

SELENIUM TOXICITY IN AQUATIC SYSTEMS

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Selenium Sources and Issues

- Micronutrient – necessary for healthy organisms and communities
- Mining – locally from shale and coal, coal combustion products
- Nationally and internationally – mining
- Agriculture – concentration from irrigation

Selenium Sources and Issues

- Water quality criteria changes ongoing
- Multiple forms occur naturally
- Bioaccumulates through food chain
- Transfers maternal via yolk sack
- Effects seen in birds and fish

Selenium Sources and Issues

- Lentic and lotic differences
- Acute versus chronic effects
- Selenate versus selenite toxicity

Introduction



Water



Periphyton



Fish Food

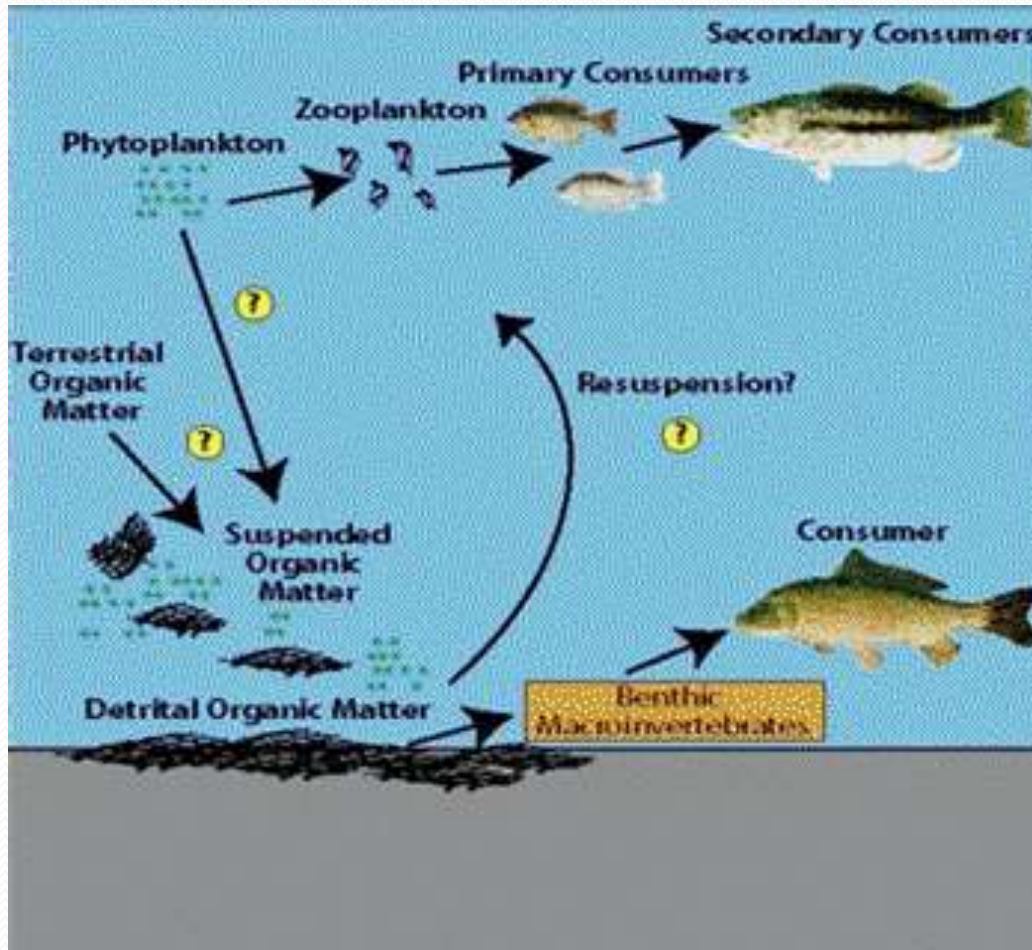
- Benthic Macroinvertebrates
- Crayfish
- Other smaller fish



