Largemouth Bass Population Structure Changes and Harvest Under a Slot Length Limit

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Abstract: Effects of changing harvest regulations on largemouth bass *Micropterus salmoides* from a 254-mm minimum length limit and 10-fish daily bag limit to a slot length limit of 356–457 mm and later to a 5-fish daily bag limit were monitored on Calaveras and Monticello reservoirs, Texas. Electrofishing was used to monitor changes in size structure at both reservoirs and density as catch per unit of effort (CPUE) at Monticello Reservoir only. A creel survey was used to monitor angler harvest at Calaveras Reservoir. In both reservoirs, $RSD_{203-355}$ decreased while $RSD_{356-457}$ and RSD_{457} increased. In Monticello Reservoir, electrofishing CPUE of largemouth bass 203–355 mm declined, while CPUE of largemouth bass 356–457 mm and ≥457 mm increased. However, the total CPUE of all stock-size largemouth bass remained similar to pre-slot length limit levels. Calaveras anglers responded to length limit changes by harvesting largemouth bass below the slot length limit. Initially, number harvested increased while weight harvested decreased. After 4 years, total harvest by weight increased to pre-slot length limit levels. After 7 years, mean weight of largemouth bass harvested had increased from 0.74 kg to 2.03 kg. The reduction in the bag limit did not distribute the harvest among more anglers or effect the proportion of anglers who caught 5 largemouth bass. Carefully chosen slot length limits can be effective for improving the quality of largemouth bass fishing in larger reservoirs.

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Investigators have acknowledged and stressed the importance of restrictive harvest limits to protect and maintain largemouth bass *Micropterus salmoides* fisheries. Fox (1975) stated size limits appeared to be the only method of regulation that has the potential to directly and predictably affect population structure of both largemouth bass and forage fish. Anderson (1974) recommended the use of minimum length limits to rebuild depleted largemouth bass stocks or to prevent overharvest in new reservoirs. Effectiveness of minimum length limits on largemouth bass populations has been well documented (Johnson and Anderson 1974, Ming and McDannold 1975, Van Horn et al. 1981, Paragamian 1982).

Slot length limits were designed to improve age and size structure by protecting specific size groups within a population and directing harvest where surplus was evident (Johnson and Anderson 1974). Their effectiveness on small impoundments (< 304 ha) has been well documented (Anderson 1976, Eder 1984, Mosher 1986, Gabelhouse 1987); however, slot length limit effects on larger reservoirs are less understood (Novinger 1984). Summers (1988) illustrated that a 300–381 mm slot length limit improved RSD in a large (950-ha) reservoir in Oklahoma.

Daily bag limits are often used in conjunction with size limit restrictions. Historically, bag limits have been used to distribute harvest more evenly among anglers and reduce harvest; however, their effectiveness is difficult to assess (Fox 1975). Redmond (1974) predicted that reducing the bag limit from 10 to 4 largemouth bass would insure a more equitable distribution of harvest in newly opened Missouri lakes. Bag limits may serve as a target or goal for anglers and consequently may influence the way they perceive fishing success (Fox 1975). No published studies were found that evaluated the effects of bag limits when used in conjunction with slot length limits.

In Texas, Calaveras and Monticello reservoirs exhibited similar trends in bass population structure within 8 years after opening to fishing under a 254-mm minimum length, 10 fish daily bag limit. Largemouth bass populations were dominated by small individuals (<356 mm). Very few large fish (≥356 mm) were found in either reservoir. The Texas Parks and Wildlife Department (TPWD) implemented a slot length limit of 356–457 mm on both reservoirs to improve largemouth bass population structure by decreasing numbers of those <356 mm and increasing numbers >356 mm. A 10-fish daily bag limit, in effect when the slot length limit was initiated, was reduced to five fish/day in September 1985 to more evenly distribute harvest among anglers. The objective of this study was to evaluate the effects of these regulation changes on largemouth bass size structure, density and angler harvest.

