Response by anglers to a differential harvest regulation on three black bass species at Skiatook Lake, Oklahoma

James M. Long
U.S. Geological Survey, Oklahoma Cooperative Fish and Wildlife Research Unit, Natural Resource Ecology and Management, 007 Agriculture Hall, Oklahoma State University, Stillwater, OK, 74078

Randy G. Hyler
Department of Zoology, Oklahoma State University, Stillwater, OK, 74078
Present address: Iowa Department of Transportation, Office of Location and Environment, 800 Lincoln Way, Ames, IA 50010.

William L. Fisher
U.S. Geological Survey, Oklahoma Cooperative Fish and Wildlife Research Unit, Natural Resource Ecology and Management, 007 Agriculture Hall, Oklahoma State University, Stillwater, OK, 74078
Present address: U.S. Geological Survey, New York Cooperative Fish and Wildlife Research Unit, Fernow Hall, Cornell University, Ithaca, NY 14853.

Angler responses to a differential harvest regulation on black bass, *Micropterus* **spp. at Skiatook Lake, Oklahoma was assessed from 1997 to 1999. This regulation allowed anglers to harvest 15 spotted bass,** *M. punctulatus* **(Rafinesque) of any size and six largemouth bass,** *M. salmoides* **(Lacepède) and smallmouth bass,** *M. dolomieu* **Lacepède greater than 356 mm (in aggregate) per day. Anglers' ability to differentiate spotted bass increased after the first year of the study, but their willingness to target or harvest spotted bass declined. Mean angler catch rates (number of fish per angling hour) for all three species remained steady throughout the study. Total harvest of largemouth bass and smallmouth bass was reduced by 1999 while total harvest of spotted bass remained steady throughout the study period. Despite the more liberal regulations as incentive, the regulation failed to accomplish the primary objective of increasing angler harvest of spotted bass because of high rates of voluntary catch and release.**

INTRODUCTION

Size limits are popular among fisheries management agencies to affect changes to the population structure of sport and forage fish (Fox 1975; Novinger 1984; but see Wilde 1997). In the southeastern USA, many reservoirs contain a combination of black bass species *Micropterus* spp., such as largemouth bass, *M. salmoides* (Lacepède), smallmouth bass, *M. dolomieu* Lacepède, and spotted bass, *M. punctulatus* (Rafinesque) that are managed concurrently, often with a common minimum size limit. However, some fisheries biologists (Kornman 1990; Buynak et al. 1991; Buynak 1995) have found that certain species, especially spotted bass, tend to "stockpile" (an overabundance of small individuals) under minimum-size limits.

With a common minimum-size limit and subsequent stockpiling, density-dependent processes, such as competition for resources, result in slower growth and a decrease of larger fish in the fishery. As a result, Novinger (1987) suggested the use of a differential black bass harvest regulation to control the abundance of slow-growing spotted bass. For such a regulation to work,

however, anglers have to be able to correctly identify each black bass species.

Differential black bass harvest regulations have rarely been used, presumably because anglers have difficulty correctly identifying spotted bass. However, such a regulation was successfully implemented on black bass in Cave Run Lake, Kentucky (Buynak et al.1991), and subsequently statewide (Buynak 1995), by using presence of a tooth patch on the tongue to differentiate between largemouth bass and spotted bass. Although 10% of the largemouth bass in Cave Run Lake also had a tooth patch, Buynak (1995) presumed that informing anglers of the tooth patch characteristic to distinguish spotted bass from largemouth bass was sufficient information to allow them to distinguish the two species. Buynak et al. (1991) found the number of largemouth bass that anglers misidentified as spotted bass to decrease in the years following the regulation change. As a result, the differential harvest regulation at Cave Run Lake was considered very successful because it met the goals of increased spotted bass harvest, decreased largemouth bass harvest, and increased largemouth bass population abundance (Buynak et al. 1991; Buynak 1995).

