Bull. Environ. Contam. Toxicol. (1987) 38:695–699

Bulletin of Environmental Contamination and Toxicology

Cadmium and Lead in Lake Ontario Salmonids

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Cadmium and lead are ubiquitous environmental contaminants and, as a result, frequently accumulate in aquatic and terrestrial food chains. Reported levels of both elements in marine and freshwater fish vary widely and often reflect localized industrial and agricultural pollutant discharges. For most Americans, fish are usually not a major dietary source of cadmium and lead. However, the United States Food and Drug Administration has estimated that the average daily dietary intake of these elements from a typical American diet represents a significant percentage (especially for cadmium) of the WHO recommended dietary guidelines (Mahaffey et al., 1975). Thus, any increase in daily intake from contaminated fish is undesirable.

Sport fishery is an annual multi-million dollar industry in New York State. The majority of this activity involves salmonid species (coho and chinook Salmon, lake and brown trout) that inhabit Lake Ontario and its associated tributaries. However, the presence of toxic chemicals - specific chlorinated hydrocarbons (e.g., mirex, PCB's, dioxin, DDT, chlordane) and heavy metals (cadmium, lead, mercury) - have been documented in several fish species and other aquatic food organisms from the lake (Buchanan, 1972; Cappon, 1984; Delfino, 1979; Kaiser, 1974; Sloan and Armstrong, 1981). In certain cases, the presence of elevated levels of PCB's, mirex and mercury has resulted in temporary fishing bans by the State Department of Environmental Conservation (DEC) and issuance of permanent advisory dietary guidelines by the State Department of Health for specific predatory species - pike, muskellunge, bass, trout, salmon (New York State DEC, 1978). These regulations, coupled with the persistent presence of these hazardous pollutants in Lake Ontario's aquatic food chain, can have a long-term negative impact on the health of people consuming its fish and the economic health of New York's sport fishery.

Currently, there are data documenting the existence of cadmium and lead in Lake Ontario salmonids. Rohrer et al. (1982) recently reported the absence of detectable residues of either

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element in edible fillets of coho and chinook salmon from Michigan tributaries to the other four laurention Great Lakes. However, flame atomic absorption spectrometry was used and the reported detectability limit (10 ppm) was greater than the trace levels that may likely have been present. The present investigation was initiated to (1) establish the existence and magnitude of cadmium and lead content of Lake Ontario salmonids, and (2) to assess the potential impact of their consumption on human dietary cadmium and lead intake.

MATERIALS AND METHODS

A total of 28 fish were used for this investigation. These included 21 whole fish and 7 skinned muscle fillets. Whole specimens were collected during September 1982 from an area 1 km offshore and 45 km west of Rochester, New York. All whole fish, after evisceration, were individually wrapped in polyethylene bags and stored at -20°C until subsampling and analysis. Data on species and approximate size are outlined in Table 1. Age of all salmon species was 3 years. For subsampling, two 5-cm-wide sections of muscle tissue (representing the anterior dorsal loin region) were obtained from each frozen specimen (Figure 1). For each analysis, 0.5 to 1.0-g portion of muscle tissue were taken from a region adjacent to the spinal chord of the appropriate tissue section. Single skinned fillets (approximately 12 cm x 5 cm) of brown trout were obtained and stored in a similar manner, and subsampled by taking a portion from the fillet center.

Duplicate analyses for cadmium and lead were performed on each specimen by using Zeeman graphite-furnace atomic absorption spectrophotometry. Samples (0.5 to 1.0-g) of finely-chopped tissue were digested using a mixture of 5 ml-concentrated nitric acid and 0.5 ml 70 percent perchloric acid. Digestions were performed in glass test tubes placed inside an aluminum heating block maintained at 180°C. Digestions were continued until the samples were clear and approximately 0.5 ml of liquid remained. After cooling, each sample was diluted with 0.7 percent nitric acid prior to analysis. All data were computed on a μg/g wet weight basis.

