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Contaminants in Great Lakes Coho and Chinook Salmon

September, 1981

MDNR Publication No. 3730-0043
December 1982

By

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and
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Funded by:

Office of Coastal Zone Management
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

and

Coastal Zone Management Program
Land Resource Programs Division
Michigan Department of Natural Resources

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SUMMARY

1. Of the twelve organochlorine and pesticide contaminants analyzed for in 71 chinook and 143 coho salmon, only dieldrin, chlordane, PCBs, and DDT (DDT+Metabolites) were found at levels higher than the analytical detection levels.

2. Dieldrin was found in both coho and chinook salmon. None of the fish analyzed contained concentrations in excess of the U.S. Food and Drug Administration (FDA) "Action Level" of 0.3 ppm. No significant changes from 1980 to 1981 were evident.

3. Chlordane (a complex mixture of compounds) was found in most samples at concentrations greater than the minimum level of analytical detection (0.1 ppm), as measured against a technical chlordane standard. Accurate quantification of chlordane is not possible at this time because of the complexity of the chlordane mixture and because of interferences from other compounds, notably PCBs and DDT. Further purification of the extracts and refinement of the gas chromatographic technique will be required before results can be reported.

4. DDT (DDT+Metabolites) was not found in any fish at concentrations greater than the FDA "Action Level" of 5 ppm.

5. PCBs concentrations in the 1981 samples were considerably lower than found in 1980 at all sites. Only 1 (of 71) chinook and 2 (of 143) coho exceeded the FDA "Action Level" of 5 ppm total PCBs.

6. The results of this study will be used by the Michigan Department of Public Health to determine if the Public Health Advisory presently in effect for Great Lakes salmon needs to be modified.

Acknowledgements

Many people and organizations contributed to this report. The DNR Fisheries Division collected the fish. The DNR Environmental Laboratory improved methods to insure low level detection and to eliminate interferences. The Great Lakes Fisheries Laboratory of the U.S. Fish & Wildlife Service provided reference samples. John Hartig, Joan Duffy, Ken Stockwell, Dan Wieton, Joe Vihtelic, and William McCracken assisted in study planning, and sample processing. Funding for this project was from the Coastal Zone Management Program, Land Resource Programs Division, DNR.

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Introduction

This is a report of organochlorine and pesticide contamination in coho and chinook salmon from Michigan's Great Lakes. Data in this report, derived from fish collected in the Fall, 1981, are intended for use to update the Public Health Advisory issued by the Michigan Department of Public Health. The advisory warns that Great Lakes salmon contain contaminants and the amount consumed should be limited. Fish-eating health advisories are published annually on the back cover of the Michigan Fishing Guide (MDNR, 1982a).

Material and Methods

Field

Fish were collected during the Fall spawning migration in 1981, at seven sites (Figure 1). Fish were selected at random for analysis.

Fish were weighed, measured (total length), and identified. Sex was determined by visual inspection of gonads. Scale samples were removed from some fish for age determination in the laboratory. Skin-on fillets were removed from each fish (Appendix A describes the filleting technique). Each sample was individually wrapped in aluminum foil, placed in a polyethylene bag, and tagged. Samples were held on ice, transported to the MDNR laboratory, and frozen (-29°C.). In all cases, samples were frozen within 12 hours of collection and remained frozen until processed for contaminant analysis.

Laboratory

The entire sample from each fish was used in the analysis. Each sample was partially thawed and then homogenized in a commercial food grinder. A twenty gram subsample of the homogenate was drawn at random for analysis.

Electron capture gas/liquid chromatography was used to measure contaminant levels. Specific details of the extraction, cleanup, and chromatographic techniques are described in MDNR (1982b).

Contaminants which were analyzed for, and the minimum concentration of each which could be measured (detection level), are:

Contaminant	Detection Level (ppm)**
*Aroclor 1016	0.1
Aroclor 1221	0.1
Aroclor 1232	0.1
Aroclor 1242	0.1
Aroclor 1248	0.1
Aroclor 1254	0.1
Aroclor 1260	0.1
Aroclor 1262	0.1
Aldrin	0.1
Lindane	0.1
Chlordane	0.1
DDT and metabolites	0.1
Dieldrin	0.01
Endosulfan	0.1
Endrin	0.1
Heptachlor	0.1
Heptachlor epoxide	0.1
Methoxychlor	0.1
Toxaphene	1.0

* Aroclor 1016 to 1262 are forms of PCBs (Polychlorinated biphenyls)

** ppm = mg/kg

Analyses were performed by the Michigan Department of Natural Resources Environmental Laboratory.

Analyses were conducted on multiple aliquots (subsamples) drawn from the same sample as a measure of analytical precision. Reference samples (samples of known contaminant concentration) were obtained from the U.S. Fish and Wildlife Service, Ann Arbor, and analyzed along with samples from this study as a measure of analytical accuracy. Appendix B is a discussion of the accuracy and precision of the data from this study.

Statistical summaries of contaminant concentrations were calculated using values which were lower than the level of detection. These values were included in the calculations at a value equal to ½ of the level of detection, e.g., if a value was reported as " 0.1", it was included in the calculations as "0.05". If more than half of the reported values in a data set were "less thans", the resultant statistic was noted as " ".

All data have been entered into STORET, the U.S. EPA data STOrage and RETrieval system.

