Organochlorine Residues in Fish from the Yazoo National Wildlife Refuge

Parley V. Winger, *U.S. Fish and Wildlife Service, Columbia National Fisheries Research Laboratory, Field Research Station, University of Georgia, School of Forest Resources, Athens, GA 30602, (404) 546–2146*

Donald P. Schultz, *U.S. Fish and Wildlife Service, 75 Spring Street, S.W., Atlanta, GA 30303*

W. Waynon Johnson, *U.S. Fish and Wildlife Service, 75 Spring Street, S.W., Atlanta, GA 30303*

Abstract: Toxaphene and DDTR (DDT plus metabolites), both exceeding 10 ppm wet weight, were found in all samples of fish collected from 9 locations on the Yazoo, Mississippi, National Wildlife Refuge. Concentrations were highest in aquatic systems receiving direct inflow from areas draining agricultural land, and lowest in areas receiving only backwater overflow or local runoff. Residue levels of toxaphene and DDTR were high enough to threaten fish-eating wildlife. Installation of flood control structures around the northern perimeter of the refuge may reduce the inflow of contaminants that now accumulate in resident biota.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 39:125–131

Aquatic systems in the Lower Mississippi Delta have a long history of contamination with agricultural chemicals. Agricultural practices, climatic factors, and soil conditions in this area are all conducive to the movement of toxic material into aquatic systems (Schmitt and Winger 1980); furthermore, a shift in the early 1970s to soybeans as a major agricultural crop (now the most intensively cultivated crop in the Lower Mississippi Delta) increased the amount of land suitable for farming. On the other hand, soybeans required less extensive use of insecticides than did the cotton and corn that they replaced (Siniard 1975). Even after the use of organochlorine insecticides was reduced, however, lakes in this area remain heavily contaminated. Many of the lakes in the Yazoo-Mississippi Delta serve as sumps for agricultural chemicals (Niethammer et al. 1984), and Bingham (1969) attributed the decline of sport fisheries in many of these lakes to high concentrations of pesticide associated with agricultural runoff. Toxaphene and DDT are the prevalent contaminants in water, sediment, and fish throughout the Delta (Herring and Cotton 1970).

The Yazoo National Wildlife Refuge (Yazoo NWR) is an island of comparatively undisturbed habitat in the Lower Mississippi Delta surrounded by agricultural land. The U.S. Department of the Interior, Fish and Wildlife Service manages this refuge primarily for overwintering waterfowl, but other wildlife species and fish are also important. Proper management of fish and wildlife for human consumption, propagation, and protection is contingent on knowledge of the prevailing contaminant conditions at this refuge. The objective of this study was to determine the level of organochlorine pesticide contamination in fish from Yazoo NWR. Residue concentrations in fish are reliable indicators of the severity of contamination and potential hazard to natural resources.

Support for this study was provided by the U.S. Department of the Interior, Fish and Wildlife Service, Division of Wildlife Refuges, Region IV, Atlanta, and the Columbia National Fisheries Research Laboratory. We thank Tim Wilkins (refuge manager), B. H. Powell (assistant refuge manager), and John Forrester (fisheries assistance) for their help in collecting fish.

Methods

The Yazoo NWR encompasses about 2,400 ha in the flat, alluvial delta lands of western Mississippi south of Greenville. Swan Lake, a crescent-shaped water body forming the northern and eastern perimeter of the refuge, is bordered by a brake of cypress, mixed hardwood, and willow. Black Bayou and Silver Lake Bayou, which drain agricultural land, discharge directly into Swan Lake, and upper Swan Lake also receives runoff from adjacent agricultural land. Alligator Pond, Big Lake, Gin Slough, Long Pond, and Green Tree Reservoir, all in the interior of the refuge, receive mainly backwater overflow or local runoff. Swan Lake and other water bodies on the refuge are important feeding, resting, and roosting areas in winter for migratory waterfowl, and provide year-round habitat for wood ducks. Bottomland forests surrounding the refuge have been cleared for agricultural development, leaving little forested habitat for wildlife. Consequently the wildlife in this area depend heavily on the wooded and wetland habitat provided by the refuge.

