Biomagnification of Mercury in the Indian River Lagoon, Florida

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Abstract

Concentrations of total mercury (THg) were determined for seven lower trophic level biota: plankton (>153 µm), anchovies (*Anchoa hepsetus*), crown conchs (*Melongena corona*), tulip snails (*Fasciolaria tulipa*), mullet (*Mugil cephalus*), pinfish (*Lagodon rhomboids*) and blue crabs (*Callinectes sapidus*) from the Indian River Lagoon (IRL) to better understand Hg biomagnification. Plankton in the IRL had about three times more THg than plankton from fairly pristine locations. Biomagnification of Hg was traced with increasing trophic level (TL) from plankton to anchovies. Resulting data were used to calculate a trophic magnification slope (TMS) of 0.23 that can be used to predict Hg concentrations in higher trophic level biota from the IRL. For example, if Hg concentrations in plankton were lowered from 42 to 13 ng/g, Hg concentrations in higher trophic level biota, including bottlenose dolphins, would decrease by ~70%.

Introduction

Mercury is a naturally occurring, ultra-trace element in Earth's crust that is enriched through anthropogenic processes including mining and coal burning at power plants. When released into the atmosphere, Hg has a residence time of up to a year. During that time, it can spread to new locations and be deposited on land or in water. Once in the water, Hg is absorbed by biota which, at high enough concentrations, can cause adverse health effects. Such health concerns in humans include neurological problems for infants, cognitive thinking problems, memory loss, speech impairments, and tremors. In the Indian River Lagoon (IRL), Hg concentrations in bottlenose dolphins (7,000 ng/g dry wt., Stavros et al., 2008) were found to be greater than concentrations in other regions in the southeast US. To better understand observed Hg enrichment in dolphins from the IRL, more information on uptake and biomagnification at lower trophic levels is needed.

Methods: Field

Sampling was carried out in the IRL and at the mouth of Crane Creek during May, 2014. Seven species of organisms were selected based on diet and availability at the two sites (Figure 1). Plankton were collected using a 153-µm mesh plankton net that was towed horizontally for 10 min. Anchovies were harvested using a 6-m seine net with 0.6-cm mesh. Pinfish and mullet were caught with a 2.4-m cast net. Snails, conchs and crabs were gathered with a 3-mm mesh dip-net.

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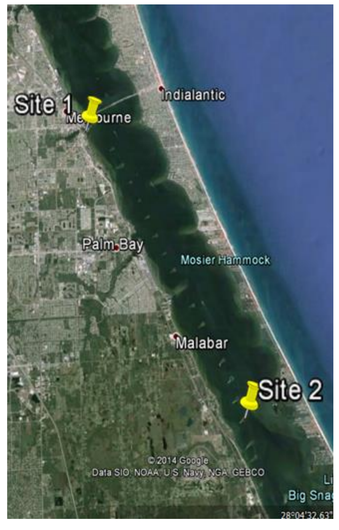

Figure 1. Map of the IRL study areas. Mouth of Crane Creek (Site 1) and IRL (Site 2).

Methods: Lab

Fish samples were filleted to remove the main portion of muscle tissue (from behind pectoral fin to start of tail), crab muscle was extracted from the legs and snails were removed from their shell. Soft tissue was freeze-dried, homogenized, and dissolved in Fisher trace metal grade HNO_3 and H_2SO_4. Dissolved samples were analyzed for THg using cold vapor atomic absorption spectrometry according to established laboratory methods (Fox et al., 2014). Accuracy, determined by analyzing SRM #1566b (oyster tissue), was within 11% of the accepted value.

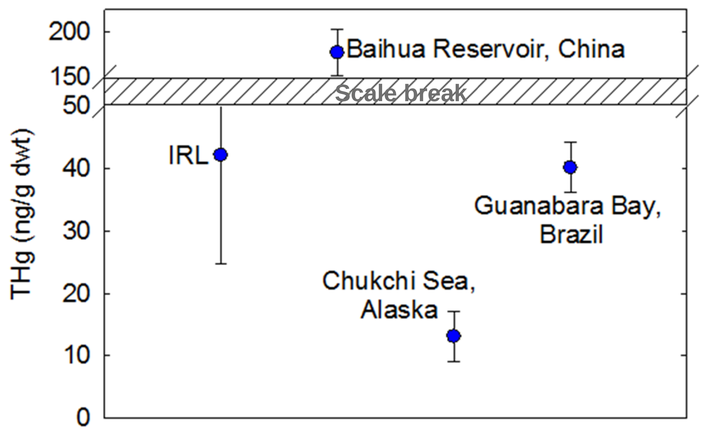

Figure 2. THg concentrations for plankton from the IRL compared to the Chukchi sea, Guanabara Bay and Baihua Reservoir.

