Evaluation of a 356- to 457-mm Slot Length Limit for Largemouth Bass in 5 Texas Reservoirs

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Abstract: Following 6 years under a 356-mm minimum length limit regulation, poorly-structured largemouth bass populations at 5 Texas reservoirs were placed under an experimental 356- to 457-mm slot length limit in September 1993. The limit was designed to target angler harvest at the relatively abundant sub-slot fish and to increase angler catch rates within the protected length range. Largemouth bass populations were monitored at each reservoir by electrofishing at 4–8 shoreline stations in 1989–1992 (pre-change) and in 1995–1996 (post-change). A general linear model statistical procedure was used to determine any significant changes ($P = 0.05$) in the CPUE or RSD for fish below (203–355 mm), within (356–456 mm), or above the slot (≥457 mm) following implementation of the limit. Pre- and post-change Wr of fish below and within the slot as well as mean lengths of age groups at capture also were compared. In addition, spring creel surveys were conducted from 1993 to 1997 at 1 of the reservoirs. Significant changes in density were detected at only 2 reservoirs where $CPUE_{203-355}$ and $CPUE_{356-456}$ were significantly lower at one and $CPUE_{356-456}$ was significantly higher at the other following implementation of the slot length limit. No significant changes in RSD values were found at any reservoir. Relative weight did not improve following the limit change. Results from the creel survey showed angler harvest of sub-slot fish was low, but did increase during the third and fourth year after the slot length limit was imposed when primarily 304–340-mm were harvested. Low fishing pressure and harvest of sub-slot bass most likely prevented the slot limit from producing the desired results at the creel reservoir and probably caused the failure at other study reservoirs as well. Other factors not related to the regulation could have potentially influenced population structure at any of the reservoirs.

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Slot length limits have been used successfully in many situations to restructure largemouth bass populations (Anderson 1976, Eder 1984, Mosher 1986, Gabelhouse

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1987, Summers 1988, Dean et al. 1991). A slot length limit is designed to protect a specific length range while allowing harvest below and above the slot length. The slot length limit is commonly used on populations where fish have "stockpiled" under a minimum length limit. Effectiveness of the regulation requires adequate harvest below the slot length range to improve growth and recruitment into the protected length range (Gabelhouse 1984). Angler acceptance and compliance, therefore, are important management considerations before implementation of these regulations. Navary (1982) reported that anglers would not harvest fish below a 275- to 381-mm slot length limit in Mississippi, thereby limiting the effectiveness of the regulation. Similar situations also were noted in 6 Kansas lakes under a 300- to 381- slot length limit (Gabelhouse 1984, 1987). Other investigators have observed high harvest under 356- to 457-mm (Dean et al. 1991) and 305- to 378-mm slot length limits (Eder 1984). Gabelhouse (1984) stated that overharvest of bass below higher slot length limits could occur if angler harvest of the larger, more desirable sub-slot fish was high.

Largemouth bass populations in 5 Texas reservoirs—Bridgeport, Weatherford, Striker, Tyler State Park, and Georgetown—were placed under 356-mm minimum length and 5-fish bag limits in 1986. Electrofishing surveys from 1989 through 1992 revealed poorly structured largemouth bass populations with most bass <356 mm and generally displaying low condition indices. Populations were considered low- to moderate-density and their growth only average (Prentice and Durocher 1978) for ecological regions inhabited. These reservoirs were placed under experimental 356- to 457-mm slot length and 3-fish daily bag limits in September 1993. The daily bag limit was increased to 5 fish in September 1994.

The purpose of the slot length limit was to increase recruitment of fish to lengths ≥356 mm by allowing harvest of fish <356 mm. The limit was not intended to produce trophy bass at these reservoirs, but to provide anglers the opportunity to harvest fish <356 mm and ≥457 mm and to increase the catch rates of fish ≥356 mm. The regulation change would be considered successful if population densities increased significantly ($P \leq 0.05$) in the protected length range.

