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Contaminant Analysis of 1981 Fall Run Coho Salmon (Onchorhynchus Kisutch)

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FOREWORD

The Great Lakes National Program Office (GLNPO) of the U.S. Environmental Protection Agency was established in Region V, Chicago to focus attention on the significant and complex natural resource represented by the Great Lakes.

GLNPO implements a multi-media environmental management program drawing on a wide range of expertise represented by Universities, private firms, State, Federal and Canadian governmental agencies and the International Joint Commission. The goal of the GLNPO program is to develop programs, practices and technology necessary for a better understanding of the Great Lakes system and to eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes system. The GLNPO also coordinates U.S. actions in fulfillment of the Agreement between Canada and the United States of America on Great Lakes Water Quality of 1978.

This study was carried out under a cooperative agreement between GLNPO, US Food and Drug Administration (USFDA) and the States of Ohio, Michigan, New York, Pennsylvania, Illinois, Indiana and Wisconsin. The samples were collected by state personnel and analyzed by USFDA. Data analysis and program coordination was provided by GLNPO.

ABSTRACT

The comprehensive analysis of coho salmon from each of the Great Lakes by a single laboratory has, for the second year, produced a set of tissue residue data on environmental contaminants whose use has been banned or severely restricted. Coho salmon from Lake Superior contained only trace amounts or low levels of most toxic substances quantified. Lake Erie fish were contaminated with low levels of a number of pesticides and industrial compounds with relatively higher residue levels in coho from Lake Huron and Lake Michigan. The highest residue levels for a number of compounds were found in coho from Lake Ontario. Because of their open water habitat preferences, the contaminant levels in coho salmon demonstrate open lake contaminant problems rather than point source or nearshore conditions. The data reported in our study generally agrees with recent findings from individual state contaminant monitoring programs although problems with varying analytical and sampling techniques preclude direct comparisons. However, current tissue residue levels are usually less than those previously reported and are lower than USFDA action levels which are used by many agencies in assessing the severity of fish contaminant problems. The major exception being the levels of mirex in fish collected from Lake Ontario which exceeded the 0.1 ug/g action level.

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INTRODUCTION

Fish contaminant monitoring programs have been implemented by state and federal agencies throughout the Great Lakes Basin with varying levels of intensity to address several toxic substance problems. The Great Lakes Fish Monitoring Strategy (GLNPO 1981) was designed and implemented to provide interagency coordination and cooperation for gathering information on the toxic substance problem in the Great Lakes. In an effort to address the potential public health concerns associated with contaminants in major game fish from each of the Great Lakes, one element of the Great Lakes Fish Monitoring Strategy calls for the collection and analysis of fall run coho salmon (*Oncorhyrchus kisutch*).

Coho salmon were chosen for contaminant monitoring because of their popularity as a sport fish, rapid growth rates and migratory behavior. Coho move about the nearshore and open water areas of a lake while maturing and are exposed to contaminants from numerous sources. As a fast growing, terminal predator in the Great Lakes, coho salmon consume large quantities of alewife and other forage fish. They may, therefore, accumulate chlorinated organics and other contaminants through direct absorption and the food chain. Numerous coho salmon of a uniform age group can be sampled relatively easily as mature fish return to tributaries to spawn at the end of their three year life cycle. Also, their three year life span provides an indication of contaminant problems over the recent past, as opposed to the extended picture given by more long lived species such as lake trout (*Salvelinus namaycush*).

METHODS

State agency personnel collected adult coho salmon using nets and other conventional equipment as the fish began their fall, upstream migrations in 1981. Where sufficient fish were available, 15 adult coho salmon were collected at each site (Figure 1) and composited 5 fillets per sample. Two year old fish supplemented the Pine Creek (Lake Superior), Kellog Creek (Lake Michigan), Chagrin River and Huron River (Lake Erie) collections. Only 4 fish were collected at Pine Creek and 6 at the Sheboygan River site. The age, mean lengths, weights and ranges for fish yielding fillets are listed in Table 1. The collecting agency froze the fish samples and shipped them to the U.S. Food and Drug Administration's (USFDA) Laboratory in Minneapolis, Minnesota for analysis.

