TRANSLOCATION MECHANISMS
OF PCB'S
IN FRESH WATER:
A FIELD STUDY

DSW 030671

CONTENTS

DSW 030672

TABLES

DSW 030673

STLCOPCB4014635

DSW 030674

FIGURES

DSW 030675

DSW 030676

INTRODUCTION

PCB's are a class of aromatic, chemically inert, nonflammable chlorinated hydrocarbons. They possess high dielectric constants, low points of volatility, are not hydrolized by water, and resists alkalies, acids and other corrosive chemicals (Peakall, 1970). Their boiling points range from 278°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; Panel, 1972). Papageorge and Wheeler (cited in Panel, 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 sysnthesis in 1881 and manufacture in 1930, thousands of tons of PCB's have escaped into our waterways. Upon enterring 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 8um 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 adsorbtive 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 (2um) and high organic content(Leland,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 it's 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 it's contamination within 9 months of the initial finding of the pollutant. Munson et al.,(1976) showed that areas of highest contamination in the upper Chesapeake Bay may have conformed 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 process involving the initial adsorption followed by absorption 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 Risebrough containing median dry and wet weight concentrations on the order of 2.0 and 0.2ppm, respectively and phytoplankton rich samples taken by Harvey with a mean of 2ppm, 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. Oysters exposed to 5ppb Aroclor 1254 for 24 weeks accumulated 425ppm or 85,000 times the water concentration (Lowe,1972). In 14 day exposures, Gammarus fasciatus concentrated Aroclor 1254 to 27,000 times the water level (1.6ug/l) and Daphnia concentrated Aroclor 1248 to 48,000 times the nominal water concentration of 300ug/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).

DSW 030680

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;Nimmo,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;Reinert,19[illegible]). The quick initial uptake was demonstrated by Hansen's experiments in which spot (Leiostomus xanthurus) accumulated 3.7 x 10^4 times the ambient water level in 14 to 28 days. Long term studies with fat headed minnows (Pimephales promelas) showed that residues were 2 to 4 times higher after 8 months than they were in fish sampled after 30 days (Mebeker, 1975;Fed. Reg.,1977;Veith,1970). In 77 day exposures, channel catfish (Ictalurus punctatus) concentrated Aroclor 1248 and 1254 to 56,370 and 61,190 times the concentration in the water, respectively, with the more chlorinated compounds accumulting 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

Sec [illegible]

DSW 030681

STLCOPCB4014643

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. Prendas and Anderson (cited in Reinert, 197 found that after a 5 minute exposure to 1 ppm C^{14}-labeled DDT, Atlantic Salmon concentrated 1.56 ppm in the liver and spleen. After one hour of exposure this value reached 31 ppm.

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~~ have 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 1242 and 1248. The concentrations in the suspend d solids (dry weight) were 4 to 10 times higher than in the sediment (dry weight). Munson theorized that this was probably because the average

DSW 030682

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 showed 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 (Hauck,1977). In a similar study area in Michigan, however, Veith (1970) found the opposite results. Lab laboratory 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. Nimmo exposed pink shrimp (Penaeus duorarum) and fiddler crabs to various concentrations of Aroclor 1254 on silt. Up-

DSW 030683

STLCOPCB4014645

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 it's 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~~ with 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. <u>Uptake of PCB's from Food</u>: Food is of major importance in the bioaccumulation of PCB's. ** Channel catfish exposed to 20 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 (Hansen, 1976). Coho salmon fed Aroclor 1254 for 240 days at concentrations of 14.5 to 14,500 ug/kg body weight per day accumulated 0.9 to 5 times the exposure levels on a whole body weight basis, the highest level reached being

DSW 030684

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 as 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 bioconcentration of PCB's from food ~~are~~ generally involve these higher weight 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 PCB accumulation 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 (Mauk,1977). Similar trends involving mussels up through fish, mammals and birds have also been found (Eberhardt,1975; Gilman,1970; Peakall,1970).

DSW 030685

Others have found that bioconcentration does occur, but that the residue levels of organisms in the trophic pyramid have no relationship (Harvey,1973). Risebrough found that plankton eating fish in the Atlantic Ocean had higher concentrations than those occupying higher trophic levels. Giam found that plankton had residue levels an order of magnitude higher than the planktivores, flying fish(cited in Risebrough, 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 tubidity 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 (LIPID CONTENT) 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.

DSW 030686

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, Ernst 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. There are, therefore, no generalizations which can be made on this weight-ppm subject. However, from these contradictory results, it is clear that the lipid - weight theory, based on

DSW 030687

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. Laboratory 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, cited in Phillips, 1978).

PCB's have not only been shown to vary with size and species of fish, some writers 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 ~~[illegible]~~ available for collection at all stations and seasons. Therefore, there is a very SMALL number of samples in some cases. This limited both the statistical applications ~~to~~ of the data and the statistical significance of many of the results.

In the laboratory, the fall and winter samples were hexane extracted 2 times and the spring and summer samples were extracted 3 times (see methods). It was thought that the ~~%~~ percent 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. ~~[illegible]~~ It appears that the first 2 washes resulted in high recovery rates (70-98%) in most cases. The lowest percent recoveries were samples of Sunfishes (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

DSW 030690

STLCOPCB4014652

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. Therfore, to reduce 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.

DSW 030691

Table 1

Hexane Extraction Recovery

Sample 392, Station 3, *Phen~~o~~acobius sp.*, 5 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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, *Phen~~o~~acobius sp.*, 4.1 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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, *Phen~~o~~acobius sp.*, 0.68 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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, *Pimephales sp.*, 0.5 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

DSW 030692

Table 1
(continued)

Sample 422, Station 5, Dorosoma cepedianum, 4.7 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
ppm Aroclor 1242	0.31	0.54	0.86	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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

DSW 030693

Table 1
(continued)

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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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, *Lepomis sp.*, 13 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

DSW 030694

Table 1
(continued)

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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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, Gambusia affinis, .7 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
ppm Aroclor 1242	2.26	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

DSW 030695

Table 1
(continued)

Sample 429, Station 4, Dorosoma,cepedianum, 3.8 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
ppm Aroclor 1242	0.33	0.10	0.43	70.8
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

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

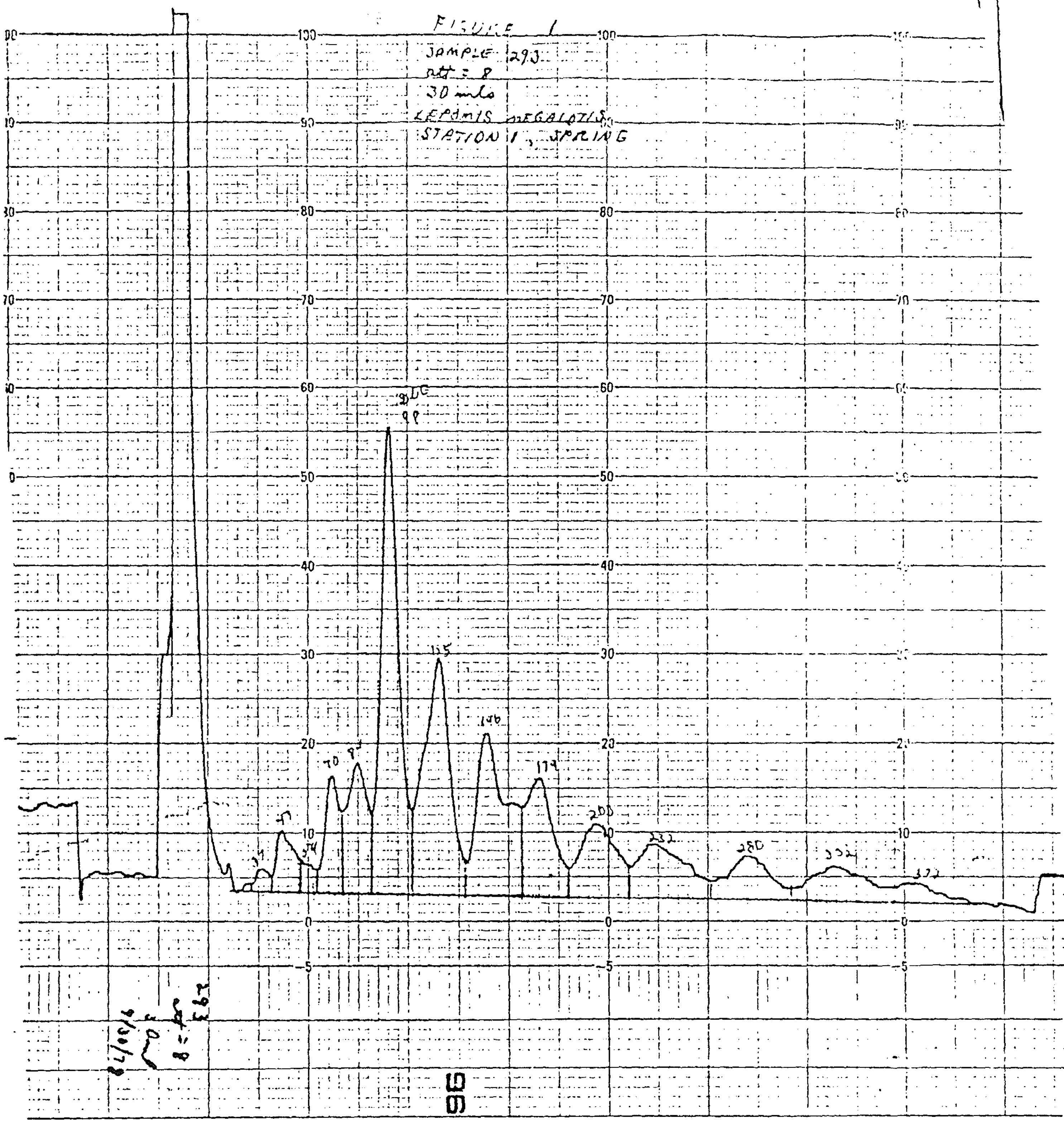
DSW 030696

Table 1
(continued)

Sample 489, Station 2, *Phenacobius sp.*, 1.0 grams

	First 2 washes	3rd wash	Total	% Recovered in First 2 washes
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

DSW 030697



DSW 030698

STLCOPCB4014660

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 resultee in high quantities of release into the stream. The study area is approximately 80 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

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 skimming off surface soil into glass jars.

2. Water for PCB and water quality analyses was taken in 4 300 ml BOD bottles.

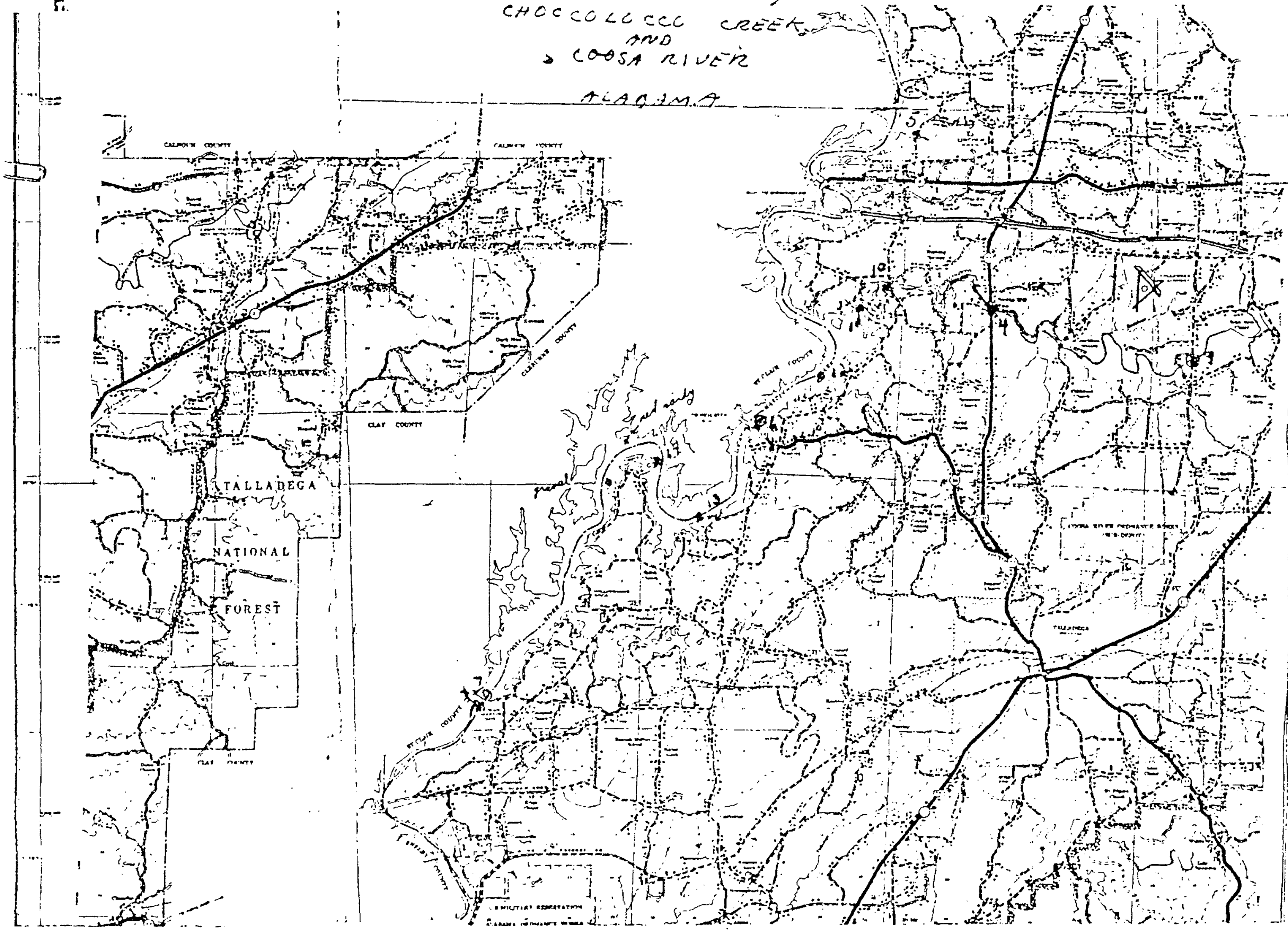
3. The fine surface sediments were skimmed off in glass jars.

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 45u glass filters.

DSW 030700

COLLECTING SITES
PCB SURVEY (1978)
CHOCCOLOCCO CREEK
AND
COOSA RIVER
ALABAMA

$1\frac{1}{2}$" = 4 miles



DSW 030701

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:

Campostoma sp.
Dorosoma sp.
Gambusia sp.
Hypentelium sp.
Lepomis sp.
Micropterus sp.
Notemigonus sp.
Notropis sp.
Percina sp.
Phenacobius sp.
Pimephales sp.
Roccus 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~~ THE STANDARD SIEVE + HYDROMETER METHODS ~~Dyrimometry~~. The extraction and cleanup methods for PCB analyses

DSW 030702

STLCOPCB4014664

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 ~~ed~~ 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 impuities 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 g (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-tpo 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

DSW 030704

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 6), the data tables (Tables 2-4) 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 retention times of 11-70 are compared individually to the corresponding peaks in 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 Respose Factors from the peaks of the appropriate standard. The following calculations were used:

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

DSW 030706

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

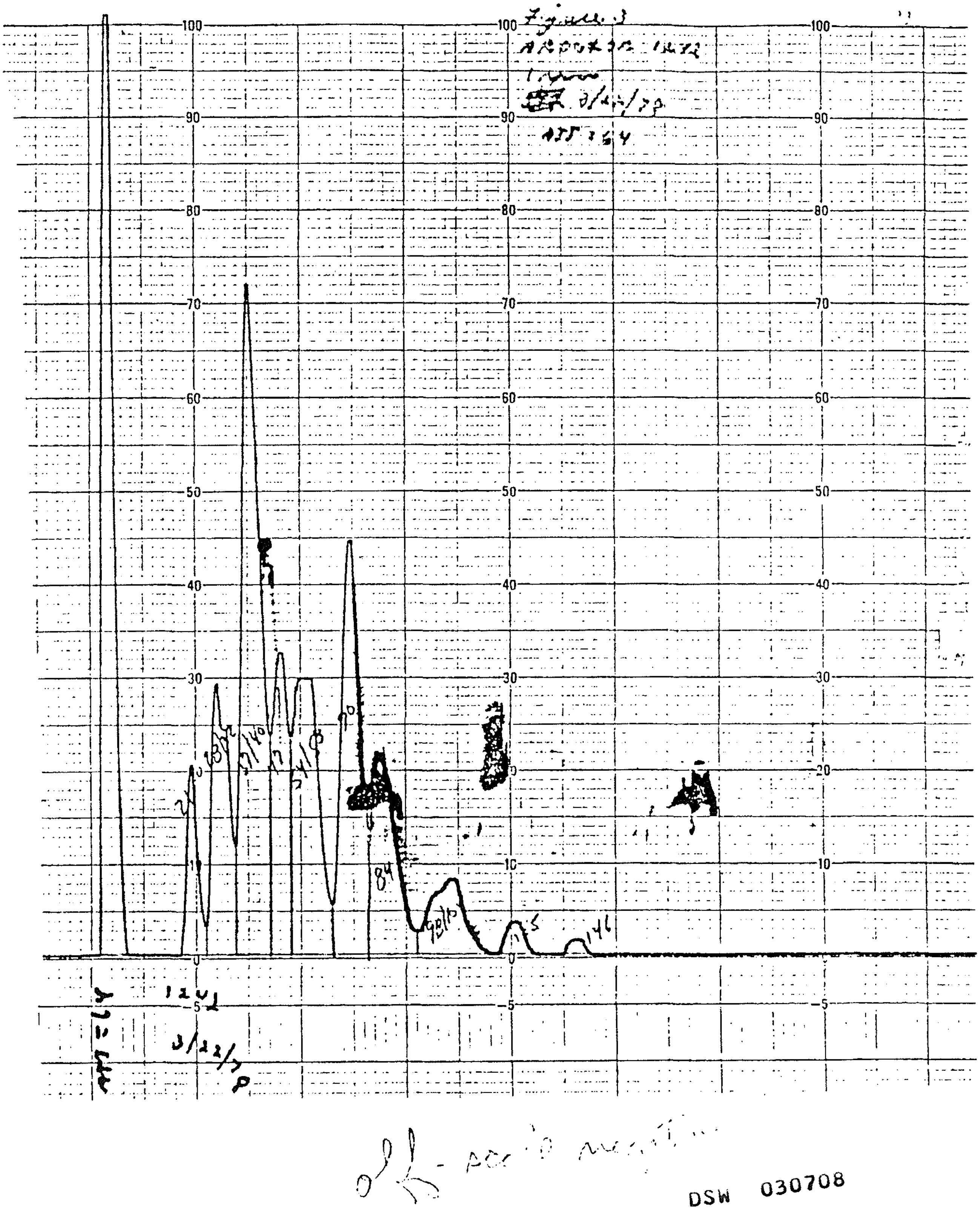
3. ppm PCB in sample = $\left(\frac{\text{total ng in sample}}{\text{ul tested}}\right) \left(\frac{\text{total volume of sample (mls)}}{\text{total weight of sample (gms)}}\right)$

Table 8 is an example of the PCB calculation for sample #78, (Fig. 7) *Campostoma sp.* from station 2, fall collection.

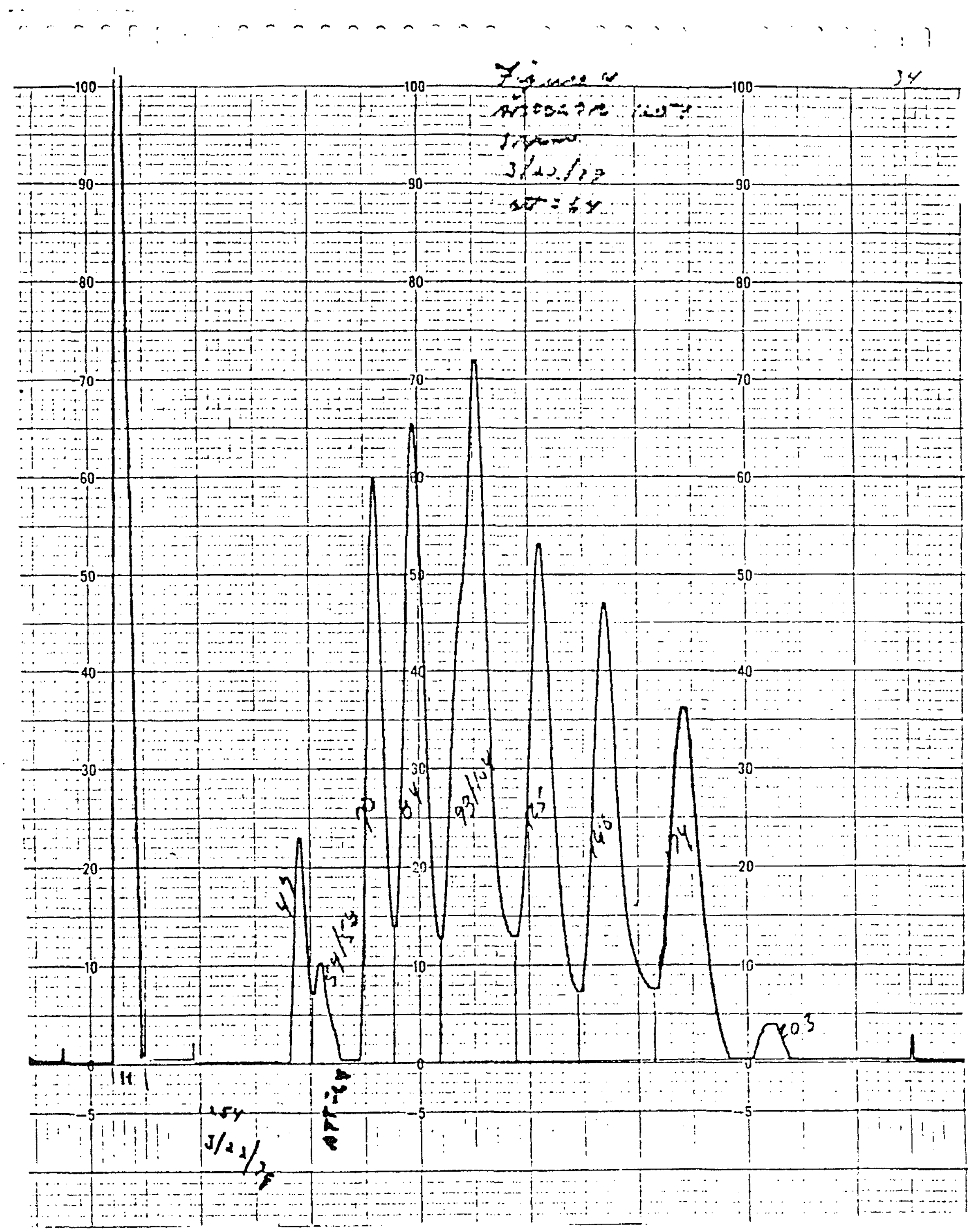
As described earlier in 'Collection and Analytical Problems', there were numerous samples which contained an unusually large peak at retention time 100 (Figure 1). Most of these occurred at staions 1,3 and 5, all controls are located near agricultural and cattle fields. This peak generally constitues 20- 30% of the Aroclor 1254 found, in both standards and other samples. In those samples where it is large (greater than 30% of the Aroclor 1254) it is adjusted to represent no more than 35% of the Aroclor 1254 measured. Table 9 shows how this was done. The residual was thought to be DDE.

DSW 030707

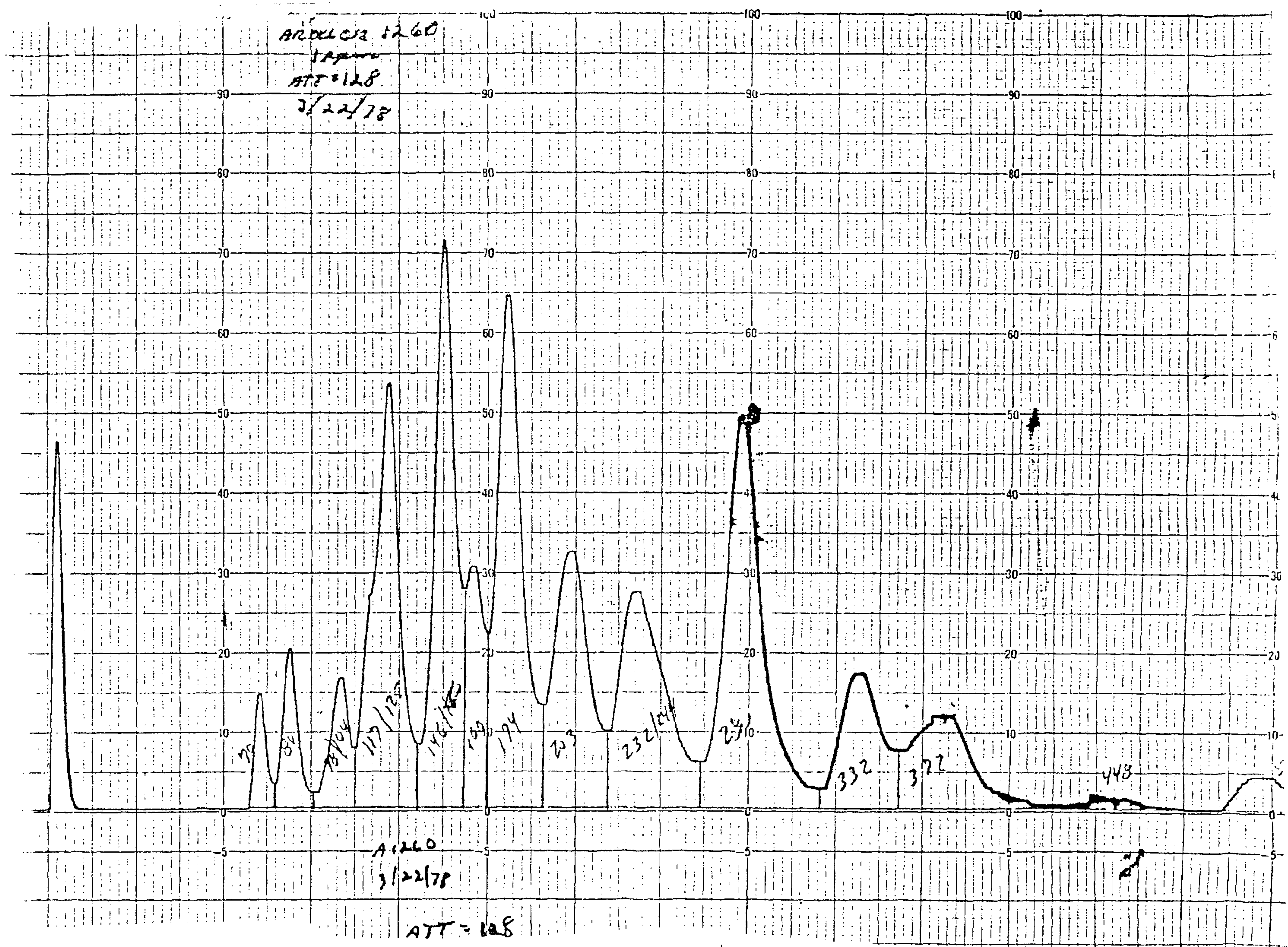
STLCOPCB4014669



DSW 030708



DSW 030709



DSW 030710

STLCOPCB4014672

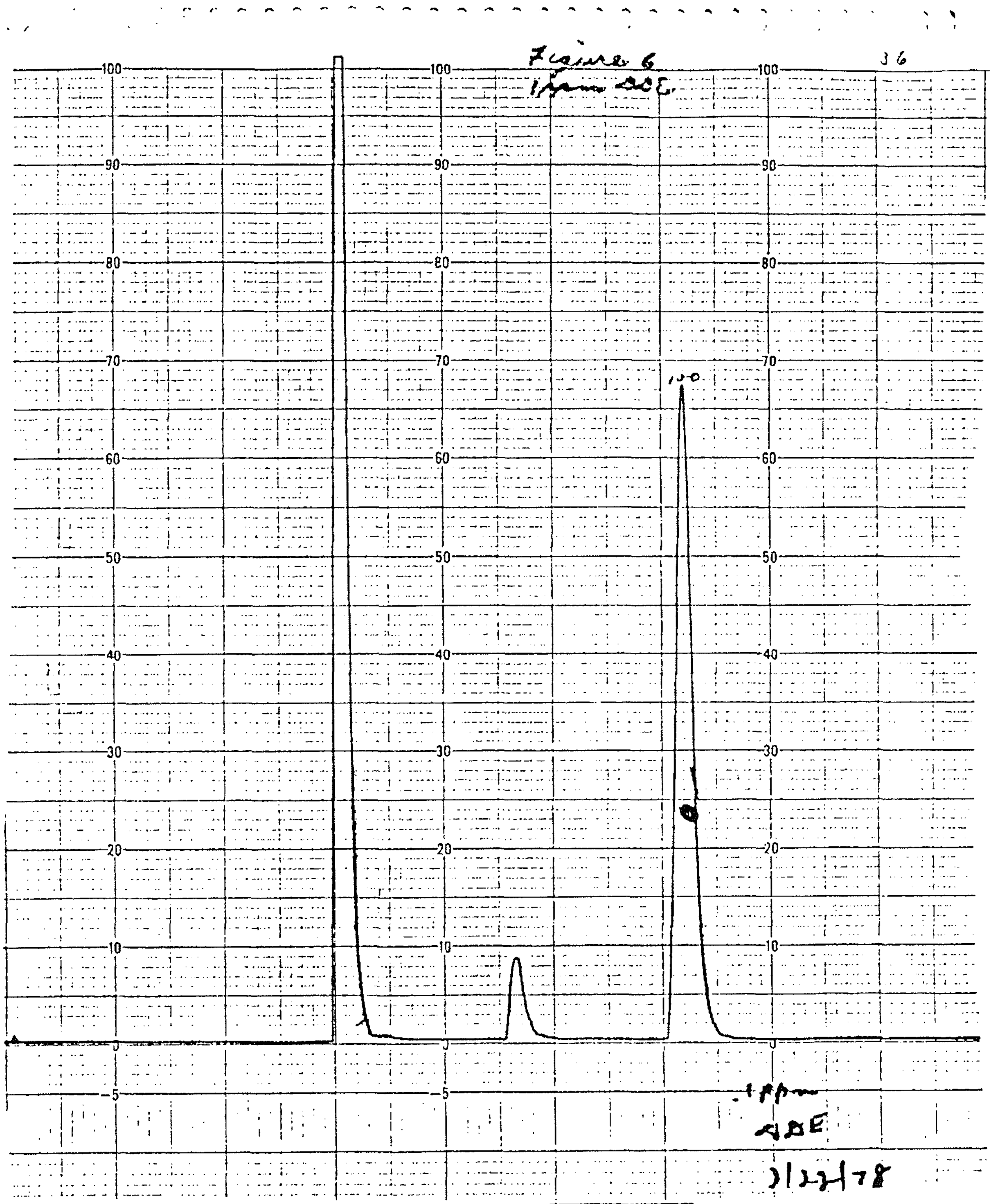
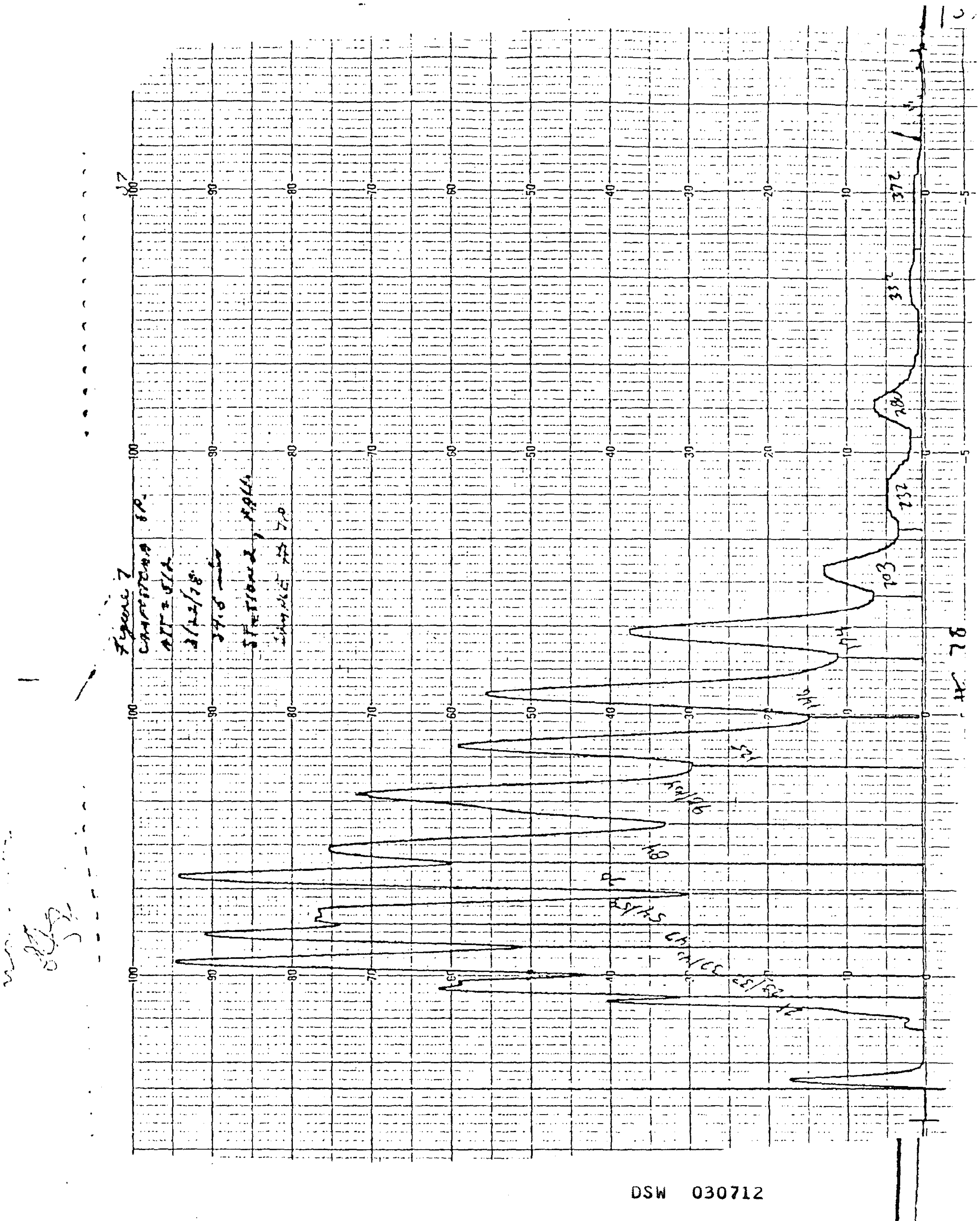


Figure 6
1ppm DCE
36
100
90
80
70
60
50
40
30
20
10
0
5
.1ppm
DDE
3/22/78

DSW 030711



DSW 030712

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 25% 3 75%
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 33% 4 67%
58	5.6	3.3	4
70	10.3	2.8	4 90% 5 10%
78	3.6	4.2	4
84	2.7	9.7	5
98	1.5	9.4	5
104	2.3	16.4	5
125	1.6	20.4	5 85% 6 15%
146	1.0	19.9	5 75% 6 25%
Total	98.5		

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent.

