Fish Mercury in the Everglades: Management Implications for Everglades Restoration

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**USGS**
Mercury Research Laboratory, Madison WI

**FGCU**
Coastal Watershed Institute, Ft Myers
Current Sport Fish THg in FW EPA

- WCA1, WCA2, WCA3, and ENP-Harvestable size
- USEPA Human Health MeHg Tissue Criterion = 0.3 mg/kg
S. FL. Black Bass vs State

- FWC Regions-Harvestable size
- USEPA Criterion - 0.3 mg/kg
Human and Ecological Risk Fish & Wildlife

• TL3 = Carnivores feeding on Omnivores (YOY BLUE and MOSQ)

Left Axis: Bass
- USEPA Human Health (0.3 mg/kg)
- Bass EHg3 (2001-14)

Right Axis: Mosq and YOY Bluegill
- USEPA WL @ TL 4 (0.346 mg/kg)
- USEPA WL @ TL 3 (0.077 mg/kg)
- MOSQ THg (mg/kg) 2009-14
- YOY BLUE THg (mg/kg) 2008-15
Ecological Risk Fish

Wild Fish Pop Effects (MeHg in Diet) Depew et al. 2012
• Growth – 2.5 mg/kg
• Behavior – 0.5 mg/kg
• Reproduction sub-clinical effects - <0.2 mg/kg
Compartmentalized EPA-Site Specific Trends

Slot Bluegill (102-178 mm)
Increasing Trends 2 locations

$\text{r} = 0.788, \text{p} = 0.0001$

$\text{r} = 0.676, \text{p} = 0.01$
Mean THg in TL3 sunfish WY1999–WY2013. Error bars = 1 SD.
Trends in Bass

WCA1, 2 and 3

Restricted Cubic spline with knots selected to best fit data.

• 1988 to 2001 - Decline
  \( t_{4023} = -27.86, \ P < 0.001 \).

• 2001 to 2013 - Increase
  \( t_{4023} = 5.38, \ P < 0.001 \)

ENPSRS

• 1989 to 2014 - Decline
  \( F_{5,691} = 5.85, \ P < 0.001 \)
Risk Management-Consumption Advisories

- Based on USEPA MeHg Rfd of 0.1 µg / kg BW – day
- Encourages 2 fish meals/week
- FL Dept of Health Criteria
  - Sensitive population: Women of childbearing age and young children
  - General population: All other individuals

<table>
<thead>
<tr>
<th>Meal Frequency¹</th>
<th>Sensitive Population</th>
<th>General Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 meals per week</td>
<td>&lt; 0.1 mg/kg methylmercury²</td>
<td>&lt; 0.3 mg/kg methylmercury</td>
</tr>
<tr>
<td>1 meal per week</td>
<td>&lt; 0.2</td>
<td>&lt; 0.6</td>
</tr>
<tr>
<td>1 meal per month</td>
<td>&lt; 0.85</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>DNE</td>
<td>≥ 0.85</td>
<td>≥ 1.5</td>
</tr>
</tbody>
</table>

Seek to encourage consumption of fish for health benefits but guide decisions toward selecting fish meals low in mercury.
Managing Public Health-Advisories

FW Fish Consumption Recommendations

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SPECIES</th>
<th>Sensitive</th>
<th>All Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>WCA2A</td>
<td>Mayan cichlid</td>
<td>1/WK</td>
<td>2/WK</td>
</tr>
<tr>
<td></td>
<td>Bluegill, Redear sunfish</td>
<td>1/MO</td>
<td>2/WK</td>
</tr>
<tr>
<td></td>
<td>Butterfly Peacock, Spotted Sunfish, Bass &lt; 14&quot;</td>
<td>1/MO</td>
<td>1/WK</td>
</tr>
<tr>
<td></td>
<td>Bass &gt; 14</td>
<td>DNE</td>
<td>1/MO</td>
</tr>
<tr>
<td>ENP SRS</td>
<td>Redear sunfish, Gray snapper</td>
<td>1 / MO</td>
<td>2 / WK</td>
</tr>
<tr>
<td></td>
<td>Bluegill, Spotted sunfish</td>
<td>1 / MO</td>
<td>1 / WK</td>
</tr>
<tr>
<td></td>
<td>Mayan cichlid</td>
<td>1 / MO</td>
<td>1 / MO</td>
</tr>
<tr>
<td></td>
<td>Common snook, Red drum, Bass &lt; 14&quot;, Yellow bullhead catfish</td>
<td>DNE</td>
<td>1 / MO</td>
</tr>
<tr>
<td></td>
<td>Bass &gt; 14 inches</td>
<td>DNE</td>
<td>1 / MO</td>
</tr>
</tbody>
</table>