The fillets in each sample were ground into a uniform tissue homogenate. An aliquot of this homogenate was weighed and analyzed for contaminant residues according to the USFDA Pesticide Analytical Manual (USFDA 1980). Contaminants were triple extracted from the fish tissue in petroleum ether and fats separated from the sample using petroleum ether/acetonitrile partitioning. The sample preparations were then added to an activated Florisil column. Three solutions of increasing polarity were put through the column providing distinct preparations for analysis with interferences due only to interactions of individual and multipeak contaminants within each extract.

Mirex and 8-monohydromirex (photomirex) were determined by a combination of official and collaborated methods. This involved the triple extraction of the contaminants from the fish tissue in petroleum ether with fats separated

Figure 1
Tributary locations for 1981 coho salmon collections

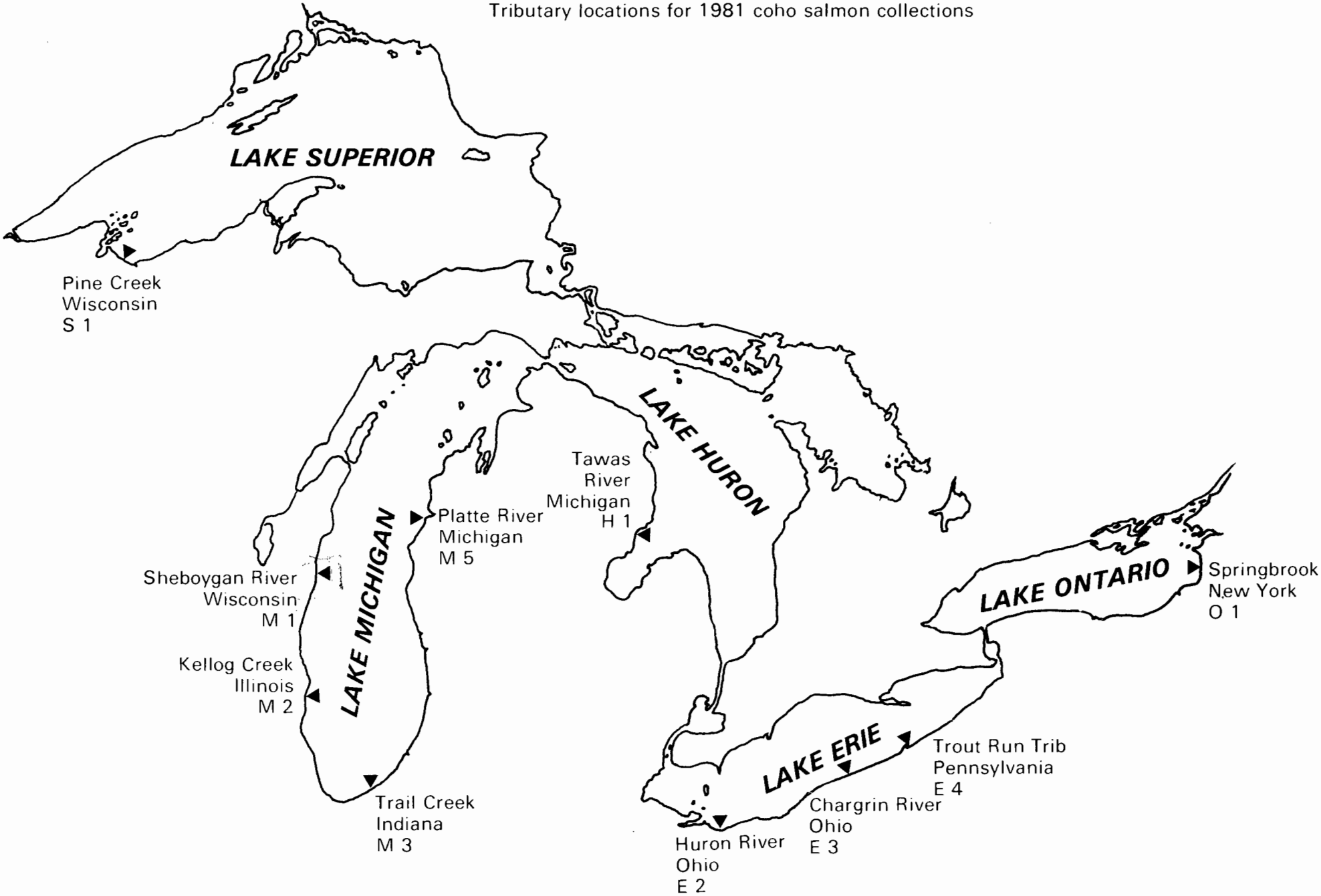

Table 1

Coho Salmon Sample Data - 1981 Collections

Collection Site and Date	Sample Number	Number of Fish Composited	Age	Mean Length (mm) (Range)	Mean Weight (kg) (Range)	% Lipid
Lake Superior						
Pine Creek - S1						
Bayfield Co, WI	1	2	3	489(457-521)	1.2 (1-1.3)	2.6
9/30/81	2	2	2	363(356-371)	.48(.451-.50)	3.5
Lake Michigan						
Sheboygan River - M1	1	2	2	356(328-384)	.75(.6-.9)	4.4
Kiwanis Park, WI	2	2	2	404(393-415)	1.0 (1.0-1.0)	5.6
9/29/81	3	2	3	598(570-625)	2.95(2.3-3.6)	2.0
Trail Creek - M3	1	5	3	674(650-782)	3.2(2.7-4.2)	2.3
Michigan County, IN	2	5	3	622(595-635)	2.3(2.1-2.4)	2.4