[b]Standard deviation of six results as a percentage of the mean of the results.

[c]From GC/MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

DSW 030713

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
125	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	1.0	26.1	7
Total	100.0		

[a]Retention time relative to p,p'-DDE=100. Measured from first appearance of solvent.
[b]Standard deviation of six results as a percentage of the mean of the results.
[c]From GC/MS data. Peaks containing mixtures of isomers are bracketed.

DSW 030714

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	[d]
⌊104			5 60%
			6 40%
117	3.3	6.7	6
125	12.3	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%
⌈232			[e]
⌊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		

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

[b]Standard deviation of six results as a mean of the results.

[c]From GC/MS data. Peaks containing mixtures of isomers of different chlorine numbers are bracketed.

[d]Composition determined at the center of peak 104.

[e]Composition determined at the center of peak 232.

DSW 030715

STLCOPCB4014677

Table 5

Response Factors for Peaks 11 to 146
from Aroclor 1242 Standard (FIGURE 3)
a 1ppm Concentration (3/22/78)

Peak #	area of peak at attenuation = 64	mean weight %	Response Factor
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
78-84	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

Reasponse Factors for Peaks 70 to 174
from Aroclor 1254 Standard (FIGURE 4)
a 1ppm Concentration (3/22/78)

Peak #	area of peak at attenuation = 64	mean weight %	Reasponse Factor
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	4.887
146-160	0.300	21.1	3.517
174	0.188	15.0	3.989

DSW 030716

Table 7

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

Peak #	area of peak at attenuation 128	area of peak at attenuation 64	mean weight %	Response Factor
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

DSW 030717

Table 8

Calculation for PCB Content of Sample #78 (FIGURE 7)
Campostoma 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	Respose Factor	ng PCB	
11-21	0.068	0.544	27.321	14.863	
28-32	0.157	1.256	13.790	17.320	1242
37-32	0.270	2.160	6.686	14.442	Standard
47	0.241	1.928	6.286	12.119	
54-58	0.274	2.192	6.139	13.457	
70	0.310	2.480	5.187	12.864	85.1107ng A1242
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 A1254
203	0.071	0.568	1.224	0.695	
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 A1260
Total				127.929	

Using Equation 3 above:

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

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

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

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

DSW 030718

Table 9
Calculation for PCB Content of Sample #293 (FIGURE 1)
Lepomis megalotis, Station 1, Sring
Sample Volume = 30mls
Sample Weight = 2.89gms
(9/30/78)

Peak #	Area at Att. 8	Area at Att. 128	Response Factor	ng PCB	
37	0.004	0.0002	9.04	0.0018	A1242
47	0.016	0.0010	7.71	0.0077	Standard
54	0.005	0.0003	7.60	0.0022	
70	0.027	0.0016	7.73	0.0123	0.024ng
84	0.052	0.0032	5.17	0.0165	
*98-104	0.128	0.0080	4.22	0.0337	A1254
125	0.079	0.0049	4.07	0.0199	Standard
146	0.078	0.0049	3.54	0.0173	
174	0.060	0.0037	2.67	0.0098	0.0972ng
203	0.045	0.0028	3.94	0.0110	
232	0.035	0.0021	3.55	0.0074	A1260
280	0.030	0.0018	2.94	0.0052	Standard
332	0.033	0.0020	2.50	0.0050	
372	0.015	0.0009	2.56	0.0023	0.0309ng
Total				0.1521	

* Peak 98-104 represents approximately 34% of the Aroclor 1254 measured. It is, therefore, reduced to only 25% of the Aroclor 1254 and it's new value is 0.022ng. The amount of Aroclor 1254 found is therefore, 0.0855ng and the total is 0.1404ng 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

DSW 030719

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, Hypentelium, Lepomis, Micropterus and Notropis. There is a significant relationship between weight and PCB concentration in all genera tested except Hypentelium. 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 GENERA, Dorosoma, Lepomis, Micropterus and Notropis at stations

---

* Significant- $p \leq 0.05$

DSW 030720

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.

DSW 030721

Table 10

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

Lepomis sp.

	DF	MS	F	p
Station	7	.2.172	35.150	0.0001
Season	3	0.196	3.176	0.0293
Weight	1	0.059	0.952	0.6675

Micropterus sp.

	DF	MS	F	p
Station	7	2.172	40.097	0.0001
season	3	0.196	3.623	[illegible]
weight	1	0.059	1.093	[illegible]

Notropis sp.

	DF	MS	F	p
Station	7	9.618	147.509	0.0001
Season	3	0.125	1.930	0.1244
Weight	1	0.926	14.212	0.0005

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

DSW 030722

Table 11

2-Way Analysis of Variance
(SPSS Program)

Dorosoma sp.

	DF	MS	F	p
Station	4	1.122	20.436	0.001
Season	3	0.170	3.099	0.046
Weight	1	0.306	5.578	0.027

Gambusia affinis

	DF	MS	F	p
Station	3	3.766	45.347	0.001
Season	2	0.034	0.414	0.674
Weight	1	1.779	21.416	0.002

Hypentelium sp.

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

Lepomis sp.

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

DSW 030723

Table 11
(continued)

Micropterus sp.

	DF	MS	F	p
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.

	DF	MS	F	p
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

DSW 030724

Table 12

2-Way Analysis of Variance
(SPSS Program)

Station 1

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

Station 2

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

Station 4

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

Station 5

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

DSW 030725

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- _Dorosoma sp._
5- _Lepomis sp._
6- _Micropterus sp._
8- _Notropis sp._

DSW 030726

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, Lepomis, 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 7ppm in a Lepomis sample to 169ppm in a Notropis sample with means ranging from 9ppm in Lepomis to 38ppm in Campostoma. 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 % decrease from station to station in all 4 species.

Tables 14 and 15 show the humic and fulvic acid content, and the organic carbon content of the sediment from Stations 1 to 8. 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

DSW 030727

particle size analysis of the sediment. The differences in particle size, organic content and humic and fluvic acid contents of the sediments at each station do not appear to affect the distribution of FCB in this system. The water quality fluctuations do not seem to affect the distribution of FCB in the system either. ~~A discussion of~~ The effect of water quality on the uptake of FCB is ~~discussed~~ discussed in section D. Therefore, either the fish concentrations do not indicate the abiotic FCB content of the stream or, ~~or~~ the~~se~~ parameters measured, humic and fluvic acid, organic content and various water quality analyses, do not greatly influence the distribution of FCB in this system. In this system, The level (residue in fishes) FCB ~~in~~ 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*, *Lepomis*, *Micropterus*, *Notropis*)

Dorosoma sp.

	Aroclor 1242 ppm	Aroclor 1242 %	Aroclor 1254 ppm	Aroclor 1254 %	Aroclor 1260 ppm	Aroclor 1260 %	Total PCB ppm	Total PCB %
Station 4, Fall	10.58		13.70		3.12		27.4	
		87		75		82		8
Station 6, Fall	1.42		3.35		0.57		5.3	
Station 4, Winter	5.33		6.51		4.04		15.8	
		89		67		94		8
Station 7, Winter	0.62		2.16		0.26		3.06	

Lepomis sp.

	Aroclor 1242 ppm	Aroclor 1242 %	Aroclor 1254 ppm	Aroclor 1254 %	Aroclor 1260 ppm	Aroclor 1260 %	Total PCB ppm	Total PCB %
Station 2, Winter	10.70		10.99		6.27		28.4	
		75		60		68		6
Station 4, Winter	2.62		4.46		2.02		7.1	
Station 2, Spring	5.01		3.61		0.69		9.3	
		49		65		*138		*126
Station 4, Spring	2.58	86	5.94	7	3.27	*151	11.7	47
		73 97		44 65		72 26		58
Station 6, Spring	0.69		3.36		0.91		4.4	
		76		62		44		61
Station 7, Spring	0.17		1.27		0.51		1.9	

* I- PCB Increase

DSW 030729

Table I3
(continued)

__Lepomis sp.__

	Aroclor 1242 ppm	%		Aroclor 1254 ppm	%		Aroclor 1260 ppm	%		Total P ppm	%
Station 2, Summer	9.54			8.14			3.[illegible]			20.8	
		> 69			> 20			> 18			> 41
Station 4, Summer	2.97		82	6.55		52	2.84		71	12.3	7[illegible]
		> 61	96		> 41	84		> 64	92		> 51
Station 6, Summer	1.18			3.88			1.02			6.0	
		> 63			> 66			> 75			> 67
Station 7, Summer	0.44			1.31			0.26			2.0	

__Micropterus sp.__

	Aroclor 1242 ppm	%		Aroclor 1254 ppm	%		Aroclor 1260 ppm	%		Total P ppm	%
Station 2, Winter	1[illegible]			16.1[illegible]			[illegible]			[illegible].1	
		> 85			> 72			> 5[illegible]			> 75
Station 4, Winter	2.[illegible]		99	4.61		94	2.[illegible]		98	10.7	9[illegible]
		> 96			> 80			> 95			> 88
Station 7, Winter	0.12			0.[illegible]			0.[illegible]			1.2	
Station 2, Spring	11.39			11.40			6.30			29.1	
		> 85			> 30			> *I27			> 40
Station 4, Spring	1.63		95	8.06		54	8.01		66	17.7	[illegible]
		> 66			> 34				74		> 55
Station 6, Spring	0.35			5.34			2.08			7.9	
Station 2, Summer	6.08			5.85			2.37			14.3	
		> 93			> 71			> 84			> 84
Station 4, Summer	0.43			1.70			0.38			2.2	

* I- PCB Increase

DSW 030730

STLCOPCB4014692

Table 13
(continued)

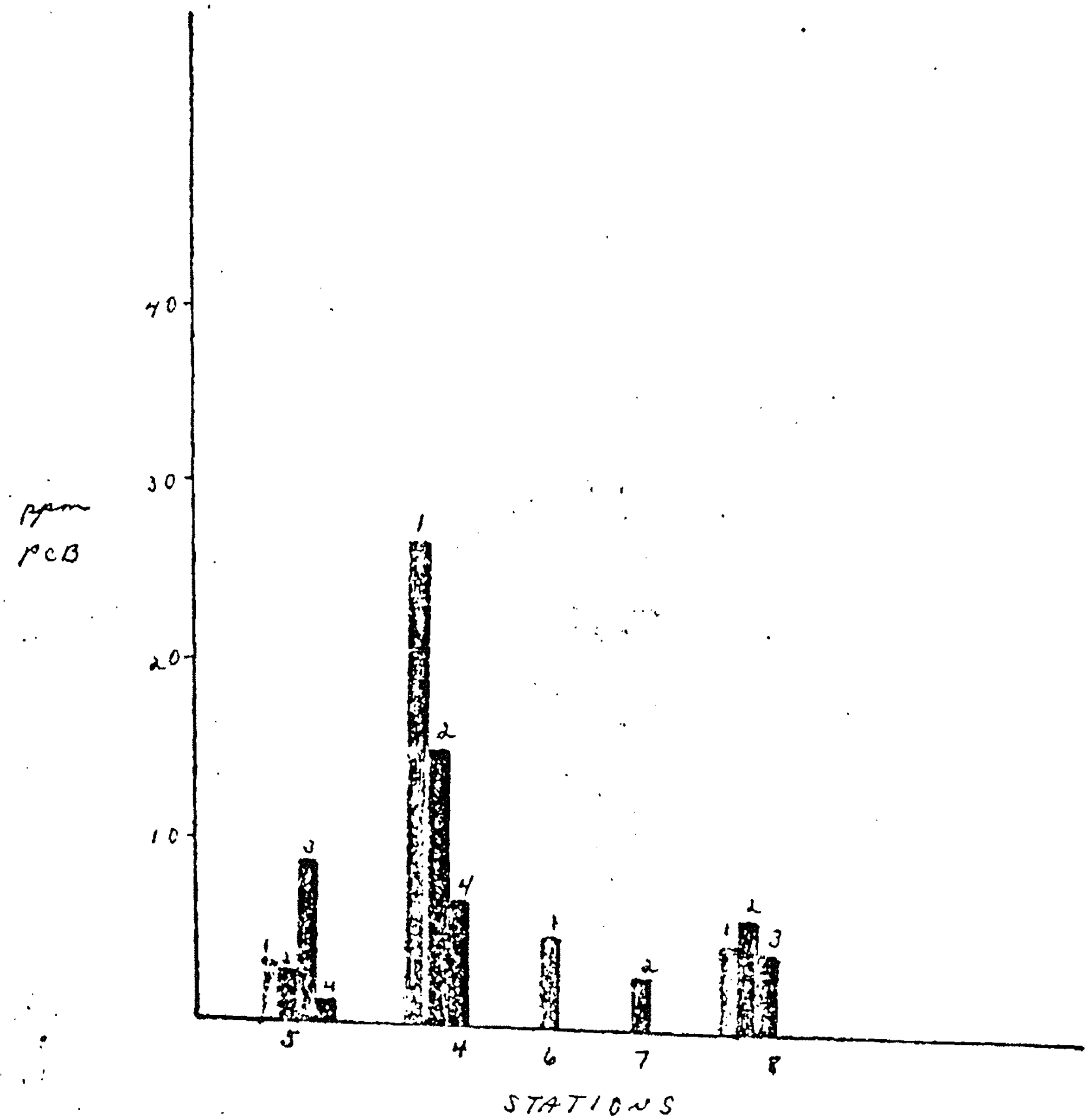
Notropis sp.

	Aroclor 1242 ppm	%	Aroclor 1254 ppm	%	Aroclor 1260 ppm	%	Total PCB ppm	%
Station 2, Fall	14.66		19.39		5.63		48.1	
		> 98		> 91		> 96		> 95
Station 6, Fall	0.36		1.92		0.24		2.4	
Station 2, Summer	15.90		18.00		8.96		42.9	
		> 95		> 87		> 95		> 92
Station 6, Summer	0.76	99	2.39	94	0.45	95	3.6	9
		> 65		> 32		> 9		> 39
Station 8, Summer	0.27		1.50		0.41		2.2	

DSW 030731

FIGURE 8.

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

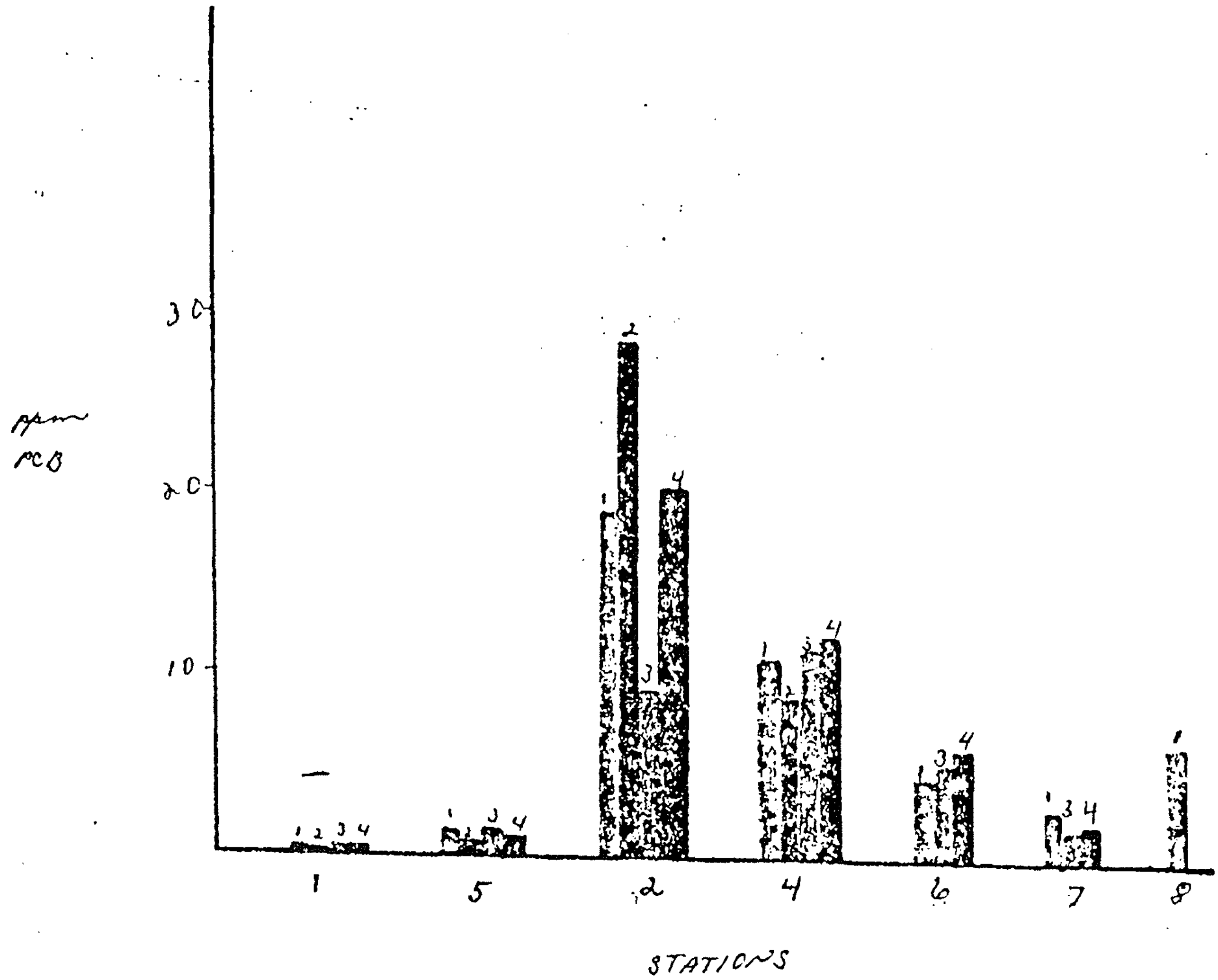


THE SEASONS ARE MARKED ABOVE EACH BAR:
1 - FALL
2 - WINTER
3 - SPRING
4 - SUMMER

DSW 030732

Figure 9

MEAN TOTAL PCB LEVELS
~~OF~~ IN LEPOMIS SP.
ON A STATION
AND SEASONAL
BASIS



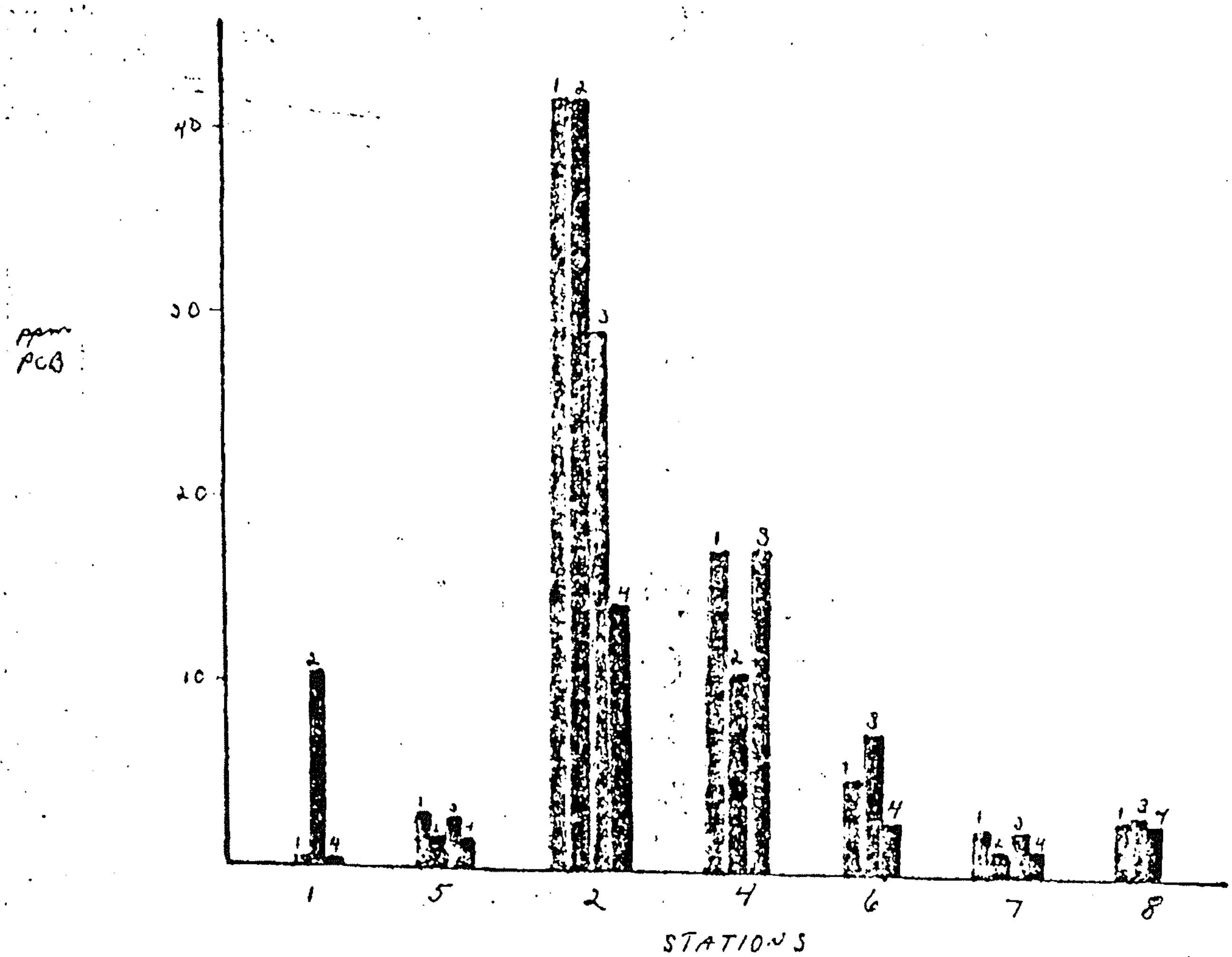
THE SEASONS ARE MARKED ABOVE EACH BAR!

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

DSW 030733

Figure 10

MEAN TOTAL PCB
IN MICROPTERUS SP
ON A STATION + SEASONAL BASIS



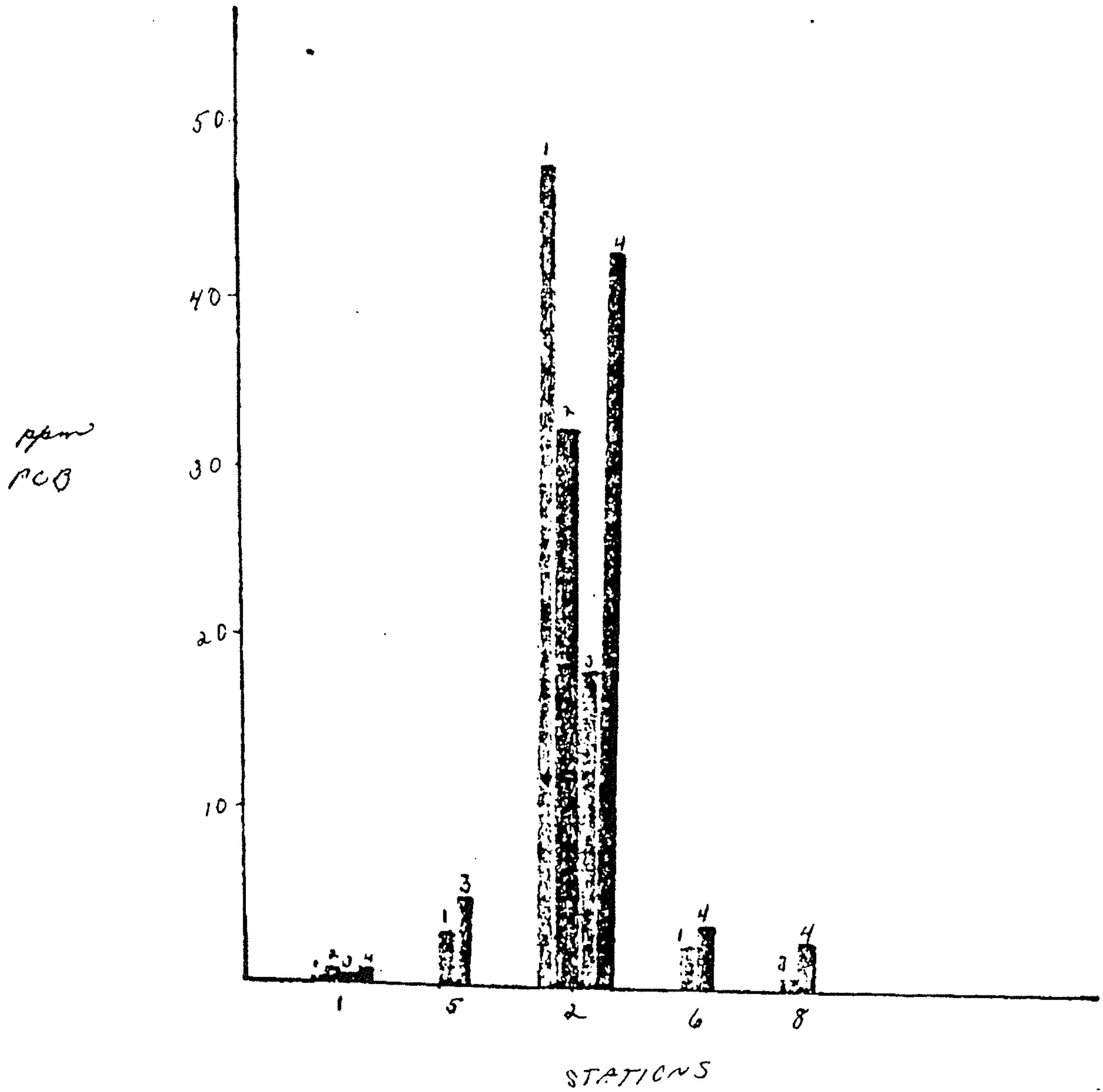
THE SEASONS ARE MARKED ABOVE EACH BAR:

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

DSW 030734

Figure

MEAN TOTAL PCB
IN NOTROPIS SP
ON A STATION + SEASONAL BASIS



DSW 030735

TABLE 14

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

Station	Fluvic Acid mg/l	Fluvic Acid mg/kg	Humic Acid mg/l	Humic Acid mg/kg
1	117	140	152	183
2	49	58	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

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

DSW 030736

Table 16

Water Quality

Fall Survey (Oct. 14, 1977)

Station	DO	Alk	Temp.	pH	Color
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

Station	Turb.	Cl	SO_4	Total Fe	Cond.
1	13	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

Station	SS	CO_2	TOC
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 $CaCO_4$
Temp- Temperature C
Color- APHA Platinum Cobalt Standard
Turb- Turbidity in FTU Formazin Turbidity Units
Cl- Chlorid (mg/l)
SO_4- Sulfate (mg/l)
Fe- Iron (mg/l)
Cond.- Conductivity (umhos/cm)
SS- Suspended Solids (mg/l)
CO_2- Carbon Dioxide (mg/l)
TOC- Total Organic Carbon (mg/l)

DSW 030737

Table 16
(continued)

Winter Survey (Jan. 11, 1978)

Station	DO	Alk.	Temp.	pH	Color
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	98
5	9.2	90	8.8	7.4	88
6	9.5	70	4.9	7.4	160

Station	Turb.	Cl	Total Fe	Cond.	SS
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

Station	CO_2
1	16
2	12
3	20
4	16
5	24
6	16

Table 16
(continued)

Spring Survey (April 14, 1978)

Station	DO	Alk.	Temp.	pH	Color
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

Station	Turb.	Cl	SO_4	Total Fe	Cond.
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

Station	SS	CO_2
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)

Station	DO	Alk.	Temp.	pH	Color
1	6.1	80	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

Station	Turb.	Cl	Total Fe	Cond.	SS
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

Station	CO_2
1	4
2	4
3	8
4	0
5	4
6	4

DSW 030740

LOCATION.--Lat 33°32'54", long 86°05'49", in SE¼ sec. 15, T. 17 S., R. 5 E., Talladega County, Hydrologic Unit 03150106, on left bank at foot of Jackson Shoals, 50 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 Eastaboga 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	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)
OCT 06...	1200	283	200	8.0	16.5	9.3	97	15	19	12
NOV 18...	1230	690	231	7.8	14.0	8.8	78	4	16	9.2
JAN 06...	1300	491	240	7.9	9.0	11.8	98	16	24	9.2
FEB 23...	1215	536	255	7.8	7.0	11.6	93	0	19	11
MAR 31...	1200	615	252	7.8	17.0	10.3	90	--	21	9.2
MAY 16...	1230	1050	--	7.4	18.0	8.8	56	0	12	6.3
JUN 30...	1115	350	352	7.4	26.0	7.3	110	6	23	12
AUG 03...	1045	225	430	7.8	26.0	7.9	110	4	23	13
SEP 12...	1530	240	425	6.8	24.0	8.4	120	13	25	14

DATE	SODIUM, DIS-SOLVED (MG/L AS NA)	SODIUM PERCENT	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	BICAR-BONATE (MG/L AS HCO3)	CAR-BONATE (MG/L AS CO3)	ALKA-LINITY (MG/L AS CACO3)	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	1.6	7.2	4.0
NOV 18...	15	29	.7	1.6	90	0	74	2.3	11	14
JAN 06...	16	26	.7	1.2	100	0	82	2.0	16	28
FEB 23...	13	23	.6	1.1	120	0	98	3.0	13	11
MAR 31...	17	29	.8	1.0	--	--	--	--	14	15
MAY 16...	8.9	25	.5	1.4	73	0	60	4.6	6.4	9.2
JUN 30...	27	35	1.1	1.4	120	0	98	7.6	--	28
AUG 03...	40	43	1.7	1.7	130	0	107	3.3	42	40
SEP 12...	36	39	1.4	1.5	130	0	107	33	36	43

TABLE 17
(CONTINUED)

02404400 CHOCCOLOCCO 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-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)
OCT										
06...	.0	6.8	115	.16	87.9	2.0	8.9	1	<1	<1
NOV										
16...	.1	8.9	122	.17	227	.40	1.7	ND	1	ND
JAN										
06...	.1	7.0	151	.21	200	.09	.42	1	<1	ND
FEB										
23...	.1	8.8	135	.18	195	.09	.41	<1	1	<1
MAR										
31...	.1	5.7	--	--	--	.90	3.8	<1	1	ND
MAY										
16...	.0	7.9	95	.13	289	1.4	6.3	ND	1	ND
JUN										
30...	.1	9.1	--	--	--	.00	.01	1	<1	ND
AUG										
03...	.1	10	241	.33	140	1.7	7.4	<1	1	<1
SEP										
12...	.1	8.9	229	.31	148	.43	1.9	4	<1	ND

DATE	COBALT, DIS-SOLVED (UG/L AS CO)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	STRON-TIUM, DIS-SOLVED (UG/L AS SR)	ZINC, DIS-SOLVED (UG/L AS ZN)	CHLOR-A PERI-PHYTON CHROMO-GRAPHIC FLUOROM (MG/M2)	CHLOR-B PERI-PHYTON CHROMO-GRAPHIC FLUOROM (MG/M2)
OCT									
06...	1	20	2	35	ND	60	20	--	--
NOV									
18...	1	220	1	<5	.2	70	40	--	--
JAN									
06...	<1	30	2	30	.2	50	60	.620	.000
FEB									
23...	1	20	ND	37	.2	110	90	--	--
MAR									
31...	ND	70	1	76	.4	50	140	--	--
MAY									
16...	2	110	3	60	.4	40	80	--	--
JUN									
30...	1	40	ND	62	<.2	30	20	--	--
AUG									
03...	<1	60	1	28	.5	70	50	--	--
SEP									
12...	1	10	4	32	<.2	40	<5	--	--

DSW 030742

TABLE 17
(CONTINUED)

MOBILE RIVER BASIN

MOBILE RIVER MAIN STEM

02407000 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, 2.0°C on several days in January 1977.

EXTREMES FOR CURRENT YEAR.--
WATER TEMPERATURES: Maximum, 33.5°C July 4; minimum, 3.5°C Jan. 22, Feb. 8, 9.

