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RADIOACTIVE ZINC (^{65}Zn), ZINC, CADMIUM AND MERCURY IN THE PACIFIC HAKE, *MERLUCCIUS PRODUCTUS* (AYRES), OFF THE WEST COAST OF THE UNITED STATES: A DATA REPORT

By Janakiram R. Naidu
and
Norman H. Cutshall

Supported by
U.S. Atomic Energy Commission
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Data Report 60 Reference 74-9

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OREGON STATE UNIVERSITY

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Date Report 60

School of Oceanography
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TABLE OF CONTENTS

	Page
INTRODUCTION	1
COLLECTION AND STORAGE	1
PREPARATION OF SAMPLES	2
ANALYTICAL METHODS	3
REFERENCE STANDARDS AND INTERCALIBRATIONS	5
REFERENCES	6
DATA	
I. ZINC-65, ZINC, CADMIUM AND MERCURY IN THE PACIFIC HAKE	7
II. MERCURY IN WATER SAMPLES	39
III. REFERENCE STANDARDS AND INTERCALIBRATIONS	49

INTRODUCTION

This report presents the results of analyses of several hundred Pacific Hake, *Merluccius productus*, for zinc (Zn), zinc-65 (^{65}Zn), cadmium (Cd), and mercury (Hg). The fish were collected off the coast of the western United States in 1969-1972. In addition, some data from mercury analyses of fresh and seawater samples collected in 1970-1973 are presented. The contents of this report were used in Mr. Naidu's doctoral thesis (Naidu, 1974). A majority (80%) of the hake samples were collected during July and August, 1969, from 32°N to 48°N along the western coast of the United States.

This study was accomplished under United States Atomic Energy Commission Contract No. AT(45-1)-2227, Task Agreement 12, and is assigned No. RLO-2227-T12-48. Karla McMechan provided great assistance in the preparation of this report.

COLLECTION AND STORAGE

Fish. Most of the samples of Pacific Hake, *Merluccius productus*, were collected by Russian scientists on board PROFESSOR DERYUGIN, in collaboration with the U.S. Bureau of Commercial Fisheries [now, National Marine Fisheries Service (NMFS)] in July and August 1969. Additional samples were collected by NMFS vessels, JOHN N. COBB, BARON and COMMANDO, and by the OSU School of Oceanography CAYUSE and YAQUINA in 1969-1972. Location of sampling stations and a summary of data collected are presented in Section I of the data.

Standard procedures for preserving the fishes were followed on all cruises: fishes were packaged in plastic bags, labelled and immediately frozen at about -10°C. In the laboratory the

fishes were kept frozen at about -25°C until time of analysis.

Water. Marine, estuarine and freshwater samples were collected for mercury analysis in 1971-73 from the OSU vessels YAQUINA and SACAJAWEA. A map of sampling sites and a summary of the data collected are presented in Section II of the data. Surface water samples were collected in a plastic bucket which was cleaned with nitric acid between sampling. Samples at depth were collected with a Van Dorn sampler. Each sample was immediately transferred into a two-liter polyethylene bottle (which had been cleaned with nitric acid), acidified with 15 ml (70%) nitric acid and kept frozen until time of analysis.

PREPARATION OF SAMPLES

Standard length measurements were taken and the fish were prepared for Zn, ^{65}Zn and Cd analyses of entire fish samples and Zn, ^{65}Zn, Cd and Hg analyses of flesh only samples.

Entire Fish: Stomach contents were removed and discarded The entire fish, skeleton included, was cut into small pieces and put into Pyrex™ beakers, previously cleaned with nitric acid and tared.

Fish Flesh: Each fish was skinned while still frozen; the muscle portion (flesh) from both sides was removed, cut into pieces and stored in Pyrex™ beakers, previously cleaned with nitric acid and tared. Approximately 30 g of the flesh of each fish was put into cold storage (~ -25°) for mercury analysis.

Samples were then dried in a hot-air-circulating oven at 90 ±5°C for approximately three days. Dried samples were removed

from the oven and immediately sealed with Saran Wrap™ to prevent moisture absorption. The dry weight was measured and corrected for the weight of the Saran Wrap™ and beaker.

After cooling, the Saran Wrap™ was removed and samples were ashed in a muffle furnace at 400°C. The temperature of the furnace was monitored with a separate thermometer and generally ranged within ±20°C of 400°C. Samples were kept in the oven for 48 hours, by which time a grey-white ash was produced. Air was constantly circulated through the muffle furnace to accelerate the ashing process, since the temperature must be kept well below 600°C (Gorsuch, 1959) to prevent loss of cadmium and zinc. After ashing, samples were removed from the furnace and again sealed with Saran Wrap™ as in the drying stage. Ashed weights were measured and corrected for Saran Wrap™ and beaker.

The ashed samples were ground to a fine powder using a mortar and pestle (cleaned with nitric acid between samples) and packed into 12 ml plastic vials. The vials were then counted for gamma-emitting radionuclides. A sub-sample of ash from each vial was subsequently taken for determination of Zn and Cd.

For mercury determinations the fish-flesh and water samples were digested using oxidizing agents prior to the analysis, as outlined in the following section.

ANALYTICAL METHODS

Zinc-65. The ashed samples were analyzed for ^{65}Zn by gamma-ray spectrometry. The twelve cm^3 plastic vials containing this ash were placed in a 5" x 5" NaI(Tl) well-type detector coupled to a 512-Channel analyzer. Counting times were from 100 to 800 minutes, depending on the level of radioactivity. After subtraction of background, the resultant data were reduced for ^{65}Zn

and ^{40}K by spectrum stripping. No other gamma-emitting radionuclides were detected in the samples. Calibration standards for ^{65}Zn and ^{40}K are certified by the supplier to within $\pm 2\%$.

Zinc and Cadmium. Following radionuclide analysis, subsamples of the ash were analyzed for Zn and Cd by atomic absorption spectrometry. The subsamples were weighed into 25 ml volumetric flasks, dissolved using 70% nitric acid, evaporated to dryness and then dissolved using 0.36N hydrochloric acid. Conventional flame methods were used for Zn analysis of the resultant solution with a Perkin-Elmer Model 303 A.A. Spectrophotometer. For the Cd analysis a Varian Techtron Model 63 Carbon Rod Atomizer coupled to a Varian Techtron Model AA-5R was used. Corrections for non-atomic absorbance were required for Cd determinations.

Details pertaining to the calibration line, absolute sensitivity, detection limit, precision and accuracy for Zn determination have been described by Larsen (1971).

The calibration line for Cd, using Fisher Standards at concentrations of 0.025 ng, 0.05 ng and 0.125 ng Cd, had a correlation coefficient (the Pearson r) of 0.99804. Using this line the absolute sensitivity (weight of an element which produces an absorbance of 0.0044 or 1% absorption) was 1.0×10^{-12}g. The relative standard deviation (RSD) of 10 replicate determinations ranges from 0.7 to 2.2% for standards and from 2 to 3% for samples.

Mercury. Fish-flesh samples were prepared for mercury analysis by digestion with 70% nitric acid and hydrogen peroxide in a reflux system. The water samples were digested in a hot water bath (~90°C) with 70% nitric acid, sulfuric acid, potassium permanganate and potassium persulfate. These are modifications

of the methods used by Buhler et al. (1973) for biological samples, and by the U.S. Environmental Protection Agency (1971) for water samples.

The oxidized samples were reduced in a system as outlined by Buhler et al. (1973) for biological samples and the U.S. EPA (1971) for water samples. Typically the reductant was stannous chloride and sulfate, or hydroxylamine hydrochloride, and the elemental mercury thus formed was volatilized into a 20 cm absorption cell. The sample absorption at 2357 Å was compared to that of standards and the concentration of mercury in the sample was calculated accordingly.

The calibration line for fish-flesh samples had a correlation coefficient of 0.997537, and the RSD ranged from 0.24 to 0.47% for the standards and 1.32% for the samples. Sample homogeneity in the hake flesh had an RSD of 2.35 to 3.69%.

For water samples the calibration line had a correlation coefficient of 0.997208, and the RSD ranged from 2.36 to 3.17% for the standards and from 3.5 to 4.2% for samples. Detection limit in this study was 3.4 ng/l.

REFERENCE STANDARDS AND INTERCALIBRATIONS

The results of intercalibration exercises and standard analyses are presented in Section III. Standard reference materials were analyzed using the same procedures used for samples and, in some cases, also by neutron activation analysis. In all cases good agreement was obtained among analytical methods. Results conform to standard reference data.

REFERENCES

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Larsen, I.L. 1971. Determination of ^{65}Zn specific activity in various tissues of the California sea mussel, *Mytilus californianus*. M.S. Thesis, Oregon State University, Corvallis, Oregon.

Naidu, Janakiram R. 1974. Radioactive Zinc (^{65}Zn), Zinc, Cadmium and Mercury in the Pacific Hake, *Merluccius productus* (Ayres), off the West Coast of the United States. Ph.D. Thesis. Oregon State University, Corvallis, Oregon.

U.S. Environmental Protection Agency. 1971. Methods for chemical analysis of water and wastes. National Environment No. 16020:121-130.

