Mercury in Several Species of Billfishes Taken Off Hawaii and Southern California

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ABSTRACT

The results of analyses of the mercury content of 37 blue marlin, *Makaira nigricans*, 56 striped marlin, *Tetrapturus audax*, and 3 swordfish, *Xiphias gladius*, are presented.

The levels of total mercury found in white muscle of blue marlin caught in Hawaiian waters ranged from 0.19 ppm to 7.86 ppm; fish specimens ranged in total weight from 96 pounds (43.5 kg) to 906 pounds (410.9 kg). A trend of increasing mercury level with increasing size of fish was noted. The mercury content in the livers of 26 blue marlin specimens examined ranged from 0.13 ppm to 29.55 ppm; there was no apparent trend noted between mercury content in the liver and size of fish.

Striped marlin from Hawaii and southern California showed a range of mercury levels in white muscle of 0.09-1.09 ppm for the 14 Hawaii samples examined and 0.03-2.1 ppm for the 42 California samples examined. The range in size of fish was 56-139 pounds (25.4-63.0 kg) and 109-231 pounds (49.4-104.8 kg) for the Hawaii and California samples, respectively. From the wide spread of mercury levels encountered in striped marlin, a trend of mercury level with size of fish could not be easily detected. Livers of nine specimens from the Hawaii catch were analyzed; mercury levels ranged from 0.05 ppm to 1.53 ppm.

Three swordfish weighing 6 pounds (2.7 kg), 100 pounds (45.4 kg), and an estimated 500 pounds (226.8 kg) contained mercury levels in white muscle of 0.04, 1.71, and 2.10 ppm, respectively.

In early December 1970 the news media stunned the nation, particularly the fishing industry, with the release of stories that some canned tuna and swordfish steaks contained mercury in excess of the Food and Drug Administration (FDA) interim guideline of 0.5 ppm (Bernstein, 1970; Fleming, 1970; Los Angeles Times, 1970; Coffey, 1971). Prior to State University of New York Professor Bruce McDuffie's discovery that mercury levels in two cans of tuna exceeded the FDA guideline, the problem of mercury in fishes was thought to be localized and confined to freshwater fish species. The high levels of mercury in freshwater fishes were attributed to dumping of waste products into waterways.

A review of the literature undertaken at the time of the announcement of mercury in tuna and swordfish revealed a wealth of information related to mercury and its toxic properties; references were primarily of incidents occurring in Japan and Sweden. Despite the wide range of available information, there was a conspicuous lack of data related to mercury levels in living organisms in the marine biosphere. For this reason the National Marine Fisheries Service embarked upon an extensive program early in 1971 to collect tissue samples of marine and estuarine fishes and invertebrates for analysis of mercury and other heavy metals (Commercial Fisheries Review, 1971).

Primarily because of their recreational value, the California Department of Fish and Game collected samples of striped marlin, *Tetrapturus audax*, and albacore, *Thunnus alalunga*, for mercury analysis during the summer of 1971.

Our purpose in this paper is to provide the results of analysis for total mercury content in samples of striped marlin, blue marlin, *Makaira nigricans*, and swordfish, *Xiphias gladius*. We will simply present these data with some brief comments of the more

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notable features. It is not our intention to review the instances of mercury poisoning, the legal aspects of the mercury guideline, nor the issue of natural versus pollution-caused heavy metal contamination.

MATERIALS AND METHODS

Of the 56 striped marlin sampled, 42 were caught off southern California, while the remaining 14 were from Hawaiian waters. All of the 37 blue marlin and 2 of the 3 swordfish were from Hawaiian waters. One small (2.7 kg) swordfish was caught with longline gear in the central equatorial Pacific. The recreational fishery provided all the California samples; data and tissues were collected either at the weighing facilities of the Balboa Angling Club or the Marlin Club of San Diego. The Hawaii samples consisted of fish caught by the commercial longline fleet and by the troll sport fishery. The commercial catch was sampled at the Honolulu fish auction, while the sport catch was from fish caught during the 1971 Hawaiian International Billfish Tournament held at Kailua-Kona, Hawaii.

With the exception of the small swordfish which was preserved in Formalin,[3] all of the samples were collected from fresh, unfrozen specimens. From ½ to 1 pound (0.23 to 0.45 kg) of white muscle tissue was excised from each fish. In the California striped marlin samples, the tissue was removed from the dorsal loin above the left pectoral fin. Nearly all the Hawaii samples came from near the caudal area because this portion is usually discarded after a buyer has purchased the fish from the auction market. In all cases the tissue sample was cleaned of skin and bone, wrapped in inert aluminum foil, labeled, and then frozen as soon as possible. After the samples had been collected they were packed in Dry Ice and shipped to the analytical laboratories by air. Liver tissue from 4 Hawaiian striped marlin and 26 blue marlin also were collected for comparative analysis.

