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PCBs: The Wisconsin Situation

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ABSTRACT

The Food and Drug Administration has set the level of polychlorinated biphenyls (PCBs) in commercially sold fish at 5 ppm. A new proposed limit will drop that level to 2 ppm. A review of PCB monitoring data suggests that present PCB intake by persons eating Lake Michigan fish exceeds the new proposed level. To date, no evidence exists stating that consumption of Lake Michigan fish adversely affects health. Warnings about fish consumption should continue. In addition, methods for proper fish preparation and new fishing guidelines are suggested.

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INTRODUCTION

PCBs are persistent, stable, environmental contaminants. Once in the ecosystem, PCBs accumulate in animal fatty tissues. In some Wisconsin fish, concentrations have been as high as 200-300 ppm. These PCBs are then passed on to man when he eats contaminated fish. In 1973 the Food and Drug Administration (FDA) set a 5 ppm limit for PCBs in commercially sold fish. The Environmental Defense Fund and the Natural Resource Defense Council have since encouraged the FDA to drop the limit to 2 ppm (a dietary intake of 0.4 ug/kg body wt/day).

Lowering the permissible level could restrict the Lake Michigan commercial fishery from whitefish, yellow perch, alewife, chubs and carp to only yellow perch and small whitefish (Table 1).

TABLE 1. PCB Levels In Commercial Fish Species From Lake Michigan, 1975-77 (Bishop, et. al. 1978).

SPECIES	LENGTH (Inches)	NUMBER FISH ANALYZED	NUMBER WITH > 5ppm PCB	NUMBER WITH > 2ppm PCB	RANGE OF PCBs (ppm)	AVERAGE PCBs (ppm)
White-fish	13.8-17.2	10	1	1	0.63-7.7	2.0
	17.3-18.1	10	1	4	0.91-5.7	2.0
	18.2-22.3	16	8	12	1.0-17.3	5.9
	22.4-28.7	11	5	9	1.5-15.2	5.9
	ALL SIZES	47	15	26	0.63-17.3	4.2
Yellow Perch	5.2-14.5	20	1	5	0.16-5.6	1.6
Alewife	4.0	10	5	10	2.4-13.6	6.7
Chubs	8.6-15.4	31	4	25	0.25-8.8	3.7
Carp	7.7-30.5	25	21	24	1.2-51.6	13.7

PCB levels in Lake Superior average less than 2 ppm in all fish tested except for large carp, lake trout over 24-inches and ciscowet. The impact of the FDA limit should be minimal on this fishery. The following commercial fisheries could be affected by the new limit: the Fox River, Root River, Lake Pepin, Lake Koshkonong, the Wisconsin River from Lake DuBay to the Wisconsin Dells, Lake Wisconsin and the Mississippi River. A detailed description of PCBs in the Mississippi Basin is found in "Polychlorinated Biphenyls in the Upper Mississippi River Basin", 1976. In addition, the carp, catfish and bullhead commercial fisheries on the lower Chippewa, Buffalo, La Crosse and Black Rivers would also be affected. Sport fisheries for these species may also be jeopardized.

The 2 ppm limit and a complete ban on the sale of commercial species from Lake Michigan would collapse 75.0 percent of Wisconsin's present commercial fishery with a 1977 catch valued at \$2.9 million (Bishop, et. al. 1978). A shift to yellow perch and small whitefish (under 18") with a corresponding smaller economic impact is more likely to occur. The actual impact on the state's commercial fisheries will depend on:

- 1) the stringency of FDA enforcement and
- 2) how successfully producers and processors can mix fish above and below the 2 ppm limit to achieve a "market basket" average below this limit.

PCB levels in Lake Michigan trout and salmon average above the 2 ppm limit (Table 2). No institutionalized requirements restrict the trout and salmon stocking program because of PCBs. However, preventing commercial harvest for public health reasons while allowing a sport harvest is questionable. If the trout and salmon sport fisheries are closed, the direct economic loss is estimated at \$9.6-\$11.2 million per year based on 1,200,000 angler trips per year at a value of \$8-\$10 per trip. These anglers harvest nearly 4 million pounds of fish a year.

