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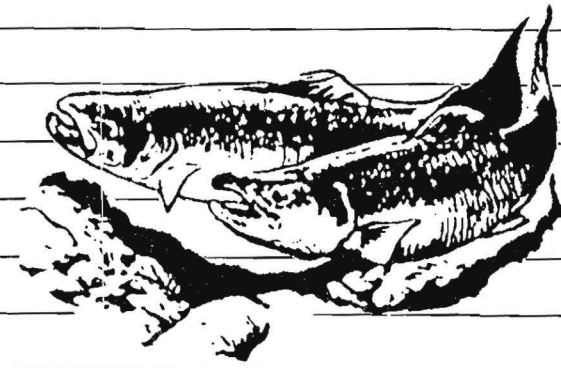

Endangered Fish in the Green River of Utah are Adversely Affected by Inorganic Contaminants in Irrigation Water

Concentrations of boron, selenium, and zinc in Ashley Creek, a tributary of the Green River in Utah, are waterborne hazards to Colorado squawfish (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus*), and bonytail (*Gila elegans*). The middle Green River provides important remnant habitat to which these three endangered species are sensitive.

The middle Green River is the site of a Department of the Interior (DOI) National Irrigation Water Quality Program investigation concerning the possible adverse effects of selenium on biota. The DOI study identified elevated concentrations of boron, selenium, and zinc in water, bottom sediments, and biological tissue (fish, aquatic invertebrates, and plants) in the Ashley Creek–Stewart Lake area of the middle Green River. No direct relation to possible effects on endangered fish was established, however.

Young-of-the-year Colorado squawfish and razorback sucker use shallow embayments for nursery habitats. The embayments are at and below the mouth of Ashley Creek and the Stewart Lake outlet. Irrigation return flows are concentrated in these areas. Although little is known about habitat use by young bonytail, they probably use similar nursery habitat. This study was conducted to evaluate the hazard of inorganic contaminants to these species in irrigation water.

Toxicity Tests Were Conducted

The first step was to determine contaminant concentrations that cause adverse effects. Three life stages (swim-up, 1-g, and 2-g fry) of Colorado squawfish, razorback sucker, and bonytail were tested. Fish were obtained as eggs from Dexter National Fish Hatchery, New Mexico; wild fish were not used in tests. Tests were conducted in water that simulated conditions in the middle Green River near Jensen, Utah (197 ppm hardness, 107 ppm alkalinity, 46 ppm calcium, 49 ppm sodium, 23 ppm chloride, 159 ppm sulfate). Fish were exposed for 4 days to either boron, lithium, selenate, selenite, uranium, vanadium, or zinc. Results of these toxicity tests were used to calculate a standard measure of toxicity, the 96-h LC50, which is the concentration of a toxicant that kills 50% of the test organisms in a 96-h exposure period.

Sensitivity Was Similar Among Species

The overall order of toxicity to all species and life stages combined, from most toxic to least toxic, was as follows (">" denotes significant difference at $P = 0.05$): vanadium = zinc > selenite > lithium = uranium > selenate > boron (Table 1). Sensitivity to the seven inorganic contaminants did not significantly differ among the three species.

Similarly, no individual life stage was consistently more sensitive to the seven inorganic contaminants than any other life stage. In general, boron, lithium, selenate, selenite, and zinc were most toxic to the swim-up life stage. Contrastingly, vanadium was most toxic to juvenile fish. The response to uranium toxicity was unique because all three species and three life stages had identical results (Table 1).

Comparison to Environmental Conditions

An assessment of the hazards of toxicants to aquatic life can be made by comparing the biological effects concentration (BEC) to the expected environmental concentration (EEC). The ratio of BEC to EEC is referred to as the margin of uncertainty, once referred to as the margin of safety. On the basis of acute toxicity information, margins of uncertainty less than 100 indicate a high potential for environmental hazard, whereas margins greater than 1,000 generally indicate a low potential.

