Chlorinated Hydrocarbon Pesticides in Major River Basins, 1957–65

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SINCE 1957, water quality data, including data on trace organic contaminants, have been collected periodically through a system of cooperatively operated sampling stations located on the major rivers and Great Lakes (*1*). During the ensuing 8 years about 6,000 samples were collected, with the carbon adsorption method (CAM) (*2*), at more than 100 stations. Initially, the extracts from these samples were examined with the best methods then available. The concentration values for the substances extracted from the carbon by chloroform and by alcohol have been reported routinely (*3–8*). A variety of chemicals has been identified in these extracts. The dried extracts have been stored for future reference.

Concurrently, improvements in sampling (*9, 10*) and analytical technology (*2*) for one type of organic contaminant, chlorinated hydrocarbon pesticides, have been substantial. Thus, recently, when widespread public awareness of the adverse effect of pesticide pollution developed, it was possible to retrieve and analyze stored carbon adsorption extracts. The results of these analyses provide a historical review of pesticide pollution in surface waters which otherwise would have been unobtainable. Moreover, the extended sensitivity of modern laboratory instrumentation now permits the analysis for pesticides with smaller bottled samples. Thus, in 1964 (*11*) and again in 1965, using bottled samples, synoptic surveys for chlorinated pesticides were conducted at approximately 100 surveillance stations.

This report presents and discusses the results of the 1965 synoptic survey as they relate to the 1964 data (*2*), and summarizes and comments on the historical occurrence of pesticides in a selection of surface water CAM samples taken during 1957–65.

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Sampling

All sampling was conducted through the coordinated and cooperative efforts of Federal, State, local, and private agencies which jointly operate an existing system of water pollution surveillance stations in each river basin.

The stations selected for sampling in the 1965 synoptic survey closely paralleled those chosen for the 1964 effort, which attempted minimum coverage of the several hydrological basins with emphasis on areas of known pesticide usage. September was selected for the sampling, as previously, to coincide generally with the post-application, low-flow period.

Also, 600 earlier CAM samples were selected

Table 1. Synoptic survey of chlorinated hydrocarbon pesticides, U.S. river basins, September 1965

Location [1]	Concentration in micrograms per liter								
	Dieldrin	Endrin	DDT	DDE	DDD	Aldrin	Heptachlor	Heptachlor epoxide	BHC
Northeast Basin									
Connecticut River:									
Enfield Dam, Conn. (82)	ND	ND	ND	ND	ND	ND	ND	ND	P
Northfield, Mass. (11)	P	ND	ND	ND	ND	ND	ND	ND	ND
Wilder, Vt. (103)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hudson River: Poughkeepsie, N.Y. (18)	ND	ND	ND	ND	P	ND	ND	ND	ND
Lake Erie: Buffalo, N.Y. (14)	ND	ND	ND	ND	ND	ND	ND	0.002	ND
Merrimack River: Lowell, Mass. (19)	0.068	ND	ND	ND	0.007	ND	P	ND	ND
St. Lawrence River: Massena, N.Y. (63)	ND	ND	ND	ND	.010	ND	0.031	.017	ND
North Atlantic Basin									
Delaware River:									
Trenton, N.J. (100)	.018	0.018	ND	ND	.018	ND	ND	ND	ND
Martins Creek, Pa. (61)	ND	ND	ND	ND	ND	ND	.025	P	ND
Potomac River:									
Washington, D.C. (130)	.003	ND	ND	ND	.007	ND	ND	.003	ND
Great Falls, Md. (40)	.016	ND	ND	ND	ND	ND	P	P	ND
Schuylkill River: Philadelphia, Pa. (74)	.014	ND	ND	ND	ND	ND	ND	P	ND
Shenandoah River: Berryville, Va. (87)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Susquehanna River:									
Conowingo, Md. (75)	.002	ND	ND	ND	ND	ND	ND	ND	ND
Sayre, Pa. (76)	P	ND	ND	ND	ND	ND	ND	ND	ND
Southeast Basin									
Apalachicola River: Chattahoochee, Fla. (57)	.016	ND	ND	ND	ND	ND	ND	ND	ND
Chattahoochee River: Lanett, Ala. (120)	.005	ND	0.017	ND	.012	ND	ND	ND	ND
Escambia River: Century, Fla. (62)	ND	ND	.017	ND	ND	ND	ND	ND	ND
Roanoke River: John H. Kerr Reservoir and Dam, Va. (91)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Savannah River:									
Port Wentworth, Ga. (47)	.022	ND	.016	ND	.006	ND	P	ND	ND
North Augusta, S.C. (48)	.051	ND	ND	ND	ND	ND	ND	ND	ND
Tombigbee River: Columbus, Miss. (95)	.100	.015	ND	ND	ND	ND	ND	P	ND
Tennessee River Basin									
Clinch River: above Kingston, Tenn. (106)	.007	.015	P	ND	ND	ND	ND	ND	ND
Tennessee River:									
Bridgeport, Ala. (77)	ND	ND	.015	ND	ND	ND	ND	ND	ND
Lenoir City, Tenn. (107)	.028	.009	ND	ND	ND	ND	.020	P	ND
Ohio River Basin									
Allegheny River: Pittsburgh, Pa. (79)	ND	ND	.004	ND	ND	ND	ND	ND	ND
Kanawha River: Winfield, Dam, W. Va. (68)	.045	P	ND	ND	ND	ND	P	ND	ND
Monongahela River: Pittsburgh, Pa. (83)	.005	.014	.016	ND	ND	ND	ND	ND	P
Ohio River:									
Cairo, Ill. (35)	.028	ND	.023	ND	.003	ND	ND	.002	0.002
Evansville, Ind. (36)	.002	ND	ND	ND	ND	ND	ND	ND	ND
Cincinnati, Ohio (37)	.006	ND	ND	ND	ND	ND	.024	ND	ND
above Addison, Ohio (117)	.007	ND	P	ND	P	ND	P	.020	ND
Wabash River: New Harmony, Ind. (105)	ND	ND	.012	ND	ND	ND	.009	.012	ND
Lake Erie Basin									
Maumee River: Toledo, Ohio (127)	.024	ND	ND	ND	ND	ND	ND	ND	ND
Upper Mississippi River Basin									
Illinois River: Peoria, Ill. (67)	ND	ND	P	ND	ND	ND	P	ND	ND
Mississippi River:									
Cape Girardeau, Mo. (23)	ND	ND	ND	ND	ND	ND	ND	ND	ND
East St. Louis, Ill. (24)	.005	ND	P	ND	ND	ND	ND	ND	ND
Burlington, Iowa (25)	.009	ND	ND	ND	ND	ND	P	P	ND
Dubuque, Iowa (26)	.024	ND	ND	ND	ND	ND	.048	.067	ND
Lock and Dam 3 below St. Paul, Minn. (27)	P	ND	ND	ND	ND	ND	ND	ND	ND
Rainy River: Baudette, Minn. (96)	ND	ND	ND	P	ND	ND	ND	ND	ND
Red River (North): Grand Forks, N. Dak. (69)	.007	.009	.034	ND	ND	ND	.155	.020	.004
Western Great Lakes Basin									
Detroit River: Detroit, Mich. (15)	.018	ND	ND	.008	ND	ND	.015	P	ND
St. Clair River: Port Huron, Mich. (64)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lake Michigan: Milwaukee, Wis. (65)	.003	ND	ND	ND	ND	ND	ND	ND	ND
Lake Superior: Duluth, Minn. (16)	ND	ND	ND	ND	ND	ND	ND	ND	ND

[1] Numbers in parentheses are those assigned to the sampling stations by the Federal Water Pollution Control Administration, Water Pollution Surveillance System.

NOTES: All but the following samples were collected Sept. 22, 1965: Rio Grande at Alamosa, Colo., Sept. 20; Bear River at Preston, Idaho, Sept. 21; Apalachicola River at Chattahoochee, Fla., Sept. 23; Ohio River at Evansville, Ind., Sept. 23; Big Horn River at Hardin, Mont., Sept 23; Rio Grande at Laredo, Tex., Sept. 23; Connecticut River at Wilder, Vt., Sept. 23; Lake Erie at Buffalo, N.Y., Sept. 23; Schuylkill River at Philadelphia, Pa., Sept. 23; Lake Superior at Duluth, Minn., Sept. 24; Waikele Stream, Hawaii, Sept. 24.

ND—indicates none detected. P—indicates presumptive. Data are reported as presumptive in instances where the results of chromatography were highly indicative but did not meet all requirements for positive identification and quantification.

