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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu and La Jolla Laboratories
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STATUS REPORT

Mercury in the Pacific Blue Marlin, *Makaira nigricans*

By

Cynthia S. Unninayar and Bernard M. Ito

INTRODUCTION

In 1971, nine species of pelagic and inshore fish from Hawaiian waters were analyzed for total and organic mercury (Rivers, Pearson, and Shultz, 1972). In eight of these species the organic mercury was greater than 80% of the total; a finding consistent with other mercury values reported in the literature (Westöö, 1967; Kamps, Carr, and Miller, 1972). In the Pacific blue marlin, however, this predominance of organic mercury was not found, but rather most of the mercury seemed to be either inorganic or an organic form which was not extractable by the organic mercury method. Because of the uniqueness of the marlin, additional samples were collected in 1972, 1973, and 1974 during the Hawaiian International Billfish Tournament in Kailua-Kona, Hawaii, to continue study of the mercury levels in this fish. This report deals primarily with our findings of 46 marlin obtained in July 1974.

METHODS

Total, organic, and inorganic mercury were determined using the flameless atomic absorption apparatus with a Perkin-Elmer 303 Atomic Absorption Spectrophotometer. Total Mercury: The homogenized sample was digested with concentrated nitric acid over low heat and further oxidized with potassium permanganate solution; excess oxidizing agents were reduced with hydroxylamine solution; mercury ions were then reduced to elemental mercury with stannous chloride and vaporized into the flameless atomic absorption apparatus (Rivers et al., 1972). Organic Mercury: The homogenized sample was extracted with benzene in a separatory funnel containing HCl, NaCl, and water; the benzene layer was then transferred to another separatory funnel and extracted with 1% cysteine solution; a portion of the cysteine solution was transferred to a flask and oxidized with permanganate and persulfate; following reduction with hydroxylamine and stannous ion, the mercury was vaporized into the

flameless apparatus (Rivers et al., 1972). Inorganic Mercury: One gram of a 1:1 tissue:water homogenate was digested with 3 ml of concentrated nitric acid in a flask for 1 hour at room temperature then diluted to an appropriate volume with water, following reduction with stannous ion, the mercury was vaporized into the flameless apparatus (Iverson and Hierliky, 1974). Inorganic analyses were performed on samples of muscle and liver to confirm that the difference between total and organic was indeed inorganic mercury. The data are not reported here but does confirm that the residual mercury is inorganic in nature.

RESULTS AND DISCUSSION

Table 1 gives the results of total and organic mercury in muscle, liver, kidney, spleen, pyloric caecum, stomach, gill, gonad, and whole blood for 14 female (weighing 39-342 kg) and 32 males (weighing 58-112 kg) Pacific blue marlin. Total mercury levels were lowest in blood (0.01-0.61, $\bar{x}$ = 0.18 ppm) and highest in kidney (0.18-77.00, $\bar{x}$ = 26.33 ppm). In muscle the total values ranged from 0.09 to 10.00, $\bar{x}$ = 3.12 ppm. Organic mercury levels were lowest in blood (0.00-0.11, $\bar{x}$ = 0.04 ppm) and highest in muscle (0.02-1.02, $\bar{x}$ = 0.40 ppm). In all tissues the organic fraction was less than 1.02 ppm.

A general analysis of variance for the 1974 samples revealed significant differences between concentrations of total mercury in males and females and between body weight and tissues although these differences were not significant for organic mercury. Additional statistical analyses considered the two sexes separately for total mercury. Table 2 gives correlation coefficients between body weight and tissues. In most cases, the relationship is highly significant. The contrast of males and females shown in Figures 1 and 2 may be due to age and/or metabolic dissimilarities since females mature at a different rate than males. To see if this difference was the same for the previous years, an analysis of covariance was performed on all samples for muscle and liver beginning with 1971. The results indicated that there is no statistical dissimilarity between either males and females or between years. As was expected, however, there was a definite difference between muscle and liver tissues. In previous years, the number of females has been smaller than in 1974 perhaps resulting in a lack of a representative sample for comparison (Rivers et al., 1972; Shultz et al., in press).

The data clearly demonstrate that the organic mercury levels are quite low relative to the total mercury. Westöö (pers. comm.) has identified the organic fraction as methyl mercury in freeze-dried samples of the marlin. Both the Swedish Laboratory and the Tokyo Metropolitan Research Laboratory of Public Health (Nishigaki, pers. comm.) have confirmed the low percentages of organic mercury in samples collected in 1971 and 1974, respectively.

The ratio of total organic mercury for gonad, blood, gill, pyloric caecum, muscle, and stomach tissues range from about 4:1 to 11:1. The ratios in spleen, liver, and kidneys, however (38:1, 45:1, 120:1, respectively), reflect an unusually high proportion of inorganic to organic mercury in these organs. Many organisms have been reported capable of transforming methyl and other types of organic mercury to an inorganic form (Norseth and Clarkson, 1970a, 1970b; Takeda and Ukita, 1970; Burrows and Krenkel, 1973; Fang, 1973; Iverson and Hierliky, 1974). In most of these cases, the conversion was thought to occur or be associated with the kidney and liver.