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

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)
MAR 15...	0945	13700	142	7.3	11.0	11.3	55	3	15	4.3
APR 11...	0930	6300	150	7.7	18.5	6.2	64	8	18	4.6

DATE	SODIUM, DIS-SOLVED (MG/L AS NA)	SODIUM PERCENT	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	BICAR-BONATE (MG/L AS HCO3)	CAR-BONATE (MG/L AS CO3)	ALKA-LINITY (MG/L AS CACO3)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2)	SULFATE DIS-SOLVED (MG/L AS SO4)
MAR 15...	5.3	17	.3	1.1	64	0	52	5.1	7.0
APR 11...	4.6	13	.3	1.4	68	0	56	2.2	9.0

DATE	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3)	ARSENIC DIS-SOLVED (UG/L AS AS)
MAR 15...	5.0	.1	7.2	78	.11	2890	.23	1.0	1
APR 11...	5.2	.1	6.3	68	.12	1500	1.1	4.9	1

DATE	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, DIS-SOLVED (UG/L AS CO)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	STRON-TIUM, DIS-SOLVED (UG/L AS SR)	ZINC, DIS-SOLVED (UG/L AS ZN)
MAR 15...	1	ND	--	90	1	31	.3	130	40
APR 11...	1	ND	1	20	ND	100	.5	80	50

DSW 030743

Table 18

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

Station	% silt or finer (0.074mm)	% clay or finer (0.005mm)
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

DSW 030744

PARTICLE SIZE ANALYSES 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

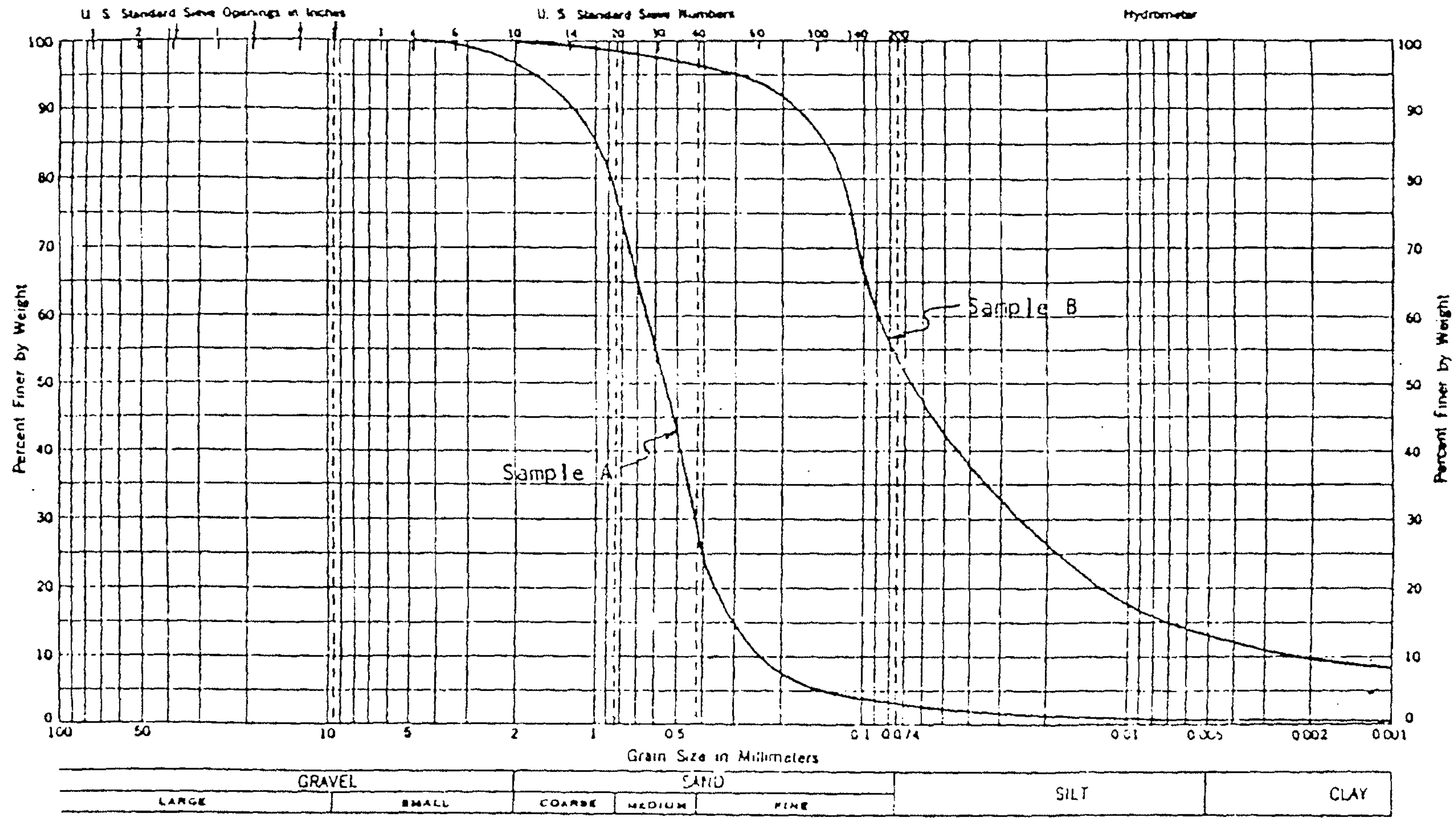
K: Station 14

DSW 030745

STLCOPCB4014707

FIGURE 12

J-2139



GRAIN SIZE CURVES

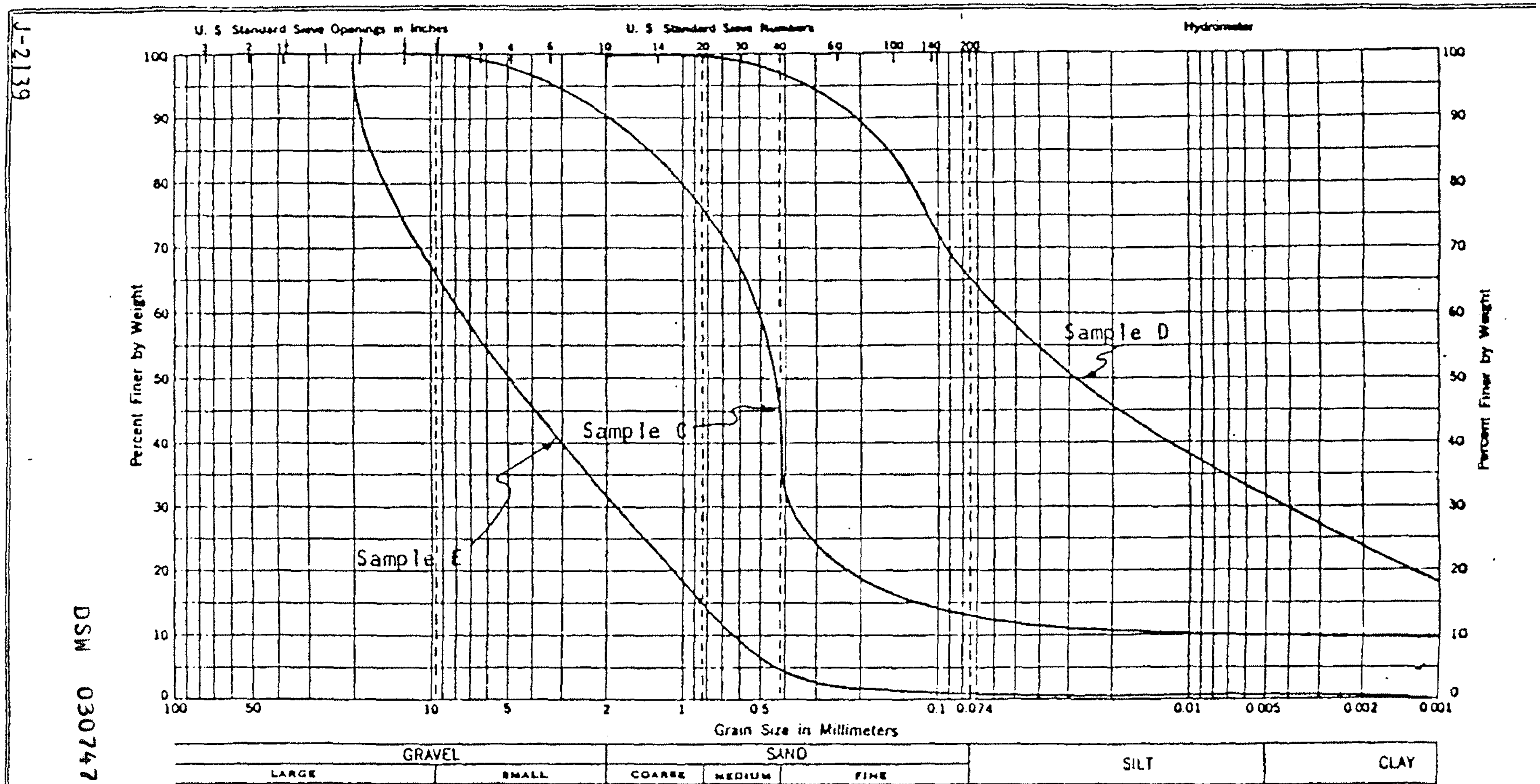
DSW 030746

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

Fig. 1

STLCOPCB4014708

Figure 13



GORE ENGINEERING, INC.
SOIL AND FOUNDATION INVESTIGATIONS

DSW 030747

GRAIN SIZE CURVES

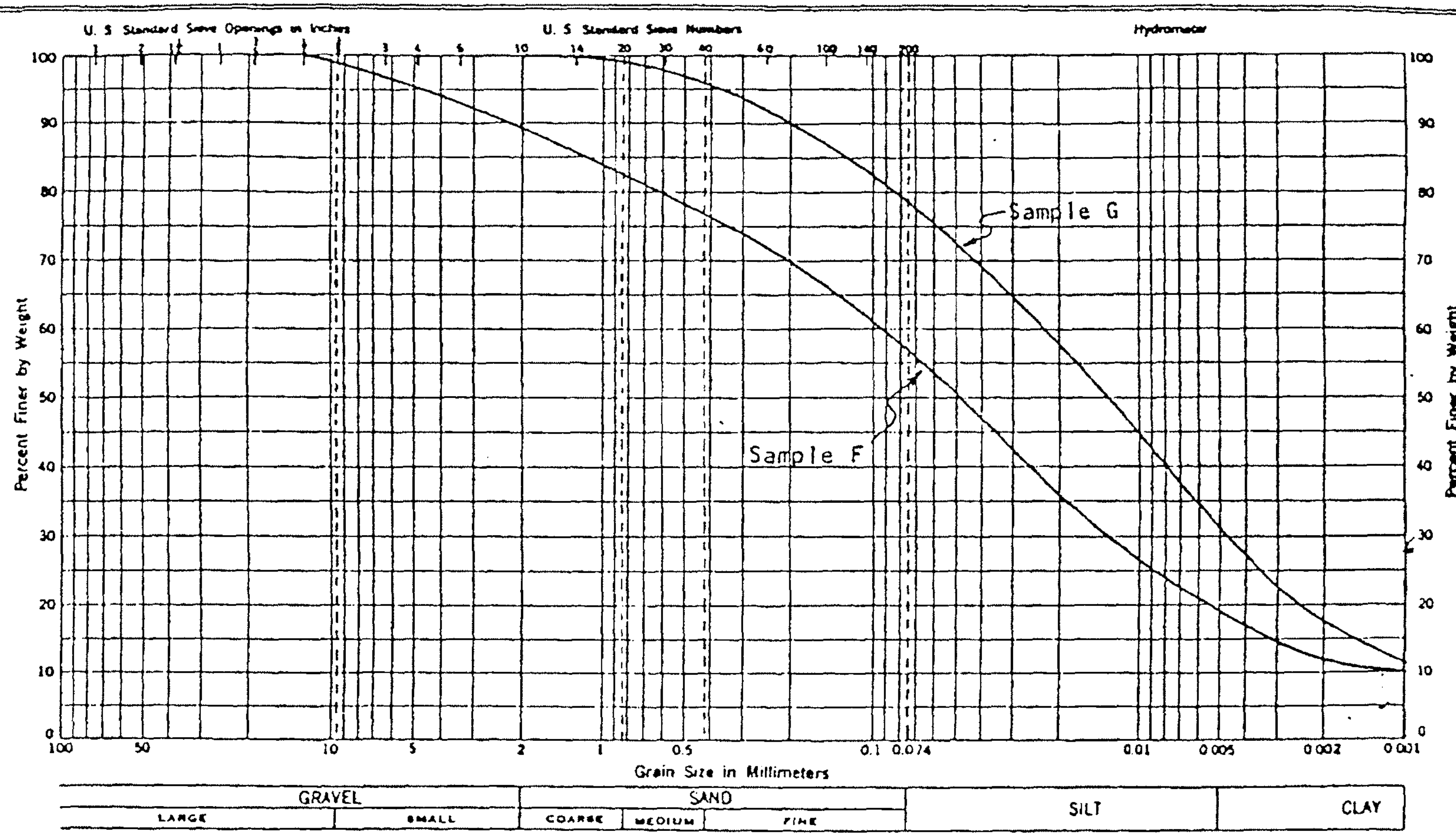
HYDROMETER & SIEVE ANALYSIS
FURNISHED SAMPLES 1/16/79
DEPARTMENT OF ENVIROMENTAL HEALTH SCIENCES
TULANE UNIVERSITY
NEW ORLEANS, LOUISIANA

Fig. 12

STLCOPCB4014709

Figure 14

J-2139



GRAIN SIZE CURVES

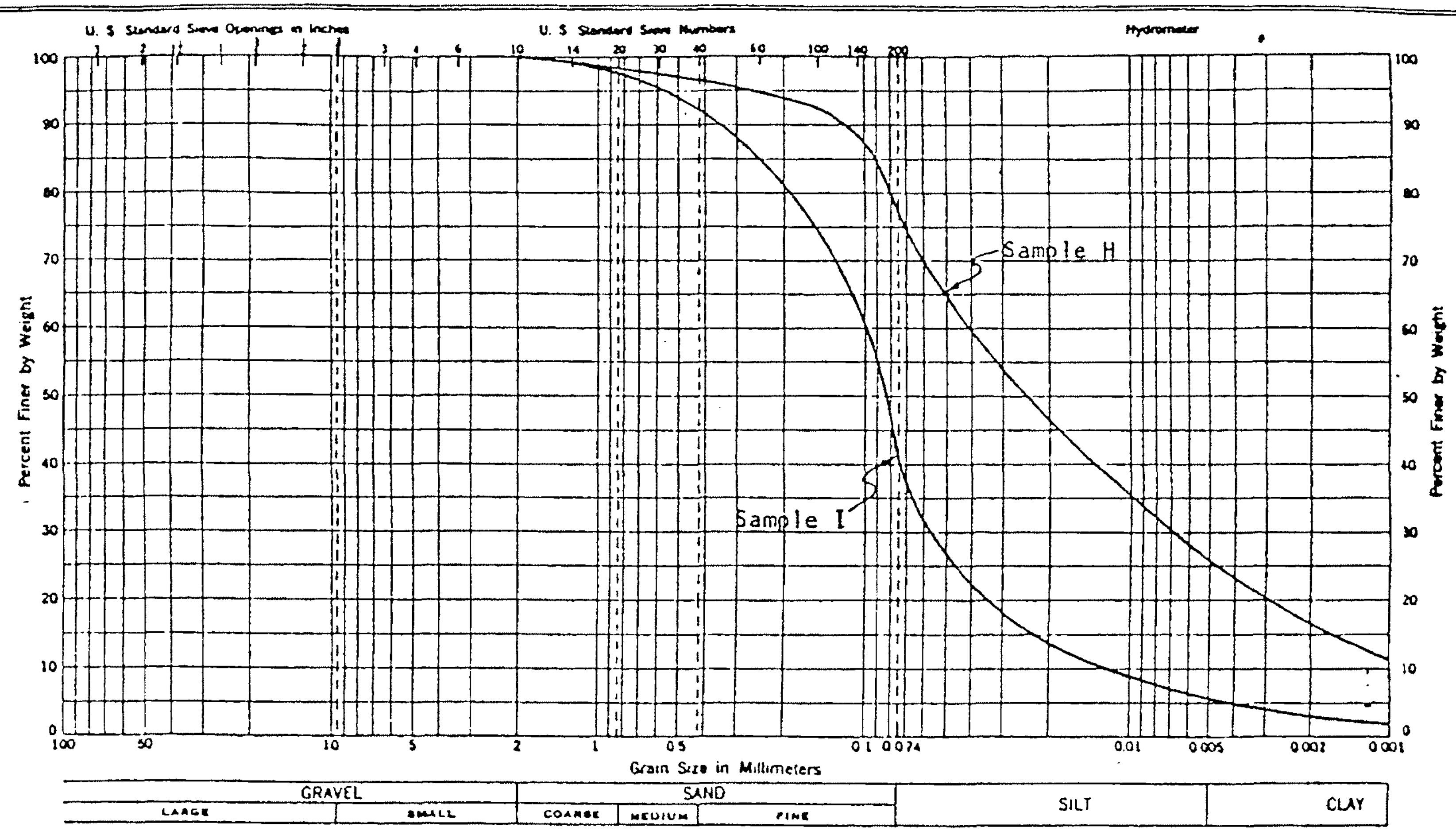
HYDROMETER & SIEVE ANALYSIS
FURNISHED SAMPLES 1/16/79
DEPARTMENT OF ENVIROMENTAL HEALTH SCIENCES
TULANE UNIVERSITY
NEW ORLEANS, LOUISIANA

DSW 030748

Fig. 14

Figure 15

J-2139



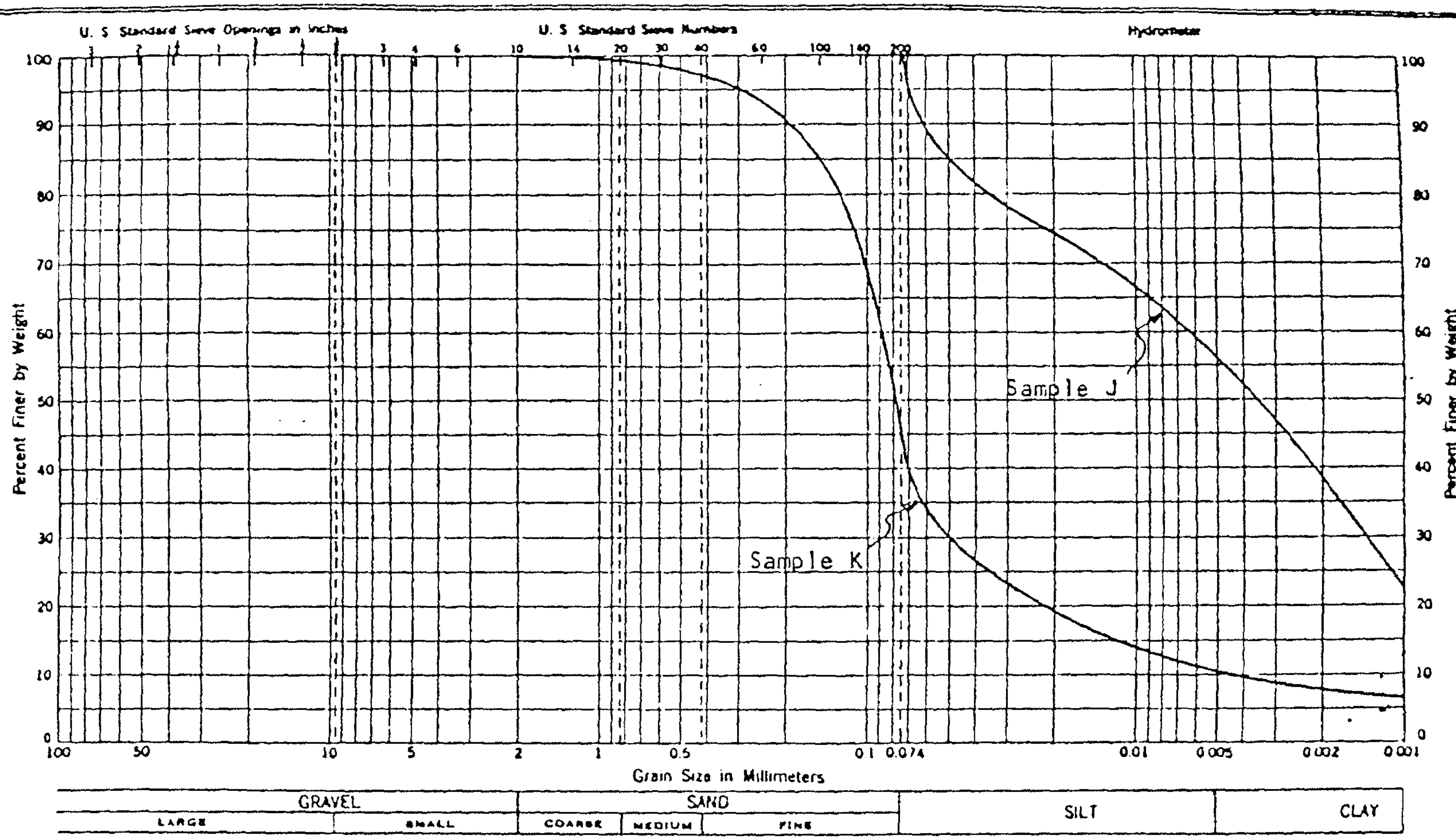
DSM 030749

GRAIN SIZE CURVES

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

Fig. 15

Figure 16.



GRAIN SIZE CURVES

HYDROMETER & SIEVE ANALYSIS
FURNISHED SAMPLES 1/16/79
DEPARTMENT OF ENVIROMENTAL HEALTH SCIENCES
TULANE UNIVERSITY

Fig.

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_{PCB} and Log Weight vs Log ppm_{PCB} Basis

	Weight vs ppm PCB			Log Weight vs Log ppm PCB	
Station	Corr. R	p	n	Corr. R	p
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, $p \leq 0.05$

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 sep~~e~~arately 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.

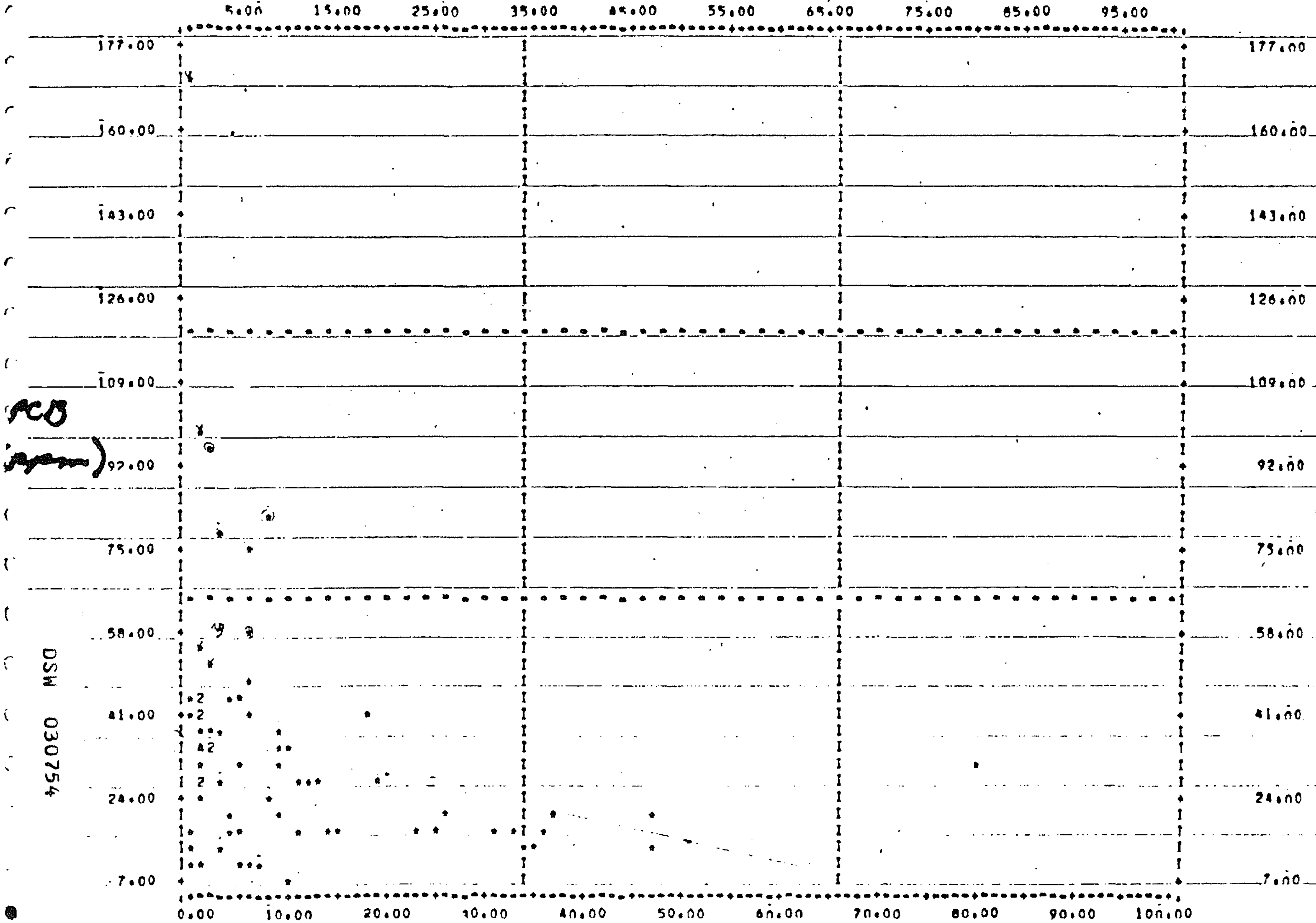
To determine whether there are seasonal influences on this weight-ppm relationship, therefore, the data ~~was~~ were analyzed on the species per station per season basis. The results are shown in Tables 22 and 23 and Figures 21-23 are plots of some of the significant cases. This breakdown of the data resulted in some very small sample sizes and ~~therefore,~~ thus 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 ppm PCB OF ALL FISH FOUND AT STATION 2, ALL SEASONS

PLOTS 04/17/79 PAGE 7

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

SCATTERGRAM OF (DOWN) CTOT (ACROSS) HEIGHT



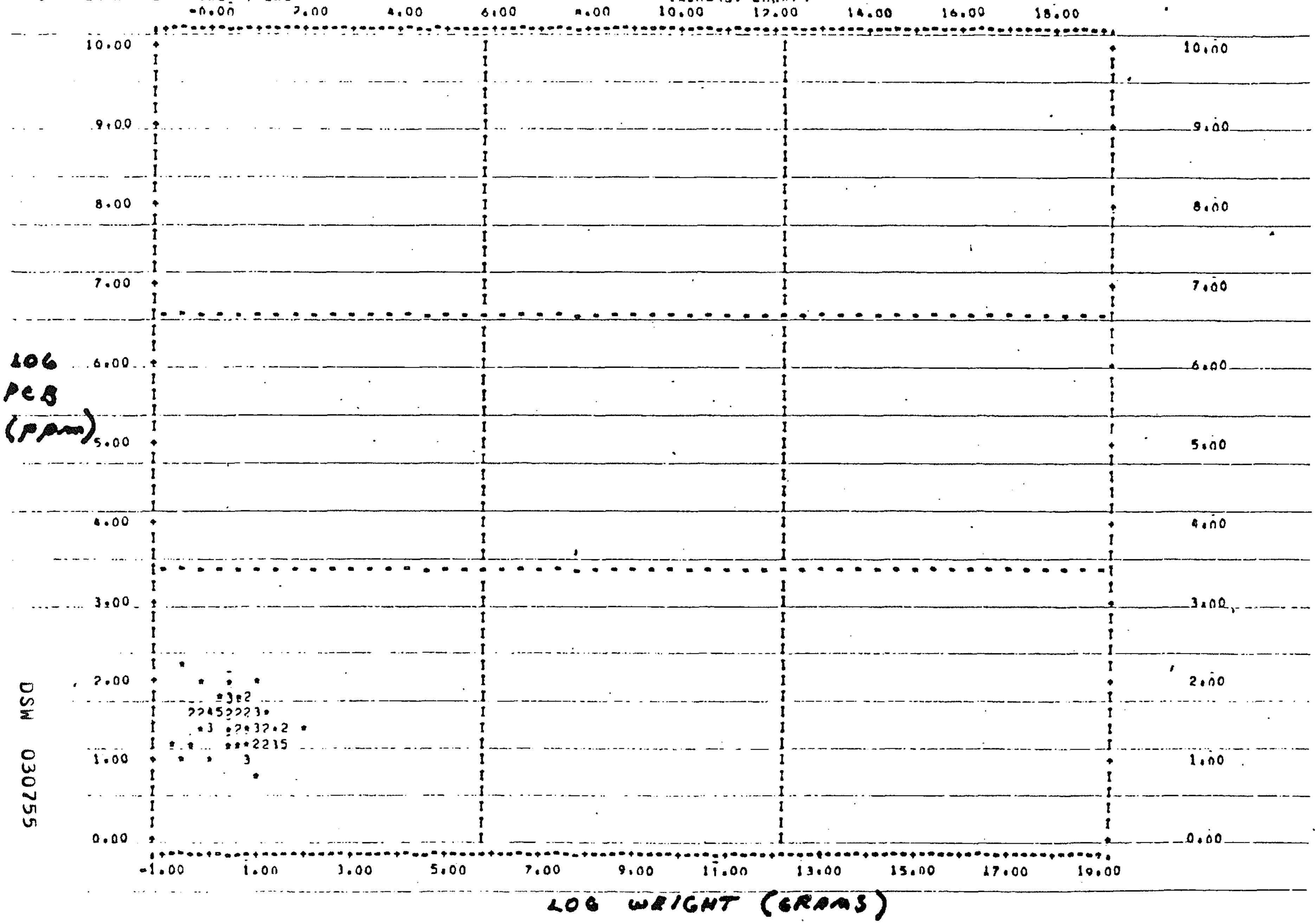
DSW 030754

THE LINEAR CORRELATION OF LOG OF WEIGHT VS LOG ppm PCB OF ALL FISH FOUND AT STATION 2 ALL SEASONS

PLOTS 04/17/79 PAGE 9

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

SCATTERGRAM OF (DOWN) LOGT (ACROSS) LOGWT



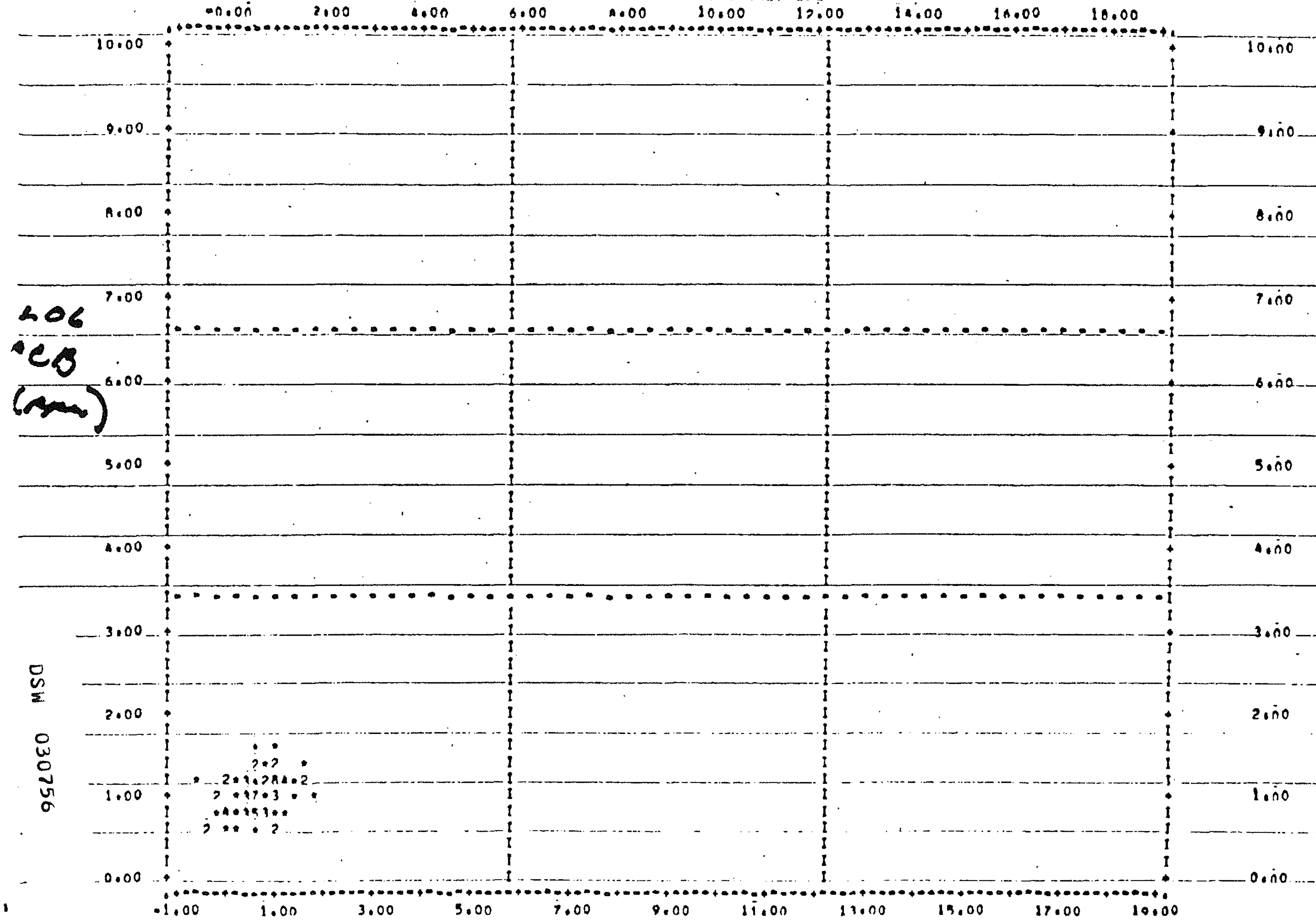
DSW 030755

STLCOPCB4014717

THE LINEAR CORRELATION OF LOG WEIGHT VS LOG ppm PCB
OF ALL FISH FOUND AT STATION 4, ALL SEASONS

PLOTS 04/17/79 PAGE 1

FILE NONAME (CREATION DATE = 04/17/79)
SCATTERGRAM OF (DOWN) LOGT (ACROSS) LOGWT



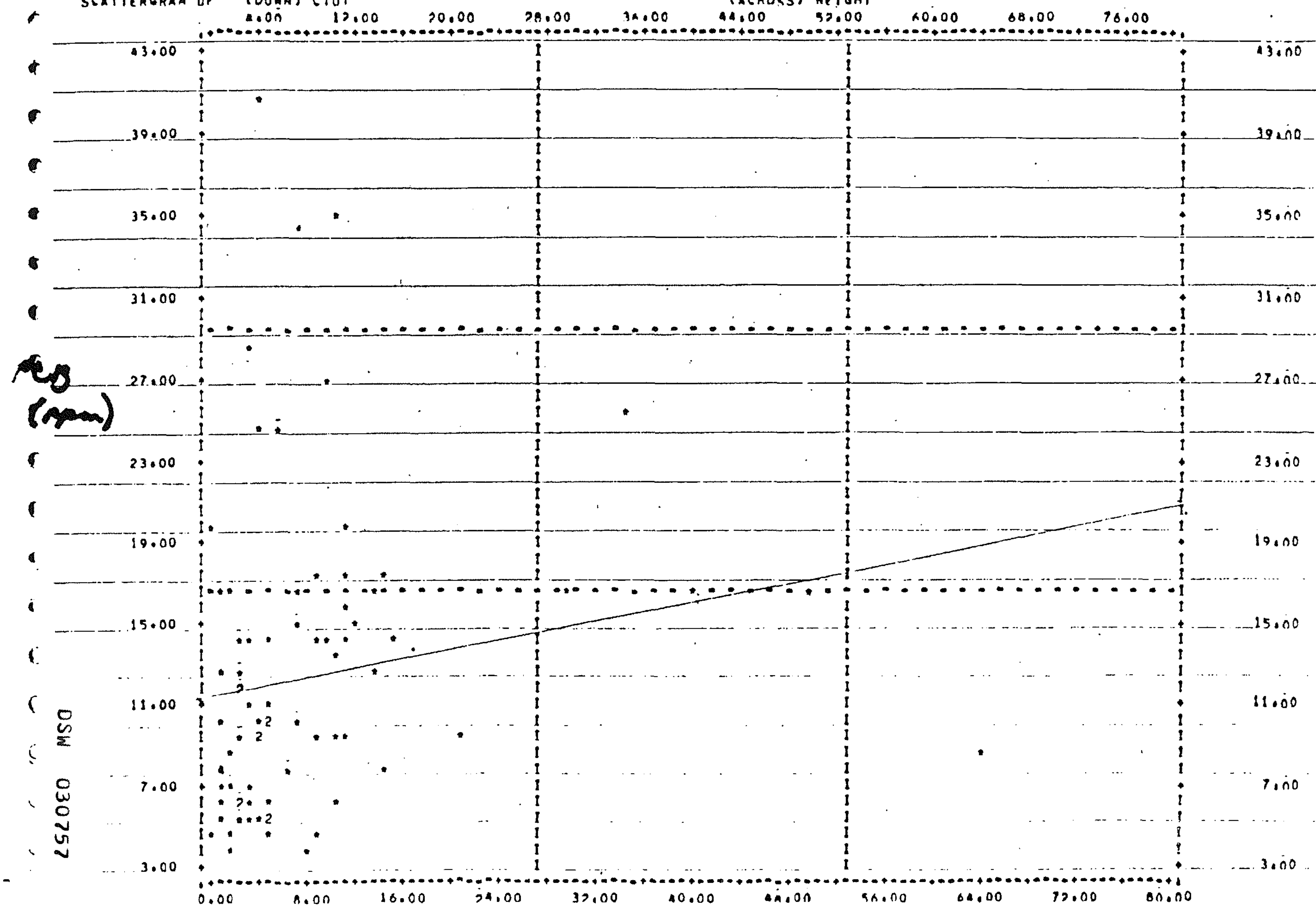
DSW 030756

THE LINEAR CORRELATION OF WEIGHT VS PPM PCB OF ALL FISH FOUND AT STATION 4, ALL SEASONS

PLOTS 04/17/79 PAGE 17

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

SCATTERGRAM OF (DOWN) CTOT (ACROSS) WEIGHT



DSW 030757

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	0.18	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, $p \leq 0.05$