At Skiatook Lake, Oklahoma fisheries biologist with the Oklahoma Department of Wildlife Conservation (ODWC) noticed a dramatic increase in the number of the spotted bass beginning in 1992 (ODWC 1995). A differential harvest regulation, aimed at increasing the number of spotted bass harvested by anglers while minimizing harvest of largemouth bass and smallmouth bass, was implemented in 1997 (Long 2000). Modeled after the successful example at Cave Run Lake, Kentucky (Buynak et al. 1991), spotted bass at Skiatook Lake were defined as any black bass species that had a tooth patch on the tongue and was not a smallmouth bass. Beginning in 1997, anglers at Skiatook Lake could harvest up to 15 spotted bass of any size per day whereas only six, in aggregate, largemouth bass and smallmouth bass ≥ 356-mm TL could be harvested per day. Previously, all black bass had to be ≥ 356-mm TL to be harvested at the rate of six, in aggregate, per day. The objectives of this study were to estimate catch and harvest of black bass and to evaluate the attitudes and opinions of anglers after implementation of the differential harvest regulation on black bass at Skiatook Lake, Oklahoma.

METHODS

Study site

Skiatook Lake is a 4,266-ha flood control reservoir, created in 1984 when the U.S. Army Corps of Engineers (USCOE) impounded Hominy Creek, and is located 8 km west of Skiatook, Oklahoma (ODWC 1995) (Figure 1). The lake was filled in stages from October 1984 to July 1989 to increase productivity (ODWC 1995) and public fishing was allowed beginning in May 1986. Largemouth bass occurred naturally, but were supplementally stocked during (1985-1986) and after (1990-1991) reservoir filling and non-native smallmouth bass were stocked in 1990 and 1991 (ODWC 1995; Long and Fisher 2005). Spotted bass occurred naturally in the system and were not stocked.

Fishing is one of the most popular recreational activities on Skiatook Lake and fishing pressure from black bass tournament anglers is particularly high (ODWC 1995). Most angler effort on Skiatook Lake is directed toward black bass and crappie, *Pomoxis* spp. (Zale and Stubbs 1991). Fish habitat in Skiatook Lake is characterized by deep clear water with steep rocky shorelines, particularly in the lower end of the lake, with abundant standing and fallen timber (Long and Fisher 2006). Skiatook Lake is highly dendritic, with 257 km of shoreline and a shoreline development index of 11.3, a mean depth of 9.7 m, and a maximum depth of 31 m (ODWC 1995). The trophic state of the lake ranges from oligotrophic near the dam to eutrophic at the

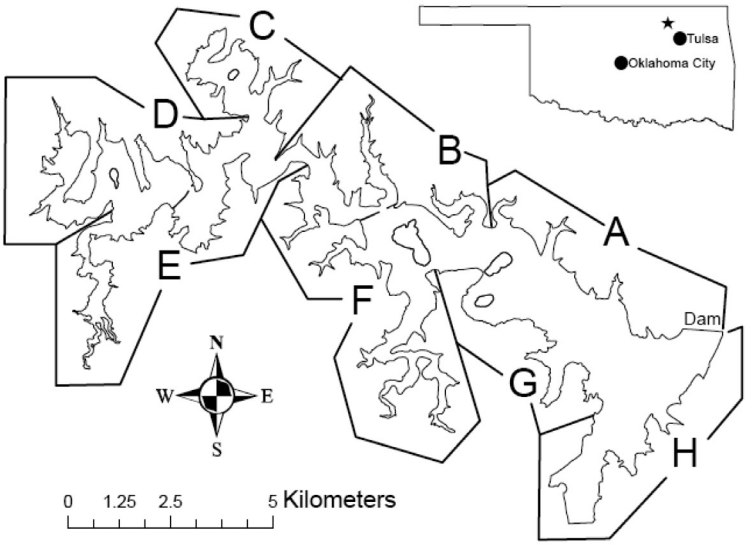

Figure 1. Creel survey sections (A-H) at Skiatook Lake, Oklahoma used from 1997 to 1999 to document angler attitudes toward a differential harvest regulation on black bass. The star indicates the approximate location of Skiatook Lake in the state.

upper end (Long and Fisher 2006) and the resident black bass community segregates according to these trophic states (Long and Fisher 2005); largemouth bass were uniform in abundance across the lake, spotted bass were more abundant in the eutrophic upper end, and smallmouth bass were more abundant in the oligotrophic lower end.

