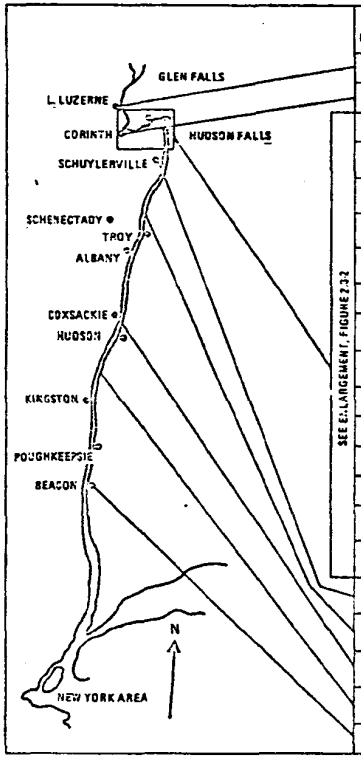
2.3.2 New York - Hudson River

The Hudson River in New York State provides an interesting ecosystem in which to study PCB's, primarily because it is the receiving water for effluents from two plants of the General Electric Co., at Hudson Falls and Fort Edward. These plants use PCB's in the production of transformers and capacitors. Summaries of extensive sampling during 1975 of the Hudson River are presented in Figures 2.3-1 and 2.3-2. The GE plants appear to be the major contributors to the PCB residue levels in the river. Although trace levels of PCB's are evident above the GE plant outfall location, levels in water and sediment at Station 1 located at the outfall of the Fort Edward plant were as high as any levels measured in the country. In the immediate area downstream from this outfall, PCB concentrations in water exceed the equilibrium solubility level by more than a factor of 10. Major effects on the levels in sediment are noted more than 35 miles downstream from the outfalls. The data indicate elevated concentrations in aquatic life far from the outfalls: fish samples approximately 40 and 66 miles downstream from the outfalls showed PCB levels in excess of 5 ppm while the same species showed only traces of PCB's directly upstream from the outfalls. Since sediment samples above the plants also show some concentration there does appear to be some PCB source upstream of the plants.



MILE POINT	DESCRIPTION	ESTIMATED PCB'S WATER (PPB)	SEDIMENT (PPM DRY)	SMALL MOUTH* BASS (PPM)	WALLEYE* (PPM)	WHITE* SUCKER (PPM)	YELLOW* PERCH (PPM)	SNAILS (PPM)	WHITE* PERCH (PPM)
223.6	AT L. LUZERNE		8						
218.8	ABOVE CORINTH	< 0.5	2.4	TRACE		TRACE	TRACE		
214.0	BELOW CORINTH		1.9						
209.9	ABOVE SHERMAN ISLAND DAM		4.8 C						
205.7	ABOVE GLEN FALLS LANDFILL		0.83	TRACE	TRACE	TRACE	TRACE		
204.8	BELOW GLEN FALLS LANDFILL		16.8						
198.9	AT PORTLAND CEMENT CO.		<0.38						
	STATION 0	<1.	8.8				17.0	1.9	
197.3	ABOVE BAKER FALLS DAM		4.8						
196.2	BELOW BAKER FALLS DAM		116. C						
	STATION 1	2800	6700					45	
	STATION 2	2.2	540.0						
	STATION 3	3.1	2580.0						
	STATION 4	<1	8.6					27.	
194.2	AT FT. EDWARD		147.9						
188.4	ABOVE THOMPSON ISLAND DAM		3707.2 C	122.9**	32.4**	41.8			
183.5	ABOVE SCHUYLERVILLE		78.5						
157.5	ABOVE WATERFORD		19	46.3	32.4	37.6			
124.9	NEAR COXSACKIE	< 0.5		13.76**			4.18		19.7
	ABOVE KINGSTON						5.28		7.72
60.8	NEAR BEACON	< 0.							

SEE ENLARGEMENT, FIGURE 2.3.2

C = MAXIMUM VALUE IN A CORE SAMPLE

* = VALUES ARE WEIGHTED AVERAGES OF SAMPLES OF FISH FROM 3 SIZE GROUPS (EXCEPT AS NOTED) TAKEN AT VARIOUS TIMES IN 1975

** = ONLY ONE FISH SAMPLED

SOURCES:

STATIONS 0-4: NADEAU, R.J. AND R.P. DAVIS, INVESTIGATION OF POLYCHLORINATED BIPHENYLS IN THE HUDSON RIVER, 1975, EPA REGION II

OTHER FISH DATA: NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, DIVISION OF FISH AND WILDLIFE, 1975, ANALYSES OF PCB'S IN FISH FLESH

OTHER WATER DATA: NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, DIVISION OF PURE WATERS, PCB MONITORING IN THE UPPER HUDSON RIVER BASIN, OCTOBER 1975

FIGURE 2.3.1 MAP OF HUDSON RIVER, NEW YORK, SHOWING DEVELOPED AREAS AND SAMPLING STATIONS WITH PCB LEVELS

MONS 062736

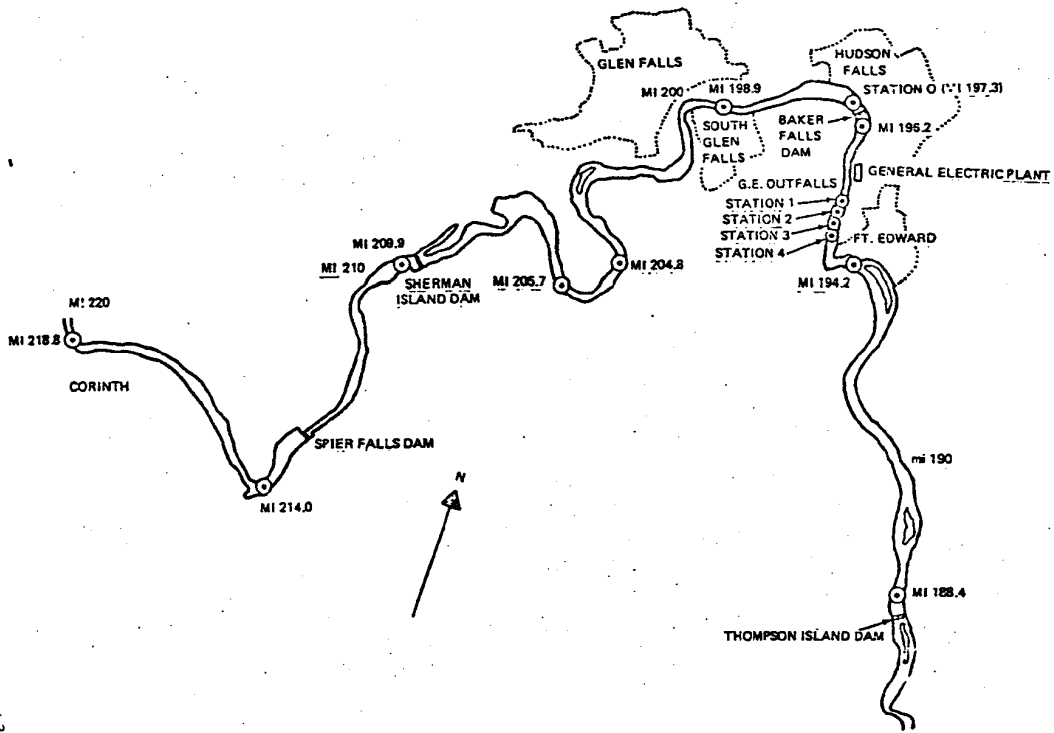


FIGURE 2.3-2 DETAILED MAP OF A PORTION OF THE HUDSON RIVER

MONS 062737

2.3.3 Maryland - Chester River

This study was conducted in the Upper Chesapeake Bay in 1971-1972;[1] the study area is shown in Figure 2.3-3 . The Bay and its tributaries receive chlorinated hydrocarbons as a result of industrial, agricultural and waste disposal activities occurring along the shorelines of these waterways and within the total watershed.

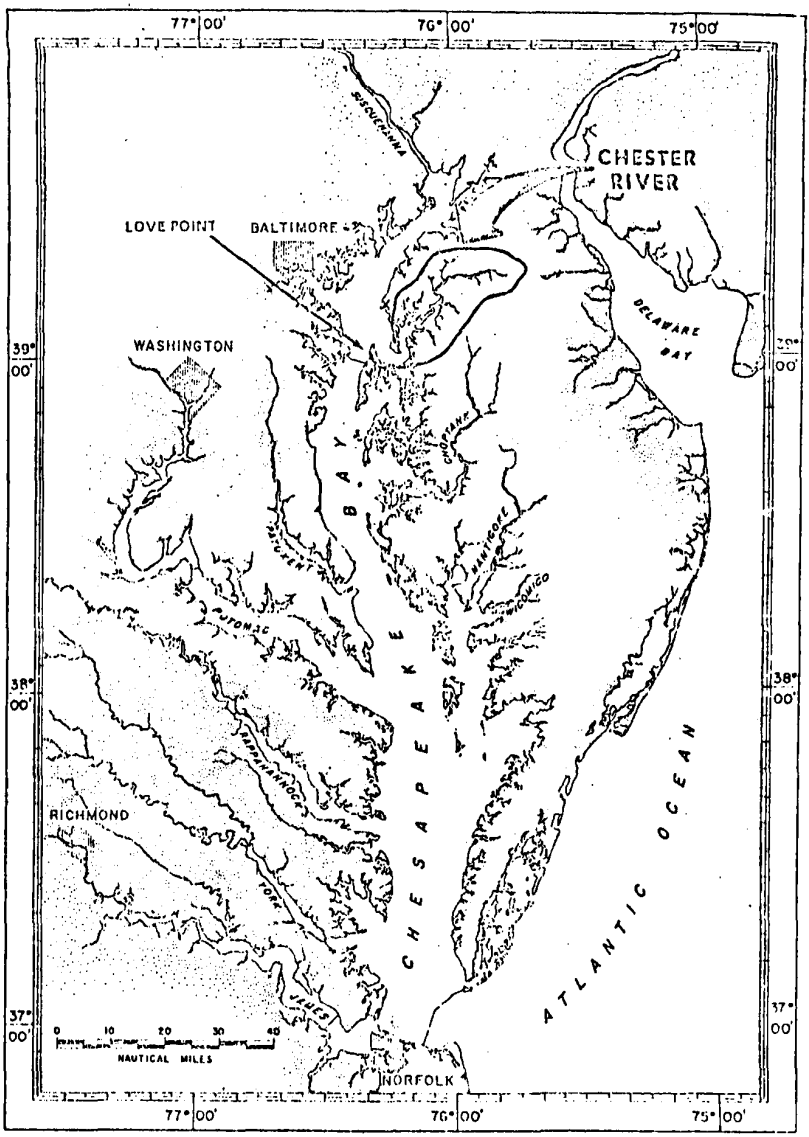
Sediment samples were collected approximately quarterly except for the last set which was taken early in order to collect data shortly after tropical storm "Agnes". The PCB's identified were almost exclusively Aroclor 1242. The first readings, taken in November 1971 ranged from 0-21 ppb with an average of 83 ppb. By April 1972 the average had climbed to 110 ppb with a range from 0-300 ppb. By June the readings taken ranged from 0-150 ppb with the average reduced to 53 ppb. After "Agnes" in July the average had again increased to 96 ppb with readings ranging from 0-180 ppb.

The explanation given for the variations is that during the early spring, massive amounts of suspended sediment from the Susquehanna River entered the Chester River and were carried upstream in the flow of water along the river bottom. The peak sediment loads from the Susquehanna generally come at the end of February, decreasing abruptly after the end of March due to a reduced flow rate of the river. An equilibrium net transport develops in the Chester River in April. In May, fine sediments were transported slowly into the Bay. However, over the year there is a movement of sediment along the river bottom into the river from the Bay. Thus, the upper Chesapeake Bay, i.e., the Susquehanna River is the major source of suspended sediments in the lower tidal portion of the Chester River.

The average values and ranges identified in biota of the Chester River taking into account variability due to seasonal fluctuations, distributional differences resulting from sample location, and species as well as individual uptake differences were as follows:

	Average (ppb)	Range (ppb)
Oysters	55	16-250
Soft shelled clams	58	13-180
Fish	18.5	2-570
Crabs	20	0.4-51

Based on data collected June 6, 1972 from the nine stations along the main river course it was determined that concentrations of PCB's decreased as a function of distance up river from its mouth at Love Point in its upstream direction at the rate of 4.20 ppb/Nautical mile.



MCNS 062739

FIGURE 2.3-3 CHART OF CHESAPEAKE BAY SHOWING MAJOR TRIBUTARIES AND LOCATION OF THE CHESTER RIVER.

2.3.4 Connecticut

In October 1974 the State of Connecticut intensively sampled bottom sediment in rivers and lakes thoughout the state. The results are shown in Figure 2.3-4, based on a computer mapping provided by the Connecticut District Office of the U.S. Geological Survey.[b] The data show PCB contamination to be both widespread and at high levels throughout the state, particularly around the highly developed areas of Hartford, New Haven, Stanford-Greenwich and all along the Housatonic River flowing from Massachusetts. The state had sampled mostly whole water for PCB's prior to 1974, with no appreciable residue levels discovered, but now has switched to a yearly bed material determination. The readings for the baseline period of October 1974 are to be updated yearly.

REFERENCES, SECTION 2.3

1. Clarke, W.D. Ed., Chester River Study, A Joint Investigation by the State of Maryland Department of Natural Resources and Westinghouse Electric Corporation, Vol. I-III, November 1972.

2. Johnson, L.G., Morris, R.L., Bulletin of Environmental Contamination and Toxicology, II, 503-510, (1974).

3. Nadeau, R.J. and R.P. Davis, Investigation of Polychlorinated Biphenyls in the Hudson River, 1974, U.S.E.P.A., Washington, D.C., 21 pp.

4. New York State Department of Environmental Conservation, Division of Fish and Wildlife, 1975, Analyses of PCB's in Fish Flesh, unpublished report.

5. New York State Department of Environmental Conservation, Division of Pure Waters, PCB Monitoring in the Upper Hudson River Basin, October 1975, unpublished report.

6. Thomas, Chester E., Assistant District Chief, Connecticut District, U.S. Geological Survey, Water Resources Division, personal communication, July, 1975.

MONS 062741

2.4 Data from Localized Monitoring Efforts - Marine Environment

2.4.1 Atlantic Ocean

In addition to the many PCB studies that have been conducted within the United States, a few studies have been carried out investigating the air, water and fish off the east coast of the United States. These studies, conducted between 1971 and 1974 covering Providence, Rhode Island; Grand Banks; Vineyard Sound; Georges Bank and Bermuda show PCB's to be extensively distributed over the Atlantic Ocean. The general sampling area is shown in Figure 2.4-1.

One of the few air studies that has been published was carried out by Harvey and Steinhauer[11] in 1973. Table 2.4-1 shows the sampling locations and Aroclor 1254 concentrations identified. The highest concentrations were in Vineyard Sound which is approximately 100-150 miles from the Boston, Hartford, New York, New Jersey complex. Over 1000 miles away at Grand Banks the concentrations were 100 times less than in Vineyard Sound. Figure 2.4-2 shows the relationship of atmospheric PCB levels with distance from these industrial areas. The seaward decrease appears to be exponential.

Later studies on PCB's in surface and subsurface waters were done by Harvey[13]. Although the concentration range across the northern North Atlantic is broad, from 1-150 ppt, the average was about 35 ppt in surface waters and 10 ppt at 200 meters depth. Looking at the lower latitudes it appears that the surface waters of the Sargasso Sea have slightly lower concentrations than other parts of the North Atlantic, averaging 27 ppt. The widespread PCB distribution implicates the atmosphere as a predominant mode of transport in the Atlantic with variations due to the seaslicks, localized rainfall or discharges from ships.

