Evaluating Methods for Assessing Exposure of Wildlife to Mercury (WQ MYP)

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US EPA ARCHIVE DOCUMENT

Agency Problem

...Office of Water is responsible for restoring and maintaining the integrity of the nation's water. To this end, the Office of Water needs scientifically defensible ...assess the ecological risks of chemical contaminants, including those that are persistent, bioaccumulative and toxic. Mercury (Hg) is an extremely toxic contaminant of ...humans and wildlife whose bioaccumulation is particularly complex, dependent not only on its chemical properties but also on environmental and ecological properties ...m and species of concern. Therefore, the Agency needs reliable methods to allow predictions of mercury bioaccumulation in fish and in other wildlife species.

Research Goals

...rch is being conducted to determine whether models can be developed to estimate bioaccumulation of mercury in fish and wildlife which are of sufficient accuracy for ...essing potential impacts to both wildlife and human fish consumers.

...and test non-lethal methods for determining mercury concentrations in fish and wildlife.

Approach

...s

...onjunction with Rhode Island Department of Environmental Management we are sampling fish from freshwater sites (lakes, ponds and reservoirs) throughout Rhode ...d.

...ples are being analyzed for mercury (Hg) concentrations and stable isotopes.

...ationships will be developed between Hg concentrations in fish and variables indicative of water quality, trophic position of fish ($\delta^{15}N$) and landscape characteristics.

...se relationships will be used to predict Hg concentrations in fish at untested sites, and predictions will be compared with measured values when sites are sampled.

...ther approach we are using to predict Hg concentrations in fish is to sample and analyze indicator organisms and fish species from multiple lakes and use relationships ...een fish and indicator organisms to predict Hg concentrations in fish at untested sites.

...have used the snapping turtle as a test indicator organism.

...ites

...onjunction with RI DEM Division of Fish and Wildlife, we are developing methods to estimate bioaccumulation of Hg in mink from collections of prey items.

...efforts have focused on development of approaches to assess dominant prey items and the relationships between mercury concentrations in prey and mink tissues.

...ections of water quality and landscape variables from stream sites are being used in conjunction with the exposure field data to construct models to predict mercury ...mulation in mink.

...al sampling

...ples of scales and fin clips of fish, of claw nails of turtles and fur of mink were analyzed for Hg concentrations and results were compared with those from analysis of ...cle tissue to determine whether these non-lethal sampling techniques can be used to sample wildlife for mercury and stable isotopes.

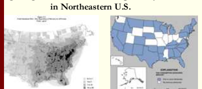
Impact and Outcomes

...elopment of models to predict bioaccumulation of mercury will allow assessment of the impact of this metal on sensitive wildlife populations over large geographical ...

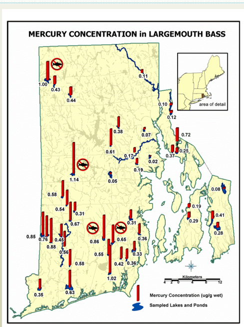
...s information is being used by the State of Rhode Island to make decisions concerning fish consumption advisories, and helps us to understand the threats to piscivorous ...life in the context of other stressors.

...s knowledge will inform decisions about mercury control that will help to sustain populations of fish-consuming wildlife.

Hg – Significant Pollutant in Aquatic Systems in Northeastern U.S.



...route of Hg to these systems appears to be through atmospheric ...t & deposition.
...ination related to fossil fuel combustion, industrial processes & ...tion of medical & municipal waste.
...te Hg is emitted from stacks, transported through atmosphere ...rs aquatic ecosystems as inorganic form.
...educing bacteria methylate inorganic Hg to Methyl Mercury (MeHg).
...Hg is toxic & more readily bioaccumulated by aquatic organisms.
...Hg constitutes 95-99% of total Hg found in fish muscle tissue.
...ccumulation in fish may pose health concerns for humans & ...ous wildlife.



Mercury Concentrations in Fish in Rhode Island

Rationale
- Need [Hg] in freshwater fish from Rhode Island to assess impacts on both wildlife and human consumers.
- Need better methods to predict [Hg] in fish at untested sites.
- Need for sublethal sampling methods to allow measurement of [Hg] and stable isotope values in fish.

Methods
- Assess the utility of water quality variables (e.g. pH, conductivity, DO) and trophic position variables ($\delta^{15}N$) for describing mercury concentrations in fish.
- Fish collection by electroshocking conducted in conjunction with Rhode Island Department of Environmental Management (RIDEM).
- Analysis of fish muscle for [Hg] by Cold Vapor Atomic Absorption spectrometry (CVAA) and stable isotopes by Isotope Ratio Mass Spectrometry (IRMS).