Creel survey

To assess angler attitudes and to monitor catch and harvest after implementation of the differential harvest regulation, a two-stage probability roving creel survey was used (Robson 1991) with intercept-interviews of anglers conducted by boat. Sampling effort was allocated by month (March-October) and day type (weekdays and weekend days) and time of day was randomly selected for sampling (Pollock et al.1994; Malvestuto and Hudgins 1996) (Table 1). Additionally, because a large proportion of effort was expected to come from fishing tournaments and holidays, advanced notice of these high use events were chosen as sampling days in place of randomly selected days when possible. Sampling effort for months and day type was proportional to effort based on counts of cars at boat ramps on Skiatook Lake provided by the U.S. Army Corps of Engineers (unpublished data). Based on these car-count data, too few anglers were present during December, January, and February (4% combined of total annual car count) to warrant sampling so effort was allocated to the remaining months. Time of day was partitioned equally between morning (AM) and evening (PM), which changed according to seasons (e.g., more daylight available in summer than fall). Time of day (AM/PM) was allocated among survey days equally in 1997, but proportionally in 1998 and 1999 based on trends in effort observed in 1997 (Hyler 2000).

The lake was divided into eight sections of equal shoreline distance that served as starting and stopping locations for the creel clerk (Figure 1). The creel clerk spent an equal amount of time in each section, interviewing and counting anglers to obtain an instantaneous count for each section

Table 1. Sampling effort among strata for a creel survey at Skiatook Lake, Oklahoma from 1997 to 1999. Surveys were one-half day long, occurring during morning (AM) or evening (PM). Day type is number of days per week and time of day is probability of selection for sampling. WD = weekday and WE = weekend day. Probability of sampling during AM on WD and WE was 0.5 for all months in 1997. Eight sections were sampled each survey day and time per section was allocated equally per day.

Month	Total survey time per day	Number of WD per week	Probability of AM sampling on WD	Number of WE per week	Probability of AM sampling on WE
March	6 hours	1	0.85	1	0.70
April	6.6 hours	2	0.80	1	0.45
May	6.6 hours	3	0.30	1	0.67
June	7.3 hours	2	0.55	1	0.40
July	7.3 hours	2	0.80	1	0.53
August	6.6 hours	2	0.54	1	0.33
September	6 hours	2	0.47	1	0.50
October	5.3 hours	1	0.72	1	0.50

(Pollock et al. 1994). Each creel day, the clerk traveled by boat in a randomly chosen direction (clockwise or counter-clockwise) beginning in a randomly chosen section (A-H) and completed the circuit within the time of day allocated. Anglers actively fishing were approached by the clerk in a boat with a trolling motor and asked if they would participate in the survey. Those anglers that agreed to participate were asked questions regarding their knowledge of the regulation change, if they were aware that spotted bass could be distinguished from largemouth bass by a tooth patch on the tongue, if they were aware that smallmouth bass could be identified by external body coloration, and whether or not they felt the regulation change was necessary. Anglers were then asked how this regulation would change their fishing habits toward spotted bass (effort and harvest), how often they kept the bass they caught, how many bass they had caught, and if they planned on keeping the bass they caught that day. Anglers that had completed the survey previously in a survey year were considered repeats and only their effort, catch, and harvest information was collected. All bass found in angler possession were identified and counted by the creel clerk.

STATISTICAL ANALYSES

Angler count data were used to estimate total annual fishing effort using the method described by Pollock et al. (1994) and 95% confidence intervals were calculated using standard errors calculated from pooled variances from the following day-type strata: weekdays, weekdays with tournaments, weekday holidays, weekend days, weekend days with tournaments, and weekend holidays. This method produces an estimate of total effort, which was more useful for our purposes than estimates of mean effort, but it also precludes the use of traditional hypothesis testing procedures such as ANOVA to determine differences among years, we so relied on overlapping confidence intervals to determine statistical significance among years.