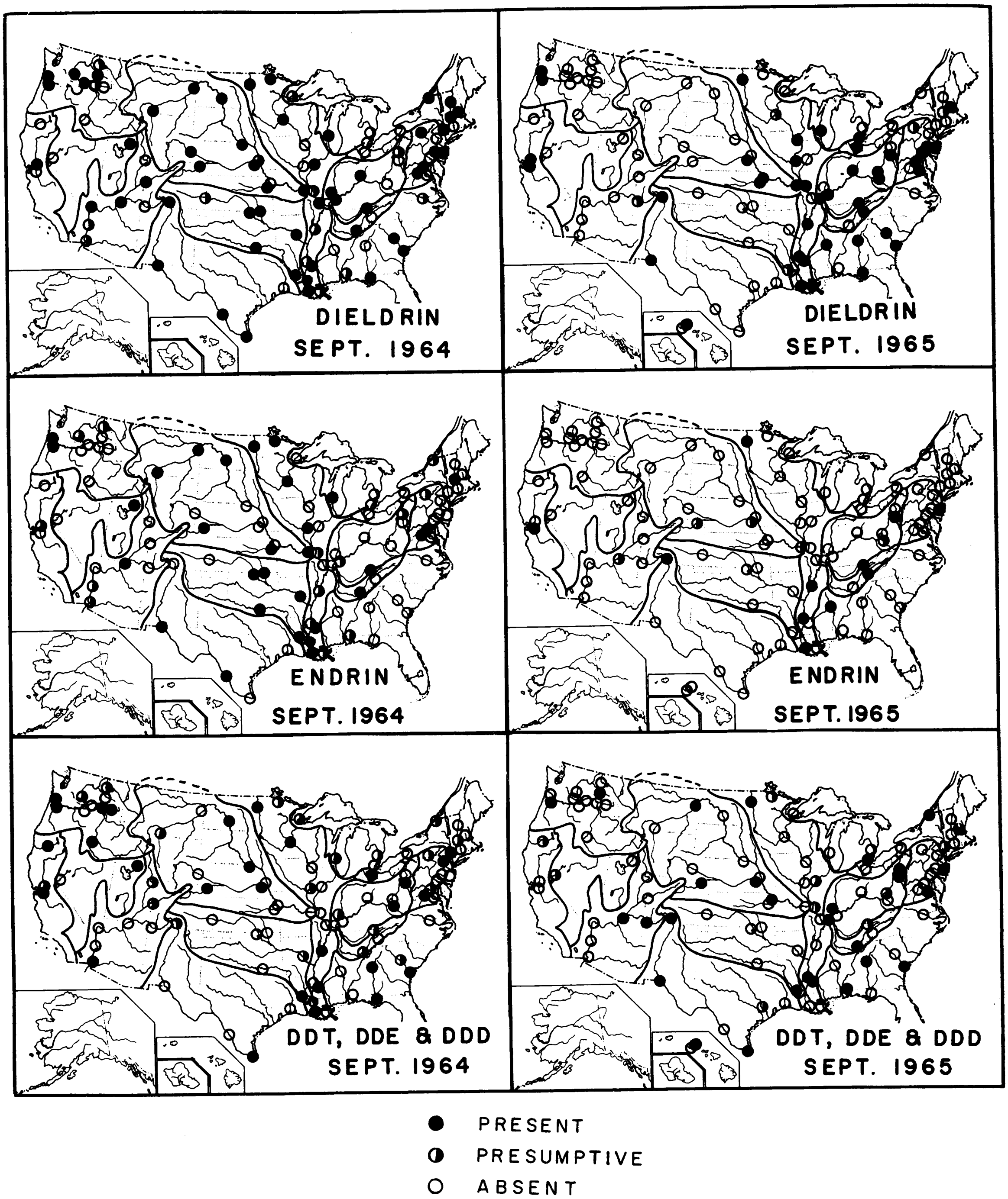
Table 1. Synoptic survey of chlorinated hydrocarbon pesticides, U.S. river basins, September 1965—Continued

Location [1]	Concentration in micrograms per liter								
	Dieldrin	Endrin	DDT	DDE	DDD	Aldrin	Heptachlor	Heptachlor epoxide	BHC
Missouri River Basin									
Big Horn River: Hardin, Mont. (104)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kansas River: DeSoto, Kans. (128)	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Missouri River:									
St. Louis, Mo. (28)	.004	P	ND	ND	ND	ND	0.020	0.007	ND
Kansas City, Kans. (29)	.023	ND	0.016	ND	0.011	ND	.008	.014	ND
Omaha, Nebr. (31)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Yankton, S. Dak. (32)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bismarck, N. Dak. (33)	ND	ND	ND	ND	ND	ND	ND	ND	ND
North Platte River: above Henry, Nebr. (94)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Platte River: above Plattsmouth, Nebr. (86)	.010	P	.039	P	.010	ND	ND	.002	ND
South Platte River: Julesburg, Colo. (92)	ND	P	.023	ND	ND	ND	ND	ND	ND
Yellowstone River: near Sidney, Mont. (55)	ND	ND	.002	0.002	.005	ND	ND	P	ND
Southwest River Basin									
Arkansas River:									
Little Rock, Ark. (131)	ND	ND	ND	ND	ND	ND	ND	ND	ND
near Ponca City, Okla. (1)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Coolidge, Kans. (2)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Red River (South)									
Alexandria, La. (42)	P	ND	ND	ND	.008	ND	ND	ND	ND
Denison, Tex. (44)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Verdigris River: Nowata, Okla. (109)	ND	ND	ND	ND	ND	ND	ND	ND	P
Lower Mississippi River Basin									
Atchafalaya River: Morgan City, La. (132)	.013	0.019	ND	ND	ND	ND	.010	ND	ND
Mississippi River:									
New Orleans, La. (20)	.005	ND	ND	ND	ND	ND	ND	ND	ND
Vicksburg, Miss. (21)	.004	ND	.017	ND	ND	ND	ND	ND	ND
Delta, La. (54)	.004	.008	.019	ND	ND	ND	ND	ND	ND
West Memphis, Ark. (22)	.018	.116	ND	ND	ND	ND	ND	.020	ND
Colorado River Basin									
Colorado River:									
Yuma, Ariz. (3)	ND	ND	ND	ND	ND	ND	ND	ND	ND
above Parker Dam, Ariz.-Calif. (4)	ND	ND	ND	ND	ND	ND	ND	ND	ND
near Boulder City, Nev. (5)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Page, Ariz. (60)	ND	P	.058	ND	ND	ND	P	P	ND
Loma, Colo. (6)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Green River: Dutch John, Utah (121)	ND	ND	ND	ND	ND	ND	ND	ND	ND
San Juan River: Shiprock, N. Mex. (93)	P	ND	.125	.009	ND	ND	.012	ND	ND
Western Gulf Basin									
Brazos River: Arcola, Tex. (SC5)	ND	ND	ND	ND	P	ND	ND	ND	ND
Rio Grande:									
Brownsville, Tex. (71)	ND	ND	ND	ND	.026	ND	.035	P	ND
Laredo, Tex. (45)	ND	ND	ND	ND	ND	ND	ND	ND	ND
El Paso, Tex. (46)	.003	ND	.012	ND	ND	ND	ND	ND	ND
below Alamosa, Colo. (72)	.029	.014	.149	ND	ND	ND	P	ND	ND
Sabine River: near Ruliff, Tex. (73)	ND	ND	ND	ND	ND	ND	P	P	ND
Pacific Northwest Basin									
Clearwater River: Lewiston, Idaho (97)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Columbia River:									
Clatskanie, Oreg. (7)	.003	ND	ND	ND	ND	ND	ND	ND	ND
McNary Dam, Oreg. (81)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pasco, Wash. (9)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pend Oreille River: Albeni Falls Dam, Idaho (113)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Snake River:									
Ice Harbor Dam, Wash. (115)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wawawai, Wash. (49)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Payette, Idaho (102)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Spokane River: Post Falls Dam, Idaho (114)	ND	ND	.037	ND	ND	ND	ND	ND	ND
Willamette River: Portland, Oreg. (124)	.005	ND	ND	ND	.013	ND	ND	ND	ND
Yakima River: Richland, Wash. (89)	ND	ND	ND	ND	ND	ND	ND	.002	ND
California Basin									
Klamath River: near Keno, Oreg. (78)	ND	ND	ND	ND	P	ND	ND	ND	ND
Sacramento River: Greens Landing, Calif. (116)	.011	ND	ND	ND	ND	ND	.020	.019	ND
San Joaquin River: near Vernalis, Calif. (122)	.005	.005	ND	ND	ND	ND	ND	ND	ND
Great Basin									
Bear River: Preston, Idaho (125)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Truckee River: Farad, Calif.-Nev. border (88)	ND	ND	P	ND	ND	ND	ND	ND	ND
Hawaii									
Waikele Stream (SC15)	.018	ND	ND	ND	.008	ND	ND	ND	ND
Kiikii Stream (SC16)	ND	ND	ND	ND	ND	ND	ND	ND	ND

for analysis, based on the results of the 1964 synoptic survey or in response to requests for information in areas experiencing fish kills assumed to be associated with pesticide pollution. Particular emphasis was given to analyzing CAM extracts from June or July samples to include periods early in the growing season.

Carbon adsorption systems. Two types of

Figure 1. Occurrence of chlorinated hydrocarbon pesticides in major U.S. river basins, synoptic surveys of 1964 and 1965



carbon adsorption systems have been employed. The first type (*2*) passes the water over a cylindrical cartridge containing coarse and fine carbon at a rate of 0.5 gallon per minute (gpm). Sample volumes are 1,000 or 5,000 gallons. A settling tank or sand strainer is usually necessary to prevent suspended matter from clogging the cartridge. The second, more recent, type (*2, 12*) employs a cartridge filled with only fine carbon through which the sample is passed at 100 milliliters per minute (approximately 1/32 gpm). The sample volume is 1,000 liters (approximately 250 gallons). No removal of suspended material is necessary. It is recognized that quantitative adsorption on, and desorption from, carbon of all organic substances does not always occur. Thus, positive values for substances measured are minimum values. Moreover, in the use of the 0.5-gpm system, the exclusion of the suspended material may have eliminated some organic compounds adsorbed on the sediment.

Grab sampling. Two 1-quart grab samples were requested for September 22, 1965, from each of the 99 points listed in table 1. Samples were collected in glass jars fitted with screw-type caps lined with Teflon (*2*).

Analytical Procedures

Carbon adsorption systems. Carbon adsorption extracts, except as noted, were analyzed according to the methods previously compiled (*2, 11*). These methods will detect dieldrin, endrin, DDT, DDE, DDD, aldrin, heptachlor, heptachlor epoxide, and BHC.

Samples were extracted with chloroform followed by ethanol according to the standard procedures. The carbon chloroform extracts were subjected to a silica gel column cleanup. The aromatic fraction thus obtained was subjected to thin-layer chromatography (*13*) and electron capture as well as microcoulometric titration gas chromatography.

The electron-capture detector is specific for all electronegative compounds. The microcoulometric titrator is specific for halogens.