During the period of February-June 1973, PCB concentrations in the marine atmosphere of the Bermuda - Sargasso Sea and Providence, Rhode Island area were measured by Bidleman and Olney[1]. It is interesting to note that most of the PCB was trapped on the polyurethane foam collection surface suggesting that PCB's are in the atmosphere mainly as vapors rather than adsorbed onto particulate matter, or that they volatilize from the trapped particles collected on the glass fiber prefilter. Table 2.4-1 gives the locations and levels identified as Aroclor 1242 or 1248.

Sargasso Sea surface water was also measured by Bidleman and Olney[1] in 1973. From Table 2.4-2 it can be seen that the concentrations were higher in the surface layer than in the subsurface samples.

Follow-up by Harvey[12], et. al., indicated that PCB concentrations in North Atlantic surface waters declined forty fold from 1972 to 1974 presumably following the cessation of certain industrial uses of those compounds. However, Longhurst and Radford dispute the decrease stating that either the analytical methods were inaccurate or Harvey's original estimate of the total amount of dissolved PCB's in the upper 200 m was incorrect. Harvey and Steinhauer have agreed[17]

that their extrapolation may well have been improper and planned more sampling for 1975.

In 1971 a seafood monitoring program[18] was conducted on the East Coast of the United States. It is difficult to make interspecies comparisons but as can be seen in Table 2.4-3 the highest Aroclor 1260 level was in flounder from Jacksonville, Florida.

Table 2.4-1
PCB Concentrations Over the Western North Atlantic

Station	Sample volume (m^3)	ng/m^3
Bermuda	560	0.5≈
	480	0.4≈
	820	0.16≈
	500	0.15≈
	1070	0.59∝
	1320	0.30∝
	918	0.65∝
	1950	0.62∝
	1740	0.55∝
	732	0.52∝
	1300	0.61∝
	860	0.21∝
33°20'N, 65°14'W	300	1.6∝
34°39'N, 66°15'W	267	0.79∝
38°48'N, 69°14'W	222	0.72∝
40°32'N, 70°20'W	196	0.83∝
Georges Bank	105	1.4≈
(41°40'N, 67°30'W)	675	0.82≈
	660	0.58≈
	655	0.61≈
	640	0.80≈
	650	1.60≈
Vineyard Sound	105	3.9≈
(41°20'N, 70°50'W)	224	5.3≈
Grand Banks	780	0.05≈
(45°16'N, 52°08'W)	960	0.07≈
	840	0.10≈
	940	0.16≈
	540	0.05≈
Providence, R.I.	392	4.0∝
	1071	2.1∝
	744	5.8∝
	76	9.4∝

≈Calculated as Aroclor 1254
∝Calculated as Aroclor 1242 or 1248

SOURCE: Harvey, R.G. and W.G. Steinhauer, Atmospheric Environment, Nature, 252, 387-388 (November 29, 1974).

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Table 2.4-2
PCB's Measured in Sargasso Sea Area, 1973

Location	Sample*	ppt**
29°56'N, 64°40'W	SM	11.2
	SS	1.6
30°45'N, 66°55'W	SM	4.9
	SS	<0.9
30°34'N, 66°59'W	SM	8.3
	SS	1.0
28°53'N, 65°07'W	SM	42.6 , 19.3
	SS	<0.9 , <0.9
29°56'N, 63°00'W	SM	3.8
	SS	<0.9
30°00'N, 64°30'W	SM	5.6
	SS	1.6
31°34'N, 63°49'W	SM	5.0
	SS	1.8
31°38'N, 63°57'W	SM	8.4
	SS	0.9

*SM - sample is surface microlayer
SS - sample is subsurface water

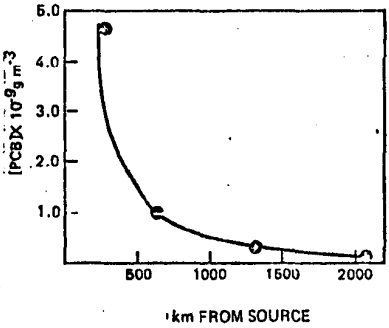
**PCB calculated as Aroclor 1260

SOURCE: Bidleman, T.F., and C.E. Olney, Science, 184, 516-518 (Feb. 8, 1974).



MONS 062746

FIGURE 2.4-1 ATLANTIC OCEAN SAMPLING SITES



SOURCE:HARVEY, G.R. AND W.G. STEINHAUER, ATMOSPHERIC ENVIRONMENT,8, 777–782, (1074).

FIGURE 2.4-2 RELATIONSHIP OF ATMOSPHERIC PCB LEVELS WITH DISTANCE FROM INDUSTRIAL AREAS

Table 2.4-3
PCB Residues in Seafood

Species	Sample Quantity	Aroclor 1260 (ppm)
	JACKSONVILLE, FLA.	
Blue crabs	15	0.08
Shrimp	1 kg	0.60
Flounder	3	0.65
Weak fish	5	0.44
Drum	5	0.17
	SAVANNAH, GA.	
Blue crabs	16	----
Shrimp	0.5 kg	----
Pilot shrimp	0.5 kg	----
Oysters	15	----
Razorback clams	28	----
Squid	5	----
Flounder	4	----
	CHARLESTON, S.C.	
Blue crabs	10	----
Shrimp	1 kg	0.02
Oysters	>15	----
Squid	>15	----
Croaker	1	----
	MOREHEAD CITY, N.C.	
Blue crabs	15	----
Shrimp	1 kg	----
Oysters	24	0.02
Clams	20	----
Scallops	12	----
Flounder	3	----
Spanish mackerel	2	----
Weak fish	2	----
Blue fish	2	----
Fish meal	0.5 kg	0.11
	CHESAPEAKE BAY	
Blue crabs	25	0.02
Weak fish	3	0.49
Striped sea bass	3	0.02
Spot	5	0.10
Herring	10	----
	DELAWARE BAY	
Blue crabs	15	0.13
Flounder	2	0.07
Weak fish	5	0.23
Striped bass	2	0.07
Mullet	5	0.21
Croaker	1	0.50

SOURCE: Markin, G.P., J.C. Hawthorne, J.L. Collins and J.H. Ford

MONS 062748

2.4.2 Bay of Fundy

As early as 1969, PCB residues were identified in harbour porpoises from the Bay of Fundy, located in the northeast section of Maine[5]. Zitko, et. al.[24], identified Aroclor 1254 in a number of different fish ranging from 0.07 ppm in the muscle of basking shark and 0.21 ppm in the muscle of sea raven to 3.55 ppm in herring oil and 218 ppm in the liver of white shark. The species studied and the levels measured are listed in Table 2.4-4.

Table 2.4-4
PCB and Chlorinated Hydrocarbon Pesticides in Aquatic Animals from the Bay of Fundy - Gulf of Maine Area.

Species	Tissue	Aroclor 1254, ppm
Herring	whole fish	0.34
Mackerel	muscle	0.35
Plaice	muscle	0.38
White hake	muscle	0.44
Ocean perch	muscle	0.32
Cod	muscle	0.55
Sea raven	muscle	0.21
	viscera	0.73
Basking shark	muscle	0.07
	liver	1.07
White shark	muscle	0.77
	liver	218
Bluefin tuna	muscle	1.54
Herring oil		3.55
Fishmeal		0.54
Double-crested cormorant	eggs	43.5
		17.2
	muscle	3.38
	liver	2.13
	subcutaneous fat	38
	abdominal fat	52
Herring gull	eggs	12.6
		5.54
	muscle liver	5.06
		6.50
	subcutaneous fat	75

SOURCE: Zitko, V., O. Hutzinger and P.M.K. Choi, Environmental Health Perspectives, 47-50, (April 1972).

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2.4.3 Gulf of Mexico - Caribbean Sea

Runoff from approximately two-thirds of the United States and one-half of Mexico enters the Gulf of Mexico and is swept generally westward to be trapped in the Western Gulf for as much as 100 years. Therefore a buildup of man-made toxic chemicals is possible in the Western Gulf especially since there is a heavy concentration of chemical manufacturers in Louisiana and Texas.[7]

The earliest samples collected in this area were brown Pelicans collected in 1969 from the Atlantic and Gulf Coast of Florida and in 1970 from Florida Bay. The highest levels, 1.0-7.5 ppm came from the Atlantic Coast while those from the Gulf Coast ranged up to 4.7 ppm and those from the Keys in the Bay only had concentrations up to 2.5 ppm. The birds represented a wide range of ages and both sexes, but the immature and adult birds always had higher residues than the young.[2]

In 1971 a seafood monitoring program[18] for the insecticide mirex was set up. Three of the stations were located in the Gulf of Mexico and identified Aroclor 1260 as indicated in Table 2.4-5. Due to the different kinds of species involved a comparison of levels is difficult to prepare. However, it is clear that the levels in samples from Mobile Bay, Alabama ranging from 0.01 to 0.40 ppm were higher than those from the Mississippi Sound where the highest level was only 0.20 ppm.

Fish and other marine organisms were collected in the Gulf of Mexico and the Caribbean Sea in May and October 1971 as shown in Figure 2.4-3. While PCB's were detected in nearly all the samples analyzed the levels were generally low. The samples from coastal waters generally had higher levels than samples from open waters. This same observation holds true for sea plankton. Of the six samples containing PCB's above 100 ppb wet weight four of them were near Coastal areas.[9]

Groupers were also collected[8] since they tend to spend their post larval life in one locality and should therefore yield data more representative of a particular area. Figure 2.4-3 shows the sampling locations. The levels are generally low although the highest levels do come from the western Gulf. Note also that at Anton Lizardo the levels in the groupers increase with increasing size as can be expected since the fat content of the fish increases with increasing size and age of the specimen. Table 2.4-6 presents some of the levels identified in 1971.

Giam et. al.[6] again took measurements from stations in the Gulf of Mexico in 1973-1974 as indicated in Figure 2.4-3 and Table 2.4-7. The concentrations in biota are lower than they were in the 1971 survey with an average according to Giam of about 20 ppb reduced from 60 ppb. It must be noted, however, that these stations were all close to the southern coast of the U.S. with no samples collected in the Western Gulf.

Table 2.4-6
Biota and Plankton from the Gulf of Mexico - 1971

Station	Biota	Weight (lbs.)	Standard Length (mm)	PCB's (ppb)
1	Flounder∞			32
2	Flounder∞			36
3	Flounder∞			59
4	Flounder∞			34
	Plankton†			678
5	Crustacean∞			151
	Crustacean∞			22
6	Shrimp∞			167
7	Rock Shrimp∞			6
	Squid∞			40
8	King Mackerel muscle∞			34
	Plankton†			<3
	Tuna muscle∞			58
9	Tuna muscle∞			36
10	Plankton†			100
11	Plankton†			30
12	Plankton†			<3
13	Plankton†			1055
14	Plankton†			44
15	Plankton†			42
16	Plankton†			191
27	GrouperΩ	3.1	398	110
		2.9	378	32
		1.9	306	14
		1.9	287	14
		0.7	222	12
28	GrouperΩ	4.9	414	33
		4.8	416	12
		2.8	338	10
29	GrouperΩ	10.0	514	7
		3.7	403	7
		2.9	354	6
30	GrouperΩ	6.0	495	5
		4.8	459	3
		1.6	315	3
		3.0	385	14
		2.4	339	6
31	GrouperΩ	3.3	352	81
32	GrouperΩ	18.0	681	220

∞Giam, C.S., A.R. Hanks, R.L. Richardson, W.M. Sackett and M.K. Wong, Pesticides Monitoring Journal, 6, 139-143, (Dec. 1972).

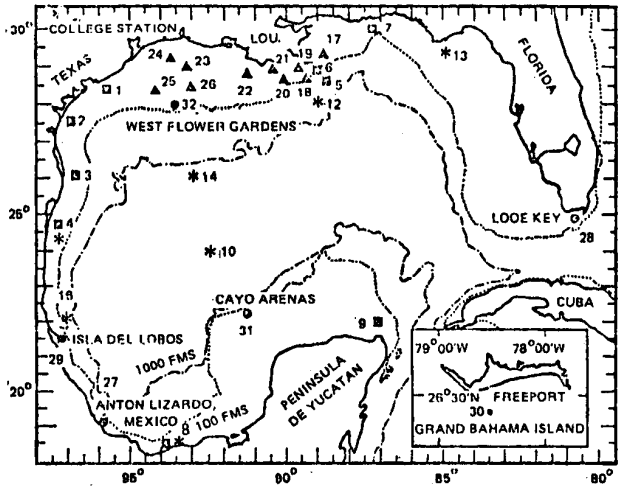
†Giam, C.S., M.K. Wong, A.R. Hanks, W.M. Sackett and R.L. Richardson, Bulletin of Environmental Contamination and Toxicology, 9, 376-382, (1973).

ΩGiam, C.S., R.L. Richardson, D. Taylor and M.K. Wong, Bulletin of Environmental Contamination and Toxicology, 11, 189-192, (1974).

Table 2.4-5
PCB Residues in Seafood

Species	Sample Quantity	Aroclor 1260 (ppm)
	MISSISSIPPI SOUND	
Crabs	15	0.07
Shrimp	1 kg	----
Squid	1 kg	0.03
Flounder	3	0.03
Speckled sea trout	3	0.20
Spanish mackerel	3	0.06
Weak fish	5	0.12
Atlantic whiting	5	0.10
Fish oil	1 liter	0.02
Fish meal	1 kg	0.02
Ground fish (unprocessed)	1 kg	0.04
	MOBILE BAY, ALA.	
Blue crabs	15	0.12
Shrimp	1.3 kg	0.01
Oysters	20+	0.03
Squid	10	0.04
Flounder	3	0.11
Speckled sea trout	1	0.40
Spanish mackerel	2	0.18
Weak fish	5	0.37
Atlantic whiting	5	0.11
Croaker	3	0.33
Red snapper	2	0.14
Mullet	5	0.11
Anchovy	>20	0.08
Shad	>10	0.09
	TAMPA BAY, FLA.	
Crabs	10	0.03
Weak fish	5	0.83
Mullet	5	0.31

SOURCE: Markin, G.P., J.C. Hawthorne, J.L. Collins, and J.H. Ford, Pesticides Monitoring Journal, 7, 139-143, (March 1974).



■ BIOTA 1971

● GROUPERS 1971

▲ BIOTA, WATER, SEDIMENT, 1973–1974

✱ PLANKTON 1971

FIGURE 2.4-3 GULF OF MEXICO SAMPLING SITES

Table 2.4-7
Concentrations of PCBs in Selected Samples
from the Gulf of Mexico, 1973-74

Station	Biota (ppb)	Water (ppt)	Sediment (ppb)
7	20	4.1	<0.2
18	11	2.1	35.0
19	22	1.7	33.0
20	23	---	<0.2
21	37	1.7	<0.2
22	14	2.1	---
23	6	2.4	---
24	11	1.3	---
25	94	0.8	<0.2
26	68	2.7	---

SOURCE: Giam, C.S., J.S. Chan, J.P. Kakareka and G.S. Neff, Trace Analyses of Phthalates and Chlorinated Hydrocarbons in Gulf of Mexico Samples.

2.4.4 California

According to Hom and Risebrough[14] PCBs have become a significant component of the marine food webs of southern California. They have been associated with a high incidence of premature births among sea lions and eggshell thinning with consequent reproductive failure in fish-eating birds.

