Statistical Analysis of Fish Tissue Toxics Data Collected by the District of Columbia

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June 1989

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89-12

Funding provided by the District of Columbia Government
Department of Consumer and Regulatory Affairs

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This summary is based on fish tissue fillets analysed for PCB 1260 and technical chlordane concentrations. The fish were collected by the District of Columbia's Department of Consumer and Regulatory Affairs. The laboratory analysis was performed by Biospherics Incorporated of Beltsville, Maryland.

PCB concentrations were detected in most of the fish tissue samples analysed. The practical quantitation limits for PCB 1260 were 0.03 ppm for seventy-eight samples, 0.3 ppm for nine, and 0.1 ppm for six samples. For chlordane the limits were 0.05 ppm for seventy-six of the samples, 0.5 ppm for nine of them, 0.1 ppm for seven samples, and 0.01 ppm for one sample. Sixteen fish were found to contain quantifiable amounts of chlordane. The US government Food and Drug Administration (FDA) action level for chlordane is 0.3 ppm. For PCB's the action level is 2.0 ppm.

The first step taken in the statistical analysis of this data was separating the results into three groups. The first group was composed of the forty channel catfish (Ictalurus punctatus) analysed. The second group contained thirty-eight largemouth bass (Micropterus salmoides). The third group contained fifteen sunfish of three different species. Of these fifteen sunfish, eight individuals were pumpkinseed sunfish (Lepomis gibbosus), six fish were redbreast sunfish (Lepomis auritus) and one individual was a bluegill sunfish (Lepomis macrochirus). All of the sunfish were collected in the Anacostia River. This grouping was made based upon differences in the feeding habits and tissue types of the different fish species. Catfish for example, tend to have more fat in their tissue than the sunfish species. Also, the results of the chemical analysis indicated that catfish had higher PCB concentrations than sunfish or bass. Figure one, the graph of PCB concentrations in fish tissue for all three groups illustrates the differences among the three groups with regard to PCB concentration clearly.

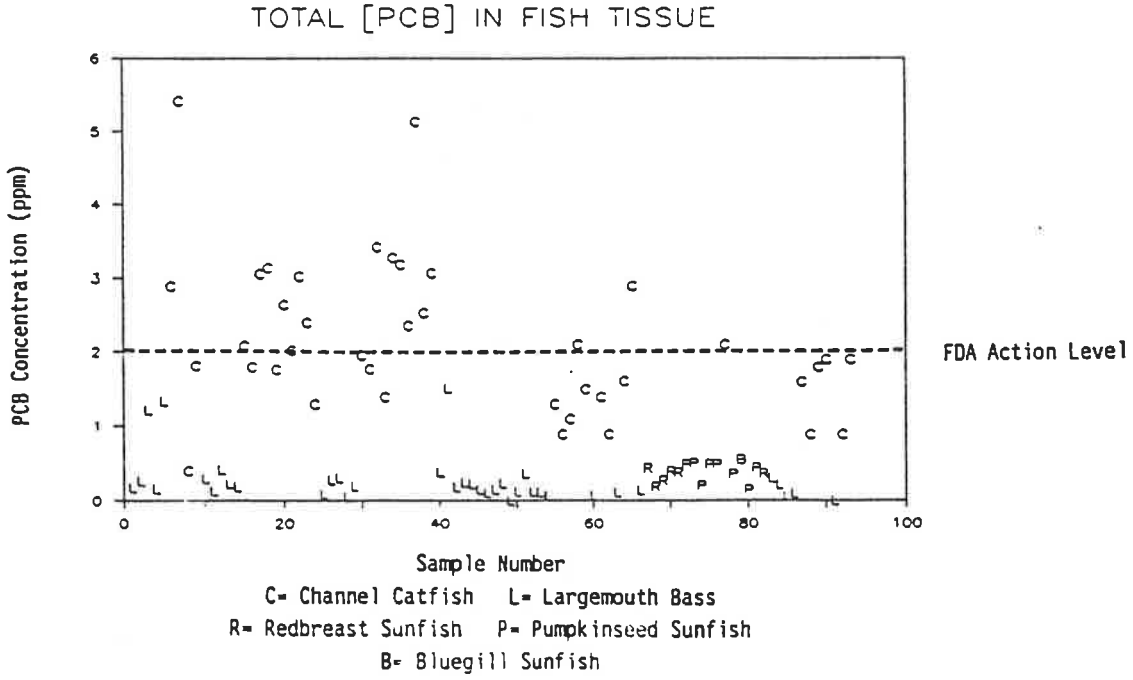


Figure 1

The statistical analysis of the three groups of data was done using the Statgraphics statistical package version 3.0. The basic statistics describing total PCB concentrations for the three groups of data are given in Table 1 below. All sunfish and bass were well below the 2.0 action level for PCB's. In fact, with the exception of three bass, all of the largemouth bass and sunfish were below 0.5 ppm PCB. The data for catfish, however, indicated higher tissue concentrations of PCBs. For the sample of forty catfish the median PCB concentration was 1.93 ppm, with a mean of 2.169 ppm. Nineteen catfish, or 47.5% of the catfish sample, were above the 2.0 ppm FDA action level for PCB.

Table 1
Fish Tissue Total PCB Concentration

Statistic	Channel Catfish	Largemouth Bass	Sunfish
Sample size	40	38	15
Average	2.169	0.271053	0.382667
Median	1.93	0.175	0.39
Mode	0.9	0.15	0.49
Variance	1.11579	0.115772	0.0163781
Standard deviation	1.05631	0.340253	0.127977
Standard error	0.167017	0.0551963	0.0330435
Minimum	0.4	BQL	0.14
Maximum	5.43	1.52	0.56
Range	5.03	1.52	0.42
Lower quartile	1.45	0.11	0.27
Upper quartile	2.9	0.28	0.49
Interquartile range	1.45	0.17	0.22
Skewness	1.16994	2.83013	-0.636553
Standardized skewness	3.02078	7.12233	-1.00648
Kurtosis	2.11699	7.59367	-0.665082
Standardized kurtosis	2.73303	9.55515	-0.525793

Figures 3, 5, and 7 show the total PCB concentration frequency distributions for the three groups of fish. These frequency distributions do not appear to exhibit any extreme departures from normality. Anyone who does not wish to rely on the distribution of the data approximating the normal distribution should examine the median and standard deviation. These statistics describe the data without relying on assumptions about the data's distribution. Based on the assumption of normality the following statistical tests were conducted.

For each group of data, t-tests of the null hypothesis that the mean total PCB tissue concentration was equal to or greater than 2.0 ppm versus the alternative that the mean concentration was below 2.0 ppm were conducted. Also 95% confidence intervals about the mean were constructed for the three groups of data. The results are given below in Table 2. Note that the null hypothesis that the mean total PCB tissue concentration is equal to or greater than 2.0 can be rejected decisively for the bass and sunfish data in favor of the alternative that the mean is less than 2.0. However, the null hypothesis cannot be rejected for the channel catfish data with any reasonable degree of confidence.

Table 2
Inferences Regarding the Mean Total PCB Concentration

Data	Number of Obs.	Mean [PCB]	95% Conf. Int. About Mean	Test for Ho: $\bar{X} \geq 2$ vs Ha: $\bar{X} < 2$ Computed t Stat.	Sig. Level
Channel Catfish	40	2.17	$1.83 < \bar{X} < 2.51$	1.01	0.84
Largemouth Bass	38	0.27	$0.16 < \bar{X} < 0.38$	-31.32	0
Sunfish	15	0.38	$0.31 < \bar{X} < 0.45$	-48.94	0

The data was also analysed for differences in fish tissue PCB levels between the Anacostia and Potomac Rivers. A two-sample t test on the catfish data does not support the hypothesis that there is a difference between the rivers with respect to PCB concentrations in fish tissue. All the sunfish were from the Anacostia River so no between river comparison was possible for that group. A two-sample t test for the largemouth bass data found a slight difference between the tissue concentrations of the fish in the two rivers. The bass in the Potomac were found to have a mean PCB concentration between 0.04 ppm and 0.33 ppm higher than that of the bass in the Anacostia. This result is stated with 95% confidence. Eight female bass were collected from the Anacostia. Additionally, ANOVA's were done on the three groups to ascertain whether individual site location explained a significant amount of variance in the data. Site location was not a significant factor for the catfish, sunfish or bass data sets.

