DELAWARE RIVER FISH TISSUE STUDY

Environmental Services Division
Environmental Protection Agency
Region III, Philadelphia, PA

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Executive Summary

In June of 1989, the Environmental Protection Agency collected fish tissue samples (filet only) at 10 stations on the Delaware River and Estuary from Lumberville, New Jersey to Bowers Beach, Delaware. The objective of the study was to expand the existing database on fish tissue contamination and to determine the adequacy of the current fish consumption advisory for bottom feeding fish between Burlington, New Jersey and the Pennsylvania-Delaware Stateline. A priority pollutant scan was performed on indicator species of gamefish (primarily bass and perch) and bottomfeeding fish or shellfish (catfish, crabs). The analytes detected included arsenic, chromium, lead, selenium, thallium, zinc, mercury, DDE, DDD, chlordane, and PCBs. The primary parameter of concern was PCBs. PCB contamination exceeded the FDA action level of 2.0 ppm at Chester, Pennsylvania and Wilmington, Delaware (mouth of Christina River) in channel catfish. High levels (>1.0 ppm) of PCBs were found in most of the bottomfeeding fish (catfish) throughout the Delaware Estuary. It is recommended that the State of Delaware consider issuing a consumption advisory to limit the consumption of bottomfeeding fish captured from the Delaware Estuary in the area between the Pennsylvania-Delaware Stateline and the C and D Canal. This would compliment the consumption advisories previously issued by the States of Pennsylvania and New Jersey.

I. Introduction

In March of 1988, the Delaware River Basin Commission (DRBC) completed a report entitled Fish Health and Contamination Study on the Delaware Estuary as part of their Delaware Estuary Use Attainability Project. The findings of that study indicated that PCB contamination exceeded the FDA Action Level in six of seven stations of composited channel catfish fillet samples. Chlordane was also found but not quantified. High levels (<1.0 mg/kg) of DDT metabolities were also found.

In response to these findings, the Pennsylvania Department of Environmental Resources (PADER) and the New Jersey Department of Environmental Protection (NJDEP) issued fish consumption advisories on bottom feeding fish in the Delaware River from Burlington Island to the City of Chester.

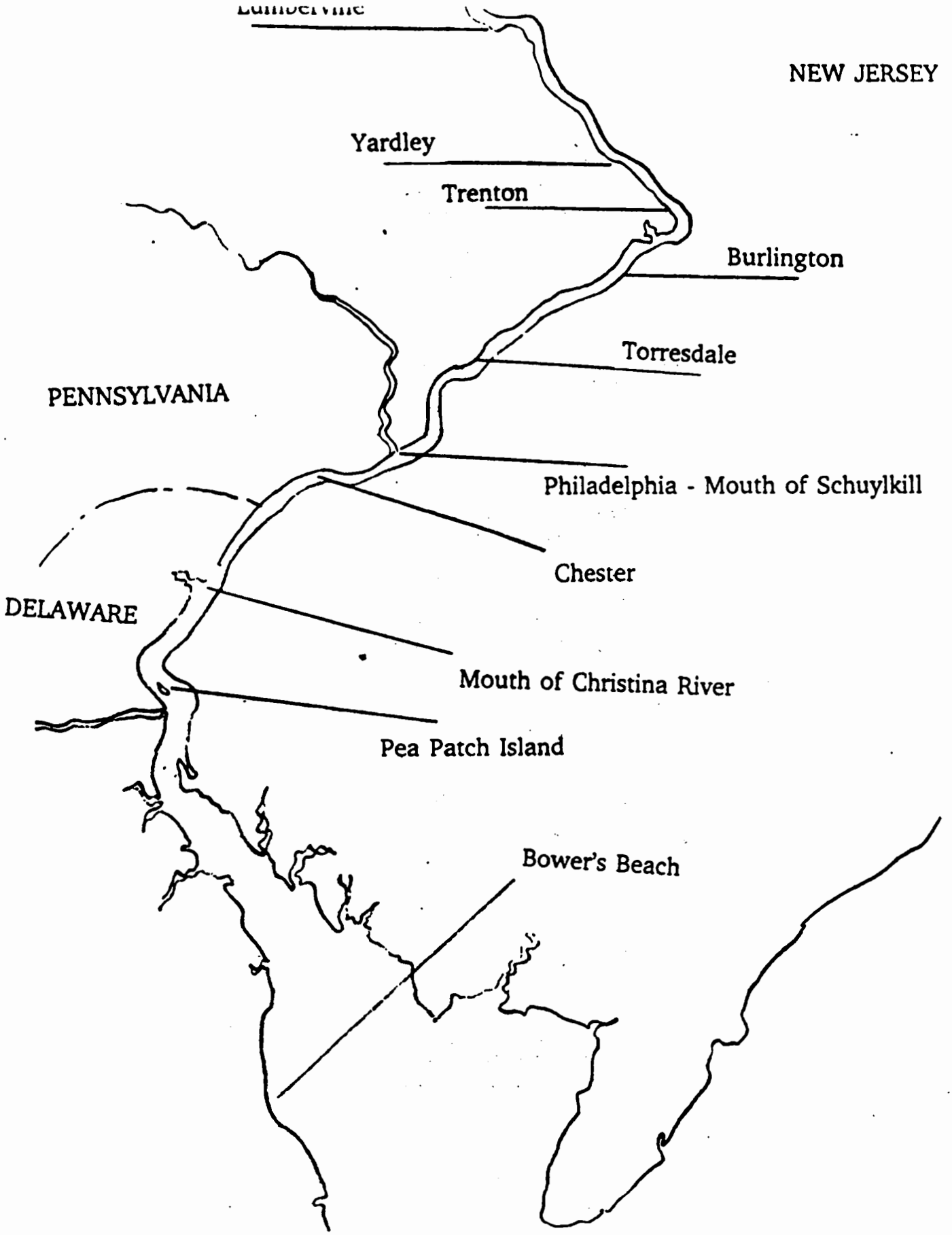
DRBC concluded in their report that the development of an estuary-wide systematic approach to fish tissue monitoring was necessary. EPA agreed with this conclusion and in an effort to initiate sampling activity decided to perform a one time sampling program to define the area of contamination and to make recommendation on the need to expand the current risk consumption advisory. The information presented in this report is a result of this EPA initiative which took place in June 1989.

II. Objective

The objective of this study was to collect data to augment the information gathered by DRBC on fish tissue contamination by determining the spatial extent of the contamination and expanding the list of parameters investigated. EPA would also review the current fish consumption advisory and make a recommendation on the need to expand the advisory based on comparisons with FDA Action Levels.

