RESPONSE OF ANGLERS TO A DIFFERENTIAL HARVEST REGULATION ON THREE BLACK BASS SPECIES IN SKIATOOK LAKE, OKLAHOMA

By

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INTRODUCTION

This thesis is composed of two manuscripts written in the format suitable for submission to the North American Journal of Fisheries Management. Each manuscript is complete without supporting materials. Chapter I is an introduction to the rest of the thesis. The manuscripts are as follows; Chapter II, "Response of anglers to a differential harvest regulation on three black bass species in Skiatook Lake, Oklahoma," and Chapter III, "Response of bass and crappies angler sub-populations to a differential black bass harvest regulation in Skiatook Lake, Oklahoma."

Chapter II.

RESPONSE OF ANGLERS TO A DIFFERENTIAL HARVEST REGULATION ON THREE BLACK BASS SPECIES IN SKIATOOK LAKE, OKLAHOMA

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Abstract

We used a two-stage probability roving creel survey from 1997 to1999 to evaluate angler responses to a differential black bass harvest regulation that was implemented January 1, 1997 at Skiatook Lake, Oklahoma. This regulation allowed anglers to harvest 15 spotted bass of any size and six largemouth and smallmouth bass greater than 356 mm (in aggregate) per day. Prior to the regulation change, all black bass were managed with a 356 mm size limit and a six fish aggregate creel limit. The change was made to minimize competition among black bass species by reducing the abundance of spotted bass through angler harvest. Increases were detected in anglers abilities to distinguish spotted bass from largemouth and smallmouth bass, the proportion of anglers that would not change the number of spotted bass they harvested per fishing trip, the proportion of anglers that would not increase their fishing effort toward spotted bass, and the proportion of anglers did not have an opinion as to whether or not the regulation change was necessary. The majority of anglers reported that they preferred to catch a few averaged size fish, did not plan on harvesting the bass caught that day, they never or rarely harvested the bass they caught, and rated their fishing trip from fair to excellent. Relaxation was the most commonly reported motive for fishing in 1998 and 1999. Throughout the study, angler knowledge of the regulation change and harvest of spotted bass did not increase. The regulation failed to accomplish the primary objective of decreasing the relative abundance of spotted bass; however, it did provide anglers with the opportunity to harvest more bass.

Introduction

Providing anglers with satisfying fishing trips requires that fisheries are managed to produce a variety of fish of reasonable size and number. This is often accomplished by imposing regulations that protect or enhance fish populations. Size limits are popular among fisheries management agencies because their effects on the population structure of sport fish and forage fish are usually predictable (Fox 1975; but see Wilde 1997). Minimum-length limits are best used to prevent over-exploitation, protect fish to spawning size, decrease the abundance of prey species (Novinger 1984; Noble and Jones 1993), and increase catch rates of quality-size fish (Kornman 1990; Nobel and Jones 1993). Populations that exhibit good growth but have low natural mortality, high fishing mortality, and low recruitment are good candidates for a minimum-length limit (Novinger 1984). Black bass Micropterus spp. often exhibit these characteristics and are successfully managed under minimum size limits. These regulations seem to work well when a fishery contains only one black bass species, but in the southeastern U.S. reservoir systems with some combination of largemouth M. salmoides, smallmouth M. dolomieui, and/or spotted bass M. punctulatus are common. The same minimum size limit is often used to manage all black bass species in a particular fishery, however, some biologists (Kornman 1990; Buynak et al. 1991, 1995) have found that black bass, especially spotted bass, tend to "stockpile" under minimum-length limits

Novinger (1987) suggested the use of a differential black bass harvest regulation to control species abundance. He reasoned that a minimum size limit,

when applied to both largemouth bass and spotted bass, would not affect both populations in the same manner, and that the slower growth rates and shorter life span of spotted bass allow for higher natural mortality rates and an increase in the amount of time until harvest. He also pointed out that for such a regulation to work, anglers would have to be able to correctly distinguish spotted bass from largemouth bass.

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). The regulation allowed harvest of any size spotted bass, but only largemouth bass greater than 381 mm. 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 and harvested constantly decreased in the years following the regulation change. Spotted bass harvest in Cave Run Lake increased in the five years following removal of the size limit, while the average size of all black bass harvested decreased. Cave Run Lake anglers harvested 59% of the spotted bass greater than 229 mm. This added harvest decreased the survival rate and increased fishing mortality but failed to increase the body condition or growth rate of spotted bass.

Skiatook Lake was opened for public fishing in 1986, and since then the black bass populations have been protected from over exploitation by both size and harvest regulations. Under the regulation, all black bass caught that are less than 356 mm must be immediately released and no more than 6 black bass, in aggregate, may be kept. Anglers as well as the spotted bass populations have benefited from this regulation. Anglers have had the opportunity to catch good numbers of quality-sized largemouth bass and smallmouth bass, while the slower-growing spotted bass have benefited from the extra protection that they receive under the regulation. However, since spotted bass grow slower than the largemouth and smallmouth bass, harvest of the spotted bass rarely takes place. This apparently has allowed the spotted bass population to stockpile under the minimum size length (ODWC 1995).

Until recently, the differential abundance of black bass species had not been a problem at Skiatook Lake; however, beginning in 1992 fisheries biologist with the Oklahoma Department of Wildlife Conservation (ODWC) noticed a dramatic increase in the number of the spotted bass with very few of them reaching the 356-mm size limit. At the same time, they also reported a significant decline in the relative weight for all sizes of this species. By 1994, body condition of largemouth bass > 300 mm had also declined, and the condition of smallmouth bass between 200 mm and 299 mm was considered unsatisfactory (ODWC 1995).

Beginning 1 January 1997, the ODWC removed the size limit on spotted bass and increased the harvest limit to 15 fish/day. These new limits only

applied to spotted bass; the previous 356-mm and 6 fish (aggregate) daily bag limit remained in effect for the largemouth bass and smallmouth bass. The purpose of this regulation change was to improve the population structure of all black bass species. An underlying assumption of the regulation change was that there is significant niche overlap among the three black bass species and allowing anglers to harvest more spotted bass will reduce interspecific competition. Clady and Luker (1982) reported that intraspecific competition affected both weight and survival of largemouth bass but not spotted bass stocked in small Oklahoma ponds. Increased harvest of spotted bass will presumably allow for better growth and, survival, and possibly higher recruitment of the largemouth bass and smallmouth bass in Skiatook Lake

My objectives were to determine the effectiveness of the regulation change in Skiatook Lake by documenting the effects of angling on the black bass population structure. Quantitative data on angler catch, harvest, and effort were gathered and monitored throughout the study period to identify trends associated with the regulation change. Qualitative data for angler knowledge, attitudes, opinions, motivations, and satisfaction level were also collected.

Methods

Study Site. --Skiatook Lake is a 4,266 ha flood control reservoir located 8 km west of Skiatook in Osage County, Oklahoma (ODWC 1995). The lake was created in 1984 when the U.S. Army Corps of Engineers (USCOE) impounded Hominy Creek. The USCOE currently manages the lake for flood control and recreation, while the ODWC manages the lake's fisheries resources. Under a

cooperative agreement between the USCOE and the ODWC, the lake was filled in stages from October 1984 to July 1989 to increase the productivity of the newly constructed reservoir (ODWC 1995). Although the lake was not at full pool, public fishing was allowed beginning in May 1986.

The Skiatook Lake has high rocky bluffs, and a steep rocky shoreline. Fish habitat is characterized by deep clear water, particularly in the lower end of the lake, a rock-covered substrate, and abundant standing and fallen timber. Skiatook Lake has a 257- km shoreline with a shoreline development ratio of 11.3 (ODWC 1995). The trophic state of the lake ranges from oligotrophic at lower end near the dam to eutrophic at the upper end (Long 2000). The lake has a mean depth of 9.7m with a maximum depth of 31m (ODWC 1995).

Popular recreational activities on Skiatook Lake include boating, camping and fishing. Fishing pressure from tournament and non-tournament anglers is high. Skiatook Lake hosted the second highest number of black bass fishing tournaments in 1994 for reservoirs over 1,000 acres in Oklahoma (ODWC 1995). Major sport fish of Skiatook Lake in addition to black bass include white crappie Pomoxis annularis, channel catfish Ictalurus punctatus blue catfish I. furcatus. flathead catfish Pylodictis olivaris, hybrid striped bass Morone saxatilis X M. chrysops and walleye Stizostedion canadense. A large proportion of angler effort is directed toward black bass and crappie (Zale and Stubbs 1991).

Angler data were collected from March-October in 1997, 1998, and 1999 using a two-stage probability roving creel survey (Robson 1991) to monitor catch, harvest, and effort, and to assess anglers' knowledge of the regulation change,

abilities to identify spotted bass, attitudes, opinions, effects on anglers fishing effort and harvest of spotted bass, and satisfaction levels (Appendix A). In 1998, our questionnaire was modified to collect information on angler motivations for fishing, preferred size of catch, mean distance traveled, age, sex and race of anglers (Appendix B).

A two-stage probability roving creel survey requires sampling time to be allocated in proportion to fishing effort. We allocated effort by the following strata: month, day type (weekend, weekdays), and day time (AM-PM) (Pollock et al.1994, Malvestuto and Hudgins 1996). Monthly sampling effort in 1997 was allocated based on monthly car count data at boat ramps from October 1993 through September 1996, which was provided by the U.S. Army Corps of Engineers. Surveys were scheduled for one weekday and one weekend day in March and October; two weekdays and one weekend day per week in April, June, July, August, and September; and three weekdays and one weekend day per week in May. All surveys were scheduled with a 0.5 probability of sampling in the AM or PM in 1997. Weekdays and weekend days were randomly selected for each week of the study (Long et al. 1997).

In 1998 and 1999, sampling time was re-allocated in proportion to 1997 monthly, day-type and day-time effort estimates. Monthly and day-type sampling remained the same as 1997. Sampling effort in the daytime stratum varied by month and day type. In March, surveys were scheduled with an 85% probability of sampling in the AM time period during weekdays and 70% on the weekends. In April, the probability of sampling a weekday morning was 80% and 45% on the

weekends. In May, sampling was conducted with a 30% probability of sampling on weekday mornings and 67% on the weekends. In June, weekday surveys were selected with a 55% probability of sampling in the AM time period and a 40% probability on weekends. In July, the probability of a morning weekday survey was 80% while weekend mornings had a 53% chance of being sampled. In August, weekday surveys were scheduled with a 54% probability of being sampled in the AM time period and a 33% probability on the weekends. In September and October, the chance of conducting a survey on a weekday morning was 47% and 72% respectively, while the chance of surveyinging on a weekend morning in both months was 50%.

The lake was divided into eight sections of equal shoreline distance that served as checkpoints as well as starting and stopping locations for the creel clerk (Figure 1). The creel clerk was required to spend an equal amount of time interviewing anglers in each section of the lake, which provided an instantaneous angler count for each section (Pollock et al. 1994). Each day, the creel clerk traveled by boat in a randomly chosen direction around the lake starting in a randomly chosen section. Anglers actively fishing were approached using 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 by the tooth patch on the tongue, if they were aware that smallmouth bass could be identified by their 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 (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. We then asked if we could measure any bass that they had kept. All bass in the angler's creel were measured to the nearest 0.1 cm and weighed to the nearest 0.1 kg. Anglers were asked about the size of fish that they would most prefer to catch and what was the most important reason that they went fishing. At the end of the survey anglers were asked for their zip code and to rate their fishing trip that day (Appendix B). Angler counts were made in conjunction with interviews to provide data on angling effort.

Monthly estimates of angler catch per unit effort (CPUE) and harvest per unit effort (HPUE) were calculated using the mean-of-ratio estimator (Malvestuto 1996). These estimates provided the number of fish caught and harvested per hour. Reported CPUE and HPUE estimates are the average of the mean daily CPUE and HPUE estimates. Due to departures from normality and homogeneity of variances we used non-parametric analysis of variance (ANOVA) and Tukey's test to compare annual CPUEs (Zarr 1996).

Angler count data were used to estimate total fishing effort using the method described by Pollock et al. (1994). Total fishing effort in 1997, 1998, and 1999 was compared using t-tests. Standard errors were calculated using pooled variances from the following day-type strata: weekdays, weekdays with tournaments, weekday holidays, weekends, weekends with tournaments, and weekend holidays. Total catch and harvest estimates were computed by

multiplying the mean daily angler CPUE and HPUE by mean daily effort estimates for an average daily total catch and harvest estimate for each of the previous strata. These estimates were then multiplied by the number of days in the study period to obtain a total catch and harvest estimate for each stratum. Total catch and harvest estimates for each stratum were summed to estimate the total catch and harvest for each black bass species (Pollock et. al. 1994). Total catch and harvest estimates from 1997, 1998, and 1999 were compared using multiple t-tests. Standard error estimates were calculated after pooling variance estimates from each of the strata used to obtain the total catch and harvest estimates.

Among-year estimates of HPUE were not compared due to a large number of daily harvest estimates that equaled zero. Instead, we compared the proportions of each black bass species caught that were harvested using the multiple two-sample test of proportions (McGrew and Monroe 1993). Length-frequency distributions were monitored by calculating a relative stock density (RSD_{356}; Anderson and Neumann 1996) for each bass species. Yearly RSD_{356} values for each species were compared with the multiple two-sample test of proportions. Since data were collected from the angler's reported catch, all fish caught were considered stock size or greater (Anderson and Gutreuter 1983). Anglers' responses to questions concerning their knowledge of the regulation change and abilities to distinguish spotted bass from largemouth and smallmouth bass were tested with ANOVA (SAS Institute 1988). Contrasts were used to detect differences between years and linear trends throughout the study period.

Yearly angler responses to the remaining survey questions were compared using Chi-square contingency tables (SAS Institute 1988). Fisher's exact test was used in cases where the cell expected values were less than 5% (SAS Institute 1988).

Mean distances traveled by anglers fishing at Skiatook Lake were found by identifying the angler's residence from the zip codes provided during the surveys and calculating the shortest driving distance to the town of Skiatook. The mean distance traveled by anglers in 1998 and 1999 were compared using a t-test.

Results

Creel surveys were conducted from March 1 through October 31 on 95 days in 1997, 92 days in 1998, and 78 in 1999. Eight hundred sixty-eight angler surveys were completed in 1997, while 601 and 395 anglers were surveyed in 1998 and 1999, respectively. In 1997, 82% of the anglers approached participated in the surveys while 3% declined and 15% were repeat surveys. In 1998 angler participation was similar to 1997, with 84% of the anglers participating in the survey, 2% declining and 14% were repeat surveys. In 1999, the percent of repeat surveys increased significantly from 1997 ($P=0.003$) and 1998 ($P=0.002$) to 23% (Table 1).

Although we detected a significant differences in the proportions of anglers fishing from a boat, dock and shoreline throughout the study period (Table 1), the vast majority of anglers surveyed in each year were fishing from a boat. In 1997, boat anglers accounted for 89% of the respondents, and similar

percentages occurred in 1998 (88%) and 1999 (89%). About 10% of surveys were from shoreline anglers, and around 1% were from dock anglers during the three years. Proportions of fishing methods were similar in 1997 and 1998 ($\underline{P}$=0.967) while differences were detected between 1997 and 1999 ($\underline{P}$=0.011) and 1998 and 1999 ($\underline{P}$=0.04). Cell Chi-square values indicated that differences between years were caused by a decrease in the proportion of shoreline anglers surveyed in 1999.

With exception of race, the demographic characteristics of anglers were similar in 1998 and 1999. The majority of anglers surveyed were white (83-86%) males (98-97%) fishing for either black bass or crappie (Table 1). We did not detect a difference in the proportions of male and female anglers between years, but the racial composition of anglers differed (Table 1). Anglers traveled a mean distance of 35 miles (range 5.4-654 mi) to fish at Skiatook Lake in 1998, and this was similar to 1999 ($\underline{P}$=0.887) when anglers traveled an average of 36 miles (range 5.4-589 mi).

In 1997, anglers spent approximately 182,599 daytime angling hours fishing at Skiatook Lake from March 1 through October 31. This was significantly higher than 136,960 hours in 1998 ($\underline{P}$=0.031) and 136,671 hours in 1999 ($\underline{P}$=0.033). CPUE of largemouth ($\underline{P}$=0.729), smallmouth ($\underline{P}$=0.981), and spotted bass ($\underline{P}$=0.368) did not change significantly throughout the study. The CPUE of unidentified bass differed among years ($\underline{P}$=005) decreasing from 1997 to 1998 ($\underline{P}$<0.005) and 1998 to 1999 ($\underline{P}$<0.005; Table 2). Largemouth bass HPUE ranged from 0.001 fish/hr in 1999 to 0.011 fish/hr in 1997. Smallmouth bass

HPUE ranged from 0.0004 fish/hr in 1999 to 0.007 fish/hr in 1998 while spotted bass HPUE were lowest in 1998 (0.062 fish/hr) and highest in 1999 (0.095 fish/hr; Table 2).