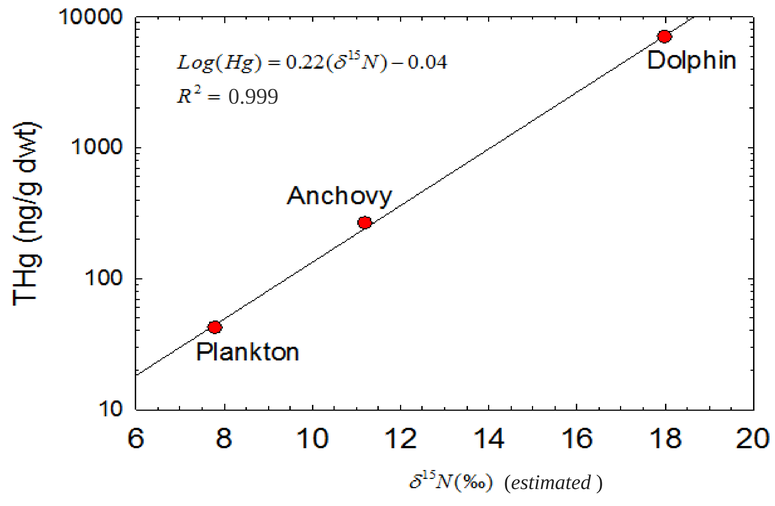

Figure 3. THg concentrations for plankton, anchovies and dolphins in the IRL with calculated TMS. TMS was used to predict Hg concentrations in dolphins.

Table 1. THg concentrations with standard deviations and sample sizes for biota from the IRL.

Animal	THg ± SD (ng/g dry wt.)	n
Plankton	42 ± 17	20
Mullet	49 ± 21	14
Crown Snail	66 ± 33	14
Tulip Snail	143 ± 45	7
Blue crab	232 ± 6	2
Anchovy	265 ± 45	19
Pin Fish	317 ± 80	10

Discussion

Plankton from the IRL were contaminated with Hg relative to the pristine Chukchi Sea, yet low when compared to Baihua, China, with known Hg contamination (Fox et al., 2014) (Wang et al., 2011). Therefore, the IRL may not be receiving heavy inputs of mercury; however, it is more contaminated with Hg than pristine regions like the Chukchi Sea. The relationship between organism and Hg concentrations was expressed as a trophic magnification slope (TMS) where Log (THg of organism) = 0.23 ($\delta^{15}N$) + 0.12. The TMS was used to predict Hg concentrations in dolphins from the IRL. The predicted concentration (~10,000 ng/g) was within the standard deviation of the actual concentrations (7,000 ng/g) (Stavros et al., 2008). The linear relationship between actual concentrations of THg in dolphins, plankton and anchovies was strong with an $R^2 = 0.999$ (Figure 3). Therefore, the TMS can be used to predict Hg concentrations in other species when the trophic level, or $\delta^{15}N$, is known. For example, if the THg concentration of plankton in the IRL were reduced to the value found in Chukchi Sea, other organisms would see a THg reduction of ~ 70%. This reduction could result in a dolphin THg value of ~2,200 ng/g, which is below the advisory level. This is a plausible lower concentration level for plankton in the IRL; concentrations can never be zero because mercury exists naturally in their surrounding environment and will always be absorbed by the plankton to some extent.

Conclusions

- Plankton in the IRL show moderate (not high) Hg contamination relative to other locations.
- Biomagnification of Hg in the IRL has a TMS = 0.23.
- Using a TMS = 0.23, Hg values in dolphins from the IRL were predicted to be ~10,000 ng/g.
- If Hg concentrations in plankton were lowered from 42 to 13 ng/g, Hg concentrations in other biota, including bottlenose dolphins, would decrease by ~70%.

References

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