Mercury biomagnification in a Chilean Patagonian marine foodweb: preliminary results

G. Chiang[1,2], K. A. Kidd[1], N. J. O'Driscoll[3], S. Jara[4], M. Diaz-Jaramillo[5] & K.R. Munkittrick[1]

[1]Canadian Rivers Institute, Department of Biology, University of New Brunswick, Saint John NB, Canada.
[2]Melimoyu Ecosystem Research Institute, Santiago, Chile.
[3]Department of Earth & Environmental Sciences, Acadia University, Wolfsville NS, Canada.
[4]Unidad de Sistemas Acuáticos, Facultad de Ciencias Ambientales, Universidad de Concepción, Concepción, Chile.
[5]Instituto de Investigaciones Marinas y Costeras, Universidad Nacional de Mar del Plata, Mar del Plata, Argentina.

41st Aquatic Toxicity Workshop 2014 OTTAWA

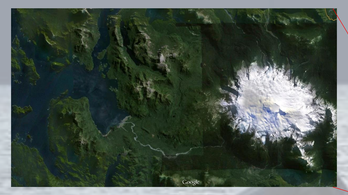
Introduction

Mercury (Hg) occurs naturally in the environment, but humans have altered its natural cycling by fossil fuel combustion and mining. Mercury is a global pollution problem, due to its long distance transport and toxicity, especially methylmercury (MeHg). There are many studies examining MeHg and its trophic transfer in Northern aquatic ecosystems however much less information is available for the southern hemisphere. Chilean Patagonia is a hotspot of biodiversity with unique geological (volcanos) and physical (high orographic precipitation rate) characteristics in a less industrialized environment and an ideal area to study Hg transfer in coastal food webs.

Materials and methods

Study Area

Melimoyu bay located in the Chiloean-Valdivian Ecoregion, a nexus between the southern limit of the cold temperate Valdivian rainforest and the northern limit of the sub Antarctic Patagonian rainforest. Its geography dominated Melimoyu volcano (2,400 m above sea level); region has a significant reservoir of freshwater (at both a national and a global level) in the ice fields, glaciers, lake bodies and rivers . The climatic and geographic differences define six predominant environmental units based on geography and climate: Archipelagos and Islands; Fjords and Channels; Mountains; Eastern Sub-mountain Range; Eastern Steppe Plains; and Ice Fields. It is important to note that the region represents a significant reservoir of freshwater (at both a national and a global level), housed in the ice fields, glaciers, lake bodies and rivers



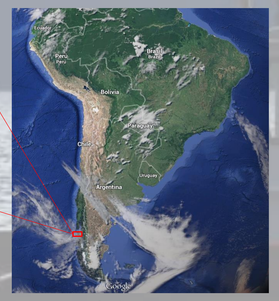
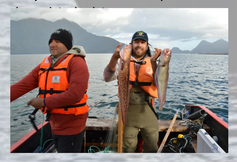


Figure 1. Location of Melimoyu Bay

Sample collection

Fish were collected using gillnets, hook-and-line and with fishing rod. In order to prevent major by catch. Macroinvertebrates were collected by scuba diving in selected microhabtats within the bay with a minor impact in the surrounding



All samples were stored in plastic bags at -20˚C. All samples were freeze-dried prior to analysis.

Stable Isotope Analysis
Dried samples were ground and the aliquots (0.25–0.30 mg) weighed in tin cups and analysed using a Delta Plus Continuous Flow Stable Isotope Ratio Mass Spectrometer (Thermo Finnigan, Bremen, Germany) coupled to a Carlo Erba Elemental Analyzer (CHNS-O EA1108, Milan, Italy).

Methyl Mercury Analysis
≈10 mg were analyzed by alkaline digestion, ethylation purge and trap GC–CVAFS (Gas Chromatograph–Cold Vapour Atomic Fluorescence Spectrophotometer) following U.S. EPA Method 1630 (U.S.EPA, 2001).

Total Mercury Analysis
≈10 mg of tissue was analyzed by DMA-80.

Quality Assurance
Certified reference materials, blanks, and replicates were analyzed within each chemical analysis.

Photographs by Gustavo Chiang, Ignacio Rudolph, Solange Jara and Rodrigo Sanchez

Results

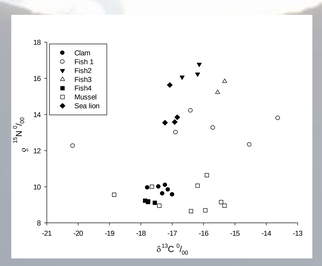


Figure 2. Plot of nitrogen (indicative of trophic position) and carbon (indicative of food source) stable isotopes of biota in a marine food webs from remote Chilean Patagonia

