Some Results of the Partial Fish Population Removal Technique in Lake Management[1]

ROBERT M. JENKINS, Oklahoma Fishery Research Laboratory, Norman

Increased knowledge of the composition of fish populations in Oklahoma lakes and wider public acceptance of the use of fish poisons has fostered new and varied techniques in fishery management. Recent procedures involving the use of rotenone, a chemical toxic to fish, have included 1) sampling of limited areas in large lakes for inventory purposes; 2) complete fish eradication in ponds and small lakes; 3) selective kill of gizzard shad and carp in lakes up to 6,000 acres; and 4) partial removal of the fish population in lakes under 400 acres.

The removal of 80 to 95 percent of the fish from a body of water where fishing is poor, and where it has been determined that the fishes are of small average size, slow-growing, and crowded, has become an important management practice (5). By drastically thinning the numbers of fish, it is anticipated that growth will accelerate and activity patterns typical of expanding populations will develop and enhance angling opportunities. In theory, maximum harvestable crops of fish may be expected on a sustained basis only from communities of a successional type rather than from a climax type, and the desired process of succession can be initiated by reducing the standing crop to a point well below the carrying capacity of the environment. The partial removal of fish (reduction of the standing crop) as a management procedure is based on this hypothesis and has been employed in lakes throughout the State since 1953 by the Oklahoma Game and Fish Department. The results from 4 out of approximately 50 lakes so treated are presented briefly, although sufficent time had not elapsed in some instances to fully evaluate the effects of this remedial step before complicating factors interrupted the process of succession. The lakes discussed are all located in Carter County, and the management and much of the field work was under the supervision of Clay Wilson, Jr., fishery biologist, Southwest District.

Franklin Pond

On June 16, 1954, a 2.1-acre pond located near Ardmore was partially treated with emulsifiable rotenone, and about 90 percent of the fish population was killed. Details of the field operation and findings have been reported previously (2). Bluegill and warmouth survived and reproduced immediately following poisoning as determined by seine hauls in August, and 300 fingerling largemouth bass were stocked in November, 1954. An estimate of the population was obtained two years following partial poisoning by the short period simultaneous mark and recapture method using 1-inch mesh wire traps (Table I). Due to a prolonged drought, the pond was reduced to 0.75 acres at the time of the trapping, April 14-May 22, 1956. Trapping was very successful, and yielded highly reliable estimates of all fish over 4 inches in length.

A comparison of the standing crop before (357 pounds per acre) and two years following partial removal (346 pounds per acre) (Table I) indicates population expansion was rapid and that the potential carrying capacity of the pond had been regained. The most striking change was the ascendancy of warmouth over pre-partial removal conditions, increasing from 26 to 540 per acre in numbers, and 3 to 120 pounds per acre in weight. Bluegill numbers were reduced by 67 percent, and the weight by 43 percent. The gain by warmouth at the apparent expense of bluegill following treatment has been noted at two similar operations, and represents one of the most significant changes wrought by this technique. Largemouth

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bass were reduced in number by 61 percent, but the standing crop increased by 5 pounds to 41 pounds per acre. White crappie had not reproduced and were doomed to extinction. All species showed an increase in condition and average weight accompanied by an overall reduction in numbers of 53 percent (Table I). Growth-rates had increased greatly; for example age-group II warmouth averaged 6.5 inches, compared to 4.3 inches previously, and age-group II bluegill averaged 6.8 inches, compared to 6.3 inches in 1954. Two-year-old bass averaged 12.6 inches compared to a pre-removal 9.1-inch average.

The total number and weight of desirable-size bluegill decreased following treatment, but warmouth and largemouth bass increased markedly (Table II), resulting in a greater availability of fish which the angler prefers. A creel census was not conducted, but field personnel who fished the pond reported a much higher rate of catch following treatment, especially of warmouth and bass. Partial population removal and stocking with bass was considered to have been successful in this experiment. The pond became dry in October, 1956, and the sediment which had accumulated over a 45-year period was removed by bulldozer.

