THE INCIDENCE OF POLYCHLORINATED BIPHENYLS AND OTHER CHLORINATED HYDROCARBONS IN RACCOON ADIPOSE TISSUE AND SELECTED AQUATIC ORGANISMS IN THE CENTRAL WISCONSIN RIVER BASIN

by

Michael Lee Knuth

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APPROVED BY THE GRADUATE COMMITTEE OF:

Byron Shaw

Dr. Byron H. Shaw
Associate Professor of Soil and Water Science

Lyle E. Nauman

Dr. Lyle E. Nauman
Associate Professor of Wildlife

Daniel O. Trainer

Dr. Daniel O. Trainer
Professor and Dean of the College of Natural Resources

James B. Hale

Mr. James B. Hale
Chief, Wildlife Research Section
Wisconsin Department of Natural Resources

ABSTRACT

The incidence and levels of polychlorinated biphenyles (PCB's) and other chlorinated hydrocarbons in 130 raccoons (<u>Procyon lotor</u>) and selected aquatic organisms in the central Wisconsin River Basin was investigated. Residues of Aroclor 1254 and 1260 were found in 67 and 41 percent, respectively, of the raccoon samples; DDE, the only other chlorinated hydrocarbon identified, was detected in a small number of samples at low levels. Raccoons collected adjacent to the river had from 0.00 ppm near Plainville to 21.00 ppm west of Plover while those more than 8 kilometers from the river contained only trace amounts of PCB. The prey of raccoons studied included fish, clams and crayfish. Small amounts of Aroclor 1254 were detected in the clams and crayfish, and concentrations up to 2.08 ppm in fish. Aroclor 1242 was detected in a few fish and clams. A definite relationship existed between the distance from the river and the PCB residues present in raccoons. No relationship was found between sex or weight of raccoons and PCB residues. Impoundments on the Wisconsin River may influence PCB concentrations in the biota.

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INTRODUCTION

Polychlorinated biphenyls (PCB's), are industrial compounds which ahve been manufactured since 1929. Monsanto Company, the only manufacturer in the United States, has produced a large number of PCB formulations. Those most common range from 21 percent chlorine designated Aroclor 1221 to 60 percent chlorine designated Aroclor 1260. Their physical properties range from oils to crystalline solids and have been used in a variety of industrial applications including coolant-insulation fluids for transformers, flourescent fixtures, insulation, plasticizers, hydraulic fluids, lubricants and sealers, carbonless paper and various protective coatings (Kleinert 1976).

Since their presence in the environment was discovered in 1966, PCB's have been found in all parts of the global ecosystem including the arctic region (Clausen and Berg 1975). The rising concern over PCB's can be attributed to their physical and chemical properties. PCB's are very stable nonpolar lipophilic compounds, thus making them susceptible to bioaccumulation which occurs as PCB's pass from lower to higher trophic levels. Mayer et al. (1977) reported that invertebrates accumulated Aroclor 1254 residues up to 6,300 times greater than exposure levels and channel catfish (*Ictalurus punctatus*) accumulated up to 61,190 times exposure levels after 77 days. Mammals and birds may be subjected to large concentrations of PCB's in their diets which tend to accumulate in various parts of the body such as adipose tissue (Matthews and Anderson 1975) skin, skeletal muscle, liver and small intestine (Peterson et al. 1976).

Although there is some information available regarding levels of PCB, DDT and dieldrin in Wisconsin fish (Kleinert et al. 1967; Kleinert et al. 1968; Degurse and Duter 1975; Kleinert 1976), there is little data regarding the levels of chlorinated hydrocarbons in Wisconsin's birds and mammals. A study on organochlorine residues in wings of adult mallard (*Anas platyrhynchos*) and black ducks (*Anas rubripes*) indicated that DDT, DDE, DDD, dieldrin and PCB's were present in all samples including some from Wisconsin (White and Heath 1976).

PCB's have diverse effects on wildlife. Bioassay studies on aquatic organisms have shown that reproduction may be affected at PCB concentrations of 5 ppb or less in the water and direct water and dietary exposures both contribute to tissue residues in fish (Stalling and Mayer 1972). PCB's administered to laying pheasent (*Phasianus colchicus*) hens affected egg production, hatchability and viability of the embryo at 12.5 mg/week doses (Dahlgren et al. 1972). Platonow and Karstad (1973) reported that low level exposure adversely affected reproduction and survival in mink (*Mustela vison*) and Aulerich and Ringer (1977) reported that a diet containing 30% Lake Michigan coho salmon (*Oncorhynchus kisutch*) resulted in reproductive failure due to the PCB's present. However, Zepp and Kirkpatrick (1976) have shown that a diet containing 10 ppm Aroclor 1254 had no effect on body weight change or reproductive characteristics in cottontail rabbits (*Sylvilagus floridanus*).

There have been studies done on raccoon populations, movement patterns, home ranges and denning habits (Urban 1970; Dorney 1954; Stuewer 1943). No information has been found concerning the effects or levels of PCB's in raccoons. Dorney (1954) and Stuewer (1943) have shown that aquatic foods are consumed by raccoons and Kleinert (1976) reported that carp (*Cyprinus carpio*) in the Wisconsin River contain PCB's.

The objectives of this study were:

1. To determine the amounts of polychlorinated biphenyls (PCB's) and other chlorinated hydrocarbons in raccoons in the central Wisconsin River Basin.

2. To determine the amount of PCB's in selected raccoon food items; carp, northern pike (*Esox lucius*), bullhead (*Ictalurus* sp.), clams (*Pelecypoda* sp.) and crayfish (*Decapoda* sp.) in the central Wisconsin River Basin.

STUDY AREA

The study area extends from Brokaw to Plainville, Wisconsin (Fig. 1) and included 7 major impoundments of the Wisconsin River which provide abundant lowland and marsh habitat (Dorney 1954). These impoundments reduce the flow rate of the Wisconsin River providing large areas where suspended material may be deposited.

The study area included 9 sample sites (Fig. 2). Five sites (1-5 in Fig. 2) adjacent to the Wisconsin River were selected for intensive study. The criteria for site selection included availability of suitable habitat, accessibility, and geographical location with respect to possible industrial or municipal sources of pollution (Kleinert 1976). Four additional sites were studied based on samples submitted by hunters and trappers during 1976 and 1977 seasons.

Site 1 is located 3 miles northwest of Mosinee above the Mosinee Flowage (T27N R7E sections 8, 9, 16 and 17). The river has moderate flow with little or no surrounding agricultural cropland. Site 2 is 1.5 miles south of the Lake DuBay dam (T25N R7E sections 14 and 23) and was characterized by a moderate flow rate. The site is surrounded by cropland with a narrow band of forested habitat adjacent to the river. Site 3 is 2 miles west of Plover (T23N R7E sections 19 and 20) below Fields Island and has a moderate to slow flow rate. This site is bordered by a golf course and there is little cropland in the area. Site 4 is 1 mile south of Nekoosa (T21N R5E sections 22 and 27) and has a moderate

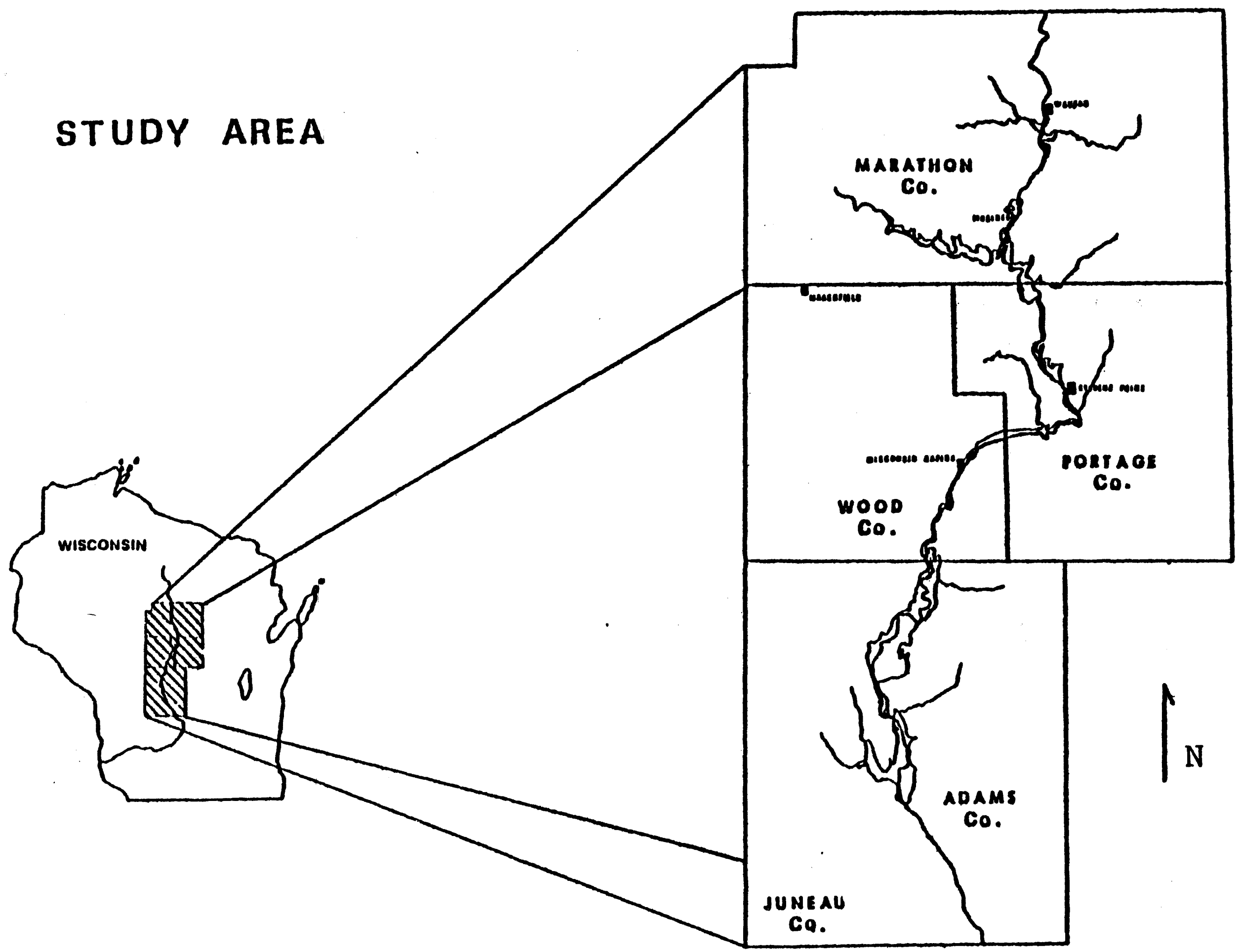

Fig. 1 PCB study area in central Wisconsin, 1976-1977.

