Recreational Fishing for Black Bass in Eastern Oklahoma Streams

Craig D. Martin,[1] *Oklahoma Cooperative Fish and Wildlife Research Unit, Department of Zoology, Oklahoma State University, Stillwater, OK 74078*

William L. Fisher,[2] *U.S. Geological Survey, Oklahoma Cooperative Fish and Wildlife Research Unit, Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078*

Abstract: We evaluated recreational fishing for black bass (*Micropterus*) species in two eastern Oklahoma streams. We conducted creel and tagging exploitation studies on the Baron Fork of the Illinois River in northeastern Oklahoma and Glover River of the Little River in southeastern Oklahoma. We used a roving creel survey on Baron Fork and the bus-route creel survey on Glover River. Over three years, exploitation rates of smallmouth bass in Baron Fork exceeded those in Glover River by about 30% and for all black bass by about 7%. Catch and harvest per unit effort, fishing pressure, and yield on Baron Fork exceeded those of Glover River. The smallmouth bass (*M. dolomieu*) fishery in Baron Fork was characterized by high catch and harvest rates, and yield was among the highest reported in the literature for smallmouth bass stream fisheries. Conversely, the fishery in Glover River was typified by lower catch and harvest; however, the average length of smallmouth bass at harvest was greater. Spotted bass (*M. punctulatus*) and largemouth bass (*M. salmoides*) made up a substantial proportion of the catch and harvest in Glover River but proportionately less in Baron Fork. Size and bag limit regulations were implemented on the black bass fisheries in these streams in 2003, and our findings support these regulations. However, stream anglers in these streams need to be re-surveyed to evaluate the effectiveness of the regulations as well as angler compliance and satisfaction.

Key words: Micropterus, creel survey, exploitation, length limits

Proc. Annu. Conf. Southeast. Fish and Wildl. Agencies 62:168–176

Warmwater stream fisheries are a valued resource in the southeastern United States (Fisher et al. 1998). In Oklahoma, stream fishing is particularly popular in the eastern part of the state where approximately 12% of licensed anglers fished in streams and rivers in 1993. A total of 70% of anglers fished for black bass (*Micropterus*) species and spent approximately U.S. $23 million on trip expenditures (Fisher et al. 2002). Although stream fishing in eastern Oklahoma is a traditional source of recreation for many local residents and enthusiasts from nearby urban areas, little is known about fishing effort, pressure, catch, and harvest in streams. In southeastern Oklahoma, Finnell et al. (1956) documented light to moderate fishing pressure in the Little River. Andrews et al. (1974) found that differences in the catch of fish above and below Broken Bow Reservoir on the Mountain Fork River were attributable to differences in water quality between these areas, and Schreiner et al. (1995) reported that the Broken Bow tailwater trout fishery generated nearly $1 million annually in angler net benefits. Apart from these studies, there have been no comprehensive surveys of recreational fishing for black bass in eastern Oklahoma streams.

Regulation of the smallmouth bass (*M. dolomieu*) recreational fishery in eastern Oklahoma streams has been considered since the 1950s. In the early 1950s, researchers were concerned over the general lack of quality size (≥ 254 mm) smallmouth bass in the Illinois River basin in northeastern Oklahoma even though stock size (< 254 mm) appeared to be abundant (Leonard and Jenkins 1952). Smith (1982) surveyed fishery resources in the upper Illinois River basin (i.e., Baron Fork and Flint Creek) and found that smallmouth bass were widely distributed and abundant; however, large adults (≥305mm) were not well represented in the samples, and he concluded that over-harvest of large smallmouth bass may be occurring. In the Glover River in southeastern Oklahoma, Orth et al. (1983) documented age, growth, and relative condition of smallmouth bass and concluded that, although these population characteristics indicated exploitation was similar to that in other streams, the Glover River was unable to sustain a quality smallmouth bass fishery. They recommended slot-length limits as an alternative restrictive harvest regulation because minimum length regulations would increase competition among sub-legal smallmouth bass for an already limited food resource. Based on a survey of black bass abundance and year-class strength at 62 sites in 21 streams in eastern Oklahoma, Stark and Zale (1991) recommended a 229 to 305-mm slot-length regulation on smallmouth

1.Current address: U. S. Fish and Wildlife Service, 4401 N. Fairfax Drive, Arlington, VA 22203

2. Current address: U. S. Geological Survey, New York Cooperative Fish and Wildlife Research Unit, and Department of Natural Resources, Cornell University, Ithaca, New York 14853

bass in northeastern streams to minimize intraspecific competition, which they postulated was occurring because of high relative abundance and slow growth rates for smaller fishes. In contrast to Orth et al's. (1983) recommendations for Glover River, Stark and Zale (1991) recommended a high minimum length regulation (>381 mm) for smallmouth bass and generous bag limits for other black bass species in southeastern Oklahoma streams. Stark and Zale (1991) hypothesized that this length limit would promote survival of younger individuals while allowing harvest of trophy fish, and that generous bag limits would concentrate angler exploitation on spotted bass (*M. punctulatus*) and subsequently allow smallmouth bass population size to increase. Balkenbush and Fisher (1999) found that the fishery potential for smallmouth bass in Glover River was limited in part by low abundance, poor year-class success, and high annual mortality resulting in low recruitment to older ages. In Baron Fork, however, smallmouth bass were abundant, exhibited good year-class success, and low annual mortality. Growth of early-age smallmouth bass was similar between streams. Dauwalter and Fisher (2008) reported higher survival of age 1+ smallmouth bass in the Baron Fork compared with Glover River populations. These studies indicate that there are distinct geographic differences in smallmouth bass populations in eastern Oklahoma that may require different management strategies.