Few fish were actually observed by the creel clerk in any year. Of the 17 largemouth bass observed in 1997, three were below the size limit. Twenty-six largemouth bass were observed in 1998 and two in 1999, and none were below the size limit. Almost all of the smallmouth bass observed were less than 356 mm in each year. In 1997, all three smallmouth in the anglers' creels were sub-legal while three of the four smallmouth measured in 1998 were below the size limit. In 1999, two of the three fished measured were sub-legal. Seventeen spotted bass were observed in 1997, 10 in 1998 and six in 1999.

The proportion of largemouth, smallmouth and spotted bass that were harvested annually did not significantly change following the regulation change ($P>0.4$). Anglers harvested 5%, 8% and 2% of the largemouth bass caught in 1997, 1998 and 1999, respectively. Three percent of the smallmouth bass and 8% of spotted bass were harvested in 1997 while 5% of the former and 6% of the later species were harvested in 1998 and 1999.

Few changes in catch and harvest estimates were detected throughout the study. Total catch of largemouth bass increased from 24,632 fish in 1997 to 31,991 fish in 1999 ($P=0.037$; Table 2). Estimates of total catch were similar between 1997 and 1998 ($P=0.704$), and between1998 and 1999 ($P=0.329$; Table 2). Total harvest decreased from 2,835 fish in 1998 to 849 fish in 1999 ($P=0.032$) while total harvest remained similar between 1997 and 1998

(P=0.436) and 1997 and 1999 (P=0.093; Table 2). Total catch and harvest of smallmouth bass were similar in each year of the study (P>0.05;Table 2). Total catch of spotted bass decreased from 14,478 fish in 1997 to 8,859 fish in 1998 (P<.001) but increased to 16,751 in 1999 (P<0.001). We did not detect any annual changes in spotted bass total harvest following the regulation change. Anglers harvested 1,391 spotted bass in 1997, which was similar to 686 in 1998 (P=0.432) and 510 in 1999 (P=0.144; Table 2). The total catch of 13,390 unidentified bass in 1997 was similar to 7,897 caught in 1998 (P=0.156) but less than 4,135 in 1999 (P=0.001). Total catch estimates were lower in 1999 than in 1998 (P=0.033; Table 2).

Largemouth bass smallmouth bass and spotted bass relative stock density estimates for fish greater than 356-mm remained similar in each of the years following the regulation change (P>0.08). Largemouth bass RSD_{356} values ranged from 34% in 1997 to 28% in 1999. Smallmouth bass RSD_{356} values ranged from 12% in 1997 to 24% in 1999, (Figure 2) and spotted bass estimates never exceeded 1%.

Anglers' knowledge of the regulation change was similar during the years following the regulation change (P=0.081), whereas the proportions of anglers that knew that spotted bass could be distinguished from largemouth by feeling for a tooth patch on the tongue (of spotted bass) increased linearly (Table 3). Also, there was a linear increase from 1997 to 1999 in the proportion of anglers who knew that smallmouth bass could be distinguished from largemouth and spotted bass by their external body coloration. The percent of the anglers reporting that

they could identify spotted bass by their tooth patch increased from 54% in 1997 to 64% in 1998 (P=0.004). The proportion (69%) in 1999 was significantly higher than in 1997 (P<0.0001) but not 1998 (P=0.114). Angler's ability to distinguish smallmouth bass increased from 77% in 1997 to 83% in 1998 (P=0.005). These percentages increased again in 1999 to 89% (P=0.036; Table 3).

The majority of anglers in each year reported that they did not have an opinion as to whether or not the regulation change was necessary and rated their fishing trips from fair to excellent in each year following the regulation change (Table 4). I detected substantial decrease in the proportions of anglers who felt the regulation change was unnecessary. Although a distinct pattern could not be detected, changes in the percentages of anglers who rated their fishing trip as very poor contributed the greatest amount to the overall Chi-square value (Table 4).

In 1998 and 1999, the majority of anglers reported that they would prefer to catch a few averaged-size fish and that relaxation was their most common motive for fishing. Following relaxation, other motives were, in order: spending time with family and friends, to experience the outdoors, competition, and catch related motives. Fourteen percent and 11% of the responses could not be classified into a category in 1998 and 1999, respectively (Table 4). One trophy fish was preferred by 18% of the anglers in 1998 and 17% in 1999. Thirteen percent of the anglers preferred to catch large numbers of small fish in 1998 and 11% in 1999 while 2% and 3% of the responses could not be classified in 1998 and 1999, respectively (Table 4).

Most anglers reported that the regulation would not effect the amount of time that they spent fishing for spotted bass in the years following the change. Only 7% of the anglers said that they would spend more time fishing for spotted bass in 1997, and this proportion declined to 4% in 1998 and 1999 (Table 5). This trend also was evident in the proportions of angler who reported that they would increase the number of spotted bass they harvested per fishing trip. Percentages decreased from 38% in 1997 to 31% and 21% in 1998 and 1999, respectively. The proportion of anglers reporting that this regulation would not effect the numbers of spotted bass they would keep increased from 54% in 1997 to 62% in 1998 to 76% in 1999 (Table 5).

Greater than 65% of the anglers combined in each year reported they either never or rarely harvested the bass they caught (Table 5). Over 60% of the anglers responded that they did not plan to keep the bass they caught that day in each year of the study. When asked if they planned to keep the bass they caught that day, over 60% of the responses were "no" in each year (Table 5). On average, 91% of the anglers interviewed did not have bass on board their boat to measure.

Discussion

Although, fisheries biologists have recognized the need for the differential black bass harvest regulation (Novinger 1984), they rarely have been implemented. Concerns about anglers' abilities to differentiate spotted bass from largemouth bass may have discouraged agencies from using such regulations. To the best of my knowledge, only two states besides Oklahoma currently use

differential harvest regulations when largemouth and spotted bass are both present. Kentucky currently uses such a regulation statewide where anglers are allowed to harvest spotted bass of any size with an aggregate daily black bass creel limit of six fish (Kentucky Department of Natural Resources 2000). Missouri currently manages Bull Shoals Lake, Lake of the Ozarks and Norfolk Lake with a 381 mm minimum size limit on largemouth and smallmouth bass while spotted bass greater than 305 mm may be harvested (Missouri Department of Conservation 2000). To date, only one study focusing on the effects of a differential black bass harvest regulation has been published in the primary literature. Understanding the impacts of such a regulation on the angling community is vital to understanding how these regulations could be used to improve fishing in areas containing more than one black bass species.

My data indicate that the age and racial composition of Skiatook Lake anglers was similar to statewide proportions. Throughout Oklahoma 71% of anglers were male and 29% were female (U.S. Department of the Interior et al. 1991). Similarly, an average of 84% of the anglers encountered at Skiatook Lake were males and 16% were female. Statewide, 89% of the anglers were white, 4% were black and 6% were other races (U.S. Department of the Interior et al. 1991) while Skiatook Lake anglers averaged 97% white, 2% black and 1% other races. Although these proportions were similar to statewide averages, they were closer to the proportions reported by Hunt and Ditton (1998) for non-guided anglers at Lake Texoma. They reported that 95% of anglers surveyed were

white and 88% were male. Skiatook anglers predominately fished from a boat, and bass and crappie were the most sought after species

Following the regulation change, spotted bass catch, harvest rates, total catch and total harvest estimates were expected to increase. Likewise if population numbers were reduced by angler harvest, spotted bass CPUE, HPUE, total catch and total harvest were expected to decrease throughout the study period. Results indicate that spotted bass CPUE did not change significantly over the three year study. Although total catch in 1998 was significantly lower than 1999, total catch was similar between 1997 and 1999. Harvest rates were less than 0.001 fish/hr in each year. Total harvest of spotted bass decreased each year but these estimates were extremely small and not statistically significant. Anglers never harvested more than 8% of the spotted bass they caught during each year of this study. From 1997 to 1999, I did not observe any anglers who harvested a limit of fifteen spotted bass. Spotted bass CPUE at Skiatook Lake averaged 0.119 fish/hr compared to a statewide average of 0.003 fish/hr (Summers 1978). These results suggest that this regulation failed to accomplish its primary objective of reducing spotted bass abundance through angler harvest.

Many of the largemouth and smallmouth bass harvested were below the size limit. Most of these fish were not misidentified rather the anglers harvested the fish regardless of the size restrictions. Since my sample sizes were small I could not determine the extent of harvest caused by anglers inability's to differentiate spotted bass from other black bass species. If anglers increase their

harvest of spotted bass in the future, it is possible that anglers could mistakenly harvest enough largemouth bass and smallmouth bass to effect the abundance and size structure of each species.

Contrary to my results, Buynak et al. (1991) found that after removing the spotted bass size limit at Cave Run Lake, Kentucky, catch rates of this species greater than 229 mm decreased in the five years following the regulation change. They also reported that the actual numbers of spotted bass observed in anglers' creels increased dramatically in the five years after the regulation change, and that anglers harvested 41% of the spotted bass caught. Prior to removing the size limit on spotted bass in Cave Run Lake, anglers harvested 0.1 fish/hr and 0.1 fish/acre. After removal harvest increased to 0.4 fish/hr. After the size limit was removed at Skiatook Lake spotted bass harvest rates never exceeded 0.01 fish/hr.

If reductions in spotted bass numbers had decreased to levels that would have minimized competition among the three black bass species, I would have expected largemouth and smallmouth bass catch rates to increase. However, largemouth and smallmouth bass CPUE remained similar during each year, with largemouth bass HPUE never exceeding 0.011 fish/hr and smallmouth HPUE less than 0.007 fish/hr. Consequently, relative stock density estimates of angler-caught largemouth bass, smallmouth bass, and spotted bass remained similar in each year following the removal of the spotted bass size limit suggesting that this regulation failed to improve the population structure of largemouth bass.

Although the ODWC placed signs at each boat ramp to inform anglers of the regulation change, angler's knowledge of the change failed to increase during this study. In contrast, anglers' abilities to distinguish spotted bass from largemouth and smallmouth bass increased during each year of the study. Little opposition to the new regulation was detected in each year. The proportions of anglers who felt that this regulation was not necessary declined from 8% in 1997 to 6% in 1998 and 2% 1999. Unfortunately little support for the regulation was found during the study. Only about one-third of the anglers felt this regulation was necessary in each year while almost two-thirds had no opinion.

Although significant differences were detected in angler's satisfaction levels, no distinct patterns in change were detected. While the average catch rate of largemouth bass (0.15 fish/hr) from 1997-1999 was almost twice as high as statewide averages (0.08 fish/hr; Summers 1978), annually, 35% to 40% of the anglers surveyed were not satisfied with their fishing trip. Since 1990, largemouth bass catch rates have apparently declined from about 0.5 fish/hr (Zale and Stubbs 1991) to 0.15 fish/hr in 1997-1999. This decrease in catch rates may explain why many anglers are not satisfied with the fishing at Skiatook Lake.

My results indicate that the opportunity to increase harvest of spotted bass was of little interest to the majority of anglers at Skiatook Lake. The majority of anglers reported that they either never or rarely kept the bass they caught; that they would not increase the amount of time they spent fishing for spotted bass; that they would not harvest more spotted bass per fishing trip; they didn't plan on

keeping the bass caught the day of the survey. In fact, the proportion of anglers reporting that they the would not change the amount of time spent fishing for or change the numbers of spotted bass they would keep increased in each year following the change. This trend was also seen in the proportion of anglers who reported that they did not plan to keep the bass they caught the day of the survey. Although the majority anglers preferred to catch a few fish in the average size range, catch-related motives were rarely reported as the most important reason fishing. All of these factors help explain why the catch and harvest statistics for spotted bass did not change throughout the study period.

While angler motivations may help to explain why anglers were not interested in harvesting spotted bass, recent studies suggest caution should be used when generalizations are made from motivational data when anglers are aggregated at the population level. In their review of seventeen angler motivation studies, Fedler and Ditton (1994) found that it was common for anglers to rate non-catch-relative motives higher than catch related motives, especially when anglers were grouped at the population level. Motivational differences have been detected at many levels including angler age, species sought, method of fishing (Hudgins 1984) and among types of bass (Ditton 1996), crappie anglers (Allen and Miranda 1996). This suggests that subdividing anglers into sub-populations to determine the effects of the regulation on each angling group would provide further insight as to why anglers did not harvest more fish after the size limit was removed and may identify sub-populations that benefited from the regulation change.

Management Recommendations. --The differential harvest regulation in Skiatook Lake has the potential to be effective in the future. However, for this to happen anglers need to be better informed about the regulation and its purpose. During surveys, many anglers commented that a slot-limit was needed to improve bass fishing at Skiatook Lake. If the ODWC could educate anglers that the differential harvest regulation served the same biological purpose as a slot-limit, anglers might be inclined to harvest more spotted bass. Anglers need to know the biological basis of this regulation. Slot limits are commonly used to restructure bass populations by increasing harvest of small fish, which reduces competition and improves growth rates (Wilde 1997). However, slot limits are most effective in aquatic systems where reproduction is high and growth rates are not optimal. Largemouth bass and smallmouth bass growth is good at Skiatook Lake but relative abundances are somewhat low. Because of this, increased harvest of small-sized bass in Skiatook Lake would do more harm than good. In contrast, spotted bass abundance is high and growth rates are poor which suggests that decreasing their abundance would benefit the fishery.

The ODWC has a variety of educational resources at their disposal, which could be used, educate anglers throughout the state. These include the Outdoor Oklahoma television program, information and education personnel, local newspapers and local news stations. Although, out-of-state anglers were encountered at Skiatook Lake, the vast majority of anglers resided in Oklahoma. Our results indicate that the mean distance traveled by anglers was approximately 35 mi. This suggests that a large proportion of anglers are from

the Tulsa metropolitan area and that publishing articles in the Tulsa newspaper promoting this regulation would be an effective way of reaching a large segment of the angling population. These articles could be submitted by information and education personnel. Anglers could be educated statewide using the Outdoor Oklahoma television program.

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Table 1. Characteristics of anglers surveyed from 1997-1999 at Skiatook Lake. Chi-square cell values are in parentheses.

Characteristic	1997 %	1998 %	1999 %	Chi-square P
		Sex		
Male	NA	83 (0.10)	86 (0.14)	
Female	NA	17 (0.37)	14 (0.76)	0.268
		Method		
Boat	89 (0.002)	88 (0.009)	89 (0.03)	
Dock	1 (1.38)	1 (0.52)	2 (6.78)	
Shore	10 (0.24)	11 (0.26)	8 (1.79)	0.027
		Species sought		
Bass	43 (1.98)	48 (0.41)	50 (1.68)	
Crappie	39 (1.52)	33 (2.03)	36 (0.005)	
Hybrid striped bass	3 (0.45)	5 (1.0)	4 (0.06)	
Other	4 (0.44)	6 (3.71)	3 (2.6)	
Nothing in particular	11 (2.56)	8 (0.38)	7 (2.6)	0.008
		Interview type		
Interviewed	82 (0.01)	84 (0.54)	75 (1.85)	
Declined	3 (0.80)	2 (0.77)	2 (0.06)	
Repeat	15 (1.03)	14 (1.74)	23 (9.73)	0.002

Table 1. Continued.

Characteristic	1997 %	1998 %	1999 %	Chi-square P
		Race		
White	NA	98 (0.02)	97 (0.05)	
Black	NA	1 (2.09)	3 (4.41)	
Hispanic	NA	<1 (0.61)	0 (1.29)	
Native American	NA	<1 (0.09)	<1 (0.09)	
Middle Eastern	NA	<1 (0.15)	0 (0.32)	0.03

Table 2. Comparisons of catch per unit effort (CPUE), harvest per unit effort (HPUE), total catch and total harvest estimates of largemouth, smallmouth, spotted and unidentified bass at Skiatook Lake from 1997 to 1999.

Year	CPUE[1] (fish/hr)	HPUE (fish/hr)	Total catch[2]	Total harvest[2]
		Largemouth bass		
1997	0.13a	0.011	24,632a	2,343ab
1998	0.16a	0.01	27,577ab	2,835a
1999	0.17a	0.001	31,991b	849b
		Smallmouth Bass		
1997	0.032a	0.0006	7,208a	130a
1998	0.065a	0.007	8,124a	610a
1999	0.04a	0.0004	5,988a	73a
		Spotted bass		
1997	0.08a	0.08	14,478ab	1,391a
1998	0.062a	0.062	8,859a	686a
1999	0.095a	0.095	16,751b	510a
		Unidentified bass		
1997	0.064a	NA	13,390a	NA
1998	0.046b	NA	7,897a	NA
1999	0.031c	NA	4,135b	NA

[1] CPUE was tested using a Kruskall-Wallis

[2] Total catch and total harvest were tested using a t-test

Letters a, b and c are used to indicate significant differences among years ($P < 0.05$). Similar letters indicate non-significant differences.

Table 3. Comparisons of angler responses to questions concerning their knowledge of the regulation change and abilities to distinguish spotted bass from largemouth and smallmouth bass at Skiatook Lake from 1997-1999.