Sixteen fish were found to posess measurable levels of chlordane. Twelve of these sixteen fish were from sites five and eight on the Anacostia River. Of these twelve, the only fish found to be over the 0.3 ppm FDA action level for chlordane were the five catfish collected from site number five. The chlordane concentrations in these fish ranged from 0.60 ppm, which is twice the FDA action level, to 1.00 ppm. The average chlordane concentration for these five fish was 0.84 ppm. No catfish or bass were collected at site eight. The other four fish showing chlordane concentrations were from four different sites. The chlordane values obtained are graphed in figure 9.

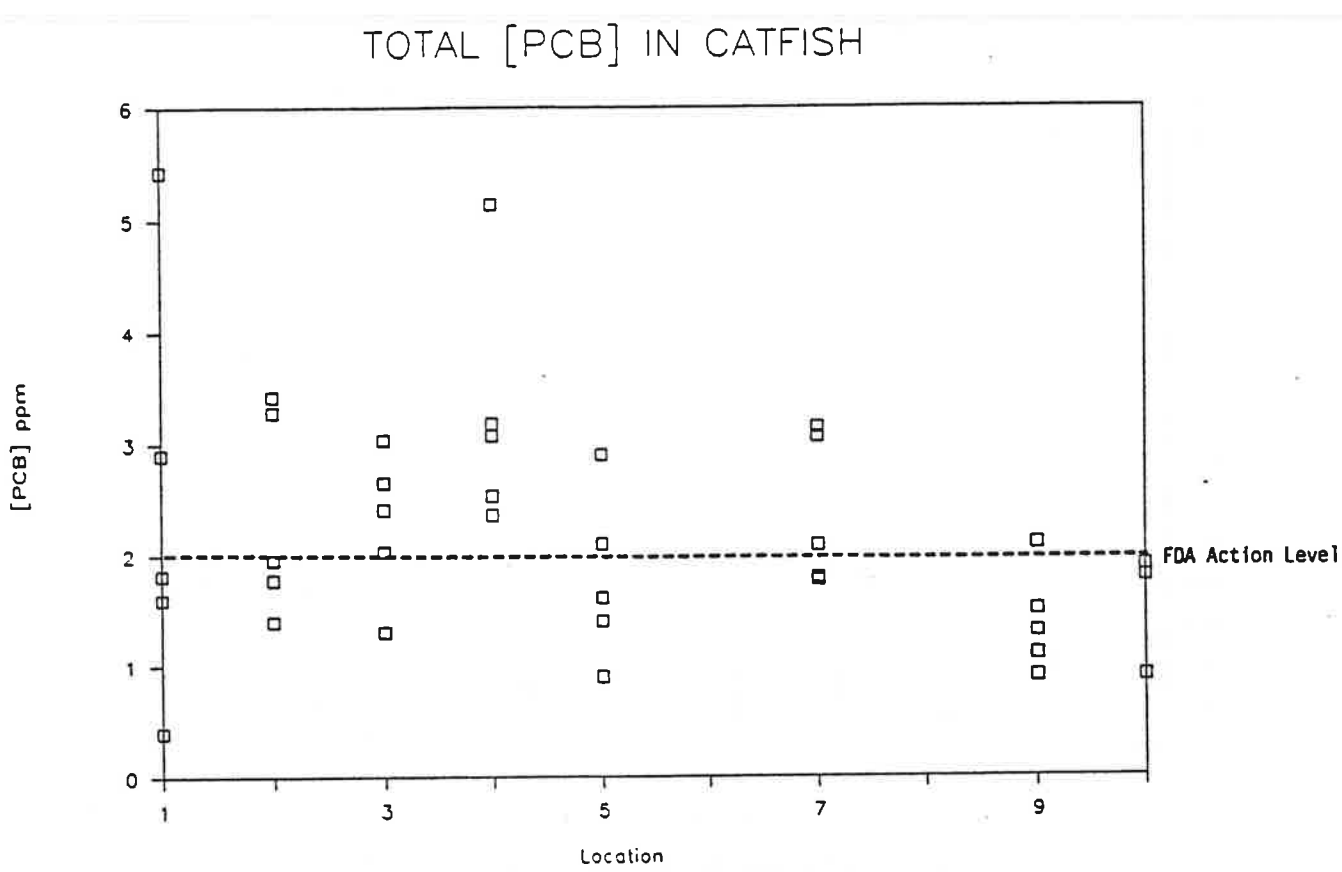


Figure 2

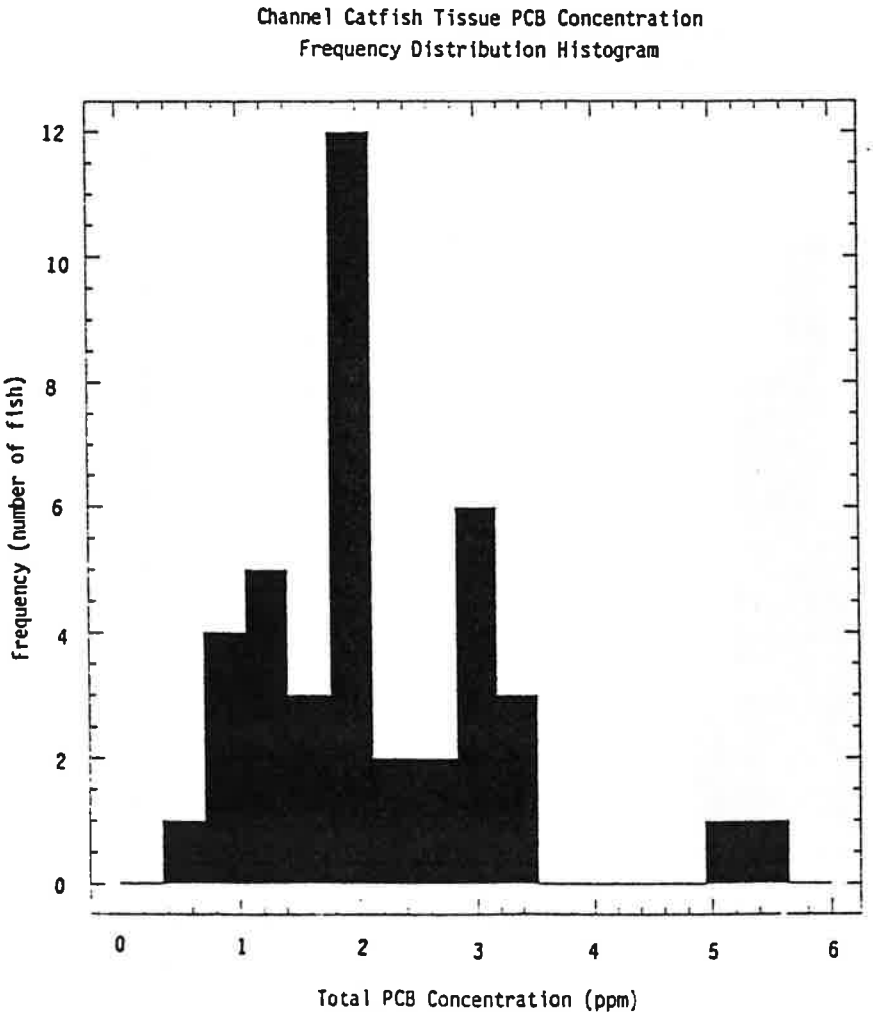


Figure 3

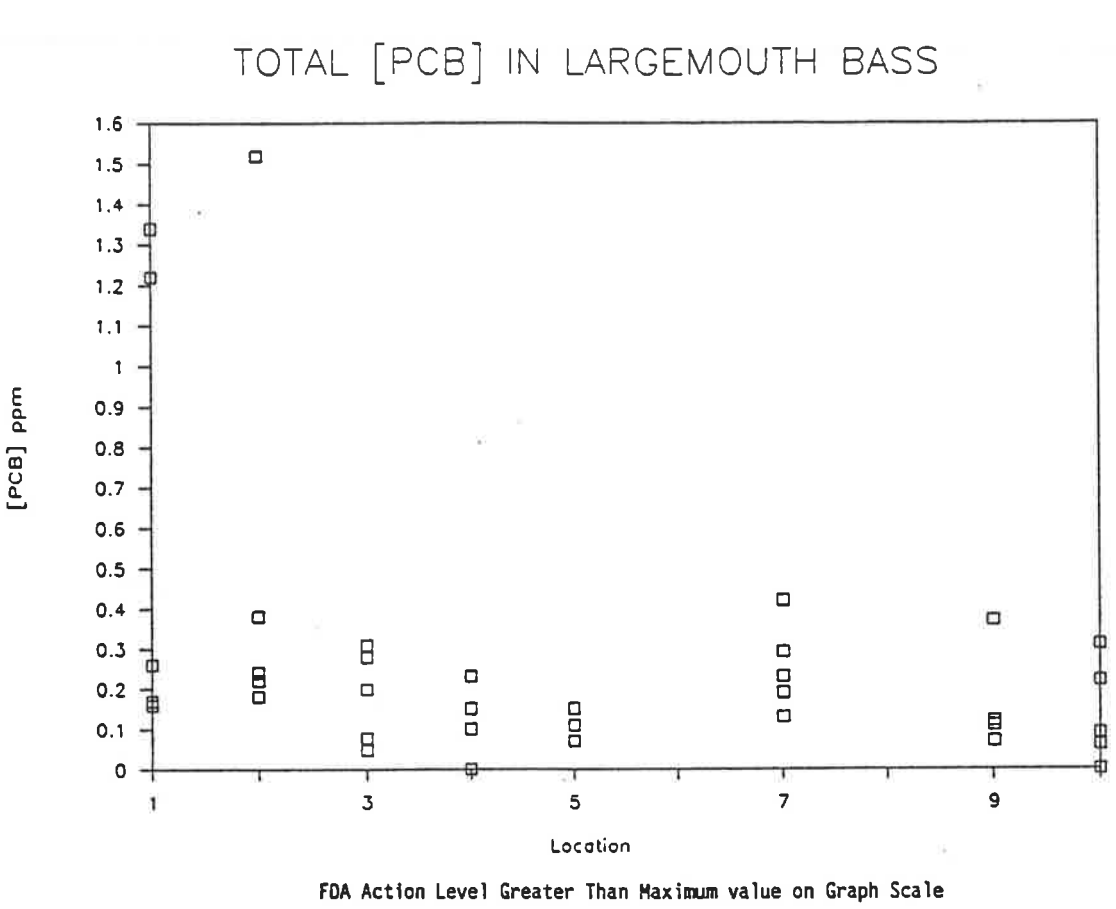


Figure 4

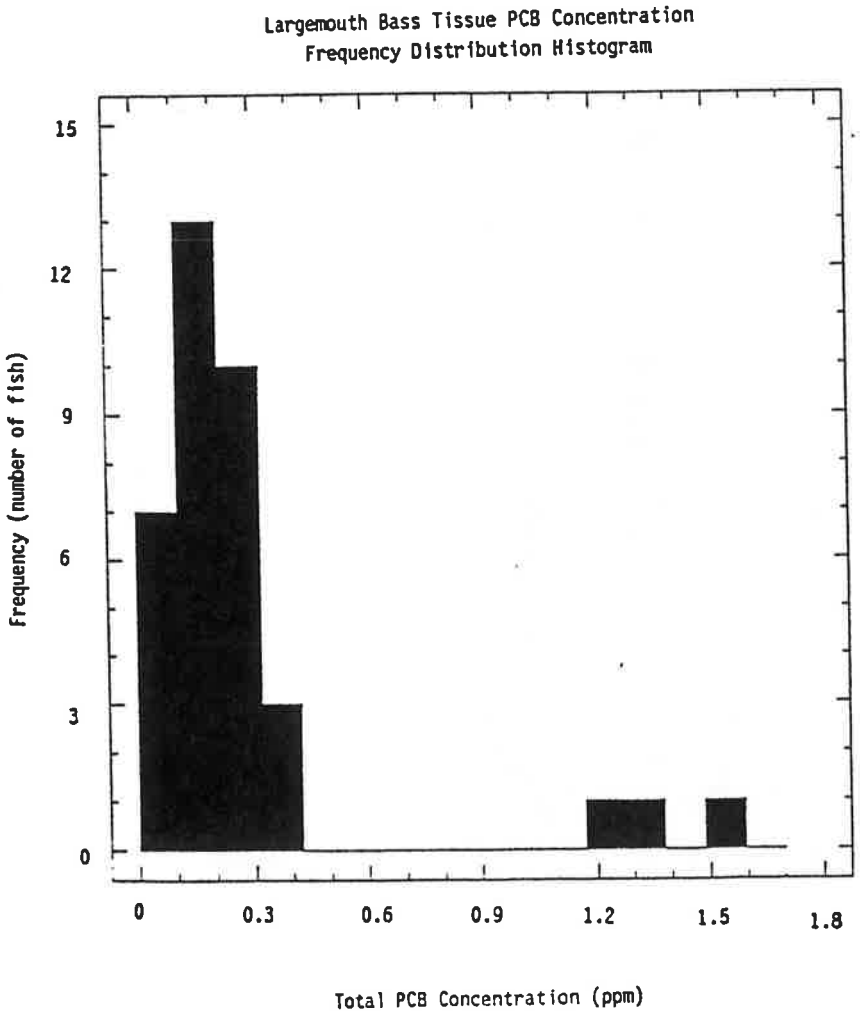


Figure 5

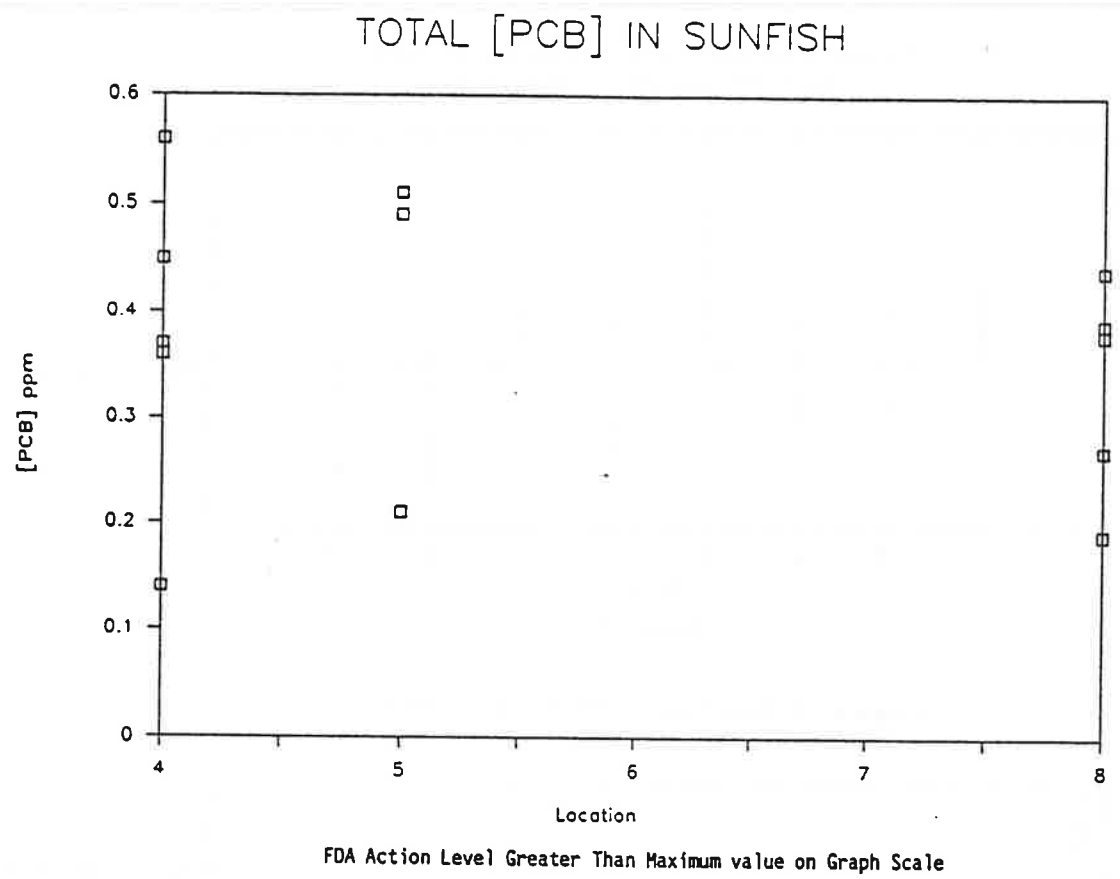


Figure 6

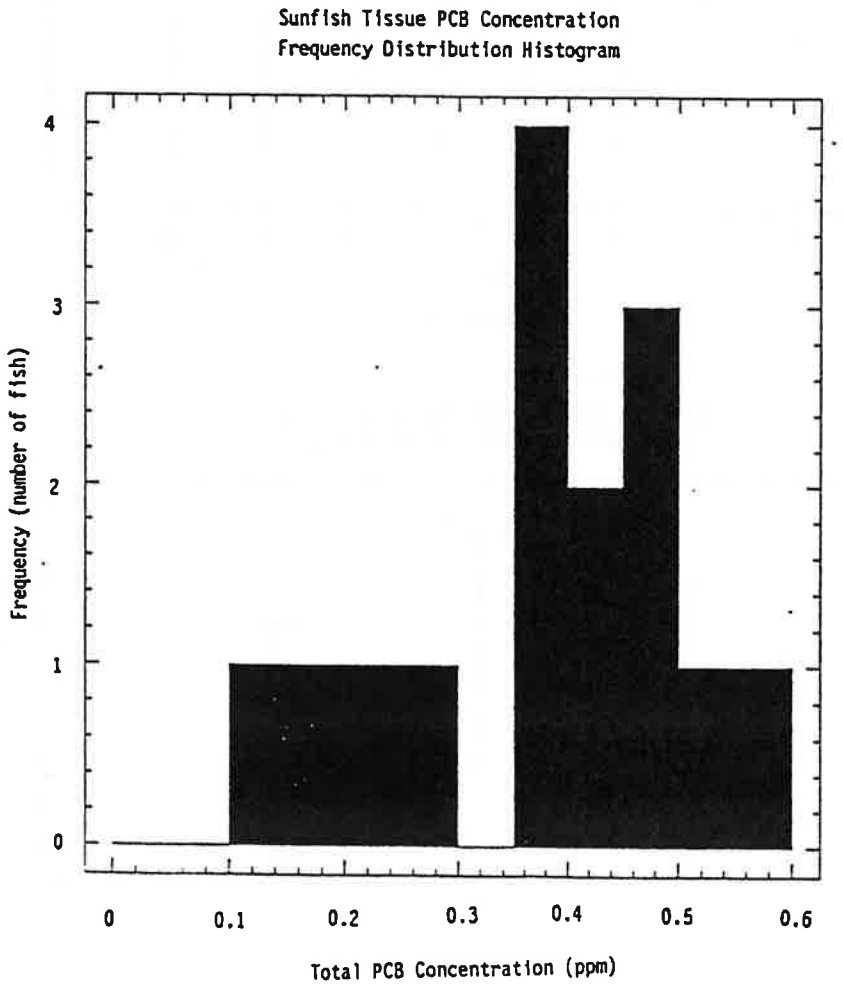


Figure 7

Channel Catfish Tissue PCB Means at Sites
With 95% Confidence Intervals

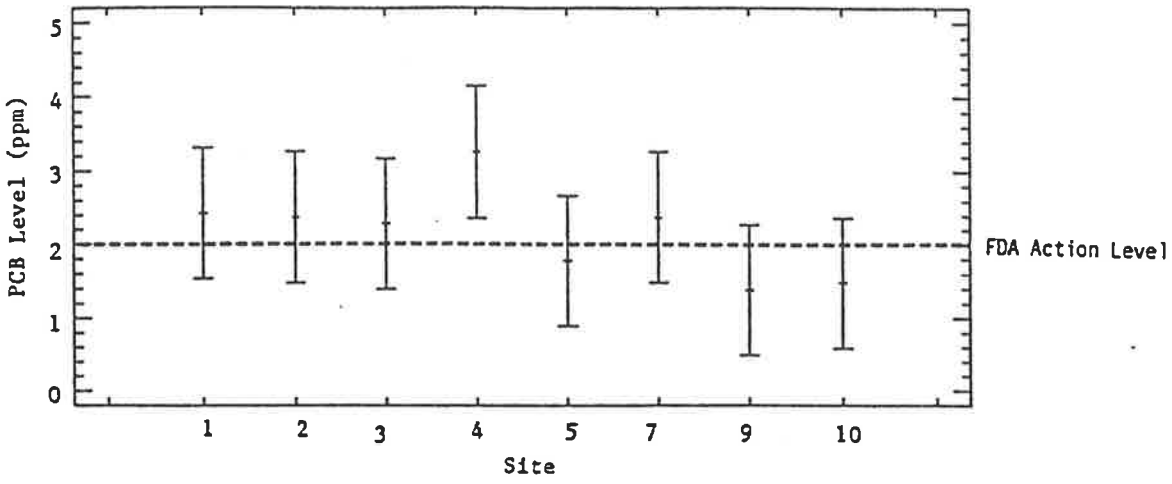


Figure 8

Largemouth Bass Tissue PCB Means at Sites
With 95% Confidence Intervals

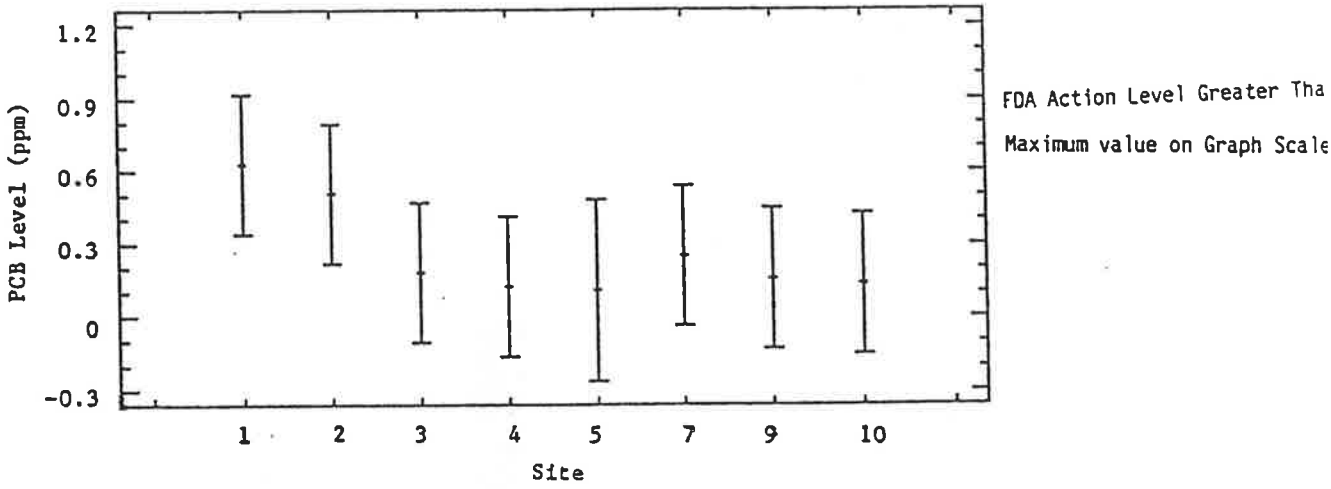


Figure 9

Sunfish Tissue PCB Means at Sites
With 95% Confidence Intervals

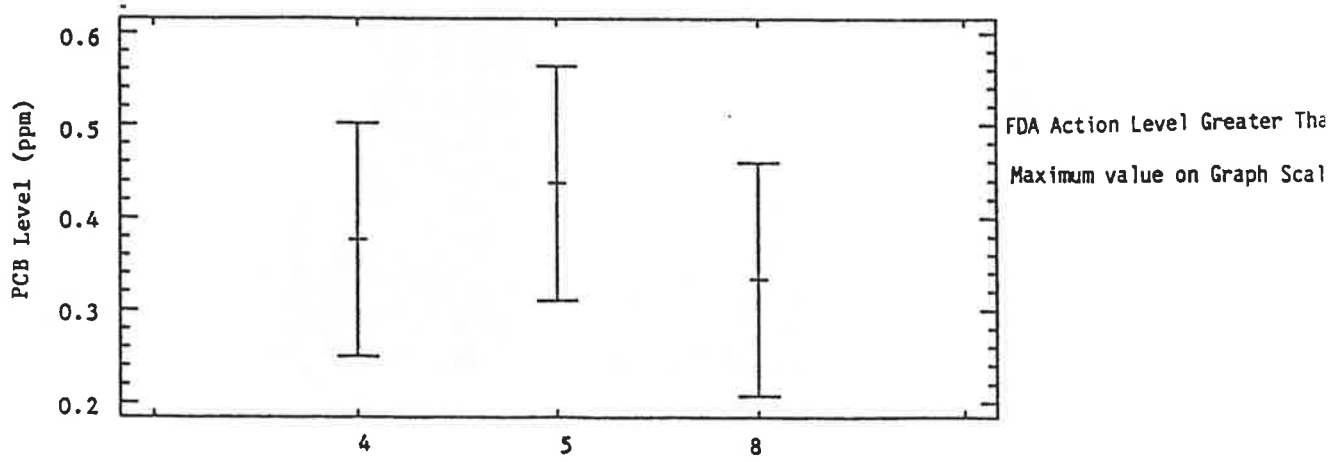


Figure 10