SECTION I

ZINC-65, ZINC, CADMIUM AND MERCURY IN THE PACIFIC HAKE

SECTION I

TABLE OF CONTENTS

Figure I Location of Sampling Stations for Pacific Hake, 1969-1972.

Table I Zinc-65, Zinc, Cadmium and Mercury in Pacific Hake.

Number	Date	Page
1	May 13, 1969	10
2	May 15, 1969	11
3	May 17, 1969	11
4	May 17, 1969	12
5	May 20, 1969	12
6	May 22, 1969	13
7	May 27, 1969	14
8	July 16, 1969	14
9	July 19, 1969	17
10	July 26, 1969	17
11	July 27, 1969	19
12	July 29, 1969	21
13	July 30, 1969	22
14	July 31, 1969	24
15	August 1, 1969	27
16	August 3, 1969	28
17	August 5, 1969	29
18	August 13, 1969	30
19	October 12, 1969	31
20	October 14, 1969	31
21	May 30, 1970	32
22	May 30, 1970	33
23	June 11, 1970	34
24	June 25, 1970	35
25	July 1, 1970	35
26	July 6-7, 1970	36
27	July 7, 1970	36
28	June 16, 1971	37
29	August 19, 1972	37

*On Fig. I

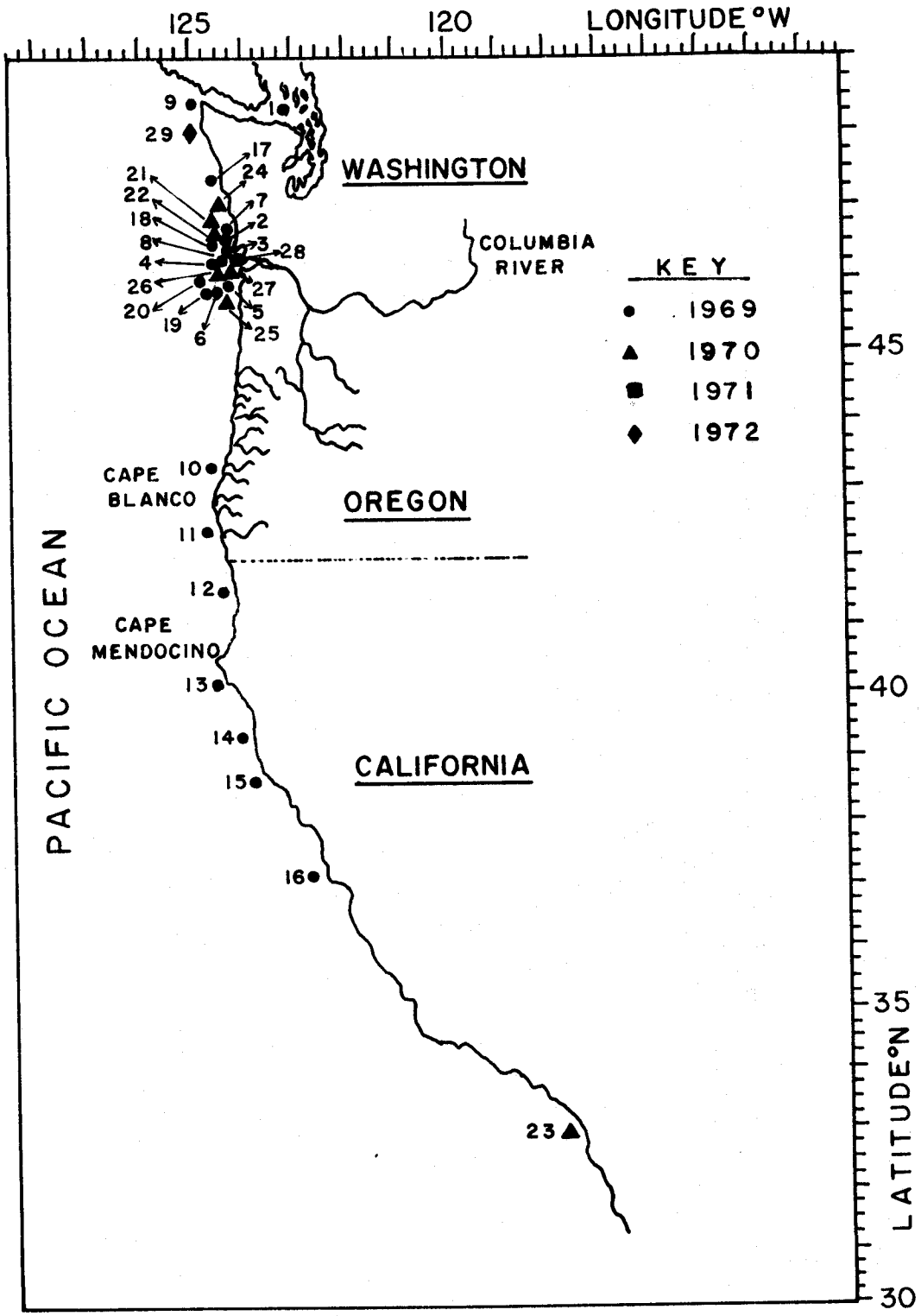


Figure I Location of Sampling Stations for Pacific Hake, 1969-72.

Table I

Zinc-65, Zinc, Cadmium and Mercury in Pacific Hake.

(Arranged by date of collection and station no. indicated on Figure I-1.)

No. 1--Puget Sound (off Pt. Wells, Washington) Vessel: (unknown)
Date: May 13, 1969 (National Marine Fisheries Service)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
316	274	63.9	8.389	a	443	-	2.00	b
320	275	64.2	8.411	a	424	-	2.25	b
368	391	84.2	12.016	a	425	-	2.70	b
391	496	105.1	14.983	a	518	-	3.02	b
424	651	136.6	21.225	a	505	-	3.11	b
456	657	133.5	19.843	a	500	-	3.09	b
Flesh								
304	98	21.1	1.353	a	363	-	0.11	0.265
312	57	11.9	0.775	a	374	-	0.26	0.282
340	132	27.7	1.865	a	396	-	0.55	0.294
356	154	30.0	2.001	a	421	-	0.65	0.315
366	100	20.3	1.141	a	416	-	1.01	0.318
379	192	40.2	2.669	a	429	-	0.82	0.322
391	182	38.1	2.398	a	426	-	1.12	0.339
412	206	41.7	2.925	a	442	-	1.39	0.351
434	237	48.2	3.126	a	455	-	1.15	0.362
466	290	63.1	4.139	a	447	-	1.50	0.381

[a] Below detection limit (approximately 5 pCi/sample); errors 20-30%.

[b] Not measured.

Table I (Continued)

No. 2--lat. 46°23.8'N, long. 124°15.4'W
Date: May 15, 1969

Vessel: BARON
Cruise: 69-6, AEC,#1

Length mm	Weight,g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
518	1039	224.9	32.508	20.2	422	48	4.71	b
530	1087	239.9	33.416	20.0	428	47	4.66	b
Flesh								
437	239	49.8	3.242	21.2	292	71	1.90	0.349
470	271	55.4	3.862	20.0	302	70	2.35	0.359
487	286	59.3	4.004	18.7	307	67	2.18	0.379
517	326	68.2	4.652	17.5	312	65	2.44	0.384

No. 3--lat. 46°21.2'N, long. 124°14.0'W
Date: May 17, 1969

Vessel: BARON
Cruise:69-6, AEC,#6

Length mm	Weight,g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
430	665	143.0	21.319	25.0	405	62	4.36	b
443	680	147.3	20.996	25.3	414	61	4.31	b
469	703	148.2	21.215	23.7	416	57	4.56	b
495	982	196.4	27.212	22.3	419	53	4.46	b
514	1020	206.6	30.169	21.2	420	50	4.62	b
516	1085	229.7	31.824	20.1	416	48	4.51	b
522	1060	228.7	30.996	21.2	426	50	4.78	b
534	1089	233.8	32.126	20.6	430	48	4.74	b
Flesh								
439	275	57.1	3.716	20.5	283	77	2.36	0.361
449	294	62.4	3.913	20.2	296	75	2.41	0.365
468	312	62.1	4.113	18.7	298	68	2.16	0.371
485	345	70.3	4.728	17.6	312	64	2.40	0.395
499	355	72.2	4.813	18.2	310	60	2.46	0.408

[b] Not Measured.

