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Contaminants in Upper Great Lakes Fishes[1/]

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At a recent meeting (January 30) of the Governor's Great Lakes Regional Interdisciplinary Pesticide Council, Mr. Donald C. Healton, Regional Director, U. S. Food and Drug Administration, Chicago, announced that future interstate shipments of Lake Michigan chubs, lake trout, or salmon will be subject to seizure because of contamination by polychlorinated biphenyls (PCB's). Mr. Healton's statement has resurfaced past concerns and questions about the status and trends of PCB's and other contaminants in Great Lakes fishes, and the implications of these contaminants in future management decisions on fisheries. The issue is further confused by reports over the past year or two that problems associated with contaminants in the Great Lakes were rapidly declining in importance. Because of the Great Lakes Fishery Laboratory's (GLFL) past and current program of contaminant monitoring, together with our participation in several interagency studies on contaminants in fish, I have been asked to review the current status of "problem" contaminants in the Great Lakes and discuss what successes or failures we have observed in the control of these contaminants.

The four fishery contaminants of major concern over the past 5 to 10 years have been DDT, dieldrin, mercury, and PCB's. For the purposes of this presentation, it would be most convenient for me to discuss each of these four contaminants individually in the chronological order of their recognition as a problem. Source material for my discussion will be data obtained by the GLFL and the Great Lakes Environmental Contaminant Survey (GLECS). GLECS is a cooperative program of fish sampling and analysis conducted yearly by Michigan's Departments of Natural Resources and Agriculture, the U. S. Food and Drug Administration--Detroit Region, and the Great Lakes Fishery Laboratory.

DDT

Several investigators, including Dr. Robert Reinert of the GLFL, identified DDT and its metabolites as a contaminant of Great Lakes fishes in the mid 1960's. Dr. Reinert also soon determined that, although present in fishes from each of the Great Lakes, DDT contamination was particularly severe in those from Lake Michigan where residues in several species exceeded the FDA guideline of 5.0 ppm. This information contributed ultimately to a decision by the States (1969-70) and eventually

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by the Federal government (1972) to ban the use of DDT. We feel that the reduction in residues that followed the 1969-70 ban of DDT in the Lake Michigan watershed will eventually be considered as a classic example of the impact of legislative controls in a large aquatic system. Within 2 years of the ban, we were able to detect a significant decline of DDT residues in fish taken at our index stations on Lake Michigan (Table 1). And now, only 5 years after the ban, DDT in bloaters is down 87% from the high in 1969-70 and is no longer considered a problem in bloaters or coho salmon, and is fast approaching this status in lake trout. Thus controls do work--and even fish, which are considered the slowest indicators of change, show such a rapid response to the elimination of contaminant sources that even the most optimistic of us in the business were surprised.

DDT was never considered to be a particular problem in Lake Superior fish, but somewhat elevated levels (2.8-7.4 ppm) of this contaminant were observed in larger lake trout from the lake during the mid 1960's. Recent collections (1973) of lake trout from Lake Superior as part of GLECS show that "elevated" levels of DDT still exist in certain areas. Large fish taken from near Isle Royale contain DDT residues in excess of the FDA guidelines (Table 2). Residues are considerably lower, however, in fish collected to the southeast or southwest of this central region. Although the data are limited, there is some indication that perhaps DDT residues have not really declined much in Lake Superior since the mid 1960's. If true, it is possible that the oligotrophic nature of the lake may have resulted in a different behavior of the compound or else the sources of DDT to the lake were not eliminated as rapidly as in Lake Michigan.

Dieldrin

Although never receiving as much publicity or concern as DDT, dieldrin has been a nagging problem in Great Lakes fishes (particularly Lake Michigan) for as long as DDT. Residues of this insecticide have routinely averaged just below the FDA guideline of 0.3 ppm in Lake Michigan fish sampled as part of our monitoring program (Table 1). In addition, we have observed no decline in dieldrin residues since the 1960's. This type of information again contributed ultimately to the EPA ban on dieldrin in 1974. We would hope that this ban will shortly result in declines of dieldrin residues in Lake Michigan fish.

Mercury

Mercury was first reported by Canadian investigators as a contaminant of Lake St. Clair fishes in early 1970. Within 1 to 2 years of this announcement, mercury had been found to exceed the FDA guideline of 0.5 ppm in at least one species of fish from each of the Great

Lakes except Lake Michigan, and appropriate fishing restrictions or warnings were issued for each of the affected lakes. Even in Lake Michigan, we found that large walleyes and an occasional very large lake trout exceeded the Guideline. The presence of mercury in fish from each of the lakes, combined with the results of studies of mercury in museum fish, soon made it apparent that elevated background levels of mercury were common to the Great Lakes, and that the existence of a few point sources, as in Lake St. Clair, were sufficient to cause problems in practically all of the lakes.

