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UPTAKE AND EFFECTS OF CHROMIUM ON MARINE FISH

Our earlier studies with a marine flatfish, the speckled sanddab (*Citharichthys stigmaeus*), had shown that the concentrations of hexavalent chromium as potassium dichromate that cause short-term mortality (less than 28 days) in this species are above 5 mg/1. Our objectives in the past year were to examine the effects of concentrations of hexavalent chromium below 5 mg/1 and to determine the effects of trivalent chromium precipitate on the sanddab.

Speckled sanddabs were collected by trawl in Santa Monica Bay and were acclimated in the laboratory for periods of 2 to 6 weeks. Tests were performed in 20-gallon flow-through aquaria using seawater transported from Marineland of the Pacific. We monitored feeding behavior, growth, bioaccumulation, and tissue damage. Tissue trace metal analyses were performed with arc emission spectroscopy by George Alexander (University of California, Los Angeles). Raymond Bendele (Texas Veterinary Medical Diagnostic Laboratory) examined specimens for tissue damage by light microscopy. Water quality was monitored by measuring temperature, salinity, pH, and concentrations of ammonia, nitrite, nitrate, dissolved oxygen, and dissolved chromium.

Three tests were performed. In the first, speckled sanddab were exposed for 44 days to four concentrations of dissolved hexavalent chromium (16, 95, 550, and 3,000 pg/liter) in the form of potassium dichromate ($K_2Cr_2O_7$). No lesions compatible with those reported for chromium toxicity (e.g., disruption of intestinal epithelial lining) were noted in speckled sanddab exposed to these concentrations for the given length of time. The levels were apparently too low to cause morphologic changes in the tissues of the exposed fish.

There was, however, significant uptake of chromium during the experiment. The results are presented in Figure 1. Although equilibrium was not reached during the 44-day exposure, it is apparent that accumulation was proportional to exposure concentration. These data suggest that uptake is an unregulated process. Similar patterns were observed in both external tissues such as the skin and the intestine and internal tissues such as the liver and the muscle. After 44 days of exposure to the highest concentration, the test animals had approximately three orders of magnitude more chromium in their intestinal tissues than did the controls. Accumulation was also evident at the 16-pg/liter exposure level. These tests confirm the biological availability of low concentrations of dissolved hexavalent chromium to fish in a marine system.

In this experiment, the means and coefficients of variation of the chromium concentrations were 3,000 pg/liter and 4.7%, 550 yg/liter and 5.87a, 95 pg/liter and 237, and 16 pg/liter and 1.5%; the control was less than 1.0 pg/liter; total ammonia concentrations did not exceed 0.37 mg/liter; and pH, temperature, and dissolved oxygen ranged from 7.63 to 8.04, 12.7°C to 13.5°C, and 7.5 to 8.6 mg/liter, respectively.

Tissue concentrations reached in this experiment are significantly higher than those seen in specimens living directly on ocean bottom sediments with chromium concentrations of up to 1,500 mg/dry kg. Concentrations of chromium in tissues of the Pacific sanddab (*Citharichthys sordidus*) from off Palos Verdes and Dana Point are presented in Table 1.

A second experiment was designed to measure growth in speckled sanddabs exposed to dissolved hexavalent chromium. Twelve females were exposed to 560 pg/liter (approximately 100 times the present effluent standard) and to control seawater for 150 days. No abnormalities in feeding behavior were observed in either group during the exposure period, although one control specimen died. The growth curves for the two treatments are presented in Figure 2. We identified no statistically significant differences between the two pretreatment curves or between the two posttreatment curves. In the control tank, mean weight (g) and standard length (SL) increased from 5.5 g and 74 mm to 10.4 g and 83 mm, respectively; in the chromium exposure tank, mean weight and length increased from 5.5 g and 73 mm to 10.8 g and 84 mm, respectively.

In this experiment, the chromium concentration in the control aquarium was less than 1 μg/liter (15 measurements),

The third experiment involved the exposure of speckled sanddabs to precipitated trivalent chromium added in the form of chromic chloride ($CrCI_3$). The hydroxide precipitate was produced, added to the test tanks, and allowed to settle in a layer on the bottom. Seawater was added on a flow-through basis. The results of this test suggested that the trivalent chromium precipitate was not biologically available. After a 78-day exposure period, mortalities in the control and in the exposed groups (one and two out of ten, respectively) were not significantly different. In addition, feeding behavior did not appear to be affected. An analysis of chromium levels in tissues of exposed and control specimens (Table 2) suggests that bioaccumulation did not occur. No lesions compatible with those described for chromium toxicity were observed in the exposed fish.

In this experiment, levels of dissolved chromium were less than 3.5 pg/liter; total ammonia concentrations did not exceed 0.43 mg/liter; and pH, temperature, and dissolved oxygen ranged from 7.67 to 8.36, 12.0 to 12.7°C, and 8.0 to 8.6 mg/liter, respectively.

In conclusion, it appears that (1) dissolved hexavalent chromium is biologically available to the speckled sanddab but the trivalent hydroxide precipitate is not; (2) accumulation of hexavalent chromium in this species occurs at very low exposure levels, appears to be unregulated, and is proportional to exposure concentration; and (3) the levels of dissolved hexavalent chromium that affect feeding behavior, limit growth, disrupt tissue structure, or cause mortality are substantially higher than those likely to be encountered in the ocean.