10/22/81	3	5	3	640(613-657)	2.5(2.4-2.7)	2.3
Kellogg Creek - M2	1	5	2	No length	.65(.45-.30)	0.8
Waukegan, IL	2	5	3	data recorded	2.02(.95-2.6)	1.1
1981	3	5	3		3.2(2.8-3.7)	1.2
Platt River - M5	1	5	3	695(610-759)	3.3(2.3-4.7)	1.3
Beuleh, MI	2	5	3	714(690-720)	3.3(3.1-3.4)	3.9
9/28/81	3	5	3	740(710-750)	3.9(3.5-4.7)	3.0
Lake Huron						
Tawas River-H1	1	5	3	680(655-741)	3.4(2.6-4.7)	3.9
Tawas City, MI	2	5	3	695(686-699)	3.7(3.2-3.5)	4.6
9/24/81	3	5	3	686(663-741)	4.1(3.6-4.7)	3.1

Table 1 (Continued)

Collection Site and Date	Sample Number	Number of Fish Composited	Age	Mean Length (mm) (Range)	Mean Weight (kg) (Range)	% Lipid
Lake Erie						
Chagrin River -E3	1	5	3	631(546-665)	3.1(2.4-3.8)	5.8
East Lake, OH	2	5	3	576(545-585)	2.1(1.8-2.3)	6.9
9/16/81	3	5	2	340(49 -432	.95(.84-1.12	6.1
Trib. to Trout Run-E4	1	5	3	515(480-560)	1.4(1.1-1.6)	5.5
Erie County, PA	2	5	3	576(570-590)	1.8(1.6-1.9)	4.6
10/5/81	3	5	3	617(620-640)	2.2(2.1-2.3)	2.9
Huron River - E2	1	5	2	416(406-432)	.95(.79-1.13)	2.7
Monroeville Dam	2	5	2&3	566(445-635)	2.1 (1.1-2.9)	3.4
10/21/81	3	5	3	635(585-698)	2.8(2.0-3.9)	2.0
Lake Ontario - O1						
Salmon River	1	5	3	786(771-786)	3.9(3.7-4.2)	2.0
Springbrook, NY	2	5	3	798(784-818)	4.6(4.4-4.8)	2.0
	3	5	3	826(814-837)	5.4(4.9-5.7)	2.8

from the samples using an unactivated Florisil column. The mirex and 8-monohydromirex were partially separated from the other contaminants using an activated Florisil column. Additional clean up was by a nitration process followed by an alumina column as described by Norstrom et al. (1980).

