Fish Population Estimates in Crystal Lake, Cleveland County, Oklahoma[1]

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Crystal Lake is a 26-acre clear-water lake in Cleveland County located at the northern perimeter of the city limits of Norman, Oklahoma. The lake has provided fishing for people of the Norman area for many years. An amicable relationship which existed between the lake owner, Mr. I. A. Tull, and the Oklahoma Fishery Research Laboratory personnel provided the opportunity to establish the continuing program of experimental fish management which began in January 1957.

The initial work plan for the lake included the eradication of the existing fish population, by the use of rotenone, followed by restocking with hatchery-reared fish. An evaluation of results of the species combination and stocking ratio was to be made in the course of conducting population estimates.

Methods and Materials

On February 21, 1957 the lake was treated with rotenone until all fish were presumed dead. In April of the same year 1,500 largemouth bass, 2,000 channel catfish, 2,000 redear sunfish and 500 warmouth were planted in the lake by the Oklahoma Department of Wildlife Conservation. All were immature fish. On May 6, 1958 an additional 1,350 bass were added and again on May 9, 160 more were placed in the lake.

The first population estimate was based on 315 traps lifts over a period of 66 trapping days extending from October 14 to December 19, 1957 during which 1,597 fish were marked and released. The second estimate, conducted from April 24 to May 15, 1958, was based on 21 days of trapping and 97 trap lifts resulting in 1,910 fish marked and returned to the water.

Cylindrical wire traps six feet long and three feet in diameter with throats on each end and constructed of a steel frame covered with one-inch-mesh poultry wire were the principal gear used for capturing fish. In addition one trap net constructed according to Crowe (1950) and utilizing nylon webbing of ½-, 1-and 1½-inch square mesh, was also used in both estimates.

The estimates were based upon continuous capture, mark, release and recapture. Clipping the upper lobe of the caudal fin served as a means of identifying fish recaptured in the earlier estimate while right pectoral fins or, for the catfish, right pelvic fins were removed during the springtime estimate. Complete daily records were kept of numbers of marked and unmarked fish captured, fishes dead or otherwise removed, and length measurements. Scale samples and sample weight measurements were also taken.

Population Estimates

The species combination of the fish stocked in Crystal Lake was chosen as a result of the suggestion by Jenkins (1957) when he stated that these four species (largemouth bass, channel catfish, redear and warmouth) pro-

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duced more harvestable-size fish in ponds in comparison with their total standing crop than any of the other fishes. It had been planned that such a planting could be evaluated through this study. It was, therefore, most displeasing to find that, when trapping began in the fall, bluegill, green sunfish and black bullhead catfish were present and had already become established as common and important species in the lake.

The population estimates were calculated by two methods. One method used was that of Schnabel (1938) which is expressed by the equation $\hat{P} = \frac{\Sigma (AB)}{\Sigma C}$ and the second was that of Schumacher and Eschmeyer (1943) expressed by the equation $\hat{P} = \frac{\Sigma (AB^2)}{\Sigma BC}$ in which P is the estimated population, A is the number of fish captured on any day, B is the number of marked fish present in the lake on that date and C is the number of recaptured fish.

Estimation of populations of largemouth bass, redear sunfish, warmouth and black bullhead catfish were calculated by both methods for each period. Too few channel catfish were captured in either period to permit estimation of the population. The same condition was encountered with hybrid sunfish in the fall period (Tables I and II). Based upon a comparison of the two formulas by Ricker (1945, 1948) wherein he stated that the Schnabel equation is at its maximum efficiency when B/P approaches zero, the Schumacher and Eschmeyer formula is most efficient when it is equal to 0.5 and that they are of equal efficiency at 0.25. The most acceptable estimate was chosen. Standard errors were calculated for the Schumacher and Eschmeyer estimates. Both methods yielded estimates that were in rather close agreement. The only conspicuous differences were those of 247 for redear and 320 for bullheads, during the fall estimate, and 151 for bullheads in the springtime estimate.

