The Effect of Homing on Channel Catfish Population Estimates in Large Reservoirs[1]

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The number of reservoirs in Oklahoma has continued to increase. Some 32 already are completed, others are in various stages of construction while still more are planned. Where fishery management was once mainly concerned with farm ponds, streams and small municipal reservoirs, it is now turning toward the more complex problems of large impoundments. Any past efforts to define and solve these problems have generally been based upon conclusions reached through study of relatively scant data. The adoption of expensive, large-scale management programs have been difficult to justify on these grounds.

There is an urgent need for more precise knowledge regarding size and structure of fish populations in Oklahoma's large impoundments. Efforts to initiate radical management programs for reservoirs at this time must necessarily proceed with some caution because of the uncertainties of interpreting relatively small sample data to evaluate results. Fish population sampling by the use of rotenone has been the only method which has offered reasonably reliable information with regard to population structure, and any further projection of these data to estimate population size for reservoirs is viewed with some apprehension.

The indirect methods of estimating population size by mark-and-recapture as presented by Schnabel (1938) and Schumacher and Eschmeyer (1943) have been applied to many Oklahoma ponds and small lakes (Jenkins, 1955, 1956 and 1958), (Houser, 1957). These techniques have generally given satisfactory results. While a certain amount of error apparently cannot be eliminated in this type of estimate, it usually can be restricted to some acceptable limit for work in smaller bodies of water. Homing is one source of error which may be encountered and if not compensated for can introduce a serious bias. This type of bias can be effec-

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tively eliminated by using randomly chosen daily trapping stations in the manner suggested by Cooper (1952).

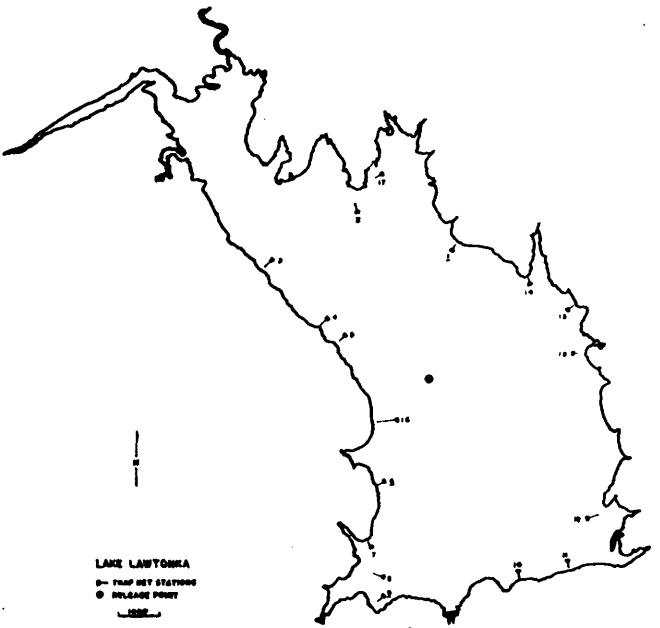

Figure 1. Map of Lake Lawtonka.

Selectivity of the gear is also a source of error for which one cannot fully compensate. Latta (1959) demonstrated that in addition to selection by mesh size, trap nets are also selective for larger fish. He points out that estimates of population size not based on size classes are too small. Based upon this conclusion he presented a method for calculating an estimate by individual size classes.

Since knowledge of population size has been shown to be of utmost importance in managing smaller bodies of water, it was considered that similar knowledge would also be required for larger lakes. With full realization that any attempt to conduct mark-and-recapture estimates on these large reservoirs would present many new problems that could not be anticipated. Such a project was undertaken during the summer of 1958 by workers at the Oklahoma Fishery Research Laboratory. The problems encountered were many, and detailed discussion will be reserved for later presentation; however, an outstanding discrepancy arising from what was apparently homing behavior in channel catfish will be considered here.