Organochlorine residues were quantified on a Hewlett-Packard gas-liquid chromatograph using a Nickel-63 electron capture detector. Total mercury was determined through flameless atomic absorption spectroscopy.

Analytical grade standards and pesticide grade solvents were used in the analysis. Analytical quantification limits were 0.005 ug/g for DDT and mirex, and 0.10 ug/g for PCB. A series of chlorinated chemicals resembling toxaphene were quantified when present at 0.25 ug/g or greater using a toxaphene standard. Several pesticides and industrial compounds which were present at low levels were not quantified unless present at concentrations above 0.05 ug/g although detection limits were 0.005 ug/g or less. Total mercury was quantified at 0.05 ug/g or greater concentrations. All fish tissue levels were computed on a ug/g wet weight basis and not corrected for extraction or recovery efficiency.

For purposes of graphical display and numerical calculations, concentrations below quantitation limits and above detection limits were assumed to be 1/2 the quantitation limits. Concentrations below the instrument detection limit were calculated as 0.

Results and Discussion

Laboratory analyses indicated the presence of 25 pesticides and industrial chemicals in the 29 coho salmon samples analyzed (Table 2). These

Table 2

Contaminant Data From the 1981 Coho Salmon Collections

Sample Number	Lake Superior		Lake Michigan											
	Pine Creek, WI		Sheboygan R.,WI.			Trail Cr.,IN			Kellogg Cr.,IL			Platte R. MI		
Aroclor 1260 (PCB)	<.1,	<.1	<.1,	.15,	.25	.20,	.24,	.29	<.1,	.14,	.17	.19,	.22,	.33
Aroclor 1254 (PCB)	<.1,	<.1	0.19,	0.59,	.99	.80,	.98,	1.16	.17,	.58,	.70	.77,	.90,	1.3
Aroclor 1248 (PCB)	ND	ND	ND	ND	ND	.22,	.27,	.32	<.1,	.16	.19	.21,	.24,	.36
Aroclor 1242 (PCB)	ND	ND	.24,	.46,	.39	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs	.1,	.1	.48,	1.2,	1.63	1.22,	1.49,	1.77	.27,	.88,	1.06	1.17,	1.36,	1.99
P,P,-DDE	.02,	.03	.05,	.23,	.53	.56,	.48,	.63	.07,	.28,	.33	.33,	.43,	.69
P,P,-DDD	ND	ND	<.005,	.01,	.02	.03,	.04,	.04	.01,	.01,	.01	<.005,	.02,	.02
P,P,-DDT	<.005,	<.005	<.005,	.02,	.04	.05,	.05,	.06	.01,	.03,	.03	.03,	.04,	.05
Total DDT	.02,	.03	.05,	.26,	.59	.64,	.57,	.73	.09,	.32,	.37	.36,	.49,	.76
"Apparent Toxaphene"	<.25,	<.25	<.25,	.6,	1.0	1.5,	1.8,	1.9	.3,	1.0,	1.1	0.9,	1.1,	1.6
Dieldrin	T	T	T,	.05,	T	T	T	T	T	T	T	T	T	T
Endrin	T	T	T	T	T	T	T	T	T	T	T	T	T	T
cis-Chlordane	T	T	T	T	T	T	T	T	T	T	T	T	T	T
trans-Chlordane	T	T	T	T	T	T	T	T	T	T	T	T	T	T
cis-Nonachlor	T	T	T	T	T	T	T	T	T	T	T	T	T	T
trans-Nonachlor	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Hexachlorobenzene	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Octachlor epoxide	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Heptachlor	T	T	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	T	T	T	T	T	ND	ND	ND	ND	ND	ND	T	T	T
Alpha-BHC	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Lindane (Gamma-BHC)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dacthal	ND	ND	T	T	T	T	T	T	T	T	T	T	T	T
pentachlorophenyl methyl ether	T	T	T	T	T	T	T	T	T	T	T	T	T	T
8, Monohydromirex (Photomirex)														
Mirex														
Mercury (total)	.05	.10	T	.08,	.24	.12	.13	.15	T	.15	.14	.20,	.16,	.19
Age of Fish (years)	2	3	2	2	3	3	3	3	2	3	3	3	3	3

T = Compound present at level less than 0.05 ug/g
ND = Compounds not detected.