For each survey day, mean angler catch per unit effort (CPUE; per angler hour) and harvest per unit effort (HPUE; per angler hour) was calculated using the mean-of-ratios estimator because effort was based

on incomplete fishing trip information (Malvestuto 1996). Mean annual CPUE was rank-transformed and compared among years with analysis of variance (ANOVA) and Tukey's post-hoc test (Zar 1999). A large number of zeros precluded analysis of annual HPUEs.

Daily total catch and harvest estimates were computed by multiplying mean daily angler CPUE and HPUE by mean daily effort estimates for an average daily total catch and harvest estimate for each day-type. These estimates were then multiplied by the number of days in the study period to obtain a total catch and harvest estimate for each day-type. Total catch and harvest estimates for each day-type were summed to estimate the total annual catch and harvest for each black bass species and 95% confidence intervals were calculated using standard errors calculated from pooled variances as was done with total fishing effort (Pollock et. al. 1994). Total catch and harvest estimates were deemed significantly different between years for each black bass species based on overlapping 95% confidence intervals.

Anglers' responses to questions concerning their knowledge of the regulation change, abilities to distinguish spotted bass from largemouth and smallmouth bass, and responses to the remaining survey questions were compared using Chi-square contingency tables. When significant differences were found, the proportions of responses were arcsine square-root transformed (equation 13.7 of Zar 1999) and compared among years using the multiple comparison procedure for proportions outlined in section 24.14 of Zar (1999) with standard errors for the difference between proportions based on different sample sizes (equation 24.84 of Zar 1999). We only tested for differences among years because our interest was focused mostly on angler responses over time.

RESULTS

From 395 to 868 angler surveys were completed each year from 1997 to 1999 (Table 2). Most anglers were fishing by boat (from 88% to 89%) and for black bass (from 43% to 50%). Less than 3% in any year declined to be interviewed, resulting in a high interview rate (from 97% to 98% including repeats). Some interviews were conducted with anglers who were interviewed previously in a survey year (from 14% to 23%) and this was highest at the end of the study period. Based on these surveys, it was estimated that anglers expended from a high of 182,599 hours of fishing in 1997 to approximately 136,000 hours in 1998 and 1999.

Angler catch rates for largemouth bass (ANOVA, $P = 0.73$), smallmouth bass (ANOVA, $P = 0.98$), and spotted bass (ANOVA, $P = 0.37$) did not significantly change throughout the study period (Table 3). However, total catch estimates varied among years for most species, except smallmouth bass. Total catch of largemouth bass was similar between 1997 and 1998 and between 1998 and 1999; spotted bass total catch was similar between 1997 and 1998 and between 1997 and 1999, but double in 1999 from 1998. Unidentified bass (i.e., those bass not identified by anglers prior to being interviewed by creel clerk because they either were not aware of the identity or did not take notice of the identity) catch rates decreased by the end of the study period. Very few black bass were observed by the creel clerk to be harvested in each study year (range: 2 – 26), resulting in harvest rate estimates for all black bass species below 0.1 fish per hour and total harvest estimates below 3,000 fish. Total harvest estimates for largemouth bass were similar between 1997 and 1998 and between 1997 and 1999, but reduced 85% from 1998 to 1999. Smallmouth bass total harvest was the lowest in 1999 compared to the other study years and spotted bass total harvest did not significantly change among years.

Awareness by anglers of the new regulation and their ability to identify each of the three black bass species produced mixed results over the study period (Table 4). Slightly more than half of anglers were

Table 2. Summary statistics of creel surveys conducted at Skiatook Lake, Oklahoma from 1997 to 1999 to assess angler attitudes and catch and harvest after implementation of a black bass differential harvest regulation. Only total effort was tested for differences; similar subscript letters indicate no significant difference among years based on overlapping 95% confidence intervals.