One study collected different levels of sediment from the Santa Barbara Basin.[14] The dated and analyzed sediments indicated that the deposition of PCB's began about 1945 probably as a result of the rapid increase in PCB use as electrical insulating fluids and paint additives during World War II. Through 1967 there was no indication of a leveling off in the rate of PCB deposition. Levels in the 1940-1945 layer were 31 ppb increasing to 49 ppb in the 1947-1952 layer, 66 ppb in the 1955-1960 layer and 103 ppb in the 1962-1967 layer.[14]

Risebrough[23] has suggested that the observation of PCB's in the sea indicate that they are dispersed by wind currents. Table 2.4-8 shows the distribution of PCB residues in several collections of marine fish collected from the Coastal waters of southern California in late 1965 and early 1966 and in marine birds collected in late 1966. Note that the levels in the birds 0.08-109 ppm were higher than those in fish, N.D.-1.2 ppm. Petrels and shearwaters breed on remote islands spending their entire lives at sea. They do not dive for fish but feed primarily upon organisms obtained at or near the surface where aerial fallout could be expected to retain temporally the water-insoluble chlorinated hydrocarbons components. Two Peregrine Falcons showed PCB levels ranging from 1.5 ppm, net weight, in the brain of an immature bird to 1,980 ppm lipid weight in the carcass of an adult bird.

Analyses of Western gull eggs[22] show that eggs from San Francisco Bay, with levels from 24-950 ppm contained more PCB's than eggs from the Farallon Islands 27 miles west of the Golden Gate Bridge with levels from 12-1010 ppm. These were both higher than eggs from Baja California where the levels were 1.2-471 ppm.

Concern over reproductive failure of the Double Crested Cormorant led to a study in 1969 of Cormorant eggs from three locations in southern California. The levels identified ranged from 12-1,100 ppm in the yolk lipids.[10] A similar concern also led to a study of Brown Pelicans on Anacapa Island in May 1969. Fat samples from six adult birds and one immature bird ranged from 77 to 366 mg/gm.[15]

Early data collected by Munson[19] in 1970 from San Diego and Orange Counties showed levels in aquatic biota ranging from <2.0 to 8.8 ppm lipid weight (N.D. - 1.0 wet weight) in San Diego and 0.62 - 38 ppm lipid weight (0.008 to 1.4 wet weight) from Orange County. However, the difference in residue levels may be due to a different type of uptake mechanism since the samples from Orange County were invertebrates while those from San Diego were fish.

In addition to the studies of Double Crested Cormorants and Brown Pelicans, Faber et. al.[4] studied Common Egrets and Great Blue Herons. The PCB levels ranged up to 15 ppm in the brain and 93 ppm in the livers of adult egrets from the Audubon Canyon Ranch. Fish which the birds might feed on from Bolinas Lagoon showed levels from 0.072-0.079 ppm.

In order to assess the potential contamination from chlorinated hydrocarbons the U.S. Geological Survey initiated a study in February 1972 of the San Francisco Bay. Bottom material was collected from 26 streams that discharge into San Francisco Bay. The results of the analyses are given in Figure 2.4-4 illustrating the widespread distribution of PCB's in the San Francisco Bay area. The readings from Steven Creek of 180 ppb and from Alamitos Creek, of 610 ppb were higher than anticipated since neither area had any apparent industrial or commercial development. Despite the extreme range up to 1400 ppb there was no significant difference between the average residue of streams discharging into the Bay south of San Francisco and those discharging into the Bay north of San Francisco.[16]

Studies of Waste Water Treatment Plants in the Southern California area will be presented in Section 2.5.3.4.

Table 2.4-8
Polychlorinated Biphenyl (PCB) Residues
in Marine Fish and Marine Birds, 1965-1966

Species Locality,	PCB
Northern Anchovy	
Terminal Island	1.0
Shiner Perch	
San Francisco Bay	0.4-1.2
English Sole	
San Francisco Bay	0.05-0.11
Monterey	0.04
Jack Mackerel	
Channel Islands	0.02
Hake	
Puget Sound	0.16
Channel Islands	0.12
Bluefin Tuna	
Body muscle	0.04
Liver	0.04
Yellowfin Tuna	
Liver	0.04
Skipjack Tuna	
Liver	0.1
Cassin's Auklet	0.16
Ancient Murrelet	0.15
Fulmar	0.08
Fulmar	0.34
Red Phalarope	0.10
Rhinoceros Auklet	0.36
Slender-billed Shearwater	2.1
Sooty Shearwater	1.2
Sooty Shearwater	0.9
Peregrine Falcon	
Breast muscle, second year Female, migrant from Artic	22
Breast muscle, immature California	10.5
Breast muscle, adult female, California	109

SOURCE: Risebrough, R.W., Chlorinated Hydrocarbons in Marine Ecosystems.

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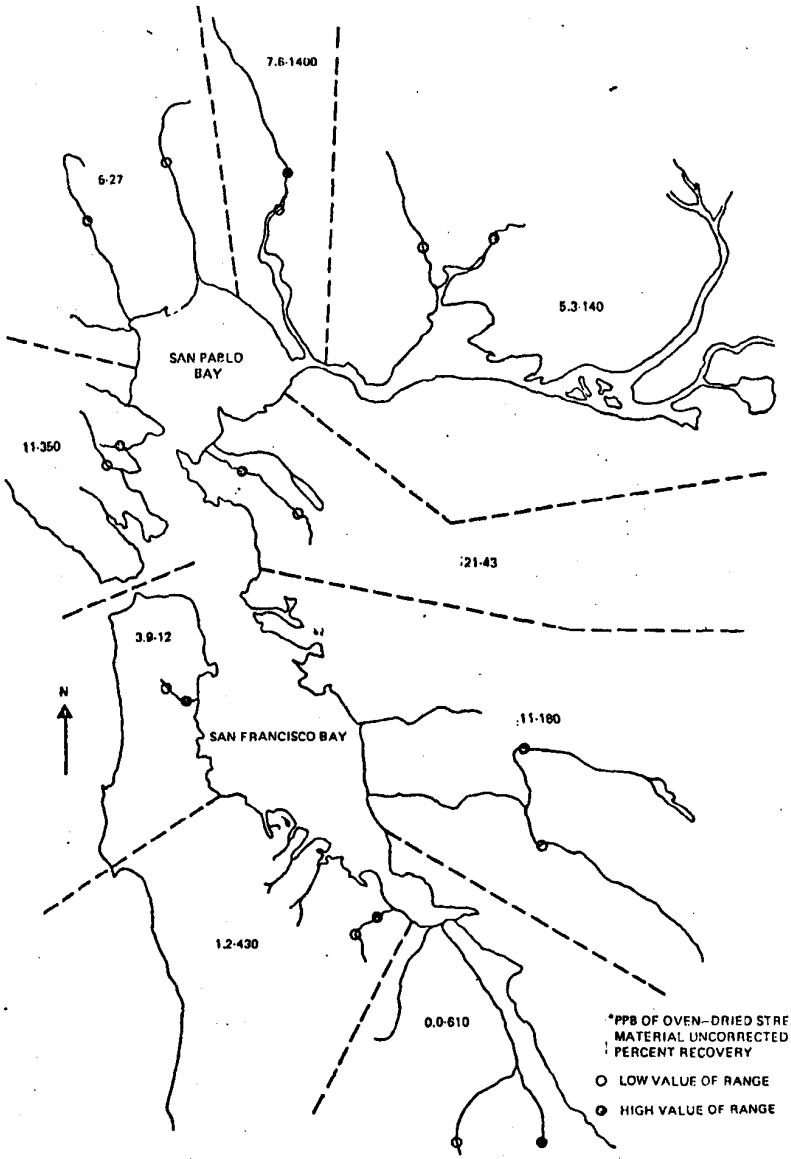


FIGURE 2.4.4 PCB'S IN SAN FRANCISCO BAY AREA STREAM BEDS

2.4.5 Escambia Bay, Florida

The first detection of Aroclor 1254 residues in Escambia Bay was in oysters in April 1969.[3] Later sampling also showed residues in water, sediment, fish, blue crabs and shrimp as indicated in Table 2.4-9. One source was apparently an industrial outfall which had had accidental leakage of a heat exchange fluid. Fish, shrimp and crabs contained higher concentrations than oysters but are also more mobile and therefore not as useful as monitors for a particular area.

Figure 2.4-5 identifies the sampling locations (stations 1-7). Less than 0.1 ppb occurred in the water at station 2 but it was not detected in lower bay water. Leaching from sediments is presumably the cause of the continued presence of Aroclor 1254 in the river water. Sediment samples taken near the outfall reached 486 ppm in August 1969.[3]

Pink shrimp collected at the same time from the bay were found to contain whole body residues of Aroclor 1254 as high as 14 ppm.[20] Residues in seven composite samples of at least five shrimp ranged from 0.6 to 120.0 ppm. Fiddler crabs collected in April 1970 from the lower Escambia River and Upper Escambia Bay had individual whole body residues of 0.45 to 1.5 ppm.

The largest accumulations were found in the sediments with the maximum residue of 61 ppm observed in the River at the outfall from the industry. The maximum in the Bay of 30 ppm was found near the mouth of the river. Although Aroclor was not detected in sediments collected above the plant, soil samples from the bank near the mouth of the river downstream from the source 6.5 km had 1.4 to 1.7 ppm. Subsequent samplings from three stations in the bay showed little change in the chemical even after nine months. Table 2.4-9 shows the levels identified for these sediment collections as stations 8-20.[20]

The amount of PCB in sediment samples appeared to decrease after the initial February 1970 survey.[21] The decrease is especially noticeable in December 1970 and October 1971. In general, the residues identified in 1971 were about one-tenth the 1970 values. Cores taken in a 1972 survey generally indicated less PCB than in 1971. Table 2.4-9 identifies the readings taken for these three years as stations 21-23.

Later surveys of biota from the estuary showed levels to remain relatively high. Table 2.4-10 compares residues in the same species or those occupying similar trophic levels captured on the same day in Escambia and East Bays; the East Bay site being about 35 kilometers from the original source of the material. Although sand seatrout and Atlantic cutlassfish could be expected to have the highest residues since they are predators the highest levels were actually found in silversides whose diet consists mainly of plankton. Note also that the concentrations in species from Escambia Bay were 5 to 10 times greater than those found in East Bay but that Aroclor 1254 was found even in species captured distant from the original source of PCB.[21]

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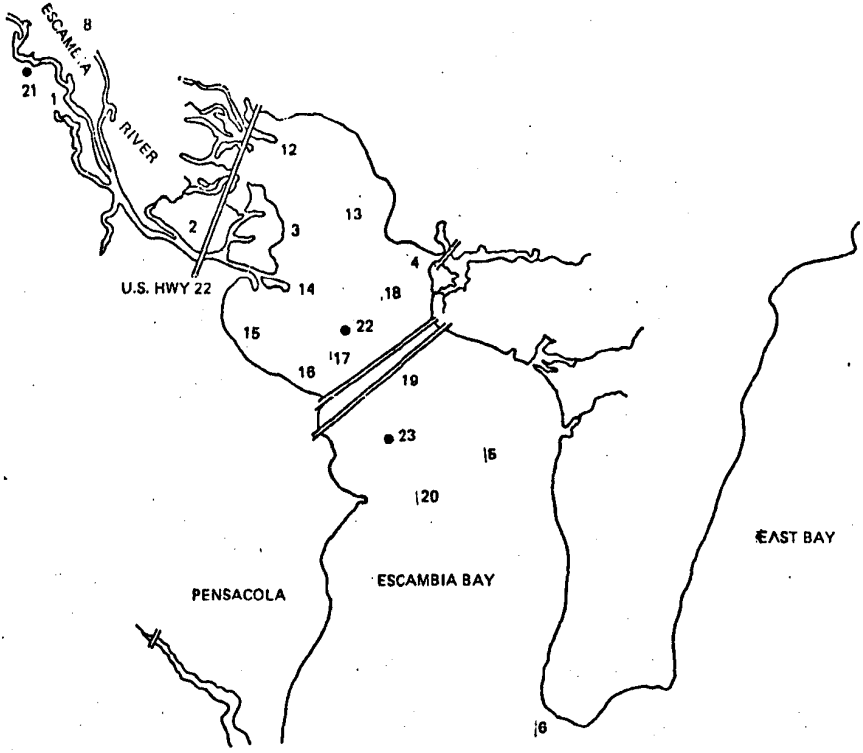


FIGURE 2.4-5 ESCAMBIA BAY SAMPLING STATIONS

Table 2.4-9
Residues of Aroclor 1254 in Samples from Escambia Bay and River

Location	Sample	Residues of Aroclor 1254 (ppm) 1969	1970	1971	1972
3	Speckled trout	20.0			
3	Flounder liver	184.0			
4	Menhaden	5.7			
4	Menhaden	11.0			
4	Menhaden	12.0			
4	Flounder liver	76.0			
4	Flounder muscle	4.5			
4	Flounder gills	19.0			
4	Croaker	12.0			
4	Pinfish	10.0			
3	Shrimp	2.5			
3	Blue crab	7.0			
3	Blue crab	6.3			
4	Shrimp	1.5			
4	Blue crab	1.0			
1	Sediment	486			
2	Sediment	<.03			
6	Sediment	1.7			
8	Sediment		N.D.		
9	Sediment		61.0		
10	Sediment		5.7		
11	Sediment		4.1		
12	Sediment		1.9		
13	Sediment		1.8		
14	Sediment		30.0		
15	Sediment		4.2		
16	Sediment		3.3		
17	Sediment		4.9		
18	Sediment		0.6		
19	Sediment		2.5		
20	Sediment		1.4		
21	Sediment 0-2 in.		78.0	8.1	0.97
	Sediment 2-4 in.		30.0	0.12	5.8
	Sediment 4-6 in.		6.1	N.D.	----
	Sediment 6-8 in.		0.4	N.D.	----
22	Sediment 0-2 in.		10.0	0.91	0.14
	Sediment 2-4 in.		11.0	N.D.	N.D.
	Sediment 4-6 in.		15.0	N.D.	N.D.
	Sediment 6-8 in.		20.0	N.D.	----
	Sediment 8-10 in.		18.0	N.D.	----
	Sediment 10-12 in.		1.2	N.D.	----
23	Sediment 0-2 in.		0.19	0.19	----
	Sediment 2-4 in.		0.08	N.D.	----
	Sediment 4-6 in.		0.02	N.D.	----
	Sediment 6-8 in.		N.D.	N.D.	----

SOURCE: Nimmo, D.R., D.J. Hansen, J.A. Couch, N.R. Cooley, P.R. Parrish and J.I. Lowe, Toxicity of Aroclor 1254 and its Physiological Activity in Several Estuarine Organisms, (unpublished).

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Table 2.4-10
Comparison of Concentrations of Aroclor 1254 Found in Species Collected in Escambia and East Bays

Species	Escambia Bay (ppm)	East Bay (ppm)
Spartina	N.D.	N.D.
Zostera	N.D.	N.D.
Olive Nerite	0.49	N.D.
Rangia	N.D.	N.D.
Penaeid Shrimp	0.98	Trace
Blue Crabs	6.90	0.46
Bay Anchovy	3.00	0.68
Catfish	3.80	0.58
Tidewater Silversides	10.00	0.95
Silver Perch	4.50	0.48
Sand Seatrout	1.50	----
Spotted Seatrout	----	0.12
Spot	1.80	Trace
Atlantic Croaker	1.60	Trace
Hogchoker	1.30	N.D.
Atlantic Cutlassfish	2.90	0.72

SOURCE: Nimmo, D.R., D.J. Hansen, J.A. Couch, N.R. Cooley, P.R. Parrish and J.I. Lowe, Toxicity of Aroclor 1254 and its Physiological Activity in Several Estuarine Organisms, (unpublished).

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MONS 062764

2.5 Data from Localized Monitoring Efforts - Industrial Plants, Products, Sewage Treatment Facilities and Landfills

2.5.1 Industrial Plants

2.5.1.1 Monsanto, Co., Sauget, Illinois

The only PCB production facility in the United States is the Monsanto plant at Sauget, Illinois which has produced PCB mixtures ranging from 20 to 68 percent chlorine. Polychlorinated terphenyls have been produced at this facility, but production was suspended in 1971. Not true.