TABLE 2. Summary of PCB Levels in Wisconsin Fish

Water	Species	Total ² Harvest	\bar{X} Length of Fish Harvested ² (inches)	\bar{X} Length of Fish in PCB ³ Analysis ³ (inches)	\bar{X} PCBs In Fillets ⁴ (inches)	Number of Fish Analyzed	95% Confidence ⁵ Low (ppm)	High (ppm)	Size Range For Fish Analyzed (inches)	Estimated % of Current Harvest <2 ppm ⁶	
Lake Michigan	L. Trout	60,678	25.5	23.3	8.73	60	7.20	10.26	>17	1.5	
	L. Trout	-	-	<16	1.48	9	0.74	2.22	<16		
	L. Trout	-	-	18.5	5.35	16	4.27	6.43	17-20		
	L. Trout	-	-	21.2	6.93	40	4.3	9.6	17-25		
	Chingokl	156,037	29.4	30.8	8.93	30	7.57	10.29	>18	18.2	
	Coho	180,974	22.5	22.2	4.85	33	3.91	5.79	>15	20.9	
	Rainbow T.	1124,737	20.8	20.6	4.33	7	2.47	6.19	>16		
	Brook T.	12,231	12.1	18.5	5.19	8	3.47	6.97	>16		
	Brown T.	87,289	18.7	18.7	3.91	29	3.01	4.81	>11		
	Walleye		16.9	16.9	1.25	11	0.41	2.10	12-21		
	N. Pike		24.9	24.1	2.4	18	1.66	3.14	13-35	= 95	
	Perch		7.1	9.1	1.39	9	0.24	2.5	7-11	= 50	
	Carp			22.5	10.55	29	3.4	17.71	8-26	x 95	
	Smelt			6.0	0.70	10	Pooled Sample		6	0	
											= 95
	Lake Superior	L. Trout	9,184		20.9	0.94	6	0.68	1.20	17-24	= 90
		Brown T.			19.5	0.40	8	0.24	0.55	17-22	95
Rainbow T.					<0.5	2				95?	
N. Pike				20.6	0.30	4	0	0.60	16-28	95?	
Walleye				19.1	0.45	13	0.09	0.80	9-21	95	
Perch			7.6	0.25	8	0.09	0.41	6-10	95		

Chinook and coho have been inadequately sampled to establish valid PCB averages. The existing data suggest that they are below the 2 ppm limit in Lake Superior.

¹Insufficient data for conclusive analysis of seasonal, locational or size differences in PCB concentration.

²From "The Great Lakes Sport Fishery - 1977"

³In most cases, the mean length of the fish sampled for PCB analysis was close to the mean length of fish in the harvest, thus the mean PCB values listed are representative of the "average" PCB burden in the harvest.

⁴From "PCB Levels in Wisconsin Fish", a compendium of PCB data supplied by T. Sheffy, Wis. DNR.

⁵Calculated according to the method of steel and torrie "Principles and Procedures of Statistics" (1960).

⁶These figures were derived by assuming a strong relationship between PCB concentration and size, estimating the size at which PCB concentration = 2 ppm, and calculating the percent of the total harvest at or below that size.