Variable	1997	1998	1999
Number of days surveyed	95	92	78
Number of surveys completed	868	601	395
Total effort (angler hours; 95% confidence interval)	182,599 (161,945 – 203,253)$_a$	136,960 (115,932 – 157,988)$_b$	136,671 (114,809 – 158,533)$_b$
Method of fishing			
Boat (%)	89	88	89
Dock (%)	1	1	2
Shore (%)	10	11	8
Species sought			
Bass (%)	43	48	50
Crappie (%)	39	33	36
Hybrid striped bass (%)	3	5	4
Other (%)	4	6	3
Nothing in particular (%)	11	8	7
Interview type			
Interviewed (%)	82	84	75
Declined (%)	3	2	2
Repeat (%)	15	14	23

aware of the regulation change throughout the study (Chi-square, $P = 0.08$). The ability of anglers who reported they knew how to identify spotted bass by the presence of a tongue patch (Chi-square, $P < 0.01$) and how to identify smallmouth bass by external body coloration (Chi-square, $P < 0.01$) increased after 1997 (multiple comparison, $P < 0.05$). In 1997, approximately 54% of anglers knew to look for a tongue patch to identify spotted bass and about 77% knew to identify smallmouth bass by external coloration. These values increased by about 10 percentage points for both questions after 1997.

Angler opinion regarding the necessity of the regulation was not independent of year (Chi-square, $P < 0.01$; Table 5), but the multiple comparisons indicated that the anglers who responded "no opinion" (from 60% to 66%) and "yes" (indicating they believed the regulation change was necessary; from 32% to 34%) were the same among years; those anglers who responded that the regulation was not necessary decreased from 8-6% in 1997-1998 to 2% in 1999. How anglers expected the regulation to affect their fishing effort directed toward spotted bass depended on year (Chi-square, $P < 0.01$). The percentage of anglers who thought their effort would increase (from 4% to 7%) or decrease (from 0% to 1%) did not change among survey years. The proportion of anglers replying that their effort directed toward spotted bass would not change was high (≥ 89%) and became higher during the last two years of the study (94% and 96% in 1998 and 1999). Similarly, the anticipated

Table 3. Comparisons of catch per unit effort (CPUE; number of fish per angler hour), harvest per unit effort (HPUE), total catch and total harvest estimates (confidence intervals [CI]) of largemouth, smallmouth, spotted and unidentified bass at Skiatook Lake from 1997 to 1999. *N* is number of fish observed harvested, which was used to estimate HPUE and total harvest. Similar subscripts indicate no significant difference among years within a species and catch/harvest statistic category.

Year	CPUE	HPUE (*N*)[1]	Total catch (95% CI)	Total harvest (95% CI)
Largemouth bass				
1997	0.13_{a}	0.01 (17)	24,632	823
			$(17{,}951 – 31{,}313)_{a}$	$(164 – 1{,}482)_{ab}$
1998	0.16_{a}	0.01 (26)	27,577	1,540
			$(18{,}900 – 36{,}254)_{ab}$	$(374 – 2{,}706)_{a}$
1999	0.17_{a}	<0.01 (2)	31,991	238
			$(31{,}720 – 32{,}262)_{b}$	$(210 – 266)_{b}$
Smallmouth bass				
1997	0.03_{a}	<0.01 (3)	4,995	130
			$(2{,}777 – 7{,}213)_{a}$	$(98 – 358)_{a}$
1998	0.06_{a}	<0.01 (4)	8,124	610
			$(4{,}047 – 12{,}201)_{a}$	$(105 – 1{,}325)_{a}$
1999	0.04_{a}	<0.01 (3)	5,988	73
			$(5{,}882 – 6{,}094)_{a}$	$(57 – 89)_{b}$
Spotted bass				
1997	0.08_{a}	0.08 (17)	14,478	1,391
			$(8{,}828 – 20{,}128)_{ab}$	$(241 – 2{,}541)_{a}$
1998	0.06_{a}	0.06 (10)	8,859	686
			$(5{,}229 – 12{,}489)_{a}$	$(58 – 1{,}314)_{a}$
1999	0.09_{a}	0.09 (6)	16,564	510
			$(16{,}377 – 16{,}751)_{b}$	$(470 – 550)_{a}$
Unidentified bass				
1997	0.06_{a}	NA	13,390	NA
			$(9{,}092 – 17{,}688)_{a}$	
1998	0.04_{b}	NA	7,897	NA
			$(4{,}529 – 11{,}265)_{a}$	
1999	0.03_{c}	NA	4,135	NA
			$(4{,}035 – 4{,}235)_{b}$	

[1] HPUE was not tested due to a large number of zeros in the data

Table 4. Percent of anglers responding "yes" when asked about knowledge of the regulation change, ability to distinguish spotted bass by the presence of a tooth patch, and ability to distinguish smallmouth bass by external body coloration during a creel survey at Skiatook Lake, Oklahoma conducted from 1997-1999. Similar subscripts indicate no significant differences among years as determined by multiple comparisons for proportions.

