

Development of toxicity reference values for white sturgeon (*Acipenser transmontanus*)



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Outline

- Background
- Acute (96h) toxicity tests
- Sub-chronic (60d) toxicity test
- Ongoing work

Sturgeon background

- The largest freshwater or anadromous fish in North America
- Benthic predator of small fish and invertebrates and an opportunistic scavenger
- Long-lived and slow to reach reproductive maturity



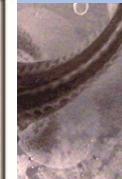
Background

- Poor rec (UCR)
- Indicati larval st
- Only lim in habit
- Juvenile survival



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Background

- Possible causes for poor recruitment:
 - Lack of suitable habitat
 - Flow regime
 - Water quality (e.g. temperature, turbidity, total dissolved gases, etc.)
 - Nutrition
 - Genetic bottlenecks or inbreeding depression
 - Predation by introduced species such as walleye
 - Interspecies competition
 - Pathogens/disease
 - Pollution
- May act either alone or in combination

Exposure of early life-stages of white sturgeon to copper, cadmium, and zinc

Objectives:

- Establish baseline laboratory toxicity data for the exposure of early life-stages of white sturgeon to Cu, Cd, and Zn
- Employ metal speciation models to predict thresholds for effects of these metals on early life-stages of white sturgeon under field conditions

Acute exposure of early life-stages

Methods:

- 96h static renewal lethality tests following ASTM guidelines for early life-stage (ELS) testing of fish (ASTM 2009: E1241-05 and ASTM 2007: E729-96)
- Nominal Concentration Ranges:
 - Cu 1 $\mu\text{g/L}$ — 400 $\mu\text{g/L}$
 - Cd 2 $\mu\text{g/L}$ — 500 $\mu\text{g/L}$
 - Zn 20 $\mu\text{g/L}$ — 5000 $\mu\text{g/L}$

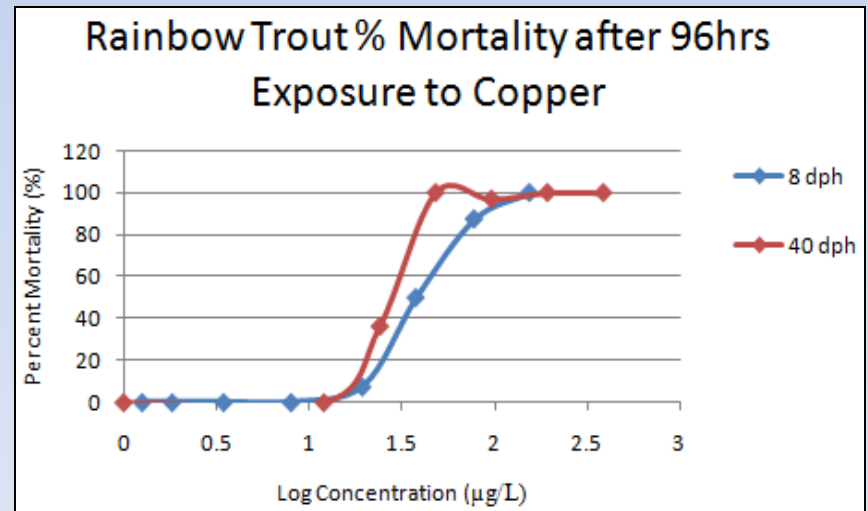
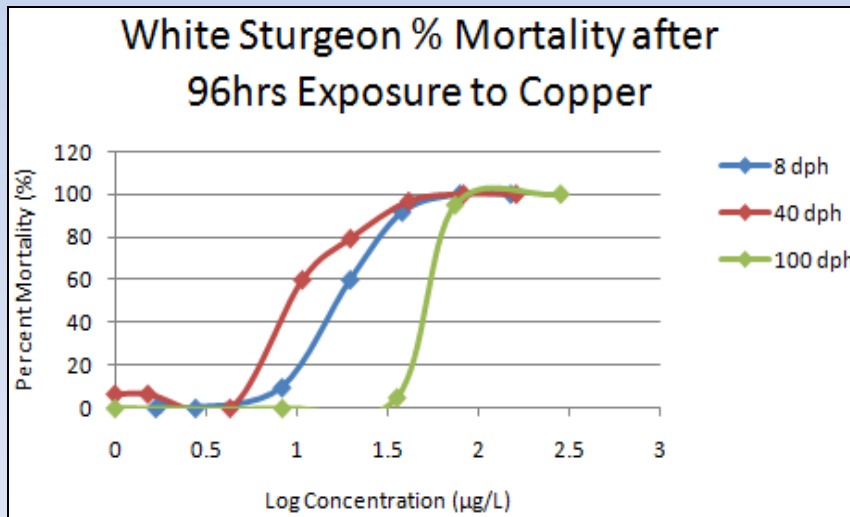
Lab and Field Exposures