III. Monitoring Network Design and Rationale

Station locations (Figure 1) were selected based upon the results of the DRBC study and the need to determine if the contamination extended beyond the area monitored by that study. Stations selected upstream of the DRBC study were Trenton at the head of tide, Yardley and Lumberville. Previous data from STORET and the EPA study, A Study of Fish Tissue and Sediment in the Lehigh and Delaware Rivers near Easton, Pa, indicated that PCB concentrations in fish tissue do not exceed the FDA Action Level of 2 mg/kg upstream of these locations. Data Collected for DRBC at Trenton and for PADER at Yardley have indicated that the FDA Action level may be exceeded in some species of whole fish at Trenton and Yardley.



SAMPLING LOCATIONS

Figure 1

Three stations were selected in the area monitored by the DRBC study. The Burlington-Bristol Bridge and Torresdale stations were chosen because of the high use of the fishery in these areas. Also, the study results indicated that the channel catfish sample from Burlington-Bristol Bridge contained a PCB concentration less than the FDA Action Level while all of the other stations exceeded the Action Level. The tidal Schylkill River (below Fairmont Dam) was selected because it serves as an accumulation point for contaminants from the Schylkill River dischargers as well as numerous combined sewer overflow points from the Philadelphia area.

In the lower end of the Delaware Estuary, three sites were identified for sampling along with one station in Delaware Bay. Chester was chosen because of the industrial discharges and the utilization of the Delaware River fishery from the Chester boat ramp. Wilmington was selected because of the numerous sources from the urban area and the potential use of the water resources from this highly populated area. The next station selected was at Pea Patch Island. Information provided by the Delaware Department of Natural Resources and Environmental Control (DNREC) indicated that the FDA Action Level for PCB's was exceeded in a sample of one large channel catfish at this site. Lastly, one station was selected in the Delaware Bay, off of Bowers Beach, to monitor for large bluefish (over 20 inches) and crabs. Previous data indicated that the smaller bluefish were not exceeding the FDA Action Level, but there were concerns about the larger fish.

IV. Parameters

A priority pollutant scan was performed on all samples. Table 1, listed below, indicates parameters (by category), EPA analytical method and quantitations limit.

Table 1
Quantitation Limits (Q.L)

Analyte	EPA Method	Q.L. (ppm)
Metals	AA/ICP	0.1
PCBs	8080	0.05
Pesticides	8080	0.01
Volatiles	8260	0.05
Semivolatiles	8270	2.0

V. Frequency

The collection of the fish tissue samples occurred during the last two weeks of June 1989. This was a one time sampling event, but it is hoped that this study will provide baseline data for a future annual fish tissue sampling program in the Delaware Estuary.

VI. Sampling Procedures

Table 2 listed below identifies the station, target species, and number of fish per sample. Samples were composited to reduce random sampling error. All individuals in the samples were weighed and measured. Except for the crabs, all samples were filleted and composited at the site by EPA personnel. Gamefish were filleted with skin-on (except bluefish). Since larger bluefish were collected, the samples were prepared with skin-off according to normal consumption preparation procedures. Bottomfeeders (catfish) were filleted with skin-off. The crabs were prepared by removing carapace, legs, hepatopancreas, and gills, and rinsed with distilled water. Stainless steel instruments (hexane and acetone rinsed) were used for sample preparation. Samples were examined for lip and skin tumors or other abnormalities.

Table 2
Target Species

Station	Species Gamefish	Number Per Sample	Species Bottomfeeder	Number Per Sample
Lumberville	S. Bass	5	Ch. Catfish	5
Yardley	S. Bass	5	Ch. Catfish	5
Trenton	L. Bass	5	Ch. Catfish	5
Burl-Bris Br.	L. Bass	5	Ch. Catfish	5
Torresdale	L. Bass	5	Ch. Catfish	5
Tidal Schykl.	L. Bass	5	Ch. Catfish	5
Chester	W. Perch	10	Ch. Catfish	5
Wilmington	W. Perch	10	Ch. Catfish	5
Pea Patch Is.	W. Perch	10	Ch. Catfish	5
Bowers Beach	Bluefish	5	Blue Claw Crabs	12

Unfortunately, the target species were not available at all of the stations. In some cases, largemouth and smallmouth bass were combined for the gamefish sample and catfish species were mixed for the bottomfeeder sample. Also, yellow perch were substituted for white perch at the Wilmington Station because of the overabundance of yellow perch compared to white perch. Also, White perch were not found at Pea Patch Island. No substitution was made because fish were unavailable. In some cases, the targeted number of individuals per sample was not met. At a minimum, 50% of the targeted number must have been captured or the sample was discarded. Table 3, listed below, presents information on the individual fish captured at each station.

Table 3
Sample Statistics

Station	Species	Fish #	Length (cm)	Weight (gm)
Lumberville, PA	Channel Cat.	1	47.0	1130.0
Lat/402428	Channel Cat.	2	39.5	575.0
Long/750219	Brown Bullhead	3	38.0	720.0
Date 6/20/89				
	Smallmouth bass	1	26.0	200.0
	Smallmouth bass	2	24.0	160.0
	Smallmouth bass	3	25.0	190.0
	Smallmouth bass	4	21.0	100.0
	Smallmouth bass	5	32.5	400.0
Yardley, PA	Channel Cat.	1	40.5	590.0
Lat/401535	Channel Cat.	2	42.0	760.0
Long/745052	Channel Cat.	3	45.0	850.0
Date 6/20/89	Channel Cat.	4	42.5	740.0
	Channel Cat.	5	43.0	810.0
	Smallmouth bass	1	40.5	900.0
	Smallmouth bass	2	44.5	1130.0
	Smallmouth bass	3	36.0	640.0
	Smallmouth bass	4	37.5	710.0
	Smallmouth bass	5	43.0	1000.0
South Trenton, NJ	Channel Cat.	1	42.0	680.0
Lat/401159	Channel Cat.	2	42.0	710.0
Long/744550	Channel Cat.	3	41.0	570.0
Date 6/21/89	Channel Cat.	4	40.5	610.0
	Channel Cat.	5	41.0	680.0
	Largemouth bass	1	37.0	910.0
	Largemouth bass	2	31.5	370.0
	Smallmouth bass	3	33.0	460.0
Burlington, NJ	Channel Cat.	1	39.0	500.0
Lat/400452	Channel Cat.	2	38.0	530.0
Long/745207	Channel Cat.	3	38.0	500.0
Date 6/21/89	Channel Cat.	4	38.0	515.0
	Channel Cat.	5	39.5	520.0
	Largemouth bass	1	39.5	820.0
	Largemouth bass	2	39.0	890.0
	Largemouth bass	*3	41.0	960.0

*collected 6/22/89

TABLE 3 (Con't)