Based on characteristic background levels of mercury in Great Lakes fishes and the known persistence of mercury in the environment, the best scientific judgement in 1971 was that even with the elimination of known sources of mercury, a severe problem would continue to exist in Lake St. Clair for tens of years. Well--so much for science. In late 1970, the alleged major source of mercury to Lake St. Clair was eliminated, and by 1972 the levels of mercury residues in our monitoring samples of rock bass, channel catfish, and probably yellow perch had fallen precipitously to below 0.5 ppm (Table 3). Mercury concentrations in walleyes had also declined more than 50% by 1972, and the decline is continuing yet today, though at a much lower rate. Again, as with DDT in Lake Michigan, the elimination of sources brought about an almost immediate decline of residues in fish to the surprise, and possible chagrin, of several investigators including myself.

In defense of science, it must be realized that mercury still is, and will continue to be, a problem in the Great Lakes. Walleyes in Lake St. Clair remain above 1 ppm and it is possible that the larger fish may never get below 0.5 ppm because of the apparent natural background of mercury in the Great Lakes. Lake trout in Lake Superior also contain excessive amounts of mercury, particularly in the area of Isle Royale (Table 2). This is probably related to the past problems with mercury in Thunder Bay and hopefully will improve in the near future. Recent (1973) samples of walleyes from southern Lake Huron contained average mercury concentrations of 0.9 ppm, and samples of walleyes from Lakes Ontario and Erie (1974) show continued high levels, with most fish of about 500 mm or larger exceeding 0.5 ppm. There are, however, some indications of a decline in average residues in Lake Erie walleyes.

PCB'S

PCB's are by no means a recently recognized problem in Great Lakes fish. Their presence in Lake Michigan fish has been known since the late 1960's and initial actions to reduce PCB losses to water were taken by EPA and the Monsanto Chemical Company in 1971. The recent actions are primarily the result of a strengthening by court decisions

of FDA's ability to enforce their Guideline of 5.0 ppm.

The GLFL has been routinely analyzing for PCB's in Lake Michigan fish since 1972. Average concentrations of PCB's in bloaters, lake trout, and coho salmon have consistently exceeded the FDA Guideline and, based on our samplings of bloaters, it would appear that residue levels have remained "static" since 1972. Analyses of lake trout performed as part of the GLECS confirm the presence of high PCB residues and indicate a pattern of greater contamination in the southern portion of the lake similar to that routinely observed over the years with DDT (Table 4). Recent reports of lake trout taken from southern Lake Michigan indicate that individual fish may contain as much as 40 to 60 ppm of PCB's. Our data and those of the GLECS show that average residues are considerably lower than that. But, regardless of whose data is used, FDA is correct in stating that Lake Michigan bloaters, lake trout, and salmon do not meet their Guideline. Size and origin of the fish are, of course, considerations in the marketability of any fish, and it is probable that residues in smaller bloaters and lake trout, particularly from the northern portion of the lake, would average below the Guideline.

The greatest concern from an environmental standpoint is the question of why we have not observed a reduction in PCB levels since the initiation of voluntary controls on their sales and use in 1971. One possible explanation is that PCB's behave differently in the environment than DDT or mercury. This may be technically true, but I do not feel it explains the complete absence of change. A more likely cause is that the controls imposed to date have failed to eliminate the major sources. The Michigan DNR has shown, for example, that elimination of PCB sources to the Saginaw River drainage resulted in an immediate reduction of residues in fish from the river. It would seem reasonable that after 3 years we would have observed at least a small decline in Lake Michigan if the sources were truly eliminated. One benefit of the recent "scare" will undoubtedly be a closer look by EPA at what the current sources of PCB's are in the Lake Michigan watershed.

As inferred earlier, PCB's are not peculiar to Lake Michigan alone. PCB analyses of Lake Superior lake trout as part of the GLECS have shown the same disconcerting pattern of elevated residues near Isle Royale as previously noted with DDT and mercury (Table 2). Because of the similarity in geographical distribution of mercury, DDT, and PCB residues in Lake Superior lake trout, it would appear that the Thunder Bay area was, and may still be, a major point source for these contaminants to the lake.

Future Contaminant "Problems"

A long list of additional potential contaminants including chlordane, hexachlorobenzene, phthalates, arsenic, cadmium, chromium, copper, and, most recently, mirex, have been found in Great Lakes fishes over the years by either the USFWS, EPA, State DNR's, or university

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research groups. The mere presence of these lesser contaminants does not represent a problem as such, but it does suggest a strong need for continued surveillance of known or potential contaminants, and more aggressive regulatory controls on the loss of contaminants to the lakes. The problem of contaminants is a double-edged sword in that they affect not only the utilization of fishes but probably also play a subtle role in their growth, reproduction, survival, and long-term potential.