Information on fishing effort, catch, and harvest, survival, mortality, and exploitation is crucial for formulating management policies (Paragamian 1984a). However, management regulations that are beneficial for one geographic region may not be applicable to another. For this reason, it is imperative to evaluate fishing effort, catch and harvest before implementing regulations (Fox 1975, Smith and Kauffman 1991). The objectives of this study were to evaluate and compare the black bass stream fisheries, particularly smallmouth bass, in two different geographic regions of Oklahoma: Baron Fork of the upper Illinois River Basin in northeastern Oklahoma and Glover River of the upper Little River Basin in southeastern Oklahoma; and use this information in conjunction with population characteristics to evaluate current management regulations.

Methods

Study Area

Baron Fork and Glover River are free-flowing rivers in eastern Oklahoma. Baron Fork is a state scenic river that flows primarily through private land except for the lower 4 km, which is owned by the U.S. Army Corps of Engineers as flood control for Lake Tenkiller. A large percentage of anglers fishing Baron Fork gain access to the stream through private land, clubs, and church camps. Along the creeled stream section, public access is restricted to three sites, two of which are bridge crossings. These sites are managed by the Oklahoma Scenic River Commission and are intensely used during the summer months by swimmers and picnickers.

Glover River flows almost entirely through land holdings of private timber companies and the U.S.D.A. Forest Service. The timber companies allow unlimited access to their land for fishing, hunting and other recreational uses. Because the topography of Glover River is mainly steep slopes and sharp ridges, most of the fishing access is limited to low-water bridge crossings and logging roads abutting the stream. Low flows and emergent boulders and bedrock in summer preclude canoeing on the river. Habitat characteristics of these streams are described in further detail in Balkenbush and Fisher (1999) and Dauwalter and Fisher (2008).

Roving Creel Survey

We used a roving creel survey on the Baron Fork (Robson 1991). We delineated a 16.7 km section was delineated and defined three sub-sections of 8.3 km (section 1), 5.5 km (section 2) and 2.9 km (section 3). We floated all sections each creel day and randomized the order floated, a process which yielded six possible creel combinations. Each combination was unique in the time it took to complete the survey. Mean creel time was 7.11 h (range, 6.08–8.08 h). Creel survey duration exceeded or was less than one-half the length of the fishing day depending on the length of daylight. Starting times were randomized using continuous uniform probabilities when survey duration was less than one-half the length of the fishing day. Work periods with this randomization scheme were biased towards the middle of the time period (Hoenig et al. 1993); however, this bias was unavoidable.

Surveys were conducted monthly (time blocks) from 1 April to 30 September in 1994 and 1995 and stratified by weekdays and weekend days. Each primary sampling unit (fishing day = sunrise to sunset) was split into two secondary sampling units (work periods), and early (morning) or late (afternoon) creel surveys were chosen for each creel day with equal (50%) probability of selection.

Length of time needed to complete angler interviews was minimized and timed checkpoints were established at the end of each sub-section to ensure that creel clerks stayed on a pre-specified schedule (Wade et al. 1991). Fishing parties were systematically skipped (i.e., every other fishing party) during high-use days to ensure time schedule commitments (Hayne 1991, Wade et al. 1991, Pollock et al. 1994). Stream sections were traveled by floating downstream in a canoe and shuttling between sub-sections. A progressive count was made while floating downstream, and all anglers in the process of fishing were included in the count (Fleener 1975, Van Den Avyle 1986, Hoenig et al. 1993). Persons considered to be actively fishing included those who were in the act of fish-