Table 2. Continued

Water	Species	\bar{X} Length of Fish in PCB Analysis	\bar{X} PCBs In Fillets (ppm)	Number of Fish Analyzed	95% Confidence Low (ppm)	95% Confidence High (ppm)	Size Range For Fish Analyzed
Sheboygan River Above JNSU Dam	All species (carp, largemouth bass, white sucker)		0.53	3	0.39	0.67	9.5-20.8
At Kohler Dam	Carp, white sucker, largemouth bass		>100.00		6.00	970.00	
At Kiwanis Park	Carp, white sucker, panfish						
Onion River	Only an 'occasional' carp	>1 ppm					
Root River		19.7	3.0	4			
Fox River, CTH 0	N. Pike	16.0	8.8	5	0	18.7	
	Panfish	6.6	7.0	8	1.5	11.8	8
	Carp only 'edible portion' analyzed	25.7	19.7	9	16.2	35.2	
Buffalo Lake	All game fish tested	10.0	<2.0		0	0.5	
	Carp		3.5				
Fox River	All species tested		<1.5		0	1.5	
At Gr. River Lock	"		<2.0		0	1.0	
At Eureka Dam	"						
Lake Puckaway	"		<2.0		0	2.0	
Big Green Lake	"		<2.0		0	1.5	
Lake Winnebago	Drum		<0.5		0	1.0	
Little Lake Butte Des Morts	Carp	17.8	25.6	11	≈20.0	≈32.0	
	Perch	12.4	<2.0		0	2.0	
	Walleye		1.5	2	-	-	
Lake Butte Des Morts	Carp	22.0	1.7	2	-	-	
Milwaukee River	Carp	16.2	20.2	160	25-		

¹ Insufficient data for conclusive analysis of seasonal, locational or size differences in PCB concentration.

² From "The Great Lakes Sport Fishery - 1977"

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METHODS

PCB data have been collected regularly from Wisconsin waters since 1970. This data provides maximum statewide coverage with minimum effort and expense. Few established sampling stations with a data base extending over several years exists, with the exception of long-term monitoring in a few areas. Collected samples vary with: season, reproductive status or sex of species collected, number and sizes of species collected, and the portion of fish that is actually analyzed for PCBs. Insufficient data to establish size, age, season, or locational relationships with PCB levels for most Great Lakes species is the result.

Data collection has been sporadic. Adequate representative samples for some species may exist one year, while little or no data for that species are available in succeeding years. Valid, long term projections for PCB trends in many species are not possible with the present data base. However, a slow decline in PCB levels in fish filets from several Lake Michigan locations is apparent (Figure 1).