Response	1997 %	1998 %	1999 %	Linear contrast P
		Knowledge of regulation change		
Yes	55[a]	55[a]	53[a]	NS
No	45[a]	45[a]	47[a]	
		Ability to distinguish spotted bass by the tooth patch		
Yes	54[a]	64[b]	69[b]	0.0001
No	46[a]	36[b]	31[b]	
		Ability to distinguish smallmouth bass		
Yes	77[a]	83[b]	89[b]	0.0001
No	23[a]	17[b]	11[b]	

Letters a, b and c are used to indicate significant differences among years ($P < 0.05$). Similar letters indicate non-significant differences.

Table 4. Angler responses to questions regarding their opinion of the regulation and preferred size of fish, motives for fishing and satisfaction levels at Skiatook Lake from 1997-1999. Chi-square cell values are in parentheses.

Response	1997 %	1998 %	1999 %	Chi-square P
Was the regulation change necessary?				
Yes	32 (0.14)	34 (0.57)	32 (0.14)	
No	8 (4.49)	6 (0.14)	2 (7.45)	
No opinion	60 (0.15)	60 (0.19)	66 (1.29)	0.006
How would you rate your fishing trip				
Excellent	8 (0.01)	7 (0.22)	9 (0.49)	
Good	22 (0.57)	25 (0.54)	24 (0.04)	
Fair	31 (0.38)	30 (0.05)	26 (1.49)	
Poor	30 (0.002)	32 (0.94)	26 (1.67)	
Very poor	10 (0.01)	6 (8.17)	15 (11.98)	0.001
What size of fish would you prefer to catch?				
Large numbers of small fish	NA	13 (0.17)	11 (0.29)	
Few average size fish	NA	67 (0.08)	69 (0.14)	
One trophy fish	NA	18 (0.02)	17 (0.03)	
Other	NA	2 (0.04)	3 (0.07)	NS

Table 4. Continued.

Response	1997 %	1998 %	1999 %	Chi-square P
		Motive for fishing		
Relaxation	NA	50 (0.49)	45 (0.81)	
Spend time with family/friends	NA	19 (0.47)	22 (0.78)	
Catch related	NA	3 (0.69)	5 (1.15)	
Experience the outdoors	NA	9 (0.66)	12 (1.1)	
Competition	NA	6 (0.02)	6 (0.03)	
Other	NA	14 (0.52)	11 (0.86)	NS

Table 5. Angler responses to questions related to their fishing habits and how this regulation would change their fishing effort and harvest of spotted bass from 1997-1999 at Skiatook Lake. Chi-square cell values are in parentheses.

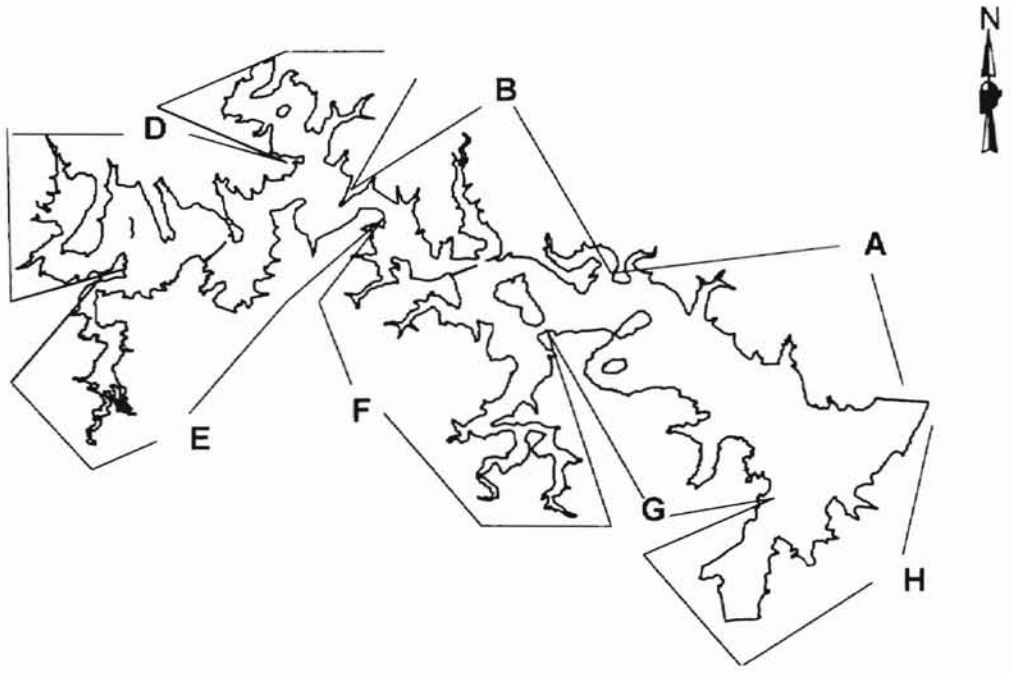
Response	1997 %	1998 %	1999 %	Chi-square P
		Effects on fishing effort		
Increase	7 (4.86)	4 (2.59)	4 (1.59)	
No change	89 (0.84)	94 (0.30)	96 (0.47)	
Decrease	1 (3.49)	0.2 (1.33)	0 (1.83)	
Unsure	3 (3.74)	1.8 (0.35)	0 (4.68)	< 0.001
		Effects on angler harvest		
Increase	38 (7.17)	31 (0.32)	21 (11.09)	
No change	54 (6.21)	62 (0.18)	76 (10.47)	
Decrease	1 (3.68)	0 (1.99)	0 (1.22)	
Unsure	7 (1.56)	7 (0.11)	3 (5.31)	< 0.001
		How often do you keep the bass you catch?		
Never	41 (0.13)	42 (.03)	43 (0.11)	
Rarely	26 (0.4)	31 (2.31)	24 (.98)	
Sometimes	3 (0.31)	10 (2.60)	14 (1.49)	
Usually	9 (1.36)	11 (0.08)	14 (1.99)	
Always	11 (6.99)	6 (2.35)	5 (4.22)	0.001

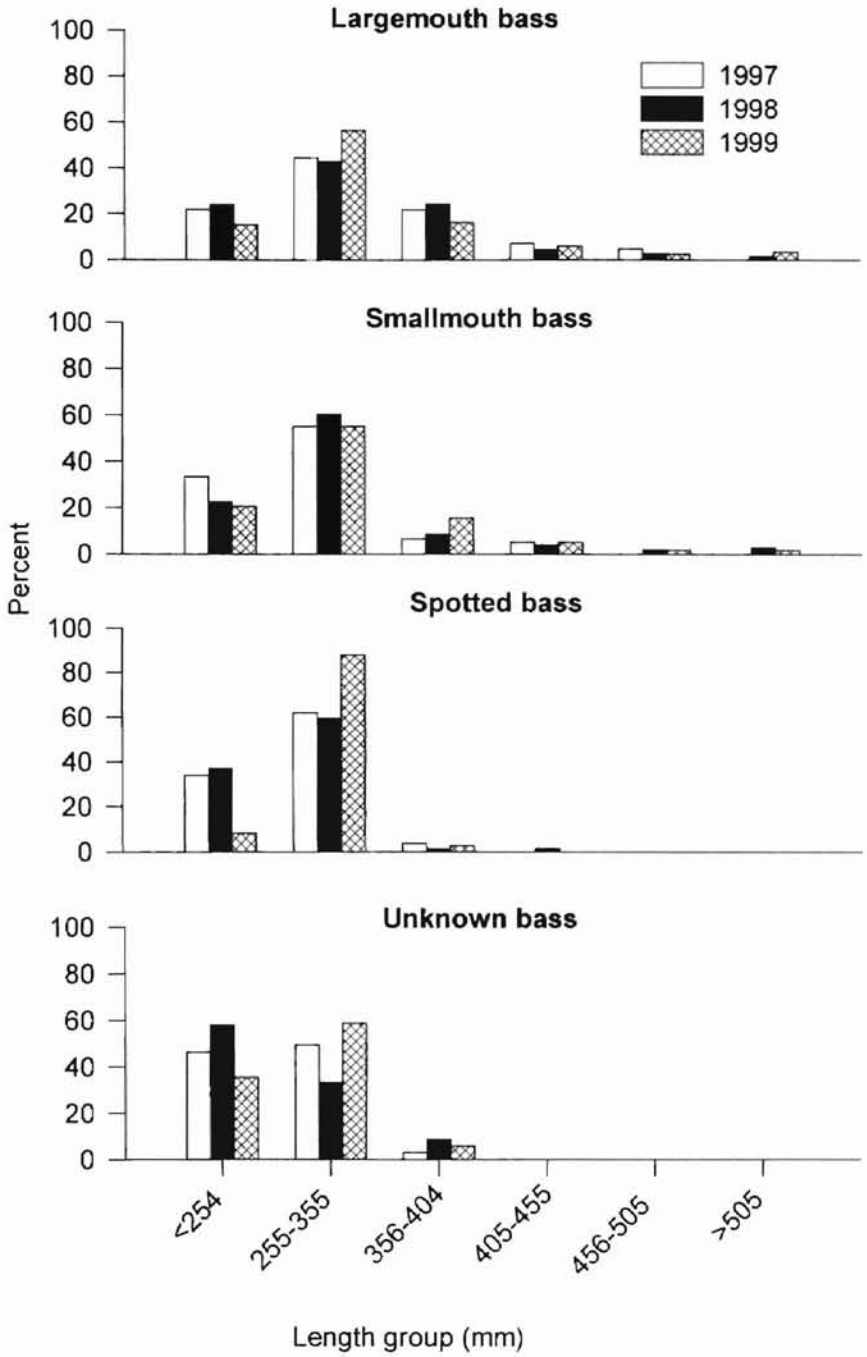
Table 5. Continued.

Response	1997 %	1998 %	1999 %	Chi-square P
	Do you plan on keeping bass caught today?			
Yes	27 (0.22)	24 (1.13)	28 (0.39)	
No	62 (0.51)	65 (0.2)	66 (0.24)	
Maybe	11 (1.06)	11 (0.33)	6 (4.91)	NS
	May I measure the bass you have?			
Yes	5 (0.002)	7 (2.59)	3 (3.67)	
No	6 (1.64)	6 (0.91)	1 (9.35)	
None	89 (0.08)	87 (0.37)	96 (1.37)	0.001

Figure 1. Creel survey sections at Skiatook Lake used from 1997 to 1999.

Figure 2. Relative length frequency distribution of angler-caught largemouth, smallmouth and spotted bass from 1997 to 1999 at Skiatook Lake, Oklahoma.





Appendix A. Creek Survey questionnaire used in 1997 at Skiatook Lake, Oklahoma.

Appendix A

Survey #_____ Survey Section_____ Date_____
Day Type **WD** **WE**

Time of Interview_____**(mil)** Method **BOAT** **DOCK** **SHORE** # in Party
Special Type **Tourn** **Hol**

INTERVIEWED **DECLINED** **REPEAT**

Times Fish/Mth_____ Start Time_____ **(mil)** Finish Time (est.) **(mil)**

Species Sought: **LMB** **SMB** **SPB** **Bass** **Crappie** **Hybrid Striped** **Other** **Nothing in Particular**

Q. The Oklahoma Department of Wildlife Conservation is interested in knowing how well it informs anglers of new regulations. Did you know that beginning Jan. 1, 1997, there is a creel limit on spotted bass of 15 fish per day with no size limit on Skiatook Lake?

YES **NO**

Q. The Oklahoma Department of Wildlife Conservation is also interested in knowing how well it informs anglers on how to distinguish "hard-to-identify" species from one another.

1. Did you know that spotted bass can be distinguished from largemouth bass in that spotted bass have a rough tooth patch on the tongue? (If no, offer to demonstrate)

YES **NO**

2. Did you know that largemouth and spotted bass can be distinguished from smallmouth bass in that smallmouth bass have vertical bars along their sides? (If no, offer to demonstrate)

YES **NO**

Q. Do you feel that this regulation change is necessary?

YES **NO** **NO OPINION**

Why?

Q. How will this new regulation change the amount of time spent fishing by you for spotted bass?

Q. How will this new regulation change the amount of spotted bass that you keep per trip?

	Spotted Bass
Effort	
Harvest	

Appendix A cont.

+ = Increase **0 = No Change** **- = Decrease** **N = No Opinion**
U = Unsure

Q. How often do you keep the bass that you catch?

NEVER **RARELY** **SOMETIMES** **USUALLY** **ALWAYS**

Q. Do you plan on keeping the bass that you catch today?

YES **NO** **MAYBE** **CULL**

Q. May I measure them?

YES **NO** **NONE**

Q. Would you please pick one of the following that is the most important reason why you go fishing?

Q. Would you please describe for me the species, numbers, and approximate sizes of all bass caught today?

Q. How would you rate today's fishing?

EXCELLENT **GOOD** **FAIR** **POOR** **VERY POOR**

Q. Would you please fill out this "Catch Card" describing your total catch (species, number, and length), length of your fishing trip, and return address upon completion of your trip and mail back? **(All Returned Cards will be entered in a $100 drawing to be awarded at the end of the year)**.
YES **NO**

ALL ANSWERS WILL BE KEPT CONFIDENTIAL

Appendix A cont.

Survey #_____ **Date**

HARVEST DATA

LMB=largemouth bass **SMB=smallmouth bass** **SPB=spotted bass**

Species	Length (cm)	Weight (kg)	Scale Sample (y,n)	Kept/ Released (K/R)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Appendix A cont.

CATCH DATA

Bass Species	Under 10.0 in.	10.0-13.9 in.	14.0-15.9 in.	16.0-17.9 in.	18.0-19.9 in.	Over 20.0 in.	Total
Largemouth Bass							
Smallmouth Bass							
Spotted Bass							
Unknown Bass							
Total							

Appendix B. Creek Survey questionnaire used in 1998 and 1999 at Skiatook Lake, Oklahoma.

Appendix B

Survey #_____ Survey Section_____ Date_____
Day Type **WD** **WE**

Time of Interview_____(mil) Method **BOAT** **DOCK** **SHORE** # in Party
Special Type **Tourn** **Hol**

INTERVIEWED **DECLINED** **REPEAT**

Times Fish/Mth_____ Start Time_____ (mil) Finish Time (est.) (mil)

Species Sought: **LMB** **SMB** **SPB** **Bass** **Crappie** **Hybrid Striped** **Other** **Nothing in Particular**

Q. The Oklahoma Department of Wildlife Conservation is interested in knowing how well it informs anglers of new regulations. Did you know that beginning Jan. 1, 1997, there is a creel limit on spotted bass of 15 fish per day with no size limit on Skiatook Lake?

YES **NO**

Q. The Oklahoma Department of Wildlife Conservation is also interested in knowing how well it informs anglers on how to distinguish "hard-to-identify" species from one another.

1. Did you know that spotted bass can be distinguished from largemouth bass in that spotted bass have a rough tooth - patch on the tongue? (If no, offer to demonstrate)

YES **NO**

2. Did you know that largemouth and spotted bass can be distinguished from smallmouth bass in that smallmouth bass have vertical bars along their sides? (If no, offer to demonstrate)

YES **NO**

Q. Do you feel that this regulation change is necessary?

YES **NO** **NO OPINION**

Why?

Q. How will this new regulation change the amount of time spent fishing by you for spotted bass?

Q. How will this new regulation change the amount of spotted bass that you keep per trip?

	Spotted Bass
Effort	
Harvest	

Appendix B cont.

+ = Increase 0 = No Change - = Decrease N = No Opinion
U = Unsure

Q. How often do you keep the bass that you catch?

NEVER RARELY SOMETIMES USUALLY ALWAYS

Q. Do you plan on keeping the bass that you catch today?

YES NO MAYBE CULL

Q. May I measure them?

YES NO NONE

Q. Would you please chose one of the following size groups of fish that you would most prefer to catch?

LARGE #S OF SMALL FISH FEW AVERAGE SIZED FISH TROPHY FISH OTHER

Q. What would you consider the single most important reason why you go fishing?

RELAXATION TIME WITH FRIENDS/FAMILY TO CATCH FISH TO CONSUME TO GET AWAY FROM PEOPLE THE CHALLENGE OF FISHING TO EXPERIENCE THE OUTDOORS COMPETITION CATCH FISH OTHER

Q. Would you please describe for me the species, numbers, and approximate sizes of all bass caught today?

Q. How would you rate today's fishing?

EXCELLENT GOOD FAIR POOR VERY POOR

Would you please fill out this "Catch Card" describing your total catch (species, number, and length), length of your fishing trip, and return address upon completion of your trip and mail back?
(All Returned Cards will be entered in a $100 drawing to be awarded at the end of the year)
YES NO
ALL ANSWERS WILL BE KEPT CONFIDENTIAL

Appendix B cont.

Survey #_____ **Date**

	< 10	10-20	20-30	30-40	40-50	50-65	> 65
AGE							
SEX							
RACE							
ZIP							

HARVEST DATA

LMB=largemouth bass **SMB=smallmouth bass**
SPB=spotted bass

Species	Length (cm)	Weight (kg)	Scale Sample (y,n)	Kept/ Released (K/R)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Appendix B cont.

CATCH DATA

Bass Species	Under 10.0 in.	10.0-13.9 in.	14.0-15.9 in.	16.0-17.9 in.	18.0-19.9 in.	Over 20.0 in.	Total
Largemouth Bass							
Smallmouth Bass							
Spotted Bass							
Unknown Bass							
Total							

Chapter III.

