

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.

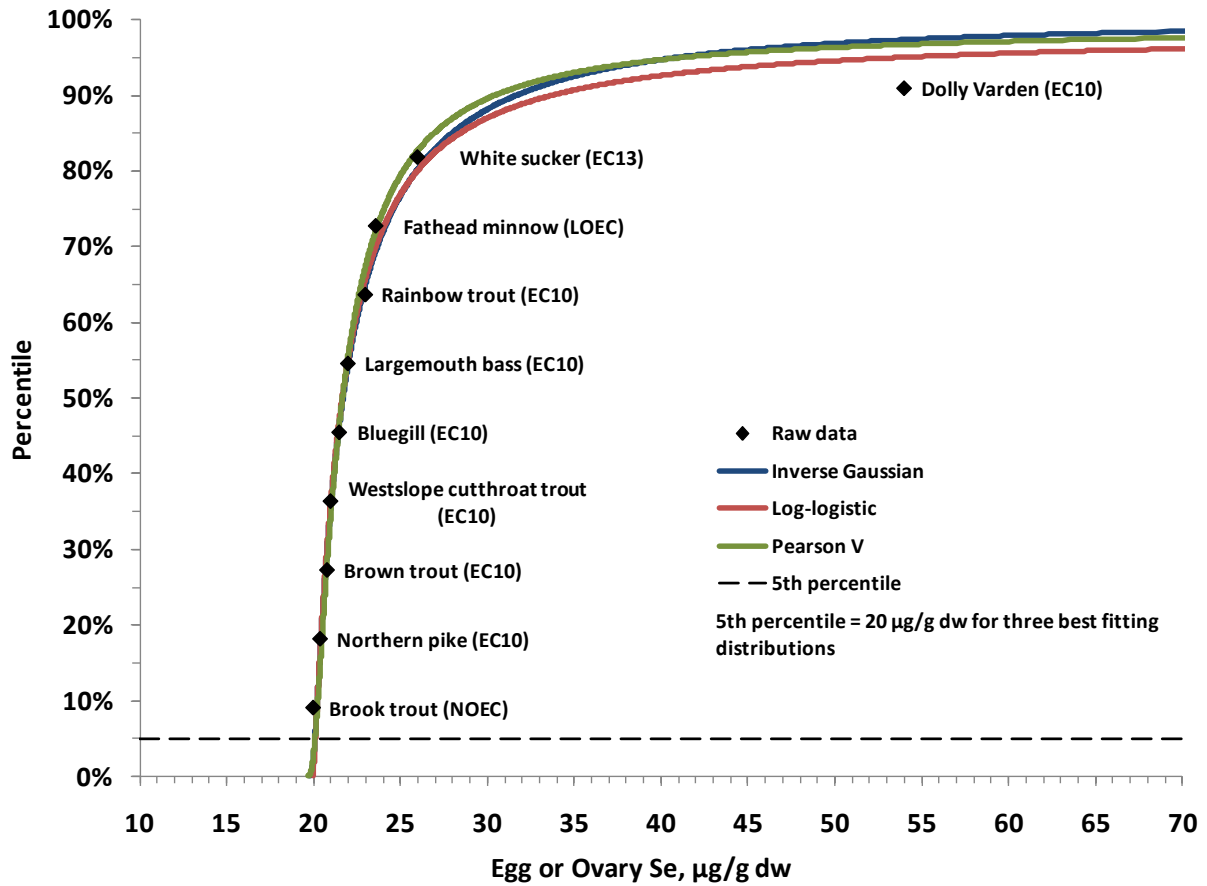
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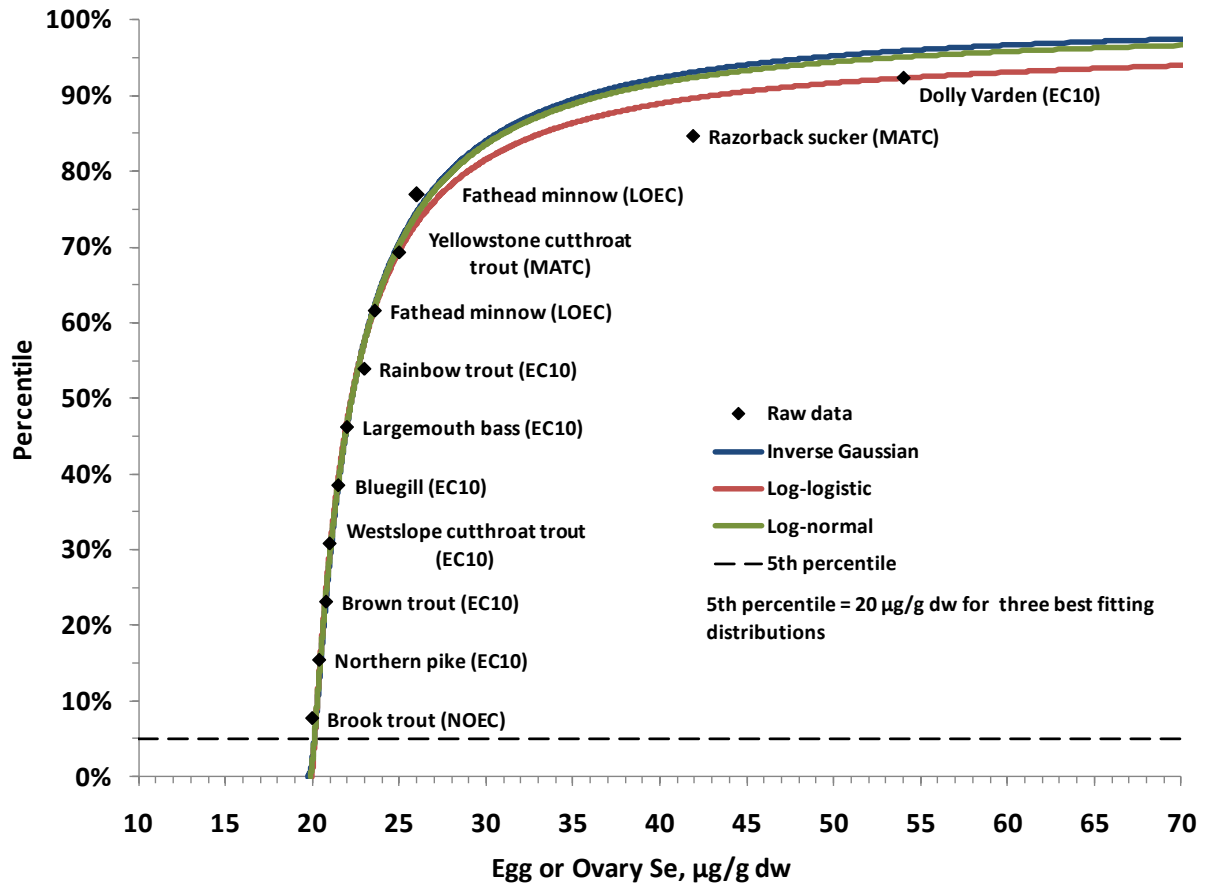
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Figure 1. Species sensitivity distributions (SSDs) based on all egg or ovary Se toxicity thresholds for fish species that occur in Canada. See Table 1 for sources of toxicity thresholds.



