Total and Organic Mercury in the Pacific Blue Marlin

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Reports on mercury contamination in fish, both fresh and salt-water varieties, state that the mercury is present primarily in the organic form. WESTÖÖ (1967) found that in fillets of fresh-water fish nearly all the mercury was present as methyl mercury. BACHE (1971) reported that lake trout, Salvelinus namacush, contained an average of 69% of the total mercury in the monomethyl form. FUKUI, et al. (1972) determined that methyl mercury was 80% of the total mercury in spearfish, Makaira mitsukurii, and 67% of the total in albacore, Thunnus alalunga. KAMPS, et al. (1972) analyzed several species of fish including swordfish and tuna and found essentially all the mercury in the methyl form.

Nine species of pelagic and inshore fish from Hawaiian waters were analyzed in a previous study (RIVERS, et al., 1972) for total and organic mercury. The ratios of total to organic in eight of these species agreed with the above observations that the organic fraction was the main mercury component in the fish. In the Pacific Blue marlin, Makaira nigricans (also classified M. ampla) this predominance of organic mercury was not found; but rather the total mercury was much greater than the organic fraction in both muscle and liver tissues. To expand these findings, additional tissues of the marlin were collected during the 1972 Billfish Tournament held in Kona, Hawaii.

Materials and Methods

Muscle, liver, central nervous tissue (brain plus optic nerve), and gonads were sampled and analyzed for total and organic mercury. The tissues were prepared as described previously (RIVERS, et al., 1972). The analyses were made using a Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer equipped with a Manning vapor chamber (MANNING, 1970).

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Results and Discussion

The results of the mercury analyses are shown in Table I. This method of analysis doesn't separate the alkyl forms from other organic forms but WESTÖÖ (1972) identified the organic mercury in freeze-dried samples of the marlin as methyl mercury. Concentrations of total mercury were greatest in liver, followed by muscle, central nervous tissue (CNT), and gonad. The organic mercury concentrations were greatest in muscle followed by liver, CNT, and gonad. Distribution experiments with other types of organisms have shown that often the liver accumulates mercury to a greater extent than the muscle and other organs (HANNERZ, 1968; SWENSSON and ULFVARSON, 1968; BERLIN and ULLBERG, 1963; ULFVARSON, 1969; GIBLIN and MASSARO, 1973; CLARKSON, 1972).

The ratios of total to organic mercury in the tissues indicate a partial physiological control over the form in which the mercury exists in the marlin. The total to organic ratios in the muscle, gonad, and central nervous tissue are similar (6:1, 4:1, 5:1, respectively). The liver, however, with a ratio of 35:1 reflects an unusually high proportion of inorganic to organic mercury in relation to other tissues. Experiments with rats indicated that methyl mercury was more slowly excreted than other mercury compounds (ULFVARSON, 1969; CLARKSON, 1972) thus biotransformation in the marlin liver to the less toxic and more easily excretable inorganic mercury could be a physiological mechanism for reducing the mercury content of the fish. Biotransformations to inorganic mercury have been reported in other species. In a study of bluegills exposed to $^{203}HgCH_3$ in their water and subsequently transferred to a Hg-free environment, BURROWS and KRENKEL (1973) found mercury concentrations in the liver and kidney to be two to seven times higher than the levels in the whole fish. During the experiment, the proportion of methyl mercury to total mercury in the whole fish remained fairly constant at 73 ± 10% but decreased rapidly in the liver and kidney to about 10%. The authors suggested that biotransformation of the methyl to inorganic mercury may occur in these organs. TAKEDA and UKITA (1970) showed that ethylmercuric compounds were metabolized to inorganic mercury derivatives in the rat and conclude that the conversion was probably taking place in the kidney. In extensive studies with methyl mercury, NORSETH and CLARKSON (1970a, 1970b, 1971) reported transformation to inorganic mercury in the rat. FANG (1973) demonstrated that guppies and snails converted phenylmercuric acetate to inorganic mercury.

