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A summary of experiments in Michigan lakes on the elimination of fish populations with rotenone, 1934-1942[1]

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Abstract

During the period 1934-42, 32 lakes in Michigan were treated with rotenone to remove or reduce unwanted fish populations, and an attempt to recover the entire fish population was made on 18 of them. The majority of these lakes were not supporting a desirable or normally-growing fish population at the time they were treated. They were mostly small, all less than 22 acres, and included lakes whose waters ranged from very soft to very hard, from acid to alkaline, from shallow to very deep.

In productivity, as measured by the standing crop of fish recovered, these lakes ranged from 10 to 194.5 pounds per acre. The lakes averaged 58.5 pounds of fish per acre of which 18.2 pounds were legal-sized game fish.

The hard-water lakes were, in general, more productive than the soft-water lakes and the warm-water lakes more productive than the trout lakes.

For centuries, natives of tropical regions have employed drugs of vegetable origin to kill or stun fish. Of comparatively recent origin, however, is the discovery that rotenone and other similar components of derris and cubé roots constitute valuable management tools for the elimination of undesirable fish populations in inland waters. So far as can be determined by the writer the first such application of these drugs was made by the Michigan Conservation Department's Institute for Fisheries Research on July 17 and 23, 1934, when two small ponds on the estate of W. O. Briggs at Birmingham, Michigan, were treated for the removal of a heavy carp population. Lacking any precedent for determining concentrations required, these pioneer workers used relatively weak concentrations of between 0.04 and 0.09 p.p.m. of rotenone. Many fish were killed, but some survived the poisoning in both ponds. Later investigations (Leonard, 1939, and others) have shown that a concentration of at least 0.5 p.p.m. of derris or cubé root of 5 percent rotenone content is required to insure a complete kill, and Brown and Ball (1942) have shown that this concentration is ineffective in waters below 48 degrees Fahrenheit.

Since the first experimental use of rotenone, 32 lakes in Michigan have been treated to remove or reduce the fish population.

It is the purpose of this report to set forth, in tabular form, the data that have been gathered during the period 1934 to 1942 on Michigan lakes treated with rotenone. Treatments of some of these lakes have been the subject of formal reports (Eschmeyer, 1937, 1938a, 1938b, 1938c, 1939;

Leonard, 1939; Greenbank, 1941; Beckman, 1941; Brown and Ball, 1943a, 1943b; Krumholz, 1944). Others have been recorded only as reports to the Michigan Department of Conservation, and still others are first recorded here.

No attempt has been made to break the material down into detailed analyses of growth rates and size and age groups within the species composition. That these waters are not, as a group, typical of the inland lakes of Michigan is evidenced by the fact that most of them were treated with rotenone to eliminate the population present so that a different and presumably better one could be introduced. Four of the lakes were treated for other reasons: Walsh Lake was poisoned to eliminate a population of fish which, although growing well, was so heavily parasitized as to be unappetizing; Howe Lake had a normally growing population but removal of the carp appeared desirable; Third Sister Lake and Deep Lake were treated as part of long-range experimental programs.

Of the 32 lakes subjected to rotenone treatment, only 18 have been recorded as having a complete kill and subsequent recovery of the entire population. In many of the lakes treated it was not feasible to attempt collection of the dead fish due to the physiography of the lake shore and bottom. Named in Table 1 are the lakes which have been poisoned, together with their location, size, and total weight and number of each fish species recovered. Not included here are nine lakes on which no effort to recover fish was made, or at most only a partial recovery was attempted.

Table 2 contains a summary of lakes in which a complete, or nearly complete, kill was made. For these lakes the area, depth, pH, methyl-orange alkalinity, presence or absence of thermocline, total weight, and

Table 1.--Number and weight of fish according to species recovered from Michigan lakes treated with rotenone. Upper figure in species column is number of fish and lower figure is weight in pounds of fish recovered.