All estimates are limited only to fishes large enough to be incapable of escaping through the meshes of the traps.

Assuming that the marked fish would redistribute themselves randomly about the lake, all were released at a single point which was remote from all trap locations. No significant differences were apparent between

Table I. Fish Population Estimates of Crystal Lake by the Schnabel and the Schumacher and Eschmeyer Methods in the Period October 14 to December 10, 1957.

Species	Fish Marked	Fish Recaptured	$\hat{P}_1$ Schnabel	$\hat{P}_2$ Schumacher Eschmeyer	Standard Errors of $\hat{P}_2$	$\frac{B}{\hat{P}}$
Largemouth bass	218	61	510	507	148	.43
Redear	813	135	2847	2600	239	.31
Bluegill	73	9	337	258	74	.22
Green sunfish	87	19	257	251	142	.34
Warmouth	72	9	312	387	95	.23
Black bullhead	334	65	1094	1314	292	.25
Total	1597	298	5357	5317		

Table II. Fish population Estimates of Crystal Lake by the Schnabel and the Schumacher and Eschmeyer Methods in the Period April 24 to May 15, 1958.

Species	Fish Marked	Fish Recaptured	$\hat{P}_1$ Schnabel	$\hat{P}_2$ Schumacher Eschmeyer	Standard Error of $\hat{P}_2$	$\hat{B}/P$
Largemouth bass	134	31	390	351	31	.38
Redear	1059	528	1823	1811	77	.58
Bluegill	203	25	1023	1007	151	.20
Green sunfish	245	124	398	400	26	.61
Warmouth	108	24	331	324	26	.33
Black bullhead	108	8	900	749	141	.12
Hybrid sunfish	53	27	93	86	10	.62
Total	1910	767	4958	4728		

the number of recaptures occurring in traps nearest the point of release and those in the most remote locations. The short period of marking was presumed to have minimized any error due to recruitment, mortality and regeneration of fins.

Choice of the dates for the estimates were made, assuming that little or no growth would occur in the intervening period, thereby eliminating differences due to recruitment, and that comparisons drawn between each estimate would reveal the extent of wintertime mortality.

Largemouth bass winter losses could not be shown since the springtime estimate was invalidated when additional fish were stocked during the marking period.

The redear sunfish population was estimated at 2,600 in the fall and 1,811 in the spring. Reference to length frequency distribution gave no indication of recruitment and the reduction of the fall population by 30 percent is attributed to winter mortality.

Table III. Summary of Fish Population Studies in Crystal Lake, October 14 to December 1957.

Species	Length range inches	Average T.L. inches	Average weight pounds	$\hat{P}$	Fish per Acre	Pounds per Acre	Percent desirable size
Largemouth bass	6.0- 8.0	6.9	0.148	170	7	0.97	
	8.7-14.5	10.4	0.556	337	13	7.21	
Total				507	20	8.28	53
Redear	3.6-10.5	6.6	0.193	2,600	100	19.30	89
Bluegill	3.4- 4.7	4.3	0.043	124	5	0.20	
	5.4- 7.2	6.3	0.174	213	8	1.42	
Total				337	13	1.62	31
Green sunfish	5.6- 7.8	6.6	0.176	251	10	1.70	88
Warmouth	5.9- 7.6	6.8	0.241	312	12	2.89	97
Black bullhead	7.4-15.5	10.4	0.602	1,314	50	30.42	98
Grand Total				5,321	205	64.21	

Table IV. Summary of Fish Population Studies in Crystal Lake, April 24 to May 15, 1958.