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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.



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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 <i>et al.</i> 1984 | Field | Larval mortality | Ovary | LOEC | <49 | 21.5 |
| | | Field | Hatchability/swim-up | Ovary | NOEC | >9.1 | |
| | Bryson <i>et al.</i> 1985a | Field | Hatchability/swim-up | Ovary | LOEC | <30 | |
| | | 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 <i>et al.</i> 1992 | Lab | Larval edema | Egg | EC10 | <u>21</u> ^b | |
| | Coyle <i>et al.</i> 1993 | Lab | Larval mortality | Egg | EC10 | <u>22</u> ^b | |
| Hermanutz <i>et al.</i> 1996 | Mesocosm | Larval edema | Ovary | EC10 | <u>30</u> ^b | | |
| Brook trout | Holm 2002; Holm <i>et al.</i> 2003, 2005 | Field | Larval deformities | Egg | NOEC | <u>20</u> ^d | 20 |
| Brown trout | Formation Environmental 2011a | Field | Alevin mortality | Egg | EC10 | <u>20.8</u> | 20.8 |
| | | | Larval deformities | Egg | EC10 | <u>22.0</u> | |
| Westslope cutthroat trout | Kennedy <i>et al.</i> 2000 | Field | Larval deformities/ mortality | Egg | NOEC | >21 | 21 |
| | Rudolph <i>et al.</i> 2008 | Field | Alevin mortality | Egg | EC10 | <u>17</u> ^b | |
| | Nautilus Environmental 2011 | Field | Alevin mortality | Egg | EC10 | <u>24.8</u> | |
| Yellowstone cutthroat trout | Hardy <i>et al.</i> 2010 | Lab | Larval deformities/ mortality | Egg | NOEC | >16.04 | 25 |
| | Formation Environmental 2011b | Field | Alevin mortality | Egg | MATC | <u>25</u> | |
| Dolly Varden | McDonald <i>et al.</i> 2010 | Field | Larval deformities | Egg | EC10 | <u>54</u> | 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 | <u><23.6</u> ^c | |
| Largemouth bass | CP&L 1997 | Lab | Larval mortality | Ovary | EC10 | <u>22</u> | 22 |
| Northern pike | Muscattello <i>et al.</i> 2006 | Field | Larval deformities | Egg | EC10 | <u>20.4</u> | 20.4 |
| Rainbow trout | Holm 2002; Holm <i>et al.</i> 2003, 2005 | Field | Larval deformities | Egg | EC10 | <u>23</u> ^{b,d} | 23 |
| Razorback sucker | Hamilton <i>et al.</i> 2005a,b | Field | Larval deformities | Egg | MATC | <u>41.9</u> | 41.9 |
| White sucker | de Rosemond <i>et al.</i> 2005 | Field | Larval deformities | Egg | EC13 | <u>26</u> | 26 |

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^aThe 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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