# Summary: Selenium and System Capacity



# Stressor**:** Selenium (µg/g egg wet weight)

# Response: System Capacity (%)

# Species: Athabasca Rainbow Trout

# (*Oncorhynchus mykiss*)

# Life Stage: egg

# System: Alberta foothills watersheds, excluding National Parks

# Function Derivation: experimental data

# Transferability of Function: This function was created for Athabasca Rainbow Trout but was based on laboratory experiments on hatchery Rainbow Trout. It should be used in other Rainbow Trout systems with caution.

# Model Validation: Model not validated on independent data.

# Detailed SR Function Description

## Derivation of the function:

## Selenium is a naturally occurring element, necessary in trace amounts for metabolic processes but toxic at high concentrations (Frost and Lish 1975; Wang and Gao 2001). A variety of natural and human causes can lead to increases in selenium in fish, including open-pit mining that exposes limestone, increases in sedimentation and run-off, and atmospheric deposition from coal-burning power plants (Barceloux 1999; Lemly 2004). In salmonid fish, observed individual-level effects of selenium toxicity include a decrease in egg incubation time, hatch rate, fry survival, juvenile survival, and juvenile growth (e.g. Hodson et al. 1980, Hamilton et al. 1986, Hamilton et al. 1990). High concentrations of selenium have been detected in east slopes streams in the range of Athabasca Rainbow Trout, apparently caused by open-pit coal mining (Palace et al. 2004). Extensive reviews of selenium in Alberta fishes and waters are found in Fortin (2010) and Pilgrim (2012).

## At a population level, decreased juvenile survival could result in decreased population size. However, to date most studies have focused on individual-level effects, but results have rarely been extrapolated to the population. The selenium stressor-response curves for Athabasca rainbow trout were derived based on the research of Pilgrim (2012). Units of selenium concentration that best described population-level effects on Rainbow Trout were egg Se (microgram/gram wet-weight) (Figure 1).

## Although the ecotoxicology of elevated selenium levels in warm and cold-water fish has been studied by numerous authors, the effects of selenium contamination remain somewhat controversial (Kennedy et al. 2000, Sappington 2002, Hardy et al. 2010). Therefore, as new population-level literature becomes available, the dose-response curve should be updated.

## Source of stressor data to apply the function:

# Athabasca Rainbow Trout and Westslope Cutthroat Trout values at this time are set to 0 but it is our expectation that monitoring from industry will have taken place and whole-body tissue concentrations would be available.

# A graph of eggs and eggs  Description automatically generatedStressor-Response Function

**Figure 1:** Stressor-response curve depicting the expected relationship between egg selenium (µg/g wet wt) and the system capacity of Athabasca Rainbow Trout populations.

Stressor-Response Table

**Table 1:** Stressor response relationship reflecting selenium egg concentration and the system capacity of Athabasca Rainbow Trout populations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Selenium (µg/g wet weight)** | **System Capacity (%)** | **SD** | **Lower Limit** | **Upper Limit** |
| 0 | 100 | 0 | 0 | 100 |
| 1.17 | 72.51855257 | 0 | 0 | 100 |
| 4.3 | 54.08974454 | 0 | 0 | 100 |
| 13 | 23.67942532 | 0 | 0 | 100 |
| 20 | 0 | 0 | 0 | 100 |
| 31 | 0 | 0 | 0 | 100 |

# SR Function Confidence and Sources of Uncertainty

This uncertainty rubric was populated based on a summary report, not by the authors of the function with the original data. These rankings should be reassessed if additional information is available.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Low Confidence** | **Moderate Confidence** | **High Confidence** |
| **Data Source for SR Function** |  | **X** |  |
| Rationale --> | The function was based on data from laboratory experiments on Rainbow Trout (Pilgrim 2012). These experiments were published as part of an MSc thesis and not peer-reviewed. They focused on individual fish performance and survival, which was extrapolated to system capacity for this function. |
| **Shape of SR Function** |  | **X** |  |
|  Rationale --> | While the effect of selenium on individual performance has been investigated, the impact on a population level is uncertain. The extrapolation from experimental data to population data was based on expert opinion.  |
| **Data Variance/****Consistency** | **X** |  |  |
|  Rationale --> | Variance around this function is largely unknown.  |
| **Applicability to System** |  | **X** |  |
|  Rationale --> | This function was based on experimental evidence on hatchery Rainbows, but not on Athabasca Rainbows populations in the watersheds of interest.  |
| **Potential Stressor Interactions**  |  |  | **X** |
|  Rationale --> | Interacting stressors are unlikely to influence this function because it was based on controlled laboratory studies.  |

# Recommended Citation

This document should be cited as:

Government of Alberta. 2024. Selenium stressor-response function for Athabasca Rainbow Trout and Westslope Cutthroat Trout. Environment and Protected Area Native Trout Cumulative Effects Model.

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

# References

Barceloux, D.G. 1999. Selenium. Clinical Toxicology 37: 145-172.

Fortin, B.L. 2010. Selenium dynamics in Canadian Rocky Mountain lakes. M.Sc. thesis, Department of Biological Sciences, University of Alberta. Edmonton, Alberta. 130 pp.

Frost, D.V., and P.M. Lish. 1975. Selenium in biology. Annual Review of Pharmacology 15: 259-284.

Hamilton, S.J., and R.H. Wiedmeyer. 1990. Concentrations of boron, molybdenum, and selenium in Chinook salmon. Transactions of the American Fisheries Society 119:500–510.

Hamilton, S.J., Palmisano, A.N., Wedemeyer, G.A., and W.T. Yasutake. 1986. Impacts of selenium on early life stages and smoltification of fall Chinook salmon. Transactions of North American Wildlife Natural Resources Conference 51:343-356.

Hardy, R.W., L.L. Oram, and G. Moller. 2010. Effects of dietary selenomethionine on cutthroat trout (*Oncorhynchus clarki bouvieri*) growth and reproductive performance over a life cycle. Archives of Environmental Contamination and Toxicology 58: 237-245.

Hodson, P.V., D.J. Spry, and B.R. Blunt. 1980. Effects on rainbow trout (*Salmo gairdneri*) of a chronic exposure to waterborne selenium. Canadian Journal Fisheries and Aquatic Science 37:233–240.

Kennedy, C.J., L.E. McDonald, R. Loveridge, and M.M. Strosher. 2000. The effect of bioaccumulated selenium on mortalities and deformities in the eggs, larvae, and fry of a wild population of cutthroat trout (*Oncorhynchus clarkii lewisi*). Archives of Environmental Contamination and Toxicology 39: 46-52.

Lemly A.D. 2004. Aquatic selenium pollution is a global environmental safety issue. Ecotoxicol Environ Saf. 59(1):44-56.

Palace, V.P., C. Baron, R.E. Evans, J. Holm, S. Kollar, K. Wautier, J. Werner, P. Siwik, G. Sterling, and C.F. Johnson. 2004. An assessment of the potential for selenium to impair reproduction in bull trout, *Salvelinus confluentus*, from an area of active coal mining. Environmental Biology of Fishes 70: 169-174.

Pilgrim, N.L. 2012. Multigenerational effects of selenium in rainbow trout, brook trout, and cutthroat trout. M.Sc. thesis, University of Lethbridge. Lethbridge, AB. 123 pp.

Sappington K.G. 2002. Development of aquatic life criteria for selenium: a regulatory perspective on critical issues and research needs. Aquatic Toxicology 57:101–113.

Wang, Z., and Y. Gao, 2001. Biogeochemical cycling of selenium in Chinese environments. Applied Geochemistry 16: 1345-1351.