Station	Species	Fish #	Length (cm)	Weight (gm)
Torresdale, PA	Channel Cat.	1	40.0	580.0
Lat/400158	Channel Cat.	2	41.5	770.0
Long/745942	Channel Cat.	3	42.5	745.0
Date 6/22/89	Channel Cat.	4	39.0	560.0
	Channel Cat.	5	42.0	730.0
	Largemouth bass	1	32.5	490.0
	Largemouth bass	2	40.0	890.0
	Largemouth bass	*3	31.5	520.0
Philadelphia, PA	Channel Cat.	1	43.0	795.0
Lat/395318	Channel Cat.	2	44.5	725.0
Long/751146	Channel Cat.	3	45.0	760.0
Date 6/23/89	Channel Cat.	4	44.5	840.0
(mouth of Schuylkill River)	Channel Cat.	5	41.5	595.0
	Largemouth bass	1	36.0	700.0
	Largemouth bass	2	30.5	420.0
	Largemouth bass	3	25.5	235.0
	Largemouth bass	4	25.0	250.0
	Largemouth bass	5	28.0	360.0
Chester Island	Channel Cat.	1	45.0	800.0
Lat/395012	Channel Cat.	2	38.0	470.0
Long/752000	Channel Cat.	3	41.5	635.0
Date 6/28/89	Channel Cat.	4	40.0	590.0
	Channel Cat.	5	45.5	780.0
	White Perch	1	16.0	55.0
	White Perch	2	17.5	65.0
	White Perch	3	16.0	60.0
	White Perch	4	15.5	45.0
	White Perch	5	24.0	185.0
	White Perch	6	17.0	75.0
	White Perch	7	21.5	165.0
	White Perch	8	16.0	65.0
	White Perch	9	16.5	65.0
	White Perch	10	15.0	50.0

*collected 6/23/89

TABLE 3 (Con't)

Station	Species	Fish #	Length (cm)	Weight (gm)
Wilmington, DE	Channel Cat.	1	47.0	925.0
Lat/394344	Channel Cat.	2	46.0	965.0
Long/753200	Channel Cat.	3	40.5	610.0
Date 6/27/89	Channel Cat.	4	46.0	960.0
	Channel Cat.	5	38.0	490.0
	Yellow Perch	1	25.5	170.0
	Yellow Perch	2	22.5	135.0
	Yellow Perch	3	23.0	175.0
	Yellow Perch	4	22.0	130.0
	Yellow Perch	5	24.5	210.0
	Yellow Perch	6	20.0	120.0
	Yellow Perch	7	22.0	120.0
	Yellow Perch	8*		
	Yellow Perch	9*		
	Yellow Perch	10*		
Pea Patch Island	Channel Cat.	1	43.0	750.0
Lat/393506	Channel Cat.	2	36.5	415.0
Long/753422	Channel Cat.	3	52.0	1840.0
Date 6/28/89	Channel Cat.	4	29.5	200.0
	White Cat.	5	30.0	400.0
Bowers Beach, DE	Bluefish	1	43.0	940.0
Lat/390508	Bluefish	2	59.0	1460.0
Long/752120	Bluefish	3	48.0	980.0
Date 6/28/89	Bluefish	4	49.5	1060.0
	Bluefish	5	54.5	1430.0
	Blue Claw Crab	1	17.5	250.0
	Blue Claw Crab	2	14.5	190.0
	Blue Claw Crab	3	17.0	220.0
	Blue Claw Crab	4	15.5	180.0
	Blue Claw Crab	5	15.6	195.0
	Blue Claw Crab	6	16.0	180.0
	Blue Claw Crab	7	15.5	210.0
	Blue Claw Crab	8	16.0	200.0
	Blue Claw Crab	9	19.0	280.0
	Blue Claw Crab	10	16.0	220.0
	Blue Claw Crab	11	15.5	210.0
	Blue Claw Crab	12	16.0	220.0
	Blue Claw Crab	13	15.5	200.0
	Blue Claw Crab	14	16.8	210.0

*Data Lost. Fish were approximately same size and weight as other yellow perch.

Fish were captured using several methods. Trotlines were used exclusively to capture catfish. Hooks were baited with hot dogs or chicken livers. Generally, the trotlines were left out approximately 4 hours. In two cases (Yardley and Chester), the trotlines were left out overnight. Predators were captured primarily with electroshocking equipment. On occasion when the electroshocking equipment malfunctioned or was unsuccessful angling was used. The bluefish and crabs from Bowers Beach were purchased from Frenche's Fish Market because equipment was not available to access Delaware Bay. The Delaware Department of Natural Resources and Environmental Control recommended Frenche's based previous experience. Since we were able to identify the approximate location of the fish collection point, we believe that this collection method was valid.

VII. Results

All of the analytical results and quality assurance information are presented in appendix A of this report. It should be noted that the volatile parameter analysis was not completed due to laboratory contamination of the samples with methylene chloride. Also, the analysis for extractable organics showed no quantifiable results for the semivolatile compounds and are therefore not discussed. Results were quantified for metals, pesticides and PCBs and are presented below in table 4.

It should also be noted that during the last week of June 1989, a massive oil spill occurred on the Delaware River from Chester, Pennsylvania to Delaware City, Delaware. During this spill, samples were collected between Chester Pennsylvania and Pea Patch Island. Although much of our equipment and bodies were contaminated with oil, there was no indication that this spill affected the fish. There was no indication from the data collected that the results were affected by the oil spill except for some trace levels of methylnaphthalene found at Chester and Pea Patch Island.

The analytical results showed very few parameters that were quantifiable. Table 5, listed below, indicates the parameters that were quantifiable as well as criteria utilized for comparison. Since FDA Action Levels are only available for a few parameters, comparisons were also made with international legal limits for fish and shellfish. These legal limits were extracted from the EPA document (EPA-503/8-89-002) Assessing Human Health Rishs from Chemcially Contaminated Fish and Shellfish: A Guidance Manual.