RESPONSE OF BASS AND CRAPPIE ANGLER SUB-POPULATIONS TO A DIFFERENTIAL HARVEST REGULATION ON THREE BLACK BASS SPECIES IN SKIATOOK LAKE, OKLAHOMA

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Abstract

We used a two-stage probability roving creel survey from 1997 to1999 to evaluate anglers responses to a differential black bass harvest regulation that was implemented January 1, 1997 at Skiatook Lake, Oklahoma. This regulation allowed anglers to harvest 15 spotted bass of any size and six largemouth and smallmouth bass greater than 356 mm (in aggregate) per day. Prior to this regulation change, all black bass were managed with a 365 mm size limit and a six fish aggregate creel limit. We detected differences in angler knowledge, opinions, fishing habits, motivations, and satisfaction levels when anglers were aggregated at the species sought level (bass and crappie anglers) based on frequency of fishing among bass and crappie anglers in 1997. However, it was clear that bass and crappie anglers were not differentially affected by the regulation change. Bass anglers were more aware of the regulation change and black bass species, greater proportions of these anglers reported they felt the regulation change was necessary compared to crappie anglers, and these anglers caught the majority of spotted bass. Our recommendations focus on targeting bass anglers through media resources to educate them on the need for increasing harvest of spotted bass.

Introduction

Over the past 25 years fisheries managers have recognized the need to provide satisfying fishing trips to all segments of the angling community. Anglers are no longer viewed as a homogenous group because different segments of the angling population are motivated to fish for different reasons (Bryan 1977; Hahn 1991; Ditton 1996; Allen and Miranda 1996; and Fisher 1997). Fedler and Ditton (1994) identified five highly-rated motivational categories: psychological and physiological, natural environment, social, fishery resource, and skill and equipment. They found that when anglers were aggregated at the population levels, several non-catch-related motivations for fishing were rated consistently more important than catch related motivations. However, this was not the case for all anglers at the sub-population level. For example, angler motivations have been shown to differ between surf and boat fishermen (Carls 1980), marine boat anglers (Dawson and Wilkins 1981), bay and offshore fisherman (Graefe and Ditton 1986), anglers and guides (Hunt and Ditton 1998), anglers fishing particular bodies of water and statewide anglers (Hunt et al. 1996) and among bass angler (Ditton 1996; Wilde et al. 1997); and crappie anglers (Allen and Miranda 1996).

More recently fisheries managers have been encouraged to use a marketing approach to satisfy the needs of all anglers when making management decisions. Ditton (1996) recommended segmenting bass anglers by fishing frequency, resident location, gender, and tournament participation. The basis for segmenting anglers is the recreational specialization concept proposed by Bryan

(1977). He described recreational specialization as a "continuum of behavior from the general to the particular, reflected by the equipment and skills used in the sport and activity setting preferences." Bryan classified trout anglers into occasional fisherman, generalist, techniques specialist, and techniques-setting specialists based on equipment preferences, orientation to fish, resource orientation, management philosophies, angling history, social context, and vacation patterns. Since then, others (Hahn 1991; Allen and Miranda 1996; and Fisher 1997) have used similar classifications to describe anglers. For example, Hahn (1991) suggested the following angler classifications: occasional anglers, generalists, species specialists, and advanced species specialist; Allen and Miranda (1996) classified crappie anglers into occasional anglers, generalists, springtime anglers, and crappie specialist; and Fisher (1997) identified seven different angler groups using cluster analysis bases on six variables relating to fishing experience and importance of catch. Because Fisher was able to identify distinct groups using cluster analysis, he felt that anglers could not be distributed along a continuum.

Hahn (1991) felt that frequency of fishing, angling years of experience, and centrality of fishing to lifestyles were good indicators of angler specialization. He found that as anglers became more specialized, catching fish became more important but harvesting fish did not, importance of conserving the resource increased, and anglers favored strict enforcement of game laws and more restrictive regulations. Similarly, Allen and Miranda (1996) found occasional crappie anglers used simple tackle, typically harvested fish, and did not have an

opinion of alternate regulations. Spending time outdoors and with fishing partners was rated highly by this group. General crappie anglers usually harvested their catch, preferred to catch many fish, regardless of size, and favored more liberal regulations. Crappie specialists were motivated by factors associated with learning about catching crappies and fisheries management, favored regulations that would improve fishing, and preferred to catch large fish.

Skiatook Lake was opened for public fishing in 1986, and since then, the black bass populations have been protected from over exploitation by both size and harvest regulations. Under the regulation, all black bass caught that are less than 356 mm must be immediately released and no more than 6 black bass, in aggregate, may be kept. In 1992 fisheries biologist with the Oklahoma Department of Wildlife Conservation (ODWC) noticed a dramatic increase in the number of the spotted bass with very few of them reaching the 356-mm size limit. At the same time, they also reported a significant decline in the relative weight for all sizes of this species. By 1994, body condition of largemouth bass >300 mm had also declined, and the condition of smallmouth bass between 200 mm and 299 mm was considered unsatisfactory (ODWC 1995). Beginning 1 January 1997, the ODWC removed the size limit on spotted bass and increased the harvest limit to 15 fish per day. These new limits only applied to spotted bass; the previous 356-mm and 6 fish (aggregate) daily bag limit remained in effect for the largemouth and smallmouth bass. The goal of this regulation change was to improve the population structure of all black bass species.

This regulation change was evaluated using a creel survey from 1997-1999 (Chapter II). Results from this survey indicated the regulation failed to change the population structure of black bass due to a lack of angler harvest. Hyler (Chapter II) recommended identifying angler groups that could be targeted for educational programs designed to inform anglers about the purpose of the regulation and the need for increased harvest of spotted bass.

Our objectives were to determine: (1) if differences existed in angler's knowledge, opinions, fishing habits, motivations, and satisfaction levels when they were aggregated at the species sought level (bass and crappie anglers) in 1997; and (2) if these differences could be detected among bass and crappie angler sub-populations based on the relative frequency of fishing and tournament participation in 1997; and (3) if this regulation differentially affected bass and crappie angler sub-populations from 1997-1999.

Methods

Study Site.--Skiatook Lake is a 4,266 ha flood control reservoir located 8 km west of Skiatook in Osage County, Oklahoma (ODWC 1995). The lake was created in 1984 when the U.S. Army Corps of Engineers (USCOE) impounded Hominy Creek. The USCOE currently manages the lake for flood control and recreation, while the ODWC manages the lake's fisheries resources. Under a cooperative agreement between the USCOE and the ODWC, the lake was filled in stages from October 1984 to July 1989 to increase the naturally high productivity of the newly constructed reservoir (ODWC 1995). Although the lake was not at full pool, public fishing was allowed beginning in May 1986.

Skiatook Lake drains forest and agricultural land, has high rocky bluffs, and a steep rocky shoreline. Fish habitat at Skiatook Lake is characterized by deep clear water, particularly in the lower end of the lake, a rock-covered substrate, and abundant standing and fallen timber. Skiatook Lake has a 257-km shoreline with a shoreline development ratio of 11.3 (ODWC 1995). The trophic state of the lake ranges from oligotrophic at lower end near the dam to eutrophic at the upper end (Long 2000). The lake has a mean depth of 9.7m with a maximum depth of 31m (ODWC 1995).

Popular recreational activities on Skiatook Lake include boating, camping and fishing. Fishing pressure from tournament and non-tournament anglers is high. Skiatook Lake hosted the second highest number of black bass fishing tournaments for lakes over 1,000 acres in Oklahoma (ODWC 1995). Major sport fish of Skiatook Lake include largemouth bass, smallmouth bass, spotted bass, white crappie Pomoxis annularis, channel catfish Ictalurus punctatus blue catfish I. furcatus. flathead catfish Pylodictis olivaris, hybrid striped bass Morone saxatilis X M. chrysops and walleye Stizostedion canadense. A large proportion of angler effort is directed towards the black bass and crappie fisheries (Zale and Stubbs 1991).

Angler data were collected from March-October in 1997, 1998, and 1999 using a two-stage probability roving creel survey (Robson 1991) to quantify catch, harvest, and effort, and to assess anglers' knowledge of the regulation change, abilities to identify spotted bass, attitudes, opinions, effects on anglers fishing effort and harvest of spotted bass, and satisfaction levels at the sub-

population level. In 1998, our questionnaire was modified to collect information on angler motivations for fishing, preferred size of catch, mean distance traveled, age, sex and race of anglers.

A two-stage probability roving creel survey requires sampling time to be allocated in proportion to fishing effort. We allocated effort by the following strata: month, day type (weekend, weekdays), and day time (AM-PM) (Pollock et al.1994, Malvestuto 1996). Monthly sampling effort in 1997 was allocated based on monthly car count data at boat ramps from October 1993 through September 1996, which was provided by the U.S. Army Corps of Engineers. Surveys were scheduled for one weekday and one weekend day in March and October; two weekdays and one weekend day per week in April, June, July, August, and September; and three weekdays and one weekend day per week in May. All surveys were scheduled with a 0.5 probability of sampling in the AM or PM in 1997. Weekdays and weekend days were randomly selected for each week of the study (Long et al. 1997).

In 1998 and 1999, sampling time was allocated in proportion to 1997 monthly, day-type and day-time effort estimates. Monthly and day-type sampling remained the same as 1997. Sampling effort in the daytime stratum varied by month and day type. In March, surveys were scheduled with an 85% probability of sampling in the AM time period during weekdays and 70% on the weekends. In April, the probability of sampling a weekday morning was 80% and 45% on the weekends. In May, sampling was conducted with a 30% probability of sampling on weekday mornings and 67% on the weekends. In June, weekday surveys

were selected with a 55% probability of sampling in the AM time period and a 40% probability on weekends. In July, the probability of a morning weekday survey was 80% while weekend mornings had a 53% chance of being sampled. In August, weekday surveys were scheduled with a 54% probability of being sampled in the AM time period and a 33% probability on the weekends. In September and October, the chance of conducting a survey on a weekday morning was 47% and 72% respectively, while the chance of surveying on a weekend morning in both months was 50%.

The lake was divided into eight sections of equal shoreline distance that served as checkpoints as well as starting and stopping locations for the creel clerk (Figure 1). The creel clerk was required to spend an equal amount of time interviewing anglers in each section of the lake, which provided an instantaneous angler count for each section (Pollock et al. 1994). Each day, the creel clerk traveled by boat in a randomly chosen direction around the lake starting in a randomly chosen section. Anglers actively fishing were approached using 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 by the tooth patch on the tongue, if they were aware that smallmouth bass could be identified by their 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 (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. We then asked if we could measure any bass that they had kept. All bass in the angler's creel were measured to the nearest 0.1 cm and weighed to the nearest 0.1 kg. Anglers were asked about the size of fish that they would most prefer to catch and what was the most important reason that they went fishing. At the end of the survey anglers were asked for a zip code and to rate their fishing trip that day. Angler counts were made in conjunction with interviews to provide data on angling effort.

Bass and crappie angler sub-populations were created based on fishing frequency in 1997. Black bass anglers were subdivided into tournament anglers, occasional anglers, frequent anglers, and devoted anglers. Occasional bass anglers were those who fished four or less times per month, frequent bass anglers fished between five and eight times per month, devoted bass anglers fished greater than eight times per month, and tournament anglers were those actively fishing in a tournament regardless of fishing frequency. Crappie anglers were divided into occasional crappie anglers (fished <4 times per month), frequent crappie anglers (fished between 4 and 7 times per month), and devoted crappie anglers (fished >7 times per month). These sub-populations were created from the relative frequency of fishing per month, which anglers provided during creel surveys. The frequencies were divided into thirds resulting in occasional, frequent and devoted angler sub-populations.

Estimates of angler sub-populations catch per unit effort (CPUE) and harvest per unit effort (HPUE) were calculated using the mean-of-ratio estimator (Malvestuto 1996). These estimates provided the number of fish caught and

harvested per hour. Since black bass CPUE did not differ significantly among years and HPUE estimates could not be directly compared due to high numbers of zero estimates (Chapter II). CPUE and HPUE estimates were calculated using pooled data from 1997-1999.

We used angler count data to estimate annual total fishing effort with the method described by Pollock et al. (1994). These estimates were summed to estimate total effort from 1997-1999. Angler sub-population effort was calculated by multiplying the proportion of each sub-population in creel surveys by our total effort estimates. Total catch and harvest estimates were computed by multiplying the angler sub-population CPUE and HPUE by sub-population total effort. Black bass catch distributions are reported as proportions of bass caught by each sub-population.

Bass and crappie angler population responses from 1997 to questions regarding their knowledge of the regulation change and abilities to distinguish spotted bass from largemouth and smallmouth bass were compared with a t-test. Responses to the remaining questions were compared using Chi-square contingency tables.

Bass and crappie angler sub-populations responses to questions concerning their knowledge of the regulation change and abilities to distinguish spotted bass from largemouth and smallmouth bass were compared with ANOVA (SAS Institute 1988). Contrasts were used to detect differences among sub-populations and linear trends among bass and crappie angler sub-populations. Sub-population responses to the remaining survey questions were compared

using Chi-square contingency tables (SAS Institute 1988). Fisher's exact test was used in cases where the cell expected values were less than 5% (SAS Institute 1988). Responses of each of the bass and crappie angler sub-populations were monitored from 1997-1999 for changes that could be associated with the regulation change using identical statistical methods as above, but now the contrasts were used to compare annual changes and linear trends through time for each sub-population.

When comparing angler sub-population responses to changes in fishing effort, changes in bass harvest, how often bass were kept, motives for fishing, and satisfaction levels, many of the possible responses were rarely reported by anglers. Consequently, response categories were combined to allow statistical testing. No opinion responses to the questions about how the regulation would change the amount of time spent fishing for spotted bass and how the regulation would change the number of bass harvested were deleted from our analysis, and those reporting they were unsure were added to the no change category. Responses of never and rarely to the question of how often do you keep the bass that you catch were combined into a category of not likely to keep the bass, while those reporting they sometimes, usually, or always kept the bass caught were combined into a category of likely to keep bass. Motivations for fishing were classified into catch and non-catch related categories. Catch related motives included catching fish to consume, catch fish, the challenge of fishing and competition. Satisfaction levels were combined to form categories of satisfied and unsatisfied anglers. Satisfied anglers were those rating their fishing trip from

fair to excellent and unsatisfied anglers were those rating their fishing trip from poor to very poor.

Mean distances traveled by anglers fishing at Skiatook Lake were found by identifying the angler's hometown from the zip codes provided during the surveys and calculating the shortest driving distance to the town of Skiatook. The mean distance traveled by bass and crappie angler populations were compared using a t-test on pooled data from 1998 and 1999, while a ANOVA was used to compare distances traveled by angler sub-populations within bass and crappie angler populations.

Results

Creel surveys were conducted on 95 days from March 1 through October 31 in 1997, 92 days in 1998, and 78 in 1999. Eight hundred sixty-eight angler surveys were completed in 1997, while 601 and 395 anglers were surveyed in 1998 and 1999, respectively. In 1997, 82% of the anglers participated in the surveys while 3% declined and 15% were repeat surveys. In 1998 angler participation was similar to 1997, with 84% of the anglers participating in the survey, 2% declining and 14% were repeat surveys. In 1999, the percent of repeat surveys increased significantly from 1997 ($P=0.003$) and 1998 ($P=0.002$) to 23%.

Bass anglers caught 70% of the largemouth bass caught from 1997-1999. Fifteen percent of these were caught by tournament anglers, 4% by devoted bass anglers, 21% by frequent bass anglers, 30% by occasional bass anglers,

11% by devoted crappie anglers, 11% by frequent crappie anglers, and 8% by occasional crappie anglers (Table 1).

From 1997-1999, 95% of the spotted bass were caught by bass anglers. Sixteen percent of these were caught by tournament anglers, 38% by devoted bass anglers, 17% by frequent bass anglers, 24% by occasional bass anglers, 2% by devoted and occasional crappie anglers and 1% by frequent crappie anglers (Table 2).

Eighty-seven percent of the smallmouth bass were caught by bass anglers during the three year study. Tournament anglers caught 6% of the smallmouth while devoted bass, frequent bass and occasional bass anglers caught 35%, 24%, and 23% of these bass respectively. Devoted frequent and occasional crappie anglers accounted for 4%, 4%, and 5% of the catch respectively (Table 3).

Crappie anglers reported 53% percent of the unknown bass while 47% of the unknown bass were reported by bass anglers from 1997-1998. Six percent of the bass caught by tournament anglers were not identified, while 11% of devoted bass anglers, 5% of frequent bass anglers, 25% of occasional bass anglers, 13% of devoted crappie anglers, 19% of frequent crappie anglers and 21% of occasional crappie anglers did not identify the bass they caught (Table 4).