Average PCB Concentrations (ppm) at Sampling Locations

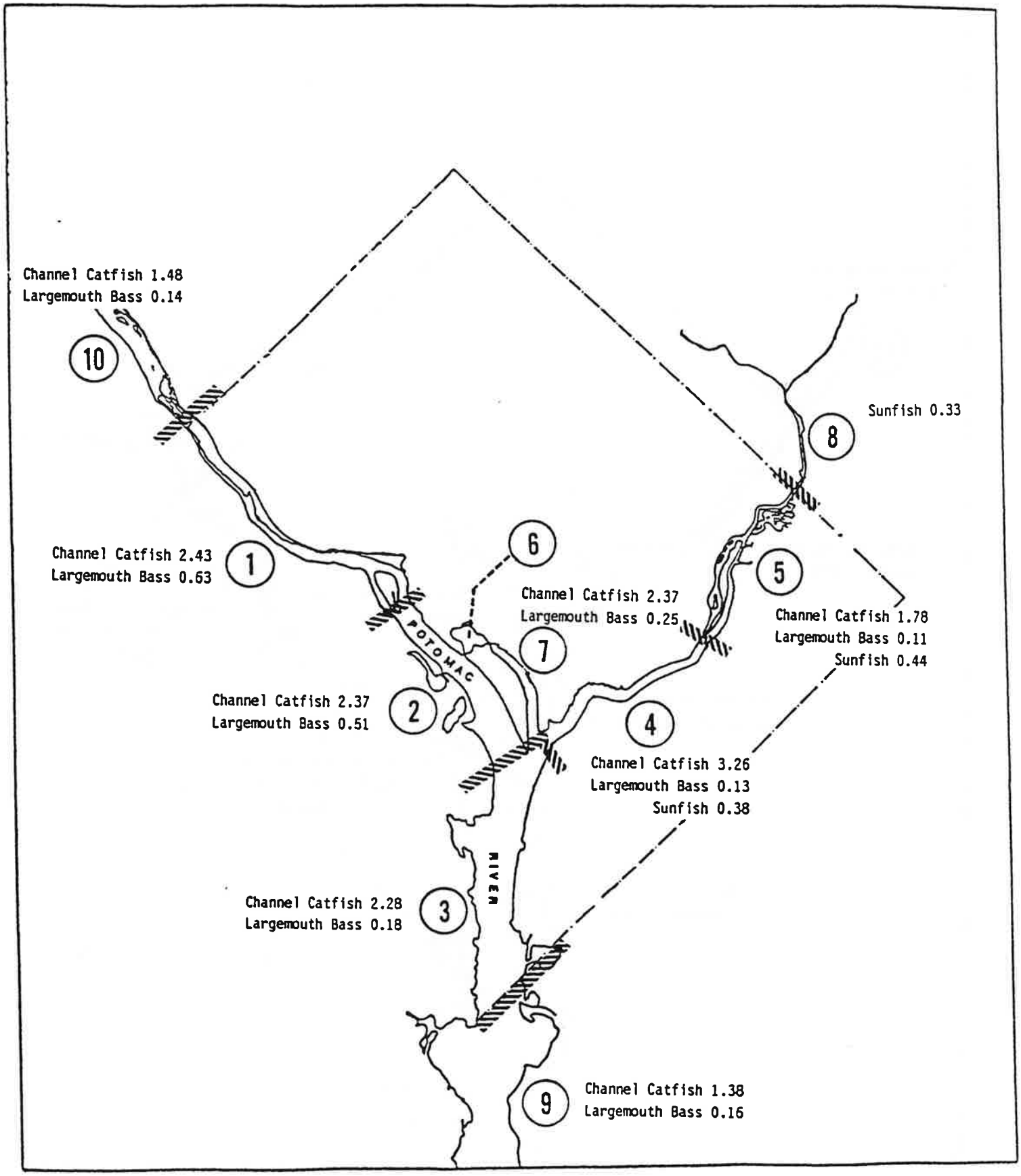


Figure 11

Average Chlordane Concentrations (ppm) at Sampling Locations

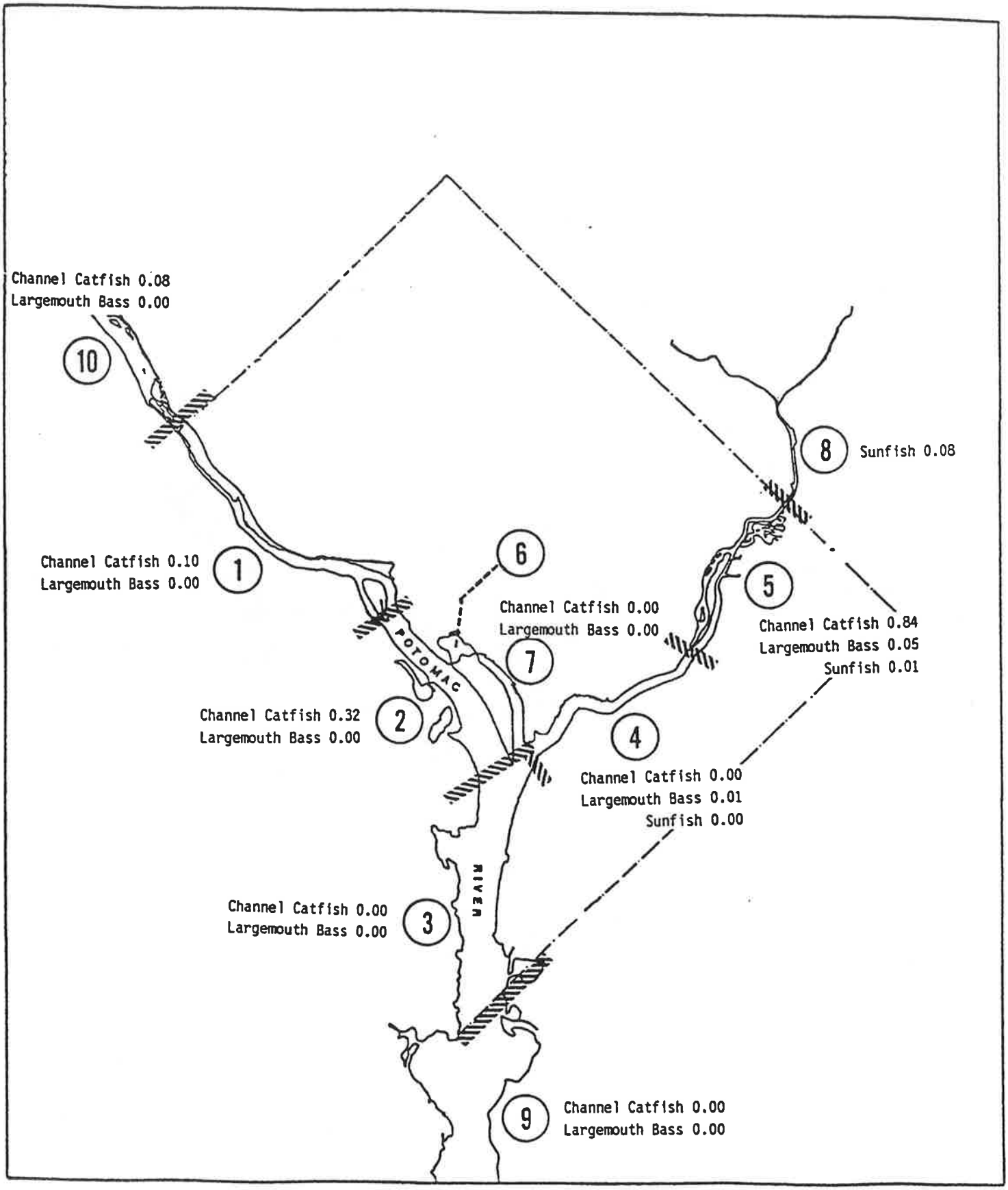


Figure 12

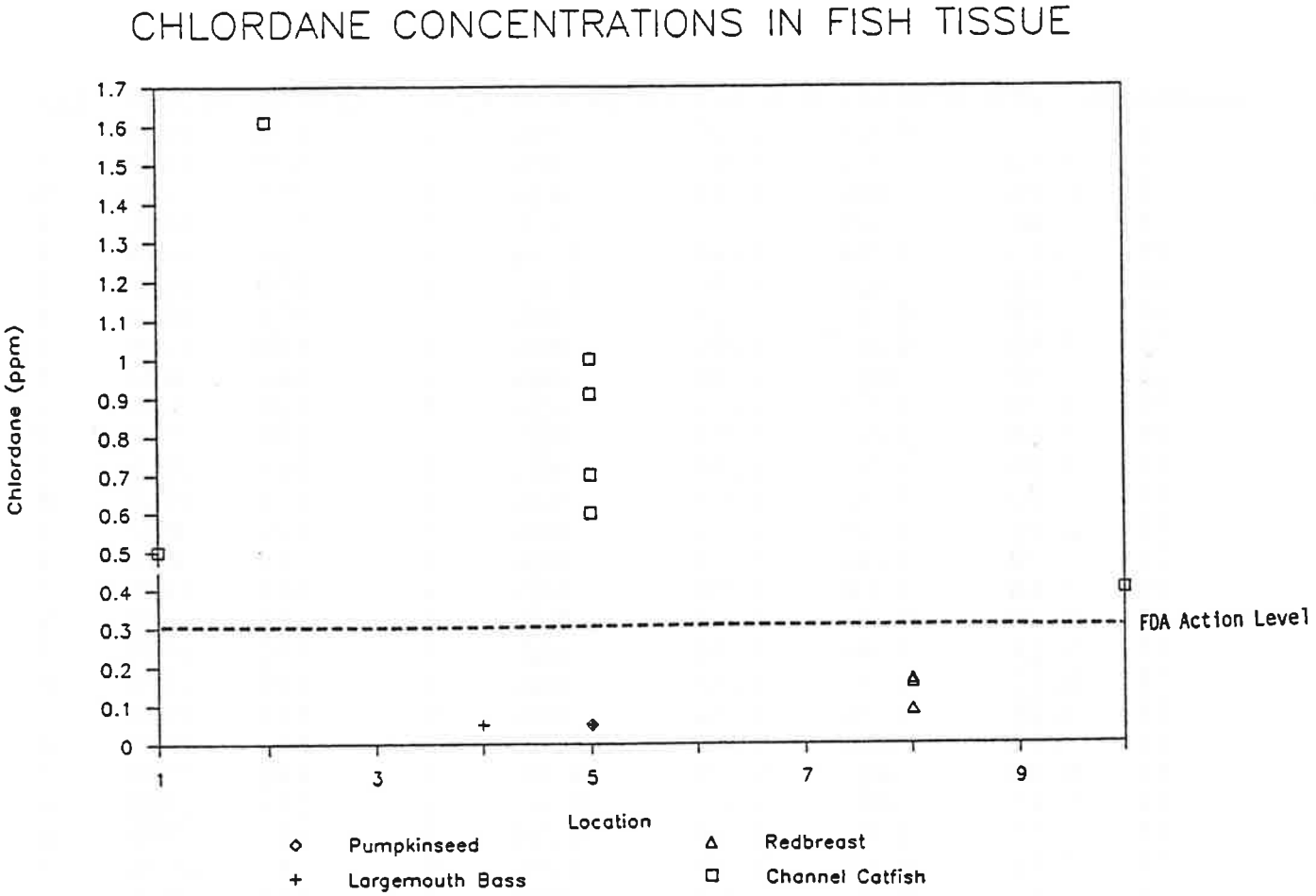

CHLORDANE CONCENTRATIONS IN FISH TISSUE
Chlordane (ppm)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
3
5
7
9
Location
FDA Action Level
Pumpkinseed
Largemouth Bass
Redbreast
Channel Catfish

Figure 13

Table 3

CATFISH TISSUE SAMPLE ANALYSIS RESULTS

SAMPLE	TOT PCB	PCB1242	PCB1260	CHLORDANE	SITE	LENGTH	WEIGHT	SEX
6	2.90	0.84	2.06	BQL	1	450	1010	F
7	5.43	1.50	3.93	BQL	1	600	2418	F
8	0.40	BQL	0.40	BQL	1	350	370	M
9	1.82	0.61	1.21	BQL	1	525	1605	F
