EXPLOITATION AND MORTALITY OF LARGEMOUTH BASS IN LAKE TOBESOFKEE, GEORGIA

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Abstract: Estimates of mortality and survival obtained from angler tag returns over a 10-month period following tagging were used to define the population changes that occurred in the largemouth bass (*Micropterus salmoides*) population of Lake Tobesofkee. Total mortality (A) of 30-cm and larger fish over the period was estimated at 0.911 and the exploitation rate (u) of these sizes was 0.564. The conditional rate of natural mortality was 0.602. These estimates were used to predict the relative abundance of various sizes of largemouth based on 1977 harvest and abundance data. Also the effects of various minimum length limits were predicted. Increased minimum legal size would have cut harvest to 23.7% and increased survival from 0.089 to 0.308.

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Lake Tobesofkee is a county-controlled impoundment of approximately 700 ha located in Bibb County just west of Macon, GA. The lake lends itself to intensive study in that it is small enough for the research to include the entire body yet large enough that the dynamics of the fishery resemble those of larger reservoirs.

The sport fishery of Lake tobesofkee had never been monitored and information generated by a creel survey was needed to define conditions on the lake and to provide background information for future work. Concern also existed thta overfishing may be a problem. The largemouth bass would be the species most likely to suffer detrimental effects as a result of high sport fishing pressure. Estimates of population size, mortality, and survival were needed to determine if a problem existed and to predict the effects of various management strategies. A mark-recapture study of the largemouth bass on Lake Tobesofkee, because of its small size, could estimate the population size within reasonable confidence limits ($p \doteq 0.25$) over an annual period utilizing angler returns. Other estimates should have similar precision. Also the exploitation and mortality rates could be used in evaluating the current regulations governing minimum legal size.

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MATERIALS AND METHODS

Description of the Study Area

Lake Tobesofkee (Fig. 1) is a 700 ha impoundment used for recreation and water conservation in Bibb County, Georgia. The surface elevation of the lake is 110 m above mean sea level. The maximum depth is 17 m and the mean depth is 4.4 m. The lake has approximately 56 km of shoreline.

Access to the lake and adjacent park lands is completely controlled on a fee basis by the county. Visitors must purchase a use permit at one of three gates before entering the park. Residential development of the lake's shore is high and during the summer months pleasure boats dominate the lake. Recreational facilities at the lake include 3 swimming beaches, camping and picnic areas, hiking trails, tennis courts, stables, and a marina.

Procedures

A non-uniform probability, roving clerk type creek survey designed by the North Carolina State University Statistics Project was conducted from March-December 1977. The entire lake was sampled a half-day on each weekend day, and holidays and on 2 weekdays each week.Data obtained included fishing pressure in hours, harvest in numbers and weight for each species, and length-frequency of the harvested largemouth bass.

Fig. 1. Location map of Lake Tobesofkee, Georgia.

During February 1977, largemouth bass of assorted sizes were captured by electrofishing, measured to the nearest 2.5 mm, tagged with individually numbered Floy[r] model FD-68BC anchor tags, and released back into Lake Tobesofkee. Legends on the flourescent orange tags read as follows: REWARD RETURN TO DNR G&F DIV FORT VALLEY GA. In addition to largemouth bass, other game species were tagged and released to de-emphasize the fact that we were studying largemouth and hopefully prevent fishermen from concentrating their efforts abnormally.

A local publicity campaign informing the general public of the study was begun following tagging. We emphasized that all species were being studied and that there was a $3 reward for the return of each tag. Returns were accepted at the park gates as fishermen left the area , making it as convenient as possible to return tags.

Mortality and survival rates were estimated by the regression method suggested by the deterministic model of Beverton and Holt (1957).

RESULTS

From 26 February through 1 March 1977, 1048 largemouth bass of assorted sizes were tagged in Lake Tobesofkee. The length-frequency distribution illustrates that the mode size in the sample was the 28 cm group (Fig. 2). Only 211 fish (20%) were legal size (30 cm or greater). The dominant size groups were composed primarily of 1975 year-class fish as indicated by the previous year's samples and known growth rates from prior years. Notable was the virtual absence of largemouth bass smaller than 21.6 cm which would have represented the 1976 year class. There was no indication that these smaller fish were missed due to sampling error.

A total of 56% of the tagged legal-sized largemouth bass were returned over the 10-month study period (Table 1). Fishing effort for largemouth bass varied from 1510 to 6055 man-hours per month. Total harvest ranged from 248 to 3191 per month.