Soil contamination studies[7] were initiated in February 1976. The sampling locations around the Monsanto facility are identified in Figure 2.5-1. The levels of Aroclor 1242, Aroclor 1260 and decachlorobiphenyl found at these sampling sites are listed in Table 2.5-1. The distribution of all PCBs analyzed appears to be higher near the plant site and generally decreasing with distance from the site. There is some evidence that higher concentrations are present in the soils located to the southeast which corresponds with the predominant wind direction in this area.

A typical chromatogram of a soil sample obtained near the plant is shown in Figure 2.5-2 along with the reference chromatograms of Aroclor 1242 and 1260 run under the same instrument conditions. Using these reference spectra, this sample contains 11 ppm Aroclor 1242, 9.3 ppm Aroclor 1260 and 1.0 ppm decachlorobiphenyl.

Total all time production about 20,000#

Table 2.5-1
PCB Levels in Soils, ppm, Monsanto

Sample Station	Aroclor 1260	Aroclor 1242	Decachlorobiphenyl	Total PCB
1	0.05	<0.01	0.097	0.147
2	0.12	<0.01	0.61	0.73
3	1.4	<0.01	0.90	2.3
4	0.31	0.68	0.38	1.37
5	0.20	<0.01	0.27	0.47
6	1.3	0.82	1.6	3.72
7	2.9	3.0	1.3	7.2
8	9.6	6.1	2.4	18.1
9	0.65	<0.01	0.12	7.7
10	0.28	0.45	0.081	0.811
11	0.10	<0.01	0.049	0.145
12	0.26	<0.01	0.081	0.341
13	9.6	10.0	1.1	20.7
14	0.03	<0.01	0.40	0.43
15	0.39	0.46	0.12	0.97

SOURCE: Unpublished Report, Contract 68-01-2978, USEPA, Office of Toxic Substances; July 1975

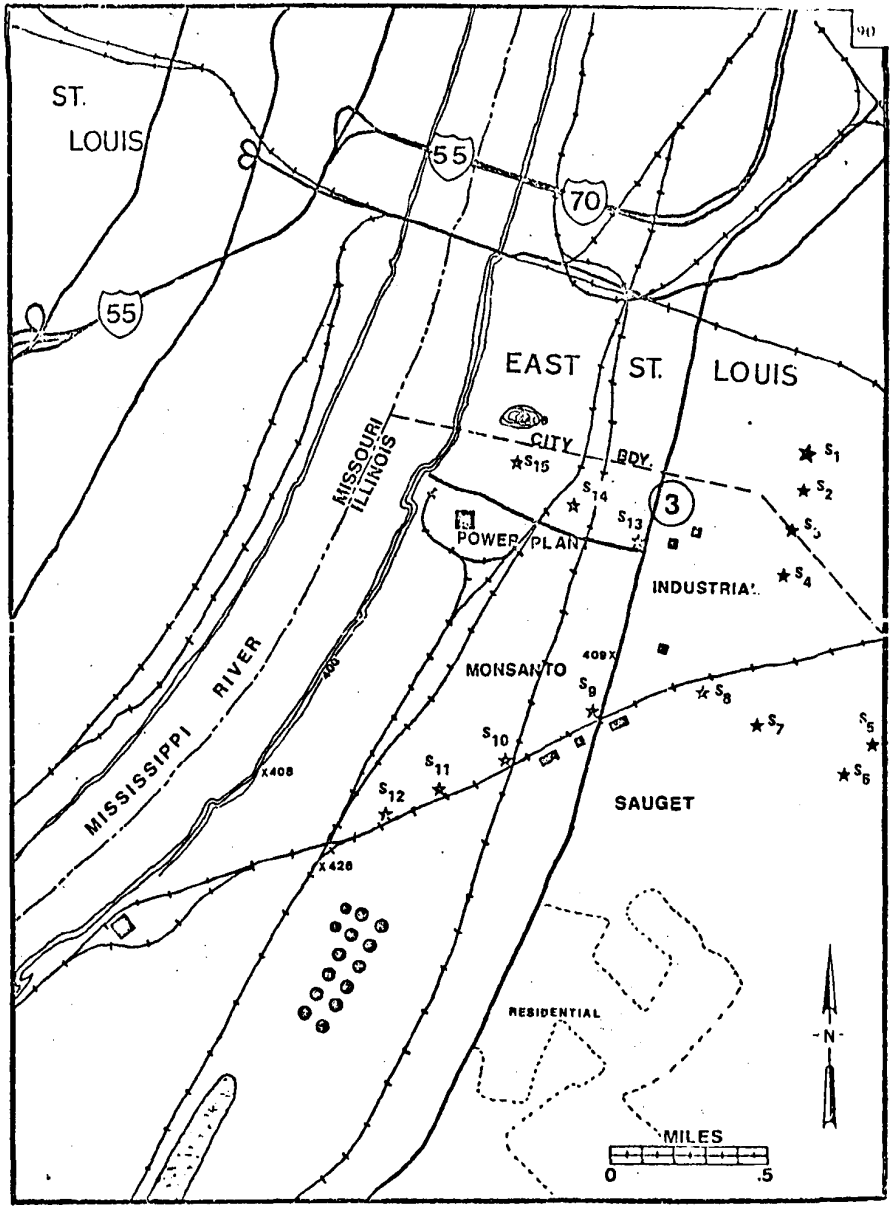


FIGURE 2.5-1 SAMPLING LOCATIONS, MONSANTO

MONS 062767

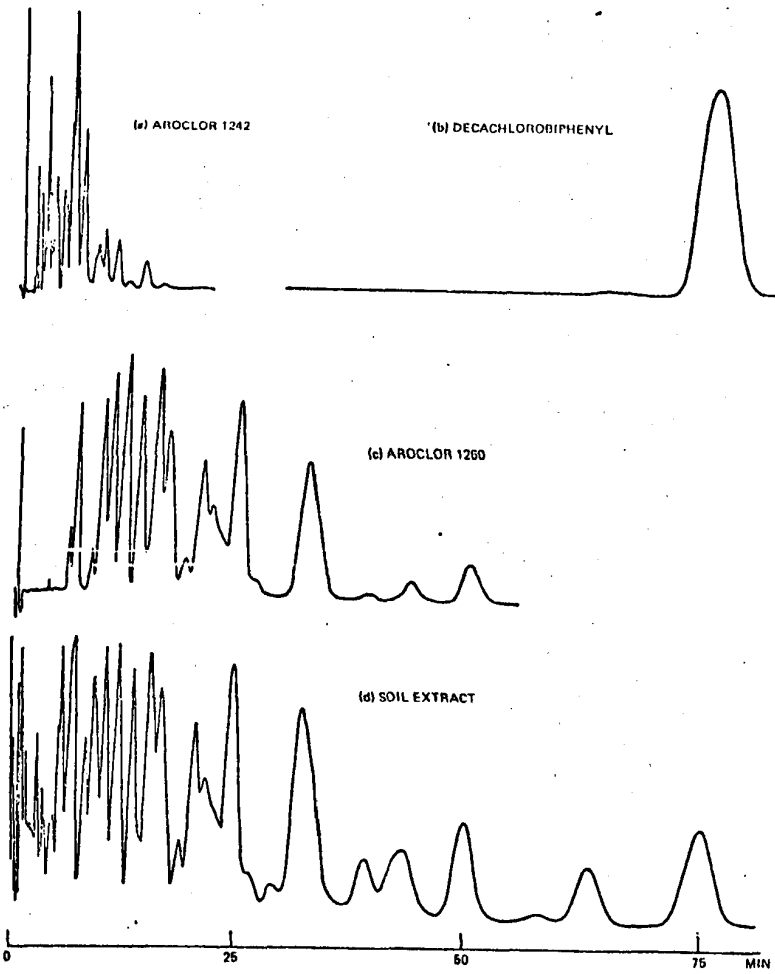


FIGURE 2.5-2 TYPICAL CHROMATOGRAMS OF STANDARD AROCLORS, DECACHLOROBIPHENYL AND A SOIL SAMPLE TAKEN IN THE VICINITY OF MONSANTO CO., SAUGET, ILLINOIS

2.5.1.2 Yates Manufacturing Co., Chicago, Illinois

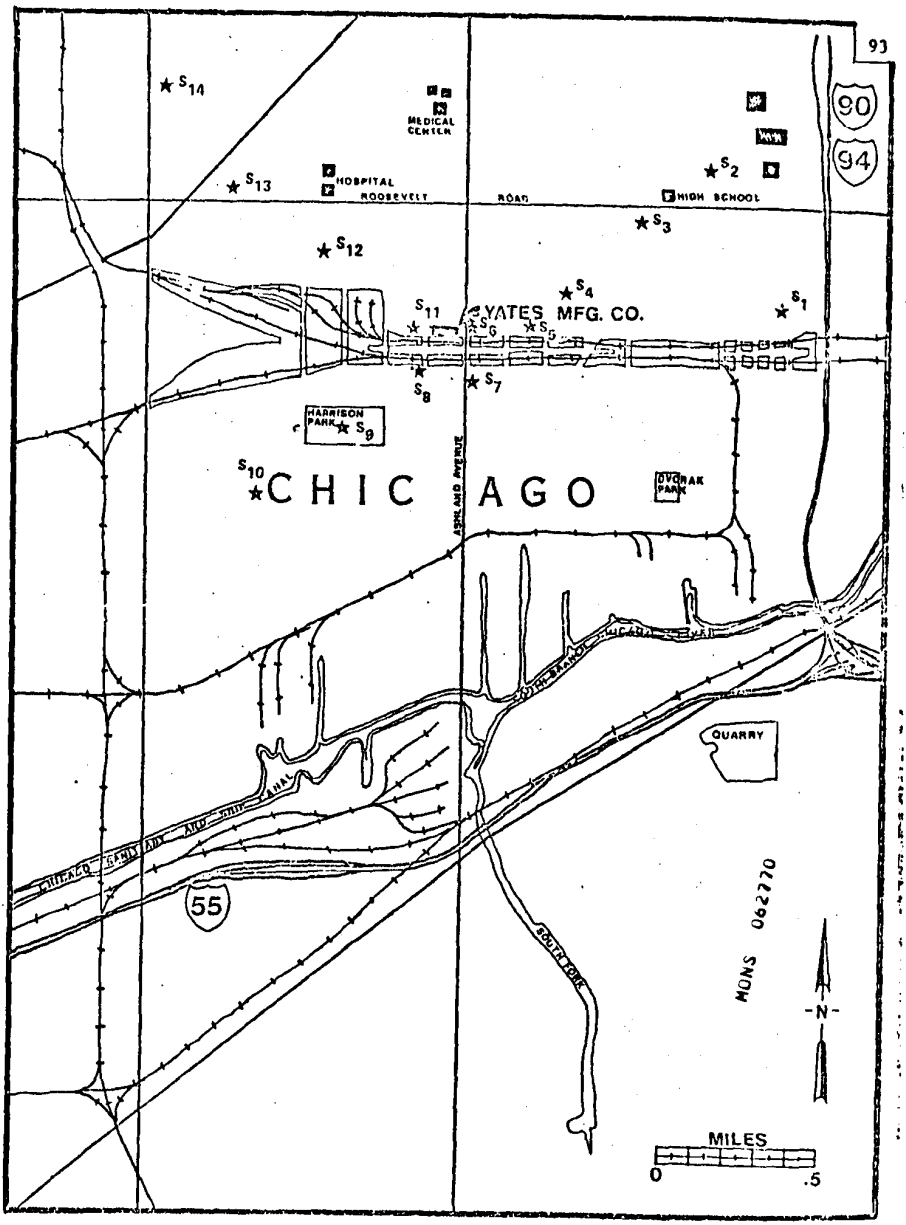
The Yates Manufacturing Co. is an investment casting wax manufacturer. Prior to 1972, Aroclors 5460, 6090 and 5442, mixtures that contain both PCBs and polychlorinated terphenyls, were used. Subsequent to 1972, this company has been purchasing decachlorobiphenyl from foreign sources.

Soil contamination studies[7] were initiated in February 1976. The sampling locations around the Yates facility used to study soil contamination are identified in Figure 2.5-3. The concentration levels of Aroclor 1242, Aroclor 1260 and decachlorobiphenyl found at these sampling sites are listed in Table 2.5-2.

Table 2.5-2
PCB Levels in Soils, ppm, Yates Manufacturing

Sample Location	Aroclor 1260	Decachlorobiphenyl	Total PCB
1	0.22	< 0.001	0.22
2	0.24	0.053	0.293
3	0.81	0.033	0.113
4	0.34	0.19	0.53
5	0.51	0.58	1.09
6	0.40	1.2	1.6
7	0.26	0.51	0.77
8	1.5	0.75	2.25
9	0.57	0.040	0.61
10	0.67	0.020	0.69
11	1.6	3.6	5.2
12	0.29	0.001	0.291
13	0.56	0.034	0.594
14	1.8	< 0.001	1.8

SOURCE: Unpublished Report, Contract 68-01-2978, USEPA, Office of Toxic Substances; July 1975


93
90
94
MEDICAL CENTER
HOSPITAL
ROOSEVELT
ROAD
HIGH SCHOOL
S14
S13
S12
S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
YATES MFG. CO.
HARRISON PARK
CHICAGO
DVORAK PARK
55
QUARRY
MONS 062770
N
MILES
0
.5

2.5.1.3 Valcast Corp., Troy, Michigan

Valcast Corp. is an investment casting facility located in a small industrial park in suburban Detroit, Michigan. PCBs are a constituent of the wax mold compound used to fashion intricate shapes which are to be cast.

Soil contamination studies[7] were initiated in February 1976. The sampling locations around the Valcast facility are identified in Figure 2.5-4. The concentration levels of Aroclor 1260 and 1242 found at these sampling sites are listed in Table 2.5-3.

Figure 2.5-5 is a typical chromatogram of a soil sample extract taken from this location. Aroclor 1260 was present in many of the soil samples taken from the Valcast area, but decachlorobiphenyl was absent. The one observed concentration of 18 ppm of Aroclor 1242 appears to be anomalously high, however, replicate analysis yielded values of 16 ppm and 19 ppm, respectively. Aroclor 1242 was not detected in any other soil samples from this area.

A small drainage ditch that passes adjacent to the north boundary of the Valcast facility was sampled. This ditch serves to remove storm-water runoff in the vicinity and receives discharged cooling water from Valcast and other local small industies. Analysis of the Valcast cooling water at the point of discharge and of water in the drainage ditch failed to detect PCB levels greater than the detection limit of 0.1 ppb Two bottom sediment samples taken from this drainage ditch, however, had concentrations as follows:

Aroclor 1242	2.3 ppm	9.4 ppm
Aroclor 1260	6.7 ppm	8.9 ppm
Decachlorobiphenyl	0.09 ppm	0.11 ppm.