Bass versus crappie populations.--In 1997, bass anglers were better informed about the regulation change than crappie anglers and how to distinguish spotted bass from largemouth and smallmouth bass (Figure 2). Sixty-eight percent of

bass anglers were aware of the regulation change compared to crappie 46% of crappie anglers ($P<0.001$). Seventy-seven percent of the bass anglers reported they could distinguish spotted bass from largemouth bass compared to 36% of crappie anglers ($P<0.001$). The proportion of bass and crappie anglers that reported they were aware smallmouth bass could be distinguished from largemouth and spotted bass was 92% and 66%, respectively ($P<0.001$)

Crappie anglers were more likely to harvest the bass they caught than bass anglers (Figure 3). In 1997, 61% of bass anglers reported they never kept the bass that they caught, 21% reported they rarely kept their bass, 8% reported they sometimes kept bass, while 6% and 4% reported they usually or always kept the bass they caught. In contrast, 26% of crappie anglers never harvested the bass they caught, 29% rarely harvested black bass, 14% sometimes harvested bass, and 6% and 8% usually or always kept the bass they caught respectively ($P<0.001$;Figure 3). When asked if they planned on keeping the bass they caught that day, 18% of bass anglers did compared to 32% of crappie anglers. However, 75% of bass anglers reported they did not plan on keeping the bass and 7% said they might compared to 52% and 16% of crappie anglers, respectively ($P<0.001$; Figure 3). Significantly more crappie anglers than bass anglers said they would increase their harvest when asked how would this regulation effect the number of bass you would keep per fishing trip ($P=0.023$; Figure 3), but there was no difference between bass and crappie anglers response to how the regulation would affect the amount of time they would spend fishing for spotted bass ($P=0.413$).

In 1997, significant differences ($P<0.001$) were detected between bass and crappie anglers when asked whether or not they felt the regulation change was necessary, what size of fish would they most prefer to catch, and what is the single most important reason why they went fishing (Figure 4). Although the majority of bass (46%) and crappie anglers (70%) did not have an opinion about the regulation change, 43% percent of the bass anglers reported the regulation change was necessary compared to 24% of crappie anglers. Very few anglers 11% bass and 6% crappie anglers felt the regulation change was not necessary. Most anglers preferred to catch a few average-size fish compared to one trophy or many small fish. Sixty-six of bass anglers and 74% percent of crappie anglers responded they preferred to catch a few average fish. Only 9% of bass anglers and 17% of crappie anglers preferred to catch large numbers of small fish while 22% and 7% preferred to catch a single trophy fish. Forty-seven percent of both bass and crappie anglers fished mainly for relaxation, which was followed by 19% and 22%, respectively, who were motivated to fish by spending time with friends and family. Spending time in the outdoors was the primary reason for fishing for 8% of bass anglers and 13% of crappie anglers. Only 10% of bass and 2% of crappie anglers reported competition as their motivation for fishing. Catch related motives made up the smallest proportions of responses for both angling groups. In 1997, 1% of bass anglers and 5% of crappie anglers reported catch related motives as the most important reason why they went fishing. Fifteen percent of bass and 11% of crappie anglers' responses could not be classified into a single category.

Angler satisfaction levels were similar between angler groups (P=0.11), with less than 10% of both groups rating their fishing trip as excellent; about 23% rated their trip as good, 30% as fair, 30% as poor and 10% as very poor. In 1997, bass anglers traveled a mean of 37 mi to fish at Skiatook Lake, which was similar to 31 mi traveled by crappie anglers (P=0.24).

Bass angler sub-populations.--Linear trends were detected among bass angler sub-population responses to questions regarding their knowledge of the regulation and black bass species. As angler sub-populations became more devoted to bass fishing their knowledge of the regulation change increased linearly from 58% of occasional bass anglers to 78% of tournament anglers (P=0.03; Figure 5). A similar trend was also evident in the proportion of anglers who reported they knew spotted bass could be distinguished from largemouth bass by feeling for the tooth patch on the tongue (P<0.001), with proportions ranging from 63% of occasional anglers (63%) to 89% of tournament anglers (Figure 5). Although more than 80% bass anglers knew smallmouth bass could be distinguished from other black bass by their external body coloration, a linear trend still existed among angler sub-populations (P=0.02; Figure 5). The proportions ranged from 86% for occasional anglers to 98% of tournament anglers.

We did not detect many differences in bass angler fishing habits among sub-populations. We found an increasing trend among angler sub-populations when asked how often they kept the bass they caught (P=0.001; Figure 6). All of the tournament anglers, 94% of frequent anglers, and (90%), of devoted anglers,

and 84% of occasional anglers reported they never or rarely kept the bass they caught (Figure 6). No difference were detected among sub-populations when anglers were asked if they planned to keep the bass they caught (P=0.31), if they would change the amount of time they would spend fishing for spotted bass (P=0.38), and if the regulation would change the number of spotted bass you would harvest per fishing trip (P=0.11). However more devoted and frequent bass anglers said the regulation change was necessary than occasional anglers (P=0.002; Figure 6)

Greater than 50% of each sub-population rated their fishing trip from fair to excellent. Proportions ranged from 54% of tournament anglers to 69% of occasional anglers, but they were not significantly different (P=0.20).

Crappie angler sub-populations.--Positive linear trends were detected among crappie angler sub-populations in their responses to the questions about the regulation change (P=0.007) and distinguishing spotted bass from largemouth bass (P=0.04; Figure 7). In 1997, 58%, 43% and 39% of the devoted, frequent, and occasional crappie anglers were aware of the regulation change, respectively (Figure 7). The proportions of crappie angler sub-populations that reported they could distinguish spotted bass from largemouth bass by feeling the tooth patch ranged from 31% of occasional anglers to 45% of devoted anglers (Figure 7). Based on their responses, there was no difference among crappie angler sub-populations in their abilities to distinguish smallmouth bass from largemouth bass by their external body coloration (P=0.11).

The majority of each crappie sub-population reported they would not change the amount of time they would spend fishing for spotted bass nor would they increase the number of bass they would harvest following the regulation change. Similar responses occurred among sub-populations for both of these questions ($P=0.83$ and $P=0.72$; respectively). Over 90% of all angler sub-populations responded that the new regulation would not effect their fishing effort directed at spotted bass, and more than half reported this regulation would not change the number of bass they would harvest per fishing trip.

We detected differences among angler sub-population responses to the questions about the frequency they kept the bass they caught ($P=0.03$) and whether or not they would keep their catch of bass ($P=0.03$; Figure 8). The proportions of anglers that never or rarely kept the bass they caught decreased with fishing frequency among crappie anglers. Eighty-four percent of devoted anglers, 75% of frequent anglers and 69% of occasional anglers reported they never or rarely harvested the bass they caught (Figure 8). As fishing frequency increased crappie anglers were less likely to harvest the bass they caught. Twenty-six percent of devoted anglers responded they planned to keep the bass caught the day of the survey, this was followed by 28% of frequent anglers and 42% of occasional anglers (Figure 8).

We did not detect differences among our classifications in anglers opinions towards the regulation change ($P=0.97$) or their fishing trip satisfaction levels in 1997 ($P=0.27$). Greater than 67% of each sub-population reported they did not have an opinion as to whether or not the regulation change was

necessary and between 55% and 66% rated their fishing trip from fair to excellent. The mean distance anglers traveled to fish Skiatook Lake was similar among sub-populations (P=0.81).

Interannual trends in angler sub-populations.--From 1997-1999, we did not detect differences in bass or crappie angler sub-populations' knowledge of the regulation change. An average of 77% of the tournament bass anglers were aware of the regulation change compared to 68% of devoted bass anglers, 69% of frequent bass anglers, 50% of occasional bass anglers, 59% of devoted crappie anglers, 49% of frequent crappie anglers and 40% of occasional crappie anglers.

Bass angler sub-populations abilities to identify spotted bass did not increase throughout the study period; however, linear increases were detected in occasional (P=0.02) and frequent (P<0.001) crappie angler sub-populations (Figure 9). Over the study period an average of 91% of tournament anglers, 84% of devoted bass anglers, 85% of frequent bass anglers and 67% of occasional bass anglers knew spotted bass could be distinguished from largemouth by feeling for the tooth patch. Frequent crappie anglers knowledge increased from 33% in 1997 to 70% in 1999, while occasional anglers knowledge increased from 31% in 1997 to 53% in 1999 (Figure 9). Contrary to this, devoted crappie anglers knowledge of spotted bass failed to increase in the years following the regulation change. An average of 53% of these anglers reported they knew spotted bass could be distinguished from largemouth by looking for the tooth patch.

From 1997-1999, greater than 85% of each bass angler sub-population knew smallmouth bass could be identified by their external body coloration from 1997 to 1999. The only bass angler sub-population that improved during this study was the devoted anglers ($P=0.01$). In 1997, 91% of these anglers reported they could identify smallmouth bass their external body coloration. Similarly, greater than 60% of crappie anglers could identify smallmouth from 1997-1999 and differences were not detected in any sub-population.

Few anglers indicated that the regulation change would effect the amount of time they would spend fishing for spotted bass, regardless of species sought or frequency of fishing, and these proportions did not change from 1997-1999. Annually, 89% to 94% of tournament anglers responded that they would not increase their fishing effort for spotted bass ($P=0.07$). Similarly, 92% to 98% of devoted bass anglers, 93% to 100% of frequent bass anglers, and 94% to 97% of occasional bass anglers reported no change in their fishing effort following the regulation change. Crappie angler sub-populations responded similar to bass anglers with 92% to 100% of devoted crappie anglers, 91% to 98% of frequent crappie anglers, and 94% to 97% of occasional anglers annually responding this regulation would not effort their fishing effort.

From 1997-1999, significant changes were detected with in the devoted bass anglers, devoted crappie anglers, and frequent crappie anglers while changes could not be detected with in tournament angler, frequent bass anglers, occasional bass anglers, and occasional crappie anglers when asked how this regulation would affect the number of bass you harvest per fishing trip. Annual

proportions of devoted bass anglers that said they would not change ranged from 54% (P=0.009) in 1997 to 78% in 1999. Similarly. proportions ranged from 57% in 1997 to 87% (P=0.01) in 1999 for devoted crappie anglers and 60% to 81% (P=0.05) of frequent crappie anglers in 1997 to 1999 respectively. From 1997-1999, an average of 80%, 72%, 73%, and 63% of the tournament (P=0.09), frequent bass anglers (P=0.29), occasional bass (P=0.35), and occasional crappie anglers (P=0.19), respectively, reported the regulation would not cause them to change the number of bass they would harvest.

Throughout our study, the majority of anglers reported they never or rarely kept the bass they caught regardless of our classifications. Following the regulation change a greater proportion of tournament anglers reported they sometimes or always harvested the bass they caught. In 1997 and 1998, 100% of tournament anglers responded they never or rarely kept the bass they caught. By 1999, 18% reported they sometimes or always harvested the bass they caught. This was the only bass angler sub-population whose responses changed from 1997-1999. On average, 89%, of devoted bass anglers and 87% of frequent and occasional anglers reported they never or rarely harvested bass. Crappie angler sub-populations responses were similar in each throughout the study. An average of eighty-six percent, 81%, and 76% of devoted, frequent, and occasional crappie anglers respectively, reported they rarely or never harvested bass.

By 1999, frequent bass anglers were more likely to keep the bass they caught the day of the survey than in 1997, while other sub-populations were as

likely to harvest bass in 1999 as in 1997. On average, 74% and 63% of devoted and occasional bass anglers reported they did not plan on keeping the bass they caught while 65%, of devoted crappie anglers, 66% of frequent crappie anglers and 50% of occasional crappie anglers responded they would not keep the bass they caught the day of the survey.

With the exception of tournament anglers, angler sub-populations' opinions of the regulation remained similar in each year of the study. In 1997, 46% of tournament anglers felt the regulation change was necessary. By 1998, 77% agreed with the regulation change this dropped to 53% by 1999. Those in favor of the regulation change ranged from 47% to 55% of devoted bass anglers, 27% to 59% of frequent bass anglers, and 24% to 34% of occasional bass angler. From 1997-1999, between 20% and 33% of devoted crappie anglers, 18% and 27% of frequent crappie anglers, and 18% and 13% of occasional crappie anglers felt the regulation was necessary.

Angler satisfaction levels failed to change from 1997-1998 for all angler sub-populations. Throughout the study 41% to 54% of tournament anglers rated their fishing trip from fair to excellent. Sixty-one to 68% of devoted bass anglers, 59% to 72% of frequent bass anglers, and 65% to 72% of occasional bass anglers were satisfied with their fishing trip. Greater than 55% of all crappie angler sub-populations were satisfied with their fishing trip in each year of the study. Sixty to 66% of devoted crappie anglers, 55% to 63% of frequent crappie anglers, and 61% to 64% of occasional crappie angler reported fair to excellent fishing trips.

As bass and crappie anglers became more devoted to fishing, catch-related motives increased proportionally (Figure 10). Fifty-six percent, 42%, 35%, and 21% of tournament, devoted, frequent, and occasional bass anglers respectively, rated catch related motives higher than non-catch related motives from 1997-1999 ($P<0.001$). Thirty-eight percent of devoted crappie anglers, 28% of frequent crappie anglers, and 21% of occasional crappie anglers rated catch related motives as the most important reason why they went fishing ($P=0.07$).

The majority of each sub-population preferred to catch a few average size fish over many small fish or one trophy fish; however, differences were not detected among bass or crappie sub-populations. Seventy-two percent, 69%, 60%, and 68% of tournament, devoted, frequent, and occasional bass anglers respectively, reported they preferred to catch a few average size fish. Sixty-seven percent, 76%, and 80% of devoted, frequent, and occasional crappie anglers preferred to catch a few average size fish.

Discussion

When anglers' were aggregated at the level of fish species sought, we found differences between bass and crappie angler sub-populations. Bass anglers knowledge of the regulation change and black bass species were significantly greater than crappie anglers. Greater proportions of bass anglers felt the regulation change was necessary, reported competition as the primary reason they went fishing, and preferred to catch a few large fish. In contrast, crappie anglers were more likely to harvest the fish they caught and to increase the number of bass they would harvest following the regulation change.

Differences were not detected in satisfaction levels or in the proportions of anglers reporting they would change their fishing effort for spotted bass.

When bass anglers were divided into groups based on their frequency of fishing and tournament participation many trends were consistent with the angler specialization concept (Bryan 1977). As bass anglers became more specialized, we detected an increase in their knowledge of the regulation, and in their ability to distinguish spotted bass from largemouth bass and smallmouth bass from largemouth and spotted bass. The proportions of angler sub-populations reporting they never or rarely harvested the bass they caught decreased from tournament to frequent to devoted to occasional anglers while the proportion that felt the regulation change was necessary increased from occasional to frequent to devoted anglers, and tournament angler responses were similar to those of frequent anglers.

We did not detect a difference in the responses of angler sub-populations to questions regarding harvest on the day of the survey, changes in fishing effort and harvest following the regulation change, or satisfaction levels. Under the angler specialization concept we would have expected less specialized anglers to catch and harvest spotted bass in greater proportions than more specialized anglers (Hahn 1991). In fact, as anglers became more specialized greater proportions reported they would increase the amount of time spent fishing for spotted bass, and with the exception of tournament anglers, who would harvest more spotted bass following the regulation change. Typically as specialization increases harvest becomes less important and conservation of resources and

acceptance of stricter regulation that improve the resource become more important (Hahn 1991). It is possible that the more specialized anglers in Skiatook Lake recognized the need to reduce the numbers of spotted bass in order to enhance the black bass resource. This theory is supported by greater proportions of anglers reporting they felt the regulation change was necessary as specialization increased.

As crappie anglers became more specialized, we detected increases in their knowledge of the regulation and their ability to identify spotted bass. Although not statistically significant, the ability of crappie angler sub-populations to identify smallmouth bass was slightly greater between occasional anglers and devoted angers. Consistent with the angler specialization concept, devoted crappie anglers kept bass less often than frequent and occasional crappie angles, and occasional crappie anglers were more likely to harvest the bass they caught.

All crappie angler sub-populations responded similarly to questions regarding changes in their fishing habits following the regulation change and opinions of the necessity of the change. This suggests that crappie anglers encountered at Skiatook Lake may be aggregated towards the upper end of the specialization continuum and prefer to catch crappie over bass. In general most crappie anglers never or rarely kept the bass they caught and were not likely to keep the bass they caught the day of the survey. Allen and Miranda (1996) found that occasional crappie anglers were likely to harvest their catch, were satisfied with existing regulations, did not fish for particular species, and were

happy to catch anything that would bite. Crappie generalists fished frequently from shore, harvested their catch, and were satisfied with the current harvest regulations. In contrast, crappie specialists preferred to catch crappies and were more likely to release small fish than occasional and general anglers (Allen and Miranda 1996).

Over the three year study, the majority of bass angler sub-populations' knowledge of the regulation and black bass species, opinions of the regulation change, fishing habits, and satisfaction levels were unchanged by the regulation. The only differences detected were that tournament anglers were more likely to harvest the bass they caught in 1999 than in previous years and greater proportions of devoted bass anglers reported they would not change the number of spotted bass they would harvest.

Similarly, we detected few differences in crappie angler sub-populations knowledge of the regulation and black bass species, opinions about the regulation, fishing habits, or satisfaction levels over the three years. Greater proportions of devoted crappie anglers reported they would not change their effort directed at spotted bass in 1998 and 1999 compared to 1997. The ability of frequent crappie anglers to identify spotted bass increased each year following the regulation change but significantly fewer of these anglers reported they would increase the number of spotted bass they would harvest.