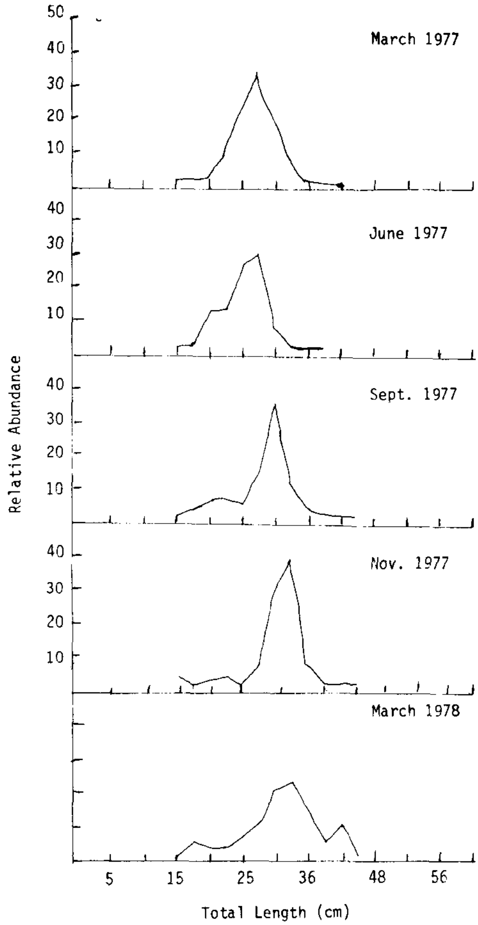

Fig. 2. Length-frequency distributions of largemouth bass collected during 1977 and 1978.

Months during which returns were made were coded 1-10 and a linear regression of the numbers returned per unit effort versus elapsed time calculated. Based on catch per unit effort (Yi), legal-sized tagged fish disappeared from the population at a relatively constant instantaneous rate (Fig. 3). Fishing mortality (F) and natural mortality (M) contributed to this decline. The total instantaneous mortality (Z) is obtained by multiplying the slope of the regression by the time over which returns were received (Fig. 3). Survival rate (S) is then S = exp (-Z). Total annual mortality (A) is obtained by subtraction, A - 1-S.

The actual fishing mortality rate is assumed to be u. Thus, this rate (0.564) is equal to the total percentage of legal-sized largemouth bass tags returned (Table 1). The instantaneous rate of fishing mortality can be obtained without bias due to tag loss (Ricker 1977) by

Table 1. Tags returned, fished-for effort, and harvest of largemouth bass on Lake Tobesofkee, Georgia, March through December, 1977.

Month	*Tags Returned* (%)	*Effort* (*hours*)	*Harvest* (*numbers*)
March	45 (21.3)	3955	1384
April	37 (17.5)	8332	3191
May	13 (6.2)	6055	884
June	6 (2.8)	2670	275
July	5 (2.4)	2214	416
August	6 (2.8)	2876	770
September	1 (0.5)	5963	1867
October	2 (0.9)	2791	1456
November	2 (0.9)	1270	248
December	2 (0.9)	1510	322
Total	119 (56.4)	37636	10813

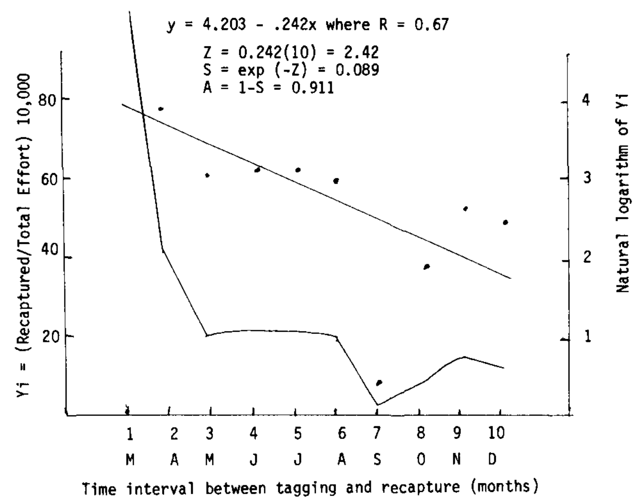

Fig. 3. Regression of the numbers of recaptures per unit effort (Yi) with coded months used to calculate mortality and survival rates.

$$F = uZ/A$$

Therefore $F = (.564)(2.420) / 0.911 = 1.498.$

Then by subtraction $M = Z - F = 0.922.$

The conditional rate of fishing mortality is

$$m = 1 - \exp(-F) = 0.776.$$

The natural mortality rate (v) by subtraction of u from A is 0.347 and the conditional natural rate is

$$n = 1 - \exp(-M) = 0.602.$$

Total rate of exploitation (u) of the population represented by legal-sized tagged fish was 0.564 of which 80% ($u = 0.450$) occurred during the first three months. During this same 3-month period, 49% of the effort for largemouth was expended and 51% of the total harvest occurred. Total rate of exploitation for largemouth less than 30 cm was 0.434 although these fish were not creeled, but supposedly released after the tag was removed.

