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Proposed Updates to Virginia's Selenium Aquatic Life Criteria

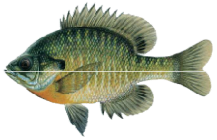
January 16th, 2014

Regulatory Advisory Panel Meeting –
Water Quality Standards Triennial Review

GEI Consultants

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- **DEQ's Se water quality standards outdated**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- **In the meantime, states may develop their own updated criteria instead of relying on EPA's outdated and inappropriate criteria from 1987**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 = 1/[f1/CMC1) + f2/CMC2)],

   Where f1 = fraction of total Se as selenite
   f2 = fraction of total Se as selenate

2. **Plus, updated acute criteria from EPA 2004**

   CMC1 = 258 µg/L

   CMC2 = $e^{(0.5812[\ln(\text{sulfate})] + 3.357)}$

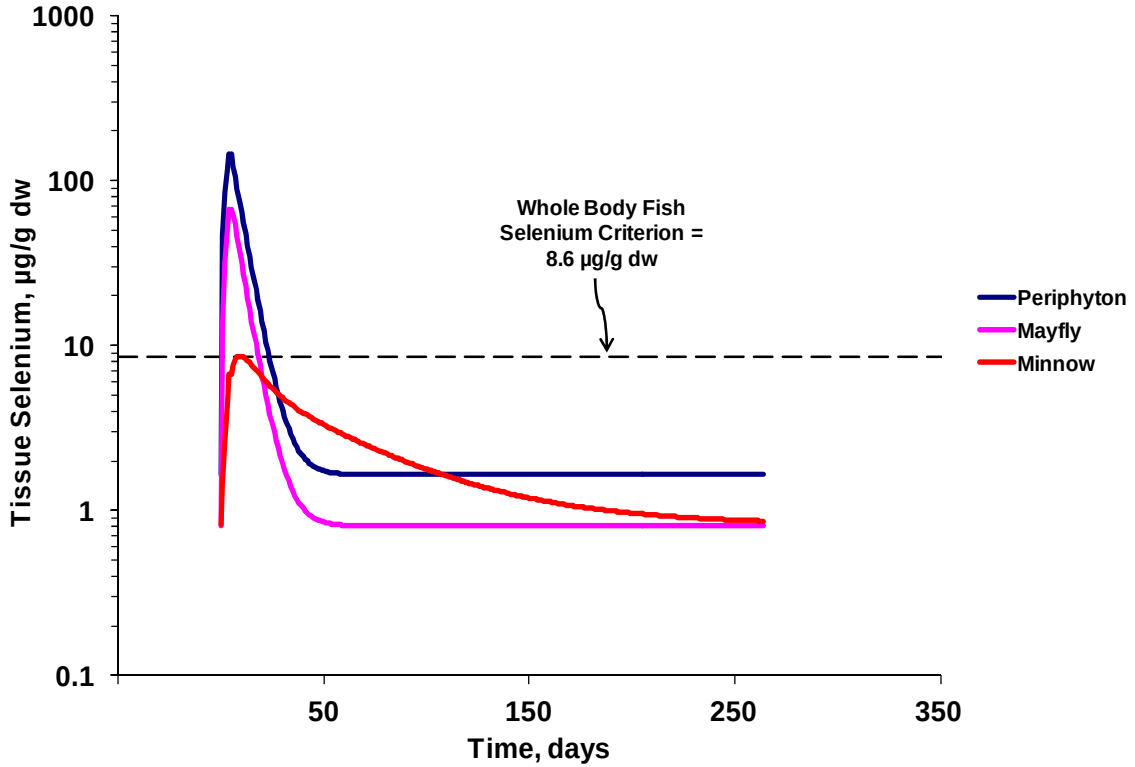
   - If sulfate = 100 mg/L, CMC2 = 417 µg/L

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 *

* Brix, K.V., and D.K. DeForest. 2008. Selenium. pp 123-171, in: *Relevance of Ambient Water Quality Criteria for Ephemeral and Effluent-Dependent Watercourses of the Arid Western United States*. Gensemer, R.W., R.D. Meyerhoff, K.J. Ramage, and E.F. Curley, editors. Society of Environmental Toxicology and Chemistry (SETAC), Pensacola, FL.

Acute Se Proposed in VA



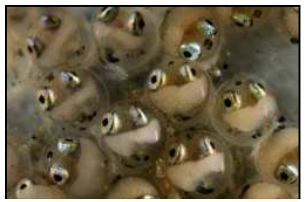
- **Example of how a biokinetic model could be used to develop "safe" acute standards, based on current model**
  - Baseline water Se conc. = 1 µg/L
  - Pulse duration = 96 hours
  - Pulse magnitude = 182 µg/L
  - Predicted to protect whole-body Se conc. ≤ 8.6 µg/g dw

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

Chronic Se Proposed in VA

- **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



VA's Chronic Database

- **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*

VA's Chronic 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

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Whole-body

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

Calculations: Chronic Whole-body Criterion

$$S^2 = \frac{\Sigma (\ln GMCV)^2 - (\Sigma \ln GMCV)^2/4}{\Sigma P - (\Sigma \sqrt{P})^2/4} = \frac{21.6930 - (9.3092)^2/4}{0.9091 - (1.85317)^2/4} = 0.5519 \qquad S = 0.7429$$

$$L = [\Sigma \ln GMCV - S(\Sigma \sqrt{P})]/4 = [9.3092 - 0.7429\ (1.85317)]/4 = 1.9831$$

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

Final Chronic Value = FCV = e^A = 8.5783 ≈ **8.6 µg/g dry weight whole-body**

VA's Chronic Criterion

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Egg/ovary

Rank	Genus	GMCV	Ln GMCV	(ln GMCV)^2	P = R/(N+1)	√P
4	*Lepomis*	22	3.0910	9.5543	0.3636	0.6030
3	*Acipenser*	21.6	3.0745	9.4528	0.2727	0.5222
2	*Esox*	20.4	3.0155	9.0932	0.1818	0.4264
1	*Salvelinus*	20	2.9957	8.9744	0.0909	0.3015
		Sum	12.1769	37.0752	0.9091	1.8532

Calculations: Chronic Egg/Ovary Criterion

$S^2 = \frac{\Sigma (\ln GMCV)^2 - (\Sigma \ln GMCV)^2/4}{\Sigma P - (\Sigma \sqrt{P})^2/4} = \frac{37.0752 - (12.1769)^2/4}{0.9091 - (1.85317)^2/4} = 0.1244$ $\quad S = 0.3527$

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

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

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

Chronic Implementation

- **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.

Chronic Implementation

- **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”

Chronic Implementation

- **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?
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