Fish for contaminant residue analyses were collected in 1980, 1982, and 1983 from 9 stations on Yazoo NWR, although not every station was sampled each year. Fish were collected with rotenone, explosives, and gill nets. Nine species were collected: yellow bullhead (*Ictalurus natalis*), channel catfish (*I. punctatus*), black crappie (*Pomoxis nigromaculatus*), white crappie (*P. annularis*), common carp (*Cyprinus carpio*), bluegill (*Lepomis macrochirus*), bowfin (*Amia calva*), bigmouth buffalo (*Ictiobus cyprinellus*), and gizzard shad (*Dorosoma cepedianum*). Although 9 species were collected from the combined stations, no species was collected at all stations during the same sampling trip. Fish were weighed and measured, wrapped individually in aluminum foil, composited by species, and frozen until analyzed for organochlorine residues. Composite samples generally consisted of 5 fish, and never less than 3.

Fish were ground whole in a Hobart[1] food grinder. After Soxhlet extraction of the sample in ethyl ether and petroleum ether, the extract was cleaned up with Florisil. We used silica gel to effect additional cleanup for analysis of certain compounds. Pesticide residues were then determined by gas chromatography. The minimum detection levels were 0.01 ppm for all organochlorine residues except toxaphene (0.35 ppm) and PCBs (0.05 ppm). Values are expressed as parts per million on a whole fish, wet-weight basis.

Results and Discussion

The preliminary survey in 1980, conducted at 4 locations on the refuge—Silver Lake Bayou, Gin Slough, Big Lake, and Alligator Lake—showed that fish from several locations were sufficiently contaminated to pose a threat to fish-eating waterfowl (Table 1). Concentrations of DDTR (DDT plus metabolites) and toxaphene were highest in Silver Lake Bayou and Gin Slough (where both exceed 10 ppm), and lowest in Big Lake and Alligator Lake.

A more intensive evaluation was undertaken in 1982 and 1983. In these later surveys, fish were resampled from Silver Lake Bayou and Gin Slough, and sampled for the first time from upper and lower Swan Lake, Black Bayou, Long Pond, and Green Tree Reservoir. Hydrologic conditions and sources of water differed at each of these 7 stations.

Over the course of the study, 75 composite samples of fish collected from Yazoo NWR were analyzed for organochlorine residues. We found DDT and its metabolites in all samples, and toxaphene was detected in 97%. Dieldrin (81%) and endrin (73%) were also commonly found, but levels seldom exceeded 0.10 ppm, except in gizzard shad at upper Swan Lake in 1982. We detected PCB (Aroclor 1254) in 80% of the samples, but concentrations did not exceed 0.50 ppm, except in common carp from Silver Lake Bayou in 1980.

Concentrations of organochlorine insecticides were highest in areas that received direct inflow of waters draining agricultural land (Swan Lake, Silver Lake Bayou, Black Bayou, and Gin Slough), and lowest in lakes receiving only local runoff or overflow (Long Pond, Green Tree Reservoir, Big Lake, and Alligator Lake). At least 2 fish species from upper and lower Swan Lake, Silver Lake Bayou, Black Bayou, and Gin Slough contained concentrations of DDTR that exceeded the Food and Drug Administration (FDA) action level of 5 ppm for fish flesh. Toxaphene concentrations were also high (especially in Swan Lake, Silver Lake Bayou, and Black Bayou) and commonly exceeded the FDA action level of 5 ppm for this compound as well. Concentrations of DDTR in fish exceeded the National Academy of Science-National Academy of Engineers (1972) level of 1 ppm recommended for the protection of fish-eating wildlife. Residue levels of toxaphene in fish from the refuge were within the range reported by Mehrle and Mayer (1977) to re-

[1]Reference to trade names or manufacturers does not imply U.S. Government endorsement of commercial products.

Table 1. Contaminant residues in whole body fish and sediment samples from the Yazoo National Wildlife Refuge, 1980–1983.