The objective of this study was to determine the effects of the 356- to 456-mm slot length limit on largemouth bass population densities, stock structural indices, and growth rates in reservoirs displaying similar structural imbalances but located in different ecological regions.

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Methods

Study reservoirs were located in the Post Oak Savannah ecological region of north central Texas (Bridgeport, 5,261 ha; and Weatherford, 463 ha), the Piney

Woods ecological region of east Texas (Striker, 971 ha; and Tyler State Park, 160 ha), and the Edwards Plateau ecological region of central Texas (Georgetown, 530 ha).

Largemouth bass populations in the 5 study reservoirs were sampled with Smith-Root GPP 5.0 electrofishing units. Standardized fall electrofishing surveys were conducted in 1989 and 1991–1996 and a summer survey was conducted on Tyler State Park in 1989. Standardized sample stations were selected to be representative of available shoreline habitats. All surveys were conducted at night. Stations were sampled annually on each reservoir (4–8 stations, according to size) and effort was 0.25 hour/station. Collected largemouth bass were measured (mm total length, TL) and weighed (g). Pre-regulation change data were collected on Bridgeport in 1991 and 1992, on Weatherford and Tyler State Park in 1989 and 1992, and on Georgetown and Striker in 1991 and 1992. Post-regulation change data were collected on all reservoirs in 1995 and 1996 except for Tyler State Park (1996 only). CPUE (number of largemouth bass/electrofishing hour) and Relative Stock Density (RSD; Anderson and Gutreuter 1983) were used to determine relative densities and proportions of 203- to 355-mm ($CPUE_{203-355}$, $RSD_{203-355}$), 356- to 456-mm ($CPUE_{356-456}$, $RSD_{356-456}$), and ≥457-mm ($CPUE_{457}$, RSD_{457}) length groups in population samples. Condition of bass in the 203- to 355-mm and 356- to 456-mm length groups was determined with the relative weight index (Wr; Wege and Anderson 1978).

A stratified sub-sample of largemouth bass ($N \geq 30$, 5/25-mm group) was taken each year for age and growth analysis. Age was determined by examination of whole otoliths or scales. Mean TL at capture was calculated for each age group.

Pre- and post-regulation estimates of mean length at age, Wr, CPUE, and RSD were compared at each reservoir with the general linear model procedure (SAS Inst. 1988). CPUE and RSD data were transformed with a log (N+1) and an arcsine-square root transformation, respectively. Significance was set at the $\alpha = 0.05$ level.

In addition to largemouth bass population sampling, roving creel surveys were conducted at Striker on 5 weekend days and 4 weekdays from 1 March to 31 May 1993–1997. Estimates of largemouth bass harvest rates (fish/hour), total catch rates (fish/hour), directed fishing effort (hours/ha), length and weight of harvested fish, and estimated lengths of released fish were determined from standardized, stratified, random creel surveys. Creel surveys were conducted in accordance with TPWD Inland Fisheries assessment procedures (TPWD 1993).

Results and Discussion

Following implementation of the slot length limit, significant changes in CPUE were detected at only 2 of the reservoirs with the exception being Georgetown, where $CPUE_{203-355}$ and $CPUE_{356-456}$ declined significantly and Weatherford, where $CPU_{356-456}$ increased significantly (Table 1). CPUE was unusually low at Georgetown and may not have been representative of the population density. This may have been due to the effects of a drought-related water level decline on bass distribution in the reservoir as noted by Colle et al. (1989) at a Florida lake or length distribution in the population as observed by Paller (1997) at a South Carolina reservoir. The

Table 1. Summary of largemouth bass population data collected during fall electrofishing at 5 Texas reservoirs, 1989–1992 (pre-regulation) and 1995–1996 (post-regulation). Length groups (mm) are 203–355 (L1), 356–456 (L2), and ≥457 (L3). Length group values for each reservoir were pooled across each regulation period and the hypothesis of no significant difference between pre- and post-regulation period was tested ($\alpha = 0.05$). *N* = total catch ≥ 203 mm. CPUE = Catch/hour.

