

Sensitivity of White Sturgeon (*Acipenser transmontanus*) to Copper at Critical Life Stages

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Abstract & Introduction

White sturgeon (*Acipenser transmontanus*) in the Columbia River have been experiencing poor recruitment for over three decades. There are many possible causes for this phenomenon, including habitat alterations, genetic bottlenecks, predation by introduced species, and pollution (e.g. chemicals released by industrial and municipal sources). Limited data are available on the acute toxicity of metals such as Cu, Cd, Zn, and Pb to white sturgeon. Studies conducted in 2008 and 2009 indicate that white sturgeon may be sensitive to Cu at certain life stages (e.g., after transition to exogenous-feeding). The purpose of this study was to address potential uncertainties associated with the sensitivity of certain critical life-stages (i.e. 8 to 100 days post hatch) of white sturgeon to waterborne contaminants such as copper. Initial 96hr LC₅₀ static-renewal toxicity tests were conducted with white sturgeon and rainbow trout larvae at 8, 40, and 100 days post hatch, both in the laboratory and Columbia River water. Fish were exposed to increasing concentrations of dissolved metal. First laboratory results indicated lethal concentrations (LC₅₀) of 15µg/L, 8µg/L, and 44µg/L of Cu for white sturgeon at 8, 40, and 100 days post hatch, respectively. It could also be shown that rainbow trout were slightly less sensitive to Cu with lethal concentrations (LC₅₀) of 35µg/L and 18µg/L at 8 and 40 days post hatch, respectively. This data suggests that white sturgeon may be a sensitive species to this element during certain life-stages. This raised questions about the specific windows during which white sturgeon are particularly sensitive in comparison to other fish species, and thus, indicates the necessity to revisit some of the existing data on species sensitivities by identifying sensitive life-stages for other species. This hypothesis is currently being verified by inclusion of additional ages, 15 and 43 days post hatch. When toxicity of Cu was assessed in river water of comparable hardness, the LC₅₀ of white sturgeon increased to 27µg/L and 18µg/L at 8 and 40 days post hatch. This indicates that sole adjustment for hardness does not accurately predict metal toxicity in this species. To further assess metal toxicity to white sturgeon we will apply the Biotic Ligand Model (BLM).



Figure 1.0: Juvenile White Sturgeon

- White sturgeon are Canada's largest freshwater fish, can grow to over 6m, weigh 800kg, and live for 100 years.
- White sturgeon have cultural importance, historically supported recreational fisheries, and are a unique part of the Columbia river and BC's biodiversity.
- In 2006, Canada added the Upper Columbia River white sturgeon to the list protected under the Species at Risk Act (SARA).

Methods

Method: Acute 96 hour static-renewal toxicity test adapted for white sturgeon from the requirements listed in American Society for Testing and Materials (ASTM) guidelines for early life-stage (ELS) testing of fish (ASTM 2009: E1241-05 and ASTM 2007: E729-96). No feeding or aeration was applied.

Water temperature was maintained at 16°C and 50% of the test solution was replaced every 12 hours.

Species: White Sturgeon (*Acipenser transmontanus*) as the test species and Rainbow Trout (*Oncorhynchus mykiss*) as a sensitive model species.

Age: 8, 40, 100 days post hatch (white sturgeon) and 8, 40 days post hatch (rainbow trout). Only white sturgeon were used in the in situ study.

Chemical: Copper (as CuSO₄) at up to 7 increasing concentrations from 1µg/L to 320µg/L.

Source Water: Laboratory exposure water was a mixture of treated city water and reverse osmosis (RO) water to achieve the following water parameters: 60ppm as CaCO₃, DOC between 1.5 and 3 mg/L. Columbia River water (Hardness: 55ppm CaCO₃; DOC: 1.2 mg/L) was used in the in situ water experiment.

Water Analysis: Cu, NH₃, alkalinity, hardness, chlorine, major cations, NO₃+NO₂, sulfate and DOC were analyzed on each replicate at the beginning and completion of the study. Temperature, conductivity, pH, and dissolved oxygen were measured on each replicate every 24 hours.

Endpoint: Survival.

Statistical Test: Calculation of the Lethal Concentration at which 50% (LC₅₀) of the population did not survive using regression analysis (Probit, Logit). NOAEC and LOAEC were determined using an ANOVA followed by a post-hoc test. All data are a function of measured copper concentration.

