Largemouth Bass Population Changes Following Implementation of a Slot Length Limit[1]

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Abstract: Following 3 years of a 356 mm (14 inch) minimum length limit on black bass, a protective length range (slot) regulation was placed on Arbuckle Reservoir, Oklahoma. This slot length limit protected both largemouth and spotted bass in the 300–381 mm (12–15 inch) range. Bass density, as indicated by spring electrofishing catch-per-effort (C/f), increased over the duration of the study. Most noteworthy was the increase in density of largemouth bass >381 mm long. Proportional Stocking Density (PSD) also improved as an indication of changes in population structure. Initially, angler compliance was low (30% illegal harvest) but improved over the course of the study. Few spotted bass achieved a size greater than the slot and their proportion in the population relative to largemouth bass increased.

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With fishing at an all-time high, bass overharvest may be the most serious problem limiting the sustained quality of fishing in most public waters (Anderson 1974). In 1978, Oklahoma embarked on a program of experimental length limits designed to improve overall quality of black bass angling. Mense (1981) stated that after a 3-year evaluation of a 356 mm (14 inch) length limit on 4 Oklahoma reservoirs, a clear definition of overharvest was still unavailable. He did, however, conclude that when the Proportional Stock Density (PSD, Anderson 1974) for largemouth bass was below 50, the possibility of overharvest could exist. Arbuckle Reservoir was part of Mense's 1979–1981 evaluation.

The bass population structure of Arbuckle from 1977 through the spring of 1979 remained in a near satisfactory condition as evidenced by acceptable PSD values. However, annual exploitation rates greater than 45% in 1978 (Mense 1981) suggested that Arbuckle Reservoir would benefit by protecting part of the bass population. In January of 1979, a 356 mm (14 inch) minimum size limit was placed on all black bass species in Arbuckle. The bass population structure under the 356 mm

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minimum length limit began to degenerate and by the spring of 1981 was clearly unsatisfactory (Mense 1981). Slower growth and higher density (stockpiling) of bass <356 mm long became evident with declining PSD's. In addition, the relative abundance of the slower growing spotted bass (Mense 1976) increased under the 356 mm length limit.

In an attempt to correct the problems encountered under the minimum length limit, a slot length limit (300–381 mm or 12–15 inch) was implemented for all black bass on Arbuckle Reservoir, beginning 1 January 1982. This would allow, and hopefully encourage, the harvest of smaller bass thus reducing competition before they entered a protective size where they would be allowed to grow to larger size before harvest.

Methods

Arbuckle is a 950-ha reservoir located in south-central Oklahoma. Impounded in 1967 by the Bureau of Reclamation, it is currently operated by the National Parks Service. Arbuckle is a relatively clear reservoir, as most of its basin lies within 2 major limestone outcroppings.

Arbuckle Reservoir was sampled by night electrofishing during spring and fall from 1982 through 1985. A quota of 500 largemouth bass (*Micropterus salmoides*) was set for each season's sample. All bass, both largemouth and spotted (*Micropterus punctulatus*), were weighed and measured to the nearest gram and millimeter, respectively. Each bass was marked with a caudal-fin hole-punch and returned to the lake. Any bass subsequently taken with a mark during that season was disregarded. Bass population indices included length frequencies PSD, Relative Stock Density (RSD), mean relative weight (Wr) by 20 mm length group, and density expressed as catch-per-effort (C/f).

In addition, random, non-uniform daylight creel surveys were conducted each year from 1982 through 1985 during the months of March through November. Sixty creel-days were scheduled and surveyed; each 3-month period contained 8 weekday and 12 weekend creel-days. The 10-hour creel-day activities were similar to those reported by Summers (1978).

Proportion harvest (PH index), originally proposed by Mense (1981), was used to compare the relative frequency of a size group in the harvest to its relative frequency in the population. The calculation is as follows:

$$PH_{stock} = \frac{A}{B} \times 100$$

where PH_{stock} is the proportional harvest of bass (200–300 mm); A is the ratio of 200–300 mm bass harvested to the total harvest stock size bass (>200 mm); and B is the ratio of 200–300 mm bass to the total number of stock size bass in electrofishing samples. PH_{slot} and $PH_{quality}$ are calculated similarly except that size ranges used are 300–381 mm and >381 mm, respectively.

Statistical analysis of C/f data indicated residuals generated were not normally distributed. Therefore, comparisons of density estimates were made by ranking C/f values and were then reanalyzed using a one-way ANOVA (SAS 1985). Because of the non-normality of the data, standard error estimates for C/f have little meaning and are not included.