South Rod and Gun Lake

As an experimental management procedure, South Rod and Gun Lake was partially treated with rotenone on June 12, 1955, following reports of poor fishing and an estimate of the population which indicated very high numbers of gizzard shad and bluegill. The methods and findings of this operation have been published previously (3). Trapping and seining following application of a rotenone concentration of approximately 0.5 ppm. to the entire lake (16.3 acres) revealed that about 5 percent of the total population survived (Table III). In order of apparent increasing tolerance to rotenone the species were gizzard shad, carp, largemouth bass, redear sunfish, black crappie, bluegill, white crappie, green sunfish, warmouth, and black bullhead. The first four species were eliminated, and black crappie disappeared within 6 months. Bluegill, green sunfish, warmouth, and black bullhead spawned immediately after poisoning, and about 750 young-of-year white crappie survived treatment. Approximately 2500 fingerling bass and 500 fingerling redear sunfish were stocked on July 1.

Mark and recapture in wire traps in January, 1956, indicated the presence of 3,070 one-year-old bass averaging 7.8 inches (66 pounds per acre), 800 one-year-old redear sunfish averaging 6.0 inches, 735 one-year-old white crappie averaging 6.0 inches, 2,010 black bullheads averaging 7.6 inches (37 pounds per acre), 40 green sunfish averaging 5.7 inches, and 30 warmouth averaging 7.1 inches, for a total standing crop of 122 pounds per acre. The rate of growth had accelerated in all species except bluegill and the condition of all fishes had improved. In fact, a marked increase in plumpness was noted only 10 days after rotenone treatment.

Trapping was resumed in June, 1956, when the lake had dropped to 10 surface acres, and a population estimate obtained by July 9 (Table IV). Bluegill had regained prominence (75 pounds per acre), and were increasing in weight daily. Largemouth bass numbers had dropped from 3,070 to 1,800 (63 pounds per acre), an estimated 600 having been caught by fishermen during the six month period. Angling for bass slowed in midsummer, but increased to a maximum catch-rate of 6 per hour in late September, averaging 0.6 pounds per fish. The total standing crop of 201 pounds per acre one year after partial removal was only 20 percent of the original total, and 41 percent of the original 486 pounds per acre of centrarchids and bullheads (Table IV). The poundage was increasing daily, however, in an environment of dark green "planktonic soup" which reduced transparency to 6-8 inches, (compared to 20 inches prior to treatment) and it is predicted that a standing crop of 500 pounds per acre will be reached within 2 years of treatment. Anglers have been pleased with the greatly increased

bass harvest and robustness of the sunfishes, and the technique has been acclaimed a success by the lake owners. The disappearance of a large percentage of the fish estimated to have survived poisoning (Table III) in one year poses the possibility that greatly accelerated growth induced by increased food and space availability is accompanied by a high mortality rate.

Ardmore City Lake

As a part of the municipal lakes improvement program of the Oklahoma Game and Fish Department, 184-acre Ardmore City Lake was treated with 2550 pounds of powdered rotenone on September 18, 1953, in an effort to kill about 80 percent of the existing fishes. The expansion of the population was studied intensively in the ensuing three years, and findings have been reported in (1) and (4). Estimates established in June, 1954, nine months after partial removal (Table V), indicated an extremely high population of young-of-year carp (63 pounds per acre), a reduced but ample sunfish population, and very few adult crappie, largemouth bass, channel catfish, and gizzard shad. By December the sunfishes had increased to 41 pounds per acre, white and black crappies to a total of 55 pounds per acre, and young-of-year carp to 140 pounds per acre.

Trapping estimates in June, 1955, 21 months after treatment, showed an increase in the carp population to 134,000 (about 200 pounds per acre), a decrease in crappie numbers to 200,000, but a gain in weight to 74 pounds per acre, and a decrease in sunfishes (bluegill, redear sunfish, warmouth, and green sunfish) from 72,000 to 52,000 (Table V). Angling was poor during 1954 and 1955, the catch consisting principally of sunfish and small carp.

