1.0 Introduction

In the north-western USA and British Columbia, Canada, populations of white sturgeon (WS; Acipenser transmontanus) are declining, primarily due to poor annual recruitment. Pollution has hypothetically been one of the primary causes for poor recruitment in the Columbia, Fraser, and Sacramento-San Joaquin rivers and their tributaries. Specifically, there are concerns about the potential toxicity of WS early life stages (ELS’s), a period of development when fish are often sensitive to the exposure of contaminants. ELS WS inhabit benthic habitats and live on the sediment surface or in the interstitial space between stones. Therefore, in addition to exposure to contaminants in the water column, sturgeon are exposed to sediments associated with contaminated sediments. Little is known about the potential toxicology of WS ELS to benthic organisms, such as fish and invertebrates, and less so to organic pollutants. In particular, there is a need for a more comprehensive understanding of contaminants in the sediment that could be influencing WS early life stages and survival. In the north-western USA and British Columbia, Canada, populations of white sturgeon (WS; Acipenser transmontanus) are declining, primarily due to poor annual recruitment. Pollution has hypothetically been one of the primary causes for poor recruitment in the Columbia, Fraser, and Sacramento-San Joaquin rivers and their tributaries. Specifically, there are concerns about the potential toxicity of WS early life stages (ELS’s), a period of development when fish are often sensitive to the exposure of contaminants. ELS WS inhabit benthic habitats and live on the sediment surface or in the interstitial space between stones. Therefore, in addition to exposure to contaminants in the water column, sturgeon are exposed to sediments associated with contaminated sediments. Little is known about the potential toxicology of WS ELS to benthic organisms, such as fish and invertebrates, and less so to organic pollutants. In particular, there is a need for a more comprehensive understanding of contaminants in the sediment that could be influencing WS early life stages and survival.

2.0 Materials and Methods

Fertilized WS eggs were obtained from the Kootenay Trout Hatchery, Fort Steele, BC. All culturing and exposure experiments presented here were conducted in the Aquatic Toxicology Research Facility (ATRF), University of Saskatchewan, Saskatoon, SK.

2.1 Aquatic Metal Exposures

1. Acute (96 h) static renewal toxicity tests were conducted with 8 day post hatch (dph) WS for Cd, Cu, and Pb exposures. In addition, two standard test species, rainbow trout (Oncorhynchus mykiss) and fathead minnow (Pimephales promelas), were exposed in parallel to Cu and Pb at 4 and 10 μg/L to determine relative sensitivity among species and life stages. WS were also exposed to Cu at 15, 45, and 100 μg/L.

2. Chronic toxicities of Cd, Cu, and Zn to ELS WS were investigated from 0 – 60 dph, under flow-through conditions (Fig 1).

2.2 Sediment Exposures

1. In total, 23 experiments were conducted using seven locations along the Columbia River: two reference and five exposure locations between the transect-bound reach of Canada and the USA, representing a sediment exposure gradient for environmental pollutants (Map 1). A water only and an artificial sediment group were included as controls.

2. Newly hatched larvae were exposed to sediments and controls for 60d in flow-through experimental chambers (Fig 2).

3. Three potential points of exposure were sampled weekly for contaminant concentration assessment (Fig 3): overlying water (OW), sediment-water interface (SWI), and porewater (PW). By use of syringe, injection devices, and peepers and diffusive gradient thin films (DGTs).

4. Biological endpoints included mortality, growth and body condition.

2.3 Sediment Exposures [5]

Results for the Columbia River sediment toxicity study presented here are preliminary and represent the opinion of the authors. Data from this study will be submitted for consideration as part of a baseline ecological risk assessment being conducted at the upper Columbia River in eastern Washington State.

3.0 Results and Discussion

Overall, early life stage white sturgeon appear to be relatively sensitive to selected environmental pollutants. Concerning metal exposures, copper is of particular interest in some of the larger North American rivers, such as the Columbia, due to past and present activities of mines, metallurgical facilities, pulp and paper mills, as well as other industrial and municipal sources. Therefore, results of metal exposures presented herein focus on this metal.

3.1 Aquatic Metal Exposures [1], [2], [3]

A chronic lethal concentrations of Cd (1.5 μg/L), Cu (5.5 μg/L), and Zn (112 μg/L) at 20% mortality occurred (LC20s) for WS were comparable to sensitive salmonid species [1].