A second estimate was attempted on Lake Lawtonka in the summer of 1959 in which channel catfish were tagged in order that closer observations could be made of supposed homing. Evidence that there is homing in fish has already been presented by Gerking (1953), Cooper (1952), Miller (1954) and others. If channel catfish do exhibit homing, we wish to know what effect it might have on determining the population size under conditions imposed by a large reservoir.

Description of the Reservoirs

Fort Gibson Reservoir is a 19,500-acre impoundment, on the Grand River in northeastern Oklahoma, constructed for flood control and hydroelectric power in 1952 by the U. S. Army, Corps of Engineers. A thorough description has already been presented (Anon., 1956).

Lake Lawtonka is a 2,000-acre municipal reservoir on Medicine Creek in Comanche County, Oklahoma near Medicine Park and serves as a water supply for the City of Lawton and the Fort Sill Military Reservation (Figure 1). It was constructed in 1905 and the dam has since been successively raised to impound more water in 1909, 1918, and 1953. A more complete description has previously been presented by Wilson (1953).

Methods and Materials

Standard equipment for both studies was the trap net, constructed according to Crowe (1950), which utilized a single pot having a one-inch stretched mesh. In the Fort Gibson study, a large trap net and a haul seine were also used. The large trap net had an 8-by 8-by 20-foot pot of two-inch stretched mesh. The heart was also of two-inch mesh and graduated in height to 18 feet. The lead was of three-inch mesh and 18 feet deep by 700 feet in length. The haul seine contained both two and three-inch mesh stretched measure. It was 18 feet in depth and 1,400 feet in length.

Because of the great length of the area sampled (27 miles) in Fort Gibson Reservoir it was divided into three areas and equal fishing effort was attempted in each. Five small trap nets were used continuously in each area and the large trap net was moved about in all areas. Seining was restricted to two areas since there were no cleared sites in the headwater region. Large open areas of deep water, rough bottom conditions and a current that occurred in the mainstream during high runoff prevented any attempt to select sampling stations randomly. Weather conditions, as well as the tremendous effort that would have been required, prevented regular weekly relocation of trap nets as planned. They were relocated periodically, but no schedule could be maintained.

All fish were marked by fin-clipping. Releases were made indiscriminately at distances of one to five miles from the station of capture.

From the period of June 3 to August 22, 1958 there were 55 days of fishing during which 367 small trap-net lifts, 25 large trap-net lifts and 40 seine hauls were made.

Only the small traps nets were used in Lake Lawtonka. Trapping stations were restricted to shoreline areas. Deep water sets below 15 feet were attempted but a lack of oxygen due to stratificaiton caused fish to die before they could be removed for marking. Using shoreline sets around this somewhat circular lake provided a situation in which homing behavior in channel catfish could be observed by releasing tagged fish at a central release point, while at the same time conducting a population estimate.

The period of study on this lake began on June 9 and ended on July 29, 1959 during which 15 trap nets were fished at 17 stations. There were 23 days of fishing in which 388 trap net lifts were accomplished. During the first 13 days 1,002 channel catfish were tagged with metal jaw tags and released. Marking of all fish by fin-clipping continued throughout the entire period.

Table 1. Length frequencies of channel catfish in creel census of 1955 and 1956, rotenone and population estimation sampling in 1958, Fort Gibson Reservoir.

Total Length Inches	Rotenone 1958	Creel Census 1955	Creel Census 1956	1958 Population Estimate Small Trap Net	1958 Population Estimate Large Trap Net	1958 Population Estimate Seine
1	1					
2	1					
3				4		
4	1			4		
5	2					
6	2	1		10		
7		1		35	4	1
8	3	4	5	67	19	
9	4	5	8	241	56	17
10	3	28	10	198	20	8
11	7	35	32	306	31	12
12	7	30	22	378	50	12
13	11	23	10	332	46	7
14	5	19	12	294	49	4
15	4	15	3	248	58	2
16	4	7	8	131	31	1
17	4	12	7	89	29	
18	2	7	5	36	11	
19	2	7	2	35	20	
20		1	1	15	9	
21		3	1	6	4	
22		3	2	9	3	
23		2	3	4	3	
24			3	3	5	
25		1		1	1	
26						
27						
28				2		
Number of fish	63	204	134	2448	449	64
Average length	12.0	13.2	13.2	12.6	13.6	11.1

Separate records were maintained for each station and all but a small number of fish were weighed and measured. Numbers marked and recaptured were recorded for each station.