Table 2.5-3

PCB Levels in Soils, ppm, Valcast

Sample Station	Aroclor 1260	Aroclor 1242
1	< 0.01	
2	< 0.01	18.0
3	0.04	
4	0.06	
5	0.05	
6	0.04	
7	0.14	
8	0.07	
9	< 0.01	
10	0.12	
11	0.01	
12	0.12	
13	0.03	
14	< 0.01	
15	0.03	
16	0.02	

SOURCE: Unpublished Report, Contract 68-01-2978, USEPA, Office of Toxic Substances; July 1975

MONS 062772

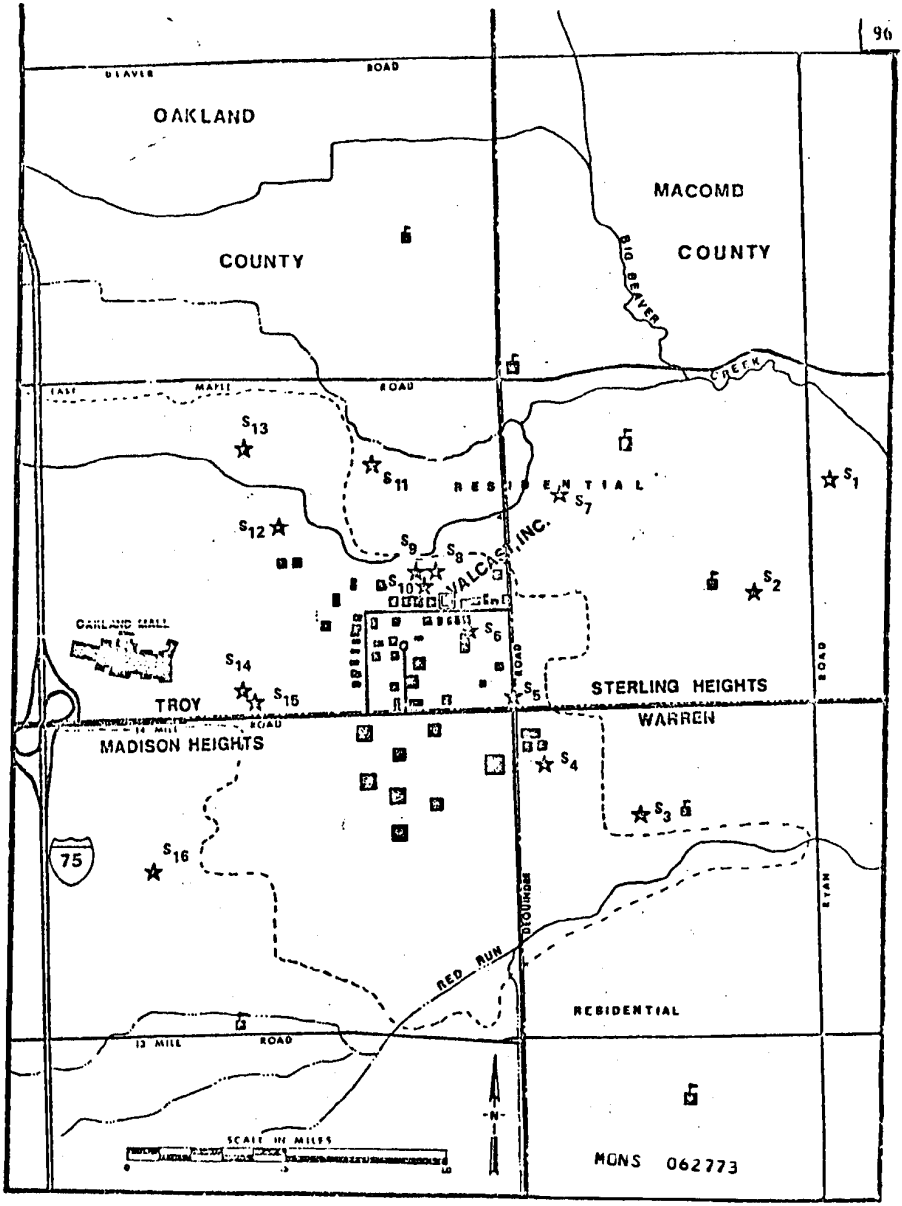


FIGURE 2.5-4 SAMPLING LOCATIONS, VALCAST

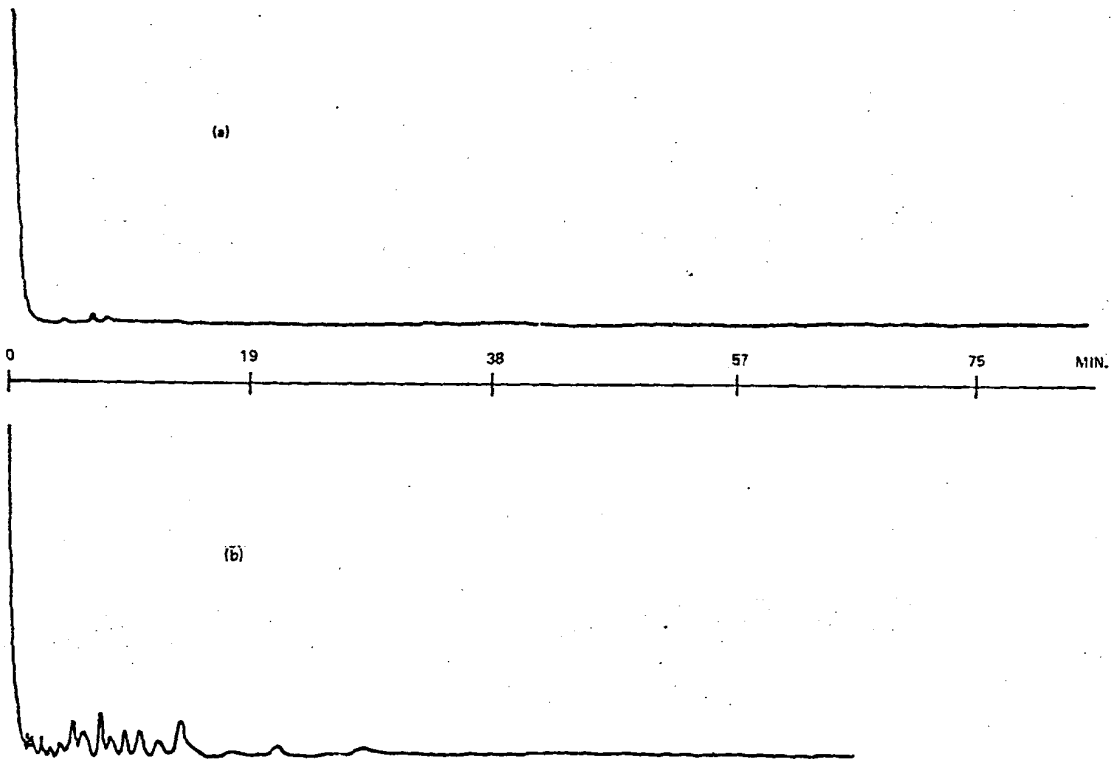


FIGURE 2.5-5 TYPICAL CHROMATOGRAMS OF SOIL SAMPLES TAKEN IN THE VICINITY OF VALCAST CORP., TROY, MICHIGAN – (a) 0.01 ppm, (b) 0.014 ppm AROCLOR 1260

MONS 062774

2.5.1.4 General Electric, Hudson Falls - Ft. Edward, N.Y.

The General Electric Plants at Hudson Falls and Ft. Edward use large quantities of PCB's for filling capacitors and transformers. Both plants have chemical waste treatment facilities, but, significant PCB and oil/grease levels are discharged by the waste stream. The NPDES Permit Application lists:

Outfall Location	Daily Average Concentration ppm Oil/Grease	PCB	Average Daily Loading (lbs.) Oil/Grease	PCB	Maximum Daily Loading (lbs.) Oil/Grease	PCB
Hudson Falls	13.7	.5	239.8	10.0	250.9	17.6
Hudson Falls	2.1	---	4.9	----	5.25	----
Ft. Edward	8.9	5.0	38.27	20.0	44.5	30.0

In the summer of 1974, EPA Region II initiated a sampling program in the general vicinity of the General Electric plants.[7] The five sampling stations established for this program are shown in Figure 2.5-6. Station 0 is upstream from the plants and serves as the control station; station 1 is located at the junction of the outfall stream from the Ft. Edward facility and the Hudson River, station 2 is located about 0.25 miles downstream from the outfall junction, station 3 is about 0.5 miles downstream from station 1, and station 4 is located about 0.75 miles downstream from station 1.

Samples collected included sediment, water, fish and snails; Arclors identified included 1016, 1254, 1248 and 1242. The levels found at each sampling location are listed in Table 2.5-4.

PCB's identified as Aroclor 1016 were conclusively identified in the water samples at detectable concentrations at all sampling locations except Station 0 (control) and station 4, the furthest downstream.

At all stations the sediments contained higher concentrations of Aroclor 1016 than the water column resulting from adsorption of PCB's on suspended or already settled materials.

The biological samples collected at station 0 contained PCB's characteristic of Aroclor 1254 and Aroclor 1248. Distinctly different from the samples at station 0 were the samples collected in the vicinity of or below the General Electric discharge. Fish data from these areas suggests that Aroclor 1242, Aroclor 1016, or a mixture of these two formulations are present in the Hudson. There are no distinguishing features which can reliably determine whether the mixture is Aroclor 1016 or 1242 at this time.

Table 2.5-4
Environmental PCB Levels from the General Electric,
Hudson Falls - Ft. Edward N.Y. Area

Media	Water (ppb)	Sediment (ppm)		Fish (ppm)	
Aroclor	1016	1016	1254	1248	1242
Station					
0	<1.0	6.9	4.0	13.0	
1	2800	6700			45[a]
2	2.2	540			
3	3.0	2980			350[b]
4	<1.0	6.6			78[c] 27[a]

[a]Snails (composite)

[b]Rock Bass

[c]Shiner Minnows

SOURCE: Nadeau R.J., and R.P. Davis, Investigation of Polychlorinated Biphenyls in The Hudson River, USEPA Region II.

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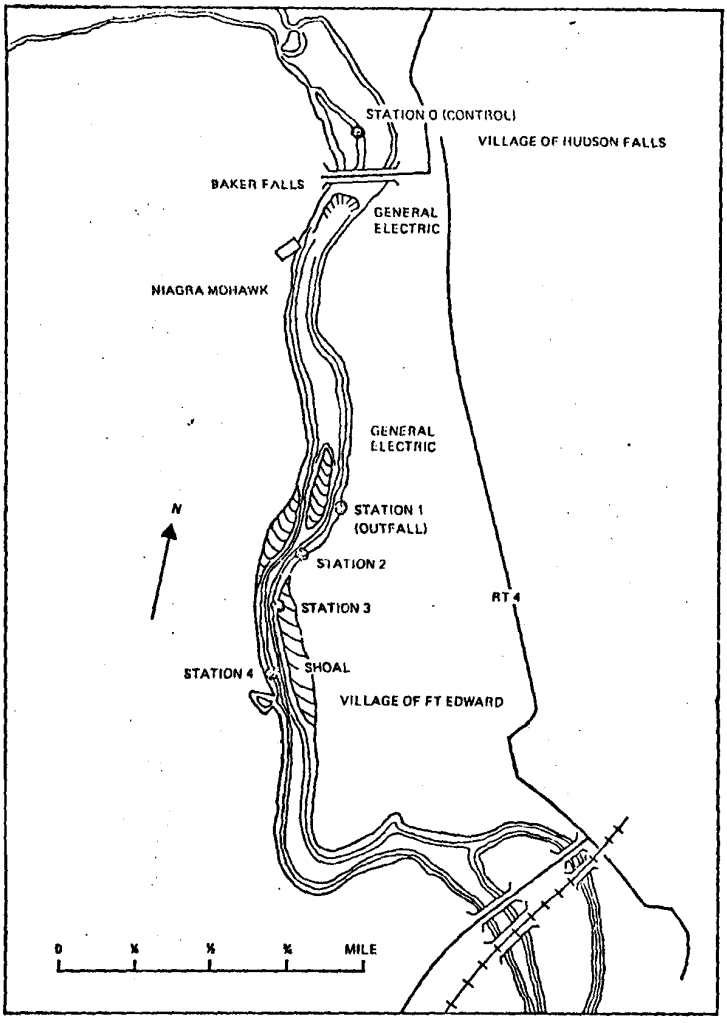


FIGURE 2.5-6 MAP OF HUDSON FALLS-FT. EDWARD, NEW YORK. NOTE LOCATION OF SAMPLING STATIONS RELATIVE TO GENERAL ELECTRIC FACILITIES.

MONS 062777

2.5.2 Sewage Treatment Facilities

2.5.2.1 Illinois

An early study[8] of discharges into Lake Michigan was conducted by the state of Illinois in 1970-1972 from locations as shown in Figure 2.5-7. Only two counties in Illinois border on the lake and all sewage treatment plant effluents and tributary stream sources enter the lake from Lake County. In most cases, sewage treatment plant effluents had higher concentrations of PCB's than the tributary streams.

PCB's were not measured in 1970; however, in 1971, 37 sediment samples were collected from tributary streams and ravines in Lake County and at stations offshore from Lake and Cook counties and analyzed for PCB's. The lake samples were collected 40 to 80 yards offshore from seven North Shore Sanitary District sewage treatment plants and at stations approximately one to three miles offshore. Aroclor 1242 in tributary sediments ranged up to 553 ppb in an unnamed channel in Waukegan and Aroclor 1254 ranged from 1.54 to 232.00 ppb in Pettibone Creek in North Chicago. Samples from open water sediments had Aroclor 1242 concentrations ranging up to 106.07 ppb. The highest level was found 40-80 yards offshore from the North Shore Sanitary District sewage treatment plant at North Chicago. Aroclor 1254 concentrations ranged from 2.48 to 46.92 ppb. Selected values are given in Table 2.5-5.

Water samples were collected in both 1971 and 1972 at the tributary streams and sewage treatment plants. Aroclor 1242 and 1254 ranged from 14.00-1810.0 ppt and 192.0-388.0 ppt in 1971 respectively and up to 653.0 ppt for Aroclor 1242 and 61.0 to 841.0 ppt for Aroclor 1254 in 1972 in tributary streams. However, in samples from sewage treatment plants Aroclor 1242 concentrations ranged from 268.0-4020.0 ppt in 1971 and up to 21.0 ppt in 1972. Aroclor 1254 concentrations ranged from 139.0-568.0 ppt in 1971 and from 97.0 to 178.0 ppt in 1972. The highest readings were from the North Shore Sanitary District at Waukegan in 1971. Table 2.5-6 presents the levels identified in water samples from Illinois Streams and Sewage Plants Tributary to Lake Michigan.