87	1.60	0.50	1.10	0.50	1	484	1090	F
30	1.96	BQL	1.96	1.61	2	535	1620	F
31	1.78	0.41	1.37	BQL	2	476	1090	M
32	3.42	0.86	2.56	BQL	2	480	1100	I
33	1.40	BQL	1.40	BQL	2	441	898	F
34	3.28	0.67	2.61	BQL	2	439	732	-
20	2.65	0.59	2.06	BQL	3	606	1710	F
21	2.03	0.79	1.24	BQL	3	504	1510	F
22	3.03	0.98	2.05	BQL	3	526	1850	F
23	2.41	1.09	1.32	BQL	3	423	802	I
24	1.30	0.42	0.88	BQL	3	439	818	I
35	3.18	0.68	2.50	BQL	4	529	1320	F
36	2.36	0.73	1.63	BQL	4	502	1100	M
37	5.14	1.44	3.70	BQL	4	503	1400	F
38	2.53	0.77	1.76	BQL	4	506	1330	M
39	3.07	0.76	2.31	BQL	4	526	1538	-
61	1.40	BQL	1.40	1.00	5	510	1360	M
62	0.90	BQL	0.90	0.60	5	485	1300	F
64	1.61	BQL	1.61	0.91	5	559	1700	M
65	2.90	0.80	2.10	0.70	5	451	790	M