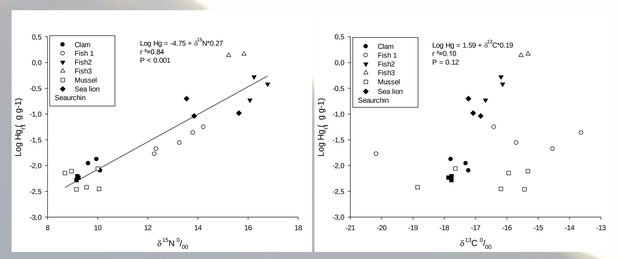
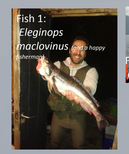
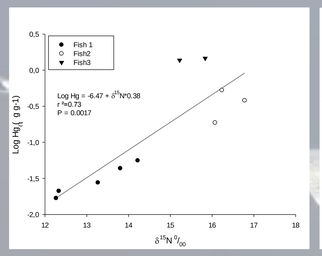


Figure 3. Linear regressions for Log Hg (MeHg for macroinvertebrates and sealion feces; total Hg for fish) versus d15N and d13C isotopes of biota in a marine food web from remote Chilean Patagonia





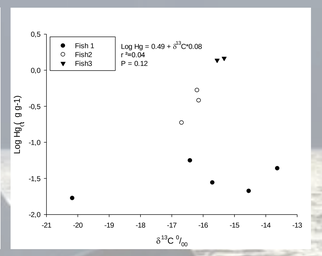


Figure 4. Linear regressions for Log Hg (Total Hg) versus d15N and d13C isotopes of fish in Melimoyu bay, Chilean Patagonia

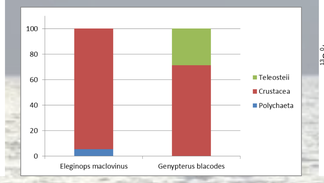


Figure 5. Stomach content frequency for fish in Melimoyu bay

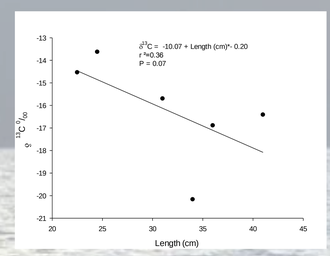


Figure 6. Linear regression for d13 Isotope versus total length in *Eleginops maclovinus* from Melimoyu bay.

- We assessed food web structure using stable isotope analysis ($\delta^{13}C$ & $\delta^{15}N$) and fish stomach content. The samples were also analyzed for total (THg) and methylmercury (MeHg).
- Preliminary data shows that benthic predatory fish muscles have higher THg (0.041-2.12 µg/g d.w.) and MeHg (0.017-1.215 µg/g d.w.) concentrations and forage in a very similar habitat (narrow $\delta^{13}C$ values, Fig 2). Benthic invertebrates have low THg (0.0073-0.0766 µg/g d.w.) and their MeHg concentration is highly variable (5-73% of THg). Regression model for the whole food web ($\log_{10}$Hg vs $\delta^{15}N$ or $\delta^{13}C$) show a higher positive slope for $\delta^{15}N$ (r^2=0.84, b=0.27, p<0.001) than for $\delta^{13}C$ (r^2=0.10, b=0.19, p=0,12) (Figure 3).
- Regression models for fish versus stable isotopes showed that *G. blacodes* and *S. chilensis* prey in very similar habitats and trophic levels, while *E. maclovinus* forages on a lower trophic level, which is related to the Hg concentrations evidenced in the predatory fish (Fig 4). Analysis of stomach content corroborates the previous, showing that *G. blacodes* preys on fish and crustaceans (Stomatopods) mainly, while *E. maclovinus* forages on small shore crabs (Fig 5).
- In this aspect, *E. maclovinus* showed a wide habitat, that is somehow related to the size of the fish. Bigger fish showed a more negative $\delta^{13}C$ signature, evidencing a segregation of the juvenile fish near shore, (Fig 6). Despite this fact, we didn't see any difference in Hg concentration related to carbon source.

Discussion & Conclusions

- Current data is showing a clear biomagnification process marine food webs in the fjords of Chile, at least near volcanic activity. The slope (0.27) for the whole food web its slightly higher than what has been reported for the northern hemisphere in coastal ecosystems (0.20, Lavoie et al 2013). For fish slope is higher (0.38) than those values reported by the same authors (0.20). DOC transport by the river could play a fundamental role in this high values.
- Fish stomach content is corroborating the trophic positions showed by δ15N signatures.
- The proximity to the shoreline and the mouth of rivers carrying down sediment from the glaciers and volcanoes could potentially be a key factor in these process, but we need to finalize all sample analysis and include all the rest of the biota.
- Ongoing work will include pelagic and near shore predatory fish and invertebrates to complete the foodweb structure and assess whether carbon source has any impact on Hg biomagnification. These preliminary data shows that biomagnification process is similar in Patagonian marine food webs to those found in subpolar and polar zones in the northern hemisphere and that there is a high potential to incorporate more Hg from possible atmospheric deposition.

Acknowledgments

This research was funded by INACH T31-11 to G. Chiang. Thanks are given to Canada Research Chairs to K.R. Munkittrick, K. A. Kidd and N. O´Driscoll. Special thanks to Captain Luis Torres from Underwater Crime Lab. (Carabineros de Chile) for the help during field sampling.

MERI Centro de Investigación de Ecosistemas de Melimoyu · UNB Saint John · NSERC CRSNG · Canadian Rivers Institute · ACADIA UNIVERSITY