MERCURY CONTENT OF OREGON GROUNDFISH[1]

E. A. CHILDS AND J. N. GAFFKE[2]

ABSTRACT

The mercury content of Oregon groundfish was determined. The mercury content of rex sole, *Glyptocephalus zachirus;* Dover sole, *Microstomus pacificus;* petrale sole, *Eopsetta jordani;* English sole, *Parophrys vetulus;* sand sole, *Psettichthys melanostictus;* starry flounder *Platichthys stellatus;* canary rockfish, *Sebastes pinniger;* flag rockfish, *Sebastes rubrivinctus;* yellowtail rockfish, *Sebastes flavidus;* rougheye rockfish, *Sebastes aleutianus;* sablefish, *Anoplopoma fimbria;* lingcod, *Ophiodon elongatus;* Pacific hake, *Merluccius productus;* and arrowtooth flounder, *Atheresthes stomias;* was significantly lower than 0.50 ppm mercury. All spiny dogfish, *Squalus acanthias,* samples contained >0.50 ppm. No highly significant relationship in those species appropriately examined between (a) catch location, (b) time of catch, (c) weight and length of fish, or (d) sex and mercury content was observed.

Although the possibility of seafood organisms containing large amounts of mercury has been of recent concern, no systematic survey of a major American marine fishery has been published. A number of freshwater studies in the United States (Willford, 1971), Canada (Uthe and Bligh, 1971; Bligh, 1972), England (Taylor, 1971), and Sweden (Ackefors, 1971), and marine studies in Canada (Zitko et al., 1971) and Sweden (Ackefors, 1971) are found in the literature. The present study was undertaken to determine the extent of mercury contamination of commercially important groundfish in the Oregon fishery, with data being obtained which would allow evaluation of the effect of species, location of catch, size of fish, time of catch, and sex on mercury content.

MATERIALS AND METHODS

Fish were obtained from each of the three major fishing areas off the Oregon Coast (Figure 1). Specimens were immediately dissected, packed in evacuated film, and held at -40°C until mercury analyses were performed. Five-gram samples of the epaxial musculature on both the right and left sides were taken for analysis, and thoroughly ground and mixed. The digestion apparatus consisted of a 250-ml flat-bottom distilling flask connected to a 45-cm cold-water condenser. The homogeneous samples were digested for 10 min in 20 ml of 1:1 (v/v) concentrated sulfuric and nitric acid, with 5-10

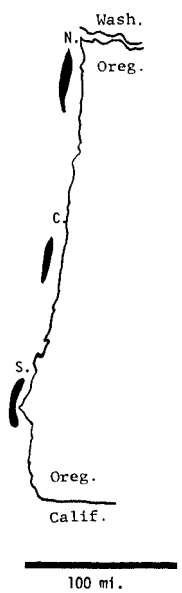

FIGURE 1.—Commercial fishing areas along Oregon coast from which samples for mercury analysis were obtained. N. - Northern coast C. - Central coast S. - Southern coast.

[1] Technical Paper No. 3422, Oregon State University Agricultural Experiment Station.

[2] Seafoods Laboratory, Department of Food Science and Technology, Oregon State University, Astoria, OR 97103.

Manuscript accepted December 1972.
FISHERY BULLETIN: VOL. 71, NO. 3, 1973.

mg V_2O_{53} added to catalyze the digestive reaction. After digestion, 10 ml of distilled, deionized water were added; the samples were allowed to cool; and 3-5 drops of hydrogen peroxide solution (30% w/w) and another 10 ml of deionized, distilled water were added. The digests were then brought to 100 ml with distilled, deionized water. The amount of mercury in the digested samples was determined by flameless atomic absorption spectroscopy (AAS) (Hatch and Ott, 1968). The method was accurate (>95% recovery) and precise (standard error of mean for duplicates <5% of mean) in this laboratory for samples containing 0.05-6.0 μg mercury (i.e., based on a 5-g sample, the method is precise and accurate for 0.01-1.2 ppm Hg). The data obtained were a measure of total mercury, and stated in ppm wet weight.

Fish were obtained at various times from August 1971 to June 1972. All data represent catches from at least two different time periods. Duplicate analyses of samples were performed, and if the duplicates varied by greater than 0.05 ppm, the data were discarded, and new analyses performed. Reagent purity, glassware cleanliness, and AAS performance were scrutinized daily.