Table 2 (Cont.)

Contaminant Data From the 1981 Coho Salmon Collections

	Lake Huron			Lake Erie									Lake Ontario		
	Tawas R.,MI			Chagrin R.,OH			Huron R.,OH			Trout Run T.,PA			Springbrook, NY		
Aroclor 1260 (PCB)	.16,	.24,	.17	.14,	.15,	.11	<.1,	.12,	.10	.16,	.17,	.13	.41,	.21,	.51
Aroclor 1245 (PCB)	.65,	.95,	.70	.56,	.62,	.44	.38,	.50,	.43	.65,	.70,	.51	1.81,	.93,	2.23
Aroclor 1248 (PCB)	.18,	.26,	.19	.15,	.17,	.12	.10,	.13,	.11	.18,	.19	.14	0.45,	.23,	.56
Aroclor 1242 (PCB)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PCBs	.99,	1.45,	1.06	.85,	.94,	.67	.53,	.75,	.64	.99,	1.06,	.78	2.67,	1.37,	3.30
P,P,-DDE	.25,	.36,	.29	.09,	.09,	.07	.03,	.05,	.05	.09,	.09,	.06	.54,	.50,	.58
P,P,-DDD	<.005,	<.005,	<.005,	.02,	.02,	.01	<.005,	<.005,	.04	.02,	.02,	.02	.08,	.06,	.07
P,P,-DDT	.03,	.05,	.04	.02,	.02,	.01	ND	<.005,	<.005	.02,	.02,	.01	.05,	.04,	.06
Total DDT	.28,	.41,	.33	.13,	.13,	.29	.032,	.055,	.092	.13,	.13	.09	.67,	.60,	.71
"Apparent Toxaphene"	1.1,	1.6,	1.4,	.6,	.6,	.4	<.25,	<.25,	<.25	.5,	.6,	.4	0.7,	0.6,	0.9
Dieldrin	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Endrin	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
cis-Chlordane	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
trans-Chlordane	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
cis-Nonachlor	T	T	T	T	T	T	T	T	T	.05,	.05,	T	T	T	T
trans-Nonachlor	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Hexachlorobenzene	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Octoachlor epoxide	T	T	T	T	T	T	ND	ND	ND	T	T	T	T	T	T
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	T	T	T	T	T	T	ND	ND	ND	T	T	T	T	T	T
Alpha-BHC	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Lindane (Gamma-BHC)	ND	ND	ND	T	T	T	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dacthal	T	T	T	T	T	T	ND	ND	ND	.09,	T	T	ND	ND	ND
pentachlorophenyl methyl ether	ND	ND	ND	T	T	T	T	T	T	T	T	T	T	T	T
8, Monohydromirex (Photomirex)													0.08,	.08,	.09
Mirex													.12,	.20,	.23
Mercury	.24,	.26,	.24	.11,	.12,	.07	.06,	.11,	.12	.11,	.13,	.12	.24,	.25,	.24
Age of fish	3	3	3	3	3	2	2	3	2/3	3	3	3	3	3	3

T = Compound present at level less than 0.05 ug/g
ND = Compounds not detected.

included pesticides currently in use in the Great Lakes Basin and substances whose use has been banned or severely restricted. Table 2 includes data on both two and three year old fish, while Table 3 and the following discussion focus only on three year old coho as these are more comparable from lake to lake and represent the highest concentrations.

Although concentrations did not approach the USFDA action level of 5 ug/g, PCB was the most prominent contaminant found (Table 2). PCBs were highest in three year old coho (Table 3) from Lake Ontario, with an average of 2.45 ug/g, while only traces were detected in Lake Superior coho. Lake Erie fish averaged 0.87 ug/g, while coho from Lakes Michigan and Huron were intermediate, with means of 1.40 ug/g and 1.67 ug/g respectively. Aroclor 1242 was found at the Sheboygan River site. This is near the PCB contaminated Sheboygan, Wisconsin area where Aroclor 1242 has been a contributing pollutant.