A prolonged drought and Ardmore municipal water use reduced Mountain Lake, which feeds into City Lake, to 15 acres, and City Lake to 107 acres by October, 1956. In view of the undesirably high population of carp, it was decided to eradicate the entire fish population in both lakes, and restock with desirable species. On October 3, 1956, three years following partial removal, 210 gallons of Pro-Noxfish (an emulsifiable rotenone product) were applied to Ardmore City Lake, containing 1300 acre-feet of water with a temperature of 73°F., in an effort to obtain a complete fish kill. Pickup and shoreline counts of windrowed fishes were continued for 3 days. Estimates (Table VI) were based on the assumption that 65 percent of the total population floated to the shore during that period—a proportion which has been established as fairly reliable at other lakes by the recovery of marked individuals.

Final estimates indicated a standing crop of 483 pounds per acre, 87 percent of which was represented by gizzard shad and carp. There were only 15 pounds of desirable-size fish per acre, indicating the profound depressing effect of the competition created by the large carp and shad populations. The strong 1954 year-classes of black and white crappie had not grown in length during 1955-6, and the average weight had actually decreased from 0.07 pounds in March, 1955, to 0.05 pounds in October, 1956. Largemouth bass and channel catfish were in surprisingly good condition, but all other species were markedly emaciated. The extremely poor condition of carp and shad points to a condition of severe overcrowding which was intensified by a reduction in water volume of about 40 percent.

It is concluded that partial removal failed to attain the desired results in this instance because of the highly successful spawning of carp and gizzard shad early in the first spring, and the rapid growth of the overwhelming numbers of their offspring which curtailed reproduction and growth of the sport fishes during the next 3 years.

Mountain Lake

Mountain Lake, located 12 miles northwest of Ardmore City Lake and connected to it by a conduit, was treated with powdered rotenone on September 16, 1953, in an attempt to reduce the fish population by about 80 percent. Population estimates were made in July, 1955, when the lake was 130 acres in size, and in September, 1956, when it had been drawn down to 15 acres (Table VII). The estimates indicated a standing crop of only 38 pounds per acre in this clear, rocky, relatively deep impoundment nearly two years after partial removal, but it was not believed that the wire traps had adequately sampled the population. Carp were not nearly as abundant as at Ardmore City Lake, where they reached a standing crop of 200 pounds per acre during the same period of time. Fishing for bass, channel catfish, and sunfish was good to excellent during 1955 and the first half of 1956.

The lake was completely drained on October 12, and all fish were recovered which did not pass through a one-inch mesh wire screen or were lost in the ooze and mud in the bottom. Approximately 8,000 pounds of carp averaging 2.6 pounds were salvaged, representing 61 pounds per acre at normal lake level. About 1200 largemouth and spotted bass averaging 0.5 pounds were rescued and stocked in Ardmore City Lake, along with 150 green sunfish, 125 warmouth, and 100 channel catfish averaging 4.8 pounds.

A comparison of the estimate of population just prior to draining, and numbers actually recovered during draining (Table VII), shows close agreement for bluegill and spotted bass. The trap estimate of largemouth bass was only 45 percent of the actual number recovered, which is typical of the disparity previously noted in estimates of this species (3). The difference in estimate and recovery of green sunfish and warmouth is probably attributable to losses during draining. The wire traps used are incapable of capturing large carp and channel catfish, and estimates of these species were impossible.

Although the effects of extreme drawdown interrupted the processes of succession following partial population removal, the reported good fishing during 1955 indicates that the operation was a temporary success and might have continued had normal lake levels been maintained. The fishes rescued represented a standing crop of 81 pounds per acre at 130 surface acres, 25 percent of which was represented by game and pan species. The desirable species undoubtedly suffered a very high mortality during the drawdown and probably represented a much greater percentage of the total standing crop in 1955. For example, there were approximately 13,000 largemouth bass in the lake in 1955 (assuming that the estimate obtained then included only 45 percent of the actual number), averaging 0.3 pounds, for an approximate standing crop of 30 pounds per acre. Carp reproduction was limited and did not curtail expansion of the game and pan fishes as at Ardmore City Lake, and growth-rates of all surviving species increased over that displayed in pre-treatment years.

