Proposed Updates to Virginia’s Selenium Aquatic Life Criteria

January 16th, 2014
Regulatory Advisory Panel Meeting – Water Quality Standards Triennial Review
Se Criteria Updates

- Virginia’s Triennial Review is currently underway
- DEQ’s Se water quality standards outdated
  - Based on EPA’s 1987 criteria values:
    - Acute: 20 µg/L
      - Calculated from chronic criterion
    - Chronic: 5 µg/L
      - Not based on laboratory-derived toxicity data
      - Derived from field-observed no-effect level from Belews Lake, NC
      - 2004 draft criteria provides a relatively up-to-date and scientifically defensible dataset
      - Additional chronic tissue-based data published since 2004 also available
- Se chronic criteria recently updated in Kentucky and approved by EPA
  - Our proposal for Virginia DEQ is based on these criteria
Selenium: EPA Status

- EPA in the process of updating the national criteria
  - However, unknown when a new draft document will be released
  - Public comment draft out in Spring 2014, final Summer 2014?
  - Release date has been delayed multiple times over the last several years

- In the meantime, states may develop their own updated criteria instead of relying on EPA’s outdated and inappropriate criteria from 1987

- Derivation of an updated Se standard is scientifically defensible
  - New acute water-column toxicity and tissue-based chronic toxicity data made available since release of the current criterion (EPA 1987) and the last draft criterion (EPA 2004)
Selenium History

- **1987**: Selenium Criteria document published
- **1998**: EPA held “Peer Consultation Workshop on Selenium Aquatic Toxicity and Bioaccumulation”
  - Concludes tissue more accurate predictor of chronic effects
- **2002**: EPA issued first draft revised criteria for external peer review
- **2004**: EPA issued second draft for public comment
  - Separate acute criteria for Se$^{+4}$ and Se$^{+6}$
    - Se$^{+4}$ criterion more stringent; Se$^{+6}$ has sulfate modifier
  - Whole-body chronic criterion tissue-based criterion of 7.91 mg/Kg
    - Screening value (cold water exposure) of 5.8 mg/Kg
Selenium History

2004: EPA draft – continued
- After significant public comment, EPA put out a “call for data”
  - Included request for more data on more fish species
  - More data on population-level studies of Se exposure
  - Desire to “re-do” the winter-stress bluegill study

2009: SETAC Pellston workshop on Se

2013: KY adopts new selenium standards
- Chronic tissue standard approved by EPA Nov 2013

2014: EPA expected to issue final revised criteria for public comment
- Likely will include methods for calculation of “safe” water column value using tissue criterion and modeled bioaccumulation factors
  - Apparently results in stringent water criteria on a national level, but impairment is based on meeting or exceeding tissue thresholds
Acute Se Proposed in VA

Based on combination of

1. **Equation based on forms of selenium (EPA 2012)**
   - Equation from “1995 updates” and the 1996 Great Lakes Initiative:
     \[ CMC = \frac{1}{f_1/CMC_1 + f_2/CMC_2}, \]
     Where \( f_1 \) = fraction of total Se as selenite
     \( f_2 \) = fraction of total Se as selenate

2. **Plus, updated acute criteria from EPA 2004**
   - \( CMC_1 = 258 \mu g/L \)
   - \( CMC_2 = e^{(0.5812[ln(sulfate)] + 3.357)} \)
     - If sulfate = 100 mg/L, \( CMC_2 = 417 \mu g/L \)
Acute Se Proposed in VA

- Acute KY standard denied by EPA
  - Reasoning:
    - Lethality is not the only appropriate endpoint
    - Dietary selenium must be accounted for
    - Should be protective of chronic tissue-based criterion

- Recommend development of acute selenium criterion that accounts for these issues

- We believe there is an approach that could do this
  - Derive using biokinetic modeling of selenium in simulated aquatic food chains that models pulse exposures
    - Expanding on a model originally developed during EPA-funded Arid West WQ Research Project *

Example of how a biokinetic model could be used to develop “safe” acute standards, based on current model