None of the individual composite samples equaled or exceeded the US Food and Drug Administration action limit of 5 ug/g for PCBs. However, one 5 fillet composite from Lake Ontario reached 3.3 ug/g leaving open the possibility that some of the individual fillets in the composite equaled or exceeded 5 ug/g and were diluted by other less contaminated fillets.

Total p,p-DDT concentrations varied widely between lakes with 3 year old coho (Table 3) from Lake Superior averaging 0.03 ug/g and Lake Ontario 0.66 ug/g. Concentrations in Lake Erie averaged only 0.12 ug/g while Lake Huron and Lake Michigan coho were intermediate with means of 0.34 ug/g and 0.54 ug/g respectively. The p,p-DDE isomer was the predominant isomer comprising between 56 and 100 percent of the total p,p-DDT. The ratio of p,p-DDD

Table 3

Mean Contaminant Concentrations in 3 Year Old Coho Salmon Composites - 1981
Mean (Standard error) in ug/g

Lake	Number of Samples	Total PCBs	Total DDT	"Apparent Toxaphene"	Mercury
Superior	1	0.1	0.03	0.125	0.10
Huron	3	1.67(0.25)	0.34(0.01)	1.37(0.25)	0.25(0.01)
Michigan	9	1.40(0.36)	0.54(0.16)	1.32(0.38)	0.16(0.04)
Erie	6	0.87(0.15)	0.12(0.02)	0.47(0.19)	0.12(0.01)
Ontario	3	2.45(0.98)	0.66(0.06)	0.73(0.15)	0.24(0.01)

Table 4

Correlation Matrix of Total PCB, Total DDT, "Apparent Toxaphene" and Mercury Concentrations in 1981 Coho Salmon Collections

	Total PCBs	Total DDT	"Apparent Toxaphene"
Total DDT	0.84		
"Apparent Toxaphene"	0.55	0.78	
Mercury	0.69	0.66	0.56

N = 29

(All are significant at the 99% confidence level.)

to p,p-DDT varied throughout the Basin. None of the total p,p-DDT concentrations approached the USFDA action limit of 5.0 ug/g.

A series of chlorinated chemicals with chromatographic characteristics similar to toxaphene were found in all samples. While toxaphene standards were used for quantitation, several of the peaks in the standards were consistently absent from the sample chromatograms. Concentrations of "apparent toxaphene" in 3 year old coho (Table 3) were highest in Lakes Michigan and Huron with average concentrations of 1.32 ug/g and 1.37 ug/g respectively. Adult coho in Lakes Ontario and Erie averaged 0.73 ug/g and 0.47 ug/g while Lake Superior coho averaged 0.125 ug/g.

As the pesticide mirex has not routinely been found in Great Lakes' fish outside the Lake Ontario Basin (Veith et al. 1979, Clark et al. 1982) only the Lake Ontario samples were analyzed for Mirex and its degradation product 8-monohydromirex. Mirex concentrations in Lake Ontario coho ranged from 0.12 ug/g to 0.23 ug/g. Photomirex (8-monohydromirex) concentrations ranged from 0.08 ug/g to 0.09 ug/g. The sum of mirex and photomirex was substantially above the USFDA action level of 0.1 ug/g. Mirex levels previously have been reported to exceed USFDA action levels in Lake Ontario salmonids and other game fish (Armstrong and Sloan 1980, NYDEC 1982, Clark, et al. 1982).

Several pesticides occurred at low levels throughout the Basin (Table 2). These include dieldrin, endrin, chlordane, nonachlor, BHC. A few other organo chlorines were detected in samples at individual sites. These include heptachlor at the Pine Creek (Lake Superior) and lindane at the Chagrin River (Lake Erie) site.