Response	1997	1998	1999
Knowledge of regulation change	55_a	55_a	53_a
Ability to distinguish spotted bass by tooth patch	54_a	64_b	69_b
Ability to distinguish smallmouth bass by coloration	77_a	83_b	89_b

Table 5. Percentage of responses by anglers regarding their opinion of the necessity of a regulation change, and its effect on their fishing effort and harvest of spotted bass in the future during a creel survey at Skiatook Lake, Oklahoma conducted from 1997-1999. Similar subscripts indicate no significant differences among years as determined by multiple comparisons for proportions.

Response	1997	1998	1999
Was the regulation change necessary?			
Yes	32_a	34_a	32_a
No	8_a	6_a	2_b
No opinion	60_a	60_a	66_a
Effects on fishing effort toward spotted bass?			
Increase	7_a	4_a	4_a
No change	89_a	94_b	96_b
Decrease	1_a	0.2_a	0_a
Unsure	3_a	1.8_a	0_b
Effects on angler harvest of spotted bass?			
Increase	38_a	31_b	21_c
No change	54_a	62_b	76_c
Decrease	1_a	0_b	0_{ab}
Unsure	7_a	7_a	3_b

level of effect on angler harvest of spotted bass depended on year (Chi-square, $P < 0.01$). The percentage of anglers expecting to increase their harvest of spotted bass was different every year, declining from 38% in 1997 to 21% in 1999. In contrast, the percentage of anglers who reported to not change their harvest of spotted bass increased every year, from 54% in 1997 to 76% in 1999.

The tendency for anglers to keep black bass for harvest depended on year (Chi-square, $P < 0.01$; Table 6). Those who reported to "never" (mean = 42%), or "rarely" (mean = 27%) keep the black bass they caught did not change among years. The percentage of anglers who "sometimes" harvested their black bass was at its low of 3% in 1997, and increased to an average of 12% afterwards. Conversely, the percentage of anglers who responded to "always" harvest their black bass was at its high in 1997 at 11%, falling to 6% or less afterwards. When asked if they planned on harvesting any of the black bass they caught that day, 62% to 66% said "no", 24% to 28% responded "yes', and <12% said "maybe", and these results

Table 6. Percentage of responses by anglers regarding the frequency at which they kept black bass for harvest and whether they would keep any bass caught that day when asked during a creel survey at Skiatook Lake, Oklahoma conducted from 1997-1999. Similar subscripts indicate no significant differences among years as determined by multiple comparisons for proportions.

Response	1997	1998	1999
How often do you keep the bass you catch?			
Never	41_a	42_a	43_a
Rarely	26_a	31_a	24_a
Sometimes	3_a	10_b	14_b
Usually	9_a	11_a	14_a
Always	11_a	6_b	5_b
Do you plan on keeping bass caught today?			
Yes	27_a	24_a	28_a
No	62_a	65_a	66_a
Maybe	11_a	11_a	6_a

were not significantly different among years (Chi-square, $P \geq 0.05$).

DISCUSSION

These results indicate that liberalizing the harvest of spotted bass as an angler incentive was an ineffective tool for managing black bass in Skiatook Lake, Oklahoma. Those anglers who reported they either never or rarely kept the bass they caught made up over two-thirds of the sample, which didn't change over time as the regulation was implemented. The anglers who reported they would not change their fishing effort directed toward spotted bass increased over time from nearly 90% to 96%. The anglers who reported no change in spotted bass harvest made up at least 50% of the sample, which increased linearly over time to comprise 76% of the sample. These increasing trends of not targeting or harvesting spotted bass were in direct contrast to the intention of the regulation change to encourage the reduction of the spotted bass population in Skiatook Lake with liberalized creel and length limits.