Other Advisories
- Pig frogs, Alligators
- 55 Coastal species; 7 are elevated in FL Bay & Keys
Managing Public Health - Alternatives

Direct Harvest away from EPA
- Urban Fisheries
- STAs - Alligator hunts, fisheries
- Other CERP Projects
- Exploit new species

Alternative Bass Fisheries

Bullseye Snakehead
*Channa marulius*
Excellent edibility; up to 15 lbs, top-water baits
Managing Sources-EPA

- Nearly all of the Hg entering the EPA is derived from atmospheric deposition.
- Deposition remains relatively constant with an N-S increase in loading.
- Deposition of mercury and subsequent methylation is the source of MeHg in EPA biota.
- FL BAY: Atm Dep likely more important than inflows (Rumbold 2010)

- E-MCM predicts decadal time-frame for reductions in fish THg
  - Immediate response
  - Protracted due to labile sed mercury supporting methylation

DEP, 2003. Integrating Atmospheric Mercury Deposition and Aquatic Cycling in the Florida Everglades...TMDL Approach.

Figure 10: Predicted dynamic response of Hg concentrations in largemouth bass in WCA 3A-15 following different reductions in Hg(DOM) deposition. Predictions are based on calibration to current loading of 35 μg/m²/yr.
Statewide Mercury TMDL (October 2013)

- DEP completed a statewide TMDL for mercury in fresh water and estuaries in September 2012.

- Two Approaches for risk assessment
  - **Market Basket**: examine distributional characteristics of fish consumption by the sensitive population and the likelihood of mercury exposure from eating fish.
  - **Indicator species**: calculate a reduction factor for 90% of largemouth bass populations to reach desired target for consumption

- Both approaches support reductions to limit human exposure
  - 86% reduction from all emission sources (local, regional, and global)
  - Waste load allocation of 23 kg/yr (MINIMAL)
Figure 7. Annual (2009) total mercury deposition (μg/m²) results from CMAQ partitioned into Florida and non-Florida sources (partition based on Florida and non-Florida tags) for 7 sites.
Statewide Distribution in Bass

Deposition, Methylation and bioaccumulation of Hg into the food web is a statewide issue
Managing Methylation and Bioaccumulation Processes

• Everglades: Hydrologically altered and spatially fragmented
• EPA consists of nearly independently operating “Marsh Impoundments” where methylation processes,
  • Varies between impoundments
  • Varies within impoundments along gradients of biogeochemical parameters (e.g. Organic Carbon, Sulfate, and Nutrients) which are influenced by management (Quantity and Quality of surface waters).
• Similarly, bioaccumulation processes vary across the EPA
Can Variability in Fish Hg concentrations can be explained by site specific characteristics (length/complexity of food web, trophic position, growth, and availability of MeHg)
Fish and prey mercury varied by location and trophic position

- Isotopes and Food habits estimated trophic position show consistent positive relationships to biota THg
  - Slopes not sig different
  - Intercepts sig different
Variations in Trophic Position do not explain variations in bass THg
Management of Mercury in the EPA

- Monitoring spatial and temporal trends in fish and wildlife mercury
  - Support risk assessment for humans and piscivorous wildlife
  - Means to evaluate influence of Everglades management
- Evidence suggests that variations in food web dynamics (complexity, length, and trophic position) are less influential than the availability of MeHg at the base of the food web
- Field studies suggest that methylation and bioaccumulation processes vary among “Marsh Impoundments” and are influenced by gradients of biogeochemical parameters (e.g. hydroperiod, Organic Carbon, Sulfate)
- This compartmentalization and complexity impedes development of concise empirical relationships between fish THg and environmental variables that influence MeHg production and bioaccumulation.

- Fish and Wildlife Hg will be reduced through
  - Reductions in Deposition
  - Managing for reductions in the rate of methylation