Mercury concentrations were well below the USFDA action limit of 1.0 ug/g. Concentrations were highest (Table 3) in coho from Lake Ontario and Lake Huron, averaging 0.24 ug/g and 0.25 ug/g respectively. Lake Michigan coho averaged 0.16 ug/g while three year old coho from Lake Erie averaged 0.12 ug/g and those from Lake Superior contained 0.10 ug/g.

Significant correlations were observed between total PCBs, total DDT, "apparent toxaphene" and mercury concentrations (Table 4). These were particularly strong between total PCBs and total DDT, where similar molecular size, structure and partition coefficient lead to similar bioaccumulation dynamics. This was also observed by Rohrer et al. (1982) in coho and chinook salmon. Mercury and the chloronated camphenes comprising "apparent toxaphene" were less strongly correlated.

Regression analysis indicated no statistically significant relationship between lipid content and total PCBs, total DDTs, or "apparent toxaphene" Armstrong and Sloan (1980) also observed no correlation between lipid content and contaminant concentration within a single collection of fish. However, they did report a strong correlation between contaminants and mean lipid content over several species.

Highest mean concentrations of DDT, PCB, and Mercury were observed in three year old coho from Lake Ontario and the lowest in Lake Superior. However, comparisons of the relative concentrations of contaminants found at various sites must be tempered by the fact that neither the size, age or the sexual composition of our samples were held constant. Contaminant levels are known to increase with size and exposure period-(age) and recent information indicates that in the fall, male coho may exhibit higher contaminant levels than females (NYDEC 1982). While the effects of age have been eliminated by

comparing only three year old fish, the size of the fish and sexual composition of our composite samples varies from site to site. The smallest coho were obtained from Lake Superior and the largest from Lake Ontario (Table 1). The relatively low contaminant levels in coho salmon from Lake Superior probably reflect the low levels of contaminant inputs from the water shed, as well as the lower productivity and the colder water temperatures which reduce growth and metabalism and thus the potential rate of contaminant uptake. This is reflected in the smaller size of the Lake Superior fish. The high level of productivity and sedimentation in Lake Erie may bind up hydrophobic contaminants and remove them from the system before they find their way into the top carnivore fishes. Lakes Huron, Michigan and Ontario, with their more intermediate levels of production and high levels of contaminant inputs, appear to have more significant fish contaminant problems.

Comparison of 3 year old coho collected in 1981 with those collected in 1980 indicates that, although statistically significant changes were not detectable between the two years, PCB and DDT concentrations were generally lower in 1981 (Table 5). No assessment of trends in contaminant levels prior to 1980 was attempted. However, the contemporary residue levels are generally less than those reported in the 1960's and early 1970's (IJC 1978). Subsequent coho salmon collections, as part of the continued monitoring effort for our program, will allow us to perform limited trend analyses. Other fish collections have been designed to specifically address trends of residue levels in open lake fish (lake trout and smelt, whole fish preparations) as part of the Great Lakes Fish Monitoring Program. These results will be reported at a later date.

Table 5

Comparison of 1980 and 1981 Levels of Major Contaminates
in 3 Years Old Coho Salmon

	Lake Erie						Lake Ontario		Lake Huron	
	Chagrin River		Trout Run Trib.		Huron River		Springbrook,NY		Tawas River	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
Total PCBs	1.07	0.895	1.17	0.94	1.00	0.75	2.90	2.45	1.95	1.17
(Range)	(1.05-1.10)	(0.85-0.94)	NA	(0.78-1.06)	(0.73-1.38)		(2.43-3.64)	(1.37-3.30)	(1.89-2.0)	(1.37-3.30)
Total DDT	0.16	0.13	0.17	0.12	0.14	0.055	0.80	0.66	0.41	0.34
(Range)	(0.15-0.18)	(0.13-0.13)	NA	(0.09-0.13)	(0.13-0.14	NA	(0.56-0.94)	(0.60-0.90)	(0.36-0.45)	(0.28-0.41)
"Apparent Toxaphene"	<.25	0.6	ND	0.50	<.25	<.25	0.77	0.73	1.5	1.37
(Range)	(<.25-<.25)	(0.60-0.60)	NA	(0.40-0.60)	(<.25-<.25)	NA	(0.50-1.00)	(0.60-0.90)	(1.4-1.6)	(1.10-1.60)
Length (mm)	610	603.5	606	569.3	635	635	773	803	719	687
(Range)	(599-627)	(576-631)	NA	(515-610)	(620-658)	NA	(731-800)	(786-826)	(701-729)	(680-695)
Weight (kg)	3.0	2.6	2.1	1.8	2.9	2.8	4.7	4.6	4.05	3.7
	(2.8-3.1)	(2.1-3.1)	NA	(1.4-2.2)	(2.6-3.1)	NA	(3.88-5.3)	(3.9-5.4)	(3.5-4.4)	(3.4-4.1)
Number of Composites	3	2	1	3	3	1	3	3	3	3
Number of Fish Per Composite	5	5	5	5	5	5	5	5	5	5