TABLE 4
Metals, Pesticides and PCBS

PARAMETER	Lumberville - CAT	Lumberville - SMB	Yardley - CHC	Yardely - SMB	Trenton - SMB/LMB	Trenton - CHC
% Lipid	7.46	0.35	5.49	0.89	1.47	10.35
Antimony (ug/g)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic (ug/g)	<0.1	0.21	<0.1	<0.1	<0.1	<0.1
Beryllium (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium (ug/g)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Copper (ug/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lead (ug/g)	<0.1	<0.1	0.11	<0.1	0.12	<0.1
Nickel (ug/g)	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Selenium (ug/g)	0.12	0.11	0.48	0.35	0.2	0.16
Silver (ug/g)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Thallium (ug/g)	<0.1	<0.1	<0.1	0.15	0.16	<0.1
Zinc (ug/g)	6.6	6.6	9.5	6.4	9.2	6.5
Mercury (ug/g)	0.11	0.13	0.19	0.31	0.26	0.08
alpha-BHC (mg/kg) wet	ND	ND	ND	ND	ND	ND
beta-BHC (mg/kg) wet	ND	ND	ND	ND	ND	ND
delta-BHC (mg/kg) wet	ND	ND	ND	ND	ND	ND
gamma-BHC (mg/kg) wet	ND	ND	ND	ND	ND	ND
Heptachlor (mg/kg) wet	ND	ND	ND	ND	ND	ND
Aldrin (mg/kg) wet	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide (mg/kg) wet	ND	ND	ND	ND	ND	ND
Endosulfan I (mg/kg wet	ND	ND	ND	ND	ND	ND
4,4' - DDE (mg/kg) wet	0.18	0.02	0.07	0.18	0.37	0.41
Endrin (mg/kg) wet	ND	ND	ND	ND	ND	ND
Endosulfan II (mg/kg) wet	ND	ND	ND	ND	ND	ND
4,4' - DDD (mg/kg) wet	0.02	0.002	0.01	0.02	0.06	0.07
Endosulfan sulfate (mg/kg) wet	ND	ND	ND	ND	ND	ND
4,4'- DDT (mg/kg) wet	ND	ND	ND	ND	ND	ND
Endrin aldehyde (mg/kg) wet	ND	ND	ND	ND	ND	ND
Endrin ketone (mg/kg) wet	ND	ND	ND	ND	ND	ND
Chlordane (mg/kg) wet	0.01	0.001J	0.003	0.003	0.007	0.02
Methoxychlor (mg/kg) wet	ND	ND	ND	ND	ND	ND
Toxaphene (mg/kg) wet	ND	ND	ND	ND	ND	ND
Total PCBs (mg/kg) wet	0.45	0.16	0.17	0.24	0.68	1.13

TABLE 4 (con't)

Metals, Pesticides and PCBS

PARAMETER	Burlington Bridge -CHC	Burlington Bridge - LMB	Torresdale - CHC	Torresdale - LMB	Schuylkill River - CHC
% Lipid	5.68	1.25	6.20	0.30	8.00
Antimony (ug/g)	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1
Beryllium (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium (ug/g)	<0.2	<0.2	<0.2	0.5	<0.2
Copper (ug/g)	<1.0	<1.0	<1.0	<1.0	<1.0
Lead (ug/g)	<0.1	0.1	0.12	<0.1	<0.1
Nickel (ug/g)	<0.8	<0.8	<0.8	<0.8	<0.8
Selenium (ug/g)	<0.1	.22	0.16	0.15	0.24
Silver (ug/g)	<2.0	<2.0	<2.0	<2.0	<2.0
Thallium (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc (ug/g)	5.4	9.3	5.6	7.8	5.9
Mercury (ug/g)	0.10	0.29	0.07	0.13	0.08
alpha-BHC (mg/kg) wet	ND	ND	ND	ND	ND
beta-BHC (mg/kg) wet	ND	ND	ND	ND	ND
delta-BHC (mg/kg) wet	ND	ND	ND	ND	ND
gamma-BHC (mg/kg) wet	ND	ND	ND	ND	ND
Heptachlor (mg/kg) wet	ND	ND	ND	ND	ND
Aldrin (mg/kg) wet	ND	ND	ND	ND	ND
Heptachlor Epoxide (mg/kg) wet	ND	ND	ND	ND	ND
Endosulfan I (mg/kg wet	ND	ND	ND	ND	ND
4,4' - DDE (mg/kg) wet	0.63	0.76	2.40	0.17	0.86
Endrin (mg/kg) wet	ND	ND	ND	ND	ND
Endosulfan II (mg/kg) wet	ND	ND	ND	ND	ND
4,4' - DDD (mg/kg) wet	0.12	0.10	0.43	0.03	0.18
Endosulfan sulfate (mg/kg) wet	ND	ND	ND	ND	ND
4,4'- DDT (mg/kg) wet	ND	ND	ND	ND	ND
Endrin aldehyde (mg/kg) wet	ND	ND	ND	ND	ND
Endrin ketone (mg/kg) wet	ND	ND	ND	ND	ND
Chlordane (mg/kg) wet	0.02	0.01	0.05	0.002	0.04
Methoxychlor (mg/kg) wet	ND	ND	ND	ND	ND
Toxaphene (mg/kg) wet	ND	ND	ND	ND	ND
Total PCBs (mg/kg) wet	0.83	0.76	1.93	0.23	1.4

TABLE 4 (con't)

Metals, Pesticides and PCBS

PARAMETER	Schuylkill River - LMB	Chester - WP	Chester - CHC	Christina River - YP	Christina River - CHC
% Lipid	0.53	2.25	8.03	0.44	5.28
Antimony (ug/g)	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic (ug/g)	<0.1	<0.1	<0.1	0.12	<0.1
Beryllium (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium (ug/g)	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium (ug/g)	<0.2	<0.2	<0.2	<0.2	<0.2
Copper (ug/g)	<1.0	<1.0	<1.0	<1.0	<1.0
Lead (ug/g)	<0.1	<0.1	<0.1	<0.1	0.11
Nickel (ug/g)	<0.8	<0.8	<0.8	<0.8	<0.8
Selenium (ug/g)	0.34	0.44	0.3	0.29	0.16
Silver (ug/g)	<2.0	<2.0	<2.0	<2.0	<2.0
Thallium (ug/g)	<0.1	<0.1	<0.1	<0.2	<0.1
Zinc (ug/g)	10.8	8.8	5.9	10.4	7.5
Mercury (ug/g)	0.14	0.19	0.09	0.11	0.18
alpha-BHC (mg/kg) wet	ND	ND	ND	ND	ND
beta-BHC (mg/kg) wet	ND	ND	ND	ND	ND
delta-BHC (mg/kg) wet	ND	ND	ND	ND	ND
gamma-BHC (mg/kg) wet	ND	ND	ND	ND	ND
Heptachlor (mg/kg) wet	ND	ND	ND	ND	ND
Aldrin (mg/kg) wet	ND	ND	ND	ND	ND
Heptachlor Epoxide (mg/kg) wet	ND	ND	ND	ND	ND
Endosulfan I (mg/kg wet	ND	ND	ND	ND	ND
4,4' - DDE (mg/kg) wet	0.10	0.38	2.77	0.01	1.03
Endrin (mg/kg) wet	ND	ND	ND	ND	ND
Endosulfan II (mg/kg) wet	ND	ND	ND	ND	ND
4,4' - DDD (mg/kg) wet	0.02	0.09	0.58	0.003	0.21
Endosulfan sulfate (mg/kg) wet	ND	ND	ND	ND	ND
4,4'- DDT (mg/kg) wet	ND	ND	ND	ND	ND
Endrin aldehyde (mg/kg) wet	ND	ND	ND	ND	ND
Endrin ketone (mg/kg) wet	ND	ND	ND	ND	ND
Chlordane (mg/kg) wet	0.006	0.15	0.08	0.01	0.04
Methoxychlor (mg/kg) wet	ND	ND	ND	ND	ND
Toxaphene (mg/kg) wet	ND	ND	ND	ND	ND
Total PCBs (mg/kg) wet	0.44	0.86	3.0	.04J	2.38