Station and sample matrix	Year	N[b]	Average weight (g)	Lipid (%)	Mean concentrations (ppm, wet-weight basis)[a] p,p' DDE	p,p' DDD	p,p' DDT	Other[c] DDT	DDTR[d]	Dieldrin	Endrin	PCB	BHC	Toxaphene
Swan Lake-Upper														
Yellow bullhead	1982	3	32	0.5	0.10	0.03	ND	0.01	0.14	ND	ND	ND	ND	0.10
Yellow bullhead	1983	3	48	2.9	0.55	0.18	0.29	0.05	1.07	0.01	ND	ND	ND	2.71
Yellow bullhead	1983	3	428	3.5	2.31	0.84	0.34	0.06	3.55	ND	ND	0.32	ND	ND
Gizzard shad	1982	3	269	6.8	7.88	1.61	ND	14.00	23.49	5.68	2.06	0.04	ND	280.33
Gizzard shad	1983	3	269	4.6	4.33	1.54	1.97	0.38	8.22	0.04	0.02	0.11	0.01	17.15
Sediment	1982	3	—	—	0.11	0.09	0.01	0.02	0.24	ND	ND	ND	ND	0.06
Swan Lake-Lower														
Yellow bullhead	1982	3	71	1.4	1.27	0.31	0.02	0.08	1.69	ND	0.01	0.01	ND	1.87
Yellow bullhead	1983	2	24	2.0	1.33	0.61	0.69	0.14	2.77	0.02	ND	0.05	0.01	7.85
Black crappie	1982	3	138	0.8	0.65	0.23	0.09	0.10	1.08	ND	ND	ND	ND	0.47
Gizzard shad	1983	3	124	2.8	2.39	1.41	1.50	0.37	5.67	0.05	0.02	0.12	0.01	15.72
Sediment	1982	3	—	—	0.05	0.05	0.01	0.01	0.12	ND	ND	ND	ND	0.04
Silver Lake Bayou														
White crappie	1980	1	NA	3.2	7.06	3.09	ND	0.74	10.89	0.09	ND	0.54	ND	10.20
Common carp	1980	1	NA	6.2	16.70	10.30	ND	0.74	21.74	0.07	ND	1.11	ND	19.30
Black crappie	1982	3	131	0.3	0.64	0.19	0.13	0.09	1.05	ND	ND	0.09	ND	0.19
Common carp	1982	3	1155	7.6	16.07	2.86	0.04	0.62	19.59	0.03	0.01	0.17	ND	7.63
Yellow bullhead	1983	3	167	4.2	0.37	1.72	0.90	0.16	3.15	0.03	0.02	0.26	0.01	0.95
Gizzard shad	1983	3	93	2.8	5.00	2.58	2.90	0.72	11.20	0.10	0.07	0.28	0.16	27.80
Sediment	1982	3	—	—	0.18	0.15	0.01	0.04	0.38	ND	ND	ND	ND	0.07
Black Bayou														
Black crappie	1982	3	233	2.4	3.99	1.49	0.52	0.56	6.55	0.02	0.01	ND	ND	2.45
Common carp	1982	3	1527	8.4	12.07	3.46	0.23	0.32	16.08	0.03	0.07	0.21	0.02	3.51
Gizzard shad	1983	3	161	1.2	1.38	0.59	0.67	0.15	2.79	0.03	0.02	0.10	ND	6.80
Channel catfish	1983	3	221	5.3	2.93	1.35	0.54	0.09	4.91	0.02	ND	0.17	ND	0.44
Sediment	1982	3	—	—	0.14	0.07	0.01	0.02	0.24	ND	ND	ND	ND	0.02

Station and sample matrix	Year	N[b]	Average weight (g)	Lipid (%)	Mean concentrations (ppm, wet-weight basis)[a]									
					p,p' DDE	*p,p'* DDD	*p,p'* DDT	Other[c] DDT	DDTR[d]	Dieldrin	Endrin	PCB	BHC	Toxaphene
Gin Slough														
Bowfin	1980	1	NA	4.8	7.81	2.16	ND	0.51	10.48	ND	ND	ND	ND	3.50
Common carp	1980	1	NA	7.5	2.61	1.13	0.01	0.57	4.32	ND	ND	0.03	ND	ND
Yellow bullhead	1982	3	153	1.6	0.81	0.11	0.03	0.07	1.02	ND	ND	ND	0.01	0.14
Bowfin	1982	1	782	1.0	1.04	0.22	0.06	0.08	1.40	ND	ND	ND	ND	0.33
Sediment	1982	3	—	—	0.20	0.04	0.01	0.02	0.27	ND	ND	ND	ND	ND
Long Pond														
Gizzard shad	1982	3	20	7.4	2.40	1.63	0.28	0.43	4.74	0.04	0.02	ND	ND	2.03
Bluegill	1982	3	27	2.1	1.39	0.49	0.08	0.07	2.04	0.01	ND	ND	ND	0.35
Green Tree Res.														
Yellow bullhead	1982	3	14	2.4	0.39	0.15	ND	0.09	0.63	ND	ND	ND	ND	0.31
Gizzard shad	1983	4	69	8.4	2.06	1.48	0.73	0.13	4.40	0.04	ND	ND	ND	6.37
Big Lake														
Bowfin	1980	1	NA	3.9	2.73	0.87	0.38	0.18	4.16	ND	ND	ND	ND	1.61
Bigmouth buffalo	1980	1	NA	6.9	0.90	0.49	0.32	0.09	1.80	ND	ND	ND	ND	0.90
Alligator Lake														
Bowfin	1980	1	NA	3.4	1.97	0.93	1.00	0.12	4.02	ND	ND	ND	ND	2.52
Yellow bullhead	1980	1	NA	4.1	2.33	0.71	0.21	0.16	3.41	ND	ND	ND	ND	1.17