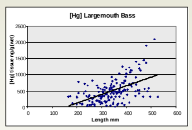
Results
- The [Hg] in fish varied widely across freshwater sites in the state and many sites had fish with concentrations that exceeded human health criterion values.
- Largemouth bass was the top level predatory fish and had the highest mercury concentrations. Among the 10 fish species tested.
- Significant relationships were found between mercury concentration and length for seven of the ten fish species, but relationships between $\delta^{15}N$ and length were not significant for any fish species.
- The value of $\delta^{15}N$ in fish and site pH were useful in reducing the variance in stepwise multiple regressions of mercury concentrations in fish by equal amounts. However, these variables covaried and the sequential addition of $\delta^{15}N$ to stepwise regressions containing pH did not increase the coefficient of determination. The water quality variables pH and conductivity combined explained 51.1% of the variance in fish mercury concentrations. The value of $\delta^{15}N$ in fish and conductivity explains 51.2% of the variance in fish mercury concentrations.

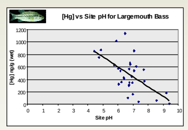
Comparisons of Mercury Concentration and $\delta^{15}N$ in Fish

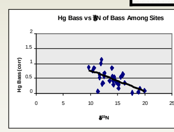
ALL FISH SPECIES

33 sites Total	Mean Length	Mean $\delta^{15}N$	Mean Hg (ng/g wet)	Length Vs $\delta^{15}N$	Length Vs Hg	$\delta^{15}N$ Vs Hg
31 LB	340	13.9	517	NS	S	S (Negative) Slope
26 YP	223	11.9	235	NS	S	S (Negative) Slope
27 BG	182	12.0	215	NS	S	S (Negative) Slope
27 PS	179	11.6	181	NS	S	S (Negative) Slope
26 CP	331	12.1	399	NS	S	S (Negative) Slope
21 BB	300	11.7	135	NS	NS	S (Negative) Slope
15 GS	178	13.0	144	NS	NS	NS
12 WP	240	11.4	229	NS	S	NS
9 WS	408	11.9	241	NS	S	S (Negative) Slope
6 BC	253	14.6	239	NS	NS	NS

LB – Largemouth Bass, YP – Yellow Perch, BG – Bluegill, PS – Pumpkinseed, CP – Chain Pickerel, BB – Brown Bullhead, GS – Golden Shiner, WP – White Perch, WS – White Sucker, BC – Black Crappie, NS – Not Significant, S - Significant







Stepwise Regression	
Variables	Variance explained in combination of variable (%)
$\delta^{15}N$ of Fish and conductivity	51.2
pH and conductivity	51.1

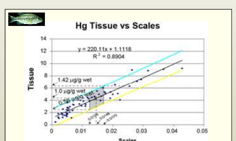
Non-lethal sampling of Largemouth Bass in Rhode Island

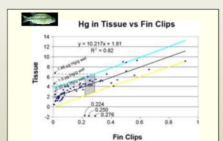
Rationale

Contaminant bioaccumulation studies often rely on the use of fish muscle fillets as the tissue of choice for the measurement of Hg. The development of non-lethal and convenient techniques to predict Hg concentrations in muscle tissue would offer researchers the capability to sample fish without sacrificing individuals. We evaluated the use of two non-lethal sampling techniques, scales and caudal fin clips, to predict the total mercury concentration in the tissues of largemouth bass (*Micropterus salmoides*) from 20 freshwater sites in Rhode Island, USA. Caudal fin clips were taken from the mid-section of the caudal fin after it had been scrubbed under deionized water to remove mucus.

Methods
- Muscle Tissue Method
  Muscle tissue samples (without skin) were taken above the lateral line, below the anterior edge of dorsal fin. Muscle tissue samples were air dried until constant weight was achieved. Hg concentrations were determined using Direct Mercury Analysis.
- Scale Method
  Scales were taken above the lateral line and stored in paper envelopes. Scales were then removed, treated with a mild soap solution, heated and ultra-sonicated to remove any residues. Scales were dried at room temperature for 48 hours. Hg concentrations were determined using Direct Mercury Analysis.
- Fin Clip Method
  Caudal fins were scrubbed with a household scouring pad, and rinsed with DI water in order to remove any mucus. Clips were taken from the mid section of the caudal fin. Clips were dried to constant weight overnight at room temperature. Total Hg concentrations were determined using Direct Mercury Analysis.

Results
- The relationship of total Hg concentrations between fin clips and muscle tissue showed an r^2 of 0.82 which may be compared with an r^2 of 0.89 for Hg concentrations between scales and muscle tissue.
- While the fin clip method of estimating Hg in tissues is more variable, the Hg concentration in fin clip samples (mean = 0.196 µg/g (dry)) was more than a factor of ten greater than in the scale samples (mean = 0.012 µg/g (dry)).
- Therefore, the fin clip method may be more applicable than the scale method where Hg concentrations in largemouth bass tissues are low, or for other fish species which may have low Hg concentrations.





Comparison of non-lethal methods for predicting Hg concentrations in the dorsal muscle tissue in four freshwater and marine fish.