Name of lake	County	Area (acres)	Date of poisoning	Total pounds of fish	Total number of fish	Black bass[1]	Rock bass	Bluegill	Pumpkinseeds	Yellow perch	Trout[2]	Minnows	Other fish[3]	Number per acre and pounds per acre
South Twin[4]	Otsego	4.3	9/20/34	...	...	...	...	...	...	4,118	...	...	...	...
				...	...	...	...	...	...	125	...	...	...	...
Ford	Otsego	10.7	9/9/36	521	41,703	...	...	...	...	4,836	27	36,840	...	3,564
						...	...	...	...	353	7	161	...	44
Clear[5]	Alcona	11.3	8/26/37	2,197	25,147	...	...	2,695	10,106	...	...	5,143	7,203	2,225
						...	...	56	452	...	...	24	1,863	195
Booth	Otsego	16.0	9/6/37	349	20,192	...	1,233	...	...	4,827	...	14,054	78	1,262
						...	53	...	...	146	...	63	86	22
Howe	Crawford	13.4	9/7/37	509	23,528	18759	...	...	775	283	...	1,118	50	1,755
						155	...	...	27	14	...	6	313	38
Walsh[4]	Washtenaw	10.2	4/25/38	943	6,267	484	...	3,271	300	144	...	837	1,231	614
						154	...	579	30	21	...	7	152	92
Pike Number 4	Oscoda	4.6	8/6/39	204	13,368	371	663	...	1,514	7,543	...	3,131	146	2,904
						22	16	...	30	65	...	9	62	44
O'Brien[4]	Alcona	10.4	8/9/39	282	31,643	2	1,013	...	1,556	2,264	2-	26,399	407	3,043
						2	39	...	13	12	11	64	141	27
Pond Number 4	Otsego	1.6	8/15/39	181	3,336	173	688	...	4	241	5	1,984	271	210
						13	42	...	0	29	2	25	70	113
Fitzek[4]	Otsego	6.2	8/15/39	119	5,716	147	632	...	...	398	12	4,487	40	921
						26	37	...	...	28	1	16	12	19
Airport	Marquette	6.8	8/20/40	97	1,281	...	...	...	...	1,232	49	...	...	188
						...	...	...	...	92	5	...	...	15
Linnbeck[6]	Menominee	5.1	9/11/40	146	22,521	29	24	...	1,142	3,000	...	18,118	208	4,416
						1	6	...	13	34	...	64	28	29
Swanzy	Marquette	20.3	9/11/40	630	10,588	241	...	319	...	8,756	...	1,272	...	521
						67	...	41	...	495	...	28	...	31
Third Sister	Washtenaw	10.0	5/6/41	867	15,454	470	...	4,057	610	...	...	8,443	1,874	1,545
						127	...	537	29	...	...	30	144	87
DeBruin's	Kalamazoo	.8	5/27/41	241	9,755	...	...	...	4,200	...	...	400	5,155	1,219
						...	...	...	65	...	...	3	173	301
Twin	Marquette	21.5	7/23/41	215	7,699	109	...	...	...	6,600	...	990	...	358
						70	...	...	...	123	...	22	...	10
East Fish	Montmorency	13.5	8/25/41	405	7,693	...	...	...	...	5,237	160	1,683	613	566
						...	...	...	...	253	15	30	108	30
North Basin Twin	Oscoda	7.8	8/29/41	539	9,224	164	...	7,672	281	...	...	[7]985	122	1,183
						43	...	446	23	...	...	6	21	69
Kimes Number 3	Newaygo	6.8	9/5/41	934	35,202	774	...	7,949	...	847	...	24,685	1,560	5,176
						129	...	472	...	48	...	33	253	137
Holland	Luce	5.3	9/10/41	435	...	...	...	...	2,491	1	86	no count	552	no total
					...	...	...	...	78	0	6	147	204	82
Deep	Oakland	14.8	9/12/41	563	27,329	785	585	16,059	5,935	817	...	...	3,144	1,847
						106	23	256	69	20	...	...	89	38
Burke	Clinton	1.8	9/1/42	108	1,038	201	...	354	73	2	...	...	408	577
						17	...	39	4	0	...	...	45	60

[1] Largemouth and smallmouth black bass
[2] Brook, brown, and rainbow trout
[3] Carp, goldfish, green sunfish, chub sucker, bullhead
[4] Incomplete kill
[5] Weights based on random sample
[6] Pick-up not complete--probably all legal-sized fish recovered
[7] Fry and minnows

Table 2.--A summary of limnological data and recovery of fish from Michigan lakes in which a complete kill and recovery was obtained.