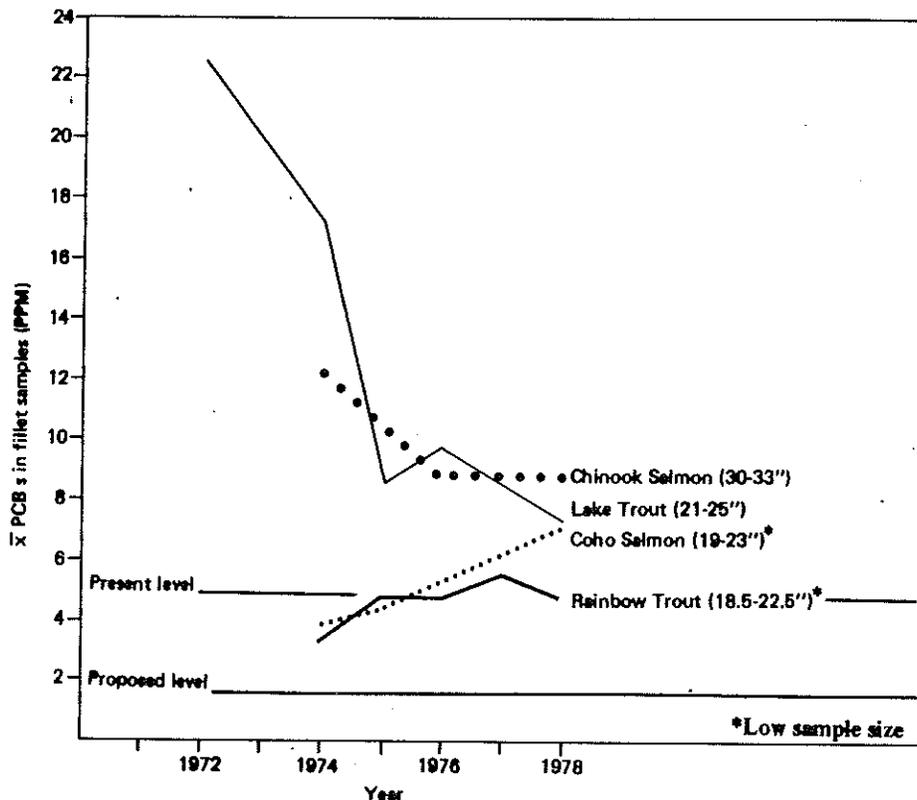


Figure 1. PCB levels in fish filets from Lake Michigan 1971-78 samples.
(from "Average PCB burdens in L. Michigan salmonids," T. Sheffy, 1978)

RESULTS AND DISCUSSION

PCB Concentrations in Wisconsin Fish

Lake Michigan trout 17 inches and larger have been heavily sampled and analysis of the data reveals more variance in PCB concentrations from a single location than between mean values for lake trout from widely separated locations. Mean PCB concentration and a high and low range at the 95.0 percent confidence level are summarized in Table 2. The following species have PCB levels above 5 ppm:

- Lake Michigan - lake trout, chinook salmon, brook trout, carp, whitefish (>18"), chubs
- Fox River - northern pike, all panfish >4", carp
- Root River - carp
- Milwaukee River - carp
- Sheboygan River - all fish >4"

In addition, the following exceed the 2 ppm limit:

- Lake Michigan - alewife and herring
- Mississippi River - buffalo, carp (see "PCB's In The Upper Mississippi River Basin")
- Little Lake Butte Des Morts - carp, northern pike >12"
- Lake Pepin - carp, buffalo, sheepshead
- Lake Koshkonong - carp >6"
- Lake Wisconsin - carp and buffalo >6"
- Wisconsin River (from Lake DuBay to the Dells) - carp and buffalo >6"
- Chippewa River (lower) - carp, buffalo, catfish and bullheads >6"
- Buffalo River (lower) - carp, buffalo, catfish and bullheads >6"
- La Crosse River (lower) - carp, buffalo, catfish and bullheads >6"
- Black River (lower) - carp, buffalo, catfish and bullheads >6"

Figure 2 indicates that only lake trout less than 16 inches are consistently fit for consumption under the 2 ppm limit.

