

STATE OF MINNESOTA
DEPARTMENT OF CONSERVATION
DIVISION OF GAME AND FISH

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LEVELS OF DDT, DDE AND ALDRIN IN MUSCLE AND BRAIN
TISSUE OF SOME MINNESOTA FISHES, 1962 - 1967

By

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Analyses by the Minnesota Department of Health

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Introduction

In 1962 a program for determining concentration levels of DDT and DDE in Minnesota fishes was set up jointly by the Minnesota Department of Conservation and Minnesota Department of Health. Since then, fish of game and non-game (rough) species have been collected each year at locations representative of forested and agricultural areas of the State. This report summarizes analyses of fish collected during the 6-year period 1962-1967. The fish were collected by Division of Game and Fish field personnel, often as part of regular lake and stream surveys. Samples of tissue were removed from the fish at the Biology Laboratory of the Division of Game and Fish and then submitted to the Department of Health for analysis.

Most of the fish were analyzed for DDT in its two forms, parapar and orthopara DDT, and for DDE, which is a derivative or break-down product of DDT that is formed under aerobic conditions such as is found in body tissues of animals. It should be noted that although DDE is a very stable and persistent compound it is of considerably lower toxicity than DDT and is not used as a pesticide. Its presence indicates previous occurrence of DDT either in the fish analyzed or at some place in the food chain. Both DDT and DDE are stored in body fats. DDD, another derivative of DDT that is formed under anaerobic conditions, such as in pond muds, and which is a third to a fifth as toxic as DDT to fish, is not reported in this series of analyses. DDD also may be stored in fish, and Kleinert *et al.* (1968) report that in analyses of "whole" Wisconsin fish it made up, on the average, about one-fourth (28 percent) of the total DDT complex--that is, the total for DDT, DDE, and DDD. It should be emphasized that since these three compounds differ in toxicity, analyses expressed in terms of "DDT complex" are not strictly comparable to those for DDT alone. In this report "DDT" means the sum of the orthopara and parapar fractions found in the analyses.

For most of the Minnesota fish, analyses were made of both muscle flesh and brain tissue. Flesh analyses were made to permit comparison of DDT levels with those established for other food stuffs. Brain tissue analyses were made because it was known that birds accumulate DDT and its derivatives in fats (lipids) of brain tissue. It was thought desirable to accumulate basic information on such accumulation in the brain tissues of fish. The concentrations reported are those that were being tolerated by fish when they were caught. It should be noted that in birds there is considerable variation in tolerance levels even among individual birds of the same species (Stickel *et al.* 1966).

In all, analyses for DDT and DDE were made of 134 fish--44 game fish and 90 rough fish. A few (8) analyses were also made for aldrin. The results of the DDT and DDE analyses, kinds of fish, and locations and dates of collection are shown in Tables 1, 2, 3 and 4.

Findings

DDT and DDE levels in fish flesh

Levels of DDT and DDE found in the muscle flesh of game fishes are shown in Table 1. The game fishes analyzed are perch, smallmouth bass, crappie, sunfish, walleye, northern pike, trout, and white bass. Table 3 lists analyses of the flesh of rough fishes, including bullheads, carp, sheepshead, redhorse, carpsucker, white sucker, catfish, and buffalofish. Such rough fish feed principally on invertebrates and plant material. In contrast, the game fishes which have a more varied diet which often includes other fish and could be expected to accumulate greater concentrations of DDT and its derivatives in the flesh.

The most obvious feature of the DDT analyses shown in Tables 1 and 3 is the general but irregular decline in concentrations found in the fish flesh since 1962. Whereas in 1962 and 1963 half the DDT analyses of flesh of game fish were 1.0 p.p.m. or higher (up to 3.43 p.p.m.), only 1 in 8 game fish analyzed in 1967 exceeded the 1 p.p.m. level. The intervening years are generally intermediate. It should be noted that many of the higher concentrations recorded are from fish taken in 1962 in forested areas of northeastern Minnesota. At that time DDT was used for control of forest insects. This method is no longer used by either Federal or State forest management agencies.

Analyses of the flesh of rough fishes also show a general decline in concentrations of DDT over the period. In 1962 and 1963 the eight rough fish analyzed all were within the range of 0.11-11.7 p.p.m. In 1967, 22 of 31 rough fish analyzed showed only trace amounts of DDT in the flesh.^{1/}

DDE levels in flesh have been fairly low throughout the period both for game and rough fish. Two of the 44 analyses for game fish exceeded 1 p.p.m., as did four of the 90 analyses from rough fish.

A feature of these analyses for both DDT and DDE is the occurrence of occasional fishes with quite high concentrations. Such fish have probably been subjected to high concentrations of DDT in localized areas. In recent years fish with high concentrations have usually come from rivers in agricultural areas; especially the lower Mississippi, Minnesota, Red, and Root rivers. In these waters such fish are associated with others that have much lower concentrations, also suggesting quite localized exposure to DDT.