Name of lake	County	Area (acres)	Maximum depth (feet)	pH	Methyl orange alkalinity	Depth of thermo-cline (feet)	Type of lake	Total fish per acre		Legal-sized game fish per acre	
								Number	Weight (pounds)	Number	Weight (pounds)
Ford	Otsego	10.7	33	8.2	127	15-18	Trout	3,897	44.1	85	8.8
Clear	Alcona	11.3	9	Alkaline	165	None	Bass	2,225	194.5	6	0.7
Booth	Otsego	16.0	31	7.9-8.2	125	None	Bass	1,262	21.8	3	0.3
Howe	Crawford	13.4	24	7.5-8.1	51	None	Bass	1,755	38.0	10	7.0
Walsh[1]	Washtenaw	10.2	20	Alkaline	131-145	None	Bass	614	92.4	167	78.9
Pike Number 4	Oscoda	4.6	18	Alkaline	148-157	None	Trout	2,904	44.3	79	14.7
O'Brien	Alcona	10.3	30	Alkaline	162-172	?	Trout	3,043	27.1	6	5.1
Airport	Marquette	6.7	28	5.4-6.2	5	12-21	Trout	188	14.3	99	9.5
Linnbeck	Menominee	5.1	25	7.6-8.4	168-211	9-15	Trout	4,416	28.5	20	5.2
Swanzy	Marquette	20.4	45	6.8-7.4	15-24	15-27	Trout	522	31.0	67	11.1
Third Sister	Washtenaw	10.0	60	6.8-7.6	85-95	12-18	Bass	1,545	86.7	170	69.6
Twin	Marquette	21.9	90	5.6-6.8	5	12-30	Trout	358	10.0	19	2.4
East Fish	Montmorency	13.5	42	7.8-8.0	190-202	15-30	Trout	565	30.0	36	4.0
North Basin Twin	Oscoda	7.8	60	7.0-8.4	66-76	15-24	Trout	1,183	69.1	42	9.9
Kimes Number 3	Newaygo	6.8	18	8.1-8.6	170	None	Trout	5,176	137.3	254	57.0
Holland	Luce	5.3	22	7.2-7.4	18-23	15-22	Trout	...	82.0	[2]0	[2]0
Deep	Oakland	14.8	61	6.8-8.4	78-108	15-27	Trout	1,847	38.0	58	21.2
Burke	Clinton	1.8	39	6.8-8.5	175-240	15-25	Trout	1,038	60.1	104	22.9

[1] Not a complete kill

[2] Only two legal fish in lake

number of fish recovered per acre, and number and weight of legal game fish per acre are recorded. Included are representatives of nearly every type of lake found in Michigan with the exception of the large lake trout-cisco lakes. They vary in size from less than 1 acre to 26 acres; in depth from 9 to 90 feet; the pH range is from acid to quite alkaline; the methyl-orange alkalinity range is wide, from 5 to 240 p.p.m.; geographically they are spread from southern Michigan to the northern part of the Upper Peninsula. In productivity as measured by the standing crop of fish recovered they range from 10 to 194.5 pounds per acre.

The total number of fish and number per acre as recorded in Tables 1 and 2 probably have little significance as it was not possible, in many lakes, to recover the entire minnow population. It is very possible that a large proportion of the young-of-the-year fish were not recovered, as the first year fish disintegrated in some lakes within a very short time following death. These age-groups would have a considerable effect upon the total numbers of fish but relatively little on the total weight.

In Table 3, the lakes for which a complete, or nearly complete, kill is recorded have been arranged according to hardness of the water. Three divisions have been made: <u>Soft</u> (below 50 p.p.m. methyl-orange alkalinity); and <u>hard</u> (above 150 p.p.m. methyl-orange alkalinity). On this basis there appears to be a direct correlation between low alkalinity and low fish production. The lakes listed as hard-water lakes have an average poundage per acre than is higher than for either of the other groups. There is, however, considerable individual variation in productivity of the lakes in all categories, and other factors that were not considered in these studies may well influence the data.