RESULTS AND DISCUSSION

The mercury content of groundfish caught off the Oregon coast is summarized in Table 1. The only species with a mean mercury content greater than the U.S. Food and Drug Administration's guideline of 0.50 ppm was spiny dogfish, *Squalus acanthias*. The *t*-function significance tests indicated the mean mercury content of arrowtooth flounder, *Atheresthes stomias*; sablefish, *Anoplopoma fimbria;* Pacific hake, *Merluccius productus*; starry flounder, *Platichthys stellatus*; rex sole, *Glyptocephalus zachirus*; Dover sole, *Microstomus pacificus*; petrale sole, *Eopsetta jordani*; English sole, *Parophrys vetulus*; sand sole, *Psettichthys melanostictus*; canary rockfish, *Sebastes pinniger*; flag rockfish, *Sebastes rubrivinctus*; and rougheye rockfish,

TABLE 1.—Mercury content of Oregon groundfish.

Species	Number of samples	Mean Hg content (ppm) ($\bar{x}$)	Range	Standard deviation	99% confidence interval (ppm)	*t*-function sig. levels for $\bar{x}$ <0.3 ppm	*t*-function sig. levels for $\bar{x}$ <0.5 ppm
Rex sole, *Glyptocephalus zachirus*	82	0.119	0.05-0.24	0.050	0.10-0.14	0.005	0.005
Dover sole, *Microstomus pacificus*	46	0.122	0.01-0.29	0.076	0.09-0.17	0.005	0.005
Petrale sole, *Eopsetta jordani*	94	0.114	0.05-0.32	0.045	0.10-0.13	0.005	0.005
English sole, *Parophrys vetulus*	128	0.108	0.06-0.21	0.032	0.10-0.12	0.005	0.005
Sand sole, *Psettichthys melanostictus*	48	0.083	0.03-0.16	0.036	0.06-0.10	0.005	0.005
Starry flounder, *Platichthys stellatus*	42	0.235	0.08-0.50	0.102	0.18-0.29	0.005	0.005
Canary rockfish, *Sebastes pinniger*	18	0.197	0.08-0.50	0.123	0.08-0.32	0.025	0.005
Yellowtail rockfish, *Sebastes flavidus*	24	0.371	0.19-0.53	0.095	0.30-0.45	NS[1]	0.005
Flag rockfish, *Sebastes rubrivinctus*	40	0.136	0.06-0.43	0.091	0.08-0.19	0.005	0.005
Rougheye rockfish, *Sebastes aleutianus*	30	0.080	0.06-0.11	0.012	0.07-0.09	0.005	0.005
Lingcod, *Ophiodon elongatus*	48	0.351	0.06-0.73	0.240	0.26-0.49	NS	0.010
Sablefish, *Anoplopoma fimbria*	52	0.138	0.03-0.65	0.148	0.07-0.21	0.005	0.005
Pacific hake, *Merluccius productus*	24	0.102	0.06-0.18	0.035	0.07-0.13	0.005	0.005
Arrowtooth flounder, *Atheresthes stomias*	26	0.154	0.01-0.33	0.089	0.08-0.22	0.005	0.005
Spiny dogfish, *Squalus acanthias*	88	0.602	0.20-1.14	0.275	0.52-0.71	NS	NS

[1] NS means not significant.

[3] The use of V_2O_5 to catalyze the digestion was originally developed by Robert Munns, Food and Drug Administration, Denver, Colo.

Sebastes pinniger; flag rockfish, *Sebastes rubrivinctus*; and rougheye rockfish, *Sebastes aleutianus* were significantly lower than 0.30 ppm at the 0.005 level. The means of all species were significantly lower than 0.50 ppm at the 0.005 significance level, with the exception of lingcod (the significance level was 0.01) and spiny dogfish (not significantly lower). Spiny dogfish were further investigated to determine if there was any difference in mercury content with regard to sex. The mean of all male samples was 0.58 ppm with a 99% confidence interval of 0.41-0.76 ppm, and the mean for female samples was 0.65 ppm with a 99% confidence interval of 0.53-0.77 ppm. The confidence interval ranges overlapped considerably and *t*-function analysis revealed no significant difference in mercury content based on sex.

Numerous species of soles and rockfishes were obtained. The mercury content of all soles was similar suggesting that their degree of exposure and metabolism of mercury may be similar. However, the mercury content of rockfishes varied widely, with yellowtail rockfish having a 99% confidence interval of 0.30-0.45 ppm, canary rockfish 0.08-0.32 ppm, and flag rockfish 0.08-0.19 ppm. These data make it difficult to predict the mercury content of marine fish on a phylogenetic basis.

For species of fish which were available along the entire coast, data were analyzed separately for each area (Table 2). There was variation among the coastal areas. Lingcod from the northern coast had a mean mercury content of 0.403 ppm, from the central coast 0.274, and from the southern coast 0.400. Conversely, sand sole from the central coast had more mercury than samples from the southern coast and Dover sole from the northern coast was lower than either of the other coastal areas. Thus, no relationship is immediately discernible between catch area and mercury content.