In both studies the population size was calculated by the Schnabel method and the Schumacher and Eschmeyer method. A third method presented by Latta (1959) was also applied to the Lake Lawtonka data.

Fort Gibson Study

The estimates of the Fort Gibson Reservoir channel catfish population, based upon 12,103 marked individuals and 685 recaptures were 112,439 by the Schnabel method, and 108,439 by the Schumacher method (Figure 2). Based upon these estimates, the standing crop was either 5.8 fish and 4.3 pounds or 5.3 fish and 4.7 pounds per acre.

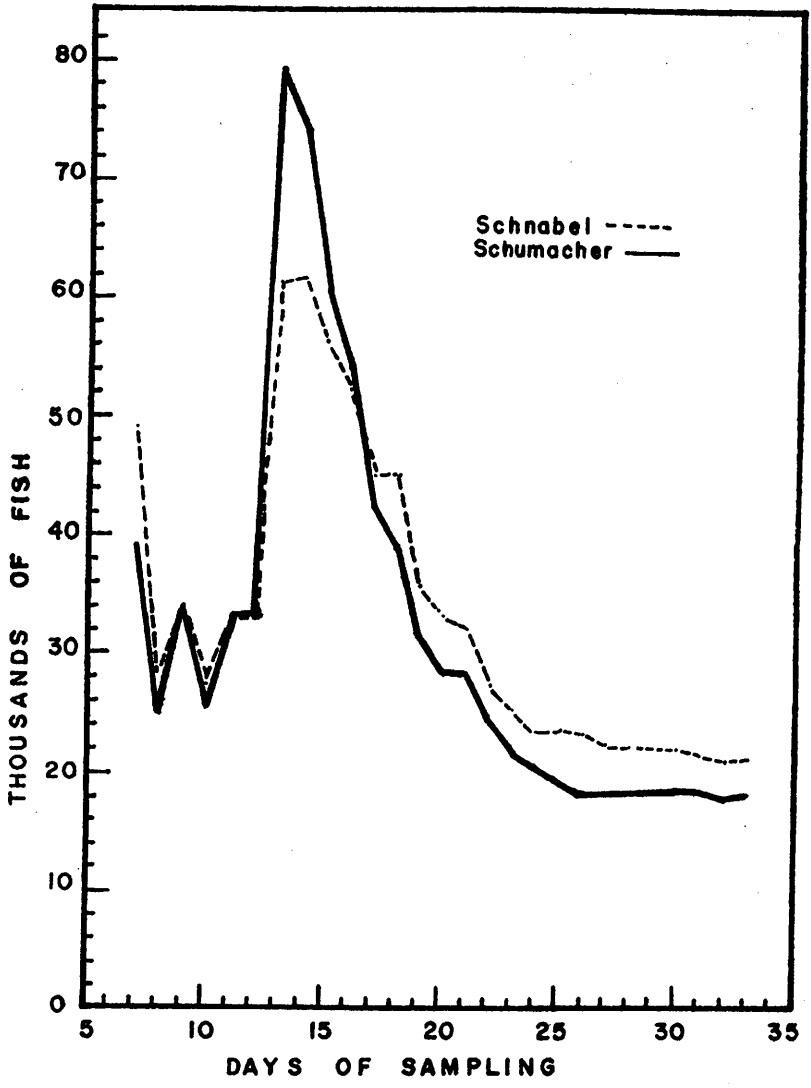

Figure 2. Channel Catfish Population Estimate for Fort Gibson Reservoir.