DSW 030758

STLCOPCB4014720

Table 21

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

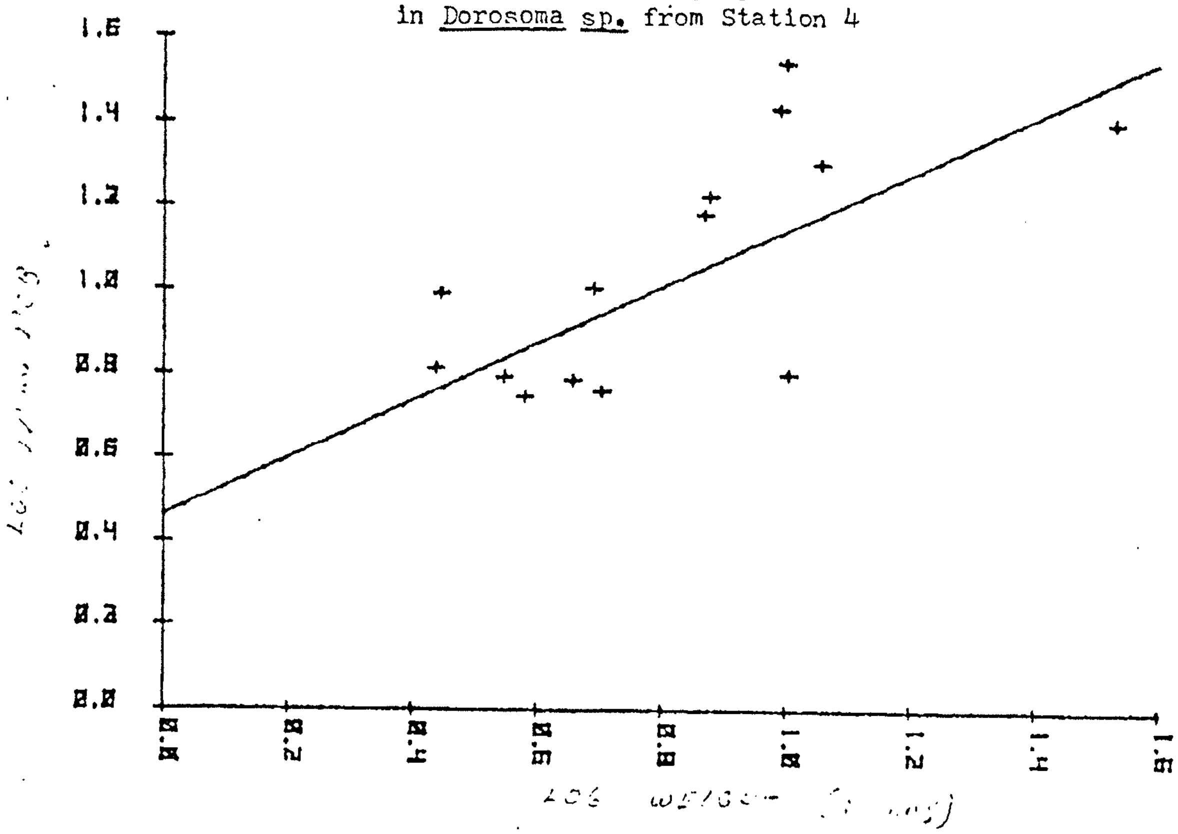
Species	Station	Corr. R	p	n
Campostoma	2	-0.50	0.19	5
" "	3	-0.26	0.18	13
Dorosoma	4	0.70	0.002*	14
" "	5	0.58	0.01*	13
" "	8	-0.09	0.42	6
Gambusia	1	-0.10	0.38	9
" "	2	0.97	0.002*	5
Hypentelium	1	-0.56	0.03*	11
" "	3	0.04	0.45	8
Lepomis	1	-0.18	0.19	25
" "	2	-0.14	0.24	25
" "	3	0.42	0.11	10
" "	4	0.46	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
Pimephales	5	0.43	0.089	11

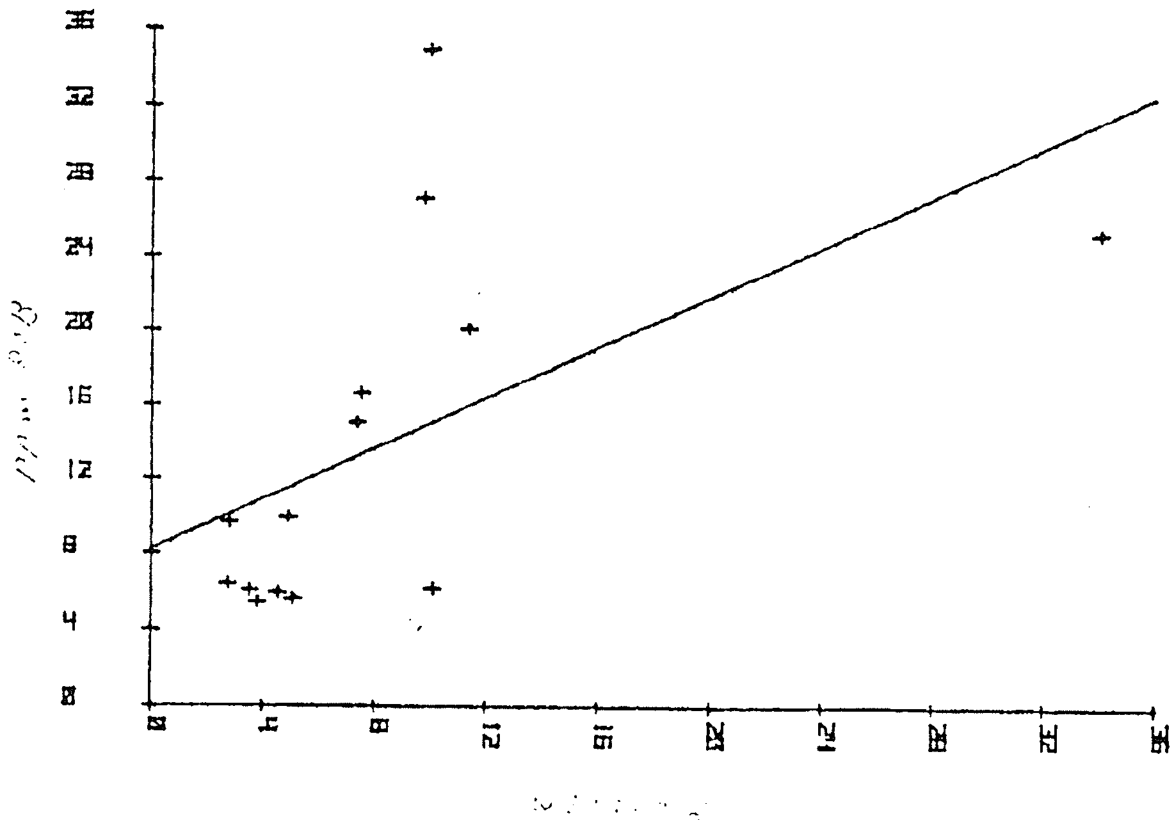
* Significant, $p \leq 0.05$

DSW 030759

Figure 19

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





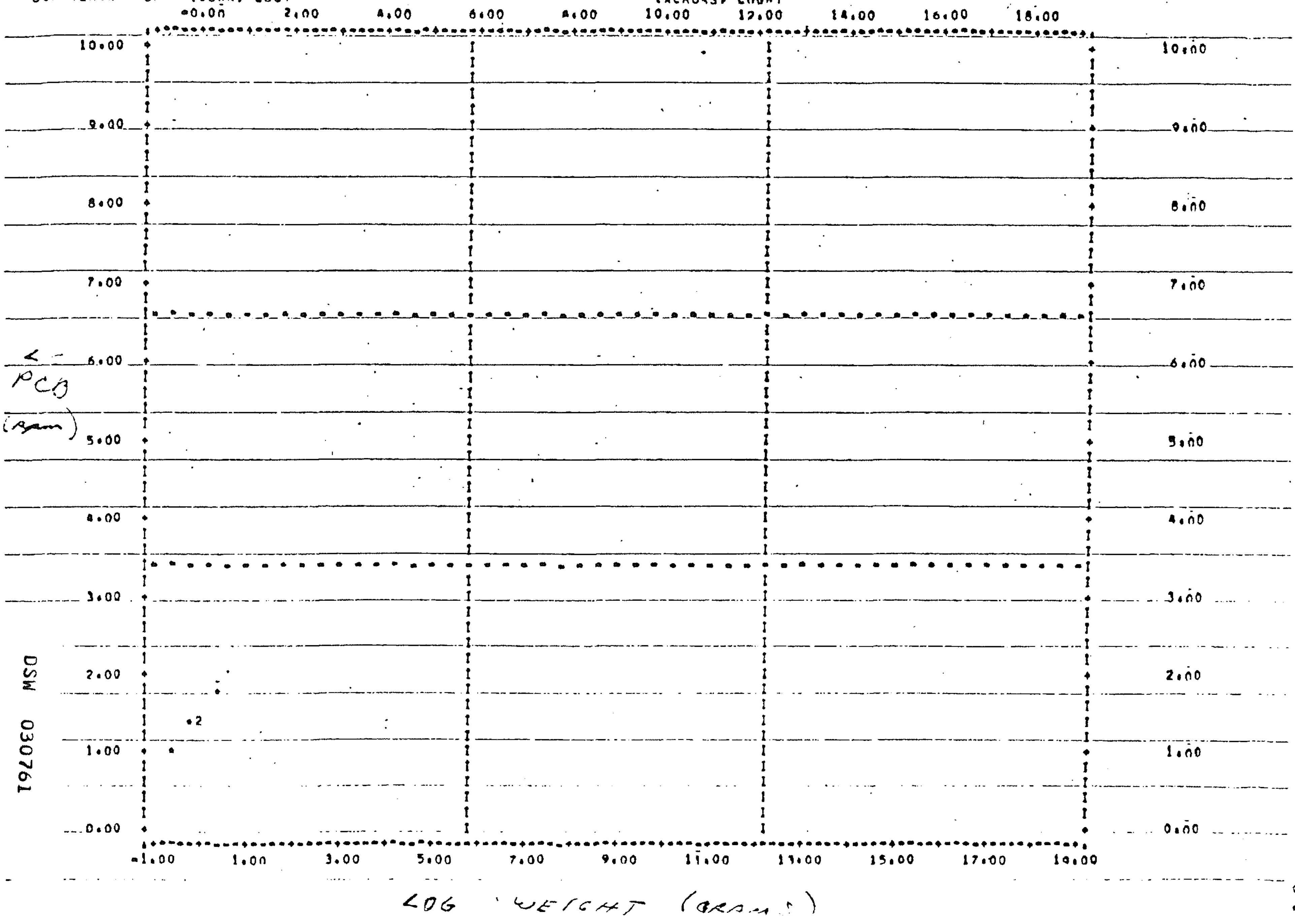
DSW 030760

THE LINEAR CORRELATION OF LOG WEIGHT VS LOG ppm PCB OF ALL GAMBUSIA FOUND AT STATION 2

PLOTS 08/17/79 PAGE 70

FILE NONAME (CREATION DATE = 08/17/79)

SCATTERGRAM OF (DOWN) LOGT (ACROSS) LOGWT



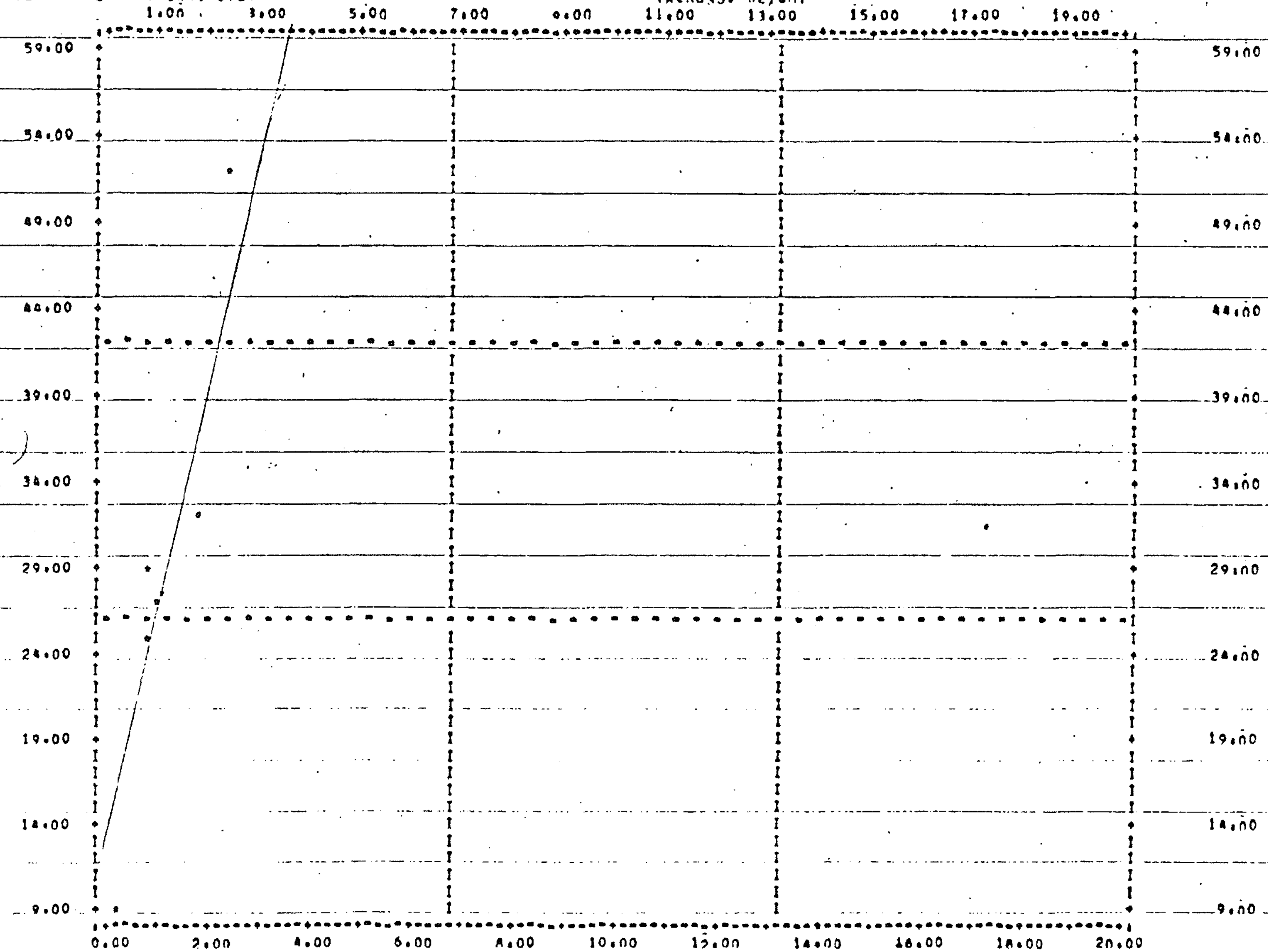
DSW 030761

THE LINEAR CORRELATION OF WEIGHT VS [illegible] PCB
OF ALL GAMBUSIA FOUND AT STATION 2

PLOTS 04/17/79 PAGE 77

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

SCATTERGRAM OF (DOWN) CTOT (ACROSS) WEIGHT



DSW 030762

STLCOPCB4014724

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 signifi- 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

DSW 030763

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	-0.36	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
Micrpoterus	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

DSW 030764

Table 22
(continued)

Species	Station	Season	Corr. R	p	n
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
Micrpoterus	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)

Species	Station	Season	Corr. R	p	n
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

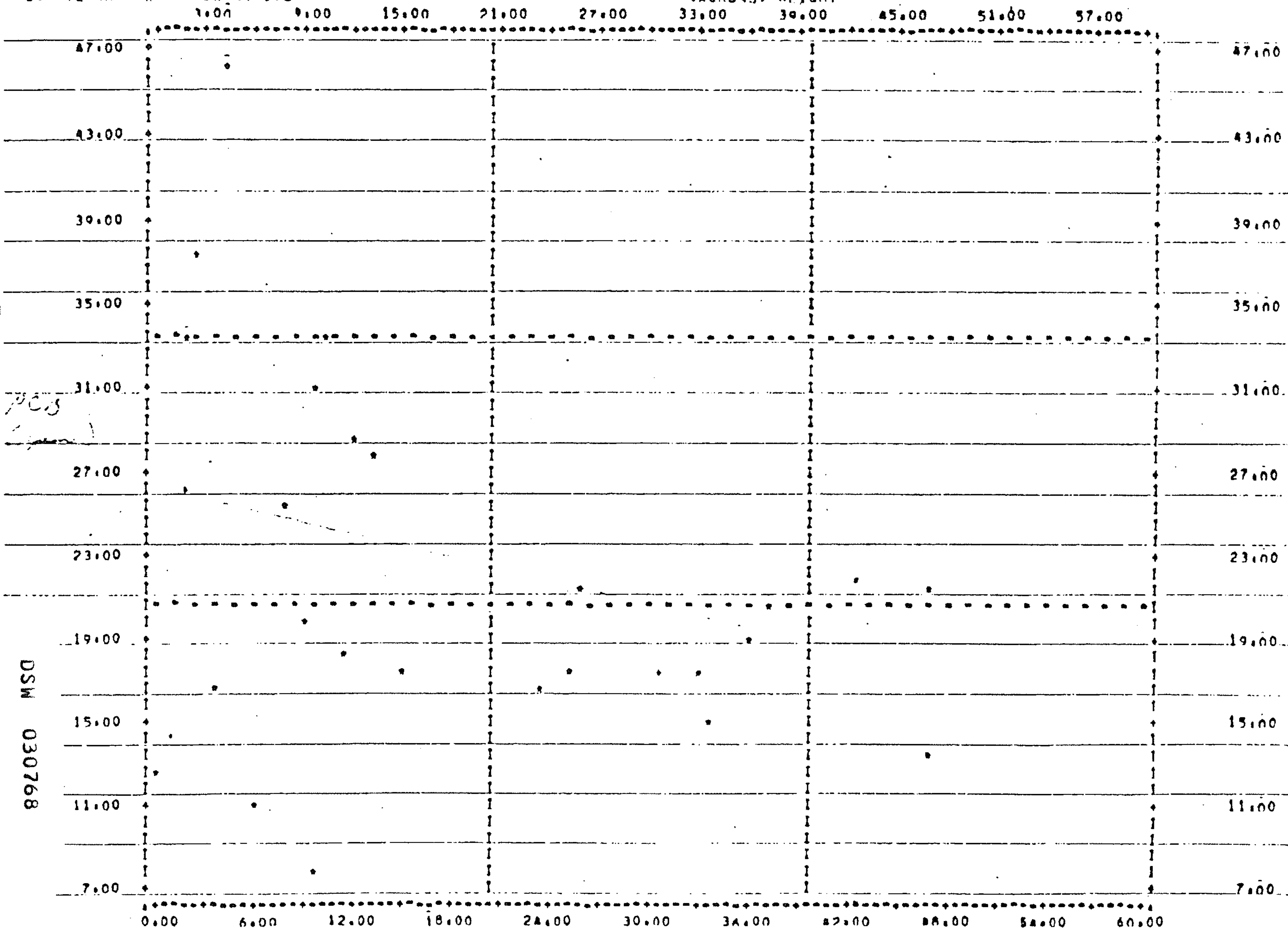
DSW 030767

THE LINEAR CORRELATION OF WEIGHT VS ~~[illegible]~~ PCB OF ALL LEPOMIS FOUND

PLOTS 04/17/79 PAGE 97

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

SCATTERGRAM OF (DOWN) CTOT (ACROSS) WEIGHT



DSW 030768

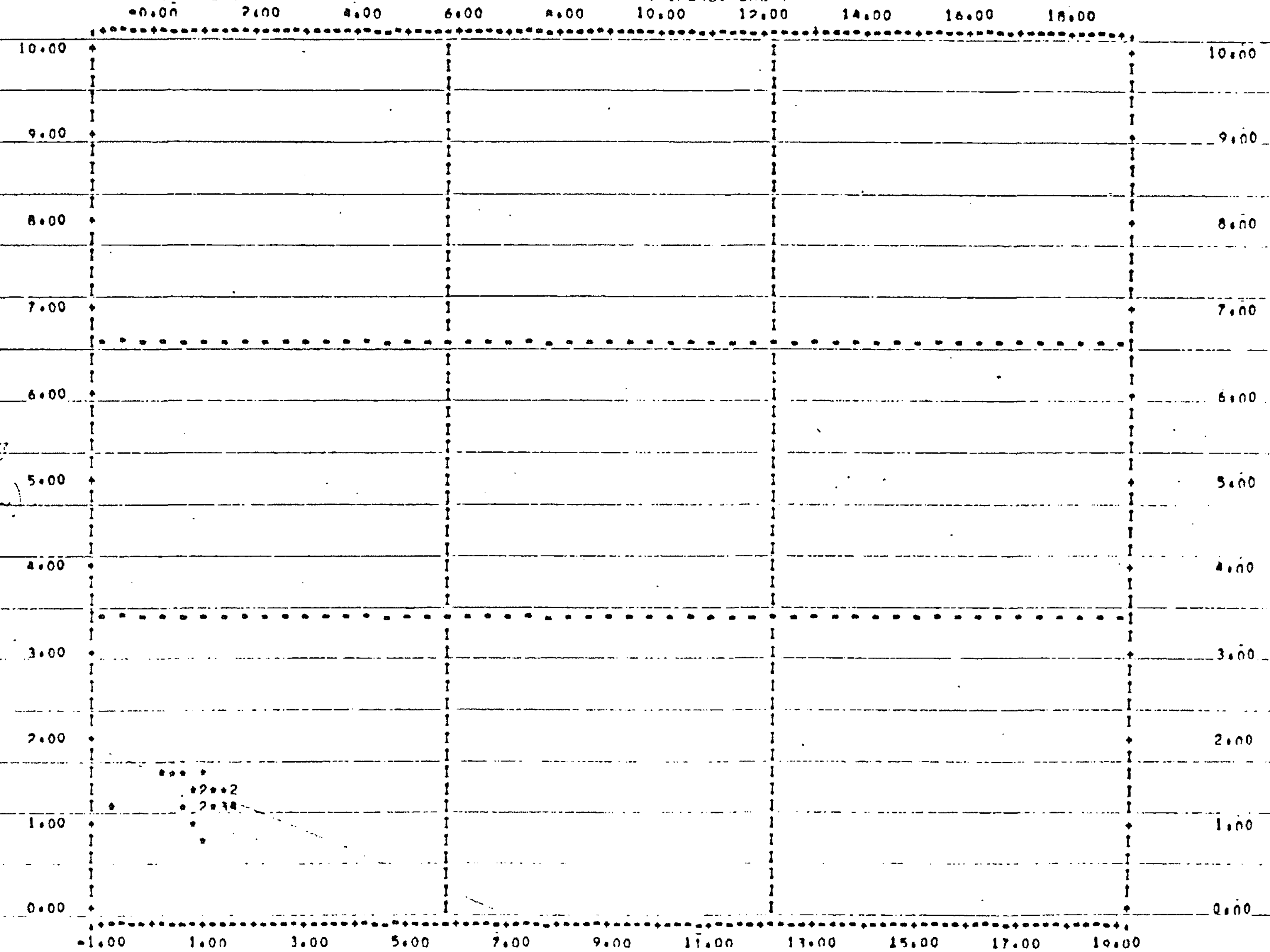
STLCOPCB4014730

THE LINEAR CORRELATION OF LOG WEIGHT VS LOG Area PCB OF GAMBUSIA.

PLOTS OF ALL LEPOMIS FOUND 04/17/79 PAGE 90

FILE NONAME (CREATION DATE = 04/17/79) AT STATION 2

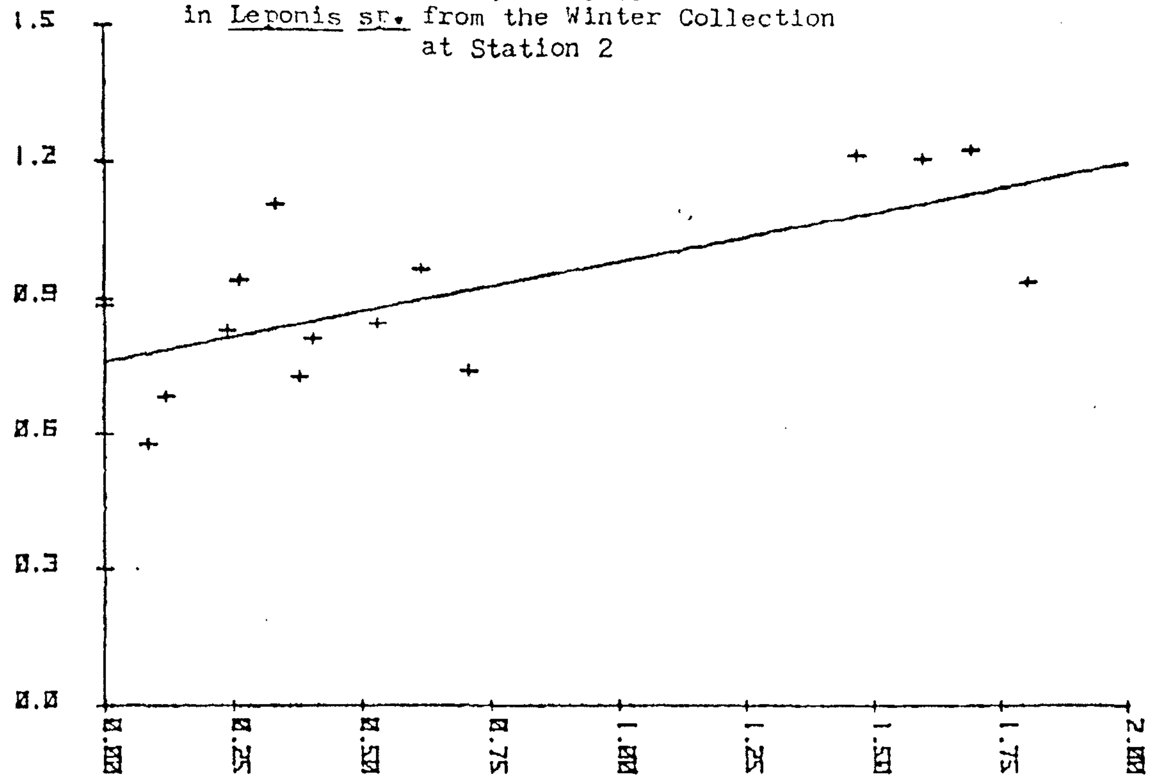
SCATTERGRAM OF (DOWN) LOGT (ACROSS) LOGHT

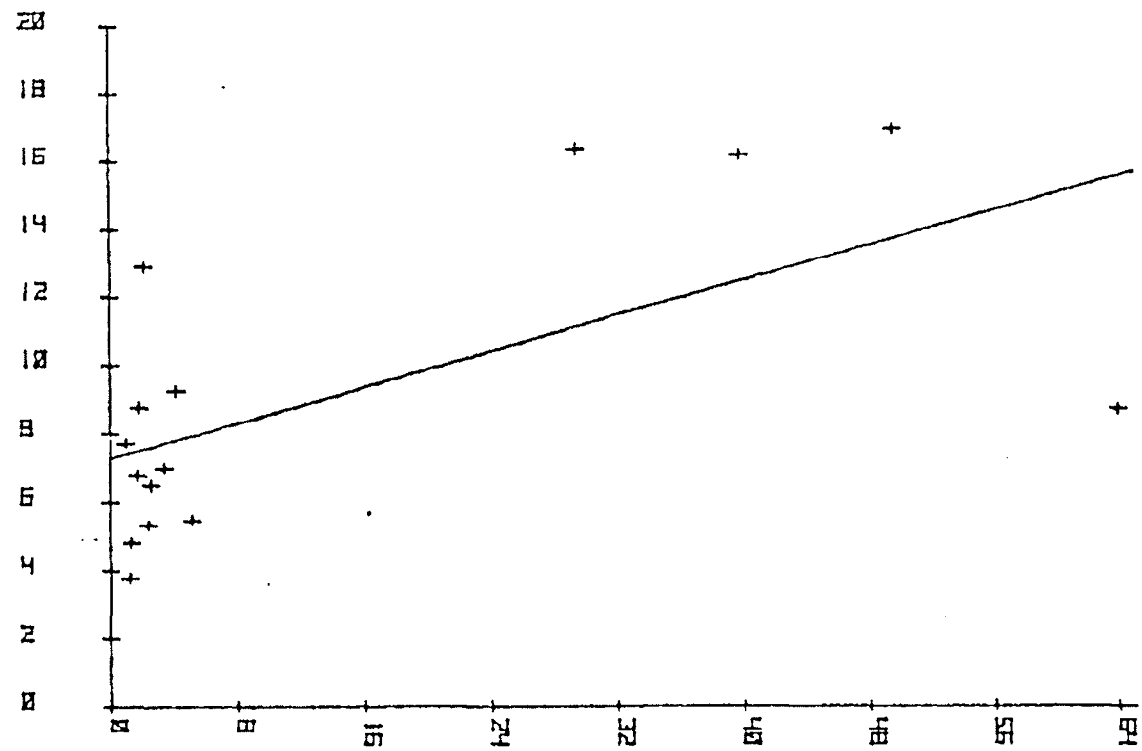


DSW 030769

Figure 22

The Linear Correlation of Weight and ppm PCB
and Log Weight-Log ppm PCB
in *Lepomis sp.* from the Winter Collection
at Station 2

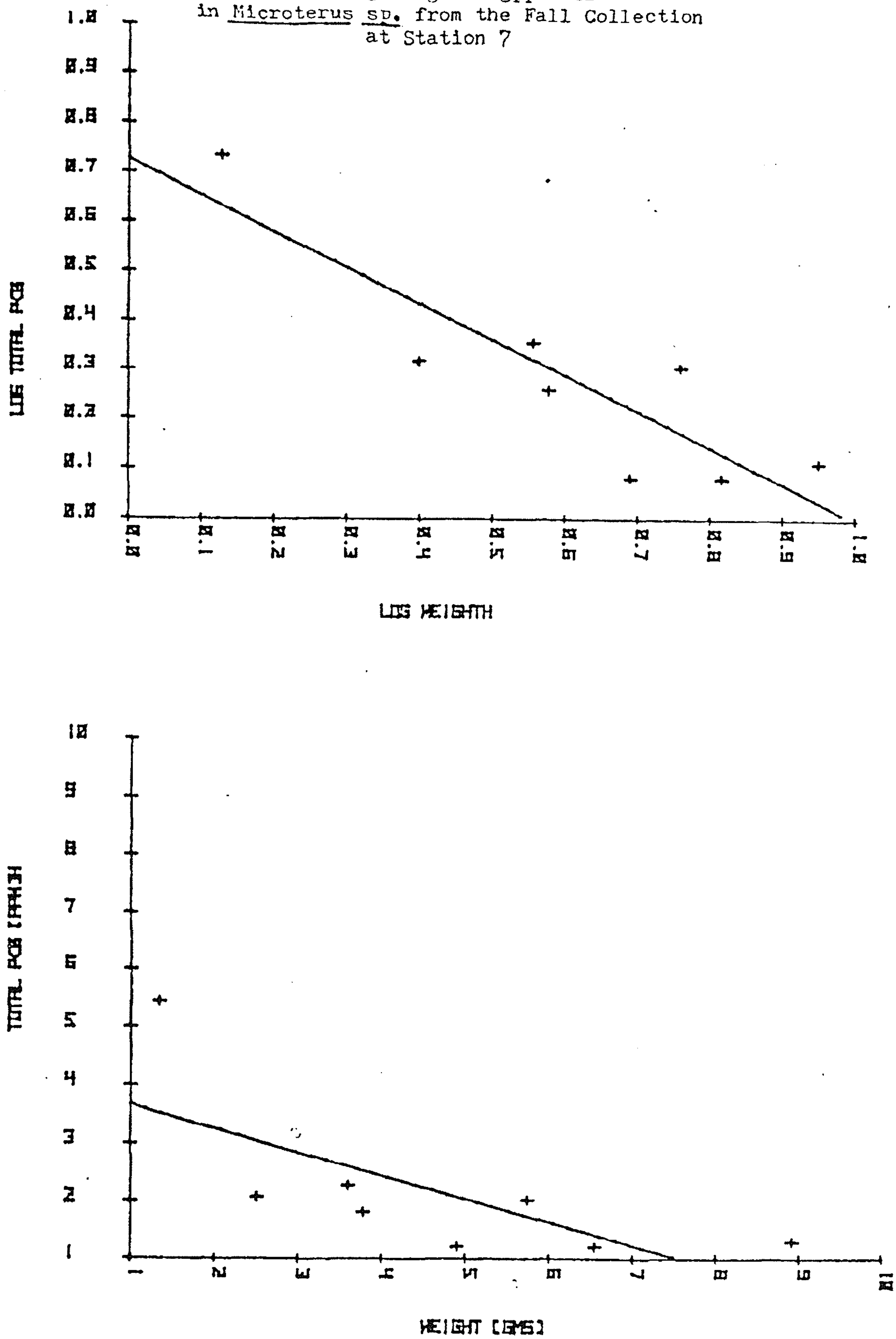




DSW 030770

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



DSW 030771

Table 24

The Multiple Regression Analysis
of Weight and PCB
in Each Genus at Each Station and Season
at the Weight^2 Level

Species	Station	Season	F	Multiple R	R^2	n
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	0.98	5

DSW 030772

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 spcificity increases both the correlation coeffient and the significance levels. In general, PCB's increase with increased weight in all species.