Fig. 2 illustrates the length-frequency distribution of largemouth bass obtained by electrofishing at various times over the 12-month period following the initial tagging effort. The decline of legal-sized fish through June 1977 can be attributed to the high exploitation during this period coupled with the lack of recruitment to legal size documented by the observed lack of growth of tagged fish. The abundance of legal-sized fish increased from June through the remaining collections due to the growth of fish into the legal-sized group and the decline in fishing effort. Apparently the sub-legal bass survived at a high rate as evidenced by their recruitment to legal size during the period of decreased fishing effort. Protection of the sub-legal bass was probably effective in light of the potential exploitation rate.

The length-frequency for March 1978 still reflects the dominant year-class of 1975 and the low recruitment of the 1976 and 1977 year-classes. If one considers the mortality estimates of the prior year, the bulk of the population present during March 1978 should suffer high moratality during that year, resulting in a relatively low population of legal-sized fish available in 1979.

When only the length-frequency of legal-sized fish is used and the 1977 distribution subjected to the mortality rates estimated, the resulting predicted 1978 population is similar to that obtained by sampling during March 1978 (Fig. 4). Five centimeters were added to the 1977 groups' lengths to allow for 1-year's growth. This assumed growth rate is similar to that observed in age-growth analysis of largemouth bass on Lake Tobesofkee in prior years (Ager, unpublished data).

The length-frequency of legal-sized fish in March 1977 was used to estimate the resulting length-frequency distribution 1-year later with various length limits (Fig. 5). Very little difference was noted in relative abundance of these length groups after only 1 year's fishing. When the results were examined as they would affect the size distribution and survival of 1000 largemouth 30-cm and larger distributed as in March 1977, survival varied from 0.089 with the 30-cm minimum limit to 0.308 with the 38-cm minimum limit. The 38-cm limit would, under these conditions, guarantee greater survival especially in the smaller size classes.

Harvest, however, would be greatly impacted if size limits had been increased. The data indicate that the harvest during 1977 under a 33-cm size limit would have been 69% of that expected from a 30-cm minimum size. Thirty-six and 38-cm minimum sizes would result in 52% and 24% of the current harvest respectively.

The size distribution of the actual harvest was also subjected to the mortality rates expected from various minimum legal size limits. The results showed a decline in harvest from the actual 10,813 to 7,675 with the 33-cm limit, 6,601 with the 36-cm limit, and 3,625 with the 38-cm limit.

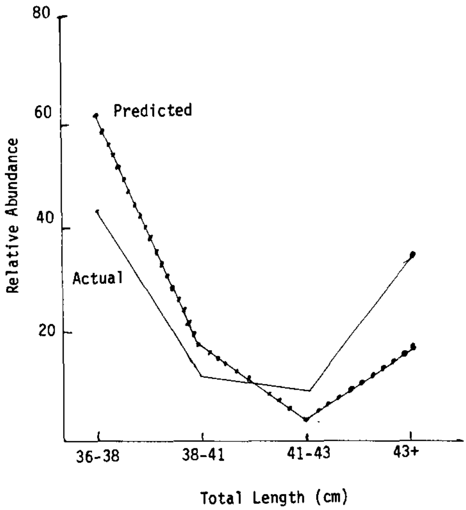

Fig. 4. Comparison of predicted and actual length-frequency distributions of largemouth bass during March 1978.

DISCUSSION

Possible sources of bias in the techniques used in this study were classified by Ricker (1977) as errors of types, A, B, and C. Type A errors would influence estimates of fishing mortality but not necessarily total mortality. Two possible sources of this type error are initial mortality of tagged fish and incomplete reporting of tags. Initial mortality was not observed in tagging studies in small ponds by this author or by Davies et al. (1977). Rawstron and Hashagen (1972) observed tagged largemouth in cages and recorded no significant mortality. Since the return of tags by fishermen was facilitated by the convenience of returning them at the gate as they left the park and there was the added impetus of a cash reward, I considere the non-reporting of tags to be negligible.