[a]ND = not detected; NA = not available
[b]number of composite samples
[c]DDMU in 1980 and 1982, *o, p'* DDT in 1983
[d]DDT plus metabolites and isomers

duce bone development in fish. Concentrations of DDTR and toxaphene in fish from Yazoo NWR exceeded levels found by Schmitt et al. (1983) in fish collected for the 1978–79 National Pesticide Monitoring Program (DDTR, 0.36 ppm; toxaphene, 0.32).

Residue concentrations measured in fish from Yazoo NWR during our study were similar to those reported for other aquatic systems in the Delta. Bingham (1969) measured 5 ppm DDTR in bluegills from Wolf Lake, and Herring and Cotton (1970) reported 0.1 to 10.6 ppm DDTR and 0.0 to 20.0 ppm toxaphene in fish from 20 lakes surveyed in the Delta. Niethammer et al. (1984) found levels exceeded 30 ppm DDTR and 15 ppm toxaphene in fish from Lake Providence and Lake Bruin in the Mississippi Delta.

Spatial trends in DDTR residues in sediment samples from the refuge were similar to those in fish: concentrations were highest in areas receiving direct water inflow. However, concentrations in sediment samples did not exceed 0.4 ppm. Toxaphene concentrations were also low, none exceeding 0.07 ppm. McHenry et al. (1982) reported similar concentrations in Wolf Lake, where they measured sedimentation rates of 5 cm per year and found organochlorine pesticides in the clayey material being deposited. They also indicated that residue levels were lower in 1979 than before the 1970s but concluded from the continued occurrence that a substantial reserve of this material must be present. High concentrations of DDE in relation to the other metabolites found in biota and sediments during our study indicate that the DDTR at the refuge is a remnant of past contamination, and that no new sources are being introduced. Toxaphene concentrations in biota should decrease with the recent (1982) restrictions on its use. Contamination of the Yazoo NWR continues, however, and probably results from relatively small amounts entering the refuge in water and sediments, particularly during periods of high flow.

Although the concentrations of organochlorine pesticides were not excessively high in sediments and were probably low in the water entering the Yazoo NWR, levels were sufficiently high to allow significant accumulation in resident fishes. Prolonged inputs of contamination, even at low concentrations, may cause excessive loading of a system. For example, Brodtmann (1976) found only low levels (in the parts per billion range) of pesticides in the Mississippi River, but estimated that (because of the large volume of discharge) 9 tons of chlorinated pesticide were being deposited in the ocean each year.

Implementation of projected plans by the U.S. Army Corps of Engineers (1976) for construction of flood protection structures in the Yazoo Basin may prove beneficial to Yazoo NWR. Our study showed a spatial gradient of contamination on the refuge, levels being highest in areas with direct inflows and lowest in lakes receiving only overflow and local runoff. Contaminant levels in fish were high enough to suggest adverse impacts on aquatic biota and fish-eating wildlife. Installation of flood control structures that allow selective releases of water to the refuge could improve the quality of the water entering the refuge. Inflow of water to the refuge could be restricted to periods when water quality is acceptable and avoided during periods when agricultural runoff is high, thereby reducing contamination of resident fish populations and other biota.

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