When considering fish flesh as food the foregoing analyses may be compared with DDT standards that have been set by the U. S. Food and Drug Administration for some other foods. No federal level has been set for fish. For some fruits and green vegetables such as apples, celery, and cabbage the maximum acceptable level is 7 p.p.m. This same level applies to animal fats in meat. Some other foods have maximum acceptable levels ranging from 1 to 3.5 p.p.m.^{2/} None is permitted in eggs and milk. In the flesh analyses for game fish no concentrations of DDT higher than 3.43 p.p.m. were found. There were five analyses higher than 7 p.p.m. for flesh of rough fish. The highest analyses found were 53 p.p.m. for a sucker taken from the Mississippi River in 1966 and 30 p.p.m. in a carpsucker taken from the Minnesota River in Blue Earth County in 1967.

1/ It might be noted the overall use of DDT in the United States declined from a peak of 79.7 million pounds in 1956 to 45.6 million in 1966.

2/ See Part 120, Subchapter B. Federal Register. Vol. 33, No. 125, June 27, 1968.

In most cases, DDT levels in fish flesh have been below that which has been permitted on some other kinds of foods.

DDT and DDE levels in fish brain tissue

Brain tissue of fish, like that in other animals, is rich in fatty material (lipids) in which DDT and its derivatives can accumulate. That such accumulation occurs can be seen by comparing Tables 1 and 2 for game fish and Tables 3 and 4 for rough fishes. DDT concentrations found in the brains of game fishes has ranged from a trace to 114 p.p.m. with a median concentration of 3.25. This may be compared with a range of a trace to 3.43 p.p.m. and median of 0.11 p.p.m. for flesh. The usual (median) concentration of DDT in the brain of game fishes was about 30 times that found in the flesh.

For the rough fish analyzed, DDT concentrations in brain tissue ranged from a trace to 456 p.p.m. with a median of 0.1 p.p.m., considerably lower than the 3.25 p.p.m. median for the game fishes. In rough fishes, as in the game fishes, DDT concentrations in brain tissue were higher than in muscle flesh.

Concentrations of DDT in brain tissue higher than 20 p.p.m. were found in 1 sheepshead, 4 redhorse, 2 white suckers, 3 perch, 1 smallmouth bass, 1 crappie, 1 bluegill, and 1 walleye. Concentrations of DDE in brain tissue higher than 1 p.p.m. were found in 2 redhorse, 1 carpsucker, 1 perch and 1 northern pike. See Table 2 and 4 for details.

Aldrin levels in fish

In 1966 and 1967, eight analyses were also made for aldrin levels from fish taken from the agricultural area of southern Minnesota. They are:

Location	County	Date	Species	Tissue	p.p.m. aldrin
Minnesota R.	-	10/18/66	Carpsucker	Muscle	.002
Minnesota R.	-	Fall 66	Carp	Brain	.046
Mississippi R.	Goodhue	9/26/66	Sucker	Brain	.012
Mississippi R.	Goodhue	9/26/66	Sucker	Brain	.007
Root R.	Houston	Fall 66	N. pike	Brain	.8
Budd L.	Martin	9/29/67	Sucker	Brain	.24
Minnesota R.	Blue Earth	10/5/67	Redhorse	Brain	.1
Root R.	Houston	10/30/67	Walleye	Muscle	.017

There are too few aldrin analyses to draw definite conclusions, other than to state they are all below 1 p.p.m. and within the same range reported for dieldrin (an analogue of aldrin that is somewhat more toxic to fish) by Kleinert et al. for "whole" Wisconsin fish (range--trace to 10 p.p.m., mean--0.17, median--0.004).

DDT and Survival of Fish Eggs

Information has been obtained from logbooks of two Minnesota fish hatcheries on the percentage of walleye eggs which have hatched in past years. These data are given in Table 5. The eggs were taken from wild fish trapped in spawning runs. Many factors affect the percentage hatch of walleye eggs, including water temperatures, condition of water supply such as silt load, and hatchery operational difficulties. This is illustrated by fluctuations in percentage hatch from one year to the next.

Aside from such short term fluctuations there appears to be no definite long-term trend in the percentage of eggs which hatched that could be attributed to toxic material, such as DDT, in the environment since 1945 when this pesticide was first used.

Effects on Fish-eating Birds and Mammals

The effect of the DDT and DDE concentrations found in the Minnesota fish upon fish-feeding birds and mammals is not certainly known, but there is no obvious indication of appreciable damage.

The take of otter by trapping has shown no regular trend either up or down since 1955, fluctuating between 273 and 549 animals a year (Table 6). Years of highest take were 1958 (549 animals) and 1967 (529 animals). Years of lowest take were 1964 with 237, 1946 with 246 and 1957 with 264. Otter feed a great deal on fish.

Similarly, there is no trend indicated on the take of mink which also feed on fish and other aquatic animals.

A 4-year study of numbers and nesting success of bald eagles and ospreys, both fish-eating birds, has been made in the Chippewa National Forest by John E. Mathison, Biologist with the U. S. Forest Service (Mathison, 1967). He found no provable decline of eagles here, and successful nests (43 percent of the 67 studied) averaged 1.4 eaglet per nest. Fifty-nine osprey nests were located in the forest, and 20 of these were studied. Mr. Mathison concluded that ospreys here "are not suffering from reproductive failure".

However, it should be emphasized that long-term and more subtle effects of pesticides in the environment are very difficult to evaluate, and it cannot be stated with complete certainty that no harm is being done by DDT and other pesticides to aquatic birds and mammals that feed on fish and other aquatic life.