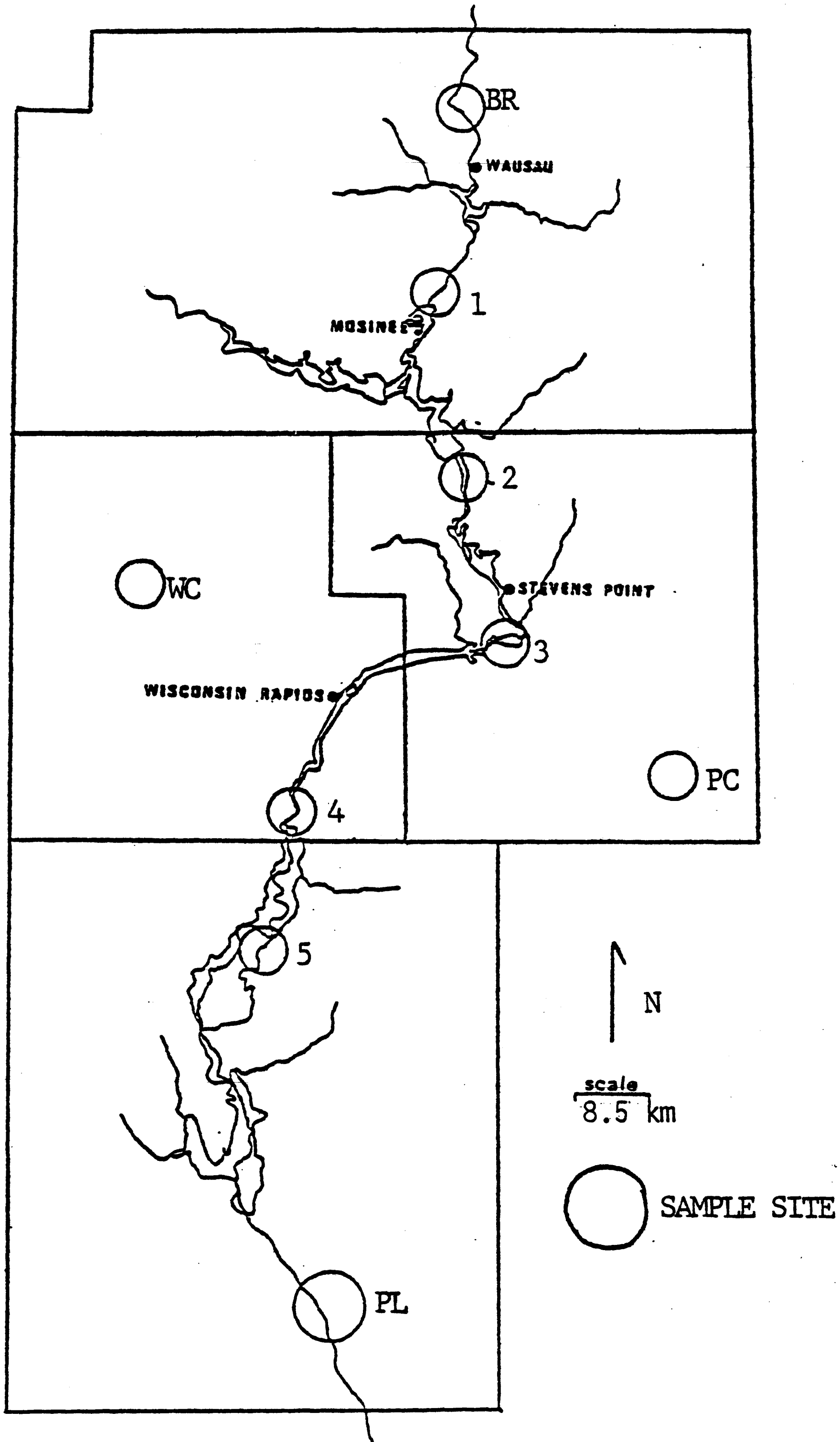

Fig. 2 Sample sites in the central Wisconsin study area, 1976-1977: (BR) Brokaw, sample sites 1-5; (PL) Plainville; (PC) SE Portage Co.; (WC) Central Wood Co.

to slow flow rate with some cropland nearby. Site 5 is located adjacent to the Petenwell Flowage 2 miles north of Monroe Center (T19N R4E sections 5, 7 and 8). This site is characterized by sand beaches with steep banks and the surrounding area has little farmland. All trapping at sites 1-4 was done along the river banks and along the shore at site 5.

Four additional sites were established where raccoon fat samples were submitted by hunters and trappers (Brokaw-BR, Plainville-PL, Southwest Portage County-PC, Central Wood County-WC). Sites BR and PL were adjacent to the Wisconsin River and sites PC and WC were removed from the river. The Brokaw site (BR) included the NW ¼ of T29N R7E. All raccoons from the Plainville site (PL) were caught within a 6 mile radius of the confluence of the Lemonweir and Wisconsin Rivers. The Portage County site (PC) included the SW ¼ of T22N R10E and samples from the cnetral Wood County site (WC) were taken in T23, 24 and 25N R3E.

METHODS

Sample Collection

Raccoons were collected using wire mesh live traps (36" x 16" x 16") at sites 1-5. Live trapping was conducted for two-one week periods at each of the 5 sites. The first trapping period was from 31 May 1977 to 20 July 1977 and trapping was repeated from 25 July 1977 to 31 August 1977. The trapped raccoons were weighed, anesthetized and a 1-2g fat sample was collected by biopsy techniques from the left rear flank area and stored in a glass vial. Immobilization was accomplished with an intramuscular injection of 11 mg/kg of body weight of ketamine hydrochloride (100 mg/ml) which took effect 1-2 minutes after injection and lasted for 10-20 minutes (Gregg and Olson 1975; Bigler and Hoff 1974). Raccoons exhibited normal heart and respiratory actions with full recovery after 1-2 hours. Surgical gauze was used to control any bleeding and the incision was closed with No. 000 plain surgical gut stiches. Raccoons were ear-tagged for identification with size 4 wing bands[1] imprinted with name, address and identification number. A second fat sample was collected if retrapped to determine change in concentration over time. After surgery the raccoon was held in a live trap until fully recovered and than released.

Additional raccoon fat samples were obtained from animals collected by hunters and trappers during the 1976 and 1977 seasons. Specific instructions were given to hunters and trappers for handling fresh samples (Appendix A) and those improperly handled or identified were omitted.

Raccoon food items were collected during the raccoon live trapping periods. A crayfish trap was set at sites 1-5. Clams were hand collected and fish were collected with a fyke net with 2.5 cm bar mesh size on the trap end, 5.0 cm bar mesh size leads and 2.73 m hoops. The weight and

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[1]National Band and Tag Co., Newport, Kentucky.

length of all fish and the total weight of each clam and crayfish was recorded upon capture. Sediment samples were collected with an Ekman dredge at sites 1, 3 and 4 between 2 August and 5 November 1977. The top 5 cm were retained for analysis and placed in hexane rinsed glass jars.

Sediment samples were stored at $4^{o}C$ and biological samples were frozen until anlayzed at the College of Natural Resources, University of Wisconsin-Stevens Point.

Sample Preparation and Extraction

Reagents used in extraction and GLC analysis were pretested for purity. Anhydrous sodium sulfate was pretreated at $650^{o}C$ for 2 hours to remove impurities.

Raccoon adipose tissue and crayfish samples were extracted by the following procedure:

1. Weigh out 0.5-1.0 g fresh sample (wet weight).
2. Add sample to a glass mortar containing a small amount of washed and ignited sand. Grind the tissue thoroughly.
3. Add granular anhydrous sodium sulfate and grind the contents to a fine dry powder.
4. Extract the pulverized tissue with three 10 ml portions of acetonitrile. Grind well and pour washes through whatman chromatographic paper No. 1 and collect filtrate in a tared 50 ml beaker.
5. Rinse mortar and filter with 10 ml acetonitrile.
6. Evaporate overnight in a ventilated hood and determine the mg of residue gravimetrically.

The percent lipid content of raccoon samples was determined by substituting petroleum ether for acetonitrile in the above extraction procedure.

The entire meat of bullheads less the head, guts, bones and skin were analyzed. Northern pike and carp were subsampled due to their large size by taking 2 - 1" wide cross-sections from just behind the pectoral fins and ahead of the anus. The bones and skin were removed and the 2 sections combined for analysis. A homogenius mixture of meat and liquor was examined from the clams. After sample preparation, fish and clams were extracted by the U.S. Food and Drug Administration's method for high moisture products (Pesticide Analytical Manual, 1975. vol. 1, section 212.13a).

Sediment samples were prepared and extracted by the procedure set forth by Goerlitz and Law (1974). All sediment samples were adjusted for percent moisture and organic matter was determined by the Walkley and Black procedure (Black 1965).

Sample Purification

All sample extracts except sediments were purified using semi-micro (25.0 cm x 5.0 mm i.d.) chromatographic columns filled with 2.0 g activated florisil (130°C for 12 hours) and topped with 1.0 cm anhydrous sodium sulfate.

After evaporation the extract is redissolved with hexane and an aliquot containing 40 mg or less of residue is transferred to a florisil column using a surgical 1.0 ml disposable pipet. PCB's and other chlorinated hydrocarbons are eluted from the column with 20 ml of 6% diethyl ether in petroleum ether (v/v) and collected in a 20 ml glass vial. The elution is reduced to an appropriate volume for chromatographic analysis.

The purification procedure for sediment extracts followed that of Goerlitz and Law (1974) with the following modifications:

1. Extracts were concentrated by evaporation under a ventilated hood.
2. The chromatographic column was 10 mm i.d. and contained 10 g of deactivated alumina (14% v/w).
3. PCB's were eluted from the column with 50 ml of hexane.
4. After alumina column cleanup the eluate was concentrated and transferred to a semi-micro florisil column for additional cleanup.

All biological samples are reported on a wet tissue weight basis and sediment samples are reported on a dry weight basis.

Gas Chromatographic Analysis

Analytical standards prepared in benzene were used as stock solutions[2]. Stock solutions of Aroclor 1242, 1254 and 1260 contained 10 ± .05 ppm and were stored at $4^{\circ}C$ when not in use. Working standards were prepared just prior to sample analysis and contained 1.0 ng/ul Aroclor.

PCB quantification methods followed that described by Sawyer (1973). A polar planimeter was used to determine total peak area of samples and reference Aroclors. In samples where DDE was suspected, the chlorobiphenyl peak which overlapped with DDE was eliminated from the area

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[2]Nanogens Analytical Specialist, Watsonville, California.

calculation. A plot of the total nanogram weight of the reference Aroclor injected versus total area was used to quantitate the amounts of Aroclor present in unknown samples.

Aroclor 1260 was quantified using 3 late eluting peaks with retention times of 10.3, 12.3, and 13.4 minutes relative to the solvent peak. These 3 peaks did not overlap with Aroclor 1254. Chromatogram tracings of Aroclor 1242, 1254 and 1260 are shown in Fig. 4 and 7. Other PCB quantitation methods have been described (Webb and McCall 1973) but the method used worked well for the sample extracts encountered in this study.

Sediment samples were calculated by peak height using 3 peaks from Aroclor 1254 corresponding to retention times of 4.6, 5.5, and 6.6 minutes. These 3 peaks were used because this area of the chromatogram was clear of interferences.

A Packard 7300 series gas chromatograph with a Ni-63 electron capture detector was used. The U-shaped glass column was 5.54 m x 4 mm i.d. and was packed with 3% SE-30 on 100/110 mesh Anakrom ABS. Nitrogen was the carrier gas with a flow rate of 60 ml/minute. The column was isothermally operated at 190°C and 225°C, respectively. The electromether attenuation was set at 128×10^{-12}.

Confirmatory identification of PCB's was done using an alternate gas chromatograph. Seven samples were rechromatographed on a Tracor MT-160 gas chromatograph with a Ni-63 electron capture detector and a 5.54 m x 6 mm i.d. glass coiled column packed with 3% ov-101 on 100/120 mesh gas chrom Q. Nitrogen was the carrier gas with a flow rate of 40 ml/minute. The column was operated isothermally at 220°C and the detector and inlet temperatures were 250°C and 233°C, respectively.

Percent recovery determinations were done on raccoon adipose tissue samples fortified with 1.0 ug of Aroclor 1254 and 1260 and 1.6 ug of Aldrin. Spikes were made just after homogenization and sodium sulfate drying and the samples were allowed to stand a few minutes prior to extraction.

Percent recovery was not determined for the fish extraction method. This method is listed in the Federal Food and Drug Administrations <u>Pesticide Analytical Manual</u>, 1975, vol. 1, section 212.13a and has been adequately proven. To assure quality control, 2 duplicate samples of fish homogenate were taken to the EPA Environmental Research Laboratory-Duluth, Minnesota for comparative analysis.

Duplicate samples of raccoons and fish samples were run during the study.

RESULTS AND DISCUSSION

The detection limit of Aroclor 1254 and 1260 was 0.20 and 0.10 ppm respectively, for raccoon and crayfish samples. The detection limit for Aroclors 1242, 1254 and 1260 for fish and clam samples was 0.005 ppm. The average percent recovery from spiked raccoon samples of Aroclor 1254, 1260 and aldrin were 86.3 ± 12.0, 97.2 ± 3.0, and 91.2 ± 4.7 percent, respectively. Goerlitz and Law (1974) reported an average recovery of 97.0 percent for a chlorinated insecticides for the sediment extraction method used. Two fish samples were determined to contain 0.91 and 0.90 ppm Aroclor 1254. These same fish samples contained 0.80 and 1.20 ppm Aroclor 1254, respectively, when analyzed by the Environmental Research Laboratory-Duluth, Minnesota. Results from duplicate sample analysis is presented in Table 1.