The margin of uncertainty for the inorganic contaminants tested is the ratio of 96-h acute toxicity values (BEC) to the maximum waterborne environmental concentrations of boron, selenium, uranium, vanadium, and zinc (EEC). EEC values were obtained from water sampled as part of the DOI irrigation drain water study of the middle Green River (Table 2). No information on lithium was available. Using the acute value for the most sensitive species and life stage as the BEC, the margins of uncertainty ranged from 85 for zinc to 8,333 for selenium as selenate (Table 3). Waterborne concentrations of selenite and zinc in Ashley Creek present a high potential hazard to these endangered fish.

Larval razorback sucker and Colorado squawfish, however, use backwaters and the mouths of tributaries where they are exposed to a mixture of inorganic contaminants. Inorganic contaminants in a mixture may be present at concentrations below their individual toxic threshold, but sufficiently high to interact additively or synergistically to cause toxicity to aquatic organisms. Therefore, the hazard of waterborne exposure of individual inorganic contaminants to endangered fish must be interpreted with caution, particularly because the Endangered Species Act of 1973 requires a degree of confidence approaching 100% that species will not be adversely affected.

No recruitment of bonytail populations has been found in the Green River, and only limited recruitment of Colorado squawfish and razorback sucker populations has taken place. Recovery of these endangered fish in the Green River has been hampered by physical, chemical, and biological changes that have taken place in recent decades. Toxic effects of inorganic contaminants from irrigation activities could well be another factor limiting the recovery of these species.

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Table 1. Acute toxicity (96-h LC50, ppm) of seven inorganic contaminants to early life stages of Colorado squawfish, razorback sucker, and bonytail tested in reconstituted middle Green River basin water at 25°C.

Species life stage	Vanadium	Zinc	Selenite	Lithium	Uranium	Selenate	Boron
Colorado squawfish							
Swim-up fry	7.8[a]	1.7[a]	14[a]	17[a]	46[a]	66[a]	279[a]
0.4–1.1g juvenile	3.8[b]	4.3[a]	36[b]	28[b]	46[a]	286[b]	>100
1.7g juvenile	4.3[b]	12[b]	32[b]	41[c]	46[a]	331[b]	527[b]
Razorback sucker							
Swim-up fry	8.8[a]	4.1[a]	15[a]	25[a]	46[a]	48[a]	233[a]
0.9g juvenile	4.0[b]	6.5[b]	8.9[b]	53[b]	46[a]	36[ab]	279[a]
2.0g juvenile	3.0[c]	16[c]	16[a]	186[c]	46[a]	25[b]	>100
Bonytail							
Swim-up fry	5.3[a]	4.8[a]	19[a]	22[a]	46[a]	55[a]	280[a]
1.1g juvenile	2.2[b]	5.8[a]	17[a]	62[b]	46[a]	246[b]	>100
2.6g juvenile	5.1[a]	23[b]	15[a]	65[b]	46[a]	217[b]	552[b]
Geometric mean	4.6	6.6	18	42	46	97	337

[a,b,c]Letters in common for each species and inorganic contaminant are not significantly different ($P = 0.05$).

Table 2. Maximum inorganic concentrations (ppm) in three waters sampled as part of the DOI reconnaissance investigation of the middle Green River in 1986-87.

Inorganic contaminants	Irrigation project drains	Ashley Creek (Green River tributary)	Green River
Boron	1.2	0.63	0.080
Selenium	0.14	0.073	0.003
Uranium	0.073	0.033	—
Zinc	0.040	0.020	0.010
Vanadium	0.005	0.002	—

Table 3. Margin of uncertainty ratios (BEC ÷ EEC) using the 96-h LC50 for the most sensitive species and life stage as the biological effect concentration (BEC), and the maximum inorganic concentrations reported in the DOI reconnaissance investigation of the middle Green River as the expected environmental concentration (EEC).

Inorganic contaminants	Ashley Creek (Green River tributary)	Green River
Zinc	85	170
Selenite	122	2,967
Selenate	342	8,333
Boron	370	2,912
Vanadium	1,100	—
Uranium	1,394	—