Species Sensitivity Distribution (SSD) Evaluation for Selenium in Fish Eggs: Considerations for Development of a Canadian Tissue-based Guideline

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Abstract

A freshwater Se guideline was developed for consideration based on concentrations in fish eggs or ovaries, with a focus on Canadian species, following the Canadian Council of Ministers of the Environment protocol for developing guideline values. When sufficient toxicity data are available, the protocol recommends deriving guidelines as the 5th percentile of the species sensitivity distribution (SSD). When toxicity data are limited, the protocol recommends a "lowest value approach," where the lowest toxicity threshold is divided by a safety factor (e.g., 10). Based on a comprehensive review of the current literature and an assessment of the data therein, there are sufficient egg and ovary Se data available for freshwater fish to develop an SSD. For most fish species Se EC10 values (10% effect concentrations) could be derived, while for some species only no-observed-effect concentrations and/or lowest-observed-effect concentrations could be identified (Table 1). Egg/ovary Se SSDs were developed based on different combinations of fish species for which appropriate Se toxicity data are available, including only species that occur in Canada (Figure 1) as well as all species, including data for two species that occur in the U.S., but not in Canada (Figure 2). The 5th percentile egg/ovary Se concentrations from the SSD were consistently 20 µg/g dry weight (dw) for the best fitting distributions. In contrast, the lowest value approach using a safety factor of 10 would result in a Se egg/ovary guideline of 2 µg/g dw, which is unrealistically conservative, as this falls within the range of egg/ovary Se concentrations in laboratory control fish and fish collected from reference sites. An egg or ovary Se guideline of 20 µg/g dw should be considered a conservative, broadly applicable guideline, as no species mean toxicity thresholds lower than this value have been identified to-date. When concentrations exceed this guideline, site-specific studies with local fish species, conducted using a risk-based approach, may result in higher egg or ovary Se toxicity thresholds.

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Figure 1. Species sensitivity distributions (SSDs) based on all egg or ovary Se toxicity thresholds for fish species that occur in Canada. See Table 1 for sources of toxicity thresholds.