Table 2. Percent of grab samples showing positive or presumptive evidence of chlorinated hydrocarbon pesticides in 1964 and 1965 synoptic surveys

Basin	Dieldrin	Endrin	DDT	DDE	DDD[1]	Aldrin	Heptachlor	Heptachlor epoxide[1]	BHC
Northeast:									
1964	72	29	14	43	[1]	14	0	[1]	0
1965	29	0	0	0	43	0	29	29	14
North Atlantic:									
1964	62	38	38	38	12	0	25	[1]	12
1965	75	12	0	0	25	0	25	50	0
Southeast:									
1964	72	14	43	29	[1]	0	43	[1]	0
1965	72	14	43	0	29	0	14	14	0
Ohio, Lake Erie, and Tennessee:									
1964	55	36	50	33	[1]	8	17	[1]	0
1965	75	33	58	0	17	0	42	33	17
Upper Mississippi:									
1964	88	62	50	50	[1]	12	12	[1]	0
1965	62	12	38	12	0	0	50	38	12
Western Great Lakes:									
1964	50	25	50	50	[1]	25	25	[1]	0
1965	50	0	0	25	0	0	25	25	0
Missouri:									
1964	91	54	27	45	[1]	9	18	[1]	0
1965	36	27	36	18	27	0	18	36	0
Southwest-Lower Mississippi:									
1964	100	100	42	42	[1]	0	25	[1]	8
1965	55	27	18	0	9	0	18	9	0
Colorado:									
1964	72	43	43	29	[1]	29	14	[1]	0
1965	14	14	29	14	0	0	29	14	0
Western Gulf:									
1964	80	40	40	40	[1]	20	0	[1]	0
1965	33	17	33	0	33	0	50	33	0
Pacific Northwest:									
1964	70	40	70	40	[1]	10	10	[1]	0
1965	18	0	9	0	9	0	0	9	0
California-Great Basin:									
1964	60	40	80	40	[1]	20	0	[1]	0
1965	40	20	20	0	20	0	20	20	0
Hawaii: 1965	50	0	0	0	50	0	0	0	0
Total:									
1964	74	46	44	39	[1]	10	17	[1]	2
1965	47	16	25	5	17	0	24	25	5

[1] 1964 analyses were at a lower level of sensitivity and not comparable with 1965 results.

Table 3. Occurrence of positive and presumptive pesticide determinations in carbon adsorption method samples and in grab samples collected during 1964 and 1965 synoptic surveys

Water year	Number samples	Dieldrin		Endrin		DDT		DDE		DDD		Aldrin		Heptachlor		Heptachlor epoxide		BHC	
		Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)
Northeast Basin																			
CAM samples:																			
1958	6	5	0.004	1	0.001	3	0.004	2	0.004	5	0.006	0	------	0	------	0	------	1	P
1959	5	4	.011	0	------	1	P	1	P	1	.003	0	------	0	------	0	------	0	------
1960	4	3	.011	0	------	0	------	3	.006	0	------	0	------	0	------	0	------	0	------
1961	6	5	.009	1	P	0	------	2	P	3	.006	1	<0.001	0	------	0	------	1	P
1962	7	6	.005	1	.001	0	------	0	------	4	.003	0	------	0	------	0	------	1	C.003
1963	9	7	.023	0	------	0	------	1	<.001	2	.006	1	P	0	------	0	------	0	------
1964	7	5	.010	0	------	1	.005	3	.002	4	P	0	------	0	------	1	0.001	1	P
Grab samples:																			
1964	7	5	>.071	2	.025	1	P	3	.004	0	------	1	P	0	------	0	------	0	------
1965	7	2	.068	0	------	0	------	0	------	3	.010	0	------	2	0.031	2	.017	1	P
North Atlantic Basin																			
CAM samples:																			
1958	2	2	<.001	1	P	1	P	2	<.001	1	.001	0	------	1	P	2	.007	1	P
1959	1	1	P	0	------	0	------	0	------	1	.002	0	------	0	------	0	------	0	------
1960	7	7	.026	1	P	2	.006	4	.002	5	.022	0	------	0	------	1	.001	2	P
1961	5	5	.010	0	------	1	.001	2	.001	1	.003	1	P	0	------	2	<.001	0	------
1962	10	8	.035	1	P	2	.003	3	.002	7	.011	1	P	0	------	0	------	0	------
1963	9	9	.033	1	P	4	.070	4	.012	5	.080	0	------	0	------	2	.008	0	------
1964	5	5	.010	2	P	4	.002	4	.002	4	.004	0	------	0	------	1	<.001	1	P
Grab samples:																			
1964	8	5	>.040	3	>.094	3	.026	3	.008	1	.083	0	------	2	P	0	------	1	P
1965	8	6	.018	1	.018	0	------	0	------	2	.018	0	------	2	.C25	4	.003	0	------
Southeast Basin																			
CAM samples:																			
1958	2	2	.002	1	<.001	1	P	2	.002	2	.031	0	------	0	------	0	------	0	------
1959	1	1	.010	0	------	0	------	1	<.001	1	.002	0	------	0	------	0	------	1	P
1960	6	6	.011	1	.001	2	.002	3	.001	5	.008	1	P	0	------	0	------	3	.022
1961	3	3	.013	0	------	1	.002	1	<.001	3	.005	1	P	0	------	0	------	2	P
1962	3	3	.020	1	P	1	.001	1	<.001	2	.007	0	------	0	------	0	------	0	------
1963	14	13	.056	0	------	8	.011	6	.001	10	.006	3	.002	0	------	0	------	1	P
1964	10	9	.035	1	.001	5	.005	6	.002	8	.008	1	P	0	------	0	------	0	------
Grab samples:																			
1964	7	5	>.118	1	P	3	.020	2	.004	0	------	0	------	3	P	0	------	0	------
1965	7	5	.100	1	.015	3	.017	0	------	2	.012	0	------	1	P	1	P	0	------
Ohio, Tennessee, and Lake Erie Basins																			
CAM samples:																			
1958	4	3	.020	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1959	4	4	.055	0	------	0	------	0	------	2	.002	0	------	0	------	0	------	0	------
1960	3	3	.021	0	------	0	------	0	------	1	P	0	------	0	------	0	------	1	.002
1961	6	6	.004	0	------	0	------	0	------	1	P	0	------	0	------	0	------	1	P
1962	5	4	.008	2	P	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1963	11	9	.006	4	.012	2	.011	2	P	2	P	0	------	0	------	0	------	0	------
1964	18	17	.005	7	P	4	P	9	.001	14	.006	1	P	0	------	0	------	0	------
Grab samples:																			
1964	12	6	.015	4	.015	6	.087	4	.004	0	------	1	P	2	P	0	------	0	------
1965	12	9	.045	4	.014	7	.023	0	------	2	.003	0	------	5	.024	4	.020	2	.002
Upper Mississippi River Basin																			
CAM samples:																			
1958	4	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1959	2	2	.004	1	.013	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1960	4	4	<.001	1	P	1	<.001	2	<.001	1	P	0	------	0	------	1	P	0	------
1961	7	5	.010	1	.001	0	------	0	------	2	.002	0	------	0	------	0	------	0	------
1962	2	2	<.001	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1963	15	14	.067	11	.007	1	P	0	------	2	.001	0	------	0	------	0	------	0	------
1964	[1] 30	36	.007	9	.004	3	<.001	7	.002	8	<.001	5	P	0	------	0	------	2	P
1965	8	8	.002	0	------	1	P	2	P	0	------	1	P	0	------	C	------	0	------
Grab samples:																			
1964	8	7	.008	5	.023	4	.072	4	.011	0	------	1	P	1	P	0	------	0	------
1965	8	4	.024	1	.009	3	.034	1	P	0	------	C	------	4	.155	3	.067	1	.004
Western Great Lakes Basin																			
CAM samples:																			
1958	1	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1959	3	2	<.001	0	------	0	------	1	P	1	<.001	0	------	0	------	0	------	0	------
1960	3	3	.002	0	------	0	------	1	P	1	.001	0	------	0	------	0	------	0	------
1961	4	3	<.001	0	------	1	.001	1	.004	1	<.0C1	1	P	0	------	0	------	0	------

NOTES: Additional samples analyzed for dieldrin and endrin only: [1] 12, [2] 2, [3] 48, [4] 1, [5] 62, [6] 1.

P—indicates presumptive.

Table 3. Occurrence of positive and presumptive pesticide determinations in carbon adsorption method samples and in grab samples collected during 1964 and 1965 synoptic surveys—Continued