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Table 1. - Concentrations of DDT and DDE in muscle flesh of Minnesota game fishes collected in various waters of Minnesota during the period 1962-1967. ^{1/}All analyses are in parts per million (milligrams per kilogram)

Location	County	Date	Species	op DDT ^{2/}	pp DDT ^{2/}	Total DDT	DDE
Caribou L.	Cook	9/10/62	Perch	.78	.50	1.28	.17
Devils Track L.	Cook	9/13/62	Perch	1.90	1.53	3.43	1.12
Cat L.	Lake	9/13/62	N. pike	.27	.22	.49	.05
Pike L.	Cook	8/15/62	Sm. bass	.18	2.23	2.41	.10
Clear L.	Waseca	10/23/63	Crappie	.36	.64	1.00	.04
Clear L.	Waseca	10/23/63	Bluegill	tr.	.81	.81	.18
Kimball L.	Cook	10/16/63	Perch	tr.	tr.	tr.	tr.
Kimball L.	Cook	10/16/63	Perch	tr.	1.00	1.00	.30
Kimball L.	Cook	10/16/63	R. trout	tr.	.90	.90	.67
Kimball L.	Cook	10/16/63	R. trout	tr.	.06	.06	.19
Root R.	Houston	sp. 64	Crappie	.32	.11	.43	.02
Itasca L.	Clearwater	9/9/64	Walleye	tr.	.04	.04	tr.
Rainy R.	Lake of Woods	9/18/64	Walleye	tr.	.04	.04	tr.
Red R.	Marshall	9/23/64	Walleye	tr.	1.05	1.05	.91
Mississippi R.	Goodhue	9/11/64	N. pike	.07	.07	.14	1.06
Kawishiwi R.	Lake	10/23/64	N. pike	.17	.17	.34	.01
Root R.	Houston	9/17/64	Walleye	.57	.23	.80	.12
Root R.	Houston	9/17/64	Wh. bass	.31	.18	.49	.07
Root R.	Houston	9/17/64	Sm. bass	.20	.19	.39	.08
Rainy R.	Lake of Woods	1965	Walleye	.071	.019	.090	.006
Kawishiwi R.	Lake	1965	Walleye	.027	.011	.038	.002
Mississippi R.	Goodhue	1965	N. pike	.024	.018	.042	.002
Mississippi R.	Clearwater	1965	Walleye	tr.	tr.	tr.	tr.
Root R.	Houston	1965	Bluegill	.023	tr.	.023	.007
Root R.	Houston	1965	P'seed	tr.	tr.	tr.	.007
Root R.	Houston	1965	Bluegill	tr.	tr.	tr.	tr.
Minnebelle L.	Meeker	Fall '66	N. pike	.009	.012	.021	.003
Minnebelle L.	Meeker	Fall '66	N. pike	.040	.018	.058	.006
Minnesota R.	-	10/18/66	Walleye	.107	.061	.168	.016
Minnesota R.	-	10/18/66	Walleye	.015	.010	.025	.003
Root R.	Houston	Fall '66	N. pike	tr.	1.7	1.7	tr.
Root R.	Houston	Fall '66	Wh. bass	.079	.048	.127	.055
Itasca L.	Clearwater	9/8/66	Walleye	tr.	tr.	tr.	tr.
Budd L.	Martin	10/17/66	Crappie	.044	.086	.130	tr.
Budd L.	Martin	10/17/66	Bluegill	.3	tr.	.3	tr.
Red R.	Marshall	10/5/66	Walleye	tr.	tr.	tr.	tr.
Blackduck L.	Beltrami	6/15/67	Walleye	tr.	tr.	tr.	tr.
Rainy R.	Lake of Woods	9/12/67	N. pike	tr.	tr.	tr.	tr.
Kawishiwi R.	Lake	10/4/67	N. pike	1.0	.4	1.4	.073
Kawishiwi R.	Lake	9/10/67	N. pike	tr.	tr.	tr.	tr.
Itasca L.	Clearwater	9/27/67	Walleye	tr.	tr.	tr.	.004
Mississippi R.	Goodhue	10/29/67	Walleye	.1	.092	.192	.053
Root R.	Houston	10/30/67	Walleye	.002	.009	.011	.004
Mississippi R.	Anoka	12/5/67	Crappie	tr.	tr.	tr.	.003

^{1/} Concentrations lower from those which could be determined quantitatively are recorded as a trace - "tr". Traces are not included in DDT totals. A dash (-) indicates no data or data incomplete.

^{2/} Orthopara and parapara fractions of DDT.

