Mercury trends in the pelagic food web of Hudson Bay: Results from Merica and ArcticNet 2003 – 2005.

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Introduction

Hudson Bay (HB) is one of the largest inland shelf seas with a vast coastal freshwater region. HB and its drainage basin receive enhanced loadings of contaminants from land and river runoff, as well as long range atmospheric transport. Mercury may become the most important contaminant in the system as the climate warms. This is due to the release of Hg from frozen basin soils upon warming, through changes in wetland distribution and/or hydro reservoir flooding. These are sites of enhanced microbial methylation of inorganic Hg (II) to methyl (MeHg), which is a toxic form of Hg that bioaccumulates.

Total mercury concentrations and stable isotopes were Quantified in biological samples collected during the 2003 and 2004 MERICA cruises, Churchill 2005 winter ice camp, and during the ArcticNet Leg 2 HB cruise aboard the *CGS Amundsen* (Sept 14 – Oct 27 2005). Water column measurements of salinity, and total mercury at various depths were also reported in an effort to better quantify physical and biological processes within the HB pelagic food web.

Methods

Water

Water samples were collected at particular depths in the water column using the Rosette in an effort to capture significant water column features. The "clean hands dirty hands" method of sampling was used in order to minimize sample contamination. Water for HgT was collected in 50 ml Falcon tubes pre-spiked with 250 µl ultra pure HCl (33-36%). Samples for methyl mercury were collected in 1 L amber bottles spiked with 5ml ultra pure HCl (33-36%). Samples were kept cold but not frozen until analysis at the University of Manitoba Ultra-Clean Trace Elements Laboratory (UCTEL) for trace level contaminants. Other nutrients including salinity, trace metals, OCs and $\delta^{18}O$ were analyzed at various analytical laboratories (data not shown).

Zooplankton and fish juveniles

See figures 1 and 2 for MERICA and ArcticNet cruise transects. Oblique, vertical, and Rectangular Mid-water Trawl (RMT) nets were deployed to obtain biota representative of each sample station. Zooplankton were sorted into families and kept frozen in Whirlpak bags at -20ºC. Sub-samples of each family were baked in an oven at 60ºC overnight (to remove excess moisture) and were sent to the University of Winnipeg for stable isotope analysis. Remaining samples were freeze dried and analyzed (dry weight) by CVAA for Hg at DFO.

Adult fish and marine mammals

Samples were obtained from subsistence hunters in northern communities surrounding HB. Sub-samples of liver and muscle tissue from the 2005 hunts are in the process of having lipids removed before they are analyzed for stable isotopes. The remaining muscle tissue from 2003 – 2004 was analyzed (wet weight) by CVAA for Hg at DFO.

Results

2003 – 2004 MERICA

Mean total mercury (HgT) in HB surface water (10m) was lower in west HB compared to east HB (see figure 1 graph: ***Longitudinal HgT gradient HB 2003 water***). Mean HgT in Hudson Strait surface water at stations HS16, 17 was 1.05 $\pm$ 0.01 ng/L which was lower than mean HgT in Hudson Strait surface water (1.6 $\pm$ 0.8 ng/L) at stations HS 11,18 (data not shown).

Mean HgT concentrations for zooplankton family Hyperidae (*Themisto spp.*) were higher for HB proper compared to concentrations for *themisto spp.* in Hudson Strait (see figure 1 graph: ***Spatial HgT for 2003-2004 zooplankton***). Mean HgT levels for *Calanus spp.* were similar in HB proper and Hudson Strait. *Calanus spp.* had lower levels of HgT compared to *Themisto spp.*

Stable isotope signatures for *Calanus* spp. and *Themisto* spp. displayed more depleted $\delta^{13}C$ signatures for stations in HB proper compared to stations in Hudson Strait (see graph 1). The $\delta^{15}N$ signatures were higher at most stations for *Themisto* spp. compared to *Calanus* spp.

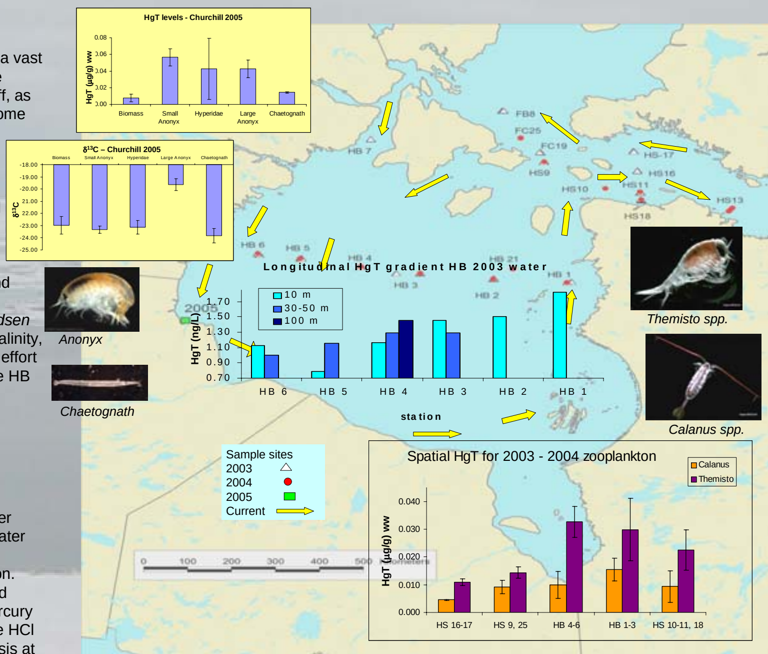


Figure 1. MERICA cruise transects 2003-2004 and results highlights.