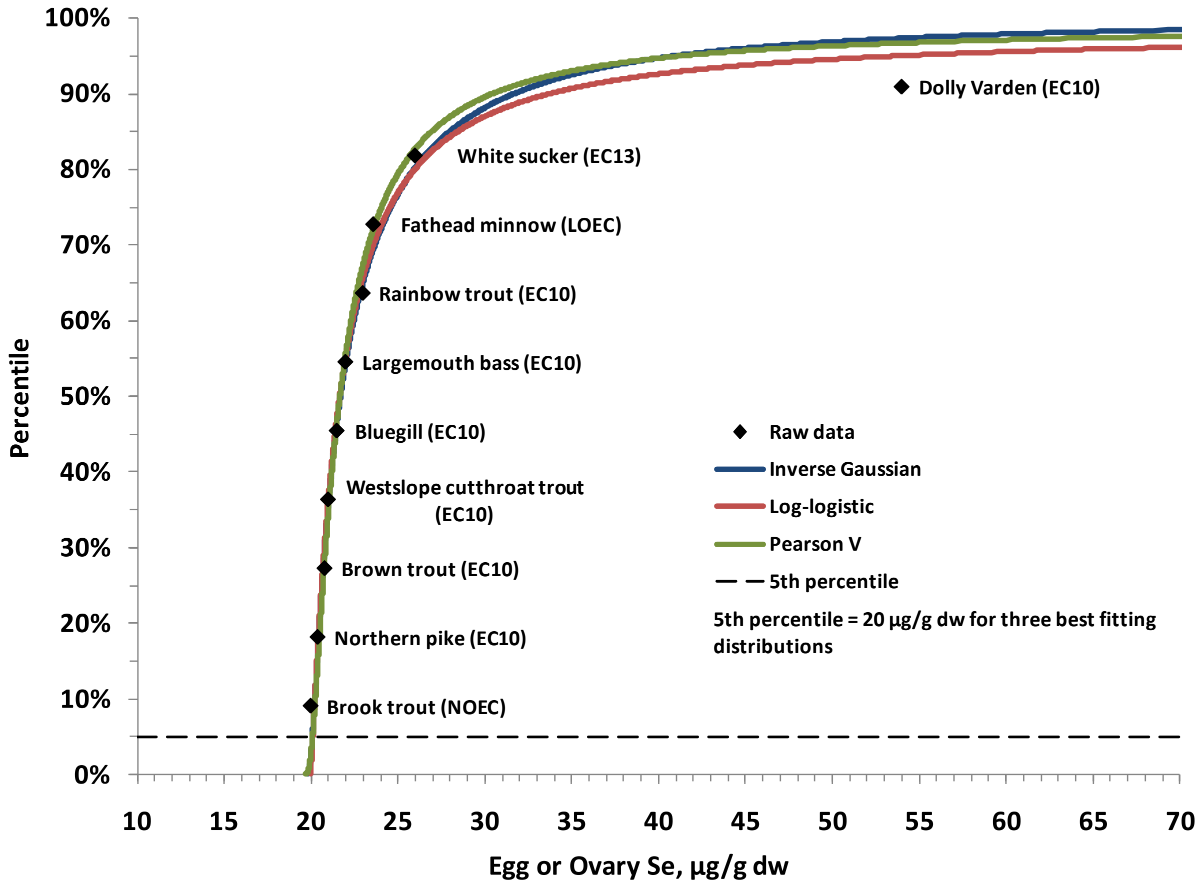

Figure 2. Species sensitivity distributions (SSDs) based on egg or ovary Se toxicity thresholds with Yellowstone cutthroat trout and razorback sucker included. See Table 1 for sources of toxicity thresholds.

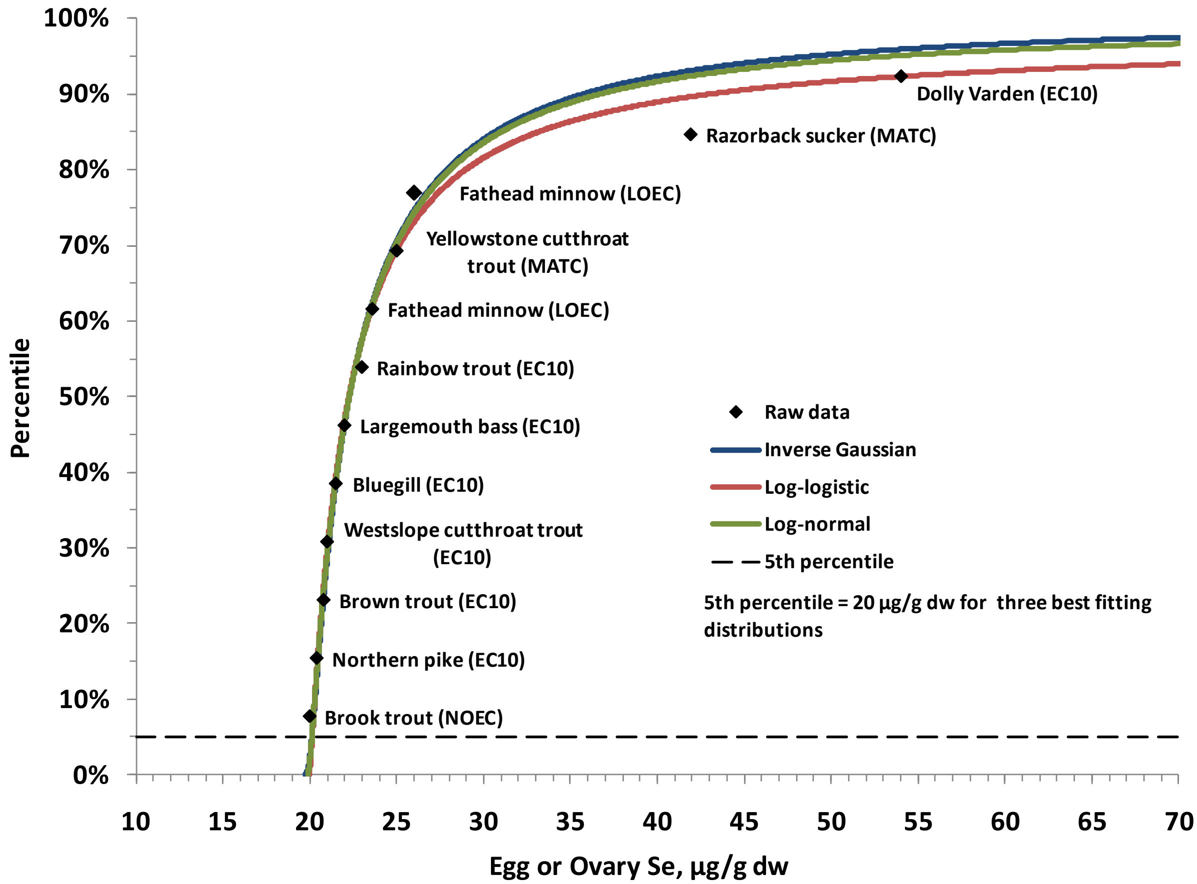

Table 1. Summary of studies evaluating selenium toxicity to embryos/larvae resulting from maternal transfer. Underlined values were used to derive the species mean Se thresholds in the far right column.