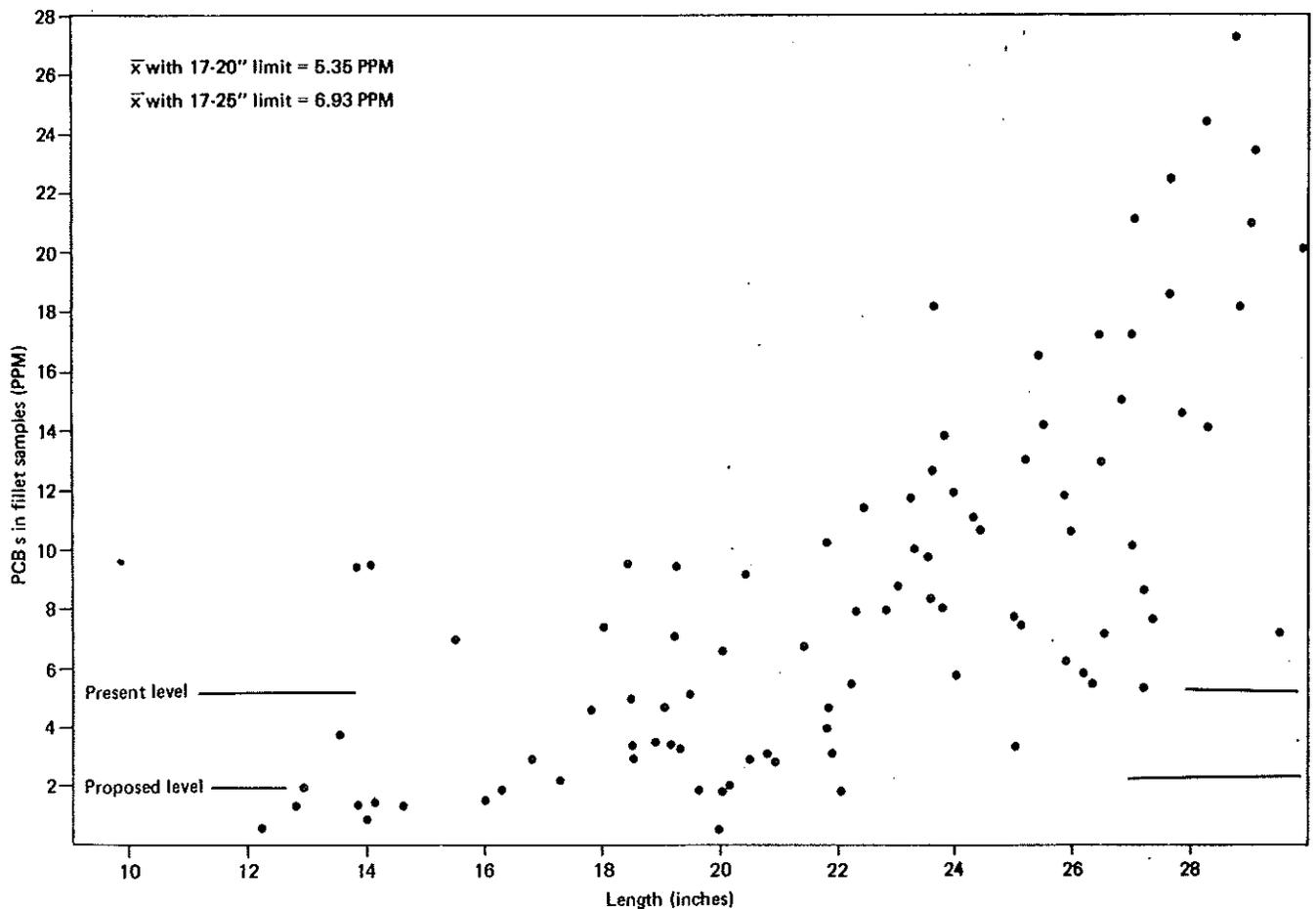


Figure 2. PCB levels in fish fillets from Lake Michigan lake trout , 1975-1979 samples.

Obtaining an Adequate Data Base

Present data on PCB levels is inadequate but an adequate data base could be established by:

- (1) Implementing a consistent sampling program which emphasizes collecting representative samples from major sport and commercial species. This should include specimens throughout the length spectrum for each species. Replicate samples at each length would be essential.

- (2) Establishing long term monitoring stations in Lake Michigan at grid locations 2203, 1004, 804 and 1001, and in Lake Superior at the entry to Superior Harbor, Chequamegon Bay and the mouth of the Brule River. Continued monitoring at these locations would add to data already collected at these sites and provide a data base for trend analysis.
- (3) Placing special emphasis on sampling lake trout <17 inches and >24 inches, chinook and coho <18 inches, rainbow, brook and brown trout <16 inches, and perch and walleye of all sizes until the data base for Lake Michigan improves.
- (4) Consistently analyzing fillet and edible portion samples and developing a conversion factor for translating PCB concentrations between the two.

Effects on the Sport Fishery

PCB concentrations in lake trout fillets from Lake Michigan average 8.7 ppm. Maximum size limits of 25, 20 and 16 inches would drop that average to 6.9 ppm, 5.4 ppm and 1.5 ppm, respectively. A maximum limit of 16 inches would bring the lake trout into compliance with the 2 ppm limit but it would also exclude 98.0 percent of the 1977 sport harvest. Similarly, maximum length limits of 18 inches for chinook and 19 inches for coho would bring their average to acceptable levels, but would exclude 82.0 percent of the chinook and 79.0 percent of the coho harvested in 1977. Consequently, the sport fishery compliance with the new PCB limit will require a redirection of angler effort and harvest.