		Relative stock density			CPUE			Relative weight	
Reservoir year	*N*	L1	L2	L3	L1	L2	L3	L1	L2
Bridgeport									
1991	63	87	11	2	41.35	4.51	0.75	95.0	92.3
1992	141	88	11	1	62.50	8.00	0.00	85.8	83.3
1995	108	90	10	0	45.00	5.00	0.00	71.6[a]	79.0
1996	69	84	13	3	38.67	4.50	1.33	79.1[a]	86.9
Striker									
1991	83	93	7	0	51.31	4.00	0.00	96.6	95.3
1992	65	89	11	0	30.67	4.61	0.00	72.2	77.5
1995	46	85	11	4	30.67	3.33	1.33	80.8	83.1
1996	39	95	5	0	26.67	1.33	0.00	89.8	92.3
Tyler State Park									
1989	74	95	5	0	70.00	4.00	0.00	87.5	86.1
1992	90	99	1	0	89.00	1.00	0.00	87.6	86.0
1996	113	99	1	0	112.00	0.50	0.00	70.0[a]	
Weatherford									
1989	112	89	10	1	66.67	7.33	0.66	88.7	88.7
1992	35	77	12	11	18.00	2.67	2.67	79.2	89.3
1995	160	74	22	4	86.00	24.00[a]	4.00		
1996	61	71	21	8	28.67	8.67[a]	3.33	84.0	92.7
Georgetown									
1991	93	94	5	1	87.00	5.00	1.00	81.1	87.0
1992	176	89	9	2	104.67	10.00	2.67	94.0	98.5
1995	50	90	10	0	30.00[a]	3.33[a]	0.00	85.3	87.6
1996	42	96	2	2	26.67[a]	0.67[a]	0.67	82.2	90.5

a. Significant change from pre-regulation period.

change at Weatherford likely reflects a sampling anomaly. No significant changes in RSD values were found at any study reservoir. The change in length limits failed to shift the distribution of fish into the protected length range at any of the study reservoirs with the possible exception of Waterford. Populations at these reservoirs remained poorly structured with most fish <356 mm. Sub-slot fish at Bridgeport and Tyler State Park were predominately 254–330 mm in length following implementation of the slot limit (Fig. 1) suggesting under-exploitation by anglers. Anglers may harvest only the largest of the sub-slot fish at these reservoirs. Novinger (1990) found anglers fishing at slot limit-regulated impoundments in Missouri released 45% of their legal catch of largemouth bass <305mm.

Wr did not improve under the slot length limit regulation at any of the study reservoirs. Post-regulation change Wr values for 203- to 355-mm fish at Bridgeport and