Water year	Number samples	Dieldrin: Number positive	Dieldrin: Maximum concentration (µg./l.)	Endrin: Number positive	Endrin: Maximum concentration (µg./l.)	DDT: Number positive	DDT: Maximum concentration (µg./l.)	DDE: Number positive	DDE: Maximum concentration (µg./l.)	DDD: Number positive	DDD: Maximum concentration (µg./l.)	Aldrin: Number positive	Aldrin: Maximum concentration (µg./l.)	Heptachlor: Number positive	Heptachlor: Maximum concentration (µg./l.)	Heptachlor epoxide: Number positive	Heptachlor epoxide: Maximum concentration (µg./l.)	BHC: Number positive	BHC: Maximum concentration (µg./l.)
1962	3	2	0.001	0		0		1	P	2	0.004	0		0		0		0	
1963	2	0		0		1	P	0		0		0		0		0		0	
1964	7	5	<.001	2	<.001	3	P	2	P	4	P	0		3	P	0		0	
Grab samples:																			
1964	4	2	.007	1	.006	2	P	2	P	0		1	P	1	P	0		0	
1965	4	2	.018	0		0		1	0.008	0		0		1	0.015	1	P	0	
Missouri River Basin																			
CAM samples:																			
1958	4	3	.005	1	P	0		0		0		0		0		0		1	0.003
1959	6	4	.005	0		0		0		0		0		0		0		0	
1960	6	4	.002	2	.004	0		0		0		0		0		1	P	0	
1961	7	5	.008	2	P	0		1	P	1	.001	0		0		0		1	P
1962	8	7	.008	4	.003	1	P	2	.003	4	.004	0		0		1	0.002	2	<.001
1963	8	7	.006	1	P	1	<.001	1	P	4	.002	1	<.001	0		0		1	.001
1964	14	10	.008	4	.001	3	<.001	4	<.001	9	.002	3	P	0		0		1	P
Grab samples:																			
1964	11	10	.023	6	.026	3	.024	5	.018	0		1	P	2	P	0		0	
1965	11	4	.023	3	P	4	.039	2	.002	3	.011	0		2	.020	4	.014	0	
Southwest Basin																			
CAM samples:																			
1958	1	1	.002	0		0		0		1	<.001	0		0		0		0	
1959	0																		
1960	0																		
1961	0																		
1962	1	1	.001	0		0		0		0		0		0		0		0	
1963	6	5	.001	6	.007	3	P	4	P	5	P	1	P	0		0		0	
1964	[2] 8	7	.002	6	.002	6	.005	6	.001-	8	.011	1	.006	0		0		0	
Grab samples:																			
1964	6	6	.008	5	.014	2	.031	1	P	0		0		1	P	0		0	
1965	6	1	P	0		0		0		1	.008	0		0		0		1	P
Lower Mississippi River Basin																			
CAM samples:																			
1958	3	3	.001	3	.004	1	P	1	P	0		0		0		0		0	
1959	4	4	.002	3	.002	2	P	2	P	2	.001	0		0		0		0	
1960	3	3	.002	3	.064	1	P	1	P	0	P	0		0		0		1	P
1961	6	5	.022	2	.029	4	P	3	P	2	.001	0		0		1	P	0	
1962	3	3	.015	3	.160	1	P	0		1	P	0		0		0		0	
1963	12	12	.058	12	.214	1	P	0		1	P	0		0		0		0	
1964	[3] 27	72	.122	74	.150	12	.010	11	.004	8	P	4	P	0		1	P	5	P
1965	[4] 33	31	.008	22	.015	9	.019	11	.011	24	.012	3	P	2	.002	11	.001	5	P
Grab samples:																			
1964	6	6	.017	6	.025	3	.047	4	.007	0		0		2	P	0		1	P
1965	5	5	.018	3	.116	2	.019	0		0		0		1	.010	1	.020	0	
Colorado River Basin																			
CAM samples:																			
1958	0																		
1959	0																		
1960	1	1	.001	0		0		0		1	.001	0		0		0		0	
1961	0																		
1962	1	0		0		0		0		0		0		0		0		0	
1963	0																		
1964	2	0		0		0		0		1	P	0		0		0		0	
Grab samples:																			
1964	7	5	.008	3	.012	3	.021	2	.004	0		2	.085	1	P	0		0	
1965	7	1	P	1	P	2	.125	1	.009	0		0		2	.012	1	P	0	
Western Gulf Basin																			
CAM samples:																			
1958	4	4	.012	1	.008	3	.052	3	.004	4	.009	0		0		0		1	P
1959	3	2	.005	1	.001	1	.007	2	.002	3	.004	0		0		0		0	
1960	5	4	.002	1	.002	2	.032	3	P	3	.006	1	P	0		1	P	1	P
1961	4	3	.008	3	.008	3	.010	3	.002	4	.012	0		0		0		1	P
1962	4	3	.001	4	.009	2	.007	2	.002	4	.009	0		0		0		1	P
1963	10	6	.006	3	.011	7	.144	4	.004	7	.019	0		0		0		2	P
1964	7	6	.001	5	.004	3	.009	4	.001	3	.010	0		0		0		0	
Grab samples:																			
1964	5	4	.032	2	.067	2	.025	2	P	0		1	P	0		0		0	
1965	6	2	.029	1	.014	2	.149	0		2	.026	0		3	.035	2	P	0	

Table 3—Continued on p. 146.

Table 3. Occurrence of positive and presumptive pesticide determinations in carbon adsorption method samples and in grab samples collected during 1964 and 1965 synoptic surveys—Continued

Water year	Number samples	Dieldrin		Endrin		DDT		DDE		DDD		Aldrin		Heptachlor		Heptachlor epoxide		BHC	
		Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)	Number positive	Maximum concentration (µg./l.)
Pacific Northwest Basin																			
CAM samples:																			
1958	3	2	<.001	0	------	1	0.005	1	P	1	<.001	1	P	0	------	0	------	0	------
1959	4	4	.002	0	------	2	.008	3	0.001	2	.003	1	0.003	0	------	0	------	0	------
1960	1	1	.001	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1961	7	6	.002	1	P	1	.004	3	.002	3	.003	0	------	0	------	0	------	0	------
1962	5	3	.002	0	------	1	.003	2	.001	3	.001	0	------	0	------	0	------	0	------
1963	12	7	.005	0	------	5	.004	3	.002	4	.003	0	------	0	------	0	------	0	------
1964	13	12	.003	1	P	4	<.001	5	<.001	10	.002	1	<.001	0	------	0	------	0	------
Grab samples:																			
1964	10	7	.015	4	0.019	7	.034	4	.005	0	------	1	P	1	P	0	------	0	------
1965	11	2	.005	0	------	1	.037	0	------	1	.013	0	------	0	------	1	0.002	0	------
California, Hawaii, and Great Basin																			
CAM samples:																			
1958	0	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------
1959	0	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------
1960	0	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------
1961	1	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------	0	------
1962	5	0	------	0	------	3	.007	2	.002	3	.001	0	------	0	------	0	------	1	0.011
1963	9	6	.005	1	.001	5	.007	3	.001	5	.006	0	------	0	------	0	------	1	.006
1964	8	4	.001	1	P	3	.009	3	.002	5	.010	0	------	0	------	0	------	0	------
Grab samples:																			
1964	5	3	.006	2	.009	4	.066	2	.011	0	------	1	P	0	------	0	------	0	------
1965	7	3	.018	1	.005	1	P	0	------	2	.008	0	------	1	0.020	1	.019	0	------
Combined																			
CAM samples:																			
1958	34	25	.020	8	.008	10	.052	11	.004	14	.031	1	P	1	P	2	.007	4	.003
1959	33	24	.055	5	.013	6	.008	12	.002	11	.004	1	.003	0	------	0	------	1	P
1960	43	36	.026	9	.064	8	.032	17	.006	17	.022	2	P	0	------	4	.001	8	.022
1961	56	46	.022	10	.029	11	.010	16	.004	4	.012	0	<.001	0	------	3	<.001	6	P
1962	57	42	.035	16	.160	11	.007	13	.003	30	.011	1	P	0	------	1	.002	5	.011
1963	117	95	.067	39	.214	38	.144	30	.012	45	.080	6	.002	0	------	2	.008	5	.006
1964	[5] 156	188	.122	108	.150	51	.010	64	.004	86	.011	16	.006	3	P	3	.001	10	P
1965	[6] 41	39	.008	22	.019	10	.019	13	.011	24	.012	4	P	2	.002	11	.001	5	P
Grab samples:																			
1964	96	71	>.118	44	>.094	43	.087	37	.015	1	.083	10	.085	16	P	0	------	2	P
1965	99	47	.100	16	.116	25	.149	5	.009	17	.026	0	------	24	.155	25	.067	5	.004

Aluminum columns 4 feet long, ¼-inch outside diameter, packed with 5 percent Dow Corning 200 silicone grease on 60- to 80-mesh acid-washed Chromosorb P were employed in both gas chromatographic instruments.

The procedure provides corroborative identification in that each of the nine pesticides (*a*) is adsorbed on carbon, (*b*) is desorbed with chloroform, (*c*) is benzene soluble, (*d*) moves on thin-layer chromatography in the same fashion as a given standard, (*e*) is eluted from the electron-capture gas chromatograph at the same retention time as, and having the same peak geometry as, a given standard, (*f*) is identical to the same standard when chromatographed with the microcoulometric titration gas chromatograph in terms of its retention time, peak geometry, and degree of chlorination, and (*g*) produces an infrared spectrum which in many cases supports the identifications made by chromatography.

Repetitive injections of reference standards of aldrin into the electron-capture gas chromatograph gave a precision of about ±1 percent throughout the 0.0001 µg. to 0.010 µg. range. The microcoulometric titration gas chromatograph has a precision of ±12.6 percent at the 0.002 µg. level and ±4.0 percent at the 0.100 µg. level. This provided for practical lower limits of sensitivity of 0.001 µg. per liter for aldrin, BHC, DDE, DDD, dieldrin, endrin, heptachlor, and heptachlor epoxide and of 0.002 µg. per liter for DDT in the CAM samples.

Water grab samples. Analytical procedures were similar to those used for the 1964 survey

Figure 2. Historical occurrence of dieldrin in major U.S. river basins, selected CAM samples from water years 1958–64