Cove rotenone samples in 1956 yielded estimates of 61 fish and 26.1 pounds per acre. In 1957, estimates by the same method were 45 fish and 34.4 pounds per acre (Houser, 1956 and 1957). From the 1958 samples 31 fish and 13.1 pounds were estimated (Summers, 1959). A creel census conducted on this reservoir during 10 months of 1954 and 1955 estimated an angler harvest of 11.1 channel catfish per acre with a weight of 11.2 pounds. During a 12 month period of 1955 and 1956, 17.1 fish and 11.1 pounds per acre were estimated for the angler harvest of the species. The population estimates compared with these results were inconsistent and appeared to have been much too small. Previous samplings have been replicated and the results obtained were consistent. For that reason it appeared that the population estimate may contain some serious error which had not been defined. It should certainly have exceeded the angler harvest and should have at least approached the results obtained by rotenone.

Selectivity by mesh size in the gear was recognized but no great discrepancies existed between the minimum size of fish effectively sampled by either anglers or trap nets and the seine (Table 1). The average length of angler-caught fish was 13.2 inches in both creel census periods. Average lengths of fish taken by each type of gear were: small trap net 12.6 inches, large trap net 13.6 inches and seine 11.1 inches.

Extrapolation of the population estimate to include the sizes of fish not sampled effectively, but which appeared in the rotenone samples, was also attempted. Based upon these samples, only 92 percent of the total population was sampled by the mark-and-recapture method. Adding an additional 8 percent, for fish too small to capture, produced an estimate of 112,394 fish. With this addition there were 5.76 fish per acre but this was still far below the minimum expected for an estimate of the standing crop.

Insufficient evidence was obtained to determine that recruitment may have affected the channel catfish population estimate, however more complete data for other species demonstrated that they had experienced a small amount. Any such bias contained in the channel catfish data would have tended to produce an estimate that was too great. This was not the case, but rather, it was considered too small.

During the course of the study it appeared that channel catfish were being recaptured at a much higher rate than were other species. Catchability was calculated and found to be much higher than for other species and homing was suspected. Incomplete, but significant, data were obtained from recaptures of a small number of distinctively marked fish which demonstrated that homing was occurring. Unfortunately the study was nearing its ends before any attempt was made to evaluate this behavior, but sufficient evidence had been provided whereby the discrepancies that were eventually revealed in the calculations might be explained. Since homing increases the number of recaptures, which in turn depresses the estimates derived through the methods used, it appears most likely that this estimate was too small as a result of the unknown extent of error introduced by homing fish.

Lake Lawtonka Study

During the 33 days of fishing on Lake Lawtonka, 3,883 channel catfish were marked and 405 were recaptured. Disregarding any influence due to homing the population estimates by the following methods were: Schumacher, 18,339; Schnabel, 21,231 (Figure 3); Latta, 24,231 (Table 2). Conspicuous differences are evident in these estimates. The Schumacher method is preferred over the first order approximation of the Schnabel

method for reasons outlined by DeLury (1958), but the simplified method presented by Latta offered a greater versatility for this estimate in which selectivity and homing were recognizable.

In his discussion on trap net selectivity and fish population statistics, Latta pointed out that a pronounced variation in catchability with size was experienced in Michigan lake studies. Bluegill, rock bass, yellow

Table 2. Population estimate of channel catfish by size without regard to effect from homing fish, Lake Lawtonka - 1959.

Length Inches	Number Measured	Number Marked M_i	Number Recaptured R_i	$\frac{R}{M}$ as percent	+Adjusted R_i	$\hat{P}$
5.0 - 5.9	2	6	0			
6.0 - 6.9	6	18	6*		6	36
7.0 - 7.9	33	99	1	6.3	6	866
8.0 - 8.9	28	84	6	5.4	5	748
9.0 - 9.9	119	356	22	5.9	21	3196
10.0 - 10.9	278	831	47	6.8	57	6474
11.0 - 11.9	209	625	54	6.9	43	4855
12.0 - 12.9	105	314	21	10.9	34	1607
13.0 - 13.9	117	350	65	14.2	50	1400
14.0 - 14.9	137	410	67	17.2	71	1389
15.0 - 15.9	103	308	52	14.8	46	1185
16.0 - 16.9	56	167	12	15.0	25	641
17.0 - 17.9	32	99	22	13.2	13	427
18.0 - 18.9	25	74	11	21.0	16	208
19.0 - 19.9	22	65	17	17.8	12	209
20.0 - 20.9	6	18	0	13.4	2	90
21.0 - 21.9	8	23	2		2	900
22.0 - 22.9	6	18				
23.0 - 23.9	1	3				
24.0 - 24.9	2	6				
25.0 - 25.9	1	3				
26.0 - 26.9	1	3				
30.0 - 30.9	1	3				
	1298	3883	405		409	24,231