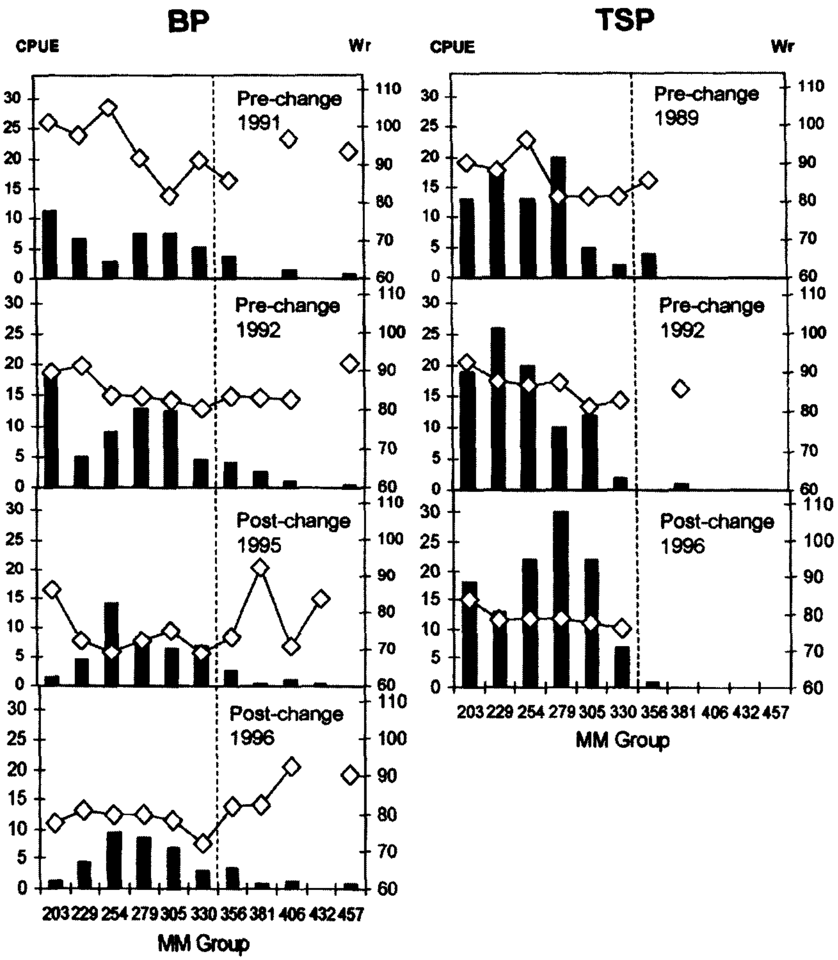

Figure 1. Length-frequency distribution (bars) and relative weight (Wr, diamonds) of largemouth bass (≥ 203 mm) collected during electrofishing sampling at Bridgeport (BP) and Tyler State Park (TSP) reservoirs, Texas.

Tyler State Park were significantly lower ($P = 0.01$) than pre-regulation change values (Table 1). The more abundant 229- to 330-mm group had the most pronounced decline (Fig. 1). Wege and Anderson (1978) found the relative densities of largemouth bass 203–304 mm in 18 Midwestern ponds were negatively correlated with the Wr of largemouth bass <381 mm. The presence of a dominant length group in generally poorer condition than the overall population suggests intense competition for available forage. Recruitment into the larger length classes would be limited under these conditions. Martin (1995) evaluated a 300- to 380-mm slot length limit on largemouth bass at Andrew Lake, Delaware, and found recruitment was lowest when CPUE of 201- to 300-mm fish peaked.

Following implementation of the slot length limit, no significant changes in growth occurred on Georgetown, Bridgeport, Weatherford, or Tyler State Park. At Striker, largemouth bass mean length at age 2 (339 mm) increased significantly (P = 0.02) from pre-change years (302 mm; Fig. 2). Some factor other than the regulation may have been responsible for this increase in growth since population structure and condition indices at Striker showed no significant changes. However, another possibility is angler harvest of the larger sub-slot length fish improved growth of age-2 fish without affecting recruitment. Post-change growth of age-2 fish also increased at Tyler State Park but the change was not significant (P = 0.06) and no significant change in structure or improvement in condition was detected. Eder (1984) noted age-2 and -3 fish (203–302 mm) at Watkins Mill Lake, Missouri, were the most vulnerable to angling under a 302–378-mm slot length limit.

Because largemouth bass populations at Striker and other study reservoirs prior to the regulation change were considered low- to moderate-density and primarily distributed below 356 mm, a major concern was whether legalizing harvest of most of the population would severely deplete their numbers. Spring creel surveys at Striker revealed a slight decline in harvest rates, from 0.04 to 0.02 fish/hour, in each of the