TABLE 4 (con't)
Metals, Pesticides and PCBS

PARAMETER	Pea Patch Island - CAT	Bower's Beach - Blue Fish	Bower's Beach Crabs
% Lipid	9.33	0.78	not reported
Antimony (ug/g)	<0.2	<0.2	<0.4
Arsenic (ug/g)	<0.1	0.14	2.6
Beryllium (ug/g)	<0.1	<0.1	<0.1
Cadmium (ug/g)	<0.1	<0.1	<0.1
Chromium (ug/g)	<0.2	<0.2	0.30
Copper (ug/g)	<1.0	<1.0	9.2
Lead (ug/g)	<0.1	<0.1	<0.1
Nickel (ug/g)	<0.8	<0.8	<0.8
Selenium (ug/g)	0.23	0.37	0.9
Silver (ug/g)	<2.0	<2.0	<0.4
Thallium (ug/g)	<0.1	<0.1	<0.1
Zinc (ug/g)	6.2	7.4	37.2
Mercury (ug/g)	0.06	0.23	0.05
alpha-BHC (mg/kg) wet	ND	ND	ND
beta-BHC (mg/kg) wet	ND	ND	ND
delta-BHC (mg/kg) wet	ND	ND	ND
gamma-BHC (mg/kg) wet	ND	ND	ND
Heptachlor (mg/kg) wet	ND	ND	ND
Aldrin (mg/kg) wet	ND	ND	ND
Heptachlor Epoxide (mg/kg) wet	ND	ND	ND
Endosulfan I (mg/kg wet	ND	ND	ND
4,4' - DDE (mg/kg) wet	0.60	0.03	ND
Endrin (mg/kg) wet	ND	ND	ND
Endosulfan II (mg/kg) wet	ND	ND	ND
4,4' - DDD (mg/kg) wet	0.13	ND	ND
Endosulfan sulfate (mg/kg) wet	ND	ND	ND
4,4- DDT (mg/kg) wet	ND	ND	ND
Endrin aldehyde (mg/kg) wet	ND	ND	ND
Endrin ketone (mg/kg) wet	ND	ND	ND
Chlordane (mg/kg) wet	0.03	ND	ND
Methoxychlor (mg/kg) wet	ND	ND	ND
Toxaphene (mg/kg) wet	ND	ND	ND
Total PCBs (mg/kg) wet	1.77	0.07	ND
			ND

Table 5

Fish Tissue Criteria
(ppm)

Parameter	International Limits (Range)	FDA Action Level
Arsenic	0.1 - 10.0	
Chromium	1.0	
Lead	0.5 - 10.0	
Selenium	0.05 - 2.0	
Thallium	-	-
Zinc	30.0 - 1000.0	
Mercury	0.1 - 1.0	1.0
DDD, DDE, DDT	2.0 - 5.0	5.0
Chlordane	0.01 - 0.3	0.3
PCBs	1.0 - 5.0	2.0

Based on the international limits for metals, two parameters could be identified as having elevated levels in fish, arsenic and selenium. Arsenic was found at Yardley in smallmouth bass at a concentration of 0.21 ppm and at Wilmington (Christina River) in yellow perch at a concentration of 0.12 ppm. Venezuela has a legal limit of 0.1 ppm and Chile has a limit of 0.12. Several other nations have limits ranging from 1.0 to 10.0 ppm which were not exceeded. Selenium was also found to exceed the Chilean limit of 0.05 at most of the stations. Other countries have levels of 1.0 - 2.0 ppm which were not exceeded. The shellfish data from the crabs collected at Bower's Beach indicated elevated levels of arsenic, selenium, and zinc when complared to the international limits lower range, but were will below the upper range limit.

Mercury, DDD and DDE, chlordane, and PCBs were found at quantifiable levels at all stations. Figures 2 through 6 indicate the spatial extent of the contamination by stations and species for each of these parameters. Only PCBs exceeded FDA Action Level. The late arrival of the data on the crabs precluded data entry in Figures 2 through 6. No organic contamination was quantified in the crabs collected at Bowers Beach.

Low level (<0.5 ppm) mercury (see Figure 2) contamination was widespread throughout the area of study. Contamination occurred in both the bottomfeeders and the predators because mercury tends to accumulate in muscle tissue rather than in the lipids where PCBs and pesticides are commonly found. The bottomfeeders in this study contained a much higher percent of lipids than the predators. Consequently, the organic contamination was much greater in the bottomfeeders. However, the mercury contamination was generally higher in the predators. The highest levels were found at Yardley, Trenton, Burlington and Bowers Beach.

Total DDT metabolites (see Figure 3) were found at high levels (>1.00 ppm) in channel catfish at Torresdale, Schylkill River, Chester and mouth of the Christina River. The levels found at Torresdale and Chester were extreme in comparison to the levels found at the other stations but still below FDA Actions Levels.

Chlordane (see Figure 4) levels were surprisingly low considering that the New Jersey Department of Environmental Protection has a fish consumption advisory in the Camden County area due to chlordane contamination in bottomfeeders exceeding the FDA Action Level of 0.3 ppm. The Chester station had the highest concentration of chlordane at 0.15 ppm in white perch. This is also surprising. Generally, the bottomfeeders such as catfish contain higher levels of pesticides than the pelagic species.

The PCB exceedances (see Figures 5) of the FDA Action Level of 2.0 ppm occurred at Wilmington, DE (mouth of Christina River) and at Chester, PA in channel catfish only. It should be noted that the catfish samples from Pea Patch Island, mouth of the Schuylkill River, Torresdale and Trenton stations contained high levels (>1.0 ppm) of PCBs. As indicated by figure 5, the PCB contamination is widespread in the Delaware Estuary with the peak concentration at Chester, PA. The high levels found in catfish should be used as an indicator of high level contamination in other bottomfeeding fish as well.

The PCB date presented in Figure 6 shows the distribution of the PCB contamination by Aroclor. Only Aroclor 1254 and Aroclor 1260 were found to be contributing to the PCB contamination. Aroclor 1254 was found to be the main contribution from the mouth of the Schylkill River to Lumberville. Aroclor 1260 was the main contributor from Chester, PA to Pea Patch Island. This could be an indication of different sources of contamination.