Acute LC50s: Cd (9 μg/L), Zn (104 μg/L), Pb (407), and Cu (Table 1).

Construction of species sensitivity distributions (SSDs) based on the acute data from this study and US EPA’s ECOTOX database ranked WS yolk-sac and early juvenile life stages in the upper 15th centile for all metals tested [2, 3].

For Cu exposures, WS were more sensitive than rainbow trout and fathead minnow at all comparable life stages tested (Table 1), and when plotted in a SSD with other fishes, the mean acute toxicity value for ELS WS was ranked between the 1st and 2nd centile (Fig 4).

ELS WS are relatively sensitive to Cd, Zn, and Pb, but LC values for chronic and acute exposures were greater than the water quality criteria and guidelines in both the United States and Canada. For Cu exposures, water quality guidelines in Canada remain protective but threshold values approach criteria in the US. Therefore, water quality guidelines and criteria for Cu may need to be evaluated on a site-by-site basis when WS early life stages are present in order to protect the aquatic environment.

Conclusions

These studies provide a portion of much needed data for white sturgeon and identified significant sensitivities among early life stages.

The aquatic metal exposure studies outline the relative sensitivity of ELS WS to Cu, Cd, Zn, and Pb compared to other fishes.

Concentrations of metals in sediment exposure matrices in the sediment exposure study were less than the most sensitive LC values determined in the aquatic metal exposure studies for Cd, Zn, and Pb, and LC values in PW for Cu were significantly higher than LC sediment exposures. This is consistent with the BLM toxic units comparison for Copper (Fig 7).

3.2 Sediment Toxicity Study

3.3 Sediment Exposures

Concentrations of metals fluctuated throughout the experiment within the matrices of the various sediments. There was a trend towards greater concentrations of metals in PW versus SWI and OW.

Greatest Cu concentrations were measured in systems containing Deadman’s Eddy (DE), Northport (NP), Little Dallas (LD), and Lower Marcus Flats (LRF) sediments (Fig 6) while no such trends were observed for the other metals.

Sensitivity of White Sturgeon (Acipenser transmontanus) to Selected Environmental Pollutants

David W. Vardy¹, John A. Doering¹, Shawn C. Beitel¹, Brett T. Tendler¹, Adam Ryan¹, Robert Santore¹, John P. Giesy¹,¹,¹,¹,¹ Markus Hecker¹,¹

1 Toxicology Centre, University of Saskatchewan, SK, Canada.
2 HDR | HydroQual, East Syracuse, NY, USA.
3 Dept. Veterinary Biological Sciences, University of Saskatchewan, Saskatoon, SK, Canada.
4 City University of Hong Kong, Hong Kong, China.
5 Cardno ENTROX Inc., Saskatoon, SK, Canada.

References and Publications

[2] Doering, J.A., Wiseman, S., Beitel, S.C., Tendler, B.J., Giesy, J.P., Hecker, M. 2012. Tissue specificity of aryl hydrocarbon receptor (AhR) mediated toxic effects in white sturgeon [1] were used to make predictions for 4 metals (Cu, Cd, Zn, and Pb) and based on water quality criteria is presented and calculated from the various life stage experiments for each specie using species sensitivity distributions (SSDs).

[3] Vardy, D.W., Doering, J.A., Beitel, S.C., Tendler, B.J., Giesy, J.P., Hecker, M. 2012. Tissue specificity of aryl hydrocarbon receptor (AhR) mediated toxic effects in white sturgeon [1] were used to make predictions for 4 metals (Cu, Cd, Zn, and Pb) and based on water quality criteria is presented and calculated from the various life stage experiments for each specie using species sensitivity distributions (SSDs).

[4] Vardy, D.W, Doering, J.A., Beitel, S.C., Tendler, B.J., Giesy, J.P., Hecker, M. 2012. Tissue specificity of aryl hydrocarbon receptor (AhR) mediated toxic effects in white sturgeon [1] were used to make predictions for 4 metals (Cu, Cd, Zn, and Pb) and based on water quality criteria is presented and calculated from the various life stage experiments for each specie using species sensitivity distributions (SSDs).


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