As predicted by the angler specialization concept, catch related motives became more important as bass and crappie anglers became more specialized

but preferred size of catch was similar among bass and among crappie angler sub-populations.

Our data suggest that segmenting anglers based on fish species sought and frequency of fishing are both viable options for targeting anglers to increase their harvest of spotted bass in Skiatook Lake. Because differences were detected in virtually all survey questions in 1997 and few differences were detected among bass anglers and among crappie angler sub-populations in the years following the regulation change, we recommend that fisheries managers target bass and crappie anglers in Skiatook Lake. Segmenting anglers on fishing frequency and species sought revealed differences among bass angler sub-populations and crappie angler sub-populations but failed to detect differences in changes in their fishing effort for and harvest of spotted bass.

Overall, harvest of black bass appears to be of little importance to anglers at Skiatook Lake. This suggests that both bass and crappie anglers at Skiatook Lake may be aggregated towards the upper end of the angler specialization continuum. Further evidence to support this theory include: (1) only about 10% of the anglers surveyed were fishing from shore (Chapter II), (2) limited shoreline access may have prevented less specialized anglers from using the resource, (3) those anglers fishing for no particular species were not included in either bass or crappie angler sub-populations (Chapter II), and (4) there is an inherent avidity bias associated with roving creel surveys (Pollock et al. 1994).

We recommend that educational efforts be directed at bass anglers in Skiatook Lake since they caught the majority of black bass caught from 1997-

1999, were better informed of the regulation and how to identify spotted bass, and felt more strongly than crappie anglers that the change was necessary. Because these anglers are targeting bass, appear to be highly specialized, catch most of the bass caught, are more knowledgeable of the regulation and black bass species, and greater proportions reported they felt the regulation change was necessary compared to crappie anglers, they have the greatest potential to affect the bass populations by increasing their harvest of spotted bass

For this regulation to significantly reduce spotted bass abundance at Skiatook Lake, anglers need to be convinced to harvest the spotted bass they catch. Since most Skiatook Lake anglers are highly specialized, appropriate methods for educating these anglers are informational articles in area newspapers and promotion of the regulation on the Outdoor Oklahoma television programs and at fishing club meetings. Ditton et al. (1992; see Allen and Miranda 1996) found that specialized anglers were more dependent on media resources, which would suggest that our recommendation would be appropriate for promoting angler harvest of spotted bass.

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Table 1.--Largemouth bass catch distributions among angler sub-populations at Skiatook Lake.

Sub-population	N	CPUE	% of surveys	Effort	Total catch	% of total catch
Tournament bass	139	0.17	11	51,101	8,687	15
Devoted bass	181	0.04	15	66,541	2,422	4
Frequent bass	137	0.24	11	50,365	11,886	21
Occasional bass	210	0.22	17	77,202	17,293	30
Devoted crappie	190	0.09	15	69,850	6,356	11
Frequent crappie	187	0.09	15	68,747	6,462	11
Occasional crappie	197	0.06	16	72,423	4,345	8
Total	1241		100	456,230	57,453	100

Table 2.--Spotted bass catch distributions among angler sub-populations at Skiatook Lake.

Sub-population	N	CPUE	% of surveys	Effort	Total catch	% of total catch
Tournament bass	139	0.13	11	51,101	6,448	16
Devoted bass	181	0.23	15	66,541	15,524	38
Frequent bass	137	0.14	11	50,365	7,122	17
Occasional bass	210	0.13	17	77,202	9,776	24
Devoted crappie	190	0.01	15	69,850	911	2
Frequent crappie	187	0.01	15	68,747	440	1
Occasional crappie	197	0.01	16	72,423	999	2
Total	1241		100	456,230	41,220	100

Table 3.--Smallmouth bass catch distributions among angler sub-populations at Skiatook Lake.

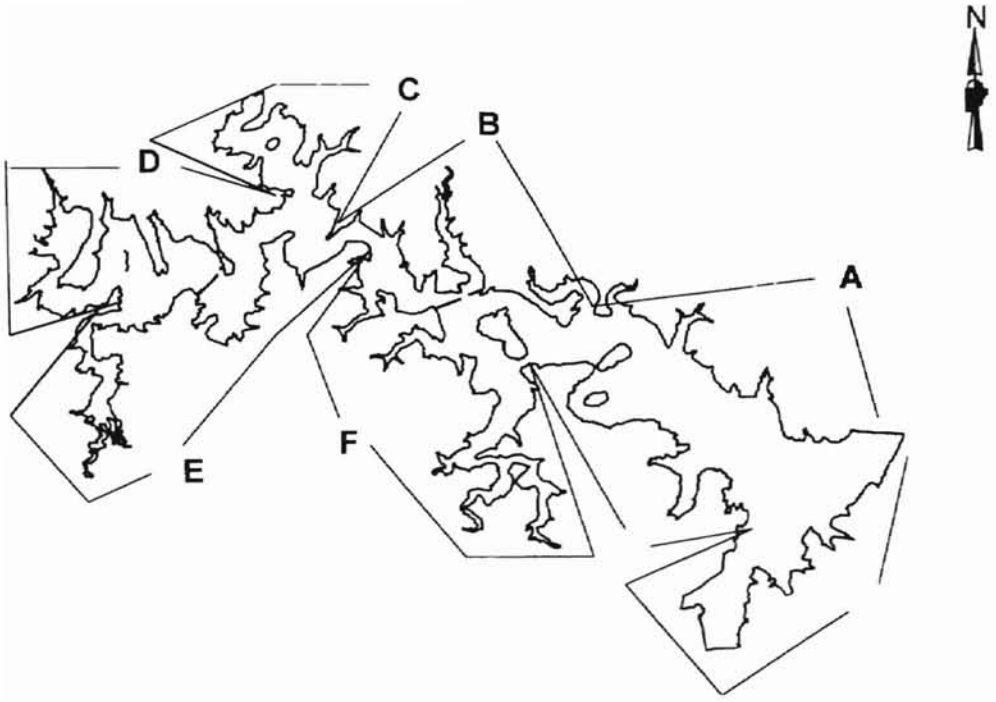
Sub-population	N	CPUE	% of surveys	Effort	Total catch	% of total catch
Tournament bass	139	0.02	11	51,101	1,242	6
Devoted bass	181	0.11	15	66,541	7,566	35
Frequent bass	137	0.10	11	50,365	5,037	24
Occasional bass	210	0.06	17	77,202	4,864	23
Devoted crappie	190	0.01	15	69,850	911	4
Frequent crappie	187	0.01	15	68,747	791	4
Occasional crappie	197	0.01	16	72,423	999	5
Total	1241		100	456,230	18,708	100

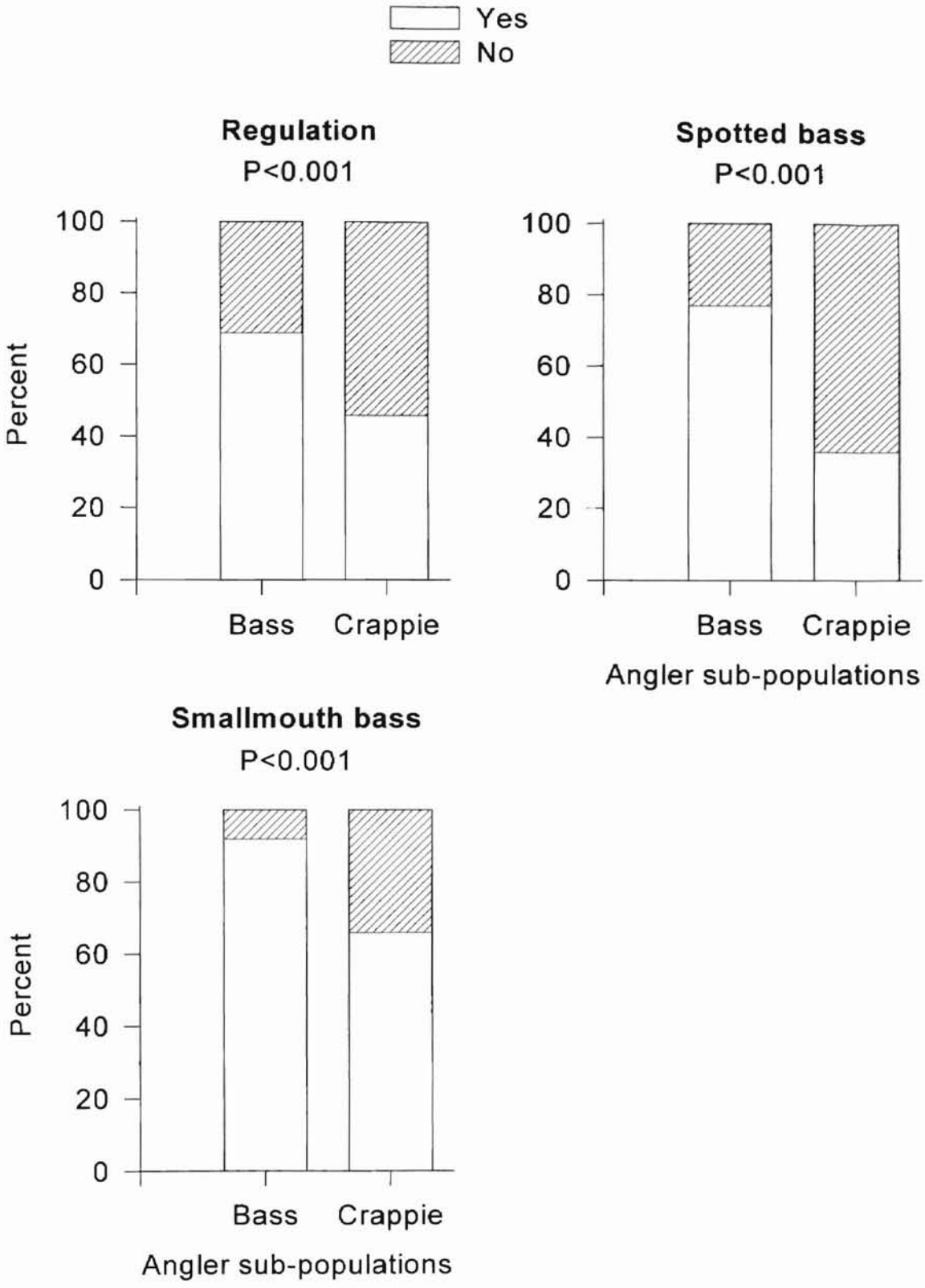
Table 4.--Unidentified bass catch distributions among angler sub-populations at Skiatook Lake.

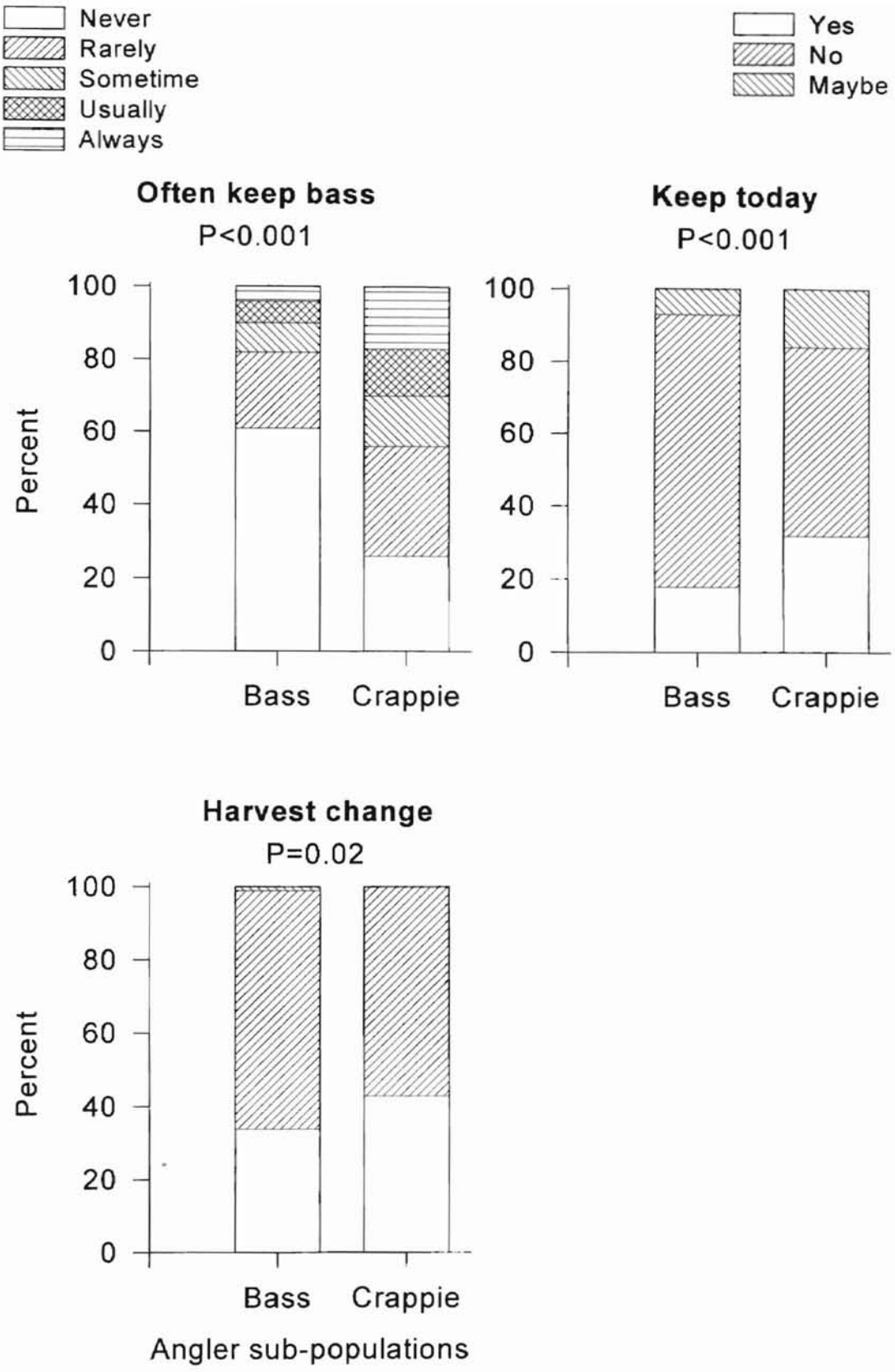
Sub-population	N	CPUE	% of surveys	Effort	Total catch	% of total catch
Tournament bass	139	0.03	11	51,101	1,431	6
Devoted bass	181	0.04	15	66,541	2,582	11
Frequent bass	137	0.03	11	50,365	1,310	5
Occasional bass	210	0.08	17	77,202	6,176	25
Devoted crappie	190	0.05	15	69,850	3,283	13
Frequent crappie	187	0.07	15	68,747	4,606	19
Occasional crappie	197	0.07	16	72,423	5,070	21
Total	1241		100	456,230	24,457	100

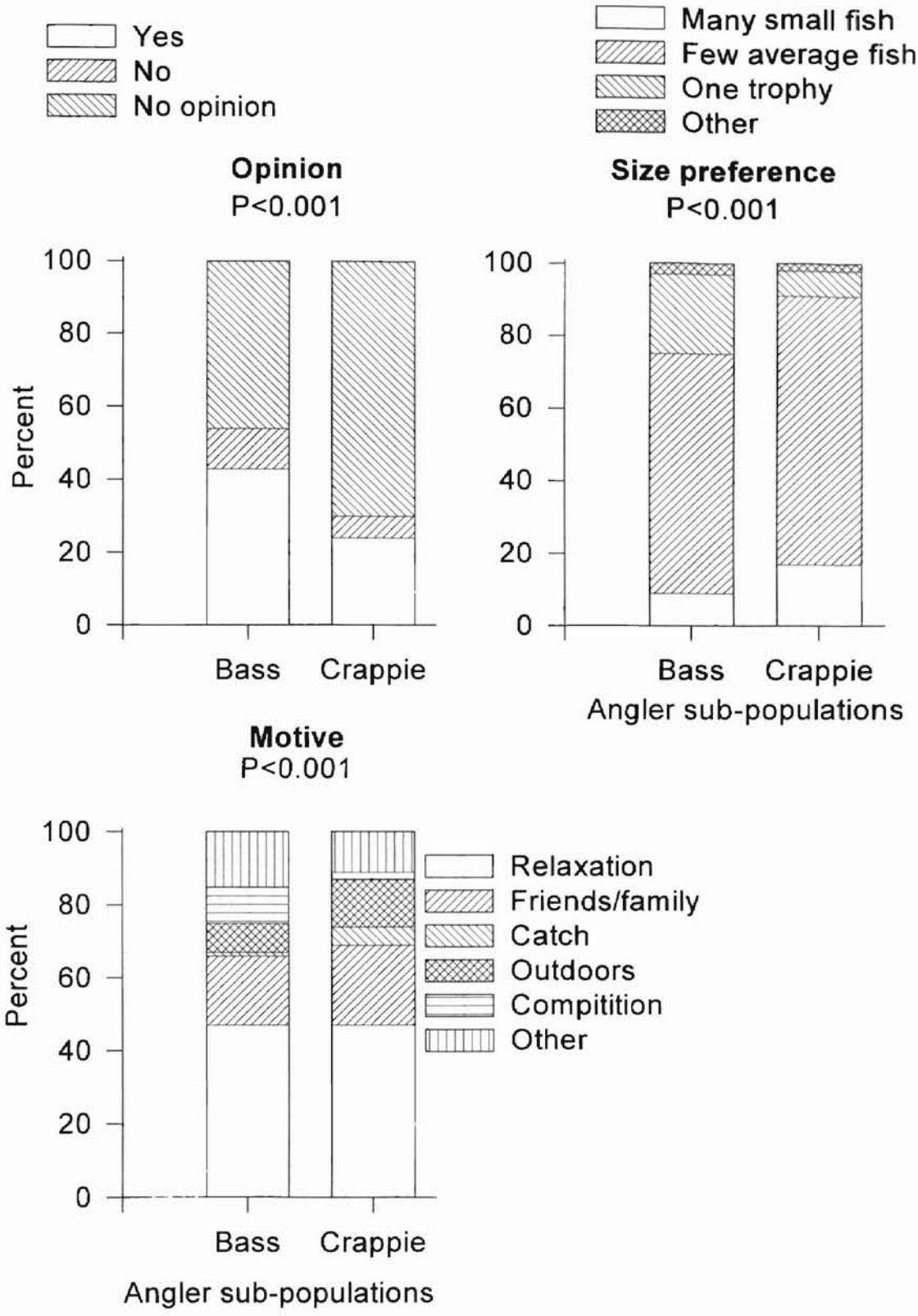
Figure 9. Crappie angler sub-populations responses to the question did you know spotted bass can be distinguished from largemouth bass by feeling for the tooth patch from 1997-1999 at Skiatook Lake.