* Combined with adjacent size classes having recaptures

\+ Determined by weighted moving average of three R_i and M_i

bullheads, brown bullheads and white suckers exhibited consistently greater catchability with increasing size. Wide variations between various size groups were seen in largemouth bass but no consistent trend was established.

Channel catfish in Lake Lawtonka generally exhibited increased catchability with size (Table 2). A population estimate by the Latta method yielded a somewhat higher estimate. No tests have been given however, whereby a comparison could be made with the precision offered by other methods. This method is expressed as the estimated population, $P_i = \frac{M_i^2}{2R_i} + \frac{M_i}{2}$, where M_i is the number of marked fish and R_i is the number of recoveries of marked fish in the i size class.

In the Lake Lawtonka study we were most interested in determining the rate at which channel catfish may return and be recaptured at a partic-

ular location after having been displaced. In an effort to obtain some kind of measure of homing, 1,002 channel catfish were jaw-tagged in the first 18 days of trapping. During the 33 days of fishing 96 tagged fish were recaptured, of which 37 or 36.9 percent were taken at their home station (Table 3). Since all 17 stations were located at different distances from the release point, ranging from 1,450 feet to 6,180 feet, the various catch-

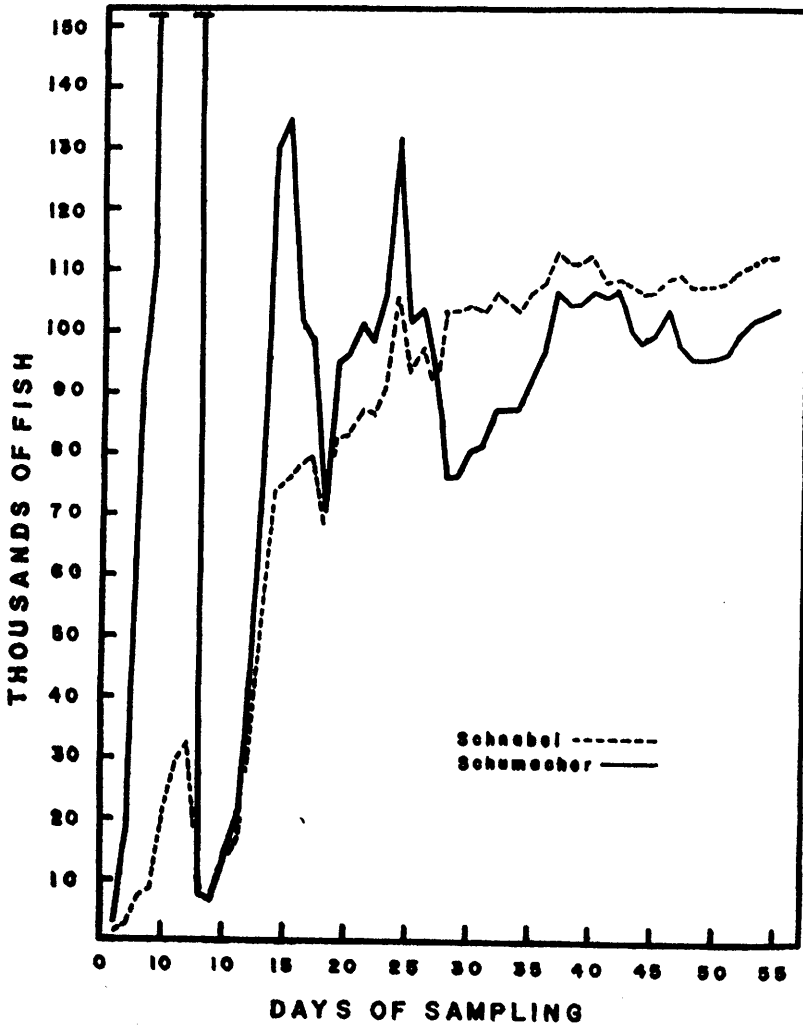

Figure 3. Population Estimates for Channel Catfish in Lake Lawtonka Disregarding the Homing Effect.