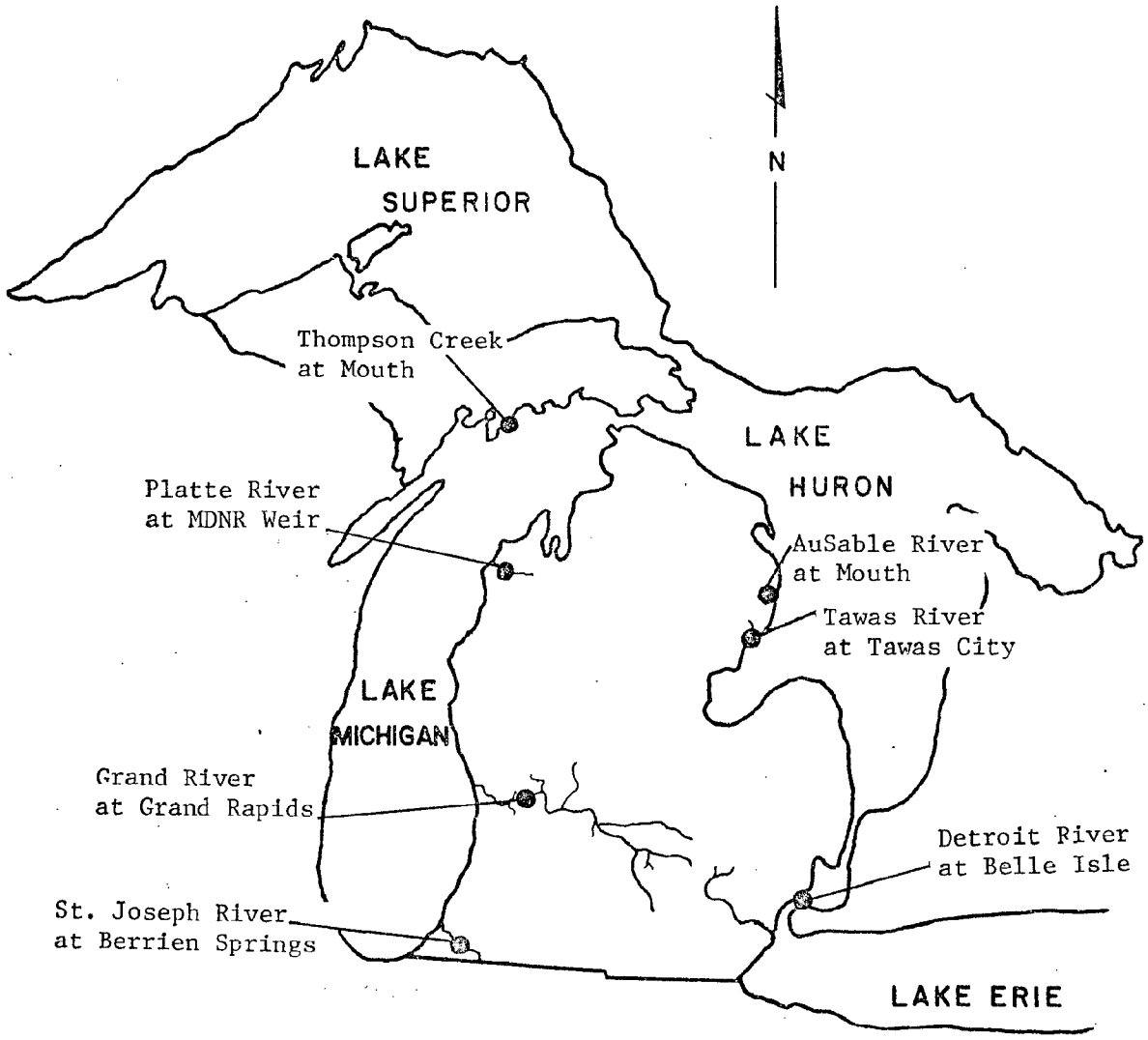


Figure 1 - Sites where coho and chinook salmon were collected in 1981 for contaminant analysis.

RESULTS AND DISCUSSION

Seventy-one chinook and 143 coho salmon were analyzed. Table 1 is a summary by species and site. Table C (Appendix C) lists vital statistics and contaminant concentrations. Only dieldrin, chlordane, PCBs, and DDT (DDT+metabolites) were found above analytical detection levels. Table 1 is a summary of these contaminants by species and site. Table C (Appendix C) lists vital statistics and contaminant concentrations for each sample.

CHINOOK

Dieldrin

The average concentration in the 71 fish was .019 ppm, with a 90% confidence interval of between .015 and .023 ppm (that is, we are confident that the true average concentration will be between .015 and .023 ppm 90 times out of every 100). The site with the highest average was the Platte River (.032 ppm); the lowest was the St. Joseph (.015 ppm). The U.S. Food and Drug Administration (FDA) "Action Level" (the maximum concentration allowable for commercial sale) is 0.3 ppm. None of the fish analyzed exceeded this level.

Chlordane

The analyses showed that the concentration of chlordane (a mixture of compounds), as measured against a "technical chlordane" standard, was higher than the minimum level of detection (0.1 ppm) in most of the chinook. Accurate quantification of chlordane is not possible at this time because of interference by other naturally occurring and synthetic (notably PCBs and DDT) compounds. Further purification of the extracts and refinement of chromatographic technique will be needed before accurate results can be reported.

PCBs

The average concentration for the 71 fish was 1.6 ppm with a 90% confidence interval of 1.4 ppm - 1.8 ppm. The site with the highest average was the St. Joseph River (1.9 ppm); the lowest was Tawas River (0.8 ppm).

The "Action Level" for PCBs is 5 ppm. Only 1 fish (6.1 ppm; AuSable) exceeded this level. The proposed "Action Level" is 2 ppm. A summary of those exceeding 2 ppm is:

	Number exceeding 2 ppm	% of total
Platte River	4	40
Grand River	1	5
St. Joseph River	9	36
Tawas River	0	0
AuSable River	4	27
All	18 (of 71)	25

Table 1 - Summary of 1981 salmon contaminant data. Data are presented as the average values with 90% statistical confidence intervals in parentheses. Table B (Appendix B) presents raw data.

Species/Location	Number of Fish Sampled (Age)	Length cm	Weight kg	Percent Fat	Dieldrin ppm	*Total PCBs ppm	Total DDT ppm
Chinook							
Platte River	10 (4-5 yr;5-4 yr;1-3 yr)	91.2 (85.3-97.0)	4.9 (4.1-5.6)	1.1 (0.6-1.6)	.032 (.013-.052)	1.9 (1.2-2.6)	.62 (.46-.78)
Grand River	19 (2-5 yr;16-4 yr;1-3 yr)	87.4 (85.5-89.3)	6.0 (5.6-6.5)	0.7 (0.5-0.9)	.016 (.011-.022)	0.9 (0.7-1.1)	.33 (.26-.40)
St. Joseph River	25 (5-5 yr;17-4 yr;3-3 yr)	88.9 (86.8-91.0)	6.4 (5.9-6.9)	0.7 (0.6-0.8)	.015 (.009-.022)	1.9 (1.6-2.2)	.73 (.63-.83)
Tawas River	2 (2-4 yr)	87.4 (73.3-101.4)	6.5 (5.8-12.5)	0.6 (0.3-1.5)	.024 (.020-.028)	0.8 (0.53-1.07)	.21 (.18-.23)
AuSable River	15 (3-5 yr;9-4 yr;3-3 yr)	84.1 (80.0-88.2)	6.1 (5.2-6.9)	0.9 (0.6-1.1)	.020 (.012-.028)	1.8 (1.7-1.9)	.31 (.23-.39)
Average (71 fish)		87.8 (86.2-89.2)	6.0 (5.7-6.3)	.8 (.7- .9)	.019 (.015-.023)	1.6 (1.4-1.8)	.50 (.44-.56)
Coho							
Thompson Creek	25 (25-3 yr)	66.4 (65.3-67.5)	3.0 (2.9-3.1)	0.8 (0.6-1.1)	.014 (.010-.017)	1.3 (0.9-1.7)	.41 (.30-.52)
Platte River	25 (25-3 yr)	68.3 (66.7-69.9)	3.0 (2.8-3.2)	1.5 (1.2-1.9)	.031 (.023-.040)	1.5 (1.0-1.9)	.37 (.28-.47)
Grand River	25 (24-3 yr;1-2 yr)	67.7 (66.0-69.3)	2.9 (2.7-3.1)	0.5 (0.4-0.6)	.011 (.007-.014)	1.2 (1.0-1.5)	.28 (.22-.34)
St. Joseph River	15 (14-3 yr;1-2 yr)	68.2 (65.8-70.5)	2.7 (2.5-3.0)	0.7 (0.5-0.9)	.014 (.008-.020)	0.7 (0.5-0.9)	.26 (.19-.32)
Tawas River	28 (3-4 yr;25-3 yr)	69.9 (67.5-72.3)	3.7 (3.3-4.1)	1.8 (1.4-2.2)	.028 (.009-.046)	1.4 (1.1-1.7)	.30 (.24-.37)
Detroit River (Belle I.)	25 (1-4 yr;24-3 yr)	68.4 (66.8-70.1)	3.2 (2.9-3.4)	1.5 (1.0-2.0)	.010 (.007-.013)	0.7 (0.6-0.9)	.08 (.06-.10)
Average (143 fish)		68.2 (67.4-68.9)	3.1 (3.0-3.2)	1.2 (1.0-1.3)	.018 (.014-.022)	1.2 (1.0-1.3)	.29 (.25-.32)