Methods

Calaveras Reservoir, a 1,397-ha impoundment, was constructed in 1969 24 km southeast of San Antonio, Texas. The reservoir has a mean depth of 5.5 m and a maximum depth of 13.7 m. Monticello Reservoir, a 810-ha impoundment, was constructed in 1972 14 km southwest of Mount Pleasant, Texas. The reservoir has

a mean depth of 6.7 m and a maximum depth of 12.2 m. Both impoundments serve as cooling reservoirs for coal-burning power plants.

Largemouth bass were collected during February through April by electrofishing. Electrofishing units were boat mounted and equipped with multiple anodes suspended from a boom extending 0.9–1.2 m in front of the boat with the boat hull as the cathode. A 3,500- or 4,500-W portable generator discharged 110-V AC directly into the water. At Calaveras Reservoir, daytime sampling was conducted annually from 1978 through 1987. Attempts were made to collect 100 stock size (≥203 mm) largemouth bass annually for analysis of population size structure. Samples were taken throughout the reservoir and catch per unit effort (CPUE) was not recorded. At Monticello Reservoir, electrofishing was conducted at night during 1976, 1978–79, 1983, and 1986–87. Before 1986, sampling was done for 1.0 to 2.0 hours without regard to location. During 1986–87, 15 minute electrofishing samples were taken at 5 sites. Each largemouth bass collected was individually weighed and measured. Length data were used to determine Relative Stock Density (RSD; Wege and Anderson 1978).

Harvest of largemouth bass in Calaveras Reservoir was determined by an on-site angler creel survey conducted during February through April, 1980–84 and 1986–87. The survey period was stratified by weekends and week days, and 5 weekend days and 4 week days were selected at random in each survey period. On each survey day, creel clerks conducted angler interviews between sunrise and sunset, 1980–84; the sample period was reduced to a randomly selected 6-hour interval, 1986–87. Creel clerks stationed at randomly selected boat ramps interviewed anglers upon their return from completed fishing trips. Creel clerks recorded species, number, and weight of all fish harvested and the number of anglers in each fishing party. Anglers also were asked which species they were seeking that day (to determine directed pressure) and the creel clerk recorded up to 3 responses. Creel clerks asked anglers when they began fishing that day, and trip length was estimated as the time from the beginning of the fishing trip to the end. Beginning in 1986, creel clerks asked anglers to recall the duration of their fishing trip rather than time they started fishing as described by McEachron et al. (1986). In 1986, creel clerks also began recording individual lengths of largemouth harvested and asked anglers how many legal and illegal-sized fish they caught and released. Fishing pressure was estimated from 3 angler counts taken at random times in randomly selected areas of the reservoir. Pressure and harvest estimates were calculated by methods presented in Lambou (1961).

Incremental RSD's (the percentage of stock length fish in each length group from electrofishing samples) were used for statistical analysis. Size structure indices evaluated before and after implementation of the slot length limit included RSD's below, within and above the slot length limit. Analysis of covariance (ANCOVA) was performed on incremental RSD values (as proportions) to test the hypothesis of no significant change in RSD of largemouth bass over years. Reservoirs were included as the covariates to test the null hypothesis of no reservoir by year interaction, which would indicate that annual trends in RSD were similar between the 2

reservoirs. Incremental RSD values in each year were weighted by the reciprocal of their variances. Where data were not collected (or recorded) by sample sites, variance estimates were based on binomial proportions. Otherwise, RSD and variance estimates were based on total ratio estimators (Cochran 1977).

Results and Discussion

Incremental RSD values were distributed normally among years except for $RSD_{356-457}$ (Shapiro-Wilk statistic, SAS 1985). Because arcsine square root transformation applied to RSD values did not reduce the data skew, untransformed RSD values were used in subsequent statistical tests.

There was no significant ($P > 0.05$) interaction between reservoirs and year for RSD in any size group tested, indicating that trends in RSD over years were similar in Calaveras and Monticello reservoirs. Analysis detected significant ($P < 0.01$) linear trends in incremental RSD over time as $RSD_{203-355}$ decreased from 1980 to 1987 (Fig. 1).