Table I (Continued)

No. 4--lat. 46°13.7'N, long. 124°28.3'W — Vessel: BARON
Date: May 17, 1969 — Cruise: 69-6, AEC,#7

Length mm	Weight,g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
400	501	113.8	15.928	30.3	402	75	4.02	b
424	553	125.3	17.221	29.0	398	73	4.40	b
444	701	147.4	21.002	27.5	403	68	4.49	b
444	691	153.9	20.999	28.8	410	70	4.28	b
459	707	149.8	22.001	26.2	415	63	4.58	b
460	666	142.5	20.416	25.6	419	61	4.55	b
461	734	154.0	21.514	24.6	409	60	4.57	b
Flesh								
432	294	59.6	3.912	22.2	288	84	1.96	0.322
438	317	64.1	4.213	22.0	290	81	2.07	0.341
442	291	58.7	3.886	21.2	295	76	2.02	0.333
461	308	62.4	4.112	20.1	302	72	2.14	0.354
469	298	60.1	3.987	19.5	308	67	2.20	0.365
475	309	62.4	4.128	20.2	307	71	2.22	0.377
479	321	65.0	4.285	18.5	303	68	2.26	0.391
486	339	68.9	4.596	18.2	300	65	2.31	0.385
501	294	60.2	3.998	18.6	315	66	2.35	0.399
560	382	77.9	5.216	16.2	320	57	2.50	0.432

No. 5--lat. 45°56.8'N, long. 124°12.2'W to lat. 45°56.8'N, long. 124°15.4'W — Vessel: BARON
Date: May 20, 1969 — Cruise:69-6, AEC,#20

Entire Fish								
445	657	141.0	20.989	20.0	426	47	4.37	b
448	664	132.4	21.999	18.7	397	47	4.30	b

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
461	728	155.2	22.244	19.2	402	48	4.65	b
474	785	176.0	25.078	18.6	404	46	4.50	b
Flesh								
460	290	62.1	4.341	15.5	312	50	2.44	0.261
463	290	63.8	4.148	15.0	306	49	2.26	0.268
464	304	61.3	4.012	15.1	310	49	2.30	0.272
473	256	53.5	3.601	14.7	308	48	2.50	0.295
No. 6--lat. 45°51.0'N, long. 124°44.7'W Date: May 22, 1969						Vessel: BARON Cruise: 69-6, AEC #28		
Entire Fish								
465	632	138.4	19.315	17.6	410	43	4.40	b
469	684	147.5	21.113	17.5	397	44	4.31	b
470	748	157.1	22.614	17.8	418	43	4.50	b
472	789	150.6	23.104	16.7	422	40	4.41	b
475	812	166.8	23.112	18.0	400	45	4.65	b
480	900	186.2	29.614	16.2	429	38	4.59	b
Flesh								
426	310	59.6	4.130	16.5	301	55	1.86	0.244
452	293	59.2	3.998	15.3	303	50	2.24	0.259
463	312	61.7	3.897	14.7	302	49	2.15	0.267
482	267	55.2	3.708	14.5	310	47	2.14	0.295
509	312	60.2	4.100	14.4	312	46	2.26	0.311

[b] Not Measured.

Table I (Continued)

No. 7--lat. 46°30.2'N, long. 124°14.5'W
Date: May 27, 1969

Vessel: BARON
Cruise: 69-6, AEC, #31

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
495	812	175.9	25.918	23.2	425	55	4.64	b
510	954	208.8	29.618	21.2	432	49	4.70	b
Flesh								
493	379	77.9	5.123	17.5	310	66	2.15	0.388
504	385	78.7	5.212	16.8	312	55	2.21	0.395
520	429	86.1	5.815	16.5	317	55	2.30	0.409
525	412	84.1	5.615	16.7	320	50	2.37	0.422

No. 8--lat. 46°17.0'N, long. 124°21.0'W
Date: July 16, 1969

Vessel: PROFESSOR DERYUGIN

Entire Fish								
369	379	76.7	11.839	31.6	373	85	3.88	b
378	406	90.1	12.721	30.0	390	77	4.10	b
399	504	109.7	15.164	30.0	397	76	4.13	b
415	589	128.4	17.623	27.5	398	69	4.40	b
440	610	130.1	19.651	25.2	421	60	4.32	b
445	614	131.4	19.748	23.8	412	58	4.60	b
460	700	145.1	21.389	23.6	413	57	4.30	b
464	702	146.6	21.431	23.0	407	56	4.60	b
471	700	142.2	23.078	23.7	415	57	4.48	b
480	882	168.7	26.878	22.4	413	54	4.68	b
509	1023	218.5	30.565	20.3	423	48	4.55	b
519	1094	238.3	32.513	21.2	425	50	4.65	b

[b] Not Measured.

Table I-1 (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
369	379	76.7	11.839	31.6	373	85	3.88	b
378	406	90.1	12.721	30.0	390	77	4.10	b
399	504	109.7	15.164	30.0	397	76	4.13	b
415	589	128.4	17.623	27.5	398	69	4.40	b
440	610	130.1	19.651	25.2	421	60	4.32	b
445	614	131.4	19.748	23.8	412	58	4.60	b
460	700	145.1	21.389	23.6	413	57	4.30	b
464	702	146.6	21.431	23.0	407	56	4.60	b
471	700	142.2	23.078	23.7	415	57	4.48	b
480	882	168.7	26.878	22.4	413	54	4.68	b
509	1023	218.5	30.565	20.3	423	48	4.55	b
519	1094	238.3	32.513	21.2	425	50	4.65	b
Flesh								
386	204	44.6	2.792	26.2	277	95	2.00	0.275
399	194	41.2	2.731	23.7	282	84	1.91	0.289
418	286	61.5	3.916	22.5	295	76	1.85	0.314
420	217	44.5	2.969	22.5	290	78	2.02	0.309
423	211	43.2	3.037	23.2	293	79	2.18	0.321
426	235	47.8	3.135	22.5	297	76	2.01	0.326
426	242	47.8	3.135	21.6	280	77	2.04	0.341
440	267	53.4	3.367	21.2	290	73	1.96	0.342
440	289	58.7	3.807	21.4	296	72	2.14	0.339

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
386	204	44.6	2.792	26.2	277	95	2.00	0.275
399	194	41.2	2.731	23.7	282	84	1.91	0.289
418	286	61.5	3.916	22.5	295	76	1.85	0.314
420	217	44.5	2.969	22.5	290	78	2.02	0.309
423	211	43.2	3.037	23.2	293	79	2.18	0.321
426	235	47.8	3.135	22.5	297	76	2.01	0.326
426	242	47.8	3.135	21.6	280	77	2.04	0.341
440	267	53.4	3.367	21.2	290	73	1.96	0.342
440	289	58.7	3.807	21.4	296	72	2.14	0.339
447	287	62.9	3.834	20.0	290	69	2.00	0.347
450	293	61.7	3.855	21.0	302	69	2.03	0.351
454	307	68.2	4.276	20.0	291	69	2.15	0.346
458	290	62.1	4.341	20.5	300	69	2.24	0.362
460	257	51.8	3.266	19.7	297	66	2.17	0.366
463	281	64.1	4.110	20.2	307	66	2.10	0.371
464	287	62.1	3.686	19.4	305	64	2.36	0.379
467	316	64.7	4.228	19.0	307	62	2.20	0.369
470	265	54.3	3.782	18.8	302	62	2.15	0.382
472	217	44.5	3.007	18.7	307	61	2.40	0.384
476	290	61.9	4.141	18.8	310	62	2.27	0.379
476	268	57.2	3.821	18.5	300	62	2.17	0.386
477	317	60.9	4.075	18.7	296	63	2.30	0.391
479	313	63.8	4.054	18.8	311	60	2.01	0.388
485	498	101.4	6.920	18.0	310	58	2.36	0.394
492	337	67.5	4.611	17.7	315	56	2.45	0.395
499	363	76.0	4.638	17.8	312	57	2.40	0.389
515	362	71.7	4.550	16.7	310	54	2.55	0.411

Table I (Continued)

No. 9--lat. 48°27.8'N, long. 124°41.9'W to lat. 48°27.5'N, long. 125°40.4'W — Vessel: COBB

Date: July 19, 1969 — Cruise: 69-9, AEC, #19

Length	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
472	740	152.7	24.121	13.8	411	34	4.22	b
495	906	199.9	28.115	13.1	418	31	4.51	b
511	960	209.8	29.889	12.7	411	31	4.76	b
Flesh								
427	311	61.5	4.139	13.6	283	48	2.22	0.354
439	294	60.5	4.002	12.7	287	44	2.00	0.365
441	289	60.1	4.021	12.5	288	43	2.12	0.366
442	312	62.3	4.151	13.2	286	46	2.27	0.372
447	277	56.0	3.685	12.1	282	43	1.97	0.362
449	347	68.7	4.562	12.5	294	43	2.17	0.371
452	289	58.6	3.998	11.5	287	40	2.03	0.382
452	273	54.7	3.814	12.2	300	41	2.38	0.391
452	285	56.8	4.005	12.5	281	45	2.37	0.394
459	305	60.2	4.312	12.0	287	42	2.19	0.400
478	355	68.5	5.011	11.3	300	36	2.27	0.392
478	363	70.3	5.125	11.8	293	40	2.13	0.395

No. 10--lat. 43°23'N, long. 124°09'W — Vessel: PROFESSOR DERYUGIN

Date: July 26, 1969

Entire Fish								
379	376	80.4	12.156	20.1	375	54	3.25	b
385	405	86.5	13.219	18.4	379	49	4.00	b
399	434	91.2	14.212	17.8	392	45	3.96	b
417	484	101.5	15.412	16.3	410	40	4.30	b

[b] Not Measured.