abilities for homing fish were compared by distance traveled (Table 4). The highest catchability was experienced at the most distant station but no trend was evident according to distances traveled.

The time elapsed between release and recapture ranged from 4 to 41 days (Table 5). Although the tendency appeared to be slightly in favor of early return to the home station, it should be pointed out, that since tagging and recapturing was carried out simultaneously many more fish with fewer days of freedom were available as the study progressed. The

Table 3. Number of tagged channel catfish recaptured at any station and at home station, Lake Lawtonka - 1959.

Length Range	*Total Number Tagged Measured	Number Tagged Recaptures	Number Homing Fish
5.0 - 5.9	0		
6.0 - 6.9	6		
7.0 - 7.9	24	1	
8.0 - 8.9	18		
9.0 - 9.9	92	3	2
10.0 - 10.9	219	15	7
11.0 - 11.9	160	10	3
12.0 - 12.9	86	2	1
13.0 - 13.9	85	8	2
14.0 - 14.9	103	17	5
15.0 - 15.9	83	19	9
16.0 - 16.9	42	7	4
17.0 - 17.9	22	3	1
18.0 - 18.9	19	5	1
19.0 - 19.9	18	4	2
20.0 - 20.9	5		
21.0 - 21.9	8	2	
22.0 - 22.9	4		
23.0 - 23.9	1		
24.0 - 24.9	2		
25.0 - 25.9	1		
26.0 - 26.9			
30.0 - 30.9	1		
	999	96	37

* Total actually 1002; three fish released without being measured.

probability of recapturing a fish in the shorter time was therefore somewhat higher. It appeared then that the number of days of freedom had little effect on homing behavior for the space of time and distance involved in this study.

A comparison of average total lengths for three groupings, by an increasing order of the number of days of freedom for homing fish, indicated that early recaptures included larger fish than those recaptured with longer periods of freedom. These differences could possibly be attributed to an increased activity of adult fish during the spawning season which occurred during the work period.

During the period of study 1,002 channel catfish had been tagged and 37 (36.9 percent) were recaptured at the home station. On the last day of the estimate all trap nets were baited with cottonseed pellets in an effort to obtain hatchery broodstock. On the following day 12 homing fish were found among the 18 additional tagged fish that were recaptured. Although not included elsewhere in this study it was interesting to note that the number of homing fish had been increased to 49 (43 percent) as a result of this one day of fishing with bait.

All mark-and-recapture estimates of population size depend upon the recapture of marked individuals. When the number of recaptures increases, the estimate is depressed. In these samples unrealistic estimates

Table 4. Catchability of homing channel catfish released at various distances from home station, Lake Lawtonka - 1959

Station Distance in Feet from Release Point	Station Numbers	Number of fish Tagged	Tagged Fish Recaptured at home Station	Catchability
1000 - 1500	16	67	2	.0299
2500 -	5, 6	99	6	.0606
3000 -	4	64	2	.0313
3500 -	1, 14	287	7	.0244
4000 -	13, 15	6	0	.0000
4500 -	2, 7	155	6	.0387
5000 -	3, 8	57	1	.0175
5500 -	9, 10, 12, 17	104	3	.0288
6000 -	11	163	10	.0613
		1002	37	.0369

were obtained when no attempt was made to compensate for homing. A previous conception of population size derived from gill-net sampling and angler catch indicated a substantial number of channel catfish existed in the lake, but these estimates tended to minimize its size.