The Hawaii samples were analyzed at a National Marine Fisheries Service Laboratory while those from California were done by a Department of Fish and Game Laboratory. In 17 of the California striped marlin sampled, muscle tissues were sent to each of the analytical laboratories.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Similar laboratory procedures were followed in all cases; this consisting basically of the semiautomatic, cold vapor, atomic absorption technique (Uthe, Armstrong, and Stainton, 1970). This technique requires a lengthy process of homogenizing, digesting, etc., prior to obtaining a total mercury value from the atomic absorption apparatus.

RESULTS

Striped Marlin

Our study covered a relatively wide size range for this species; the smallest weighed 56 pounds (25.4 kg) and the largest 231.5 pounds (105.0 kg). Generally, the larger striped marlin were from southern California while the smaller fish were from Hawaii. Total mercury values averaged 0.8 ppm and ranged from a low of 0.03 ppm in a 135-pound (61.2 kg) fish to 2.1 ppm in a 231.5 pound (105.0 kg) fish, the largest sampled (Fig. 1). Seventy percent or 42 fish exceeded the FDA guideline of 0.5 ppm. A trend line calculated for these data indicates a general increase in total mercury with increasing size of fish. However, as Figure 1 indicates, the increase is erratic and impossible to predict. While the largest fish resulted in the highest mercury content, it is well to note that the second largest, a 218 pounder (99.0 kg), was tested at 0.29 ppm, a figure well below the FDA guideline.

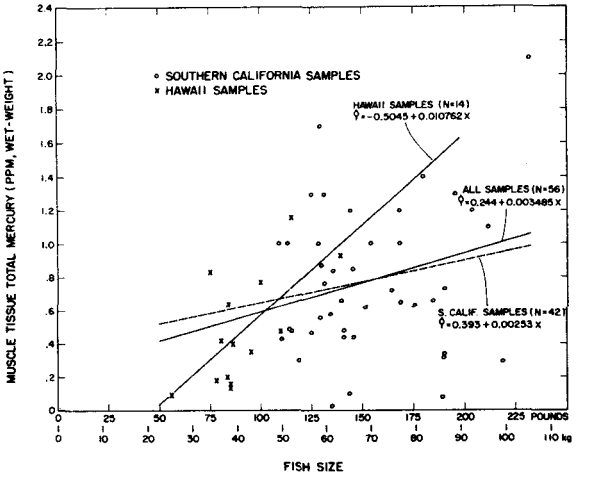

Figure 1.—Relationship between total mercury (ppm) in white muscle tissue and size of fish of striped marlin from southern California and Hawaiian waters.

Table 1.—Comparison of mercury levels in striped marlin tissues analyzed by two laboratories.

	Laboratory no. 1	Laboratory no. 2
Mean HG	0.77 ppm	0.84 ppm
Standard deviation	0.35	0.50
>0.5 ppm	15 fish	12 fish
<0.5 ppm	2 fish	5 fish
High value	1.0	2.1
Low value	0.4	0.1

Some of this variability may be due to analytical technique for it should be remembered that different laboratories provided the analytical data. While analytical methods were being developed there appeared to be considerable variability between laboratories, although the reproducibility within a given laboratory was very high. Our data from the 17 samples that were run by two of the laboratories tend to bear out this feature. Extreme values were repeatable within both laboratories, but there were differences between the laboratories. These differences are illustrated best in tabular form (Table 1).

Looking at individual samples, one laboratory was not consistently high or low and no two values for a particular fish were identical. In several instances one laboratory reported mercury values over the FDA guideline while the other was below. Again, neither laboratory was consistent in this respect.

The livers from four Hawaiian fish also were analyzed for total mercury. Mercury levels of the three small fish (81, 83, and 96 pounds—36.7, 37.6, and 43.5 kg, respectively) were all less than 0.2 ppm, but the single large fish of 139 pounds (63.0 kg) had a value of 1.54 ppm.

Blue Marlin

The mercury data for all the blue marlin were from fish taken in Hawaiian waters. Total mercury levels of white muscle tissue in this species ranged from 0.7 ppm to 7.86 ppm in fish weighing between 96 and 906 pounds (43.5 and 410.9 kg). The results are presented in Figure 2. When compared to striped marlin, the mercury levels in blue marlin were much higher. Only 7 of the 37 blue marlin tested had levels less than 1.0 ppm, while for striped marlin 45 of the 56 fish tested were below that level. The highest value recorded for blue marlin was 7.86 ppm which, surprisingly, was not from the largest specimen, but from a fish weighing 211 pounds (95.7 kg).