Table 3.--Lakes in which complete recovery of poisoned fish was attempted, arranged according to hardness of water.

Name of lake, county and region	Area (acres)	Methyl orange alkalinity	Type of lake (fish)	Pounds per acre
Soft-water lakes--methyl orange alkalinity 50 Grand average pounds of fish per acre, 28.0				
Airport, Marquette, I	6.8	5	Trout	14.5
Swanzy, Marquette, I	20.4	15-24	Trout	31.0
Witch Twin, Marquette, I	21.5	5	Trout	10.0
Holland, Luce, I	5.3	18-23	Trout	82.0
Howe, Crawford, II	13.4	44-51	Bass	38.0
Intermediate lakes--methyl orange alkalinity 50-150 Grand average pounds of fish per acre, 53.6				
North Basin Twin, Oscoda, II	7.8	66-76	Trout	69.1
Third Sister, Washtenaw, III	10.0	88-90	Bass	86.7
Deep, Oakland, III	14.8	78-108	Trout	38.0
Ford, Otsego, II	10.7	127	Trout	44.1
Booth, Otsego, II	16.0	125	Bass	21.8
Walsh, Washtenaw, III	10.2	131-145	Bass	92.4

The region in which each lake is located is recorded in the table to show its general geographical location. These regions are operational divisions of the Fish Division of the Conservation Department and are located as shown on the accompanying map, Figure 1.

The lakes were divided into two categories, "trout" and "bass," on the basis of their ability to support trout or only warm-water fish. Third Sister Lake, here classified as a "bass" lake, is actually a marginal trout lake. A comparison of productivity of the 18 lakes on this basis, shown in Table 4, indicates that the "bass" lakes are considerably more productive than the "trout" lakes.

Because of the long period covered by this report and the fact that the data were collected and recorded by several workers in a non-uniform manner, no definite comparisons and conclusions can be drawn, but the data do show the very considerable differences in productivity of fish, measured by the recovery of fish following poisoning, found in the smaller lakes of the state, and that no one index of productivity, as measured on these lakes, appears to point to the reason for the differences.

To briefly summarize the data: The average size of the lakes having a complete pick-up was 10.6 acres; the lakes averaged 58.5 pounds of fish per acre of which 18.2 pounds were legal-sized game fish. The average total number of fish in the lakes is not believed to be a reliable figure due to difficulties of recovering small fish and minnows, but the average of 68 legal game fish per acre is probably a close approximation of the legal-size fish population.

When considering the total fish production of these lakes it is well to note that the counts and weights were made on recovered fish and definite evidence is lacking that would determine whether all, or only part,

Figure 1.--Map showing location of lakes treated with rotenone, 1934-1942.

Table 4.--Comparison of total pounds and pounds of legal-sized fish per acre in "bass-and trout-type" lakes.

Type of lake	Total pounds of fish per acre	Pounds of legal-sized fish per acre
Trout	47.7	13.2
Bass	81.3	31.3

of the fish killed were recovered. It is possible that some of the fish may go to the bottom in deep water and never be recovered.

Twelve of the lakes listed as having a complete kill were trout lakes and six were warm-water lakes. Following removal of their undesirable populations, the 12 lakes were planted with trout from state fish hatcheries and the use of live minnows as bait prohibited. To date, six of these are known to have been repopulated with warm-water fish, three contain only trout, and the records are not complete for three. Ineffective barrier dams on outlets, incomplete poisoning or release of unused bait may explain repopulation.

The fact that half of the lakes that were to be managed for trout only have warm-water species present, and the evidence that in many of the other lakes undesirable species have been introduced, points out that in the rehabilitation of lakes the job is only partly completed when the unwanted population has been removed. Considerable effort will have to be made in the future to safeguard against the introduction of unwanted species if the removal of fish is to be a worth while and economical undertaking.

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