DDT IN FISH: Second Report

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A preliminary study of the occurrence of DDT in Connecticut wildlife was made in 1963 and the results published (Turner, 1965). The availability of records of large-scale airplane spraying made it possible to compare the amounts of DDT found in wildlife from "sprayed" and "unsprayed" areas. Fish from unsprayed areas contained an average of 0.5 ppm of DDT on a fresh weight basis, and those from sprayed areas 0.8 ppm. Tompkins (1965) published results of analyses including samples from some of the waters included in our study. In general his results were consistent with ours. His 1964 samples showed "an apparent great decrease in DDT residuals in fish from summer 1963 to spring 1964."

As pointed out by Tompkins (1963), analysis of fish offers a convenient and hopefully reliable way to monitor the presence of DDT. DDT is only slightly soluble in water, but it is picked up freely by organisms living there. Minute quantities thus enter the food chain. Tompkins (1965) also pointed out the relationship between age of fish and quantity of DDT accumulated.

In addition to the obvious comparison of sprayed and unsprayed areas, the preliminary study established a basis for continued monitoring as required. Another series of samples was collected in 1967 from four sites. As in the preliminary study, samples were obtained with the cooperation of Cole W. Wilde, Chief, Fisheries Division, State Board of Fisheries and Game. The State Board of Pesticide Control suggested analysis of a series of fish from the Connecticut River near Haddam Neck, collected in connection with an ecological study of the River in the vicinity of a nuclear power plant.

The analyses were made by Lloyd G. Keirstead of the Station staff, and are acknowledged with thanks both for selection of methods and for careful and meticulous work. In the 1963 study, DDT in fish was determined by the Schecter-Haller colorimetric test (Horowitz, 1960). This test does not discriminate between DDT and TDE (DDD). In the present study, the procedure of Stanley and LeFourve (1965) was used, and DDT and related compounds were measured by gas chromatography. When the samples from the Connecticut River were examined, interference obscured the areas on the chromatogram where DDT and TDE should register. Mr. Keirstead found that the compounds that interfered could be

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pushed out of the standard FDA florisil column with 150 ml of petroleum ether. The DDT and TDE could then be eluted with 200 ml of 6 per cent V/V ethyl ether in petroleum ether as in the regular FDA procedure.

The interfering compounds were propably polychlorinated biphenyl compounds, PCB's. These contaminants were found in birds in Britain by Holmes, Simmons and Tatton (1967), in seals and porpoises from Britain and Canada by Holden and Marsden (1967), in birds and fish by Risebrough et al. (1968) and in fish, mussels, and birds from the Netherlands by Koeman et al. (1969). PCB compounds are used industrially in manufacture of paints, resins, and plastics. Risebrough et al. (1968) consider PCB's to be as hazardous to wildlife as DDT and its associated derivatives. They reported larged quantities in wildlife from industrial areas than in regions remote from industry. Tarrant and Tatton (1968) found small quantities of PCB in all samples of rainwater collected in the British Isles.

Results

All results have been expressed in parts per million on the basis of fresh weight.

Data for the individual fish from the Connecticut River are given in Table 1. Henderson, Johnson, and Inglis (1969) have published data for yellow perch collected from the River at Windsor Locks, Connecticut. Tompkins (1965) reported on analyses from the "Connecticut River, South" in his earlier study. The map designated this site as just north of the Connecticut state line. Results of these three sets of analyses are given in Table 2. Our data for Haddam Neck are reasonably close to those for Windsor Locks. Both show somewhat less DDT than found by Tompkins (1965), but a great deal more DDE.

Samples from Compensating Reservoir and Rainbow Reservoir were examined by both colorimetric and chromatographic methods so that the results could be compared. Table 3 gives the results, which indicate that the amounts determined by colorimetric test were larger than the average amount determined by chromatography. In the series from Compensating Reservoir, chromatography indicated more DDT plus TDE in two samples, about the same in two, and less in the remaining three. Chromatography indicated less DDT and TDE in all three samples from Rainbow Reservoir. The colorimetric test, usually believed to be less precise than chromatography, certainly did not underestimate the quantity of DDT.

Analyses from the two other locations are given in Table 4, and comparisons with results of the 1963 analyses in Table 5.

The amount of DDT used in Connecticut has been reduced sharply beginning in 1963. In that year, the Administrative Policy Committee which was responsible for regulation of airplane spraying reduced the amount of DDT permitted in woodland spraying by half, and restricted mosquito spraying with DDT to areas in which mosquitoes were transmitting human disease. In 1965 the State Board of Pesticide Control banned airplane spraying with DDT in woodlands.