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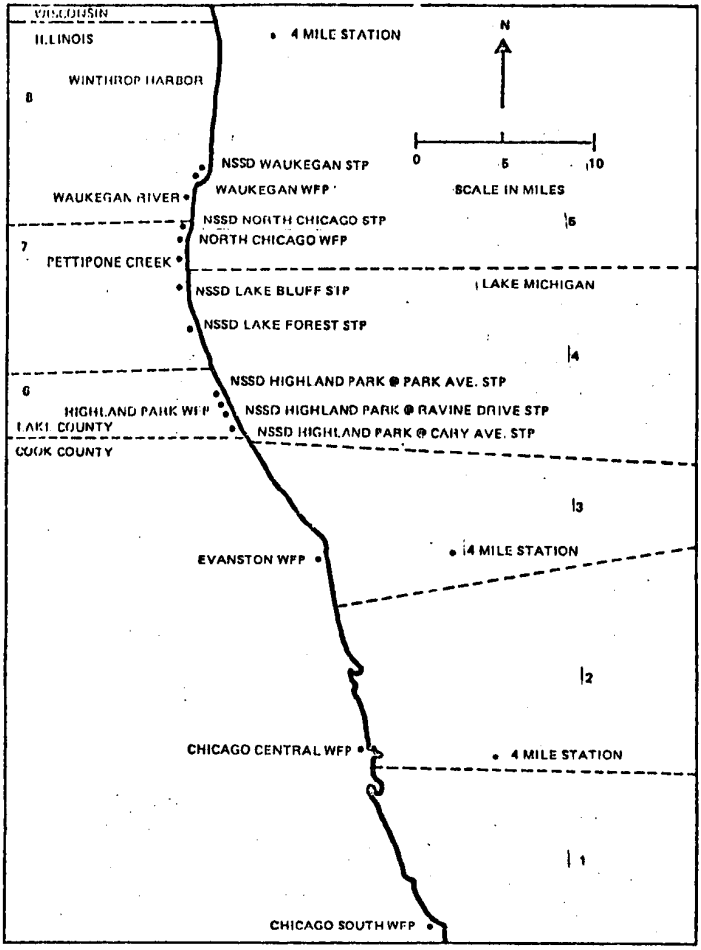


FIGURE 2.5-7 LOCATIONS OF WATER AND SEDIMENT SAMPLING STATIONS

Table 2.5-5
Polychlorinated Biphenyls in Sediments from Lake Michigan
and Tributary streams in Illinois 1971
(ppb) dry weight basis

Location		Aroclor 1242	Aroclor 1254
<1 to 3 miles offshores			
Cook County	1	N.D.-18.55	2.48-17.25
	2	17.23-83.35	9.38-46.92
	3	3.58-13.65	3.15-12.42
Lake County	4	7.43-19.25	5.26-17.45
	5	4.98-46.11	8.36-34.52
Highland Park	STP	11.11	12.42
Lake Forest	STP	10.51	7.02
Lake Bluff	STP	44.36	14.45
North Chicago	STP	106.07	26.54
Waukegan	STP	17.32	11.97
10-50 yards upstream from Lake			
Lake County	6	N.D.-4.32	1.54-17.90
	7	1.31-173.40	2.54-232.00
	8	1.77-553.00	2.56-131.00

SOURCE: USEPA, Pesticide Monitoring Programs: Lake Michigan and Tributaries in Illinois, EPA 600/3-74-002

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Table 2.5-6
Polychlorinated Biphenyls in Water Samples from
Illinois Streams and Sewage Plants Tributary to Lake Michigan
1971 - 1972, (ppt)

Location	Aroclor 1242	Aroclor 1254
1971		
Waukegan River	1810.0	388.0
Pettibone Creek	140.0-187.0	192.0-194.0
Waukegan STP	601.0-4020.0	139.0-568.0
North Chicago STP	268.0-1070.0	153.0-260.0
1972		
Waukegan River	57.0-120.0	61.0-136.0
Pettibone Creek	N.D.-653.0	107.0-841.0
Waukegan STP	N.D.-17.0	97.0-139.0
North Chicago STP	N.D.-21.0	100.0-178.0

SOURCE: USEPA, Pesticide Monitoring Programs: Lake Michigan and Tributaries in Illinois, EPA 600/3-74-002

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2.5.2.2 Michigan

Samples collected in 1971 and 1972 from municipal waste water treatment plant effluents throughout Michigan[4] indicated these plants as a major source of PCB's with an average concentration of 2.55 ppb for 60 effluents sampled. Only seven of the effluents exceeded 1 ppb but one, the Bay City treatment plant on the Saginaw River, had an average effluent concentration of 120 ppb with a high of 340 ppb.

Samples collected from 58 waste water treatment plants in 1973 averaged 0.52 ppb. The Bay City PCB discharge had been greatly reduced as a result of control measures in industries served by the waste water treatment plant.

Sewage Sludge from 57 of the 58 plants tested in 1973 showed Bay City to have the highest concentration of PCB's in the sludge being removed by the treatment process averaging 352 ppm compared to a state wide average of 15.6 ppm.

The range of values for all waste water treatment plants sampled in 1971-1973 are given in Table 2.5-7.

Table 2.5-7
PCB Levels from Waste Water Treatment Plants, Michigan

City	Effluent (1971-72) (ppb) Aroclor 1254	Effluent (1971) (ppb) Aroclor 1242	Effluent (1971) (ppb) Aroclor 1254	Sludge (1971) (ppb) Aroclor 1242	Sludge (1971) (ppb) Aroclor 1254
Adrian	0.41-14.00				
Albion	0.44		0.34		1.5
Ann Arbor	<0.10-0.14		0.25		1.1
Battle Creek	0.16-0.92		<0.10		2.8
Bay City	5.70-340.00	3.20		352.0	
Benton Harbor St. Joseph	0.31-0.99		0.20		13.8
Brighton	0.38				<0.1
Charlotte	0.61		0.34		6.8
Constantine	0.85		0.46		2.1
Detroit	0.88-3.00	2.15	32.1		
Dexter	<0.10		0.23		3.2
E. Lansing	0.35-0.69		0.18		4.6
Escanaba	0.29				5.9
Essexville	0.21-0.28		0.10		3.9
Flint	<0.10-1.30		<0.10		6.3
Flushing	0.52				
Gladstone	0.19	0.44			4.1
Grand Haven	<0.50		<0.10		4.1
Grand Rapids	0.37-0.68	1.05			11.8
Holland	0.42-0.79	<0.10			0.8
Houghton-Hancock	<0.10	0.18			5.5
Iron Mountain-Kingsford	0.55-1.20	0.69			9.5
Ironwood	0.16		0.29		5.2
Jackson	<0.10	<0.10			3.0
Kalamazoo	0.19-1.30	1.12	23.3		
L'Anse	<0.10		0.31		4.4
Lansing	0.13-0.23	0.22			5.3
Manistique	<0.20	0.63			1.5
Marquette	0.35	0.29			2.8
Marshall	<0.10	0.15			3.9
Menominee	0.35	0.57			4.2
Midland	0.13-0.40	<0.10			2.9
Milford	<0.10		2.20		
Monroe	0.33-0.60	<0.10			3.3
Mt. Clemens	1.40-10.00		2.90	175.0	
Mt. Pleasant	<0.10	0.29			6.5
Muskegon	0.28	0.83			12.7
Muskegon Heights	0.37	0.18			11.0
Niles	0.68	0.48			7.8
Norway	0.40	<0.10			<0.1

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Table 2.5-7 (cont.)

City	Effluent (1971-72) (ppb) Aroclor 1254	Effluent (1973) (ppb) Aroclor 1242	Effluent (1973) (ppb) Aroclor 1254	Sludge (1973) (ppb) Aroclor 1242	Sludge (1973) (ppb) Aroclor 1254
Ontonagon	<0.10				
Owosso	<0.10	0.12			2.0
Parchment	<0.10				
Pontiac (Auburn Rd)	<0.10-0.61		0.60		
Pontiac (E. Blvd)	0.15-1.30		0.54		
Portage	1.90				
Port Huron	0.28-0.52		1.80		
Saginaw	0.74-3.80		0.77		5.0
St. Ignace	<0.20	0.31			1.5
South Haven	<0.10				
Swartz Creek	<0.10				
Three Rivers	<0.30	<0.10			4.1
Trenton	0.14-1.10	<0.10			<0.1
Warren	0.10-0.16	<0.10			<0.1
Wayne County (Wyandotte)	0.17-0.64	0.40		2.01	
Wyoming	0.44-0.55	0.22			2.0
Ypsilanti	0.21-0.22		0.31		<0.1
Ypsilanti Twp #1	<0.10-0.12	<0.10			<0.1
Ypsilanti Twp #2	0.16-0.19	<0.10			<0.1
Cadillac		0.53			15.0
Howell					2.4
Sault Ste. Marie		0.73			1.8
Traverse City		<0.10			

SOURCE: Monitoring for Polychlorinated Biphenyls in the Aquatic Environment, Michigan Water Resources Commission, May 1973

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2.5.2.3 Wisconsin

Samples from sewage treatment facilities in Wisconsin were collected in March 1970. The PCB concentrations identified in the effluents ranged from 0.04 to 0.25 ppb and are presented in Table 2.5-8.[9]

In 1971 11 municipal sewage treatment plants in eleven southeastern Wisconsin cities were sampled as shown in Figure 2.5-8. Table 2.5-9 shows the results of this study and indicates that six of the eleven sewage plants had effluents ranging from 0.1 to 0.5 ppb of Aroclor 1254 while two sites were greater than 1.0 ppb for the same Aroclor. However Portage had 42 ppb of Aroclor 1248 in the effluent with 5.2 ppm in the digester sludge.

It is interesting to note that even though Port Washington is not as highly industrialized as Grafton the effluents from both cities contained approximately the same concentrations of PCB's ranging from 0.12 to 0.23 ppb.

Since the concentrations for Cedarburg were so high a special 24 hour study was conducted. The concentrations in raw sewage began to increase at the beginning of the working day from 0.54 ppb to a maximum of 3.1 ppb at 4:00 p.m. Table 2.5-10 presents the readings taken. The concentration in the final effluent appears to begin increasing from 0.33 ppb at midnight to a maximum of 0.77 ppb at 2 p.m. The concentration of PCB's in the effluent is approximately 30 percent of that in the influent. The concentration of PCB's in the sludges is approximately 1,000 times higher than in the fluid wastes. These data demonstrate that the time of sampling waste effluents is of importance in mass transport estimates.[1]

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Table 2.5-8
Concentrations of PCBs in Outfalls into the
Milwaukee River on March 26, 1970

Location	Aroclor	PCB Concentration (ppb)
West Bent STP effluent	1254	0.25
Fredonia STP effluent	1254	0.12
Tributary at Fredonia	1260	0.04
Saukville STP effluent	1260	0.13
Chemical plant effluent, Saukville	1242	2.50
Grafton STP effluent	1254	0.04

SOURCE: Veith, G.D., and G.F. Lee, Water Research, 5, 1107-1115, (1971)

Table 2.5-9
PCB Concentrations in the Effluents from 11 Southeastern
Wisconsin Sewage Treatment Plants, 1971

City	PCB Concentrations (ppb)	Estimated Mass Transport (in lb/day)
Beaver Dam	0.05	0.0002
Port Washington	0.12-0.22	0.0027
Grafton	0.07-0.23	0.0008-0.0015
Cedarburg	0.28-1.1	0.0027-0.018
Racine	0.60-0.83	0.142
Burlington	0.08-0.14	0.0017
Lake Geneva	2.2-2.8	0.018
Walworth	0.17-0.34	
Beloit	3.89-11.75	0.0038-0.0052
Ft. Atkinson	1.24-2.48	
Portage	32-42	0.0015

SOURCE: Dube, D.J. Polychlorinated Biphenyls in Effluents from Sewage Treatment Plants in Southeastern Wisconsin

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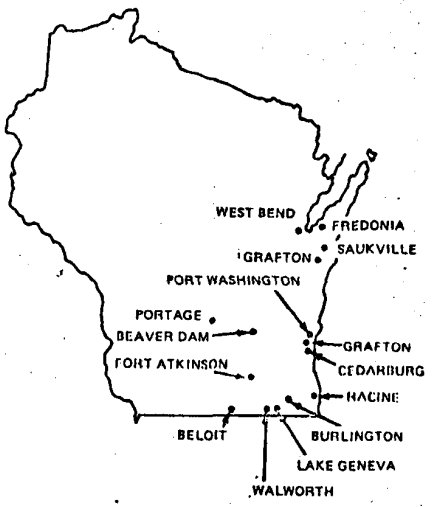


FIGURE 2.5-8 WISCONSIN CITIES WHERE MUNICIPAL SEWAGE TREATMENT PLANTS WERE SAMPLED IN 1971

Table 2.5-10
A 24-hour Survey of PCB's in the Cedarburg Treatment Plant on April 15, 1971

Time	Flow (in gal/min)	PCB Concentrations (in ppb)[1] In the Influent	In the Effluent	In the Primary Trickling Filter
0:00	1480	0.30	0.33	-----
1:00	1360	-----	-----	0.19
2:00	1300	0.20	0.10	-----
4:00	1250	0.13	0.35	-----
6:00	1200	-----	0.16	-----
8:00	2000	0.54	0.39	-----
10:00	2100	0.40	0.50	-----
12:00	1900	1.7	0.23	0.69
14:00	1900	1.5	0.77	-----
16:00	1850	3.1	0.70	-----
17:00	1900	-----	-----	0.25
20:00	1950	0.30	0.22	-----
21:00	1800	-----	-----	0.14
22:00	1650	0.36	0.34	-----

[1]The Chromatograms of the samples most closely resembled the chromatogram of Aroclor 1254.

SOURCE: Dube, D.J. Polychlorinated Biphenyls in Effluents from Sewage Treatment Plants in Southeastern Wisconsin

2.5.2.4 Ohio

Very little information is available from the Ohio River. The values reported are given in Table 2.5-11.

Table 2.5-11
PCB Levels from Sewage Treatment Plants, Ohio, 1971

Collection Site	Aroclor Detected	Concentration (ppb)
Dayton	1254	17
Hamilton	1248	10
Middleton	----	N.D.

SOURCE: Polychlorinated Biphenyls and the Environment, Interdepartmental Task Force on PCB's, May 1972

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2.5.2.5 California

In 1970 over a billion gallons of waste water entered the sea each day from urban sewage systems in California. Since two kilograms of PCB output per day are equivalent to one ton per year, outfalls of 9 sewage treatment plants discharging waste to the sea in California were sampled in an effort to identify potential PCB sources. The samples were all taken from sewage outfalls at sites closest to the points of entry into the sea as shown in Figure 2.5-9. The highest output was reported in Los Angeles County which is one of the most industrialized areas in the state. Table 2.5-12 shows the PCB levels identified in the samples collected.[5]

The only other available data were collected in early 1975 on sludge as part of the California Compliance Monitoring Survey for Chlorinated Hydrocarbons.[6] The results obtained are listed in Table 2.5-13.

Only one plant was sampled in both studies, the Hyperion Plant in Los Angeles. The 1970 sludge samples had 78.5 and 98.1 ppb concentrations while the 1975 readings ranged from 1,000-1,400 ppb.