Conclusions

Partial removal of the fish population from four lakes in an attempt to improve fishing met with varying degrees of success. Largemouth bass production increased significantly in the 2-acre pond and 16-acre lake. The desired improvement in angling for bass was attained only one year after treatment, and pan fish fishing was augmented within two years. In the two larger lakes, 130 and 180 acres in size, partial removal produced incongruous results. Carp survived and reproduced in the smaller lake, but did not curtail the expansion of bass and other desirable species during the following two years. However, the expansion of carp numbers in the 180-acre lake was explosive and seriously hampered the development of the centrarchid population. The accompanying great numbers of gizzard shad

in the latter undoubtedly contributed also to the suppression of desirable fish (3). This parallel abundance of carp and gizzard shad may indicate some degree of protocooperation between the two species, inasmuch as shad were not present in the 130-acre lake and the standing crop of carp remained relatively low following rotenone treatment.

Results at these four lakes indicate that partial removal of fish in lakes where carp and gizzard shad are not present, or are eliminated, followed immediately by stocking with fingerling bass at the rate of about 150 per acre, can improve fishing for game and pan fishes within two years. If carp and shad are present, it is a risky procedure of unproven value, and should not be recommended until means can be developed to eliminate these undesirable species completely.

The technique of fostering artificial succession in lakes in order to maintain a near constant state of population expansion presents many possibilities to fishery managers working with man-made impoundments. If the rotenone toxicity levels for different species are sufficiently widespread to permit the selective kill of unwanted fishes (as is true of gizzard shad and sunfishes), great strides can be made toward improved fishing. In addition to species toxicity thresholds, much more knowledge is needed concerning the action of rotenone under varying physical and chemical conditions encountered in state waters throughout the year before partial elimination can be wisely and economically employed. Present rotenone costs necessitates an expenditure of approximately one dollar per acre-foot to produce the desired results which might well be cut in half if more were known about the selective action of the poison under various temperatures and alkalinities. Cost will be an important factor as it is probable that the treatment will have to be repeated every 3-5 years.

An obviously more desirable means of maintaining a condition of succession in artificial lakes would be through a very intensive harvest by sport fishermen, but this is an impossibility at present due to the severe limitations imposed on methods of capture by the fishing public. Extensive and costly manipulations of fish populations will probably be in increasing demand so long as these manipulations do not destroy the intangible value of the "trophy" which the angler is seeking.

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TABLE I. Comparison of the fish population in Franklin Pond before and 2 years following removal of about 90 percent of the population and restocking with 300 fingerling largemouth bass.

Species	Number per acre		Pounds per acre		Average weight		Average C(TL)	
	Before	After	Before	After	Before	After	Before	After
Bluegill	3,550	1,160	316	181	0.09	0.16	61	68
Largemouth bass	267	105	36	41	0.14	0.39	40	47
Warmouth	26	540	3	120	0.12	0.22	75	76
White crappie	7	2	2	4	0.29	2.00	42	72
Total	3,850	1,807	357	346				

TABLE II. Comparison of the estimated number and weight of desirable-size fish* in Franklin Pond before and 2 years following removal of about 90 percent of the population and restocking with 300 largemouth bass.

Species	Desireable-size fish							
	Number per acre		Pounds per acre		Average total length		Maximum length	
	Before	After	Before	After	Before	After	Before	After
Bluegill	1420	490	262	126	6.8	7.0	8.1	9.9
Largemouth bass	6	23	6	23	12.2	12.3	21.0	13.4
Warmouth	7	410	2	104	7.2	6.8	7.9	8.9
White crappie	2	2	1	4	10.6	13.3	12.1	13.4
Total	1435	925	271	257				

* Bluegill and warmouth 6 inches or more in length, crappie 8 inches or more, and largemouth bass 10 inches or more.

TABLE III. Estimated number of fish which survived poisoning of South Rod and Gun Lake on June 12, 1955, and were alive on July 9, 1956.

Species	Number surviving	
	June 30, 1955	July 9, 1956
Gizzard shad	0	0
Bluegill	2,275	60
Black crappie	160	0
White crappie	1,920	750
Redear sunfish	0	0
Largemouth bass	0	0
Warmouth	330	75
Green sunfish	3	20
Carp	0	0
Black bullhead	2	1
Total	4,690	906
Percent surviving	4.57	0.88

TABLE IV. Comparison of the estimated fish population in South Rod and Gun Lake before, and 1 year following, removal of 95 percent of the population and restocking with approximately 2500 fingerling bass and 500 fingerling redear sunfish.

