How Fish Tissue Data is Used to Develop a Fish Advisory

SRRTTF Workshop February 9, 2016

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Office of Environmental Public Health Sciences
Washington Statewide Mercury Advisories:

- Northern Pikeminnow: DO NOT EAT
- Largemouth and Smallmouth bass: 2 Meals per Month
# Fish Advisory vs. NTR

<table>
<thead>
<tr>
<th><strong>Fish Advisories</strong></th>
<th><strong>NTR Criteria</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CR = RfD x BW / Concentration Fish</td>
<td>Concentration Fish = RfD x BW / CR</td>
</tr>
<tr>
<td>Not used to set Standards</td>
<td>Used to set Standards or Screening levels</td>
</tr>
<tr>
<td>“How much can I safely consume”</td>
<td>“How clean do the fish need to be”</td>
</tr>
<tr>
<td>Applies to everyone</td>
<td>Ideally targets 90-95% consumers</td>
</tr>
<tr>
<td>Less conservative (use a range of cancer risks, focus on non-cancer endpoints)</td>
<td>Conservative (e.g. 1 in 1 million cancer)</td>
</tr>
<tr>
<td>Attempts to balance risks and benefits and considers “background” and contaminant levels in other foods, etc.</td>
<td>Does not consider health benefits of consuming fish – based primarily on risk</td>
</tr>
<tr>
<td>Reactive/Proactive – responding to what is in the environment, prevent exposure</td>
<td>Proactive/Reactive – before &amp; after contamination occurs (discharge &amp; cleanup standards)</td>
</tr>
<tr>
<td>Provide advice</td>
<td>Trying to prevent the need for FAs</td>
</tr>
</tbody>
</table>
Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories

Volume 1
Fish Sampling and Analysis
Third Edition

Vol. 1: Sampling & Analysis
Vol. 2: Risk Assessment
Vol. 3: Risk Management
Vol. 4: Risk Communication

http://water.epa.gov/scitech/swguidance/fishshellfish/techguidance/technical_index.cfm
Fish Advisory in a Nutshell

1. Determine contaminant concentration in fish
2. Develop Screening Levels based on CRs
3. Compare concentrations in fish to screening levels
4. Incorporate Risk Management & Risk Communication decisions
5. If criteria exceeded, calculate “safe” CR

Fish Advisory
PCBs – Why the Concern

- Fish are a primary source of exposure to PCBs

- PCBs known to impact the immune system, cause neurological and developmental problems, and have reproductive effects. Evidence for carcinogenicity in animals, potential carcinogen in humans

- We’re all exposed to PCBs
  - PCB detected in serum of 100% of U.S. population sampled 2003–04 by CDC
Approach(es) to PCBs

Evaluate Total PCBs based on:
  - Single or combined Aroclors
  - Adding congeners or subset of congeners

Utilize EPA’s IRIS values & ATSDR’s MRL
  - Non-cancer Reference Dose (RfD)*
    - Based on Aroclor 1254
  - Minimal Risk Level (MRL)**
  - Dioxin-like TEF
  - Cancer – Cancer Slope Factor (CSF)*
    - Based on Aroclor mixtures

*http://www.epa.gov/iris
Screening Levels

- Can be developed for cancer and non-cancer endpoints and for differing consumption rates

- DOH uses two consumption rates
  - 59.7 g/day = 2 meals per week
    - Based on AHA & ADA recommendations
    - Fish Advisory Action level
  - 175 g/day = 23.5 meals per month
    - Based on proposed FCR
    - Fish Advisory Public Health Goal (PHG)

Much like Drinking Water Standards, we can have action levels (MCLs) & Goals (MCLGs) but with no regulatory authority
PCB Screening Levels (SL)

Noncancer endpoint

$$SL_{PCB \text{ Conc.}} = \frac{RfD \times BW}{CR}$$

Cancer endpoint

$$SL_{PCB \text{ Conc.}} = \frac{ARL \times BW}{CSF \times CR}$$

<table>
<thead>
<tr>
<th>Analyte</th>
<th>RfD Non–cancer (mg/kg–day)</th>
<th>CSF Cancer (mg/kg–day)$^{-1}$</th>
<th>Tissue SL (59.7 g/day) ppb</th>
<th>Tissue SL (175 g/day) ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB</td>
<td>0.000002</td>
<td>–</td>
<td><strong>23</strong></td>
<td>8</td>
</tr>
<tr>
<td>PCB*</td>
<td>0.000003</td>
<td>–</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>PCB</td>
<td>–</td>
<td>2</td>
<td>0.59</td>
<td>0.20</td>
</tr>
</tbody>
</table>

* Based on MRL
Calculated Meal Limits

- Non-cancer Meal Limits
  - \[ Consumption \ Rate = \frac{RfD \times BW}{Conc.\textit{PCBs}} \]

- Cancer Meal Limits
  - \[ Consumption \ Rate = \frac{ARL \times BW}{CSF \times Conc.\textit{PCBs}} \]
Dioxin–like PCBs
TEQ Approach