*PCB = polychlorinated biphenyl
ppm = mg/kg

DDT

The average concentration for the 71 fish was 0.5 ppm with a 90% confidence interval of 0.44 ppm to 0.56 ppm. The site with the highest average was the St. Joseph River (0.73 ppm); the lowest was the Tawas River (0.21 ppm). The FDA "Action Level" for DDT is 5 ppm. None of the fish analyzed in this study exceeded this level. The highest level found in any sample was 1.2 ppm (two from the St. Joseph and one from the Platte).

COHO

Dieldrin

The average concentration in the 143 fish was .018 ppm (Table 1), with a 90% confidence interval between .014 and .022 ppm. The site with the highest average was the Platte River (.031 ppm); the lowest was the Detroit River (.01 ppm). One fish (from Tawas) equaled the FDA "Action Level" of 0.3 ppm.

Chlordane

The analyses showed that the concentration of chlordane (a mixture of compounds), as measured against a "technical chlordane" standard, was higher than the minimum level of detection (0.1 ppm) in most of the coho. Accurate quantification of chlordane is not possible at this time because of interference by other naturally occurring and synthetic (notably PCBs and DDT) compounds. Further purification of the extracts and refinement of the chromatographic technique will be needed before accurate results can be reported.

PCBs

The average concentration in the 143 fish was 1.2 ppm with a confidence interval of 1.0 - 1.3 ppm. The site with the highest average was the Platte River (1.5 ppm); the lowest was the St. Joseph River and the Detroit River (both with 0.7 ppm).

Two (1.4% of total) fish exceeded the FDA "Action Level" of 5 ppm (6.7 ppm at Thompson Creek; 5.7 ppm at Platte River). A summary of those exceeding the proposed 2 ppm "Action Level" is:

	Number exceeding 2 ppm	% of total
Thompson Creek	4	16
Platte River	5	20
Grand River	4	16
St. Joseph River	0	0
Tawas River	6	21
Detroit River	0	0
All	19 (of 143)	13%

DDT

The average concentration for all fish was 0.29 ppm with a 90% confidence interval of 0.25 ppm - 0.32 ppm. The site with the highest average was Thompson Creek (0.41 ppm); the lowest was the Detroit River (0.08 ppm). None of the fish exceeded the 5 ppm "Action Level". The highest concentration in any one sample was 1.6 ppm (Thompson Creek).

PRECISION AND ACCURACY OF DATA

An analysis of accuracy (a measure of how close the analytical results are to actual; Appendix C) indicates that the data from this study accurately reflect the concentrations in the samples. An analysis of precision (a measure of how close reported measurements are to each other; Appendix C) indicates that concentrations of contaminants from this study could be, on the average, between 20 percent to 40 percent (depending on the contaminant) higher or lower than those values reported.

COMPARISON WITH OTHER DATA

Comparison with 1980 DNR Data

Table 2 compares 1980 and 1981 concentrations (see MDNR, 1981 for details of 1980 results). Average concentrations of PCBs and DDT were substantially lower in 1981 for both chinook and coho salmon at all sites which were sampled both years. Dieldrin was lower in 1981 at some sites but higher at others, but showed no significant changes.

Comparison with 1981 FDA Data

Coho salmon were collected simultaneously at the Platte River and Tawas River for analysis by the Food and Drug Administration (FDA). Fifteen fish from each site were composited into 3 5-fish samples and analyzed by the FDA. A comparison of the average contaminant concentrations from the FDA analyses and DNR analyses is:

	Percent Fat		Total PCBs (ppm)		Total DDT (ppm)	
	FDA	DNR	FDA	DNR	FDA	DNR
Coho						
Tawas	4.0	0.6	1.1	0.8	.34	.21
Platte	2.7	1.1	1.5	1.9	.54	.62

Percent fat values from the DNR analysis were lower. PCB and DDT values were similar. Chlordane was not found above the level of detection.

Table 2 - Comparison of 1980 with 1981 salmon contaminant levels. Data are average concentrations.

	Percent Fat		Dieldrin (ppm)		Total PCBs (ppm)		Total DDT (ppm)	
	'80	'81	'80	'81	'80	'81	'80	'81
CHINOOK								
Platte River	3.3	1.1	.050	.032	6.4	1.9	1.72	.62
Grand River	3.0	0.7	.050	.016	5.3	0.9	1.47	.33
St. Joseph River	2.4	0.7	.100	.015	8.2	1.9	2.13	.73
Tawas River	2.3	0.6	.020	.024	3.0	0.8	0.75	.21
COHO								
Platte River	5.4	1.5	.010	.031	2.5	1.5	.67	.37
Grand River	2.7	0.5	.030	.011	1.8	1.2	.51	.28
St. Joseph River	2.2	0.7	.050	.014	4.4	0.7	1.01	.26
Tawas River	6.6	1.8	.020	.028	2.7	1.4	0.40	.30
Detroit River	4.4	1.5	.020	.010	1.2	0.7	0.10	.08

LITERATURE CITED

MDNR. 1981. Organochlorine and Heavy Metal Residues in Coho and Chinook Salmon of the Great Lakes - 1980. Michigan Department of Natural resources, Publication Number 3730-0031, Lansing, Michigan.