Table 2. - Concentrations of DDT and DDE in brains of Minnesota game fishes collected from various waters in Minnesota during the period 1962-1967. All analyses are in parts per million (milligrams per kilogram) ^{1/}

Location	County	Date	Species	opDDT ^{2/}	ppDDT ^{2/}	Total DDT	DDE
Caribou L.	Cook	9/10/62	Perch	28.0	29.0	57.0	19.0
Devils Track L.	Cook	9/13/62	Perch	37.4	25.7	63.1	8.87
Cat L.	Lake	9/13/62	N. Pike	4.65	4.85	9.50	.59
Pike L.	Cook	8/15/62	SM Bass	tr.	13.76	13.76	4.11
Clear L.	Waseca	10/23/63	Crappie	15.25	36.42	51.67	.92
Clear L.	Waseca	10/23/63	Bluegill	tr.	27.19	27.19	tr.
Kimball L.	Cook	10/16/63	Perch	2.26	39.64	41.90	31.23
Kimball L.	Cook	10/16/63	Perch	tr.	2.94	2.94	1.88
Kimball L.	Cook	10/16/63	R. Trout	tr.	11.13	11.13	9.59
Kimball L.	Cook	10/16/63	R. Trout	tr.	14.94	14.94	12.77
Root R.	Houston	Spr. 64	Crappie	tr.	5.92	5.92	tr.
Itasca L.	Clearwater	9/9/64	Walleye	tr.	5.74	5.74	.39
Rainy R.	L. of Woods	9/18/64	Walleye	tr.	1.39	1.39	.61
Red R.	Marshall	9/23/64	Walleye	.004	.10	.104	.04
Mississippi R.	Goodhue	9/11/64	N. Pike	6.24	1.77	8.01	.65
Kawishiwi R.	Lake	10/23/64	N. Pike	5.71	8.39	14.10	.09
Root R.	Houston	9/17/64	Walleye	12.97	8.67	21.64	1.96
Root R.	Houston	9/17/64	W. Bass	1.96	1.25	3.21	.48
Root R.	Houston	9/17/64	Sm. Bass	5.71	4.84	10.55	2.04
Rainy R.	L. of Woods	1965	Walleye	2.50	.8	3.30	2.20
Kawishiwi R.	Lake	1965	Walleye	.37	.19	.56	.043
Mississippi	Goodhue	1965	N. Pike	.78	.30	1.08	.059
Mississippi R.	Clearwater	1965	Walleye	tr.	tr.	tr.	tr.
Root R.	Houston	1965	Bluegill	tr.	tr.	tr.	tr.
Minnebelle L.	Meeker	Fall 66	N. Pike	4.8	6.5	11.3	.6
Minnebelle L.	Meeker	Fall 66	N. Pike	.013	.016	.029	.152
Minnesota R.	-	10/18/66	Walleye	12.0	13.0	25.00	1.0
Minnesota R.	-	10/18/66	Walleye	.8	.3	1.1	.068
Root R.	Houston	Fall 66	N. Pike	.3	.2	.5	.2
Root R.	Houston	Fall 66	W. Bass	.006	.003	.009	1.4
Itasca L.	Clearwater	9/8/66	Walleye	tr.	.9	.9	.5
Budd L.	Martin	10/17/66	Crappie	2.5	14.0	16.5	tr.
Budd L.	Martin	10/17/66	Bluegill	67.0	47.0	114.0	6.0
Red R.	Marshall	10/5/66	Walleye	tr.	tr.	tr.	tr.
Blackduck L.	Beltrami	6/15/67	Walleye	tr.	.1	.1	.1
Rainy L.	L. of Woods	9/26/67	N. Pike	tr.	tr.	tr.	tr.
Kawishiwi R.	Lake	10/4/66	N. Pike	3.2	tr.	tr.	tr.
Kawishiwi R.	Lake	9/10/67	N. Pike	3.2	5.0	8.2	.3
Kawishiwi R.	Lake	9/10/67	N. Pike	tr.	tr.	tr.	tr.
Itasca L.	Clearwater	9/27/67	Walleye	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	10/29/67	Walleye	1.0	.85	1.85	0.5
Root R.	Houston	10/30/67	Walleye	tr.	.3	.3	tr.
Mississippi R.	Anoka	12/5/67	Crappie	tr.	tr.	tr.	tr.

^{1/} Concentrations lower than those which could be determined quantitatively are recorded as a trace--"tr.". Such traces are not included in the totals for DDT. A dash (-) indicates no data or data incomplete.

^{2/} Orthopara and parapara fractions of DDT

Table 3.- Concentrations of DDT and DDE in muscle flesh of Minnesota rough fish collected in various waters of Minnesota during the period 1962-1967. All analyses are in parts per million (milligrams per kilogram)^{1/}