Sample Collection

In the fall of 1976 and the summer and fall of 1977, 130 raccoon adipose samples from the central Wisconsin study area were analyzed for PCB's and other chlorinated hydrocarbons. At sample sites 1-5, 43 raccoons; including 3 retrapped, were captured, sampled, tagged and released. Hunters and trappers submitted 87 raccoon samples during the 1976 and 1977 seasons. Raccoon samples which were not collected from 1 of the 9 sites were used to provide supporting data (Appendix B). The entire distribution of collected raccoon samples is illustrated in Fig. 3. Sufficient biographical information was not available for 32 of the 130 raccoon samples and are not included in Fig. 3. There were 61 females and 61 males and the sex was not reported for 8 raccoons.

The sample size of various food items was limited by the time required for sample analysis, abundance and ecological importance of the organism. Crayfish were found only at site 3 and 12 clams were collected from sites 2, 3 and 4. Fish were collected at all 5 sites.

TABLE 1. Results of duplicate analysis of raccoon and fish samples.

Sample‡	PCB RESIDUES - PPM 1254	1260
R86 I	1.60	0.16
II	1.64	0.16
R93 I	0.50	Trace*
II	0.50	Trace
B3-4 I	0.07	ND**
II	0.06	ND
Carp 2-3 I	0.91	0.04
II	0.90	0.05
Carp 3-4 I	0.05	ND
II	0.05	ND
Carp 1-5 I	0.30	Trace
II	0.29	Trace
N 1-4 I	0.15	0.02
II	0.16	0.01
III	0.20	0.02

‡ - R-denotes Raccoon, B-denotes Bullhead, N-denotes Northern Pike.

* - Trace = <.01 ppm

** - ND-Not Detected-Detection Limit = .005 ppm

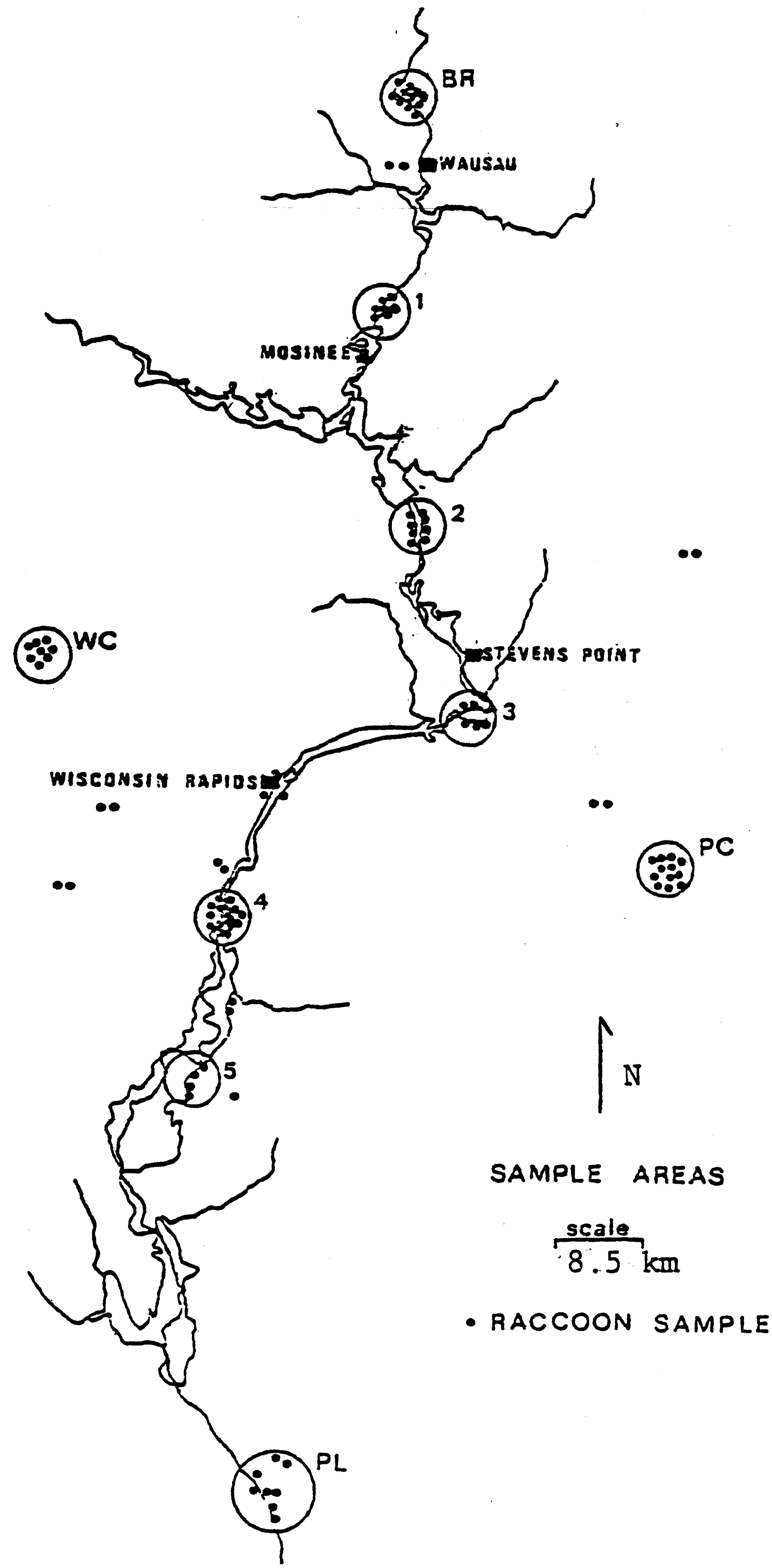

Fig. 3. Locations where raccoon samples were collected within the central Wisconsin study area, 1976-1977.

PCB's in Raccoons

PCB Aroclors 1254 and 1260 were identified in raccoon adipose tissue samples. Aroclor 1254 was detected in 67 percent of all raccoon samples with levels ranging from not detectable to 21.00 ppm. Aroclor 1260 was detected in 41 percent and levels ranged from not detectable to 5.01 ppm. A representative chromatogram tracing of raccoon sample extracts and 1254 and 1260 standards are illustrated in Fig. 4. Extracts from raccoons closely resembled standard preparations.

The number of samples, range and mean concentrations of Aroclor 1254 and 1260 from the 9 sites in central Wisconsin are presented in Table 2. Analysis of variance of raccoon adipose samples indicated they were significantly different between sample sites ($P<0.01$) for both Aroclor 1254 and 1260. The histogram in Fig. 5 compares the average levels from the 9 sites. Raccoons at site 3 had the highest levels of Aroclor 1254 and 1260 with a mean of 11.02 ppm (SD = 8.64, r = 1.92-21.00) and 2.52 ppm (SD = 1.24, r = 1.38-4.31), respectively. Aroclor 1260 occurred at lower levels than 1254 at all sample sites (Table 2). Clam and sediment samples from site 3 did not contain the highest PCB levels, however the highest fish PCB concentrations were found there.

Dorney (1954) reported that crayfish and fish were staple foods of the raccoon throughout the year. The higher levels of Aroclor 1254 in fish and the presence of

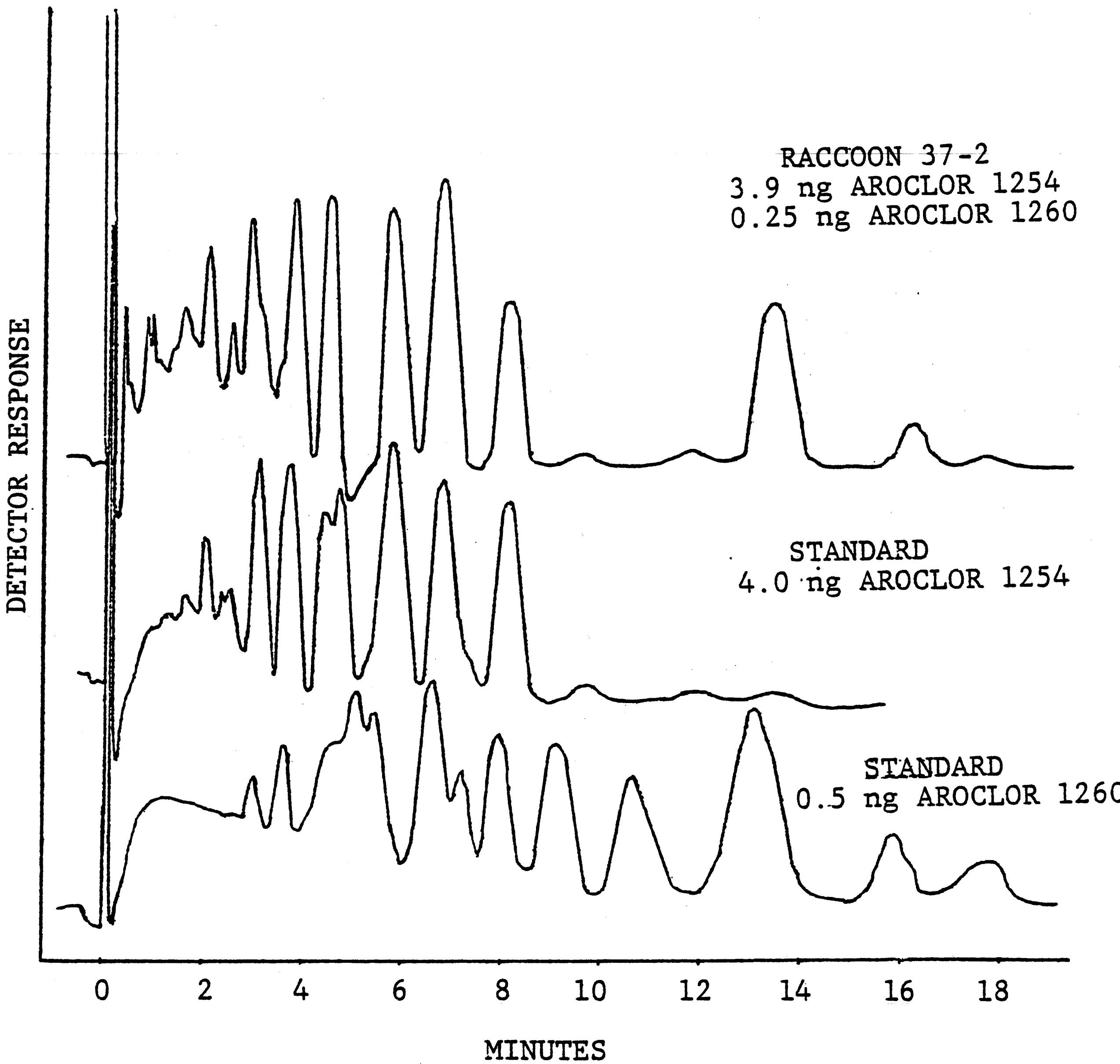

Fig. 4. GLC Chromatogram of raccoon dipose tissue extract from below Lake DuBay (site 2) showing presence of Aroclor 1254 and 1260.

TABLE 2. Number of samples, range, mean and standard deviation for PCB concentrations in raccoon adipose tissue from 9 sites in central Wisconsin, 1976-77.

Sample Site	Number of Samples	ppm Aroclor 1254[1/] Range	ppm Aroclor 1254[1/] Mean ± s.d.	ppm Aroclor 1260 Range	ppm Aroclor 1260 Mean ± s.d.
BR	11	T[2/] - 2.39	0.92 ± 0.70	0.00 - 0.38	0.15 ± 0.14
1	7	1.23 - 5.35	3.18 ± 1.69	T - 1.49	0.59 ± 0.52
2	8	0.00 - 3.49	1.23 ± 1.35	0.00 - 0.59	0.13 ± 0.20
3	5	1.92 - 21.00	11.03 ± 8.64	1.38 - 4.31	2.52 ± 1.24
4	16	T - 6.29	1.88 ± 1.57	0.00 - 5.01	0.68 ± 1.19
5	6	0.57 - 5.14	2.79 ± 1.52	0.00 - 1.55	0.63 ± 0.57
PL	8	0.00 - 0.20	0.11 ± 0.10	0.00 - T	0.01 ± 0.03
PC	12	0.00 - T	0.01 ± 0.04	0.00 - 0.00	0.00 ± 0.00
WC	8	0.00 - T	0.02 ± 0.05	0.00 - 0.00	0.00 ± 0.00

[1/] Detection Limit = 0.10 ppm fro Aroclor 1254, 0.05 ppm for Aroclor 1260

[2/] Trace = <.2 ppm for 1254, <.10 ppm for 1260.