NA = not available

Table 5 (Continued)

Comparison of 1980 and 1981 Levels of Major Contaminates
in 3 Years Old Coho Salmon

	Lake Superior		Lake Michigan							
	Pine Creek, WI		Sheboygan River		Trail Creek		Kellog Creek		Platt River	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
Total PCB	0.10	0.10	1.90	1.63	2.01	1.49	1.80	0.97	1.89	1.51
(Range)	(<.1-<.1)	NA	(1.51-2.35)	NA	(1.69-2.36)	(1.22-1.77)	(1.46-2.31)	(0.88-1.06)	(1.53-2.59)	(1.17-1.99)
Total DDT	0.03	0.03	0.54	0.59	0.71	0.65	0.62	0.345	0.55	0.54
(Range)	(.02-.04)	NA	(0.45-0.66)	NA	(0.49-1.03)	(0.57-0.73)	(0.51-0.70)	(0.32-0.37)	(0.43-0.76)	(0.36-0.76)
"Apparent Toxaphene"	0.375	0.125	1.43	1.0	1.5	1.73	0.87	1.05	1.33	1.20
(Range)	(<.25-0.60)	NA	(1.2-1.7)	NA	(1.4-1.7)	(1.5-1.9)	(0.8-1.0)	(1.00-1.10)	(1.0-1.6)	(0.9-1.6)
Length (mm)	529	489	644	598	676	645.3	676	NA	675	716.3
(Range)	(487-561)	NA	(606-671)	NA	(629-710)	(622-674)	(660-695)	NA	(640-714)	(695-740)
Weight (kg)	1.24	1.2	2.45	2.95	3.46	2.7	3.51	2.6	3.24	3.5
(Range)	(1.1-1.75)	NA	(1.88-3.01)	NA	(2.74-4.15)	(2.3-3.2)	(3.38-3.67)	(2.0-3.2)	(2.73-4.13)	(3.3-3.9)
Number of composites	3	1	3	1	3	3	3	2	3	3
Number of fish per composite	5	2	5	2	5	5	5	5	4,4,3	5

NA = not available

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The comprehensive analysis of coho salmon from each of the Great Lakes by a single laboratory has, for the second year, produced a set of tissue residue data on environmental contaminants whose use has been banned or severly restricted. Coho salmon from Lake Superior contained only trace amounts or low levels of most toxic substances quantified. Lake Erie fish were contaminated with low levels of a number of pesticides and industrial compounds with relatively higher residue levels for a number of compounds in coho from Lake Ontario. Because of their open water habitat preferences, the contaminant levels in coho salmon demonstrate open lake contaminant problems rather than point source or nearshore conditions. The data reported in our study generally agrees with recent findings from individual state contaminant monitoring programs although problems with varying analytical and sampling techniques preclude direct comparisons. However, current tissue residue levels are usually less than those previously reported and are lower than USFDA action levels which are used by many agencies in assessing the severity of fish contaminant problems. The major exception being the levels of mirex in fish collected from Lake Ontario which exceeded the 0.1 ug/g action level.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
PCB, DDT Contaminants	Fish contaminants	

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