Table I (Continued)

Length	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
430	619	123.1	18.514	16.1	412	39	4.22	b
446	664	132.4	21.999	14.7	409	36	4.50	b
450	670	132.4	22.030	15.0	408	37	4.50	b
459	653	135.8	20.155	15.0	416	36	4.65	b
460	628	133.9	19.191	14.5	403	36	4.51	b
462	632	138.4	19.315	14.7	417	35	4.40	b
465	658	147.8	21.094	14.1	417	34	4.55	b
470	684	147.5	21.113	14.8	431	34	4.70	b
470	738	162.7	22.641	14.5	409	35	4.61	b
470	785	176.0	25.078	14.1	413	34	4.64	b
481	939	199.9	28.277	13.9	435	32	4.56	b
485	902	187.5	29.725	14.1	413	34	4.65	b
490	976	210.0	30.001	14.0	432	33	4.54	b
491	962	215.8	29.932	14.3	408	35	4.70	b
511	1083	236.7	30.952	13.9	437	32	4.64	b
523	1054	235.2	30.998	13.6	418	33	4.65	b
Flesh								
372	197	42.4	2.787	18.2	275	66	1.65	0.188
384	199	43.2	2.663	16.3	267	61	1.80	0.195
399	206	43.2	2.853	15.2	284	54	2.01	0.210
414	277	60.1	3.809	13.8	297	46	1.96	0.199
423	219	45.0	3.126	13.6	277	49	1.95	0.222
436	233	47.0	3.284	12.5	283	44	2.05	0.234
443	289	59.6	4.021	12.9	301	43	2.10	0.246
446	314	68.0	4.291	12.4	279	45	2.10	0.239
450	317	65.6	4.116	12.1	306	40	2.29	0.249
458	320	66.4	4.511	12.2	305	40	2.00	0.255
466	317	69.1	4.511	12.0	292	41	2.15	0.264

[b] Not Measured

Table I (Continued)

Length	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
470	283	57.6	3.965	12.3	312	39	2.44	0.259
488	328	60.6	4.261	11.2	291	39	2.35	0.264
488	402	77.4	5.168	11.4	300	38	2.50	0.271
496	359	71.4	4.776	12.0	317	38	2.48	0.268
510	297	58.3	3.956	11.3	302	37	2.41	0.281
519	294	56.6	3.796	11.6	316	37	2.50	0.275
No. 11--lat. 42°23'N, long. 124°43'W						Vessel: PROFESSOR DERYUGIN		
Date: July 27, 1969								
Entire Fish								
369	352	77.7	11.694	17.9	387	46	4.00	b
374	374	79.1	12.005	15.5	375	41	3.85	b
376	402	87.3	12.999	14.6	390	38	4.01	b
384	453	100.4	14.323	13.8	395	35	3.90	b
398	494	108.2	15.415	11.7	386	30	4.28	b
412	519	112.6	16.212	11.4	390	29	4.22	b
422	605	125.8	18.112	11.2	413	27	4.16	b
430	618	123.1	18.514	10.3	414	25	4.30	b
435	632	125.2	18.914	10.4	393	26	4.51	b
440	616	126.1	19.030	10.0	416	24	4.27	b
443	672	128.4	19.705	10.0	402	25	4.33	b
446	681	143.8	21.999	10.1	420	24	4.30	b
448	692	142.9	22.030	10.0	416	24	4.44	b
453	725	157.3	22.451	9.5	420	23	4.39	b
468	748	157.1	22.614	9.9	419	24	4.35	b
470	789	159.6	23.104	9.6	417	23	4.52	b
478	812	166.8	23.112	9.2	427	22	4.46	b
485	958	196.6	27.460	9.7	416	23	4.50	b

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
469	1029	205.8	28.516	9.2	425	22	4.61	b
511	1022	212.7	30.100	9.3	418	22	4.42	b
524	1136	228.4	32.001	9.5	431	22	4.56	b
Flesh								
386	202	44.2	2.733	10.9	265	41	1.86	0.188
394	196	41.5	2.616	9.1	281	33	2.04	0.194
415	294	61.5	3.884	8.8	292	30	2.14	0.199
423	293	63.8	4.012	7.7	286	27	2.09	0.211
431	221	45.8	2.895	7.7	296	26	2.23	0.224
447	268	53.0	3.553	7.5	301	25	2.31	0.215
449	357	70.7	4.681	7.0	291	24	2.20	0.232
453	252	51.1	3.575	7.2	288	25	2.34	0.241
455	269	55.0	3.717	7.5	295	25	2.40	0.239
459	335	67.3	4.460	7.3	306	24	2.26	0.244
461	285	59.1	3.917	6.9	299	23	2.11	0.247
478	474	95.6	6.314	7.1	312	23	2.40	0.248
478	310	61.7	4.057	6.5	298	22	2.12	0.244
482	403	84.2	5.366	7.0	308	23	2.40	0.249
482	306	64.0	4.176	7.1	315	23	2.53	0.251
492	392	77.8	5.326	6.8	303	22	2.27	0.258
503	326	65.0	4.349	7.0	306	23	2.31	0.261
511	374	73.9	4.959	6.8	320	21	2.50	0.270
513	345	71.4	4.905	6.9	317	22	2.44	0.268
515	392	75.2	5.031	6.4	315	21	2.52	0.265
520	311	60.8	4.712	6.3	325	19	2.35	0.264
528	446	86.3	5.900	7.0	322	22	2.50	0.266

[b] Not Measured.

Table I (Continued)

No. 12--lat. 41°32'N, long. 124°16'W Vessel: PROFESSOR DERYUGIN

Date: July 29, 1969

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
375	373	84.0	11.992	14.0	381	37	3.70	b
388	420	92.5	13.102	10.7	390	28	3.84	b
397	470	106.03	15.169	10.0	391	26	4.10	b
409	553	120.6	18.455	9.1	393	23	4.01	b
417	546	115.3	17.186	8.2	404	22	4.13	b
421	552	117.2	17.210	7.7	401	19	4.06	b
426	551	118.1	16.134	8.4	402	21	4.20	b
430	628	136.2	18.812	7.5	401	19	4.24	b
430	638	139.0	18.992	7.7	402	19	4.03	b
430	639	139.4	19.076	8.1	410	20	4.12	b
433	676	135.7	19.087	8.0	405	20	4.16	b
435	678	137.3	19.102	7.5	401	19	4.30	b
435	637	137.9	19.181	8.1	412	20	4.44	b
445	678	155.2	21.892	7.0	408	17	4.46	b
452	755	168.5	23.712	7.5	406	18	4.45	b
467	698	153.2	21.835	7.0	405	17	4.53	b
473	854	189.5	27.122	6.7	415	16	4.55	b
488	931	205.7	29.725	6.2	411	15	4.62	b
503	963	218.6	29.914	6.4	416	16	4.65	b
510	1061	217.6	31.001	6.2	422	15	4.46	b
514	1042	213.2	30.513	5.8	417	14	4.55	b
522	1043	221.5	31.163	6.1	420	15	4.55	b
526	1067	220.3	31.437	6.1	419	15	4.65	b
Flesh								
369	81	16.4	1.139	9.1	272	34	1.95	0.135

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
375	198	41.8	2.751	7.5	273	28	1.86	0.132
387	203	43.3	2.715	7.0	274	26	1.96	0.147
395	206	43.5	2.853	6.2	275	23	1.94	0.160
415	272	56.1	3.526	5.0	282	18	2.04	0.171
422	278	60.8	3.819	5.5	283	19	2.00	0.165
428	324	63.3	4.331	4.9	288	17	2.10	0.168
438	274	64.8	3.819	4.9	287	17	2.15	0.179
443	266	56.1	3.721	4.7	293	16	2.04	0.170
459	390	78.8	5.122	4.4	290	15	2.32	0.180
467	326	65.4	4.312	4.0	300	13	2.10	0.191
467	362	72.8	4.721	4.1	291	14	2.40	0.178
468	318	61.3	4.061	4.5	297	15	2.02	0.199
473	314	61.9	4.236	4.0	296	14	2.15	0.210
475	311	62.2	4.215	4.3	305	14	2.35	0.224
490	398	81.6	4.975	4.2	303	14	2.10	0.234
501	317	60.3	3.952	3.8	310	13	2.30	0.241
514	412	81.6	5.617	4.0	306	13	2.31	0.252
514	357	73.3	5.011	3.7	312	12	2.26	0.269
524	257	49.8	3.396	3.8	314	12	2.27	0.242
No. 13--lat. 40°08'N, long. 124°20.0'W Vessel: PROFESSOR DERYUGIN								
Date: July 30, 1969								
Entire Fish								
315	237	50.4	7.264	9.8	327	30	3.00	b
342	318	70.5	9.923	6.7	362	19	3.75	b
366	380	79.2	11.331	4.8	377	13	3.66	b
384	480	108.1	15.402	4.9	385	13	4.10	b
399	514	106.1	15.399	4.0	392	10	3.86	b