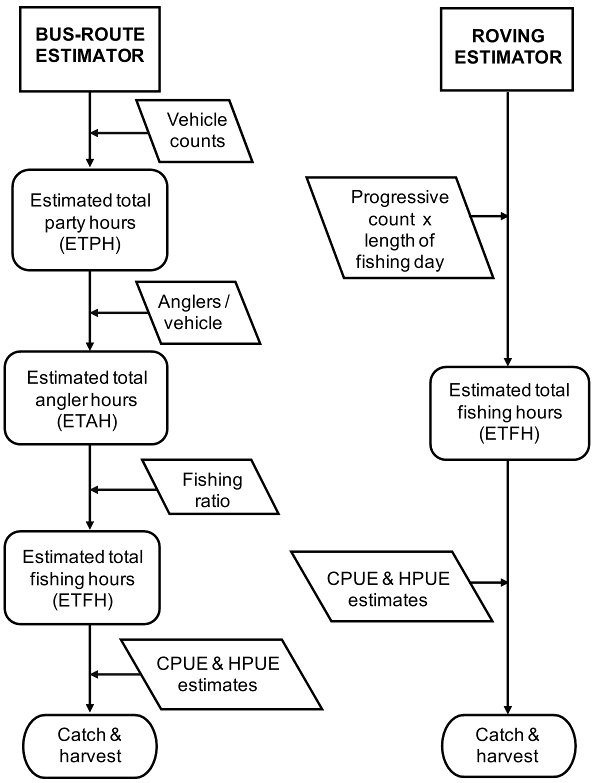

Figure 1. Flow chart depicting bus-route and roving creel survey estimation on Glover River and Baron Fork, respectively, of fishing pressure, catch, and harvest.

ing, moving between fishing sites, changing fishing tackle, or moving into or out of the fishery (Phippen and Bergersen 1987, 1991). Sub-sections were not started during inclement weather (e.g., severe rainstorms) to ensure clerk safety. Catch cards were distributed to anglers who had not completed their fishing trips to obtain complete trip information and additional catch information.

To obtain an estimate of fishing pressure for the entire fishing day, the progressive count was multiplied by the number of hours in the fishing day (Figure 1). Mean of the ratios was used to calculate CPUE and HPUE estimates (Pollock et al. 1994, Pollock et al. 1997).

Bus-route Creel Survey

We used a bus-route creel survey on Glover River (Robson and Jones 1989, Pollock et al. 1994). Two stream sections (24.3 and 3.7 km) were delineated, 11 access points were defined, and a circuitous creel route was mapped along the river. Surveys were conducted monthly from 16 March to 15 September in 1994 and 1995. Monthly sampling periods were stratified into weekday and weekend primary sampling units (fishing days). Six randomly-chosen days, three week days and three weekend days, were surveyed each month. The fishing day was defined as sunrise to sunset, and two secondary sampling units (work periods) were defined for each day. Early (morning) or late (afternoon) starting times, locations, and direction of travel were randomly chosen for each survey. Waiting times were partitioned among access sites proportional to their probability of being fished. Surveys were nine hours and wait periods were on average 56% (range, 277–327 min; mean, 304 min) of the total survey length. Wait periods at creel sites ranged in length of time from 14 to 42 min. Schedules were used to keep creel clerks on specified arrival and departure times. At each access site, clerks counted the number of vehicles, interviewed anglers, and placed postage-paid self-addressed recreational survey cards on all parked vehicles.

To ensure that the bus-route survey sampled the majority of anglers in Glover River, we verified it with a roving creel survey. In June 1994, five roving creel surveys were conducted concurrently with the bus-route survey. Six sections were defined on the river and four were randomly chosen with uniform probabilities for each verification survey. Procedures described above were used for the roving creel surveys. Estimates of fishing pressure, catch, and harvest did not significantly differ (t-test; $P > 0.10$) between the bus-route and roving verification estimates. Ninety percent (18 of 20) of the anglers encountered during the roving survey were using bus-route creel access areas.

Estimated total party hours (ETPH) were derived from instantaneous arrival and departure counts of parked vehicles at access sites (Figure 1). We adjusted ETPH estimates that included stream users who were not fishing (e.g., campers) by multiplying ETPH by the average number of anglers per vehicle. The resulting product represented an estimate of the number of angler hours during the creel day (estimated total angler hours, ETAH). This estimate includes time spent by anglers fishing and doing other activities (e.g., swimming, camping). To obtain an estimate of actual fishing hours, we adjusted ETAH by a fishing ratio correction factor. This ratio was estimated by dividing the average length of time spent fishing by the total length of time at the stream. The resulting product estimated the actual number of fishing hours during the creel day (estimated total fishing hours, ETFH). The mean of the ratios was used to calculate CPUE and HPUE estimates (Pollock et al. 1994).

Based on 1993 pilot creel surveys, stream flows greater than 70.8 m^3/sec on Baron Fork and Glover River were designated as non-fishable. Monthly strata estimates were adjusted to reflect the number of "fishable" days (Fleener 1975, Spiller et al. 1988).

Relative standard error (100 x SE/mean) estimates were used to compare the precision of annual, monthly, and strata estimates between the two methods. Estimates ≤20% of the mean were considered precise, whereas those not falling within the recommended range of precision were considered imprecise (Malvestuto 1983).

Survey Implements

On-site survey cards (i.e., recreational survey cards for the bus-route creel and catch cards for the roving creel) were used to obtain additional catch and harvest information and to calculate fishing ratios and the number of anglers per vehicle on the bus-route creel survey (Figure 1). Survey questions were constructed to ensure that potential respondents (anglers and other stream users) were not positively or negatively influenced by questionnaire wording, especially as it pertained to their likelihood of returning the survey card. For this reason, each stream user was able to answer all questions on the survey card except the last one about the number of fish caught and harvested. We included this question on the card to gather catch and harvest data because this information was limited in the 1993 pilot creel surveys. Information signs and flyers were posted at all access sites explaining the recreational aspect of the project and expressing the need for cooperation. As an added incentive to increase response rates from all stream users, a $100 cash drawing was offered to survey card consignees.