Results

Largemouth Bass Density

Largemouth bass density, as determined by electrofishing C/f values, generally increased over the duration of this study (Table 1) with a significant change ($P < 0.0001$) observed between 1982 and 1985. This increase in density was not associated with any size class that might indicate stockpiling. Stock size largemouth (201–300 mm) C/f values fluctuated as did those in the protective length range. Most noteworthy were the spring electrofishing C/f values of largemouth bass >381 mm. The density of these sized fish showed a steady increase throughout the study with the 1985 spring electrofishing C/f significantly larger ($P < 0.001$) than the value recorded in 1982.

Catch-per-unit-effort, calculated for both spotted and largemouth bass combined, also revealed increasing density throughout this study (Table 2). Relative abundance of the two species, however, indicated that the proportional number of spotted bass in Arbuckle Reservoir was generally increasing.

Population Structure

Under the 356 mm minimum length limit implemented in 1979, PSD and RSD_{14} values declined to 28 and 8, respectively by 1981 (Mense 1981). However, with the change to a slot length limit regulation in 1982 the population structure rebounded and steadily improved (Table 3).

Table 1. Electrofishing catch-per-unit-effort (C/f)[a] of largemouth bass for 1982 through 1985 in Arbuckle Reservoir.

Year	Effort (min)	Total C/f	C/f by length class 201–300 mm	301–381 mm	≥381 mm
			Spring		
1982	900	13.2	5.4	2.4	0.3
1983	840	12.2	6.6	4.1	0.5
1984	690	18.5	5.7	6.8	0.6
1985	315	25.1	9.0	3.4	1.4
			Fall		
1982	870	8.8	3.7	1.7	0.2
1983	840	11.2	2.9	2.1	0.4
1984	450	17.7	5.8	2.0	0.6
1985	315	21.6	11.3	2.1	0.4

[a]15 minutes = 1 unit of effort.

Table 2. Annual catch-per-effort (C/f)[a] for largemouth and spotted bass collected during spring electrofishing on Arbuckle Reservoir.

Year	Largemouth C/f	Spotted bass C/f	Total C/f	% spotted bass
1982	13.2	2.7	15.9	17.0
1983	12.2	3.7	15.9	23.3
1984	18.5	4.7	23.2	20.3
1985	25.1	11.4	36.5	31.2

[a]15 minutes = 1 unit of effort.

Length frequencies from spring electrofishing (Fig. 1) revealed the tendency for the Arbuckle largemouth bass population to structure itself into two distinct modes. The first mode (100–250 mm) contained both Age 1 and Age II fish. Spawning and young-of-the-year survival conditions were very favorable in Arbuckle Reservoir. As a result, high recruitment levels were observed annually. The second mode (250–350 mm) contained several year-classes of fast and slow growing bass as determined by otolith analysis (Summers 1987).

Spotted bass population structure did not improve with the slot regulation. A small number of bass >381 mm observed in spring electrofishing samples in 1982 (C/f <0.1) were not seen again in subsequent years.

Condition

The condition of Arbuckle's largemouth bass population described by Relative Weight (W_r) could generally be considered as marginal (Wege and Anderson 1978). Acceptable W_r values were usually seen for bass <180 mm and >440 mm long (Fig. 2). Most other size classes exhibited W_r values in the low to mid 80s. While these values are generally not considered acceptable, they certainly do not represent a poor conditioned largemouth bass population. The increasing density of the bass population was not reflected in a trend toward poorer condition. In fact, there were no obvious trends in condition over the duration of the study. Bass in the slot (300–381 mm) exhibited no significant differences ($P < 0.05$) in W_r values than those length ranges of 181–300 mm or 381–440 mm.

Table 3. Proportional stock density (PSD), Relative stock density (RSD_{14}) and Proportional harvest (PH) indices for 1982 through 1985 in Arbuckle Reservoir.