Although the above demonstrations occurred under artificial laboratory conditions not necessarily applicable to the natural environment, they nevertheless offer convincing evidence that the conversion of methyl mercury to inorganic mercury in the Pacific blue marlin is an adaptive response to environmental mercury contamination.

LITERATURE CITED

Burrows, W. D., and P. A. Krenkel. Environ. Sci. Tech. 7, 1127 (1973).

Fang, S. C. Arch. Environ. Cont. Tox. 1, 18 (1973).

Iverson, F., and S. L. Hierliky. Cont. Tox. 11, 85 (1974).

Kamps, L. R., R. Carr, and H. Miller. Bull. Environ. Cont. Tox. 8, 273 (1972).

Norseth, T., and T. W. Clarkson. Arch. Environ. Health. 21, 717 (1970a).

Norseth, T., and T. W. Clarkson. Biochem. Pharmacol. 19, 2775 (1970b).

Rivers, J. B., J. E. Pearson, and C. D. Shultz. Bull. Environ. Cont. Tox. 8, 257 (1972).

Shultz, C. D., D. Crear, J. E. Pearson, and J. B. Rivers. Bull. Environ. Cont. Tox. (in press).

Takeda, T., and T. Ukita. Tox. Appl. Pharmacol. 17, 181 (1970).

Westöö, G. Acta Chem. Scand. 21, 1790 (1967).

February 21, 1975

Table 1.--Total and organic mercury in tissues of 46 Pacific blue marlin, *Makaira nigricans* (milligram/kilogram wet weight; mercury calculated as inorganic mercury).