MERCURY LEVELS IN DELAWARE RIVER FISH TISSUE COLLECTED IN 1989

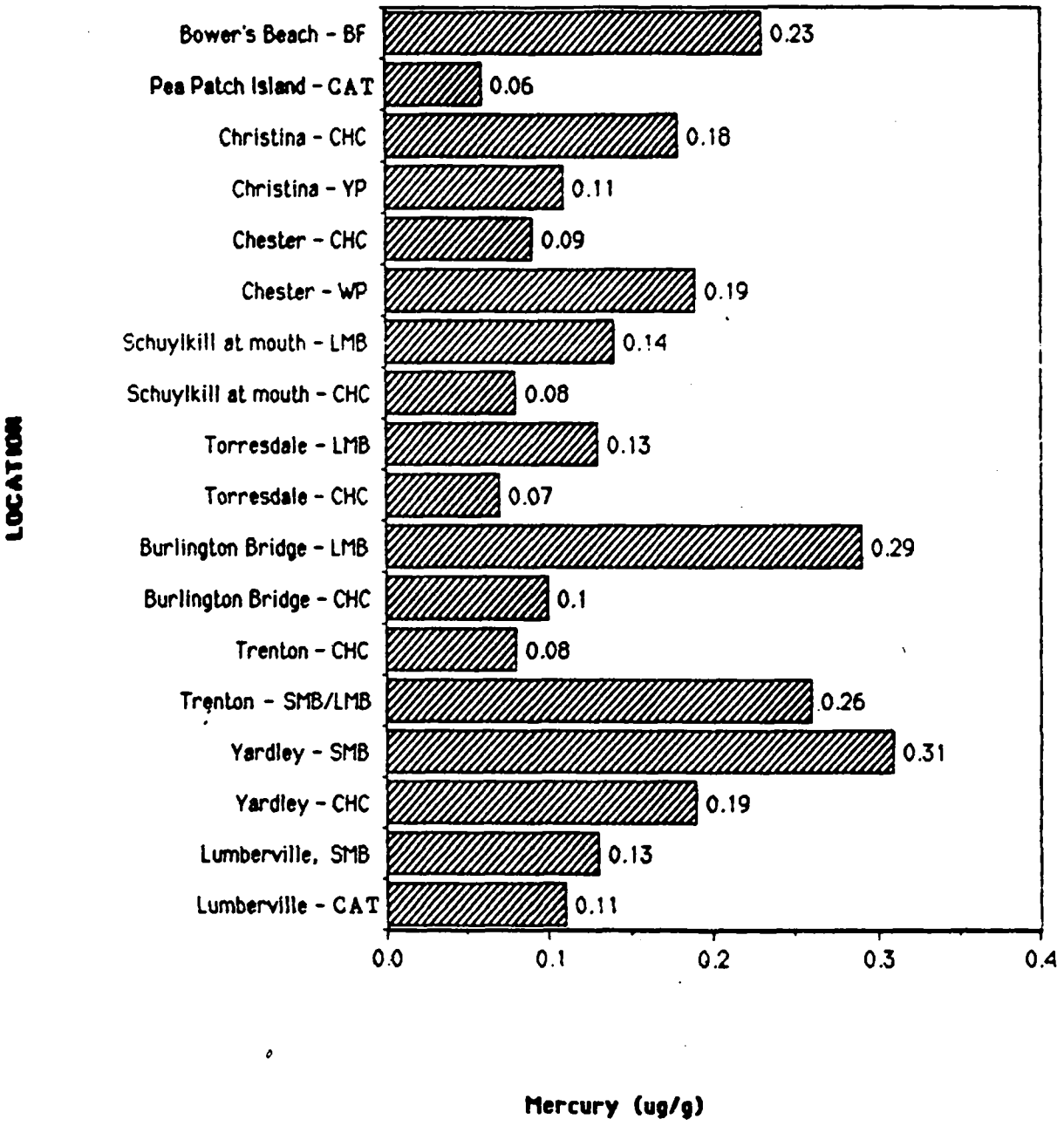


Figure 2

DDT METABOLITES (DDE AND DDD) LEVELS IN DELAWARE RIVER FISH TISSUE COLLECTED IN 1989

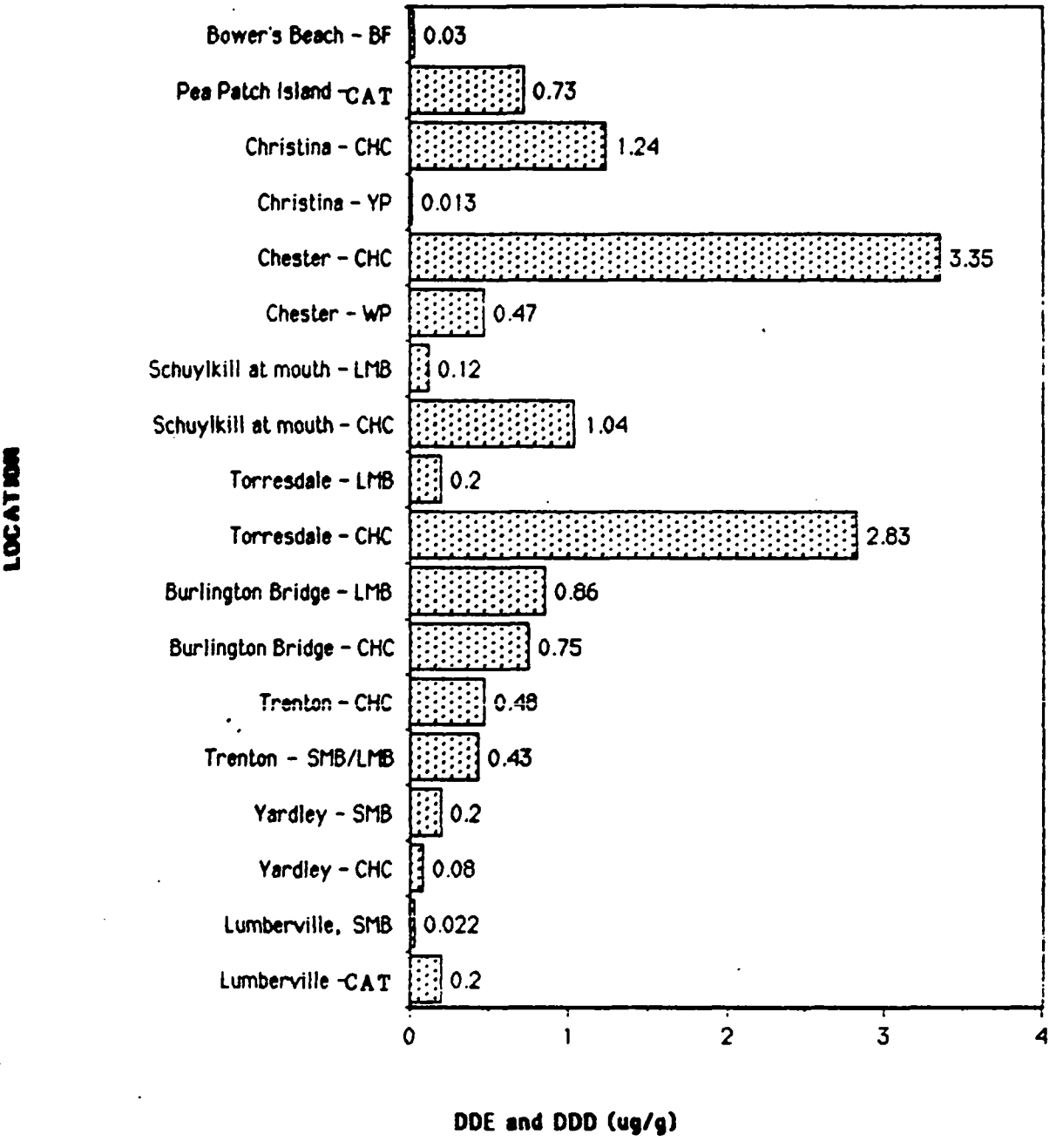


Figure 3

CHLORDANE LEVELS IN DELAWARE RIVER FISH TISSUE COLLECTED IN 1989

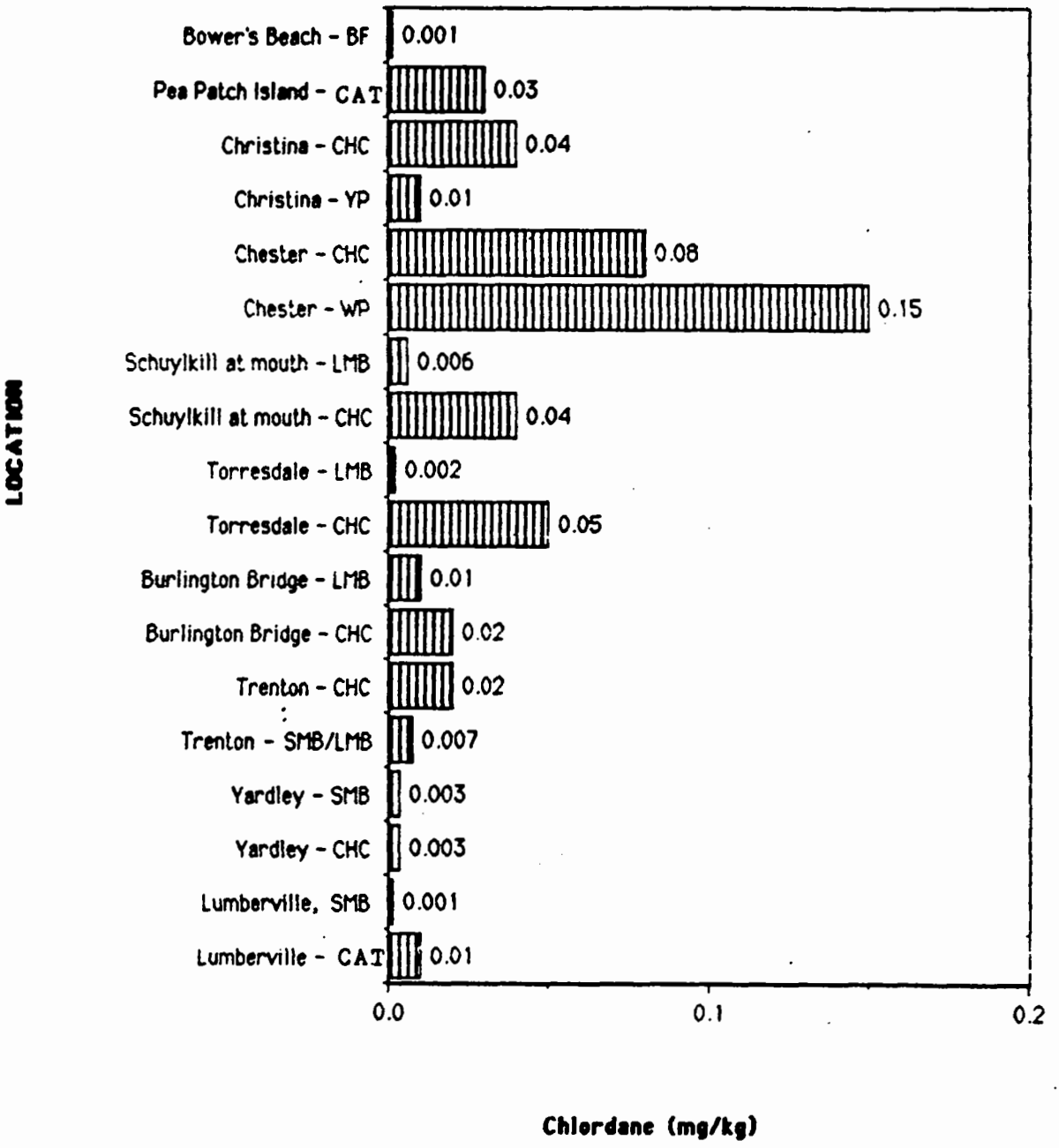


Figure 4

PCB LEVELS IN DELAWARE RIVER FISH TISSUE
COLLECTED IN 1989