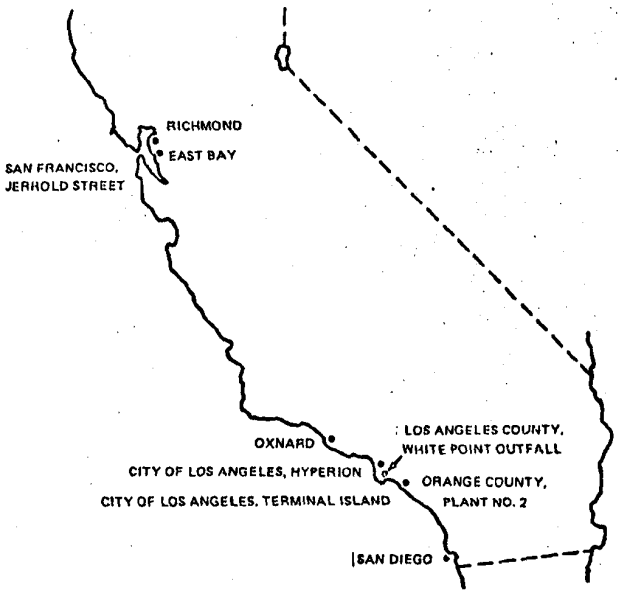


FIGURE 2.5-9 LOCATIONS OF TREATMENT PLANTS SAMPLED, CALIFORNIA

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Table 2.5-12
PCB Compounds in Urban Sewage Outfalls in California - 1970

Sampling Station	Description	Flow	PCB Type	PCB ppb	PCB est. kg/day
Richmond	Serves most of Richmond including one of the most heavily industrialized regions of the Bay Area.	21.5	----	N.D	-----
EBMUD East Bay Municipal Utility District	Discharges primary treated waste water and digested sludge into San Francisco Bay.	155	1260	3.1-3.8	2.0
San Francisco (Southeast Sewage Treatment Plant)	Serves the industrial area of San Francisco.	31.5	1260	3.8-5.8	0.6
Oxnard	Serves Oxnard.	10.0	----	N.D	-----
Hyperion Waste Water (City of Los Angeles) Sludge	Mostly domestic sources.	340 5	1254 1254	0.16-0.37 78.5-92.1	0.4 1.6
White Point	Serves Long Beach, Torrance and other heavily industrialized areas of Los Angeles County.	350	1242, 1254	76	100
Terminal Island	Serves Wilmington and Terminal Island seas. Processes mostly industrial waste.	9.3	1242	5.8-12.8	0.35
Orange County (plant #2)	Serves most of Orange County.	130	1242	0.21-0.64	0.18
San Diego	Serves San Diego and surrounding communities.	80		N.D	

SOURCE: Schmidt, T.T., R.W. Risebrough and F. Gress, Bulletin of Environmental Contamination and Toxicology 6, 235-243, (1971)

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Table 2.5-13
PCB Levels in Sludge, California, 1975

Location	Description	Polychlorinated Biphenyls (ppm) Aroclor 1254	Aroclor 1260	Aroclor 1242
Orange County Sewage Treatment Plant	Fountain Valley Digester Sludge	----	----	38-40
Hyperion Sewage Treatment Plant	Los Angeles, Digester Sludge	1.0-1.4	----	----
Fort Ord Sewage Treatment Plant	Secondary Digester Sludge	0.2-0.4	----	----
Treasure Isle Sewage Treatment Plant	Sludge	0.4-0.6	----	----
Travis Air Force Base, Sewage Treatment Plant	Digester Sludge	0.6-0.8	----	----
Mather Air Force Base	Sacramento Primary Digester Sludge	0.4-0.6	----	----
McClellan Air Force Base	Secondary Sludge	----	4.5-5.5	----
Beale Air Force Base	Primary Digester	0.3-0.5		

SOURCE: Unpublished Data, USEPA National Field Investigation Center, August 1975

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REFERENCES, Section 2.5

1. Dube, D.J. Polychlorinated Biphenyls in Effluents from Sewage Treatment Plants in Southeastern Wisconsin

2. Nadeau, R.J., and R.P. Davis, Investigation of Polychlorinated Biphenyls in the Hudson River, USEPA Region II

3. Polychlorinated Biphenyls and the Environment, Interdepartmental Task Force on PCB's, May 1972

4. Monitoring for Polychlorinated Biphenyls in the Aquatic Environment, Michigan Water Resources Commission, May 1973

5. Schmidt, T.T., R.W. Risebrough and F. Gress, Bulletin of Environmental Contamination and Toxicology 6, 235-243, (1971)

6. Unpublished Data, USEPA National Field Investigation Center, August 1975

7. Unpublished Report, Contract 68-01-2978, USEPA, Office of Toxic Substances; July 1975

8. USEPA, Pesticide Monitoring Programs: Lake Michigan and Tributaries in Illinois, EPA 600/3-74-002

9. Veith, G.D., and G.F. Lee, Water Research, 5, 1107-1115, (1971)

2.6 Data from Localized Monitoring Efforts - Cities

2.6.1 Jacksonville, Florida

Samples of ambient air, water, soils and bottom sediments were collected in the vicinity of Jacksonville, Florida, on September 10, October 6-7 and November 20-21, 1975, for PCB analysis.[1]

Figure 1 illustrates the sampling locations in the Jacksonville area. The outlined area on Figure 2.6-1 circumscribes a municipal sewage sludge disposal site which has been used for the past several years by the City of Jacksonville.

AIR DATA

Air samples were collected at the fire station off Fort Caroline Road using a high-volume sampler equipped with polyurethane foam as the collection medium. Measured PCB concentrations are reported in Table 2.6-1 for the 24-hour period of November 20-21, 1975. The levels measured throughout this period ranged from 4 to 9 ng/m^3, with the lowest levels being observed during the early morning period. Chromatograms indicated the presence of the lower substituted PCB components of Aroclors 1221 and 1016. Quantitation of the PCB levels was performed after perchlorination to decachlorobiphenyl.

WATER, BOTTOM SEDIMENT AND SLUDGE DATA

The analytical data for water, bottom sediment and sludge are summarized in Table 2.6-2 for the sampling points shown on Figure 2.6-1. PCB content of bottom sediments range from 10 to 572 ppb, surface water concentrations ranged from the analytical detection limit of 20 ppt to 285 ppt, expressed as decachlorobiphenyl. The highest sediment concentration (572 ppb) was observed near the cooling water discharge of the Jacksonville Electric Authority Southside Generating Station. This may be related to use of PCB-containing materials at the generating station. Intermediate concentrations were observed in sections of the St. John's River which is surrounded by urban and industrial development. Drainage creeks from the municipal sewage sludge landfill area had bottom sediments of lower concentration. Inspection of gas chromatographic elution patterns indicates the presence of Aroclor 1260 in these sediment samples.

A concentration level of 720 ppb was measured for fresh sludge taken from the Monterey sewage treatment plant. Two-year-old sludge, taken from the landfill area, had a concentration level of 119 ppb.

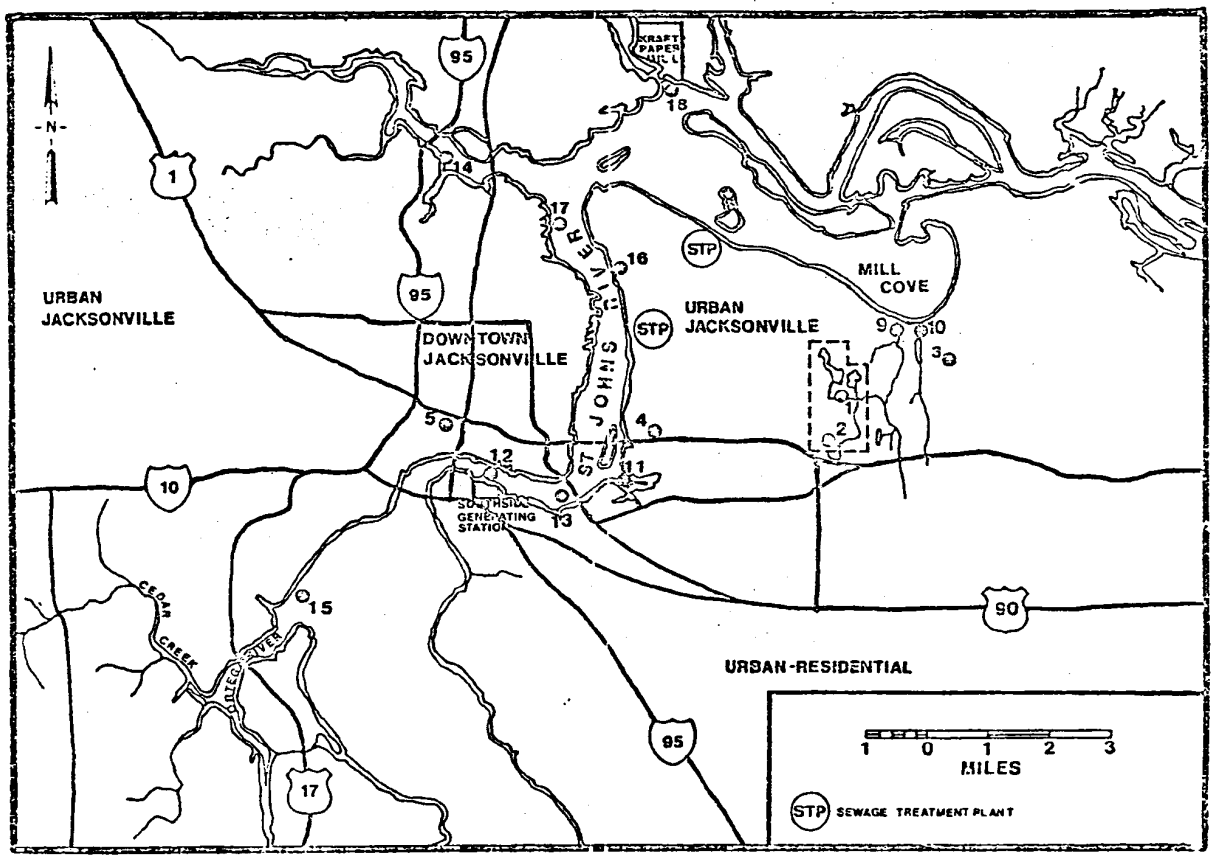


FIGURE 2.6.1 SITE MAP OF JACKSONVILLE, FLORIDA VICINITY SHOWING SAMPLE LOCATIONS

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Table 2.6-1
PCB in Ambient Air in the Vicinity of Jacksonville, Florida

Date	Period	Concentration (ng/m^3)*
11/20/75	1200-1600	9
11/20/75	1200-1800	8
11/20/75	1800-2400	9
11/20/75	2000-2400	7
11/21/75	2400-0600	4
11/21/75	0600-1200	6

* Reported as decachlorobiphenyl.

Table 2.6-2
PCB Analysis of Environmental Samples
in the Jacksonville, Florida, Area.

Sample Site	Sample Type	Site Description	Concentration (ppb)*
1	Sludge	Monterey sewage treatment plant	720
2	Soil	SW section of sludge landfill; about two years old	119
3	Soil	Air collection site	68
9	Sediment	Unnamed Stream into Mill Cove	10
10	Sediment	Ginhouse Creek	21
11	Sediment	Arlington River Mouth	74
11	Water	Arlington River Mouth	0.260
12	Sediment	Generating Station Discharge	572
13	Sediment	St. John's River	142
14	Sediment	Trout River	167
14	Water	Trout River	0.020
16	Water	Jacksonville College Pier	0.285
17	Water	St. Joseph's River	0.103
18	Water	Broward River Mouth	0.020

*Reported as decachlorobiphenyl.

SOURCE: Unpublished Report. Contract 68-01-2978, Office of Toxic Substances, EPA, December 1975.

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REFERENCES, Section 2.6

1. Unpublished Report. Contract 68-01-2978, Office of Toxic Substances, EPA, December 1975.

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3.0 Behavior of PCB's in the Environment

In general, PCB environmental movement is dependent on stability, solubility and volatility. These properties will control their transport via air, soil, water and/or sediment depending on the partition coefficient in each phase.

General discussions on the thermal, photochemical and chemical properties of PCB's have recently been published by Hutzinger, Safe and Zitko[5]. Various transport mechanisms have received considerable attention[3,4]. Current air data indicates that the predominant movement of PCB's in the atmosphere is not attached to particulates as is the case with DDT, but rather as the free unbound molecular species.

Some of the complexities of the behavior of PCB's in the environment include the following characteristics which are discussed in subsequent sections: (a) the complexity of the composition of different Aroclor products, (b) the difficulty in definition of water solubility and adsorption properties due to the complexity of the mixtures, and (c) the variability of the volatilization process depending on the starting mixture and point of release. By coupling these areas, the focus will be on those PCB properties that influence environmental sample collection, control their distribution in environmental samples and present potential difficulties in environmental sampling.

3.1 Composition of Aroclor Products

PCB's have been manufactured in the United States by the Monsanto Industrial Chemicals Company, and marketed under the trademark Aroclor with a numerical designation[6]. Table 3-1 provides an overview of the major Aroclors produced with their associated chlorine content. These Aroclor products are mixtures of different isomers. A typical analysis of the currently produced products and the associated chlorobiphenyl composition is shown in Table 3-2. In addition, the number of potential isomers making up the chlorobiphenyl component are also indicated. From this chemical analysis, Aroclor 1221 can be considered primarily as a monochlorobiphenyl and is the only Aroclor with a significant biphenyl concentration; Aroclor 1016 and 1242 are primarily trichlorobiphenyls, with the 1016 having a lower penta and hexa content than the 1242 product; Aroclor 1254 is primarily a pentachlorobiphenyl product. The composition of the different isomers could be quite different for each product.

3.2 Water Solubility of PCB's

The water solubility of various Aroclor products and some chlorobiphenyl isomers has been measured by different investigators. A limited set of reported values are shown in Table 3-3. The solubility for all three monochlorobiphenyl isomers is listed and range from 1190-5900 ppb. The solubilities for all of the higher chlorobiphenyl isomers have not been measured and only representative compounds are listed to

show the range of values possible and the component solubilities for Aroclor 1221; for the dichlorobiphenyls, the 2,4-, 2,2'-, 2,4'-, 4,4'-dichloro isomer is listed out of a possible 12 isomers and range in solubility from 80-1880 ppb; for the trichlorobiphenyls, only the 2,2',5-trichloro is listed out of a possible 24 isomers; for the tetrachlorobiphenyls only the 2,2',5,5'-tetrachloro is listed out of a possible 42 isomers. These values indicate that PCB's have low solubilities and the solubility decreases with the number of chlorine atoms present in the isomer, i.e., the lower isomers containing chlorine show the highest solubility. Factors that contribute to the variability of the results include adsorption to particulate matter or wall surfaces and the slow equilibration process.

Studies by Haque et. al.,[3] show that equilibration of Aroclor 1254 in water required approximately two months to reach complete equilibrium, with the major portion being achieved in a week. These studies also included various types of adsorbent surfaces ranging from sand to highly organic soil samples. The adsorption increased strongly with the organic content of the adsorbent studied. Starting with an original concentration of Aroclor 1254 at 56 ppb, the addition of 100 grams of sand or silica gel had very little effect on the final PCB concentration. However, by adding a high organic content soil, the final PCB concentration was reduced by approximately 85%.

Studies by Eichelberger[1] on the behavior of PCB's in river water over a 16 week period indicated that the levels of recovery of 10 ppb spiked Aroclor 1242 samples were 87, 76, 73, 60, 53 and 43 percent for zero time, 1, 2, 4, 8 and 16 weeks respectively. Losses were attributed to irreversible adsorption on either the walls of the sample container or the silt contained in the sample.

3.3 Interactions of PCB's with Soils

The behavior of PCB's in soil is a complex process dependent on a number of factors which include surface properties and composition. Soil composition can be identified by characterizing the percentage of sand, silt, clay and organic carbon. Depending on the surface properties, soils can act as an effective barrier to PCB migration in landfill sites and as an effective sink to PCB's deposited via aerial fallout. Once the PCB's are adsorbed, factors that would influence PCB movement are leaching when water is added to the soil and re-evaporation under normal atmospheric conditions.

In a series of experiments directed at understanding the leaching properties for various soils that could be encountered at different landfill sites, different types of soils were studied[10]. These experiments percolated water through a column packed with soil coated with Aroclor 1016 and monitored the effluent water. Breakthrough of the PCB's was found to be related to the clay content of the soil. Soils with the higher clay content retained the PCB's. The isomer distribution in the

effluent reflected the different water solubility and adsorption properties characteristic of the Aroclor 1016 isomers. The less chlorinated isomers were more readily leached. Results from these experiments are shown in Figure 3-1, where an Aroclor 1016 and 1221 standard solution is compared with the leached mixture. The resulting isomer distribution is significantly changed from the starting Aroclor 1016 and has a closer resemblance to the isomer pattern of Aroclor 1221. In the worst case, less than 0.05% of the total Aroclor 1016 available was leached under conditions equivalent to forty years of annual rainfall.

Adsorption and evaporation studies[3] with Aroclor 1254 on different soils show that due to the few adsorption sites in sand, sand surfaces adsorb relatively small amounts when compared to the other types of soils. Consequently the vaporization loss from a sand surface will be significantly higher than soil surfaces where it is more tightly bound. The less chlorinated isomers show a greater loss than those isomers of high chlorine content.