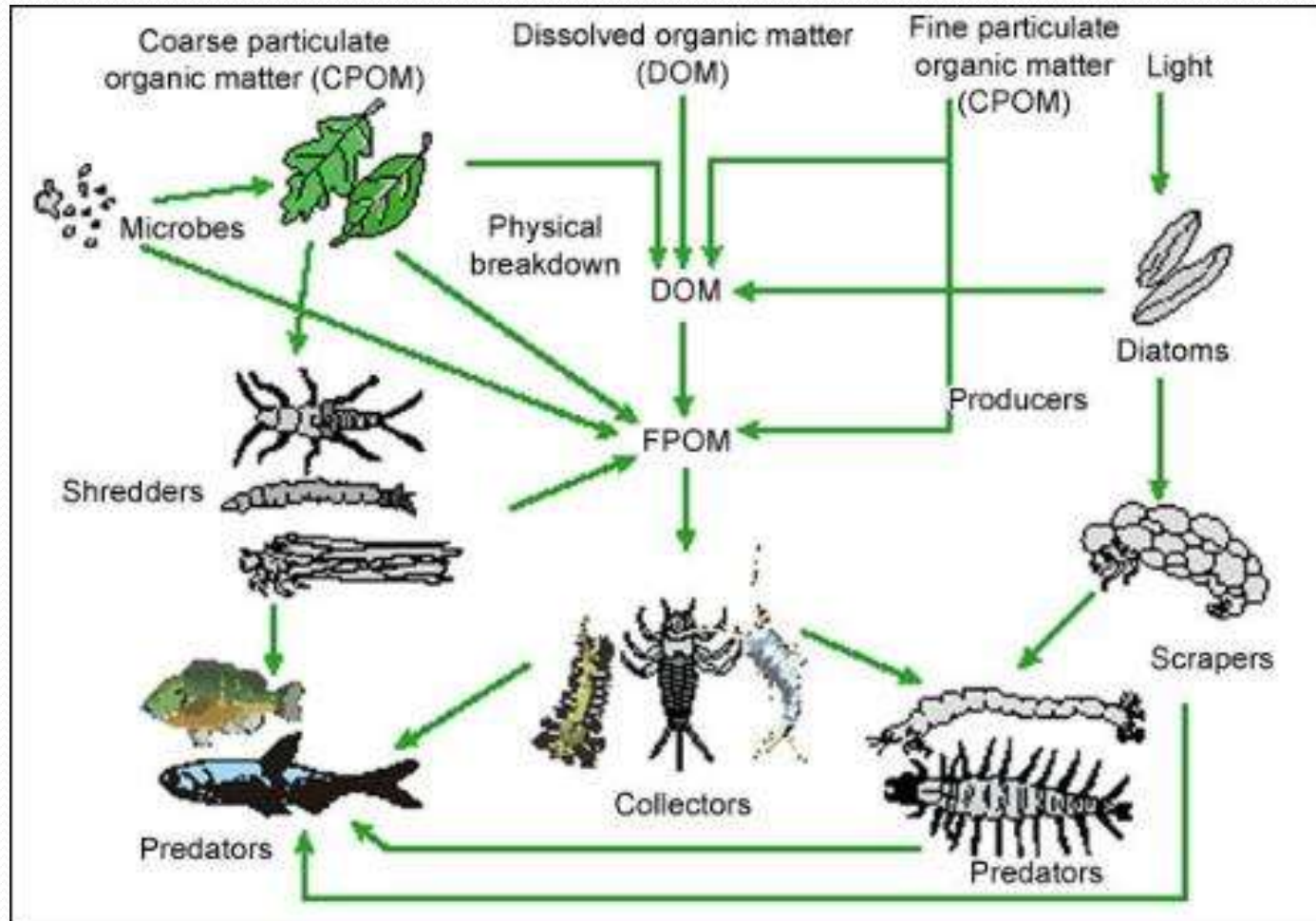
Specific Fish Species

- Creek chub
- Green sunfish
- Hog sucker

Lake food chain



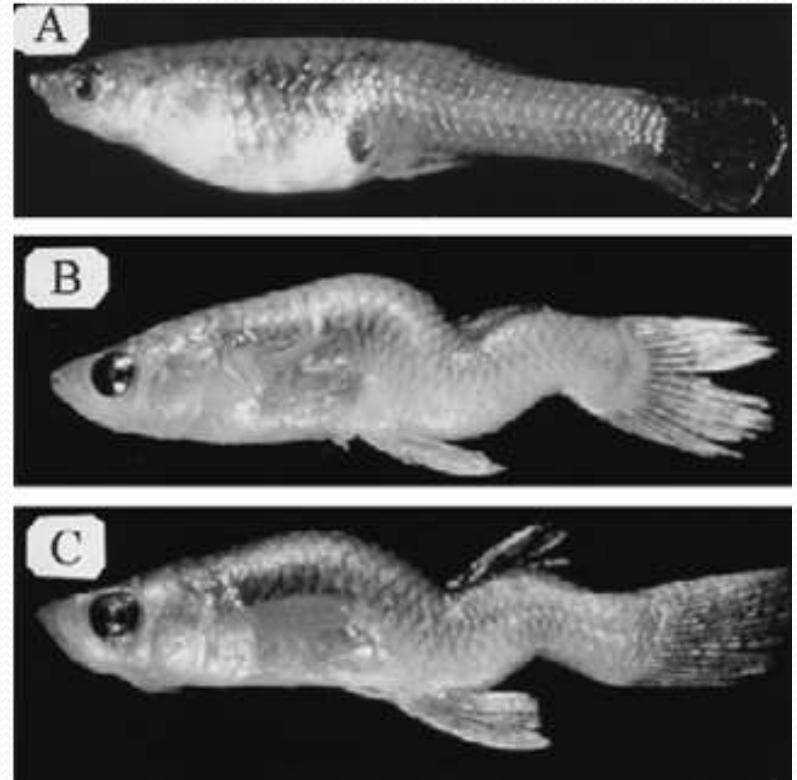
Stream food chain



Hatfield 2007 at: <http://www.orangesenquak.com/river/ecology+biodiversity/aquatic+ecology/liae/chains+and+webs.aspx?print=1>

Chronic effects on fish

- Individual effects
 - Teratogenic deformities
 - Edema
- Community level effects
 - Reduced survival
 - Reduced recruitment
 - Population declines



(Lemly, 1997)

Chronic effects on fish

- Threshold levels
 - 7.9 mg/kg dw whole body
 - 18 – 20 mg/kg egg/ovary
 - Conversion
- Reproductive studies evaluating deformities – EC₁₀
- Predictive modeling

A Reproductive and Trophic Transfer Study Associated With Selenium Concentrations in the Upper Mud River Watershed

Amanda Wilson

Marshall University
Master of Environmental Science

Presented at the International Conference on Acid Rock
Drainage, Ottawa Canada, May 2012



Ongoing work - evaluating the mechanics of selenium bioaccumulation

- Monthly collections of water, periphyton, macroinvertebrates and fish