Species	Reference	Adult Exposure	Endpoint	Tissue	Endpoint Statistic[a]	Se (µg/g dw)	Species Mean Se Threshold (µg/g dw)
Bluegill	Bryson *et al.* 1984	Field	Larval mortality	Ovary	LOEC	<49	21.5
	Bryson *et al.* 1985a	Field	Hatchability/swim-up	Ovary	NOEC	>9.1	
		Field	Hatchability/swim-up	Ovary	LOEC	<30	
	Bryson *et al.* 1985b	Field	Hatchability/swim-up	Ovary	NOEC	>14.8	
		Field	Hatchability/swim-up	Ovary	NOEC	>9.2	
	Gillespie and Baumann 1986	Field	Larval edema	Ovary	LOEC	<38.6[c]	
	Doroshov *et al.* 1992	Lab	Larval edema	Egg	EC10	21[b]	
	Coyle *et al.* 1993	Lab	Larval mortality	Egg	EC10	22[b]	
	Hermanutz *et al.* 1996	Mesocosm	Larval edema	Ovary	EC10	30[b]	
Brook trout	Holm 2002; Holm *et al.* 2003, 2005	Field	Larval deformities	Egg	NOEC	20[d]	20
Brown trout	Formation Environmental 2011a	Field	Alevin mortality	Egg	EC10	20.8	20.8
			Larval deformities	Egg	EC10	22.0	
Westslope cutthroat trout	Kennedy *et al.* 2000	Field	Larval deformities/ mortality	Egg	NOEC	>21	21
	Rudolph *et al.* 2008	Field	Alevin mortality	Egg	EC10	17[b]	
	Nautilus Environmental 2011	Field	Alevin mortality	Egg	EC10	24.8	
Yellowstone cutthroat trout	Hardy *et al.* 2010	Lab	Larval deformities/ mortality	Egg	NOEC	>16.04	
	Formation Environmental 2011b	Field	Alevin mortality	Egg	MATC	25	25
Dolly Varden	McDonald *et al.* 2010	Field	Larval deformities	Egg	EC10	54	54
Fathead minnow	Ogle and Knight 1989	Lab	Reproduction	Ovary	NOEC	>10.92	<23.6
	Schultz and Hermanutz 1990	Mesocosm	Larval edema/lordosis	Ovary	LOEC	<23.6[c]	
Largemouth bass	CP&L 1997	Lab	Larval mortality	Ovary	EC10	22	22
Northern pike	Muscatello *et al.* 2006	Field	Larval deformities	Egg	EC10	20.4	20.4
Rainbow trout	Holm 2002; Holm *et al.* 2003, 2005	Field	Larval deformities	Egg	EC10	23[b,d]	23
Razorback sucker	Hamilton *et al.* 2005a,b	Field	Larval deformities	Egg	MATC	41.9	41.9
White sucker	de Rosemond *et al.* 2005	Field	Larval deformities	Egg	EC13	26	26

[a] The endpoint statistics were reported by the original study authors unless otherwise noted.
[b] EC10 values were calculated by the authors of this paper from the concentration-response data reported in the original studies. EC10 values were derived as follows: (1) Doroshov *et al.* (1992): probit model fit to concentration-response data for larval edema; (2) Coyle *et al.* (1993): probit model fit to concentration-response data for larval mortality at 5 days post-hatch; (3) Hermanutz *et al.* (1996): probit model fit to concentration-response data for larval edema; (4) Rudolph et al. (2008): linear model fit to concentration-response shown in Figure 1 in Rudolph et al. (2008); (5) Holm (2002); Holm *et al.* (2003, 2005): Derived from Figure 2a in Holm *et al.* (2005).
[c] Dry weight ovary Se concentrations were estimated assuming 85% moisture, based on data for bluegill ovaries (Gillespie and Baumann 1986).
[d] Dry weight ovary Se concentrations were estimated assuming 61% moisture, based on data for rainbow trout eggs (Holm *et al.* 2005).
EC10 = 10 percent effect concentration; EC13 = 13 percent effect concentration (see text); NOEC = no-observed-effect concentration; LOEC = lowest-observed-effect concentration; MATC = maximum-acceptable-toxicant concentration (geometric mean of NOEC and LOEC).

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