A possible addition to demethylation in the liver is the biotransformation of organic to inorganic mercury by bacteria within the intestinal tract prior to absorption. The ability of some bacteria to convert organic mercury to inorganic mercury has been reported (FURUKAWA, et al., 1969; SPANGLER, et al., 1973).

As shown in Table II, the total and organic mercury in most tissues is significantly correlated to weight implying accumulation of mercury in these tissues. Whether the lack of correlation between total mercury in the liver and weight is due to demethylation and excretion is unclear.

TABLE I

Total and organic mercury in muscle, central nervous tissue, liver, and gonad of 19 Pacific Blue marlin (ppm, mg/kg wet weight) (Mercury calculated as inorganic Hg)

Fish wt	Total mus	Organic mus	Total CNT	Organic CNT	Total liver	Organic liver	Total gonad	Organic gonad
113	0.51	0.09	0.17	0.17	3.50	0.10	--	--
121	0.35	0.11	0.17	0.03	0.66	0.03	0.06	0.03
122	0.30	0.06	0.60	0.10	1.30	0.03	--	--
136	1.88	0.51	0.21	0.09	7.88	0.20	0.39	0.09
138	0.37	0.23	0.08	0.08	0.76	0.07	--	--
143	3.20	0.11	0.46	0.05	11.80	0.05	0.60	0.03
145	1.40	0.32	0.32	0.06	3.00	0.14	0.20	0.04
146	1.42	0.11	0.25	0.02	3.90	0.05	--	--
148	1.20	0.33	0.16	0.02	6.40	0.10	--	--
150	1.05	0.19	0.19	0.06	5.70	0.09	0.22	0.10
154	0.46	0.11	0.08	0.02	0.45	0.20	0.11	0.05
169	1.70	0.35	0.21	0.07	11.00	0.13	--	--
170	1.20	0.22	0.38	0.02	2.24	0.05	0.10	0.01
177	3.00	0.41	0.38	0.07	9.12	0.25	0.35	0.09
193	3.14	0.56	0.86	0.22	7.80	0.25	--	--
242	3.86	0.64	0.28	0.04	8.40	0.31	0.66	0.22
265	1.42	0.41	0.25	0.10	4.00	0.13	--	--
268	4.33	0.58	3.20	0.13	23.00	0.24	--	--
436	8.35	1.43	0.94	0.29	8.80	1.00	--	--
Avg 181	2.06	0.36	0.48	0.09	6.30	0.18	0.30	0.07

All of the marlin were caught off the Kona side of the island of Hawaii near an active volcano. SIEGEL, et al. (1973) found relatively high concentrations of mercury in plants and fungi near the volcano. Studies on trout in New Zealand revealed greater levels of mercury in fish living near areas of high geothermal activity than those living in areas of low or no geothermal activity (WEISSBERG and ZOBEL, 1973). The mercury in the marlin may be an additional example of mercury contamination from natural causes.

TABLE II

Correlation coefficients of relationships between total mercury and organic mercury in muscle, liver, central nervous tissue, gonad, and fish weight of Pacific Blue marlin.
(*$p < 0.05$ **$p < 0.01$)

	Fish Wt	Tot Mus	Org Mus	Tot CNT	Org CNT	Tot Liv	Org Liv	Tot Gon
Tot Mus	0.88**							
Org Mus	0.91**	0.91**						
Tot CNT	0.46*	0.50*	0.37					
Org CNT	0.63**	0.64**	0.70**	0.38				
Tot Liv	0.43	0.61**	0.43	0.79**	0.28			
Org Liv	0.88**	0.89**	0.94**	0.28	0.72**	0.29		
Tot Gon	0.55	0.94**	0.58	0.47	0.40	0.89**	0.48	
Org Gon	0.79*	0.61	0.79*	0.13	0.24	0.42	0.78*	0.64

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