The slot length limit effectively restructured the bass populations at both reservoirs. The proportion and density of small largemouth bass decreased. Before the slot length limit was implemented, mean $RSD_{203-355}$ was 73 and 84 in Calaveras and Monticello reservoirs, respectively. Afterwards, the mean $RSD_{203-355}$ was 35 in both reservoirs. Mosher (1986) reported similar decreases in RSD of largemouth bass below a slot length limit of 12–15 in (305–381 mm) at 9 of 13 Kansas lakes.

In Monticello Reservoir, the CPUE of largemouth bass below the slot length limit decreased and the CPUE of fish within and above the slot length limit increased. A declining CPUE for largemouth bass ≤356 mm indicated a reduced density for fish below the slot length limit (Table 1). Similarly, Gabelhouse (1987) noted electrofishing CPUE decreased for stock to quality (203–302 mm) largemouth bass following implementation of a slot length limit of 30–38 cm in a Kansas pond.

The proportion and numbers of intermediate and larger sized largemouth bass increased after the slot length limit was implemented. $RSD_{356-457}$ values increased significantly ($P < 0.01$) in both reservoirs (Fig. 1). Mean $RSD_{356-457}$ was 25 in Calaveras Reservoir and 14 in Monticello Reservoir in years prior to implementation of the slot length limit. Afterwards, these values increased to 53 for Calaveras Reservoir and 52 for Monticello Reservoir. Mosher (1986) similarly reported increased RSD for largemouth bass within a slot (305–381 mm) in 8 of 13 Kansas lakes. Summers (1988) also noted an increase in RSD_{356} following implementation of a 300- to 381-mm slot length limit.

The proportion of largemouth bass larger than 457 mm also increased significantly ($P < 0.01$) in both reservoirs (Fig. 1). Prior to implementation of the slot length limit, RSD_{457} was 2 for both Calaveras and Monticello reservoirs. This value increased to 12 for Calaveras Reservoir and 13 for Monticello Reservoir. These changes were similar to findings reported by Eder (1984) where RSD_{15} (RSD_{381}) increased significantly following implementation of a slot length of 305–378 mm on Watkins Mill Lake, Missouri.