Contrary to the results of Buynak et al. (1991), anglers at Skiatook Lake appeared unwilling to differentially harvest black bass to produce the desired management result. Buynak et al. (1991) found that anglers helped accomplish their management goals of increasing harvest of the smaller, undesirable spotted bass, which was incentivized through the enactment of a regulation. At Skiatook Lake, however, anglers appeared unwilling to utilize the benefits of the regulation change and became even less willing to harvest fish over the course of this study. In a survey of 47 state fisheries chiefs, Quinn (1996) found that black bass was the species group that showed the largest increase in voluntary catch-and-release from the 1980s to the 1990s; up to a 250% increase in some instances. Nationwide, this increase has been attributed to a variety of reasons including an evolving conservation ethic of anglers, the influence of tournaments, angler concern with the health of the fishery, and the influence of fishing organizations (Quinn 1996). Which of these or other factors, singularly or in concert, has influenced the high rate of voluntary catch-and-release at Skiatook Lake is unknown and worthy of further study.

Fishing tournament activity, as suggested by Quinn (1996), could have played

a role in explaining angler unwillingness to harvest bass at Skiatook Lake. During this study, Skiatook Lake consistently ranked as one of the top five reservoirs in Oklahoma for fishing tournaments based on number of anglers participating (Gilliland 1997, 1998, 1999). Thus, fishing-tournament activity can be viewed as a surrogate for the degree of specialization by angler groups. More specialized anglers tend to be disproportionately influenced by fishing media and organizations, which have generally promoted catch-and-release fishing (Quinn 1996, Myers et al. 2008). The degree of non-harvest tendency among bass anglers at Skiatook Lake followed a specialization gradient: 100% of tournament anglers reported to never or rarely keeping bass for harvest compared to 90% of devoted bass anglers, and 84% of occasional bass anglers (Hyler 2000). As a result, the large amount of tournament activity likely played a role in preventing the regulation from succeeding. With increasing specialization and concomitant rates of voluntary catch and release by black bass anglers, fisheries managers will have a reduced capacity to affect black bass populations through the use of size and bag limits alone (Allen et al. 2008). To address this, managers will have to become better at determining and addressing angler motivations (Wilde and Ditton 1994, Ditton 1996) if they want to continue to use size and bag limits as a tool for managing black bass populations.

ACKNOWLEDGMENTS

We thank D. Fenner, M. Brown, S. Fletcher M. Willis, and E. Tejan for help with field work. K. Pope (Nebraska Cooperative Fish and Wildlife Research Unit), B. Wentroth (Oklahoma Department of Wildlife Conservation), and two anonymous reviewers provided constructive comments that improved this manuscript. Oklahoma Department of Wildlife Conservation provided funding for this project with a Federal Aid in Sportfish Restoration Grant, F-41-R. The Oklahoma Cooperative Fish and Wildlife Research Unit is jointly supported by the U.S. Geological Survey, Oklahoma State University, the Oklahoma Department of Wildlife Conservation, the Wildlife Management Institute, and the U.S. Fish and Wildlife Service. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

REFERENCES

Allen MS, Walters CJ, Myers RM. 2008. Temporal trends in largemouth bass mortality, with fishery implications. N Am J Fish Man 28:418-427.

Buynak GL, Kornman LE, Surmont A, Mitchell B. 1991. Evaluation of a differential-harvest regulation for black bass in Cave Run Lake, Kentucky. N Am J Fish Man 11:277-284.

Buynak GL. 1995. Evaluation of a differential-black bass size limit regulation on largemouth and spotted bass. Frankfort (KY): Kentucky Department of Fish and Wildlife Resources Fisheries Bulletin No.96. 30 p.

Ditton RB.1996. Understanding the diversity among largemouth bass anglers. In: Miranda LE, DeVries DR, editors. Multidimensional approaches to reservoir fisheries management. Bethesda (MD): American Fisheries Society. p 135-144.

Fox AC. 1975. Effects of traditional harvest regulations on bass population and fishing. In: Clepper H, editor. Black bass biology and management. Washington, D.C.: Sport Fishing Institute. p 392-398.