Location	County	Date	Species	opDDT ^{2/}	ppDDT ^{2/}	Total DDT	DDE
Pike Lake	Cook	8/15/62	Sucker	.27	.35	.62	.09
Clear L.	Waseca	10/23/63	Bullhead	tr.	.69	.69	.15
Clear L.	Waseca	10/23/63	Bullhead	5.59	6.11	11.70	.94
Clear L.	Waseca	10/23/63	Carp	tr.	.24	.24	.03
Clear L.	Waseca	10/23/63	Carp	tr.	.11	.11	.03
Clear L.	Waseca	10/23/63	Bullhead	tr.	.33	.33	.02
Clear L.	Waseca	10/23/63	Sheepshead	.20	.16	.36	.08
Clear L.	Waseca	10/23/63	Sheepshead	.11	.61	.72	.05
Rainy R.	Koochiching	Spr. 64	Redhorse	tr.	.43	.43	tr.
Rainy R.	Koochiching	Spr. 64	Redhorse	tr.	.17	.17	.03
Root R.	Houston	Spr. 64	Redhorse	tr.	tr.	tr.	.02
Mississippi R.	Goodhue	4/15/64	Redhorse	11.10	3.77	14.87	1.66
Minnesota R.	Blue Earth	5/4/64	Carp sucker	tr.	.55	.55	1.48
Minnesota R.	Hennepin	5/4/64	Carp	tr.	.53	.53	.50
Kawishiwi R.	Lake	Spr. 64	Sucker	.02	.06	.08	tr.
Rainy R.	L. of Woods	9/18/64	Sucker	tr.	.23	.23	tr.
Red R.	Marshall	6/64	Redhorse	tr.	.06	.06	.03
Itasca L.	Clearwater	6/26/64	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	9/23/64	Sucker	.04	2.02	2.06	.26
Itasca L.	Clearwater	9/9/64	Sucker	tr.	.05	.05	.01
Itasca L.	Clearwater	6/26/64	Sucker	.01	.05	.06	.02
Mississippi R.	Goodhue	9/11/64	Sucker	.93	.93	1.86	.31
Mississippi R.	Goodhue	9/11/64	Redhorse	9.45	9.45	18.90	8.30
Root R.	Houston	9/17/64	Redhorse	2.37	1.36	3.73	.31
Root R.	Houston	9/17/64	Catfish	tr.	tr.	tr.	tr.
Root R.	Houston	1965	Redhorse	tr.	tr.	tr.	tr.
Root R.	Houston	1965	Catfish	tr.	tr.	tr.	tr.
Kawishiwi R.	Lake	1965	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	1965	Buffalo	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	1965	Sucker	tr.	tr.	tr.	tr.
Rainy R.	L. of Woods	1965	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	1965	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Anoka	1965	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Anoka	1965	Sucker	tr.	tr.	tr.	tr.
Kawishiwi R.	Lake	1965	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	1965	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Clearwater	1965	Sucker	tr.	tr.	tr.	tr.
Root R.	Houston	1965	Sucker	.037	.011	.048	.020
Root R.	Houston	1965	Carp	tr.	tr.	tr.	tr.
Minnesota R.	-	10/18/66	Carp sucker	tr.	tr.	tr.	tr.
Minnesota R.	-	Fall 66	Carp	.093	.034	.127	.025
Minnesota R.	-	10/18/66	Carp	.012	tr.	.012	tr.
Minnesota R.	-	10/18/66	Buffalo	.002	tr.	.002	tr.
Minnesota R.	Hennepin	Fall 66	Shad	tr.	tr.	tr.	tr.
Minnesota R.	Blue Earth	10/18/66	Carp	.003	tr.	.003	.001
Minnesota R.	Blue Earth	10/18/66	Carp	tr.	tr.	tr.	tr.
Mississippi R.	-	Fall 66	Redhorse	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	9/26/66	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	9/26/66	Sucker	.058	53.	53.058	.021
Root R.	Houston	Fall 66	Redhorse	tr.	tr.	tr.	tr.
Root R.	Houston	Fall 66	Redhorse	tr.	2.0	2.0	tr.
Rice Cr.	Anoka	9/14/66	Sucker	tr.	tr.	tr.	tr.

Table 3.- (Continued)

Location	County	Date	Species	opDDT ^{2/}	ppDDT ^{2/}	Total DDT	DDE
Rice Cr.	Anoka	9/14/66	Sucker	tr.	tr.	tr.	tr.
Rice Cr.	Anoka	9/14/66	Sucker	tr.	tr.	tr.	tr.
Itasca L.	Clearwater	9/8/66	Sucker	tr.	tr.	tr.	tr.
Budd L.	Martin	10/24/66	Sucker	tr.	tr.	tr.	tr.
Budd L.	Martin	10/17/66	Sheepshead	tr.	.063	.063	.031
Red R.	Marshall	10/5/66	Sucker	.069	tr.	.069	.011
Rainy R.	L. of Woods	10/5/66	Sucker	.022	tr.	.022	.27
Minnesota R.	Hennepin	6/15/67	Carp	.2	.3	.5	.2
Minnesota R.	Hennepin	6/15/67	Carp sucker	tr.	.001	.001	.001
Mississippi R.	Anoka	6/15/67	Carp	tr.	tr.	tr.	.002
Kawishiwi R.	Lake	6/15/67	Sucker	tr.	tr.	tr.	tr.
Rice Cr.	Anoka	6/22/67	Carp	tr.	tr.	tr.	tr.
Rainy R.	L. of Woods	6/22/67	Sucker	tr.	tr.	tr.	17.
Itasca L.	Clearwater	6/26/67	Sucker	tr.	tr.	tr.	.002
Minnesota R.	Blue Earth	6/29/67	Carp	tr.	tr.	tr.	.002
Hall L.	Martin	6/29/67	Sucker	tr.	tr.	tr.	tr.
Minnesota R.	Blue Earth	6/29/67	Carp sucker	.002	.003	.005	.047
Minnesota R.	Blue Earth	6/29/67	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	7/7/67	Sucker	tr.	tr.	tr.	.002
Root R.	Houston	7/7/67	Catfish	tr.	tr.	tr.	.072
Mississippi R.	Goodhue	7/17/67	Redhorse	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	7/17/67	Redhorse	tr.	tr.	tr.	tr.
Root R.	Houston	7/17/67	Catfish	tr.	tr.	tr.	tr.
Root R.	Houston	7/17/67	Carp	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	7/17/67	Redhorse	tr.	tr.	tr.	tr.
Rainy R.	L. of Woods	9/12/67	Sucker	tr.	tr.	tr.	tr.
Kawishiwi R.	Lake	10/4/66	Sucker	.6	tr.	.6	.2
Kawishiwi R.	Lake	9/10/67	Sucker	tr.	tr.	tr.	tr.
Itasca L.	Clearwater	9/27/67	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	9/27/67	Sucker	1.2	.5	1.7	.29
Budd L.	Martin	9/27/67	Sucker	.5	.4	.9	.002
Minnesota R.	Blue Earth	10/5/67	Redhorse	.065	tr.	.065	.031
Minnesota R.	Blue Earth	10/5/67	Carp sucker	20.	10.	30.	.2
Root R.	Houston	10/30/67	Sucker	tr.	tr.	tr.	.010
Root R.	Houston	10/30/67	Catfish	tr.	tr.	tr.	.013
Root R.	Houston	10/30/67	Carp	tr.	tr.	tr.	.004
Minnesota R.	Hennepin	12/5/67	Carp	.016	.012	.028	.028
Long L.	Ramsey	3/12/68	Sucker	.033	tr.	.033	.031