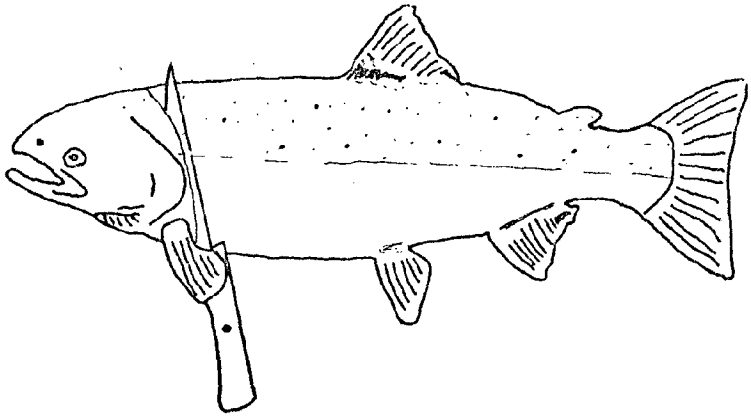
MDNR. 1982a. Michigan Fishing Guide. Published annually by the Michigan Department of Natural Resources, Lansing.

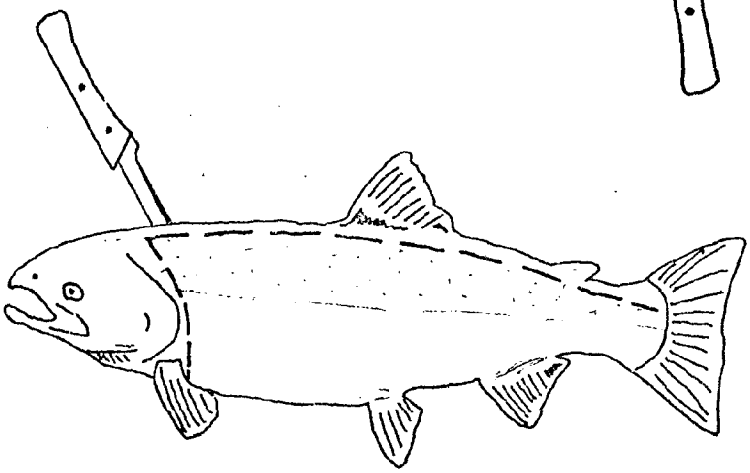
MDNR. 1982b. Analytical Procedures for Organic Residue Analysis: Scan 4. Polychlorinated Biphenyls and Organochlorine Pesticides. Environmental Laboratory, MDNR, Lasning. June 23, 1982 edition.

APPENDIX A

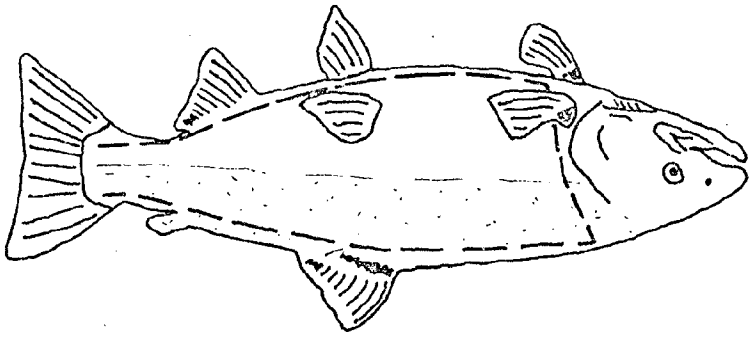
Figure A - Procedure for preparation of "standard fillets" analyzed in this study.

1. Make a cut behind the entire length of the operculum (gill cover) cutting through the skin and flesh to the spinal column.



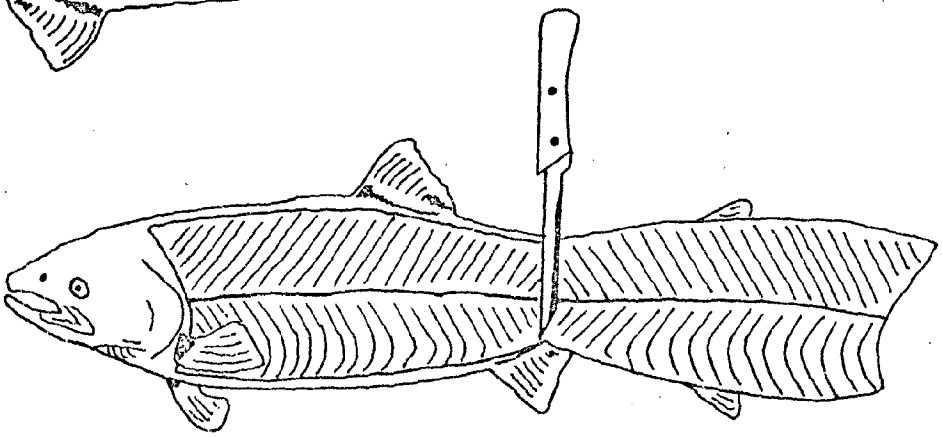


2. Make a shallow cut through the skin (on either side of the dorsal fin) from the base of head to the posterior end of the caudal peduncle.



3. Make a cut along the belly from the base of the pectoral fin to the posterior end of the caudal peduncle. This cut is made on both sides of the anus and the anal fin.

4. Remove the fillet and then remove any major bones.



APPENDIX B

Table B. Great Lakes salmon contaminant data. Fish were collected in September, 1981. PCB = polychlorinated biphenyl; MG/KG = ppm; < = less than.

