

TRANSLOCATION MECHANISMS

OF PCB'S

IN FRESH WATER:

A FIELD STUDY

MONS 050304

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INTRODUCTION

PCB's are a class of aromatic, chemically inert, nonflammable chlorinated hydrocarbons. They possess high dielectric constants, low points of volatility, are not hydrolyzed by water, and resist alkalies, acids and other corrosive chemicals (Peakall, 1970). Their boiling points range from 328°C for Aroclor 1221 to 415°C for Aroclor 1268. All PCB's are stable at 150°C. The lower chlorinated compounds are more soluble in water than the more highly chlorinated ones and are preferentially distilled at atmospheric pressure without appreciable decomposition (Hutzinger, 1974; Fanel, 1972). Fagnano and Wheeler (cited in Fanel, 1972) found that the solubilities of Aroclors 1242, 1248, 1254, 1260 and 1016 are 200 ppb, 100 ppb, 50 ppb, 25 ppb and 250 ppb, respectively. However, the true solubility is difficult to determine accurately, and these values may be subject to change. PCB's are very soluble in lipids, but the solubilities are not known.

Since their synthesis in 1881 and manufacture in 1930, thousands of tons of PCB's have escaped into our waterways. Upon entering streams and shallow lakes, PCB's are adsorbed to the sediment and onto particulate matter (Choi, 1976).

found that the chlorinated hydrocarbon concentration in sediment is closely related to both organic content and particle size. It has a great affinity for particles 8 μ m or less which is in the silt-clay range. Experimental evidence shows that the total organic carbon as well as humic and fluvic acid content in sediment bears a linear relationship to the chlorinated hydrocarbon concentration, and the amount of organic material in surficial sediments is directly proportional to the clay size fraction. Fine silts and clays are closely associated with humic substances; they exist as organoclay complexes and have a high adsorptive capacity for PCB's. There is some environmental verification for the above experimental findings. PCB's were found associated with the top 2-3 cm in Escambia Bay, Florida (Duke, 1970). PCB's were also concentrated in the top 2-3 cm, but occurred commonly at 6-12 cm in the sediment of southern Lake Michigan and the highest concentrations were found associated with small particles (2 μ m) and high organic content (Ireland, 1972).

Once PCB's have adsorbed to sediments, there is little leaching (Haque, 1976). PCB's are probably transported on the suspended solids. Due to its low solubility, the transport of soluble PCB is probably negligible. Due to these properties, high concentrations of PCB's are usually found near points of discharge. There has been, however, little environmental documentation of the movement of PCB's through a system from a

point source or of the half-life of PCB's in a given system. The sediment of Escambia Bay was shown to have lost much of its contamination within 9 months of the initial finding of the pollutant. Munson et al., (1976) showed that areas of high-est contamination in the upper Chesapeake Bay may have con-formed to the currents from the initial point source.

PCB's in the water, suspended solids and sediments are available for bioaccumulation by means of direct ingestion and/ or absorption through the general integument and across the gills. The main route of entry is difficult to ascertain.

1. Uptake of Soluble PCB's: Many have investigated the bioconcentration of soluble PCB. It has been demonstrated in laboratory experiments that both invertebrates and fish can accumulate PCB's to levels of 10^3 to 10^5 times the levels in the ambient water (Federal Reg., 1977). In view of the low solubility and high adsorptive capacity, the uptake of soluble PCB's by plankton and invertebrates may be a pro-cess involving the initial adsorption followed by ^badsorption into the cell (Sodergren, 1973).

Tetrahymena pyriformis, a ciliated protozoan, accumulated Aroclor 1254 to 60 times the dosed water level or 167.9ppb Aroclor 1254 (dry weight) when exposed to 10ppb for 7 days (Cooley, 1972). Environmental plankton samples taken from the Atlantic Ocean by Risetrough containing median dry and wet weight concentrations on the order of 10^0 and 0.2×10^0 , respec-

tively and phytoplankton rich samples taken by Harvey with a mean of $2 \mu\text{ppm}$, wet weight, confirm that uptake of PCB's in the environment does occur and to a greater degree than seen in experimental results. Urey showed that both tetrachloro- and hexachlorobiphenyl were concentrated by dead Chlorella cells by 6,000 and 15,000 times the water concentration, respectively. These amounts were greater than in his experiments with living cells, which seems to indicate that the concentration of PCB by Chlorella may be a result of a simple chemical partition between the water and the lipid in the cells.

The short term exposure of invertebrates to Aroclor 1254 resulted in the bioaccumulation of 160 to 6,300 times the ambient water concentrations (Walker, 1976). This factor is even greater after long term exposure. Cysters exposed to 5 ppb Aroclor 1254 for 24 weeks accumulated 425 ppm or 85,000 times the water concentration (Lowe, 1972). In 14 day exposures, Cancerus fasciatus concentrated Aroclor 1254 to 27,000 times the water level ($1.6 \mu\text{g}/\text{l}$) and Daphnia concentrated Aroclor 1248 to 48,000 times the nominal water concentration of $30 \mu\text{g}/\text{l}$ (Nebeker, 1974). The initial bioaccumulation of PCB by invertebrates is rapid and appears to reach a steady state after the first week of exposure (Walker, 1975).

The adsorption of PCB's to, and the absorption across the general integument and through the gills of shrimp, have been cited as possible mechanisms of invertebrate uptake of soluble PCB's (Khan, 1976; Nisino, 1971, 1974).

Fish also exhibit a rapid initial uptake of PCB followed by a gradual decrease in the rate until a steady state is approached (Fed. Reg., 1977; Hansen, 1971; Reiser, 1976). The quick initial uptake was demonstrated by Hansen's experiments with (Leiostomus xanthurus) in which spot accumulated 3.7×10^4 times the ambient water level in 14 to 28 days. Long term studies with fathead minnows (Pimephales promelas) showed that residues were 2 to 4 times higher after 9 months than they were in fish sampled after 30 days (Hecker, 1975; Fed. Reg., 1977; Yelth, 1970). In 30 day exposures, channel catfish (Ictalurus punctatus) concentrated DDTs 1248 and 1254 to 56,250 and 61,130 times the concentration in the water, respectively, with the more chlorinated compounds accumulating more than the less chlorinated ones (Hansen, 1976). The uptake of soluble PCB's may be due to the permeability of the fish body or gill surface and its ability to partition PCB directly from the water. Chlorinated hydrocarbons have very high partition coefficients, that is, they are much more soluble in lipid than in water. Those more highly chlorinated PCB's have higher partition coefficients than the lower chlorinated ones. The higher the partition coefficient, the greater the ability to

bioaccumulate (Reinert, 1970). This uptake mechanism has been postulated to be a major pathway of PCB entry into fresh water fish (Sodergren, 1973). It can result in high accumulation in a very short period of time. ^(CITED IN REINERT, 1970) Frendas and Anderson found that after a 5 minute exposure to $1 \mu\text{M}$ C^{14} -labeled PCB, Atlantic Salmon concentrated $1.56 \mu\text{M}$ in the liver and spleen. After one hour of exposure this value reached $3 \mu\text{M}$.

2. Bioconcentration of PCB's from Suspended Solids: In view of the high adsorptive capacity of PCB's to small particles and organic substances, suspended solids may also be a major source of PCB's to organisms. There are, however, no laboratory experiments to confirm their involvement and the field data ^{has} given conflicting evidence.

A Chesapeake Bay study by Munson (1975) showed that the PCB concentration in suspended solids and sediment samples varied greatly from station to station in the same collecting period and in the same station at different collecting periods. In general, those water samples with high suspended solids also had high PCB concentrations which usually resembled Aroclor 1254 and 1262 with some Aroclor 1248 and 1248. The concentration $\times$ in the suspended solids (dry weight) were 4 to 10 times higher than in the sediment (dry weight). Munson theorized that this was probably because the average

Grain size in the suspended solids is much smaller than the bottom sediment and also because phytoplankton was included in the suspended solids samples. Munson estimated from his data that PCB's are bioconcentrated in passing from suspended solids to zooplankton by a factor of 5.4 and in passing from suspended solids and plankton to shellfish by a factor of 4,000. This estimate, however, did not take into account any concentration of soluble PCB that may have occurred.

Data on a system involving the Mississippi River and a lake fed by it show higher PCB levels in fish from areas of higher turbidity suggesting that suspended solids may play a role in the bioaccumulation of PCB by fish (Buck, 1970). In a similar study area in Michigan, however, Tolin (1970) found the opposite results. Lab^{4, 5} experiments need to be done to determine the bioconcentration factors of organisms in relation to suspended solids, as suspended solids are a very important vehicle for PCB distribution.

3. Uptake of PCB from the Sediment: Sediment serves as a sink for PCB accumulation. In general, PCB levels are higher in the biota than in the sediments, as confirmed by both laboratory and field data. (Munson 1969) ^(Munson 1969) Mimeo-exposed pink shrimp and fiddler crabs to various concentrations of Aroclor 1254 on silt. Up-

take was directly related to the amount in the sediment. The hepatopancrease of shrimp and fiddler crabs exposed to sediment containing 61^{ppm} PCB for 30 days had an average of 240^{ppm} and 80^{ppm}, respectively, resulting in bioconcentration factors of 4 and 1.3, respectively (Nimmo, 1971). Caged shrimp () in Escambia Bay, Florida, exposed to its contaminated sediments also accumulated PCB's, however, their accumulation appeared to reach a plateau which was not demonstrated in the lab^(Nimmo, 1971). Field data from Escambia Bay showing that burrowing shrimp contain higher residue levels than non-burrowing ones, and samples collected from the Milwaukee River and other areas where organisms collected from stations of high residue levels in the sediment had higher concentrations than those found in other areas, confirm that sediment plays a large role in mediating PCB's. The accumulation of PCB's from the sediments may be due either to contact and absorption through the skin and gills, or by ingestion.

4. Uptake of PCB's from Food: Food is of major importance in the bioaccumulation of PCB's. Channel catfish exposed to 2^{ppm} Aroclor 1242 in food for 252 days accumulated PCB's exponentially with exposure time and remained relatively constant during periods of PCB-free feed after 84 days of exposure (Jensen, 1976). Coho salmon fed Aroclor 1254 for 240 days at concentrations of 10.5 to 14,500 ug/kg body weight per day accumulated 0.2 to 5 times the exposure levels on a whole body weight basis, the highest level reached being

300ppm (Stalling, 1972).

Laboratory experiments seem to point to direct uptake of soluble PCB's from water as the major route of entry into organisms. However, food exposure may pose the biggest threat in the environment. Although the bioaccumulation factors are lower for food exposure, the greater dosage in food (both in the environment and lab^{oratory} experiments) leads to equally high or higher concentrations in the exposed organisms, and does not appear to reach a steady state condition in the uptake of soluble PCB's. Also, the PCB's which organisms are exposed to in the water are generally those of low chlorination (higher solubility). In contrast, the bioaccumulation of PCB's from food are generally those higher chlorinated PCB's which have a higher partition coefficient, are more difficult to metabolize, and therefore, have a higher potential for bioaccumulation in the food chain.

Evidence for food chain relationships in bioaccumulation have been found in the environment. PCB residues in fish have been directly related to their feeding habits and lipid content. Carp in the Mississippi River contained 4 to 5 times the level of their food organism, the may fly (Bauk, 1977). Similar trends involving mussels up through fish, mammals and birds have also been found (Eberhardt, 1975; Wilson, 1970; Peakall, 1970).

Others have found that bioconcentration does occur, but that the residue levels of organisms in the trophic pyramid have no relationship (Harvey, 1973). Birchbrough found that plankton eating fish in the Atlantic Ocean had higher concentrations than those occupying higher trophic levels. Jiam found that plankton had residue levels an order of magnitude higher than the planktivores, flying fish (cited in Birchbrough, 1972). Munson (1975) and Fowler (1978) also found evidence against the food chain relationship.

These inconsistent results are due to a combination of both the availability and retention of PCB's. The availability of PCB's to each organism is influenced by such things as size, geomorphology, flow and turbidity of the water system, in conjunction with each organism's home range, feeding habits and behavior patterns, as previously discussed. The retention of PCB's is a result of the storage and metabolic capabilities of the organism. Also, much of the above data has been accumulated in the laboratory and/or assumptions have been based on analyses of pooled data collected in many parts of the world. Therefore, the modes of entry of PCB's into aquatic organisms have been vague and the relative importance of each mode of entry has not yet been ascertained.

After uptake, PCB's are stored in the lipid. This fact introduces many variables. The effect of lipids on the concentration of PCB's found in fish may be the cause of the variation seen in concentrations with other factors such as weight and season within species, and the variation of residue levels between species. It has been suggested that PCB concentration increases with size, age or weight. Bache et al., (1972) found that PCB concentration correlated significantly to age, length and weight of trout [^]from Cayuga Lake. PCB concentrations were noted to be more variable among older fish than younger. By contrast, ~~Knobler et al.~~ ⁽¹⁹⁷⁶⁾ found that PCB's in the muscle of squid (Loligo forbesi) tended to decrease in concentration with increased body weight. Olson et al., (1973) reported no correlation of PCB levels in muscle of Esox lucius to age or weight using either wet or lipid weight basis. Ther^e [^]are, therefore, no generalizations which can be made on this weight-pgm subject. However, from these contradictory results, it is clear that the lipid - weight theory, based on

the partitioning of PCB directly from the water, is not the only contributing factor for increases or decreases in PCB concentration with weight.

The possibility of uptake rates being different in teleosts of different ages or sizes, but of the same species, may also be a contributing factor to the variability of residues of fish. ^(water) Lab studies have shown that the uptake of C^{14} DDT was much faster by smaller fish than larger. This uptake rate difference may be related to their different metabolic rates. *(Murphy & Murphy, 1971, & in Sullivan, 1978)*

PCB's have not only been shown to vary with size and species of fish, ^(water) some have also found that there are seasonal differences in PCB concentration. This may be due to a difference in the lipid metabolism of fish of different size with season, or a shift in lipid content due to spawning or environmental stress.

The differences in PCB content in fish in the environment are probably related to all of the above factors, and thus they must be sorted out to determine which are the major factors in PCB accumulation.

This study was undertaken to determine the contamination of a river-reservoir system with distance from a point source of contamination as reflected by the residue levels in fish; to determine the half-life of PCB in this

system; to determine whether a wet weight-PCB correlation exists either on a weight-ppm or log-log basis and whether there are seasonal effects on these relationships; to determine whether there are species differences in PCB concentration; to correlate these differences with feeding habits, abiotic parameters and lipid content, thereby determining the major route of entry to fish; and to ~~compare~~ the sample chromatograms to determine whether there are great metabolic differences between the fish that may account for species differences in PCB concentration.

I. COLLECTION AND ANALYTICAL PROBLEMS

All species of fish were not ^{available for collection} ~~collected~~ at all stations and seasons. Therefore, there is a very small number of samples in some cases. This limited both the statistical applications ^{of} ~~to~~ the data and the statistical significance of many of the results.

In the laboratory ^{for} the fall and winter samples were hexane extracted 2 times and the spring and summer samples were ^{percent} ~~ex-~~tracted 3 times (see methods). It was thought that the [^]recovery of each method may cause some problems in the comparability of the species and seasons. Table 1 gives the percent recovery from the 2-wash and 3-wash methods in fish from the spring collection. ~~It appears that the~~ It appears that the first 2 washes resulted in high recovery rates (70-98%) in most cases. The lowest percent recoveries were samples of Sunfish (Lepomis) and those fish of very low PCB content. There is no consistent recovery level, either as related to station, species or size of the sample and, therefore, no correction factor for lack of recovery has been used in the data. The differences in recovery between the seasons do not appear to affect the relationship within or between species, stations or seasons. For example, in many cases those fish collected

in the fall and winter have the highest residue levels and the accumulation by each species relative to the others is consistent throughout the year, i.e. Lepomis generally accumulates PCB to lower levels than other fish in all seasons. It must, however, be kept in mind when comparing PCB concentrations on a seasonal basis, that the fall and winter levels may be slightly low.

Reduction of DDE suspected peak: Sample #293 a sample of Lepomis megalotis from station 1, spring collection (Figure 1). shows great height in a peak which may be DDE or some other substance aside from PCB. This large peak occurs almost exclusively at Station 1, a control station next to an agricultural and cattle field. After analyzing many samples from other stations and comparing them to the standards, it was found that the PCB peak (98-104) which is overlapped by DDE usually constitutes from 20-30% of the Aroclor 1254 measured. Therefore, to reduce the bias in the station 1 samples, this peak was reduced to 25% of the Aroclor 1254 measured in all samples where it was found to be higher than that. The residual was thought to be DDE. All samples which had this reduction are marked in the data sheets presented in Appendix A. An example of the calculations is presented in the section on analytical methods.

Table 1

Hexane Extraction RecoverySample 392, Station 3, Phenocobius ⁴sp., 5 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	19.04	2.04	21.09	90
ppm Aroclor 1254	47.74	4.82	52.57	90.8
ppm Aroclor 1260	14.71	0.16	14.87	99
ppm Total PCB	65.42	7.03	72.45	90.3

Sample 393, Station 3, Phenocobius ⁴sp., 4.1 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	3.66	0.30	3.96	92
ppm Aroclor 1254	9.84	0.73	10.58	93
ppm Aroclor 1260	6.72	0.24	6.96	96
ppm Total PCB	20.22	1.28	21.51	94

Sample 394, Station 3, Phenocobius ⁴sp., 0.68 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	7.75	0.71	8.52	90.9
ppm Aroclor 1254	12.09	0.82	12.92	93
ppm Aroclor 1260	3.19	0.16	3.35	95
ppm Total PCB	23.04	1.70	24.75	93

Sample 414, Station 5, Finerhales ⁴sp., 0.5 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	0.09	0.05	0.14	65
ppm Aroclor 1254	0.24	0.20	0.44	54
ppm Aroclor 1260	0.13	0.02	0.15	86
ppm Total PCB	1.11	0.27	1.39	80

Table 1
(continued)

Sample 422, Station 5, Dorosoma cepedianum, 4.7 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	0.11	0.02	0.13	83
ppm Aroclor 1254	0.55	0.06	0.62	89
ppm Aroclor 1260	0.04	0.00	0.04	90
ppm Total PCB	0.71	0.09	0.80	88.6

Sample 507, Station 2, Lepomis sp., 4 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	14.49	7.10	21.60	67
ppm Aroclor 1254	14.37	4.58	18.95	75.8
ppm Aroclor 1260	4.91	0.57	5.49	89
ppm Total PCB	33.78	12.27	46.05	73

Sample 532, Station 7, Lepomis sp., 7 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	0.31	0.54	0.85	36
ppm Aroclor 1254	0.99	0.78	1.78	55
ppm Aroclor 1260	0.27	0.14	0.42	65
ppm Total PCB	1.58	1.48	3.06	51.6

Sample 192, Station 2, Lepomis sp., 14 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	1.86	2.78	4.64	40
ppm Aroclor 1254	4.47	2.39	6.87	65
ppm Aroclor 1260	5.77	0.36	6.14	94
ppm Total PCB	12.11	5.54	17.65	68

Table 1
(continued)

Sample 401, Station 8, Roccus sp., 12 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	0.06	0.03	0.09	64
ppm Aroclor 1254	0.34	0.10	0.45	76
ppm Aroclor 1260	0.05	0.02	0.08	72
ppm Total PCB	0.47	0.16	0.63	74

Sample 493, Station 2, Notropis sp., 1.4 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	21.33	6.10	27.44	77.7
ppm Aroclor 1254	24.43	4.88	29.32	83
ppm Aroclor 1260	9.58	0.63	10.22	93.7
ppm Total PCB	55.36	11.63	66.99	82.6

Sample 494, Station 2, Notropis sp., 1.4 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	13.67	3.72	17.40	78.5
ppm Aroclor 1254	15.24	3.04	18.29	83
ppm Aroclor 1260	7.82	0.38	8.20	95
ppm Total PCB	36.74	7.16	43.91	83.6

Sample 497, Station 2, Leucis sp., 13 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	9.39	4.84	14.24	65
ppm Aroclor 1254	7.48	2.50	9.99	74.9
ppm Aroclor 1260	3.10	0.15	3.26	95
ppm Total PCB	19.99	7.51	27.50	72.7

Table 1
(continued)

Sample 498, Station 2, Lernaea sp., .19 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	4.33	1.51	5.84	74
ppm Aroclor 1254	4.65	1.02	5.67	81.9
ppm Aroclor 1260	1.22	0.21	1.44	85
ppm Total PCB	10.21	2.75	12.96	78.7

Sample 499, Station 2, Gentusia affinis, .7 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	10.47	3.62	14.10	74
ppm Aroclor 1254	10.71	1.81	12.53	85.5
ppm Aroclor 1260	2.26	0.41	2.67	84.6
ppm Total PCB	23.45	5.85	29.31	80

Sample 502, Station 2, Notropis sp., 18 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	6.03	2.63	8.67	69
ppm Aroclor 1254	14.16	7.35	21.51	65.8
ppm Aroclor 1260	10.75	1.49	12.24	87.8
ppm Total PCB	30.95	11.47	42.42	72.9

Sample 428, Station 4, Dorosoma cepedianum, 2.7 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	2.25	0.24	2.50	90
ppm Aroclor 1254	2.92	0.20	3.13	93
ppm Aroclor 1260	0.82	0.03	0.85	96
ppm Total PCB	6.01	0.48	6.49	92.6

Table 1
(continued)

Sample 429, Station 4, Dorosoma cecedianum, 3.8 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	1.93	0.18	2.11	91
ppm Aroclor 1254	2.53	0.15	2.68	94
ppm Aroclor 1260	0.71	0.02	0.73	97
ppm Total PCB	5.17	0.35	5.53	93.6

Sample 475, Station 6, Micropterus sp., 7.9 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	0.41	0.08	0.49	83.6
ppm Aroclor 1254	1.98	0.34	2.32	85
ppm Aroclor 1260	0.46	0.04	0.51	90
ppm Total PCB	2.86	0.47	3.34	85.8

Sample 478, Station 6, Micropterus sp., 2.7 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	0.33	0.10	0.43	76.8
ppm Aroclor 1254	1.35	0.33	1.69	80
ppm Aroclor 1260	0.33	0.03	0.37	89
ppm Total PCB	2.02	0.47	2.50	80.8

Sample 480, Station 6, Micropterus sp., 3.3 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	0.26	0.05	0.32	84
ppm Aroclor 1254	1.34	0.18	1.52	88
ppm Aroclor 1260	0.24	0.02	0.27	90
ppm Total PCB	1.85	0.25	2.11	87.7

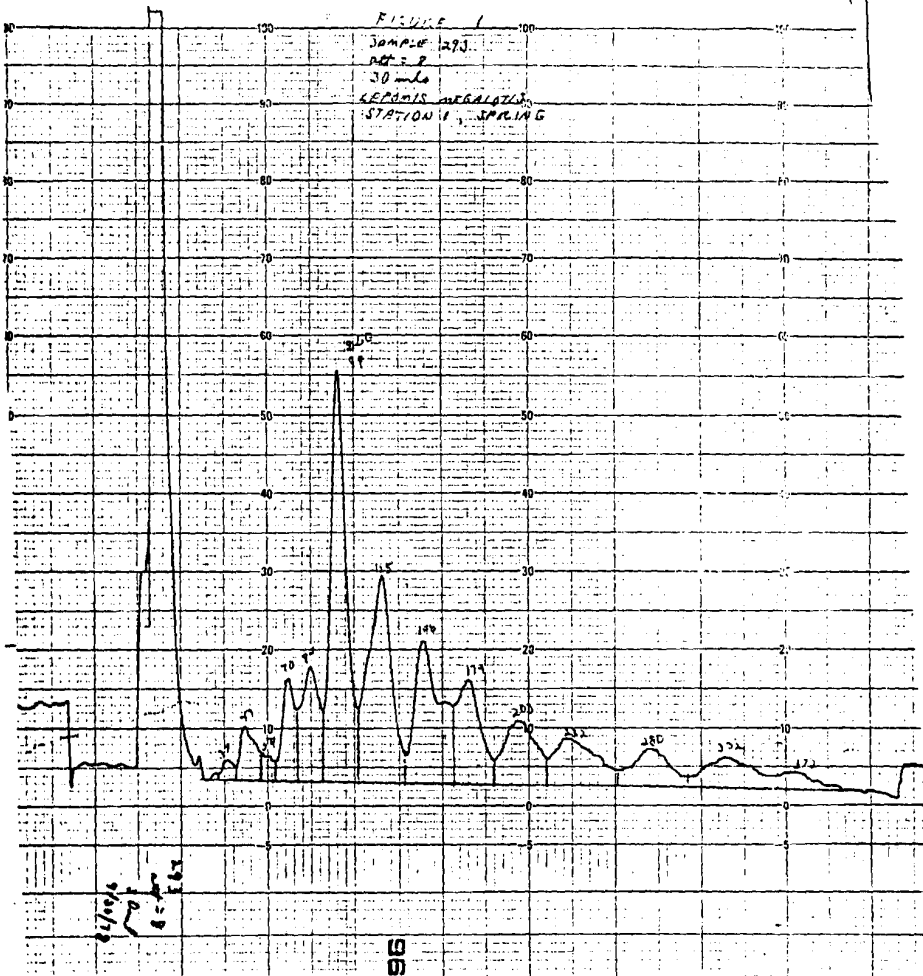
Table 1
(continued)

Sample 489, Station 2, Phenocobius sp., 1.0 grams

	<u>First 2 washes</u>	<u>3rd wash</u>	<u>Total</u>	<u>% Recovered in First 2 washes</u>
ppm Aroclor 1242	21.09	3.37	24.47	86
ppm Aroclor 1254	14.01	1.44	15.46	90
ppm Aroclor 1260	4.30	0.11	4.42	97
ppm Total PCB	39.41	4.93	44.35	88.8

Figure 1

SAMPLE 29J
 ALT = 2
 30 mls
 LEPTONIS MEGALOTIS
 STATION 1 SPRING



II. IN-FIELD STUDY OF PCB CONTAMINATION

It has been established that PCB's are very hazardous to aquatic organisms. Attempts to characterize PCB behavior in the aquatic systems by comparison of data by different investigators, collected at different locations and times of the year and taken from areas of unconfined, ill-defined contamination (oceans and lakes) have led to only partial success. The study of many components of a more well defined area, such as this segment of stream and reservoir, previously heavily contaminated by PCB from a known point source, should lead to more conclusive results.

A. Methodology:

A stream-reservoir system in Anniston, Alabama was chosen for this study. This site was the location of a major manufacturer of PCB's which results in high quantities of release into the stream. The study area is approximately 50 miles long including a 51 mile section of Choccolocco Creek and a 30 mile section of the Coosa River and Logan Martin Lake.(see Figure 2).

The collecting sites were as follows:

- Station 1: Choccolocco Creek, Highway 9 bridge crossing (control)
- Station 2: Choccolocco Creek, Highway 109 bridge crossing
- Station 3: Cheaha Creek, Highway 109 bridge crossing
- Station 4: Choccolocco Creek, Highway 77 bridge crossing
- Station 5: Coosa River, Highway 72 bridge crossing (control)
- Station 6: Coosa River, Stemely Bridge, Logan Martin Reservoir
- Station 7: Logan Martin Reservoir, above Logan Martin Dam
- Station 8: Logan Martin Reservoir, below Logan Martin Reservoir
- Station 9: Choccolocco Creek, Highway 109 bridge crossing
- Station 10: Choccolocco Creek, Highway 63 bridge crossing
- Station 11: Mouth of Choccolocco creek
- Station 12: Coosa River, Just below the mouth of Poorhouse Creek

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Station 13: Logan Martin Reservoir, 3 miles south of Highway 34 bridge

Station 14: Logan Martin Reservoir, 6 miles south of Highway 34 bridge

This was a one year survey with quarterly fish samples taken from Stations 1 to 8 and one summer collection was taken at Station 9. Stations 1, 3 and 5 were control stations and all others were

stations of possible PCB contamination. Quarterly water and sediment samples were taken from Station 1 to 6. Dredged sediment samples were taken at Stations 10 to 14 during the summer collecting period only.

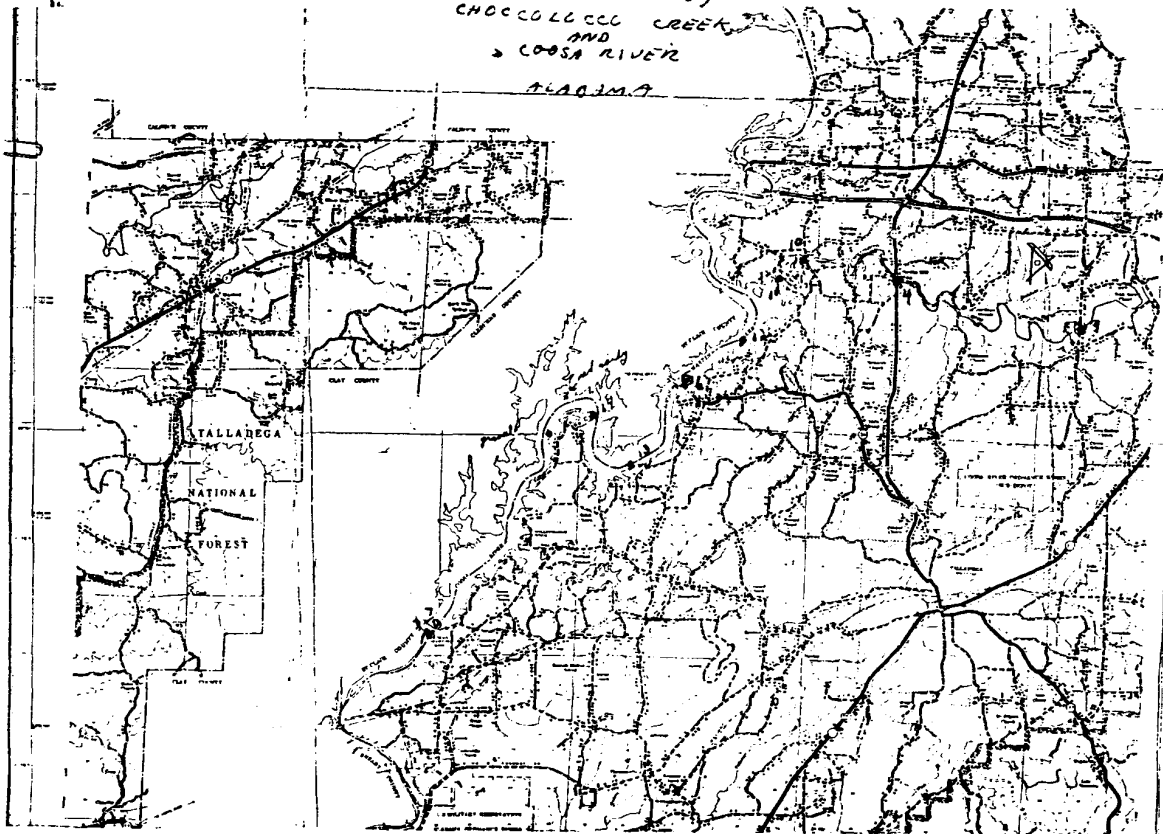
Abiotic Components: PCB's have low solubility and a high adsorptive capacity for sediments and suspended solids.

1. Soil from the banks of the river was collected by skinning off surface soil into glass jars.
2. Water for PCB and water quality analyses was taken in 4 300 ml BOD bottles.
3. The fine surface sediments were skimmed off in glass jars.
4. To obtain suspended solids a pump was used to collect 5 gallons of subsurface water in prewashed polyethylene or metal cans and later filtered on 45 μ glass filters.

COLLECTING SITES
PCB SURVEY (1978)
CHOCOLOCCO CREEK
AND
COOSA RIVER

1 1/2" = 1 mile

FLA03M.9



Biotic Components: To study the bioconcentration of PCB's, 12 genera of fish representing different trophic levels were collected. The fish were identified to species, but only the genera were used in the statistical analyses. The following genera were collected with a 10 foot seine:

Camponotoma sp.
Dorosoma sp.
Carassius sp.
Hypentelium sp.
Lepomis sp.
Micropterus sp.
Morone chrysops sp.
Notropis sp.
Percina sp.
Phoxinotus sp.
Pomoxis sp.
Rutilus sp.

The species are listed in Appendix A.

Plankton was collected by pumping 10 gallons of water through a plankton net. Due to lack of plankton, it was collected in the fall only.

B. Chemical Analyses:

Standard water quality measurements of dissolved oxygen, alkalinity, pH, color, chloride, turbidity, sulfite, total iron, conductivity, suspended solids, and carbon dioxide were made with the D.O. meter and Hach Kit.

The organic carbon, humic and fluvic acid concentrations were measured by the Walkley-Black Method and Chen's techniques, respectively. The particle size analyses were done by the STANDARD SIEVE ANALYSIS. The extraction and cleanup methods for PCB analyses

of the sediment, soil and fish were done according to Veith's and EPA's methods, respectively.

A Microtek 220 gas chromatograph equipped with a Ni-63 electron capture detector, a 6 foot x 0.25 inch o.d. glass U-shaped tube packed with OV-101 and a nitrogen carrying gas. The flow rate of the nitrogen carrying gas was 20 to 25ml/minute. The inlet, column oven and detector were operated at 225, 200 and 350°C, respectively. The chromatograms were interpreted by the Webb-McCall Method.

All of the above mentioned methods are presented in the following pages.

C. PCB Analyses: In the PCB analyses, the samples must first be extracted and then cleaned of other impurities before being analyzed by gas chromatography.