- 12 PCB congeners act similarly to 2,3,7,8-TCDD
- Multiply relative toxicities (TEF), add to get total TEQ \((\text{TEQ} = \Sigma [C_i] \times \text{TEF}_i)\)
- Effects thought to be mediated through AhR (aryl hydrocarbon) receptor binding
  - Activates metabolizing enzymes e.g., Cyto-P450
    - Production of toxic metabolites, gene transcription
    - Adverse cellular processes and function
      - Immuno, reproductive, endocrine, teratogenic, carcinogenic
Calculated Consumption Rates for Multiple Contaminants with same Health Endpoint

\[
CR = \left( \frac{BW \times CF}{MS} \right) \times \left( \frac{MRL_{PCBS}}{Conc._{PCBS}} + \frac{RfD_{Hg}}{Conc._{Hg}} + \frac{RfD_{PBDEs}}{Conc._{PBDEs}} \right)
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>RfD/MRL - Reference Dose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCBs</td>
<td>0.00003</td>
<td>mg/kg-day</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>PBDEs</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>BW - body weight</td>
<td>60 (adult ♀)</td>
<td>kg</td>
</tr>
<tr>
<td>CF – conversion factor</td>
<td>30.4</td>
<td>days/month</td>
</tr>
<tr>
<td>MS – meal size</td>
<td>0.227</td>
<td>kg/meal</td>
</tr>
<tr>
<td>Conc. – concentration</td>
<td>mean</td>
<td>mg/kg</td>
</tr>
</tbody>
</table>
Benefits of Fish Consumption

- 2007 NAS IOM Seafood Choices: Balancing Benefits and Risks
  - Seafood is nutritious, high-quality protein, low in saturated fat, rich in polyunsaturated fats (Omega-3 Fatty Acids EPA &DHA)

- Eating fish confers health benefits
  - Prevention of irregular heart contractions
  - Prevention of arteriosclerosis
  - Prevents inflammation
  - Lower PB
  - Possible reduction of certain cancers
  - Higher cognitive abilities
Summary of Evidence of Effects of Consumption of Fish/Fish Oil on Cardiovascular Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Clinical Effect</th>
<th>Strength of Evidence</th>
</tr>
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<tbody>
<tr>
<td>CHD Mortality</td>
<td>≈ 35% decrease</td>
<td>Strong</td>
</tr>
<tr>
<td>CHD death</td>
<td>≈ 50 - 90% decrease</td>
<td>Strong</td>
</tr>
<tr>
<td>Sudden death*</td>
<td></td>
<td>Strong</td>
</tr>
<tr>
<td>Ischemic Stroke</td>
<td>≈ 30% decrease</td>
<td>Moderate</td>
</tr>
<tr>
<td>Nonfatal CHD</td>
<td>Modest benefit?</td>
<td>Equivocal</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>≈ 30% decrease</td>
<td>Limited</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>≈ 30% decrease</td>
<td>Limited</td>
</tr>
</tbody>
</table>

source: Mozaffarian and Rimm, 2006
*Albert CM et al. 2002
Emerging Evidence of Effect of Consumption of Fish/Fish Oil on Other Health Outcomes

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<th>Health Outcome</th>
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<tbody>
<tr>
<td>• Reduced preterm birth</td>
</tr>
<tr>
<td>• Improved brain function, motor and visual benefits to infants &amp; children</td>
</tr>
<tr>
<td>• Significantly reduced rates of age-related cognitive decline and dementia, including Alzheimer’s Disease</td>
</tr>
<tr>
<td>• Sharply reduced incidence of early age-related macular degeneration and late AMD</td>
</tr>
<tr>
<td>• Reduced need for traditional anti-inflammatory drugs in treatment of rheumatoid arthritis</td>
</tr>
<tr>
<td>• Treatment or prevention of depression and other mood disorders, including postpartum depression</td>
</tr>
</tbody>
</table>
American Heart Association:
- Patients without documented heart disease:
  - Eat a variety of fish at least twice a week
- Patients with documented heart disease:
  - Consume about 1 g of Omega-3 fatty acids (EPA+DHA) per day preferably from fatty fish
- Patients who need to lower triglycerides:
  - 2 to 4 g of Omega-3 fatty acids per day

American Diabetes Association:
- Eat 2–3 servings of fish per week to lower the risk of diabetes

Noted in NAS IOM, 2007
“Consumption of two servings (approximately eight ounces) per week of fish high in EPA and DHA is associated with reduced risk of both sudden death and heart disease death in adults. To benefit from the potential cardio-protective effects of EPA and DHA, the weekly consumption of two serving of fish, particularly fish rich in EPA and DHA, is suggested.”

Noted in NAS IOM, 2007
Recommendations to Encourage Seafood Consumption

National Healthy Mothers, Healthy Babies Coalition:

Pregnant, breastfeeding and postpartum women are recommended to consume a minimum of 12 ounces of seafood per week (salmon, tuna, sardines), or DHA-fortified eggs. Six ounces of the recommended fish per week can come from albacore tuna.
Contaminant Risk

Omega-3 Benefit

Fish Consumption

Omega-3 Benefit

Combined Risk

Contaminant A Risk

Contaminant B Risk
Decline in fish consumption

After federal mercury advisory 1/01

Meal servings per month

Month surveyed

- Pre-advisory
- Post-advisory

- fish combined
- canned tuna
- dark meat fish

Modifying the Calculated Results to Incorporate Risk Management & Risk Communication Decisions

- Benefits
- Background or ambient levels
- Contaminants in other foods
- Risks posed by other foods
- Contaminant reduction from preparation and cooking
- Simplifying message
Spokane River Fish Advisory
Update 2009/2016

**Statewide Mercury Advisory:** Smallmouth & Largemouth Bass – 2 meals/month
Northern Pikeminnow – No Consumption

**Lake Spokane (Long Lake):**
Two meals per month:
Largemouth & Smallmouth Bass

One meal per month:
Brown Trout & Largescalar Sucker
2016 – Carp: No Consumption

Good fish choices include:
2 meals per week rainbow trout, yellow perch
1 meal per week - mt whitefish

**From Nine Mile Dam to Upriver Dam:**

Do Not Eat:
Largescalar Sucker

All other fish
One meal per month

**From Upriver Dam to the Idaho Border:**

Do Not Eat Fish
Catch & Release Only
Non-cancer Background conc. 6.5 ppb
NTR Std 5.3 ppb
Public Health Goal
Eat Fish, Be Smart, Choose Wisely

Questions

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