Year	PSD	RSD_{14}	PH_{stock}	PH_{slot}	$PH_{quality}$
1982	33	7	82	100	397
1983	43	8	90	115	120
1984	57	9	120	75	79
1985	35	13	110	71	77

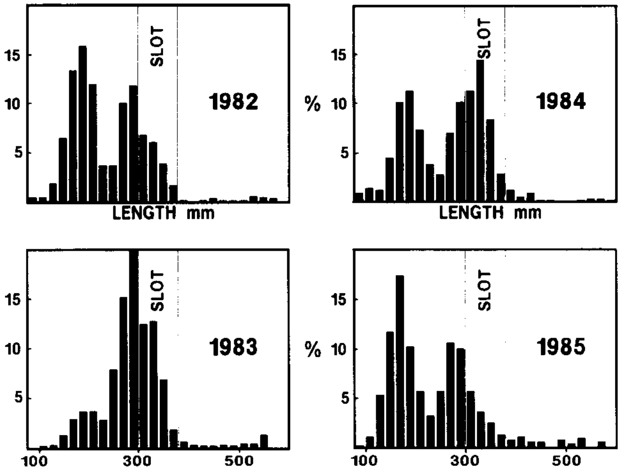

Figure 1. Relative length frequency of largemouth bass from 1982–1985 in Arbuckle Reservoir.

Sportfish Harvest

One of the main criteria in the evaluation of any type of regulation used in trying to manage fish populations is public acceptance. The public must perceive that this regulation is beneficial, thereby making compliance rates high. This was not the case in Arbuckle Reservoir. From 1982 through 1984, about 1 out of 3 bass harvested from the lake was from the slot size range (Table 4). Regulation compliance improved and by 1985 only 13.7% of all bass harvested were coming from within the slot. It is interesting to note, however, that during 1982 through 1985, if one were to concede 12 mm on each end of the slot (ie., 312 to 369 mm as the slot), the illegal harvest is reduced by almost 50%.

Fishing pressure estimates showed wide variation over the course of this study (Table 4). The estimate in 1984 was due mainly to high fishing pressure that occurred when climatic conditions remained favorable for fishing during most of the spring months (March, April, and May) of that year. Bass harvest of larger individuals (bass >381 mm, Table 4) did not strongly correlate to fishing pressure estimates ($r^2 = 0.54$). Mean annual bass harvest during the slot length limit did approach the annual value of 5605 fish estimated in 1978 before any size regulations were in place (Summers 1987) and was up substantially from the 855 bass harvest estimate reported in 1980 by Mense (1981) under the 356 mm minimum length limit. Anglers specifically seeking bass accounted for only 66% of the total bass harvest during the slot length limit.

Total harvest of bass by size groups also revealed large annual fluctuations (Table 4). In 1985 there was a significant reduction ($P < 0.01$) in the relative number of bass being illegally taken within the slot indicating improved compliance.

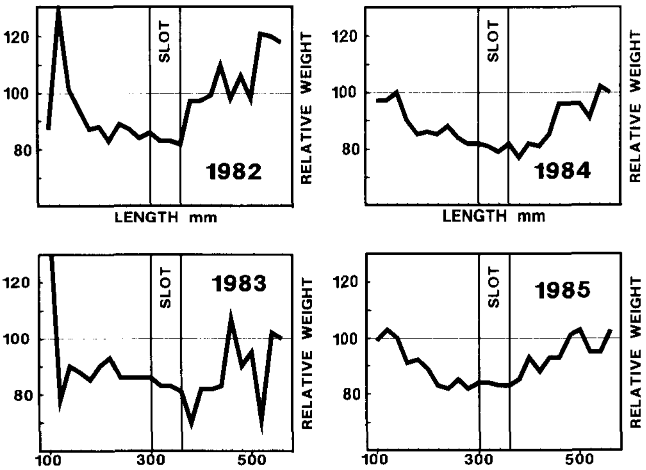

Figure 2. Mean relative weight by 20 mm length group for largemouth bass from 1982–1985 in Arbuckle Reservoir.

Harvest of bass greater than 381 mm showed the same fluctuation as total harvest. Spotted bass comprised 17%–22% of the total annual harvest during this study.

Proportional Harvest (PH) indices revealed several encouraging trends in the slot regulation evaluation (Table 3). PH_{stock} values increased over the study period while PH_{slot} values decreased. These are desirable factors toward successful implementation of this kind of regulation. $PH_{quality}$ values decreased indicating disproportional harvest of this larger size of bass. $PH_{quality}$ values after 1982 were within acceptable ranges (Mense 1981) to maintain suitable bass population structure.

Discussion

The management premise of any slot length limit is that overharvest of bass within a certain size range is occurring but that high recruitment of bass causes the need for reducing density, thereby maintaining good growth before the bass enter the slot. The key here is the angler harvest of bass under the slot. If anglers are

Table 4. Annual largemouth bass harvest for 1982 through 1985 in Arbuckle Reservoir.