1. Extraction

Water Extraction: Take 200 ml filtered water. shake in separatory funnel with 50 ml of hexane (Veith, 1971).

Soil and Sediment Extraction: Use 10 to 50 (wet weight) of soil or sediment. Soxlet extract for 12 to 24 hours with 250 ml nanograde hexane.

Suspended solid extraction: Take glass filters previously used to filter 5 gallons of sample water. Extract for 12 to 24 hours in a soxlet extractor with 250 ml nanograde hexane.

Fish Tissue Extraction (EPA Method): A composite sample of fish (several fish of the same species and similar length and weight) weighing 5 to 15 g (wet weight) is put into a skrew-top teflon capped test tube (155 mm x 25 mm).

1. Add 5 ml acetonitrile and blend on a polytron for 1 minute
2. Centrifuge and decant liquid into 200 mm x 25 mm skrew topped, teflon capped test tube
3. Repeat steps 1 and 2
4. Add 5 ml acetonitrile and vortex mix for 30 seconds
5. Centrifuge and decant. Add liquid to the above
6. Repeat steps 1 to 5

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7. Add 25 ml of 20% aqueous sodium sulfate solution and 5 ml of nanograde hexane to decanted liquid
8. Shake for one minute. Remove top hexane layer with pipet and transfer to 25 ml Kuderna Danish Concentrator Tube.
9. Repeat steps 7 and 8 two more times
10. Concentrate hexane to 0.5 ml

2. Florisil Cleanup

Florisil Preparation: Activate florisil by heating at 130 C over night. Add 20 g to a size "B" chromaflex column and top with 2 g of anhydrous sodium sulfate.

Sediment, Soil and Suspended Solid Cleanup: The extracts of the sediment, soil and suspended solids are transferred directly to the florisil column.

Tissue Extract Cleanup: The tissue extract is transferred to the florisil column with 40 ml of 5% ethyl ether in hexane solution.

D. Interpretation of Chromatograms: The Webb-McCall method (1973), "Quantitative PCB Standards for Electron Capture Gas Chromatography; A Technique to Quantitate PCB's in Environmental Samples" was used to interpret the samples.

The chromatograms of PCB's from environmental samples usually show some evidence of degradation or metabolism. A sample may contain a single partially degraded Aroclor or a combination of Aroclors. Such samples can be quantitated by using the standard

Aroclors (Figures 3-5) and DDE (Figure 4), the data tables (Tables 1-4) and some computational rules. The key principle is that the total amount of PCB present is the sum of the amounts from all individual peaks.

To quantitate PCB's, chromatograph known amounts of the standards. Measure the area for each peak. Using the Tables 2-4 determine the Response Factor (ng PCB/area) for each peak. (Tables 5-7). Chromatograph the sample and measure the area of each peak. Multiply the area of each peak by the Response Factor for that peak.

Environmental Samples Containing More Than One Aroclor: Most PCB-contaminated fish, water and sediment samples contain residues of several Aroclors. Usually the sample chromatogram can simply be divided into 3 separate areas and the peaks in each area quantitated by using the appropriate Aroclor. Peaks with the retention times of 11-70 are compared individually to corresponding Aroclor 1242, peaks with retention times of 84-174 are compared to the corresponding peaks in Aroclor 1254 and peaks of larger retention time are compared with those peaks in Aroclor 1260. The peak areas of the samples are multiplied by the Response Factors from the peaks of the appropriate standard. The following calculations were used:

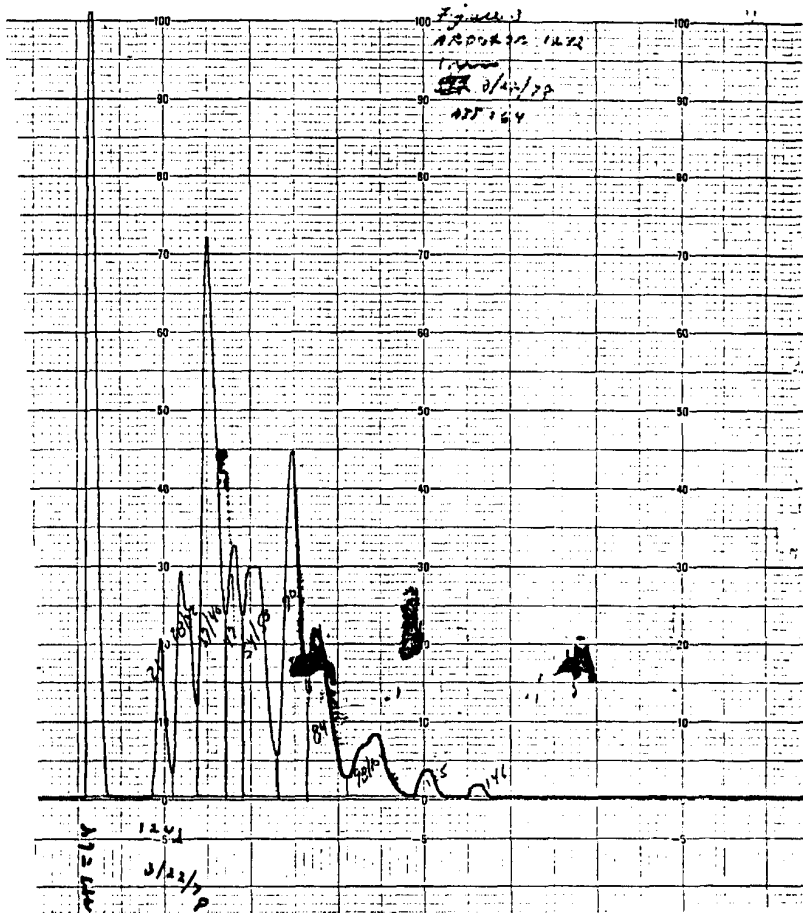
$$1. \text{ Response Factor for each peak} = \frac{\left(\frac{\text{ng/ul in standard}}{\text{area of the standard}} \right) \left(\frac{\text{ul tested}}{\text{each peak}} \right) \left(\frac{\text{mean weight \% represented by}}{\text{each peak}} \right)}$$

2. ng PCB in sample peak = (area of sample peak) (Response Factor)

3. ppm PCB in sample = $\left(\frac{\text{total ng in sample}}{\text{ul tested}} \right) \left(\frac{\text{total volume of sample (nl)}}{\text{total weight of sample (gms)}} \right)$

Table 8 is an example of the PCB calculation for sample #78, (7/24/77)
Campestris sp. from station 3, fall collection.

As described earlier in 'Collection and Analytical Problems', there were numerous samples which contained an unusually large peak at retention time 100 (Figure 1). Most of these occurred at stations 1, 3 and 5, all controls ~~and~~ located near agricultural and cattle fields. This peak generally constitutes 20-30% of the Aroclor 1254 found, in both standards and other samples. In those samples where it is large (greater than 20% of the Aroclor 1254) it is adjusted to represent no more than 25% of the Aroclor 1254 measured. Table 9 shows how this was done. The residual was thought to be DDE.



211 - 12/20/32 1272

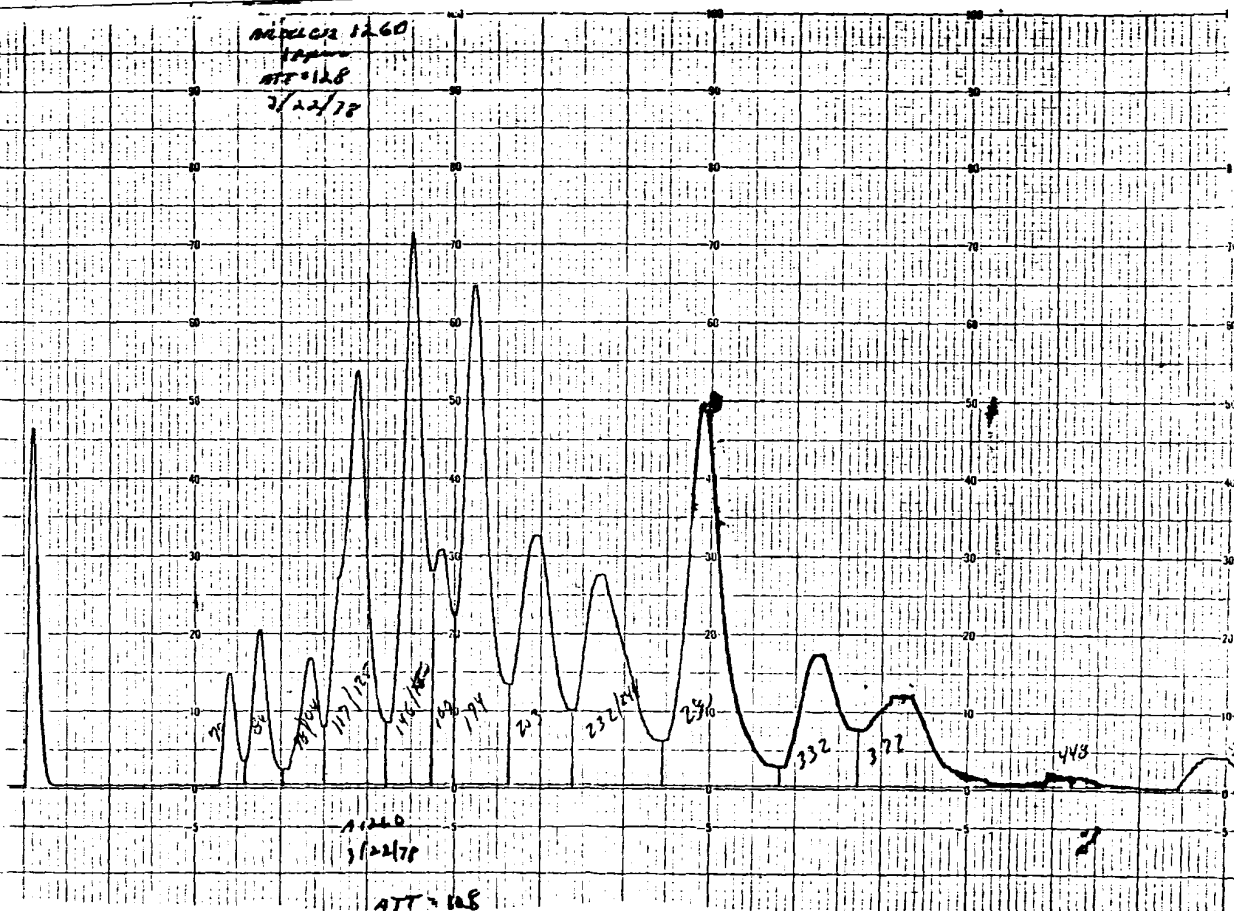
MONS 050341

MODEL 12 1260

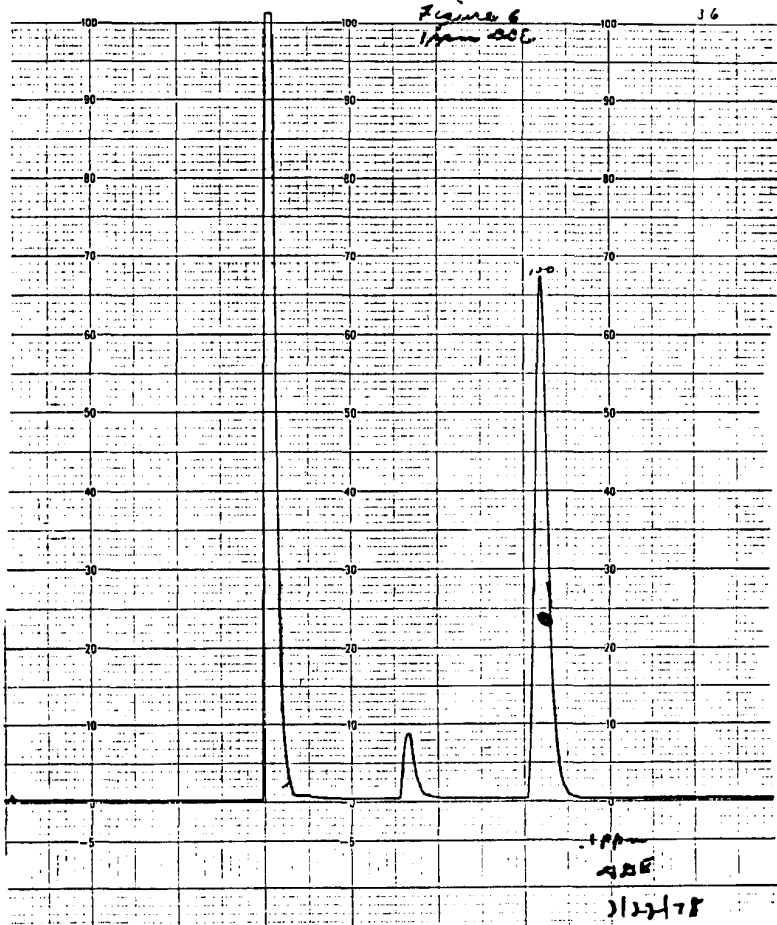
12.4mm

ATT = 12.8

2/22/78



MONS 050343



MONS 050344

MONS 050345

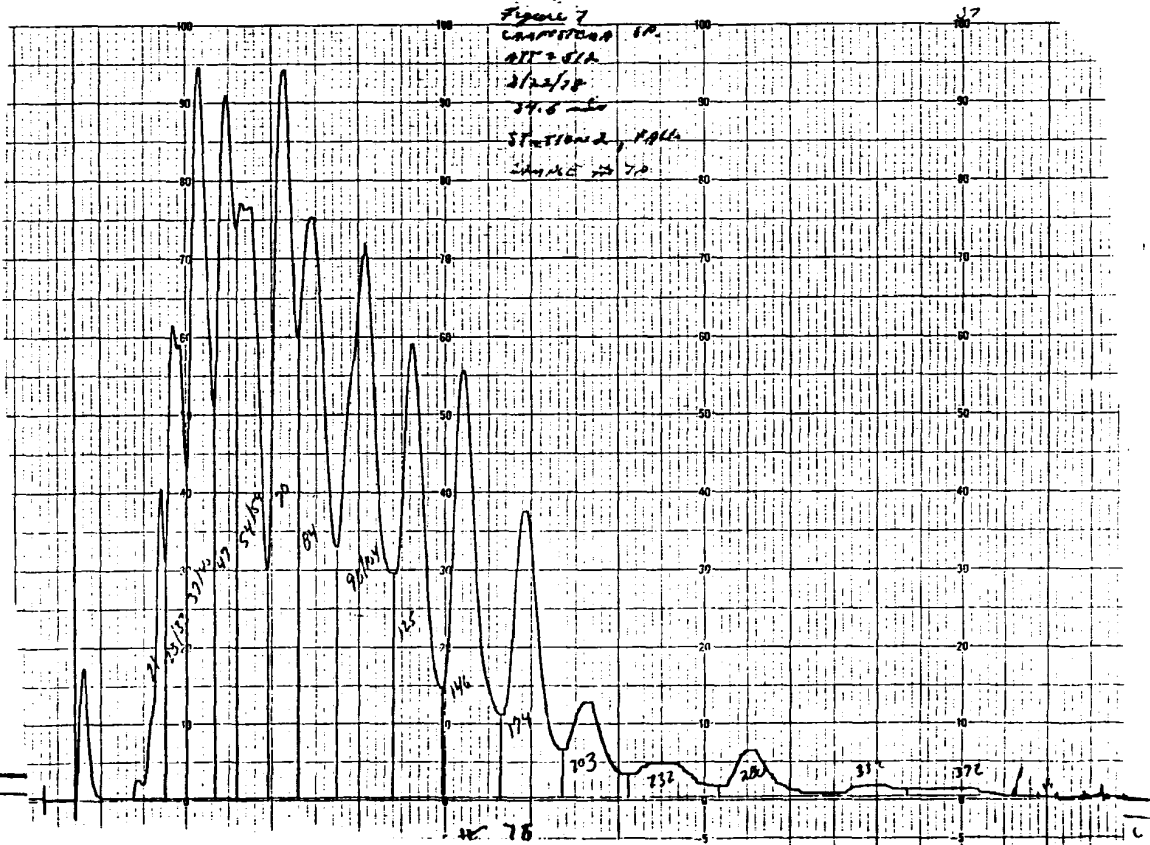


Table 2

Composition of Aroclor 1242
(Webb-McCall, 1973)

RRT ^a	Mean Weight Percent	Relative Std. Dev. ^b	No. of Chlorines ^c
11	1.1	35.7	1
16	2.9	4.2	2
21	11.3	3.0	2
28	11.0	5.0	2
			3
32	6.1	4.7	3
37	11.5	5.7	3
40	11.1	6.2	3
47	8.8	4.3	4
54	6.8	2.9	3
			4
58	5.6	3.3	4
70	10.3	2.8	4
			5
78	3.6	4.2	4
84	2.7	9.7	5
98	1.5	9.1	5
104	2.3	16.4	5
125	1.6	20.4	5
			6
146	1.0	19.9	5
			6
Total	95.5		

^aRetention time relative to p,p'-DDE=100. Measured from first appearance of solvent.

^bStandard deviation of six results as a percentage of the mean of the results.

^cFrom GC/MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

Table 3
Composition of Aroclor 1254
(Webb-McCall, 1973)

RRT ^a	Mean Weight Percent	Relative Std. Dev. ^b	No. of Chlorines ^c
47	6.2	3.7	4
54	2.9	2.6	4
58	1.4	2.8	4
70	13.2	2.7	4 [25%
			5 [75%
84	17.3	1.9	5
98	7.5	5.3	5
104	13.6	3.8	5
123	15.0	2.4	5 [70%
			6 [30%
146	10.4	2.7	5 [30%
			6 [70%
160	1.3	8.4	6
174	8.4	5.5	6
203	1.8	18.6	6
232	1.9	26.1	7
Total	100.0		

^aRetention time relative to p,p'-DDE=190. Measured from first appearance of solvent.

^bStandard deviation of six results as a percentage of the mean of the results.

^cFrom GC/MS data. Peaks containing mixtures of isomers are bracketed.

Table 4
Composition of Aroclor 1260
(Webb-McCall, 1973)

RRT ^a	Mean Weight Percent	Relative Std. Dev. ^b	No. of Chlorines ^c
70	2.7	6.3	5
84	4.7	1.6	5
98	3.8	3.5	5 ^d
104			5 60%
			6 40%
117	3.3	6.7	6
125	12.8	3.3	5 15%
			6 85%
146	14.1	3.6	6
160	4.9	2.2	6 50%
			7 50%
174	12.4	2.7	6
203	9.3	4.0	6 10%
			7 90%
222			7
244	9.8	3.4	6 10%
			7 90%
280	11.0	2.4	7
332	4.2	5.0	7
372	4.0	8.6	8
448	.6	25.3	8
528	1.5	10.2	8
Total	98.6		

^aRetention time relative to p,p'-DDE=100. Measured from first appearance of solvent. Overlapping peaks that are quantitated as one peak are bracketed.

^bStandard deviation of six results as a mean of the results.

^cFrom GC/MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

^dComposition determined at the center of peak 104.

^eComposition determined at the center of peak 232.

Table 5

Response Factors for Peaks 11 to 146
from Aroclor 1242 Standard (H:G:O:R: 3)
a 1ppm Concentration (3/22/78)

<u>Peak #</u>	<u>area of peak at attenuation ≈ 64</u>	<u>mean weight %</u>	<u>Response Factor</u>
11-21	0.028	15.3	27.321
28-32	0.062	17.1	13.790
37-40	0.169	22.6	6.686
47	0.070	8.6	6.286
54-58	0.101	12.4	6.139
70	0.107	10.3	4.813
77-84	0.061	6.3	4.164
98-104	0.040	3.8	4.750
125	0.010	1.6	8.000
146	0.007	1.0	7.143

Table 6

Response Factors for Peaks 70 to 174
from Aroclor 1254 Standard (H:G:O:R: 4)
a 1ppm Concentration (3/22/78)

<u>Peak #</u>	<u>area of peak at attenuation ≈ 64</u>	<u>mean weight %</u>	<u>Response Factor</u>
70	0.034	6.2	9.118
84	0.019	4.3	11.316
98-104	0.127	13.2	5.197
125	0.177	17.3	4.867
146-160	0.300	21.1	3.517
174	0.188	15.0	3.989

Table 7

Response Factor for Peaks 203 to 528
 from Aroclor 1260 Standard (FIG 2/26 5")
 a 1ppm Concentration (3/22/78)

<u>Peak #</u>	<u>area of peak at attenuation 128</u>	<u>area of peak at attenuation 64</u>	<u>mean weight %</u>	<u>Response Factor</u>
203	0.190	0.380	9.3	1.224
232-244	0.212	0.424	9.8	1.156
280	0.296	0.592	11.0	0.929
332	0.114	0.228	4.2	0.921
372	0.114	0.228	4.0	0.877
448	0.010	0.020	0.6	1.500
528	0.043	0.086	1.5	0.372

Table 8

Calculation for PCB Content of Sample #78 (FIGURE 7)

Camptostoma sp., Station 2, Fall

Sample Volume = 34.5mls

Sample Weight = 11.83 grams

(3/22/78)

Peak #	area at att. 512	area at att. 64	Response Factor	ng PCB	
11-21	0.068	0.544	27.321	14.563	
28-32	0.157	1.256	13.790	17.320	
37-32	0.270	2.160	6.686	14.442	1242
47	0.241	1.928	6.286	12.119	Standard
54-58	0.274	2.192	6.139	13.457	
70	0.310	2.480	5.187	12.864	85.1107ng Al242
78-84	0.322	2.576	4.887	12.589	
98-104	0.384	3.072	3.517	10.804	1254
125	0.242	1.936	3.989	7.723	Standard
146-160	0.241	1.928	3.343	6.445	
174	0.170	1.360	3.000	4.080	41.641ng Al254
203	0.071	0.568	1.224	0.595	
223-244	0.040	0.320	1.156	0.370	
280	0.046	0.368	0.929	0.342	
332	0.008	0.064	0.921	0.059	1260
372	0.014	0.112	0.887	0.099	Standard
448	- - -	- - -	1.500	- - -	
528	- - -	- - -	0.872	- - -	1.565ng Al260
Total				127.929	

Using Equation 3 above:

$$\text{Aroclor 1242} = \left(\frac{85.11 \text{ ng}}{5 \text{ ul}} \right) \left(\frac{34.5 \text{ ml}}{11.83 \text{ grams}} \right) = 49.6289 \text{ ppm}$$

$$\text{Aroclor 1254} = \left(\frac{41.641 \text{ ng}}{5 \text{ ul}} \right) \left(\frac{34.5 \text{ ml}}{11.83 \text{ grams}} \right) = 24.2808 \text{ ppm}$$

$$\text{Aroclor 1260} = \left(\frac{1.565 \text{ ng}}{5 \text{ ul}} \right) \left(\frac{34.5 \text{ ml}}{11.83 \text{ grams}} \right) = 0.9125 \text{ ppm}$$

$$\text{Total PCB} = \left(\frac{127.929 \text{ ng}}{5 \text{ ul}} \right) \left(\frac{34.5 \text{ ml}}{11.83 \text{ grams}} \right) = 74.597 \text{ ppm}$$

MONS 050351

Table 9
Calculation for PCB Content of Sample #293 (Figure 1)
Lexowin Coalition, Station 1, Spring
Sample Volume = 30mls
Sample Weight = 2.69gms
(9/30/78)

Peak #	Area at Att. 8	Area at Att. 128	Response Factor	ppm PCB	
37	0.004	0.0002	9.64	0.0018	Al242 Standard
47	0.016	0.0010	7.71	0.0077	
54	0.005	0.0003	7.60	0.0022	
70	0.022	0.0016	7.23	0.0123	
84	0.052	0.0032	5.17	0.0165	Al254 Standard
*98-104	0.128	0.0060	4.22	0.0337	
125	0.079	0.0049	4.07	0.0199	
146	0.072	0.0049	3.54	0.0173	
174	0.060	0.0037	2.67	0.0068	Al260 Standard
203	0.045	0.0028	3.04	0.0110	
232	0.035	0.0021	3.55	0.0074	
260	0.030	0.0018	2.04	0.0052	
272	0.033	0.0020	2.50	0.0050	Total
282	0.015	0.0009	2.56	0.0023	
Total				0.1321	

* Peak 98-104 represents approximately 34% of the Aroclor 1254 measured. It is, therefore, reduced to only 22% of the Aroclor 1254 and it's new value is 0.0239. The amount of Aroclor 1254 found is therefore, 0.0359ppm and the total is 0.1404ppm PCB.

The new figures are then used in Equation 3 as in Table 9 to yield the following results:

0.0486ppm Aroclor 1242

0.1768ppm Aroclor 1254

0.0639ppm Aroclor 1260

0.2903ppm Total PCB

III. RESULTS

A. DATA SUMMARY

Tables 10 and 11 show the results of the 2-way Analysis of Variance. Two different programs were used, both yielding similar results. Table 10, from the South Carolina Program, shows that both the station location and collecting season have a significant* influence on the accumulation of PCB by Micropterus and Notropis. The weight of the fish apparently had no effect. The accumulation of PCB by Lepomis was affected by both the station location and weight, but not by season. Only Lepomis, Micropterus and Notropis were tested in this program.

Table 11, is the SPSS Anova Table. A 2-way analysis using total PCB by weight with station and season was done on Dorosoma, Gambusia, Hyphantelium, Lepomis, Micropterus and Notropis. There is a significant relationship between weight and PCB concentration in all ~~24~~ tested except Hyphantelium. The station location is significant in all 6 ~~GENERA~~ while the season is significant in the accumulation of PCB by Dorosoma, Micropterus and Notropis.

Table 12 is the Anova from another analysis of variance (SPSS Program) to determine whether there is a significant difference in the accumulation of PCB between ~~4~~ ⁵ ~~GENERA~~, Dorosoma, Lepomis, Micropterus and Notropis at stations

* Significant- $p \leq 0.05$

1,2,4,5 and all 4 genera from stations 6,7 and 8 collectively. Again it shows that weight is significant in the accumulation of PCB by these genera at all stations except #1. It also shows that there are significant differences in the mean residue levels of these 4 genera at stations 2 and 5.

All of these analyses, therefore, show that the accumulation of PCB by fish is related to station location, weight, season and species of fish.

MONS 050354

Table 10

2-Way Analysis of Variance
(So. Carolina Program)

lebonia sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	7	.2172	35.150	0.0001
Season	3	0.196	3.176	0.0293
Weight	1	0.059	0.959	0.6676

Micropterus sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	7	2.172	49.097	0.0001
Season	3	0.186	3.623	0.0167
Weight	1	0.059	1.093	0.2968

Notropis sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	7	9.618	147.509	0.0001
Season	3	0.125	1.930	0.1244
Weight	1	0.026	14.212	0.0005

DF- Degrees of Freedom

MS- Mean Square

p- significance of F

Table 11
2-Way Analysis of Variance
(SPSS Program)

Dorosoma sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	4	1.122	20.436	0.001
Season	3	0.170	3.099	0.044
Weight	1	0.306	5.579	0.027

Gambusia affinis

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	3	3.766	45.347	0.001
Season	2	0.034	0.414	0.654
Weight	1	1.779	21.416	0.002

Hypentelium sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	2	2.456	12.434	0.001
Season	2	0.021	0.105	0.901
Weight	1	0.285	1.443	0.251

Ieromis sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	7	9.752	142.837	0.001
Season	3	0.087	1.280	0.283
Weight	1	8.389	122.866	0.001

Table 11
(continued)

Micropterus sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	7	1.936	29.010	0.001
Season	3	0.240	3.601	0.020
Weight	1	2.291	34.329	0.001

Notropis sp.

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Station	5	8.333	152.382	0.001
Season	3	0.293	5.354	0.003
Weight	1	1.525	27.887	0.001

DF- Degrees of Freedom
MS- Mean Square
p- Significance of F

Table 12

2-way Analysis of Variance
(SPSS Program)

Station 1

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Weight	1	0.611	3.727	0.059
Species (5,6,8)	2	0.115	0.704	0.499

Station 2

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Weight	1	0.303	5.709	0.020
Species (5,6,8)	2	0.170	3.203	0.048

Station 4

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Weight	1	0.329	7.414	0.008
Species (2,5,6)	2	0.099	2.223	0.116

Station 5

	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Weight	1	2.336	31.836	0.001
Species (2,5,6,8)	3	0.364	4.959	0.004

Table 12
(continued)

Stations 6,7 and 8

	DF	MS	F	p
Weight	1	0.689	8.111	0.005
Species (2,5,6,8)	3	0.154	1.809	0.150

DF- Degrees of freedom

MS- Mean Square

p- significance of F

Species 2- Dorcopsoma sp.
 5- Leptomys sp.
 6- Micropterus sp.
 8- Notomys sp.

B. THE DISTRIBUTION OF PCB IN THE RIVER-RESERVOIR SYSTEM AS REFLECTED BY THE RESIDUE LEVELS OF 4 SPECIES OF FISH

PCB levels of all samples are presented in Appendix A. The mean Aroclor 1242, 1254, 1260 and total PCB for each species at each station and season are presented in Appendix B. Figures 8 to 11 are histograms displaying these mean residue levels (total PCB) of Dorosoma, Lernaeis, Micropterus and Notropis ^{at} stations 1 to 8 and all 4 seasons. In general, fish collected at control station #1 on Choccolocco Creek have very low PCB levels (<1ppm). Fish from the other control station (#5) on the Coosa River are in the 2ppm range. There are 2 exceptions. One fish sample each of Dorosoma and Micropterus from stations 1 and 5, respectively, are in the 10ppm range. Very high levels are found in fish from station 2. They range from ^a 7 in ^{a sample} Lernaeis to ^a 160ppm in ^a Notropis sample with means ranging from 8ppm in Lernaeis to 8ppm in Cannontoma. These levels decrease with increasing distance from the outfall to Logan Martin Dam (Station 7) where mean levels are in the 3ppm range. However, there is a slight increase ^{at} station 8, just below Logan Martin Dam in all 4 genera. There is no apparent high accumulation of PCB in the reservoir (stations 6 and 7). Table 13 shows the ^{general trend} decrease from station to station in all 4 species.

Table ¹⁴ and 15 show the humic and fluvic acid content, and the organic carbon content of the sediment from Stations 1 to 4. Tables 16 and 17 give the water quality data collected at the survey sites and the USGS site, respectively (see Fig. 1 for collecting sites). Table 18 and Figures 12 to 16 show the

particle size analysis of the sediment. The differences in particle size, organic content and humic and flavic acid contents of the sediments ^{at each station} do not appear to affect the distribution of PCB in this system. The water quality fluctuations do not seem to affect the distribution of PCB in the system either. ~~As a result of~~ The effect of water quality on the uptake of PCB is ^{discussed} ~~discussed~~ in section D. Therefore, either the fish concentrations do not indicate the abiotic PCB content of the stream or, ~~or these~~ parameters measured, humic and flavic acid, organic content and various water quality analyses, do not greatly influence the distribution of PCB in this system. The ^{final (net) uptake} ~~final (net) uptake~~ PCB ^{at} each station is closely related to the distance from the outfall.

Table 13

Percent Decrease of All Aroclors
with Distance from the Outfall
in 4 Generac
of Fish

(Dorosoma, Lepis, Micropterus, Notropis)

Dorosoma sp.

	Aroclor 1242 ppm %	Aroclor 1254 ppm %	Aroclor 1260 ppm %	Total PCB ppm %
Station 4, Fall	10.58 > 87	13.70 > 75	3.12 > 82	27.4 > 8
Station 6, Fall	1.42	3.35	0.57	5.3
Station 4, Winter	5.33 > 89	6.51 > 67	4.04 > 64	15.8 > 5
Station 7, Winter	0.62	2.16	0.26	3.06

Lepis sp.

	Aroclor 1242 ppm %	Aroclor 1254 ppm %	Aroclor 1260 ppm %	Total PCB ppm %
Station 2, Winter	10.70 > 75	10.88 > 60	6.27 > 68	28.4 > 6
Station 4, Winter	2.62	4.46	3.02	7.1
Station 2, Spring	5.01 > 86 > 73 > 76	3.61 > 65 > 44 > 62	0.60 > *I38 > *I51 > 73 > 64	9.2 > I26 11.7 > 58 > 61
Station 4, Spring	2.58	5.94	3.27	11.7
Station 6, Spring	0.69	3.26	0.91	4.4
Station 7, Spring	0.17	1.22	0.51	1.9

* I- PCB Increase

Table I3
(continued)

Lernaeis sp.

	Arcolor 1242	Arcolor 1254	Arcolor 1260	Total I ^a
	ppm %	ppm %	ppm %	ppm %
Station 2, Summer	9.54 > 69	8.14 > 20	3.40 > 18	20.8 > 41
Station 4, Summer	2.07 > 61 82	6.55 > 41 58	2.84 > 64 71	12.3 > 51 77
Station 6, Summer	1.18 > 63 96	3.88 > 66 84	1.02 > 75 92	6.0 > 67 97
Station 7, Summer	0.44	1.31	0.26	2.0

Microseturus sp.