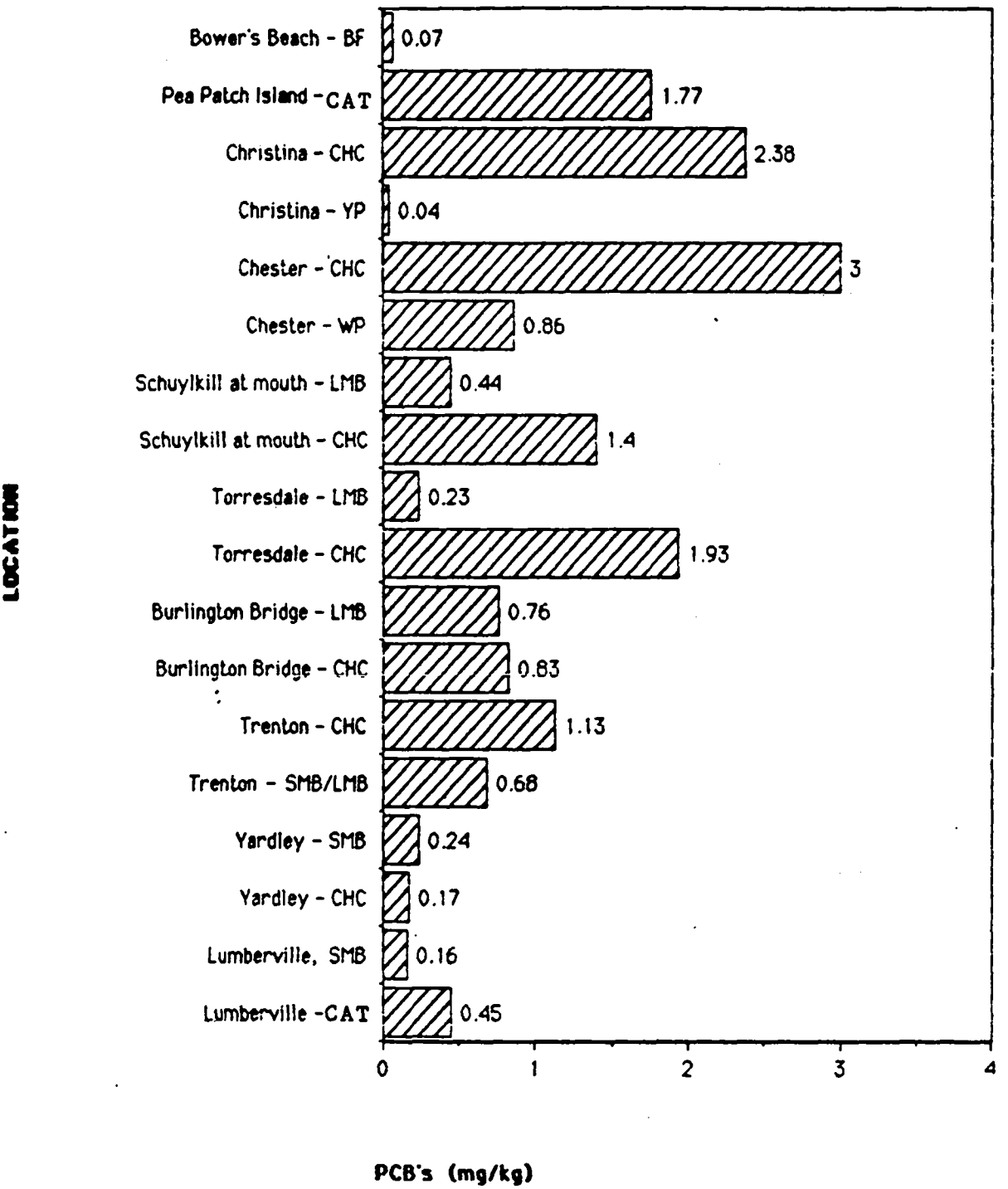


Figure 5

A COMPARISON OF AROCLOR 1254 AND AROCLOR 1260 IN FISH TISSUE COLLECTED FROM THE DELAWARE RIVER IN 1989

Note : Aroclor 1254 was found in higher concentrations than Aroclor 1260 from Lumberville to the mouth of the Schuylkill. At and downstream of Chester, this pattern was reversed and Aroclor 1260 was found in larger concentrations.

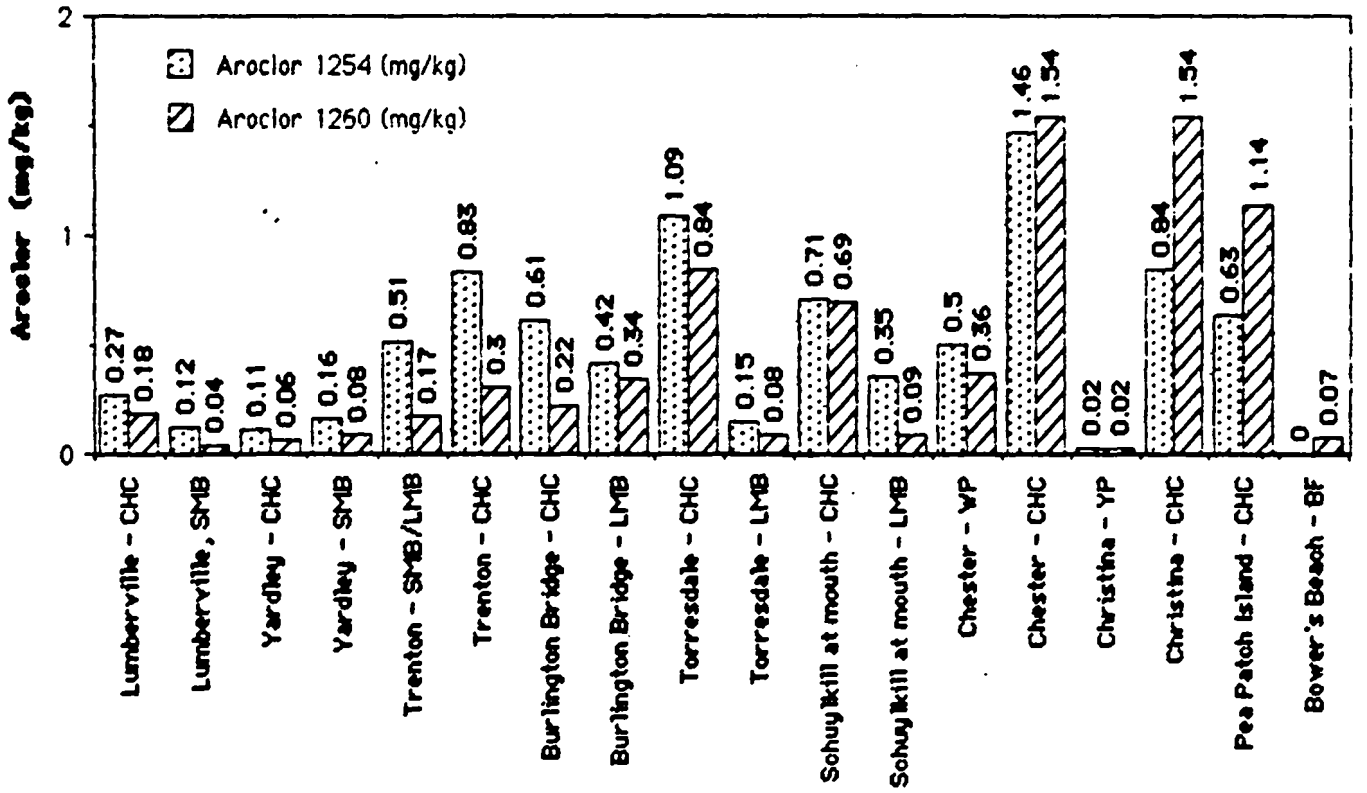


Figure 6

VIII. Recommendation:

Based on the level of PCBs found at Chester, mouth of Christina River and Pea Patch Island, we recommend the State of Delaware to consider issuing an advisory not to consume bottomfeeders from the tidal Delaware between the Pennsylvania-Delaware stateline to the C&D canal. This advisory would be similar to the advisories, issued by Pennsylvania and New Jersey for the Delaware River.

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Appendix A