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
415	519	120.8	16.994	3.7	400	9	4.20	b
417	583	128.7	18.013	4.0	396	10	4.25	b
422	598	126.8	17.549	3.5	404	9	4.27	b
432	632	131.2	18.914	3.6	403	9	4.20	b
440	664	131.7	19.543	3.2	408	8	4.50	b
448	667	132.4	19.541	3.3	409	8	4.21	b
457	738	155.2	21.112	3.3	407	8	4.33	b
462	646	135.4	20.279	3.1	412	8	4.45	b
494	944	207.6	29.624	3.1	418	8	4.30	b
515	1056	223.8	30.915	2.9	419	7	4.35	b
528	1077	221.8	31.737	2.8	423	7	4.50	b
Flesh								
299	96	19.7	1.432	6.0	215	28	1.00	0.104
315	103	21.4	1.403	4.3	237	18	1.00	0.092
332	157	29.8	2.316	3.5	248	14	1.52	0.114
358	185	38.0	2.645	3.0	266	11	1.65	0.128
374	200	42.7	2.815	2.0	265	8	1.77	0.133
392	189	38.3	2.512	1.9	273	7	1.80	0.120
396	214	45.2	2.956	1.9	282	7	1.75	0.139
402	213	44.9	2.951	1.7	279	6	1.90	0.150
412	234	45.0	3.129	1.8	286	6	2.04	0.159
418	249	52.1	3.571	1.7	287	6	2.15	0.151
418	291	63.3	4.001	1.7	280	6	2.00	0.162
425	167	35.7	2.265	1.7	285	6	2.30	0.170
425	231	44.9	3.010	1.7	288	6	2.17	0.166
432	172	34.4	2.243	1.6	293	5	2.15	0.188
437	283	55.5	3.776	1.7	286	6	1.96	0.192
439	255	50.3	3.375	1.8	295	6	2.20	0.181

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
440	309	63.0	4.012	1.7	293	6	2.40	0.199
449	368	72.1	4.811	1.6	296	6	2.45	0.201
450	270	53.3	3.409	1.6	292	5	2.40	0.211
450	299	61.6	3.912	1.6	298	5	2.50	0.219
452	351	73.1	4.544	1.5	295	5	2.44	0.206
459	281	60.0	3.865	1.5	303	5	2.37	0.218
461	308	64.5	4.212	1.6	304	5	2.50	0.222
464	301	58.9	3.837	1.5	299	5	2.41	0.215
475	267	54.7	3.712	1.4	303	5	2.55	0.228
489	331	66.9	4.403	1.5	309	5	2.40	0.232
500	317	60.3	3.952	1.4	308	5	2.52	0.241
521	303	59.2	3.959	1.2	311	4	2.60	0.249
538	409	87.2	5.249	1.2	312	4	2.35	0.243
No. 14--lat. 39°16'N, long. 123°56.5'W Vessel: PROFESSOR DERYUGIN								
Date: July 31, 1969								
Entire Fish								
270	86	18.7	2.666	1.9	200	10	1.80	b
286	105	21.4	3.092	2.0	290	7	2.50	b
295	121	25.5	3.666	2.1	315	7	2.42	b
298	136	27.2	3.889	2.0	311	7	3.00	b
298	133	27.8	3.912	2.2	308	7	2.67	b
309	159	34.1	4.704	2.3	321	7	2.86	b
312	162	32.0	5.110	2.3	333	7	3.20	b
315	184	41.5	5.847	2.1	329	7	2.75	b
325	208	47.0	6.728	2.2	348	6	3.50	b
332	246	53.3	7.291	2.1	356	6	3.22	b

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
335	267	56.3	7.918	2.0	347	6	3.51	b
336	271	57.7	8.005	2.1	362	6	3.37	b
342	328	67.2	9.585	2.0	357	6	3.60	b
352	336	71.2	9.995	1.9	373	5	3.56	b
365	379	82.2	11.839	1.8	373	5	3.85	b
400	484	99.3	14.212	1.7[c]	388	4	4.20	b
409	551	119.9	16.455	1.6	400	4	4.16	b
421	611	127.6	18.210	1.7	395	4	4.02	b
437	645	135.5	19.151	1.6[c]	410	4	4.36	b
454	657	134.6	20.274	1.2	404	3	4.30	b
470	765	164.2	23.104	1.2	411	3	4.20	b
486	902	206.5	29.725	1.1	417	3	4.35	b
509	1021	214.5	30.009	1.0	414	2	4.36	b
521	1039	218.2	31.001	1.0	423	2	4.60	b
Flesh								
270	74	14.4	1.143	0.9	177	5	0.21	0.079
282	92	18.6	1.344	0.9	198	5	0.50	0.082
286	65	12.3	0.973	0.9	200	4	0.75	0.081
298	87	15.9	1.226	0.9	222	4	0.92	0.089
298	61	11.1	0.863	0.8	217	4	1.00	0.092
299	98	19.6	1.398	0.9	221	4	0.80	0.090
302	97	20.1	1.444	1.0	218	4	1.10	0.099
303	100	18.9	1.370	0.8	225	4	1.15	0.089
304	94	19.6	1.295	0.9	222	4	1.06	0.095
306	106	21.9	1.487	0.9	228	4	0.94	0.101
306	100	20.5	1.411	0.8	230	4	1.20	0.095

[b] Not Measured

[c] Values with 25-30% error

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
309	111	22.4	1.562	0.8	227	4	1.05	0.099
310	103	21.7	1.520	0.8	232	3	1.22	0.089
312	81	16.7	1.098	0.9	229	4	1.00	0.105
314	104	20.5	1.456	0.9	226	4	1.30	0.112
316	93	20.0	1.337	0.9	241	4	1.03	0.101
316	103	21.4	1.403	0.9	233	4	1.20	0.112
322	290	56.6	4.172	1.0	232	4	1.40	0.117
324	104	21.3	1.506	0.8	247	3	1.51	0.105
324	132	27.7	1.865	0.9	237	4	1.27	0.120
326	128	26.4	1.845	0.9[c]	250	4	1.60	0.117
326	140	27.6	1.998	0.9	243	4	1.49	0.123
337	127	28.0	1.838	0.9	260	3	1.58	0.129
342	293	59.8	4.191	0.8	246	3	1.40	0.138
345	143	29.8	2.037	0.8[c]	260	3	1.50	0.135
352	148	28.7	1.923	0.9	265	3	1.81	0.122
362	175	35.7	2.461	0.8	257	3	1.90	0.148
389	194	42.2	2.611	0.8[c]	284	3	2.06	0.175
412	273	57.2	3.621	0.7[c]	277	3	2.25	0.188
430	250	52.3	3.285	0.7	280	3	1.92	0.175
449	234	43.6	2.973	0.7[c]	283	2	2.33	0.204
452	196	39.8	2.738	0.5[c]	290	2	2.20	0.196
469	267	54.7	3.841	0.5[c]	295	2	2.26	0.188
482	297	62.5	4.373	0.5[c]	304	2	2.43	0.201
499	326	67.3	4.226	0.4[c]	311	1	2.20	0.198
512	396	77.1	5.385	0.4[c]	296	2	2.55	0.211
532	338	64.2	4.556	0.4[c]	312	1	2.59	0.218

[c]Values with 25-30% error.

Table I (Continued)

No. 15--lat. 38°41.0'N, long. 123°45.0'W Vessel: PROFESSOR DERYUGIN

Date: August 1, 1969

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
305	148	29.3	4.362	2.2	325	7	2.86	b
309	196	35.4	5.413	2.0	326	6	3.00	b
311	219	46.0	5.971	2.1	325	7	2.92	b
317	227	48.0	6.540	1.9[c]	335	6	3.10	b
320	321	47.5	5.982	1.7[c]	345	5	3.12	b
323	249	50.2	6.623	1.9	342	6	3.20	b
325	245	44.6	6.500	1.6[c]	345	5	3.11	b
343	303	59.5	8.365	1.5[c]	359	4	3.44	b
351	339	71.2	10.102	1.4[c]	362	4	3.80	b
370	363	81.2	9.953	1.2[c]	382	3	3.61	b
385	398	93.3	12.101	1.2[c]	390	3	3.76	b
415	524	107.1	15.123	1.0[c]	402	2	4.00	b
450	683	154.8	19.901	1.0[c]	407	2	4.14	b
492	927	192.2	25.911	1.0[c]	417	2	4.36	b
511	1051	229.9	29.519	0.9[c]	421	2	4.60	b
Flesh								
311	85	17.8	1.137	1.0	225	4	1.30	0.111
328	133	27.3	1.912	0.8	248	3	1.36	0.119
337	125	27.1	1.788	0.7[c]	247	3	1.35	0.122
350	153	31.5	2.147	0.6[c]	256	2	1.71	0.149
361	177	36.5	2.523	0.6	261	2	1.57	0.152
378	196	42.5	2.642	0.5	275	2	2.00	0.164
390	186	38.8	2.463	0.5[c]	277	2	1.71	0.171
411	253	55.1	3.472	0.5[c]	283	2	2.14	0.162

[b] Not Measured.