DSW 030773

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:

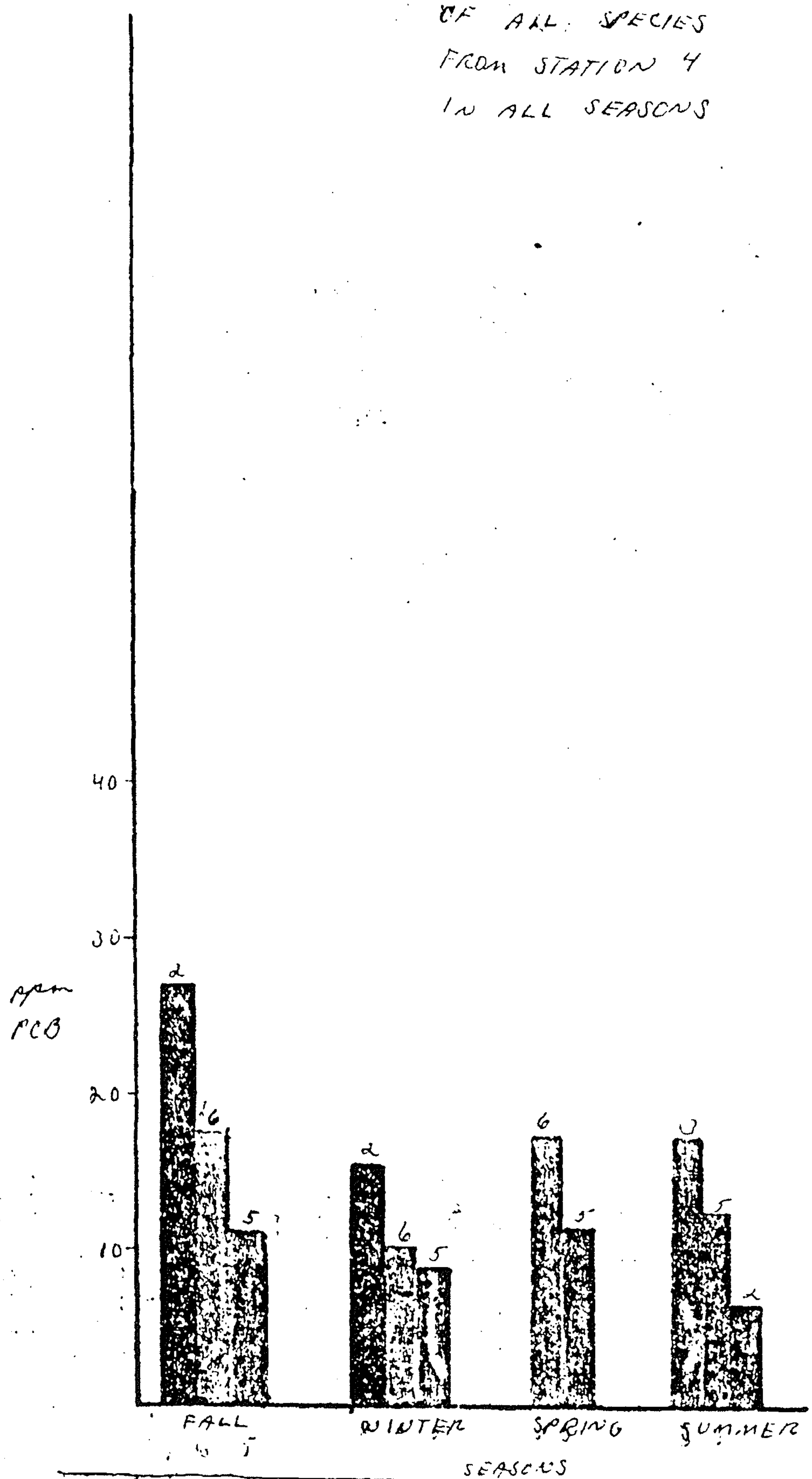
By comparing the water quality analyses (Table I6) with the fluctuating PCB concentrations of fish (Figures 8-11 and 24-25) the influences of the abiotic parameters on the uptake of PCB by fish may be identified. The changes in residue levels of Dorosoma, Lepomis, Micropterus and Notropis throughout the stations and seasons do not directly coincide with the fluctuations in dissolved oxygen, carbon dioxide, temperature or alkalinity. For example, although temperature

DSW 030774

DSW 030775

Figure 20

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



* THE SPECIES ARE MARKED ABOVE EACH BAR:

DSW 030776

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. Therfore, 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 Dorosomas' 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 makes 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 pattern 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 fluxuations in PCB levels in any species at any station or season. There is no correlation of sulfate or conductivity with the seasonal fluxuations in fish, but again, they follow similar spacial trends which do correlatn with PCB levels.

In summary, the mean PCB concentration in each species at each station fluxuates with the seasons. These seasonal changes in each species vary from station to station, and a comparison of the seasonal fluxuations 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 fluxuations 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.

DSW 030778

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 26 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 dissolved

DSW 030779

oxygen and tubidity and low carbon dioxide 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 4, 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, detritavore, 1st carnivore and omnivore. In this low contaminated control station, there is a nearly normal food chain relationship with detritavore being second in importance to tertiary carnivore. At stations 2 and 9, those most highly contaminated stations, a similar relationship exists. However, the detritavore accumulates PCB to the highest level. At station 4, Dorosoma accumulates the highest levels and the relationship is herbivore, carnivore, omnivore. As seen above, however, Dorosoma probably 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 stations (1,2,4,9) on Choccolocco Creek. Stations 6,7 and 8, however, are much more variable. At these stations Lepomis, the omnivore, accumul-tes more PCB, relative to the other species, than they did on Choccolocco Creek. There are no samples of botton feeders at these stations, so their relationshipto the other species is not know. 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	Micrpterus	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

DSW 030782

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	9.32

Summer	Notropis	Phenacobius	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

DSW 030783

Table 25
(continued)

Station 4

Fall	Dorosoma	Percina	Micropterus	Lepomis	Notemogoneus
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

DSW 030784

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

DSW 030785

Table 25
(continued)

Station 6

Fall	Dorosoma	Micrpoterus	Lepomis	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

DSW 030786

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

DSW 030787

Table 25
(continued)

Statiom 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

DSW 030788

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 Hypentelium. 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 fluctions 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 falland 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 Lepomis.

The lack of correlation between season and PCB concentration in Gambusia and Hypentelium 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 re-lated 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)

DSW 030790

Species	% Oil
Dorosoma cepedianum	23.1
Campostoma sp.	1.2-1.9
Perca flavience	0.8-1.1

E. METABOLIC DIFFERENCES IN SPECIES

Figures 26-29 show the seasonal differences in the accumulation of each Aroclor (1242, 1254 and 1260) at stations 1 to 8 in Dorosoma, 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 the same species from the same station but in different seasons (Notropis, , station 2, all 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, ~~when comparing~~ a comparison for the same species from the same season but different stations (Micropterus, stations 2,4 and 6, fall collections) (Figures 43-45) shows a loss of some of the peaks of lower retention time with increased

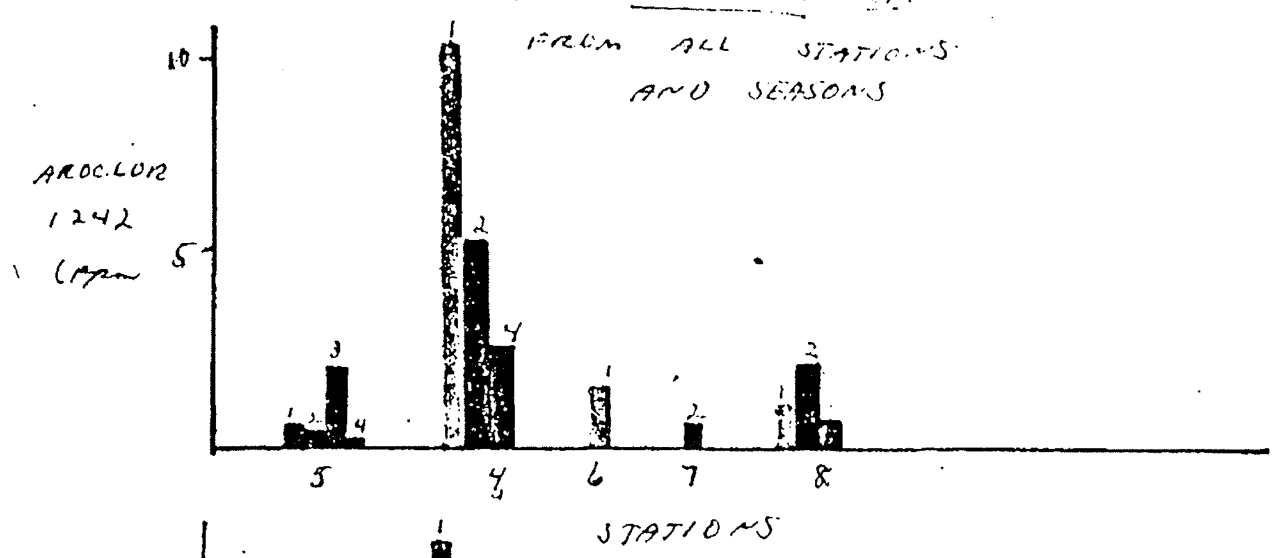
DSW 030791

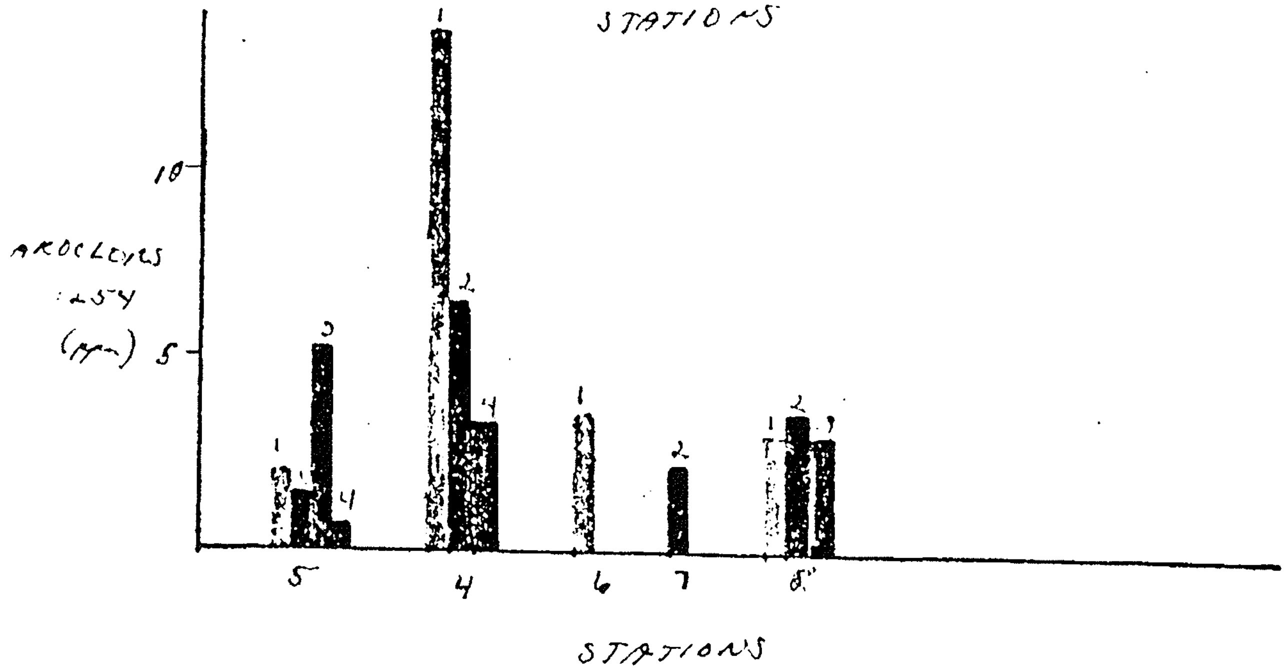
distance from Stations 2 to 6. Otherwise all peaks are the same with similar relative heights.

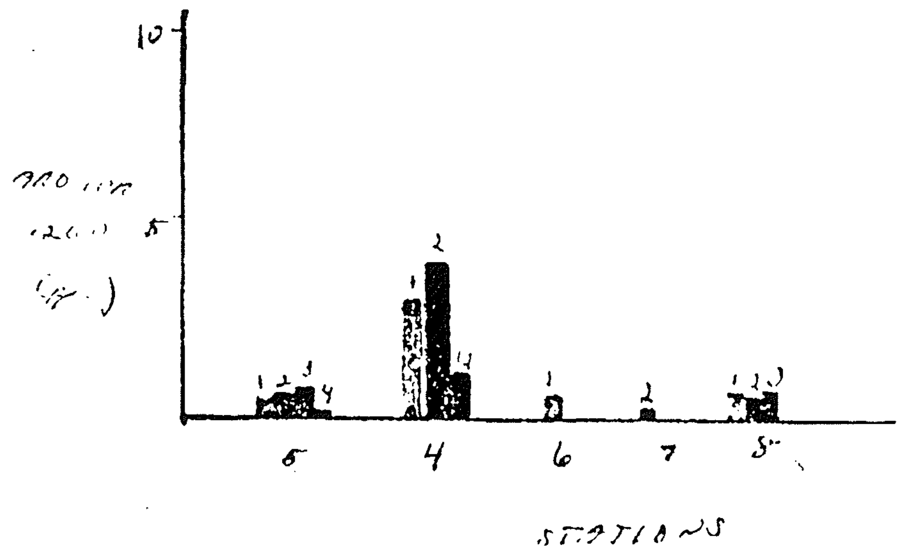
Therefore, the differences seen in species accumulation of PCB (see section D) ~~is~~ are probably not due to differences in metabolic ~~ability~~ activity.?

DSW 030792

THE MEAN LEVELS OF AROCLORS 1242, 1254 AND 1260 IN DOROSOMA SP. FROM ALL STATIONS AND SEASONS



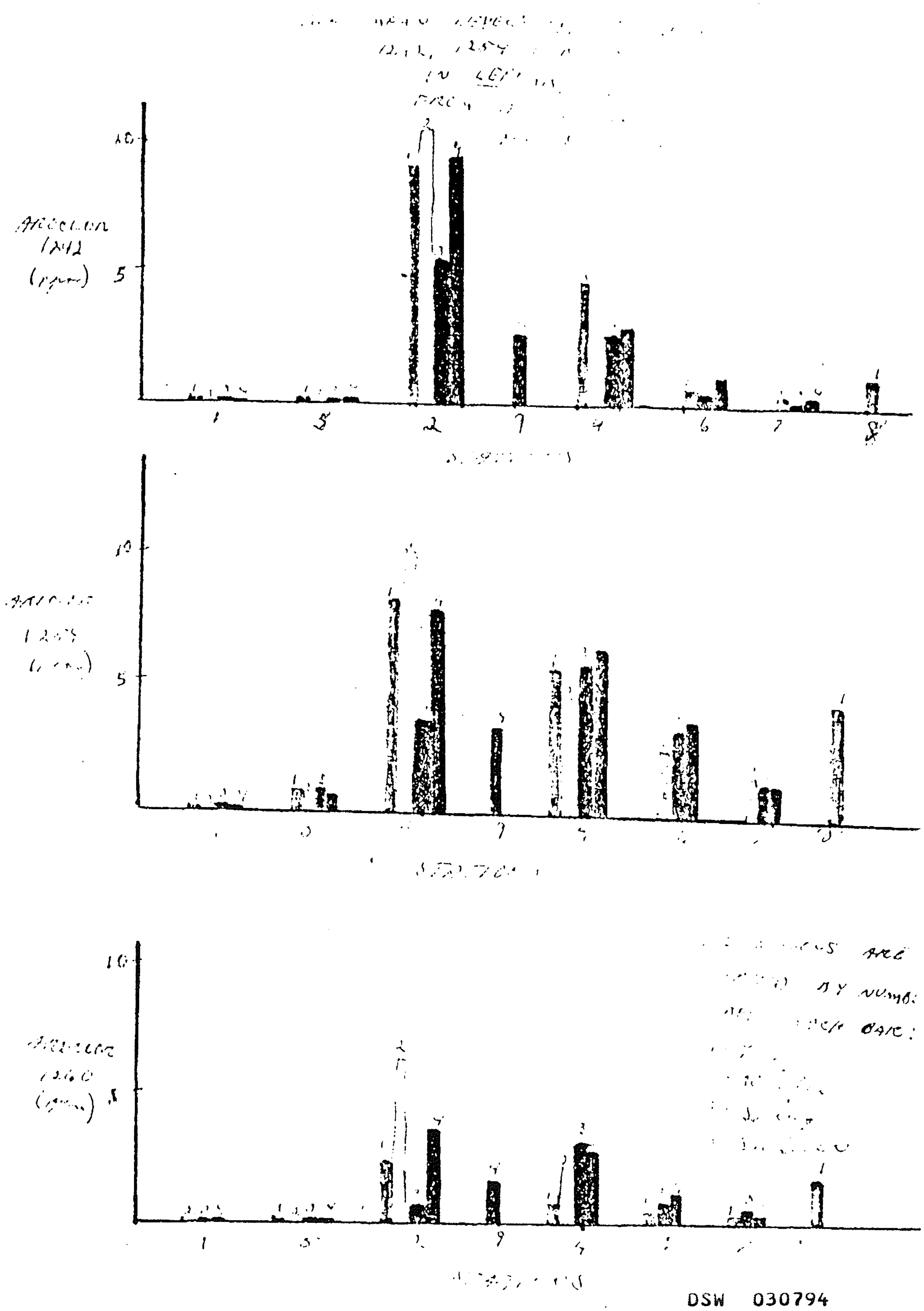




The seasons are marked by numbers above each bar:
1- Fall
2- Winter
3- Spring
4- Summer

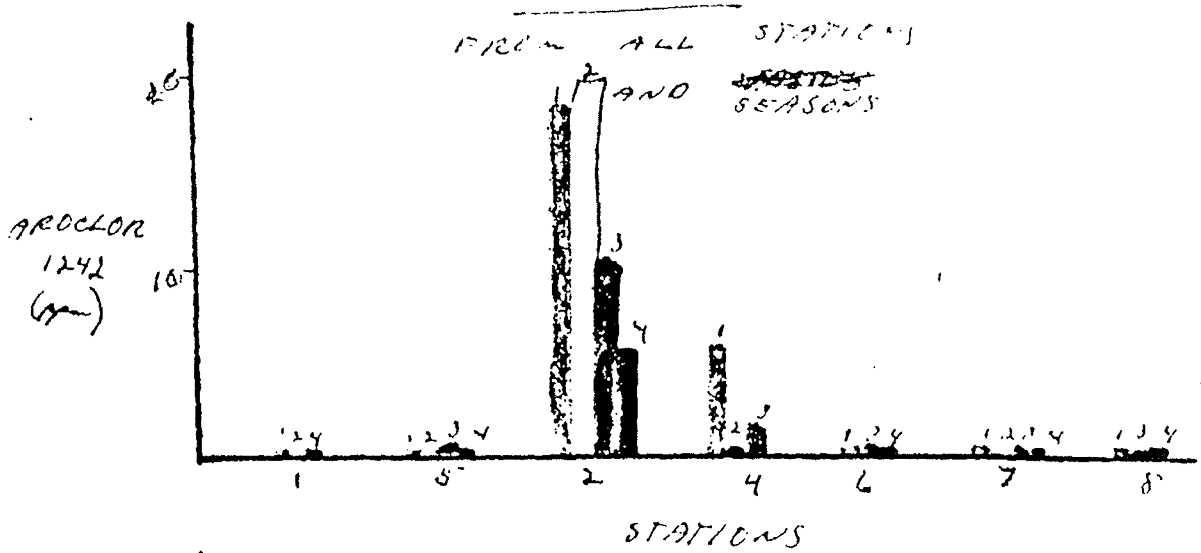
DSW 030793

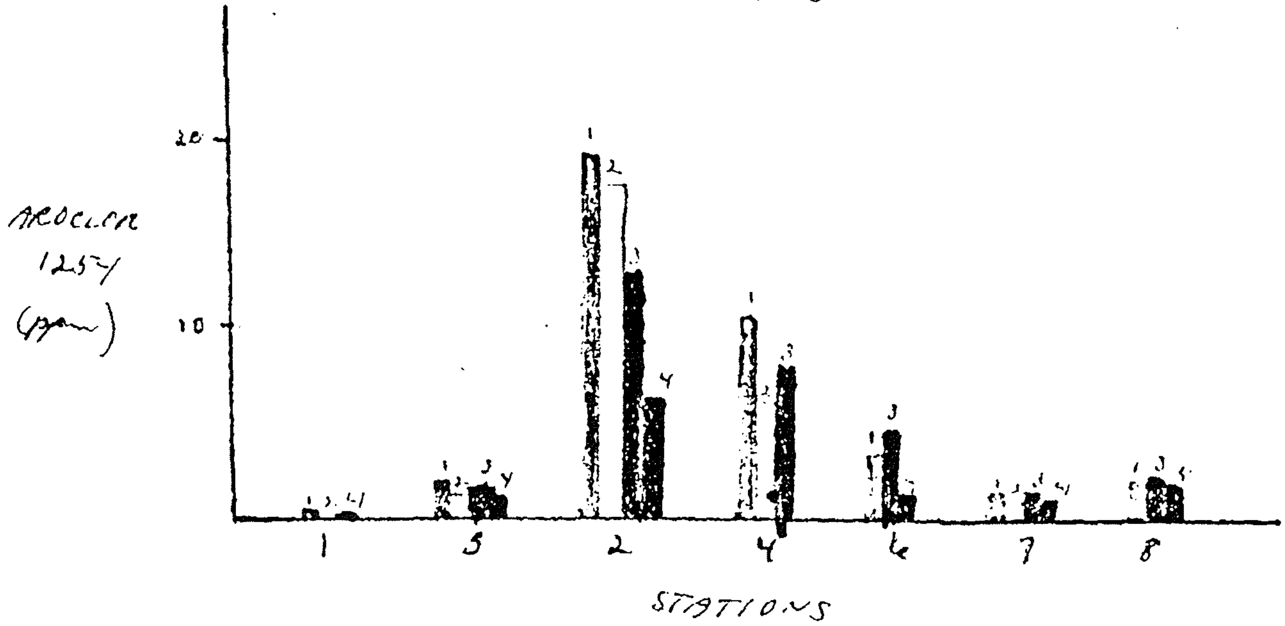
STLCOPCB4014755

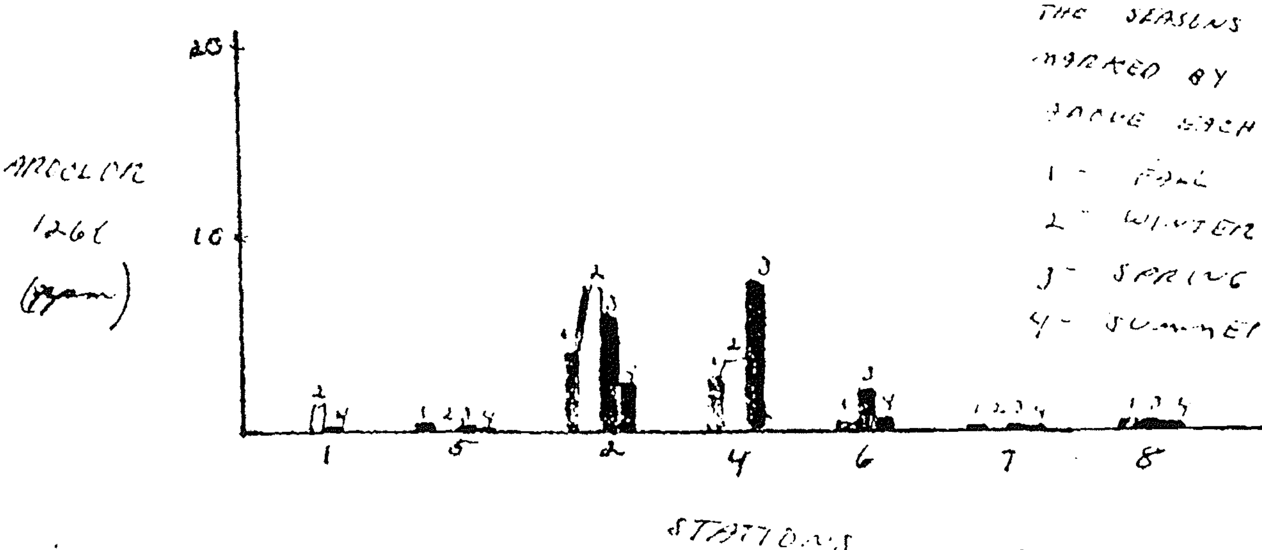


DSW 030794

THE MEAN LEVELS OF AROCLORS
1242, 1254 AND 1260
IN MICROPTERUS SP
FROM ALL STATIONS AND ~~WATERS~~ SEASONS





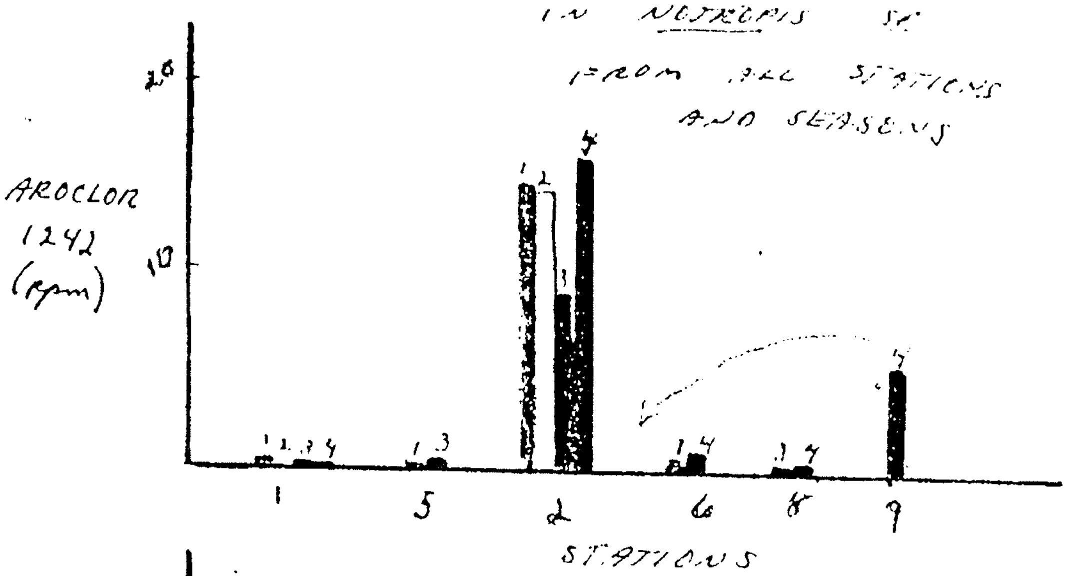


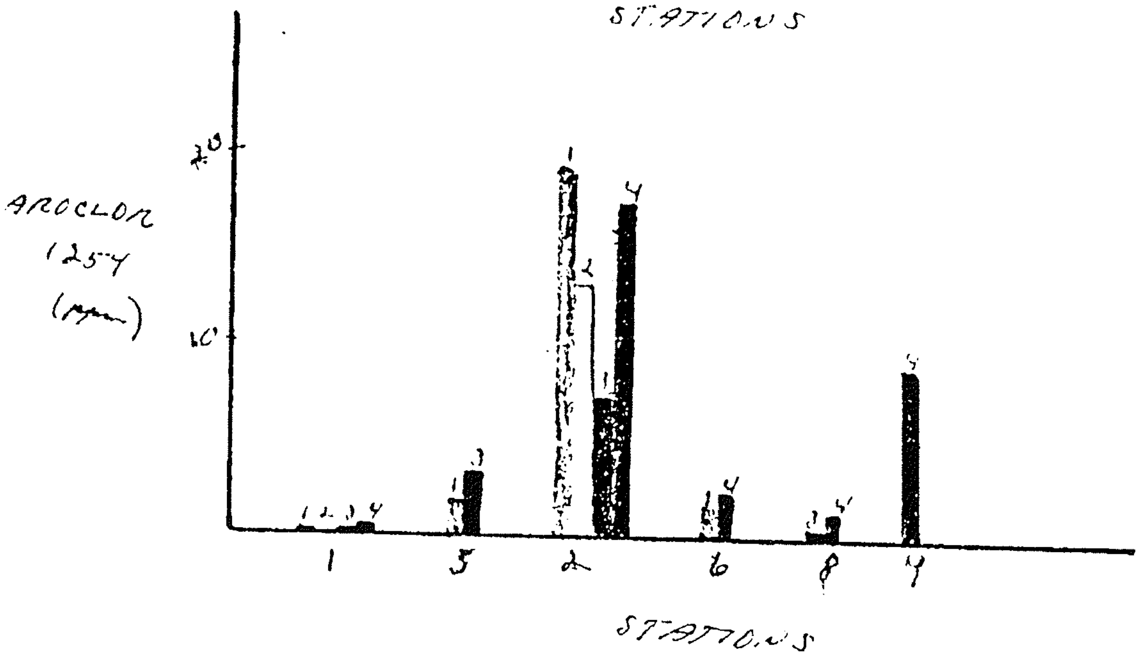
THE SEASONS ARE MARKED BY NUMBER ABOVE EACH BAR:
1 - FALL
2 - WINTER
3 - SPRING
4 - SUMMER