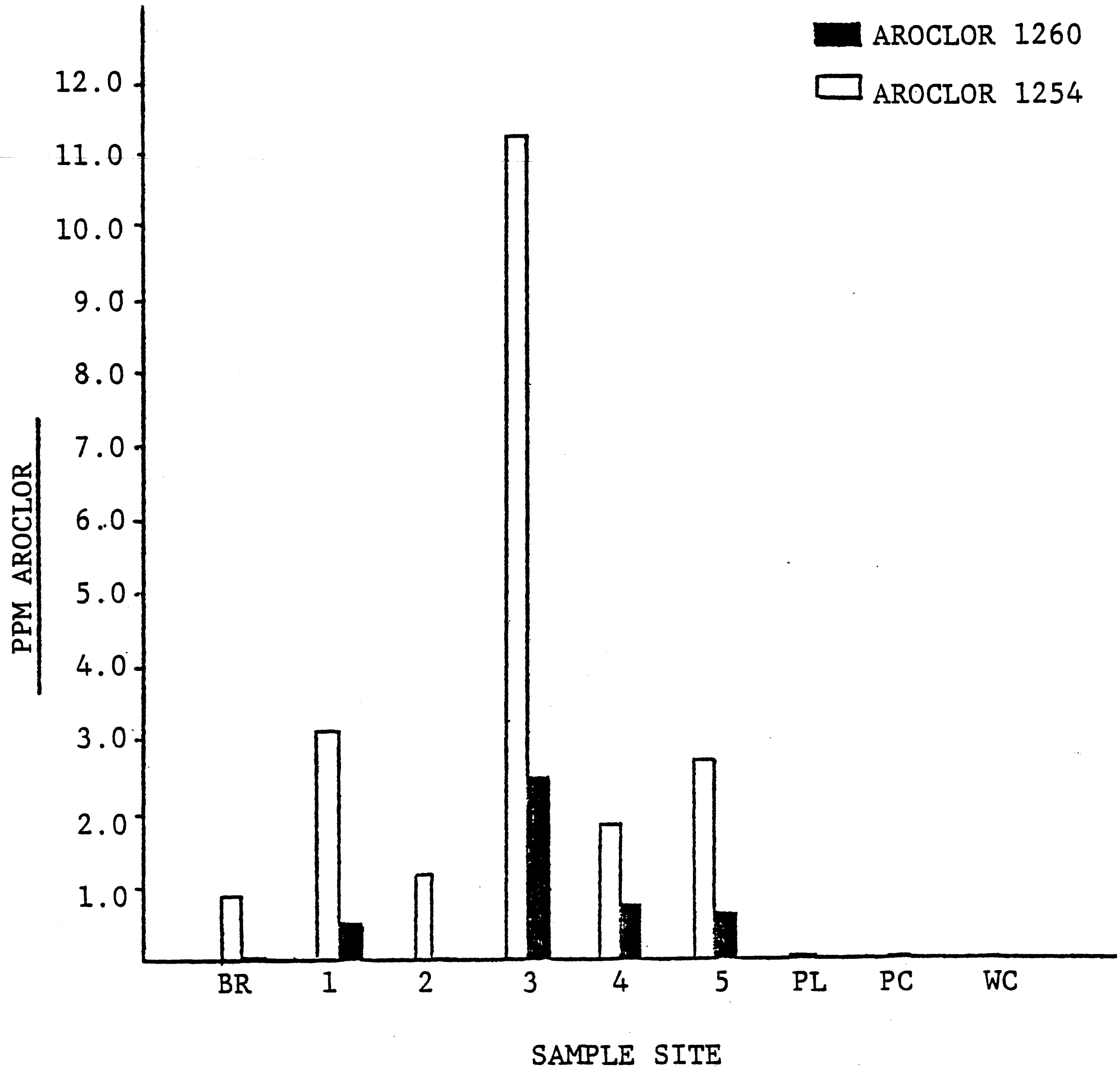

Fig. 5. Mean PCB concentration in raccoon adipose samples for the nine sample sites in central Wisconsin: (BR) Brokaw, sample sites 1-5; (PL) Plainville; (PC) SE Portage Co.; and (WC) Central Wood Co.

PCB's in crayfish at site 3 may be sources of PCB's to raccoons. The overall mean of Aroclor 1254 for raccoons captured from the 7 river sites was 2.38 ppm (SD = 3.74, r = not detectable - 21.00). The overall mean of Aroclor 1254 for the fish species was 0.17 ppm (SD = 0.39, r = not detectable - 2.08). Therefore, the average bioaccumulation factor from fish to raccoons is 14X. At site 3, raccoons and fish averaged 11.03 ppm (SD - 8.64, r = 1.92-21.00) and 0.42 ppm (SD = .39, r = 0.02-0.91), respectively, of Aroclor 1254 which is a 26 fold bioaccumulation factor. Woodwell et al. (1967) found bioaccumulation factors for DDT in a Long Island Estuary to be 10 to 100 X for each trophic level. The residue levels in fish at site 3 and throughout the basin could contribute to the raccoon levels found. Urban (1970) reported that in a managed waterfowl marsh raccoons spent 73 percent of their time each night in shallow water areas.

A definite relationship exists between the distance from the river and the PCB residues present in raccoons. Aroclor 1254 was detected in only 10 percent and Aroclor 1260 was not detected in 20 samples collected at non-river sites PC and WC (Fig. 2). The combined mean for these two sites was 0.01 ± 0.05 ppm Aroclor 1254. In raccoon samples collected adjacent to the river the mean concentrations of Aroclor 1254 and 1260 was 2.38 ± 3.74 and 0.66 ± 1.21 ppm, respectively, and they occurred in 94 and 71 percent of all samples, respectively. Raccoons captured more than

8 kilometers from the river contained only trace amounts or less of Aroclor 1254 and 1260. Stuewer (1943) reported the average home range of adult male raccoons was 1.67 kilometers. The average range for females and juveniles was less than 1.67 kilometers. Urban (1970) reported that the average home range on a managed waterfowl marsh was 119.6 acres. Data collected in this study indicates that only raccoon samples collected near the Wisconsin River are being exposed to PCB's.

Kleinert (1976) listed possible sources of PCB's in Wisconsin including sediment release, emission sources such as incineration and subsequent airborne fallout, landfill sites from which leachate may be contaminated, and various outfalls of municipal and industrial plants. The Wisconsin Department of Natural Resources has identified pulp and paper mills as the largest point source of PCB's in Wisconsin due to the large volume of wastewater they discharge (Kleinert 1976). Specific sources of PCB's in the Wisconsin River were not investigated, however those listed above could be possible sources.

Dorney (1954) and Stuewer (1943) observed a change in raccoon food habits at various times of the year. During early spring and fall, raccoons fed on aquatic foods whereas during the summer they fed primarily on fruits and berries. Sample sites 1-5 were first trapped in June and early July and again in late July and August. The influence of time and possible change in food habits on PCB levels can be analyzed by placing the raccoon samples into early and late summer groups (Table 3). The mean concentration of Aroclors 1254 and 1260 for samples collected in June and early July was 3.99 ± 5.27 ppm and 0.97 ± 1.35 ppm, respectively. During late July and August the mean concentrations were 2.77 ± 2.85 ppm and 0.99 ± 1.90 ppm, respectively.

A t-test indicated the decrease was not significant ($P < 0.05$) for either Aroclor, however levels dropped for Aroclor 1254 but not Aroclor 1260. Aroclor 1260 is very stable and not easily eliminated once aquired (Matthews and Anderson 1975; Peterson et al. 1976). Excretion into the bile as a polar metabolite in the rat decreases with degree of chlorination and highly chlorinated compounds such as hexachlorobiphenyl (Aroclor 1260) are never entirely metabolized over an infinite period of time (Matthews and Anderson 1975). A major requirement for hydroxylation by oxygenase activity is that two unsubstituted carbon atoms be present on the biphenyl structure. Two unsubstituted adjacent carbon atoms in 2,4,5,2',5'-pentachlorobiphenyl (Aroclor 1254) allows for enzymatic attack on the 2',5'-dichloro-ring. In the case of hexachlorobiphenyl no adjacent carbons are available, thus inhibiting arene oxide formation (Peterson et al., 1976). They also report that hexachlorobiphenyl is removed from rats slowly and the majority is excreted primarily in the form of the parent compound. These studies indicate that metabolism of PCB's decreases with percent chlorination which could explain the

TABLE 3. Affect of season on concentrations of Aroclor 1254 and 1260[1/] in raccoon adipose tissue collected adjacent to the Wisconsin River, 1977.

Sample No.	4 June - 17 July		26 July - 22 August	
	1254	1260	1254	1260
		SITE 1		
R30-1	4.75	0.47		
R33-1	1.23	T		
R57-1			1.84	0.34
R58-1			4.26	1.11
R59-1			5.35	0.47
R60-1			1.39	0.18
R61-1			3.43	1.49
		SITE 2		
R29-2	ND	ND		
R34-2	2.18	0.14		
R35-2	T	ND		
R36-2	1.18	0.19		
R37-2	2.52	0.16		
R38-2	3.49	0.59		
R62-2			T	ND
R63-2			T	ND
		SITE 3		
R39-3	6.93	1.53	2.67	0.56
R40-3	5.80	2.11	7.78	1.30
R41-3	19.51	3.25	10.87	8.36
R42-3	21.00	4.31		
R68-3			1.92	1.38
		SITE 4		
R43-4	3.10	5.01		
R44-4	6.29	0.93		
R45-4	2.73	0.45		
R46-4	0.73	ND		
R47-4	2.42	0.52		
R48-4	2.22	0.84		
R49-4	1.30	0.22		
R50-4	T	ND		

TABLE 3. (Continued)

Sample No.	4 June - 17 July 1254	4 June - 17 July 1260	26 July - 22 August 1254	26 July - 22 August 1260
R51-4	1.03	0.19		
R69-4			3.77	0.58
R70-4			1.73	0.63
R71-4			0.49	0.15
R72-4			1.84	0.49
R73-4			0.71	0.23
R74-4			0.72	0.44
R75-4			0.77	0.18
SITE 5				
R53-5	0.57	ND		
R54-5	2.18	0.87		
R55-5	5.14	1.55		
R56-5	3.07	0.83		
Overall Mean	3.99 ppm	0.97 ppm	2.77 ppm	0.99 ppm

1/ All concentrations are in ppm. ND - not detected (<.10 ppm 1254 <.05 ppm 1260). T - trace = .10-.20 ppm 1254, .05-.10 ppm 1260.

drop in Aroclor 1254 concentrations toward late summer when aquatic foods are less important. This relationship with time may cause bias in the interpretation of the results since at some sites the majority of the samples were collected early as opposed to others which were mostly collected in late summer.

Three raccoons from site 3 were sampled in June and contained 6.93, 5.80 and 19.51 ppm Aroclor 1254. Resampling in August yielded 2.67, 7.78 and 10.87 ppm, respectively. Although one raccoon level increased slightly, two decreased considerably, which may indicate a change of food habits in summer. Another possibility may be that raccoon's are increasing their total body fat toward the end of the summer. This increase may produce a dilutional effect on PCB's within the body. However this should also reduce Aroclor 1260 levels and this did not occur.

No relationship was found between the sex of raccoons and PCB residues. When analyzed by sex, the mean concentration of Aroclor 1254 was 1.67 ppm (SD = 3.16, = not detectable - 19.51) for males and 1.30 ppm (SD = 3.31, = not detectable, 21.00) for females. The mean concentrations for Aroclor 1260 for males and females was 0.39 ppm (SD = .89, = not detectable - 5.01) and 0.33 ppm (SD = 0.76, = not detectable - 4.31), respectively. A t-test indicated no significant difference for either Aroclor ($P < .05$).