- Selenium evaluation of each food web component (including whole body and egg ovary for fish)
- Evaluating reproduction for selenium effects
- 3 sampling sites – for dose response

Chronic effects on fish

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Selenium bioaccumulation among select stream and lake fishes in West Virginia – WVDEP 2009

Site	Stream Code	Avg. Water Column Conc. (ppb)	Avg. Fish Tissue Conc. (ppm)	Avg. Sunfish Tissue Conc. (ppm)	Avg. Minnow Tissue Conc. (ppm)	Avg. BAF (L/kg)
Mining Influenced Streams		9.39	6.21	6.07	5.74	1179
Beech Creek	WVKC-10-T-15	12.30	7.55	7.34	7.64	613
Pond Fork	WVKC-10-U	2.40	3.64	4.03	2.76	1515
White Oak Creek	WVKC-35	15.80	6.77	7.12	6.42	428
Seng Creek	WVKC-42	27.20	8.16	NA	8.16	300
Hughes Fork	WVKG-5-B-4	5.30	7.97	NA	7.97	1503
Pinnacle Creek	WVOG-124	2.50	6.02	6.78	5.11	2520
Kiah Creek	WVO-2-Q-18	1.60	2.70	2.73	2.68	1690
Mud River	WVOGM	8.00	6.89	8.43	5.20	862
*Sycamore Creek	WVKC-47-E	1.00	4.00	NA	4.00	4448
Reference Stream						
Ash Fork	WVKG-5-H	0.94	2.50	NA	2.50	2500