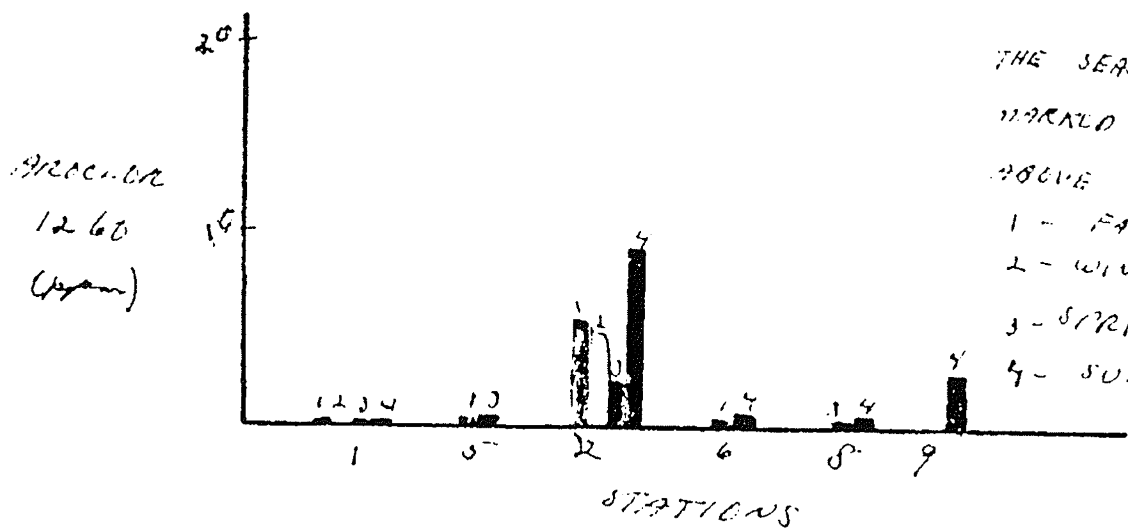
DSW 030795

6

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







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

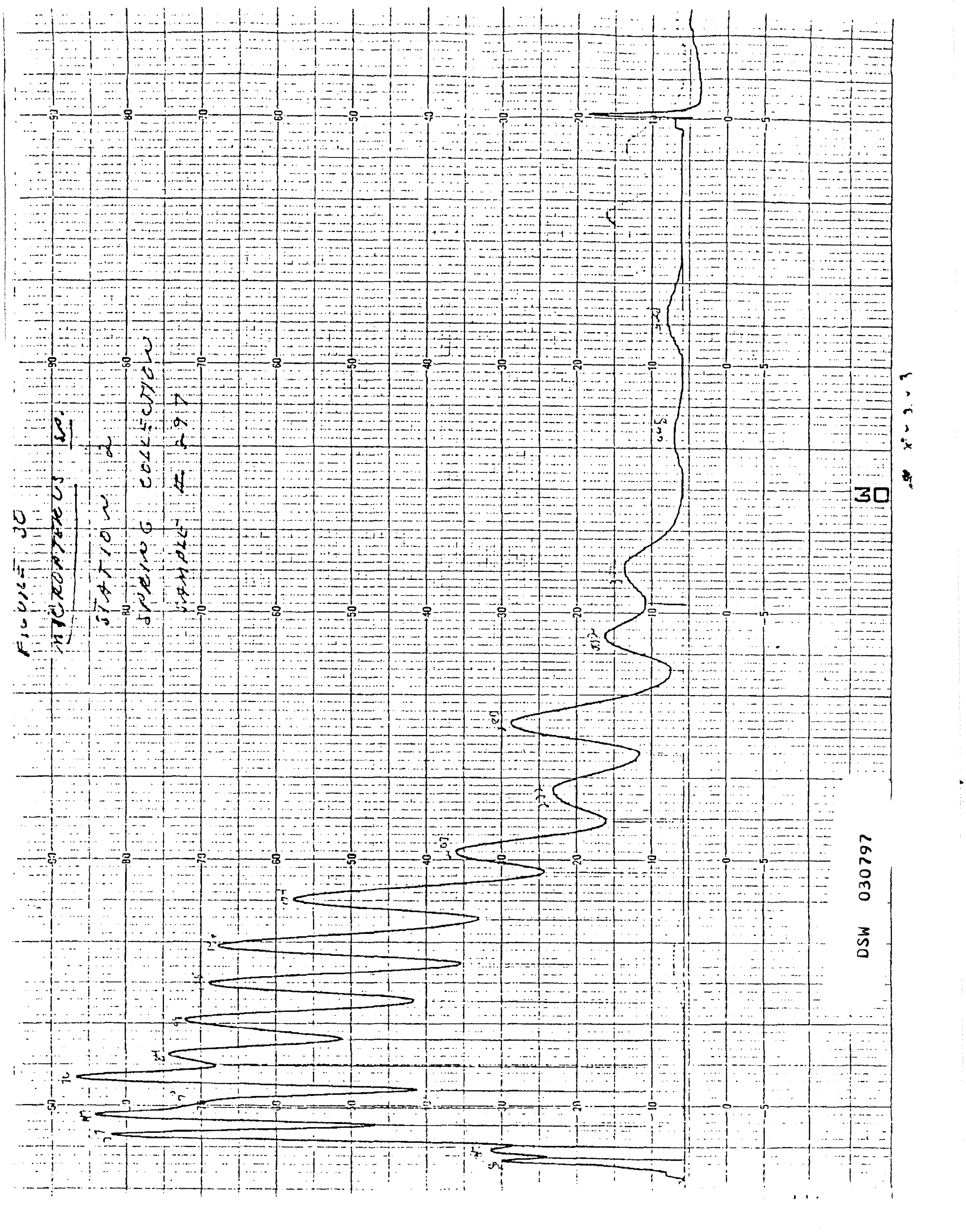


FIGURE 30
STATION 2
SPRING COLLECTION
SAMPLE # 297
DSW 030797

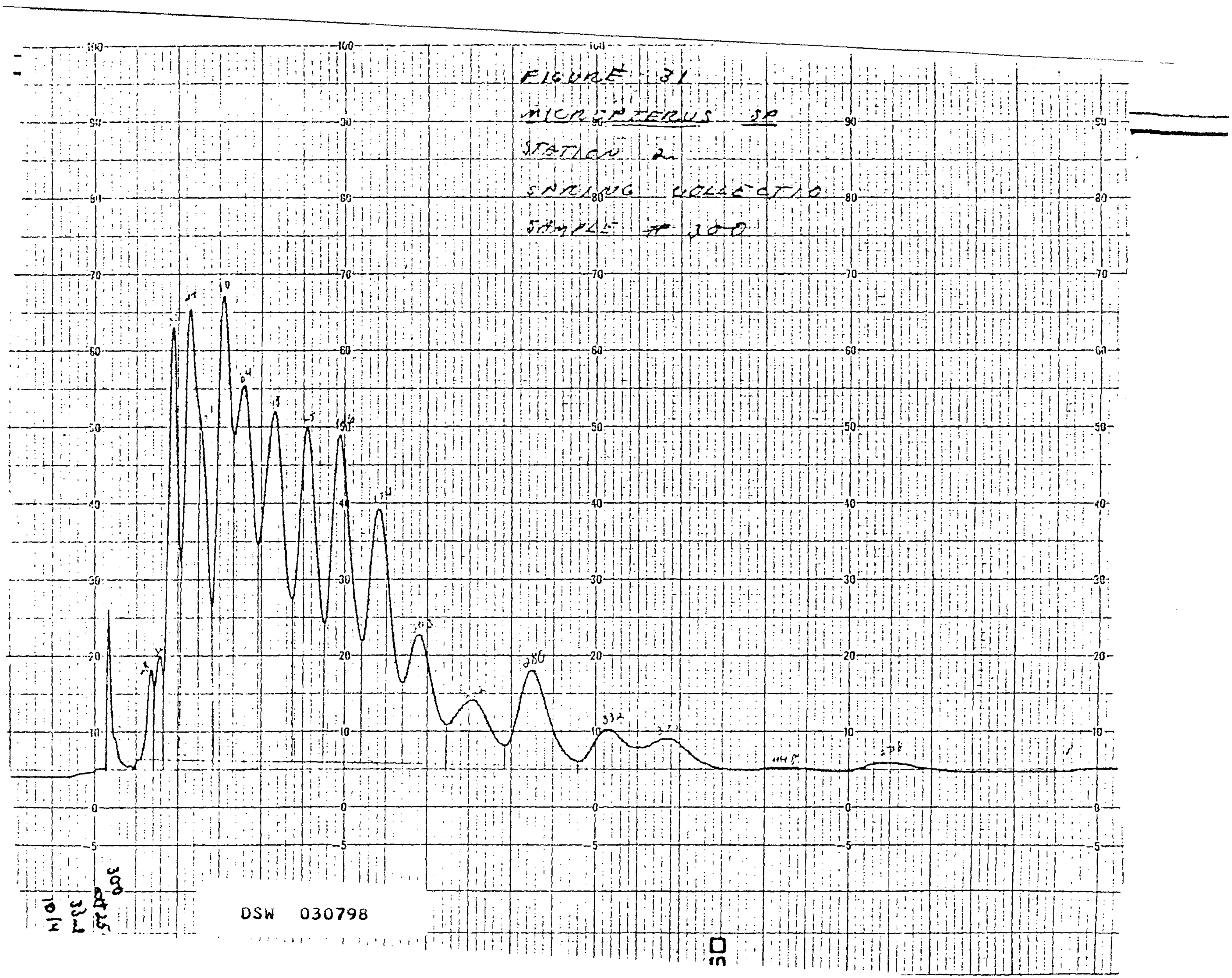
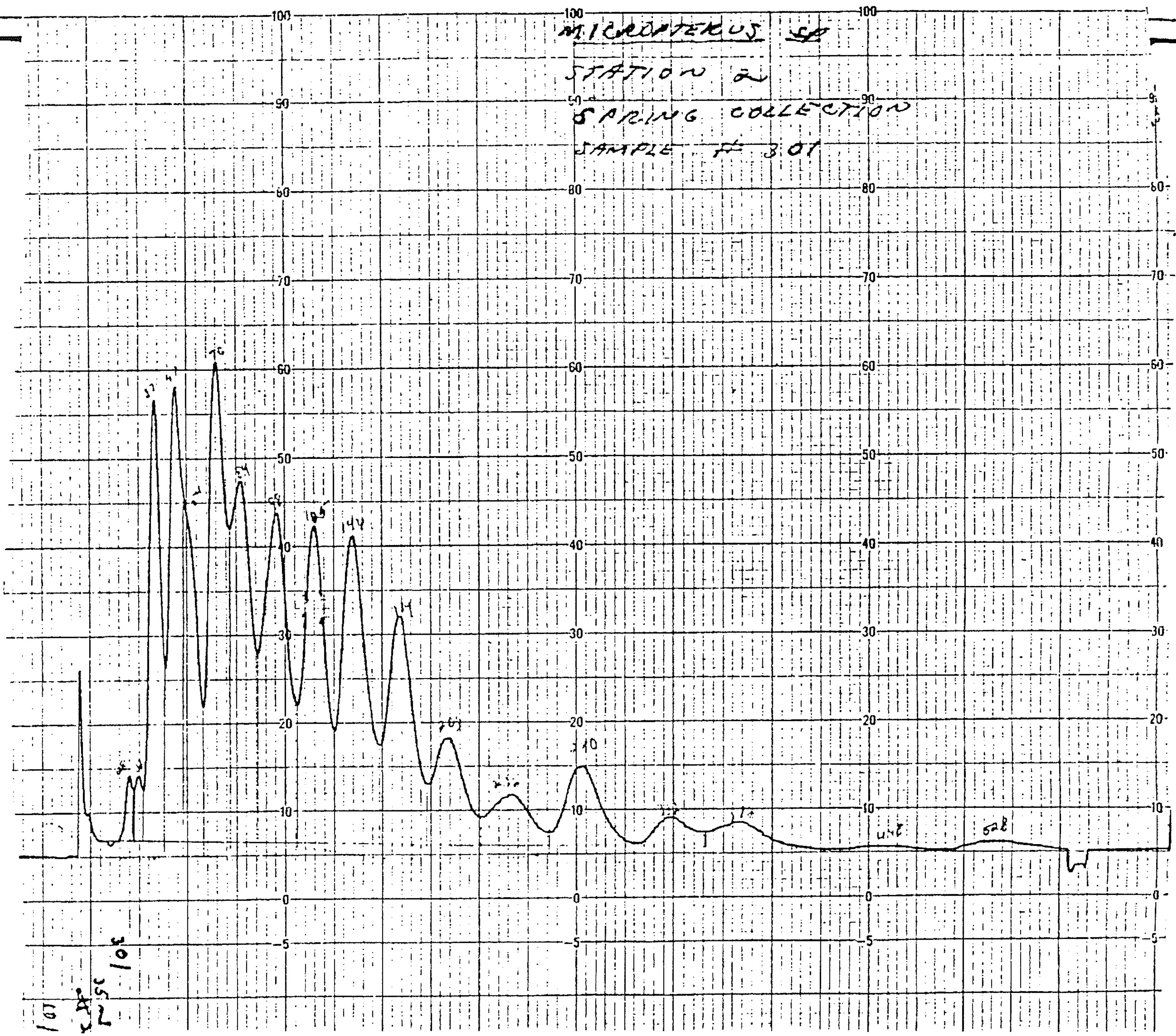
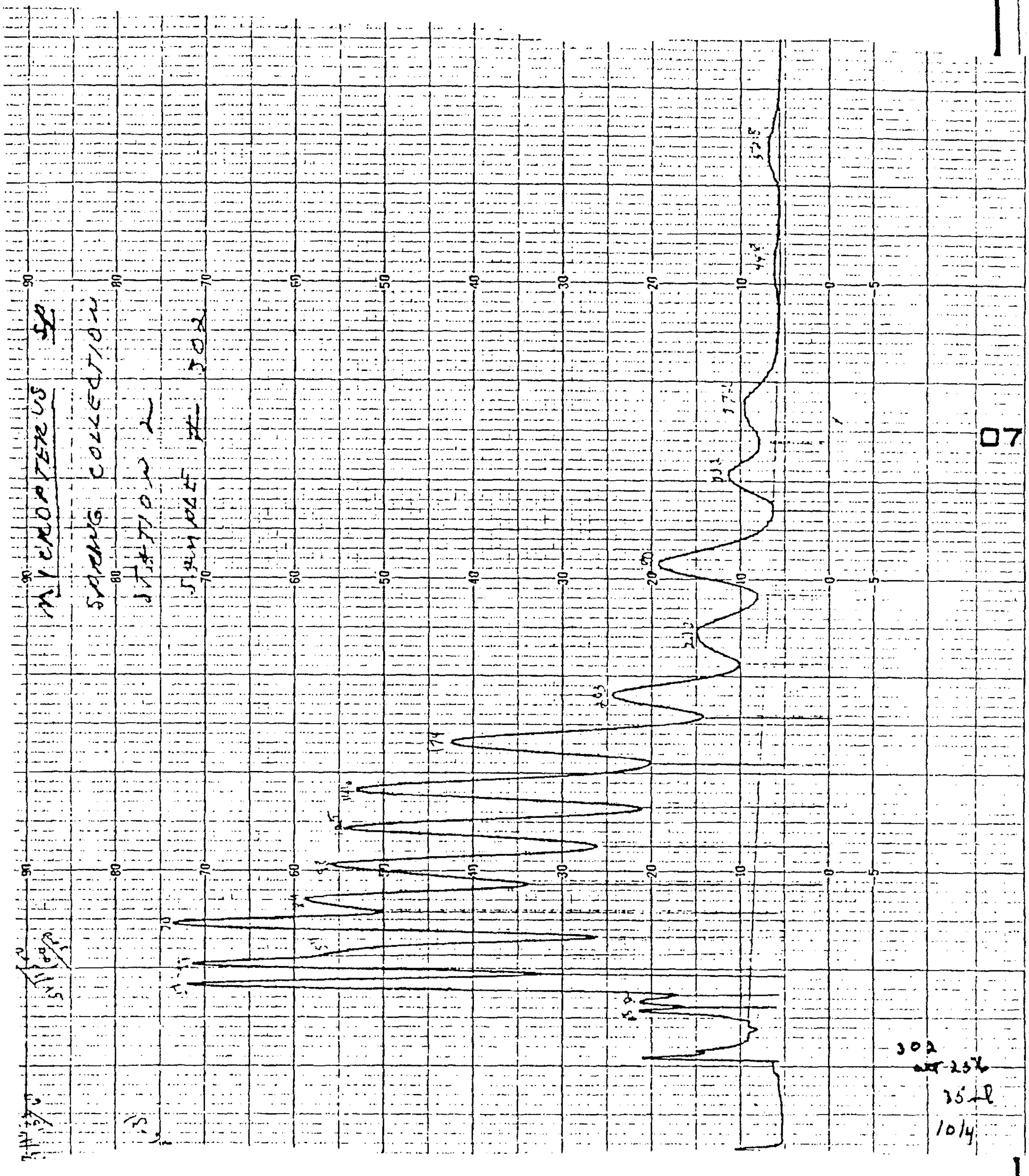


FIGURE 31
MICROPTERUS SP
STATION 2
SPRING COLLECTION
SAMPLE # 300
300
att 25
33 ml
10/4
DSW 030798

FIGURE 32

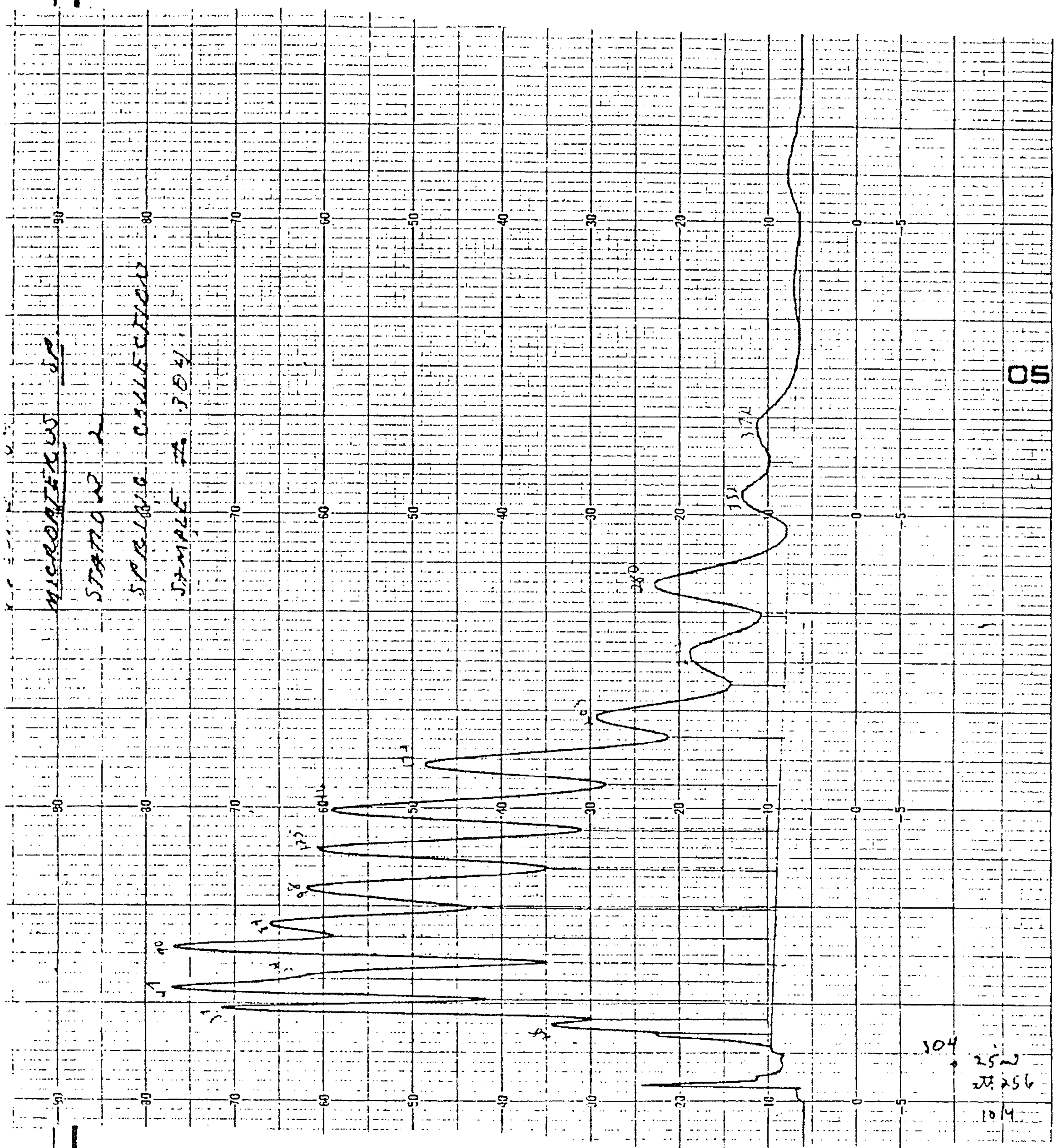


DSW 030799



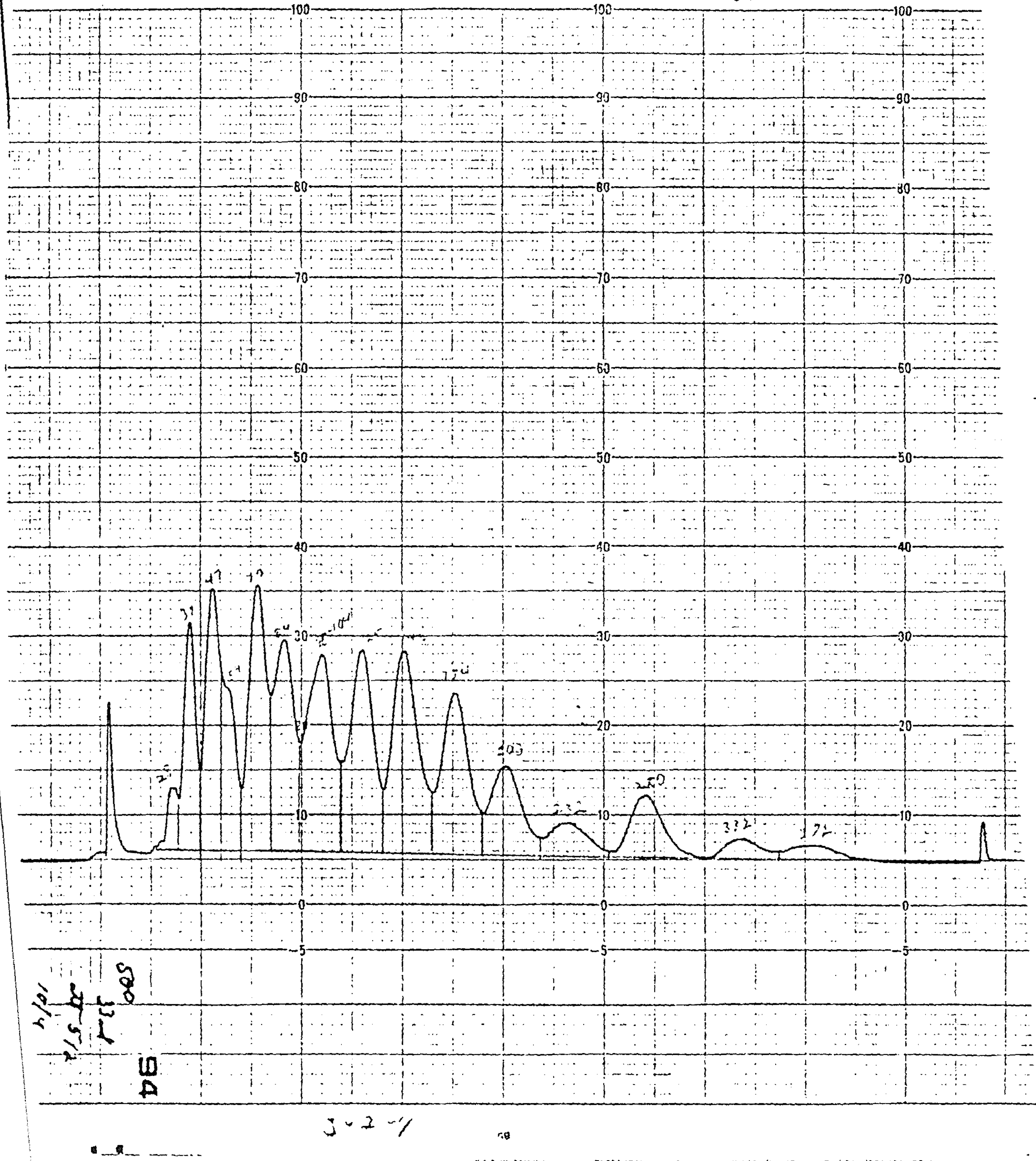
DSW 030800

STLCOPCB4014762



DSW 030801

FIGURE 35
GAMBUSIA SP.
STATION 2
SUMMER COLLECTION



DSW 030802

STLCOPCB4014764

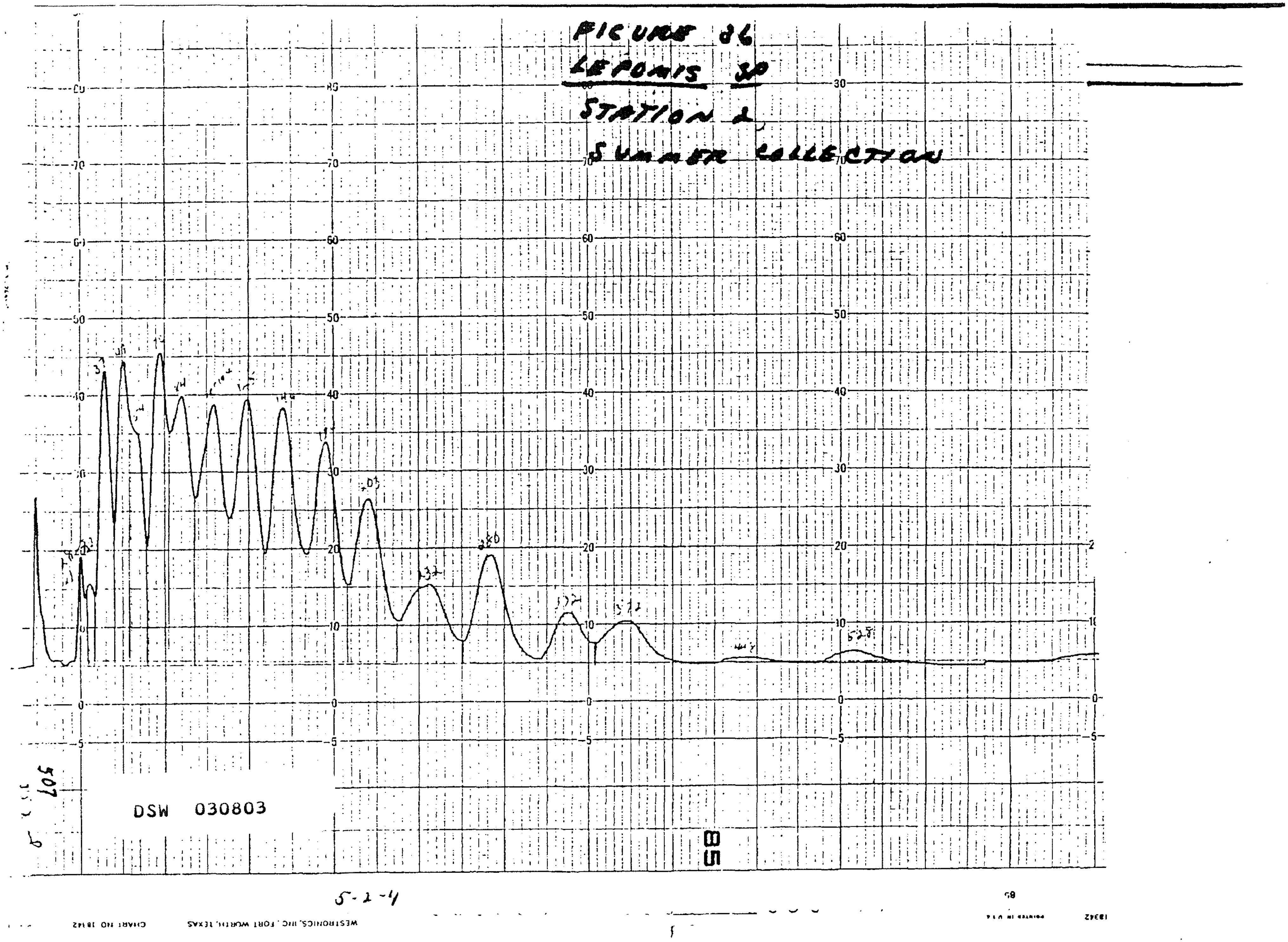
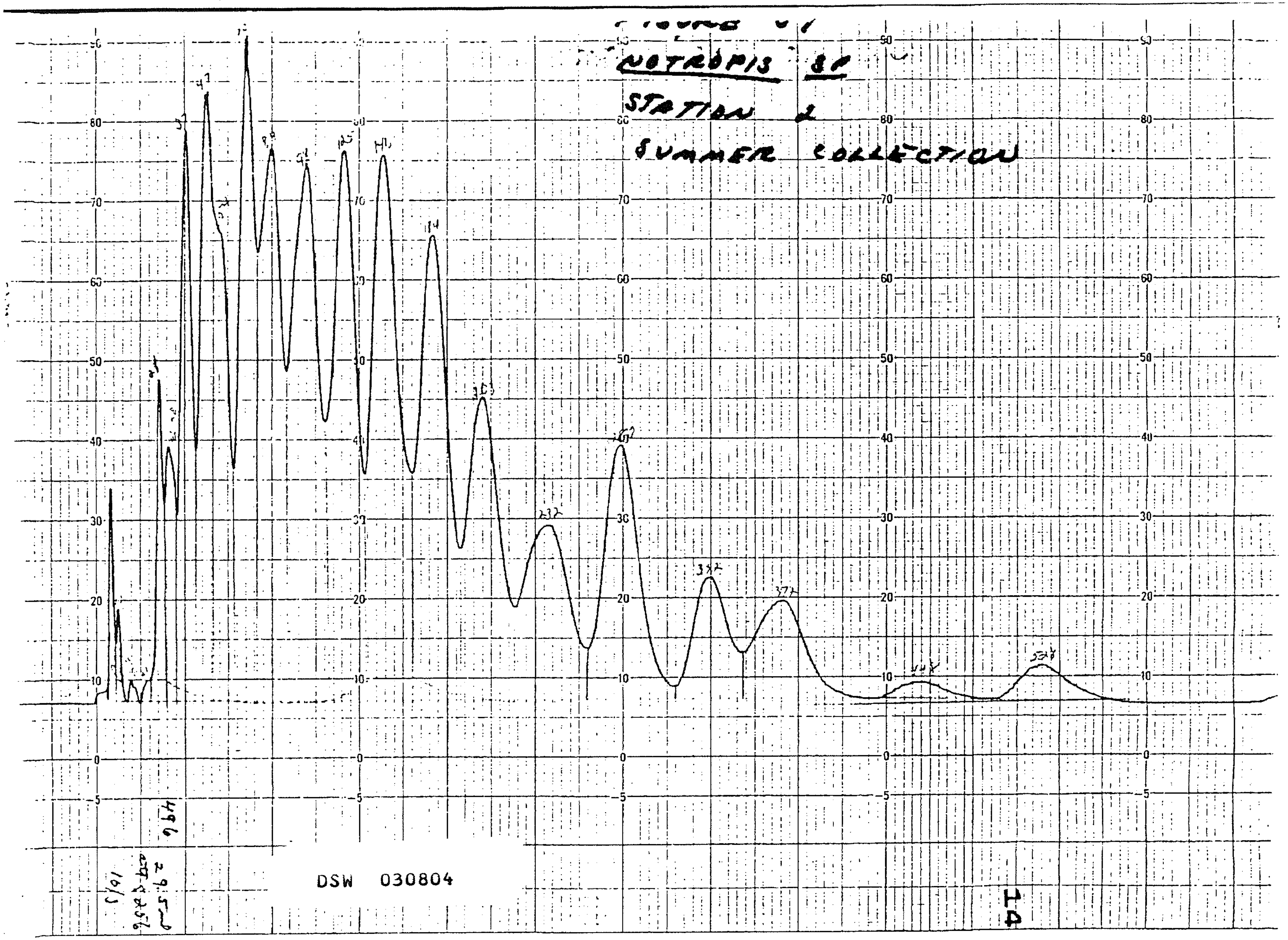


FIGURE 26
LEPOMIS 30
STATION 2
SUMMER COLLECTION
DSW 030803
85
507
5-2-4
WESTRONICS, INC. FORT WORTH, TEXAS
CHART NO 18142