REFERENCES

Ford, R.F. 1965. Distribution, population dynamics and behavior of a bothid flatfish, *Citharichthys stigmaeus*. Ph.D. thesis. University of California, San Diego.

Table 1. Chromium concentrations (mg/dry kg) in Pacific sandabs collected off Palos Verdes and Dana Point (February and March, 1975).

	Palos Verdes Shelf	Dana Point
Muscle		
No. of samples	4	9
Median	–*	–*
Range	–*	–*
Skin on eyed side		
No. of samples	8	10
Median	1.4	0.7
Range	–* to 2.6	–* to 2.6
Skin on blind side		
No. of samples	10	10
Median	0.5	<0.4
Range	–* to 2.9	–* to 1.8
Kidney		
No. of samples	10	–
Median	–*	–
Range	–* to 1.9	–

*Below limit of detectability

Table 2. Levels of chromium (mg/dry kg) in the tissues of speckled sanddab exposed to precipitated trivalent chromium.

	Control	Cr^{+3} Precipitate
Skin on eyed side		
No. of fish	5	5
Median	3.9	4.0
Range	0.7 to 11.1	0.8 to 10.6
Muscle		
No. of fish	6	4
Median	–*	–*
Range	–*	–* to 2.0
Liver		
No. of fish	6	5
Median	–*	0.3
Range	–* to 0.5	–* to 0.4

*Below the limit of detectability

Figure 1. Chromium accumulation in tissues of speckled sanddab following 44-day exposure to hexavalent chromium ($k_2Cr_2O_7$).

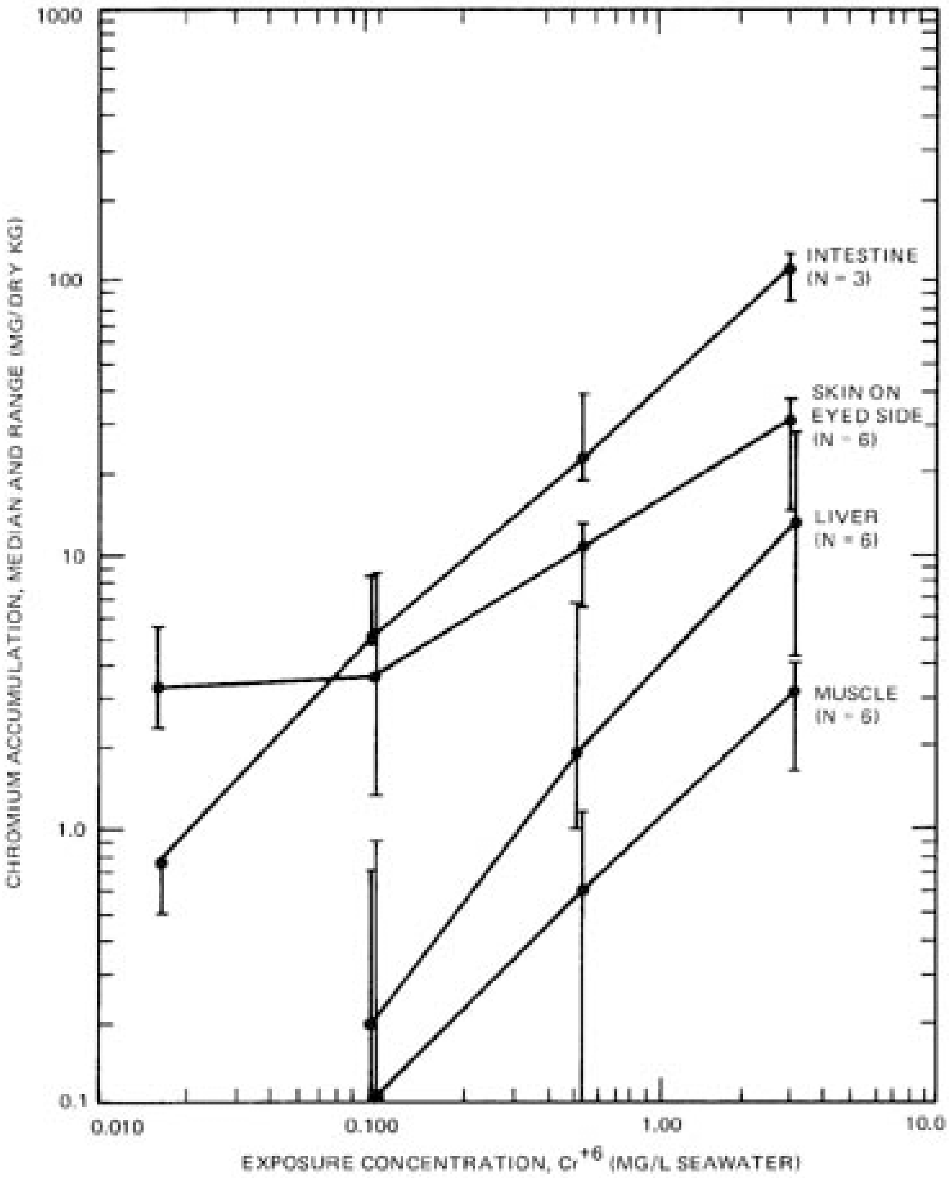

Figure 2. Growth of speckled sanddab exposed to 560 ppb hexavalent chromium for 150 days.