*Not used in derivation of averages

Selenium bioaccumulation among select stream and lake fishes in West Virginia – WVDEP 2009

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Mining Influenced Impoundments						
Upper Mud River Reservoir	WVOGM-(L1)	3.50	23.11	23.11	NA	6601
East Lynn Lake	WVO-2-Q-(L1)	1.00	2.96	2.96	NA	2965
Reference Impoundments						
Elk Fork Lake	WVO-32-M-(L1)	1.00	1.03	1.03	NA	1033
Plum Orchard Lake	WVK-65-Z-(L1)	1.00	1.69	1.69	NA	1694



Selenium WB and E/O Fish Tissue Concentrations



Selenium WB and E/O Fish Tissue Concentrations

Determining safe level for selenium in fish - Reproductive effects

- Develop dose-dependent response (deformities and egg/ovary concentration) – EC₁₀
- Evaluate effects threshold for deformity in fish
- Establish whole body to egg/ovary conversions

Introduction



Means, 1995

Reproductive Study Methods

Egg and Fish Tissue Collection



Fish Nest

Reproductive Study Methods



Reproductive Study Methods



Reproductive Study Methods

Deformities (continued)



POTESTA, 2009



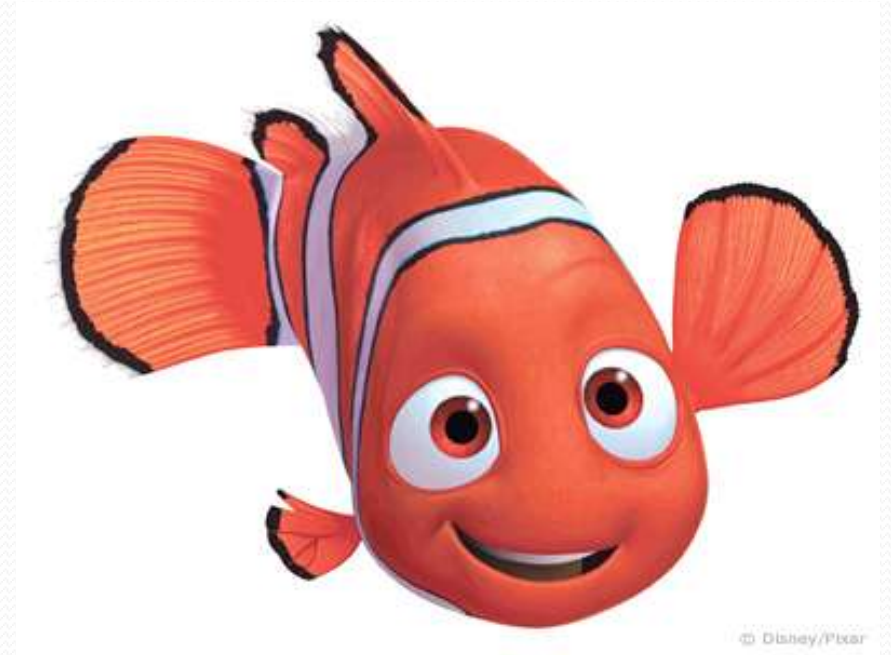
POTESTA, 2009

Reproductive Study Methods

Deformities (continued)



POTESTA, 2009



© Disney/Pixar

Finding Nemo,
2003



Teratogenic deformities in relation to selenium whole-body fish tissue concentrations – single watershed