Table 1. Residues in individual yellow perch from the Connecticut River, in parts per million fresh weight.

	p,p' DDT	TDE	DDE
	0.84	1.12	1.58
	0.43	0.61	0.64
	0.26	0.50	0.48
	0.33	0.70	0.49
	0.21	0.44	0.55
	0.29	0.63	0.66
	0.34	0.48	0.70
	0.17	0.42	0.51
	0.08	0.23	0.22
	0.12	0.43	0.65
	0.54	0.79	0.90
	0.33	0.75	0.99
	0.59	0.82	0.99
	0.33	0.70	0.67
	0.39	0.97	0.99
	0.20	0.51	0.54
	0.33	0.56	0.54
	0.20	0.44	0.41
	0.18	0.45	0.42
	0.26	0.52	1.27
	0.45	0.77	0.60
	0.36	0.48	0.64
	0.33	0.67	0.61
	0.36	0.60	1.06
	0.13	0.34	0.39
	0.70	0.85	0.84
	0.34	0.76	0.85
	0.32	0.57	1.47
	0.78	0.70	1.71
Ave.	.35	.61	.77
Max.	.84	1.12	1.71
Min.	.08	.23	.22

It is obvious that the average amount of DDT in fish did decrease between 1963 and 1967. Differences in method of analysis make exact comparisons difficult, but the decrease seemed to be in the order of 20 per cent. Thus the decline on the average was less than the difference between "sprayed" and "unsprayed" areas in 1963. Moreover, both areas showed the decline at about the same degree.

Tompkins (1965) found a direct relation between age of fish and amount of DDT. The fish from Aspinook Pond followed this trend but the samples from Bantam Lake did not. This is perplexing, because all large-scale spraying in the vicinity of Bantam Lake had ceased. The relatively high DDT content of 2- and 3-year-old fish is difficult to explain.

Table 2. Average, maximum, and minimum residues in yellow perch from the Connecticut River in parts per million fresh weight. Present study designated Haddam Neck; data for Windsor Locks from Henderson, et al. (1969); and for Connecticut River South from data of Tompkins (1965). Tompkins data reduced to fresh-weight basis as suggested on page 6 of his paper.

Source and Year		p,p' DDT	TDE	DDE	Total
Haddam Neck 1967	Ave.	.35	.61	.77	1.73
	Max.	.84	1.12	1.71	3.78
	Min.	.08	.23	.22	.53
Windsor Locks 1967-68 *(Henderson, et al. 1969)*	Ave.	.62	.60	.69	1.91
	Max.	.91	1.09	1.41	3.41
	Min.	.41	.25	.33	1.11
Conn. River South 1963 *(Tompkins, 1965)*	Ave.	.9		.25	
	Max.	1.35		2.50	
	Min.	.23		0	
1964 *(Tompkins, 1965)*	Ave.	.55		.33	
	Max.	6.1		2.0	
	Min.	.125		.2	

Table 3. Residues in yellow perch except as noted, each determination from a composite, results in parts per million fresh weight.

Location	No.	Age	Colorimetric	Chromatographic		
			DDT plus TDE	DDT	TDE	Total
Compensating Reservoir	5	3-4	1.28	0.67	0.47	1.14
	5	3-4	1.71	0.96	0.54	1.50
	5	3-4	1.32	0.93	0.53	1.46
	5	3-4	1.11	0.79	0.36	1.15
	5	3-4	2.17	1.46	0.66	2.12
	5	3-4	1.41	0.74	0.45	1.19
	5	3-4	1.01	0.27	0.38	0.65
Average			1.43			1.32
Rainbow Reservoir	3	4	0.66	0.20	0.29	0.49
	2	5	1.22	0.20	0.55	0.75
	3*	—	1.00	0.21	0.37	0.58
Average			0.96			0.61

*white perch

Table 4. Residues in individual yellow perch in parts per million fresh weight (chromatographic)

Location	Age of fish	DDT	TDE	DDE
Aspinook Pond	3	0.04	0.16	0.50
	4	0.09	0.20	0.42
	5	0.98	0.54	0.91
	6	0.10	0.31	0.62
	6	0.05	0.31	0.81
	7	0.14	0.51	1.05
	7	0.20	0.52	1.17
	8	0.22	0.38	0.87
Average		0.23	0.37	0.79
Bantam Lake	2	0.17	0.15	0.51
	2	0.23	0.30	0.39
	3	0.18	0.20	0.33
	3	0.29	0.37	0.82
	3	0.26	0.16	0.58
	4	0.21	0.20	0.42
	4	0.08	0.08	0.32
	4	0.15	0.12	0.33
Average		0.20	0.20	0.46

Discussion

The DDT in Connecticut waters may come from three sources: (1) drift or contamination from large-scale local spraying, (2) "fall-out" from the atmosphere, the contamination occurring either inside or outside Connecticut, and (3) pollution of rivers. Once in a body of water, the DDT may also persist by re-circulation.

In Connecticut, DDT spraying on a large scale was reduced drastically in 1963-64, and restricted still further since 1965. It is inconceivable that contamination from local spraying continued at the same level in this period as before 1963.

Table 5. Comparison of 1963 and 1967 analyses. Chromatographic is the sum of DDT and TDE. Parts per million fresh weight. (Percentages in parentheses are reductions in amount of DDT.)