Gilliland G. 1997. Oklahoma bass tournaments. Oklahoma City (OK): Oklahoma Department of Wildlife Conservation Annual Report F-44-D. 22 p.

Gilliland G. 1998. Oklahoma bass tournaments. Oklahoma City (OK): Oklahoma Department of Wildlife Conservation Annual Report F-44-D. 19 p.

Gilliland G. 1999. Oklahoma bass tournaments. Oklahoma City (OK): Oklahoma Department of Wildlife Conservation Annual Report F-44-D. 20 p.

Hyler RG. 2000. Response of anglers to a differential harvest regulation on three black bass species in Skiatook Lake, Oklahoma [MSc thesis]. Stillwater (OK): Oklahoma State University. 110 p. Available from: OSU Library.

Kornman LE. 1990. Evaluation of a 15-inch size limit on black bass at Grayson Lake. Frankfort (KY): Kentucky Department of Fish and Wildlife Resources Fisheries Bulletin No. 90.

Kuehl RO. 1994. Statistical principles of research design and analysis. Belmont (CA): Duxbury Press. 686 p.

Long JM. 2000. Evaluation of a differential harvest regulation on black bass populations in Skiatook Lake [PhD dissertation]. Stillwater (OK): Oklahoma State University. 123 p. Available from: OSU Library.

Long JM, Fisher WL. 2005. Distribution and abundance of black bass in Skiatook Lake, Oklahoma after introduction of smallmouth bass and a liberalized

harvest regulation on spotted bass. N Am J Fish Man 25:49-56.

Long JM, Fisher WL. 2006. Analysis of environmental variation in a Great Plains reservoir using principal components analysis and geographic information systems. Lake and Res Man 22:132-140.

Malvestuto SP. 1996. Sampling the recreational creel. In: Murphy BR, Willis DW, editors. Fisheries techniques: 2nd edition. Bethesda (MD): American Fisheries Society. p 591-623

Malvestuto SP, Hudgins MD. 1996. Optimum yield for recreational fisheries management. Fisheries 21(6): 6-17.

Myers R, Taylor J, Allen M, Bonvechio TF. 2008. Temporal trends in voluntary release of largemouth bass. N Am J Fish Man 28:428-433.

Novinger GD. 1984. Observations on the use of size limits for black basses in large impoundments. Fisheries 9(4):2-5.

Novinger GD. 1987. Evaluation of a 15-inch minimum length limit on largemouth bass and spotted bass catches at Table Rock Lake, Missouri. N Am J Fish Man 7:260-272.

Oklahoma Department of Wildlife Conservation. 1995. Surveys and recommendations - Skiatook Reservoir. Oklahoma Department of Wildlife Conservation Performance Report Project No. 44-D-9.

Pollock KH, Jones CM, Brown TL.1994. Angler survey methods and their applications in fisheries management. Bethesda (MD): American Fisheries Society, 371 pp.

Quinn S. 1996. Trends in regulatory and voluntary catch-and-release fishing. In: Miranda LE, DeVries DR, editors. Multidimensional approaches to reservoir fisheries management. Bethesda (MD): American Fisheries Society, pp. 152-162

Robson DS. 1991. Roving creel surveys. In: Guthrie D, Hoenig JM, Holliday M, Jones CM, Mills MJ, Moberly SA, Pollock KH, Talhelm DR, editors. Creel and angler surveys in fisheries management. Bethesda (MD): American Fisheries Society, pp. 19-24

Wilde GR. 1997. Largemouth bass fishery responses to length limits. Fisheries 22(6):14-23.

Wilde GR, Ditton RB. 1994. A management-oriented approach to understanding diversity among largemouth bass anglers. N Am J Fish Man 14:34-40.

Zale AV, Stubbs K. 1991. Development of a white crappie fishery in a stage-fill impoundment in Oklahoma. Oklahoma Department of Wildlife Conservation. Federal Aid in Sportfish Restoration Final Report F-41-R.

Zar JH. 1999. Biostatistical Analysis, 4th ed. Englewood Cliffs (NJ): Prentice Hall. 875 pp.

Received: May 18, 2012; Accepted September 21, 2012.