[1] FIELD ID	LOCATION	SEX	[2] SPECIES CODE	AGE YEARS	LENGTH IN MM	WEIGHT IN GRAMS	FAT PERCENT	DIEL-DRIN MG/KG	TOTAL PCB MG/KG	TOT DDT +METABS MG/KG
D061	AUSAB	M	CHN	3	686.	2460.	0.575	0.0085	0.72	0.101
062	AUSAB	F	CHN	4	800.	5340.	0.14	<0.010	0.93	0.110
063	AUSAB	F	CHN	4	882.	6030.	1.20	0.034	2.50	0.340
064	AUSAB	M	CHN	5	973.	8620.	0.82	0.045	1.70	0.280
065	AUSAB	F	CHN	4	863.	6690.	1.10	0.052	1.60	0.280
066	AUSAB	F	CHN	4	879.	7720.	1.30	<0.010	2.80	0.330
067	AUSAB	F	CHN	4	902.	7380.	0.79	<0.010	2.00	0.230
068	AUSAB	M	CHN	5	942.	8540.	0.30	<0.010	1.70	0.420
069	AUSAB	F	CHN	4	839.	5120.	0.15	<0.010	0.98	0.110
D070	AUSAB	M	CHN	3	686.	3390.	1.08	0.0355	1.35	0.285
071	AUSAB	F	CHN	3	702.	3940.	1.60	0.045	1.20	0.320
073	AUSAB	M	CHN	5	948.	8520.	0.42	0.017	1.40	0.290
074	AUSAB	F	CHN	4	910.	6580.	0.11	<0.010	1.00	0.350
T075	AUSAB	F	CHN	4	795.	5530.	1.04	0.005	1.07	0.2733
D72	AUSAB	M	CHN	4	807.	5300.	2.20	0.026	6.10	0.870
D143	GRANDR	M	CHN	4	890.	5460.	0.16	0.005	1.65	0.440
176	GRANDR	F	CHN	4	820.	6330.	0.22	0.011	0.57	0.150
177	GRANDR	M	CHN	5	952.	8180.	1.70	<0.010	1.40	0.380
178	GRANDR	M	CHN	4	890.	6460.	0.26	<0.010	1.10	0.140
180	GRANDR	M	CHN	5	970.	5960.	0.10	<0.010	0.78	0.290
D181	GRANDR	M	CHN	4	910.	7000.	0.33	0.013	0.785	0.260
182	GRANDR	M	CHN	4	860.	6760.	1.70	0.044	1.30	0.540
183	GRANDR	M	CHN	4	928.	6720.	0.25	0.013	0.74	0.360
184	GRANDR	M	CHN	4	862.	5200.	1.00	<0.010	0.97	0.370
Q185	GRANDR	M	CHN	4	850.	5720.	1.66	0.0155	1.15	0.3825
186	GRANDR	M	CHN	4	855.	5840.	1.20	0.054	0.88	0.440
187	GRANDR	M	CHN	4	835.	5880.	0.51	0.025	0.67	0.330
188	GRANDR	M	CHN	4	820.	5280.	0.56	0.014	0.48	0.270
189	GRANDR	F	CHN	4	920.	7840.	1.60	<0.010	2.10	0.870
190	GRANDR	M	CHN	4	860.	5640.	0.84	0.032	1.30	0.500
191	GRANDR	F	CHN	3	774.	3640.	0.10	<0.010	0.13	0.056
192	GRANDR	M	CHN	4	868.	4840.	0.33	0.013	0.44	0.140
193	GRANDR	M	CHN	4	898.	7100.	0.88	0.022	0.53	0.260
194	GRANDR	M	CHN	4	845.	5000.	0.12	0.014	0.25	0.075
101	PLATTE	M	CHN	5	970.	4960.	1.30	0.100	2.90	0.730
102	PLATTE	F	CHN	5	1020.	5070.	0.38	<0.010	1.40	0.510
103	PLATTE	M	CHN	4	925.	3530.	2.20	0.055	4.80	1.200
104	PLATTE	M	CHN	5	1060.	5400.	2.00	0.088	2.50	0.920
105	PLATTE	F	CHN	4	875.	6790.	0.16	0.012	0.80	0.250

Table B continued

FIELD ID	LOCATION	SEX	SPECIES CODE	AGE YEARS	LENGTH IN MM	WEIGHT IN GRAMS	FAT PERCENT	DIEL-DRIN MG/KG	TOTAL PCB MG/KG	TOT DDT +METABS MG/KG
106	PLATTE	M	CHN	4	800.	4990.	2.50	0.018	2.40	0.710
107	PLATTE	M	CHN	4	780.	4240.	0.46	<0.010	0.94	0.380
108	PLATTE	M	CHN	4	900.	6560.	0.90	0.016	1.30	0.560
109	PLATTE	F	CHN	5	1020.	5180.	0.30	<0.010	1.10	0.600
T110	PLATTE	M	CHN	3	765.	2050.	0.5733	0.0187	0.8533	0.300
D201	ST JOE	M	CHN	4	810.	5420.	0.98	0.005	0.78	0.600
202	ST JOE	F	CHN	4	830.	5080.	0.55	<0.010	0.92	0.690
203	ST JOE	M	CHN	4	890.	6040.	1.10	0.079	2.40	1.200
204	ST JOE	M	CHN	4	845.	4980.	0.74	<0.010	1.80	1.200
205	ST JOE	M	CHN	4	860.	5260.	0.42	0.021	0.96	0.390
206	ST JOE	M	CHN	4	835.	5060.	0.54	<0.010	0.88	0.330
207	ST JOE	M	CHN	3	810.	4280.	0.90	0.049	1.80	1.000
208	ST JOE	M	CHN	4	915.	6200.	0.45	<0.010	1.80	0.660
209	ST JOE	F	CHN	4	910.	7040.	1.10	<0.010	1.10	0.910
210	ST JOE	M	CHN	4	885.	6140.	1.00	<0.010	1.60	0.790
211	ST JOE	M	CHN	3	815.	4580.	0.45	0.019	1.50	0.490
D212	ST JOE	M	CHN	5	975.	8060.	0.905	0.008	4.05	1.15
213	ST JOE	M	CHN	4	835.	5620.	0.56	<0.010	0.56	0.240
214	ST JOE	M	CHN	5	1015.	9120.	0.66	0.015	2.30	0.870
215	ST JOE	M	CHN	5	950.	6760.	0.43	<0.010	2.20	0.660
216	ST JOE	M	CHN	4	905.	7000.	0.94	<0.010	1.60	0.610
217	ST JOE	M	CHN	5	1000.	10680.	0.30	<0.010	1.50	0.430
218	ST JOE	M	CHN	4	885.	6500.	0.58	<0.010	1.60	0.420
219	ST JOE	M	CHN	5	990.	8300.	1.10	<0.010	2.90	1.100
220	ST JOE	F	CHN	4	915.	7300.	0.21	<0.010	1.00	0.360
D221	ST JOE	M	CHN	4	865.	5740.	1.25	0.033	2.70	0.895
222	ST JOE	M	CHN	3	805.	3760.	0.49	<0.010	1.80	0.470
223	ST JOE	M	CHN	4	860.	5900.	0.39	<0.010	2.90	0.720
224	ST JOE	M	CHN	4	900.	6860.	1.40	0.063	4.40	1.100
T225	ST JOE	M	CHN	4	920.	7960.	0.64	0.0143	2.80	0.9333
027	TAWAS	M	CHN	4	842.	5210.	0.83	0.023	0.86	0.210
029	TAWAS	F	CHN	4	905.	7880.	0.43	0.025	0.74	0.200