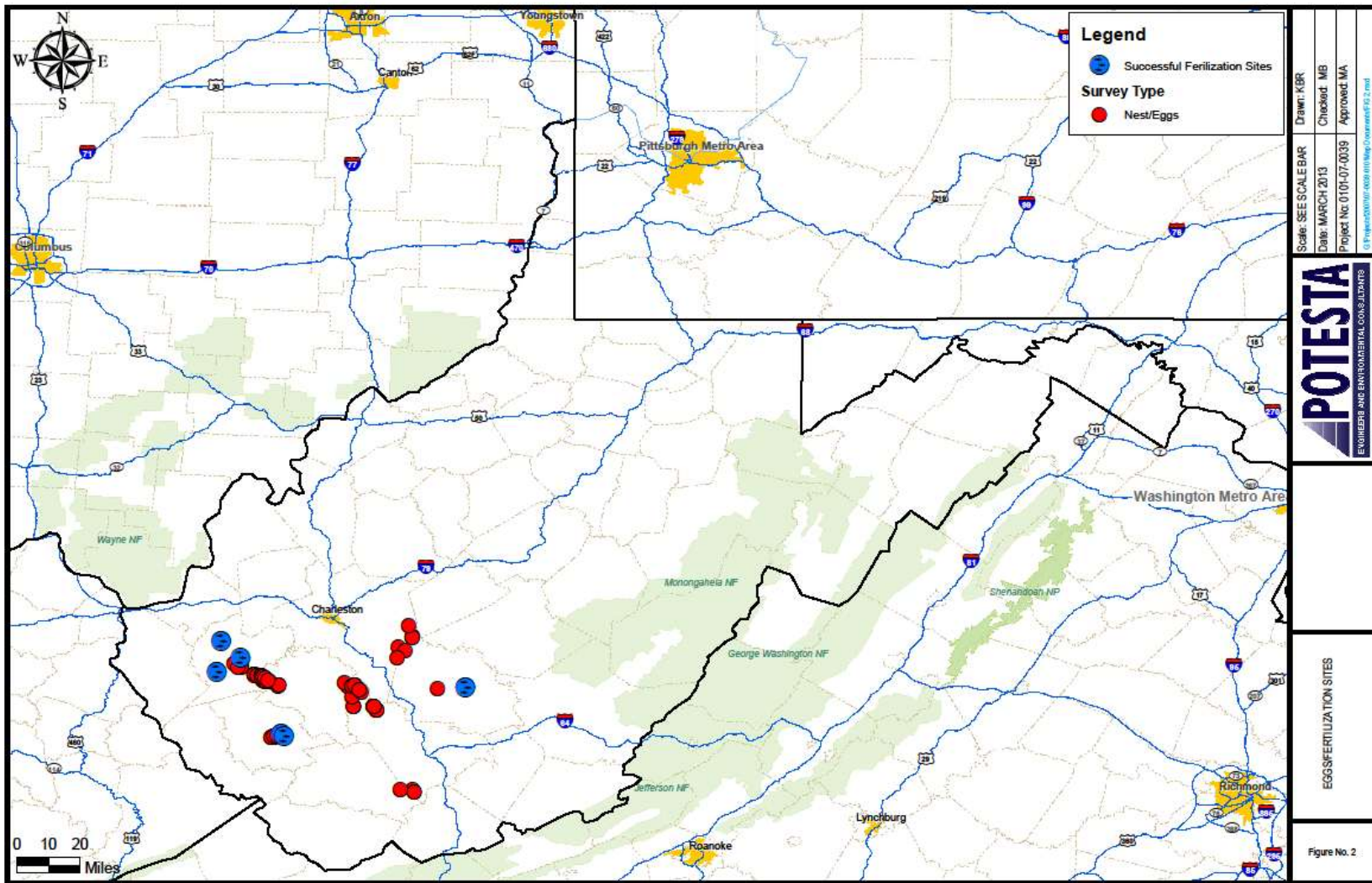
Teratogenic deformities in relation to selenium whole-body fish tissue concentrations – statewide