Fish Consumption By Anglers

Several recent surveys of Lake Michigan anglers suggest that they are unlikely to change their preference for Great Lakes fishing though they are aware of the PCB problem. (1978 DNR statewide Outdoor Recreation Survey; 1977 Great Lakes Sport Fishing Association Survey) Also, their consumptive patterns may not change if a lower PCB level is set. Over half of the anglers surveyed usually or always consumed the salmon and trout they caught and were aware of PCB warnings. Thirty percent of those surveyed reported that the warnings caused them to eat less fish than before, and only one percent reported that the warnings had halted their consumption altogether. More than 90.0 percent reported that warnings did not influence the frequency of their fishing trips on Lake Michigan.

Annual salmon and trout consumption averaged 15 pounds per person in these surveys. Seventy percent of the respondents ate trout and salmon twice a month or less, while 20 percent ate salmon more than once a week despite health warnings. Forty percent reported that PCB publicity caused them to alter fish preparation. When asked whether stocking should continue even though fish would continue to have high levels of PCBs as adults, 93.0 percent felt stocking should continue. In a situation similar to that in Wisconsin, 91.0 percent of New York salmon anglers felt that a new salmonid hatchery should be built despite the fact that the receiving waters were contaminated with MIREX, an organochloride pesticide.

Other surveys show that anglers prefer chinook salmon over smaller species. Preliminary analysis of the 1978 Great Lakes Creel Census suggests that many anglers target fish for large chinook. Given these insights, it is apparent that any changes in the Great Lakes stocking program or major changes in the regulations affecting the fishery, (e.g., a size limit prohibiting possession of the larger PCB-laden fish), would meet considerable opposition. This opposition could come from the fishing public-at-large and especially from organized fishing groups.

Health Risks To Humans

"The Final Report of The Subcommittee on the Health Effects of PCBs and PBBs" (1978) concluded that there is a critical need for studies concerning long term effects of dietary intake of PCBs. The work of Kimbrough, et. al. (1978) has shown that although symptoms of PCB intoxication are similar in many species, the doses required to elicit even a minimal response vary between species. It is clear that the effects are a function of total PCB intake (i.e., $\mu\text{g}/\text{kg}$ body wt/day).

The FDA recommends a maximum limit of 0.4 $\mu\text{g}/\text{kg}$ body wt/day for PCB intake under the new ruling. This is a maximum "safe" limit on total intake of 175-200 μg over a lifetime. These limits are normally set by extrapolating a maximum safe dose based on experiments with laboratory animals. A 10:1 safety margin is used.

The "safe" or "no effect" limit for PCB intake has not been established. The tolerance has been set by weighing adequate public health protection against excessive losses of food to consumers.

Only two major studies on the epidemiological effects of PCB consumption on humans have been conducted. The best known study deals with the "Yusho" victims in Japan. That study showed that the lowest symptomatic dose was equivalent to an intake of about 200 $\mu\text{g}/\text{kg}$ body wt/day over 50 days (Kuratsune, et. al., 1972).

Humphrey, et. al. (1976) studied a group of Lake Michigan fish consumers in Michigan. Total intake of trout and salmon was at least 24-26 pounds per year, although some individuals ate as much as 180 pounds of salmonids per year. PCB levels in trout and salmon eaten by the group ranged from 10.5 to 12.2 ppm for coho and from 18.9 to 22.9 ppm for lake trout. These levels are higher than those observed in the 95.0 percent confidence range for Wisconsin fish. Based on reported fish consumption levels, this translates to an average intake of 1.7 µg/kg body wt/day (range 0.5-3.9 µg/kg body wt/day), more than four times the new FDA recommended limit. Although no adverse effects were noted in any of the subjects, average PCB levels in blood samples were considerably higher than in the control group (0.007 ppm - control group versus 0.073 - heavy fish consumers). In conclusion, the authors stressed the need for long-term monitoring of the fish eating group to screen for any latent effects. Many members had been eating Lake Michigan salmon and trout for at least 10 years prior to the study and yet exhibited no apparent adverse effects.