[c] Values with 25-30% error.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
424	133	28.5	1.798	0.4[c]	287	2	2.01	0.170
447	123	25.2	1.643	0.4[c]	288	1	2.43	0.190
458	256	55.8	3.515	0.4[c]	293	2	2.27	0.191
470	284	55.3	3.872	0.4[c]	300	1	2.25	0.194
481	265	55.1	3.275	0.4[c]	296	1	2.23	0.196
490	405	82.8	5.124	0.4[c]	304	1	2.34	0.190
510	392	77.6	5.156	0.4[c]	305	1	2.60	0.188
522	334	65.0	4.331	0.3[c]	306	1	2.64	0.195
544	344	70.4	4.338	0.3[c]	308	1	2.41	0.202
No. 16--lat. 37°03.0'N, long. 122°38.0'W Vessel: PROFESSOR DERYUGIN								
Date: August 3, 1969								
Entire Fish								
400	425	91.5	13.056	1.9	400	5	4.09	b
415	586	132.3	17.454	1.2	397	3	4.10	b
430	667	143.4	18.752	1.1	408	3	4.24	b
441	690	158.7	20.865	1.4	402	4	4.35	b
454	686	165.0	21.744	1.0	410	3	4.43	b
461	650	136.5	19.023	0.9	408	2	4.73	b
465	682	137.9	19.111	1.1	409	3	4.44	b
466	654	144.7	19.116	1.1[c]	412	3	4.31	b
484	962	223.8	29.020	0.9[c]	413	2	4.83	b
490	971	224.1	29.084	0.8[c]	415	2	4.62	b
492	930	211.3	28.031	0.9[c]	411	2	4.80	b
492	998	224.3	31.514	0.9[c]	418	2	4.54	b

[b] Not Measured.

[c] Values with 25-30% error.

Table I (Continued)

Length mm	Weight Wet	Weight Dry	Weight Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
496	1001	225.7	31.451	0.7[c]	415	2	4.73	b
500	1004	226.1	29.025	0.5[c]	415	1	5.81	b
500	962	222.5	31.611	0.7[c]	420	2	4.59	b
Flesh								
414	283	59.4	3.712	0.5[c]	280	2	1.82	0.134
431	218	45.7	2.912	0.5[c]	291	2	2.00	0.144
451	297	61.4	3.876	0.5[c]	297	2	2.15	0.150
465	316	66.5	4.115	0.5[c]	300	2	2.04	0.165
467	228	45.4	3.161	0.4[c]	294	2	2.05	0.153
469	304	60.6	3.997	0.5[c]	293	2	2.10	0.170
470	304	60.4	4.109	0.4[c]	297	1	2.19	0.181
477	401	84.9	5.623	0.4[c]	300	1	2.40	0.179
485	432	88.4	5.995	0.4[c]	302	1	2.06	0.192
498	408	80.0	5.332	0.4[c]	300	14	2.05	0.200
512	450	88.2	6.123	0.3[c]	303	1	2.36	0.212
528	354	69.6	4.728	0.2[c]	305	1	2.27	0.218
532	384	77.0	5.133	0.2[c]	308	1	2.34	0.224

No. 17--lat. 47°18.9'N, long. 124°37.7'W to lat. 47°18.7'N, long. 124°40.2'W Vessel: COBB

Date: August 5, 1969 Cruise: 69-9, AEC, # 23

Flesh								
410	267	54.6	3.527	20.1	295	68	1.96	0.349
430	327	69.2	4.296	18.8	289	65	2.03	0.354
436	262	53.5	3.514	17.9	297	60	2.20	0.364
439	275	60.4	3.815	18.0	302	60	2.26	0.366

[b] Not Measured.

[c] Values with 25-30% error.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
440	279	59.8	3.822	17.5	294	59	2.21	0.374
443	269	59.6	3.692	17.6	295	60	2.22	0.371
447	294	59.6	3.921	17.1	288	60	2.25	0.382
545	358	72.5	4.798	15.0	320	47	2.47	0.411
No. 18--lat. 46°13.1'N, long. 124°14.8'W to lat. 46°12.1'W, long. 124°15.3'W						Vessel: COBB		
Date: August 13, 1969						Cruise: 69-9, AEC, #32		
Entire Flesh								
431	674	140.8	20.994	26.2	400	65	4.50	b
440	690	152.7	21.821	26.3	406	65	4.35	b
Flesh								
427	285	60.7	3.816	21.2	293	76	1.91	b
434	294	62.5	3.935	21.3	290	74	2.01	b
451	307	64.9	4.123	21.2	302	73	2.09	b
462	321	67.5	4.315	20.7	297	70	2.17	b
463	324	68.5	4.337	21.0	294	70	2.22	b
475	304	62.4	4.119	20.8	303	70	2.30	b
482	302	62.1	4.086	19.5	304	68	2.13	b
483	312	63.7	4.227	20.5	315	70	2.45	b
496	358	73.7	4.875	18.8	312	69	2.53	b
501	361	73.7	4.912	19.2	313	68	2.50	b
509	386	79.6	5.234	18.7	317	66	2.46	b
517	452	91.8	6.123	18.0	318	65	2.42	b
536	527	107.9	7.223	17.5	317	67	2.62	b

[b] Not Measured.

Table I (Continued)

No. 19--lat. 45°50.9'N, long. 124°22.6'W to lat. 45°51.2'N, long. 124°23.2'W

Vessel: CAYUSE

Date: October 12, 1969

Cruise: C6910C, BMT # 132

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
488	905	189.1	29.814	17.5	426	41	4.60	b
490	906	189.2	29.891	17.1	421	41	4.51	b
500	1002	226.3	30.883	17.5	434	40	4.50	b
Flesh								
439	289	63.9	4.016	16.2	276	59	1.85	0.240
449	268	53.0	3.563	15.1	292	52	2.22	0.259
458	317	64.6	4.336	15.7	298	53	2.34	0.285
471	358	64.4	4.829	15.4	300	52	2.11	0.309
492	461	92.1	6.054	15.0	307	49	2.35	0.318

No. 20--lat. 45°50.9'N, long. 124°20.2'W to lat. 45°50.8'N, long. 124°22.6'W

Vessel: CAYUSE

DATE: October 14, 1969

Cruise: C6910C, OFC #14 OTB #300

Entire Fish								
475	854	189.5	27.122	17.5	417	42	4.35	b
480	906	203.1	28.939	18.0	426	42	4.50	b
492	991	215.7	30.001	17.7	425	42	4.40	b
503	966	210.7	29.899	17.1	431	40	4.51	b
Flesh								
412	269	55.3	3.467	17.5	290	60	1.85	0.239
427	314	61.8	4.129	16.7	292	57	1.90	0.249
437	277	59.5	3.828	15.6	288	54	2.10	0.251

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
442	259	54.3	3.650	15.7	287	55	2.15	0.261
453	258	52.5	3.623	14.8	300	49	2.00	0.281
470	336	67.9	4.654	14.5	305	47	2.06	0.259
482	324	59.3	4.155	13.9	302	46	2.30	0.278
482	367	70.4	4.656	14.2	312	45	2.49	0.288
No. 21--lat. 46°38.0'N, long. 124°42.0'W						Vessel: COBB		
Date: May 30, 1970						Cruise: 70-06, AEC, #2		
Entire Fish								
458	682	149.5	20.595	17.5	400	44	4.40	b
461	673	148.1	20.514	17.1	406	42	4.44	b
478	861	190.8	27.223	16.1	415	39	4.50	b
492	935	206.6	29.695	16.6	417	40	4.59	b
503	956	209.3	29.908	15.4	421	37	4.60	b
515	1018	214.3	30.110	15.0	412	36	4.65	b
Flesh								
466	301	61.3	4.002	15.5	305	58	2.36	0.378
488	377	76.4	5.112	15.0	310	55	2.22	0.395
506	389	79.4	5.342	14.0	316	49	2.12	0.412

Table I (Continued)

No. 22--lat. 46°34.2'N, long. 124°13.0'W to lat. 46°33.2'N, long. 124°13.1'W

Vessel: COBB

Date: May 30, 1970

Cruise: 70-06, AEC, Phase #1 Haul # 3

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
456	258	55.5	7.553	17.2	420	41	4.50	b
462	320	70.9	9.538	16.8	417	40	4.52	b
466	262	55.3	7.780	17.0	418	41	4.50	b
469	335	66.8	9.564	16.3	421	39	4.41	b
470	292	61.3	8.956	16.7	426	39	4.63	b
474	316	66.6	9.325	16.2	420	39	4.59	b
510	299	63.2	8.756	15.0	432	35	4.61	b
514	335	74.9	10.226	14.5	425	34	4.70	b
425	586	123.2	17.234	18.5	401	46	4.10	b
446	706	153.8	21.132	17.7	389	45	4.19	b
459	724	162.3	21.996	16.7	395	42	4.44	b
477	898	198.2	27.312	16.0	402	40	4.59	b
492	986	217.8	29.761	15.5	410	38	4.50	b
512	1024	229.5	30.119	15.2	407	37	4.54	b
541	1097	244.5	32.345	14.4	435	33	4.74	b
Flesh								
428	298	61.2	3.921	17.5	292	66	2.16	b
432	313	64.5	4.126	16.4	294	67	2.10	b
456	382	78.6	5.110	16.2	304	58	2.29	b
471	319	65.7	4.226	15.3	313	55	2.30	b
481	376	76.3	5.002	15.4	312	53	2.34	b
489	376	75.6	5.006	14.6	317	50	2.29	b

[b] Not Measured.