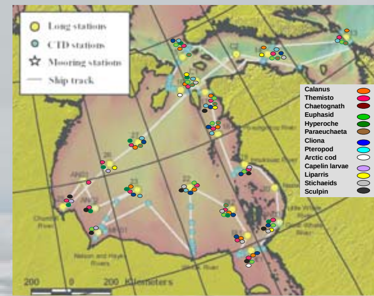
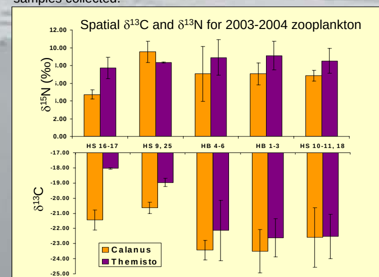


Figure 2. ArcticNet cruise transect 2005 - biological samples collected.



Graph 1. Stable isotope signatures for two prevalent zooplankton families in Hudson Bay.

Results (ctd.)

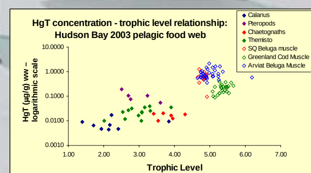
Trophic level was calculated by the following equation:

$TL = 2 + (\delta^{15}N - \delta^{15}N_{Calanus\ spp.})/3.8$ (Fisk et. al.)

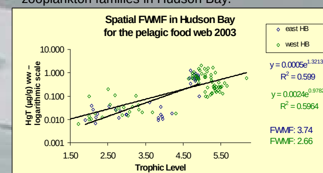
As the trophic level increased, mercury concentration increased (Graph 2a). Spatial Food Web Magnification Factors (FWMFs) were calculated for linear relationships by the following equation:

$FWMF = e^{b}$ (Fisk et. al.)

The FWMF for East HB was higher than that of West HB (Graph 2b).



Graph 2a. Mercury concentration as a function of trophic level: 2003 HB pelagic food web.



Graph 2b. Spatial Food Web Magnification Factors for the HB pelagic food web 2003.

2005 Churchill

Mercury levels were higher in Amphipods *(Anonyx)* and Hyperidae compared to Biomass and Chaetognaths collected (see figure 1 graph: ***HgT levels – Churchill 2005***). A less depleted $\delta^{13}C$ value was observed for larger Amphipods (*Anonyx spp.*) compared to the rest of the biota collected (see figure 1 graph: ***δ13C – Churchill 2005***).

Discussion

The trends seen in the surface water HgT concentrations are explained by the strong North Atlantic current (see figure 1. yellow arrows). A strong flow of seawater enters Hudson Strait along the southern shore of Baffin Island (stations HS16, 17). The current enters HB along the northwest shore and flows counterclockwise around the Bay (Coriolis effect). The current flows out of HB along the Northern shore of Quebec (stations HS 11, 18). This is one explanation of the higher mean HgT levels in East HB water due to longer residence time of the water in east HB. Not only atmospheric deposition of Hg but land and river runoff will contribute Hg as a water mass circulates around the Bay, thus causing an increase in surface water HgT levels by the time it reaches East HB stations.

Higher concentrations of HgT in HB proper zooplankton families compared to Hudson Strait may be explained by the major river influences driving up the HgT concentration in HB, including the Churchill, Nelson, and Great Whale Rivers. The more depleted $\delta^{13}C$ levels for zooplankton in HB proper compared to Hudson Strait are indicative of more terrestrial influence due to fast flowing water runoff from rivers in HB proper. *Themisto spp.* had higher $\delta^{15}N$ values and therefore higher calculated trophic levels than *Calanus* spp. on average due to the carnivorous diet of *Themisto* spp. Regional FWMFs were calculated, however the slopes of the graphs were entirely dependent on the higher trophic level fish and marine mammals, which makes apparent differences suspect. More investigation is needed in this area.

The significantly lower $\delta^{13}C$ values for large *Anonyx* in Churchill 2005 is due to the fact that they are caught on the ocean floor i.e. in a more benthic environment compared to the other zooplankton collected. Most of the biomass from the Churchill 2005 collection is a mixture of phytoplankton and ice algae, therefore a lower HgT level is expected for these samples.

Acknowledgements

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Summary

1. Water total mercury concentrations in East Hudson Bay were higher than in West Hudson Bay in 2003.
2. Total mercury concentrations in two abundant zooplankton families (Hyperidae and Copepods) were higher in Hudson Bay compared to Hudson Strait in 2003 and 2004 due to the flow of the strong North Atlantic current.
3. Spatial $\delta^{13}C$ values for zooplankton were more depleted in Hudson Bay compared to Hudson Strait due to a higher terrestrial influence caused by water runoff from rivers.
4. Food Web Magnification Factors (FWMFs) were calculated to be 3.74 for East Hudson Bay and 2.66 for West Hudson Bay in 2003.
5. Results from Churchill 2005 displayed depleted $\delta^{13}C$ values for pelagic zooplankton compared to benthic amphipods and higher levels of HgT in *Anonyx* and *Hyperidae* families compared to the biomass.
6. Samples from the ArcticNet Leg 2 cruise 2005 are in process (figure 2).

Future

More fish species from HB are required in order to completely map out the pelagic food web. Methods for fishing alternative to trawling off of the Amundsen include angling and netting from local community fishing vessels. The quest for representative sample sizes of Arctic Cod and other pelagic fish species continues. Further size comparisons among *Themisto spp.* in relation to HgT may provide insight to bioaccumulation within this zooplankton family.

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