1/ Concentrations lower than those which could be determined quantitatively are recorded as a trace--"tr.". Such traces are not included in DDT totals. A dash (-) indicates no data or data incomplete.

2/ Orthopara and parapara fractions of DDT.

Table 4. - Concentrations of DDT and DDE in brains of Minnesota rough fish collected from various waters in Minnesota during the period 1962-67. All analyses are in parts per million (milligrams per kilogram)^{1/}

Location	County	Date	Species	op DDT ^{2/}	pp DDT ^{2/}	Total DDT	DDE
Pike L.	Cook	8/15/62	Sucker	tr.	4.31	4.31	.65
Clear L.	Waseca	10/23/63	Bullhead	6.20	8.95	15.15	.73
Clear L.	Waseca	10/23/63	Bullhead	tr.	.63	.63	.10
Clear L.	Waseca	10/23/63	Carp	1.39	2.64	4.03	tr.
Clear L.	Waseca	10/23/63	Carp	tr.	1.43	1.43	tr.
Clear L.	Waseca	10/23/63	Bullhead	tr.	7.10	7.10	tr.
Clear L.	Waseca	10/23/63	Sheepshead	12.59	9.10	21.69	tr.
Clear L.	Waseca	10/23/63	Sheepshead	5.69	9.46	15.15	tr.
Rainy R.	Koochiching	spr. '64	Redhorse	14.06	16.51	30.57	.65
Rainy R.	Koochiching	spr. '64	Redhorse	tr.	4.34	4.34	.72
Root R.	Houston	spr. '64	Redhorse	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	4/15/64	Redhorse	370.76	85.25	456.01	200.0
Minnesota R.	Blue Earth	5/4/64	Carp	tr.	10.65	10.65	47.87
Minnesota R.	Hennepin	5/4/64	Carp	tr.	3.02	3.02	.75
Kawishiwi R.	Lake	spr. '64	Sucker	--	--	--	--
Rainy R.	Lake of Woods	9/18/64	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	6/64	Redhorse	tr.	tr.	tr.	tr.
Itasca L.	Clearwater	6/26/64	Sucker	.06	.06	.12	tr.
Red R.	Marshall	9/23/64	Sucker	tr.	2.38	2.38	.22
Itasca L.	Clearwater	9/9/64	Sucker	.34	.36	.70	.15
Itasca L.	Clearwater	6/26/64	Sucker	tr.	.04	.04	.04
Mississippi R.	Goodhue	9/11/64	Sucker	218.36	38.67	257.03	4.01
Mississippi R.	Goodhue	9/11/64	Redhorse	84.49	59.22	143.71	49.97
Root R.	Houston	9/17/64	Redhorse	1.01	.87	1.88	.15
Root R.	Houston	9/17/64	Catfish	1.96	1.72	3.68	.93
Root R.	Houston	1965	Redhorse	tr.	330.0	330.00	tr.
Root R.	Houston	1965	Catfish	tr.	tr.	tr.	tr.
Kawishiwi R.	Lake	1965	Sucker	1.3	1.3	2.6	.1
Mississippi R.	Goodhue	1965	Buffalo	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	1965	Sucker	tr.	tr.	tr.	tr.
Rainy R.	Lake of Woods	1965	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	1965	Sucker	2.35	.7	3.05	.2
Mississippi R.	Anoka	1965	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Anoka	1965	Sucker	--	--	--	--
Kawishiwi R.	Lake	1965	Sucker	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	1965	Sucker	tr.	tr.	tr.	.006
Mississippi R.	Clearwater	1965	Sucker	tr.	tr.	tr.	tr.
Root R.	Houston	1965	Sucker	tr.	tr.	tr.	tr.
Root R.	Houston	1965	Carp	tr.	tr.	tr.	.029
Minnesota R.	-	10/18/66	Carp	tr.	.5	.5	tr.
Minnesota R.	-	Fall '66	Carp	.607	tr.	.607	.178
Minnesota R.	-	10/18/66	Carp	tr.	.033	.033	tr.
Minnesota R.	-	10/18/66	Buffalo	tr.	tr.	tr.	tr.
Minnesota R.	Hennepin	Fall '66	Shad	.7	.54	1.24	.7
Minnesota R.	Blue Earth	10/18/66	Carp	.24	tr.	.24	.016
Minnesota R.	Blue Earth	10/18/64	Carp	tr.	tr.	tr.	tr.

