) Bloom, N.S. and Crecelius, E.A., 1987. *Mar. Chem.* 21(3):377. 7) Marsh, P. and Hey, M., 1989. *Arctic.* 42(1):41.