- White sturgeon: 8 dph, 40 dph, 100 dph
- Rainbow trout: 8 dph, 40 dph

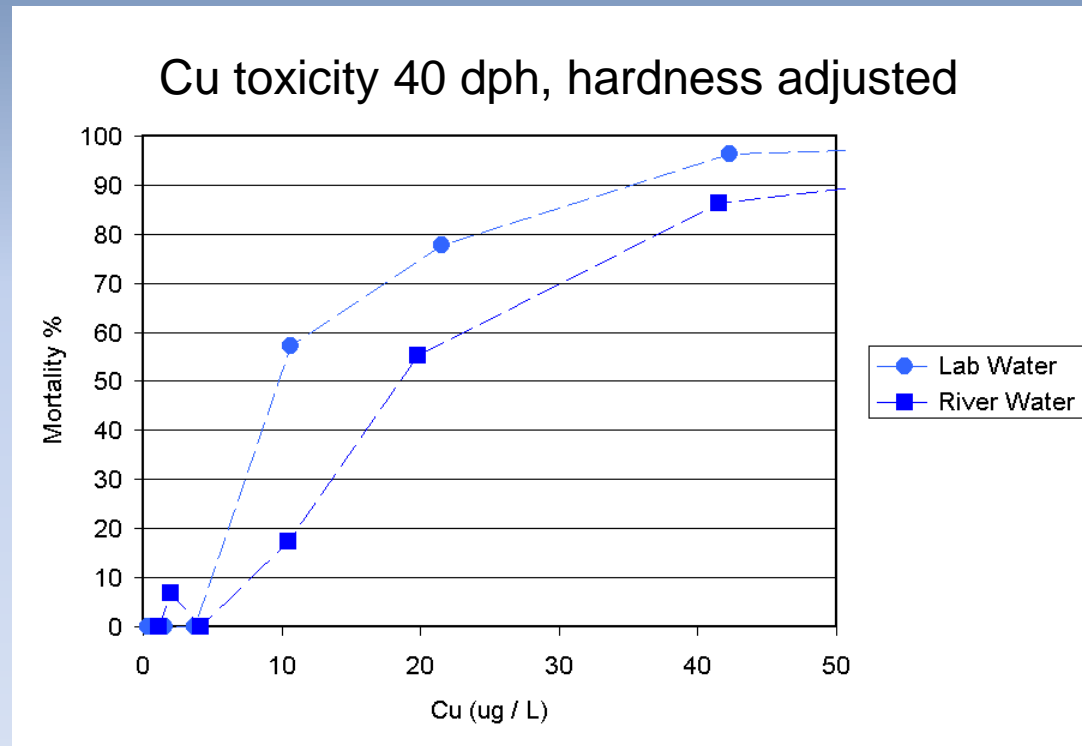


Results- copper lab 2009

- White sturgeon were more sensitive to waterborne copper at both early life-stages tested as compared to rainbow trout
- Early juvenile life-stage (40 days post hatch [dph]) was more sensitive to Cu compared to the yolk-sac life-stage (8 dph)