Table 4. - Continued

Location	County	Date	Species	op DDT ^{2/}	pp DDT ^{2/}	Total DDT	DDE
Mississippi R.	--	Fall '66	Redhorse	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	9/26/66	Sucker	tr.	11.0	11.0	.090
Mississippi R.	Goodhue	9/26/66	Sucker	tr.	tr.	tr.	tr.
Root R.	Houston	Fall '66	Redhorse	tr.	tr.	tr.	tr.
Root R.	Houston	Fall '66	Redhorse	tr.	tr.	tr.	tr.
Rice Cr.	Anoka	9/14/66	Sucker	1.4	3.3	4.7	tr.
Rice Cr.	Anoka	9/14/66	Sucker	.1	.4	.5	.059
Rice Cr.	Anoka	9/14/66	Sucker	tr.	tr.	tr.	tr.
Itasca L.	Clearwater	9/8/66	Sucker	tr.	tr.	tr.	tr.
Budd L.	Martin	10/24/66	Sucker	tr.	tr.	tr.	tr.
Budd L.	Martin	10/17/66	Sheepshead	tr.	tr.	tr.	tr.
Red R.	Marshall	10/5/66	Sucker	.2	1.3	1.5	tr.
Rainy R.	Lake of Woods	10/5/66	Sucker	tr.	tr.	tr.	tr.
Minnesota R.	Hennepin	6/15/67	Carp	tr.	.019	.019	.014
Minnesota R.	Hennepin	6/15/67	Carp	tr.	.1	.1	tr.
Mississippi R.	Anoka	6/15/67	Carp	tr.	.1	.1	.043
Kawishiwi R.	Lake	6/15/67	Sucker	tr.	tr.	tr.	.020
Rice Cr.	Anoka	6/22/67	Carp	tr.	tr.	tr.	tr.
Rainy R.	Lake of Woods	6/22/67	Sucker	tr.	tr.	tr.	tr.
Itasca L.	Clearwater	6/26/67	Sucker	tr.	tr.	tr.	tr.
Minnesota R.	Blue Earth	6/29/67	Carp	tr.	tr.	tr.	tr.
Hall L.	Martin	6/29/67	Sucker	tr.	tr.	tr.	tr.
Minnesota R.	Blue Earth	6/29/67	Carp	tr.	tr.	tr.	tr.
Minnesota R.	Blue Earth	6/29/67	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	7/7/67	Sucker	tr.	tr.	tr.	tr.
Root R.	Houston	7/7/67	Catfish	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	7/17/67	Redhorse	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	7/17/67	Redhorse	tr.	tr.	tr.	tr.
Root R.	Houston	7/17/67	Catfish	.038	tr.	.038	.021
Root R.	Houston	7/17/67	Carp	tr.	tr.	tr.	tr.
Mississippi R.	Goodhue	7/17/67	Redhorse	tr.	tr.	tr.	tr.
Rainy R.	Lake of Woods	9/12/67	Sucker	tr.	tr.	tr.	tr.
Kawishiwi R.	Lake	10/4/66	Sucker	1.0	2.2	3.2	.17
Kawishiwi R.	Lake	9/10/67	Sucker	.023	tr.	.023	tr.
Itasca L.	Clearwater	9/27/67	Sucker	tr.	tr.	tr.	tr.
Red R.	Marshall	9/27/67	Sucker	25.0	44.0	69.0	.25
Budd L.	Martin	9/27/67	Sucker	tr.	tr.	tr.	.1
Minnesota R.	Blue Earth	10/5/67	Redhorse	.16	tr.	.16	.061
Minnesota R.	Blue Earth	10/5/67	Carp	tr.	tr.	tr.	tr.
Root R.	Houston	10/30/67	Sucker	.029	tr.	.029	tr.
Root R.	Houston	10/30/67	Catfish	.068	tr.	.068	tr.
Root R.	Houston	10/30/67	Carp	.032	.034	.066	tr.
Minnesota R.	Hennepin	12/5/67	Carp	.18	tr.	.18	.27
Long L.	Ramsey	3/12/68	Sucker	tr.	tr.	tr.	tr.

^{1/} Concentrations lower than those which could be determined quantitatively are recorded as a trace - "tr". Such traces are not included in DDT totals. A dash (-) indicates no data or data incomplete.

^{2/} Orthopara and parapara fractions of DDT.