WT KG	SEX	TOTL MUSC	ORGN MUSC	TOTL LIVR	ORGN LIVR	TOTL KIDN	ORGN KIDN	TOTL SPLN	ORGN SPLN	TOTL STOM	ORGN STOM	TOTL P.C.	ORGN P.C.	TOTL GILL	ORGN GILL	TOTL GOND	ORGN GOND	TOTL BLD	ORGN BLD
39	F	0.09	0.02	0.13	0.13	0.18	0.04	0.08	0.02	0.06	0.06	0.17	0.08	0.21	0.02	--	--	0.02	0.02
58	M	0.33	0.16	0.22	0.11	0.78	0.09	0.19	0.05	0.09	0.06	0.20	0.11	0.19	0.02	0.03	0.03	0.03	0.03
60	M	0.52	0.40	0.78	0.39	0.77	0.20	0.26	0.16	0.18	0.03	0.36	0.17	0.19	0.05	--	--	0.11	0.03
60	M	0.98	0.32	3.60	0.25	7.10	0.12	1.78	0.13	0.48	0.08	0.61	0.23	0.31	0.05	0.10	0.06	--	--
63	M	1.68	0.18	4.65	0.19	8.45	0.16	1.80	0.10	0.60	0.06	0.80	0.26	0.13	0.03	0.27	0.09	0.11	0.05
64	M	0.72	0.15	3.35	0.19	8.35	0.16	2.12	0.12	0.43	0.08	0.61	0.21	0.12	0.03	0.12	0.05	0.06	0.03
64	M	1.96	0.14	7.00	0.09	17.80	0.09	2.60	0.03	0.86	0.06	1.12	0.13	0.24	<0.01	0.22	0.03	0.03	0.02
66	M	1.32	0.24	5.44	0.13	10.20	0.10	0.94	0.02	0.50	0.06	1.02	0.12	0.14	0.02	0.13	0.03	0.06	0.02
68	M	0.36	0.12	2.25	0.10	4.60	0.07	0.88	0.10	0.36	0.04	0.42	0.13	0.08	0.01	--	--	0.08	<0.01
68	M	2.20	0.42	3.00	0.24	16.10	0.19	4.00	0.06	0.83	0.11	0.96	0.31	0.18	0.03	0.16	0.13	--	--
69	M	0.66	0.32	1.30	0.23	3.10	0.14	0.64	0.05	0.17	0.11	0.42	0.18	0.08	0.03	0.08	0.07	0.05	0.04
72	M	2.00	0.32	11.45	0.13	19.60	0.15	4.05	0.05	1.05	0.08	1.07	0.14	0.22	0.02	0.18	0.05	0.04	0.02
72	M	1.64	0.16	8.90	0.16	15.40	0.10	4.85	0.16	1.06	0.03	--	--	0.25	0.01	--	--	0.06	0.02
73	M	2.72	0.24	13.40	0.11	29.40	0.07	--	--	1.12	0.04	1.39	0.15	0.20	0.01	0.10	0.07	0.04	0.03
75	F	3.44	0.56	9.70	0.28	16.20	0.26	5.75	0.11	0.90	0.09	1.02	0.32	0.31	0.05	--	--	0.05	0.02
75	M	3.60	0.32	19.80	0.19	30.80	0.16	6.95	0.13	2.10	0.15	3.04	0.17	0.25	0.03	0.40	0.05	0.07	0.03
75	M	1.88	0.26	13.60	0.16	16.00	0.15	4.70	0.06	1.72	0.04	1.24	0.15	0.28	0.02	0.40	0.05	--	--
75	M	1.80	0.18	15.60	0.11	18.00	0.06	3.90	0.10	--	--	1.30	0.08	0.25	0.02	0.26	0.03	--	--
76	M	3.04	0.31	15.00	0.14	21.00	0.12	--	--	1.30	0.04	1.70	0.14	0.26	0.02	0.26	0.04	0.39	0.04
79	M	3.60	0.36	13.40	0.39	18.20	0.19	6.95	0.22	1.84	0.15	2.10	0.40	0.39	0.08	0.40	0.13	0.58	0.09
79	M	2.16	0.36	9.60	0.36	21.40	0.14	4.70	0.14	1.14	0.11	1.60	0.33	0.21	0.05	0.25	0.05	0.63	0.05
79	M	3.60	0.36	11.80	0.15	24.00	0.15	5.40	0.12	1.18	0.06	2.50	0.21	0.27	0.02	0.27	0.05	--	--
82	M	3.32	0.20	14.00	0.10	46.40	0.09	12.80	0.03	2.10	0.05	1.60	0.20	0.35	0.01	0.64	0.03	0.07	0.01
85	M	3.60	0.33	24.80	0.20	42.50	0.15	11.50	0.08	2.72	0.09	2.65	0.23	0.33	0.03	0.30	0.05	0.00	0.02
86	M	4.12	0.41	15.40	0.33	36.50	0.13	10.60	0.19	--	--	2.40	0.29	0.24	0.05	0.31	0.12	0.06	0.05
86	M	3.80	0.58	10.60	0.47	29.00	0.34	9.50	0.20	1.72	0.16	2.00	0.35	0.32	0.08	0.26	0.10	0.12	0.05
93	M	5.50	0.35	20.40	0.11	40.00	0.20	11.40	0.11	2.28	0.06	2.80	0.17	0.53	0.02	0.37	0.07	0.61	0.04
96	M	3.00	0.32	9.60	0.22	27.00	0.19	7.00	0.12	1.54	0.02	1.65	0.27	0.32	0.02	0.31	0.05	0.05	0.04
97	M	3.90	0.56	23.20	0.33	41.00	0.28	10.00	0.23	1.54	0.12	3.00	0.29	0.32	0.04	--	--	--	--
101	M	4.80	0.39	30.60	0.24	77.00	0.19	13.80	0.16	2.04	0.14	3.05	0.28	0.30	0.05	0.52	0.05	0.16	0.05
102	M	5.80	0.50	39.20	0.27	77.00	0.22	11.40	0.12	3.00	0.11	3.95	0.27	0.38	0.06	0.70	0.08	0.57	0.05
104	M	3.90	0.39	--	--	39.50	0.39	11.40	0.12	2.10	0.09	2.40	0.27	0.34	0.03	0.64	0.05	0.14	0.04
112	M	5.65	0.35	15.60	0.15	56.00	0.15	12.80	0.12	1.74	0.05	3.95	0.16	0.44	0.03	--	--	0.24	0.04
112	M	6.50	0.58	21.00	0.28	37.00	0.26	11.20	0.19	2.00	0.15	2.10	0.28	0.32	0.03	0.41	0.08	0.12	0.05
115	F	0.80	0.46	4.80	0.30	6.00	0.19	1.40	0.12	0.44	0.11	0.60	0.23	0.15	0.03	0.15	0.10	0.05	0.04
128	F	1.18	0.66	5.60	0.21	9.00	0.28	4.10	0.18	0.56	0.10	0.60	0.19	0.20	0.07	0.35	0.29	0.05	0.04
135	F	1.68	0.41	3.40	0.22	9.00	0.26	3.60	0.22	0.88	0.17	1.25	0.30	0.35	0.07	0.33	0.20	0.10	0.05
140	F	1.82	0.65	5.20	0.35	7.50	0.37	6.20	0.39	0.84	0.30	1.55	0.58	0.35	0.15	0.24	0.11	0.13	0.11
149	F	0.84	0.36	2.80	0.34	4.00	0.25	2.90	0.29	0.80	0.21	1.10	0.41	0.38	0.09	0.23	0.19	0.09	0.06
155	F	7.20	0.86	20.40	0.42	57.00	0.37	17.60	0.46	2.24	0.39	3.85	0.65	0.59	0.14	0.84	0.43	0.40	0.09
181	F	4.00	0.67	5.60	0.68	26.00	0.58	9.70	0.58	1.46	0.28	3.45	0.84	0.35	0.15	0.39	0.17	0.53	0.09
188	F	4.00	0.65	15.40	0.42	48.50	0.26	7.30	0.30	0.84	0.21	2.30	0.38	0.50	0.09	--	--	0.45	0.02
190	F	3.90	0.42	8.60	0.23	24.50	0.24	9.50	0.25	0.96	0.15	1.75	0.31	0.46	0.08	0.48	0.10	0.11	0.05
222	F	5.30	0.51	16.00	0.46	51.00	0.35	17.40	0.21	1.54	0.21	3.25	0.74	0.66	0.08	--	--	0.19	0.02
260	F	8.40	0.92	16.00	0.58	36.50	0.56	13.20	0.45	1.96	0.24	3.05	0.82	0.69	0.22	1.60	0.25	--	--
342	F	10.00	1.02	18.80	0.76	76.00	0.86	16.20	0.66	2.72	0.47	4.50	0.98	0.96	0.34	2.15	0.65	--	--
Mean 106		3.12	0.40	11.58	0.26	26.33	0.22	6.93	0.18	1.27	0.12	1.83	0.30	0.32	0.06	0.40	0.11	0.18	0.04

Table 2.--Correlation coefficients for body weight and tissue for males and females for total and organic mercury.