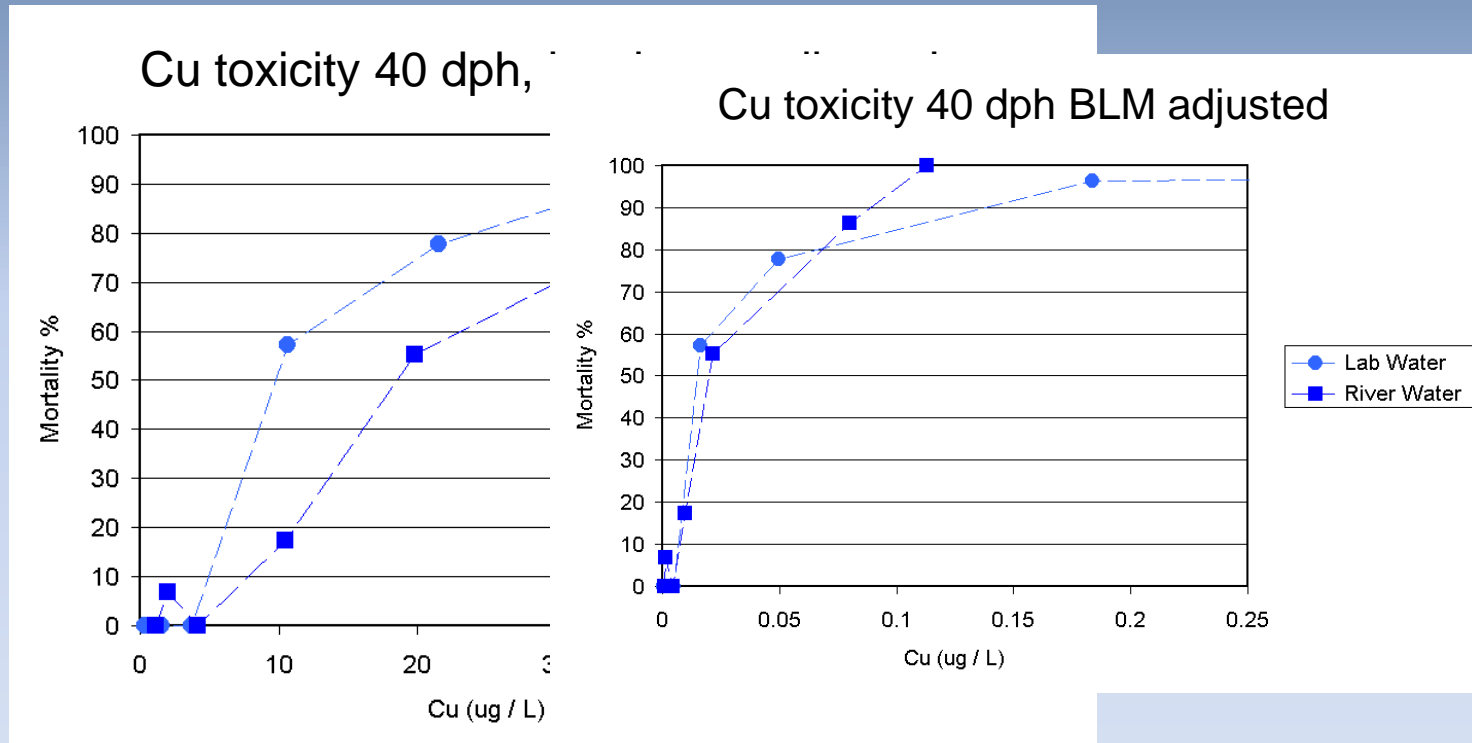
Copper comparison lab to field



Results: Acute exposure

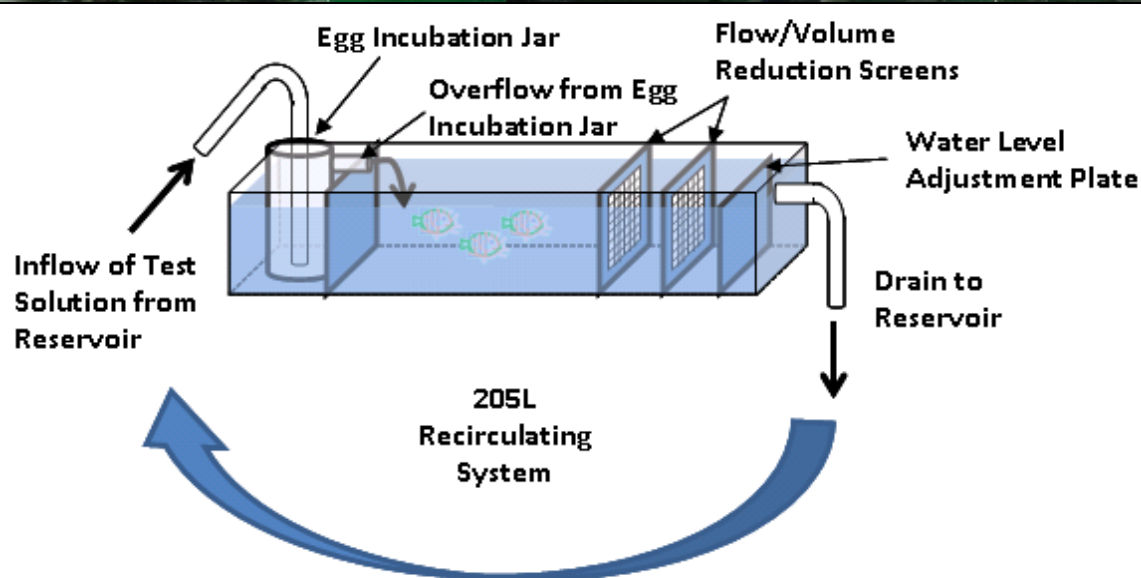
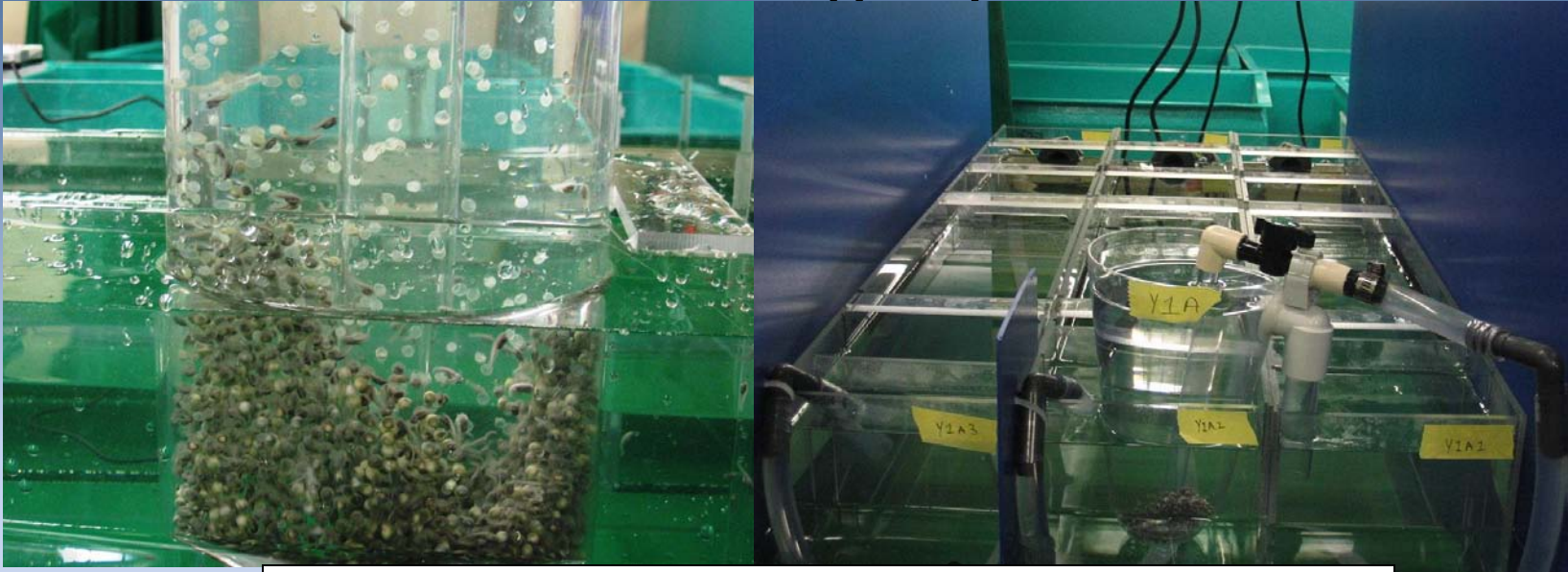
		96-h LC50 (µg/L)					
Year		Copper		Cadmium		Zinc	
White sturgeon	Life-stage	Lab	In situ	Lab	In situ	Lab	In situ
2008	8 dph	30	22	9	39	104	472
2009	8 dph	15	27				
2009	40 dph	8	18				
2009	100 dph	44					
Rainbow trout							
2009	8 dph	35					
2009	40 dph	18					

