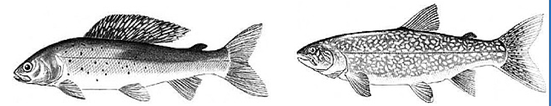
Effect of Total Dissolved Solids on Fertilization and Development of Two Salmonids



Baker JA[1], Elphick JR[1], McPherson CA[2], Chapman PM[2]

[1] Nautilus Environmental, Burnaby, BC [2] Golder Associates Ltd, Burnaby, BC

Abstract

Salmonids have been reported to be sensitive to effects associated with total dissolved solids (TDS) in some previous tests, with fertilization being reported to be a particularly sensitive life stage in some cases. There is general agreement that fish early life stages are the most sensitive life stages to TDS. The testing reported here evaluated the effect of TDS related to the Snap Lake Diamond Mine (NWT) on Lake Trout and Arctic Grayling in exposures encompassing the embryo-alevin-fry early life stages. Two exposures were conducted with each species, one that was initiated prior to fertilization, and the other subsequent to fertilization. For these species, fertilization was not adversely affected by TDS related to the Mine at concentrations >1,400 mg/L. For the specific TDS composition tested, these two fish species were less sensitive than water fleas and showed similar lack of effects at the highest tested concentrations as did a diatom, an alga, a rotifer, and a chironomid.

Introduction

Total Dissolved Solids (TDS) is primarily comprised of bicarbonate, chloride, sulfate, calcium, magnesium, sodium and potassium. The relative contribution of these ions to TDS varies substantially in different natural waters and industrial effluents and the difference in composition affects the risk of toxicity.

In most cases, early life stages of salmonids are more susceptible to adverse conditions than adults, and high TDS levels have been shown to cause effects to these life stages [1]. For example, fertilization success has been identified as the most sensitive life stage of some Pacific salmon species to elevated TDS [2]. However, other studies have indicated a low degree of sensitivity to TDS of other salmonids [3,4].

The study presented here evaluated the sensitivity to TDS of early life stages of two salmonid species that are important to Snap Lake (NWT): Lake Trout (*Salvelinus namaycush*) and Arctic Grayling (*Thymallus arcticus*). These fish were tested using a blend of major ions consistent with that observed in Snap Lake in order to assess potential effects on these species.

Methodology

- "Synthetic" lake water was prepared by dissolving reagent-grade salts (shown in Table 1) into very low ionic strength dechlorinated municipal (Metro Vancouver) tap water.
- The nominal TDS concentration of the synthetic lake water was approximately 1,500 mg/L, with individual ions present at ratios consistent with Snap Lake.
- Dilutions were prepared to achieve a nominal concentration series of 1,500, 1,000, 667, 444, and 296 mg TDS/L.

Table 1. Concentrations (mg/L) of salts used to prepare synthetic TDS mixtures.

Constituent added	*Concentration added (mg/L)*
NaCl	291.8
KCl	26.3
$MgCl_2.6H_2O$	35.2
$MgSO_4$	161.3
$CaCl_2.2H_2O$	1,106.1
$NaHCO_3$	185.3
Total (excluding hydration water)	1,516.2

- Toxicity tests were conducted according to procedures adapted from embryo-alevin-fry exposures for Rainbow Trout [5], summarized in Table 2.
- Two methodologies were used for fertilization for each species.
  - dry fertilization involved fertilization of the eggs prior to test initiation;
  - wet fertilization involved fertilization in the test solutions.

Table 2. Summary of test conditions: embryo-alevin-fry toxicity test.

Test organism source	Wild collected Lake Trout (Shuswap Lake) and Arctic Grayling (Sukunka River tributary)
Test organism age	Eggs and milt; initiated using both wet and dry fertilization
Test type	Static-renewal (three times per week, except daily during the 30-day feeding period)
Test duration	Fertilization to 30 days post-swim-up (165 and 69 days for Lake Trout and Arctic Grayling, respectively)
Test vessel	4-L plastic containers
Test volume	2 L
Test replicates	4 replicates for Lake Trout; 3 replicates for Arctic Grayling
No. of organisms	30 per replicate
Test temperature	7 ± 1°C
Feeding	*Artemia* daily for 30 days following swim-up
Photoperiod	24 hours dark until hatch; 16:8 hr light:dark thereafter
Aeration	Gentle aeration throughout test
Test endpoints	Survival, length, dry weight of fry
Test acceptability criterion for controls	≥65% normal surviving fry

Methodology

Dry Fertilization

Environment Canada [5]

Eggs were mixed with milt and left for 20 minutes

Eggs transferred to test solutions prior to water hardening

Wet Fertilization

adapted from Stekoll et al. [2] and Brix et al. [3]

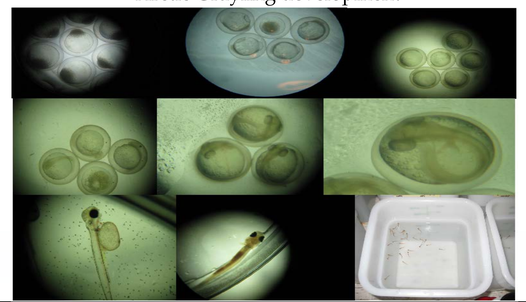
Eggs (30) and milt (20 µL) separated within container

Test solution (50 mL for Lake Trout, 20 mL for Arctic Grayling) added to containers, so that fertilization occurred in the test solutions.

Results

- Acceptable fertilization and development was achieved for both the Lake Trout and Arctic Grayling, with control survival in the tests greater than 75%.
- No adverse effect on survival of the Arctic Grayling was observed after the 69-d exposure, for either fertilization method.
- The most sensitive endpoint determined for the 140-d exposure with Lake Trout was an LC20 of 991 mg/L TDS determined from the dry fertilization test.

Arctic Grayling development



Results

- Growth of the Arctic Grayling and Lake Trout was not adversely affected by TDS; point estimates for length and dry weight exceeded the highest concentration tested.
- There were no effects on frequency of deformities.
- Wet fertilization was not more sensitive to TDS in comparison to dry fertilization, indicating that TDS did not adversely affect fertilization.

Table 4. Point estimates (mg/L measured TDS)

Species	Fertilization Type	Survival		Dry weight		Total length	
		LC20	*LC50*	*IC20*	*IC50*	*IC20*	*IC50*
Arctic Grayling	Dry	>1,419	>1,419	>1,419	>1,419	>1,419	>1,419
	Wet	>1,414	>1,414	>1,414	>1,414	>1,414	>1,414
Lake Trout	Dry	991 (NC)	>1,490	>1,490	>1,490	>1,490	>1,490
	Wet	>1,484	>1,484	>1,484	>1,484	>1,484	>1,484

NC: Confidence Limits Not Calculable

Discussion

There was no evidence of increased sensitivity associated with the fertilization endpoint, consistent with Brix et al. [3], who reported that fertilization of Arctic Grayling and Dolly Varden eggs was not adversely affected at TDS concentrations of 2,782 and 1,817 mg/L, respectively. Results reported here are not consistent with those reported by Stekoll et al. [2] for exposures using eggs of various anadromous salmon species, which indicated that TDS concentrations as low as 250 mg/L impaired fertilization in some species of Pacific salmon, and produced subsequent developmental effects on the developing fry.

For the TDS composition tested, these fish species were less sensitive than water fleas and showed similar lack of effects at the highest tested concentrations as did a diatom, an alga, a rotifer, and a chironomid.

References

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