- Baseline water Se conc. = 1 µg/L
- Pulse duration = 96 hours
- Pulse magnitude = 182 µg/L
- Predicted to protect whole-body Se conc. ≤ 8.6 µg/g dw
Chronic Se Proposed in VA

- Fish tissue-based chronic criterion most appropriate

- Considered and evaluated tissue data from:
  - Studies EPA used in 2004
  - Additional data published since 2004
  - Other reviews (DeForest, Adams, Ohlendorf)

- Used EPA Criteria Calculation Methods (Stephan et al. 1985)
  - Improvement over past approaches that simply default to lowest numbers
Most studies present either whole-body or egg/ovary

- Used translators to develop complete whole-body and egg/ovary databases
  - Existing translators
    - Fathead minnow from GEI 2008, Bluegill and Trout from NAMC-SWG White Paper
  - Updated “all species” translator
    - Added to database used in NAMC-SWG White Paper
- Calculation of both whole-body or egg/ovary tissue chronic criteria provides flexibility in field sampling
Toxicity data available for relevant fish species (including naturalized and surrogate species) used to calculate GMCVs

1. Bluegill*
2. Brook trout*
3. Northern pike*
4. Largemouth bass*
5. Brown trout
6. White sturgeon
7. Rainbow trout
8. Eastern mosquitofish
9. White sucker
10. Fathead minnow

*Four most Se-sensitive species in database
While not all of those species are in every stream, they are either present in some streams or are surrogates for species that do occur:

- Must be protective of all species which could or do occur in VA waters
  - Per EPA criteria calculation guidelines
- In addition, inclusion of a variety of species captures the variability in sensitivity and ensures the criterion is adequately protective
### VA’s Chronic Criterion

**Whole-body**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Genus</th>
<th>GMCV</th>
<th>In GMCV</th>
<th>(ln GMCV)^2</th>
<th>P = R/(N+1)</th>
<th>√P</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Micropterus</td>
<td>10.96</td>
<td>2.3943</td>
<td>5.7324</td>
<td>0.3636</td>
<td>0.6030</td>
</tr>
<tr>
<td>3</td>
<td>Esox</td>
<td>10.92</td>
<td>2.3906</td>
<td>5.7149</td>
<td>0.2727</td>
<td>0.5222</td>
</tr>
<tr>
<td>2</td>
<td>Salvelinus</td>
<td>10.34</td>
<td>2.3360</td>
<td>5.4570</td>
<td>0.1818</td>
<td>0.4264</td>
</tr>
<tr>
<td>1</td>
<td>Lepomis</td>
<td>8.92</td>
<td>2.1883</td>
<td>4.7886</td>
<td>0.0909</td>
<td>0.3015</td>
</tr>
<tr>
<td></td>
<td><strong>SUM</strong></td>
<td>9.3092</td>
<td>21.6929</td>
<td>0.9090</td>
<td>1.8531</td>
<td></td>
</tr>
</tbody>
</table>

**Calculations: Chronic Whole-body Criterion**

\[
S^2 = \sum (\ln \text{GMCV})^2 - \left( \sum \ln \text{GMCV} \right)^2/4 = 21.6930 - (9.3092)^2/4 = 0.5519
\]

\[
S = 0.7429
\]

\[
\sum P - \left( \sum \sqrt{P} \right)^2/4 = 0.9091 - (1.85317)^2/4
\]

\[
L = \left[ \sum \ln \text{GMCV} - S(\sum \sqrt{P}) \right]/4 = [9.3092 - 0.7429(1.85317)]/4 = 1.9831
\]

\[
A = S(\sqrt{0.05}) + L = (0.7429)(0.2236) + 1.9831 = 2.1492
\]

Final Chronic Value = FCV = \(e^A\) = 8.5783 ≈ 8.6 µg/g dry weight whole-body
# VA’s Chronic Criterion