BLM adjusted copper toxicity



Adjustment based upon the BLM developed by Hydroqual

Sub-chronic exposure studies conducted using a flow-through system

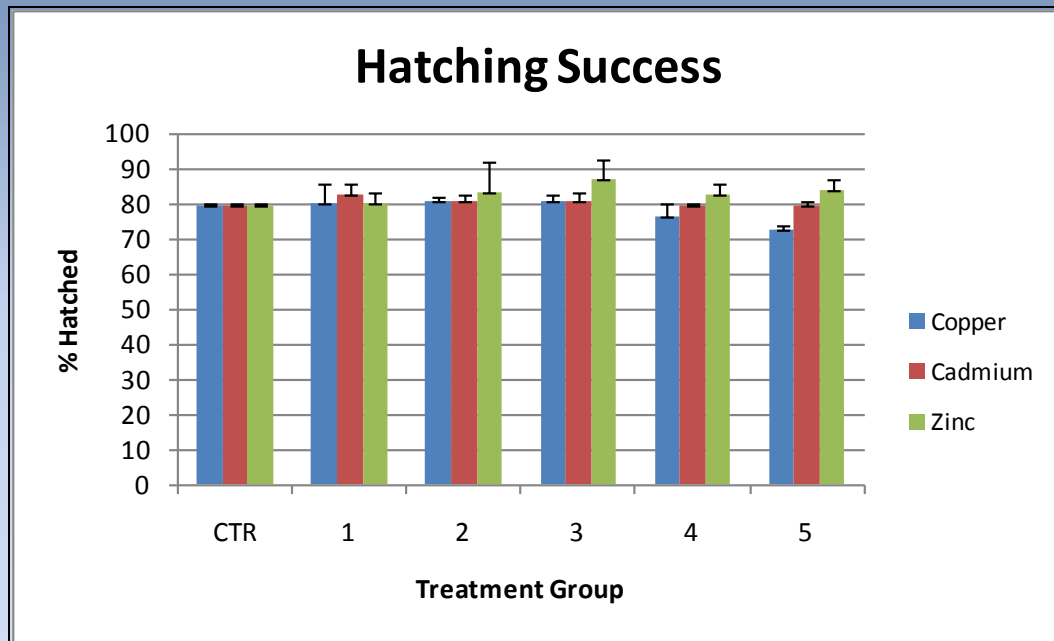


Methods

- 5 different exposure concentrations per metal based upon environmentally relevant concentrations found in the Columbia River and concentrations anticipated to produce toxic effects
 - Cu 0.2 $\mu\text{g/L}$ (ppb)—260 $\mu\text{g/L}$
 - Cd 0.02 $\mu\text{g/L}$ (ppb)—82 $\mu\text{g/L}$
 - Zn 1 $\mu\text{g/L}$ (ppb)—1300 $\mu\text{g/L}$
 - 6 fold increase
- Endpoints include hatchability, mortality, and body condition