	Arcolor 1242	Arcolor 1254	Arcolor 1260	Total I ^a
	ppm %	ppm %	ppm %	ppm %
Station 2, Winter	1.34 > 85	14.1 > 72	7.4 > 58	22.1 > 75
Station 4, Winter	2.26 > 96 99	4.41 > 90 94	2.22 > 95 98	10.7 > 88 97
Station 7, Winter	0.12	0.26	0.1	1.2
Station 2, Spring	11.30 > 85	11.40 > 30	6.30 > 127	29.1 > 40
Station 4, Spring	1.63 > 65 95	8.05 > 34 94	3.01 > 74 66	17.7 > 55 97
Station 6, Spring	0.35	5.34	2.08	7.9
Station 2, Summer	6.08 > 93	5.85 > 71	2.37 > 84	14.3 > 84
Station 4, Summer	0.43	1.70	0.38	2.2

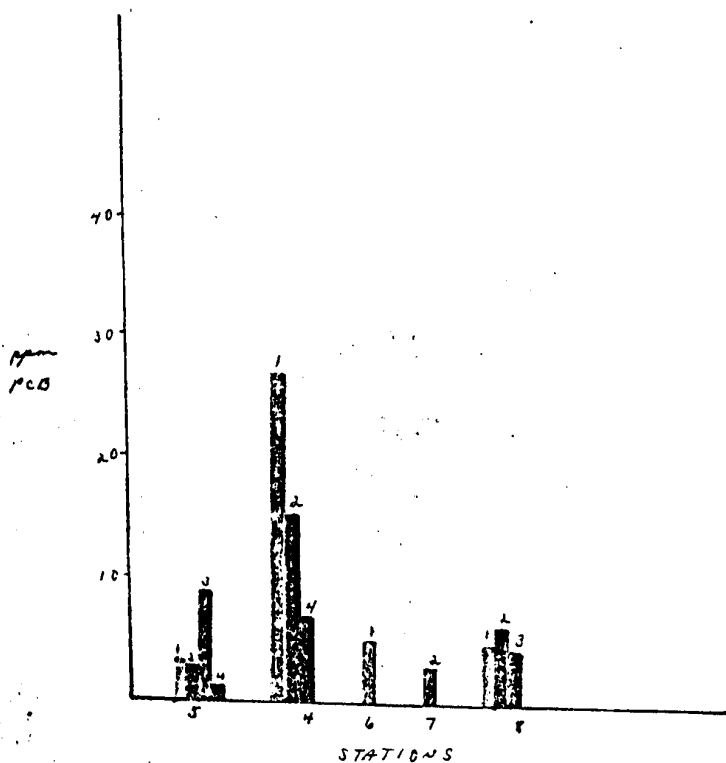
* I- PCB Increase

Table 13
(continued)

	<u>Notropis</u> <u>sp.</u>			
	Aroclor 1242 ppm %	Aroclor 1254 ppm %	Aroclor 1260 ppm %	Total PCB ppm %
Station 2, Fall	14.66 > 98	19.39 > 91	5.63 > 96	48.1 > 95
Station 6, Fall	0.36	1.92	0.24	2.4
Station 2, Summer	15.90 > 95	18.00 > 87	8.96 > 95	42.9 > 92
Station 6, Summer	0.76 > 65	2.39 > 32	0.45 > 9	3.6 > 39
Station 8, Summer	0.27	1.50	0.41	2.2

FIGURE 8.

MEAN TOTAL PCB LEVELS
IN DOROSOMA SP
ON A STATION +
SEASONAL BASIS



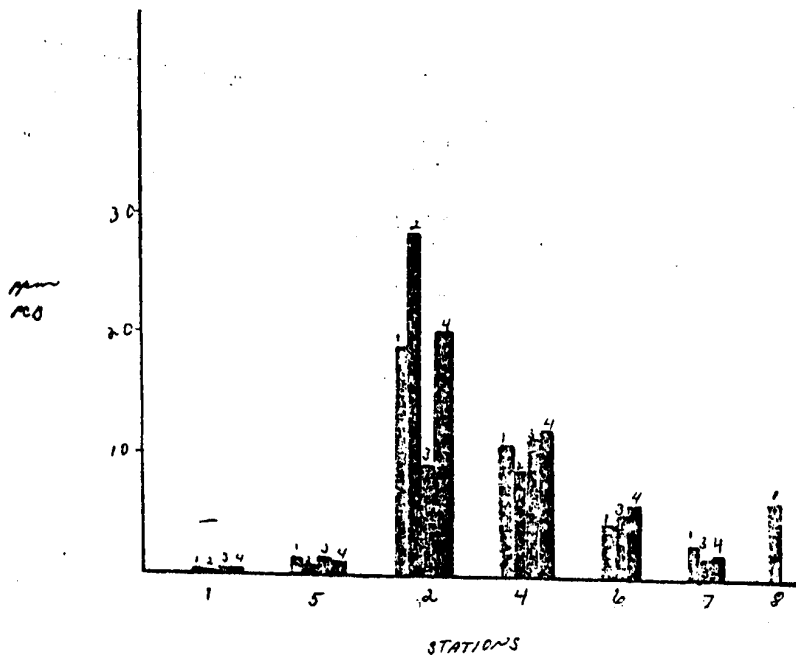
THE SEASONS ARE MARKED ABOVE EACH BAR:

- 1 - FALL
- 2 - WINTER
- 3 - SPRING
- 4 - SUMMER

MONS 050365

Figure 9

MEAN TOTAL PCB LEVELS
~~DATA~~ LEPCOMIS SP.
 ON A STATION
 AND SEASONAL
 BASIS



THE SEASONS ARE MARKED ABOVE EACH BAR:

- 1- FALL
- 2- WINTER
- 3- SPRING
- 4- SUMMER

MONS 050366

Table 13
Winter 1/16/78
Station 4

Sample Number	Species	Average Weight	1242	1254	1260	Total
212	L. megalotis	.9900	1.7594	4.0724	1.8730	7.7079
204	L. macrochirus	1.2290	.5055	2.4306	.8466	3.7828
206	" "	1.3254	.9949	2.6212	1.2132	4.8294
205	" "	1.7458	1.3363	3.4833	1.9391	6.7639
214	L. megalotis	1.8308	2.3300	4.3823	2.0640	8.7769
215	" "	2.1524	2.8515	5.9119	4.1437	12.9071
208	L. macrochirus	2.4059	1.1450	2.7679	1.4338	5.3469
217	L. megalotis	2.5511	1.4196	3.7281	1.3360	6.4839
207	L. macrochirus	3.4132	1.2149	3.5610	2.2212	6.9971
216	L. megalotis	4.1435	3.5729	3.9721	1.7201	9.2652
213	" "	5.1205	1.5357	2.9538	.9904	5.4800
253	" "	23.2148	--	--	--	--
252	" "	29.8491	5.2796	7.5718	3.5540	16.4054
251	" "	39.8579	6.1021	7.7304	2.3695	16.2920
250	" "	49.6747	6.2332	7.6711	3.0946	16.9891
249	L. macrochirus	64.3015	3.1502	4.6404	1.5112	8.7019
211	D. cepedianum	7.3537	4.7863	6.2385	4.1031	15.1279
210	" "	7.5341	6.2821	6.6255	3.7603	16.6590
209	" "	10.1191	2.6004	2.9532	.7351	6.2388
247	" "	34.1144	7.6749	10.2486	7.4723	25.3359
210	M. coosae	9.7859	5.6988	5.6988	4.6226	14.0814
218	" "	14.4093	3.5215	3.5215	1.9400	7.4264

Table 14
Spring 4/14/78
Station 4

Sample Number	Species	Average Weight	1242	1254	1260	Total
332	L. marginatus	2.7825	1.3951	5.9521	4.7051	11.5565
331	L. macrochirus	3.3242	1.0077	3.2516	1.1659	5.4254
331	L. marginatus	3.7239	2.8256	4.8230	2.2728	9.9215
329	" "	4.3344	5.0544	12.3239	7.3252	24.7745
330	" "	4.8537	2.6229	5.3414	2.5032	10.5021
328	" "	10.5141	1.3624	4.9460	3.4673	9.7788
327	" "	13.5351	3.2574	6.4473	3.0783	12.7832
326	" "	20.9773	3.0563	4.4313	2.1692	9.6568
334	M. punctulatus	10.9306	1.6387	8.0657	8.0185	17.7230

Table 15
Summer 8/3/78
Station 4

Sample Number	Species	Average Weight	1242	1254	1260	Total
428	D. cepedianum	2.7498	2.5087	3.1310	.8504	6.4905
427	" "	2.7939	3.3218	4.8182	1.6121	9.7521
430	" "	3.5307	2.3174	3.7065	1.2610	6.1887
429	" "	3.8151	2.1136	2.6863	.7325	5.5326
426	" "	4.5503	2.6393	2.7223	.7027	6.0649
425	" "	4.9130	3.4383	4.9486	1.5573	10.0442
424	" "	5.0738	2.4676	2.6231	.6272	5.7181
448	G. affinis	.2859	3.3761	11.8875	4.3333	19.5970
441	L. macrochirus	.3751	1.0072	2.4526	.8934	4.3533
446	L. sp.	.4205	.9603	2.9545	1.0793	5.0047
447	" "	.5133	1.3356	3.2356	1.3057	5.8780
435	L. cyanellus	.7155	1.8776	5.7723	2.4993	10.1493
442	L. macrochirus	.7596	1.5578	4.7154	1.7223	7.9987
445	L. microlophus	.8277	2.3773	3.8517	1.4975	7.7256
443	" "	.8332	3.3734	9.2376	3.9806	15.5957
444	L. marginatus	1.0867	2.2563	3.5281	1.0428	6.3273
436	L. cynnellus	1.0406	1.3977	4.5237	1.5519	7.4754
440	L. macrochirus	1.0986	2.7614	7.5557	2.6681	12.6853
431	L. cyanellus	2.2295	1.8219	7.5576	4.5134	14.0231
434	" "	3.1657	3.0221	5.9722	3.3236	11.2427
433	" "	3.9559	10.9560	21.2876	8.3046	40.4707
432	" "	8.7307	3.5268	6.8906	4.0644	14.4820
438	L. megalotis	10.9361	4.0612	7.4643	3.0473	15.4978
439	" "	10.9998	3.9904	7.1512	3.3818	14.5236
437	" "	11.8181	4.3049	7.3676	3.5538	15.1663

Table 16
Fall 10/5/77
Station 5

Sample Number	Species	Average Weight	1242	1254	1260	Total	DCB
141	L. macrochirus	.9060	.1674	.8733	.0572	1.0979	
142	" "	1.4070	.1057	.6410	.0477	.7945	
128	L. microlophus	2.0400	.1187	.5043	.0841	.7072	
146	L. megalotis	2.0894	.1636	.8822	.0664	1.1124	
144	L. macrochirus	2.4353	.2172	2.0555	.2130	2.5003	
148	L. megalotis	2.7171	.12	.7893	.0603	.9552	
149	" "	2.7849	.1817	.9762	.0915	1.2495	x
32	L. microlophus	2.8858	.0799	.4947	.0247	.5994	x
147	L. megalotis	3.1929	.710	1.0579	.0950	1.3362	
31	L. microlophus	3.5555	.1225	.8136	.0411	.9772	x
150	L. megalotis	4.2168	.1517	.7006	.1342	.9366	x
129	L. microlophus	5.9076	.2684	1.3913	.1339	1.7937	
143	L. macrochirus	11.4299	.1082	1.3015	.1740	1.5819	
137	Pinephales sp.	.1348	.1390	1.1514	.0587	2.5217	
133	" "	.1952	.1244	.9428	.0778	1.1352	x
176	" "	.9168	.2438	1.5606	.0642	1.6689	
139	" "	2.1683	.1857	1.6201	.0908	1.8767	
134	" "	2.2174	.1738	1.2474	.0689	1.4904	x
138	" "	2.3221	.3382	1.9543	.1055	2.3952	
135	" "	2.4670	.3901	2.9067	.1771	3.4742	
132	" "	2.6145	.1939	1.5354	.0706	1.8000	
131	" "	3.3437	.5022	4.3089	.2522	5.0988	
125	D. cepedianum	5.0349	.4273	1.7355	.5280	2.3157	
126	" "	17.3150	.8754	2.4517	.0966	3.4237	x
127	N. crysoleucus	1.5495	.1474	.2065	.0886	.6530	
140	N. venustus	1.4312	.1557	1.8598	.3045	2.3261	
130	M. punctulatus	5.0548	.1245	2.0584	.3558	2.5370	
33	P. caprodes	12.1416	.4592	2.1071	.0977	2.6640	x

Table 17
Winter 1/15/78
Station 5

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
227	L. macrochirus	.3950	.0032	.0430	.0069	.0523	
228	" "	.8707	.0084	.1849	.0316	.2250	
226	" "	1.0992	.0248	.4611	.0644	.5504	
221	L. megalotis	1.3817	.0291	.6271	.1036	.7599	
225	" "	1.9668	.0318	.5547	.0784	.6650	
222	" "	2.0925	.0506	.6700	.0700	.7908	
223	" "	3.2926	.0357	.7059	.1059	.8476	
224	L. macrochirus	3.6123	.0330	.5618	.0814	.6763	
257	" "	30.7078	.5084	2.5102	.6583	3.6770	
229	D. cepedianum	4.2895	.2153	1.2418	.0742	1.5314	x
232	" "	4.9291	.1864	1.2946	1.2017	1.6013	x
233	" "	5.5039	.7791	1.8635	.8976	3.5403	
270	" "	6.3879	.5442	1.9954	.1681	2.7077	x
230	" "	9.5379	.0452	.4733	.0498	.5683	
254	" "	26.1044	1.0286	2.6953	.4944	4.2184	
220	M. punctulatus	2.7074	.0403	1.0657	.1631	1.2691	
255	M. salmoides	21.4469	.2243	1.3765	.3592	1.9701	
256	Roccus chrysops	40.7712	.3851	3.0676	.8420	4.2948	

Table 18
Spring 4/14/78
Station 5

Sample Number	Species	Average Weight	1242	1254	1260	Total	DLE
350	M. punctulatus	5.7950	.0520	.0282	.0972	.7775	
351	M. coosae	12.6682	.1355	1.7023	.3807	2.2185	
378	" "	35.5847	.3345	2.9622	.5359	3.8329	
352	D. cepedianus	16.2935	.3431	.8664	.0936	1.3031	
379	" "	28.0201	4.0385	10.7762	1.3719	16.1867	x
360	L. macrochirus	1.5781	.1299	.8056	.1126	1.0422	
359	" "	2.6700	.1144	.7775	.1449	1.0369	
368	L. marginatus	2.8486	.0510	.8673	.1266	1.0395	
362	L. symmetricus	3.0063	.0559	.7594	.0707	.8862	
360	L. marginatus	3.5924	.0795	.6065	.0947	.7808	
363	L. symmetricus	3.8784	.0135	.3668	.0358	.4162	
367	L. marginatus	4.7420	.1268	.8169	.0852	1.0290	
358	" "	4.8337	.0999	1.2377	.1554	1.4931	
366	" "	5.6412	.0351	.7946	.0562	.8854	
365	" "	5.8246	.0675	1.2764	.0824	1.4264	
364	" "	7.1031	.0319	.6367	.0560	.7266	
354	L. macrochirus	7.9334	.1713	2.9654	.3105	3.4473	
353	" "	9.5764	.0493	1.0757	.2538	1.3788	
355	L. megalobius	11.8463	.0913	1.3212	.1176	2.1802	
377	" "	20.2348	.2379	.9071	.1501	1.2370	
356	M. ventriosus	3.7516	.4953	3.6658	.6533	4.8145	

Table 19
Summer 8/3/78
Station 5

Sample Number	Species	Average Weight	.1242	.1254	.1250	Total	DES
412	M. punctulatus	1.7578	.1504	.5194	.1430	.7629	
411	" "	2.6238	.1064	.8904	.1695	1.1665	
406	M. salmoides	9.1917	.0683	.6458	.1332	.8474	
410	M. punctulatus	9.5690	.0660	.6238	.1254	.8154	
407	M. salmoides	11.0995	.0812	3.4234	.1612	3.6658	
423	D. cepedianum	.3889	--	--	--	--	
418	" "	2.2079	--	--	--	--	
420	" "	3.4010	.1664	.8107	.1934	1.1907	
421	" "	3.7027	.2506	1.0908	.1482	1.4798	
422	" "	4.7950	.1352	.5659	.0462	.7470	x
405	L. macrochirus	.4697	.1165	.5819	.1051	.7236	
402	" "	.6123	.0707	.7435	.1514	.9658	
404	" "	.7680	.0844	.4564	.0690	.6690	
409	" "	1.0464	.0862	.5786	.0370	.7519	
403	L. micropophus	1.8527	.1560	1.3139	.1538	1.6238	
413	L. macrochirus	7.8234	.1333	.9061	.1227	1.2222	
417	L. megalotis	8.3556	.2794	1.9357	.1024	2.3176	
415	L. macrochirus	10.7245	.0614	.5921	.1009	.7305	
416	" "	13.0248	.0337	.2189	.0327	.2845	
414	Pimochales sp.	.5221	.1470	.4430	.1547	1.3307	
408	" "	1.4726	.1663	1.7726	.3683	2.3009	

Table 20
Fall 10/5/78
Station 5

Sample Number	Species	Average Weight	1242	1254	1260	Total
20	<i>M. venustus</i>	1.3038	.3632	1.8260	.2473	2.4430
21	<i>Pinophales</i> sp.	2.7464	.3780	1.6336	.1266	2.1380
156	<i>L. megalotis</i>	3.4635	.5864	1.9760	.3031	2.8656
46	<i>L. macrochirus</i>	4.1023	.7046	2.0330	.1627	2.9010
154	<i>L. megalotis</i>	5.1669	.4553	1.3305	.1034	1.8954
153	"	6.3954	.0943	.1901	.1508	.4351
45	<i>L. macrochirus</i>	7.6449	1.3462	3.7866	.3517	6.6120
152	<i>L. megalotis</i>	7.9668	.3733	1.0065	.0136	1.3935
151	"	8.5113	.5705	4.4782	.6314	5.6803
155	"	10.3570	1.4133	5.0528	.8074	7.2835
44	<i>L. macrochirus</i>	11.6250	.8672	2.1550	.2019	3.8360
260	<i>L. megalotis</i>	18.5657	.9768	2.4140	.3456	3.7355
262	"	12.2170	1.2498	3.6983	.5579	5.5061
261	"	14.7443	1.3533	3.9384	.5429	5.9347
263	<i>D. cepedianum</i>	49.8427	1.4215	3.3506	.5754	5.3537
49	<i>M. punctulatus</i>	2.6333	.1915	2.1361	.0700	2.2960
51	"	3.1859	.1591	2.4243	.1120	2.7060
48	"	4.0227	.3700	2.6865	.1522	3.2210
50	"	4.1467	.2357	2.1032	.0344	2.4270
47	"	7.6827	1.0469	9.6309	.8706	11.5570

Table 21
Spring 4/14/78
Station 6

Sample Number	Species	Average Weight	1242	1254	1260	Total
349	<i>M. punctulatus</i>	4.0053	.5521	5.3465	2.6333	7.9820
346	<i>L. marginatus</i>	6.3393	.4008	2.0636	.5433	3.0878
345	<i>L. megalotis</i>	7.2954	1.1566	4.6850	1.1183	6.9602
343	<i>L. marginatus</i>	8.0027	.4532	3.3495	1.0753	4.8782

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Table 22
Summer 8/3/78
Station 6

Sample Number	Species	Average Weight	1242	1254	1250	Total
485	L. macrochirus	1.1801	.3635	1.3205	.2318	1.9551
484	"	1.8403	.2730	1.1206	.1582	1.5519
486	L. cyanellus	1.8782	.2970	1.2305	.2039	1.7315
482	L. macrochirus	2.6563	.2739	1.0719	.1674	1.5132
483	L. cyanellus	3.1444	.6700	1.7011	.3173	2.6835
481	"	5.1142	1.6963	4.5905	.7069	6.9958
468	L. marginatus	12.5237	1.0508	4.0314	.9796	6.0521
469	L. megalotis	13.3776	.9929	4.1764	1.2183	6.3877
470	"	16.4201	.6467	2.3066	.1357	3.0892
553	L. marginatus	25.1057	1.1121	4.1095	.7539	5.9756
544	"	25.7146	.4409	2.1405	.4434	3.0249
540	L. megalotis	28.8143	1.8108	9.8712	3.4453	15.1274
543	L. marginatus	41.3426	4.1164	10.6283	3.5746	18.3193
539	L. megalotis	43.0192	2.8854	7.7380	3.1994	13.8268
541	L. marginatus	59.6801	1.5859	3.3056	.5178	5.4092
542	L. sp.	99.6445	.7645	2.8573	.3375	3.9575
479	M. punctulatus	2.7292	.5610	2.0910	.3738	3.0259
478	"	2.7482	.4374	1.6903	.3723	2.5003
480	"	3.3104	.3200	1.5235	.2730	2.1167
474	"	6.9894	--	--	--	--
475	"	7.9340	.4978	2.3272	.5164	3.3416
472	M. salmoides	14.4216	.2062	1.4844	.4292	2.1298
473	"	18.3747	.1367	.8652	.2077	1.2097
471	M. punctulatus	18.4909	.5050	1.4851	.3238	2.3148
556	"	19.8603	.7796	2.1851	.5541	3.5283
557	P. caprodes	22.1918	.9386	2.1023	.2267	3.2678
477	N. venustus	.6520	.6244	2.3842	4740	3.4827
476	"	1.4901	.8961	2.4113	.4350	3.7425

Table 23
Fall 10/5/77
Station 7

Sample Number	Species	Average Weight	1242	1254	1260	Total
34	M. punctulatus	1.3463	1.0318	4.1133	.3107	5.7550
163	" "	2.5153	.3365	1.5306	.2180	2.0852
162	" "	3.6025	.4535	1.5513	.2767	2.2821
160	" "	3.7813	.3239	1.3682	.1354	1.2835
161	" "	4.9055	.2267	.6315	.1539	1.2122
159	" "	5.7405	.4372	1.4710	.1301	2.0384
158	" "	6.5518	.2158	.9001	.0965	1.2146
157	" "	8.9292	.1205	.6616	.3188	1.3009
35	L. megalotis	17.9248	.4066	1.0550	.0369	1.4990
256	" "	22.8666	.6484	2.6942	.4042	3.2269

Table 24
Winter 1/16/78
Station 7

Sample Number	Species	Average Weight	1242	1254	1260	Total
234	M. punctulatus	2.4159	.1296	.6512	.1108	1.2516
237	D. cepedianum	5.4146	.6942	2.3088	.1371	3.2204
236	" "	6.3366	.1854	1.7394	.3547	2.2326
235	" "	8.1677	.9923	2.3642	.3083	3.6649

Table 25
Spring 4/14/78
Station 7

Sample Number	Species	Average Weight	1242	1254	1260
335	L. microlepis	9.1583	.2168	2.1481	.8414
337	L. cyanellus	16.2096	.1364	.3740	.1748
342	M. punctulatus	2.9953	.2790	1.5152	.4293
343	" "	3.0968	.1982	1.3397	.2851
341	" "	4.0161	.2343	1.1776	.3543
340	" "	4.4433	.4427	2.0505	.3945
339	" "	6.8246	.3114	1.1642	.3515
338	" "	9.0797	.2932	1.3471	.4261

Table 26
Summer 8/3/78
Station 7

Sample Weight	Species	Average Weight	1242	1254	1250	Total
465	M. punctulatus	1.6676	.1973	1.5275	.6993	1.9242
464	" "	2.0490	.1570	.5394	.2026	.9491
463	" "	2.7576	.3307	.6605	.1054	1.0967
462	" "	2.9252	.2334	.9309	.1735	1.3344
466	M. salmoides	3.2966	.1296	.5034	.0546	.7277
461	M. punctulatus	3.7885	.2901	.8080	.1548	1.2530
459	" "	6.0870	.3774	1.6627	.2018	2.2417
460	L. cyanellus	1.2132	.2352	.8520	.2085	1.2958
458	" "	2.3444	.3061	.5710	.0672	.9345
457	L. macrochirus	8.9947	.2453	.5715	.0747	.3915
455	" "	10.9957	.5855	1.3924	.2100	2.1618
450	L. megalotis	11.0062	.3386	.9235	.0955	1.3577
452	L. marginatus	13.4303	.3415	.7062	.0772	1.1251
454	L. macrochirus	14.0307	.5471	1.3776	.2555	2.1842
456	L. macrochirus	14.6839	.3182	1.1504	.1821	1.6508
449	L. megalotis	15.9581	.1474	.4533	.1320	.7329
451	L. marginatus	17.2815	.6457	1.5513	.5003	2.6973
453	" "	17.9965	.3036	.6311	.2058	1.3856
532	L. microlophus	20.3233	.8608	1.7808	.4240	3.0638
531	L. cyanellus	23.5956	.5487	1.1421	.1384	1.8691
536	L. megalotis	27.0635	.1905	.5548	.1059	.8548
534	" "	30.3050	.9214	3.1851	.4657	4.5864
534	L. marginatus	31.3732	.7744	2.2126	.2959	3.2839
530	L. cyanellus	38.7443	.2609	1.1279	.2273	1.6152
535	L. macrochirus	40.4944	.7329	3.4029	.9527	5.1662
533	L. microlophus	65.1710	.0857	1.0028	.4204	1.5159

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Table 27
Fall 10/5/77
Station 8

<u>Sample Number</u>	<u>Species</u>	<u>Average Weight</u>	<u>1242</u>	<u>1254</u>	<u>1260</u>	<u>Total</u>
165	M. punctulatus	6.4358	.4444	2.0140	.5570	3.0155
23	L. megalotis	7.1522	1.3882	4.4170	.4805	6.2860
265	D. cepedianum	22.1524	.3810	1.7385	.3316	2.4512
264	" "	35.5650	1.6642	4.3738	.9312	6.9692
268	Roccus chrysops	54.6175	.4601	2.5868	.8046	3.8516
267	" "	57.2133	.6684	2.8096	1.1877	4.6658
266	" "	88.5009	.9504	2.2578	.4218	3.6315

Table 28
Winter 1/16/78
Station 8

<u>Sample Number</u>	<u>Species</u>	<u>Average Weight</u>	<u>1242</u>	<u>1254</u>	<u>1260</u>	<u>Total</u>
239	D. cepedianum	4.4364	.2539	3.5429	.2741	4.0540
240	" "	4.8650	.7836	2.5282	.3955	3.6974
241	" "	6.2158	5.4625	5.2241	1.0417	11.7285

Table 29
Spring 4/14/78
Station 8

Sample Number	Species	Average Weight	1242	1254	1260	Total
372	N. chyssocephalus	12.8245	.1739	.5525	.0930	.8194
371	M. punctulatus	10.7783	.3537	2.2684	.5136	3.1419
376	D. cepedianum	23.8031	.7088	3.0652	.6903	4.4644

Table 30
Summer 8/3/78
Station 8

Sample Number	Species	Average Weight	1242	1254	1260	Total
399	M. punctulatus	2.9069	.2141	1.2031	.2020	1.6193
398	" "	3.9332	.6453	1.5445	.3206	2.5104
397	" "	4.4987	.9553	3.2201	.7593	4.9349
400	" "	5.2860	.1114	1.3924	.5035	2.0134
397	M. salmoides	5.8758	.2975	2.2362	.6755	3.2093
395	N. chyssocephalus	7.5952	.2716	1.5915	.4126	2.2219
401	Roccus chrysops	12.0549	.0985	.4553	.0809	.6345
558	" "	20.9416	.2426	1.3960	.2573	1.6712

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Table 31
Summer 8/3/78
Station 9

Sample Number	Species	Average Weight	1242	1254	1260	Total
380	N. stilbius	.3753	4.4734	8.5607	3.5738	15.6079
384	" "	2.5037	5.9270	13.9479	4.1800	24.0549
386	" "	3.7144	2.8695	5.6708	2.8450	11.3654
380	N. venustus	4.2972	8.7061	9.1720	3.4903	21.4094
389	L. megalotis	4.2018	4.1511	2.7002	1.6764	11.4334
387	L. microlophus	5.7074	.1894	1.0516	.1648	1.4052
382	L. macrochirus	13.8782	3.5664	5.8833	2.8669	12.3166
394	Phenacobius sp.	.6877	8.5290	12.9233	3.3595	24.7527
393	" "	4.1457	3.9644	10.5834	6.0638	21.5117
392	" "	5.6187	21.0910	52.5748	14.6725	72.4554

APPENDIX B.

CAPSULATION OF THE BENTHOS FIELD DATA

MONS 050478

Table 32

Capsulation of Current Benthos Information

Benthos Data*

Sampling Station	Species	Period	Concentration of PCBs (ppm)			
			Total	1242	1254	1260
1	<u>Corbicula sp.</u> (bivalve mussel)	Fall of 1977	0.14 (0.08)	0.039 (0.036)	0.083 (0.044)	0.016 (0.013)
1	"	Winter of 1977	0.14 (0.09)	0.084 (0.064)	0.044 (0.021)	0.0071 (0.0059)
2	"	Fall of 1977	5.65 (1.39)	2.86 (0.77)	2.54 (0.67)	0.25 (0.09)
2	"	Winter of 1977	7.72 (2.05)	4.30 (1.23)	3.32 (0.70)	0.29 (0.10)
2	<u>Sphaeridae sp.</u> (native clam)	Winter of 1977	1.95	1.10	0.68	0.17
5A	<u>Corbicula sp.</u>	Winter of 1977	4.51 (1.72)	0.76 (0.35)	3.47 (1.46)	0.29 (0.18)
6	"	Fall of 1977	1.36 (1.03)	0.42 (0.32)	0.78 (0.76)	0.08 (0.07)
6	<u>Anodonta Imbicillis</u> (native mussel)	Fall 1977	0.25 (0.12)	0.09 (0.11)	0.14 (0.02)	0.019 (0.016)
6	<u>Corbicula sp.</u>	Winter of 1977	7.97 (2.41)	1.99 (0.71)	5.40 (1.85)	0.55 (0.23)
6	<u>Anodonta Imbicillis</u>	Winter 1977	2.17 (1.19)	1.08 (1.08)	1.05 (0.14)	0.05 (0.02)

*() = One Standard Deviation

APPENDIX C
AVERAGE PCB CONCENTRATION
OF EACH GENUS
ON A STATION PER SEASON BASIS

MONS 050480

	<u>A1242</u>	<u>A1254</u>	<u>A1260</u>	<u>Total ECB</u>
<u>Campostoma</u>				
Station 2				
fall	21.91	18.67	6.34	46.93
spring	14.06	25.58	4.27	82.67
Station 3				
fall	0.52	1.54	0.21	2.26
spring	0.14	0.54	0.20	0.88
<u>Dorosoma</u>				
Station 4				
fall	10.58	13.77	3.12	27.41
winter	5.33	6.51	4.01	15.87
summer	2.68	3.51	1.06	7.11
Station 5				
fall	0.65	2.09	0.31	2.86
winter	0.46	1.59	0.48	2.36
spring	2.19	5.82	0.73	8.74
summer	0.19	0.81	0.12	1.13
Station 6				
fall	1.42	3.35	0.57	5.35
Station 7				
winter	0.62	2.16	0.26	3.06
Station 8				
fall	1.02	3.05	0.63	4.71
winter	2.17	3.76	0.56	6.50
spring	0.70	3.06	0.69	4.46
<u>Gambusia</u>				
Station 1				
fall	0.10	0.07	0.00	0.18
spring	0.05	0.22	0.06	0.35
summer	0.35	0.16	0.04	0.25

	<u>A1242</u>	<u>A1254</u>	<u>A1260</u>	<u>Total FCB</u>
<u>Gambusia</u>				
Station 2				
fall	22.35	24.93	1.62	51.66
spring	11.78	11.53	3.64	26.96
summer	10.25	9.13	1.77	21.16
Station 3				
fall	0.69	1.10	0.08	2.26
Station 4				
summer	3.37	11.88	4.33	19.59

<u>Hypentelium</u>				
Station 1				
fall	0.11	0.08	0.00	0.20
winter	0.36	0.35	0.14	0.87
summer	0.05	0.26	0.02	0.35
Station 2				
winter	25.26	22.49	9.07	56.83
Station 3				
fall	0.06	0.22	0.08	0.37
winter	0.03	0.13	0.07	0.22

<u>Leomina</u>				
Station 1				
fall	0.04	0.06	0.00	0.11
winter	0.09	0.33	0.06	0.48
spring	0.05	0.21	0.04	0.31
summer	0.05	0.14	0.03	0.23
Station 2				
fall	9.28	8.13	2.28	19.69
winter	10.71	10.99	6.27	28.41
spring	5.01	3.61	0.60	9.22
summer	9.45	8.14	2.46	20.09

	<u>A1242</u>	<u>A1254</u>	<u>A1260</u>	<u>Total PCB</u>
<u>Lernaeis</u>				
Station 3				
fall	0.11	0.47	0.14	0.73
winter	0.24	0.37	0.11	0.73
spring	0.11	0.35	0.16	0.63
Station 4				
fall	4.88	5.52	0.77	11.20
winter	2.62	4.46	2.02	9.10
spring	2.58	5.94	3.27	11.79
summer	2.97	6.55	2.84	12.37
Station 5				
fall	0.13	0.96	0.09	1.20
winter	0.08	0.70	0.13	0.91
spring	0.08	1.06	0.12	1.26
summer	0.11	0.81	0.10	1.02
Station 6				
fall	0.85	2.67	0.35	4.03
spring	0.69	3.36	0.51	4.57
summer	1.18	3.88	1.02	6.09
Station 7				
fall	0.52	1.87	0.26	2.66
spring	0.17	1.27	0.51	1.97
summer	0.44	1.31	0.26	2.02
Station 8				
fall	1.38	4.41	0.48	6.28
Station 9				
Summer	2.63	3.21	1.56	8.38