There was no consistent relationship between the weight of raccoons captured and the concentrations of PCB's found. In some instances juvenile raccoons had higher concentrations than many adults from the same site. At site 4, 3 juvenile raccoons weighing between 2.3 and 2.5 kg and 1 adult weighing 7.2 kg were captured. The 3 juveniles contained 1.73, 1.84 and 3.77 ppm Aroclor 1254, respectively, and the adult contained 0.49 ppm. This relationship was not always typical. At site 1, 3 raccoons weighing 1.6, 5.9 and 9.5 kg contained 3.43, 4.26 and 5.35 ppm Aroclor 1254, respectively. Allen et al. (1974a) showed that transplacental migration of PCB's can occur in monkey's. This could also be occuring in young raccoons since they contained PCB levels similar to the adults (Table 4).

PCB's which have been absorbed after ingestion are distributed to major tissues including skelatal muscle, liver, skin, blood, adipose tissue and small intestine (Hashimoto et al. 1976; Matthews and Anderson 1975; Peterson et al. 1976). Hashimoto et al. (1976) studied this distribution after prolonged oral administration to male rats and reported the highest concentrations in adipose tissue. PCB's are lipophilic compounds and presence of subcutaneous fat in raccoons provides PCB storage potential.

Determination of the percent lipid content helped to characterize the composition of the adipose tissue collected. Burns (1974) in a study on organochlorine pesticides and PCB residues in biopsied human adipose tissue considered less than 30 percent lipid content insufficient for analysis as adipose tissue. The percent lipid was determined on 58

TABLE 4. Comparison of Aroclor 1254 and 1260 in adult and juvenile raccoons near Nekoosa, Wisconsin, 1977.

		PCB Residue - ppm	
Sample No.	Weight (kg)	1254	1260
ADULTS			
R43-4	5.2	3.10	5.01
R44-4	7.9	6.29	0.93
R45-4	4.5	2.73	0.45
R46-4	6.6	0.73	ND
R47-4	5.0	2.42	0.52
R48-4	4.5	2.22	0.84
R49-4	6.8	1.30	0.22
R50-4	5.2	T	ND
R51-4	4.5	1.03	0.19
R71-4	7.2	0.49	0.15
R75-4	5.0	0.77	0.18
	Mean =	1.93 ± 1.75	0.77 ± 1.44
JUVENILES			
R69-4	2.5	3.77	0.58
R70-4	2.3	1.73	0.63
R72-4	2.5	1.84	0.49
R74-4	2.0	0.72	0.44
R73-4	1.8	0.71	0.23
	Mean =	1.75 ± 1.25	0.47 ± 0.16

samples (Appendix B) and the mean was 64.4 percent (SD = 7.88, r = 37-81).

The amount of adipose tissue in raccoons may influence PCB metabolism. PCB's located in the liver some time after exposure have been mobilized from other tissues; brain, skin, and adipose tissue (Allen et al. 1974b). They also report that during periods of reduced food intake by monkey's, mobilization of lipid tissue containing PCB's into the blood stream for transport to the liver. Relocation of PCB's from adipose tissue may enhance their toxicity to particular organs of the body and rapid removal of adipose tissue may occur during periods of illness or starvation (Allen et al. 1974a). They also reported that in non-human primates in large percentage of the PCB's returned to the liver are not redeposited but progressively excreted. If PCB's in raccoons exhibit similar metabolic pathway's as in non-human primates and rats (Allen et al. 1974a; Allen et al. 1974b; Hashimoto et al. 1976; Matthews and Anderson 1975; Peterson et al. 1976) the liver may be exposed to high PCB levels during prolonged periods of hibernation or during lactation when fat reserves are mobilized.

PCB's in Raccoon Food Items

The food habits of the raccoon are varied and depend on locally available foods. A study in Michigan showed that in spring raccoons fed primarily on acorns. small rodents, crayfish and insects and during the summer the primary foods were berries, fruits, caterpillars and insects (Stuewer 1943). In the Horicon Marsh, crayfish were the staple food throughout the year with muskrat kits the next most important food item. Various species of fish were taken throughout the year, and corn and grapes were used in the fall (Dorney 1954). Small amounts were detected in crayfish and clams (Table 5). No PCB residues were found in clams from site 3 and 4 but site 2 contained residues of Aroclor 1242. Chromatogram tracings of representative clam extracts and Aroclor 1242 standard are shown in Fig. 6 and 7. Clams at site 4 contained an unknown compound which will be discussed in a later section.

The location, number of samples, mean weight, length and PCB residues found in fish and clams is given in Table 6. Aroclor 1242 was present in all fish at sites 1 and 2 and in clams at site 2. Sites 3, 4 and 5 contained Aroclor 1254 and 1260. Representative chromatogram tracings of fish extracts with Aroclor 1242 and 1254 standards are shown in Fig. 8 and 9. This residue composition may indicate a source of Aroclor 1242 above Lake DuBay and a source of Aroclor 1254 between Lake DuBay and Plover.

Aroclor 1242 residues were not present in raccoon extracts. There are two possible hypothesis; (1) raccoon are not feeding on these aquatic food items and thus 1242 is not ingested; (2) raccoons may be capable of metabolizing Aroclor 1242 much more readily than 1254 or 1260 and thus it is being eliminated from their body. The first hypothesis

TABLE 5. Summary of Aroclor 1254 residues in sediment, fish and other food items collected throughout the study area, 1977.

Item	No. of Samples	ppm Aroclor 1254‡ Range	ppm Aroclor 1254‡ Mean
Sediment	17	0.001 - 0.114	0.018
Carp	14	0.00 - 2.08	0.37
Northern Pike	11	0.00 - 2.26	0.04
Bullhead	11	0.00 - 0.30	0.09
Clams*	12	0.00 - 0.00	0.00
Crayfish	3	0.00 - 0.05	0.03

‡ Detection Limit = 0.005 ppm, quantifiable = 0.01 ppm; sediment quantifiable limit = 0.001 ppm.

* Aroclor 1254 was not found, only Aroclor 1242 was identified in clams from site 2.

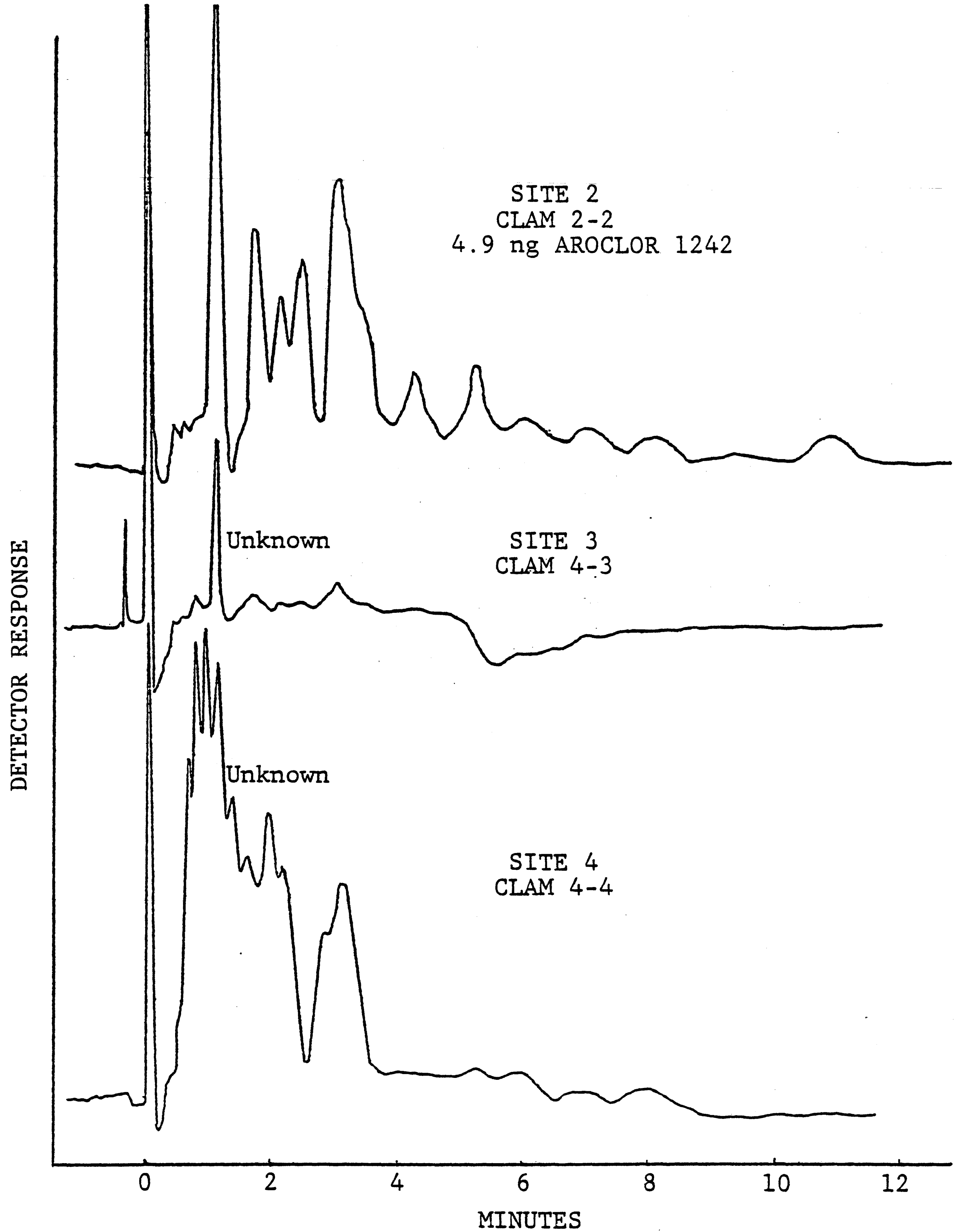

Fig. 6. GLC chromatograms comparing clam extracts from the Wisconsin River and the unknown peaks found.

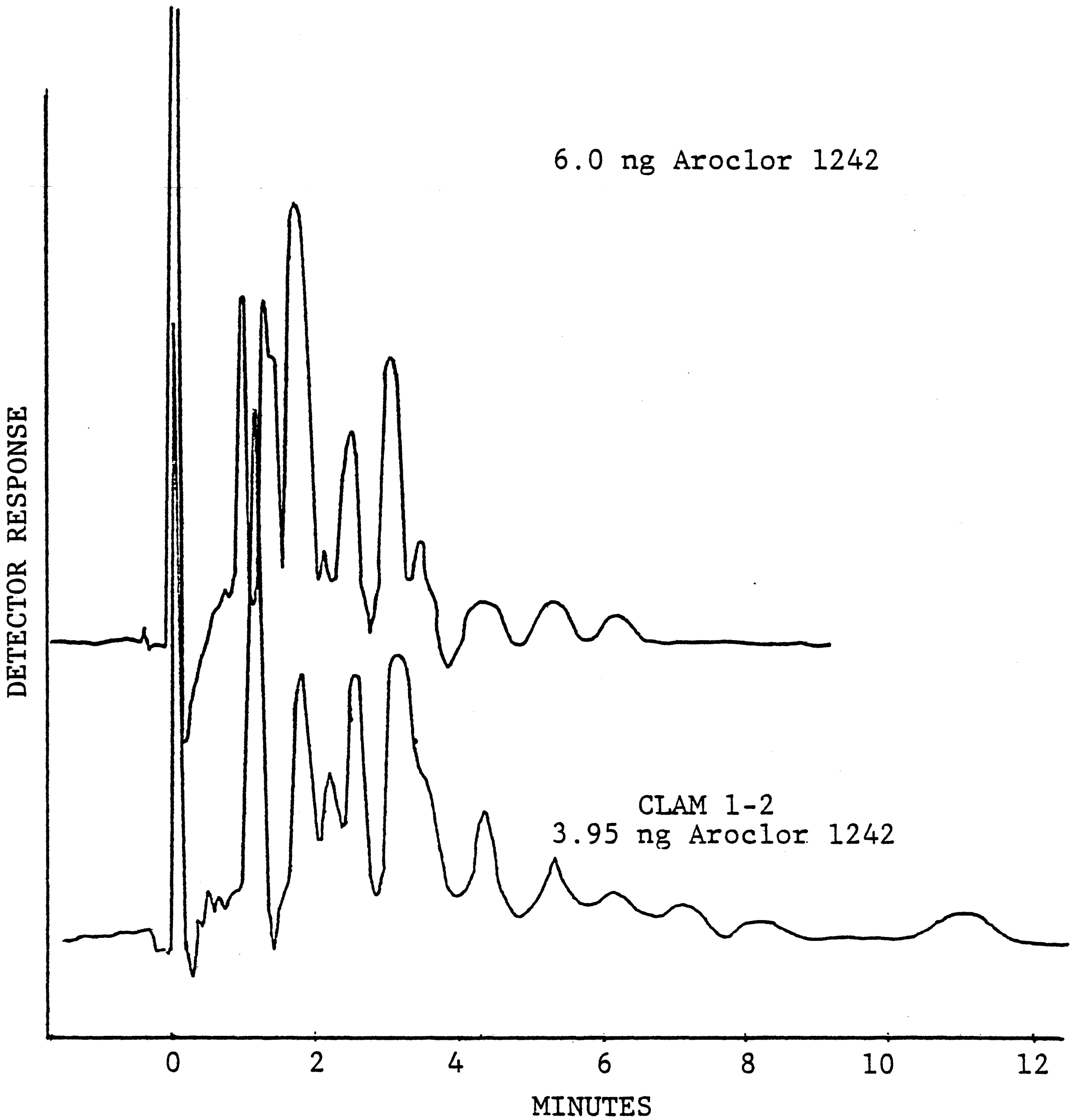

Fig. 7. GLC chromatograms showing the resemblance between standard Aroclor 1242 and clam extracts from below Lake DuBay.