We at the GLFL will continue to monitor known or potential contaminant problems in the Great Lakes to the best of our ability. We will also continue to participate as much as possible in interagency programs attempting to define and control contaminant problems such as the GLECS, the Lake Michigan Toxic Substances Committee, the IJC Reference Group on Upper Lakes Pollution, and the National Pesticide Monitoring Program. Hopefully, we can contribute through these groups to a better coordination of contaminant research and monitoring programs in the future. Our ultimate goal is the elimination of problems before they become "crises" similar to those created by DDT, mercury, and PCB's. And finally, we are making every reasonable effort to improve our ability to evaluate what these contaminants mean in terms of possible toxicological effects on fish, and their adverse role, if any, in curtailing the productivity of Great Lakes fish stocks.

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Table 1.--Concentrations of pesticides and PCB's in fall collections of Lake Michigan bloaters and lake trout off Saugatuck, Michigan, and coho salmon from between Ludington and Frankfort, Michigan.

Species and year	Number of fish	Average length (mm)	Total DDT (ppm)[1/]	Dieldrin (ppm)[1/]	Total PCB's (ppm)[1/]
Bloaters					
1969	120	270	9.94 (0.33)	0.27 (0.01)	-
1970	28	263	9.87 (1.44)	0.19 (0.02)	-
1971	60[2/]	264	6.24 (1.13)	0.27 (0.06)	-
1972	120[3/]	255	4.33 (0.48)	0.18 (0.03)	5.66 (0.95)
1973	160[3/]	250	2.09 (0.26)	0.28 (0.02)	5.24 (0.37)
1974	110[3/]	257	1.33 (0.14)	0.28 (0.03)	5.57 (0.31)
Coho salmon					
1969	11	621	11.82 (2.69)	0.21 (0.02)	-
1970	13	651	14.03 (1.29)	0.12 (0.02)	-
1971	15	674	9.85 (1.41)	0.11 (0.01)	-
1972	10	693	7.17 (1.09)	0.13 (0.04)	10.93 (2.12)
1973	29	620	4.48 (0.34)	0.09 (0.01)	12.17 (0.77)
Lake trout					
1970	18	613	19.19 (3.27)	0.27 (0.05)	-
1971	20	579	13.00 (1.76)	0.20 (0.03)	-
1972	9	648	11.31 (3.26)	0.20 (0.06)	12.86 (4.75)
1973	30	602	9.96 (1.36)	0.27 (0.03)	18.93 (2.08)

[1/] Concentrations in whole fish, wet weight with 95% confidence interval in parentheses.

[2/] Composite samples, 5 fish/sample.

[3/] Composite samples, 10 fish/sample.

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TABLE 2.

SUMMARY OF 1973 GLFCS DATA

Prepared by the Michigan Department of Agriculture

LAKE TROUT

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE SUPERIOR						
MS-1	<17"	4	2.1	2.4	.57	tr
	17-20"	1	2.4	2.9	.51	tr
	>20"	6	7.9±1.4	5.3± .9	.80±.30	.08±.05
MS-2	<17"	3	.3	.5	.18	tr
	17-20"	3	.9	1.8	.36	tr
	>20"	5	1.8± .6	4.2±1.8	.43±.17	.04
MS-3	<17"	12	.9± .7	1.6±1.4	.29±.12	.03
	17-20"	16	1.1± .7	1.9±1.3	.32±.15	.04
	>20"	19	3.3±1.4	4.7±2.2	.69±.27	.06
MS-4	17-20"	6	0.7± .3	1.0± .5	.25±.05	.01
	>20"	15	2.1±1.7	3.3±2.7	.48±.17	.03
MS-5	17-20"	4	.5	.8	.32	.02
	>20"	5	1.5± .2	1.8± .5	.30±.05	.03
MS-6	<17"	3	.6	.9	.21	.01
	17-20"	3	1.0	1.0	.26	.02
	>20"	6	1.4±.3	1.4± .2	.34±.04	.04

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Table 3.--Mercury concentrations in fillets of selected Lake St. Clair fishes collected in the fall of the year.

Species and year	Number of fish	Average length (mm)	Average weight (g)	Total mercury (ppm)[1/]
Walleye				
1970	56	506	1214	2.83 (0.37)
1972	68	445	831	1.38 (0.16)
1973	77	485	1105	1.18 (0.10)
1974	60	501	1174	1.07 (0.10)
Rock bass				
1970	45	185	164	1.24 (0.27)
1972	40	174	121	0.49 (0.08)
1973	36	178	126	0.37 (0.07)
1974	50	209	211	0.37 (0.06)
Yellow perch				
1970	45	198	106	1.22 (0.17)
1973	45	191	91	0.31 (0.08)
1974	43	228	158	0.28 (0.04)
Channel catfish				
1970	15	538	1867	1.62 (0.45)
1972[2/]	9	363	519	0.37 (0.19)
1973[2/]	8	461	1023	0.35 (0.08)
1974[2/]	20	490	1135	0.35 (0.04)

[1/] Concentrations expressed as elemental mercury in wet weight of tissue with 95% confidence interval in parentheses.

[2/] Whole fish.

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