Location	1963 Colorimetric	1967 Colorimetric	1967 Chromatographic
Compensating Reservoir	1.8	1.43 (20%)	1.32 (27%)
Rainbow Reservoir	1.3	.96 (26%)	.61 (53%)
Bantam Lake	.5		.39 (21%)
Aspinook Pond	.85		.60 (28%)

It is now well established that there is global movement of DDT in air. Wheatley and Hardman (1965) found that rainwater in one rural location in England contained minute quantities of DDT. Tarrant and Tatton (1968) reported DDT in rainwater at seven locations in Britain, including London. Connecticut undoubtedly receives its share of this fall-out.

DDT is only very slightly soluble in water, and when present in water soon either settles out or becomes attached to the waxy surfaces of aquatic plants or animals. DDT occurring in discrete particles of soil, or in parts of plants, may be transported some distance in rivers. They tend to settle out when there is little current. The degree of contamination of rivers is still uncertain. The preliminary study included both impoundments in rivers and bodies of water independent of rivers. The differences were not consistent enough to establish the amount of DDT moved in the rivers. However, it is obvious that Compensating Reservoir in the Farmington River has a higher concentration of DDT than Rainbow Reservoir which is downstream. Tompkins (1965) reported more DDT in his "central Connecticut River" sample than in the north or south locations.

In terms of comparison between 1963 and 1967, the following may be said. There was in 1963 an undetermined amount of DDT existing in the waters. This quantity would be expected to decrease at an unknown rate. To it would be added drift from local applications, fall-out from the atmosphere, and where applicable movement of DDT in rivers. The most significant known reduction is drift from local applications. The fall-out since 1963 has originated mostly from sources outside of Connecticut. Use of DDT in the United States has decreased by almost 50 per cent in the past 10 years (Anon. 1969). However, use of DDT in some other parts of the world has remained at a very high level. For the record, the major use of DDT abroad has been and is for control of mosquitoes carrying human diseases in tropical and subtropical countries. The data from our tests would indicate that movement in some rivers was substantial. Compensating Reservoir is located in the Farmington River, as is Rainbow Reservoir. The 1967 contamination of fish in both was less than in 1963. Aspinook Pond is in the Quinnebaug River and contamination also decreased. The decrease was about the same as noted in Bantam Lake, not associated with a river. Fish from the Connecticut River were less contaminated than those from Compensating Reservoir. It is impossible to arrive at an estimate of contamination in rivers from pollution (rather than direct application or fall-out). In some cases it may be the principal source of DDT in the waters. There is no evidence in the data that it is increasing.

The re-circulation of DDT in bodies of water is likely to persist for extended periods of time. The most obvious cause of "disappearance" is physical — the settling of the DDT to the bottom and covering by mud. Even in this case overturn may aid in continued distribution. In this environment DDT is relatively stable. O'Brien (1967) has reviewed the metabolism of DDT, and noted that it can be converted to TDE by some animals, some plants, and even lake water. TDE was not determined separately in 1963. However, Ames (1966) reported that TDE represented 22 per cent of the total residues in 1962, and 5 per cent in 1963 in osprey eggs. Ames also reported a range of from 5 per cent to 18.2 per cent of TDE in total residues in fish from Connecticut in 1963. In our analyses, TDE constituted 35 per cent of the total residues from Aspinook Pond, and 43 per cent from Bantam Lake. The data of Henderson et al. (1969) confirm this. This would indicate that there has been a decided increase in the amount of TDE produced in the interim. If we assume that fish convert the same proportion each season, the increase must be in conversion of the DDT circulating in the environment.

In Ames 1963 study, 24 per cent of the total residue in fish was DDE. In our analyses, the proportion was 54 per cent from Bantam Lake, and 62 per cent from Aspinook Pond. Henderson et al. (1969) report 44 per cent.

Sternburg and Kearns (1952) found that insects can and do convert DDT and DDE by enzymatic action. Certainly insects are involved in the food chain in water. It is also possible that this increase in DDE may also be traced to re-circulating DDT.

Thus the quantities of DDT metabolized to TDE and DDE in the 1967 samples may indicate that a large portion of the total residue has come from re-circulating DDT.

The data provide no clue as to how long DDT and its metabolites may persist in bodies of water. Metabolism to TDE reduces toxicity only slightly if at all. There are few data on DDE. Butler (1965) reports that 0.052 ppm is the amount which causes 50 per cent mortality or loss of equilibrium in adult shrimp. In an earlier study, Butler (1963) found that only 0.0055 ppm of DDT was required to produce the same effect. Butler (1965) also reported that DDE at 1.0 ppm had no effect on juvenile fish, while 0.1 ppm of DDT caused loss of equilibrium. Effects on growth of oyster shells indicated that DDE was about half as toxic as DDT in comparing studies of 1965 and 1963. Heath et al. (1969) reported that 10 ppm DDE fed to Mallard ducks for 2 years produced thin egg shells and a lower percentage hatched. This amount is considerably larger than the amounts found in Connecticut fish.

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PUBLICATION

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