77	2.10	0.80	1.30	1.00	5	547	1670	F
15	2.09	0.69	1.40	BQL	7	444	834	F
16	1.80	0.27	1.53	BQL	7	528	1420	M
17	3.06	0.64	2.42	BQL	7	499	1200	M
18	3.14	0.93	2.21	BQL	7	460	1000	F
19	1.77	0.31	1.46	BQL	7	386	522	M
55	1.30	BQL	1.30	BQL	9	620	2680	M
56	0.90	BQL	0.90	BQL	9	569	2040	F
57	1.10	BQL	1.10	BQL	9	483	1140	F
58	2.10	BQL	2.10	BQL	9	455	1010	F
59	1.50	BQL	1.50	BQL	9	399	654	F
88	0.90	BQL	0.90	BQL	10	451	740	M
89	1.80	0.30	1.50	0.40	10	480	1060	M
90	1.90	BQL	1.90	BQL	10	510	2000	M
92	0.90	BQL	0.90	BQL	10	372	422	-
93	1.90	BQL	1.90	BQL	10	370	418	-
Average	2.17	0.46	1.71	0.17		485.55	1231.8	
St. Dev	1.04	0.43	0.71	0.37		62.22	519.86	
Maximum	5.43	1.50	3.93	1.61		620	2680	