Type B errors will result in a bias of the estimate of total mortality but not necessarily in the estimate of fishing mortality. The primary reason for this type error would be a continuous loss of tags. Preliminary findings in Tennessee (Hayes, personal communication) indicate an annual loss of 0.10-0.12 with the Floy[r] FD-68B anchor tags. Work by Crumpton (personal communication) in Florida indicate retention rates with this tag of about 0.75-0.90 over 6-9 month periods. Unpublished tag retention work by the author indicates less than 0.10 loss over an annual period in a diverse, natural population. Wilbur and Duchrow (1973) recorded a retention rate of 0.88 with this tag in a bass-bluegill (*Lepomis macrochirus*) pond over a 3-month period. I feel that higher losses may result in the bass-bluegill ponds due to bluegill pulling tags from the bass. Under natural circumstances, bluegill are generally less numerous and smaller. Returns of tags from Lake Tobesofkee over 18 months support these relatively low loss rates. Consequently for the calculations made in this paper, annual loss was considered negligible.

Type C errors which would result from changes in behavior associated with tagging were assumed to be inconsequential.

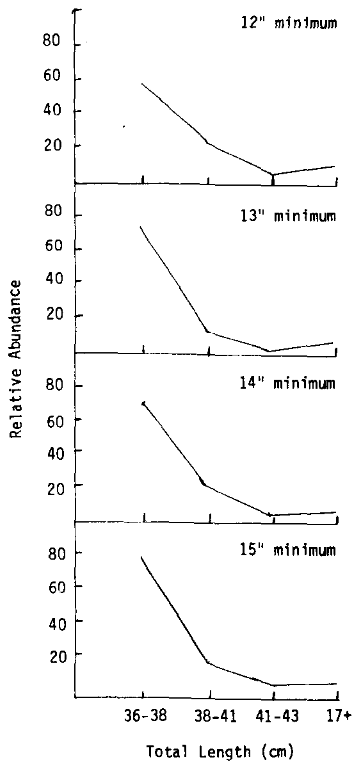

Fig. 5. Predicted length-frequency distributions resulting from various minimum legal size limits imposed on the actual population in March 1977.

Recognizing the limitations of results obtained in any tagging study (Ricker 1977), the information herein represents an attempt to quantify actual changes which occur in an exploited population of largemouth bass. I feel that the estimates made represent the rates of population change adequately for management purposes.

Clearly the situation which was discovered on Lake Tobesofkee in March 1977 will culminate eventually in relatively poor bass fishing due to weak 1976 and 1977 year classes. Increases in the minimum size could postpone this impact until later years, and minimize the apparent effects by reducing the harvest by regulation before the weak year classes become apparent to fishermen. Increasing the minimum legal size would trade greater harvest in numbers during 1977 and 1978 for somewhat greater harvest over what would otherwise be expected during 1979 and 1980. This is due to the rate of conditional natural mortality (0.602) that acts without fishing.

Changes in rates of survival of largemouth bass not only affect that species, but also the mortality, condition, and abundance of other groups and species. Inadequate too, is our knowledge of the effects of the population structure, and subsequently the structure of the harvest, on fishing pressure, and ultimately on mortality rates which will determine future population structure.

Over an annual period, the length-frequency of a population may change drastically due to growth and differential mortality, making the establishment of length limits and their subsequent effects uncertain. A significant change in total mortality may result however, from a length limit which affects fishing mortality over only a 3 to 4-month period. This could affect a more normally distributed population since during this time of highest fishing mortality, growth and recruitment between cm-classes may not be a factor.

LITERATURE CITED

Beverton, R. J. H. and S. J. Holt. 1957. On the dynamics of exploited fish populations. Can. Min. Agric. Fish and Food, Fish. Inv. Ser. II, 19, 533 p.

Davies, W. D., W. L. Shelton, D. R. Bayne, and J. M. Lawrence. 1977. Fisheries and limnological studies, West Point Reservoir, Alabama-Georgia. Final report. Waterways Exp. Stn. Corps of Engineers. Vicksburg, Miss.

Rawstron, R. R., and K. A. Hashagen, Jr. 1972. Mortality and survival rates of tagged largemouth bass (*Micropterus salmoides*) at Merle Collins Reservoir. Calif. Fish Game 58:221-230.

Ricker, W. E. 1977. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can. Bull 191. 382 p.

Wilbur, R. L., and R. M. Duchrow. 1973. Differential retention of five Floyr tags on largemouth bass (*Micropterus salmoides*) in hatchery ponds. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 26:407-413.