TABLE 6. Location, number of samples, mean weight, length and PCB concentrations found in fish and clams in the Wisconsin River, 1977.

Sample Site	No. of Samples	Mean Weights (kg)	Mean Length (cm)	Mean PCB Residues - PPM‡ 1242	1254	1260
			Northern Pike			
1	3	1.048	54.6	0.47	ND	ND
2	4	.523	40.6	0.08	ND	ND
3	1	1.200	61.1	ND	0.26	<.01
4	3	1.026	52.7	ND	0.08	<.01
5	--	--	--	--	--	--
			Carp			
1	2	3.745	60.9	2.07	ND	ND
2	4	2.081	50.8	0.95	ND	ND
3	2	2.450	56.5	ND	0.90	0.03
4	3	0.946	39.0	ND	0.14	ND
5	3	1.659	47.3	ND	0.89	0.04
			Bullhead			
1	--	--	--	--	--	--
2	4	0.133	20.1	0.36	ND	ND
3	3	0.237	25.7	ND	0.15	0.07
4	4	0.260	24.9	ND	0.12	ND
5	--	--	--	--	--	--
			Clam			
1	--	--	--	--	--	--
2	4	64.8	--	0.06	ND	ND
3	4	89.3	--	ND	ND	ND
4	4	14.5	--		Not Quantifiable	
5	--	--	--	--	--	--

‡ Detection Limit = 0.005 ppm, Quantifiable = 0.01 ppm.

ND = Not detected.

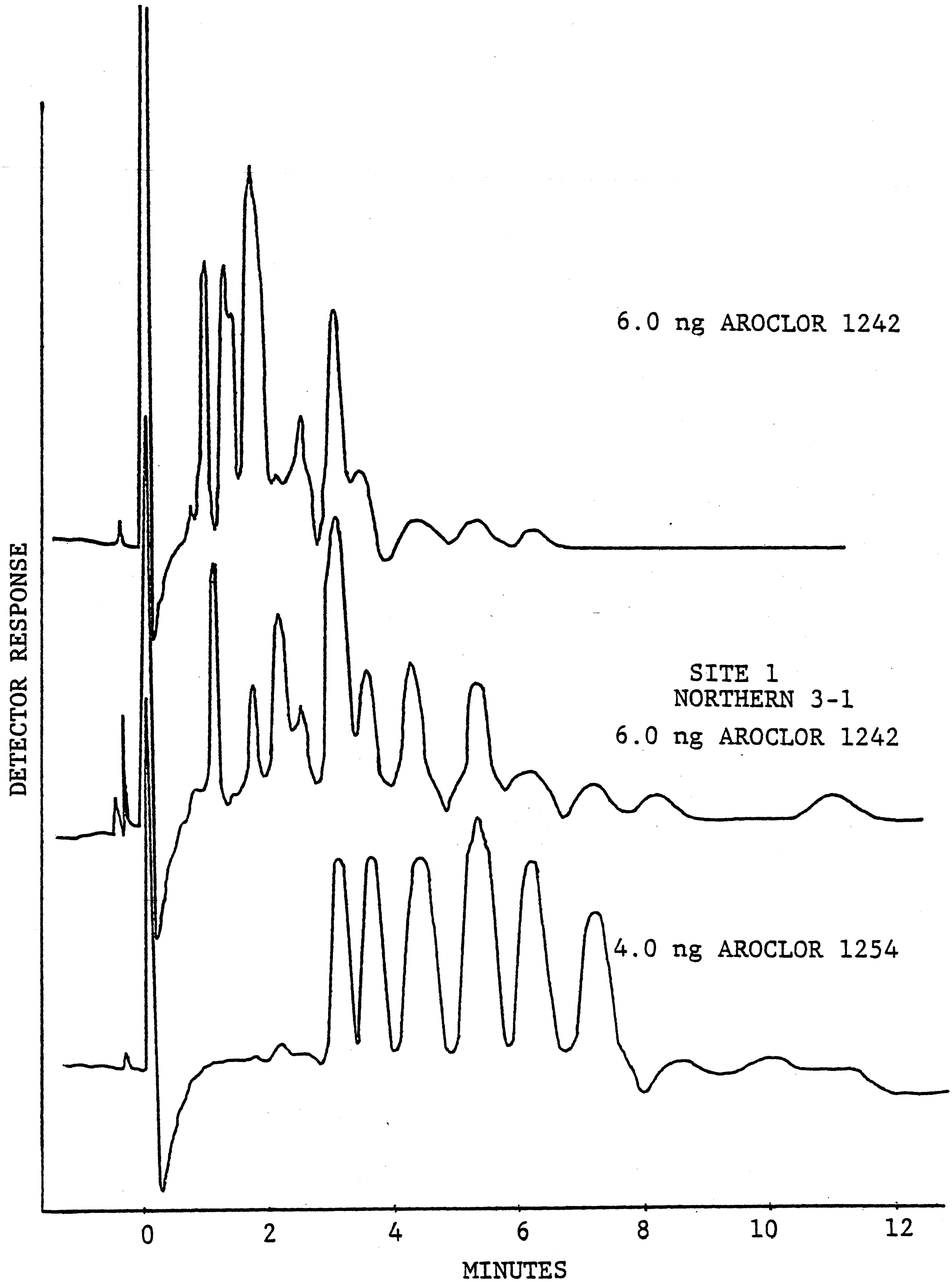

Fig. 8. GLC chromatograms of standard Aroclors 1242 and 1254 with Northern extract taken north of Mosinee.

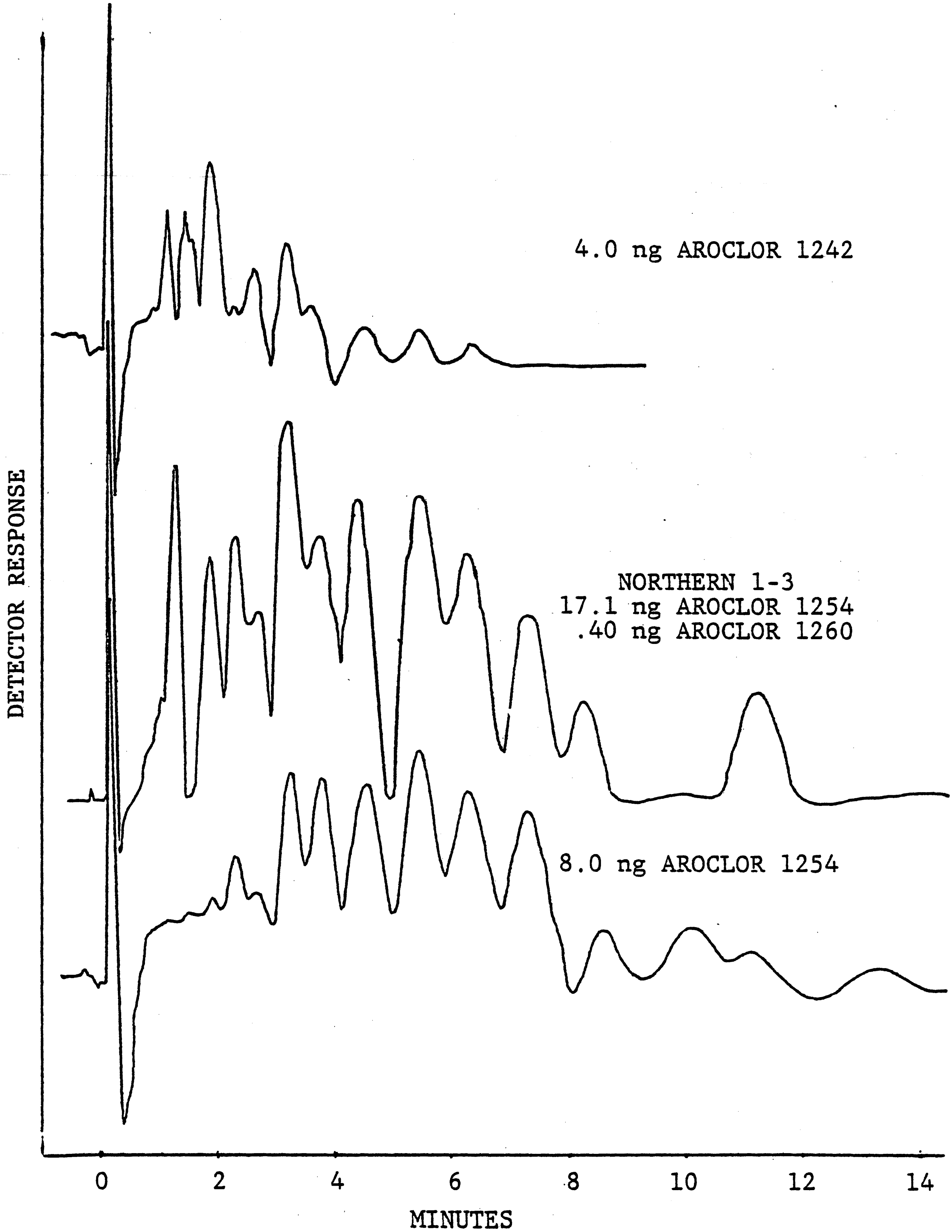

Fig. 9. GLC chromatograms of standard Aroclors 1242 and 1254 with Northern extract taken south of Stevens Point.

is unlikely because other studies have shown that raccoons regularly feed on aquatic foods. There is strong evidence to support the second hypothesis. Platonow and Karstad (1973) reported that mink significantly reduced the first 8 emerging peaks of Aroclor 1254 in all tissues. Allen et al. (1974a) reported a near absence of peaks with lower retention time in fat tissues from monkey's fed Aroclor 1248. These early eluting peaks represent lower chlorinated isomers which would predominate in Aroclor 1242.

The sample size for the various fish species collected was small due to sample preparation time, but with available data, sample site 3 contained the highest Aroclor 1254 residues (Table 6). This paralles isomer levels found in raccoons.

The levels of PCB's found in the Wisconsin River carp were lower than levels reported by the Wisconsin Department of Natural Resources in 1976. They reported that carp taken within the study area ranged from 0.25 to 13.5 ppm PCB with a mean of 3.25 ppm. In 1977, I found that carp ranged from not detected to 2.08 ppm with a mean concentration of 0.37 ppm (SD = 0.59, r = not detectable - 2.08) as Aroclor 1254. There are many variables which influence the PCB levels in fish. The age, weight, location taken, species, portion of sample used for analysis and distance from a possible point source of pollution are just a few example's of factor's which may have caused the large difference in PCB levels.