In freshwater fish it has been noted that there is a correlation between length and mercury content (Bligh, 1972). All present data were scrutinized by regression analysis to determine if a similar correlation existed in Oregon groundfish (Table 3). No highly discernible linear correlation (i.e., correlation coefficient greater than 0.90) between either length or weight and mercury content was noted. Graphs of mercury concentration vs. length are pre-

TABLE 2.—Mercury content of Oregon groundfish according to coastal area.

Species	Northern coast		Central coast		Southern coast	
	Mean	99% confidence interval	Mean	99% confidence interval	Mean	99% confidence interval
Rex sole	0.122	0.10-0.14			0.122	0.08-0.16
Dover sole	0.076	0.06-0.09	0.094	0.04-0.15	0.193	0.13-0.25
Sand sole			0.102	0.07-0.13	0.060	0.04-0.08
Starry flounder	0.266	0.18-0.35	0.194	0.12-0.27		
Lingcod	0.403	0.27-0.53	0.274	-0.21 to 0.76	0.400	-1.63 to 2.42
Sablefish	0.143	0.06-0.22			0.098	-0.07 to 0.27

TABLE 3.—Regression analysis of mercury content of Oregon groundfish vs. length and weight.

Species	Length correlation coefficient	Length range (cm)	Weight correlation coefficient	Weight range (kg)
Rex sole	0.546	27.0- 39.0	0.638	0.09- 0.46
Dover sole	0.254	34.0- 56.0	-0.065	0.30- 1.95
Sand sole	0.675	29.0- 50.0	0.609	0.22- 1.30
Starry flounder	-0.012	23.0- 55.5	-0.012	0.30- 2.80
Canary rockfish	0.307	40.0- 51.0	0.516	1.40- 3.20
Yellowtail rockfish	-0.517	39.0- 49.0	-0.443	1.30- 2.52
Flag rockfish	0.659	31.0- 44.0	0.479	0.22- 0.93
Rougheye rockfish	0.372	32.0- 37.0	0.353	0.55- 0.80
Lingcod	0.572	43.0-102.0	0.585	0.85-10.62
Sablefish	0.793	35.0- 88.0	0.728	0.38- 6.35
Pacific hake	0.462	26.5- 64.0	0.241	0.75- 1.25
Arrowtooth flounder	0.318	41.9- 53.3	0.230	0.64- 1.25
Spiny dogfish	0.469	65.0-108.6	0.486	0.42- 5.60