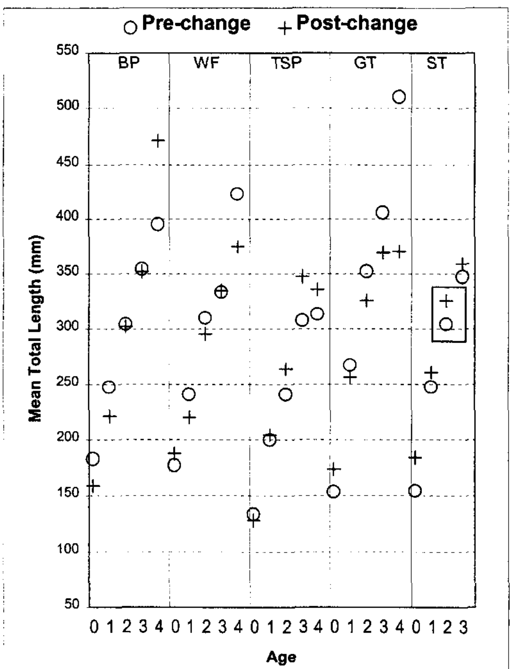

Figure 2. Age and mean length at capture for sub-sampled largemouth bass collected during fall electrofishing at Bridgeport (BP), Weatherford (WF), Tyler State Park (TSP), Striker (ST), and Georgetown (GT) reservoirs, Texas, 1988–1993 (pre-regulation change) and 1994–1996 (post change). Significant change enclosed by rectangle.

first 2 years under the slot limit. Anglers released a high percentage (92%) of their sub-slot fish catch in 1994, either because of their unwillingness to harvest small fish or because they were unaware of the regulation change. In 1996 and 1997, harvest rates increased to 0.14 and 0.13 fish/hour, respectively, suggesting better angler acceptance of sub-slot fish. Anglers kept primarily larger sub-slot fish ≥305 mm in 1996 and 1997. Total catch rate increased the first spring (1.04 fish/hour) under the slot length limit as anglers caught and released sub-slot fish, but declined the following year (0.66 fish/hour) and remained lower throughout the study (Table 2). Catch rate of slot-length fish was low each spring indicating, as did the structural and CPUE data, that increased recruitment into the protected length range did not occur. The mean weight of fish harvested the first year under the slot length limit (0.30 kg) was approximately 60% smaller than that (0.71 kg) under the minimum length limit. Following this initial decline, mean weight of harvested fish increased to 0.45 kg by the end of the study period. Angler compliance was good during the entire study except in 1997 when 16.6% of bass harvested were within the protected length range (Table 2). These fish were just over 356 mm in length suggesting illegal harvest was not intentional.

Directed fishing effort at Striker prior to and following the limit change did not change to a great extent (range 2.99–5.83 hours/ha) and would be considered low. Springtime directed effort for largemouth bass at Lake Calavaras, Texas, where a 356- to 457-mm slot length limit successfully restructured the population, ranged from 27.34 to 79.19 hours/ha during a 7-year study (Dean et al. 1991). Considering the post-change harvest rate at these pressure levels and the relatively unchanged population structure at Striker, it is unlikely over-harvest occurred. It is more likely that sub-slot fish were under-harvested during this study resulting in little or no effect on the Striker largemouth bass population. The extent of angler harvest on sub-slot fish at study reservoirs other than Striker was not assessed. Properly designed creel surveys can provide valuable insight about a regulation but may not be practical at some of the lesser-utilized reservoirs due to budgetary and labor constraints. Also,

Table 2. Creel estimates for anglers seeking largemouth bass (SE in parentheses) at Striker Reservoir, Texas, March–May, 1993–1997.

Creel parameter	1993[a]	1994	1995	1996	1997
Harvest rate (fish/hour)	0.04	0.02	0.02	0.14	0.13
	(0.030)	(0.015)	(0.011)	(0.038)	(0.045)
Mean weight (kg/fish)	0.71	0.30	0.32	0.47	0.45
	(0.123)	(0.036)	(0.695)	(0.021)	(0.064)
Total catch (fish/hour)	0.84	1.04	0.66	0.67	0.35
	(0.110)	(0.385)	(0.190)	(0.211)	(0.078)
Hours/ha seeking bass	5.73	4.40	5.83	2.99	5.21
	(0.795)	(0.524)	(0.048)	(0.401)	(0.582)
Percent anglers seeking	60	52.60	74.90	51.30	48.50
	(8.316)	(6.933)	(5.970)	(11.446)	(13.997)
Illegal harvest (%)	4.10	0.00	0.00	0.00	16.60

a. Pre-regulation change.

because there were no angler opinion and attitude surveys on any study reservoirs, it was not known if anglers were satisfied with the slot length limit regulation despite its apparent failure to restructure populations. At Striker, none of the anglers interviewed by creel clerks expressed dissatisfaction with the limit.