PCB's in Wisconsin River Sediment's

PCB's were found in all sediment samples collected and the mean concentration was 18 ppb (SD = 30, r = 1-114 ppb) dry-weight basis (Table 7). Due to early eluting interfering peaks, Aroclor 1242 may have been present but not identified, thus all sediment results are reported as Aroclor 1254. Relatively low PCB levels were found at sites 3 and 4 with site 1 showing the most contamination. Due to the coarse bottom material in the main channel of the river, sampling was restricted to backwater bays and sloughs where suspended sediment deposition is occuring as fine particles of organic matter, silts and clays. Choi and Chen (1976) reported that adsorption tends to increase with organic matter and a good relationship between organic matter and PCB levels was found at each site. Fulk et al. (1975) and Choi and Chen (1976) present evidence that transfer of chlorinated hydrocarbons from sediment to a solution phase is negligible and Oloffs et al. (1973) reported that all detectable residues of Aroclor 1260 had moved from the water to the underlying sediments in 6 weeks, thus sediments may be a permanent sink for removal of PCB's from the hydrologic environment.

The data indicates a relationship between sample concentrations and impoundments near the sample site. Raccoon PCB concentrations tended to be lower below existing impoundments. Fig. 5 illustrates the fluctuation of mean PCB levels between the sites and there is a drop in concentra-

TABLE 7. Percent organic matter and PCB concentrations in Wisconsin River sediments, 1977.

Sample No.	Percent Organic Matter	PCB* ug/kg Dry-Weight Basis	PCB* ug/kg Organic Matter Basis
Area 1			
1-1	0.10	8	4150
2-1	0.10	4	4100
3-1	3.75	48	1272
4-1	8.59	114	1334
6-1	8.84	66	752
Area 3			
1-3	6.07	12	314
2-3	1.29	5	396
3-3	1.05	2	186
4-3	0.47	3	682
5-3	0.95	3	366
6-3	1.01	5	521
Area 4			
1-4	0.93	1	133
2-4	16.50	10	39
3-4	17.11	8	49
4-4	19.43	7	36
5-4	0.67	1	166
6-4	19.08	5	28

* Detection limit; 1 ug/kg.

tion between site 1 (mean 1254 = 3.18 ± 1.69) and site 2 (mean 1254 = 1.23 ± 1.35) which are seperated by Lake DuBay and the Mosinee Flowage. Another drop occurs between site 5 (mean 1254 = 2.79 ± 1.52) and site PL (mean 1254 = 0.11 ± 0.10) which are seperated by the Pentenwell and Castle Rock Flowages. There are other possible factors which may influence these concentrations changes such as distance from a source, whether industrial or municipal, and flow rate of the river at a particular site, however it is possible these flowages are absorbing the PCB's.

I found a mean concentration of 18 ppb PCB (Aroclor 1254) in Wisconsin River sediments. The results of the sediment analysis are comparible to those found by various state testing laboratories. Some reported are: Milwaukee harbor 6.420 ppb; Lake Pepin 266 ppb; Lower Green Bay east of Fox River mouth 193 ppb; and most Mississippi River samples and tributaries were less than 30 ppb (Minn.-Wis. PCB Task Force 1976; Kleinert 1976).

Other Hydrocarbons Detected

PCB Aroclors 1242, 1254 and 1260 were the only chlorinated hydrocarbons quantified. DDE, a metabolite of DDT was identified in a few raccoon adipose samples and had a retention time of 4.2 minutes relative to the solvent peak. DDE was not quantified due to the low levels detected (<0.2 ppm) in a small portion of the samples.

A single peak with a retention time of 1.1 minutes was frequently observed (Fig. 6 and 8). No positive identification of the peak was made.

Extracts of aquatic organisms from site 4 contained an unknown hydrocarbon. This compound was only found in the aquatic organisms and not in the raccoons. The chromatogram tracings in Fig. 10 and 11 illustrate the region in which the unknown compound eluted on the chromatograph. It was characterized by 4-6 peaks eluting within 1.8 minutes of the solvent peak. Standard BHC (Hexachlorocyclohexane) is a mixture of isomers eluting in 1.8 minutes (Fig. 11), but identification by gas chromatography alone was inconclusive and mass spectral analysis would be necessary for positive identification.

IMPLICATIONS AND RECOMMENDATIONS

I do not think the PCB levels in raccoons near the Wisconsin River pose a threat to human consumption. The PCB's in adipose tissue are generally higher than in muscle tissue (Hashimeto et al. 1976; Matthews and Anderson 1975). Peterson et al. (1976) reported that in the absence of adipose tissue, muscle becomes the major storage depot. I suggest that samples from raccoon adipose and muscle tissue from other areas of the state known to be contaminated by PCB's be tested. The Wisconsin Department of Natural Resources should consider issuing precautionary measures to people eating raccoons taken near contaminated areas of the state. Removal of fat during preparation and cooking

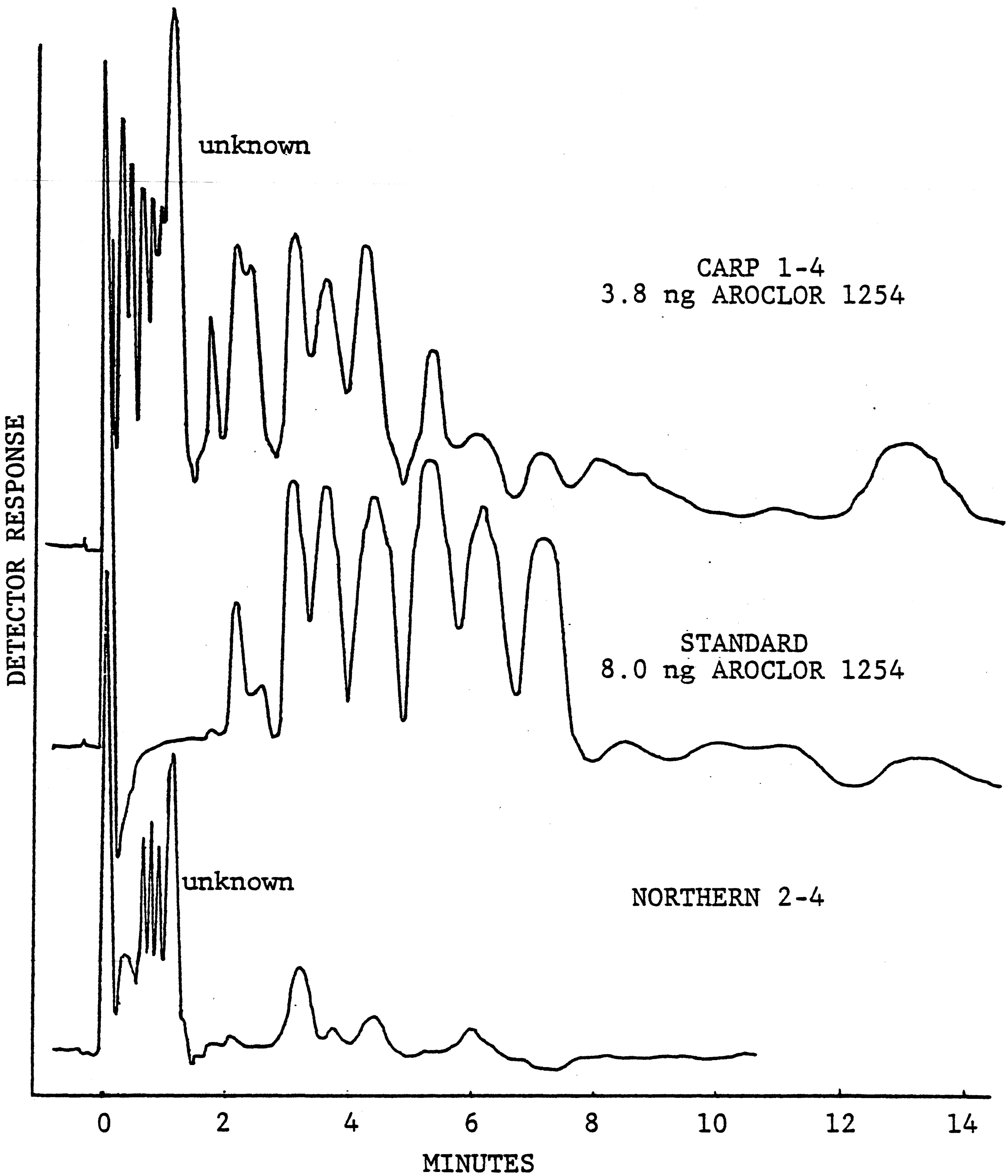

Fig. 10. GLC chromatograms showing the unknown present in fish extracts collected south of Nekoosa.

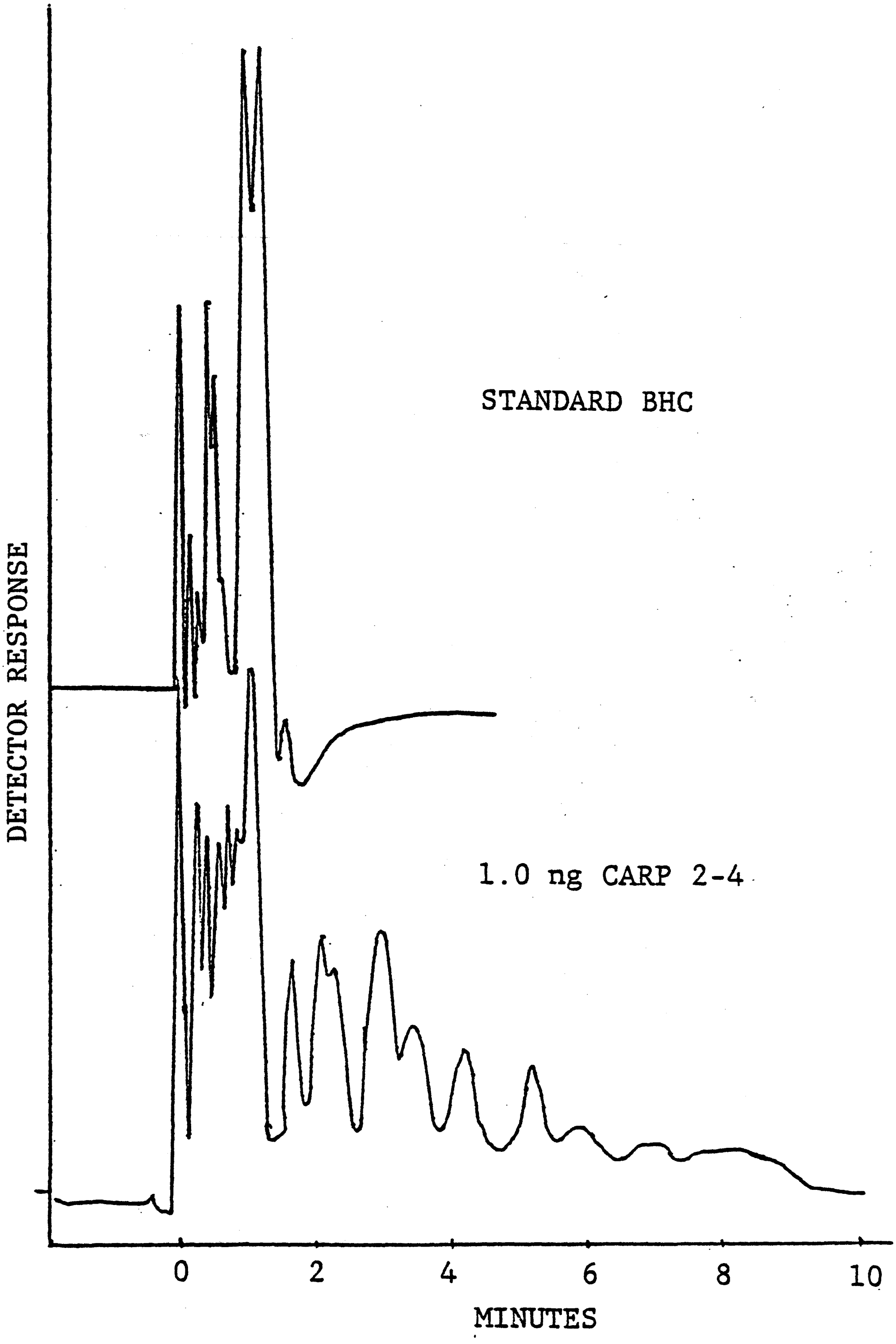

Fig. 11. GLC chromatograms of standard BHC and carp extract containing unknown compound.

will remove a large percentage of the PCB's in the animal.