Results: Hatching Success

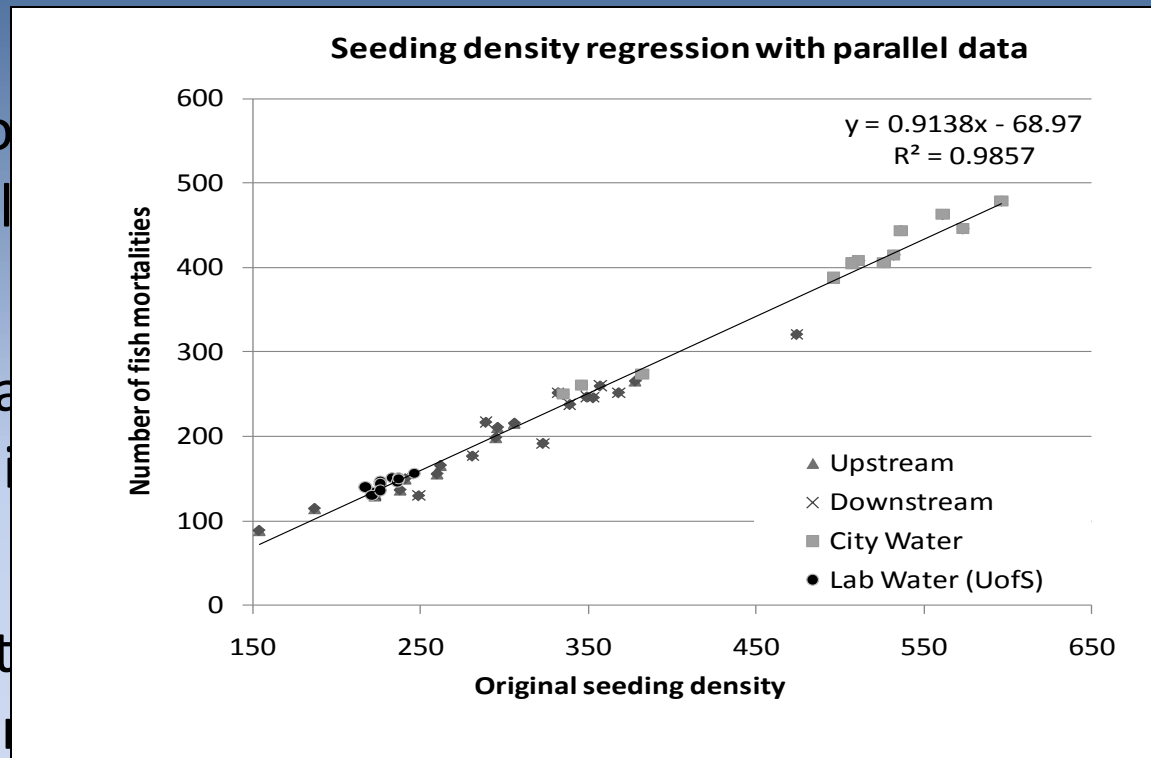
- Hatching success was greater than 79% for all treatments except for the second greatest and greatest Cu concentrations (108 and 217 $\mu\text{g/L}$)



- No significant differences ($p > 0.05$) in hatching success among treatment groups or between any of the treatments and the controls

Results: Mortality

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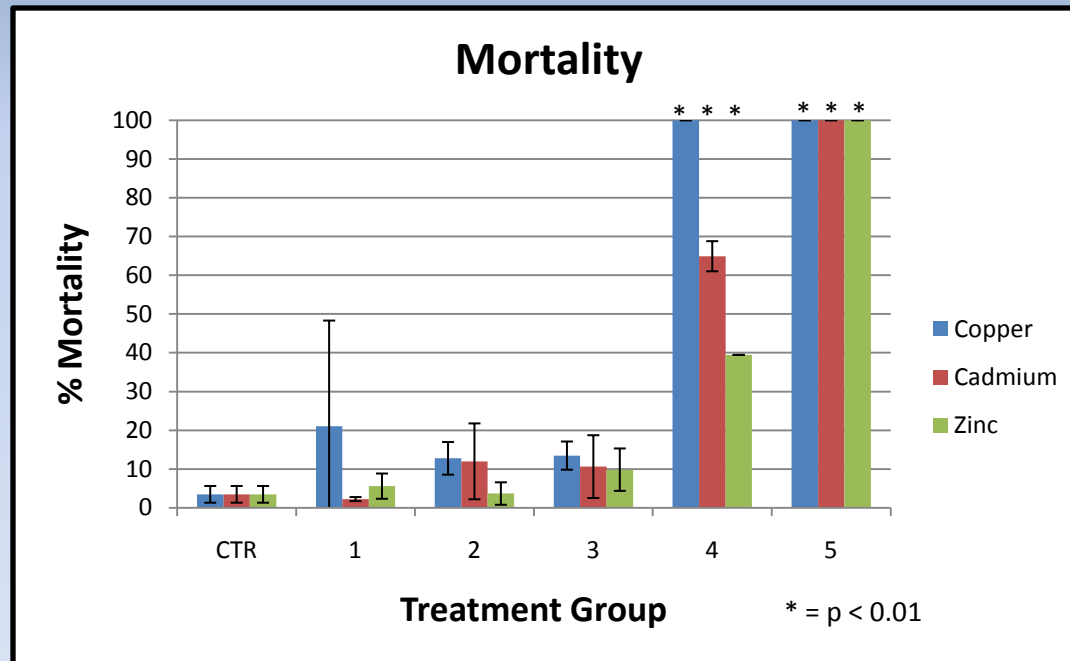
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Seeding density regression with parallel data. Simple linear regression comparing original seeding density in number of fish to the number of fish surviving at exposure termination in experimental chambers. For this regression, data from a parallel study conducted at the U of S with the same fish was added. (Tompsett et al. personal communication)