BQL = Below Quantitative Limits

Table 4

LARGEMOUTH BASS TISSUE SAMPLE ANALYSIS RESULTS

SAMPLE	TOT PCB	PCB1242	PCB1260	CHLORDANE	SITE	LENGTH	WEIGHT	SEX
1	0.17	BQL	0.17	BQL	1	283	295	M
2	0.26	BQL	0.26	BQL	1	296	336	F
3	1.22	BQL	1.22	BQL	1	359	509	F
4	0.16	BQL	0.16	BQL	1	248	176	F
5	1.34	BQL	1.34	BQL	1	429	1260	F
40	0.38	BQL	0.38	BQL	2	435	1300	F
41	1.52	BQL	1.52	BQL	2	410	1100	M
42	0.18	BQL	0.18	BQL	2	290	340	F
43	0.24	BQL	0.24	BQL	2	318	530	M
44	0.22	BQL	0.22	BQL	2	310	450	F
25	0.08	BQL	0.08	BQL	3	300	415	F
26	0.28	0.08	0.20	BQL	3	319	519	F
27	0.31	0.11	0.20	BQL	3	372	928	F
28	0.05	BQL	0.05	BQL	3	310	508	F
29	0.20	0.09	0.11	BQL	3	280	322	F
45	0.15	0.04	0.11	BQL	4	383	1100	F
46	0.10	0.03	0.07	BQL	4	329	531	F
47	0.15	0.03	0.12	BQL	4	344	634	F
48	0.23	0.03	0.20	0.05	4	317	500	F
49	BQL	BQL	BQL	BQL	4	302	416	F
60	0.07	BQL	0.07	0.05	5	315	511	F
63	0.11	BQL	0.11	0.05	5	339	636	F
66	0.15	BQL	0.15	0.05	5	345	604	F
10	0.29	BQL	0.29	BQL	7	369	680	M
11	0.13	BQL	0.13	BQL	7	355	620	M
12	0.42	0.04	0.38	BQL	7	330	480	M
13	0.23	BQL	0.23	BQL	7	356	654	M
14	0.19	0.05	0.14	BQL	7	291	338	F
50	0.12	BQL	0.12	BQL	9	339	752	F
51	0.37	0.03	0.34	BQL	9	426	1319	F
52	0.12	BQL	0.12	BQL	9	356	671	F
53	0.11	BQL	0.11	BQL	9	367	692	F
54	0.07	BQL	0.07	BQL	9	355	576	F
83	0.31	BQL	0.31	BQL	10	306	380	F
84	0.22	BQL	0.22	BQL	10	403	890	F
85	0.06	BQL	0.06	BQL	10	351	582	F
86	0.09	BQL	0.09	BQL	10	374	640	F
91	BQL	BQL	BQL	BQL	10	283	332	M
Average	0.27	0.01	0.26	0.01		339.32	619.11	
St. Dev	0.34	0.03	0.34	0.02		44.12	281.15	
Maximum	1.52	0.11	1.52	0.05		435	1319	

BQL = Below Quantitative Limits

Table 5

SUNFISH TISSUE SAMPLE ANALYSIS RESULTS

SAMPLE	TOTAL PCB	PCB1242	PCB1260	CHLORDANE	SITE	SPECIES	LENGTH	WEIGHT	SEX
78	0.36	0.04	0.32	BQL	4	PUMPKIN	143	65	F
79	0.56	0.10	0.46	BQL	4	BLUEGILL	168	104	F
80	0.14	BQL	0.14	BQL	4	PUMPKIN	146	60	M
81	0.45	0.07	0.38	BQL	4	PUMPKIN	136	62	F
82	0.37	0.07	0.30	BQL	4	REDBREAST	161	86	F
72	0.49	0.05	0.44	0.05	5	PUMPKIN	138	40	M
73	0.51	0.07	0.44	BQL	5	PUMPKIN	135	49	M
74	0.21	0.05	0.16	BQL	5	PUMPKIN	127	30	F
75	0.49	0.08	0.41	BQL	5	PUMPKIN	145	62	M
76	0.49	0.05	0.44	BQL	5	PUMPKIN	133	38	F
67	0.44	0.08	0.36	BQL	8	REDBREAST	151	73	F
68	0.19	BQL	0.19	BQL	8	REDBREAST	148	64	F
69	0.27	BQL	0.27	0.17	8	REDBREAST	149	70	F
70	0.39	BQL	0.39	0.09	8	REDBREAST	151	68	F
71	0.38	BQL	0.38	0.16	8	REDBREAST	146	67	F
Average	0.38	0.04	0.34	0.03			145.13	62.53	
St. Dev	0.12	0.03	0.10	0.06			10.281	17.98	
Maximum	0.56	0.10	0.46	0.17			168	104	

BQL = Below Quantitative Limits

Table 6

TISSUE SAMPLES FOUND TO HAVE DETECTABLE AMOUNTS OF CHLORDANE

SAMPLE	TOTAL PCB	PCB1242	PCB1260	CHLORDANE	SITE	SPECIES	LENGTH	WEIGHT	SEX
87	1.60	0.50	1.10	0.50	1	CH CAT	484	1090	F
30	1.96	BQL	1.96	1.61	2	CH CAT	535	1620	F
48	0.23	0.03	0.20	0.05	4	LMB	317	500	F
61	1.40	BQL	1.40	1.00	5	CH CAT	510	1360	M
77	2.10	0.80	1.30	1.00	5	CH CAT	547	1670	F
64	1.61	BQL	1.61	0.91	5	CH CAT	559	1700	M
65	2.90	0.80	2.10	0.70	5	CH CAT	451	790	M
62	0.90	BQL	0.90	0.60	5	CH CAT	485	1300	F
72	0.49	0.05	0.44	0.05	5	PUMPKIN	138	40	M
60	0.07	BQL	0.07	0.05	5	LMB	315	511	F
66	0.15	BQL	0.15	0.05	5	LMB	345	604	F
63	0.11	BQL	0.11	0.05	5	LMB	339	636	F
69	0.27	BQL	0.27	0.17	8	REDBREAST	149	70	F
71	0.38	BQL	0.38	0.16	8	REDBREAST	146	67	F
70	0.39	BQL	0.39	0.09	8	REDBREAST	151	68	F
89	1.80	0.30	1.50	0.40	10	CH CAT	480	1060	M
AVG	1.02	0.16	0.87	0.46			371.94	817.88	
ST DEV	0.86	0.28	0.68	0.46			151.43	579.44	
MAX	2.9	0.8	2.1	1.61			559	1700	