Species	Length range inches	Average T.L. inches	Average weight pounds	A P	Fish per Acre	Pounds per Acre	Percent desirable size
Largemouth bass	4.6- 8.0	6.9	0.149	147	6	0.84	
	8.9-12.9	10.2	0.519	204	8	4.07	
Total				351	14	4.91	37
Redear	3.9-10.4	6.6	0.213	1,811	70	14.83	95
Bluegill	2.9- 3.5	3.2	0.018	19	1	0.01	
	3.8- 5.5	4.7	0.100	872	33	3.35	
	5.9- 7.4	6.6	0.207	132	5	1.05	
Total				1,023	39	4.41	15
Green sunfish	3.4- 8.5	6.4	0.200	400	15	3.08	90
Warmouth	6.1- 8.2	7.1	0.284	324	12	3.54	100
Black bullhead	7.7-14.6	9.9	0.640	900	35	2.15	98
Hybrid sunfish	4-4- 4.7	4.6	0.070	6	*t	0.01	
	5.7- 8.6	7.3	0.284	80	3	0.87	
Total				86	3	0.88	89
Grand Total				4,895	188	53.80	

*t Less than 1

The increased estimate of bluegills in the spring, which rose from the 337 fall estimate to 1,023, appears to have resulted from recruitment. A totally new length group of fish appeared in the later sample which greatly increased the estimate of smaller fish. The larger fish remained in a distinct length group which exhibited a 38 percent decrease, falling from 213 to 132 over the winter period. Without assigning any of the difference to sampling error this appears to estimate the winter mortality in the group.

Green sunfish evidently experienced some recruitment since the comparison of estimates revealed an increase from fall to spring, increasing from 251 to 400. A number of smaller fish had been captured in the later estimate but could not clearly be separated from the entire sample.

While some growth had occurred in warmouth in the period between the estimates, no evidence of recruitment was seen in the distribution of lengths. The difference between the two estimates was so small it could not realistically be considered apart from the sampling error.

The black bullhead catfish estimate decreased from 1,314 in the fall to 900 in the spring. No evidence of recruitment was seen and the 31.5 percent loss was, therefore, attributed to mortality.

An estimate of the standing crop during the fall of 1957 was 205 fish per acre and 64.2 pounds per acre. Comparison of the fall and spring estimates, exclusive of bass, reveals a lower standing crop following the winter period, decreasing from 185 to 174 fish per acre and 55.93 to 48.89 pounds per acre. Based upon an arbitrary choice for desirable sizes of 10 inches for bass, 6 inches for sunfishes and 8 inches for bullheads it was evident that, within one growing season, a very large portion of the population had reached a harvestable size (Tables III and IV).

Conclusions

The manner in which unwanted species became re-established in Crystal Lake, following the rotenone treatment, has not been determined. However, it was assumed that, in spite of the application of amounts greatly in excess of that normally prescribed, certain species survived. Evaluation of the species combination and stocking ratio has been obviated by the event. However, plans for succeeding studies include removing all fish not included in the four species originally stocked. It is hoped that this may yet provide a basis for such an evaluation.

The two indirect methods of determining fish population sizes both yielded reasonable estimates either of which would be acceptable in formulating a management plan. It appears that the Schnabel method is most applicable to large populations where the ratio of marked fish to the estimate of the population will remain small, whereas the Schumacher and Eschmeyer method would perform better in smaller populations. When removals are made in future studies a third method based on declining catch per unit of effort will be used.

The mortality rates established for redear, bluegills and black bullheads were attributed to natural causes alone since no angling had been permitted. Providing an effective creel census is maintained, when the lake is eventually opened to fishing, future studies will consider methods of establishing annual mortality rates from both angling and natural causes. These data imply that approximately one-third of the populations of these species succumbed to natural causes during the winter of 1957-58.

The expected vigorous growth by the new population was verified by average lengths attained during the first year. While no evidence of reproduction was seen in the species stocked, it is anticipated that the standing crop will surpass the 64.21 pounds per acre attained in the first year and approach the average of 341 pounds seen in 42 Oklahoma ponds by Jenkins (1957). Evidently more than one year is required for this level to be reached.

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