Muscle	Liver	Kidney	Spleen	Stomach	Pyloric caecum	Gill	Gonad	Blood
Body weight/male--Total mercury								
0.898**	0.765**	0.830**	0.884**	0.773**	0.828**	0.696**	0.751**	0.318
Body weight/female--Total mercury								
0.834**	0.694**	0.795**	0.759**	0.822**	0.820**	0.897**	0.947**	0.575**
Body weight/male and female--Organic mercury								
0.794**	0.762**	0.865**	0.837**	0.812**	0.859**	0.877**	0.823**	0.358*

*P<0.05
**P<0.01

Figure 1 Total and organic Hg in muscle vs Body weight

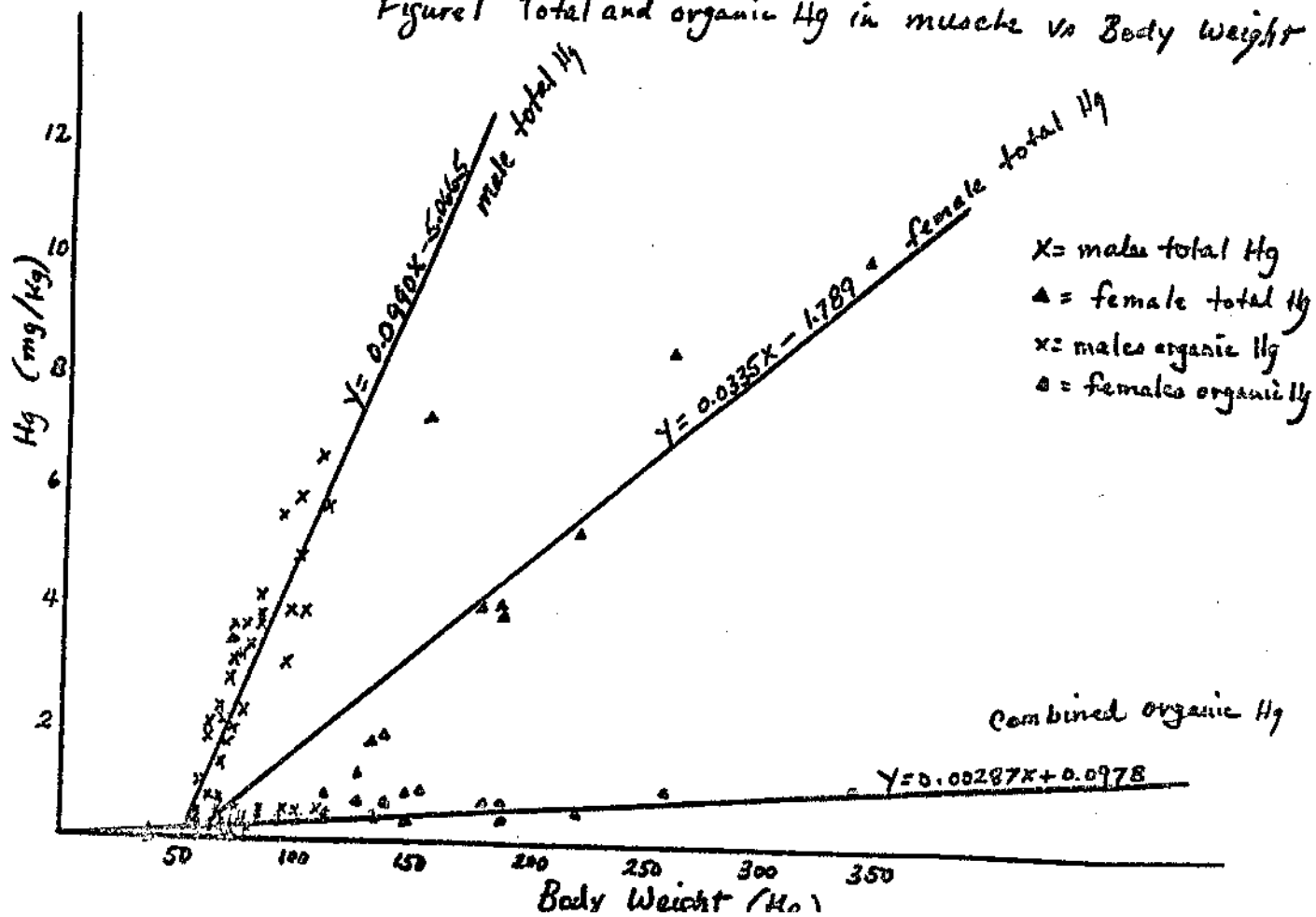
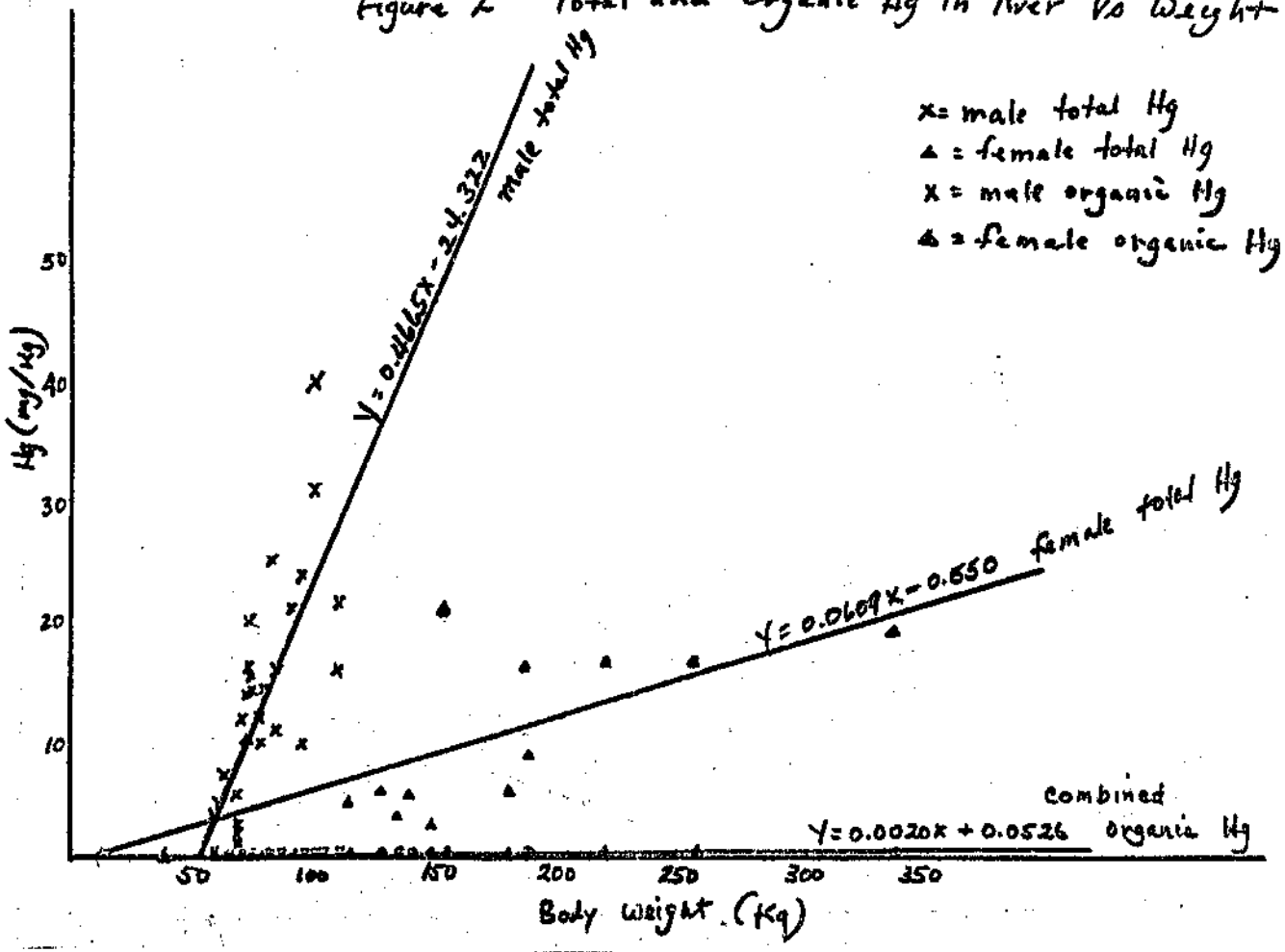


Figure 2 Total and organic Hg in liver vs weight



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Date: March 28, 1975

Reply to Attn. of:

To: Richard S. Shomura, Director, Honolulu Laboratory, F142

From: Tamio Otsu, Chief, Tuna Assessment and Development Investigations

Subject: Trip Report: Trip to Japan, January 31-February 22, 1975

My itinerary on this trip to Japan was as follows:

January 31 - 1345, departed Honolulu via PAA 831.

February 1 - 1740, arrived Tokyo.

2-9 - In Shimizu, Shizuoka Prefecture. Attended Japanese Tuna Research Conference, visited staff members of Far Seas Fisheries Research Laboratory, Tokai University, Faculty of Marine Science and Technology, eel culture farms in Hamamatsu, and the Shizuoka Prefectural Warm Water Utilization Research Center in Hamaoka City.

10-12 - In Kochi City, Kochi Prefecture. Visited with staff members of the Nansei Regional Fisheries Research Laboratory.