DSW 030804

14

8-2-4

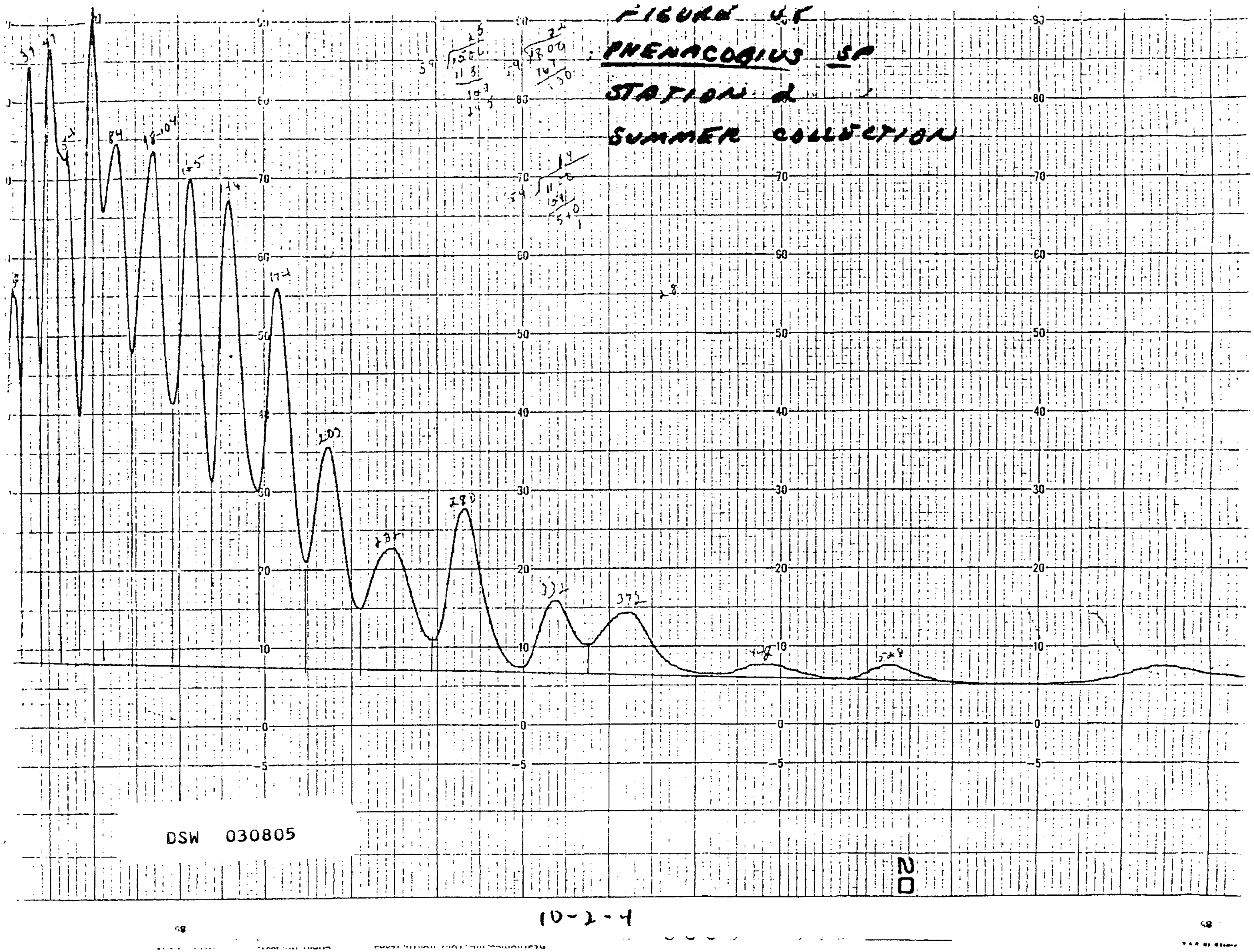
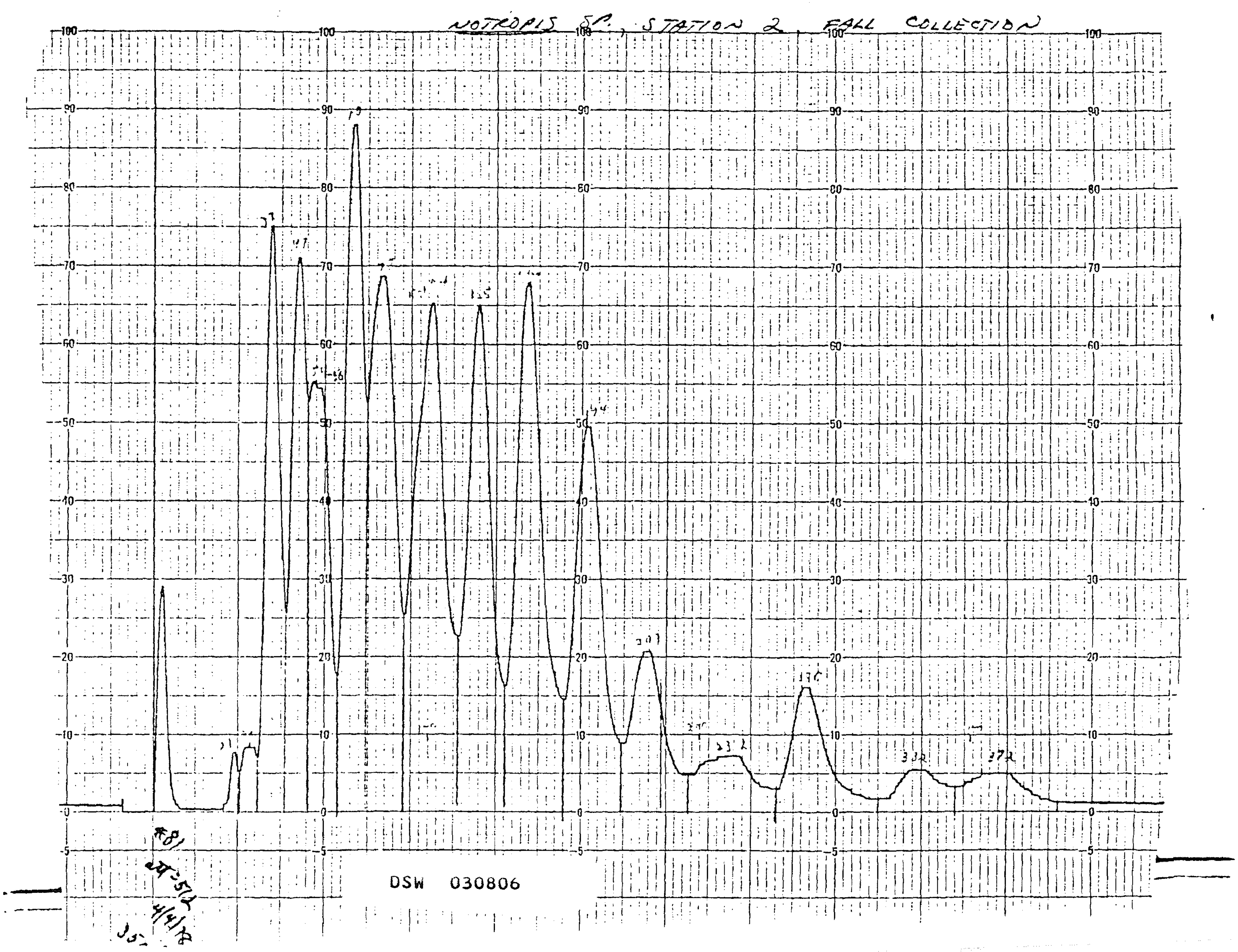
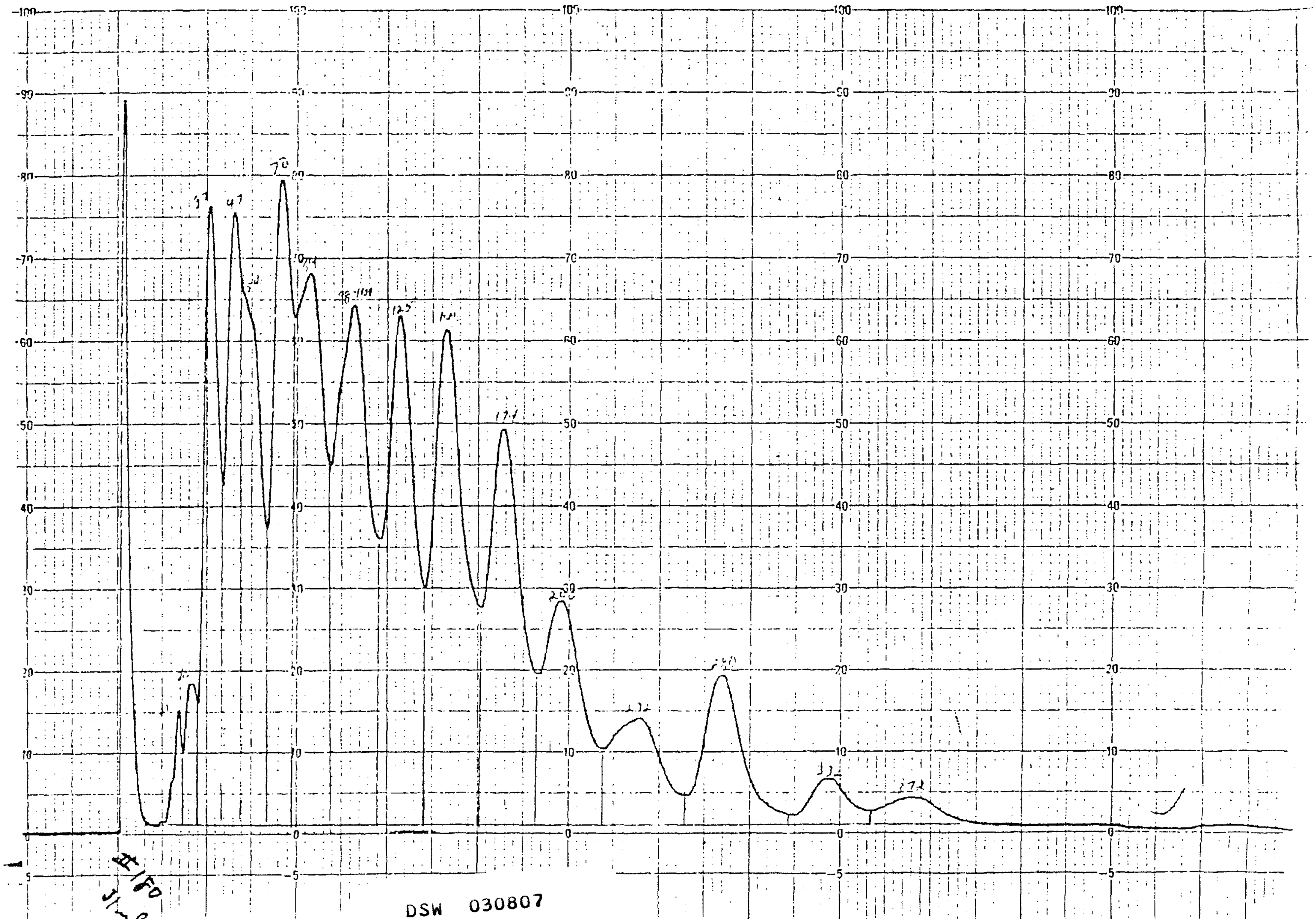
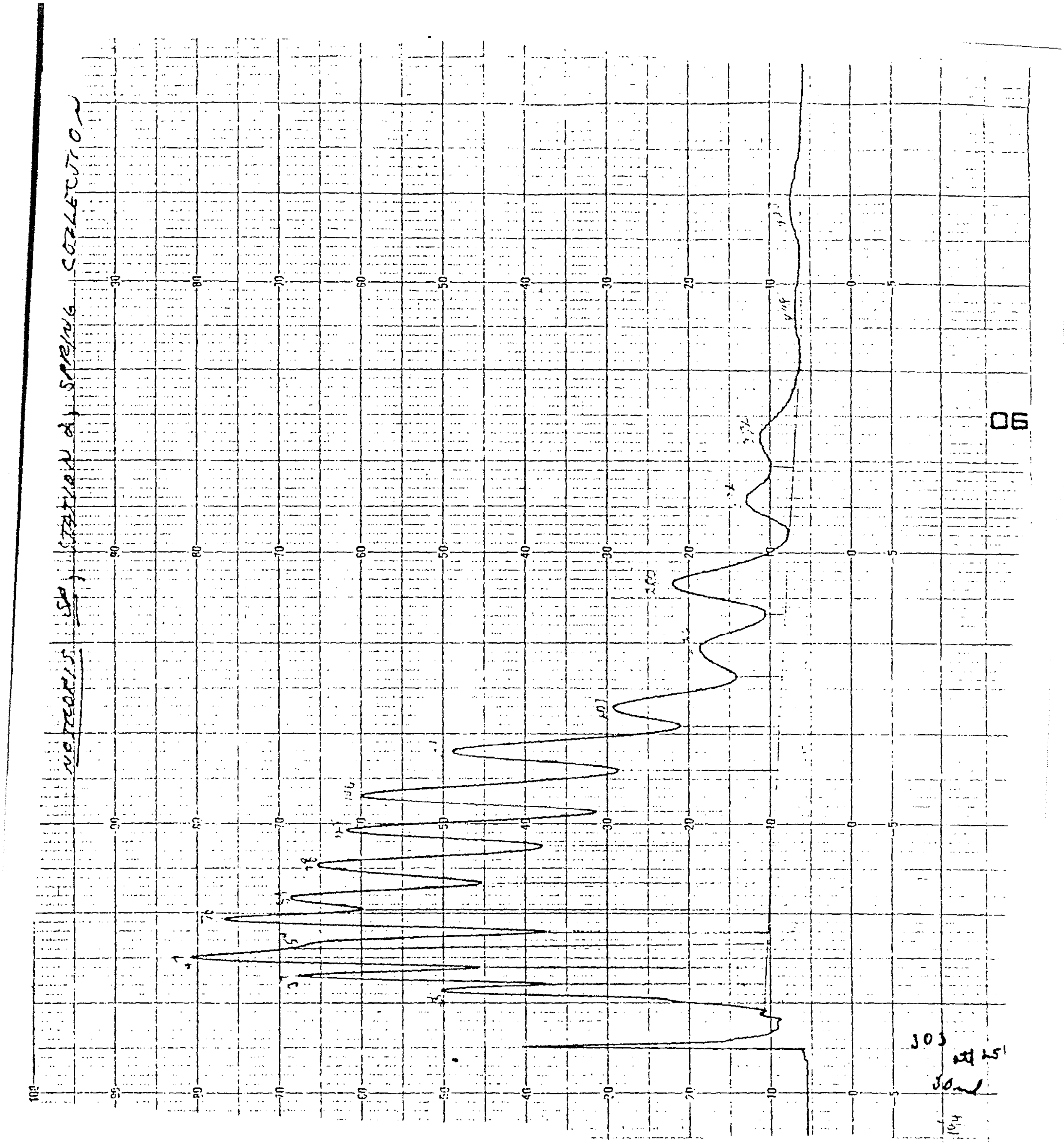


FIGURE 4.5
PHENACOGIUS SP
STATION 2
SUMMER COLLECTION
84
18-104
172
203
187
180
332
375
528
20
DSW 030805
10-2-4


NOTROPIS SP., STATION 2, FALL COLLECTION
DSW 030806

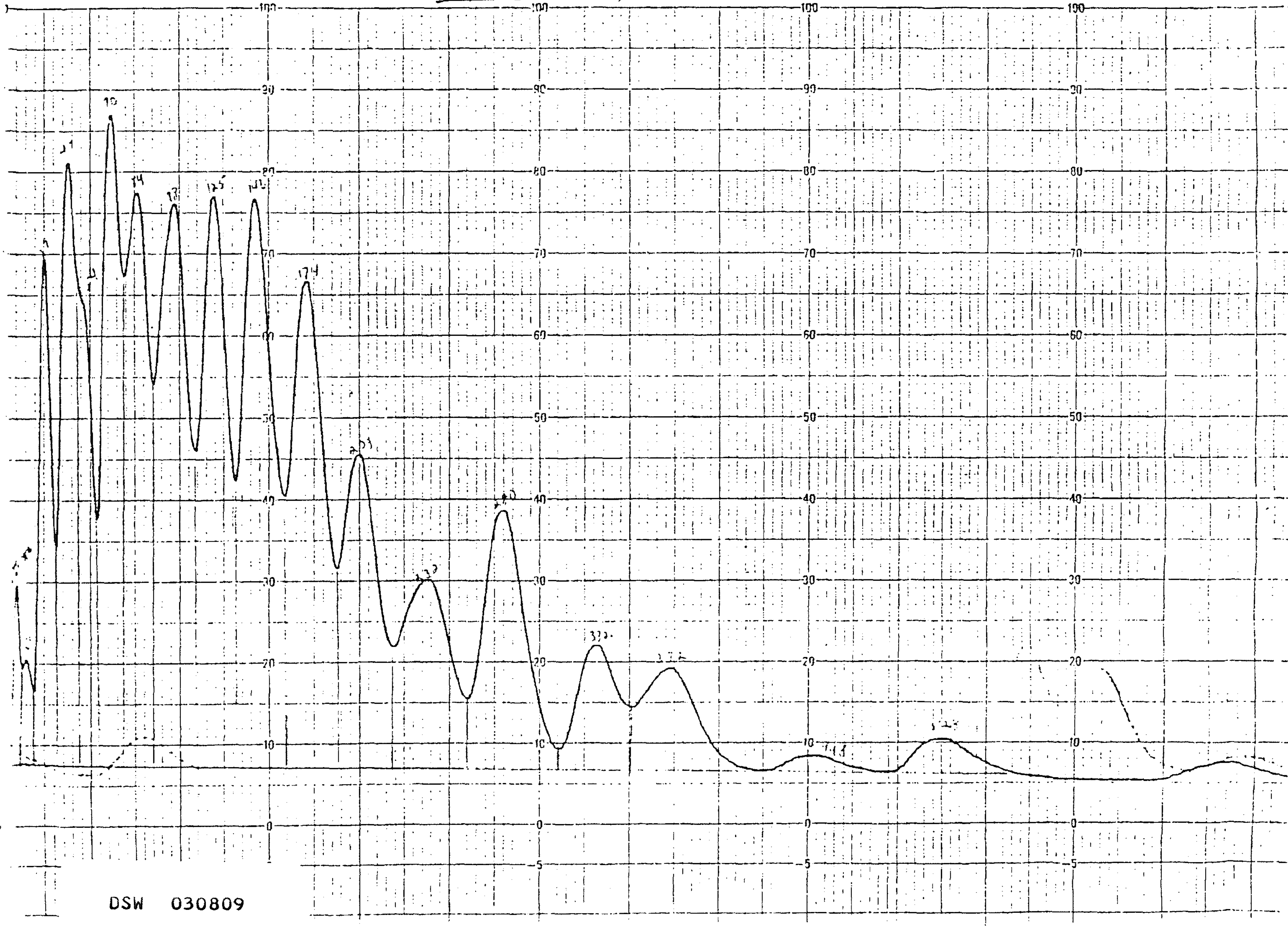
NOTROPIS SP, STATION 2, WINTER COLLECTION





DSW 030808

Notropis sp., STATION 2, SUMMER COLLECTION



DSW 030809

STLCOPCB4014771

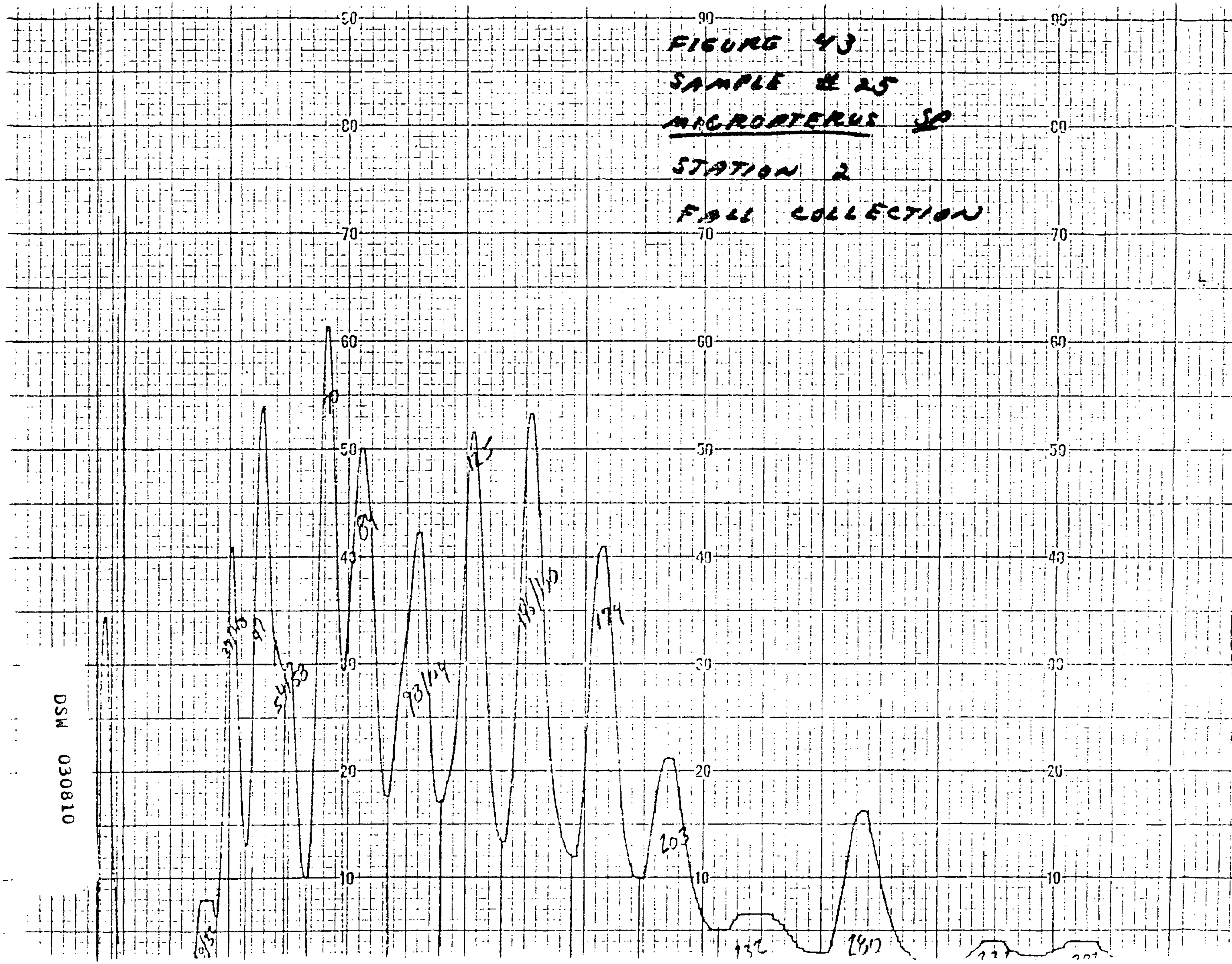
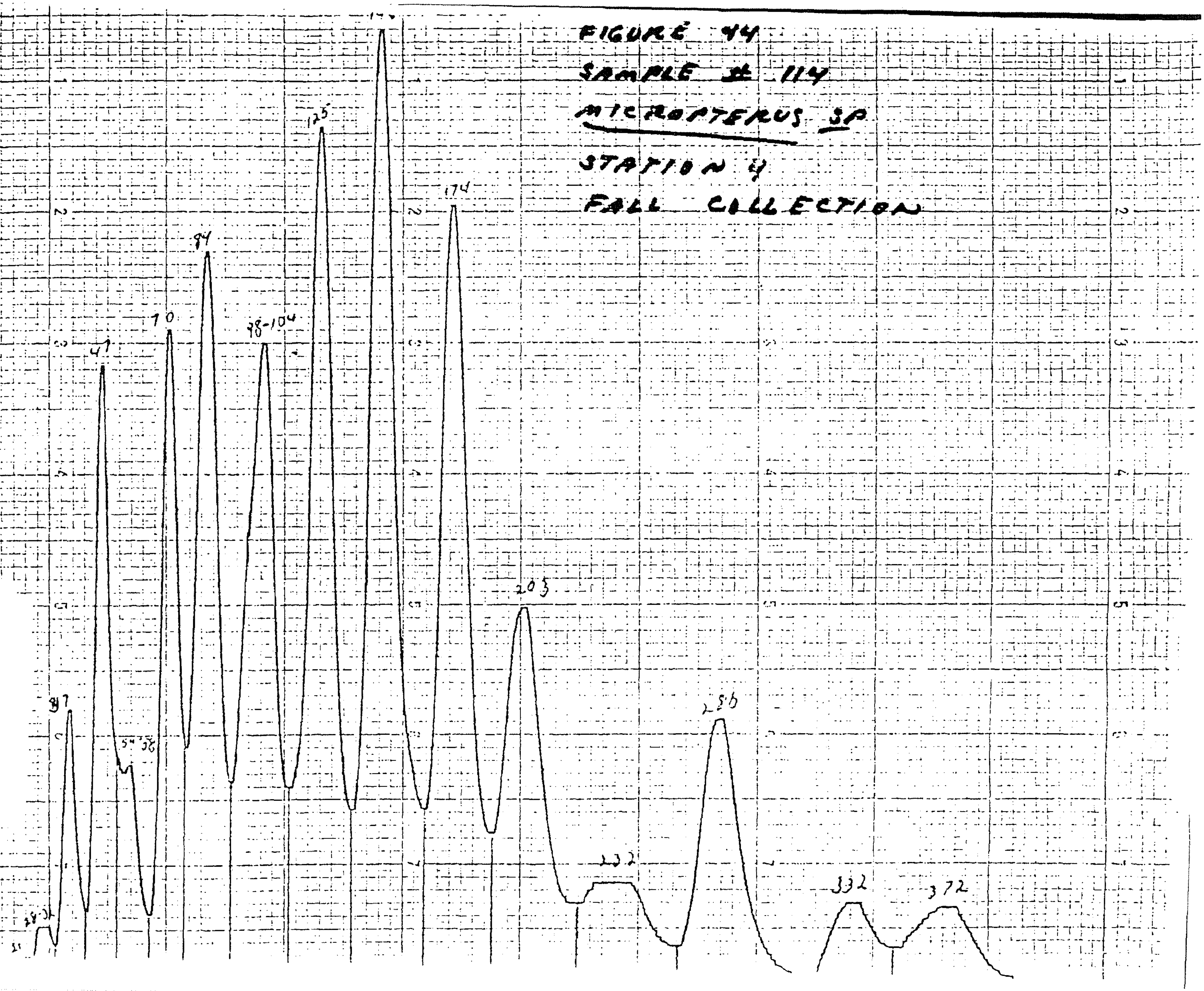


FIGURE 43
SAMPLE # 25
MICROPTERUS SP
STATION 2
FALL COLLECTION
10
20
30
40
50
60
70
80
90
203
174
132
180



DSW 030811

STLCOPCB4014773

IV. DISCUSSION

This ~~paper~~ 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 once highly contaminated stream; to determine whether the reservoir 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 food gathering 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 were first summarized. The summary of the data presented in the Anova Tables (Tables 10-12) shows that there are certain main effects 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 these relation-

DSW 030812

STLCOPCB4014774

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, 1972). 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 were ~~was~~ analyzed on a species per station basis. In THOSE SIGNIFICANT ~~many~~ cases the linear fit became much closer, however, there were many which showed no 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 were ~~was~~ broken down again to the species per station per season level and the linear analyses were ~~was~~, again performed. The linear fit of the significant cases AGAIN became closer, however, 50% of the cases were not significantly correlated.

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

DSW 030815

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 it's distribution in this system, i.e. fish from areas of high clay content (Stations 4 and 6) do not have higher PCB concentrations than those from areas of lower clay content (Station 2). Regardless of the sediment type, areas of such confined 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 mediated from the sediment to the fish? Is it mainly 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 Anova Tables (Tables 10-12) show that there are significant differences in species concentration at Stations 2 and 4, and the differences are evident when comparing all species at the other stations in the histograms (Figures 8-11 and 14-[illegible]).

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 detritavores, 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):

detritivore → tertiary carnivore
→ 1st carnivore
omnivore
planktivore

DSW 030817

The detritavore 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 dis 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
Campostoma
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.

DSW 030818

for thelipid 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 *Campostoma* while both accumulate similar levels of PCB, and the variation in lipid content of the other fish (*Campostoma* 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 identicle 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 spacial 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 detritavores 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 _Dorosoma_ (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.

DSW 030820

APPENDIX A

PCB RESIDUE LEVELS OF ALL SAMPLES

DSW 030821

KEY FOR THE TABLES

Fish Nomenclature

C. anomalum	Campostoma anomalum	stoneroller
D. cepedianum	Dorosoma cepedianum	gizzard shad
G. affinis	Gambusia affinis	mosquito fish
H. etowanum	Hypentelium etowanum	hog sucker
L. sp.	Lepomis sp.	sunfish
M. sp.	Micropterus sp.	bass
N. crysoleucas	Notemigonus crysoleucas	golden shiner
N. stilbius	Notropis stilbius	silverstripe shiner
N. texanus	Notropis texanus	weed shiner
N. venustus	Notropis venustus	blacktail shiner
P. caprodes	Percina caprodes	log perch
P. nigrofaciata	Percina nigrofacita	blackbanded darter
Phenacobius sp.		minnows
Pimephales sp.		minnows
Roccus chrysops		white bass

LOCATION OF THE STATIONS

Station 1: Choccolocco Creek, Highway 9 Bridge crossing. (control)
Station 2: Choccolocco Creek, Highway 109 Bridge crossing .
Station 3: Cheeha Creek, Highway 109 Bridge crossing. (control)
Station 4: Choccolocco Creek, Highway 77 Bride crossing.
Station 5: Coosa River, Highway 72 Bridge crossing. (control)
Station 6: Coosa River; Stemley Bridge, Logan Martin Reservoir.
Station 7: Logan Martin Reservoir, above Logan Martin Dam.
Station 8: Logan Martin Reservoir, below Logan Martin Dam
Station 9: choccolocco 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.

DSW 030822

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	DCS
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	.8881	.0852	.0956	.0149	.1958	x
28	" "	1.0183	.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. coosae	6.7548	.0814	.1969	.0189	.2972	x
56	M. punctulatus	8.6031	.5527	1.6982	.0145	2.2655	x
54	" "	11.8104	.0169	.0272	.0007	.0449	x
55	" "	12.9858	.0171	.1705	.0049	.1925	x
66	H. etowanum	2.8984	.4163	.1044	.0100	.5309	x
67	" "	4.5829	.0030	.0343	.0025	.0399	x
59	" "	6.4714	.0437	.1016	.0104	.1558	
68	" "	7.4993	.0154	.0753	.0084	.0992	x
71	N. venustus	.3360	.0096	.0561	.0256	.0913	x
72	" "	.4687	.0185	.0926	.0301	.1414	x
70	" "	.8303	.0128	.0799	.0037	.0965	x
69	" "	1.5131	.0032	.1299	.0098	.1431	x
75	P. nigrofasciata	.6247	.0236	.1685	.8734	1.0657	x
74	" "	.8814	.0239	.0474	.0280	.0994	x
73	" "	2.9405	.0201	.2250	.0858	.3310	x
52	P. caprodes	4.2306	.0633	.0848	.0041	.1523	x
53	G. affinis	.4885	.1098	.0779	.0003	.1881	x

Table 2
Winter 1/16/78
Station 1

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
175	H. etowanum	.4980	.1201	.2415	.0909	.4526	x
170	" "	1.5400	1.4968	1.2519	.5286	3.2774	
173	" "	1.9776	.0735	.0977	.0226	.1940	x
172	" "	2.5081	.1505	.1548	.0826	.3869	x
171	" "	3.4266	.0050	.0320	.0130	.0502	x
167	L. macrochirus	.2242					
168	" "	.4187	.0196	.0675	.0010	.0884	x
169	" "	.5449	.1633	.6067	.1190	.8891	
176	N. venustus	.1047	.1975	.2003	.0436	.4415	
175	" "	.4980	.1201	.2415	.0909	.4526	
174	" "	2.1670	.6813	.5436	.9460	1.7224	
166	M. punctulatus	11.46	1.7163	6.5870	1.9478	10.2513	

Table 3
Spring 4/14/78
Station 1

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
288	L. macrochirus	.3541	.0800	.1083	.0406	.1919	x
293	L. megalotis	.4141	.0525	.1902	.0660	.3088	x
289	L. macrochirus	.5613	.0632	.3325	.0503	.4462	x
294	L. megalotis	.6840	.0308	.1022	.0475	.1805	x
290	L.macrochirus	.7295	.0477	.1931	.0426	.2836	
291	" "	1.0221	.1655	.7499	.0750	.9905	
284	L. sp.	1.2862	.0375	.1648	.0464	.2488	x
292	L. macrochirus	1.3543	.0357	.1351	.0375	.2584	
285	L. sp.	1.4896	.0220	.2016	.0577	.2814	
286	" "	1.7472	.0253	.1078	.0223	.1555	x
287	" "	2.5488	.0372	.0760	.0055	.1184	x
271	N. venustus	.3190	.0406	.2317	.0570	.3293	x
272	" "	.6433	.0794	.4023	.1297	.6116	
273	" "	.9673	.0755	.1532	.0454	.2742	x
274	" "	1.8291	.0592	.1535	.0411	.2539	x
277	N. texanus	1.2935	.0793	.1802	.0514	.3210	x
276	" "	3.5472	.0470	.2180	.0905	.3559	x
275	N. venustus	3.9985	.0517	.2732	.0355	.4106	x

DSW 030824

Table 3 (continued)

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
278	G. affinis	.3016	.0282	.1638	.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 8/3/78
Station 1

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
524	G. affinis	.4732	.0537	.2234	.0684	.3455	x
523	" "	.5721	0625	.1659	.0406	.2691	x
522	" "	.7652	.0460	.1296	.0391	.2147	
521	" "	1.1721	.0385	.1240	.0386	.2012	x
513	N. stilbius	.4348	.1694	.3835	.0811	.6341	x
517	" "	1.8439	.1055	.3047	.0856	.4960	x
514	N. venustus	2.1783	.1382	.3650	.0793	.5826	x
518	N. stilbius	2.4117	.0316	.1343	.0840	.2499	x
515	N. venustus	6.0994	.0672	.2168	.0786	.3626	x
516	" "	8.8915	.7235	1.1080	.2595	2.0911	x
509	H. etowanum	--					
510	" "	1.0752	.0685	.2753	.0000	.3551	x
511	" "	1.6862	.0490	.2486	.0570	.3542	x
529	L. macrochirus	1.6672	.0233	.1073	.0308	.1615	x
528	" "	3.0578	.0210	.1693	.0355	.2260	x
527	" "	4.5279	.1181	.1701	.0391	.3273	x
520	M. punctulatus	1.5488	.0465	.3350	.0761	.4578	x
519	M. coosae	1.7708	.0764	.2498	.0734	.3998	x
508	Phenacobius sp.		.1766	.3970	.0765	.6501	

DSW 030825

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	1.5057	25.5510
243	" "	25.3639	6.7508	6.9504	3.4567	17.1581
244	L. megalotis	30.6782	9.1720	6.3023	1.8793	17.3537
246	" "	35.9327	9.5508	6.8926	2.2884	18.7319
25	M. coosae	6.0728	25.3959	27.5447	3.1036	56.3300
245	" "	19.3908	11.7530	10.9691	5.5532	28.2754
76	G. affinis	2.3741	22.3513	24.9336	1.6235	51.6610
79	C. anomalum	2.0577	58.4825	29.7584	7.3000	95.5410
80	" "	3.0577	50.6953	23.9907	3.8572	78.5020
78	" "	5.9165	49.6289	24.2808	.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	21.3318	1.3897	40.5730
85	" "	.4937	20.7956	20.6274	1.4621	42.8971
81	" "	.6964	63.7489	30.4316	3.9856	98.1767
82	" "	1.1029	5.3523	5.1289	.4984	10.9797

Table 6
Winter 1/16/78
Station 2

Sample Number	Species	Average Weight	1242	1254	1260	Total
183	N. venustus	.4879	9.2744	7.8145	1.5259	18.6199
182	" "	.7839	16.7666	15.2037	4.2783	36.2487
181	" "	1.4906	17.2427	16.2598	5.9139	39.4166
180	" "	2.5873	17.9524	15.9606	4.7594	39.2653
179	" "	3.0069	11.8716	10.6885	4.5554	27.3157
178	" "	4.5071	12.2032	11.7625	7.1459	31.1118
177	" "	9.9587	15.9476	14.1560	6.1547	36.2885
184	M. punctulatus	6.1064	19.1496	16.1953	6.8041	42.1491
187	L. megalotis	1.7415	15.8824	13.9744	3.7511	33.6252
186	" "	2.4118	15.2825	15.3498	4.1573	37.7897
185	" "	3.7003	6.3054	6.4746	3.8782	16.6583
190	" "	9.3054	10.7388	11.5852	8.3639	30.6880
191	" "	10.1466	13.5570	12.5037	7.5076	33.5684
193	" "	11.9637	8.5603	10.2239	10.1305	28.9149
192	" "	14.8738	4.6448	6.8723	6.1404	17.6577
188	H. etowanum	3.2172	25.2631	22.4918	9.0760	56.8310

DSW 030826

Table 7
Spring 4/14/78
Station 2

Sample Number	Species	Average Weight	1242	1254	1260	Total
295	C. anomalum	6.2150	21.9168	18.6765	6.3407	46.9342
296	G. 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. chysocephalus	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	2.0692	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
491	Phenacobius sp.	.5723	17.3131	13.0177	3.9533	34.2843
490	" "	.8847	22.0199	15.3359	5.0202	42.3762
489	" "	1.0193	24.4709	15.4620	4.4207	44.3537
488	" "	1.4740	17.9782	12.2482	3.5081	33.7345
487	" "	1.7675	18.9130	12.9184	3.3914	33.2229
406	N. stilbius	.9782	14.1781	13.8547	5.0464	33.0792
405	" "	1.1843	14.6008	12.8022	6.4638	33.8665
403	" "	1.4902	21.3398	24.4323	9.5856	55.3608
404	" "	1.4945	17.4077	18.2987	8.2092	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

DSW 030827

Table 8 (continued)

Sample Number	Species	Average Weight	1242	1254	1260	Total
498	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	8.8563	9.5920	7.2379	2.7069	19.5370
506	" "	11.3385	8.0930	7.1229	3.1280	18.3445
497	" "	13.3494	14.2405	9.9947	3.2678	27.5032
549	L. macrochirus	23.1021	7.8549	6.7656	2.2593	16.8798
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	13.2396
548	L. macrochirus	46.8784	10.2453	8.0663	3.4511	21.7628
501	G. affinis	.2270	4.5827	4.0006	.5993	9.1827
499	" "	.7127	14.1007	12.5373	2.6769	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 10/5/77
Station 3

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
95	N. sp.	1.2632	1.2064	2.6538	.3069	4.1672	
93	" "	2.0157	.4861	2.5927	.3807	3.4590	
94	" "	2.0683	.2776	1.8724	.2265	2.3770	
92	" "	2.5253	.2397	1.0488	.1368	1.4253	x
91	" "	4.4294	.2875	1.1371	.1685	1.5933	x
89	L. cyanellus	2.7989	.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	.1167	1.3172	
87	L. macrochirus	10.5992	.1827	.5082	.4328	1.1238	
42	H. etowanum	1.8347	.1112	.2590	.1020	.4720	
41	H. etowanum	3.9677	.0548	.2502	.1179	.4220	
86	G. affinis	.2082	1.3330	1.9105	.1318	3.3760	
40	" "	.3089	.0592	.2937	.0458	.3990	
37	M. coosae	2.2832	.0352	.2850	.0299	.3501	
36	" "	4.9678	.0000	.0000	.0000	.0000	all