Results: Sub-chronic exposure

- Significant mortalities ($p < 0.01$) relative to the controls were seen in the two greatest doses tested for each metal exposure



Sub-chronic Lethal Concentrations

Metal	LC20	LC50
	Measured Conc. ($\mu\text{g/L}$)	Measured Conc. ($\mu\text{g/L}$)
Cu	7.2	13.1
Cd	1.6	5.0
Zn	120	285

Sub-chronic species comparison

	Species			
	White sturgeon (<i>Acipenser transmontanus</i>)	Rainbow trout (<i>Onchorhynchus mykiss</i>)	Rainbow trout (<i>Onchorhynchus mykiss</i>)	Mottled sculpins (<i>Cottus bairdi</i>)
Life-stage test initiated	Larvae	Larvae	Swim-up fry	Swim-up fry
Test duration	60 days	58 days	28 days	28 days
Water hardness (CaCO ₃)	70 mg/L	170 mg/L	103 mg/L	103 mg/L
Cu chronic Value	7.2µg/L	16µg/L	40µg/L	13µg/L
Cd chronic Value	1.6µg/L		1.9µg/L	1.3µg/L
Zn chronic Value	120µg/L		219µg/L	128µg/L
Reference	Vardy et al. Submitted.	Besser et al. 2005	Besser et al. 2007	Besser et al. 2007

Note: Values are not normalized for differences in water quality

Water quality guidelines

- Based on the LC values, the United States national recommended water quality criteria for aquatic life (CCC) and the Canadian water quality guidelines (CWQG) for the protection of aquatic life for Cu, Cd, and Zn are protective of white sturgeon early life-stages where applicable (CCME, 2003; EPA 1987, 2001, 2007,2009)

Metal	LC20	LC50	CCC ^a	CWQG ^b
	Measured Conc. (µg/L)	Measured Conc. (µg/L)	(µg/L)	(µg/L)
Cu	7.2	13.1	^c	2.8
Cd	1.6	5.0	0.19	0.017
Zn	120	285	87	30

^a CCC refers to the Criteria Continuous Concentration for fresh water species adjusted to the average hardness of 70 mg CaCO₃/L observed during the experiments (EPA, 2009)

^b CWQG refers to the Canadian Water Quality Guidelines for the protection of aquatic life adjusted to the average hardness of 70 mg CaCO₃/L observed during the experiments (CCME, 2003)

^c Site specific guidelines - Freshwater criteria calculated using the Biotic Ligand Model (BLM)

Conclusions

- These studies suggest that certain early life-stages of white sturgeon are relatively sensitive to Cu, Cd, and Zn
- The present study helps to characterize white sturgeon sensitivity to metals
- Based on these initial results, it would appear that both US and Canadian water quality guidelines are protective of early life-stages of white sturgeon; further assessment including BLM evaluations will be performed

Ongoing work

- Although the presented data is adjusted for hardness, work is ongoing to apply the Biotic Ligand Model (BLM) to account for variation in toxicity as a result of a wider range of water parameters (pH, cations, alkalinity, DOC)
- Additional research is focusing on the effects of contaminated sediment on early life-stages of white sturgeon

Acknowledgements

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Thank you!

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