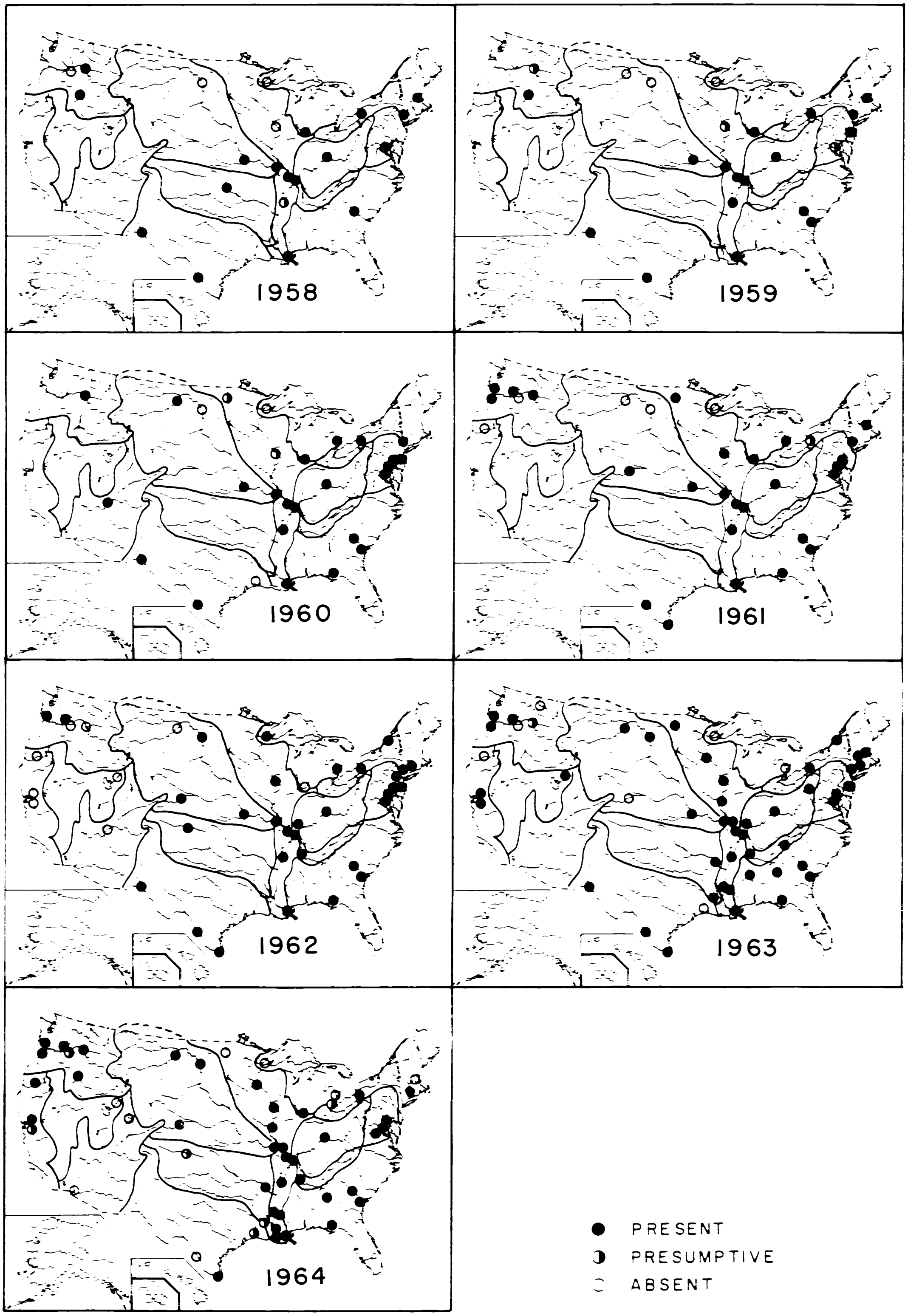
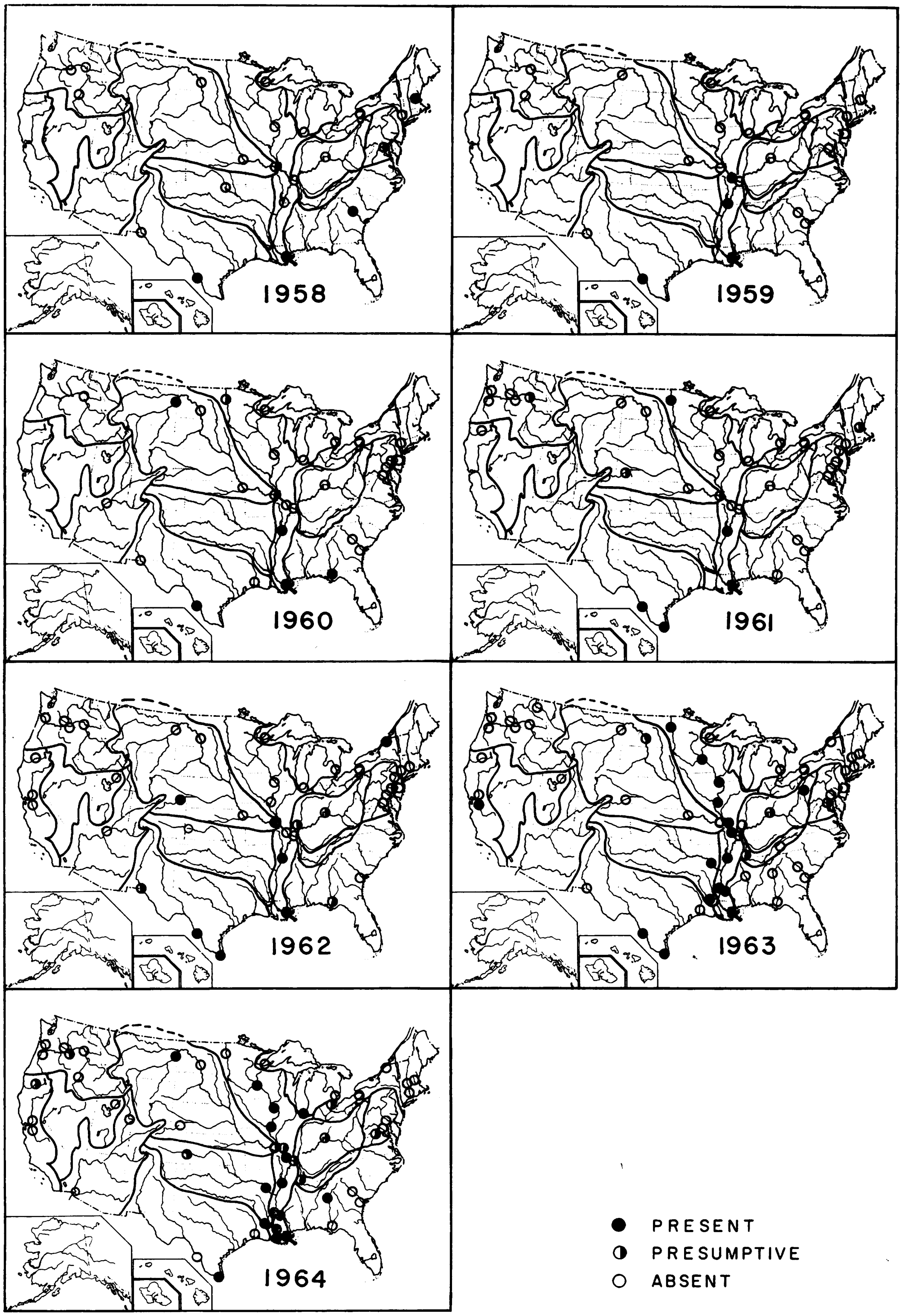


Figure 3. Historical occurrence of endrin in major U.S. river basins, selected CAM samples from water years 1958–64



(*11*) and included liquid-liquid extraction, thin-layer chromatography, and gas chromatography. All grab samples were extracted with a mixture of hexane-benzene (9:1) by a semiautomatic extraction procedure which provides for recoveries ranging from 77 to 95 percent (*14*). Extracts of the water grab samples were subjected to thin-layer chromatography (*13*) and electron capture as well as microcoulometric titration gas chromatography.

The practical limits of sensitivity for the grab samples was 0.002 μg. per liter for all nine pesticides. No corrections were made for recovery efficiencies for either the semiautomatic extraction or for the thin-layer chromatography in which recoveries of 75 to 104 percent obtain.

Results and Discussion

The results of the 1965 synoptic survey of pesticides at 99 stations in major river basins of the conterminous United States and Hawaii are listed in table 1. A qualitative comparison of these data with those gathered in 1964, shown in figure 1, indicates a reduction in the incidence of dieldrin in 1965, particularly in the western States. Endrin occurred less in all river basins except the lower Mississippi basin, and the incidence of DDT and its congeners remained essentially unchanged.

The frequency of occurrence of the nine pesticides in September 1964 and 1965 are shown in table 2. The comparison of the 1964 data with the 1965 data for heptachlor epoxide, aldrin, and the DDT group must be cautious because procedural improvements restrict unqualified comparison.

The results of both synoptic surveys as well as the data obtained from a selection of stored CAM samples collected since 1958 are summarized in table 3. Data are arranged by water years in which the reporting period is October 1 through September 30. We anticipate that detailed results will be published in a statistical review and compilation of data from the Federal Water Pollution Control Administration's surveillance system. The results are summarized here to provide a general background for the following discussion.

A comparison of results from 251 analyses from samples collected near the end of the water year with 274 samples from the rest of the year did not reveal any consistent difference in pesticide levels. The synoptic survey data are thus considered reasonably representative of the year.

A 7-year illustrative summary of the occurrence of dieldrin, endrin, and the DDT group is shown in figures 2–4. Obviously, dieldrin has dominated the pesticide picture throughout the period of record (fig. 2). This is also consistent with the results of the two synoptic surveys. Figure 3 shows endrin appearing occasionally in early CAM samples. This was followed by sharp increases in incidence in 1962 and 1963, with maximum occurrence in 1964. The reduction in endrin found in the synoptic survey of 1965 was reflected in CAM samples from the Mississippi River; this is discussed later in greater detail. A moderate increase in the occurrence of DDT and congeners over the years is indicated in figure 4.

The frequency of occurrence, by river basin, of the dominant pesticides is summarized in figure 5. The bar graphs for the "combined" data support the observations just presented, as do data from the individual river basins. In some of these basins, however, rather wide year-to-year variations are indicated, possibly because of the limited number of samples analyzed thus far.

Concentrations of pesticides found during the two synoptic surveys and in the stored extracts are generally extremely low and fall in the parts-per-trillion range. Occasionally, however, levels approach those which are reportedly toxic to fish (*15–17*). The 10 stations showing the highest concentrations in the 1965 synoptic survey are listed in table 4. Table 5 presents comparable data for 1958–65 from CAM samples. Both tables indicate a tendency for a particular station to show higher levels of more than one pesticide; this is also evident in the 1964 synoptic survey data (*11*).

The recurrent fish kills on the lower Mississippi River which took place during fall and winter months and the identification of endrin as the cause of the 1963–64 kill have been widely reported (*18*).