Information gathered from recreational survey cards and from interviews included the parties' arrival time and departure time, time spent fishing, number of anglers in party fishing, number of vehicles in party, number of fish caught and kept, length of fish being harvested, plus other related fishing information (Fisher et al. 2002).

Exploitation and Mortality Rates

Black bass greater than 180 mm were collected by electrofishing and angling to evaluate catch and exploitation rates. Fish were tagged abdominally with 16 x 6-mm disk and 65-mm streamer Floy Tag FM-94 internal anchor tags and released where they were captured. Tags were implanted anterior to the anus, away from the midline, parallel to the body cavity, and adjacent to the posterior end of the pelvic fin (Weathers et al. 1990). Reward signs for tagged fish were posted at each access site, along the stream channel, at private and public camps, and at local convenience food marts. These signs instructed anglers to send tags to Oklahoma State University, and to indicate whether they kept or released the fish, the catch location, the date of capture, and whether they used artificial or natural baits. A limited edition stream angler cap and entry into a $100 cash drawing was offered to each participant as an incentive to increase tag returns. Anglers who returned tags but did not record all the needed information were sent a pre-addressed postage paid envelope with a request asking them to return additional information. Anglers not responding to the written request were contacted by phone and asked to provide the omitted information.

Ricker's (1975) model for computation of biological statistics for fish populations was used to estimate annual mortality, survival rates, and exploitation. Total mortality (A) was equal to fishing mortality (u) plus natural mortality (v) or $1 - e^{-Z}$, where Z is the instantaneous mortality rate, u is instantaneous fishing mortality (F) times A/Z, and v is instantaneous natural mortality (M) times A/Z (Van den Avyle and Hayward 1999). Exploitation and survival of black bass were determined by marking fish in consecutive years. Two angler return rates were used to bracket a low-end and high-end catch and exploitation rate by assuming 100% and 64% of anglers who caught fish with tags returned the tag as instructed. This study did not assess the accuracy of these rates but used the estimates and methodology derived by Weathers and Bain (1992). Although exploitation estimates were calculated using 100% and 64%, this study made the assumption that the 64% estimate was a closer approximation to the actual tag return rate (non response) by anglers.

Results

Seventy-one creel surveys were conducted on Baron Fork and 78 creel surveys on Glover River in 1994 and 1995. During the creel year, an average of 3.7 (± 3.2 SD) and 2.7 (± 2.4 SD) interviews per creel were conducted on Baron Fork and Glover River, respectively. About one-third of the distributed catch cards were returned by Baron Fork anglers and over one-fourth of the recreational survey cards were returned by Glover River anglers. Interviews where anglers had not accumulated 0.75 hours of fishing were omitted from analyses.

Fishery Characteristics

Although catch rates for all centrarchid species (i.e., *Ambloplites rupestris, Lepomis cyanellus, L. macrochirus, L. megalotis, Micropterus dolomieu, M. punctulatus, M. salmoides*) were similar for the two years combined between Baron Fork and Glover River, harvest rates in Glover River were greater and catch and harvest rates differed for black bass and smallmouth bass (Table 1). Catch rates for black bass were over three times and catch rates for smallmouth bass were four times greater in Baron Fork than in Glover River.

Fishing pressure and total catch were greater in the Baron Fork than in the Glover River and varied monthly in both streams. Annual fishing pressure on Baron Fork (BF) exceeded fishing pressure on Glover River (GR) by 18% in 1994 (BF 284 ± 11 h/ha, GR 234 ± 16 h/ha) and by 46% in 1995 (BF 220 ± 15 h/ha, GR 140 ± 17 h/ha). Total annual catch from Glover River was one-third less

Table 1. Catch per unit effort (CPUE) and harvest per unit effort (HPUE) estimates (± SE) for centrarchids, black bass, and smallmouth bass creeled from Baron Fork and Glover River, 1994 and 1995. *P* denotes significance level for Mann-Whitney tests of CPUE and HPUE between streams for both years combined.