Microcraterus

Station 1				
fall	0.15	0.44	0.00	0.61
winter	1.71	6.58	1.04	10.25
summer	0.06	0.29	0.07	0.42

	<u>A1242</u>	<u>A1254</u>	<u>A1260</u>	<u>Total FCB</u>
<u>Micropterus</u>				
Station 2				
fall	18.57	19.25	4.32	42.30
winter	19.14	16.19	6.80	42.14
spring	11.39	11.49	6.30	29.19
summer	6.08	5.85	2.37	14.30
Station 3				
fall	0.01	0.14	0.01	0.17
spring	0.14	1.13	0.63	1.91
Station 4				
fall	5.87	10.03	1.61	17.52
winter	2.86	4.61	3.28	10.75
spring	1.63	8.06	8.01	17.72
Station 5				
fall	0.12	2.05	0.35	2.53
winter	0.13	1.22	0.26	1.61
spring	0.17	1.76	0.33	2.27
summer	0.08	1.22	0.14	1.45
Station 6				
fall	0.40	3.91	0.25	4.47
spring	0.55	5.34	2.08	7.98
summer	0.43	1.70	0.38	2.52
Station 7				
fall	0.39	1.57	0.20	2.17
winter	0.12	0.96	0.16	1.25
spring	0.29	1.50	0.37	2.17
summer	0.24	0.95	0.14	1.34
Station 8				
fall	0.44	2.01	0.55	3.01
spring	0.35	2.26	0.51	3.14
summer	0.44	1.91	0.50	2.87
<u>Notropis</u>				
Station 1				
fall	0.01	0.08	0.01	0.11
winter	0.33	0.32	0.36	0.73
spring	0.06	0.23	0.07	0.36
summer	0.20	0.41	0.11	0.73

	<u>A1242</u>	<u>A1254</u>	<u>A1260</u>	<u>Total FCB</u>
<u>Notronis</u>				
Station 2				
fall	14.66	19.39	5.63	48.15
winter	14.46	13.15	4.80	32.60
spring	8.91	7.05	2.20	18.17
summer	15.91	18.03	8.94	42.90
Station 3				
fall	0.49	1.86	0.24	2.60
winter	0.40	1.16	0.45	2.02
spring	0.63	2.45	0.73	3.94
Station 5				
fall	0.15	2.10	0.30	2.66
spring	0.49	3.66	0.65	4.81
Station 6				
fall	0.36	1.82	0.24	2.44
summer	0.76	2.39	0.45	3.61
Station 8				
spring	0.17	0.55	0.09	0.83
summer	0.27	1.53	0.41	2.22
Station 9				
summer	5.49	9.35	2.52	18.37

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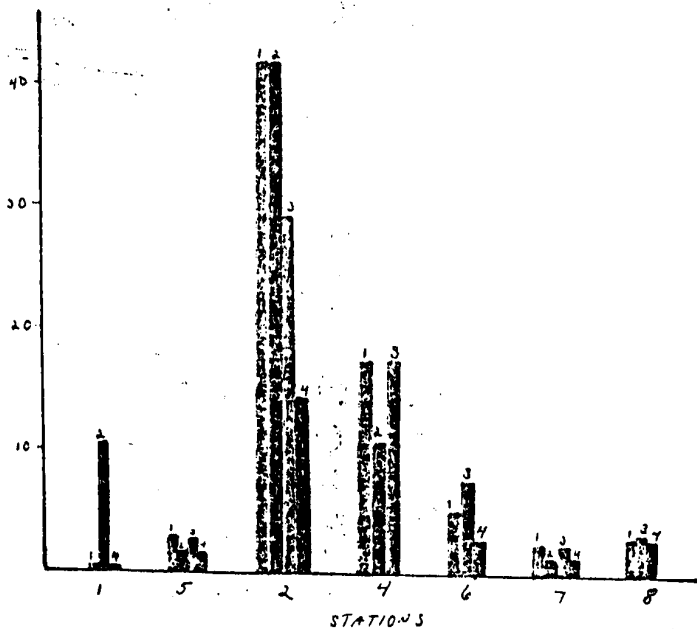
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Figure 10

MEAN TOTAL PCB
IN MICROPTERUS SP.
ON A STATION &
SEASONAL BASIS



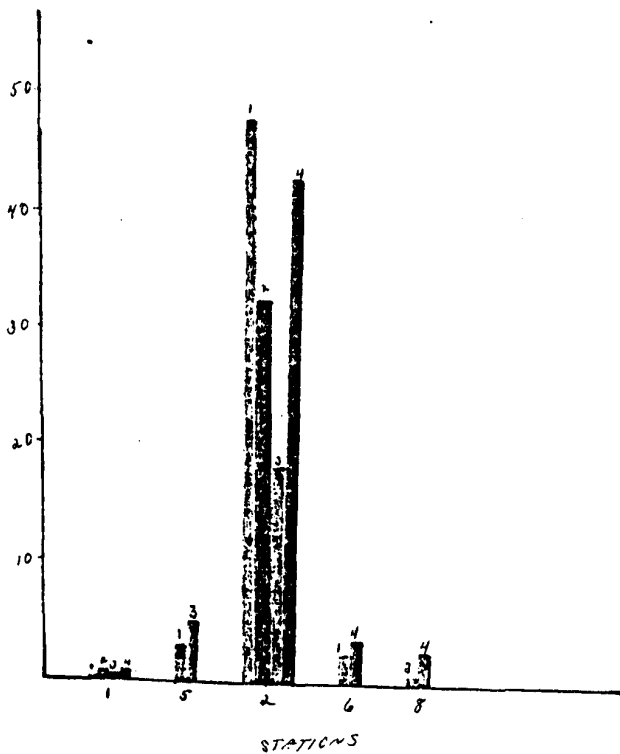
THE SEASONS ARE MARKED ABOVE EACH BAR:

- 1- FALL
- 2- WINTER
- 3- SPRING
- 4- SUMMER

MONS 050367

Figure
MEAN TOTAL PCB
IN NOTROPIS SP
ON A STATION &
SEASONAL BASIS

ppm
PCB



MONS 050368

TABLE 14

Humic and Fluvic Acid Content of Sediment
From Station 1 to 6
(Chen, 1972)

<u>Station</u>	<u>Fluvic Acid</u>		<u>Humic Acid</u>	
	<u>mg/l</u>	<u>mg/kg</u>	<u>mg/l</u>	<u>mg/kg</u>
1	117	140	152	183
2	49	59	221	265
3	62	74	178	214
4	175	210	134	161
5	123	147	137	164
6	77	92	141	169

TABLE 15

Organic Carbon
(Walkley-Black Method)
OF SEDIMENT FROM
STATIONS 1 TO 6

<u>Station</u>	<u>% Carbon</u>
1	0.711
2	0.197
3	0.251
4	>0.8
5	0.720
6	0.155

Table 16
Water Quality

Fall Survey (Oct. 14, 1977)

<u>Station</u>	<u>DO</u>	<u>Alk</u>	<u>Temp.</u>	<u>pH</u>	<u>Color</u>
1	9.6	60	16.6	7.1	20
2	7.7	90	16.7	7.5	48
3	9.1	110	16.7	7.9	30
4	7.3	90	18.8	7.6	45
5	7.5	60	26.0	8.2	95
6	6.6	60	25.5	7.3	55

<u>Station</u>	<u>Turb.</u>	<u>Cl</u>	<u>SO₄</u>	<u>Total Fe</u>	<u>Cond.</u>
1	19	2.5	0	0.35	115
2	19	20	14	0.22	220
3	16	2.5	2	0.20	200
4	18	10	4	0.16	190
5	24	2.5	7	0.20	150
6	24	5	9	0.23	160

<u>Station</u>	<u>SS</u>	<u>CO₂</u>	<u>TOC</u>
1	6	8.0	8.3
2	10	20.0	11.5
3	11	12.0	12.9
4	8	12.0	8.0
5	12	4.0	14.1
6	17	12.0	----

DO- Dissolved Oxygen (mg/l)
 Alk- Alkalinity in mg/l as CaCO₃
 Temp- Temperature C
 Color- APHA Platinum Cobalt Standard
 Turb- Turbidity in FTU Formazin Turbidity Units
 Cl- Chlorid (mg/l)
 SO₄- Sulfate (mg/l)
 Fe- Iron (mg/l)
 Cond.- Conductivity (umhos/cm)
 SS- Suspended Solids (mg/l)
 CO₂- Carbon Dioxide (mg/l)
 TOC- Total Organic Carbon (mg/l)

MONS 050370

Table 16
(continued)

Winter Survey (Jan. 11, 1978)

<u>Station</u>	<u>DO</u>	<u>Alk.</u>	<u>Temp.</u>	<u>pH</u>	<u>Color</u>
1	8.9	30	4.4	6.8	55
2	9.3	35	4.4	7.0	105
3	8.9	65	6.6	7.4	72
4	9.7	50	4.9	7.4	88
5	9.2	90	8.8	7.4	88
6	9.5	70	4.9	7.4	160

<u>Station</u>	<u>Turb.</u>	<u>Cl</u>	<u>Total Fe</u>	<u>Cond.</u>	<u>SS</u>
1	62	2.0	0.48	67	8
2	75	11.5	0.89	130	21
3	42	2.0	0.20	150	22
4	60	8.0	0.39	140	38
5	55	3.0	0.50	155	18
6	68	3.5	0.52	112	22

<u>Station</u>	<u>CC</u>
1	16
2	12
3	20
4	16
5	24
6	16

Table 16
(continued)

Spring Survey (April 14, 1978)

<u>Station</u>	<u>DO</u>	<u>Alk.</u>	<u>Temp.</u>	<u>pH</u>	<u>Color</u>
1	8.8	80	15.8	7.0	120
2	8.7	100	18.8	7.1	99
3	9.0	130	19.0	7.5	140
4	7.9	120	21.0	7.5	70
5	12.2	160	24.0	9.4	180
6	7.7	80	22.0	8.3	300

<u>Station</u>	<u>Turb.</u>	<u>Cl</u>	<u>SO₄</u>	<u>Total Fe.</u>	<u>Cond.</u>
1	42	5	3	0.15	119
2	49	20	18	0.25	220
3	32	5	2	0.42	152
4	24	20	15	0.12	230
5	64	5	3	0.49	183
6	88	10	8	0.07	138

<u>Station</u>	<u>SS</u>	<u>CO₂</u>
1	162	4
2	245	4
3	140	8
4	122	8
5	202	0
6	182	8

Table 16
(continued)

Summer Survey (Aug. 13, 1978)

<u>Station</u>	<u>DO</u>	<u>Alk.</u>	<u>Temp.</u>	<u>pH</u>	<u>Color</u>
1	6.1	60	26	6.5	20
2	7.2	140	25.5	7.3	10
3	6.0	140	26	7.7	10
4	10.4	130	32	8.7	30
5	7.4	90	32	7.0	5
6	6.4	100	30	6.9	3

<u>Station</u>	<u>Turb.</u>	<u>Cl</u>	<u>Total Fe</u>	<u>Cond.</u>	<u>SS</u>
1	5	5	0.19	105	2
2	10	90	0.08	505	3
3	10	60	0.05	470	---
4	30	30	0.08	290	5
5	5	15	0.01	200	8
6	3	10	0.02	180	3

<u>Station</u>	<u>CO₂</u>
1	4
2	4
3	8
4	0
5	4
6	4

02404400 CHOCOLOCOCO CREEK AT JACKSON SHOALS, NEAR LINCOLN, AL

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LOCATION.--Lat 33°32'54", long 86°05'49", in SE¼ sec. 15, T. 17 S., R. 5 E., Talladega County, Hydrologic Unit 03190100, on left bank at foot of Jackson Shoals, 30 ft (15 m) upstream from Alabama Power Company Jackson Shoals transformer station, 900 ft (274 m) upstream from highway bridge, 1.8 mi (2.9 km) downstream from Hartsbago Creek, and 4.5 mi (7.2 km) southeast of Lincoln.

DRAINAGE AREA.--484 mi² (1,254 km²).

PERIOD OF RECORD.--October 1976 to current year.

REMARKS.--Miscellaneous samples of chemical data published for water years 1965-68, 1974.

COOPERATION.--Water-quality samples were collected by the U.S. Geological Survey and were analyzed by the Geological Survey of Alabama.

WATER-QUALITY DATA, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
(ND denotes constituent not detected)

DATE	TIME	SPECIMEN- FLOW- INSTANT- FANEDUS (LFS)	SPE- CIFIC CON- DUCT- ANCE (MICHO- MMHS)	PH	TEMPER- ATURE (DEG C)	DISTOL- DIS- SOLVED (MG/L)	HAPO- NESS (MG/L AS CACO3)	HAPO- NESS- MUNICAM- MUNATE (MG/L AS CACO3)	CALLIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM DIS- SOLVED (MG/L AS MG)
OCT										
06...	1200	203	200	8.0	18.5	9.3	97	15	14	12
NOV										
18...	1230	040	231	7.8	14.0	8.8	78	4	16	9.2
JAN										
06...	1300	491	240	7.9	9.0	11.8	98	10	24	9.2
FEB										
23...	1215	538	255	7.8	7.0	11.6	93	8	19	11
MAR										
31...	1200	615	252	7.8	17.0	10.3	90	--	21	9.2
MAY										
16...	1230	1058	--	7.4	18.0	8.8	56	8	12	6.3
JUN										
30...	1115	350	352	7.4	26.0	7.3	110	8	23	12
AUG										
03...	1045	229	430	7.8	26.9	7.9	110	4	23	13
SEP										
12...	1538	240	425	8.0	24.0	8.4	120	13	25	14

DATE	SODIUM DIS- SOLVED (MG/L AS NA)	SODIUM PENCENT	SODIUM AD- SUM- TION RATIO	POTAS- SIUM DIS- SOLVED (MG/L AS K)	MICRO- MUNATE (MG/L AS MCO3)	CAN- MUNATE (MG/L AS CO3)	ALUM- INITY (MG/L AS AL2O3)	CARBON DIOXIDE DIS- SOLVED (MG/L AS CO2)	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE DIS- SOLVED (MG/L AS CL)
OCT										
06...	5.0	10	.2	1.2	100	0	82	1.8	7.2	4.0
NOV										
18...	15	29	.7	1.8	98	0	74	2.3	11	14
JAN										
06...	16	26	.7	1.2	100	0	82	2.8	16	28
FEB										
23...	13	23	.6	1.1	140	0	98	3.0	13	11
MAR										
31...	17	29	.8	1.8	--	--	--	--	14	15
MAY										
16...	8.9	25	.5	1.4	73	0	60	4.6	8.4	9.2
JUN										
30...	27	35	1.1	1.4	128	0	98	7.8	--	28
AUG										
03...	40	43	1.7	1.7	130	0	197	3.3	42	40
SEP										
12...	30	39	1.4	1.5	130	0	197	33	36	43

24

02404400 CHOCOLOCCO CREEK AT JACKSON SHOALS, NEAR LINCOLN, AL--Continued

WATER-QUALITY DATA, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
(ND denotes constituent not detected)

DATE	FLUO- NIOB- SOLVED (MO/L AS F)	SILICA, US- SOLVED (MO/L AS SIO2)	SULFOS- SUM OF CONSTIT- TUNTS- US- SOLVED (MO/L)	SULFOS, DIS- SOLVED TUNTS PER AC-F)	SULFOS, US- SOLVED TUNTS PER UNF)	NITRO- GEN, NITRATE DIS- US- SOLVED (MO/L AS N)	NITRO- GEN, NITRATE SOL- US- SOLVED (MO/L AS NO3)	AMMONI- UM, US- SOLVED (MO/L AS NH4)	CALCIUM US- SOLVED (MO/L AS CU)	CUM- NIOB- US- SOLVED (MO/L AS CR)
UCT										
00...	.8	0.0	119	.16	87.9	2.0	0.9	1	1	1
NOV										
00...	.1	0.0	128	.17	227	.40	1.7	NU	1	
JAN										
00...	.1	7.0	181	.21	200	.09	.42	1	1	NU
FEB										
00...	.1	0.0	136	.10	196	.09	.41	1	1	1
MAR										
00...	.1	5.7	--	--	--	.90	3.8	1	1	NU
APR										
00...	.0	7.0	98	.13	220	1.0	0.3	NU	1	
MAY										
00...	.1	9.1	--	--	--	.00	.01	1	1	1
JUN										
00...	.1	18	204	.33	100	1.7	7.4	1	1	1
JUL										
00...	.1	0.0	229	.21	100	.04	1.4	1	1	1

DATE	COMBAT	INDB	LEAD	RAMBO	MCURRY	STONER	CMURPHY	CMURPHY
	US SULVER AS CO	US SULVER AS FL	US SULVER AS PW	US SULVER AS MI	US SULVER AS MI	US SULVER AS MI	US SULVER AS MI	US SULVER AS MI
OCT								
08...	1	40	2	30	40	00	20	--
NOV								
10...	1	20	1	45	2	70	40	--
JAN								
08...	41	30	2	30	2	50	00	000
FEB								
23...	1	20	NU	37	2	110	40	--
MAR								
21...	NU	70	1	70	4	50	140	--
NOV								
10...	2	110	2	60	4	40	00	--
JUN								
20...	1	40	NU	62	4	20	20	--
AUG								
02...	41	00	1	20	5	70	50	--
SEP								
12...	1	10	4	30	2	40	40	--

MONS 050375

TABLE 17 (CONTINUED)

98

MOBILE RIVER BASIN MOBILE RIVER MAIN STEM

92407090 COOSA RIVER AT CHILDERSBURG, AL--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--October 1962 to current year.

PERIOD OF DAILY RECORD.--

WATER TEMPERATURES: October 1962 to current year.

INSTRUMENTATION.--Temperature Recorder since October 1962.

COOPERATION.--Water-quality samples were collected by the U.S. Geological Survey and were analyzed by the Geological Survey of Alabama.

EXTREMES FOR PERIOD OF DAILY RECORD.--

WATER TEMPERATURES: Maximum, 36.0°C July 6, 1969; minimum, 2.6°C on several days in January 1977.

EXTREMES FOR CURRENT YEAR.--

WATER TEMPERATURES: Maximum, 32.5°C July 4; minimum, 3.5°C Jan. 22, Feb. 6, 9.

WATER-QUALITY DATA, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978

(ND denotes constituent not detected)

DATE	TIME	STREAM- FLOW, INSTANT- TAMEBUS (CFS)	SPE- CIFIC CON- DUCT- ANCE (MICHO- MHOS)	PH	TEMPER- ATURE (DEG C)	DISSOLV- ED SOLIDS (MG/L)	MANG- NESE AS CACO3	MANG- NESE MANGANESE (MG/L)	CALCIUM DISE- SOLV- ED AS CA	MAGNE- SIUM DISE- SOLV- ED AS MG
NOV 15...	0900	12700	142	7.3	11.8	11.3	56	3	15	4.3
APR 11...	0930	6300	150	7.7	10.5	6.2	66	0	10	4.6
DATE	AS NA	SODIUM PNCENT	SODIUM AS- SOLV- ED RATIO	POTAS- SIUM DISE- SOLV- ED AS K	BICAR- BONATE DISE- SOLV- ED AS HCO3	CAN- BONATE DISE- SOLV- ED AS CO3	ALUM- INATE DISE- SOLV- ED AS AL(OH)	AMMONI- UM DISE- SOLV- ED AS NH4	SULFATE DISE- SOLV- ED AS SO4	
NOV 15...	5.3	17	.3	1.1	64	8	52	5.1	7.0	
APR 11...	4.6	13	.3	1.0	60	0	50	2.4	4.0	
DATE	AS CL	CHLO- RIDE DISE- SOLV- ED AS CL	FLUO- RIDE DISE- SOLV- ED AS F	SILICA DISE- SOLV- ED AS SiO2	SOLIDS, SUM OF CONSTIT- UENTS DISE- SOLV- ED (MG/L)	SOLIDS, DISE- SOLV- ED (MG/L)	SOLIDS, DISE- SOLV- ED (MG/L)	NITRO- GEN, NITRATE DISE- SOLV- ED AS N	NITRO- GEN, NITRATE DISE- SOLV- ED AS N	AMMONI- UM DISE- SOLV- ED AS NH4
NOV 15...	5.0	.1	7.2	76	-11	2090	-23	1.0	1	
APR 11...	5.2	.1	6.3	60	-12	1500	1.1	4.9	1	
DATE	AS CU	COPPER DISE- SOLV- ED AS CU	CADMA- TUM DISE- SOLV- ED AS Cd	IRON, DISE- SOLV- ED AS FE	LEAD, DISE- SOLV- ED AS Pb	MANGA- NESE DISE- SOLV- ED AS Mn	MANGA- NESE DISE- SOLV- ED AS Mn	SILICO- N DISE- SOLV- ED AS Si	ZINC, DISE- SOLV- ED AS Zn	
NOV 15...	1	ND	--	90	1	31	.3	130	40	
APR 11...	1	ND	1	20	ND	100	.5	80	50	

MONS 050376

Table 18

Particle Size of the Sediment
(See Fig. 1 for Station Locations)

<u>Station</u>	<u>% silt or finer (.074mm)</u>	<u>% clay or finer (0.005mm)</u>
1	.0-5-3	0.5
2	13-55	8-13
3	10-13	10
4	38-65	18-38
5	0.5	0.5
6	19-56	10-19
G	31-79	12-31
H	25-75	12-25
I	6-42	2-6
J	56-100	23-56
K	10-42	7-10

PARTICLE SIZE ANALYSIS OF SAMPLES TAKEN DURING THE SUMMER
COLLECTING PERIOD

Sample A: Station 1

B: Station 2

C: Station 3

D: Station 4

E: Station 5

F: Station 6

G: Station 10

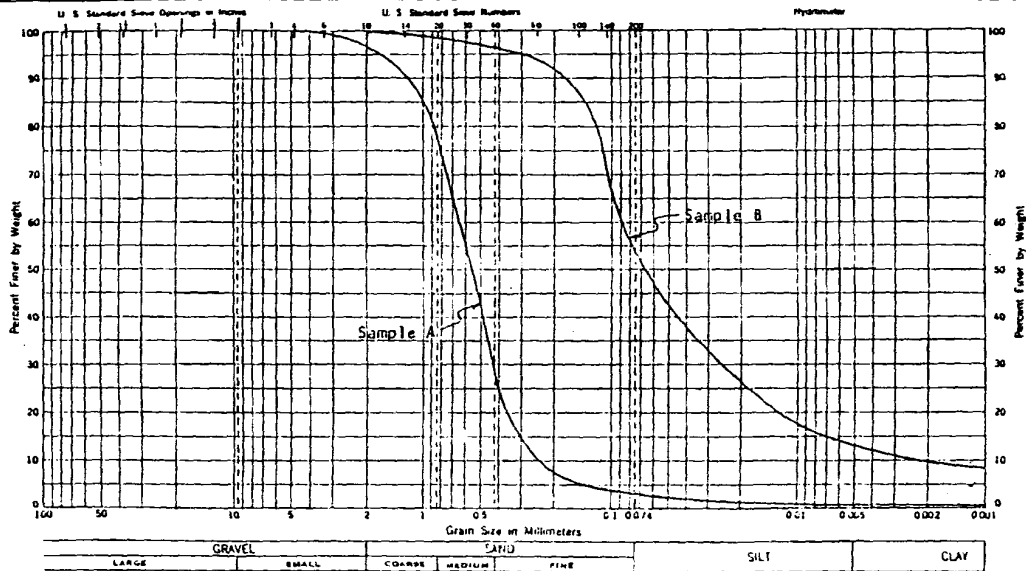
H: Station 11

I: Station 12

J: Station 13

K: Station 14

FIGURE 12

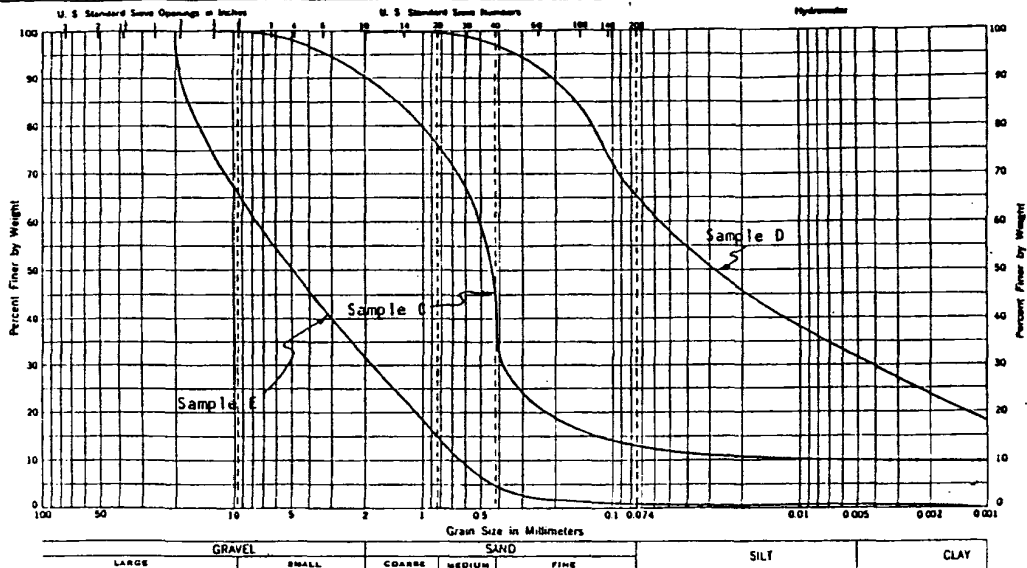


GRAIN SIZE CURVES

HYDROMETER & SIEVE ANALYSIS
 FURNISHED SAMPLES 1/16/79
 DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES
 TULANE UNIVERSITY
 NEW ORLEANS, LOUISIANA

MONS 050379

Figure 13

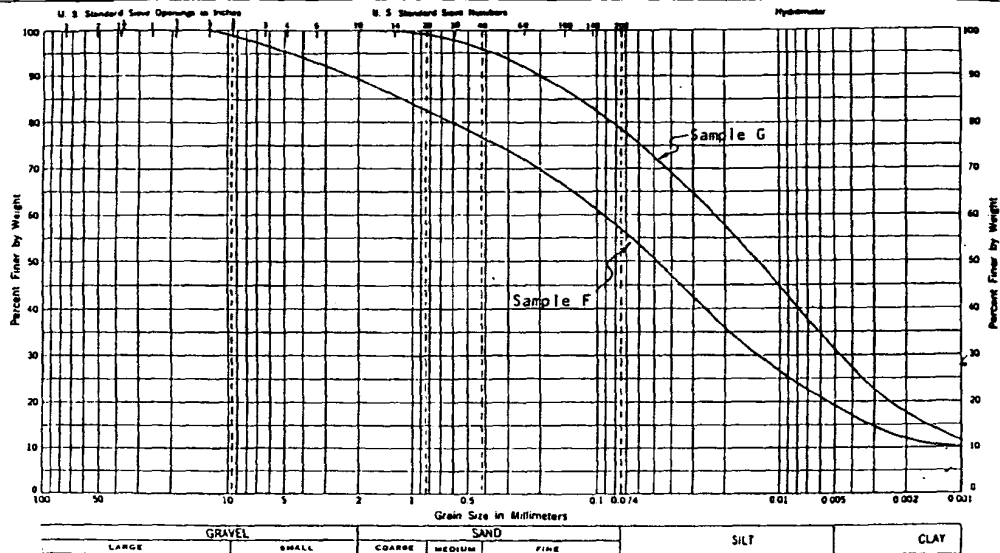


GRAIN SIZE CURVES

MONS 050380

HYDROMETER & SIEVE ANALYSIS
FURNISHED SAMPLES 1/16/79
DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES
TULANE UNIVERSITY
NEW ORLEANS, LOUISIANA

Figure 14



GRAIN SIZE CURVES

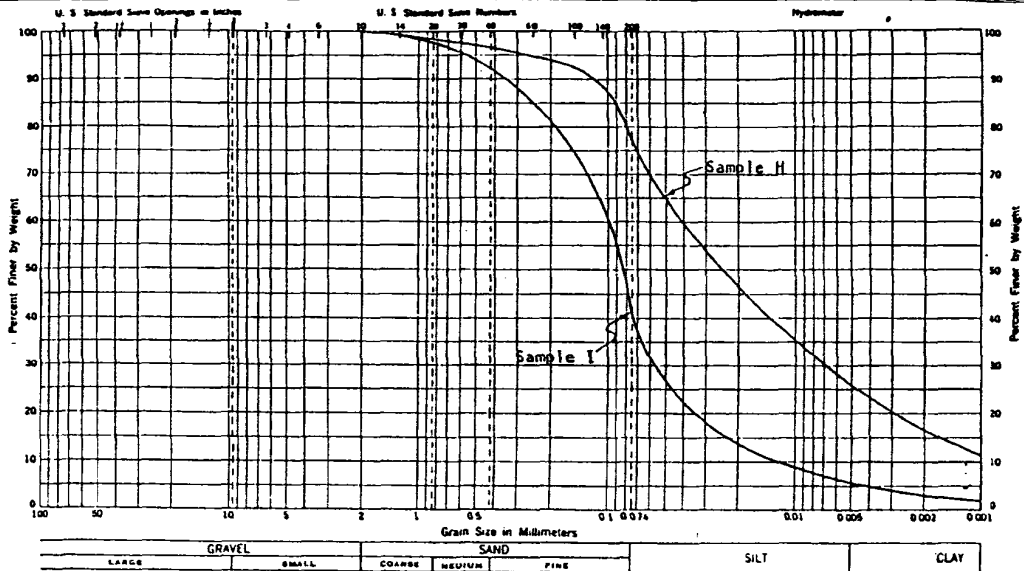
HYDROMETER & SIEVE ANALYSIS
 FURNISHED SAMPLES 1/16/79
 DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES
 TULANE UNIVERSITY
 NEW ORLEANS, LOUISIANA

MONS 050381

J-2138

Fig. 14

Figure 15



GRAIN SIZE CURVES

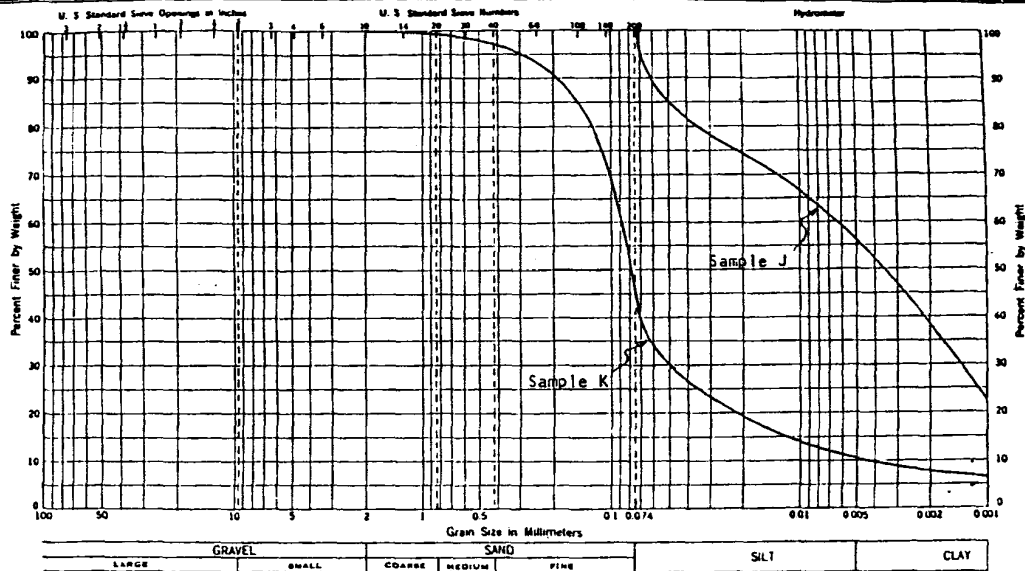
HYDROMETER & SIEVE ANALYSIS
 FURNISHED SAMPLES 1/16/79
 DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES
 TULANE UNIVERSITY
 NEW ORLEANS, LOUISIANA

MONS 050382

J-2139

Fig. 15

Figure 16



GRAIN SIZE CURVES

HYDROMETER & SIEVE ANALYSIS
 FURNISHED SAMPLES 1/16/79
 DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES
 TULANE UNIVERSITY
 NEW ORLEANS, LOUISIANA

MONS 050383

C. THE RELATIONSHIP OF WET WEIGHT TO PCB CONCENTRATION. *IN FISH*

Figures 17 and 18 compare the weight-ppm and log weight-log ppm correlations of all species combined at Stations 2 and 4. The statistics for all stations are summarized in Table 19. The weight vs ppm plots are significant at 5 stations; 1,2,4,5 and 6. Four of the 8 stations are significant in the log-log model; 2,4,5 and 6. Therefore, combining the results of both methods, 5 of 8 stations show a significant correlation between weight and ppm PCB, Stations 1,2,4,5 and 6. Station 1 is significant in the weight-ppm model only and stations 7 and 8 are not significant in either. The significance levels are not consistently better in either model. The correlation coefficients also are not greatly affected by either model. Four of the 5 significant correlations show a positive relationship between body weight and PCB concentration (Stations 1,4,5 and 6) while station 2 has a weak but significant negative correlation.

From this analysis then, there appears to be an increase of PCB level with weight, with the exception of Station 2. However, the mixture of species causes the correlations to be very weak and in the case of station 2, to be negative.