A major technical assistance project to define

Figure 4. Historical occurrence of DDT, DDE, and DDD in major U.S. river basins, selected CAM samples from water years 1958–64

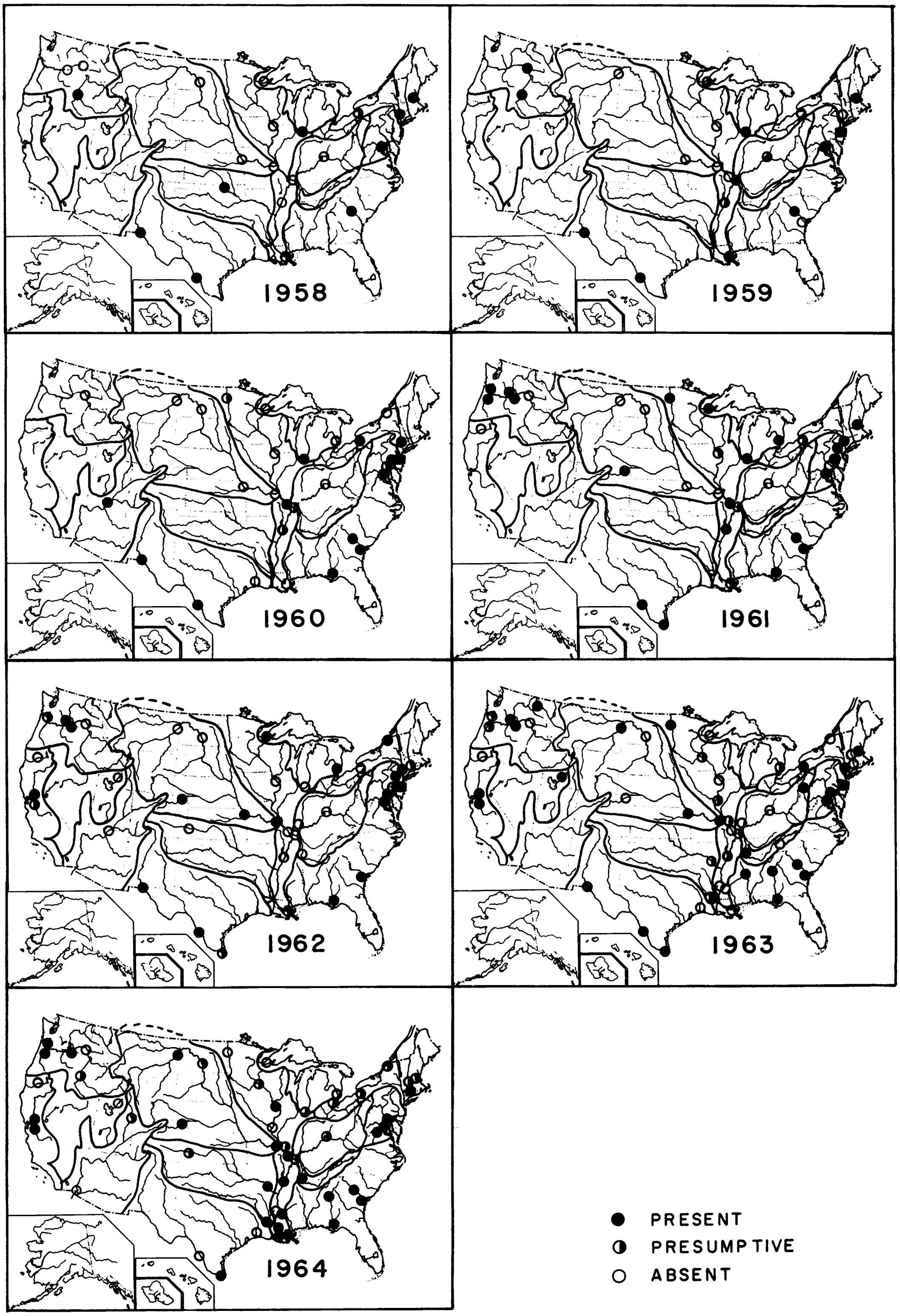


Figure 5. Percent occurrence of selected pesticides in CAM samples, 1958–64

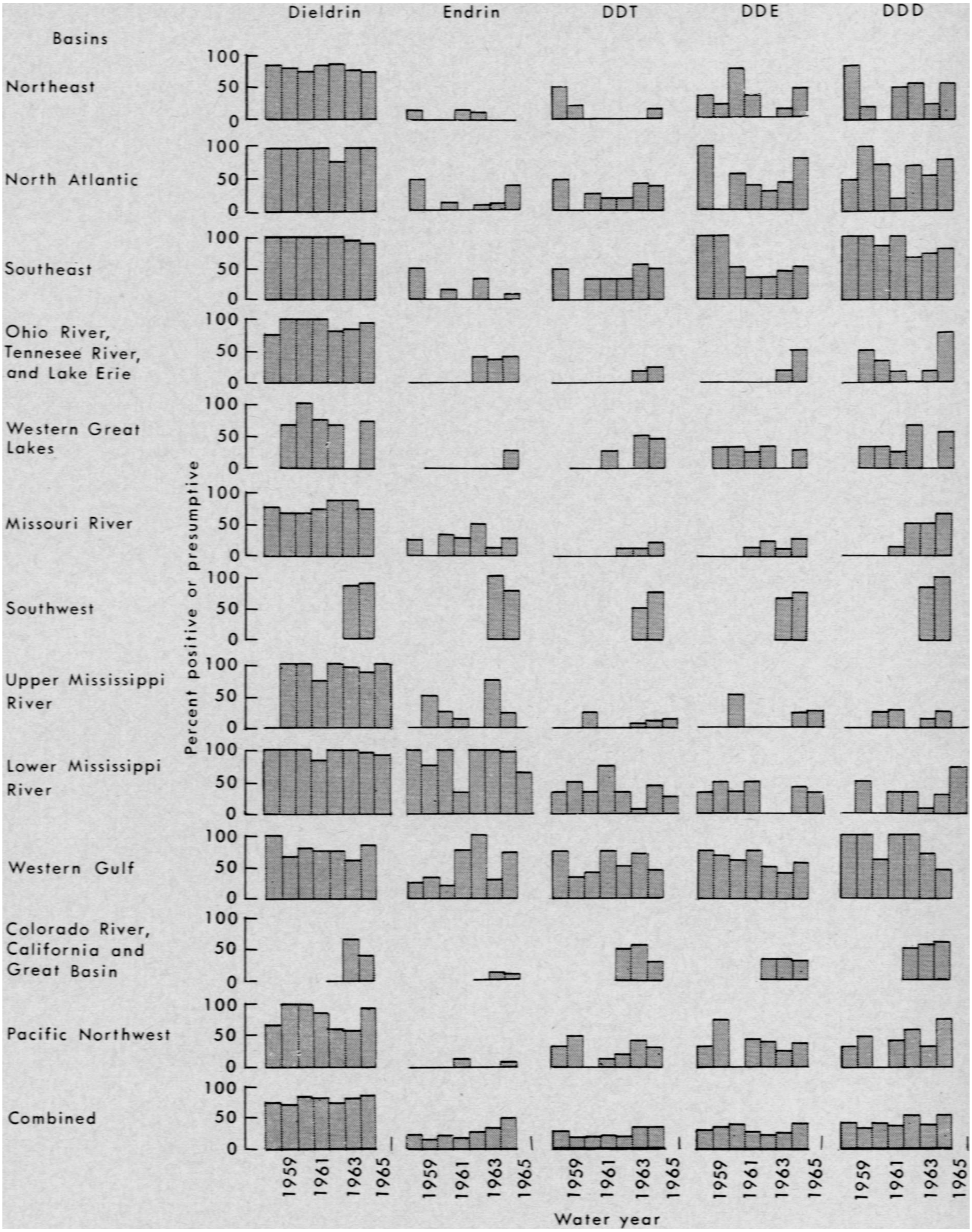


Table 4. Levels of chlorinated hydrocarbon pesticides, by order of decreasing concentrations, for about 10 synoptic sampling stations at which the highest levels were observed, September 1965 [1]

River and location	Concentration (μg. per l.)
Dieldrin	
Tombigbee: Columbus, Miss	0.100
Merrimack: Lowell, Mass	.068
Savannah: North Augusta, S.C	.051
Kanawha: Winfield Dam, W. Va	.045
Rio Grande: Alamosa, Colo	.029
Tennessee: Lenoir City, Tenn	.028
Ohio: Cairo, Ill	.028
Mississippi: Dubuque, Iowa	.024
Missouri: Kansas City, Kans	.023
Savannah: Port Wentworth, Ga	.022
Endrin	
Mississippi: West Memphis, Ark	.116
Atchafalaya: Morgan City, La	.019
Delaware: Trenton, N.J	.018
Tombigbee: Columbus, Miss	.015
Clinch: Kingston, Tenn	.015
Rio Grande: Alamosa, Colo	.014
Monongahela: Pittsburgh, Pa	.014
Tennessee: Lenoir City, Tenn	.009
Red (North): Grand Forks, N. Dak	.009
Mississippi: Delta, La	.008
DDT	
Rio Grande: Alamosa, Colo	.149
San Juan: Shiprock, N. Mex	.125
Colorado: Page, Ariz	.058
Platte: Plattsmouth, Nebr	.039
Spokane: Post Falls Dam, Idaho	.037
Red (North): Grand Forks, N. Dak	.034
Ohio: Cairo, Ill	.023
South Platte: Julesburg, Colo	.023
Mississippi: Delta, La	.019
Mississippi: Vicksburg, Miss.[2]	.017
DDE	
San Juan: Shiprock, N. Mex	.009
Detroit: Detroit, Mich	.008
Yellowstone: Sidney, Mont	.002
Platte: Plattsmouth, Nebr	P
Rainy: Baudette, Minn	P
Other stations	0
DDD	
Rio Grande: Brownsville, Tex	0.026
Delaware: Trenton, N.J	.018
Willamette: Portland, Oreg	.013
Missouri: Kansas City, Kans	.011
St. Lawrence: Massena, N.Y	.010
Platte: Plattsmouth, Nebr	.010
Waikele Stream: Waipahu, Hawaii	.008
Red (South): Alexandria, La	.008
Merrimack: Lowell, Mass	.007
Potomac: Washington, D.C	.007
Heptachlor	
Red (North): Grand Forks, N. Dak	.155
Mississippi: Dubuque, Iowa	.048
Rio Grande: Brownsville, Tex	.035
St. Lawrence, Massena, N.Y	.031
Delaware: Martins Creek, Pa	.025
Ohio: Cincinnati, Ohio	.024
Missouri: St. Louis, Mo	.020
Tennessee: Lenoir City, Tenn	.020
Sacramento: Greens Landing, Calif	.020
Detroit: Detroit, Mich	.015
Heptachlor epoxide	
Mississippi: Dubuque, Iowa	.067
Red (North): Grand Forks, N. Dak	.020
Ohio: Addison, Ohio	.020
Mississippi: West Memphis, Ark	.020
Sacramento: Greens Landing, Calif	.019
St. Lawrence: Massena, N.Y	.017
Missouri: Kansas City, Kans	.014
Wabash: New Harmony, Ind	.012
Missouri: St. Louis, Mo	.007
Potomac: Washington, D.C	.003
BHC	
Red (North): Grand Forks, N. Dak	.004
Ohio: Cairo, Ill	.002
Verdigris: Nowata, Okla	P
Connecticut: Enfield Dam, Conn	P
Monongahela: Pittsburgh, Pa	P
Other stations	0