## Egg/Ovary

<table>
<thead>
<tr>
<th>Rank</th>
<th>Genus</th>
<th>GMCV</th>
<th>Ln GMCV</th>
<th>(ln GMCV)^2</th>
<th>P = R/(N+1)</th>
<th>√P</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Lepomis</td>
<td>22</td>
<td>3.0910</td>
<td>9.5543</td>
<td>0.3636</td>
<td>0.6030</td>
</tr>
<tr>
<td>3</td>
<td>Acipenser</td>
<td>21.6</td>
<td>3.0745</td>
<td>9.4528</td>
<td>0.2727</td>
<td>0.5222</td>
</tr>
<tr>
<td>2</td>
<td>Esox</td>
<td>20.4</td>
<td>3.0155</td>
<td>9.0932</td>
<td>0.1818</td>
<td>0.4264</td>
</tr>
<tr>
<td>1</td>
<td>Salvelinus</td>
<td>20</td>
<td>2.9957</td>
<td>8.9744</td>
<td>0.0909</td>
<td>0.3015</td>
</tr>
</tbody>
</table>

**Sum**: 12.1769 37.0752 0.9091 1.8532

### Calculations: Chronic Egg/Ovary Criterion

\[
S^2 = \sum (\ln \text{GMCV})^2 - (\sum \ln \text{GMCV})^2/4 = 37.0752 - (12.1769)^2/4 = 0.1244 \quad S = 0.3527
\]

\[
\Sigma P - (\Sigma \sqrt{P})^2/4 = 0.9091 - (1.85317)^2/4
\]

\[
L = [\sum \ln \text{GMCV} - S(\sum \sqrt{P})]/4 = [12.1769 - 0.3527(1.85317)]/4 = 2.8808
\]

\[
A = S (\sqrt{0.05}) + L = (0.3527)(0.2236) + 2.8808 = 2.9597
\]

Final Chronic Value = FCV = e^A = 19.2918 ≈ **19.3 µg/g dry weight egg/ovary**
Chronic Implementation

- Field tissue collections are potentially expensive and difficult for the regulated community

- Proposed a multi-step criterion
  - Begins with screening of water-column data to weed out locations with low Se and limited risk to aquatic life
  - Use current national/Virginia chronic criterion of 5.0 μg/L as a threshold
    - If exceeded, triggers the requirement to collect fish tissues (whole-body or egg/ovary) to assess attainment
Step 1. Determine whether the water column concentration at the site exceeds 5.0 µg/L threshold.

- If water column concentration for total Se ≤5.0 µg/L, the water body is meeting its aquatic life use
  - Waterbody considered “in attainment”

- If the water column concentration for total Se >5.0 µg/L, proceed to Step 2.
Step 2. Determine whether the site is in attainment of the tissue criterion.

- Whole body ≤ 8.6 µg/g total Se dw, or
- Egg/ovary tissue ≤ 19.3 µg/g total Se dw

If each species-composite fish tissue has a Se concentration less than the appropriate tissue-based criterion, the water body is meeting the chronic Se standard.
- Waterbody considered “in attainment”
If a species-composite fish tissue has a Se concentration that *exceeds* the tissue criterion, the site is considered in non-attainment of the water quality standard.
Updated Se Criteria

- **Protective:**
  - Acute and tissue-based chronic are based on best available science
    - Use of either whole-body or egg/ovary tissue for chronic criterion provides maximum flexibility in field sampling

- **Implementation: Consistent with other EPA fish tissue-based criterion**
  - 0.3 mg/kg (wet wt.) of *methylmercury* in fish fillet
    - EPA issued implementation guidance (2010)
    - EPA clearly defined how fish tissue criterion would be more protective of human health compared to a water-based value
  - Many similarities with proposed Se fish tissue criteria
  - Se-specific implementation guidance will likely be needed

- **Interesting example: SARDA Hg**
Summary

- **Proposed criteria based on best available science**
  - Tissue-based chronic criterion should be consistent with approach expected in pending updated Se criteria from EPA

- **Multi-step criterion minimizes need for tissue sampling where water-column [Se] very low**

- **Major improvement over the outdated 1987 EPA Se criteria currently in use**

- **Effects of changes**
  - Potentially significant bearing on basis for
    - Current 303(d) listings
    - TMDLs
    - Effluent limits for NPDES permittees
      - Especially where ambient concentrations can exceed current criteria
Any questions?

scanton@geiconsultants.com