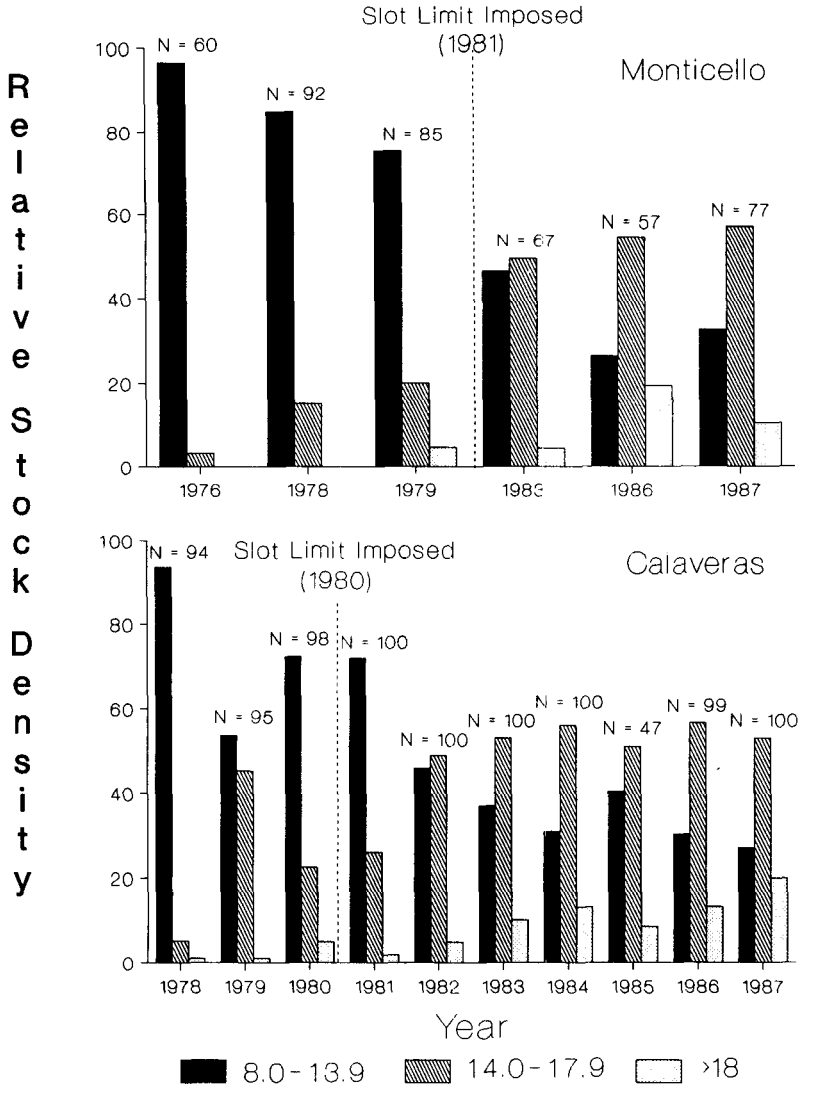

Figure 1. Relative stock density (RSD) of 203–355 mm, 356–457 mm, and ≥457 mm largemouth bass collected during spring electrofishing surveys at Monticello Reservoir, Titus County, Texas, and Calaveras Reservoir, Bexar County, Texas. Surveys at Monticello were conducted after dark; those at Calaveras were conducted during daylight hours. Dashed vertical line indicates time of implementation of a 356- to 457-mm slot length limit on largemouth bass. Bag limit was reduced from 10 to 5 in September 1985 at both reservoirs.

Table 1. Catch per unit effort (*N*/hour) of largemouth bass by length group collected by nighttime spring electrofishing before (1976–79) and after (1983–87) implementation of a 356–457-mm slot length limit at Monticello Reservoir, Titus County, Texas.

Year	Effort (hour)	Length group			Total
		203–355	356–457	≥457	
1976	1.25	46.4	1.6	0.0	48.0
1978	2.00	39.0	7.0	0.0	46.0
1979	1.00	64.0	17.0	4.0	85.0
1983	1.25	24.8	26.4	2.4	53.6
1986	1.25	12.0	24.8	8.8	45.6
1987	1.25	20.0	32.0	9.6	61.6

Increases in density for largemouth bass within and above the slot length limit at Monticello Reservoir were indicated by increased CPUE for fish 356–457 mm and ≥457 mm (Table 1). Gabelhouse (1987) reported similar increased CPUE for largemouth bass within and above a slot length limit in a Kansas pond. Summers (1988) also reported an increased catch rate for largemouth bass above a slot length limit of 300–381 mm at Arbuckle Reservoir in Oklahoma.

These changes in population structure appeared to have no impact on total abundance of stock-size largemouth bass in Monticello Reservoir (Table 1). An apparent increase in numbers of stock-sized individuals was observed in 1979, before implementation of the slot length limit. This increase was attributed to sampling error since catch rates increased for all size groups; proportions were consistent with those from previous years' samples. Results differ from those of Eder (1984) who reported a decrease in the abundance of ≥177-mm largemouth bass under a slot length limit of 305–378 mm at Watkins Mill Lake, Missouri.

Initially, Calaveras anglers acceptance of the slot length limit appeared to be poor as directed fishing pressure declined 62% from that observed under the 254-mm minimum length limit (Table 2). By 1987, directed fishing pressure returned to levels equal to those observed before the slot length limit was imposed. Changes in angler perception and directed pressure may be in part related to changes in largemouth bass population structure. However, Eder (1984) stated that fishing pressure did not increase after the largemouth bass population improved under a 305–378-mm slot length limit at Watkins Mill Lake, Missouri.

The initial decrease in mean weight together with increased numbers of largemouth bass harvested (Table 2) indicated the majority of largemouth bass harvested were <356 mm. The year after the slot length limit was imposed, the mean weight of largemouth bass harvested decreased 81% while harvest by number increased 95%. Total weight of largemouth bass harvested decreased 60% during the same period. Eder (1984) reported that 98% of the harvest at Watkins Mill Lake was comprised of fish <305 mm long after implementation of a slot length limit of 305–

Table 2. Harvest and pressure statistics by anglers seeking largemouth bass in Calaveras Reservoir, Bexar County, Texas, February–April. Standard errors in parentheses. Slot length limit imposed November 1980.