Table B continued

FIELD ID	LOCATION	SEX	SPECIES CODE	AGE YEARS	LENGTH IN MM	WEIGHT IN GRAMS	FAT PERCENT	DIEL-DRIN MG/KG	TOTAL PCB MG/KG	TOT DDT +METABS MG/KG
D301	BELL I	M	CHO	3	700.	3080.	0.855	0.005	1.40	0.300
302	BELL I	M	CHO	3	640.	2840.	1.50	<0.010	0.68	<0.100
303	BELL I	F	CHO	3	630.	2240.	4.50	0.034	1.50	0.140
304	BELL I	M	CHO	3	700.	2860.	2.30	0.021	0.91	<0.100
305	BELL I	M	CHO	4	820.	5020.	2.30	0.023	1.80	<0.100
306	BELL I	M	CHO	3	730.	3420.	0.84	<0.010	0.40	<0.100
307	BELL I	M	CHO	3	670.	2660.	1.60	0.014	0.98	<0.100
308	BELL I	F	CHO	3	655.	2900.	0.62	<0.010	0.69	<0.100
309	BELL I	F	CHO	3	720.	3680.	0.41	<0.010	0.32	<0.100
D310	BELL I	M	CHO	3	650.	2300.	0.725	0.005	0.43	0.050
311	BELL I	F	CHO	3	605.	2040.	0.63	<0.010	0.31	<0.100
312	BELL I	F	CHO	3	650.	2840.	0.47	<0.010	0.38	<0.100
313	BELL I	M	CHO	3	630.	2220.	2.30	<0.010	1.30	0.120
314	BELL I	F	CHO	3	690.	3380.	1.40	<0.010	0.64	<0.100
315	BELL I	F	CHO	3	670.	3460.	0.54	<0.010	0.21	<0.100
316	BELL I	F	CHO	3	680.	3120.	0.33	<0.010	0.46	<0.100
317	BELL I	F	CHO	3	755.	3680.	1.30	<0.010	0.53	<0.100
318	BELL I	F	CHO	3	695.	3600.	1.40	<0.010	0.46	<0.100
319	BELL I	F	CHO	3	670.	2930.	0.63	<0.010	0.34	<0.100
320	BELL I	M	CHO	3	675.	2800.	0.94	<0.010	0.35	<0.100
D321	BELL I	M	CHO	3	755.	5040.	6.70	0.026	1.50	0.155
322	BELL I	M	CHO	3	690.	2580.	1.50	0.014	0.37	<0.100
323	BELL I	M	CHO	3	725.	3440.	0.94	<0.010	0.46	<0.100
324	BELL I	F	CHO	3	695.	3820.	0.82	<0.010	0.49	<0.100
T327	BELL I	F	CHO	3	610.	3120.	2.57	0.0247	0.8267	0.2767
D130	GRANDR	M	CHO	3	673.	2520.	1.25	0.0515	1.85	0.640
D133	GRANDR	F	CHO	3	682.	3000.	0.145	0.005	0.625	0.160
151	GRANDR	F	CHO	3	698.	2920.	0.22	<0.010	1.20	0.190
152	GRANDR	F	CHO	3	591.	2060.	0.58	0.014	0.67	0.200
153	GRANDR	F	CHO	3	635.	2280.	0.14	<0.010	1.10	0.200
154	GRANDR	M	CHO	3	658.	2380.	0.38	<0.010	2.00	0.240
155	GRANDR	M	CHO	3	772.	3660.	1.00	<0.010	2.90	0.830
D155	GRANDR	F	CHO	3	655.	2760.	0.16	0.005	1.85	0.275
156	GRANDR	M	CHO	3	703.	3240.	0.94	0.014	1.20	0.290
158	GRANDR	F	CHO	3	656.	2660.	0.04	<0.010	0.52	0.120
159	GRANDR	F	CHO	3	648.	2300.	0.37	0.014	0.67	0.170
160	GRANDR	M	CHO	3	690.	3880.	0.27	<0.010	2.30	0.220
161	GRANDR	F	CHO	3	722.	3720.	0.62	0.035	1.30	0.400
162	GRANDR	F	CHO	3	670.	3100.	0.80	<0.010	1.20	0.250