13-15 - In Tokyo. Visited Federation of Japan Tuna Fisheries Co-operative Associations, Sanyo Hydrographic Survey Co., American Embassy, etc.

16-17 - In Sendai. Visited the Tohoku Regional Fisheries Research Laboratory in Shiogama City.

18-21 - In Tokyo. Visited the Overseas Fishery Cooperation Foundation, the Japan Marine Fisheries Resource Research Center, Iwatani & Co., Ltd., and met with personnel of the Universal Marine Consultant Co., Nichiro Gyogyo Kaisha, Bumble Bee Seafoods Company, University of Tokyo, etc.

22 - 2230, departed Tokyo via PAA 830.

- 1000, arrived Honolulu.

This trip report is arranged by subject matter. The following subjects are covered:

A. The Japanese Tuna Research Conference

B. The Japanese tuna fishery, its present dilemma

C. Purse seining in the western Pacific

D. Japanese southern water skipjack tuna fishery, July 1974-January 1975

E. Skipjack tuna fishery survey in Micronesia

F. Capturing skipjack tuna live bait on the high seas

G. Bluefin tuna rearing experiments in Japan

H. Use of live bigeye scad, Trachurus japonicus, as longline bait

I. Antarctic krill

J. Unusual abundance of eel (unagi) elvers

K. Japanese coastal fishermen encounter problems with Soviet fishermen

L. Miscellaneous

1. Sardines
2. Building boom continues for large skipjack tuna vessels
3. Roback automatic fishing machines

M. List of persons contacted during trip

A. THE JAPANESE TUNA RESEARCH CONFERENCE

The Japanese Tuna Research Conference is convened each year, generally in February, to bring together representatives of various organizations conducting work on tunas, to discuss the previous year's accomplishments and to consider plans for future work. It is conducted entirely in the Japanese language, but certain foreign institutions are invited to send representatives. The Inter-American Tropical Tuna Commission (IATTC) and the Southwest Fisheries Center have sent representatives to most of the recent conferences.

The Conference this year was held again at the Chuo Kominkan (Civic Center) of Shimizu City, Shizuoka Prefecture, on February 4-6, 1975. In attendance were about 200 persons representing the tuna industry

(prefectural and national fisheries cooperatives), national and prefectural fisheries agencies, fisheries high schools, and universities. The IATTC was represented by its Director, Dr. James Joseph, who presented a summary of the work of the IATTC through an interpreter, Dr. Ichiro Yamanaka. The IATTC reports are of interest to the participants since Japan is a member of the Commission. I spoke in Japanese on the results of our project to transport anchovy from California to Hawaii to augment the Hawaiian bait supply and help expand the local skipjack tuna fishery. This talk was well received and generated a great deal of discussion. This was the seventh time I had participated in the annual tuna conference.

B. THE JAPANESE TUNA FISHERY, ITS PRESENT DILEMMA

The Japanese tuna industry this year is facing a major depression, a situation which has developed following the "oil shock" of 2 years ago and the subsequent inflationary trend. The problems are compounded by generally declining tuna longline catch rates and depressed tuna prices. When compared with the "mercury shock" of about 4 years ago, or the "canned tuna decomposition" problem of 3 years ago, both of which caused heavy losses to the tuna industry in Japan, the present situation is considered far more serious. Some sources predict that perhaps as many as 20% to 30% of the tuna longline vessels will soon become inactive, many going into bankruptcy. The problem and causes are complex, but some of the more obvious reasons for the present state are these:

1. Tripling of oil prices in the last year.

2. Increased cost of fishing gear (particularly those oil-related products) and provisions needed for extended fishing operations.

3. Generally declining catch rates throughout the areas of operation.

4. Depressed fish prices in Japan.

5. The virtual closing of the U.S. markets to Japanese exports of albacore, yellowfin and skipjack tunas.

These problems are not restricted to Japan alone; they affect Korea and Taiwan and other tuna fishing nations as well. Korea and Taiwan may be even more affected since their longline vessels fish strictly for the export market, whereas a segment of the Japanese longline fleet fishes primarily for the domestic sashimi market. This is not to say that vessels fishing for the domestic market are not also having their problems at this time.

The increased oil prices, having gone from $40 to $50 per ton a year or so ago to the present $110-$130 per ton, have resulted in a daily

fuel cost of more than $400 for vessels that burn about 3.5 tons of fuel per day (e.g. many of the Korean vessels in the 220-280 ton category). Added to this is the high cost of fishing gear and other provisions needed for extended fishing trips. In the meanwhile, catch rates have been declining in all oceans where these longline vessels fish. Reports indicate that catches in some areas have now fallen to less than 1 ton per day of fishing. A recent report from American Samoa shows that albacore catches have fallen far below a ton a day. It is easy to see that ex-vessel revenues of $500-$550 per day will not pay for the present high cost of operations.

The longline vessels (Korean and Taiwanese) based in American Samoa have had to extend their fishing grounds farther and farther away from the base. Fishing trips have increased in length to about 6 months for the larger vessels of about 250 tons, while 140-ton vessels are out 3 to 4 months. And still many of the vessels are returning to port with less than a full load. A source believed that about 30 Korean vessels will soon leave American Samoa, probably to return to Korea.