Table I (Continued)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
492	450	89.7	6.002	14.7	308	50	2.50	b
503	381	76.1	5.119	14.6	319	51	2.48	b
525	371	74.4	4.996	14.2	317	49	2.54	b
545	445	89.9	5.998	13.9	326	46	2.50	b
No. 23--lat. 32°50.4'N, long. 117°26.2'W to lat. 32°54.7'N, long. 117°26.5'W						Vessel: (Unknown)		
Date: June 11, 1970						(National Marine Fisheries Service)		
Entire Fish								
277	75	15.1	2.519	a	256	-	1.66	b
282	106	20.6	3.176	a	300	-	2.00	b
300	126	29.5	4.001	a	316	-	2.52	b
319	178	36.8	4.710	a	340	-	3.44	b
332	211	42.1	5.770	a	350	-	3.42	b
352	349	77.3	9.151	a	365	-	3.41	b
375	395	86.5	12.686	a	369	-	3.92	b
384	355	60.7	10.020	a	382	-	3.86	b
402	375	75.0	10.990	a	387	-	4.10	b
Flesh								
294	93	17.1	1.357	a	217	-	1.08	0.066
298	62	11.3	0.876	a	213	-	1.19	0.070
312	103	20.9	1.400	a	235	-	1.14	0.079
341	135	28.1	1.914	a	257	-	1.72	0.084
374	205	44.6	2.912	a	262	-	1.90	0.102
396	219	45.3	3.005	a	282	-	2.15	0.111

[a] Below detection limit (approximately 5 pCi/sample).

[b] Not Measured.

Table I (Continued)

No. 24--lat. 46°55'N, long. 124°28'W — Vessel: COMMANDO

Date: June 25, 1970 — Cruise: 70-6, #6

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
478	876	183.1	25.619	15.3	407	38	4.35	b
492	964	207.5	29.653	14.1	422	33	4.44	b
511	1044	224.9	31.026	14.0	424	33	4.51	b
Flesh								
469	317	64.0	4.221	15.1	312	55	2.30	0.375
480	322	65.4	4.362	14.8	309	54	2.44	0.388
495	377	76.4	5.113	13.6	315	47	2.37	0.395

No. 25--lat. 45°49.1'N, long. 124°16.7'W — Vessel: COMMANDO

Date: July 1, 1970 — Cruise: (Unknown)

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Entire Fish								
459	699	147.7	20.610	16.2	411	39	4.50	b
468	717	149.1	21.034	15.2	441	34	4.61	b
482	857	174.0	24.211	15.0	427	35	4.40	b
Flesh								
484	333	70.7	4.559	13.1	314	42	2.55	0.295
488	445	89.8	5.922	12.5	306	41	2.46	0.302
492	336	67.5	4.596	12.7	320	40	2.41	0.314

[b] Not Measured.

Table I (Continued)

No. 26-- lat. 46°00.2'N, long. 124°15.2'W — Vessel: YAQUINA

Date: July 6-7, 1970 — Cruise: Y7007A

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
490	969	215.3	29.823	16.1	410	39	4.46	b
510	1044	218.5	30.562	16.0	417	38	4.64	b
525	1086	224.0	31.116	15.1	418	36	4.78	b

No. 27--lat. 45°59'N, long. 124°12'W — Vessel: COMMANDO

Date: July 7, 1970 — Cruise: Haul # 17

Entire								
471	785	166.1	23.009	16.3	436	37	4.25	b
482	965	208.7	28.998	16.2	444	36	4.50	b
491	996	211.8	29.799	15.7	441	36	4.65	b
515	1054	219.7	31.001	15.5	443	35	4.66	b
Flesh								
477	284	57.9	3.916	13.2	319	41	2.50	0.291
499	317	60.3	3.952	12.5	325	39	2.53	0.314
538	444	85.5	5.865	12.6	330	38	2.60	0.325
543	329	66.4	4.396	11.9	332	36	2.65	0.361
552	468	98.9	6.232	11.2	326	34	2.61	0.395

[b] Not Measured.

Table I (Continued)

No. 28--Columbia River Mouth, near Chinook Point: lat. 46°17.0'N, long. 124°10.0'W — Vessel: YAQUINA

Date: June 16, 1971 — Cruise: Y7106

Length mm	Weight, g Wet	Dry	Ashed	^{65}Zn pCi/g ash	Zn µg/g ash	Specific Activity nCi/g Zn	Cd µg/g ash	Hg µg/g wet
Flesh								
535	454	93.5	6.211	7.7	320	22	2.36	0.412
615	520	100.6	7.132	6.7	322	20	2.66	0.452

No. 29--lat. 48°00'N, long. 124°49.5'W — Vessel: YAQUINA

Date: August 19, 1972 — Cruise: Y7208

Flesh								
469	374	77.7	5.231	2.93	310	1	b	0.411
472	367	74.1	5.162	1.89	316	1	b	0.432

[b] Not Measured.

SECTION II

MERCURY IN WATER SAMPLES

SECTION II

TABLE OF CONTENTS

Figure II Location of Sampling Stations for Water Samples, 1971-73.

Table II Mercury in Water Samples.

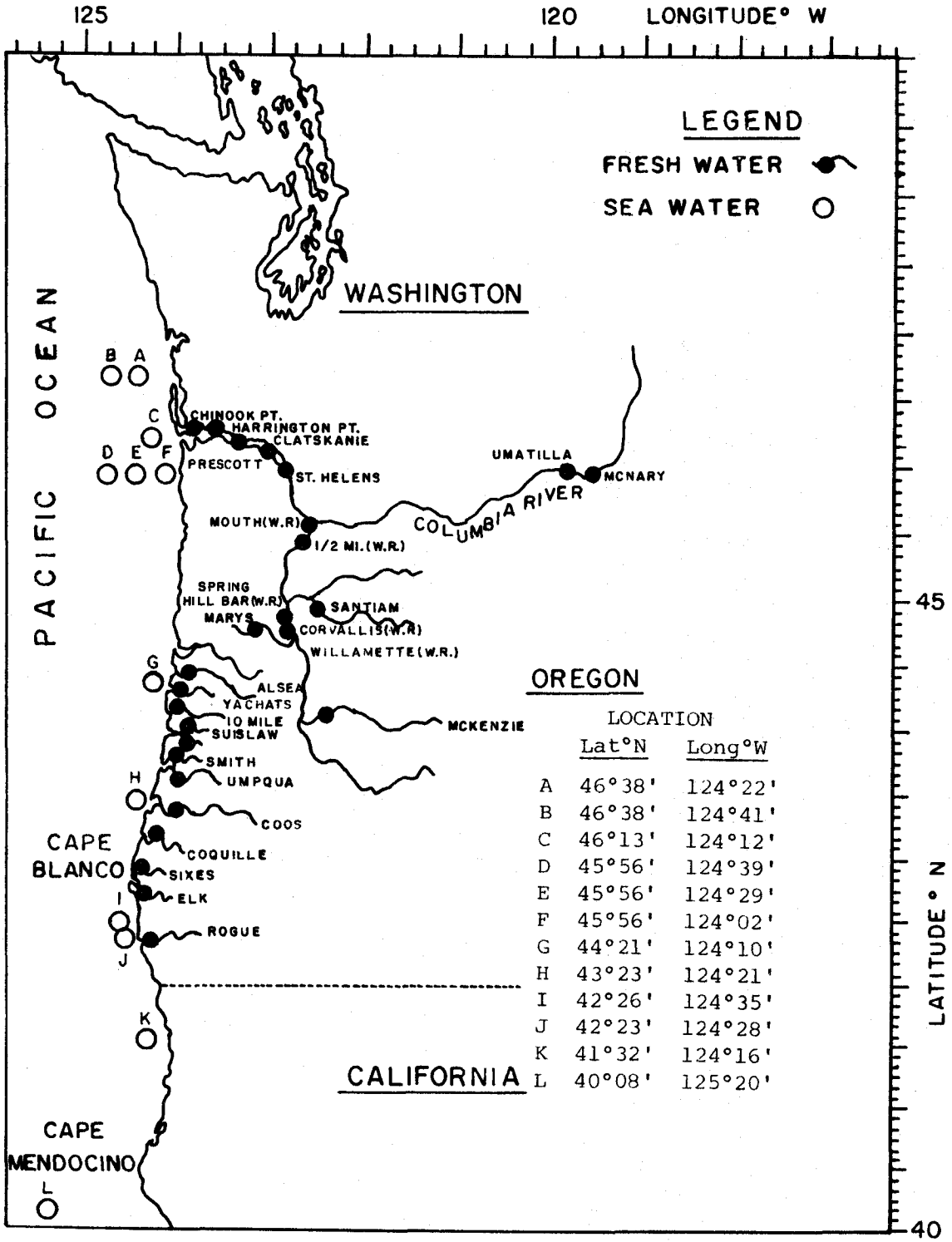
A. Sea Water Samples, Collected, 1972-73

B. River and Estuarine Water Samples, Collected 1971-73.

(1) Fresh Water Samples, Columbia River, 1971.

(2) Estuarine Water Samples, Columbia River at Chinook Point, 1971-72.

(3) Fresh Water Samples, Other Oregon Rivers, 1971,973.



LOCATION

	Lat°N	Long°W
A	46°38'	124°22'
B	46°38'	124°41'
C	46°13'	124°12'
D	45°56'	124°39'
E	45°56'	124°29'
F	45°56'	124°02'
G	44°21'	124°10'
H	43°23'	124°21'
I	42°26'	124°35'
J	42°23'	124°28'
K	41°32'	124°16'
L	40°08'	125°20'

Figure II Location of Sampling Stations for Water Samples, 1971-73.