In the future data will be evaluated using the Biotic Ligand Model (BLM) from www.hydroqual.com/wr_blm.html.



Figure 2.0: Experimental Setup consisted of randomly distributed 5 L polyethylene buckets.

Results

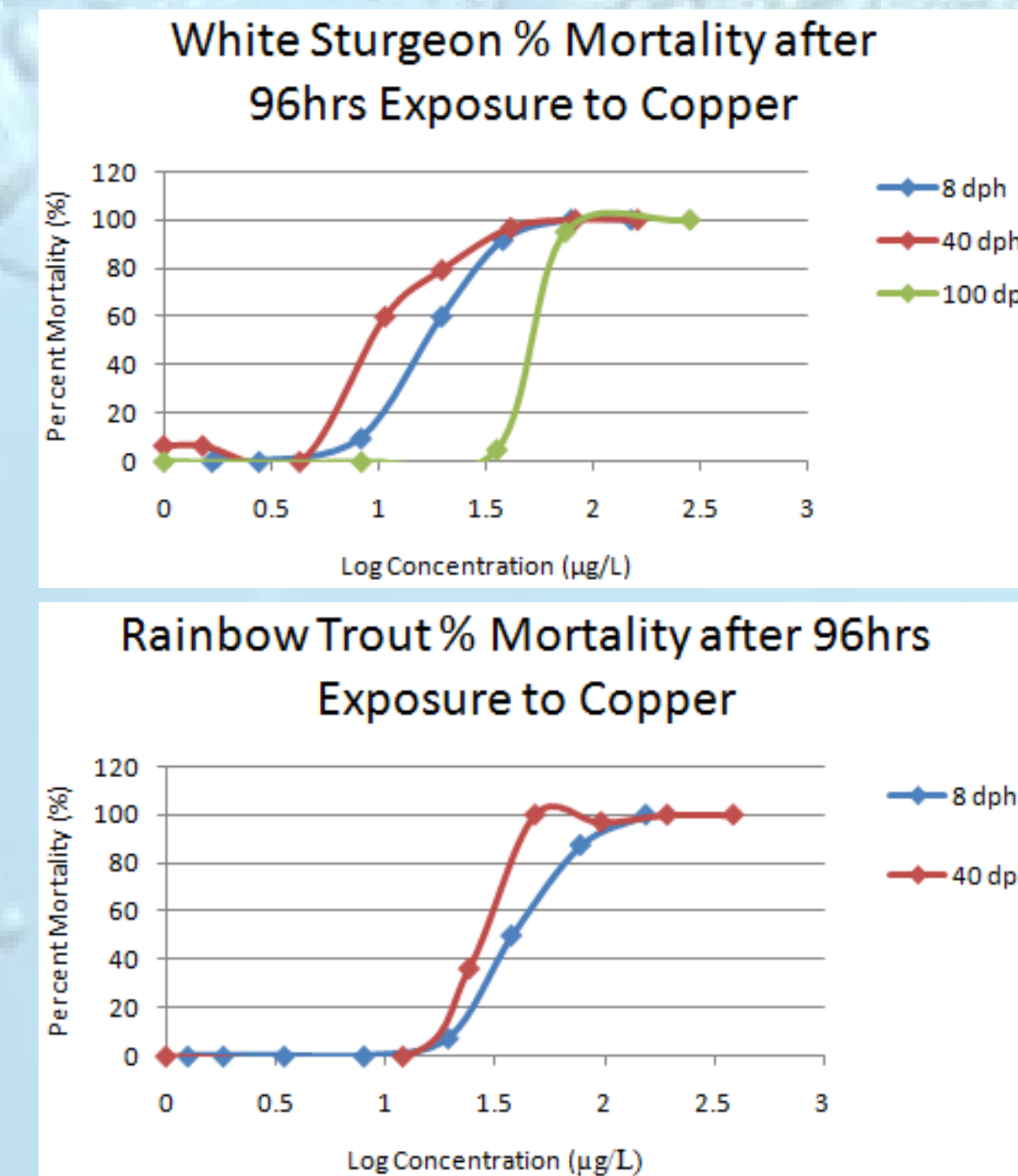


Figure 3.0: Mortality to copper after 96hrs for White Sturgeon and Rainbow Trout at Early Life-stages. dph = days post hatch.