		Centrarchids[a]		Black bass		Smallmouth bass	
		CPUE	HPUE	CPUE	HPUE	CPUE	HPUE
Year	*n*	(fish/ha)	(fish/ha)	(fish/ha)	(fish/ha)	(fish/ha)	(fish/ha)
Baron Fork							
1994	103	1.91 ± 0.20	0.57 ± 0.12	1.02 ± 0.14	0.30 ± 0.08	0.87 ± 0.13	0.27 ± 0.07
1995	64	2.20 ± 0.37	0.48 ± 0.11	1.28 ± 0.20	0.21 ± 0.07	1.22 ± 0.20	0.19 ± 0.06
Combined	167	1.92 ± 0.18	0.49 ± 0.08	1.12 ± 0.12	0.26 ± 0.06	1.00 ± 0.11	0.24 ± 0.05
Glover River							
1994	89	1.76 ± 0.25	0.72 ± 0.13	0.36 ± 0.10	0.13 ± 0.04	0.25 ± 0.09	0.10 ± 0.03
1995	51	1.85 ± 0.31	0.75 ± 0.27	0.31 ± 0.09	0.08 ± 0.04	0.24 ± 0.07	0.06 ± 0.03
Combined	140	1.61 ± 0.18	0.65 ± 0.11	0.34 ± 0.07	0.11 ± 0.03	0.25 ± 0.06	0.08 ± 0.02
P		0.0621	0.0340	<0.0001	0.3661	<0.0001	0.2298

a. Includes sunfishes (*Ambloplites rupestris*, *Lepomis cyanellus*, *L. macrochirus,* and *L. megalotis*) and black bass (*Micropterus dolomieui*, *M. punctulatus*, and *M. salmoides*).

in 1994 (GR 455 ± 27 *n*/ha, BF 661 ± 18 *n*/ha) and two-thirds less in 1995 (GR 254 ± 32 *n*/ha, BF 643 ± 35 no/ha) than that from Baron Fork. Fishing pressure was greatest in May, June and July on Glover River and from June through September on Baron Fork; total catch followed a similar monthly pattern but differed between years (Figure 2). Catch composition differed substantially between streams and years. During both years, sunfish dominated the catch in Glover River (86% in 1994, 64% in 1995) but were a smaller proportion of the catch in Baron Fork (38% in 1994, 46% in 1995). Black bass were a substantially larger proportion of catch in Baron Fork (50% in 1994 and 1995) than in Glover River (14% in 1994, 19% in 1995) (Table 1). Smallmouth bass was the dominant black bass species caught in both streams (Table 1), but spotted bass and largemouth bass made up a larger proportion of the catch in Glover River than in Baron Fork.

Total annual harvest was similar between Baron Fork and Glover River; however, during 1994 and 1995, black bass harvest was four to five times greater in Baron Fork (Table 2). Black bass harvest was dominated by smallmouth bass in both streams, but its congeners made up a higher percentage of total black bass harvest in Glover River (23%) than in Baron Fork (12%). During the two years, total annual black bass and smallmouth bass yields were two to four times greater in Baron Fork than in Glover River, spotted bass yield was similar in both streams, and largemouth bass yield in Baron Fork was nearly twice that of Glover River (Table 2). In 1994, smallmouth bass harvested in Glover River were significantly ($P < 0.05$) longer (mean TL = 324 ± 64 mm SD, $n = 49$) and heavier (mean mass = 471 ± 258 g SD) than those in Baron Fork (mean TL = 271 ± 45 mm SD, mean mass = 257 ± 112 g SD,

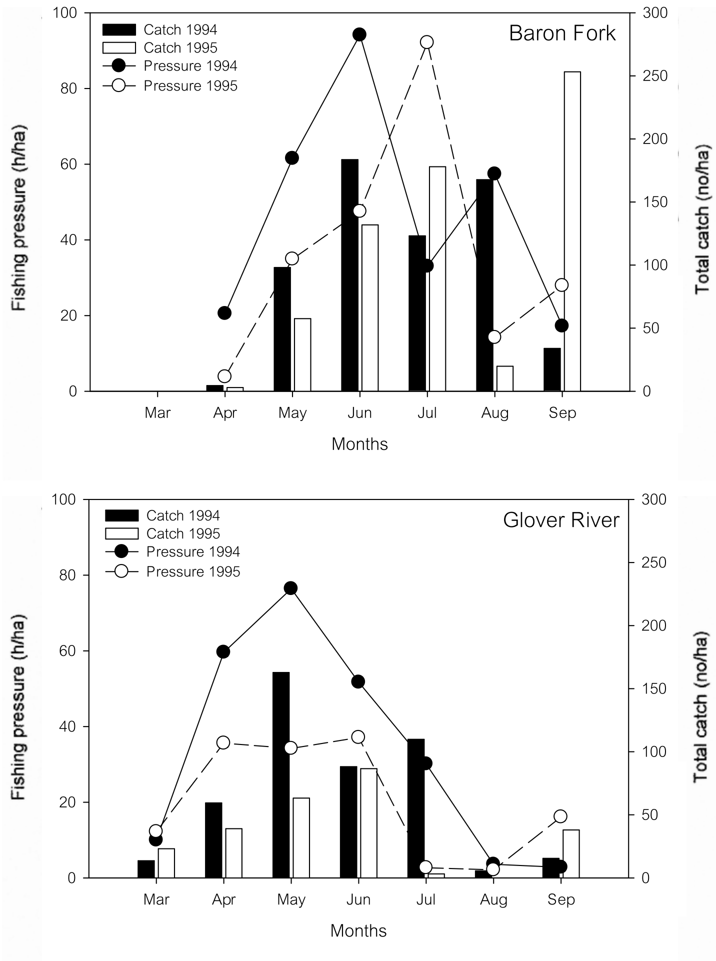

Figure 2. Estimates of monthly fishing pressure for and total catch of fish in the Baron Fork and Glover River and Baron Fork, 1994–1995. Baron Fork estimates began on 1 April and ended 30 September, Glover River estimates began on 16 March and ended on 15 April.