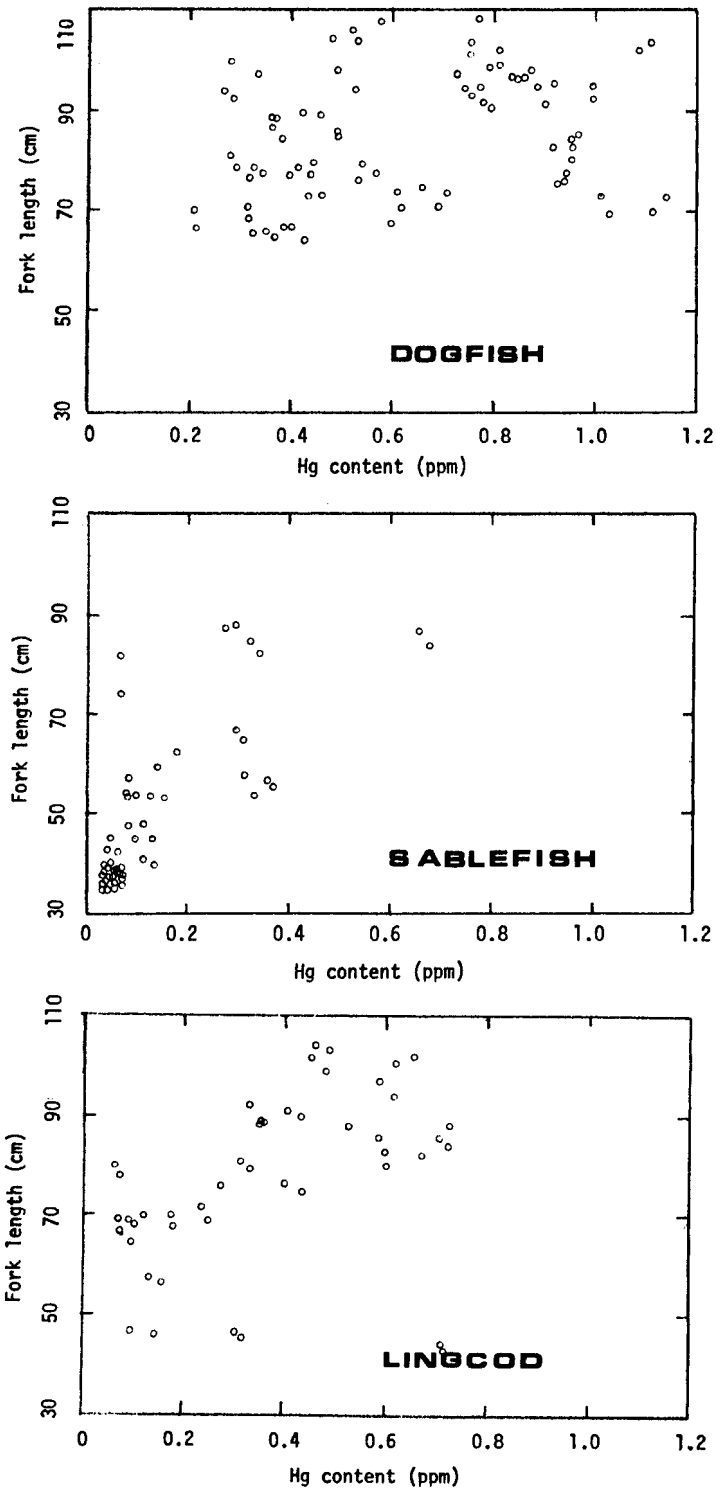

FIGURE 2.—Relation of mercury content to fork length in spiny dogfish, sablefish, and lingcod.

sented for samples of spiny dogfish, sablefish, and lingcod in Figure 2. The graphs of spiny dogfish and lingcod show a random spread. Since this study was concerned with commercially important fish, no attempt was made to acquire extremely small or large individuals. Naturally, the lack of linear correlation observed cannot be extended beyond the noted size ranges. It was thought there might be correlations within specific catch areas which were obliterated when the data were pooled; however, regression analysis of each catch area also showed no highly discernible linear correlation between length or weight and mercury content.

Fish taken at different times of the year did not contain greatly different amounts of mercury, with the exception of sablefish. In this species, 20% of the samples taken in August 1971 had a mercury content greater than 0.50 ppm, while samples obtained later in the study contained no fish with greater than 0.20 ppm mercury.

When these data were compared with those for the Bay of Fundy and Nova Scotia Banks (Zitko et al., 1971), Oregon groundfish were found to contain, on the average, slightly more mercury. However, the mean mercury content of Oregon groundfish was less than that reported for a number of Swedish coastal areas (Ackefors, 1971). In summary, Oregon groundfish contain small amounts of mercury, and the 99% confidence intervals suggest there is little probability of normal commercial catch samples exceeding the 0.50 ppm guideline established by the U.S. Food and Drug Administration.

ACKNOWLEDGMENTS

This study was financed in part by the National Oceanic and Atmospheric Administration (maintained by the U.S. Department of Commerce) Institutional Sea Grant No. 04-3-158-4. We thank D. L. Crawford, program director of the Seafoods Laboratory, for his administrative direction; V. L. Parsons for superior technical assistance; and Paul Heikkila, Ken Hilderbrand, Dean Murray, Joe Fenander, Fred Anderson, and the Otter Trawl Commission of Oregon for aid in collecting samples.

LITERATURE CITED

ACKEFORS, H.
1971. III. Effects of particular pollutants. Mercury pollution in Sweden with special reference to conditions in the water habitat. Proc. R. Soc. Lond. B. Biol. Sci. 177: 365-387.

BLIGH, E. G.
1972. Mercury in Canadian fish. Can. Inst. Food Sci. Technol. J. 5:A6-A14.

HATCH, W. R., AND W. L. OTT.
1968. Determination of sub-microgram quantities of mercury by atomic absorption spectrophotometry. Anal. Chem. 40:2085-2087.

TAYLOR, D. J.
1971. Report on a survey of fish products for metallic contamination undertaken in southwest England and south Wales during early 1971. J. Assoc. Public Anal. 9:76-85.

UTHE, J. F., AND E. G. BLIGH.
1971. Preliminary survey of heavy metal contamination of Canadian freshwater fish. J. Fish. Res. Board Can. 28:786-788.

WILLFORD, W. A.
1971. Heavy metals research in the Great Lakes. *In* Prevalence and effects of toxic metals in the aquatic environment, p. 53-65. Proceedings of workshop on toxic metals in water, Water Resources Institute, University of North Carolina, Raleigh.

ZITKO, V., B. J. FINLAYSON, D. J. WILDISH, J. M. ANDERSON, AND A. C. KOHLER.
1971. Methylmercury in freshwater and marine fishes in New Brunswick, in the Bay of Fundy, and on the Nova Scotia Banks. J. Fish. Res. Board Can. 28:1285-1291.