Investigators have documented reproductive failure in laboratory animals because of PCB transfer across the placenta. Dr. Allen, UW-Madison, found that while intakes as low as 7 µg/kg body wt/day did not affect adult monkeys, it did result in symptoms of PCB intoxication in their offspring. Riesebrough and Brodine (1970) reported that human milk with background concentrations of PCBs (60 ppb) represented a PCB intake of 9 µg/kg body wt/day to nursing infants. Consequently, these authors advise that all pregnant or nursing mothers avoid eating any PCB-laden fish.

Dr. E. Kendrick, UW-Madison, will initiate a study of fish consumers in the Sheboygan area. His findings should shed light on the health risks associated with long-term consumption of Lake Michigan commercial and sport species in Wisconsin. In addition, Dr. J. Rankin, UW-Madison, is initiating a similar study of the Washington Island fishermen.

SUMMARY

The 1973 FDA PCB limit was designed to restrict intake to 1 µg/kg body wt/day. The new proposed limit drops that intake allowance to 0.4 µg/kg body wt/day. If we assume that the average consumption of Lake Michigan fish by Wisconsin sport anglers is 15 lbs per year, then their average PCB intake is 0.63 µg/kg body wt/day. Since fish consumption and PCB concentrations for trout and salmon in Wisconsin are 42.0 percent and 35.0 percent lower, respectively, than the values reported by Humphrey et. al. (1976), the intake figure they report for their study group was adjusted accordingly to derive the value for Wisconsin anglers.

Data presented here is based on PCB levels in fillets. The International Joint Commission recommends that fillets for analysis have both belly fat and lateral line attached. Lindsay, et. al. (1976) reported that trimming belly fat and the lateral line before cooking could reduce the ingested levels of PCBs by 25.0-30.0 percent. If Lindsay is correct, then the actual intake of PCBs by Wisconsin anglers practicing fillet trimming may average as low as 0.47 µg/kg body wt/day.

Theoretically, a greater safety margin could be maintained by adjusting the present bag and size limits. Although data are scant, Lake Michigan coho and chinook <18 inches and lake trout <16 inches are under the FDA's PCB limit of 2 ppm. By setting these as an upper size limit, the "meat angler" would be complying with the FDA ruling. A trophy fishery could be maintained by establishing a special "trophy only" bag limit of one trout or salmon above 25 inches per day. Under this modification, "slot limit" fish above the 2 ppm limit but below "trophy" size would escape harvest.

Evidence suggests that management measures for coho salmon can reduce the average PCB level in creel fish. Angler returns from three out of four discreetly marked plants of coho weighing more than 0.1 pounds each when planted were significantly greater during their first year in the lake than during their second year, (Pfender and Poff, 1979). When fish were smaller at planting, returns were dominated by fish taken in their second year in the lake. Since exposure time appears to be a factor in PCB accumulation, it may be possible, by manipulating stocking practices, to encourage a greater harvest of immature, less contaminated coho.

Although there is no evidence to date that the consumption of Lake Michigan fish adversely affects health, warnings about fish consumption should continue. Based on the information reviewed for this report, anglers should limit their consumption to two meals of Lake Michigan trout and salmon per month (less than 12 lbs/year). In addition, warnings advising children and pregnant or nursing women against eating any Lake Michigan fish should be issued. Such advisories are within the purview of the Department of Health and Social Services and it is their principal responsibility to issue such warnings.

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