- Under the test conditions evaluated, white sturgeon were ~2-times as sensitive to waterborne copper at both tested life-stages as compared to rainbow trout.
- The most sensitive life-stage of trout and white sturgeon to copper were found to be at 40 dph, shortly after swim up (Table 1, Figure 3):
 - During the yolk sac (8 dph) and juvenile (100 dph) stages white sturgeon found to be approximately twice and six times less sensitive than at 40dph.
 - Rainbow trout were found to be approximately two-times less sensitive when exposed at 8 dph.
- The life-stage of a fish could be a determining factor in its sensitivity to a waterborne contaminant such as copper.
- White sturgeon exposed to Cu in Columbia River source water were found to be two-times less sensitive than under the laboratory test conditions.

Table 1: White sturgeon and rainbow trout NOAEC (No Observed Adverse Effect Concentrations), LOAEC (Lowest Observed Adverse Effect Concentration), and LC₅₀ for copper at early life-stages adjusted to a hardness of 50ppm as CaCO₃. All values expressed in µg/L.

	White Sturgeon			Rainbow Trout		
	NOAEC	LOAEC	LC ₅₀	NOAEC	LOAEC	LC ₅₀
8 dph	2.3	7.1	14.8	7.0	16.9	34.8
40 dph	3.7	9.3	7.8	8.4	17.5	18.3
100 dph	7.2	30.9	44.3	-	-	-

Conclusions & Ongoing Research

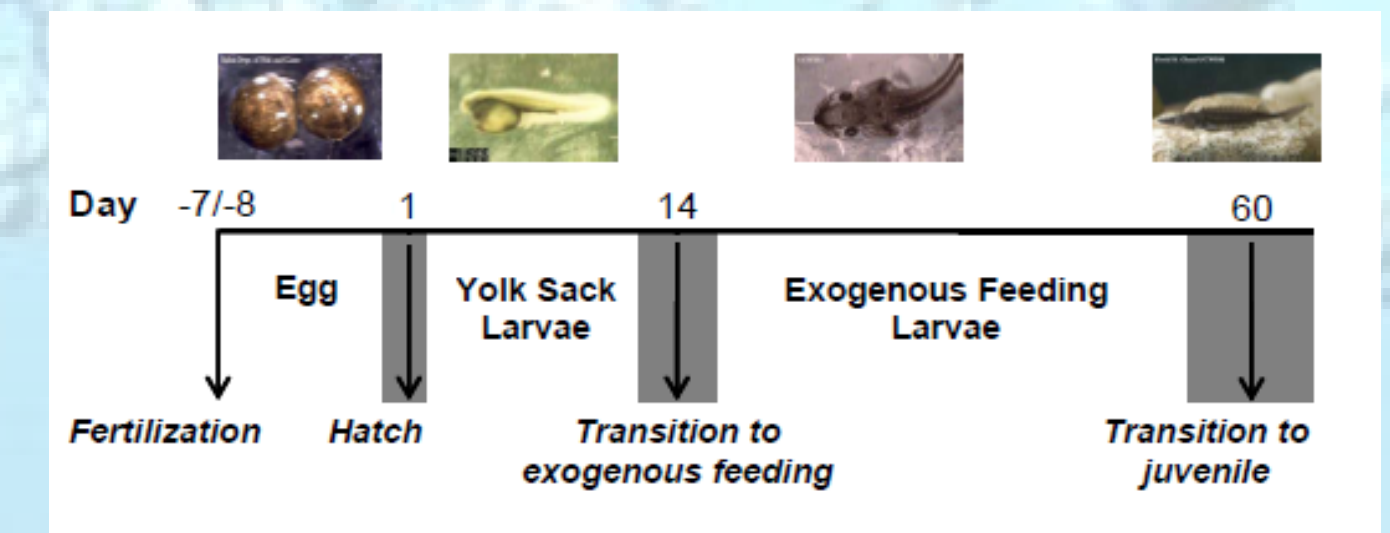


Figure 5.0: White Sturgeon Life-stages

- White sturgeon were more sensitive to waterborne copper during the exogenous feeding larval stage (14 to 60 dph) compared to the yolk sack (1 to 14 dph) and the juvenile (+60 dph) life-stages.
 - For certain chemicals such as copper, sensitivity may be significantly influenced by the age of the organisms tested.
 - It is hypothesized that similar life-stage dependent sensitivities exist for other fish species, warranting further investigation of this phenomenon to enable more objective assessment of the sensitivity of a species to waterborne contaminants such as copper.
- Sole adjustment of Cu toxicity for hardness did not explain observed differences in toxicities between river and laboratory water (Figure 6):
 - Metal toxicity to aquatic organisms is also dependent upon water parameters such as pH, cations (calcium, magnesium, sodium), alkalinity, and DOC, which may greatly vary LC₅₀ values.