Table 2. Monthly and annual fishing pressure and catch estimates and relative standard error (SE/mean x 100) estimates for black bass from Baron Fork and Glover River, 1994 and 1995.

		Black bass		Smallmouth bass		Spotted bass		Largemouth bass	
Parameter		Baron Fork	Glover River	Baron Fork	Glover River	Baron Fork	Glover River	Baron Fork	Glover River
Harvest (*n*/ha)	1994	94 ± 33	22 ± 28	82 ± 33	16 ± 27	3 ± 36	2 ± 34	9 ± 42	3 ± 51
	1995	69 ± 43	13 ± 32	62 ± 42	10 ± 33	1 ± 40	0 ± 0	6 ± 60	3 ± 39
Yield (kg/ha)	1994	22.5 ± 33	8.4 ± 24	19.5 ± 34	6.2 ± 24	0.6 ± 55	0.8 ± 36	2.2 ± 40	1.2 ± 35
	1995	18.3 ± 46	8.2 ± 36	15.9 ± 44	4.1 ± 36	0.2 ± 40	0 ± 0	2.3 ± 70	1.5 ± 54

Table 3. Catch rate and fishing and natural mortality of smallmouth bass and black bass in Baron Fork and Glover River, 1993–1995. Estimates based on 64% and 100% tag return rates for tagged fish.

		Baron Fork						Glover River					
		Catch rate		Fishing mortality		Natural mortality		Catch rate		Fishing mortality		Natural mortality	
	Year	64%	100%	64%	100%	64%	100%	64%	100%	64%	100%	64%	100%
Smallmouth bass	1993	0.23	0.15	0.10	0.06	0.84	0.88	0.31	0.20	0.13	0.08	0.87	0.92
	1994	0.36	0.23	0.16	0.10	0.68	0.75	0.09	0.06	0.04	0.02	0.96	0.98
	1995	0.20	0.13	0.09	0.06			0.16	0.10	0.07	0.04		
Black bass	1993	0.21	0.13	0.09	0.06	0.85	0.89	0.30	0.19	0.16	0.10	0.84	0.90
	1994	0.34	0.22	0.15	0.10	0.68	0.75	0.13	0.08	0.07	0.04	0.93	0.96
	1995	0.19	0.12	0.08	0.05			0.12	0.08	0.07	0.04		

Table 4. Length regulations, catch, harvest and release rates, mean fishing pressure per hectare, mean length at harvest, and yield estimates for smallmouth bass fisheries in rivers and streams. Range or mean estimates are reported for multiple-year studies. Unit conversions and other estimates were made by the authors where appropriate.

Stream, state	Length regulation (mm)	Mean CPUE (fish/h)	Mean HPUE (fish/h)	Release rate (%)	Mean fishing pressure (h/ha)	Length at harvest (mm)	Yield (kg/ha)	Yield (*n*/ha)	Yield (*U*)[c]	Source
Baron Fork, OK	229–305	1.00	0.24	81	252	270	17.7	72	0.06–0.16[d]	This study
Glover River, OK	305	0.25	0.08	65	187	315	5.2	13	0.02–0.16[d]	This study
Tennessee River, AL	None	0.51[a]	0.16[a]	68	26	360	6.7	9	0.35–0.55[d]	Weathers and Bain 1992
Galena River, WI	None	0.32	0.14	57	185–257	<290	8.2	24–38	0.34	Forbes 1989
Courtois Creek, MO	None	0.10		NA[b]	264–470	<300	6.7–14.8			Fleener 1975
Maquoketa River, IA	305	0.22	0.04	88	635–934	340	4.5–12.1		0.14–0.23[e]	Paragamian 1984b
Shenanhoah River, VA	279–356	0.53		70	233–247			4–72		Smith and Kaufman 1991
Potomac River, MD	254	0.51	0.06	88	98	<300	3.6		0.12	Sanderson 1958

a. CPUE and HPUE estimates based on anglers fishing specifically for smallmouth bass.
b. NA= not available
c. *U* = annual fishing mortality. Mean estimate reported for multiple year studies.
d. Estimates derived from 100% and 64% response rates
e. Estimates for smallmouth bass >200 mm.

n = 80); however, the average length of fish harvested in 1995 was identical (Glover River mean TL = 267 ± 64 mm SD, *N* = 23; Baron Fork mean TL = 267 ± 67mm SD, *n* = 53).