Table II Mercury in Water Samples, Collected 1971-73.

A. Seawater Samples, Collected 1972-73

(1). Oregon State University Cruise: Y7208A.

Fig. II-1 Reference	Location Lat.°N	Long. °W	Date	Time (hrs)	Depth (m)	Mercury (µg/l)
A	46°38'	124°22'	8.18.72	0115	0	.065
				0130	40	.050
B	46°38'	124°41'	8.17.72	1745	0	.050
				1800	80	.055
C	46°13'	124°12'	8.17.72	1240	0	.040
				1310	30	.040
D	45°56'	124°39'	8.16.72	2004	0	.030
				2040	100	.025
E	45°56'	124°29'	8.16.72	2335	0	.0925
				2330	75	.085
F	45°56'	124°02'	8.17.72	0715	0	.050
				0720	25	.040

(2). Oregon State University Cruise: Y7301E.

G	44°21'	124°10'	1.19.73	1400	0	.050
				1410	10	.045
H	43°23'	124°21'	1.20.73	0112	0	.065
				0124	11	.055
I	42°26'	124°35'	1.23.73	0735	0	.080
J	42°23'	124°28'	1.20.73	1130	0	.035
				1145	80	.040
K	41°32'	124°16'	1.20.73	2200	0	.040
				2215	30	.035
L	40°08'	125°20'	1.21.73	0505	0	.040
				0520	150	.050

Table II (Continued)

B. River and Estuarine Water Samples, Collected 1971-73

(1) Fresh Water Samples, Columbia River, 1971.

Location (Figure II-1)	Date	Mercury (µg/l)
McNary	5.16.71	.033*
	6.01.71	.022
	7.01.71	.020
	7.01.71	.021
	8.02.71	.019
	8.02.71	.018
Umatilla	6.01.71	.019
	7.01.71	.020
	7.19.71	.021
	8.02.71	.022
	8.02.71	.022
St. Helens	6.05.71	.021
	6.05.71	.024
Prescott	5.12.71	.039*
	5.26.71	.022*
	6.05.71	.018
	6.05.71	.019
	6.09.71	.020
	6.24.71	.019
	7.08.71	.021
	7.22.71	.022
	8.04.71	.022

* Values with 10-20% error.

Table II (Continued)

Location (Figure II-1)	Date	Mercury (µg/l)
Clatskanie	5.26.71	.029*
	6.05.71	.022
	6.05.71	.024
	6.09.71	.025
	6.24.71	.020
	7.08.71	.021
	7.22.71	.018
	8.04.71	.021
Harrington Point	5.26.71	.042*
	6.05.71	.033
	6.09.71	.039
	6.25.71	.036
	7.07.71	.040
	7.21.71	.037
	8.04.71	.041

*Values with 10-20% error.

Table II (Continued)

(2) Estuarine Water Samples, Columbia River at Chinook Point, 1971-72.

Date of Collection	Time of Collection	Time of High Tide[a]	Mercury (μg/l)
6.09.71	1400	1424	.043
6.25.71	1500	1548	.046
7.07.71	1230	1324	.044
7.21.71	1300	1324	.040
8.05.71	1200	1254	.037
8.19.71	1200	1254	.033
9.17.71	1200	1218	.030
10.08.71	1500	1536	.029
11.04.71	1300	1348	.024
12.29.71	1000	1048	.028
2.11.72	1000	1021	.031
3.17.72	1400	1500	.033
4.27.72	1230	1305	.036
5.25.72	1130	1206	.039
6.27.72	1400	1433	.042
7.27.72	1400	1436	.045
8.28.72	1500	1540	.041

[a]U.S. Dept. of Commerce, Environmental Science Services Administration. Coast and Geodetic Survey: Tide Tables, High and Low Water Prediction. West Coast of North and South America. 1971:86-89; 1972:86-88, for Astoria (Tongue Point), Oregon. Time meridian 120°W. 0000 is midnight. 1200 is noon. Daylight savings time is not used.

Table II (Continued)

(3) Fresh Water Samples, Other Oregon Rivers, 1971, 1973

Location (Fig. II-1)	River Empties Into Ocean At	Date	Mercury (μg/l)
Alsea River, 7 mi. E of Waldport at Highway 34 Bridge	Waldport (44°25'N)	3.02.73	.091
Yachats River at Highway 101 Bridge	Yachats (44°19'N)	3.02.73	.083
10 Mile Creek at Highway 101 Bridge	South of Yachats (44°17'N)	3.02.73	.116
Siuslaw River, 1 mi. upstream from confluence with north fork	Heceta Beach (44°00'N)	3.02.73	.104 .104
Siuslaw River, north fork, 1/4 mi. upstream from above sampling	Heceta Beach (44°00'N)	3.02.73	.116
Smith River, South Side of Smith River Road, 3 mi. from Highway 101	Winchester Bay (43°42'N)	3.02.73	.110 .143
Umpqua River, Umpqua wayside, 10 mi. upstream from Reedsport	Winchester Bay (43°40'N)	3.02.73	.161 .151
Coos River, 1 1/2 mi. upstream from east side, south bank	Coos Bay (43°20'N)	3.02.73	.0227 .0232
Coquille River, Public Boat Landing, Riverton	Bandon (43°08'N)	3.02.73	.037
Sixes River, 200 yds. from Highway 101, north bank	Cape Blanco (42°50'N)	3.02.73	.049 .056

Table II (Continued)

Location (Fig. II-1)	River Empties Into Ocean At	Date	Mercury (µg/l)
Elk River, 1/2 mi. downstream from Highway 101, north bank	S. of Cape Blanco (42°46'N)	3.02.73	.038 .039
Rogue River, 1 mi. above Highway 101, north bank	Gold Beach (42°26'N)	3.02.73	.037
Willamette River,			
a) near mouth		6.05.71	.022
b) 1/2 mi. from mouth		6.05.71	.024
c) Spring Hill Bar		4.29.71	.044*
d) Corvallis		4.29.71	.029*
Santiam River at Highway I5 Bridge		4.29.71	.021*
Marys River at Philomath		3.02.73	.095
McKenzie River at Hendrick's Bridge		4.29.71	.039*

*Values at 10-20% error.

SECTION III

REFERENCE STANDARDS AND INTERCALIBRATIONS

SECTION III

TABLE OF CONTENTS

Table III-1. Results of Analysis of Standard Biological Materials for Zinc, Cadmium and Mercury.

Table III-2. Mercury Determination in U.S. EPA Water Standards.

Table III-3. Interlaboratory Comparisons of Mercury Determinations.

Table III-1

Results of Analyses of Standard Biological Materials for Zinc, Cadmium and Mercury

Sample	Element	Concentrations Found, μg/g		NBS
		Atomic Absorption Spectrophotometry	Neutron Activation Analysis	Certified Value
Orchard Leaves[a]	Zn	27.7 ± 0.1	25.1 ± 0.4	25 ± 3
	Cd	<0.1	0.13 ± 0.01	0.11 ± 0.02
	Hg	0.160 ± 0.002	-----	0.155 ± 0.015
Bovine Liver[b]	Zn	136 ± 0.2	130 ± 2	130 ± 10
	Cd	0.28 ± 0.03	0.30 ± 0.01	0.27 ± 0.04
	Hg	0.0151 ± 0.0006	-----	0.016 ± 0.002
Hake Sample # 314	Zn	177 ± 2	178 ± 7	-----
	Cd	0.21 ± 0.01	0.21 ± 0.01	-----

[a] National Bureau of Standards-Standard Reference Material-1571.

[b] National Bureau of Standards-Standard Reference Material-1577.

Table III-2

Mercury Determination in U.S. EPA Water Standards[a]

EPA Standard	Value Obtained in this Study (μg/l)	EPA Value (μg/l)
Ampule No. 1 (inorganic mercury)	0.35 ± 0.02	0.34
Ampule No. 2 (inorganic mercury)	4.2 ± 0.11	4.2
Ampule No. 3 (organic and inorganic mercury)	6.31 ± 0.003	6.3
Ampule No. 4 (organic mercury)	4.2 ± 0.06	4.2

[a]U.S. Environmental Protection Agency, Corvallis, Oregon.

Table III-3

Interlaboratory Comparisons of Mercury Determinations
(Concentrations in μg/kg)

Oceanography		Agricultural Chemistry	Radiation Center			
Atomic Absorption Spectrophotometry			Neutron Activation Analysis			
			Instrumental[b]			Radiochemical
10 g flesh + H_2SO_4 + $KMNO_4$ + H_2O_2	10 g flesh + HNO_3 + H_2SO_4 + H_2O_2 (Reflux)	10 g flesh + HNO_3 + H_2SO_4 + H_2O_2 (Reflux)	68 kev	77 kev	279 kev	77 kev
0.03	0.06	0.055	0.058	0.061	0.066	0.049
0.1	0.12	0.11	0.119	0.109	0.122	0.095
0.09	0.16	0.15	0.165	0.155	0.172	0.149

[a] By J. Naidu at labs in OSU School of Oceanography, OSU Radiation Center and OSU Department of Agricultural Chemistry.

[b] Without chemical separation. Three determinations were made on each sample using each of the major photopeaks in the gamma-ray spectrum.

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