Table 7

SAMPLES FROM SITES FIVE AND EIGHT NOT FOUND TO CONTAIN CHLORDANE

SAMPLE	TOTAL PCB	PCB1242	PCB1260	CHLORDANE	SITE	SPECIES	LENGTH	WEIGHT	SEX
76	0.49	0.05	0.44	BQL	5	PUMPKIN	133	38	F
73	0.51	0.07	0.44	BQL	5	PUMPKIN	135	49	M
74	0.21	0.05	0.16	BQL	5	PUMPKIN	127	30	F
75	0.49	0.08	0.41	BQL	5	PUMPKIN	145	62	M
68	0.19	BQL	0.19	BQL	8	REDBREAST	148	64	F
67	0.44	0.08	0.36	BQL	8	REDBREAST	151	73	F
AVG	0.39	0.06	0.33	0.00			139.83	52.67	
ST DEV	0.13	0.03	0.12	0.00			8.69	15.12	
MAX	0.51	0.08	0.44	0			151	73	

Fish Tissue Toxics Results From Sites Eight, Nine, and Ten

An independent analysis of fish tissue toxics concentrations at sites eight, nine, and ten can be found below. These sites were examined because they lie in Maryland waters just outside of the boundaries of the District of Columbia. Site number eight is the Anacostia River upstream from the District line. Site number nine is the Potomac River downstream from the Woodrow Wilson Bridge. Site number ten is the Potomac River upstream from Chain Bridge.

Four of the twenty-five fish at these three sites were found to contain chlordane. Three of these fish were redbreasts from site number eight. The only fish over the action level for chlordane was a catfish from site number ten.

Average PCB levels at these sites are provided below. Table 2 shows that none of the groups from these three sites can be said to be over the federal action level for PCB with 95% confidence. Note also that no more than five fish of any species were collected from any site. Thus the above statement is based on only four degrees of freedom. Also, an ANOVA done on the full data set did not support the hypothesis that there was a significant degree of error explained by sorting the results by site.

Table 1
Fish Tissue Analysis Results For Sites Eight, Nine, and Ten

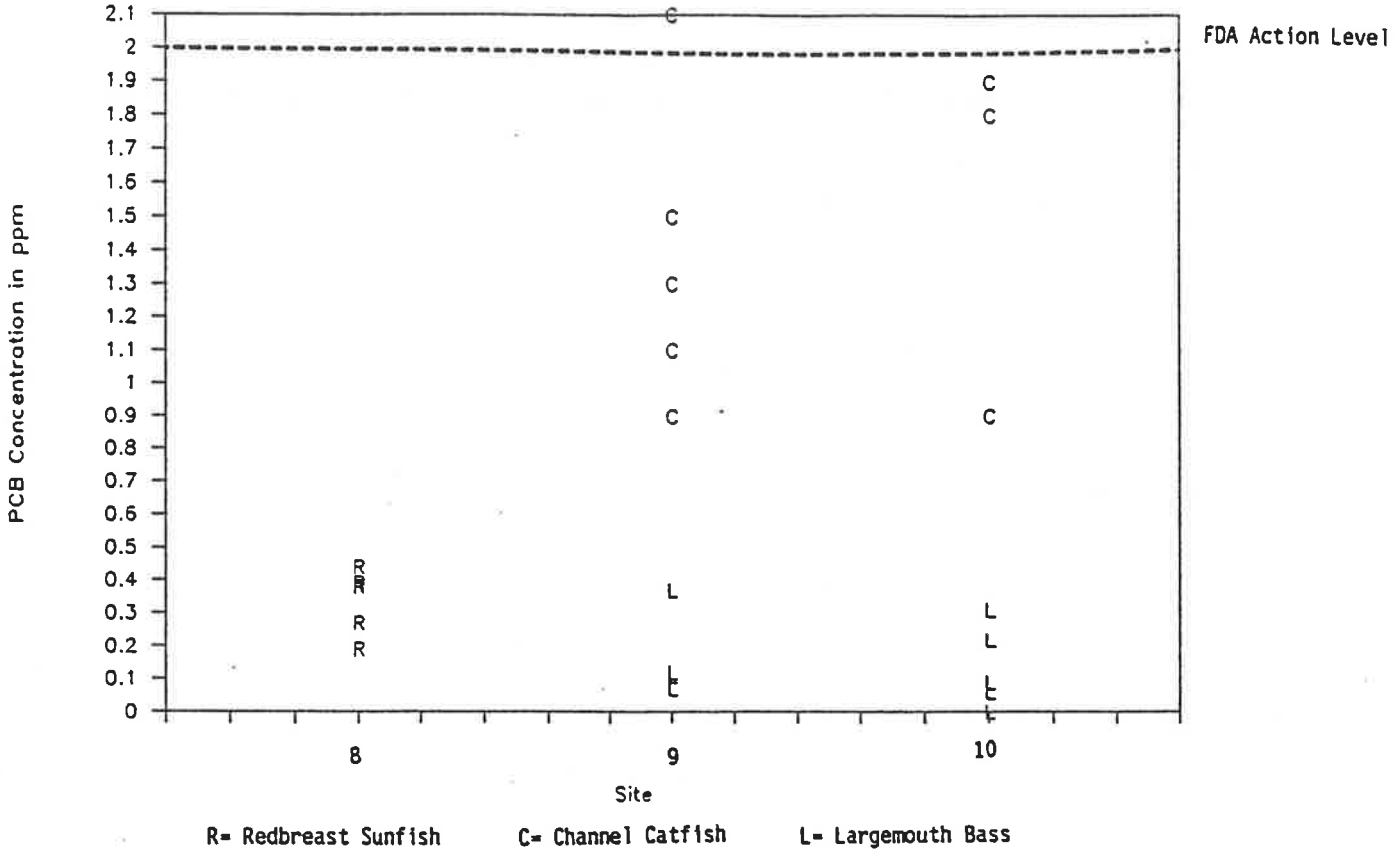
Site 8			Site 9			Site 10		
Redbreast Sunfish			Channel Catfish			Channel Catfish		
ID #	PCB	CHLORDANE	ID #	PCB	CHLORDANE	ID #	PCB	CHLORDANE
70	0.39	0.09	59	1.5	BQL	88	0.9	BQL
71	0.38	0.16	56	0.9	BQL	89	1.8	0.4
68	0.19	BQL	57	1.1	BQL	90	1.9	BQL
69	0.27	0.17	58	2.1	BQL	92	0.9	BQL
67	0.44	BQL	55	1.3	BQL	93	1.9	BQL
MEAN	0.334	0.084		1.38	0		1.48	0.08
# OF FISH	5	5		5	5		5	5
			Largemouth Bass			Largemouth Bass		
			ID #	PCB	CHLORDANE	ID #	PCB	CHLORDANE
			54	0.07	BQL	83	0.31	BQL
			53	0.11	BQL	84	0.22	BQL
			51	0.37	BQL	86	0.09	BQL
			50	0.12	BQL	85	0.06	BQL
			52	0.12	BQL	91	0	BQL
			MEAN	0.158	0		0.136	0
			# OF FISH	5	5		5	5

BQL = Below Quantitative Limits

Table 2
Inferences Regarding the Mean Total PCB Concentration

Data	Number of Obs.	Mean [PCB]	95% Conf. Int. About Mean	Test for Ho:$\bar{X} \geq 2$ vs Ha:$\bar{X} < 2$ Computed t Stat.	Sig. Level
Channel Catfish					
Site 9	5	1.38	$0.81 < \bar{X} < 1.95$	-3.01	0.020
Site 10	5	1.48	$0.82 < \bar{X} < 2.13$	-2.19	0.047
Largemouth Bass					
Site 9	5	0.16	$0.01 < \bar{X} < 0.31$	-34.24	0.000002
Site 10	5	0.14	$-0.02 < \bar{X} < 0.29$	-33.02	0.000002
Sunfish					
Site 8	5	0.33	$0.21 < \bar{X} < 0.46$	-36.65	0.000002

Tissue PCB Concentrations by Site



Fish From Sites 8, 9, and 10 Which

Tested Positive for Chlordane