Year	Total angling pressure (hours)	Total harvest (*N*)	Harvest by length class (*N*)		
			<300 mm	300–381 mm	>381 mm
1982	43,751	4,752	1,742 (57%)	1,422 (30%)	587 (13%)
1983	62,839	3,251	1,773 (56%)	1,065 (31%)	412 (13%)
1984	200,960	11,688	7,130 (61%)	3,857 (33%)	701 (6%)
1985	78,726	3,642	2,549 (70%)	583 (16%)	510 (14%)

unwilling to accept small bass, in this case <300 mm, then the slot limit is, in effect, a 381 mm minimum length limit. Annual harvest at Arbuckle Reservoir was comprised of 55% to 70% of bass <300 mm. While this may appear like a large portion of the total harvest, it may not have been enough. Relative weight values did not improve between 1982 and 1985 within the slot even though there was a trend toward higher relative harvest of sub-slot sized bass. Angler willingness to harvest smaller bass appears varied. Eder (1984) reported 98% of the bass harvested in a small Missouri impoundment were <300 mm. Navary (1982) showed that Mississippi anglers would not accept a bass less than 275 mm. He felt this caused the failure of a 275–381 mm slot regulation to produce better quality fishing. Gabelhouse (1984) also felt that not enough small bass were harvested with a 300–381 mm slot regulation on 5 Kansas lakes. He further postulated that if the minimum size of the slot limit was increased in order to allow a more desirable size bass to be harvested or if angler acceptance of subslot-sized bass is extremely high, it is possible that overharvest of subslot-sized bass may occur. It is unknown if the number of bass slightly greater than 300 mm harvested from Arbuckle illegally was the anglers desire to harvest a larger fish or simply just what the anglers thought they could get away with. These cases point to the importance of considering angler acceptance and compliance when selecting any type of size limiting harvest regulations.

The apparent overall effect of both length regulations on Arbuckle Reservoir was to numerically increase the density of bass. This increase was also reported by Hamilton (1984) for another Oklahoma reservoir under a similar slot regulation. It is important to note that the increase in density seen through increase in electrofishing catch rate values does not necessarily reflect an increase in biomass of bass. Intuitively, restrictive harvest regulation does not have the ability to change the long-term carrying capacity of a lake. It merely shifts the total biomass into different size categories, thereby changing the relative number of a certain size fish and changing the C/f values. Harvest does play an important role in this shift, however. If smaller bass are taken out rapidly this allows the remaining bass to grow faster due to reduced competition, become protected within the slot and eventually increase the number of fish above the slot. This was seen to a certain extent in Arbuckle Reservoir. The total C/f of bass increased under the 356 mm minimum length limit. This is understandable since the size structure of the population was shown to deteriorate, providing more, smaller bass. Catch rates values remained high under the slot length limit but an increase in the C/f of bass >381 mm was also observed. This was possible because a substantial percentage (X = 61%) of the bass being removed were <300 mm.

A dominant length mode was usually seen annually inside the slot. We had hoped to see this mode move relatively intact through the slot and present itself to the anglers as a large number of more quality sized fish to be harvested. This was never apparent for two reasons. Angling mortality within the slot was too great. PH_{slot} indices generally indicated that the bass were being harvested at the same rate as their relative proportions within the population. The proportional harvest of these fish may have been greater, however, without the slot regulation. Second, natural mortality was probably also taking its toll on this size of bass. Some individuals were aged at ≥5 within the slot and with total annual mortality exceeding 50% (Novinger 1984) there may be too few bass remaining to justify this type of management.

One drawback of the slot length limit at Arbuckle Reservoir dealt with the spotted bass population. Only on rare occasions were spotted bass >381 mm long observed. This virtually limited the legal harvest of spotted bass to individuals <300 mm. Because of their slower growth rates, few spotted bass were able to grow beyond the slot.

Although the electrofishing C/f of largemouth bass >381 mm increased throughout the study, the harvest of bass of this size did not increase proportionally. In this study there was no correlation between C/f values and angler harvest values for any size-class of bass. This points to the fact that researchers and managers must be very careful in using creel data to evaluate the success or failure of any length limit regulation. Sportfish harvest on a body of water is controlled more by fishing pressure than any other activity and fishing pressure can be influenced by factors such as climate, economics, and other sociological factors over which a fisheries manager has little control. It is felt that changes in density and population structure that could relate to sportfish harvest are more meaningful and better evaluate the trends of an experimental regulation.

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