Table B continued

FIELD ID	LOCATION	SEX	SPECIES CODE	AGE YEARS	LENGTH IN MM	WEIGHT IN GRAMS	FAT PERCENT	DIEL-DRIN MG/KG	TOTAL PCB MG/KG	TOT DDT +METABS MG/KG
164	GRANDR	M	CHO	3	696.	3160.	1.30	<0.010	2.90	0.510
165	GRANDR	F	CHO	3	685.	3240.	0.76	<0.010	1.50	0.450
166	GRANDR	F	CHO	3	681.	3220.	0.33	0.011	0.94	0.190
167	GRANDR	F	CHO	3	685.	3140.	0.44	<0.010	0.58	0.210
168	GRANDR	M	CHO	3	731.	3000.	0.06	<0.010	0.30	0.110
169	GRANDR	F	CHO	3	713.	3380.	0.30	0.016	0.83	0.160
170	GRANDR	M	CHO	3	720.	4220.	0.53	<0.010	1.50	0.430
172	GRANDR	M	CHO	3	707.	3100.	0.58	0.017	0.51	0.150
173	GRANDR	F	CHO	3	663.	2620.	0.60	<0.010	0.98	0.270
174	GRANDR	M	CHO	2	510.	1280.	0.69	0.010	0.67	0.180
T175	GRANDR	F	CHO	3	670.	2660.	0.2133	0.005	0.47	0.1233
126	PLATTE	M	CHO	3	695.	3090.	0.85	<0.010	1.20	0.580
D127	PLATTE	M	CHO	3	625.	1800.	1.11	0.014	1.45	0.620
128	PLATTE	F	CHO	3	740.	4160.	3.10	0.100	5.70	1.200
129	PLATTE	F	CHO	3	740.	4030.	1.70	0.029	3.00	0.580
130	PLATTE	F	CHO	3	670.	2440.	3.10	0.049	4.50	0.910
131	PLATTE	M	CHO	3	635.	2100.	2.70	0.056	1.20	0.390
132	PLATTE	M	CHO	3	740.	3280.	1.90	0.058	1.10	0.330
133	PLATTE	F	CHO	3	640.	2560.	2.40	0.034	2.30	0.420
134	PLATTE	M	CHO	3	695.	3060.	3.00	0.047	1.50	0.410
135	PLATTE	F	CHO	3	595.	2060.	3.50	0.031	1.00	0.270
136	PLATTE	M	CHO	3	675.	2790.	1.50	<0.010	1.20	0.230
D137	PLATTE	M	CHO	3	670.	2390.	0.91	0.014	0.43	0.102
138	PLATTE	F	CHO	3	670.	2480.	0.52	0.018	0.56	0.150
139	PLATTE	F	CHO	3	710.	3260.	1.00	0.031	1.20	0.270
140	PLATTE	M	CHO	3	745.	4230.	0.34	<0.010	0.36	0.070
141	PLATTE	F	CHO	3	655.	2630.	0.45	0.012	0.52	0.120
142	PLATTE	M	CHO	3	650.	2580.	0.38	0.014	0.49	0.120
143	PLATTE	F	CHO	3	560.	2740.	3.90	0.086	2.50	0.760
144	PLATTE	F	CHO	3	730.	3570.	0.28	<0.010	0.31	0.072
145	PLATTE	F	CHO	3	680.	2860.	1.30	0.056	1.50	0.450
146	PLATTE	F	CHO	3	715.	3510.	0.80	0.029	1.30	0.380
D147	PLATTE	F	CHO	3	720.	3080.	1.75	0.0435	1.25	0.295
148	PLATTE	M	CHO	3	695.	3080.	0.88	0.019	1.10	0.260
149	PLATTE	F	CHO	3	705.	3680.	0.39	<0.010	0.62	0.140
T150	PLATTE	F	CHO	3	720.	3450.	0.60	0.0153	0.7267	0.210
226	ST JOE	F	CHO	3	685.	2800.	0.10	<0.010	0.28	0.120
227	ST JOE	M	CHO	2	545.	1420.	1.50	<0.010	1.60	0.530
228	ST JOE	M	CHO	3	735.	3210.	0.86	<0.010	0.90	0.330
229	ST JOE	F	CHO	3	745.	2420.	0.14	<0.010	< 0.10	0.100
230	ST JOE	F	CHO	3	685.	3180.	0.78	0.019	0.62	0.170
231	ST JOE	F	CHO	3	700.	3300.	1.30	0.050	1.80	0.600
232	ST JOE	F	CHO	3	730.	3040.	1.10	0.013	0.93	0.270

Table B continued

FIELD ID	LOCATION	SEX	SPECIES CODE	AGE YEARS	LENGTH IN MM	WEIGHT IN GRAMS	FAT PERCENT	DIEL-DRIN MG/KG	TOTAL PCB MG/KG	TOT DDT +METABS MG/KG
232	ST JOE	F	CHO	3	730.	3040.	1.10	0.013	0.93	0.270
D233	ST JOE	F	CHO	3	665.	2540.	0.16	0.005	0.37	0.145
234	ST JOE	F	CHO	3	650.	2240.	0.10	<0.010	0.10	0.080
235	ST JOE	M	CHO	3	685.	2960.	1.40	0.025	0.10	0.330
236	ST JOE	M	CHO	3	665.	2120.	1.40	0.032	1.10	0.340
237	ST JOE	F	CHO	3	700.	3020.	0.39	0.010	0.97	0.200
238	ST JOE	M	CHO	3	740.	3420.	0.70	0.023	0.60	0.310
T239	ST JOE	F	CHO	3	694.	3300.	0.2233	0.0067	0.4667	0.1727
240	ST JOE	M	CHO	3	600.	1850.	0.34	<0.010	0.60	0.170
D001	TAWAS	F	CHO	3	696.	4260.	4.80	0.027	2.95	0.660
002	TAWAS	M	CHO	3	743.	4530.	0.68	0.016	0.85	0.140
003	TAWAS	M	CHO	3	642.	2540.	2.50	0.025	1.50	0.800
004	TAWAS	M	CHO	3	655.	2500.	1.80	0.019	1.20	0.590
005	TAWAS	F	CHO	3	734.	4180.	0.47	<0.010	0.74	0.110
006	TAWAS	F	CHO	3	650.	2850.	0.82	0.012	0.68	0.120
007	TAWAS	M	CHO	3	724.	3990.	2.40	0.024	1.40	0.210
008	TAWAS	F	CHO	3	631.	2940.	0.55	0.015	0.73	0.054
009	TAWAS	M	CHO	3	712.	4000.	1.60	0.019	0.64	0.150
D010	TAWAS	F	CHO	3	656.	2840.	0.935	0.015	0.655	0.270
011	TAWAS	F	CHO	3	616.	2360.	0.98	<0.010	0.53	0.120
012	TAWAS	M	CHO	3	667.	2960.	2.20	<0.010	0.60	0.210
013	TAWAS	M	CHO	3	602.	1980.	1.30	<0.010	0.59	0.120
014	TAWAS	F	CHO	3	600.	2390.	1.20	<0.010	0.56	0.130
015	TAWAS	M	CHO	3	719.	3480.	1.20	<0.010	3.30	0.340
016	TAWAS	F	CHO	3	686.	3580.	0.45	<0.010	1.10	0.099
017	TAWAS	F	CHO	3	647.	2860.	0.66	<0.010	1.40	0.120
018	TAWAS	F	CHO	3	686.	3490.	2.20	0.086	0.97	0.240
019	TAWAS	M	CHO	3	762.	4700.	5.30	0.300	1.70	0.610
020	TAWAS	M	CHO	3	744.	4350.	3.50	<0.010	3.60	0.590
D021	TAWAS	M	CHO	3	656.	2760.	2.80	0.0205	2.75	0.410
022	TAWAS	F	CHO	3	660.	3170.	1.40	0.021	2.00	0.420
023	TAWAS	F	CHO	3	715.	4020.	2.50	<0.010	1.80	0.220
024	TAWAS	F	CHO	3	678.	3890.	3.10	<0.010	3.00	0.720
T025	TAWAS	F	CHO	3	663.	3260.	1.69	0.0183	0.8467	0.1860
026	TAWAS	F	CHO	4	888.	5970.	0.64	<0.010	0.69	0.180
028	TAWAS	F	CHO	4	920.	8810.	0.45	<0.010	1.70	0.250
T030	TAWAS	M	CHO	4	811.	5140.	1.83	0.091	1.38	0.430
D251	THOMCK	F	CHO	3	680.	3020.	0.655	0.0235	1.65	0.550
252	THOMCK	F	CHO	3	685.	3200.	1.10	<0.010	2.30	0.870
253	THOMCK	M	CHO	3	640.	2680.	1.70	<0.010	2.00	0.810
254	THOMCK	F	CHO	3	700.	3780.	0.75	0.019	1.70	0.400
255	THOMCK	M	CHO	3	695.	3360.	0.88	0.029	2.60	0.810
256	THOMCK	F	CHO	3	650.	2910.	0.88	0.013	0.65	0.220
257	THOMCK	M	CHO	3	720.	3300.	0.65	<0.010	1.20	0.430

Table B continued.