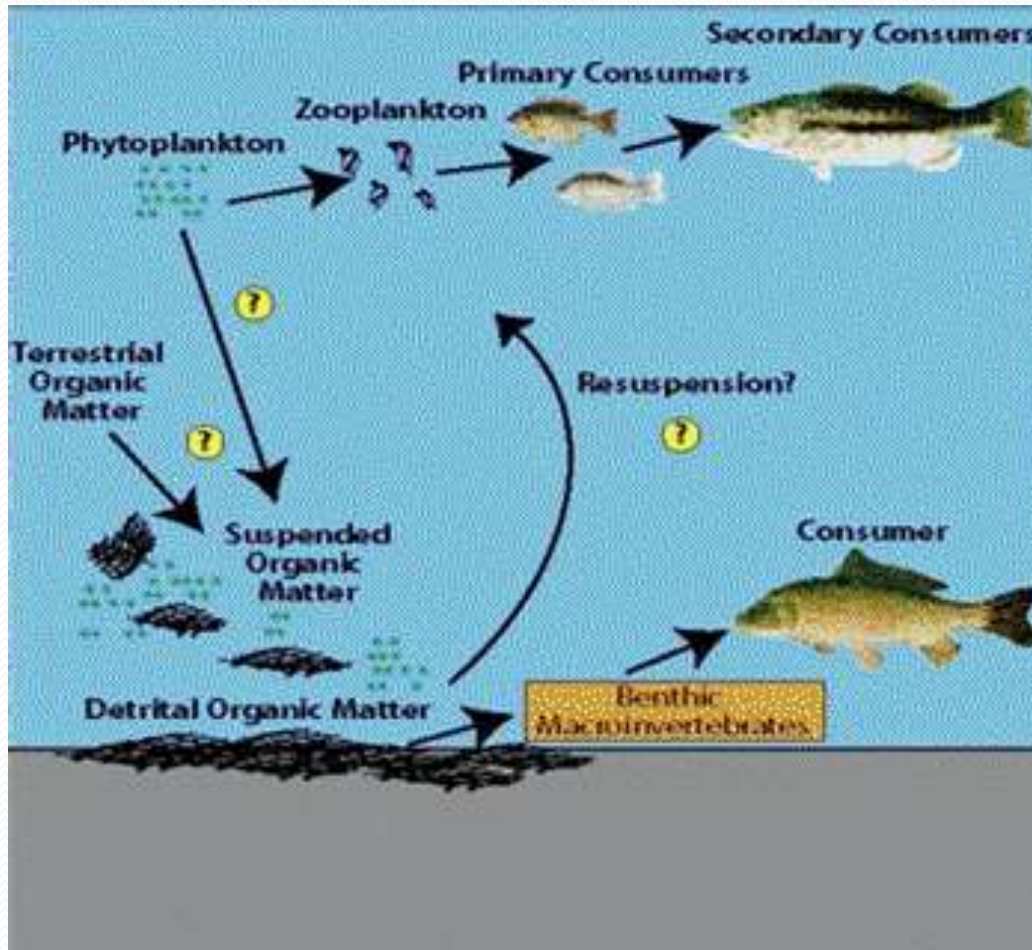
Whole-body fish tissue selenium from mining influenced streams in West Virginia

Summary – lotic fish toxicity

- Graph represents over 14,000 larval fish
- Tissue concentrations generally not sufficient to induce greater than 10% deformity
- Background deformity rates less than 1%
- Selenium toxicity generally not indicated by tissue concentrations and deformity rates in lotic environments



Lake food chain



<http://wwwrcamnl.wr.usgs.gov/isoig/projects/fingernails/images/bigFIG2-aquaticfoodweb.gif>

Summary – lentic fish toxicity

- Greater potential for toxicity in lentic environments
- Specific examples of elevated selenium in fish tissue
- Deformity rates in Mud River Reservoir not greater than 10%
 - (13% in WVDEP first year of study but less than that in subsequent years)

Macroinvertebrate toxicity

- Proposed dietary thresholds range from 3 to 11 ug/g dw
- Not generally believed to be an issue
- Endpoints – reduction in growth and fecundity
- One paper indicating reduction in mayfly size and fecundity – utilized selenite to load periphyton
- Work ongoing looking at periphyton and benthic macroinvertebrate selenium concentrations.



Benthic selenium concentrations - 2009

Acknowledgements

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