[1] No aldrin detected.
[2] Same concentration found in Chattahoochee River at Lanett, Ala., and Mississippi River at Vicksburg, Miss.

NOTE: P—indicates presumptive.

Table 5. Levels of chlorinated hydocarbon pesticides, by order of decreasing concentrations for about 10 CAM stations at which the highest levels were observed, water years 1958–65

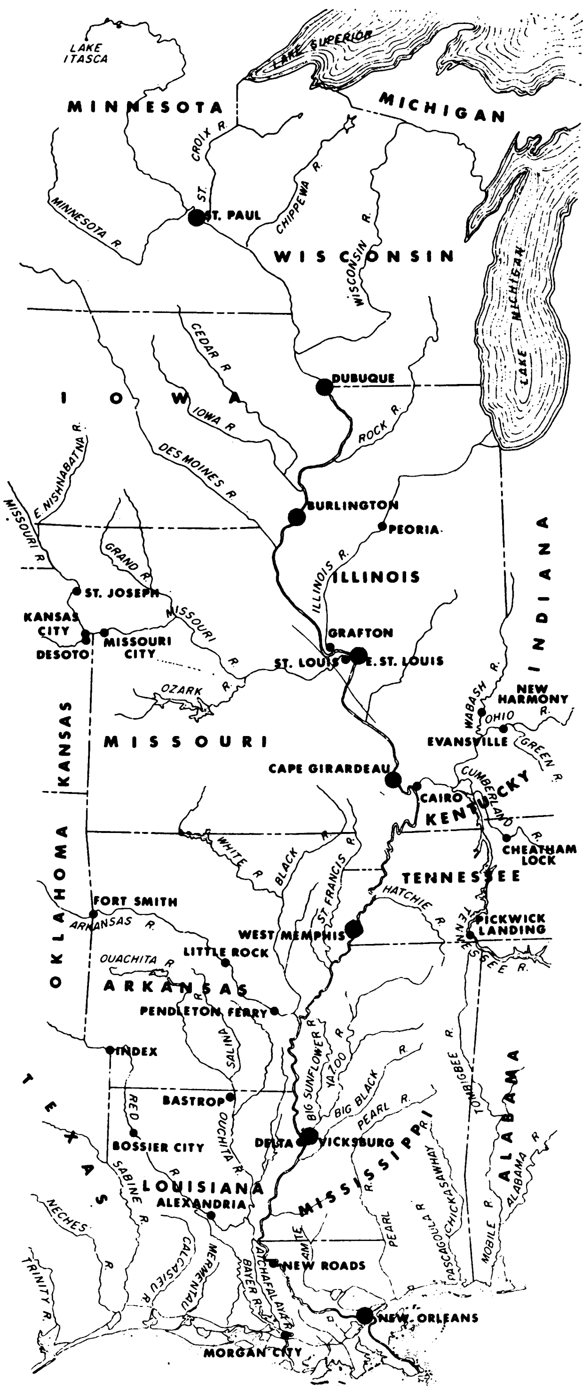
River and location	Concentration (μg. per l.)
Dieldrin	
Mississippi: West Memphis, Ark	0.122
Savannah: North Augusta, S.C	.056
Ohio: Cincinnati, Ohio	.055
Schuylkill: Philadelphia, Pa	.035
Mississippi: New Orleans, La	.034
Delaware: Philadelphia, Pa	.033
Apalachicola: Chattahooche, Fla	.024
Mississippi: Vicksburg, Miss	.023
Mississippi: Delta, La	.022
Savannah: Port Wentworth, Ga.[1]	.016
Endrin	
Mississippi:	
West Memphis, Ark	.214
New Orleans, La	.160
Vicksburg, Miss	.072
Delta, La	.044
Connecticut: Enfield Dam, Conn	.023
Atchafalaya: Morgan City, La	.015
Mississippi: Cape Girardeau, Mo	.013
Allegheny: Pittsburgh, Pa	.012
Rio Grande: Brownsville, Tex	.011
Mississippi: New Roads, La	.010
DDT	
Rio Grande:	
Brownsville, Tex	.144
Laredo, Tex	.052
El Paso, Tex	.032
Ohio: Cairo, Ill	.023
Mississippi: New Orleans, La	.019
Delaware: Philadelphia, Pa	.015
Chattahoochee: Lanett, Ala	.011
Tennessee: Pickwick Landing, Tenn	.011
Mississippi: Vicksburg, Miss	.010
Sacramento: Green's Landing, Calif.[2]	.009
DDE	
Delaware: Philadelphia, Pa	.012
Mississippi: Vicksburg, Miss	.011
Hudson: Poughkeepsie, N.Y	.006
South Platte: Julesburg, Colo	.005
Mississippi: New Orleans, La	.004
Rio Grande:	
Brownsville, Tex	.004
Laredo, Tex	.004
Lake Superior: Duluth, Minn	.004
12 stations in various river basins	.002
DDD	
Delaware: Philadelphia, Pa	0.080
Savannah: North Augusta, S.C	.031
Rio Grande:	
Brownsville, Tex	.019
El Paso, Tex	.012
Mississippi: New Roads, La	.012
Red (South): Alexandria, La	.011
San Joaquin: Vernalis, Calif	.010
Rio Grande: Laredo, Tex	.009
Apalachicola: Chattahoochee, Fla	.008
Sacramento: Green's Landing, Calif.[3]	.006
Aldrin	
Red (South): Alexandria, La	.006
Snake: Wawawai, Wash	.003
Chattahoochee: Lanett, Ala	.002
Savannah: North Augusta, S.C	<.001
Merrimack: Lowell, Mass	<.001
Yakima: Richland, Wash	<.001
Yellowstone: Sidney, Mont	<.001
19 stations in various river basins	P
Heptachlor	
Atchafalaya: Morgan City, La	.002
Mississippi: West Memphis, Ark	P
Potomac: Great Falls, Md	P
Detroit: Detroit, Mich	P
Other stations	0
Heptachlor epoxide	
Mississippi: West Memphis, Ark	.020
Missouri: St. Louis, Mo	.002
Mississippi: New Orleans, La	.001
St. Lawrence: Massena, N.Y	.001
Potomac: Great Falls, Md	<.001
6 stations in various river basins	P
BHC	
Apalachicola: Chattahoochee, Fla	.022
Sacramento: Green's Landing, Calif	.011
Red (North): Grand Forks, N. Dak	.004
St. Lawrence: Massena, N.Y	.003
Missouri: Kansas City, Kans	.003
Ohio: Cairo, Ill	.002
Savannah: North Augusta, S.C	<.001
15 stations in various river basins	P

[1] Same concentration in Merrimack River at Lowell, Mass.
[2] Same concentration in Tombigbee River at Columbus, Miss.
[3] Same concentration in Tennessee River at Pickwick Landing Dam, Tenn.

NOTE: P—indicates presumptive.

the sources, transport mechanisms, biological concentration, and uptake factors, as well as related hydrologic features is now underway (*19*). In support of this investigation, a large

Figure 6. Mississippi River and Delta area



Dots indicate water pollution surveillance stations.

number of CAM samples taken since 1958 have been analyzed for pesticides. The locations of water pollution surveillance stations in the Mississippi River and Delta area are shown in figure 6. The dots indicate stations for which data are summarized in figures 7 and 8.