Table 5.- Percentage hatch of walleye eggs in two Minnesota fish hatcheries by years as recorded in hatchery logbooks

1. Cutfoot Sioux Hatchery near Deer River, Itasca County

<u>Year</u>	<u>Eggs taken</u>	<u>Percent hatched</u>
1946	161,544,407	72.0
1947	146,867,459	59.0
1948	139,556,968	45.55
1949	162,423,000	71.0
1950	62,385,000	56.9
1951	150,126,000	56.0
1952	15,385,000	61.5
1953	175,260,000	61.7
1954	112,776,000	62.4
1955	176,022,000	50.0
1956	55,118,000	66.8
1957	123,698,000	45.0
1958	188,342,250	47.0
1959	146,263,000	59.0
1960	63,335,700	73.56
1961	152,942,390	61.0
1962	55,618,000	48.8
1963	125,467,000	51.5
1964	64,430,498	37.25
1965	155,871,200	61.52
1966	179,578,000	63.83
1967	143,453,000	68.43
1968	194,261,628	57.0

Data supplied by Warren Kirsch, Fisheries Manager, Grand Rapids

2. Pine River Hatchery near Brainerd, Crow Wing County

<u>Year</u>	<u>Eggs taken</u>	<u>Percent hatched</u>
1932	160,515,000	83.0
1933	130,140,000	87.0
1934	90,320,000	77.0
1935	85,420,000	78.0
1936	72,957,000	81.0
1937	13,176,000	77.0
1938	118,820,000	76.0
1939	131,662,000	71.0
1940	112,817,000	74.8
1956	24,024,000	74.7
1957	22,654,000	73.4
1958	51,084,000	70.1
1959	62,832,000	79.9
1960	36,432,000	80.8
1962	38,544,000	73.3
1963	67,056,000	76.3
1964	59,004,000	82.4
1965	19,668,000	50.0
1966	31,744,000	52.1
1967	58,608,000	42.5
1968	74,750,000	65.2

Data supplied by Jerome H. Sevada, Fishery Manager, Brainerd

Table 5.- (Continued)

3. Detroit Lakes Hatchery at Detroit Lakes, Becker County
(Eggs from several sources)

<u>Year</u>	<u>Eggs taken</u>	<u>Percent hatched</u>
1954	22,684,000 (Various)	63
1955	60,856,000 (Various)	51
1956	35,136,000 (L. Sallie)	63
1957	17,664,000 (L. Sallie)	60
1958	24,190,000 (L. Sallie)	65
1959	-	-
1960	-	-
1961	19,580,000	62
1962	13,068,000 (Tamarack R.)	65
1962	21,230,000 (L. Sallie)	60
1963	20,064,000 (Tamarack R.)	58
1963	21,476,000 (L. Sallie)	71
1964	47,160,000 (L. Sallie)	57
1965	63,960,000 (L. Sallie)	54
1966	34,680,000 (L. Sallie)	34*
1967	21,780,000 (Tamarack R.)	42*
1967	31,080,000 (L. Sallie)	54
1968	12,672,000 (Tamarack R.-Lot I)	54
1968	29,568,000 (Tamarack R.-Lot II)	49
1968	29,480,000 (Sallie L.)	41

* Long incubation periods

Data supplied by William Joy, Fishery Manager, Detroit Lakes

4. Otter Tail Hatchery, Otter Tail County

<u>Year</u>	<u>Eggs taken</u>	<u>Percent hatched</u>
1962	7,290,000 (Tamarack R. Lot II)	67
1962	6,732,000 (Tamarack R. Lot I)	68
1962	5,002,000 (Otter Tail R.)	63
1963	10,032,000 (Tamarack R.)	69
1963	3,416,000 (Otter Tail R.)	70
1964	-	-
1965	4,800,000 (Sallie L.)	55
1965	854,000 (Otter Tail R.)	86
1966	28,674,000 (Dead R.)	52
1966	4,392,000 (Rolland Cr.)	57
1967	29,972,000 (Dead R.)	67
1968	22,774,000 (Dead R.)	77

Data supplied by William Joy, Fishery Manager, Detroit Lakes

Table 5.- (Continued)

5. Washkish Hatchery, Beltrami County

Eggs all from Tamarack River and Red Lake.

<u>Year</u>	<u>Eggs taken</u>	<u>Percent hatched</u>
1950	24,125,000	50
1951	25,200,000	Transferred
1952	118,010,000	58
1953	108,108,000	63
1954	156,552,000	54
1955	82,236,000	53
1956	100,980,000	57
1957	50,952,000	55
1958	87,384,000	47
1959	28,528,000	59
1960	43,428,000	63
1961	138,468,000	63
1962	97,000,000	62
1963	87,088,000	66
1964	51,744,000	67
1965	42,900,000	57
1966	2,376,000	Transferred
1967	77,748,000	54
1968	97,152,000	65

Data supplied by William Joy, Fishery Manager, Detroit Lakes

Table 6.- Trapping catch of otter and mink in Minnesota in years 1936-1967^{1/}

Year	Otter	Mink
1936	-	37,977
1937	-	33,098
1938	-	40,262
1939	-	30,512
1940	seasons	50,287
1941	monthly	53,657
1942	closed	34,615
1943	-	50,373
1944	-	79,220
1945	-	95,782
1946	-	110,850
1947	-	43,239
1948	-	66,270
1949	-	61,797
1950	-	37,769
1951	-	30,187
1952	-	52,973
1953	-	55,853
1954	-	65,152
1955	391	56,151
1956	246	47,880
1957	264	41,634
1958	549	56,087
1959	450	42,201
1960	428	44,978
1961	485	31,200
1962	273	55,696
1963	425	46,267
1964	237	40,310
1965	391	42,578
1966	480	37,000
1967	529	33,000

^{1/} Calculated from trapper report cards.