Through identification of recaptured homing fish a basis was provided for distributing a compensation for homing throughout the various size classes. Estimates were determined using the Latta method. Through adjustment of the number of recaptures in the data an increased estimate was obtained. Catchabilities for each size class were calculated for both the homing and for all fish. The catchabilities for homing fish were subtracted from the average of all fish which should have removed the homing effect. Because of the variability, moving averages of three of these catchabilities were used together with the numbers of marked fish to obtain an adjusted number of recaptures. After this adjustment the population estimate was calculated for each size class. The total population size obtained by this method was 38,729 fish which appeared far more acceptable on the basis of the impression formed from sampling conducted prior to the estimate. Standing crop based upon this estimate was 19.4 fish and 10.86 pounds per acre (Table 6). Unfortunately the small number of recoveries of both the smaller and larger fishes prevented a uniformity in the treatment for homing in all size classes. For these size classes the estimate was direct and average catchability for all fish in the particular size class was used. Better estimates should be possible if the data for fish not adequately sampled are treated differently. Those fish in the lower as well as in the upper extremities of the length range could be aggregated and a single group estimate calculated for each. The results

Table 5. Time elapsed between release and recapture of homing channel catfish, Lake Lawtonka - 1959.

Number of days of Freedom	Number of Recaptured Homing Fish	Total Length Averages
4	2	
5	1	
6	1	
7	2	15.4
8	1	
9	2	
10	1	
14	2	
16	5	
17	1	
18	1	
20	1	
21	2	13.6
22	2	
23	2	
24	2	
25	2	
30	1	
31	2	
33	1	
36	1	13.3
40	1	
41	1	

obtained may then be distributed throughout each length range in question on the basis of length frequency of the marked fish rather than by recaptures alone. A more equitable distribution of the weight estimate should be realized by this procedure.

Discussion

Methods presently in use for estimating population size by mark-and-recapture have been shown to perform quite adequately in smaller bodies

of water. These methods have not been fully tested for reservoirs but similar information on these populations is also needed. Sampling by rotenone, fishing gear and creel census are the principal techniques currently used in reservoir population study. Their importance is widely recognized and accepted but most workers agree that in interpretation of these data there generally remains a considerable margin of uncertainty. Management recommendations must, therefore, observe some restraint. Sound, but revolutionary and controversial, programs may fail or never be attempted because of a lack of more reliable population statistics that may be needed to justify the recommendations. Population estimates by mark-and-recapture used in conjunction with other accepted methods could greatly improve the precision with which reservoir populations are measured.

Table 6. Summary of estimated channel catfish population in Lake Lawtonka, 1959.

Length-range	Average Total Length	Number of Fish	Number per acre	Average Weight Pounds	Total Pounds	Pounds per acre
5.6 - 7.9	7.3	4986	2.5	0.103	524	0.26
8.0 - 12.9	10.6	23,393	11.7	0.356	8328	4.16
13.0 - 17.9	14.8	8806	4.4	0.965	8498	4.25
18.0 - 26.9	20.0	1544	0.8	2.835	4377	2.19
Total	12.8	38,729	19.4		21,727	10.86

Many problems have yet to be met and solved before this method can be adopted as a standard. Using present gear, the effort required is tremendous and the many sources of error which affect an estimate under these conditions have not been clearly defined.

Moving traps daily to randomly selected stations is a satisfactory method for removing homing effect when working in ponds and small lakes but this procedure is virtually impossible for reservoir work. The size of the reservoir, amount and kind of gear used, weather conditions and water depth are all controlling factors that make this approach impractical in attempts to estimate reservoir populations. Since random sampling was not possible permanent trapping stations were used. By incorporating a tagging program, a basis was provided on which to correct the estimate for bias due to homing.

For large populations a considerable effort is required before sufficient data can be obtained for an estimate within the time limitations imposed by mortality and recruitment. Every advantage should be taken of previous knowledge regarding time of year when the rate of catch is highest. Compensation for variable catchability such as that seen in adult fish during the spawning season can be made through the size-class population estimates.

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