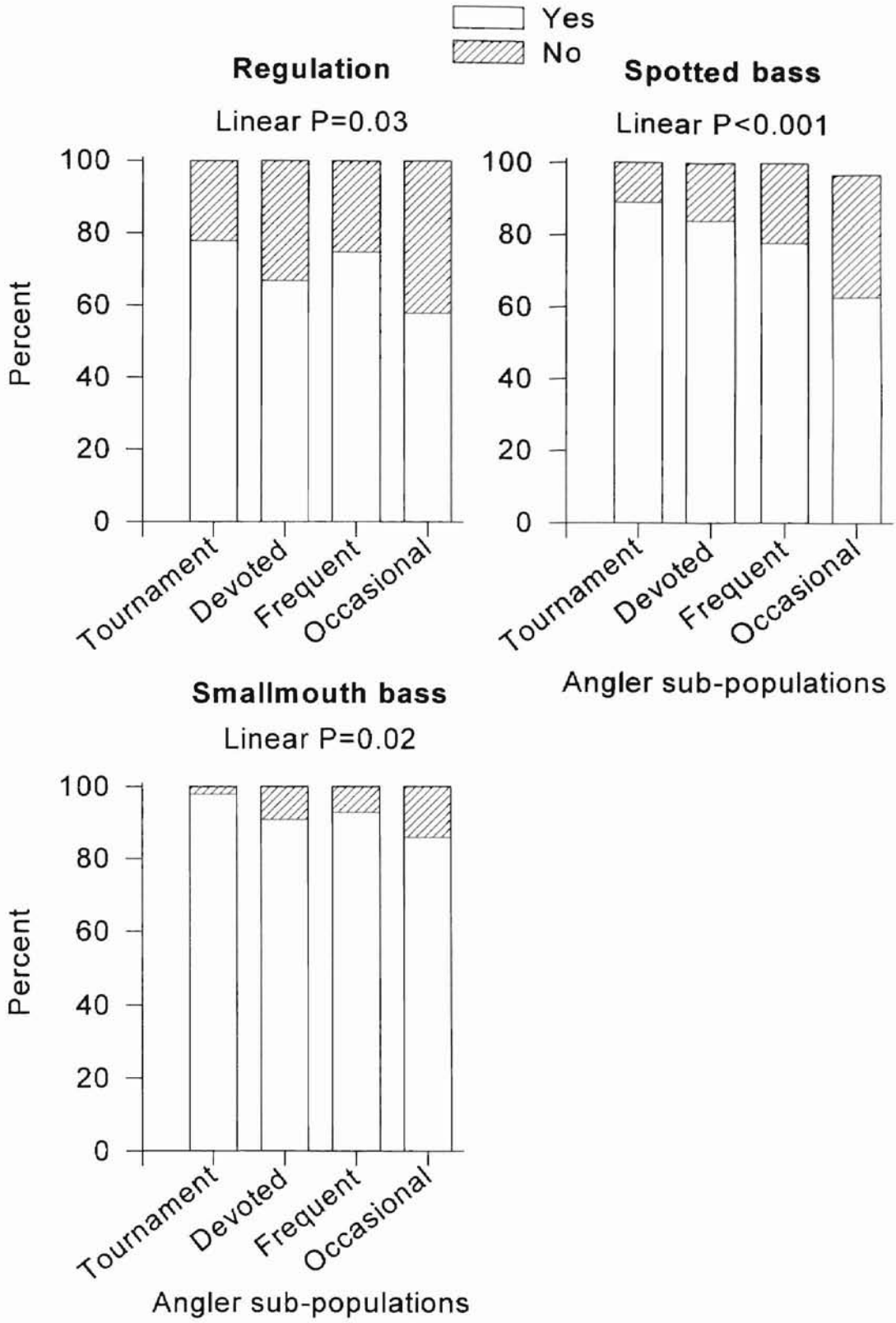
Figure 10. Bass and crappie angler sub-populations responses to the question what is the most important reason why you go fishing from 1998-1999 at Skiatook Lake.

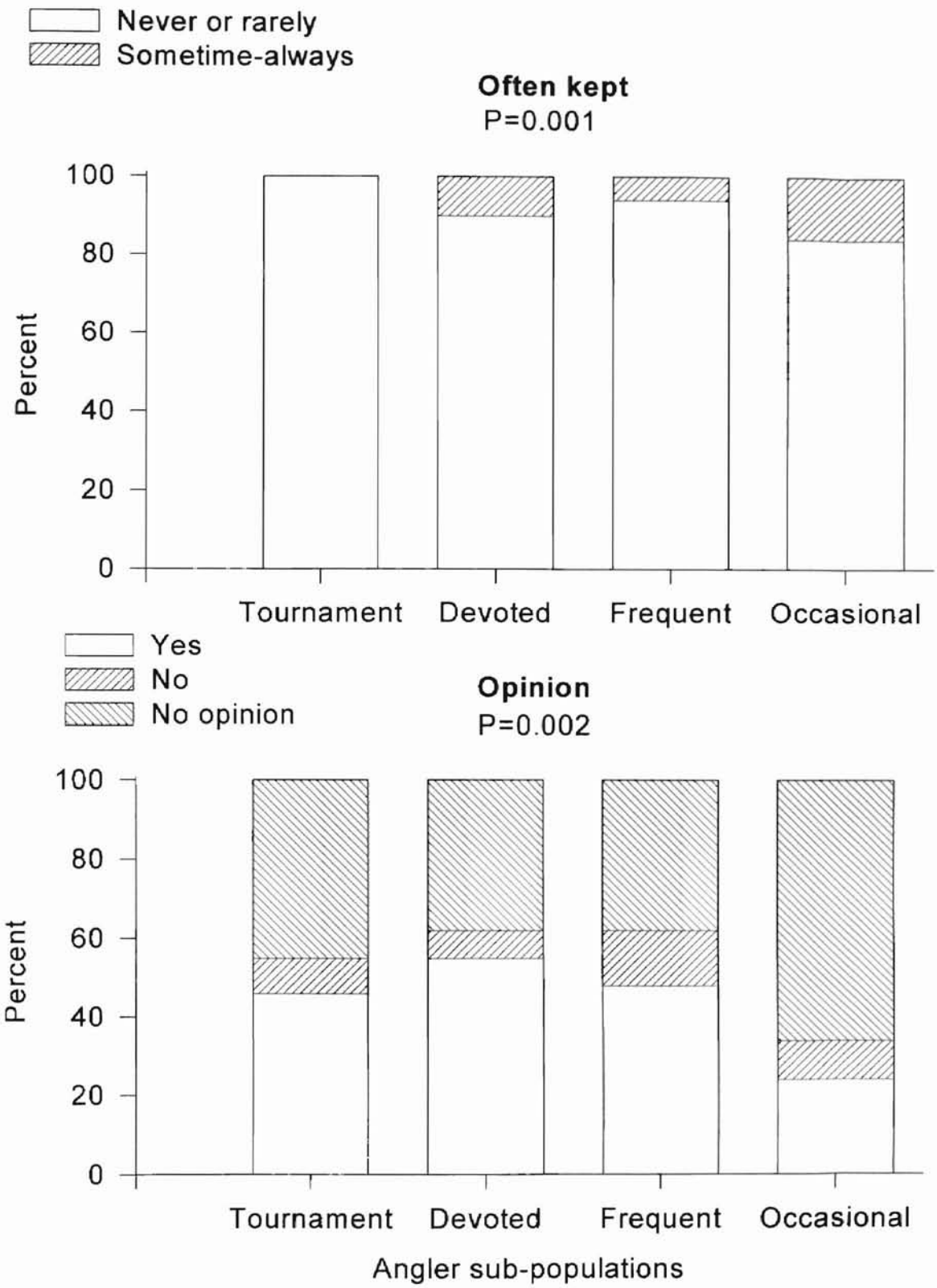

N
C
B
D
A
F
E

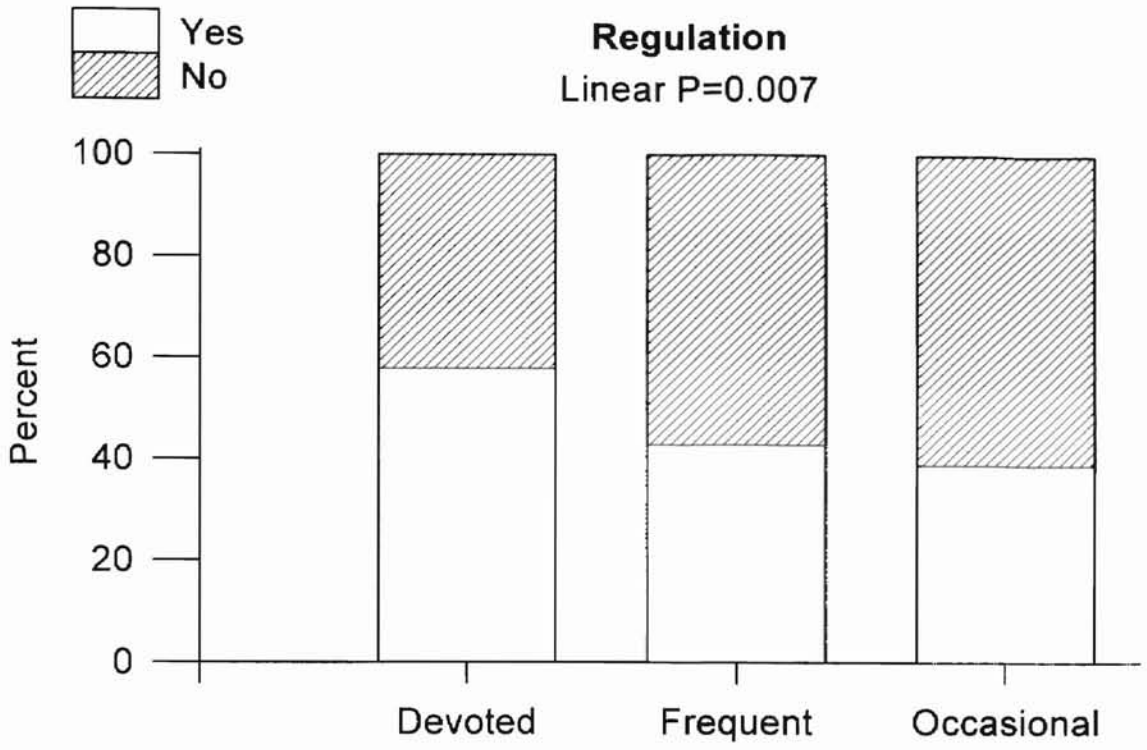

Yes
No
Regulation
P<0.001
Spotted bass
P<0.001
Smallmouth bass
P<0.001
Percent
100
80
60
40
20
0
Bass
Crappie
Angler sub-populations

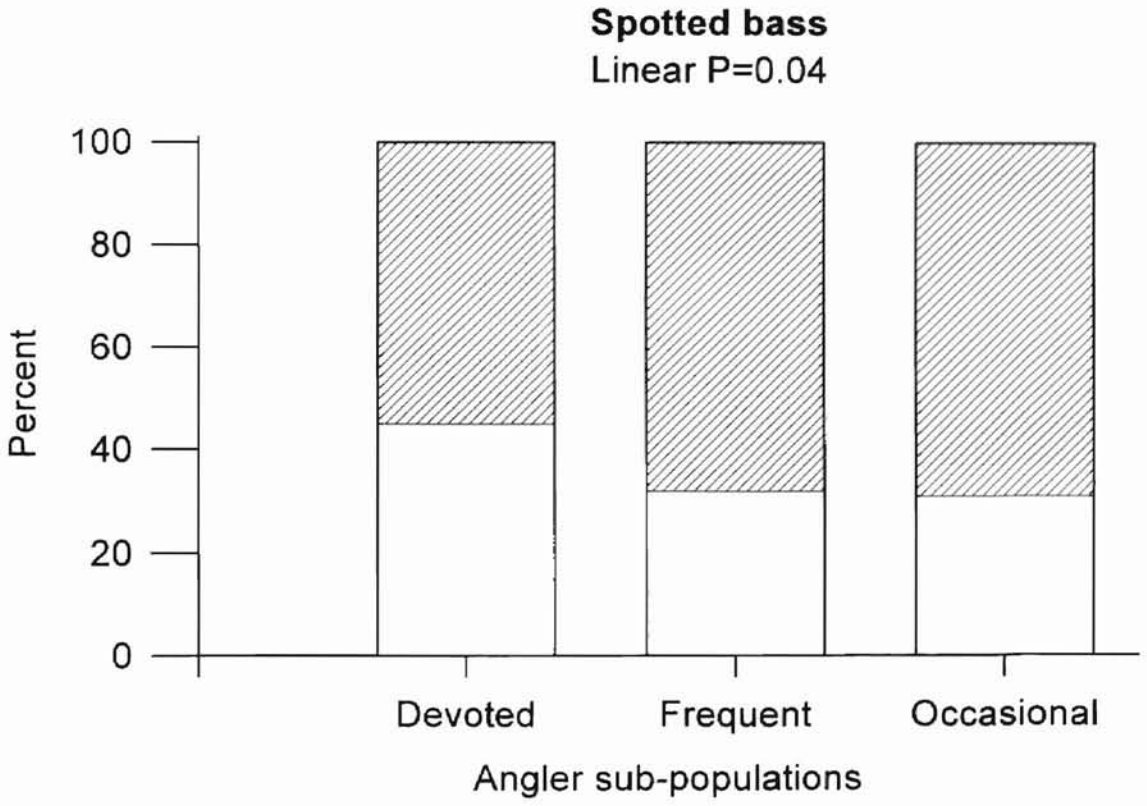

Never
Rarely
Sometime
Usually
Always
Yes
No
Maybe
Often keep bass
P<0.001
Keep today
P<0.001
Percent
100
80
60
40
20
0
Bass
Crappie
Harvest change
P=0.02
Angler sub-populations