To determine the accumulation trends of each species, these linear analyses were done on each species at each station.

Table 19

Linear Correlation Analysis of All Species Combined
at Each Station
on the Weight vs ppm and Log Weight vs Log ppm Basis
PCB PCB

<u>Station</u>	<u>Weight vs ppm PCB</u>			<u>Log Weight vs Log ppm PCB</u>	
	<u>Corr. R</u>	<u>p</u>	<u>n</u>	<u>Corr. R</u>	<u>p</u>
1	0.40	0.0001*	80	0.05	0.31
2	-0.28	0.006 *	74	-0.31	0.003 *
3	-0.13	0.15	57	-0.21	0.052
4	0.19	0.042 *	78	0.35	0.0007 *
5	0.51	0.00001 *	86	0.42	0.00002 *
6	0.35	0.005 *	52	0.43	0.0006 *
7	0.21	0.067	49	0.16	0.12
8	0.07	0.37	21	0.10	0.33

* Significant, $p \leq 0.05$

MONS 050385

The statistics are summarized in Tables 20 and 21 and Figures 19 and 20 are plots of 2 of the significant relationships. Again, there are highly significant correlations between wet weight and ppm PCB with both linear models. Thirteen of 29 cases or 44% were significant when combining the results of both models. Six of the 13 were significant in both models, 9 in the log-log model and 10 in the weight-ppm model. Of the 13 significant cases 9 have a positive correlation and 4 are negative. These negative correlations are not specific to any one station or species. The correlation coefficients are greater when analyzing each species separately than when they were all analyzed together at each station. The log-log model gives slightly stronger and more highly significant results. In summary, there is a tendency for PCB to accumulate with weight and the log-log model is a slightly better description of the relationship than the weight-ppm model.

To determine whether there are seasonal influences on this weight-ppm relationship, therefore, the data was analyzed on the species per station per season basis. The results are shown in Tables 22 and 23 and Figures 21-23 are plots of some of the significant cases. This breakdown of the data resulted in some very small sample sizes and therefore, only those cases with 5 or more points were analyzed. Of 41 analyses 12, or 30%, were significant. Of the 12, 6 were signifi-

THE LINEAR CORRELATION OF WEIGHT VS AGE PCB

PLOTS

OF ALL FISH FOUND AT 04/17/79

PAGE 1

FILE MONAGE (CREATION DATE = 04/17/79)

SCATTERGRAM OF (DOWN) CTO

STATION 2, AGE 19.00

4.00 15.00 25.00 35.00 45.00 55.00 65.00 75.00 85.00 95.00

177.00

177.00

160.00

160.00

143.00

143.00

126.00

126.00

109.00

109.00

92.00

92.00

75.00

75.00

58.00

58.00

41.00

41.00

24.00

24.00

7.00

7.00

0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00 90.00 100.00

MONS 050387

PCB
(age)

100

THE LINEAR CORRELATION OF LOG OF WEIGHT VS LOG PP-PEB

86

PLOTS

OF ALL P130 POUNDS BY STATION 2

PAGE

FILE NNAME (CREATION DATE = 04/17/79)

ALL SEASONS

SCATTERGRAM OF (DOWN) LOGT

(ACROSS) LGHT.

4.00

7.00

4.00

6.00

8.00

10.00

12.00

14.00

16.00

18.00

10.00

10.00

9.00

9.00

8.00

8.00

7.00

7.00

6.00

6.00

5.00

5.00

4.00

4.00

3.00

3.00

2.00

2.00

1.00

1.00

0.00

0.00

-1.00

1.00

3.00

5.00

7.00

9.00

11.00

13.00

15.00

17.00

19.00

LOG WEIGHT (GRAMS)

NONS 050388

LOG
PEB
(ppm)

9382
 2245221
 3 2532+2
 3 2215

FILE NO. 1779
 SCATTERGRAM OF (DOWN) CTOT (ACROSS) WEIGHT
 00/17/79 PAGE 17

THE LINEAR CORRELATION OF WEIGHT IN POUNDS
 OF ONE FISH FOUND AT STATION 4, ALL SEASONS

0.00 12.00 20.00 28.00 36.00 44.00 52.00 60.00 68.00 76.00

43.00 43.00

39.00 39.00

35.00 35.00

31.00 31.00

27.00 27.00

23.00 23.00

19.00 19.00

15.00 15.00

11.00 11.00

7.00 7.00

3.00 3.00

0.00 8.00 16.00 24.00 32.00 40.00 48.00 56.00 64.00 72.00 80.00

WEIGHT (Pounds)

MONS 050390

Table 20

The Linear Correlation of Weight and ppm PCB
of Each Genus of Fish per Station

Species	Station	Corr. R	p	n
Campostoma	2	+0.46	0.21	5
" "	3	-0.19	0.26	13
Dorosoma	4	0.56	0.01*	14
" "	5	0.70	0.003*	13
" "	8	-0.10	0.42	6
Gambusia	1	0.014	0.35	9
" "	2	0.96	0.004*	5
Hypentelium	1	-0.34	0.15	11
" "	3	-0.04	0.45	8
Lepomis	1	0.003	0.49	25
" "	2	-0.36	0.03*	25
" "	3	0.36	0.15	10
" "	4	0.20	0.06	47
" "	5	0.56	0.00002*	46
" "	6	0.37	0.019*	31
" "	7	0.32	0.067	23
Micropterus	1	0.35	0.19	8
" "	2	-0.51	0.08	5
" "	4	-0.68	0.045*	6
" "	5	0.66	0.013*	11
" "	6	-0.15	0.302	14
" "	7	-0.118	0.295	23
" "	8	0.206	0.328	7
Notropis	1	0.635	0.001*	20
" "	2	-0.25	0.95	28
" "	3	0.018	0.47	17
Percina	1	-0.54	0.13	6
Phenocobius	2	-0.41	0.244	5
Pimephales	5	0.579	0.030*	11

* Significant, $p \leq 0.05$

MONS 050391

Table 21

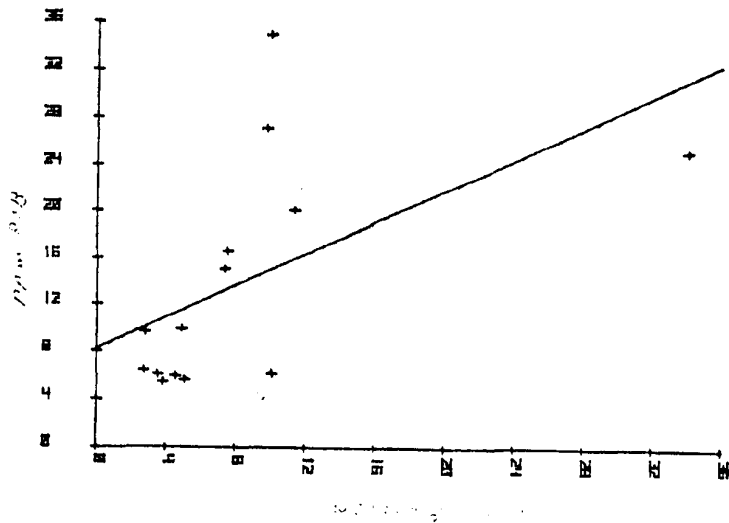
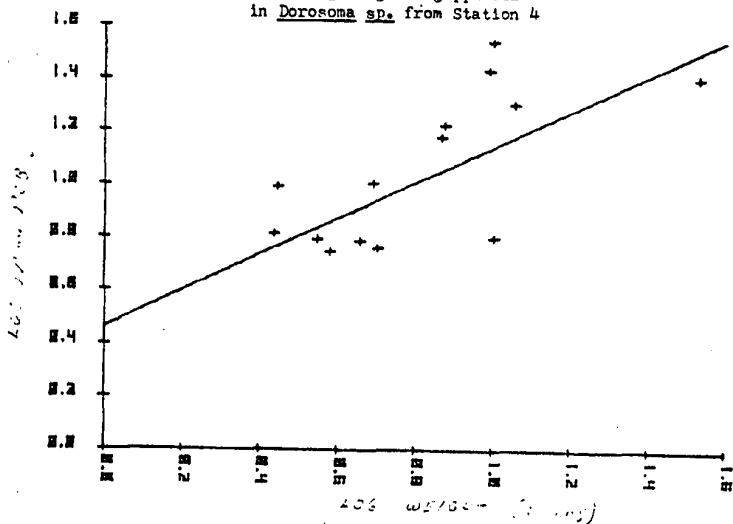
The Linear Correlation of Log Weight and Log ppm PCB
of Each Genus of Fish per Station

Species	Station	Corr. R	p	n
Campostoma	2	-0.50	0.19	5
" "	3	-0.26	0.18	13
Dorosoma	4	0.70	0.002*	14
" "	5	0.58	0.01*	13
" "	8	-0.09	0.42	6
Gambusia	1	-0.10	0.38	9
" "	2	0.97	0.002*	5
Hypentelium	1	-0.56	0.03*	11
" "	3	0.04	0.45	8
Lepomis	1	-0.18	0.19	25
" "	2	-0.14	0.24	25
" "	3	0.42	0.11	10
" "	4	0.46	0.0002*	52
" "	5	0.52	0.00009*	46
" "	6	0.58	0.0003*	31
" "	7	0.34	0.0519	23
Micropterus	1	0.06	0.44	8
" "	2	-0.68	0.09	5
" "	4	-0.61	0.07	7
" "	5	0.59	0.02*	11
" "	6	-0.14	0.312	14
" "	7	-0.077	0.36	23
" "	8	0.404	0.18	7
Notropis	1	0.35	0.061	20
" "	2	-0.41	0.013*	28
" "	3	-0.06	0.408	17
Percina	1	-0.38	0.22	6
Phenocobius	2	-0.28	0.32	5
Pinephales	5	0.43	0.089	11

* Significant, $p \leq 0.05$

Figure 19

The Linear Correlation of Weight and ppm PCB
and Log Weight-Log ppm PCB
in Dorosoma sp. from Station 4



MONS 050393

THE LINEAR CORRELATION OF LOG WEIGHT VS LOG μ CO
OF ALL GAMOUSIA POUND 00/11/79 PAGE 76

FILE NAME (CREATION DATE 4 04/17/79)
SCATTERGRAM OF (DOWN) LOG

AT STATION 2

(ACROSS) LOG

0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00 18.00

10.00 10.00

9.00 9.00

8.00 8.00

7.00 7.00

6.00 6.00

5.00 5.00

4.00 4.00

3.00 3.00

2.00 2.00

1.00 1.00

0.00 0.00

-1.00 1.00 3.00 5.00 7.00 9.00 11.00 13.00 15.00 17.00 19.00

LOG WEIGHT (GRAMS)

46050 SNOW

PCO
(gram)

0.2

THE LINEAR CORRELATION OF WEIGHT VS ~~THE~~ ~~NO~~

PLOTS

OF ALL GRABUSTIA POUNDS

06/17/79

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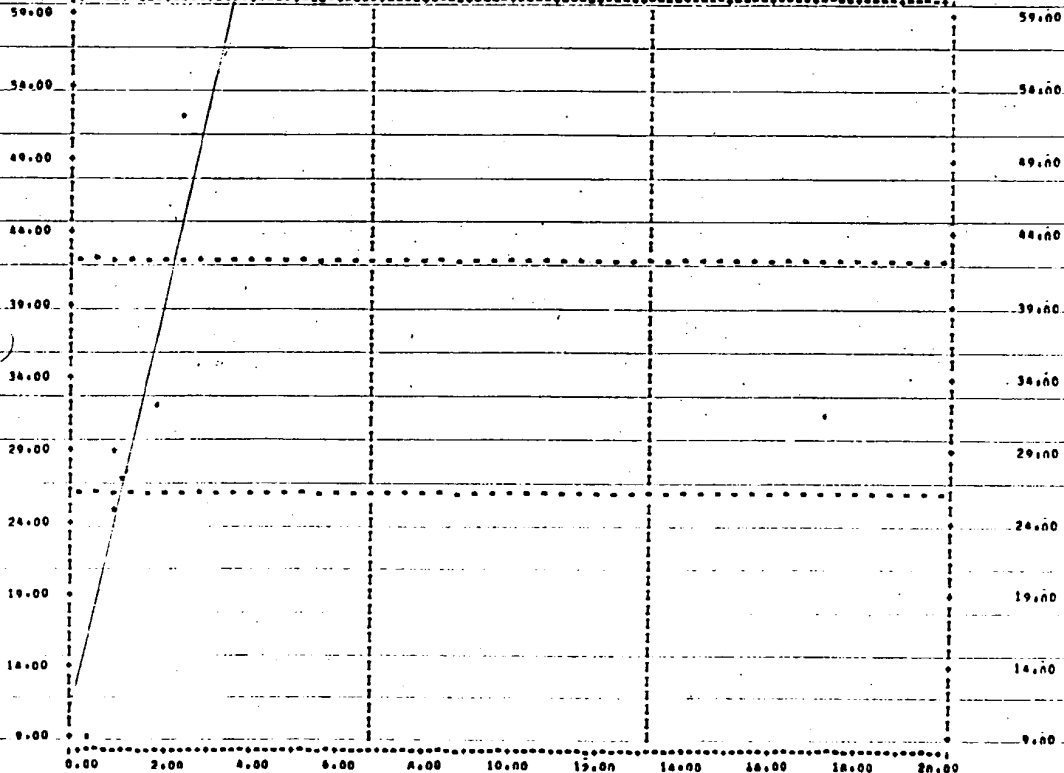
FILE NAME (CREATION DATE = 06/17/79)

STATION 2

SCATTERGRAM OF (DOWN) CYOT

(ACROSS) WEIGHT

1.00 3.00 5.00 7.00 9.00 11.00 13.00 15.00 17.00 19.00



MONS 050395

cant in both models, 8 in the weight-ppm model and 10 in the log-log model. Ten of the 12 showed a positive relationship between wet weight and ppm PCB and 2 had negative correlation coefficients. Both of the negative correlations were in different species and stations.

From these analyses we again see that there is a tendency for PCB's to accumulate with weight. The increased strength of the correlations in these analyses indicates that season does influence the relationship between wet weight and PCB concentration.

To determine whether a more complex curvilinear model could better describe the weight-PCB relationship, multiple regression analyses were done on the fish on a species by station by season basis. Of the 41 analyses, 8 had a significant multiple R at the weight squared level (Table 24). All 8 were also highly significant on the log-log model. Therefore, there appears to be no reason to use a more complex model.

In summary, the analysis of data collected on a river-reservoir system in Alabama shows that the log-log linear model best describes the accumulation of PCB by fish. It generally gives slightly higher correlation coefficients and greater significance levels than the simple wet weight-ppm or multiple regression models do. Both the strength of correlation and the significance levels are affected by the

Table 22

The Linear Correlation of Weight and ppm PCB
in Each Genus at Each Station and Season

Species	Station	Season	Corr. R	p	n
Campostoma	3	fall	-0.20	0.32	5
" "	3	spring	-0.33	0.25	6
Dorosoma	4	summer	-0.09	0.41	6
" "	5	winter	-0.57	0.11	7
Hypentelium	1	fall	-0.70	0.14	5
" "	1	winter	-0.31	0.30	5
" "	3	winter	0.76	0.06	5
Lepomis	1	fall	0.49	0.08	9
" "	1	spring	-0.24	0.23	11
" "	2	winter	-0.36	0.20	7
" "	2	summer	-0.35	0.12	12
" "	3	fall	0.83	0.04*	5
" "	4	fall	0.51	0.04*	12
" "	4	winter	0.62	0.006*	15
" "	4	spring	-0.12	0.38	8
" "	4	summer	0.34	0.08	17
" "	5	fall	0.32	0.14	13
" "	5	winter	0.98	0.00001*	9
" "	5	spring	0.32	0.11	15
" "	5	summer	-0.006	0.49	9
" "	6	fall	0.40	0.09	12
" "	6	summer	0.32	0.11	16
" "	7	summer	0.37	0.050*	19
Micropterus	1	fall	-0.13	0.41	5
" "	5	summer	0.50	0.19	5
" "	6	fall	0.95	0.005*	5
" "	6	summer	-0.17	0.34	8
" "	7	fall	-0.70	0.02*	8
" "	7	spring	0.06	0.49	6
" "	7	summer	0.50	0.12	7
" "	8	summer	0.31	0.30	5

* Significant, p 0.05

Table 22
(continued)

<u>Species</u>	<u>Station</u>	<u>Season</u>	<u>Corr. R</u>	<u>p</u>	<u>n</u>
Notropis	1	spring	-0.07	0.43	7
" "	1	summer	0.71	0.05*	6
" "	2	fall	-0.61	0.13	5
" "	2	winter	0.26	0.29	7
" "	2	spring	-0.09	0.41	7
" "	2	summer	-0.10	0.40	7
" "	3	fall	-0.74	0.07	5
" "	3	spring	-0.08	0.39	11
Phenocobius	2	summer	-0.41	0.24	5
Pimephales	5	fall	0.53	0.06	9

Table 23

The Linear Correlation of Log Weight and Log ppm PCB
in Each Genus at Each Station and Season

Species	Station	Season	Corr. R	p	n
Campostoma	3	fall	-0.21	0.31	5
"	3	spring	-0.38	0.22	6
Dorosoma	4	summer	-0.15	0.36	6
"	5	winter	0.26	0.30	7
Hypentelium	1	fall	-0.53	0.23	5
"	1	winter	-0.43	0.23	5
"	3	winter	0.66	0.10	5
Lepomis	1	fall	-0.40	0.14	9
"	1	spring	-0.28	0.20	11
"	2	winter	-0.30	0.25	7
"	2	summer	0.07	0.47	12
"	3	fall	0.90	0.01*	5
"	4	fall	0.30	0.17	12
"	4	winter	0.69	0.001*	15
"	4	spring	0.03	0.46	8
"	4	summer	0.69	0.001*	17
"	5	fall	0.36	0.11	13
"	5	winter	0.89	0.0005*	9
"	5	spring	0.42	0.056	15
"	5	summer	-0.001	0.49	9
"	6	fall	0.40	0.09	12
"	6	summer	0.69	0.001*	16
"	7	summer	0.41	0.03 *	19
Micropoterus	1	fall	-0.30	0.30	5
"	5	summer	0.41	0.24	5
"	6	fall	0.91	0.01*	5
"	6	summer	-0.23	0.28	8
"	7	fall	-0.87	0.002*	8
"	7	spring	0.16	0.37	6
"	7	summer	0.26	0.28	7
"	8	summer	0.41	0.24	5

* Significant, p 0.05

Table 23
(continued)

<u>Species</u>	<u>Station</u>	<u>Season</u>	<u>Corr. R</u>	<u>p</u>	<u>n</u>
Notropis	1	spring	-0.11	0.40	7
" "	1	summer	0.29	0.28	6
" "	2	fall	-0.73	0.07	5
" "	2	winter	0.45	0.15	7
" "	2	spring	-0.32	0.21	7
" "	2	summer	0.02	0.47	7
" "	3	fall	-0.81	0.04	5
" "	3	spring	-0.24	0.23	11
Phenocobius	2	summer	-0.28	0.32	5
Pimephales	5	fall	0.39	0.14	9

THE LINEAR CORRELATION OF WEIGHT VS ~~AGE~~ PCA

plots

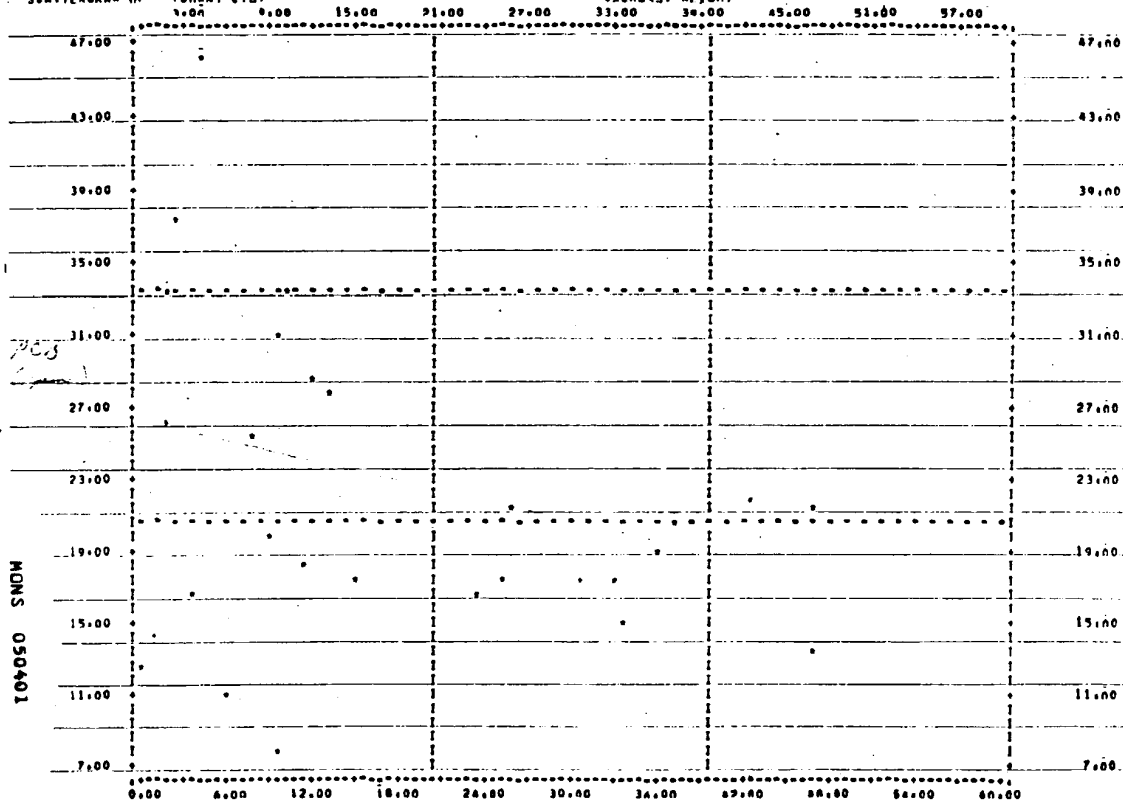
ON 444 SEP 13 1979

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FILE WDNAME (CREATION DTF = 08/17/70)

SCATTERGRAM OF TONING CYCLE

(ACROSS) WEIGHT



MONS 050401

THE LINEAR CORRELATION OF LOG WEIGHT VS LOG AREA

OF GAMBIA

PLOTS

OF ALL LOGS

2010

06/17/79

PAGE 90

FILE NAME (CREATION DATE = 06/17/79)

SCATTERGRAM OF (LOGS) LOG

2010

(LOGS) LOG

0.00

2.00

4.00

6.00

8.00

10.00

12.00

14.00

16.00

18.00

10.00

10.00

9.00

9.00

8.00

8.00

7.00

7.00

6.00

6.00

5.00

5.00

4.00

4.00

3.00

3.00

2.00

2.00

1.00

1.00

0.00

0.00

-1.00

1.00

3.00

5.00

7.00

9.00

11.00

13.00

15.00

17.00

19.00

MONS 050402

Figure 22

The Linear Correlation of Weight and ppm PCB
and Log Weight-Log ppm PCB
in Leponis s.f. from the Winter Collection
at Station 2

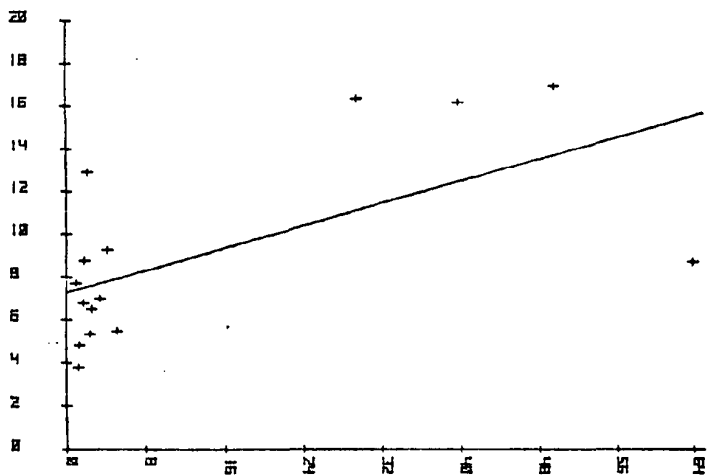
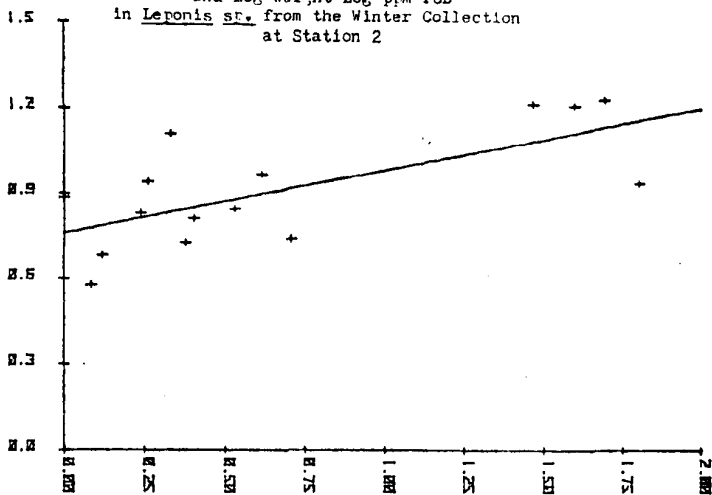
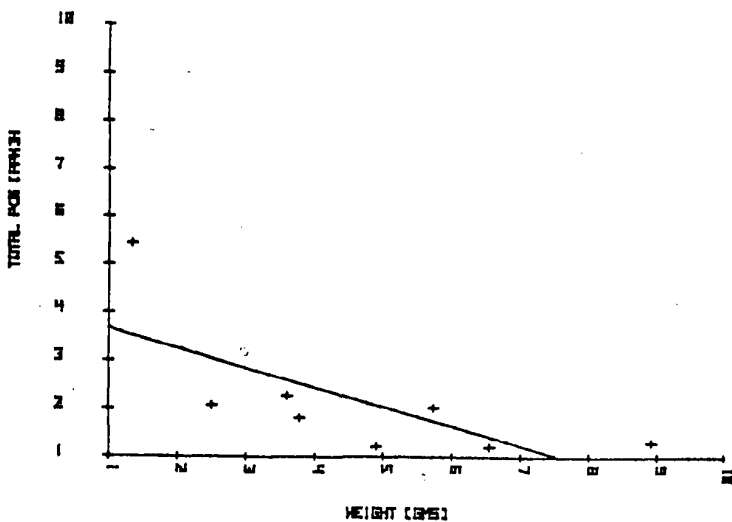
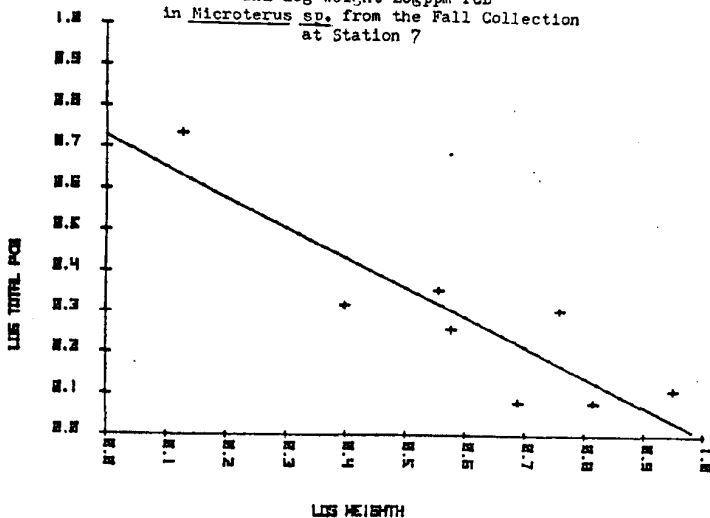


Figure 23

The Linear Correlation of Weight and ppm PCB
and Log Weight-Logppm PCB
in Microterus sp. from the Fall Collection
at Station 7



MONS 050404

Table 24

The Multiple Regression Analysis
of Weight and PCB
in Each Genus at Each Station and Season
at the Weight² Level

<u>Species</u>	<u>Station</u>	<u>Season</u>	<u>Multiple</u>			<u>n</u>
			<u>F</u>	<u>R</u>	<u>R²</u>	
Lepomis	4	fall	7.26	0.78	0.61	11
Lepomis	4	winter	17.00	0.86	0.74	14
Lepomis	4	summer	5.9	0.67	0.45	16
Lepomis	5	winter	103.0	0.98	0.97	8
Lepomis	6	summer	6.8	0.71	0.51	15
Lepomis	7	summer	3.63	0.56	0.31	18
Micropterus	7	fall	8.5	0.87	0.77	7
Notropis	1	summer	76.2	0.99	0.99	5

number of points per plot, the species and season of collection.

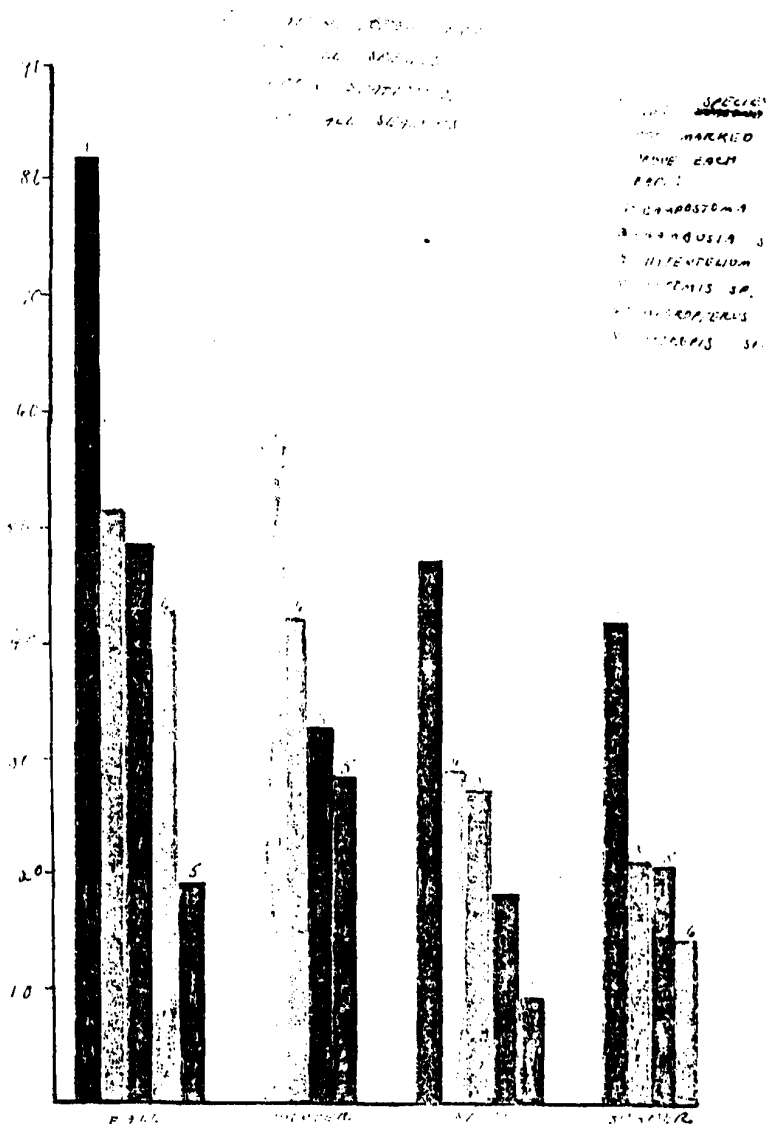
As the data are considered in terms of station, species and season, the sample numbers decrease and so do the number of significant cases. However, greater specificity increases both the correlation coefficient and the significance levels. In general, PCB's increase with increased weight in all species.

D. SPECIES DIFFERENCES IN PCB ACCUMULATION

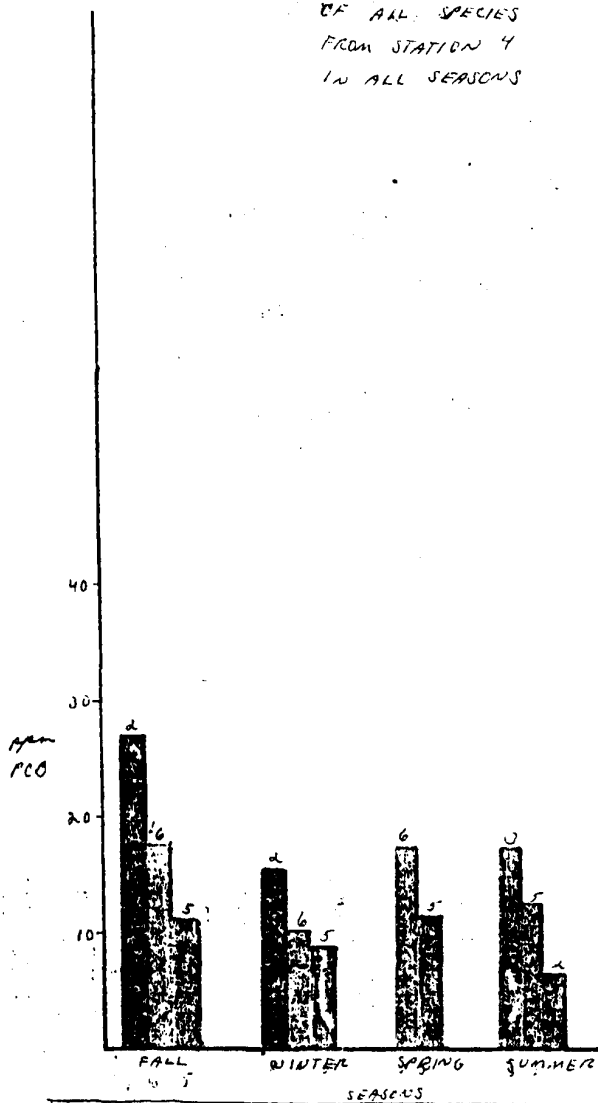
Figures 24 and 25 are histograms comparing the mean PCB levels of each species in all seasons at stations 2 and 4, respectively. They show that there are large differences in species accumulation. As seen in the Anova Table (# 12), the PCB concentrations of 4 species are significantly different at stations 2 and 5. Although the relationship of each species to the others is not consistent throughout all seasons and stations, there are generalizations about the accumulation of PCB by fish that can be drawn. The differences in residue levels between the species, and the fluctuating levels of each species with station and season may be related to feeding patterns, lipid contents or water quality changes.