Species	Scale vs. Tissue (r^2)	Fin Clip vs. Tissue (r^2)
Largemouth Bass (*Micropterus salmoides*)	0.89	0.85
Yellow Perch (*Perca flavescens*)	n/a	0.77
Red Drum (*Sciaenops ocellatus*)	< L.O.D.	0.30
Snook (*Centropomus undecimalis*)	0.60	0.50

Mercury Concentrations in Snapping Turtles in Rhode Island

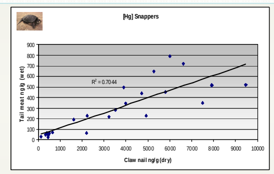
Rationale

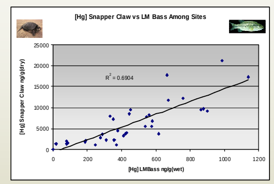
Present models created to predict mercury concentration in fish from water quality and landscape variables are not capable of predicting mercury concentrations in fish from untested sites with sufficient accuracy to protect human health and to establish exposure field data for use in determining risk to sensitive wildlife populations. One approach that may allow more accurate predictions is to sample and analyze indicator organisms and fish from freshwater sites, analyze their tissues and use the results to develop predictive relationships to allow prediction of mercury concentrations in fish from untested sites.

Snapping turtles are large, high trophic level organisms with a high degree of site fidelity, and therefore may be useful as indicator organisms. In addition, snapping turtles are still captured and consumed for food and knowledge of their concentration of mercury may be useful for assessing potential impacts on human health.

Methods
- Analysis of turtle tissue and claw nail for [Hg] (CVAA) and stable isotopes (IRMS).
- Snapping turtles and fish were sampled from 35 freshwater sites (lakes ponds, and reservoirs) in Rhode Island.
- In a small study, relationships of mercury concentrations and values of stable isotopes were developed between samples of turtle tail muscle and claw nail.
- Mercury concentrations and values of stable isotopes were measured in fish and in the snapping turtles and a comparative relationship was developed.

Results
- Comparisons of stable isotopes and mercury concentrations between samples of muscle (tail muscle biopsy) and claw nail (claw nail clip) showed significant relationships between the samples and indicated that the claw nail sampling had promise as a non lethal technique for assessing stable isotope values and mercury concentrations in muscle tissue of snapping turtles.
- Comparisons of nitrogen stable isotopes and mercury concentrations between largemouth bass and snapping turtles among sites showed significant relationships. The results showed that mercury concentrations and $\delta^{15}N$ were similar between muscle of largemouth bass and snapping turtles. This indicated that these organisms occupy an similar trophic position at sites and indicated that snapping turtles may be a useful indicator organism for mercury contamination at freshwater sites.





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Mercury Concentrations in Mink in Rhode Island

Rationale

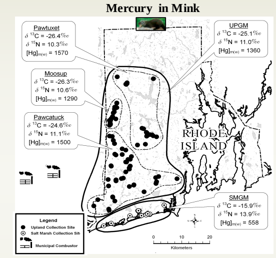
Methods are needed to allow predictions of bioaccumulation in wildlife for contaminants that are widespread and for which availability is determined by a variety of site specific factors.

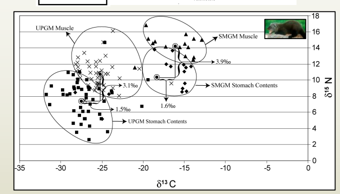
As in other states in the northeastern U.S., Rhode Island receives a substantial input of mercury deposition from the atmosphere. Mink range throughout much of Rhode Island, and as piscivorous wildlife they are potentially vulnerable to the effects of mercury accumulated in their diet. However, data on the concentrations and distributions of mercury in this state were unknown.

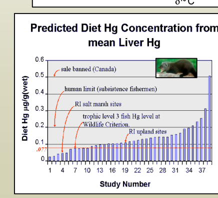
Methods
- Analysis of mink muscle, liver and stomach contents for [Hg] (by CVAA) and muscle and stomach contents for stable isotopes (by IRMS).
- Stomach contents were analyzed and dominant prey items were enumerated.
- These data were used to determine the distribution of mercury in mink and to examine relationships of stable isotope values and Hg concentrations between mink tissues and their stomach contents.

Results
- There was considerable variation in the extent of accumulation of mercury in mink in Rhode Island.
- The accumulation in salt marsh sites 558 ng Hg/g (wet) was two to three times lower than that found in the upland sites (~ 1500ng Hg/g (wet)).
- The highest mercury concentrations in mink were at levels found to cause neurochemical changes in mink, however, at present the impacts on wild mink populations is unknown.
- The study found that utilization of stomach content analysis, to identify major prey items, followed by collection and analysis of appropriate field prey may represent an approach for estimating Hg exposure for mink.

Mercury in Mink







Collaborators

- Alan Libby, Charles Brown, Phillip Edwards, Lori Gibson - RI DEM, Fish and Wildlife
- Eric Schneider – RI DEM, Water Resources
- Douglas Adams – Florida Fish and Wildlife Commission
- Robert Vanderslice – RI Dept. of Health

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