DSW 030828

Table 9 (continued)

Sample Number	Species	Average Weight	1242	1254	1260	Total
38	P. nigrofaciata	2.8013	2.3560	7.6063	.9959	10.9560
22	" "	3.4142	.0040	.3403	.0402	.4132
39	" "	4.6897	.7104	4.4427	.6407	4.6897
98	C. anomalum	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
96	" "	11.2848	.0470	.4221	.0257	.4950
102	" "	14.1099	.9091	2.0795	.3143	3.1632

Table 10
Winter 1/16/78
Station 3

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
202	H. etowanum	2.9003	.0336	.0832	.0226	.1390	x
203	" "	3.0511	.0117	.1184	.0553	.1855	x
201	" "	5.6232	.0296	.0657	.1628	.1420	x
200	" "	7.9479	.0289	.1285	.0199	.1774	x
199	" "	10.2373	.0947	.2586	.1230	.4764	x
198	" "	19.0121	.0287	.1753	.0357	.2374	x
197	L. megalotis	2.3470	.5936	.4814	.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
194	N. venustus	.4241	.4094	1.1603	.4526	2.0225	

DSW 030829

Table 11
Spring 4/14/78
Station 3

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
325	N. texanus	1.7199	.3256	1.3664	.5551	2.2675	
324	" "	2.0627	1.2005	3.4823	1.1332	5.8162	
316	N. stilbius	2.3725	.5086	2.1819	.7252	3.4158	
323	N. texanus	2.4045	.2679	1.8780	.5486	2.6945	
322	" "	3.7161	.3149	1.1369	.2927	1.7466	
321	N. stilbius	3.7572	.3609	1.0975	.3193	3.0607	
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. coosae	6.2905	.1490	1.1311	.6347	1.9144	
319	P. nigrofaciata	1.2640	.1918	.7353	.3606	1.2879	
314	C. anomalum	2.7370	.0843	.6033	.1989	.8867	
315	" "	3.6318	.2991	1.3250	.4824	2.1066	
313	" "	4.2492	.0701	.3263	.2276	.6241	
311	" "	5.6567	.0407	.2298	.0454	.3160	
312	" "	7.9287	.2333	.4251	.1850	.8435	
375	" "	20.4925	.1319	.3571	.0701	.5593	x

DSW 030830

STLCOPCB4014792

Table 12
Fall 10/5/77
Station 4

Sample Number	Species	Average Weight	1242	1254	1260	Total
104	L. macrochirus	2.1966	5.1918	6.1254	.8075	11.9546
105	" "	2.9817	6.5909	6.8006	.7253	14.1610
106	" "	3.9124	4.4537	4.2965	.5768	9.3355
27	" "	4.8491	4.5163	5.9431	.6307	11.0450
117	L. megalotis	4.8733	2.1854	1.8647	.1751	4.2250
119	" "	6.3104	3.0310	3.5681	.2401	7.4393
120	" "	7.5744	4.6382	4.5078	.6782	9,8243
103	L. macrochirus	8.7304	4.2434	4.7139	.5674	9.5251
122	L. megalotis	11.4249	5.0564	3.6657	.4783	9.2005
123	" "	13.7299	7.1843	7.6212	1.4303	16.2363
118	" "	14.1414	6.2773	9.8294	1.5818	17.6886
124	" "	14.8035	5.2245	7.3884	1.3774	13.9904
26	N. crysoleucas.	8.0749	1.2870	2.3322	.3340	3.9640
116	" "	8.4581	1.3788	2.2531	1.1658	4.8178
108	D. cepedianum	9.7876	9.9501	14.2582	2.9272	27.1362
109	" "	10.0011	14.2057	17.7011	3.3103	34.9803
107	" "	11.3999	7.6043	9.3656	3.1472	20.1200
111	P. caprodes	1.9752	6.4980	8.6546	1.4839	16.6466
110	" "	3.5613	12.8138	17.2362	1.9852	25.7790
112	M. punctatus	4.4563	5.8770	7.6528	1.0099	14.5702
113	" "	5.4304	8.4165	13.7677	2.1963	24.3800
114	" "	8.6202	6.0582	9.8792	1.4042	17.3417
115	" "	10.4935	3.1286	8.8247	1.8395	13.7923

DSW 030831

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	1.8760	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	3.4883	1.9391	6.7639
214	L.megalotis	1.8308	2.3300	4.3828	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	16.2020
250	" "	49.6747	6.2332	7.6711	3.0846	16.9891
249	L. macrochirus	64.3015	3.1502	4.0404	1.5112	8.7019
211	D. cepedianum	7.3837	4.7863	6.2385	4.1031	15.1279
210	" "	7.5341	6.2821	6.6265	3.7603	16.6690
209	" "	10.1191	2.6004	2.9532	.7361	6.2398
247	" "	34.1144	7.6749	10.2486	7.4723	25.3959
219	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	5.9581	4.2051	11.5585
333	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	5.0844	12.3239	7.3262	24.7345
330	" "	4.8537	2.6229	5.3414	2.5082	10.5021
328	" "	10.5141	1.3624	4.9490	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

DSW 030832

STLCOPCB4014794

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	6.4903
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	1.6573	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	.9608	2.9645	1.0793	5.0047
447	" "	.5133	1.3356	3.2366	1.3057	5.8780
435	L. cyanellus	.7155	1.8776	5.7723	2.4993	10.1493
442	L.macrochirus	.7596	1.5578	4.7164	1.7223	7.9987
445	L. microlophus	.8277	2.3773	3.8517	1.4975	7.7266
443	" "	.8332	3.3934	9.2246	3.9806	16.5987
444	L. marginatus	1.0067	2.2563	3.5281	1.0428	6.8273
436	L. cyanellus	1.0406	1.3977	4.5257	1.5519	7.4754
440	L. macrochirus	1.0985	2.7614	7.5557	2.6681	12.9853
431	L. cyanellus	2.2295	1.8219	7.5876	4.6134	14.0231
434	" "	3.1657	3.0221	5.9722	2.2236	11.2427
433	" "	3.9559	10.9560	21.2096	8.3046	40.4707
432	" "	8.7307	3.5268	6.8905	4.0644	14.4820
438	L. megalotis	10.9361	4.0612	7.4943	3.9423	15.4978
439	" "	10. 9998	3.9904	7.1512	3.3818	14.5236
437	" "	11.8181	4.3049	7.3076	3.5538	15.1663

DSW 030833

Table 16
Fall 10/5/77
Station 5

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
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	.9866	x
129	L. microlophus	5.9076	.2684	1.3913	.1339	1.7937	
143	L. macrochirus	11.4299	.1082	1.3019	.1740	1.5819	
137	Pimephales sp.	.1348	.1390	1.1514	.0587	2.5217	
133	" "	.1952	.1244	.9428	.0378	1.1362	x
136	" "	.9168	.2438	1.5606	.0642	1.8689	
139	" "	2.1683	.1857	1.6201	.0908	1.8967	
134	" "	2.2174	.1738	1.2474	.0689	1.4904	x
138	" "	2.3221	.3382	1.9543	,1055	2.3982	
135	" "	2.4670	.3901	2.9067	.1771	3.4742	
132	" "	2.8145	.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. crysoleucas	1.5495	.1474	.2065	.0886	.6530	
140	N. venustus	1.4312	.1557	1.8596	.3045	2.3201	
130	M. punctulatus	5.0548	.1245	2.0584	.3598	2.5370	
33	P. caprodes	12.1416	.4592	2.1071	.0977	2.6640	x

DSW 030834

STLCOPCB4014796

Table 17
Winter 1/16/78
Station 5

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
227	L. macrochirus	.3950	.0032	.0430	.0060	.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	.3692	1.9701	
256	Roccus chrysops	40.7712	.3851	3.0676	.8420	4.2948	

DSW 030835

Table 18
Spring 4/14/78
Station 5

Sample Number	Species	Average Weight	1242	1254	1260	Total	DDE
350	M. punctulatus	5.7950	.0520	.6282	.0972	.7775	
351	M. coosae	12.6882	.1355	1.7023	.3807	2.2185	
378	" "	35.5847	.3345	2.9622	.5359	3.8329	
352	D. cepedianum	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	1.0482	
359	" "	2.6700	.1144	.7775	.1449	1.0369	
368	L. marginatus	2.8486	.0510	.8678	.1206	1.0395	
362	L.symmetricus	3.0063	.0559	.7594	.0707	.8862	
369	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	.7949	.0562	.8854	
365	" "	5.8246	.0675	1.2764	.0824	1.4264	
364	" "	7.1031	.0319	.6367	.0580	.7285	
354	L. macrochirus	7.9334	.1713	2.9654	.3105	3.4473	
353	" "	9.5764	.0493	1.0757	.2538	1.3768	
355	L. megalotis	11.8463	.0913	1.9712	.1176	2.1802	
377	" "	20.2348	.1379	.9[illegible]71	.1301	1.2570	
356	N. venustus	3.7516	.4955	3.6658	.6533	4.8145	

DSW 030836

STLCOPCB4014798

Table 19
Summer 8/3/78
Station 5

Sample Number	Species	Average Weight	.1242	1254	1260	Total	DDE
412	M. punctulatus	1.7578	.1004	.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	.1264	.8164	
407	M. salmoides	11.0998	.0812	3.4234	.1612	3.6658	
423	D. cepedianum	.3889	--	--	--	--	
418	" "	2.2079	--	--	--	--	
420	" "	3.4010	.1864	.8107	.1934	1.1907	
421	" "	3.7027	.2506	1.0808	.1482	1.4798	
422	" "	4.7950	.1352	.5659	.0462	.7470	x
405	L. macrochirus	.4697	.1165	.5019	.1051	.7236	
402	" "	.6123	.0707	.7436	.1514	.9658	
404	" "	.7680	.0844	.4564	.0690	.6090	
409	" "	1.0464	.0862	.5786	.0870	.7519	
403	L. microlophus	1.8527	.1560	1.3139	.1538	1.6238	
413	L. macrochirus	7.8234	.1333	.9661	.1227	1.2222	
417	L. megalotis	8.3556	.2794	1.9357	.1024	2.3176	
415	L. macrochirus	10.7245	.0614	.5981	.1008	.7306	
416	" "	13.0248	.0337	.2189	.0327	.2345	
414	Pimephales sp.	.5221	.1470	.4430	.1547	1.3907	
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	N. venustus	1.3038	.3632	1.8260	.2473	2.4430
21	Pimephales sp.	2.7464	.3780	1.6336	.1268	2.1380
156	L. megalotis	3.4635	.5864	1.9760	.3031	2.8656
46	L.macrochirus	4.1023	.7046	2.0330	.1627	2.9010
154	L. megalotis	5.1669	.4553	1.3305	.1034	1.8894
153	" "	6.3954	.0943	.1901	.1508	.4351
45	L. macrochirus	7.6449	1.3462	3.7866	.3517	6.6120
152	L. megalotis	7.9668	.3733	1.0065	.0136	1.3935
151	" "	8.5118	.8706	4.4782	.6314	5.9803
155	" "	10.3570	1.4133	5.0628	.8074	7.2835
44	L. macrochirus	11.6280	.8672	2.1590	.2019	3.8260
260	L. megalotis	18.5557	.9768	2.4140	.3456	3.7366
262	" "	12.2170	1.2498	3.6983	.5579	5.5061
261	" "	14.7443	1.3533	3.9384	.6429	5.9347
263	D. cepedianum	49.8427	1.4215	3.3568	.5754	5.3537
49	M. punctulatus	2.6383	.1915	2.1361	.0700	2.3980
51	" "	3.1859	1591	2.4943	.1120	2.7660
48	" "	4.0227	.3700	2.6885	.1622	3.2210
50	" "	4.1467	.2397	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	M. punctulatus	4.0055	.5521	5.3455	2.0333	7.9320
346	L. marginatus	6.3393	.4808	2.0636	.5433	3.0878
345	L. magalotis	7.2954	1.1566	4.6850	1.1185	6.9602
343	L. marginatus	8.0027	.4532	3.3495	1.0755	4.8782

DSW 030838

Table 22
Summer 8/3/78
Station 6

Sample Number	Species	Average Weight	1242	1254	1260	Total
485	L. macrochirus	1.1801	.3635	1.3205	.2318	1.9551
484	" "	1.8603	.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	2.6885
481	" "	5.1142	1.6983	4.5905	.7069	6.9958
468	L. marginatus	12.5237	1.0508	4.0314	.9798	6.0621
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	2.8894	7.7380	3.1994	13.8268
541	L. marginatus	59.6801	1.5859	3.3056	.5176	5.4092
542	L. sp.	99.6445	.7645	2.8573	.3375	3.9595
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	" "	19.8608	.7796	2.1851	.5641	3.5288
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. puntulatus	1.3463	1.0318	4.1133	.3109	5.4550
163	" "	2.5153	.3365	1.5306	.2180	2.0852
162	" "	3.6025	.4535	1.5513	.2767	2.2821
160	" "	3.7813	.3239	1.3692	.1354	1.8285
161	" "	4.9055	.2267	.8316	.1538	1.2122
159	" "	5.7406	.4372	1.4710	.1301	2.0384
158	" "	6.5518	.2158	.9001	.0986	1.2146
157	" "	8.9292	.1205	.8616	.3188	1.3009
35	L. megalotis	17.9248	.4066	1.0550	.0369	1.4990
256	" "	22.8666	.6484	2.6942	.4842	3.8269

Table 24
Winter 1/16/78
Station 7

Sample Number	Species	Average Weight	1242	1254	1260	Total
234	M. punctulatus	2.4159	.1296	.9512	.1698	1.2516
237	D. cepedianum	5.4146	.6942	2.3988	.1371	3.2404
236	" "	6.3366	1884	1.7394	.3547	2.2826
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. microlepus	9.1583	.2108	2.1831	.8514
337	L. cyanellus	16.3996	.1364	.3740	.1748
342	M. punctulatus	2.9953	.2790	1.5152	.4293
343	" "	3.0968	.1982	1.3357	.2851
341	" "	4.0181	.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

DSW 030840

Table 26
Summer 8/3/78
Station 7

Sample Weight	Species	Average Weight	1242	1254	1260	Total
465	M. punctulatus	1.6676	.1973	1.5275	.0993	1.8242
464	" "	2.0490	.1570	.5894	.2026	.9491
463	" "	2.7576	.3307	.6605	.1054	1.0967
462	" "	2.9852	.2334	.9309	.1735	1.3344
466	M. salmoides	3.2986	.1296	.5034	.0947	.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	.9445
457	L. macrochirus	8.9947	.2453	.5715	.0747	.8916
455	" "	10.9957	.5855	1.3924	.2100	2.1818
450	L. megalotis	11.0062	.3386	.9235	.0955	1.3577
452	L. marginatus	13.4303	.3415	.7062	.0772	1.1251
454	L. macrochirus	14.0807	.5471	1.3796	.2559	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	.8311	.2508	1.3856
532	L. microlophus	20.3233	.8698	1.7808	.4240	3.0638
531	L. cyanellus	23.5956	.5487	1.1421	.1783	1.8691
536	L. megalotis	27.0635	.1905	.5548	.1095	.8548
538	" "	30.3060	.9314	3.1851	.4699	4.5864
534	L. marginatus	31.3732	.7744	2.2126	.2969	3.2839
530	L. cyanellus	38.7443	.2609	1.1279	.2273	1.6162
535	L. macrochirus	40.4944	.7329	3.4829	.9527	5.1682
533	L. microlophus	65.1710	.0857	1.0098	.4204	1.5159

DSW 030841

Table 27
Fall 10/5/77
Station 8

Sample Number	Species	Average Weight	1242	1254	1260	Total
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

Sample Number	Species	Average Weight	1242	1254	1260	Total
239	D. cepedianum	4.4264	.2669	3.5429	.2741	4.0840
240	" "	4.8650	.7836	2.5282	.3856	3.6974
241	" "	6.2158	5.4625	5.2241	1.0417	11.7285

DSW 030842

Table 29
Spring 4/14/78
Station 8

Sample Number	Species	Average Weight	1242	1254	1260	Total
372	N. chysocephalus	12.8246	.1739	.5525	.0930	.8194
371	M. punctulatus	10.7783	.3537	2.2684	.5196	3.1418
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	.2820	1.6993
398	" "	3.9332	.6463	1.5445	.3206	2.5134
397	" "	4.4987	.9553	3.2201	.7593	4.9349
400	" "	5.2860	.1114	1.3934	.5035	2.0134
397	M. salmoides	5.8758	.2975	2.2362	.6755	3.2093
395	N. chysocephalus	7.5952	.2716	1.5315	.4186	2.2218
401	Roccus chrysops	12.0549	.0985	.4553	.0809	.6365
558	" "	20.9416	.2426	1.3706	.2578	1.8712

DSW 030843

STLCOPCB4014805

Table 31
Summer 8/3/78
Station 9

Sample Number	Species	Average Weight	1242	1254	1260	Total
390	N. stilblus	.3753	4.4734	8.5907	3.5738	16.6379
384	" "	2.5037	5.9270	13.9479	4.1800	24.0549
386	" "	3.7144	2.8695	5.6708	2.8450	11.3854
380	N. venustus	4.2972	8.7061	9.1920	3.4903	21.4094
388	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	14.8725	72.4554

DSW 030844

APPENDIX B.

CAPSULATION OF THE BENTHOS FIELD DATA

DSW 030845

Table 32

Capsulation of Current Benthos Information

Benthos Data*

Sampling Station	Species	Period	Concentration of PCBs (ppm) Total	1242	1254	1260
1	Corbricula sp. (bivalve musk)	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	Sphaeridae sp. (native clam)	Winter of 1977	1.95	1.10	0.68	0.17
5A	Corbricula sp.	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	Anodonta Imbicillis (native mussel)	Fall 1977	0.25 (0.12)	0.09 (0.11)	0.14 (0.02)	0.019 (0.016)
6	Corbricula sp.	Winter of 1977	7.97 (2.41)	1.99 (0.71)	5.40 (1.85)	0.55 (0.23)
6	Anodonta Imbicillis	Winter 1977	2.17 (1.19)	1.08 (1.08)	1.05 (0.14)	0.05 (0.02)

*(   ) = One Standard Deviation

DSW 030846

APPENDIX C

AVERAGE PCB CONCENTRATION

OF EACH GENUS

ON A STATION PER SEASON BASIS

DSW 030847

STLCOPCB4014809

	A1242	A1254	A1260	Total PCB
Campostoma				
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
Dorosoma				
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
Gambusia				
Station 1				
fall	0.10	0.07	0.09	0.18
spring	0.05	0.22	0.06	0.35
summer	0.05	0.16	0.04	0.25

DSW 030848

	A1242	A1254	A1260	Total PCB
Gambusia				
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
Hypentelium				
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
Lepomis				
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	0.69	9.32
summer	9.45	8.14	3.46	20.89

DSW 030849

	A1242	A1254	A1260	Total PCB
Lepomis				
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	0.91	4.97
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
Micropterus				
Station 1				
fall	0.15	0.44	0.00	0.61
winter	1.71	6.58	1.94	10.25
summer	0.06	0.29	0.07	0.42

DSW 030850

	A1242	A1254	A1260	Total PCB
Micropterus				
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	3.81	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
Notropis				
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

	A1242	A1254	A1260	Total PCB
Notropis				
Station 2				
fall	14.66	19.39	5.63	48.15
winter	14.46	13.15	4.90	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	3.52	18.37

DSW 030852

BIBLIOGRAPHY

Anonymous, "PCB Degradation", Mar. Poll. Bull., Vol. 7, no. 5, 1976.

Anonymous, "U.S. Water Pollution Standards for PCB's: PCB's in the Hudson River", Mar. Poll. Bull., Vol. 7, no. 11, 1976.

Bache, C.A., "Polychlorinated Biphenyl Residues: Accumulation in Cayuga Lake Trout with Age", Sci., Vol. 177, 1972.

Ballschmiter, K., Zell, M. and Neu, H.J., "Persistance of PCB's in the Ecosphere: Will Some PCB Components "Never" Degrade?", Chemosphere, No.2, 1978.

Bidleman, T.F., "Chlorinated Hydrocarbons in the Sargasso Sea, Atmosphere and Surface Water", Sci., Vol. 183, 1974.

Boyle, R.H., "Poisoned Fish, Troubled Waters (PCB's in Rivers and Lakes)", Sports Ill., Sept. 1, 1975.

Boyle, R.H., " The Spreading Menace of PCB", Sports Ill., Dec. 1, 1975.

Bunce, N.J. and Kumar, Y., "An Assessment of the Impact of Solar Degradation of PCB's in the Aquatic Environment", Chemosphere, No. 2, 1978.

Burdick, G.E., "The Accumulation of DDT in Lake Trout and the Effect on Reproduction", Trans Am. Fish. Soc., Vol. 93, no. 2, 1964.

Carlander, K.D., " Handbook of Freshwater Fishery Biology", Vol. 1, Iowa State University Press, Ames, Iowa, 1969.

Carlander, K.D., "Handbook of Freshwater Fishery Biology", Vol. 2, Iowa State University Press, Ames, Iowa, 1977.

Chau, A.S.Y. and Sampson, R.C.J., "Electron Capture Gas Chromatographic Methodology for Quantitation of PCB's. Survey and Compromise", Envirn. Letters, Vol. 8, no. 2, 1975.

Chen,

Chiou, T. Cary, "Partition Coefficient and Bioaccumulation", Envir. Sci. and Tech., Vol. 11, no. 5, 1977.

DSW 030853

Choi, W.W. and Chen, K.Y.,"Associations of Chlorinated Hydrocarbons with Fine Particles and Humic Substances in Nearshore Surficial Sediments", Environ. Sci. and Tech., Vol. 10, no. 80, 1976.

Cooley, N.R., Keltner, J.M. Jr. and Forester, J.," Mirex and Aroclor 1254: Effect on and Accumulation by Tetrahymena pyriformis, Strain W", J. of Protozoology, Vol. 19, no. 4, 1972.

Cooley, N.R.,"Effects of Aroclor 1248, a PCB, on Growth of Populations of Tetrahymena pyriformis", ASB Bull., Vol. 19, no. 2, 1972.

Crump-weisner, H.J., Feltz, H.R. and Yates, M.L., "A Study of the Distribution of PCB's in the Aquatic Environment", Pest. Monit. J., Vol. 8, no. 157, 1974.

Dennis, D.S.," PCB's in the Surface Waters and Bottom Sediments of the Major Drainage Basins of the United States", Nat. Conf. on PCB's, 1975; EPA Nat. Tech. Info. Service, PB253-248.

Duke, T.W.,"A PCB (A1242) in the Water, Sediment and Biota of Escambia Bay, Fla.", Bull. Envir. Cont. and Tox., Vol. 5, 1970.

Duke, T.W. and Wilson, A.J. Jr.,"Chlorinated Hydrocarbons in Livers of Fishes from the Northeastern Pacific Ocean", Pest. Monit. Jour., Vol. 5, no. 2, 1971.

Eberhardt, L.L.,"Some Methodology for Appraising Contaminants in Aquatic Systems", J. Fish. Res. Board Can., Vol. 32, no. 10, 1975.

Ernst, W., "Residues of Chlorinated Hydrocarbons in Marine Organisms in Relation ti Size and Ecological Parameters: I. PCB, DDT and DDD in Fishes and Molluscs from the English Channel", Bull. Env. Cont. and Tox., Vol. 18, no. 1, 1976.

Federal Register,"PCB Toxic Pollutant Effluent Standards", Fed. Reg., Vol. 42, no. 22, 1977.

Fowler, S.W. and Elder, D.L.,"PCB and DDT Residues in Mediterranean Pelagic Food Chain", Bull. Env. Cont. and Tox., Vol. 19, no. 2, 1978.

Fulk, R.," Laboratory Study of the Release of Pesticide and PCB Materials to the Water Column During Dredging and Disposal Operations", Dredged Material Research Program; Contract Report Number D-75-6, 1975.

Gaffney, P.E.,"Carpet and Rug Industry Case Study I: Water and Wastewater Treatment Plant Operations", J. WPCF, Vol. 48, no. 11, 1976.

Gilman, D. and Lee, G.F.,"A Review of Chlorinated Biphenyl Contamination in Natural Waters", Water Research, Vol. 4, 1970.

Hansen, D.J. et al,"Chronic Toxicity, Uptake and Retention of Aroclor 1254 in Two Estuarine Fishes", Bull. Env. Cont. and Tox., Vol. 6, no. 2, 1971.

Hansen, D.J. et al,"Aroclor 1254 in Eggs of Sheephead Minnows: Effect on Fertilization Success and Survival of Embryos and Fry", Proceedings of the 27th Anual Conference of the Southeastern Ass. of the Game and Fish Comm., 1973.

Hansen, D.J. and Parrish, P.R. and Forester, J.,"Aroclor 1016: Toxicity to and Uptake by Estuarine Animals", Environ. Res., Vol 7, 1974a.

Hansen, D.J.,"Aroclor 1016: Toxicity to and Uptake by Estuarine Animals", Environ. Res., Vol. 7, 1974.

Hansen, D.J., Schimmel, S.C. and Matthews, E.,"Avoidance of Aroclor 1254 by Shrimp and Fishes", Bull. Env. Cont. and Tox., Vol. 12, 1974b.

Hansen, D.J.,"PCB's: Effects on and Accumulaion by Estuarine Organisms", Proceeding Nat. Conf on PCB's, 1975.

Hansen, D.J., Schimmel, C.S. and Forester, J.,"Effects of Aroclor 1016 on Embryos, Fry, Juveniles and Adults of Sheepshead Minnows (Cyprinodon variegatus)", Trans. Am. Fish. Soc., Vol. 104, no. 3, 1975.

Hansen, D.J. et al,"Effects of Dietary Aroclor 1242 on Channel Catfish (Ictalurus punctatus) and the Selective Accumulation of PCB Components", J. Res. Board Can., Vol. 33, 1976.

Haque, R. and Schnedding, D., "Studies on the Adsorbtion of Selected PCB's on Several Surfaces", J. Environ. Sci. Health, B11(2), 1976.

Harvey, G.R.,"PCB's in North Atlantic Ocean Water", Sci., Vol. 180, 1972.

Harvey, G.R. et al,"Observations on the Distribution of Chlorinated Hydrocarbons in Atlantic Ocean Organisms", J. Mar. Res., Vol. 32, no. 2, 1973.

DSW 030855

Hinz, R. and Matsumura, F.,"Comparative Metabolism of PCB Isomers by Three Species of Fish and the Rat", Bull. Environ. Cont. and Tox., Vol. 18, no. 5, 1977.

Hutzinger, O., Safe, S.,and Zitko, V.,"The Chemistry of PCB's", Cleveland CRC Press, 1974.

Iwata, Y. Westlake, W.E. and Gunther, F.A."Varying Persistence of PCB's in 6 California Soils Under Laboratory Conditions", Bull. Environ. Cont. and Tox., Vol.9, no.4, 1973.

Jensen, S.,"A New Chemical Hazard", New Sci., Vol. 32, 1966.

Kelso, J.R. and Frank, R.,"Organochlorine Residues, Mercury, Copper and Cadmium in Yellow Perch, White Bass and Smallmouth Bass, Long Point Bay, Lake Erie", Trans. Am. Fish. Soc., Vol. 3, 1974.

Khan, M.A., "Adsorption of PCB (A1254) on Shrimp", Bull. Envir. Cont. and Tox., Vol. 16, no. 4, 1976.

Lagler, K.F."Ichthyology" 2nd ed., John Wiley and Sons Inc., 1977.

Leland, H.V., Bruce, W.N. and Shimp, N.F."Chlorinated Hydrocarbon Insecticides in Sediments of Southern Lake Michigan", Environ. Sci. and Tech., Vol. 7, no. 9, 1973.

Love, R.M." The Chemical Biology of Fishes", Academic Press, NewYork, 1970.

Lowe, J.I. et al,"Effects of PCB(Aroclor 1254) on the American Oyster, Crassostrea virginica", Mar. Biol., Vol. 17, no. 3, 1972.

Mauck, W.L. and Olson, L.E.,"PCB's in Adult Mayflies (Hexagenia bilineata) from the Upper Mississippi River", Bull. Envir. Cont. and Tox., Vol. 17, no. 4, 1977.

Munson, T.O. et al,"Transport of Chlorinated Hydrocarbons in the Upper Chesapeake Bay", Nat. Conf. on PCB's, 1975: EPA Nat. Tech Info. Service, PB253-248.

Nebeker, A.V. and Puglisi, F.A.,"Effect of PCB's on Survival and Reproduction of Daphnia, Gammarus and Tanytarsus", Trans. Am. Fish. Soc., No. 4, 1974.

Nebeker, A.V.,"Summary of Recent Information Regarding Effects of PCB's on Freshwater Organisms", Nat. Conf. on PCB's, 1975; EPA Nat. Tech. Info. Service, PB253-248.

Nimmo, D.R.,"PCB's Absorbed from Sediments by Fiddler Crabs and Pink Shrimp", Nature, Vol.231, 1971.

Nimmo, D.R. et al,"Toxicity and Distribution of Aroclor 1254 in the Pink Shrimp, Penaeus duorarum", Mar. Biol., Vol.11, no. 3, 1971.

Nimmo, D.R. et al,"Accumulations of Aroclor 1254 in Grass Shrimp (Palaemonetes pugio) in Laboratory and Field Exposures", Bull. Envir. Cont. and Tox., Vol. 11, 1974.

Nisbet, I.C.T., Sarafim,"Rates and Routes of Transport of PCB's in the Environment", Envir. Health Persp., Experim. Issue 1, 1972.

Olson,

Panel on Hazardous Trace Substances, "PCB's: Environmental Impact", Environ. Research, Vol. 5, 1972.

Parrish, P.R., Hansen, D.J. and Couch, J.N.,"Effects of Aroclor 1254, a PCB, on Oysters, Crassostrea virginica", ASB Bull., Vol. 19, no. 2, 1972.

Parrish, P.R.,"Aroclor 1254, DDT and Dieldrin: Accumulation and Loss by American Oysters (Crassostrea virginica) Exposed Continually for 56 Weeks", Proceedings of the Nat. Shellfish Ass., Vol. 64, No. 7, 1974.

Peakall, D.P. and Lincer, J.L.,"PCB's: Another Longlife Widespread Chemical in the Environment", BioSci., Vol. 20, no. 17, 1970.

Peakall, D.P.,"PCB's: Occurrence and Biological Effects", Res. Rev., Vol. 44, 1972.

Phillips, D.J.H.,"Use of Biological Indicator Organisms to Quantitate Organochlorine Pollutants in Aquatic Environments- A Review", Environ. Poll., Vol. 16, 1978.

Reinert, R.E.,"Pesticide Concentrations in Great Lakes Fish", Pest. Monit. Jour., Vol. 3, 1970.

Risebrough R.W., et al,"PCB's in the Global Ecosystem", Nature, Vol. 220, 1968.

Risebrough, R.W. and deLappe, B.,"Accumulation of PCB's in Ecosystems",Environ. Health Persp., Exper. Issue 1, 1972.

Risebrough, R.W., et al,"Bioaccumulation Factors of Chlorinated Hydrocarbons Between Mussels and Seawater", Mar. Poll. Bull., Vol. 7, no. 12, 1976.

Sanborn, J.R.,"Uptake of 3 PCB's, DDT and DDE by Green Sunfish, Lepomis cyanellus", Bull. Envir. Cont. and Tox., Vol. 13, 1975.

Sodergren, A.,"Transport, Distribution and Degradation of Chlorinated Hydrocarbon Residues in Aquatic Model Ecosystems", Oikos, Vol. 24, 1973.

Stalling, D.L. and Mayer, F.L. Jr.,"Roxicity of PCB's to Fish and Environmental Residues in Fish", Environ. Health Persp., Vol. 1, 1972.

Sundstroem, G., Hutzinger, O. and Safe, S.,"Metabolism of Chlorobiphenyls: Review.",Chemoshere, Vol. 5, no. 5, 1976.

Thurston, C.E. et al,"Composition of Certain Species of Fish. II. Comparative Data for 21 Species of Lake and River Fish",

Tucker, E.S.,"Migration of PCB's in Soil Induced by Percolating Water", Bull. Envir. Cont. and Tox., Vol. 13, no. 1, 1975.

Urey, J.C. et al,"Bioconcentration of 4 Pure PCB Isomers by Chlorella pyrenoidosa", Bull. Envir. Cont. and Tox., Vol. ?, 1971.

Veith, G.D. and Lee, G.F.,"A Review of Chlorinated Biphenyl Contamination in Natural Waters", Water Research, Vol. 4, 1970.

Veith, G.D. and Lee, G.F.,"PCB's in Fish from the Milwaukee Region", Proc. 14th Conf. Great Lakes Research, 1971.

Veith, G.D.,"Baseline Concentrations of PCB's and DDT in Lake Michigan Fish, 1971", Pest. Monit. Jour., Vol. 9, no. 1, 1975.

Walker, C.R.,"Pre-1972 Knowledge of Nonhuman Effects of PCB's", Nat. Conf. on PCB's, 1975; EPA Nat. Tech. Info. Service, PB 253-248.

Walker, C.R.,"The Occurrence of PCB in the National Fish and Wildlife; Monitoring Program", Nat. Conf. on PCB's, 1975; EPA Nat. Tech. Info. Service, PB253-248.

Walker, C.R.,"PCB's and Fishery Resources", Fisherier, Vol. 1, no. 4, 1976.

Walkley-and Black, "The Walkley-Black Method for Determining the Organic Carbon Content of Soil",

Water Resources Data for.Alabama, U.S. Geological Survey Water Data Report, AL-78-1, Water Year.1978.

Webb, R.G. and McCall, A.C.,"Identities of PCB Isomers in Aroclors", J. of the AOAC, Vol. 55, no. 4, 1972.

Webb, R.G. and McCall, A.C.,"Quantitative PCB Standards for Electron Capture Gas Chromatography", J. Chrom. Sci., Vol. 11, 1973.

Wilford, W.A. et al,"Trends of PCB's in Three Lake Michigan Fishes", Nat. Conf. on PCB's, 1975; EPA Nat. Tech. Info. Service, PB253-248.