1. Water quality as related to the accumulation of PCB by fish:

By comparing the water quality analyses (Table 1d) with the fluctuating PCB concentrations of fish (Figures 3-11 and 24-25) the influences of the abiotic parameters on the uptake of PCB by fish may be identified. The changes in residue levels of Dorosoma, Lepomis, Micropterus and Notropis throughout the stations and seasons do not coincide directly with the fluctuations in dissolved oxygen, carbon dioxide, temperature or alkalinity. For example, although temperature



MEAN TOTAL PCO
OF ALL SPECIES
FROM STATION 4
IN ALL SEASONS



MONS 050409

* THE SPECIES ARE MARKED ABOVE EACH BAR:

may somehow be affecting the uptake of PCB, the drop in temperature in the winter coincides with an increase in residue level in Micropterus and Lepomis at Station 2, and a decrease of the mean PCB levels in the same 2 species at Station 4. Therefore, no generalizations about the effect of these parameters can be made. The pH levels are fairly consistent throughout the survey and therefore probably have little to do with the changes of PCB found in the fish. Turbidity and suspended solids have the same seasonal trends. They are low in the summer and fall and high in the winter and spring. The suspended solids as a mediator of PCB would most greatly affect Dorosoma, a filter feeder. Since Dorosoma's highest mean PCB levels most frequently occur in the fall and therefore, suspended solids probably do not greatly affect PCB uptake by fish. The limited number of TOC analyses make it difficult to draw any conclusions about its possible effects on PCB uptake. The chloride content follows the same pattern as the PCB contamination. It is highest at station 2 and decreases with increasing distance from the outfall in all seasons. The 2 control stations have similarly low levels of both chloride and PCB. However, an increase in chloride at Station 5 in the summer does not coincide with an increased PCB concentration at that station and season. Iron also follows the same pat-

term of decreased concentration with increased distance in the spring and summer. In the fall and winter, however, Station 6 has slightly higher levels than Station 4 and the iron concentration at Stations 1 and 5 is ~~very~~ variable. Seasonally, the iron concentration increases from fall to winter, and decreases from winter to summer. Again these trends cannot be correlated with the fluctuations in PCB levels in any species at any station or season. There is no correlation of sulfate or conductivity with the seasonal fluctuations in fish, but again, they follow similar spacial trends which do correlate with PCB levels.

In summary, the mean PCB concentration in each species at each station fluctuates with the seasons. These seasonal changes in each species vary from station to station, and a comparison of the seasonal fluctuations of all species at the same station show that Lepomis and Micropterus have similar trends at Stations 2 and 4, and Gambusia and Notropis have a similar trend at Station 2. (Figures 24-25). The seasonal fluctuations of PCB concentrations do not appear to be directly related to seasonal changes in dissolved oxygen, carbon dioxide, temperature, alkalinity, pH, turbidity, or suspended solids. Those water quality parameters that may affect PCB UPTAKE by fish are chloride, iron, sulfate and ~~and~~ other ions detected in the conductivity measurements.

2. Feeding patterns and PCB accumulation:

Both the trophic relationships of fish and the different methods of food collection may be related to their PCB bio-concentration.

The method of food collection, especially that of filter feeders, may be important when considered in conjunction with the transport of PCB in water. Suspended solids have often been suggested as a major source of PCB to fish. If this is true, the filter feeders would be most greatly affected and should reflect the changes seen in turbidity and suspended solids. As seen in the previous section, the suspended solids and the mean PCB concentrations of Dorosoma do not correlate. Therefore, suspended solids, while they may be a method of PCB transport, do not appear to be a major source of PCB contamination to fish.

Table 70 lists the fish from each station and season in order from the highest mean concentration (total PCB) to the lowest along with their trophic relationships and spawning seasons. Although the seasonal trends in suspended solids are not related to PCB concentration in fish, photosynthetic organisms, however, as a major food source of PCB to fish have not been ruled out. A close look at the water quality (Tables 16-17) shows that spring collection in Station 3 and the summer collection from Station 4 have high turbidity.

oxygen and turbidity and low carbon dioxide ^h which suggests that there may be a great amount of algae or phytoplankton present. Dorosoma, a plankton feeder, however, shows high levels of PCB in the spring at station 5 (based on one sample) but low levels at station ^x4, summer. There is also no increase in PCB in Lepomis, which also do some filter feeding, at these same 2 stations. Therefore, although Dorosoma accumulate PCB to a higher level than other fish, it does not appear to be related to either suspended solid organo-clay complexes or phytoplankton. A look at the other trophic relationships gives the following results; At station 1, the order from highest to lowest PCB level is tertiary carnivore, detritivore, 1st carnivore and omnivore. In this low contaminated control station, there is a nearly normal food chain relationship with detritivore being second in importance to tertiary carnivore. At stations 2 and 9, those most highly contaminated stations, a similar relationship exists. However, the detritivore accumulates PCB to the highest level. At station 4, Dorosoma accumulates the highest levels and the relationship is herbivore, carnivore, omnivore. As seen above, Dorosoma however, ¹probably does not accumulate the major portion of its PCB from food. Therefore, the food relationship probably does not hold at this station. Station 5, the control station on the Coosa River, shows the same trophic relationship as the other ^(1, 2, 4, 9) stations on Choccolocco Creek. Stations 6, 7 and 8, however, are much more variable. At these stations Lepomis, the omnivore,

accumulates more PCB, relative to the other species, than they did on Choccolocco Creek. There are no samples of bottom feeders at these stations, so their relationship to the other species is not known. It is assumed, however, that they would be relatively high.

It appears, then, that bioconcentration is occurring in this system and a trophic relationship is evident with sediment playing a large role in transmitting PCB to fish along with higher food organisms, while suspended solids probably play only a small role. As shown by the high concentrations of Dorosoma, there are other factors which influence the accumulation of PCB by fish.

Table 25

List of Genera from Highest Mean Accumulation of PCB
to Lowest at Each Station and Season
Along with Their Trophic Level
and Spawning Season

Station 1

Fall	Micropterus	Percina	Hypentelium	Gambusia	Notropis	Lepomis
Trophic Level	tert. carn	t-carn	detrit	1st carn	omni.	omni.
Feeding Type	site	site.	sucker	grazer	grazer	grazer
Spawning	sp-su		sp	sp-fl	su-fl	sp-fl
Mean PCB (ppm)	0.61	0.41	0.20	0.18	0.11	0.11

Winter	Micropterus	Hypentelium	Notropis	Lepomis
Trophic Level	t-carn	detrit.	omni.	omni.
Feeding Type	site	sucker	grazer	grazer
Spawning	sp-su	sp	su-fl	sp-fl
Mean PCB (ppm)	10.25	0.87	0.73	0.48

Spring	Percina	Notropis	Gambusia	Lepomis
Trophic Level	t-carn	omni	1st carn	omni
Feeding Type	site	grazer	grazer	grazer
Spawning		su-fl	sp-fl	sp-fl
Mean PCB (ppm)	0.57	0.36	0.35	0.31

Summer	Notropis	Phenocobius	Micropterus	Hypentelium	Gambusia	L
Trophic Level	omni	detrit	t-carn	detrit	omni	c
Feeding Type	grazer	sucker	site	sucker	grazer	g
Spawning	su-fl	sp-su	sp-su	sp	sp-fl	s
Mean PCB (ppm)	0.73	0.65	0.42	0.35	0.25	0

fl- fall
w- winter
sp- spring
su- summer

MGNS 050415

Table 25.
(continued)

Station 2

Fall	Campostoma	Gambusia	Notropis	Micropterus	Lepomis
Trophic Level	detrit	1st carn	omni	t-carn	omni
Feeding Type	sucker	grazer	grazer	site	grazer
Spawning	su-fl	sp-fl	su-fl	sp-su	sp-fl
Mean PCB (ppm)	82.67	51.66	48.15	42.30	19.69

Winter	Hypentelium	Micropterus	Notropis	Lepomis
Trophic Level	detrit	t-carn	omni	omni
Feeding Type	sucker	site	grazer	grazer
Spawning	sp	sp-su	su-fl	sp-fl
Mean PCB (ppm)	56.83	42.14	32.60	28.41

Spring	Campostoma	Micropterus	Gambusia	Notropis	Lepomis
Trophic Level	detrit	t-carn	1st carn	omni	omni
Feeding Type	sucker	site	grazer	grazer	grazer
Spawning	su-fl	sp-su	sp-fl	su-fl	sp-fl
Mean PCB (ppm)	46.93	29.19	26.96	18.17	9.22

Summer	Notropis	Phenocobius	Gambusia	Lepomis	Micropterus
Trophic Level	omni	detrit	1st carn	omni	t-carn
Feeding Type	grazer	sucker	grazer	grazer	site
Spawning	su-fl	sp-su	sp-fl	sp-fl	sp-su
Mean PCB (ppm)	42.90	37.59	21.16	20.89	14.30

MONS 050416

Table 25
(continued)

Station 4

Fall	Dorosoma	Percina	Micropterus	Lepomis	Notemigonus
Trophic Level	plank	t-carn	t-carn	omni	omni
Feeding Type	filter	site	site	grazer	grazer
Spawning	sp		sp-su	sp-fl	sp-su
Mean PCB (ppm)	27.41	22.71	17.52	11.20	4.39

Winter	Dorosoma	Micropterus	Lepomis
Trophic Level	plank	t-carn	omni
Feeding Type	filter	site	grazer
Spawning	sp	sp-su	sp-fl
Mean PCB (ppm)	15.87	10.75	9.10

Spring	Micropterus	Lepomis
Trophic Level	t-carn	omni
Feeding Type	site	grazer
Spawning	sp-su	sp-fl
Mean PCB (ppm)	17.72	11.79

Summer	Gambusia	Lepomis	Dorosoma
Trophic Level	1st carn	omni	plank
Feeding Type	grazer	grazer	filter
Spawning	sp-fl	sp-fl	sp
Mean PCB (ppm)	19.59	12.37	7.11

Table 25
(continued)

Station 5

Fall	Dorosoma	Percina	Microp.	Pimeph.	Notrop.	Lep.	Notem.
Trophic Level	plank	t-carn	t-carn	detrit	omni	omni	omni
Feeding Type	filter	site	site	sucker	grazer	graz	grazer
Spawning	sp		sp-su	sp-su	su-fl	su-fl	sp-su
Mean PCB (ppm)	2.86	2.66	2.53	2.32	2.66	1.20	0.65

Winter	Roccus	Dorosoma	Micropterus	Lepomis
Trophic Level	t-carn	plank	t-carn	omni
Feeding Type	site	filter	site	grazer
Spawning		sp	sp-su	sp-fl
Mean PCB (ppm)	2.86	2.36	1.61	0.91

Spring	Dorosoma	Notropis	Micropterus	Lepomis
Trophic Level	plank	omni	t-carn	omni
Feeding Type	filter	grazer	site	grazer
Spawning	sp	su-fl	sp-su	sp-fl
Mean PCB (ppm)	8.74	4.81	2.27	1.26

Summer	Pimephales	Micropterus	Dorosoma	Lepomis
Trophic Level	detrit	t-carn	plank	omni
Feeding Type	sucker	site	filter	grazer
Spawning	sp-su	sp-su	sp	sp-fl
Mean PCB (ppm)	1.84	1.45	1.13	1.02

Table 25
(continued)

Station 6

Fall	Dorosoma	Micropoterus	Leponis	Notropis	Pimephales
Trophic Level	plank	t-carn	omni	omni	detrit
Feeding Type	filter	site	grazer	grazer	sucker
Spawning	sp	sp-su	sp-fl	su-fl	sp-su
Mean PCB (ppm)	5.35	4.47	4.03	2.44	2.13

Spring	Micropterus	Lepomis	Percina
Trophic Level	t-carn	omni	t-carn
Feeding Type	site	grazer	site
Spawning	sp-su	sp-fl	
Mean PCB (ppm)	7.98	4.97	3.88

Summer	Lepomis	Notropis	Percina	Micropterus
Trophic Level	omni	omni	t-carn	t-carn
Feeding Type	grazer	grazer	site	site
Spawning	sp-fl	su-fl		sp-su
Mean PCB (ppm)	6.09	3.61	3.88	2.52

Table 25
(continued)

Station 7

Fall	Lepomis	Micropterus
Trophic Level	omni	t-carn
Feeding Type	grazer	site
Spawning	sp-fl	sp-su
Mean PCB (ppm)	2.66	2.17

Winter	Dorosoma	Micropterus
Trophic Level	plank	t-carn
Feeding Type	filter	site
Spawning	sp	sp-su
Mean PCB (ppm)	3.06	1.25

Spring	Micropterus	Lepomis
Trophic Level	t-carn	omni
Feeding Type	site	grazer
Spawning	sp-su	sp-fl
Mean PCB (ppm)	2.17	1.97

Summer	Lepomis	Micropterus
Trophic Level	omni	t-carn
Feeding Type	grazer	site
Spawning	sp-fl	sp-su
Mean PCB (ppm)	2.02	1.34

Table 25
(continued)

Station 8

Fall	Leponis	Dorosoma	Roccus	Micropterus
Trophic Level	omni	plank	t-carn	t-carn
Feeding Type	grazer	filter	grazer	site
Spawning	sp-fl	sp		sp-su
Mean PCB (ppm)	6.28	4.71	4.04	3.01

Winter	Dorosoma
Trophic Level	plank
Feeding Type	filter
Spawning	sp
Mean PCB (ppm)	6.50

Spring	Dorosoma	Micropterus	Notropis
Trophic Level	plank	t-carn	omni
Feeding Type	filter	site	grazer
Spawning	sp	sp-su	su-fl
Mean PCB (ppm)	4.46	3.14	0.83

Summer	Micropterus	Notropis	Roccus
Trophic Level	t-carn	omni	t-carn
Feeding Type	site	grazer	site
Spawning	sp-su	su-fl	
Mean PCB (ppm)	2.87	2.22	1.25

3. Lipids and spawning as related to PCB concentration:

The Anova Tables (10 and 11) show that there is a significant correlation between season and PCB concentration in Micropterus, Dorosoma, and Notropis, but not in Lepomis, Gambusia or Hyphantelium. These correlations may be due to changes in lipid during spawning seasons. Table 25 includes both the mean PCB concentration of each species and its spawning season. Just prior to spawning, lipid percentage should be highest and therefore PCB's should also be highest, if one accepts the lipid-water partition theory as the main route of PCB entry to fish. Even though some fish in this study are very small, the same weight fluctuations do occur during spawning season (Love, 1971).

Micropterus spawn in the spring and summer. Figures 10, 24 and 25 show that the highest PCB concentrations in Micropterus at Stations 4, 6 and 8 and nearly the highest concentrations at Stations 5 and 7 do occur in the spring collections.

Notropis spawn in the summer and fall and the highest average residue levels are also found in these seasons (see Figures 11, 24 and 25).

Dorosoma spawn in the spring relating its spawning season with the correlation between season and PCB concentration seen in Anova Table 11.

Lepomis spawn from spring to fall (April to October). Their high residue levels occur over all seasons. There is no

correlation between season and PCB content in Lernaeis.

The lack of correlation between season and PCB concentration in Gambusia and Hymentellium is probably due to a lack of samples and therefore, no conclusions can be drawn.

In conclusion, it seems likely that the fluctuations in lipid content due to spawning does affect the PCB content at least in some species.

The differences in PCB accumulation between species may also be due, in part, to species differences in lipid content. Table 26 shows the lipid content of various fish. As seen in earlier sections, Dorosoma generally accumulate PCB's to greater levels than other species, and this accumulation is probably not food related. Dorosoma's high PCB content are probably related to their relatively high lipid content. Therefore, the lipid partitioning means of uptake must be very important in the PCB accumulation by this species.

The differences in lipid content among the other species is probably not very great and, therefore, their large differences in PCB content must be related to factors other than lipid partitioning. (NOTE: I am having difficulty finding the lipid contents of many of my species. When I am able to find the information, Table 26 will be expanded and the last paragraph above will be clarified.)

Table 26
(Thuston, 1959)
The Lipid Content
of Several Fish
(Central States Area)

Species	% Oil
<u>Dorosoma cepedianum</u>	23.1
<u>Campestris</u> sp.	1.2-1.9
<u>Perca flavescens</u>	0.8-1.1

MOQS 050423

E. METABOLIC DIFFERENCES IN SPECIES

Figures 25-29 show the seasonal differences in the accumulation of each Aroclor (1242, 1254 and 1260) at stations 1 to 8 in Borosoma, Lepomis, Micropterus and Notropis, respectively. All 4 species accumulate similar relative amounts of the 3 Aroclors at all stations. All Aroclors decrease with increasing distance from the outfall. Table 13 shows the percent decrease of each Aroclor from station to station in each species. Aroclors 1242 and 1260 decrease most rapidly with distance, while 1254 dissipates more gradually. Thus, there are no metabolic differences evident in the amounts of Aroclors accumulated by each species.

A comparison of chromatograms can show possible metabolic differences by the absence or presence of different peaks or changes in their relative heights. Figures 30-34 demonstrate that all fish of the same species collected at the same station and season have the same peaks in their chromatograms. Figures 35-38 compare all species present at Station 2, fall collection. Again all have the same peaks. Figures 39-42, samples of (Notropis, station 2, all seasons) the same species from the same station but in different seasons show that there are no seasonal differences in the peaks present. The relative heights of all chromatograms discussed above are also very similar. Finally, ^{a comparison for} when comparing the same species from (Micropterus, stations 2, 4 and 6, fall collections) the same season but different stations (Figures 43-45) show a loss of some of the peaks of lower retention time with increased

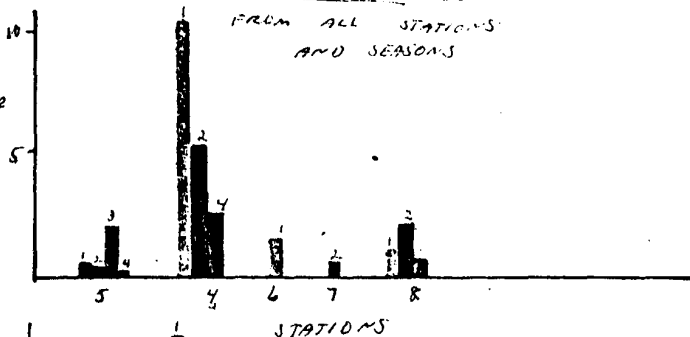
distance from Stations 2 to 6. Otherwise all peaks are the same with similar relative heights.

Therefore, the differences seen in species accumulation of PCB (see section D) ^{are} ~~is~~ probably not due to differences in metabolic ^{activity} ~~activity~~?

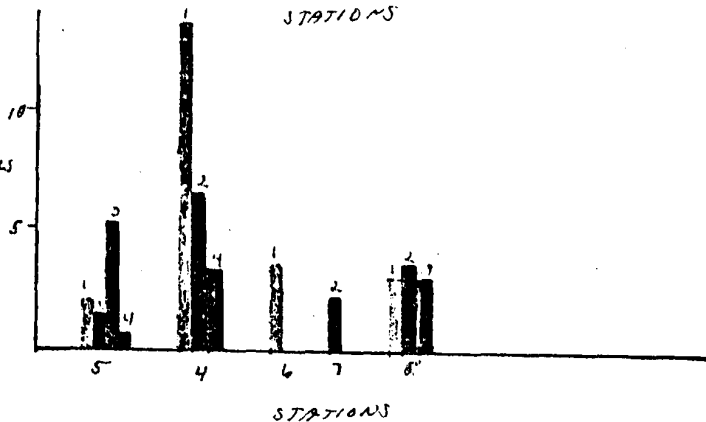
MONS 050425

THE MEAN LEVELS OF AROCLOYS
1242, 1254 AND 1262
IN OCROSCUS SP.
FROM ALL STATIONS
AND SEASONS

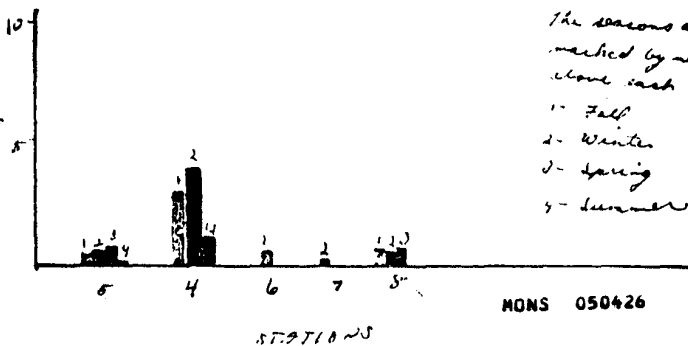
AROCLOYS
1242
(ppm)



AROCLOYS
1254
(ppm)



AROCLOYS
1262
(ppm)

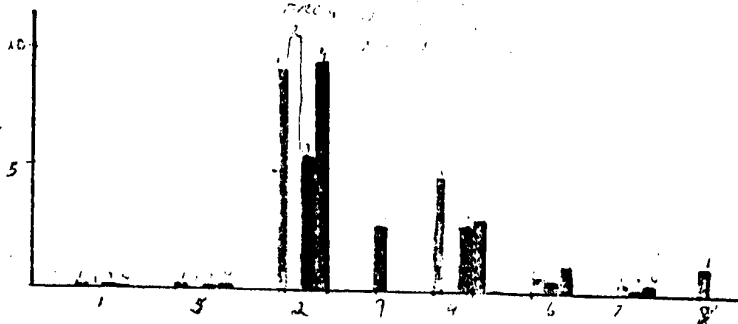


The seasons are
marked by numbers
above each bar:

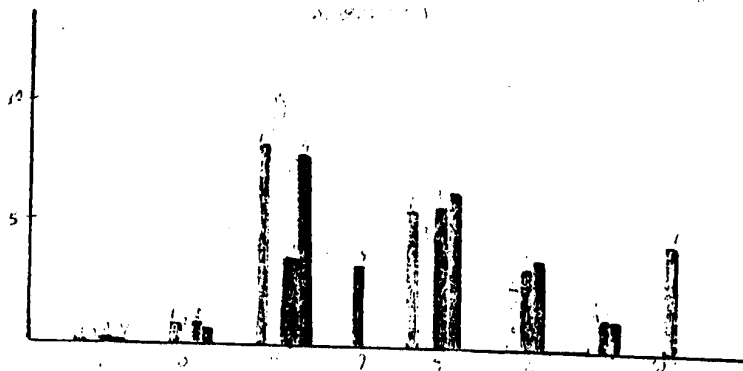
- 1- Fall
- 2- Winter
- 3- Spring
- 4- Summer

MONS 050426

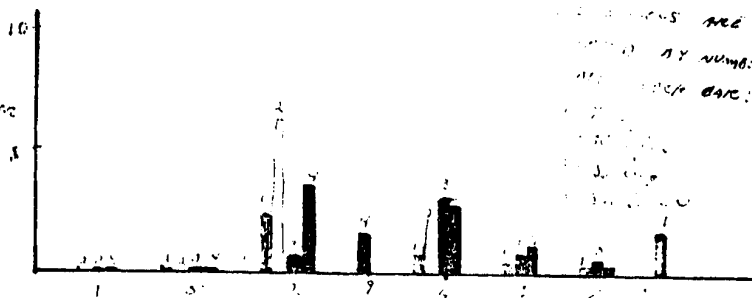
Section
1242
(1700)



1209
(100)



12.000
(12.000) 1

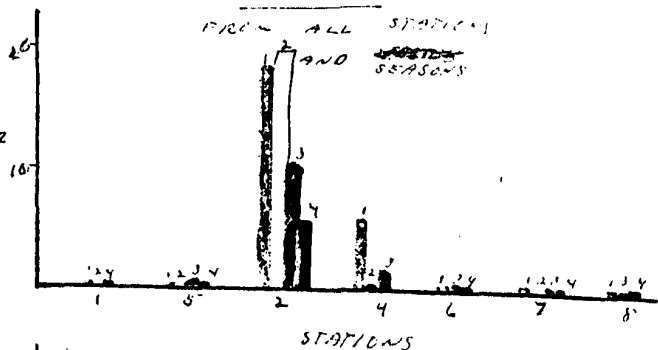


MONS 050427

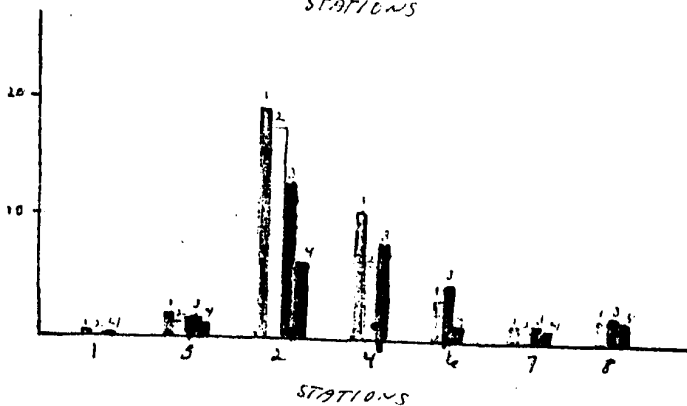
3-101
PC

THE WIND LOADS OF MICROPTERUS
1242, 1254 AND 1266
THE MICROPTERUS SP
FROM ALL STATIONS
AND SEASONS

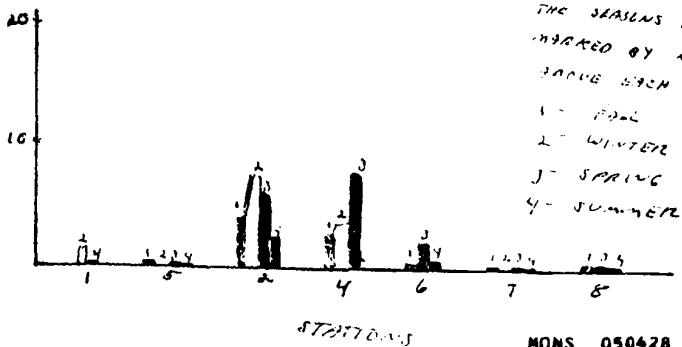
AROCLOM
1242
(gpm)



AROCLOM
1254
(gpm)

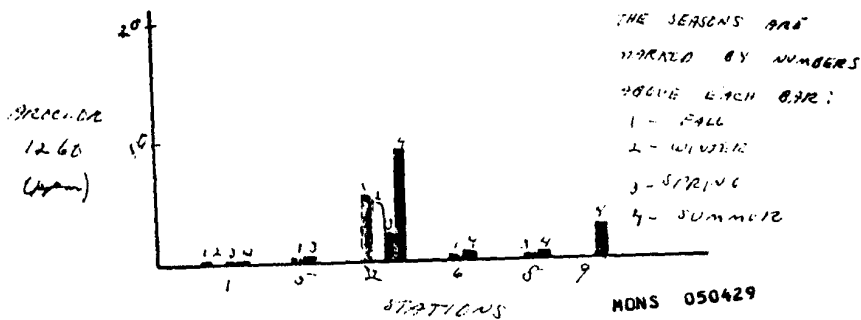
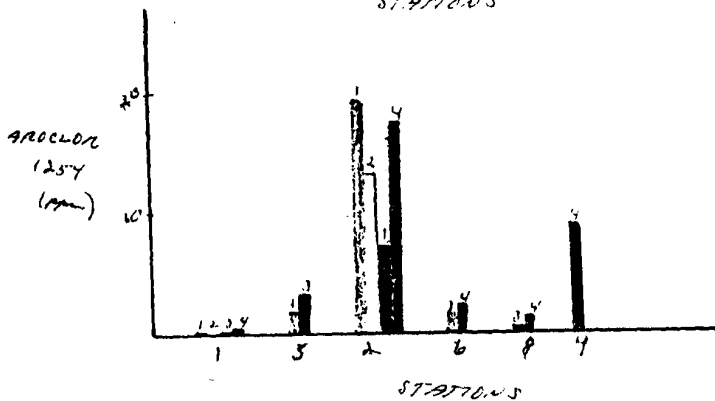
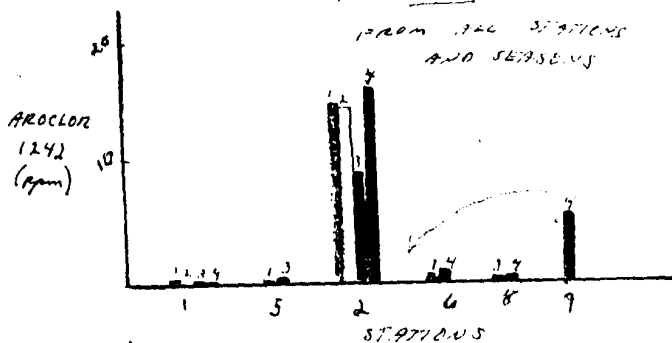


AROCLOM
1266
(gpm)