Probably most serious of all is the virtual closure of the American market to Japanese exports of albacore, yellowfin and skipjack tunas. Japanese sources reported that the U.S. canners have built up a large inventory of canned tuna as well as raw materials, and that they are no longer importing tunas from Japan (and presumably from other countries) or are offering prices for these fish that are agonizingly low. They attribute the large inventory to such causes as 1) declining meat prices in the U.S., and 2) bad publicity given "contaminated" canned tuna recently, both resulting in lower tuna consumption in the U.S. Some expressed hope that U.S. consumption of fish would increase during the Lenten Season and U.S. canners would then resume importing.

During my visit the newspapers and weekly magazines in Japan were giving considerable coverage to the financial problems of the Nichiro Gyogyo Kaisha. They reported that poor management had caused the company to overextend its operation to the point of near-bankruptcy. The company president and others in positions of leadership were removed and replaced by bank officials, and many of the executives were demoted in rank. The company reported that tuna and skipjack operations were to be terminated, and that 633 employees connected with this division would be released.

There are 13 Nichiro-owned skipjack tuna fishing vessels based in Tema, Ghana. The company decided to tie up all of the vessels, return the men to Japan, and terminate their employment. Subsequently, however, the powerful Seamen's Union in Japan has apparently forced Nichiro Kaisha to retract these plans (according to a news article dated February 20). One company official told me that these 13 skipjack tuna vessels had been built especially for operation in the waters off West Africa and are not suitable for Japanese waters. They are

built with very low freeboard, and fishermen fish off the sides and stern, but not at the bow as on traditional Japanese skipjack tuna vessels. The disposition of these vessels is a big problem, he said.

The reasons given for the problems encountered in the Ghana operation were 1) low prices offered for skipjack and yellowfin tunas by the U.S. canner; 2) ICCAT regulations setting forth minimum sizes of yellowfin tuna to be taken off West Africa, which make operations difficult; and 3) increased cost of operations. Certainly this must be a simplified explanation of the problems faced by the Nichiro Kaisha, but it points to the generally depressed condition throughout the tuna industry.

During the "mercury shock" when the tuna fishery was faced with plummeting fish prices and decreased consumption, the Federation of Japan Tuna Fisheries Co-operative Associations (Nikkatsuren) did much to ease the problem. The Nikkatsuren carried out an intensive promotional campaign to assist in the recovery. They also purchased considerable amounts of fish, particularly albacore, and held them in freezers to stabilize prices. As a countermeasure to today's problem where Japan is unable to export its fish, Nikkatsuren apparently is planning construction of more freezers in order to purchase and store away the fish until the present situation eases.

Another serious problem faced by the tuna industry (particularly the producers) is that they have no direct control over prices. The depressed prices are attributable, in part, to the import of tunas into the Japanese markets directly by foreign fishing vessels. Vessels from Korea, Taiwan, and those flying the Panamanian flag (but manned mostly by Koreans) are delivering fish to Japanese ports. Such imports of fish amounted to 60,000 tons last year and the amount has increased year after year. This situation is apparently unavoidable under present Japanese law. Because most of these imports are from Korea, negotiations were carried out recently to see if they would limit the amount of tuna delivered directly. The Koreans have apparently agreed to limit the number of vessels delivering directly to Japan to the present 160 vessels, or approximately a third of the Korean longline fleet. No agreement was reached on the amount to be delivered, however.

The foregoing account is based on scattered information provided by numerous sources and some of the statements are unverified. It is certain that the problems facing the Japanese tuna industry are given here in a most simplified form. Nevertheless, the important message is that the people in the industry consider the situation most serious, and that the Japanese word "fukyō" (depression) is most commonly used to describe the Japanese tuna fishery today.

C. PURSE SEINING IN THE WESTERN PACIFIC

For several years now, the Japanese have been sending chartered seiners to the western equatorial Pacific to conduct exploratory purse seining for skipjack and yellowfin tunas. Initially, the Japan Fisheries Agency undertook this work, and it was later carried on by the Japan Marine Fisheries Resource Research Center (JAMARC). It has now come to the stage where the Japanese consider purse seining to be commercially feasible, and several commercial seiners are operating in the western Pacific and in the Coral Sea. Catches are averaging close to 10 tons per set; the vessels are achieving success in catching fish in 80% of the sets made. The average catches are lower than in the eastern tropical Pacific purse seine fishery, but these Japanese seiners are considerably smaller than the average U.S. seiners, most being from 250 to 500 gross tons in size.

The Japanese initially found it extremely difficult to successfully set around the schools as the fish tended to escape before the net could be pursed. They also found that certain types of schools were more difficult to capture than others, and that the time of day seemed to make a great difference. Today, the Japanese believe that they can achieve success under the following conditions:

1. Schools must be associated with drifting objects (driftwood, etc.).
2. Sets must be made either early in the morning or at dusk.
3. Nets must be larger than those used in the eastern Pacific.