RESULTS AND DISCUSSION

Data on the cadmium and lead content in the edible muscle samples are presented in Table 2. The mean concentration values for both elements tended to be rather uniform with no significant species differences. The observed concentrations were similar to those reported for 13 marine finfish species (including sockeye salmon) in a recent U.S. National Marine Fisheries Service seafood survey (Zook et al., 1976). However, some of the higher cadmium values were close to the upper region of the commonly-reported concentration ranges for marine fish - 0.2 ppm (Sidwell and Ambrose, 1975). The mean cadminum levels were also higher than the mean range of 0.007 to 0.063 ppm reported for selected freshwater species (yellow perch, white

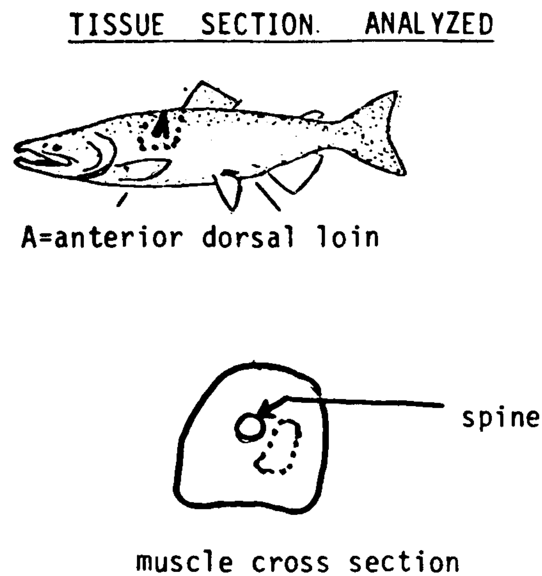

Figure 1. Muscle tissue section and subsampling region.

Table 1. Salmonid specimens studied.

Type	Species	N	Length, range (cm)
Salmon	Coho	6	80-100
	Chinook	5	80-100
Trout	Lake	7	30-80
	Brown	3	60-80
		7	skinless fillet

bass, smallmouth bass) from Lake Erie (Kelso and Frank, 1974). Although the lead concentrations for the present fish samples were up to 3 times higher than the corresponding cadmium levels, they were within the concentration ranges reported in the above papers. The main cause for the lead and elevated cadmium contamination in Lake Ontario salmonids is the industrial activity and resultant effluent discharges from Eastern Lake Erie and the Niagara River, along with the tendency for the dispersed pollutants to be concentrated along the southern shoreline of the lake (Delfino, 1979). The fact that salmonids are predatory species would also account for higher pollutant levels in their edible muscle tissue.

Of pertinent concern from a human health standpoint is the potential long-term toxicity hazard from consuming salmonids from Lake Ontario containing the present tissue cadmium and lead levels. The WHO/FAO provisional tolerated daily adult intakes are 57.1 and 429g μg for cadmiun and lead, respectively (Joint WHO/FAO Expert Committee on Food Additives, 1972). Assuming a

Table 2. Cadmium and lead content in salmonid edible tissue.

		Cd ($\mu g\ g^{-1}$)		Pb ($\mu g\ g^{-1}$)	
Species	N	Range	Mean(SD)[a]	Range	Mean(SD)
Coho salmon	6	0.04-0.16	0.11 (0.04)	0.23-0.46	0.30 (0.09)
Chinook salmon	5	0.07-0.18	0.11 (0.04)	0.18-0.29	0.26 (0.04)
Lake trout	7	0.04-0.17	0.10 (0.04)	0.13-0.30	0.23 (0.04)
Brown trout	3	0.05-0.21	0.11 (0.07)	0.28-0.30	0.29 (0.01)
	7[b]	0.06-0.11	0.08 (0.02)	0.13-0.34	0.22 (0.07)

[a]SD = standard deviation

[b]Skinless fillets

single weekly meal of 250 grams of fish containing 0.21 ppm Cdand 0.46 ppm Pb - the highest concentrations found in this study - the corresponding average daily intakes would be 7.5 and 16.4 μg, or 13.1 and 3.8 percent of the respective WHO/FAO provisional tolerable intakes. The cadmiun data are of greater significance, especially for more susceptable population groups (children, nursing mothers, pregnant women).

The results of this study suggest that consumption of Lake Ontario salmonids will probably not result in any immediate human health hazard if done infrequently (i.e., no more than one meal per week). However, the relatively high cadmium levels are of concern and warrant future monitoring of cadmium (and lead) tissue content in salmonids from the lake.

Acknowledgments. Sincere appreciation is expressed to Dr. J.A. Makarowicz, Dept. Biol. Sci., SUNY at Brockport, Brockport, NY, for providing the salmonid specimens. Supported by a grant from the National Institute of Environmental Health Sciences (ES-01247). Presented at the 27th Conference of the International Association for Great Lakes Research, St. Catherines, Ontario, Canada, May, 1984.

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Received August 9, 1986; accepted November 20, 1986