THE SEASONS ARE
MARKED BY NUMBER
NAME EACH BAR:
1- FALL
2- WINTER
3- SPRING
4- SUMMER

THE MEAN LEVELS OF AROCLOR
1242, 1254 AND 1260
IN NOTROPIS SE
FROM THE STATIONS
AND SEASONS



MONS 050429

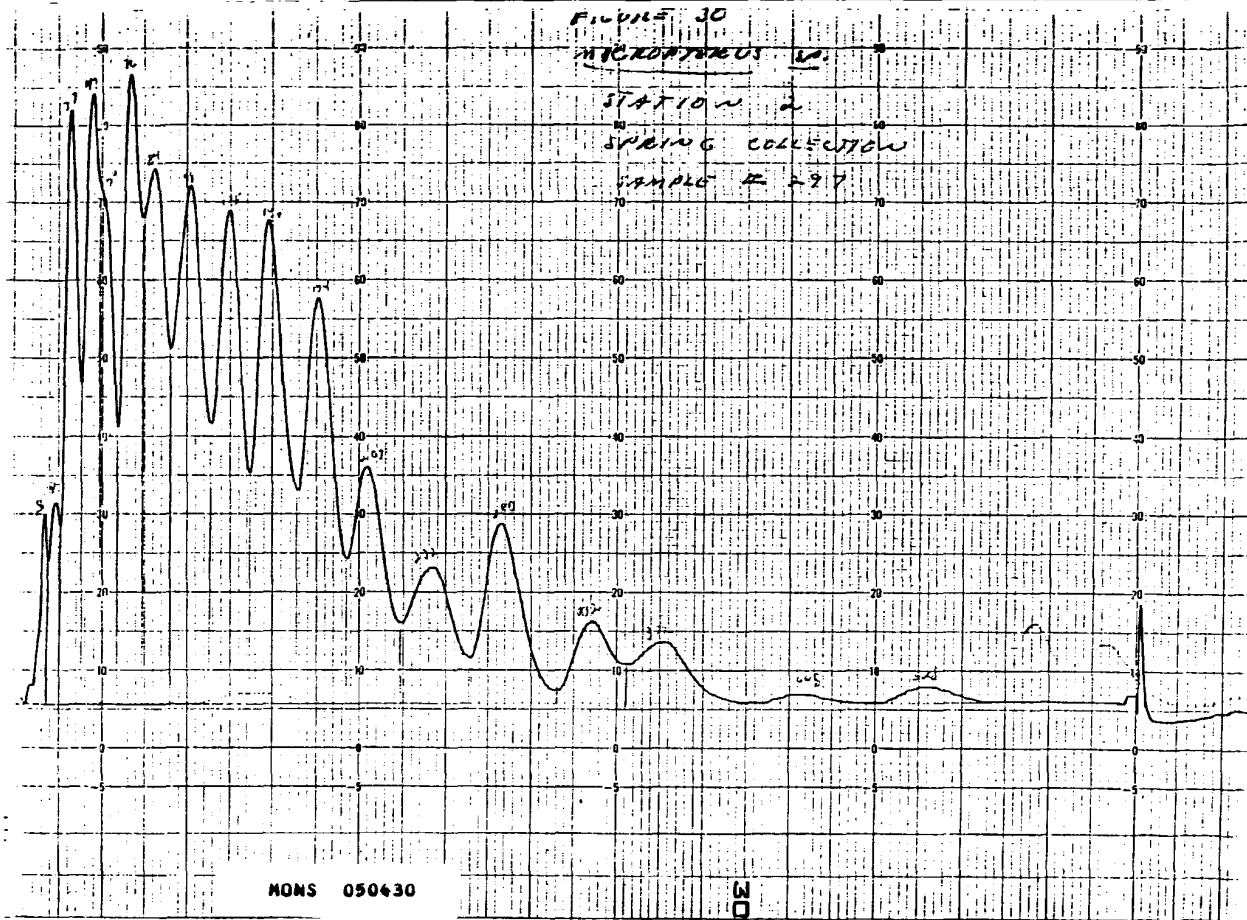
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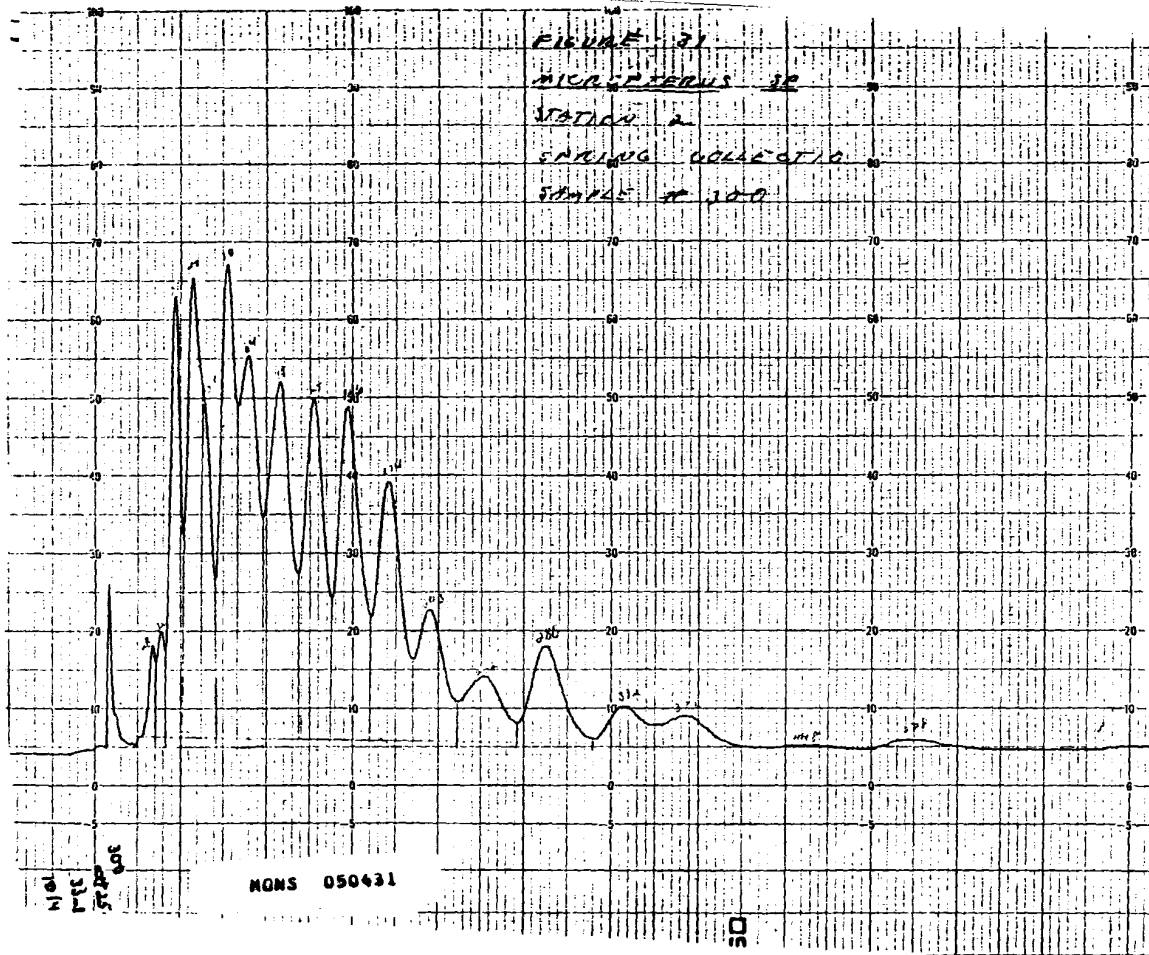
ИСКОНАТЪКЪС	20.
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station 2

SPRING COLLECTION

SAMPLE # 297

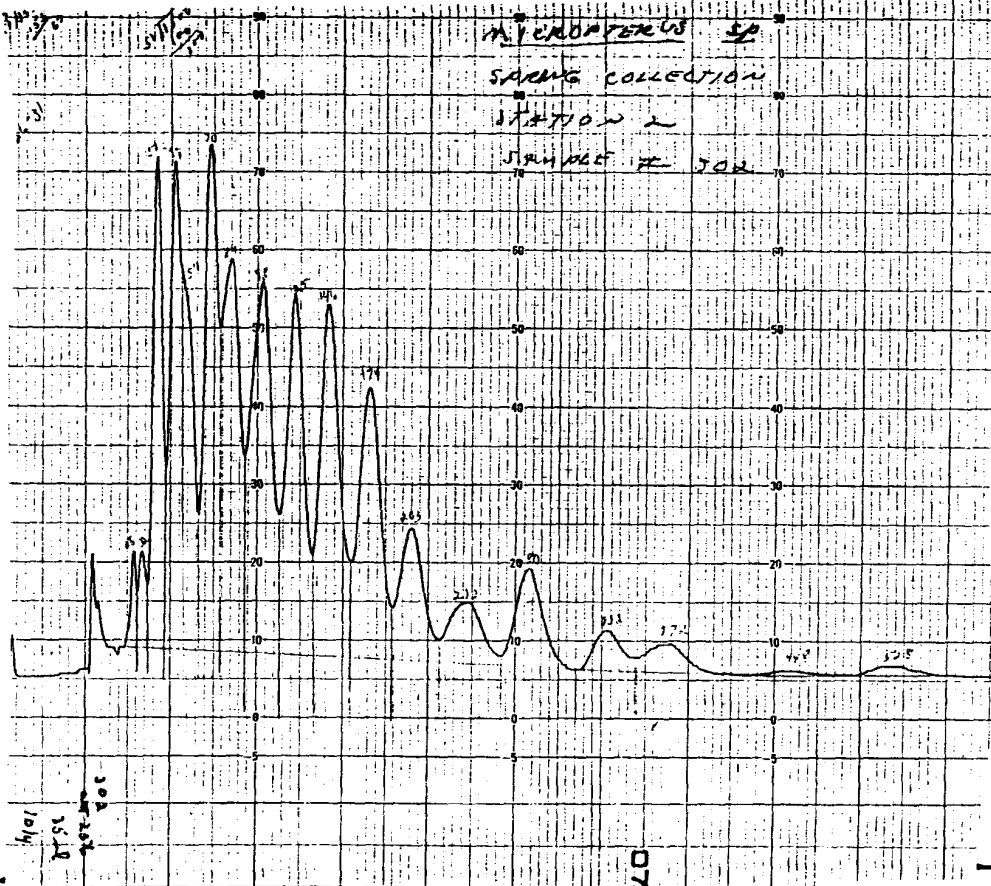


$$5 \times 10^5 \approx 100$$


MYCOMPTERUS

Station 2

ЛАНДЭС-ХЕ-ХОХ



107

5-2-3

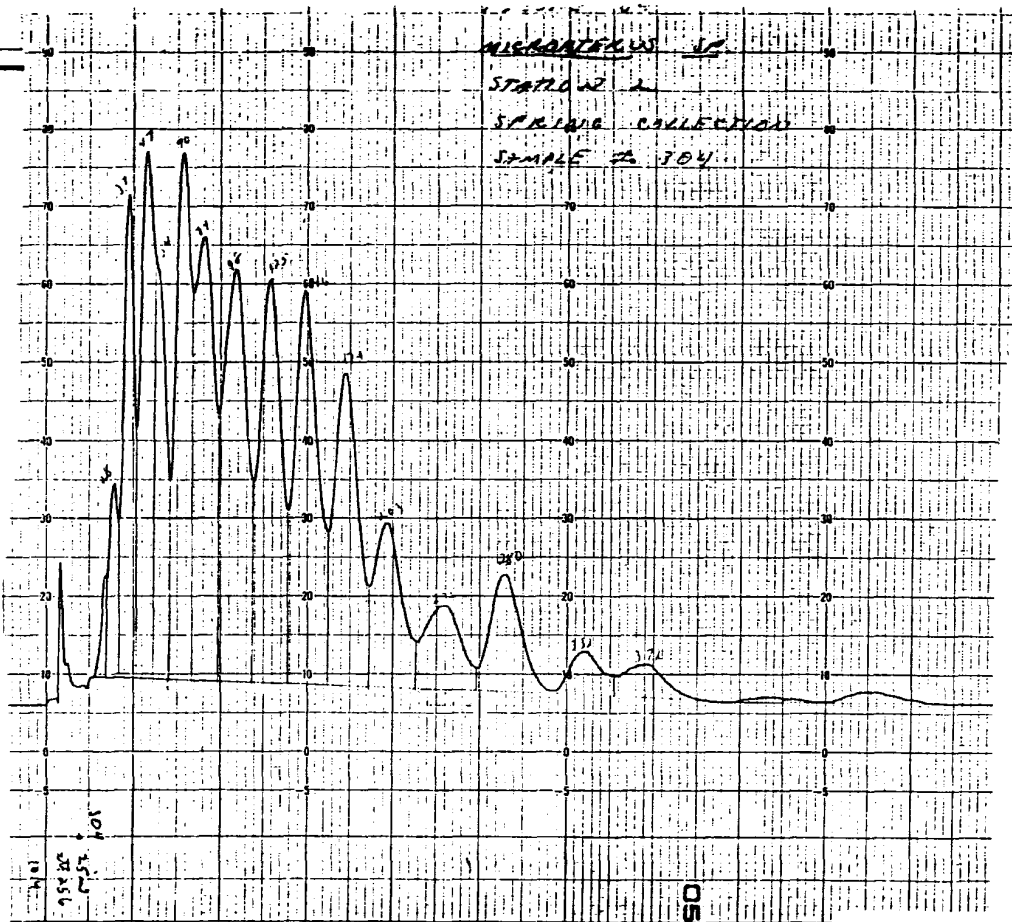
MONS 050433

MICROTEXT W 5

STATION 22

5/21/66 COLLECTION

57114E 2 304



MONS 050434

FIGURE 35
CAMBUSIA SP.

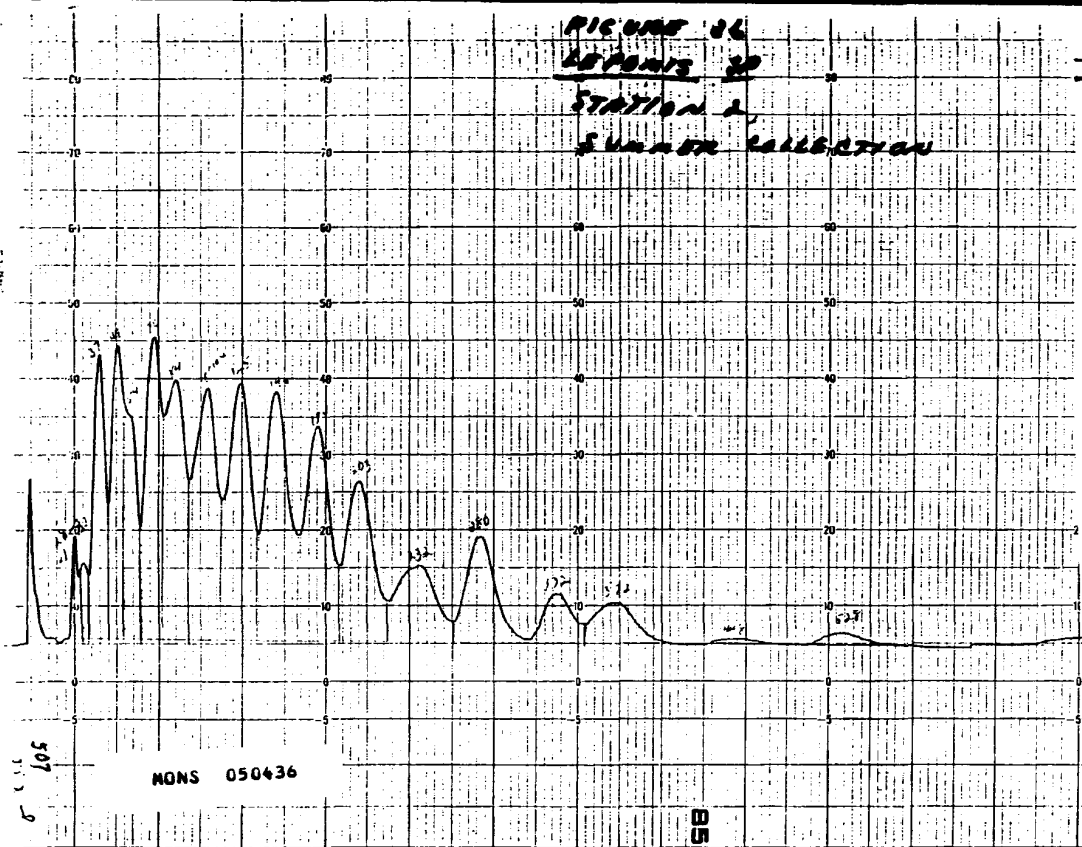
STATION 2

SUMMER COLLECTION



MONS 050435

PICURE 06
 REPORTS 20
 STATION 2
 SUMMER COLLECTION



MONS 050436

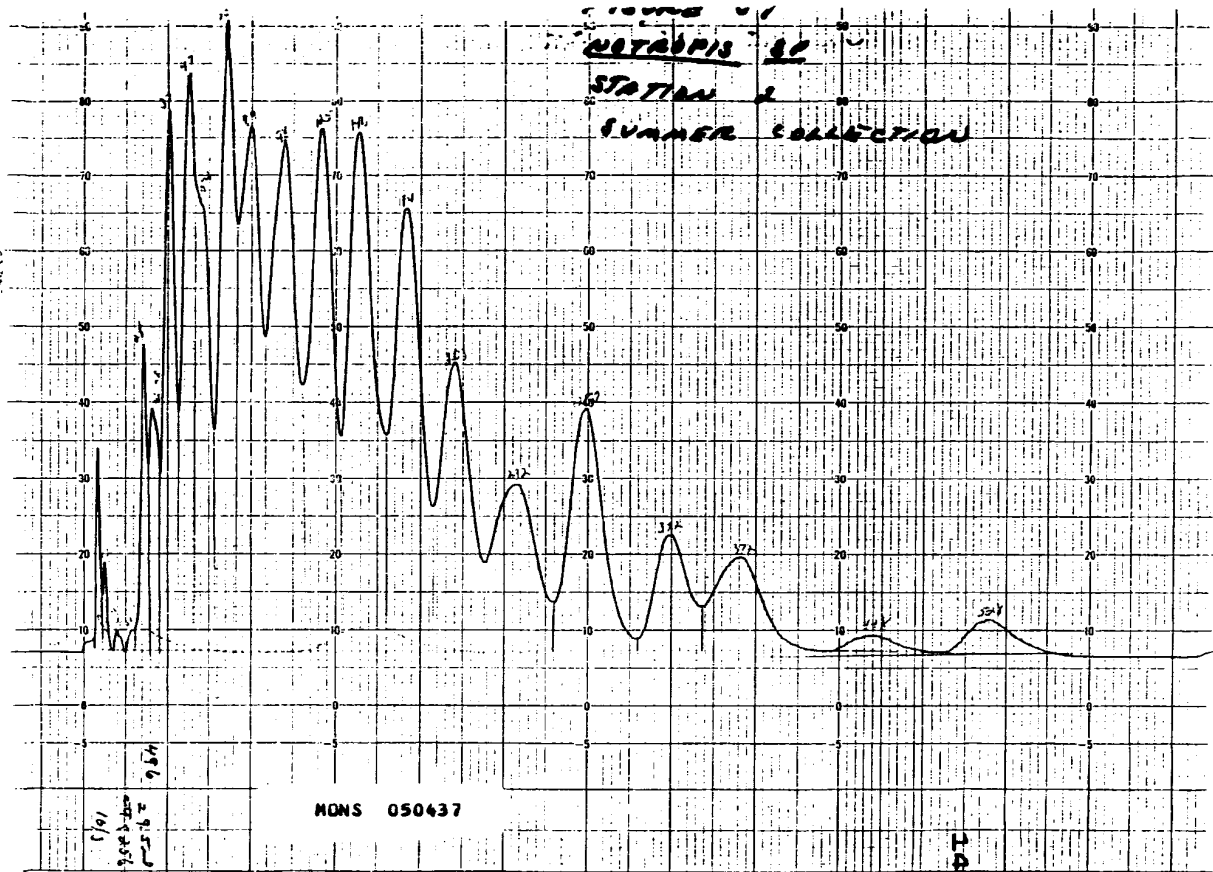
05

5-2-4

NETADPIS 30

STATION 2

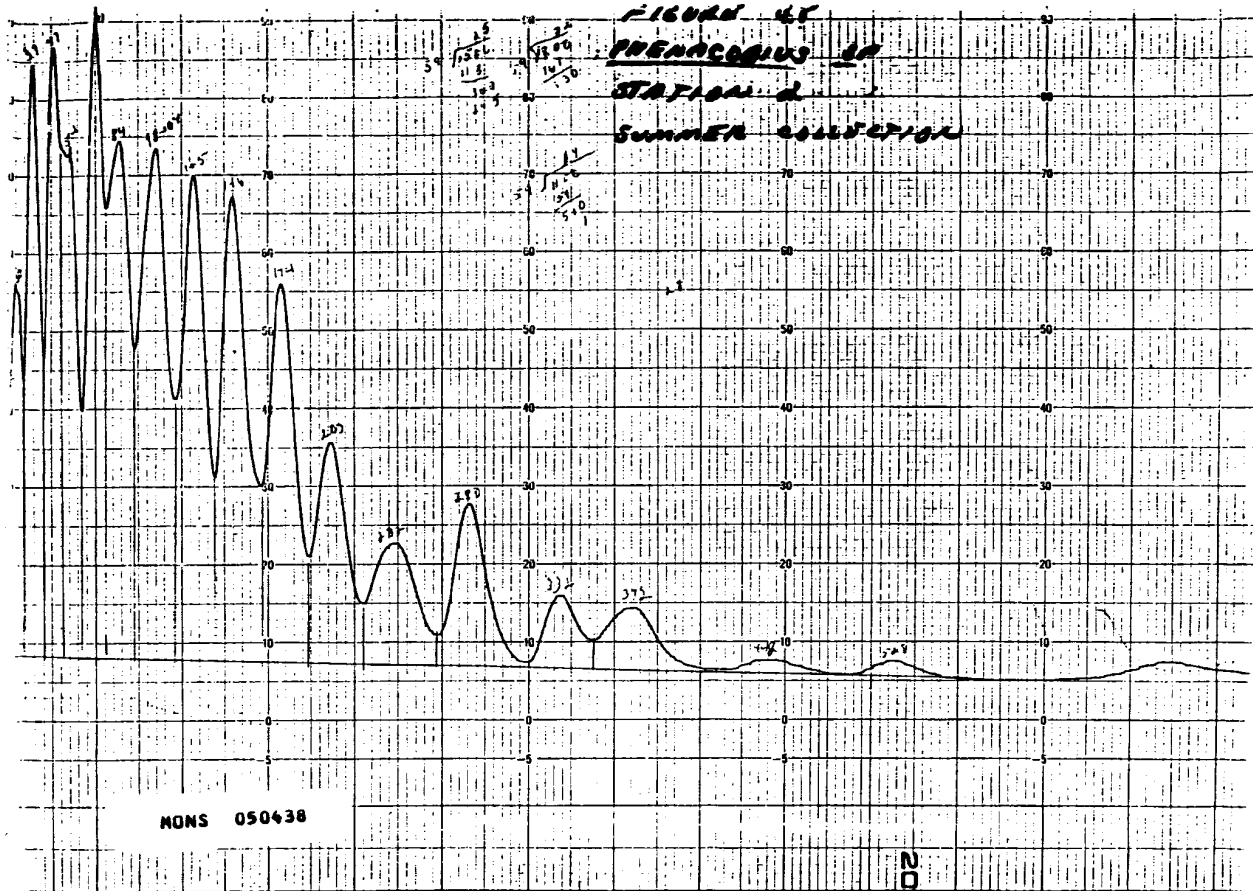
SUMMER COLLECTION



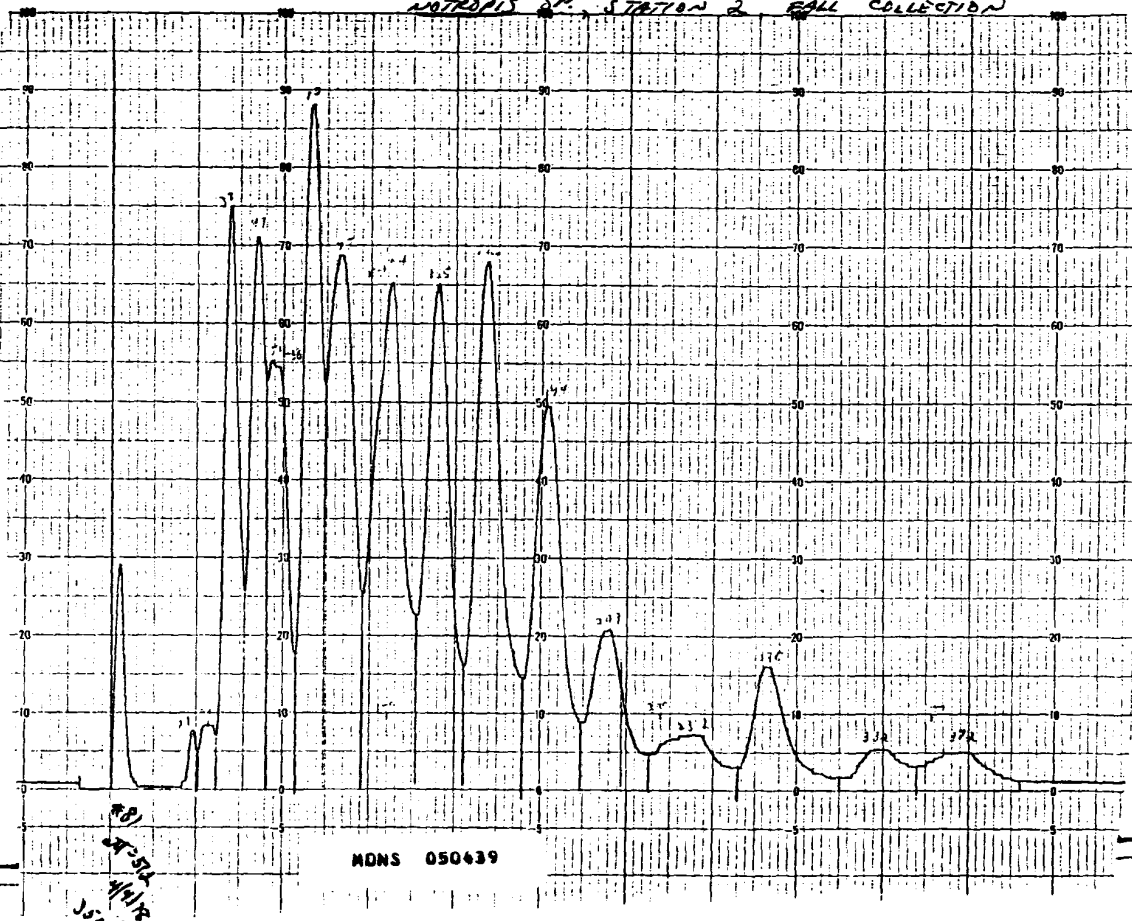
8-3-4

10

FIGURE 45
PNEUMOCOCCUS AT
STATION 2
SUMMER COLLECTION



ANTHROPUS SP., STATION 2 BALL COLLECTION



MONS 050439

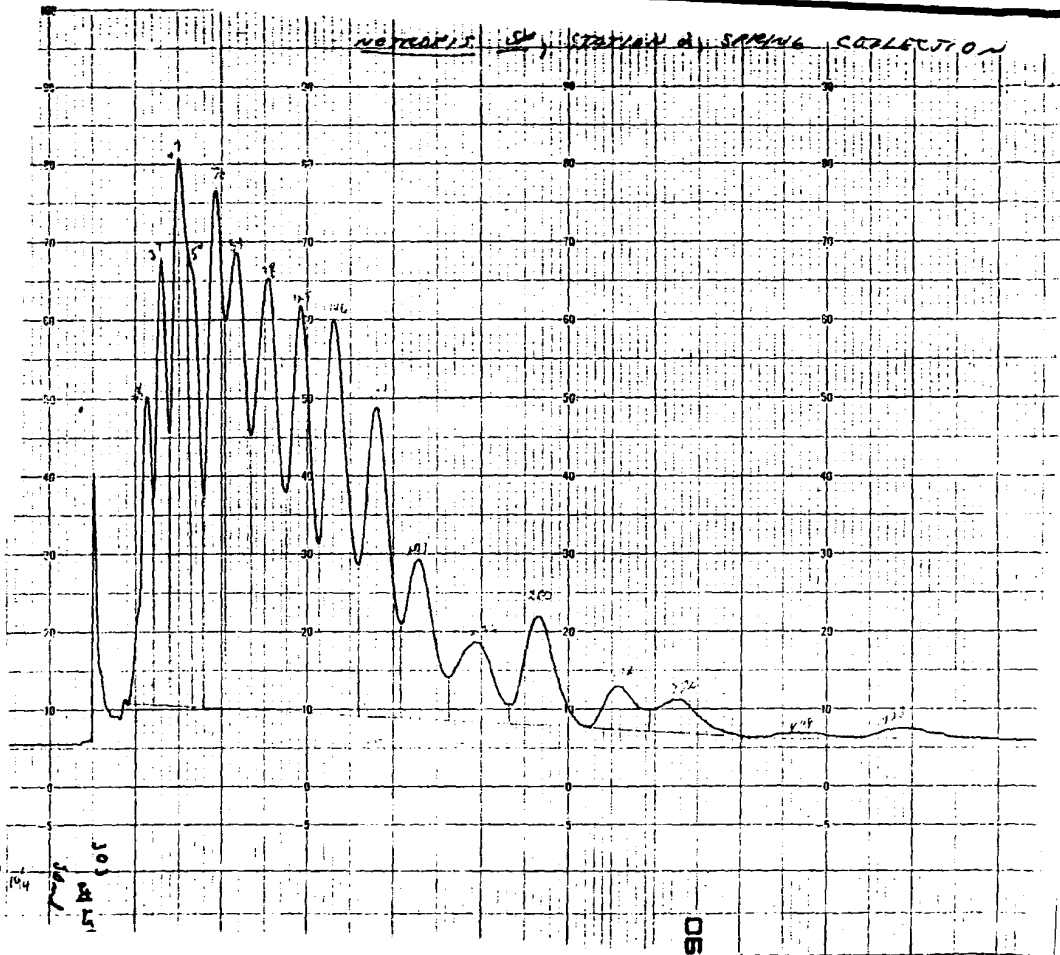
8/5/54
4/1/54
35

NOTROPIS SA STATION 2, WINTER COLLECTION



MONS 050441

NOTES: 15, STATION 2, SAMPLING COLLECTION



06

NOTROPIS SP. STATION 2, SUMMER COLLECTION

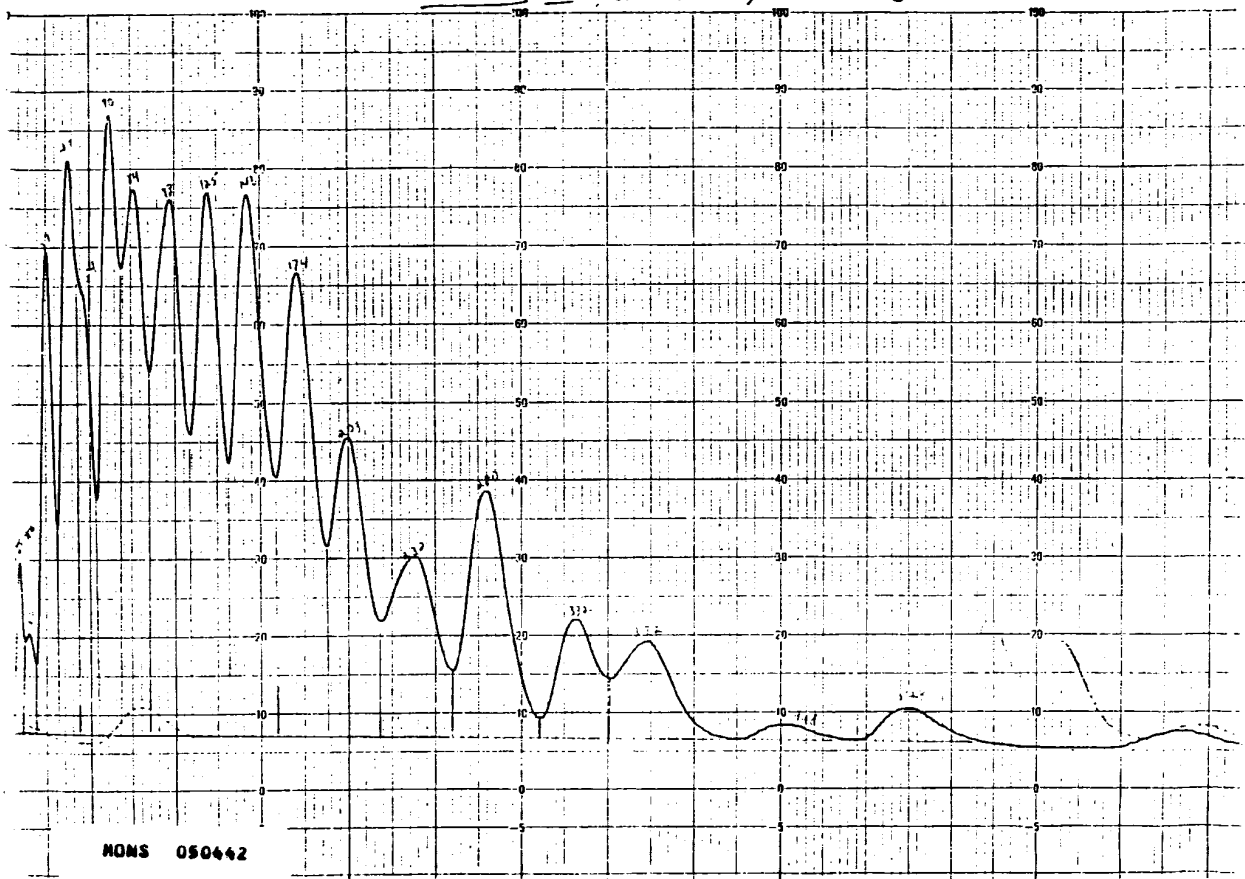


FIGURE 43

SAMPLE # 25

MACROPTERUS Sp

579710-2

FBI COLLECTION

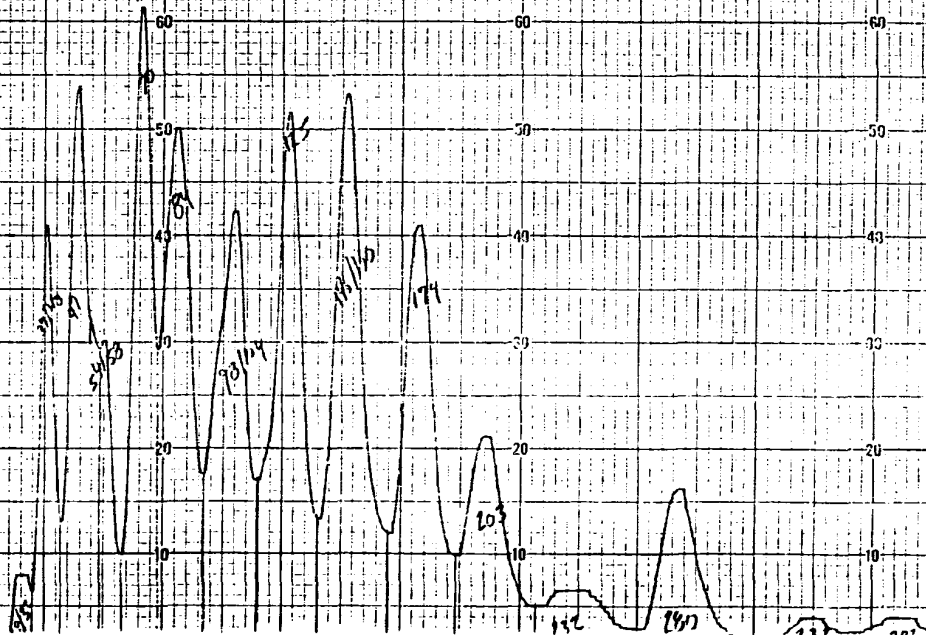


FIGURE 44

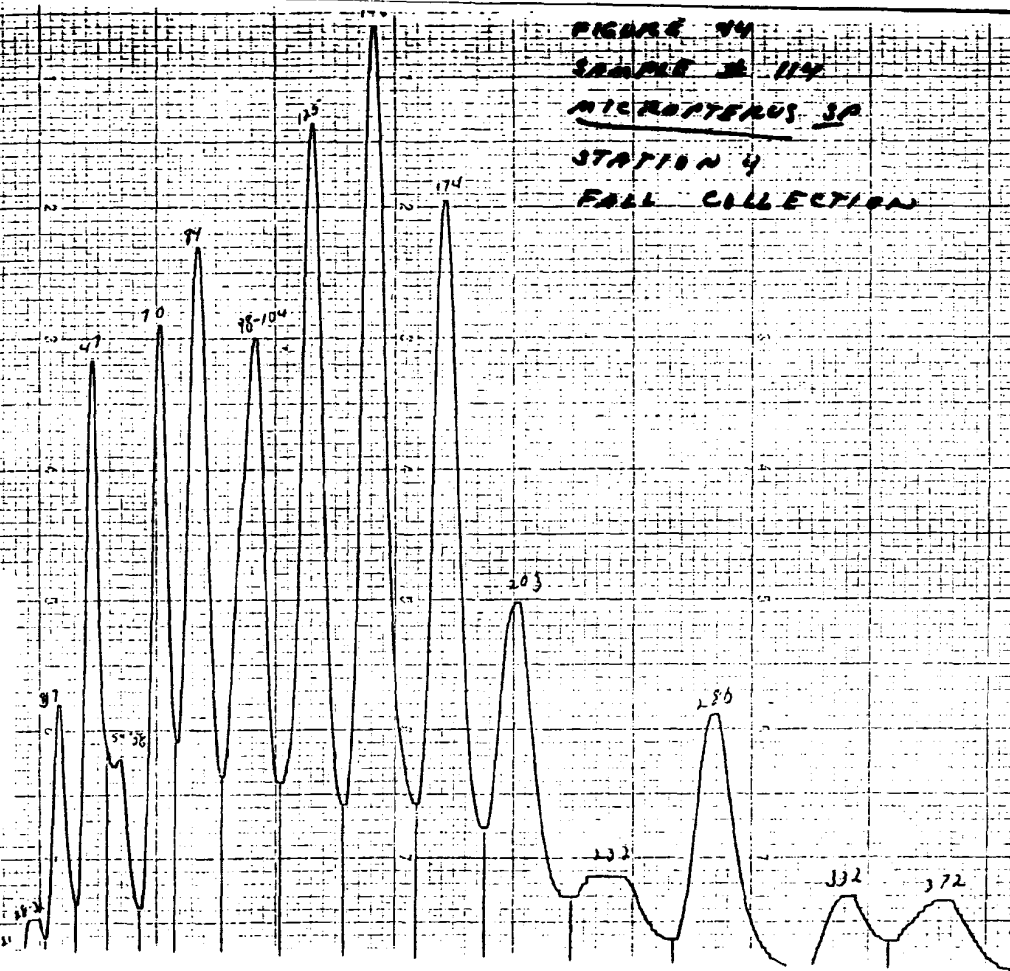
SAMPLE # 114

MICROTHERUS SP

STATION 4

FALL COLLECTION

MONS 050444



IV. DISCUSSION

This ~~study~~^{study} was undertaken ^{to} determine the relationship of the contaminated abiotic components (water, sediment, suspended solids) with the bioaccumulation of PCB by fish; to determine the half-life of PCB's in this organically contaminated stream; to determine whether the Rivermain has acted as a "sink" for PCB accumulation and storage; to determine whether a wet weight-PCB concentration relationship exists, and whether it fluctuates with the seasons; to determine whether there are differences in species accumulation and if so, whether they are most closely related to feeding mechanisms, food chain relationships, differences in lipid concentrations in each species or differences in metabolic ability of each species.