Consequently, the fishing masters on the seiners constantly search for drifting objects and associated schools, and when such a school is found they often follow it until early morning, tracking it overnight by marking the drifting object with radio buoy and lights, or dusk before making their set.

The purse seine nets used in the western equatorial Pacific (area north of Papua New Guinea) and in the Coral Sea are larger than those used in the eastern Pacific. The following examples of net sizes are provided:

Vessel	Area used	Size of net
Nippon Maru	Eastern Pacific and West Africa (U.S.-type seiner)	110 m deep x 1,025 m long or 118 m deep x 1,350 m long
Hayabusa Maru	North of Papua New Guinea	220 m deep x 1,600 m long
No. 58 Tokiwa Maru	North of Papua New Guinea	250 m deep x 1,960 m long

Vessel	Area used	Size of net
No. 55 Hakuryu Maru	Japan coastal waters for skipjack and yellowfin tunas	150 m deep x 1,500 m long or 220 m deep x 1,500 m long
Wakaba Maru	do.	220 m deep x 1,500 m long
No. 23 Taikei Maru	do.	200 m deep x 1,500 m long
No. 28 Kohoku Maru	do.	261 m deep x 2,025 m long
No. 85 Seishin Maru (two-boat seining)	do.	350 m deep x 1,700 m long
No. 7 Konpira Maru (two-boat seining)	do.	240 m deep x 2,400 m long

The results of the most recent charter cruises were reported by JAMARC as follows:

Vessel: Fukuichi Maru, 500 tons
Survey area: Around the Caroline archipelago
Survey period: June 18-November 30, 1974

First cruise

Departed Yaizu on June 20. Started survey southward beginning around the Bonin Islands, and worked as follows: June 24-25, south of Hahajima; July 1-8, west of the Carolines at 6°-7°N, 141°-143°E; July 9-15, east of Palau; July 16-August 2, southeast of Palau at 3°-4°N, 136°-138°E; August 7-16, Western Carolines at 4°-6°N, 142°-147°E.

Made a total of 27 sets and caught 229 tons of skipjack tuna, and 53 tons of yellowfin tuna for a total of 282 tons. The catch per set amounted to 10.4 tons; the maximum catch was 32 tons per set. A full load was obtained on August 16 so the survey was terminated and the vessel returned to Yaizu.

Second cruise

Fukuichi Maru departed Yaizu on September 2 en route to fishing grounds. Started fishing in waters southeast of Palau. Fishing was not as good as on the earlier cruise. Worked in area 0°-8°N, 135°-145°E, and on October 7 arrived in Guam, where they unloaded 22 short tons of skipjack tuna. Only 10 sets had been made for a catch of 22 tons of skipjack tuna and 33 tons of yellowfin tuna, a total of 55 tons.

Third cruise

Fishing commenced on October 12 in the area 4°-8°N, 145°-151°E (eastern Carolines). Three sets resulted in 18 tons of fish. In waters southeast of Palau at 2°-5°N, 140°-145°E, 14 sets resulted in 127 tons of fish. Up to this point, fishing conditions were as poor as on second cruise. Only two sets had resulted in about 10 tons per set; others were in the order of 1 to 3 tons per set. However, toward the end of the survey period, on November 6, a catch of 20 tons was made at 2°N, 144°E. Since it looked as though fishing would improve after this, the cruise period was extended. The vessel fished until November 18 and returned to Yaizu on November 26.

During the charter period, the Fukuichi Maru fished 53 schools associated with drifting objects, and caught 168 tons of yellowfin tuna, 320 tons of skipjack tuna, and 12 tons of miscellaneous species, for a total of 500 tons. The target catch of 468 tons was exceeded by 32 tons.

According to JAMARC, there are now five or six commercial seiners working in the Coral Sea (15°S, 147°E) for yellowfin tuna.

The average catches as well as the success rate of seining in the western equatorial Pacific must be considered in the light of fishing effort. If vessels avoid making sets during midday, this cuts down fishing effort considerably. The size of the seiners (small relative to U.S. seiners) may be the saving grace in this particular fishery.

Because Japanese seiners are so completely dependent upon drifting objects in order to make successful sets on skipjack and yellowfin tunas in the western equatorial Pacific, Japanese researchers would like to develop artificial drifting objects that will aggregate tunas for seining. Studies have already indicated that there is promise in this approach.

D. JAPANESE SOUTHERN WATER SKIPJACK TUNA FISHERY, JULY 1974-JANUARY 1975 (From a preliminary report prepared by Mr. Tamotsu Tanaka, Yaizu Branch, Tohoku Regional Fisheries Research Laboratory.)

July-August 1974 (See corresponding charts.)

Because fishing was poor in the Marianas area, many of the larger vessels (larger than 299 tons) went south and fished around lat. 3°-6°N, long. 143°-158°E, as well as around lat. 1°N, long. 168°-173°E. Initially, the catches ranged from 3 to 20 tons per day, averaging between 5 and 7 tons, with considerable variation from vessel to vessel. The first part of August the fishing grounds east of long. 160°E became very unproductive. Vessels shifted westward to lat. 2°-6°N, long. 145°-155°E, where fishing was somewhat better; there some