Year	Kg/bass	*N*/ha	Kg/ha	Hours/ ha
1980	0.74	7.98	5.50	73.63
	(0.08)	(2.07)	(1.60)	(9.71)
1981	0.14	15.54	2.18	56.44
	(0.00)	(2.35)	(0.28)	(5.76)
1982	0.21	7.51	1.59	54.69
	(0.02)	(1.61)	(0.31)	(6.89)
1983	0.82	0.69	0.60	27.34
	(0.16)	(0.44)	(0.39)	(9.29)
1984	1.20	4.89	5.78	66.87
	(0.08)	(1.28)	(1.30)	(10.77)
1986	1.25	5.19	6.43	79.19
	(0.07)	(1.21)	(1.52)	(15.02)
1987	2.03	2.79	5.66	74.03
	(0.08)	(0.94)	(1.90)	(21.24)

378 mm. These results differed somewhat from Gabelhouse (1987) who reported Kansas anglers were unwilling to harvest largemouth bass <30 cm long.

Improvement in size structure of the Calaveras Reservoir largemouth bass population was accompanied by an increase in the mean weight of largemouth bass harvested. From 1980 to 1987 the mean weight of largemouth bass harvested increased from 0.74 kg to 2.03 kg (Table 2). By 1987, total weight harvested was equivalent to that observed before the slot length limit was imposed and is attributed to the harvest of larger bass (Table 2). Eder also found that total harvest (weight) increased after a slot length limit was imposed and the quality improved as the harvest of largemouth bass ≥381 mm long increased from 1 to 5 fish/acre. During 1986 and 1987, largemouth bass anglers at Calaveras Reservoir reported they caught and released 1.4 and 3.0 largemouth bass, respectively, for every largemouth bass harvested. In addition, the majority of fish caught-and-released were in the slot-size range (69% in 1986; 82% in 1987).

During 1980–84 creel surveys on Calaveras Reservoir, <1% of the anglers that caught fish harvested ≤5 largemouth bass under the 10-fish daily bag limit. The highest percentage occurred in 1981 when anglers were first allowed to harvest the surplus of largemouth bass under 356 mm. During 1981–84 an estimated 11% of the anglers accounted for almost 75% of the largemouth bass harvest under the slot length limit with a 10-fish daily bag limit. The percentage of anglers that caught at least 5 largemouth bass decreased each year after 1984. During 1986–87, after the daily bag limit was reduced to 5 largemouth bass, no anglers were observed with a 5 fish limit and 75% of the largemouth bass harvest was attributed to only 7% of the anglers. In Calaveras Reservoir, no increase in the proportion of anglers catching a

limit or a redistribution of the harvest among more anglers was observed. However, lack of bass density information makes interpretation of bag limit impacts more difficult. For example, if recruitment were limited after the harvest of surplus bass below the slot length limit, population densities would remain lower than pre-regulation levels and the chances of harvesting a bass would decrease because fewer bass would be available for harvest. If bass population densities had declined, then a lower bag limit may cushion the impact of a restrictive length limit by maintaining the distribution of harvest among anglers, but a limit significantly lower than 5 fish per day would be necessary to affect the proportion of anglers harvesting fish on Calaveras Reservoir. A reduced bag limit may lower the expectations of anglers who view them as a standard to judge fishing success. If anglers believe a reduced limit is an attainable standard, they may perceive that fishing has improved even when they catch the same number of largemouth bass.

The regulation effectively restructured the size distribution of largemouth bass populations in both reservoirs studied. Largemouth bass densities in Monticello Reservoir were maintained under the slot length limit. Without density data, the improved size structure on Calaveras Reservoir can not be attributed exclusively to the growth of small fish into protected size ranges. However, mean weight of largemouth bass harvested increased as expected after the slot length limit was imposed. Fishing pressure for bass also returned to pre-regulation levels after a brief decline, indicating that anglers may have perceived the fishery to be at least as good as before the regulation was imposed. Carefully chosen slot length limits seem to be effective for improving the quality of largemouth bass fishing in larger reservoirs.

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