As with striped marlin, the range in mercury level for blue marlin is large. However, there appeared to be an indication of a positive relationship between mercury level and fish size when a regression was fitted to the data (Fig. 2). Again, this relationship shows a wide variation around the regression. We would find it difficult to use these data for predicting mercury content in a given specimen.

For comparative purposes we have plotted the linear regression presented by Rivers, Pearson, and Schultz (1972) for blue marlin samples from Hawaiian waters. Since many of the same fish tested by Rivers et al. (1972) were included in our study, we can only conclude that the marked difference in regressions is due to differences in analytical technique. There is agreement, however, that the levels of mercury in blue marlin are considerably higher than the FDA guideline.

The livers of 26 blue marlin also were analyzed for total mercury. The values ranged from 0.13 ppm

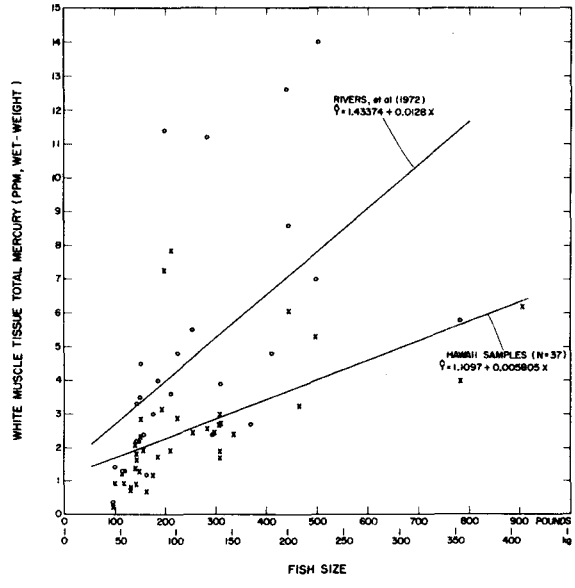

Figure 2.—Relationship between total mercury (ppm) in white muscle tissue and size of fish of blue marlin from Hawaiian waters. (o denotes Rivers et al. (1972) samples, x denotes our samples.)

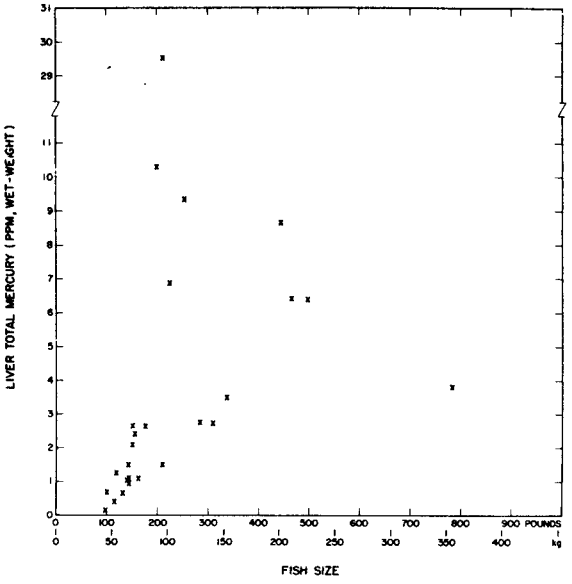

Figure 3.—Relationship between total mercury (ppm) in liver tissue and size of fish of blue marlin from Hawaiian waters.

to a phenomenal 29.55 ppm (Fig. 3). Based upon published literature the latter may be the highest level of total mercury reported for any fish. Coincidentally, this high value was from the same 211-pound (95.7-kg) fish whose white muscle tissue contained the extremely high level of 7.86 ppm total mercury. There does not, however, appear to be a consistent relationship between total mercury content in livers and the content in white muscle tissues.

Swordfish

Only the muscle tissue from three swordfish was analyzed for total mercury. The mercury level in a juvenile swordfish weighing 6 pounds (2.7 kg), which had been preserved in Formalin, measured 0.04 ppm. The analyses from two other fresh specimens from Hawaiian waters weighing 100 pounds (45.4 kg) and 500 pounds (226.8 kg), were 1.7 and 2.1 ppm total mercury, respectively.

DISCUSSION

Results of this investigation may be considered a contribution to the fund of information pertaining to this controversial subject. Confirmation of high mercury levels in billfishes and the relationship of mercury to size, sex, or other variables will require further study.

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