Exploitation

A total of 627 black bass in Baron Fork and 282 black bass in Glover River were tagged with abdominal anchor tags in the spring of 1993, 1994, and 1995. In Baron Fork, 544 smallmouth bass, 33 spotted bass, and 50 largemouth bass were tagged, and in Glover River, 181 smallmouth, 68 spotted, and 33 largemouth bass were tagged. Mean length of tagged fish was 266 mm (SD = 53) and 275 mm (SD = 63) on Baron Fork and Glover River, respectively. The mean number of days tagged fish were at large before being caught by anglers was 94 d (SD = 115) on Baron Fork and 153 d (SD = 146) on Glover River. The maximum number of days tagged fish were at large before being caught was 563 d on Baron Fork and 592 d on Glover River. Although exploitation estimates were calculated using 100% and 64% tag return rates (Table 3), we focused on the 64% response rate because it was the more conservative estimate. From 1993 to 1995, mean exploitation of smallmouth bass on the Baron Fork (mean = 10.7%, SD = 3.8%) was about one-third greater than on the Glover River (mean = 8.0%, SD = 4.6%) (Table 3). Catch rates were higher than exploitation rates on both streams indicating that a large proportion of the bass caught were released.

Black bass fishing mortality varied among years but was similar between Baron Fork and Glover River (Table 3). Fishing mortality averaged 10.7% (SD = 3.8%) in Baron Fork and 10.0% (SD = 5.2%) in Glover River from 1993 to 1995. However, average black bass natural mortality for 1993 and 1994 was about 15% higher in Glover River (mean = 88.5%, SD = 6.4%) than in Baron Fork (mean = 76.5%, SD = 12.0%; Table 3).

Comparisons of smallmouth bass fisheries in Baron Fork and Glover River with those reported in the literature indicate that both of these streams sustain quality fisheries (Table 4). Mean fishing pressure on Baron Fork and Glover River was similar to that of other streams in North America. Both catch and harvest rates on Baron Fork were among the highest reported in the literature; however, CPUE on Glover River was among the lowest and HPUE was intermediate (Table 4). Smallmouth bass yields on Baron Fork were among the highest reported in the literature.

Discussion

The trends in catch and harvest rates we observed for smallmouth bass in Baron Fork and Glover River during 1994 and 1995 paralleled the direction, but not the magnitude, of the population trends and characteristics for this species reported by Balkenbush and Fisher (1999). The substantially higher catch (six times) and harvest (five times) rates of smallmouth bass from Baron Fork versus Glover River corresponded with sizeable differences (1.4 to 4.0 times) in population biomass abundance between these two rivers (Balkenbush and Fisher 1999). Stark and Zale (1991) also found a similar but more pronounced trend for these two streams. This suggests that anglers were utilizing these two fisheries proportionately. Similarly, differences in angling characteristics between the two streams corresponded with differences in population characteristics. In Baron Fork, the comparatively large catch did not yield many harvestable fish of quality size, as indicated by the small length at harvest (mean = 269 mm) compared with that (mean = 296 mm) in Glover River. Correspondingly, Balkenbush and Fisher (1999) found similar growth in younger age (age 1 and 2), but slightly faster growth in older age (age 3+) smallmouth bass in Baron Fork compared with those in Glover River. Comparison of these fishery characteristics with those reported in other studies (Table 4), however, indicates that both streams sustain quality smallmouth bass fisheries.

Annual harvest estimates of smallmouth bass obtained from our survey compared with total estimates for standing stock of havestable-sized (age 1+) smallmouth bass (Balkenbush and Fisher 1999) indicated substantially higher yield in Baron Fork than in Glover River but considerable interannual variation in both streams. In Baron Fork, smallmouth bass harvest was 92% of the estimated standing stock in 1994 but dropped to 65% in 1995. In contrast, harvest in Glover River was 43% of the estimated standing stock in 1994 but only 17% in 1995. Correspondingly, fishing pressure was one-third (1994) to two-thirds (1995) higher in Baron Fork than in Glover River, and pressure declined 31% in Baron Fork and 40% in Glover River between 1994 and 1995. These findings suggest that, on average, Baron Fork had much lower surplus production of smallmouth bass than Glover River, although production varied considerably between years in both streams.

Annual catch of other black bass species (i.e., spotted bass and largemouth bass) was similar in magnitude but proportionately greater in Glover River than in Baron Fork. This trend was similar to Balkenbush and Fisher's (1999) standing stock estimates of other black bass species in Glover River but differed from those in Baron Fork. For 1994 and 1995 combined in Glover River, the proportion of angler catch of spotted bass and largemouth bass (22%) was nearly identical to their standing stock (23%; Balkenbush and Fisher 1999). However, during this same period, angler catch of spotted bass and largemouth bass in Baron Fork consisted of only 6% of the total catch, while standing stock of these species was 40% (Balkenbush and Fisher 1999). Several factors may account for the differential catch between streams. First, Baron Fork anglers were more selective for smallmouth bass than those in Glover River; 88% of all 1993–1995 tag returns from Baron Fork were from smallmouth bass compared with 56% of all tag returns from Glover River. Second, abundances of all three black bass species in both streams were highly variable between years. Balkenbush and Fisher (1999) found that the abundance of other black bass species in Baron Fork was nearly four times greater in 1995 than in 1994, whereas in Glover River, other black bass species made up just over half of the total standing stock in 1994 but none were captured in 1995. Likewise, Stark and Zale's (1991) standing stock estimates of other black bass species from 1988 and 1989 differed greatly from Balkenbush and Fisher's (1999). Stark and Zale (1991) found that the standing stock of other black bass species in Glover River in 1988 was nearly three times (71%) greater than that of smallmouth bass (29%), whereas in Baron Fork smallmouth bass standing stock was 93% of the total black bass catch.