Raccoon fur prices have steadily increased resulting in increased hunting and trapping pressure on the raccoon population. The possible stress induced by PCB contamination may adversely affect the raccoon population in areas where their food supply is contaminated. The effect of PCB's on raccoons is unknown but fetotoxicity and placental transfer in rabbits (Villeneuve et al. 1971; Grant et al. 1971), transplacental movement, low level and short term effects in monkeys (Allen et al. 1974a) and reproductive failure in mink (Aulerich and Ringer 1977; Platanow and Karstad 1973) have been related to PCB's.

Raccoons contain PCB's in their adipose tissue and the source can be linked to the Wisconsin River. Adults and juveniles contained similar PCB levels suggesting placented movement. Possible mortality and effects on reproduction in raccoons due to PCB's to my knowledge, has never been investigated. This research should be initiated to determine if current exposure levels are likely to affect the raccoon populations along the Wisconsin River.

SUMMARY AND CONCLUSIONS

1. Polychlorinated biphenyls are present in raccoons and aquatic organisms of the Wisconsin River. Residues of Aroclor 1254 and 1260 were found in 67 and 41 percent of the raccoon samples, respectively. Aroclor 1242 was not present in raccoons but was found in fish and clams.

2. Significantly different PCB concentrations ($P<0.01$) exist between the 9 sample sites. Site 3 was the most contaminated site for raccoons and fish. Raccoons captured greater than 8 kilometer's from the river contained only trace amounts of PCB's.
3. PCB levels did not differ significantly between males and females ($P<.05$) and there was no relationship between PCB levels and raccoon weight.
4. Aroclor 1254 levels in raccoons decreased toward late summer ($P<0.38$) but 1260 did not decrease. The decrease may be due to a change in food habits.
5. Aroclor 1242 was found in clams and fish below Lake DuBay but were absent in raccoon adipose tissue. Raccoons may be capable of metabolizing lower chlorinated PCB isomers.
6. DDE, a metabolite of DDT, was detected at low levels (<0.20 ppm) in a small number of raccoon samples. No other hydrocarbons were identified.

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APPENDIX A. Instructions given to hunter's and trapper's for submitting raccoon samples.

RACCOON RESEARCH PROJECT-U.W.S.P.

Study Title: Incidence of polychlorinated biphenyls (PCBs) and other chlorinated hydrocarbon insecticides in raccoons.

Introduction

Polychlorinated biphenyls (PCBs), are industrial chemicals very similar in their biological action to DDT. They are known to be widespread throughout the environment and may pose a threat to many wildlife species. Samples of mamals and fish at the top of the aquatic food chain should be analyzed for PCBs since there is a great possibility that residues found in these specimens could easily enter the human food chain.

Study Area

The study area is from Wausau to the Petenwell Dam along the Wisconsin River and includes the counties of Marathon, Portage, Wood, Adams and Juneau.

What is needed from hunters and trappers:

Cooperation from area hunters and trappers in the counties listed above is important for the completion of the research. I need rear flank fat samples for analysis from raccoons in the five county area. I am especially interested in receiving fat samples and information on the 48 raccoons which were trapped, tagged and released this summer in the study area.

Instructions for submitting fat samples:

1) When a raccoon has been captured fill out the information card supplied with the sample bag. Leave any unsure information blank.

2) Immediately after skinning the animal cut a small portion of fat about the size of a walnut off the carcass and if possible include a small of muscle tissue from the same area.

3) Place the sample and information card for that animal in a plastic bag and freeze immediately.

4) If an ear tagged raccoon is found, place the ear tag along in the sample bag.

Appendix A. (continued)

5) After the season I will contact you and make arrangements to pick-up samples.

Any questions contact:

Michael Knuth
1016 Edgewood Avenue
Stevens Point, WI 54481
341-2993

your cooperation is greatly appreciated.

Appendix B. PCB residues in raccoon adipose tissue samples collected from 9 sites in central Wisconsin, 1976-1977.

Sample No.	Sex	Weight (kg)	% Lipid	PCB Residue - ppm[1/] 1254	PCB Residue - ppm[1/] 1260
		S I T E BR			
R15	F	7.7		0.81	ND
R16	M	4.1		0.85	0.17
R17	F	4.5		0.68	0.10
R18	M	4.3		0.61	0.17
R19	F	5.4		0.49	ND
R21	M	4.3		2.39	0.37
R22	M	9.5		1.03	0.24
R23	M	3.6		T	0.18
R24	M	4.1		2.01	0.38
R124	F	10.0	64	T	ND
R125	M	5.0	42	0.96	ND
		S I T E 1			
R30-1	M	7.7		4.75	0.47
R33-1	M	5.9		1.23	T
R57-1	M	6.8	66	1.84	0.34
R58-1	F	5.9	63	4.26	1.11
R59-1	M	9.5	60	5.35	0.47
R60-1	M	5.7	58	1.39	0.18
R61-1	F	1.6	76	3.43	1.49
		S I T E 2			
R29-2	F	7.7		ND	ND
R34-2	M	6.1		2.18	0.14
R35-2	M	5.4		T	ND
R36-2	F	5.4		1.18	6.19
R37-2	-	-		2.52	0.16
R38-2	-	4.5		3.49	0.59
R62-2	M	5.9	37	T	ND
R63-2	M	6.6	61	T	ND
		S I T E 3			
R39-3	M	7.2		6.93	1.53
R40-3	F	5.0		5.80	2.11
R41-3	M	1.8		19.51	3.25
R42-3	F	5.0		21.00	4.31
R68-3	M	1.8		1.92	1.38

Appendix B. (continued)

Sample No.	Sex	Weight (kg)	% Lipid	PCB Residue - ppm 1254	PCB Residue - ppm 1260
		SITE 4			
R43-4	M	5.2		3.10	5.01
R44-4	M	7.9		6.29	0.93
R45-4	F	4.5		2.73	0.45
R46-4	M	6.6		0.73	ND
R47-4	F	5.0		2.42	0.52
R48-4	F	4.5		2.22	0.84
R49-4	M	6.8		1.30	0.22
R50-4	F	5.2		T	ND
R51-4	F	4.5		1.03	0.19
R69-4	M	2.5	56	3.77	0.58
R70-4	F	2.3	52	1.73	0.63
R71-4	F	7.2	65	0.49	0.15
R72-4	F	2.5	64	1.84	0.49
R74-4	M	2.0		0.72	0.44
R75-4	F	5.0		0.77	0.18
R73-4	F	1.8		0.71	0.23
		SITE 5			
R53-5	M	4.8		0.57	ND
R54-5	F	5.7	63	2.18	0.87
R55-5	M	5.0	41	5.14	1.55
R56-5	M	5.0		3.07	0.83
R94	-	-	58	3.46	0.36
R95	M	8.2	65	2.35	0.15
		SITE PL			
R126	-	7.2	67	0.29	T
R127	M	10.4	68	ND	ND
R128	F	9.1	59	T	ND
R129	F	4.5	66	T	ND
R130	F	9.1	61	T	ND
R131	M	4.5	60	ND	ND
R132	M	5.4	67	T	ND
R133	-	-	62	ND	ND
		SITE PC			
R110	M	4.1	67	ND	ND
R111	M	10.4	68	ND	ND
R112	F	8.2	65	ND	ND
R113	F	4.1	58	ND	ND

Appendix B. (continued)

Sample No.	Sex	Weight (kg)	% Lipid	PCB Residue - ppm 1254	1260
R114	F	9.1	64	ND	ND
R115	M	11.8	67	ND	ND
R117	F	4.1	65	T	ND
R119	F	9.1	67	ND	ND
R120	M	4.5	69	ND	ND
R121	M	5.4	66	ND	ND
R122	F	4.1	72	ND	ND
R123	F	3.6	72	ND	ND
		SITE WC			
R102	F	7.2	75	ND	ND
R103	F	8.2	67	ND	ND
R104	M	9.5	66	ND	ND
R105	M	9.1	81	ND	ND
R106	F	9.5	77	ND	ND
R107	M	7.2	70	ND	ND
R108	M	8.2	71	T	ND
R109	M	14.1	71	ND	ND
		NO SPECIFIC SAMPLE SITE2/			
R3*	F	6.1		ND	ND
R4*	M	6.4		ND	ND
R31*	M	7.0		0.78	T
R32*	F	7.9		2.55	0.84
R76*	F	9.5	70	ND	ND
R78*	F	10.0	58	ND	ND
R82*	M	6.8	71	ND	ND
R83*	F	9.1	64	ND	ND
R85*	F	7.2	57	0.22	ND
R88	F	8.2	73	ND	ND
R89	M	10.9	68	ND	ND
R90	F	3.6	67	ND	ND
R91	M	5.4	66	T	ND
R99	F	4.5	66	ND	ND
R100	F	7.7	66	ND	ND
R116	M	11.3	63	ND	ND
R118	M	11.3	65	ND	ND

1/ ND - not detected, lower limit of sensitivity - 1254 = .10 ppm 1260 = .05 ppm. T - Trace amount - 1254 = .10-.20 ppm 1260 = .05-.10 ppm.

2/ * means sample was collected within 5 miles of Wisconsin River.

Appendix C. PCB residues in fish and clams collected at sites 1-5 on the Wisconsin River, 1977.

Sample No.[1/]	Length (cm)	Weight (g)	PCB Residue - ppm[2/]		
			1242	1254	1260
S I T E 1					
Carp 2-1	--	4540	0.83	ND	ND
Carp 3-1	60.9	2951	3.32	ND	ND
N 2-1	50.8	725	0.39	ND	ND
N 3-1	43.2	420	0.59	ND	ND
N 1-1	69.8	2000	0.44	ND	ND
S I T E 2					
Carp 6-2	41.9	1135	0.29	ND	ND
Carp 5-2	55.9	2497	1.49	ND	ND
Carp 1-2	--	--	0.98	ND	ND
Carp 3-2	54.6	2610	1.06	ND	ND
N 1-2	27.5	130	0.05	ND	ND
N 4-2	53	800	0.05	ND	ND
N 5-2	53	1000	0.17	ND	ND
N 2-2	29	162	0.04	ND	ND
B 3-2	--	--	0.52	ND	ND
B 4-2	19.7	131	0.48	ND	ND
B 5-2	20.9	142	0.33	ND	ND
B 6-2	19.7	127.5	0.11	ND	ND
Clam 1-2	--	75.8	0.06	ND	ND
Clam 2-2	--	54.9	0.08	ND	ND
Clam 3-2	--	43.3	0.04	ND	ND
Clam 4-2	--	85.3	0.05	ND	ND
S I T E 3					
Carp 1-3	58	2500	ND	0.90	0.02
Carp 2-3	55	2400	ND	0.91	0.04
N 1-3	61.1	1200	ND	0.26	T
B 3-3	23.5	170	ND	0.13	ND
B 4-3	25.5	242	ND	0.30	0.20
B 5-3	28.2	299	ND	0.02	ND
Clam 3-3	--	86.4	ND	ND	ND
Clam 4-3	--	62.9	ND	ND	ND
Clam 5-3	--	56.2	ND	ND	ND
Clam 6-3	--	151.8	ND	ND	ND
S I T E 4					
Carp 3-4	39	964	ND	0.05	ND
Carp 2-4	43	1201	ND	0.04	ND

Appendix C. (continued)

Sample No.	Length (cm)	Weight (g)	PCB Residue - ppm		
			1242	1254	1260
Carp 4-4	35	672	ND	0.33	ND
N 2-4	63	1686	ND	T	ND
N 1-4	56	1068	ND	0.15	0.02
N 4-4	39	323	ND	0.07	T
B 1-4	20	138	ND	0.21	ND
B 4-4	31	442	ND	0.04	ND
B 3-4	25.5	184	ND	0.07	ND
N 2-4	23	274	ND	0.15	ND
Clam 1-4	--	11.3	--	--	--
Clam 2-4	--	12.2	--	--	--
Clam 3-4	--	25.2	--	--	--
Clam 4-4	--	9.5	--	--	--
		SITE 5			
Carp 2-5	67	3691	ND	2.08	0.11
Carp 1-5	37	628	ND	0.30	T
Carp 3-5	38	658	ND	0.28	T

1/ Sample designation, N - Northern Pike, B - Bullhead.

2/ Detection Limit = .005 ppm, T - Trace = .005-.10 ppm

ND - Not detected