FIELD ID	LOCATION	SEX	SPECIES CODE	AGE YEARS	LENGTH IN MM	WEIGHT IN GRAMS	FAT PERCENT	DIEL-DRIN MG/KG	TOTAL PCB MG/KG	TOT DDT +METABS MG/KG
257	THOMCK	M	CHO	3	720.	3300.	0.65	<0.010	1.20	0.430
258	THOMCK	F	CHO	3	630.	2910.	0.48	<0.010	1.10	0.200
259	THOMCK	M	CHO	3	695.	3160.	2.90	0.023	6.70	1.600
D260	THOMCK	F	CHO	3	685.	3140.	0.60	0.005	0.94	0.215
261	THOMCK	F	CHO	3	625.	2640.	0.53	<0.010	0.82	0.330
262	THOMCK	M	CHO	3	665.	2850.	0.90	<0.010	1.40	0.450
T263	THOMCK	F	CHO	3	645.	3170.	0.5833	0.017	1.27	0.3967
264	THOMCK	F	CHO	3	700.	3780.	0.43	<0.010	0.99	0.410
265	THOMCK	F	CHO	3	670.	3220.	0.61	<0.010	1.10	0.330
266	THOMCK	F	CHO	3	700.	3190.	0.53	<0.010	1.10	0.330
267	THOMCK	F	CHO	3	645.	2460.	0.38	0.017	0.45	0.160
268	THOMCK	F	CHO	3	670.	3180.	0.29	0.016	0.35	0.130
269	THOMCK	M	CHO	3	655.	2820.	2.40	0.048	1.00	0.420
270	THOMCK	M	CHO	3	585.	1870.	1.20	0.030	0.80	0.300
D271	THOMCK	F	CHO	3	675.	3170.	0.64	0.0125	0.385	0.145
272	THOMCK	M	CHO	3	680.	3040.	0.34	0.011	0.59	0.220
273	THOMCK	F	CHO	3	595.	2280.	0.36	0.011	0.40	0.140
274	THOMCK	F	CHO	3	670.	2870.	0.10	<0.010	0.20	0.056
275	THOMCK	F	CHO	3	645.	3170.	1.00	0.016	0.76	0.230

1 - D, T, or Q prefix to field ID of sample indicates that sample was analyzed in Duplicate, Triplicate, or Quadruplicate as a measure of analytical precision.

2 - CHN = chinook salmon
CHO = coho salmon

APPENDIX C

Accuracy and Precision

Accuracy

Accuracy is the closeness of a measured value to its true value. All analyses have some degree of accuracy error. One way to measure accuracy is to compare the values obtained from a sample of unknown contaminant level to those obtained from samples of known level. The sample of known level is a "standard".

For this study, samples of known levels of polychlorinated biphenyls were obtained from the U.S. Fish & Wildlife Service Laboratory, Ann Arbor. The average concentration in the reference sample was 13.19 mg/kg (ppm) with a 95 percent confidence interval of between 12.8 ppm and 13.6 ppm. The average was derived from analysis of ten replicate aliquots. The aliquots were chosen at random from hundreds made from a homogeneous puree of 18 lake trout (Northrup, 1982).

The MDNR Environmental Laboratory analyzed 22 of these reference aliquots along with the samples from this study. The average concentration in those 22 samples was 12.80 ppm with a standard deviation of 4.8. Statistically, we are confident that 95 out of every 100 estimates of the average will be within a range of 10.90 to 14.70 ppm. Since the confidence interval of the standard overlaps with this, we consider that the data from this study accurately represents the concentrations in the samples.

Precision

Precision is the closeness of repeated measurements to the same quantity. All analyses have some degree of precision error. One way to measure precision is to repeat the analysis of a sample. For the analyses conducted in this study, multiple (2, 3, or 4) aliquots (subsamples) were drawn from a homogenized sample and were analyzed. Twenty-two coho and 12 chinook samples were analyzed in this manner.

As a measure of precision, the "coefficient of variation" (CV) was calculated for each of the 34 samples. The CV is a way of expressing the amount of variation among the multiple observations. The CV is the standard deviation expressed as a percentage of the average, and is calculated as follows:

$$CV = \text{standard deviation}/\text{average}$$

Table C presents the average CVs found for each site and species. For both coho and chinook, dieldrin was the most variable with CVs of 46.4 percent and 40.8 percent, respectively. Therefore, concentrations reported could be approximately 40 percent higher or lower due to analytical methodology.

Percent fat, DDT (DDT + metabolites), and PCBs had the lowest CVs for both species. Concentrations reported could be approximately 20 percent higher or lower due to analytical methodology.

A review of Table C indicates that the magnitude of the CVs was not related to species or site. None of the sites or species showed consistently higher or lower CVs for the four parameters (percent fat and three contaminants). The variability of the analytical results (as measured by the CVs) appears to be random and not related to factors unique to species or site. However, variability does appear to be related to parameter (e.g., dieldrin data are more variable than PCBs and percent fat).

Northrup, D. 1982. Personal Communication. Laboratory Scientist, U.S. Fish & Wildlife Service, Great Lakes Fisheries Laboratory, Ann Arbor, Michigan.

Table C - Summary of analytical precision. Twenty-two coho and 12 chinook were each analyzed more than once to determine the precision of the analytical method. The Coefficient of Variation (CV) is a measure of variability. The average CV's for each site and species are presented.

	Coefficient of Variation			
	% fat	dieldrin	*PCBs	DDT
COHO				
Thompson Creek	18.0%	26.4	21.8	20.0
Platte River	12.7	30.0	20.8	13.2
Grand River	18.8	24.3	22.5	19.4
St. Joseph River	28.6	17.9	33.9	21.0
Tawas River	27.1	69.1	14.2	41.3
Detroit River (Belle Isle)	13.1	21.9	15.9	12.3
Average (N=22)	18.9	46.4	20.4	21.2
CHINOOK				
Platte River	18.2	25.6	23.7	21.9
Grand River	23.6	43.3	26.7	29.3
St. Joseph River	17.3	36.3	16.1	13.8
Ausable River	18.9	29.2	11.4	20.9
Tawas River	43.3	102.1	33.7	35.6
Average (N=12)	21.5	40.8	19.7	21.9

*PCB= total polychlorinated biphenyls

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