We estimated that nearly one-fifth of the smallmouth bass population was caught each year. In fisheries where catch and release fishing is substantial, exploitation rates may be over estimated (Garner et al. 1984). For this reason, we instructed anglers to clip the tag off if they planned on releasing the fish or to remove the entire tag if they planned on keeping the fish. Estimates of exploitation were derived from anglers who returned tags from the fish they harvested. Fishing mortality was relatively low in Baron Fork and Glover River when compared to estimates from other streams (Table 4). However, if these studies did not account for anglers releasing fish, then the proportion of anglers catching tagged fish was similar to exploitation rates reported by others (Table 4). We assumed 100% tag-retention and no tag-induced mortality for our exploitation analyses. Although Weathers et al. (1990) tested these assumptions over a 3-month period and found tag-induced mortality and tag shedding to be negligible, in this study several fish sampled one-year after tagging had developed lesions at the point of tag entry into the body cavity. Tag-induced mortality or tag shedding would have caused a downward trend in our exploitation estimates.

The smallmouth bass population in Glover River is characterized by high mortality rates with only a small percentage occurring from angler harvest. Orth et al. (1983) estimated total annual mortality for smallmouth bass in Glover River at 61% and Balkenbush and Fisher (1999) 67%. Our estimate of fishing mortality on Glover River ranged from 4% to 13%. Of 161 smallmouth bass in the Little River and Mountain Fork drainage, Finnell (1955) found no bass over 6 years and only 18 (11%) greater than age 3. Similarly, only 12% of the smallmouth bass aged by Orth et al. (1983) and

4% of those aged by Balkenbush and Fisher (1999) were greater than 3 years; neither found fish older than 6 years. Finnell (1955) described fishing pressure as moderate to light, and assuming fishing pressure has increased since the 1950s it seems that fishing has had little impact on the age structure of smallmouth bass in Glover River.

Currently, angler catch and harvest are regulated in Baron Fork and Glover River. These regulations, implemented in 2003, were based on black bass population characteristics in these streams (Stark and Zale 1991, Balkenbush and Fisher 1999) and preliminary findings from this study (Martin 1995, Fisher et al. 1997, Fisher et al. 2002). In Baron Fork and other tributaries of the upper Illinois River, the daily bag limit for black bass is six fish, with no size limit on spotted and largemouth bass. Smallmouth bass, however, are protected by a slot limit (229–305 mm) with only one fish over 305 mm allowed in the daily bag. Increasing harvest of catchable smallmouth bass in Baron Fork may increase growth of all age classes, but because of the already high voluntary release rate (81%), we are uncertain that anglers are complying with the slot-length regulation that encourages harvest of small-sized smallmouth bass. In Glover River, the daily bag limit for black bass is six fish, with no size limit on spotted and largemouth bass; however, there is a 305-mm minimum on smallmouth bass and only three of these fish can be greater than 305 mm. The Glover River is unable to sustain smallmouth bass yields as high as those in Baron Fork, perhaps because of high natural mortality, which seems to be limiting the abundance of larger older-aged fish, and variable recruitment, due in part to the environmental variability and ruggedness of the region (Balkenbush and Fisher 1999, Dauwalter and Fisher 2008). To evaluate the effectiveness of these regulations, including angler compliance and their level of satisfaction, anglers need to be re-surveyed in streams of the upper Illinois River Basin in northeastern Oklahoma (e.g., Baron Fork) and of the upper Little River Basin southeastern Oklahoma (e.g., Glover River). In conjunction with angler surveys, black bass populations should be surveyed to assess abundance and age and size structure.

Acknowledgments

We gratefully acknowledge D. Enck, D. Hickman, G. Robel (deceased), J. Spencer, R. Simmonds, J. Stanovick, G. Thomas, B. Warde, T. Wynn, A. Zale, and personnel from the Oklahoma Cooperative Fish and Wildlife Research Unit for their assistance in various phases of the study. The paper was improved by the thoughtful comments of three anonymous reviewers. Funding for this project was provided by a Federal Aid in Sport Fish Restoration Grant F-41-R from the Oklahoma Department of Wildlife Conservation. The Oklahoma Cooperative Fish and Wildlife Research Unit is a cooperative program of the U.S. Geological Survey, Oklahoma Department of Wildlife Conservation, Oklahoma State University, Wildlife Management Institute, and U. S. Fish and Wildlife Service.

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