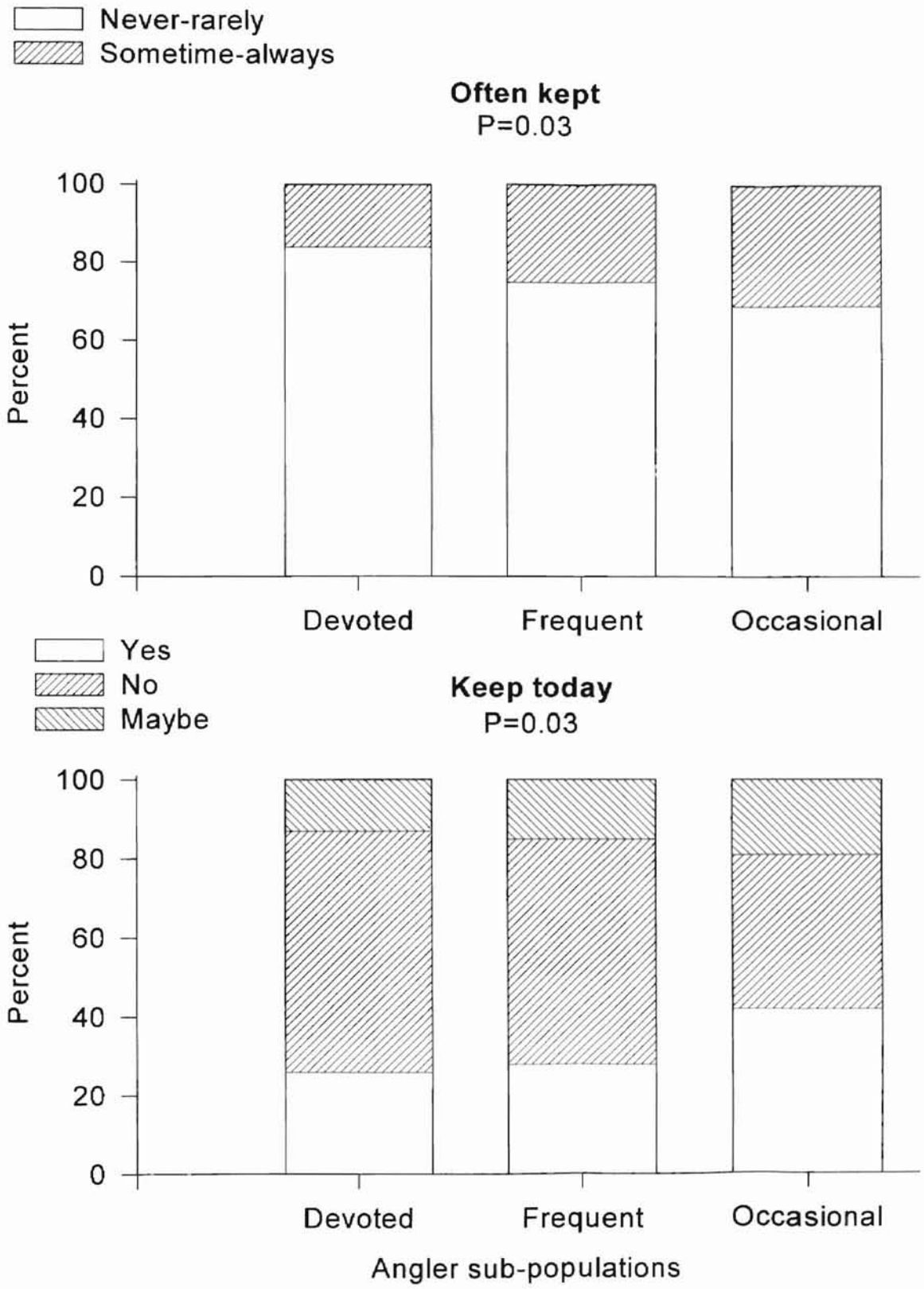

Yes
No
No opinion
Opinion
P<0.001
Many small fish
Few average fish
One trophy
Other
Size preference
P<0.001
Percent
100
80
60
40
20
0
Bass
Crappie
Angler sub-populations
Motive
P<0.001
Relaxation
Friends/family
Catch
Outdoors
Compitition
Other

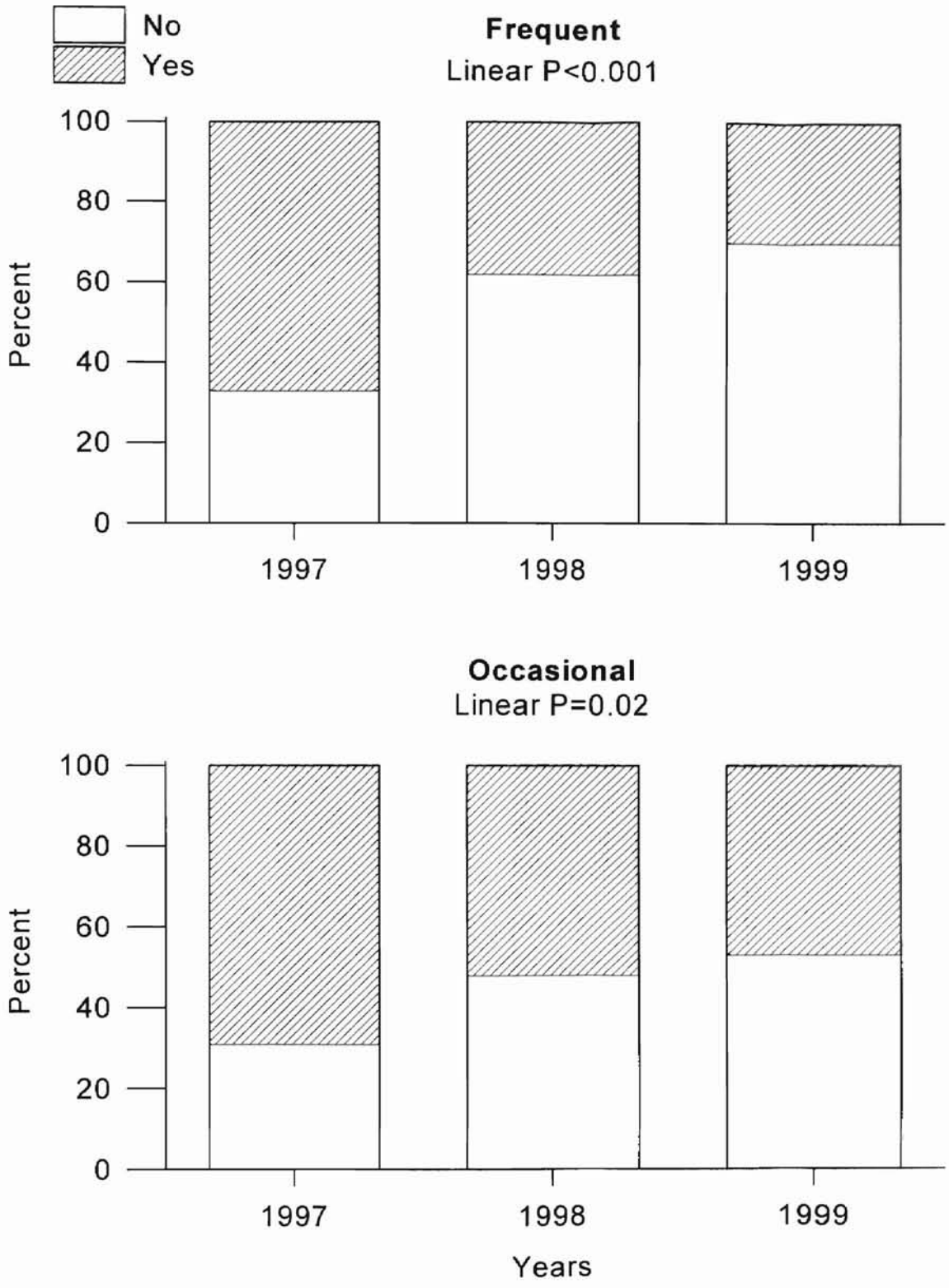

Yes
No
Regulation
Linear P=0.03
Spotted bass
Linear P<0.001
Smallmouth bass
Linear P=0.02
Percent
100
80
60
40
20
0
Tournament
Devoted
Frequent
Occasional
Angler sub-populations

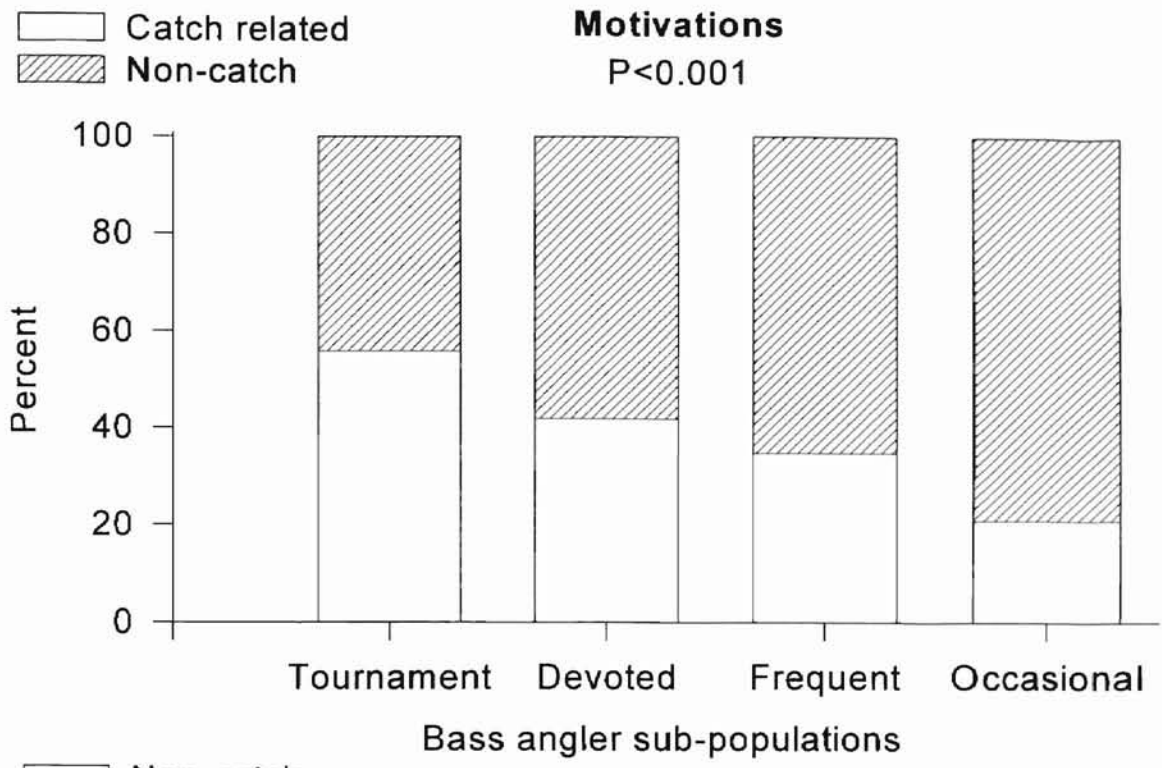

Never or rarely
Sometime-always
Often kept
P=0.001
100
80
60
40
20
0
Percent
Tournament
Devoted
Frequent
Occasional
Yes
No
No opinion
Opinion
P=0.002
100
80
60
40
20
0
Percent
Tournament
Devoted
Frequent
Occasional
Angler sub-populations

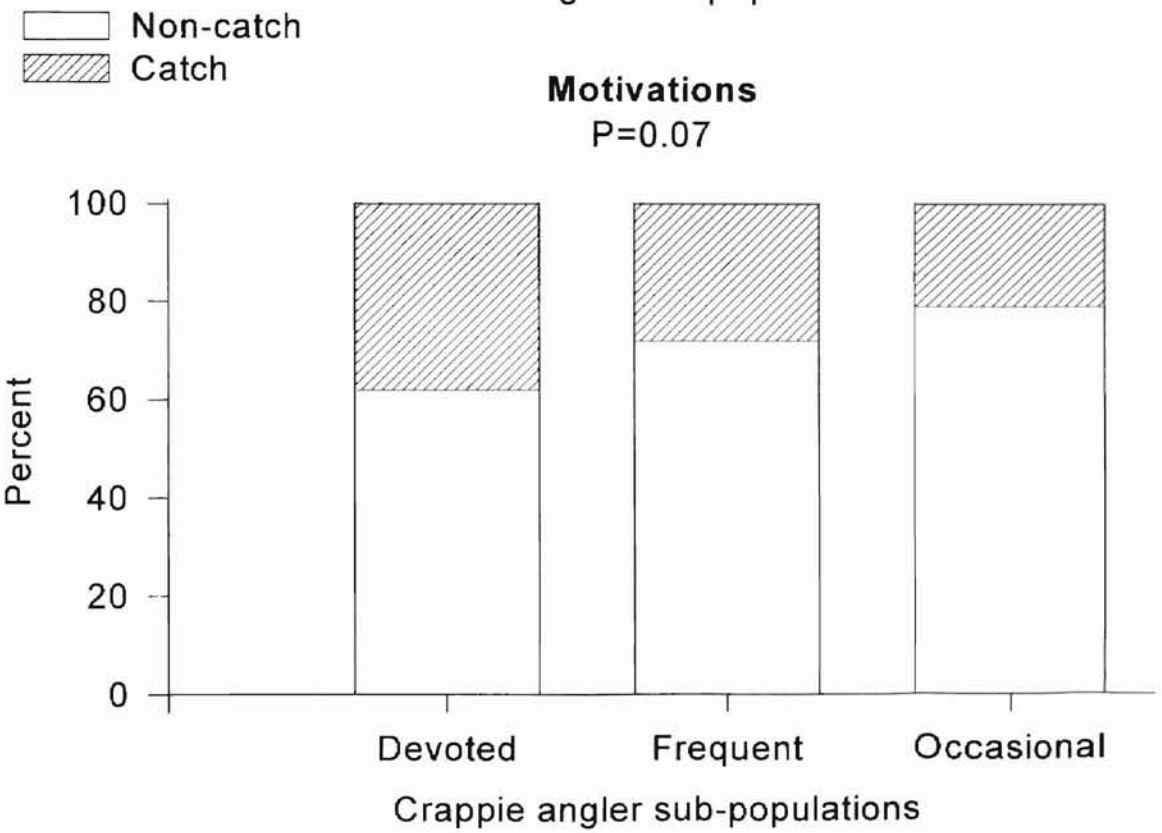

Yes
No
Regulation
Linear P=0.007
100
80
60
40
20
0
Percent
Devoted
Frequent
Occasional


Spotted bass
Linear P=0.04
100
80
60
40
20
0
Percent
Devoted
Frequent
Occasional
Angler sub-populations


Never-rarely
Sometime-always
Often kept
P=0.03
Percent
100
80
60
40
20
0
Devoted
Frequent
Occasional
Yes
No
Maybe
Keep today
P=0.03
Percent
100
80
60
40
20
0
Devoted
Frequent
Occasional
Angler sub-populations


No
Yes
Frequent
Linear P<0.001
100
80
60
40
20
0
Percent
1997
1998
1999
Occasional
Linear P=0.02
100
80
60
40
20
0
Percent
1997
1998
1999
Years


Catch related
Non-catch
Motivations
P<0.001
100
80
60
40
20
0
Percent
Tournament
Devoted
Frequent
Occasional
Bass angler sub-populations


Non-catch
Catch
Motivations
P=0.07
100
80
60
40
20
0
Percent
Devoted
Frequent
Occasional
Crappie angler sub-populations

Appendix A. Oklahoma State University Institutional Review Board Human Subjects Review for 1997-1999.

Appendix A.

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 10-21-96 IRB#: AS-97-016

Proposal Title: EVALUATION OF A DIFFERENTIAL HARVEST REGULATION ON BLACK BASS POPULATIONS IN SKIATOOK LAKE, OKLAHOMA

Principal Investigator(s): William L. Fisher, James M. Long

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING. AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

Signature: _____ Date: October 23, 1996
Chair of Institutional Review Board

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: February 24, 1998 **IRB #: AS-98-046**

Proposal Title: ANGLER CATCH, HARVEST AND EFFORT ASSOCIATED WITH A DIFFERENTIAL BLACK BASS HARVEST REGULATION. SKIATOOK LAKE, OKLAHOMA; A HUMAN DIMENSIONAL APPROACH

Principal Investigator(s): William L. Fisher, Randy Hyler

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:

Signature: _____
Chair of Institutional Review Board

Date: February 26, 1998

cc: Randy Hyler

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

DATE: 02-24-98 **IRB #:** AS-98-046A

Proposal Title: **ANGLER CATCH, HARVEST AND EFFORT ASSOCIATED WITH A DIFFERENTIAL BLACK BASS HARVEST REGULATION. SKIATOOK LAKE, OKLAHOMA: A HUMAN DIMENSIONAL APPROACH**

Principal Investigator(s): William L. Fisher, Randy Hyler

Reviewed and Processed as: Continuation

Approval Status Recommended by Reviewer(s): Approved

Signature: Carol Olson Date: January 14, 1999

Carol Olson, Director of University Research Compliance
cc: Randy Hyler

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

Randy G. Hyler

Candidate for the Degree of

Master of Science

Thesis RESPONSE OF ANGLERS TO A DIFFERENTIAL HARVEST REGULATION ON THREE BLACK BASS SPECIES IN SKIATOOK LAKE, OKLAHOMA

Major Field: Wildlife and Fisheries Ecology

Biographical:

Education: Graduate from North Polk High School, Alleman, Iowa; received Bachelor of Science degree in Fisheries and Wildlife Biology from Iowa State University, Ames Iowa in December 1993; Completed the requirements for the Master of Science degree with a major in Wildlife and Fisheries Ecology at Oklahoma State University in December 2000.

Experience: Employed by the Iowa Department of Natural Resources at Big Creek State Park as a Natural Resource Aide from March 1996 to April 1996; Employed by the Iowa Department of Natural Resources Fisheries Bureau in Brighton, Iowa as a, Natural Resource Aide from April 19/96 to October 1996; Employed by the Oklahoma Cooperative Fish and Wildlife Research Unit at Oklahoma State University, Stillwater, OK as a Fisheries Technician (Field Assistant II) from October 1996 to August 1997; Employed by the Oklahoma Cooperative Fish and Wildlife Research Unit at Oklahoma State University, Stillwater, OK as a Graduate Research Assistant from August 1997 to the present.

Professional Memberships: American Fisheries Society, Oklahoma Chapter of the American Fisheries Society, Oklahoma Academy of Science.