Species	Number per acre		Pounds per acre		Average weight		Average C(TL)	
	Before	After	Before	After	Before	After	Before	After
Gizzard shad	3,000	0	513	0				
Bluegill	2,330	835	366	75	0.16	0.09	64	64
Black crappie	250	0	44	0				
White crappie	480	45	42	9	0.09	0.20	46	49
Redear sunfish	90	70	21	20	0.31	0.28	65	65
Largemouth bass	80	180	27	63	0.34	0.35	42	47
Warmouth	30	18	4	3	0.21	0.19	62	76
Green sunfish	20	36	2	3	0.10	0.08	60	61
Carp	5	0	21	0	3.72		60	
Black bullhead	1	30*	3	28*	3.00	0.90	64	60
Total	6,286	1,214	1,043	201				

* After removal of 125 (30 pounds) per acre by traps.

TABLE V. Estimated number of fish in Ardmore City Lake on various dates between rotenone treatments on Sept. 18, 1953, and October 3, 1956, established by the simultaneous mark and recapture method using wire traps.

Species	Estimated population of fish over 4 inches in length				
	July 1, '54	Jan. 1, '55	July 1, '5[illegible]	Mar. 1, '56	Oct. 3, '56
Gizzard shad	.....	.....	.....	.....	365,000
Carp	59,000	.....	134,000	.....	85,000
Crappie	.....	263,000	200,000	98,000	70,000
Bluegill	5,600	50,000	31,000	.....	24,000
Largemouth bass	.....	330	470	.....	3,000
Redear sunfish	2,250	.....	6,000	.....	1,300
Black bullhead	.....	2,900	1,600	1,900	1,200
Warmouth	1,220	11,700	8,000	.....	970
Green sunfish	2,440	7,670	6,500	.....	520
Channel catfish	.....	.....	.....	.....	370

TABLE VI. Estimated number of fish windrowed and number killed (assuming 65% appeared) following rotenone treatment of 107-acre Ardmore City Lake on October 3, 1956.

SPECIES	Estimated number windrowed	Number killed, assuming 65% appeared	Pounds per acre	Average weight (pounds)	Average total length (inches)	Desirable size-fish (pounds per acre)
Gizzard shad	237,000	365,000	215	0.063	5.9	
Carp	55,000	85,000	206	0.400	9.9	
Crappie*	45,000	70,000	33	0.051	5.5	**
Bluegill	16,000	24,000	9	0.040	4.2	**
Largemouth bass	2,000	3,000	13	0.450	8.0	10
Redear sunfish	850	1,300	**	0.035	4.1	**
Black bullhead	800	1,200	2	0.200	8.5	**
Warmouth	600	970	1	0.116	5.4	**
Green sunfish	300	520	**	0.093	4.9	**
Channel catfish	250	370	3	0.738	12.0	3
Total	357,800	551,360	483			15

* Black crappie, 70%; white crappie, 30%.
** less than 1 pound.

TABLE VII. The estimated fish population in Mountain Lake as established by mark and recapture in wire traps July 8, 1955 and October 5, 1956 and recovery during draining, October 12, 1956.

SPECIES	ESTIMATED POPULATION			POUNDS PER ACRE		
	July 8, 1955 130 acres	October 5, 1956 15 acres	October 12, 1956 10 acres	July 8, 1955 130 acres	October 5, 1956 15 acres	October 12, 1956 10 acres
Bluegill	12,700	9,700	10,000	17	87	136
Largemouth bass	5,900	360	800	12	14	46
Spotted bass	1,800	375	400	4	9	14
Green sunfish	1,670	850	150	4	8	2
Warmouth	36	1,430	125		15	1
Longear sunfish	700			1		
Redear sunfish	2	1+	50			1
Bullheads	11		2			
Carp	4	7+	3,050		1	800
Blue sucker	1	0	8			1
Black crappie	1	0	1			
Channel catfish		5+	123			59
River carpsucker		2	2			
Black buffalo		3	3			
Total	22,824	12,733	14,714	38	134	1,060