As with any population assessment, various factors in this study could have potentially affected results. Because assessments were conducted in the fall, there exists the possibility that CPUE of the larger adult fish would have been less than in spring months when fish may have been more vulnerable (Carline et al. 1984). Fall surveys were considered advantageous, however, from the standpoint of obtaining CPUE and Wr estimates with the most efficient use of manpower and resources. Variance of estimates was high at some sites likely due to the relatively small sample sizes. Some loss in sampling accuracy would be expected in these situations along with the increased likelihood that statistical tests would fail to detect a true change. Some of the study reservoirs where CPUE was low may have needed additional sampling to provide more reliable estimates as observed by Miranda et al. (1996). They stated that variance may be affected by variables other than CPUE including short-term and seasonal climatic variability and degree of habitat heterogeneity within a reservoir. Scales instead of otoliths were used as aging structures at 2 study reservoirs to avoid sacrificing fish. While aging errors are more likely with scales (Devries and Frie 1996), this probably did not affect comparisons because samples contained relatively young fish (≤ 4 years), which intuitively would be the easiest to age accurately. Considering the population characteristics of study reservoirs throughout the investigation, other factors not related to the regulation may have influenced population structure. Those thought by management biologists to have the greatest potential for impact were water clarity at Tyler State Park (K. W. Storey, pers. commun.), water level and habitat conditions at Georgetown (D. R. Terre, pers. commun.), and the relatively abundant spotted bass population in Striker (Parks and Seidensticker 1996). Since it was beyond the scope of this study to assess these factors, the contribution of each, if any, towards the failure of the regulation at each reservoir was not ascertained.

Management Implications

The change from a 356-mm minimum length limit to a 356- to 457-mm slot length limit failed to restructure populations at study reservoirs and the desired result of increasing the density of fish within the protected length range was not achieved. There were positive aspects to the regulation, however, as anglers had the opportunity to harvest a large portion of the population at these reservoirs that they would not have under the minimum length limit. Protection of the larger size fish in the population may also improve reproductive success as reported by Goodgame and Miranda (1993). Results at Striker indicated angler harvest of sub-slot fish was not sufficient for the limit to be effective. Based on population structure and condition values, this was suspected at other study reservoirs as well. Insufficient harvest of sub-slot fish has also been observed where lower limits have been imposed (Gabelhouse 1984, Navary 1982). Results from this study and others (Martin 1995, Summers 1988) show slot length limits will not produce the desired results on reservoirs with poorly structured bass populations if fishing pressure and harvest of sub-slot fish is low. Angler education programs, as well as an analysis of angler expectations, may need to be initiated prior to the implementation of the limit to determine the chances of success. Martin (1995) reported anglers would not retain sub-slot fish on a Delaware pond despite substantial educational effort. Other measures such as youth education programs, alternative regulations, or other means of harvest may need to be investigated.

While length limit regulations are effective tools to manipulate population structure, biotic or environmental factors not related to the regulation also may exert an influence. If these factors are severe, corrective measures may be essential to improve population structure, although in some situations not practical or cost-effective. Extreme environmental conditions, such as the drought-related water level reduction at 1 study reservoir, may give a false indication of the regulation's impact. Regulation investigations should be of sufficient duration to allow for variability from these types of events.

As a result of this study, a change in length limit regulation was proposed for Striker, Weatherford, and Tyler State Park to the statewide 356-mm minimum length limit effective 1 September 1999. The slot length limit was left in place at Bridgeport and Georgetown where sampling subsequent to the study revealed a significant improvement in population structure.

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