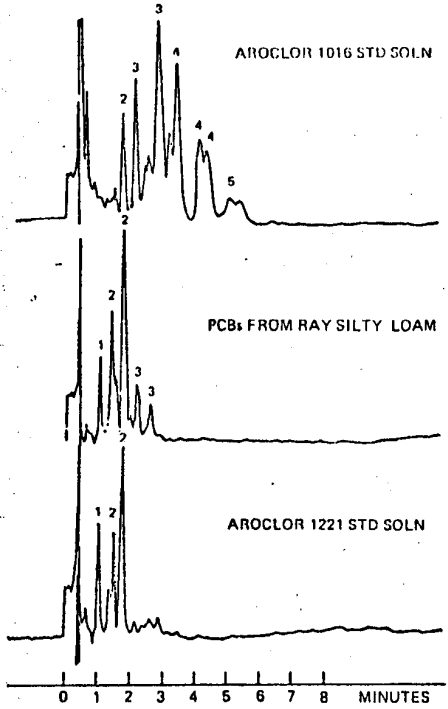
3.4 Evaporation of PCB's from Water

The transfer of PCB's from water to the air environment may be significantly faster than expected when considering that these compounds have a high molecular weight, low solubilities and low vapor pressures[6,7]. On examination, these compounds exhibit very high activity coefficients in aqueous solution resulting in high equilibrium vapor partial pressures and consequently high evaporation rates. The rates are relatively insensitive to temperature. For different Aroclor products, the evaporation process is complex depending on the chlorobiphenyl isomers present, leading to different isomer concentrations in each phase with time. The calculated half-lives for Aroclor 1242 and 1254 for a water depth of one meter are 12.1 and 10.3 hours respectively. Using the half-life values, if a monitoring station is located one hour downstream from a source of Aroclor 1242, by the time the water reaches the station, approximately one twentieth of the initial levels may have been evaporated. Where the water body is turbulent, the evaporation rate will be increased significantly.

3.5 Environmental Sampling Guidelines

Based on these limited studies, the following guidelines and precautions are suggested:

(1) laboratory measurements of field samples should be made as soon as possible;
(2) concentration levels of field samples measured in the laboratory will be lower than actual concentrations;
(3) concentration levels in water may be much lower in some areas depending on the type of suspended particulate matter;
(4) samples collected at plant outfalls will be non-equilibrium samples;



SOURCE: MIEURE, J.P., O. HICKS, R.G. KALEY AND V.W. SAEGER, "CHARACTERIZATION OF POLYCHLORINATED BIPHENYLS," NATIONAL CONFERENCE ON POLYCHLORINATED BIPHENYLS, CHICAGO, ILL., NOVEMBER 19-21, 1975

FIGURE 3-1

(5) sampling methods should be employed which reduce the problem of irreversible adsorption on container walls;
(6) soil samples will have an enriched high chlorobiphenyl isomer concentration;
(7) leached water and air samples will have an enriched lower chlorobiphenyl isomer concentration;
(8) true identification of the specific Aroclor released into the environment becomes more difficult with time.

Table 3-1
AROCLOR PRODUCTS
Produced by Monsanto

Currently in Production	Discontinued	Percent Chlorine
1221		21
	1232	32
1016		41
1242		42
	1248	48
1254		54
	1260	60
	1262	62
	1268	68

Table 3-2
COMPOSITION OF SOME AROCLORS

Chlorobiphenyl Composition	Number of Isomers	Chlorobiphenyl Percent Distribution of some Aroclors 1221	1016	1242	1254
$C_{12}H_{10}$		11	<0.1	<0.1	<0.1
$C_{12}H_9Cl$	3	51	1	1	<0.1
$C_{12}H_8Cl_2$	12	32	20	16	<0.5
$C_{12}H_7Cl_3$	24	4	57	49	1
$C_{12}H_6Cl_4$	42	2	21	25	21
$C_{12}H_5Cl_5$	46	<0.5	1	8	48
$C_{12}H_4Cl_6$	42	ND	<0.1	1	23
$C_{12}H_3Cl_7$	24	ND	ND	<0.1	6
$C_{12}H_2Cl_8$	12	ND	ND	ND	ND

ND = None detected, <0.1%

Table 3-3
SOLUBILITY OF AROCLORS AND CHLOROBIPHENYLS IN WATER

Aroclor Products	Solubility (ppb)	Media	References
1016	225-250	distilled water	10
1221	200	distilled water	8
1242	200	distilled water	9
1254	300-3000	fresh water	12
1254	300-1500	salt water	12
1254	50	distilled water	9
1254	56	distilled water	3
1254	40	distilled water	8
Chlorobiphenyl Compounds			
2-chlorobiphenyl*	5900		5
3-chlorobiphenyl	3500		5
4-chlorobiphenyl*	1190		5
2,4-dichlorobiphenyl	1400		5
2,4-dichlorobiphenyl	637		2
2,2'-dichlorobiphenyl*	1500		5
2,4'-dichlorobiphenyl*	1880		5
4,4'-dichlorobiphenyl*	80		5
2,2',5-trichlorobiphenyl	248		2
2,2',5,5'-tetrachlorobiphenyl	46		11
2,2',5,5'-tetrachlorobiphenyl	26		2

*These are the major chlorobiphenyl compounds in Aroclor 1221; the other major constituent is biphenyl which has a solubility in water of 4600 ppb.

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4.0 Occurrence of PCB's In Food

Some of the earliest findings of PCB's in foods occurred during the fall of 1969 in coho salmon and milk from West Virginia which was traced back to the misuse of a transformer fluid containing PCB's for defoliant spraying adjacent to dairy pasturage. In 1971 PCB's were found in poultry from North Carolina. Contaminated fish meal was implicated as the causative agent. The contamination was traced back to a leak in heat exchange equipment using PCB's. The fish meal samples examined contained from 14 to 30 ppm of PCB's. Follow-up sampling of eggs showed that 71 of 224 eggs contained residues in excess of 0.5ppm ranging from 0.6 to 4.2.ppm.[2]

The Food and Drug Administration conducts a comprehensive food surveillance program yearly to determine pesticide residues, PCB's, heavy metals and other contaminants in the dietary intake of consumers in the United States and to target emerging problems and trends. The FDA has analyzed all raw agricultural commodities sampled under the pesticide surveillance program for PCB's since 1969. PCB's have been encountered most frequently in fish, both freshwater (catfish, chub, and smelt) and saltwater (porgies, sea trout, bonita and sardines), with trace levels in shellfish. Table 4-1 presents the results of this program from July 1970 to September 1971.[7]

The total diet studies for FY 70 and FY 71 showed composite samples containing PCB residues up to 0.36 ppm. The positive readings were found in meat, fish, poultry, dairy and the grain and cereal composites. The 0.36 ppm value was found to be caused by migration of PCB's from the grayboard container and dividers to packaged shredded wheat.[2]

The FY 73 study included thirty market basket samples from representative areas of the United States consisting of the total 14-day diet of a 15-20 year old male in the region of collection including about 117 individual food items.[1]

These 117 food items are separated after any necessary preparation into twelve food group composites for analysis:

I	Dairy Products
II	Meat, Fish and Poultry
III	Grain and Cereal Products
IV	Potatoes
V	Leafy Vegetables
VI	Legume Vegetables
VII	Root Vegetables
VIII	Garden Fruits
IX	Fruits
X	Oils, Fats and Shortening
XI	Sugar and Adjuncts
XII	Beverages (including drinking water)

Most of the PCB levels identified in 1973 were trace amounts resulting in a daily intake of only 1 µg/day. The most frequent occurrences were in the meat-fish-poultry and grain-cereal products groups with 33% and 17% positive analyses. It has been suggested that environmental contamination may be the source in the first group and lingering recycled paper contamination in the second group.

Of 30 composites examined for each commodity group PCB residues were only determined in five of the groups as follows:

Group	Frequency
Dairy Products	3
Meat, Fish and Poultry	10
Grain and Cereal Products	5
Potatoes	1
Oils, Fats and Shortening	1

The range for all 20 positives was trace to 0.073 ppm. In fact 19 of the 20 readings were only trace amounts with the 0.073 ppm composite appearing in the Grain and Cereal Products group.[1]

Data for 1974 are not available yet. However preliminary information is that there were only 14 positive readings with 13 of them in the Meat, Fish and Poultry Group and the other one in the sugar and adjuncts group. The range of levels measured was trace to 0.05 ppm with the maximum levels in the Meat, Fish and Poultry group.[3]

Using the preceding figures it is estimated by FDA that the daily intake of PCB's from all twelve food group composites was 1.07 µg/day in 1973 and 0.388 µg/day in 1974.[3]

Table 4-1
PCB Residues in Selected Food Commodities
July 1970 - September 1971

	Number of samples examined	Number of samples positive	Percent positive	PCB levels, ppm, Low	high	Average
Fish	670	363	54	T	35.29	1.87
Cheese	1344	91	6	T	1.0	.25
Milk	941	69	7	T	27.8	2.27
Shell eggs	550	161	29	T	3.74	.55
Fish by-products	---	13	--	T	5.0	1.17
Total (excluding fish by-product)	3505	684	19			1.14

SOURCE: Kolbye, A.D., Jr., Environmental Health Perspectives, 85-88, April 1972.

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5.0 Exposure and Biological Accumulation of PCB's in Man

5.1 National Monitoring Programs

The National Human Monitoring Program for Pesticides is conducted by the Office of Pesticide Programs, EPA. Small samples of adipose tissue from postmortem examinations and from specimens submitted for pathological examination during therapeutic surgery are collected and analyzed for the presence of chlorinated hydrocarbon insecticides. Analysis for PCB's was begun in 1968. Summaries of the data from 1971 are reported in Table 5.1-1 and from 1972 to 1974 in Table 5.1-2.

Note that although classes are different in the two sets of results, the proportion of samples showing traces of PCB's is increasing: 50.7%, 1971; 73.99%, 1972; 75.49%, 1973; 90.93%, 1974. The increase between 1973 and 1974 is dramatic. However, the percentage of tissues which contained quantifiable (greater than 1.0 ppm) of PCBs appears to be remaining relatively constant (31.1%, 58.53%, 35.08%, 40.30%, 1971-74).

5.2 Localized Studies

There have been several localized studies showing the presence of PCB's in both human plasma and milk. A 1968 study in Charleston County, South Carolina[3], reported that of 612 plasma samples collected from healthy volunteers, 45% showed some PCB residue. Levels ranged to a maximum of 29 ppb with a mean plasma residue of 2.12 ppb. This study also tested for the significance of several factors on PCB levels, concluding only that residues were more frequent and higher in whites and urban residents. A follow-up study conducted in 1972[1] in the Charleston area sampled plasma and scalp hair specimens from 37 refuse burners and 54 controls. PCB residues were not detected in hair samples, but 81% of the refuse burners (compared with only 11% of the controls) had detectable PCB residues in plasma. Median levels for those with detectable amounts in plasma were 2.6 ppb for the refuse workers and 3.7 ppb for the controls, with maximums of 14.1 ppb and 20.2 respectively.

A 1971-72 study[5] of 40 human milk samples in Colorado discovered PCB residues in 20% of the samples in ranges from 40 to 100 ppb. A 1971 study of 47 lactating women in Texas[2] reported an absence of PCB residues both in milk from all subjects and in serum from 28 subjects. A minor study of blood samples from nine cachectic patients and 15 healthy nonpatients from Missouri and surrounding states[4] reported detectable PCB residues in all patients (mean 48 ppb, range 10-100 ppb) and none detectable in the nonpatients. No conclusions were drawn.

Table 5.1-1
PCB Concentrations in Human Adipose Tissue, 1971

Sample Size	Absent Number	%	Trace to Below 1 ppm Number	%	1-2 ppm Number	%	2 ppm Number	%
637	314	49.3	125	19.6	165	25.9	33	5.2

SOURCE: Yobs, Anne R., Environmental Health Perspectives, 1, 79-81 April 1972.

Table 5.1-2
PCB Concentrations in Human Adipose Tissue, 1972-1974

	Sample Size	Absent Number	%	Below 1 ppm Number	%	1-3 ppm Number	%	73 ppm Number	%
1972	4102	1067	26.01	634	15.46	2079	50.68	322	7.85
1973	1277	313	24.51	513	40.17	378	29.60	70	5.48
1974	1047	95	9.07	530	50.62	371	35.43	51	4.87

SOURCE: Kutz, F.W., Project Officer, National Human Monitoring Program for Pesticides, Office of Pesticides Programs, U.S. EPA, Washington, DC.

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6.0 Environmental Trends

There are few data bases or environmental studies which provide an adequate basis for sound analytic determinations of national trends in environmental levels of PCB's. Such a data base would be a result of a system of studies involving consistent sampling across media, i.e., statistical samples taken at the same locations at representative time periods, analyzed according to standard protocols, taken over a period of time long enough to establish a trend. Some studies do show consistent sampling within specific media, e.g., the Great Lakes Environmental Contaminant Survey, but the literature is full of snapshot studies with neither predecessor nor successor, and baseline studies which have not been followed by any further work. Thus, whether due to funding, modification of priorities or personnel changes, long-term consistency and coordination have not been achieved. As a result, the conclusions drawn in this section represent qualitative judgements drawn from the large mass of generally uncoordinated PCB studies analyzed.

Even recognizing all the faults of the available data base, the sheer mass of data supports the conclusion that there is widespread contamination of the environment by PCB's. There are regional variations, but effects are consistent across all media (e.g., water, sediment, fish, birds), generally showing greater concentrations of PCB's in highly developed areas and in areas of industrial activity. Over the past five years of increasing recognition of and attention to the problems of PCB's, the situation has shown no improvement nationally. Conscious efforts have, however, resulted in substantial improvement in some localized instances.

PCB contamination of the nation's waterways was termed widespread by the USGS over the period 1971-1972; more recent data from the USGS up to 1975 has shown no reduction in either levels or in geographical dispersion. Although sampling stations in the USGS data base are not expected to be representative of the U.S. and the data suffers from multiple observations at some stations and spot readings at others, over the period 1971-1975 states which had reported PCB's in sediment continued to do so while six of the 23 states which had shown no contaminated samples in 1973 did report some contamination in 1974. Sediment concentrations are imperfect indicators of current contamination levels and whole water measurements would be better. However, the currently practiced analytical protocol for water measurements, which limits detectability to 0.1 ppb, leads to a preponderance of zero readings in whole water which mask the very real problem of PCB contamination in the nation's waters. In almost all cases in which samples of both whole water and bottom sediment were taken simultaneously and the sediment had a non-zero PCB level, concentration in the water was reported as zero ppb. This occurred even when the concentration in bottom sediment was as high as 4000 parts per billion! Were water measurements to be taken at the parts per trillion level as some recent studies have done, whole water readings would certainly show PCB contamination, to an extent similar to that shown by sediment readings.

The results of the U.S. Fish and Wildlife Service's fish monitoring activities show that stations which have reported high concentrations in the past continue to do so, and that the higher concentrations are associated with river systems having significant industrial activity. Such results are consistent with those for water and sediment from the USGS water quality file. The fish data, however, shows a decline in both the proportion of composites with some PCB residues and the proportion with residues in excess of 0.5 ppm in the 1970-73 sampling program. Levels of detection are generally lower in 1973 than in previous years. While there are cautionary notes (see section 2.1.5), some improvement in PCB contamination appears evident, although mostly at those stations with prior low contamination levels.

Water is recognized as being a major sink and transport mechanism for PCB's and, therefore, residue levels in water and fish are significant. Yet other media confirm the stability and breadth of contamination over the nation. Data on human adipose tissue show a steady climb over the years 1971-74 in the percent showing traces of PCB's. Soil monitoring shows that sixty percent, i.e., 3 of 5 cities sampled each year since the National Soils Monitoring Program started have had at least one positive PCB sample. Bird monitoring conducted as part of the U.S. Bureau of Fish and Wildlife's portion of the National Pesticides Monitoring Program shows residue levels in black ducks and mallards increasing between 1969 and 1972 in the Atlantic and Mississippi flyways and slightly decreasing in the Central and Pacific Flyways. PCB residues in starlings for 1970, 1972 and 1974 appear to be decreasing, yet PCB residues have been found in all samples each year, underscoring the ubiquitous nature of PCB's throughout the country.