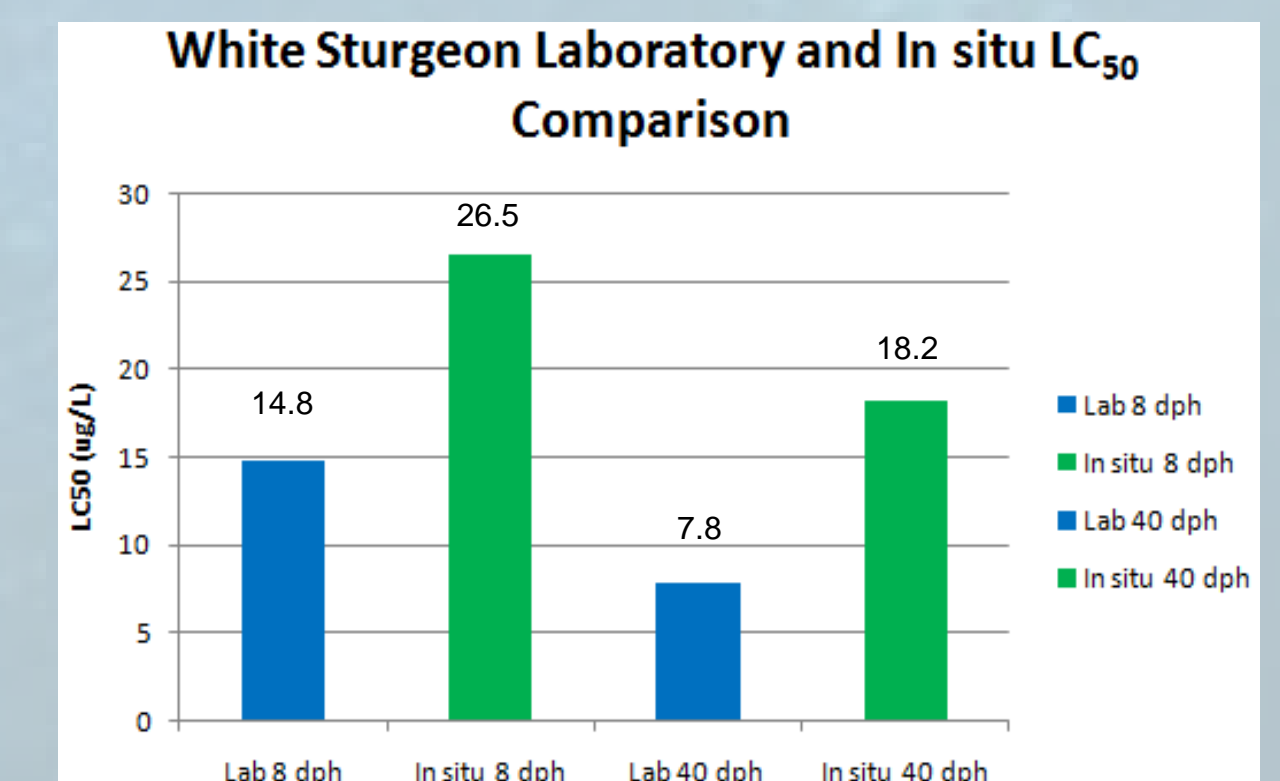


Figure 6.0: White sturgeon LC₅₀ comparison between laboratory and river water 96hr acute copper toxicity studies. All values adjusted to a hardness of 50ppm CaCO₃ and expressed as µg/L.

- Due to uncertainties associated with the sole adjustment of toxicities of metals such as copper based on hardness, further data evaluation will apply the Biotic Ligand Model (BLM) to account for variation in copper toxicity as a result of a wider range of water parameters (pH, cations, alkalinity, DOC).
- Analysis of the 2010 laboratory acute copper toxicity studies with white sturgeon and rainbow trout at 15 and 43 dph is ongoing.