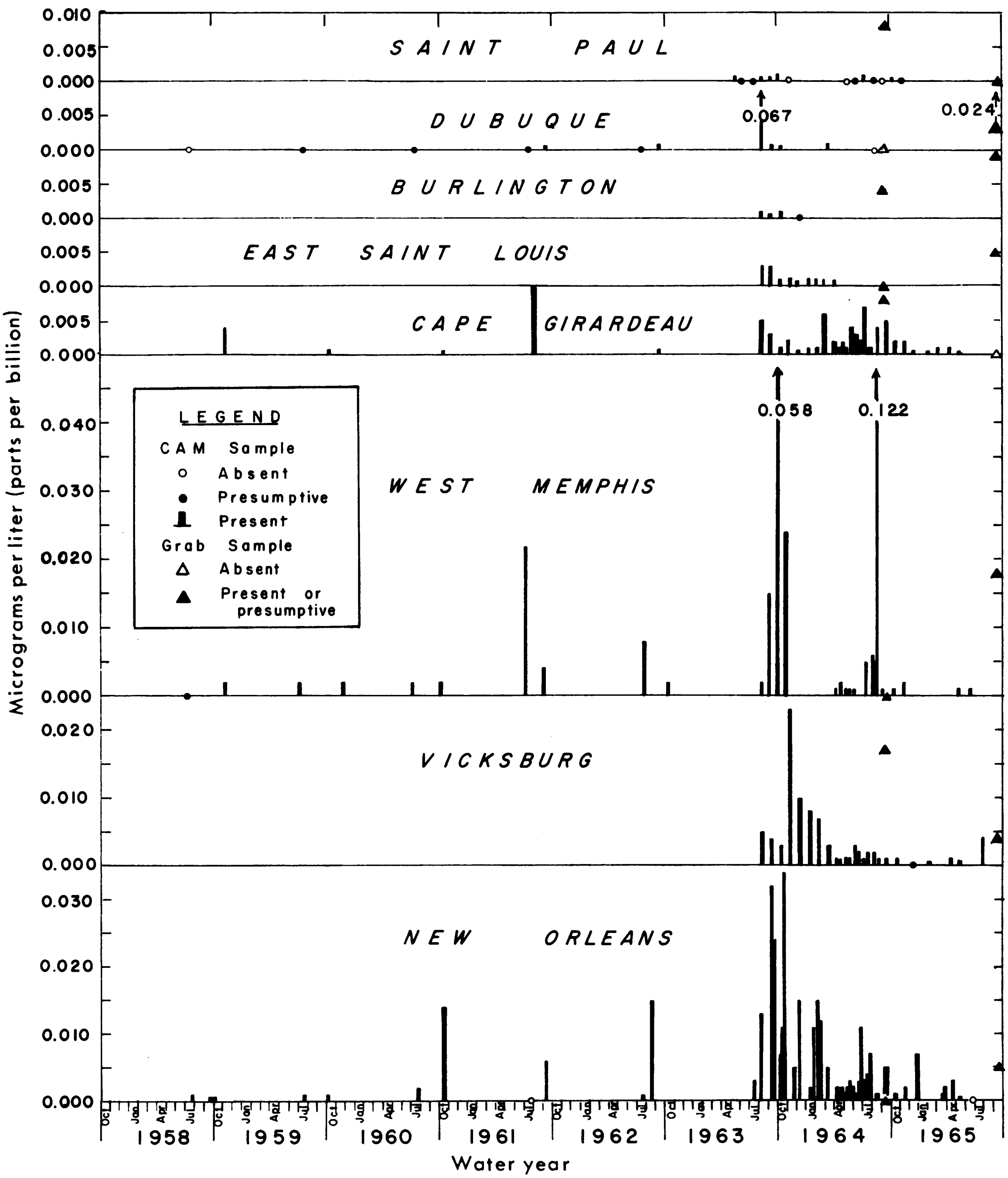
Concentrations of dieldrin from selected CAM samples are presented in figure 7. Widths of bars on the graph represent continuous sampling periods. Results from the 1964 and 1965 synoptic surveys have also been included. Levels of 0.005 μg. per liter or greater have occurred fairly frequently since October 1961. Higher levels were found in the lower Mississippi from summer 1963 through spring 1964, with only occasional highs thereafter. The figure also shows that higher levels of dieldrin were found in two samples from Dubuque, at widely separated times, indicating pulses presumably related to local pesticide applications.

The concentration of endrin in the Mississippi River is shown in figure 8. The occurrence of high concentrations at and below West Memphis is even more striking than that for dieldrin, particularly when the fivefold difference in vertical scales of the two figures is considered. Concentrations of endrin have shown a general decrease since about spring 1964, although a single sample from West Memphis during the 1965 synoptic survey approached earlier maximums. No major fish kills have been reported on the lower Mississippi River during fall or winter of 1964–65 or 1965–66.

The concentration of a pesticide in solution and adsorbed on solids in water is most probably a function of the amount reaching the water, the volume of water available for dilution, and the degradability of the pesticide. Concentrations of persistent or difficultly degradable pesticides in drainage basins where these pesticides are used regularly should be reasonably constant. Concentrations of readily degradable pesticides, on the other hand, could be expected to vary widely depending on the period available for degradation.

A comparison of the 10 highest values for each pesticide obtained in (*a*) the 1964 survey (*11*), (*b*) the 1965 survey (table 4), and (*c*) the historical CAM data (table 5) indicates that the results of CAM sampling and grab sampling have given noticeably similar results for the more stable pesticides, dieldrin, endrin, DDT, DDE, and DDD. On the other hand, higher levels of heptachlor and its epoxide and of aldrin in the grab samples suggest that these compounds are much less persistent. It is not possible, however, to separate degradation of these pesticides in the environment from degradation in either the carbon column or subsequently in the storage vial. The BHC data do

Figure 7. Historical occurrence of dieldrin in the Mississippi River main stem, selected CAM samples from water years 1958–65



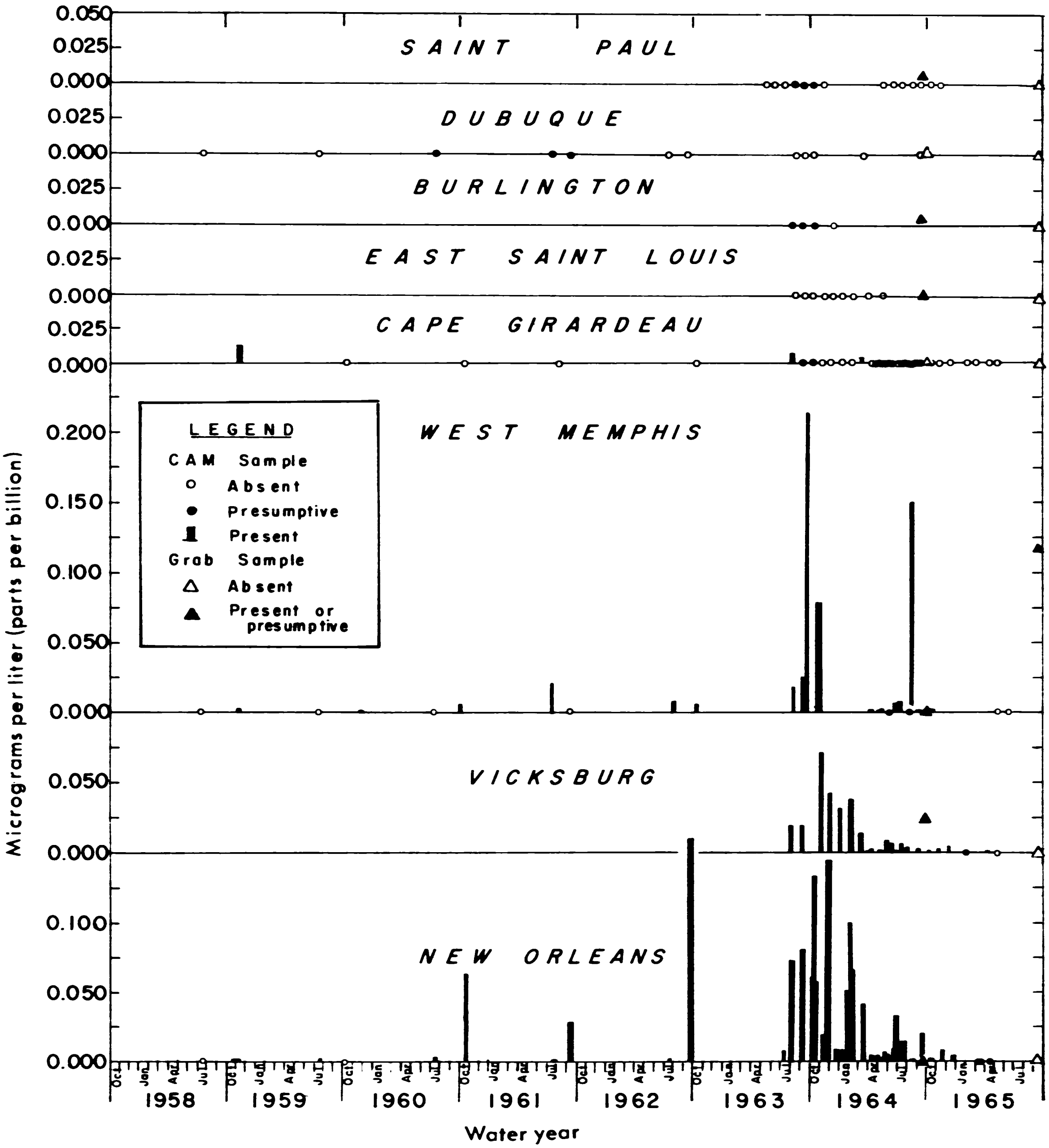
not fit either category, presumably because of a sampling artifact. This material was found comparatively rarely.

Summary and Conclusions

The results of the synoptic pesticide surveys of 1964 and 1965 and the examination of stored carbon adsorption extracts for water years 1958 through 1965 reveal that dieldrin has dominated pesticide occurrences in all river basins since 1958.

Endrin occurrence reached a maximum, particularly in the lower Mississippi River in the fall of 1963 (the first quarter of water year 1964). Since then, endrin levels have decreased. Major fish kills in the lower Mississippi, which

Figure 8. Historical occurrence of endrin in the Mississippi River main stem, CAM samples from water years 1958–65



had previously occurred during the late fall months, were not reported in 1964 or 1965.

DDT and its congeners have been fairly common since 1958. There has been a slightly increasing trend in these occurrences.

There is a noticeable agreement in data from grab samples and CAM samples in both frequency of occurrence and concentrations of chlorinated hydrocarbon pesticides. This suggests that occasional synoptic surveys may be adequate to characterize pesticide levels on a broad scale in those places where there are no dominant sources of pollution. In areas such as the lower Mississippi River, however, the variability of both dieldrin and endrin clearly requires a greater sampling frequency, possibly including continuous sampling backup with the CAM method. This is consistent with earlier studies (*20*) which show that, as a dominant source of pollution is approached, more frequent sampling is necessary.

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