In order to accomplish this, the data ^{was} ~~are~~ summarized. The summary of the data presented in the above Tables (Tables 10-12) show^d that there^e are certain variables which influence the accumulation of PCB by fish. In this system, the station location, and in some cases, the weight of the organism and season of collection affect this accumulation.

A closer look at these factors and their effect on each species was then undertaken to better describe the relation-

ships.

Many papers have attempted to show that there is a correlation between length, weight or age of fish and their PCB residue levels (Reinert, 1970; Kelso, 1974; Bache, 1973). Bache found that all three parameters were significantly correlated to PCB concentration in trout from Cayuga Lake. There was, however, considerable variability among older fish than younger and in areas of higher PCB contamination than in areas of lesser. In contrast, Olson et al., (1973) reported no correlation of PCB levels in muscle of pike (Esox lucius) to age or weight using either wet or lipid weight based concentrations.

Eberhardt (1975) has suggested that, if there is a correlation between weight and PCB concentration, a linear model using log weight vs log PCB concentration describes the relationship better than the simple weight vs PCB concentration model. Thus, the influence of fish weight on PCB accumulation was examined at each station in this system using both the log weight vs log ppm PCB and weight vs ppm PCB models. The data were analyzed, first using weight as a basis for PCB accumulation regardless of species, followed by each species at each station and then on a species per season basis.

The first analysis of PCB accumulation of all fish combined at each station was done to determine whether weight alone is the determining factor in PCB accumulation or whether a clustering of each species would become apparent. There was no clustering evident, however, the weight and PCB concentrations were significantly correlated, even though their correlation coefficients were very low. This suggests that the lipid-water partitioning of PCB may be contributing to the PCB concentration, but that other factors may also have an influence on PCB uptake. To determine whether differences in species were influencing this relationship, the data ~~was~~^{was} analyzed on a species per station basis. In ~~some~~^{these significant} cases the linear fit became much closer, however, there were many which showed no ~~correlation~~^{correlation}. Therefore, the differences in species do affect the weight-ppm relationship, but there must be other factors involved. It was thought that seasonal changes in lipid content may be a major cause of the deviation of species from the linear models. Thus, the data ~~was~~^{was} broken down again to the species per station per season level and the linear analysis ~~was~~^{was} again performed. The linear fit of the significant cases ~~became~~^{became} closer, however, 50% of the cases were not significantly correlated.

The results of this study show that, in fact, a log-log model is a better description of the weight-ppm re-

relationship than the simple weight-ppm model, and that, in general, PCB concentration tends to increase with increasing weight and may be related to both species and season. Fitting data to a linear model is often difficult due to a lack of samples when the data are broken down to the necessary level of species per station per season, and the small variation in the size of the fish. Also, the increased PCB concentration with increased weight theory is based on the assumption that the lipid percentage increases with fish growth. This is not always true. In wild trout, there was no direct correlation between body lipid content and size (Love, 1971). This may account for the lack of any correlation or lack of significance in many of the cases.

The use of regression models to determine whether a more complicated relationship between weight and PCB concentration exists did not improve the overall results.

One can conclude from the above that the lipid-water partitioning of PCB may be a route of entry to fish, but that other factors may be influencing this uptake.

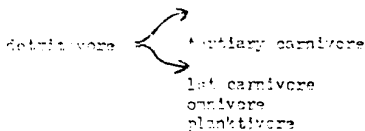
As it was ascertained that the weight vs ppm PCB relationship is variable, and the range of fish sizes is generally small, the mean values of PCB residue in fish were used to describe the contamination of the river system and to show the influence of station location which was shown to be a major effect on PCB concentration in the ANOVA Tables (10-12). This stream was heavily contaminated with PCB's from 1930 to 1971. The fish residues indicated that the stream is still

highly contaminated near the prior source of PCB and decreases with increasing distance from the source. It appears that there is no major build-up of PCB in the reservoir. These findings indicate that the PCB's are highly immobile, as was shown in the lab^{by} Choi (1971). Although PCB's have a high affinity for clay, the differences in sediment types do not appear to have a great effect on its distribution in this system, i.e. fish from areas of high clay content (Stations 4 and 6)⁵ do not have higher PCB concentrations than those from areas of lower clay content (Station 2). Regardless of the sediment type, areas of such longstanding PCB contamination must be a result of PCB adsorption to stationary substances in those areas. Thus, the major source of PCB to fish must be the sediment. How then are PCB's being assimilated from the sediment to the fish? Is it solely through soluble PCB being leached from the sediment, and subsequently absorbed through the skin, on the suspended solids, being absorbed through the gills or directly ingested?

The first step in studying these questions is to determine whether there are species differences in PCB accumulation. The Arcata Tables (Tables 10-12) show that there are significant differences in species concentration at Stations 2 and 6, and the differences are evident when comparing all species at the other stations in the histograms (Figures 8-11 and 14-17).

Since PCB's are thought to be transported mainly on suspended solids the suspended solids may be a route of entry into fish, especially filter feeders. A comparison of the fluctuations in turbidity and suspended solids and the PCB levels of Dorosoma, a filter feeder, show that there is no relationship, and therefore, suspended solids probably do not greatly influence PCB uptake by fish. A comparison of the fluctuations in other water quality parameters and the changes in fish PCB concentrations show that only chloride, sulfate and other ions may affect the concentration of PCB by fish. Dissolved oxygen, carbon dioxide, alkalinity and temperature seem to have no relationship to the differences in PCB levels in fish and changes in seasons.

The trophic relationships were then examined, although all species were not found at all stations and seasons, the trophic rankings of those that were found are remarkably similar (Table 25). They show that those species of highest accumulation are generally detritivores, planktivores and tertiary carnivores, followed by 1st carnivores and omnivores. This gives evidence of a strong food chain relationship for PCB concentration. Table 27 shows the general food classification of those fish collected. If a food chain were followed, the fish would accumulate PCB's in the following order (from highest to lowest):



The detritivore is ranked so highly because the sediment usually contains such high levels of PCB. This is the general order of accumulation found in this study.

These relationships, however, may not be due to feeding habits alone. As seen above, Dorosoma accumulates very high levels of PCB. This is similar to Risebrough's findings (1972) in which a planktivore had greater PCB residue levels than fish occupying higher positions in the trophic pyramid. Since Dorosoma do not attain most of their residue from either food or suspended solids and planktivores usually contain high lipid contents, their high accumulation is probably related to their high lipid contents (see Table 26).

If accumulation is strictly lipid based, the fish would accumulate PCB's in the following order (from highest to lowest):

- * Dorosoma
- Camptostoma
- Micropterus

This is also the approximate order found in this study, however, when more data is available, the relationships will hopefully become more clear.

The correlation of PCB concentration to weight of all species and the spawning seasons of Dorosoma, Micropterus and Notropis along with the high accumulation of the PCB by the high lipid species, Dorosoma, all give a very strong case

* This is based on the limited data found in Table 26.

for the lipid partitioning route of uptake by fish.

It is difficult to determine whether the consistent relationships of PCB accumulation among fish shown in Table 25 are a result of a food chain or lipid phenomenon. Since Dorosoma have 12 to 20% more lipid than do Carpentaria while both accumulate similar levels of PCB, and the variation in lipid content of the other fish (Carpentaria included) is fairly small (based on only limited data) while the differences in PCB accumulation are sometimes very large, it seems likely that the lipid content is not the only factor influencing PCB accumulation by fish.

Both food and lipid partitioning may be major routes of PCB entry to fish. Detritous feeders and tertiary carnivores pick up similar levels of PCB through their food (and some lipid partitioning) as do fatty fish (Dorosoma) through mainly partitioning. It seems likely, then, that fish of similar body composition would accumulate similar amounts of PCB from the water by partitioning, and this accumulation is enhanced by that which is accumulated through the food.

To determine whether differences in metabolism among species are causing the differences in species accumulation of PCB's, many chromatograms were compared and found to be almost identical both in number of peaks and relative peak heights. It was therefore assumed that there are no great metabolic differences among the species.

In conclusion, PCB's are seen to be relatively immobile

maintaining high levels near the source of the contamination and slowly declining with increased distance from the outfall, even though the contamination was discontinued seven years prior to the study; the PCB's tend to increase with increasing weight of the fish; the accumulation of PCB's by fish does not seem to be related to any water quality parameters except chloride, sulfate, iron and other ions which exhibit similar spatial patterns of water concentration as do the PCB's (as reflected by the fish concentrations); there are species differences in PCB accumulation; these differences are closely related to both feeding habits and lipid contents; the food chain has detritivores and tertiary carnivores accumulating PCB's to the highest levels followed by 1st carnivores and omnivores; the lipid relationship to PCB accumulation is shown by the high accumulation of PCB by Gyrinocheilus (higher than the tertiary carnivore), the correlation of weight and PCB concentration and the correlation of seasonal changes in lipid content due to spawning and PCB concentration; and finally, there are no great metabolic differences among species which could account for the differences in PCB residue levels.

APPENDIX A
PCS RESIDUE LEVELS OF ALL SAMPLES

MONS 050454

KEY FOR THE TABLES

Fish Nomenclature

<u>C. anomalum</u>	<u>Campestris anomalum</u>	stoneroller
<u>D. cepedianum</u>	<u>Dorosoma cepedianum</u>	gizzard shad
<u>G. affinis</u>	<u>Gambusia affinis</u>	mosquito fish
<u>H. etowanum</u>	<u>Hypentelium etowanum</u>	hog-sucker
<u>L. sp.</u>	<u>Lepomis sp.</u>	sunfish
<u>M. sp.</u>	<u>Micropterus sp.</u>	bass
<u>N. crysoleucas</u>	<u>Notemigonus crysoleucas</u>	golden shiner
<u>N. stilbius</u>	<u>Notropis stilbius</u>	silverstripe shiner
<u>N. texanus</u>	<u>Notropis texanus</u>	weed shiner
<u>N. venustus</u>	<u>Notropis venustus</u>	blacktail shiner
<u>P. carodes</u>	<u>Percina carodes</u>	log perch
<u>P. nigrofasciata</u>	<u>Percina nigrofasciata</u>	blackbanded darter
<u>Phenacohilus sp.</u>		minnows
<u>Pimephales sp.</u>		minnows
<u>Roccus chrysops</u>		white bass

LOCATION OF THE STATIONS

- Station 1: Choctolocco Creek, Highway 9 Bridge crossing. (control)
- Station 2: Choctolocco Creek, Highway 109 Bridge crossing.
- Station 3: Cheaha Creek, Highway 109 Bridge crossing. (control)
- Station 4: Choctolocco Creek, Highway 77 Bridge crossing.
- Station 5: Coosa River, Highway 72 Bridge crossing. (control)
- Station 6: Coosa River; Stanley Bridge, Logan Martin Reservoir.
- Station 7: Logan Martin Reservoir, above Logan Martin Dam.
- Station 8: Logan Martin Reservoir, below Logan Martin Dam
- Station 9: Choctolocco Creek, Highway 109 Bridge crossing, (between station 2 and 4).

OTHER COMMENTS

- 1) Average weight - the weight per fish from a composite sample of fish of approximately the same length & weight; given in grams wet wt.
- 2) All Aroclors are in ppm based on wet weight. MGNS 050455
- 3) (--) in a column means that the data is not yet available.
- 4) The DDE column: an (X) is placed in this column if the ng of peak 100 (assumed to be DDE) represents greater than 30% of Aroclor 1254. When this occurred, the data was adjusted so that the peak (100) represented no more than 25% of the Aroclor 1254, and this data is presented in the table. (All) means that only DDE was found in the sample. (This hopefully eliminates a great DDE influence on the data.)

Table 1
FALL 10/5/77
Station 1

Sample Number	Species	Average Weight	1242	1254	1260	Total	DOE
30	L. macrochirus	.2732	.0000	.0000	.0000	.0000	all
61	" "	.2770	.0742	.0545	.0070	.1359	x
62	" "	.4858	.0169	.0585	.0070	.0825	x
29	" "	.5419	.0000	.0000	.0000	.0000	all
64	L. megalotis	.7333	.0276	.1415	.0041	.1733	
60	L. macrochirus	.8821	.0852	.0256	.0149	.1958	x
28	" "	1.0123	.0213	.0855	.0013	.1080	x
63	" "	1.7199	.0329	.0829	.0061	.1220	x
65	" "	1.7672	.1199	.0568	.0034	.1803	x
57	M. punctulatus	4.8570	.1046	.1403	.0061	.2511	x
58	M. cossae	6.7348	.0814	.1969	.0169	.2972	x
56	M. punctulatus	8.6031	.5527	1.6952	.0145	2.2555	x
54	" "	11.8104	.0169	.0272	.0007	.0449	x
55	" "	12.9858	.0171	.1705	.0049	.1925	x
66	H. stowanus	2.8684	.4163	.1044	.0200	.5307	x
67	" "	4.5829	.0030	.0343	.0025	.0399	x
59	" "	6.4714	.0437	.1016	.0104	.1558	
68	" "	7.4293	.0154	.0753	.0084	.0992	x
71	M. vorustus	.3350	.0096	.0561	.0214	.0873	x
72	" "	.4687	.0185	.0926	.0301	.1412	x
70	" "	.8383	.0126	.0790	.0037	.0956	x
69	" "	1.5131	.0032	.1299	.0073	.1404	x
75	P. microfaciata	.6247	.0236	.1685	.0714	1.0637	x
74	" "	.8814	.0239	.0474	.0280	.0994	x
73	" "	2.9405	.0201	.2250	.0858	.3310	x
52	P. caprodes	4.2306	.0633	.0840	.0041	.1523	x
53	G. affinis	.4045	.1095	.0779	.0093	.1968	x

Table 2
Winter 1/16/78
Station 1

Sample Number	Species	Average Weight	1242	1254	1260	Total	DWG
175	H. etowanua	.4960	.1201	.2415	.0709	.4325	x
170	"	1.5400	1.4966	1.2519	.5226	3.2774	
173	"	1.9776	.0735	.0977	.0226	.1940	x
172	"	2.5081	.1505	.1548	.0826	.3869	x
171	"	3.4266	.0050	.0320	.0130	.0500	x
167	L. macrochirus	.2242					
168	"	.4187	.0196	.0675	.0010	.0881	x
169	"	.5449	.1633	.5067	.1190	.8891	
176	M. venustus	.1047	.1975	.2003	.0436	.4415	
175	"	.4980	.1201	.2415	.0909	.4525	
174	"	2.1670	.5813	.5436	.9460	1.7224	
166	M. punctulatus	11.46	1.7163	6.5870	1.9478	10.2513	

Table 3
Spring 8/14/78
Station 1

Sample Number	Species	Average Weight	1242	1254	1260	Total	DWG
285	L. macrochirus	.3541	.0800	.1083	.0606	.2489	x
293	L. megalotis	.4141	.0525	.1902	.0650	.3077	x
287	L. macrochirus	.5613	.0632	.3326	.0503	.4461	x
294	L. megalotis	.6240	.0308	.1022	.0475	.1805	x
290	L. macrochirus	.7205	.0477	.1931	.0456	.2864	
291	"	1.0221	.1655	.7409	.0750	.9814	
284	L. sp.	1.2862	.0375	.1646	.0904	.2925	x
292	L. macrochirus	1.3543	.0857	.1351	.0375	.2583	
285	L. sp.	1.4896	.0220	.2016	.0577	.2813	
286	"	1.7472	.0253	.1078	.0233	.1564	x
287	"	2.5488	.0372	.0760	.0055	.1187	x
271	N. venustus	.3190	.0406	.2317	.0570	.3293	x
272	"	.6433	.0794	.4023	.1287	.6104	
273	"	.9673	.0755	.1532	.0454	.2741	x
274	"	1.8291	.0592	.1535	.0411	.2538	x
277	N. texanus	1.3735	.0793	.1802	.0414	.3009	x
276	"	3.5472	.0470	.2180	.0904	.3554	x
275	N. venustus	3.9965	.0517	.2732	.0855	.4104	x

Table 3 (continued)

Sample Number	Species	Average Weight	1242	1254	1260	Total	DEB
278	G. affinis	.3016	.0282	.1538	.0573	.2493	x
279	" "	.5290	.0509	.3015	.1036	.4561	x
280	" "	.6122	.0483	.1780	.0373	.2636	x
281	" "	.7755	.1122	.2700	.0731	.4553	x
282	P. nigrofaciata	1.2649	.0696	.3399	.1278	.5374	
283	" "	1.5836	.1166	.3440	.1530	.6137	

Table 4
Summer 8/3/73
Station 1

Sample Number	Species	Average Weight	1242	1254	1260	Total	DEB
524	G. affinis	.4732	.0537	.2234	.0664	.3455	x
523	" "	.5721	.0625	.1659	.0406	.2691	x
522	" "	.7652	.0460	.1296	.0391	.2147	
521	" "	1.1721	.0365	.1240	.0396	.2012	x
513	N. stilbius	.4348	.1694	.3835	.6311	.6341	x
517	" "	1.8439	.1055	.3947	.0856	.4960	x
514	N. venustus	2.1783	.1382	.3659	.0793	.5626	x
518	N. stilbius	2.4117	.0316	.1343	.0640	.2499	x
515	N. venustus	6.0994	.0672	.2168	.0766	.3606	x
516	" "	8.8915	.7235	1.1080	.2595	2.0911	x
509	H. etowanum	--					
510	" "	1.0752	.0685	.2753	.0000	.3551	x
511	" "	1.6852	.0490	.2486	.0570	.3542	x
529	L. macrochirus	1.6672	.0233	.1073	.0308	.1615	x
526	" "	3.0578	.0210	.1593	.0355	.2260	x
527	" "	4.5279	.1181	.1701	.0391	.3273	x
520	M. punctulatus	1.5488	.0465	.3350	.0761	.4578	x
519	M. crosse	1.7708	.0764	.2498	.0734	.3998	x
502	Phenacobius sp.		.1766	.3970	.0785	.6501	

Table 5
Fall 10/5/77
Station 2

Sample Number	Species	Average Weight	1242	1254	1260	Total
24	L. cyanellus	7.6803	11.6756	12.3925	1.5037	25.5510
243	" "	25.3639	6.7503	6.9504	3.4567	17.1581
244	L. megalotis	30.6782	9.1720	6.3023	1.8793	17.3537
246	" "	35.9327	9.5503	6.8925	2.2884	15.7319
25	M. coosae	6.0728	25.3937	27.5447	3.1035	56.3300
245	" "	19.3908	11.7530	10.9691	5.5532	28.2754
76	G. affinis	2.3741	22.3513	24.9335	1.6235	51.6610
79	C. annulatus	2.0577	58.4825	29.7564	7.3000	95.5410
80	" "	3.0577	50.6953	23.9907	3.8572	78.5020
78	" "	5.9165	49.6289	24.2803	.9125	74.5970
77	" "	8.0441	52.8870	24.2899	5.0390	82.0490
83	N. venustus	.2466	78.1123	70.3948	20.9093	169.4165
84	" "	.3571	17.8513	21.3518	1.3277	40.5730
85	" "	.4937	20.7936	20.6274	1.4621	42.8971
81	" "	.6964	63.7489	30.4316	3.9856	93.1767
82	" "	1.1029	5.3523	5.1287	.4954	10.9797

Table 6
Winter 1/16/78
Station 2

Sample Number	Species	Average Weight	1242	1254	1260	Total
143	N. venustus	.4879	9.2744	7.8145	1.5259	18.6159
132	" "	.7839	15.7666	15.2037	4.2783	36.2497
181	" "	1.4906	17.2427	16.2592	5.9132	39.4166
179	" "	2.5873	17.9524	15.9636	4.7594	32.2653
173	" "	3.0062	11.8716	10.6835	4.5554	27.3157
177	" "	4.5071	12.2032	11.7625	7.1439	31.1118
		9.0587	15.9476	14.1560	6.1547	36.2835
184	M. punctulatus	6.1064	19.1496	16.1953	6.8041	42.1491
187	L. megalotis	1.7415	15.3824	13.9744	3.7511	33.6232
186	" "	2.4116	15.2825	15.1498	4.1573	37.7897
135	" "	3.7003	6.3034	6.4746	3.8782	16.6583
100	" "	9.3054	10.7338	11.5852	8.3539	30.6880
191	" "	10.1456	13.5570	12.5037	7.5076	33.5584
103	" "	11.9537	8.5603	10.2232	10.1305	33.9140
102	" "	14.8738	4.6448	6.8723	6.1404	17.5577
188	H. etowanum	3.2172	25.2531	22.4915	9.0760	56.3310

Table 7
Spring 4/14/78
Station 2

Sample Number	Species	Average Weight	1242	1254	1260	Total
295	C. anomalus	6.2150	21.9168	13.6765	6.3407	48.9342
296	C. affinis	1.0331	11.7896	11.5362	3.6411	26.9670
297	N. venustus	.8392	13.2897	11.5408	3.7021	28.5327
302	" "	3.0358	7.8671	5.9867	1.2732	15.1272
301	" "	3.6547	11.1193	7.9279	1.7042	20.7514
300	" "	5.4645	8.2131	6.7937	1.5121	16.5190
303	N. chysoccephalus	5.4670	5.0636	3.3106	.7802	9.1544
304	" "	6.8252	5.8821	4.9030	1.2389	12.0241
299	N. venustus	11.1818	11.5900	10.2324	5.3548	27.1773
298	" "	14.2448	8.2627	5.7536	2.0792	16.1055
305	L. megalotis	5.8778	5.6467	4.4591	.9695	11.0718
306	" "	9.8028	4.3783	2.7771	.4175	7.5730
373	M. coosae	80.0912	11.3965	11.4916	6.3075	29.1956

Table 8
Summer 8/3/78
Station 2

Sample Number	Species	Average Weight	1242	1254	1260	Total
401	Phenacobius sp.	.5723	17.3131	13.0177	3.9533	34.2843
400	" "	.8847	22.0199	15.3359	5.0202	42.3762
400	" "	1.0193	24.4709	15.4520	4.4207	44.3537
488	" "	1.4740	17.9782	12.2432	3.5081	33.7345
487	" "	1.7675	18.9130	12.9184	3.3914	33.2229
406	N. stilbius	.9782	14.1781	13.9547	5.0464	33.0792
405	" "	1.1843	14.6008	12.8022	6.4638	33.6665
407	" "	1.4900	21.3398	24.4323	7.5856	55.3503
404	" "	1.4945	17.4077	18.2987	8.2022	43.9157
402	" "	2.7637	21.1890	24.1969	11.6814	57.0674
504	N. venustus	4.8050	15.7528	16.8469	10.4320	43.0317
503	" "	8.5410	14.1797	12.2969	8.0094	34.5044
502	" "	18.1093	8.6714	21.5163	12.2488	42.4373

Table 8 (continued)

Sample Number	Species	Average Weight	1242	1254	1260	Total
493	L. sp.	.1913	5.8472	5.6764	1.4434	12.9672
507	L. marginatus	4.3067	21.6036	18.9537	5.4981	46.0557
505	L. megalotis	8.8553	9.5920	7.2379	2.7059	19.5370
506	" "	11.3385	8.0930	7.1229	3.1280	18.3445
497	" "	13.3494	14.2405	9.5947	3.2678	27.5032
549	L. macrochirus	23.1021	7.8549	6.7656	2.2573	16.8793
552	" "	25.6936	8.6778	9.3672	5.5837	21.6288
551	" "	33.0074	8.3582	5.4105	3.2930	17.0618
547	L. cyanellus	33.7480	6.9748	5.4704	2.6791	15.1244
546	L. megalotis	37.2835	9.0745	7.9290	3.5940	20.5976
545	" "	46.8474	2.8570	5.7048	4.6777	13.2395
548	L. macrochirus	46.8784	10.2453	8.0663	3.4511	21.7629
501	G. affinis	.2270	4.5827	4.6006	.5993	9.1827
499	" "	.7127	14.1007	12.5373	2.5769	29.3152
500	" "	.8057	12.0708	10.8732	2.0470	24.9910
550	M. punctulatus	34.8773	6.0809	5.8507	2.3704	14.3022

Table 9
Fall 19/5/77
Station 3

Sample Number	Species	Average Weight	1242	1254	1260	Total	DFS
85	N. sp.	1.2632	1.2064	2.5538	.3059	4.1672	
93	" "	2.0157	.4861	2.5927	.3607	3.4590	
94	" "	2.0693	.2776	1.8724	.2265	2.3770	
92	" "	2.5253	.2397	1.0488	.1368	1.4253	x
91	" "	4.4294	.2875	1.1371	.1655	1.5933	x
89	L. cyanellus	2.7959	.0931	.1519	.0312	.2764	
90	" "	4.0521	.1192	.3067	.0473	.4733	
43	L. macrochirus	6.0652	.0352	.3754	.0796	.4900	
88	L. cyanellus	7.4903	.1633	1.0378	.1157	1.3172	
87	L. macrochirus	10.5992	.1827	.5082	.4328	1.1238	
42	H. etowahya	1.8377	.1112	.2590	.1020	.4722	
41	H. etowahya	3.9677	.0548	.2502	.1179	.4229	
86	G. affinis	.2082	1.3330	1.9105	.1318	3.3760	
40	" "	.3089	.0592	.2937	.0458	.3990	
37	M. cooras	2.2832	.0352	.2650	.0299	.3301	
36	" "	4.9678	.0000	.0000	.0000	.0000	all

Table 9 (continued)

Sample Number	Species	Average Weight	1242	1254	1260	Total
98	P. nigrofasciata	2.8013	2.3550	7.6053	.9959	10.9560
99	"	3.4142	.0040	.3403	.0402	.4132
100	"	4.6897	.7104	4.4427	.6407	4.6877
98	C. anomalus	1.5232	1.8991	4.0808	.5237	6.5008
99	"	2.3961	.1163	.7078	.0947	.9166
97	"	3.2028	.1229	.5601	.0941	.8674
100	"	7.1151	.1182	1.2077	.2351	1.5616
101	"	9.5790	.4790	1.7011	.1850	2.3653
95	"	11.2848	.0470	.4221	.0257	.4950
102	"	14.1099	.9091	2.0755	.3143	3.1532

Table 10
Winter 1/16/78
Station 3

Sample Number	Species	Average Weight	1242	1254	1260	Total	DEB
202	H. etneum	2.9003	.0335	.0332	.0226	.1536	x
203	"	3.0511	.0117	.1184	.0553	.1855	x
201	"	5.6232	.0296	.0857	.1828	.1420	x
200	"	7.9479	.0289	.1285	.0199	.1774	x
199	"	10.2373	.0947	.2566	.1230	.4754	x
198	"	19.0121	.0287	.1753	.0357	.2374	x
197	L. megalotis	2.3470	.5936	.4314	.1047	1.1798	x
196	"	3.9173	.0247	.1265	.0665	.2178	x
195	"	10.0416	.0992	.2371	.0917	.4281	x
269	L. macrochirus	70.3218	.2530	.6691	.1932	1.1155	x
104	N. venustus	.4241	.4094	1.1603	.4526	2.0225	

Table 11
Spring 4/14/78
Station 3

Sample Number	Species	Average Weight	1212	1254	1260	Total	DDE
325	N. texanus	1.7199	.3255	1.3564	.5551	2.2675	
324	"	2.0627	1.2005	3.4823	1.1332	5.6162	
316	N. stilbius	2.3725	.5036	2.1819	.7252	3.4158	
323	N. texanus	2.4045	.2679	1.8780	.5486	2.6945	
322	"	3.7161	.3149	1.1389	.2927	1.7466	
321	N. stilbius	3.7572	.3609	1.0975	.3193	3.6607	
310	N. chysocephalus	4.0016	.7019	2.6689	.9395	4.3104	
317	N. stilbius	4.0391	.7624	3.4316	1.2379	5.4319	
320	"	5.2842	1.9309	8.1734	1.7471	11.8515	
318	"	5.8106	.2487	1.1399	.3535	1.7423	x
307	N. venustus	9.5501	.3290	.4672	.2438	1.0402	x
308	L. macrochirus	9.2246	.1136	.3576	.1638	.6351	
309	M. coosa	6.2905	.1490	1.1311	.6347	1.9144	
319	P. nigrofasciata	1.2640	.1918	.7353	.3606	1.2879	
314	C. anomalum	2.7370	.0843	.6033	.1989	.8867	
315	"	3.6313	.2991	1.3250	.0824	2.1066	
313	"	4.2492	.0701	.3253	.2276	.6241	
311	"	5.6557	.0407	.2298	.0454	.3160	
312	"	7.9257	.2333	.4251	.1850	.8435	
375	"	20.4925	.1319	.3571	.0701	.5593	x

Table 12
Fall 10/5/77
Station 4

Sample Number	Species	Average weight	1242	1254	1250	Total
104	L. macrochirus	2.1966	5.1218	6.1254	6.0755	11.7546
105	" "	2.9817	6.5909	6.8006	7.2533	14.1610
106	" "	3.9124	4.4537	4.2955	4.5758	9.3355
27	" "	4.8491	4.5163	5.9431	6.3097	11.9450
117	L. megalotis	4.8733	2.1854	1.8647	1.1751	4.2250
119	" "	6.3104	3.0310	3.5681	2.401	7.4393
120	" "	7.5744	4.6382	4.5078	6.6782	9.8243
103	L. macrochirus	8.7304	4.2434	4.7139	4.5674	9.5251
122	L. megalotis	11.4249	5.0564	3.6657	4.4737	9.2005
123	" "	13.7299	7.1843	7.6212	1.4303	16.2363
118	" "	14.1814	6.2773	9.8894	1.5812	17.6886
124	" "	14.8035	5.2245	7.3584	1.5774	13.9904
26	M. crysoleucas.	8.0749	1.2370	2.3322	1.3340	3.8640
116	" "	8.4581	1.3788	2.2531	1.1658	4.6178
108	D. cepedianum	9.7876	9.9501	14.2582	2.9272	27.1362
109	" "	10.0011	14.2057	17.7011	3.3103	34.9683
107	" "	11.3999	7.6043	9.3556	3.1472	20.1260
111	P. caprellae	1.6752	6.4980	8.6546	1.4339	16.6646
110	" "	3.5613	12.8138	17.2362	1.9852	29.7799
112	M. punctulatus	4.4563	5.8770	7.6528	1.0659	14.5702
113	" "	5.4364	8.4165	12.7677	2.1963	24.3800
114	" "	8.6202	6.0582	9.8792	1.4042	17.7417
115	" "	10.4935	3.1286	8.8247	1.8395	13.7923